GEOLOGY AND MINERALISATION IN THE SOUTH HEEMSKIRK TIN FIELD, WEST TASMANIA

Dissertation submitted by

KEITH WELLS B. Sc (Lond.)

in July 1978

in partial fulfilment of the requirements for the Degree of Master of Science (Exploration and Mining Geology) (predominantly by course work) in the Faculty of Science of the James Cook University of North Queensland.

242002

DECLARATION

I declare that this thesis is my own work and has not been submitted in any form for another degree or diploma at any university or other institute of tertiary education. Information derived from the published or unpublished work of others has been acknowledged in the text and a list of references is given.

K. Wells.

K. WELLS

24th July 1978

ABSTRACT

Within the South Heemskirk Tinfield are two major types of granite : An older 'red' adamellite which consists of a coarse-grained and a medium-grained, porphyritic variety and a younger, more alkaline, medium-grained, 'white' granite, associated with the Sn mineralisation. Geochemically, the 'red' and 'white' granites are similar, their major element contents being equivalent, although their minor element contents : Li, Rb, TiO_2 and Sn show some divergence. However neither granite shows a clear cut geochemical signature.

Both granites are well jointed : However, the dominant, vertical joint in the 'white' granite which strikes approximately N.N.E. - S.S.W. contrasts with the dominant E. - W. joint in the 'red' granite. These joints together with some larger lineaments have had a dominant control on the main phase of hydrothermal alteration, which largely manifests itself as greisen veins developed along the joints and altering the adjacent granite. These veins consist of a central zone of quartz and topaz and/or tourmaline, bounded by a white mica/quartz zone, with an area of argillic alteration outside that. In the central zone there appears to be a trend from quartz/topaz in the 'red' granite to quartz/tourmaline in the white. Breccias are developed in some of the larger veins.

The other common hydrothermal feature is quartz/tourmaline nodules, which are concentrated along the red/white contact, rather than with the veins and are thought to be related to a late magmatic/early hydrothermal event, not the main phase of hydrothermal activity.

Sn mineralisation, usually associated with sulphides, can occur in all three zones of the greisen veins. The veins, are thought to, pass down into a deeper mica/quartz greisen, carrying sulphides, developed just beneath the red/white contact.

242004

CONTENTS

242005

LIST OF FIGURES

(Figs. 4–6: In Pocket)

1. INTRODUCTION

1.1. Location, Physiography, History

The South Heemskirk Tinfield is located at 41°54'S, 145°8'E, approximately 12 kms West of Zeehan, West Tasmania. The area examined in this thesis comprises the central part of the Tinfield, immediately West and South of Lake Cumberland, including the Federation Mines area and the Montague and Sweeney's mines. Access is via the unsealed Zeehan-Trial Harbour-Granville Harbour road: Within the area some four-wheel drive and numerous walking tracks occur.

The area is part of the Heemskirk-Agnew mountain range and altitudes vary from 180m in the West to 510m on Cumberland Hill: Immediately East, of the area, Mt. Agnew reaches 846m. Drainage in the area is largely joint controlled and deeply incised, due to rejuvenation and the relief is often extreme. The area has a temperate marine climate with mean monthly temperatures varying from 8°C in winter to 15°C in summer and a rainfall of 2500mm p.a., distributed throughout the year. The low temperatures, high rainfall and underlying granite combine to produce a thin, acid skeletal/peaty soil, which generally supports only low grass and sedges. However, thicker bush, which inhibits movement, occurs along some creeks and on some of the more sheltered slopes.

Alluvial tin was discovered near Mt. Heemskirk in 1876 (Waterhouse 1916): The Mt. Bischoff mine was being developed at this time and a "boom" quickly developed on the Heemskirk field. Rich patches of detrital cassiterite led to exaggerated reports and speculation gave rise to the pegging of large areas, some of which were under the sea. The boom collapsed very quickly and by 1890 only a few prospectors remained on the field. A number of factors led to the failure: At least fifteen companies established batteries and plant at great expense before establishing workable ore reserves and while many of the ore shoots are rich, they are very irregular and no capital remained for systematic prospecting and development. In addition, some of the ore is pyritic, which the plant was not equipped to treat and in some cases black tourmaline and hematite appear to have been mistaken for cassiterite (Blissett 1962).

Production to date:

Mine	Concentrate (Tons)	Tin Content (Tons)
S. Heemskirk to 1916	200	Est. 120
Federation Mine	322.13	193.86
Maynes Mine (not in study area)	200	Est. 140
Miscellaneous	44.71	23.86
	766.84	477.74

Several attempts have been made to re-open some of the mines, particularly the Federation Mine, which was the biggest producer on the field: But again capital was spent on buildings and treatment plants (Scott 1928) and little on the development of ore reserves; and the attempts failed. In recent years, several companies have looked at the area or prospects in the area.

1.2. Geological Background and Previous Work

Western Tasmania consists of three main structural units (Fig. 1): Two Precambrian blocks, the Tyennan and Rocky Cape Greanticlines, which form the margins of a relatively narrow, arcuate basin, the Dundas Trough, which was the site of Lower Paleaozoic sedimentation and volcanic activity. This cycle of deposition was terminated in the Early Devonian by a major period of deformation, the Tabberabberan Orogeny. The deformation was followed by the emplacement of a series of high level, late tectonic, granitoid plutons (Solomon et al 1977) including: The Dolcoath, King Island, Housetop, Granite Tor, Meredith, Pieman Heads and Heemskirk granites. They have been

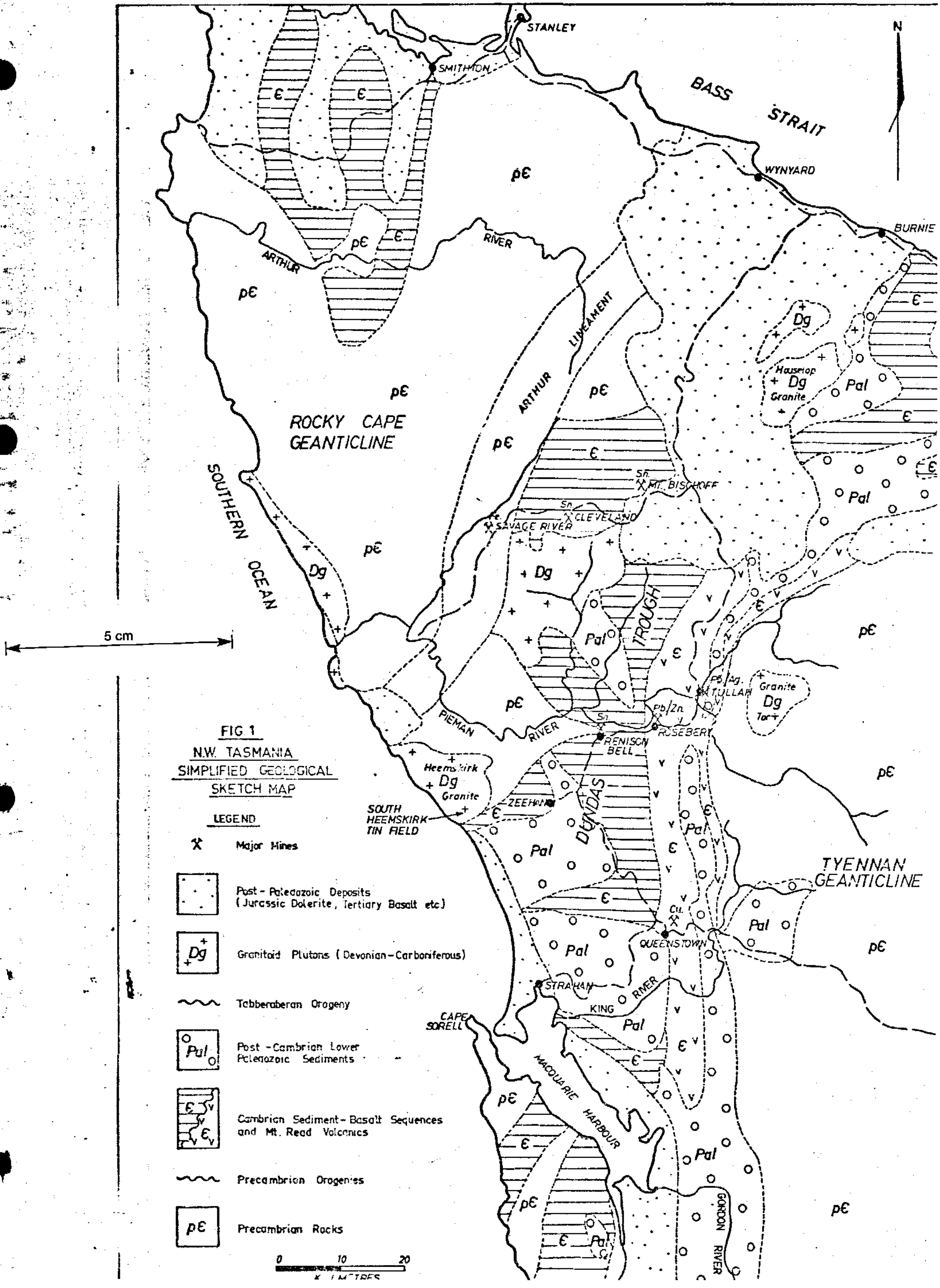


FIG 1
N.W. TASMANIA
SIMPLIFIED GEOLOGICAL
SKETCH MAP

dated between 345 and 375 million years B.P. (McDougall and Leggo 1965, Brooks 1966), which corresponds to a Middle to Late Devonian age.

The Heemskirk Granite has gently sloping contacts, which appear to be reflecting the anticlinorial structure of the country rocks into which it is intruded (Klominsky 1972) and while on a local scale the contacts are markedly discordant, on a regional scale the granite is roughly concordant with the surrounding rocks (Green 1963). The temperature of intrusion has been estimated at 650°C (Groves 1967, Klominsky 1972), with a depth of intrusion between 1 and 5 kms (Groves 1967): On mineralogical and other grounds it has been suggested that the Pieman Heads, Meredith and Heemskirk granites are connected at depth (Klominsky 1972); the greater abundance of tin deposits in the Heemskirk granite being attributed to the granite being a higher level cupola than the other intrusions and/or the least unroofed by erosion (Groves 1967).

The earliest reports on the South Heemskirk Tinfield are Tasmanian Government examinations of the whole or portions of the field and include: Thureau (1881, 1882, 1884), Montgomery (1893, 1895), Twelvetrees (1900), Waller (1902), Waterhouse (1916), Loftus-Hills (1920), Scott (1928) and Keid (1943a). Waterhouse (1916) is still by far the most comprehensive and detailed account of the individual prospects. In recent years several examinations have been undertaken on the granite: As part of larger mapping programmes (Blissett 1962), as part of a study of mineralised granites in Tasmania (Groves 1967, Klominsky and Groves 1970) or in Eastern Australia (Rattigan 1964); or as a study of certain aspects of the entire Heemskirk massif (Brooks 1965, Heier & Brooks 1965, Klominsky 1972). The majority of workers have agreed with Waterhouse's original division of the Heemskirk granite into two broad categories, the red and the white; although the subtypes recorded by each worker have varied. Heier and Brooks (1965) on the basis of Sr^{87}/Sr^{86} ratios and Rb/Sr ratios concluded that the white granite was the older of the two types: However, their method is discounted by Klominsky (1972) and their conclusions are not supported by any other workers, including the writer.

1.3. Present Study

Previous work on the Heemskirk Granite has indicated that the granite "mass" is a multiphase intrusion. Work on Sn granites, elsewhere in the world has shown that they also tend to be multiphase intrusions; the tin mineralisation being related to the younger granite, which is geochemically specialised. In view of this, the present work has consisted of geological mapping and geochemical sampling in order to define the particular granite/alteration style and/or structure related to the tin mineralisation.

2. GEOLOGY

2.1. Rock Types

Within the study area there are two major granite types (Fig. 2), termed the 'red' and the 'white'. These correspond to the 'red' and 'tin' granites of Waterhouse (1916).

The 'red' or 'older' granite can be divided into two subtypes: A coarse-grained variety and a medium-grained, porphyritic type. Both these granites are similar to each other and although they can be mapped into two broad units, there is a broad range of rock types, intermediate between them; and outcrops of coarse-grained granite occur, frequently, within the medium-grained, porphyritic variety (Fig. 2).

Petrologically the 'red' granites vary from adamellites to granites. The coarse-grained type being essentially an adamellite consisting of quartz (30%), perthitic orthoclase (40%), plagioclase (25%) and biotite (5%): The quartz tends to be anhedral, slightly stressed and often contains ultrafine needles of rutile, the orthoclase is subhedral and when fresh, pigmented with ultrafine hematite; the plagioclase, usually oligoclase, occasionally albite, is generally subhedral to euhedral and nearly always shows some patchy argillic alteration; the biotite is exceptionally dark, is often marginally chloritised and contains inclusions of radioactive metamict zircon and magnetite euhedra. Accessory minerals include zircon and magnetite, ultrafine apatite, xenotime and fluorite (Fander 1977).

The medium-grained porphyritic granite appears to be more alkaline than the coarse-grained variety, being a granite rather than an adamellite; with orthoclase forming more than two thirds of the felspars. The rock generally consists of phenocrysts of orthoclase and oligoclase in a medium-grained groundmass of: Quartz, orthoclase, biotite and minor oligoclase. As in the coarser grained adamellite the quartz is generally rutilated and the accessory minerals: Magnetite, zircon, apatite and ?xenotime are also similar. Weak argillic alteration of the felspars is common and secondary anatase has been observed with biotite (Fander 1978).

The difference in composition between the two, 'red' granites may be primary: However, the majority of the medium grained granite sections examined are from areas closer to the major outcrop(s), of the younger, 'white' granite, than the coarser grained, adamellite samples. Some slightly altered coarse-grained rocks (2/11, 2/12) appear to straddle the boundary between adamellites and granites (Fander 1977); and one coarse-grained, slightly altered sample (1/19) from adjacent to a greisen vein also appears to be a granite. The variation between the two granites, therefore, may be due to 'alteration' connected with the intrusion of the younger 'white' granite, rather than primary.

The 'white' granite grades from fine-grained to medium-grained: Coarse-grained 'white' granites described by previous workers (eg. Klominsky 1972) do not occur within the area examined. The white granite is a biotite microgranite (Fander 1978), similar to the medium-grained 'red' variety, but it is generally not porphyritic and it has less biotite. Petrologically it consists of anhedral, rutilated, stressed quartz, often micrographically intergrown with orthoclase, subordinate argillised albite and minor chloritised biotite: Accessory minerals vary from those of the red granite and although traces of metamict zircon and ?xenotime may occur the majority consist of introduced tourmaline and muscovite with rare patches of topaz and possibly cassiterite.

Although designated as 'red' and 'white' granites, the colour in both types varies considerably; particularly in the 'red' granite which can vary from bright red-pink-blue/green-white: This colour variation appears to be due to patchy deuteric alteration (a common feature in granites) and is related to the intrusion of the red granite. The bright red/pink colour in the fresh, unaltered granite is due to ultrafine, hematite pigmentation in the orthoclase; increased argillic alteration of the felspars results in the development of "cloudy, argillic, whitish material which either masks the hematite or combines with it to give a buff colour" (Fander 1977). Other features related to the deuteric alteration include partial oxidation and marginal choritisation of biotites, the development of albitic mantles around previously formed orthoclase and some of the perthitic textures may also be due to deuteric albitisation (eg. Sample 2/4). There are some indications that the 'white' granite in a completely fresh state would also have been pink (Fander 1978). The generally lighter colour appears to be due to a greater, but varying degree of alteration, which is probably a combination of deuteric alteration and the later hydrothermal alteration (see Section 2.3.).

Previous workers on the Heemskirk Granite (Rattigan 1964, Klominsky 1972) while generally agreeing on the two broad types and their general relationships considered that there was no obvious relationship between the 'white' and the 'red' granites. However, within this study area some of the relationships are quite clear. Numerous small 'white' microgranite intrusions occur within the 'red' granites; the main areas of 'white' granite are medium-grained but against the contacts with the 'red' granite they are chilled and become fine grained: This is very obvious approaching the contact which crosses the old Federation Haulage and along the contact East of the Central Federation workings. The actual contact, where visible, is either very sharp and often marked by a quartz vein or a 'white' greisen vein; or the fine-grained white granite is visible "eating" into the 'red' variety and small xenoliths and numerous felspar xenocrysts, giving a pseudoporphyritic appearance, are common close to the contact, eg. Cumberland Hill: The xenoliths and xenocrysts do not occur in the main areas of medium-grained 'white' granite away from the contacts.

