THE GEOLOGY AND ECONOMIC POTENTIAL

OF THE

HIBBS ULTRAMAFIC BELT

IN THE

NODDY CREEK AREA OF

SOUTH WEST TASMANIA

AUGUST 1972

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ABSTRACT

The Hibbs Ultramafic Belt at Noddy Creek in South West Tasmania, is interpreted as a typical " alpine type" ultramafic body with related gabbro and diorite intrusions and calc-alkaline extrusions.

The ultramafic belt was emplaced into Cambrian geosynclinal sediments as slices of upper mantle material along major thrust planes thought to be associated with a subduction zone in the earths crust. Despite intense serpentisation, shearing, and peripheral metasomatism the primary textures are well preserved, and it has been possible to reconstruct much of the original igneous history of the different rock assemblages and to examine their possible relationships.

The deposits of chrysotile asbestos are localised in an arcuate wider section of the ultramafic belt. There have been several phazes of tectonic movement and serpentinisation of the ultramafics, which have combined to promote fibre growth under certain structural conditions. The chrysotile deposits have survived a later period of shearing and metasomatism.

PART 1. INTRODUCTION

The Broken Hill Pty. Co. Ltd. which holds a mineral exploration title over this part of South-West Tasmania, has been studying the economic potential of the Hibbs Ultramafic Belt over a number of years. From December 1970 to July 1971, a team of geologists from the company evaluated the potential of the chrysoltile asbestos depostits located at Noddy Creek in the northern part of this belt. The author was a member of this party and carried out exploration in this area, intermittently from February to June 1971. During this period the author carried out 80% of the detailed geological mapping of the ultramafic complex, at a scale of 50 feet to one inch. All the petrological specimens were collected, examined and described by the author, except for twenty four rocks sent to the Australian Mineral Development Laboratories (A.M.D.E.L.) for description and trace element analysis.

Partial rock analysis of seven specimens was also carried by A.M.D.E.L. and seventeen specimens were analysed at the Geochemical and Mineralogical Laboratories (GEO.MIN) Sydney.

The petrological work and x-ray diffraction analysis of these rocks was performed by the author at the B.H.P. Melbourne Research Laboratories.

The major emphasis has been on the ultramafic rocks in order to establish their original petrological character, distribution and relationship with other associated rock types, such as the gabbroic rocks of the mafic suite. As part of this work, associated igneous, volcanic and sedimentary rocks were examined in some detail to obtain an integrated view of the association and its possible petrogenetic significance.

A secondary objective of this work, was to try and define the petrological, structural, and chemical environment in which the chrysotile asbestos has formed, in order to predict where similar deposits are likely to be found.

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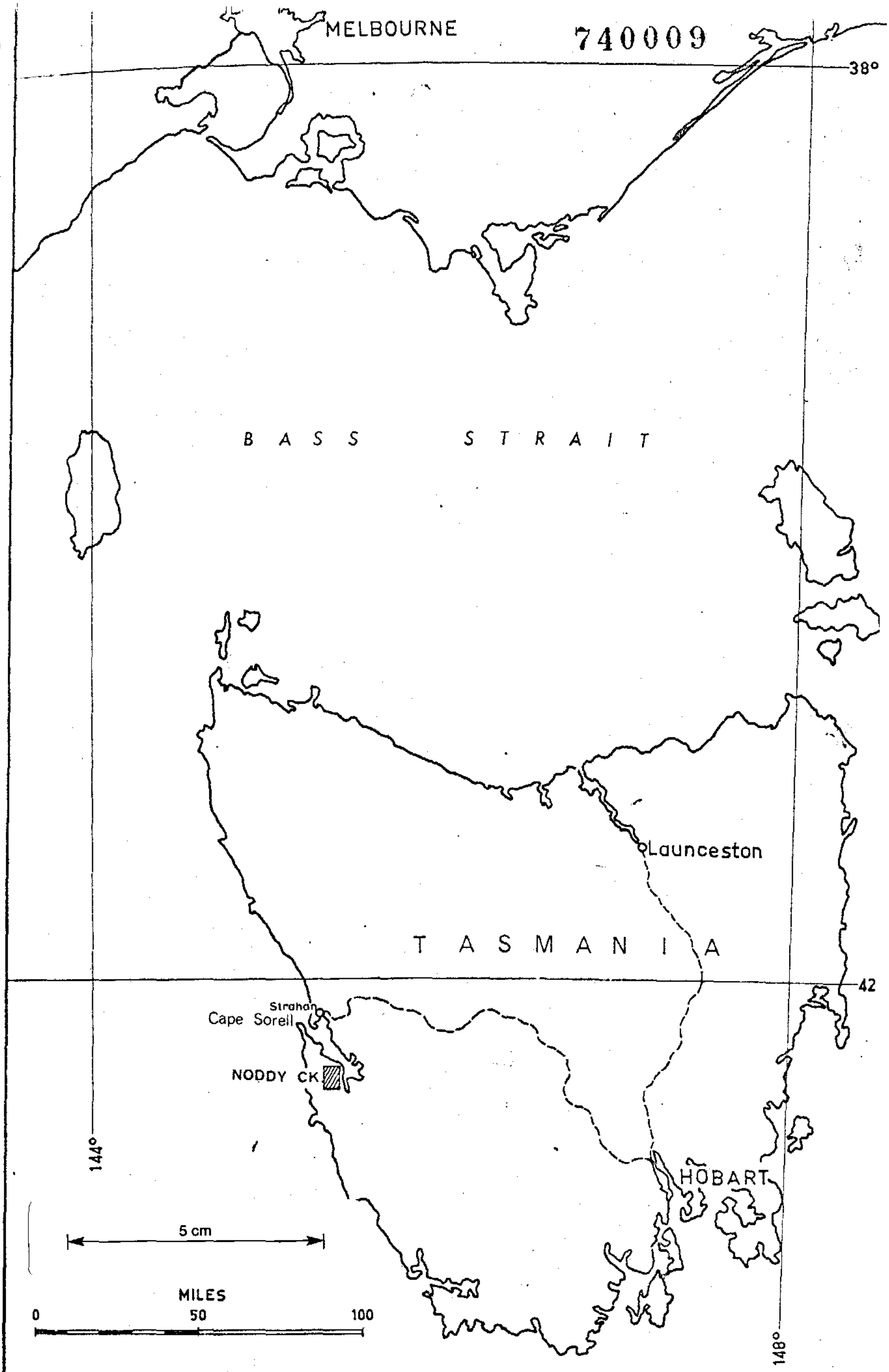

Centre Melbourne	THE BROKEN HILL PROPRIETARY CO. LTD. FIG 1	Project No.
Date 25 - 7 - 72	LOCATION MAP NODDY CREEK AREA - TASMANIA	Drawing No. A4·1455

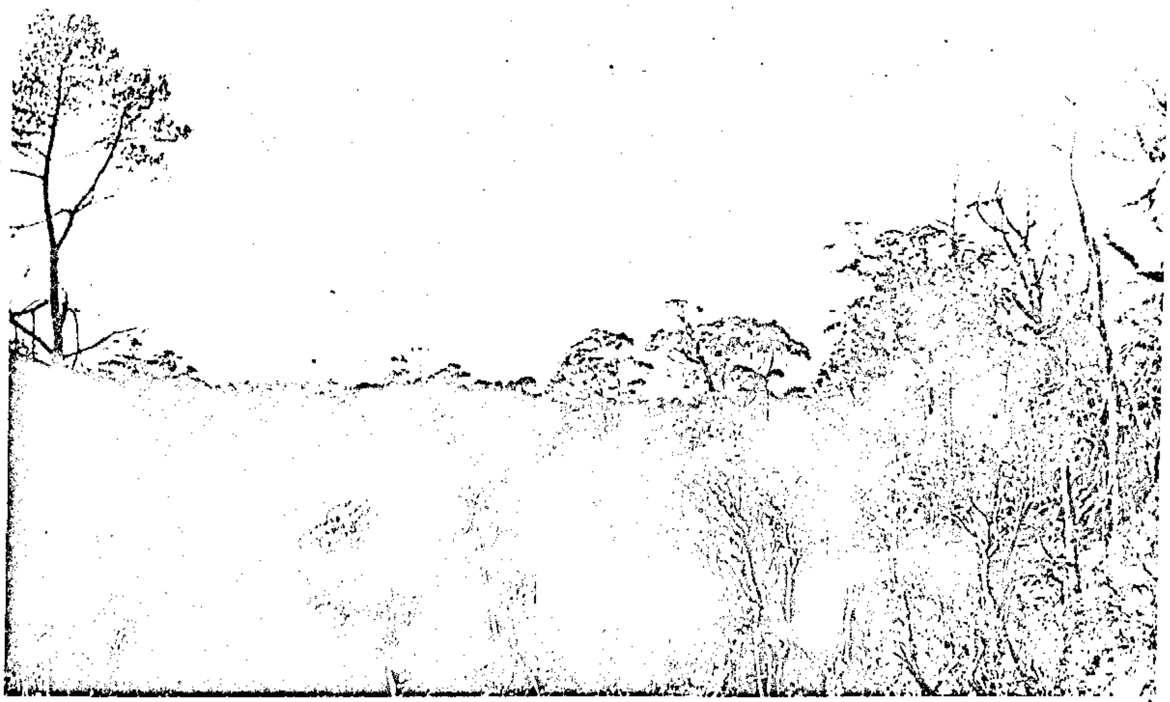

PLATE 1. View looking North from the 20N line at Noddy Creek, across Macquarie Harbour to Mt. Sorell in the distance.

(A) LOCATION AND ACCESS OF STUDY AREA

The Hibbs Ultramafic Belt occupies a narrow 25 kilometre long strip from Asbestos Point on the southern shore of Macquarie Harbour, south ~~easterly~~ westerly across the Sorell Peninsula to Hibbs Lagoon to the west coast, and also a circular complex near the mouth of the Spero River.

The area dealt within this study is situated five miles south of Asbestos Point, in that part of the headwaters of the Nelson River, known as the Noddy Creek area.

Access to the area is achieved by launch from Strahan to landings at Asbestos Point, or Birches Inlet camp, which is approximately 15 kilometres by road south-east from Noddy Creek. From the landings, tracks suitable for four wheeldrive or tracked vehicles lead to a former B.H.P. campsite beside Helipad 3 at Noddy Creek. Bulldozed tracks have been driven south along the ultramafic belt to Hibbs Lagoon and there are a number of helicopter pads in the area.

(B) PHYSIOGRAPHY; VEGETATION AND CLIMATE

The Noddy Creek area forms part of a gently undulating, 800 foot high plateau, a remnant of the Tertiary Henty suface. This surface has been deeply dissected by many creeks, rejuvenated by post glacial-uplift. To the north and east the creeks flow steeply over frequent waterfalls into Macquarie Harbour and Birches Inlet, while to the south and west the Neilson and Modder Rivers flow more slowly in deeply incised valleys down to the west coast.

The whole area is covered by thick temperate rain forest. Myrtle and sassafras forest, with patches of horizontal scrub, generally covers the Cambrian sediments, while scattered Eucalyptus with a dense undergrowth of Bauera Manuka (ti-tree) and cutting grass cover the ultrabasics.

The climate is mild and wet with annual rainfall of about 60 inches a year, most of which falls in winter. The prevailing westerly winds provide warm, dry conditions in summer, when the maximum temperature can reach 95 degrees F.; but bring cold wet weather for the rest of the year. Weather conditions usually limit the effective field exploration period to 8 months between November and June.

(C) SUMMARY OF THE REGIONAL GEOLOGY

A detailed account of the Lower Palaeozioc geology of Tasmania is given in Carey (1953), Spry and Banks (1962) and Solomon (1965). From Early Cambrian to Middle Devonian times, sedimentation occurred under geosynclinal conditions with marine shelf environments late in the interval. This sedimentation was laid down in a series of troughs developed between the Rocky Cape Geanticline in the North West of Tasmania and the Tyennan Geanticline in Central Tasmania. Geosynclinal sedimentation was dominant in the Cambrian with the formation of argillites and greywackes of the Crimson Creek Formation of possible Lower Cambrian age (Blissett 1962) and the Middle to late Cambrian Dundas Group of greywackes and conglomerate and its equivalents.

The Mt. Read volcanic arc developed adjacent to theTyennan Geanticline at the same time as the deposition of the Dundas

Group in the west.

Cambrian ultramafics occur along the whole of the length of this geosynclinal sequence, outcropping in an arc from Beaconsfield in the north, through Waratah, and Dundas in the central area, south to the Hibbs Belt. The Adamsfield and Boyles River ultramafics occur in a separate trough on the eastern side of the Precambrian Tyennan Geanticline in central Tasmania. The ultramafics appear to occur between the Early Cambrian Crimson Creek Formation (Blissett 1962) and the Middle to Upper Cambrian, Dundas Group. This is thought to be due to a combination of tectonic emplacement before deposition of the Middle Cambrian sediments, and post-Cambrian faulting (Rubenach 1971).

Late Cambrian granite and diorite bodies intrude the sedimentary volcanic sequence in a line, from the north of Queenstown to the south west coast at Lower Rockey Point. These were associated with the Jukesian Movement which produced uplift and erosion of the Cambrian rocks and restricted Ordovician sedimentation to narrow basins within the Dundas Trough. The Caroline Creek Sandstone and the Gordon River Limestone which were deposited in such basins in the region lie both conformably and unconformably on the Cambrian at different locations.

Extensive faulting, uplift, and erosion since the Tabberabberan Orogeny has removed any record of later Paleozoic or Mesozioc sedimentation in the region, except in the Pt. Hibbs area to the south.

Thick arenaceous sediments have developed in the Tertiary Mac-Quarie Harbour Graben. Pleistocene uplift of the Sorell Peninsula, has promoted extensive erosion and formation of Recent alluvium along the river valleys to the south

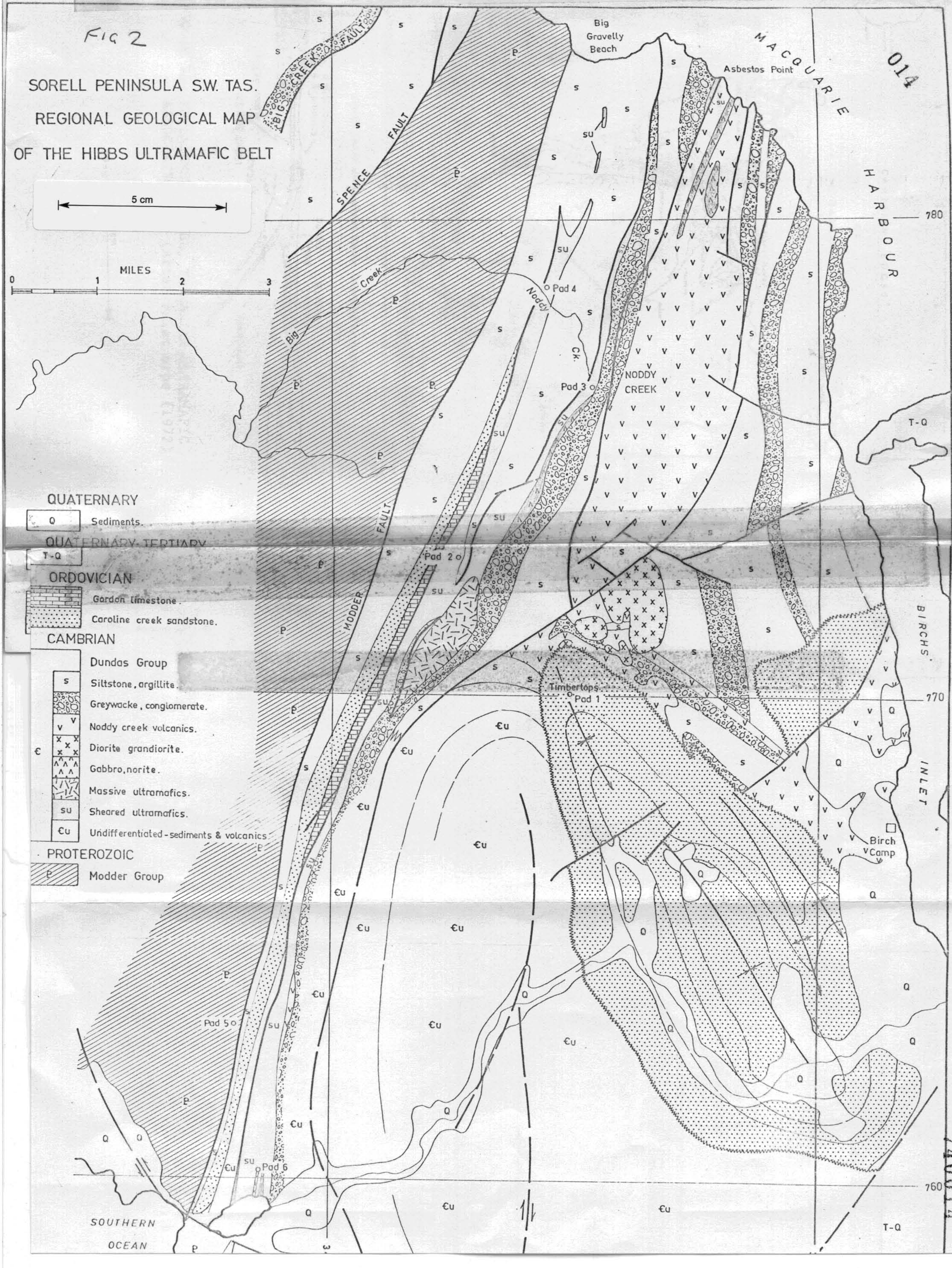

Fig 2
SORELL PENINSULA S.W. TAS.
REGIONAL GEOLOGICAL MAP
OF THE HIBBS ULTRAMAFIC BELT
5 cm
MILES
0 1 2 3
QUATERNARY
Q Sediments.
QUATERNARY-TERTIARY
T-Q
ORDOVICIAN
Gordon limestone.
Caroline creek sandstone.
CAMBRIAN
Dundas Group
s Siltstone, argillite.
Greywacke, conglomerate.
v Noddy creek volcanics.
Diorite grandiorite.
Gabbro, norite.
Massive ultramafics.
su Sheared ultramafics.
Єu Undifferentiated - sediments & volcanics
PROTEROZOIC
Modder Group
BIG CREEK FAULT
SPENCE FAULT
MODDER FAULT
Big Creek
Noddy Ck.
NODDY CREEK
Big Gravelly Beach
Asbestos Point
MACQUARIE HARBOUR
BIRCHS INLET
Birch Camp
Pad 1
Pad 2
Pad 3
Pad 4
Pad 5
Pad 6
Timbertops
SOUTHERN OCEAN
780
770
760

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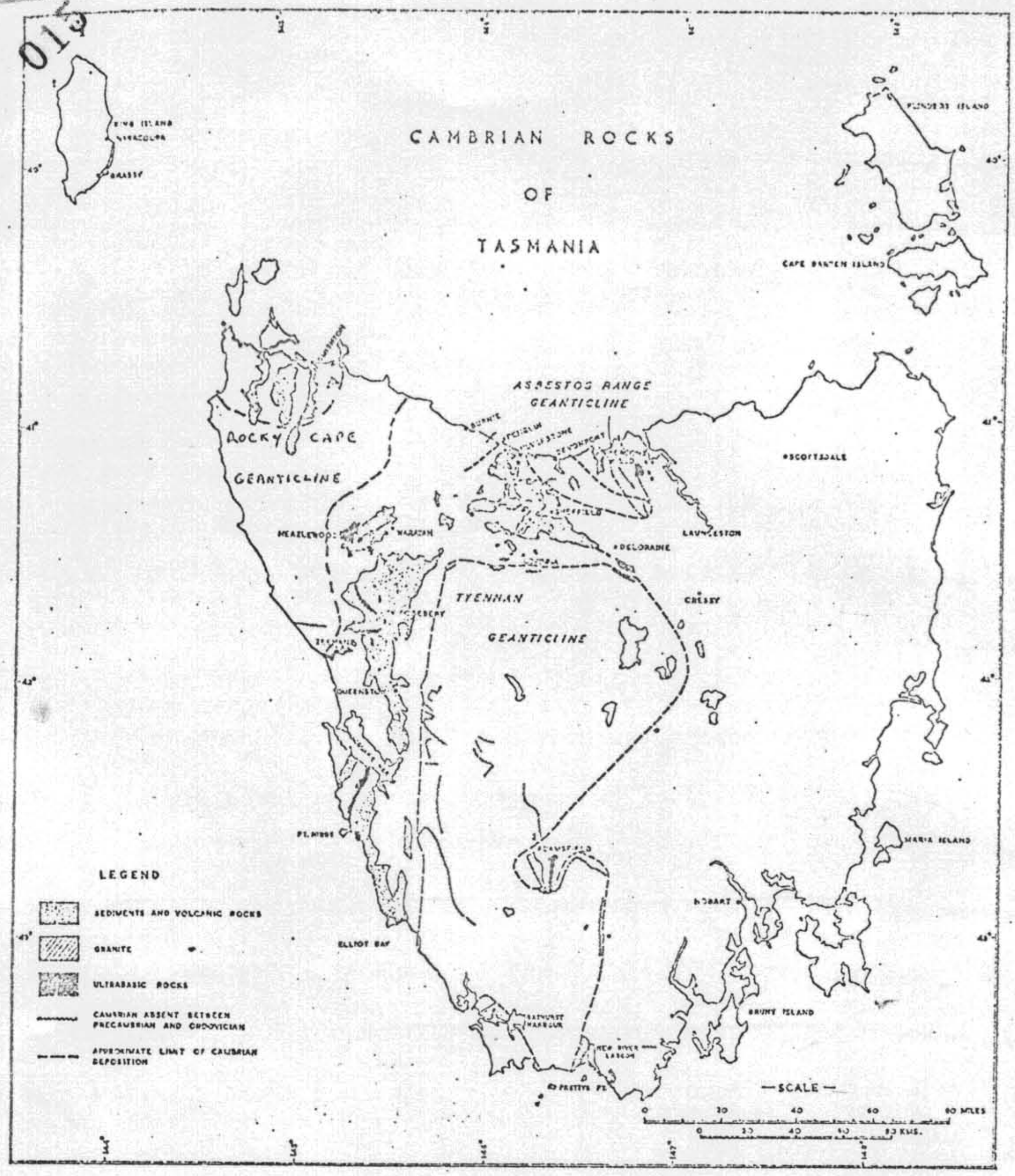

Distribution of the Cambrian System (compiled by Banks).

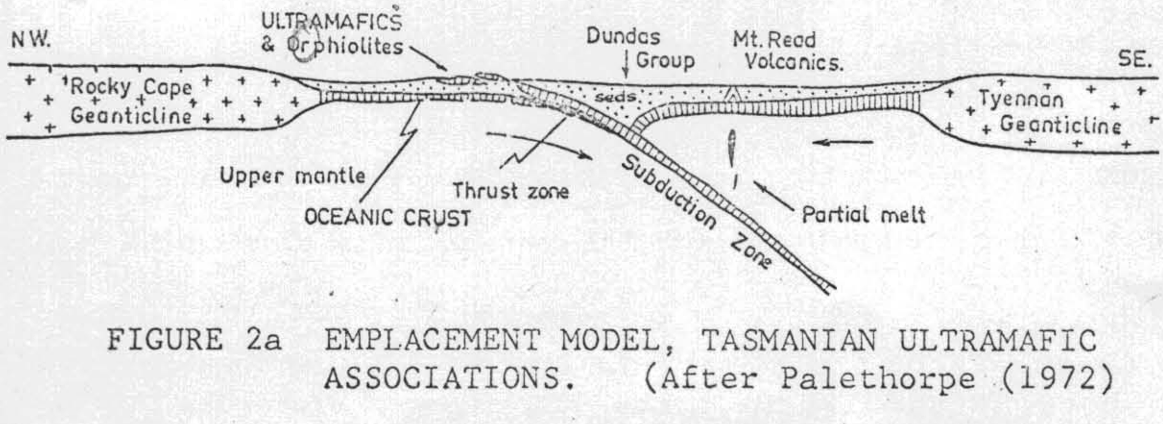

FIGURE 2a EMPLACEMENT MODEL, TASMANIAN ULTRAMAFIC ASSOCIATIONS. (After Palethorpe (1972)

5 cm

(B) PREVIOUS GEOLOGICAL WORK ON THE HIBBS ULTRABASIC BELT
mafic

The presence of ultrabasic rocks at Asbestos Point and the Spero River was known in the early 1920's and according to Reed (1921) the Spero River body was considered by the prospectors to be the southern extension of the Birch's Inlet body. The area between the two intrusive bodies was apparently prospected for osmiridium, but with only minor success. Taylor (1955) in his discussion of asbestos in Tasmania, rejected the possibility that serpentinite extends continuously between the two known occurrences, due to "The marked difference in the type of serpentinite occuring in the two areas. In the Spero area the the sepentinite cuts out a few chains north of the river, and the fact that at Asbestos Point the serpentinite definitely disappears a little over half a mile south of the coast". However he did state that the facts "do not preclude the possibility that patches of serpentinite may appear along the Spero Asbestos Point line."

In 1956 a large concession in south west Tasmania was taken up for mineral exploration purposes by a combined exploration group comprising the Mt. Lyell Mining and Railway Co. Ltd., and Electrolytic Zinc Co. of Australasia. They conducted an aerial magnetic survey over the region and proceeded with extensive ground surveys over anomalous areas including the Hibbs ultramafic belt which they termed the Modder River ultrabasics.

They outlined a belt of serpentinites continuous for about 20 kilometers which consisted of serpentinised pyroxenites, and gabbro which were generally sheared, dipped steeply to the east and from magnetic evidence they were sheet like bodies having a vertical pitch. In their summary of the economic potential of the though not in significant amounts, (Sic), Geochemical work showed the widespread presence of nickel which was apparently very finely and sparsely disseminated as no nickel minerals were recognised. Osmiridium was virtually absent from the area" (Elms). The exploration licence over the area was allowed to lapse in 1962, and in 1964 the B.H.P. Co. Ltd. began exploration in the region.

Exploration in the Noddy Creek area began in the 1967/68 field season, with the bulldozing of several miles of access tracks across and along the ultramafic belt, together with reconnaissance geological mapping of the area. In the 1970/71 field season, a detailed geological mapping and drilling programme was undertaken to evaluate extensive chrysotile asbestos occurrences in the ultramafics, located during previous base metal exploration at Noddy Creek.

The author was a member of this exploration team and was responsible for the majority of the detailed mapping on a scale of 1" to 50' over the entire area, undertaken from March to June 1971.

The Noddy Creek track system was surveyed, and a grid placed over the area, with its origin at Pad 3. Costeans across the ultramafic body were cut to bedrock at approximately 500 foot (165 metre) intervals and are referred to in the text as the 500 foot North line (5N), or the 1000 foot South line (10S), etc.

The author has reported the details of previous exploration in this area because of the paucity of geological information known about this part of Tasmania, and the lack of any recent or past publications apart from Taylor (1955) of the detailed geology of any part of the Early Paleozoic rocks to the west of Birches Inlet.

PART 2 - GEOLOGY OF THE NODDY CREEK AREA

(A) STRATIGRAPHY

The geosynclinal sequence into which the Hibbs Ultramafic Belt is intruded contains up to 34,000 feet (11,000 metres) of Cambrian greywacke, argillite and andesitic volcanics as well as small bodies of diorite and gabbro. In the west the base of the Cambrian is faulted against Precambrian metamorphic rocks and the top of the Cambrian is conformably overlain by Ordovician sandstone. To the east the Cambrian is unconformably overlain by the Ordovician Caroline Creek Sandstone; a considerable thickness is missing (Hall et al 1969). All age relationships observed in the Cambrian sequence indicate younger beds towards the east.

The ultramafic belt outcrops as a single unit from Hibbs Lagoon to a position approximately 15 kilometres south of Asbestos Point (3 kilometres south of Pad 2). From this locality two diverging bodies, the eastern and western ultramafics outcrop continuously northwards until they are both faulted out about 3 miles south of the shores of MacQuarie Harbour. The eastern and western bodies join briefly a one kilometre south of Pad 2, where the total thickness of ultramafic is 1,000 metres, the thickest part of the whole belt.

This study deals specifically with the eastern ultramafic body, and its adjacent sediments along a strip 3 kilometres long and a kilometre wide, centred on Helipad 3 at Noddy Creek.

(i) SEDIMENTS

The sediments to the west of this ultramafic body are a monotonous sequence of pale grey to black siltstones with minor bands of pyritic carbonaceous siltstone, greywacke and shale. The regional strike is N20°E and the dips are essentially vertical although they lie in an easterly direction near the ultramafic contact.

Bedding structures and laminations are well exposed in track cuttings and along cleared traverses. Adjacent to the ultramafic contact from line 15S to 30N line at Noddy Creek is a black to dark grey pyritic, graphitic-carbonceous siltstone, which from exposures in various costeans is highly sheared and slightly hornfelsed at the contact. This contact looks like a faulted contact due to the smooth contact surface, the shearing, and the straightness of the contact over at least 1,300 metres. Brecciation and fault gouge on the 15S line confirms the faulted nature of the contact.

The sediments to the east of the ultramafic body have the same strike and vertical dips as the sediments to the west but are noteably coarser. They consist of greywacke, siltsones, sandstones and conglomerates. The sediments adjacent to the ultramafic-mafic contact have all been metasomatized and highly sheared for distances varying between 15 metres and 30 metres from the contact. These altered sediments are more fully discussed under the heading of Metasomatism.

Immediately east of Pad 3 at Noddy Creek are several distinct bands of conglomerate 3 - 5 metres thick which alternate with greywackes and siltstones. These congomerates contain elongated and sheared clasts of milky quartz, greywacke, argillite, and fragments of fuchsite rich schist. A large fuchsite rich pebble examined by Rubenach in 1968 appeared to have gabbroic texture and as a result was considered to have been derived from the gabbros associated with the ultramafic belt. Thus the eastern contact of the belt may have been an erosion surface for a short interval during the Cambrian. Graded bedded from conglomerates, through greywackes to siltstone appears to take place in the sediments to the east of the ultramafic belt. This is typical of the Dundas Group according to Banks (1956). East of Helipad 3 the greywacke is 225 Metres wide but it thins considerably to the north and is only 30 metres wide along the 20N line (McGregor 1968). At this locality the greywacke is intruded by gabbro and exhibits honfelsed contact rocks. Greywacke continues east of the gabbro to where it is faulted against volcanics further to the east. Approximately 300 metres north of Helipad 3 several thin lenses of serpentine intrude the greywackes about 70 metres from the main ultramafic contact. These lenses have sheared margins and some metasomatism of the sediments has taken place.

Approximately 650 metres south of Helipad 3, 350 metres of greywacke is faulted against the ultramafic belt to the west, and conformably underlies 160 metres of siltstone to the east. This siltstone unit is faulted against volcanics to the east and is very similar to the siltstones to the west of the ultramafics, but is not thought to be its equivalent.

(ii) VOLCANICS

The Noddy Creek Volcanics are faulted against the greywackes and siltstone east of Noddy Creek but to the north are conformable with the greywacke (McGregor 1968).

The volcanics are up to 225 metres thick east of Noddy Creek and consist dominantly of andesitic lavas of two types mixed with tuffs, agglomerates, minor spilites, and basalts.

At Timbertops, 7 kilometres south east of Noddy Creek, the volcanics are intruded by a number of bosses of hornblende diorite, quartz diorite, and porphyritic microgranite, while at the northern end of the volcanic belt they are intruded by gabbro. The volcanics have undergone metasomatic alteration resulting in the introduction of chlorite, calcite and epidote, with minor pyrite and chalcopyrite mineralization.

Minor volcanic horizons are known to occur in the greywacke units. These are much altered, usually chloritized and silicified and were probably porphyritic andesites and quartz porphyries. A typical example is the completely altered vesicular volcanic rock present between gabbro and sediments on the eastern contact along the 10S line. No attempt has been made to correlate the Noddy Creek Volcanics (after Hall et al) with other Cambrian volcanic rocks, because age relations have not been satisfactorily worked out for these other volcanics. The author suggests that, because of their petrologic composition and stratigraphic position conformable with Dundas Group sediments, the Noddy Creek volcanics could be correlated with Mt. Read Volcanics to the north of MacQuarie Harbour.

The stratigraphic details of the sucession given here, were taken from unpublished B.H.P. Co. Reports by Hall et al (1968) and McGregor (1968), because the geological mapping by the author at

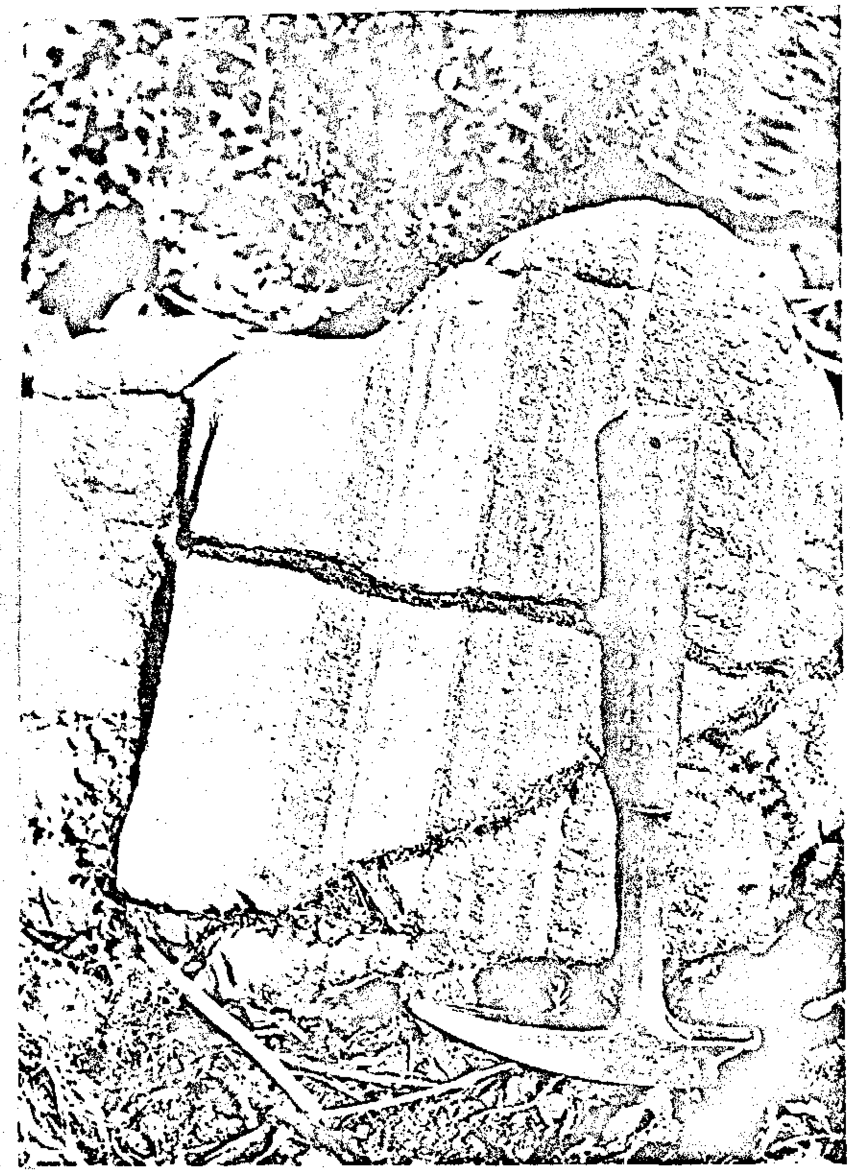

PLATE 2. Outcrop of massive serpentinised and steatitised pyroxenite, exhibiting near vertical primary igneous layering. 10S line Noddy Creek.

Noddy Creek was almost exlusively confined to the ultrabasic body and the immediately enclosing sediments.

(iii) ULTRAMAFICS

The eastern ultramafic belt through the Noddy Creek area extends in a NNE direction from Pad 3 for a distance of approximately 3,300 metres where upon it is faulted out. To the south west from Pad 3 it extends for at least 2,250 metres and then may be faulted out for a short distance before continuing on for several kilometres to where it thins and presumably cuts out or merges at depth with the western ultramafic belt.

Within the study area the ultramafic belt varies between 80 metres and 280 metres wide averaging 165 metres wide. The ultramafics consist of banded pyroxenite, minor peridotite, norite, gabbro, serpentinite, and minor diorite, granodiorite, and lamprophyre. Altered equivalents of most these rock types outcrop extensively especially along the margins of the intrusive complex. In general the mafic rocks, norite and gabbro are confined to the southern end of the belt, but they also occur as narrow intrusions in the north along the contacts of the ultramafics. All these rock types and their metasomatized equivalents are described separately and in detail in the following chapters.

(B) STRUCTURE

(i) THE SORELL PENINSULA

The regional structure of the Sorell peninsula was poorly known before the advent of large scale mineral exploration with area in the late 1950's. Aerial surveys indicated a broad zonal arrangement of the rock units, separated by major NNE trending faults. Field work by mining companies, noteably Lyell-E.Z. Exploration Company and later the B.H.P. Co. Ltd., has resulted in the production of a fairly detailed geological and structural picture of the region.

Three major normal strike slip faults trending NE-NNE occur in the western part of the Sorell Peninsula. The two westerly faults known as the Liberty fault and the Spence fault have produced a graben structure, filled with essentially Cambrian but possibly Precambrian sediments. This structural block is known as the Double Cove Belt (Hall et al, 1968). It is flanked on either side by Precambrian sediments of the Modder Group which have been regionally metamorphosed to the greenschist facies. The Modder Group has a regional strike of N20°E, is isoclinally folded with a prominent axial plane cleavage and has essentially vertical dips.

The third major fault known as the Modder Fault, separates the Precambrian to the west and Cambrian-Ordovician sediments to the east. The Spence and Modder faults produce between them a horst structure of Modder Group sediments.

The Cambrian sediments and volcanics east of the Modder Fault, are known collectively as the Hibbs Belt. This belt has been subject to tectonic stress from the east and west and has subsequently been folded into tight but open folds with a general NNE strike and steep to vertical dips. This compression has also produced a number of slightly oblique strike slip faults along which the ultramafic and gabbroic rocks have been reintruded. These faults have produced considerable vertical movement but little or no horizontal movement.

To the south and south east of the Noddy Creek area the fold axes swing to the south east and a prominant syncline plunging gently to the South East and capped by ordovician sediments is well exposed. Directly to the south an anticline plunging to the north west has been inferred.

(ii) THE NODDY CREEK AREA

At Noddy Creek the regional strike is N20°E and the ultrabasic body forms a slightly discordant structure through the area. Between the 20S line and the 60N line there is a marked convex eastwards flexure in the intrusive body. This is interpreted as being produced by folding of the ultramafics or by a curved fault along the western contact of the body. Evidence for the existance of this fault is widespread, and is set out below:-

(1) Highly sheared serpentine occurs at the contact all exposures.

(2) The contact rock from 20S to 50N is a graphitic siltstone, this horizon would clearly be a weak zone the sedimentary sequence and faulting could be expected along it.

(3) The contact is fairly smooth except for minor irregularities in the 10N and 50N areas. Black fault gouge is seen in the costeans across the contact at the 00 foot line and the 15S line (ref. Plate 3)

(4) On the 10N line 2 metres of ochreous clay derived from decomposed crushed serpentinite, occurs at the contact with sediments. The sediments in all cases appear to have been little disturbed except right on the contact where intense shearing has taken place.

The eastern contact of the ultramafics and gabbroic rocks is highly irregular compared to the western contact. Intrusion and reintrusion of the norite gabbro bodies along the contact between the ultramafic and the sediments explains the irregularities south of Pad 3 but north of this area another explanation appears to be required.

It is suggested that after the intrusion of the gabbroic rocks in late Cambrian times the area was temporarily uplifted and the eastern contact of the ultrabasic body was exposed to erosion for

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a short period. The area subsided again and was covered with the greywacke-conglomerate sequence presently adjacent to the ultramafic contact. Evidence for this erosion of the ultramafics is as yet not totally convincing and is based mainly on the presence of fuchsite rich conglomerate clasts which exhibit relic gabbroic texture, adjacent to the eastern ultramafic contact at Helipad 3. Iron rich chromian spinel and titanomagnetite possibly derived from the ultramafics is present in specimen No. 71/L1-58, a conglomerate from Helipad 3.

The irregularity of the eastern contact at Noddy Creek may also be explained by the presence of cross faults cutting the complex, but there is no direct evidence of the existance of such faults, mainly due to the poor exposure and sheared nature of the rocks along the contact. It may be important to note that north west trending shears and small faults, have been observed in the conglomerates and greywackes to the east of the contact between the 5N and 10N lines. These shears may extend into the ultramafic body, as has occurred north of the 10,000 foot line, where N.W. trending cross faults have truncated the ultramafic body.

McGregor (1968) has interpreted two strike trend faults about one hundred metres east of the serpentinite contact. These faults have interposed a narrow block of sediments between the eastern serpentine-gabbro complex and also after metasomatism of the sediments by the gabbro. Within the eastern faulted block the continuous nature of both the gabbro and its hornfelsed contact rock, indicate that either the gabbro is more extensive at depth along the serpentinite contact north of Helipad 3, or, that it has been eroded from the contact where the surface now exists. This close relationship between the gabbro and hornfels also serves to show that the gabbro not the serpentinite is responsible for the contact metasomatism experienced

PLATE 5. Faulted contact between highly sheared and decomposed serpentinites on the left and sheared carbonaceous pyritic siltstone on the right. West end line 15S. Note the sharp contact and the bleached nature of the serpentinite on the contact.

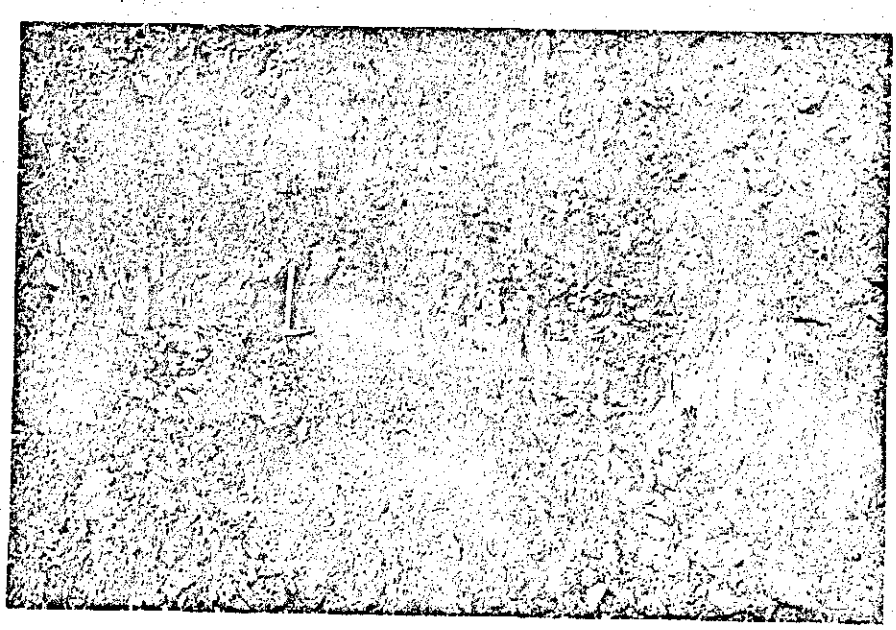

PLATE 6. Intrusive contact between (?) layered gabbro weatherd yellow-brown, and light green vertically sheared serpentinite east end 25N line. Note the irregular ½ metre thick (?) carbonaceous contact zone below talc rich gabbro.

along the eastern side of the complex.

The two easterly strike slip faults mentioned above are interpreted to have originated during the Jukesian movement of the Tyennan Orogeny, i.e. late Cambrian or early Ordovician age. There has undoubtedly been further movement along these faults and also shearing within and adjacent to the ultramafic-gabbroic complex. This movement probably occurred during the Middle Devonian Tabberabberan Orogeny when compression from the east and west produced the major folding in the Cambrian and Ordovician sediments. A later set of compression directions from the north east and south west, produced the large plunging folds situated 10 - 15 kilometres south west of the Noddy Creek area.

The ultramafic body itself is highly sheared, with more than 4/5 of the whole body being sheared to some degree. Because of this tremendous amount of shearing, strike or cross faults are unrecognisable in the field as such, although they may be present.

Little attention was given by the author to the structure of the individual areas within the complex. However taking the complex as a whole, areas of shearing, their general shearing direction, if any, and the extent of shearing, were noted on the 1' to 50' geological fact maps covering the complex (Figs 13 - 21). Elongated blocks of pyroxenite, serpentinised pyroxenite or massive serpentinite occur throughout the ultramafic body as pods within sheared serpentinite and subparallel to the intrusive margins. Both margins of the serpentinite belt are highly sheared parallel with the ultramafic contacts. Shear planes around massive serpentinite tend to parallel the discordant trends of the contacts of massive rock, and resemble structures in incompetent rocks surrounding boudins (Langlands 1971). not listed

This relationship is a general feature of the ultramafic body as a whole and is constantly repeated right down to very small scale structures.

PLATE 7. Minor structures in the greywackes to the east of the ultramafics, in road cutting. Note the thin bedding, imbricate faults and tight isoclinal folding.

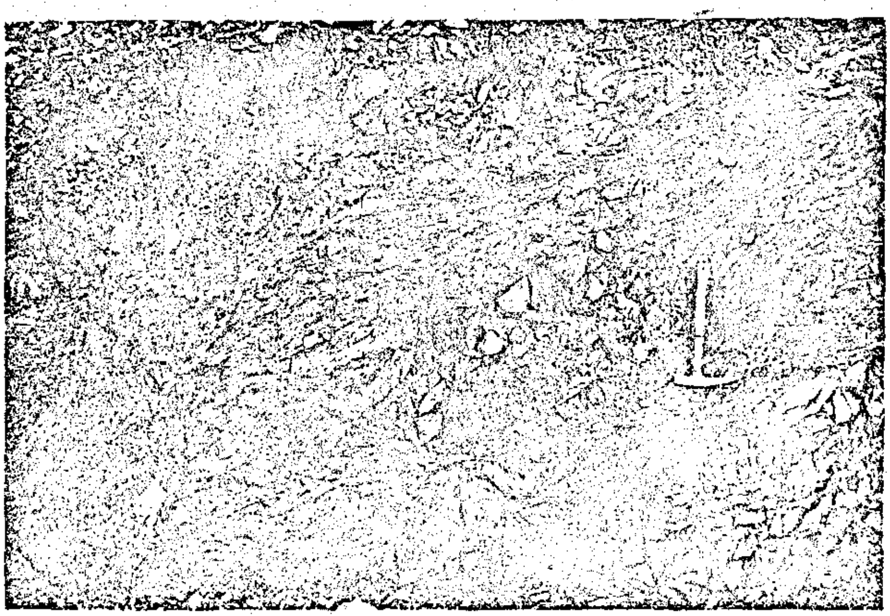

PLATE 8. Typical massive and sheared serpentinite type 3. Stichtite bearing, central zone 45N line. Note the development of white slip fibre along shears near hammer.

During the regional compression of the Tabberabberan Orogeny, the serpentinite body acted as a rheid - (after Carey) and was deformed internally by shearing while the body as a whole remained essentially intact. Lenses of serpentinite and gabbro are known to exist apart from the main complex and are thought to be emplaced by secondary thrusts genetically related to the main thrust sheets.

The extreme nature of the internal shearing can be seen in shear zones on the surface and in drill core, where large and small scale brecciation and shearing has produced masses of unconsolidated wafer-thin flakes of foliated serpentinite. No attempt was made to map in detail, minor structures such as micro-crenulations, lineations or tension gashes. However the minor petrological structures such as micro-layering were noted and are reported in the chapter on petrogenesis of serpentinites.

