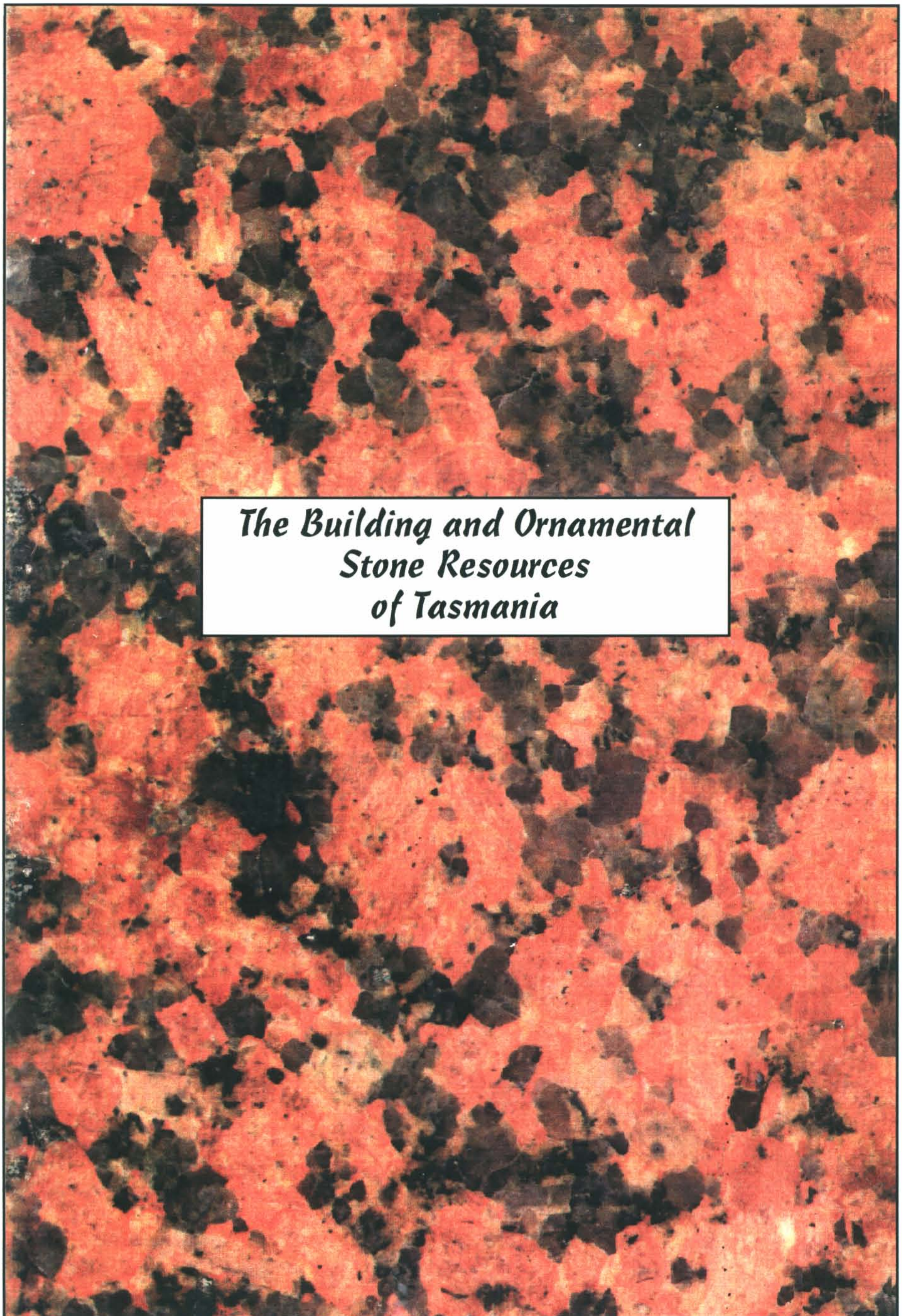

The Building and Ornamental Stone Resources of Tasmania

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The building and ornamental stone resources of Tasmania

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and
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CHAPTER ONE

INTRODUCTION

1.1 Natural stone as a building and ornamental material

Natural dimension stone has been extensively used as a building material in the past. With the advent of cheap artificial building materials the use of stone changed from being a normal building material to becoming increasingly seen as a prestige material. The aesthetic qualities of stone have not, in the writer's opinion, been surpassed by artificial materials, and it is most likely that stone will continue to be favoured into the future.

Human society uses most of the Earth's mineral and stone resouces in a highly processed form, in which they lose their original character (eg, metals, industrial minerals). The use of stone as a building material is different, in that it is precisely the natural aesthetic qualities of the material for which it is valued. The fact that architects and others commonly favour the use of stone in a building whenever budgets will allow it, suggests that the colours, textures and structures of natural stone have a universal appeal which the artificial alternatives of concrete, brick, glass and steel cannot match.

It is tempting to suggest that even after thousands of years of cultural development in urban environments, people still find a totally artificial environment somewhat alienating. Thus, the use of natural building materials in the urban environment may take some of the artificial "edge" off that environment. Given that the human mind evolved in, and can thus be at ease in, a predominantly natural environment, the use of pleasing natural elements, including stone, may serve in a small way to reduce the stress of modern urban life.

Of course, this cannot alone account for the use of stone in modern buildings, especially in such cases as the modern use of granite cladding on high-rise buildings where the natural qualities of the material are less obvious. In fact, a major reason for the current boom in the use of stone is simply that good stone can be a more durable material than many of the artificial alternatives.

The sought after nature of building stone means that stone can command a high price for relatively small volumes of good material. A moderate amount of stone, sandstone, granite and slate, is currently quarried in Tasmania for building purposes. Although some exploration and evaluation of stone resources has previously been carried out, there has been a need for a systematic evaluation of Tasmania's potential dimension stone resources, whose results can be made public in order to encourage the utilisation of Tasmania's full range of stone resources.

1.2 Modern stone use

Over the last 25 years or so the use of stone in major buildings has increased dramatically. The most important applications of stone today are as veneers (wall cladding, exterior and interior) and as paving. Stone furniture (including bench-tops, tables, etc) is also an important application, while gravestones remain a mainstay of the industry. The traditional use of stone as massive masonry blocks has almost disappeared (except in restoration work) due to the high costs involved, and has been replaced by the use of thin veneers.

Although much marble has been used for external veneers, the durability problems associated with marble are resulting in a trend towards greater use of more durable granite veneers, particularly on high-rise buildings. The use of granites is presently booming, particularly in places such as Hong Kong and Japan.

Sandstone and limestone, being of inherently lower durability than granite, are not well suited to high-rise exterior cladding, but can be successful exterior claddings on low-rise buildings. (Although limestone has rarely been used on Australian buildings during the last 30 years, it is widely used in Europe and the USA).

Comparatively low-durability stones can be successfully used in interior applications such as foyers, furniture, and so on. Marble, with its wide range of appealling colours and textures, is favoured for such purposes, although serpentine, travertine and granites are also widely used.

Slate, which can be very durable, is commonly used both internally and externally for wall cladding and paving. Granites are used for paving, but may not hold a good polish in areas of high traffic. Softer, less durable stones such as sandstone and serpentine are not generally suitable for paving, although they are also used.

Stone is generally required to be of fairly even colour and texture for use in covering large areas, such as external cladding. However, vari-coloured or patterned stone can find applications in relatively small features intended to be viewed at close range, such as feature walls, prestige foyers, stone furniture, and fireplaces.

1.3 Purpose of this report

The aim of this project is to conduct a comprehensive survey of both the existing and the potential availability of building and ornamental stone resources in Tasmania, for use as blocks, veneer and paving slabs, tiles, monumental works, and in other building applications.

For the purposes of this report, the term "building and ornamental stone" refers to stone used in block or slab form (ie, "dimension stone"), and as terrazzo, but not to stone used as crushed aggregate for concrete, or in other forms.

This systematic evaluation of building stone potential in Tasmania should give a clear indication of the potential for a significant building stone industry. This information can be used as a basis for expanding existing stone enterprises, and for encouraging the development of new enterprises using Tasmanian stone.

The potential for production of exportable stone is of particular interest. This is stone of high durability which is likely to be in high demand in virtue of having colours, textures or other aesthetic qualities which are unusual or in short supply elsewhere. More common stone varieties of high quality which are available in large quantities, easily extractable in large blocks, and in easily accessible locations, may also be exportable.

For instance, Tasmania possesses perfectly acceptable true granite deposits, but these have to compete with the wide variety of high quality granites available throughout eastern Australia (a very large proportion of current dimension stone exploration in Australia is directed towards "true" granite). While a sufficiently unique and high-quality Tasmanian granite could compete for the export market, more "ordinary" grey and red granites are less likely to be able to compete against the many similar interstate granites which are available.

On the other hand, good yellow/brown sandstone is currently in short supply on mainland Australia, so that a good quality source within the abundant yellow/brown Tasmanian Triassic sandstone would find a good market throughout Australia (although not overseas, since there is very little international trade in sandstone).

Again, the abundant Tasmanian Jurassic dolerites are a "black granite" of good appearance which may be very competive for the export market if a good source can be located. Interest in Tasmanian dolerite has already been expressed in south-east Asia. Similarly, if good "granite" sources can be located in the Mt. Read Volcanics, some of those unusual and attractively patterned stones may have export potential for ornamental interior applications.

1.4 Scope of the project

This is a broad survey encompassing all types of building and ornamental stone. The work includes a review of all building stone sources currently being worked in Tasmania. However, the most important part of the work consists of exploration for new stone resources.

The exploration has been conducted in the most comprehensive fashion possible commensurate with the time available. The procedure followed has been to first delineate all known geological units and associations which may have potential for occurrence of the various stone types, using existing geological mapping and other available data. As many as possible of these units and associations have been examined in the field, on a regional reconnaissance basis, to assess their probable potential. The most important product of this work is the listing of particular geological units, and geographical areas of such units, considered to have the best potential for production of high quality building stones.

Within the body of this report, geological units are assessed as being of high, medium or low prospectivity as possible sources of dimension stone(see Appendix One for definitions of these categories). These assessments are based on existing data and field observations made during this project. It should be noted that there always remains the possibility that units considered to be of low prospectivity could concievably contain acceptable deposits.

The broad scope of this survey is such that it has in general not been possible to proceed to the next logical stage of undertaking detailed exploration in each area of high potential, in order to carefully determine whether a usable stone resource can be confirmed to exist, and to locate the best quarry sites available. To be conducted properly, each study of a promising area would be a significant undertaking in itself, involving detailed field observations, drilling and trial excavations, and comprehensive laboratory testing.

Instead, the purpose of this report has been to provide an indication of the range of stone types available in Tasmania, and to recommend areas in which detailed exploration for the various stone types can be most profitably concentrated. It is hoped that this information will provide an impetus for interested parties to undertake the next stage of detailed exploration of such areas.

Naturally, a number of possible quarry sites have nonetheless been located during the present work, and are mentioned in this report. However, since limited time restricted the amount of work which could be done on each area, it should not be assumed that potential quarry sites listed are the best available in any particular area. Before deciding to drill or quarry such sites, it would be prudent to closely examine the whole of an area since even better sites may well exist nearby.

1.5 Previous work

Most previous geological evaluations of Tasmanian building stone sources have been concentrated on sandstone deposits (eg, Banks 1972, Threader 1969 & 1982), and involved drilling and determination of well known parameters such as compressive strength, bulk density, petrography and salt crystallisation test soundness.

In the late 1970's, serious efforts to study the durability of Tasmanian sandstones began with work on the historic buildings of the Port Arthur settlement. This work resulted in a recognition of the importance of the swelling clay smectite (montmorillonite), and of wet/dry environmental cycles, in the decay of Tasmanian sandstones (Cripps & Spratt 1979, Spry & Spencer 1979, Green & Woolley 1981, and Spratt 1982).

The technical properties of a range of Tasmanian building sandstones have been determined by Spry (1983), Sharples *et al.* (1984) and Sharples (1990). However, some samples tested were from weathered outcrops, and the range of tests conducted were less than would now be considered necessary. There remains a need for a comprehensive set of data on a representative range of fresh samples from current Tasmanian quarries.

A geological investigation of the Back Creek Slate Quarry was conducted by Turner (1981), and Bacon (1987) reviewed existing information on Tasmanian slates. Technical testing of the Coles Bay red granite was reported on by West & Spry (1985), and Bacon (1989) briefly reviewed current sources and prospects for granite, "black granite" and marble in Tasmania.

The present report is the first attempt to comprehensively assemble information on all Tasmanian building and ornamental stone quarries and exploration prospects. It is hoped that the information herein will encourage more extensive exploration for new stone sources.

1.6 Tasmanian dimension stone quarry operators

The following is a listing of current Tasmanian dimension stone quarry operators, as referred to in quarry descriptions in this report:

"Cobbs Stone" (Mr E. Howells) (sandstone)
P.O. Box 298
Orford 7190
Phone (002) 571319

Dunn Monumental Masons Pty. Ltd. (granite, sandstone)
150 Bass Highway
Prospect,
Launceston 7250
Phone (003) 449966

Etna Stone Pty. Ltd. (sandstone)
11 Warwick St.
Hobart 7000
Phone (002) 343794

Northern Tasmania Quarries Pty. Ltd. (granite)
P.O. Box 7
Orford 7190
Phone (002) 571254

Pontville Freestone (sandstone)
5 Christie Av.
West Moonah,
Hobart 7009
Phone (002) 729199

Rizzolo Stone & Concrete Pty. Ltd. (sandstone)
9 Farley St.
Derwent Park,
Hobart
(P.O. Box 176, Glenorchy, 7010)
Phone (002) 723588

Tasmanian Slate Company (slate)
(Mr Graeme Johnston)
Pipers River 7252
Phone (003) 827127

Unique Stone Paving (sandstone)
77 Stanley St.
Oatlands 7120
Phone (002) 541458

P. Youd & S. Knowles (slate)
c/- Post Office
Mole Creek 7304
Phone (003) 631261

1.7 Acknowledgements

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Discussions with R. Berry, S. Forsyth, M.P. McClenaghan, A. Spry and S. Stephens were of particular value in assisting the development of this work. Thanks are also due to all the quarry operators who allowed me free access to their quarries.

CHAPTER TWO

EXPLORATION, EVALUATION AND DEVELOPMENT OF STONE RESOURCES

2.1 Exploration and testing procedures

This section gives:

1 A brief description of the procedure and rationale followed in the reconnaissance-level assessment of Tasmania's building and ornamental stone resources for this project.

2 A more detailed description of recommended stone exploration and evaluation procedures for detailed exploration programs leading to quarry development.

2.1.1 Reconnaissance assessment of building and ornamental stone resources

As explained in the introduction, this project is intended as a broad-scale reconnaissance of Tasmania's building stone resources. As such, its primary purpose is not to produce a list of proven quarry sites ready for development, but rather to determine the stone types, geological units, and geographical areas within Tasmania which are considered most prospective for investigation as potential building and ornamental stone resources.

Therefore, this report provides brief reconnaissance-level evaluations of prospects considered worthy of more detailed exploration leading to actual quarry development. Such detailed exploration will probably be the responsibility of those individuals and enterprises interested in investigating the resources outlined in this report. Section (2.1.2) below outlines exploration and evaluation procedures proposed for such following stages of detailed work.

Due to the limited time available to complete this reconnaissance level evaluation, the following strategy was used to cover the widest range of potential stone resources in the most efficient manner possible:

1) Literature survey

The types of building and ornamental stones to be evaluated were classified as follows:

Sandstone
Slate
True Granite
Black "Granite"
Other "Granite"
Marble
Serpentine
Other Carbonates (travertine, limestone/dolomite dimension stone)
Other Stone Types (conglomerates, etc)

These stone types are defined in relevant sections of this report; the definitions are largely based on stone industry usage, rather than strict geological definitions.

A detailed survey was made of existing data and mapping of Tasmanian geological associations. For each stone type, a comprehensive listing was made of all known geological units (and the geographical distribution of those units) which are considered likely or possible to contain rock units fitting the stone industry description of the type.

These listings have been made as comprehensive as possible, and include rock units occurring in inaccessible areas, and units already thought or known to be of sub-standard quality for building use. The purpose of this is simply to make the survey as complete as possible, and to guide future stone explorers by indicating not only promising prospects, but also prospects considered unworthy of detailed attention.

2) Field reconnaissance

From the list of prospects, inaccessible rock units, and those known to be of low prospectivity, were eliminated from the field program. High-priority prospects were listed, and a field program designed to cover as many of these as possible. A set of data sheets were designed to allow rapid recording of the most important stone characteristics, and easy transference of this data to a computerised data base.

In the field, a brief reconnaissance was made of each prospective area to locate the best and most representative outcrops of each rock unit. The best outcrops are normally road cuttings and other excavations, since these give both the freshest and most easily accessible exposures. Although the best outcrops for quarry development may eventually be found away from such excavations, it is considered that existing excavations will normally give a fair indication of likely quality and variation within a unit. Very few prospective rock units in accessible areas do not have some sort of excavated exposures available.

Within the time available it would not have been possible to undertake detailed exploration of any rock unit to locate ideal quarry sites, and many rock units have been listed as promising even though no usable quarry sites or ideal-quality outcrops have been located. In many cases it is simply a matter of the observed outcrops having been basically a promising stone, but with minor flaws of a sort whose known variability is such that more detailed work may locate unflawed outcrops in the region.

Where prospects were found to have pervasive characteristics which rule them out as building stone, only the minimum data sufficient to indicate their unsuitability was recorded.

3) Laboratory work

Samples were collected from all promising prospects. Due to the time limitations in this work, it was not considered feasible to do comprehensive laboratory tests as a part of this project (although a few quick tests such as XRD and thin section analysis have been done). Rather, stone prospects have been evaluated here in terms of aesthetic appearance and field characteristics. Detailed laboratory testing is considered more appropriate in individual evaluations of prospects.

4) Aesthetic evaluation

As part of the aesthetic evaluation of prospective stone types, samples of the most promising stone types have been slabbed and polished (or otherwise prepared as appropriate to the stone type). Photographs of all such samples are included in this report, and a sample collection is submitted with this report (available for examination at the Tasmanian Development Authority and the Department of Resources & Energy, Division of Mines & Mineral Resources).

This will allow potential developers to make their own judgement as to the likely worth of the various prospects.

2.1.2 Detailed exploration and evaluation procedures

Procedures for the evaluation and testing of known prospective quarry sites are fairly well established. Currier (1960) gives an interesting and useful outline of methods for the appraisal of dimension stone deposits. Later sections of this report give a more up to date outline of criteria for the evaluation of particular prospects (see sections 2.2 and 2.3).

However, whereas the mineral industry has developed a high level of expertise in the science (and art) of exploring for metallic and other mineral deposits, serious attempts to explore for new sources of building and ornamental stone in a systematic and scientifically-based fashion are a relatively recent phenomenon. Historically, prospective dimension stone quarry sites have generally been located by chance.

With the current increase in the use of natural building stone, and with the more stringent quality and durability requirements now applied, it is necessary to develop methods of locating high quality stone sources in the most efficient manner possible.

The most appropriate methods of exploring for particular types of dimension stone will vary somewhat depending upon the characteristics, distribution and geological mode of occurrence of the particular stone type. On the other hand, certain basic exploration strategies will be common to most stone types.

The following discussion is a tentative exploration strategy designed specifically for Tasmanian sandstones. It is presented here in order to encourage future development of stone exploration techniques in general.

Sandstone exploration and evaluation procedures

High quality building sandstone is a particularly difficult substance for which to explore successfully. The difficulty arises from three factors, which apply to all stone types but are especially relevant to sandstone. These factors are:

1) Most sandstone is of low quality

A random sampling of sandstone outcrops in virtually any part of the world will quickly reveal that nearly all outcrops one finds are of too low a quality, in terms of field criteria and/or laboratory criteria, to be successfully used as a durable and attractive building material.

This fact is emphasised by a consideration of actual building stone quarries. Although most quarries have in the past been located by more-or-less "random" methods, we can at least assume that quarry sites chosen were the best stone that the quarrymen of the time could find. It is therefore telling to note that, taking the case of Tasmanian sandstone quarries, of the 28 modern and historic sandstone quarries studied by Sharples *et al.* (1984), only three or four meet most of the technical criteria for good building sandstone.

2) Most sandstone does not outcrop

We are trying, therefore, to locate the (probably) less than 1% of all sandstone which is of appropriate quality for building. However, we are further hampered by the fact that only a small percentage of the total area of sandstone which exists actually outcrops; most of it is soil covered.

There is at present no method of efficiently assessing the quality of soil-covered areas of sandstone. The physical and chemical differences between high and low quality sandstones are considerably more subtle than the differences between a metallic orebody and the surrounding barren rocks, so that there are no known methods of distinguishing high from low quality building sandstones on a regional or local scale by means of gravity, magnetic, electrical, seismic, geochemical or other such regional survey methods.

And while drilling is an important tool in sandstone evaluation, we can only drill after we have located a promising outcrop. Drilling vast borehole grids for reconnaissance testing of sub-soil sandstone quality would be highly uneconomical!

In any case, many soil covered sandstone deposits would be difficult to quarry efficiently, due to problems of overburden and unsuitable site topography.

Thus, exploration for that small proportion of sandstone which is of high quality relies on actual viewing, sampling and testing of the small proportion of all sandstones which actually outcrop at the surface.

3) Natural outcrops are affected by weathering, and may not give all the information we need
Most sandstone outcrops are weathered. Such outcrops can give reliable information on sandstone colour, texture, bedding and jointing or fracturing. However, weathering causes subtle mineralogical and intergranular texture changes which can significantly reduce stone strength, increase porosity, and alter mineralogical compositions to a depth of some metres below the natural outcrop surface.

Surface samples taken from natural outcrops may not yield reliable laboratory test data which we need to properly evaluate the quality and durability of building sandstone. The only outcrops which can yield reliable laboratory test data are fresh excavations such as road cuttings and existing quarry faces.

Since such fresh outcrops form only a small proportion of all sandstone outcrops, it is necessary to evaluate sandstone outcrops initially only in terms of those few criteria which can be reliably determined on weathered outcrops. Once outcrops are located which are promising in terms of these criteria, it is essential to obtain fresh sub-surface samples, by either drilling or excavation, which can then be reliably subjected to laboratory tests.

Current work by the writer suggests that north-facing (in Tasmania) and/or bare natural outcrops suffer the greatest degree of weathering alteration due to the extremes of temperature and moisture variations which they experience. Soil-covered and/or permanently shaded south-facing outcrops suffer less such variations, and so their weathering may be less pronounced, with the result that near-surface samples may in fact be nearly fresh and unaltered.

This implies that south-facing outcrops overlain by a thin soil layer will have very little weathered surface stone which must be removed to get at fresh stone. Such sites would be ideal for quarrying. However, until these observations are confirmed it is best to proceed on the assumption that all natural outcrops are significantly weathered.

The limitations on building sandstone exploration
The problem of building sandstone exploration can be summarised as follows:

Of all sandstone which exists, only a small proportion is of high quality. Of that small proportion, only a small percentage actually outcrops and is thus potentially able to be discovered. And the recognition of that small percentage of outcropping high quality stone is made still harder by the fact that most outcrops can only yield part of the information we need to recognise good stone.

Keys to location of high quality building sandstone

There is a small amount of geological information ("exploration models") which can be used to assist in locating geological units and areas which have the greatest potential for containing high quality building sandstones. These geological exploration models are briefly summarised Chapter Four, but are treated in some detail in Sharples (1990). These models only indicate which general units and areas might be the most promising prospects; beyond that there is little alternative but to painstakingly examine as many outcrops as one can in the field.

Exploration models include:

1) Known sedimentological and palaeo-environmental data

Existing geological data can indicate which geological units (and to some extent, which areas within those units) are most likely to contain sandstone beds having the sedimentological characteristics required to yield high quality sandstones. The most prospective sandstones are those with high-quartz and low-clay compositions, minimal proportions of other minerals, fine -medium grainsize, moderately to well sorted, thick massive bedding, and minimal mud-bands, clay pellets, quartz pebbles and other sedimentological imperfections.

Based on these criteria, existing data indicates that the most prospective sandstone units in Tasmania are the lower parts of the Triassic sandstone sequence (Upper Parmeener Supergroup), and the Permian Lower Freshwater Sequence (Liffey Group and correlates).

Within a particular unit, certain geographical areas may be more or less prospective for durable sandstone depending upon the palaeo-environments and palaeo-geography of the original depositional basin (see Ch. 4), and bulk colour is also dependant on clay mineral compositions which are thought to be at least partly controlled by regional palaeo-geographical influences (see Ch. 4).

2) Density and proximity of faulting and igneous intrusions

Sandstone may be more closely jointed and fractured within a few metres of individual major faults and igneous intrusions; however on a regional scale the density (frequency) of jointing is probably related more to the regional frequency of major faults. Regional variations in fault and joint density are discussed in Ch. 4.

Dolerite intrusions are thought (see Ch. 4 & Sharples 1990) to be a major cause of the distinctive brown ferruginous staining patterns ("liesegang rings") commonly found in Tasmanian sandstones (generally within 300 - 500 metres of intrusive dolerite contacts). Thus, depending on whether a uniform or a strongly patterned colouration is desired, one would search respectively away from, or close to, an intrusive dolerite contact.

3) Boldness of natural outcrops

The greater the density (ie, the closer the spacing) of joints, fractures and major bedding planes in sandstone, the greater is the susceptibility of the stone to weathering and erosion . For this reason it is commonly found that the largest, steepest and boldest sandstone outcrops tend to have widely spaced joints and fractures, and thick bedding layers.

Since wide jointing and thick bedding are desirable features for building sandstone quarries, examination of bold outcrops (located by airphoto interpretation and field reconnaissance) should be a priority.

4) Sandstone variation over short distances
The characteristics of sandstone deposits can vary markedly over short distances, both horizontally and vertically. Tasmanian Triassic and Permian sandstones were deposited in fluvial environments in which water flow regimes were continually changing as a result of channel migration and other factors. This resulted in periodic changes in the types of bedding structures formed, so that it is common to finding massive, cross-bedded and plane bedded layers alternating within a single sandstone deposit, as well as differing proportions of mud-bands, clay pellets and quartz pebbles within different beds.

Mineralogical composition may also vary over short distances both horizontally and vertical, although the causes of such variations are not well understood. It is equally common, however, to find large areas and thicknesses of sandstone having similar clay compositions.

The importance of these variations is that although one outcrop may be unsuitable in terms of bedding, clay composition or other characteristics, it is in many cases possible to find nearby outcrops having much better characteristics. Thus, an entire unit or area should not be written off as a building stone prospect on the basis of one poor outcrop. It is necessary to examine a significant number of outcrops within an area before one can decide whether the whole unit or area is of uniformly low quality, or whether there is sufficient variability for the area to continue to be regarded as potentially prospective.

Recommended sandstone exploration and evaluation procedures
In view of all the above considerations, the following is an outline of the most efficient method of exploration for high quality building sandstones, in the case that one is beginning from a situation of having little or no information on already-known sources of high quality stone within a region. Should information of the latter sort be available, it may of course give additional clues to the location of further similar deposits.

The basic principle of sandstone exploration is that available outcrops are first assessed in terms of those criteria which can be reliably determined on natural outcrops. Once outcrops which are promising in terms of these criteria are located, the next step is to obtain fresh sub-surface samples, first by drilling and then by excavation, for comprehensive laboratory testing.

A systematic program of exploration for high quality building sandstones within a given region would procede as follows:

1) Literature Research
The most promising geological units, and geographical areas within those units, are determined in the light of the available exploration keys, by reference to existing geological mapping, reports, air-photos and other data. Areas which would be unsuitable for quarrying by reason of inaccessibility, land tenure and use, or other environmental factors are eliminated from consideration.

2) Field Assessment
As many outcrops as possible are examined on a field reconnaissance basis, with priority being given to bold outcrops and fresh excavations such as road cuttings. Outcrops are assessed in terms of jointing and fracturing, colour and texture, bedding dip, type and thickness, structures and textural defects, and also in terms of site access and topographic and environmental suitability for quarrying. A unit or area is not rejected as unprospective unless a significant number of outcrops have all indicated uniformly poor quality stone.

Existing sandstone buildings can give a clue to location of high quality deposits. Much of the prospective sandstone in Tasmania occurs in areas which have been settled for well over 100 years, and many buildings in these areas were constructed of local sandstone. Examination of old sandstone buildings in a prospective area can give a very good indication of the durability of the various sandstone types used. When a good sandstone which has stood up well over time in a building is located, local folklore or records may be able to direct one to the original quarry site (these are usually small pits which were only used for a few local buildings).

Where this approach can be used, one may be able to short-circuit the process of locating sources of high quality stone, and the quarries located will have the added advantage of having an existing track-record of good durability.

In respect of bedding types, although "ideal" bedding type sequences might in theory occur within a local succession, in practice the prediction of bedding sequences (leading to prediction of the location of, say, massive beds) is not possible due to unpredictable variations in the original depositional environment (see Ch. 4). Thus, it is not generally worthwhile to take careful note of the occurrence of non-prospective bedding types (eg, micaceous cross-bedding, or planar bedding) in an attempt to use them to predict the location of massive (or any other) bedding outcrops. Rather, the most efficient strategy appears to be to simply doggedly explore for massive beds on the ground and ignore other bedding types!

Ideally, a number of potentially high-quality outcrops will be located during a program of field reconnaissance. These should all be subjected to further evaluation as below, with the less prospective sites being identified and eliminated from consideration as the program of evaluation progresses to more and more detailed (and expensive) stages. One would hope to finish with a short list of only a few highest quality sites from which a final choice can be made.

When outcrops have been located which are suitable in terms of all the above criteria, small surface samples may be collected and subjected to X- Ray Diffraction testing and thin section microscopy for determination of mineral types, including clays, present. The proportions of such minerals detected, and the intergranular texture of the stone, must be interpreted with caution since these criteria are likely to be affected by weathering. While weathering may affect the proportions of minerals present, it has been found that the actual types of minerals present in subsurface fresh stone will generally still be present in the weathered stone, so that an initial test of surface samples for the presence of deleterious minerals such as the swelling clay smectite is of value.

3) Subsurface sampling and laboratory testing

If significant quanties of deleterious minerals are not present in the surface samples, the next step is to obtain fresh samples from a depth of at least two metres below the existing natural outcrop surface. Except in the rare case that a recent excavation exists, this will necessitate test drilling and exploratory excavations.

It is preferable to first conduct cored drilling is , since it allows one to obtain regularly spaced samples from precisely determined locations (and causes little environmental disturbance, which is a bonus in the case that testing ultimately leads to abandonment of the site). Cores of approximately 50mm diameter are preferable, since this is a standard sample size for many of the quality tests required. In certain situations (such as where vehicular access has not yet been prepared) the use of a small "back-pack carried" core drill yielding smaller diameter cores may be appropriate.

Drilling should be conducted to at least the maximum depth to which it is considered quarry development will be feasible. A grid of several holes is useful to determine the distribution of any quality variations in the deposit, and for reserves and wastage estimations. A grid spacing of 20 metres is normally adequate.

Since drill core only supplies a small volume of sample for testing (and it is also concievable that the mechanical stresses induced during drilling may affect stone properties by causing micro-fracturing), successful core testing should be followed by trial excavations to obtain block samples for exhaustive testing.

The importance of obtaining fresh samples by drilling and excavation prior to any final decision on opening a quarry cannot be under-estimated. It is far cheaper to spend a few thousand dollars on a drilling and testing program than it is to spend tens of thousands of dollars on opening a quarry, only to later discover that the deposit is sub-standard due to variations or physical criteria which could have been determined by a drilling and testing program.

A comprehensive laboratory testing program is carried out on the fresh samples obtained. Such a program should, as a minimum, encompass the following tests:

- -Mineralogy (mineral types and %) [by thin section point counting]
- -Clay mineralogy [by X-Ray Diffraction]
- -Intergranular Texture [by thin section line traverse]
- -Effective porosity, water absorption, dry bulk density [at 20°C, 1 atm.]
- -Ultrasonic Pulse Velocity
- -Point Load Strength Index [wet, airdried, oven dried, parallel and perpendicular to bedding, wet/dry ratios]
- -Sodium Sulphate Soundness Test

The following tests are also worthwhile if feasible or considered appropriate:

- -Compressive Strength (as for Point Load test)
- -Flexural strength
- -Abrasion resistance
- -Dimensional instability

Accessible stone reserves and estimated wastage due to defects and quality variations are calculated at this time.

4) <u>Quarry development</u>
If upon completion of these tests the stone quality and reserves are determined to be suitable, quarry development can be confidently undertaken, involving land-owner negotiations, stone lease application, environmental and local council approvals, and preparation of vehicular access and working areas. Where stone quality variations are present, quarrying should be carefully planned to optimise quarry operation. Attention must be paid to minimising environmental impact, and the quarry should be developed in such a way as to facilitate the ultimate rehabilitation of the site.

The quality of natural stone (of all types) may vary markedly over short distances, due to differing degrees of weathering, or to inhomogeneities in the original rock as formed. For this reason, at intervals during the lifetime of the quarry further laboratory tests are recommended to ensure continuity of stone quality.

The following algorithm (overleaf) graphically illustrates the above recommended exploration procedure:

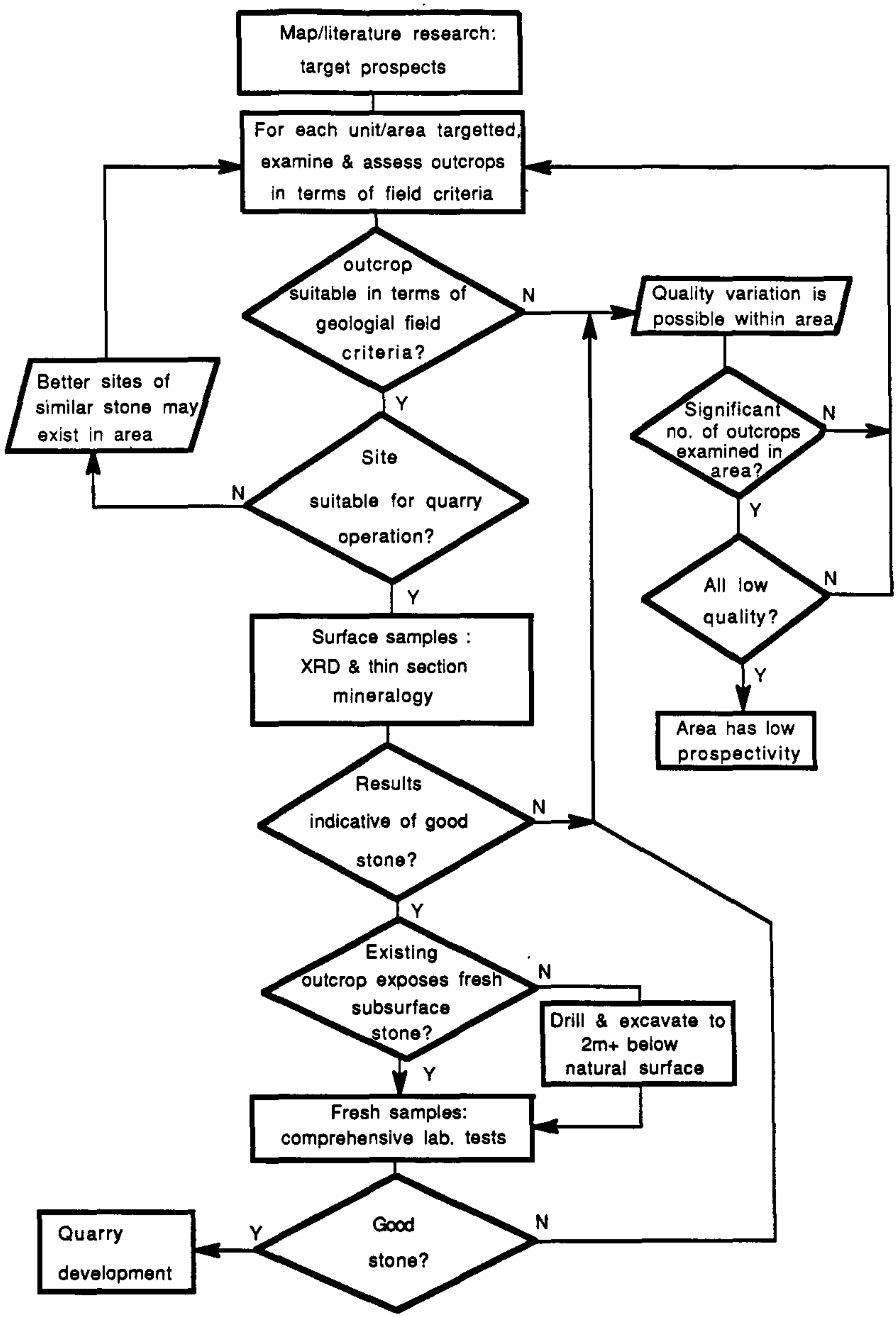

Figure 2. 1 Sandstone exploration and evaluation procedures

2.2 General criteria and legal requirements for building stone quarry sites (all stone types).

This section briefly lists criteria of a non-geological nature which determine the suitability and viability of potential stone quarry sites, and lists the legal requirements which currently apply to stone quarry operations in Tasmania.

2.2.1 Quarry site suitability and viability

Access

The economics of many building stone operations are such that few quarry operators can afford to construct access roads over long distances or across difficult terrain. Potential quarry sites need to be close to existing roads and other infra-structure. For this reason, certain potential building stone deposits in areas currently difficult of access will only become viable if infra-structure is provided by other, un-related development projects (the massive pyroxenites at Adamsfield are an example of this).

In addition, even where road access does exist, it is necessary to consider transport distances from the quarry to the processing location, and to ports in the case of stone intended for export.

Ease of quarrying

Topography, slope angle and overburden determine whether stone can be economically extracted from a site. It is generally uneconomic to remove more than a few metres of overburden (soil, unsuitable stone) from above a deposit of good quality stone. It is also necessary to be able to form a flat platform at the base and/or top of an outcrop face upon which to commence working.

In long term quarrying operations the most common method is to work back into a face on horizontal benches with working faces ideally about four metres high.

The ideal quarry site would begin from an outcropping face of good stone, with minimal overburden and with horizontal or gently sloping ground below. A rising slope gradient above the face of 1 in 10 is ideally the steepest slope angle which will allow quarry benches to be extended back far enough for economical stone extraction on four metre faces. A higher slope angle means shorter benches, so that new benches must be commenced more often, with consequent higher operating costs.

Reserves and wastage

The reserves of a potential quarry site are the amount of good quality stone (measured in cubic metres or tonnes) which can be extracted over the life of the quarry, before further extraction becomes difficult or uneconomic by reason of site topography, variations in stone quality, or intrusion onto adjacent areas where quarrying is not permitted for legal or environmental reasons.

Reserves are determined by the dimensions of the body of high quality stone present, the location of adjoining or intermingled bodies of low quality stone, the topography of the site, and the lateral and vertical distances over which quarrying will ultimately be extended.

Wastage is the proportion of the quarried stone body which will ultimately be discarded due to imperfections or simply to trimming of larger blocks in the quarry or processing works. Wastage is determined by joint and fracture spacings, and the proportion and distribution of imperfections and low quality stone which may occur as bands, patches, and in other forms. Wastage is also a function of the type and efficiency of the quarrying and processing methods used, and on the degree to which the operator can use stone blocks obtained from sections of the quarry having closer joint and fracture spacings.

Reserves and wastage can only be roughly estimated by examination and measurement of surface outcrops. In order to obtain reliable figures for reserves and wastage, it is necessary to drill the entire projected quarry pit area on a regular grid (typically with a 20 metre spacing), down to the maximum depth to which it is considered quarry development could occur. In this way stone quality variations and quantities can be accurately measured on a three dimensional grid.

2.2.2 Legal and environmental requirements for opening and operation of building stone quarries

Currently, the legal requirements for opening and operation of a building stone quarry in Tasmania are:

1) Mining Lease, from the Department of Resources and Energy.

2) Licence to Operate Scheduled Premises, from the Department of Environment and Planning (if production is to be greater than 1000 tonnes per annum).

3) Local Council planning approval.

<u>Mining Lease</u>

Mining leases can only be operated on land subject to the provisions of The Mining Act, 1929. State Reserves, National Parks and many other land categories primarily set aside for conservation purposes are not subject to the provisions of this act; in these mining will not be permitted.

On private land, a lease will not usually be issued without The Department being provided with a copy of an agreement drawn up between the landholder and the lease applicant.

Standard forms are available from The Department; application for a mining lease should be made on these. The Department can give assistance and advice on the preparation of applications if required. The Act requires that the ground being applied for be physically "marked out" by placing, in the field, the appropriate notice at one corner of the land in question.

Mining leases for stone may be up to 100 ha. in size, and can be granted for a maximum period of 21 years, with the right of renewal if worked according to the conditions applied to the lease. Annual rent is payable on 1st July each year; leases are subject to forfeiture if the rent is not paid.

A royalty is payable on certain materials which are taken under a stone lease. From crown land, the royalty is payable to the government; on private land the lessee - landowner agreement must provide for a royalty payment to the landowner. Leases also contain a labour covenant which requires the holder to employ one man for each four ha. or part thereof comprised in the lease for a period of not less than three months in each year. Part of the labour covenant may be made up by the use of machinery. Leases are subject to forfeiture for failure to comply with the labour covenant.

Leases may contain such other covenants and conditions as the minister may approve and are subject to cancellation for non-compliance. In addition to special conditions which may be applied in any particular case, all leases now provide for controlled methods of mining so as to cause minimum disturbance of the environment, planned disposal of tailings, and rehabilitation of mined areas. A deposit may be required as a guarantee for observance of the conditions of the lease. Lessees are responsible to meet the whole of the cost of rehabilitation works.

On receipt of an application for a mining lease, the Department of Resources and Energy will, where necessary, negotiate lease conditions with other land management agencies such as the Forestry Commission (for State Forest) and the Department of Environment and Planning (for crown land). Lease applications in Conservation, Protected or other sensitive areas are subject to approval by an Interdepartmental Working Group made up of representatives from the Departments of Resources and Energy, Environment and Planning, Parks Wildlife and Heritage, and the Forestry Commission.

Licence to operate Scheduled Premises

A Licence to operate Scheduled Premises will be needed if the planned operation is to produce more than 1000 tonnes of stone. The Department of Environment and Planning draw up guidelines for each project on a site-specific basis; the applicant must then either prepare himself, or employ consultants in this field to produce, an Environmental Management Plan. The licence application is advertised, and a 2-3 month period allowed for public comment and objection.

Quarries producing less than 1000 tonnes may be scheduled at the discretion of the Director, although this is not usual. Very small quarries, producing a few tonnes of stone per year, are subject to operating conditions agreed upon by the Departments of Environment and Planning, and Resources and Energy.

Possible environmental problems associated with quarry operations include:

- -Visual impact of quarry from roads, houses and scenic viewpoints.
- -Noise, vibration, dust emmissions.
- -Effects of vehicular traffic to and from quarry.
- -Damage to vegetation, pasture and crops.
- -Interference with stock and wildlife.
- -Silting of watercourses.
- -Introduction of pests, weeds and diseases (eg, dieback fungus).

Quarry development and operations must be planned to minimise or eliminate these problems.

Local Council planning approval

All quarrying activities are subject to local council planning regulations, and an application must be lodged with the appropriate council.

2.3 Criteria for high quality and durability stone (all types)

A large proportion of natural stone is not suitable for building purposes by reason of low durability or unsuitable aesthetic characteristics.

Stone in the urban or built environment is subject to numerous stresses which can cause early failure or decay. Such stresses include salt attack, wet/dry and hot/cold cycling, mechanical stresses and acidic pollution attack. Useful discussions of the decay processes which may attack building stone are given by (amongst others) Winkler (1973), Amoroso & Fassina (1983), Spry (1988), Gere *et al.* (1989) and Sharples (1990). It is important that stone be of a technical quality sufficient to withstand the decay processes likely to be encountered in the particular building environment in which it is to be used.

Other aesthetic, mineralogical and textural characteristics of stone, while not causing physical decay or failure, may nonetheless be considered unattractive or likely to lead to unattractive consequences (eg, sulphide minerals oxidising to produce unsightly stains).

No official Australian standards for stone quality have yet been defined. The American Society for Testing and Materials (ASTM) lays down criteria for good building sandstone (ASTM C 616), slate (ASTM C 406 [roofing slate] and C 629 [structural slate - walls and paving]), granite (ASTM C 615), exterior marble (ASTM C 503 - includes travertine and serpentine), and limestone (ASTM C 568). See: ASTM Annual Standards Book (Vol. 04.08 - Soil and Rock, Building Stone).

However, unofficial Australian standards for stone quality have been developed from local experience, and in some respects are more stringent than those given in the above ASTM publications. See Spry (1983 & 1988), Ray (1988), and Gere *et al.* (1989). The standards quoted in the following sections are derived from both ASTM literature, and Australian sources as referenced.

In general, the standards and criteria quoted can be considered to apply to specification of stone of the highest durability and quality for use in stressful situations; less stringent criteria may be acceptable in certain applications such as interiors.

However, it is necessary to be wary in using many of the standards quoted below. Firstly, some (especially the ASTM standards) were developed for massive masonry, and are not necessarily relevant to modern applications such as veneers. Secondly, the stresses on building stone vary markedly depending on the location and manner in which the stone is used. Therefore, stone which does not fully comply with the most stringent standards may in fact be adequate for certain low-stress applications. And finally, there still does not exist a complete and widely-accepted consensus as to which stone properties (and what values of those properties) are of relevance in deciding upon the suitability of stone for particular applications.

Further, stone is an extremely variable material. Although it would be desirable to find a stone which is excellent in respect of all criteria, such an ideal can rarely be attained. More commonly, a stone will have a mix of good and more mediocre qualities.

The upshot of all this is that it is necessary to weigh the importance of the various criteria in respect of the proposed stone application in order to decide whether the stone is adequate for the purpose. This requires experience of observing past stone performance, and an understanding of the nature of stone properties and behaviour, as much as reference to standard criteria.

Standard methods of performing the tests required for stone quality evaluation are listed in Section 2.4.

Freshness

SANDSTONE	Sandstone must be quarried from below the natural surface zone of intense weathering, which may extend some metres below the original outcrop surface in badly weathered exposures. Stone in this zone can superficially appear fresh, and yet be considerably weaker than deeper, less altered stone.
SLATE	Slate quarried from superficial weathered outcrop layers may be weakened, bleached or iron-oxide stained. Staining is useful in certain applications, but for strong, evenly coloured slates it is necessary to quarry below the surface weathering zone.
ALL "GRANITES"	Granite should be fresh and unweathered, so that it is free of feldspars and micas altering to clay, and similar problems. Near surface granite is commonly of a lighter colour (where not iron-oxide stained) than granite at depth, as a result of incipient weathering. Whether or not such incipient weathering will be significantly deleterious to stone durability will depend on the degree to which the various critical physical parameters detailed below are affected.

Jointing breaks and fracturing

Joint breaks and fractures are unacceptable within a finished dimension stone piece, since they result in strength reduction and accelerated weathering.

They may be open (uncemented or only lightly cemented by iron oxides), or else cemented (annealled) by secondary mineral deposits. Fine, tight "hairline" fractures, if not strongly cemented, are just as unacceptable as major joint breaks.

SANDSTONE	Deep breaks should be spaced at least 2.0 metres apart (although stone with closer breaks may be usable for some purposes such as production of brick-size blocks or paving slabs). Blocks must be free of minor or incipient fractures.
SLATE	Breaks must be spaced widely enough to allow extraction of blocks of the required size. For tiles split and sawn to shape, wider joint spacings means less wastage in trimming tiles. Crazy paving is often sold as tiles with joint-bounded edges, so closer jointing is required for this type.
ALL "GRANITES"	Ideally should be spaced widely enough to allow extraction of unflawed blocks of dimensions 2 x 1.3 x 1 metre or larger (Ray 1988). Closer jointing may in some cases be acceptable for purposes such as tile cutting, although wastage will be greater. Weathering around joints should be minimal. Strong annealled fractures cemented with durable minerals (ie, veins) may sometimes be acceptable, and add aesthetic interest to the stone (see "veins").

MARBLE, SERPENTINE	Spaced greater than 2.0m apart (panel production; smaller spacings may be acceptable for tile production). Well annealled fractures acceptable for many applications. Minor open fractures may be acceptable for certain interior applications if used bonded to a suitable backing. Close open fracturing acceptable for terrazzo manufacture.

Cracks and microcracks

ALL "GRANITES"	Common in eastern Australian "true granites". Should be minor or absent for most purposes (eg, exterior use and paving). Parallel microcracking can cause a distinct strength reduction and anisotropy, can increase porosity and permeability, and yield different ability to take polishing in different directions. These effects can make stone unacceptable for veneers (cladding), although in some cases it may still be acceptable for larger dimension blocks or interior use if oriented correctly.

Lineations and foliations

ALL "GRANITES"	Foliation structures may enhance aesthetic appearance of stone, but are only acceptable provided they do not contain weak or unstable minerals, and do not have a tendancy towards easy splitting. In particular, lineations of mica (eg, in gneiss) are unacceptable.

Cleavage

SLATE	No more than one distinct cleavage direction. Cleavage surfaces must generally be flat and even, without kinks or undulations(but see also below). Slate must be coherent (ie, must not be excessively fissile, flakey or split too easily along cleavage). Roofing Slate: Curvature must not exceed 3 millimetres in 300mm on split surfaces. Knots and knurls are not objectionable on the top face, but protuberances must not project more than 1.5mm beyond the split surface. Structural Slate: Slightly uneven cleavage surfaces, with minor pits and nodes, can be desirable for aesthetic reasons.

Bedding (and "ribbons")

SANDSTONE	Blocks, veneers: Massive (or very faintly cross-bedded) stone in beds approx. 2.0 metres or more thick. Tiles, slabs: Plane bedded or distinctly cross-bedded.
SLATE	There must be no tendancy to split along original bedding direction, if that direction is different to cleavage direction. Highest quality slate (roofing, some other exterior applications): No bedding structures or soft ribbons to be present for grades S1 and S2 (see grade definitions under

"Water Absorption")
"Slate for exterior application in ambient acidic atmospheres or in industrial areas where heavy air pollution occurs shall be free of carbonaceous ribbons" (ASTM C 629)

Structural slate (interior and exterior):
Subdued bedding structure may be acceptable if there is no splitting tendancy along bedding (unless cleavage is along bedding).
Ribbons may be acceptable provided they are not softer and composed of less stable minerals.
Harder ribbons may stand out as ridges when exposed to wear or weathering.

Colour

SANDSTONE

Stable (free of siderite, pyrite, marcasite).
Blocks, veneers: Uniform, patterning and imperfections absent or subdued.
Ornamental tiles, slabs, domestic "bricks": Strong, regular patterning.

SLATE

Slate is selected for overall satisfactory and natural appearance. Colour may be uniform or variegated, dark or lighter, depending on intended usage.
Colour stability is required. Some dark slates bleach with weathering due to the presence of chlorite (Spry 1988,p.62). Such a bleaching tendancy is likely to be apparent in surface outcrops. Oxidation of iron minerals may cause brown staining with weathering.

ALL "GRANITES"

Must be aesthetically appealing and stable (see mineralogy below).
Uniform colouration commonly required, but non-uniform colouration (eg, breccias, segregations, veins) can be acceptable or even desirable for certain purposes.
Colour commonly darkens at greater depths within a deposit.

MARBLE

White, uniform (subtle grey streaks acceptable) normally required for exterior cladding.
Wide range of colours and patternings may be acceptable for interior and decorative applications. Black and pink marbles commonly used, but dominantly grey marbles rarely in demand.
Stable: minerals prone to colour change, bleaching and staining must be absent (eg, siderite,pyrite,pyrrhotite, serpentine, chlorite). Spry (1988,p.62) notes that black marbles tend to whiten in polluted atmospheres.

SERPENTINE

Generally dark green, often with attractive networks of white veins.

Structure

ALL "GRANITES"	Massive (uniform and isotropic) structure commonly preferred, but segregations, flow structures, breccias and gneissic structures may be attractive for certain applications.
MARBLE	Fossils, bedding, cleavage, folding, viens, stylolites. Generally required to be minimal or absent for exterior cladding panels. Acceptability for decorative and interior applications varies according to effect on stone durability and aesthetic appeal of structures.
SERPENTINE	Commonly occurs (and used) in the form of attractive, strongly annealled breccias.

Texture

SANDSTONE	Fine to medium grained. Moderately to well sorted. Grains require moderate to high sphericity and minimal common orientation.
SLATE	Texture is normally uniformly fine; coarser bands would require rejection of the stone.
ALL "GRANITES"	Equi-granular (uniform), porphyritic, porphyroblastic and other textures may all be acceptable for particular uses. Finer grainsizes preferable for paving, due to higher abrasion resistance.
MARBLE	Uniform, fine - medium grainsize with irregular interlocking grain boundaries (exterior and paving applications). Coarse grainsizes may be acceptable for some interior applications, but grainsizes of greater than 1mm dia. commonly result in poor performance (Spry *pers. comm.* 1990).

Intergranular texture

SANDSTONE	High percentage of quartz/quartz contacts (cut-off values are difficult to define; 20-30% may be adequate if other stone characteristics are good. 50% or above is an excellent value). Clay matrix should be predominantly in the form of interstitial fillings and pellets, rather than as intergranular layers and films.

Textural defects

SANDSTONE	Minimal or absent:	quartz pebbles clay pellets clay or mud bands concretions porous spots

SLATE	Cracks, viens, pebbles, soft clay bands, other defects should be absent.
ALL "GRANITES"	Granites may polish better, and have different strengths, in different directions. This may partly result from anisotropic (foliated) arrangements of grains, but is very commonly a result of microcracking. Minimal textural anisotropy is required for most purposes (especially veneers), although some minor anisotropy may be acceptable for large dimension blocks or interior veneers if laid correctly oriented.

Segregations

ALL "GRANITES"	Colour/texture segregations (layers, bands, patches and variations) may be acceptable if evenly distributed, if distributed in such a way that adjacent slabs can be matched in an attractive way, or if individual segregations are large enough to be extracted separately.

Xenoliths, veins, dykes, flow structures, breccias, pyroclastics

ALL "GRANITES"	May be aesthetically attractive, if structures evenly distributed and do not significantly mar stone appearance. Boundaries between these structures and stone groundmass must not be cracked or susceptible to cracking. Should not contain unstable minerals (see below). The stone must be strong and sound in all respects.

Vesicles

ALL "GRANITES"	Unacceptable (regardless of vesicle size) for polished stone. Microscopic vesicles can result in uneven polish. May be acceptable for non-polished stone applications.

Amygdales

ALL "GRANITES"	Unacceptable if filled with unstable minerals. If filled with stable minerals, may be acceptable for both polished and unpolished applications; aesthetic effect is the main criterion.

Ability to take polish

ALL "GRANITES"	Relevant to polished applications only. Depends upon absence of vesicles, cracks, microcracks,unstable minerals (see below); soft minerals or minerals susceptible to weathering may leave pits and dull patches on polished surfaces (eg, soft micas and feldspars partly altered to clay). Textural isotropy (see "Textural defects" above).

MARBLE, SERPENTINE — Must be free of open seams, cracks, pits or minerals liable to weather out and produce pits (eg, tremolite and clays).
Must be free of excessively hard minerals (eg, quartz, chert nodules).

Chemical Composition

ALL STONE TYPES — Chemical analysis of dimension stone is rarely of significance in regard to stone durability, except insofar as chemical composition is related to mineralogy.

Mineralogy

SANDSTONE — High percentage of quartz (minimum 60% (ASTM C 616); 85% or higher is ideal).
Low percentage of clay (10% or less is ideal, but 20% may be acceptable depending upon intergranular texture: small quantities of intergranular clay as layers and films can be more detrimental than larger amounts of interstitial clay and pellets).
Dense interstitial iron oxide cement may make a minor contribution to increasing stone strength, but its effect is generally overshadowed by clay and quartz proportions.
Deleterious minerals: Smectite: absent or trace only
Mica: minimal, randomly distributed (concentration on bedding planes causes easy splitting).
Graphite: as for mica.
Feldspar and carbonate: minimal, less than 5% preferable.
Gypsum, soluble salts; absent.

SLATE — Detrimental minerals in slates may be primary, or else secondary minerals formed through diagenetic processes. Detrimental minerals in slate can include:
Carbonaceous ribbons (see "ribbons" above).
Excessive chlorite (may cause bleaching).
Ferrous iron minerals which may oxidise to give brown (or other) stains (eg, pyrite, siderite). Note that many slates are used with a minor pyrite content, and that slates with abundant pyrite on cleavage surfaces are sometimes used as rustic slates (but in such latter cases an impermeable surface coating should be applied to reduce the tendancy for the pyrite to tarnish or stain).
Smectite clay (swelling clay which may cause cracking and crumbling).
Calcite (viens, etc): susceptible to solution in acid environments.
Salts, gypsum: may produce decay through salt attack.

ALL"GRANITES"

Unstable minerals (commonly secondary minerals) which may weather out, change colour or promote stone decay must not be present. Such minerals may include:

Pyrite and other metallic sulphides: may oxidise and produce dark stains, but do not always do so. Spry (*pers. comm.* 1990) suggests that stone which is quarried unweathered and with fresh pyrite will tend not to stain, whereas partly altered pyrite in slightly weathered deposits will break down quickly and cause staining when used in a building.

Siderite: may weather out and/or oxidise causing staining.
Calcite: may weather out (pitting)
Zeolites: "
Weathered feldspars: " (partly altered to clay)
Micas, clays (all types): " (mica unavoidable in "true" granite)
Tremolite (amphibole): "
Smectite (montmorillonite) clay: swelling clay which may cause stone decay if present along grain boundaries and/or in significant amounts.
Some olivines: may break down causing pitting and staining.
Chlorite, serpentine: prone to colour fading with exposure to sunlight.

MARBLE

Predominantly carbonate minerals; calcite preferred, dolomitic marbles may be more durable, but magnesite marbles can be excessively hard to work.
Free of smectite, excessively hard minerals, and free of minerals liable to weather out, change colour or stain (as above).

SERPENTINE

Susceptible to bleaching and cracking in sunlight; should not be used in exterior applications.
Asbestos veins are common in serpentines - weak and unacceptable. Health hazard to work with.

Strength

GENERAL

Apart from the relevance of flexural strength or modulus of rupture to the use of stone in thin tiles or veneers, stone strength (compressive and tensile) does not at first sight seem directly relevant to stone durability, since nearly all stones have sufficient strength to withstand normal loadings in a building. However, stone strength is relevant, in that it reflects the type and degree of intergranular or intercrystalline bonding in a stone, which in turn partly determines the response of stone to decay processes.

All stone types have some degree of strength anisotrophy, although this is most marked in sedimentary and metamorphic types. In general, assessment of stone strength should be based on the weakest direction (slate is an exception to this rule).

Spry (*in* Gere *et al.* 1989,p.52) gives the following general classification of stone strength categories:

Class	Compressive Strength (MPa, dry)	Modulus of Rupture (MPa, dry)
Very weak	<7	<1
Weak	8 - 20	1.1 - 2.0
Medium	21 - 70	2.1 - 7.0
Strong	71 - 140	7.1 - 15
Very strong	>140	>15

Some stone types (eg, sandstone) are inherently weaker than others (eg, granite), and this must be taken into account in planning appropriate stone types for particular applications.

SANDSTONE — The following are minimum strength values for moderate quality sandstones. Highest quality sandstones will have strengths up to double these values.

SLATE — Marked strength anisotropy relative to cleavage makes flexural strength an important criterion for slates.

ALL "GRANITES" — Minimal anisotropy required for veneers; some anisotropy may be acceptable for large dimension blocks provided they are laid in correct orientation (ie, with direction of lowest strength horizontal).

Unconfined Compressive Strength (UCS)

SANDSTONE

Oven-dried (65° C for 48 hrs):	35 MPa min.	(Spry 1983)
Soaked (in water for 48 hrs):	30 MPa min.	" "
Ratio wet/dry:	0.6 - 0.5 min.	" "

SLATE — N/A (See Modulus of Rupture)

ALL "GRANITES" — 131 MPa (dry) minimum (ASTM C 615)

MARBLE — Marbles vary between 50 to 200 MPa (dry). Strength is rarely a limiting factor in marbles but a low value would warn of low durability.
52 MPa (dry) minimum (ASTM)

LIMESTONE

Low density:	12.3 MPa min.	(ASTM)
Medium density:	27.4 MPa "	"
High density:	54.7 MPa "	"

Point Load Strength Index (Is50) .
(= tensile strength)

SANDSTONE	Oven-dried (65° C for 48 hrs):	1.5 MPa min
	Soaked (in water for 48 hrs):	1.25 MPa min.
	Ratio wet/dry:	0.6 min
SLATE	N/A (See Modulus of Rupture)	
ALL "GRANITES"	5.46 MPa (dry) minimum	
MARBLE	2.17 MPa (dry) minimum	

[-These values are calculated from the above compressive strength values using:

UCS = 24 x (Is50) (Broch & Franklin 1972)]

Flexural Strength & Modulus of Rupture

Related parameters, determined by different tests. Strength in bending. Important in design of thin veneers and paving tiles. Flexural strength is of greater importance in veneers than modulus of rupture (Spry *in* Gere *et al.* 1989, p.51).

SANDSTONE

Medium strength:	2.1 - 7.0 MPa	(Spry 1988)
High strength:	7.1 - 15.0 MPa	" "

SLATE

The strong cleavage characteristic of slate causes it to have a marked strength anisotropy with respect to the "grain" (cleavage).
Minimum dry modulus of rupture required for all slate types and applications (ASTM C 406 & ASTM C 629):

Across grain	62.1 MPa
Along grain	49.6 MPa

ALL "GRANITES" 10.34 MPa (dry) minimum (ASTM C 615)

MARBLE 7.0 MPa (dry) minimum (ASTM C 503)

LIMESTONE

Low density:	2.8 MPa	min. (ASTM)
Medium density:	3.4 MPa	" "
High density:	6.9 MPa	" "

Effective Porosity (vol.%, 1 atm)

SANDSTONE 11.0% max; 8.0% ideal (Spry 1988)

SLATE 0.1% maximum (Spry 1988,p.64)

ALL "GRANITES"	Porosity in granites is significant from the point of view of weathering decay processes, and is also of significance in applications such as paving tiles and bench-tops, since greater porosity means greater susceptibility to staining. Granites tend to resist staining, but may absorb engine oil or red wine stains (Spry 1988, p.33). 0.4% maximum (Spry 1988, p.64) (for non-vesicular stone)
MARBLE	0.1% maximum for exterior applications (Spry 1988,p.64). Spry (1988,p.18) gives the following porosity categories for marble: 0.1 - 0.2% Durable 0.2 - 0.4% Satisfactory >0.5% Low durability The lowest porosity category above is desirable for paving tiles, in order to minimise staining susceptibility.
LIMESTONE	Low density: 20% Max. (Spry, *in* Gere *et al.* 1989,p.50) High density: 1% Max. " " "

Water Absorption (wt. %, 1 atm)

SANDSTONE	5.0% max. (Spry 1988)
SLATE	The maximum allowable water absorption (weight %) figures for slate set out below are specified in ASTM C 406 and ASTM C 629, and are equivalent to effective porosity (vol.%) values considerably less stringent than the maximum porosity for slate recommended by Spry (1988) above. It would therefore be desirable to use Spry's limit in order to achieve the highest durability. The maximum water absorption recommended by the American Society for Testing and Materials (ASTM) varies according to the grade and proposed use of the stone: Requirements for roofing slate and for other exterior applications are generally more stringent than for interior applications. ASTM C 406 defines 3 grades of roofing slate, depending on the service life expected: S1: 75-100 years S2: 40-75 years S3: 20-40 years

Max. Water Absorption (ASTM Test Method C 121)

Roofing Slate (ASTM C 406)	Grade S1	0.25
	Grade S2	0.36
	Grade S3	0.45
Structural Slate (ASTM C 629)	Exterior	0.25
	Interior	0.45

ALL "GRANITES"	0.4% maximum	(ASTM C 615)	(for non-vesicular stone)

Note that this value is not equivalent to the value given above for maximum allowable effective porosity in granites, and that Spry's effective porosity limit is in effect more stringent.

MARBLE: ASTM C 503 gives a maximum permissible water absorption for exterior applications of 0.75% by weight (2.02% by volume), but Spry (1988,p.18) says this is too high (see effective porosity above).

LIMESTONE	Low density:	12.0% Max.	(ASTM)
	Medium density:	7.5% Max.	"
	High Density:	3.0% Max.	"

Dry Bulk density (tonnes/cubic metre)

SANDSTONE	2.2 min. (Spry 1988) [2.41 min. ASTM C 616]
ALL "GRANITES"	2.76 min. (ASTM C 615)
MARBLE	2.79 min. (calcite marble) 3.02 min. (dolomite marble) (ASTM)
LIMESTONE	Low density: 1.90 min. (ASTM) Medium density: 2.33 min. " High density: 2.76 min. "
TRAVERTINE	2.48 min. (ASTM)
SERPENTINE	2.90 min. (ASTM)

Abrasion Resistance Important criterion in paving applications (Spry 1988).

SANDSTONE	8.0 minimum Taber Abrasion Value (ASTM C 616)
SLATE	8.0 minimum Taber Abrasion Value (ASTM C 629) for both interior and exterior applications.
ALL "GRANITES"	Rarely a limiting factor in granites, whose Taber Abrasion values may range from 10 to 140 (Spry 1988, p.33, including basalts).
MARBLE	10 minimum Taber Abrasion Value (ASTM)
LIMESTONE	10 minimum Taber Abrasion Value (ASTM)

ALL STONE TYPES — Spry (1988, p.33) gives the following minimum values required for particular applications:

Use	Taber Abrasion Value (min)
light duty domestic	7
medium duty commercial	12
heavy duty	15

Acid Resistance (weather resistance)

SLATE — For structural slate, ASTM C 629 requires:
Exterior use: 0.38 mm max.
Interior use: 0.64 mm max.

Dimensional Instability

GENERAL — Particularly important in design of thin veneers. Encompasses effects of thermal expansion (co-efficient of linear thermal expansion) and wet/dry swelling/contraction.

MARBLE — Very important for marbles, due to susceptibility to deformation.

ALL STONE TYPES — 0.1% maximum linear dimensional change (Spry 1988, p.68).

Sodium Sulphate Soundness Test (full immersion) - (Spry 1983, 1988):

SANDSTONE

% mass loss at 15 cycles	Durability Classification
< 1	A
1 - 5	B
6 - 10	C
>10	D

(NOT REALLY APPLICABLE TO OTHER STONE TYPES - Spry 1988, p.67)

Ultrasonic Pulse Velocity (Spry 1983):

SANDSTONE

>3000 metres/second:	High strength stone
2000 - 3000 m/s:	May be good quality stone, depending on other characteristics.
<2000 m/s:	Likely to be low quality stone.

(NO DATA FOR OTHER STONE TYPES)

Elasticity (Young's Modulus)

GENERAL — Important in the design of thin veneers. Limiting values not available to this author at the time of writing.

2.4 Stone testing methods

This section gives references to standard testing procedures for the determination of the criteria listed in Section 2.3 above. In most cases details of the test methods are not given here, except in cases where no published standard exists yet.

Many of the tests required for building stone evaluation have been standardised by the American Society for Testing and Materials (ASTM), and the standard test methods may be found in the annual ASTM Standards book (Vol. 04.08: Soil & Rock, Building Stones).

In addition, the Standards Association of Australia (SAA) set up a working group in 1982 to prepare a set of Australian building stone testing standards (Working Group CE/12/6/4 - Methods for Sampling and Testing Building Stones). Draft standards for a number of tests have been completed, as noted below.

Stone testing methods for assessment of each criteria listed in Section 2.3 are as follows:

Freshness

Assessment by field observation (colour and strength changes), microscopic examination (alteration of minerals and intergranular texture) and mineralogical analysis (eg, presence of chlorite in dolerite indicates incipient alteration).

Joint breaks and fracturing

Field observation of outcrops, drill-cores, etc.

Cracks and micro-cracking

Micro-cracking is detectable on polished slabs, or by thin section examination using coloured resins (Ray 1988). The degree of micro-cracking in a stone can be quantified by using line traverses to count the number of micro-cracks in a standard 100mm traverse (several traverses - eg, five - per specimen). The form and alignment of micro-cracks should be noted (eg, parallel, random, grain-boundary cracks, intra-crystalline cracks, etc).

Lineations and foliations	Field observation on fresh outcrops,	assessment of cut slabs, etc
Cleavage	"	"
Bedding and "ribbons"	"	"
Structure	"	"
Textural defects	"	"
Segregations	"	"
Xenoliths, veins, dykes	"	"
Flow structures, breccias, etc	"	"
Vesicles, amygdales	"	"

Patches of fine microscopic vesicles (which may produce an uneven polish on basalt "black granites") can be detected by Ultrasonic Pulse Velocity testing of smooth slabs, and should also be detectable with stained thin sections.

Colour

Colour and colour patterning should be assessed on fresh exposures and cut or polished specimens. The colour of specimens should be determined in both wet and dry condition, since wetting commonly tends to darken stone colours.

Colour can be described in everyday informal terms, but for more exacting descriptions colours are classified by direct comparision with the "Rock Color Chart" available from the Geological Society of America (P.O. Box 9140, Boulder, Colorado, 80401, USA). The alpha-numerical colour classification system used on the chart was developed by the Munsell Color Company (2441 N. Calvert St., Baltimore, Maryland, 21218, USA), and is used in this report.

Texture

Roughly determined on fresh hand specimens; accurate determination by thin section microscopy.

Intergranular texture

Determined by microscopic line traverses of thin sections.

Ability to take polish

Can be inferred from presence or absence of defects in fresh specimens, but the ultimate test is commercial polishing of a typical slab.

Mineralogy

Most minerals can be identified by a combination of thin section microscopy (eg, see Kerr 1977) and X-Ray Diffraction, although in some cases more specialised methods will be necessary.

Determination of volumetric mineral percentages in a stone is performed by point counting a microscope thin section (see Pettijohn *et al.* 1973, Folk 1974).

Determination of total clay percentage by point counting may yield a higher volume percentage than would be obtained by sedimentation analysis, which measures the content of particles of true clay size (less than 2 microns). Although clay content determined by point counting may also include larger "coarse clay" or "fine mica" (sericite) grains, this determination is considered (Sharples 1990) more useful, since sericite will have a similar effect on sandstone durability to that of "true" clay.

Compressive Strength

ASTM C 170: Standard Test Method for Compressive Strength of Natural Building Stone.

SAA (draft): Compressive Strength.

Point Load Strength Index

See: Broch & Franklin (1972)
Bieniawski & Franklin (1972)

Modulus of Rupture

ASTM C 99: Standard Test Method for Modulus of Rupture of Natural Building Stone.
SAA (draft): Modulus of Rupture.

Flexural Strength

ASTM C 880: Flexural Strength.
ASTM C 120: Standard Test Method for Flexural Testing of Slate.
SAA (draft): Flexural Strength of Stone Products.

Water Absorption, Effective Porosity, Bulk Density

ASTM C 97: Standard Test Method for Absorption and Bulk Specific Gravity of Natural Building Stone.
ASTM C 121: Standard Test Method for Water Absorption of Slate.
SAA (draft): Water Absorption, Apparent Porosity and Bulk Density of Building Stone.

Abrasion Resistance

ASTM C 241: Standard Test Method for Abrasion Resistance of Stone subjected to Foot Traffic.
ASTM C 18: Abrasion Resistance.
SAA (In Prep.): Abrasion Resistance.

Acid Resistance (Weathering Resistance)

ASTM C 217: Acid Resistance.

Dimensional Instability

A relatively new test method, not yet fully standardised. The test is being developed at the AMDEL laboratory (South Australia).
SAA (In Prep.): Dimensional Instability.

Sodium Sulphate Soundness Test

SAA (draft): Sodium Sulphate Soundness Test (Full Immersion)

Ultrasonic Pulse Velocity

Ultrasonic Pulse Velocity (UPV) can be conveniently measured using the lightweight battery (or mains) powered PUNDIT instrument manufactured by C.N.S. Instruments Ltd. (London).
The limitations and appropriate circumstances for the use of UPV measurements on sandstones are discussed by Sharples (1985).

CHAPTER THREE

SUMMARY OF PROMISING STONE RESOURCES IN TASMANIA

3.1 Introduction

This chapter is an index to all currently worked building and ornamental stone quarries in Tasmania, and to all promising stone resources identified in the course of this project.

In the following chapters, stone resources and quarries are ordered according to geological age and association, and each is discussed in the degree of detail considered necessary for adequate description and assessment of likely quality as a building stone resource. The prospectivity of each geological association as a potential building stone resource is classified as "high", "medium" or "low" in accordance with the criteria laid down in Section (A 1.3) of Appendix One.

In this chapter, quarries and potential resources considered to be promising are briefly listed without details, and are ordered into categories according to aesthetic and practical criteria only. The page numbers alongside each listed quarry or prospect refer the reader to the section of this report in which full details can be found.

3.2 Sandstone

Uniformly coloured brown sandstone (large block sizes)

		Page No.
PROSPECTS:	QUARTZ SANDSTONE SEQUENCE Tasmania Basin. Linden - Oatlands - Blessington belt particularly prospective.	63
QUARRIES:	COBBS HILL QUARRY (Plates 3.1, 4.7) Very high durability, but maximum unflawed block sizes only one metre diameter (approx.). Examples of usage: Mainly domestic (brick-size blocks).	74
	ELDERSLIE QUARRY (Plate 3.1) Moderate durability (significant dimensional instability). Example of usage: Portico restoration, Old Supreme Court (1989) (cnr. Murray & Macquarie St.s, Hobart)	74
	OATLANDS QUARRY (Plates 3.1, 4.2) Moderate durability. Example of usage: Hobart Stock Exchange, Macquarie St. (1988)	76
	LINDEN QUARRY (Plates 3.1, 4.5) Moderate to high durability except in situations where wet/dry cycling can strongly affect stone (minor smectite content). Some subdued brown banding. Examples of usage: G.P.O. Hobart (1901) Supreme Court, Salamanca Place, Hobart (≈1980) Commonwealth Law Courts, Davey St., Hobart (1984)	76

Uniformly coloured grey-white sandstone (large block sizes)		Page No.
PROSPECTS:	LOWER FRESHWATER SEQUENCE Tasmania Basin (north, northwest, northeast). Restricted deposits, only one good deposit currently known (Nunamara Quarry).	58
	QUARTZ SANDSTONE SEQUENCE Tasmania Basin. Widespread deposits.	63
QUARRIES:	NUNAMARA QUARRY (Plate 3.2) Moderate to high durability, some brown banding close to joints. Examples of usage: Parliament House, Hobart (N. end extensions, 1970's) Old St. Mary's Hospital restoration, cnr. Davey St. and Salamanca Place, Hobart (1983)	61
	PONTVILLE WHITE SANDSTONE QUARRY (Plate 3.2) Moderate durability only, "snowy" white stone. Examples of usage: St. Davids Cathedral restoration (entrance cnr Murray & Macquarie St.s, Hobart, 1970's)	72
	BUCKLAND QUARRY (Plates 3.2, 4.1) Moderately good durability likely (new quarry). Examples of usage: New quarry.	78

Brown-banded sandstone (large block sizes)		
PROSPECTS:	LOWER FRESHWATER SEQUENCE Tasmania Basin (north, northwest, northeast), close to intrusive dolerite contacts. Restricted deposits, only one good deposit currently known (Nunamara Quarry).	58
	QUARTZ SANDSTONE SEQUENCE Tasmania Basin, close to intrusive dolerite contacts. Widespread deposits.	63
QUARRIES:	NUNAMARA (Plate 3.2) Moderate to high durability, colour banding within 1.0 - 1.5 metres of joints. Examples of usage: Parliament House, Hobart (N. end extensions, 1970's) Old St. Mary's Hospital restoration, cnr. Davey St. and Salamanca Place, Hobart (1983)	61
	PONTVILLE BROWN (Plate 3.2) Moderate durability only, quarry nearly worked out. Examples of usage: Mainly domestic use (Hobart region). Bowen Bridge, Hobart, eastern abutments (1984)	72

Brown-banded sandstone (slabs and flagging)

3.3 Slate

Metamorphic slate (uniform black and white-rimmed varieties)

Page No.

"Sedimentary"/metamorphic slate (uniform black & rustic/pyritic varieties)

PROSPECTS: COWRIE SILTSTONE CORRELATES: LAWSON RIVER SILTSTONE 87
Arthur - Horton River region.

QUARRY: TAYATEA QUARRY (Plate 3.5) 89
Uniform black and brown "rustic" and pyritic varieties interlayered.
Large slab sizes available.
Example of usage: Tall Timbers Hotel, Smithton, 1989 (Paving, ornamental walls of rustic and pyritic varieties).

3.4 "True" Granite

Grey granite
(Equi-granular, and porphyritic varieties which appear equigranular except on close inspection)

PROSPECTS: DIDDLEUM GRANODIORITE (Plate 3.5) 121
NE Tas. Large body, good quarry sites, close to Launceston.
Potentially good quality "ordinary" grey granite.
Medium-grained.

TULENDEENA GRANODIORITE (Plate 3.6) 122
NE Tas. Similar to Diddleum Granodiorite, less extensive.

PORCUPINE CREEK GRANODIORITE 122
NE Tas.

GARDENS GRANODIORITE (Plate 3.6) 129
NE Tas. Similar to Diddleum Granodiorite, poor outcrop.

RUSSELLS ROAD ADAMELLITE (Plate 3.6) 123
NE Tas. Medium- to coarse-grained, somewhat lighter colour than the granodiorites. Large body, good quarry sites available.

POIMENA ADAMELLITE (Plate 3.6) 131
NE Tas. Medium- to coarse-grained, somewhat lighter colour than the granodiorites. Very large body, good quarry sites available.

QUARRY: MEMORY ROAD QUARRY ("Martich") (Plate 3.6) 123
Russells Road Adamellite.

Page No.

Grey-white granite
(Distinctly lighter colour than above "grey" granites. Equi-granular, and porphyritic varieties which appear equigranular except on close inspection)

PROSPECTS: HEEMSKIRK "WHITE" GRANITE 114
Western Tas. Medium-grained, parts of body rich in black tourmaline nodules.

MT. PEARSON ADAMELLITE (northern part) (Plate 3.7) 132
NE Tas. Coarse-grained, reminiscent of interstate "Riverina Granite".

ANSONS BAY SOUTH ADAMELLITE (southern part) (Plate 3.7) 137
NE Tas. Coarse-grained, very light "white" colour with black biotites. Poor outcrop.

Porphyritic grey granite
(Distinctly porphyritic varieties)

PROSPECTS: SCAMANDER TIER GRANODIORITE (Plate 3.7) 128
NE Tas. Medium grey with distinctive white phenocrysts (somewhat uneven phenocryst distribution).

Light pink granite (equi-granular)

PROSPECTS: HOUSETOP GRANITE (Plate 3.8) 115
NW Tas., close to Burnie. Medium- to coarse-grained, colour varies from light pink to dark reddish-brown.

RUSSELLS ROAD ADAMELLITE 123
NE Tas. Medium- to coarse-grained. Generally a grey granite, but subtle pink colour present in some of northern part of body.

TOMBSTONE CREEK PLUTON (Plate 3.8) 127
NE Tas. Fine- to coarse-grained, typically light grey-pink colour.

QUARRY: BLESSINGTON QUARRY ("Jaydon") (Plates 3.8, 6.2) 127
Tombstone Creek Pluton.
Examples of usage: Domestic interior features.

Red, red-brown and brown granites (equi-granular)

PROSPECTS: HEEMSKIRK RED GRANITE (Plate 3.8) 112
Western Tas. Fine- to coarse-grained, colour varies from bright red to lighter and duller or darker reds.

HOUSETOP GRANITE (Plate 3.9) 115
NW Tas., close to Burnie. Medium- to coarse-grained, colour varies from light pink to dark reddish-brown to a strong brown colour.

		Page No.
	COLES BAY ADAMELLITE (Plate 3.9) Eastern Tas. Medium- to coarse-grained, bright red colour.	141
QUARRIES:	COLES BAY QUARRY ("Nelson Red") (Plate 3.9) Coles Bay Adamellite, bright red. Examples of usage: Old quarry, numerous examples in Tas. and mainland. Eg,: Commonwealth Bank, Cnr Elizabeth and Liverpool St.s, Hobart.	142
	TRIAL HARBOUR QUARRY ("Anajul") (Plate 3.8) Heemskirk Red Granite, dark red. Examples of usage: New quarry.	114
	UPPER NATONE QUARRY PROSPECT Housetop Granite, distinctly brownish - dark red colour. Quarry not yet developed.	116

Porphyritic "brown" granite
Unusual chilled margin variety, colour difficult to define.

PROSPECTS:	RUSSELLS ROAD ADAMELLITE (Plate 3.9) NE Tas. Chilled margin	123
	OTHER GRANITOIDS? Chilled Margins	
QUARRY:	DIDDLEUM QUARRY ("Tequila") (Plates 3.9, 6.1) Coarse phenocrysts in fine- to medium-grained groundmass. Example of usage: 116 Murray St., Hobart (1990)	124

3.5 Black Granite

Fine-grained black basaltic types

PROSPECTS:	SPILITE BASALT (Crimson Creek Fm. correlate) (Plate 3.9) Smithton region, NW Tas. Dark black with attractive annealled veins and amygdules. Least fractured Cambrian basalt.	156
	TERTIARY BASALT (Plates 3.10, 7.6) NW Tas., Central Plateau. Dark black, microscopic vesicles cause polishing problems.	186
QUARRY:	MIENA ("Royburg Black") (Plates 3.10, 7.6) Tertiary basalt. Large dark black slabs. Polishing problems due to microscopic vesicles. Good potential for unpolished paving, etc.	191

Medium- to coarse-grained doleritic types Page No.

PROSPECTS: JURASSIC DOLERITE & GRANOPHYRE (Plates 3.10, 7.1-5) 163
Widespread, most prospective in NE Tas. Varies from dark-grey and grey-greenish mottled varieties to uniform dark black varieties. Fine fracturing is a problem, but considered best Tasmanian black granite prospect.

3.6 Other granites

Coarse-grained green pyroxenite

PROSPECTS: CAMBRIAN ULTRA-MAFIC COMPLEXES 199
Outcrops at Adamsfield UMC, possible occurrences elsewhere. Attractive green stone, but dubious prospect due to fracturing access problems.

Pegmatitic gabbros (rhodingites)

PROSPECTS: CAMBRIAN ULTRA-MAFIC COMPLEXES (Plate 3.12) 200
Outcrops at Heazlewood R. UMC, occurrences elsewhere. Attractive mottled dyke rock, but dubious prospect due to fracturing.

Vari-coloured crystalline volcanics

PROSPECTS: MT. READ VOLCANICS (Plates 3.11, 8.1-4) 201
Western Tasmania (Dundas Trough). Attractive porphyritic lavas, agglomerates and breccias. Uniform and brightly mottled varieties, polish well. Exciting possibility, but fracturing may be a problem.

3.7 Marbles

Metamorphic Marbles

PROSPECTS: MAGNESITE MARBLE (Plate 3.13) 222
NW Tas. (Arthur Lineament). Very attractive altered dolomite, crystalline, polishes well. Dubious prospect due to fracturing.

CRYSTALLINE DOLOMITIC (?) MARBLE 220
Glovers Bluff, S. Tas. Recent discovery, not evaluated yet. Pure composition, very colourful.

OTHER METAMORPHOSED PRECAMBRIAN DOLOMITES? 220
No others known yet, but possible exploration target.

Page No.

"Sedimentary" Marbles

PROSPECTS: PRECAMBRIAN/EOCAMBRIAN/CAMBRIAN DOLOMITES 224,226,227
Western Tasmania. Some interest, but predominantly of poor outcrop and difficult access.

ORDOVICIAN LIMESTONES 229
Widespread. Interesting potential for dark-grey to black marble with white veins, fossils, etc.