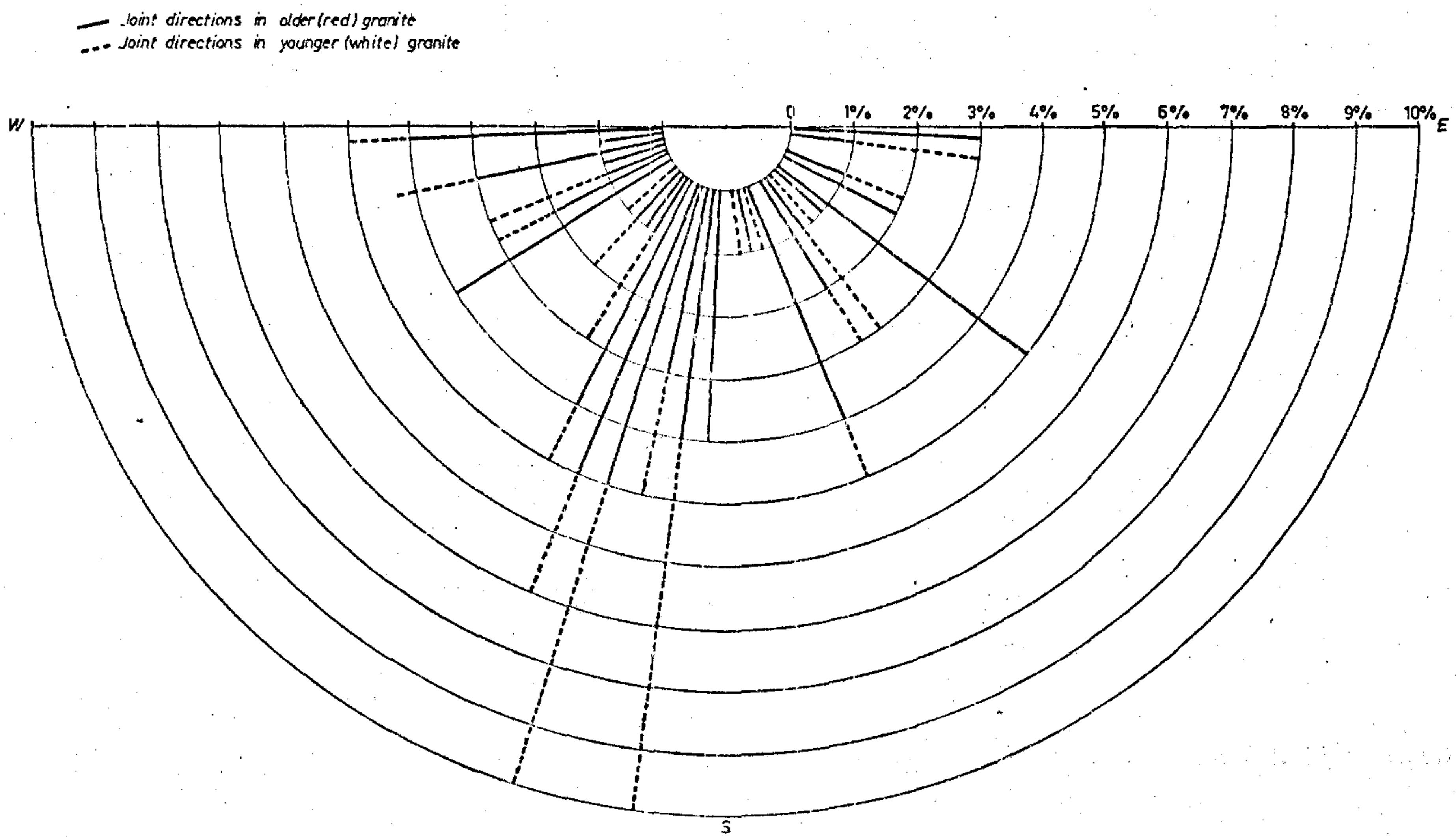
2.2. Structure

Within the study area the granite is well jointed with one set of 'flat' and two major sets of 'vertical' joints, approximately at right angles to each other. A third minor, but locally important, vertical joint set is also detectable in places (Fig. 3a). The 'red' granite has a typically open joint pattern and smooth outcrop which contrasts markedly with the close spaced jointing and rougher outcrops of the fine grained 'white' granite. Further away from the contact, jointing in the medium-grained 'white' granite once again becomes more open but it is still not as even as that in the 'red' granite.

Examination of Fig. 4 shows a change in the dominant, vertical, joint direction from approximately N.N.E. - S.S.W. in the North Western part of the area (N.W. of a line through the Montague/Coleman's/Phar Lap/ Waxman & Weston's workings) to approximately East-West in the South Eastern half of the area (Figs 3b + 3c). These dominant joint directions, particularly in the N.W. part of the area, persist throughout the different granite types, i.e. they have similar joint directions (Figs 3d + 3e). It is suggested that the dominant joint direction in all the older 'red' granites was originally East-West; but in the Western half where the 'red' granite is shallow and close to the contact with the 'white' granite, the originally dominant joint direction has been superseded by the later dominant N.N.E. - S.S.W. joints associated with the younger 'white' granite. (Figs 3b + 3d).

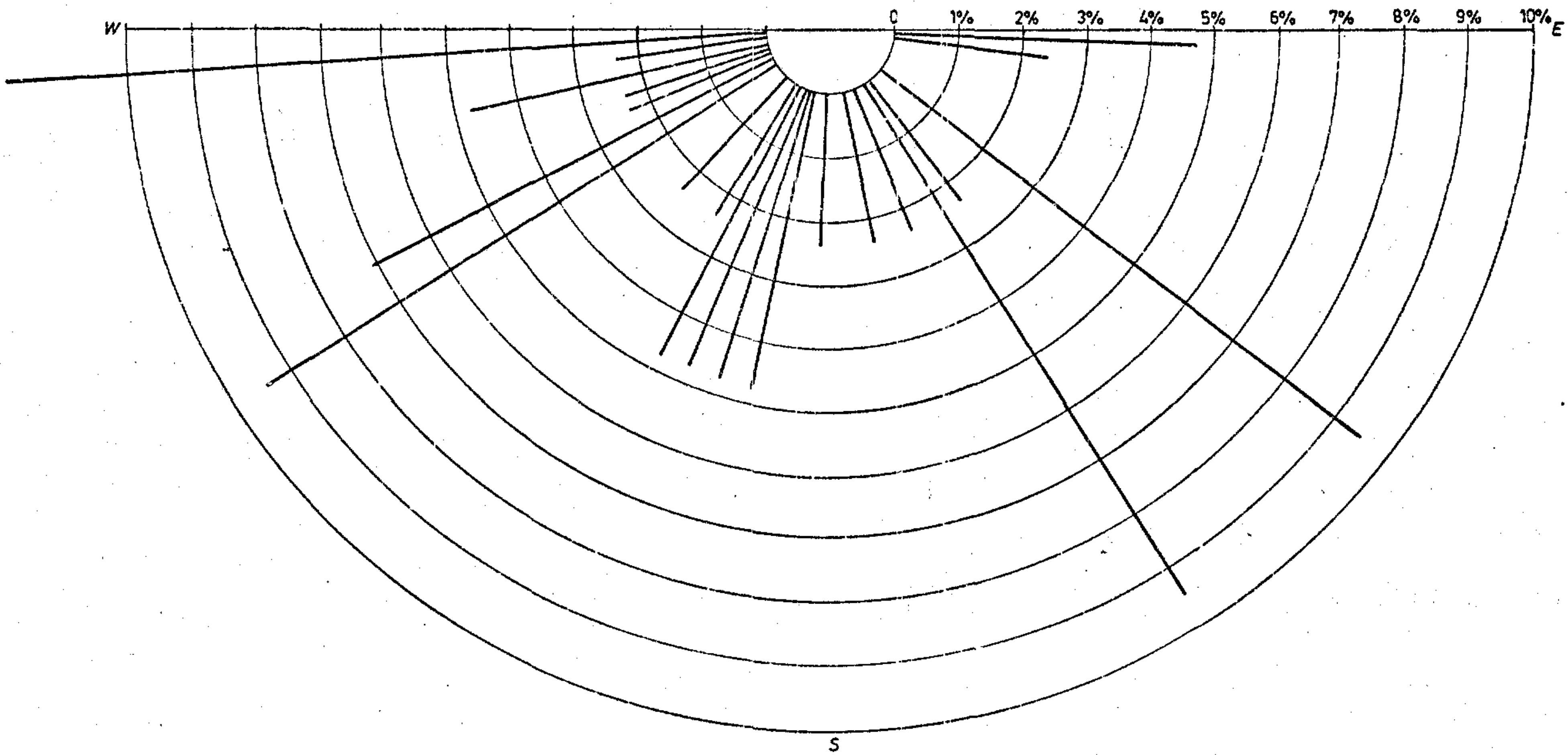
In the 'red' granite East and South of Lake Cumberland the 'flat' joints attain a Southerly dip, which appears to become steeper Southwards. This is believed to be related to the shape of the original intrusive/country rock contact: Similarly, coarse

Fig.3a :Rose Diagram: Vertical Joint Directions (strike) : Federation Area



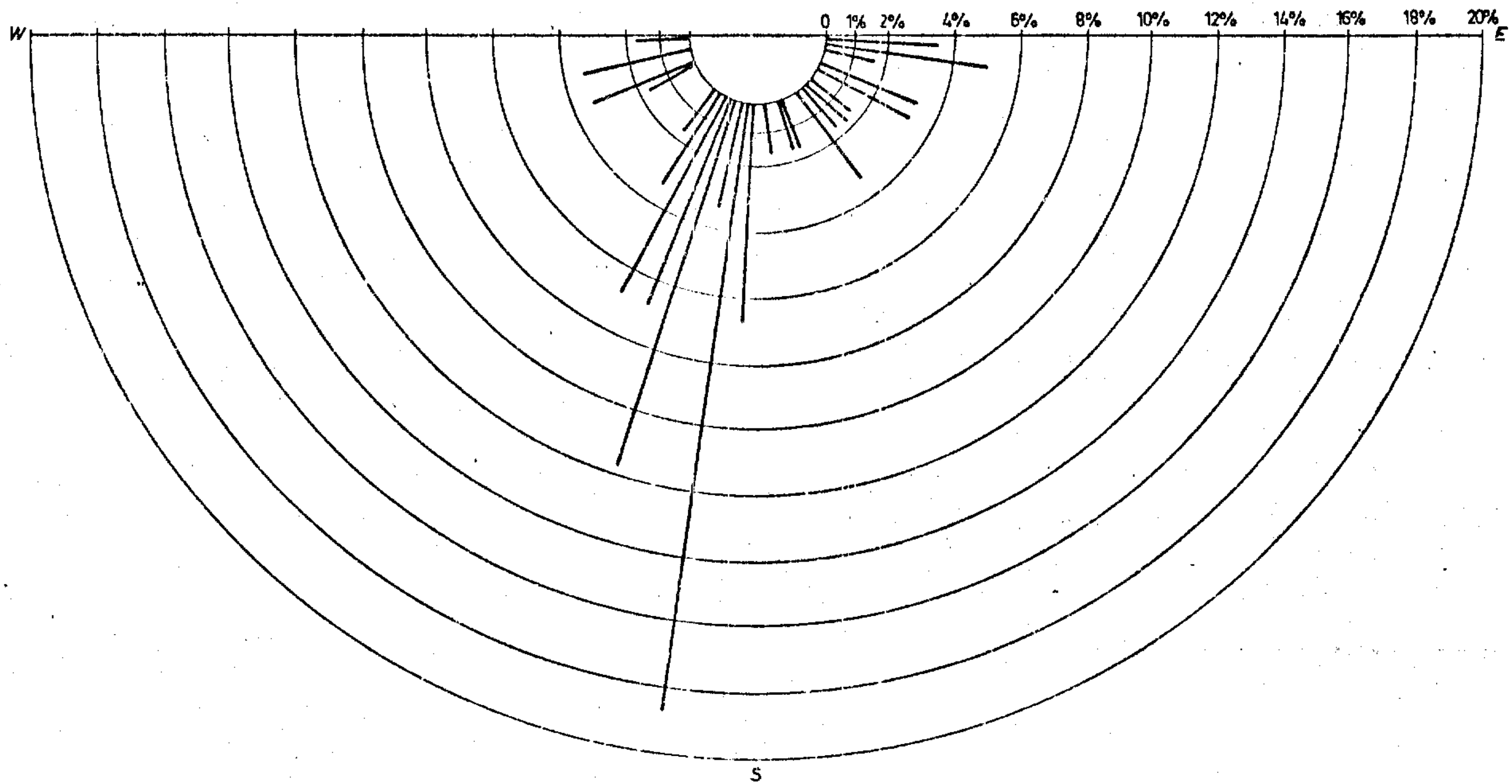
242016

Fig. 3b :Rose Diagram : Vertical Joint Directions (strike) : Area S.E. of a line through Montague / Coleman's / Phar Lap / Long Adit / Waxman & Westons Workings



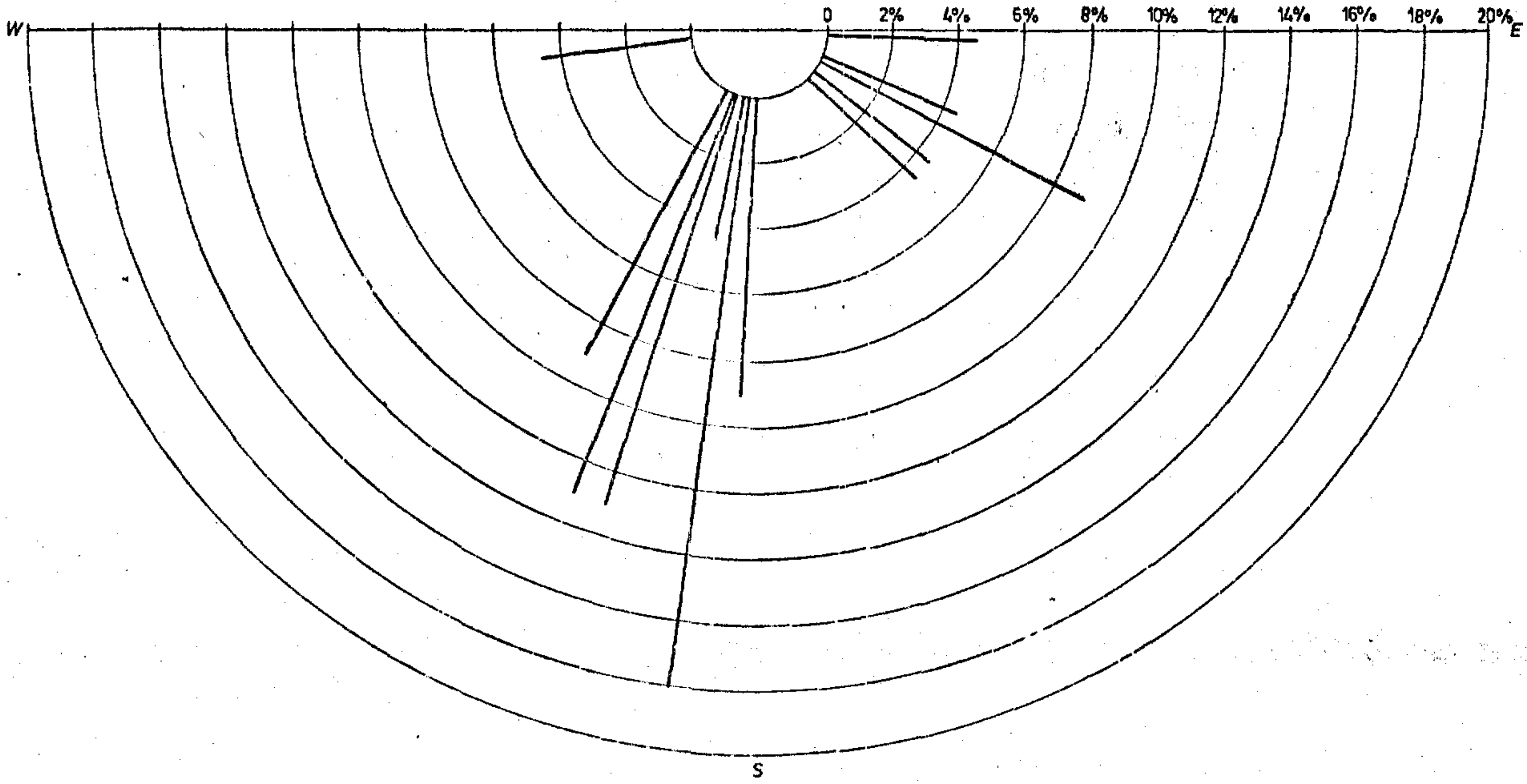
242017

Fig. 3c : Rose Diagram : Vertical Joint Directions (strike) : Area N.W. of a line through Montague / Coleman's / Phar Lap / Long Adit / Waxman & Westons Workings