(c) GENESIS OF THE ULTRAMAFIC-GABBROIC COMPLEX

The Tasmanian ultramafic complexes are very similar to each other in their petrology position in the stratigraphic sequence, and time of emplacement. Therefore it is considered quite likely that they have similar origins and genesis.

It is suggested in Rubenach (1971) in his study of the Tasmanian ultramafic complexes - "that the ultramafics together with the gabbros, dolerites and volcanics associated with many of them, originally may have formed as oceanic crust during the spreading apart of the Precambrian blocks in the late Proterozoic or early Cambrian. During the early phase of the development of the Mt. Read Volcanics as an island arc, slices of this oceanic crust were tectonically emplaced as the ultramafic or ophiolite complexes".

current theories of genesis of this type of complex.

A study of the regional geology and the detailed geology of the Noddy Creek area, has enabled the author to propose a theory of the genetic history of the complex.

The ultramafic body is considered to have possibly originated from a magma formed at the mantle-crust interface by heating of the upper mantle material. Movement along a subduction zone in the crust produced a trough in the developing geosyncline between Precambrian blocks in western Tasmania. Continued movement of the crustal blocks facilitated the upward movement of the differentiating magma into the crust. Periodically, tectonic movements emplaced the ultramafic material as crystal mushes, along low angle thrust planes into the eugeosynclinal sequence of Dundas Group sediments. Rapid cooling of the ultramafic body during emplacement resulted in the body behaving originally like a hot crystalline diapir, and finally as a cool crystalline partially serpentinized, layered intrusive emplaced concordantly and bounded by thrust faults. As the temperature of the body cooled below 500°C, pervasive partial serpentinization took place in the still rising body. This was facilitated by the absorption of water from the surrounding sediments. As a "cool" intrusive the body produced no marked metamorphic contact aureole in the higher reaches of the crust.

Shortly after this first phaze of serpentinisation, gabbros and norites were intruded into the ultramafic body and along its contacts with the sediments. Some metasomatism around the edges of these mafic rocks may have taken place at this time. In the Middle Cambrian continued thrusting or general uplift of the sediments may have briefly exposed the complex to erosion, giving rise to ultrmafic detrital material in the overlaying sediments.

'alpine type' ultramafic body and very similar to the other Cambrian ultramafics in Tasmania, and to the ultramafic bodies in the Great Serpentine Belts of New South Wales.

This proposed genetic theory is elaborated upon and discussed in later chapters dealing with the primary ultramafic and mafic rocks.

(D) METAMORPHISM

The ultramafic-mafic body and its surrounding sediments have undergone considerable and varied changes due to metamorphism.

Generally the Cambrian sediments have not experienced any appreciable metamorphism during or after consolidation and tectogenesis. Locally, however, considerable metamorphism has occurred around Cambrian acid to intermediate intrusions such as are found 9 kilometres south east of Noddy Creek. At Noddy Creek, the ultramafic body has undergone almost complete serpentinisation which was followed by metamorphism to a small degree. The mafic rocks, experienced only minor serpentinisation but were highly metamorphosed especially along the margins of the bodies. The Lamprophyric dyke intrusions, and the sediments surrounding the intrusive complex, have also been partially metamorphosed.

The serpentinisation of the ultramafic body is dealt with under the section headed serpentisation. All the rest of the metamorphic changes have been grouped under the heading of Metamorphism and Metasomatism and are reported in that section.

PART 3. THE PETROLOGY OF THE ULTRAMAFIC-MAFIC COMPLEX

The petrology of this body is described under the five general headings listed below :

A. The Primary Ultramafic Rocks
B. The Primary Mafic Rocks.
C. The Lamprophyric Suite.
D. Serpentinisation.
E. Metamorphism and Metasomatism.

It was decided to study the body in this way in order to illustrate the genetic sequence of these complex rock types and the series of alterations that they have been subjected to.

(A.) PRIMARY ULTRAMAFIC ROCKS.

As described previously almost the whole of the original ultramafic body has been serpentinized. Unserpentinised primary rocks are fairly rare and are only found in the central parts of massive blocks of marginally serpentinised pyroxenite. Three such blocks exist at Noddy Creek.

The first is the western part of the body from the 4S line to 10N line and the second and largest block in the central part of the belt from the 7S line to the 15S line. A third minor body outcrops south of the 00' line to the 4S line on the eastern side of the ultramafics, and may be the northern extension of the second block. Massive partially serpentinized pyroxenites outcrop as partly rounded or pod shaped bodies in serpentinite, which are covered by a buff coloured iron rich weathered crust about 1 cm. thick. The large outcrops of primary ultramafic rock have a thinner weathered crust and are dark green to black in colour depending on the degree of serpentinization. They also exhibit layering which is emphased by differential weathering of individual layers.

(i) Classification.

Thin section rock descriptions have been made by the author and by A.M.D.E.L. for a number of specimens from the first two blocks of massive primary rocks. These have formed the basis for the classification of the rock types at Noddy Creek. The ultramafic assemblage is given below :

1. Peridotite
2. Websterite
   (a) Olivine Websterite
   (b) Enstatite Clinopyroxenite
   (c) Hypersthene Clinopyroxenite
   (d) Augite Hypersthenite
3. Clinopyroxenite
4. Hypersthenite
5. Enstatolite - Bronzitite

With only one exception all the primary rocks examined were pyroxenites. A wide range of pyroxenite rock types from olivine clinopyroxenite through to monomineralic orthopyroxenites such as hypersthenite, have been identified. A study of the serpentine textures of specimens within or marginal to these massive serpentinized pyroxenite blocks has shown that olvine was present in phaze layers. Some of the serpentinites were probably formed from olivine rich rocks such as Lherzolite, harzburgite and other varieties of peridotite.

Thus it can be shown that the primary ultramafic rocks at Noddy Creek, are pyroxenites with a small percentage of peridotite.

(ii) PRIMARY MINERALOGY AND TEXTURES

The primary ultramafic rocks are considered to have been crystallized within a magma chamber and exhibit typical cumulate textures.

The cumulus minerals identified are :

1. Olivine
2. Orthopyroxene
3. Clinopyroxene
4. Chromite
5. Magnetite

Olivine

As stated previously olivine is relatively rare. This is partially due to the fact that olivines are normally the first mineral group affected by serpentinisation so it is not surprising that little unaltered olivine occurs in these rocks and it should be expected that peridolites originally were present in larger amounts at Noddy Creek. The presence of detrital osmiridium and gold in the Big Gravelly beach area on the southern shores of McQuarie Harbour indicate the presence of peridotite rocks at the northern end of the Western Ultramafic Belt about 5 miles north-north west of Noddy Creek. The olivine is present as small to medium sized, equant, euhedral-subhedral or rounded crystals. In specimen 71/L1-53 the olivines in the peridotite phaze average 1.5mm in diameter while in the olivine websterite phaze they average 1.mm varying from 0.5 mm to 1.5 mm in diameter.

Serpentinisation of the olivines produces a typical feather or hour glass mesh texture in the serpentine within which the original equant crystal bounderies of the olivine can sometimes be faintly dicerned. This is especially obvious when opaque material resulting from the serpentinisation follows fractures in the original olivines and along their crystal boundaries (Ref. plate 27)

Orthopyroxene

The Orthopyroxenes are the dominant mineral species in the primary ultramafic rocks. Hypersthene and enstatite are both common constituents of these rocks and Bronzite is also suspected. Bronzite has not been positively identified because all these

minerals have only be identified by optical methods and not by chemical or analytical methods, such as x-ray diffraction.
The Orthopyroxenes are present as cumulus minerals only in the websterites, but they occur also as post cumulus material in the orthopyroxenites. In clinopyroxene rich rocks, the orthopyroxene may be present only in exsolution lamellae with clinopyroxenes, or as subhedral crystals, usually with schiller texture, which crystallized first and are scattered through the clinopyroxenes.

Clinopyroxene

Clinopyroxenes are also a common primary rock constituent and are taken to be mostly augites on examination of their optical properties. Clinopyroxenes in fact have been identified in almost all the primary igneous rocks including the lamprophyres which outcrop at Noddy Creek. In the ultramafic rocks and particularly the websterites, clinopyroxene is present mostly as post-cummulas material. This has an average diameter of 0.3 mm between the large cumulus orthopyroxenes with diameters in the range of 4-5 mm. Large cummulus clinopyroxenes up to 4mm and 4.5 mm in diameter occur in clinopyroxenite and olivine websterite respectively. Clinopyroxene is also present as exsolution lamellae within large orthopyroxenes exhibiting schiller texture. Twinning in the clinopyroxenes is quite common, particularly in the large cummulus crystals but also in the interstital post cummulus material.

Chromite

Chromite has been identified in thin or polished sections of most of the ultramafic rocks including sepentinites. It is present as a 1-2% minor constituent cumulate mineral between the pyroxenes and occurs as equant, euhedral to subhedral crystals.

Chromite is scattered in an apparent random manner in both pyroxenites and serpentinites, being disseminated evenly through a rock when it is present. However it appears to occur preferentially in orthopyroxenites and websterites, in deference to clinopyroxenites and peridotites. This may be a local trend or may be entirely misleading, as only a dozen thin sections of these rocks were examined.

Magnetite

There is no positive evidence to suggest that this mineral occurs as a primary cumulate mineral. It often does not occur in the massive pyroxenites and when it is present the rock is partially serpentinised and most of the magnetite occurs within fractures. However some equant subhedral magnetite crystals which may be of primary origin exist within the pyroxenites.

Textures in the Ultramafic Rocks.

The ultramafic rocks exhibit typical cumulate textures. The peridotite layers (ref. 71/L1-53) show that olivine was the first cumulate to form, followed by minor orthopyroxene and lastly clinopyroxene. The clinopyroxene formed as cumulus minerals especially near the margins of the layer, but usually it occurred as post cumulus material between the other two mineral phases. Chromite is notibly rare 1%, or absent from the peridotite layers. This specimen exhibits a ratio contact between Peridotite and Olivine Websterite.

Specimen (71/L1-101) is completely serpentinised, however the textures in the serpentine indicate the former presence of olivine and orthopyroxenes. Size grading in the minerals appears to occur in one layer. At the "base" large planar laminated bastiles (2-3mm in diameter) give rise to smaller bastiles with possible intercumulate serpentinised olivine remnants. This in turn grades up to indistinquishable serpentine material, possibly forming after small olivine crystals. Above this fine grained serpentine layer, serpentine with much coarser texture is present, suggestive

038

of former large cummulate pyroxenes. The change in the distribution and amount of opaques between the layers is very marked. Layering is also evident in the hand specimen. It appears that this specimen exhibits crystal graded bedding as well as phaze contacts between layers. Specimen (71/L1-164) exhibits apparent phaze layering in serpentinite (Ref. Plate 27) with distinct textural colour and hardness differences between layers of peridotite and pyroxenite.

(iii) DESCRIPTIONS OF ROCK TYPES

(a) Peridotite specimen No. 71/L1-53

The thin section of this specimen crosses a ratio boundary in the rock, and thus two rock types occur in the one slide. They are Peridotite and olivine websterite.

The Peridotite layer contains about 75% olivine, 20% augite and 5% enstatite. The olivines are equant and average 1.5mm in diameter ranging from 0.6 mm to 2.2mm. They are subhedral when in contact with other olivines and euhedral in contact with clinopyroxenes which form both cumulus and post cumulus material.

Talc has begun to replace the olivines and orthopyroxenes marginally and along fractures. Chrome spinel is not evident in this phaze of the specimen and since there is little serpentinisation, magnetite occurs only in trace amounts, within the serpentine filled fractures. (Ref. Plate 9)

(b) Websterite

Four varieties of this group of pyroxenites have been identified.

(i) OLIVINE WEBSTERITE Specimen (71/L1-53)

This layer in the specimen contains 45% clinopyroxene, 40% olivine and 15% orthopyroxene with traces of altered chromite.

The olivine are smaller than in the peridotite layer and average

PLATE 9. SPECIMEN 71/L1-53 PERIDOTITE BAND
Talc is rimming and filling cracks in the olivines. Amphibole (tremolite) is forming in the matric between the olivines and pyroxenes. MAGx2.5xNICOLS

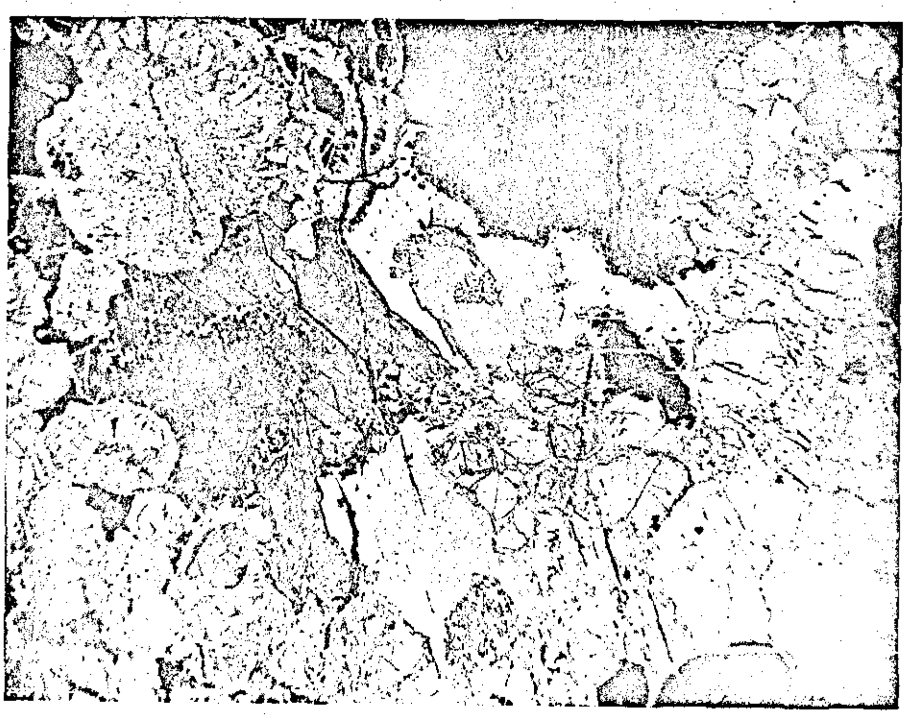

PLATE 10. SPECIMEN 71/L1-53 OLIVINE WEBSTERITE BAND
The olivine is being replaced by talc (top left). The tremolite (centre left) has replaced former clino-pyroxene, it is fractured and filled with chlorite and magnetite crystals. MAGx2 5xNICOLS

5 cm

mm in diameter. They are surrounded by large augites up to 4.5 mm in diameter, sometimes twinned and exhibiting crude planer lamination parallel to the boundary of the rock types. Large orthopyroxenes, mm in diameter, probably near enstatite in composition are scattered in small groups through the rock. Chromite now almost completely altered to titanomagnetite occurs as scattered rounded grains. Tremolite and/or hornblende is altering from the large clinopyroxenes and forms subhedral laths with ragged ends due to growth patterns in the tremolite. (Ref. Plate 10)

(ii) ENSTATITE CLINOPYROXENITE Specimen (71/L1-56)

This is a light grey medium-coarse grained massive rock. It has been partially sheared, serpentinised and metasomatically altered to tremolite-chlorite and talc (Ref. Plate 12). The clinopyroxene probably augite has remained essentially unaltered and constitutes approximately 60% of the rock. Enstatite originally approximately 40% of the rock, exhibits schiller texture with chinopyroxene exsolution lamellae, all but 5% of the enstatite has now been altered. The first alteration product was the formation of bastite pseudomorphs after the enstatite crystals and was followed by tremolite-chlorite as felted masses in shear zones. Irregular late stage serpentine veins appear to cut across the pyroxene crystals at a high angle to the cleavage and are subparallel to each other. These serpentine veins have been partially altered to chlorite and talc.

Very minor opaques are present, and are probably a mixture of cumulus chromite and magnetite produced by serpentinisation of enstatite.

Specimen (71/L1-64) This rock was very similar in original composition to the previous specimen. The twinned clinopyroxene remains mostly

5 cm

1.0mm

PLATE 11. SPECIMEN 71/L1-157 SERPENTINISED ORTHOPYROXENITE
The pyroxenes have been replaced marginally by talc. Late stage serpentine veins with fibro-lamellar texture cut the rock. Subhedral (?) chromite crystals occur within the pyroxenes. MAGx2.5xNICOLS

1.0mm

PLATE 12. SPECIMEN 71/L1-56 ENSTATITE CLINOPYROXENITE
This rock is slightly crushed. Tremolite, chlorite and talc are developing from the pyroxenes in the shear zones. Note the twinning in the clinopyroxenes and the bent lamellae in the shear zones. MAGx2 5xNICOLS

unaltered but the enstatite is cut by irregular serpentine veins and there is minor tremolite and chlorite alteration of large crystals of enstatite with exsolution texture. The tremolite has formed from the exsolved blebs of clinopyroxene. Extensive areas of saussurite and clay appear to be alterations of orthopyroxene and possibly also clinopyroxene.

(iii) HYPERSTHENE CLINOPYROXENITE Specimen (71/L1-49)

Originally clinopyroxene constituted 60% of the rock and orthopyroxene the remaining 40% but since its crystallization this rock has been subject to extensive alteration processes. The clinopyroxene remains essentially unaltered and is present as equi-granular subhedral crummulate crystals and large poikalitic post cummulus crystals surrounding both cummulus orthopyroxene and clinopyroxene (Ref. Plate 14). The hypersthene is almost completely altered; 50% of it forming amphibole - probably hornblende and the rest altering to cloudy brownish material composed mostly of chlorite which replaces both amphibole and hypersthene. Epidote is also suspected to have formed with the amphibole but only constitutes 1% of the rock. Within and adjacent to minor shear zones through the rock tremotile and talc have formed. No opaques were visible in the section.

(iv) AUGITE HYPERSTHENITE (71/L1-50)

This specimen is a hard dark grey to black, medium grained, massive, highly serpentinised pyroxenite. Clinopyroxene forms 5% of the rock and is largely unaltered although amphibole has formed marginally to crystals and also replaces exsolution lamellae of clinopyroxene in the hypersthenes. The orthopyroxenes, originally forming 90% of the rock, are now altering to serpentine in three forms :

5 cm

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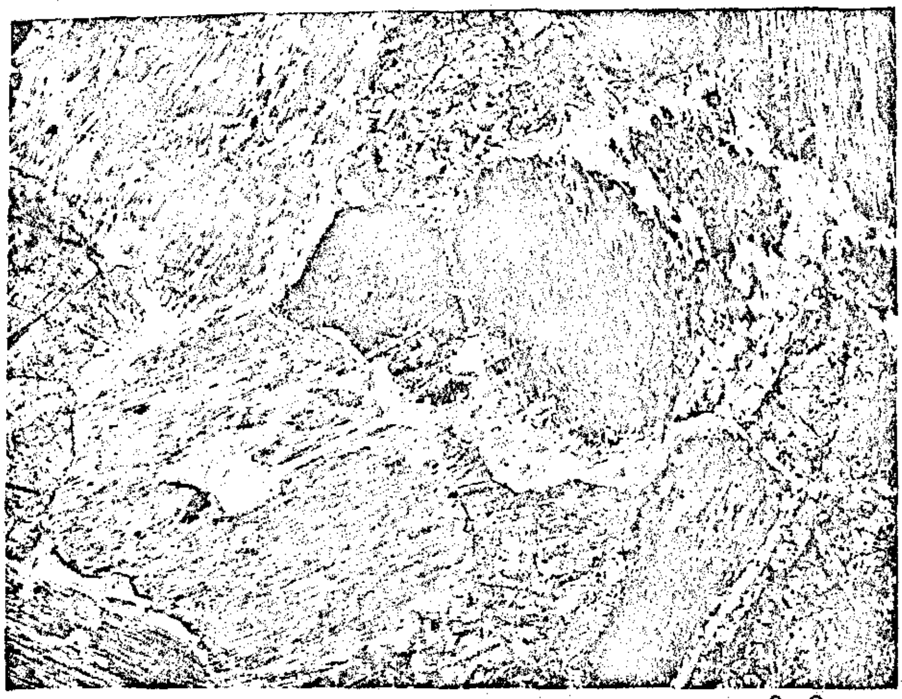

0.2mm

PLATE 13. SPECIMEN 71/L1-49 HYPERSTHENE CLINOPYROXENITE
The large orthopyroxenine (bottom left) has been almost completely altered to chlorite (dark) and tremolite-actinolite (light) crystals as fine needles or as irregular crystals. The clinopyroxenes (centre right) remain largely unaltered. MAGx100xNICOLS

1.0mm

PLATE 14. SPECIMEN 71/L1-158 STEATITIZED ORTHOPYROXENITE
Talc has almost completely altered this rock. Only the outlines of the original pyroxenes, and cleavage traces indicate the former cumulate rock texture.
MAGx2 5xNICOLS

044

1. Bastile pseudomorphs after the hypersthenes.

2. Mesh texture serpentine replacing the bastites.

3. Late stage serpentine veins.

Talc and chlorite form late stage veins replacing the serpentine. The chlorite forms light-dark green masses with possible rare clinoch ore exhibiting deep blue interference colours.

Chromite crystals which form 2% of the rock are fractured and embayed. They are sometimes equant and others are rounded probably due to marginal formation of titanomagnetite during serpentinisation.

(c) Clinopyroxenite (71/L1-55)

In hand specimen this rock is green to grey, medium grained and partially sheared with tension gashes filled by guartz. The augite crystals which up to 4 mm in diameter, are distinctly laminated and twins are common. The crystals are subhedral to anhedral in outline reflecting post cumulus overgrowth filling the interstices between the cummulate clinopyroxenes. Shearing has bent the augite lamellae adjacent to shears and has formed crush zones of broken augite crystals. The augites are mostly altered to tremolite and then talc, and set in a matrix of crushed chloritised pyroxene. Opaques appear to be absent and little or no serpentisation has taken place.

(d) Hypersthenite (71/4-69)

This specimen was preliminarily identified in the field as a bronzitite due primarily to the coarse grained, euhedral interlocking texture of the pyroxenes. In hand specimen it is a light to dark greenish grey rock which is partially serpentinized. Microscopic examination suggests that the orthopyroxene is mostly hypersthene of which 50% has been altered to serpentine and talc. Some altered crystals exhibit diallage parting and the original chlinopyroxene intergrowths have been altered to hornblende. Talc has extensively replaced the pyroxenes along grain boundaries and along fractures as a matt of fine grained flakes which constitute 40% of the rock. Epidote is rare and replaces pyroxene adjacent to fractures. Serpentine occurs as large late stage veins of fibrous and non fibrous material and is partially replaced by chlorite in the centre of these veins.

(c) Enstatolite - Bronzitite (71/L1-10)

Previous workers at Noddy Creek have described orthopyroxenite rocks from the 10S line as enstatolites and bronzitites. Palethorpe indentified two enstatolites from the drill core of DDH1 in the 10S area. The author personally has not described such rocks, however specimen (71/L1-158) described by A.M.D.E.L. but examined by the author may be a bronzitite which has been highly steatitized. In hand specimen the rock is coarse grained with large grains up to 1 cm across of steatitised ferromagnesian minerals which on the weathered surface have a distinct bronze colour. A detailed petrographic study of this specimen is reported in A.M.D.E.L. as sample NC.10 (Appendix 3)

Specimen No. B6274 (B.H.P. Rock Index) from the 00 foot line as Noddy Creek was described by Corbett as an enstatilite. It shows "interlayered bands of fine and coarse enstatite with intergrown green crystals of enstatite-climopyroxene, replaced by antigorite. Igneous banding is sharp but not usually sheared."

Thus it is seen that both enstatolite and bronzitite form part of the primary rock assemblage at Noddy Creek.

(iv) Secondary Mineralization

As seen from the previous descriptions of the rock types in the ultramafic assemblage, most of the rocks have undergone considerable alteration. This alteration has been subdivided into three types or stages. These stages are serpentinisation, metasomatism and weathering of the rocks. All these stages are described in detail in later chapters, but a list of the alteration products (in the order of decreasing importance) is given below :-

1. Serpentinite
2. Talc
3. Tremolite
4. Chlorite
5. Amphibole-hornblende
6. Saussurite and clay
7. Epidote
8. Titanomagnetite.

(v) Petrogenesis

(a) The parent magma from which the ultramafics and gabbros were both derived was originally derived from the upper-mantle and has undergone two separate periods of melting and crystal differentation. The resultant ultramafic body at Noddy Creek is deficient in Al, Na, K_2, Ti and V and enriched in Mg and Cr; except for Al these trends are repeated in other Tasmanian Ultramafic assemblages. It is proposed that the original parent material was a tholeiitic magma trending towards an ultramafic magma..

(b) Emplacement and Origin of Rock Types.

The parent magma was coneived at the crust-mantle interface by the partial melting and crystal differentiation of ultramafic material at the base of the magma chamber. Some volatile rich liquid was removed at this stage leaving the melt as a whole depleted in K and Ti and possible V and Zr. The liquid siphoned off may have moved up through the crust and eventually formed oceanic tholeiites (Green 1971). The Bald Hill Complex in N.W. Tasmania has an olivine rich, chromium poor basal unit, compared to the overlying ultramafic horizons. This is interpreted in Palethorpe (1971) to be consistant with partial melting of the upper mantle material at 40KD producing a melt strongly enriched in chromium, leaving residual olivine rich material depleted in this element.

At Noddy Creek the paucity of olivine rich rocks and the low Cr content in the peridotites may be explained by a similar process of partial melting, together with removal of the residual material by early thrusting or emplacement in lower levels of the crust.

Palethorpe (1971) states that "If the interpretation that Australian ultramafic associations are representative of oceanic crust is correct, then their emplacement must be related to the conversion of oceanic crust to continental crust. The theory most acceptable to the evidence involves the interation between lithospheric plates moving towards each other."

The Mt. Read volcanic arc and the Dundas Trough are considered to be a contemporaneous 'Island arc - ocean trench' system created by the movement of a crustal block in the west under a crustal block (Tyennan Geanticline) in the east.

Movement of the downgoing plate has been shown by Minear and Toksoz (1970), to produce high heat flux at the base of the crust and is responsible for the diapiric upwelling of shear-heated mantle material. Thus overlapping of the Precambrian custal blocks caused by plate tectonic action, created a subduction zone, and produced downward movement of the Dundas Trough. Concomitant upward movement of the magma occurred from the lower to the higher parts of the crust and during this period there was progressive crystallization near the base of the magma chamber. This resulted in a layered crystal mush of ultramafic-composition and a liquid melt of pyroxene-felspar material.

Contemporaneous periodic thrusting removed the partially crystallized layered sequence of basal dunite and peridotite with overlaying pyroxenites and emplaced it as a low angle thrust slice into the base of the eugeosynclinal pile forming in the Dundas Trough. Continued crystallization in the magma chamber produced layered norites and gabbros which were immediately removed by thrusting and emplaced into and along the margins of the still cooling ultramafic body. At the same time the tholeiitic and calc-alkaline fraction of the melt were erupted along the Mt. Read Volcanic Arc to the east of the Dundas Trough while gabbro and doleritic bodies were emplaced into the volcanic sequence.

The last differentiate of the magma was probably a diorite-quartz diorite melt which was intruded into the Noddy Creek volcanics. At the same time a series of lamprophyric and microdiorite dykes invaded the ultramafic complex as well as the sedimentary-volcanic sequence. These later intrusions were probably pene-contemporaneous with the Late Cambrian intrusive of the Darwin Granite to the north and the Lower Rocky Point Granite to the south.

There is strong evidence for the thrust emplacement of the Hibbs Ultramafic Belt but it has been largely obscured by later reintrusion and strong alteration of the intrusive rocks and marginal sediments. The following factors are considered relevant to thrust emplacement of the ultramafics.

1. The presumed basal (western) margins in particular of the complex are faulted and strongly sheared and are moderately to highly altered in parts to tremolite, chlorite, prehnite or amphibolitic rocks. Similar geological conditions in other complexes are interpreted

by Palethorpe (1971) to be due to high pressure thrusting.

2. The Faulted margins of the belt are subparallel and close to the edge of the Precambrian-Cambrian contact which is a major fault zone in the region.

According to Taliaferro(1943) "a non-hydrostatic stress field is required to bring any peridotite magma or hot crystalline diapir from its normal possible level of intrusion, i.e. (The Mohrovic Discontinuity) into crustal rocks; and at shallower depths is responsible for the 'cold intrustion' of serpentinised peridotite as slickensided and shear bounded bodies."

The author proposes that the hot semicrystalline mass of ultramafic material removed from the magma chamber by thrusting, began to cool rapidly while it was being emplaced up into the crust, and below the 500°C isotherm, serpentinite began to form marginally around the body. The metasomatic aureole around the body which formed when the intrusive was a hot crystalline diapir began to diminish as upward movement continued and cooling accelerated. The aureole was largely left behind when serpentinisation began, at this stage the ultramafic body began to exhibit the features of a 'cold intusive'.

In his study of the Lizard Peridotite mass Green (1968) stated that "where the driving mechanism is the 'rheidity' difference between peridotite and country rock and external stress field, internal movement would be localized in the zone of greatest rheidity difference, i.e. near the margin of the body. Thus to re-establish the local stress field, the core of the body has a tendency to move upwards as a passive body while relative movement is localized in the margin".

these two driving mechanisms, thrusting and rheidity induced flow, were responsible for the movement of the ultramafic body into the higher reaches of the crust.

(c) Contact Effects

As discussed in the previous section, the ultramafic body most likely had a strong contact metamorphic aureole after it was tectonically removed from the magma chamber and while it was a hot crystallic body. The Lizard peridotite body and several other high temperature intrusives are examples of bodies which remained at this stage of development of the 'Alpine type' ultramafic intrusive sequence.

As the Hibbs Ultramafic body rose in the crust, it cooled and solidified and largely left its metamorphic aureole behind. The onset of serpentinisation drastically reduced the metasomatism produced by the body. The serpentinisation was due to the introduction of connate water which probably originated largely from the sediments at the base of the Dundas Trough. Thus fluid movement was towards the intrusive and not away from it at this stage.

It is thought that the contact metasomation present at Noddy Creek is due to two separate events. The first was the arrival of thrust emplaced gabbroic intrusions shortly after the onset of serpentinisation in the ultramafic mass. These gabbroic bodies due to their rapid emplacement, probably along the same thrust plane as the preceeding ultramafics, were still quite hot when they intruded the ultramafics. They reacted marginally with the pyroxenites, serpentinites and country rocks to produce narrow, tremolite rich, chlorite-talc rich, and hornfels zones respectively with these rocks.

The second period of metasomatism occurred concurrently with the emplacement of the nearby quartz diorites and the lamprophyric intrusions. This produced local alteration of the ultramafic-mafic complex to greenschist and amphibolite facies.

Talc-chlorite alteration was dominant on the eastern margin of the complex while hornfels type alteration occurred on the west margin of the complex. Later shearing and faulting and weathering has obscured these relationships somewhat, but it can be said that the contact metasomatic alteration around the intrusive complex, is post emplacement in origin and very localized in extent.

(d) Crystallization Sequence

The high degree of tectonic action and metamorphic alteration which the ultramafic body has experienced has precluded any detailed study of the crystallization sequence in the intrusive. Olivine rich rocks now serpentinized were originally peridotites and possibly harsburgites or dunites! The extent of these rocks are not known but it is suggested that they form only a small percentage of the ultramafic assemblage at Noddy Creek.

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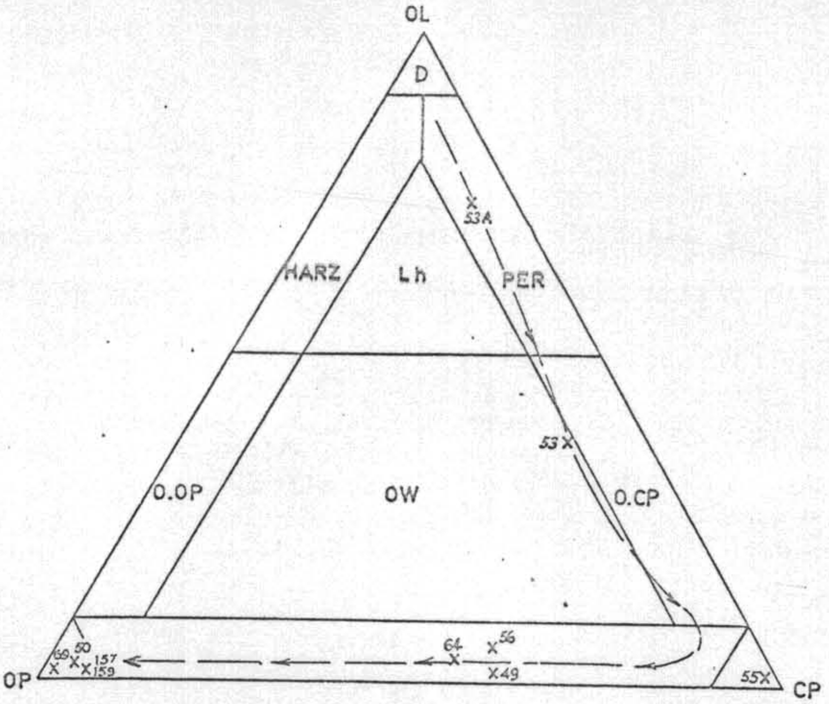
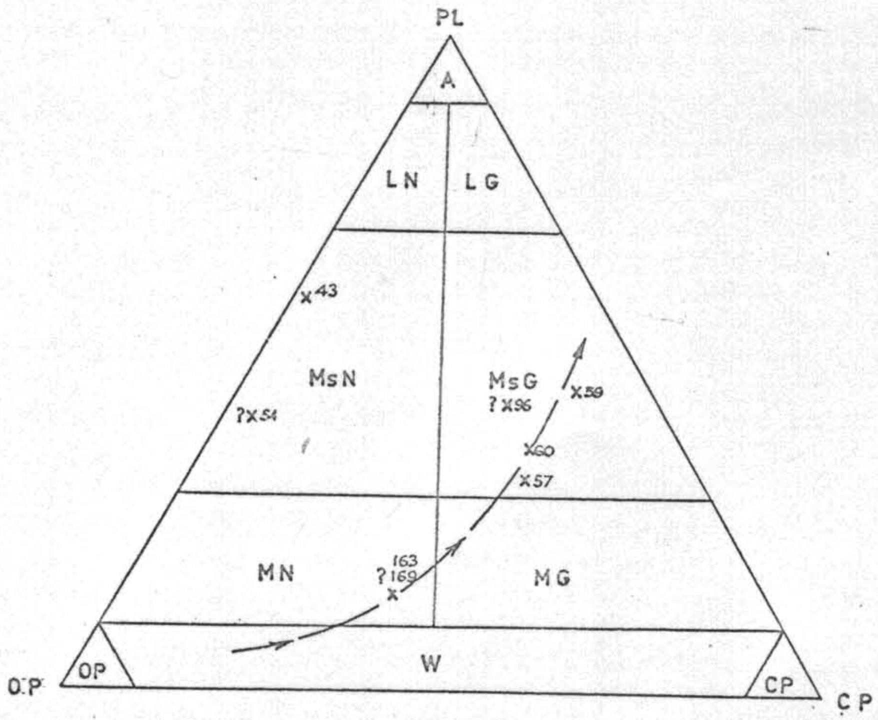


MODAL CLASSIFICATION OF THE ULTRAMAFIC ROCKS

(After Goode, 1971)

— ← — Shows proposed differentiation trend.



MODAL CLASSIFICATION OF THE MAFIC ROCKS

(After Goode, 1971)

— → — Possible differentiation trend.

The bulk of the ultramafic rocks are pyroxenites which exhibit a wide compositional range from olivine, orthopyroxene and clinopyroxene rich websterites to monomineralic pyroxenites. Plagioclase is the only phase which is entirely absent. There are no chromite rich layers as such, instead the Cr rich spinel is disseminated throughout the rock types, with a preponderance to websterites over other rock types.

(e) Layering

Small scale layering from 1cm to 10 cm thick is a feature of the pyroxenites south of Helipad 3 at Noddy Creek. It is also present in massive serpentinites and serpentinized pyroxenites within the chrysotile asbestos rich zone along the western part of the ultramafic belt from 20N to 40N. From the examination of thin sections across this layering it is seen that both phase and ratio contacts occur, with the latter type probably being more common. No attempt was made to determine any possible rhythmic nature of the layering in the field. However, it was noted that crude graded bedding appeared to be present in some layers. This may however just be a function of the weathering of ratio-contacts between layers or due to the change in grain size between fine and coarse layered pyroxenite.

Selected samples taken over a narrow sequence of layers, and based on superficial textures and colours, show that the layering appears to be a function of the degree of serpentinisation and/or steatitization together with changes in the grain size of cumulate pyroxenes.

Several isolated measurements of the strike and dip of the layering indicate that the average strike is parallel to the regional strike of N20°E and the dips vary from vertical to 30° to the east or west; again conforming to the regional dip of sediments and the ultramafic body.

There is no evidence of strong magmatic currents producing 'sedimentary type' structures in the layered ultramafics, neither is there evidence for flow differentiation of the type described by Bhattacharji (1967). The author interprets the layering as the result of crystal fractionation in the magma chamber and gravity settling of the crystals to form cumulus layers. These crystal layers were later cemented by post-cumulus growth of interstitial material and/or adcumulus growth in the case of monomineralic pyroxenites.

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...Y MAFIC ROCKS

...eral Features of the Mafic Lenses.

... gabbros and norites which make up the bulk of the original mafic ...k assemblage appear to be emplaced marginally to the ultramafic body, ... irregular lenticular bodies. They are extensively developed ...long the western margin of the complex from the 6N area to 20S line and along the eastern margin from 5N to 20S line and further south ...yond the immediate study area. Along the 20S line the gabbro is at least 300 metres wide and bodies of granodiotite (up to at least 30 metres wide) are reported to occur within it. Further north the gabbro attains a maximum width of 250 metres along the 7S line and appears from its irregular outline, to have intruded the ultramafic body and to have replaced some ultramafic material.

The gabbros are generally heterogeneous in grain size and mineralogy and may be commonly layered. Poor exposure and extensive alteration of the primary minerals have militated against the field study of these rocks. The gabbros from isolated massive rounded outcrops, in which the rocks are medium to coarse grained, generally equigranular and contain lenses or layers of coarse grained pyroxene rich material. They weather to mottled pale green and white rocks cut by reticulating milky quartz veins and veins upto several inches wide composed of prehnite rich material in the highly altered areas. (Ref. Plate 15)

Along the western (basal) margin of the intrusive complex, the mafic rocks are extensively sheared and veined and have been altered to varying degrees to tremolite, chlorite, and prehnite rich rocks, and in some extreme cases to rodingites.

Along with the shearing has come some late stage magmatic material which has formed small concordant pegmatitic dykes of

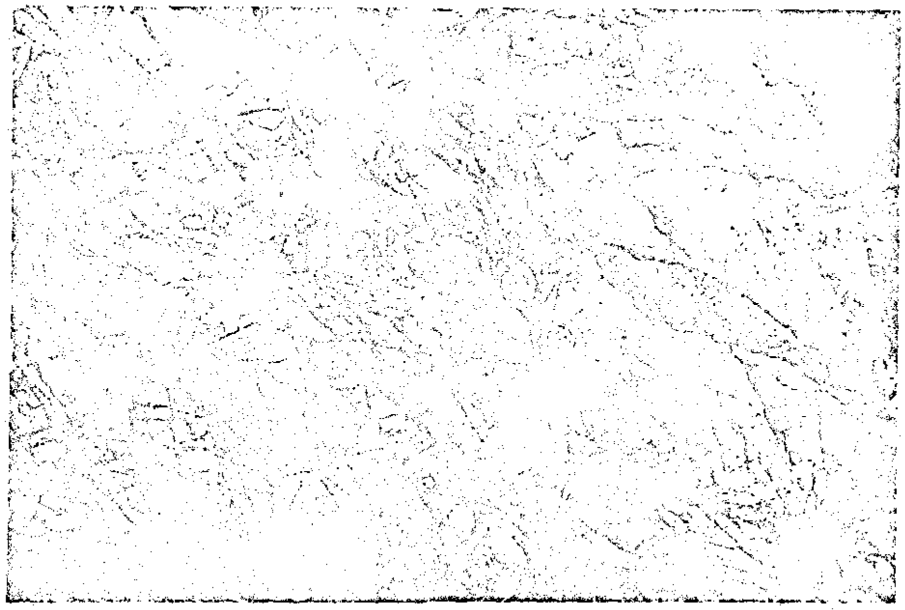

PLATE 15. OUTCROP OF WEATHERED, ALTERED GABBRO ON THE WESTERN END OF THE OOFT. LINE

These rocks are chlorite rich and the white veins are either prehnite, albite, quartz or zoisite.

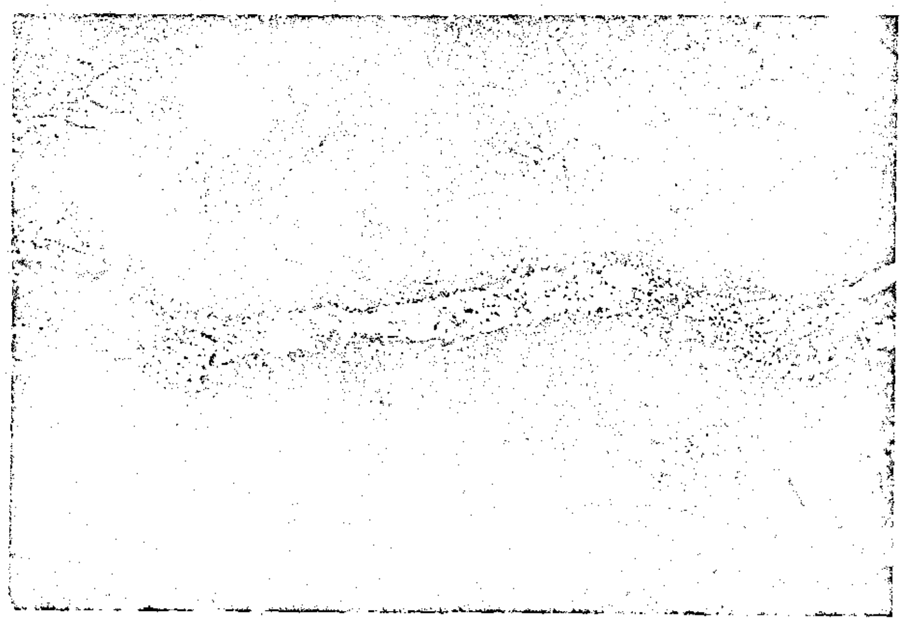

PLATE 16. VEIN OF CARBONATE RICH MATERIAL IN A CLINOPYROXENITE

Note the reaction rims along the vein, and the colour of the rock in outcrop. This colour is similar to weathered outcrops of gabbroic rocks, and may testify to the release of calcium from the clinopyroxenes.

hornblende diorite (specimen 71/L1-48).

PRIMARY MINERALOGY AND TEXTURES

The mafic rock assemblage was formed by the combination of three major mineral species, namely plagioclase, orthopyroxene and clinopyroxene. No attempt was made to accurately identify the chemical composition of any of these minerals and identification was based solely on microscopic examination of thin sections of selected rock specimens.

Hypersthene is the dominant orthopyroxene present although enstatite occurs in specimen 71/L1-163. Clinopyroxenes are more common than other pyroxenes in these rocks and both augite and the more calcium rich variety diopside aresuspected to be present. The pyroxenes have undergone extensive, amphibolitization, chloritization, epidotization, steatitization and serpentinisation, which makes interpretation of the original minerals and textures difficult. The plagioclase content in these rocks varies from 15% in the pyroxene rich varieties, to 60% in the leucogabbros, and the composition of the felspar appears to be in the bytownite - labradorite range. Most of the felspar has been altered to saussurite, clay or prehnite.

Amphibolite, probably hornblende, is present in some specimens and may be a primary mineral, however, in most cases (71/L1-48) excepted) it is suspected that it is merely an alteration product of clino-pyroxene.

Three types of textures are observed in these specimens. The first and most common is the allotriomorphic granular texture, e.g. specimen No. 71/L1-60. It appears that the plagioclase has crystallized after the pyroxenes in most cases, and forms interstitial and sometimes poikilitic crystals between and around the pyroxenes. Sometimes.

either the plagiocalse or the pyroxenes exhibit subhedral or euhedral outlines, and the texture becomes hypidiomorphic granular i.e. 71/L1 - 39. Specimen 71/L1 - 48 has strong hypidiomorphic granular texture with euhedral hornblende set in a matrix of granular felspar.

The third texture observed in these rocks is the subophitic texture. In this type the felspar forms euhedral to subhedral radial growth patterns of laths, within or partially enclosed by pyroxene grains. The plagiocalse appears to have crystallized first in this type.

Two specimens nos. 71/L1 - 59 and 169 exhibit changes in the pyroxene/felspar ratio to form mineral graded layers within the gabbros. Another specimen 71/L1 - 60 shows good planar lamination of the pyroxenes in layers, and specimen 71/L1 - 39 exhibits euhedral pyroxene crystals within anhedral plagioclase crystals. These three textural features are evidence for the possible fractional crystallization origin of some of these rocks.

ii) GEOCHEMISTRY

Limited chemical analyses of these rocks, (Table 1) show that they are marginally rich in Mg and Ca and marginally low in Al_2O_3 compared to similar rocks from the Bushveld Igneous Complex and the Skaergaard Intrusion. The total alkali T_1O_2, and total Fe contents are low, this is particularly so in the case of Na_2O and total Fe (3.7%). The K_2O content (0.6%) is high for these rocks and reflects their highly differentiated nature. This high K_2O content is also repeated in the lamprophyres.

All these values except for iron, are compatible with the theory that these rocks are the result of continued differentiation of the magma which produced the ultramafic assemblage.

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TABLE 1. CHEMICAL ANALYSIS OF THE MAFIC ROCKS (as Oxide WT %)

	71/L1-60	71/L1-161	71/L1-163	71/L1-169	
SiO_2	49.3				
Al_2O_3	13.5				
Total Fe	3.7				
MgO	10.0				
CaO	12.6				
Na_2O	0.6				
K_2O	0.6				
T_1O_2	<0.1				
TOTAL	90.4 (by GEOMIN)				
	TRACE ELEMENT ANALYSES WT.PPM		(by A.M.D.E.L.)		A.V.PPM
Ni	82	70	140	80	97
Cr	700	50	75	50	58
Co	30	20	55	25	33
Cu	-	5	35	5	15
Pb	-	5	5	5	5
Zn	-	25	35	30	30

(iv) CLASSIFICATION

Only a dozen specimens of the mafic rocks at Noddy Creek were selected for microscopic examination, but these specimens show adequately the evolutionary trend in the mafic rock sequence. The mafic assemblage is given below :

1. Ortho-Norite
2. Augite-Norite
3. Enstatite Gabbro
4. Hypersthene Gabbro
5. Gabbro
6. Pegmatitic Hornblende Diorite
7. Granodiorite

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Some of these rocks have undergone considerable metasomatic alteration and have become essentially metamorphic rocks, a study of these changes and descriptions of the rock types are given in the section under Metamorphism and Metasomatism.

The mafic assemblage shows a marked similarity in mineralogy, with the exception of the felspar phase, to the ultramafic assemblage. The norites and gabbros being the mafic equivalents of the pyroxenites and websterites.

These minerlogical similarities together with the chemical similarities (discussed later under Petrogenesis) leads the author to suggest that the ultramafic and mafic rock suites were derived from the same parent magma. A similar conclusion was reached by Rubenach (1972) with regard to the gabbro and pyroxenites of the Serpentine Hill Complex, 25 miles north of Queenstown in western Tasmania.

