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A PHOTOGEOLOGICAL INTERPRETATION

of the

QUEENSTOWN - ROSEBERY AREA

WESTERN TASMANIA

# REPORT ON

# A PHOTOGEOLOGICAL INTERPRETATION

# OF THE

# QUEENSTOWN - ROSEBERY AREA,

# WESTERN TASMANIA

June - August
1968

for

THE MT. LYELL MINING AND RAILWAY CO. LTD.

by

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GEOSURVEYS OF AUSTRALIA PTY. LIMITED

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## I. INTRODUCTION

A photogeological interpretation of the Queenstown - Rosbery area was requested by Mr. J.D. Campbell, Consulting Geologist to the associated Companies, New Consolidated Gold Fields (Australasia) Pty. Ltd., The Mt. Lyell Mining and Railway Co. Ltd. and Renison Ltd.

The project area embraces portions of the Zeehan, Murchison, Strahan and Lyell 1-mile military map sheets, being bounded approximately by the 41° 45' and 42° 07½' parallels of South latitude and the 145° 20½' East and 145° 43½' meridians of East longitude.

The rugged West Coast Ranges form the backbone of this high-rainfall, thickly-forested portion of the west coast district of Tasmania.

## II. METHOD

The author spent four days in the Queenstown - Zeehan - Rosebery area inspecting part-sections of the Cambrian, Ordovician and Siluro - Devonian formations.

Aerial photographs at an approximate scale of 40 chains to 1 inch were used for the photogeological interpretation, the geological information being plotted directly onto alternate photographs using wax pencils. Different colours were used for:-

| | | |
|---|---|---|
| Geological boundaries | - | red |
| Trends of bedding, foliation, etc. | - | blue |
| Linears, lineaments, faults, etc. | - | black |

This information was then plotted onto controlled compilation base sheets, kindly made available by the Tasmanian Department of Lands and Surveys, at a scale of 45 chains to 1 inch. Mr. D. Owen transferred the geological boundaries, lineaments, bedding trends etc. to the base sheets by means of the "Stereotope" plotter, thereby ensuring that the detail was plotted in its true orthogonal position. This is of particular importance as the elevation differences in the terrain result in large relief displacements in the photography.

After preparation of colour-rough maps at this scale (45 chains to 1 inch) and checking and re-interpretation of certain areas, the finally - drafted maps were photo-enlarged to the final presentation scale of 2" = 1 mile.

## III. GEOLOGY AND PHOTOGEOLOGY

The general geology of this area is relatively well known, although more recent detailed mapping by the various Mining Companies should result in a clearer understanding of the stratigraphy, particularly of the Cambrian rocks.

Being previously unfamiliar with the geology of Tasmania, extensive use was made of previous geological mapping of the western (Zeehan 1-mile sheet - Tasmanian Geological Survey) and southern (Exploration Department, The Mt. Lyell Mining and Railway Co. Ltd.) portions of the area. In a general way, the Pre Cambrian, Ordovician and Siluro-Devonian terrains were relatively easily recognised. However, the areas occupied by Cambrian rocks yielded rather sparse and disappointing results from the viewpoint of possible lithologic variations, structural information etc. This is probably partly due to the fact that the Cambrian formations include a large proportion of volcanics and their associated tuffaceous sediments. These would naturally be deficient in readily mappable mark horizons and additionally may weather more deeply and thus better support the extremely dense rain forest, for which the area is noted. In fact, this lack of readily mappable lithologic boundaries and bedding or lineation trends was used to deduce that large areas of the terrain are underlain by Cambrian rocks. From the exploration viewpoint, the lack of photogeological character within the Cambrian rocks is disappointing, as these are the host-rocks for the presently known major mineral fields of the area.

The results of the survey from a structural point of view may be a little more encouraging, in that a pattern of strong lineaments has been mapped. Many of these coincide very closely with known faults, both major and minor, within mapped areas (Zeehan 1-mile sheet and Mt. Lyell area). Thus many of the major lineaments in the lesser known northeastern portions of the project area may also be interpreted as faults and aid in the structural interpretation of the area as a whole.