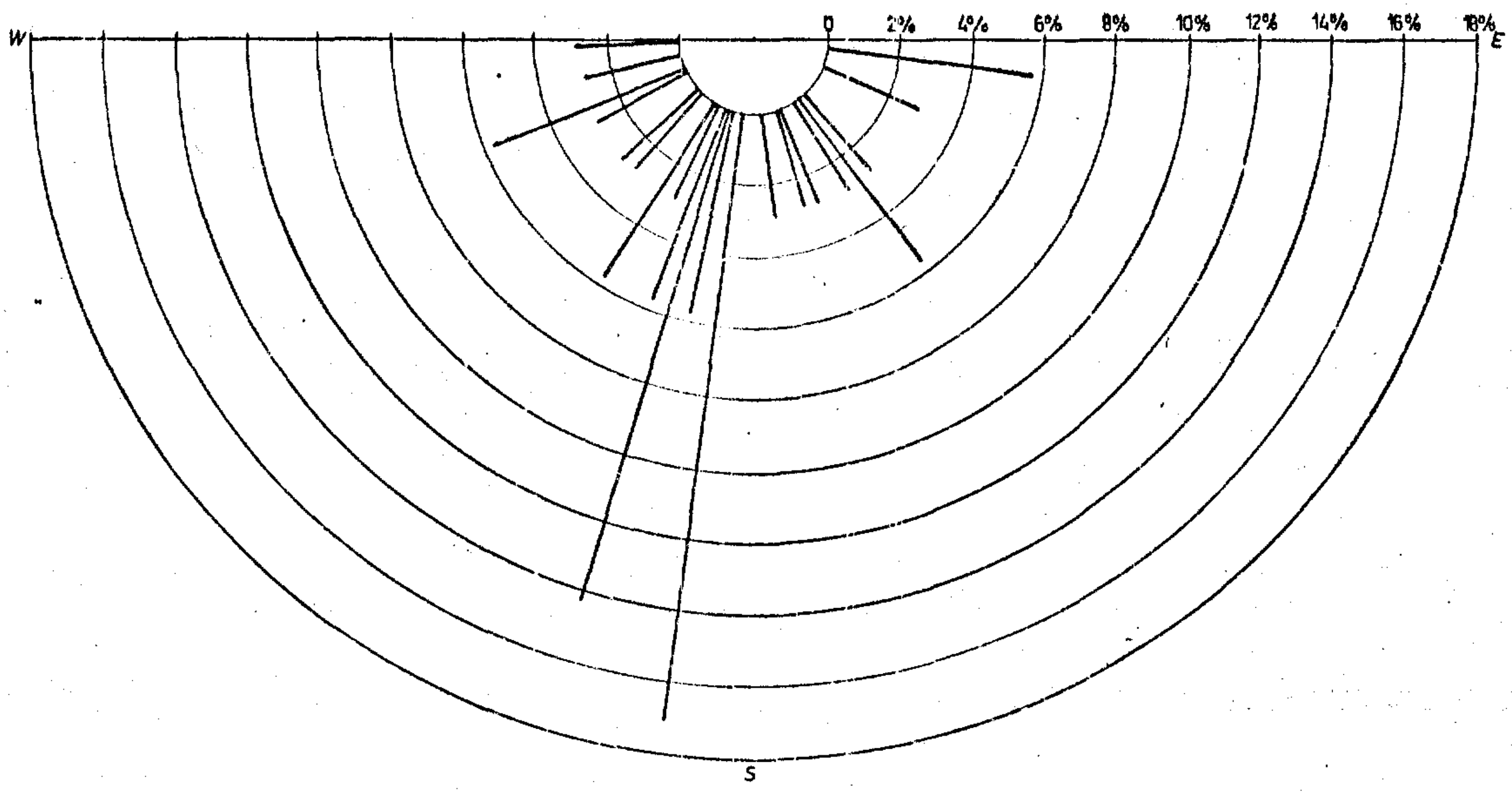
242018

Fig. 3d : Rose Diagram : Vertical Joint Directions (strike) in older red granite : N.W. of a line through Montague / Coleman's / Phar Lap / Long Adit / Waxman & Westons Workings



242019

Fig. 3e : Rose Diagram : Vertical Joint Directions (strike) in younger (white) granite



242020

foliation evident, particularly in the coarse-grained 'red' granite, close to the Southern contact with the country rock and again occasionally in the 'white' granite, close to the 'red' granite contact; is thought to be a linear flow structure developed, along the margins, during the act of intrusion.

The other obvious feature on Fig. 4 are two East-West major lineament "complexes". These are very obvious in aerial photographs (A.A.M. Job No. 12419, Run 4) but appear to have had little effect on the distribution of the 'red' and 'white' granites.

All the lineaments and nearly all the joints appear to predate the main phase(s) of hydrothermal alteration and both joints and lineaments have had a dominant control on the alteration/mineralisation. The quartz topaz and/or tourmaline greisen veins, so typical of the area, have all developed along the pre-existing joints (Fig. 2): The major lineaments occasionally appear to terminate the alteration eg. Coleman's, but elsewhere are the site of extensive alteration & mineralisation (Fig. 4), particularly at the intersection with other lineaments, eg. Sweeney's; or major joints eg. Phar Lap, Tributors-West Federation: Joint intersections also appear to have been favourable sites for mineralisation, eg. Black Face-Central Federation (Fig. 5). Some later, minor 'joints', possibly related to the main phase of hydrothermal activity, have developed principally in the fine-grained 'white' granite, in areas of the most intensive alteration and occasionally offset the pre-existing joints.

2.3. Alteration and Mineralisation

Alteration of varying intensity appears to affect all the granites, ranging from minor deuteric alteration in the coarse-grained 'red' adamellites (Section 2.1.) to total metasomatic replacement. However, two alteration features are very distinctive and characteristic of the area:

a) Tourmaline nodules

b) Greisen veins (white 'dykes')

2.3.1. Tourmaline Nodules

The tourmaline nodules vary in size from less than 10mm in diameter to over 200mm in diameter; the majority being between 50mm and 100mm in diameter. Some nodules have very sharp boundaries being almost totally tourmalinised and occasionally consist of coarse, radial schorl; but the majority are tourmaline rich segregations, the tourmaline having replaced the mica and felspars, the quartz grains being essentially un-affected.

The majority of the nodules are concentrated either in pre-existing 'fissures', or along the 'white' granite/'red' granite contacts including some of the smaller microgranite intrusions, eg. Sweeneys and are frequently associated with numerous, small, narrow tourmaline veinlets, particularly in the 'white' granite. The nodules occur in both types of granite; in the 'red' granite they rapidly disappear away from the contact, while in the 'white' they decrease in number and size, although occasional patches occur, the tourmaline existing as individual grains/crystals, eg. South of Black Face Lode, Central Federation (similar rock have previously been described as a tourmaline microgranite (Rattigan 1964)): Elsewhere, further away from the contact (?), the tourmaline either disappears or becomes a minor accessory mineral.

The concentration of the main mass of nodules along the 'red'/'white' contact, rather than with the greisen veins (Fig. 2), suggests that the formation of these nodules is related to the intrusion of the 'white' granite rather than the later main phase of hydrothermal alteration. Durasova and Barsukov (1973) experimenting with boron-bearing silicate melts found that a boron rich phase separated out as immiscible bubbles within the silicate melt: This could explain the tourmaline nodules if they were confined to the margins of the 'white' granite. However, it does not explain how tourmaline rich "bubbles" develop in the older, 'red' granite, particularly as the red granite surrounding the nodules is relatively unaltered. One, large, schorl-type nodule was observed with a semi-pegmatitic "neck", leading to it (Sample 4/15) and nodules also occur along pre-existing joints/lineaments within the red granite, eg. lineament, S.E. corner of Lake Cumberland. The formation obviously involves the penetration of some boron-rich hydrothermal "fluid", into the red granite; but the mechanism is not understood.

A second, relatively minor, phase of tourmaline nodule formation appears to be associated with the main phase of hydrothermal alteration and the introduction of the greisen veins. Nodules, identical in appearance to the previous type, occasionally appear adjacent to the veins, eg. sample 1/19 or further along the same joint penetrated by a greisen vein, eg. sample 2/2: At 4/24 a quartz-topaz greisen vein which penetrates the 'red' granite is marked by a narrow zone of tourmaline nodules where it intersects the 'white' granite.

The great majority of the tourmaline nodules, i.e. the ones thought to be related to the intrusion of the white granite, are barren, containing no Sn. However, the later ones introduced with the main hydrothermal alteration, may carry Sn; eg. some nodules analysed from Coleman's Workings contained 8.55% Sn, 8.62% Sn and 0.59% Sn respectively.

2.3.2. Greisen Veins

The most obvious product of hydrothermal alteration, in the area, are greisens veins developed, extensively, along pre-existing joints and lineaments. These vary in size from less than 100cms to in excess of 20m wide and up to 800m in length: The majority being in the vicinity of 3m - 5m wide and up to 400m long.

They consist of a central zone of quartz and topaz and/or tourmaline, bounded by a narrow zone of white mica, with an outer zone of argillic alteration: The complex may be cut by later narrow quartz or tourmaline veins, eg. 8/8. In outcrop usually only the central quartz/topaz/tourmaline zone is visible and early workers in the Tinfield often referred to the veins as "white dykes" (Waller 1902).

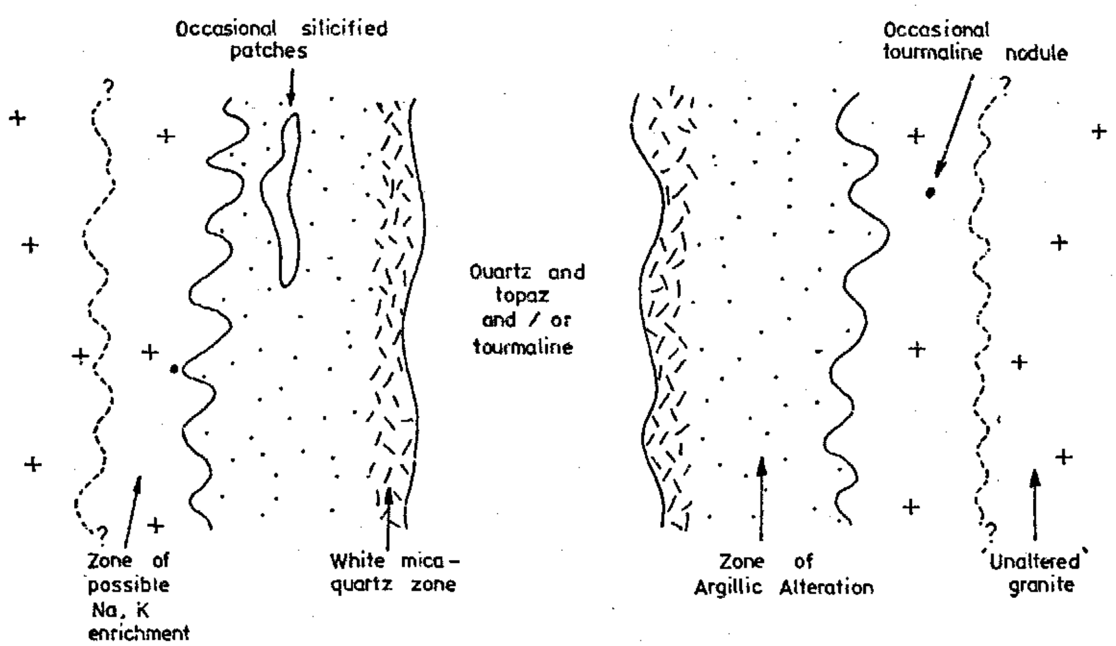


Fig. 7: Diagrammatic cross section through a greisen vein

Similar greisen veins with a corresponding arrangement of alteration zones have been described from other tin provinces, around the world, eg. Mühlleithen and Gottesberg, Erzgebirge (Wasternack et al 1974) and Beuss (1962) also refers to similar alteration in granites.

The alignment and morphology of the veins is exclusively controlled by the pre-existing structures, both 'vertical' and 'flat': Hydrothermal 'fluids' having penetrated along joints and cracks (Fig. 2) altering the adjacent granite; original joint blocks in the granite may be outlined by quartz/topaz and/or tourmaline veins and the entire block argillised, eg. West Federation Workings (Fig. 6). In the majority of the veins the original quartz grains remain relatively unaffected throughout all the zones; the biotite, felspars etc. being replaced by tourmaline and/or topaz in the centre and by white micas or clays (argillised) in the outer zones. A further marginal zone is suspected where the granite is altered by the addition of Na, and it can become albitised (eg. Sample 2/4) and/or K and the rock becomes more alkaline; adamellite could be changed to granite (eg. Sample 1/19). The rock texture within the vein complex is usually similar to the granite surrounding it: Eg., an East-West vein (5/3), East of the Central Federation Workings crosses from coarse-grained 'red' into fine-grained 'white' then back into coarse-grained 'red' granite and the texture of the vein is correspondingly coarse-grained, fine-grained and coarse-grained within the respective rock types; similarly a vein separating coarse-grained red (6/11) and fine-grained white granite (6/8), North of the West Federation Workings is fine grained on one side and coarse-grained on the other. The original joint pattern both along the vein and across it are also usually preserved, occasionally being marked by the addition of later (?) tourmaline. In some cases metasomatic alteration has been more intense and completely replaced the original textures (Fander 1978), eg. Sample 3/2: Outside of the immediate study area some veins are known to penetrate the original country rock and similar topazfels, termed "silexite" have been described from Northern N.S.W. (Griffin & Weber 1972).

The greisen veins appear to die away 'upwards' and either merge back into the original granite; eg. the broad greisen vein forming the

Western shore of Lake Cumberland is less altered at the Northern end, and on the Northern shore, along its projected strike, the original granite is only slightly argillised and paler in colour; or the vein may give way to a narrow clay seam, eg. Sweeney's Mine access road.

There appears to be a transition in the mineralogy of the veins from the 'red' to the 'white' granite: In the red granite, the central part of the veins consists predominantly of topaz and quartz (topazfels) with little or no tourmaline and the white mica/quartz zone is well developed; approaching the 'white' granite, the tourmaline content increases at the expense of the topaz and the veins in and around the 'white' granite are largely of the tourmaline/quartz variety. This trend is even visible on individual veins, eg. the Black Face Lode, Central Federation ranges from tourmaline rich at the Northern end, with no detectable topaz, to topaz rich at the Southern end with no visible tourmaline (Fig. 5). A similar phenomenon has been noted by workers elsewhere in the world, eg. Wasternack et al (1974), who have considered it to be a depth function, the topaz rich greisen forms the apex of the greisen system (Karel & Sucek 1974) with tourmalinisation increasing and partially replacing the topaz, downwards: In places the entire rock may be tourmalinised, eg. Black Face, Central Federation, and the tourmalinisation can extend out into the argillic zone, eg. Coleman's Workings. There appears to be two varieties of tourmaline, in the area; a more common dense black variety and occasionally a green/blue variety, which has been considered to be preferentially associated with Sn mineralisation, eg. Eastern Workings.

242028

2.3.3. Breccias

Breccias are developed, in the area, associated with the evolution of the greisen veins. To date, they have only been positively identified in the Black Face Lode, Central Federation, which is well exposed (Fig. 5); with one smaller outcrop tentatively identified in the West Federation workings (Fig. 6).

There are two main types of breccia:

a) A hydrothermal intrusion breccia
and b) A collapse breccia.

The hydrothermal intrusion breccia is well exposed in the Black Face Open-Cut, Central Federation workings, and is related to the intense boron metasomatism at the Northern end of the Black Face Lode. The entire greisen vein is totally tourmalinised and within this tourmalinisation the breccia occurs as an irregular pipe-like (?) body, approximately 20m across with several branch like, narrow dykes extending off the main "pipe": Banding (original joints?) within the unbrecciated greisen is cut by the "pipe". The breccia itself has an open framework with fragments being subrounded and generally upto 10cms in diameter, separated by a mass of finer fragments and rock flour: The entire mass is totally tourmalinised and the original rock type(s) is not identifiable. Towards the margins of the breccia, in the top of the open cut, large blocks of the surrounding rock are broken off or partially broken off into the breccia. Tourmalinised greisen, next to the breccia, has boxworks developed in it, which consist of limonitic and iron stained "vughs" in in a tourmaline "sponge": Some pyrite occurs in a silicified pod within the argillic zone, immediately adjacent to the breccia; also the "pipe" coincides with an I.P. anomaly and it is thought to contain sulphides, probably pyrite. Identical hydrothermal breccias have been described from Llalagua and Choroloque, Bolivia (Sillitoe et al 1975).

Above the hydrothermal intrusion breccia, just outside the strongly tourmalinised zone a slightly different breccia occurs. This is an open framework, polymict breccia (C.F.5.) and consists of two types of subrounded fragments: Larger fragments upto 25cms in diameter, average 10cms, of the surrounding greisen and smaller fragments upto 15cms in diameter, average 7cms, of a fine grained, strongly tourmalinised micro-granite/aplite (?), not seen anywhere else in the area. These fragments are embedded in a matrix of tourmaline and hematite: Similar outcrops of tourmaline/hematite "cements" occur in the Cross Lode, West Federation (W.F.4 & W.F.2) but no fragments have been observed within them. The occurrence of the fine grained tourmalinised rock, not seen elsewhere, is considered to be evidence for upward movement of fragments within the breccia "pipe" and this type of breccia is thought to represent the upper margin of the hydrothermal intrusion breccia.

The collapse breccias occur higher up, above the hydrothermal breccia, towards the topaz rich end of the Black Face Lode. Two outcrops (C.F.3 & C.F.4) have been identified and they consist of subrounded-subangular fragments of the adjacent greisen, approximately 10cms across. The fragments are rimmed by a relatively narrow layer of fine-grained, dense black tourmaline, which is in turn mantled by cox-comb quartz crystals, that have obviously developed in 'free' space and can often seen to be lining voids. In places later narrow quartz veins cut through the breccia. The presence of voids and the apparent limited vertical extent of these breccias is taken as evidence of collapse.

2.3.4. Mineralisation

Mineralisation is associated with the greisen vein complexes. Sn is known to occur in all three zones of the greisen veins, i.e. in the quartz/topaz and/or tourmaline zone, in the white mica/quartz zone and in the argillic zone; it is often accompanied by sulphides, usually pyrite and/or arsenopyrite.

The majority of the old workings were exploiting the quartz/topaz and/or tourmaline zones. Sn as cassiterite occurs mainly in the tourmaline rich areas and samples carrying upto 15.0% Sn have been collected from Coleman's workings; but historically grades have averaged around 1.0% Sn. Botryoidal cassiterite has been reported from the Wakefield Mine (Waterhouse 1916). Pyrite occurs, although it appears to be more common in the higher silica (lower tourmaline) area, bismuthinite is common, particularly in the West Federation workings where grades upto 2.57% Bi have been recorded (Keid 1943); hematite occasionally occurs, usually with tourmaline and is sometimes magnetic, wolframite occurs in vughs mainly in the topaz rich areas eg. Wolfram Trench, also columbite/tantalite are suspected (1/12). Molybdenite and fluorite have been recorded but are rare.

Cassiterite can occur in the white mica/ quartz zone but it is comparatively rare: However rich Sn mineralisation in the argillic zone, usually accompanied by pyrite, can merge into this zone: Eg. Tributors workings, West Federation exploited a very irregular pipe like body, varying from 7.6m (25') x 4.5m (15') at surface to 1.5m (5') x 0.3m (1') at 35m (115') below surface (the deepest development), which assayed 19.5% Sn and consisted of coarse cassiterite varying from 1mm - 25mm across, associated with pyrite crystals upto 25mm; this is in a clay like gangue, described by Waterhouse (1916) as paragonite. Similar coarse pyrite crystals collected from a zone of argillic alteration at Phar Lap workings assayed at 3.25% Sn, but it is not known whether this occurs as cassiterite or stannite.

The largest body of mineralisation detected so far occurs at Sweeney's Mine, which is located approximately 0.7 km South East of the Lake Cumberland Dam and 1.0 km North of the Trial Harbour-Zeehan road. Here, a large body of argillic alteration which is believed to be controlled by the plunge, of the intersection of two major Southerly (?) dipping lineaments, which cross just North of the mine (Fig. 4). This zone of argillic alteration contains at least one pod, probably more, of sulphide mineral-isation, whose appearance postdates the argillic and sericitic alteration (Fander 1977). In the main adit the surrounding red, coarse-grained adamellite has become dark green, in colour, due to the alteration of the felspars to green/yellow clays and biotite to chlorite; occasional soft clay seams also occur. The mineralisation consists mainly of: Pyrite, sphalerite, fluorite and some cassiterite disseminated throughout the altered granite; massive, black sphalerite veins, which probably post-date the other sulphides also occur: Other sulphides include galena, fine needles of boulangerite and rare molybdenite. Towards the margin of the altered zone the sulphides disappear and the granite becomes progressively less altered, assuming a yellow/ green colour. However, the contact between, the less altered yellow/green granite and the 'unaltered' red granite is fairly sharp.

In the upper parts, of the Sweeney mineralisation, nearly all the Sn occurs as very fine-grained cassiterite (1μ - 20μ) with coarser clusters, 200mm across, being friable due to the cassiterite grains having interstitial sericite. The fine grained nature of the cassiterite was considered by Fander (1977) as suggesting a "low temperature of formation with insufficient energy available to develop larger crystals" and he considers the assemblage to represent "a low temperature 'outer halo' of weak greisenisation". Deeper down in the mineralisation there is a change in mineralogy, possibly due, in part, to a higher temperature; the fine-grained cassiterite gradually gives way to Ag rich, coarse-grained stannite, upto 1.5mm across; which is associated with some chalcopyrite and semi-massive pyrrhotite: Paralleling the change to stannite is the appearance of increasing amounts of topaz, which occurs as aggregates and may be pseudomorphing after felspars; the gangue can also include some siderite (Fander 1977). Deeper yet again, the mineralogy appears to revert to an assemblage similar to the higher one, i.e. the majority of the Sn occurs as cassiterite and this may be the 'top' of a separate sulphide lense (?). Similar, but higher grade, mineralisation has been described from Huari-Huari, Bolivia (Coburn et al. 1977) and sphalerite bearing greisen veins have been reported from Luruei, Nigeria (Kinnaird, pers. comm.).

3. GEOCHEMISTRY

Studies in the Erzgebirge tin province of Eastern Europe have shown that there are no significant differences in major element chemistry between the younger, tin granite and the older, non-tin granite (Tischendorf et al 1971). This situation is repeated at Heemskirk where the major element content of the 'red' and 'white' granites are similar to both each other and other tin bearing granites from around the world.

	Heemskirk		Erzegebirge	World
	Red Granite	White Granite	Average	Average
SiO_2	75.24	74.44	73.67	73.44
TiO_2	0.20	0.19	0.12	0.22
Al_2O_3	12.68	13.55	13.36	13.61
Fe_2O_3	0.62	0.31	0.59	0.92
FeO	1.27	1.50	1.24	1.38
MnO	0.04	0.04	0.05	0.06
MgO	0.31	0.37	0.26	0.47
CaO	0.74	0.82	0.75	1.30
Na_2O	2.91	2.75	3.17	3.13
K_2O	5.21	4.96	4.91	4.76
P_2O_5	0.04	0.10	0.21	0.12
H_2O^+	0.56	0.68	0.90	0.42
H_2O^-	0.25	0.16	0.23	0.16
No. of analyses	7	7	46	42

Fig. 8: To show the average major element composition of the 'red' & 'white' granites, Heemskirk compared with tin-bearing granites from the Erzgebirge and the World
(From: Klominsky and Groves, 1970)

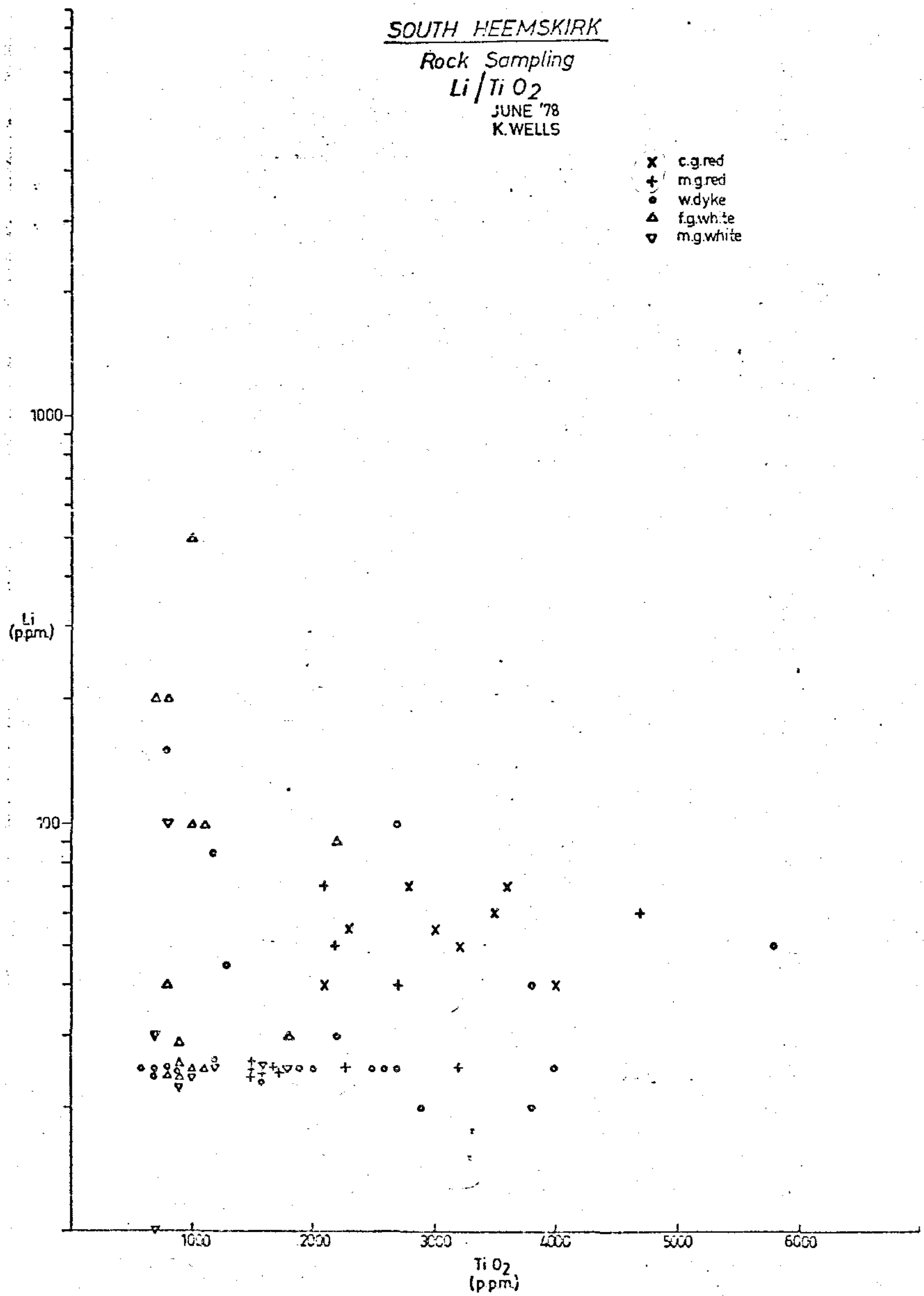
242035

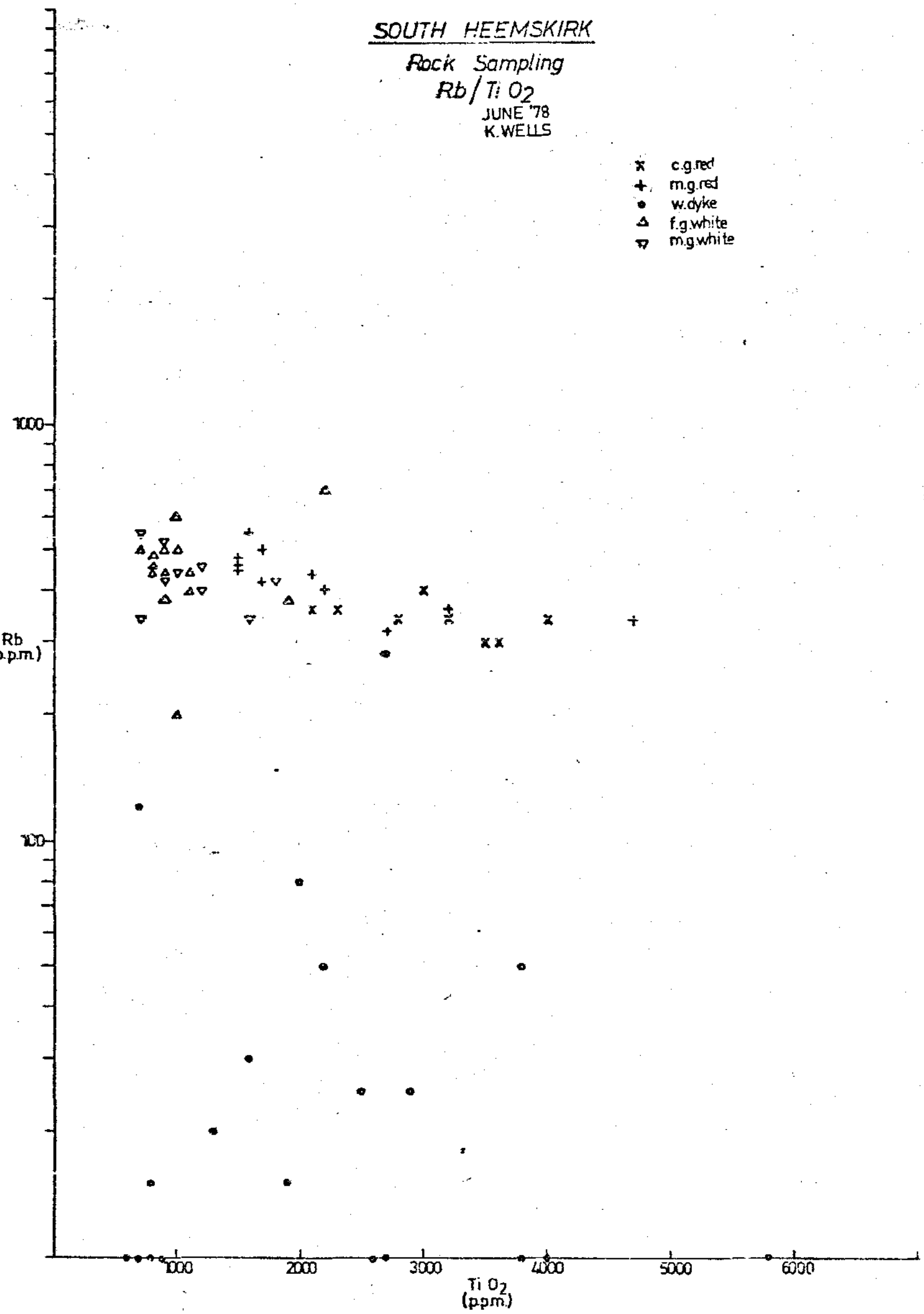
However, the difference in minor and trace element contents can be very significant. Tischendorf et at (1971) have indicated that (in the Erzgebirge) tin-rich granites are enriched relative to tin-poor granites in: Sn, Li, F and Rb, while the tin-poor granites are relatively richer in Ti. Consequently rock samples, collected during the geological mapping programme, were analysed for: Sn, Li & TiO_2. It had also been intended to analyse for total F: However, due to difficulties with the analytical technique, this had to be abandoned and as an alternative, all the samples were subsequently analysed for Rb. Comparison of South Heemskirk data with some Erzgebirge data shows that while absolute levels differ, the relative distribution of trace elements has a similar trend and correlation coefficients undertaken on the data show some sympathetic variations. (Appendix 3).