ROCK DESCRIPTIONS

(a) Ortho-Norite specimen 71/L1-43A

The original constituents of this rock were enstatite 40% and plagioclase 40% making the rock a mesocratic norite. The crystals are equigranular, forming an allotriomorphic granular texture. The unaltered enstatite crystals up to 1mm long, exhibit twinning and the lamellae are commonly bent due to shearing of the rock. The pyroxene alteration products are, mostly, serpentine in the form of bastite pseudomorphs, and later chloritization followed by late stage talc replacement of the serpentine along fractures. The felspar is wholly altered, mostly to saussurite and also partially to green and brown fine grained chlorite. Weathering of the rock has produced clay and minor iron ore.

(b) Augite Norite specimen No. 71/L1-54

This specimen has been highly altered and is now a metamorphic rock. Relics of the primary minerals occur, which suggest that the original rock was a meso-norite. The original constituents being plagioclase 40% and dominant orthopyroxene 60% with exsolution texture. Minor primary clinopyroxene crystals may be present with the orthopyroxene and all are set in an allotriomorphic granular texture. The rock now contains 30% tremolite-actinolite, 40% prehnite and 20% chlorite with minor talc, muscovite, quartz and relic pyroxenes. The tremolite has replaced the pyroxenes as large anhedral crystals possibly actionolite, and as small needles in the orthopyroxenes. Chlorite also replaces the pyroxenes as fine grained masses, some of which show deep blue interference colours typical of clinochlore. Prehnite occurs as replacement intersitial material with muscovite between the original pyroxenes and as late stage veins with minor quarts inclusions cutting the rock. The prehnite is derived from original felspar. Minor talc replaces both chlorite and tremolite along small fractures. Remnant exsolution texture is seen with chlorite replacement of orthopyroxene and thin blebs of tremolite up to 1.3mm long replacing the exsolved clinopyroxene. Due to the presence of augite the rock may be called an augite-norite.

(c) Enstatite Gabbro specimen No. 71/L1 - 163

This specimen is a melagabbro with only 15% original plagioclase felspar content. The primary mineral relationships are obscured by the fact that more than 50% of the rock has been replaced by the metamorphic minerals chlorite, tremolite, and talc. This rock was one of a suite of 24 rocks sent to A.M.D.E.L. for examination, and is fully described by them as sample No. NC 15 in Appendix No. 3.

(d) Hypersthene Gabbro specimen nos. 71/L1-57 and 60.

Both these specimens are mesogabbros and contain only 30-40% original felspar. They have been highly altered, sheared and veined.

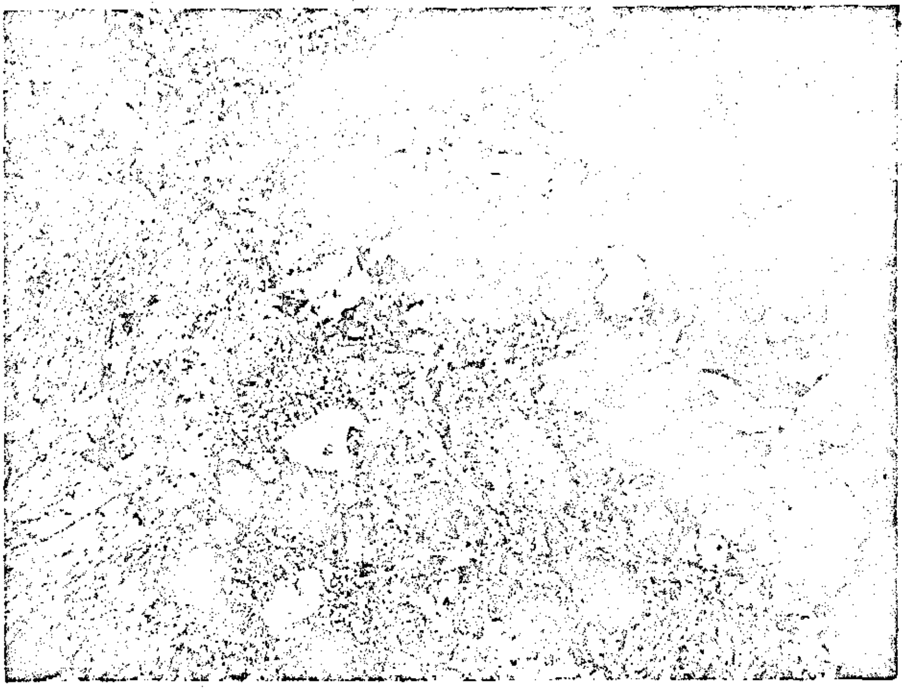
In specimen 71/L1-57, the orthopyroxenes are largely altered to chlorite and talc, while the clinopyroxenes are altered to tremolite. The clinopyroxenes show relic twinning and contain plates of exsolved hypersthene. Specimen 71/L1 - 60 on the other hand, shows little or no replacement of the clinopyroxenes and only chlorite replacement of the orthopyroxenes.

Plagioclase occurs as twinned crystals now being replaced by saussurite and as albite veins with mosaic texture cutting prehnite rich material in shear zones in specimen 71/L1 - 57 (ref. plate 17). In specimen 71/L1 - 60 the felspar has altered to saussurite and minor clay.

The textures of the two rocks are markedly different. Specimen 71/L1 - 57 shows radial growths of plagioclase laths in subophitic relationship to the granular pyroxenes, while specimen 71/L1 - 60 shows the more normal allotriomorphic granular texture.

(e) Gabbro specimen no. 71/L1 - 59

This specimen is a medium grained, quartz veined, mottled light bluish green and white rock. The felspar which originally comprised 50% of the rock has been partially altered to saussurite and then to clay. It is also present as uncommon twinned crystals of albite in late stage veins of quartz and prehnite. The dominant pyroxene is augite which has partially altered to hornblende. Hypersthene is an uncommon constituent originally probably 5% of the rock and occurs as large phenocrysts 1.5-3mm in diameter. It has altered largely to tremolite crystals to 0.9mm



1.0mm

PLATE 17. SPECIMEN 71/L1-57 METASOMATISED NORITE
This photograph shows the contact between vein filling prehnite and albite (upper right) and altered norite. The clinopyroxenes (centre bottom) have altered to tremolite and chlorite and fine grained secondary albite forms the matrix. MAGx2.5xNICOLS

5 cm

long with some chlorite and talc. Crude layering is evident with plagioclase being dominant in one section of the slide and pyroxene in the other. Measurements of the felspar/pyroxene ratios are difficult due to alterations and shearing in the rock.

(f) <u>Hornblende Diorite</u> specimen No. 71/L1 - 48

In hand specimen this rock is pegmatitic in relation to the surrounding rocks, and is light grey, quartz veined, and sheared.

The primary mafic mineral hornblende which constitutes about 20% of the rock occurs as large, averaging 2 cm long, euhedral crystals set in an interlocking granular matric of intermediate plagioclase. The texture is hypidiomorphic granular. The felspar shows perdline and albite twinning indicative of andesine composition, and is altering extensively to the secondary products, saussurite and chlorite (ref. Plate 18)

The hornblende is also altering in places to a light green tremolite but this mostly occurs in the shear zones. Shears are prominent in this rock, and are filled with crushed primary rock now mostly altered. Quartz veins which carry interstitial plagioclase with albite twinning (ref. Plate 19) occur in the shear zones and also fill fractures in primary plagioclase. Minor calcite is also present in the shears. Interstitial opaques in the altered felspar are probably magnetite and ilmenite.

This rock because of its mineralogy and texture is regarded as a late stage mafic intrusive rock and was seen to occur only in the gabbros along the western margin of the complex in the 5N area.

5 cm

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1.0mm

PLATE 18. SPECIMEN 71/L1-48 HORNBLENDE DIORITE
A large felspar (right) exhibits pericline and albite twinning, shearing has distorted the lamellae. A chlorite crystal (centre bottom) has been formed along a fracture zone. Primary hornblende and secondary tremolite form the rest of the rock. MAGx2 5xNICOLS

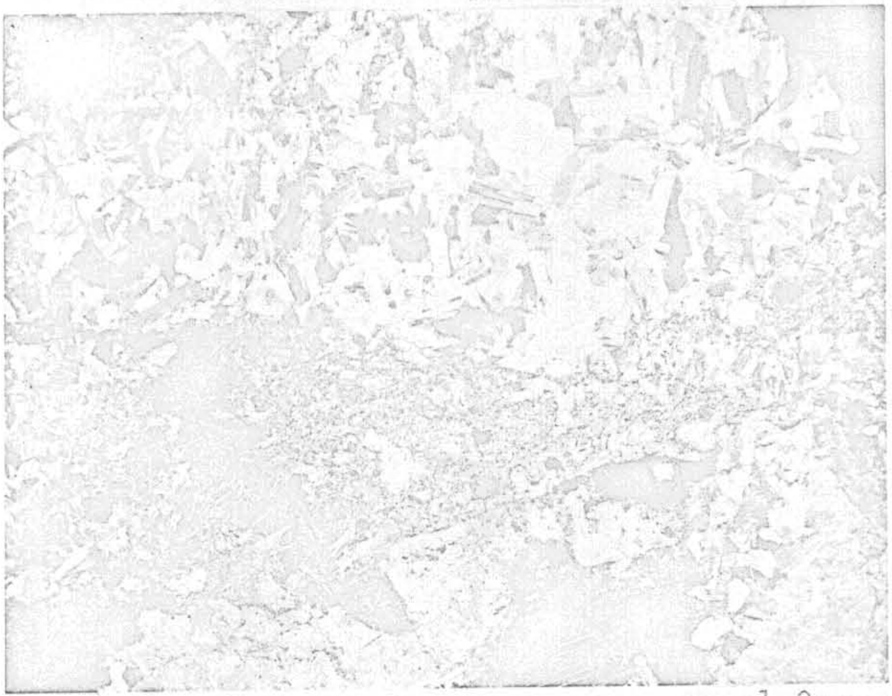

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PLATE 19. SPECIMEN 71/L1-48 HORNBLENDE DIORITE, FRACTURE ZONE IN ROCK
Albite (top) forms the bulk of the vein material, with chlorite and tremolite forming marginal to the unaltered primary plagioclase and hornblende. MAGx2 5xNICOLS

(g) Granodiorite

Previous workers Corbett and McGregor (1968) have described rocks classified as granodiorites from the Noddy Creek area. The author has not seen any granodiorites within the study area but they undoubtedly do occur to the south within the wide gabbroic mass on the eastern side of the complex between the 20S and 30S lines. The granodiorite is reported to be fine to medium grained, equigranular, and light green grey in the fresh specimen. It weathers to a buff colour and outcrops as irregular jointed boulders within the coarse grained poorly outcropping gabbro.

Specimen B6281 (B.H.P. Rock Index) from the 00 feet line at Noddy Creek, and described by Corbett, is "mottled with patches of dark chlorite in white groundmass. Aggregates of plagioclase and quartz; orthoclase has altered to sericite. Iron ore strings parallel to chlorite plates; possible autobrecciation before choritization. The parent rock is a quartz diorite". This means that late stage intrusives containing quartz with plageoclase and orthoclase have invaded the gabbros at Noddy Creek as well as the Noddy Creek Volcanics to the east.

(VI) SECONDARY MINERALOGY

It can be seen from the rock desciptions that the primary minerals have been extensively acted upon by solutions of metasomatic origin to form a variety of secondary products. Completely new metamorphic rocks have formed in some cases and as such have not been described in this section under Primary Mafic Rocks.

The secondary minerals, their alteration processes and resultant rock types are all fully described in the section under Metamorphism and Metasomatism.

ii) PETROGENESIS

The mafic rocks are considered to have been intruded in stages over short intervals into and along the margins of the existing ultramafic body. These rocks are probably derived from the same parent magma as the ultramafics and represent with the advent of the felspar phase, a continuation of the differentiation trend found in the ultramafics. The pegmatitic hornblende diorite is thought to be the hypabyssal equivalent of the granodiorite and this in turn is probably closely related to the diorites and quartz diorites which occur within the Noddy Creek Volcanics to the southeast.

In the 5N area where the exposure is relatively good, the gabbros seem to be highly lenticular or dyke-like in shape and transition rocks between pyroxenites and gabbros were expected to occur. However, no felspatic pyroxenites or fine grained chilled margins were seen during petrological examination of these rocks.

This means that the gabbroic rocks in this area were fairly cool when they intruded the pyroxenites.

This is definitely not the case with all the massive gabbroic intrusions along the eastern margin of the ultramafics where some contact metasomatism usually in the form of talc rich rocks, is evident (ref. Plate No. 6).

(c) THE LAMPROPHYRIC SUITE

(i) General Features

The lamprophyres occur as discontinuous, narrow, lensing, boundinaged, black to light grey dykes throughout the serpentinites of the ultramafic complex. They also occur in the sediments to the east of the complex, and one dyke between the 7S and 10S line has been traced from the eastern sediments across half the ultramafic body. The dykes with the exception of the one transgressive dyke, are all parallel to the general cleavage - shearing direction in the intrusive complex and tend to be intruded close to or on the contact between massive and sheared serpentine or pyroxenite. The dykes tend to have sharp boundaries but they may be gradual where extensive chloritization, silicification or other metamorphic alteration of the surrounding serpentine has occurred.

(ii) MINERALOGY AND TEXTURES

These rocks have been termed lamprophyres, because of their porphyritic textures, felspar rich matrix and dominant biotite mica phenocrysts.

Alkali felspar is the common matrix forming mineral in the majority of the eleven specimens examined. In two specimens the matrix was partly composed of plagiocalse felspar. A few specimens usually the darker coloured types were chilled during emplacement and exhibit extremely fine grained matrices composed of devitrified glass altering to fine grained chlorite. Fine grained crystals of biotite, rare hornblende, and sphene are commonly present in the mesostasis of these rocks. The phenocrysts are dominant biotite, less common augite and rare hornblende, calcite, and quartz.

PLATE 20. BOUDINAGED LAMPROPHYRIC DYKE cut by veins of carbonate material and surrounded by sheared serpentinite.
EAST END 25N LINE

PLATE 21. CONTACT ALTERATION OF LAMPROPHYRIC DYKE ROCK
Extensive marginal chlorite alteration of the dyke and the adjacent serpentinite (right). Chrysotile fibre has formed in fractures within the dyke (left).

These rocks are all altered to some degree by metamorphism or metasomatism. Clinopyroxene has altered to amphibole, biotite to chlorite and felspar to saussurite, sericite or chlorite. Some of the specimens are vesicular and others contain quartz rich zenoliths.

The overall texture in these rocks is porphyritic and hypidiomorphic granular with equant phenocrysts set in a fine grained matrix of equant mafic minerals and subhedral to anhedral interlocking plates of twinned or untwinned felspar.

(iii) GEOCHEMISTRY

The geochemical study of these rocks is restricted to one partial rock analysis and three trace element analyses. This is insufficient information for any comparative study of this suite and serves only to indicate the differentiation trend in the rocks of this complex. Specimen 71/L1 - 67 described as a vogesite, has high silica and potassium content and a low magnesia, calcium and sodium content. This suggests that this rock is a late stage extrusive from a highly differentiated magma. The volatiles, particularly K_2O (8.2%) are high and show an increasing trend from the ultramafics through the gabbros and appear to be concentrated in the lamprophyres.

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TABLE 2. CHEMICAL ANALYSES OF THE LAMPROPHYRES (as oxide WT%)

	vogesite 71/L1 - 67	? 71/L1 - 162	augite minette 71/L1 - 167	augite minette 71/L1 - 168	
SiO_2	54.6				
Al_2O_3	15.2				
Total Fe as what?	6.3				
MgO	3.3				
CaO	2.7				
Na_2O	1.2				
K_2O	8.2				
T_1O_2	0.7				
Total	92.2 (By GEOMIN)				

Trace Element Analyses WT. PPM. (By A.M.D.E.L.)

	71/L1 - 67	71/L1 - 162	71/L1 - 167	71/L1 - 168	A.V.
Ni	30	70	50	90	60
Cr	60	55	25	80	55
Co	24	20	30	35	27
Cu	-	25	35	15	25
Pb	-	30	45	5	27
Zn	-	70	100	90	87

(iv) Classification and Rock Description

The classification of the lamprophyric suite is based on the dominant matrix component, in this case felspar, and the dominant mafic phenocryst (after Rosenbusch). All but three of the specimens examined can be classified as augite minettes. The assemblage is given below :-

(a) Augite Minette
(b) Minette
(c) Vogesite
(d) Augite Kersantite

(a) Augite Minette specimens 71/L1 - 89, 90, 91, 104, 138, 167, 168.

A typical example is specimen 71/L1 - 104 which is a dark grey medium to fine grained biotite rich rock in hand specimen. On detailed examination it contains 15% biotite and 15% augite as euhedral phenocysts set in a fine grained matrix of orthoclase biotite and augite. The orthoclase also fills rare vesicles and is partly altered to clay. The mafics are altered to chlorite.

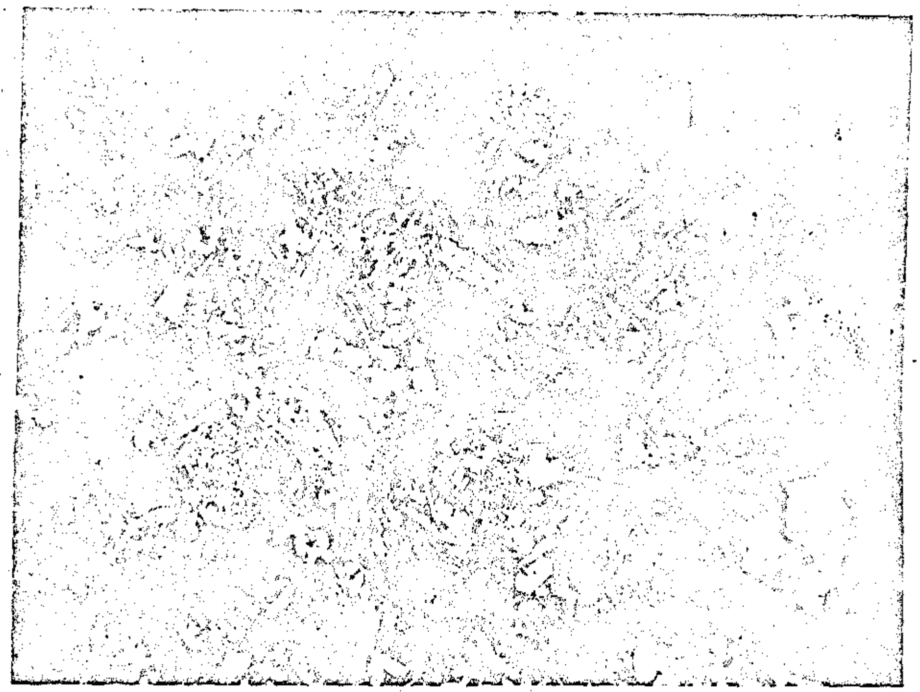
The biotite phenocrysts in the other minettes may constitute up to 20%, while the augites may constitute up to 30%. Hornblende phenocrysts may also form up to 5% of the rock. Chlorite is the dominant alteration product in these rocks, and other secondary products are epidote, talc, calcite, and saussurite. Plagioclase may also be present in small amounts in the matrix e.g. 71/L1 - 138, and is interstitial to the orthoclase felspar.

(b) Minette specimen no. 71/L1 - 139

This specimen differs from the other minettes in that it does not contain any pyroxene or amphibole and it has plagioclase as well as orthoclase in the matrix. Quartz and spinel probably magnetite or ilmenite form minor phases in the matrix. Specimen 71/L1 - 161 described by A.M.D.E.L. is considered by the author to be also a minette, in which the biotite has been replaced by chlorite. It, however, has no plagiocalse present, and quartz crystals up to 0.1mm are scattered an uncommon phenocrysts in the matrix.

(c) Vogesite specimen No. 71/L1 - 67B

5 cm



1.0mm

PLATE 22. SPECIMEN 71/L1-168 AUGITE MINETTE
Biotite and pyroxene phenocrysts set in a fine grained glassy mesostasis which is partially chloritic. Serpentine, possibly after olivine or pyroxene forms rare irregular elongated masses. MAGx2.5xNICOLS

0.2mm

PLATE 23. SPECIMEN 71/L1-168 AUGITE MINETTE
A more detailed view of the above photograph showing fine grained augite and bitoite crystals in the matrix
MAGx100xNICOLS

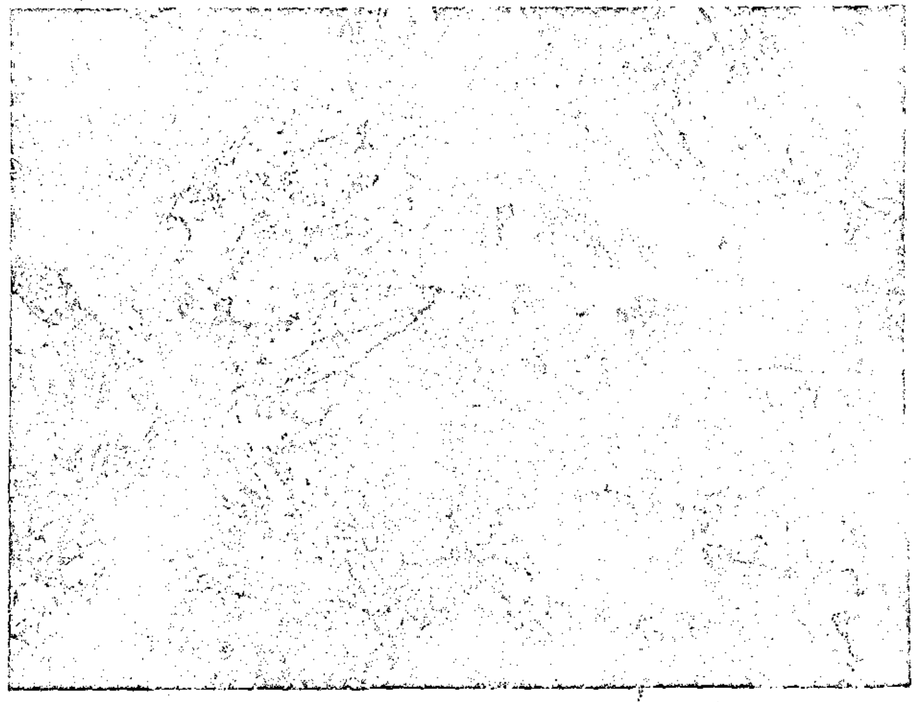


PLATE 24. SPECIMEN 71/L1-167 AUGITE MINETTE
Vesicle filled with orthoclase and rimmed almost completely by biotite laths now altered to chlorite. Small equant crystals of pyroxene are also altering to chlorite along fractures. MAGx2 5xNICOLS

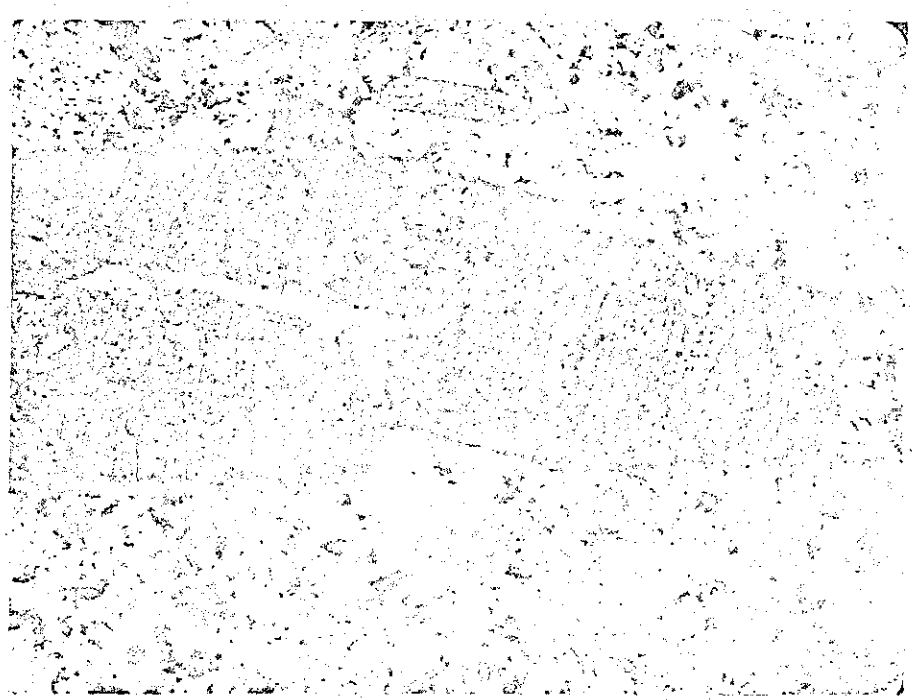


PLATE 25. SPECIMEN 71/L1- 67 VOGESITE
Large (6mm) twinned hornblende phenocryst set in a fine grained matrix of orthoclase with laths of hornblende, possible biotite and sericite and chlorite partially replacing original (?) pyroxene.
MAGx2 5xNIC

hornblendes have ragged ends which are indicative of fast growth being halted by premature crystallization of the matrix. The hornblendes are altering to tremolite which forms laths up to 1.5mm in diameter. Epidote and chlorite may also be forming from corroded phenocrysts of pyroxene. Orthoclase felspar also forms phenocrysts (5%) set in the intergranular matrix dominated by orthoclase and containing small randomly orientated crystals of the same compostion as the phenocrysts. This rock is closely related to the augite minettes and differs from them only in the dominance of hornblende over biotite in the phenocrysts.

(d) Augite Kersantite specimen no. 71/Ll - 52

This is a specimen in which the phenocrysts (60%) dominate over the matrix. On visual estimation of total rock content the phenocrysts are: biotite 35%, augite 20% and felspar 5 - 10%. The biotites are bimodal in size and are randomly orientated brown laths averating 0.35mm in diameter extending up to 0.7mm in diameter. The augites are sometimes altered wholly or marginally to amphibole. The felspars form large phenocrysts and are mostly altered to muscovite or sericite with crystals up up to 1.3mm in diameter.

The groundmass is fine grained and consists mostly of chlorite altered from original glass with some mafics, sericite, saussurite, clay, and minor opaques.

The texture is panidiomorphic and vesicular, with the ground-mass filling the vesicles which are often partially rimmed with mafic phenocrysts. It appears that the rock was crystallized too quickly for the felspar to form in the matrix. The rock was classified a kersantite on the basis of the plagioclase phenocrysts, and not as an alnöite on the basis of the glassy matrix.

(c) PETROGENESIS

The lamprophyres are clearly the last phase of igneous intrusion at Noddy Creek, as they intrude all the other rock types. They were also emplaced before the last phase of shearing, serpentinisation and metasomatism in the ultramafics.

They are younger than the Dundas Group sediments and are most likely associated with the intrusions of Late Cambrian biotite rich granites and/or quartz diorites known at Mt. Darwin to the north, at Timbertops south-east of Noddy Creek and further south at Lower Rocky Point.

Mica rich lamprophyre dykes were reported by Taylor (1955) from south of the Spero River, 25 kilometres south of Noddy Creek. They were in the form of numerous narrow dykes into the Precambrian sediments, and were characterized by numerous inclusions of angular fragments of quartzite, torn from the walls during emplacement. One of the dykes at Noddy Creek, specimen 71/L1 -91, contains zenoliths of garnet bearing siliceous gneiss and quartzite probably also from the Precambrian basement. Lamprophyric or doleritic dykes have been reported from further south along the Hibbs Belt and micro-diorite rocks have been reported from the Noddy Creek Volcanics. Thus there is a regional relationship between the dykes and the rest of the ultramafic complex.

Specimens 71/L1 - 139 and 161 which are minettes, together with specimen 71/L1 - 67A which is a vogesite, have been selected as representative of the rock types present within the obliquely transgressive dyke in the southern part of the Noddy Creek area (Fig. 4). This dyke (it is assumed from field relationships to be the one body) is considered to be the hypabyssal equivalent of the small and intimately associated hypersthene diorite, quartz dolerite, granodiorite and prophyritic microgranite plutons present nearby and within the ultramafic complex. Specimen 71/L1 52 the augite kersantite is the hypabassal equivalent of the diorite bodies, and the augite minettes represent the very last explusion of liquid melt from the parent magma chamber of all these related rocks.

This suite of rocks has been termed lamprophyres for reasons already outlined, but it is quite reasonable that some of the dyke rocks could be called micro-diorites or micro-syenites. It is felt, however, that as a suite the rocks exhibit the character of lamprophyres.

(D) SERPENTINISATION

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(i) Distribution of Rock Types

Recent world wide geological mapping of serpentinites has emphasized the importance of distinguishing in the field between massive and sheared serpentinites. This practice was followed during the detailed mapping at Noddy Creek, and the colour, appearance, texture, and relationships of the rock types were also noted. An attempt has been made to correlate the widely spaced outcrops and to relate the microscopic petrography and geochemistry to the field rock types.

At Noddy Creek five main serpentine rock types ranging from massive partially serpentinised ultramafics to highly serpentinized and sheared varieties were identified. They are as follows :-

Type 1. Massive, dark green, partially to wholly serpentinised occassionally cross-fibre bearing layered ultramafic.

Type 2. Massive light to dark green cross-fibre bearing serpentinite.

Type 3. Blocky, massive and sheared light to dark green, often stichtite bearing serpentinite.

Type 4. Sheared and highly sheared, brecciated, light to dark green serpentinite.

Type 5. Compact but sheared, dark green to black, magnesite bearing serpentinite.

In general it may be said that Types 1 and 2 are progressively more serpentinised while Types 3 to 5 are progressively more sheared and/or metamorphosed. In future discussion all these rock types will be referred to by their numbers.

Type 1. This type of serpentinite e.g. 71/L1 - 50 is found within and around massive unserpentinised pyroxenite and peridotite. It has formed as a result of the initial partial serpentinisation of the ultramafic body during emplacement, and is composed of bastite pseudomorphs after orthopyroxene, and mesh texture serpentineafter olivine and/or

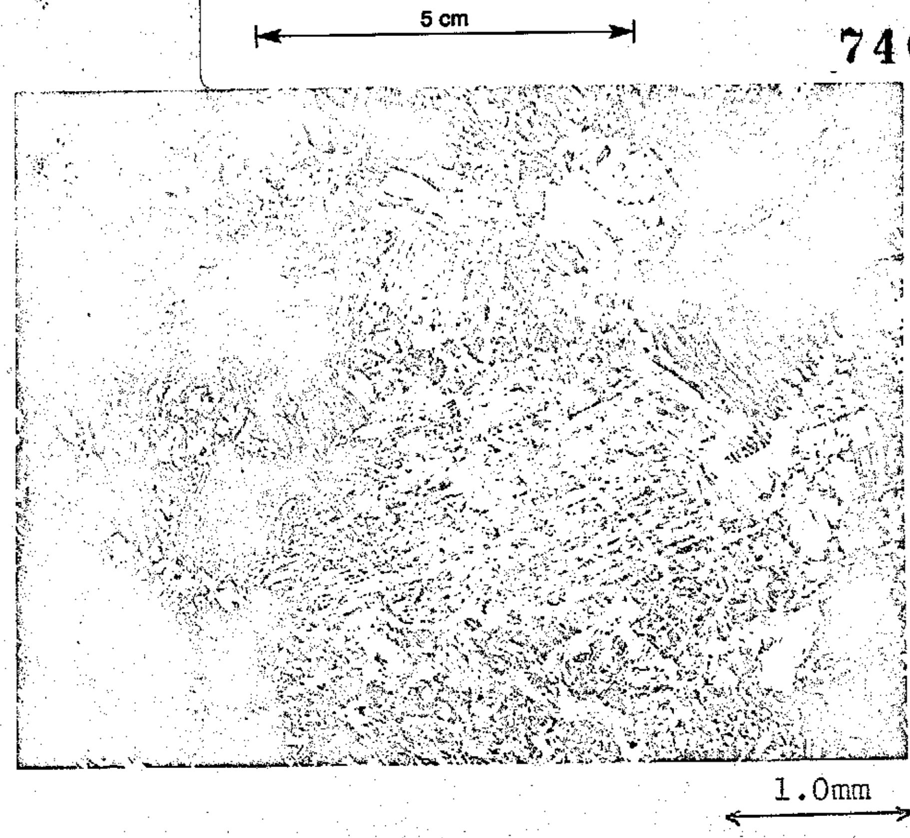


PLATE 26. SPECIMEN 71/L1-50 TYPE 1 SERPENTINITE
SERPENTINISED AUGITE HYPERSTHENITE
Bastites after orthopyroxene have been cut by later serpentine veins giving a fibro-lamellar texture. Exsolution lamellae of both ortho and clinopyroxene are present. Equant chromite grains are sometimes fractured and embayed by serpentine. MAGx2 5xNICOLS

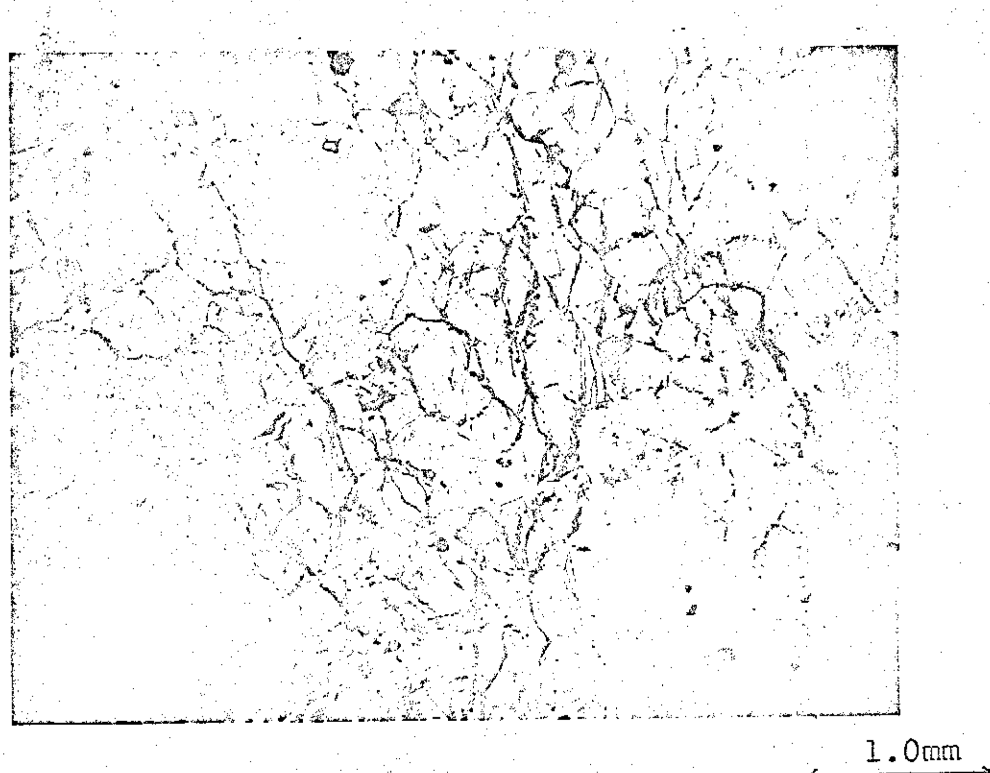


PLATE 27. SPECIMEN 71/L1-164 TYPE 2 SERPENTINITE
Chrysotile veins en-echelon and parallel to original layering in the primary rock. Bastite and mesh-texture serpentine present, magnetite has formed in fractures around crystals and rims former (?) chromites.
MAGx2 5xNICOLS

clinopyroxene. Metamorphic alteration may also occur in this rock type and results in the formation of chlorite and remolite from the pyroxenes. Talc is often present in small but variable amounts.

Type. 2. Type 2 serpentinite is quite common at Noddy Creek and forms the host rock for the majority of the chrystotile asbestos deposits. It generally outcrops between Type 1 serpentinite or primary ultramafic. andTypes 3 and 4 which are the blocky and sheared varieties of serpentinite. This serpentinite may exhibit layering e.g. specimen 71/L1 - 164, and other primary textures of the original ultramafic. It is typified by specimen 71/L1 - 120 which is a light green massive serpentinite with strong cross fibre development in parellel veins, and minor magnetite occurring as stringers through the rock. This rock type is discussed more fully in connection with cross fibre asbestos.

Type 3. Rock Type 3 is typically light green and contains disseminated blebs of lilac coloured stichtite, specimens 71/L1 - 4 and 172 are good examples of this rock type. Serpentine blocks averaging 10cm in diameter ranging from 5cm to 50cm, are separated by thin zones of shearing and slickensides, in which slip fibre, magnetite or brucite may occur. Cross fibre is present only as thread veins, 1/32inch in sheared specimens but in the larger blocks, more typical of Type 2 serpentinite, asbestos may form bunches of ribbon fibre containing veins of up to 2/16 inch in width, this however is not common. (ref. plate 40) This serpentine type is found mostly near the centre of the serpentinite mass and is probably the product of partial shearing of Type 2 serpentinite.

The stichtite serpentinite occurs in one main body from north of the 6000'N line along the western margin of the ultramafic to the 4500'N line where it spreads to the centre of the body and continues south as central unit to just south of the 500'N line where it cuts out on the surface. Two other small areas of stichtite bearing serpentinite are known, including a massive vein of stichtite up to 3 metres long and [illegible]cm wide on the western part of the 1500'S line. Type 3 serpentinite has been shown by drilling to widen northwards at depth and appears to encompass the whole of the ultramafic belt along the 4000'N line,(ref. Fig.12).

In thin section, Type 3 serpentinite shows a typical dominant fibro-lamellar texture, with rare bastites and fine grained mesh texture which embays and veins the bastites.

Stichtite altering from chromite forms blebs avering 2mm in diameter and comprises on the average 2% of the rock, rare massive veins of stichtite are also present (Specimen 71/L1 - 46.)

It may be important to note that stichtite has not been found elsewhere in the Hibbs Belt. It is found exactly where the largest known deposit of chrysotile is located, yet from field evidence, chrysotile cross fibre and disseminated stichtite are locally mutually exclusive (Langlands 1971). This problem is partially resolved by the fact that, cross fibre is present in the stichtite zones, but is of very limited extent and position in the ultramafic body is discussed fully under metasomatism of the serpentinites.

Type 4. Type 4 serpentinite is found surrounding or adjacent to all other serpentine types except Type 1, which is usually shielded from the sheared serpentinite by massive Type 2 serpentinite. Sheared serpentinite is almost ubiquitus along the margins of the ultramafic - the only exceptions being where gabbros lie directly adjacent to massive serpentine Types 1 or 2. It is found between the fibre zones and the stichtite serpentine and outcrops widely in the central part of the body from the 10N line southwards beyond the 20S line.

The sheared serpentine may be light green to nearly black in colour, and is composed of flakes or lenticular chips with polished or slickensided faces. The dominant texture of this type is represented by well foliated, brecciated, shredded, platy, andfibrous serpentine similar to the sheared serpentinites reported by Page (1967).

Within the sheared serpentinites, slip fibre in bunches up to several inches long and up to an inch wide is commonly developed. Fibrous magnetite with massive serpentine also occurs in some zones, specimens up to 10 cm. long are known, and the total iron content of these rocks is high. Rare late stage cross fibre veins have been identified cutting some of the less sheared varieties, but these veins are usually truncated after a short distance.

Type 5. Type 5 serpentinite is a dark compact rock, with waxy lustre which has obviously been highly sheared and then reformed into a brittle but massive rock. When broken, it shatters into small lenticular fragments, similar to some varieties of sheared serpentinite. This rock is found only along the margins of the ultramafic body and particularly along the eastern contact adjacent to basic intrusives.

It is well developed on the eastern contact of the 5500'N line, but is less obvious on other lines. It appears to be formed as a result of the combination of intense shearing and moderately high temperatures (400° - $500^{\circ}C$) produced during metasomatism. This metasomatism was possibly related to the intrusion of the basic intrusions along the margins of the ultramafic body. Fibrous magnesite and possibly talc are related to this period of metasomatism, as magnestite is not found in any other rock type, (ref. Plate 41). Vary rare late stage cross fibre veins have developed after metasomatism. All previous chrysotile veins were cahnged to picrolite the fibrous form of antigorite during the formation of Type 5 serpentinite.

(ii) Mineralogy

The mineral assemblages of the serpentinites at Noddy Creek were determined by a combination of optical and X-ray techniques. Earlier work in this field by Page (1968), Aumento (1968), and Coleman and Keith (1971) were referred to extensively for information relating to serpentine mineralogy.

Three serpentine minerals were identified from the Noddy Creek serpentinites. They are lizardite, clinochrysotile and antigorite, with lizardite being the dominant species forming about 60% of the serpentine products. Lizardite appears to have directly replaced the primary minerals olivine andorthopyroxene and also clinopyroxene to a lesser extent. Due to the high pyroxene content in these rocks bastite pseudomorphs after orthopyroxene are a very common occurrence especially in serpentine Types 1 - 3 which are the massive varieties.

Lizardite is pale green to colourless in thin section and may occur in all serpentine types except Type 5. It may form mesh texture serpentine after bastites, or after olivines, with clinochrysotile forming the framework enclosing lizardite cores. Serpentinised olivine which was only recognised in a few specimens, takes the form of mesh texture or more rarely 'hourglass' texture which is produced by the outward growth of serpentine along fractures within olivine crystals and their margins.

Clinopyroxene is the last primary silicate minerals to alter to serpentine, and often it seems to alter preferentially by metamosphism to chlorite or tremolite.

Exsolution lamellae of clinopyroxene, usually parallel to the 100 face, are often seen in otherwise completely serpentinised orthopyroxenes. Clinopyroxenes alter to mesh textures composed primarily of lizardite.

The clinochrysotile content of the rocks generally increased with the deformation of the rocks and is particularly high in sheared serpentines or in those massive serpentinites which contain numerous parallel or concentric veins of chrysotile asbestos, e.g. specimen 71/L1 - 125.

The X-ray diffraction data suggests that orthochrysotile also appears to be present in small amounts with clinochrysotile in the sheared rock types. Chrysotile asbestos which is composed entirely of clinochrysotile, is described at length in later chapters.

The third major serpentine mineral identified was antigorite, which comprises about 10% of the total serpentine products. Type 5 serpentine is almost wholly made up of this mineral, and it is also present in minor amounts in all other types except Type 2. Antigorite forms a type of mesh texture with 'feathery' mesh borders, this texture may be extremely fine grained. Antigorite appears to replace all other serpentine minerals, and a good example is the replacement of chrysotile in veins by picrolite the fibrous form of antigorite.

Brucite is present in very small quantities in these rocks and is restricted to the slickensided and slip fibre filled shears and veins in rock Types 3 and 4. Brucite was only identified in specimens of slip fibre sent for X-ray determination of their chrysotile fibre content and was present as the dominant mineral in 7 of the 9 samples tested, (refer appendix 2). The fibrous form of brucite known as nemalite appeared to be present in some specimens.

Magnetite is ubiquitous in all specimens of serpentinite and is present in several forms. It occurs as finely spread dust throughout lizardite mesh texture serpentine of the darker green varieties of massive and sheared serpentinite. More commonly magnetite forms isolated crystals or stringers within fracture filled serpentine.

The original crystal outlines are mirrored by the magnetite strings (Ref. Plate 27). Magnetite is also predominant as faint parallel lines in bastites where serpentinsation has developed along the cleavage of the pyroxene. The third occurrence of magnetite is within shear planes in serpentinite types 3 and 4. Here it forms thin layers or coatings along shear planes or as fibrous masses several inches long mixed with massive or fibrous serpentine. The magnetite in the shear zones appears to have been remobilized by shearing of rock Types 1 - 3.

The chromite in the primary rocks has been affected marginally due to serpentinisation. Some grains have reaction rims with the serpentine, which are composed of titanomagnetite, other grains are merely rounded (ref. Plate 36). Commonly chromite grains are fractured and filled with (?) serpentine, this is strong evidence for expansion due to serpentinisation (ref. Plate 35). Later metasomatic action on the chromites has produced stichtite in well defined zones within the ultramafic body.

Pentlandite is found as rare blebs or smears in massive serpentinites from the 6N area to the 26N area in a zone parallel to the proposed basal margin of the ultramafic body. The blebs up to 6mm in diameter may be veined or rimmed by secondary bravoite or violarite (Ref. Plate 34). The pentlandite and associated minerals may have formed during serpentinisation of nickel rich peridotite rocks.

Talc and carbonate have formed as a result of serpentinisation but these minerals appear to be more related to metasomatism of the serpentinites and are discussed under that heading.

In summary, lizardite and clinocrysotile are the main components of the serpentinites and these are accompanied by less common antigorite and magnetite with very minor chromite, related stichtite, pentlandite and brucite.