## A. STRATIGRAPHY

The following is a brief summary of the stratigraphy with some additional comments on the photogeological characteristics of the rocks of the various age-groups.

### (a) PreCambrian

According to available published maps, rocks of Pre-Cambrian age outcrop in the northwestern corner and along the eastern margin of the Project area.

Those of the latter area are regarded to be older Pre-Cambrian in age and have been described to comprise low to medium grade quartzose schists, schistose quartzites, phyllites and amphibolites. These areas form somewhat rugged and dissected ranges, which are in the main relatively free of vegetation cover, except in the deeper valleys where heavy rain forests prevail. Colour tones on airphotos vary from medium to light grey with the more resistant massive quartzitic bands showing very light tones. These latter beds often contain thin, dark toned, recessive interbeds which are probably phyllite to schist in composition. Other dark-toned, well vegetated areas of larger aereal extent are probably underlain by schistose to amphibolitic rock types. Bedding trends are relatively abundant in certain areas, although individual beds cannot be traced over long distances. The major causes for this are probably related to the somewhat monotonous lithology and very complex, recumbent folding.

In the extreme northeastern corner of the Project area, the older Pre-Cambrian metamorphics have been intruded by granite which is regarded to be of Devonian age related to the Taberabberan Orogeny. The areas underlain by granite are variable in photo-tone from white to light grey in the higher regions (bare of vegetation), to dark in the topographically lower areas (densely forested). The higher areas of good outcrop are typically rough, massive, tor-like outcrops with a "hackled" appearance, due to east-west and north-south jointing. The more subdued outcrop areas show a well-marked north-northwest trending lineation on airphotos. This may be due to foliation in the granite related to contemporaneous or later regional stress effects.

The younger Pre-Cambrian rocks outcropping in the northwestern corner of the Project area, are reported to consist of quartzites and slates with minor dolomites, conglomerates and volcanics. These areas are of generally light photo-tone and the higher regions are essentially free of vegetation. This younger Pre-Cambrian terrain is highly dissected, with the development of an almost dendritic drainage pattern. However, close examination of many of the multitude of darker-toned feeder tributaries shows them to be alligned parallel to bedding linears. This suggests that these may be thin recessive interbeds (?slates) within the more resistant, light toned (?quartzitic) beds.

For the purpose of this Project, the photogeologically similar older and younger Pre-Cambrian rocks, occurring in widely separated areas, have both been designated with the common symbol p Ꞓ on the accompanying maps.

(b) ?Upper Proterozoic to ?Lower Cambrian

A group of sediments of uncertain age and designated on the maps as ? Є or ?p Є appears to unconformably overlie the younger Pre-Cambrian in the northwestern corner of the Project area. These are thought to also occur in a narrow (? anticlinal) zone to the northwest and southwest of Mt. Dundas.

This group is of dark photo-tone and consists of alternating resistant and recessive beds which are covered by heavy forest growth. According to Solomon (1965), lithologies are quartzites, slates, and thin conglomerates (Oonah Group) and are generally referred to as the Success Creek phase. Bedding traces are generally poor to medium, but are on the whole, better defined than in the overlying Cambrian sediments.

(c) Cambrian

The rocks overlying the Success Creek phase comprise the unfossiliferous Crimson Creek Formation (argillite), which is succeeded by the Dundas Group of lower-Middle Cambrian to middle-Upper Cambrian sediments. In addition to the above mentioned Cambrian sediments, there is a thick pile of volcanic rocks named the Mt. Read Volcanics, whose relationship to the Cambrian sediments is imperfectly understood. Generally the Mt. Read volcanics have been interpreted to stratigraphically overlie sediments of the Success Creek phase in the vicinity of Mt. Dundas, and to be age equivalents of the Crimson Creek Formation and Dundas Group to the west.