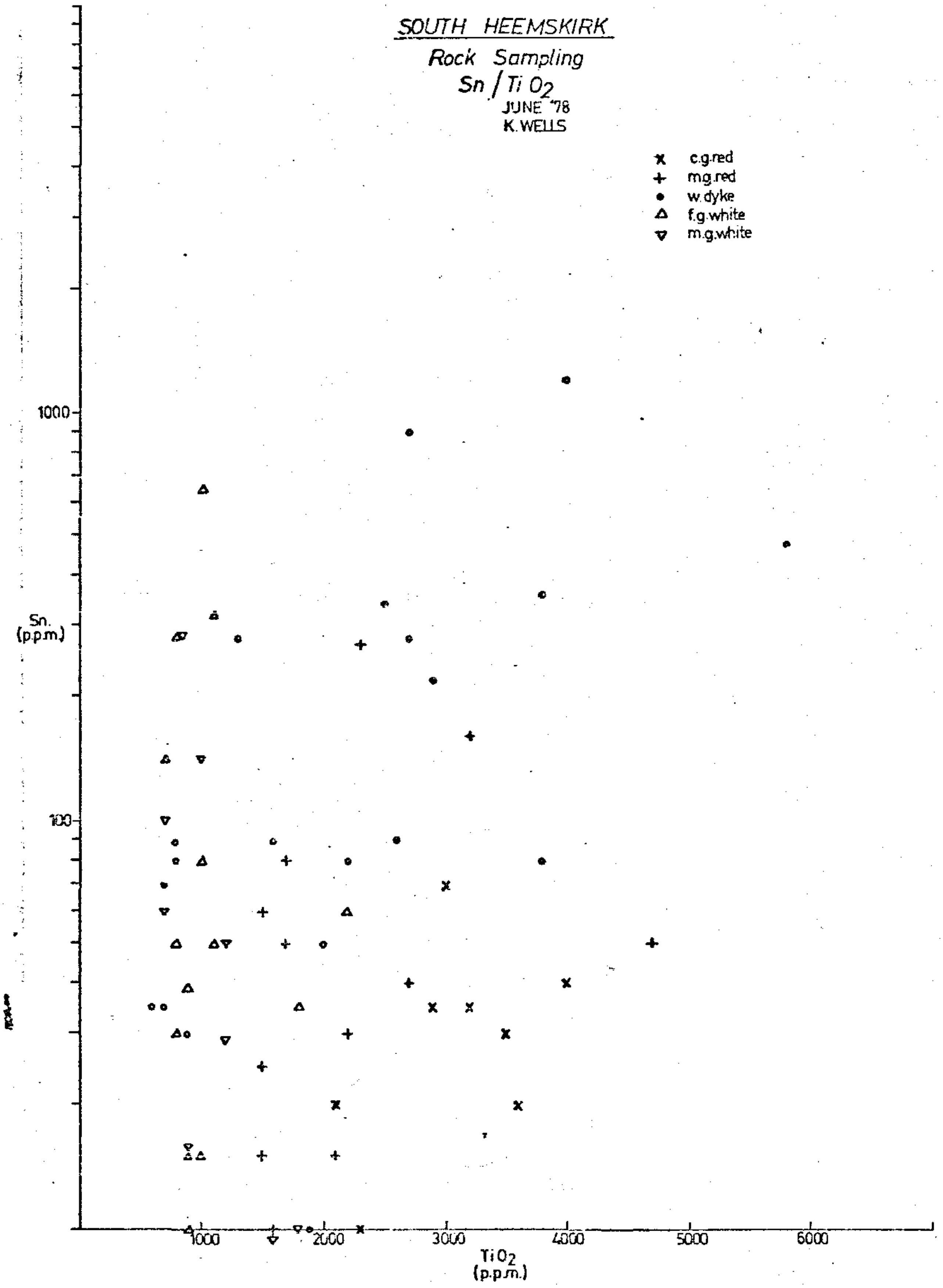
	NON-TIN GRANITE		TIN GRANITE	
	Heemskirk (unaltered)	Erzgebirge	Heemskirk (unaltered)	Erzgebirge
Li	25-70	50-300	25-500	300-1200
Rb	300-550	180-750	200-700	750-2200
Sn	5-80	5-18	10-650	20-50
TiO_2	2100-4700	(Ti) 700-3000	700-2200	(Ti) 100-700
No. of samples	18		23	

Fig. 9: To show differences in trace element content (p.p.m.) between tin and no-tin granites from South Heemskirk and the Erzgebirge (data from Tischendorf et al 1971)

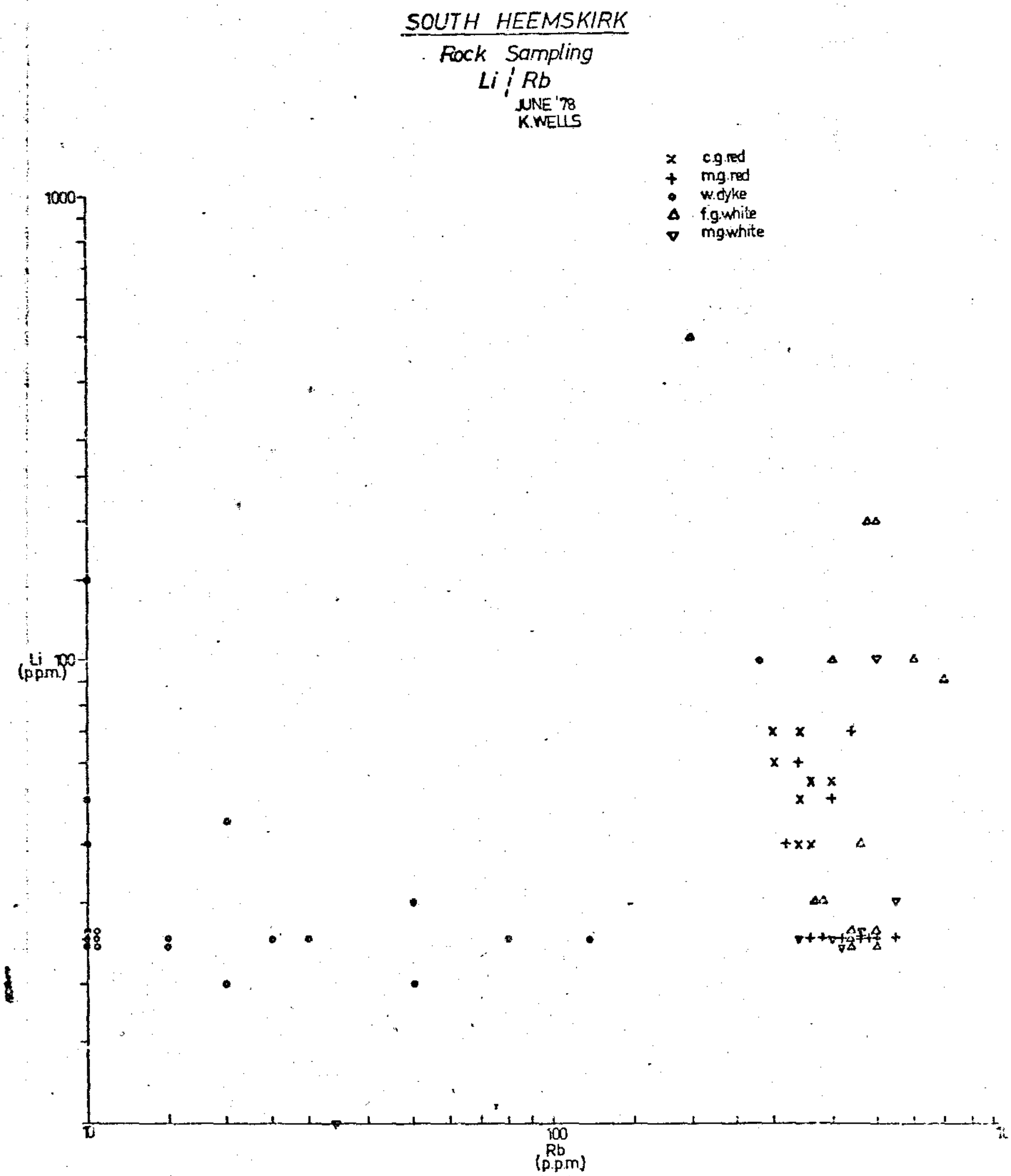
However, when examined in detail, by means of graphs, the overlap in values from the two granites, particularly Sn and Rb, apparent in Fig. 9 precludes any clear differentiation of the two granites on geochemical grounds. Of the four elements examined, TiO_2 appears to show the clearest separation and this is the most obvious in the Li/TiO_2 and Rb/TiO_2 graphs.


SOUTH HEEMSKIRK
Rock Sampling
Li / Ti O2
JUNE '78
K.WELLS
c.g.red
m.g.red
w.dyke
f.g.white
m.g.white
1000
Li (p.p.m.)
100
1000
2000
3000
4000
5000
6000
Ti O2 (p.p.m.)

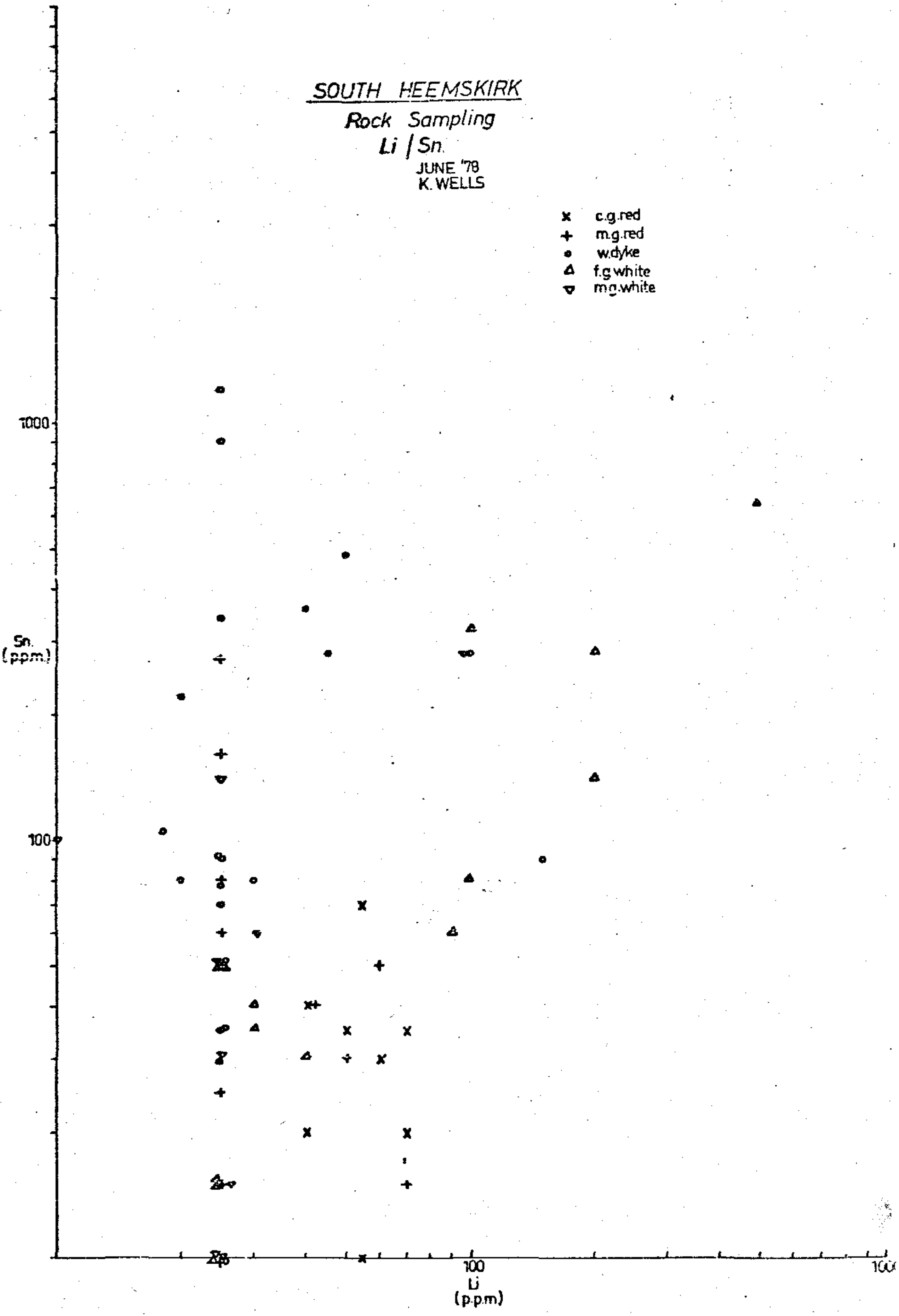

SOUTH HEEMSKIRK
Rock Sampling
Rb / Ti O2
JUNE '78
K.WELLS
c.g.red
m.g.red
w.dyke
f.g.white
m.g.white
1000
100
Rb (p.p.m.)
1000
2000
3000
4000
5000
6000
Ti O2 (p.p.m.)

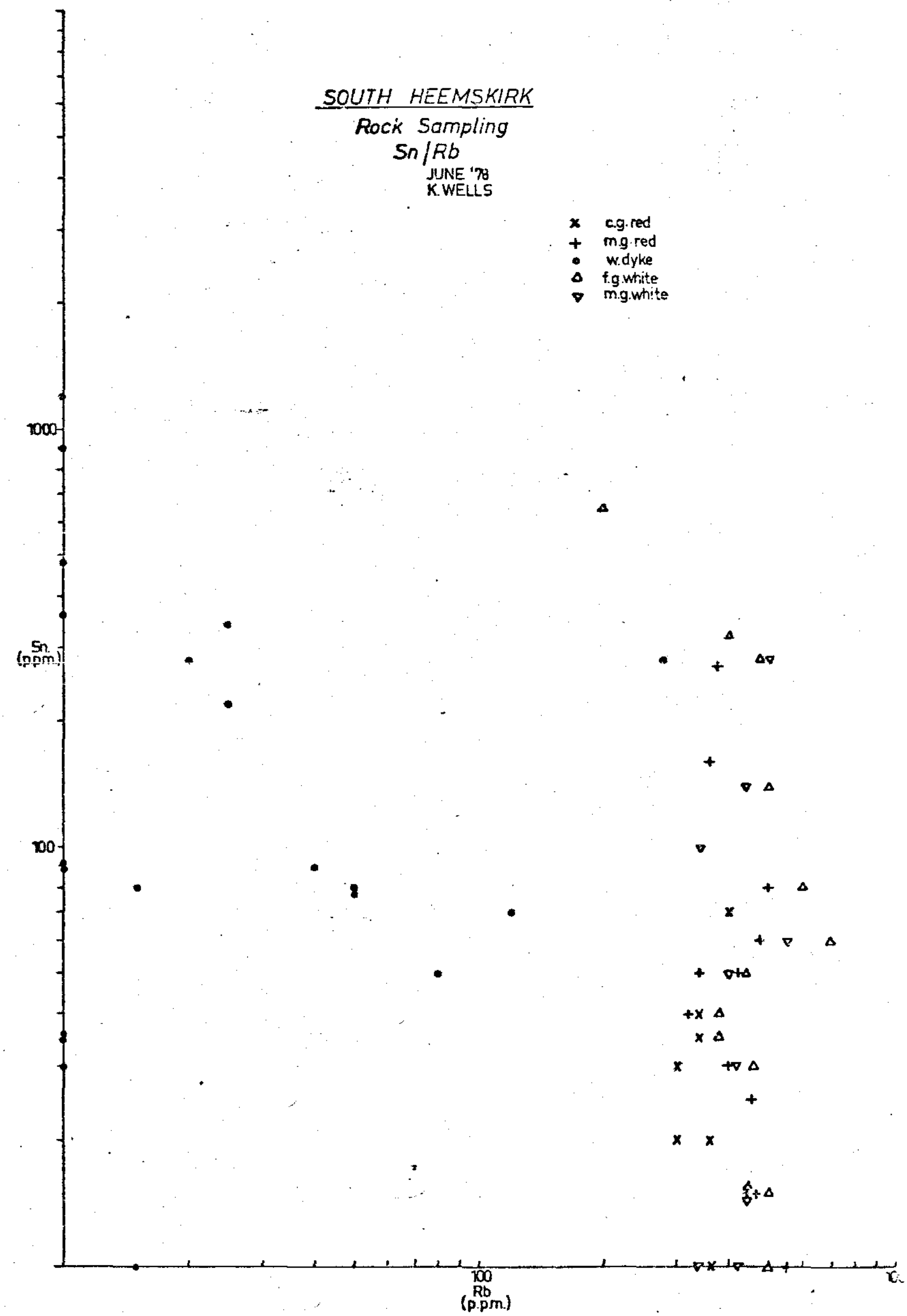

SOUTH HEEMSKIRK
Rock Sampling
Sn / Ti O2
JUNE '78
K. WELLS
c.g.red
m.g.red
w.dyke
f.g.white
m.g.white
1000
100
Sn.
(p.p.m.)
1000
2000
3000
4000
5000
6000
Ti O2
(p.p.m.)

242039


SOUTH HEEMSKIRK
Rock Sampling
Li / Rb
JUNE '78
K.WELLS
c.g.red
m.g.red
w.dyke
f.g.white
m.g.white
1000
Li 100
(p.p.m.)
10
100
Rb
(p.p.m)

242040


SOUTH HEEMSKIRK
Rock Sampling
Li / Sn.
JUNE '78
K. WELLS
c.g.red
m.g.red
w.dyke
f.g.white
m.g.white
1000
100
Sn. (p.p.m.)
100
Li (p.p.m)


SOUTH HEEMSKIRK
Rock Sampling
Sn/Rb
JUNE '78
K. WELLS
c.g. red
m.g. red
w. dyke
f.g. white
m.g. white
1000
Sn.
(p.p.m.)
100
100
Rb
(p.p.m.)

The Li values also show some obvious trends; very high Li in some of the f.g. white granites is related to the development of mica greisens: However, the older, 'red', non-tin granites appear to have higher Li contents than the 'unaltered', younger, 'white', tin granite, which is in direct contrast to the results from Erzgebirge. A similarity in Li values between medium grained 'red' granite and 'white' granite may be due to alteration of the 'red' close to the white contact (see Section 2.1.). However, the value of the Li data is reduced, due to a lower detection limit of 25 p.p.m. in the analytical method.

The white quartz/topaz/tourmaline greisen veins are characterised by having very low Rb values; probably relating to the replacement of the felspars and mica. Apart from this the Rb data appears to show little or no separation between the 'red' non-tin granite and the 'white' tin granite. Sn values again show negligible separation of the two populations and while the Li/TiO_2, Li/Rb and Rb/TiO_2 graphs show tendencies towards different groupings, none of the data is clear cut and further analyses, probably including total F, would be required to establish clear cut geochemical signatures.

4. DISCUSSION

The South Heemskirk Tinfield appears to have numerous features typical of endogranitic Sn mineralisation and has several characteristics comparable with other well known Sn fields, particularly the Krusne Hory-Erzgebirge of Eastern Europe.

Most post-Precambrian, primary Sn mineralisation appears to be related to shallow, post orogenic intrusions and granites of Western Tasmania conform to this model being; "high level, late tectonic plutons" (Solomon et al 1977) and again like many significant Sn granites, the Heemskirk granite, at least, is multiphase: This is a similar situation to the Erzgebirge where the granite plutons have been described as "post kinematic and multiphase....their emplacement intrusive, partly extrusive" (Tischendorf et al 1974).

Although the younger, Sn granite at South Heemskirk appears to be generally more fine-grained and more alkaline (Section 2.1.), petrologically, both granites are very similar; although their accessory minerals do differ (Section 2.1.) and are similar to those of the Sn and non-Sn granites of Eastern Europe:

Sn Granite		Non-Sn Granite	
Erzgebirge	S. Heemskirk	Erzgebirge	S.Heemskirk
apatite, zircon opaque minerals	zircon, apatite, magnetite	topaz, fluorite,	tourmaline topaz, muscovite.

To show the different accessory minerals of Sn and non-Sn granites
(S. Heemskirk data: Fander (1977), Erzgebirge data: Tischendorf et al (1971)).

Both granites are believed to originate from the same magma source by a process of differentiation, the later product being more alkaline and leucocratic. The geochemical data appears to repeat/confirm the idea of a common source: There being little difference in the major element geochemistry and even though there is a tendency towards divergence in their minor element contents (Section 3.), neither granite appears to have a clear cut chemical signature, like those reported from the Erzgebirge (Tischendorf et al 1971).

The numerous tourmaline nodules, in the area, are considered to be mainly related to the intrusion of the 'white' granite, rather than the later main phase hydrothermal activity (Section 2.3.1.). However, examination of Fig. 2 reveals that the nodules are mainly developed along the 'red'/'white' granite contacts adjacent to where the later greisen development was most intense and could suggest that the tourmaline nodules are related to the main phase of hydrothermal alteration. However, this spatial relationship is probably largely coincidental, both the tourmaline "bubbles" (nodules) and later hydrothermal fluids migrating to the highest part (cupola) of the younger granite:

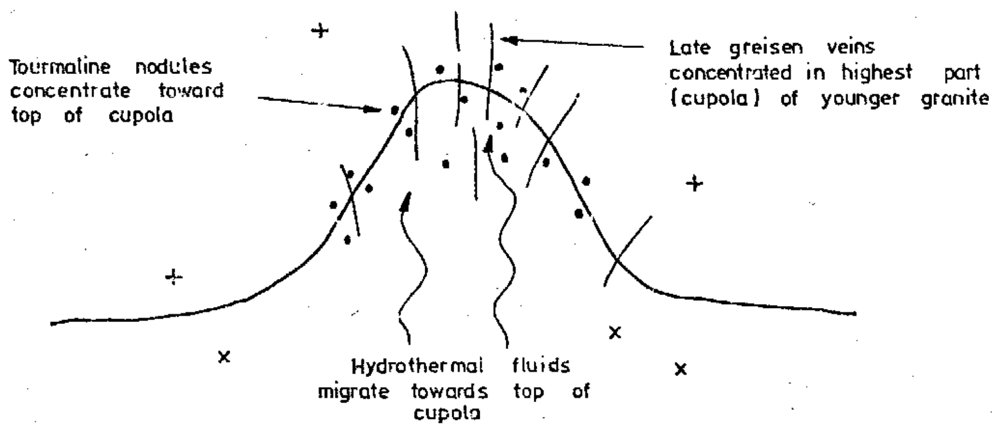


Diagram: To explain coincidence of tourmaline nodule and greisen vein distribution.

Also some late magmatic/early hydrothermal alteration probably occurred with the formation of the nodules and this may have made the granite more susceptible to the later main hydrothermal alteration.

The physical conditions of the granite intrusion (Section 1.2.) correspond to those of the tin rich "non-facies" granites of Letnikov and Legeydo (1973) and the depth of intrusion, 1 - 5 km (Groves 1967) covers the optimum range, 2 - 4 km, of greisen development (Scherba 1968). The greisen veins, as developed at South Heemskirk, may represent later infilling of fissures, developed along pre-existing joints, which are areas of pressure release: "...a decreasing pressure proves to be the main factor in the passage of fluids from their super-critical to pneumatolytic-hydrothermal state" (Scherba 1968). They hydrothermal activity post-dates and obviously effects both granites and there appears to be a subtle alteration of the granites, particularly in the 'red' close to the contact with the white granite and adjacent to the greisen veins, due to the addition of Na/K. Similar greisen veins to those at South Heemskirk have been described, from parts of the Erzgebirge, by Wasternack et al (1974), where the veins are also strictly controlled, by pre-existing structures and can be found upto 600m below and 400m above the contact of the two granites: The vertical extent of the greisen veins at South Heemskirk is unknown but they can be identified over a vertical distance of at least 400m.

The breccias found, to date, only in the Black Face Lode appear to have formed simultaneously with the development of the greisen veins. The hydrothermal intrusion breccia is presumed to have formed during the intense boron metasomatism (tourmalinisation), which must have taken place in that part of the 'vein'; blocks being plucked from the walls and broken and rounded by movement within the breccia: As the metasomatic activity decreased and pressure eased the upper part of the system is thought to have collapsed, forming the collapse breccias. Similar hydrothermal intrusion breccias at Gottesberg, G.D.R. have been described by Schust & Wasternack (1974) as "syn-metasomatic polymict breccias.." with "..more or less dyke-like bodies", they can like the Black Face Lode pass upward into topaz bearing rocks, eg. Schneckenstein and also similarly the breccia at Auersberg Mt. is tourmalinised. The relationships between the granite types and alteration/mineralisation is summarised in Fig. 10.

In pocket c Fig. 6

A majority of the Heemskirk granite, at least in the Southern area, is thought to consist mainly of the white granite and 'windows' of white granite such as the one around and extending North of the Central Federation workings are considered to be, probably, high points (cupolas) in the underlying white granite 'topography', just exposed by erosion: Hence, the intensive hydrothermal alteration in and around the Black Face and the extensive area of fine grained 'nodular granite' to the North (Fig. 11). The numerous fine grained, 'white', micrograpite intrusions throughout the red granite, particularly East of Coleman's/South of Lake Cumberland suggest that the 'red' granite forms only a "shallow" layer above the younger, 'white', tin granite. According to Karel and Sucek (1974) the quartz topaz greisen veins, which also occur throughout this area, form the apical part of the greisen system and pass downwards into micaceous greisens. The greisen system at South Heemskirk appears to carry more sulphides than many other greisen systems, eg. Erzgebirge, Blue Tier (Groves & Taylor 1973) and an extensive I.P. anomaly, over the same area, East from Coleman's Mine; may indicate the presence of a sulphide bearing mica greisen, beneath a shallow layer of the coarse grained 'red' granite: The hematitic and pyritic micaceous greisen, at Waxman and Weston's workings, samples of which carry upto 0.26% Sn, is developed in the margin of the fine grained 'white' granite, immediately 'beneath' the 'red' granites, and may represent the margin of such a greisen (Fig. 11).

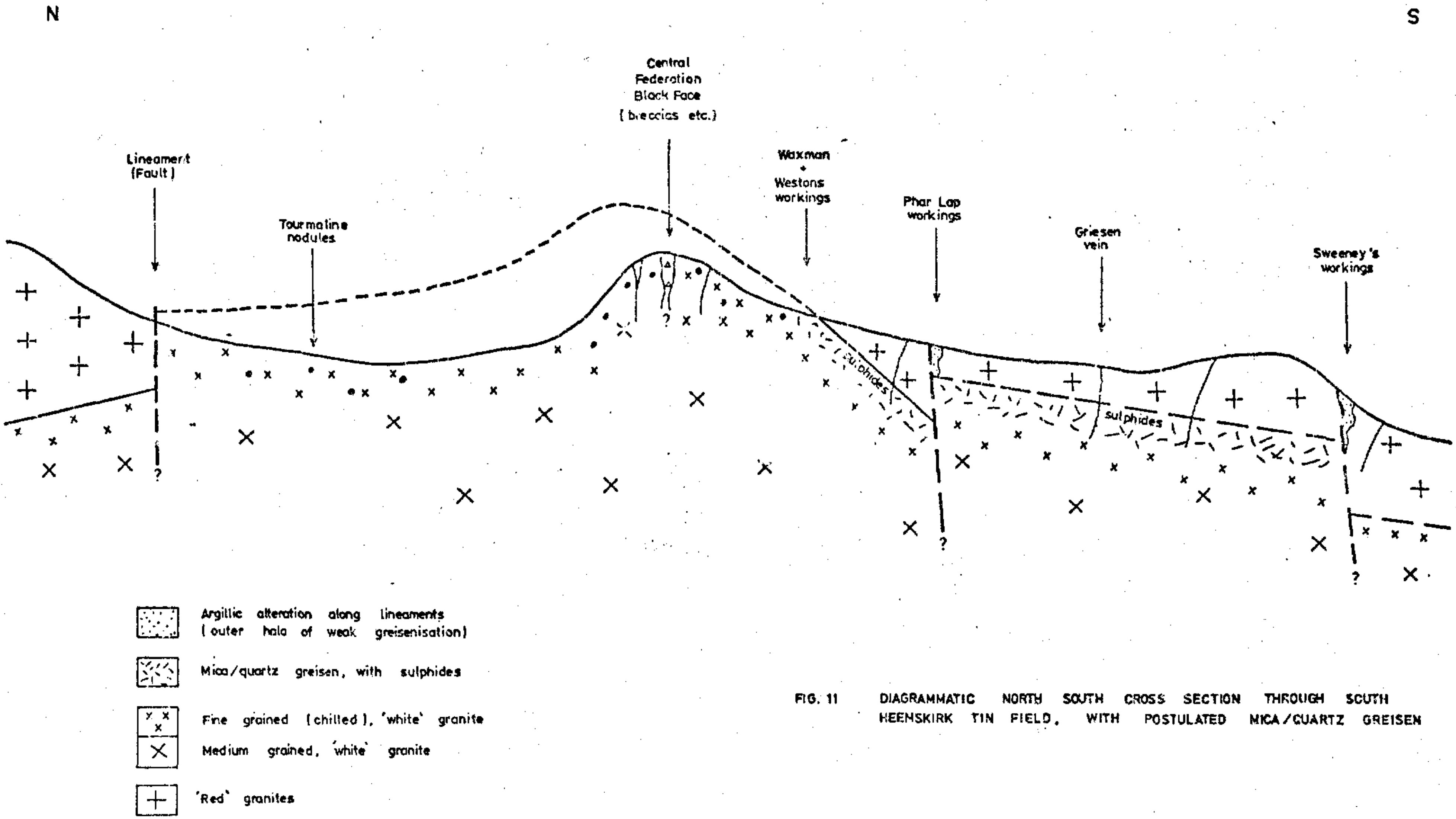


FIG. 11 DIAGRAMMATIC NORTH SOUTH CROSS SECTION THROUGH SOUTH HEEMSKIRK TIN FIELD, WITH POSTULATED MICA/QUARTZ GREISEN

5. ACKNOWLEDGEMENTS

I would like to acknowledge and thank Dr. R.G. Taylor and Prof. W.C. Lacy for their help and guidance throughout the course. To thank Renison Ltd. for the opportunity to undertake the work and the Renison geological staff for their discussion and some of their comments. Lastly, to thank my wife, Heather for her help and understanding during the course.

REFERENCES

Beus A.A.	1962	Wall Rock Alterations of Hydrothermal-pneumatolytic Deposits of Rare Elements. Int. Geol. Rev., 4, p.1144-1152.
Blissett A.H.	1962	Explanatory Report Zeehan 1 mile Geological Map Tas. Dep. of Mines.
Brooks C.	1966	The Rubidium-Strontium Ages of some Tasmanian Igneous Rocks J. Geol. Soc. Aust. 457-469.
Coburn J.L., Vargas A.P. and Bhappu R.B.	1977	Process Development for selective flotation of silver, zinc and tin from Huari-Huari Ore. A.G.M. - A.I.M.E.
Durasova N.A. and Barsukov V.L.	1973	The Behaviour of Tin in Liquating Boron-Bearing Silicate Melts Geokhimiya No. 8., p.1232-1234 (Translated from)
Fander H.W.	1977	Petrographic Report 77/4/6 Unpub. Rep. for Renison Ltd.
"	"	Petrographic Report 77/7/7 Unpub. Rep. for Renison Ltd.
"	"	Petrographic Report 77/8/24 Unpub. Rep. for Renison Ltd.
"	1978	Petrographic Report 78/4/24 Unpub. Rep. for Renison Ltd.

242050

Green T.H.	1963	The Geology of the Trial Harbour District. Proc. of Royal Soc. Tas. Vol. 100
Griffin H.I. and Weber C.R.	1972	Geological Mapping at the Fielders Hill, Wolframite Mine. Geol. Surv. N.S.W. Rep. No. 1972/155.
Groves D.I.	1967	The Granitic Rocks Associated with Cassiterite-Pyrrhotite Mineral-isation . Geol. of W. Tas. Symp.: Uni. of Tas.
Groves D.I. and Taylor R.G.	1973	Greisenisation and Mineralisation at the Anchor Tin Mine, N.E. Tas. I.M.M. Sect B., 82, p. B135-146.
Heier K.S. and Brooks C.	1966	Geochemistry and the Genesis of the Heemskirk Granite, West Tasmania. Geochim. et Cosmochim. Acta. 30, p. 633-645.
Karel V. & Sucek P.	1974	Vertical extent of tin deposition at the Hub stock near Horni-Slavkov M.A.W.A.M. Vol 1. Geol. Surv. Czech.
Keid H.G.W.	1943a	The South Heemskirk Tinfield Unpub. Rep. - Dep. Mines, Tas.
Klominsky J.	1972	The Heemskirk Granite Massif, W. Tas. - a study of chemical variability in plutonic rocks. Unpub. Ph.D. Thesis, Uni. of Tas.

Klominsky J. and Groves D.I.	1970	The Contrast in Granitic Rock Types associated with Tin and Gold mineralisation in Tasmania. Proc. Aus. I.M.M. No. 234
Letnikov F.A. and Legeydo V.A.	1973	Tin Geochemistry of Granitoids in Relation to Depth of Formation. (Trans from) Geokhimiya No. 12, pp. 1894-1898.
Loftus-Hills	1920	Report on the Federation Tin Mine, Heemskirk. Tas. Dept. of Mines.
McDougall I. and Leggo P.J.	1965	Isotopic Age Determinations on Granitic Rocks from Tasmania J. Geol. Soc. Aust. 12., p.295-333.
Montgomery A.	1893	Report on the Progress of the Mineral Fields of the County of Montagu. Tas. Govt. Rep.
"	1895	Report on the Progress of the Mineral Fields in the Neighbourhood of Zeehan. Tas. Govt. Rep.
Rattigan J.H.	1964	Geochemical Characteristics of Australian Granitic Rocks in Relation to the Occurrence of Tin. Unpub. Ph.D. Thesis, Uni. of N.S.W.
Scherba G.N.	1968	Greisens Parts I and II Internat. Geol. Rev. Vol. 12 No. 2.

Schust F. and Wasternack J.	1974	Breccia Pipes and Greisenisation in the Saxonian Erzgebirge and Vogtland Region (G.D.R.) M.A.W.A.M. Vol. 1. Geol. Surv. Czech.
Scott J.G.	1928	Report on Federation Tin Mines Ltd., South Heemskirk. Tas. Dept. of Mines.
Sillitoe R.H., Halls C. and Grant J.N.	1975	Porphyry Tin Deposits in Bolivia Econ. Geol. Vol.70. pp.913-927
Soloman M., Green G.R. & Reid K.O.	1977	Geological History of W. Tasmania Excursion Guide No. 31AC. 25th Int. Geol. Cong.
Thureau G.	1881	Reports on the Mineral Districts of the W. Coast of Tas.-Nol, Pieman River Goldfield, No.2 Mt. Heemskirk. Tas. Govt. Rep.
Thureau G.	1882	An Interim Report on the Stanniferous Deposits of Mt. Heemskirk. Tas. Govt. Rep.
"	1884	Parliament of Tasmania, No. 89, Western Mining Districts. Tas. Govt. Rep.
Tischendorf G., Hosel G., Lange H. and Bolduan H.	1971	The Geochemical and Structural Control of the Tin Mineralisation in the Erzgebirge. Soc. Min. Geol. Japan. Spec. Issue 3, 15-19.

Tischendorf G., Lange H. and Schust F.	1974	On the Relation between Granites and Tin Deposits in the Erzgebirge, G.D.R. M.A.W.A.M. Vol. 1. Geol. Surv. Czech.
Twelvetrees W.H.	1900	Report on the Mineral Districts of Zeehan and Neighbourhood. Tas. Govt. Rep.
Waller G.A.	1902	Report on the Tin-ore Deposits of Mt. Heemskirk. Tas. Govt. Rep.
Wasternack J., Kuhne R. and Schulze H.	1974	Late Magmatic and High to Medium Temperature Postmagmatic Metasomatism in Saxonian Erzgebirge (G.D.R.). M.A.W.A.M. Vol.1. Geol. Surv. Czech.
Waterhouse L.L.	1916	The South Heemskirk Tinfield. Tas. Geol. Surv. Bulletin No. 21.
-	1977	Job No. 12419 Run 4 Photo. Nos. 419 & 420. A.A.M. aerial photog. for Renison Ltd.

242054

BIBLIOGRAPHY

Baumann L.	1970	Tin Deposits of the Erzgebirge I.M.M. 79 p. B68-75.
Baumann L., Stemprok M., Tischendorf G. & Zoubek V.	1974	Metallogeny of Tin and Tungsten in the Krusne Hory-Erzgebirge. Pre-Symposium Excursion Guide - Geol. Surv. Czech.
Blanchard R.	1947	Some Pipe Deposits of E. Australia Econ. Geol. 42. pp.265-304.
Both R.A. and Williams K.L.	1968	Mineralogical Zoning in the Lead-Zinc Ores of the Zeehan Field, Tasmania. J. Geol. Soc. Aust. 15. 121-137, 217-243.
Carter D.N.	1978	Greisens-Environments and Mineralisation. M.Sc. Seminar J.C.U.N.Q.
Green T.H.	1966	Thermal Metamorphism in the Trial Harbour District, Tasmania. J. Geol. Soc. Aust. 13(2) pp.405-418.
Handley G.A.	1977	Albitisation. B.Sc. (Hons) Thesis. J.C.U.N.Q.
Holland H.D.	1972	Granites, Solutions and Base Metal Deposits. Econ. Geol. Vol. 67. No.3.
Schwartz G.M.	1959	Hydrothermal Alteration. Econ. Geol. Vol. 54. No. 2.

Stemprok M. (Ed.)	1974	Metallization Associated with Acid Magmatism (M.A.W.M.) Vol. 1. Geol. Surv. Czech.
Stemprok M.	1978	Differentiation of some elements by ore-bearing granites. M.A.W.A.M. Vol. 3. Geol. Surv. Czech.
Taylor R.G.	1976	Tin Deposits - Geology & Exploration. A.M.F. Course Notes.
Tolok A.A. and Fedchin F.G.	1969	Vertical Metasomatic Zonality in the Tin Deposits of the Soviet Far East and its significance in estimating the amount of ore mineralization at depth. Internat. Geol. Rev. V.12. No. 10.
?	1901	Metasomatic Processes in Fissure Veins. Trans. A.I.M.E. Vol. 30 p.619-626.

APPENDIX 1

A.M.G. Co-ordinates of places, geological and geochemical samples referred to:

Sample No.	A.M.G. Co-ordinates	Sample No.	A.M.G. Co-ordinates
1/1	349730E 5358570N	4/11	350350E 5360470N
1/6	349730E 5359040N	4/14	350200E 5360380N
1/7	"	4/15	350180E 5360380N
1/8	"	4/20	350320E 5360070N
1/9	"	4/21	350350E 5359940N
1/10	"	4/22	350410E 5359950N
1/12	"	4/24	350600E 5360140N
1/14	349890E 5358870N	5/3	350800E 5359950N
1/19	350100E 5358850N	5/7	350700E 5359820N
1/20	350350E 5358900N	5/8	350700E 5359900N
1/21	350600E 5358950N	5/11	350600E 5359830N
1/29	350230E 5358500N	5/16	350260E 5359830N
2/2	350980E 5358930N	5/17	350145E 5359850N
2/3	350955E 5358840N	5/19	350225E 5359780N
2/4	350800E 5358710N	5/22	350290E 5359710N
2/6	350800E 5358660N	6/2	350120E 5359780N
2/8	351120E 5358670N	6/4	350050E 5359930N
2/11	351120E 5359760N	6/10	349680E 5360025N
2/12	351100E 5359770N	6/13	349790E 5359850N
2/13	350950E 5359700N	7/3	349830E 5359350N
2/14	351040E 5359640N	8/6	349875E 5359260N
2/17	350880E 35959620N	8/8	349690E 5359330N
2/18	350820E 35959620N	8/9	349665E 5359330N
2/19	350750E 5359560N	8/10	349575E 5359370N
2/20	350750E 5359530N	9/6	349360E 5359700N
3/2	350410E 5359350N	9/9	348730E 5358900N
3/5	350700E 5359675N	W.F.3	349830E 5359600N
3/7	350650E 5359750N	W.F.25	"
3/12	350300E 535945N	C.F.3 & 4	350300E 35959820N
3/15	350180E 5359280N	C.F.5	"
4/1	350960E 5359850N	West Federation including: Tributors, Fowler & Dunn's, Geason's Cross Lode.	349830E 5359600N
4/6	351025E 5360200N		
4/8	350900E 5360260N		

Sample No.	A.M.G. Co-ordinates	Sample No.	A.M.G. Co-ordinates
Central Federation inc. Black Face, Munroe's Shaft, Inclined Shaft.	350300E 35959820N	F.g.(chilled) 'white' granite	
		-Federation Haulage	349700E 535930N
		-East of Central Federation	350750E 5359800N
Waxman and Westons	350820E 35959620N		
Eastern Workings	350800E 5359950N		
Phar Lap	350180E 5359280N		
Coleman's	349730E 5359040N		
Sweeney's inc. access road	351270E 5358160N		
Montague	349830E 535833N		
Wakefield	349880E 5358160N		
Greisen vein between 6/11 (f.g.) and 6/8 (c.g.)	349740E 5360000N		
Tourmaline microgranite S.S.W. of Central Federation	350150E 5359540N		
Tourmaline nodules along lineament S.E. corner of Lake Cumberland	351700E 5358980N		

APPENDIX 2

Geochemical Data (p.p.m.)

Sample No.	Sn	TiO_2	Li	Rb	Comments
1/1	30	3500	60	300	Coarse grained 'red' granite.
1/10	40	4000	40	340	"
2/3	20	2100	40	360	"
2/8	35	2800	70	340	"
2/12	35	3200	50	340	"
8/6	5	2300	55	360	"
1/29	20	3600	70	300	"
5/8	70	3000	55	400	Soft, altered c.g. 'red' granite
1/7	50	4700	60	340	Medium grained, 'red' granite.
2/4	40	2700	40	320	"
2/19	15	2100	70	440	"
2/20	30	2200	50	400	"
3/20	160	3200	<25	360	Soft, altered m.g. 'red' granite adjacent to greisen vein.
4/8	50	1700	<25	420	Medium grained 'red' granite.
4/11	80	1700	25	500	"
4/22	60	1500	<25	480	"
5/17	25	1500	"	460	"
6/2	5	1600	"	550	"
6/4	15	1500	"	460	"
1/14	35	1800	30	380	Narrow 'white' microgranite intrusion.
2/13	30	800	40	460	Fine grained 'white' granite.
2/17	80	1000	100	600	F.g. quartz-mica greisen.
2/18	60	2200	90	700	" with hematite.
3/7	15	900	<25	440	Fine grained 'white' granite.
3/7 Fe	280	800	200	480	Fe oxides and mica 'vein' in F.g. 'white' granite.
3/15	320	1100	100	400	F.g. quartz-mica greisen.
4/6	50	800	<25	440	Red coloured F.g. 'white' granite.
6/10	140	700	200	500	Quartz mica 'greisen' developed adjacent to Quartz-topaz 'vein'.
6/13	650	1000	500	200	Pyritic f.g. 'white' granite.

Sample No.	Sn	TiO_2	Li	Rb	Comments
8/9	15	1000	25	50	Fine grained 'white' granite.
2/7	40	900	30	380	"
W.F.25	50	1100	<25	440	" - argillically altered.
1/21	100	700	10	340	Medium grained 'white' granite.
4/1	50	1200	<25	440	"
5/7	15	900	"	440	"
5/16	10	1800	"	420	"
7/3	140	1000	"	440	"
8/10	280	800	100	500	"
9/9	60	700	30	550	"
9/6	30	1200	25	460	"
5/11	10	1600	"	340	"
1/6	480	5800	50	5	Tourmaline & clay - Coleman's.
1/8	360	3800	40	10	'Total' tourmalinisation - "
1/9	280	2700	100	280	Quartz-Topaz greisen vein.
1/12	80	3800	20	50	"
1/20	80	2200	30	50	"
2/14	1200	4000	25	5	"
3/5	50	2000	<25	80	"
3/12	35	600	"	5	"
3/2 dyke	80	800	"	15	Quartz-Tourmaline "Schorl" vein.
4/14	280	1300	45	20	Hematitic, quartz & topaz(?) greisen vein.
4/20	30	900	<25	5	Quartz-Topaz greisen vein.
4/21	90	1600	"	30	"
5/3 c.g.	90	2600	"	5	Quartz-Tourmaline greisen vein.
5/3 green	900	2700	"	"	" " (dravite) " "
5/19	10	1900	<25	15	F.g. breccia fragment (C.F.5).
5/22	35	700	"	10	Quartz-Topaz greisen vein.
8/8	70	700	25	120	" with tourmaline veins
W.F.3 s.g.	340	2500	25	25	Tourmaline and hematite (High S.G.).
2/6	220	2900	20	25	Quartz-Topaz greisen vein.
3/7 T	90	800	150	5	Quartz-Tourmaline " "

APPENDIX 3

Spearman Rank Correlation Coefficients - Geochemical Data

The Spearman Rank Correlation Coefficient is a non-parametric statistical test and does not depend on the data being normally distributed (Marshall 1970).

The coefficient is calculated by:

$$r_s = 1 - \frac{6 (\sum di^2)}{N (N^2 - 1)}$$

where, r_s = correlation coefficient

di = difference in rank

N = number of samples.

The value r_s can range from -1 (totally antipathetic variation) to +1 (totally sympathetic variation). The significance of any given value will vary according to N and the variability can be tested quantitatively by reference to significant tables for r in standard statistical references, eg. Koch & Link, Vol. 1 (1970).

All the elements tested so far appear to have strong positive correlations:

TiO_2/Rb	0.68	99.95% correlation
TiO_2/Sn	0.78	"
TiO_2/Li	0.81	"
Li/Rb	0.82	"
Li/Sn	0.83	"
Sn/Rb	0.88	"

Surprisingly, in view of Table , the TiO_2 content varies sympathetically with the other elements; although the TiO_2 coefficients do have the lowest correlations. These positive correlations are possibly due to the overlap in values of Sn, Li and Rb from the 'red' and 'white' granites.

N.B. Correlation Coefficients calculated on 'unaltered' granites only. Greisen vein samples and obviously altered 'red' and 'white' granites not included.

REFERENCES

Koch G.S. and Link R.F. 1970 Statistical Analysis of Geological Data. J. Wiley & Sons Inc.

Marshall N.J. 1970 Geostatistics in geochemical exploration - a review. U.N. Resources Dev. Series No. 38, 314-340.

TiO_2/Rb

Sample No.	TiO_2	Rank	Rb	Rank	di	di^2
1/1	3500	16	300	1	15	225
1/10	4000	18	340	3	15	225
2/3	2100	10	360	4	6	36
2/8	280	14	340	3	11	121
2/12	3200	15	340	3	12	144
8/6	2300	12	360	4	8	64
1/29	3600	17	300	1	16	256
1/7	4700	19	340	3	16	256
2/4	2700	13	320	2	11	121
2/19	2100	10	440	8	2	4
2/20	2200	11	400	6	5	25
4/8	1700	8	420	7	1	1
4/11	1700	8	500	11	3	9
4/22	1500	6	480	10	4	16
5/17	1500	6	460	9	3	9
6/2	1600	7	550	12	5	25
6/4	1500	6	460	9	3	9
1/14	1800	9	380	5	4	16
2/13	800	2	460	9	7	49
2/18	2200	11	700	13	2	4
3/7	900	3	440	8	5	25
4/6	800	2	440	8	6	36
6/11	900	3	500	11	8	64
8/9	1000	4	500	11	7	49
2/7	900	3	380	5	2	4
1/21	700	1	340	3	2	4
4/1	1200	5	400	6	1	1
5/7	900	3	440	8	5	25
5/16	1800	9	420	7	2	4
7/3	1000	4	440	8	4	16
8/10	800	2	500	11	9	81
9/9	700	1	550	12	11	121
9/6	1200	5	460	9	4	16
5/11	1600	7	340	3	4	16
						2077

$$\text{Rank Correlation} = 1 - \frac{6\ (\sum di^2)}{N\ (N^2 - 1)}$$

$$= 1 - \frac{6\ (2077)}{34\ (1156-1)} \qquad 1 - \frac{12462}{39270}$$

$$= 1 - 0.32$$

$$= 0.68$$

Positive Correlation of >99.95%.

TiO_2/Sn

Sample No.	TiO_2	Rank	Sn	Rank	di	di^2
1/1	3500	16	30	7	9	81
1/10	4000	18	40	9	9	81
2/3	2100	10	20	5	5	25
2/8	2800	14	35	8	6	36
2/12	3200	15	35	8	7	49
8/6	2300	12	5	2	10	100
1/29	3600	17	20	5	12	144
1/7	4700	19	50	10	9	81
2/4	2700	13	40	9	4	16
2/19	2100	10	15	4	6	36
2/20	2200	11	30	7	4	16
4/8	1700	8	50	10	2	4
4/11	1700	8	80	12	4	16
4/22	1500	6	60	11	5	25
5/17	1500	6	25	6	0	
6/2	1600	7	5	2	5	25
6/4	1500	6	15	4	2	4
1/14	1800	9	35	8	1	1
2/13	800	2	30	7	5	25
2/18	2200	11	60	11	0	
3/7	900	3	15	4	1	1
4/6	800	2	50	10	8	64
6/11	900	3	<5	1	2	4
8/9	1000	4	15	4	0	
2/7	900	3	40	9	6	36
1/21	700	1	100	13	12	144
4/1	1200	5	50	10	5	25
5/7	900	3	15	4	1	1
5/16	1800	9	10	3	6	36
7/3	1000	4	140	14	10	100
8/10	800	2	280	15	13	169
9/9	700	1	60	11	10	100
9/6	1200	5	30	7	2	4
5/11	1600	7	10	3	4	16
						1465

$$\text{Rank Correlation} = 1 - \frac{6\ (\Sigma di^2)}{N\ (N^2 - 1)}$$

$$= 1 - \frac{6\ (1465)}{34\ (1156-1)}$$

$$= 1 - \frac{8790}{39270}$$

$$= 0.78$$

Positive Correlation of $>$99.95%.

<u>TiO_2/Li</u>

Sample No.	TiO_2	Rank	Li	Rank	di	di^2
1/1	3500	16	60	7	9	81
1/10	4000	18	40	4	14	196
2/3	2100	10	40	4	6	36
2/8	2800	14	70	8	6	36
2/12	3200	15	50	5	10	100
8/6	2300	12	55	6	6	36
1/29	3600	17	70	8	9	81
1/7	4700	19	60	7	12	144
2/4	2700	13	40	4	9	81
2/19	2100	10	70	8	2	4
2/20	2200	11	50	5	6	36
4/8	1700	8	<25	1	7	49
4/11	1700	8	25	2	6	36
4/22	1500	6	<25	1	5	25
5/17	1500	6	"	1	5	25
6/2	1600	7	"	1	6	36
6/4	1500	6	"	1	5	25
1/14	1800	9	30	3	6	36
2/13	800	2	40	4	2	4
2/18	2200	11	90	9	2	4
3/7	900	3	<25	1	2	4
4/6	800	2	"	1	1	1
6/11	900	3	"	1	2	4
8/9	1000	4	25	2	2	4
2/7	900	3	30	3	0	
1/21	700	1	< 25	1	0	
4/1	1200	5	"	1	4	16
5/7	900	3	<25	1	2	4
5/16	1800	9	"	1	8	64
7/3	1000	4	"	1	3	9
8/10	800	2	100	10	8	64
9/9	700	1	30	3	2	4
9/6	1200	5	25	2	3	9
5/11	1600	7	"	2	5	25
						1279

$$\text{Rank Correlation} = 1 - \frac{6\ (\Sigma di^2)}{N\ (N^2 - 1}$$

$$= 1 - \frac{6\ (1279)}{34\ (1156-1)}$$

$$= 1 - \frac{7674}{39270}$$

$$= 1 - 0.19$$

$$= 0.81$$

Positive Correlation >99.95%

242068

<u>Li/Rb</u>

Sample No.	Li	Rank	Rb	Rank	di	di^2
1/1	60	7	300	1	6	36
1/10	40	4	340	3	1	1
2/3	40	4	360	4	0	
2/8	70	8	340	3	5	25
2/12	50	5	340	3	2	4
8/6	55	6	360	4	2	4
1/29	70	8	300	1	7	49
1/7	60	7	340	3	4	16
2/4	40	4	320	2	2	4
2/19	70	8	440	8	0	
2/20	50	5	400	6	1	1
4/8	<25	1	420	7	6	36
4/11	25	2	500	11	9	81
4/22	<25	1	480	10	9	81
5/17	"	1	460	9	8	64
6/2	"	1	550	12	11	121
6/4	"	1	460	9	8	64
1/14	30	3	380	5	2	4
2/13	40	4	460	9	5	25
2/18	90	9	700	13	4	16
3/7	<25	1	440	8	7	49
4/6	"	1	440	8	7	49
6/11	"	1	500	11	10	100
8/9	25	2	500	11	9	81
2/7	30	3	380	5	2	4
1/21	<25	1	340	3	2	4
4/1	"	1	400	6	5	25
5/7	<25	1	440	8	7	49
5/16	"	1	420	7	6	36
7/3	"	1	440	8	7	49
8/10	100	10	500	11	1	1
9/9	30	3	550	12	9	81
9/6	25	2	460	9	7	49
5/11	"	2	340	3	1	1
						1210

$$\text{Rank Correlation} = 1 - \frac{6\ (\Sigma di^2)}{N\ (N^2-1)}$$

$$= 1 - \frac{6\ (1210)}{34\ (1156-1)}$$

$$= 1 - \frac{7260}{39270}$$

$$= 0.82$$

Positive Correlation of $>$99.95%

Sn/Li

Sample No.	Sn	Rank	Li	Rank	di	di^2
1/1	30	7	60	7	0	
1/10	40	9	40	4	5	25
2/3	20	5	40	4	1	1
2/8	35	8	70	8	0	
2/12	35	8	50	5	3	9
8/6	5	2	55	6	4	16
1/29	20	5	70	8	3	9
1/7	50	10	60	7	3	9
2/4	40	9	40	4	5	25
2/19	15	4	70	8	4	16
2/20	30	7	50	5	2	4
4/8	50	10	<25	1	9	81
4/11	80	12	25	2	10	100
4/22	60	11	<25	1	10	100
5/17	25	6	"	1	5	25
6/2	5	2	"	1	1	1
6/4	15	4	"	1	3	9
1/14	35	8	30	3	5	25
2/13	30	7	40	4	3	9
2/18	60	11	90	9	2	4
3/7	15	4	<25	1	3	9
4/6	50	10	"	1	9	81
6/11	<5	1	"	1	0	
8/9	15	4	25	2	2	4
2/7	40	9	30	3	6	36
1/21	100	13	<25	1	12	144
4/1	50	10	"	1	9	81
5/7	15	4	<25	1	3	9
5/16	10	3	"	1	2	4
7/3	140	14	"	1	13	169
8/10	280	15	100	10	5	25
9/9	60	11	30	3	8	64
9/6	30	7	25	2	5	25
5/11	10	3	"	2	1	1
						1120

$$\text{Rank Correlation} = 1 - \frac{6\,(\Sigma di^2)}{N\,(N^2 - 1)}$$

$$= 1 - \frac{6\,(1120)}{34\,(1156-1)}$$

$$= 1 - \frac{6720}{39270}$$

$$= 0.83$$

Positive Correlation of $<$ 99.95%

Sn/Rb

Sample No.	Sn	Rank	Rb	Rank	di	di^2
1/1	30	7	300	1	6	36
1/10	40	9	340	3	6	36
2/3	20	5	360	4	1	1
2/8	35	8	340	3	5	25
2/12	35	8	340	3	5	25
8/6	5	2	360	4	2	4
1/29	20	5	300	1	4	16
1/7	50	10	340	3	7	49
2/4	40	9	320	2	7	49
2/19	15	4	440	8	4	16
2/20	30	7	400	6	1	1
4/8	50	10	420	7	3	9
4/11	80	12	500	11	1	1
4/22	60	11	480	10	1	1
5/17	25	6	460	9	3	9
6/2	5	2	550	12	10	100
6/4	15	4	460	9	5	25
1/14	35	8	380	5	3	9
2/13	30	7	460	9	2	4
2/18	60	11	700	13	2	4
3/7	15	4	440	8	4	16
4/6	50	10	440	8	2	4
6/11	< 5	1	500	11	10	100
8/9	15	4	500	11	7	49
2/7	40	9	380	5	4	16
1/21	100	13	340	3	10	100
4/1	50	10	400	6	4	16
5/7	15	4	440	8	4	16
5/16	10	3	420	7	4	16
7/3	140	14	440	8	6	36
8/10	280	15	500	11	4	16
9/9	60	11	550	12	1	1
9/6	30	7	460	9	2	4
5/1	10	3	340	3	0	
						810

242073

$$\text{Rank Correlation} = 1 - \frac{6\,(\Sigma di^2)}{N\,(N^2 - 1)}$$

$$= 1 - \frac{6\,(810)}{34\,(1156-1)}$$

$$= 1 - \frac{4860}{39270}$$

$$= 0.88$$

Positive Correlation of $>$ 99.95%

LEGEND

ALTERATION

- Argillic Alteration
- Quartz and Topaz and/or Tourmaline
- Total tourmalinisation, occassionally with hematite
- Hydrothermal } Breccias
- Collapse } Breccias
- (above group:) White alteration 'Dykes' (Greisen Veins)
- Quartz - mica greisen
- Area of Tourmaline nodules

ROCK TYPES

- Fine grained } 'White' younger granite
- Medium grained } 'White' younger granite
- Medium grained, usually porphyritic } 'Red' older granite
- Coarse grained } 'Red' older granite

- Major Lineament
- Joint with dip
- Joint, vertical
- Foliation
- Definite } Geological Boundaries
- Approximate } Geological Boundaries
- Inferred } Geological Boundaries
- Old mine or prospect

242074

5 cm

COMPILATION NOTE

This sheet is a composite of photogrammetric contours superimposed on a half tone reproduction of compiled orthophotos from aerial photography dated 12·12·77.

Orthophoto base mapping and photogrammetric contours by Australian Aerial Mapping Pty. Ltd.

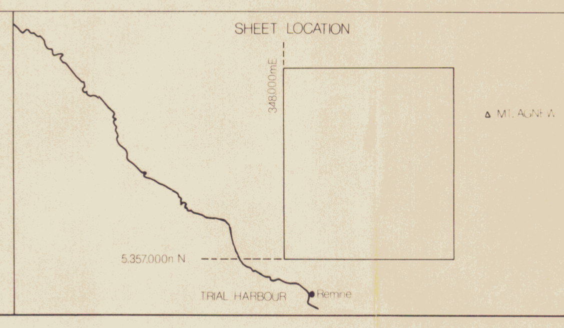
Aerial photography	Wild RC8
Aerial triangulation	Wild A8
Contouring	Wild B8
Orthophotos	Zeiss Topocart

REFERENCE

- 100 Contours
- 115 Depressions
- +60·5 Spot Heights
- RL 503·98 Control

N.B. Broken lines indicate lower reliability
Contour interval 10 metres
Spot heights to 0·5 metres
Reduced levels to Australian Height Datum
Co-ordinates Australian Map Grid
Grid interval 500 metres

SHEET LOCATION



RENISON LIMITED

HEEMSKIRK AREA
GEOLOGICAL INTERPRETATION

GEOLOGIST: K. Wells	SCALE 1:5000 METRES
DRAUGHTSMAN: F. Colson	100 0 100 200
DATE: June 1978	
REVISIONS 1019	DRAWING NO. FIG. 2

78-128H

1020

LEGEND

- Major lineaments
- Dominant joints
- Subsidiary joints
- Rock type boundaries
- Major workings

242075

5 cm

COMPILED FROM AERIAL PHOTOGRAPHS: A.A.M. JOB Nº 12419, RUN 4 Nº's 419, 420

COMPILATION NOTE

This sheet is a composite of photogrammetric contours superimposed on a half tone reproduction of compiled orthophotos from aerial photography dated 12.12.77.

Orthophoto base mapping and photogrammetric contours by Australian Aerial Mapping Pty. Ltd.

Aerial photography	Wild RC8
Aerial triangulation	Wild A8
Contouring	Wild B8
Orthophotos	Zeiss Topocart

REFERENCE

- 100 Contours
- 115 Depressions
- +60·5 Spot Heights
- 40 RL 503·98 Control

N.B. Broken lines indicate lower reliability
Contour interval 10 metres
Spot heights to 0·5 metres
Reduced levels to Australian Height Datum
Co-ordinates Australian Map Grid
Grid interval 500 metres

SHEET LOCATION

348000mE
5,357,000n N
MT. AGNEW
TRIAL HARBOUR
Renrne

RENISON LIMITED

HEEMSKIRK AREA

STRUCTURAL INTERPRETATION

GEOLOGIST:	K. WELLS	SCALE 1:5000 METRES
DRAUGHTSMAN:	J. MATTHEWS	100 0 100 200
DATE:	JUNE 1978	
REVISIONS	1020	DRAWING NO. FIG. 4

78-1284

ALTERATION

- Argillic Alteration
- Quartz and Topaz and/or Tourmaline
- Total tourmalinisation, occassionally with hematite
- Hydrothermal, Collapse } Breccias

} White alteration 'Dykes' (Greisen Veins)

- Quartz - mica greisen
- Area of Tourmaline nodules

ROCK TYPES

- Fine grained, Medium grained } 'White' younger granite
- Medium grained, usually porphyritic; Coarse grained } 'Red' older granite

- Major Lineament
- Joint with dip
- Joint, vertical
- Foliation
- Definite, Approximate, Inferred } Geological Boundaries
- Old mine or prospect

RENISON LIMITED

CENTRAL FEDERATION WORKINGS
GEOLOGY INTERPRETATION

SCALE. 1:500 METRES

DRAWN	K. Wells
TRACED	F. A. Colson
DATE	9. 7. 78
SCALE	1: 500
DRAWING No.	

FIG. 5

78-1284

1021

ALTERATION

- Argillic Alteration
- Quartz and Topaz and/or Tourmaline
- Total tourmalinisation, occassionally with hematite
- Hydrothermal } Breccias
- Collapse } Breccias

White alteration 'Dykes' (Greisen Veins)

- Quartz - mica greisen
- Area of Tourmaline nodules

ROCK TYPES

- Fine grained } 'White' younger granite
- Medium grained } 'White' younger granite
- Medium grained, usually porphyritic } 'Red' older granite
- Coarse grained } 'Red' older granite

- Major Lineament
- Joint with dip
- Joint, vertical
- Foliation

- Definite } Geological Boundaries
- Approximate } Geological Boundaries
- Inferred } Geological Boundaries
- Old mine or prospect

RENISON LIMITED

WEST FEDERATION WORKINGS
GEOLOGY INTERPRETATION

SCALE. 1:500 METRES

10 0 10 20 30

DRAWN	K. WELLS
TRACED	F. COLSON
DATE	10·7·78
SCALE	1:500
DRAWING No.	

FIG. 6

78-1284 242077 1022

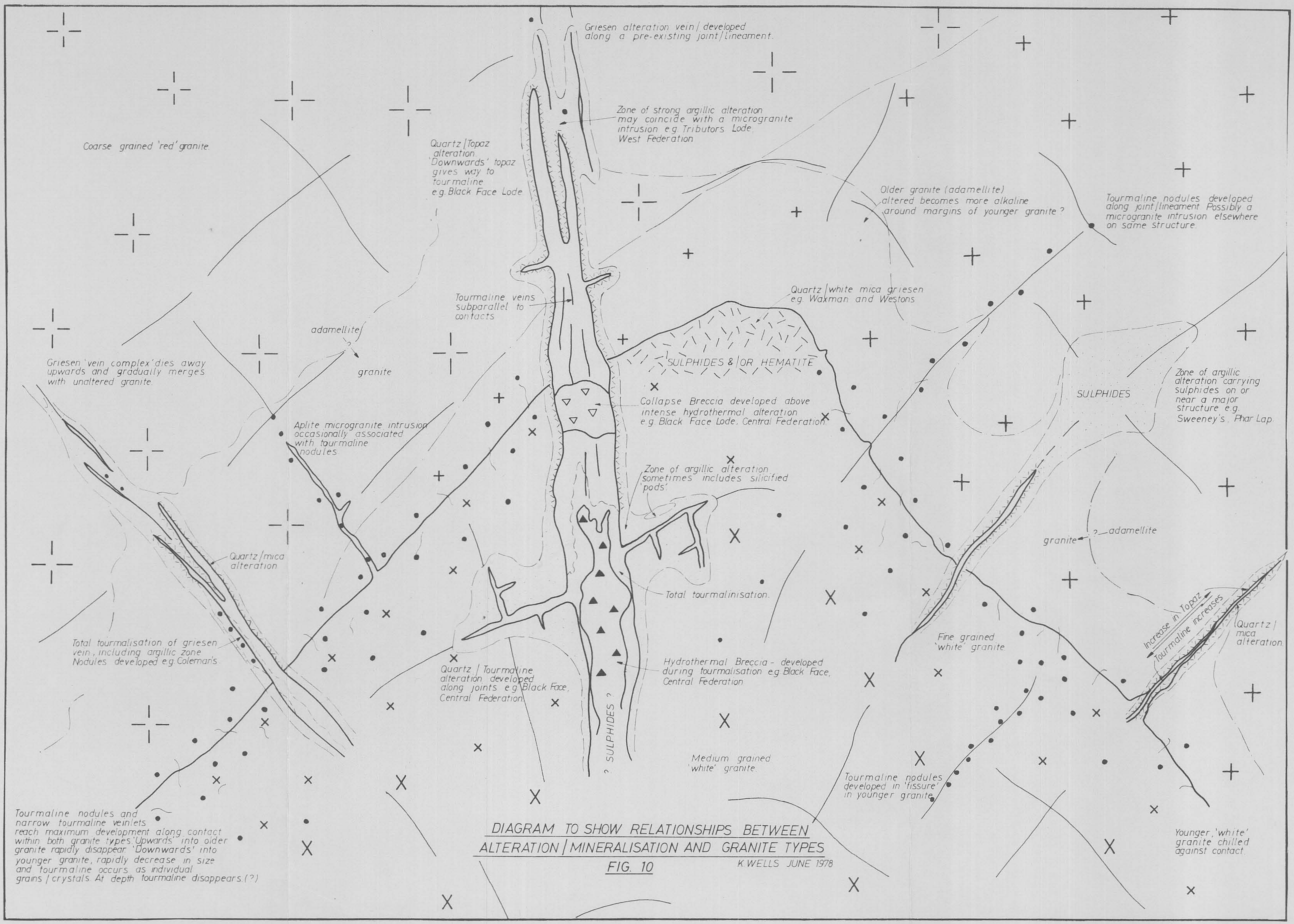


DIAGRAM TO SHOW RELATIONSHIPS BETWEEN ALTERATION / MINERALISATION AND GRANITE TYPES

FIG. 10

K. WELLS JUNE 1978