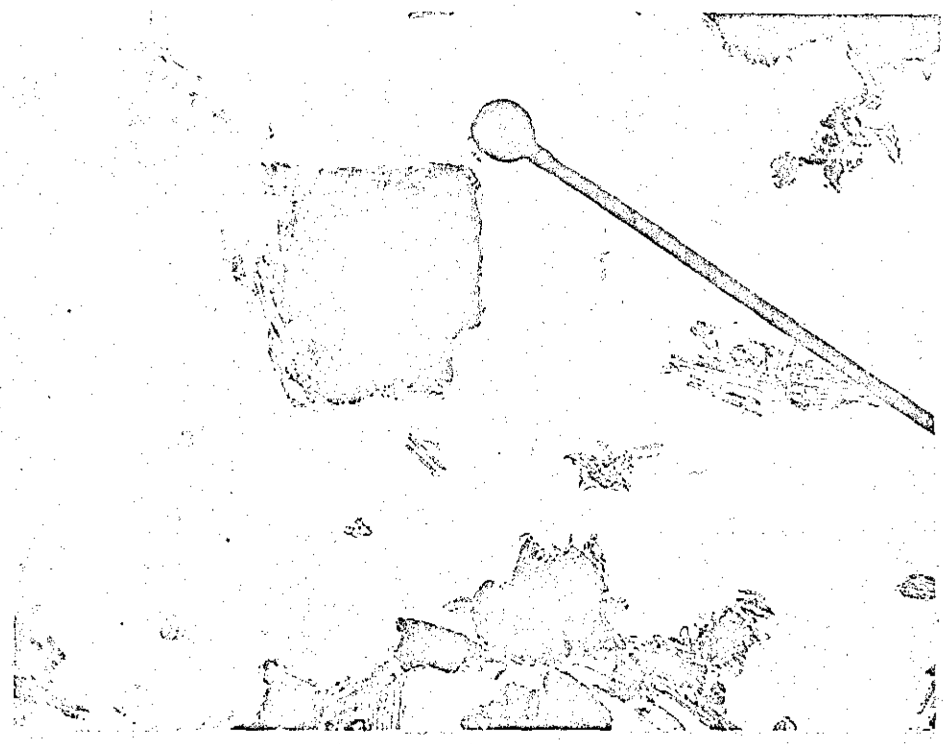


PLATE 28. SPECIMEN 71/L1-120 SERPENTINITE
The long hollow tubes are chrysotile fibrils. The massive plates are lizardite. MAGx60,000

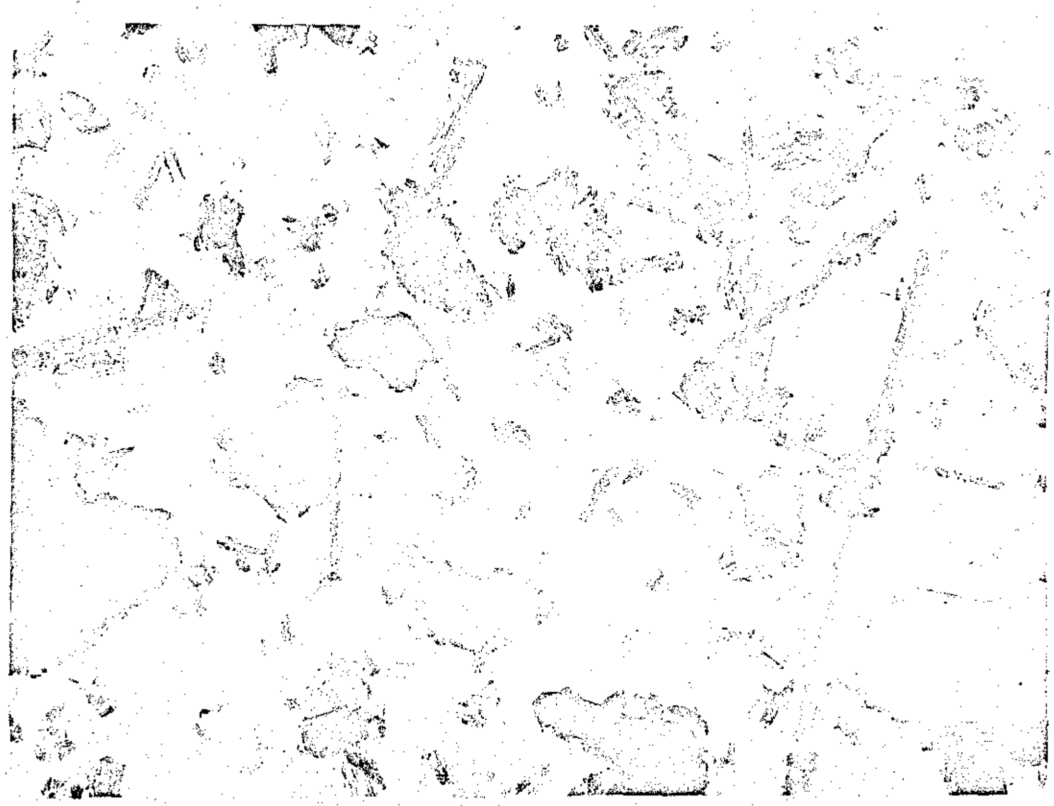


PLATE 29. SPECIMEN 71/L1-41 SERPENTINITE
Electron micrograph showing lizardite and chrysotile serpentine types. MAGx40,000

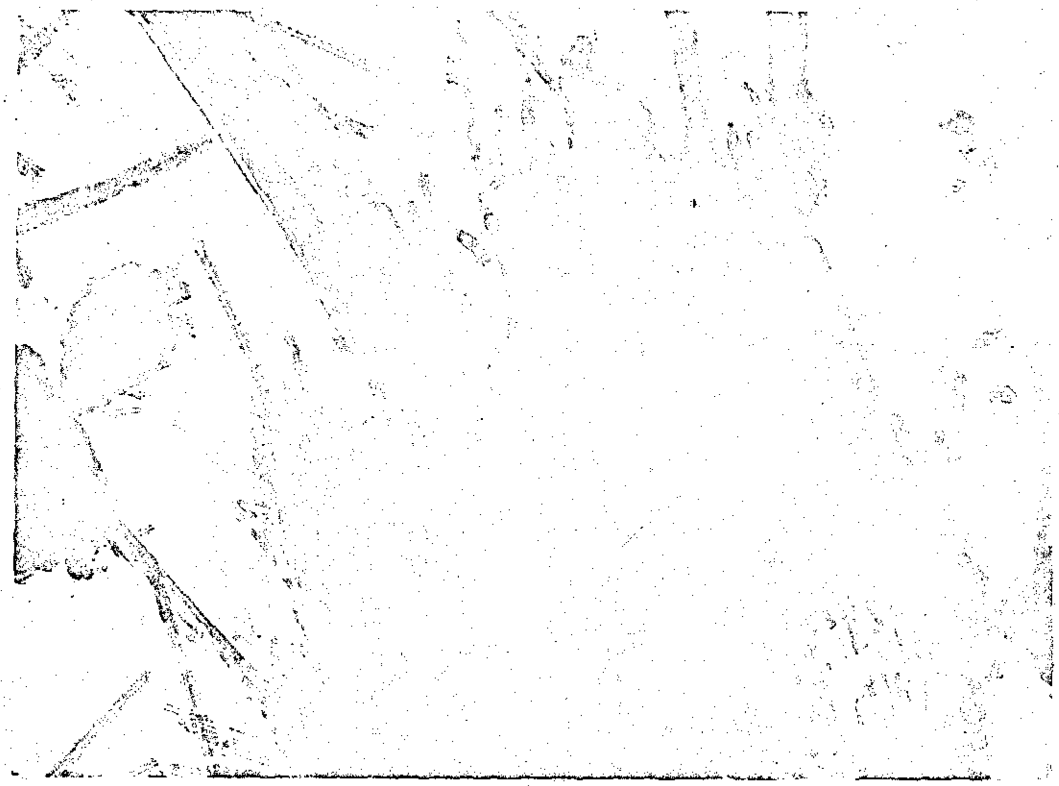


PLATE 30. SPECIMEN 71/L1-125A CHRYSOTILE FIBRE
Electron micrograph of a bundle of fibres. Lizardite plates also present indicating that minor lizardite occurs in the fibre veins. MAGx40,000

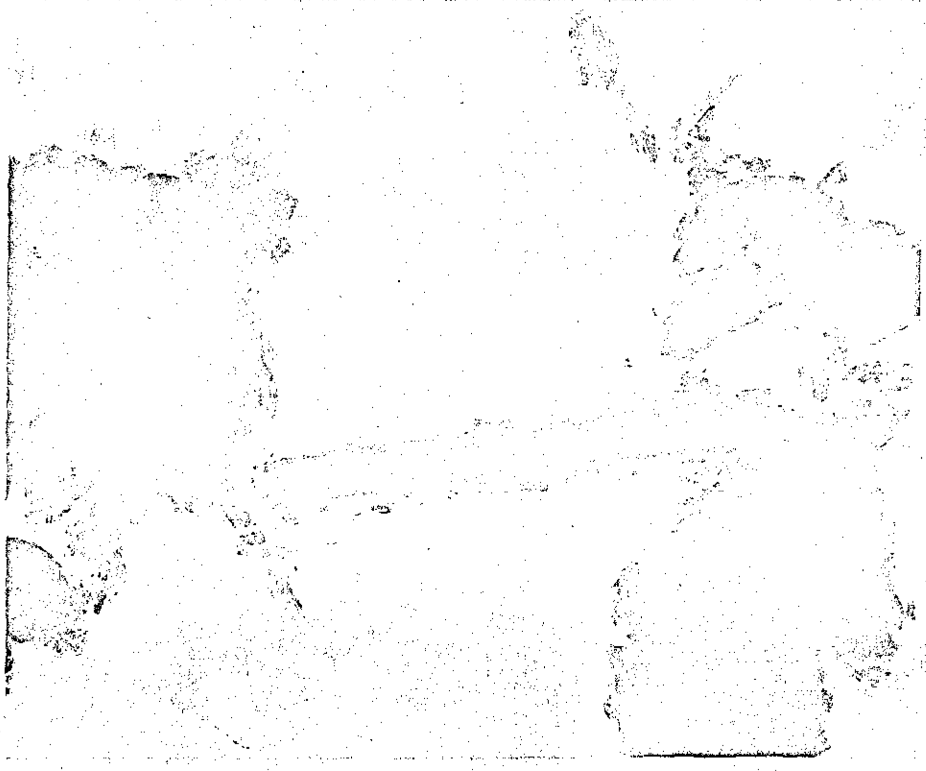
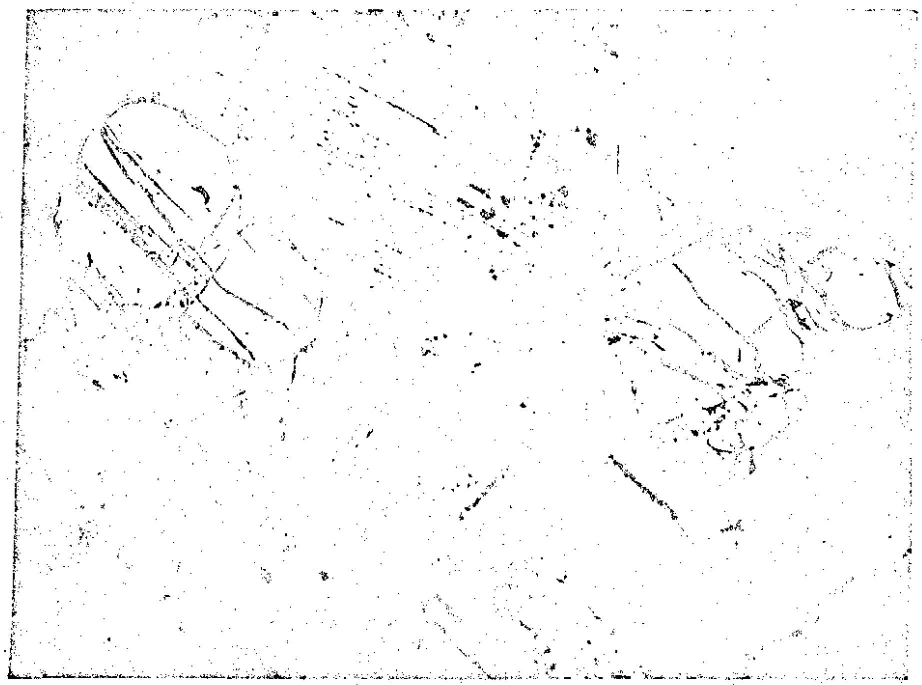


PLATE 31. SPECIMEN 71/L1-126 ANTIGORITE SERPENTINITE
Electron micrograph showing antigorite laths and

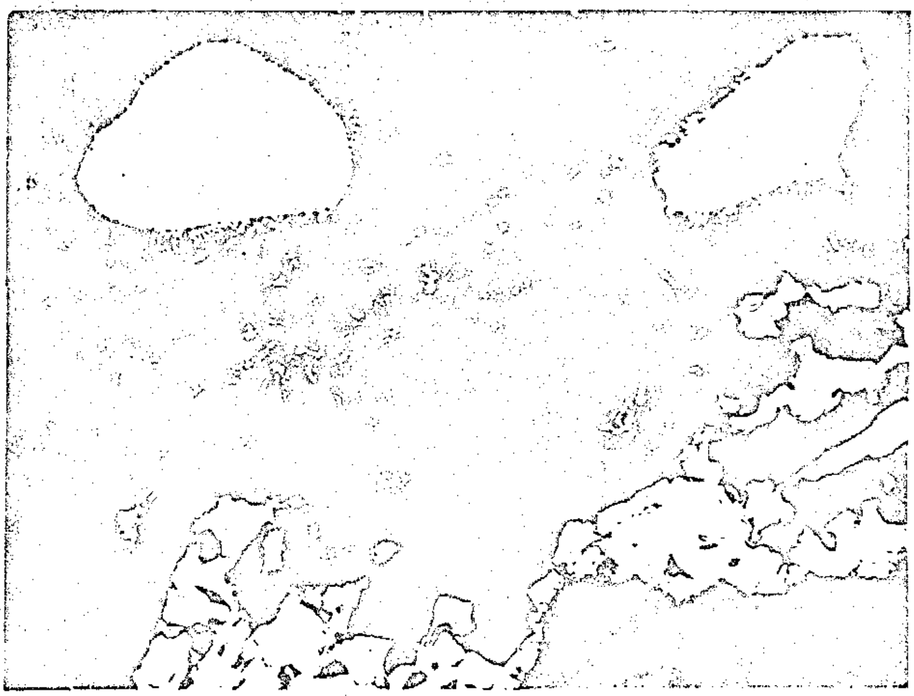
PLATE 32. SPECIMEN 71/L1-50 LIZARDITE SERPENTINITE
Typical plates of lizardite. MAGx60,000

PLATE 33. SPECIMEN 71/L1-50 LIZARDITE SERPENTINITE
Laue diffraction pattern of the large lizardite plate in plate 32. This is a typical diffraction pattern for lizardite.



1.0mm

PLATE 35. SPECIMEN 71/L1-50 SERPENTINISED PYROXENITE
Subhedral chromite grains, rounded, embayed and fractured by serpentine.
REFLECTED LIGHT
MAGx2 5



1.0mm

PLATE 36. SPECIMEN 71/L1-46 SERPENTINITE
Chromite grains surrounded by flame structures of titanomagnetite within serpentine. Magnetite forms large irregular masses (bottom) at the border between serpentine and stichtite rich serpentine.
REFLECTED LIGHT
MAGx2 5

(iii) Geochemistry

Fourteen rock specimens representative of the different serpentine types, mostly from the 25N line, were analysed in order to study any compositional changes that has taken place due to serpentinisation.

Six specimens of serpentinite from various drill cores at Noddy Creek were sent to the A.M.D.E.L. laboratories for partial rock analysis and a further twenty-four rocks from the Hibbs Ultramafic Belt, thirteen of which came from Noddy Creek were sent for trace element analysis (Appendix 3). Results from these groups of analyses were compared with the analyses of four peroxenites and six serpentinites, from DDH 1 Noddy Creek, performed by Palethorpe (1971), refer Table 3.

The author has noted that the comparison of the analyses of serpentine rocks from various localities may not be valid due to the probable differing nature of their primary rocks and also the fact that these analyses were performed at different laboratories. The observed changes in the rock composition due to serpentinisation must be considered to be only general trends.

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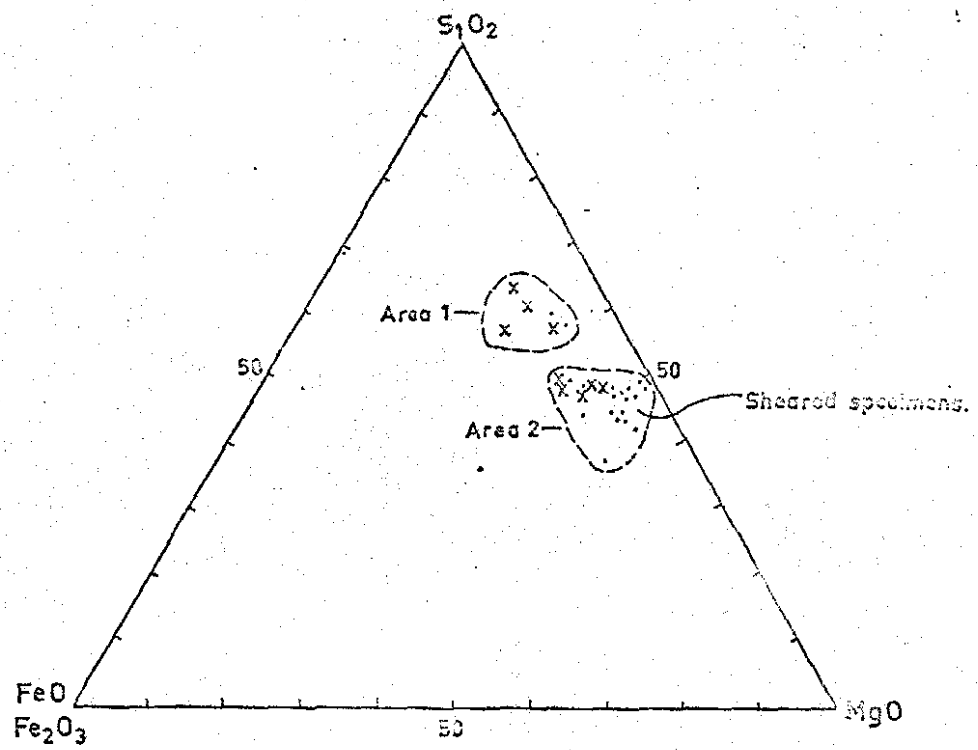
TABLE 3

CHEMISTRY OF THE NODDY CREEK ULTRAMAFICS

	NEW ANALYSES		PALETHORPE'S ANALYSES	
	No. of Analyses	Mean Value	No. of Analyses	Mean Value
SiO_2	21	37.5 %	10	45.01 %
Al_2O_3	21	0.4	10	1.33
Total Fe	21	4.8	10	9.31
MgO	21	39.8	10	31.85
CaO	21	<0.1	10	3.10
Na_2O	14	<0.1	10	0.03
K_2O	14	<0.1	10	0.02
TiO_2	21	<0.1	10	0.03
Ni	27	1611	10	875
Cr	25	2924	10	3710
Co	26	84	10	88
Pb	6	4	-	-
Zn	13	45	-	-
Cu	13	8	3	2

Palethorpe's analyses represent mostly massive serpentinites and primary pyroxenites, while the authors analyses were performed largely on sheared and massive serpentinites. The effects of serpentinisation of the primary ultramafic rocks are clearly shown.



S.M.F. DIAGRAM SHOWING DISTRIBUTION OF PYROXENITES AND SERPENTINITES AT NODDY CREEK

AREA 1. SHOWS THE PYROXENITE GROUP
AREA 2. SHOWS THE SERPENTINITE GROUP

X ANALYSES AFTER PALETHORPE
. NEW ANALYSES

NOTE: The increase in the MgO/SiO_2 ratio during serpentinization and the decrease in iron due to shearing.

Overall, there is a marked increase in the MgO/SiO_2 ratio with the probable loss of both silica and magnesia in solution and a strong decrease in the calcium content due to serpentinisation. The total iron content remains unchanged in the serpentinites, however in the more sheared specimens the iron has been released from the serpentine network and forms masses of magnetite in the shears. Local concentrations of iron may occur in the massive serpentinites, an example is specimen 71/L1 - 119 which contains 23.8% total Fe. The iron is present as individual crystals and stringers of magnetite.

The alumina content of the rocks is very low (0.4%) and is little affected by serpentinisation except in highly serpentinised and sheared varieties where the alumina content decreases marginally.

The trace elements Cr and Co appear to have been little affected by serpentinisation. The Cr values although variable are high for ultramafic rocks in general, and average approximately 3000 ppm Cr.

The nickel content in the primary ultramafic rick is uniformly low, 1000ppm, due mainly to the high pyroxene content of these rocks. During serpentinisation Ni is released from the primary silicate lattice and concentrates in the serpentine lattices or combines with iron and sulphur in solution to form pentlandite. The average Ni content of the serpentinites is approximately 1800ppm, which shows that the serpentinisation process has tended to concentrate the nickel in the serpentinites. However, it must be considered that no olivine bearing primary rocks were analysed, and the increased average Ni content of the serpentinites may be due to Ni released from these primary rocks. A possible example of the mobility of the nickel is provided by the presence of morenosite ($NiSO_4.7H_2O$) as a thin [illegible]

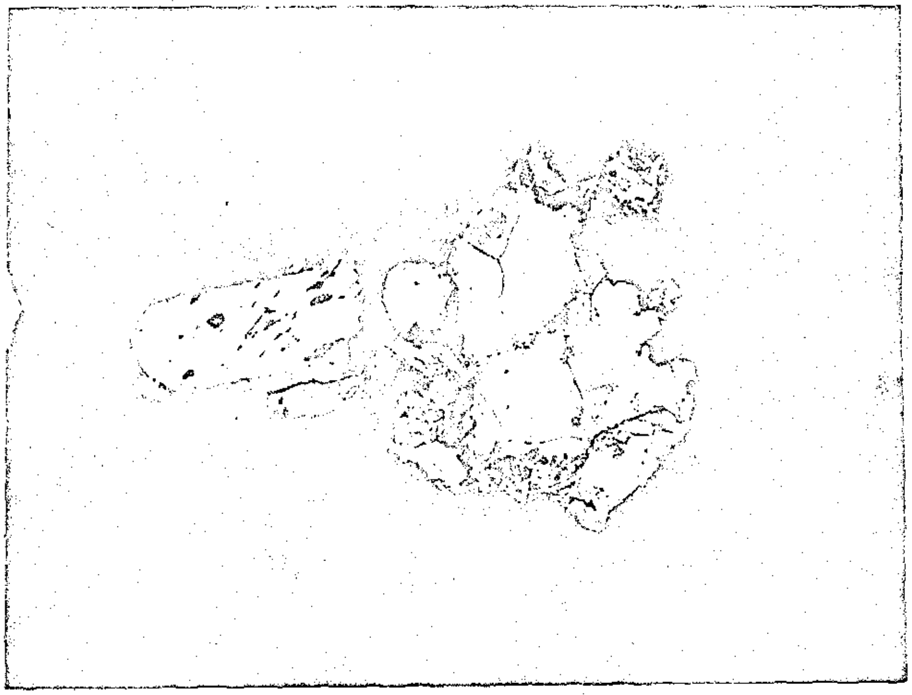
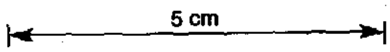


PLATE 34. SPECIMEN 71/L1-119 SERPENTINITE
Large irregular mass of pentlandite (centre) rimmed by bravoite, which also fills cracks in the pentlandite. To the left is a magnetite crystal with serpentine inclusions. This specimen is very rich in magnetite which is thought to form during serpentinisation.

REFLECTED LIGHT
MAGx2 5



and pyritic graphitic shale, on the 15S line. McGregor (1968) states that this may be caused by the oxidation of NiS e.g. pentlandite, but also "may have been deposited by a process, whereby the pyrite in the shale was oxidized to $FeSO_4$, and this was carried in acid waters through the serpentinite where nickel was collected and depositied as a fine coating of $NiSO_4$".

The volatiles Na_2O and K_2O and also TiO_2 are present in trace elements in both primary and secondary rocks and are little effected by serpentinisation.

The calcium present in the primary rocks is contained in the clinopyroxenes of the websterites. During serpentinisation the Ca^{+2} radicle is released into solution and is carried away in the meteroic waters because it cannot fit into the crystal lattices of any of the serpentine products at Noddy Creek. The following reaction

$$\text{(1)}\quad \underset{\text{olivine}}{MgSiO_4} + \underset{\text{diopside}}{CaMgSiO_3} + \underset{\text{fluid}}{H_2O + O_2} \longrightarrow \underset{\text{serpentine}}{Mg_3Si_2O_5(OH)_4} + \underset{\text{brucite}}{Mg(OH)_2} + OH + \underset{\text{calcium}}{Ca^{++}}$$

may explain the release of calcium into solution but may not have occurred widely due to the fact that both olivine and particularly brucite are minor phases in these rocks.

Coleman and Keith in reference to reaction (1) state that "when orthopyroxene exceeds 40wt per cent in harzburgites, there is enough silica available to produce serpentine and magnetite without brucite". It seems that the paucity of brucite at Noddy Creek occurred because there was too much iron in the system to be incorporated in the serpentine lattices and it was forced to crystallise as magnetite. The calcium rich waters resulting from reaction (1) may team up with SiO_2 rich waters to form talc and carbonates, e.g. specimen 71/L1 - 131. They may also react with basic rocks such as gabbros to form Ca, Mg, Al

SiO_2 rich rocks such as chlorites and ultimately rodingites, e.g. specimen 71/L1 - 135.

Evidence for the presence of silica in solution resulting from serpentinisation may possibly occur along the western end of the 7S line, where extensive silicifation of metasomatised gabbros has taken place. Alternatively the silica may have been derived from meteoric waters from the enclosing sediments.

(iv) Processes of Serpentinisation and Formation of Serpentine Types.

Page (1967) considered two reactions to be most significant in nature:-

(2) Fe bearing olivine + enstatite H_2O + O_2 ⟶
(fluid)

clinochrysotile + lizardite + magnetite

(3) Fe bearing olivine + H_2O + O_2 ⟶
clinochrysotile + lizardite + brucite + magnetite

Reaction (3) occurs at lower temperatures than reaction (2). These two reactions plus reaction (1) could explain the processes of serpentinisation.

All three reactions require only the introduction of a fluid rich in water and oxygen and can take place in low pressure conditions in the temperature range from less than 50°C to slightly above 400°C. In general these reactions occur at higher temperatures when under higher enclosing pressures.

It is evident that the process of serpentinisation at Noddy Creek as in other serpentinised ultramafics e.g. Burro Mountain - California, has taken place over a long period of time and occurs in a number of stages. Each stage has a distinctive serpentine mineral assemblage related to the different pressure-temperature conditions that existed in the ultramafic body.

There appears to be three main phases of serpentinisation at Noddy Creek, which are also common in most ultramafic bodies which contain economic chrysotile asbestos deposits.

Phase A. A pervasive partial serpentinisation extending from the margins throughout the ultramafic mass, the degree of serpentinisation may only be slight and varies between localities. It is considered that 50% of the ultramafics at Noddy Creek have been altered in this phase, and Type 1 serpentinite is a typical product.

Phase B. Superimposed on Phase A is a later phase of through serpentinisation developed along shear zones, faults, intrusive margins, and fracture systems.

Phase C. A final phase is developed within the serpentine zones of Phase B which includes serpentine Types 2 to 4. This phase is typical of the development of chrysotile and to a lesser extent antigorite and results often in the formation of economic asbestos deposits.

Phase A serpentinisation occurred during the emplacement of the ultramafic body as discussed previously and resulted in the formation mainly of lizardite bastites with some clinochrysotile in the mesh textured serpentinite. Phase B followed cooling and shearing of the body and resulted in the formation of lizardite and clinochrysotile in approximately equal amounts within mesh textured serpentinite.

Phase C resulted firstly and primarily in the formation of chrysotile veins composed of massive and fibrous clinochrysotile with a little orthochrysotile. These veins appear to fill tension gashes and fracture systems in the massive serpentinites. The second stage of Phase C is relatively minor at Noddy Creek, but seems to be more extensive in other ultramafic bodies. This stage is the formation of due to the effects of shearing stress during metamorphism of lizardite-clinochrysotile serpentinites. The resultant rock is Type 5 serpentinite with picrolite which replaces former chrysotile veins. Phase C may last a long time (even right up to the present), with repeated shearing of the rock and a continuous flow of magnesium rich solutions passing through these zones.

(v) Origin of Fluids for the Serpentinisation Process

Bowen and Tuttle (1949) have deduced from experimental work that large scale serpentinisation is due to the introduction of extraneous hydrothermal solutions, during the final stages of cooling (400°C) of the intrusive mass, or during a separate period of low heating. If the source of fluids is in fact extraneous, it would be expected that serpentinisation would be concentrated along the more permeable fractured zones within the ultramafic mass, and would tend to increase towards the margin of the mass. This appears to be the situation at Noddy Creek, with the introduction of connate water derived from the compaction of enclosing Dundas Group Sediments. However, there remains the possibility that Phase A of serpentinisation may have taken place partially or wholly by the action of magmatic water enclosed in the rising mass of crystalline ultramafic. Hydrothermal solutions related to the emplacement of the gabbros, diorites and granodiorites and may have played an important part in the metamorphism of the lizardite-clinochrysotile serpentinites to antigrorite along the margins of the ultramafic mass.

(vi) Cross-Fibre Chrysotile at Noddy Creek.

Chrysotile fibre development has puzzled scholars for a number of decades but recent research in this field has provided several working hypothesis for the genesis of chrysotile fibre.

The formation of chrysotile has been attributed to both fissure filling and replacement of wall rock material, and it seems that both processes must be postulated to account for all the field and microscopic evidence. No serious attempt was made to study the fibre veins at Noddy Creek but it appears that the cross fibre developed by outward growth from one or both sides of tension fractures in massive serpentinites. Partings are common as irregular lines through the larger veins and illustrate the differential growth of fibre from the vein walls. Occassionally inclusions of wall rock occur, testifying to possible wall rock replacement or to continued of later movement and production of fractures during fibre development. Massive light green serpentine veins marginal to or within cross fibre veins may be wall rock serpentine in the process of alteration to clinochrysotile and ultimately to cross fibre. Alternatively these massive lenses may be rapidly crystallized serpentine from the magnesia rich fluids providing material for the fibre growth.

There are several generations of chrysotile fibre development at Noddy Creek which together produced five main vein types (After Langlands 1971).

1. Stockwork veins
2. Widely spaced sub-parallel veins
3. Gash veins
4. Thread veins
5. Ribbon fibre veins.

All these vein types may be found in association in the massive Type 2 serpentinite.

1. Stockwork cross fibre is typical of the very rich areas of fibre development and is present as a three dimentional vein network in massive serpentinites e.g. 40N line western cross fibre body, also 15S line cross fibre zone. In a few cases a rectangular network was noted and these veins were usually 1" in width (refer Plate 39).

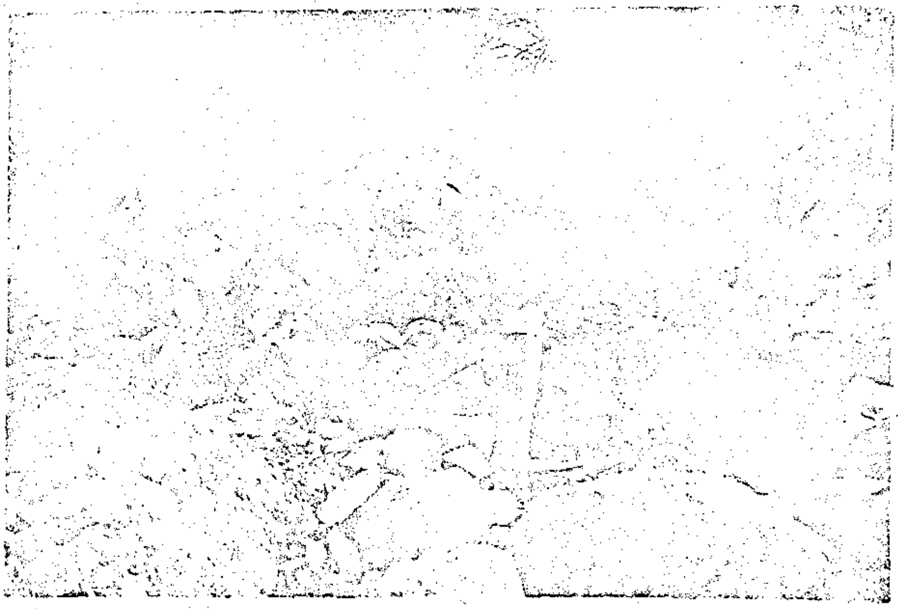


PLATE 37. VIEW OF AN OUTCROP OF TYPICAL CROSS-FIBRE BEARING type 2 serpentinite. Chrysotile veins up to 1" thick are shown.

PLATE 38. OUTCROP OF CROSS-FIBRE RICH MASSIVE SERPENTINITE SURROUNDED BY SHEARED SERPENTINE
Note the combination of stockwork and ribbon fibre types of chrysotile.

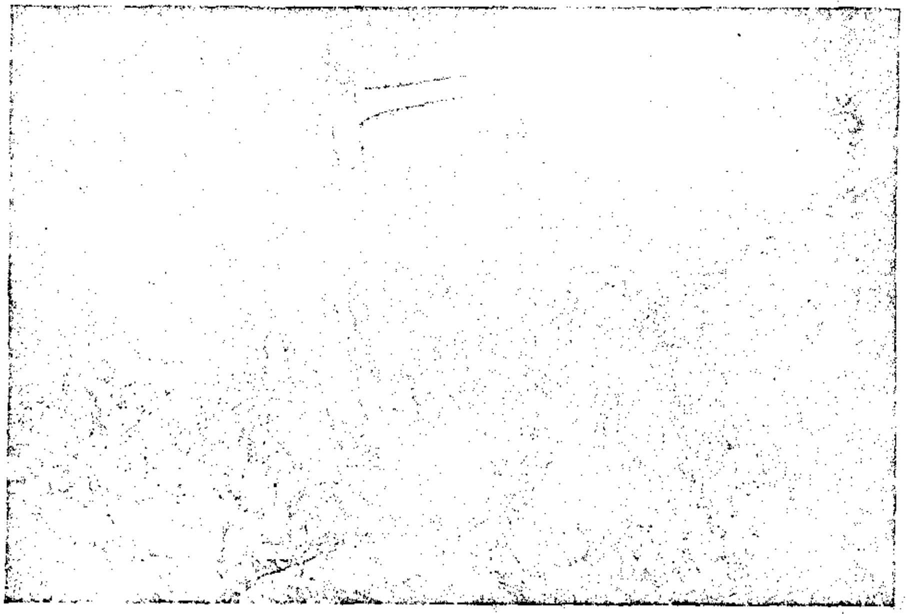


PLATE 39. CHRYSOTILE CROSS FIBRE IN MASSIVE SERPENTINITE.40N LINE
The cross-fibre is in a rectangular network. One set of veins lie parallel to the original layering in the primary rock and another weaker set at right angles to the former set.

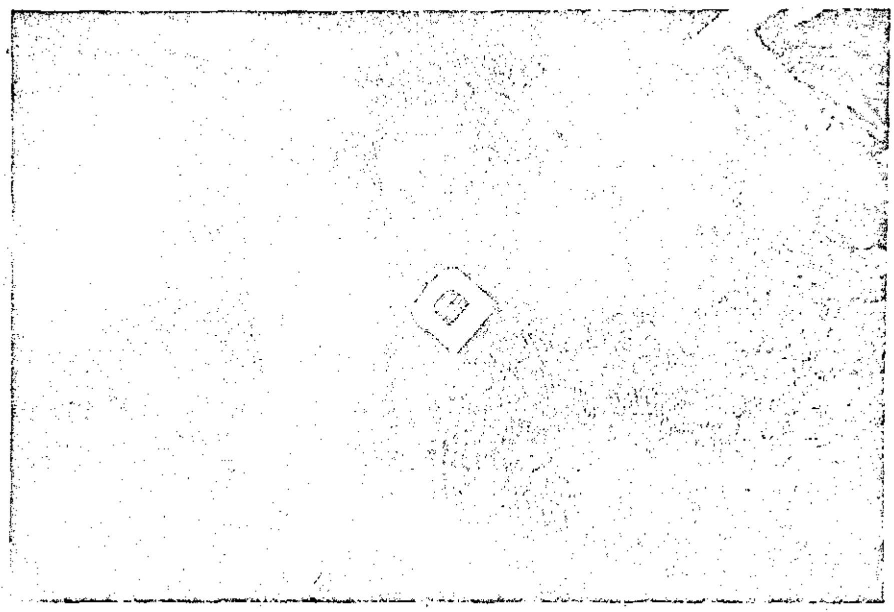


PLATE 40. TYPICAL RIBBON FIBRE ASBESTOS developed in massive light green serpentinite and surrounded by dark green sheared (?) antigorite rich serpentinite. Note the increased spacing and width of the veins from right to left.

2. Widely spaced, subparallel veins occur parallel to the layering of serpentinised pyroxenite. In hand specimen and under microscopic examination, these veins are seen to occur as coalescing en-echelon gash veins along the contacts between layers in the original primary rock. The most notible development of this type is in the southern zone from 10S to 15S and in the western zone along the 30N line (refer Plate 27).

3. Gash veins are not more than a few inches long and seen in section the maximum vein width and therefore the longest fibres occur towards the middle of the vein. Gash veins in massive serpentinite occur throughout the area but are only a minor form of asbestos mineralization.

4. Thread veins are very narrow often discontinuous veins less than 1/32 of an inch thick. They occur in all serpentine types except Type 5 and may be the forerunner of other vein types, particularly ribbon fibre and gash veins.

Near minor shears, within fibre zones, movement along cross fibre veins has tilted the fibre at an angle to the vein walls or has created kink bands in the wider veins. Rarely has shearing caused the fibre to become oriented parallel to the vein walls, so that it resembles slip fibre.

5. Ribbon fibre serpentinite exhibits numerous closely spaced, parallel veinsless than ¼" wide, and occurs as concentric spheroids and ellipsoids around barren cores of serpentinite or serpentinized pyroxenite. (refer Plate 6).

There is a high percentage of fibre in these rocks, up to 40% in some cases, and it is interesting to note the increased spacing and width of the fibre veins away from the centre of the barren cores. The scale of ribbon fibre development at Noddy Creek varies from small bodies several centimetres across, to large massive bodies 10 metres or more across. In fact, by distorting this ribbon fibre model a little one could say that most of the cross fibre deposits at Noddy Creek are remanants of partially eroded large scale ribbon fibre bodies, having massive cores and sheared margins, with other cross fibre types superimposed on the simple ribbon fibre structure.

Taking the analogy further, it is possible to generalize about the structural and petrological conditions which led up to fibre development at Noddy Creek. The cross fibre at Noddy Creek occurs in massive serpentinite and serpentinised pyroxenite in two basically parallel zones of disconnected pods. These zones, known as the eastern and western zones are surrounded by narrow shear zones and are separated by a zone of partially sheared disseminated stichtite bearing serpentinite. It is proposed that these two zones of massive bodies, were the least serpentinized areas after Phase A of serpentinization and during Phase B they acted as resistant bodies in the ultramafic zone. During further serpentinsation they expanded marginally forming a shell of generally concentric tension fractures around each body. Phase C of serpentinisation saw the development of chrysotile asbestos in these tension fractures forming ribbon fibre bodies. This fibre development is often complicated by the presence of stockworks, and parallel fibre veins in tension gashes related to differential expansion between layers of the original ultramafic rock types.

Thus the fibre bodies at Noddy Creek may be seen as combinations of fibre vein types 1 - 3 in shells of partial shells around massive pods of partially serpentinised pyroxenite.

(vii) Slip Fibre

Two types of slip fibre were seen at Noddy Creek. They are :-

1. Sheared cross fibre
2. Brucite slip fibre.

The first of these types, from X-ray analysis appears to be of minor importance, and occurs only in shears cutting cross fibre zones. The brucite rich slip fibre is found widely distributed in sheared serpentinite and the less sheared stichtite bearing serpentinite. It occurs in veins up to 2 cms wide or as silky fibrous smears on shear planes (Langlands 1971). In some of the wider veins, fibre lengths up to 15 cms have been observed. These longer fibres are brittle and are commonly associated with (?) talc and magnetite. When weathered, slip fibre typically forms distinctive sticky grey masses on rock faces. Slip fibre forms much less than 5% of the total rock volume in the shear zones in which it occurs.

Riorden (1957) and Laubscher (1964) consider that some cross fibre in asbestos deposits has been derived by recrystallization under favourable stress conditions of picrolite and colloidal serpentine. The author agrees that cross fibre may be derived from the light green colloidal serpentine which often occurs within cross fibre veins, but does not consider that much cross fibre is derived from picrolite. Field relations at Noddy Creek show that picrolite occurs only in dark green to black massive Type 1 or Type 5 serpentinites. It appears that in Type 1 serpentinite on the 10S and 15S lines, and Type 5 serpentinite on the 55N and 15S lines, picrolite has replaced both cross fibre and slip fibre. This has occurred during reheating and marginal shearing of massive ultramafic bodies and is possibly related to the emplacement of the adjacent gabbroic intrusions.

Coleman (1971) in studies of North American serpentinites has observed that picrolite is formed when chrysotile veins undergo shearing. This agrees with the author's limited study at Noddy Creek.

(viii) Metasomatism of Serpentinite

Various types of metasomatism or metamorphism have affected the serpentinites at Noddy Creek but their overall effect has been marginal, with less than 10% of the rock minerals being of metasomatic origin. The metamorphic mineral phases are :-

1. Chlorite
2. Magnesite
3. Talc-carbonate
4. Stichtite

1. The chlorite present in the serpentines is of very minor importance and has only been observed in a few specimens near the ultramafic contacts. Chlorite replaces chrysotile in veins and in the mesh texture serpentine marginal to these veins, this alteration is particularly strong in asbestos veins which invade the country rock, e.g. at the western end of the 30N line.

2. Magnesite is typically found in the antigorite rich sheared serpentines marginal to the ultramafic body. The magnesite (e.g. specimen 71/L1 - 127) which has been identified by X-ray diffraction, forms irregular lenses parallel to the shearing direction in the host rock.

The most likely method of the formation of magnesite was by simple carbonisation of serpentine.

PLATE 41. MAGNESITE VEIN WITHIN COMPACT SHEARED TYPE 5 SERPENTINE
This serpentine has been metasomatically altered to antigorite.

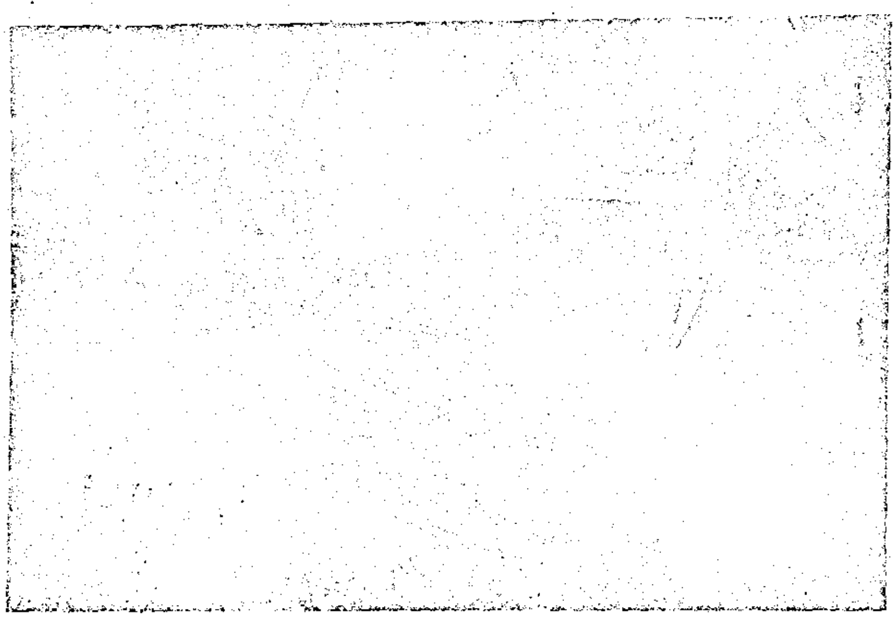


PLATE 42. MASSIVE STICHTITE BEARING SERPENTINITE TYPE 3
Note the slip fibre vein containing fibrous magnetite parallel with the hammer. The thin vein below it is cross fibre asbestos.

(4) $H_4MgSi_2O_9 + 3CO_2 \longrightarrow MgCO_3 + 2H_2O + 2SiO_2$
serpentine in fluid magnesite in solution

Magnesite may also have formed with serpentine by the hydrothermal alteration of olivine or brucite when the partial pressure of CO_2 was above 0.5MOL% as in the following reactions :-

(5) $2Mg_2SiO_4 + 2H_2O + CO_2 \longrightarrow Mg_3\ Si_2O_5\ (OH)_4 + MgCO_3$

(6) $Mg\ (OH)_2 + H_2O + O_2 + 3CO_2 + Mg_3Si_2O_5\ (OH)_4 \longrightarrow H_4MgSi_2O_9 + 3MgCO_3 + 2H_2O$

3. Talc-carbonate alteration within the serpentinites is weak and is restricted to zones of shearing adjacent to basic intrusives. Specimen 71/LI -131, a talc carbonate rock is probably the surface expression of the contact between serpentinised pyrxenite and gabbro intersected by DDH7 on line 20N.

Talc is often not related to carbonate alteration in the serpentinites and is found in shear zones within Type 3 serpentinite. Talc alteration of partially or unserpentinised ultramafics is widespread in the Hibbs Belt but was only found to occur extensively at Noddy Creek in the massive ultramafic body between the 10S and 15S line.

4. Stichtite. The formation and distribution of this rare hydroxyl carbonate is discussed in detail because of the excellent exposures of this mineral at Noddy Creek and the lack of previous documentation on the subject.

To date, stichtite $MgCO_3.5Mg(OH)_2 2Cr(OH)_3 2H_2O$ has only been reported from Ontario, Canada, the U.S.S.R., and at Dundas in Western Tasmania about 70 kilometres north of Noddy Creek.

The author has also tentatively identified as stichtite, a lilac coloured mineral present as thin films along carbonate alteration zones within fractures of a podiform chromite deposit at Coobina, approximately 50 kilometres east of Mt. Newman in Western Australia. Microscopic evidence of several specimens, 71/L1 - 41, 172 and 46 shows that stichtite forms by the action of CO_2 rich solutions upon chromite and occurs as wavy masses in the serpentine around broken chromite grains or within fractures in the chromite. Refer Plates 43 and 44.

A discription of a typical stichtite bearing serpentinite specimen 71/L1 - 172 (NC24) is given in appendix 3.

It is not known why stichtie is so rare in nature and it is assumed that stichtite results from an unusual combination of pressure-temperature conditions during metasomatism, and also the chmistry of the chromites. None of these factors have been studied in this thesis and it is suggested that some experimental work is required to elucidate this problem.

Field mapping of the distribution of this rock type has provided some observations which may be of some importance.

1. The stichtie occurs in well defined zones within the serpentinised ultramafic body. These zones were originally partially sheared serpentinite between blocks of massive serpentinite and adjacent shear zones.

2. Stichtite bearing serpentinite and good chrysotile asbestos deposits are mutually exclusive because of their different structural settings. The chrysotile forms in the massive serpentinite, while the stichtite is in the more sheared varieties.

3. The main stichtite zone stretches from the 60N line to the 5N line, with an extension on the 15S line. Stichtite is not found anywhere else in the Hibbs Ultramafic Belt, and it is thought that the intrusion of gabbros at Noddy Creek may have helped stichtite formation.

4. Stichtite usually takes the form of small blebs from 1mm - 1 cm in diameter, averaging 4mm, which are usually oval in shape due to the effects of shearing. Rare massive lenses up to 1 $\frac{1}{4}$ metre wide and 3 metres long, such as at the western end of the 15S line are assumed to be formed by late shearing and concentration of the stichtite blebs.

5. Talc does not usually occur visibly with the stichtite, but it sometimes forms thin lenses within massive stichtite which gives the rock a curious spotted appearance, e.g. specimen 71/L1 - 46.

6. The change from non-stichtite bearing serpentinite to stichtite bearing varieties is fairly sharp, ranging from a few centimeters to 3 meters. The transition zone is marked by dark spots scattered in the rock which on closer inspection are identified as chromite grains altering marginally to stichtite. The cross fibre present in small amounts in the stichtite rocks does not cut any stichtite which means that the stichtite probably formed after the main period of chrysotile fibre formation. Stichtite is related to the talc and carbonate alteration which occurs elsewhere in the serpentinites at Noddy Creek.