3.8 Serpentines

No potential for large panels. Potential exists for terrazzo, small ornamental carvings, and possibly for small tiles.

Dark- to medium-green serpentines

PROSPECTS: CAMBRIAN SERPENTINISED ULTRA-MAFIC COMPLEXES 235
Numerous occurrences, most promising include Forth UMC (small carvings, ?tiles), Serpentine Hill UMC (terrazzo), Cape Sorell UMC (small carvings, ?tiles, but remote area). Other UMC's possibly prospective for small carvings, etc.

3.9 Other stone types

Limestone and dolomite
Potential use as unpolished masonry blocks, veneers and paving.

PROSPECTS: ORDOVICIAN LIMESTONES 242
Widespread, dense and strong, high potential for this usage.

PERMIAN LIMESTONES 242
Hobart area, similar to Ordovician limestones.

Colourful siliceous conglomerates
Potential use as colourful ornamental stone (interiors, etc).

PROSPECT: OWEN CONGLOMERATE (Plate 3.12) 244
Western Tasmania (Dundas Trough). Strong, durable, likely to take good polish. Reddish colouration. Available in large erratic boulders (environmentally acceptable sources).

Colourful siliceous hornfels
Potential use as colourful and durable paving and feature walls.

PROSPECT: HORNFELS - CASTLE CAREY MUDSTONE (Plate 3.13) 246
Fingal area, NE Tas. Bright purple with colourful liesegang rings. Strong, siliceous, best occurrences in joint blocks 0.3 metre or less diameter.

1

2

3

4

Plate 3.1 SANDSTONE:

1:	Quartz Sandstone Sequence:	Cobbs Hill Quarry	(x 0.7)
2:	" " "	Elderslie Quarry	(x 0.7)
3:	" " "	Oatlands Quarry	(x 0.7)
4:	" " "	Linden Quarry	(x 0.7)

5 cm

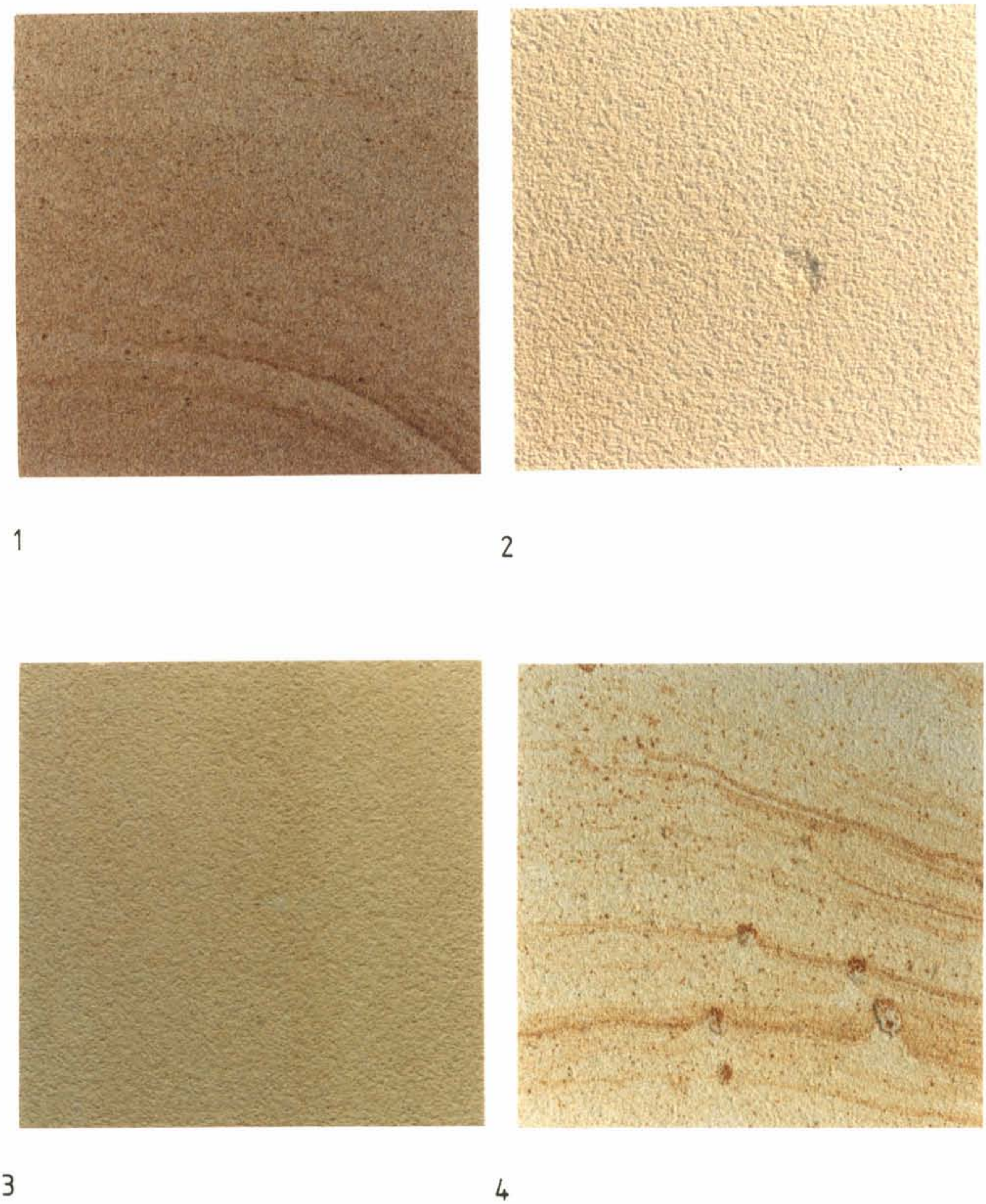

Plate 3.2 SANDSTONE:	1) Lower Freshwater Sequence:	Nunamara Quarry	(x 0.7)
	2) Quartz Sandstone Sequence:	Pontville White Quarry	(x 0.7)
	3) " " "	Buckland Quarry White	(x 0.7)
	4) " " "	Pontville Brown Quarry	(x 0.7)

5 cm

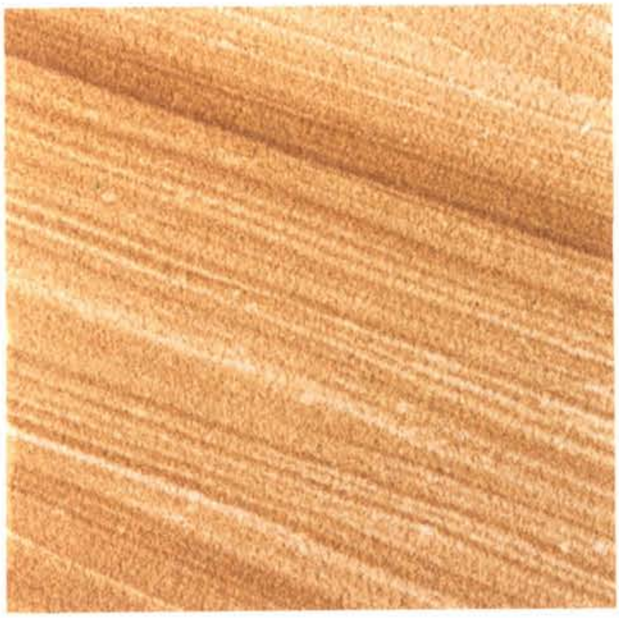

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Plate 3.3 SANDSTONE: 1) Quartz Sandstone Sequence: Buckland Quarry Brown (x 0.7)
2) " " " Molesworth Quarry (x 0.7)
3) " " " Mike Howes Marsh Quarry (x 0.7)

5 cm

1

2

Plate 3.4	SLATE:	1) Mathinna Beds - Lutite Association:	Back Creek Quarry
		2) " " " "	Bangor Quarry

5 cm

1

2

Plate 3.5 SLATE: 1) Cowrie Siltstone correlate: Tayatea Quarry
"TRUE" GRANITE: 2) Diddleum Granodiorite (site G/Ne/27/3)

5 cm

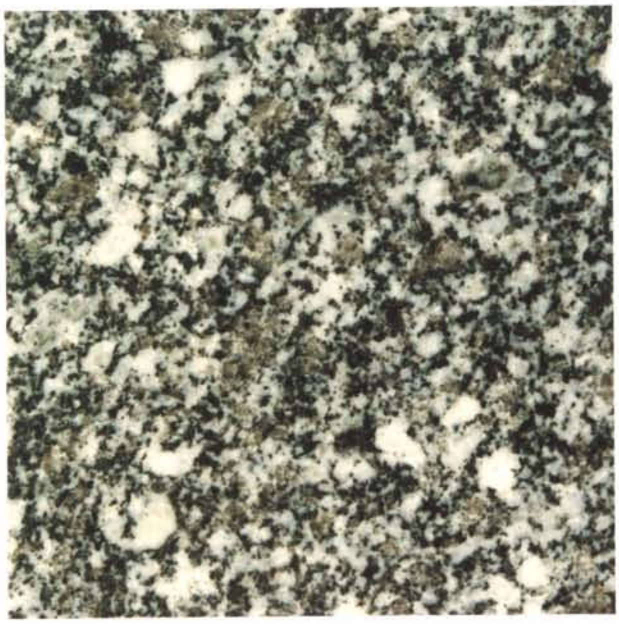

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Plate 3.6 "TRUE" GRANITE:
1) Tulendeena Granodiorite (site G/Ne/7/1) (x 0.7)
2) Gardens Granodiorite (site G/Ne/12/1) (x 0.7)
3) Russells Rd. Adamellite: Memory Rd. Qry - "Martich" (x 0.7)
4) Poimena Adamellite (site G/Ne/13/1) (x 0.7)

5 cm

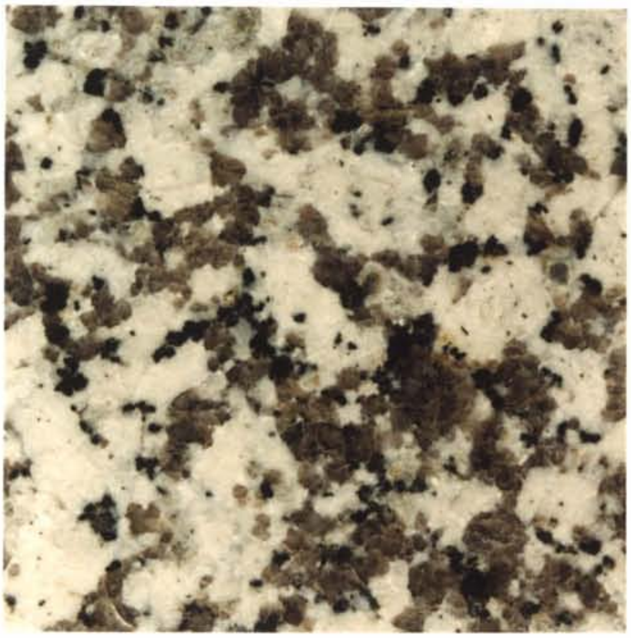

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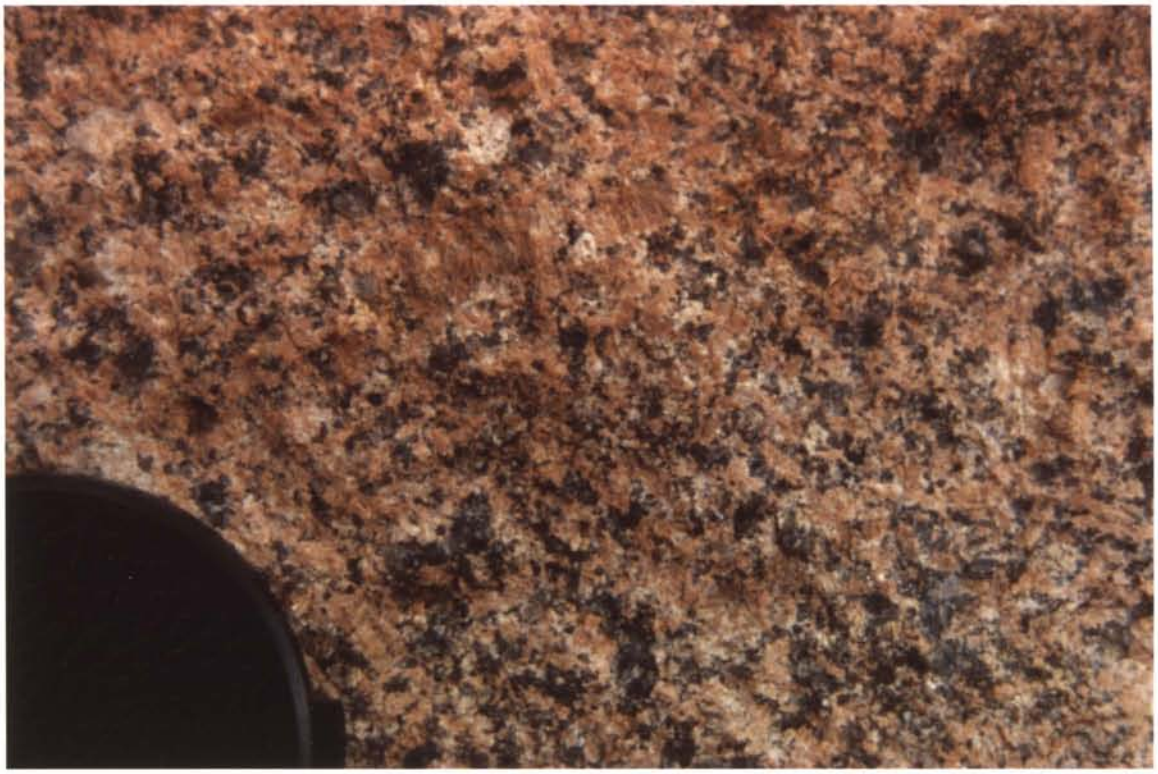
Plate 3.7 "TRUE" GRANITE: 1) Mt. Pearson Adamellite (site G/Ne/20/1) (x 0.7)
2) Scamander Tier Granodiorite (site G/Ne/ 1/1) (x 0.7)
3) Ansons Bay South Adamellite (site G/Ne/11/1)

5 cm



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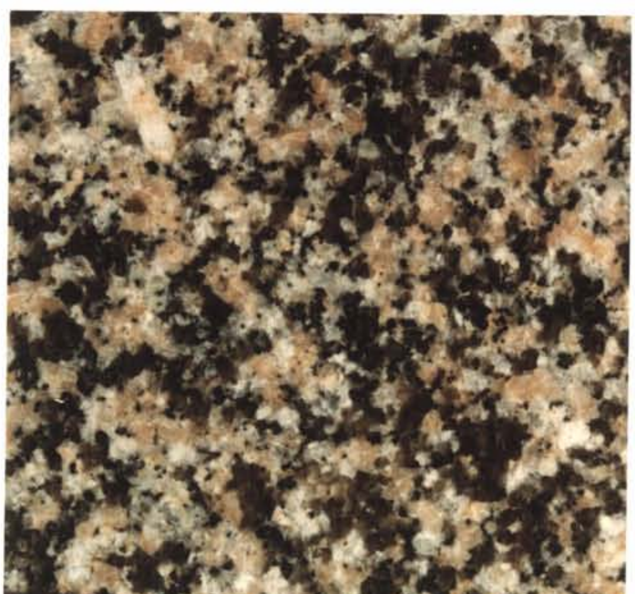

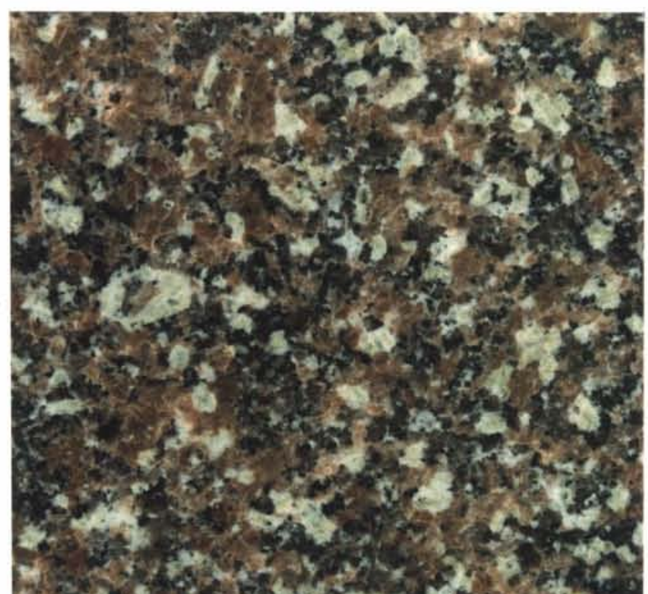

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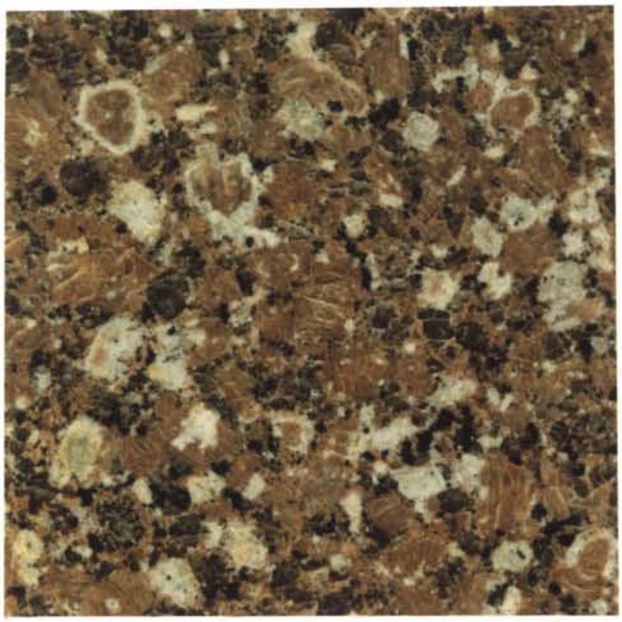
Plate 3.8 "TRUE" GRANITE: 1) Housetop Granite (pink) (site G/Dr/3/1)
2) Tombstone Creek Pluton: Blessington Qry - "Jaydon" (x 0.7)
3) Heemskirk Red Granite: Trial Harbour Qry - "Anajul" (x 0.7)

5 cm



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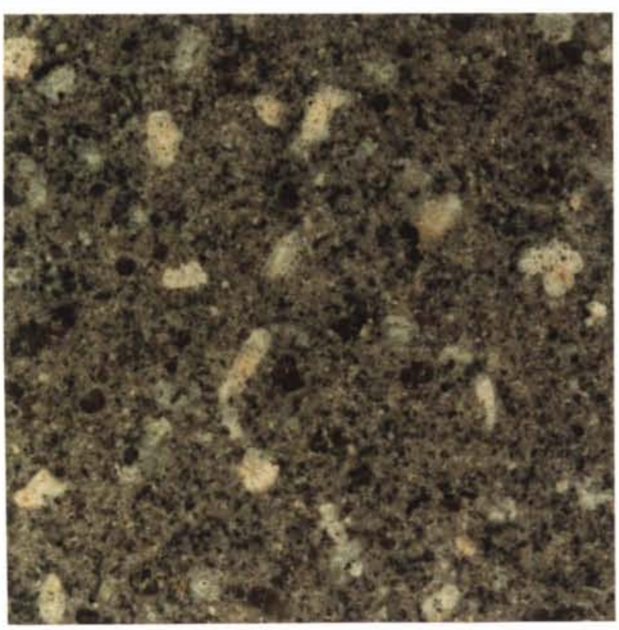

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Plate 3.9 "TRUE" GRANITE: 1) Housetop Granite (brown) (site G/Dr/ 4/1) (x 0.7)
2) Coles Bay Adamellite: Coles Bay Qry - "Nelson Red" (x 0.7)
3) Russells Rd. Adamellite: Diddleum Qry - "Tequila" (x 0.7)
BLACK "GRANITE": 4) Spilite Basalt (site Bg/ Rb/7/1) (x 0.7)

5 cm

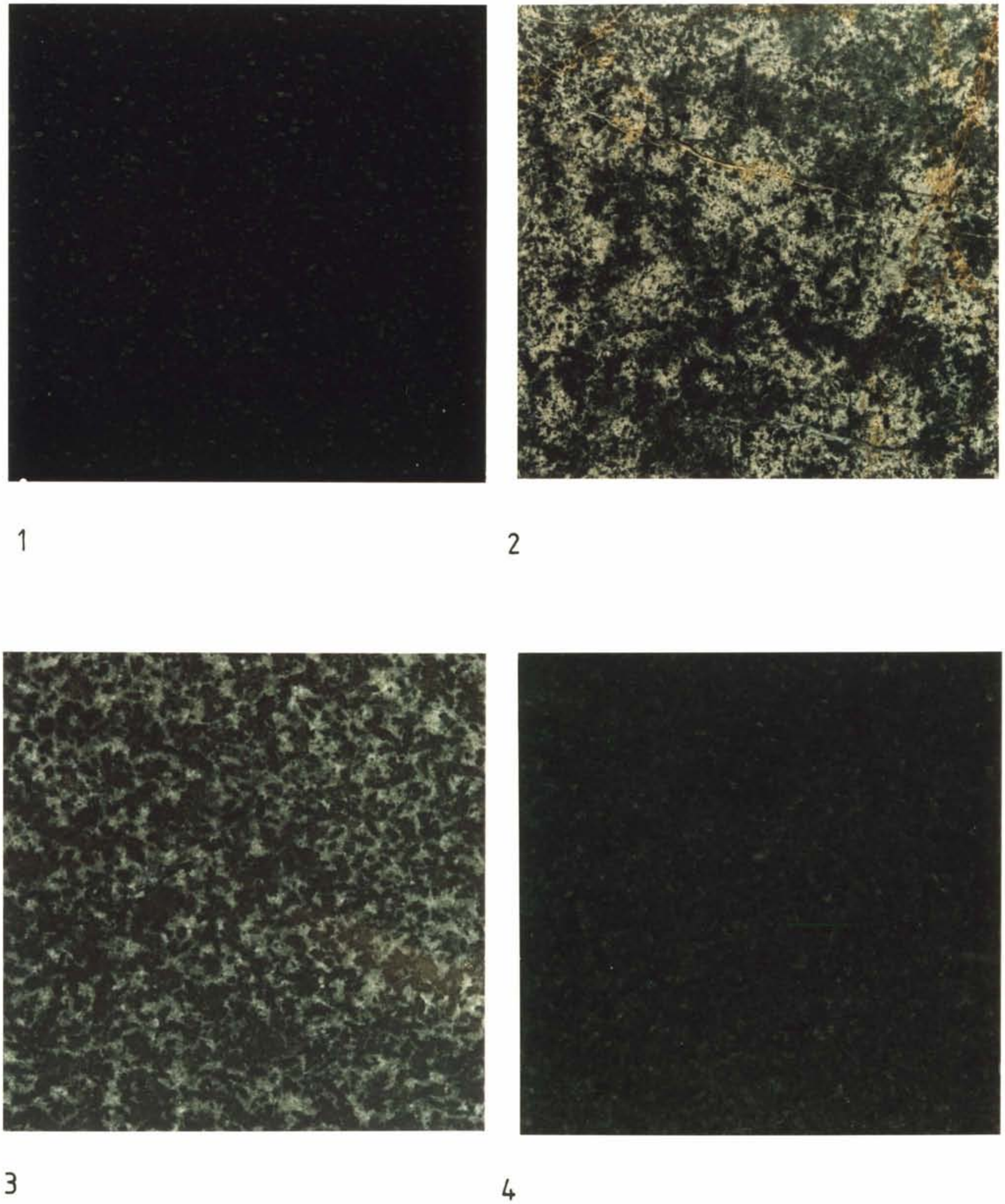
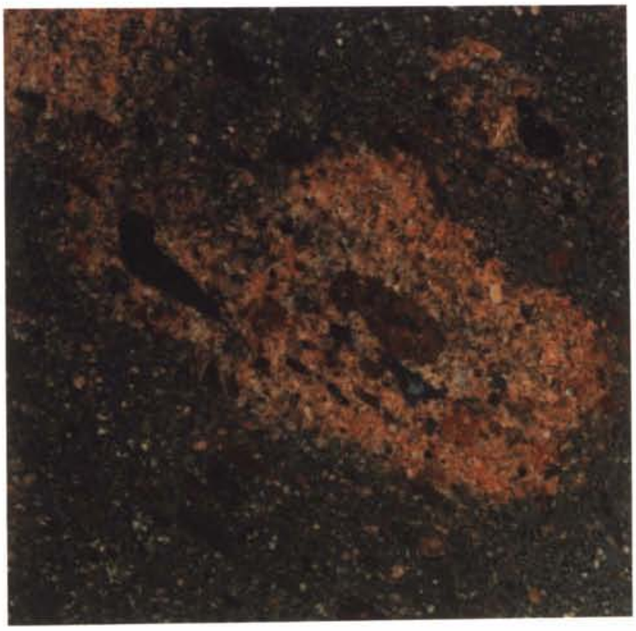


Plate 3.10 BLACK "GRANITE": 1) Tertiary basalt: Miena Quarry - "Royburg Black" (x 0.7)
2) Jurassic Granophyre (site Bg/Ts/3/1) (x 0.7)
3) Jurassic dolerite/granophyre (site Bg/Ts/3/2) (x 0.7)
4) Jurassic dolerite (site Bg/Tn/1/1) (x 0.7)

5 cm



1

2

3

4

Plate 3.11 OTHER "GRANITE": 1) Mt. Read Volcs: Pink agglomerate (site Og/Dr/1/1)(x 0.7)
2) " " " Agglomerate (site Og/Dr/1/2)(x 0.7)
3) " " " Porphyritic lava (site Og/Dr/4/1)(x 0.7)
4) " " " Porphyritic lava (site Og/Dr/5/1)(x 0.7)

5 cm

1

2

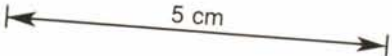
Plate 3.12 OTHER "GRANITE": 1) Rhodingite (pegmatitic gabbro): Heazlewood UMC
OTHER STONE: 2) Owen Conglomerate: (site X/Dr/2/1)

5 cm

1

2

Plate 3.13	MARBLE:	1) Magnesite Marble:	Arthur River (site M/Rb/7/2)(x 0.7)
	OTHER STONE	2) Coloured hornfels:	Castle Carey Mudstone (site X/Ne/1/1) (x 0.7)



CHAPTER FOUR

SANDSTONE

4.1 Definition and description

Sandstone is a clastic sediment, composed of sand grains with mean diameters between 0.0625 and 2.0 millimetres, which are bound together by a matrix of silt and/or clay, and by chemically precipitated cements which may include silica, iron oxides or hydroxides, and calcium carbonate. The sand grains generally are dominantly quartz, but may also include feldspar and other minor minerals or rock fragments.

Since minerals vary in their chemical and physical stability, the highest possible proportion of stable minerals is required for durable sandstone. High quartz content is necessary, and the lowest possible content of clays, feldspars, micas, carbonates and other unstable minerals is desirable. A certain amount of clay is present in most Australian building stones, but the stability of various types varies. Illite and kaolinite are common and not especially detrimental to stone durability, except insofar as any clay tends to lower stone strength as the clay content increases. However, smectite (or "montmorillonite") shows marked swelling behaviour when wetted, and sandstone containing any more than trace quantities of this clay will have reduced durability.

Quartz sandstones are prospective as building sandstones; however greywackes or lithic, highly feldspathic, carbonaceous and calcareous sandstones contain an abundance of weak or unstable minerals, and are generally not suitable for building purposes (although some have been used, often with a notable lack of success).

Sandstones may be classified by their mean grainsizes. The following grainsize categories (which differ slightly from those used by Spry 1983) are used in this work (from Berkman and Ryall 1976):

	Mean grain diameter (mm)
Very Coarse	1.0 - 2.0
Coarse	0.5 - 1.0
Medium	0.25 - 0.5
Fine	0.125 - 0.25
Very Fine	0.0625 - 0.125

Most sandstones used for building purposes have grainsizes in the fine to medium categories.

The strength and porosity of sandstone is largely determined by its microscopic texture, which encompasses grainsize, degree of sorting of grainsizes, grain shape and orientation, grain packing and intergranular texture (percentage and distribution of various types of clay or cement bonds between grains). Quartz/ quartz bonds are generally strong and quartz/clay bonds weaker, with clay present in the form of intergranular layers and films causing greater strength reduction than similar volumes of clay in pellets or interstitial masses.

The colour of Tasmanian sandstones is largely dependant upon the presence or absence of iron oxides or hydroxides in the form of chemically precipitated cements. In the absence of iron cements, the sandstones generally have a uniform grey-white colouration produced by the white clay matrix and translucent quartz grains. A uniformly distributed iron cement yields a uniform yellow or brownish colour, while the concentration of iron cement into bands or patches yields yellow or brownish colour patterns such as regular concentric rings ("Liesegang

Rings"), bands, patches, spots and nodules.

The rapid colour darkening after quarrying which occurs in some New South Wales sandstones, as a result of the oxidisation of siderite (iron carbonate) in those stones, has not been found in Tasmanian sandstones. Pyrite or marcasite would produce dark weathering stains if present (minor in Tasmanian sandstones).

Sandstone is deposited in horizontal (or low-angle) layers known as beds. The bedding planes separating beds represent minor or temporary changes in depositional conditions, and can potentially be planes of weakness along which the stone may tend to split. Three types of bedding are common in Tasmanian sandstones:

Massive bedding	Thick beds with no internal structure (see Plate 4.2).
Cross-bedding	Successive beds, or "sets", with an internal structure of inclined laminations, which in some cases are slumped or otherwise deformed.
Plane bedding	Distinct, closely spaced horizontal bedding planes which commonly split easily. Often known as flagging or flagstone (see Plate 4.6).

Some sandstone deposits may contain textural "defects" which are generally regarded as undesirable for building and ornamental stone. Such defects may include quartz pebbles, clay pellets, thin clay or mud bands, iron oxide concretions, and porous "sanding" balls.

Sandstone outcrops normally contain breaks or fractures which, if of a more or less planar and parallel nature, are referred to as joints. Deep fractures and joints should be spaced at least two metres or so apart in order that large unbroken blocks of sandstone can be extracted (although some quarries such as Cobbs Hill (Plate 4.7) have successfully operated with closer fracture spacings, by producing small dimension blocks for domestic use).

Fractures on the surface of naturally weathered outcrops can be deceptive, in that they may in some cases be purely the result of weathering processes, and extend only a few centimetres into the stone body.

Sandstone in the surface metre (or more) thick layer of naturally weathered outcrops may be significantly weakened by weathering processes, even though colour and other characteristics may seem little changed. Current investigations by the author suggest that north-facing (in Tasmania) and/or bare natural outcrops suffer the greatest degree of weathering alteration due to the extremes of temperature and moisture variations which they experience. Soil-covered and/or permanently shaded south-facing outcrops suffer less such variations, and so weathering of sandstone in such situations may be less pronounced, such that near-surface samples may in fact be nearly fresh and unaltered.

This implies that south-facing outcrops overlain by a thin soil layer may have very little weathered surface stone which must be removed to get at fresh stone, and such sites would be ideal for quarrying. However, until this hypothesis is confirmed, it is best to proceed on the assumption that all natural outcrops are significantly weathered close to the surface.

Surface outcrop samples cannot be relied upon to give a good indication of sandstone strength or intergranular texture. Although preliminary evaluation of potential sandstone sources can give useful indications of likely stone quality from outcrop samples, at least in terms of bedding, jointing, colour and mineral types present (including smectite presence), a definitive evaluation requires samples obtained from at least two or three metres below natural outcrop surfaces, by means of excavation or drilling.

4.2 Sandstone applications

Potential building applications for sandstone vary according to the bedding type and durability of the sandstone. High quality work (eg, restoration of historic buildings) in high stress locations (eg, base-courses, window sills, tops of walls) requires only the highest durability stone. Stone of lower durability may be quite adequate for ashlar walls, domestic walls, and interior applications.

In terms of bedding type, potential sandstone applications include the following:

Massively bedded (faint cross-bedding may be acceptable)	Uniform brown or grey/white (subdued colour patterning may be acceptable)	Masonry blocks:	restoration ashlar walls brick-size domestic blocks
		Tracery, carving	(high durability required)
		Veneers, cladding	(high flexural strength required) Sandstone should only be used for cladding low-rise buildings; not suitable for thin veneers or high-rise buildings due to relatively low durability. Sandstone veneers should not be thinner than 75-100mm.
Cross-bedded (strongly)		Tiles, slabs	
Plane bedded (flagging)	Mainly domestic use. Strong colour patterning generally preferred.	"Bookleaf" wall construction	(naturally bedded)
		Paving slabs	(minimal porosity required to reduce staining; high abrasion resistance & high modulus of rupture needed; few sandstones are truly suitable for paving for these reasons)
		Ornamental walls, fireplaces, etc	(Generally face-bedded)

4.3 Sandstone quarrying in Tasmania

Sandstone has been the most abundantly quarried building stone in Tasmania since the early days of European settlement. Major historic and disused sandstone quarries are listed and described in Sharples *et al* (1984) and Sharples (1990). Much of the early stone used was of very poor quality, and the historic buildings in which they were used are commonly now in a bad state of decay. Examples are the Cambrian greywacke sandstones (up to approx. 50% clay!) used in the Sarah Island penitentiary (only part of one wall still stands), and the smectite-rich Port Arthur, Kangaroo Point Green and Domain sandstones. The poor state of buildings constructed with these stones illustrates the importance of careful stone choice in construction of buildings intended to be of lasting value in the urban environment.

Currently or recently operating sandstone quarries in Tasmania are listed below (see also Figure 4.1); details and descriptions are provided in section (4.5) of this report, in Sharples *et al.* (1984) and in Sharples (1990). All these deposits are of Triassic age except for the Nunamara quarry, which is of Permian age.

Pontville Brown	Brown liesegang banding	Etna Stone
Pontville White	Uniform white	Etna Stone / Rizzolo
Cobbs Hill	Uniform brown	Etna Stone
Elderslie	Uniform brown	Rizzolo Stone & Concrete
Nunamara	Grey/white with some brown banding	Dunn Monumental Masons
Oatlands	Uniform brown	Dunn Monumental Masons
Linden	Uniform brown (subtle brown banding)	A. Ashbolt
Buckland	Grey/white with some brown banding	T. Howells
Molesworth	Flagstone: brown liesegang banding	Pontville Freestone
Mike Howes Marsh	Flagstone: brown liesegang banding	Unique Stone Paving

4.4 Sandstone sources and prospects in Tasmania

Numerous geological associations of all ages in Tasmania contain sandstone beds. However, very few of these associations have been found to have potential for building sandstone production, on account of intense jointing, high clay content, unstable mineralogy, thin and discontinuous occurrence, and other reasons.

Nearly all building sandstone production to date has been from the Permian and Triassic age associations listed below, and these continue to be the only associations considered to have potential for building sandstone production. See Sharples (1990) for a fuller discussion of sandstone exploration prospects.

The following associations are considered prospective:

PERMIAN	Lower Freshwater Sequence (Liffey Group, Mersey Coal Measures, correlated units)	-North, NW and NE Tas.
TRIASSIC (Early Triassic)	Quartz Sandstone Sequence (Unit 2 of Forsyth *in* Burrett & Martin 1989)	-Tasmania Basin (SE, central and central-northern Tas. Numerous areas)

4.5 Evaluation of sandstone sources and prospects in Tasmania

The following discussion is a brief summary of detailed information in Sharples (1990).

PERMIAN
North and northeastern Tasmania
Lower Freshwater Sequence

PROSPECTIVITY - High

The Permo-Carboniferous sedimentary rocks of the Tasmania Basin (SE, central and northern Tasmania) form a sequence of tillites (at the base), overlain by predominantly glacio-marine siltstones, mudstones and minor limestones, sandstones, conglomerates and coals known as the Lower Parmeener Supergroup (Forsyth *et al.* 1974).

Clarke & Banks (1975) subdivided the Lower Parmeener Supergroup into Upper and Lower Marine Sequences, with an intervening Lower Freshwater Sequence. The Lower Freshwater Sequence (also termed the Lower Bernacchian non-marine interval: Clarke, *in* Burrett & Martin 1989,p.302) comprises terrestial and minor marine deposits of sandstone, coal and lutites (mudstones and siltstones). Correlated units belonging to the Lower Freshwater Sequence include the Liffey Group, Mersey Group and Mersey Coal Measures (northern Tasmania), and the Faulkner Group (in the Hobart area).

Only one building sandstone quarry (Nunamara) is currently operating in the Lower Freshwater Sequence sandstones (see p. 61), and no other promising prospects are currently known in the sequence. However, the high quality of the Nunamara sandstone suggests that exploration for further such deposits is warranted.

The Lower Freshwater Sequence represents a regressive pulse during the predominantly marine filling of the Tasmania Basin. The Sequence varies from six to fifty metres (modally 21 - 25m) thick, and was deposited under post-glacial cold climate conditions in a broad fjord-like basin bordered on the southwest, northwest, west and northeast by low hills from which sand and some gravel were shed. The basin opened to the sea in the southeast, with fluvial plains extending just south of Hobart at their maximum extent, and the sea being restricted to an area south of Margate (the Hickman Formation) for most of the period (Martini & Banks 1989).

In general, the fluvial deposits are characterised by well-sorted, quartz-rich, cross-bedded sandstone with pods of conglomerate and scattered siliceous pebbles in some places. The sandstone tends to be coarser around the margins of the basin, and finer in the southeast. Lutites become dominant in the southeast, with the Faulkner Group in the Hobart area consisting predominantly of siltstone with thin intervals of poorly-sorted conglomeratic sandstone, and the Boullanger Formation (Maria Island) consisting mainly of mudstone and sub-ordinate siltstone. Minor coals were deposited in a number of places.

The Lower Freshwater Sequence has suffered little tectonic deformation, so that bedding dips are generally close to horizontal.

Martini & Banks (1989) identified 22 distinct sedimentary facies in the Lower Freshwater Sequence, which are grouped into marine, coastal-alluvial plain, alluvial and piedmont facies groups. Although several of the facies identified by Martini & Banks could concievably include deposits of building-quality sandstone, a good way to start identifying exploration prospects is to consider the only currently-known building-quality sandstone deposit in the Lower Freshwater Sequence: the Nunamara Quarry.

The characteristics of the Nunamara Quarry deposit (see p. 61) correspond in most respects to the "alluvial meandering stream deposit" (Am) facies of Martini & Banks, which they describe as:

"Am (alluvial meandering):
Well-developed sandy fining and thinning upward sequences (1-5m thick), generally with cross-beds at the base, some massive and plane beds, capped by prevalent cross-laminations; some units may have a few basal, fine, well-rounded pebbles in thin layers, but no anomalous feature or lonestone have been found anywhere which could not be explained as formed by fluid flow; silty and sandy deposits, in places with thin coal and torbanite interlayers and plant fragments, separate the recurring sandy sequences; this facies is interpreted as bar and floodplain deposits of meandering streams." (Martini & Banks 1989,p.30).

Martini & Banks recognise four regions within the Tasmania Basin, each of which contain a predominance of particular facies associations:

1) North-eastern area (includes Fingal - St. Mary's area) - Coarse gravelly alluvial fans, braided streams and meandering streams as well as some marine facies.

2) North and north-western area (includes Nunamara and Preolenna) - Sandy fluvial deposits of meandering streams and minor braided streams.

3) Central-north area (includes Latrobe-Interlaken area, and further south) - Sandy alluvial and coastal plains predominate. Along the N-S central axis of the basin, there is a change from primarily alluvial floodplain in the north to coastal floodplains interdigitating with near-shore deposits in the south. The northern alluvial floodplains included a few river channels, but were dominated by alluvial floodplain facies deposits.

4) Southern area (Hobart - Eaglehawk area) - Primarily coastal sediments (subtidal and perhaps intertidal).

The most prospective of these four regions for fluvial meandering stream deposits of the sort which the Nunamara sandstone appears to be is the north and northwestern area, within which Nunamara is in fact situated. There is probably also some potential in the northeastern area, although coarse pebbly (braided stream or piedmont facies?) sandstones are common close to the landward margins of the basin, which were hilly areas at the time of deposition.

The central-north and southern areas appear to have little potential for Nunamara-type sandstones. The alluvial floodplain and coastal plain facies of the central-north appear unprospective for building sandstones (see facies descriptions in Martini & Banks), while the Hobart area is clearly well to the southeast of the limits of the prospective areas (and indeed, the Faulkner Group rocks have been observed to be predominantly excessively fine-grained).

This facies model only indicates broad areas of Tasmania which may be most prospective for sandstones of the Nunamara type - it is unlikely that local occurrences of a particular facies can be predicted in detail, due to the rapid (and in practice unpredictable) lateral and vertical facies variations characteristic of fluvial deposits; actual occurrences in a prospective region can only be found by detailed fieldwork.

It is possible that facies within the Lower Freshwater Sequence other than the Nunamara type may also include good building sandstones (eg, the marine "sand bar" (Sb) facies of Martini &

Banks is a possibility); such facies will not necessarily be most prevalent in the same areas as the Nunamara type sandstones.

Nunamara Sandstone Quarry

The Nunamara Sandstone Quarry (Fig. 4.1) is located NE of Launceston, at Grid Ref. EQ278203 (site S/Tn/1/1), and is operated by Dunn Monumental Masons Pty. Ltd. under stone lease 1113 P/M.

The sandstone was mapped as the Liffey Group by Longman (1964). The main quarry face is 7 - 10 metres high and about 40 metres long, and is situated on a moderately steep slope. Considerable reserves are still accessible.

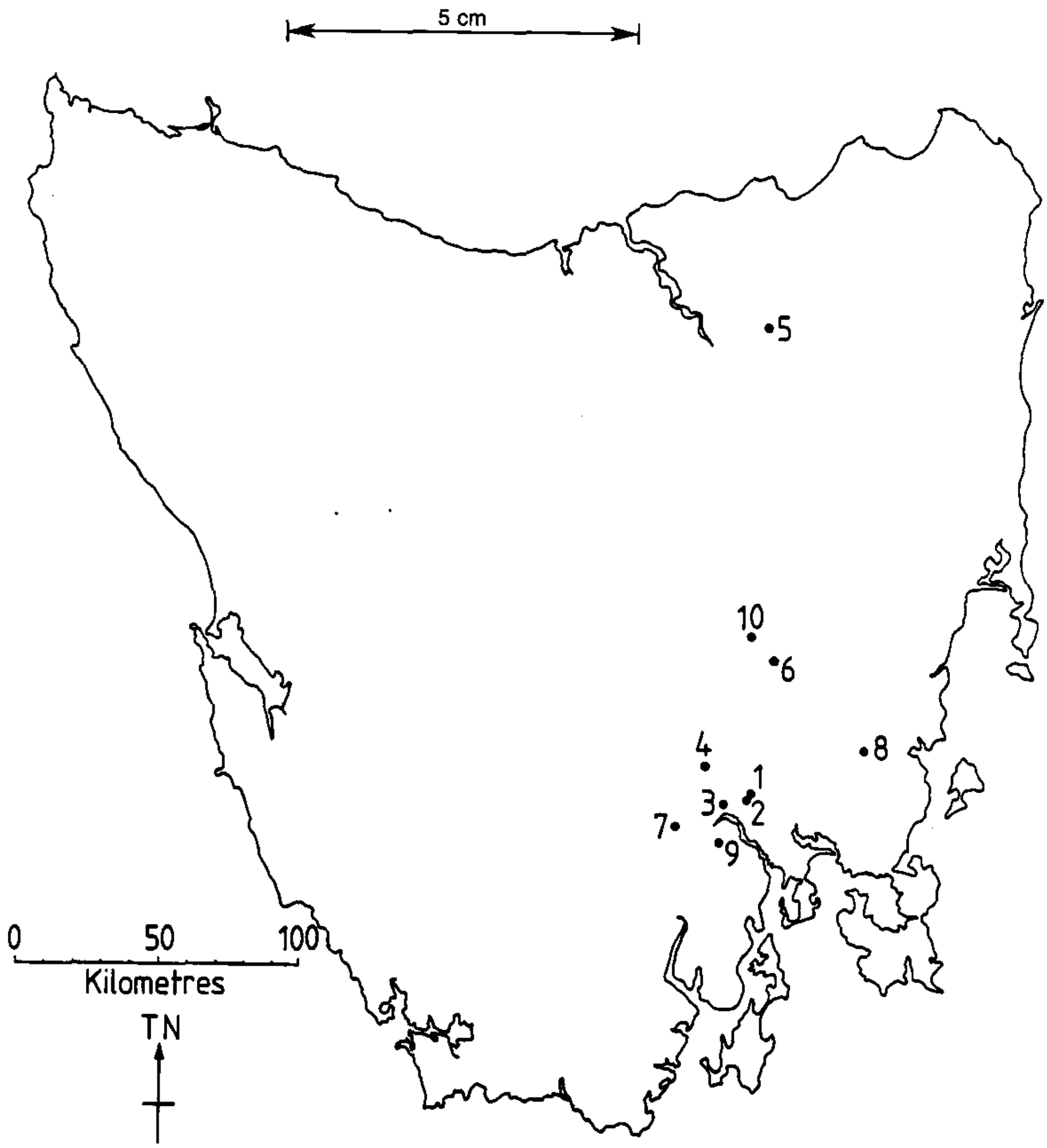
The main face comprises fine-to medium-grained, moderately well sorted fluvial sandstones. The bedding in the main face dips 4° towards 220° T, and comprises two metres of faintly cross-bedded sandstone overlain by a thin quartz pebble conglomerate which fines up into a 3.5m thick massive sandstone bed, overlain by 1.5m of faintly crossbedded sandstone, then 1.0m of laminated very fine sandstone and mudstone, then 3.0m of faintly cross-bedded sandstone with thin interlayers of laminated very fine sandstone and mudstone. This is overlain by a thick mudstone bed.

The cross-bedded sandstone shows no tendancy to split along cross-bed laminations, which are practically invisible on fresh surfaces. The massive sandstone, and the nearly-massive cross-bedded sandstone, are the quarry products.

The stone has a very light grey (N8) to yellow-grey (5 Y 6/3) colour, with brown liesegang rings developed only within 1.0 - 1.5m of joints (an intrusive dolerite body outcrops 10-20 metres stratigraphically above the quarry). See Plate 3.2.

Through most of the quarry, two main subvertical joint sets, with spacings of 1.0 - 4.0 metres, control quarrying operations.

The stone is considered to be of good technical quality, and suitable for use in high stress applications including restoration work (see Table 4.1).



Key to numbered quarries:

1 Pontville Brown stone Quarry
2 Pontville White stone Quarry
3 Cobbs Hill Quarry
4 Elderslie Quarry
5 Nunamara Quarry
6 Oatlands Quarry
7 Linden Quarry
8 Buckland Quarry
9 Molesworth Quarry
10 Mike Howes Marsh Quarry

FIGURE 4.1 Current or recently operating sandstone quarries in Tasmania

EARLY TRIASSIC
Tasmania Basin
Quartz Sandstone Sequence

PROSPECTIVITY - High

General description
Following the deposition of the predominantly marine sediments of the Lower Parmeener Supergroup, the Tasmania Basin became a predominantly terrestial, fluvial depositional environment from Late Permian to Triassic times. These terrestial sediments belong to the Upper Parmeener Supergroup (Forsyth *et al.* 1974), which has been sub-divided into four units by Forsyth (1987).

Although small proportions of sandstone suitable for building purposes could occur in Units 1 and 3 of Forsyth (1987), Unit 1 contains an abundance of feldspathic and carbonaceous sandstone, while Unit 3 is rich in lithic sandstones and lutites. In comparision with Unit 2 (below), these units have low prospectivity. Unit 4 of Forsyth (1987) comprises lithic sandstones and coal measures, and is entirely unsuitable for building sandstone.

The great majority of Tasmanian building sandstones quarries have been located within Unit 2 of Forsyth (1987), which is known as "The Quartz Sandstone Sequence", and it continues to be the most promising prospect.

The Quartz Sandstone Sequence is of Early Triassic age, and outcrops widely throughout central, northern and southeastern Tasmania, reaching stratigraphic thicknesses of up to 280 metres (Forsyth, Fig. 8.12b, *in* Burrett & Martin 1989). Broadly, the sequence contains well-sorted, commonly cross-bedded fluvial quartz sandstone with abundant quartz grain overgrowths, feldspathic quartz sandstone, and minor coloured lutites (Forsyth, *in* Burrett & Martin 1989).

The Quartz Sandstone Sequence has suffered little tectonic deformation, so that bedding dips are generally close to horizontal.

Clay minerals present in the Quartz Sandstone Sequence include illite, kaolinite, smectite (montmorillonite), mixed layer illite/smectite, and vermiculite. Chlorite is less common, and halloysite is known from the Cobbs Hill Quarry. Mica and graphite can be locally abundant in the sandstones.

The Quartz Sandstone Sequence very broadly tends to fine upwards from medium- and coarse-grained at the base to fine- and very fine-grained sandstones, and to lutites at the top (Leaman 1976 & 1977, Forsyth 1984 and *in* Burrett & Martin 1989). Forsyth (*in* Burrett & Martin 1989) divides the Quartz Sandstone Sequence on a regional scale into a thick (approx. 200m) lower dominantly sandstone interval, and a thin (20 - 60m) upper predominantly lutite interval.

In the Hobart/Brighton area, the rock sequences mapped by Leaman (1972) and Leaman *et al.* (1975) as Rls and Rlq correspond to the dominantly sandstone interval, as does rock unit Rp in the Oatlands/Bothwell/Interlaken area (Forsyth *et al.* 1976, Forsyth 1984, 1986, 1989), and parts of the Knocklofty Formation and Ross Sandstone in various parts of Tasmania (Forsyth 1987).

Thick intervals (60 - 80m) in the dominantly sandstone interval consist entirely of sandstone formed by cycles of fluvial deposition. Forsyth (1984, & *in* Burrett & Martin 1989,p.317) describes typical cycles as being characterised by a fining up sequence grading from medium to coarse sandstone at the base to medium-fine grained and rarely muddy rocks higher up. The basal beds in each cycle may be massive or cross-bedded. If present, clay pellets or quartz pebbles are most common at the base of cycles. Low angle cross-bedding occurs both high and low in cycles, and fine planar laminations and ripple cross-laminations occur high.

The Quartz Sandstone Sequence is considered to have been deposited by low sinuosity rivers flowing towards the east or southeast from source areas in the west or northwest (Forsyth *in* Burrett & Martin 1989). Collinson *et al.* (1987) consider the Quartz Sandstone Sequence to have been deposited in a braided (rather than meandering) river system, with migrating channel, bar and sandflat environments. The quartz sandstone beds constitute channel, braid and minor point bar deposits, whilst the lutites represent cut-off channel, lacustrine and over-bank deposits.

Exploration models
A number of important features of sandstone deposits, which are relevant to building stone quality and durability, are discussed below with a view to their predictablility on a regional or local scale. These subjects are discussed in greater detail in Sharples (1990).

Textural properties: intergranular texture, strength and porosity
Textural properties, together with mineralogical factors such as total clay content, determine sandstone strength and porosity, as noted in section 4.1 (see Sharples 1990).

There appear to be very few means by which the occurrence of sandstones having good textural characteristics yielding high strength and low porosity can be predicted on either a local or a regional scale.

As noted above, in a broad way grainsize decreases and lutite (ie, clay-rich) content increases going stratigraphically up through the Quartz Sandstone Sequence as a whole, and also going up through individual depositional cycles. Thus we might in general expect to find sandstones with stronger and less porous quartz-rich and clay-poor intergranular textures most common towards the base of the Quartz Sandstone Sequence as a whole, and also towards the base of individual cycles.

In this respect it is noteworthy that in the Hobart and Brighton regions Leaman (1972) and Leaman *et al.* (1975) mapped the bulk of the Quartz Sandstone Sequence as units "Rls" and "Rlq", of which Rls is generally the basal unit. Although some old disused sandstone quarries in the Hobart area occurred in Rlq, all current quarries near Hobart are in Rls.

However, these vertical (stratigraphic) patterns are only very broadly applicable; in detail lutite content may vary markedly and in a complex fashion through the Quartz Sandstone Sequence, and individual depositional cycles are very often truncated and incomplete, so that no simple pattern can be confidently applied.

Laterally, there is little evidence of predictable regional or local textural variations. With the possible exception that coarse pebbly sandstones in the northwest, near Lake St. Clair, may represent a piedmont facies of the Quartz Sandstone Sequence close to its source area, no consistent grainsize or lutite-content variations have been measured across the Tasmania Basin.

Sandstones in the far southeast near Port Arthur (distal area?) appear to have no finer grainsize or greater lutite content, on average, than sandstones in the (more proximal?) Midlands. (No quantitative studies have been conducted to confirm this observation, which is simply based on qualitative field observations). The lack of progressive lateral textural gradients across the Tasmania Basin suggests that the preserved sandstone depositional basin is a part of an initially much larger, low-gradient basin with a rather distant provenance (S. Forsyth, *pers. comm.*, 1990).

Not only can lateral textural variations not be predicted on a regional scale, but they are also unpredictable on a local scale, due to random local variations in the sedimentary environment resulting from fluvial channel switching, cut-off, flooding, and other events.

Beyond textural variations resulting from the original depositional environment, diagenesis has had a significant effect on sandstone textures, particularly through groundwater-controlled dissolution and precipitation of silica and clays. Insufficient information is presently available to determine whether predictable regional, local or stratigraphic patterns might have occurred in such diagenetic textural alterations.

It has been noted (Sharples 1990) that polygonal surface weathering fractures (pachydermal fractures) may form on outcrops of sandstone having a high proportion of soft quartz-clay intergranular bonds. This can be a useful field indicator of sandstones with weak intergranular textures resulting in poor wet-dry strength ratios.

Bedding

Apart from flagstone, building sandstone is required to be either massively bedded, or to have faint cross-beds with no splitting tendancy (ie, no mica or graphite on cross-bed laminations). See Plates 4.1, 4.2 & 4.6.

As noted above, fluvial sandstones in channel, braid and point bars are deposited in cycles, which generally have massive or large-scale crossbeds towards the base, and finer beds and laminations near the top. An "ideal" sequence of bedding types within each depositional cycle can be defined, based on theoretical considerations and observation of complete cycles (see discussion in Sharples 1990).

On the face of it, this suggests that observations of outcrops on a local scale would allow prediction of the likely location of, say, massive beds (ie, at the base of each cycle). In practice, however, such predictions will rarely be possible. Most fluvial depositional cycles tend to be at least partly truncated by contemporaneous reworking of sediments, so that complete cycles are not commonly preserved, and the sequence of bedding types preserved cannot be predicted.

In practice, the only way to find massive or faintly cross-bedded sandstones is to just look at as many outcrops as possible!

Thickly bedded sandstones are preferable to thinly bedded sandstones, since the major splitting planes between beds are more widely spaced. Bedding thickness is partly related to grainsize (Blatt *et al.* 1972,p.115), with coarser sands producing thicker beds. Thus, it can be broadly predicted that thicker sandstone beds will occur in the more basal parts of the Quartz Sandstone Sequence, and also within the basal parts of individual sedimentary cycles. This corresponds to the textural trends discussed above, which also imply that there are not likely to be predictable regional or local lateral trends in bedding thickness.

A good field indicator is that thicker-bedded sandstones tend to form bolder outcrops, due to the relative lack of (weak) bedding planes for erosion to attack (the same principle applies to widely-jointed sandstones, as discussed below).

Mineralogy

The possible predictability of quartz and total clay contents in sandstone is discussed under "Textural properties" (above).

The occurrence of the swelling clay smectite (montmorillonite) in the clay matrix of a sandstone is particularly significant due to its swelling and contraction behaviour when subjected to wetting/drying cycles. All clays will swell with wetting to some extent, due to absorption of water into intercrystalline spaces within clay aggregates. However, the swelling is particularly marked with smectite, since not only does it experience such "inter-crystalline" swelling, but it also experiences "intra-crystalline" swelling due to taking up water molecules within the crystal structure of individual clay grains themselves.

This behaviour means that sandstones containing a significant proportion of smectite within their clay matrices will expand and contract significantly with normal environmental wet/dry cycles, resulting in an increased tendancy towards sandstone decay. Examples of this behaviour are documented by Sharples (1990).

Smectite content varies markedly through the Quartz Sandstone Sequence. In certain regions (eg, Port Arthur, Bothwell) significant amounts of smectite are a common constituent of the sandstones. Detailed X-Ray Diffraction analysis of regularly spaced samples from a borehole near Bothwell (Tas. Dept. Mines DDH "Thorpe", Sharples 1984) showed that significant proportions of smectite were present throughout a 230 metre stratigraphic thickness of the Quartz Sandstone Sequence (ie, through nearly the entire stratigraphic column of the sequence). Moreover, the proportions of smectite in the drill-hole varied markedly, with alternating horizons 2 - 10m+ thick containing either no smectite, or significant quantities of the clay.

In contrast, numerous outcrops of the Quartz Sandstone Sequence in the Ross area are uniformly free of smectite, while most outcrops in the region of the Elderslie Sandstone Quarry contain only trace amounts of smectite (Sharples 1990).

This suggests there is a strong lateral (regional) control on the distribution of smectite within the Quartz Sandstone Sequence, with significant amounts of smectite being intermittently present throughout the stratigraphic depth of the sequence in areas such as Bothwell, and virtually absent in other regions such as Ross and Elderslie.

It has been suggested (*see* Sharples 1990) that the smectite is a product of distant vulcanism during the Early Triassic. It is possible that the regional variations in smectite distribution may reflect the paths of volcanic dust plumes carried from particular volcanic centres by prevailing Early Triassic winds. An alternative possibility is that the regional variations may reflect differing provenances of particular fluvial systems within the overall Early Triassic depositional basin.

Apart from the particular instances mentioned above, there is as yet insufficient clay mineralogy data available to outline in detail the distribution of regions of high and low smectite content within the Tasmania Basin. It is also not yet possible to determine whether there may also be some degree of stratigraphic control on smectite distribution (possibly related to periods of varying intensitiy of volcanic activity throuh the Early Triassic).

The collection of further detailed data on clay mineralogy from sandstones throughout the Tasmania Basin would be of interest both from the point of view of sandstone exploration, and also of palaeo-geographical and palaeo-environmental studies.

The distribution of vermiculite clay is discussed in the following section on colour:

Colour and colour patterning
Three major colouration types are recognised (Sharples 1990) in the Quartz Sandstone Sequence:

1) Uniform grey-white bulk colour (see Plate 4.1).

2) Uniform brown bulk colour (see Plate 4.2).

3) Brown ferruginous "Liesegang Ring" patterns (commonly superimposed on a grey-white bulk colouration). See Plate 4.3.

The original (depositional or early diagenetic) colour of sandstones in the Quartz Sandstone Sequence is considered to have been a uniform grey-white bulk colour. The deposition of the Early Triassic sandstones is thought to have taken place in a cool temperate or sub-polar arid or seasonally arid environment (Camp & Banks 1978), which would have inhibited oxidation of iron in the sands prior to burial.

In cases where significant quantities of iron are not available from either internal (eg, vermiculite or chlorite) or external (eg, adjacent dolerite) sources, the sandstones have retained their grey-white colouration through burial, uplift and exposure, so that even in weathered outcrops, only a very thin (av. 10mm) weathering "rind" on outcrop surfaces has been coloured red or brown by iron staining.

Uniform, unpatterned brown bulk colouration is considered (Sharples 1990) to form when sources of iron are available within the stone to be oxidised during the process of uplift and exposure to oxidising conditions. X-Ray diffraction analysis of brown Quartz Sandstone Sequence sandstones indicates that goethite (iron hydroxide) is the predominant oxidised iron mineral responsible for the brown colouration. Microscopic examination of sandstone thin sections indicates that the goethite occurs as finely dispersed staining of clay masses, and as small evenly distributed intergranular blebs.

The two most common sources of iron in the Quartz Sandstone Sequence are the clays vermiculite and chlorite. Chlorite is the less common of the two (although it occurs more abundantly in Middle and Late Triassic lithic sandstones), and tends to only oxidise to yield a brown bulk colour within a few metres of weathered outcrop surfaces (Sharples 1990).

Vermiculite, on the other hand, is a relatively common iron-rich constituent of uniformly brown-coloured sandstones in the Quartz Sandstone Sequence. Uniform brown colouration is observed in outcrop to extend over ten metres below the surface in vermiculite-rich sandstones (a good example is exposed in a large road cutting at Melton Mowbray), and Hale (*in* Spry & Banks 1962,p.219) notes that brown colouration may occur to a depth of over 100 metres in boreholes, but eventually passes down into grey sandstones.

It is considered (Sharples 1990) that the iron-rich vermiculite clays begin oxidising to produce evenly distributed ferruginous staining and cementing in sandstones, commonly at considerable depths, when erosion and uplift has allowed masses of vermiculite-rich sandstone to enter the zone of oxidising groundwater circulation.

It is difficult to speculate on the origin of the vermiculite with the available data. However, a strong suggestion of a regional distribution pattern is evident in data presented in Sharples (1990). The data indicates that uniform brown vermiculite-rich sandstones are abundant in a belt extending from the Linden/Elderslie area in the south, through Melton Mowbray to the

Oatlands area. Further brown vermiculite sandstones in the English Town/Blessington area, east of Launceston, may be an extension of this "belt".

The data upon which this interpretation is based is somewhat restricted, however, and proper interpretation must await a more comprehensive spread of data from throughout the Tasmania Basin.

In contrast to uniform brown bulk colouration, the attractive striped patterns of ferruginous staining in sandstones known as "Liesegang Rings" are considered to result from groundwater transport of iron into the sandstone from nearby external sources of abundant iron, such as dolerite. Data collected by Sharples (1990) shows that strong to moderately intense Liesegang Ring patterns form in sandstones within 500 metres (most commonly within 300 metres) of an intrusive dolerite contact.

It is considered that groundwaters leach iron from the dolerite under conditions of incipient weathering, and then pass into the adjacent sandstone, precipitating the iron in brown goethite rings as evaporation of the groundwaters occurs in the near-surface zone of fluctuating water table levels. The rings tend to form attractive concentric patterns around joints or parallel to outcrop surfaces. Sharples (1990) found that Liesegang Rings tend not to form where the contact between the dolerite and the sandstone is a fault, probably as a result of iron-rich waters emerging from the dolerite being diverted away along the fault.

Other minor colouration types in the Quartz Sandstone Sequence include a pale greenish-grey bulk colour (apparently related to a significant chlorite content), scattered spots, nodules and irregular patches of ferruginous staining, "bleached" white patches superimposed on brown ferruginous staining, and other miscellaneous patterns such as black manganese oxide spots and dendrites. These are discussed in Sharples (1990).

Joint and fracture spacing

Most jointing in the Quartz Sandstone Sequence is related to tectonic faulting; jointing due to unloading and heating/cooling stresses resulting from dolerite and basalt intrusion appears to be minor.

Individual faults only produce localised increases in joint density within a few metres. For instance, a fault with a six metre displacement occurs at the eastern end of the Permian Nunamara Sandstone Quarry. Intense jointing occurs within seven metres of the fault, but beyond that distance a uniform regional joint spacing of 1.0 - 4.0 metres predominates.

The important relationship between faulting and jointing appears to be found on a more regional scale: that is, the average joint density over reasonably large areas is related to the regional fault density over the area (regional fault and joint densities both being related to the intensity of the regional stress field which formed them).

Berry & Banks (1985) found that much of the faulting in the Parmeener Supergroup of southeastern Tasmania could be related to at least two major tectonic episodes. A major NNW compressional event in the Mesozoic (active before and after intrusion of dolerite in the Jurassic) established a wrench faulting pattern with strike slip faults striking 100 degrees and 170 degrees, and reverse faults striking NE. A subsequent phase of Early to Middle Tertiary normal faulting produced a horst and graben system, including the Derwent Graben, by E to NE extension, involving re-activation of earlier faults striking 170 degrees. Finally, a Late Tertiary phase of strike slip and reverse faulting, related again to NNW compression, may have affected faults in the Hobart region.

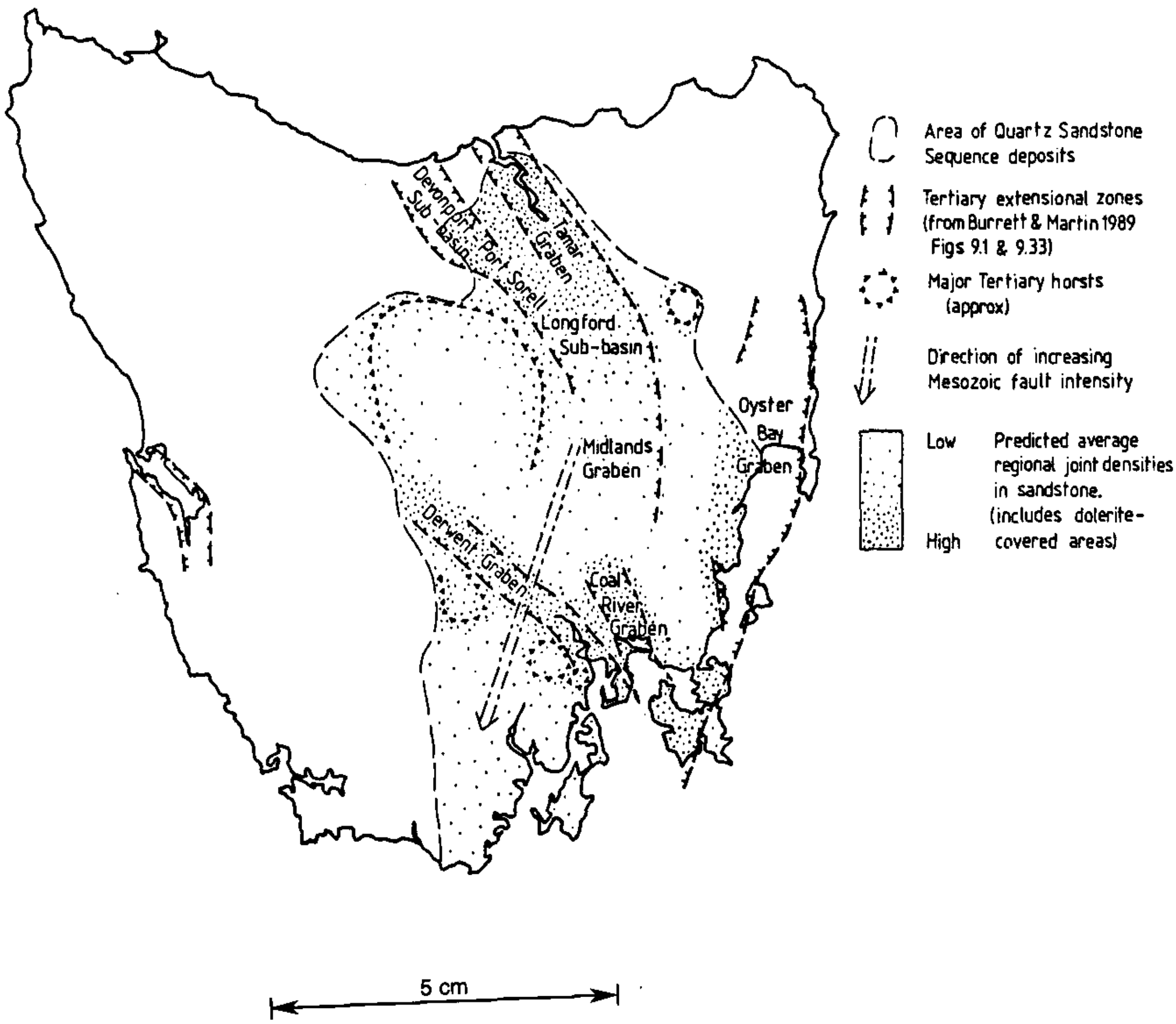


FIGURE 4.2 Predicted regional variation in Mesozoic and Tertiary fault/joint densities in the Tasmania Basin (Interpretation based on work by R. Berry , *Publn. in prep.*). Area of Quartz Sandstone Sequence occurrence indicated.

Continuing work (R. Berry, *pers. comm.* 1990, *publn. in prep.*) has shown that regional variations occur in the density of faulting related to these events. This work is leading to an ability to predict likely average regional jointing densities in various parts of the Tasmania Basin.

Berry has found that the Mesozoic faulting is most intense in southernmost and western Tasmania, and decreases in intensity north of Hobart. The least intense Mesozoic faulting occurs in the northeast, from the Lake Leake area northwards (see Fig. 4.2).

Berry measured the Mesozoic faulting in the stronger and more brittle Jurassic dolerites, in which the faulting is well expressed. While the Mesozoic faulting (and associated jointing) can be expected to be less intense in the weaker and more elastic Triassic sandstones, the same general pattern of decreasing Mesozoic fault and joint density can be expected towards the northeast.

The Tertiary horst and graben faulting is (naturally) most intense within the major horst and graben structures, including the Derwent and Tamar grabens, and the Ben Lomond, Central Plateau, Mt. Field, Mt. Dromedary and Mt. Wellington horst blocks (Colhoun, *in* Burrett & Martin 1989,p.405). Tertiary faulting associated with the opening of the Tasman Sea (Oyster Bay Graben) is also quite intense along the east coast (see Fig. 4.2).

The Mesozoic faulting appears to have had a relatively small effect on the Quartz Sandstone Sequence, with numerous widely jointed outcrops occurring south of Hobart. This may be a result of the sandstones being somewhat less strongly cemented, and thus more elastic, in the Mesozoic than they were during the Tertiary faulting.

On the other hand, the Tertiary faulting had a strong effect on the sandstones, with sandstones in the Derwent Graben (eg, at Linden and Cobbs Hill quarries) having a generally high density of faulting and jointing, while sandstones just north of the graben (in the Elderslie - Melton Mowbray region) are less faulted and commonly very widely jointed.

Combining the effects of Mesozoic and Tertiary faulting, one would expect the widest joint spacings to occur in outcrops in the northeast, outside Tertiary horst and graben structures. Interestingly, very widely spaced jointing occurs in Quartz Sandstone Sequence outcrops in such a situation near Blessington (site S/Ts/3/3, grid ref. EQ393009), east of Launceston.

This is one of only a small number of areas in the northeast where the Quartz Sandstone Sequence deposits are not covered by Jurassic dolerite sheets. However, since the Mesozoic faulting seems to have had less effect on the sandstones than the Tertiary faulting, widely-spaced jointing can be expected (and indeed occurs) further to the south outside major Tertiary faulting structures (eg, Midlands - Elderslie region).

Joint spacing in response to a given tectonic stress varies according to grainsize and bedding thickness. Thicker bedding tends to be related to coarser grainsizes, and both these factors are commonly associated with wider joint spacings (Legge 1967).

Stronger and more brittle rocks tend to develop greater joint or fracture densities in response to a given tectonic stress than do weaker and more elastic rocks. Thus, the very high-strength Cobbs Hill stone has developed relatively intense fracturing, probably as a result of both being within the faulted Derwent Graben, and within 80 metres of a large fault (see Plate 4.7). On the other hand, the lower-strength Elderslie Quarry stone, with its high proportion of soft intergranular clay bonds, is very widely jointed despite occurring within 120 metres of a major fault.

Plate 4.1 Buckland Quarry: Grey-white bulk colouration The sandstone has very faint cross-bedding, which is not visible on this fresh surface.

Plate 4.2 Oatlands Quarry: Brown bulk colouration in massively bedded sandstone.

5 cm

A useful field indicator of widely jointed sandstones is that they tend to form large, bold outcrops, as a result of the widely spaced joints providing fewer weaknesses for weathering and erosion to attack.

Current or recently operating quarries in the Quartz Sandstone Sequence
A large number of sandstone quarries have operated in Tasmania in the past, most of which are now disused. Details of these quarries are given in Sharples (1990). All the presently or recently operating quarries in the Quartz Sandstone Sequence are briefly described below, and technical properties of representative samples are listed in Table 4.1.

Pontville Brown Sandstone Quarry
The Pontville Brown Sandstone Quarry (Fig. 4.1) is located north of Hobart, at Grid Ref. EN220734 (site S/Ts/65/2), and is operated by Etna Stone Pty Ltd under stone lease 812 P/M.

The sandstone has been mapped as unit "Rls" (Leaman *et al.* 1975). The quarry consists of a wide pit with three metre high faces and flat benches from which the stone is sawn *in situ* into brick-size blocks for domestic use.

The bedding dips 14° towards 264°T, and comprises a fine-grained, moderately well sorted massive bed 2 - 3 metres thick which is under- and overlain by cross-beds with minor clay bands and clay pellets near the base of the upper cross-bed unit.

The stone has a very light grey (N8) to pale yellowish-orange (10 YR 8/6) bulk colour which is dominated by strong brown Liesegang Ring banding (see Plate 3.2). Both Tertiary basalt and Jurassic dolerite occur within 200 metres of the quarry.

A feature of the stone is the presence of small (av. 10mm dia.) porous spots which may weather to produce small dimples on weathered surfaces.

A normal fault with several metres displacement exists behind the main (north-east) face, and joints in the quarry vary from closely to widely spaced.

The stone is of only moderate durability (see Table 4.1), and is considered suitable for domestic and other low-stress applications.

The accessible stone in the quarry is close to being worked out, so that the quarry has a limited productive lifetime.

Pontville White Sandstone Quarry
The Pontville White Sandstone Quarry (Fig. 4.1) is located only 200 metres southwest of the Pontville Brown Sandstone Quarry, at Grid Ref. EN219733 (site S/Ts/65/1), and is held by Etna Stone Pty Ltd under stone lease 724 P/M. The quarry is operated intermittently by Rizzolo Stone and Concrete Pty Ltd, and has been operated in historical times.

The sandstone has been mapped as unit "Rls" by Leaman *et al.* (1975). The quarry consists of an approximately 150 metre diameter pit with three metre high faces.

QUARRY	Sample No.	Colour	Bedding Type	Effective Porosity (vol. %)	Air-dried Point Load Strength Index (Av., random directions, MPa)	Ultrasonic Pulse Velocity (m/sec, normal to bedding)	Quartz %	Total Clay %	Quartz/Quartz Intergranular Bonds (%)	Clay Mineralogy D = Dominant CD = Co-dominant SD = Sub-dominant M = Minor T = Trace
Nunamara	N1 (1)	Grey-white, some brown liesegang rings.	Massive, faint crossbeds	10.66	1.19 (old result; other results in excess of 2.0 MPa)	2143	-	25	-	Kaolinite (D) Illite (SD) Vermiculite (M)
Pontville Brown	Etna 1 (1)	Grey-white with strong brown Lies. rings.	Massive	10.76	1.18	-	-	18	-	Illite (D) Kaolinite (M) Smectite (M)
Pontville White	Etna 3 (1)	Uniform "snowy" white	Massive	12.06	0.80	-	-	15	-	Illite (D) Kaolinite (M) Smectite (T)
Cobbs Hill	c/1/1 (1,2)	Uniform brown with brown nodules	Massive	9.74	6.23 (anomalous?)	-	88	10	51.4	Illite (CD) Kaolinite (CD) Smectite (M) Halloysite (M)
Elderslie	7 (3)	Uniform brown	Massive	10.35	3.43	2680	-	15 - 20	low	Illite (D) Vermiculite (SD) Smectite (T)
Oatlands	Riz 1 (1)	Uniform brown	Massive	16.35	0.90	-	-	24	-	Illite (D) Vermiculite (SD) Kaolinite (M) Smectite (M)
Linden	L1 (1)	Uniform brown, mod. brown lies. rings	Massive	9.11	1.82	-	-	14	-	Illite (CD) Kaolinite (CD) Smectite (M) Chlorite (T)
Buckland	67/1/1 (2)	Grey-white with strong brown lies. rings	Faintly cross-bedded	13.63	1.25	-	65	32	20	Illite (SD) Kaolinite (D)
	67/1/4 (2)	uniform grey-white	Faintly cross-bedded	9.63	1.37	-	81	17	34	Illite (CD) Kaolinite (CD)
Molesworth	FB 1 (1)	Grey-white with strong brown lies. rings.	Planar (flagging)	8.97	2.11	-	-	23	-	Illite (CD) Kaolinite (CD)
Mike Howes Marsh	MH 1 (1)	Grey-white with strong brown lies. rings.	Planar (flagging)	10.15	2.46	2637	-	23	-	Illite (SD) Kaolinite (D)

Data Sources: (1) Sharples (1990); (2) Private reports by C. Sharples; (3) AMDEL test results, for Victorian Ministry of Housing and Construction.

TABLE 4.1 Technical properties of representative fresh samples from current Tasmanian sandstone quarries

The bedding dips 13° towards 214°T, and consists of a fine-grained, moderately well sorted massive unit, with a one metre thick cross-bedded unit being exposed on the southeast side of the quarry. The stone is generally quite uniform, with only a few 0.2 metre thick clay pellet bands.

The stone has a uniform "snowy" white colour (N8 - N9) with no ferruginous colouration apart from minor stains on fracture surfaces (See Plate 3.2). A feature of the stone is the presence of small (av. 10-20mm dia.) porous spots which may weather to produce small dimples on weathered surfaces.

Sub-vertical joints in the quarry are spaced 1 - 3 metres apart.

The stone is of moderate durability only (see Table 4.1), and is considered suitable for low stress situations.

Cobbs Hill Sandstone Quarry

The Cobbs Hill Quarry (also known as the Tongatabu Quarry, and not to be confused with "Cobbs Stone" from the Buckland Quarry) is situated north of Bridgewater, at Grid Ref. EN15857033 (site S/Ts/18/1, see Fig. 4.1). The quarry is operated by Etna Stone Pty Ltd under stone lease 818 P/M.

The sandstone is mapped as unit "Rls" by Leaman *et al.* (1975). The quarry consists of several benches totalling 27 x 22 metres across, with a face up to three metres high. Brick-size blocks are sawn *in situ* , and used largely for domestic applications.

The bedding dips 14° towards 270° T, and is medium-grained, moderately well sorted and massively bedded in the quarry working, with faintly cross-bedded outcrops below the existing quarry. Quartz pebbles and clay pellets are absent from the current quarry face, but occur in a few narrow bands in lower outcrops.

The stone has a uniform brown bulk colour (pale yellowish-orange 10 YR 8/4), free of ferruginous banding (see Plate 3.1). However, dark brown ferruginous nodules 10 - 15mm diameter are a common feature of the stone.

A major fault occurs 80 metres southwest of the quarry, and the quarry is dominated by multi-directional close-spaced joints (maximum spacing 1.0 metres). See Plate 4.7.

The stone is very strong, and is considered to be a high durability stone suitable for use in high-stress applications (see Table 4.1). Unfortunately, the close jointing limits the size of unflawed blocks which are available, with the result that most usage to date has been in the form of brick size blocks.

Elderslie Sandstone Quarry

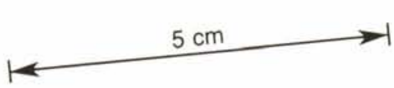
The Elderslie Quarry (Fig. 4.1) is located 2.5 km east of Elderslie (north of Bridgewater), at Grid Ref. EN08808270 (site S/Ts/51/2). The quarry is operated by Rizzolo Stone & Concrete Pty Ltd under stone lease 1357 P/M.

The sandstone has been mapped as unit "Rls" by Leaman *et al.* (1975). The quarry is currently worked on several faces approximately four metres high.

The bedding dips 10° towards 214° T. The quarry product is a two to three metre thick fine-

Plate 4.3 Mike Howes Marsh Quarry: Strong Liesegang Ring colour banding.

Plate 4.4 Buckland Quarry: Sawn blocks showing liesegang ring banding and circular patches



grained, moderately well sorted massive bed, which is overlain by several metres of micaceous, graphitic cross-bedded sandstone. The massive unit is generally clean and homogenous, apart from one large clay lense. Small clay pellets are common in the overlying cross-bedded sandstone.

The sandstone is a uniform brown colour (yellowish-brown 10 YR 6/4), and is free of liesegang rings or other ferruginous patterning (see Plate 3.1). Subtle brownish-green spots up to 150mm diameter occur scattered through the massive bed, along with small black manganese oxide spots which are only apparent at close range.

Joints are very widely spaced (5 - 15m+ spacing), and pachydermal fractures occur on natural weathered outcrop surfaces.

The stone has a relatively weak intergranular texture, and is of only moderate durability (see Table 4.1). The stone is suitable for use in low to moderate stress applications such as plain vertical ashlar walls.

Oatlands Sandstone Quarry

The Oatlands Quarry (Fig. 4.1) is located just south of Oatlands, at Grid Ref. EP297152 (site S/Ts/32/1), and is held by the estate of R.T. Fish under stone lease 1090 P/M. The quarry is operated by Dunn Monumental Masons Pty Ltd.

The sandstone is mapped as unit "Ru" (undifferentiated Triassic) by Forsyth *et al.* (1976), but is typical of sandstones of the Quartz Sandstone Sequence. The quarry consists of a single face 2 - 3 metres high and 30 metres long.

The entire face consists of a near-horizontal fine-grained, moderately well sorted massive bed, with a single 0.1 -0.2m thick clay pellet band near the base (see Plate 4.2).

The stone has a uniform brown (greyish-orange 10 YR 7/4) bulk colour, and is free of colour patterning, apart from a scattering of 1 - 2mm diameter black manganese oxide spots which are only noticeable at close quarters (see Plate 3.1).

A single set of subvertical joints strike 344° T and are spaced 3 - 7 metres apart, except for a single one metre wide zone of intense fracturing.

The stone is of only moderate durability, and is rather similar to the Elderslie Quarry stone in colour, texture and mineralogy (see Table 4.1). The stone is suitable for low to moderate stress applications, and has been used successfully in plain vertical ashlar walls. It is susceptible to salt attack and must be properly damp-coursed.

Linden Sandstone Quarry

The Linden Quarry (also known as "Bryn Estyn Quarry") is located 5 km west of New Norfolk, at Grid Ref. DN99956500 (site S/Ts/5/4, see Fig. 4.1), and is held by Mr A. Ashbolt under stone lease 861 P/M. The quarry has not been operated for several years, but renewed quarrying is planned.

The sandstone has been mapped as unit "Rls" by Leaman (1972). The quarry consists of several faces on a moderate to low-angle slope. The top face, which is up to four metres high and 45 metres long, exposes the quarry product, which is a fine- to medium-grained, moderately well-sorted massive sandstone bed 6 - 8 metres thick and dipping 8° towards 316° T. The massive

Plate 4.5 Linden Quarry sandstone: Example of recent use on the Commonwealth Law Courts (Hobart).

Plate 4.6 Mike Howes Marsh Quarry: An example of planar-bedded flagstone. In this example, durable sandstone beds alternate with soft clayey laminations.

5 cm

bed has minor clay pellets in its lower 2 - 4 metres, and is both over- and underlain by strongly laminated cross-bedded sandstone.

The stone has a uniform brown (greyish-orange 10 YR 7/4) bulk colour (see Plate 3.1), and contains moderately intense to subtle brown liesegang ring banding concentric about joints.

The quarry is dominated by two sets of subvertical joints striking 8° T and 273° T, whose spacing varies markedly across the quarry, from zones of intense jointing (<0.5m spacing) to zones of up to four metre spacings. Significant wastage has in the past resulted from quarrying of closely spaced zones. Future quarry operations should be planned around optimum utilisation of moderately to widely jointed zones.

The stone has low porosity, high strength, and a strong intergranular texture resulting in minimal dimensional instability (see Table 4.1). It is a moderate to high durability stone in situations of low to moderate stress. However, a small content of smectite swelling clay means that cracking may occur if the stone is used in situations such as flat ledges where water may pool and soak into the stone.

The Linden stone has been used for a considerable period, examples including the Hobart G.P.O. (1901) and the Hobart Supreme Court and Commonwealth Law Courts (early 1980's, see Plate 4.5).

<u>Buckland Sandstone Quarry</u> (Trade name: "Cobbs Stone")
The Buckland Quarry ("Cobbs Stone", not to be confused with the Cobbs Hill Quarry) is located six kilometres north of Buckland, near the crest of "The Cobs Hill" at Grid Ref. EN575880 (site S/Ts/67/1, see Fig. 4.1). The quarry has been operated since late 1988 by Mr E. Howells, under stone lease 1339 P/M.