As previously mentioned the photogeologic study of the Cambrian terrain has yielded very poor results. The region is very heavily forested and little lithologic variations or bedding linears could be delineated from airphotos. No definite criteria could be found to distinguish Cambrian sediments from volcanics, except in the very rare cases where bedding lineations were mapped. Because of the fact that the Mt. Read volcanics are the important host-rocks to the major mineral fields in the West Coast region, the lack of photo-mappable features is disappointing. However, a pattern of major and minor linears and lineaments within the Cambrian terrain may assist in the structural interpretation of faults, shears, joints etc., which may possibly have provided the channelways for mineralizing fluids.

Uppermost Cambrian rocks have been mapped as the Jukes Conglomerate, the pebbles of which have been derived from erosion of the Mt. Read volcanics. This unit occurs east of Mt. Owen.

Intrusive ultrabasic and hypabyssal rocks of possible Cambrian age have been distinguished throughout the area. The serpentinites in the areas north of the Pieman River and Serpentine Hill respectively, are characterized by a low scrubby vegetation and slightly more resistant nature, as compared to the enclosing Cambrian sediments. Basic igneous intrusives into Cambrian sediments could not be distinguished.

Small plug-like intrusive rocks of light photo-tone and rough "hackled" texture, can be equated with mapped feldspar-porphyry bodies, mainly in the Queenstown vicinity. A more extensive area with similar photogeological characteristics, has been tentatively interpreted as porphyry in the region between Mt. Read and Red Hills. However, mapped porphyries to the immediate west of the Mt. Tyndall Range, could not be recognised on airphotos.

(d) <u>Ordovician</u>

Ordovician rocks form the highest and most rugged terrain along the west coast region. The lower unit is the Owen Conglomerate, which is essentially conglomeratic in its lower parts, with a gradual upward reduction in grain size to sandstone. This unit has been further subdivided into three members, a lower, middle and upper Owen Conglomerate, on the basis of field mapping. The Owen Conglomerate bears an unconformable relationship to the underlying Cambrian sediments and volcanics.

Some variation between rugged, poorly bedded, conglomerate units and less rugged, well bedded sandstone units is evident in some areas from photogeology, but such variations could not be traced over wide areas and the Owen Conglomerate has been largely mapped as one unit. Local strong strike-divergences, unrelated to obvious faults, were noticed in some limited areas within the Owen Conglomerate. Such local unconformities or major current-beds have been observed in the field.

The Owen Conglomerate is succeeded by the Gordon Limestone, which consists of fossiliferous marine limestones and shales. This is a markedly recessive unit as compared to the resistant Owen Conglomerate and has been doubtfully mapped from airphotos in only a few localities. The Gordon Limestone may outcrop poorly within scree-slopes and alluviated areas, much more widely than is shown on the accompanying maps.

The Ordovician sequence rapidly thins in a westward direction from the West Coast Ranges, in the southern portions of the Project area.

Further north in the vicinity of Zeehan, the Zeehan Conglomerate (equivalent to the Owen Conglomerate) and the overlying Moina Sandstone, are again strongly developed. Some Ordovician has been doubtfully interpreted to lie stratigraphically between photo-interpreted Cambrian and Silurian rocks, in the region to the southeast of Professor Range. However, Silurian rocks are known to disconformably overlie Cambrian sediments to the east and north of Zeehan and this may apply also to the above mentioned area.

(e) Siluro-Devonian

The Gordon Limestone is overlain apparently conformably by a sedimentary sequence of Silurian to Lower Devonian age. However, as mentioned above, Siluro-Devonian rocks in the vicinity of Zeehan appear to disconformably overlie Cambrian sediments, with the Ordovician being absent.

In general, this mid-Palaeozoic sequence commences at the base with a marked resistant unit, the Crotty Quartzite, which is in turn succeeded by alternating recessive and resistant units (Amber Slate, Keel Quartzite, Austral Creek Siltstone, Florence Quartzite, Bell Shale etc.). For the purposes of this interpretation the Siluro-Devonian has been grouped together and not subdivided into units. Most of the area underlain by Siluro-Devonian rocks has been mapped in the field and subdivided into units (Zeehan 1-mile sheet). The boundaries between recessive and resistant units are sometimes sharply defined but are often scree covered. The uppermost unit of the sequence is the recessive Bell Shale which covers a large area west of Queenstown and is characterised by a marked dendritic drainage pattern in some areas.

The lower units of the Siluro-Devonian sequence are readily distinguished on airphotos by their well-bedded character, the presence of prominent strike ridges which are traceable over long distances, and by their relatively simple fold pattern. The higher resistant arenite members are usually bare of vegetation, while the recessive interbeds (shale, siltstone, etc.) are often thickly vegetated.

(f) Permian

Near-horizontally bedded cappings of probable Permian glacial sediments are preserved in a few places on the elevated country along the eastern margin of the Project area. They appear to rest with violent unconformity on steeply dipping Pre-Cambrian quartzites. These sediments are characterised by a subdued topography, even though preserved as ridge cappings in a generally high, steeply dissected, topographic setting. The outcrops are usually relatively bare of vegetation and often contain white patches, probably resulting from weathering of shales, clays etc. These easily weathered deposits owe their preservation to the overlying protective cappings of resistant Jurassic dolerite, such as occur at Mount Dundas and Eldon Peak (east of the Project area).

(g) Jurassic

The only definite Jurassic within the Project area is the horizontal capping of vertically jointed (columnar) dolerite preserved at Mt. Dundas. Such cappings become increasingly frequent to the immediate east of the Project area (Eldon Peak etc.), where they appear to rest on sub-horizontal (?) Permian sediments.

(h) Quaternary

Quaternary morainic and glacial deposits are common throughout the area and have been distinguished where possible.

Other mappable Recent units include scree and talus deposits (Qt) and alluvium (Qa).

## B. STRUCTURE

### (a) General

In a regional sense, the main portion of the Project area may be regarded as a lower to middle-Palaeozoic geosyncline (Dundas Trough), situated between flanking Pre-Cambrian highlands to the west and east.

The tectonic history of the various Palaeozoic orogenies appears to be quite complex, although the Tabberabberan Orogeny is regarded to be the most important. Solomon (1965) suggested that two phases of orogenic movement occurred, the first of which produced broad folding on pre-existing north-south trends. The second phase produced northwest folds and west-northwest to east-west transcurrent fractures.

The major fold axes within the area are, from west to east (Solomon 1965):-

Zeehan - Mt. Pearse Synclinorium.
Dundas and West Coast Anticlinoria.
King and Sophia Synclinoria.

#### ZEEHAN - MT. PEARSE SYNCLINORIUM

The general axis of this synclinorium is composed of a series of synclinal axes in the youngest (Siluro-Devonian) strata to have been affected by the mid-Devonian Tabberabberan Orogeny. This region is severely dislocated by at least two major, latitudinal, transcurrent faults. The main synclinorium axis trends north-northwesterly from a point 5 miles west of Queenstown to Zeehan, from where it is shown (Solomon 1965) to curve arcuately to a northeasterly direction.

Within the general main syncline, individual fold axes strike northwest to north-north-west and many plunge-reversals, with the development of elongated basinal or pound structures, are common.

WEST COAST AND DUNDAS ANTICLINORIA

The West Coast Anticlinorium refers to the general anticlinal axis running north-south through the vicinity of Queenstown. Although sufficient detail of structural trends within the Mt. Read volcanics is not yet known, the major anticline is inferred from the central core of Cambrian rocks, being flanked by outward dipping Owen Conglomerat. on the western and eastern limbs.

The Linda Fault zone (transcurrent east-west Fault) appears to offset the major anticline axis to the west, where it continues further north as the Dundas Anticlinorium. This major anticlinal axis trends arcuately from north-northwest to northerly near Mt. Dundas and thence probably north-northeast toward Rosebery. Its presence is inferred by the narrow belt of (?) Upper Pre-Cambrian or (?) Lower Cambrian Success Creek rocks, which are flanked to the west and east by Cambrian and overlying Ordovician rocks. Lack of photo-mappable detail in both Success Creek and overlying Cambrian rocks, precludes the delineation of individual structures along this zone, although some fold nosings based on very doubtful premises, may be inferred.

KING AND SOPHIA SYNCLINORIA

The King Synclinorium presumably refers to the general north trending synclinal zone, the downfaulted keel of which is occupied by Siluro-Devonian sediments in the King River vicinity, to the east of Queenstown.

Further north, the West Coast Ranges (Mt. Sedgwick - Mt. Tyndall - Mt. Murchison - Mt. Farrell), composed of Ordovician rocks, are flanked to the west and east by Cambrian sediments and volcanics. This zone is regarded as a major synclinal axis.

This general setting of major, arcuate, approximately north-south trending fold axes, has been greatly modified and complicated by later northwest trending fold axes and faults, generally referred to the second phase of the Tabberabberan Orogeny.

(b) Folding

The major structural provinces within Palaeozoic rocks of the Dundas Trough have been briefly discussed above.

Folding in the Pre-Cambrian rocks is difficult to delineate on airphotos. Some vague convergences of strike and fold-nosings are apparent along the eastern margin of the Project area. These are probably valid, although various workers have observed large scale recumbent folding, particularly in the older Pre-Cambrian.

In general, trends within the Success Creek phase sediments, appear to truncate those within the younger Pre-Cambrian in the northwest corner of the Project area. Thus the Penguin Orogeny has been postulated to have occurred in Late Proterozoic times, prior to deposition of the Success Creek phase.

The overlying Crimson Creek Argillite of Cambrian age appears conformable with the Success Creek rocks. Because of the lack of markers within Success Creek and Cambrian formations, little can be deduced from airphotos about the nature of the folding, which however is assumed to be more intense than in the overlying Ordovician and Siluro-Devonian rocks.

Folds in the Ordovician and younger sediments, trend from north-northwest to northwest and may be associated with east-west transcurrent faulting, as described by Solonom (1965) for the Linda Fault Zone.

Later orogenies were probably of the epeirogenic type, involving mainly block-faulting and gentle warping.

 



(c) <u>Faulting</u>

Many strong lineaments of major and minor lateral extent have been mapped from the airphotos. As many of these correspond closely to known faults within mapped areas (Zeehan 1-mile sheet and Queenstown area), a similar relationship may be inferred for the lesser known eastern and northern portions of the Project area.

The major lineament directions apparent from this study are eastwest, north-northwest and north-northeast. Solomon (1965) has advanced the following tectonic analysis of the Lower Palaeozoic orogenies:-
............"The Tabberabberan Orogeny was the first major interruption to sedimentation and probably consisted of two phases. The first represented a continuation of earlier tectonic movements, with differential vertical movements producing broad folding on pre-existing trends. The second involved development of a new strain pattern dominated by northwest folds and west-northwest to east-west transcurrent fractures, which also show vertical movement."

Solomon envisages a tectonic framework in which the dominant stresses are due to east-west directed transcurrent shear, with north-side-west movement. He continues:- "The conjugate north-south transcurrent faults are rare, though a possible example occurs 5 miles west of Queenstown. Post-Permian tectonics are essentially tensional and epeirogenic, the principal structures being north-west gravity faults, possibly in conjunction with north-south transcurrent faults.........."

The major east-west transcurrent faults are the Linda Fault in the vicinity of Queenstown, the Little Henty Fault along the lower reaches of the Henty River and the Balstrup Fault some 2½ miles north of the Little Henty Fault. (The Reader is referred to the published Zeehan 1-mile geological map for these names). The latter two faults are readily traceable as strong lineaments with totally different lithologies and structures on either side. The Linda Lineament, in particular, cannot be easily traced farther west than a point some 5 miles west of Queenstown.

Three major zones of strong north to north-north-east trending lineaments are dominating features in the Project area. The principal two of these bound the prominent West Coast Ranges on the east and west respectively, while the third zone extends from near the Professor Range through Mt. Dundas and continues to the north of the Project area. This group of strong fractures is probably related to the earlier phase of the Tabberabberan Orogeny and may also reflect ancient faults, which have controlled the configuration of the Dundas Trough and the later Owen Basin.

The strong zone of en-echelon lineaments to the west of the West Coast Ranges was interpreted mainly on the basis of drainage lineaments and other topographic features, but their structural significance is unknown beacause of the lack of detail within the Cambrian. Within the Mt. Tyndall lease, field mapping completed to date would indicate that extensive movement has not occurred along these lineaments, as individual shale beds have been mapped to continue uninterrupted in a north-northwesterly direction across the Henty River lineament. The strong lineament zone to the east of the West Coast Range, appears in places to form a fault contact between Pre-Cambrian and Cambrian rocks and is a persistent zone of individual en-echelon lineaments throughout the area. This may similarly reflect ancient faults which formed the eastern hinge zone of the Dundas Trough.

The third group of stronger lineaments in the Project area trends north-west to north-northwest and these are particularly persistent throughout the Owen Conglomerate forming the West Coast Ranges. Northeast trending complementary tension fractures of a more minor nature, are apparent in many areas. Being conspicuously abundant in the more competent Owen Conglomerate and Siluro-Devonian quartzites, these lineaments are interpreted to represent faults which formed by eventual rupturing along this northwest direction, approximately parallel to the fold axes of the second phase of the Tabberabberan Orogeny.

Solomon (1965) points out that the Mt. Lyell copper deposits lie within the Linda Fault Zone, which, although regarded in its westerly extensions as an east-west transcurrent fracture, appears to swing arcuately to a southeast direction and to feather-out into numerous lesser faults, in the vicinity of Queenstown.

The zone of upturning of the Owen Conglomerate along the western flank of the West Coast Ranges, is apparent by the presence of numerous tight structures with steep to probably overturned western limbs. This is generally referred to as the Great Lyell Fault Zone, but is not conspicuous on airphotos as a definite fault or lineament. Further north from Lake Margaret to Lake Julia, the western Cambrian - Owen Conglomerate contact is extensively masked by Pleistocene glacial and Recent scree deposits. Further north again, the structure may be simpler, as illustrated by the relatively undistrubed though assymetric, synclinal keel forming the prominent Mt. Murchison.

## IV. CONCLUSIONS

As previously mentioned, the photogeological study of the more prospective Cambrian rocks has been disappointing because of severely limited photo-mappable lithologic variations and hence a general lack of mappable structure. However, a well defined lineament pattern produced by major orogenies, dating from Pre-Cambrian to probably Tertiary times, has been mapped.

From an economic viewpoint, the orebodies of Rosebery, Renison Bell, Hercules and Mt. Lyell, appear to be associated in a general way with north-northwest to north-west trending lineaments. However, in the case of Mt. Lyell, the north-south trend of steep upturning (The Great Lyell Fault Zone), along the western flank of the West Coast Ranges, has been regarded as the main ore-localizing structure. This zone would probably be an older fracture of the north to north-northeast type, which was re-activated during the first phase of the Tabberabberan Orogeny.

On a purely structural basis, the search for new orebodies in the Mt. Tyndall Lease would probably be confined to the vicinity of the steeply upturned western flank of the West Coast Range, perhaps concentrating in areas where northwesterly directed lineaments are most prevalent (viz. 3 to 4 miles north of Lake Margaret and in the Red Hills area).

However, later detailed work in the Mt. Lyell region, has produced evidence that mineralization may also be controlled by a "favourable horizon" within the Mt. Read volcanics. If this proves to be correct, the Mt. Lyell orebodies would be regarded as due to localization in a "favourable horizon" under certain structural conditions.

The problem of extending this detailed mapping of the Mt. Read volcanics on a regional basis to the Mt. Tyndall area, is a difficult one, particularly in view of heavy vegetation, weathered outcrop and Pleistocene glacial cover. Consideration should be given to the possible application on a trial basis, of recent photogeologic techniques, which may possibly prove of value in rapidly delineating lithologic variations (i.e. "favourable horizons") and structure within the Mt. Read volcanics, in this heavily forested area.

Such techniques may include colour airphotography and infra-red or radar photography. The radar technique is reputedly able to penetrate soil and snow cover as well as being particularly useful in areas of heavy vegetation.

Colour air-photography can be useful by virtue of colour changes due to zones of alteration haloes around mineralized areas. Whether such colour changes would be masked by the heavy forest cover of this area is a controversial matter.

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