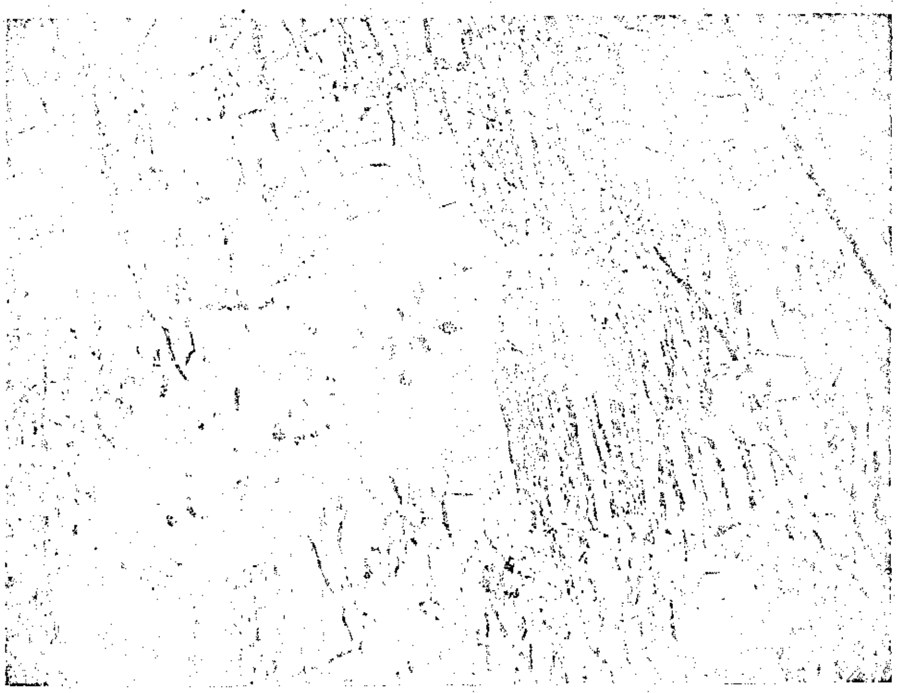


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PLATE 43. SPECIMEN 71/L1-172 STICHTITE BEARING SERPENTINITE
On the left stichtite is forming around broken chrom[illegible] grains. Serpentine with fibro-lammellar and mesh texture surrounds the "bleb". A chrysotile vein is seen in the top right corner. MAGx2 5xNICO[illegible]

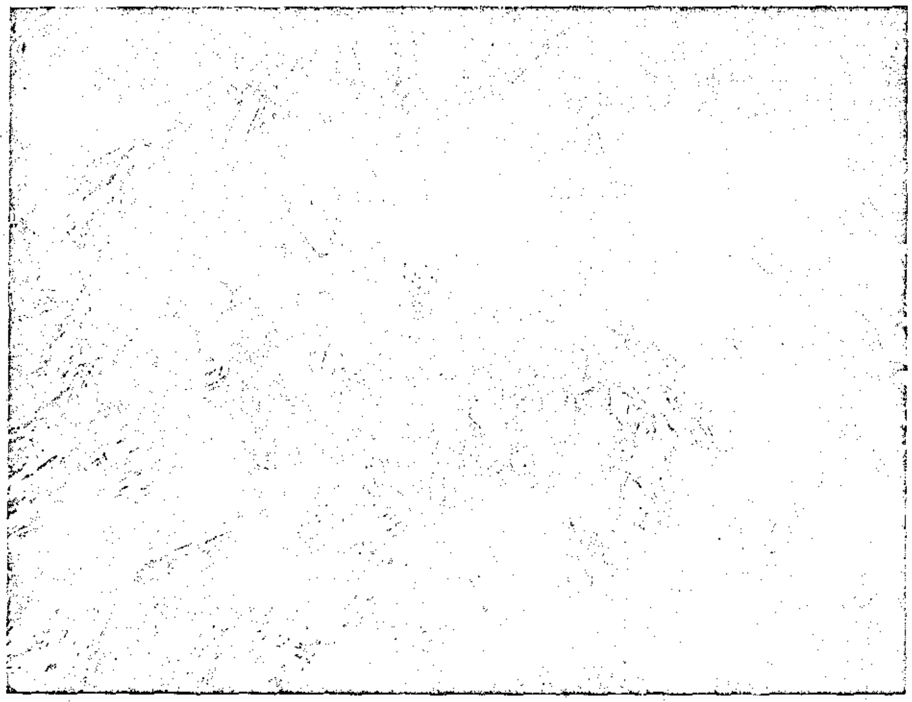

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PLATE 44. SPECIMEN 71/L1-46 MASSIVE VEIN OF STICHTITE IN SHEARED SERPENTINITE
On the right a chromite grain is split in two and is rimmed by stichtite. This is set in mesh texture, lizardite serpentine, near the border with the massive stichtite zone (left), which contains irregular masses of (?) chromite and magnetite. MAGx100xNICOLS

(B) METAMORPHISM AND METASOMATISM

All the rock types of the ultramafic complex at Noddy Creek have undergone one or more periods of metasomatism by fluids derived from the intrusive mass itself, a related intrusive or the surrounding sediments. It appears that metasomatism and metamorphism of the complex began shortly after the initial pervasive serpentinisation of the ultramafic body, was strong during the intrusion of the acid to intermediate bodies and continued well after Phase B, the main period of serpentinisation of the ultramafic body. There are several stages evident in the metasomatic process at Noddy Creek. These are similar if not identical to the stages reported to occur in some of the other ultramafic complexes in Tasmania.

Some examples are the formation of stichtite at Dundas and the presence of rodingites at Beaconsfield. These stages are also referred to by Martin (1970) in his discussion on the effects due to serpentinisation. He states that "In open highly sheared environments where there is ready water excess through cracks and faults, large volumes of fluid may be involved..................continuous flow of such fluid means that their composition will change as the ultramafic becomes progressively serpentinized and hence they will be capable of differing metasomatic effects at different times".

The different rock suites at Noddy Creek, have therefore been altered at various times to form a wide range of secondary products. This was due firstly to the different primary mineral assemblages, and secondly to the varying temperature and composition of the metasomatic fluid. Taking the alteration of the gabbros as an example there appears to be a general alteration trend which may be ralated to the temperature of the rocks and/or the altering fluid.

Hess (1933) proposed that the hydrothermal alteration or steatitization of an ultrabasic body, produced a series of alteration products dependent upon the temperature of the hydrothermal solutions. These minerals replaced each other and the unaltered ultramafic as the temperature of the fluids dropped. At Noddy Creek a similar mineral succession to that reported by Hess has replaced the ultramafic and mafic rocks. The alteration sequence of mafic minerals, in order of decreasing temperature formation, is hornblende, actinolite, tremolite, chlorite, talc, and carbonate. The plagioclase in the mafic rocks has also undergone a variety of alterations which may be related to the temperature of the altering fluids. The alteration products are saussurite, zoisite, prehnite, chlorite, talc, and clay.

Field and microscopic evidence suggests that the metamorphism of the ultramafic complex took place with little or no change in the total rock volume and with only minor loss of mineralized fluids into the surrounding sediments, which were locally metasomatised as a result.

The hydrothermal alteration of the different rock suites and the resultant minerals and rocks formed are discussed below in possible chronological order of alteration.

(i) <u>THE ULTRAMAFIC SUITE</u>

Metamorphism and metasomatism of the ultramafic rocks has produced four common minerals, they are, hornblende, tremolite, chlorite and talc. The metasomatism of serpentinites has already been described and has resulted in the formation of talc, talc-carbonate and stichtite.

Hornblende apparently has formed, at high temperatures, from clinopyroxene and possibly orthopyroxene. (e.g. Specimen No. 71/L1 - 53). This may have occurred during Phase A of serpentinisation, but more likely it occurred during the emplacement of the gabbroic suite. The hornblende has largely been replaced by tremolite, so that its former extent is not known. However, it is estimated that up to 50% of clinopyroxenes in the websterites which had not been serpentinized, had altered to hornblende.

Tremolite has formed after hornblende and has replaced it and its derived pyroxenes, but rarely forms more than 10% of any ultramafic rock. Tremolite may occur replacing exsolved plates of clinopyroxene in an orthopyroxene altered to chlorite, or as tiny needles in shear zones together with chlorite or talc. More often it takes the form of large bright green, moderately birefringent laths with ragged ends.

Chlorite may be in the form of large plates after pyroxenes or as fine cloudy aggregates in veins or shears replacing tremolite or serpentine. Chlorite may form up to 15% of a rock, especially in sheared varieties.

Talc may be found in small amounts in most specimens of ultramafic rock at Noddy Creek. It may form as a pervasive replacement mineral in massive primary rocks little effected by serpentinisation (refer Plate 14) or merely as alteration rims around crystal grains (refer Plate 11). In highly serpentinised rocks, the talc usually forms late stage veins, or is associated with tremolite or chlorite in shear zones.

Some specimens (e.g. 71/L1 -158), have been almost completely altered to talc, but on the average talc only forms 10% of the total rock volume in any one specimen.

Saussurite and epidote are rare alteration minerals in these rocks and form in negligible amounts from the ultramafic body.

Thus the ultramafic rocks as a whole have been subjected to considerable metamorphic and metasomatic alteration, generally after serpentinisation which is a completely separate process. The rocks have rarely been completely altered by metasomatism , instead, the alteration has been patchy with generally less than 40% of the primary minerals undergoing any form of hydrothermal alteration.

(ii) THE MAFIC SUITE

Alteration of this group of rocks by hydrothermal solutions has been most extensive and has resulted in the formation of several completely different metamorphic rock types. The gabbroic rocks are rarely altered less than 50% and usually only clinopyroxene and some plagioclase felspar remain unaltered. The result of metasomatism is a suite of rocks rich in tremolite, chlorite, and prehnite with associated hydrogrossular, talc, carbonate, albite and quartz.

The three main rock types formed as a result of metamorphism and metasomatism are :

i. Amphibolite
ii. Tremolite-chlorite-prehnite rocks
iii. Rodingites

These rocks are formed by extreme alteration of gabbro and norite bodies along the margins of the complex, or where the mafic intrusive body is small and surrounded by ultramafic rocks.
The amphibolite occurs in only one locality, as a lens up to 45 metres wide intersected along the 15S line between the western contact and the surrounding gabbro. The tremolite-chlorite-prehnite-quartz rocks are scattered along the margins of the intrusive body and outcrop best along the western side of the complex from the 15S north to the 6N area. They are also known to occur along the eastern contact of the complex and have marginally altered from the large gabbroic bodies outcropping from the 5N line south beyond the 20S line.

Rodingite is distinguished by the presence of hydrogrossular garnet and is found in only the most highly altered specimens of former gabbro. It has been found as a tectonic inclusion within sheared serpentinite along the 10N line and is probably present within the altered gabbros along the western margin of the complex.

(a) <u>Amphibolite</u> Specimen No. 71/L1 - 160

In hand specimen, the rock is pale green-grey and exhibits a distinctive texture of large crystals several millimetres long randomly orientated throughout the rock. This rock is fully described by A.M.D.E.L. in Appendix 3, but has also been examined in detail by the author. The original primary rock is most likely a pyroxenite but may have been a gabbro with a high mafic content. It is proposed that the whole rock was altered to tremolite (now only 65%) which has been steatitized at a later date with the replacement of some tremolite by talc, minor chlorite, quartz and possibly some felspar. (Refer Plate 45).

(b) <u>Tremolite-chlorite-prehnite or quartz rich rocks</u>
Specimens 71/L1 - 103, 161

Specimen 71/L1 - 161, described by A.M.D.E.L. was taken from the edge of a gabbro body and consequently it has been highly altered. This rock has been fractured and veined by late stage calcium and quartz rich material in the form of dominant prehnite (70%) with quartz, calcite, and pyroxene. The main part of the rock is slightly less metasomatised with some original pyroxene remaining unaltered. In general tremolite and chlorite have developed from the pyroxenes and zoisite and albite from the plagioclase.

The rock as a whole is considered to be altering rowards a rodingite. Another typical specimen of altered gabbroic rock is specimen 71/L1 - 103, which is a quartz-chlorite-tremolite rock formed by the alteration of a wedge by gabbro between pyroxenite

1.0mm

PLATE 45. SPECIMEN 71/L1-160 AMPHIBOLITE
Large blades of tremolite are set in a fine graine ramifying network of talc, which has partly replac the tremolite. A large quartz crystal (top centre is deeply embayed and broken and may be replacing tremolite.
MAGx2 5xNI

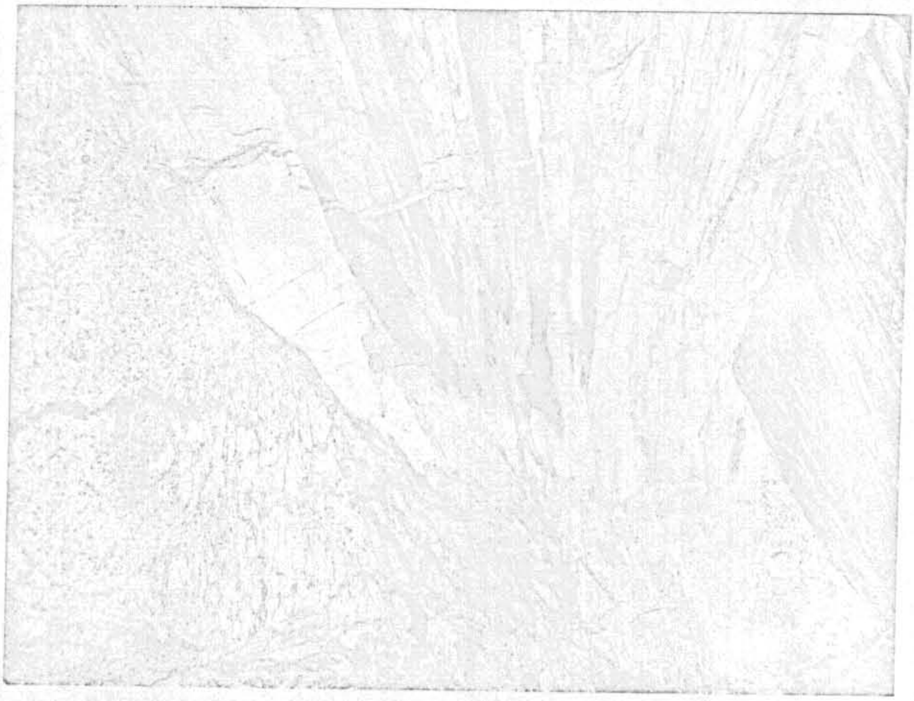

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PLATE 46. SPECIMEN 71/L1-135 RODINGITE
Large tremolite blades up to 1cm long are seen on t right. Prehnite forms distinctive crystals with "b tie" habit (bottom left). Hydrogrossular garnet fo a fine grained mass above the prehnite.
MAGx2 5xNIC

5 cm

and sediments on the eastern contact along the 15S line. In hand specimen, this rock is light to dark grey with a medium grained faintly dicernable allotriomorphic granular texture partially observed by shearing. Actinolite and tremolite have been developed from the pyroxenes, and chlorite with some minor epidote is found in veins cutting phenocrysts and in shear zones. Large irregular crystals of quartz are scattered through the rock and appear to be the last mineral species to develop. The quartz was probably formed from solutions derived from the adjacent sediments. There has been much iron staining particularly along fractures; this is probably a weathering effect.

(c) Rodingite   Specimen 71/L1 - 135.

This specimen was found as an isolated inclusion approximately ½ metre in diameter, set in sheared serpentinite.

It is a particularly interesting specimen because of the crude concentric zonal arrangement of the mineral species around the core of the rock and also the presence of chrysotile ribbon fibre around the rodingite within the surrounding serpentinite. The general zonal arrangement of minerals within the rodingite from the margin to the centre of the block is, chlorite → Chlorite + saussurite → prehnite → tremolite → hydrogrossular.

This zonal arrangement is identical to that found by Coleman (1966) at the contacts between serpentine and gabbro-basalt rocks altering to rodingites, in the New Zealand Ultramafics.

The tremolite is found in large (1 cm.) crystals with radiating habit between the prehnite and the hydrogrossular and also as small prisms within the fine grained matt of garnet. The prehnite is distinguished by its unusual 'bow-tie' habit, and forms large crystals becoming finer at the contacts with other minerals. Some saussurite and plagioclase forms marginal to the prehnite and chlorite. The saussurite is obviously altering from the plagioclase which shows albite type twinning. Chlorite forms the contact zone between the serpentinite and the rest of the altered gabbro. It is a fine grained mass, fibrous in parts showing patchy anomalous interference colours and including altered plagioclase and other unidentified fine grained secondary products. The Hydrogrossular garnet is colourless to white in thin sections and forms a dense fine grained matt enclosing tremolite crystals and some prehnite (refer Plate 46).

Coleman (1966) states that "the important reaction characterising the metasomatism of these various rock types indicated they probably developed only under high confining pressures. The universal silica loss and calcium metasomatism favour the possibility that the alteration is contemporaneous with serpentinisation". The alteration of plagioclase to hydrogrossular is accompanied by a decrease in the rock volume. This may help to explain the presence of ribbon fibre around the rodingite, as the chrysotile may have formed in tension cracks related to this volume change during the formation of rodingite.

(7) $CaO.Al_2O_3.2SiO_2 + CaO + 3H_2O \longrightarrow CaO.Al_2O_3.1.5.SiO_2.3H_2O$

anorthite — fluid — hydrogrossular

$+ 0.5\ SiO_2$

The introduction of Ca required in this reaction is provided by serpentinisation of clinopyroxene. Barnes & O'Neill (1969) found that water issuing from only partly serpentinised ultramafic rocks are highly alkaline (PH11 - 12) and contain Al and Ca in high quantities.

The quartz in these metasomatised gabbroic rocks may have originated from the enclosing sediments or from the alteration of the ultramafics by the development of compounds of the chlorite family, or by rodingisation of the gabbroic rocks. There is ample evidence of silicification, not only of gabbros, as on the western end of the 75 line but also of the contact sediments, as in the eastern end of the 4S line.

(iii) THE LAMPROPHYRIC SUITE

Metasomatism of the lamprophyres has occurred but is generally not extensive, and usually not more than 15% of a specimen is altered. The chief alteration produced is chlorite, with less common epidote and sericite, and rare talc and calcite. The matrix is most commonly altered in preference to the phenocrysts, especially when the matrix is partly or wholly composed of glass. Chlorite usually forms 10% of a specimen but may form up to 60% of a rock as in specimen 71/L1 - 91 which was taken from the margin of a dyke. The alteration here, is probably due to a reaction between the lamprophyre and the surrounding serpentinite, as has been seen at various localities at Noddy Creek. The chlorite may alter from biotite or rarely from pyroxnene but usually it forms from felspar phenocrysts or groundmass and also from glass which often is present in the groundmass.

Epidote sometimes forms from felspar together with chlorite; in all cases it amounts to less than 5% of a specimen. Sericite has replaced some felspar in two specimens which have undergone chlorite alteration. Talc and calcite are rare alteration minerals and form from felspar as late stage minerals along fractures in these rocks.

It is considered that most of this alteration occurred shortly after the emplacement of the lamprophyres by contact metamorphism or by reactions with the hydrothermal fluid associated with the dykes and the waters circulating through the serpentinites.

(iv) PROCESSES OF METASOMATISM IN THE IGNEOUS ROCKS OF THE NODDY CREEK COMPLEX.

We have seen that all the primary minerals in the different rock suited have been altered to some dgree. Metasomatism was particularly severe in the mafic rock suite of gabbros, norites, and diorites and resulted ultimately in the formation of amphibolites and rodingites. Table 4 shows the alterations including serpentinisation which have been observed to occur in the primary minerals of all the rocks suites.

The first alteration to occur in these rocks was serpentinisation - an autometamorphic process, followed shortly after by amphibolitization, chloritisation and uralitization. The final stages of alteration were steatitization or talc carbonate alteration and silification both metasomatic processes. Overlying all of this is weathering, a near surface phenomena which has affected all rocks to some degree.

TABLE 4.

OBSERVED ALTERATION TO THE PRIMARY MINERALS IN THE ULTRAMAFIC AND MAFIC ROCKS

PRIMARY MINERALS	MAJOR ALTERATION PRODUCT	MINOR ALTERATION PRODUCT	TRACE ALTERATION PRODUCT
Olivine	Serpentine +	Magnetite +	Pentlandite
	Rare	Chlorite	
	Rare	Talc	
Orthopyroxene	(Bastite) Serpentine	Magnetite	
		Chlorite	Sericite
		Talc	Prehnite
	Rare	Tremolite-Epidote	Epidote
Clinopyroxene	Serpentine	Talc	
	Tremolite	Chlorite +	Magnetite
		Zoisite	
Hornblende	Tremolite	Chlorite	
		Talc	
Plagioclase	Saussurite	Talc	
		Clay	
		Prehnite	
		Chlorite + Epidote	
[illegible]ite	Stichtite +	Magnetite	
	Titanomagnetite	Magnetite	

(v) COUNTRY ROCK ALTERATION

Along the margins of the ultramafic complex narrow zones of metasomatically altered sediments, tuffs and volcanics have been formed. Where gabbro is adjacent to the contact, marginal faulting and shearing with the introduction of carbonated waters has converted the original gabbroic rocks into talc-chlorite schists which merge with the metasomatised country rock. All these alterations are late stage metasomatic effects produced by connate waters derived from the serpentinization process mixed with hydrothermal solutions related to the emplacement of near by acid igneous intrusions. Carbonates are a minor but important mineral group to be formed concurrently with talc alteration.

Several specimens of altered sediment or pyroclastic rock, taken from along the eastern contact, have high muscovite-sericite contents. The presence of muscovite may be explained by low grade regional metamorphism of the sediments to the greenschist facies of metamorphism or as a result of the introduction of metasomatic fluid from the ultramafic complex. The latter explanation is considered more likely especially when fuchsite, the chromium rich variety of muscovite is common in these rocks.

Along the western contact of the ultramafic complex, specifically between the 15S line and the 40N lines, minor contact metasomatism has occurred. The sediments immediately adjacent to the contact for a distance up to 15 metres but more commonly only 2 - 3 metres, have been slightly metasomatised with the formation of localised hornfels rocks. The original contact rock in most cases was a dark grey pyritic graphic siltstone, this has been fractured and veined and some 'baking' of the sediment appears to occur, as in specimen 71/L1 - 76. The most extensive metasomatism occurs along the 30N line, where serpentine solutions have entered the sediment and crysotile fibre has developed up to 3 metres away from the main serpentine contact (e.g. specimen 71/L1 - 82). Chloritic replacement of the serpentine and the sediment followed fibre development and this in turn was followed by talc replacement developing outwards from fractures into the carbonaceous sedimentary material.

Several small isolated bodies of gabbro are known to intrude sediments on both sides of the ultramafic complex, and these bodies have small metasomatic aureoles.

Along the eastern side of the ultramafics, a major fault does not exist as along the western contact, and tectonism has been restricted to extensive local shearing of the sediments and the igneous contact rocks. This zone of shearing extends up to 100 metres into the sediments and there is a gradual decrease in schistosity away from the ultramafic contact. Good exposures of sheared and metasomatised contact sedimentary rocks are found on the 20N, 10N, 00 and 4S lines. Along the contact in this area, talc schists and talc chlorite schists (eg. specimen 71/L1 - 132) are common and outcrop over widths varying between 15 and 30 metres. They grade into schistose greywacke and conglomerate and then into less sheared sediments away from the contact along the 00 line. In the 25N area fluids from the ultramafic body have induced muscovite, chlorite and talc alteration.

Specimen 71/L1 - 42, probably a former tuff is composed of 15% chlorite and 85% muscovite-sercite. The muscovite is pale green in hand specimen and under the microscope is suggestive of Fuchsite - the Cr rich variety.

Specimen 71/L1 - 163 from the same area contains 75% chlorite 20% quartz and minor opaques and appears to be a schistose chloritized greywacke. On the eastern end of the 15S line altered volcanic rock occurs on the contact. Specimen 71/L1 - 68 is composed entirely of quartz and chlorite, with quartz filling vesicles and as veins in a fine grained matrix of quartz and chlorite. Specimens of conglomerate 71/L1 - 58 and 71/L1 - 136 exhibit some metasomatic alteration. In the first specimen there are thin lenses of chlorite and also minor muscovite, in the second specimen a large clast contains 35% fuchsite-muscovite and talc-chlorite and carbonate alteration together form 20% of the clast.

In summary, the metasomatic alteration of the country rocks at Noddy Creek is confined to narrow zones adjacent to the ultramafic body and is locally intense where shearing has taken place. The main alteration minerals are talc and chlorite with lesser Cr rich mica and some carbonate.

PART 4. ECONOMIC POTENTIAL

The prime purpose of mapping the geology of the Hibbs Ultramafic Belt was to discover if it held any mineral deposits of economic significance. Extensive exploration in the area has been carried out since 1967. The search has been mainly for base metals, but recent exploration has been confined to the discovery of chrysotile asbestos deposits.

(A) BASE METALS

The base metal potential of thebelt is not considered to be good for various reasons which will be outlined. There are three important metals which may be expected to occur in this environment. They are nickel, chromium, and osmiridium, which are discussed separately below.

(i) Nickel

Trace element analysis of primary ultramafic rocks and derived serpentinites, show that the average nickel content is 1600 ppm. This figure compares favourably with the average value for ultramafic rocks which is 1500 ppm according to Goles (1967). Most of the nickel in these rocks is trapped within the serpentine lattice, however some nickel sulphides have developed possibly during serpentinisation. The sulphides are found as isolated blebs or smears in serpentinite along a zone near the western (basal) margin of the ultramafics from the 10N line to the 30N line. No massive concentrations of sulphide or gossan were found during mapping or drilling of the area and the mineralization present is considered to be of no economic importance.

(ii) Chromium

Trace element analysis of the ultramafic rocks at Noddy Creek and elsewhere in the Hibbs ultramafic Belt have shown that these rocks contain on the average 3,000 ppm Cr, and therefore are relatively enriched in this element. Microscopic studies of these rocks reveal that a 1-2% chromian spinel content is average, but the chromite grains tend to be disseminated rather than be bunched together as layer differentiates. This means that it is unlikely that any massive chromite lenses or layers were developed during differentation or later during tectonic remobilization of these rocks. At Noddy Creek, the prospect of massive chromite development is even more remote due to the common alteration of chromite to stichtite.

(iii) Osmiridium

This metal is found in trace amounts in a number of the Tasmanian ultramafic complexes, and important deposits have been mined in the past at Bald Hill and Adamsfield. No trace osmiridium or any other platinoid metal has been found by the B.H.P. Co. Ltd. during its extensive exploration of the Hibbs Ultramafic Belt. The Lyell-Electrolytic zinc group exploration company which previously held the area, reported that during "field work in the creeks draining north into Gravelly Beach, many grains of dissemenated chromite (magnetically susceptable) were found, together with osmiridium and gold". This is the only report of finding osmiridium in the area, and it is considered that though some osmiridium may be present in the ultramafic rocks, further extensive exploration for the metal is not warranted.

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(B) NON-METALLIC MINERALS

The non-metallic mineral potential of the ultramafics appears to be much greater than the metallic potential. Two distinct types of mineral deposit may be expected in this environment. They are, chrysotile asbestos deposits and talc-soap stone-magnesite deposits. The latter type of deposit is considered first.

(i) Talc and Magnesite.

The Hibbs ultramafic Belt due to the nature of its emplacement has been subjected to a continual series of tectonic induced movements and extensive metasomatism particularly along the margins. Both talc and soapstone alteration (after Hess 1955) has occurred along the Belt of ultramafics. The soapstone type being restricted to areas where gabbroic intrusives occur, while talc alteration seems to be less restricted and talc occurs extensively in areas of intense shearing as well as directly altering from massive ultramafic bodies. These alteration processes may have been thorough enough in some parts to produce high quality talc rock in sufficient quantities to produce an economic deposit.

Petrological studies at Noddy Creek have shown that magnesite formation is relatively rare in the ultramafics. This is probably the general case throughout the Ultramafic Belt. There is very little or no development (over the ultramafics) of laterite which may have subsequently concentrated Mg rich material at the base of laterite profile. These two factors suggest that there is little prospect of a magnesite deposit in these rocks.

(ii) Chrysotile Asbestos

Perhaps the best prospect of finding an economic mineral deposit in the Hibbs ultramafic Belt, lies in presence of chrysotile asbestos in these rocks. Small quantities of asbestos have been found throughout the entire belt. This means that the correct environment for the formation of chrysotile asbestos has occurred at some time in all parts of the belt. In the eastern ultramafic belt at Noddy Creek extensive development of asbestos has warranted a detailed and thorough exploration programme designed to outline the size and economic potential of the deposits. This programme was carried out during a six month period from January to June 1971 and a comprehensive report on it has been written by Langlands (1971). The following discussion outlines the nature and distribution of chrysotile deposits and the factors involved in their genesis.

(a) Distribution of the fibre bodies

There are three main zones of cross-fibre development at Noddy Creek. A western zone from about 05N to 55N, an eastern zone from 05N to 55N, and a southern zone from 10S to 20S, (see figure 3). The fibre in the eastern and western zones is developed in massive serpentinites and completely serpentinised pyroxenites often enclosed in an envelope of sheared serpentinite containing magnetite and slip fibre. The two zones are separated by a belt of sheared and partially sheared pale green serpentinite with disseminated stichtite and some slip fibre. The fibre in the southern zone occurs in massive serpentinite on the western margin of a pyroxenite body and east of a zone of sheared serpentinite (refer Fig.4). Massive cross-fibre development in these three zones is patchy and deposits occur as irregular lenticular-ellipsoidal or tabular bodies within massive serpentinite.

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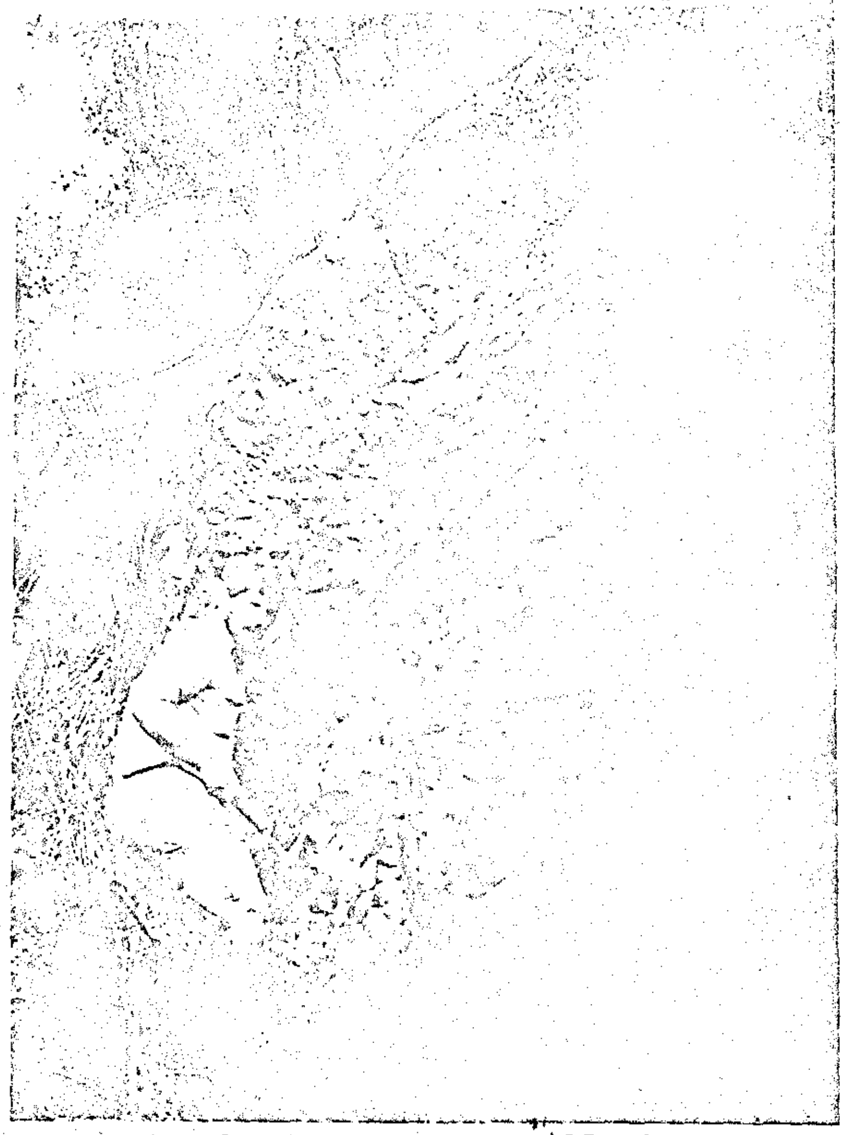


PLATE 3. Pyroxenite boulder outcrop, 35N line showing a patch of ribbon fibre (white) in the centre of the block being examined by a geologist.

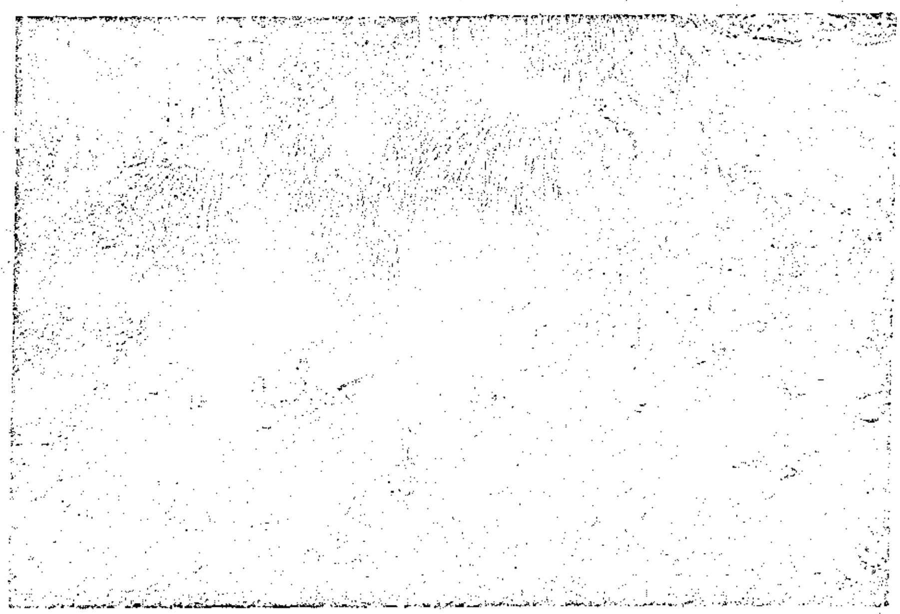


PLATE 4. Serpentinised pyroxenite outcrop in the 55N costean. The flaged stakes mark the outer limits of the ribbon fibre zone around the massive rock. Sheared serpentinite surrounds the whole block.

It is suspected that, the irregular nature of the deposits is primarily due to the effects of shearing and cross faulting and that, within the three zones of fibre development "hidden" deposits occur at depth below areas of surface shearing. An example of this type of deposit occurs on the west side of the 20N line, where diamond drillhole 8 intersected a greatly increased width of cross fibre bearing serpentinite below a narrow surface outcrop of fibre development surrounded by sheared serpentinite (refer Figure 5.)

Within the sheared serpentinite along strike and adjacent to known cross fibre deposits slip fibre is sporatically developed. X-ray determination of this material has shown that most of it is brucite and only about one quarter of the specimens examined contained chrysotile fibre. This means that slip fibre has little potential as a secondary source of chrysotile fibre. The various types of cross fibre veins, their nature, relationships and importance at Noddy Creek have been discussed previously and may be referred to under, Serpentine types, in the section on Serpentinisation.

(b) Type and quality of cross fibre.

The results of milling of a number of selected specimens of cross fibre bearing serpentinite, show that the fibre is of high quality and excellent for industrial use. The standard Canadian grading of fibre has been applied to the asbestos at Noddy Creek and types 4 to 7 are the calculated grades which can be recovered after milling of ore rock. This means that the average fibre length at Noddy Creek is fairly short, being in the order of 1/16" - 3/16" thick. In outcrop a fibre vein greater than 1" thick was rarely seen (refer plate 47).

(c) Factors involved in the Formation of Chrysotile Deposits at Noddy Creek.

During exploration for chrysotile deposits in the Hibbs Ultramafic Belt an attempt was made to develop a model which related the possible and apparent factors involved in producing and preserving a chrysotile deposit. These factors are set out below and discussed in detail.

(1) Intense aeromagnetic anomaly.

(2) Increase in width and broad and flexure of the Ultramafic belt.

(3) The presence of massive highly serpentinised ultramafic.

(4) The presence of structural controls to promote thorough serpentinization and to provide the correct stress environment for fibre development.

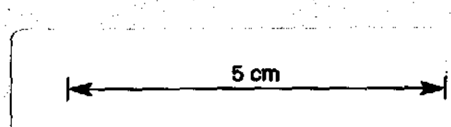
(5) The proximity of gabbroic and dioritic bodies.

(6) The presence of stichtite.

On the regional scale the Hibbs Ultramafic Belt is delineated very clearly by the presence of a narrow, tightly contoured linear, positive aeromagnetic anomaly. Within this anomaly the Noddy Creek area is defined by uniformly intense magnetics, which are interpreted to be due to a high degree of serpentinisation and subsequent formation of magnetite. Ground magnetics have shown that there is no correlation between the intensity of magnetism and cross fibre development although the magnetics are more variable over the massive fibre zones than over the sheared serpentinite.

The chrysotile deposts at Noddy Creek are found within a zone of increased width of ultramafics which is also a broad flexure in the ultramafic belt. The increase in width of the ultramafics has effectively meant that massive zones of serpentinite, which

PLATE 47. Large veins of chrysotile asbestos up to two inches thick and split by irregular partings which reduce the maximum fibre length to one inch. This is high quality asbestos fibre.



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are the host bodies or chrysotile fibre, have been preserved in the highly sheared belt. The curvature of the belt at Noddy Creek may represent merely a change in the dip of the basal thrust zone of the ultramafics or it may be produced by folding. In the latter case considerable fracturing or shearing in the ultramafics possibly also promoting fibre development, may have occurred.

The presence of bodies of massive serpentinized ultramafic rock is considered essential for the formation of chrysolite fibre deposits. These bodies under the correct stress environment, probably during serpentinisation are fractured and later invaded by the solutions which crystallise to form chrysotile cross fibre. Structural control of the mineralization is highly important, and it is evident that just the right degree of faulting, shearing, fracturing, and tension must occur to provide access to fluids producing serpentinisation and fibre development.

Excessive tectonic movement will result in sheared serpentinite which is useless as a host for cross fibre. It will also destroy any previously formed chrysotile fibre.

Gabbro and diorite intrusives into the ultramafic sequence may have produced shearing in the serpentinites, and related hydrothermal solutions may have contributed to fibre development; however, there is no definite observable genetic relationship between these intrusions and cross-fibre formation.

At Noddy Creek stichtite is extensively developed in a belt between the two main fibre zones, and where stichtite is developed chrysolite asbestos is not found in any quantity. It is considered that stichtite is formed predominantly after the cross fibre in the central sheared zone of serpentinite between the fibre zones, and the two minerals are unrelated genetically.

In summary, the chrysotile deposits at Noddy Creek are located in a arcuate wider section of the Eastern Ultramafic Belt. The ultramafics are highly serpentinised and sheared, containing massive pods of cross-fibre bearing serpentinite. Structural controls of serpentinisation and fibre development may have been provided by faulting and shearing of the ultramafic body by post emplacement movement, flexuring due to folding and/or by the emplacement of gabbros and diorite into the ultramafic body. The presence of a magnetic anomaly over the area and the formation of stichtite are not regarded as indicative of chrysotile asbestos development.

PART 5. SUMMARY OF THE GEOLOGICAL HISTORY OF THE NODDY CREEK AREA.

(1) Development of a narrow rift or trough between Precambrian blocks in western and northern Tasmania during late Precambrian or early Cambrian tiems.

(2) Deposition of mainly argillaceous sediments (siltstone shales and minor sandstone) of early and Middle Cambrian age within the developing Dundas Trough.

(3) During late Middle Cambrian times the Hibbs Ultramafic suite was intruded as a thrust bound slice of mantle material into these Cambrian sediments. Concurrently with emplacement of the ultramafics, autometamorphism took place and partial serpentinisation occurred.

(4) Gabbro was intruded along the margins of ultramafic belt shortly after the emplacement of the ultramafics.

(5) A short period of uplift and erosion took place and was followed by deepening of the Dundas Trough and the deposition of the Dundas Group, a sequence of greywackes, conglomerates, and minor siltstones.

(6) Together with the deposition of these Middle-Late Cambrian sediments, basic-intermediate and acid lavas, tuffs and agglomerates of the Noddy Creek Volcanics were laid down to the east of the ultramafic belt.

(7) In late Cambrian times, diorite and quartz diorite bodies were intruded into the sediments and gabbros, producing considerable metasomatism in both sediments and ultramafics.

134 (8) Lamprophyres and micro-diorites were intruded at this stage into both sediments and igneous rocks.

(9) At the close of the Cambrian minor tectonism producing uplift and erosion occured. During this period extensive shearing within the ultramafic belt occurred.

(10) Sandstones and limestone of Orodvicion age were deposited in shallow basins within the Dundas Trough.

(11) The Tabberrabberan Orogeny in late Middle Devonian times terminated sedimentation in the Dundas Trough, and all previous sediments were highly folded. Strike slip movement of faults probably occurred and the ultrmafic complex was again sheared.

(12) There is no evidence of any further sedimentation until Tertiary times when thick shallow water sequences were developed in several fault bounded troughs in the MacQuarie Harbour and Birches Inlet areas.

(13) Due to Teriary uplift, rapid erosion of the Lower Palaeozoic sediments has taken place in the Quaternary period and extensive alluvial flats are being developed in several localities.

PART. 135 DISCUSSIONS OF RESULTS AND CONCLUSIONS

The Hibbs Ultramafic Belt at Noddy Creek has been studied in detail and a comprehensive account given of the primary ultramafic and mafic suites together with the secondary alteration processes, serpentinisation and metamorphism.

Much attention has been paid to the serpentinites and particularly to the chrysotile bearing varieties because of their significance in relation to chrysotile asbestos deposits. It is considered that the main factors involved in the formation of the chrysotile deposits have been through serpentinisation combined with extensive shearing of the ultramafics. The small extent of later metasomatism and shearing of the massive serpentinites has preserved the chrysotile fibre.

The pyroxenites which dominate the ultramafic suite have been mostly altered to serpentinite, and chrysotile asbestos has formed in considerable quantities with the massive serpentinite. Late metasomatism of the serpentinites particularly in the sheared varieties, has produced widespread alteration of chromite to stichtite - a rare hydroxyl-carbonate mineral. The presence of stichtite may signify the existence of unusual chemical and physical conditions in the intrusive at the time of its formation.

Metamorphism and metasomatism have produced extensive alteration of the mafic rocks, resulting in the formation of amphibolites and rodingites.

Considering the chemical and mineralogical characteristics of the primary ultramafic and mafic suites, it is suggested that these rocks were derived by partial differentiation of Upper Mantle material. This material has been subsequently moved into the crust, undergone further differentiation and emplaced as thrust bound intrusives possibly along a subduction zone into Cambrian sediments within the Dundas Trough.

The lamprophyres, diorites and grano-diorites which intrude the sedimentary-volcanic sequence as well as the Ultramafic Belt are considered to have been the last differentiates from the same magma from which the ultramafic, gabbroic and volcanic rocks were derived.

The economic mineral potential of the Hibbs Ultramafic Belt has been studied and it is considered that the base metal potential in these rocks is not high, and that the best prospects for economic mineralization lie in the non-metallic minerals, talc and asbestos.

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APPENDIX 1

CHEMICAL ANALYSES

AND

MINERALOGY OF THE

SERPENTINITES

AND SLIP FIBRE SPECIMENS

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METHODS OF STUDY

The determination of the serpentine types and the composition of the slip-fibre specimens was achieved by several methods. The X-Ray diffraction was performed by a Siemens Diffractometer using a scintillation counter - 1.5 kv and a Debye Scherrer camera, having a 4½" diameter lens. Graphical traces of the diffraction peaks were found more useful than photographic traces, in the determination of the serpentine types. The serpentine types can be distinguished by their different shaped diffraction peaks in the 22^o, 41^o and 71^o 2θ areas using Cobalt Radiation (35 kv, 14 mA). Mixtures of serpentinies in these specimens was quite a common occurrence, and made for difficult determination of the percentages of the serpentine types in each specimen. In these cases the values given are only very approximate.

In some specimens the serpentine types were in doubt, and in these cases, electron micrographs were taken to try and visually identify the particles. This method was generally successful, however the author could not decipher between plates of lizardite and those of antigorite, the chrysotile rods being easily distinguished. The machine used for this work was a G.O.E.L. Electron microscope type JEMT operating at 100 kv.

The differential thermal analyses method was not used on any of these specimens.

The powder diffraction file from "Joint Committee on Powder Diffraction Standards" by American Society for Testing and Materials was used to determine the spacings of the peaks and to identify the mineral which they belonged to.

In the following tables the strength of each peak is given relative to the highest peak in the trace of each specimen. The highest peak is given a rating compared to other traces and may be very strong (V.S.) to moderately strong (M.S.). The scale of the peak heights given in these tables are as follows, from highest to lowest:-

VS, S, MS, M, MW, W, VW, WW

002

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CHEMICAL COMPOSITION (as oxide wt %)

Spec. No.	71/L1-41	71/L1-46	71/L1-50	71/L1-69	71/L1-118	71/L1-119	71/L1-120
SiO_2	40.0	26.5	40.3	51.7	37.6	29.9	39.7
Al_2O_3	0.1	1.3	0.8	0.9	0.7	0.7	0.6
Total Fe	3.2	7.7	9.0	6.2	9.6	23.2	2.1
MgO	40.7	36.5	34.9	32.0	37.0	29.9	41.2
CaO	✓	✓	0.6	1.6	0.1	✓	0.1
Na_2O	✓	0.1	✓	0.1	0.1	✓	✓
K_2O	✓	✓	✓	✓	✓	✓	✓
TiO_2	✓	✓	✓	✓	✓	✓	✓
	~85 %	~65%	~82%	~90%	~85%	~80%	~83%

what is rest ?