The sandstone was mapped by Blake (1958) as the Ross Sandstone, which is a correlate of the Quartz Sandstone Sequence (Forsyth 1987). The quarry consists of a two-step face 4 - 6 metres high and 50 metres long at the crest of a steep hill. The quarry face can easily be worked back for a considerable distance on a gentle slope near the top of the hill.

The bedding dips 10° towards 97° T, and consists of fine-grained, moderately well sorted cross-bedded sandstone whose laminations are generally free of mica, and so are virtually invisible on fresh faces and show no splitting tendancy (see Plate 4.1). Only minor clay pellet bands are visible in outcrops below the main face.

In terms of colour, two varieties of stone are available from the quarry. Much of the stone has a uniform, unpatterned grey-white (pale grey-white to very pale orange 10 YR 8/2) bulk colouration (see Plates 3.2, 4.1). Discrete patches within the quarry have strong brown liesegang ring banding (see Plates 3.3, 4.4), which are considered to be related to an intrusive dolerite body approximately 200 metres southwest of the quarry. The areas of liesegang ring patterning are laterally discontinuous, and appear to be fading in intensity four metres below the outcrop surface.

An unusual feature of the stone is the presence of subtle circular patches 10 - 200mm diameter in which the stone is commonly slightly stronger than elsewhere. In the uniform grey-white stone these patches show up as subtly darker areas, which however fade slightly to become almost indiscernable with exposure. In the brown "striped" stone, the liesegang rings are deflected around and within the circular patches, forming attractive patterns (see Plate 4.4).

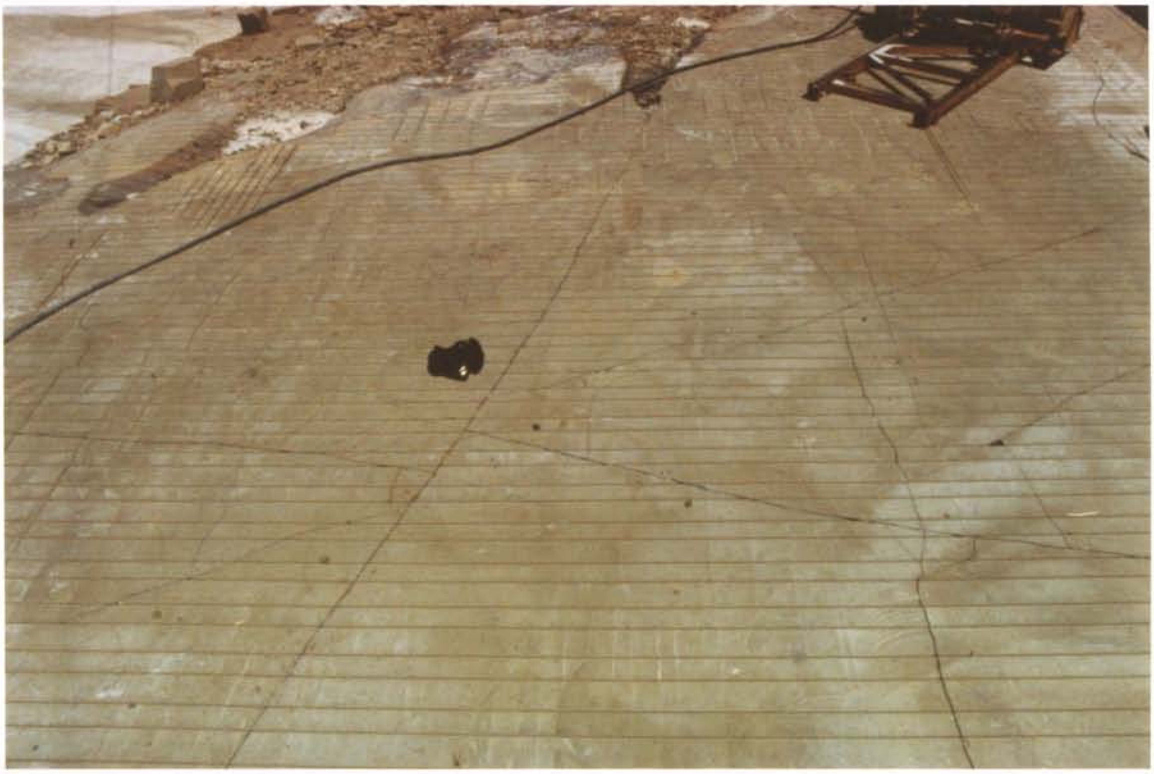


Plate 4.7 Cobbs Hill Quarry: High strength brown sandstone with closely spaced joints and fractures.

5 cm

The stone is very widely jointed indeed, with subvertical joints typically 10 - 30 metres apart (although closer joints occur at the west end of the quarry).

The uniform grey-white stone has a notably higher technical quality than the brown striped stone (see Table 4.1), possibly as a result of increased authigenic clay precipitation due to increased groundwater activity in the brown stone (associated with the formation of the liesegang rings).

Both stone types are completely free of smectite swelling clay. The uniform grey-white stone has moderate strength and low porosity resulting from a moderately strong intergranular texture, and is likely to be suitable for use in moderate-stress locations although a moderate loss of strength on soaking is a problem. The brown stone has a distinctly higher clay content, and has a slightly high porosity and significant loss of strength upon soaking. It is suitable for use in low stress applications such as domestic walls and interior features (for which, indeed, its colourful character is most appropriate).

Molesworth Sandstone Quarry

The Molesworth Quarry (Fig. 4.1) is located near Hobart, at Grid Ref. EN106603 (site S/Ts/3/1). The quarry is operated by Messrs Jim Finlayson and Graeme Boon ("Pontville Freestone") under stone lease 984 P/M.

The sandstone has been mapped as unit "Rls" by Leaman (1972). The quarry consists of a face 200 metres long and up to 15 metres high on a moderately steep slope. Despite the high, steep face, the quarry has significant accessible reserves as the upper part of the face is quarried by dropping large stone masses to the quarry floor with small explosives.

The quarry product is in the form of flagstone slabs. The bedding dips 5° towards 225° T, and consists of medium-grained, moderately well-sorted planar beds which split easily into slabs about 20 - 100mm thick at the base of the face (becoming thicker towards the top). No clay pellets or quartz pebbles were noted.

The stone has a grey-white (very light grey N8 to very pale orange (10 YR 8/2) bulk colour, which is dominated by strong brown liesegang ring bands within half a metre or so of joints (an intrusive dolerite mass occurs approximately 300 metres west of the quarry). The central parts of large joint blocks are commonly a uniform grey-white colour, free of banding. See Plate 3.3.

A normal fault in the centre of the quarry has produced some close jointing, but much of the deposit has multiple-direction sub-vertical joints spaced 1 - 3 metres apart.

The stone is considered to be of high technical quality, being free of smectite, and with a high strength and low porosity (Table 4.1). The stone has high durability, but its use is limited by the strong planar bedding. The stone has been used almost entirely as feature wall slabs and brick-size blocks for high-durability domestic walls.

Mike Howes Marsh Sandstone Quarry

The Mike Howes Marsh Quarry (Fig. 4.1) is located 10 km northwest of Oatlands, at Grid Ref. EP236239 (site S/Ts/61/1). The quarry is operated by Unique Stone Paving (Mr Greg Howard) under stone lease 1189 P/M.

The sandstone has been mapped as unit "Rp" by Forsyth (1986), and is a part of the Quartz

Sandstone Sequence (Forsyth 1987). The quarry pit is currently worked over a 150 x 150 metre area, on faces approximately one metre high.

The quarry product is in the form of flagstone slabs. The bedding dips 6° towards 345° T, and consists of fine-grained, moderately to well-sorted flat planar beds 20 - 80mm thick, regularly interbedded with clay-rich micaceous sandstone beds or laminae <1.0 to 20mm thick (see Plate 4.6). The clayey laminations allow easy splitting and removal of stone with a fork lift, but if not completely removed from the flagstones tend to produce surface flaking. No clay pellets or quartz pebbles were noted.

The stone has a very light grey (N8) bulk colour, but is dominated by strong, attractive brown liesegang ring banding (an intrusive dolerite dyke occurs 300 metres east of the quarry). See Plates 3.3, 4.3.

Subvertical joints are spaced 1.0 to (commonly) 4.0 - 5.0 metres apart.

The sandstone is free of smectite, and has moderate to low porosity and a high strength (see Table 4.1), and is a high quality, durable flagstone when the clayey laminations are removed. Large quantities of the stone are exported to the mainland for ornamental slab work.

CHAPTER FIVE

SLATE

5.1 Definition and description

In geological terms, slate is a fissile (easy splitting) fine grained rock, formed by low-grade metamorphic alteration of fine-grained sedimentary rocks such as siltstone, in which only incipient recrystallisation of original grains has occurred. A cleavage (direction of easy splitting) is developed, which may be independant of the original sedimentary bedding direction (Am.Geol.Inst.1962; Joplin 1968).

The stone industry definition of slate is slightly broader than this, and includes any fine-grained rock which can be evenly split into thin sheets. We can recognise two classes of slate:

1) "True" metamorphic slate has a strong cleavage resulting from the development of a pervasive planar fabric in response to tectonic forces. On a microscopic scale, the planar fabric is commonly the result of an alignment of clay, sericite and/or mica particles, and of microscopic elongate disruptions or "stringers" in the stone's fabric. Fine silica grains may also be elongated and oriented in a common direction.

Metamorphic slates can commonly be cleaved at any point into slabs as thin or as thick as may be desired, and are generally stronger than sedimentary slates (below). In Tasmania, the slates of the Mathinna Beds (eg, Back Creek, Bangor) are true slates in this sense.

2) Sedimentary "slate" is generally a hard, fine-grained plane-laminated sedimentary rock (eg, shale, siltstone) which may have undergone minor metamorphism, but which still cleaves along the original bedding direction. The cleavage may result from the presence of bedding planes along which splitting preferentially occurs, from a primary planar depositional fabric, and/or from the development of a minor planar fabric parallel to bedding as a result of overburden pressures.

Sedimentary slates cannot always be split at any desired point into slabs of any thickness; in some cases clean splitting planes may be restricted to distinct bedding plane laminations.

In Tasmania, "Kirkup's Slate" (Carboniferous rhythmite) is an example of sedimentary slate, and the Precambrian Lawson River Siltstone "slate" is more akin to sedimentary than to metamorphic slates.

For the purposes of this report, slates are understood in the broad industry sense.

Slate is a silicate rock, usually containing quartz, mica, chlorite and sometimes dark graphite. Minor minerals present may include tourmaline, rutile, epidote, sphene and iron minerals such as magnetite, pyrite and haematite (Williams *et al* 1954,p.212). The presence of pyrite is somewhat detrimental since it can produce brown staining. However, although many slates contain a small proportion of this mineral, they generally still perform well.

Slate is processed for building use by splitting along the cleavage planes into tiles or panels of varying thickness. A good quality slate can have very high strength and durability (Winkler 1973,p.25), and can be stronger than granite. However, less metamorphosed slates may still have strong bedding planes preserved at an angle to the cleavage. If bedding is strong enough to allow splitting in both the bedding and the cleavage directions, the slate is unlikely to be usable for building purposes. In other cases the bedding may not split so easily, but bedding planes may still show up as lines or "ribbons" where the cleavage surface split transects them. Depending upon the hardness and mineral composition of such ribbons, the slate may or may not be a useful building material.

Slate is generally used with flat, smooth cleavage surfaces. Slightly irregular cleavages may produce slight pits and nodes on split cleavage surfaces, which can enhance the appearance of the stone for some ornamental applications. On the other hand, distinctly uneven, undulating or kinked cleavages, or the presence of more than one distinct easily-splitting cleavage direction, will render the slate unusable (Ray 1988).

Slate may be of uniform or variegated colours. Dark grey or purple-grey colours (as often seen in slate roofing and paving tiles) are common, but a wide range of possible slate colours exist. ASTM C 406 lists the following slate colour categories: black, blue-black, grey, blue-grey, purple, mottled purple and green, green, purple variegated; slate may change to green, white, buff or brown with weathering.

Strongly and variably coloured slates are sometimes known as "rustic slates" (Ray 1988). In some slate deposits, colourful iron-oxide stained slates are produced from the upper weathering zone, while the deeper stone may be of a darker, more uniform grey or purple colour. Bleaching of slate may occur in near-surface weathering zones, commonly as a result of the alteration of chlorite (Spry 1988,p.62).

According to Ray (1988), a trend is developing in slate usage, away from the colourful rustic slates, and towards more uniform, and particularly paler, colours.

Spry (1988,p.33) says that slate is generally impermeable, and since it is commonly surface-sealed it tends not to stain easily.

Since slate is normally used in thin slabs (tiles or panels), it's flexural strength (or modulus of rupture) is important, particularly for paving purposes. Compressive or tensile strengths are less important strength criteria, and generally are not limiting factors (Spry 1988,p.66 quotes dry compressive strengths for typical slates as ranging from 70 to 160 MPa, which implies strong to very strong stone).

Tasmanian slates are not generally strong enough for use as roofing tiles (although the Back Creek and Bangor slates have been used for that purpose), but many will be acceptable for paving and wall cladding.

5.2 Slate applications

Roofing tiles	Dark uniform colours commonly used (eg, in historic buildings). Roofing slate must be of very high quality; little Australian slate is of sufficient quality.
Veneers (wall cladding) (Interior/exterior)	Uniform slabs used on buildings such as Hobart Supreme Court (South Australian Mintaro slate). Vari-coloured rustic slates popular for ornamental feature w
Paving tiles	Even coloured slates and vari-coloured rustic slates (for "crazy paving") both used. Abrasion resistance very important.

5.3 Slate quarrying in Tasmania

Several slate deposits have been worked in Tasmania, and three quarries are currently operating on a small scale (see descriptions). Most of these deposits have been described by Turner (1981) and Bacon (1987).

The Back Creek slate quarry (at Turquoise Bluff, north of Launceston) has been operated intermittently from 1979 to the present by the Tasmanian Slate Company. The slate is black to grey, but is extracted in joint-bounded slabs having white leached rims. Slate was previously extracted in the same area from 1876 until at least 1882 (Bacon 1987).

A black slate was quarried in two areas near Bangor between approximately 1872 and 1888 (Bacon 1987). A small amount of slate is still extracted intermittently just south of Bangor. The slates at Turquoise Bluff and Bangor are part of the Ordovician - Silurian age Mathinna Beds of northeastern Tasmania.

In northwestern Tasmania, two slate leases were held in 1917 over an area of varved (laminated) siltstones and mudstones of Carboniferous age known as "Kirkup's Slate Deposit" (Williams 1917, Bacon 1987) located on the Arthur River approximately 1.5km south of the junction of Parrawe Creek. Commercial slate extraction apparently did not take place.

Slate is currently (1990) being extracted from a quarry in the Tayatea region of NW Tasmania. This slate belongs to the Lawson River Siltstone (correlate of the Cowrie Siltstone of the Precambrian Rocky Cape Group), and varies from a uniform dark grey-black slate to a rustic slate with brown iron-oxide markings and abundant pyrite. Slabs of the rustic variety have been used in the Tall Timbers Hotel at Smithton (1989).

An old slate quarry in Rocky Cape Group sediments on Robbins Island (NW Tasmania) is recorded by Buckby (1988). It is likely that other small slate quarries supplying only very localised markets have existed in Tasmania in the past.

5.4 Slate sources and prospects in Tasmania

PRECAMBRIAN

Tyennan Block		Fisher Group (quartzites and slates)	Mersey River
Rocky Cape Block	Western part:	Rocky Cape Group	
		Cowrie Siltstone	Rocky Cape - Smithton
		Neasy Quartzites & Slates	Dip Range/Meunna Hills
		Lawson River Siltstone	Arthur R./Lawson Rivt./ Horton River area.
		Balfour Slates & Sandstones	Gardiner Pt./Balfour/ Norfolk Range area.
		Interview Siltstone	Pedder R./Lower Pieman River.
		Rupert Beds	Pieman Heads.
		Rocky Cape Grp. correlates	Far NW, Hunter group of islands, Robbins Is.
		Bernafai Volcanics intercalated "Corinna Slate"	Corinna
	Eastern part:	Burnie Formation greywackes and slates	Burnie area
		Oonah Formation greywackes, slates, basalts	Widespread: Hellyer R. to Zeehan area.
King Island		Cleaved siltstone & mudstone	Eastern King Is.
Badger Head Block		Slates and slaty mudstones	Port Sorell - Beaconsfield
Modder River Inlier		?Oonah Fm. correlates (incl. slate)	Modder River area
Cape Sorell Inlier		Laminated meta-siltstones	Cape Sorell
Jubilee Block		Pandani Group slates	Mt Anne area
		Humbolt Slate	Tim Shea
		Numerous other slate occurrences	Weld R., S. of Jubilee Ra. Huon R. on Arthur Plains Blakes Opening The Razorback

CAMBRIAN

Dundas Trough	Dundas Group		
		White Spur Formation	Farrell Rivt./Howards Rd.
		Hodge Slate	Dundas
			Howards Rd.
		Que River Shale	Que River

Numerous other"laminated siltstones and Mudstones" occur in beds correlated with the Dundas Group in various parts of Tasmania, some of which may be slates.

	Mt. Read Volcanics		
		Farrell Slates	Tullah

ORDOVICIAN - DEVONIAN

Western Tasmania	Eldon Group & correlates		
		Amber Slate	Zeehan
			Queenstown
			Huskisson River
Tyennan Block	Eldon Group correlates		
		Bell Shale correlate	
		(cleaved siltstone)	Olga River
		Slates	Loddon River
		Amber Slate correlate	Bubs Hill
North-eastern Tas.	Mathinna Beds		
		Lutite Association (slate)	East Tamar River
		(Ordovician)	(Bangor, Back Creek)
		Arenite-Lutite Association	Numerous areas
		(Siluro-Devonian)	
		Sandstones abundant,	
		Slates minor.	

UPPER CARBONIFEROUS

Western Tasmania	Wynyard Tillite		
		Rhythmite claystones	Arthur River
			Henty Plantation (Strahan)
Tasmania Basin	Stockers Tillite		
		Rhythmite claystones	Lake River

5.5 Evaluation of slate sources and prospects in Tasmania

A number of slate prospects are listed in section 5.4 above, but are not discussed below. These were not examined during this project, and are considered unlikely to be prospective by reason of inaccessibility, poor outcrop, and/or a history of multiple tectonic deformations.

PRECAMBRIAN

Rocky Cape Block

The Rocky Cape Block is a large area of northwest Tasmania broadly consisting of two regions of comparatively unmetamorphosed Precambrian rocks, separated by a linear belt of metamorphic rocks known as the Arthur Lineament (or "Arthur Metamorphic Complex"). The comparatively unmetamorphosed rocks are mainly sedimentary sequences, with a small component of igneous intrusions and volcanic flows, and are prospective for slates. The sediments to the west of the Arthur Lineament are referred to the Rocky Cape Group, whereas those to the east belong to the Burnie and Oonah Formations.

Western Rocky Cape Block: Rocky Cape Group

The Rocky Cape Group has been studied in detail in the Rocky Cape area of the NW coast. The stratigraphy of the Rocky Cape Group is summarised below (from Gee 1971):

TOP	JACOB QUARTZITE	Quartz sandstone, minor shale
	IRBY SILTSTONE	Interbedded dolomite, sandstone, siltstone, mudstone, greywacke and argillite, with over 40 metres of black siltstone near the base.
	DETENTION SUBGROUP	Predominantly quartzite, with approximately 10% of the subgroup consisting of siltstone. The thickest siltstone horizon is known as The Port Slate, and consists of grey siltstone with abundant sandstone lenses.
BOTTOM	COWRIE SILTSTONE	Black pyritic finely laminated siltstone with thin sandstone beds in parts, and a well-developed slaty cleavage.

The Jacob Quartzite, Irby Siltstone and Detention SubGroup have little potential as high quality slate sources, since what little slate they contain is interbedded with coarser sedimentary rocks on an outcrop scale. The Jacob Quartzite and Detention SubGroup were examined at areas Sl/Rb/3 and Sl/Rb/4 during this project.

On the other hand, a correlate of the Cowrie Siltstone is considered highly prospective for good quality slate:

Cowrie Siltstone correlates - Lawson River Siltstone

PROSPECTIVITY - High

The Cowrie Siltstone and equivalent units outcrop throughout most of the western part of the Rocky Cape Block, and is considered to be a shallow marine sequence forming the lower part of the Rocky Cape Group (the base is not exposed). The distribution of the Cowrie Siltstone and it's equivalents can be summarised as below (*from* Turner, *in* Ch.2, Burrett & Martin 1989):

Cowrie Siltstone	Black shale, siltstone, slate	North coast - Smithton region
Neasy Quartzites & Slates	Quartzite, phyllite, slate	Dip Range - Muenna Hills
Lawson River Siltstone	Siltstone, slate, impure quartzite, greywacke	Arthur R. - Lawson Rivt. - Horton River area.
Balfour Slates & Sandstones	Shale, slate,siltstone, sandstone	Gardiner Pt. - Balfour - Norfolk Range.
Interview Siltstone	Slate, siltstone, quartzite, conglomerate	Lagoon R. - Lower Pieman R.
Rupert Beds	Quartzite, mudstone, siltstone, conglomerate, rare dolomite	Pieman Heads - Rupert Point.
Lower Rocky Cape Group.	Quartzarenite, minor mudstone, shale, siltstone, dolomite.	Gardiner Pt. - coastal strip west of Smithton Basin - Hunter Group of Islands.

The Neasy Quartzites & Slates, Interview Siltstone, Rupert Beds and Lower Rocky Cape Group equivalents in the Gardiner Pt./Hunter Group of islands region were not examined during this project. Of these, the Interview Siltstone and Rupert Beds are in areas currently inaccessible for quarrying, and the sediments of the Gardiner Pt./Hunter Group region are predominantly of sandstone grade.

The Cowrie Siltstone was examined at several sites in the coastal region between Rocky Cape and Smithton (areas Sl/Rb/5,6 & 9). The siltstone in these areas varies in colour from dark grey to pale cream, and outcrops were observed with a somewhat undulating tectonic cleavage occurring at an angle to distinct bedding laminations. Lennox (*in* Brown 1989,p.39) notes that two or more distinct cleavages may be present in the Cowrie Siltstone in addition to a bedding cleavage. The nature of the cleavage is such as to preclude production of good quality slate from these areas.

The Balfour Slates and Sandstones were examined near the Frankland River (area Sl/Rb/7). The "best" slate outcrop examined in this area (site Sl/Rb/7/1) was a slate with fine sandstone laminations, distinctly undulose cleavage, and open jointing fractures spaced approximately 0.1 to 0.3 metres apart. For these reasons, the stone is not considered prospective.

The Lawson River Siltstone was examined at several sites over a large area from south of the Horton River to the Wedge Plains area, north of the Arthur River (area Sl/Rb/8), and is considered prospective for good quality slate over the whole area (see Fig. 5.1).

The Lawson River Siltstone is similar at all sites examined. The siltstone is uniformly fine-grained, and is of a uniform dark grey-black colour with minor subtly lighter laminations showing the finely laminated bedding.

The stone is strong and coherent, and cleaves parallel to bedding into perfectly flat, planar sheets (see Plate 3.5). Cleavage seems to occur most easily along fine bedding laminations, rather than simply at any desired point, and would thus appear to be primarily a sedimentary "cleavage" rather than a metamorphic one (see section 5.1). Additional metamorphic cleavages, if present, are subtle and do not interfere with the dominant bedding cleavage. This is in contrast to the equivalent Cowrie Siltstone in the Smithton quadrangle to the north, which has several distinct metamorphic slaty cleavages at an angle to bedding (Lennox, *in* Brown 1989,p.39). The bedding/cleavage dips at varying angles, and shows minor warping on a quarry scale.

The spacing of jointing fractures varies widely over short distances, from a little as 0.1 to 4.0 metre (+) spacings. Although large slabs are obtainable, considerable wastage due to zones of intense jointing can be expected at most sites.

Pyrite is common in all outcrops examined, occurring as sparsely distributed nodules 10mm or more in diameter, and as 1 - 5mm thick bedding plane laminations spaced 50 - 200mm apart. While pyrite is generally considered detrimental to building slates, the Tayatea slate (see below) has been extracted in such a way as to display its pyrite content for ornamental purposes.

Films of brown iron oxide occur on joint surfaces and along intermittent prominent cleavage (bedding) planes.

Two varieties of slate are potentially available from the Lawson River Siltstone. One is a "rustic" slate, with ornamentation due to brown iron oxide staining and pyrite laminations and nodules. It will probably be necessary to surface-seal slate used in this fashion in order to inhibit tarnishing and staining of the pyrite.

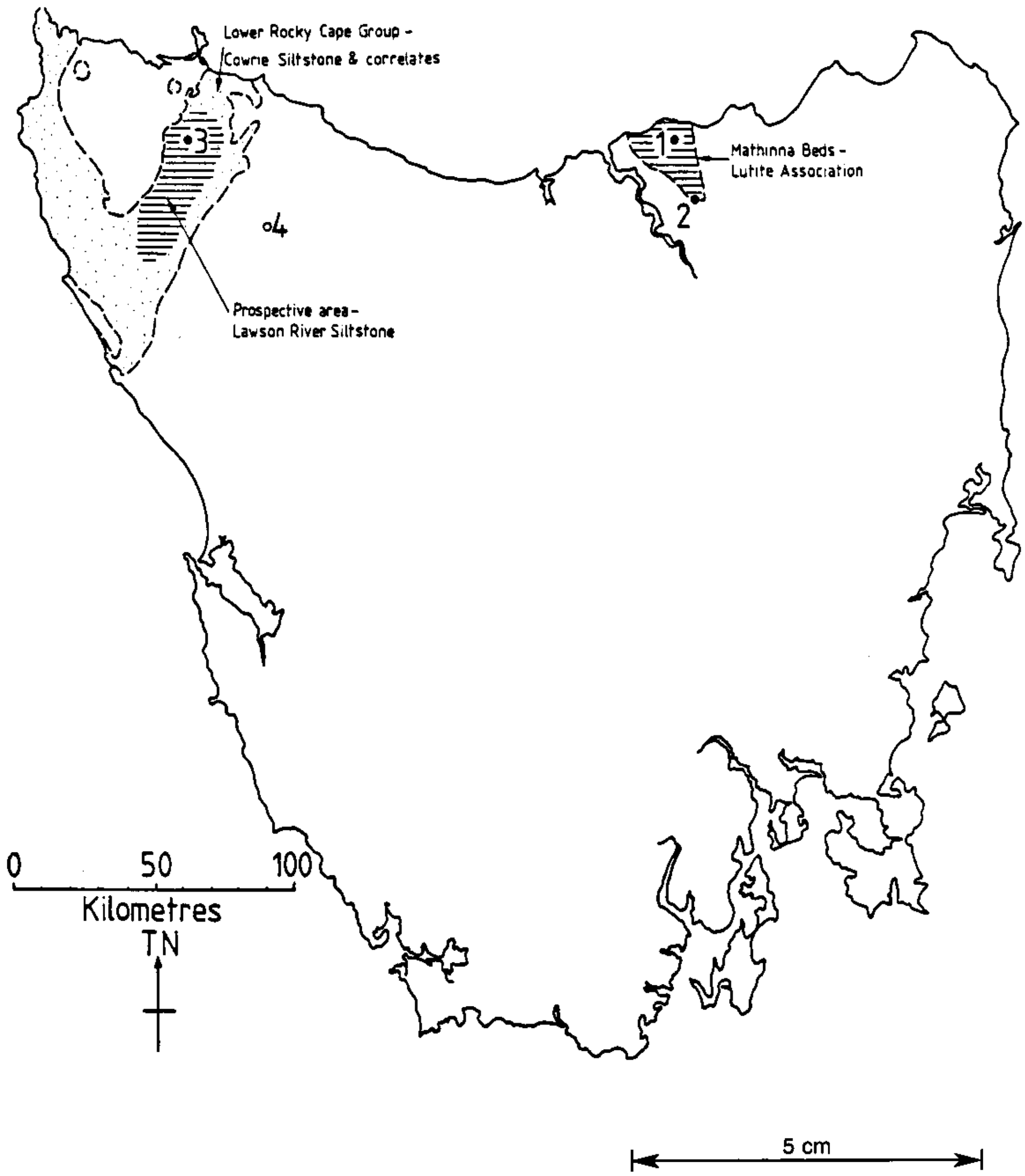
The other variety is a uniform grey-black structural slate. At the outcrops examined to date this uniform variety could only be obtained by selective splitting to separate out "rustic" slate slabs from the 50 - 200mm thick uniform bands. This would clearly be a wasteful procedure unless it were possible to split, stockpile and sell both varieties. However, with sufficiently detailed exploration over the large area of Lawson River Siltstone, it is possible that reserves of slate having a much lower pyrite content than those examined to date can be found.

A further problem to be considered is that the apparent tendancy of the slate to split along distinct bedding laminations rather than simply at any desired point may result in some inconvenience in processing.

Future evaluation work on this slate should include testing of flexural strength, abrasion resistance and mineralogy, in order to determine the range of applications to which the stone can best be put.

Tayatea Slate Quarry

Ornamental "rustic" slate was extracted from site SI/Rb/8/4 in 1989 for use in the Tall Timbers Hotel (Smithton). This site, referred to as the Tayatea Slate Quarry, is a pre-existing road-metal quarry on Wedge Plains Rd. immediately west of Dollie Creek, at Grid Ref. CQ50305530 (see Fig. 5.1). Stone lease 17 M/89 covering the site was pegged by P. Youd and S. Knowles in 1989. The slate belongs to the Lawson River Siltstone, and corresponds closely to the description given above (see Plate 3.5).



Key to numbered sites:

1 Back Creek Quarry
2 Bangor Quarry
3 Tayatea Quarry
4 Kirkups Slate Deposit

Figure 5.1 Tasmanian slate quarries and prospective geological associations.

Western Rocky Cape Block: Bernafai Volcanics

Corinna Slate (intercalated unit within Bernafai Volcanics)

PROSPECTIVITY - Low

Spry & Banks (1962,p.109) recorded a unit known as the "Corinna Slate" intercalated with the Bernafai Volcanics in the Corinna - Brown Plains area north of the Pieman River. The Bernafai Volcanics form part of a PreCambrian sequence which is thought to overlie the Rocky Cape Group adjacent to the southern part of the Arthur Lineament.

A visit to the area (area Sl/Rb/13) failed to locate any slaty outcrops. The Corinna Slate is therefore tentatively considered to be of low prospectivity.

Eastern Rocky Cape Block: Burnie and Oonah Formations

PROSPECTIVITY - Low

A broad belt of relatively un-metamorphosed PreCambrian sedimentary rocks with minor lavas to the east of the Arthur Lineament extends from Burnie southwest to the Zeehan area. These rocks consitute the Burnie and Oonah Formations, and are considered to be a deeper water trough sequence in contrast to the shallow marine sequences of the Rocky Cape Group.

The Burnie and Oonah Formations comprise predominantly greywackes (poorly sorted sandstones) and slaty laminated mudstones and siltstones, with lesser amounts of mafic lavas, conglomerate and carbonates (see Burrett & Martin 1989, Ch. 2).

The Burnie Formation was examined in areas Sl/Rb/1 & 2 (near Burnie), and the Oonah Formation in areas Sl/Rb/10 (Zeehan-Pieman River area) and Sl/Rb/11 (north of the Pieman River).

Near Burnie, the slaty mudstone occurs in beds generally less than 0.5 metres thick, monotonously interbedded with quartzite greywacke beds. Apart from the difficulty this would create in quarrying, the slate beds themselves are generally rather undulating and have closely spaced jointing fractures (joints commonly only a few hundreds of millimetres apart).

Similarly in the Zeehan and Pieman River regions, the slaty beds of the Oonah Formation were observed to have strongly undulating and rather fissile (easy-splitting) cleavages, and in all cases were intensely jointed with fractures typically only 0.1 to 0.3 metres apart.

The generally intense fracturing, undulating cleavages, and common greywacke interbeds appear to rule out the Burnie and Oonah Formations as sources of good quality slate.

CAMBRIAN
Dundas Trough
Dundas Group

The Dundas Group is a middle - upper Cambrian age sequence of sedimentary rocks forming a conglomeratic flysch sequence associated with, and inter-fingering with, the Mt. Read Volcanics which occur on the eastern margin of the Dundas Trough (Ch. 5, Burrett & Martin 1989,p.160). A wide variety of sedimentary rock types are present within the Dundas Group, including several shale, siltstone and mudstone units which can be described as slates. A number of these units were examined during this project:

Dundas Group - Hodge Slate

PROSPECTIVITY - Low

The Hodge Slate was examined at site Sl/Dr/1/1 (Grid ref. CP69206370), in the vicinity of the Razorback Mine at Dundas, west of Zeehan.

The "slate" is a uniformly textured fine-grained siltstone of dark grey-back colour with abundant yellow-brown banding and mottling. Laminated bedding is indicated by paler bands and laminations. A poorly developed slaty cleavage is present, but the stone splits with almost equal ease in all directions. Joint fracturing is intense, with breaks spaced generally much closer than 0.5 metres apart.

The intense fracturing and poor cleavage would rule out this stone as a source of slate.

Dundas Group - Que River Shale

PROSPECTIVITY - Low

The Que River Shale outcrops in the Que River - Bulgobac River area, and has been described by Corbett & Komyshan (1989) as comprising a sequence of pyritic siltstone and shale, with minor greywackes and tuffs. Outcrops were examined at site Sl/Dr/3/1 (Grid ref. CP892934), in road cuttings beside the Murchison Highway. Loose slate lumps at the Cradle Mt. Link Road/ Hellyer Railway crossing are probably derived from the Que River Shale.

The shale is a dark grey (N3), uniformly fine-grained, strong and coherent stone. At site Sl/Dr/3/1 bedding is faintly visible as pale laminations, but the stone splits easily along a strong tectonic cleavage oriented at an angle to bedding. Cleavage surfaces are planar but split slightly unevenly. Brown iron-oxide staining is common on major cleavage planes. Jointing is intense, with several sets of parallel open joint fractures spoaced 0.02 - 0.5 metres apart laterally.

Small pieces of the slate appear to be a relatively strong and uniform slate; however the intense fracturing is likely to make the stone an un-attractive slate prospect.

Mt. Read Volcanics

The Mt. Read Volcanics sequence of the Dundas Trough is dominated by volcanic and volcaniclastic rocks, but also contains minor units of sedimentary rock, including the Farrell Slates:

Mt. Read Volcanics - Farrell Slates

PROSPECTIVITY - Low

The Farrell Slates outcrop in the Tullah area, between the Murchison and Mackintosh Rivers, and have been mapped by Corbett & McNeill (1986, 1988). The unit comprises slates, sandstones and tuffs which have been strongly cleaved due to their location within the major Henty Fault zone.

The Farrell Slates were examined in the Murchison River Gorge (site Sl/Dr/2/1, grid ref CP85537650), and NE of the Mackintosh Dam (site Sl/Dr/2/2, grid ref. CP87578340). At the sites examined they are dark grey, very fine-grained slates, in places interbedded with fine grained sandstone, and have abundant red-brown staining and common quartz veins. The slate has distinctly plane-laminated bedding, with a dominant slightly undulating and kinked cleavage parallel to bedding. At least one secondary cleavage is present, cutting across the bedding cleavage. Intense open fractures occur spaced 0.1 - 0.5 metres apart on average, and result from both parallel joint sets and other irregular fracturing.

The intense fracturing and multiple cleavage rule out the use of this stone as a slate.

ORDOVICIAN - DEVONIAN
North-eastern Tasmania
Mathinna Beds

The Mathinna Beds are a sequence of Pre-Upper Carboniferous folded sedimentary rocks outcropping in northeastern Tasmania (Banks, *in* Spry & Banks 1962). Two major subdivisions are recognised: a pre-dominantly lutite association of Ordovician age which is restricted to a small area on the north-east side of the Tamar River estuary, and arenite - lutite association of Silurian - Devonian age which outcrops over a large area of northeastern Tasmania (Baillie *et al.*, *in* Burrett & Martin 1989, p.234). Turner (1980) has postulated a fault separating the Lutite Association from the younger Arenite-Lutite Association to the east.

Only the Lutite Association is considered to be prospective for building-quality slates.

Mathinna Beds - Lutite Association

PROSPECTIVITY - High

The Ordovician-age Lutite Association outcrops in the Lefroy - Pipers River - Bangor area, northeast of the Tamar River (see Fig. 5.1). It has been mapped by Marshall *et al.* (1965) as "Sma - predominantly slate and phyllite", associated with interbedded horizons of "Sms - predominantly siltstone and sandstone", and by Gee & Legge (1971) as "LPm - dominantly sandstone, with slate layer".

The Lutite Association is a folded argillaceous (clay-rich) unit consisting dominantly of lutite (slate, sub-ordinate phyllite) with a sub-ordinate arenite component (sandstones and coarse siltstones). The sandstones vary from sparse laminae to beds over two metres thick, commonly graded and of turbidite origin (Baillie *et al.*, *in* Burrett & Martin 1989, p.234).

The Lutite Association possesses a strong planar tectonic (metamorphic) cleavage (often flat-lying), as well as a later upright crenulation cleavage which is best developed in the more pelitic (argillaceous) rocks (*Ibid.*). Since the pelitic rocks are the slates, deposits in which both cleavages are well developed are likely to be unsuitable for use as slates; the best slates will be those in which the crenulation cleavage is absent or very minor, leaving only one strong planar tectonic cleavage.

Unlike some clay-rich "slates" such as the Carboniferous rhythmites of the Wynyard Tillite, the slates of the Mathinna Beds Lutite Association are generally quite hard and strong as a result of low-grade metamorphic alteration associated with production of their tectonic cleavage.

Slates have been (and continue to be) quarried intermittently from the Lutite Association in the Bangor and Back Creek districts. These quarries were examined during this project, and are described below.

Apart from visiting these quarries, no other exploration was undertaken in the Lutite Association. The quarries are probably typical of the better slates available in the Lutite Association, and there seems little doubt that further exploitable deposits of similar quality exist in the region.

The indications are therefore that moderate quality slates of dark uniform colour, and even to slightly irregular cleavage are available in up to 1 - 2 metre diameter block sizes. However considerable wastage may occur in some deposits due to zones of close jointing, and presence of discolouration and pyrite. Strength and other tests need to be conducted to determine the range of applications for which the better Lutite Association slates will be acceptable

Bangor Slate Quarry

The Bangor Slate Quarry (site Sl/Ne/1/1) is situated at Grid ref. EQ110367, on a steep hill-slope just off the Bangor Road (see Fig. 5.1). The surrounding area is freehold farming land. The quarry has recently (1989) been applied for by P. Moore and T. Parish (Stone Lease 2 M/89).

The quarry has been worked intermittently since the mid-1870's (Bacon 1987), and a number of old tunnels and shafts can still be seen in addition to the main quarry face. The current main quarry face is an approximately 15 metre high x 15 metre long face on the steep hillslope, and it looks as if it would be somewhat difficult to operate on a large scale unless major preparatory work were done.

The slate is a very fine-grained, hard and uniformly textured stone, of uniform dark grey (N3) colour (see Plate 3.4), but with common creamy-white and brown iron-oxide layers and coatings on many exposed cleavage planes. At least 50% of the slate seen cleaves free of these (weathering-related?) colourations. Minor scattered pyrite grains are present.

The slate has very faint plane-laminated beds 20 - 200mm thick which dip at about 20° towards the NE. However, splitting occurs not along bedding, but rather along the distinct, planar to slightly undulose tectonic cleavage which dips at about 30° towards the W. Minor linear "crinkles" a few millimetres high on cleavage planes appear to be "ribbons" produced by the intersection of major bedding planes. The slate splits slightly unevenly along the cleavage into sheets which can be as thin as 3 - 5 mm.

At least two sets of open parallel joint fractures are present, with joint spacings in the range 0.1 - 1.5m apart horizontally.

The slate appears to be of moderate quality, although it cleaves slightly unevenly, and jointing and discolouration would result in significant wastage in applications for which uniformly dark-coloured slabs are required. Past use of the slate for roofing tiles has apparently suffered from the problem of pyrite grains weathering and falling out to leave small holes which allow leakage of water to occur.

Another slate quarry known as the "Justs" was worked in the Bangor district around 1872 (Bacon 1987). This quarry is situated at Grid ref. EQ100390, and was not examined in the present project.

Back Creek Slate Quarry

The Back Creek Slate Quarry (site Sl/Ne/1/2) is situated near Turquoise Bluff, at Grid Ref. EQ045561, on State Forest land (see Fig. 5.1). The quarry was first worked in 1876, and is currently operated by Mr Graeme Johnston (the Tasmanian Slate Co., Stone Lease 63 M/79). The Back Creek Slate Quarry has previously been described by Marshall (1969), Turner (1981), and Bacon (1987).

The quarry currently consists of old and new faces varying from one to ten metres high within an area approximately 200m N-S x 50m E-W. Spoil dumps cover much of the area. Future rationalisation of the quarry operation will necessitate removal of some of these dumps, and formulation of a careful plan aimed at systematic extraction of the stone.

Outcrops within the quarry area consist of laminated slate bands up to several metres thick interbedded with clayey and sandy mudstone beds (fine greywacke) which are generally 100-200 mm thick. The bedding dips at ≈50° towards the ENE, and in the slate beds is essentially planar with only minor warping. Distinct laminations define slate beds 100mm to over 1.0metres thick. Finer slate bedding laminations are faintly visible on weathered surfaces, but show no splitting tendancy and do not show up as "ribbons" on cleavage surfaces.

A good coherent planar tectonic (metamorphic) cleavage is present, dipping at ≈10° towards ENE - NNE. The slate cleaves easily at any point along flat, even planes which in some cases show a slight curvature, or minor crinkling (probably due to a minor secondary crenulation cleavage). The slate splits more evenly along cleavage than does the Bangor slate.

The slate is a uniform, very fine-grained dark grey to greyish-black (N2 - N3) stone which is quite hard and strong. Pyrite is rare or absent, although minor quartz veins are present.

A parallel E-W joint set of open subvertical joints dominates the deposit, with joint spacings varying from 0.2 to 2.0 metres apart. Other secondary joint sets are present, as a result of which the slate is extracted in joint blocks varying in diameter from 0.1 to 1.0 metres (+) diameter (larger joint blocks are commonly elongate).

Some more intensely jointed zones may be present, although when the quarry was visited it was difficult to distinguish such intensely jointed zones from the intense fracturing which occurs in the upper surface zone of the deposit (see below).

Joint surfaces within at least 5-10 metres of the natural surface are bleached white (see Plate 3.4), and commonly have thin coatings of brown iron oxide, blue turquoise, and whitish wavellite.

Near the surface the white bleaching which rims each joint block extends up to 15mm or so into joint blocks without any apparent detrimental effect on slate strength, and is also found around fine fractures and sometimes as thin coatings on incipiently splitting cleavage surfaces. The bleaching appears to be a result of near-surface weathering alteration of chlorite in the slate (Spry 1988,p.62), probably caused by oxygenated waters moving along joint planes.

The bleached rims become thinner with depth, and evidence from the lower quarry faces, old adits, and a nearby costean indicate that the bleached rims dissappear at around ten metres below the natural surface, leaving only a uniformly coloured black slate below that depth.

Apart from the white bleaching, the major weathering effects in the quarry are a softening and intense fracturing of the slate within 1 - 2 metres of the natural surface, and the presence of minor diffuse brown leisegang rings, also in near-surface beds. The surface 1 - 2 metre thickness of slate therefore constitutes wastage.

The white-rimmed joint blocks are cleaved into slabs averaging 150 - 300mm diameter which are sold as "crazy paving" tiles; the flat, uniformly black cleaved slabs with white rims are considered quite attractive. Larger slabs are also trimmed and sold as square tiles, and some slate is crushed into chips and sold for garden use. The Back Creek Slate has been used for roofing tiles in the past, apparently successfully.

The Back Creek Slate is of moderately good quality, being a strong, evenly-cleaving slate available in slabs of reasonable size (unfractured joint blocks up to one or even two metres diameter), and apparently free of pyrite. While the white bleached rims produce an interesting "crazy paving" tile in the near-surface layers, development of the quarry to a greater depth will also open up the possibility of exploiting the underlying uniformly dark-coloured slate as tiles and large uniform panels.

There is, however, likely to be considerable wastage in more closely-jointed parts of the quarry. Any future planning of quarry operations will require some mapping of joint-frequency distribution through the quarry in order to determine the most efficient strategy for long-term development of benches and faces. A comprehensive range of laboratory tests, including mineralogy, flexural strength and abrasion resistance are also recommended as these will help determine the full range of applications for which the slate may be acceptable.

Other Leases: Lefroy/Back Creek Area

Two other Stone Leases (23 M/86 and 1330 P/M) for slate quarrying are currently held in the Lefroy/Back Creek area. No information about their current quarrying operations is available to the writer.

Mathinna Beds - Arenite/Lutite Association

PROSPECTIVITY - Low

The Arenite-Lutite Association crops out over large areas of northeast Tasmania east and southeast of the Lutite Association. The Arenite-Lutite Association consists predominantly of alternating beds of quartzwacke (poorly sorted sandstone) or poorly sorted siltstone, and mudstone. The mudstone interbeds have in places been described as "slates" (Baillie & Powell, *in* Burrett & Martin 1989,p.235).

Numerous outcrops of the Arenite-Lutite Association were sighted during the present fieldwork, but none having potential as building slate deposits were noted. The "slate" generally occurs as thin beds (typically a few hundred millimetres thick or less) regularly interbedded with sandstone. Even if the slate beds were of reasonable quality, the high proportion of sandstone beds in most outcrops would result in prohibitive difficulty and wastage in extraction of the slate.

UPPER CARBONIFEROUS
Western Tasmania
Wynyard Tillite - Rhythmite Claystones

Sedimentation within the Upper Carboniferous to Triassic age Parmeener Supergroup commenced with deposition of thick glacial tillite beds (boulder beds) over wide areas of Tasmania in the Upper Carboniferous (known as the Wynyard Tillite in NW Tasmania).

In some areas the tillites are interbedded with fine-grained laminated glacio-lacustrine sediments known as rhythmite claystones ("varves"). Particularly well-graded rhythmite claystone deposits occur in the Arthur River, Strahan and Lake River areas (Clarke, *in* Burrett & Martin 1989,p.298).

Although the Tasmanian Upper Carboniferous rhythmite claystones do not possess a significant tectonic cleavage, they have been considered as potential slates because their laminated bedding allows them to split easily into thin, uniform sheets.

Arthur River

PROSPECTIVITY - Low

Kirkup's Slate Deposit

The Wynyard Tillite in the Arthur - Hellyer River area is described by Williams and Lennox (*in* Seymour 1989). In the Hellyer Gorge area the Wynyard Tillite consists entirely of thickly bedded tillite consisting of cobbles and boulders in a dark grey calcareous matrix. However to the west, near the Arthur River, the lower part of the formation is dominantly composed of rhythmite claystone with only thin interbeds of tillite.

An outcrop of the rhythmite claystone, which later became known as Kirkup's Slate Deposit, was discovered by Henry Hellyer in 1827 (Bacon 1987) on the eastern banks of the Arthur River about 1.5 km south of the junction of Parrawe Creek and the Arthur River (see Fig. 5.1). Two leases over the deposit were issued in 1917, to J. Kirkup and C.C. Plante (Bacon 1987). These apparently expired without any commercial slate extraction having occurred.

Kirkup's Slate Deposit was described in glowing terms by Williams (1917), who wrote of immense cliffs of high quality slate splitting to the size of "Ladies, Countesses and Duchesses" (the mind boggles..). However, examination of the area (Sl/Rb/12) during the present project indicates that William's impression of the slate's quality is somewhat over-optimistic.

Kirkup's Slate Deposit (Site Sl/Rb/12/1, grid ref. CQ758290) outcrops in cliffs approximately 100 metres above the eastern bank of the Arthur River. The cliffs themselves were not examined directly during the present project since they are now covered in dense scrubby forest which covers the steep slopes above the river, but loose blocks apparently derived from the cliffs were examined just above the river.

The bedding in the deposit dips at approximately 15 - 20° (Baillie *et al.* 1986), and according to Williams (1917) the deposit consists of two rhythmite horizons, each about 30 metres thick, separated by tillite beds below, between and above. The rhythmite claystone, as seen in loose boulders below the cliffs, consists of alternating beds of finely laminated soft mudstone or claystone, and very hard, fine-grained quartz sandstone layers with cross-laminated rippling. Minor pebbly layers up to 10mm thick also occur. The mudstone/sandstone layers vary in thickness from a few millimetres to 0.1 metre or more, with the bedding planes (along which the "slate" cleaves) being planar to (commonly) slightly undulating.

The mudstone layers are a uniform medium dark grey (N4), while the sandstone colour varies from grey to yellowish or brownish grey. The mudstone is soft and frets easily. Williams (1917) recorded obtaining unfractured slabs up to 13 feet long, and by comparision with site Sl/Rb/12/2 (see below), such wide fracture spacings probably do occur in the deposit. However, closely spaced joint fracture networks were noted in the blocks examined.

Apart from the access difficulties, Kirkup's Slate Deposit appears to have low potential as a slate deposit due to the soft nature of the slaty mudstone, the commonly slightly undulating cleavage, and the high proportion of hard sandstone interbeds.

Further outcrops of the rhythmite claystone were examined to the north of Kirkup's deposit, in road-cuttings extending along Blackwell Road for several hundred metres north of grid ref. CQ75382952 (site Sl/Rb/12/2). These outcrops dip eastwards at approximately 16°, and may in part be lateral equivalents of the beds in Kirkup's deposit.

At site Sl/Rb/12/2 sandstone interbeds are rare (some were noted in outcrops towards the northern part of the site). The outcrops consist of very fine-grained, uniformly textured claystone or mudstone which is plane-laminated and cleaves easily along flat bedding planes into slabs 2 - 200mm thick. The claystone is of medium dark-grey colour (N4), with abundant white, yellow, yellowish-olive, purple and brown bands. The claystone is rather soft, and frets easily. Open sub-vertical joint fractures are spaced 0.5 - 3.0 metres+ apart, so that large slabs could be extracted.

The stone at site Sl/Rb/12/2 would be a good slate deposit, were it not for the soft, clay-rich, nature which gives the stone very low durability.

In summary, the rhythmite claystone "slates" at Kirkup's deposit and surrounding areas near the Arthur River appear to be too clay-rich and soft to be used as building or ornamental slates, even in those deposits which are not rendered unusable by the presence of abundant hard sandstone interbeds.

Strahan - Henty Plantation

PROSPECTIVITY - Low

A correlate of the Wynyard Tillite outcrops at the Henty Forestry plantation, north of Strahan, and includes rhythmite claystone deposits (Baillie *et al.* 1977). These rhythmites were observed in road-cutting outcrops at grid ref. CP610380 (area Sl/Dr/4).

The Henty Plantation rhythmites are light grey (N6), fine-grained mudstones with a small proportion of sand-size grains and rare pebble and cobble-size dropstones. Like the Arthur River rhythmites, the Henty Plantation rhythmites are plane-laminated, and cleave easily along bedding. However, the stone is again rather soft and frets easily upon exposure. Observed joint fracture spacings are generally rather close, with spacings of 0.3 - 1.0 metres laterally being typical.

The Henty Plantation rhythmites are similar to the Arthur River rhythmites, and are unsuitable for use as slates for similar reasons - primarily, excessive softness and tendancy to fret, probably related to a high clay content.

Tasmania Basin
Stockers Tillite - Rhythmite claystones
Lake River

PROSPECTIVITY - Low

The Stockers Tillite, which is a correlate of the Wynyard Tillite, outcrops in the Lake River area, on the northeast side of the Western Tiers (Matthews 1974). Well-graded rhythmite deposits occur within the tillite in this area (Clarke, *in* Burrett & Martin 1989,p.298). These were not examined during the present work, but are likely to be similar to the Arthur River and Henty Plantation rhythmites, and thus unsuitable for use as slates.

CHAPTER SIX

GRANITE
("True Granite")

6.1 Definition and description

In the stone industry, the term "granite" covers most hard crystalline silicate stone types capable of taking a polish (as opposed to the softer crystalline rocks like marble), and generally includes all rocks of igneous origin (ie, formed by the solidifying of a molten magma or lava). The term would also encompass certain metamorphic rocks such as gneiss.

The geological definition of granite is much narrower, and for the purposes of this report the present chapter deals with "true" granites in the geological sense. Other "granites" in the stone industry sense ("black granites" and other miscellaneous types) are dealt with in subsequent chapters.

Defined geologically, granite is a plutonic igneous rock (one which has cooled and solidified from magma at depth below the Earth's surface) of "acid" composition (ie, containing over 66% silica, free or combined; Carmichael *et al.* 1974, p.29), consisting mainly of alkali potassium feldspar (orthoclase) and quartz. Subordinate constituents may include sodic plagioclase feldspar (usually oligoclase or andesine), muscovite, biotite, hornblende and rarely pyroxene (Am.Geol.Inst. 1962). A number of other minor minerals may be present, some of which can be unstable and thus detrimental to stone quality for building purposes (see Ch. 2). These latter are commonly secondary minerals (Ray 1988), which have formed in the stone subsequent to its initial solidification.

Granites are of medium to coarse grainsize; fine-grained volcanic igneous rocks of similar composition (eg, rhyolites) are classed with "Other Granites" in this report. The grainsize classification for granites (and other igneous rocks) is as follows (Berkman & Ryall 1976):

	Mean grain diameter (mm)
Pegmatitic	>30.0
Coarse	5.0 - 30.0
Medium	1.0 - 5.0
Fine	<1.0

Major granite types include (*from* Carmichael *et al.* 1974, p.39):

Type	Mineral assemblages (in addition to quartz)
Granite:	Potassium feldspar dominant, oligoclase generally subordinate; with biotite alone or with hornblende or muscovite.
Adamellite, Quartz Monzonite:	Potassium feldspar and oligoclase-andesine approximately equal; with some biotite and/or hornblende.
Granodiorite:	Andesine-oligoclase dominant, potassium feldspar sub-ordinate, with some biotite and/or hornblende. (Some granodiorites may be dark enough to be "black granites" Ray 1988, p.56).
Soda Granite:	Albite or albite-oligoclase (plagioclase) dominant, with small amounts of aegirine or sodic amphibole.

Granite vein or dyke rocks:	Pegmatite	Very coarse and mineralogically complex.
	Aplite	Fine grained white granite consisting of quartz, albite (sodic plagioclase), potassium feldspar and muscovite.

Geologically, the term "Granitoid" is used to encompass all the above varieties of "true granite".

Granite colour is most commonly a light grey. Of the "true granites", granodiorite may sometimes be of a sufficiently dark grey shade to be classified as "black granite" in the stone industry sense. No granodiorite occurrences in which this is the case were located during this project.

Red, pink, brown or yellow granites may result from iron in the feldspars (commonly in the K-feldspars). Such colouration is considered to result from metasomatism during the later stages of granitoid emplacement (M.P. McClenaghan, *pers. comm.* 1990). The metasomatic effect may be patchy and gradational, with the result that many granite bodies show significant variation in intensity of the reddish colouration. Some granite bodies, such as the Mt. Stronach and Mt. Pearson bodies, show a complete gradation from pink to grey in various places.

Red granites such as the Heemskirk Red Granite and the Housetop Granite commonly also contain greenish feldspars, which are considered to result from the presence of epidote, also formed by metasomatism (M.P. McClenaghan, *pers. comm.* 1990).

Common granite textures are:

Equi-granular (uniform): All grains of similar size. Equi-granular granites are most commonly favoured as a building material.

Porphyritic: Large crystals (phenocrysts) set in a groundmass of smaller-sized grains. Porphyritic granites are sometimes used as decorative stone (eg, South Australian "Kingston Blue" granite).

Other structures and features which may occur in granites include:

Massive structure: Uniform colour and texture throughout a body of granite, no banding or other segregations and variations.

Foliation: See "Other Granites".

Segregations: Regions of differing colour and/or texture within an outcrop-scale body of granite. Segregations may include patches or bands, and may be regularly or irregularly distributed.

Xenoliths: Fragments of rock (commonly different granite types) incorporated into the granite magma as it intrudes the country rock before solidifying. Commonly rounded in shape and darker in colour.

Veins and dykes: Veins may be tension fractures filled with secondary minerals which may or may not be detrimental to the aesthetic and durability qualities of the stone (eg, quartz, calcite, zeolites). Other veins or dykes may be pegmatites or aplites which intruded the still-cooling granite magma at a late stage in the granite intrusion process.

Joint Breaks and fractures: Large breaks, generally due to tectonic, cooling or unloading stresses in the earth's crust. Coarser granites tend to have wider joint spacings. Intense planar parallel macro-fractures occur in a few Tasmanian granites.

Cracks and micro-cracks: Microcracks are very fine cracks affecting individual crystals within a granite. These may occur naturally (eg, micro-cracks may develop around individual grain boundaries during magma cooling, and fine cracking can result from tectonic stresses in the Earth's crust), or may be produced during quarrying, especially if explosives are used. They can weaken the rock, accelerate weathering decay by increasing porosity and allowing access for water, and may result in polishing flaws.

Fading and colour change after quarrying and exposure are not common problems with granites (Ray 1988), although Spry (1988, p.62) notes that some minor lightening or darkening may occur.

It is common for naturally weathered granite outcrops to be slightly softened (due to weathering of feldspars), and of slightly lighter colouration, and/or stained yellow or brown by iron oxides, for a depth which may extend several metres below the natural outcrop surface.

It is also not uncommon for feldspars in faintly pink metasomatised granites to develop an intensified pink colouration in the outer 100mm or so of an outcrop, or adjacent to joints. This effect was noted in the Ben Lomond Granite, Tombstone Creek Pluton, and Mt Stronach Pluton during this project. Care must be taken to determine the true fresh sub-surface colour of granites.

In many areas granite has weathered to a "rotten" sandy soil to significant depths. Even in cases where weathering of granite is not pronounced, slight alteration of feldspars to clay (which rarely develops quickly in granite after quarrying, but may be present in granite as quarried) can cause the stone to take a poor polish (leaving dull patches and pits).

For these reasons, it is commonly impossible to get an accurate indication of stone colour and strength from natural surface outcrops. A surprisingly efficient method of determining granite freshness is to break it with a large hammer; fresh granite is very difficult to break, whereas even slightly weathered granites break with relative ease. Proper evaluation of granite colour and quality requires fresh exposures, obtained by means of drilling or trial excavations.

6.2 Granite applications

Granite is commonly used in polished form, but may also be used with honed, flamed, exfoliated or other surface finishes.

Large dimension blocks	Minor use in modern buildings. Load bearing structures (large monuments, base courses and plinths, bridge piers, retaining walls, etc). High strength and durability required. Minimal strength and textural anisotropy may be acceptable, but blocks should be correctly oriented with direction of lowest strength horizontal.
Veneers (wall cladding) (interior/exterior)	Major modern use (high & low-rise buildings) Aesthetic appearance important, must take good polish. Highest durability required for exteriors.

	High flexural Strength required for thin veneers, Young's Modulus of elasticity and Co-efficient of linear thermal expansion important. Significant micro-cracking or strength anisotropy unacceptable for exterior veneers.
Furniture, decorative features	Benches, table-tops, etc. Resistance to staining important. May be bonded to strong backing.
Paving tiles	Abrasion resistance, modulus of rupture / flexural strength and resistance to staining (low porosity) important. Polished granite tiles can be difficult to maintain in good condition since feldspars in the granite can easily lose their polish. High-wear locations require the finest grainsize possible, as this yields the highest abrasion resistance.
Paving blocks ("setts")	Small blocks which can be used for a "cobble-stone" type of paving (driveways, etc). Closely jointed granites may be usable for small setts.
Monuments Memorials (gravestones)	High durability required for exterior applications, as for dimension blocks and exterior cladding.
Granite "Terrazo"	Granite is sometimes used crushed and reconstituted. Most granites can be used for this purpose, regardless of flaws, although weathered deposits would probably be unacceptable if clay content is high. Some Coles Bay red granite is currently used for this purpose.

6.3 Granite quarrying in Tasmania

Granite has been produced for many years from the red granite quarries at Coles Bay,and has performed well in service despite the presence of weathered feldspar (clay) inclusions which have been considered to make the stone unsuitable for export. The Coles Bay granite is currently quarried on a small scale by Northern Tasmania Quarries Pty Ltd.

More recently, a number of granite quarries have been opened by Dunn Monumental Masons Pty Ltd. The currently operating Tasmanian granite quarries are listed below; details are provided in a later section of this chapter. All the granites currently quarried are of Devonian - Carboniferous age.

Coles Bay	("Nelson Red" or "Hobart Red")	Red & yellow	Northern Tasmania Quarries
Memory Road, NE Tas.	("Martich")	Grey	Dunn Monumental Masons
Diddleum, NE Tas.	("Tequila")	"Brown"	" " "
Blessington, NE Tas.	("Jaydon")	Pink	" " "
Trial Harbour, W Tas.	("Anajul")	Red	" " "

Nargun Pty. Ltd. has recently (1989) taken out a stone lease on the Housetop Granite (Devonian, Burnie region) for production of reddish brown dimension stone at a promising quarry site.

6.4 True granite sources and prospects in Tasmania

The following is a complete listing of all true granite bodies outcropping in Tasmania (*from* Camacho *and* McClenaghan, *in* Burrett and Martin 1989, and map sources). Granite "suites", as given in McClenaghan (*Ibid.*), are listed for convenience in grouping granite bodies.

PRECAMBRIAN		
King Island	West Coast Granite	King Island
CAMBRIAN		
Dundas - Fossey	Darwin Granite	Mt. Darwin
Mt. Trough	Murchison Granite	Murchison R. Gorge
	Timbertops Granite	S. of Macquarie Harbour
	Elliot Bay Granite	Elliot Bay
Tyennan Block	Dove "Granite" (granodiorite); 3 bodies.	Mersey - Forth Rivers.
DEVONIAN - CARBONIFEROUS		
King Island	*Grassy Suite:*	
	Grassy Granodiorite	King Island
	Bold Head Granodiorite	"
	Sea Elephant Adamellite	"
Rocky Cape Block	*Interview Suite:*	
	Three Hummock Is. Adamellite	Three Hummock Is.
	Interview Granite	Pieman R. - Sandy Cape
	Pieman Suite:	
	Pieman Granite	Pieman Heads
	Heemskirk White Granite	N. of Trial Harbour
	Housetop Suite:	
	Heemskirk Red Granite	N. of Trial Harbour
Dundas - Fossey		
Mt. Trough	Meredith Batholith:	Savage R. Rd. - Pieman Rd.
	Meredith Mafic Phase:	
	Wombat Flat Adamellite	
	Pieman Suite:	
	9 "felsic" Adamellite Plutons	
	Housetop Suite:	
	Housetop Granite	S. of Burnie (Natone - Kara)
	Dolcoath Granite	Lake Cethana
	Meredith Mafic Phase + Pieman Suite:	
	Renison Complex	
	Pine Hill Granite	Renison Bell
	Suite unspecified:	
	Grandfathers Granite	Cape Sorell
	Beulah Granite	Sheffield

Tyennan Block	*Pieman Suite:*	
	Granite Tor Granite	Mackintosh R. region, W.Tas.
	Suite unspecified:	
	Birthday Granite	Upper Forth River
	Lone Pine Granite	Upper Forth River
	Babel Island Suite:	
	Cox Bight Granite	Port Davey region
	Southwest Cape Granite	"
Northeast Tasmania	**Flinders & adjacent islands:**	
	Gardens , Wybalenna, Poimena Suites	Flinders & adjacent islands
	Lady Barron, Musselroe, Boobyalla Suites	"
	Babel Island Suite	"
	Scottsdale Batholith	
	Diddleum Suite:	
	Diddleum Granodiorite	Diddleum Plains - Scottsdale
	Tulendeena Suite:	
	Tulendeena Granodiorite	Tulendeena
	Porcupine Creek Granodiorite	East of Ben Nevis
	Russells Rd. Suite:	
	Russells Road Adamellite	Mt. Maurice, Russells Rd.
	Upper Blessington Pluton	Upper Blessington
	Mt. Stronach Suite:	
	Mt. Stronach Pluton	Mt. Stronach
	Tombstone Creek Pluton	Tombstone Creek
	Blue Tier Batholith	
	Scamander Tier Suite:	
	Scamander Tier Granodiorite	Terryvale - St. Helens - Scamander
	Catos Creek Granodiorite	Catos Creek
	Gardens Suite:	
	Gardens Granodiorite	Gt. Musselroe R./The Gardens
	George River Granodiorite	St. Helens
	Pyengana Suite:	
	Pyengana Granodiorite	Pyengana, Mt. Young area
	Poimena Suite:	
	Poimena Adamellite	Poimena - Waterhouse Pt.
	Musselroe Suite:	
	Mt. Pearson Adamellite	Mt. Pearson - Granite Knob
	Lottah Suite:	
	Lottah Pluton	Lottah - Goulds Country
	Mt. Paris Pluton	Mt. Paris - Derby
	Little Mt. Horror Granite	Little Mt. Horror
	Mt. Cameron Granite	Mt. Cameron
	Suite unspecified:	
	Sheoak Hill Pluton	Sheoak Hill (Ringarooma Bay)

	St. Mary's Area	
	Babel Island Suite:	
	Picaninny Creek Adamellite	Chain of Lagoons
	Scamander Tier Suite:	
	St. Mary's Porphyrite	St. Mary's
	Suite unspecified:	
	Granodiorite	Picaninny & Long Points
	Eddystone Batholith	
	Musselroe Suite:	
	Musselroe Adamellite	Gt. Musselroe Bay
	Ansons Bay South Adamellite	Ansons Bay & to north
	Boobyalla Suite:	
	Ansons Bay North Adamellite	Cape Naturaliste southwards
	Boobyalla Adamellite	Boobyalla
	Babel Island Suite:	
	Mt. William Granite	Mt. William
	Avoca Region	
	Babel Island Suite:	
	Ben Lomond Granite	Avoca - Rossarden
	Royal George Granite	St. Pauls River
Tasmania Basin (east coast)	*Boobyalla Suite:*	
	Bicheno Adamellite	Bicheno
	Coles Bay Adamellite	Freycinet Peninsula
	Maria Island Granites	Maria Island
	Babel Island Suite:	
	Deep Glen Bay Adamellite	Forestier Peninsula
	Suite unspecified:	
	Bluestone Bay - Wineglass Bay Granodiorites	Bluestone - Wineglass Bay

6.5 Evaluation of true granite sources and prospects in Tasmania

PRECAMBRIAN
King Island
West Coast Granite

PROSPECTIVITY - Low?

The dominant and earliest granite type in this large body is a K-feldspar porphyritic biotite adamellite. Later minor intrusives include biotite granodiorite, equi-granular biotite adamellite, biotite-muscovite granite, aplite and pegmatite (Cox, *in* Burrett & Martin 1989,p. 26). The entire granitoid mass is deformed, with common shear surfaces (Turner, *Ibid.* ,p.27).

This large granite was not studied during this project. Relatively intense fracturing is likely, and in any case it is probable that the relatively remote location would cause practical and economic problems in quarrying and transport of the granite.

CAMBRIAN
Dundas - Fossey Mt. Trough
Murchison Granite

PROSPECTIVITY - Low

The Murchison Granite outcrops in the Murchison River gorge east of Tullah (see Fig. 6.1), and is accessible via Hydro-Electric Commission roads. The granite has been described by Polya (1981), and has more recently been mapped by Corbett & McNeill (1986, 1988). In the present work, the granite was examined at sites G/Dr/1/1 & 2, near the Murchison Dam.

The Murchison Granite has a dark grey-green colour with abundant pinkish-brown to red feldspars. Variation in red feldspar content has produced diffuse patches and bands of distinctly redder stone. It is generally a medium-grained, equi-granular granite, but has a patchy texture resulting from the presence of abundant irregular patches 10-30mm dia. of fine-grained, dark grey-green, porphyritic stone. Quartz veins and minor pyrite crystals are present.

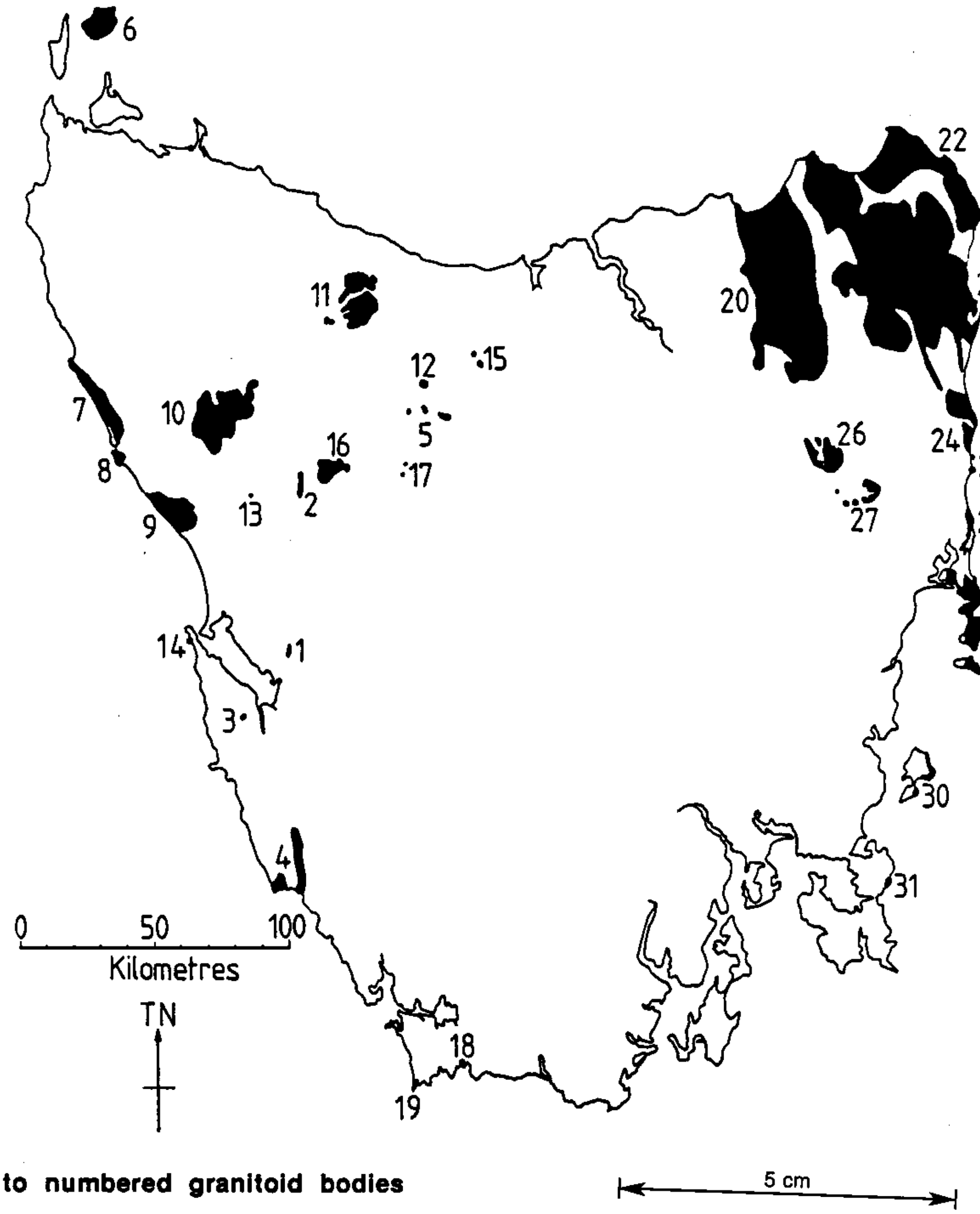
The granite is intensely jointed and fractured, with typical joint spacings of 0.3 to 0.5 metres.

Although the granite has an interesting appearance in some outcrops, the intense jointing (and presence of pyrite) rules out ornamental use of the stone.

Darwin Granite
Timbertops Granite
Elliot Bay Granite

PROSPECTIVITY - Low

These small Cambrian granite bodies were not studied during this project. The Timbertops and Elliot Bay granites are located in regions which are currently too remote for dimension stone quarrying (see Fig. 6.1).



Key to numbered granitoid bodies

<u>Cambrian</u>		
1 Darwin Granite	10 Meredith Batholith	21 Blue Tier Batholith
2 Murchison Granite	11 Housetop Granite	22 Eddystone Batholith
3 Timbertops Granite	12 Dolcoath Granite	23 St. Mary's Porphyrite
4 Elliot Bay Granite	13 Pine Hill Granite	24 Picaninny Creek Adamellite
5 Dove Granite	14 Grandfathers Granite	25 Picaninny/Long Pt. Granod.
	15 Beulah Granite	26 Ben Lomond Granite
<u>Devonian - Carboniferous</u>	16 Granite Tor Granite	27 Royal George Granite
6 Three Hummock Is. Adam.	17 Birthday/Lone Pine Gran.s	28 Bicheno Adamellite
7 Interview Granite	18 Cox Bight Granite	29 Coles Bay Adamellite
8 Pieman Granite	19 South West Cape Granite	30 Maria Island Granites
9 Heemskirk Granite	20 Scottsdale Batholith	31 Deep Glen Bay Adamellite

Figure 6.1 True Granite bodies in Tasmania

The age of the granites, and their location in the multiply-deformed Dundas Trough, suggest that they are likely to be as intensely fractured as the Murchison and Dove Granites.

Tyennan Block
Dove Granite

PROSPECTIVITY - Low

The Dove Granite, originally thought to be of Devonian age (Jennings 1963), but now considered to be a Cambrian granitoid (Leaman & Richardson 1989), outcrops as three small bodies intruding the northern edge of the Tyennan Block, in the Mersey, Forth and Dove River valleys (see Fig. 6.1). Outcrops are commonly deeply weathered and are largely of difficult access in rugged terrain.

It appears that only the roof of the granite intrusion is exposed, so that many marginal phases outcrop, resulting in significant variation in stone type between various outcrops (Jennings 1963). Granite types exposed include grey biotite granite, pink and grey granodiorites, and granodioritic aplite dykes. The stone varies from fine to coarse grainsize, and is generally equigranular in texture.

Outcrops observed in the Mersey River valley north of Lake Parangana (area G/Tb/1) were deeply weathered, greyish-red in colour, and of equi-granular medium-grained texture. The stone contains pyrite, and is intensely shattered, having open joint breaks spaced 0.1 - 0.3m apart. Weathering - resistant aplite dykes up to 0.5m thick outcrop prominently.

The difficult access and terrain, the relatively small total area of granite combined with the common deep weathering and consequent rarity of fresh outcrops, and the observed intense jointing make the Dove Granite a low priority for dimension stone exploration.

DEVONIAN - CARBONIFEROUS

The majority of Tasmanian "true" granites are of Devonian or Early Carboniferous age. Only granites of this age have been quarried to date in Tasmania for dimension stone use.

King Island

Grassy Granodiorite
Bold Head Granodiorite
Sea Elephant Granodiorite

PROSPECTIVITY - Low?

These three granite bodies are chemically and texturally similar, and are considered to be related bodies (Comacho, *in* Burrett & Martin 1989,p.256). The Grassy Granodiorite is porphyritic with large pink K-feldspar phenocrysts. The Bold Head and Sea Elephant Granodiorites are texturally similar.

These granites were not studied during this project. It is likely that the relatively remote location would cause practical and economic problems in quarrying and transport of the granites.

Rocky Cape Block

Three Hummock Island Adamellite

PROSPECTIVITY - Low

The Three Hummock Island Adamellite (Fig. 6.1) consists of two types, a feldspar-porphyritic biotite adamellite and a biotite-muscovite-tourmaline adamellite.

This granitoid was not studied during this project. It is likely that the relatively remote location would cause practical and economic problems in quarrying and transport of the granite.

Interview Granite & Pieman Granite

PROSPECTIVITY - Low

On geophysical evidence, Leaman & Richardson (1989) consider these two areas of surface outcrop (Fig. 6.1) to be parts of the same granite body, which they group together as the Pieman Granite. However, McClenaghan (*in* Burrett & Martin 1989,p.256) notes that while the two granites have similar mineralogies, they are chemically distinct.

The Pieman granite is petrologically similar to the white Heemskirk Granite, being coarse-grained and equi-granular to porphyritic, with common tourmaline nodules (McClenaghan *Ibid.*).

Neither the Pieman nor the Interview Granite was studied in this project. They are located in remote country having difficult access.

Heemskirk Granite

The Heemskirk Granite (Fig. 6.1) occurs on the west coast immediately north of Trial Harbour and west of Zeehan. Two-wheel drive vehicular access only exists on the northern and southern margins of the granite body.

The Heemskirk Granite is a composite body consisting of a red granite at the top of the intrusion, which has been intruded by a slightly younger "white" (grey) granite which forms the western and major part of the body (McClenaghan *in* Burrett & Martin 1989,p.255). Recent (1990) mapping of the Heemskirk Granite by M.P. McClenaghan (*pers. comm.*) has confirmed the distribution of the two granite types as previously mapped by Klominsky (1972; *see* Fig. 6.2).

Abundant tourmaline nodules occur throughout the white granite, but are also present in some parts of the red (Klominsky 1972, M.P. McCLenaghan *pers. comm.* 1990, see Fig. 6.2). The greatest number of toumaline nodules occur towards the top of the intrusion.

Both the red and white granites have predominantly quartz / K-feldspar / plagioclase / biotite / tourmaline mineralogies.

Heemskirk Red Granite

PROSPECTIVITY - High

The red granite extends from the north to south of the Heemskirk Granite, particularly in the central and eastern parts (see Fig. 6.2). Much of the red granite is strongly weathered, but numerous areas of fresh outcrop exist.

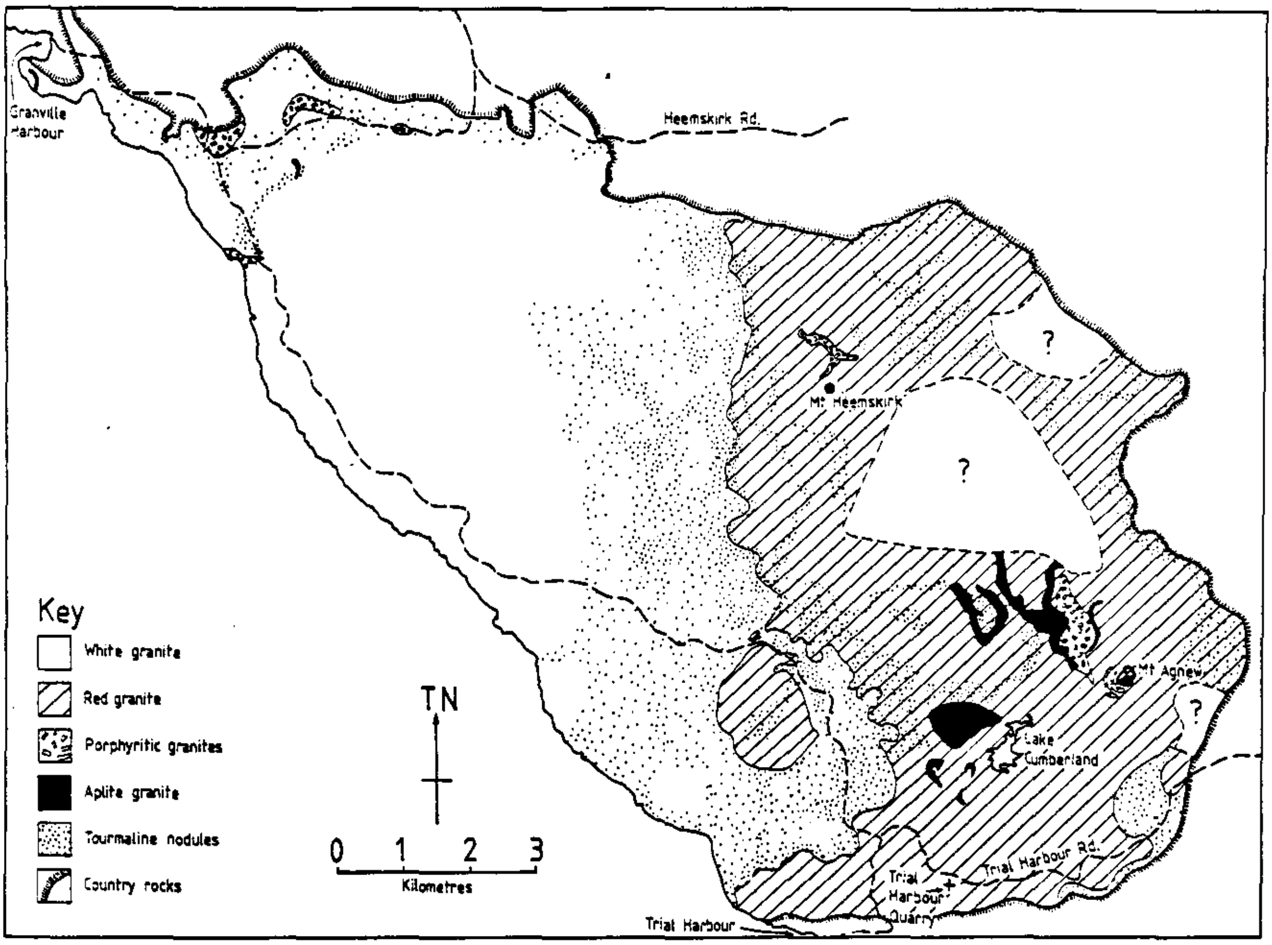
The red colour (see Plate 3.8) is the result of the presence of red K-feldspars, and was probably caused by metasomatism. The red colour varies considerably through the body, from a bright red (eg, near Lake Cumberland) to lighter and duller reds.

Recent mapping (M.P. McClenaghan, *pers. comm.* 1990) indicates that the red granite occurs in the form of multiple sheets which intruded in a number of pulses. Each pulse produced a sheetlike body which chilled at the margins, where it intruded earlier sheets. Thus, grainsize within each sheet varies from coarse to fine, and these variations are repeated through successive sheets.

The granite is predominantly of an equi-granular texture, although a quartz-porphyritic variety was noted in a fine-grained red granite on the northern chilled margin of the pluton.

The writer has observed sparse dark tourmaline nodules in the red granite near it's northern margin (south of the Heemskirk Road), but these are absent in exposures along the Trial Harbour Road in the south, near the "Anajul" quarry (see below). Klominsky (1972) mapped the distribution of tourmaline nodules in the Heemskirk Granite (see Fig. 6.2).

Joint spacings are predominantly wide (1.0 - 8.0m) in the medium to coarse-grained varieties, but close spacings (<0.5m) were noted in fine-grained red granites near the Heemskirk road. Strong joint patterns are evident in airphotos, suggesting that the parallel microcracking in the "Anajul" quarry (see below) is likely to be prevalent through much of the red granite. However, Klominsky's (1972) mapping indicated some variation in joint density through the granite, which may be related to variation in micro-cracking intensity.



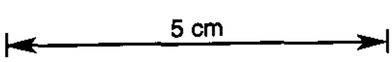


Figure 6.2 Distribution of granite types in the Heemskirk Granite (from Klominsky 1972).

Trial Harbour Red Granite Quarry (Trade name: "Anajul")
Dunn Monumental Masons P/L commenced quarrying the Heemskirk Red Granite at a site (G/Rb/1/1, see Fig. 6.2) immediately adjacent to the Trial Harbour Road in mid-1989 (stone lease 79 M/88, grid ref. CP502573). The site consists of large natural outcrops on the crest of a small ridge.

The quarried granite is a pale - moderate red colour (5 R 6/4) with a tinge of green (see Plate 3.8). The colour results from red K-feldspars and a pale green (epidote-contaminated?) feldspar variety. The granite is massive, uniformly medium to coarse-grained and equi -granular in texture. No xenoliths or veins were apparent in fresh outcrops at the site, although two 0.4m thick fine-grained porphyritic aplite dykes occur. Surface weathering has resulted in some bleaching and brown iron-oxide staining within 20 - 100mm only of natural outcrop surfaces.

Jointing breaks are spaced between 2.0 and 8.0 metres apart, allowing extraction of large blocks. Fine parallel discontinous intra-crystalline micro-cracks are common. These will limit the use of the stone as an exterior veneer, but should be acceptable for many other applications.

Apart from the region of the existing "Anajul" quarry, numerous other accessible and quarriable outcrops of Heemskirk Red Granite probably exist (eg, an area of red granite on the Granville Harbour Rd. (4WD), 3 - 4 km north of Trial Harbour, may be suitable).

Heemskirk "White" Granite

PROSPECTIVITY - "High"

The freshest parts of the white Heemskirk Granite occurs towards the NW part of the intrusion, in the Granville Harbour region (M.P. McClenaghan *pers. comm.* 1990; see Fig. 6.2).

In this region, outcrops on the Heemskirk and Granville Harbour (coast) roads show the granite to be typically an equi-granular medium-grained light grey ("white") stone whose appearance is dominated by an abundance of black tourmaline nodules 10 - 50mm diameter. Joint spacings vary from less than two metres to over four metres apart.

Practicable quarry sites are available, and the stone is likely to be of good technical quality. While the abundance of black tourmaline nodules set against a grey (near-white) groundmass might not be considered aesthetically pleasing, previous mapping (see Fig. 6.2) has shown that parts of the granite are free of nodules.

Dundas - Fossey Mt. Trough

Meredith Batholith

PROSPECTIVITY - Low

The Meredith Batholith (see Fig. 6.1) is a large composite body which has been divided into ten different plutons (Camacho, *in* Burrett & Martin 1989,p.254). These plutons comprise one mafic type (Wombat Flat Adamellite) and nine felsic types. Camacho recognised two predominant textural types in the batholith: an equi-granular fine- to medium-grained grey biotite adamellite, and a porphyritic biotite adamellite, both with the same mineralogy.

The Meredith Batholith is almost entirely situated in wild country with difficult access, between the Pieman and Savage River Roads. The northern extremity of the batholith outcrops on the Savage River road a few kilometres west of Waratah; at this site the granite is an equi-granular, medium-grained grey granite with fine quartz veins and closely spaced joints (max. 0.5m spacings).

A coarse-grained equi-granular grey variety was also observed near the southern extremity of the batholith, a few hundred metres north of the Pieman Road near the Stanley River. Wider joint spacings (in the order of several metres) were evident at this site.

The Meredith Batholith is a remote granitoid which would pose access and environmental problems for quarrying operations. Available information indicates that the stone is largely a grey granite.

Housetop Granite

PROSPECTIVITY - High

The Housetop Granite (Fig. 6.1) is one of the largest granite bodies in W. and NW Tasmania, although it is partly covered by Tertiary basalts. It outcrops in the Natone to Kara region, south of Burnie.

The largest (southern) area of outcrop is centred on Mt. Housetop, and is predominantly within crown land used for forestry purposes. A major area of outcrop to the north, in the Emu River to Blythe River area, is covered by Freehold land and Timber Reserves, while lesser areas of outcrop occur in the Kara Mine region and to the east of the Blythe River near Riana. Vehicular access is fair to good in most areas.

Deep weathering, yielding outcrops of "rotten" granite, is widespread, although large natural outcrops of relatively un-altered granite are common, especially in the southern area. However, freshly broken exposures are rare, so that determination of the colour and texture of the fresh stone is often difficult because of the 10 - 20mm thick outer layer of whitish-grey or brown weathered stone which occurs on most natural outcrops.

Baillie and Lennox (*in* Seymour 1989, p.45) consider the Housetop Granite to be a single granite body within which individual plutons cannot be mapped. This implies that variation within the granite is limited. In general, the Housetop Granite is an equi-granular to sparsely porphyritic, medium to coarse-grained biotite granite (*Ibid.*), of pink to reddish-brown colour.

Minor variants include a fine-grained quartz-feldspar porphyry, and a pink fine to medium grained equi-granular adamellite near the western margin of the main southern body (*Ibid.*). However, Camacho (*in* Burrett & Martin 1989,p.255), also considers that three granite types can be distinguished within the Housetop Granite (the Kara, Natone and Housetop types), based on petrographic character. Further work will be necessary to determine whether such variations significantly affect stone quality & appearance from the dimension stone point of view.

Reconnaissance exploration during the present work indicated that a reddish-brown to pink colour is widespread throughout the granite. Distinctly brown granites also occur within the Housetop Granite, so that there is a range of colours from pink through to brown in the granite body.

Most of the granite is of medium-grained equi-granular texture. Closely spaced jointing (av. 0.5m spacing) is common, but there are also numerous bold outcrops with widely-spaced jointing (four metre+ spacings).

The granite was examined at sites G/Dr/3/1 & G/Dr/4/1.

Site G/Dr/3/1 is located in the southern portion of the Housetop Granite, and consists of scattered large boulders and low outcrops in a recently logged area beside the Blythe Rd. at grid ref. DQ047311. Joint fractures are spaced up to four metres (or more) apart, and the granite is a pink or pale reddish-brown (10 R 5/4) colour, of medium-grained, equi-granular texture and massive, uniform, structure (see Plate 3.8). The fresh stone is attractive, and the site could be easily quarried. It is probable that numerous other similarly prospective sites could also be located in the region.

Site G/Dr/4/1 consists of fresh exposures in a road cutting on the Upper Natone Rd., at grid ref. DQ087393 in the northern portion of the Housetop Granite. Joint fracture spacings vary from 0.5 to 3.0 metres+ apart. The stone is of coarse-grained equi-granular texture and massive uniform structure. The fresh colour is a moderate red (5 R 5/4) to pale reddish-brown (10 R 5/4) overall, but has both brown-red and pale greenish feldspars. On polishing the stone has a distinctly brown colour (see Plate 3.9). Microcracks are fairly common, but may be partly related to blasting in the specimen polished.

The stone seems rather attractive, and is of similar character (but browner colour) to the Heemskirk Red Granite at site G/Rb/1/1 ("Anajul"). Although site G/Dr/4/1 is unsuitable for quarrying due to it's location, the attractive and apparently high quality nature of the stone indicates high potential for the general region.

In summary, the major portions of the Housetop Granite have high potential for attractive pink, reddish-brown and brown granites in an area of generally good access and close to Burnie.

<u>Upper Natone Quarry Prospect</u>
In 1989, Nargun Pty Ltd pegged a stone lease (1293 P/M) at Upper Natone (site G/Dr/4/2, grid ref. DQ08103880) for production of reddish-brown dimension stone from the Housetop Granite. This lease is only 500m from site G/Dr/4/1, and the site is an old quarry face with adequate access and wide joint spacing. The stone is virtually identical in colour and texture to that at site G/Dr/4/1, and the prospect appears highly promising.

Dolcoath Granite

PROSPECTIVITY - Low

The Dolcoath Granite (Fig. 6.1) is a small (≈1.5km dia.) body outcropping in the Forth River Valley near Lake Cethana. The granite was not examined during this project, but Jennings (1979) describes it as a medium- to coarse-grained cream to pink biotite granite with common narrow aplite veins and dykes. Joint or fracture patterns are not known to the writer.

The small extent of the outcropping granite would give little scope for location of a practical quarry site yielding high-quality stone.

Renison Complex - Pine Hill Granite

PROSPECTIVITY - Low

The Renison Complex is a composite body which has been intersected at depth in the Renison Bell Mine. Camacho (*in* Burrett & Martin 1989,p.255) recognises three granite types within the Complex; a porphyritic variety, an equi-granular medium- to coarse-grained variety, and an equi-granular fine-grained variety.

The small Pine Hill Granite (Fig. 6.1), outcropping 2 km south of the mine, is considered to be a surface outcrop of the Renison Complex. The Pine Hill Granite was not visited during this project, but is strongly greisenised (see Camacho, *Ibid.*). This, together with the very small extent of the surface outcrops, suggest that the dimension stone potential of this granite is very low.

Grandfathers Granite

PROSPECTIVITY - Low

The Grandfathers Granite is a relatively large granite body which, however, is almost entirely situated offshore to the southwest of Cape Sorell (Leaman & Richardson 1989). The only onshore outcrops occur in a few tiny coastal exposures near the Grandfathers Hills (Fig. 6.1), where adamellite was noted by Baillie *et al.* (1977).

The onshore outcrops are in a remote coastal location having difficult access for quarrying, and this together with their very small extent implies low prospectivity for dimension stone quarrying.

Beulah Granite

PROSPECTIVITY - Low

The Beulah Granite outcrops patchily across the Beulah - Paradise region, just south of Sheffield (Fig. 6.1), and has been described by Jennings (1979). The Beulah Granite may be a multiple intrusion (Leaman & Richardson 1989), and Jennings records both granite and granodiorite outcrops.

In general, the Beulah Granite comprises medium to fine-grained equi-granular varieties with both light grey and pinkish colourations.

A visit to the area, which is farming country of only moderate relief, located only very poor natural outcrops. It is likely that the poor outcrop results from deep weathering of the granite, which in turn may be indicative of predominantly closely-spaced jointing. Whatever the cause of the poor outcrop, however, its effect is that exploration for potential dimension stone quarry sites in the small area of known surface granite is likely to be unproductive.

Tyennan Block
Granite Tor Granite

PROSPECTIVITY - Low

The Granite Tor granite intrudes Precambrian rocks in relatively inaccessible country east of Tullah and Lake Mackintosh (Fig. 6.1). The rock is a coarse-grained biotite-muscovite granite with large phenocrysts (megacrysts) of K-feldspar.

The inaccessible nature of the Granite Tor Granite would make dimension stone exploration and quarrying difficult and probably uneconomic.

Birthday & Lone Pine Granites

PROSPECTIVITY - Low

The Birthday and Lone Pine Granites outcrop in the upper Forth River valley (Fig. 6.1), and are two very small areas of granite outcrop which are considered to be extensions of the Granite Tor Granite body (Leaman & Richardson 1989). They were not examined during this project.

The Lone Pine Granite is described by Jennings (1963) as a poorly outcropping light to dark grey granite with aplite and pegmatite dykes, and associated greisen. The Birthday Granite has been described as a biotite-muscovite granite with pinkish-white feldspars, which becomes porphyritic near the country-rock contact (MacLeod *et al.* 1961).

The tiny surface area and poor exposure of these granites would appear to make them uninviting dimension stone prospects.

Cox Bight & Southwest Cape Granites

PROSPECTIVITY - Low

The Cox Bight and Southwest Cape Granites are two small bodies intruding Precambrian rocks in the far southwest of Tasmania (Fig. 6.1). The Cox Bight Granite is a coarse-grained to sparsely feldspar-porphyritic light coloured biotite granite with minor muscovite, and the Southwest Cape Granite is a Coarse-grained foliated biotite granite with phenocrysts of feldspar and biotite (D.J. Jennings, *in* Burrett & Martin 1989,p.256).

These granites are located within and near the World Heritage-listed Southwest National Park. Apart from the land use restrictions, the remote location and small size of these granite bodies would make them unprospective as dimension stone sources.

North-east Tasmania

The Devonian granitoids of north-east and eastern Tasmania (Fig. 6.3) are all considered to be the outcropping "roof " projections of a single major north-south oriented sub-surface "batholith" (Leaman *et al.* 1980). The single batholith is however a composite body comprising a number of different compositional "suites". The various suites are considered to represent distinct magmas resulting from the melting of different source rocks (McClenaghan *in* Burrett & Martin 1989,p.267).

The major outcropping granitoid bodies in north-east Tasmania are the Scottsdale, Blue Tier and Eddystone Batholiths, each of which is subdivided into a number of distinct plutons containing different granitoid types. Several other granitoid bodies outcrop outside these major batholiths.

Flinders and adjacent islands

Granitoids form about 70% of the palaeozoic basement of the Furneaux Islands (Flinders and adjacent islands) and include granitoids having affinities with granitoids in onshore northeastern Tasmania (Reid, *in* Burrett & Martin 1989).

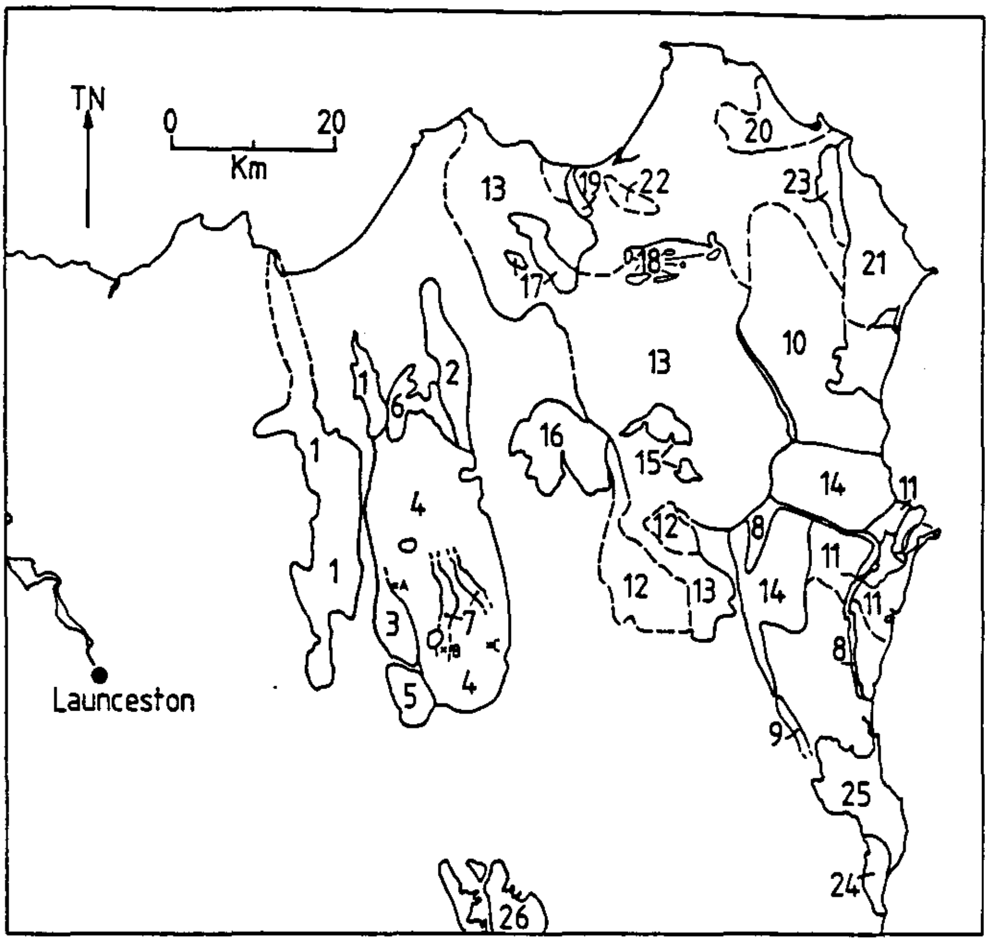
These granitoids were not examined during this project, although it is highly likely that they include granites of dimension stone quality. While some infrastructure exists on Flinders Island, it is likely that, as with King Island, problems of transport and remoteness from major Tasmanian centres would make an economically viable dimension stone quarry difficult to establish at the present time.

Scottsdale Batholith

The only currently operating granite dimension stone quarries in northeastern Tasmania are located in the Scottsdale Batholith, which is favoured because of it's proximity to Launceston (see descriptions later). Grey granite veneers on many Tasmanian buildings (eg, granite on the Central Library of the University of Tasmania, Sandy Bay, said to be of Tasmanian origin - R.Varne *pers. comm.*) are remarkably similar to the granodiorites of the Scottsdale Batholith. Some dimension stone has been quarried from the Diddleum Granodiorite in the past (J. Dunn, *pers. comm.* 1990), although no details are known.

The Scottsdale Batholith is approximately half composed of granodiorite, together with adamellites (Russells Rd. Adamellite) and alkali-feldspar granites (Mt. Stronach and Tombstone Creek plutons).

The granodiorites of the Scottsdale Batholith (and indeed, throughout NE Tasmania) show little variation, being massive, medium- to coarse-grained, dark grey rocks, commonly with abundant fine-grained dioritic enclaves (xenoliths) (McClenaghan *in* Burrett & Martin 1989,p.257).



5 cm

Key to numbered granitoid bodies:

Scottsdale Batholith:

1 Diddleum Granodiorite
2 Tulendeena Granodiorite
3 Porcupine Creek Granodiorite
4 Russells Road Adamellite
5 Upper Blessington Pluton
6 Mt Stronach Pluton
7 Tombstone Creek Pluton
15 Lottah Pluton
16 Mt Paris Pluton
17 Little Mt Horror Granite
18 Mt Cameron Granite
19 Sheoak Hill Pluton

Blue Tier Batholith

8 Scamander Tier Granodiorite
9 Catos Creek Granodiorite
10 Gardens Granodiorite
11 George River Granodiorite
12 Pyengana Granodiorite
13 Poimena Adamellite
14 Mt Pearson Adamellite

Eddystone Batholith

20 Musselroe Adamellite
21 Ansons Bay Adamellite
22 Boobyalla Adamellite
23 Mt William Granite

Other

24 Picaninny Creek Adamellite
25 St Mary's Porphyrite (see "Black Granite")
26 Ben Lomond Granite

Current Dimension Stone Quarries:

A: Diddleum ("Tequila") B: Blessington ("Jaydon") C: Memory Road ("Martich")

FIGURE 6.3 Granitoid bodies of north-eastern Tasmania

Diddleum Granodiorite

PROSPECTIVITY - High

Granodiorites which probably belong to the Diddleum Granodiorite outcrop at Bridport, on the north coast, and the granodiorite extends south from there through Scottsdale and the Diddleum Plains to an area east of Mt. Barrow (see Fig. 6.3).

The granodiorite was examined at Diddleum Plains (site G/Ne/27/1), west of Scottsdale (site G/Ne/27/2), and near Mt. Barrow (site G/Ne/27/3).

The granodiorite is of rather uniform character throughout, being a biotite-hornblende granodiorite ("Dsg" of Brown *et al.* 1977) of massive, medium-grained, equi-granular to sparsely porphyritic texture and medium grey overall colour (N5 -7) at all sites examined (see Plate 3.5). The colour derives from black biotites and ferromagnesian minerals together with white quartz and feldspars. Porphyritic granodiorite occurs at some contacts with the surrounding country rocks (Longman 1966).

The granodiorite may in places have a variably developed planar fabric (foliation) defined by elongation of quartz aggregates and ferromagnesian minerals (McClenaghan *et al.* 1982). The foliation is well developed within a few kilometres of the batholith margin, but is poorly developed or absent in the more central parts (*Ibid.*). This igneous foliation is not likely to produce a splitting tendancy.

Veins or dykes appear to be rare, but a common feature is the presence of sparse rounded to ovoid fine-grained dark-grey dioritic xenoliths 20 - 200mm in diameter. Longman (1966) noted that the dioritic xenoliths are most abundant close to the contact with sedimentary rocks, where they are commonly oriented parallel to the contact (and to the foliation; McClenaghan *et al.* 1982).

A moderate amount of outcrop exists, generally in the form of large rounded boldly outcropping masses with joint spacings varying from 3 to over 5 metres apart. Easily accessible and quarriable outcrops were noted on freehold land at Diddleum Plains (around grid ref. EQ386253), but there is no doubt that further quarriable sites can be found throughout the region, in both State Forest and on private land. Of particular interest is an area just north of Diddleum Plains known as "The Boulders" (EQ388264). Numerous very large granodiorite boulders could be quarried in this area with virtually no environmental impact.

The granodiorite is close to Launceston, and is probably the most prospective region in Tasmania for production of a uniform and "ordinary", but easily quarriable and probably high quality, grey granite. Varieties rich in dark xenoliths and with a discernable foliation will be found close to the batholith margins, while varieties with fewer xenoliths and a non-oriented fabric are more likely to occur several kilometres in from the margins.

Tulendeena Granodiorite

PROSPECTIVITY - Medium

The Tulendeena Granodiorite outcrops in an area extending northwards from Tuleendena and Kamona, west of Scottsdale (see Fig. 6.3). The granitoid has been mapped by Brown *et al.* (1977) as a biotite-hornblende granodiorite ("Dsg").

Outcrop is poor in road-cuttings along the Tasman Highway (site G/Ne/7/1), where only scattered fresh "corestones" remain in a deeply weathered horizon of "rotten" granite. The granodiorite in these exposures is a medium light grey (N6), massive, medium- to coarse-grained equigranular stone tending to porphyritic with coarse feldspars (see Plate 3.6).

Sparse dark grey dioritic xenoliths 20 - 100mm in diameter are present (McClenaghan *et al.* 1982) also noted a proportion of sandstone xenoliths in the Kamona - Tulendeena area; the presence of these would be unacceptable in dimension stone granite due to their different durability characteristics). The outcrops have been blasted and joint or fracture spacings cannot be determined. A specimen (G/Ne/7/1/1) polished well with minor pitting and very little microcracking.

The granodiorite has a variably developed planar fabric (foliation) defined by elongation of quartz aggregates and ferromagnesian minerals (McClenaghan *et al.* 1982). As with the Diddleum Granodiorite, the foliation is probably best developed within a few kilometres of the batholith margin, and poorly developed or absent in the more central parts (*Ibid.*). This igneous foliation is not likely to produce a splitting tendancy. Where the foliation is well developed, elongated xenoliths tend to be oriented parallel to it.

While it is probable that quarriable outcrops can be found north of the Tasman Highway, the stone is of similar character to the Diddleum Granodiorite, and is perhaps a little less conveniently situated for quarrying.

Porcupine Creek Granodiorite

PROSPECTIVITY - Medium?

The Porcupine Creek Granodiorite occurs in the southern part of the Scottsdale Batholith, north of Upper Blessington (see Fig. 6.3), and is currently being mapped by the Geological Survey of Tasmania as part of the Alberton Quadrangle.

The Porcupine Creek Granodiorite was not examined during this project, but the general uniformity of the granodiorites in northeastern Tasmania (McClenaghan, *in* Burrett & Martin 1989,p.257) suggests that it will be of similar character and dimension stone potential to the Diddleum and Tulendeena Granodiorites.

Russells Road Adamellite

PROSPECTIVITY - High

The "Russells Road Adamellite" is a "grab-bag" term encompassing all the adamellites in the Scottsdale Batholith (see Fig. 6.3), and it is possible that ongoing mapping in the Alberton Quadrangle will result in a sub-division into smaller plutons (M.P. McClenaghan *pers. comm.* 1990).

In the Ringarooma Quadrangle (Brown *et al.* 1977) the adamellites of the northern half of the Russells Road Adamellite are mapped as "Dsau", encompassing "Dsac","Dsah", and "Dsaw". Geological Survey mapping of the southern part of the pluton, in the Alberton Quadrangle, is currently in progress.

In general, the Russells Road Adamellite varies from a white-grey colour (eg, at grid ref. EQ595219, similar to the "white-grey" Mt. Pearson Adamellite), to a slightly darker light-grey (N7-8, as at the Memory Road quarry; see Plate 3.6). It is a medium- or coarse- to very coarse-grained, equi-granular to sparsely porphyritic biotite adamellite (McClenaghan *et al.* 1982, & McClenaghan, *in* Burrett & Martin 1989,p.257).

In some (patchily distributed) places, particularly in the northern part of the body adjacent to the Mt. Stronach Pluton, a subtle pink colour is present in the rock (*Ibid.* , & M.P. McClenaghan *pers. comm.* 1990). This colour variation probably represents patchy metasomatic alteration. The patches of pink colouration probably vary considerably in size, from diameters of hundreds of metres or more to small patches only ≈0.5m diameter (as observed in a fresh outcrop at Billycock Hill (site G/Ne/6/1, grid ref. EQ56493840)).

Foliated (planar) fabric is not evident in the Russells Road Adamellite, other than in a small adamellite on the eastern margin of the Tulendeena Granodiorite, which is separated from the main adamellite body (Brown *et al.* 1977, McClenaghan *et al.* 1982).

Xenoliths are very rare (possibly absent away from the batholith margins), although one xenolith was noted in adamellite at Billycock Hill (site G/Ne/6/1), immediately adjacent to the contact with the intruded Mathinna Group sedimentary rocks.

A moderate amount of good natural outcrop occurs in the Russells Road Adamellite, and very wide joint spacings (3.0 - 8.0m+) were noted in places. Micro-cracking varies from very minor (as at Memory Road and Diddleum quarries) to quite prevalent (eg, at grid ref. EQ595219).

The Russells Road adamellite is considered to be highly prospective for uniformly textured granites of light grey colour (lighter than granodiorites such as the Diddleum Granodiorite), free of xenoliths and foliated fabrics. Varieties of a generally very subtle pink-grey colour are also available, probably mainly in the northern part of the pluton.

Two currently worked dimension stone quarries exist in the Russells Road Adamellite:

<u>Memory Road Granite Quarry (Trade name: "Martich")</u>
The Memory Road Quarry (site G/Ne/26/1, grid ref. EQ586146, see Fig. 6.3) has been worked by Dunn Monumental Masons Pty. Ltd. since 1985 under stone lease 69 M/85. The site consists of very large boulders and a bedrock quarry face ≈8 metres long and 3 metres high on the crest of a steep escarpment.

The adamellite is a massive, medium- to coarse-grained sparsely porphyritic stone with white

K-feldspar phenocrysts up to 30 x 15 mm in size (see Plate 3.6). The overall colour of the stone is light grey (N7), and no segregations, veins or dykes are apparent. Xenoliths are very rare. Micro-cracking is very minor. The stone polishes well, although a little pitting of biotites occurs. Joints are very widely spaced (typically 8 metres or more apart).

The stone is a high quality grey granite, probably suitable for external veneers, and large reserves are available in very large block sizes.

Diddleum Granite Quarry (Trade name: "Tequila")
The Diddleum Quarry (site G/Ne/26/2, grid ref. EQ471223, see Fig. 6.3) has been worked by Dunn Monumental Masons Pty. Ltd. since 1987 under stone lease 64 M/87. The site consists of large (5 metre+ diameter) boulders on a slope just below the crest of a ridge (see Plate 6.1).

The stone is rather unusual, being a part of the chilled margin of the Russells Road Adamellite where it intruded the older Porcupine Creek Granodiorite immediately to the west (see Fig. 6.3).

The stone is porphyritic, with abundant rounded feldspar and quartz phenocrysts averaging 10mm diameter set in a groundmass of fine to fine/medium grainsize. The phenocrysts are present throughout, but are more concentrated in clumpy patches 0.5 - 1.0 metres diameter. The stone colour is hard to define, having a grey (N7) to slightly "grey-brown" groundmass with slightly pinkish patches, and phenocrysts of white, pale pink, and very pale greenish colouration (see Plate 3.9).

Slightly undulose, sub-parallel bands 20 - 100mm thick are common, and are distinguished by a slightly finer average grainsize and slightly paler colour than the rest of the stone. No xenoliths appear to be present, but the stone contains a few aplite dykes which are planar, 10 - 20mm thick, fine-grained, and of grey to pinkish colour.

Micro-cracks are rare, only being notable within quartz phenocrysts. Joints are widely spaced, with none being apparent in boulders up to five metres in diameter.

This stone is likely to be of high technical quality, and has recently (early 1990) been used for external cladding of the ground floor of a new building at 116 Murray St., Hobart.

It is not clear whether any of the boulders exposed at the quarry site are actually bedrock; unless bedrock is located the available reserves will be relatively small. Since the stone is a chilled margin variety, the texture and character of the stone can be expected to change considerably over some tens of metres going eastwards away from the contact with the Porcupine Creek Granodiorite; on the other hand, the stone character may remain fairly constant going north or south, parallel to the contact. It is likely that stone of similar character could be found at other sites along the contact between the Russells Road Adamellite and the Porcupine Creek Granodiorite.

Upper Blessington Pluton

PROSPECTIVITY - ?

The Upper Blessington Pluton (see Fig. 6.3) is a biotite-hornblende granodiorite (Calver *et al.* 1988) situated at Upper Blessington, on predominantly freehold land. The pluton was not examined during this project, but is currently being mapped by the Geological Survey of

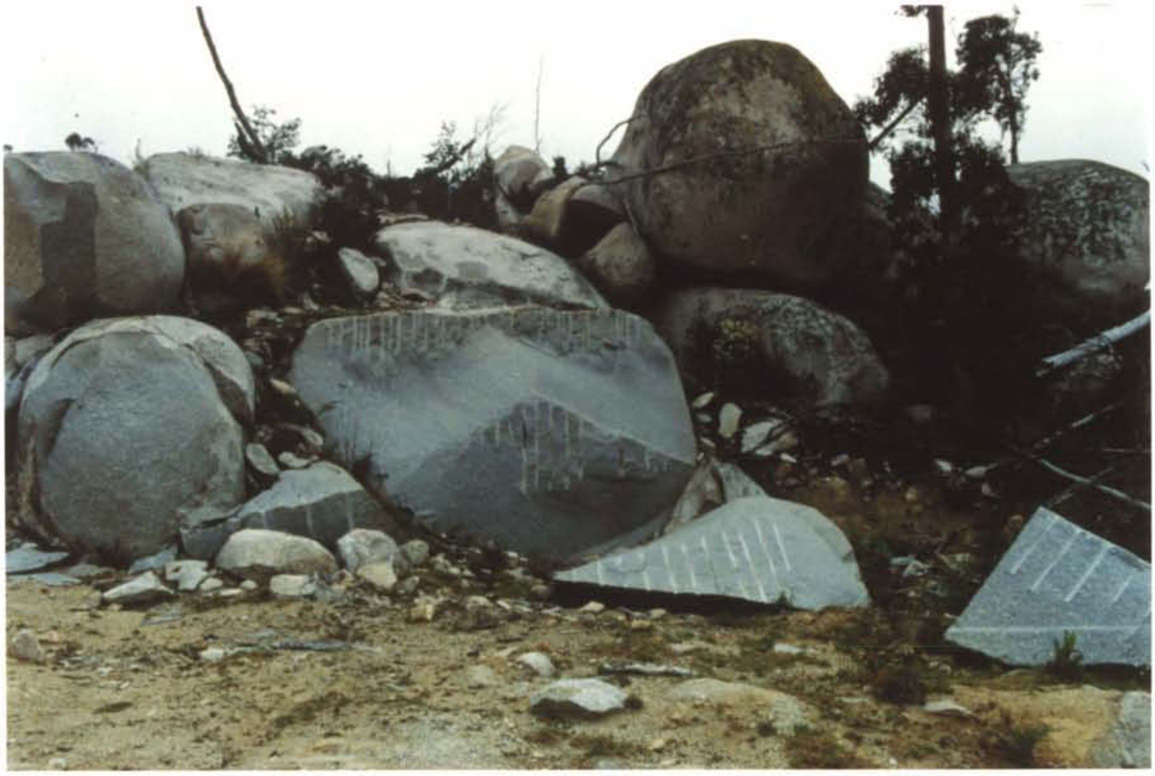


Plate 6.1 Russells Road Adamellite chilled margin: Diddleum Quarry ("Tequila"). This quarry illustrates low environmental impact quarrying of large boulders.

Plate 6.2 Tombstone Creek Pluton: Blessington Quarry ("Jaydon"). This quarry illustrates well-planned bedrock quarrying.

5 cm

Tasmania in the Alberton Quadrangle, within which most of the pluton is located.

The Upper Blessington Pluton is probably of similar character to the other granodiorites in the Scottsdale Batholith, but contains abundant patches of Mathinna Group sedimentary rocks (M.P. McClenaghan, *pers. comm.* 1990) which are either roof pendants or large rafts ("mega-xenoliths").

Mt Stronach Pluton

PROSPECTIVITY - Low?

The Mt. Stronach Pluton (see Fig. 6.3) outcrops in the Mt. Stronach to Kamona-Butlers Saddle region, east of Scottsdale. It was originally mapped as a pink biotite adamellite ("Dsam", Brown *et al.* 1977), but chemical analysis (McClenaghan *et al.* 1982) indicated a composition more typical of an alkali granite, and it is now regarded as an alkali-feldspar granite (McClenaghan, *in* Burrett & Martin 1989,p.259.

Moderately good outcrops occurs, but in many places is strongly weathered (possibly as a result of prevalent close jointing), and this has caused an intensification of the pink colour in some places (see below).

The Mt. Stonach Pluton alkali-feldspar granite is massive and of equi-granular and generally medium-grained texture, although varying to fine- or coarse-grained in a few places. Xenoliths, veins, dykes and other segregations are rare.

The Mt. Stronach Granite is a pink granite, but the colour varies considerably through the pluton. In a large road-cutting west on the Tasman Highway west of Kamona (site G/Ne/8/1, grid ref. EQ53554214) the granite has a uniform moderate pink (5 R 7/4) colour (possibly a weathering-enhanced colouration). However, fresh faces in the Mt. Stronach road metal quarry (site G/Ne/8/2, grid ref. EQ46803982) show a very light grey (N8) colour with a subtle scattering of pale pink feldspars, although a distinctly pink colour is developed within ≈100mm of joints, indicating the influence of weathering.

Grey colouration with only a trace of pink was noted in several outcrops north of Mt. Stronach (Jensens Road area), while a fairly distinct pink to red colour is developed in outcrops from the Tasman Highway south to Butlers Saddle.

The patchy pink colour is considered to result from metasomatism, and M.P. McClenaghan (*pers. comm.* 1990) suggests that the Mt. Stronach Pluton may simply be a strongly metasomatised portion of the predominantly grey Russells Road Adamellite to the south.

The Mt. Stronach Pluton is predominantly closely jointed, with joint spacings generally in the range of 0.1 - 1.0 metres (maximum 1.5m) apart at the sites mentioned above.

Although granites of a pleasing subtle-to-strong pink colour might be obtained from the Mt. Stronach Pluton, and some large blocks may be obtainable in places, the prevalence of close jointing would mean excessive wastage, and an apparent tendancy towards excessive weathering also indicates low potential for this pluton as a dimension stone source.

Tombstone Creek Pluton

PROSPECTIVITY - High

As it is currently known, the Tombstone Creek Pluton (see Fig. 6.3) consists of two sheets within the Russells Road Adamellite, in the Alberton Quadrangle near Ben Nevis (northeast of Upper Blessington). The full extent of the sheets is not yet known, but Geological Survey mapping currently in progress should eventually define their extent. The western and eastern sheets dip west and east respectively, and prior to erosion may have been joined as a domal or antiformal structure (M.P. McClenaghan *pers. comm.* 1990). Most of the pluton outcrops poorly, although some moderately good outcrops exist.

The Tombstone Creek Pluton is an alkali-feldspar granite (McClenaghan, *in* Burrett & Martin 1989,p.259). It is a massive, equi-granular, fine- to coarse-grained granite, typically of a light greyish-pink colour, with a slight greenish tinge in some of the feldspars (see Plate 3.8). The "pinkness" of the granite varies markedly from place to place, and the pluton has a more basic composition (suggesting darker colouration) towards the south. Joint spacings up to 4.0 metres apart are known, although a moderate amount of micro-cracking seems to be prevalent.

Pink granite is currently quarried at the Blessington Quarry (see below). This quarry is situated about two kilometres south of the current mapped extent of one of the Tombstone Creek Pluton sheets, but is on strike with the sheet and of a character considered typical of the pluton (M.P. McClenaghan *pers. comm.* 1990). It is therefore considered that the quarry falls within the Tombstone Creek Pluton. Although the pluton was only examined in detail at the quarry, the quality of the stone there implies a high potential for similar stone in areas.

Blessington Granite Quarry (Trade name: "Jaydon" or "Jaded Pink")
The Blessington Quarry east of Ben Nevis (site G/Ne/25/1, grid ref. EQ537146, see Fig. 6.3) has been operated by Dunn Monumental Masons Pty. Ltd. since 1987 under stone lease 63 M/87. The quarry site currently consists of a face about 3 metres high and 8 metres long, with a long gentle-to-flat slope running away behind and above the face (see Plate 6.2).

The granite is massive, coarse-grained and equi-granular, and has an attractive light greyish - pink (5 R 8/2) overall colour resulting from light pink and faintly green-tinged feldspars and dark grey quartz grains (see Plate 3.8). No veins, dykes or segregations are apparent, although very rare dark-grey, fine-grained xenoliths 20 - 50mm diameter are present.

Subvertical joints are generally spaced about 1.0 - 4.0 metres apart, although one zone of closely (0.1 - 0.5m) spaced jointing was noted in the quarry. A small amount of fine microcracking is evident on polished slabs.

An approximately one metre deep surface weathering zone is exposed at the top of the quarry face, in which closer fracturing is prevalent. An intensified pink colouration occurs within 0.2m of natural outcrop surfaces, as a result of weathering.

The granite is currently being used for interior features (prestige wash-basin surrounds, etc), and appears to be of high quality for such applications.

An outcrop of virtually identical granite occurs at grid ref. EQ542135, over a kilometre south of the quarry, suggesting that a large mass of closely similar stone exists in the region. This, together with the fact that the site topography will allow the current quarry face to be easily worked back for a considerable distance, means that very large reserves of "Jaydon" stone are obtainable at the Blessington Quarry.

Blue Tier Batholith
The Blue Tier Batholith is the largest outcropping granitoid mass in Tasmania, comprising a number of distinct plutons considered to be derived from different magmas (McClenaghan *in* Burrett & Martin 1989,p.267).

Granodiorite makes up less than one third of the Blue Tier Batholith, while adamellites are widespread (Poimena & Mt. Pearson Adamellites) and alkali-feldspar granites occur in the Lottah, Mt. Paris, Little Mt. Horror and Mt. Cameron bodies.

The individual plutons within the Blue Tier Batholith are described and evaluated below:

Scamander Tier Granodiorite

PROSPECTIVITY - Medium/High

The Scamander Tier Granodiorite is a grey, variably porphyritic, coarse to fine-grained biotite hornblende granodiorite (mapped as "Dbgp" - McClenaghan *et al.* 1987), which is considered to be an intrusive equivalent of the extrusive St. Mary's Porphyrite further to the south. Parts of the granodiorite are rich in xenoliths of the Mathinna Beds sedimentary rocks. Some parts of the granodiorite (eg, just north of St. Helens) are rich in large K-feldspar phenocrysts and lacking in hornblende (McClenaghan *Ibid.*).

The Scamander Tier Granodiorite has intruded the Mt. Pearson Adamellite in the form of a thin elongate dyke which trends north from Terryvale, then eastwards north of the George River, and finally extends south from St. Helens and along Scamander and Skyline Tiers to terminate near Scamander (see Fig. 6.3). The margins of the dyke are fine-grained.

The Scamander Tier Granodiorite has been examined at sites G/Ne/1/1 & 2, which are within the north-south trending part of the dyke between St. Helens and Scamander. A brief reconnaissance of the western part of the dyke, in the Terryvale - Goshen area (area G/Ne/19), found only very poor outcrop.

Site G/Ne/1/1 is located on the crest of Skyline Tier, just north of Scamander, and is typical of numerous good outcrops along Skyline and Scamander Tiers. There is a good likelyhood of locating adequate quarry sites along these tiers, which are accessible by forestry roads.

At site G/Ne/1/1, the granodiorite is of light grey colour overall (N 6.5), and is a massive porphyritic stone of medium to coarse groundmass grainsize with abundant (10 - 40 vol.% of stone) elongate white feldspar phenocrysts varying in size from 10 to 40mm diameter (see Plate 3.7). The phenocrysts may show a common orientation, and have an uneven, or "clumpy" distribution through the stone. Dark grey, fine-grained, rounded xenoliths 0.04 - 0.1m diameter occur through the stone.

Joint fractures are spaced two metres or more apart, although closer spacings may also occur. A few fine fractures are present in sample slabs polished for this project, but are likely to be blasting fractures produced during road-making at the outcrop site. Microcracking is minimal.

The porphyritic granodiorite at Site G/Ne/1/1 seems aesthetically attractive, and is the most strikingly porphyritic granite seen in Tasmania during this project. However, the uneven phenocryst distribution and a slightly "dirty" grey cast to the stone's colour could possibly be considered drawbacks. The stone appears technically adequate for dimension stone production. The site could possibly be quarried, but it is likely that further exploration in the region would locate superior sites.

Site G/Ne/1/2 is located on Binalong Bay Rd. just north of St. Helens, and is an example of a variety of porphyritic Scamander Tier Granodiorite lacking in hornblende and very rich in large K-feldspar phenocrysts. The granodiorite is a light grey colour (N7), and has a medium to coarse-grained groundmass. The phenocrysts are white elongate feldspar crystals up to 30mm long, having a crude common orientation and comprising 60-70 % of the stone by volume. Segregations are present in the form of thin bands and patches up to 0.4m diameter of dark-grey fine to medium-grained granodiorite. Jointing fractures are rather closely spaced (av. 0.3 to 1.0m spacing).

The granodiorite at site G/Ne/1/2 is attractive, but close jointing and an unsuitable location would rule out quarrying at this site.

In general, the Scamander Tier Granodiorite is an attractive grey porphyry which in some outcrops is of adequate technical quality for ornamental use. Good quarry sites are likely to exist on Skyline and Scamander Tiers, and possibly elsewhere.

Catos Creek Granodiorite

PROSPECTIVITY - ?

The Catos Creek Granodiorite is a porphyritic biotite-hornblende granodiorite chemically and petrographically similar to the Scamander Tier Granodiorite (McClenaghan *et al.* 1987), and like the latter is considered to be an intrusive equivalent of the St. Mary's Porphyrite.

The Catos Creek Granodiorite (see Fig. 6.3) outcrops as a N-S trending dyke ("Catos Creek Dyke" - Turner & Calver 1987,p.61) intruding Mathinna Bed sedimentary rocks south of the Avenue River and Catos Creek Rd., and is the southern part of a composite dyke whose northern part consists of adamellites belonging to the Mt. Pearson Adamellite. The Catos Creek Granodiorite is mapped as "Dbgp" on the St. Helens Geol. Atlas Sheet (McClenaghan *Idid.*), and as "Dapl" on the St. Mary's Sheet (Turner *et al.* 1984). The granodiorite porphyry groundmass is very finegrained along the eastern margin of the dyke (Turner *Ibid.*).

The Catos Creek Granodiorite outcrops in an area of State Forest which is currently difficult of (vehicular) access, and it has not been examined during this work. It's chemical and petrological similarity to the Scamander Tier Granodiorite means that it would probably be a similar ornamental stone to the latter.

Gardens Granodiorite

PROSPECTIVITY - Low/Medium

The Gardens Granodiorite (Fig. 6.3) is a large body extending from Great Musselroe River (east of Gladstone), south-eastwards to the coast at The Gardens (north of St. Helens).

The Gardens Granodiorite has been mapped in the Eddystone (Baillie 1984) and Blue Tier (McClenaghan & Williams 1983) quadrangles as equigranular, medium- to coarse-grained biotite-hornblende granodiorite ("Dbg"). It is similar in character to many other granodiorites in north-eastern Tasmania (McClenaghan, *in* Burrett & Martin 1989,p.257).

The northern half of the Gardens Granodiorite occupies low-lying country and outcrops very poorly. The southern half of the body is hillier, but even so very little outcrop was located along Ansons Bay, Tebrakunna and Peter's Roads.

The only reasonable outcrops located in the present work were coastal outcrops at The Gardens (Margery's Corner, Site G/Ne/12/1, grid ref. FQ064405). At this location the stone is a fairly typical massive, medium-grained, equi-granular granodiorite of relatively dark "medium light grey" (N6) colour (see Plate 3.6). No dykes were seen and dark grey fine-grained rounded dioritic xenoliths 20 - 30mm diameter occur sparsely. Jointing is comparitively intense, with spacings typically in the 1.0 - 2.0m range. A specimen (G/Ne/12/1/1) polished well with little pitting, and shows virtually no microcracking.

The Gardens Granodiorite has a similar aesthetic character to granodiorites in the Scottsdale Batholith, but is poorly outcropping and relatively distant from major centres. Comparitively close jointing is observed; if widespread such jointing would account for the relatively poor outcrop over the pluton as a whole. In view of the availability of similar stone in better locations with more outcrop, the Gardens Granodiorite is considered to have low prospectivity.

A number of bodies of varying granite type have been mapped within the Gardens Granodiorite, including a porphyritic coarse-grained biotite adamellite, dioritic and gabbroic varieties of the granodiorite, and varieties lacking in hornblende (Baillie 1984, McClenaghan & Williams 1983). These bodies are relatively restricted and were not examined.

George River Granodiorite

PROSPECTIVITY - Low

The George River Granodiorite occurs in the area around St. Helens (see Fig. 6.3), and is very poorly outcropping. No exposures even approaching dimension stone quality were seen during this work.

The George River Granodiorite was mapped by McClenaghan *et al.* (1987) as a sparsely porphyritic coarse-grained biotite-hornblende granodiorite ("Dbgsp"), varying in places to coarse-grained monzodiorites and monzonites. Very close jointing (<0.4 metre spacings) is observed in outcrops on Ansons Bay Road. If this close jointing is typical of the granodiorite, it would explain the poor outcrop throughout the pluton.

The lack of good outcrops, and possible close jointing throughout the George River Granodiorite, gives this body low potential as a dimension stone source.

Pyengana Granodiorite

PROSPECTIVITY - Low

The Pyengana Granodiorite comprises two bodies (northeast and southwest) separated by a portion of the Poimena Adamellite (see Fig. 6.3). Much of the granodiorite is in State Forest and has poor vehicular access. Small portions of the granodiorite have been mapped in the Ringarooma and St. Helens Quadrangles (Brown *et al.* 1977, & McClenaghan *et al.* 1987), but the bulk lies within the Alberton Quadrangle and has not yet been mapped in detail.

Good outcrop is rare throughout the Pyengana Granodiorite, and most exposures consist of deeply weathered "rotten" granodiorite with fresh corestones.

The northeastern portion of the Pyengana Granodiorite occurs in the North George River to Pyengana region (area G/Ne/17). A fresh corestone just north of the North George River Bridge on the Tasman Highway is a massive, equigranular, medium-grained granodiorite of light bluish-grey (5 B 7/1) colour, which contains abundant dark grey xenoliths 0.1 - 0.4m in diameter.

In the southeast corner of the northeastern portion of the Pyengana Granodiorite, McClenaghan *et al.* (1987) mapped a strongly foliated medium- to coarse-grained biotite granodiorite ("Dbgbf").

Close jointing (spacing <0.5m) was noted in most outcrops seen in the northeastern portion, although some joints spaced 1 - 3 metres apart were noted.

The southwestern portion of the Pyengana Granodiorite is located in the Weldborough to Mt.Young region (area G/Ne/18). The northern extremity of this portion (west of Weldborough) was mapped by Brown *et al.* (1977). These outcrops are described by McClenaghan *et al.* (1982) as a grey, medium-grained, equi-granular biotite-hornblende granodiorite ("Dbg") containing common dioritic xenoliths 20 - 500mm in diameter.

The best outcrops located in the SW portion occur at St. Columba Falls, where the stone is a massive, equi-granular, medium-grained , light grey (N8) granodiorite with black biotites, very similar in appearance to the granodiorite in the northeastern portion. Jointing is closely spaced (typically <0.5 m spacings).

The Pyengana Granodiorite is generally of a similar aesthetic character to many other granodiorites in northeastern Tasmania, particularly the Diddleum Granodiorite. However, access is poor in many parts, widespread deep weathering results in poor outcrop, and closely spaced jointing (which may account for the deep weathering characteristic of the granodiorite) is widespread. The Pyengana Granodiorite is considered to have low prospectivity as a dimension stone source.

Poimena Adamellite

PROSPECTIVITY - High

The Poimena Adamellite is a very large body which comprises the largest part of the Blue Tier Batholith (see Fig. 6.3), although it is probable that it is a composite body, and recent mapping suggests that the biotite adamellite southeast of Pyengana (separating the two portions of the Pyengana Granodiorite) is a separate pluton (McClenaghan, *in* Burrett & Martin 1989,p.257).

In general, the Poimena Adamellite is medium- to coarse-grained (av. grainsize 5mm; McClenaghan & Williams 1982) biotite adamellite with abundant K-feldspar megacrysts 2 - 5 cm long (McClenaghan, *Ibid.*). The Poimena Adamellite outcrops in the Boobyalla, Ringarooma, Blue Tier and St. Helens Quadrangles (Brown *et al.* 1977, Baillie *et al.* 1979, McClenaghan & Williams 1983, McClenaghan *et al.* 1987). Nearly all of the Adamellite is mapped as porphyritic coarse-grained biotite and biotite - minor muscovite adamellite ("Dbapc"), with minor variants (including fine- and medium-grained varieties) mapped in the Ringarooma and

Blue Tier Quadrangles.

McClenaghan *et al.* (1982) described the Poimena Adamellite as a pale grey coarse-grained porphyritic biotite adamellite showing considerable compositional and textural uniformity (see Plate 3.6). The phenocrysts consist of rectangular K-feldspars ranging from 30 - 75mm in length, and comprise from a few percent to ≈50% of the rock in various places. The groundmass of the adamellite may range from medium- to coarse-grained.

Sparsely distributed xenoliths up to 0.5 m diameter are present in most areas (including hornfelsed Mathinna Beds xenoliths near contacts). Compositional layering occurs in the Poimena Adamellite south of Pioneer, but is rare or absent in other areas. During the present work a distinct foliation was noted in some outcrops in the southern part of the Poimena Adamellite, but generally no distinct alignment of grains is seen.

Outcrop is poor over much of the region, but large bold outcrops occur in places. Joints are close (0.2 - 1.0 m spacings) in some outcrops, but numerous outcrops of widely jointed (2 - 5m+ spacing) adamellite were noted.

Two potentially viable quarry sites (below) were located during this work, and it is likely that numerous other viable sites could be found in this huge pluton.

In the northern part of the pluton, large outcrops and boulders beside Waterhouse Road (site G/Ne/13/1, grid ref. EQ68656875) have been exposed by fairly recent excavations and blasting. The adamellite is light grey (N7) with distinct black biotites, and is a fresh, massive, medium- to coarse-grained porphyritic stone with white feldspar phenocrysts up to 30mm long (see Plate 3.6). Minor dark grey fine- to medium-grained xenoliths 0.1 - 0.4m diameter are present, but no other dykes or segregations were noted. Joints are generally spaced 3 - 5 metres apart, and considerable quantities of large fresh boulders are lying around ready to remove from the site!

In the southern part of the pluton a similarly widely jointed adamellite of virtually identical description is exposed in boulders and large natural outcrops beside Tebrakunna Road at site G/Ne/4/2 (grid ref. EQ911502). This site is probably quarriable, and further promising outcrops occur nearby along Counsels and Tebrakunna Roads.

Samples from both sites (G/Ne/4/2 & G/Ne/13/1) polished well, and show only a moderate amount of randomly oriented intra-crystalline microcracking.

In summary, numerous quarriable outcrops of attractive light grey porphyritic adamellite of medium- to coarse-grainsize exist in the Poimena Adamellite, which is therefore considered to be prospective as a source of dimension stone granites of potentially high quality.

Mt Pearson Adamellite

PROSPECTIVITY - High

The Mt. Pearson Adamellite outcrops in the St. Helens region, and is divided into northern and southern parts by an east-west trending dyke of the Scamander Tier Granodiorite (see Fig. 6.3). Recent work (McClenaghan *in* Burrett & Martin 1989,p.259) has shown that this body is composite, with the southern part west of St. Helens having probably been intruded later than the northern mass centred on Mt. Pearson.

The Mt. Pearson Adamellite occurs in the Blue Tier and St. Helens Quadrangles (McClenaghan & Williams 1983, McClenaghan *et al.* 1987), where it is mapped as the unit "Dbasc", which is described as a porphyritic to seriate to equigranular coarse-grained biotite - minor muscovite adamellite. The porphyritic varieties have very abundant K-feldspar phenocrysts 2-6 cm long. Xenoliths are not reported, and were not observed in this project.

Southern part
In the southern part (areas G/Ne/2 &3) the adamellite has undergone considerable metasomatic alteration resulting in abundant patchy pink colouration, and the rock ranges in composition from adamellite to minor intrusions of pink alkali-feldspar granites and fine- to medium-grained biotite granites (McClenaghan *et al.* 1987).

Typical unaltered exposures observed in the southern part during this project consisted of massive coarse-grained equi-granular adamellite, of very light grey (N 7.5) colour with black biotites. Pink alteration is visible at many sites, varying from irregular patches only a few metres (or less) diameter in fresh grey stone, to strongly weathered outcrops having abundant pinkish colouration. The patchy pink colour is present in fresh stone, but is enhanced by weathering.

Although large bold outcrops exist, much of the altered adamellite in the southern part is deeply weathered, with fresh outcrops consisting of corestones or large outcrops surrounded by a deep "rotten" granite soil horizon. Jointing is relatively intense throughout the area, with major joints averaging 0.1 - 2.0 metres apart and often accompanied by pervasive sets of fine parallel fractures spaced about 10mm apart.

The characteristic deep weathering, and relatively intense jointing and fracturing, give the southern part of the Mt. Pearson Adamellite low potential as a dimension stone source.

Northern part
However, the northern part of the Mt. Pearson Adamellite (area G/Ne/20) shows much less pink metasomatic alteration (McClenaghan *et al.* 1987, M.P. McClenaghan *pers. comm.* 1990), and is predominantly a massive, coarse-grained porphyritic grey adamellite of attractive character, although some deeply weathered outcrops on the inland side of Sloop Lagoon were noted to have a strong pink colouration.

Fresh boulders of a very attractive grey-white adamellite have been used on the coast at Sloop Lagoon Bridge (site G/Ne/20/1, grid ref. FQ0737), and are thought to have been quarried from a nearby site within the northern part of the Mt. Pearson Adamellite (fresh bedrock outcrops on the Gardens Road south of Sloop Lagoon consist of stone identical to the Sloop Lagoon bridge boulders).

The adamellite in the boulders is massive, coarse-grained and porphyritic, with white feldspar phenocrysts up to 30mm long being so abundant that the stone is virtually an equigranular pegmatitic adamellite. The stone is light grey (N7) overall, with white phenocrysts dominating the grey quartz grains (see Plate 3.7). No segregations or xenoliths are present, and the boulders appear to be derived from a widely jointed source.

A sample (G/Ne/20/1/1) polished well although a moderate amount of randomly oriented microcracking is evident. The stone is of very similar appearance to the mainland "Riverina" granite (J.Dunn *pers. comm.* 1990), and a quarriable source would be very valuable.

Numerous good outcrops of similar appearance to the Sloop Lagoon bridge boulders occur within the northern part of the Mt. Pearson Adamellite, and in particular are accessible along the coast and inland along Ansons Bay Road. Inland outcrops would probably be more suitable for quarrying from an environmental point of view. Wide joint spacings (1 - 5 metres) were observed in outcrops in these two areas.

Summary

In summary, whilst the southern part of the Mt. Pearson Adamellite is considered unprospective, the northern part is highly prospective for unaltered, massive coarse-grained white-grey adamellites of attractive appearance and potentially of high technical quality.

Lottah Pluton

PROSPECTIVITY - ?

The Lottah Pluton is an alkali-feldspar granite situated near Lottah, in the central Blue Tier region (see Fig. 6.3). The Lottah Pluton has previously been considered to have a sheetlike form, but detailed mapping has shown that a steep-sided dome is more likely . The Lottah Pluton comprises equigranular and porphyritic varieties, and is described by McClenaghan & Williams (1982).

The equigranular alkali-feldspar granite is mapped as "Dbae" in the Ringarooma Quadrangle (Brown *et al.* 1977) and "Dbfe" in the Blue Tier Quadrangle (McClenaghan & Williams 1983). It is described by McClenaghan & Williams (1982) as a coarse- to medium-grained granite of pink to cream colour. The porphyritic alkali-feldspar granite is mapped as "Dbapq" in the Ringarooma Quadrangle, and is of fine- to medium-grainsize (Brown *et al.* 1977) with similar textural and mineralogical characteristics to the equigranular variety.

The Lottah Pluton was not examined during this project, and it's prospectivity as a dimension stone source cannot be assessed at this stage.

Mt. Paris Pluton

PROSPECTIVITY - Low/Medium

The Mt. Paris Pluton, situated in the Branxholm/Derby/Mt. Paris Dam region (Fig. 6.3), is an alkali-feldspar granite of similar form and lithology to the Lottah Pluton, to which it is probably connected at depth (McClenaghan, *in* Burrett & Martin 1989,p.260).

The Mt. Paris Pluton lies in the Ringarooma Quadrangle, and was mapped by Brown *et al.* (1977) as an equigranular fine- to coarse-grained biotite-muscovite granite ("Dbau", "Dbae"), varying in places to a porphyritic, fine- to medium-grained biotite-muscovite granite with phenocrysts of feldspar and rounded quartz ("Dbapq"). These granite types are further described by McClenaghan *et al.* (l982,p.48-51 & 53).

Both equigranular and porphyritic exposures were examined during this project. The granite is generally medium-grained, and xenoliths are rare or absent. The colour varies from greyish-yellow (5 Y 8/4) in equigranular granite near Mt. Paris Dam (site G/Ne/5/1, grid ref. EQ69503650), to light grey (N7.5 - 8) with a subtle tinge of yellow in fresh exposures of equigranular and porphyritic varieties in road cuttings along the Tasman Highway. It is possible that the yellower varieties are more weathered.

The granite is commonly of a uniformly massive structure, but a large fresh roadcutting just west of Derby (site G/Ne/5/3, grid ref. EQ65274455) exposes a grey to grey-yellow, medium - to coarse-grained equigranular variety which has minor horizontal to inclined layers and patches 0.1 - 1.0 metre thick of fine dark grey aplite with coarse phenocrysts.

Outcrop is relatively abundant through the pluton, but many exposures show signs of weathering alteration. Porphyritic granite at site G/Ne/5/2 (grid ref. EQ64104349) has feldspar phenocrysts altering to clay in otherwise fresh-seeming granite.

Jointing is relatively closely spaced in many exposures (0.2 - 0.5m spacings are typical, with some joints spaced up to 2.0m apart), although weathered outcrops near Derby appear to have major joints spaced over 5.0 metres apart. At site G/Ne/5/3 the granite tends to break parallel to visible joints, indicating the presence of pervasive fine parallel fractures.

A yellow granite prospect near Derby, investigated several years ago by Northern Tasmania Quarries Pty Ltd , was found to be unusable due to a similar pervasive fine parallel fracture system.

The granites of the Mt. Paris Pluton are generally of unspectacular aesthetic appearance, and the pluton appears to be subject to relatively intense jointing and fine fracturing. Probably as a result of the latter, exposures of the granite show a tendancy to be somewhat weathered.

The Mt. Paris Pluton is therefore likely to have low potential as a dimension stone source.

Little Mt. Horror Granite

PROSPECTIVITY - Low

The Little Mt. Horror Granite (Fig. 6.3) is an alkali-feldspar granite of possible sheet-like form in the northern part of the Blue Tier Batholith around the Little Mt. Horror area. It has been mapped in the Ringarooma and Boobyalla Quadrangles (Brown *et al.* 1977, & Baillie *et al.* 1979) as dominantly fine- to medium-grained granite ("Dbau").

According to McClenaghan *et al.* (1982,p.53) the Little Mt. Horror Granite Pluton includes a complex distribution of aplite, biotite-muscovite granite, and biotite-muscovite adamellite of fine- to medium-grainsize and varying from equigranular to porphyritic. Groves *et a*ι (1977) described the granites of the Little Mt. Horror area as being equigranular pink granites.

The region of the Little Mt. Horror Granite has generally poor access except along Banca Road. The area along Banca Road was examined during this work, and was found to be a low relief area with generally poor outcrop. Weathered outcrops examined varied from pale-grey to very pale pinkish- brown in colour, and were closely jointed (av. 0.2 metre spacings) in the area immediately SW of Little Mt. Horror itself.

The poor access and poor outcrop in the Little Mt. Horror Granite make it a low priority for dimension stone exploration. Strong weathering of outcrops appears to be widespread, and may result from close jointing through the area.

Mt. Cameron Granite

PROSPECTIVITY - ?

The Mt. Cameron Granite is another alkali-feldspar granite body (McClenaghan, *in* Burrett & Martin 1989,p.260) which outcrops at Mt. Cameron, west of Gladstone (Fig. 6.3).

The Mt. Cameron Granite outcrops in the Boobyalla, Ringarooma and Eddystone Quadrangles (Brown *et al.* !977, Baillie *et al.* 1979, Baillie 1984), and is described in McClenaghan *et al.* (1982) and Baillie (1986). Mapped rock units belonging to the Mt. Cameron Granite include "Dbge" (described by Baillie (1986) as a pink equigranular medium-grained biotite-muscovite granite), "Dbapq", "Dbapq'", Dbapf", Dbapsf'" (dominantly fine- to medium-grained porphyritic biotite-muscovite granite) and "Dbae" (fine- to coarse-grained equigranular biotite-muscovite granite).

The Mt. Cameron Granite was not examined in this project, and it's prospectivity cannot be assessed at this stage.

Sheoak Hill Pluton

PROSPECTIVITY - Low

The Sheoak Hill Pluton outcrops at Sheoak Hill, in the northern part of the Blue Tier Batholith (Fig. 6.3). It is mapped by Baiilie *et al.* (1979, Boobyalla Quadrangle) as "Dbaem" (equigranular, dominantly medium-grained, biotite muscovite granite/adamellite).

Most of the pluton has low topography with poor exposures except along the coastline and in roac cuttings along Waterhouse Road. An exposure examined on Waterhouse Road (area G/Ne/15) consists of massive, fine- to medium-grained equigranular granite of very light grey (N8) colour. No segregations or xenoliths were observed, and McClenaghan *et al.* (1982,p.48) notes that xenoliths are rare in the pluton.

On Waterhouse Road, jointing in the granite is closely spaced (20-300mm spacings), although spacings become wider towards the eastern side of the pluton. McClenaghan (*Ibid.*) notes that contacts between the pluton and adjacent rocks are either shear zones or poorly exposed, suggesting that close jointing is likely to be prevalent through this small pluton.

The poor exposure, likely predominance of close jointing, and relatively uninteresting aesthetic quality of the Sheoak Hill Pluton, render it a low-potential dimension stone prospect.

Eddystone Batholith
The Eddystone Batholith consists of adamellite bodies (Ansons Bay, Musselroe and Boobyalla Adamellites), together with the Mt. William alkali-feldspar granite. The adamellites of the Eddystone Batholith are texturally and mineralogically similar to the Mt. Pearson Adamellite, but are characterised by the presence of garnet and commonly cordierite (McClenaghan, *in* Burrett & Martin 1989,p.260).

Musselroe Adamellite

PROSPECTIVITY - Low

The Musselroe Adamellite is a biotite-garnet-cordierite adamellite (McClenaghan, *in* Burrett & Martin 1989,p.260) which outcrops in the far northeast of Tasmania at Great Musselroe Bay (Fig. 6.3). It occurs in the Eddystone Quadrangle (Baillie 1984) and is described by Baillie (1986).

The dominant rock type is a variably porphyritic biotite-garnet adamellite ("Depc"). The adamellite is coarse- to very coarse-grained, light grey in colour, and contains K-feldspar (and some cordierite) phenocrysts. Xenoliths of various types are common, and compositional layering is well developed at the northern end of Great Musselroe Bay. Other minor granitoid types occur within the pluton (Baillie 1986).

Except along the coastline, the topography of the area is very flat and outcrop is consequently rather poor. The Musselroe Adamellite was not examined during this work. Although the area is accessible, it's relative remoteness from major centres and poor outcrop suggest a low priority for dimension stone exploration. The best exposures would be on the coast, but these would probably be unsuitable for quarrying due to environmental considerations.

Ansons Bay Adamellite

PROSPECTIVITY - Medium

The Ansons Bay Adamellite is a large body extending from the Mt. William region south to Ansons Bay (Fig. 6.3). It is texturally and mineralogically similar to the Mt. Pearson Adamellite, with the addition of garnet and cordierite. Minor textural, and also chemical and isotopic, differences between the north and south parts of this body suggest that it is composite, and it is sub-divided into the Ansons Bay North and South Adamellites (McClenaghan, *in* Burrett & Martin 1989).

The Ansons Bay Adamellite outcrops in the Eddystone and Blue Tier Quadrangles (McClenaghan & Williams 1983, Baillie 1984), where it is mapped as "Depc" and "Dag". In general, the adamellite is described as a variably porphyritic, coarse- to very coarse-grained biotite-garnet-minor muscovite adamellite. According to Baillie (1986), the adamellite is light grey in colour, contains 20 - 70% K-feldspar phenocrysts set in a 5 - 15mm grainsize groundmass, and commonly contains xenoliths of various sorts.

Nearly all the Ansons Bay Adamellite falls within the Mt. William National Park, and moreover is generally rather poorly outcropping due to the low topographic relief in the area. However, the southernmost part of the adamellite, near Ansons Bay, falls outside of the National Park and contains outcrops of a very attractive grey-white granite:

Small blasted outcrops occur on the Eddystone Road near Ansons Bay, at site G/Ne/11/1 (grid ref. FQ08655928). The adamellite is a massive, coarse-grained porphyritic stone of very light grey-white colour (N8), with black biotites and white feldspar phenocrysts averaging 30mm long (see Plate 3.7). No segregations, dykes or xenoliths were seen. Although outcrop is restricted, it is evident that joints are spaced in excess of 1.5 metres apart.

While outcrop is locally poor, if a quarriable site containing similar stone could be located in the region, the stone would be a very attractive near-"white" granite with black biotite "speckling". Although the stone is porphyritic, the dominant white colouration disguises this fact and gives a uniform overall appearance. The Ansons Bay South Adamellite is therefore considered to have medium prospectivity as a dimension stone source.

A minor variant of the Ansons Bay Adamellite outcrops at Eddystone Point, and has been used in the construction of the Eddystone Lighthouse (Baillie 1986). This is an equigranular coarse-grained biotite adamellite of grey colouration.

Boobyalla Adamellite

PROSPECTIVITY - Low

The Boobyalla Adamellite outcrops south of Ringarooma Bay (Fig. 6.3), and is mineralogically and texturally similar to the Ansons Bay Adamellite but does not contain cordierite (McClenaghan *in* Burrett & Martin 1989,p.260). It is mapped in the Boobyalla Quadrangle as "Dbag", which is described as porphyritic, fine- to coarse-grained garnet-bearing biotite-muscovite adamellite (Baillie *et al.* 1979).

The marginal parts of the pluton are of fine- to medium-grainsize, while at a distance of over half a kilometre from contacts it dominantly coarse-grained (McClenaghan *et al.* 1982,p.47).

The Boobyalla Adamellite was examined along Waterhouse Road (area G/Ne/16), where it is of a medium grey colour, porphyritic and of fine- to coarse-grainsize. The area has low relief and outcrop is very poor. Closely spaced jointing (0.1 - 0.4m) was noted in road cuttings.

The Boobyalla Adamellite is considered to have low prospectivity as a source of dimension stone.

Mt. William Granite

PROSPECTIVITY - Low

The Mt. William Granite outcrops in the Mt. William area (Fig. 6.3), and is an alkali-feldspar granite. It is an equigranular, medium grained biotite-muscovite granite of pink to brownish colour (McClenaghan *in* Burrett & Martin 1989,p.260, Baillie 1986). The Mt. William Granite is mapped by Baillie (1984) as "Deem" (Eddystone Quadrangle).

The Mt. William Granite lies almost entirely within the Mt. William National Park, and is poorly outcropping due to the predominantly low-relief topography. Outcrops at Gumhill Creek (site G/Ne/9/1, grid ref. FQ01457530) are weathered, and show a dull grey-white colouration with pink patches. Jointing is closely spaced (0.1 - 1.0m). According to Baillie (1986), the granite is invariably altered.

The poor outcrop, National Park land tenure, and unpromising nature of observed outcrops give the Mt. William Granite low prospectivity as a source of dimension stone.

Other Granitoids - Eastern Tasmania

Picaninny Creek Adamellite

PROSPECTIVITY - Low

The Picaninny Creek Adamellite outcrops in the Mt. Elephant - Chain of Lagoons area east of St. Mary's (Fig. 6.3), and has been mapped as "Daec" (biotite-hornblende - trace pyroxene adamellite) by Turner *et al.* (1984) in the St. Mary's Quadrangle.

The Picaninny Creek Adamellite is equigranular to sparsely porphyritic and generally coarse-grained. Only a few xenoliths are present, but thin fine- to medium-grained dykes of aplite are particularly abundant in the southern part of the body (Turner & Calver 1987).

Road cuttings along the Tasman highway (area G/Ne/22) show the adamellite to be grey in colour, and intensely jointed (0.1 - 0.3m spacings).

On currently available information, the Picaninny Creek Adamellite appears to have low prospectivity for dimension stone.

Picaninny & Long Point Granodiorite

PROSPECTIVITY - Low

A granodiorite ("Dg" of Turner *et al.* 1984 & Turner & Calver 1987) outcrops at Picaninny and Long Points, south of the Picaninny Creek Adamellite (Fig. 6.1).

The granodiorite ranges from coarse and equigranular to medium-grained and slightly porphyritic (Turner & Calver 1987). Xenoliths and aplite dykes are common, and compositional banding and foliation are present.

The only outcrops of this granodiorite occur in the coastal exposures mentioned above. Since these sites would be environmentally unsuitable for quarrying, the granodiorite is considered to have low prospectivity.

St. Mary's Porphyrite

PROSPECTIVITY - Low/Medium

The St. Mary's Porphyrite is a relatively dark-coloured body outcropping east of St. Mary's, and is considered to be the extrusive equivalent of the Scamander Tier and Catos Creek Granodiorites (McClenaghan *et al.* 1987).

Due to it's darker colouration, the St. Mary's Porphyrite is discussed in the "Black Granite" chapter of this report.

Ben Lomond Granite

PROSPECTIVITY - Low/Medium

The Ben Lomond Granite (area G/Ne/24) occurs south of Ben Lomond in the Storeys Creek - Avoca area (Fig.s 6.1, 6.3). It is an alkali-feldspar granite, and has been mapped in the Ben Lomond Quadrangle by Calver *et al.* (1988).

The topography of the area is hilly, and there is abundant outcrop, both in road cuttings and bold natural outcrops. The predominant granite type is an equi-granular to porphyritic, fine- to coarse-grained granite with variable amounts of K-feldspar phenocrysts ("Dla", "Dlaf" & "Dlac" of Calver *et al.* 1988).

This type is regarded as a pink granite (McClenaghan, *in* Burrett & Martin 1989,p.259), although observations by the writer near Rajah Rock and in road cuttings on the Storey's Creek Road in the Castle Carey Rivulet valley indicate that fresh granite is of a grey to grey/very pale pink colour, but may weather superficially to a quite dark pink colour. The depth of superficial pink colouration may vary from centimetres to metres, and patches of remanent grey colour surrounded by pink colouration can be observed in cuttings on Storey's Creek Road. The granite has probably developed an early very pale pink colour in some areas due to metasomatism, which is later intensified by weathering (as is also noted in other "pink granites" such as the Mt. Stronach Pluton).

Abundant quartz veins occur in the granite along Storey's Creek Road, but xenoliths and other segregations were not observed during this work.

This predominant granite type is intruded by irregular dykes of pale grey "micro-granite" (McClenaghan *in* Burrett & Martin 1989,p.259). This type is mapped as "Dlg" by Calver *et al.* (1988), and is described as a porphyritic, fine- to medium-grained alkali-feldspar granite.

Jointing in the Ben Lomond Granite is variable. The western half of the granite body has a number of large faults related to the Castle Carey Structure, and outcrops in this area commonly have close jointing (0.5 - 1.0 metre spacings), although joint spacings up to 3.0 metres wide are noted. The western half of the pluton has less faulting, and joints are spaced five metres or more apart at places such as Rajah Rock.

Outcrops of fresh grey granite observed during this work were of a fairly dull aesthetic character. Alteration due to weathering is widespread, and would result in unpredictable variations in both stone colour and technical quality.

Despite the designation of the Ben Lomond Granite as a "pink" granite, it appears that it would be difficult to locate outcrops in which a uniform pink colour was available in relatively fresh stone. The Ben Lomond Granite is considered to be essentially of low prospectivity for dimension stone, although it could be considered to have medium prospectivity for fairly ordinary grey granites.

Royal George Granite

PROSPECTIVITY - Low/Medium

The Royal George Granite (Fig. 6.1, area G/Ne/23) is an alkali-feldspar granite which outcrops at Royal George, south of the Ben Lomond Granite. The Royal George Granite is similar to the Ben

Lomond Granite, and consists of a generally equigranular, coarse-grained granite with minor bodies of microgranite and granite porphyry (McClenaghan *in* Burrett & Martin 1989,p.260).

The Royal George Granite occurs in the Snow Hill Quadrangle, which has recently been mapped by the Geological Survey of Tasmania (map sheet *in publication*). The main area of coarse-grained granite occurs to the northeast of Royal George township (J.L. Everard, *pers. comm.* 1990), and is a light grey granite of porphyritic to equigranular texture. This area is predominantly widely jointed (five metre spacings typical). Brief observations during the present project indicated that the granite is massive, and no xenoliths or other segregations were noted. Outcrop is reasonably good, although deep weathering was commonly observed.

To the south and west of Royal George township, the granite is generally a fine-grained microgranite with poor outcrop and intense jointing (J.L. Everard, *pers. comm.* 1990).

Although the area has not been assessed in detail, it is possible that coarse-grained grey granite of reasonable technical quality could be obtained in the area northeast of Royal George township. However, widespread weathering is likely to be a problem, and the grey granite has a fairly ordinary aesthetic character, so that it is probably of low priority as a dimension stone exploration prospect.

Bicheno Adamellite

PROSPECTIVITY - ?

The Bicheno Adamellite occurs in the Bicheno region (Fig. 6.1). It is a dominantly coarse-grained biotite adamellite with minor cordierite and garnet (McClenaghan *in* Burrett & Martin 1989,p.260), and is very widely jointed in many places.

The Bicheno Adamellite has not been mapped in detail, and was not examined during this work. Therefore, no assessment of it's prospectivity for dimension stone quarrying is offered here. It is situated on freehold and vacant crown land, parts of which would be suitable for quarrying.

Coles Bay Adamellite

PROSPECTIVITY - High

The bulk of the Coles Bay - Freycinet Peninsula area is composed of an adamellite (McClenaghan *in* Burrett & Martin 1989,p.259) known as the Coles Bay Adamellite (Fig. 6.1).

Both red (eg, the Hazards) and grey (eg, north of Coles Bay) varieties are present. However, the adamellites have not been mapped in detail, and the extent of each type is not known.

The oldest and best known granite dimension stone quarry in Tasmania, the Coles Bay Granite Quarry, is situated in the red Coles Bay Adamellite, in a small enclave excised from Freycinet National Park. Several sites have been quarried in the past, but the quarry described below is the only currently working site. The Coles Bay red adamellite has the brightest red colour of any known Tasmanian granite, and has been in demand for polished veneers and other uses in Tasmania and on the mainland since the 1930's.

Since the bulk of the Coles Bay Adamellite occurs within the Freycinet National Park, it would be a valuable exercise to properly map the extent of the red adamellite in order to determine whether any new red granite quarries could be established outside the National Park boundaries.

Much of the Coles Bay Adamellite outcrops boldly, and wide joint spacings are evident throughout "The Hazards" area. However, the current quarry site is the only outcrop examined in this project, and little published information is available on the granite in other areas.

Coles Bay Granite Quarry (Trade names: "Nelson Red", "Coles Bay Red", "Hobart Red" "Tasmanian Red")

The only currently operating quarry in the Coles Bay Red Adamellite is located on the eastern shoreline of Freycinet Peninsula, south of Coles Bay, in a small area excised from the surrounding National Park (site G/Tn/1/1, grid. ref. FP053329). The quarry is operated by Northern Tasmania Quarries Pty. Ltd. under stone lease 11363/M (4 Ha, pegged 8/10/1934). Although stone has been transported from the quarry by water in the past, current access is by road.

Northern Tasmania Quarries P/L also hold two other stone leases nearby, 8W/72 and 89 M/72, but these are not currently operating.

The current quarry has been examined and samples tested by AMDEL (West & Spry 1985, Spry & West 1988). The quarry was also examined during the present work.

The quarry is situated just above the shoreline, and consists of a very high main face about 60m long and 20m high, with smaller subsiduary benches adjacent. An Italian Consortium operated it in 1968-1979 and left it in a condition difficult to develop. Considerable work is now necessary to establish a series of benches which can be worked efficiently.

The stone dominantly consists of 35% red K-feldspar, 30% grey quartz, 25% yellowish plagioclase feldspar and 5% black biotite (West & Spry 1985). It is massive, equigranular, and of medium- to coarse-grainsize (5 - 20mm dia. grains). Micro-cracking is very minor, the stone is un-foliated, free of veins or aplite dykes, and only one small xenolith was observed in the entire quarry face.

The granite is considered to occur in two main varieties: The dominant variety (see Plate 3.9)is of red colour (5 R 6/6), and there is a sub-ordinate variety of yellow (5 Y 8/4) colour. The yellow variety occurs in patches up to 8 metres diameter, mainly close to the original surface or adjacent to major joints; it is considered to be a variety which has been somewhat altered by weathering, although it is still technically adequate for many applications. Other minor variants in the quarry are a pink variety and a darker red variety.

The most troublesome defect of the stone is the presence of scattered plagioclase feldspar grains which have altered to yellow-green clay, and which cause polishing defects and may weather out in service to leave pits. In some blocks up to 20-30 of these were noted per square metre of block surfaces. The alteration of the feldspars is considered to be an effect of magmatic hydrothermal activity (Spry & West 1988) rather than of weathering, and would therefore occur at depth and have an unpredictable distribution within the deposit.

The K-feldspars tend to be relatively unaltered, but some of the biotite is partially altered to chlorite, which also may result in minor pitting in service (West & Spry 1985).

Three major vertical or subvertical jointing directions are present in the quarry, striking 225° T, 165°T and 95° T, with joints in various of these sets spaced from 0.5 to 20.0 metres apart (average about 1.0 - 6.0m spacings). A few sub-horizontal joints of probable unloading origin are also present. Very large unflawed blocks can be obtained, with some wastage in places due to closely-jointed zones. Future quarry development should be designed around optimum utilisation of the dominant jointing directions.

A range of laboratory tests carried out on the red stone are detailed by West & Spry (1985), and amongst other tests, indicate marginally acceptable water absorption, slightly low bulk density, satisfactory compressive strength, ultrasonic pulse velocity and modulus of elasticity, and marginal modulus of rupture. The values obtained by West and Spry (1985) are given below:

Property		Value
Water Absorption (% by weight)		0.36
Bulk Density		2.60
Compressive Strength (MPa)	Dry	129
	Soaked	106
	Ratio soaked/dry	0.82
Young's Modulus of Elasticity (x 10^3 MPa)	Dry	43.2
	Soaked	40.2
Modulus of Rupture (MPa)	Dry	8.9
	Soaked	9.7
Ultrasonic Pulse Velocity (m/sec)		4590

Table 6.1 Laboratory test values for Coles Bay Red Adamellite (*from* West & Spry 1985)

The Coles Bay red granite has been widely used for polished veneers (internal and external), paving, granite "terrazzo", and other purposes. A small amount of pitting (as described above) has been noted on polished slabs used externally, although many examples of such external use have retained a good appearance over many years. Its bright red colour is in demand, and it will probably continue to find a niche in the Australian market.

Spry & West (1988) recommend that the stone is not suitable as a first class external veneer or paving stone, but that it is acceptable for tiles and monumental work. Due to the presence of altered minerals, it is probably not competitive for overseas export.

Granodiorites - Bluestone Bay/Wineglass Bay

PROSPECTIVITY - ?

A small body of granodiorite is present on the eastern side of Freycinet Peninsula, in the Bluestone Bay - Wineglass Bay area, and is believed to be older than the adjacent red Coles Bay Adamellite (McClenaghan *in* Burrett & Martin 1989,p.257 - 259).

The granodiorite occurs partly in the Freycinet National Park and partly in vacant crown land. It has not been mapped or described in detail, and was not visited during this project. However, it is likely to be similar to other granodiorites in northeast Tasmania. No assessment of its prospectivity can be given at this stage.

Maria Island Granite

PROSPECTIVITY - Low

Two main granite types occur on Maria Island (Fig. 6.1): a coarse-grained grey porphyritic granite with K-feldspar phenocrysts, and a pink fine- to medium-grained variably porphyritic granite with K-feldspar and quartz phenocrysts (Clarke & Baillie 1984).

Maria Island is a National Park, and consequently these granites are not available for dimension stone quarrying. In any case access to the granites is difficult, and they were not examined during this project.

Deep Glen Bay Adamellite

PROSPECTIVITY - Low

The Deep Glen Bay Adamellite (Fig. 6.1) outcrops on the southeastern coastline of Forestier Peninsula (Gulline 1982). It is a fine- to medium-grained porphyritic biotite adamellite/granite with K-feldspar and quartz phenocrysts (McClenaghan *in* Burrett & Martin 1989,p.259).

The Deep Glen Bay Adamellite outcrops exclusively in coastal exposures, which are commonly cliffs. It is difficult of access, and the topography of the outcrops is likely to be quite unsuitable for quarrying operations.

CHAPTER SEVEN

BLACK GRANITE

7.1 Definition and description

The term "black granite" is a stone industry term encompassing all hard igneous rocks having a predominantly black, greenish-black, blue-black or dark greyish-black colour and capable of taking a polish. (Note that "true" granites in the geological sense (see Chapter Six) rarely have such dark colours.) Black granites are highly prized ornamental stones.

For the purposes of this report the term "black granite" is used in the broad stone industry sense. For convenience, igneous varieties of "bluestone" are included amongst the black granites. "Bluestone" is a stone industry term referring to a dark stone such as basalt or dolerite, generally used in unpolished form as paving slabs or dimension stone blocks (certain dark non-igneous rocks such as argillite are also termed "bluestone", but are not considered in this chapter).

Black granites derive their dark colour from a preponderance of dark minerals including pyroxenes, amphiboles, olivines, and sometimes grey feldspars.

Black granites may be either volcanic (fine-grained, formed by solidification of magmas and lavas at or near the Earth's surface), or plutonic (medium to coarse grained, formed by solidification of magmas at depth below the Earth's surface). Grainsize categories for black granites, and igneous rocks in general, are as follows (Berkman & Ryall 1976):

	Mean grain diameter (mm)
Pegmatitic	>30.0
Coarse	5.0 - 30.0
Medium	1.0 - 5.0
Fine	<1.0

Most black granites belong to one of the following geological categories:

Ultramafic (ultrabasic) rocks
Contain less than 45% silica (Carmichael *et al.* 1974, p.29). Free quartz and feldspars

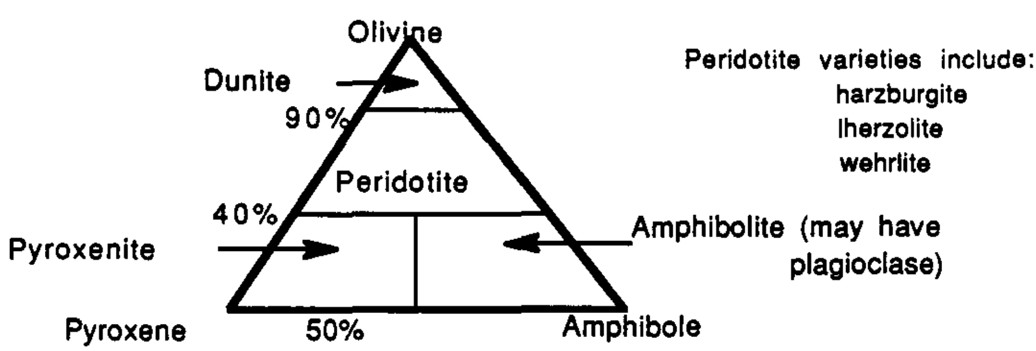


Figure 7.1 : Geological classification of ultramafic rocks.

generally absent. Composed essentially of dark ferro-magnesian silicates (pyroxene, amphibole, olivine, spinel), with minor primary metallic oxides and sulphides, and native metals (Am.Geol.Inst. 1962). Ultramafic rocks are sub-divided according to the proportion of various ferro-magnesian silicates present (Berkman & Ryall 1976, Am.Geol.Inst. 1962).

Many amphibolites are actually metamorphic rocks produced by regional metamorphism of basic or ultrabasic igneous rocks. For convenience, amphibolites are here grouped together with the purely igneous "black granites".

Basic Rocks
Contain 45 to 52% silica, free or combined (Carmichael *et al.* 1974, p.29). Composed of plagioclase feldspar, pyroxene (commonly augite), and usually olivine. Minor amphibole (hornblende) and free quartz occur in some varieties, together with minor accessory minerals.

Basic rocks include the following varieties (See Carmichael *et al.* 1974):

Gabbro - dolerite - basalt — Mineralogically, these rocks are similar, but they vary in grainsize:

Gabbro (incl. Norite)	Plutonic, coarse grained
Dolerite (diabase)	Plutonic, medium grained
Basalt (incl. spilite)	Volcanic, fine grained

These types compose the major group of basic igneous rocks. Essentially composed of plagioclase, augite (pyroxene), and commonly olivine. Minor primary minerals which may be present include quartz, hornblende (amphibole), other pyroxenes, biotite, ilmenite, magnetite and feldspathoids.

Granophyre — Considered by Carmichael *et al.* (1974,p.39) as an acid granitic rock, but included here since Tasmanian granophyres occur as a differentiate of dolerite intrusions. Granophyres consist of a characteristic intergrowth of anorthoclase or sanidine feldspars and quartz, together with minor pyroxene, iron-rich olivine, or biotite (*Ibid.*).

Norite — A variety of gabbro having dominant hypersthene pyroxene (augite pyroxene subordinate or absent). Pegmatitic gabbros or norites may have a sufficiently light overall colour to not be "black granites", in which case they are treated under "Other Granites" for the purposes of this report.

Troctolite — Composed of calcic plagioclase and olivine. Black with white spots.

Intermediate Rocks
Igneous rocks containing 52 to 66% silica, free or combined (Carmichael *et al.* 1974, p.29). Generally of lighter colour than basic or ultramafic rocks, but some intermediate varieties have been used as black granites (eg, diorites):

Diorite - Andesite — Diorite is a plutonic rock (volcanic equivalent: andesite) consisting essentially of andesine (plagioclase), hornblende (amphibole), and/or pyroxene. Some diorites may have olivine and are transitional to gabbros. Quartz diorite (tonalite) has quartz, biotite, hornblende, and andesine (volcanic equivalent: dacite). Quartz diorite is transitional to granodiorite (Carmichael *et al.* 1974, p.38).

Acid Rocks
Plutonic acid rocks are "true" granites (generally light grey or pink/red/yellow/brown in colour; see Ch. Six). The granodiorite variety can sometimes be sufficiently dark in colour to be classed as "black granite" (Ray 1988, p.56), although none so dark were identified during this project.

Secondary mineral veins or inclusions may form in black granites through alteration processes subsequent to their original formation. These can include minerals (eg, zeolites, clays including swelling clays) which may be detrimental to stone durability or ability to take a polish.

Common black granite textures are:

Equi-granular (Uniform): All grains of similar size

Porphyritic: Large crystals (phenocrysts) set in a finer groundmass. Not to be confused with amygdaloidal, brecciated, or spherulitic structured volcanics, which also have large fragments set in a finer groundmass, but in which the large fragments are not individual crystals.

Pyroclastic, agglomerate and breccia textures: Volcanic rocks consisting of fragments produced by explosive eruption or mass-flow of volcanic deposits, consolidated in a finer groundmass. Potentially an attractive ornamental stone if strongly bonded.

Structures and other features which may occur in black granites include:

Massive structure: Uniform colour and texture throughout a body of black granite.

Segregations and layering: Regions of differing colour and/or texture within an outcrop-scale body of black granite. Distinct layering is a common feature of ultramafic rocks. Segregations may be evenly or irregularly shaped and distributed patches or bands.

Flow structures: Alignments of crystals due to flow in partially solidified rock (eg, volanic pillow structures). May be aesthetically attractive.

Xenoliths: Fragments of exotic rock incorporated into the molten magma at depth. Rounded greenish xenoliths of ultramafic rocks sometimes occur in Tasmanian basdalts.

Veins and dykes: May be tension fractures filled with secondary minerals which may or may not be detrimental to the aesthetic and durability qualities of the stone (eg, quartz, calcite, zeolites).

Other veins or dykes may be later intrusions of different igneous rock types.

Vesicles: Cavities formed by gas bubbles in volcanic rocks (common in basalts). May range in size from microscopic to 10mm diameter or larger, and can be uniformly distributed or concentrated into specific patches or cylindrical "pipes". If large vesicles are so numerous as to give the stone a spongy texture, it may be termed "scoriaceous" (eg, basalt scoria). Fine or microscopic vesicles may be difficult to detect, but can render the stone unable to take a good polish.

Patches of fine vesicles within otherwise sound stone can be detected using Ultrasonic Pulse Velocity testing.

Amygdales: Vesicles filled with secondary minerals. If such minerals are soft or unstable, they will be detrimental to the stone's ability to take a polish.

Joint breaks and fractures: Large breaks, generally due to tectonic, magma cooling or unloading stresses. Regular polygonal columnar joints are a common feature of dolerite and basalt, and are formed during cooling and shrinkage of magmas and lavas. Coarser rocks tend to have wider joint spacings.

Cracks and microcracks: These may occur naturally (eg, microcracks may develop around individual mineral grain boundaries during magma cooling, and fine cracking can result from tectonic stresses in the Earth's crust), or may be produced during quarrying, especially if explosives are used. They can weaken the rock, accelerate weathering decay by increasing porosity and allowing access for water, and may result in polishing flaws.

7.2 Black granite applications

Large dimension blocks	Minor use in modern buildings. Load-bearing walls and structures (including base courses, plinths, ashlar walls, large monuments, etc. Black granites such as basalts make a good base course for a sandstone building, being more resistant to rising and salt damp decay than sandstones normally are.). Can be polished, honed, or rough faced. The latter is a common "bluestone" application in walls. High strength and durability required. Dense stone generally used, although minor vesicles are accepted in non-polished applications (even scoria basalt has been used in buildings; Winkler 1973, p.6).
Veneers (wall cladding) (interior/exterior)	Major modern use (high & low rise buildings) Must take good polish, no vesicles of any size acceptable. Highest durability required for exteriors. High flexural strength required for thin veneers.
Paving tiles	Common use on city pavements in Melbourne. Abrasion resistance and modulus of rupture / flexural strength important. Finer grainsizes yield higher abrasion resistance. Minor occurrence of vesicles acceptable for unpolished tiles.
Furniture, decorative features	Benches, table-tops, etc. Vesicles must not be present. Must take good polish.
Monuments Memorials (gravestones)	High durability and ability to accept good polish required, as for exterior cladding.

7.3 Black granite quarrying in Tasmania

Jurassic-age dolerite and Tertiary-age basalt are widely quarried in Tasmania, but almost entirely as road metal. Historically, dolerite "bluestone" has been widely used in rough-faced dimension block form in buildings, although usually only as base-courses and other minor decorative portions of buildings. In a few cases such as the Church of Apostles, Launceston (Brickbats 1989), entire buildings have been constructed of Tasmanian dolerite. The quarry sources are unknown, but probably local.

Jurassic dolerite was quarried from a source near Mt. Nelson (Hobart) several decades ago for use as headstones in the Cornelian Bay cemetary (J.Dunn, *pers. comm.*). It is likely that the source was moderately jointed, in common with most Hobart dolerites, so that wastage would have been significant.

More recently (mid 1980's) a Tertiary basalt ("Royburg Black") near Miena was quarried by Dunn Monumental Masons Pty Ltd for use in polished panels. However, this stone suffers from the presence of microscopic vesicles. The stone is still commercially available, but is not currently being quarried.

In the mid to late 1980's, Wolston Developments Pty Ltd (a wholly owned subsiduary of Monier Ltd), explored for ornamental black granites in western Tasmania. Amongst others, a dimension stone Exploration Licence was held over Cambrian ultramafics at Heazlewood River, but has since been relinquished.

Current interest in black granite in Tasmania is increasing, with a number of leases having been recently pegged, although no new quarries have as yet been developed:

Mineral Holdings Aus. Pty. Ltd. have recently (1989) taken out a Stone Lease on an area of Jurassic dolerite at Campbell Range (NW Tas) for evaluation and possible production of dimension stone. However the stone is very closely jointed.

Also in 1989, Nargun Pty. Ltd. applied for an Exploration Licence for dimension stone on the Savage River Pipeline Road, in an area previously mapped as Tertiary basalt.

In early 1990, Tasmanian Hardrock Pty. Ltd. applied for an Exploration Licence over an area of Jurassic dolerite near Bell Bay.

7.4 Black granite sources and prospects in Tasmania

The following is a listing of black granite prospects, based on Bottrill & Williams (1989), and numerous other sources.

PRECAMBRIAN

ULTRAMAFICS - Amphibolites (Meta-dolerites?)

Tyennan Block		Mt.Mary/Flat Bluff Collingwood Range Raglan Range Mt. McCall Strathgordon area Kelly Basin (Port Davey)
Rocky Cape Block	Whyte Schist (amphibolite bodies)	Pieman R., Corinna Whyte R., Savage River

	Keith Metamorphics (amphibolite bodies)	Arthur River area to NW coast.
BASIC ROCKS		
Rocky Cape Block	Cooee Dolerite	NW Coast (Burnie - Smithton) to Pieman River mouth area.
	Burnie & Oonah Formations (minor basalts)	Burnie area Zeehan
	Bernafai Volcanics	Corinna

CAMBRIAN Note: UMC = "Ultramafic Complex".

ULTRAMAFICS (including associated basic rocks, particularly gabbros)

Dundas and Fossey Mountain Troughs	Heazlewood River UMC (includes pyroxenite & troctolite)	Luina region
	Mt Stewart UMC	Savage River region
	Wilson River UMC	Pieman River region
	Huskisson River UMC	Pieman River region
	Serpentine Hill UMC	Renison region
	Dundas UMC	Dundas
	Howards Rd. Ultramafics	S. & E. of Howards Rd.
	Moores Pimple Ultramafics	Moores Pimple
	Ultramafics	Wilmot - Cethana bodies.
	Cape Sorell UMC	Cape Sorell
	Spero Bay UMC	Spero Bay
	Trial Harbour UMC	Trial Harbour
	Wandle Rd. Ultramafics	Wandle Rd/Mt.Bischoff
Forth Block	Forth UMC	Ulverstone
Badger Head Block	Andersons Creek UMC	Beaconsfield
Adamsfield Trough	Adamsfield UMC	Adamsfield, Scotts Pk. Rd.
	Boyes River UMC	Boyes River
Jubilee Block	Ultramafic bodies	Styx R./ Weld R.
South Coast	Rocky Boat Harbour UMC	Rocky Boat Harbour

BASIC ROCKS (not within UMC's)

Dundas - Fossey Mt. Trough	Crimson Creek Fm. - basalts	Pieman R. area
	Motton Spilite (basalts)	Devonport - Sheffield
	Basalt - andesite association	Cleveland - Waratah
	McIvors Hill Gabbro	Zeehan
	Howards Tram Gabbro	S. of Mt. Dundas
	Gabbros	Upper Howards Rd. Colebrook Hill Moores Pimple Henty River Spero Bay

		Heemskirk/Pieman
	Mt. Read Volcanics:	
	Dundas Group basalts (Cdba)	Que R. - Hellyer Mine ? Melba/Ring R. (Cdbr)
	Henty R. Sequence basalts (Chfab)	Henty River
	Western Sequence basalt (Cwbm)	Miners Ridge
	basalt (Cwba)?	Lynch Creek Madam Howards
Smithton Basin	Crimson Crk. Fm. correlate (spilite basalts)	Smithton area Trowutta Redpa/Togari Arthur River
Badger Head Block	Altered dolerite dykes	Port Sorell
O'Connors Station Inlier	Basic/intermediate volcanics	O'Connors Peak
INTERMEDIATE - ACID ROCKS		
Dundas - Fossey Mountain Troughs	Mt. Read Volcanics:	
	Dundas Grp. andesites (Cdba)	Que R./Hellyer Mine area?
	Henty R. Sequence Andesites (Chfa)	Henty River
	Central Volcanic Complex Andesites (Ccva)	Burns Peak Sterling River Antony Rd. Mt. Lyell area
	Western Sequence Andesites (Cwba)?	Lynch Creek Madame Howards
	Tyndall Group equivalent (Farrell-Murchison Sequence: felsic volcanics Ct, Emv)	Murchison Gorge area
CAMBRO - ORDOVICIAN		
BASIC ROCKS		
Dundas Trough	Denison Group Conformable basalt - dolerite sequence.	Black Bluff Range
DEVONIAN - CARBONIFEROUS		
BASIC ROCKS		
North-East Tas.	Dolerite dykes	Numerous, associated with Eddystone and Blue Tier granite batholiths

Dundas Trough	Dolerites	Mt. Charter/Hellyer Mine area.
INTERMEDIATE ROCKS		
North-East Tas.	Hogans Rd. Diorite	St. Helens region.
	Diorite	SE of Mt. Barrow E. of Myrtle Bank
	Xenolithic Diorite	St. Mary's
ACID ROCKS		
	St. Mary's Porphyrite	St. Mary's
TRIASSIC		
BASIC ROCKS		
	Basalt	St. Mary's
JURASSIC		
BASIC ROCKS		
	Dolerite	Widespread; NE Tas. most promising region.
	Granophyre	Margate/Red Hill Great Lake Numerous other areas.
	Basalt	Lune River
TERTIARY		
BASIC ROCKS		
	Basalt	Numerous bodies throughout Tasmania; major prospects: NW Tas. Central Plateau

7.5 Evaluation of black granite sources and prospects in Tasmania

A number of black granite prospects listed in section 7.4 (above) are not discussed in the following sections. Such prospects were not examined during this project, but are considered unlikely to be prospective dimension stone sources by reason of inaccessibility, multiple deformations, or restricted occurrence.

PRECAMBRIAN

BASIC ROCKS
Rocky Cape Block
Cooee Dolerite

PROSPECTIVITY - Low

Numerous relatively thin dykes of Late Precambrian dolerite, correlated with the Cooee Dolerite near Burnie, intrude Precambrian sedimentary sequences of the Rocky Cape Group and Burnie Formation on both sides of the Arthur Metamorphic Complex. The dolerite dykes are known to outcrop discontinuously from Burnie southwest to the Pieman River Heads region (Williams & Turner 1973).

Outcrops of the Cooee Dolerite were examined near Burnie (site Bg/Rb/1/1, grid ref. DQ063556) and at Hellyer (site Bg/Rb/5/1, grid ref. CQ683735). The dolerite is medium grained, moderate grey colour, and of massive to faintly banded structure. However, closely spaced (often parallel) sets of joint fractures are ubiquitous, averaging 100 - 300mm apart.

The relatively light colour of these outcrops, and their closely jointed nature, suggests a probable low prospectivity for the Cooee Dolerite over the whole of NW Tasmania.

CAMBRIAN

ULTRAMAFIC ROCKS
All Ultramafic Complexes

PROSPECTIVITY - Low/Medium?

Significant volumes of ultramafic rock occur within Tasmanian ultramafic complexes, whose locations are shown in Fig. 10.1.

When fresh, Tasmanian ultramafic rocks (dunites, peridotites, pyroxenites) are commonly very dark black, dense, crystalline fine to coarse grained rocks which would probably take a good polish to produce an excellent "black granite". In most cases, the ultramafic rocks have approximately planar igneous banding, with bands varying from centimetres to several metres thick.

Sadly, however, most (probably all) of the Tasmanian Cambrian ultramafics are unsuitable for use as dimension stone due to extensive serpentinisation, prevalent asbestos veins, and intense fracturing:

In some of the ultramafic complexes (eg, Dundas and Boyes River UMC's), the original ultramafics have been almost entirely altered to serpentine. In other cases (eg, in the Serpentine Hill UMC at the Serpentine Hill Quarry, site Bg/Dr/2/1, grid ref. CP68106770), corestones of unaltered ultramafic rock are surrounded by thick serpentinite "sheaths". In other cases, serpentinite occurs as veins filling closely spaced fractures in the ultramafics.

Soft asbestos veins are common in most of the ultramafic complexes, and stone containing them would be quite unsuitable for dimension stone use, due to the weakness of the veins and health problems in working such stone.

The ultramafic complexes were tectonically emplaced as thrust sheets (Williams, *in* Burrett & Martin 1989,p.482), and have subsequently been subjected to several phases of deformation. As a result, all the ultramafic complexes observed by the writer (Heazlewood, Wilson River, Serpentine Hill, Dundas, Andersons Creek and Adamsfield UMC's) have intense, closely spaced open joints and fractures, and it is considered unlikely that any widely-jointed ultramafics free of fine fractures exist in Tasmania.

The Heazlewood River UMC (areas Bg/Dr/8 & 9; Rubenach 1973 & Brown 1986) is the most promising ultramafic complex examined by the writer, and was the focus of black granite exploration by Wolston Developments Pty. Ltd. in the mid-1980's. However, most of the stone observed during this project is nonetheless inferior from a dimension stone point of view:

Serpentinisation is relatively minor in the Heazlewood UMC, being generally restricted to thin fracture-coatings, and asbestos vein abundance varies through the complex from abundant to sparse or absent. Attractive dark black to greenish-black pyroxenites were observed at sites Bg/Dr/8/1 and Bg/Dr/9/1 (road cuttings on the Waratah road, and natural exposures near Brassey Hill).

Major joints are spaced an average of 0.5 metres apart, although at the Waratah Road site a 15 metre long exposure had major joints spaced 1.0 to 3.0 metres apart laterally. However, closer examination reveals the presence of numerous closely (10 - 200mm) spaced fine fractures, which are annealled with soft serpentine and/or other dark minerals. It is possible that fine fractures free of serpentinisation may be strongly annealled at a depth of some metres, but there is no clear evidence to support this assumption.

A specimen of pyroxenite (Bg/Dr/8/1/1) from the Waratah Rd. site polished well to a dark black colour, and is dominated by a "lattice-work" pattern of anastomosing laminations and fine black annealled fractures. The annealled fractures are quite strong. It is possible that this outcrop could yield usable polished slabs, although they might require a bonded backing for strength.

An interesting rock, troctolite, occurs within the Heazlewood UMC. The troctolite is a massive dark black rock with white feldspar grains giving the stone a distinctly white-speckled appearance. However, fracture spacings generally average 0.5m apart or less, and the writer only observed a single block with a 1.0 metre joint spacing. It is likely that finer fractures were hidden by the weathered surface of the outcrop.

An unusual ultramafic deposit occurs at Wandle Road, adjacent to the upper Arthur River (Williams & Brown 1983, Brown & Williams *in* Seymour 1989,p.39). This deposit consists of several ultramafic bodies which are unusual (in Tasmania) in that they are apparently undeformed, are not extensively serpentinised, and appear to have intruded the surrounding rocks as sills. It was considered that these characteristics might make the Wandle Road ultramafics prospective as dimension stone; however field examination of road-cutting outcrops by the writer revealed, once again, the prevalence of intense close fracturing.

BASIC ROCKS
Dundas - Fossey Mountain Trough

Crimson Creek Formation - basalts and Motton Spilite

PROSPECTIVITY - Low

The Crimson Creek Formation is an Early Cambrian sequence underlying the Dundas Group and outcropping widely in the western part of the Dundas Trough. The Crimson Creek Formation comprises a turbidite sequence of volcaniclastic lithic greywacke, laminated siltstone and mudstone, and interlayered horizons of tholeittic basalts (Brown 1986).

Over the southern part of the area, the Crimson Creek Formation basalts were not examined during this project, but apparently consist of relatively thin basalt horizons which are likely to be intensely fractured, in view of their early deposition within the multiply-deformed Dundas Trough.

However, overall the proportion of basaltic to sedimentary rocks in the Crimson Creek Formation increases from south to north (Brown 1986,p.71). Thick sequences of volcaniclastics and basalts correlated with the Crimson Creek Formation occur in the Luina - Mt. Cleveland area, to the north of the Meredith granite ("Ecc", Brown 1986). The volcaniclastic sequences were observed along the Savage River road near Luina, and are intensely fractured. No basalt outcrops of any possible dimension stone interest were noted.

On the north coast near Penguin (Burns 1963), a thick volcanic sequence of pillowed and massive spilite basalts with interbedded sediments, known as the Motton Spilite, is considered a possible correlate of the Crimson Creek Formation basalts, although this correlation is considered questionable on geochemical grounds (Brown, *in* Burrett & Martin 1989,p.57).

The Motton Spilite was examined in road cuttings near Lodders Point (area Bg/Dr/7). It is a fine-grained, equigranular basalt of dark green-black colour with pale green vein-like streaks. However, jointing and fracturing is intense, with open multiple-direction fractures averaging only 0.2 - 0.5m apart. This unit is not prospective for dimension stone.

Cleveland - Waratah Associations: basalt - andesite lavas and associated rocks

PROSPECTIVITY - Low

Following the Crimson Creek Formation basaltic lavas in the Luina - Mt. Cleveland region, Brown (1986) has identified second and third Early-Middle Cambrian mafic - andesitic volcanic phases in the Cleveland - Waratah region. These comprise a suite of high magnesian andesitic lavas (Eba) and a suite of low-titanium, tholeittic, basalt-andesite lavas (Ebm).

The basalt lavas (Ebm) were examined in road cuttings and quarries on the Mt. Cleveland road north of the Savage River road, and were found to be intensely fractured (fracture spacings generally <0.2m apart. The andesite lavas were not examined, but their nearby location and similar tectonic history imply a similarly highly fractured nature.

Several small pods of "massive ultramafic cumulate" (Ebp, Brown 1986) occur within the Cleveland - Waratah associations, just east and west of Luina township. These outcrops are a dark green-black uniform structureless rock. As usual, they are intensely fractured.

The McIvors Hill (and other) Gabbros

PROSPECTIVITY - Low

A number of Cambrian Gabbro bodies occur within the Dundas Trough. One of the largest of these bodies is the McIvor's Hill gabbro, which outcrops along the Trial Harbour road, west of Zeehan (Blissett 1962 a & b).

The McIvor's Hill gabbro (area Bg/Dr/1) is a medium-grained, equi-granular rock of uniform dark grey-green colouration and a coarsely layered structure (layers av. 0.5m thick). It would probably polish well to yield an attractive black granite.

However, the gabbro is intensely jointed, with major fractures spaced an average of 0.1 m (rarely 1.0m) apart, and is thus unsuitable as a source of dimension stone.

A similar gabbro associated with the Serpentine Hill Ultramafic Complex (site Bg/Dr/2/2, justsouth of Serpentine Hill) was also examined and found to be intensely fractured (fracture spacings generally less than 0.1m).

A number of other gabbro bodies exist within the Dundas Trough, but were not examined during this project. The Dundas Trough has been subjected to multiple phases of deformation and faulting, which has produced strong jointing and shearing throughout most of the Cambrian sequences. It is therefore highly likely that other Cambrian gabbros within the Trough will have similar intense jointing and fracturing, making them unprospective for dimension stone.

Smithton Basin
Spilite Basalts - Crimson Creek Formation correlate

PROSPECTIVITY - Low/Medium

A sequence of volcaniclastic lithic greywacke, siltstone, mudstone and spilite basalt occurring in the Smithton Basin of northwest Tasmania (see Fig. 7.2) is considered to be a correlate of the Early Cambrian Crimson Creek Formation of the Dundas Trough (Brown, *in* Burrett & Martin 1989, p.55). In contrast to the Crimson Creek Formation basalts of the Dundas Trough, the Smithton Trough basalts are apparently somewhat less deformed, and show some possible potential as sources of dimension stone.

The proportion of basalt in the sequence varies through the Smithton Trough. According to Brown, the main area of basalt forms a ridge from north of Smithton, south through Trowutta, and then across the Arthur River to the Frankland River. Further correlated basalts are known to underlie the region west of the Montague River between Redpa and Togari, and extending north from the Arthur River to Robbins Island.

In this project, the basalts were examined in the Smithton to Arthur River area, where they have been mapped by Lennox *et al.* (1982) as amygdaloidal spilite basalts (examined in areas Bg/Rb/6 - 9). The basalts are commonly altered, and include both porphyritic and non-porphyritic varieties. Pillow structures, amygdules and vugs are common (Brown, *in* Burrett & Martin 1989, p.55, & Brown 1989,p.68-77).

At site Bg/Rb/9/1 (a road metal quarry just north of Smithton, at grid ref. CQ426785), the basalt is an attractive massive fine-grained dark black rock with medium-grained dark green

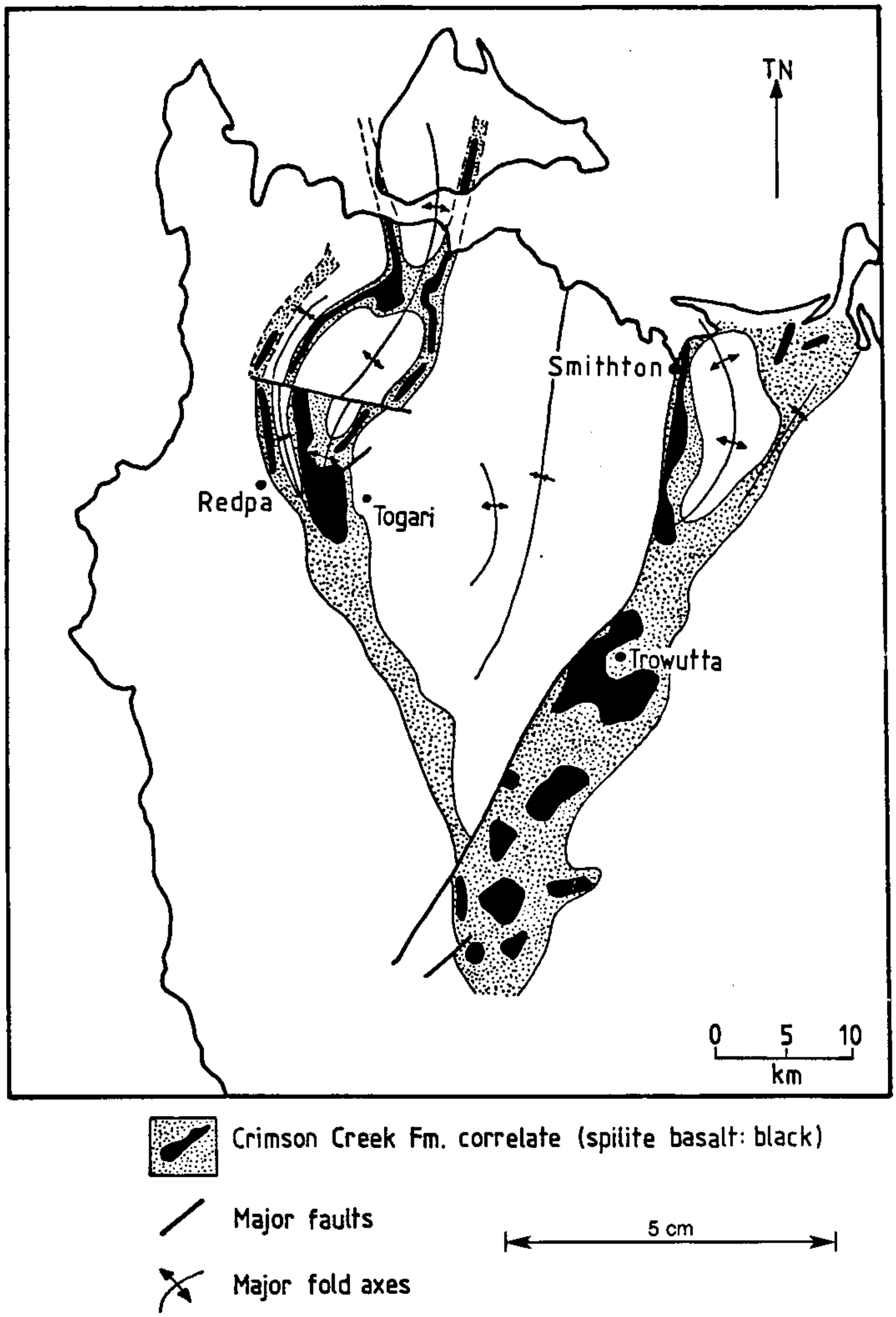


Figure 7.2 Distribution of Cambrian basalts in the Smithton Basin. Adapted from Williams & Turner 1973, and Baillie & Crawford 1984.

pyroxene phenocrysts. Sparse pale coloured amydales up to 30mm diameter and 1 - 5mm thick linear veins (annealled fractures) are filled with hard, pale minerals and give interest to the appearance of the stone (see Plate 3.9). Careful mineralogical analysis would be necessary to ensure that none of these minerals are deleterious to stone durability.

Previous mineralogical work (Lennox & Baillie *in* Brown 1989,p.68-77) has identified vug and amygdule fillings of opaline and ?calcareous minerals, chlorite, quartz including agate, dolomite, calcite and feldspar. Blebs of pyrrhotite and native copper have also been found.

A sample (Bg/Rb/7/1/1) took a fair polish with minimal pitting, although small dull patches (av. 1mm dia.) are evident on the polished surface.

At the sites examined, open joints are generally spaced an average of 0.1 - 0.5 metres apart, but some unfractured blocks over 1.0 metre wide were seen.

This "black granite" is an attractive stone, of a distinctly different character to the Tasmanian Tertiary basalts, and is likely to be of good quality and durability. Any micro-vesicles have probably been filled with secondary minerals during the long diagenetic history of these rocks.

The Smithton Basin Sequences have been extensively folded and faulted (see Fig. 7.2). However, the Smithton spilite basalts are the most widely-jointed Cambrian basalts seen during this project. Although average open joint spacings at the sites examined were insufficiently wide for a viable ornamental stone quarry, the joint spacings show sufficient variation (ie, some wide spacings) to suggest that further evaluation of the stone throughout the Smithton Basin would be warranted.

Badger Head Block
Dolerite dykes

PROSPECTIVITY - Low

A swarm of altered Cambrian dolerite and micro-dolerite dykes occur on the eastern side of Port Sorell (Gee & Legge 1971). One of these dykes was examined at Griffiths Point (area Bg/Bb/1), where the dolerite is a dark black rock, but has intense closely-spaced joints averaging 0.2 - 0.3 metres apart.

Other dolerite dykes in the area are most likely to have similar close jointing. The prospectivity of the dykes for dimension stone is considered to be low.

BASIC - ACID ROCKS
Dundas Trough
Mt. Read Volcanics and Dundas Group Volcanics: Mafic - felsic volcanics

PROSPECTIVITY - Low

A thick pile of volcanic and sedimentary rocks belonging to the Mt. Read Volcanics and the Dundas Group were deposited in the Dundas Trough during middle to late Cambrian times. These volcanics were of dominantly andesitic-rhyolitic (felsic) composition, and are generally not of a sufficiently black colour to be classified as "black granites". They are discussed in the "Other

Granites" chapter.

However, a small proportion of dark-coloured basaltic and andesitic volcanics occur within these sequences, and in addition several of the felsic volcanic sequences are of a black colour. Several examples of such black volcanic rocks were examined in the Mt. Read Volcanics

Andesitic volcanics belonging to the Central Volcanic Complex of the Mt. Read Volcanics are well exposed in road cuttings along the Antony Road, west of the Tyndall Range (area Bg/Dr/3, "Ecva", Corbett & McNeill 1988). The andesites are massive rocks, of fine grained texture with light feldspar and dark ferro-magnesian phenocrysts 1 - 10 mm diameter. The overall colour of the fresh rock is a dark but somewhat "dull" grey/green, with some lighter pale green patches 100-200mm diameter comprising about 30% of the stone's volume. Joint fracture spacing averages <0.5m, although rare 1.0 metre spacings occur.

Unusually dark-coloured quartz-feldspar-phyric felsic volcanics belonging to the Farrell/Murchison Sequence of the Mt. Read Volcanics (Corbett & McNeill 1986, 1988) were examined at the Murchison Dam (site Bg/Dr/4/1). These massive, fine-grained, porphyritic dark grey-black rocks are strongly cleaved in some outcrops, and intensely fractured in all outcrops.

Basalts in the Dundas Group and Mt. Read Volcanics were not examined in this work. However the multiple deformations which have affected the Cambrian deposits of the Dundas Trough mean that close fracturing can be expected to be a persistent problem in all rocks within these sequences. Although a small proportion of "wide" jointed rocks are observed in places within the Mt. Read Volcanics (see "Other Granites"), location of marginally viable dimension stone quarry sites is likely to be difficult.

Given that other rock units in Tasmania are considered to be highly prospective for good black granite deposits, the effort required to locate a reasonable deposit in the Dundas Trough volcanic sequences does not seem justified. This is in contrast to the interesting vari-coloured felsic volcanics within the Mt. Read Volcanics, whose unusual colouration is such that further investigation seems worthwhile (see section 8.5).

DEVONIAN

BASIC ROCKS
Northeastern Tasmania
Dolerite dykes

PROSPECTIVITY - Low

A swarm of narrow NE - SW trending dolerite dykes of probable Late Devonian age have intruded Mathinna Bed sedimentary rocks and Devonian granite bodies of the Eddystone and Blue Tier Batholiths in northeastern Tasmania. They have been mapped on the Eddystone, Blue Tier, St. Helens and Ringarooma 1:50,000 Geological Atlas sheets (Brown *et al.* 1977, McClenaghan & Williams 1983, Baillie 1984, McClenaghan *et al.* 1987).

The dykes are steeply dipping, and up to 50 metres wide (on the Eddystone Sheet, Baillie 1986), although more commonly only 5 - 10 metres wide (McClenaghan 1984). Individual dykes up to six kilometres long have been mapped on the Blue Tier Sheet. The dykes are particularly well developed immediately east of the central Blue Tier area, where they have a regular strike of 40° to 50° T.

During this project, the dolerite dykes were examined in the Mt William area (ENE of Gladstone, area Bg/Ne/3), and in the Ansons Bay - Pioneer area (area Bg/Ne/4). The dykes outcrop very poorly: of eight mapped dykes briefly visited in these areas, bedrock outcrop was only located at one site (Ansons River bridge, on the Ansons Bay Road). At the other sites only loose boulders of dolerite were located. Only two of the sites are recorded separately in the data base. Most of the dykes were originally mapped on the basis of persistent float rather than bedrock outcrop (M.P. McClenaghan, *pers. comm.* 1990), although some outcrop might be found by following the dykes across country.

At the Ansons River Bridge, a poor dolerite outcrop beneath Mathinna Bed sedimentary rocks is very weathered ("rotten" stone), and joint fractures are closely spaced (0.1 - 0.2 metre spacings or less). The size of unfractured dolerite boulders at sites Bg/Ne/3/1 (Mussel Roe Rd., near Mt William) and Bg/Ne/4/1 (Tebrakunna Rd., upper Great Mussel Roe River area) indicate joint spacings ranging from less than 0.5 to possibly 1.0 metres. The boulders consist of very hard, fresh dolerite with an outer crust 4 - 5mm thick of brown iron oxide. The dolerite is massive, and of fine to medium grained equi-granular texture. The fresh dolerite is a dark grey-black colour (N3), with a slight bluish tinge.

The only well exposed bedrock outcrops of the dolerites currently known occur on the shore platform at Georges Bay Heads (McClenaghan *et al.* 1987). The exposures are located at St. Helens Point (FQ130296) and at Grants Point (FQ119320), and were not examined during this project. Although these deposits would not be quarriable for environmental reasons, it would be useful to examine them since they would give a good indication of the likely nature of the bedrock (jointing, etc) in the numerous poorly exposed inland occurrences.

The dolerites polish well without significant pitting or microcracking, and colours vary from grey-black (Bg/Ne/3/1/1) to a very intense and attractive jet-black (Bg/Ne/4/1/1). Fine fractures are evident in specimen Bg/Ne/4/1/1.

According to McClenaghan *et al.* (1982, p.83) and McClenaghan & Williams (1983), grains of iron oxide and iron sulphide are commonly present. Pyrite is abundant in specimen Bg/Ne/4/1/1. These minerals would potentially result in discolouration and "streaking" of the stone if used as a building material (although this may partly depend on the abundance and freshness of the iron minerals).

The poor outcrop, possible close jointing, and presence of deleterious iron minerals renders these Devonian dolerite dykes of low priority as black granite exploration targets.

Dundas Trough
Dolerites

PROSPECTIVITY - Low

A few small bodies of Devonian dolerite have been mapped in the Mt. Charter - Hellyer Mine area of the Dundas Trough (Komyshan 1986, Corbett & Komyshan 1989). One of these areas was examined, on the northwest side of Mt. Charter (area Bg/Dr/12).

No bedrock outcrop was located, but apparently unjointed boulders up to a metre long occur commonly as surface float. The stone is massive, medium-grained and equi-granular. It has a pleasingly dark "medium bluish-grey" (5 B 5/1) colour.

Although the stone has a pleasing colour and texture for a black granite, the lack of bedrock outcrop makes assessment difficult. The restricted areas of occurrence make the stone much less prospective, on current knowledge, than comparable black granite prospects such as the Jurassic dolerites and Tertiary basalts.

INTERMEDIATE ROCKS
Northeastern Tasmania
Hogan's Road Diorite

PROSPECTIVITY - Low

Coarse-grained black diorites outcrop at Hogans Road, near the upper Scamander River (McClenaghan *et al.* 1990). The diorite bodies (<1km diameter) occur within strongly hornfelsed rafts ("mega-xenoliths"?) of Mathinna Bed sediments within the Poimena Adamellite (McClenaghan 1984).

Small roadside outcrops at Grid ref. EQ870184 were examined by the writer and found to be poorly exposed and intensely fractured. A larger body nearby (EQ867176) is covered by eucalypt regrowth, but is accessible along 4WD tracks. This body may be somewhat less fractured.

However, the poor outcrop, degree of fracturing noted in the roadside outcrop, and small extent of the diorites indicate low prospectivity.

Diorites (Diddleum Granodiorite)

PROSPECTIVITY - Low

Longman (1964, 1966) mapped a number of small diorite bodies near the western margins of the Diddleum Granodiorite (eg, SE of Mt. Barrow & E. of Myrtle Banks). However Longman gave no details of these diorites, and they were not visited during the present work.

Their location and orientation suggests that, as with the Hogan's Road Diorite, they may be disrupted basement rocks, and thus are likely to be very fractured.

Xenolithic Diorite (Picaninny Creek Adamellite)

PROSPECTIVITY - Low

A band of richly xenolithic, medium grained quartz diorite occurs in a band on the northern margin of the Picaninny Creek Adamellite at it's contact with the St. Mary's Porphyrite (Turner *et al.* 1984, Turner & Calver 1987,p.63), east of Mt. Elephant.

This diorite was noted examined in this work, and no information is available as to it's jointing, aesthetic appearance or technical quality. Many of the xenoliths are themselves fine-grained diorite (Turner & Calver *Ibid.*), and it is possible that the stone could have an interesting non-uniform appearance.

ACID ROCKS
Northeastern Tasmania
St. Mary's Porphyrite

PROSPECTIVITY - Low

The St. Mary's Porphyrite is the only known Devonian volcanic deposit, and is considered to be the extrusive equivalent of the Scamander Tier and Catos Creek Granodiorites (Turner *et al.* 1984, McClenaghan *et al.* 1987, M.P. McClenaghan *pers. comm.* 1990). It is discussed here rather than under "True Granites" since it's relatively dark colour would probably classify it as a "black granite" in stone industry terms.

The St. Mary's Porphyrite (see Fig.6.3) outcrops between St. Mary's and the east coast, and is described by Turner & Calver (1987). The St. Mary's Porphyrite is intrusive in the southwest part (Dpm of Turner & Calver), and is an extensively recrystallised extrusive ash -flow tuff of dominantly dacitic (minor rhyolitic) composition (Dpr) in the larger northern and eastern part of the body. The intrusive part of the body was not examined during this project.

The extrusive recrystallised ash-flow tuffs were examined at St. Mary's Pass and on the coast south of Falmouth. In both places the stone is a massive medium dark grey (N4) having a very fine-grained groundmass with abundant phenocrysts 1 - 8mm in diameter (quartz and pyroxene). Dark grey fine-grained xenolith-like bodies 20 - 200mm diameter are common constituents along the coast south of Falmouth.

At St Mary's Pass (site Bg/Ne/5/1, grid ref. FP012991) the stone has close, multi-directional joints spaced an average of 0.02 - 0.5m apart. Turner (*in* Turner & Calver 1987,p.47) notes that the northern extrusive rocks are generally "short jointed".

However, in fresh road cuttings along Four Mile Coast Road south of Falmouth (especially near Mariposa Beach), joint spacings may be as wide as 2 - 3 metre spacings, although such large joint blocks are interspersed with closely jointed zones.

Although joint spacings are potentially acceptable in a few places, no practical quarry sites have been located. The stone would probably polish to an appearance similar to lighter varieties of dolerite, but it is likely that any quarry would have significant wastage due to the existence of closely jointed zones in most outcrops.

TRIASSIC

BASIC ROCKS
North-eastern Tasmania
Basalt

PROSPECTIVITY - Low

Basalts of Middle Triassic age are exposed near St. Mary's (Turner *et al.* 1984, Turner & Calver 1987,p.32). Much of the basalt close to contacts is strongly altered, but the middle parts of thicker (max. 30m) sections are typical uniform black basalt. The basalt is typically closely jointed, including the development of well-formed close columnar joints in some places. The small volume of exposed fresh basalt, and it's typically close jointing, imply low dimension stone prospectivity for the Triassic basalts.

JURASSIC

BASIC ROCKS
All Regions
Dolerite & Granophyre

PROSPECTIVITY - Medium

Thick sheets, sills and dykes of Jurassic - age dolerite are widespread in Tasmania, the largest bodies occurring as intrusions into the Carboniferous to Triassic age Parmeener Supergroup sedimentary rocks of the Tasmania Basin (central and eastern Tasmania).

The Jurassic dolerites are currently considered to be the most promising potential source of polished black granite dimension stone in Tasmania. These are very similar in colour and texture to South African dolerites which have been widely used for ornamental purposes (an example of the South African stone can be seen on the columns on the Murray St. (Hobart) facade of Myers Department Store, and a similar dolerite has been used on the Elizabeth St. entrance of the Hydro-Electric Commission building). The South African Karroo Dolerites are of a similar Jurassic age to the Tasmanian dolerites, and the intrusion of both was related to the beginning of the break-up of Gondwana.

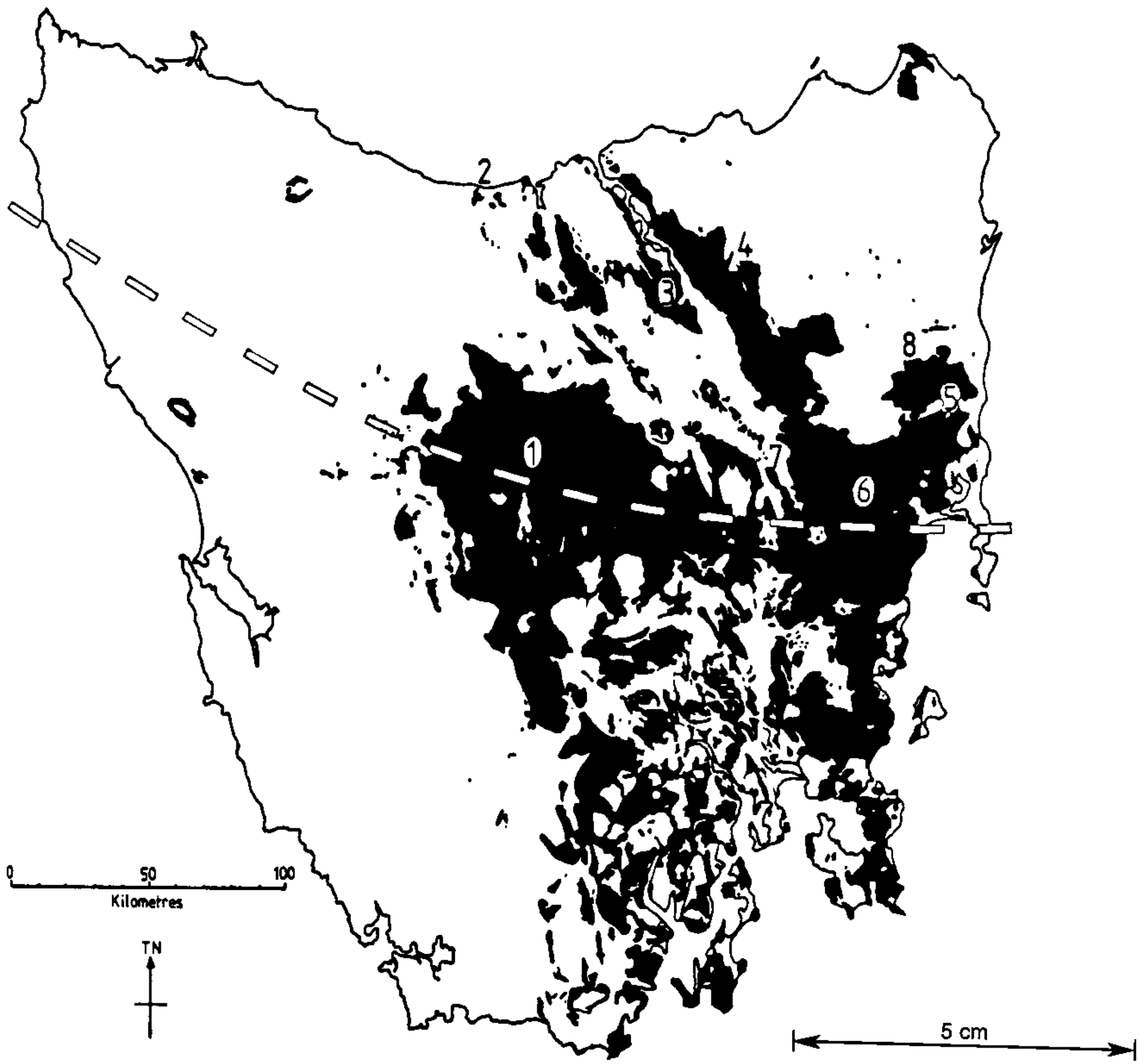
Very large quantities of Jurassic dolerite exist in Tasmania, where surface exposures cover close to half the total land surface of the State, and some is widely jointed and polishes well to a very dark black colour. There appears to be excellent potential for locating high quality deposits for use as polished veneers, slabs, and other building and ornamental purposes.

The following discussion gives information on variation in colour, texture and jointing styles and densities in the Tasmanian Jurassic dolerites, with the intention of providing a broad guide to exploration for high quality dimension stone. Some information is also given on areas examined during this project.

Composition, colour and texture variation
The dolerite magma was intruded as a liquid, as indicated by the glassy to very fine-grained chilled margins of the intrusions. Away from chilled contacts, the dolerite is characteristically a medium-grained, even textured rock which is generally free of igneous banding (see Plate 7.1). Typically, dolerite consists of pyroxene, plagioclase and iron oxides in a groundmass (mesostasis) of quartz and feldspar which is commonly slightly altered, in which case it may contain chlorite. Minor accessory minerals may include pyrite, chalcopyrite, hornblende, biotite, apatite, and rare fluorite and zircon. Carbonate, chlorite and zeolites may also occur (Hergt & McDougall, *in* Burrett & Martin 1989,p.378).

Vertical differentiation of grainsizes and mineral content through thick dolerite sills has occurred due to fractional crystallisation and sinking of heavy crystalline aggregates (pyroxenes) under the influence of gravity (McDougall 1964,p.129; Carmichael *et al* 1974,p.450). The sinking of equi-dimensional crystal aggregates rather than individual elongate crystals is considered to explain the general lack of igneous lamination in most dolerites (McDougall *Ibid.*), although over a quarter of the dolerite bodies have subtle layers up to one metre thick (Leaman 1990). Due to this differentiation, the densest, most pyroxene-rich (and thus darkest coloured) zone of medium-grained dolerite occurs in the lower parts of large sills (McDougall 1964; Calver, *in* Turner & Calver 1987,p.65-71).

The composition and differentiation of large dolerite sills has been found to be remarkably similar throughout Tasmania (Calver *Ibid.*). Large dolerite sills may exceed 400m in vertical



▭ ▭ ▭ - Notional line separating region of increasingly intense Mesozoic faulting and jointing (towards the south) from potentially prospective region of decreasingly intense Mesozoic faulting and jointing (to the north).

Key to numbered map locations:

1 Central Plateau	5 Douglas River
2 Devonport	6 Lake Leake
3 Launceston	7 Campbelltown
4 Nunamara	8 Fingal Tier

FIGURE 7.3 Distribution of Tasmanian Jurassic dolerite (black). Variation in Mesozoic jointing densities indicated, based in work by Dr. R.F.Berry (publication *in prep.*). Tertiary horst and graben structures not shown, but are potentially important causes of dolerite fracturing.

thickness. Typical grainsize and compositional variations (and resulting colour variations) in large dolerite sills are illustrated in Figure 7.4 , and are briefly described as follows:

McDougall (1964) found that the Great Lake dolerite sill could be vertically sub-divided into a number of zones, which appear to be generally applicable throughout Tasmania:

Contact Zone: Calver (*Ibid.*)found that the chilled margins extending one metre or so from dolerite/country rock contacts consist of closely jointed, greenish-grey aphanitic (micro- or crypto-crystalline textured) dolerite.

Beyond this, the contact zones consist of uniformly fine-grained (<0.7mm av. grainsize) black platy-jointed dolerite extending 10 - 40m into the dolerite body. The mesostasis is glassy, and the dolerite may appear macroscopically glassy in some outcrops. Forsyth (1984) only observed fine-grained dolerite close to dolerite margins.

The contact zones represent the original composition of the dolerite magma, since they formed by rapid cooling of the magma against the country rocks before differentiation due to fractional crystallisation occurred.

Calver (*Ibid.*) has noted the presence of porphyritic glassy dolerites on Fingal Tier, of a sort which has not been encountered elsewhere in Tasmania. In the few localities where it has been observed, it consists of a dominant (50 - 90%) black aphanitic groundmass containing pyroxene and plagioclase phenocrysts 1 - 4 mm long. The rock is "massively to poorly" jointed (ie, widely jointed?) or else has polygonal columnar jointing. Thicknesses of up to 30m are known, below which the porphyritic glassy dolerite grades downwards into coarser normal dolerites.

Calver suggests that the glassy dolerite formed by sudden quenching near the top of the dolerite sill in a part of Fingal Tier where nearly the whole sill thickness may be preserved. The fine dark nature of the stone, and the possibly widely jointed nature, suggest possible interest from a dimension stone point of view. The outcrops were not visited during this project.

Upper Zone: A zone equivalent to McDougalls (1964) "Upper Zone" was not found in the Fingal Tier dolerite sheet (Calver *Ibid.*), possibly due to erosion having removed the upper part of the sheet in most places on the Tier.

McDougall (1962) noted that dolerite coarsens to medium grainsize within 20m or so of marginal contacts (Calver found this occurs within 10 - 40m), so passing into the Upper or Lower zone dolerites.

McDougall (1964) identified the medium-grained Upper Zone in the Great Lake Sheet as having a low proportion of mesostasis (<10%), and being less silicic than the Central Zone below. Forsyth (1984, 1989) has characterised the upper parts (= "Upper Zone"?) of major dolerite sills as a zone in which gradational to abrupt lateral variation occurs between fine and medium-coarse dolerite masses, in contrast to the more uniform and even- grained lower two thirds of the sills (the central and lower zones).

McDougall (1964) found that thin "pegmatitic dolerite" veins (av. grainsize 3mm) are common in the Upper Zone and the upper part of the Central Zone.

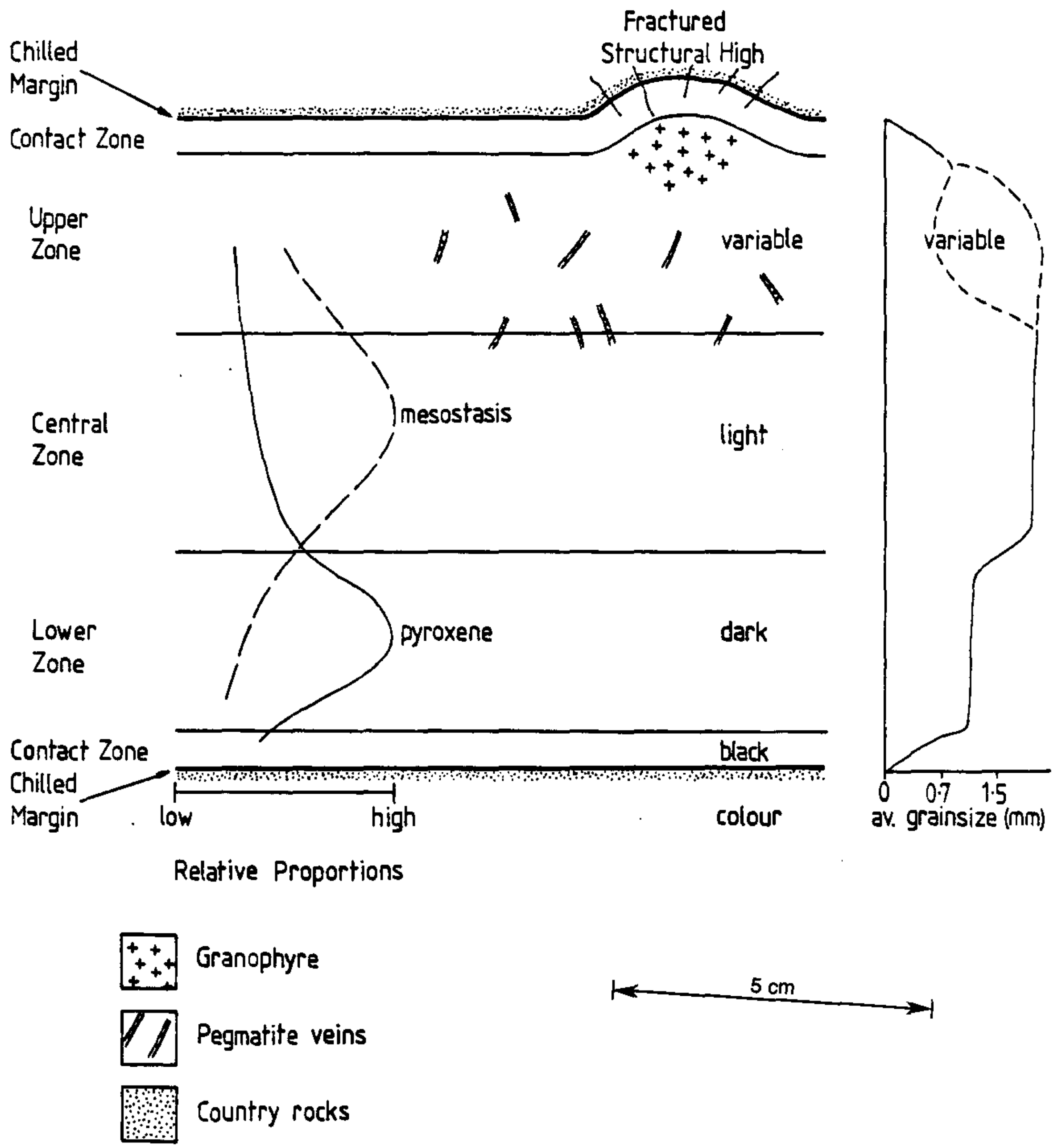


FIGURE 7.4 Typical compositional and grainsize variation through thick Tasmanian Jurassic dolerite sills. Based on McDougall (1964) and Calver (*in* Turner & Calver 1987)

Granophyre: Of some potential dimension stone interest is the occurrence of laterally and vertically restricted granophyre bodies adjacent to the upper contact of dolerite sheets(McDougall 1962, 1964, & Forsyth 1989). Granophyre is considered to be a differentiate from the dolerite magma which has formed in structural highs in the roof of the intrusions, where fracturing of the roof rocks has allowed escape of volatiles, creating a low pressure region into which silicic residual liquid from the cooling dolerite magma would stream and concentrate (McDougall 1964).

Granophyre is defined by McDougall as a dolerite differentiate containing greater than 50% (silicic) mesostasis. Tasmanian granophyres are relatively light coloured mottled rocks of medium to coarse grainsize, consisting of light-coloured plagioclase crystals, dark feather-like pyroxene crystals, olivine and iron minerals, all set in a light to dark brown coloured, poorly crystallised groundmass (mesostasis) of quartz and K-feldspar which comprises 50 - 80% of the rock (see Plate 3.10).

Granophyres can take on a slightly greenish-grey tinge, and with their mottled appearance some might be considered attractive as a polished stone. Significant granophyre deposits occur at Red Hill near Margate (McDougall 1962) and at Great Lake (McDougall 1964), but numerous other small deposits have been reported in many Jurassic dolerite bodies throughout Tasmania.

Leaman (1975,p.181; & *in* Burrett & Martin 1989,p.454) noted that in the Hobart region granophyres are only located adjacent to feeder centres. They are thus more likely to have wide jointing due to slower cooling (less cooling joints) and also to their larger grainsize (less affected by tectonic jointing). In fact, McDougall (1962, Plate 6) illustrates manifestly widely jointed granophyre at Red Hill, and joint spacings of up to two metres were noted in granophyric rocks in the same area (site Bg/Ts/3/2) by the present writer.

On the other hand, Banks *et al.* (*in* Burrett & Martin 1989,p.378) and Forsyth (1989) note that granophyre seems to weather and decompose more rapidly than the more mafic dolerite phases, suggesting possible lower durability of granophyre as a dimension stone.

Central Zone: This is the most silicic zone (apart from granophyres) of the dolerite sheets, with abundant mesostasis (10-30%; Calver *Ibid.*) and a predominance of plagioclase over pyroxene (McDougall 1964). It is consequently lighter in colour than dolerites in the other zones (albeit still dark enough to be classed as "black granite").

Dolerites in the central zone have a uniform and comparitively coarse (medium) grainsize averaging 1.5 - 2.0mm dia. (pyroxene grains). The central zone may be very thick (300m+ in the Fingal sheet; Calver *Ibid.*).

Lower Zone: This most mafic zone is defined by McDougall (1964) as that zone in which pyroxene is present in a greater proportion than plagioclase, and represents the zone into which gravity-settling has concentrated the highest proportion of the heavy, dark-coloured pyroxene crystals. Only 8 - 15% light coloured mesostasis is present in lower zone dolerites (McDougall *Ibid.*). The dolerites of the lower zone are therefore the darkest coloured dolerites apart from the platy jointed black contact-zone dolerites, and may polish to a nearly jet-black colour in some instances (eg, specimen Bg/Tn/1/1/1, which is a probable lower zone dolerite; see Plate 3.10).

Lower zone dolerites have a uniformly fine to medium grainsize which, at an average pyroxene grainsize of 0.5 - 1.0mm (McDougall *Ibid.*), is somewhat finer than the central zone dolerites. The lower zone is about 100m thick in the Fingal dolerite sheet (Calver *Ibid.*).

Jointing and fracturing - style and density variation

Despite the huge volume of dolerite in Tasmania, no deposits suitable for extraction of large unflawed blocks for dimension stone work have yet been exploited (nor, to the writers knowledge, located). This is because of the prevalence of close jointing and, in particular, the presence of fine fractures within seemingly-widely jointed deposits.

For this reason, exploration for dimension stone quality black granite in Tasmania must pay special attention to the causes and distribution of jointing and fracturing in the Jurassic dolerites.

As a general tendancy, jointing of all styles tends to be more widely (or, less densely) spaced in coarser grained rocks (Legge 1967), so that coarser grained dolerites (see above discussion of dolerite grainsize variation) will tend to be wider jointed than regional or local jointing controls might otherwise lead one to expect. However, coarser dolerites tend to be lighter in colour.

Again,the joint density in rock bodies exposed to a given stress is greater in more competant, or stronger and more brittle, rocks. Thus, the density of tectonic jointing in Tasmanian dolerites is generally greater than in adjacent (older) sandstones which are weaker and more plastic. However, strength differences within dolerite bodies can be expected to be negligible compared to those between dolerite and sandstone, so that joint density variations within dolerite bodies can be expected to show little variation purely as a result of strength differences.

Apart from the influence of grainsize, jointing density in the dolerite is controlled by factors relating to the style and origin of the jointing. Jointing in the dolerite results from unloading, magmatic cooling, and regional tectonic stresses:

<u>Unloading jointing</u>

Horizontal jointing commonly occurs in dolerite, and in some cases may be related to unloading (the release of overburden stress through erosion of overlying rock), although much of the horizontal sheet jointing in the dolerite appears to be instead related to cooling (see below).

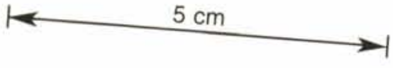
Unloading jointing does not appear to be very significant in Tasmanian Jurassic dolerites. This is probably because they were emplaced within the Parmeener Supergroup at depths in the order of only one to three kilometres (*see* Everard, *in* Turner & Calver 1987,p.144), and thus had less overburden stress to relieve than do rocks such as the true granites which are emplaced at greater depths.

<u>Cooling joints</u>

Close to the margins of dolerite intrusions, rapid cooling has produced fine-grained dolerites accompanied by closely spaced (av. 10mm) parallel joints known as "platy" jointing (see Plate 7.2). Platy jointing occurs oriented at right angles to the upper and basal marginal contacts of

Plate 7.1 Jurassic dolerite; typical fresh appearance (Campbelltown Quarry, site Bg/Ts/2/1).

Plate 7.2 Two sets of typical platy jointing in Jurassic dolerite (Mt. Barrow, site Bg/Tn/2/4).



the dolerite intrusions (Banks *et al.* in Burrett & Martin 1989,p.377; Forsyth 1989,p.47), and is vertically oriented on steeply dipping (ie, side) intrusion margins (Forsyth 1984,p.99 & 1989,p.47).

Calver (*in* Turner & Calver 1987,p.68) found that fine-grained dolerite with "hackly" (= platy?) jointing extended 10 - 40 metres above the basal dolerite contact in drill-holes on Fingal Tier.

However,Forsyth (1984, p.99, & 1989, p.47) notes that platy jointing (described as "hourglass" jointing) may also extend throughout thin dolerite sheets of medium (0.7 - 3.0mm av.) grainsize, such as the Table Mountain and Woods Quoin sheets (Oatlands and Interlaken Quadrangles), in which it is controlled by larger scale columnar joints.

Both Calver (*Ibid.* , p.67-68) and the present writer have noted similar closely spaced platy joints, forming radiating sets several metres in diameter which abut each other at high angles, in dolerites of medium grainsize (0.7 - >1.5mm) on Fingal Tier.

This radiating pattern suggests that the cooling responsible for the joints commences at scattered points several metres apart, so that the platy joints develop radially outwards from each nucleus (the individual joint planes elongating perpendicular to the intrusive contact and radially out from the cooling nucleus) until an adjacent domain of cooling radial jointing is encountered. Calver (*in* Threader & Bacon 1983) notes that wider columnar joints are associated with the platy jointing in the medium-grained dolerites (as also noted by Forsyth above). Probably each column represents a single cooling "domain" with an internal radial joint pattern.

Parts of the Fingal Tier dolerite sheet are known to be over 400m thick (Calver,*in* Turner & Calver 1987), and in parts the top contact zone of the sheet has been eroded off. Thus, the occurrence of radiating platy jointing in medium-grained dolerites within the sheet seems to present a problem, since in thick sheets platy jointing is expected to dissappear away from the fine-grained marginal contacts (see below).

In the areas where the writer has observed the radiating platy jointing (eg, NW of Horseshoe Marsh), the surface exposures appear to be only about 100m above the base of the dolerite sill, based on drillhole data (Turner *et al.* 1984). Geophysical and drilling data indicate that preserved dolerite sheet thicknesses are comparitively thin in many parts of Fingal Tier away from feeder pipes(Leaman & Richardson 1981, Fig.30, and Turner *et al.* 1984). It is possible that the original sheet thickness in these particular areas was not significantly greater than the preserved thicknesses, so that platy jointing formed throughout these thinner parts of the Fingal Tier sheet in a manner similar to that observed by Forsyth (above) in thin medium-grained sheets in the Oatlands and Interlaken Quadrangles.

Further field observations of jointing styles in outcrops representative of the Contact, Central and Lower Zones of both thick and thin sheets will be necessary to definitively determine whether platy jointing on Fingal Tier only occurs in marginal contact zones and through the thinner dolerite sheets, or whether it also extends throughout large parts of the thicker sheets.

In the latter case, an alternative explanation must be sought. A possibility worth considering is that the radial platy jointing may be an unusual form of unloading fracturing.

In any case, the normal situation in larger sills was that cooling was slower, so that as grainsize increases away from the margins close platy jointing is replaced by wider spaced columnar (or "cubic") and sheet jointing.

Vertical or sub-vertical columnar jointing results from cooling and shrinkage of the dolerite following it's intrusion as a molten magma, and takes the form of regularly spaced polygonal joint patterns with spacings of 1 - 5 metres (see Plate 7.3). The columns are generally oriented perpendicular to the bounding margins of tabular dolerite sills (Leaman 1975). In the Hobart region, Leaman (1975) found that columnar jointing is common close to the margins of dolerite bodies, and that the size of the columns (ie, the joint spacing) increases further (laterally) into the bodies, where cooling was slower. Thus, larger (thicker and wider) dolerite bodies will tend to have wider columns in their (laterally) central parts. These are also likely to become less distinct or dissappear in the (vertically) central parts of very thick sheets.

Calver (*in* Threader & Bacon 1983,p.12-13) found that at Fingal Tier columnar jointing was ubiquitous in medium grained dolerites of 0.5 - 1.5mm grainsize (ie, the Lower Zone and possibly part of the Central Zone). However, he found columnar jointing to be poorly developed in coarse grained (up to 4mm grainsize) dolerites (Central Zone?) south of Fingal Tier at Coggle Hills (Grid Ref. EP8767)

Columnar jointing is commonly accompanied by continuous sheet joints cutting through columns and oriented parallel or sub-parallel to tabular dolerite sill margins (see Plate 7.3). These joints are generally horizontal or sub-horizontal, but may sometimes be inclined (Forsyth 1984,p.99; Forsyth 1989,p.47; Banks *et al.* in Burrett & Martin 1989,p.377-8). These sheet joints are generally spaced several metres apart vertically, and appear to be cooling (rather than unloading)joints.

In thick dolerite sheets, close to feeder centres where cooling processes were extended (Leaman 1975,p.181), cooling joints can be expected to be either absent or very widely spaced. A bold outcrop adjacent to a large feeder complex just south of Fingal ("The Vertical Acre") shows no apparent columnar cooling joints at all.

This pattern can be expected to hold true throughout Tasmania, and implies that the central parts of large dolerite intrusions, and near feeder pipes, are the areas most prospective for dolerites with very wide, or no, columnar jointing.

Dr R.F. Berry (*pers. comm.* 1990) also notes that regional (tectonic) jointing does not form as readily in distinctly columnar-jointed dolerite bodies as it does in bodies with widely spaced, or no, columns. This is because the tectonic strains are partly absorbed by the existing columnar and sheet joints.

Regional (tectonic) jointing

Joints resulting from tectonic stresses are common in Tasmanian dolerites, and may generally be distinguished from unloading or cooling joints by their directions and patterns of occurrence.

Tectonic jointing results from regional stresses which are expressed on a larger scale by both folding and faulting of rock masses. Folding deformation is negligible or absent in Tasmanian Jurassic dolerites, so that tectonic jointing in the dolerites is related to those regional stress fields which have also produced faulting in the dolerites.

Closely spaced joints occur adjacent to faults (Legge 1967). Such close jointing typically occurs within only about five to seven metres of faults in Tasmanian Triassic sandstones (Sharples 1990). While the zone of close jointing around faults can be expected to extend further in the stronger and more brittle dolerites, it can be expected that the zone will still be localised.

The important relationship between faulting and tectonic jointing appears to be expressed on a more regional scale: the average joint density over reasonably large areas is related to the average fault density over those areas because both the jointing and the faulting are a response to the same regional stress field.

Berry & Banks (1985) found that much of the faulting in the Parmeener Supergroup of SE Tasmania (and also affecting the Jurassic dolerites) could be related to at least two major tectonic episodes:

A major NNW compressional event in the Mesozoic (active before and after the intrusion of the dolerite) established a wrench faulting pattern with strike slip faults striking 100° and 170°, and reverse faults striking NE. A subsequent phase of Early to Middle Tertiary normal faulting produced a horst and graben system, including the Derwent and Tamar Grabens, by E to NE extension, involving re-activation of earlier faults striking 170°. Finally, a Late Tertiary phase of strike slip and reverse faulting, related again to NNW compression, may have affected faults in the Hobart region.

Continuing work (R.F.Berry, *pers. comm.* 1990, publication *in prep.*) has shown that regional variations occur in the density of faulting related to these events.

Berry has measured the Mesozoic faulting in the Jurassic dolerites throughout Tasmania, and has found that the effects are most intense in southernmost and western Tasmania, and decrease in intensity north of Hobart. The least intense Mesozoic faulting occurs in the northeast, from about the Lake Leake area northwards (see Fig. 7.3).

Decreasing Mesozoic fault intensity towards the north and northeast ostensibly provides a neat explanation for the fact that, on a large regional mapping scale, the dolerites and Permo-Triassic sedimentary rocks of the Tasmania Basin are much more intensely disrupted, by larger and more common faults, south of a notional line passing south of Lake Leake (see Fig. 7.3). North of this line, in contrast, large uninterrupted surface outcrops of dolerite are more widespread, and have probably been disrupted by fewer faults, which were of smaller throw (albeit a number of large Tertiary fault movements have occurred in the north of the State).

The Tertiary horst and graben faulting is most intense within the major horst and graben structures (eg, Derwent and Tamar grabens). However there is evidence that the Tertiary faulting had less effect on the jointing of the dolerites within these structures than did the Mesozoic faulting: the present writer has noted widely spaced jointing in dolerites at Launceston, within the intensely faulted Tamar Graben. This may be because the Tertiary tectonic stresses were largely absorbed by such pre-existing Mesozoic tectonic (and cooling) joints as were already present in the dolerite.

So the Mesozoic wrench faulting, which occurred more or less synchronously with dolerite intrusion, and was produced by the commencement of the break-up of Gondwana to the southwest of Tasmania, was the dominant event which has produced tectonic jointing in Tasmanian Jurassic dolerites. The intensity of the Mesozoic faulting drops towards the northeast, so that one could predict that dolerites in the south of Tasmania would be in general intensely jointed, while those towards the northeast would be widely jointed except where cooling stresses have produced locally intense jointing.

Plate 7.3 Widely spaced columnar and sheet jointing in Jurassic dolerite (Campbelltown Quarry, site Bg/Ts/2/1). This joint spacing would be ideal for dimension stone quarrying were it not for the presence of hairline fractures within joint blocks. Note also the effects of blasting (lower LHS).

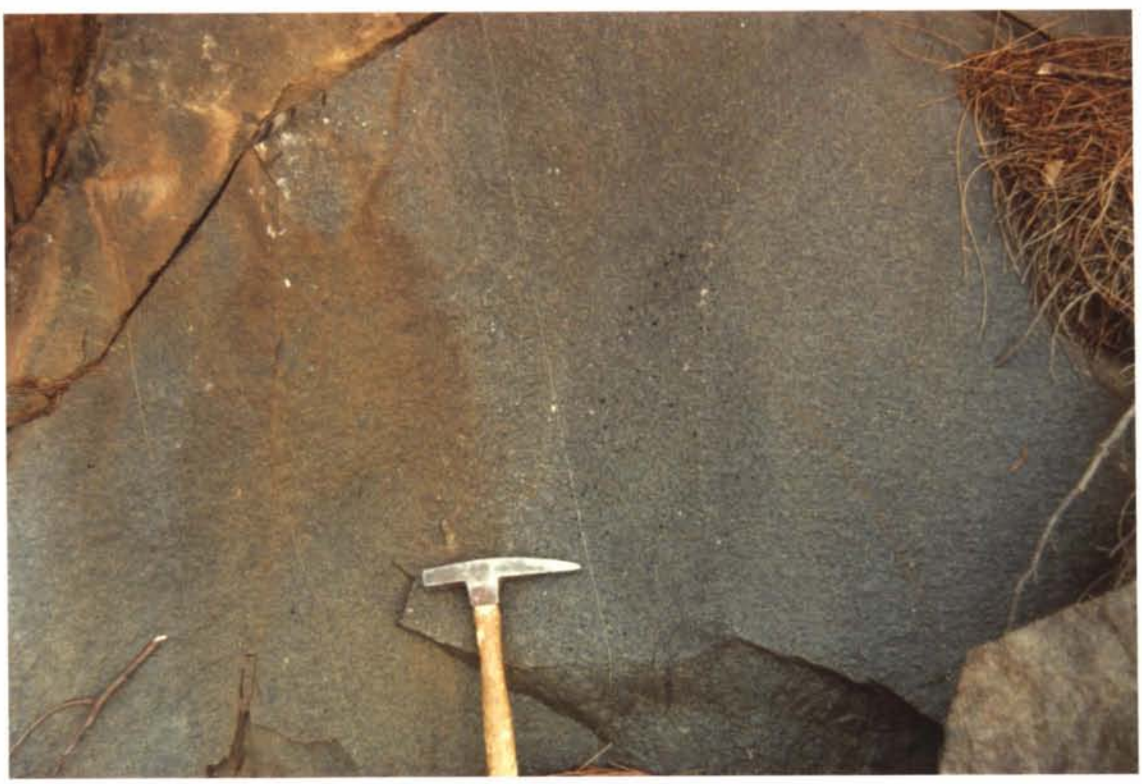


Plate 7.4 Hairline fractures in Jurassic dolerite (Campbelltown Quarry, site Bg/Ts/2/1). Annealled fractures are filled with calcite or zeolites, while an open fracture is visible in the brown-stained patch.

5 cm

Observations made during this project support these predictions very well indeed: south of Campbelltown, most dolerite outcrops observed have had intense multiple-direction jointing, much of it clearly of tectonic origin (with the exception of some very coarse grained, and thus widely jointed, granophyric dolerites in the Red Hill area, near Margate). On the other hand, dolerites with wide (2m+) joint fractures (many of which appear to be cooling rather than tectonic joints) are observed commonly north of Campbelltown (see also "Prospective Regions" below).

Fine ("hairline") fractures

However, a particularly insidious problem with Jurassic dolerites, including many of those widely jointed outcrops observed in the north and northeast of the state, is the presence of very fine hairline fractures occurring within the large blocks formed by the main joint breaks (see Plate 7.4). These fine fractures may be planar to somewhat irregular in shape, and may extend from only a few centimetres to a metre or more in length. They may be very difficult to see on weathered (or even freshly broken) outcrop surfaces, but show up distinctly on polished slabs.

These fractures constitute an unacceptable weakness in many otherwise widely jointed dolerites such as some of those in the Launceston and Nunamara areas (J.Dunn, *pers. comm.*). In many cases where they have been observed, they were the only defect preventing the outcrops in question from being considered as highly prospective dimension stone quarry sites.

The origin and nature of the fine hairline fractures is presently unclear; they may be either a tectonic or perhaps a cooling phenomenon. Whilst fine fractures in the dolerites are in some cases annealled with white minerals (zeolites or calcite, see Plate 7.4), in most cases they are relatively clean and show fairly unaltered edges, in contrast to the larger Mesozoic tectonic and cooling joints, which are usually more or less coated with ferruginous and other minerals. This suggests a relatively recent age; one possibility worth investigating is that while the major phase of tectonic jointing of the dolerites took place in the Mesozoic, these finer and cleaner fractures may represent fracturing which took place during either the Early-Mid Tertiary or ?Late Tertiary tectonic events mentioned above.

As suggested above, the major Mesozoic and cooling joints in the dolerite may have absorbed most of the Tertiary tectonic stresses, so that the only net physical effect within pre-existing dolerite joint blocks was a more subtle hairline fracturing. If so, this suggests that the hairline fracturing will be most prevalent within the Early - Middle Tertiary horst and graben structures, and perhaps in areas thought to have been affected by the Late Tertiary compressional event.

Since they cause a major problem in many otherwise excellent dolerite deposits, a better understanding of their nature may greatly assist in the location of a viable dolerite dimension stone quarry. Detailed field observations over a wide area would allow testing of the hypothesis suggested above.

Other features of Tasmanian Jurassic dolerites

Sulphide minerals such as pyrite are present in some deposits as disseminated grains; such deposits should theoretically not be used for ornamental purposes since oxidation of the sulphides will produce brown streaks. However, polished South African dolerite slabs on the Myers building (Hobart) contain sulphide grains, and yet have not caused significant staining despite several decades exposure.

Spry (*pers. comm.* 1990) suggests that if pyrite in stone is fresh and unweathered when quarried it will be much slower in breaking down than if it is already partly altered when quarried. Thus, a small pyrite content in essentially unaltered dolerite may not be detrimental. A good test of incipient alteration in dolerite would be to check for the presence of chlorite in the mesostasis (see p. 163).

Thin veins of calcite and zeolites are commonly present in Tasmanian Jurassic dolerites, and must be avoided due to their physical weakness and chemical instability.

Summary: Exploration models for location of high quality dolerite dimension stone

On a regional scale, it seems clear that the most prospective part of the state for widely-jointed dolerite dimension stone is in the northeastern quadrant, approximately northeast of Campbelltown, in which the Mesozoic wrench faulting and associated jointing was least intense. If the fine hairline fractures commonly found within wide joint blocks in the northeast are indeed related to Tertiary tectonism, then it will also be necessary to avoid the vicinity of Tertiary horst and graben structures in the northeast, and/or areas affected by the possible Late Tertiary compressional event.

In the south of the state, non-columnar jointed dolerite can be expected to be strongly affected by Mesozoic faulting and jointing. Columnar dolerite in the south commonly appears be less affected due perhaps to the absorption of tectonic strains along column joints, but observation of large well-formed columnar dolerites in the south such as the Mt. Wellington Organ Pipes indicates that significant jointing still occurs within the columns.

In the northeast, non-columnar dolerite is likely to be only relatively mildly affected by tectonic jointing , while widely-columnar jointed dolerite might hopefully be even less affected by tectonic jointing due to absorption of tectonic strains along column joints.

The major exception to this regional guideline is that major dolerite feeder structures in the more southerly parts of the state may, in virtue of having relatively coarse grainsizes, be less affected by tectonic jointing. This may apply especially to granophyres which are relatively coarse-grained and considered by Leaman (1975) to occur near feeders. Wide joint spacing has been noted in some coarse granophyric rocks (granophyres plus coarse transitional Upper Zone dolerites)at Red Hill, well south of Hobart in the zone of intense Mesozoic faulting and jointing.

Beyond this regional exploration key, the search for dolerites of appropriate texture, colour and joint spacing depends on the characteristics of the individual dolerite bodies, each of which must be considered on an individual basis.

Relatively thin dolerite bodies commonly contain closely spaced platy or other cooling joints throughout their thickness. Therefore the most prospective dolerite bodies will be those thick (>100m or so thick) and laterally extensive sills in which widely spaced sheet and columnar cooling joints can be expected to occur away from the upper, lower and side marginal contact zones. Best of all may be thick dolerite sheets adjacent to large feeder pipes, where cooling was most prolonged and columnar or sheet jointing may be very widely spaced to almost non-existent (such as at "The Vertical Acre" near Fingal; see Plate 7.5).

Although the fine-grained dolerites characteristic of intrusion margins have an excellent dark "black granite" colour and texture, it is annoying that such fine-grained dolerites are characterised by closely spaced marginal platy jointing, making them quite unsuitable for working as dimension stone.

An example is specimen Bg/Tn/7/1/1, a fine-grained dolerite from west of Horseshoe Marsh (Fingal Tier region), which is probably part of the contact zone of a dolerite sheet. This specimen polishes very well indeed, yielding attractive and very dark black polished surfaces. The outcrop is plagued by large scale platy jointing.

While some outcrops have been noted in which apparent platy joints are up to 100mm apart, so that slabs of that thickness might be obtained for veneer slabs, in most cases closer examination reveals the presence of much closer spaced incipient platy fractures within the slabs.

In regard to colour and texture within those inner portions of large sills where widely spaced cooling joints can be expected, three characteristic types of dolerite are available (not counting granophyre), all of which may potentially be of interest for dimension stone work:

1) The darkest and most finely-grained wide-jointed dolerites available will be the fine to medium grained pyroxene-rich dolerites derived from the "Lower Zone" of McDougall (1964; see above). In the example of the Fingal Tier dolerite sheet, this Lower Zone occupies the lower 100 metre thickness of a 400 metre (+) thick sill whose upper part is no longer preserved.

   A probable lower zone specimen polished during this project (Bg/Tn/1/1/1) yielded a very dark black polish, with no notable pitting or other flaws (see Plate 3.10). Unfortunately, this particular specimen came from within the Tertiary Tamar Graben, and the outcrop had an unacceptable amount of fine hairline fracturing.

2) The volumetrically dominant widely-jointed dolerites in thick sills are the lightest-coloured and coarsest-grained: the silicic, medium-grained dolerites of the Central Zone of McDougall (*Ibid.*).

Both the Lower and Central Zone dolerites are uniformly even-grained "black granites" free of igneous foliation, layering or segregations.

3) However, it is possible that interesting widely-jointed dolerites with segregations of varying grainsize and colour, and with veins of pegmatitic dolerite, could be obtained from the Upper Zone. Widely jointed dolerites of such a description occur marginal or transitional to granophyres at Red Hill (site Bg/Ts/3/2), and were considered potentially attractive by the present writer.

In summary, the most prospective location for dark, widely jointed dolerite will be within the Lower Zone of thick, laterally extensive dolerite sills in north-eastern Tasmania (and probably away from Tertiary Horst and graben structures). The areas with the most widely spaced cooling joints will be those well away from the lateral margins of sills, and adjacent to major feeders, although it is possible that the presence of some well-formed but widely spaced cooling joints may be desirable in that they may have lessened the prevalence of tectonic joints within cooling-joint blocks, by having absorbed tectonic stresses along the cooling joints.

In contrast, granophyres (and associated rocks), being both relatively coarse-grained and probably associated with feeders, have the potential to be relatively widely jointed wherever they are located. Exploration for granophyres ought therefore to concentrate on locating the largest possible bodies (which will always be near the upper contact zone of dolerite bodies, and probably adjacent to feeders), in any accessible locations, which should then be carefully assessed for indications of incipient weathering alteration (to which they are prone).

Prospective regions
Good dolerite exposures are common throughout Tasmania, as road-cuttings, road-metal quarries and cliffs. Literally hundreds of such exposures were briefly examined during this project, in all regions of Tasmania.

As predicted by the above discussion of jointing, the vast majority of these outcrops in regions approximately south of Campbelltown are closely jointed (av. 0.1 - 0.5m horizontal spacing between open joints), and are often deeply weathered due to the close jointing. Such outcrops can be immediately seen to be unsuitable as sources for dimension stone blocks and veneer slabs, and in most cases were not specifically recorded in the data base compiled during this work.

The following comments refer to areas in the north - northeast of the state where the Mesozoic faulting and jointing responsible for tectonic jointing in the dolerites is least intense (see Figure 7.3).

<u>The Central Plateau</u>
The Central Plateau is capped by a thick and extensive dolerite sill which was examined at a reconnaissance level during this project (areas Bg/Tw/1,2 & 7, and Bg/Ts/1). Throughout the northern, northeastern and eastern parts of the plateau surface, close platy jointing is prevalent, in association with major joints spaced an average of 0.5m apart. Rare 1-2m diameter joint blocks were noted, but these only occur sparsely and the presence or absence of fine hairline fractures was not determined. It seems probable that much of the plateau surface is close to the original upper margin of the sill, and is thus unprospective due to the widespread occurrence of platy cooling joints (although the coarser Great Lake granophyres described by McDougall (1964) may well be prospective; see discussion above).

While more widely spaced cooling joints could be expected to be exposed in Central or Lower Zone dolerites on the slopes of the escarpment bounding the plateau, the escarpment also approximately marks the zone of Tertiary faulting which formed the major Central Plateau horst block (Colhoun, *in* Burrett & Martin 1989,p.405). It is therefore likely that Tertiary fracturing is prevalent on the escarpment.

Large (1-3m diameter) well formed columnar joint blocks are well exposed in canals above Waddamana, on the southern slopes of the plateau (at grid ref. DP808420, area Bg/Tw/7). However, this site is likely to have been significantly influenced by Mesozoic faulting, and the columns are observed to contain multi-directional joint fractures spaced an average of 0.5m or less apart.

<u>Devonport - Launceston - Nunamara region</u>
Outcrops of dolerite having wide (1 - 3m) joint spacings occur commonly in the Devonport - Launceston - Nunamara regions (areas Bg/Tn/1, 2 & 5). This is predictably in accord with their location in the north of the state, in an area of low Mesozoic fault intensity (see Figure 7.3). Examples of these widely jointed dolerites can be seen at Cataract Gorge, in a small quarry just west of Nunamara (site Bg/Tn/2/1, grid ref. EQ23551595), and on the Midlands Highway just south of Launceston (site Bg/Tn/1/1, grid ref. EQ129068). A specimen from site Bg/Tn/1/1 yielded an excellent dark black polish (Plate 3.10).

However, wherever these dolerites were closely examined (eg, at the Nunamara and Midlands Highway sites), they have been found to contain an unacceptable density of fine hairline fractures, often hard to discern on weathered surfaces, which are typically spaced 0.5m or so apart.

The Devonport - Launceston - Nunamara areas are within or immediately adjacent to the Tertiary faulting structures of the Tamar Graben and the Devonport - Port Sorell Sub-basin. As previously suggested, it is possible that the fine fracturing observed is a result of faulting within these structures; in any case, unacceptable hairline fractures are prevalent with the ostensibly widely-jointed dolerites of the region, causing the prospectivity for high quality dolerite dimension stone to be lowered.

Tasmanian Hardrock Pty Ltd applied for an Exploration Licence (EL 10/90) over Jurassic dolerite near Bell Bay in early 1990. This area is within the Tamar Graben.

Douglas River - Snow Hill - Lake Leake - Tooms Lake region

A huge area of continuous dolerite outcrop occurs in the Midlands to east coast area of Tasmania, extending from north of the Douglas River south to Orford and beyond. South of a line approximately joining Swansea - Lake Leake - Campbelltown this area is considered likely to be unprospective due to increasing Mesozoic fault and jointing intensity (see Fig. 7.3) and was not examined during this project, except along the Tasman highway south of Swansea, where close jointing predominates (average joint spacings: 0.1 - 0.3m). Further reconnaissance inland south of Lake Leake and away from the Tertiary east coast Oyster Bay Graben may be warranted.

From Lake Leake north to the Douglas River (area Bg/Tn/6), reconnaissance exploration was conducted along the main roads only (Lake Leake Rd B34; Old Coach Road C301 from Cranbrook to Royal George; and McKays Rd (M Rd.) from Lake Leake to the Upper Apsley River). Scattered patches of intense platy jointing were noted throughout the area, but are less prevalent than in the Fingal Tier area further north (see below). The dominant jointing style in the region is close (0.1 - 0.5m spacing) multi-directional open iron-oxide lined jointing of probable tectonic origin.

However, the reconnaissance exploration revealed the existence of isolated patches of dolerite having relatively wide (1 - 2m spacing) joints. Examples of such patches occur on McKays Rd. between The Cygnet and Upper Apsley Rivers, north of Apsley Myrtle Forest Reserve, and near the junction of the Old Coach Rd. and McKay's Rd (grid ref. EP845648). The widely jointed patches appear to be laterally restricted, with closely jointed outcrops being observed nearby, and the presence or absence of fine hairline fractures could not be determined due to the ferruginous weathering surfaces of most of the outcrops.

Despite the restricted extent of the widely jointed outcrops which were located in this brief reconnaissance, their presence indicates that more detailed exploration in the area may be worthwhile.

A regional, qualitative, provisional geophysical survey (Leaman & Richardson, Fig. 5, *in* Threader & Bacon 1983) has suggested the location of thicker dolerite sheets in part of the Snow Hill region. This data will be of assistance in location of outcrops having widely-spaced cooling joints (see discussions of exploration models elsewhere in this section).

The Snow Hill region appears highly prospective in terms of regional joint patterns: it it well towards the north-eastern zone of low Mesozoic fault intensity, and lies inbetween the Tamar/Midlands Tertiary Graben to the west and the east coastal zone of Tertiary faulting (the Oyster Bay Graben).

The Snow Hill region is however affected in part by a major faulting structure of possible Tertiary age, which is dominated by two major N-S trending parallel faults which extend from the Castle Carey Fault (S. of Ben Lomond) and pass west of Royal George, through Lake Leake and well south towards Tooms Lake (J.L. Everard *pers. comm.* 1990, Snow Hill 1:50,000 Geol. Sheet, *in prep.*).

This major structure is likely to affect the jointing of dolerites in it's regional vicinity, but there is still a large area, particularly west of the Castle Carey structure and east of the Tamar/Midlands Graben, which is likely to have very low tectonic faulting and jointing densities. This area can be considered highly prospective on the basis of current knowledge, and it is recommended that exploration be conducted in the area using local exploration models similar to that discussed below for the Fingal Tier area.

The possible potential of this region is suggested by an outcrop located at it's western extremity:

This outcrop consists of two adjacent abandoned road metal quarries 6.5km east of Campbelltown along the Lake Leake road (site Bg/Ts/2/1, grid ref. EP471563). Strong vertical columnar joints in the quarries are spaced an average of 1.5 - 2.0 metres apart, with horizontal sheet joints spaced 2 - 3m vertically apart (see Plate 7.3). Such joint blocks would be an ideal size for dimension stone quarrying.

Fine planar white (zeolite or calcite filled) fractures are sparsely present within the joint blocks, as are clean planar to somewhat irregular hairline fractures (see Plate 7.4). Although the concentration of fine fractures in the quarries is probably excessive for dimension stone, careful examination of some relatively unweathered broken surfaces failed to reveal any hairline fractures over distances of 1 - 2 metres horizontally.

The dolerite in the quarries is a uniformly medium-grained, even textured rock of medium dark grey (N4) to medium bluish-grey (5 B 5/1) colour (see Plate 7.1), and potentially a very attractive polished "black granite".

Fingal Tier and surrounding region

In terms of regional tectonic jointing patterns, the Fingal Tier region is potentially amongst the most prospective regions of Tasmania for widely-jointed dolerites. The dolerites on Fingal Tier and the adjacent Mt. Nicholas region are, apart from a few restricted mountain-top dolerites north of Mathinna and low-lying dolerites at Cape Portland, the most north-easterly Jurassic dolerites outcropping in Tasmania. They are thus potentially the least affected by Mesozoic jointing, and are also well outside the Tertiary Tamar Graben (although Fingal Tier is affected by some faulting which may be an extension of the Tertiary east coast Oyster Bay Graben).

Since the Fingal Tier dolerite Sheet is also over 400 metres thick in parts, with an already-identified dark pyroxene-rich "Lower Zone" (Calver, *in* Turner & Calver 1987), laterally very extensive, and contains several large feeder structures (see below), it is highly prospective in terms of all the exploration guidelines discussed above.

Reconnaissance exploration on the Fingal Tier plateau surface (area Bg/Tn/7) during this project revealed a predominance of closely spaced platy jointing.

However, two lines of preliminary evidence suggest that very widely jointed dolerites of dimension stone quality may indeed be found in the region:

1) A Tasmanian Mines Department gravimetric survey (Leaman & Richardson 1981) identified a major feeder structure in the Fingal Tier Sheet south of Fingal township. The thick dolerite sill adjacent to this feeder outcrops boldly on the Fingal Tier escarpment immediately south of Fingal in the form of a large cliff known as "The Vertical Acre" (see

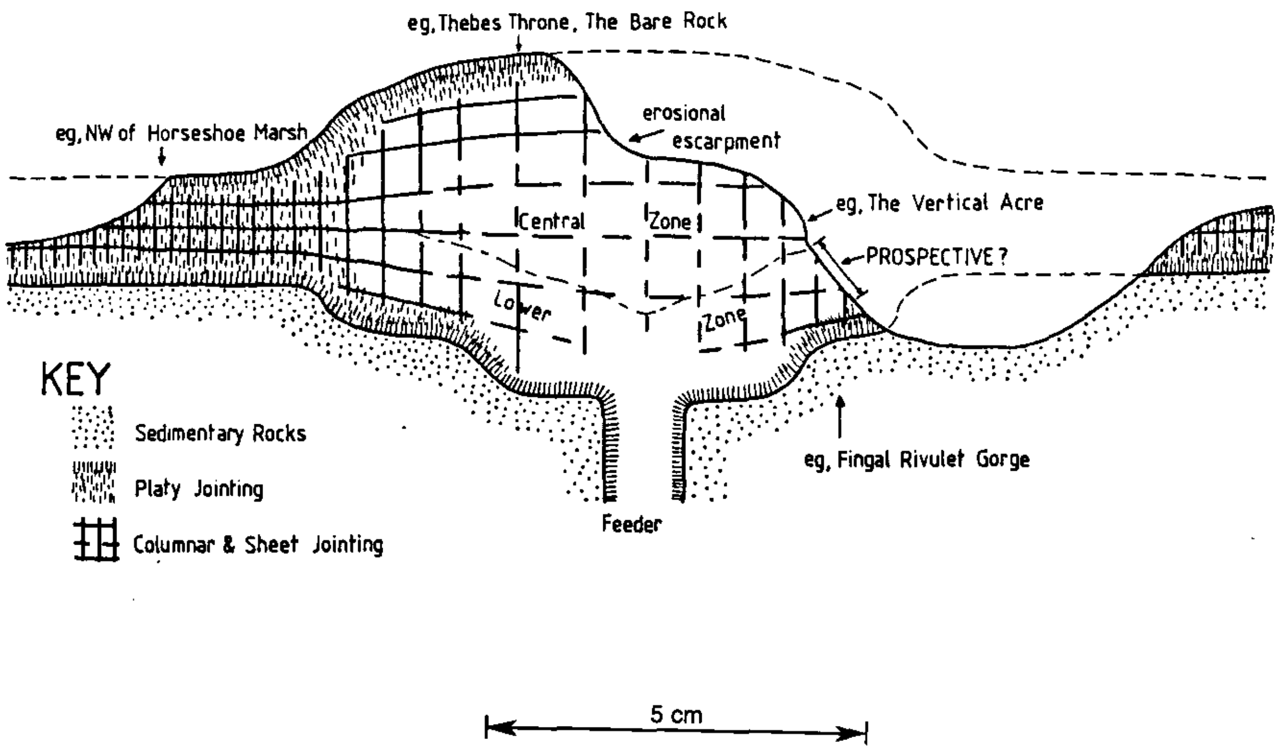
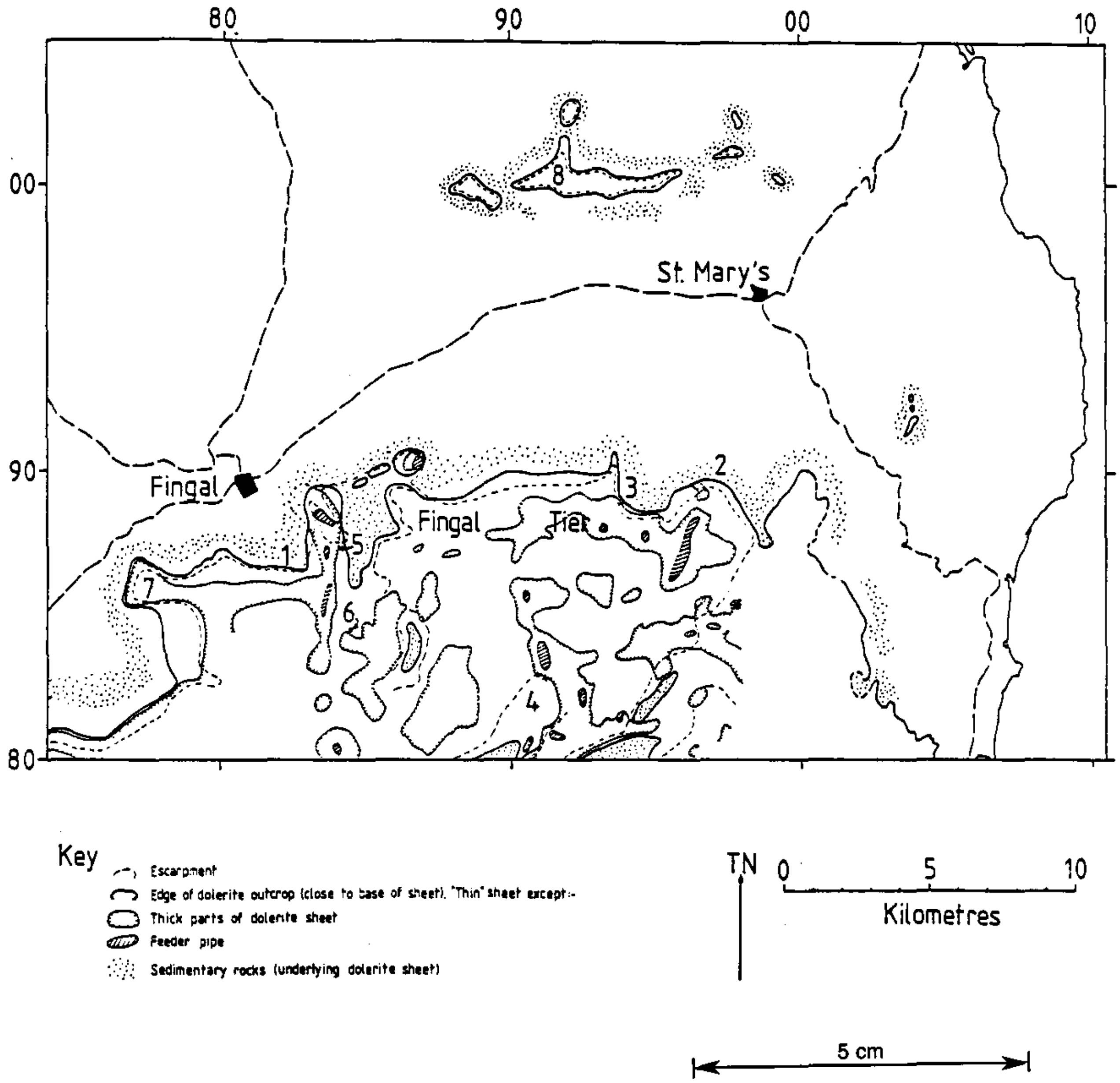


Figure 7.5 Exploration model for wide (cooling) jointed dark Lower Zone dolerites in the Fingal Tier region. Expected variation in cooling-joint distribution and spacing indicated diagrammatically through idealised feeder/thick sheet/thin sheet dolerite intrusion. Influence of tectonic jointing not indicated.

Due to the similarity of Jurassic dolerite structure and petrology throughout Tasmania, this model is probably applicable state-wide.



Key to numbered locations:

1 The Vertical Acre
2 The Bare Rock
3 Thebes Throne
4 Horseshoe Marsh
5 Fingal Rivulet Gorge
6 Dept. of Mines Drill-hole no. 75
7 Mt. Edgecumbe
8 Mt. Nicholas

Figure 7.6 The Fingal Tier Jurassic dolerite sheet. Outcrop boundaries from Turner *et al.* (1984). Dolerite feeders and thick sheets from gravity-magnetic interpretation (Leaman & Richardson 1981, Fig. 30, and Leaman & Richardson *in* Threader & Bacon 1983, Figs 5 & 13).

Plate 7.5). The Vertical Acre is completely free of columnar jointing, and apart from a few large inclined, and widely spaced, tectonic joints, and some discrete zones of closely spaced jointing, its smooth bare surface gives no indication of close jointing, in contrast to strongly jointed outcrops several hundred metres either side of the cliff.

2) A number of Mines Department boreholes on Fingal Tier encountered large thicknesses of very widely jointed dolerite - so widely jointed in fact that during drilling, the cores were sometimes artificially broken to allow removal of the core barrel from the hole (C.Bacon & V. Threader, *pers. comm.*). In particular, one of the boreholes in which very wide jointing was encountered was hole 75 (Dept. of Mines Drill Logs), which was drilled through the edge of an area indicated by geophysical surveys (see Fig. 7.6) to be a substantially thicker dolerite sheet than the surrounding region.

Due to the presence of significant coal measures in the Triassic sedimentary sequences of the Fingal region, the Fingal Tier dolerite sheet has been studied in some detail by means of surface mapping, drilling, and geophysical surveys (Leaman & Richardson 1981, Threader & Bacon 1983, Turner *et al.* 1984, Turner & Calver 1987).

This data base provides an excellent basis for locating dimension stone prospects in the Fingal Tier dolerite sheet using the exploration models outlined earlier in this discussion. The most promising exploration targets for dark-coloured, massive, widely (columnar) jointed dolerites appear to be in locations where erosion has exposed the Lower Zone of thick dolerite sheets close to feeders and well away from lateral margins or thin portions of the sheets (where platy and close columnar jointing may predominate). This exploration model is illustrated in Fig. 7.5.

Major feeder pipes and significantly thickened parts of the dolerite sheet have been mapped by gravity and magnetic surveys (see Fig. 7.6), while major escarpments exposing the Lower Zone within or adjacent to these feeders and thick sheets have been located by surface mapping (indicated on Fig. 7.6, see Turner *et al.* 1984).

A number of areas on, below or near Fingal Tier fit the proposed exploration model and are therefore regarded as prospective. Such areas include:

The Vertical Acre	The widely jointed dolerites exposed in The Vertical Acre would be unquarriable for both practical and environmental (aesthetic) reasons. Furthermore, the only way to closely examine the outcrop for fine fractures would be by means of technical rock-climbing or long abseils!
Fingal Rivulet Gorge	However, bold and apparently widely jointed (probable Lower Zone) dolerites in a thick sheet with adjacent feeder pipes outcrop nearby at around Grid Ref. EP840875 in the Fingal Rivulet Gorge. This site is currently reached by following the Fingal water supply road and then continuing up the gorge on foot. Whilst the gorge may not be quarriable for both practical and environmental reasons, the site is close to Fingal and would provide a good test of the exploration model.
Thebes Throne/Bare Rock	Lower Zone dolerites probably outcrop towards the base of the escarpment from west of Thebes Throne to below Bare Rock, and are adjacent to a feeder/thick sheet complex.

Plate 7.5 "The Vertical Acre", Fingal. Part of a thick dolerite sheet adjacent to a large feeder complex. Very wide jointing in the lower central part of the cliff contrasts with close jointing either side of the face.

Plate 7.6 Miena basalt quarry (site Bg/Tw/5/1), showing very wide basalt columns.

Mt. Edgecumbe	The escarpment from Mt. Edgecumbe south is eroded into a thick sheet, towards the base of which Lower Zone dolerites are likely to be exposed.
Horseshoe Marsh area	The escarpment of the hills immediately north and south of Horseshoe Marsh (at around Grid Refs EP910830 & EP915815) exposes a thick sheet adjacent to feeder pipes. Horseshoe Marsh is close to the base of the sheet so that Lower Zone dolerites are probably exposed on these escarpments. The escarpment SW of Horseshoe Marsh at around Grid Ref. EP885805 also exposes a thick sheet close to it's basal contact.
Upper Fingal Rivulet	At around Grid Ref. EP855835, a thick sheet is exposed above underlying sandstones. The Lower Zone probably outcrops, and this is the thick sheet adjacent to which the widely jointed dolerites in Drill-hole 75 were found.
Mt. Nicholas	Bold outcrops of apparently widely jointed dolerite occur near the summit, so that this region may also be prospective. However, the absence of positive gravity anomalies (Calver, *in* Turner & Calver 1987,p.87) suggests that feeder pipes are not present below Mt. Nicholas, so that the dolerite is the remanent of a downwards transgressing sheet of unknown original thickness.

Further prospects fitting the proposed exploration model occur in the Fingal region, and can be located in the same manner as those above, using the same geological and geophysical data base.

A number of faults on Fingal Tier have been inferred from geophysical data (Leaman & Richardson *in* Threader & Bacon 1983). These have not been indicated on Fig. 7.6, since it is considered that some of them may not be faults in the dolerite, but basement structures or up-down steps in the dolerite sheet (Leaman & Richardson *Ibid.* , C.A.Bacon *pers. comm.* 1990).

However, at least some of the inferred faults are undoubtedly real tectonic faults affecting the dolerite, and Leaman & Richardson (*Ibid.*) note that the inferred faults include at least two large grabens. This faulting is possibly Tertiary faulting associated with the east coast Oyster Bay Graben, and could therefore potentially be responsible for tectonic jointing and/or fine fractures within dolerites having otherwise widely-spaced cooling joints. It is to be hoped that any such tectonic fracturing will be less prevalent in dolerites having widely spaced, well-formed cooling joints which may have absorbed some of the tectonic strains exerted during the faulting.

The jointing in the dolerite cored during Dept. of Mines drilling was logged in some of the holes drilled on Fingal Tier (C.A. Bacon, *pers comm.* 1990, Drilling Records, Tas. Dept. of Mines). It would be useful, in the initial stages of a dolerite dimension stone exploration program, to review the drilling data for holes cored in regions considered prospective for widely jointed dolerites. The locations, and microfiche records of the logged drill-holes, are given in Threader & Bacon (1983). Registers of drilling records may be viewed at the Tasmanian Department of Resources and Energy.

Underground exposures of thin dolerite dykes in the Duncan Colliery (below Fingal Tier) are unlikely to provide useful jointing information since the underground workings do not intersect any part of the actual dolerite sheet.

Dolerite outliers north of Fingal
A number of isolated mountain-top remanents of Jurassic dolerite sills occur north of Fingal, mostly within the Alberton Quadrangle (currently being mapped by the Geological Survey of Tasmania). These outliers include Tower Hill, Ben Nevis, Mt. Saddleback, Mt. Blackboy, Mt Victoria, Mt. Albert and Mt. Young.

These outliers are of interest in that they lie in the far northeast of the state, where Mesozoic jointing was least intense, and they may also be relatively unaffected by Tertiary jointing since they lie outside the major Tertiary horst and graben zones.

No information on these outliers is currently available to the writer. They may be of interest, although in some cases their mountain-top locations may make them undesirable quarry prospects from an environmental and a practical point of view.

Low-lying Jurassic dolerites in the extreme northeast of Tasmania, around Ringarooma Bay, have ubiquitous closely spaced "slabby" (ie, platy) jointing (McClenaghan *et al.* 1982, Baillie 1986). The dolerites appear to be exposures of the upper and lower contact zones of several dolerite sheets (Baillie, *in* McClenaghan *et al.* 1982,p.89).

NW Tas. - Campbell Range (Quarry Prospect)
In 1989, Mineral Holdings Aust. Pty. Ltd. took out a stone lease (14 M/89) on an area of Jurassic dolerite at Campbell Range, north of the Arthur River (site Bg/Rb/14/1, at grid ref. CQ72254380). The dolerite outcrops well on the crest of a ridge, in an accessible and easily quarriable location. However, several sets of strong parallel tectonic joints are present throughout the outcrop area, with maximum spacings of approximately 0.5 metres. These render the stone quite unsuitable as a source of dimension stone.

Southern Tasmania (Lune River)
Basalt

PROSPECTIVITY - Low

A basalt exposed near Lune River is considered to be of Jurassic age (Williams, *in* Burrett & Martin 1989,p.493), and as such is the only known location in Tasmania where the widespread Jurassic dolerite magma reached the surface.

The Jurassic basalt is well to the south of Tasmania, in the region where the Jurassic dolerites were most intensely affected by Mesozoic faulting (see tectonic faulting discussion in "Jurassic Dolerite" above). This, together with the fine-grained nature of the basalt, suggests that it will have intense tectonic jointing. The basalt was not examined during this project.

TERTIARY

BASIC ROCKS
All Regions
Basalt flows

PROSPECTIVITY - High

Tertiary-age basalt flows are widespread in Tasmania, although less volumetrically significant than the Jurassic dolerites. Major deposits occur in the Hobart - Derwent Valley - Central Plateau region, northwestern and northeastern Tasmania, and in the Midlands to Devonport area.

The Tertiary basalts consist of uniform, massive, fine-grained dark black flows of varying thickness, interlayered with more easily eroded pyroclastic tuffs and flow-foot breccias. The massive basalts, when unweathered, are very dense and strong, and polish to a uniform dark black colour, in some cases containing subtle dark brown grains 1-2mm in diameter (see Plate 3.10). Macroscopic vesicles and amydules are present in some deposits, but a more insidious problem is the presence of microscopic vesicles which inhibit the stone from taking a good polish.

The onshore basalts range in age from Palaeocene (Early Tertiary, 59 million years old) to Late Miocene (Late Tertiary, 8 million years ago), with the peak of vulcanism occurring in the mid-Tertiary (Sutherland & Sutherland *et al.*, *in* Burrett & Martin 1989,p.383 - 398).

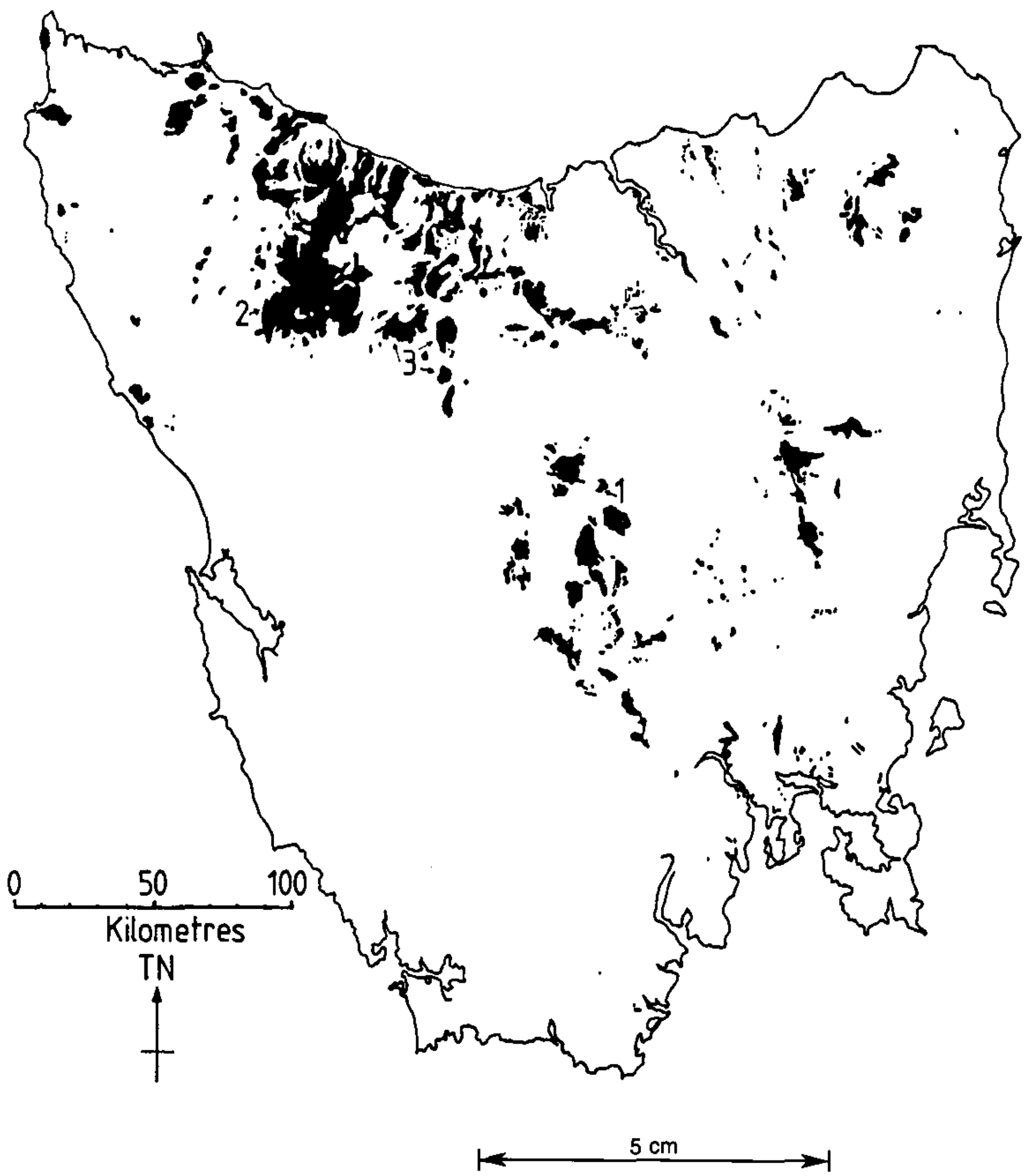
At first sight the relatively young age of the basalts could be taken to suggest that there is potential for deposits with less tectonic joint fracturing than is the case with older deposits; however, the fine-grained nature of the stone conversely makes it more susceptible to developing close open jointing from tectonic stresses than is the case with coarser rocks such as dolerite (Legge 1967).

Although the basalts have in some cases intruded along Tertiary faults (Sutherland *et al.*, *Ibid.*), they were erupted significantly after the peak of the Early to Mid-Tertiary faulting which produced the major Tasmanian horst and graben structures (Sutherland, *Ibid.*). While faults displacing basalts can be seen in some exposures, these do not represent substantial movements (*Ibid.*).

Although the basalts have therefore escaped the major phase of Early-Mid. Tertiary faulting and jointing, Davidson *et al.* (1984) have recognised re-activation of Early-Mid Tertiary extensional faults (as strike slip and reverse faults) in Bass Strait during the latest Eocene to Recent, with most activity in the Mid-Miocene. Berry & Banks (1985) suggest similar re-activation should have occurred in the Hobart area (Derwent Graben), and it is to be expected that this would apply to other onshore Early-Mid. Tertiary extensional fault zones.

Thus the Tertiary basalts have probably been subjected to continuing tectonic stresses, particularly within the major Tertiary graben (and horst?) zones. Whilst this later tectonic activity appears to have been insufficiently intense to produce major faulting in the basalts (Sutherland, *above*), it would have produced tectonic jointing and fracturing in the fine-grained basalts.

The youngest basalts would be least affected by this tectonic jointing. Sutherland *et al.* (*in* Burrett & Martin 1989,p.386-398) note that the oldest basalts (59 - 46 Ma) occur in eastern Tasmania, while the youngest (16 - 8 Ma) occur in western Tasmania, near the north



Key to Numbered locations:

1 Miena basalt quarry (Central Plateau)
2 Guilford - Waratah - Hampshire region
3 Middlesex - Emu - Borradale Plains regions

Figure 7.7 Distribution of Tertiary basalts in Tasmania.

coast. Some of these young basalts probably post-date the Mid-Miocene peak of re-activated faulting in the Bass Basin (Bass Strait), and since they also occur outside the Tertiary extensional zones (Bass Basin, Devonport-Port Sorell Sub-basin, etc), are likely to be as little affected by regional tectonic jointing as any Tertiary basalts in Tasmania.

As with Jurassic dolerite (see above), columnar jointing occurs in basalt (formed during cooling of basalt lavas), and is likely to be widest-spaced (or absent) towards the central parts of large and thick basalt flows where cooling of the lava was slowest (see Plate 7.6). Sutherland (*in* Burrett & Martin 1989,p.383 - 386) notes that some thick (50-180m) flows cooled slowly enough to develop marked changes in coarseness and texture. The largest (and possibly thickest) volume of basalt occurs in the laterally very extensive basalt sheet in NW Tasmania (Burnie - Guilford) (*Ibid.*). Although this sheet is composed of a succession of thinner individual extrusions (Everard, *in* Seymour 1989), some very wide cooling columns are already known to be present (see below).

The relative "youth" of the Tertiary basalts also implies that there has been less opportunity for diagenetic processes to cement open joints and fill vesicle cavities with durable mineral cements, as has occurred in Cambrian basalts at Smithton for instance.

The occurrence of non-annealled joint breaks, together with open vesicle cavities and soft amygdule fillings, cause problems in in the use of Tertiary basalts as polished dimension stone. Everard (*in* Seymour 1989,p.33) has identified carbonates, zeolites and the swelling clay smectite in amygdules in the Tertiary basalts of the Guilford region.

Although large macroscopic vesicles are easily detected and avoided, the basalt quarried near Miena by J.Dunn for use as polished slabs was found to polish dully in parts, apparently due to the presence of discrete patches or "pipes" of microscopic vesicles. (Ultrasonic Pulse Velocity measurements on slabs of the Miena basalt conducted by the present writer yielded lower velocities in the dull-polishing areas, suggesting the influence of microscopic cavities).

Field identification of microscopic vesicle patches is probably impossible, since visual inspection of fresh quarry faces in the Miena basalt gives no indication of their presence. Sutherland (*Ibid.*) notes that vesicles and vesicle "pipes" are common in basalts of saturated composition. This suggests the possibility that exploration for basalts free of microscopic vesicles should concentrate on undersaturated basalts.

However, Sutherland *et al.* (*Ibid.*) note that, statewide, there is a progressive dissappearance of more saturated basalts towards the southwest. This information may not be of great assistance in exploration, since available data (see above) suggests that the best basalt dimension stone in terms of tectonic and cooling jointing is likely to occur in the large northwestern basalt flows.

Possibly a more useful key to the location of basalts free of microscopic vesicles is the distribution of vesicles within individual flows:

Since vesicles in basalt flows form by the release and expansion of gases as the pressure on the lavas is released during extrusion, large macroscopic vesicles form on the tops of lava flows. Microscopic vesicles can be expected to be a feature of basalts which have solidified deeper within the lava flows. It is possible that microscopic vesicles may become minor or absent deep within the thicker basalt flows.

However, the basalt sheets are probably composed in most cases of numerous thinner individual flows (eg, *see* Everard *in* Seymour 1989), each of which would develop it's own vesicles when extruded. It is not clear whether Tertiary basalt flows thick enough to be in parts free of microscopic vesicles exist in Tasmania (or, indeed, what the critical thickness would be).

At this stage, it is considered that Tasmanian Tertiary basalts have considerable potential for the location of widely jointed deposits of dark black, fine-grained stone capable of taking a good polish. Should it eventuate that the occurrence of microscopic vesicles inhibiting polishing is a ubiquitous problem, the widely-jointed deposits will nonetheless provide an excellent source of unpolished basalt for use as massive building blocks, large paving tiles (such as are used in Melbourne inner city pavements), and similar applications.

Tertiary basalt prospects

Weathering of Tertiary basalts has given rise in many areas to deep horizons of rich soil supporting some of Tasmania's best agricultural areas. As a result, basalt outcrop in many areas is very poor, making exploration difficult.

In many such areas, the few basalt outcrops which are exposed are found to be broken up by closely spaced open columnar joints, together with other closely spaced joints. This close jointing, which has facilitated the deep weathering of such basalts, is widespread throughout most areas of Tertiary basalt observed during this project.

Elsewhere, the poor basalt outcrop is simply a result of the relative lack of tectonic disruption which has taken place to provide topographic relief conducive to the exposure of basalt sections. The best outcrops of basalt are found in either artificial excavations, or in areas (eg, in NW & NE Tasmania), where river erosion has cut through basalt sheets to produce exposures on valley escarpments.

NW Tasmania - Guilford to Emu/Borradale Plains region

The relatively young and volumetrically huge basalt deposits in the Burnie - Guilford area of northwest Tasmania appear to be most prospective in terms of likely cooling and tectonic joint spacings. As elsewhere, very little surface outcrop is available over much of this region which, especially towards the southern parts, has only low topographic relief. However, a few observed outcrops suggest that widely jointed basalt is indeed present under a relatively thin soil cover in the southern part of the area (Waratah - Guilford - Hampshire). Drilling (Everard, *in* Seymour 1989,p.29) has shown that the basalt reaches thicknesses of over 300 metres, consisting of over 50 individual flows.

The potential prospectivity of the northern part of the region, near Burnie, was not determined during this project, but outcrop is generally very poor and Everard (*in* Seymour 1989,p.29) suggests that the basalt sheet probably thins towards the north.

Natural outcrops at Waratah Falls (site Bg/Dr/10/1, grid ref. CQ771108) have joint spacings varying from 0.1 to over 1.0 metres apart. However, the outcrop contains abundant macroscopic vesicle cavities indicating a flow-top environment. Excavated basalt blocks over one metre in diameter occur in roadworks between Waratah and the Meredith granite contact.

Basalt exposures in cuttings and quarries along the Murchison Highway are predominantly closely jointed (<0.1m spacings). However, a good artificial excavation south of Guilford at the intersection of the Cradle Mountain Link Road and the Hellyer Railway (site Bg/Dr/10/2, grid ref. CP93409872) demonstrates that widely (columnar) jointed basalts occur in the region:

The railway cutting exposes large vertical joint columns ranging from 1.0 to 1.5 metres in diameter under a one to two metre thick soil horizon. The basalt has a uniform massive fine-grained texture, and is dark brownish black (5 YR 2/1) in colour with brown grains 0.5 -

2.0mm diameter scattered throughout the groundmass. It would polish similarly to the "Royburg Black" basalt (see below).

Although rare amygdules ≈10mm diameter are present, the stone would be prospective if it were not for the fact that the large joint columns are plagued by natural multiple-direction fractures, spaced 0.1 metres or more apart.

The presence of such large basalt columns supports the potential of the Guilford region basalt flows. During the late 1980's, the Tasmanian Department of Mines drilled through this basalt sheet in a number of locations, as part of the "Mt. Read Volcanics Sub-basalt Drilling Project". Examination of basalt cores and logs obtained during this project may be a valuable initial exploration tool, in that it may allow determination of fracture spacings and microscopic vesicle distribution through thick sections of the sheet. Thin section examination of basalt core sections using coloured resins, and Ultrasonic Pulse Velocity testing, would allow determination of micro-vesicle distribution through cored sections.

Some results from the Sub-basalt drilling project are presented by Everard (*in* Seymour 1989). He noted that the basalt sheet consists of 50 or more individual flows, most being only a few metres thick, with the thickest measured being 30.7 metres thick. The basalt in the drill-holes is commonly vesicular on a macroscopic scale.

In order to locate potential dimension stone quarry sites, free of close cooling fractures and microscopic vesicles, it will probably be necessary to locate sites in which river erosion has exposed the deeper parts of thick flows within the basalt sheet, although whether any flows will be thick enough to avoid microscopic vesicles is not clear.

Wide columnar joint spacings have also been noted in Tertiary basalt areas to the east of the Guilford region, which have been dissected by river erosion. These areas (the Middlesex Plains, Mt. Claude - Emu Plains area, and probably also the Borradale Plains) are part of the same tholeiitic basalt association as the Guilford area (Sutherland, *in* Burrett & Martin 1989, Fig. 9.26), and so may represent dissected portions of the same extensive basalt sheet.

At Middlesex plains, basalt columns up to 1.0m+ wide have been noted in some outcrops on the Cradle Mountain and Cradle Mt. Link roads. On Emu Plains, south of Gads Hill (at grid ref. DP303961), columns up to 0.9m diameter outcrop which are free of fractures over vertical lengths of up to 1.5 metres. Large basalt cliffs above the Mersey River (east of Gads Hill) suggest wide joint spacings on the eastern escarpment of the basalt plateau, but were not examined closely.

In 1989, Nargun Pty. Ltd. applied for an exploration licence for dimension stone on the Savage River Pipeline road (EL 28/89, grid ref. CQ535205). No details are available, but the site has been previously mapped as Tertiary basalt (Williams & Turner 1973). The area is close to the (prospective) Waratah - Guilford basalt sheet, and may be a dissected portion thereof.

Central Plateau - Miena/Waddamana region

Basalts on the Central Plateau are the only other Tertiary basalts located during this project which have dimension stone potential. These belong to a tholeittic association similar to the Guilford region basalts (Sutherland *Ibid.*), and occur in a central area of the Central plateau Tertiary horst block which is likely to have been little affected by re-activated late Tertiary tectonism.

A large basalt area near Liawanee, west of Great Lake, is very low-lying and has little outcrop. In the St. Patricks Plains area, south of Great Lake, poor basalt outcrops having columns 1.0 -

1.5m in diameter have been noted, but not closely examined. West of Waddamana and the Ouse River, Tertiary basalt covers a large area, but outcrops poorly. Columnar joints 0.1 - 0.5 metres diameter were seen.

However, a basalt area (Bg/Tw/5) just south of Great Lake and east of Miena contains the best Tertiary basalt deposit which has been used for dimension stone production in Tasmania to date. The basalt outcrops in a low (2-5m high) cliff escarpment extending for over 1.0 kilometres E W to the south of Burbury's Creek. The "Royburg Black" basalt has been extracted from a quarry in this escarpment:

Miena Basalt Quarry (Trade name: "Royburg Black")
The Miena Basalt quarry (site Bg/Tw/5/1, grid ref. DP803517, see Fig. 7.7) is held under Stone Lease 1196 P/M, and was quarried by Dunn Monumental Masons P/L in the mid-1980's for the production of polished "black granite" slabs marketed under the name "Royburg Black".

Due to the presence of microscopic vesicle patches which result in dull patches when the stone is polished, the stone is no longer being quarried for this purpose, although cut slabs are still available. There is now some interest in using the stone as unpolished paving slabs, a purpose for which it is well suited.

The quarry is located 200m east of the Lake Highway on freehold land used for grazing, and consists of two faces 2.0 - 5.0 metres high, each about 10 - 15 metres long. The basalt is of uniformly massive, fine-grained texture. The stone is dark brownish-black (5 YR 2/1) in colour, containing up to 40% by volume of dark brown grains 0.5 - 2.0mm diameter scattered throughout. The stone polishes to a pleasing dark black colour in which the brown grains are only subtly discernable (see Plate 3.10). The stone is very strong and fresh surfaces "ring" well when struck with a hammer. Examination of fresh surfaces gives no indication of the microscopic vesicles, whose effect only becomes apparent upon polishing. No macroscopic vesicles or amygdules were noted in the quarry.

The quarry faces are dominated by prominent vertical cooling columns 1.0 - 1.5m in diameter (see Plate 7.6). Within the columns, horizontal fractures are spaced 0.5 - 2.0 metres apart vertically, and very little other fine fracturing was noted. Thus, unflawed blocks of dimensions up to 1.5 x 1.5 x 2.0 metres are obtainable. Considerable reserves are available.

CHAPTER EIGHT

OTHER "GRANITE"

8.1 Definition and description

As used in the stone industry, the term "granite" encompasses hard crystalline silicate rock types capable of taking a polish (as opposed to the "softer" crystalline types such as marble). In practice this generally means igneous rocks (rocks formed by the solidifying of molten magma or lava), a usage which is adopted in this report. Some non-igneous rocks are often included amongst the "granites"; for instance, Wallace (1971) included hard metamorphic quartzites. Although this particular usage is not followed in this report, some metamorphic rocks such as gneiss, granulite and migmatite are here classed as "granites" in the stone industry sense. These are rocks which have undergone extreme metamorphism and recrystallisation to the extent that they have acquired a somewhat granitic texture (and in some cases have actually begun to melt).

"True" granites in the geological sense (plutonic igneous rocks of acid composition, having coarse to medium grainsize) and "black granites" (dark coloured igneous rocks) are important granite types which are covered in separate chapters. This chapter deals with all remaining "granites", which encompass a wide variety of colours, textures and geological types.

(A) Igneous "other granites"

Igneous granites may be volcanic (fine-grained, formed by solidification of lavas at or near the Earth's surface), or plutonic (medium to coarse grained, formed by solidification of magmas at depth below the Earth's surface). Grainsize categories for igneous rocks in general are as follows (Berkman & Ryall 1976):

	Mean grain diameter (mm)
Pegmatitic	>30.0
Coarse	5.0 - 30.0
Medium	1.0 - 5.0
Fine	<1.0

Igneous "granites" can be classified into the following geologically defined categories:

Ultramafic (ultrabasic) rocks
Contain less than 45% silica (Carmichael *et al.* 1974, p.29). Free quartz and feldspars normally absent. Composed essentially of dark ferro-magnesian silicates (Pyroxene, amphibole, olivine, spinel), with minor metallic oxides, sulphides and native metals (Am.Geol.Inst.1962).

Most ultramafic rocks are very dark in colour and are treated in the chapter on "Black Granites". Some, however, can be of a sufficiently distinctive colour as to not be so classified. For instance, some very coarse-grained pyroxenites have a distinct green colour and might be classified in the stone industry as "greenstones" rather than as "black granites".

Basic rocks
Contain 45 - 52% silica, free or combined (Carmichael *et al.* 1974, p.29). Composed of plagioclase feldspar, pyroxene (commonly augite), and usually olivine. Minor amphibole (hornblende) and free quartz may occur, as well as minor accessory minerals.

Basic rocks include basalt, dolerite and gabbro. These types are generally dark in colour, and are discussed under "black granites". However, some basic rocks can be of a sufficienty light or unusual colouration to be classified otherwise. Such varieties include:

Pegmatitic gabbro and norite ("Rhodingite") Norite is a variety of gabbro having dominant hypersthene pyroxene (with augite pyroxene sub-ordinate or absent). Due to their very coarse grainsize, pegmatitic gabbros and norites can have a relatively light and varied colouration.

Anorthosite Classed amongst gabbroic basic rocks, but consisting almost entirely of plagioclase feldspar with only minor pyroxene and/or olivine. Generally light in colour.

Intermediate rocks
Contain 52 - 66% silica, free or combined (Carmichael *et al.* 1974), p.29). Some varieties are of sufficiently dark colour to be classed as "black granites", but many fall into the category of "other granites". Major varieties include:

Diorite - Andesite Diorite is a plutonic rock (volcanic equivalent: andesite) consisting essentially of andesine (plagioclase), hornblende (amphibole) and/or pyroxene. Some diorites may have olivine and are transitional to gabbro (Carmichael *et al.* 1974, p.38).

Quartz diorite (tonalite) - Dacite This group is transitional to acid rocks (granodiorites, rhyodacites). Quartz diorite is a plutonic rock (volcanic equivalent: dacite) consisting of quartz, biotite, hornblende and andesine (Carmichael *et al.* 1974, p.38).

Syenite - Trachyte Syenite is a plutonic rock (volcanic equivalent: trachyte) consisting of potash soda feldspar (sanidine or anorthoclase), sub-ordinate albite-oligoclase, and one or more mafic minerals (hornblende and/or biotite, less commonly augite). Minor amounts of quartz or feldspathoid indicate transitions to granites or nepheline syenites respectively (Carmichael *et al.* 1974, p.39).

Plutonic nepheline syenite (volcanic equivalent: phonolite) contains feldspathoids, potash soda feldspars, and commonly mafic minerals such as biotite, alkali hornblende and aegirine. Tinguaite is a porphyritic phonolite (Carmichael *et al.* 1974, p. 37, 39).

Monzonite - Latite Monzonite is a plutonic rock (volcanic equivalent: latite, transitional between andesites and trachytes) which is similar to syenite, but with sub-equal amounts of potash feldspar and oligoclase - andesine (Carmichael *et al.* 1974, p. 34, 39).

Acid rocks
Contain over 66% silica, free or combined (Carmichael *et al.* 1974, p.29). The plutonic varieties are "true granites", discussed separately. Volcanic acid rocks are classed as "other granites", and include:

Rhyodacite	Volcanic equivalent of granodiorite. Composed of dominant andesine-oligoclase feldspars, sub-ordinate potash feldspar, and biotite and/or hornblende. Quartz may occur (Carmichael *et al.* 1974, p.34, 39).
Rhyolite, quartz porphyry	Volcanic equivalent of granite in the geological sense. Composed of quartz, oligoclase feldspar, sanidine (potash feldspar), and minor ferro-magnesian minerals (biotite, hypersthene pyroxene, augite pyroxene, hornblende and olivine). Porphyritic varieties are called quartz porphyry (Carmichael *et al.* 1974, p.34).

(B) Metamorphic "granites"

These are rocks which have undergone high-grade metamorphism (heating and pressure), and have recrystallised to the extent that they have acquired a crystalline texture somewhat similar to igneous granites. They are therefore included, for convenience, with "other granites".

Grainsizes are defined for these metamorphic rocks using the same categories given (above) for igneous rocks.

Metamorphic "granites" include:

Gneiss	Medium to coarse-grained rocks rich in feldspar and quartz. Crude undulating banding or foliation may be defined by sub-parallel streaks of hornblende or mica (Verhoogen *et al.* 1970, p.546; Williams *et al.* 1954, p.174). Foreign gneisses have been used in Australian buildings, including a green gneiss which has been used for columns in the main foyer of the new Parliament House in Canberra.
Granulite	Even-grained rocks lacking in micas or amphiboles, although foliation or lamination may occur due to the presence of flat lenses of quartz and/or feldspar. Quartz-feldspar or feldspar-pyroxene-garnet mineral assemblages are typical (Verhoogen *et al.* 1970, p.546; Williams *et al.* 1954, p.174).
Migmatites	Commonly are rocks formed under conditions of high-grade metamorphism in which actual melting has commenced. Migmatites consist of a high grade metamorphic rock streaked and veined with true granite (Williams *et al.* 1954, p.165).

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The following textures are found in granites:

Equi-granular (uniform) All grains of similar size.

Granular All grains equi-dimensional, without preferred orientation or alignment.

Porphyritic (Igneous rocks) Large crystals (phenocrysts) set in a groundmass of finer grainsize (not to be confused with amygdaloidal, brecciated or spherulitic structured volcanics, which also have large fragments set in a finer groundmass, but in which the larger fragments are not individual crystals).

Porphyroblastic (Metamorphic rocks) Large crystals (porphyroblasts) set in a groundmass of finer grainsize.

Pyroclastic (tuff), agglomerate and breccia textures Deposits of volcanic rock fragments, produced by explosive eruption and/or mass flow of volcanic deposits, consolidated in a finer groundmass. Potentially attractive stone if strongly bonded.

Structures and other features which may be found in granites include:

Massive structure Uniform colour and texture throughout a body of granite.

Gneissic structure (Metamorphic rocks) Coarse metamorphic banding, due to bands of differing grainsize and/or composition, in which grains may be elongated and sub-parallel. Gneissic structure may produce a splitting tendancy, depending on the composition and grain orientation within bands.

Lineations and foliation Foliations are sub-parallel structures, often of metamorphic origin, which sometimes produce a tendancy to splitting. Cleavage in slates, and gneissic structures, can be regarded as foliations. (Williams *et al.* 1954, p.169). Lineations are parallel alignments of elongated grains in bands, which produce a foliation.

Segregations and layering Regions of differing colour and/or texture within an outcrop-scale body. Segregations may be evenly or irregularly shaped and distributed patches or bands.

Flow structures Alignments of crystals due to flow in partially solidified rock.

Xenoliths Fragments of exotic rock incorporated into molten magma prior to cooling and solidification.

Veins and dykes May be tension fractures filled with secondary minerals, which may or may not be detrimental to the aesthetic and durability qualities of the stone (eg, quartz, calcite, zeolites). Other veins or dykes are late-stage intrusions of different igneous rock types.

Vesicles Cavities formed by gas bubbles in volcanic rocks. May range in size from microscopic to 10mm diameter or larger, and can be uniformly ditributed or concentrated in specific patches or cylindrical "pipes". Fine or microscopic vesicles may be difficult to detect, but can render stone unable to take a fine polish. Patches of fine vesicles within otherwise sound stone can be detected using Ultrasonic Pulse Velocity testing.

Amygdales	Vesicles filled with secondary minerals which are detrimental to stone quality if unstable, but only an aesthetic consideration if stable.
Joint breaks and fractures	Large breaks, generally due to tectonic, cooling or unloading stresses. Coarser rocks tend to have wider joint spacings.
Cracks and microcracks	These may occur naturally (eg,microcracks may develop around individual mineral grain boundaries during magma cooling, and fine cracking can result from tectonic stresses in the Earth's crust), or may be produced during quarrying, especially if explosives are used. They can weaken the rock, accelerate weathering decay by increasing porosity and allowing access for water, and may result in polishing flaws.

8.2 `Other granite´ applications

Large dimension blocks	Minor use in modern buildings. Load-bearing walls and structures (including base-courses, plinths, ashlar walls, monuments). High strength and durability required. Minor vesicles may be acceptable for non-polished applications.
Veneers (wall cladding) (interior/exterior)	Major modern use. Must take good polish, no vesicles of any size acceptable. Highest durability required for exteriors. High flexural strength required for thin veneers. Aesthetic appearance particularly important.
Paving tiles	Abrasion resistance and modulus of rupture / flexural strength important. Finer grainsizes yield higher abrasion resistance. Minor occurrence of vesicles may be acceptable for unpolished tiles.
Furniture, decorative features	Benches, table-tops, etc. Must take good polish, vesicles must not be present. Aesthetic appearance important, breccias and other non-uniform types may be in high demand.
Monuments Memorials (gravestones)	High durability and ability to accept good polish required, as for exterior cladding.

8.3 "Other granite" quarrying in Tasmania

There is no record of any of the stone types considered in this chapter having been quarried in Tasmania to date for building or ornamental purposes.

8.4 "Other granite" prospects in Tasmania

PRECAMBRIAN	Gneiss, migmatite	King Island
CAMBRIAN		
ULTRAMAFIC ROCKS		
Adamsfield Trough	Adamsfield UMC	
	Massive green pyroxenites	Adamsfield
BASIC ROCKS		
Dundas Trough	Heazlewood River UMC	
	(rhodingite)	Heazlewood River
	Serpentine Hill UMC	
	(rhodingite)	Serpentine Hill
Badger Head Block	Andersons Creek UMC	
	(rhodingite)	Beaconsfield
INTERMEDIATE - ACID ROCKS		
Dundas Trough	Mt. Read Volcanics:	
	Tyndall Group & correlates (Mainly quartz - feldspar - porphyritic volcanics and volcaniclastics) (Ct)	Mt. Huxley/S. Darwin Pk. Hellyer Mine/Mt. Cripps Fury River Antony River area Moxon Saddle/Tyndall Crk Lake Dora Mt. Lyell area Lynch Creek
	Central Volcanic Complex (dominantly felsic, porphyritic lavas, tuffs, agglomerates, etc) (Ccv)	Mt. Block/Mt. Read belt. Lake Margaret/Mt Darwin
	Western Sequence (Mainly lavas and pyroclastics with sediments) (Cw, Cws)	Langdon/Yolande Rivers Queenstown/King River Garfield River
	Dundas Grp. (felsic lavas, tuffs, agglomerates) (Cdv, Cdt, Cdtv,Cdlf,Cdwt)	Mt. Charter/Que R. area Williamsford/Howards Rd
Fossey Mt. Trough	Mt. Read Volcanics correlates:	
	Minnow Keratophyre	Cethana/Beulah, etc
	Beulah Formation	Beulah/Claude Rd.
	Bull Creek Formation	Lorinna/Moina

DEVONIAN - CARBONIFEROUS
METAMORPHICS

NE Tasmania	Migmatite	Bridport

CRETACEOUS
INTERMEDIATE ROCKS

SE Tasmania	Alkaline Intrusives	Cygnet

8.5 Evaluation of "other granite" prospects in Tasmania

PRECAMBRIAN

Gneiss, migmatite

PROSPECTIVITY - ?

Gneiss and migmatite are metamorphic "granites" formed under condition of very high grade metamorphism, and Precambrian varieties have ony been recorded at a few localities in Tasmania:

Turner (*in* Burrett & Martin 1989,p.45) records relict blocks of gneiss and migmatite veinlets in schists adjacent to eclogite in the Collingwood River - Lyell Highway area (Tyennan Block).

On King Island, sedimentary and igneous rocks in the metamorphic aureole of the Precambrian West Coast Granite have been metamorphosed to an unusually high degree compared to the aureoles of other Tasmanian granites (Eastoe 1979,p.2), and have been multiply deformed. It is possible that gneisses and migmatites of dimension stone potential could occur in this area.

No Tasmanian gneisses or migmatites were examined during this project, and their dimension stone potential cannot be assessed at this stage.

CAMBRIAN

ULTRAMAFIC IGNEOUS ROCKS
Adamsfield Ultramafic Complex
Massive Pyroxenite

PROSPECTIVITY - Low/Medium

An interesting outcrop of very coarse-grained massive green pyroxenite occurs within the Adamsfield Ultramafic Complex (see Fig. 10.1).

This occurrence has been mapped as "Erpx" (massive orthopyroxenite) in the Pedder Quadrangle (Turner *et al.* 1985), and is located at around Grid Ref. DN462660, on the western slopes of the Sawback Range. Access is by very rough 4WD tracks.

Outcrop is relatively poor, but outcrops up to several metres have been examined. Jointing is commonly intense, but some outcrops had no apparent fractures over distances of a metre or more. Such wide jointing is very unusual in Tasmanian Ultramafic Complexes, and is probably related to the unusually coarse grainsize of the stone.

The pyroxenite is equigranular and very coarse-grained, with grains over 10mm in diameter. The layering characteristic of most Tasmanian ultramafic rocks is not evident in this massive stone. The colour is an attractive "greyish olive-green" (5 GY 3/2), and the stone polishes well to give a rather attractive appearance.

From a dimension stone point of view, the stone is worth further examination, although significant wastage could be expected since the jointing, whilst being unusually widely spaced compared to other Tasmanian ultramafic rocks, is still rather more intense than is desirable.

However, the locality is within the recently declared extensions to Tasmanias World Heritage Area, and is thus unlikely to be available for quarrying. While it is the only occurrence of such a rock type in Tasmania which is currently known to the writer, the possibility of similar rocks in other Ultramafic Complexes is worth investigating.

BASIC IGNEOUS ROCKS
Dundas Trough (& elsewhere)
Heazlewood River Ultramafic Complex (& other UMC's)
Rhodingites (Pegmatitic gabbro/norite)

PROSPECTIVITY - Low/Medium

Rhodingite is an attractive coarse-grained igneous rock of basic composition which occurs in some Tasmanian ultramafic complexes in the form of small dyke-like intrusions. As with the Adamsfield massive pyroxenite, the coarse-grained nature of the rhodingites causes them to have unusually widely spaced joints compared to their ultramafic host rocks.

Rhodingites were examined in the Heazlewood Ultramafic Complex (see Fig. 10.1) of the Dundas Trough. A good outcrop occurs beside a 4WD track on Brassey Hill, at Grid ref. CQ58900782.

The rhodingite occurs as vertically oriented bands (dykes?), up to two metres wide and some tens of metres long, within an area of dunite. Surface jointing fractures are spaced up to only 0.5 metres apart, although some of these may anneal at depth. The stone has a uniformly coarse mottled appearance, consisting of dark green-black pyroxene grains 5 - 40mm long set in an off-white feldspar groundmass (see Plate 3.12). The stone is hard and crystalline, and would probably polish well to give a rather attractive ornamental stone.

Further poor exposures of rhodingite are known in the Brassey Hill and Gabbro Hill areas of the Heazlewood Ultramafic Complex (Grid Ref.s CQ58190845, CQ59550856, CQ59130887). Occurrences of rhodingite are also known in the Serpentine Hill and Andersons Creek Ultramafic Complexes (see Fig. 10.1), and probably occur in other Cambrian ultramafic complexes as well.

Whilst all the rhodingites are likely to occur in bodies of restricted size, there is some potential for joint spacings of a metre or so. While such jointing would be very marginal for a dimension stone source, the rather unusual and interesting nature of the stone suggests that evaluation of rhodingite occurrences throughout the Tasmanian Cambrian Ultramafic Complexes would be a worthwhile exercise.

INTERMEDIATE - ACID IGNEOUS ROCKS
Dundas and Fossey Mountain Troughs
Mt. Read Volcanics

PROSPECTIVITY - Medium

The Mt. Read Volcanics are a belt of Cambrian felsic and intermediate (minor mafic) volcanic rocks which outcrop extensively from Elliot Bay in the south, through the Queenstown to Que River area, and as far east as the Sheffield area (see Fig. 8.1). The volcanics are highly mineralised and have long been considered Tasmania's most important source of metallic mineral deposits.

However, the Mt. Read Volcanics include many hard crystalline deposits of unusual and very colourful appearance, which are considered by the writer to have considerable interest as vari-coloured ornamental "granites" for use in such applications as prestige foyers, furniture, and the like. The potential of the Mt. Read Volcanics as ornamental stone does not seem to have been previously considered, and much work will be necessary to properly evaluate them from this point of view.

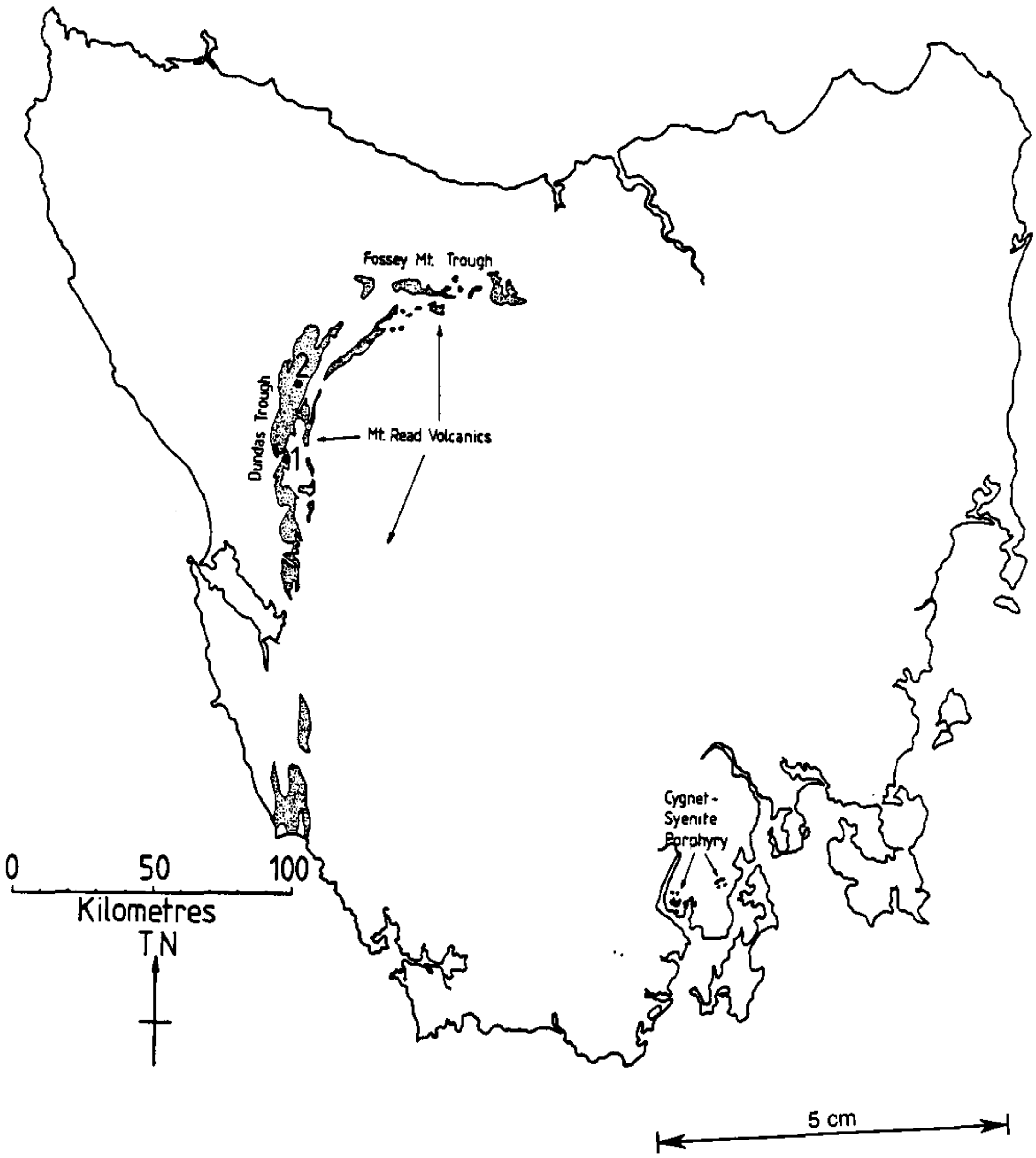
The stratigraphy and petrography of the Mt. Read Volcanics has been summarised by Corbett & Solomon (*in* Burrett & Martin 1989,p.84-153). An excellent series of 1:25,000 scale geological maps covering much of the Mt. Read Volcanic belt has been prepared during 1986-1989 by the Geological Survey of Tasmania, as part of the "Mt. Read Volcanics Project".

As described by Corbett & Solomon (*Ibid.*), the Mt. Read Volcanics in the Queenstown to Que River regions of the Dundas Trough are broadly sub-divided into the following sequences:

Western Sequence
A volcano-sedimentary sequence which at least partly forms the base of the Mt. Read Volcanics. This sequence includes tuffs, lavas and intrusive porphyries, interbedded with greywacke, shale and mudstone. Where it was examined during this project, along the Antony Road and Murchison Highway in the Yolande River regions (Area Og/Dr/2), this sequence was seen to consist predominantly of intensely jointed and easily weathered sedimentary rocks. The Western Sequence is probably of little dimension stone interest.

Central Volcanic Complex
This widespread complex overlies and partly interfingers with the Western Sequence, and consists predominantly of feldspar-porphyritic lavas and pyroclastic volcanics of felsic and andesitic composition, with only minor lenses of sedimentary rocks. During this project, as noted below, porphyritic lavas and andestic pyroclastic breccias were observed which have considerable aesthetic appeal,and are hard, crystalline and moderately widely-jointed. The Central Volcanic Complex is considered to have considerable dimension stone potential.

Tyndall Group (and correlates)
The Tyndall Group is the youngest part of the Mt. Read Volcanics, and comprises quartz/feldspar porphyritic lavas and pyroclastic tuffs and agglomerates, together with volcaniclastic and other sedimentary rocks. Strikingly attractive agglomerates belonging to the Tyndall Group were observed in the Antony Road area during this project, and are hard, crystalline rocks with moderately wide jointing in places. The Tyndall Group is considered to have considerable dimension stone potential.



Key to numbered locations: (Mt. Read Volcanics)

1 Antony Road: agglomerates, tuffs and breccias (sites Og/Dr/1/1-2, Og/Dr/7/1)
2 Pieman Road: porphyritic lavas (site Og/Dr/4/1)

Figure 8.1 Tasmanian "other granite" prospects.

Dundas Group
Although generally considered to be a unit separate from the Mt. Read Volcanics, the Dundas Group is laterally equivalent to parts of the Mt. Read Volcanics. The Dundas Group is predominantly composed of sedimentary rocks, but also includes significant masses of volcanic rocks, particularly in the Que River - Hellyer Mine area. Although volcanic rocks assigned to the Dundas Group were not examined during this project, they may have dimension stone potential.

There are two major problems which will inhibit the use of the Mt. Read volcanics as sources of dimension stone, jointing/fracturing and undesirable mineralogies:

1) Jointing/fracturing

The Mt. Read Volcanics have been subjected to multiple tectonic deformations. Considerable tectonic activity took place during the Cambrian (Corbett, *in* Burrett & Martin 1989,Ch. 5), producing uplifts, faulting, and in a few places, cleavage development (*Ibid.* , p.165). It is considered possible that the Dundas Trough may have been a suduction zone during the deposition of the Mt. Read Volcanics.

Faulting and folding in the Late Cambrian - Early Ordovician produced both thrusting and grabens in which later sediments were deposited overlying the volcanics (*Ibid.*,p.162, 181).

Further deformation during the Devonian Tabberaberan Orogeny produced up to three cleavages in Cambrian rocks of the Dundas Trough (*Ibid.*, p.165), and may be responsible for the huge 90° bend in the Mt. Read Volcanics belt from approximately the Que River area eastwards to the Sheffield area (*Ibid.*, p.168). The Devonian tectonism produced major folding and fault movements in the Dundas Trough (Williams & Seymour, *in* Burrett & Martin 1989, Ch. 7).

As a result of all this tectonism, closely spaced jointing and fracturing is predominant throughout the Mt. Read Volcanics in the Dundas and Fossey Mountain Troughs, with outcrops having unfractured masses greater than one metre diameter being rare.

However, a few outcrops have been observed which have major joints spaced up to several metres apart, and in which fine hairline fractures are not discernable over distances of a metre or more (see Plate 8.4). This indicates a potential for locating deposits sufficiently unfractured for dimension stone use.

While the difficulty of locating sufficiently widely-fractured deposits is such that the Mt. Read Volcanics might be considered unprospective were they a rock type more easily available in unfractured deposits elsewhere, the unique nature of the volcanics suggests that the extra effort required to find good deposits may be worthwhile.

D. Seymour (*pers. comm.*) notes that the more widely- jointed outcrops in the Mt. Read Volcanics are commonly recognisable by their outcrop in the form of bold tors and cliffs. Beyond this, the best strategy for locating areas of minimal jointing and fracturing will be to collate the available information on the distribution of more- and less-deformed regions in the Mt. Read Volcanics, with the aim of exploring the least deformed regions.

R.F.Berry (*pers. comm.* , 1990) suggests that the least deformed region in the Mt. Read Volcanics may be in the area just north of Black Bluff, which is inbetween the Henty Fault zone to the west, and a zone of thrust faulting around Cethana to the east. Correlates of the Tyndall and Dundas Groups occur in this area. However, outcrop in the area is

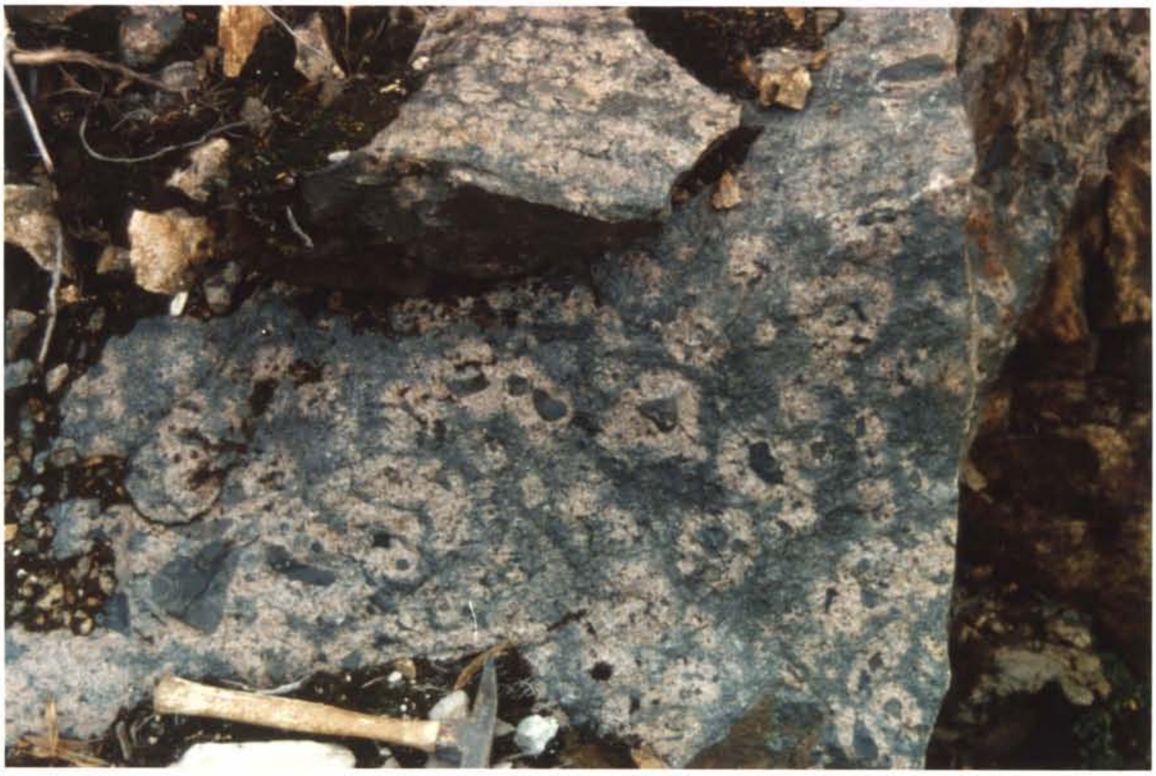


Plate 8.1 Mt. Read Volcanics: Pink agglomerate (Tyndall Group) on the Antony Road (site Og/Dr/1/1).

Plate 8.2 Mt. Read Volcanics: Pink banded volcaniclastics (Tyndall Group) on the Antony Road (site Og/Dr/1/1).

5 cm

generally poor.

2) Undesirable mineralogies

Large deposits of metallic ores, particularly suphides, occur in the Mt. Read Volcanics, and sulphide grains are commonly found scattered through less mineralised areas.

Since such metallic minerals can be detrimental to ornamental stone (due primarily to their potential to oxidise and produce staining), the best quality ornamental stone is likely to be found in the least mineralised parts of the Mt Read Volcanics. It is notable that all major polymetallic deposits are located within two kilometres of the western margin of the volcanic belt (Williams, *in* Burrett & Martin 1989,p.480), although lesser deposits occur scattered throughout the belt.

It is a curious paradox that the parts of the volcanic sequence likely to be most prospective for ornamental stone are precisely those parts which are least prospective for ore minerals!

An additional reason for avoiding the vicinity of metallic ore deposits is that the hydrothermal processes considered to be responsible for the ore genesis have produced significant alteration of the wall rocks, extending up to 200m into the hanging wall at major deposits (Solomon, *in* Burrett & Martin 1989,p.123). The alteration products include sericite (fine mica), chlorite and carbonate, all of which are weak, soft or soluble minerals which would significantly lower the durability of otherwise hard and crystalline volcanic rocks.

Mt. Read Volcanics deposits examined for dimension stone potential

It was only possible to undertake a brief reconnaissance of the Mt. Read Volcanics during this project, and there is no doubt that further work will locate considerable deposits of interesting appearance, and of technical quality (apart from fracturing) sufficient for use as polished veneer slabs, furniture, and so on.

No deposits with sufficiently wide fracture/joint spacings to be exploited have yet been located. However, the fracture spacings observed in some deposits (eg, see Plate 8.4) suggest that there is potential for deposits with fractures spaced widely enough for at least marginally economic dimension stone quarries to be operated. With a stone of sufficiently outstanding and unusual character, such "marginal" quarries might be viable in view of the potentially very high value of the stone.

The following interesting deposits were observed during this work:

Tyndall Group -Agglomerate/tuff

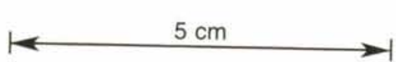
Strikingly patterned and coloured volcanic agglomerates and tuffs belonging to the Tyndall Group (Et *of* Corbett 1986) outcrop in road cuttings on the Antony Road around grid reference CP81205860 (site Og/Dr/1/1, see Fig. 8.1).

Two varieties were observed in adjacent outcrops. One variety is a hard crystalline medium-grained tuff consisting of regularly alternating sub-planar dark grey-green and pink bands varying from 10 - 100mm thick (see Plate 8.2). The other variety has a similar medium-grained dark grey-green matrix, but contains an abundance of rounded agglomerate clasts 10 - 100mm diameter, each of which is surrounded by a strong pink aureole (see Plates 3.11, 8.1).

Both varieties appear rather attractive, although they could be considered a bit "garish" for some applications, and samples of both have polished very well with only minor pitting and

Plate 8.3 Mt. Read Volcanics: Green andesitic breccia (Central Volcanic Complex) on the Antony Road (site Og/Dr/7/1).

Plate 8.4 Mt. Read Volcanics: Widely jointed outcrop on the Pieman Road (Central Volcanic Complex porphyritic lavas, site Og/Dr/4/1).



very minor micro-cracking. In fresh outcrops, major joints vary from <1.0 to 2.0 - 3.0 metres apart. Fine hairline fractures are present, but careful examination of several faces failed to reveal discernable fractures over distances of a metre or more. Potential quarry sites are located nearby (although there would still be considerable wastage due to fracturing in the observed outcrops).

At the same site, a mysterious loose boulder was found (sample Og/Dr/1/2/1) which consisted of a volcanic breccia or agglomerate distinctly different in character to the adjacent outcrops. This boulder consists of sub-angular red clasts 5 - 40mm in diameter, set in a dark brown fine grained foliated groundmass containing medium grained quartz and feldspar phenocrysts (see Plate 3.11). The stone stone polishes very well with minimal pitting and no microcracking, although a few breccia clasts take a slightly dull polish. The stone seems very attractive, and is unlikely to be considered "garish".

It is not possible to determine the joint spacing of this allocthonous boulder, although some fine fractures are evident. The source of the boulder is unknown, and the transport mechanism could be either glacial (an erratic) or human (roadworks). The impressive colour and patternning of the stone means that an effort to locate the outcrop source could be well worthwhile.

Central Volcanic Complex - Andesitic breccia

A fresh road cutting on the Antony Road at grid reference CP80105527 (site Og/Dr/7/1, see Fig. 8.1) exposes an andesitic breccia (Ecva *of* Corbett 1986) consisting of dark green breccia fragments 10 - 200mm diameter set in a slightly lighter green (greenish-grey 5 G 5/1) fine-grained groundmass with medium to coarse-grained light and dark-coloured phenocrysts (see Plate 8.3). Joints are spaced 0.5 - 2.0 metres apart, and in places no hairline fractures are evident over distances of a metre or more. The stone is hard and crystalline, and is likely to yield a good polish.

The colour variation between groundmass and breccia fragments is quite subtle, and the stone would probably have a similar appearance to some imported brecciated serpentines - and with the advantage of being more durable than the latter.

Central Volcanic Complex - Porphyritic lavas

A feldspar-hornblende porphyritic lava (Ecvlm *of* Corbett & McNeill 1986) is exposed in road cuttings on the Pieman Road, 500m west of the Murchison Highway, at grid reference CP83648125 (site Og/Dr/4/1, see Fig. 8.1).

At the eastern end of the outcrop, the stone is a uniform fine-grained dark green (10 Y 4/2) stone with medium-grained white feldspar and black hornblende phenocrysts. Over a hundred metres or so westwards, the same stone varies to a type dominated by irregular pink and red mottled patches 10 - 50mm in diameter (see Plate 3.11). Both varieties are hard and crystalline, and polish well with no micro-cracks and pitting varying from non-existent to slightly pitted (weathering effect?).

Joint spacing varies from 0.1 - 0.4 metres to approximately 2.0 metres, although the prevalence of fine hairline fractures is difficult to determine (see Plate 8.4).

Central Volcanic Complex - Other outcrops

At grid reference CP79258035 (site Og/Dr/4/3) on the Pieman Road, a spherulitic feldspar-quartz porphyry outcrops in a road cutting which has joints spaced up to 1.0 - 5.0 metres apart. The stone is of a somewhat drab light grey colour, but the outcrop is of interest in that it illustrates the potential for widely jointed deposits within the Mt. Read Volcanics.

Along the Murchison Highway on the southern slopes of Mt. Black (site Og/Dr/5/1, grid ref. CP806732), road cuttings expose a hard crystalline feldspar-porphyritic lava of pale red to greyish-green colour which polishes well without micro-cracks or pitting (see Plate 3.11). The outcrops are closely jointed, and the stone appearance is perhaps a little drab, but it illustrates yet another variety of potential ornamental stone in the volcanic complex.

Exploration for ornamental stone in the Mt. Read Volcanics

Exploration for ornamental stone sources in the Mt. Read Volcanics should commence with a review of available data regarding the distribution of highly mineralised and intensely deformed zones, so that prospective regions likely to have the widest joint spacings and minimal content of metallic minerals can be identified.

Within such regions, a review of rock specimens held in repositories at the Tasmanian Mines Department and the University of Tasmania may be useful in identifying potentially attractive lithologies. Airphotos of the most prospective regions may assist in location of bold (and thus widely-jointed?) outcrops.

In considering exploration for ornamental stone in the Mt. Read Volcanics, it must be borne in mind that such a venture is somewhat speculative, since no outcrops of sufficiently wide joint and fracture spacing for economic dimension stone quarrying have yet been located or quarried. Although the above discussion suggests that such deposits may exist, the alternative, that they do not, is still a distinct possibility.

DEVONIAN - CARBONIFEROUS

METAMORPHIC "GRANITES"
Northeastern Tasmania
Migmatite

PROSPECTIVITY - ?

Migmatites occur in the metamorphic aureole of the Diddleum Granodiorite at Bridport (Skrzeczynski 1971). The migmatites were not examined in this work, and their potential as ornamental stones is unknown.

The best outcrops occur on the foreshore at Granite Point, just north of Bridport. This site is a Geological Monument (Eastoe 1979,p.104), and would not be quarriable for environmental reasons. However, further outcrops of the migmatite are likely to occur inland.

This occurrence of migmatite adjacent to a Tasmanian Devonian/Carboniferous granitoid is unusual (Eastoe 1979), and it is not known whether any similar occurrences exist elsewhere in the state.

CRETACEOUS

INTERMEDIATE IGNEOUS ROCKS
Southern Tasmania Basin
Alkaline Intrusives (Syenite porphyries and related dyke rocks)

PROSPECTIVITY - Low

Alkaline intrusives of Cretaceous age ("Cs") occur in the Cygnet to Kettering region of southeast Tasmania (Leaman & Naqvi 1967, Farmer 1981, 1985; see Fig. 8.1). The intrusions consist of a swarm of numerous small dykes and sills associated with a number of larger sheet-like bodies, the latter outcropping at Black Jack Ridge, Mt Mary - Mt Windsor, Silver Hill, around Wheatley's Bay, around Regatta Point (Port Cygnet), at Farewell Hill, immediately west of Underwoods Hill, and at Helliwells Point (Farmer 1985). The sills and dykes intrude Permo -Carboniferous sedimentary rocks and Jurassic dolerites in swarms of bodies averaging 5 to 20 metres thick (Farmer 1985).

Outcrop of the Cretaceous rocks is generally poor, largely consisting of a few road metal quarries, shoreline exposures, and poor road cutting outcrops. The poor outcrop is probably due to the intensely jointed and weathering - prone nature of the rocks.

Syenite porphyry (Banatite)

The major rock type, which forms the larger sheet-like bodies and also many of the smaller dykes, is syenite porphyry (banatite). This rock was observed in areas Og/Ts/1 - 5 during this project.

The dominant variety of syenite porphyry observed in this work (areas Og/Ts/2 & 3) is a light grey (N7) to light grey/ green (5 GY 6/1) porphyritic rock, having a fine-grained groundmass with abundant small (av. 1 - 2mm dia.) dark green ferromagnesian phenocrysts, and common rectangular grey-white feldspar phenocrysts averaging 8 x 15mm in size (see Plate 8.5). The stone colour is a little drab, although the large pale phenocrysts set in a pale green groundmass give it some appeal.

The appearance of the syenite porphyry varies in places to less attractive varieties. A drab grey variety lacking feldspar phenocrysts was noted in area Og/Ts/1 (near Kettering), and a brownish variety on Silver Hill road (area Og/Ts/5).

The syenite porphyry appears prone to weathering: many outcrops are deeply weathered, and in many specimens the ferro-magnesian phenocrysts have been preferentially replaced by soft brown iron-oxides. Farmer (1985) noted that the groundmass has extensively altered to soft kaolinite clay in some outcrops.

X-Ray Diffraction analysis of a typical syenite porphyry specimen (Og/Ts/2/1/1) during this work showed evidence of weathering in a specimen which appears as fresh as any in the near-surface zone. No kaolinite was found, but it showed the presence of significant amounts of illite (or fine-grained mica) and smectite clay. The smectite (or "montmorillonite") is likely to have been formed by initial alteration of the ferro-magnesian minerals in the rock upon near-surface exposure, and is probably responsible for the significant weathering observed in many outcrops: Smectite exhibits marked swelling and contraction behaviour with wetting and drying, and is known to be responsible for rapid decay in other stone types such as sandstone. Once smectite formed in the syenite porphyry during early stages of weathering, it would tend to accelerate decay of the stone in surface outcrops through it's swelling behaviour.

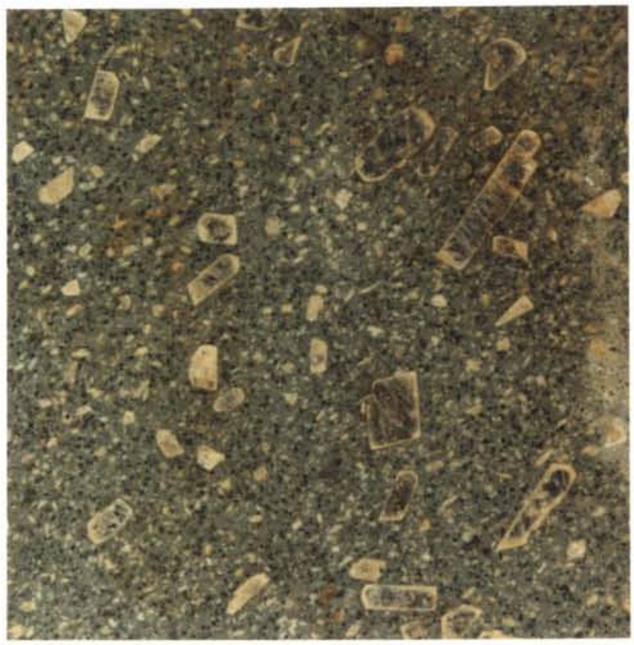
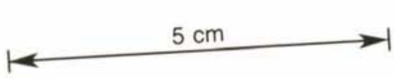


Plate 8.5 Syenite porphyry (banatite) from the Cygnet region (site Og/Ts/2/1). (x 0.7)

Plate 8.6 Tinguaite porphyry from Cygnet region (site Og/Ts/4/1).



Microscopic examination of a thin section of specimen Og/Ts/2/1/1 showed that the groundmass and the small dark phenocrysts are indeed extensively altered to clay, while the large feldspar phenocrysts show incipient or partial alteration to clay along micro-cracks and around the rims. Polishing of a slab of the same specimen yielded a somewhat dull polish with extensive pitting, particularly of the small dark phenocrysts.

In all outcrops observed in this project, the syenite porphyry has intense, multiple direction open jointing fractures. Joint spacings average 0.1 to 0.5 metres apart - too intense to be a viable dimension stone source. Leaman & Naqvi (1967,p.81) also noted that the syenites are generally "strongly" jointed.

The rocks in the Cygnet Peninsula area have been strongly affected by a large domal structure and extensive radial and tangential faulting. The dome structure and most of the faults appear to have originated prior to intrusion of the syenites, in pre-Jurassic dolerite times (Leaman & Naqvi 1967,p. 52-53, Farmer 1985,p.87). However, the termination of some syenite bodies on faults (Farmer 1985,p.87) suggests continued fault movement after the syenite intrusion. Such post-syenite intrusion fault movements in this intensely faulted region are likely to be responsible for the intense syenite jointing observed.

In summary, although the syenite porphyry has the potential to be a somewhat attractive polished stone, it's prospectivity is lowered due to the intense jointing which seems to be ubiquitous in the region, and to the fact that the stone shows evidence of being particularly susceptible to weathering in the near-surface zone and upon exposure. The poor *in situ* durability of the stone suggests that even if quite fresh material could be quarried, it would tend to alter and decay rapidly upon exposure.

Minor dyke rocks

Several minor alkaline intrusive rock types occur as thin dykes, and in some cases are very attractive. These types include tinguaite porphyry, sanidine-garnet porphyry, garnet trachyte, syenite aplites and pegmatites, and garnet orthoclase.

A thin dyke of tinguaite porphyry was examined just north of Langdons Point, Port Cygnet (Site Og/Ts/4/1). The dyke is only 0.65 metres thick, and is exposed over a 10 - 15m strike length between low tide and the land-ward edge of the shore platform, where it is covered by soil.

The stone is of a particularly attractive appearance, consisting of abundant coarse, light yellow-brown sanidine crystals set in a fine-grained green groundmass. The sanidine crystals are arranged in attractive "swirling" patterns (see plate 8.6).

Open joints are spaced from 0.1 to a maximum of 0.9 metres apart through the dyke. Although the stone is strong and clean on fresh surfaces, broken surfaces about twenty years old show a distinct lightening of the green colour, and are distinctly pitted. Although a polished slab of this stone has lasted for at least a similar period on display inside the Geology Department of the University of Tasmania without deterioration, the weathering observed at the outcrop site suggests that the stone is susceptible to decay, possibly related to kaolinisation or smectite formation, in exposed situations.

This particular site is regarded as a Geological Monument (Eastoe 1979), and quarrying would most likely be opposed for that reason. In any case quarrying would not be feasible in this location. Despite the attractive appearance of the stone, available reserves are very small, the dyke thickness and joint spacing mean that slabs generally could not be cut any larger than approximately 0.5 x 0.7 metres in size, and the stone is suspected to be susceptible to rapid surface deterioration in any exterior, exposed location.

To date, the minor alkaline intrusive rock types have only been located on the well-exposed shore platforms of the Cygnet region. Undoubtedly they also occur inland, but the thinness of the dykes, and the generally poor outcrop in the region make their detection very difficult.

These considerations, together with the small volume, probable generally close-spaced jointing and susceptibility to decay of the minor dyke rocks, probably rule them out as significant ornamental stone prospects, despite the attractive appearance of some of the rock types present.

CHAPTER NINE

MARBLE

9.1 Definition and description

Marble is a favoured ornamental stone due to it's beauty, wide variation in appearance, and ease of working. It has been defined geologically by Joplin (1968,p.22) as "recrystallised limestone with granular texture and variable grainsize, and consisting exclusively of calcite".

The stone industry uses a much broader definition of "Marble" which includes true marbles, hard fine-grained limestones, travertine, serpentine, and sometimes even granites (in Italian terminology - Spry 1988, p.8).

For the purposes of this report, the present chapter deals with true marbles in the geological sense, and some hard "crystalline" limestones; the other stone types referred to above are treated in separate chapters.

In this chapter, then, marble is understood to be a wholly or partly recrystallised carbonate stone, formed from a parent carbonate sedimentary rock (limestone or dolomite) by regional or contact metamorphism (and sometimes metasomatism). Marble may be composed of interlocking grains (crystals) of calcite ($CaCO_3$), dolomite ($CaMg(CO_3)_2$) or magnesite ($MgCO_3$) with a granular texture.

Origin of Marbles

We can distinguish the following geological classes of marbles:

1) "Sedimentary Marbles": dense crystalline limestones and dolomites (minor diagenetic or metamorphic recrystallisation only).

2) True "Metamorphic Marbles": wholly recrystallised carbonate rock. May be:
Contact metamorphic marble (thermal metamorphism).
Regional metamorphic marble (thermal + pressure metamorphism).

3) "Calc-silicate hornfels" and "Skarn" Marbles: marbles containing both recrystallised carbonate grains, and/or a significant content of calcium- and magnesium-silicate minerals (and/or additional metallic and other minerals).

Formed by a combination of metamorphic and/or metasomatic processes, resulting in both recrystallisation of the carbonate minerals, and addition of new mineral components from external sources ("metasomatism"). Instead of, or in addition to, the metasomatic input, calc-silicate marbles may form by re-crystallisation of impure limestones which originally contained quartz, clay and/or other silicate minerals.

Due to their content of silicate, metallic and other minerals, these "marbles" are rarely used as an ornamental stone.

Diagenetic recrystallisation has had a significant effect on Tasmanian dolomites and limestones of Precambrian, Cambrian and Ordovician age. Numerous deposits of dense, fine-grained dolomites and limestones have been produced by such recrystallisation, some of which may take a polish well enough to be considered as "sedimentary marbles".

Regional metamorphism related to Precambrian tectonic events has (in association with Mg-metasomatism) produced the Precambrian magnesite marbles described in Section (9.5) below. Elsewhere, however, regional metamorphism of Tasmanian limestones and dolomites appears to be minimal, although many Precambrian and Palaeozoic carbonate deposits have undergone folding.

The main agent of contact metamorphism of Tasmanian carbonate rocks is the Carboniferous-Devonian granite intrusions described in Chapter Six. These large granite bodies have had significant thermal effects on the surrounding country rocks, and a number of locations are known where they have intruded limestones. In all presently known cases the resulting contact metamorphism (and associated metasomatism) has produced only skarns and calc-silicate "marbles", although the possibility of pure carbonate marbles occurring in parts of these deposits is not ruled out.

Williams *et al.* (1954,p.191-194) note that, properly speaking, "calc-silicate hornfels" marbles are those formed by simple contact metamorphism of originally impure (eg, argillaceous and siliceous) carbonate sediments, whereas "skarns" are formed from carbonates (which may have been originally quite pure) into which large amounts of Si, Al, Fe, and Mg have been metasomatically introduced during contact metamorphism.

This distinction points out a useful exploration key: true calc-silicate (hornfels) marbles will only grade into pure carbonate marbles if, and where, originally pure beds of carbonate limestone existed prior to metamorphism; otherwise, calc-silicate marbles will simply grade into impure limestones going away from the intrusive contact.

On the other hand, true skarns will tend to occur in a zone between the intruding granite (from which the metasomatising fluids are derived) and a zone of marble outside the metasomatic skarn zone (*Ibid.* ,p.192). Thus, mineralogical mapping of a skarn might suggest areas where pure marbles may exist nearby.

It is unlikely that the younger Jurassic dolerite or Tertiary basalt intrusions had a sufficient thermal effect on the surrounding country rocks to produce contact metamorphic marbles. Leaman (1975), Clarke & Baillie (1984), and Farmer (1985) have noted that contact metamorphism associated with Tasmanian Jurassic dolerites is confined to only a few metres of country rock surrounding intrusive contacts. From this Leaman (*Ibid.*) and Farmer (*Ibid.*) concluded that the dolerite was a "dry" magma low in aqueous phases.

Thus, in contrast to the earlier granite intrusions, the Jurassic dolerite intrusions probably did not produce a sufficiently intense or long-lasting thermal affect on any intruded limestones to cause significant recrystallisation of large bodies of limestone.

Characteristics of Marbles

Grainsize may vary markedly in marbles. Spry (1988,p.12) gives the following grainsize categories for marble:

	Mean grain diameter (mm)
Very Coarse	>5.0
Coarse	1.0 - 5.0
Medium	0.5 - 0.9
Fine	0.1 - 0.4
Very Fine (Crypto-crystalline)	<0.1

Grainsize strongly influences the quality and durability of marble. Spry (1988,p.18) notes that in general, the finer the grainsize, the stronger, harder and more durable marble is. Grainsizes greater than 1mm dia. tend to cause significant problems in stone usage (Spry, *pers. comm.* 1990).

Grainsize tends to be very fine in less metamorphosed marbles (grading to hard limestones or "sedimentary marbles"), and medium to coarse in metamorphic marbles. Contact metamorphic marbles are commonly coarser grained than regionally metamorphosed types (Spry 1988).

Grain boundaries have an important effect on marble durability (Spry 1988). Smooth, simple boundaries produce lower strength than irregular interlocking boundaries, and are more easily weathered. Marble porosity lies mainly along grain boundaries, and tends to increase with increasing grainsize. Higher porosity implies less intergranular bonding, and thus lower strength. Since individual pores in marble are generally very small, the stone also tends to have a high suction, making it susceptible to staining.

Individual carbonate crystals (calcite, dolomite, magnesite) have the property of responding to temperature variations by expanding and contracting to differing degrees in different crystallographic directions. This causes distortion of crystal shapes which, in interlocking crystal aggregates, can lead to permanent deformation of the stone mass and to the opening of new pores along stressed grain boundaries (Spry 1988). This deformation can be more marked with coarser grains, and leads to lowered strength and increased porosity, which in turn allows the entry of more water which can then further accelerate the deformation and decay processes. The result may be warping of vertical panels, sagging of horizontal slabs, and cracking. The outer surfaces of panels exposed to the weather tend to expand more, causing an outward bowing (Spry 1988). Dimensional instability is a particularly important laboratory criterion in assessment of marble quality.

Impure and dolomitic marbles tend to be finer grained and more durable than pure and calcitic marbles (Spry 1988). Magnesite marbles may be significantly harder than calcitic varieties, and consequently are more difficult to work (John Dunn, *pers. comm.* 1989). (On the Mohs Hardness Scale, calcite has a hardness of 3, dolomite 3.5 - 4, and magnesite 3.5 - 4.5; Deer, Howie & Zussman, 1966).

Purer and more strongly metamorphosed marbles are commonly whiter and more uniform in colour than less pure "sedimentary limestone-marbles" (Winkler 1973). The bulk (body) colour of marbles can vary from white through pink to dark black. Colour variation can be aesthetically desirable in many applications. Red, pink, green, grey, black, white, and other colour variations may occur in streaks, bands, viens, annealed fractures and fossils, as a result of the presence of mica, graphite, calcite masses, ferric and ferrous iron, and other minerals.

Minor impurities commonly occur in marbles, and may or may not be deleterious. The only significance of some impurities may be the colour they impart to the stone, as above. On the other hand, silica veins, patches or grains are undesirable since their greater hardness will cause differential polishing and weathering properties. Contact metamorphism of pure dolomites (Mg - limestone) may produce brucite and periclase-bearing marbles, and a minor silica impurity in the original dolomite can produce forsterite (sometimes later altered to serpentine) or diopside (Williams *et al.* 1954,p.189). Other possible marble impurities are discussed by Williams (*Ibid.* p.188-194).

Deleterious minerals in marble (Spry 1988) may include siderite, pyrite and pyrrhotite (which may weather and stain), serpentine and chlorite inclusions (which may bleach or weather out), tremolite and clay inclusions (which may weather out leaving pits), and smectite swelling clay (which may cause stone to crumble).

Biological, sedimentary or metamorphic structures can be present in marbles, and may increase the aesthetic attractiveness of the stone, but can in some cases also decrease it's durability. Such structures may include fossils, sedimentary bedding, metamorphic cleavage, tectonic folding, stylolites and open or annealled fractures (= veins). Viens in marble can be attractive and are often favoured (especially white calcite viens in dark-hued marbles), but may in some cases also contain weak and deleterious minerals.

As with any building stone, it is desirable for open fractures or jointing breaks in marble to be spaced as far apart as possible, so that large blocks can be worked. There are, however, some exceptions to this rule with marbles. Marbles commonly have subtle grey annealled fractures (veins) which do not affect stone strength or durability. Major veins may also produce a stone which is still strong, and especially attractive for interior applications due to it's striking network of filled fractures. Again, a sufficiently unique and attractive marble which has minor uncemented fractures can be used in certain applications (eg, interior walls, benches and tabletops) if it is suitably bonded to a strong backing. Finally, most marbles can be broken up and used for terrazzo.

9.2 Marble applications

Large dimension blocks	Minor use in modern buildings.
Exterior veneers (cladding)	Modern use decreasing, due to durability problems. Highest durability essential, since marble is very susceptible to wet/dry and hot/cold variations. Furthermore, the solubility of carbonate minerals makes marble particularly susceptible to solution and corrosion when exposed to carbonated rain water, acid rain, atmospheric sulphur compounds or organic acids, all of which may be present in urban environments. Uniform white colour with only subdued grey streaks (fine annealled fractures) commonly preferred. Careful wall design and correct processing, fixing, maintenance and cleaning of marble is particularly important to avoid marble failure in external applications (Spry 1988). High flexural strength is important for thin veneers (Spry, *in* Gere *et al.* 1989,p.51).
Interior veneers (cladding)	Major modern use (fewer durability problems).
Interior furniture, decorative features (benches, table-tops,etc)	Most marbles can be used. Types with minor open fracturing may be usable in certain applications. Attractive colour variations and structures such as viens, major annealled fractures and fossils commonly favoured for aesthetic reasons. Careful design still essential, as for exterior applications. High flexural strength important for thin veneers.
Paving (tiles)	Stressful marble application due to abrasion (feet), impacts and loading (dropped and heavy items), rising damp, staining (salt damp, food, drink, cleaning agents) and surface attack (dirt, grime, chemically reactive cleaning agents). High durability required, including fine grainsize, high abrasion resistance, high modulus of rupture / flexural strength, and low porosity (to minimise susceptibility to staining). Proper damp-coursing and cleaning methods appropriate to the stone must be used.
Monuments	
Memorials (gravestones)	
Statuary	Pure white, fine-grained, uniform or "massive" marbles traditionally preferred (Winkler 1973,p.24). High durability required due to (commonly) exterior location.
Terrazzo	Marbles with fairly close open fractures can be used, as can virtually any other marble. (Reconstituted or terrazzo marble now makes up a significant proportion of marble sold in Europe).

9.3 Marble quarrying in Tasmania

To date, no marble has been quarried for building or ornamental purposes in Tasmania. The Arthur River magnesite marble has recently been investigated as a potential ornamental marble (being promoted as "Tasmatine Marble"), but no dimension stone quarry has been developed.

9.4 Marble prospects in Tasmania

Spry (1986) has described a range of Australian marbles, but at that time no Tasmanian marbles with building or ornamental potential were known. The following is a listing of Tasmanian geological units and associations having possible potential as marble prospects. Some have been intruded by later granites which commonly formed calc-silicate hornfelses and skarns, and may have formed marbles by contact metamorphism. While many of the Precambrian - Cambrian dolomites have not been so intruded, they may in places have formed crystalline marbles by regional metamorphism and/or diagenetic recrystallisation.

PRECAMBRIAN		
Glovers Bluff Inlier	"Crystalline" Dolomite	Lower Weld River
Rocky Cape Block	Savage Dolomite	Corinna
	Keith Metamorphics/Whyte Schist (Magnesite bodies)	Arthur River/Cann Creek Savage R./Main Creek /Bowry Creek
Jubilee Block	Pandani Group (dolomite beds) Clark Group (dolomite beds)	Mt. Anne/Mt. Bowes The Needles
EOCAMBRIAN (Late Precambrian to Early Cambrian)		
Dundas Trough	Success Creek Group (dolomite adjacent granite)	Stanley River Whyte/Heazlewood Rivers
Smithton Basin	Black River Dolomite (Success Crk. Grp. correlate)	East, south & west margins of basin.
Tyennan Block	Jane Dolomite (Success Crk. Grp. correlate)	Jane River Maxwell River Surprise River
Jubilee Block	Weld River Group (dolomite) (Success Crk. Grp. correlate)	Mt. Bowes/Mt. Anne Weld Valley Tim Shea Blakes Opening Cracroft R. Hastings Inlier
CAMBRIAN		
Smithton Basin	Smithton Dolomite ("crystalline" varieties)	Smithton/Montagu /Duck R./Montagu R.
ORDOVICIAN		
Badger Head Block	Denison Group - Cabbage Tree Fm. ("marble")	Beaconsfield

	Widespread	Gordon Group Limestone ("sedimentary marbles")	Mole Creek Florentine Valley, etc
	Dundas and Fossey Mt. Troughs	Gordon Group Limestone (Contact metamorphosed Limestones)	Kara region Moina region Mt. Ramsay? Mt. Stewart? Wilson River?
DEVONIAN			
	Dundas Trough	Spero Bay Group (Pt. Hibbs Limestone)	Point Hibbs
PERMIAN			
	Tasmania Basin (East Tas.)	Upper Marine Sequence (Berriedale Limestone & correlates)	
TERTIARY/QUATERNARY			
	Superficial, often soft limestones; alteration to marble unlikely.		

9.5 Evaluation of marble prospects in Tasmania

Some of the marble prospects listed in section 9.4 are not discussed below. These prospects were not examined during this project, and are considered unlikely to be good marble prospects by reason of inaccessibility, minor and restricted occurrence, or known lack of a dense crystalline nature.

PRECAMBRIAN

Glovers Bluff Inlier - Lower Weld River
"Crystalline" Dolomite marble

PROSPECTIVITY - Medium

The Glovers Bluff Inlier is a small region of probable Precambrian rocks emplaced within Palaeozoic deposits in the Lower Weld River Valley, northwest of Geeveston (see Fig. 9.1). To date, the geology of the inlier has been only sketchily mapped, although current mineral exploration in the area will undoubted produce a significant improvement in this situation.

Very pure quartzites, and dolomites with associated diopside and serpentine, occur in the inlier, and are considered to be of Precambrian age (Turner,*in* Burrett & Martin 1989,p.30). The correlation of the dolomites is unclear; they might possibly be equivalent to the Precambrian Pandani or Clark Group dolomites of the Jubilee Block to the north (Calver, *ir* Burrett & Martin 1989, p.27 - 30).

Very recent (1990) mineral exploration drilling in the inlier has intersected an easterly dipping horizon of marble (presumably recrystallised dolomite) up to 20 metres thick. The marble is reported to be of a very pure carbonate composition, and of a colourful appearance. No further details are currently available.

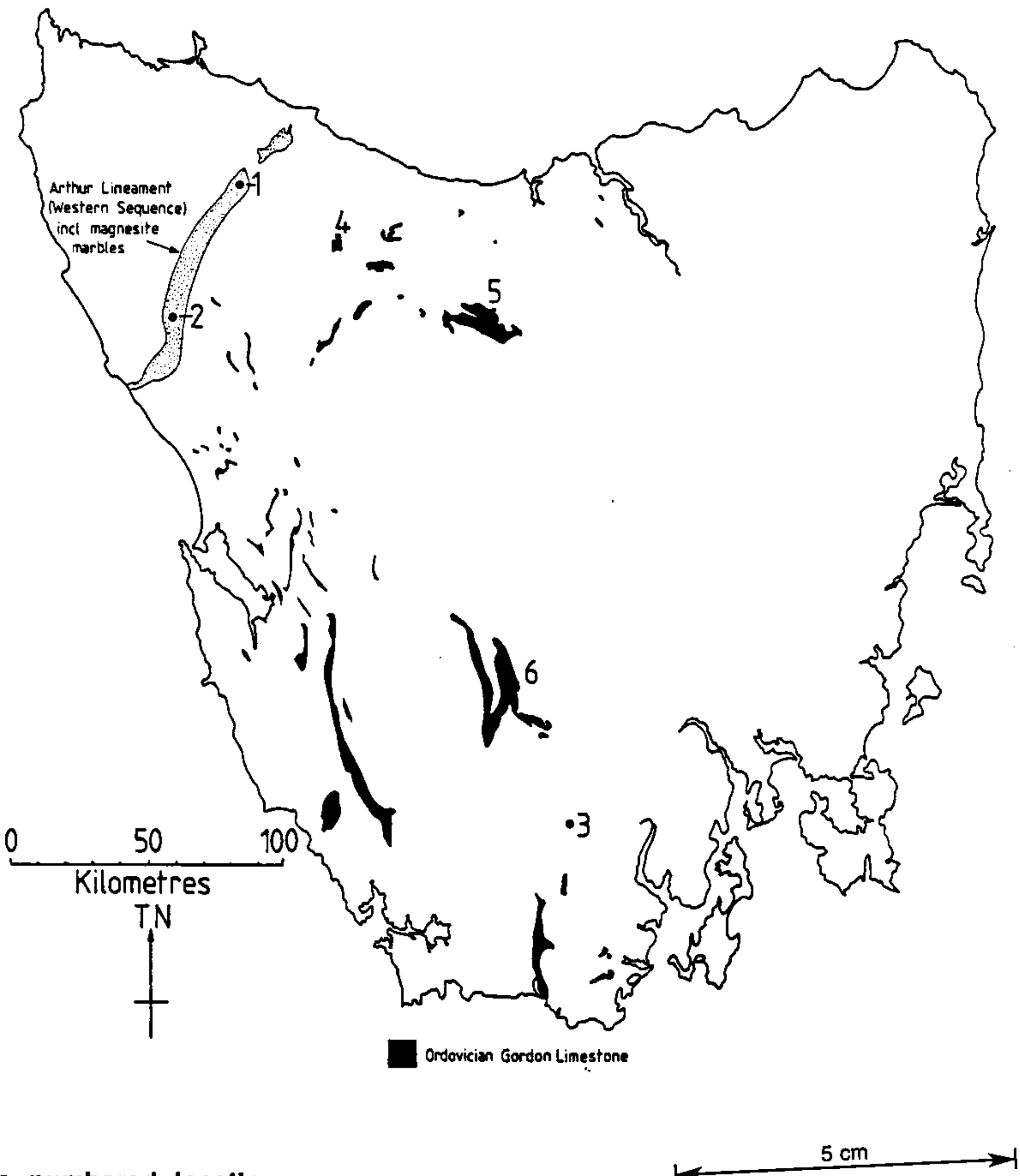
A coarse-grained metamorphosed limestone or dolomite has previously been observed in poor creek bed outcrops below the Glovers Bluff quartzite quarry (N.Turner *pers. comm.*), and this may be a surface outcrop of the same marble horizon described above.

Other metamorphosed Precambrian dolomites

PROSPECTIVITY - ?

It is probable that the Glovers Bluff marble is a Precambrian dolomite which has experienced a higher grade of regional metamorphism than is generally the case in Tasmanian Precambrian dolomites (the Arthur Lineament magnesites discussed below being the only other example currently known to this writer).

Further exploration may locate additional deposits of similarly metamorphosed dolomites, which may be prospective marbles.



Key to numbered locations:

1 Arthur River/Cann Creek magnesite deposits.
2 Main Creek/Bowry Creek magnesite deposits.
3 Glovers Bluff marble prospect.
4 Kara area: Contact metamorphosed Ordovician limestone.
5 Mole Creek area: Ordovician limestone.
6 Florentine Valley: Ordovician limestone.

Figure 9.1 Marble Prospects in Tasmania

Rocky Cape Block - NW Tasmania
Keith Metamorphics / Whyte Schist - Magnesite marbles

A linear belt of metamorphosed and deformed Precambrian rocks trends southwest through the less metamorphosed Precambrian rocks of the Rocky Cape block, and is referred to as the Arthur Metamorphic Complex (Turner, *in* Burrett & Martin, 1989,p.22) or the Arthur Lineament (see Fig. 9.1). The complex includes the Keith Metamorphics (north coast), Keith Beds (Arthur River) and the Whyte Schist (SW end).

The Whyte Schist is divided into eastern and western sequences, which are also present at the Arthur River, whilst most of the Keith Metamorphics appear to be equivalent to the western sequence. The western sequence contains amphibolites, schists, and carbonate (dolomite/magnesite) horizons, and is considered to be a possible metamorphosed equivalent of the Bernafai Volcanics, Savage Dolomite, and associated clastics of the Corinna region, adjacent to the Arthur Metamorphic Complex (Turner, *in* Burrett & Martin,1989,p.23).

Lenses of magnesite form part of a distinctive formation within the western sequence, and are known from the Savage River/Main Creek/Bowry Creek area in the southwest of the Arthur Metamorphic Complex, and from the Cann Creek/Arthur River/Lyons River/Keith River area to the northwest (see Fig. 9.1). It is thought that the magnesite formed by Mg-metasomatism of dolomite (Frost 1982).

The lenses are considered prospective as sources of industrial magnesite. However, since the metamorphism and metasomatism of these bodies has resulted in significant carbonate recrystallisation, they are also true marbles, albeit unusual in being composed dominantly of magnesite carbonate rather than calcite or dolomite.

Cann Creek/Arthur River/Lyons River/Keith River - Magnesite Marbles

PROSPECTIVITY - Low/Medium

Deposits of magnesite in the Arthur River area (Fig. 9.1) are currently held under Retention Licences by CRAE, and a deposit near Cann Creek is within an Exploration Licence held by Mineral Holdings Aus. Pty. Ltd. The magnesite in this area has been examined in recent years both as a possible source of industrial magnesite and for use a dimension stone. Samples of the material have been promoted under the trade name "Tasmatine Marble".

An account of some of the exploration work (drill logs, sample descriptions, geological maps and analytical data) are given in MacKenzie (1984). The magnesite occurs in lenses interbedded with dolomite, sandy dolomite and quartz sandstone; these carbonate-rich units being 150 - 400 metres thick in the Lyons/Keith/Arthur River area. Individual magnesite beds of 70 m and up to 182m thickness have been recorded (*Ibid.*). Some replacement of dolomite by quartzite is known. At Cann Creek, the top 25m of dolomite has been replaced by quartzite, forming a surface cap over the carbonate. The carbonate sequences are in turn interbedded on a larger scale with schist, amphibolite and pyritic siltstone horizons.

Outcrop of the magnesite is generally poor. Surface outcrops of magnesite marble have been excavated at site M/Rb/7/2 (Grid Ref. CQ70524086), on a steep slope immediately north of Victory Springs and Farquhars Bridge on the Arthur River. Despite the excavation, outcrop at the site is still discontinuous, due to a deep soil horizon over a very uneven sub-soil karst surface.

Examination of the site during this project showed the magnesite to be a generally massive, white to pale yellow fine-grained marble, varying in a few places to a faintly laminated pale grey marble, and in others to a white marble with grey mottling (this mottled variety also occurs at nearby Cann Creek). The grey patches may be dolomitic. In most outcrops, the marble is essentially a re-cemented breccia dominated by a complex and attractive network of veins (annealled fractures) up to 40mm or more thick, containing white coarse-grained crystalline carbonate. Minor brown and yellow staining resulting from iron oxides occurs along some veins, and as minor bands and patches. See Plate 3.13.

However, open jointing fractures are also present, with joints spaced as little as 0.1 - 0.5 metre apart in many exposures, although some intervals up to 2.0 metres wide were noted to be free of open joints. Weak iron oxide cementing is present in some joints.

Marble samples from both this site and the nearby Cann Creek site (not visited during this project) have been cut and polished by Dunn Monumental Masons Pty. Ltd.; the stone is considered very attractive, albeit somewhat more difficult to work than normal calcite marbles due the the greater hardness of magnesite. The close fracturing is considered a major problem.

The close open jointing and fracturing of the marble means that there may not be any viable dimension stone quarry sites within the magnesite lenses.

Savage River/Main Creek/Bowry Creek - Magnesite marbles

PROSPECTIVITY - Low/Medium

Magnesite in the Main Creek/Bowry Creek area (Fig. 9.1) at the southern end of the Arthur Metamorphic Complex, SW of Savage River township, was not visited during this project, but has been described by Jennings *et al.* (1967,p.79):

In Main and Bowry Creeks the magnesite occurs as conformable lenses trending along a regional NNW strike within vertically or steeply east-dipping host rocks comprising muscovite-chlorite schist and phyllite, and arenaceous rocks. One lens in Main Creek is exposed continously for nearly 300 metres along strike with a width of 200 metres across strike, and other smaller lenses are exposed in the upper reaches of Main Creek over a distance of 300 metres +.

The magnesite is white, weathering to a pinkish colour. It is fine grained with recrystallised (coarse grained?) veins. In the eastern part of the Main Creek deposit the magnesite is banded by parallel layers of silica about 10mm thick.

The similarity of this description to that of the Arthur River magnesites, and the similar geological environment (ie, within the Arthur Metamorphic Complex) suggest that the Main & Bowry Creek magnesites can be correlated with the Arthur River Magnesites, and that they will have similar aesthetic and jointing characteristics to the latter.

Conclusions - Magnesite Marbles

Discontinuous pods of magnesite are known in the two parts of the Arthur Metamorphic Complex which have been examined in detail, the Arthur River and Savage River areas. Since they trend in a manner conformable with the strike of the Arthur Metamorphic Complex it appears probable that the magnesites are present in the less-explored intervening regions, so that they probably occur discontinuously from Preolenna SSW to the Pieman River area as a conformable stratigraphic unit. They may be metamorphosed and metasomatised equivalents of the Savage Dolomite in the Corinna area.

Close open jointing is a problem in the Arthur River area and is likely to be a problem elsewhere although further exploration could potentially locate more widely jointed deposits. Although the magnesite grades in places to a dolomite composition, no occurrences of calcitic marble have been reported.

The magnesite marbles of the Arthur Metamorphic Complex can be considered to be an aesthetically attractive stone of low to medium prospectivity. However, there appears to be little likelihood of locating softer pure calcitic marbles within the Complex.

Jubilee Block
Pandani & Clark Group dolomites

PROSPECTIVITY - Low

Precambrian dolomites occur within the Pandani and Clark Groups in the Mt. Anne, Mt. Bowes and The Needles areas (*see* Calver, *in* Burrett & Martin 1989,p.28). The dolomites were not examined during this project, and are largely within areas of difficult access which are included in the current World Heritage Area nomination.

EOCAMBRIAN (Late Precambrian to Early Cambrian)

Dundas Trough
Success Creek Group - contact metamorphic marbles?
The Success Creek Group is a sequence of clastic and carbonate sedimentary rocks of EoCambrian (late Precambrian - Early Cambrian) age, forming the basal part of the Dundas Trough sequences. The Group has been defined (Brown 1986,p.23) as consisting of four mappable formations. Carbonate beds occur in the uppermost unit, the Renison Bell Formation, which consists of siltstone, mudstone, sandstone and carbonate beds, overlain by the "red rock" member of haematitic chert and mudstone, with minor carbonate, lithic greywacke and conglomerate units.

The Success Creek Group in the Dundas Trough contains a high proportion of siliceous sediments, contrasting with correlated units elsewhere in Tasmania (the Black River, Jane, and Weld River Group Dolomites - see below) in which carbonate sediments are more predominant. Thus, while the thick, clean dolomite beds of the latter units may be prospective for "sedimentary marbles", the main hope for the occurrence of marbles in the relatively minor carbonate units of the Success Creek Group appeared to be in those few locations where significant contact metamorphism has occurred.

The carbonates of the Success Creek Group have been intruded by a younger (Devonian-Carboniferous) granite in the Stanley River area (Meredith Granite). In addition, a carbonate-bearing possible correlate of the Success Creek Group (Brown 1986,p.28) in the Whyte River - Heazlewood River area has been intruded by the Meredith Granite. These occurrences were considered to be possible marble prospects.

The dolomite horizons of the Renison Bell Formation in the Renison Bell Mine have been extensively mineralised by fluids derived from the Renison Complex-Pine Hill Granite, but are not in direct contact with the main granite mass close to the surface. There does not appear to have been any significant marble formation.

The indications of the work conducted during this project are that good quality contact metamorphic marbles are unlikely to be found in the Success Creek Group carbonate beds.

Stanley River

PROSPECTIVITY - Low

At Stanley Reward, on the Stanley River adjacent to the Pieman Road, dolomite-bearing horizons of the Success Creek Group are intruded by the Meredith Granite immediately to the north. The Success Creek Group at this location comprises mudstones, oolitic chert, siltstones and dolomitic beds up to 15+ metres thick, overlain by haematitic chert of the "Red Rock" member of the Renison Bell Formation (Brown 1986,p.27).

The Stanley River prospect was examined during this project (site M/Dr/1/1, Grid Ref. CP58038159). Outcrop is very poor, with most of the site covered by very dense vegetation. Rock types observed included haematitic chert, white chert with black oolites (silicified carbonates), mudstone and sandstone. No dolomite, recrystallised to marble or otherwise, was identified. Close open jointing occurs in the rock types observed, with joint spacings averaging 0.05 - 0.2 metres apart.

If a widely jointed dolomitic marble did exist at the Stanley River, it is most likely that it would form a reasonably bold outcrop standing out from the soft, closely jointed sandstones and mudstones which were observed. Since such outcrops do not appear to exist, it can be safely assumed that even if any dolomite beds in the area have been marbilised by intrusion of the adjacent granite, they must have close open jointing similar to the other beds observed at the site, and thus be unsuitable for use as an ornamental stone.

Whyte River - Heazlewood River

PROSPECTIVITY - Low

A probable correlate of the Success Creek Group occurring in the Whyte - Heazlewood River area (Brown 1986, p. 28 & Fig. 2) is intruded by the Meredith Granite in the Mt. Youngbuck area. The occurrence was not visited during this project, but is described by Brown (*Ibid.*) as consisting predominantly of quartzitic greywacke, interbedded with mudstone, siltstone, conglomerate and carbonate units.

The dominantly siliceous nature of the unit suggests that contact metamorphosed carbonate beds are likely to be minor, difficult to locate, and quite likely impure and siliceous. The contact metamorphic zone is in an area of difficult access, and is considered to be of low prospectivity.

Success Creek Group correlates - sedimentary marbles?

Smithton Basin
Black River Dolomite

PROSPECTIVITY - Low/Medium

The Black River Dolomite is the older of two carbonate successions in the Smithton Basin, and is considered to be a correlate of the Success Creek Group (Brown, *in* Burrett & Martin 1989,p.52). The Black River Dolomite has previously been considered a part of the Smithton Dolomite, but is now regarded as a separate sequence (*Ibid.*).

The Black River Dolomite has been mapped as a part of the Smithton Dolomite in the Forest Area (Lennox *et al.* 1982), and is currently being mapped in the Trowutta Quadrangle by the Geological Survey of Tasmania.

The Black River Dolomite consists of massive dolomite with nodular chert, laminated dolomite, and stromatolitic cherty dolomite (Brown *in* Burrett & Martin 1989,p.52). Near Forest, only a very thin layer of chert occurs in a 290 metre thickness of the unit, indicating that the chert (silicified carbonate) is probably only a near-surface groundwater effect (*Ibid.*).

Dolomite outcrop in the Smithton Basin is generally poor. The Black River Dolomite outcrops in a road metal quarry on the Sumac Road at site M/Rb/4/1 (Grid ref. CQ361420), where it is a laminated grey stone which is closely jointed and splits easily along bituminous laminations. This site is clearly not prospective for marble.

However, McNeil (1961) noted good outcrops of dolomite on the Arthur and Rapid Rivers, comprising grey to white, fine- to coarse-grained dolomites which are commonly thickly bedded and of mottled colouration.

No outcrops of massive dolomite free of chert were examined during this project, but it is possible that such outcrops could be prospective as sedimentary marbles. However, poor outcrop, close jointing and dull grey colour are likely to make it a poor prospect.

Tyennan Block
Jane Dolomite

PROSPECTIVITY - Low

The Jane Dolomite comprises great thicknesses of clean dolomite with thin basal siliclastics overlying large areas of the Precambrian Tyennan Block in the Jane, Maxwell and Surprise River areas. Calver (*in* Burrett & Martin 1989,p.54) tentatively correlates the Jane Dolomite with the Success Creek Group. In contrast to the Success Creek Group in its type area (the Dundas Trough), the Jane Dolomite contains a high proportion of carbonates relative to it's siliceous content.

Virtually all outcrops of the Jane Dolomite occur within wilderness areas, and are of difficult access. The Jane Dolomite has in most areas been mapped only on a regional scale. Outcrops examined by the writer in the Lightning Plains area, south of Frenchmans Cap, consisted of a dense grey fine-grained stone having open joints commonly spaced four metres or more apart.

No locations are known in which contact metamorphism of the Jane Dolomite is likely to have occurred, and alteration through regional metamorphism is minimal. Any deposits which could be considered "marbles" would be of the "sedimentary marble" variety.

The inaccessiblity of the Jane Dolomite, and location within areas of National Park status, makes further evaluation of the stone as a potential dimension stone impractical.

Jubilee Block
Weld River Group dolomites

PROSPECTIVITY - Low

Thick dolomite sequences outcropping in the Jubilee Block (upper Weld River valley and adjacent areas) are assigned to the Weld River Group (Calver,*in* Burrett & Martin 1989,p.53-54), and have been tentatively correlated with the Success Creek Group (*Ibid.*).

Dolomite outcrops considered to correlate with the Weld River Group occur on the southern slopes of Tim Shea, at Blakes Opening on the Huon River, east of the Cracroft River (south of the Razorback), and in the Hastings Caves area (Hastings Inlier).

As with the Jane Dolomite, access to most areas of the Weld River Group is difficult, and no outcrops were examined during the present project. Calver (*Ibid.*) describes the Weld River Group dolomites as comprising white to pale-grey dolomites, commonly fine-grained and massively bedded, interbedded with cross-bedded, commonly siliceous dolomites and conglomerate and mixtite (open framework conglomerate).

No significant contact metamorphism of the dolomites is known, and regional metamorphism is of a low grade (subgreenschist facies - *Ibid.*).

Although some of the pale, fine grained massive dolomites could potentially provide a "sedimentary marble", the general inaccessibility makes evaluation of the dolomite a low priority.

CAMBRIAN

Smithton Basin
Smithton Dolomite

PROSPECTIVITY - Low/Medium

The Smithton Dolomite as currently understood (see Brown *in* Burrett & Martin 1989,p.52) is the upper of two carbonate sequences in the Smithton Trough which were both until recently grouped together as the Smithton Dolomite. The lower sequence is now known as the Black River Dolomite (*Ibid.*).

The Smithton Dolomite outcrops in the central part of the Smithton Basin, in the Duck and Montague River drainage basins, and underlies a fossiliferous middle-upper Cambrian sequence. It appears to overlie a Crimson Creek Formation correlate, although the relationship is not clear, and so is probably of Cambrian age. Part of the dolomite near Smithton township has been mapped by Lennox *et al.* (1982), although the Black River Dolomite was included as "Smithton Dolomite" in the latter mapping.

Outcrop of the Smithton Dolomite is generally poor, as it is largely situated in flat, low-lying country. Nye *et al.* (1934) and Hughes (1957) described the dolomite as being, in general, a fine-grained grey stone with chert bands and minor siltstone. This finegrained stone is intensely jointed and thinly bedded.

However, Nye *et al.* and Hughes record that outcrops of a coarse-grained crystalline dolomite, usually white with a grey or yellow tinge, and evidently produced by recrystallisation of the fine-grained type, occur in a few spots near Smithton. The crystalline dolomite is massively or thickly bedded and jointing is not prominent. Examples of the crystalline dolomite outcrop at Watsons Bend Quarry 1km west of Smithton (Grid ref. CQ396766), and in quarries 20 chains west of Blackwood Bridge (Grid ref. CQ397755).

Outcrops of crystalline dolomite corresponding to the above description could not be located during the present work. However, blocks of a fine-grained crystalline dolomite were sampled on the road to Watsons Bend Quarry (site M/Rb/5/1, grid ref. CQ405766). A sample of this dolomite polished very well indeed, but is of a rather drab grey colour.

The indication from this site is that if massive, widely jointed blocks of the Smithton Dolomite could be located which have a pleasing colour and appearance, then they would form a high-quality marble. However the very poor outcrop of the dolomite will make the location of such an outcrop difficult, and the indications are that most outcrops will be closely jointed and of rather drab appearance.

ORDOVICIAN

Badger Head Block
Denison Group - Cabbage Tree Formation "Marble"

PROSPECTIVITY - Low

The Cabbage Tree Formation outcrops in the Beaconsfield area of northern Tasmania, and consists predominantly of quartzose sandstone and minor conglomerate (Gee & Legge 1979,p.26 - 27).

A disused "limestone" quarry within the Cabbage Tree Formation was described by Montgomery (1891) and Twelvetrees (1903) as the "marble quarry", and Nye (1924) described the quarried stone as a "tuffaceous limestone of secondary origin".

The quarry, which is situated on Salisbury Creek immediately east of the West Tamar Highway - Flowery Gully Road junction, at Grid ref. DQ862372, is now water-filled, and was not visited during the present project.

The nature of the "marble" is somewhat mysterious. Presumably it is a small lens of carbonate rock within the surrounding quartz sandstone.

The restricted extent of the "marble" and the current difficulty of examining the (now underwater) outcrop, limit any interest this deposit may have as an ornamental marble source.

Widespread Regions
Gordon Group Limestone - "sedimentary marbles"

PROSPECTIVITY - Medium

The Gordon Group is a thick sequence of carbonate sediments (limestone and dolomite), with minor siliceous beds, outcropping in numerous areas in the western half of Tasmania (see Fig. 9.1). The carbonate sediments are interpreted as shallow marine and tidal flat lime muds deposited on a broad shelf covering much of Tasmania in the Ordovician, with some deeper marine carbonates occurring on the south coast at Surprise Bay.

The limestone is generally of grey to dark grey colour when freshly exposed, varying to rarer light-coloured varieties. It is generally fine grained, and may be quite dense. Although the Gordon group is gently to moderately folded, alteration due to regional metamorphism appears to be minimal. However, diagenetic recrystallisation of the original lime mud is widespread.

Bedding varies from finely laminated to massive. Fossils are common, as are structures such as "birdseyes" (small blebs of crystalline calcite), oncolites (algal balls), calcite veins, and stylolites (dark sub-horizontal anastomosing lines). Analyses quoted by Banks (*in* Burrett & Martin 1989,p.223) indicated that over two thirds of a suite of Gordon Group limestones tested had calcite contents of over 90%, and 6% had over 97.5% calcite. Quite pure calcite limestones are common in the Gordon Group. Joint spacing is variable,but many outcrops have open joints spaced several metres apart.

Although no specimens were polished during this project, it is considered that some of the darker and denser recrystallised limestones of the Gordon Group may polish well as a dark grey to black "sedimentary marble", with aesthetic interest being provided by white calcite veins and fossils, stylolites, and other structures.

In exploring for deposits of potential "sedimentary marble" within the Gordon Group, care must be taken to avoid such imperfections as thin bedding, argillaceous bands, silicified fossils, chert (silica) nodules, and relatively thick carbonaceous deposits along stylolites.

A wealth of information is available on the Gordon Group Limestones in certain easily accessible areas such as the Ida Bay, Florentine Valley and Mole Creek regions (Fig. 9.1, *see* Banks & Burrett *in* Burrett & Martin 1989,p.201-224, and references therein). This data will be invaluable in identifying horizons and outcrops of limestone having desirable characteristics for marble production in these and some other regions.

Although a large proportion of the Gordon Group limestones are subject to the imperfections mentioned above, the vast amounts of the limestone available in easily accessible and quarriable regions enhances the likelyhood of locating good deposits, and the limestones are accordingly considered to be of medium prospectivity for "sedimentary" marble.

Dundas and Fossey Mt. Troughs
Gordon Group Limestone - Contact Metamorphosed Limestones
Although regional metamorphism of Gordon Group limestones appears to be insignificant from the point of view of potential marble production, contact metamorphism of the limestones due to intrusion of Devonian - Carboniferous granites has occurred in some parts of the Dundas and Fossey Mountain Troughs. These occurrences are discussed below:

Kara region - Calc-silicate hornfels "marble" & Skarn

PROSPECTIVITY - Low/Medium

An area of Gordon Group Limestone outcropping in the Kara Mine region, south of Hampshire and east of St. Valentines Peak, has been intruded by the Devonian-age Housetop Granite (Baillie *et al.* 1986).

The limestone outcrops are generally poor and have been contact metamorphosed and metasomatised, producing respectively a wollastonite-bearing calc-silicate hornfels over most of the area, and magnetite skarns in three isolated localities including the Kara Mine site (Green, *in* Seymour 1989,p.27, and Baillie & Lennox, *Ibid.*). Limestone specimens described by Green contain recrystallised quartz grains and altered sericite, suggesting that the original pre-metamorphic limestone was an impure siliceous and argillaceous (clayey) limestone.

The wollastonite-bearing calc-silicate hornfels has only been described in detail in one locality, at Wollastonite Creek (Grid Ref. CQ997288). One site (M/Dr/3/1) was visited during the present project, where a fresh (blasted) outcrop four metres high is exposed 30 metres east of Wollastonite Creek. Superficially, the stone appears to be a good, fairly uniformly coloured crystalline marble. The stone has a uniform, fine-grained crystalline texture, and is of a white to very light grey (N8) colour with subtle grey mottling and planar grey bands. Open subvertical joint spacings vary from 0.5 to 2.0 metres apart, and fine, strong annealled veins averaging 1.0 to 3.0mm thick occur spaced 10 - 50mm apart in attractive networks.

However, thin section examination of a typical specimen (M/Dr/3/1/1)revealed that the stone is dominated (50-60%) by elongate fibrous crystals of wollastonite ($CaSiO_3$), and also contains 10-20% quartz and ≈20% diopside.

Bottrill & Bacon (*in* Seymour 1989,p.76) found that specimens from the same site contained wollastonite, diopside, calcite, quartz, feldspars and minor accessory pyrite, chalcopyrite, sphene, epidote, leucoxene, zircon and amphibole. They considered that the diopside, pyrrhotite and feldspar probably indicated metamorphic alteration of original dolomite, pyrite and kaolinite clay respectively, indicating an original limestone of dolomitic, pyritic and argillaceous composition.

Williams *et al.* (1954,p.193) considers the wollastonite/pyroxene (eg, diopside) assemblage to be typical of calc-silicate hornfels formed from more calcic argillaceous limestone varieties.

The mineralogy of the wollastonite calc-silicate hornfels "marble" is quite unsuited to use as an ornamental marble: the metallic minerals may weather to produce staining, the hard quartz component will cause differential polishing and weathering problems, and the dominant fibrous wollastonite grains are prone to easily falling or weathering out (Spry, *pers. comm.*, 1989), causing pitting of polished surfaces.

An additional problem is that the outcrop contains hard (siliceous) chert bands 100mm or more thick spaced a metre or so apart within the calc-silicate "marble".

Possibly purer calcitic marbles may be present elsewhere in the Kara region, these having formed from contact metamorphism of beds of limestone free of siliceous and argillaceous material. In view of the relatively sketchy information presently available regarding compositional variation in the limestones of the Kara region, this possibility is certainly worth further examination. However, the available information does indicate that the bulk of the Kara Gordon Group limestones were of an originally impure siliceous and argillaceous nature.

Moina region - skarn

PROSPECTIVITY - Low

In the Moina region, west of Cethana, the basal horizons of the Gordon Group limestones, and underlying transitional zone beds (Florentine Valley Mudstone correlate) have been metamorphosed and metasomatised by the intrusion of the nearby Devonian Dolcoath Granite, resulting in the production of skarn deposits (Jennings *et al.* 1959, Jennings 1979, Leaman & Richardson 1989, Pemberton & Vicary 1989).

The most recent mapping (Pemberton & Vicary 1989) shows that the skarns outcrop in the River Lea, Iris River and Bismuth Creek valleys near Lake Gairdner. These occurrences were not visited during the present project. Jennings (1979,p.28,73, 84 & 89) describes the skarns as comprising two dominant types, a calc-silicate garnet skarn and a richly metalliferous magnetite-fluorite skarn.

The garnet skarns consist mainly of garnet and pyroxene or actinolite, while the magnetite-fluorite skarns contain up to 40% magnetite and 20% fluorite (*Ibid.*). Accessory minerals include quartz, feldspar, epidote, biotite, vesuvianite, sericite, chlorite, pyrite, pyrrhotite, arsenopyrite and other metallic minerals.

Information regarding texture, appearance, structures and jointing is not available. However the composition of the skarns, which are rich in metallic minerals and contain relatively small quantities of calcite, rules out any consideration of their use as ornamental marbles.

Mt Ramsay, Mt. Stewart, Wilson River areas - Contact metamorphosed limestones?

PROSPECTIVITY - Low

Brown (1986) has mapped three localities in which Gordon Group limestones have been intruded by the Devonian - Carboniferous Meredith Granite, these being in the Mt. Ramsay, Mt. Stewart, and Wilson River areas, north of the Pieman River.

In all three cases, access is difficult. However, Brown (*Ibid.* p.61) notes that the limestones observed on the sides of the Huskisson Syncline (ie, close to the Mt. Ramsay and Wilson River limestone/granite contacts) contain abundant mudstone laminae. They are therefore impure limestones which are more likely to have altered to calc-silicate hornfels than to pure calcite marbles when contact metamorphosed.

CHAPTER TEN

SERPENTINE

10.1 Definition and description

Serpentine (or more correctly, serpentinite rock) is a relatively soft green rock, commonly veined with magnesium and calcium carbonates. Apart from the green colour, serpentine may have structures similar to those of marble, and is commonly regarded in the stone trade as a variety of marble. It is quite distinct mineralogically, however, and for that reason is treated separately in this report. Stone trade names for serpentine include "Green Marble" and "Verde Antique".

True carbonate marbles may indeed contain serpentine in some instances: contact metamorphism of magnesian limestones with minor silica impurities may produce marbles containing small quantities of pyroxene and olivine, which in turn can undergo serpentinisation to form a serpentine-bearing marble (Williams *et al.* 1954,p.189).

Serpentines are hydrated magnesium silicates which may include either of two distinct minerals, antigorite and chrysotile, which may be difficult to distinguish visually (Am.Geol. Inst.,1962). Other minerals which may be present in serpentinite rocks include lizardite, brucite and minor magnetite. The chrysotile may occur in the form of fibrous asbestos; veins of asbestos are a common feature of Tasmanian serpentines, and are detrimental to ornamental stone quality due to their softness (in addition, the presence of asbestos makes serpentine dangerous to work for health reasons). However, annealled fractures and veins composed of more resistant minerals are generally considered aesthetically desirable.

Serpentines quarried overseas are commonly re-cemented breccias which are reasonably strong and of considerable aesthetic appeal.

Serpentines are considered to form by a low-temperature reaction between cooling ultramafic rocks (especially peridotites - see Ch. 7) and water introduced from external sources (Carmichael *et al.* 1974,p.608). Circulating oceanic and meteoric waters appear to be major agents of serpentinisation, through alteration of the olivine and pyroxene minerals constituting the original ultramafic rocks.

Most serpentine in Tasmania occurs in Cambrian-age Ultramafic Complexes which have been serpentinised to varying degrees. In some places (eg, the Dundas and Boyes River UMC's) the original ultramafic rocks have been almost completely replaced by massive serpentine, but a more common situation is relatively unaltered masses ("corestones") of ultramafic rock surrounded by "sheaths" of serpentine (this latter type is well exposed in the Serpentine Hill UMC at the Serpentine Hill quarry). In many outcrops, serpentine occurs only as thin coatings on fracture surfaces, within less altered ultra-mafic rocks.

10.2 Serpentine applications

Serpentines are in general not suitable for exterior use in exposed situations, due to the relative softness of the stone, and to the tendancy of serpentine colours to fade if exposed to direct sunlight. Appropriate applications for serpentine may include:

Interior veneers (cladding tiles and slabs)	
Interior furniture and decorative features	Benches, table-tops, etc. Slightly fractured types can be used attached to a strong backing.
Paving tiles	Not recommended due to stone's softness, but is sometimes used.
Terrazzo	Crushed serpentine bound together with an artificial cement; most fresh serpentines can be used for this purpose, even if intensely shattered.
Ornamental carvings	Bookends, etc. Potentially a good use for some Tasmanian serpentines.

10.3 Serpentine quarrying in Tasmania

There is no record of serpentine having been quarried in Tasmania for the production of large blocks or polished slabs for building applications.

Serpentine was quarried at Andersons Creek (Beaconsfield) circa 1960 (Lancaster 1980, p.25). The stone was crushed for terrazzo production.

Small blocks of serpentine are currently used for the production of small ornamental carvings (Simon Stephens, *pers. comm.* 1990).

10.4 Serpentine prospects in Tasmania

Serpentines primarily occur in Tasmania in association with ultramafic complexes (UMC) of Cambrian age.

PRECAMBRIAN		
Glovers Bluff Inlier	Serpentine (assoc. with dolomite)	Lower Weld River.
Rocky Cape Block	Arthur Metamorphic Complex (Serpentines associated with magnetite deposits) (*Burrett & Martin 1989,p.23)*	Savage R. Iron ore mine.
CAMBRIAN		
Dundas Trough	Dundas UMC	Dundas
	Serpentine Hill UMC	Renison region
	Mt Stewart UMC	Savage River region
	Heazlewood River UMC	Luina region
	Wilson River UMC	Pieman River region
	Huskisson River UMC	Pieman River region
	Howards Rd. Ultramafics	S. & E. of Howards Rd.
	Moores Pimple Ultramafics	Moores Pimple

	Ultramafics	Wilmot/Cethana bodies.
	Cape Sorell UMC	Cape Sorell
	Spero Bay UMC	Spero Bay
	Trial Harbour UMC	Trial Harbour
Forth Block	Forth UMC	Ulverstone
Badger Head Block	Andersons Creek UMC	Beaconsfield
Adamsfield Trough	Adamsfield UMC	Adamsfield, Scotts Pk. Rd.
	Boyes River UMC	Boyes River
Jubilee Block	Ultramafic bodies	Styx R./ Weld R.
South Coast	Rocky Boat Harbour UMC	Rocky Boat Harbour

10.5 Evaluation of serpentine prospects in Tasmania

A number of prospects listed in section 10.4 above are not discussed in detail. These were not examined during this project, and little information on their potential as serpentine deposits is available.

CAMBRIAN

Serpentinised Ultra-Mafic Complexes

The bulk of serpentine deposits in Tasmania occur within the Cambrian Ultra-Mafic Complexes. These complexes are thought to have been tectonically emplaced as thrust sheets (Williams, *in* Burrett & Martin 1989,p.482), and have subsequently been subjected to multiple phases of deformation. This, at the outset, suggests that fairly intense shearing will occur in the serpentines.

The most extensive Ultra-Mafic Complexes occur in the Dundas Trough of western Tasmania, and comprise layered dunite, peridotite, pyroxenite and associated gabbros (see Ch. 7) which in most cases have undergone partial serpentinisation. A number of other Cambrian Ultra-Mafic Complexes outcrop elsewhere in Tasmania (see Fig. 10.1).

At the outset of this project, the Dundas Ultra-Mafic Complex, east of Zeehan, was considered the most promising serpentine prospect since it is easily accessible, and has been almost completely altered to massive serpentine. This and a number of other Ultra-mafic Complexes have been examined during this work.

However, the conclusion drawn from the work conducted in this project is that the Ultra-Mafic Complexes show little potential for production of serpentine which can be used in dimension stone form as polished slabs, tiles and veneers.

The serpentines are almost ubiquitously intensely sheared, producing closely spaced networks of open fractures and weak asbestos-filled veins. With the possible exception of the Cape Sorell and Forth UMCs, most of the serpentines appear to be too fractured even for the production of small carved ornaments, let alone tiles and veneer slabs (Simon Stephens, *pers. comm.* 1990).

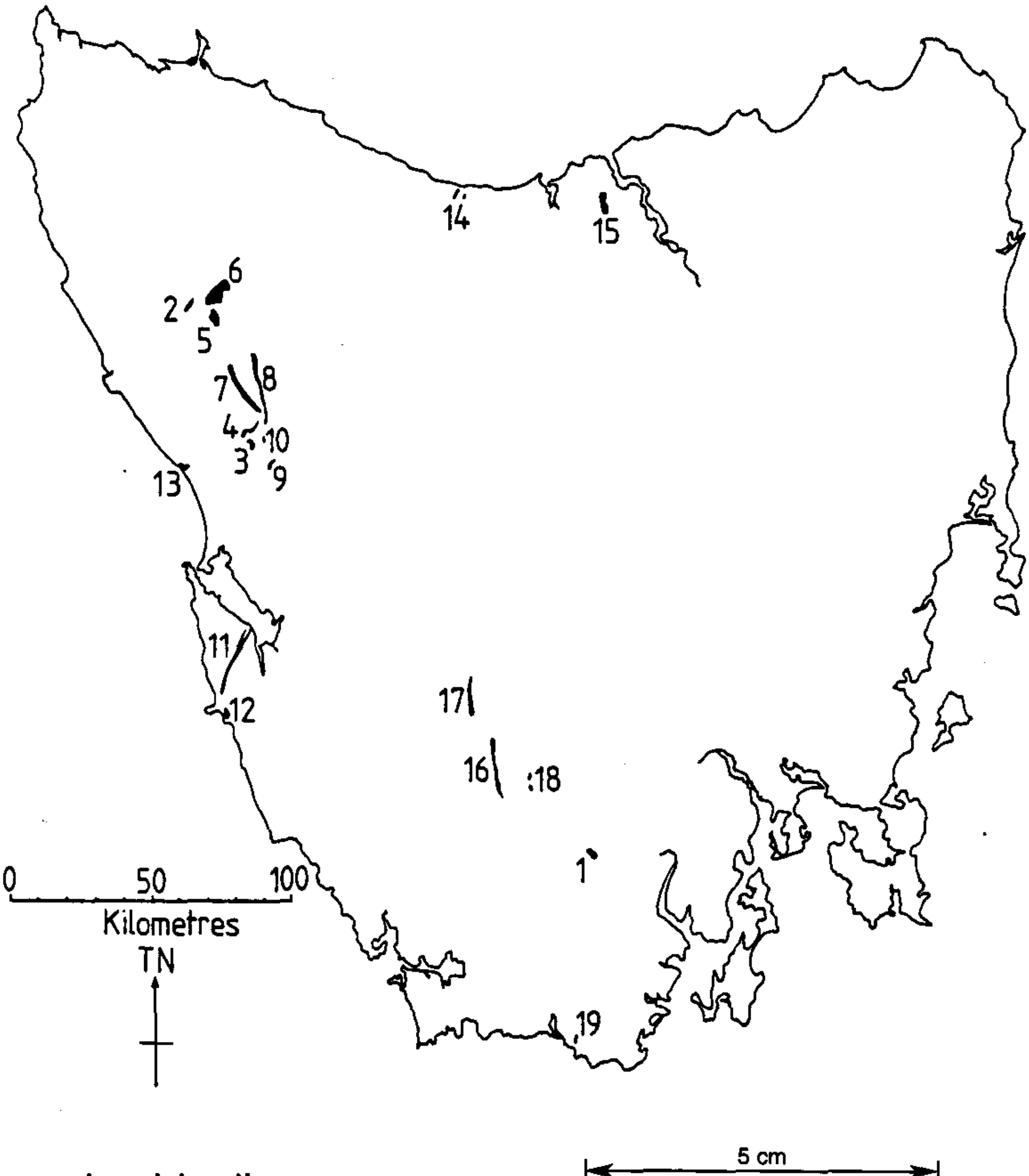
The most promising potential ornamental use of the serpentines appears to be for production of terrazzo.

Dundas Trough
Dundas Ultra-Mafic Complex

PROSPECTIVITY - Low

The Dundas Ultra-Mafic Complex (area Sr/Dr/1, see Fig. 10.1) is a faulted block surrounded by Cambrian sedimentary rocks of the Dundas Group, covering an area of approximately three square kilometres at Mt. Razorback, east of Zeehan, and consisting almost entirely of massive serpentine with a small residual area of partially serpentinised ultra-mafic rocks at the north -western end (Brown 1986, p.122 & Fig. 1).

Several good excavated outcrops of the serpentine were examined at site Sr/Dr/1/1, near the Razorback Mine. The serpentine is of a green to yellowish-green colour with subtle dark green



Key to numbered locations:

<u>Precambrian</u>
1 Glovers Bluff Inlier
2 Savage River Serpentines

<u>Cambrian</u>
3 Dundas UMC
4 Serpentine Hill UMC
5 Mt. Stewart UMC
6 Heazlewood River UMC
7 Wilson River UMC
8 Huskisson River UMC
9 Howards Rd. ultramafics
10 Moores Pimple
11 Cape Sorell UMC
12 Spero Bay UMC
13 Trial Harbour UMC
14 Forth UMC
15 Andersons Creek UMC
16 Adamsfield UMC
17 Boyes River UMC
18 Styx/Weld R. ultramafics
19 Rocky Boat Harbour UMC

Figure 10.1 Serpentine Deposits in Tasmania to black mottling in parts. It is uniformly fine-grained and generally massive (structureless) with some areas of subtle relict banding from the original ultra-mafic deposits. Thin asbestos veins are common.

The serpentine is intensely sheared, with multiple-direction open fractures spaced between 10 and 100mm apart in all outcrops seen.

Serpentine Hill Ultra-Mafic Complex

PROSPECTIVITY - Low

The Serpentine Hill Ultra-Mafic Complex (area Sr/Dr/2, see Fig. 10.1) has been described by Rubenach (1974) and Brown (1986). The complex is located around the Murchison Highway south of Renison Bell, and consists of intrusive and layered bodies of pyroxenite and peridotite, and intrusive gabbro. The pyroxenites and peridotites have been extensively serpentinised.

The complex was examined at the Serpentine Hill Quarry, adjacent to the Murchison Highway (site Sr/Dr/2/1). The serpentine itself is of similar appearance to that found in the Dundas UMC, being of green to yellowish-green colour, with darker mottles and dendrites. It is uniformly fine-grained and contains an abundance of asbestos veins a few millimetres thick.

The serpentine occurs in masses up to several metres thick, surrounding peridotite/pyroxenite cores which may be up to several metres diameter.

The serpentine is intensely sheared, with open fractures spaced less than 100mm apart on average, although the degree of shearing varies: some zones of very intense shearing have fractures spaced only millimetres apart, whereas several blocks of serpentine were noted which appear to have open fractures spaced several hundreds of millimetres apart.

Although a few of the less-sheared serpentine blocks could conceivably be used in moderately large slabs bonded to a suitable backing, the predominance of intense shearing, and the occurrence of peridotite/pyroxenite core-stones dispersed through the serpentine, would make quarrying the few less-sheared zones somewhat un-economic.

Heazlewood River Ultra-Mafic Complex

PROSPECTIVITY - Low

TheHeazlewood River Ultra-Mafic Complex (see Fig. 10.1) outcrops along and north of the Savage River Rd., and has been described by Rubenach (1973).

Outcrops examined along the Savage River Rd. and on 4WD tracks to the north (area Sr/Dr/4) comprise relatively unaltered dunites, pyroxenites and harzbugites which have networks of close open joints with average spacings of 0.1 to 0.5 metres. In all the outcrops examined, serpentinite occurs mainly as thin coatings on fracture surfaces.

Wilson River Ultra-Mafic Complex

PROSPECTIVITY - Low

The Wilson River Ultra-Mafic Complex (see Fig. 10.1) is an elongate body extending NW from the Pieman River to the Harman River area, and has been described by Brown (1986).

Much of the complex consists of serpentinised dunite, peridotite and pyroxenite, commonly containing relict grains or blocks of unaltered minerals and ultra-mafic rock. Brown indicates that the serpentinite is sheared throughout the Complex.

Good outcrops were examined along the Pieman Rd. in the Serpentine Ridge area (area Sr/Dr/3). Most of the ridge consists of serpentinite after dunite and peridotite, varying from massive serpentinite (eg, just east of the Wilson River) to thin veins of serpentine in dunite. The massive serpentinite is pale green with thin dark veins and mottling, and is intensely sheared in all outcrops examined.

S. Stephens (*pers. comm.* 1990) reports that a black serpentine is present in the Wilson River UMC, although it tends to go grey upon exposure.

Cape Sorell Ultra-Mafic Complex

PROSPECTIVITY - Low/Medium

The Cape Sorell Ultra-Mafic Complex is located in a remote area south of Macquarie Harbour (see Fig. 10.1), and has been mapped by McClenaghan and Findlay (1989). Access is by boat and then along foot tracks constructed for mineral exploration. The area (Sr/Dr/6) was not visited during this project.

The predominant rock type in the complex is sheared serpentinised pyroxenite (McClenaghan and Findlay 1989). However McClenaghan and Findlay mapped a small region of unsheared serpentinised pyroxenite around Grid Ref. CN652965. S. Stephens (*pers. comm.* 1990) has reported that an area of serpentinite near Noddy Creek has joint spacings as wide as any serpentinite in the Dundas Trough, and this may be the same occurrence.

Attractive apple-green serpentines with black dendrites and purple stichtite spots are obtainable in the Cape Sorell UMC (S. Stephens *pers. comm.* 1990), and unfractured blocks large enough for carving bookends, turnings, and the like, are available. Minor asbestos veins are present.

Actual joint spacings in the serpentinite are not known to the writer at this time, but the remote location, combined with the likely occurrence (in common with all other serpentinites examined in the Dundas Trough) of numerous fine hairline fractures, make this occurrence a low priority exploration target.

Forth Block
Forth Ultra-Mafic Complex

PROSPECTIVITY - "High" (for small ornaments)

The Forth Ultra-Mafic Complex (see Fig. 10.1) is a mass of serpentinite replacing peridotite which has been emplaced within the Precambrian Forth Metamorphic Complex (quartzite, garnet schist and amphibolite) just east of Ulverstone (Burns 1963, 1964). Serpentinite deposits are exposed along the western side of Claytons Rivulet and in a small body on the Forth River.

An interesting deposit of the serpentinite is exposed at Grid ref. DQ330408 (site Sr/Dr/5/1), on the northern side of a stone lease held by Ulverstone Quarries, who currently quarry the adjacent quartzite. The serpentinite is fine grained and has an overall dark green colour. Polishing of specimens reveals a complex, small-scale "flowing" patchy and banded structure, comprising lighter and darker green patches plus dark red flecks 5 - 10mm in diameter which give the stone a very attractive appearance.

Major open joint breaks in the deposit are spaced about 0.3 - 0.5m apart, and additional irregular fine hairline fractures are apparent in hand specimen. The stone does not "fall apart" along these fractures, but will split relatively easily along them under impact. Minor asbestos veins are present, and Burns (1964) described large aligned "xenoliths" of amphibolite in the deposit.

The serpentines of the Forth UMC have the most widely-spaced open joint breaks and fractures known in any Tasmanian serpentine deposit (Simon Stephens *pers. comm.* 1990). They are suitable for the production of ornamental carved items (eg, bookends, paper weights), and could be suitable for small cladding tiles for interior use if bonded to a suitable backing. However the fracturing is too intense for production of veneer slabs.

Badger Head Block
Andersons Creek Ultra-Mafic Complex

PROSPECTIVITY - Low

The Andersons Creek Ultra-Mafic Complex (area Sr/Bb/1) outcrops west of Beaconsfield (see Fig. 10.1). It has been described by Gee & Legge (1979), and was visited by the present writer.

The Complex comprises serpentinite, pyroxenite and gabbro, with serpentinite being more abundant in the southern part of the Complex. The serpentinite is dark green and has a massive to mesh-serpentine texture with common asbestos veins. Most of the serpentine is intensely fractured and sheared with common slickenslides. Gee & Legge report outcrops of less deformed serpentinite, but do not specify locations.

In general, the serpentinites are too sheared and fractured to be used for any purpose other than terrazzo (for which they have indeed been used previously - see Section 10.3 above). It would be interesting to locate the less deformed outcrops of Gee & Legge, but by comparision with other Tasmanian serpentinites these are likely to have an abundance of hairline fractures, if not asbestos veins and other defects as well.

Adamsfield Trough
Adamsfield Ultra-Mafic Complex

PROSPECTIVITY - Low

The Adamsfield Ultra-Mafic Complex (area Sr/Tb/1, see Fig. 10.1) is accessible from the Gordon River Road by 4WD tracks, and has been described by Brown *et al.* (1989).

The Complex is less thoroughly serpentinised than the Boyes River UMC to the north (see below), comprising serpentinite and partially serpentinised peridotites, as well as a relatively unaltered coarse massive pyroxenite.

The Complex was tectonically emplaced along major N-S faults, and has been folded during the Devonian in the core of an anticline. As a result of these (and possibly other) tectonic events, the Complex is generally closely jointed (av. 0.3m joint spacings or less), and all the serpentinites are intensely sheared with common "crushed" and slickenslided zones.

Boyes River Ultra-Mafic Complex

PROSPECTIVITY - Low

The Boyes River Ultra-Mafic complex (area Sr/Tb/2) outcrops in remote country to the west of the Denison Range and the Stepped Hills, north of Adamsfield (see Fig. 10.1), and was not visited during this project. The Complex has been described by Brown *et al.* (1989).

The Boyes River UMC is essentially totally serpentinised, consisting of serpentinite showing coarse relict layering and minor layers of remanent unaltered pyroxenite. The serpentinite is intensely sheared and contains abundant asbestos veins.

CHAPTER ELEVEN

OTHER STONE TYPES

11.1 Introduction

A number of potential types of building and ornamental stone exist in Tasmania which do not fit neatly into the categories employed in the preceding chapters.

In most cases, these other stone types were not specifically examined or assessed during this work. Hence, most of the potential prospects for these other stone types are only briefly listed and described here in order to alert the reader to their existence and possible significance.

11.2 Limestone and dolomite prospects in Tasmania

Unpolished limestones and dolomites are widely used in Europe and the USA, as massive masonry, veneers and paving. Some limestone has in the past been used in this fashion on mainland Australia (eg, Adelaide), and a very soft and porous white limestone quarried at Mt. Gambier (S.A.) is currently a popular domestic building material due to its pleasing appearance and ease of working.

Limestone has rarely been used as a building material in Tasmania, its purpose having been fulfilled by the widespread and easily available Early Triassic sandstones. However, large deposits of durable, thick-bedded and widely-jointed limestones and dolomites exist in Tasmania, some of which would potentially be excellent building stones for use in places not affected by acid pollution.

These deposits are briefly discussed below:

PRECAMBRIAN/CAMBRIAN

Western & southern Tasmania
Dolomites

PROSPECTIVITY - Low

Thick deposits of dolomite occur widely in western Tasmania (see descriptions in Chapter Nine), and include hard, dense, fine-grained grey-coloured deposits which are in some cases thickly bedded and widely jointed. Some of these would probably make a good unpolished building stone of high durability.

However, as described in Chapter Nine, most of the dolomites are in inaccessible regions, and/or form regions of low topography with poor outcrop. They are therefore of low prospectivity compared to the Ordovician limestones described below.

ORDOVICIAN

Widespread
Gordon Group ·mestones

PROSPECTIVITY · High

Deposits of Ordovician limestone also occur widely in Tasmania, as described in Chapter Nine (see Fig. 9.1). The Ordovician limestones are characteristically fine-grained, dense and strong, and of a dark grey colour with white calcite or quartz fossils and veins. Many outcrops are widely jointed and thickly bedded, and would make a durable unpolished building stone.

The Ordovician limestones have been commercially exploited as an industrial material at Mole Creek, Railton, Ida Bay, and in other areas. Many of the currently exploited quarries, or nearby deposits, would probably be suitable as sources of dimension stone, although proper evaluation of their technical qualities would be necessary.

PERMIAN

Tasmania Basin (Eastern Tasmania)
Upper Marine Sequence - Berriedale Limestone

Prospectivity - ?

The predominantly clastic rocks of the Permian marine sequences contain a number of limestone horizons, most notable of which are the Upper Bernacchian Berriedale Limestone and correlates, which may reach up to 60 -75 metres in thickness (Clarke & Banks 1975, Clarke *in* Burrett & Banks 1989,p.303).

The Berriedale limestone is a grey, dense, fossiliferous limestone which has been quarried as an industrial and agricultural material in the Hobart region. The Berriedale Limestone was not examined during this work, and details as to its quality as a building material are not available. It is quite possible that it may be a source of good durable dimension stone close to Hobart.

TERTIARY/QUATERNARY

Widespread, predominantly coastal regions
Recent Limestones

PROSPECTIVITY - ?

Hughes (1957) records limestone deposits of Tertiary and Quaternary age in a number of locations, including Flinders and King Islands, Smithton, Sorell and elsewhere. Most of these limestones are soft unconsolidated deposits of limited extent, although it is possible that soft but consolidated deposits of a character similar to the soft Mt. Gambier Limestone may exist in Tasmania.

None of these limestones were examined during the present work, and very little recent information on them is available. Their prospectivity cannot be properly assessed at this stage, although it is likely that soft consolidated limestones of the Mt. Gambier type, if present, would only occur in small deposits in Tasmania. Such limestones are certainly not a major feature of Tasmanian geology.

11.3 Travertine deposits in Tasmania

PROSPECTIVITY - Low

Travertine is a variety of limestone which is commonly deposited around springs where carbonate-enriched waters reach the surface. It is a fine-grained limestone which may be very hard and which shows a layered (often mounded) structure, commonly with large macroscopic pore spaces.

Hard white travertine containing very large pores is a well known Italian export which is used as a polished "marble" veneer throughout the world (including a number of Tasmanian buildings, such as the Tasmania Bank building in the Elizabeth St. Mall, Hobart). These Italian travertines are very thick and extensive hot spring deposits, and there is no record of any deposits of similar extent or quality in Tasmania.

A hard, partly silicified, travertine of Tertiary age occurs in a small area at the head of Geilston Bay, in Hobart (Hughes 1957, Tedford *et al.* 1975). This deposit is now almost entirely covered by a school playing ground, and in any case its partly siliceous nature would make it unsuitable as a building stone.

Calcareous "Spring Mound Deposits" of Quaternary age occur at Pulbeena and Mella, in the Smithton area (Hughes 1957, Summons 1979, Brown 1989). These have been described as travertine (Summons 1979), but are a soft friable deposit interbedded with peat, clay, sand and clay. They have no dimension stone potential. A similar deposit occurs at Pawleena, near Sorell (Hughes 1957).

Numerous small deposits of hard travertine occur throughout Tasmania, as superficial and fissure-filling deposits. Examples can be seen at Benders Quarry (Lune River), Beams Quarry (Flowery Gully), Taroona, and in many other localities. Although some of these deposits would be of a quality sufficient for dimension stone, they are commonly only a few centimetres thick, and only extend over areas of a few square metres.

There is no evidence of deposits of travertine suitable for dimension stone usage in Tasmania.

11.4 Miscellaneous other stone types

PRECAMBRIAN

Tyennan Block and other minor areas
Metamorphic Quartzite

PROSPECTIVITY - Low

Very hard white metamorphic quartzites outcrop extensively throughout the Tyennan Block of western Tasmania, and in a few other smaller regions. Although the quartzite is commonly interbedded with schist and phyllite, some deposits (eg, at Glovers Bluff) are quite pure. The white quartzites would polish well, and would be a stone of similar appearance to white marble, but with a very high durability.

However, such hard metamorphic quartzites would be very difficult to work, which is one reason why the softer marbles are preferred for ornamental work. In addition, the Tasmanian quartzites are intensely fractured. They are not considered to be prospective as ornamental stones.

PRECAMBRIAN - CAMBRIAN

Several areas
Soapstone (Talc)

PROSPECTIVITY - ?

Soapstone (Talc) is a very soft variety of stone which is sometimes used for small ornamental carvings, although it is too soft to be used for building purposes.

A number of deposits of soapstone occur in Tasmania (Bacon 1987a), in association with serpentinised ultramafic rocks and as an alteration product of dolomite. Notable deposits occur at Gawler (Ulverstone district) and Marshalls Creek (Port Sorell).

These were not examined during this project, and their suitability as an ornamental stone has not been assessed.

CAMBRIAN

Ultra-mafic Complexes
Ultramafic-hosted metallic ores

PROSPECTIVITY - ?

The writer has observed polished specimens of metallic ores hosted by dark green-black ultramafic rocks from the Heazlewood River Ultramafic Complex (see Fig 10.1) which had a strikingly attractive character. It is possible that such ores could make an attractive and very unusual type of ornamental stone for use in prestige interiors.

Ornamental stone of such a type would be subject to problems of tarnishing and staining of the metallic ores, and would probably require a protective coating of some sort. In addition, the Tasmanian ultra-mafic complexes are all intensely fractured, as discussed elsewhere in this report. However, for such an unusual stone, intended for interior use, it might be worth giving consideration to the use of slightly fractured slabs bonded to a strong backing.

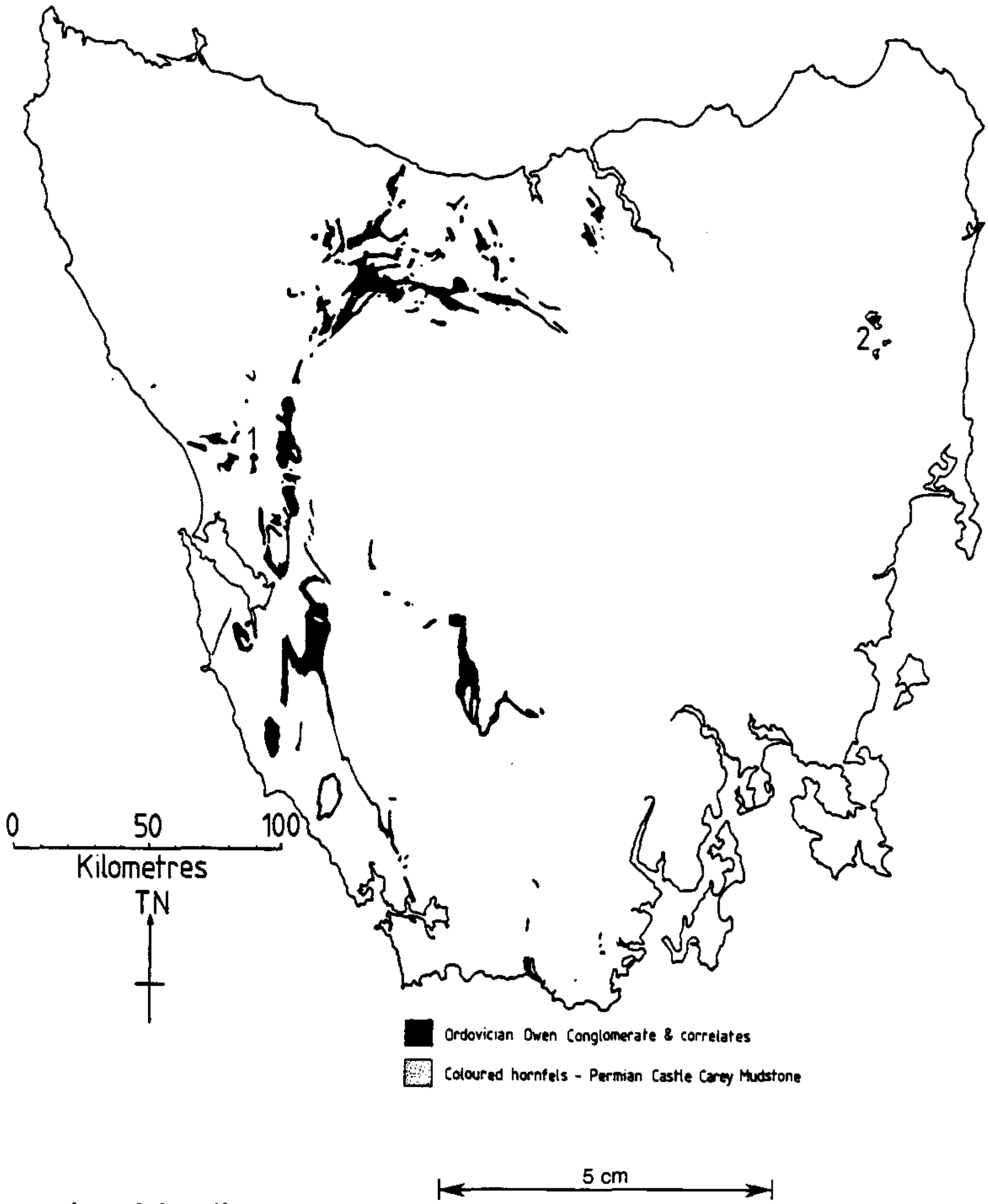
Ore deposits from other geological associations (eg, the Cambrian Mt. Read Volcanics) may have similar ornamental potential.

LATE CAMBRIAN - ORDOVICIAN

Dundas Trough and other areas
Denison Group - Owen Conglomerate and correlates

PROSPECTIVITY - High

The Denison Group underlies the Ordovician Gordon Group limestones in many parts of Tasmania, and includes thick sequences of very hard coarse siliceous conglomerate which



Key to numbered locations:

1 Henty River Bridge: Owen Conglomerate boulder deposits.
2 Fingal region: Coloured hornfels prospect.

Figure 11.1 Distribution of Owen Conglomerate and correlates in Tasmania. Also shown is coloured hornfels distribution (Fingal).

outcrop boldly, forming a large part of many mountains such as Mt. Roland and the Tyndall Range. See Fig. 11.1.

The conglomerates are referred to the Owen Conglomerate, Roland Conglomerate, and equivalent units. They typically contain an abundance of rounded cobble-size quartz and quartzite clasts set in a matrix which is commonly of a strong reddish colour, although it varies in places to paler shades (see Plate 3.12).

The conglomerate is generally very hard and siliceous, with a well-bonded matrix. It would form an unusual ornamental stone of high durability, attractive coarse texture, and striking red colouration. Although some deposits might be considered to have too garish a "beetroot-red" colour, a wide range of shades of red are available. The major problem with working the stone would probably be its hardness, but this may be offset by the unusual appearance of the stone. It might not achieve a large market, but could be in some demand as a "specialty" stone.

In many areas (eg, Mt. Roland region) the conglomerate is quite closely jointed. However, in the Dundas Trough region it is commonly widely jointed, forming large tors and cliffs on the West Coast Range. Most of these outcrops are in scenically attractive and environmentally sensitive areas which would not be available for quarrying.

However, an alternative source of Owen Conglomerate exists which would be both environmentally acceptable and probably also easier to quarry:

On the western side of the West Coast Range, between Queenstown and Tullah, Pleistocene glaciation has formed large deposits of the Owen Conglomerate in the form of glacial erratic boulders at relatively low levels. Examples can be seen in areas such as the Murchison Highway bridge over the Henty River (see Fig. 11.1).

The boulders range in size from less than a metre to ten metres or more in diameter, and generally contain very widely spaced tectonic joints (spacings in the order of five metres or more). Whole boulders could be removed for working, or some of the larger boulders could be individually worked in the manner of a normal bedrock outcrop. Subsequent to working a boulder, no bedrock scars would remain to indicate that quarrying had taken place.

PERMIAN

Northeastern Tasmania - Fingal Region
Coloured hornfels - Castle Carey Mudstone

PROSPECTIVITY - High

A deposit of brightly-coloured silicified mudstone (hornfels) outcrops in an existing road metal quarry on the Tower Hill Road (C429) at Grid Ref. EP76459420 (site X/Ne/1/1), between Tower Hill and Fingal (see Fig. 11.1). The hornfels has been investigated as an ornamental stone by Messrs C. and D. Beswick.

The hornfels belongs to the Permian Castle Carey Mudstone (Calver *et al.* 1988), and has probably been silicified and iron-stained by an originally-overlying Jurassic dolerite sheet, which has now been eroded off. (Similarly silicified mudstones occur southeast of Fingal, immediately beneath the Fingal Tier dolerite sheet.)

The outcrop comprises horizontal planar alternating beds of sandstone, mudstone and siltstone.

The siltstone occurs only in very thin fissile beds, while the sandstone and mudstone beds range from 0.3 - 1.0 metre thick. The ratio of sandstone:mudstone is approximately 2:1.

The sandstone is poorly sorted, contains glacial dropstones, and has poorly developed colouration.

The mudstone beds are the prospective ornamental material. The mudstone is uniformly very fine-grained and hard, being partly silicified. It varies from massive (structureless) to finely laminated as a result of the presence of fine undulating stylolites (C.Calver, *pers. comm.* 1989). The stylolites produce a tendancy towards fretting, so that only the massive variety is prospective.

The striking feature of the mudstone is the presence of abundant joint-controlled liesegang rings of purple, red, brown, yellow and white colouration, superimposed on a purplish bulk colour (see Plate 3.13). The colour rings form simple concentric patterns in some blocks, but can have very irregular and attractive patterns in blocks having extra silicified fractures.

Several sets of vertical joints occur in the quarry, with spacings varying from 0.1 - 1.0 metres apart. The most brightly coloured joint blocks tend to be those with spacings of 0.3 metres or less.

The ornamental stone product from this quarry would be coloured mudstone joint blocks of 0.3m or less diameter. Such blocks would be removed by using an excavator or light explosives to loosen large rock masses following by selection of usable blocks. While the prevalence of non-ornamental sandstone and large mudstone blocks would cause a very high wastage, this problem can be solved by continued use of the wastage as road metal.

The ornamental mudstone blocks can be sawn into slabs, honed, and lacquered to bring out the colouration. They would be suitable for use as ornamental paving and feature wall tiles. The stone is likely to be highly durable and abrasion-resistant, due to its silicified nature.

Laboratory testing of a sample of the coloured mudstone indicated that the unaltered clays present comprise only illite and kaolinite, and the sample had a high bulk density and low porosity:

Dry Bulk Rock Density	2.45	t/m^3
Water Absorption	3.95	wt.%
Effective Porosity	9.69	vol.%

Similar silicified mudstones have been mapped in the area southeast of Fingal Township (Calver *et al.* 1988). These were not examined during this work, but may contain further reserves of similar coloured hornfels (see Fig. 11.1).

GLOSSARY OF TERMS

This glossary is not an exhaustive listing of stone industry terms, but is intended to explain some of the more commonly encountered terms. Many of the industry terms defined below are used in a very loose fashion, and may on occasion be used in even broader ways than the definitions given here. Many of the following terms are listed in Spry (1988), some are simply derived from everyday usage in the stone industry.

Stone Types

Rock	Geological term, refers to natural consolidated mineral assemblages as they occur in the Earth's crust.
Stone	Predominantly an industry term; refers to rock materials used for building or ornamental purposes.
Dimension stone	Natural stone cut into blocks of specific dimensions for use in buildings. The term includes thin veneers as well as thicker blocks.
Building Stone	Stone used for building purposes (other than crushed aggregate for use in concrete). The term may overlap "monumental" and "ornamental" stone in some instances.
Monumental Stone	Stone used for monuments, ranging from gravestones to statues and large monumental structures.
Ornamental Stone	Stone chosen for its attractive aesthetic qualities, although it must also satisfy high technical standards. Most commonly used for ornamental interior features, although some may be used for exterior polished panels.
Flagstone, Flagging	Sandstone which splits along planar, closely spaced bedding planes, and is used as slabs for paving and ornamental veneers.
Freestone	Usually applied to sandstone, sometimes to limestone. Stone which splits with equal ease in any direction (ie, massive), and can thus be worked as dimension stone. Also loosely applied to flagstone and fieldstone.
Bluestone	A vague term, encompassing hard, commonly dark and fine-grained building stones. May include basalt, dolerite, argillite, hornfels, dolomite or quartzite.
Marble	"Soft", attractive crystalline stone types, capable of taking a polish (include true marbles and serpentines, in stone industry parlance).
Granite	Hard, attractive crystalline silicate stone types, capable of taking a polish (industry parlance).

Shape Terminology

Fieldstone Rubble	Irregular stone blocks, which have not been squared or worked to shape.
Semi-squared Squared rubble Shoddies	Roughly dressed and squared up.
Ashlar blocks	Finely dressed blocks squared on at least four sides.

Construction Terminology

Masonry blocks	Thick load-bearing blocks.
Cladding, veneer	Thin, non load-bearing slabs affixed to an internal load-bearng structure (brick, concrete, etc.)
Ashlar	Squared and dressed stone blocks laid in walls in courses of uniform thickness.
Bookleaf	Wall construction using flagstones laid with bedding horizontal.
Panels	Large squared veneer slabs.
Tiles	Thin squared slabs of small dimensions (commonly 150 - 300mm), used for paving, roofs or walls.
Paving	Tiles or slabs used for walkways. Generally squared.
Crazy paving	Unsquared paving slabs, generally bounded by natural joint surfaces.

Bedding orientation (sandstone):

Naturally bedded	Blocks laid with bedding horizontal.
Edge-bedded	Blocks laid with bedding vertical and perpendicular to the face of the wall.
Face-bedded	Blocks laid with bedding vertical and parallel to the face of the wall.

Surface finish terminology

Split	Surface naturally split (eg, slate)
Dressed	Finished in a specified manner, such as:

Rock-faced (rusticated)	Ashlar blocks with the sides smooth (sawn)and the exposed face rough.
Smoothed	Ashlar blocks with sides and exposed faces smooth and flat (eg, sawn).

Traditionally finished	Exposed faces picked, bush-hammered, chiseled, furrowed, or other finishes.

Honed — Surface partially ground to give a flat, smooth, matte finish.

Polished — Surfaces flat and smooth with a high gloss finish.

Exfoliated — Surface roughness produced by flaming of granite.

Geological classification terminology

Igneous — Rocks which have formed by solidification of molten magma.

Include:
Volcanic: Solidified from magmas extruded at the Earth's surface (eg, basalt, porphyritic lavas).
Plutonic: Solidified at depth below the Earth's surface (eg, "true" granite).

Sedimentary — Produced by the accumulation and consolidation of particles or precipitates of mineral matter eroded from older rock masses and transported to the site of deposition by water, wind, or other agents. Volcanic tuffs, agglomerates and breccias are a special case.

Include:
Clastic: Rocks formed by physical accumulation of solid particles, commonly later bonded by a chemically precipitated cement (eg, sandstone).
Chemical: Rocks formed by the accumulation of chemical precipitates out of solution (eg, some limestones).

Metamorphic — Rocks formed by alteration of igneous or sedimentary rocks in response to increased temperatures and/or pressures.

Include:
Contact: Metamorphism resulting primarily from increased heating due to intrusion of magmas nearby. (eg, hornfels, some marbles)
Regional: Metamorphism resulting from increased pressure and temperature, usually as a result of tectonic and orogenic (mountain-building) events (eg, slate, gneiss, some marbles).

Geological description terminology

Texture — Relationships between grains in a rock (stone); encompasses grainsize, shape, sorting, orientation, intergranular contact and cementing types, etc.

Fabric — A textural property: the degree and type of orientation of grains in a rock (stone).

Structure — Larger features super-imposed on texture: bedding, banding, segregations, etc.

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APPENDIX ONE

STONE PROSPECTS DATA BASE

A 1.1 Introduction

A computerised data-base on Tasmanian building stone quarries and prospects was set up by the writer during the work involved in preparing this report, and is intended to be continually used and expanded in future work.

The latter part of this appendix is a listing of entries in the data base to date. A full printout of all geological information on each site is not given here, since all relevant information is given in the body of this report. However, it is considered useful to record here a brief outline of the structure of the data-base.

The data base is divided into building/ornamental stone categories, according to the usage adopted in this report. The various stone categories are defined in the body of the report. Within each stone category, the data base contains details of areas and sites examined. Where areas or sites clearly had no potential as building stone sources, only minimum details are given (sufficient to indicate why the areas or sites have little potential).

A 1.2 Area, site and sample numbering system

This data base is intended to be in continuing use, and continually upgraded, well beyond the current project. In order to facilitate the maintenance of a "universal" data base in which all information relevant to Tasmanian building stones can be stored, a systematic numbering system in which all stone areas, sites and samples can be placed, has been devised.

The (alphanumeric) numbering system comprises six fields. All the fields are used in numbering samples, but only the first three fields are used to number areas, and the first four to number sites (including quarries).

The six fields are :

|← AREA No. →|
|← SITE No. →|
|← SAMPLE No. →|

1 / 2 / 3 / 4 / 5 / 6

Field 1 -Stone Category
" 2 -Geological "province" of Tasmania
" 3 -Area No. (within "province")
" 4 -Site No. (within area)
" 5 -Sample No. (from within site)
" 6 -Sample source type

Sample source type (field 6) need not always be included in specimen numbers for labelling and similar purposes, but must always be included in the data-base.

The following is an explanation of each field:

1. Stone Category
An abbreviation is used to indicate the stone category, in the stone industry sense, for which the area, site or sample is prospective . The categories are as defined in the relevant chapters of this report.

Where a single geological area or site is prospective for more than one building stone category, the same area or site will be numbered and described separately and differently under each relevant stone category .

The stone categories are:

ABBREVIATION	STONE CATEGORY	
S	Sandstone	
Sl	Slate	
G	"True" Granite	Acid plutonic igneous rocks
Bg	"Black Granite"	Dark coloured igneous rocks
Og	"Other Granites"	All other igneous rocks, and some metamorphics
M	Marble	Metamorphosed or fine crystalline limestones
Sr	Serpentine	
T	Travertine	
L	Limestone, Dolomite	-Non-crystalline varieties (masonry, etc)
X	Miscellaneous other stone types	

2. Geological "province" of Tasmania
For convenience in classifying data, the state is divided into geographical areas, which are broadly (but not rigorously) based on particular distinctive geological associations characteristic of each area. The areas are thus geological provinces.

For simplicity, a defined "province" may include superficial deposits of younger age than the associations which characterise the province, and also inliers of older geological associations.

Where a defined area (field 3) crosses the defined boundary of a "province", the area is considered to fall within the province in which the greater part of the area lies.

In numbering areas, sites and samples, an abbreviation for each province is placed in field 2. The provinces, and their abbreviations, are as defined below:

ABBREVIATION	"PROVINCE"	GEOLOGICAL ASSOCIATIONS AND REGIONS
Tb	Tyennan Block	Precambrian metamorphics and adjoining less metamorphosed Precambrian rocks (Jubilee Block), together with adjacent Palaeozoic rocks (Adamsfield Trough - Florentine Valley, New River - south coast sequences, Franklin, Olga and Loddon River areas), Granite Tor, and overlying Permo-Carboniferous sediments near Cradle Mt.
Rb	Rocky Cape Block	Precambrian Rocky Cape Block associations from Trial Harbour to east of Burnie. Includes King

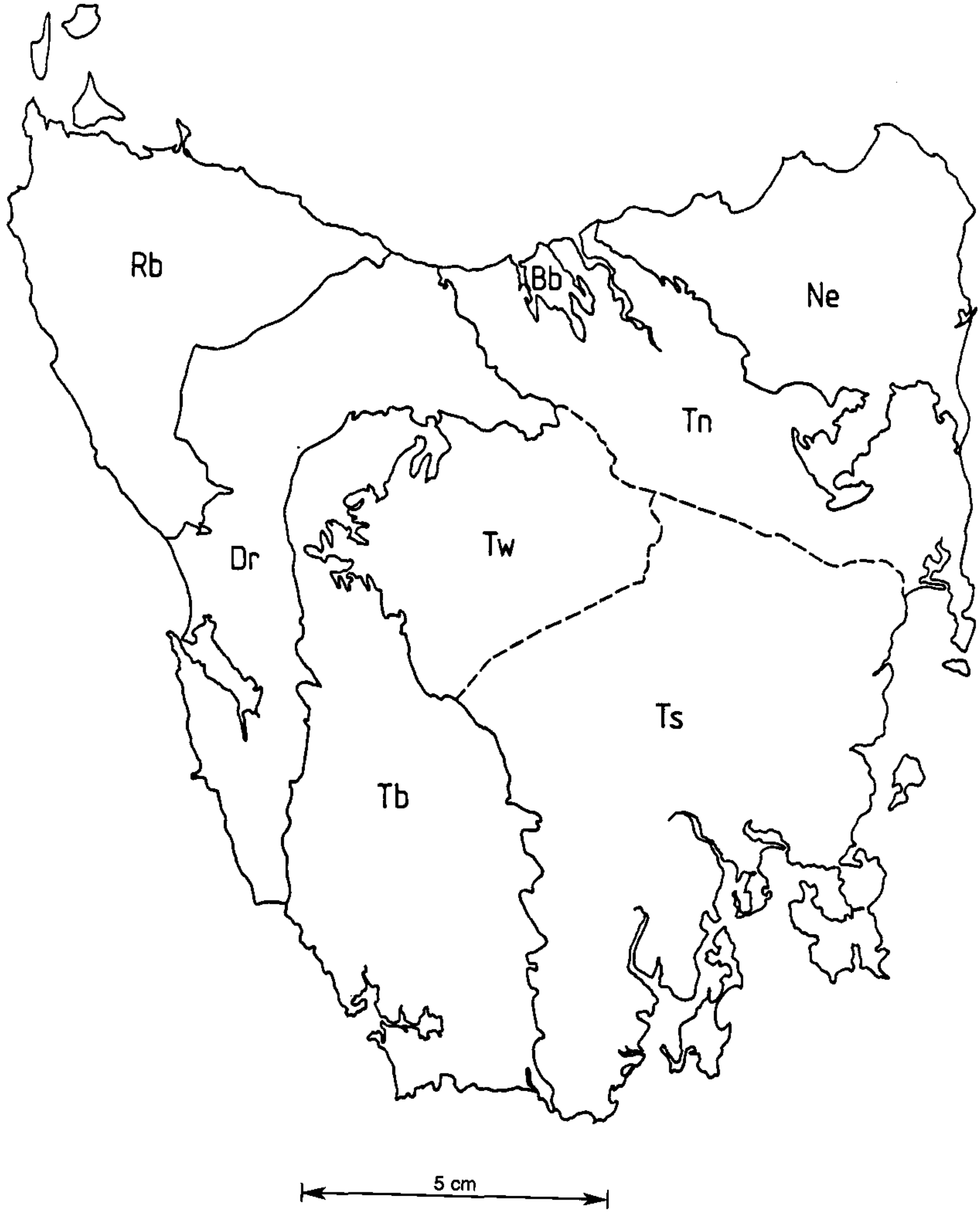

Figure A1.1 Geological provinces of Tasmania, as defined for the purposes of database classifcation.

		Island, Smithton Basin, Heemskirk, Pieman and Interview Granites, Permo-Carboniferous sediments and Tertiary basalts south of Wynyard.
Bb	Badger Head Block	Precambrian rocks and adjacent lower Palaeozoic rocks
Dr	Dundas Trough	Eocambrian - Cambrian associations; includes Dial Ra. and Fossey Mt. Troughs, Forth Block and inliers south of Macquarie Harbour (Precambrian), Devonian - Carboniferous granites, overlying Palaeozoic sediments, and overlying Tertiary basalts.
Ne	North-eastern Tas.	Ordovician - Devonian Mathinna Beds and Devonian - Carboniferous granites. Includes small areas of Parmeener Supergroup and Jurassic dolerite separated from the main Tasmania basin. Includes Flinders Island.
T	Tasmania Basin	Main Carboniferous - Triassic Parmeener Supergroup basin, plus Jurassic dolerites and Tertiary basalts.
	Three sub-divisions of Tasmania Basin:	
Ts	Tasmania Basin South	Area south of Swansea - Campbelltown - Lake River - Tarraleah. Includes Deep Glen and Maria granites, Glovers Bluff and Hastings Precambrian inliers, Lune River Lower Palaeozoics and Cygnet Cretaceous syenites.
Tw	Tasmania Basin West	Western part of basin, bounded on the north by the base of the western Tiers to Lake River, thence to Woods Lake - Tarraleah.
Tn	Tasmania Basin North	Northern part of basin. Includes Freycinet and Bicheno granites, and O'Connors Peak inlier.

3. Area (within province)

For each stone category, within each geological province, each discrete mapped area of any prospective geological unit or association is numbered 1 - ∞ in the order that they are examined.

A discrete mapped area is bounded by major faults, boundaries with different mapped units, or by transitions to significantly different compositions, colours, textures, etc.

For each geological province and each stone category, only one unique series of area numbers will be used for prospective areas, so that it will be possible for unrelated geological units or associations to have consecutive area numbers if they are prospective for the same category of building stone.

In order to compile a reference list defining each area, the first data base record for each area within a specific stone category/geological province contains sufficient details to define its location, and the site numbers field is left blank. If no specific sites within the area were defined, the initial (and in such cases, only) data record for the area also contains whatever geological observations were made. Where particular sites were examined, following data records describe each site in turn.

If a particular area of a particular geological unit or association is prospective for more than one category of building stone, the area will be independently numbered and described under each relevant stone category. Thus, the same physical area may have two or more different area numbers (under different stone categories) within the overall data base.

4. Site (within area)
Within each discrete area, particular sites (outcrops, quarries) are numbered 1 - ∞ in the order that they are examined.

5. Sample (from within site)
At each unique site, lump samples are numbered 1 - ∞ in the order in which they are collected.

6. Sample source type
Since sample freshness (degree of weathering) can have a marked effect on the physical and mineralogical properties of some stone types, it is important to record the condition of the source. This will give an indication of the extent to which the characteristics of the sample are likely to reflect the nature of fresh, sub-surface stone obtained from the same site.

The condition of the source is recorded in a general way in field 6, by noting the general type of source as below. More precise details regarding age of exposures, and depth below or behind excavated or natural faces from which the sample was taken, would be supplied in detailed sample descriptions.

Source condition or type is indicated by a letter, as below:

---

a Fresh drill core or excavated faces (< 10 years exposure)

b Old drill core or excavated faces (> 10 years exposure, or unknown)

c Naturally weathered outcrop face.

d Random outcrop sample (condition and freshness unknown)

A 1.3 Database records

Introduction

The following pages are a listing of basic information from the database compiled during this project. The listing comprises area and site numbers, locations (grid references), geological unit or association, and prospective stone type. The listing is given simply as a reference list to sites mentioned in this report, and does not include the detailed geological observations on each site. All relevant geological observations on significant sites are given in the body of the report.

Grid references and prospectivity categories used in this report and database are defined as follows:

PROSPECTIVITY Assessed in terms of site suitability and technical stone quality; aesthetic quality of stone not considered here.

Areas:

High	Workable outcrops of probably good quality stone located.
Medium	No workable outcrops of good quality stone located, but such stone is known or thought likely to exist in area.
Low	No indication that good quality stone sources are likely to exist.

Sites:

High	Workable site, stone of good quality.
Medium	Site probably not workable, but stone quality fair to good (probably better sites nearby).
Low	Site not workable, and/or stone quality low.

Co-ordinates AMG grid co-ordinates, as per Universal Transverse Mercator Grid, Australian Map Grid Zone 55G. Co-ordinates given consist of the 100,000 metre square identification letters, followed by eastings, then northings. *See* Burrett & Martin (1989, p.516).

SANDSTONE

Stone	Prov	Area	Site	PROSPECTIVITY	Geol age	Geol unit	Location	Co ordinates	Rock types
S	Ne	1	-	LOW	Permian	Lower Freshwater Sequence (Liffey Group corr	North of Mathinna: Blackboy Plain - Diligers Flat area.		Pebbly sandstone
S	Ne	1	1	LOW	Permian	Lower Freshwater Sequence (Liffey Group corr	Between Devlin Creek & Diligers Flat	EQ756173	Pebbly sandstone
S	Ts	1	-		Early Triassic	Rls (Quartz Sandstone Sequence)	Molesworth, area north of Molesworth Rd.		
S	Ts	1	1		Early Triassic	Rls (Quartz Sandstone Sequence)	Molesworth	EN124613	
S	Ts	2	-		Early Triassic	Rls (Quartz Sandstone Sequence)	Molesworth; fault-bounded area east of Wyre Forest Rd.		
S	Ts	3	-		Early Triassic	Rls (Quartz Sandstone Sequence)	Molesworth: Collins Cap Rd area.		
S	Ts	3	1	HIGH	Early Triassic	Rls (Quartz Sandstone Sequence)	MOLESWORTH QUARRY	EN106603	Quartz arenite
S	Ts	4	-		Early Triassic	Rls (Quartz Sandstone Sequence)	New Norfolk: Triffets Rd. area		
S	Ts	5	-	HIGH	Early Triassic	Rls (Quartz Sandstone Sequence)	Linden - Plenty Valley Rd area.		
S	Ts	5	1	MEDIUM	Early Triassic	Rls (Quartz Sandstone Sequence)	Plenty Valley Rd.		
S	Ts	5	2	LOW	Early Triassic	Rls (Quartz Sandstone Sequence)	Plenty Valley Rd.		
S	Ts	5	3	?HIGH	Early Triassic	Rls (Quartz Sandstone Sequence)	Plenty Valley Rd.	DN967636	
S	Ts	5	4	HIGH	Early Triassic	Rls (Quartz Sandstone Sequence)	LINDEN QUARRY	DN99956500	Quartz sandstone
S	Ts	6	-		Early Triassic	Rls (Quartz Sandstone Sequence)	Magra - Black Hills		
S	Ts	6	1	LOW	Early Triassic	Rls (Quartz Sandstone Sequence)	Black Hills Rd.	EN027677	
S	Ts	7	-		Early Triassic	Rls (Quartz Sandstone Sequence)	Magra - Mt. Dromedary		
S	Ts	8	-	MEDIUM	Early Triassic	Rls (Quartz Sandstone Sequence)	Bluff Rd. area (SW of Elderslie)		
S	Ts	8	1		Early Triassic	Rls (Quartz Sandstone Sequence)	Bluff Rd	EN038806	
S	Ts	8	2		Early Triassic	Rls (Quartz Sandstone Sequence)	Bluff Rd		
S	Ts	9	-		Early Triassic	Rls (Quartz Sandstone Sequence)	Pelham Tier, NW of Elderslie		
S	Ts	9	1		Early Triassic	Rls (Quartz Sandstone Sequence)	Pelham Rd.		
S	Ts	9	2		Early Triassic	Rls (Quartz Sandstone Sequence)	Pelham Rd.		
S	Ts	10	-	MEDIUM	Early Triassic	Rls (Quartz Sandstone Sequence)	Huntingdon Tier (W. of Dysart)		
S	Ts	10	1		Early Triassic	Rls (Quartz Sandstone Sequence)	Huntingdon Tier Rd.	EN145843	
S	Ts	10	2		Early Triassic	Rls (Quartz Sandstone Sequence)	Huntingdon Tier Rd.	EN149858	
S	Ts	10	3		Early Triassic	Rls (Quartz Sandstone Sequence)	Clifton Vale Rd.		
S	Ts	11	-		Early Triassic	Rls (Quartz Sandstone Sequence)	Andersons Creek area, SE of Elderslie		
S	Ts	12	-		Early Triassic	Rls (Quartz Sandstone Sequence)	Sand Hill - Heathy Hills, Elderslie		
S	Ts	12	1	MEDIUM	Early Triassic	Rls (Quartz Sandstone Sequence)	S. of Letterbox Gully, E. bank Jordan River.	EN073867	
S	Ts	12	2		Early Triassic	Rls (Quartz Sandstone Sequence)	Sand Hill, W. bank of Jordan River		
S	Ts	12	3		Early Triassic	Rls (Quartz Sandstone Sequence)	Sand Hill, W. bank of Jordan River		
S	Ts	13	-		Permian	Faulkner Group, Pf (Lower Freshwater Sequenc	Collinsvale		
S	Ts	14	-		Early Triassic	Rls (Quartz Sandstone Sequence)	Coal River - Kangaroo Rivt. area, NE of Campania.		
S	Ts	14	1		Early Triassic	Rls (Quartz Sandstone Sequence)	Browns Mt. Rd	EN389821	
S	Ts	14	2		Early Triassic	Rls (Quartz Sandstone Sequence)	Browns Mt. Rd		
S	Ts	15	-		Early Triassic	Rls (Quartz Sandstone Sequence)	NE of Colebrook (Eldon Rd.)		
S	Ts	16	-		Permian	Faulkner Group, Pf (Lower Freshwater Sequenc	Upper Dromedary		
S	Ts	17	-		Early Triassic	Rls (Quartz Sandstone Sequence)	Millvale Creek Rd (W. of Cobbs Hill, Dromedary area)		
S	Ts	18	-		Early Triassic	Rls (Quartz Sandstone Sequence)	Cobbs Hill		
S	Ts	18	1	HIGH	Early Triassic	Rls (Quartz Sandstone Sequence)	COBBS HILL QUARRY	EN15857033	
S	Ts	19	-		Early Triassic	Rls (Quartz Sandstone Sequence)	Black Brush, SE of Broadmarsh		
S	Ts	20	-		Early Triassic	Rls (Quartz Sandstone Sequence)	Huon Hwy. - Mountain River		
S	Ts	20	1		Early Triassic	Rls (Quartz Sandstone Sequence)	Bullock Hill	EN084413	
S	Ts	20	2		Early Triassic	Rls (Quartz Sandstone Sequence)	Crawfords Hill	EN117417	
S	Ts	21	-		Triassic	Rs (Quartz Sandstone Sequence)	Coningham		
S	Ts	22	-		Triassic	Rs (Quartz Sandstone Sequence)	Howden-Tinderbox-Blackmans Bay		
S	Ts	23	-		Triassic	Ross Sandstone (Quartz Sandstone Sequence)	Gretna region		
S	Ts	23	1		Triassic	Ross Sandstone (Quartz Sandstone Sequence)	Bluff Rd.	DN969779	
S	Ts	23	2		Triassic	Ross Sandstone (Quartz Sandstone Sequence)	Bluff Rd., opposite Gretna Tip		
S	Ts	23	3		Triassic	Ross Sandstone (Quartz Sandstone Sequence)	Near Marked Tree Rd.	DN954853	
S	Ts	23	4		Triassic	Ross Sandstone (Quartz Sandstone Sequence)	Sibley's Gully, Marked Tree Rd.		
S	Ts	24	-		Triassic	Rp (Quartz Sandstone Sequence)	Melton Mowbray area.		
S	Ts	24	1	LOW	Triassic	Rp (Quartz Sandstone Sequence)	Midlands Highway, Melton Mowbray	EN151980	Quartz Sandstone
S	Ts	24	2		Triassic	Rp (Quartz Sandstone Sequence)	Midlands Highway, north of Melton Mowbray		
S	Ts	24	3	LOW	Early Triassic	Rp (Quartz Sandstone Sequence)	MELTON MOWBRAY QUARRY	EN153979	Quartz arenite
S	Ts	24	4	HIGH	Early Triassic	Rp (Quartz Sandstone Sequence)	LOVELY BANKS QUARRY, Melton Mowbray	EN141985	Quartz arenite (Tr
S	Ts	25	-		Triassic	Ru (Quartz Sandstone Sequence?)	Jericho		
S	Ts	26	-		Triassic	Ru (Quartz Sandstone Sequence?)	Huntworth Creek, north of Jericho		
S	Ts	27	-		Permian	Upper Freshwater Sequence, Pcm (Cygnet Coa	Wattle Hill Rd., Stonor		
S	Ts	27	1		Permian	Upper Freshwater Sequence, Pcm (Cygnet Coa	Wattle Hill Rd.		
S	Ts	28	-		Early Triassic	Rls (Quartz Sandstone Sequence)	Stonor- Baden area		
S	Ts	28	1		Early Triassic	Rls (Quartz Sandstone Sequence)	Wattle Hill Rd.	EP345030	
S	Ts	28	2		Early Triassic	Rls (Quartz Sandstone Sequence)	Stonor Rd.		
S	Ts	29	-		Early Triassic	Rls (Quartz Sandstone Sequence)	Stonor - Rhyndaston		
S	Ts	30	-		Triassic	Rp (Quartz Sandstone Sequence)	Lovely Banks Rd., east of Melton Mowbray		
S	Ts	30	1	MEDIUM	Triassic	Rp (Quartz Sandstone Sequence)	Lovely Banks Rd	EN244964	
S	Ts	30	2		Triassic	Rp (Quartz Sandstone Sequence)	Lovely Banks Rd	EN237977	
S	Ts	31	-	MEDIUM	Triassic	Rl (Rls - Quartz Sandstone Sequence?)	Hunting Ground, Clifton Vale Rd.		
S	Ts	31	1		Triassic	Rl (Rls - Quartz Sandstone Sequence?)	Hunting Ground, Clifton Vale Rd.	EN098910	
S	Ts	32	-	HIGH	Triassic	Ru (undifferentiated - Quartz Sandstone Sequen	Oatlands region (includes existing and historic dimension		Quartz sandstone
S	Ts	32	1	HIGH	Early Triassic	Ru (undifferentiated - quarry prob. in Quartz Sa	OATLANDS QUARRY (SW of township)	EP297152	Quartz sandstone
S	Ts	32	2	HIGH	Triassic	Ru (undifferentiated - Quartz Sandstone Sequen	Oatlands Golf Course	EP31451640	Quartz sandstone
S	Ts	33	-		Triassic	Rp (Quartz Sandstone Sequence)	Mt. Seymour		
S	Ts	34	-		Permian	Upper Freshwater Sequence, Pcm (correlate of (	Crichton Rd.		
S	Ts	34	1		Permian	Upper Freshwater Sequence, Pcm (correlate of (	Crichton Rd.		
S	Ts	35	-		Permian	Upper Freshwater Sequence, Pcm (correlate of (	Baden		
S	Ts	36	-		Early Triassic	Rls (Quartz Sandstone Sequence)	Baden - Tunnack		
S	Ts	37	-		Early Triassic	Rls (Quartz Sandstone Sequence)	South of Tunnack		
S	Ts	37	1		Early Triassic	Rls (Quartz Sandstone Sequence)	Eldon Rd., south of Tunnack	EN361961	
S	Ts	38	-	LOW	Early Triassic	Rls (Quartz Sandstone Sequence)	Johnsons Hill, Clifton Vale Rd.		
S	Ts	39	-	HIGH	Triassic	Rp (Quartz Sandstone Sequence)	East of Bothwell		
S	Ts	39	1	HIGH-MEDIUM	Triassic	Rp (Quartz Sandstone Sequence)	RIFLE RANGE QUARRY, Rifle Range Hill, Bothwell	EP015058	
S	Ts	39	2	HIGH	Triassic	Rp (Quartz Sandstone Sequence)	THE "FLAGGING QUARRY", Bothwell.		
S	Ts	40	-		Permian	Malbina Formation (massive sandstone horizon,	East of Sorell (Little Hill/Mt. Elizabeth/Table Hill/Hilltop)		
S	Ts	41	-		Triassic	Rlq (Quartz Sandstone Sequence)	Risdon Vale - Grasstree Hill		
S	Ts	42	-		Triassic	Rlq (Quartz Sandstone Sequence)	Several discrete areas E, NE, & SE of Richmond		
S	Ts	43	-		Triassic	Rlq (Quartz Sandstone Sequence)	Woodlands Crk. area, between Tea-Tree & Campania.		
S	Ts	43	1		Triassic	Rlq (Quartz Sandstone Sequence)	"Oaklington", Tea Tree Rd.	EN296754	
S	Ts	43	2		Triassic	Rlq (Quartz Sandstone Sequence)	Near Corner Grices Rd. & Tea Tree Rd.		
S	Ts	43	3		Triassic	Rlq (Quartz Sandstone Sequence)	Grices Rd.		
S	Ts	43	4		Triassic	Rlq (Quartz Sandstone Sequence)	Grices Rd.		
S	Ts	43	5		Triassic	Rlq (Quartz Sandstone Sequence)	Tea Tree Rd.		
S	Ts	43	6		Triassic	Rlq (Quartz Sandstone Sequence)	Williams Rd.		
S	Ts	43	7		Triassic	Rlq (Quartz Sandstone Sequence)	Tea Tree Rd.		
S	Ts	44	-		Triassic	Rss (Quartz Sandstone Sequence)	White Hill (NE of Forcett, Sorell district)		Quartz sandstone
S	Ts	44	1		Triassic	Rss (Quartz Sandstone Sequence)	E. of Mackies Hill, several outcrops in vicinity	EN590630	Quartz sandstone
S	Ts	45	-		Triassic	Rs (Quartz Sandstone Sequence)	Kellevie area (north of Copping)		
S	Ts	46	-		Triassic	Rs (Quartz Sandstone Sequence)	Copping		
S	Ts	46	1	LOW	Triassic	Rs (Quartz Sandstone Sequence)	Arthur Highway, S. of Copping, near "Renwood"	EN660565	

S	Ts	47	-		Triassic	Rlq (Quartz Sandstone Sequence)	Longley		
S	Ts	47	1		Triassic	Rlq (Quartz Sandstone Sequence)	Longley	EN156415	
S	Ts	47	2		Triassic	Rlq (Quartz Sandstone Sequence)	Longley	EN156417	
S	Ts	48	-		Triassic	Rlq (Quartz Sandstone Sequence)	Molesworth, just S. of Molesworth Rd.		
S	Ts	49	-		Triassic	Rlq (Quartz Sandstone Sequence)	Broadmarsh - Black Brush Rd. turnoff.		
S	Ts	49	1		Triassic	Rlq (Quartz Sandstone Sequence)	Elderslie Rd., at Black Brush Rd. turnoff	EN128748	
S	Ts	50	-		Early Triassic	Rl (Rls?) (Quartz Sandstone Sequence)	North of Elderslie, immediately west of areas 12 & 51		
S	Ts	50	1		Early Triassic	Rl (Rls?) (Quartz Sandstone Sequence)	Royden		
S	Ts	51	-	HIGH	Early Triassic	Rls (Quartz Sandstone Sequence)	Immediately east of Elderslie township.		
S	Ts	51	1		Early Triassic	Rls (Quartz Sandstone Sequence)	East side of Jordan River, under HEC powerline.	EN067828	
S	Ts	51	2	HIGH	Early Triassic	Rls (Quartz Sandstone Sequence)	ELDERSLIE QUARRY, 2.5 km east of Elderslie township	EN08808270	
S	Ts	51	3		Early Triassic	Rls (Quartz Sandstone Sequence)	500m north of site S/Ts/51/2		
S	Ts	51	4		Early Triassic	Rls (Quartz Sandstone Sequence)	200m north of site S/Ts/51/2		
S	Ts	51	5		Early Triassic	Rls (Quartz Sandstone Sequence)	200m SW of site S/Ts/51/2		
S	Ts	52	-		Early Triassic	Rls (and Rl: Hobart sheet) (Quartz Sandstone Se	Back Tea Tree Rd. and Malcolms Hut Rd.		
S	Ts	53	-		Early Triassic	Rls (Quartz Sandstone Sequence)	Howlett's Rd. (N. of Native Hut Rivt., NNW of Campania)		
S	Ts	54	-		Early Triassic	Rls (Quartz Sandstone Sequence)	Freemans Creek area, NNW of Campania		
S	Ts	54	1		Early Triassic	Rls (Quartz Sandstone Sequence)	Native Corners Rd.		
S	Ts	55	-		Triassic	Rlq (Quartz Sandstone Sequence)	Howards Rd., NW of Campania.		
S	Ts	56	-		Early Triassic	Rls (Quartz Sandstone Sequence)	Yarlington (west of Colebrook)		
S	Ts	57	-		Early Triassic	Rls, & Rl (Quartz Sandstone Sequence)	Harry Walker Tier, & "Rl" fault slice between Harry Walk		
S	Ts	57	1	MEDIUM	Triassic	Rl (Quartz Sandstone Sequence)	East side Cockatoo Gully Rd., just below Harry Walker Ti	EN113844	
S	Ts	58	-		Triassic	Rsm	Between Pawleena & Sorell		Sandstone, shale, r
S	Ts	58	1		Triassic	Rsm	Between Pawleena & Sorell	EN459666	
S	Ts	59	-	HIGH	Triassic	Rs (Quartz Sandstone Sequence)	Five km S. of Surges Bay		Quartz sandstone
S	Ts	59	1	HIGH	Triassic	Rs (Quartz Sandstone Sequence)	Five km S. of Surges Bay	EN02301228	Quartz sandstone
S	Ts	59	2	HIGH	Triassic	Rs (Quartz Sandstone Sequence)	Five km S. of Surges Bay	EN02201221	Quartz sandstone
S	Ts	59	3	MEDIUM	Triassic	Rs (Quartz Sandstone Sequence)	Five km S. of Surges Bay	EN02451186	Quartz sandstone
S	Ts	59	4	MEDIUM	Triassic	Rs (Quartz Sandstone Sequence)	Five km S. of Surges Bay	EN02501169	Quartz sandstone
S	Ts	60	-		Triassic	Rss (Quartz Sandstone Sequence)	Wiggins Creek, NE of Forcett, Sorell area		Quartz sandstone
S	Ts	60	1		Triassic	Rss (Quartz Sandstone Sequence)	Wiggins Creek, where road crosses	EN564631	Quartz sandstone
S	Ts	61	-	HIGH	Triassic	Rp (Quartz Sandstone Sequence)	Mike Howes Marsh, NW of Oatlands		Quartz sandstone
S	Ts	61	1	HIGH	Triassic	Rp (Quartz Sandstone Sequence)	MIKE HOWES MARSH QUARRY	EP236239	Quartz sandstone
S	Ts	62	-	?	Early Triassic	Quartz Sandstone Sequence	Bothwell-Hermitage region		Quartz arenite
S	Ts	63	-	?	Early Triassic	Quartz Sandstone Sequence	Boggy Marsh Rivulet Valley (NE of Victoria Valley) - Ouse		Quartz arenite
S	Ts	64	-	?	Early Triassic	Quartz Sandstone Sequence	Osterley - Strickland area		Quartz arenite
S	Ts	65	-	HIGH	Early Triassic	Rls (Quartz Sandstone Sequence)	Pontville region		
S	Ts	65	1	HIGH	Early Triassic	Rls (Quartz Sandstone Sequence)	PONTVILLE WHITE SANDSTONE QUARRY	EN219733	
S	Ts	65	2	HIGH	Early Triassic	Rls (Quartz Sandstone Sequence)	PONTVILLE BROWN STONE QUARRY	EN220734	
S	Ts	66	-	LOW	Middle Triassic	Rim (Unit 3 of Forsyth in Burrett & Martin 198	Kempton		Lithic Sandstone, c
S	Ts	66	1	LOW	Middle Triassic	Rim (Unit 3 of Forsyth in Burrett & Martin 198	Kempton	EN166913	Lithic sandstone w
S	Ts	67	-	HIGH	Early - ?Mid. Tr	Quartz arenites undiff., including Quartz Sandsto	Buckland - Stonehenge region		Quartz arenite
S	Ts	67	1	HIGH	Early Triassic	Quartz Sandstone Sequence ("Ross Sandstone" (	BUCKLAND QUARRY (N side of crest of "The Cobs" hill)	EN575880	Quartz arenite (Tra
S	Tn	1	-	HIGH	Permian	Liffey Group, Plg (Lower Freshwater Sequence)	Nunamara - Patersonia region (several discrete Plg bodies		Sandstone, mudsto
S	Tn	1	1	HIGH	Permian	Liffey Group, Plg (Lower Freshwater Sequence)	NUNAMARA QUARRY, 4.1 km east of Nunamara	EQ278203	Sandstone, mudsto
S	Tn	2	-		Permian	Liffey Group, Plg (Lower Freshwater Sequence)	Karoola - Lilydale area (several discrete Plg bodies).		
S	Tn	2	1	LOW	Permian	Liffey Group, Plg (Lower Freshwater Sequence)	Karoola	EQ125340	Sandstone, mudsto
S	Tn	3	-	?MEDIUM	Early Triassic	Rq (Quartz Sandstone Sequence)	English Town, (NE of Deddington) - Blessington		Quartz sandstone
S	Tn	3	1	LOW	Early Triassic	Rq (Quartz Sandstone Sequence)	"Ngapara", English Town	EQ424011	Quartz sandstone
S	Tn	3	2	LOW	Early Triassic	Rq (Quartz Sandstone Sequence)	"Ngapara", English Town	EQ432006	Quartz sandstone
S	Tn	3	3	??HIGH - MEDIUM	Early Triassic	Quartz Sandstone Sequence ("Knocklofty Sands	Blessington	EQ393009	Quartz Sandstone
S	Tn	4	-	?	Permian	Lower Freshwater Sequence	St Pauls Dome area (Royal George - Avoca)		Sandstones, other
S	Tn	5	-	LOW	Permian	Aberfoyle Formation (Lower Freshwater Sequer	Rossarden - Mangana		Sandstone, shale,

SLATE

Stone	Prov	Area	Site	PROSPECTIVITY	Geol age	Geol unit	Location	Co ordinates	Rock types
Sl	Rb	1	-	LOW	PreCambrian	Burnie Formation (Burnie Quartzite & Slate)	East of Burnie ; Wivenhoe - Heybridge		quartzite & slate
Sl	Rb	1	1	LOW	PreCambrian	Burnie Formation (Burnie Quartzite & Slate)	Cutting beside Bass Highway	DQ13406280	Greywacke quartzite, slate
Sl	Rb	1	2	LOW	PreCambrian	Burnie Formation (Burnie Quartzite & Slate)	Round Hill, west end of large road-metal quarry bes	DQ1090629	quartzite, slate
Sl	Rb	2	-	LOW	PreCambrian	Burnie Fm. (Burnie Quartzite and Slate)	West of Burnie; Somerset - Lower Cam River		quartzite, slate
Sl	Rb	2	1	LOW	PreCambrian	Burnie Fm. (Burnie Quartzite and Slate)	Murchison Hwy. road cutting, just south of Somers	DQ01806530	interbedded quartzite and slate
Sl	Rb	3	-	LOW	PreCambrian	Rocky Cape Group - Jacob Quartzite	Sisters Creek - Breakneck Pt. (Bass Hwy), & Irby's		Quartzite, minor shale
Sl	Rb	4	-	LOW	PreCambrian	Rocky Cape Grp. - Detention Subgroup	Sisters Hills area (Montumana - Sisters Creek		Quartzite, minor siltstone
Sl	Rb	4	1	LOW	PreCambrian	Rocky Cape Grp. - Detention Subgroup	Sisters Hills, cutting on Bass Hwy.	CQ77306480	quartzite, shale interbedded
Sl	Rb	5	-	LOW	PreCambrian	Rocky Cape Grp. - Cowrie Siltstone	Rocky Cape "township" - NE of Bass Hwy		siltstone
Sl	Rb	5	1	LOW	PreCambrian	Rocky Cape Grp. - Cowrie Siltstone	Cutting on Bass Hwy.	CQ73206970	siltstone
Sl	Rb	6	-	LOW	PreCambrian	Rocky Cape Grp. - Cowrie Siltstone	Hellyer - Pt. Lata - Black River - Mawbanna		siltstone
Sl	Rb	6	1	LOW	PreCambrian	Rocky Cape Grp. - Cowrie Siltstone	Bass Hwy. cutting near Cowrie Pt.	CQ61407610	siltstone
Sl	Rb	7	-	LOW	PreCambrian	Rocky Cape Grp. - Balfour Slates and Sands	Frankland River - Balfour area		slate, sandstone
Sl	Rb	7	1	LOW	PreCambrian	?middle unit of Balfour Slate & Sandstone	At "The Clump", just west of Frankland R., at turno	CQ208376	interlaminated slate & sandston
Sl	Rb	7	2	LOW	PreCambrian	?upper greenish unit of Balfour Slate and Sa	Balfour Rd., east of Frankland River	CQ222390	Siltstone
Sl	Rb	8	-	HIGH	PreCambrian	Rocky Cape Group: Lawson River Siltstone	Sumac Rd. - Lawson Rivulet - Arthur River region		Slate
Sl	Rb	8	1	HIGH	PreCambrian	Rocky Cape Group: Lawson River Siltstone	Sumac Rd., south of Horton River.	CQ360278	Slate
Sl	Rb	8	2	LOW	PreCambrian	Rocky Cape Group: Lawson River Siltstone	Sumac Rd.	CQ365267	Slate
Sl	Rb	8	3	?MEDIUM	PreCambrian	Rocky Cape Group: Lawson River Siltstone	Mt. Bertha Rd. Quarry, Mt. Bertha Rd.	CQ424374	Slate
Sl	Rb	8	4	HIGH	PreCambrian	Rocky Cape Group: Lawson River Siltstone	TAYATEA SLATE QUARRY, Wedge Plains Rd., imme	CQ60306530	Slate
Sl	Rb	9	-	LOW	PreCambrian	Rocky Cape Group - Cowrie Siltstone	Mawbanna region, south of major E-W transcurrent		Siltstone (slate?)
Sl	Rb	9	1	LOW	PreCambrian	Rocky Cape Group - Cowrie Siltstone	Turners Plain, off Daisies Rd.	CQ554635	Siltstone
Sl	Rb	9	2	LOW	PreCambrian	Rocky Cape Group - Cowrie Siltstone	Dip Rd.	CQ587664	Siltstone
Sl	Rb	10	-	LOW	Precambrian	Oonah Formation	Zeehan - Pieman River		Slate, greywacke quartzite
Sl	Rb	11	-	LOW	Precambrian	Oonah Formation	Pieman Rd., between Stringers Crk. area and Slan		Siltstone, sandstone, mudstone
Sl	Rb	12	-	LOW	Upper Carbon	Wynyard Tillite	Arthur - Hellyer River Region		Rhythmite claystone (varves),
Sl	Rb	12	1	LOW	Upper Carbon	Wynyard Tillite	KIRKUP'S SLATE DEPOSIT, Arthur River	CQ758290	Rhythmite claystone (varves;
Sl	Rb	12	2	LOW	Upper Carbon	Wynyard Tillite	Near Arthur R., 0.5 km N. of Kirkup's Slate deposit	CQ75382962	Rhythmite claystone (varves; =
Sl	Rb	13	-	LOW	PreCambrian	"Corinna Slate" (Spry & Banks 1962, p.109	Corinna - Brown Plains		?
Sl	Dr	1	-	LOW	Cambrian	Dundas Group - Hodge Slate	Dundas		Siltstone
Sl	Dr	1	1	LOW	Cambrian	Dundas Group - Hodge Slate	Razorback Mine, Dundas	CP69206370	Siltstone
Sl	Dr	2	-	LOW	Cambrian	Mt. Read Volcanics - Farrell Slates (Cf)	Murchison Gorge - Mackintosh Dam (Tullah)		Slate, sandstone, tuff
Sl	Dr	2	1	LOW	Cambrian	Mt. Read Volcanics - Farrell Slates (Cf)	Murchison Gorge	CP85537650	Slate
Sl	Dr	2	2	LOW	Cambrian	Mt. Read Volcanics - Farrell Slates (Cf)	NE of Mackintosh Dam	CP87578340	Slate, sandstone
Sl	Dr	3	-	LOW	Cambrian	Dundas Group - Que River Shale (Cds)	Que River - Bulgobac River area		Pyritic siltstone & shale, with
Sl	Dr	3	1	LOW	Cambrian	Dundas Group - Que River Shale (Cds)	Murchison Highway at Bulgobac River	CP892934	Shale
Sl	Dr	4	-	LOW	Upper Carbon	Wynyard Tillite correlate (Pigtr)	Strahan Plantation	CP610380	rhythmite siltstone within tillit
Sl	Ne	1	-	HIGH	Ordovician	Mathinna Beds (Sma - "Lutite Association)	Back Creek - Bangor		Slate, some phyllite.
Sl	Ne	1	1	"HIGH"	Ordovician	Mathinna Beds (Sma - "Lutite Association)	BANGOR SLATE QUARRY	EQ110367	Slate
Sl	Ne	1	2	HIGH	Ordovician	Mathinna Beds (Sma - "Lutite Association)	BACK CREEK SLATE QUARRY (Turquoise Bluff)	EQ045561	Slate with clayey-sandy mudst

TRUE GRANITE

Stone	Prov	Area	Site	PROSPECTIVITY	Geol age	Geol unit	Location	Co ordinates	Rock types
G	Tb	1	-	LOW	Cambrian (inc	Dove "Granite" (Mersey R. body)	Mersey R. valley N. of Parangana		Granodiorite, granodioritic apl
G	Rb	1	-	HIGH	Devonian/Carb	Heemskirk Red Granite	Trial Harbour - Mt. Heemskirk		Red Granite
G	Rb	1	1	HIGH	Devonian/Carb	Heemskirk Red Granite	TRIAL HARBOUR RED GRANITE QUARRY (Just S. of Tri	CP50225725	Red Granite. Trade name "ANA
G	Dr	1	-	LOW	Cambrian	Murchison Granite (Cgr)	Murchison River Gorge		Granite
G	Dr	1	1	LOW	Cambrian	Murchison Granite (Cgr)	Murchison Dam Rd.	CP88007365	Granite
G	Dr	1	2	LOW	Cambrian	Murchison Granite (Cgr)	Sophia Tunnel Rd.	CP88207413	Granite
G	Dr	2	-	LOW	Devonian	Beulah Granite (cluster of outcropping	Beulah - Paradise area (Sheffield Quad.)		Granite & granodiorite
G	Dr	3	-	HIGH	Devonian	Housetop Granite (southern part)	Mt Housetop - Kara - Upper Natone region		Biotite granite (with minor v
G	Dr	3	1	MEDIUM - ?HIGH	Devonian	Housetop Granite (southern part)	East of Lake Kara	DQ047311	Biotite granite
G	Dr	4	-	HIGH	Devonian	Housetop Granite (Northern part)	Natone - Upper Natone area		Biotite granite
G	Dr	4	1	MEDIUM	Devonian	Housetop Granite (Northern part)	South of Natone	DQ087393	Biotite granite
G	Dr	4	2	HIGH	Devonian	Housetop Granite (Northern part)	QUARRY PROSPECT, south of Natone	DQ08103880	Granite
G	Ne	1	-	MEDIUM	Devonian	Scamander Tier Granodiorite	St. Helens - Skyline Tier - Scamander (includes discon		porphyritic granodiorite (Dbgp)
G	Ne	1	1	MEDIUM	Devonian	Scamander Tier Granodiorite	Skyline Rd., Skyline Tier, Scamander	FQ03551434	Porphyritic granodiorite (Dbgp
G	Ne	1	2	?MEDIUM	Devonian	Scamander Tier Granodiorite	Binalong Bay Rd., St. Helens	FQ065269	Biotite Granodiorite (Dbgp), ho
G	Ne	2	-	LOW	Devonian	Mt. Pearson Adamellite (Southern Part	Granite Knob - Avenue River - Black Tommy's Hill (elo		Biotite granite intruding(?) biot
G	Ne	2	1	LOW	Devonian	Mt. Pearson Adamellite (Southern Part	Black Tommy's Hill, Avenue River valley.	EQ94780835	pink granite intruding(?) grey
G	Ne	2	2	LOW	Devonian	Mt. Pearson Adamellite (Southern Part	Beside Granite Knob Rd., at Brilliant Crk.	EQ92731514	Adamellite (Dbasc)
G	Ne	2	3	LOW	Devonian	Mt. Pearson Adamellite (Southern Part	Scamander R. bridge, Granite Knob Rd.	EQ92601550	Adamellite + granite (Dbasc)
G	Ne	3	-	?LOW	Devonian	Mt. Pearson Adamellite (Southern Part	Mothers Hill (N) - Granite Knob (S); elongate body.		Adamellite (Dbasc)
G	Ne	3	1	LOW	Devonian	Mt. Pearson Adamellite (Southern Part	Junction Hogans & Granite Knob Rds	EQ92001655	Adamellite (Dbasc)
G	Ne	4	-	HIGH	Devonian	Poimena Adamellite (Southern part)	S.Mt.Cameron-Moorina-Lottah-Pyengana Saddle-Billy		Adamellite (Dbapc)
G	Ne	4	1	LOW	Devonian	Poimena Adamellite (Southern part)	Weld Hill, Tasman Highway	EQ75004256	Adamellite (Dbapc)
G	Ne	4	2	HIGH	Devonian	Poimena Adamellite (Southern part)	Tebrakunna Rd., near Counsels Rd.	EQ911502	Biotite-muscovite adamellite (D
G	Ne	5	-	MEDIUM?	Devonian	Mt. Paris Pluton	Derby-Branxholm-Mt. Paris Dam region.		Granite/adamellite (Dbau)
G	Ne	5	1	MEDIUM-LOW	Devonian	Mt. Paris Pluton	Mt. Paris Rd.	EQ69503650	Granite/adamellite (Dbau)
G	Ne	5	2	LOW	Devonian	Mt. Paris Pluton	Tasman Highway east of Branxholm	EQ64104349	Granite/adamellite (Dbapq)
G	Ne	5	3	LOW	Devonian	Mt. Paris Pluton	Tasman Highway just west of Derby	EQ65274455	Granite/adamellite (Dbae)
G	Ne	6	-	MEDIUM	Devonian	Russells Rd. Adamellite (Northern part	West of Legerwood - Tulendeena (east of Scottsdale)		"pink" adamellite (Dsac)
G	Ne	6	1	MEDIUM	Devonian	Russells Rd. Adamellite (Northern part	Tasman Highway, Billycock Hill	EQ56493840	"pink" Adamellite (Dsac)
G	Ne	7	-	MEDIUM	Devonian	Tulendeena Granodiorite	Tulendeena - Kamona - Davis Hill		Granodiorite (Dsg)
G	Ne	7	1	LOW	Devonian	Tulendeena Granodiorite	Tasman Highway, 1 km S. of Tulendeena	EQ55104029	Granodiorite (Dsg)
G	Ne	8	-	?LOW	Devonian	Mt. Stronach Pluton (Dsam)	Mt. Stronach - Kamona - Butlers Saddle		Alkali-feldspar granite
G	Ne	8	1	LOW	Devonian	Mt. Stronach Pluton (Dsam)	Tasman Highway, west of Kamona	EQ53554214	Alkali-feldspar granite
G	Ne	8	2	LOW	Devonian	Mt. Stronach Pluton (Dsam)	Road metal quarry, Mt. Stronach	EQ46803982	Alkali-feldspar granite
G	Ne	9	-	LOW	Devonian	Mt William Granite	Mt William area, ENE of Gladstone		Alkali-feldspar granite (Deem)
G	Ne	9	1	LOW	Devonian	Mt William Granite	Gumhill Creek	FQ01457530	Alkali-feldspar granite (Deem)
G	Ne	10	-	LOW	Devonian	Ansons Bay North Adamellite	Mt. William National Park, ENE of Gladstone		Biotite-garnet granite/adamelli
G	Ne	11	-	?MEDIUM	Devonian	Ansons Bay South Adamellite	Ansons Bay - Eddystone Point (incl. Mt William Nationa		Biotite-garnet-minor muscovite
G	Ne	11	1	MEDIUM	Devonian	Ansons Bay South Adamellite	Eddystone Rd., within Mt William National Park	FQ08655928	Biotite-garnet-minor muscovite
G	Ne	12	-	LOW - ?MEDIUM	Devonian	Gardens Granodiorite	Great Mussel Roe River to The Gardens		Predominantly biotite-hornblenc
G	Ne	12	1	LOW - ?MEDIUM	Devonian	Gardens Granodiorite	The Gardens (Margery's corner)	FQ064406	Biotite-hornblende granodiorite
G	Ne	13	-	HIGH	Devonian	Poimena Adamellite (northern part)	Waterhouse Pt - Boobyalla River		Biotite-muscovite granite/adam
G	Ne	13	1	HIGH	Devonian	Poimena Adamellite (northern part)	Waterhouse Rd., just E. of Banca Rd junction	EQ68656875	Biotite-muscovite granite/adam
G	Ne	14	-	LOW?	Devonian	Little Mt. Horror Granite	Little Mt. Horror - White Rock Tier		Biotite-muscovite granite/adam
G	Ne	15	-	LOW	Devonian	She-Oak Hill Pluton	She-Oak Hill - Waterhouse Rd. (between Banca Rd. junc		Biotite-muscovite granite/adam
G	Ne	16	-	LOW	Devonian	Boobyalla Adamellite	South of Boobyalla, between Boobyalla & Ringarooma R		Garnet-bearing biotite muscov
G	Ne	17	-	LOW	Devonian	Pyengana Granodiorite (NE portion)	North George River - Pyengana		Granodiorite
G	Ne	18	-	LOW	Devonian	Pyengana Granodiorite (SW portion)	SW of Pyengana (Weldborough - Mt. Young area)		Granodiorite
G	Ne	19	-	LOW	Devonian	Scamander Tier Granodiorite (W. part)	Goshen - Terryvale area (W. of St. Helens)		Biotite-hornblende Granodiorite
G	Ne	20	-	MEDIUM	Devonian	Mt. Pearson Adamellite (Northern Part	Binalong Bay - Mt Pearson - Ansons Bay Rd.		Biotite-muscovite adamellite (D
G	Ne	20	1	MEDIUM	Devonian	Mt. Pearson Adamellite (Northern Part	Sloop Lagoon, coast and Bridge	FQ0737	Biotite-muscovite adamellite (D
G	Ne	21	-	LOW	Devonian	George River Granodiorite	St. Helens - Lower George River		Biotite - hornblende Granodiorit
G	Ne	22	-	LOW	Devonian	Picanniny Creek "Adamellite"	Chain of Lagoons - Mt. Elephant area		Granite
G	Ne	23	-	LOW	Devonian	Royal George Granite	Royal George		Granite
G	Ne	24	-	LOW - ?MEDIUM	Devonian-Carb	Ben Lomond Granite	Rossarden - Avoca area.		Alkali-feldspar Granite
G	Ne	25	-	HIGH	Devonian	Tombstone Creek Pluton	Upper Ringarooma River - Tombstone Creek - Ben Nevi		Alkali - Feldspar Granite
G	Ne	25	1	HIGH	Devonian	Tombstone Creek Pluton	BLESSINGTON GRANITE QUARRY (just E. of Ben Nevis)	EQ537146	Alkali - Feldspar Granite (Trade
G	Ne	25	2	LOW	Devonian	Tombstone Creek Pluton? (poss. just o	Tombstone Creek area.	EQ555197	Alkali - feldspar granite?
G	Ne	26	-	HIGH	Devonian	Russells Rd. Adamellite (southern part	Mt. Maurice - Upper Esk area.		Adamellite
G	Ne	26	1	HIGH	Devonian	Russells Rd. Adamellite (southern part	MEMORY ROAD GRANITE QUARRY	EQ586146	Adamellite (Qtz, K-feldspar, pl
G	Ne	26	2	HIGH	Devonian	Russells Rd. Adamellite (southern part,	DIDDLEUM GRANITE QUARRY	EQ471223	Adamellite (chilled margin); Tr
G	Ne	27	-	HIGH	Devonian	Diddleum Granodiorite	Diddleum Plains - Scottsdale		Granodiorite
G	Ne	27	1	HIGH	Devonian	Diddleum Granodiorite	Diddleum Plains	EQ386253	Granodiorite
G	Ne	27	2	HIGH	Devonian	Diddleum Granodiorite	Scottsdale (area to west of town)	EQ412395	Granodiorite
G	Ne	27	3	MEDIUM	Devonian	Diddleum Granodiorite	NW of Mt Barrow	EQ360206	Granodiorite
G	Tn	1	-	HIGH	Devonian	Coles Bay Adamellite - red variety	Coles Bay - "The Hazards"		Adamellite
G	Tn	1	1	HIGH	Devonian	Coles Bay Adamellite - red variety	COLES BAY GRANITE QUARRY, SW of Parsons Cove.	FP053329	Adamellite (Trade name "NELSC

BLACK GRANITE

Stone	Prov	Area	Site	PROSPECTIVITY	Geol age	Geol unit	Location	Co ordinates
Bg	Rb	1	-	LOW	Precambrian	Cooee Dolerite: swarm of dykes intruding Burnie Formation.	Burnie - Cooee area	
Bg	Rb	1	1	LOW	Precambrian	Cooee Dolerite	Burnie-Cooee foreshore	DQ063556
Bg	Rb	2	-	LOW	Precambrian	Cooee Dolerite - dykes intruding Rocky Cape Group.	Rocky Cape - Jacobs Harbour shoreline	
Bg	Rb	3	-	LOW	Tertiary	Basalt	Wynyard - Boat Harbour - Myalla area	
Bg	Rb	4	-	LOW	Tertiary	Basalt	Montumana - Rocky Cape "township" area (between Hellyer low	
Bg	Rb	5	-	LOW	Precambrian	Cooee Dolerite - swarm of dykes intruding Cowrie Siltstone.	Hellyer - Port Latta area	
Bg	Rb	5	1	LOW	Precambrian	Cooee Dolerite (large dyke)	Hellyer Township (Detention River mouth)	CQ683735
Bg	Rb	6	-	LOW	Cambrian	Spilite Basalt (Smithton Trough)	Scotchtown - Ollington's Hill - Collin's Corner	
Bg	Rb	6	1	LOW	Cambrian	Spilite Basalt (Smithton Trough)	Collin's Corner	CQ406686
Bg	Rb	7	-	MEDIUM?	Cambrian	Spilite Basalt (Smithton Trough)	Copper Creek (S. of Collins Corner), small area on hill just east	
Bg	Rb	7	1	LOW	Cambrian	Spilite Basalt (Smithton Trough)	Beside Trowutta Rd.	CQ405675
Bg	Rb	8	-	MEDIUM?	Cambrian	Spilite Basalt (Smithton Trough)	Arthur River at Kanunnah Bridge (Sumac Rd.)	
Bg	Rb	8	1	LOW	Cambrian	Spilite Basalt (Smithton Trough)	South side of Kanunnah Bridge, Sumac Rd. (Arthur R.)	CQ306463
Bg	Rb	9	-	MEDIUM?	Cambrian	Spilite Basalt (Smithton Trough)	Smithton Township - Copper Mine Point area	
Bg	Rb	9	1	MEDIUM	Cambrian	Spilite Basalt (Smithton Trough)	North of Smithton	CQ426785
Bg	Rb	10	-	LOW	Tertiary	Basalt	Alcomie area	
Bg	Rb	10	1	LOW	Tertiary	Basalt	Alcomie area	CQ473684
Bg	Rb	11	-	LOW	Tertiary	Basalt	Forest area (Smithton region)	
Bg	Rb	12	-	LOW	Precambrian	Supposedly 3 Cooee Dolerite dykes	Tayatea Rd., between Rapid & Little Rapid Rivers	
Bg	Rb	13	-	LOW	Jurassic	Dolerite Cone Sheet	Pieman Rd., near Stringers Crk., N. side of Pieman River	
Bg	Rb	14	-	LOW	Jurassic	Dolerite	Takone - Campbell Range, NW Tas.	
Bg	Rb	14	1	LOW	Jurassic	Dolerite	PROSPECT, Campbell Ra. (N. of Arthur River, NW Tas.)	CQ72254380
Bg	Bb	1	-	LOW	Cambrian	Swarm of dolerite dykes	Port Sorell (E. side)	
Bg	Dr	1	-	LOW	Cambrian	McIvor's Hill Gabbro	McIvor's Hill & to west.	
Bg	Dr	2	-	LOW - ?MEDIUM	Cambrian	Serpentine Hill Ultramafic Complex	Serpentine Hill	
Bg	Dr	2	1	LOW-?MEDIUM	Cambrian	Serpentine Hill Ultramafic Complex	Serpentine Hill quarry	CP68106770
Bg	Dr	2	2	LOW	Cambrian	Serpentine Hill Ultramafic Complex	South of Serpentine Hill	CP68006727
Bg	Dr	3	-	LOW - ?MEDIUM	Cambrian	Mt. Read Volcanics: Central Volcanic Complex : Andesitic Volc	Antony Rd., west of Mt. Tyndall	
Bg	Dr	4	-	LOW	Cambrian	Mt. Read Volcanics: Farrell/Murchison Sequence (Cl, Cmv) (-	Mt. Murchison - Murchison Gorge - Mt. Farrell area.	
Bg	Dr	4	1	LOW	Cambrian	Mt. Read Volcanics: Farrell/Murchison Sequence (Cl, Cmv) (-	Murchison Dam abutments	CP87507325
Bg	Dr	5	-	LOW	Tertiary	Basalt flows	Barrington - Sheffield - Paradise	
Bg	Dr	6	-	LOW - ?MEDIUM	Tertiary	Basalt; large/thick plateau-capping flows	S. of Mt Claude to Emu Plains area (plateau)	
Bg	Dr	7	-	LOW	Cambrian	Dundas Group - Molton spilite	Penguin - Lodders Pt.	
Bg	Dr	8	-	MEDIUM?	Cambrian	Heazlewood R. Ultramafic Complex: Caudry's Hill Pyroxenites	Caudry's Hill, Heazlewood River.	
Bg	Dr	8	1	MEDIUM?	Cambrian	Heazlewood R. Ultramafic Complex: Caudry's Hill Pyroxenites	Caudry's Hill, Heazlewood River.	CQ55250758
Bg	Dr	9	-	MEDIUM - LOW?	Cambrian	Heazlewood R. Ultramafic Complex: Brassey Hill Harzburgites	Brassey Hill, Heazlewood River	
Bg	Dr	9	1	LOW?	Cambrian	Heazlewood R. Ultramafic Complex: Brassey Hill Harzburgites	Brassey Hill, Heazlewood River	CQ600089
Bg	Dr	10	-	MEDIUM	Tertiary	Large basalt flows	Hampshire - Guilford - Mt. Pearse region	
Bg	Dr	10	1	MEDIUM ?	Tertiary	Basalt flow	Waratah Falls, Waratah	CQ771108
Bg	Dr	10	2	MEDIUM ?	Tertiary	Basalt flow	Intersection of Hellyer Railway & Cradle Mt. Link Rd.	CP93409872
Bg	Dr	11	-	MEDIUM ?	Tertiary	Basalt flows	Middlesex Plains region	
Bg	Dr	12	-	LOW?	Devonian	Dolerite mass	NW side of Mt Charter	
Bg	Dr	13	-	LOW?	Cambrian	Wilson River Ultramafic Complex	Wilson River	
Bg	Dr	13	1	LOW	Cambrian	Wilson River Ultramafic Complex	Serpentine Ridge, Wilson River area.	CP672793
Bg	Ne	1	-	LOW	Tertiary	Basalt	Branxholm - Legerwood - Ringarooma	
Bg	Ne	2	-	LOW	Tertiary	Basalt	Derby - Winnaleah	
Bg	Ne	3	-	LOW	Devonian	Swarm of dolerite dykes (Ddl)	Mt. William area, ENE of Gladstone.	
Bg	Ne	3	1	LOW	Devonian	Dolerite dyke (Ddl) in Mathinna Beds.	Mussel Roe Rd., just outside Mt. William National Park	EQ975724
Bg	Ne	3	2	LOW	Devonian	Dolerite dyke (Ddl) in Mt. William Granite.	Mt. William National Park	EQ991741
Bg	Ne	4	-	LOW	Devonian	Swarm of dolerite dykes (Ddl)	Ansons Bay - Pioneer region	
Bg	Ne	4	1	LOW	Devonian	Dolerite dyke (Ddl)	Tebrakunna Rd., near Counsels Rd (at True Granite site G/Ne/4	EQ911502
Bg	Ne	5	-	MEDIUM	Devonian	St. Mary's Porphyrite (Dpr): extrusive (N.) part of porphyrite	E. of St. Mary's	
Bg	Ne	5	1	LOW	Devonian	St. Mary's Porphyrite (Dpr): extrusive (N.) part of porphyrite	St. Mary's Pass	FP012991
Bg	Ts	1	-	LOW - ?MEDIUM	Jurassic	Dolerite	E. Central plateau: Tunbridge - Interlaken - Steppes area	
Bg	Ts	2	-	MEDIUM - ?HIGH	Jurassic	Dolerite	Swansea-Lk Leake-Campbelltown-Woodbury-Little Swanport R.	
Bg	Ts	2	1	MEDIUM - ?HIGH	Jurassic	Dolerite (Jdl)	6.5km east of Campbelltown (main Rd. junction)	EP471563
Bg	Ts	3	-	MEDIUM	Jurassic	Dolerite differentiates	Margate - Red Hill - Kettering	
Bg	Ts	3	1	LOW	Jurassic	Dolerite differentiates	Channel Hwy just N. of Nichols Rivt. Rd. turnoff.	EN199276
Bg	Ts	3	2	MEDIUM	Jurassic	Dolerite differentiates - Red Hill Dyke	Red Hill - Van Morey Rd (outside granophyre area mapped by F.	EN191336
Bg	Tw	1	-	LOW - ?MEDIUM	Jurassic	Dolerite	Northern Central Plateau - Projection Bluff to Liawenee	
Bg	Tw	2	-	LOW - ?MEDIUM	Jurassic	Dolerite	NE Central Plateau: Arthurs Lake - Poatina area.	
Bg	Tw	3	-	LOW	Tertiary	Basalt	W. of Great Lake (Liawenee - Miena area)	
Bg	Tw	4	-	MEDIUM	Tertiary	Basalt	St. Patricks Plains (just N. of The Steppes)	
Bg	Tw	5	-	HIGH	Tertiary	Basalt Flow	S. end of Great Lake, E. of Miena	
Bg	Tw	5	1	HIGH	Tertiary	Basalt Flow	MIENA BASALT QUARRY (S. end of Great Lake, E. of Miena)	DP603517
Bg	Tw	6	-	LOW	Tertiary	Basalt (Tb)	West of Waddamana/Ouse River	
Bg	Tw	7	-	LOW - ?MEDIUM	Jurassic	Dolerite (Jdl)	Waddamana region	
Bg	Tn	1	-	MEDIUM ?	Jurassic	Dolerite	Perth-Launceston-Legana area (W. side of Tamar & N. Esk River	
Bg	Tn	1	1	MEDIUM ?	Jurassic	Dolerite	Midlands Hwy (Expressway) just S. of Launceston	EQ129068
Bg	Tn	2	-	MEDIUM ?	Jurassic	Dolerite sheet (large area)	Turners Marsh - Nunamara - Ben Lomond - Avoca area (E. of Ta	
Bg	Tn	2	1	MEDIUM ?	Jurassic	Dolerite	Just W. of Nunamara, S. side of Tasman Hwy	EQ23651596
Bg	Tn	2	2	MEDIUM	Jurassic	Dolerite	Slag Hill, NE of Evandale	EQ290018
Bg	Tn	2	3	LOW	Jurassic	Dolerite	Cox's Hill, S. of Musselboro	EQ359062
Bg	Tn	2	4	LOW	Jurassic	Dolerite (Jdl)	Mt Barrow (summit region)	EQ356196
Bg	Tn	2	5	LOW	Jurassic	Dolerite (Jdl)	Deddington region	
Bg	Tn	3	-	?LOW	Jurassic	Dolerite	Exton - Birralee - Franklin Rivt.	
Bg	Tn	4	-	LOW	Tertiary	Basalt	Westbury - Deloraine - Elizabeth Town	
Bg	Tn	5	-	?MEDIUM	Jurassic	Dolerite	Devonport (W. side of Mersey R.)	
Bg	Tn	6	-	MEDIUM	Jurassic	Dolerite	Avoca-Campbelltown-Lk Leake-Cranbrook-Douglas R.-Royal Ge	
Bg	Tn	7	-	LOW?	Jurassic	Dolerite	Fingal Tier - Douglas R. - Mt. Puzzler	
Bg	Tn	7	1	LOW	Jurassic	Dolerite	W. of Horseshoe Marsh, S. of Fingal Tier	EP90258130
Bg	Tn	8	-	LOW	Tertiary	Basalt	SW of Avoca	

OTHER GRANITES

Stone	Prov	Area	Site	PROSPECTIVITY	Geol age	Geol unit	Location	Co ordinates
Og	Dr	1	-	HIGH	Cambrian	Mt. Read Volcanics - Tyndall Group (Ct)	Antony Rd - Tyndall Creek (W. side of Mt. Julia/Mt. Tyndall)	
Og	Dr	1	1	HIGH?	Cambrian	Mt. Read Volcanics - Tyndall Group (Ct)	Antony Rd., between Tyndall & Newton Creeks	CP81205860
Og	Dr	1	2	HIGH?	Cambrian	Mt. Read Volcanics - Tyndall Group (Ct)	Antony Road area, between Tyndall & Newton Creeks	? CP81205860
Og	Dr	2	-	LOW	Cambrian	Mt. Read Volcanics - Western Sequence (Cw) (Ctx of Lyell 1:50	Antony Rd/Murchison Hwy, from Henty R. S. to Strahan turnoff.	
Og	Dr	3	-	LOW	Cambrian	Mt. Read Volcanics: Central Volcanic Complex Ccvl	Tullabardine Dam area	
Og	Dr	3	1	LOW	Cambrian	Mt. Read Volcanics: Central Volcanic Complex Ccvl	Tullabardine Dam, eastern abutment	CP87858128
Og	Dr	4	-	MEDIUM	Cambrian	Mt. Read Volcanics: Central Volcanic Complex: Ccv (entire port	Pieman Rd. - Mackintosh Bridge - Lake Rosebery -Mt. Block area	
Og	Dr	4	1	MEDIUM	Cambrian	Mt. Read Volcanics: Central Volcanic Complex: Ccvim	Pieman Rd., 500m west of Murchison Highway	CP83648125
Og	Dr	4	2	?MEDIUM	Cambrian	Mt. Read Volcanics: Central Volcanic Complex: Ccvim	S. side of Mackintosh Bridge, Murchison Highway	CP85378007
Og	Dr	4	3	LOW - MEDIUM	Cambrian	Mt. Read Volcanics: Central Volcanic Complex: Cps	Pieman Rd., just west of Farrell Siding (Emu Bay Railway)	CP79258035
Og	Dr	5	-	MEDIUM	Cambrian	Mt. Read Volcanics: Central Volcanic Complex: Ccv, (entire port	Lake Rosebery - Mt Black - Rosebery - Mt Read area	
Og	Dr	5	1	MEDIUM	Cambrian	Mt. Read Volcanics: Central Volcanic Complex: Ccv.	Southern slopes of Mt. Black	CP806732
Og	Dr	6	-	LOW	Cambrian	Minnow Keratophyre (Cmk)	Cethana - Lower Beulah area (Mt. Roland region)	
Og	Dr	7	-	MEDIUM - HIGH?	Cambrian	Mt. Read Volcanics - Central Volcanic Complex (Ccv)	Red Hills - Basin Lake, West Coast Range	
Og	Dr	7	1	MEDIUM - HIGH?	Cambrian	Mt. Read Volcanics - Central Volcanic Complex (Ccv)	Antony Rd.	CP80105527
Og	Ts	1	-	LOW	Cretaceous	Alkaline intrusives (Cs) - swarm.	Kettering - Oyster Cove Region	
Og	Ts	1	1	LOW	Cretaceous	Alkaline intrusives (Cs) - small intrusion <100m dia.?	Nicholls Rivulet Road	EN169274
Og	Ts	1	2	LOW	Cretaceous	Alkaline intrusives (Cs) - small intrusion ≈300m dia.	Corner Nicholls Rivt. Rd. & Hughes Rd.	EN160268
Og	Ts	2	-	?MEDIUM - LOW	Cretaceous	Alkaline intrusives (Cs) - swarm	Nicholls Rivulet (E & NE side of Port Cygnet)	
Og	Ts	2	1	LOW	Cretaceous	Alkaline intrusives (Cs) - cluster of small (≈20m dia.) intrusio	Nicholls Rivt. Rd., near Channel Hwy. junction	EN08001976
Og	Ts	3	-	LOW - ?MEDIUM	Cretaceous	Alkaline intrusives (Cs) - sheets & swarm of small dykes.	Mt Windsor - Mt Mary - Kings Hill region, Cygnet	
Og	Ts	3	1	LOW	Cretaceous	Alkaline intrusives (Cs) - small dykes in Permo-Carboniferou	Kings Hill gravel quarry	EN036203
Og	Ts	4	-	LOW	Cretaceous	Alkaline intrusives (Cs) - sheets and small dykes	W. shore of Port Cygnet, Lymington to Cygnet	
Og	Ts	4	1	LOW	Cretaceous	Alkaline intrusives (Cs) - Thin dyke in Permian Mudstone.	100m north of Langdons Pt., Port Cygnet	EN06901770
Og	Ts	5	-	LOW	Cretaceous	Alkaline intrusives (Cs) - large mass	Silver Hill area, Cygnet	
Og	Ts	5	1	LOW	Cretaceous	Alkaline intrusives (Cs) - large mass	Silver Hill area, Cygnet	EN010228

MARBLE

Stone	Prov	Area	Site	PROSPECTIVITY	Geol age	Geol unit	Location	Co ordinates
M	Rb	1	-	?	Cambrian	Smithton Dolomite	Roger River to Roger River West area	
M	Rb	2	-	?	Cambrian	Smithton Dolomite	Roger River West - Ekberg Creek - Arthur River - Stevens Rivt.	
M	Rb	3	-	?	EoCambrian	Black River Dolomite	Blackwater Rivt. - Arthur River - Salmon River	
M	Rb	4	-	?	EoCambrian	Black River Dolomite	Lake Chisholm - Sumac Rivulet area	
M	Rb	4	1	LOW	EoCambrian	Black River Dolomite	Sumac Quarry	CQ361420
M	Rb	5	-	?	Cambrian	Smithton Dolomite	Smithton town region, to west of N-S spilite belt.	
M	Rb	5	1	LOW	Cambrian	Smithton Dolomite	On road to Watsons Bend Quarry.	CQ405766
M	Rb	6	-	?	EoCambrian	Black River Dolomite	Irishtown - Lke Mikany region (east of N-S spilite belt)	
M	Rb	6	1	LOW	EoCambrian	Black River Dolomite	Fahey's Lane	CQ468705
M	Rb	7	-	MEDIUM?	Precambrian	Keith Metamorphics (several discrete magnesite "pods"), v	Cann Creek - Farquars Rd. (Arthur River)	
M	Rb	7	1	MEDIUM?	Precambrian	Keith Metamorphics (a discrete magnesite "pod" interbedde	Victory Mine, adjacent Farquahars Rd, 30 m from Arthur River.	CQ70334060
M	Rb	7	2	MEDIUM?	Precambrian	Keith Metamorphics (a discrete magnesite "pod" interbedde	Southern Creek, near Farquahars Rd., Arthur River.	CQ70524086
M	Dr	1	-	LOW	EoCambrian	Success Creek Group: Esu (correlate of "Red-rock" Member	Stanley River at Pieman Rd. ("Stanley Reward")	
M	Dr	1	1	LOW	EoCambrian	Success Creek Group: Esu (correlate of "Red-rock" Member	Stanley River just N. of Pieman Rd. ("Stanley Reward")	CP58038159
M	Dr	2	-	MEDIUM?	Ordovician	Gordon Limestone	Mole Creek region	
M	Dr	3	-	MEDIUM	Ordovician (D	Gordon Group (limestones)	Kara region	
M	Dr	3	1	MEDIUM?	Ordovician (D	Gordon Group (limestones)	Wollastonite Creek, Kara region	CQ997288

SERPENTINE

Stone	Prov	Area	Site	PROSPECTIVITY	Geol age	Geol unit	Location	Co ordinates
Sr	Tb	1	-	LOW	Cambrian	Adamsfield Ultramafic Complex	Adamsfield	
Sr	Tb	2	-	LOW	Cambrian	Boyes River Ultramafic Complex	W. of Denison Ra./Stepped Hills	
Sr	Bb	1	-	LOW	Cambrian	Andersons Creek Ultramafic Complex	Andersons Creek area, W. of Beaconsfield.	
Sr	Dr	1	-	LOW (?HIGH for Terrazzo)	Cambrian	Dundas Ultramafic Complex	Dundas	
Sr	Dr	1	1	LOW (?HIGH for Terrazzo)	Cambrian	Dundas Ultramafic Complex	Dundas - Razorback Mine	CP69406367
Sr	Dr	2	-	LOW-?MEDIUM	Cambrian	Serpentine Hill Ultramafic Complex	Serpentine Hill, Murchison Highway	
Sr	Dr	2	1	LOW-?MEDIUM	Cambrian	Serpentine Hill Ultramafic Complex	Serpentine Hill Quarry	CP68106770
Sr	Dr	3	-	LOW	Cambrian	Wilson River Ultramafic Complex	Serpentine Ridge area, Wilson River	
Sr	Dr	4	-	LOW	Cambrian	Heazlewood River Ultramafic Complex	Heazlewood River	
Sr	Dr	5	-	MEDIUM	Cambrian	Forth Ultramafic Complex, emplaced within Precambrian	Forth Block, Ulverstone area	
Sr	Dr	5	1	MEDIUM-"HIGH"	Cambrian	Forth Ultramafic Complex, emplaced within Precambrian	"Ulverstone Quarries", above Clayton's Rivt., E. of Ulversto	DQ330408
Sr	Dr	6	-	LOW - ?MEDIUM	Cambrian	Cape Sorell Ultramafic Complex	Noddy Creek area, S. of Macquarie Harbour	

OTHER STONE TYPES

Stone	Prov	Area	Site	PROSPECTIVITY	Geol age	Geol unit	Location	Co ordinates	Rock types
X	Dr	1	-	LOW	Ordovician	Roland Conglomerate	Mt Roland - Mt Claude		Siliceous conglomerate
X	Dr	2	-	HIGH?	Late Cambrian-Early Ord	Owen Conglomerate	West Coast Range: Mt Sorell - Mt. Far		Siliceous conglomerates & sandstones
X	Dr	2	1	MEDIUM	Quaternary glacial boulde	Owen Conglomerate	Henty River bridge	CP732496	Siliceous conglomerates & sandstones
X	Ne	1	-	HIGH	Permian	Castle Carey Mudstone	Southeast of Tower Hill, Fingal area		Interbedded silicified mudstone, pebbly sandstone, siltsto
X	Ne	1	1	HIGH	Permian	Castle Carey Mudstone	Tower Hill Rd., Mangana - Fingal	EP76459420	Interbedded silicified mudstone(hornfels), pebbly sandst