TRACE ELEMENT ABUNDANCES (ppm)

	71/L1-41	71/L1-46	71/L1-50	71/L1-69	71/L1-118	71/L1-119	71/L1-120
Ni	1900	2500	1100	300	1400	1700	1400
Cr	2300	>1%	6000	3300	>1%	6400	6600
Co	80	240	94	44	110	180	80

MINERALOGY

	71/L1-41	71/L1-46	71/L1-50	71/L1-69	71/L1-118	71/L1-119	71/L1-120
Lizardite	X	XX	X	NA	XX	x	X
Chrysotile	XX	X			XX	XX	XX
Antigorite	x		XX		TR	x	
Brucite		TR					
Magnetite	TR	TR	TR		TR	x	TR
Chromite							
Stichtite	TR	TR					
Talc					TR		
Tremolite							
Chlorite						TR	TR

NOTE: XX = ≥50% x = 10-25% NA = Not Available
X = 25-50% TR = <10% ✓ = <0.1%
(ANALYSES)

003

740149

CHEMICAL COMPOSITION (oxide wt %)

Spec. No.	71/L1-121	71/L1-122	71/L1-123	71/L1-124	71/L1-125	71/L1-126	71/L1-129
SiO_2	39.4	38.8	39.1	39.9	38.8	39.9	41.2
Al_2O_3	0.2	0.3	0.2	0.2	0.4	0.2	0.2
Total Fe	2.5	3.5	5.0	2.4	1.3	5.2	1.5
MgO	41.5	41.2	40.3	42.8	41.2	39.5	42.0
CaO	0.1	✓	✓	✓	✓	0.2	✓
Na_2O	✓	✓	✓	✓	✓	✓	✓
K_2O	✓	✓	✓	✓	✓	✓	✓
TiO_2	✓	✓	✓	✓	✓	✓	✓
TRACE ELEMENT ABUNDANCE (ppm)							
Ni	1900	1800	2100	2100	1200	2300	1300
Cr	2100	5200	3400	2500	800	1900	450
Co	60	70	90	72	60	70	64
MINERALOGY							
Lizardite	XX	XX	X	X		x	
Chrysotile	XX		XX	XX	XX	x	x
Antigorite			TR	x	x	XX	XX
Brucite							
Magnetite	TR	TR	x	TR	TR	TR	TR
Chromite							
Stichtite							
Talc							
Tremolite							
Chlorite							

CHEMCIAL COMPOSITION (oxide wt %)

Spec. No.	71/L1-142	71/L1-143	71/L1-144	71/L1-145	71/L1-146	71/L1-147	71/L1-148
SiO_2	39.1	36.7	34.5	35.3	34.1	41.9	36.7
Al_2O_3	0.7	0.5	0.2	0.3	0.3	0.5	0.3
Total Fe	4.3	4.8	4.8	5.5	5.8	7.7	6.0
MgO	39.6	40.1	41.9	40.0	40.4	34.5	39.9
CaO	0.1	0.1	0.1	0.1	0.1	0.1	0.1
TiO_2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
			TRACE ELEMENT ABUNDANCES (ppm)				
Ni	1300	2500	2400	2200	1800	1000	2800
Cr	5500	2500	3750	2500	6000	2250	550
Co	90	100	52	92	120	96	100
Cu	12	6	14	18	8	8	18
Pb							
Zn	60	36	26	30	34	90	40

005

TRACE ELEMENT ABUNDANCE (ppm)

Spec. No.	71/L1-156	71/L1-157	71/L1-158	71/L1-159	71/L1-160	71/L1-161	71/L1-162
Ni	1300	580	380	750	200	70	70
Cr	780	370	1600	470	1100	50	55
Co	120	50	50	70	25	20	20
Cu	< 5	5	< 5	5	15	5	25
Pb	< 5	< 5	5	5	< 5	5	30
Zn	45	25	65	35	45	20	70

TRACE ELEMENT ABUNDANCE (ppm)

Spec. No.	71/L1-163	71/L1-164	71/L1-165	71/L1-167	71/L1-168	71/L1-169	71/L1-172
Ni	140	1600	100	50	90	80	1900
Cr	75	1200	35	25	80	50	620
Co	55	90	60	30	35	25	70
Cu	35	< 5	110	35	15	5	5
Pb	5	5	5	45	5	< 5	5
Zn	35	80	100	100	90	30	15

SLIP FIBRE SPECIMENS

Specimen	71/L1-75	71/L1-173	71/L1-174	71/L1-175	AA 2606	AA 2607	AA 2608	AA 2609	AA 2610
Lizardite	X	TR	TR	TR	x	TR	X	x	TR
Chrysotile	TR		TR		XX	x	X	X	TR
Antigorite	XX	x	X	x	x	x	X	TR	x
Brucite	x	XX	XX	XX		XX		XX	XX
Magnetite	TR		TR	TR	TR	TR	TR	TR	TR
Chromite	TR								
Stichtite			TR	TR		TR	TR	TR	TR
Talc									
Tremolite			TR	TR					
Chlorite	TR	TR				TR	TR	TR	TR

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007

APPENDIX 2

X-RAY DIFFRACTION OF

SERPENTINITES

AND

SLIP FIBRE SPECIMENS

008

MINERAL			71/L1-41		71/L1-46		71/L1-50		71/L1-118	
Lizardite			dA°	I	dA°	I	dA°	I	dA°	I
dA°	I/I	HKl								
7.4	100	001	7.3	S						
4.6	80	020			4.595	W				
3.9	50	021								
3.67	80	002	3.64	M	3.656	MS				
2.875	10	022								
2.505	100	201			2.507	MW	2.510	MW	2.505	W
2.156	80	202	2.15	UW	2.155	VW	2.153	VW		
1.799	50	203	1.796	VVW	1.798	VVW				
1.538	80	060			1.539	W	1.539	VW	1.537	M
1.505	80	204	1.505	VW	1.502	VW	1.507	VW	1.505	VW
1.416	50	062								
Antigorite										
7.33	100	006					7.35	S		
4.60	60	020					4.602	W		
3.66	100	0,0,12					3.65	M		
3.02	5	0,2,11					3.00	VW		
2.502	100	206								
2.425	10	0,0,18					2.429	VW		
2.335	70	209	2.33	VVW						
2.140	60	2,0,12							2.143	VVW
1.791	10	2,0,18								
1.535	80	060								
Clino-chrysotile										
7.36	100	002*			7.35	VS			7.35	S
4.56	50	0.20	4.59	VW					4.57	W
3.66	80	004							3.66	MS
2.549	50	202	2.55	VVW						
2.500	50	202*	2.495	MW						
2.456	80	202			2.45	W			2.451	W
2.451	65	202*								
2.285	20	040*	2.29	VVW						
2.096	50	204								
1.536	80	060	1.536	W						
1.531	65	060*								
1.464	30	0.010*								
*Denotes with orthochrysotile										
Brucite										
4.77	90	001			4.778	VW				
2.365	100	101								
1.794	55	102								
1.573	35	110								
1.494	18	111								
1.373	16	103								

009

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MINERAL	71/L1-41		71/L1-46		71/L1-50		71/L1-118	
Stichtite	dA°	I	dA°	I	dA°	I	dA°	I
7.30 100 3.91 2.60	7.80 2.61	VW VVW	7.85 3.918 2.61	VW VVW VVW				

740156

010

MINERAL			71/L1-119		71/L1-120		71/L1-121		71/L1-122		71/L1-123	
LIZARDITE			dA°	I	dA°	I	dA°	I	dA°	I	dA°	I
dA°	I/I_1	HKl										
7.4	100	001							7.36	US		
4.6	80	020			4.63	W	4.59	W	4.615	W		
3.9	50	021										
3.67	80	002							3.656	S		
2.875	10	022										
2.505	100	201			2.505	MW	2.506	M	2.505	M	2.505	MW
2.156	80	202			2.163	VVW	2.154	VW	2.154	W		
1.799	50	203							1.797	VW	1.795	VVW
1.538	80	060	1.539	MW	1.538	W	1.538	W				
1.505	80	204			1.502	VW	1.504	VW	1.505	VW	1.507	VW
1.416	50	062										
Antigorite												
2.149	60	2012									2.147	VW
1.791	10	2018										
1.535	80	060										
1.501	70	2024	1.502	VW								
Clinochrysotile $\bar{c}$ ortho*												
7.36	100	002*	7.33	MS	7.35	S	7.35	VS			7.35	S
4.56	50	0.20*	4.58*	VW							4.58	W
3.66	80	0.04	3.65	M	3.66	M	3.66	S			3.66	MS
2.549	50	$20\bar{2}$										
2.500	50	202*	2.498	MW								
2.456	80	202			2.465	W	2.455	W			2.455	W
2.285	20	040*										
2.096	50	204										
1.536	80	060									1.537	W
1.531	65	060*										
1.464	30	0.010*										
2.594	40	201			2.60	VVW						
Chlorite												
3.83					3.83	VVW						
2.443			2.443	MW								

011

MINERAL			71/L1-124		71/L1-125		71/L1-125A		71/L1-126		71/L1-129	
LIZARDITE												
dA°	I/I2	HK1	dA°	I	dA°	I	dA°	I	dA°	I	dA°	I
7.4	100	001										
4.6	80	020	4.614	W								
3.9	50	021										
3.67	80	002										
2.875	10	022							2.88	VVW		
2.505	100	201	2.505	MW								
2.156	80	202										
1.799	50	203										
1.538	80	060										
1.505	80	204	1.505	VW					1.507	VW		
1.416	50	062										
Antigorite												
7.33	100	006							7.29	S	7.28	S
4.60	60	020									4.60	W
4.40	10	023							4.43	VW	4.46	VW
3.66	100	0012							3.642	MS	3.63	MS
3.02	5	0211										
2.502	100	206			2.503	VW			2.498	MW	2.50	M
2.425	10	0018							2.438	W	2.43	W
2.335	70	209										
2.149	60	2012	2.149	W					2.145	VW		
1.791	10	2018	1.793	VVW							1.792	VW
1.535	80	060							1.534	W	1.535	W
1.501	70	2024									1.502	VVW
Clinochrysotile c̄ ortho*												
7.36	100	002*	7.24	VS*	7.33	S	7.40	MS				
4.56	50	020*			4.57	W	4.54	W				
3.66	80	004	3.65	MS	3.64	M	3.60	M				
2.549	50	20$\bar{2}$										
2.500	50	202*										
2.456	80	202	2.45	W	2.455	MW	2.452	W			2.46	W
2.285	20	040*										
2.096	50	204										
1.536	80	060	1.536	W								
1.531	65	060*			1.532	W	1.533	VW				
1.464	30	0.0.10*										
2.594	40	201										

SLIP FIBRE SPECIMENS

MINERAL LIZARDITE			71/L1-75		71/L1-173		71/L1-174		71/L1-175	
dA°	I/I1	HKl	dA°	I	dA°	I	dA°	I	dA°	I
7.4	100	001								
4.6	80	020								
3.9	50	021					3.89	VW		
3.67	80	002								
2.505	100	201	2.515	VW						
1.538	80	060	1.538	VW						
1.505	80	204								
1.416	50	062	1.42	VW	1.42	W	1.42	VW	1.42	W
Antigorite										
7.33	100	006	7.30	M	7.26	VVW	7.35	M	7.33	W
4.40	10	023	4.44	VVW						
2.335	70	209	2.33	VW	2.34	M	2.34	MS	2.34	M
3.66	100	1102	3.64	M	3.65	VW	3.65	M	3.65	W
Clinochrysotile										
2.096	50	204	2.11	W			2.10	VW		
1.536	80	060					1.535	VW		
Brucite										
4.77	90	001			4.77	US	4.77	VS	4.76	VS
2.365	100	101			2.37	S	2.37	WM	2.365	M
1.794	55	102			1.794	S	1.795	M	1.796	MS
1.573	35	110			1.575	W			1.574	VM
1.494	18	111			1.49	VW				
1.373	16	103			1.37	M	1.37	WM	1.373	M
Magnetite										
2.535	100						2.53	WM	2.53	W
1.485							1.483	WM		
Stichtite										
7.78							7.78	W	7.79	VW
3191									3.89	VVW
Chlorite										
2.02			2.02	VVW	2.02	WM				
Tremolite										
1.588									1.588	VN
1.432							1.43	WM	1.432	VW

SLIP FIBRE SPECIMENS

MINERAL			No. 2606		No. 2607		No. 2608		No. 2609		No. 2610	
LIZARDITE												
dA°	I/I$_2$	HKl	dA°	I	dA°	I	dA°	I	dA°	I	dA°	I
3.9	50	021										
1.536	80	202	1.537	W			1.538	W	1.540	W		
1.416	50	062	1.421	W	1.422	W	1.422	W	1.422	W	1.421	W
Antigorite												
7.33	100	006			7.33	MS					7.30	MS
3.66	100	1102										
2.335	70	209	2.35	M	2.35	M	2.34	MS	2.35	MW	2.34	MS
Clinochrysotile												
7.36	100	002	7.35	S			7.35	S	7.35	S		
4.56	50	020					4.56	VVW				
3.66	100	0012										
2.456	80	202	2.458	W	2.45	W						
2.096	50	204							2.105	VW		
1.536	80	0600			1.534	W					1.534	W
1.464	30	0010									1.463	VVW
Brucite												
4.77	90	001			4.78	VS			4.77	MS	4.78	VS
2.365	100	101			2.365	MW						
1.794	55	102			1.795	MW			1.795	VW	1.797	MW
1.573	35	110										
1.494	18	111										
1.373	16	103			1.373	VW					1.375	W
Magnetite												
2.98					2.98	VW					2.97	VW
2.535			2.535	W	2.535	MW	2.535	MW	2.535	MW	2.53	M
1.615			1.615	VVW			1.615	VVW	1.615	VW	1.615	W
1.485			1.485	VVW	1.485	VW	1.482	VW	1.482	VW	1.485	W
Stichtite												
7.78					7.73	W			7.82	VW	7.80	W
3.91					3.91	VVW					3.91	VW
2.60					2.60	VW	2.60	W				
Chlorite												
3.83												
2.443							2.935	W	2.44	W	2.44	W
2.025											2.025	W
2.00					2.005	VVW			2.003	VVW	2.00	VVM
1.510												

MINERAL / Tremolite			No. 2606		No. 2607		No. 2608		No. 2609		No. 2610	
dA°	I/I_2	HKI	dA°	I	dA°	I	dA°	I	dA°	I	dA°	I
1.588 1.431											1.431	W
Undetermined			4.47	VW			4.48 2.115	VW VW	4.48	VW	2.117	MW

APPENDIX 3

ROCK SPECIMENS

LOCATIONS AND

DESCRIPTIONS

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ROCK SAMPLE INDEX

Sample No.	Rock Type Description	Locality	Laboratory Work
71/L1-39	GABBRO, sheared weathered and altered.	3500N E.end ~645' PEG	TS
71/L1-40	SERPENTINITE - Layered, massive, light green X-fibre similar to NC 16.	3000'N W.end	
71/L1-41	SERPENTINITE - STICHTITE Bearing light green similar to NC 24.	3000'N central zone	TS P.R.A.
71/L1-42	?TUFF - MUSCOVITE - CHLORITE rich sediment FN.GR.LT. GRN. fuchsite bearing	2500'N OPP 454'PEG on eastern end	TS
71/L1-43	GABBRO - serpentinised and metasomatised -saussurite, weathered - grey brown	2500'N E end in road 100' N of costean	TS
71/L1-44	GABBRO - weathered and meta-somatised	2200'N costean B/N 200'-245' PEGS on eastern road	
71/L1-45	LAMPROPHYRE - dark grey dyke rock	2500'N.W end ~ 200' PEG	
71/L1-46	SERPENTINITE - massive	2500'N central approx.450' mark	TS P.R.A.
71/L1-47	LAMPROPHYRE - black, similar to NC 20	1000'N W end ~ 370' mark	
71/L1-48	PEGMATITE HORNBLENDE - DIORITE	600'N area ~200' W of road	TS
71/L1-49	HYPERSTHENE CLINOPYROXENITE blue-grey med. gr.	500'N opp. 500' PEG	TS
71/L1-50	AUGITE HYPERSTHENITE - black fn-med gr. serpentinised	600'N 100' west of road	TS
71/L1-51	PYROXENITE - serpentinised black med-cor gr.	600'N 90' west of road	
71/L1-52	AUGITE KERSANTITE - dark grey fn-med gr.	500'N 20'N of 590' mark	TS
71/L1-53	PERIDOTITE - OLIVINE WEBSTERITE med. gr. serpentinised.	500'N 20'N of 580' mark	TS

71/L1-54	NORITE:- CHLORITE - TREMOLITE prehnite rock - green-grey med. gr. qtz. veins	600'N area ~180'W of road	TS
71/L1-55	CLINOPYROXENITE - green-grey med. gr. qtz. veins	00' line 140'N of 550' mark	TS
71/L1-56	ENSTATITE CLINOPYROXENITE COR. GR. partially serpentinised altered	250'N area 40'W of road	TS
71/L1-57	NORITE med. gr. c̄qtz. veins chlorite-saussurite-prehnite-tremolite c̄ minor sulphides, similar to NC 13.	00' line ~1030'S side of road	TS
71/L1-58	CONGLOMERATE grey, sheared contains altered chromite	approx. 200'N area helipad 3	TS/PS
71/L1-59	GABBRO - layered med. gr. qtz-saussurite rich. similar to NC 13	00' W end ~535' mark	TS
71/L1-60	NORITE - serpentinite and saussurite rich, cor gr.	600'N area ~150' from road	TS P.R.A.
71/L1-61	GABBRO - dark grey, med. gr. tremolite-chlorite-saussurite rich	00' line ~380'PEG	TS
71/L1-62	QTZ - CARBONATE VEIN ROCK. talc rich	400'S line 250' mark	TS
71/L1-63	GABBRO - silicified and altered chlorite dmiliar to NC 21	700'S line ~210' mark	
71/L1-64	ENSTATITE/CLINOPYROXENITE - lt. grn. sheared, serpentinite, saussurite	700'S ~150' mark	TS
71/L1-65	LAMPROPHYRE-ANDESITIC composition lt. grey (weathered) similar to NC 14	700'S.~200'S of 700' PEG on road	-
71/L1-66	LAMPROPHYRE-ANDESITIC COMP.	700'S 50'S of 600'PEG in costean	-
71/L1-67	LAMPROPHYRE-VOGESITE lt. grey	700'S.100's of 400' PEG in costean along N-S line	TS
71/L1-68	QTZ.-CHLORITE VOLCANIC ROCK vesicular lt. gr. qtz. veined	1000'S E end ~950' mark	TS

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71/L1-69	HYPERSTHENITE - serpentinized and steatitized	1000'S W end ~500' peg	TS P.R.A.
71/L1-70	AMPHIBOLITE - lt.grey cor-gr. similar to NC 12	1000's W end ~275 mark	-
71/L1-71	LAMPROPHYRE - grey med. gr.	1500'N W end 280' mark	-
71/L1-72	GABBRO - weathered cor. gr. similar to NC 3	Fern Ck. costean 2000'N of Pad 2 ~250' from E end,	-
71/L1-73	ENSTATITE v. cor. gr. talc rich similar to NC 2	costean 6000'S of pad 2 central zone	-
71/L1-74	SERPENTINITE - light green massive with slip fibre and magnetite	1000'N 500'peg.	XRD of slip fibre
71/L1-75	SERPENTINITE - dk. green massive with magnetite	1000'N E end 780' peg	-
71/L1-76	CARBONACEOUS SILTSTONE - partially metasomatised	100'N 250' mark near contact	-
71/L1-77	BASIC-INT VOLCANIC AGGLOMERATE lt-dk grn.	near helipad 9 on great N-S road	-
71/L1-78	SERPENTINITE - Micro ribbon fibre texture and brown mineral	DHNC4 343.5'	TS
71/L1-79	SERPENTINITE - massive, dark, mottled c̄ stichtite	DHNC5 525.9'	
71/L1-80	SERPENTINITE - cross fibre bearing, chlorite and tremolite alteration and talc	DHNC5 360.6'	TS
71/L1-81	SHEARED SERPENTINITE - minor +ve D.M.G. sulphide	DHNC5 160.6'	
71/L1-82	CONTACT ALTERED SILTSTONE - c̄ ribbon fibre. Serpentinite, chlorite and talc metasomatism	DHNC5 123.8'	TS
71/L1-83	SERPENTINITE - c̄ stichtite and magnetite	DHNC7 461.3'	
71/L1-84	SERPENTINITE - pale, massive c̄ miner finely disseminated +ve D.M.G. sulphide	DHNC7 341.8'	

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71/L1-85	SERPENTINITE - massive, granular c̄ minor slip fibre	DHNC7 295.3'	
71/L1-86	SHEARED SERP. - c̄ +ve D.M.G. sulphide, slip fibre and magnetite	DHNC7 200.5'	
71/L1-87	PARTIALLY SERPENTINISED PYROXENITE	DHNC7 145.0'	
71/L1-88	SERPENTINITE - c̄ cross fibre and minor +ve D.M.G. sulphide	DHNC7 131-3'	
71/L1-89	LAMPROPHYRE-AUGITE MINETTE - c̄ dark banding, chlorite replacement of matrix	DHNC7 113.5'	TS
71/L1-90	LAMPROPHYRE-AUGITE MINETTE, CHLORITE & TALC REPLACEMENT - c̄ garnetiferous xenolith	DHNC7 110.5'	TS
71/L1-91	LAMROPHYRE-AUGITE MINETTE - from margin of dyke	DHNC7 105.0'	TS
71/L1-92	SHEARED SERP. - c̄ +ve D.M.G. sulphide	DHNC7 93.0'	
71/L1-93	SHEARED GABBRO	DHNC7 69.7'	
71/L1-94	SERPENTINITE - massive, pale c̄ stichtite	DHNC7 104.5'	
71/L1-95	SHEARED SERP. - c̄ slip fibre, magnetite, stichtite	DHNC8 133.2'	TS
71/L1-96	CHLORITE, CO_3 SERPENTINE ROCK - altered norite or gabbro. sericite-chlorite-amphibole rock	DHNC8 445.3'	TS
71/L1-97	SERPENTINITE/PYROXENITE - c̄ minor criss fibre	DHNC8 290.5'	
71/L1-98	SERPENTINITE - pale, granular, c̄ stichtite and magnetite	DHNC9 332.6'	TS
71/L1-99	SERPENTINITE - pale, granular c̄ stichtite and magnetite	DJNC9 199.0'	
71/L1-100	SERPENTINITE - c̄ cross fibre	DHNC9 170.0'	
71/L1-101	PYROXENITE - serpentinized layered rock	DHNC9 142.5'	TS

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71/L1-102	PARTIALLY SERPENTINISED PYROXENITE	DHNC9 103.0'	
71/L1-103	SHEARED GABBRO(?) - lt-dk grey med gr carbonated qtz. chlorite, tremolite rock	DHNC9 22.7'	TS
71/L1-104	LAMPROPHYRE AUGITE MINETTE - dk. grey vesicular lamprophyre dyke rock	5500'N line eastern end approx. 570' mark	TS
71/L1-105 (A & B)	TALC CONTACT ROCK - massive talc rich contact rock B/N lamprophyric dyke and sheared serpentinite	5500'N as above	
71/L1-106	SERPENTINITE - massive serpentinite (P.S.) with stichtite	3500'N eastern end approx. 579' mark	
71/L1-107 (P10/2)	ACID PROPHYRY - pale green cream weathering (Kaolinised) c̄ felspar, quartz phenocrysts	Noddy Creek Pad 10 approx. 1200'N 300'E	
71/L1-108 (P10/2)	ACID PROPHYRY	Noddy Creek Pad 10 approx. 300'E	
71/L1-109 (P10/3)	BASALTIC(?) VOLCANIC - fine grained	Noddy Creek Pad 10 approx. 2100'S	
71/L1-110 (P10/4)	INT-BASIC VOLCANIC - pale green weathering c̄ lath felspar phenocrysts	Noddy Creek Pad 10 approx 2300'S	
71/L1-111 (P10/5)	ACID PROPGYRY	Noddy Creek Pad 10 25S approx. 160'E	
71/L1-112 (P10/6)	BASIC-INT VOLCANIC - c̄ lath felspar phenocrysts	Noddy Creek Pad 10 25S approx. 1300'E	
71/L1-113 (P10/7)	ACID PORPHYRY	Noddy Creek Pad 10 approx 3420S	
71/L1-114 (P10/8)	BASALTIC(?) VOLCANIC - dark green, chloritic micro-vesicular	Noddy Creek Pad 10 approx 3500S	
71/L1-115 (P10/9)	GREYWACKE - pale grey-green alightly sheared	Noddy Creek Pad 10 area near contact c̄ acid porphyry approx. 4500'S along track from 25S	

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71/L1-116	GREYWACKE c̄ PEBBLES - siltstone and ? acid volcanic clasts		

Samples 71/L1 107-116 inc refer Noddy Creek Area Run 1971 Run 3/94

71/L1-117A	MASSIVE SULPHIDE/GOSSAN - sample from blue green sheared basic/ intermediate rock type near contact with agglomerate	Outcrop near mouth of adit Brickmakers Bay 600'SE of Asbestos Point Landing	
71/L1-117B	"	"	
71/L1-118	SERPENTINITE-LIZ 50%-CLINO50% - black massive serpentinite magnetic	2500' line approx. 300' peg	GEOMIN P.R.A.
71/L1-119	SERPENTINITE-clino-80%-LIZ 20% - dark green serpentinite with magnetite, pentlandite associated with asbestos fibre	2500'N approx 3300' mark	P.R.A.
71/L1-120	SERPENTINITE - light green serpentinite with strong X-fibre and minor magentite	2500'N approx. 370' mark	P.R.A.
71/L1-121	SERPENTINITE- LIZ. 10%-CLINO.- pale green serpentinite, magnetite in shear planes minor X-fibre	2500' approx. 385' mark	P.R.A.
71/L1/122	SERPENTINITE-LIZ - dark green serpentinite v. minor magnetite, serp-pseudomorphs after pyroxenes?	2500'N approx. 405' mark	P.R.A.
71/L1-123	SERPENTINITE-CLINO+LIZ - sheared serp. with magnesite	2500'N approx. 610' mark	P.R.A.
71/L1-124	SERPENTINITE-LIZ 80% ANT 20% - dark green serp. fibrous magnetite on shear planes	2500'N approx. 630' mark	PRA
71/L1-125	SERPENTINITE-CLINO - ribbon fibre bearing serp. with pentlandite	2650'N approx. 150' due north of 300' peg on 2500'N line	P,R.A.
71/L1-126	SERPENTINITE-ANT& SOME LIZ 20% - dark green compact sheared serpentinite c̄ carbonate veins in shear planes	5500'N approx. 750' mark	P,R.A.
71/L1-127	CARBONATE VEIN - fibrous carbonate dolomite ? with sheared serp?	5500'N approx. 750' mark	

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71/L1-128	INTERMEDIATE DYKE OR SILICIFIED GABBRO - quartz rich leucocratic dyke rock possible silicified gabbro	3500'N approx. 695' peg	-
129	SERPENTINITE-ANT & CLINO 10% - light green serpentnite with fine X-fibre.	5000'N approx. 400' peg stream section	GEOMIN P.R.A.
130	CARBONACEOUS SILTSTONE - dark grey carbonaceous siltstone partly metasomatized c̄ CO_3 veins.	3000'N approx. 115' peg	
131	TALC-CARBONATE SCHIST - brown-grey sheared talc rock with qtz. zenoliths and green mineral-fuchsite ? magnetite.	2000'N approx. 875' mark	TS
132	TALC SCHIST - blue-grey schistose talc rock	2000'N approx. 1000' peg	
133	HORNFELS? - dark grey hornfelsized sediment with quartz veins and pyrite	2000'N approx. 200' beyond 1000' peg	
134	SILICIFIED GABBRO - grey med. gr. basic rock silicified with narrow qtz. veins	2000'N approx. 300' beyond 1000' peg	
135	RODINGITE AND SERPENTINITE - lens in serpentinite. Grey with hydragarnet and prehnite identified	100'N approx. 500' mark	TS
136	FUCHSITE RICH QTZ-CARBONATE MUSCOUVITE SCHIST - light green soft, sheared rock with pyrite	Approx. 750'N in stream bed on road behind helipad 3	TS
137 (A & B)	CONGLOMERATE - sheared conglomerate c̄ fuchsite ? clasts	1500' from Timbertops Road west along road to 1500'S line	
138	LAMPROPHYRE, AUGITE MINETTE - Dark grey bitoite rich lamprophyre	1000' from Timbertops Road west along road to 1500'S line	TS
139	LAMPROPHYRE, MINETTE - bitoite rich lamprophyre	1000'S line approx. 1130' mark	TS
140	PLAGIOCLASE RICH ROCK - light grey felspar rock with thin magnetite veins	400'S approx. 285' mark	

71/L1-142	SERPENTINITE - chip sample	DHNC2 160'-170'	AMDEL P.R.A.
143	SERPENTINITE c̄ DISSEM. STICHTITE - chip sample	DHNC 3 175'180'	P.R.A.
144	SHEARED SERPENTINITE - chip sample	DHNC4 155'160'	P.R.A.
145	SHEARED SERPENTINITE c̄ STICHTITE - chip sample	DHNC 6 295'300'	P.R.A.
146	MASSIVE MOTTLED SERP. - chip sample	DHNC 7 285'-290'	P.R.A.
147	HARD DARK MASSIVE SERP. - chip sample	DHNC 8 245'-250'	P.R.A.
148	PALE MASSIVE SERPENTINITE - chip sample	DHNC 9 195'-200'	P.R.A.
149 (NC 1)	PYROXENITE - completely altered to talc	½ml. SSE of pad 2	AMDEL (TS & TEA) thin section and trace element analyses
150 (NC 2)	PYROXENITE - steatitised tremolite-talc alteration	1ml. SSE of pad 2	
151 (NC 3)	GABBRO COR. GR. altered saussurite and tremolite rich	½ml. NE of pad 2 Fern Ck. costean 2 ~2300'E of main track	
152 (NC 4)	ANDESITE ? - altered-chlorite plagioclase rich	as above ~ 2300'E of track	"
153 (NC 5)	BASIC DYKE ROCK? - dolerite fn. gr. dark green	½ml. N of Pad 2 Fern Ck. costean 1	"
154 (NC 6)	GABBRO - plagioclase, chlroite amphibole	as above	"
155 (NC 7)	TALC SCHIST - light blue grey derived from sheared serpentinite	Fern Ck. costean 1,~ 1300'E of track	"
156 (NC 8)	SERPENTINITE - dark green massive	Noddy Creek 100'S line 600' peg	"
157 (NC 9)	ORTHOPYROXENITE - dark green med. grained	100'S line ~500' peg	"

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71/L1-158 (NC 10)	STEATITIZED PYROXENITE BRONZITE?	as above	"
159 (NC 11)	SERPENTINIZED ORTHOPYROXENE - dark green med. grained	as above	"
160 (NC 12)	AMPHIBOLITE - lt. grey green coarse grained	1000'S line 300' peg	"
161 (NC13)	GABBRO cut by a prehnite rich vein. med. grn. green-grey	00' line 550' peg	"
162 (NC 14)	Fine gr. grey-green lamprophyre minette. Same as 71/L1-65	Main N-S road 250S of 700S Line	TS by AMDEL Anal. for Cu,Pb,Zn, Co, Ni, Cr
163 (NC 15)	med. gr. dk. grey gabbro. Similar to 71/L1-57	0 line approx. 1000' peg	"
164 (NC 16)	Massive dk. green layered serpentinite c̄ chrysotile cross fibre. Same as 71/L1-40	3000N line approx. 150' peg	"
165 (NC 17)	Orange-green basic volcanic rock near contact c̄ ultramafics. From same place 71/L1-44A	250'N 2000N line Eastern road	"
166 (NC 18)	Cream chert c̄ black spinel crystals. Similar to rock on 5500'N line 71/L1-105B	½ml. NE pad 2 Fern Ck. costean (new) approx. 2400' E of N-S track	"
167 (NC 19)	Grey med. gr. basic lamprophyre dyke	5000N line approx. 900' peg	"
168 (NC 20)	Black med. gr. biotite lamprophyre dyke	1000N line approx. 370' peg	"
169 (NC 21)	Light grey-green altered gabbro? c̄ qtz. veins. Similar to 71/L1-63	700S line 200' peg	"
170 (NC 22)	Massive pyrite c̄ chalcopyrite in limonite goethite matrix	600' SE of Asbestos Pt. landing	"
171 (NC 23)	Qtz. veined green altered ultramafic rock with disseminated pyrite, chalcopyrite and bornite?	½ NE of pad 2 Fern Ck. costean (new) 1500'E of N-S track	"

71/L1-172 (NC 24)	Apple green serpentinite c̄ stichtite and thin less than or equal to 1/16" chrysotile fibre veins. Similar to 71/L1-41B.	300'N line approx. 500' peg	"

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Please address all correspondence to the Director
In reply quote: MP 3/4/1/0

3 August 1971

B.H.P. Geological Office
PO Box 1352N
HOBART TAS 7001

REPORT MP 5484/71

YOUR REFERENCE:	Letter - R.J.C. 1.6.71
MATERIAL:	24 rocks
LOCALITY:	Noddy Creek, Tasmania
IDENTIFICATION:	NC 1-24
DATE RECEIVED:	15/6/71
WORK REQUIRED:	Petrography

Investigation and Report by: Dr B. G. Steveson

Officer in Charge, Mineralogy/Petrology Section: Dr K. J. Henley

K. J. Henley

for F. R. Hartley
Director

740173

027

PETROGRAPHY OF 24 ROCKS FROM NODDY CREEK, TASMANIA

1. SUMMARY

This collection of rocks contains some interesting, but occasionally obscure, specimens. In order to understand the relationships among the samples a classification and summary is given below. This is only a tentative division and should be regarded in that light.

I(a) Normal Cambrian ultrabasics

Nos. 1, 2, 8, 9, 10, 11, 16, 24.
These are pyroxenites (probably) now extensively altered by talc and serpentine.

I(b) Strongly altered ultrabasics

Nos. 15, 18.
More altered equivalent of I(a).

II(a) Normal Cambrian hypabyssal basic intrusives

Nos. 3, 4, 5.

II(b) Strongly altered, metasomatised basic intrusives

Nos. ?6, 12, 13, 21.
These rocks have been sheared, altered and veined and metasomatism has altered their composition so that the original features are now difficult to deduce.

III Intermediate, hypabyssal rocks, probably Cambrian, associated with ultrabasics

Nos. 14, 19.

IV Rocks with unknown affinities, possibly Cambrian lavas or tuffs

Nos. 4, ?6, 7, 17.

V Lamprophyric rock of unknown affinities

No. 20, possibly 19.

VI Mineralised rocks

Nos. 22, 23.

2. PETROGRAPHY

Sample: NC 1 :TS 26988 71/L1-149

Rock Name:
Talc Rock

Hand Specimen:
A compact massive rock with a dark green colour. The sample is aphanitic but probably consists of talc. A thick crust of red-brown weathered material has developed.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Talc	98
Chlorite	1
Quartz	1

The sample consists almost exclusively of talc (confirmed by X-ray diffraction) in a mat of fine-grained flakes. In detail, patches of the smallest flakes are rimmed by areas of slightly coarser talc which in turn are followed by the discontinuous net-work of quartz. Consequently, the rock has a "boxwork"-like texture with a zonation of grainsize within such "box."

Quartz and chlorite form similarly fine-grained material in a discontinuous network. In the case of chlorite, the long straight zones appear to mark the cleavage of the previous mineral (now replaced by chlorite). Quartz forms equant, interlocking anhedral crystals.

Except for the pattern of chlorite "veins" and the grain size of talc, the original texture of this rock has been completely replaced by that of secondary talc, chlorite and quartz.

The rock was originally a coarse ultrabasic rock, probably a pyroxenite. Some traces of 120° cleavage suggest the presence of some original amphibole.

Sample: NC 2 :TS 26989 71/L1-150

Rock Name:

Steatised ultrabasic rock

Hand Specimen:

The hand specimen is compact, dense and has a dark green colour. On the weathered surface the outline of large crystals can be seen.

Thin Section:

An optical estimate of the constituents gives the following:

	%
Talc	80
Tremolite	5-10
Orthopyroxene	10
Clinopyroxene	3-5
Serpentine	1-2

A mat of small talc flakes has replaced most of this rock and only rounded, veined remnants of the original minerals remain. Tremolite has grown in some cases and is now common in association with serpentine.

Most of the pyroxene has been replaced by talc and isolated fragments of orthopyroxene and clinopyroxene, 3-4 mm in diameter, have been veined and "rounded" by talc.

Some tremolite is similar in size to the pyroxene but, although it too has irregular, embayed contacts with the talc, it has not suffered such extensive replacement. Where the tremolite is veined, serpentine occupies the cracks and, in one place, a small group of tremolite blades nests in a patch of serpentine in the mass of talc. The tremolite is colourless. All present amphibole is secondary, though part occurs in inter (pyroxene) granular areas.

The talc itself occurs as a dense aggregate of nearly submicroscopic flakes. Elongate talc crystals can be recognized only adjacent to fissures in the rock.

Opaque grains, some of which have cube outlines, are widely scattered throughout the thin section.

This sample consists of relic pyroxene crystals set in a dense mat of secondary talc. Serpentine and tremolite are accessory minerals. Undoubtedly the original rock was ultrabasic in nature and if it contained any olivine, this has now been entirely replaced. The rock was probably a pyroxenite, with minor primary amphibole.

Sample: NC 3 :TS 26990 71/L1-151.

Rock Name:
Altered gabbro(?)

Hand Specimen:
A weathered pale rock. The cut surface contains sharply defined areas of dark green mafic minerals in paler zones of altered feldspar.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Tremolite	65
Altered feldspar	35
Opaques	Trace

Large pale green to colourless tremolite crystals form an interlocking texture with areas of altered feldspar. Some intergranular areas of tremolite are relatively fine-grained and have some radial textures.

The large tremolite crystals are generally about 4 mm in diameter and have simple, but anhedral, shapes. In some crystals areas of local fracturing of the tremolite appear to be related to cracks passing through the rock. Two generations of amphibole appear to be present. The alteration of one form to the other, in certain grains, giving a curious mottled effect.

The altered feldspar is now an exceedingly fine-grained aggregage of mica, clay and possibly chlorite and its origin as feldspar can only be conjectured since the material is impossible to recognise microscopically. These areas tend to have an irregular interstitial form.

Amongst the altered feldspar and large tremolite crystals are small (1-2 mm) patches of finer grained tremolite. Individual crystals are less than 0.3 mm long and are subhedral with well developed prism faces. Commonly these elongate crystals have a radiating texture.

This rock was possibly a gabbroic igneous rock, which had been converted to an amphibolite. The minerals of the latter have been almost completely replaced. However, such is the extent of this alteration, that such an origin must remain an hypothesis only.

Sample: NC 4 :TS 26991 71/L1-152.

Rock Name:

Altered andesite

Hand Specimen:

The weathered surface is pale green and contains crystals about 2-3 mm in diameter. The rock is compact and massive.

Thin Section:

An optical estimate of the constituents gives the following:

	%
Plagioclase	55
Amphibole	<5
Chloritic groundmass	40
Zircon	Rare

Set in a fine-grained groundmass are extensively sericitised plagioclase feldspars and rarer, less altered colourless amphiboles. Superficially there appear to be phenocrysts but because of the large proportion of these minerals it seems possible that the groundmass was originally as coarse and its present small grainsize is the result of alteration processes.

The average diameter of the plagioclase crystals is 1-1.2 mm and most crystals are equant and rounded; some, however, are severely embayed by the groundmass, have most irregular shapes and sutured boundaries. Sericitisation of the plagioclase is ubiquitous and is especially marked in the centres of the crystals.

Amphibole crystals are elongate flakes up to 1.5 mm long, though many are less than half this length. Most crystals, and especially the smaller ones, are ragged and altered at the margins.

These two phases - amphibole and plagioclase - occur in a groundmass which is a mat of fine-grained chlorite with ?amphibole, feldspar and/or quartz. The minerals are too small for positive identification. In some cases the chlorite crystals are 0.5 mm long where this groundmass abuts against coarse feldspar or amphibole, but this is rare.

The initial mineral phases in this probable andesite have suffered extensive degradation and alteration. The groundmass of chlorite and framework silicates has embayed the phenocrysts of feldspar and amphibole.

Sample: NC 5 :TS 26992 71/L1-153

Rock Name:
Altered igneous rock (?dolerite)

Hand Specimen:
The hand specimen is stained a pale brown colour but a broken surface shows small, dark grains of ferromagnesian minerals, some of which appear to be micaceous.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Chlorite	15
Tremolite	70-75
Opaques	1
Pale biotite (phlogopite?)	10

The texture of this rock is largely that of the alteration products and original textures are exceptional. Chlorite and tremolite are undoubtedly the products of metamorphic or other processes. The pale biotite may be a relict of the original rock.

The largest pale biotite crystal is 4 mm long and most crystals are more than 1 mm in length. Rather bladed, though subhedral, crystals are typical. Many crystals are both partially resorbed and extensively altered so that a precise identification is not possible. The contrast in grain size between this biotite and the other crystals suggests that the biotite may well be a relict primary mineral.

Tremolite and chlorite are elongate subhedral or anhedral crystals generally less than 0.6 mm long. They form a dense interlocking aggregate with some irregular areas of chlorite.

Undoubtedly the rock was igneous - possibly containing quite coarse pale biotite. Now, the primary minerals have been completely replaced by chlorite and tremolite The replacement is probably related to a phase of low grade regional metamorphism.

Sample: NC 6 :TS 26993 71/L1-154

Rock Name:
Altered andesitic dolerite or gabbro

Hand Specimen:
NC 6 is similar to NC 4. Although NC 6 is darker in colour it has the same textural features in hand specimen.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Plagioclase	40
Untwinned feldspar	20
Chlorite	10-20
Amphibole (tremolite)	15-20
Quartz	3-5
Opaques	Trace

This medium-grained igneous rock has an interlocking allotriomorphic granular texture. Extensive sericitisation of feldspar, chloritisation of amphibole and veining by quartz testify to the thorough secondary alteration suffered by the rock.

Most of the feldspar shows Albite Law twinning and is consequently plagioclase (albite); the untwinned feldspar is similar in habit, alteration and refractive index and is probably plagioclase, the twinning being obscured by the alteration products. Most feldspar crystals are 1-1.5 mm long and have anhedral shapes. Commonly the crystals show evidence of some deformation. Alteration products are micas, clay and ?epidote.

The amphibole is a pale green tremolite occurring as ragged anhedra, rarely more than 1.5 mm in length. Chlorite has replaced varying amounts of the tremolite and some pseudomorphs of chlorite (after amphibole) can be seen.

Quartz has replaced some of the rock and now has two forms: isolated patches of quartz (and some new plagioclase) are scattered throughout the rock; and veins of quartz, about 0.2-0.4 mm wide. The latter show a poorly-developed comb structure.

In summary, this is an andesite or dolerite which has been converted to amphibolite, and has then undergone a final stage of veining and replacement by silica. From an examination of the thin section it appears that this later alteration is the result of relatively low temperature, surficial processes rather than metamorphism.

Sample: NC 7 :TS 26994 71/L1-155

Rock Name:
Talcose rock

Hand Specimen:
The cut surface of this rock is a dark green colour. It contains friable ferruginous material which is clearly weathered. A weak foliation (defined by veins of reddish iron hydroxide) can also be seen.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Talc	90
Serpentine	5-10
Opaques	<1
Iron hydroxide	1-2
Quartz and feldspar	2-3

The slide shows a mat of fine-grained talc similar to that described in other thin sections in this suite. The other minerals occur only in accessory amounts.

Flakey serpentine occurs in well-defined areas in the talc. These are typically 0.7-1.0 mm across and have an irregular, but usually equant, shape. The talc is cut by discontinuous seams of dark brown iron hydroxides which in places swell out to form loose, porous masses of this goethite or limonitic material.

The thin section also contains a "nodule" about 1 cm x 1 cm in size. This consists of limonite patches, opaque grains and some areas of quartz and feldspar. The last two minerals occur in some places as anhedra 0.2 mm across in an allotriomorphic random texture. The quartz shows extreme undulose extinction. Some singly twinned crystals appear to be feldspar.

On the whole this sample is similar to other talc-rich rocks described in this report. It seems to be weathered slightly and it contains nodules of siliceous and iron-rich material. No determinable traces of primary ferromagnesic minerals remain, though the clusters of serpentine material are probably replacing early ferromagnesian ?phenocrysts. Other structures suggest infilled vugs. This is an interesting specimen texturally and the rock may have been an ultrabasic volcanic rock - or a tuff.

Sample: NC 8 :TS 26995 71/L1-156

Rock Name:
Serpentinite

Hand Specimen:
A massive compact rock free of any structure or heterogeneity. The rock is fine-grained and dark green in colour.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Serpentine	99
Opaques	1

Serpentine has completely replaced the minerals of this rock leaving only isolated euhedra and subhedra of chromite. The grain size of the serpentine is less than 0.01 mm over most of the slide - in other parts the flakes are bigger. These differences in grain size and relic indications of cleavage are the only evidence of the morphology of the original minerals. It is likely that they were equant and about 0.5 m in diameter. Everywhere in the slide the serpentine has a flaky appearance and fibro-lamellar structures of antigorite.

Such grain behaviour as is recognisable suggests that the larger primary grains were orthopyroxenes.

Sample: NC 9 :TS 26996 71/L1-157

Rock Name:
Altered orthopyroxenite

Hand Specimen:
This is similar to other rocks in this collection except that in the cut surface, remnants of the original ferromagnesian minerals can be seen in the dark aphanitic serpentine.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Orthopyroxene	85-90
Clinopyroxene	Trace
Serpentine	5-7
Talc	3-5
Epidote	Trace
Amphibole	Trace
Opaques	Trace

Orthopyroxene is the dominant mineral in this rock. Crystals are equant, rounded and 1-3 mm in diameter. In many places the textures of the orthopyroxene suggest a cumulate igneous rock. Clinopyroxene is only a minor component and occurs widely but in small anhedral crystals no more than 0.15 mm across.

The other minerals in the rock result from alteration and replacement of the pyroxene. Talc occurs as a rim around all the pyroxene crystals. Normally the talc appears to have grown perpendicular to the rim of the adjacent pyroxene but since it is rather finer grained it is not always possible to recognise the texture of the talc.

Serpentine forms both discrete areas up to 1 mm across and cross-cutting replacement veins. The latter pass through pyroxene, talc and patches of serpentine indiscriminately and hence are later than all three.

Both tremolite and epidote occur in widely spread clusters or anhedral crystals and have replaced some serpentine, talc and pyroxene. Neither is an important phase in this rock.

Chromite is recognisable among the opaques.

This is an ultrabasic igneous rock, consisting predominantly of orthopyroxene. Talc, serpentine and amphibole and epidote have successively replaced the pyroxene. The talc forms distinctive corona structures around the orthopyroxene.

Sample: NC 10 :TS 26997 71/L1-158

Rock Name:
Steatised rock

Hand Specimen:
Large grains, up to 1 cm across, can be seen on the cut surface - these are the outlines of steatised ferromagnesian minerals. On the weathered surfaces these grains have a distinct bronze colour.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Talc	95
Opaques	Trace
Serpentine	Trace
?Olivine	Rare
Orthopyroxene	<5

The rock is a cumulate ultrabasic rock which has been replaced almost entirely by talc. The outlines of the original ferromagnesian minerals are delineated by zones of brown-stained material and a little exsolved opaque. The differing cleavage directions in the original mineral (?pyroxene) are picked out by the talc and this helps in recognising different grains. These original crystals were about 5 mm in diameter, equant and formed an homogeneous interlocking mass. Some small crystals of ?olivine and ?orthopyroxene can still be seen.

The talc itself is a fine-grained material, widespread over the whole of the thin section. Some recrystallisation has caused a coarsening of the talc but most still retains the flaky, almost sub-microscopic grains typical of talc in steatised ultrabasic rocks.

The sample shows a continuation of the alteration of ultrabasic rocks displayed by other rocks in this selection. Serpentinisation is only of limited extent, but most original minerals have been replaced now by talc.

Sample: NC 11: TS 26998 71/L1-159

Rock Name:

Serpentinised orthopyroxenite

Hand Specimen:

The specimen is similar to NC 10 but the ferromagnesian minerals are paler in colour and probably less altered to talc. Both NC 10 and NC 11 are massive and fresh.

Thin Section:

An optical estimate of the constituents gives the following:

	%
Orthopyroxene ...	60
Clinopyroxene	less than 5
Talc	10-15
Serpentine	25
Chromite	Trace

Texturally the sample shows two alteration processes: the pseudomorphous replacement of pyroxene by talc and serpentinisation. As can be seen from the proportions listed above both processes have replaced a considerable proportion

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of the rock. All the pyroxene remaining is veined by talc and all stages in this alteration can be seen.

The original, unaltered pyroxenes were probably 4-5 mm in diameter, though many have been reduced to smaller dimensions on replacement by talc. The crystals are rounded and equant and many of the orthopyroxenes have distinct schiller structure. A distinct cumulate texture can still be recognised with intergranular clinopyroxene amongst the orthopyroxene. The former are normally only about 0.3 mm in diameter.

Talc occurs as a very fine-grained mat of crystals in fractures in pyroxenes and rimming already replaced material.

Serpentinisation has followed the development of talc. Serpentine in some places fills the centres of veins in pyroxene, rimmed already with talc. In those parts of the rock predominantly serpentine, this mineral has a fibrolamellar structure typical of serpentinites.

Chromite occurs as isolated, broken grains, usually in the serpentine. Such grains are relicts of the orthopyroxenite - their pale colour suggests that they have been altered during serpentinisation.

In summary, this is an ultrabasic rock, consisting almost entirely of orthopyroxene. Serpentinisation and steatisation (replacement by talc) have caused the replacement of about 40% of the rock.

Sample: NC 12 :TS 26999 71/L1-160

Rock Name:

Altered ultrabasic or basic rock

Hand Specimen:

The sample is compact and massive and has a pale green, soapy appearance. Crystals several millimetres long are present.

Thin Section:

An optical estimate of the constituents gives the following:

	%
Tremolite	65
Talc	30
Quartz/feldspar	2-3
Opaques	Trace
?Chlorite	less than 1

Large blades of tremolite dominate the texture of this rock and talc forms only a fine-grained ramifying network amongst the tremolite and has apparently replaced some of it.

Tremolite has two habits; large anhedral crystals with embayed contacts and "included" patches of talc and subhedral blades only altered to talc along cleavages and on the terminal edges. Most crystals are 3-5 mm long but many of the more altered type have, naturally, been reduced to smaller dimensions.

Quartz forms notably anhedral, deeply embayed and broken crystals, generally less than 1 mm across. In one case, a quartz crystal has an extremely irregular shape but occupies an area of 3 x 3 mm. One part of this crystal, in turn, embays a tremolite crystal and appears to have partially replaced it. Small grains of felsic material appear weakly altered. These untwinned grains are possibly of altered feldspar.

The final process has clearly been the development of talc. This mineral forms a fine-grained mass (similar to TS 27005) which has replaced much of the rock.

Chlorite occurs in small patches (less than 1 mm) of fine-grained material amongst the talcose groundmass.

The origin of this rock is somewhat obscure, except that it has an ultrabasic or basic composition and the present minerals are products of the complete breakdown of primary minerals. Metasomatic alteration may have occurred.

Sample: NC 13 :TS 27000 71/L1-161

Rock Name:

Altered igneous rock with metasomatic band

Hand Specimen:

Two distinct types of rock are present: a band of white material occurs in a pale-green igneous rock. The latter generally is of medium grainsize except for a coarser zone adjacent to the white band.

Thin Section:

An optical estimate of the constituents gives the following:

	%
WHITE PART	
Prehnite	70
Quartz	10
Calcite	5-7
Sphene	Trace
Pyroxene	10
GREEN PART	
Pyroxene	20
Tremolite	45
Chlorite	20
Quartz	<5
?Zoisite	10
?Albite	5

The slide consists of two different rock types, distinguished as white and green above. Both probably represent metasomatised basic igneous rock and in the white part such metasomatism has been particularly extensive.

The less metasomatised, green part has an allotriomorphic granular texture of medium grain-size. Tremolite, pyroxene and chlorite pseudomorphs after these occur as anhedral crystals with a mean size of about 0.8 mm . The amphibole is secondary and forms, in some places, in areas between equant tremolite and pyroxene so that it has a later, void-filling appearance. Many crystals are rimmed by relatively coarse tremolite. Zoisite forms large equant crystals and also occurs as inclusions in albite anhedra.

The pale part of the slide consists largely of prehnite crystals, many of which have well-developed crystal faces against quartz but irregular boundaries with prehnite. The grain size ranges up to 1 mm.

Cavities in this material have been filled with clear, unstained quartz which forms "pools" in the prehnite aggregate.

Carbonate, sphene and pyroxene (?diopside) are much less abundant constituents of this rock.

The prehnite-rich material is thought to be a highly metasomatised band (?vein) within the less thoroughly metasomatised igneous rock. The latter has affinities with rodingites.

Sample: NC 14 :TS 27001 71/L1-162

Rock Name:
Altered microsyenite

Hand Specimen:
A compact, structureless rock of a nondescript grey colour. Crystals about 1 mm across can be seen.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Chlorite	5-7
Altered untwinned feldspar	85
Epidote	3-5
Quartz	1-2
Apatite	Trace
Opaques	Rare

This medium grained igneous rock has an allotriomorphic granular texture with a minor development of intergranular fine-grained material. Untwinned alkali-feldspar (identification confirmed by staining) is the predominant mineral, associated with subordinate secondary epidote and chlorite.

Most feldspars form a tightly interlocking mass of sericitised crystals generally about 0.5 mm across. The feldspars have well-marked and simple boundaries and show an igneous texture only slightly modified by resorption of feldspar.

The chlorite forms both elongate crystals pseudomorphous after amphibole or ?biotite and also occurs as small fine-grained aggregates.

The coarse chlorite flakes (up to 0.3 mm long) are generally subhedral and have well-developed cleavages. The fine-grained chlorite forms interstitial areas probably derived from the replacement of an original mineral.

The epidote is associated with chlorite and has the anhedral form typical of secondary epidote.

Quartz forms small individual crystals, 0.1 mm across, widely scattered throughout the rock.

An oval-shaped xenolith in the rock, about 1 cm x 7 mm in size consists of alkali-feldspar like that of the bulk of the rock. Chlorite and epidote occur in much lower proportions in the xenolith, but, apart from this, it is very similar to the remainder of the rock.

Sample: NC 15 :TS 27002 71/L1-163

Rock Name:

Altered ultrabasic rock

Hand Specimen:

Similar to other ultrabasicspartially replaced by talc. In the cut surface many crystals 1-2 mm in diameter occur in a dark greenish matrix.

Thin Section:

An optical estimate of the constituents gives the following:

	%
Chlorite	25
Plagioclase	15
Clinopyroxene	25
Orthopyroxene	25
Tremolite	15
?Talc	20
Opaques	2

The rock is an igneous rock which has suffered extensive alteration and replacement. The mineralogy suggests that the precursor was ultrabasic in nature. Except for the

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grainsize of pyroxenes, amphiboles and chlorite pseudomorphs no relict of the original texture remains.

All the minerals except talc and the opaques have a similar habit and can be described together. Chlorite forms as pseudomorphs after the amphibole and pyroxene. Most crystals are 0.8-1.5 mm in diameter but they range down to about 0.5 mm. The grains have irregular boundaries and have been partially resorbed by the matrix; some crystals have embayed or even cuspate shpes.

Some crystals consist of pyroxene partially altered to tremolite, only remnants of the pyroxene remain in the centre of the tremolite. Other crystals consist wholly of pyroxene or tremolite; others are completely chloritised. One distinctive type consists of chlorite with opaques (derived from the alteration of the mafic mineral to chlorite) arranged in a regular pattern, apparently defining cleavage directions in the original mineral.

The groundmass in which these minerals occur is too fine-grained for positive identification. Characteristic of this groundmass is the broken and fractured appearance.

This is an unusual specimen containing orhopyroxene (very nearly enstatite in composition), clinopyroxene and amphibole. The texture of the groundmass may be due to intergranular crushing leaving rounded porphyroblasts.

Sample: NC 16 :TS 27003 71/L1-164

Rock Name:
Serpentinite

Hand Specimen:
This is a typical aphanitic serpentinite with bands of black and green material cut by thin veins.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Serpentine	98
Opaques	1-2

NB: Pages 19, 20 & 21 are missing

This is a medium-grained rock with an allotriomorphic granular texture. Alteration is shown by biotite (to chlorite) and by extensively stained K-feldspar.

The bulk of the rock is brown-stained, untwinned orthoclase occurring as anhedra, commonly 0.5-0.2 mm in diameter. Most of these crystals include or are penetrated by pyroxene and chlorite blades so that the rock has a poorly developed sub-ophitic texture. A vesicle, 4 mm in diameter, consists almost wholly of K-feldspar having a radiating habit.

Other small vesicles contain quartz crystals, typically large anhedra with relatively simple outlines.

The pyroxene crystals have a distinctive form: the crystals are equant (rarely bladed) and altered along fractures. In some places small knots of sericite and chlorite probably represent completely replaced pyroxene. Chlorite is also a common secondary mineral developed from biotite. Most chlorite flakes are about 0.3 mm long but there is a great range of sizes, from 0.07 mm to 0.8 mm. In a few cases "cores" of the original brown biotite are preserved.

Quartz is mainly confined to the vesicles, but some small patches occur in the main body of the rock, usually associated with chlorite. Granular epidote is a relatively common alteration product.

This rock is an altered syenite or microsyenite, rich in alkali-feldspar and containing as principal mafic minerals biotite (now altered to chlorite) and pyroxene.

Sample: NC 20 :TS 27007 71/L1-168

Rock Name:
Glassy volcanic rock (?lamprophyre)

Hand Specimen:
Shining surfaces of a micaceous mineral are present in the surface of this black, fine-grained rock. On the cut surface some crystals about 0.5-1.0 mm in diameter can be seen but these are rather indistinct.

Thin Section:
An optical estimate of the constituents gives the following:

NB: Pages 23 & 24 are missing

Sample: NC 22 :TS 27009 71/L1-170

Rock Name:
Pyritic rock

Hand Specimen:
The sample consists of partially oxidised fine-grained pyrite. Some silicification is apparent. Fine-grained limonitic material rims this "nodule" of pyrite.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Dark brown opaque	90
Quartz	5-10
Tourmaline	Trace
Carbonate	1

The dominant mineral in this rock is an opaque to semi-opaque dark red mineral probably either limonite or goethite. It forms a rather open, porous mass of fine-grained material. In some parts of the section two distinct phases (varying in opacity) can be delineated.

In separated patches within this goethite are quartz, carbonate and traces of tourmaline. Quartz forms, in some places, crystals up to 2 mm long which have grown across a vein. More commonly the quartz (and carbonate) are fine-grained and their shapes are defined by the surrounding goethite.

Little can be said of the origin of this rock except that the carbonate and goethite are probably secondary, the latter having replaced most of the rock.

Sample: NC 23 :TS 27010 71/L1-171

Rock Name:
Quartz (vein-filling?)

Hand Specimen:
Siliceous material has veined and fractured a pale green igneous rock. Pyrite occurs finely disseminated in the latter and in cavities (3-4 mm across) in the former. Much of the surface is pitted and iron stained.

Thin Section:

An optical estimate of the constituents gives the following:

	%
Quartz	99
Opaque (pyrite?)	less than 1

Most quartz occurs as anhedral, strained crystals, generally about 1-2 mm across. In detail the grain boundaries are distinctly sutured, a feature indicating some weak stress after crystallisation. The rest of the quartz is finer-grained, making up a tightly interlocking mosaic of sutured crystals showing undulose extinction. Zones of the finer-grained quartz are broadly linear with parallel long axes and between these zones there is a suggestion of weakly developed comb-structure. In some places there is a mixing of the two types of quartz and the rock's texture is confused.

Opaque grains, 0.2-0.5 mm across, occur in clusters and isolated crystals. Many grains have cube outlines (or are parts of cubes) and are probably pyrite.

Although field evidence would be needed in order to decide the origin of this rock, it appears to be, perhaps, vein-filling material; or at any rate, related to such a stress feature.

Specimen: NC 24 :TS 27011 71/L1-172

Rock Name:

Serpentinite

Hand Specimen:

A bright green serpentinite containing patches, about 2 mm across, of pink-purple stichtite. The latter are rimmed by dark green zones.

Thin Section:

An optical estimate of the constituents gives the following:

	%
Serpentine	97
Stichtite	2-3
Opaques	Trace

The texture of the original rock is completely obliterated by that of the serpentine. The latter has a typical, intersecting fibro-lamellar network.

Veins of cross-growing serpentine effectively define cells filled with fine-grained serpentine, much of which has grown away from the bordering vein serpentine. Within this mass of serpentine are some large flakes up to 2 mm in diameter. These flakes are embayed and fractured by the fine grained serpentine. Stichtite and the opaques are closely related: the opaques occur as equant anhedra surrounded by stichtite, the fibres of which radiate outwards from the opaques. A typical example of this arrangement is 20 x 8 mm in size and contains fifteen opaque crystals, one of which is 0.3 mm across. These stichtite masses appear to have developed by replacement of the opaques after serpentinisation.

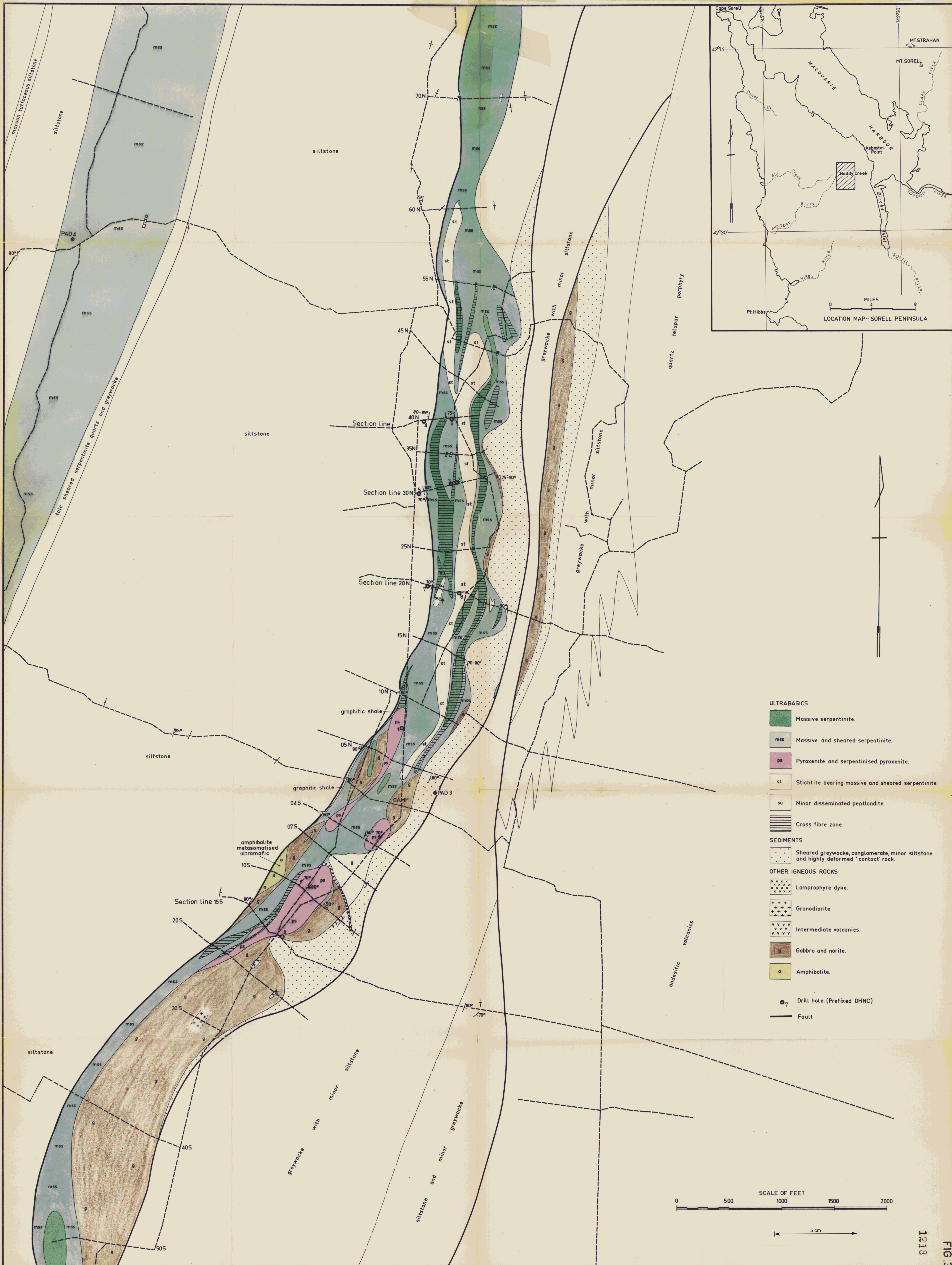

FIG. 3

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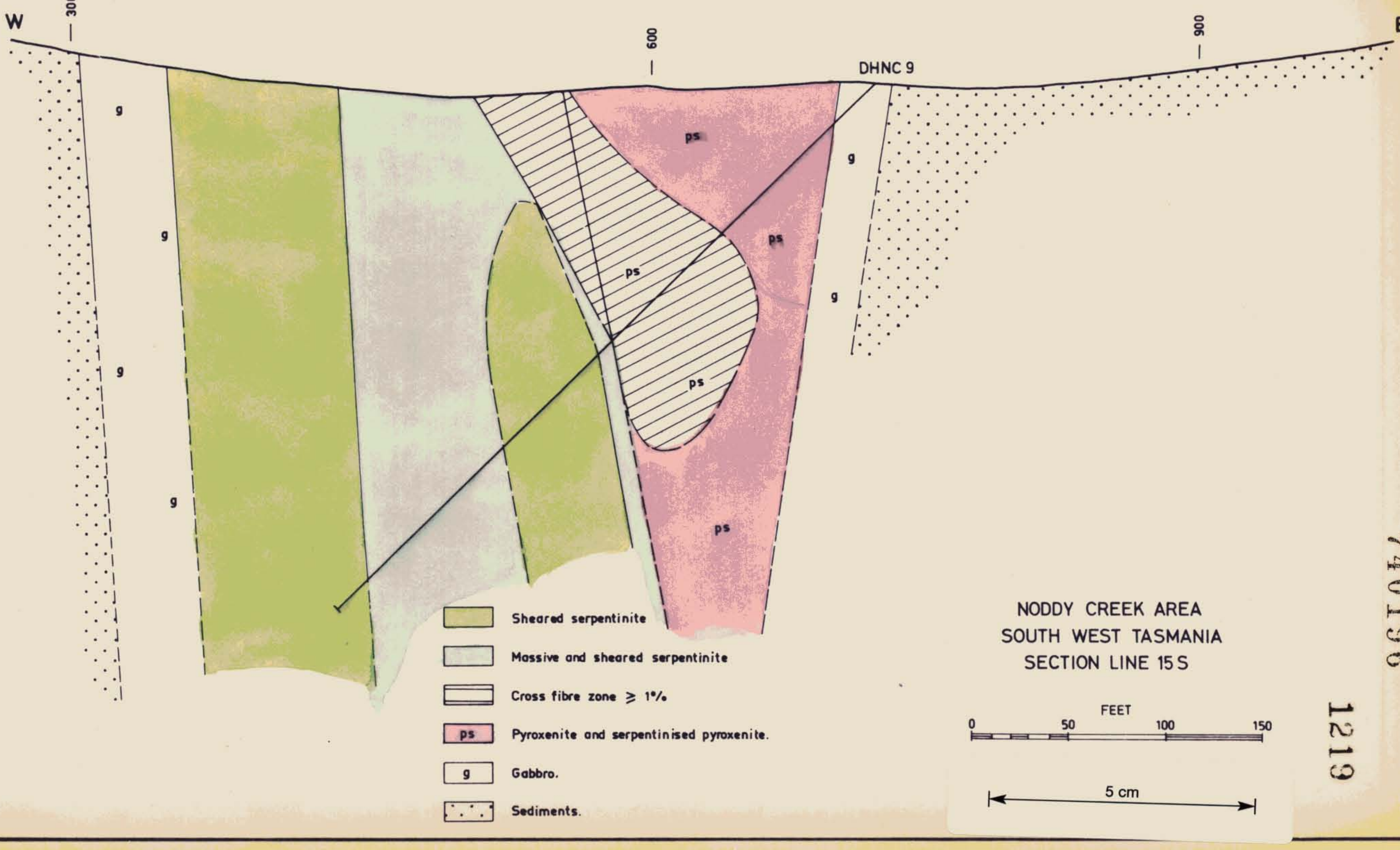

NODDY CREEK AREA
SOUTH WEST TASMANIA
SECTION LINE 15 S

FIG. 4.

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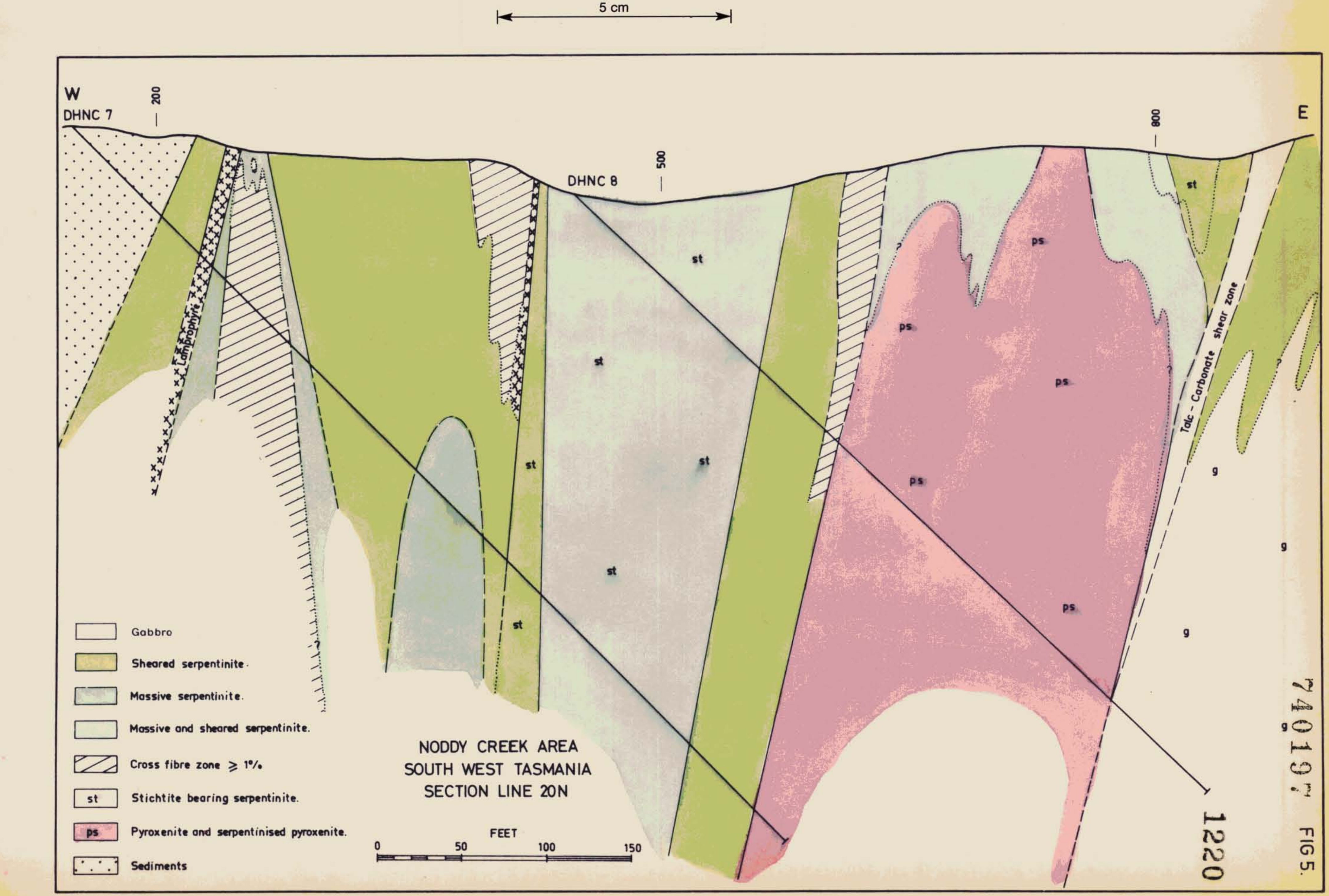
5 cm
W
E
DHNC 7
DHNC 8
200
500
800
Lamprophyre
Talc - Carbonate shear zone
st
ps
g
Gabbro
Sheared serpentinite.
Massive serpentinite.
Massive and sheared serpentinite.
Cross fibre zone ≥ 1%
st Stichtite bearing serpentinite.
ps Pyroxenite and serpentinised pyroxenite.
Sediments
NODDY CREEK AREA
SOUTH WEST TASMANIA
SECTION LINE 20N
FEET
0
50
100
150
1220
7401 97

FIG 5.

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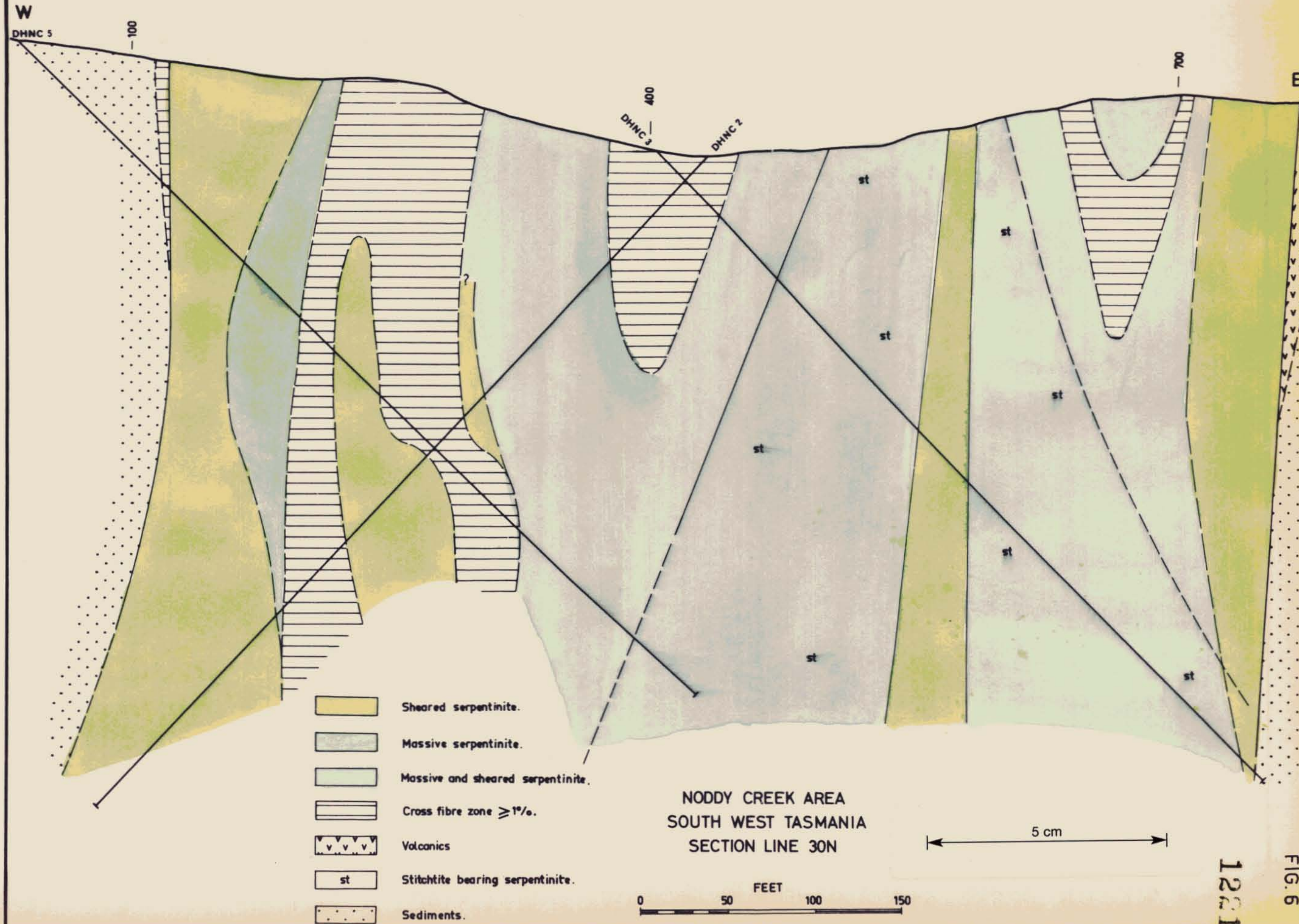

NODDY CREEK AREA
SOUTH WEST TASMANIA
SECTION LINE 30N

FIG. 6

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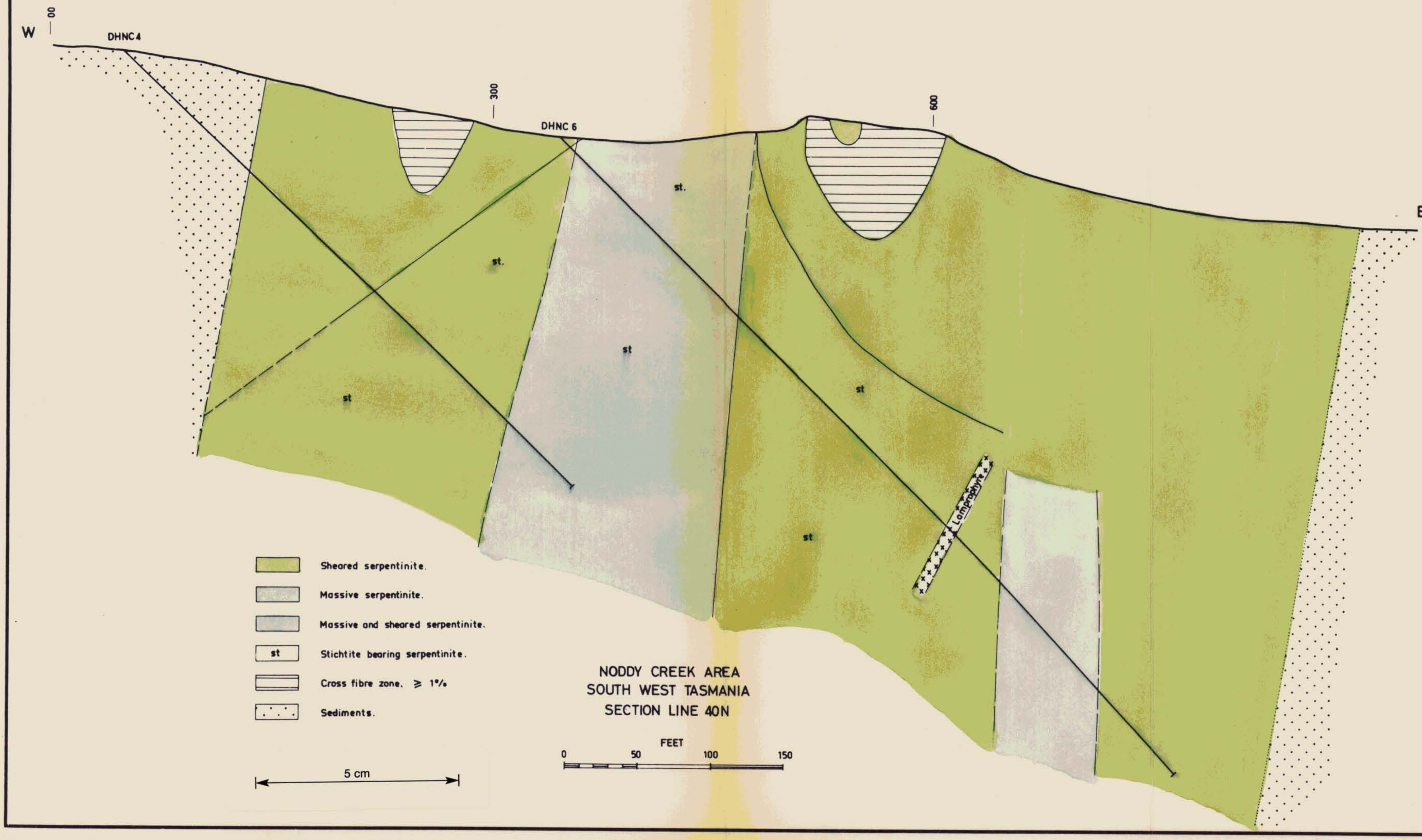
FIG. 7.



NODDY CREEK AREA
SOUTH WEST TASMANIA
SECTION LINE 40N

FIG. Nº. 8

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	Overburden and scree.
	Sheared serpentinite.
	Massive and sheared serpentinite.
	Massive serpentinite.
ps	Pale green
ds	Dark green
s	Serpentinite.
py/s	Pyroxenite and serpentinite.
s/py	Serpentinised pyroxenite
	Cross fibre zone.
st	Stichtite.
	Siltstone
	Greywacke and siltstone.
grf shl.	Graphite shale
	Basic intrusive.
	Intermediate intrusive
l	Lamprophyre
	Gabbro.
qtz.	Quartz.
lamp.	Lamprophyre.

Vertical scale. 1" = 4000 gammas.

Horizontal scale. 1" 50'.

Numbers on horizontal scale increase eastward unless otherwise indicated.

Centre HOBART	THE BROKEN HILL PROPRIETARY CO. LTD. E.L. 13/65. SOUTH WEST TASMANIA. NODDY CREEK. GEOLOGICAL KEY FOR MAGNETIC PROFILES	Project No.
Date 9-9-71.		Drawing No. A4-7

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Fig. 9.

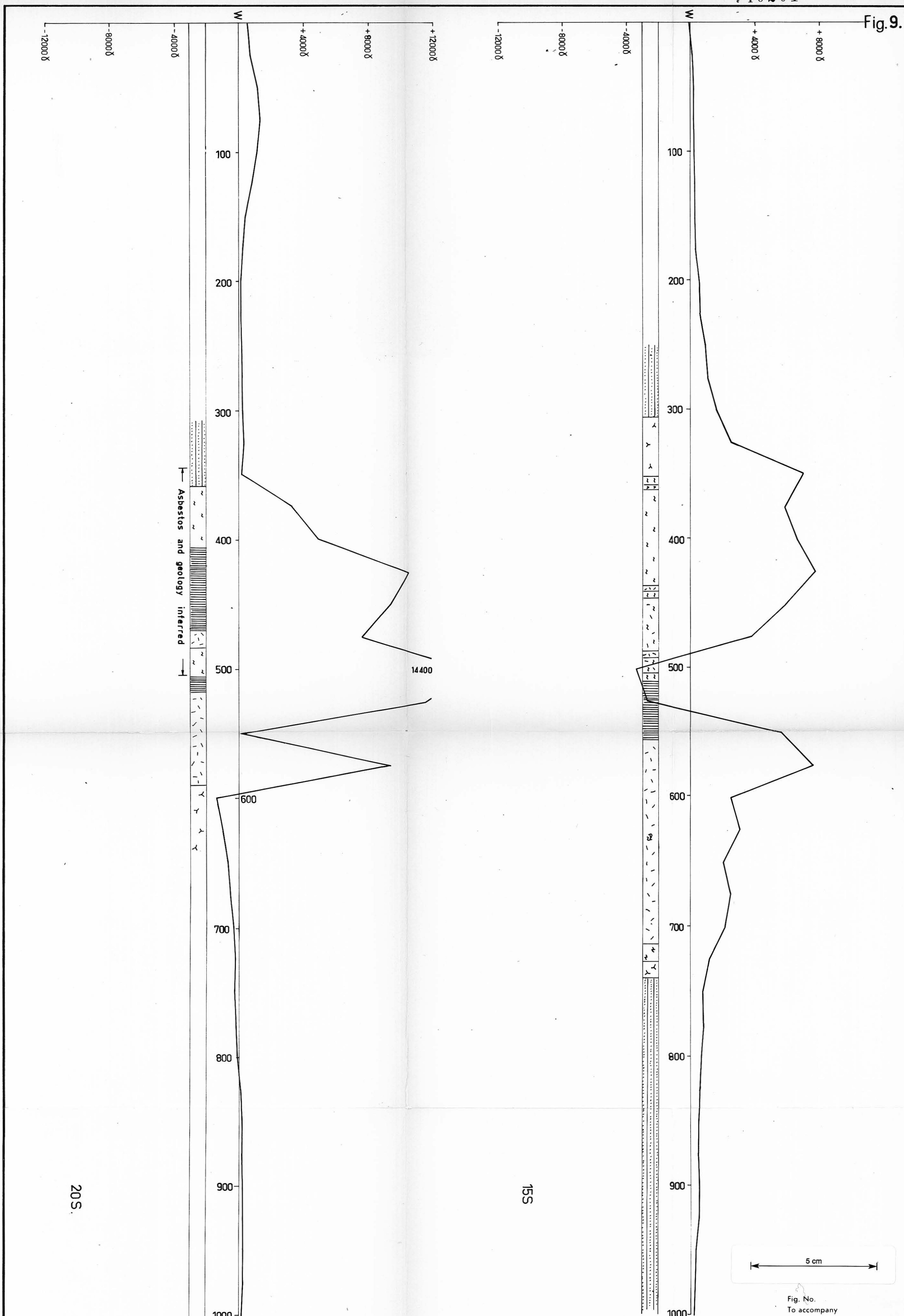

Fig. No.
To accompany
Dated

THE BROKEN HILL PROPRIETARY CO. LTD.
EXPLORATION DEPARTMENT

E.L. 13/65. SOUTH WEST TASMANIA.
NODDY CREEK.
MAGNETIC PROFILES :- 20S & 15S.

Drawn: P.H. M.L.	Date: Aug 1971.	Centre: HOBART.
Traced: M.L	Project No.:	Drawing No.: A2-1
Checked:		

Revisions:

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Fig.10.

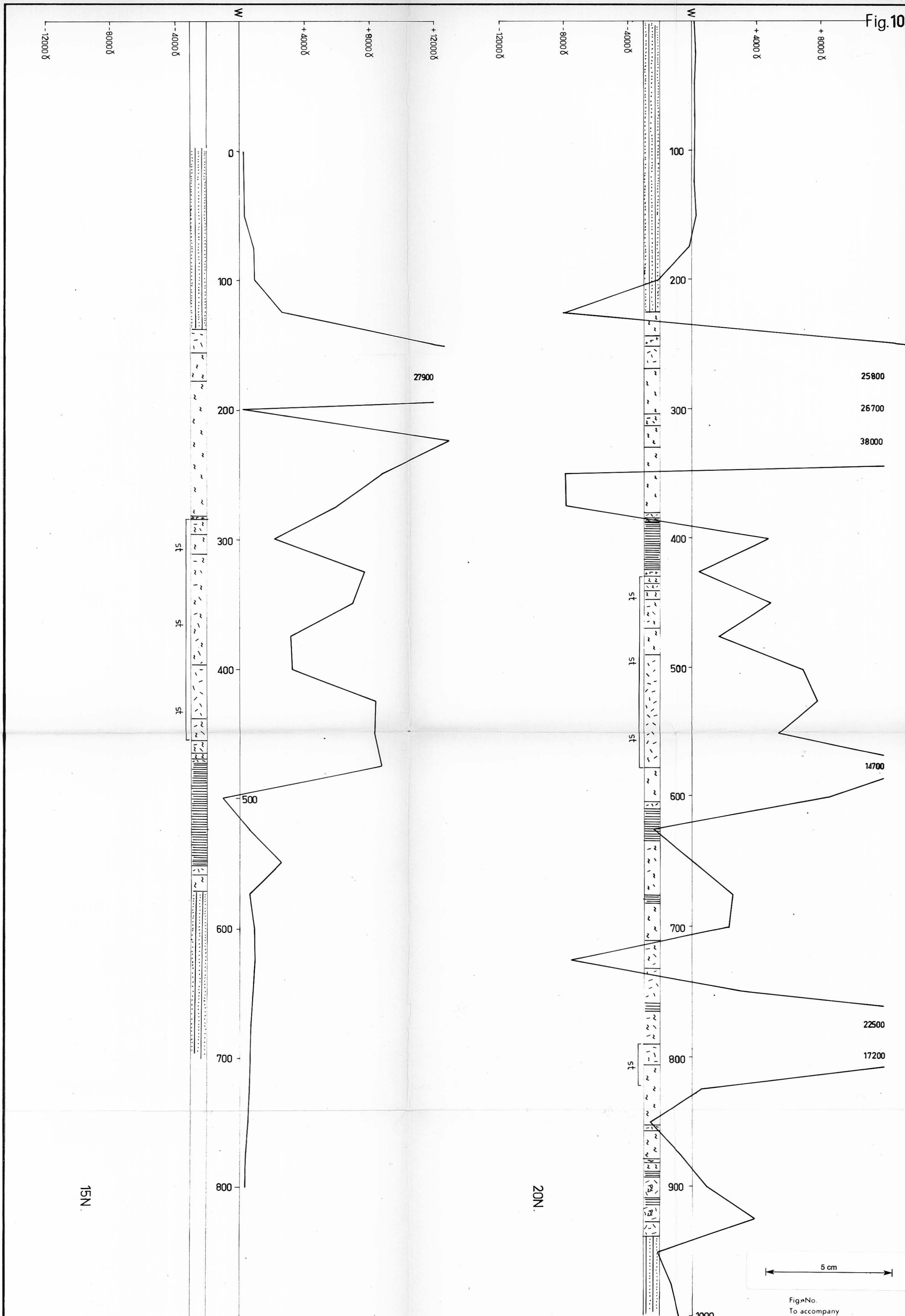


Fig. No.
To accompany
Dated

THE BROKEN HILL PROPRIETARY CO. LTD.
EXPLORATION DEPARTMENT

E.L. 13/65. SOUTH WEST TASMANIA.
NODDY CREEK.
MAGNETIC PROFILES :- 15N & 20N.

Revisions	Drawn: P.H. M.L.	Date: Aug 1971.	Centre: HOBART.
	Traced: M.L	Project No.:	Drawing No.: A2-5
	Checked:		

740203 1226

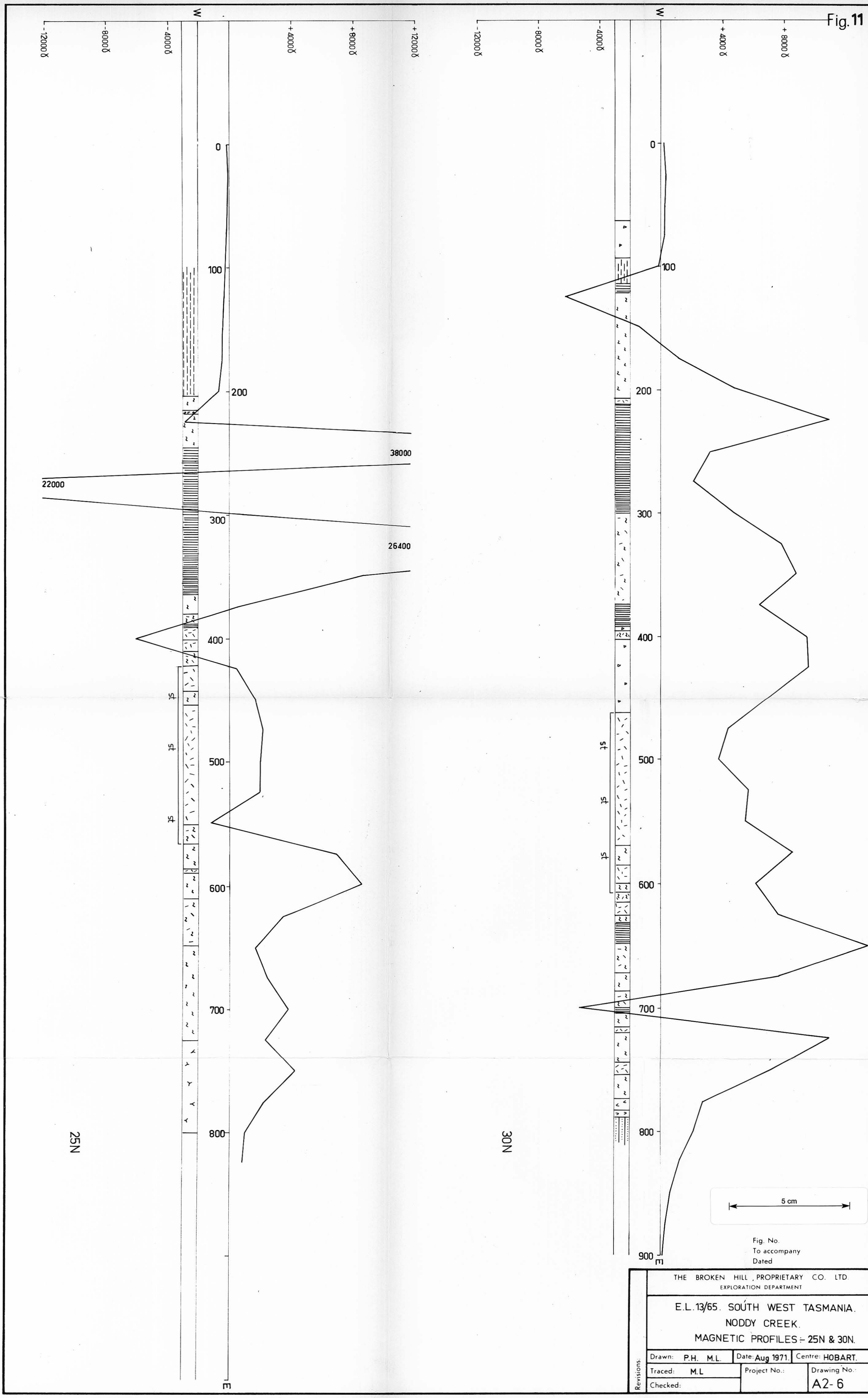


Fig. 11
W
E
-12000δ
-8000δ
-4000δ
+4000δ
+8000δ
+12000δ
0
100
200
300
400
500
600
700
800
900
38000
22000
26400
st
25N
30N
5 cm
Fig. No.
To accompany
Dated
THE BROKEN HILL PROPRIETARY CO. LTD
EXPLORATION DEPARTMENT
E.L. 13/65. SOUTH WEST TASMANIA.
NODDY CREEK.
MAGNETIC PROFILES :- 25N & 30N.
Drawn: P.H. M.L.
Date: Aug 1971.
Centre: HOBART.
Traced: M.L
Project No.:
Drawing No.: A2-6
Checked:
Revisions:

740204 1227

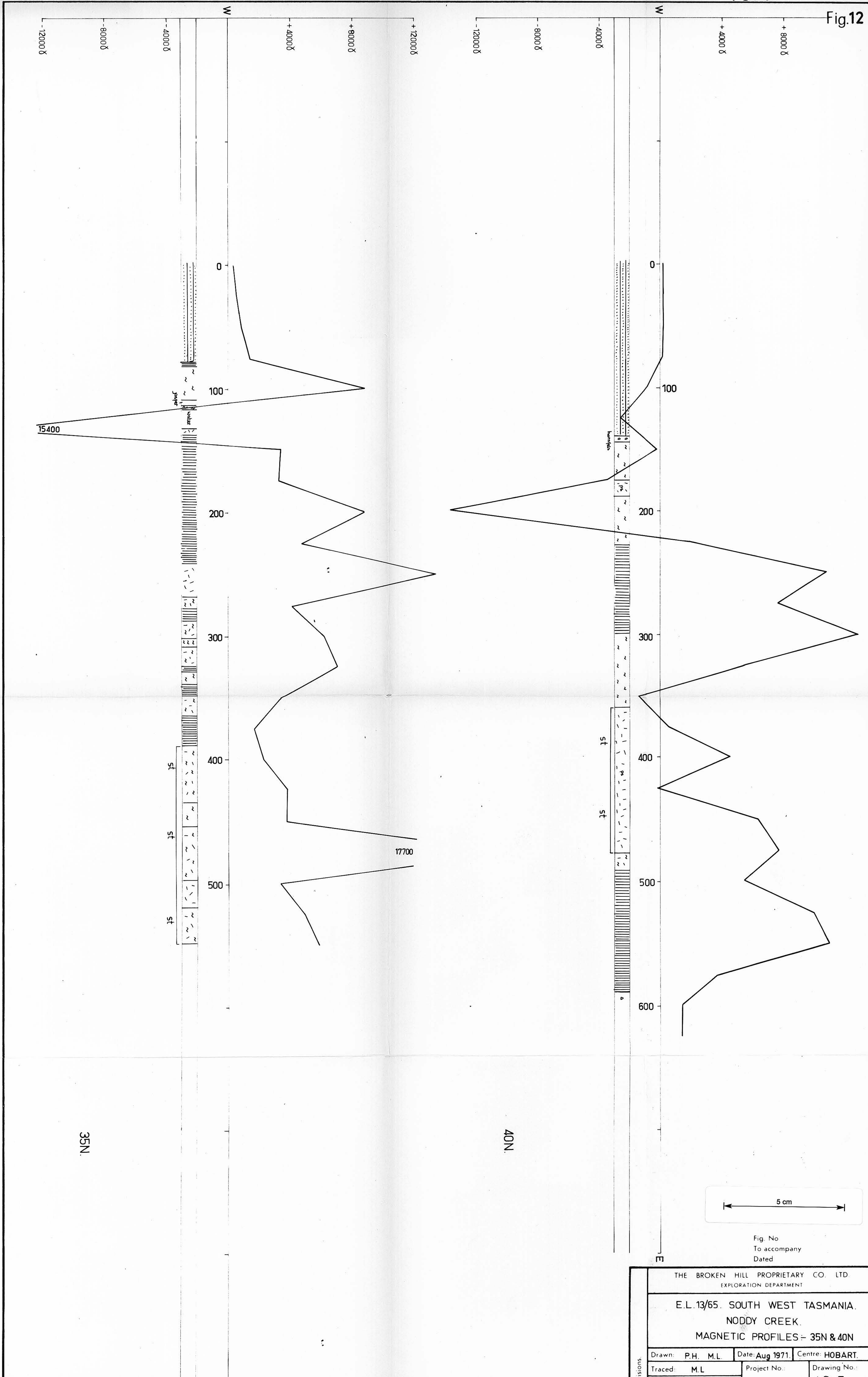


Fig. No
To accompany
Dated

THE BROKEN HILL PROPRIETARY CO. LTD.
EXPLORATION DEPARTMENT

E.L. 13/65. SOUTH WEST TASMANIA.
NODDY CREEK.
MAGNETIC PROFILES :- 35N & 40N

Revisions.	Drawn: P.H. M.L.	Date: Aug 1971.	Centre: HOBART.
	Traced: M.L	Project No.:	Drawing No.: A2-7
	Checked:		

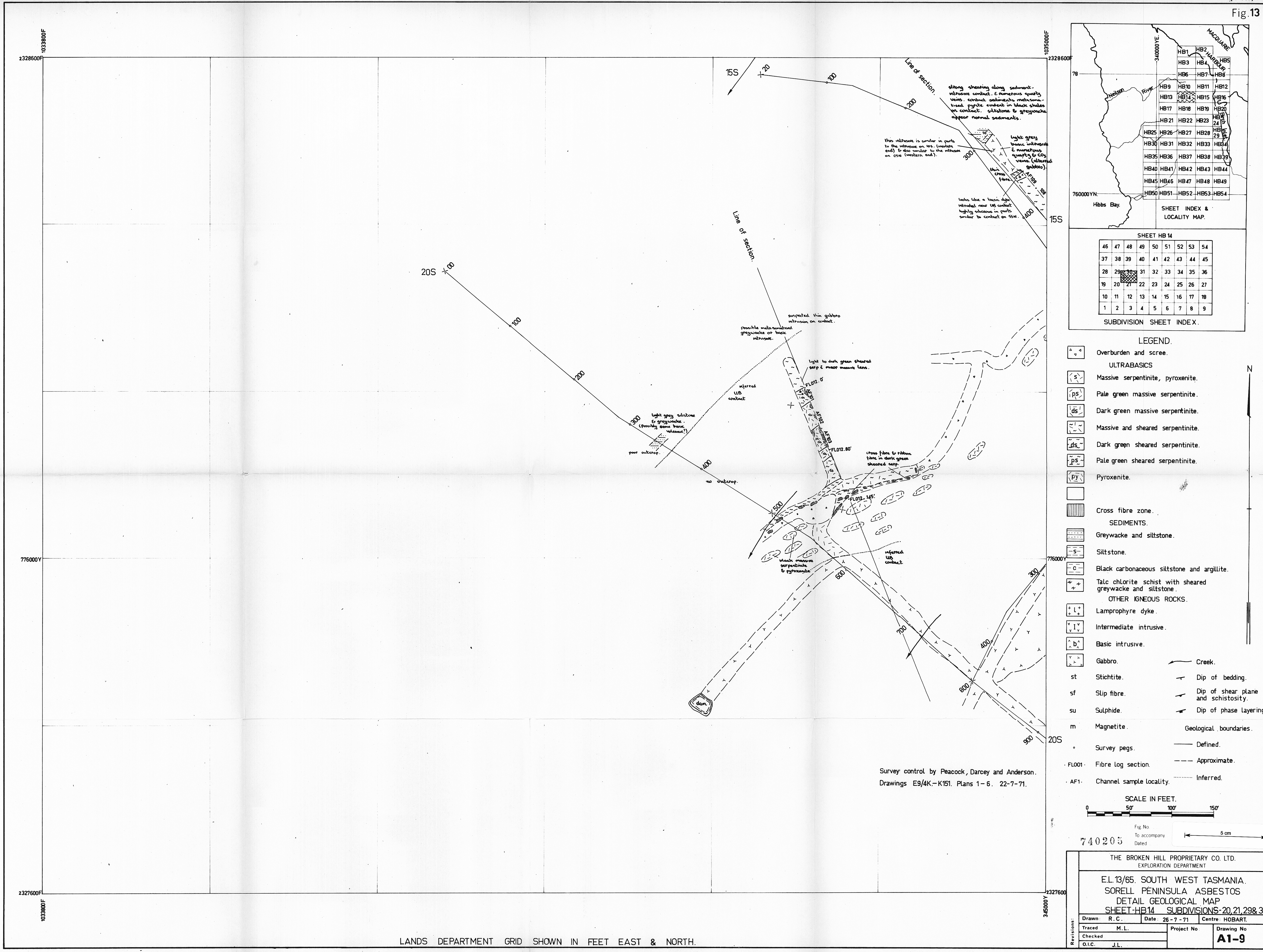
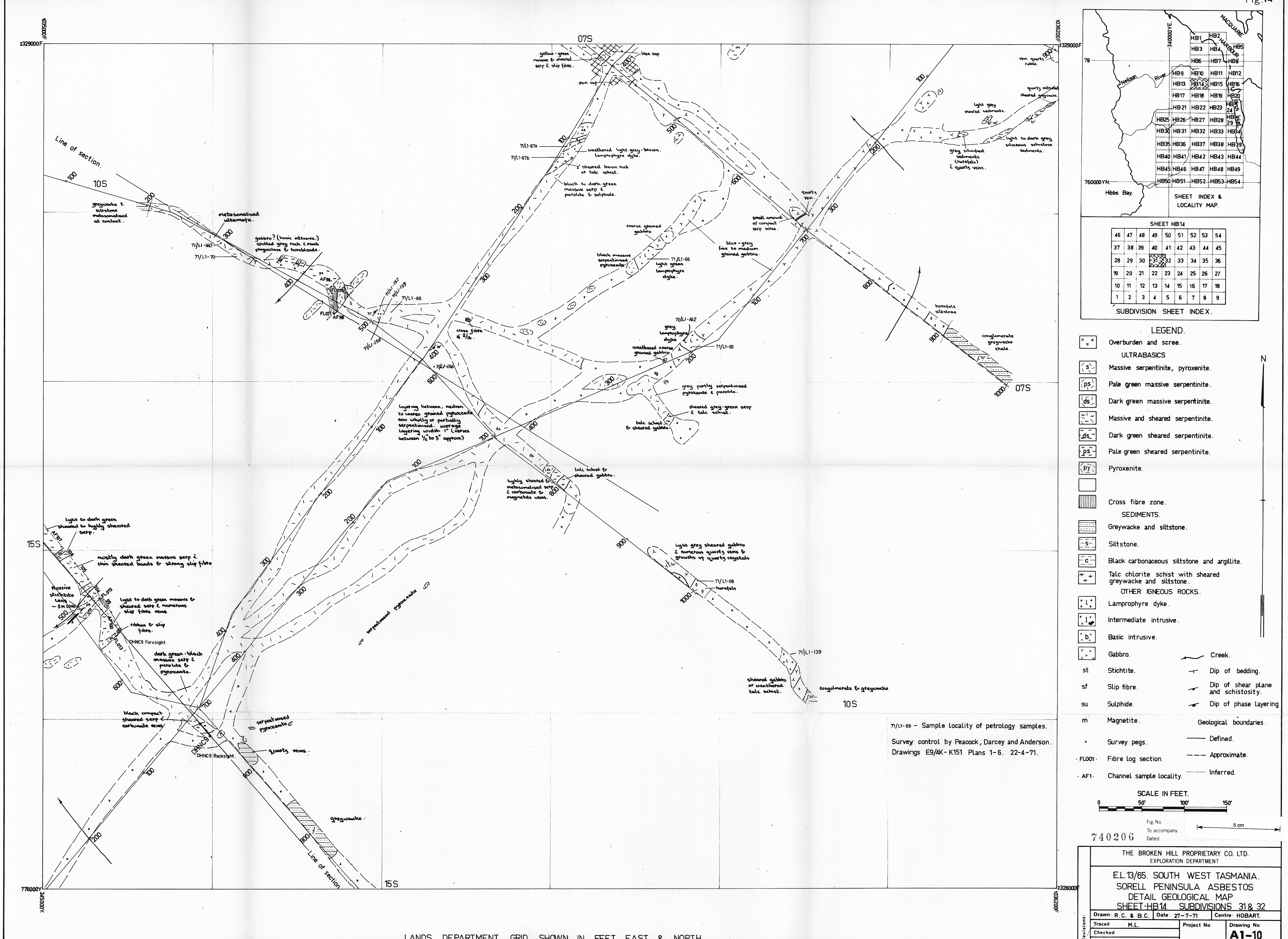
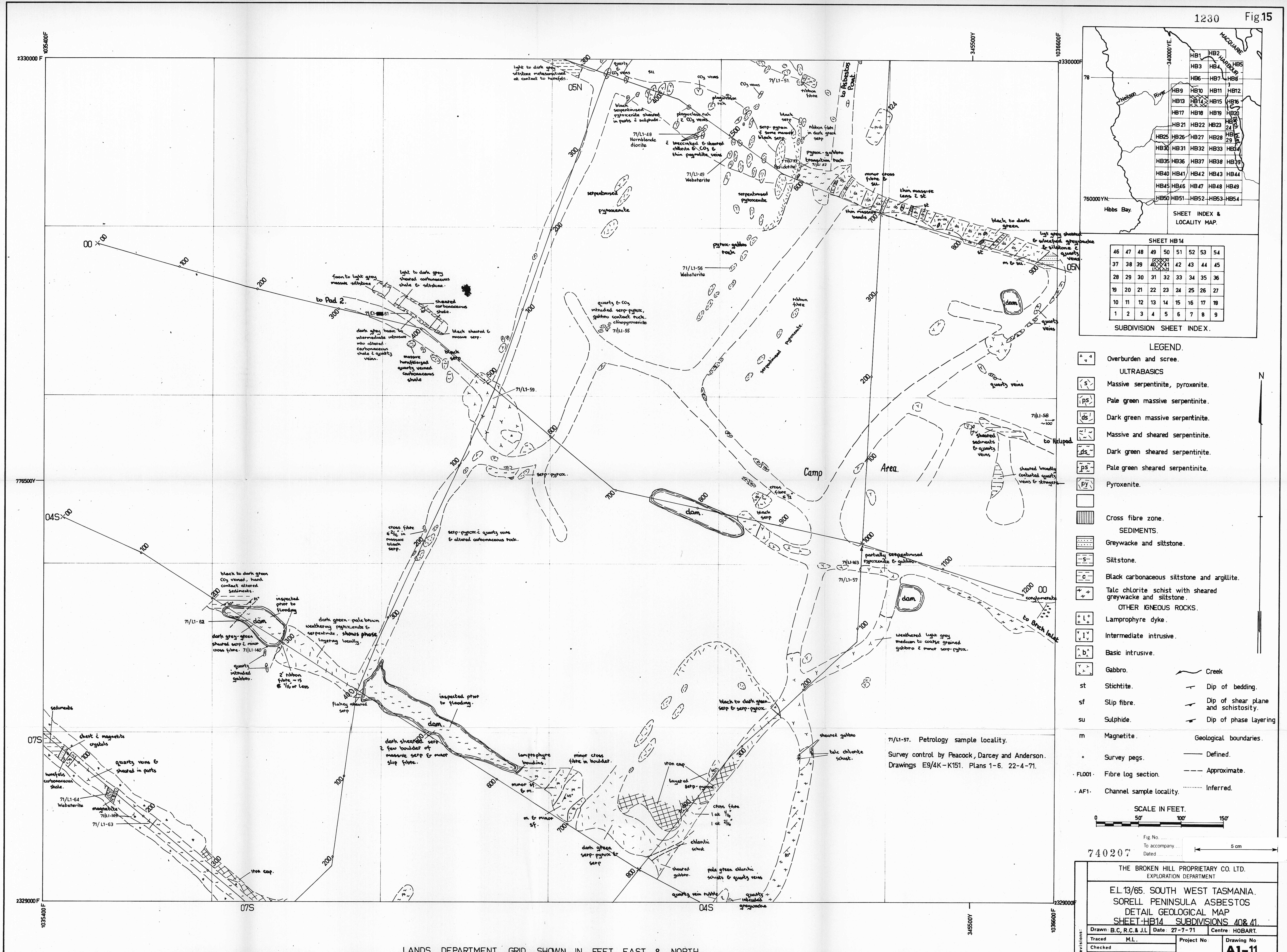


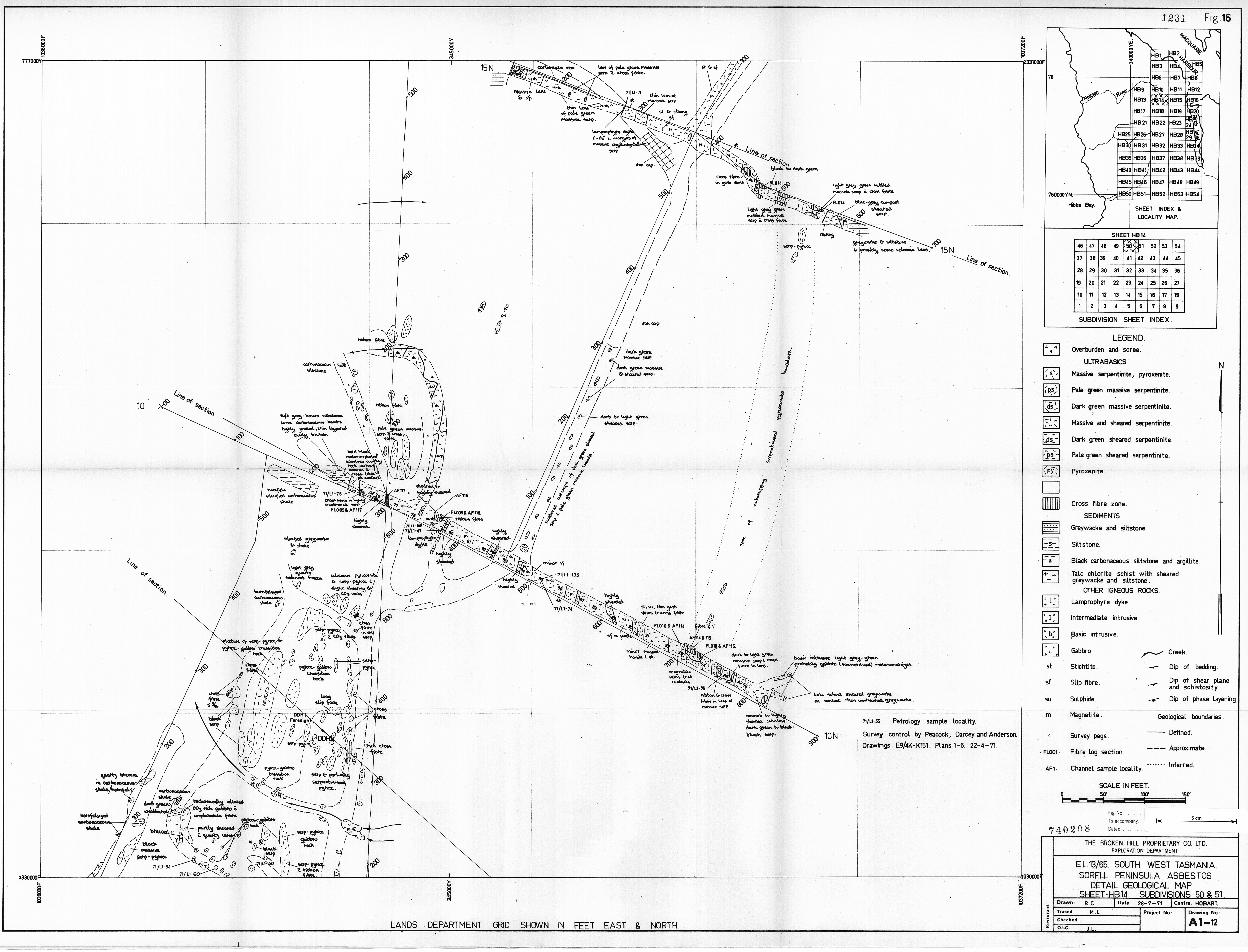
Fig.13
1328
2328600F
1033800F
1035000F
2328600F
776000Y
776000Y
2327600F
1033800F
2327600
345000Y
15S
15S
20S
20S
Line of section.
Line of section.
strong shearing along sediment-ultrabasic contact. ĉ numerous quartz veins. contact sediments metasomatised pyrite evident in black shales on contact. siltstone & greywacke appear normal sediments.
this ultrabasic is similar in parts to the ultrabasic on 10s (western end) & also similar to the ultrabasic on 05N (western end).
light grey basic intrusive ĉ numerous quartz & CO3 veins (altered gabbro).
thin cross fibre
looks like a basic dyke intruded near UB contact highly siliceous in parts similar to contact on 55N.
suspected thin gabbro intrusion on contact.
Possible metasomatised greywacke or basic intrusive.
inferred UB contact
Light to dark green sheared serp ĉ minor massive lens.
FL012. 0'
AF101
AF102
AF103
FL012.80'
cross fibre & ribbon fibre in dark green sheared serp.
FL012. 145'
light grey silstone & greywacke. (Possibly some basic volcanic?)
poor outcrop.
no outcrop.
black massive serpentinite & pyroxenite
inferred UB contact
dam
Survey control by Peacock, Darcey and Anderson.
Drawings E9/4K.-K151. Plans 1-6. 22-7-71.
MACQUARIE HARBOUR
Nelson River
Birch Inlet
340000YE.
760000YN.
Hibbs Bay.
78
HB1 HB2 HB3 HB4 HB5 HB6 HB7 HB8 HB9 HB10 HB11 HB12 HB13 HB14 HB15 HB16 HB17 HB18 HB19 HB20 HB21 HB22 HB23 HB24 HB25 HB26 HB27 HB28 HB29 HB30 HB31 HB32 HB33 HB34 HB35 HB36 HB37 HB38 HB39 HB40 HB41 HB42 HB43 HB44 HB45 HB46 HB47 HB48 HB49 HB50 HB51 HB52 HB53 HB54
SHEET INDEX & LOCALITY MAP.
SHEET HB 14
46 47 48 49 50 51 52 53 54
37 38 39 40 41 42 43 44 45
28 29 30 31 32 33 34 35 36
19 20 21 22 23 24 25 26 27
10 11 12 13 14 15 16 17 18
1 2 3 4 5 6 7 8 9
SUBDIVISION SHEET INDEX.
LEGEND.
Overburden and scree.
ULTRABASICS
s Massive serpentinite, pyroxenite.
ps Pale green massive serpentinite.
ds Dark green massive serpentinite.
Massive and sheared serpentinite.
ds Dark green sheared serpentinite.
ps Pale green sheared serpentinite.
py Pyroxenite.
Cross fibre zone.
SEDIMENTS.
Greywacke and siltstone.
s Siltstone.
c Black carbonaceous siltstone and argillite.
Talc chlorite schist with sheared greywacke and siltstone.
OTHER IGNEOUS ROCKS.
L Lamprophyre dyke.
I Intermediate intrusive.
b Basic intrusive.
Gabbro.
st Stichtite.
sf Slip fibre.
su Sulphide.
m Magnetite.
Survey pegs.
FL001 Fibre log section.
AF1 Channel sample locality.
Creek.
Dip of bedding.
Dip of shear plane and schistosity.
Dip of phase layering
Geological boundaries.
Defined.
Approximate.
Inferred.
N
SCALE IN FEET.
0 50' 100' 150'
740205
Fig No
To accompany
Dated
5 cm
THE BROKEN HILL PROPRIETARY CO. LTD.
EXPLORATION DEPARTMENT
E.L. 13/65. SOUTH WEST TASMANIA.
SORELL PENINSULA ASBESTOS
DETAIL GEOLOGICAL MAP
SHEET-HB14 SUBDIVISIONS-20, 21, 29 & 30
Drawn: R.C. Date: 26-7-71 Centre: HOBART.
Traced M.L.
Checked
O.I.C. J.L.
Project No
Drawing No A1-9
Revisions:
LANDS DEPARTMENT GRID SHOWN IN FEET EAST & NORTH.



07S
10S
15S
Line of section.
SHEET INDEX & LOCALITY MAP.
Hibbs Bay.
Nelson River
MACQUARIE HARBOUR
SHEET HB14
SUBDIVISION SHEET INDEX.
LEGEND.
Overburden and scree.
ULTRABASICS
Massive serpentinite, pyroxenite.
Pale green massive serpentinite.
Dark green massive serpentinite.
Massive and sheared serpentinite.
Dark green sheared serpentinite.
Pale green sheared serpentinite.
Pyroxenite.
Cross fibre zone.
SEDIMENTS.
Greywacke and siltstone.
Siltstone.
Black carbonaceous siltstone and argillite.
Talc chlorite schist with sheared greywacke and siltstone.
OTHER IGNEOUS ROCKS.
Lamprophyre dyke.
Intermediate intrusive.
Basic intrusive.
Gabbro.
st Stichtite.
sf Slip fibre.
su Sulphide.
m Magnetite.
Survey pegs.
FL001 Fibre log section.
AF1 Channel sample locality.
Creek.
Dip of bedding.
Dip of shear plane and schistosity.
Dip of phase layering
Geological boundaries.
Defined.
Approximate.
Inferred.
N
SCALE IN FEET.
0 50' 100' 150'
71/L1-69 – Sample locality of petrology samples.
Survey control by Peacock, Darcey and Anderson.
Drawings E9/4K-K151 Plans 1-6. 22-4-71.
LANDS DEPARTMENT GRID SHOWN IN FEET EAST & NORTH.
Fig. No.
To accompany
Dated
5 cm
740206
THE BROKEN HILL PROPRIETARY CO. LTD.
EXPLORATION DEPARTMENT
E.L. 13/65. SOUTH WEST TASMANIA.
SORELL PENINSULA ASBESTOS
DETAIL GEOLOGICAL MAP
SHEET-HB14 SUBDIVISIONS 31 & 32
Drawn: R.C. & B.C.
Date: 27-7-71
Centre: HOBART.
Traced M.L.
Checked
O.I.C. J.L.
Project No:
Drawing No: A1-10
Revisions:



1230
Fig.15
SHEET INDEX & LOCALITY MAP.
MACQUARIE HARBOUR
Nelson River
Hibbs Bay.
SHEET HB14
SUBDIVISION SHEET INDEX.
LEGEND.
Overburden and scree.
ULTRABASICS
Massive serpentinite, pyroxenite.
Pale green massive serpentinite.
Dark green massive serpentinite.
Massive and sheared serpentinite.
Dark green sheared serpentinite.
Pale green sheared serpentinite.
Pyroxenite.
Cross fibre zone.
SEDIMENTS.
Greywacke and siltstone.
Siltstone.
Black carbonaceous siltstone and argillite.
Talc chlorite schist with sheared greywacke and siltstone.
OTHER IGNEOUS ROCKS.
Lamprophyre dyke.
Intermediate intrusive.
Basic intrusive.
Gabbro.
st Stichtite.
sf Slip fibre.
su Sulphide.
m Magnetite.
Survey pegs.
FL001 Fibre log section.
AF1 Channel sample locality.
Creek
Dip of bedding.
Dip of shear plane and schistosity.
Dip of phase layering
Geological boundaries.
Defined.
Approximate.
Inferred.
SCALE IN FEET.
0 50' 100' 150'
71/L1-57. Petrology sample locality.
Survey control by Peacock, Darcey and Anderson.
Drawings E9/4K-K151. Plans 1-6. 22-4-71.
Camp Area.
dam.
to Pad 2.
to Heliped.
to Birch Inlet.
to Asbestos Point.
740207
THE BROKEN HILL PROPRIETARY CO. LTD.
EXPLORATION DEPARTMENT
E.L.13/65. SOUTH WEST TASMANIA.
SORELL PENINSULA ASBESTOS
DETAIL GEOLOGICAL MAP
SHEET HB14 SUBDIVISIONS 40 & 41.
Drawn B.C, R.C. & J.L. Date 27-7-71 Centre HOBART.
Traced M.L.
Checked
O.I.C. J.L.
Project No
Drawing No A1-11
Revisions:
LANDS DEPARTMENT GRID SHOWN IN FEET EAST & NORTH.



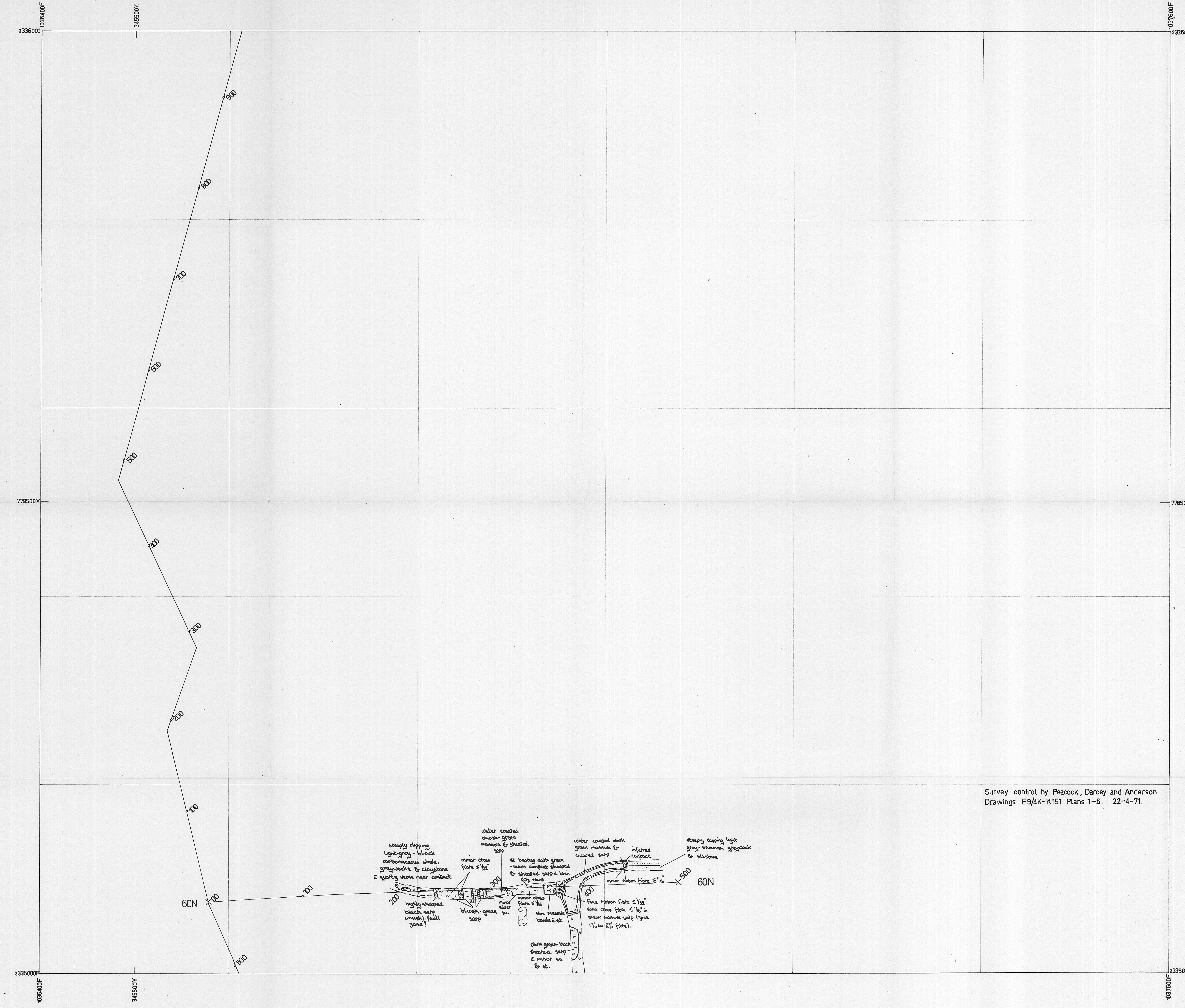
1231 Fig.16
SHEET INDEX & LOCALITY MAP.
MACQUARIE HARBOUR
Nelson River
Hibbs Bay.
SHEET HB14
SUBDIVISION SHEET INDEX.
LEGEND.
Overburden and scree.
ULTRABASICS
Massive serpentinite, pyroxenite.
Pale green massive serpentinite.
Dark green massive serpentinite.
Massive and sheared serpentinite.
Dark green sheared serpentinite.
Pale green sheared serpentinite.
Pyroxenite.
Cross fibre zone.
SEDIMENTS.
Greywacke and siltstone.
Siltstone.
Black carbonaceous siltstone and argillite.
Talc chlorite schist with sheared greywacke and siltstone.
OTHER IGNEOUS ROCKS.
Lamprophyre dyke.
Intermediate intrusive.
Basic intrusive.
Gabbro.
st Stichtite.
sf Slip fibre.
su Sulphide.
m Magnetite.
Survey pegs.
FL001 Fibre log section.
AF1 Channel sample locality.
Creek.
Dip of bedding.
Dip of shear plane and schistosity.
Dip of phase layering
Geological boundaries.
Defined.
Approximate.
Inferred.
SCALE IN FEET.
0 50' 100' 150'
71/L1-55 Petrology sample locality.
Survey control by Peacock, Darcey and Anderson.
Drawings E9/4K-K151. Plans 1-6. 22-4-71.
Line of section.
15N
10N
740208
THE BROKEN HILL PROPRIETARY CO. LTD.
EXPLORATION DEPARTMENT
E.L. 13/65. SOUTH WEST TASMANIA.
SORELL PENINSULA ASBESTOS
DETAIL GEOLOGICAL MAP
SHEET-HB14 SUBDIVISIONS 50 & 51.
Drawn: R.C. Date: 28-7-71 Centre: HOBART.
Traced M.L
Checked
O.I.C. J.L.
Project No
Drawing No A1-12
LANDS DEPARTMENT GRID SHOWN IN FEET EAST & NORTH.


1232
Fig. 17
SHEET INDEX & LOCALITY MAP.
MACQUARIE HARBOUR
Nelson River
Hibbs Bay.
760000YN.
340000YE.
HB1 HB2 HB3 HB4 HB5 HB6 HB7 HB8 HB9 HB10 HB11 HB12 HB13 HB14 HB15 HB16 HB17 HB18 HB19 HB20 HB21 HB22 HB23 HB24 HB25 HB26 HB27 HB28 HB29 HB30 HB31 HB32 HB33 HB34 HB35 HB36 HB37 HB38 HB39 HB40 HB41 HB42 HB43 HB44 HB45 HB46 HB47 HB48 HB49 HB50 HB51 HB52 HB53 HB54
SHEET HB 10
46 47 48 49 50 51 52 53 54
37 38 39 40 41 42 43 44 45
28 29 30 31 32 33 34 35 36
19 20 21 22 23 24 25 26 27
10 11 12 13 14 15 16 17 18
1 2 3 4 5 6 7 8 9
SUBDIVISION SHEET INDEX.
LEGEND.
Overburden and scree.
ULTRABASICS
Massive serpentinite, pyroxenite.
Pale green massive serpentinite.
Dark green massive serpentinite.
Massive and sheared serpentinite.
Dark green sheared serpentinite.
Pale green sheared serpentinite.
Pyroxenite.
Cross fibre zone.
SEDIMENTS.
Greywacke and siltstone.
Siltstone.
Black carbonaceous siltstone and argillite.
Talc chlorite schist with sheared greywacke and siltstone.
OTHER IGNEOUS ROCKS.
Lamprophyre dyke.
Intermediate intrusive.
Basic intrusive.
Gabbro.
st Stichtite.
sf Slip fibre.
su Sulphide.
m Magnetite.
Survey pegs.
FL001 Fibre log section.
AF1 Channel sample locality.
Creek.
Dip of bedding.
Dip of shear plane and schistosity.
Dip of phase layering
Geological boundaries.
Defined.
Approximate.
Inferred.
SCALE IN FEET.
0 50' 100' 150'
N
71/L1-42. Petrology sample locality.
Survey control by Peacock, Darcey and Anderson.
Drawings E9/4K-K151. Plans 1-6. 22-4-71.
740209
Fig. No.
To accompany
Dated
5 cm
THE BROKEN HILL PROPRIETARY CO. LTD.
EXPLORATION DEPARTMENT
E.L. 13/65. SOUTH WEST TASMANIA.
SORELL PENINSULA ASBESTOS
DETAIL GEOLOGICAL MAP
SHEET-HB10 SUBDIVISIONS 5&6.
Drawn: R.C.
Date 30-7-71
Centre: HOBART.
Traced M.L.
Checked
O.I.C. J.L.
Project No
Drawing No
A1-14
Revisions:
LANDS DEPARTMENT GRID SHOWN IN FEET EAST & NORTH.
2332000F
777000Y
1036400F
345500Y
1037600F
2331000
25N
20N
Line of section
Line of section.
DHNC7 Foresight.
dam.
dam
grey siltstones metasomatised near contact & cross fibre
dyke rock 2" thick
suspected contact
dark green compact sheared serp & carbonaceous veins near contact
dark green massive serpentinite & serpentinised pyroxenite & minor cross fibre & abundant magnetite.
dark green & green massive serp & cross fibre & pentlandite blebs, magnetite throughout.
lamprophyre dyke
localised cross fibre in hard dark serp
minor +ve DMG disseminated sulphide.
dyke contact vertical.
ribbon fibre
light green sheared serp & thin massive bands
light to dark green massive & sheared serp & cross fibre in massive lens.
cross fibre
ribbon fibre
lamprophyre dyke
dyke cuts out & serpentinised basic core asbestos fibre has been cooked massive cryptocrystalline serp in walls of dyke.
boulders of dark green black serp-pyrox & cross fibre
zone of chocolate coloured serp-pyrox boulders
serp-pyrox boulder zone
diffused magnetite blebs
cross fibre
highly sheared serp & fibrous magnetite
cross fibre 2/16
pale green massive serp & serp-pyrox boulders & cross & ribbon fibre.
light to dark green massive serp & cross & slip fibre
massive boulders of dark green serp & light green massive cross fibre bearing serp
ribbon fibre.
massive boulders set in sheared serp envelopes
large blobs of stichtite.
iron cap.
ribbon fibre shells.
pinkish-light grey talc schists & silicified sheared volcanics
brown sheared sediments & quartz veins probably greywacke & siltstone.
red-brown altered sheared serp
volcanics?
brown-black soil horizon on contact
weathered carbonaceous siltstone shear zone & talc schist margins.
light brown sheared volcanic sediments
grey-brown intermediate volcanics & few quartz veins.
brown highly contorted serp (possible fault zone.)
sheared greywacke
intruded quartz volcanic.
sheared light brown volcanics
leucocratic medium to fine grained volcanics
light grey medium grained intermediate volcanics
grey-brown sheared volcanics
grey silicified greywacke quartz veins
weathered greywacke & siltstone.
fine cross fibre
gradational boundary
thin breccia zone
slightly sheared greywacke shale
shear
black serp-talc contact
finely laminated talc schist.
Greywacke & siltstone
Hornfels/Gabbro?

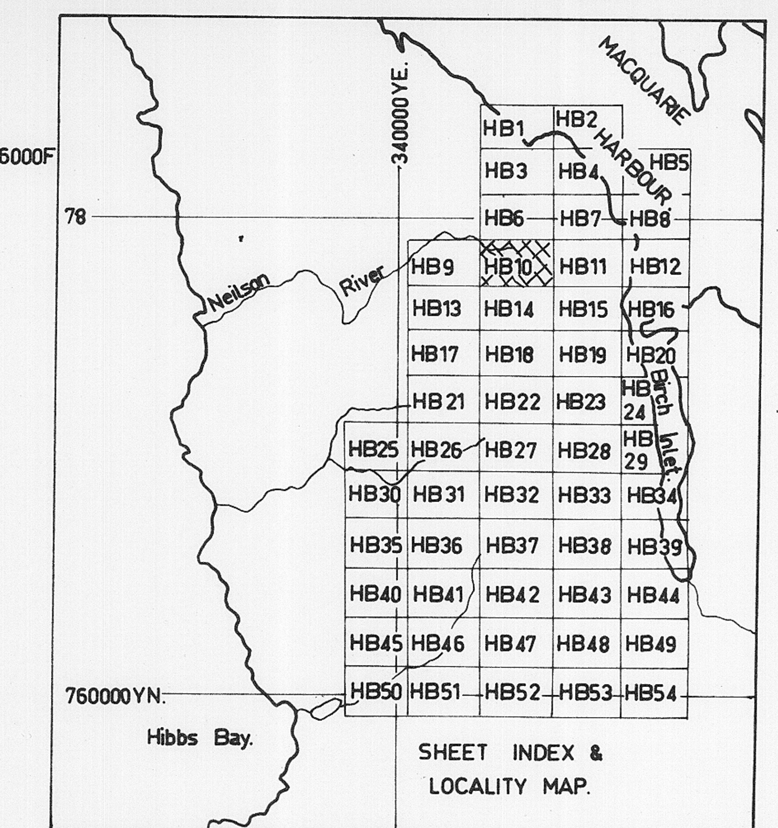

1233 Fig.18
SHEET INDEX & LOCALITY MAP.
MACQUARIE HARBOUR
Nelson River
Hibbs Bay.
340000YE.
760000YN.
SHEET HB10
SUBDIVISION SHEET INDEX.
LEGEND.
Overburden and scree.
ULTRABASICS
Massive serpentinite, pyroxenite.
Pale green massive serpentinite.
Dark green massive serpentinite.
Massive and sheared serpentinite.
Dark green sheared serpentinite.
Pale green sheared serpentinite.
Pyroxenite.
Cross fibre zone.
SEDIMENTS.
Greywacke and siltstone.
Siltstone.
Black carbonaceous siltstone and argillite.
Talc chlorite schist with sheared greywacke and siltstone.
OTHER IGNEOUS ROCKS.
Lamprophyre dyke.
Intermediate intrusive.
Basic intrusive.
Gabbro.
st Stichtite.
sf Slip fibre.
su Sulphide.
m Magnetite.
Survey pegs.
FL001 Fibre log section.
AF1 Channel sample locality.
Creek.
Dip of bedding.
Dip of shear plane and schistosity.
Dip of phase layering
Geological boundaries.
Defined.
Approximate.
Inferred.
SCALE IN FEET.
0 50' 100' 150'
71/L1-40 Petrology sample locality.
Survey control by Peacock, Darcey and Anderson.
Drawings E9/4K-K151. Plans 1-6. 22-4-71.
35N
30N
Line of section.
TRIG.
740210
5 cm
THE BROKEN HILL PROPRIETARY CO. LTD.
EXPLORATION DEPARTMENT
E.L. 13/65. SOUTH WEST TASMANIA.
SORELL PENINSULA ASBESTOS
DETAIL GEOLOGICAL MAP
SHEET-HB10 SUBDIVISIONS 14 & 15
Drawn R.C. B.C Date 2-8-71 Centre HOBART.
Traced M.L
Checked
O.I.C. J.L.
Project No
Drawing No A1-15
Revisions:
LANDS DEPARTMENT GRID SHOWN IN FEET EAST & NORTH.

1234 Fig.19
SHEET INDEX & LOCALITY MAP.
MACQUARIE HARBOUR
Nelson River
Hibbs Bay.
340000YE.
760000YN.
SHEET HB10
SUBDIVISION SHEET INDEX.
LEGEND.
Overburden and scree.
ULTRABASICS
Massive serpentinite, pyroxenite.
Pale green massive serpentinite.
Dark green massive serpentinite.
Massive and sheared serpentinite.
Dark green sheared serpentinite.
Pale green sheared serpentinite.
Pyroxenite.
Cross fibre zone.
SEDIMENTS.
Greywacke and siltstone.
Siltstone.
Black carbonaceous siltstone and argillite.
Talc chlorite schist with sheared greywacke and siltstone.
OTHER IGNEOUS ROCKS.
Lamprophyre dyke.
Intermediate intrusive.
Basic intrusive.
Gabbro.
st Stichtite.
sf Slip fibre.
su Sulphide.
m Magnetite.
Survey pegs.
FL001 Fibre log section.
AF1 Channel sample locality.
Creek
Dip of bedding.
Dip of shear plane and schistosity.
Dip of phase layering
Geological boundaries.
Defined.
Approximate.
Inferred.
SCALE IN FEET.
0 50' 100' 150'
Survey control by Peacock, Darcey and Anderson.
Drawings E9/4K-K151 Plans 1-6. 22-4-71.
740211
Fig. No
To accompany
Dated
5 cm
THE BROKEN HILL PROPRIETARY CO. LTD.
EXPLORATION DEPARTMENT
E.L.13/65. SOUTH WEST TASMANIA.
SORELL PENINSULA ASBESTOS
DETAIL GEOLOGICAL MAP
SHEET-HB SUBDIVISIONS 23 & 24
Drawn B.C. R.C.
Date 3-8-71
Centre - HOBART.
Traced M.L.
Checked
O.I.C. J.L.
Project No
Drawing No A1-16
Revisions:
LANDS DEPARTMENT GRID SHOWN IN FEET EAST & NORTH.
2334000F
2333000F
777700Y
1036400F
1037600F
345500Y
51N
50N
45N
40N
Line of section
Line of section.
boulders of dark green massive serp in & along track.
boulders of massive serp
metasomatised sheared serp
inferred UB contact
intimate mixture of dyke rock & compact black sheared serp
3" cross fibre
cross fibre
boulders of ribbon fibre.
pale green massive serp, rf & abundant cross fibre
massive black serp - pyrox c cross fibre.
black compact sheared & massive serp c pockets of fibre 2' av 1.75%.
CO3 veins
rf. in massive lens.
sheared to highly sheared & schistose c sf, minor massive serp c st & gash vein cross fibre
siltstone & greywacke dipping ~60° & carbonaceous seds & black serp on contact.
sheared to highly sheared c st in minor massive bands
ribbon & cross fibre in massive bands
cross fibre in thin lens
lamprophyre dyke?, basic intrusive. 71/L1-167
highly sheared c CO3 veins
siltstones & carbonaceous shale.
black weathered massive serp.
dark grey thinly bedded siltstones
2' weathered white clay vein on contact & asbestos in black serp.
boulders of pale green compact sheared serp
pale green sheared & dark green massive serp
boulders indicate massive & sheared serp c st spots
ps c st
2'-5' boulders of dark green massive serp.
iron cap.
sheared & highly sheared serp c thin lens of massive serp c st
pale green massive lens & cross fibre
cross fibre vein
sheared & compact sheared serp
ribbon & cross fibre
compact sheared serp
dark green massive & pale green sheared serp
dark green massive & black compact sheared serp
calcite not. Shear
dark compact sheared serp
inferred UB contact.
clay
grey siltstone metasomatised at contact poor exposure.
dam
contorted pyrite carb. shale, sheared serp c cross fibre
some m & sf veinlets
scrub
m. veinlets
fibre specimen from dump (gash vein).
DHNC4
DHNC3
FL005 FL006 FL007 FL015 FL019 FL020 FL021
AF58 AF75

1235 Fig.20
2335000F
1036400F
345500Y
1037400F
778000Y
1037600F
2335000
LANDS DEPARTMENT GRID SHOWN IN FEET EAST & NORTH.
55N
minor massive bands, sf & st
FL022
minor pf lens
black serp lens
pf in pale green massive serp 2½ at 8%
pf shell 10' at 4%
hornfels
chert? siliceous contact rock
71/L1-105a&b
71/L1-104
grey-green highly sheared serp
no definite contact
partly metasomatised dark green-black compact sheared serp c CO3 veins & picrolite.
Line of section.
cross fibre vein ¼"
71/L1-126
some "cooked" cross fibre.
6" CO3 vein 71/L1-127
sheared serp c massive lens & boulders c ribbon & cross fibre
ps c cross fibre
cross fibre
grey siltstone & slate.
TRIG
71/L1-104. Petrology sample locality.
Survey control by Peacock, Darcey and Anderson.
Drawings E9/4K-K151. Plans. 1-6. 22-4-71.
MACQUARIE HARBOUR
Neilson River
Hibbs Bay.
340000YE.
760000YN.
78
SHEET INDEX & LOCALITY MAP.
SHEET HB10
SUBDIVISION SHEET INDEX.
LEGEND.
Overburden and scree.
ULTRABASICS
Massive serpentinite, pyroxenite.
Pale green massive serpentinite.
Dark green massive serpentinite.
Massive and sheared serpentinite.
Dark green sheared serpentinite.
Pale green sheared serpentinite.
Pyroxenite.
Cross fibre zone.
SEDIMENTS.
Greywacke and siltstone.
Siltstone.
Black carbonaceous siltstone and argillite.
Talc chlorite schist with sheared greywacke and siltstone.
OTHER IGNEOUS ROCKS.
Lamprophyre dyke.
Intermediate intrusive.
Basic intrusive.
Gabbro.
st Stichtite.
sf Slip fibre.
su Sulphide.
m Magnetite.
Survey pegs.
FL001 Fibre log section.
AF1 Channel sample locality.
Dip of bedding.
Dip of shear plane and schistosity.
Dip of phase layering
Geological boundaries.
Defined.
Approximate.
Inferred.
SCALE IN FEET.
0 50' 100' 150'
N
740212
THE BROKEN HILL PROPRIETARY CO. LTD.
EXPLORATION DEPARTMENT
E.L. 13/65. SOUTH WEST TASMANIA.
SORELL PENINSULA ASBESTOS
DETAIL GEOLOGICAL MAP
SHEET-HB10 SUBDIVISIONS 31 & 32
Drawn R.C. Date 4-8-71 Centre HOBART.
Traced M.L.
Checked
O.I.C. J.L.
Project No
Drawing No A1-17
Revisions:



LANDS DEPARTMENT GRID SHOWN IN FEET EAST & NORTH.



SHEET HB10

46	47	48	49	50	51	52	53	54
37	38	39	40	41	42	43	44	45
28	29	30	31	32	33	34	35	36
19	20	21	22	23	24	25	26	27
10	11	12	13	14	15	16	17	18
1	2	3	4	5	6	7	8	9

SUBDIVISION SHEET INDEX.

LEGEND.

- Overburden and scree.

ULTRABASICS

- s — Massive serpentinite, pyroxenite.
- ps — Pale green massive serpentinite.
- ds — Dark green massive serpentinite.
- Massive and sheared serpentinite.
- ds — Dark green sheared serpentinite.
- ps — Pale green sheared serpentinite.
- py — Pyroxenite.
- Cross fibre zone.

SEDIMENTS.

- Greywacke and siltstone.
- s — Siltstone.
- c — Black carbonaceous siltstone and argillite.
- Talc chlorite schist with sheared greywacke and siltstone.

OTHER IGNEOUS ROCKS.

- L — Lamprophyre dyke.
- I — Intermediate intrusive.
- b — Basic intrusive.
- Gabbro.
- st — Stichtite.
- sf — Slip fibre.
- su — Sulphide.
- m — Magnetite.
- Survey pegs.
- FL001 — Fibre log section.
- AF1 — Channel sample locality.

- Dip of bedding.
- Dip of shear plane and schistosity.
- Dip of phase layering

Geological boundaries.

- Defined.
- Approximate.
- Inferred.

N

SCALE IN FEET.

0 50' 100' 150'

740213

Fig. No. ......
To accompany......
Dated......

5 cm

THE BROKEN HILL PROPRIETARY CO. LTD.
EXPLORATION DEPARTMENT

E.L.13/65. SOUTH WEST TASMANIA. SORELL PENINSULA ASBESTOS DETAIL GEOLOGICAL MAP SHEET-HB10 SUBDIVISIONS 41-42

Drawn: R.C.	Date: 9-8-71	Centre: HOBART.	
Traced M.L.	Project No	Drawing No	
Checked		A1-18	
O.I.C. J.L.			

Revisions: