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No. 48

MAGNETITE DEPOSITS OF THE SAVAGE RIVER-ROCKY RIVER REGION

by

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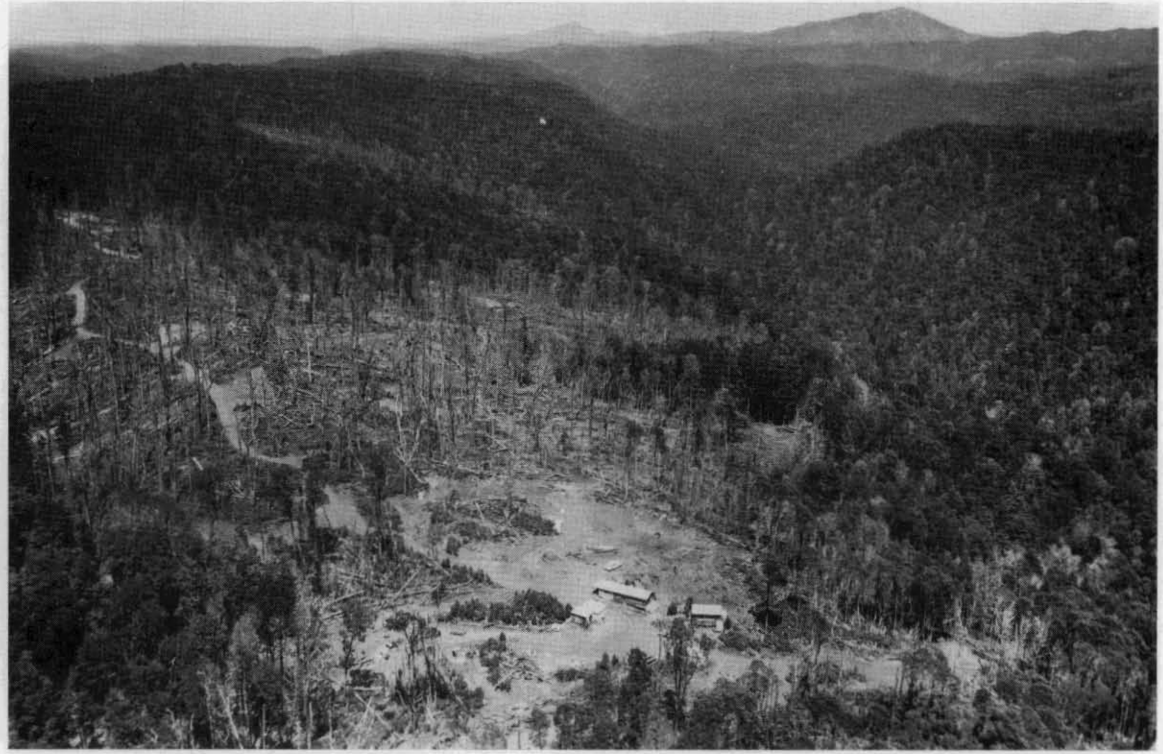
PREFACE

The ironstone outcrop at Savage River was known to the early prospectors of 90 years ago when they were prospecting for gold nearby. Later miners who recovered osmiridium from the Savage River also knew of the iron deposit but difficult access and high freight limited interest in the area to the easily recovered and easily marketed heavy minerals. The ironstone body was investigated in 1919 and again in 1939 but it had to wait until geological exploration and ore dressing methods improved to their present standard before the magnitude and potential value of the ore-body could be understood.

The author reported on the study of this region and successfully submitted it as a thesis for the degree of M.Sc. This Bulletin has been adapted for publication from his thesis. The large amount of information made available in the district shows how much larger a contribution to knowledge may be expected when the whole West Coast Region of Tasmania can be studied as a complete unit.

J. G. SYMONS, Director of Mines.



The central Savage River area, looking SW. Photo—" The Mercury ", Hobart.

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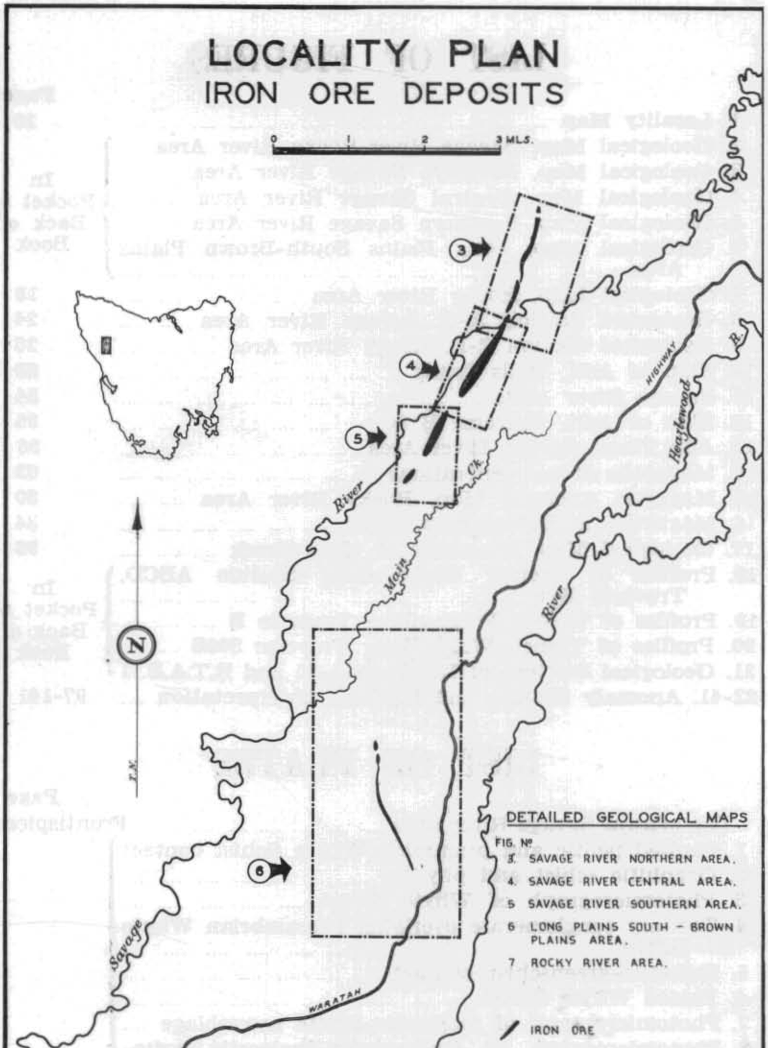
LOCALITY PLAN
IRON ORE DEPOSITS
0 1 2 3 MLS.
3
4
5
6
7
N
T.N.
Savage
River
Main Ck.
River
Heazlewood R.
HIGHWAY
WARATAH
Whyle
Rocky River
PIEMAN R.
TO CORINNA
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FIG. Nº
3. SAVAGE RIVER NORTHERN AREA.
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5 SAVAGE RIVER SOUTHERN AREA.
6 LONG PLAINS SOUTH - BROWN PLAINS AREA.
7 ROCKY RIVER AREA.
IRON ORE

FIGURE 1.

5 cm

MAGNETITE DEPOSITS OF THE SAVAGE RIVER - ROCKY RIVER REGION

Abstract

Magnetite deposits which extend discontinuously from the Savage River to the Rocky River in NW Tasmania were mapped on a regional and detailed scale. Magnetite is associated with amphibolite or disseminated in meta-sediment. The total ore reserves have been initially estimated at approximately 50 million tons of low to medium grade ore per 100 feet depth. The ore can be beneficiated to yield a high grade magnetite concentrate. Silica, feldspar and/or carbonate metasomatism is generally associated with the magnetite deposits.

Folded, steeply dipping Precambrian Whyte Schist underlies most of the area, separated by an inferred major fault from less metamorphosed and deformed Precambrian Corinna Slate to the SW. Bodies and concordant linear sheets of amphibolite in Whyte Schist may be genetically related to a Cambrian serpentinized basic and ultrabasic complex. A Devonian granitic stock and flat-lying Tertiary sediments and basalt are present in the area.

Widely separated exposures of magnesite rock in meta-sediments may represent a deposit of substantial reserves.

Structural control of magnetite deposition, texture and structure of the ore, wall rock alteration, gangue minerals and paragenesis indicate a magmatic hydrothermal origin for the magnetite.

Introduction

The regional and detailed geological survey of the Savage River-Rocky River region in 1963 and 1964 was undertaken as a result of renewed interest in the magnetite deposits of Tasmania after the lifting of the embargo on the export of iron ore from Australia by the Commonwealth Government in December, 1960.

The ban on the export of iron ore was relaxed in order to stimulate interest in the search for new deposits and to encourage more detailed investigation of known deposits in Australia.

LOCATION, ACCESS AND SIZE OF AREA

The magnetite deposits occur in the isolated NW part of Tasmania (fig. 1). Mineralization is present in three separate areas within a distance of 13½ miles, extending from the Savage River to a point south of the Rocky River. The Savage River deposit straddles the Savage River roughly midway between Waratah and Corinna about 2½ miles west of the Corinna road. The other magnetite deposits along this belt occur in the Long Plains South-Brown Plains area and in the Rocky River area. The intervening terrain between the Savage River deposit, Long Plains South-Brown Plains deposit and Rocky River deposit is barren or sparsely mineralized.

The only route of approach to the deposits is from the Waratah-Corinna road. Access to the Savage River central deposit is by a rough gravel road 4 miles long which leaves the Corinna road at a point 21 miles from Waratah (fig. 2). The gravel road continues as a four-wheel drive track into the northern area as far as traverse G00 on the baseline. Access to the southern area of the Savage River deposits is along a bulldozed track which connects with the Long Plains South deposit. This track is negotiable only by four-wheel drive vehicles at the driest time of the year.

Ingress to the Long Plains South-Brown Plains deposit is achieved by three rough access roads which have been bulldozed from different points along the Waratah-Corinna road (fig. 2). The road branching off the Corinna road at a point 31 miles from Waratah serves the Long Plains South deposit and ultimately reaches the central Savage River area.

A four-wheel drive track to the Rocky River deposit turns off the Corinna road about 34 miles from Waratah and descends over a distance of 2 miles to the Whyte River. It terminates at the river which can be crossed on foot when the water level is low, or by means of a cage slung between the banks when it is in flood. The easiest route to the deposits south of the Whyte River is along the old water race.

The regional geological map (fig. 2) includes the area bounded on the west by the Savage River, on the east by the Corinna-Waratah road, on the south by the Whyte and Rocky Rivers, and in the north by an arbitrary line about 1½ miles north of traverse G.8 in the northern area of the Savage River deposit.

The uninhabited, undeveloped tract of country bounded by these features is about 15 miles long by 2 miles wide, occupying part of sheet C/4 of the Magnet Quadrangle, and part of sheets A/2, A/4, and C/2 of the Corinna Quadrangle. Access by vehicle is possible but restricted to one or two roads in the area.

The area to the east of the Waratah-Corinna road is not readily accessible. The boundary of the granite, observed in the headwaters of the Rocky River, has been deduced farther north from photo-interpretation.

METHOD OF INVESTIGATION

Initially the area was regionally mapped using air photos (scale 1:23,760) wherever geographical features could be pinpointed on roads and rivers. The geological and survey data were plotted on topographic sheets (scale 1:15,840) of the Magnet and Corinna Quadrangles, which served as base maps for the area. Roads were surveyed by their intersection with traverse lines or by compass and tape measurements. The individual deposits were mapped in greater detail along traverse lines cut for the Bureau of Mineral Resources (B.M.R.), using their contoured magnetic anomaly maps for reference. The ground geophysical work of the B.M.R. extended from the Brown Plains area to an area north of the Savage River, the single continuous baseline being approximately 11 miles long, cut in heavily timbered terrain. An aneroid barometer was used on traverse lines for altitude readings where the pegs were obliterated or missing.

The detailed geology of the southern, central, and northern areas of the Savage River deposit was plotted on maps (scale 1 inch = 200 feet) of the surveyed base and traverse lines, originally compiled by the B.M.R. to show the magnetic anomalies of these areas.

In the Rocky River deposit existing traverse lines cut by Rio Tinto Australian Exploration in 1959 were recut and surveyed by officers of the department. A ground magnetometer survey and a geological survey of part of the area were subsequently made.

Traverses along river beds, creek beds and bulldozed roads yielded more geological information than traverses along cut lines, thus the geological boundaries of the various map units were defined mostly from outcrops observed along exposed sections. Adits were mapped by the use of tape and compass, and bulldozed trenches by the use of a theodolite.

The area was investigated in the field seasons of 1963 and 1964, and diamond drill cores were examined and logged in the winter of 1963.

ACKNOWLEDGEMENTS

The writer wishes to acknowledge the assistance rendered by members of the Department of Mines in various aspects of the compilation of this report. Mr. B. Cox prepared thin and polished sections of minerals and rocks collected from the area and selected from drill core. Mr. R. Jack assisted greatly with the apparatus used in photographing various slides and sections and in developing the glass plates. Mr. G. Everard, department petrologist, gave advice on mineral identification in a number of thin sections. Mr. K. Kendall of the drawing office and his staff were responsible for the compilation of plans and sections from base maps. Mr. W. St. C. Manson, Chief Chemist and Metallurgist, and his staff assayed or chemically analysed the various samples submitted to the Department of Mines Laboratory in Launceston. In addition, the writer benefited by advice and ideas suggested in discussions with officers of the Department of Mines.

A special word of thanks is accorded Mr. W. Pitulej, prospector and companion, whose assistance in the field during the course of the investigation was invaluable.

The writer also wishes to acknowledge gratefully the help given in the field by various officers of the licence holders, Mining and Industrial Investigations Pty. Ltd.

HISTORY AND PREVIOUS LITERATURE

Sprent (1877), during explorations in 1876-77, discovered the iron deposits on the Savage River and also gold on the Whyte River which attracted more attention and led later to the boom on the Corinna Goldfield where at one time 500 men were employed. Prospectors naturally turned their attention to the deposits in the Savage River area as a possible source of gold.

Exploration work before the turn of the century consisted of shafts, adits and trenches excavated by various gold and silver mining companies in the belief that precious metal and base metal sulphides existed at depth. In 1891 the Savage River Company drove a crosscut south of the Savage River to intersect the lode at a depth of about 400 feet, and the Huzza Company drove two adits on the north bank of the river. In 1895 the Rio Tinto Company N.L. (no connection with Rio Tinto Australian Exploration) was formed and continued operations for a few years, during which a total of 1550 feet is reported to have been driven in the unsuccessful search for gold and copper. This is the last recorded exploratory mining work on the Savage River deposits trying to prove economic quantities of precious and base metal sulphides.

Published company assays show appreciable gold and silver values but these are considered to be unreliable estimates. Assays of the core recovered from diamond drilling the deposit and of a surface pyrite sample from the Rocky River deposit have not indicated the presence of gold or silver. Nickel, cobalt, gold and silver, if they exist, are thought to be minutely disseminated in the amphibolite bodies.

The Rocky River area was also explored before 1900. Smith (1897) and Twelvetrees (1903) reported on a number of adits that had been driven to intersect pyritic iron ore lodes in the search for gold, silver and copper. The adit shown on the map of the Rocky River deposit (fig. 7) is 800 feet long, but now cannot be penetrated beyond 200 feet due to collapse. The investigation by the early prospectors of the Rocky River deposits as a source of precious and base metal sulphides was also unsuccessful.

Early references to mineral occurrences in the Savage River-Rocky River region include those by Sprent (1877), Smith (1897), Jones (1898) and Twelvetrees (1900, 1903, 1908).

Twelvetrees and Reid (1919), first reported on the Savage River deposits (known then as the Rio Tinto lodes) as a source of iron ore. They divided the ore into five main lenses and a number of smaller lenses and concluded that the ore consisted mainly of magnetite and hematite with pyrite apparently separated in bands. The ore reserves were estimated at 20 million tons. Reid (1924) described iron ore occurrences between the Meredith and Whyte Rivers and reported on the nature and extent of the ore bodies and relationship to the country rock.

The Hoskins Iron and Steel Company excavated 16 trenches on the Savage River deposit in 1926, the first exploratory work done to test the deposits as a source of iron, but found that the ore was too pyritic. Woolnough (1939) after a cursory investigation, concluded that Reid's estimate of ore reserves had been optimistic, that the nature and quality of the ore rendered it unattractive for blast furnace smelting according to world practice at that time, and that future investigation would need to be conclusive and therefore expensive. Woolnough's report marked the end of an era, during which geologists and prospectors had no recourse to modern aids in exploration and geological mapping. They were guided only by their observations of surface features, which are so scant that many conclusions based on these features are uncertain. Exploration and investigation of the Savage River-Rocky River region, dating from 1956, have been more scientific. The results have aided the writer in the compilation of the maps and report.

The early history of mining, detailed above, indicates the change in geological thought regarding the deposits over a span of about 70 years. Their economic significance during this time was never fully realized, partly because they were so inaccessibly located and poorly exposed. Modern exploration techniques in delineating ore bodies had not yet evolved; but the composition of magnetite was probably the greatest single factor detracting from its use as ore. Technologic science had not advanced to the stage where impurities in the ore could be removed or controlled. Today such techniques are known, and ore of the type found in the Savage River-Rocky River region is no longer considered refractory.

A revival of interest in the deposits within the last 10 years has resulted in a systematic programme of exploration and geological mapping. The area was reserved from occupation under the Mining Act on the 31st August, 1955, to enable the Department of Mines to assess the area.

At the request of the Department of Mines the B.M.R. made an airborne magnetometer survey during May, 1956, which proved so encouraging that they agreed to make a comprehensive ground magnetometer survey. A pack track was cleared into the area and magnetic surveys were carried out (Keunecke, 1957; Sedmik, 1960; Eadie, 1961, 1962).

Preliminary geological maps of the Savage River and Long Plains South deposits accompanied reports by Hughes (1957) and Tetlow (1959).

After the initial ground magnetometer and geological surveys were completed in 1957, two diamond drillholes were bored in the northern area to test the deposits. Camping and drilling equipment was transported by helicopter. The completion of test drilling in June, 1958, followed by ore dressing investigations of the core, marked the end of the first stage in the exploration of the area.

Rio Tinto Australian Exploration Pty. Ltd. (R.T.A.E.), not connected with the earlier Rio Tinto holding, held areas adjacent to the Savage River deposit under a Special Prospecting Licence until 1961. In 1959 this company drilled a hole (R.T.A.E. 1) in the Long Plains South deposit.

The second stage of exploration commenced in 1959 with the construction of an access road from the Corinna-Waratah road to the central area of the Savage River deposit. Diamond drillholes Nos. 3 to 10 were bored by the Department of Mines in the central Savage River area.

In 1961 an Exploration Licence was granted to Mr. E. R. Hudson of Industrial and Mining Investigations Pty. Ltd., who undertook to continue diamond drilling, to arrange smelting tests, and to investigate the possibilities of an integrated steel plant in Tasmania.

On completion of drillhole No. 16, iron ore reserves based on drillhole sections were calculated by Symons (1962) for the area between Magnetite Creek and the Savage River.

Mineragraphic investigations of Savage River magnetite were made by officers of the Commonwealth Scientific and Industrial Research Organization (Baker and Edwards, 1958; Williams and Edwards, 1958; Edwards, 1960).

Ore dressing tests in the Department of Mines Laboratory (Manson, 1959, 1960, 1962), and smelting tests in the U.S.A. proved the ore suitable for steel production. The absence of suitable coking coals in Tasmania together with the availability of large local hydro-electric resources focussed interest in the Strategic-Udy electric smelting process with its advantage of providing a control on the impurity content of ore.

A parcel of material representing crude ore and concentrate was sent with a parcel of Tasmanian coal to the United States Strategic-Udy plant at Niagara Falls for testing. The tests were successful and demonstrated that both pig iron and specification grade carbon steel could be produced from Savage River iron ore.

The iron ore is also amenable to pelletizing. If the deposits are to be exploited using this process it is envisaged that the ore would be pulverized at the site and transported by pipeline to a port where the pulp would be beneficiated and converted to pellets.

PHYSIOGRAPHY

Climate and Vegetation

Rainfall ranges from 80 to 100 inches a year; precipitation may occur throughout the year but is greatest in winter from May until September. Fog at night and early in the day is frequent in autumn and spring.

The areas of the magnetite deposits are thickly forested with rain-forest vegetation. Myrtle, sassafras and giant manferns grow in profusion but blackwood, dogwood, leatherwood and candlewood are more sparse or grow in isolated patches. Celery-top pine is present in a few places. Horizontal scrub and bauera is so dense in certain areas that progress on foot is greatly retarded. The ground is strewn with fallen timber and mantled with decaying vegetation. Bracken fern, mosses and lichen thrive in the moist climate. Drainage is poor on Long Plains, Brown Plains, West Plains and Little Plains; these areas are generally sodden or marshy and covered with button grass.

Topography and Geomorphology

The last 20 miles of the road to Corinna traverses the watershed between the Whyte River to the east and the Savage River to the west. The greatest relief is 800 feet provided by the deep youthful valleys eroded by the two rivers. Relief decreases with distance from the major valleys and Brown Plains and Little Plains in the south of the mapped area are still preserved from headward erosion at an altitude ranging from 750 to 800 feet. The maximum altitude is about 1,200 feet in the area of the Savage River deposit, and decreases to about 900 feet in the area of the Rocky River deposit. The gradient is 1 in 4 for a distance of half a mile west of the southern Savage River deposit, but in many places the gradient is steeper over a shorter distance.

The incised meanders of the Whyte and Savage Rivers are aligned roughly parallel to the strike of the country rocks. The rivers flow in a south or southwesterly direction as far as their confluence with the Pieman River. Tributary rivulets and creeks are superimposed and generally transect the strike of the country rock. Headward erosion acting outwards from the tributaries has produced a trellis drainage pattern, controlled by the structure of the underlying metamorphosed sedimentary rock.

The most striking physiographic feature in the Savage River-Rocky River region is the level but highly dissected surface of sub-aerial erosion first described by Gregory (1903) as the Henty Peneplain on the West Coast. In the north of the map sheet the Henty Surface or Lower Coastal Surface is formed at an altitude of 1,200 feet but slopes gently SW where the remnants of the surface are still preserved at an altitude between 900 and 950 feet.

The landscape formed by erosion predominates over that formed by structural features although rock structure has controlled the pattern of erosion which is in a stage of youth. The surface truncates Whyte Schist, amphibolite and the ore zones with no marked change of relief. Davies (1959) and Scott (1960) attributed the land forms in Tasmania to uplifted sub-aerial erosion levels, with the possible exception of the Henty Surface which might be of marine origin. The writer considers that the non-fossiliferous Tertiary gravels on the Corinna road, overlying a lignite bed in one place, indicate a sub-aerial origin for the surface.

Davies (1959) suggested that landscape in Tasmania was derived from a middle to late Tertiary uplift of a single peneplain which had been derived from an early (Eocene-Oligocene) period of planation, but the exact age of the different surfaces is a matter of conjecture. Dissection of the Henty Surface after uplift is thought to have taken place in the Pleistocene (Davies, 1962, p. 244).

The height of the Henty Surface relative to sea level was perhaps 100 feet greater than it is today. Blake (1939) recorded that a bore in the lower Savage River intersected 135 feet of river sediments before reaching bedrock, which indicates that the lower Savage and Pieman Rivers have drowned valley systems.

Rock Exposures and Topography of the Deposits

The best record of changes that have taken place in the country rock owing to mineralization or otherwise is preserved in drill core from the inclined drillholes. The average depth of weathering is 100 feet; so unweathered rock is thus exposed mainly in deeply incised sections. Fresh rock crops out in the Whyte, Rocky and Savage Rivers, in a few of the more deeply dissected creeks, and along sections of bulldozed road. Outcrops are highly weathered in many of the smaller creeks with steep gradients; or the bed of the creek may be filled with material washed in from positions up slope. The proportion of the surface occupied by fresh bedrock is estimated at less than 5 per cent, the remaining area being covered with grey or brown clay soil.

The linear magnetite bodies and mineralized zones form crests, ridges and scarps in the central and northern Savage River deposits and the Rocky River deposit. The most pronounced scarp in the central area of the Savage River deposit is formed by a face of oxidized iron about 60 feet in height at 450 feet west on traverse 250 S (fig. 4). Other pronounced scarp faces and ridges of iron ore exist on traverses A, B, C0B8 and between 2000 S and 2500 S in the central area (fig. 4) and on traverses D20 to E5 in the northern area

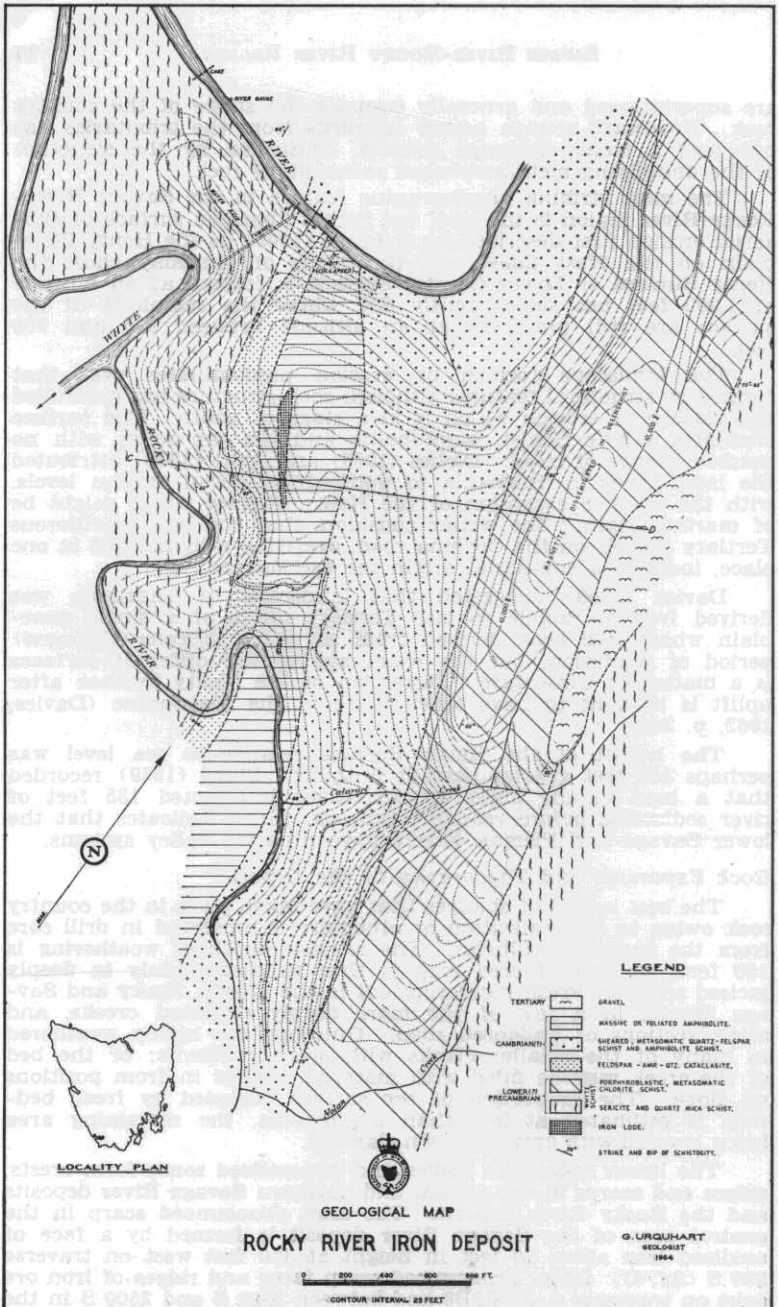

WHYTE RIVER
ROCKY RIVER
Cataract Creek
Nolan Creek
N
LOCALITY PLAN
LEGEND
TERTIARY
GRAVEL.
CAMBRIAN(?)
MASSIVE OR FOLIATED AMPHIBOLITE.
SHEARED, METASOMATIC QUARTZ-FELSPAR SCHIST AND AMPHIBOLITE SCHIST.
FELDSPAR - AMP. - QTZ. CATACLASITE.
LOWER(?) PRECAMBRIAN
WHYTE SCHIST
PORPHYROBLASTIC, METASOMATIC CHLORITE SCHIST.
SERICITE AND QUARTZ MICA SCHIST.
IRON LODE.
STRIKE AND DIP OF SCHISTOSITY.
GEOLOGICAL MAP
ROCKY RIVER IRON DEPOSIT
G. URQUHART
GEOLOGIST
1964
0 200 400 600 800 FT.
CONTOUR INTERVAL 25 FEET

FIGURE 7.

(fig. 3). The scarps are faces of vertical lodes and are not related to faulting. The ridges are generally mantled with iron boulder scree and/or red soil which may indicate the presence of an iron lode concealed beneath overburden.

Minor scarp faces and boulder strewn ridges 5-40 feet wide and up to 10 feet in height in the southern, central and northern Savage River deposits mark some underlying lodes. The ridges can be traced for distances up to 500 feet. Exposures of lode iron in the Savage River deposits are confined to trenches and adits, to the few places where scarps are formed of iron ore, and to the section of the deposit on the north bank of the Savage River. Elsewhere in the area mineralization can be reasonably inferred from boulder strewn ridges but relatively few lodes are represented on the surface in this manner. Much of the magnetite is concealed beneath scree or decaying vegetation. Diamond drilling, deep trenching by bulldozer, bulldozed roads and the re-opening of caved-in adits for inspection have yielded exposures, intersections and contacts of country rock and iron ore which have aided in the detailed mapping of the deposits.

Topographic expression of the iron deposits is less defined in the Long Plains South-Brown Plains deposits. The geology has been mapped from relatively few exposures in creeks and along road sections. Widths of iron ore are indefinite because of scattered insignificant outcrops. The most reliable evidence of width and grade of mineralization is from the geological log and assay results of the core from drillhole R.T.A.E.1. The largest exposure of iron and scree is between traverses 11000 N and 11500 N (fig. 6) where the iron has been uncovered by a bulldozed road. Iron ore is also exposed in a few creek beds, and in tracks which have been bulldozed along the baseline.

Geological boundaries in the Rocky River deposit are fairly easy to map from rock exposures in the Whyte and Rocky Rivers which transect the strike of the country rock. Fresh rock exposed in Cataract Creek an. Nolan Creek confirm the geological boundaries. Iron lodes are exposed only on the centre line, line 4 S, line 12 S, and in Cataract Creek upstream from the water race (fig. 7). Dimensions of lodes, which are in the form of minor scarps and blocks 5-10 feet high on the hillslopes, are difficult to estimate because of rubble associated with the outcrops. The width of the mineralized zone exposed in Cataract Creek below the waterfall is 40 feet.

A magnetite-bearing zone forms the ridge extending from the Whyte River to the Rocky River. The ridge is underlain by red soil derived from the weathering of green sedimentary schist

General Geology

The outstanding features of the geology are shown on fig. 2 and in the summary below. The metamorphosed rocks of "Lower" Precambrian Whyte Schist form meridional belts in the region between the Whyte and Savage Rivers (fig. 2). Less metamorphosed "Upper" Precambrian sediments are shown in the SW portion of the map and probably underlie the region to the west of the Savage River, extending southwards to the Pieman River area.

Amphibolite bodies and sheets, possibly Cambrian in age, are emplaced along the general strike of the psammitic and pelitic beds which constitute the Whyte Schist. The amphibolite is considered to be of igneous origin. Magnetite deposits in the Savage River, Long Plains South-Brown Plains and Rocky River areas are enclosed in amphibolite. The widths of these amphibolite bodies are variable. In the Rocky River area meta-sediments of the Whyte Schist are mineralized adjacent to amphibolite.

Magnesite and magnesium-rich dolomite lenses in amphibolite and meta-sediments in the proximity of magnetite deposits appear to have been formed by replacement of the host rock, and a hydrothermal origin related to that of the iron deposits is suggested.

Cambrian ultrabasic rock, including serpentinite, is shown in the NE of the map. It occupies a large area to the north of the mapped area.

Cambrian (?) cataclasite (possibly a sheared quartz diorite), a dyke-like body, separates amphibolite and Whyte Schist in the Rocky River area.

Devonian granite flanks the Whyte Schist formation to the east of the Whyte River where it forms a range of hills and mountains.

Tertiary basalt and sediments form plateaux in widely separated areas.

Recent alluvial deposits in the valleys of the Savage River, Whyte River, Rocky River and Main Creek have been economically important in the past.

Summary of exposed rock formations in the Savage River-Rocky River region

Age	Rock Unit and Character	Thickness in feet	Economic value
Quaternary	Iron scree	0-15	High grade iron
	River banks and terraces of gravel and alluvium	0-20	Carries gold, chromite and osmiridium
	Gravel overlying Whyte Schist	0-5	Has been worked for gold
Tertiary	Basalt	0-30	No recognized mineral value
	Conglomerate, gravel, grit, siltstone, mudstone and lignite	0-40	Tin and traces of chromite and gold have been recovered in Brown Plains area
	Unconformity		
Devonian	Meredith Granite—granite, porphyry, aplite, &c.		Probable source of tin

Summary of exposed rock formations in the Savage River-Rocky River region—*contd.*

Age	Rock Unit and Character	Thickness in feet	Economic value
	Intrusive relationship?		
Cambrian?	Rocky River Cataclasite—sheared quartz diorite, slightly recrystallized	100-200	No recognized mineral value
	Fine- and medium to coarse-grained amphibolite in Whyte Schist	Variable	Host rock to magnetite in Savage River, Long Plains South and Rocky River areas
Cambrian	Bald Hill Complex—serpentinized basic and ultrabasic complex	?	Source of chromite, osmiridium and possibly gold. Contains magnetite
	Intrusive Relationship?		
"Upper" * Precambrian (?)	Corinna Slate—slate and argillite	?	No recognized mineral value
"Lower" * Precambrian (?)	Whyte Schist—pelitic and psammitic rocks (Magnesite in a horizon at or near the transition of the rock types.)	?	Gold in pyrite-graphite zones in Main Creek area? Magnetite bearing chlorite schist in Rocky River deposit. High grade replacement magnesite bodies in Main and Bowry Creeks

* The "Lower" and "Upper" divisions of the Precambrian represent metamorphosed and less metamorphosed rocks. The terms have been retained to comply with previous nomenclature used by the Tasmanian Department of Mines although the field relationship of the rocks is not certain.

Stratigraphy and Petrology

SEDIMENTARY AND METAMORPHOSED SEDIMENTARY ROCKS

"LOWER" PRECAMBRIAN WHYTE SCHIST

The first record of metamorphosed Precambrian rocks in the area was by Twelvetrees (1903), who described the assemblage between Main Creek and Long Plains. Long Plains Schist was the name given to the formation by Twelvetrees (1908). Spry (1962, p. 110) termed the rock exposed in the Pieman and Whyte Rivers the Whyte Schist formation.

The Whyte Schist is distributed in a belt between the Savage and Whyte Rivers, which were the arbitrary boundaries selected for mapping.

Extension of the Whyte Schist beyond the map limits towards the west and north is very likely and continuation of the Whyte Schist to the south is indicated in the reports of Spry and Ford (1957) and Spry (1964) who traced the formation in an arc extending from the Pieman River to the West Coast.

The Whyte Schist is divided into two rock units:—

(*a*) A psammitic assemblage of silty shale, siltstone, mica-quartz schist and phyllite, black graphite-pyrite schist and quartzite. It contains mudstone and minor intercalated bands of chlorite schist.

(*b*) A dominantly pelitic assemblage of argillite, clay shale, phyllite, and chlorite-muscovite schist. Bands and zones of siltstone, mica-quartz schist and quartzite are intercalated in the succession.

The pelitic and psammitic assemblages are conformable, but the steep attitude and isoclinal folding of the rocks (fig. 8), and paucity of top and bottom features, make the determination of relative age uncertain. The pelitic rocks lie below psammitic rocks in one exposure of the contact (Pl. 1).

Rock units (*a*) and (*b*) are shown as separate map units. The phyllite in the psammitic assemblage is characteristically lustrous, the silver-grey sheen of the fresh rock being imparted by muscovite and sericite. The psammitic sediments are grey or white and the assemblage as a whole is pale in colour. Quartz veins, stringers and augen are visible in outcrops of sericitic phyllite and muscovite schist (Pl. 2) but banding parallel to foliation can only be detected microscopically in chlorite schist.

The pelitic sediments are greenish-black or pale green and weather to a brown clay.

The distribution of the two rock units is in parallel belts. Not only lithology but soil cover and topography differentiate the rocks at their contact. On the access road to the Savage River deposit the boundary between the psammitic (silty) and pelitic (argillaceous) units is marked by a difference in altitude of about 100 feet. The same difference in altitude marks the boundary between the two units on the access road to the Long Plains South deposit. The psammitic unit is more resistant to erosion and underlies the higher ground. The relief between the two units decreases southward and the contact is not sharply demarcated, possibly because the boundary is gradational.

Under the microscope the structure of phyllite is seen to be banded, imparted by original layer to layer differences in composition of quartz, albite and platy minerals (Pl. 3). Augen-shaped or subhedral individual crystals of albite, or aggregates 0.4 to 0.6 mm in size are present as porphyroblasts. Many of the larger albite porphyroblasts are carlsbad-twinned and carry inclusions of muscovite, quartz, epidote, and dolomite in strings parallel to the schistosity. Quartz crystals, discrete or in aggregates, show undulose extinction. Chlorite in small amount is generally interleaved with muscovite. Sphene, magnetite, and epidote are accessory minerals.

Thin sections of chlorite schist under the microscope show a similar structure and texture. Albite crystals up to 1 mm in size, many of them carlsbad-twinned, and/or lenses of quartz aggregates produce the porphyroblastic texture. Schistose structure is due to preferred orientation of platy minerals. Albite shows sieve structure caused by inclusions of sphene, epidote, chlorite and magnetite parallel to schistosity. One or two albite crystals have been rotated and the strings of inclusions are not parallel to the host schistosity. Chlorite shows anomalous birefringence and strong pleochroism (green → brown). Fine lamellae of highly birefringent pleochroic mica (biotite?) is characteristic of the chlorite schist. Strings of sphene in chlorite are parallel to the schistosity.

The metamorphic grade of Whyte Schist corresponds to the albite-muscovite-chlorite subfacies of the Greenschist Facies. Albite porphyroblasts are absent or sparse and fine-grained in chlorite schist and phyllite in the Savage River area but increase in amount and size south towards the Rocky River area where the grains reach a maximum diameter of about 1.5 mm in chlorite schist. Albite porphyroblasts in sericitic phyllite and schist of the psammitic assemblage from the same areas are smaller in size.

Bedding schistosity is dominant in Precambrian rocks. Axial plane schistosity in folded incompetent (phyllite) beds is prominent but does not obliterate bedding schistosity. Facings in the isoclinally folded rocks have been determined from cross and graded bedding in very few places along the main road. Thickness of the different facies in the respective rock units is variable because of rapid facies changes and facies intercalations. Phyllite is generally thinly-bedded in layers 2-12 mm thick in a homogeneous section, but many exposures show rhythmic alternations of phyllite with phyllite of slightly different composition, with siltstone, or with one of the other facies of the unit. Single beds of mica-quartz schist, siltstone, and quartzite range from a few inches to about 20 feet in thickness. The thickness of quartzite west of the baseline in Main Creek is much greater but isoclinal folding complicates the determination of thickness. The section exposed for 200 to 300 yards along the Savage River road from the turnoff is one of the longest continuous sections that can be seen.

The source of Precambrian rocks, which are the oldest in Tasmania, is not known. Deposition of clay, shale, silt and sandstone beds fluctuated rapidly in a basin which was later uplifted

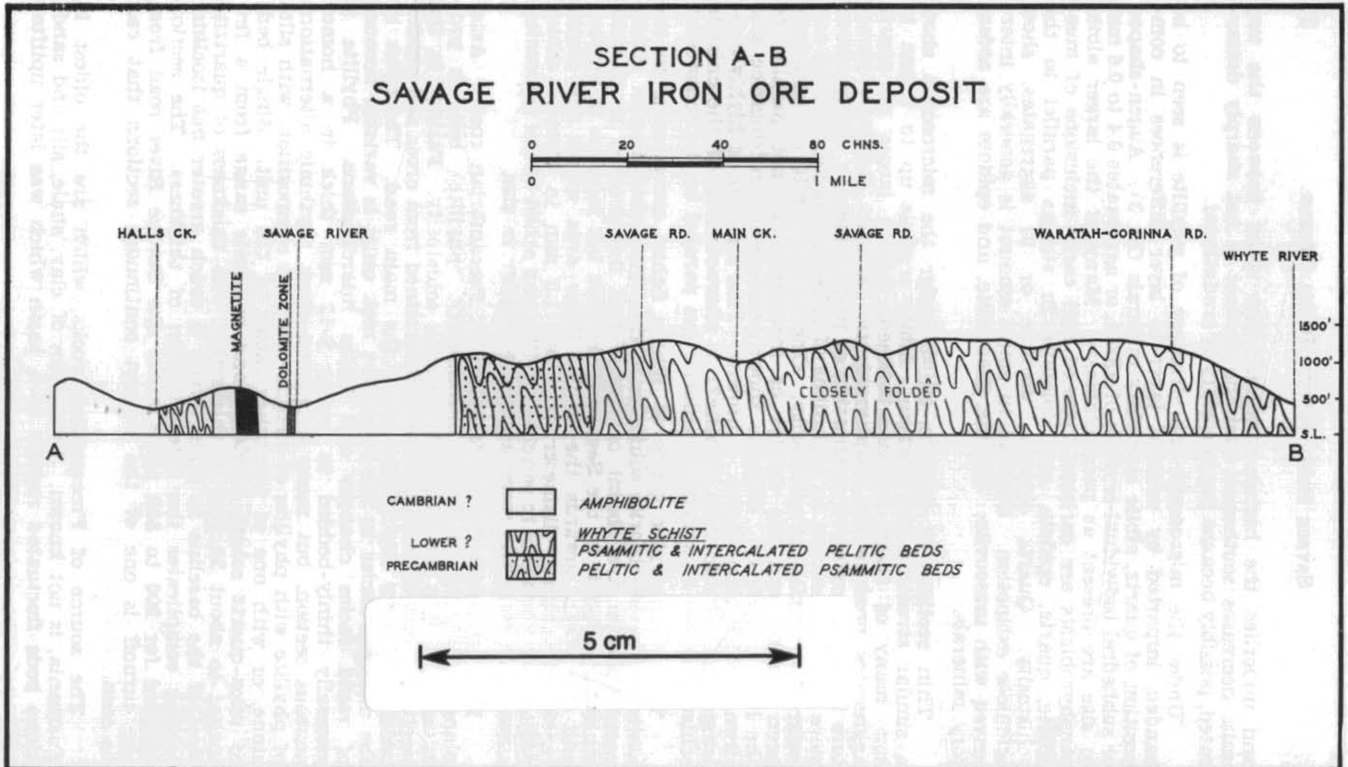

SECTION A-B
SAVAGE RIVER IRON ORE DEPOSIT
0 20 40 80 CHNS.
0 1 MILE
HALLS CK.
SAVAGE RIVER
SAVAGE RD.
MAIN CK.
SAVAGE RD.
WARATAH-CORINNA RD.
WHYTE RIVER
MAGNETITE
DOLOMITE ZONE
CLOSELY FOLDED
1500'
1000'
500'
S.L.
A
B
CAMBRIAN ?
AMPHIBOLITE
LOWER ? PRECAMBRIAN
WHYTE SCHIST
PSAMMITIC & INTERCALATED PELITIC BEDS
PELITIC & INTERCALATED PSAMMITIC BEDS
5 cm

FIGURE 8.

to form a geanticline. The green chlorite schist facies and metapelite possibly are derived from volcanic ash.

The contact between the two rock units of the "Lower" Precambrian formation is best exposed on the access road to the Savage River where it is gradational in a 100 feet section from quartz schist and phyllite into brown-weathering green clay, argillite and schist. In the Long Plains South area one observed contact of the two units is conformable and sharp between quartz-mica schist and green and black chlorite schist. The contacts have been offset by two parallel reverse faults (Pl. 1).

The relationship of "Lower" Precambrian Whyte Schist to "Upper" Precambrian Corinna Slate is obscure. The crucial contact section along the Waratah-Corinna road about 5 miles from Corinna is covered with Tertiary sediments.

Air-photo study of the area west of the Savage River not accessible to the writer indicates a change in the regional strike of rocks of presumable "Upper" Precambrian age. Steeply-dipping fold patterns suggest a different order of folding. An unconformity or fault may therefore exist. The difference in altitude between "Upper" and "Lower" Precambrian rocks in the area west of Brown and Little Plains between the Corinna road and the Savage River is about 350 feet and may be due to a fault.

Flat-lying plains and plateaux of Tertiary sediment and basalt overlie steeply-dipping Whyte Schist, with a 70° to 85° structural discordance.

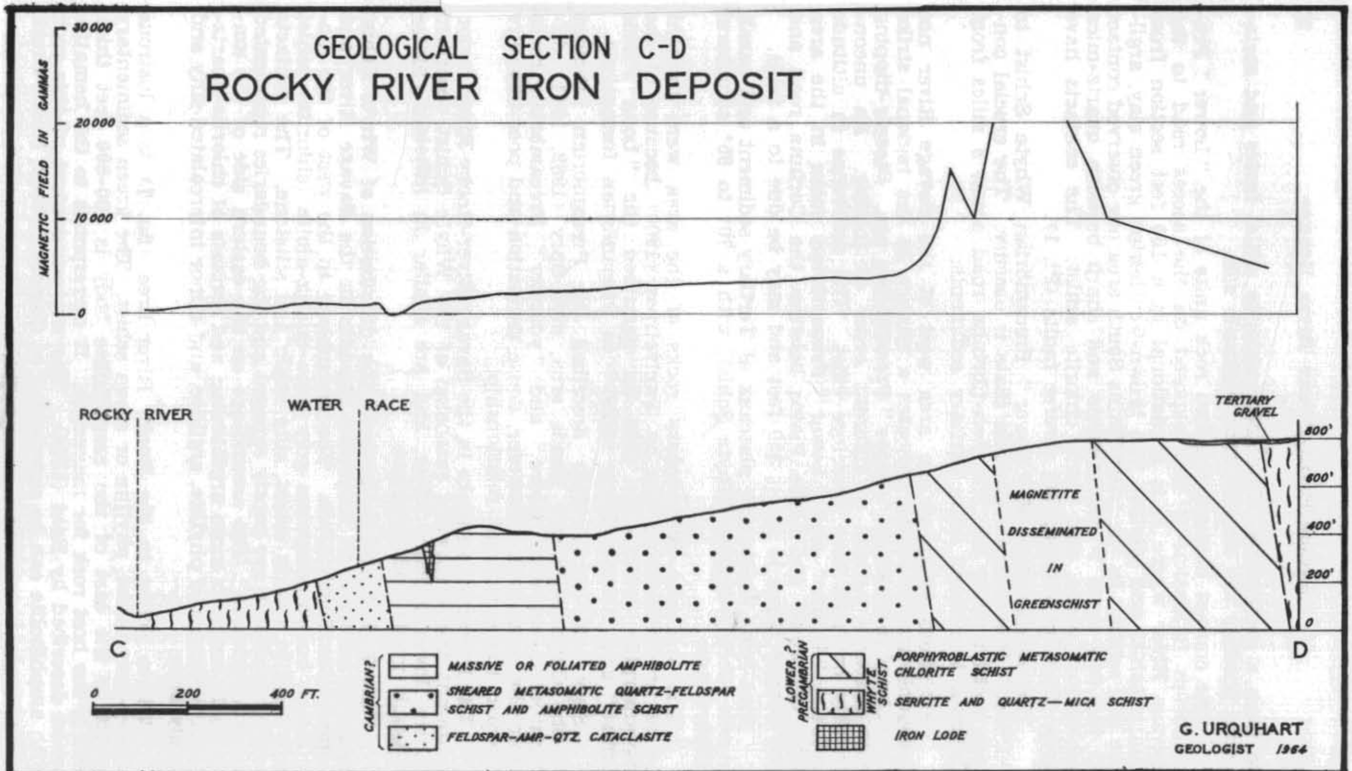
The schistose sedimentary rocks of the area were thought to be pre-Silurian in age by Twelvetrees (1900) because of the metamorphic grade. In 1908 he described the "Long Plains schist" and "Rocky River schist" as Precambrian formations.

Spry and Ford (1957) described the Precambrian lithology in the Corinna-Pieman Heads area, and Spry (1962, 1964) differentiated between "older" and "younger" Precambrian rocks from the same area. However, dense vegetation and poor exposure obscure the structural relationship.

The Precambrian rocks in the Savage River-Rocky River region represent the northward extension of the Whyte Schist described in the lower Pieman River, and are similar in lithology, metamorphic grade and structure.

Figs. 3, 4, 5 and 6 illustrate the distribution of Whyte Schist in areas adjacent to magnetite deposits in the Savage River and Long Plains South areas. The assemblage to the west of the amphibolite bodies comprises grey mica-quartz-albite (chlorite) schist and phyllite, quartz schist, silty shale and siltstone. The contacts with amphibolite are poorly exposed and the boundaries represented are approximate. The assemblage on the eastern side of the amphibolite bodies is more argillaceous and consists of chlorite-quartz-sericite schist and phyllite, argillite, and minor intercalated silty and sandy beds.

Whyte Schist in the Rocky River area (fig. 7) is a lustrous silvery-grey schist, phyllite or green schist. The green sedimentary schist to the east of the amphibolite body is 600-800 feet thick and is the host rock for magnetite. It corresponds to the hematite schist described by Reid (1924). The western contact of this rock with amphibolite can be ascertained in Cataract Creek, Nolan Creek



GEOLOGICAL SECTION C-D
ROCKY RIVER IRON DEPOSIT
MAGNETIC FIELD IN GAMMAS
30 000
20 000
10 000
0
ROCKY RIVER
WATER RACE
TERTIARY GRAVEL
MAGNETITE
DISSEMINATED
IN
GREENSCHIST
800'
600'
400'
200'
0
C
D
0
200
400 FT.
CAMBRIAN?
MASSIVE OR FOLIATED AMPHIBOLITE
SHEARED METASOMATIC QUARTZ-FELDSPAR SCHIST AND AMPHIBOLITE SCHIST
FELDSPAR-AMP-QTZ. CATACLASITE
LOWER ? PRECAMBRIAN
WHYTE SCHIST
PORPHYROBLASTIC METASOMATIC CHLORITE SCHIST
SERICITE AND QUARTZ—MICA SCHIST
IRON LODE
G. URQUHART
GEOLOGIST 1964

FIGURE 8.

and farther south in the Rocky River. The eastern contact with grey schist and phyllite is not clear; in one creek section green schist and grey schist appear to be intercalated in the boundary zone.

The Whyte Schist pelitic and psammitic rocks in each of the deposits dip to the east or northeast at consistently steep angles ranging from 70° to vertical (figs. 8, 9).

"UPPER" PRECAMBRIAN CORINNA SLATE.

Spry (1964) termed the rocks which crop out for 5 miles along the road into Corinna "Corinna Slate". Exposures are poor away from the road. Brown-weathering argillite, greenish slate and micaceous siltstone are exposed in a few places on the road section from Little Plains to Corinna. Part of the western contact of Whyte Schist with these rocks of presumed "Upper" Precambrian age is sharp, with a difference in elevation as much as 350 feet, but contacts elsewhere are not so easy to define. Bedding attitudes near the contact are similar. The difference in outcrop elevation may be due to differential weathering or a fault.

Spry (1964, p. 39) described the Corinna Slate as thinly-bedded and weakly cleaved at an angle to the bedding. Microscopically the rock is fine-grained and consists chiefly of quartz, sericite and a little chlorite. Accessories are sphene, tourmaline or iron ore. On the Corinna road the difference in lithology from Whyte Schist is readily apparent as the slate-argillite assemblage does not contain quartz augen and stringers. Corinna Slate was included in the "younger" Precambrian by Spry (1964, p. 29).

TERTIARY SEDIMENTS

General

Flat-lying beds of mudstone, silt, grit, gravel and conglomerate form Brown Plains, Little Plains and West Plains 5 to 7 miles distant from Corinna. A basalt cap has preserved a thin bed of sediments from erosion in the area of the Savage River deposit, but the basalt and sediments have been removed by erosion in other places. Where seen in contact with steeply-dipping Whyte Schist the contrast is striking and the contact is clearly a great unconformity (Pl. 4).

The thickness of sediments on Brown Plains, exposed in a section on the track leading to the Rocky River, ranges from 1 foot up to a maximum of about 40 feet. The thickness of an individual bed may vary a great deal from place to place.

Scott (1926) recorded a depth of about 2 feet of soil and rubble overlying schist in holes drilled in the vicinity of tin workings on Brown Plains. On Little Plains the aggregate thickness of sediment and rubble ranges from 1 foot to 6 feet.

Mudstone bands in the Tertiary sediments are white or grey but have been darkened within a few feet of the surface by organic-rich water draining the button grass plains, and converted to a dark carbonaceous mudstone. Silt and grit layers have similarly been affected in favourable areas. No fossils have been observed in the fine clastic sediments.

Beds of unconsolidated, poorly-sorted, subangular to rounded pebbles consist mainly of opaque white quartz but include black and grey chert, grey quartzite, tourmaline granite, pale sandstone and schist. The quartz pebbles (average size 2 inches) are set in a finer matrix of silica grains and grit. Cobbles and boulders, 6 inches to 1 foot in size, fill scour depressions at the base. Some conglomerate lenses, the lithified equivalents of pebble beds, rest directly on schist. Other lenses appear near the top of the succession of Tertiary sediments.

The beds of mudstone, silt, grit, pebble and conglomerate interfinger and coalesce. Cross bedding in the finer clastic sediments is common. The succession is variable; in places any one of the beds may rest unconformably on schist and so form the base of the sediments.

A flat-lying bed of lignite 6 feet thick, overlain by Tertiary gravel and siltstone, is exposed in a road cut about 4 miles from Corinna.

Leaf impressions in lignite and ligneous clay from the Waratah district were described by Johnston (1888) as belonging to the genera *Eucalyptus, Quercus, Laurus, Cycadites* and *Ulmus.*

Most of the white opaque pebbles in the pebble beds and conglomerate are locally derived from vein material in Whyte Schist. The presence of a few tourmaline granite fragments suggests a derivation also from the Meredith Granite area to the east.

Montgomery (1894, p. 29, 30) regarded gravels at about 800 feet above sea level north of the Pieman River as marine and formed on a plain of marine erosion. Waterhouse (1914) regarded the gravels as fluviatile and Twidale (1957, p. 12, 13) considered them to be marine or fluvio-glacial. The writer considers the lack of fossils, the presence of lignite and the lithology and structure of the beds as evidence of rapid sedimentation in a shallow terrestrial basin.

Tertiary Sediments in areas of Magnetite Deposits

Thin sediments lie beneath basalt locally, but elsewhere in Tasmania basalt has been reported intercalated with Tertiary sediments. A layer of gravel, probably no more than 2 or 3 feet thick, underlies basalt in the southern Savage River area. The white quartz gravel is rounded, up to half an inch in diameter, and is seen in a few places on the track to the Long Plains South area (fig. 5).

Scattered boulders of conglomerate in the area between Magnetite Creek and 4,700 S (fig. 5) are exposed on the hillslopes, but distribution is irregular. It is not certain that all the exposures of conglomerate represent bedrock; some of the conglomerate has possibly been transported down slope. Large blocks are exposed between traverse 4,500 S and the creek about 200 feet to the south (fig. 5). The constituents of conglomerate in one or two exposures in this area are poorly-sorted and poorly-rounded, and represent basal conglomerate occupying depressions in the original plain of erosion. Boulders of grey quartzite up to 1 foot in size comprise part of the rock. Elsewhere the angular constituents are white vein quartz and grey quartzite between 1 and 2 inches in size, in a matrix of quartz grains and grit. The basal conglomerate resembles the poorly-sorted material occupying scour depressions in Whyte Schist in the Brown Plains area. The constituents as given above indicate a derivation from the east.

The basal conglomerate is not mineralized and hand panning (by W. Pitulej) of the streams draining the area in which conglomerate occurs did not indicate the presence of gold, tin or chromite.

Iron ore in the Long Plains South-Brown Plains deposit is masked by a veneer of partly redistributed Tertiary grit and gravel extending from traverse 3,000 S to traverse 00 on the Corinna road (fig. 6). The magnetic anomalies are present beneath alluvium which ranges from less than 1 foot to about 5 feet thick.

An unknown thickness (probably no more than two feet) of gravel, grit and siltstone underlies basalt in the northern Savage River area. A weaker magnetic anomaly is evident beneath the Tertiary rocks capping the magnetite lodes.

Blocks of Tertiary conglomerate 10-20 feet in size are scattered in the bed of the Savage River over a distance of 800 feet upstream from the bridge.

In the Rocky River area, grit and gravel resembling Tertiary material form a veneer 2 or 3 feet thick over green sedimentary schist on the eastern side of the deposit north of Cataract Creek (fig. 7).

QUATERNARY DEPOSITS

These can be divided into three categories:—

(i) Recent sediments forming terraces, pebble banks and alluvial deposits in the beds and along the banks of the main rivers and creeks. The raised terraces in the Savage River are 5-10 feet thick in places and have been trenched and pitted by the early prospectors in their search for gold and osmiridium.

(ii) Unsorted beds of detritus, 1-5 feet in thickness, mostly quartz weathered from the siliceous Whyte Schist assemblage. These are widespread in the area.

(iii) Iron ore detritus overlying iron-rich areas.

Hematite, magnetite and limonite scree ranging from shingle (average size 1 inch) up to blocks 2-3 feet across, is ubiquitous in the vicinity of the magnetite lodes in the northern Savage River area and hinders the surface mapping of the deposits. Iron scree is plentiful in the area between traverses D34A and F7 (fig. 3) where it may be as much as 3 feet thick.

Iron ore scree in the form of gravel, shingle, pebbles, cobbles and boulders is also widespread in the central area, associated with magnetite lodes. The distribution of the iron ore scree indicated in the trench profiles (figs. 18, 19 and 20) is very irregular and varies from pockets about 15 feet deep along the trench walls to places with little scree cover, or none at all. Pebbles and cobbles (average size 2 inches) are consolidated into breccia and conglomerate by a ferruginous cement on the track leading to the adit west of drillhole No. 12 (fig. 4).

Iron scree is associated with magnetite deposits of the southern Savage River area and the Long Plains South area, but is less widespread than in the central and northern Savage River areas. Detritus shed from the deposits is masked by vegetation and humus. Such conditions make it difficult to know, without the aid of the magnetic anomaly maps, that the areas contain magnetite deposits.

IGNEOUS AND METAMORPHOSED IGNEOUS ROCKS

Five periods of igneous activity are represented by the metamorphic and igneous rock types:—

(i) Intrusion of ultrabasic and basic magma in late (?) Cambrian time, forming rocks which are represented in the Bald Hill area by pyroxenite, peridotite, serpentinite and gabbro.

(ii) Subsequent intrusion of basic magma in the Cambrian (?) represented by amphibolite which is host to magnetite metallization. (Age of amphibolite is discussed on p. 39).

(iii) Intrusion of acidic magma in the Rocky River area (as the final stage of Cambrian igneous activity?).

(iv) Intrusion of acidic rocks in the Devonian represented by the Meredith Granite.

Most granite bodies in Tasmania were emplaced as a late phase of or after the dominant Devonian Tabberabberan Orogeny, and have been dated in the 320-370 million year B.P. range.

(v) Extrusion of basalt in Tertiary time.

Basalt, in adjacent areas of Tasmania, overlies sediments containing fragments of marsupial animals and flowering plants of Tertiary age.

PERIDOTITE, PYROXENITE, SERPENTINITE AND GABBRO AT BALD HILL

Early reports on the geology of the Bald Hill area include those by Twelvetrees (1913) and Reid (1921) who stated that Bald Hill is near the northern end of a strip of serpentine extending about 30 miles in a SE direction, and ranging from 1 to 5 miles wide. Serpentine has been traced 7 miles north of the Waratah-Corinna road.

The lithology of the complex at Bald Hill has been given by Reid (1921) in describing serpentinized rocks of the peridotite, pyroxenite and gabbro series. Rock from the Corinna road at the 19 miles hut, which is almost on the boundary of the serpentinized ultrabasics, was described by Reid (1921, p. 3) as a dark mottled harzburgite considerably serpentinized and containing magnetite.

Reid in his description of the pyroxenite series stated that bronzitite from Bald Hill is olive-green and coarsely crystalline, containing blebs, streaks and irregularly shaped bunches of magnetite, and more rarely chromite. An analysis of a sample of this rock, collected by Reid and analysed in the Geological Survey Laboratories showed the composition to be:—

	%
SiO_2	55.16
MgO	28.05
FeO	10.70
Al_2O_3	3.50
CaO	Nil
Total	97.41

Common accessory minerals in the gabbro series were described by Reid (p. 26) as idiomorphic magnetite and chromite. The complex is similar to other ultrabasic masses at Adamsfield, Anderson Creek and Argent Tunnel and probably belongs to the same Cambrian tectonic phase.

The magnetite content of the different rock types is regarded as significant when considering an origin for magnetite deposits in the Savage River-Rocky River region.

AMPHIBOLITE

Amphibolite bodies in Whyte Schist are closely associated with magnetite in the Savage River deposit, Long Plains South-Brown Plains deposit and the Rocky River deposit. The occurrence of amphibolite in the intervening area between the three deposits is not continuous, contrary to the belief expressed in some of the earlier reports, nor are the amphibolite bodies as wide as previously thought. The distinction in the field between weathered amphibolite, and weathered schist and phyllite is difficult, except in some river and creek sections where fresh rock may be exposed. This, no doubt, has been the reason for the greater extent assigned to the rock by previous workers. The topographic expression of amphibolite does not distinguish it from meta-sediments of the Whyte Schist, except perhaps that trellis drainage patterns characteristic of underlying schist are not formed on areas underlain by amphibolite.

The distribution of amphibolite and its altered equivalents within the ore zone is shown on fig. 21 which is a vertical representation of the rock types intersected by diamond drillholes in the central and northern areas, and by drillhole R.T.A.E.1. in the Long Plains South deposit.

Amphibolite in the core is a blue-grey or greenish fine-grained massive-looking rock, in places fractured or having an incipient schistosity. Drill cores generally show variable magnetism from weak to fairly strong. Assays indicate that the Fe content in magnetite ranges from about 2 to 5 per cent. Amphibolite of this type is recorded in the logs of the cores as "barren" country rock to distinguish it from magnetite-bearing rock having a higher iron content.

Amphibolite in the Long Plains South-Brown Plains deposit is conformable in steeply-dipping chlorite schist of the metapelite assemblage, and is well exposed over a width of about 500 feet in Bowry Creek between traverses 12000N and 13000N (fig. 6). A section through the amphibolite body is poorly exposed in the creek between traverses 6000N and 7000N where the rock is estimated to be 200-300 feet wide. Outcrops of amphibolite elsewhere along the line of the deposits are masked or poorly exposed. In general the width of the magnetic anomaly in the Long Plains South-Brown Plains area appears to be directly related to the width of the host amphibolite rock.

In the Rocky River area, a division of amphibolite into massive or foliated rock, and sheared metasomatized (altered) amphibolite is shown on the geological map (fig. 7). The boundaries are transitional and represent the general distribution of amphibolite and altered amphibolite over a width of about 900 feet in rocks exposed mainly in the Whyte and Rocky Rivers and along the water race. Zones of massive amphibolite do occur in the metasomatized and sheared amphibolite but cannot be delineated as mappable units.

Fine-grained amphibolite from the Savage River, Long Plains South-Brown Plains, and Rocky River deposits is megascopically uniform in colour, texture and structure. The mineral composition is similar, and the chemical composition of amphibolite from the Savage River, from the Rocky River, and from the lower Pieman River does not differ very much.

Criteria used in the field to differentiate between weathered amphibolite and weathered meta-sediment were:—

(i) Weathered sedimentary schist is generally silty compared to the greasy "feel" of amphibolite when scratched with a geological pick.

(ii) Detrital quartz grit from quartz pods in phyllite overlies brown soil in a few places. Soil derived from amphibolite may contain iron oxide scree but does not contain quartz grit.

(iii) Weathered or fresh fine-grained phyllite is difficult to recognize from schistose amphibolite in a number of outcrops. Elongate quartz lenses up to half an inch in length, which may be present in phyllite, distinguish between meta-sediment and amphibolite.

(iv) Much of the amphibolite away from the ore zones is fairly massive and characteristically weathers in blocky irregular fragments quite different from the platy fragments of schist and phyllite.

The amphibolite bodies from the Savage River area to the Rocky River area are disposed along the general line of strike in Whyte Schist. The amphibolite body containing the Savage River deposits increases in width from the southern to the northern area, and is aligned roughly parallel to an adjacent amphibolite body on the western side in which magnetite is not deposited. Amphibolite is fairly massive in outcrop, the schistosity in many places being only faintly discernible. The foliated amphibolite (greenschist) is best seen in the diamond drill core as zones in amphibolite. Field exposures of amphibolite in most places indicate a greenish-grey, dense, fine-grained rock which is generally feebly magnetic. Grey, foliated, fine-grained rock grades into the normal grey-green amphibolite about 300 feet below the confluence of Halls Creek and the Savage River. Foliation is well marked in both rock types, especially the grey variety, which appears to be a flaser rock derived from an igneous rock by shearing. Magnetic foliated amphibolite is also exposed in the lower reaches of Halls Creek near the junction with the Savage River.

Fragments of grey, glossy, highly-cleaved rock between the deposit and the Savage River in the central area may be similarly sheared and recrystallized. Highly-altered igneous rock with ramifying carbonate veinlets and stringers is exposed west of the central area in the bed of the Savage River.

The greenish colour of amphibolite is due to the abundance of chlorite, actinolite, tremolite and epidote minerals. Thin section study of amphibolite under the microscope shows that the mineral assemblage consists of plagioclase feldspar, chlorite, actinolite, epidote, sphene, quartz, apatite, magnetite and pyrite (slides 64-104; 64-102; 64-91; 64-90). Percentages of minerals differ in the slides, chlorite and actinolite forming perhaps 40 to 60 per cent by volume; feldspar 35 to 50 per cent; epidote and sphene 10 to 20 per cent; and quartz, apatite and opaque minerals 5 to 10 per cent. Microscopically the structure in thin section is schistose, imparted to the rock by the parallel alignment of amphibole, chlorite, epidote and sphene crystals.

The plagioclase is mostly albite-oligoclase and occurs as shapeless, irregular grains in the fabric of the rock. Isolated grains are albite- and carlsbad-twinned. Much of the albite-oligoclase is poikiloblastic, containing inclusions of other minerals, mainly epidote, sphene and actinolite. The minerals form zones of inclusions concentrated toward the perimeter of some feldspar grains in slide 64-104. Bladed crystals and slender prisms of actinolite are generally imperfectly terminated and intimately associated with and surrounded by chlorite. Actinolite is strongly pleochroic, pale brown or green to deep blue-green. Chlorite is pale green in irregular masses enclosing residual actinolite. The mineral is of low birefringence and contains sphene. Epidote in colourless grains and elongate prisms 0.02 to 0.05 mm in size parallels the schistosity in slide 64-102. Quartz and apatite occur in minor amount. Sphene grains and clusters up to 1 mm in size lie parallel to the schistosity in slide 64-90. The opaque minerals consist of magnetite and pyrite in well-formed crystals up to 1 mm in size in the shape of octahedra, squares, triangles and rhombs. A few of the magnetite crystals are cut by fractures.

Greenschist derived from amphibolite is prominent in the alteration zones around some magnetite concentrations. It can be distinguished in the drill core, but cannot be widely delineated by surface mapping. The minerals of greenschist rock consist mainly of chlorite and tremolite (or actinolite), and accessory epidote and sphene.

The distinction between amphibolite and greenschist in many sections of drill core is an arbitrary one based on the relative schistosity of the rock; the contacts shown on the geological sections of the drillholes (fig. 21) are therefore not necessarily sharp or inclusive; the greenschist zone may include relatively massive widths of amphibolite. In many of the core sections the transition from amphibolite into greenschist is gradual from massive-looking amphibolite through rock having incipient schistosity into foliated greenschist. Some core sections show a sharp contact between the two rock types, but such contacts are not numerous.

Core from drillhole R.T.A.E.1, collared between traverses 11000 N and 11250 N in the Long Plains South deposit (fig. 6), shows that amphibolite is massive between magnetite-bearing schistose (greenschist) zones.

Foliated zones occur in the massive amphibolite of the Rocky River deposit but are difficult to map as separate units.

The texture, structure and most of the minerals in amphibolite rock have been formed by metamorphic reconstitution. The metamorphic grade of amphibolite is given by the mineral association of chlorite, epidote and actinolite, and the absence of biotite, indicating regional low grade metamorphism of the Greenschist Facies, rather than the Epidote-Amphibolite Facies.

The amphibolite body which is host to magnetite concentrations in the area north of the Savage River can be traced over a width of about 4,500 feet, but it tapers rapidly southward to a width of about 100 feet.

In the Long Plains South-Brown Plains deposit the width of the amphibolite sheet which can be traced from traverse 3500 N to traverse 13000 N, is between 300 and 500 feet (fig. 6). Amphibolite bodies of lesser width have also been noted.

Width of amphibolite ranges from 900 feet to 1,200 feet in an area between the Whyte and Rocky Rivers.

Discordant and concordant amphibolite dykes have been reported from the lower Pieman River by Spry and Ford (1957) and Spry (1964). The rocks are petrographically similar but it is questionable whether the amphibolite is continuous between exposures noted in the Rocky River area and the Pieman River.

Medium- to coarse-grained amphibolite crops out on the north and south banks of the Savage River on traverse H1, approximately 400 feet west of the baseline (fig. 3); on the track from the central area down to the river (fig. 4); and on the track north of the river. Exposures of weathered, medium-grained amphibolite have been mapped on track sections mainly by textural differences when compared with the structureless weathered form of the fine-grained amphibolite. The best evidence of more coarsely textured amphibolite was obtained in diamond drillholes Nos. 3-8, 14-16, 18 and 20 from core intersections of medium- and coarse-grained amphibolite within the mass of fine-grained amphibolite (fig. 21). Dimensions of the more coarsely textured amphibolite bodies are variable from bands a few inches thick up to a maximum core intersection of about 220 feet in drillhole No. 14. The detailed maps of the central and northern areas (figs. 3, 4) show the inferred geological boundaries of the medium- to coarse-grained amphibolite from core intersections. The boundaries on surface are not generally evident, except in a few places.

Certain diamond drill cores of the grey-green medium- to coarse-grained amphibolite show a dolerite texture. Magnetite content, like that in the fine-grained amphibolite, is variable. Strongly magnetic sections may alternate with those showing feeble magnetism or none at all.

In thin sections the mineral assemblage consists of chlorite, actinolite, epidote, albite, sphene, quartz, magnetite and pyrite, roughly in order of abundance, about the same as in the fine-grained amphibolite but the schistose structure and equigrained texture is less marked. In slide 64-92 epidote and chlorite are in roughly equal amount and make up 70 to 80 per cent of the slide. Actinolite has been mostly converted to chlorite but residual blades and needles are still evident. Simple twinning resembling carlsbad twinning is present in a few feldspar crystals, commonly filled with inclusions. Epidote is present as granular aggregates up to 1 mm in size. Sphene is present in grains or dark clustered aggregates, and granular clusters surround magnetite crystals in slide 64-94. Magnetite and pyrite are sparse but show well-developed crystal outlines. The average size of the opaque minerals is 0.1 mm.

Three different types of contact between fine and more coarsely textured amphibolite have been noted:—

(i) The transition between the two amphibolite rock types is abrupt and in places discordant where the contact is a plane in the core along which the core readily splits. A contact such as this appears to be intrusive but the medium- to coarse-grained amphibolite which would be the intrusive rock does not show chilled margins.

(ii) The contact between the amphibolite rock types is sharp but not separated by a well-defined plane. The crystals are intergrown at the contact, and the core does not split readily along the plane. This type of contact may result from the injection of a magma into an igneous mass of similar composition still partially fluid. Thin section study of one contact did not yield information on the origin or relative age of the rock types, because alteration was too great.

The sharp contacts described in (i) and (ii) between the differently textured amphibolite rock types are preserved in relatively few drill cores. Commonly the core has been broken and ground away by the rotation of the drill bit or the contacts have been sheared and converted into schist zones.

(iii) The change from fine-grained amphibolite is gradational. In many places progressive change of rock type over a continuous distance ranging from about 5 feet to 20 feet suggests formation in place without successive injection. The chemical analysis of medium-grained amphibolite (cf. Table 2) does not show any marked increase in salic constituent or decrease in femic constituent when compared with analyses of fine-grained amphibolite. Not much compositional differentiation has occurred.

Transition of the contact of type (iii), from fine-grained amphibolite into medium-grained amphibolite, is seen in the core from drillholes Nos. 3, 4, 5, 7 and 8. Sharp contacts described in (i) and (ii) above can be seen in medium- to coarse-grained amphibolite core from drillhole No. 7, intersected at a depth between 175 and 228 feet. The upper contact (at 175 feet) is intrusive into fine-grained amphibolite and corresponds to type (i). Narrow bands of fine-grained amphibolite which alternate over a distance of about 2 feet with more coarsely textured amphibolite bands constitute the lower contact and correspond to type (ii).

The textural and structural variations of the three types of contact suggest that the more coarsely textured amphibolite formed largely in place but intruded some parts of the fine-grained magma which had crystallized more rapidly.

ORIGIN OF AMPHIBOLITE

The origin of the amphibolite is of importance when considering the source of the magnetite, and must influence any theories of ore genesis proposed for the deposits. It has been suggested to me that amphibolite is a metamorphosed sedimentary rock and that magnetite, associated with amphibolite, might be derived from sediments.

The writer believes the amphibolite to be a metamorphosed igneous rock for the following reasons:—

(i) The lithology and form of field exposures of amphibolite are quite distinct from that of the Whyte Schist: amphibolite outcrops are generally massive but the meta-sediments are highly schistose.

(ii) Microscopic study of thin sections shows that banding of quartz and feldspar in Whyte Schist is ubiquitous and that quartz augen and albite porphyroblasts have formed in the rock.

The fabric in amphibolite is not layered or banded, and quartz augen and feldspar porphyroblasts have not formed in these masses during metamorphism.

(iii) Amphibolite and adjacent meta-sediments have the same metamorphic grade, but the meta-sediments do not contain amphibole. Actinolite and tremolite in amphibolite clearly show retrogressive metamorphism by alteration to chlorite but metamorphism in the meta-sediments is progressive.

(iv) The transition from fine-grained amphibolite into medium- and coarse-grained amphibolite is gradual, or sharp, discordant, and typical of igneous intrusion.

(v) The bodies of amphibolite are concordant with Whyte Schist in the Savage River-Rocky River region, but Spry (1964, p. 24) recorded some which are discordant to the foliation of the Whyte Schist.

The writer concludes from the foregoing evidence that the amphibolite has been derived from igneous rocks.

The intrusive or extrusive nature of the magma has not been established. The amphibolite is very fine-grained, which suggests that the original rock may have been extrusive, but pillow lava, amygdaloidal and vesicular rock, flow banding or other features associated with extrusive rocks have not been seen.

A narrow sheet of amphibolite concordant with the adjacent sedimentary schist is exposed in a creek in the Long Plains South-Brown Plains deposit at 6500N, 3000E (approx.) (fig. 6).

Larger bodies of amphibolite can be seen in Magnetite Creek (central Savage River area); on traverses 9000S and 10000S west of the baseline in the southern area (fig. 5); and in the Long Plains South-Brown Plains deposit (fig. 6). Elsewhere amphibolite is emplaced as wide belts of rock, which show neither intrusive nor extrusive rock structures. Meta-sediments adjacent to amphibolite bodies are not contact-metamorphosed and altered to hornfels-type rock; therefore a low temperature for the igneous rock is inferred.

CORRELATION AND AGE OF AMPHIBOLITE

Chemical composition

Table 1 lists the chemical analyses of "older" (Lower) and "younger" (Upper) Precambrian rocks from Tasmania. Analyses of amphibolite from the Savage and lower Pieman Rivers and of Cambrian basic lavas are given in Table 2 to show the chemical affinities of rock types from different regions, which may aid in correlating the igneous rocks.

TABLE 1

	1	2	3	4	5	6	7	8	9
SiO_2	48.48	41.16	43.16	50.92	36.32	44.78	44.44	54.64	48.38
Al_2O_3	15.68	15.94	16.12	16.83	5.39	13.44	17.97	15.22	14.52
Fe_2O_3	3.92	2.57	2.89	1.11	7.34	2.41	1.74	1.17	5.87
FeO	10.98	18.35	14.86	9.78	4.83	16.22	8.32	7.81	9.21
MgO	5.72	4.21	5.89	7.99	32.08	7.01	4.74	5.39	5.07
CaO	8.37	12.12	10.22	9.87	2.90	9.12	9.42	7.96	7.20
Na_2O	2.47	1.17	1.63	1.15	0.08	1.65	2.86	1.69	2.22
K_2O	1.17	0.21	0.32	1.12	0.03	0.47	3.04	2.23	1.50
H_2O-	0.10	0.04	0.18	0.14	0.58	0.07	0.26	0.02	0.49
H_2O+	1.42	2.31	2.68	0.96	9.67	1.58	3.53	2.85	3.40
MnO	0.21	0.32	0.24	0.18	0.15	0.36	0.22	0.13	0.18
TiO_2	0.80	2.00	2.00	0.60	0.10	2.81	3.00	0.68	2.20
P_2O_5	Nil	0.18	0.12	0.02	Nil	0.40	0.72	0.10	0.22
FeS_2	....	....	....	....	....	....	....	....	....
Cr_2O_3	....	....	....	....	0.45	....	....	....	....
CO_2	....	....	....	....	....	....	....	....	....
	99.32	100.58	100.31	100.67	99.92	100.32	100.26	99.89	100.46

Older Precambrian Igneous Rocks (Spry 1962, p. 280-281)
Analyst, W. St. C. Manson

1. Amphibolite, hornblende-rich; lower Forth River
2. Amphibolite, garnet-rich; lower Forth River
3. Amphibolite, Kelly Basin, Port Davey, No. 4956
4. Eclogite, Lyell Highway, No. 5851
5. Tremolite-chlorite schist; lower Forth River
6. Amphibolite, Raglan Range

Younger Precambrian Igneous Rocks (Spry 1962, p. 280-281)
Analyst, W. St. C. Manson

7. Coarse dolerite (Cooee), Burnie, No. 4864
8. Dolerite (Cooee), Detention River, No. 4861
9. Dolerite (Interview River Dyke Swarm), Pieman River

In tentatively correlating the amphibolite from the Savage River as Cambrian in age, the Na_2O : K_2O ratio and Na_2O per cent composition are figures which have been used as an index. This amphibolite (excluding No. 10 which is greenschist) is comparable with amphibolite from the lower Pieman area in having a Na_2O content greater than 2.5 per cent and the Na_2O : K_2O ratio greater than 5 : 1 (except for assay No. 11). The maximum Na_2O content is 3.3 per cent in the amphibolite from the Savage River and 4.99 per cent in that from the lower Pieman River. The maximum Na_2O : K_2O ratio for these rocks is 30 : 1 and 40 : 1 respectively.

Analyses of Cambrian basic igneous rocks (two only are shown as examples) most closely resemble analyses of amphibolite from the Savage River, Whyte River and Pieman River areas. The Na_2O content in most assays is greater than 2.5 per cent and the Na_2O : K_2O ratio is generally greater than 5 : 1.

TABLE 2

	10	11	12	13	14	15	16	17	18
	Savage River				Lower Pieman			Cambrian Basic	
SiO_2	36.82	48.12	49.12	48.02	49.20	62.64	48.38	50.01	48.35
Al_2O_3	12.64	13.76	12.81	12.73	13.59	13.87	11.52	15.38	16.82
Fe_2O_3	4.51	3.70	6.19	3.77	2.78	1.18	7.05	4.86	2.85
FeO	9.24	8.95	7.42	11.19	10.98	3.17	7.15	9.21	10.21
MgO	20.91	7.66	6.93	6.93	6.66	6.33	7.11	5.85	4.46
CaO	5.86	9.68	9.40	8.42	8.13	6.16	7.10	6.35	9.55
Na_2O	0.61	2.50	3.30	3.00	3.18	4.99	4.43	4.77	3.78
K_2O	0.05	0.56	0.60	0.10	0.08	0.93	0.30	0.40	0.42
H_2O-	0.10	0.11	0.16	0.13	0.05	Nil	0.06	0.23	0.32
H_2O+	7.65	2.95	2.60	3.07	3.28	1.12	2.50	2.60	2.32
MnO	0.17	0.20	0.19	0.32	0.21	0.11	0.22	0.21	0.10
TiO_2	1.15	1.44	1.34	1.66	1.63	0.10	2.02	0.73	0.78
P_2O_5	0.11	0.14	0.12	0.19	0.21	Nil	0.12	0.09	N.D.
FeS_2	....	....	....	....	....	....	2.00	....	....
Cr_2O_3	Nil	Nil	Nil	....	....	....	....	....	....
CO_2	Nil	Nil	Nil	0.20	....	....	....	0.13	....
	99.82	99.77	100.18	99.73	99.98	100.60	99.96	100.82	99.96

Amphibolite, Savage River
Analyst, W. St. C. Manson.

10. Greenschist. DDH.4. 650-652 feet
11. Fine-grained amphibolite. DDH.14. 399-402½ feet
12. Medium-to coarse-grained amphibolite. DDH.14. 494-495½ feet
13. Fine-grained amphibolite. Savage River, above bridge

Amphibolite, Lower Pieman-Whyte River (Spry 1962, p. 280-281)
Analyst, W. St. C. Manson

14. Amphibolite, Lower Pieman
15. Amphibolite, Rocky-Whyte River junction No. 5795
16. Glaucophane amphibolite, Lower Pieman River

Cambrian Basic Lavas
Analyst, B. Scott.

17. Spilite, King Island (Scott, 1951)
18. Spilite, Grooms Slip (Scott, 1952)

The chemical analyses of "older" and "younger" Precambrian rocks listed in Table 1 show, by contrast, that the Na_2O content in the "older" Precambrian rocks does not exceed 2.5 per cent and the Na_2O : K_2O ratio is less than 5 : 1. The Na_2O per cent is variable in "younger" Precambrian rocks but the Na_2O : K_2O ratio is consistently less than 5 : 1. In assays Nos. 7 and 8 the K_2O per cent is in fact greater than the Na_2O per-cent.

Though Spry (1962) tentatively assigned an older Precambrian age to amphibolite within the Whyte Schist, the writer suggests a Cambrian age, based on similarities of chemical composition in these and other Tasmanian igneous rocks. However, the degree of alteration of amphibolite compared with these rocks makes the correlation uncertain.

Mineralogy and texture

Textural differences of "younger" Precambrian dolerite, and amphibolite in Whyte Schist would appear to preclude correlation of the two rock types. Spry (1962, p. 256) identified the mineral assemblage of intrusive doleritic dykes as actinolite, chlorite, albite, epidote, prehnite, &c., which is similar to the amphibolite from the Savage River, but rock textures are notably different. The "younger" Precambrian dolerite dykes still retain their original textures whereas amphibolite in Whyte Schist has been recrystallized, the igneous texture destroyed, and a metamorphic structure imposed.

The mineral composition of igneous rock attributed to the "older" Precambrian may represent a higher metamorphic grade of these rocks and denote a greater age. Garnet and pyroxene have been identified (Spry, 1957b, 1958) and distinguish this amphibolite from the Savage River type.

Thus the amphibolite in the Whyte Schist cannot be correlated with "younger" Precambrian on textural evidence nor is it similar mineralogically to some "older" Precambrian rocks reported from Tasmania. Chemically the amphibolite may be related to Cambrian basic igneous rocks.

Magnetic anomalies

The regional aeromagnetic contours of the northern area of the map sheet indicate that the minimum value in gammas over amphibolite is much the same as the value over the ultrabasic complex and serpentinite at Bald Hill. Correlation of amphibolite with the Cambrian complex at Bald Hill is tenuous on this evidence, but Reid (1921), in describing this complex, noted that magnetite was ubiquitous, and segregated in blebs and streaks in one specimen of pyroxenite. Upstream from the Savage River deposit magnetite is obtained in every pan concentrate of river sediment. Pebbles and boulders of magnetite are seen as far up the river as the diversion tunnel at Burnt Spur. The pebble and boulder magnetite very probably came from Nineteen Mile Creek which drains an area of ultrabasic rocks and is a tributary of the Savage River. The equal abundance of magnetite boulders and pebbles in the Savage River channel above and below the intersection of the lode indicates that magnetite must also be concentrated in the Cambrian ultrabasic rocks and serpentinite. This fact is stated as further evidence of a possible correlation of the amphibolite at Savage River with the Cambrian ultrabasic suite at Bald Hill.

Alteration

The alteration of amphibolite involving albitization, chloritization, carbonation and silicification adjacent to or near the magnetite bodies is characteristic of Cambrian lavas and igneous rocks elsewhere in Tasmania.

Age

The similarity of amphibolite to Cambrian igneous rocks in chemical composition, alteration, and magnetic anomaly, and the difference of amphibolite from Precambrian igneous rocks in texture, mineralogy and chemical composition is not conclusive evidence of the Cambrian age of the amphibolite when these characteristics are compared individually. However, the overall similarities and differences do suggest a Cambrian age for the amphibolite.

METASOMATIC AMPHIBOLITE SCHIST

Wall rock alteration of amphibolite and greenschist within the zone of the deposit intersected by diamond drilling in the central and northern Savage River areas (fig. 21) has resulted in rocks which have been classified as carbonate greenschist (and amphibolite), quartz-feldspar-(carbonate) amphibolite schist and carbonate rock, all of which are here included under the general heading of metasomatic amphibolite schist. The limits of metasomatized rock have been drawn to show the extent of alteration, but variable thicknesses of unaltered amphibolite and greenschist are included within the rock type.

The metasomatized zones are best revealed in the drill core, from which their geological boundaries are represented by projection to surface on maps of the northern and central areas (figs. 3, 4). Drilling ceased in many of the holes in the central area shortly after penetrating the altered rocks situated 200-300 feet west of the line of the deposits, consequently the width of these is unknown. Metasomatized rock in the northern area trends almost parallel to the deposit on the western side from the Savage River to traverse D18A (fig. 3). The trend apparently crosses that of the magnetite between traverses D18A and D34A because altered rock has been recorded from drillholes Nos. 1 and 2 on the eastern side of the deposit. The width of metasomatized amphibolite ranges from 20 feet to 400 feet (approx.).

Carbonate Greenschist and Amphibolite

Carbonate greenschist in hand specimen is distinctly schistose. Magnetite and pyrite are disseminated along the schistosity in places. Calcite (or dolomite) is aligned parallel to the schistosity in streaks, lenses and films.

The petrology is much the same as that described for greenschist but calcite grains 0.1-0.3 mm in size replace chlorite and in section (64-86) are bordered by an alteration to talc about 0.1 mm wide. Under the microscope the schistosity is seen to be crenulated in one or two thin sections.

Amphibolite altered by carbonate metasomatism shows in thin section that amphibole and chlorite of the groundmass are preferentially replaced by carbonate.

Quartz-feldspar-(carbonate) Amphibolite Schist

This is a banded rock in hand specimen, the individual bands generally up to an inch in width, composed of quartz, feldspar and a carbonate, and separated by greenschist layers of approximately the same width. Carbonate (calcite) is interstitial to the quartz and feldspar in some rocks.

Thin sections of the rock under the microscope show layers consisting dominantly of quartz and feldspar aggregates, alternating with layers consisting of chlorite, actinolite, sphene and epidote. Amphibole may be completely altered to chlorite or remain only as vestigal crystals. The quartz, feldspar and carbonate minerals form a granulose structure, in which the feldspar (albite-oligoclase) may be carlsbad- and albite-twinned, or untwinned. The feldspar does not generally contain inclusions; where inclusions are present they consist of chlorite or calcite in a disordered arrangement. Sphene and epidote occur mostly in the chlorite-amphibole layers. Magnetite and pyrite are equally dispersed through the rock or they may be concentrated in the dark, chlorite-rich bands.

Thin section study of the feldspar in these rocks indicates differences from the feldspars of unmetasomatized amphibolite and meta-sediments, which show less twinning of the crystals or crystals commonly containing inclusions in an ordered arrangement which may be parallel or transverse to the schistosity. These differences suggest a later origin for the banded quartz-feldspar aggregate because metamorphism and recrystallization of the constituent feldspar is not so intense.

The maximum core width of metasomatized amphibolite is 470 feet in drillhole No. 25 (fig. 21).

Carbonate Rock

The occurrence of carbonate rock (mainly magnesium-rich "dolomite", also calcite and magnesite) with magnetite bodies, or in close proximity to them in the Savage River area, Long Plains South-Brown Plains area, and the Rocky River area indicates that the formation of carbonate rock is associated in some way with iron mineralization.

Carbonate rock (mostly "dolomite") is exposed along the bed of the Savage River between traverse C28D and the bridge (fig. 3), in scattered outcrops upstream from the bridge for about 1,400 feet, and in the end of Halls Creek adit over a length of 35 feet (fig. 10). Dolomite was also intersected by drillhole No. 14 between 257 feet and 278 feet, 282 feet and 285½ feet, 302½ feet and 303 feet, and 439 feet to 442 feet.

Exposures of dolomite in the river below the bridge are irregular in size and shape. An outcrop about 25 feet wide on the northern bank supports the bridge. Highly talcose schist separates this outcrop from one a little farther up the road which is 25 feet wide and 10 feet high. Dolomite in the river section below the bridge is greyish-white, fine- to coarse-grained, talcose and sheared. In places the rock is seamed with talc to such an extent that the rock becomes a dolomitic talc schist. In Halls Creek adit a transition can be seen from dark greenschist, through yellowish talc dolomite schist, into white finely crystalline carbonate rock.

Thin section study of fine-grained dolomite from the adit shows that grain size is variable (0.1-0.5 mm in slides 64-97 and 64-99); crystals are subhedral to euhedral and twinned parallel to both diagonals in a few crystals. Fine-grained recrystallized aggregates occupy zones of micro-shearing. Schistose structure is imparted by talc streaks and bands up to 2 mm wide, or talc may be in veinlets or disseminated in the interstices between carbonate crystals.

Sheared dolomite in the adit is separated from medium grade ore by a major shear zone up to 1 foot wide (fig. 10). An assay (analyst W. St. C. Manson) of carbonate rock from Halls Creek adit showed the percentage composition as:—

SiO_2	Fe_2O_3	CaO	MgO	CO_2	Total
5.39	2.54	25.6	22.5	43.5	99.53

Dolomite intersected in the boreholes is white or faint pink and fine-grained. Under the microscope chlorite is seen as wisps in the carbonate matrix, and magnetite appears to replace carbonate. Core contacts are not well preserved but dolomite is associated with magnetite or carbonate greenschist, or separates fine and more coarsely textured amphibolite.

Dolomite is exposed in narrow vertical lenses and bands in schistose amphibolite at three different sites upstream from the bridge. The most clearly observed outcrop is in the river between traverses D9A and D4 (fig. 3) where the contact of dolomite and amphibolite is exposed in the rocky channel. The dolomite forms a 20 feet wide band parallel to the schistosity of the amphibolite host rock. The eastern contact is exposed in the rock bank but the western contact is below water. The transition from foliated amphibolite into dolomite is evident over 5 feet, from hard amphibolite into soft carbonate greenschist containing augen of dolomite about 3 mm long aligned in the schistosity. The carbonate greenschist changes imperceptibly into talc schist which forms a selvage up to 12 mm thick at the dolomite contact. The outer zone of dolomite is very irregular and typical of schistose amphibolite which has been invaded, replaced and assimilated by carbonate rock. Lenses, pods and irregular pockets of dolomite ranging in size from one or two inches up to 2 feet in length are embodied in a talcose schist matrix and constitute a sharply defined eastern contact (Pl. 5). The bodies coalesce over a distance of about 2 feet from the contact to form the 20 feet wide dolomite zone, which is free from altered amphibolite but carries irregular ridges and masses of opaline silica.

The chemistry of the change from amphibolite into dolomite is not fully understood. Bain (1924) indicated the reactions which take place between ferromagnesian minerals and solutions containing water, silica and carbon dioxide to form replacement magnesite deposites, e.g.—

$$\underset{\text{forsterite}}{9(MgO)_2SiO_4} + 3SiO_2 + 12H_2O = \underset{\text{serpentine}}{6H_4Mg_3Si_2O_9}$$

$$6H_4Mg_3Si_2O_9 + 3CO_2 = 3MgCO_3 + 5H_4Mg_3Si_2O_9 + 2SiO_2 + 2H_2O$$

$$3MgCO_3 + 3CaCO_3 = \underset{\text{dolomite}}{3(CaCO_3 . MgCO_3)}$$

Possibly similar reactions between ferromagnesian minerals of greenschist in shear zones of the amphibolite and solutions containing carbon dioxide and water were not carried to completion and resulted in the replacement dolomite deposits of the Savage River.

Dolomite rock in the Savage River, and in core from drillhole No. 14 indicates a zone about 200 feet wide and 1,800 feet long in which irregular bodies and lenses of dolomite occur sporadically (fig. 3). The zone lies 600 feet on the eastern side of the magnetite deposits and is parallel to the trend.

The small lenses of dolomite in the core of drillhole No. 14 represent the southern extent of the rock, beyond which it has not been traced on the surface or from the core of holes drilled in the central area. Dolomite in Halls Creek adit does not lie within the dolomite zone and may be an isolated lens adjacent to the magnetite orebody.

Metasomatic alteration into quartz-feldspar amphibolite schist or carbonate greenschist is not evident in the core of drill-hole R.T.A.E.1 in the Long Plains South-Brown Plains deposit, but dolomite was intersected in the end of the hole.

The broad boundaries of metasomatized rock (quartz-feldspar-carbonate amphibolite schist) in the Rocky River area are shown in fig. 7. The green sedimentary schist is also altered (silicified and feldspathic) in a few places.

A thin band of dolomite 2-3 feet wide is exposed on the western bank of the Rocky River about 20 feet upstream from the junction with Nolan Creek. The occurrence, localized in a zone of schistosity in amphibolite, is similar to dolomite in the bed of the Savage River and presumably originated in the same way.

CATACLASITE IN THE ROCKY RIVER AREA

Sheared, metamorphosed, fine- to medium-grained rock described as cataclasite crops out in the Whyte and Rocky Rivers (fig. 7). The greyish-white crystalline rock to the west of the mineralized belt is a regionally conformable dyke-like body 100-200 feet wide, separating amphibolite and silvery-grey lustrous schist belonging to the Whyte Schist.

The rock is difficult to trace in the area between exposures in the main river channels because of vegetation and overburden. A friable, decomposed igneous (?) rock exposed in the section of the water race between the centre line and line 8S (fig. 7) is thought to be an altered equivalent of the cataclasite, but the weathered form of the rock may be misleading.

In thin section the mineral assemblage consists of feldspar (oligoclase-andesine), quartz, amphibole, epidote, chlorite, muscovite and sphene. Feldspar constitutes about 80 per cent of the rock in grains up to 2 mm in size. The rock is sheared, but not markedly schistose. The matrix consists of a fine-grained, equigranular recrystallized aggregate of feldspar and quartz showing undulose extinction. Amphibole (probably actinolite) constitutes 10 to 20 per cent of the rock as unoriented elongate crystals partly altered to chlorite in the matrix of the rock. The plagioclase feldspar shows albite- and carlsbad-twinning and contains many small rod-like inclusions of a high relief mineral (actinolite?) aligned parallel to the albite twin plane, and concentrated in the centre of a few feldspar crystals, suggesting that the crystals may be zoned. Muscovite and clusters of sphene are accessory minerals. The mineral composition indicates that the original rock may have been a quartz diorite.

The contacts of cataclasite with amphibolite are not clearly exposed, but the rock forms a narrow bar across the Whyte River and a waterfall about 5 feet high in the Rocky River. The cataclasite crops out as irregular discordant bodies in the fine-grained amphibolite, but no visible textural, structural, or mineralogical changes near the contacts indicate that the rock is intrusive.

The cataclasite is possibly equivalent in age to rocks described by Nye (1923) from an area in the vicinity of Bald Hill between the Heazlewood and Whyte Rivers where syenite and diorite dykes intrude the ultrabasics and their serpentinized derivatives. Nye assigned a Devonian age to all these rocks, but the ultrabasic rocks are now considered to be Cambrian. Gabbroic rocks in the Waratah district described by Groves and Solomon (1964, p. 9) have a similar mineral assemblage and have been classed as Cambrian.

The three metamorphosed and igneous rock types represented in the Cambrian, viz. ultrabasics and serpentinite at Bald Hill, amphibolite in the Savage River-Rocky River region, and cataclasite (quartz diorite?) in the Rocky River deposit, may represent successive intrusive stages in the differentiation of a subterranean basic or ultrabasic magma reservoir. The age and space relationship of the ultrabasic complex and amphibolite is not clear, but cataclasite is discordant and apparently intrusive into amphibolite in the Whyte and Rocky Rivers. Nye (1923, p. 40, 41) reported dykes of syenite and diorite intruding ultrabasic rock and serpentinite of the Bald Hill complex. The cataclasite may therefore represent a late stage of differentiation.

MEREDITH GRANITE

The Meredith Granite boundary has been represented on the map sheet to the east of the Whyte River (fig. 2), but the field mapping of this rock unit was prevented by lack of access. The granite stock of the Meredith Range crops out over an area of about 120 square miles, extending from Parsons Hood in the south to within two miles of Waratah (Groves and Solomon, 1964, p. 11). The rock types constituting the stock were described by Reid (1921) as granite, granite-porphyry, aplite and quartz tourmaline.

Near Waratah the rock types are adamellite and associated quartz-feldspar porphyries.

The tin, silver, lead and zinc mineralization in the Waratah district were ascribed by Groves and Solomon (1964) to hydrothermal and pneumatolytic action of the acid igneous rocks. Accessory minerals characteristic of Devonian granite mineralization include fluorite, monazite, topaz, bismuthinite and wolframite, which are not present in the Savage River-Rocky River region.

TERTIARY BASALT

Tertiary basalt forms a plateau in the northern and southern areas of the Savage River deposits (figs. 3 and 5); between traverses 25000N and 29000N to the south of the southern Savage River area (fig. 2); and is exposed in a small belt about 300 feet long on the road to Corinna at the edge of Little Plains. The rock overlies the Henty Surface at an altitude ranging from 750 feet to 1,300 feet. The shapes of the basalt caps are irregular owing to headward erosion of streams draining the flat-lying areas.

Basalt, under the microscope, is seen to consist of euhedral phenocrysts of olivine and augite in a fine-grained groundmass which consists of twinned feldspar laths, augite, magnetite granules, serpentine and possibly tremolite. The augite is fresh, but olivine is altered to iddingsite and serpentine in varying degrees. Pseudomorphs of these alteration products after olivine are noted in some crystals.

Basalt in the northern Savage River area is exposed as a cliff face 12-15 feet high on traverse F7 east of the map area, but thickness decreases over the line of lode where it may be 5 feet thick, and probably decreases northward along the line of lode. In this area, it overlies flat-lying Tertiary gravel, siltstone or mudstone, which may be 3 or 4 feet thick.

In the southern Savage River deposit, basalt occupies the irregular shaped area shown on fig. 2. The eastern boundary is generally indistinct but the western boundary in many places in marked by a change in relief of about 10 feet. The best exposure is seen on traverse 9000S east of the baseline (fig. 5) where the basalt boundary is a scarp face up to 10 feet high. No marked change in topography is apparent west of the baseline on traverse 9000S owing to a gradual decrease in the thickness of the basalt westward along the traverse.

A weak 10,000 gamma magnetic anomaly (corresponding to the mineralized zone) shows up beneath the basalt between traverses 7000S and 8000S west of the baseline.

The dating of Tasmanian basalts is still uncertain but correlation into two main types (Spry, 1962, p. 274) can be made on composition:—

(i) The saturated olivine basalts, or augite-olivine basalts which contain about 50 per cent silica.

(ii) The unsaturated olivine basalts. These are much lower in silica, contain titanaugite and are commonly alkaline.

A comparison of the mineral assemblage and texture of basalt at Savage River with types (i) and (ii) shows that it is similar to a saturated olivine basalt at Waratah but it cannot be dated accurately at present, except that it is earlier than Upper Pleistocene when the Henty Surface, on which the basalt lies, was dissected (Banks and Ahmad, 1959). Tasmanian basalts include some that are older than Upper Oligocene and others that are younger than Middle Miocene (Banks, 1962, p. 241).

Structure

PRECAMBRIAN ROCKS

Subdivision of the Precambrian in Tasmania generally, and in the Savage River-Pieman River region particularly, is difficult because the metamorphosed and "unmetamorphosed" rocks have a similar range of lithologies and the metamorphic grade is fairly similar. The regional and detailed tectonic styles of Whyte Schist and "unmetamorphosed" Precambrian rock appear to differ.

The metamorphosed sedimentary rocks contain amphibolite and greenschist; the "unmetamorphosed" sedimentary rocks contain basic sills and dykes (Spry, 1962, p. 256). No indisputable unconformity between metamorphosed and "unmetamorphosed" sedimentary rocks has been found in Tasmania, but a thrust plane or fault (inferred in the Savage River-Rocky River region) generally delineates the boundary between the two rock types.

At localities in Tasmania where metamorphosed and "unmetamorphosed" Precambrian rocks are adjacent, the "unmetamorphosed" sedimentary rocks are upper and probably younger. The relationship is obscure in the Savage River area but to conform with previous practice (Burns, 1964) the terms "Lower" and "Upper" have been retained for the metamorphosed and less metamorphosed rocks.

The Whyte Schist trends north from the Rocky River deposit and ranges in strike from N10°W to N20°E (fig. 2). The beds dip steeply to the east at an angle between 70° and vertical. The regional strike changes to a direction about N20°E roughly midway between the southern Savage River deposit and the Long Plains South-Brown Plains deposit, but the steep dip of the rock remains unchanged.

The pelitic and psammitic units of the "Lower" Precambrian Whyte Schist are conformable in exposures of the contact along the access road into the Savage River deposit and along the track north of the Long Plains South-Brown Plains deposit at 16000N, 2000E approx. (fig. 2).

The western boundary of "Lower" metamorphosed Precambrian Whyte Schist with "Upper" less metamorphosed Precambrian Corinna Slate, shown only in the SW corner of the map sheet (fig. 2), is inferred as a fault contact.

Amphibolite rock of Cambrian (?) age is found in the pelitic unit of the Whyte Schist and is generally bounded on the western side by silty sediments of the psammitic unit.

Cataclasite rock separates amphibolite from Whyte Schist on the western side in the Rocky River deposit.

The Problem of the Division of the Precambrian Rocks

One of the unsolved problems in the Precambrian geology of Tasmania is whether the indisputably metamorphosed and relatively unmetamorphosed rocks can be divided into "older" (lower) and "younger" (upper) formations respectively, on differences of metamorphic grade and structural style. Both the indisputably metamorphosed and relatively unmetamorphosed rocks have a similar range of lithologies and an unconformity between them has not yet been found.

SUBDIVISION BY STRUCTURAL STYLES

Spry (1962) distinguished between indisputably metamorphosed "older" Precambrian rocks and relatively unmetamorphosed "younger" Precambrian rocks from different areas of Tasmania on their structural styles. The present writer has applied Spry's criteria to the Precambrian rocks in the Savage River-Rocky River region.

Foliation

According to Spry, one or more foliations are present in the metamorphosed rocks. Most phyllites and schists contain two or three distinct foliations and the bedding is commonly obliterated but the foliation of the "unmetamorphosed" sediments is less marked. Many quartz sandstones do not possess cleavage, and many pelites contain only axial plane cleavage. A bedding plane foliation is present in many rocks.

The present writer observed two distinct foliations in Whyte Schist: a dominant bedding schistosity which is well preserved, and secondary axial plane cleavage more marked in phyllite than silty layers. Corinna Slate is weakly foliated or lacks foliation in argillite.

Bedding

According to Spry, bedding can be recognized in the "unmetamorphosed" sediments by textural and compositional banding. Sedimentary structures are well preserved. In metamorphosed rocks, bedding and lithologic structures are only preserved in structurally protected parts of the rock.

The present writer readily recognized bedding in Whyte Schist by textural and compositional banding. Cross bedding and graded bedding were seen in a few places.

Lineation

Spry stated that lineation in metamorphosed rocks appears as ribbing in quartzite, corrugations of foliation, quartz rods, boudins, fold mullions, parallelism of prisms of hornblende or zoisite, elongate quartz and muscovite, and intersections of foliations. The lineations are parallel or nearly parallel to the axes of minor folds. Some "unmetamorphosed" sediments do not show lineation, others do show it by crenulations, joint drags or by the intersection of axial plane cleavage with bedding.

The present writer has observed lineation in Whyte Schist by elongate quartz pods in the plane of schistosity parallel to the axes of minor folds, by crenulations and corrugations of foliation, and by the intersection of axial plane cleavage with bedding.

Isoclinal Folds

According to Spry, isoclinal folds which range in size from hundreds of feet across down to microscopic dimensions are most distinctive of the metamorphosed rocks. The "unmetamorphosed" sediments generally show rather open concentric folds with radial joints in quartzite and tighter concentric or similar folds in pelite.

The present writer detected isoclinal folds in Whyte Schist on a scale which is restricted to the size of the road cuts where they are exposed. The folds range in size from 2 or 3 feet across down to an inch or less (Pl. 6). Isoclinal folds of much greater wavelength are inferred from photo interpretation of the change of strike area east of the Corinna road (fig. 2).

Microfabric

Spry stated that quartzite in the metamorphosed rocks ranges from massive varieties with crushed, "mortar" texture, to platy rocks composed of flattened and elongated grains. Schist contains rolled garnet porphyroblasts and albite with helicitic structures. In the "unmetamorphosed" Precambrian sediments some quartzite shows crushed texture but most of the quartz grains retain their clastic shape and are bonded by an undeformed silica cement.

The present writer has not seen garnet in rocks from the Savage River-Rocky River region. Albite porphyroblasts do show rotation in certain crystals but in most the lines of inclusions are parallel to the schistosity.

Conclusions

In the Savage River-Rocky River region the tectonic style of the Whyte Schist compared to the tectonic styles of the "older" and "younger" Precambrian of Spry is not distinctive of either one or the other, so that subdivision is uncertain on these criteria. Observation of structural and tectonic style in Corinna Slate ("younger" Precambrian of Spry) is hampered by poor exposure along the Corinna road. The rock does not appear to show the same degree of tectonism as the Whyte Schist. The regional structure of "younger" Precambrian rocks (including Corinna Slate) in the area of the Pieman River between the Whyte River and Pieman Heads consists of open folds and a series of smaller folds which are more complex (Spry 1964, p. 40, fig. 4).

The inferred large scale isoclinal folds and the small scale isoclinal folds in Whyte Schist therefore appear dissimilar to the more open type of folding in the "younger" Precambrian rocks described by Spry from the lower Pieman River.

SUBDIVISION BY REGIONAL METAMORPHISM

Subdivision of the Precambrian has also been suggested on the grade of regional metamorphism. Spry (1962, p. 124) described the Frenchman Orogeny separating the "older" and "younger" Precambrian ". . . as that metamorphic and tectonic event which produced garnet, mica and albite schists". However, Burns (1962, p. 316) suggested that ". . . at least on the North Coast the difference in metamorphic grade and tectonic style may be the result of an early Cambrian deformation along localized shear belts and that the two associations are approximately the same age".

The metamorphic grade of Whyte Schist containing albite porphyroblasts is not distinctly different from some "younger" Precambrian rocks in the area described by Spry (1964, p. 44), who stated that "All belong to the lowest sub-facies of the Greenschist Facies and contain members of the assemblage quartz, albite epidote, chlorite, muscovite, actinolite, magnetite and calcite".

However, in the region indicated by fig. 2 the metamorphic grade of Corinna Slate is apparently lower than that of adjacent Whyte Schist because small irregular grains of albite seen only under the microscope in the rock are not porphyroblastic.

The writer suggests that Precambrian rock in the Savage River-Rocky River region was faulted in the late Precambrian along a line which is the present contact between "Lower" and "Upper" Precambrian rocks. An elongated narrow block, thrust against a larger competent mass of Precambrian rock was more deformed than the adjacent rock. Tectonic style and metamorphic grade characteristic of the Whyte Schist was imposed in the area, possibly by the Penguin Movement which was defined by Spry (1962, p. 124) as the tectonic event in later Precambrian time separating "unmetamorphosed" Precambrian rock from Cambrian rock.

The tectonic style of Whyte Schist has been compared to the general tectonic style of the metamorphosed and "unmetamorphosed" Precambrian rocks in Tasmania. These structural features in the Savage River-Rocky River region are discussed more fully below.

Folding

Small scale inclined isoclinal folds with a wavelength ranging from an inch or less to about 3 feet and an amplitude about twice the wavelength, plunge in opposite directions in road exposures of Whyte Schist in the northern and southern areas of the map sheet (fig. 2), indicating a regional anticlinal structure with an E-W axis.

Isoclinal folds having a greater wavelength and amplitude are inferred but cannot be seen in the small exposures provided by the road cuts.

Secondary axial plane cleavage, parallel to the trend of the Whyte Schist, is related to isoclinal folding. Rarely, in an exposure of interbanded phyllite and siltstone the phyllite displays perfect axial plane cleavage which is lacking in the siltstone unit. The secondary axial plane foliation does not everywhere coincide with the bedding schistosity. The strike of the two foliations may differ by 30° or 40° in some small outcrops which are concluded to represent truncated sections of large scale plunging isoclinal folds.

Lineations in the plane of schistosity such as corrugations, elongate quartz lenses up to 2 inches in size, crenulations of the bedding schistosity (which produce a tectonic ripple-like structure in some quartz-mica schist), and intersections of axial plane cleavage with bedding, reflect the plunge of small isoclinal folds, drag folds, and probably major folds as well. The axes of folds are aligned parallel to the schistosity and general trend of the formation; the plunge of folded rock ranges from horizontal to vertical and is variable over short distances of the road section. Measurements of plunge are not recorded from many exposures away from road sections owing to lack of outcrop.

The small scale isoclinal folding and the inferred larger scale isoclinal folding of Whyte Schist has resulted from E-W compression, probably in the Precambrian. Solomon (1962, p. 317) considered that the structural form and tectonic styles of Precambrian rocks are related to pre-Ordovician movements.

The regional anticlinal structure superimposed on isoclinally folded Whyte Schist along the section of the Corinna road from the 20 mile peg to the 34 mile peg may be an upward bulge due to greater mobility in the central part of the arch during the main folding, or may be the result of the doming of the sediments by granite intrusion after the Devonian Tabberabberan Orogeny because:—

(i) E-W foliation resulting from N-S compression has not been observed in the Whyte Schist.

(ii) The crest of the regional anticlinal flexure-fold lies near the regional change of strike which possibly originated by lateral thrusting aside of sediments by granite.

(iii) A dominantly E-W tensional joint pattern, which dips steeply to the north and south is present in some competent siliceous rock units.

Faulting

The escarpment between "Upper" and "Lower" Precambrian rock may be due to a fault but lack of outcrop makes this difficult to establish.

Faults do not show clearly on aerial photographs and are difficult to observe in the field, probably because many are strike faults. A faulted rock face is exposed on the track in the area between Long Plains South and the southern Savage River deposit at approximately 16000N 2000E (fig. 2; Pl 1).

Two faults and possibly three have displaced the conformable contact between quartz-mica schist of the psammitic assemblage and green schist of the pelitic assemblage. The displacement is 10 feet in the upper fault and 2 feet in the middle fault. The direction of movement is recorded at N45°E. The parallel faults strike N13°E and dip at angles between 50° and 60° to the east. The geometric solution of the pattern of the faults shows that they are reverse faults having a net slip vector with the following measurements:—

Plunge: 36° in a direction N45°E
Rake: 47°
Length: 13 feet
Strike slip: 10 feet
Dip slip: 9½ feet.

The faults at this locality are the only ones in the Savage River-Rocky River region which are so clearly shown and for which the net slip can be defined. Other faults, including the major fault inferred at the contact of "Lower" and "Upper" Precambrian rock, may be similar in type.

Jointing

Joints trending in an easterly direction and dipping steeply to the north and south have been recorded along the Corinna road in sandstone, siltstone and quartz-mica schist of the psammitic Whyte Schist assemblage. Some joints are closely spaced but not associated with any secondary foliation of the rock in the same direction. The joint patterns may have originated by doming of the sediments by granite.

Structural Evolution in Precambrian Rock

The structure of "Lower" and "Upper" Precambrian rock is insufficiently known to allow the formulation of anything more than an idea of the origin. The writer suggests that "Lower" and "Upper" Precambrian rocks were contemporaneous but different facies in the Savage River-Rocky River region, not separated by an orogeny. Isoclinal folds in Whyte Schist were formed by E-W compression and were possibly controlled by major faults which appear to separate "Upper" and "Lower" Precambrian rock. The "Lower" Precambrian Whyte Schist, in the form of a narrow, elongate, downfaulted (?) block, was less competent than the adjoining large block of "Upper" Precambrian rock to the west, which acted as a buttress. Compression, which may have taken place in a series of pulses, imposed the small scale isoclinal folds and inferred large scale isoclinal folds in the Whyte Schist but formed broad open folds in the "Upper" Precambrian rock. Subsequent amphibolite intrusion into the Whyte Schist was apparently controlled by the lithology of the formation or possibly by a major overturned anticlinal or synclinal fold axis. The regional structure was further modified when the Meredith Granite thrust aside and domed the Whyte Schist, causing a regional change of strike and a broad anticline to form on the Corinna road section.

CAMBRIAN (?) AMPHIBOLITE

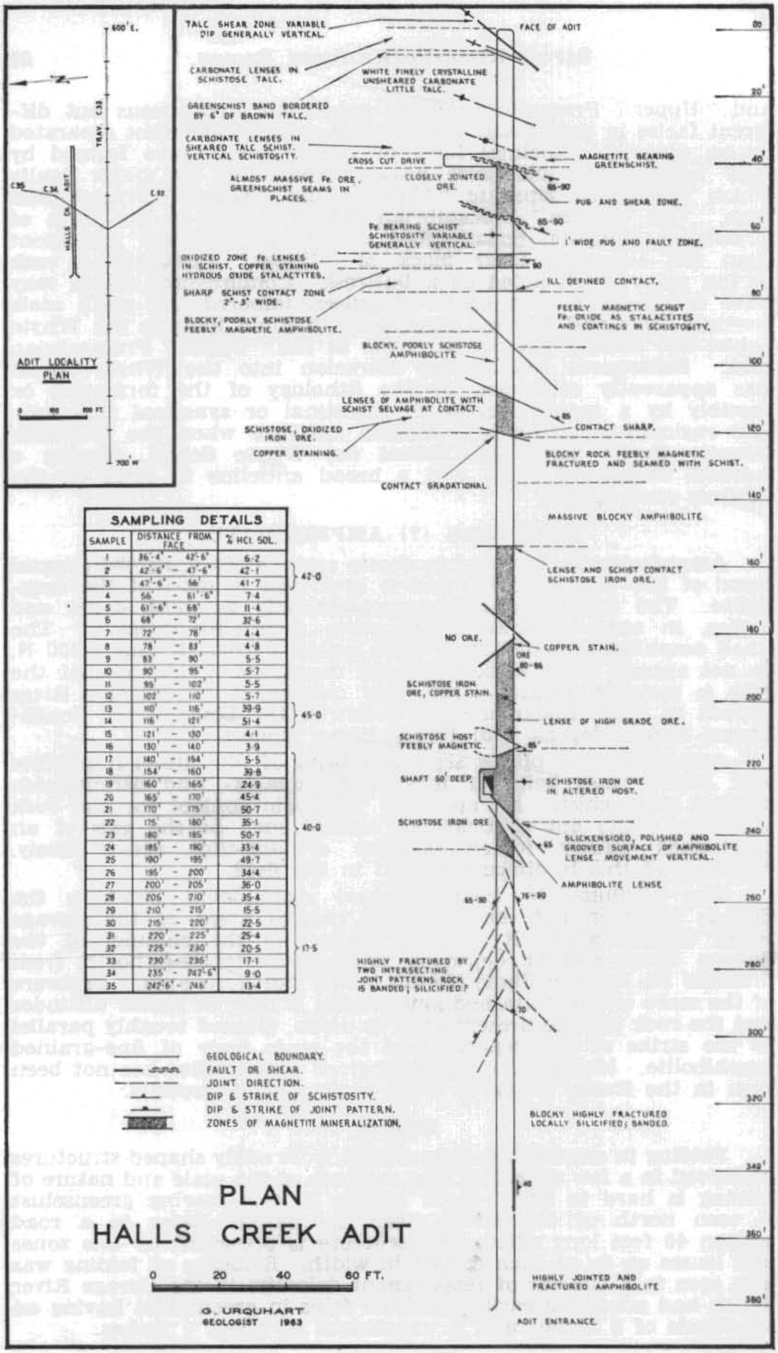
Amphibolite is emplaced in sheets and masses along the general trend of the Whyte Schist, and is host rock to most of the magnetite. The rock is absent, or present only as small dykes and bodies, in areas separating the main magnetite deposits. The small amphibolite bodies, e.g., those between 17000 N and 18000 N, do not appear to be associated with magnetite. Thickness of the rock is variable, from a large body centred on the Savage River deposit to small linear sheeted bodies in the Long Plains South-Brown Plains deposit and Rocky River deposit.

Amphibolite in places separates belts of chlorite-rich phyllite and schist from belts of muscovite-, quartz- and sericite-rich phyllite and schist. An apparent lithologic control for the rock therefore exists but a structural control such as the axis of an overturned tightly folded syncline or anticline seems likely. Evidence of this is difficult to find in the field.

The medium- to coarse-grained amphibolite straddles the Savage River in the northern and central areas of the Savage River deposit where it is best exposed in the channel of the Savage River and at depth in boreholes extending north from drillhole No. 4 to drillhole No. 20 in the northern area. Exposure of the more coarsely grained amphibolite is poor at higher altitudes and the rock may be present only at depth, aligned roughly parallel to the strike of the deposits and the main body of fine-grained amphibolite. Medium- to coarse-grained amphibolite has not been seen in the Rocky River or Long Plains South deposits.

Folding

Folding in amphibolite is suspected from oddly shaped structures preserved in a few cores but field evidence of the scale and nature of folding is hard to find. Open folding in talc-bearing greenschist is seen north of the bridge over the Savage River in a road section 40 feet long where the structure is preserved by talc zones and lenses up to an inch or two in width. Evidence of folding was also seen in a boulder of replacement dolomite in the Savage River which had preserved earlier isoclinal folds in greenschist having an amplitude of 6 inches and a wavelength of about 4 inches.



SAMPLING DETAILS

SAMPLE	DISTANCE FROM FACE	% HCL SOL.	
1	36'-4" - 42'-6"	6·2	
2	42'-6" - 47'-6"	42·1	42·0
3	47'-6" - 56'	41·7	
4	56' - 61'-6"	7·4	
5	61'-6" - 68'	11·4	
6	68' - 72'	32·6	
7	72' - 78'	4·4	
8	78' - 83'	4·8	
9	83' - 90'	5·5	
10	90' - 95'	5·7	
11	95' - 102'	5·5	
12	102' - 110'	5·7	
13	110' - 116'	39·9	45·0
14	116' - 121'	51·4	
15	121' - 130'	4·1	
16	130' - 140'	3·9	
17	140' - 154'	5·5	40·0
18	154' - 160'	39·8	
19	160' - 165'	24·9	
20	165' - 170'	45·4	
21	170' - 175'	50·7	
22	175' - 180'	35·1	
23	180' - 185'	50·7	
24	185' - 190'	33·4	
25	190' - 195'	49·7	
26	195' - 200'	34·4	
27	200' - 205'	36·0	
28	205' - 210'	35·4	
29	210' - 215'	15·5	17·5
30	215' - 220'	22·5	
31	220' - 225'	25·4	
32	225' - 230'	20·5	
33	230' - 235'	17·1	
34	235' - 242'-6"	9·0	
35	242'-6" - 246'	13·4	

FIGURE 10.

5 cm

Folding in the rocks indicates that deformation occurred after schistosity had been imposed.

Irregular terminations of ore zones between traverses 500 S and 1000 S in the central area (fig. 4) between traverses C1 and CX near the Savage River and between traverses D14A and D18A in the northern area (fig. 3) suggest that fold structures in greenschist (and faulting?) might account for the broad, non-linear patterns of the magnetic anomalies over these areas.

A 4 inch long piece of core from drillhole R.T.A.E.1 in the Long Plains South area shows a band of magnetite localized by a pre-existing isoclinal fold structure in the schistose host rock.

Faulting

Brecciated fault zones or faults of large displacement have not been recorded in amphibolite. Slickensides indicative of movement between adjacent zones of competent amphibolite and incompetent greenschist are exposed in Halls Creek adit (fig. 10) and were seen in serpentinized planes in the drill core. Displacements of any magnitude show as mylonitized zones or shear zones along which carbonate rock is formed in places, e.g., dolomite in the face of Halls Creek adit and in the Savage River upstream and downstream from the bridge. An E-W fault is inferred in the northern area between traverses D14A and D18A (fig. 3) to account for the termination of mineralization south of the inferred fault, and for the change in attitude of mylonite schist from a northerly to an easterly direction.

Weathered silty schist crops out to the east of drillhole No. 25 (fig. 3) but cannot be traced on traverses to the south of D18A, possibly because of a fault displacement.

Brecciation and shearing of dolomite in the Savage River below the bridge indicate dislocation along a line which trends north, parallel to the magnetite deposits. This is one of the few places where evidence of rupture can be seen.

Blocks of silicified and brecciated ferruginous rock lie on the track to Long Plains about 400 feet north of the basalt knoll (fig. 4). A fault in this locality may account for the abrupt decrease in width of the mineralized zone south of Magnetite Creek, but a traverse of the creek did not prove a fault to exist. Exposure of faults in the central and northern areas is too scanty for conclusions to be reached about their directions, displacements or relative ages.

Post-ore dislocation and deformation as shears and faults in magnetite are seen in the adits (figs. 10 to 13). The minor dislocations trend in a northerly direction parallel to the line of the deposits. In Halls Creek adit (fig. 10) a 15 feet wide ore zone at the crosscut is a faulted block bounded by two near vertical shear zones about 1 foot wide.

Jointing

Certain exposures of amphibolite are highly cross-jointed, e.g., where medium-grained amphibolite and fine-grained amphibolite crop out together in the Savage River. The attitude of joint patterns recorded by compass is unreliable in the area where magnetism is great. Vertical jointing in an easterly direction was recorded below Halls Creek, and in a northerly direction upstream

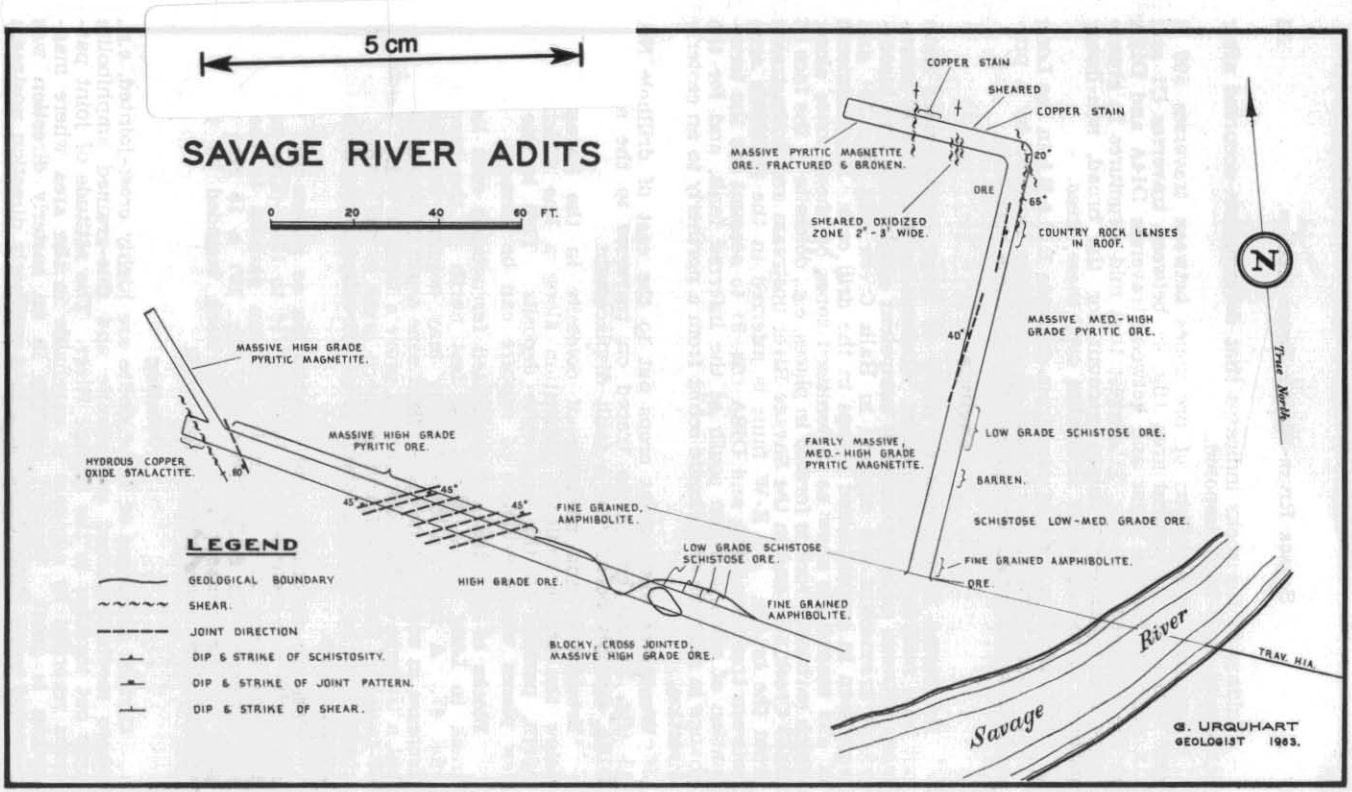

5 cm
SAVAGE RIVER ADITS
0
20
40
60 FT.
COPPER STAIN
SHEARED
COPPER STAIN
MASSIVE PYRITIC MAGNETITE ORE. FRACTURED & BROKEN.
20°
ORE
65°
SHEARED OXIDIZED ZONE 2" - 3' WIDE.
COUNTRY ROCK LENSES IN ROOF.
N
MASSIVE MED.- HIGH GRADE PYRITIC ORE.
40°
True North
MASSIVE HIGH GRADE PYRITIC MAGNETITE.
LOW GRADE SCHISTOSE ORE.
MASSIVE HIGH GRADE PYRITIC ORE.
FAIRLY MASSIVE, MED.- HIGH GRADE PYRITIC MAGNETITE.
HYDROUS COPPER OXIDE STALACTITE.
80°
BARREN.
45°
45°
45°
FINE GRAINED, AMPHIBOLITE.
SCHISTOSE LOW-MED. GRADE ORE.
LEGEND
LOW GRADE SCHISTOSE SCHISTOSE ORE.
FINE GRAINED AMPHIBOLITE.
GEOLOGICAL BOUNDARY
HIGH GRADE ORE.
ORE.
SHEAR.
FINE GRAINED AMPHIBOLITE.
JOINT DIRECTION
River
BLOCKY, CROSS JOINTED, MASSIVE HIGH GRADE ORE.
TRAV. HIA.
DIP & STRIKE OF SCHISTOSITY.
DIP & STRIKE OF JOINT PATTERN.
DIP & STRIKE OF SHEAR.
Savage
G. URQUHART
GEOLOGIST 1963.

FIGURE 11.

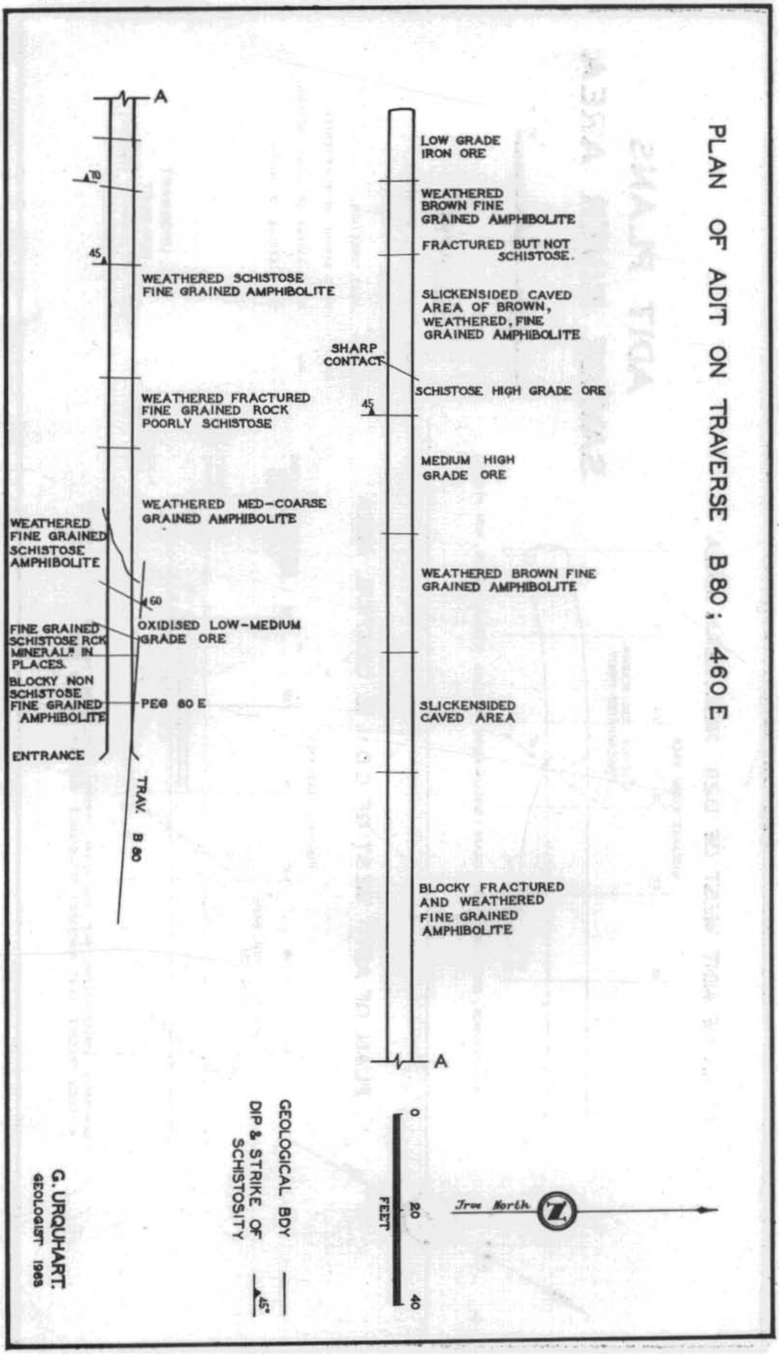


FIGURE 12.

5 cm

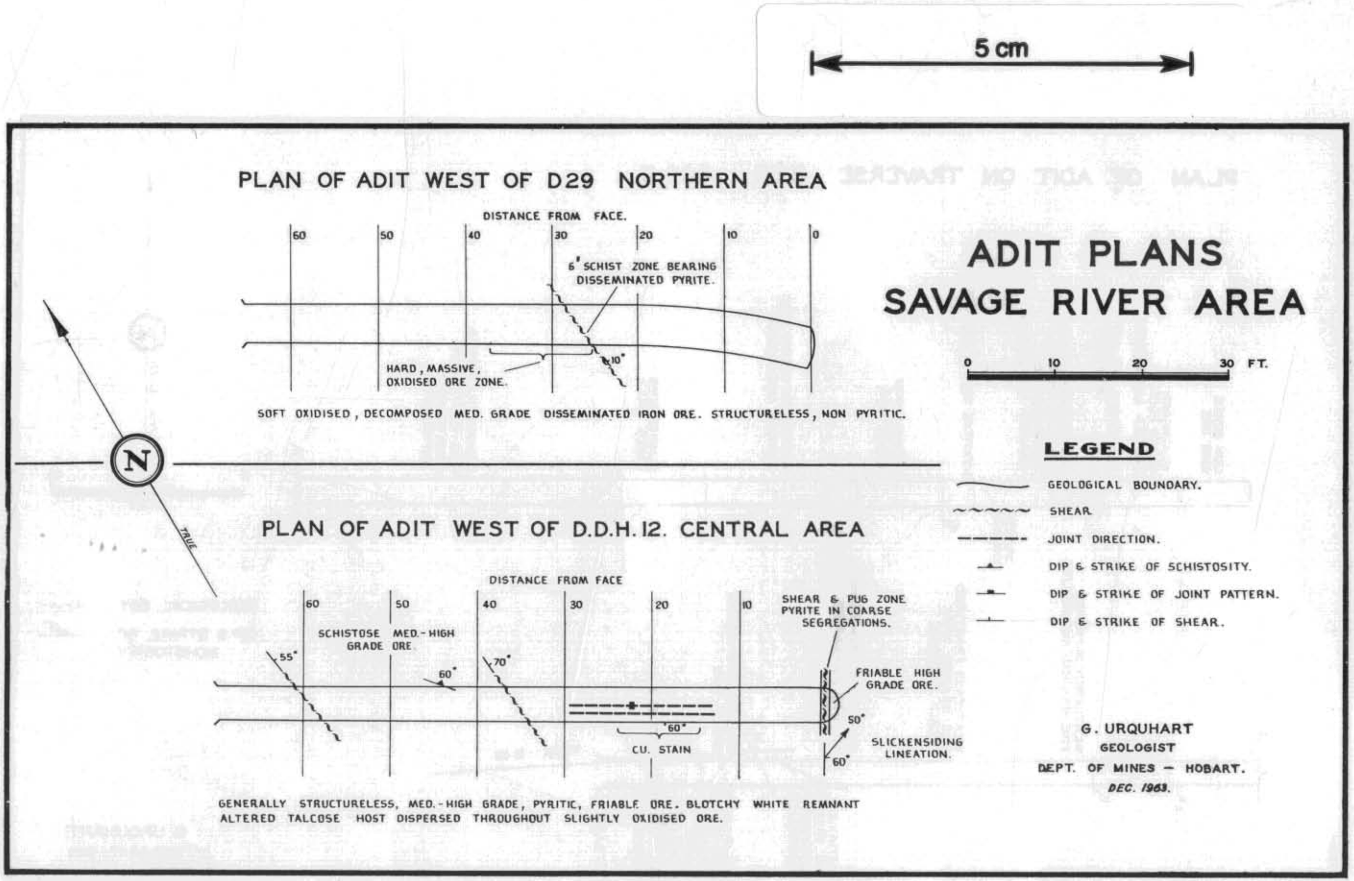

5 cm
PLAN OF ADIT WEST OF D29 NORTHERN AREA
DISTANCE FROM FACE.
60
50
40
30
20
10
0
6' SCHIST ZONE BEARING DISSEMINATED PYRITE.
10°
HARD, MASSIVE, OXIDISED ORE ZONE.
SOFT OXIDISED, DECOMPOSED MED. GRADE DISSEMINATED IRON ORE. STRUCTURELESS, NON PYRITIC.
N
TRUE
PLAN OF ADIT WEST OF D.D.H. 12. CENTRAL AREA
DISTANCE FROM FACE
60
50
40
30
20
10
SCHISTOSE MED.-HIGH GRADE ORE.
55°
60°
70°
60°
CU. STAIN
SHEAR & PUG ZONE PYRITE IN COARSE SEGREGATIONS.
FRIABLE HIGH GRADE ORE.
50°
60°
SLICKENSIDING LINEATION.
GENERALLY STRUCTURELESS, MED.-HIGH GRADE, PYRITIC, FRIABLE ORE. BLOTCHY WHITE REMNANT ALTERED TALCOSE HOST DISPERSED THROUGHOUT SLIGHTLY OXIDISED ORE.
ADIT PLANS
SAVAGE RIVER AREA
0
10
20
30 FT.
LEGEND
GEOLOGICAL BOUNDARY.
SHEAR.
JOINT DIRECTION.
DIP & STRIKE OF SCHISTOSITY.
DIP & STRIKE OF JOINT PATTERN.
DIP & STRIKE OF SHEAR.
G. URQUHART
GEOLOGIST
DEPT. OF MINES — HOBART.
DEC. 1963.

FIGURE 13.

from the bridge. Plans of the adits (figs. 10 to 13) show that the main joints in ore and amphibolite are aligned in NW or NE trending patterns which vary in dip from 40° to vertical. A north-trending pattern is roughly parallel to the post-ore shear direction (cf. Savage River adit, fig. 11).

Joint patterns are not mineralized and were probably formed after magnetite was deposited. Some joint patterns in amphibolite are similar in direction to joint patterns in Whyte Schist.

Schistosity and Cleavage

Schistosity in amphibolite is considered a major structural control of mineralization and will be described in greater detail in the section on mineral deposits (see P. 59). The amphibolite host of the different deposits displays schistosity to a greater or lesser extent in directions which are parallel or sub-parallel to the schistosity in Whyte Schist.

Measurement of the attitude of amphibolite schistosity in the Savage River indicates that it is variable, dipping steeply east or west. The schistosity is considered to be due to shearing and recrystallization of near-vertical zones in amphibolite. The number of schistose zones decreases upstream from the bridge to the boundary of amphibolite and the rock appears to be more massive with distance from the mineralized zone. Downstream from the bridge, below the confluence of Halls Creek and the Savage River, highly cleaved rock is exposed in one outcrop which shows a lens of uncleaved amphibolite about 1 foot in size oriented in the schistosity.

Geological History

Deposition of the Precambrian sediments in deep water, possibly a miogeosyncline, is suggested by the scarcity of cross-bedded structures and absence of a conglomerate unit, at least in the "Lower" division of the Precambrian. Conglomerate units are present in rocks of the lower Pieman River area (Spry, 1964), which indicate a fluctuating basin of deposition. With the onset of compression from east and west, part of the geosyncline was faulted into a narrow elongated basin, less competent and thus more easily deformed than the adjoining stable block to the west. A progressive rise with shortening possibly accompanied deformation, but shearing was not active. Deformation ended with the uplift of the folded rocks at the close of the Precambrian, to form the southern extent of the Rocky Cape Geanticline. During Lower Palaeozoic time the folded Precambrian rocks of the Rocky Cape Geanticline supplied material to shallow rapidly fluctuating basins of deposition between the geanticlinal land masses in Tasmania. Basic and ultrabasic magnetite-chromite-osmiridium-bearing (and gold-bearing?) igneous rocks invaded Cambrian sediments in the Bald Hill area, and basic magnetite-bearing rocks (amphibolite), very similar in composition to Cambrian basic lavas elsewhere in Tasmania, were intruded along lithologic and probably structural boundaries in Precambrian rock. Parallel and curving fracture zones in the amphibolite were subsequently recrystallized into greenschist zones, along which iron was later introduced, possibly as the end product of differentiation. Cambrian (?) acid igneous rock (quartz diorite?) was intruded as a dyke separating Precambrian schist and amphibolite in the Rocky River area. The rock may represent a late stage in the differentiation of a basic magma reservoir.

The area of Precambrian rock continued to supply sediment until the Lower Devonian. The Tabberabberan Orogeny between Lower and Middle Devonian was a major orogeny in Tasmania and folding, jointing and probably faulting can be attributed to this period of mountain building. The last phase of this activity was the intrusion of large plutonic bodies of granite (Meredith Granite) and related igneous rocks into inferred anticlinal axes of arcuate folds which were roughly parallel to the geanticlinal margins. Elsewhere in Tasmania marine and terrestrial sedimentation recommenced in the late Carboniferous or Permian but sediments of this age, if they ever were deposited, have not been preserved in the district. The region was denuded between the Devonian and late Cretaceous and a peneplain formed in the early Cainozoic.

Tertiary terrestrial sediments containing tin, gold and chromite were transported from the north and east and deposited in shallow freshwater lakes. The sedimentary phase was succeeded by Tertiary basalt flows which were of far greater extent than the present outcrops indicate. The peneplain was disrupted by uplift in the late Tertiary and dissection, which commenced in the Pleistocene, has resulted in the youthful stage of topography evident today.

Recent alluvial deposits in the major rivers and creeks carry gold, osmiridium, chromite and tin but the deposits are no longer economically significant.

Geology of the Magnetite Deposits

INTRODUCTION

The magnetite deposits are classified into three types, based on field and core evidence:—

(i) The Savage River type is the dominant one in the northern and central areas of the Savage River deposit, but is also found in deposits to the south. Magnetite is located within schistose, or originally schistose zones of the amphibolite mass.

(ii) The Savage River South and Long Plains South-Brown Plains type in which magnetite is localized at the contact of a linear amphibolite body and a meta-sediment, or is concentrated in the amphibolite.

(iii) The Rocky River type in which magnetite is mainly disseminated in chlorite schist, a metamorphosed sediment adjacent to amphibolite. Wall rock alteration and gangue mineral introduction may be absent or show fewer minerals than in type (i).

The classification is based mainly on the relationship of magnetite to host rock and not on the genesis of metallization because the processes of ore formation are not fully understood in all three areas.

STRUCTURE AND STRUCTURAL CONTROL OF MINERALIZATION

Schistosity

Schistose zones in amphibolite, and magnetite concentrated along the schistosity, are evident in the core from practically all the drillholes in the Savage River deposits. This form of structural control of mineralization is also shown by an outcrop of " barren " amphibolite grading into magnetite-bearing greenschist, exposed beyond drillhole No. 16 on the track leading to Magnetite Creek (fig. 4).

Halls Creek adit, driven in fresh rock, displays the relationship of ore lode to country rock in three dimensions and confirms core evidence that magnetite in many places follows the schistosity of the host rock. Magnetite commonly occupies vertical or steeply-dipping zones of schistosity (greenschist) which may grade into massive blocky amphibolite or terminate sharply against it in a clearly demarcated boundary. Mineralization (in greenschist) ceases at or near the transition from greenschist into massive amphibolite. Small lenses of amphibolite about 1 foot wide are present in places in the schist near the amphibolite boundary. Narrow zones of schist (bearing magnetite) curve around these lenticular and planar amphibolite bodies. The large amphibolite lens 235 feet from the face in Halls Creek adit (fig. 10) shows vertical slickensided markings indicating the direction of differential movement.

Zones of schistosity controlling magnetite emplacement are not so well shown in the trench section because the host rock is deeply weathered.

Evidence from Halls Creek adit especially, from the Savage River adits, from mineralized cores and isolated fresh exposures of magnetite concentrated in greenschist, indicates that schistosity of the host rock is the major structural control of mineralization.

The amphibolite probably yielded to stress by microbrecciation and formed linked, sheeted and irregular shear zones prior to magnetite deposition. Stress in amphibolite was also relieved within the zones of shearing by recrystallization to greenschist, which for the most part has obliterated any evidence of microbrecciation.

Sections through the drillholes (see Appendix) show the attitudes and distribution of the magnetite lodes within zones of original shearing which extend over about 700 feet in the section of drillholes Nos. 8 and 9 (fig. 28).

The alternating magnetite-bearing zones, amphibolite and greenschist zones are represented as planar features on the diagrammatic sections to facilitate computation of ore reserves. Correlation of the ore, amphibolite and greenschist zones between adjacent drillholes is difficult on plan and suggests that zones of schistosity curve, ramify, interconnect, narrow and widen in the main mass of the amphibolite, along both strike and dip of the deposit.

Contact Zone Localization

Surface mapping of the southern Savage River and Long Plains South-Brown Plains areas shows that magnetite deposits are apparently restricted to linear bodies of amphibolite 100 feet to about 500 feet wide, or their contacts with meta-sediment. The amphibolite bodies are aligned in the general trend of the meta-sediments which plunge 50°-70° to the south in one exposure of isoclinally folded black graphite-pyrite schist in the creek downstream from the baseline crossing at 6250N.

Core from drillhole R.T.A.E.1 (Long Plains South, fig. 6) indicates that schistose magnetite-bearing zones within the mass of amphibolite are similar to schistose magnetite-bearing zones in amphibolite of the central and northern Savage River areas.

A slab-like body of iron 5-10 feet wide, about 200 feet long and in places up to 20 feet high is exposed along the baseline north from traverse 4500 N (fig. 6), and forms an unusual topographic feature. The iron body appears to be formed at or near the eastern contact of amphibolite with sedimentary schist; farther east magnetite is disseminated in a friable silty matrix and may represent mineralization of sedimentary schist adjacent to amphibolite.

Dissemination

The rocks trend in a northerly direction in the Whyte and Rocky Rivers and generally dip steeply to the east. Strike and dip attitudes of rocks exposed on the steep hillslopes are not everywhere consistent with the regional structure. The variations are most likely due to soil creep. Large scale tight isoclinal folding in metasediment is inferred from changes in the direction of dip in the Whyte River section but cannot be seen in outcrop. Some hand specimens of green sedimentary schist and metasomatized amphibolite show tight isoclinal folding on a small scale, the folds having an amplitude of 2 or 3 inches and a wave length of half an inch or less. Tight folding such as this in homogeneous rock is difficult to observe in outcrop.

Small magnetite deposits in amphibolite are localized along vertical or steeply-dipping zones of schistosity in the Rocky River deposit. Disseminated magnetite in green sedimentary schist gives rise to the main anomaly (figs. 7, 9, 16) but the major structural control of mineralization is obscure. An obvious and evident structural control is the foliation of the green schist along which magnetite is dispersed, but the reason for the linear epigenetic mineralization over a restricted width within the rock is not understood. A large scale tight fold structure, fault or shear zone may be the major structural control of mineralization in these rocks. Displacement due to faulting, fault breccia, or other evidence of faulting has not been seen.

Mineralogy and Paragenesis

METALLIC MINERALS

Mineragraphic investigations of Savage River ore from drill-holes Nos. 1 and 3 by the Commonwealth Scientific and Industrial Research Organization were made by Baker and Edwards (1958), Williams and Edwards (1958) and Edwards (1960). The results of their polished section examinations are summarized below.

The eight core specimens selected for investigation by Baker and Edwards (1958) were taken at depths between 322 and 623 feet from mineralized rock in which magnetite was the dominant opaque mineral and pyrite ranged from a trace amount to 5 per cent. The size of the magnetite grains ranges from 0.05 mm to 2 mm. Ilmenite, rutile and hematite are associated with the ore, but are absent from the wall rock.

Ilmenite is present in magnetite in the form of lamellae about 0.005 mm long by 0.001 mm wide in the (111) planes of magnetite. The ilmenite lamellae are so small in places that they can scarcely be identified.

Rutile lamellae (or rods) which are larger than ilmenite but not as numerous, are also aligned in the (111) planes of magnetite. They average 0.02 mm long by 0.002 mm wide but attain a size up to 0.05 mm long and 0.003 mm wide.

Exsolution rods or lamellae in a few grains lie at right angles to one another, as though oriented in the (100) planes of magnetite, and Baker and Edwards concluded that the exsolved mineral is ilmenite and not ulvospinel. The rectangular orientation may be due to the perpendicular alignment of the magnetite crystal to the plane of the polished section.

A suite of 44 specimens representative of the core from drill-hole No. 3 between 31 feet and 920 feet was examined and discussed by Edwards (1960). The results are summarized as follows:—

The magnetite grains (0.5-2 mm in size) in many of the specimens have been mildly sheared to form prominent networks of parting planes, or have been closely fractured. Silicate and carbonate fill the parting planes and some fractures. Rutile in places accompanies the carbonate, ilmenite is scarcer. Gangue also tends to form thin films in the grain boundaries of the magnetite crystals.

Rutile and a uniaxial carbonate mineral which may be siderite occur interstitially with magnetite, or fringing it in fine sub-graphic intergrowths 0.1-0.5 mm in size. The intergrowths are locally abundant and constitute 1 to 2 per cent of the ore. More coarsely grained rutile, as much as 0.8 mm across, is present in a few areas.

Hematite is present in the oxidized zone where the magnetite grains have been converted to hematite (martite) along the grain boundaries, but patches of hematite are rare at depth.

INTERSTITIAL ILMENITE, RUTILE AND HEMATITE

Interstitial grains of ilmenite, rutile, and hematite are larger than exsolutions and generally complex. Ilmenite grains 0.3 to 0.4 mm in size occur along grain boundaries of magnetite, or fill interstices between them and invariably contain minute exsolution bodies of hematite aligned in the (0001) planes of ilmenite.

Patches of hematite up to 0.04 mm across containing exsolved ilmenite were seen in magnetite.

Rutile patches are present in the grain boundaries or interstices of magnetite, and rutile, intergrown with hematite, is enclosed in magnetite in a few places.

Micro-graphic and sub-graphic intergrowths of the three minerals with each other and with magnetite also exist.

The intergrowths consist of:—

- Rutile and magnetite.
- Rutile and hematite, in ilmenite.
- Rutile, ilmenite, and magnetite.
- Rutile, hematite and magnetite, some intergrowths enclosed by ilmenite.
- Rutile, ilmenite, hematite and magnetite intergrowths forming cores to ilmenite crystals.

SULPHIDE MINERALS

Pyrite is the predominant sulphide mineral, in many areas forming irregular grains which do not exceed 3 mm across. It occurs in gangue areas or at the margins of gangue areas, and is ophitically intergrown with small blades of actinolite or tremolite. A proportion of the pyrite is intergrown in coarser areas of magnetite where the age relationship is obscure. Some areas of pyrite are studded with inclusions of magnetite; in other areas the magnetite probably occurs in grain boundaries and interstices of pyrite. Pyrite may be moulded on magnetite aggregates but elsewhere magnetite is moulded on pyrite and in places the two minerals are finely intergrown. Baker and Edwards (1958) concluded from this evidence, which is supported by the lack of cross-cutting pyrite veins, that magnetite and pyrite were contemporaneous.

Chalcopyrite is generally restricted to pyrite areas where it occurs as "bleb-like" inclusions, as small interstitial patches, and as discontinuous seams in grain boundaries and at the contacts of pyrite and magnetite or pyrite and gangue. Chalcopyrite veinlets fill fractures in pyrite, but do not extend beyond pyrite into gangue or magnetite.

A few grains of chalcopyrite are fringed with films of chalcocite (digenite) up to 0.005 mm wide.

Traces of bornite associated with blue chalcocite were presumed by Baker and Edwards to have formed during the alteration of chalcopyrite to chalcocite, but minute amounts of primary bornite in chalcopyrite were also noted. The authors also observed covellite fringing chalcopyrite, and minute bodies of cubanite (possibly pyrrhotite) and sphalerite.

MAGNETITE

The study and identification by the writer of some of the minerals and textures of polished sections, especially those containing a high percentage of magnetite, was hampered by the pitted surface of the ore. The magnetite is susceptible to plucking along the parting planes, and ilmenite, rutile, hematite, silicate and carbonate were not identified in these planes. Fig. 14 shows a well-formed magnetite crystal about 2 mm long in a groundmass of finer grained magnetite, which suggests that magnetite is of two generations. In this polished section (No. 64-66), the finer

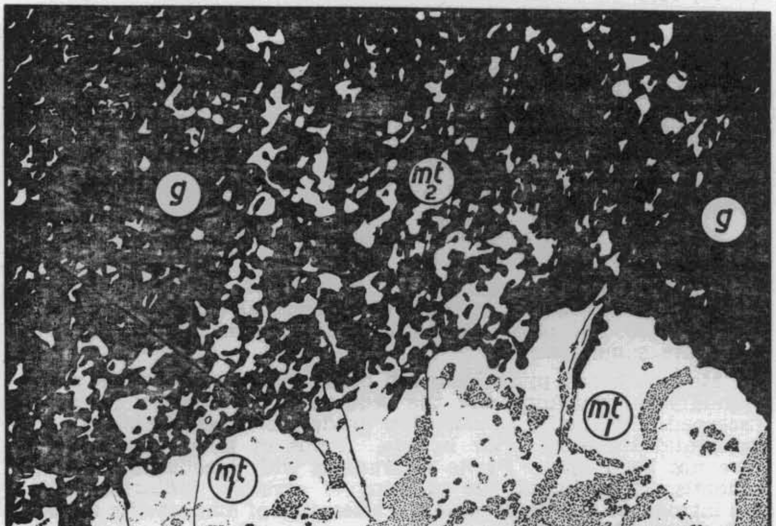


FIGURE 14.—Magnetite (mt) of two generations. Gangue (g) indicated. ×64

grained magnetite is also moulded round a euhedral pyrite grain and is formed in a fissure of the pyrite. Pyrite therefore appears to be earlier than at least one magnetite generation.

Plate 7 shows magnetite on the periphery of pyrite areas, and internally replacing pyrite along grain boundaries producing in places an intergrown texture. A small area of bladed gangue in magnetite can be seen in the upper centre of the plate, and less clearly in the magnetite areas of plates 8 and 11.

PYRITE AND CHALCOPYRITE

Pyrite in plates 8 and 9 occupies and partly fills areas of host rock and is partly formed around some magnetite crystals which in plate 9 have poorly-formed crystal outlines. The pyrite areas in plates 9 and 11 are studded with a few rounded magnetite grains.

Blebs of chalcopyrite are enclosed in pyrite (pl. 8) and two areas of chalcopyrite are formed between the grain boundary of magnetite and pyrite. A border of blue-grey chalcocite separates chalcopyrite from magnetite, apparently a reaction product between the two minerals. Larger chalcopyrite areas in pyrite (pl. 10) are concentrated at the margins of pyrite grains or along pyrite grain boundaries and do not extend far into the host rock.

Bladed host rock minerals (chlorite, serpentine, possibly tremolite and actinolite) are intergrown at the margins of some pyrite areas but also form intergrowths within pyrite in a few places (pl. 11, 16).

SUMMARY

Summarizing the age relationships indicated by the writer's study of polished sections it may be said that:—

Magnetite in places is intergrown at the margins with bladed host rock minerals (mainly chlorite and serpentine) characteristic of the greenschist mineral assemblage. Magnetite was therefore deposited after the original amphibolite rock was converted into greenschist.

Magnetite in part seems to be of two different ages; one phase at least is post pyrite deposition.

The magnetite-ilmenite-hematite-rutile types of intergrowth are partly localized in patches of interstitial host rock enclosed by magnetite, and may have formed after magnetite was emplaced or at the same time.

Magnetite and pyrite in much of the low grade ore has mutual boundary relationships and the sequence of deposition cannot be discerned. Magnetite in some low grade ore is peripheral to pyrite areas and therefore later in age. Veins of magnetite or pyrite have not been seen. Pyrite intergrown with secondary host rock minerals, generally at the margins of crystals, indicates that it was introduced during or after the alteration of amphibolite minerals into greenschist minerals.

Pyrite in medium to high grade ore is generally restricted to interstitial films, wisps and patches of host rock separating magnetite grains and appears to have formed after magnetite was introduced.

The age relationship of pyrite and magnetite is not consistent. The minerals were probably deposited contemporaneously with phases of one mineral locally preceding the other.

Chalcopyrite is closely associated with pyrite, in many places localized along pyrite grain boundaries and more rarely at the contact of magnetite and pyrite. Chalcopyrite deposition is consequently later than pyrite and probably also later than magnetite, but the chalcopyrite-magnetite sequence is obscure.

GANGUE MINERALS

Introduced non-metallic gangue minerals include quartz-feldspar aggregates, calcite and dolomite, which form the altered metasomatized amphibolite schists and dolomitic rocks to the west and east respectively of the mineralized belt in the central and northern Savage River area.

The gangue minerals observed in some thin sections in more direct association with magnetite include apatite, quartz, albite, calcite and dolomite in combinations of one or more minerals with altered wall rock to form the host rock to magnetite and pyrite. The sequence of gangue minerals, and their age relationship to metallization are not quite clear.

Quartz and feldspar in combined mosaic aggregates in metasomatized rock indicate a contemporaneous origin, but the minerals also occur separately in the ore zones. Pyrite is concentrated at the grain boundaries of quartz and carbonated amphibolite (slide 64-77), which indicates that it is later than quartz. Some crystals of vein albite contain inclusions of carbonate but the feldspar-carbonate sequence has not been established.

Two generations of dolomite have been seen (slide 64-75; 64-77). Dolomite veinlets of the later generation transect gangue quartz, which has formed earlier than at least one of the dolomite phases. Magnetite has formed later than dolomite (and calcite) which it preferentially replaces in carbonated amphibolite.

Twelvetrees and Reid (1919, p. 84) noted that large bodies of crystalline dolomite in the NW of the State are associated with basic igneous rock (subsequently assigned to the Cambrian age) either in the rock or at the contact with meta-sedimentary formations. Occurrences of replacement dolomite in basic igneous rock were noted at the Comet and South Comet Mines at Dundas, in the Madame Melba and Kapi Mines, at the Magnet silver-lead mine, in the Victory Mine (Arthur River) and in the Rocky River mine. They stated that the association of dolomite with ultrabasic rocks appeared to be general in Tasmania.

The characteristic alteration of Cambrian lavas (and intrusive rocks) consists of albitization, chloritization, carbonation and silicification, processes which Bradley (1954) considered to be of Devonian age. Groves and Solomon (1964, p. 11) considered the alteration to be Cambrian and albite in rocks of the Waratah district to be primary and/or deuteric in origin.

The age of silica, feldspar, calcite, dolomite and magnesite metasomatism in the Savage River-Rocky River region is not known, but these minerals and other gangue minerals associated with the magnetite deposits or near them are considered by the writer to have been emplaced in the period of iron mineralization.

Thin section studies of Savage River rocks suggest that feldspar, quartz, and the carbonate minerals preceded magnetite formation. The age relationship of apatite is not clear, except that it is intergrown with chlorite at the grain boundaries of a few crystals similar to intergrowths of chlorite, serpentine and tremolite with pyrite and magnetite at grain boundaries (Pl. 16). Apatite crystals occur in areas of host rock adjacent to magnetite; enclosed in the interstices of magnetite crystals or enclosing grains of magnetite.

Barite in the vicinity of magnetite mineralization in the Rocky River deposits is a gangue mineral which has not been observed elsewhere.

WALL ROCK ALTERATION

Wall rock alteration on a large scale indicated by the detailed maps of the central and northern areas has formed metasomatized rock (including carbonate greenschist, quartz-feldspar-(carbonate) amphibolite schist and "dolomite" rock) within and adjacent to the belt of magnetite deposits.

"Dolomite" in the northern Savage River area occurs discontinuously to the east of the deposit; the metasomatized amphibolite schists in the central and northern areas occur to the west of the magnetite deposits.

Wall rock alteration adjacent to magnetite deposits on the small scale indicated by microscopic examination of thin sections indicates that:—

Chloritization varies with the intensity of mineralization. In tenuously mineralized or low grade ore, chlorite is associated with other minerals to form the host rock. In higher grades of ore chlorite is commonly the only gangue mineral. Two chlorite minerals are present in some thin sections.

The amphibole present in the groundmass of sparsely mineralized rock is tremolite, as distinct from the amphibole of amphibolite rock which is actinolite.

Talc is closely associated with magnetite and pyrite in the chlorite groundmass of low to medium grade ore where it apparently formed by alteration of chlorite, but is not prevalent in the highest grades of ore.

Alteration halos of talc in places surround carbonate minerals, e.g., "dolomite" in the Savage River.

The microscopic study of wall rock alteration in some medium to high grade ore shows mainly chlorite and talc (plus minor tremolite and serpentine) associated singly or together with one or more introduced gangue minerals consisting of apatite, albite, quartz, calcite, or dolomite. Asbestos in places is also an alteration of wall rock preceding iron mineralization.

Thin sections of narrow, fairly massive, amphibolite bands between ore lenses show variable textures and mineral assemblages. The mineral composition, texture and structure of slide 64-330 is very similar to the normal unaltered amphibolite. The minerals consist of highly chloritized amphibole, feldspar, epidote, sphene, opaque minerals and accessory quartz. Scattered magnetite grains show well-formed angular crystal outlines characteristic of the normal amphibolite. Epidote content is greater and appears to have formed at the expense of feldspar.

The mineral assemblage of another amphibolite band between magnetite lenses is seen under the microscope to consist of highly chloritized amphibole and epidote in equal proportion forming about 90 per cent of the rock. Sphene is the accessory mineral. Magnetite in irregularly scattered poorly formed grains is generally associated with sparse feldspar crystals, which it partly replaces. Thin section study of this rock (slide 64-331) suggests that magnetite was mobilized and that epidote formed from the breakdown of feldspar.

Some drillhole intersections adjacent to mineralized zones show core which in hand specimen is blotchy, mottled greenish-grey rock, generally altered to chlorite and epidote (pl. 12). The rock represents amphibolite which has probably been altered by hot carbonated solutions in the process known as propylitization. Magnetite introduced subsequently into the rock follows a very irregular pattern of replacement as indicated in the plates.

CONCLUSIONS

The paragenesis suggested for mineral deposition in the Savage River area is:—

> Quartz and feldspar; carbonate mineral; apatite; successive phases of pyrite and magnetite; rutile-ilmenite-hematite-magnetite intergrowths; chalcopyrite; other copper, iron, zinc and nickel sulphides.

Ore Genesis

Any origin proposed for the main magnetite deposits of the central and northern Savage River areas must take into consideration the nature of mineralization in deposits to the south.

Different theories of the origin of magnetite which have been suggested or considered are sedimentary, magmatic segregation, metamorphic and hydrothermal magmatic.

SEDIMENTARY ORIGIN

The theory of a sedimentary origin postulated for magnetite would need to show that the host rocks are sedimentary derivatives.

Magnetite deposits in the Savage River-Rocky River region are not considered to be sedimentary iron formations because the amphibolite resembles more closely a metamorphosed igneous rock (see p. 36). The magnetite in green sedimentary schist of the Rocky River deposit has every indication of an epigenetic replacement origin.

Sedimentary iron formations are characteristically banded and finely laminated. The end members of the iron formation facies consist of sulphide, carbonate, silicate, and oxide (James, 1954). The ore deposits in the Savage River-Rocky River region in no way resemble such iron formations in structure or lithology.

MAGMATIC SEGREGATION

The consideration of a magmatic source for the deposits is seemingly over-ruled by the occurrence of magnetite in sedimentary rock of the Rocky River deposit.

The types of magmatic deposit described by Bateman (1950) include early and late disseminations, segregations and injections of magnetite associated with igneous rocks. An early magmatic origin, in which magnetite crystallized first and segregated from the parent magma, has been suggested for the main Savage River deposits, but study of mineralization in the field, in drill core, and in thin and polished sections shows that magnetite crystallized late and replaced silicate minerals formed in shear zones. The volume of amphibolite in the southern Savage River area and Long Plains South-Brown Plains area would also militate against a theory of early crystallization, differentiation and gravity accumulation of magnetite. Deposits ascribed to early magmatic segregation are generally associated with large bodies of plutonic igneous rock, e.g., the titaniferous magnetite, chromite, nickel and platinum lenses and layers occurring near the base of the Bushveld Igneous Complex (Hall, 1932).

Evidence today is incontrovertible that iron and titanium in certain types of basic magma are concentrated in the residual magma during crystallization. Magnetite may accumulate and crystallize as the last mineral to form, and parallel the primary igneous structure in the host rock. Alternatively if the rocks are tectonically disturbed during crystallization the iron-rich liquid in the residual magma may be forced or filter pressed into consolidated portions of the parent magma or into overlying rock. The injected nature of these deposits distinguishes them from late magmatic segregations in place.

Osborne (1928) described deposits of this type from the Adirondacks and elsewhere in which titaniferous magnetite is concentrated in differentiated intrusive rock invading the host rock.

Magnetite in the central and northern Savage River areas is not intrusive as dykes or lodes, nor is it associated with differentiated intrusive rocks. The medium- to coarse-grained amphibolite in the centre of the area shows both intrusive contacts and gradual transitions into fine-grained amphibolite, but it is not differentiated, nor is magnetite enriched in the rock.

Fine-grained amphibolite sheets, host to mineralization in the southern Savage River and Long Plains South deposits, are texturally and petrographically similar to the main amphibolite body in the Savage River area, and do not represent differentiated intrusives. Magnetite in amphibolite is not considered to be an early or late magmatic segregation of the parent rock.

METAMORPHIC ORIGIN

Edwards (1956) and Hawley (1956) wrote papers reviewing theories of ore deposition and comparing metamorphic and magmatic origins of ore deposits. The subject is exceedingly complex inasmuch as criteria which are distinctive of a metamorphic origin are difficult to separate from those associated with a magmatic origin.

Metamorphic deposits are generally the result of heat and pressure driving rock minerals towards equilibrium with a new environment. The processes include local melting, recrystallization, ionic diffusion in the solid and dry state, or diffusion with the aid of water and possibly other volatiles and the expression of these liquids during orogenic and epeirogenic movements (Hawley, 1956, p. 5). The ore constituents may be in a highly disseminated state or in a concentrated state.

Hawley stated that, as far as he was aware " no one . . . has yet secured or assembled the data necessary to make a thorough analysis of all conditions requisite for the mobilization and later concentration of common ore metals." The collector mechanism and transport of ore minerals in magmatically derived deposits on the other hand has been proved in the field and shown experimentally by different workers including Morey (1922) and Goranson (1931).

Host rock as a source of magnetite ore was suggested by Hagner, Collins and Clemency (1963) for deposits in the Sterling Lake District of New York State. Their conclusions were based on a wealth of analytical data on pyroxene amphibolite which is host to magnetite. These deposits are similar in some respects to the Savage River magnetite; their geology and results of analytical work are accordingly summarized as a means of comparison:—

> No visible " openings " or channels such as shear zones, faults or zones of brecciation were found along which ore-forming material might have moved.
>
> All of the constituents found in the ore bodies were available in the host rock.
>
> Where massive ore has developed, all of the host rock minerals decrease in amount but, where the ore is lower grade, magnetite has apparently formed largely at the expense of plagioclase and some pyroxene.
>
> Titrimetric, optical emission spectrographic and fluorescent X-ray analyses show that the percentage of iron in the mafic silicates and total rock decreases with proximity to the ore zone.

Hagner *et al.* concluded that highly dispersed material was released from amphibolite and concentrated into ore bodies. Magnetite replaced pyroxene amphibolite along a low pressure zone where the structure of the host rock changes markedly. Movement of material was largely along foliation, lineation and grain boundaries. Energy required to activate and move the elements from the mafic silicates is believed to have been supplied by temperature and pressure changes during metamorphism and by the introduction of replacement gneiss and pegmatite.

In the Savage River deposits channels for the ore minerals were provided by greenschist zones, probably formed by shearing and recrystallization.

Most of the constituents of the ore zones, including chlorite, carbonate, serpentine, talc, apatite, introduced quartz and feldspar, and asbestos are not the normal constituents of amphibolite.

Magnetite in very low grade ore selectively replaces chlorite. Chloritization is extensive in higher grades of ore.

Quantitative work on the host rock adjacent to magnetite-bearing zones has not been done, but thin section study indicates that some rocks are highly altered to chlorite and epidote and that the primary magnetite constituent of amphibolite was apparently mobilized. The rock is propylitized in some sections adjacent to ore zones.

Wall rock alteration and gangue mineral introduction could be explained by the secondary hydrothermal solutions proposed by Schneiderhöln (1954), made available by metamorphic processes accompanying orogenies or tectonically by dynamic metamorphism, to remobilize disseminated primary ore.

Insufficient analytical work has been done to show whether the Savage River magnetite replacement deposits could have originated by metamorphism and regeneration, but they do show significant differences in the structural control of mineralization, wall rock alteration and gangue minerals when compared with the Sterling Lake metamorphic-metasomatic magnetite deposits.

HYDROTHERMAL ORIGIN

The main differences outlined above are considered by the writer to be indicative of a hydrothermal origin for the ore, with magnetite forming by deposition in permeable greenschist channels and replacement outward from these zones. The paragenesis of mineralization in which gangue minerals were introduced first, followed by alternating phases of magnetite and sulphide with magnetite predominantly early in medium to high grade ore, strongly indicates a hydrothermal magmatic origin. The normal paragenesis of gangue, oxide and sulphide in magmatic deposits is difficult to explain in metamorphic derived deposits. Hawley (1956, p. 7) mentioned Uitenbogaardt (1953) as affirming that exsolution intergrowths, such as titanhemite and Fe_2O_3-bearing ilmenite in amphibolitic rocks, could only have developed from solid solutions formed under magmatic conditions.

The writer considers that the magnetite deposits are genetically related to the primary magnetite-bearing amphibolite rocks and possibly also to the magnetite-bearing ultrabasic and serpentinite body at Bald Hill, which is Cambrian in age. The amphibolite may be a derivative from a widespread underlying basic reservoir rock, intruded along a structural line of weakness. Differentiation of the reservoir rock and intrusion possibly formed the Bald Hill Complex. Iron was concentrated, segregated and purified in the magma reservoir prior to forming replacement deposits in the Savage River-Rocky River region.

The Kiruna magnetite deposit in Sweden, originally ascribed to a late magmatic segregation and injection origin, indicates that iron can be concentrated elsewhere and purified to a high degree before emplacement. Shand (1947) indicated a process by which this can be accomplished, namely, the self-oxidation of a ferrous hydroxide hydrosol.

e.g. $3Fe(OH)_2 = Fe_3O_4 + 2H_2O + H_2$

AGE OF MINERALIZATION

Campana and King (1963, p. 48) considered that the minerals of the Cambrian metallogenetic epoch in western Tasmania are essentially chalcopyrite, pyrite, galena and sphalerite, with barite in the gangue and gold in the sulphides as unusual mineralogical characteristics.

Nickeliferous sulphide, osmiridium and chromite minerals, such as those found at Bald Hill, were regarded as basic derivatives of pre-Ordovician basic and ultrabasic rocks, belonging to the Cambrian metallogenic epoch. The writer would also include disseminated magnetite of the Bald Hill Complex in this group.

Devonian mineralization in NW Tasmania consists of silver-lead-zinc deposits, and cassiterite-bearing veins associated with the Meredith Granite or pyrrhotite-cassiterite bodies associated with porphyry. Campana and King stated that accessory minerals characteristic of Devonian granitic rocks are fluorite, monazite, topaz, bismuthinite, wolframite and tourmaline. Contact metasomatic pyrite-magnetite deposits are formed where the granite is in contact with other basic igneous rocks, e.g., Tenth Legion Mine.

A consideration of metallization in the two epochs suggests to the writer that magnetite deposits in the Savage River-Rocky River region belong to the Cambian metallogenic epoch. The accessory minerals characteristic of Devonian granite mineralization are not present, conversely barite which is characteristic of Cambrian mineralization is present in the Rocky River area.

IMPURITIES IN ORE

The iron and impurity contents of averaged assays of drill core are shown in the Appendix.

Impurities consist of silica, alumina, titanium, manganese, phosphorus, sulphur and vanadium. The maximum content of these impurities in assays of core sections are shown below:—

SiO_2	46.6	(From D.D.H. 11)
Al_2O_3	15.2	(From D.D.H. 11)
Ti	1.6	(From D.D.H. 17)
Mn	0.19	(From D.D.H. 4)
P	1.40	(From D.D.H. 18)
S	15.4	(From D.D.H. 16)
V	0.44	(From D.D.H. 14)

Some individual assays of shorter lengths of core may show impurity contents greater than those listed above.

The average impurity of ore in the central area was calculated using the percentages given by Symons (1962, pp. 128, 129) for low and medium grade ore:—

	Per cent
Titanium	0.42
Phosphorus	0.15
Sulphur	4.7
Vanadium	0.27

Silica and alumina generally show a decrease with increase in ore grade.

The titanium content in the northern area varies with the grade of ore intersected, the higher grades of ore containing more titanium. Ore containing more than 50 per cent Fe commonly contains more than one per cent Ti (cf. D.D.H. Nos. 1, 2, 17, 25). The high titanium content is thus related to high grade magnetite lodes, particularly in drillholes Nos. 1 and 2. The average grade of this block of ore is 42.8 per cent Fe, which is higher than the average grade of ore found elsewhere in the northern area.

The correlation between ore grade and titanium content is not so definite in the central area. The amount of titanium varies inconsistently in high grade ore and also in lower grades of ore, but the overall average impurity is less than in the northern area.

Assays of core from drillhole R.T.A.E.1 and drillhole No. 28 in the Long Plains South-Brown Plains deposit similarly show variable amounts of titanium. The maximum Ti impurities can be correlated with high grade magnetite lodes only in certain sections.

Buddington, Fahey and Vlisidis (1955) regarded titanium in titaniferous magnetite, which constitutes the Savage River ore, as becoming an important element in geologic thermometry for temperature ranges between 550°C and 1000°C and in the interpretation of the physicochemical history of many rocks. They considered that rocks metamorphosed in the lower part of the temperature range for the amphibolite facies have magnetite with 1 to 3 per cent TiO_2 and that rocks reconstituted in the garnetiferous granulite facies or in the higher temperature range of the amphibolite facies, commonly have magnetite with 3 to 4 per cent TiO_2. Much experimental work, however, remains to be done before the titanium content of magnetite is accepted as a standard in geologic thermometry.

Of the metallic impurities present in the ore, vanadium is most closely and consistently related to intensity of iron mineralization, the content increasing with increase in grade of the ore. Ore containing 50 per cent Fe or more generally contains vanadium in amounts between 0.35 and 0.45 per cent (cf. D.D.H. Nos. 11-16, 18).

The sulphur content of ore varies considerably in assays from different drillholes but tends to be less in higher grades of ore when compared with lower grades of ore from the same drillhole, e.g., D.D.H. Nos. 1, 2, 6, 7 and 25, but the relationship is not consistent.

Manganese and phosphorus impurities are not seemingly related to the grade of iron ore.

Zoning of impurities across the width of the deposits is not readily apparent from core assays nor can any differentiation be made on the amount of impurities present in the ore at different depths (cf. D.D.H. Nos. 3, 21 and 22, 5 and 6, 10 and 23, and 14).

Magnetite Deposits

CENTRAL AND NORTHERN SAVAGE RIVER AREAS

MAGNETIC ANOMALIES AND FORM OF DEPOSIT.

The magnetic anomaly in the northern area extends from the Savage River to traverse F20, a distance of 8,500 feet (fig. 3). The anomaly is very weak and narrow between traverses D9A and D18A where mineralization is probably negligible. Anomalies greater than 50,000 gammas were recorded between the Savage River and traverse D4, between traverses D18A and D23A, and between traverses D30 and E7.

The main magnetic anomaly in the central area extends 6,000 feet from Magnetite Creek to the Savage River. Anomalies greater than 50,000 gammas were inconsistently recorded over this length and show as elongate disconnected areas on the magnetic contour map.

The sections in the Appendix represent diagrammatic sections of lodes intersected by diamond drillholes. The magnetic anomaly above each section has been drawn from the contoured magnetic anomaly maps of the central and northern areas produced by the B.M.R. The core intersection of magnetite-bearing zones and the core schistosity apparent in the zones have been plotted along the length of each inclined borehole. The zones of mineralization were then correlated with the magnetic anomalies on surface and drawn on the sections according to the interpretation of anomalies suggested by Eadie (1962) who gave examples of four types as follows:—

(i) A narrow anomaly with steep gradients due to a magnetic body of small width close to the surface. Although the anomaly may have a large amplitude, its narrowness indicates that the body is of small width and probably of minor economic significance. An example is the anomaly on traverse 2500 S with a peak at 225 feet E (D.D.H. No. 16, Appendix).

(ii) A broad anomaly of high amplitude and steep gradients due to a wide deposit of magnetic material at, or close to, the surface. The continuation of such a deposit to depth is indicated by a gradual rise in the anomaly before the steep gradients commence. Examples are the anomalies above the sections of drillholes Nos. 1 and 2 (Appendix).

(iii) A broad anomaly of moderate amplitude and low gradients, due to magnetic material at depth. This is represented by the anomaly between 1500 W and 2100 W on the section of drillholes Nos. 8 and 9, and by the anomaly between 00 and 500 feet W on the section of drillhole No. 15 (Appendix).

(iv) An anomaly with very irregular features indicating a highly disturbed magnetic field. This type of anomaly usually occurs in a region of extensive outcrop. The irregularities tend to mask the contribution to the anomaly of magnetic materials at greater depth. Anomalies of this type are shown on the sections of drillholes Nos. 5 and 6, and on the section of drillhole No. 7 (Appendix).

The dip of a magnetic body influences the gradient of the corresponding anomaly. The gradient of an anomaly due to an easterly dipping magnetite body will be more gradual to the east of the anomaly maximum, as represented on the section of drillhole No. 4 between 600 feet west and 1,000 feet west. Eadie (1962) also gave the anomaly on traverse 6000 S as an example.

Eadie (1962) stated that the amplitude alone of a magnetic anomaly is not of great significance and that an assessment of the importance of an anomaly depends also on a consideration of its width, and its gradient, which in turn is related to the grade of magnetite body. An arbitrary division into low grade magnetite (less than 40 per cent HCl-soluble iron) and medium to high grade magnetite (greater than 40 per cent HCl-soluble iron) is shown on the drillhole sections and on the core logs of drillholes (fig. 21).

Outcrops of high grade magnetite generally correspond to areas on the contoured magnetic anomaly map greater than 50,000 gammas. Low grade iron deposits near surface are related in places to a magnetic anomaly in the range 20,000 to 30,000 gammas. Maximum values of anomalies (up to 122,000 gammas) have been recorded in the three areas of the Savage River deposits.

Interpretation of the form of magnetite bodies represented in drillhole sections and their attitudes has also been influenced by:—

(*a*) Surface outcrops and core intersections of magnetite-bearing zones which can be correlated in a few sections.

(*b*) The grade of the magnetite-bearing zones intersected in the drillhole.

(*c*) The structure evident in core, i.e., schistosity of magnetite relative to the core axis, plotted along the length of the drillhole.

(*d*) The amplitude, width, gradient and shape of the magnetic anomaly.

The tabular form and planar dimensions of the magnetite bodies in the drillhole sections (see Appendix) are idealized sections through the deposit. A knowledge of the structural control of mineralization along zones of schistosity which may widen and narrow, separate and coalesce along the dip and strike, indicates the difficulty in representing the true form of magnetite bodies in the mineralized zones.

Surface maps of the medium and high grade magnetite bodies in the southern, central and northern areas were partly compiled from outcrops of oxidized magnetite, which are scanty or else small and liable to be confused with boulders of iron rubble. The distribution of the medium and high grade zones beneath the soil and rubble cover has been mainly inferred from the magnetic anomaly maps and the drillhole sections.

The trenches recently excavated by bulldozer on traverses B8, B and 500 S in the central area (figs. 18, 19 and 20) afford a comparison between the magnetic anomaly and the oxidized magnetite bodies exposed in the trenches. The distribution of medium to high grade lodes does correspond with the magnetic anomaly contours, at least in the trenches.

Magnetite-bearing zones were intersected by drillholes Nos. 8 and 9 over a maximum horizontal width of 700 feet in the central Savage River area (D.D.H. 8 and 9, Appendix).

The width intersected by drilling in the northern area is less and ranges from 100 feet to about 300 feet. The deepest hole drilled (drillhole No. 14 in the northern area, fig. 3) intersected the main magnetite lodes of the ore zone over a horizontal width of about 260 feet, at a depth below the bed of the Savage River ranging from 600 feet to 960 feet. The drillhole indicates that the magnetite deposits are present at depth without decreasing in width.

In sections through the deposit, the mineralized belt comprises a succession of vertical or steeply-dipping lodes of low, medium and high grade magnetite alternating with variable widths of amphibolite or greenschist (figs. 10, 11, 12, 13). The linear ridge of magnetite 5-10 feet high in the central area between traverses 2000 S and 2500 S (fig. 4) appears to be formed along the eastern contact of meta-sediments and amphibolite.

The horizontal width of medium to high grade magnetite deposits ranges from seams less than an inch thick to a maximum lode width of about 200 feet, illustrated in the section of drillhole No. 3 (see Appendix). In many sections the majority of lodes are up to 100 feet wide. Individual medium to high grade lodes generally contain minor bands of country rock which do not reduce the average grade below 40 per cent iron.

The classification of mineralized rock in many drillhole sections as low grade ore containing less than 40 per cent iron, is due to thinner bands of medium to high grade magnetite more widely distributed in amphibolite, yielding an average low grade zone over the aggregate width. Magnetite in some uniformly low grade zones without many intersections of amphibolite is generally disseminated in distinctly foliated greenschist, in places partly altered to talc.

Individual high and low grade magnetite lodes and country rock bands cannot be correlated with certainty between adjacent drillholes owing to great lateral variation in width and grade of the mineralized zones. Variation in grade and width is also rapid in a vertical direction, best indicated in the section of drillholes Nos. 5 and 6 (Appendix). The holes were drilled from the same collar but at different inclinations. The width of the medium to high grade zone in drillhole No. 5 is much reduced in drillhole No. 6. Variation in grade over a greater vertical distance is shown also in the lode intersected by drillhole No. 22 near surface and the same lode at depth intersected by drillhole No. 3 (Appendix).

MINERALIZATION AND STRUCTURE

The origin of structure in the amphibolite body of the central and northern Savage River area has been discussed above (p. 51). A sheeted succession of parallel, sub-parallel and coalescing greenschist zones in amphibolite appears to have formed in zones of microbrecciation in amphibolite. Plastic deformation and metamorphic reconstitution resulted in a greenschist mineral assemblage and obliteration of microbrecciation and shearing in most zones.

The permeability of greenschist or host rock was a structural control in the deposition of magnetite, which in the initial phase is localized along or between chlorite folia, or more rarely along fibres of asbestos. Magnetite needles have been observed in asbestos which has formed from the alteration of amphibolite (pl. 13). Magnetite pervasively replaces host rock (greenschist or amphibolite with more intense metallization.

The replacement of country rock by magnetite to varying degrees, depending upon the intensity of metallization, results in different grades of ore, having a texture and structure generally characteristic of each grade.

In low grade ore, corresponding to the first phase of iron mineralization, magnetite is diffusely disseminated in the greenschist or cleaved amphibolite along the schistosity. With increasing intensity of metallization magnetite is deposited outward from the margins of the greenschist zones and may replace fairly massive amphibolite.

Texture and structure of the ore depends upon the nature of the original rock, i.e., whether the rock was a foliated greenschist or a structureless amphibolite. Magnetite centres have segregated in the cleavage planes of poorly mineralized cleaved or schistose rock. The magnetite centres have joined and replaced the host in more intensely mineralized rock.

All stages in the formation of low to high grade ore can be seen from magnetite and pyrite diffusely disseminated in schistose rock to magnetite centres disseminated along the schistosity. The centres coalesce to form magnetite stringers and bands in altered greenschist. Finally a stage is reached where stringers and bands merge, and magnetite extensively replaces the host rock which is evident only as a remanent matrix in the ore. The schistosity apparent in some exposures of the lode on surface and in certain cores of medium to high grade magnetite is therefore a relict structure inherited from the original rock.

The structure patterns described above, corresponding to successive stages of magnetite replacement in schist do not result when fairly massive amphibolite is mineralized. Magnetite progressively replaces amphibolite from multiple centres of growth with increasing intensity of metallization or as a massive front (Bateman, 1950, p. 143). The ore is not schistose.

Pyrite is the most common and readily observed metallic mineral closely associated with magnetite. Veinlets and disseminations of pyrite in greenschist free from magnetite have not been seen in many cores.

Magnetite in low grade ore (less than 40 per cent iron) is disseminated along the cleavage as irregular segregations, wisps, shreds, or blebs, or in thin bands. Pyrite is generally associated with the magnetite disseminations in a mutual boundary relationship or magnetite may be moulded onto pyrite; alternatively pyrite and magnetite may be successively banded in thin layers.

In medium grade ore (an arbitrary classification of magnetite containing 40 to 55 per cent HCl-soluble iron), metallization is more extensive and pyrite selectively replaces the remanent host rock in the ore or is found at the contact between host rock and magnetite, but magnetite itself is not a centre for pyrite replacement. Ore of this grade is blotched, mottled or more rarely banded with pyrite, depending upon the pattern of magnetite replacement in the original host rock.

In high grade ore containing more than 55 per cent iron, magnetite replacement is almost complete and pyrite selectively replaces the remanent interstitial host rock uniformly interspersed in the magnetite. The ore is speckled with fine disseminations of pyrite, or may be massive and almost free of pyrite. In general, high grade, massive, finely crystalline magnetite contains less pyrite than low and medium grade ore.

Summarizing the evidence of mineralization in hand specimens of different grades of ore, it may be stated that:—

(i) In low grade ore, magnetite and pyrite are closely associated, and apparently formed at the same time. Structure in the host rock influenced the initial replacement by magnetite and pyrite, but the sequence of metallization is not clear.

(ii) In medium grade ore, pyrite selectively replaces areas of host rock, or is emplaced along the contact between magnetite and host rock.

(iii) In high grade ore pyrite replaces the remanent host rock matrix of the ore. The matrix is scanty, consequently pyrite content of the ore is low.

PETROLOGY

The petrology of amphibolite has been discussed above (p. 33). Euhedral magnetite and pyrite (pl. 14) are considered to be relict minerals of the original magma and the crystals, some of which have fractured and moved apart, retain crystal outlines because of their strong force of crystallization.

Thin sections of low grade mineralized greenschist show under the microscope that the groundmass consists mainly of chlorite, tremolite, sphene and opaque minerals (magnetite and pyrite). Talc, carbonate, accessory apatite, rutile and epidote occur in some slides while bladed tremolite crystals 0.1-0.2 mm long in some thin sections form a fine-grained aggregate in a groundmass altered to chlorite. The crystals show weak pleochroism compared to the blue-green actinolite in amphibolite rock. Irregular grains of magnetite up to 0.1 mm in size are preferentially distributed in chlorite-rich bands up to 0.5 mm wide containing scattered residual blades of tremolite (pl. 15). Sphene in granular clusters and strings is also preferentially formed in the chlorite layers. Calcite in slide 64-86 is present as irregular patches 0.1-0.3 mm in size surrounded by a talc selvage, and as thin films between chlorite folia. Magnetite replaces carbonate in some slides.

The study of these slides is noteworthy as they show that diffuse magnetite and pyrite is more concentrated in the chlorite-rich zones of the host rock, in which most of the amphibole is tremolite.

Microscopic study of more highly mineralized low grade schistose rock shows magnetite and pyrite in a groundmass consisting mainly of chlorite which may contain scattered relict blades of tremolite. Talc is associated with the opaque magnetite, either filling interstices between grains or as an alteration halo surrounding or close to irregular shaped disseminations and segregations of magnetite and pyrite. A mineral identified as serpentine is sparsely distributed in parallel elongate shreds in the groundmass of slides 64-70 and 64-71 and, is intergrown with chlorite lamellae in the margins of opaque minerals, mainly pyrite, producing a serrated outline of the grain.

Two chlorite minerals are present in some thin sections. One mineral consists of unoriented, thick and thin tabular crystals which are irregularly terminated (slide 64-79). It is colourless and has very weak birefringence. The other mineral, in places adjacent to pyrite, is yellowish brown, non-pleochroic and shows Berlin blue interference colours. The crystal habit is indistinct in the patchy areas occupied by this mineral because of the fine grain. Some crystals appear scaly, others tabular.

In slides 64-70 and 64-72 magnetite and pyrite, comprising an estimated 30 to 40 per cent area of each slide, exist together and show mutual boundary relationships. In slide 64-71, however, pyrite and magnetite exist as discreet, shapeless minerals in the groundmass. Apatite crystals containing inclusions of talc are intergrown at the margins with chlorite lamellae (pl. 16).

Noteworthy in the slides examined of this grade of mineralization is the extensive chloritization of the groundmass, the association of talc with pyrite and magnetite, and the intergrown form of chlorite and serpentine with pyrite, magnetite, and apatite at the grain boundaries.

Thin sections of medium to high grade ore, in which magnetite and pyrite constitute 60 per cent or more of the rock, show under the microscope that the opaque minerals are shapeless grains up to 2 mm in size, enclosing a matrix in which chlorite is ubiquitous. Various slides show different associations of minerals: in slide 64-85 the interstitial minerals are chlorite, calcite, apatite, and albite which contains inclusions of calcite. In slide 64-85 the matrix to the metallic minerals consists of chlorite and apatite; in slide 64-80 interstices are filled with chlorite, dolomite and sparse apatite; in slide 64-63 with chlorite, intergrown in the grain boundaries of magnetite. Magnetite in the hand specimen of this slide is in subhedral grains between 1 and 2 mm in size. In the slides indicated above, pyrite fills some of the interstices between magnetite grains.

A thin section (64-77) of carbonated amphibolite under the microscope shows dolomite replacing blades and needles of actinolite and tremolite arranged in a schistose pattern. Dolomite veinlets also transect the carbonated groundmass and an area of gangue quartz. Weak pyrite mineralization consists of a few scattered grains preferentially disposed in carbonate or carbonated amphibole, or the contact of amphibolite with introduced quartz gangue. The study of this slide indicates that carbonate is present in two phases, one later than quartz, and also that pyrite is apparently later than quartz and preferentially replaces carbonate.

The groundmass in slide 64-75 consists of a structureless aggregate of carbonate and albite intersected by veinlets of dolomite up to 0.3 mm wide. Opaque minerals, which consist mostly of magnetite in irregular patches and well-formed crystals in the groundmass, terminate against the dolomite veinlets which seem to cut through them. Study of the thin section shows that magnetite appears to replace the earlier of the two carbonate phases.

TEXTURE OF MAGNETITE AND PYRITE

Magnetite and pyrite grains in "barren" amphibolite have well-formed crystal outlines which in thin section show as cubes, rhombs, and triangles. In places the crystals (up to 0.5 mm in size) are fractured and the angular fragments have moved some distance apart.

Magnetite and pyrite in low grade rock is generally disseminated in wisps, shreds, blebs, and bands without any particular shape. In places subhedral magnetite centres of growth are up to 2 mm in size.

Magnetite in medium and high grade ore varies from fine- to medium-grained, with a maximum grain size in the crystalline ore of about 2 mm. The grains of magnetite show both poorly formed and well-formed crystal outlines. Unoxidized high grade ore (up to 66 per cent iron) is generally fine-grained and massive in appearance. It may be friable, like the ore exposed in the adit to the west of drillhole No. 12, or densely coherent.

The shapes of pyrite disseminations in medium and high grade ore are controlled by areas of interstitial host rock in which pyrite is dispersed. Pyrite cubes in places occupy minor open fractures.

OXIDIZED IRON ORE

The depth of weathering determined by diamond drilling ranges from 30 feet to 120 feet. The average depth of weathering is 100 feet. Ore within the oxidized zone is composed of magnetite, hematite and limonite and is enriched to a grade ranging from about 60 to 67 per cent iron. Pyrite is weathered and leached from the magnetite, leaving vugs and cavities in the limonitic ore. Lodes intersected in the trenches (figs. 18, 19, 20) show that much of the magnetite is oxidized to ore which ranges in magnetism from strong to weak, or is non-magnetic.

Limonite in places forms a "skin" up to half an inch thick coating hematite and magnetite, or may fill fissures and pockets in the ore. Hematite and limonite is pseudo-stratified above limonite-coated magnetite in a 5 feet high lode outcrop in the northern area east of E5 (fig. 3).

Williams and Edwards (1958) described two polished sections of ore from the oxidized zone of the Savage River deposit. In one section magnetite is almost completely altered to hematite (martite) and limonite. Ilmenite and rutile, as lamellae in the original magnetite grains, and as irregular shaped particles in the grain boundaries, remain as residuals in hematite. Limonite occurs as irregular areas in the hematite and appears to have formed from the alteration of hematite close to the surface. In the other polished section of ore, which is strongly magnetic, magnetite is almost unaltered and is associated with ilmenite, rutile and hematite.

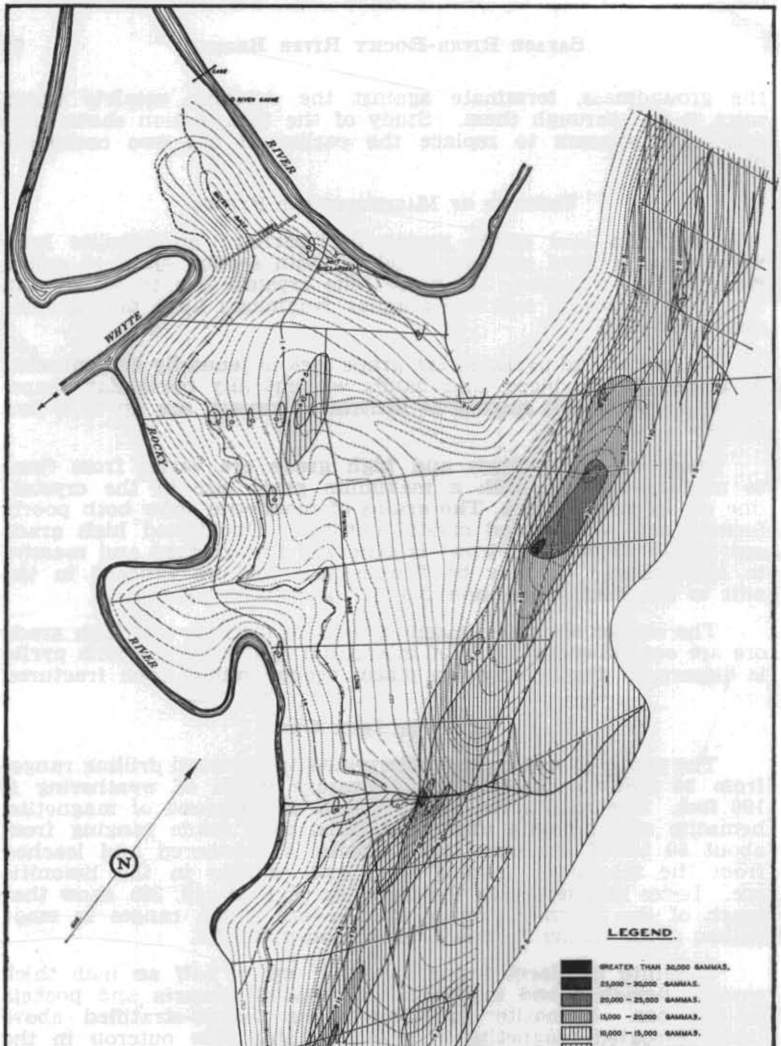


FIGURE 15.

5 cm

SOUTHERN SAVAGE RIVER AND LONG PLAINS SOUTH-BROWN PLAINS AREAS

The results of geophysical work in these areas are given in reports by Keunecke (1958), Sedmik (1961) and Eadie (1962, 1963).

The magnetic anomaly in the southern Savage River area extends for more than 6,000 feet from Magnetite Creek to traverse 6500 S (fig. 5), having a value greater than 50,000 gammas between traverses 5400 S and 6000 S. The anomaly is weak or absent between traverses 6500 S and 8500 S, but has a strength of 50,000 gammas between 9000 S and 9500 S. The width of the anomaly in the southern area ranges from 200 feet to about 400 feet.

The magnetic anomaly in the Long Plains South area trends continuously for over 2 miles from traverse 250 N near the Waratah-Corinna road, to traverse 11,500 N (fig. 6) where it ceases abruptly. The anomaly indicates mineralization over a width ranging from about 40 feet to a maximum of 600 feet between traverses 11000 N and 11,500 N, where the greatest amplitude of the vertical magnetic field shown on the section (Eadie 1963, pl. 9) is 158,000 gammas. Eadie interpreted the contour and profile anomalies as representing elongate magnetite lenses dipping to the east. The mineralized zone in this deposit is narrower than that in the central and northern Savage River areas.

No significant magnetic anomalies were recorded in the area between traverse 11,500 N in the Long Plains South deposit and the southern end of the Savage River deposits, a distance of about 3½ miles.

The form of these deposits is not defined by exposures in trenches or adits. A shaft was sunk on traverse 6500 S in the southern area many years ago, and a drillhole (R.T.A.E. 1) was bored by Rio Tinto Australian Exploration Pty. Ltd., in 1959, at a point approximately 11,085 N, 345 E in the Long Plains South deposit (fig. 6).

The horizontal width of the main steeply dipping magnetite zone intersected by drillhole R.T.A.E. 1 is 120 feet (see Appendix): this figure may represent the average width of low or medium to high grade lenticular magnetite bodies along the length of the deposit. The magnetite cropping out in the road near the drillhole is distinctly schistose and dips steeply to the east.

The impurity content of magnetite from the Long Plains South deposit is quantitatively and qualitatively similar to the impurities in magnetite from the Savage River deposit (cf. Appendix).

ROCKY RIVER AREA

Magnetite in the Rocky River area and in deposits to the south were mentioned as a source of iron by Twelvetrees and Reid (1919). Reid (1924) reported on the mineralized areas after a brief examination. Atkinson (1960) did not consider deposits in the Rocky River area large enough or of sufficiently high grade to encourage further exploration.

Early in 1964 the Department of Mines re-examined the area. Old traverses were re-cut and cleared, and topographic, magnetometer and geological surveys were made by officers of the Department of Mines. The results of the investigations are shown on figs. 7, 9 and 15.

The main magnetic anomaly (fig. 15) aligned in the green sedimentary chlorite schist has a maximum value between 30,000 and 35,000 gammas on traverse 8S, 1,000 feet east of the old water race which was used as a baseline for the survey.

The magnetic field of intensity less than 15,000 gammas is continuous along the strike of the chlorite schist over a distance of about 1 mile; contours (at 5,000 gammas intervals) of the magnetic field greater than 15,000 gammas intensity form isolated areas of higher anomaly along the strike. The width of the +10,000 gammas anomaly ranges from 150 feet in the south to a maximum of about 350 feet on traverse CL. The average width of mineralization is estimated to be 200 feet. The profile of the anomaly on section CD (fig. 9) indicates a more gradual gradient on the eastern side of the maximum, and weak magnetite metallization is probably conformable to the foliation in the steep easterly dipping chlorite schist. A separate, weak, magnetic anomaly having a peak magnetic field of more than 10,000 gammas is shown on traverse CL over an area underlain by massive or foliated amphibolite.

The anomalies formed over sedimentary schist and amphibolite correspond to two different types of magnetite deposit:—

(i) Magnetite disseminated along the foliation of green sedimentary chlorite schist or dispersed equally through the rock.

(ii) Magnetite lodes in amphibolite, formed in schistose zones.

In type (ii), which corresponds to ore formation in the Savage River and Long Plains South areas, the surface magnetite lodes on traverses CL, 4 S and 12 S (fig. 7) are variably oxidized and altered to hematite and limonite yielding an assay greater than 60 per cent HCl-soluble iron. The oxidation of these shallow seated (?) bodies of magnetite and conversion to non-magnetic hematite and limonite probably accounts for the weak, in places non-existent, magnetic anomaly associated with this type of deposit.

The adit on the Whyte River was driven prior to 1900 and crosscuts from it intersected a lenticular body of unoxidized magnetite over a distance of nearly 800 feet. The maximum width of the lode according to Twelvetrees (1900) was 30 feet. The adit has collapsed at a point 200 feet from the entrance, and ingress is prevented. The ore is generally fine-grained and similar in texture, structure and wall rock alteration to the magnetite at Savage River. An assay of the unweathered lode material dumped from the adit (Atkinson, 1960, p. 7) indicated a composition of:—

Per cent

HCl sol. Fe	TiO_2	SiO_2	Mn	P_2O_5	S	Al_2O_3
55.8	0.35	5.46	0.04	0.17	4.71	0.53

which conforms to the iron and impurity content of medium to high grade Savage River magnetite.

The 40 feet unweathered mineralized section exposed at the base of the first waterfall upstream from the water race in Cataract Creek (fig. 7) was sampled over sections 25 feet and 15 feet long by Atkinson. The 25 feet section assayed 16.6 per cent Fe and the 15 feet section as follows:—

Per cent

HCl sol. Fe	TiO_2	SiO_2	Mn	P_2O_5	S	Al_2O_3
32.8	0.44	37.9	0.19	0.13	0.61	4.39

Magnetite in the creek section forms a massive lode 2 to 3 feet wide, and is also dispersed in cleaved, silicified, altered sedimentary? schist, marginal to amphibolite. The original nature of the rock is difficult to see. Barite as pockets in the cliff wall of the waterfall is an uncommon gangue mineral.

In mineralization of type (i), magnetite is disseminated in irregular small masses and lenses up to half an inch in size along the foliation of green, porphyroblastic (albite), chlorite schist in which feldspar and quartz appear to be introduced minerals. Magnetite is also present as layers and bands up to 3 inches wide along the schist foliation. On traverse 32 S near the western boundary between sedimentary chlorite schist and amphibolite, magnetite is dispersed in perfect octahedral equigranular crystals through the foliated chlorite schist. The crystals are as much as 2.5 mm in size and constitute perhaps 20 to 30 per cent of the rock.

Magnetite in chlorite schist, in the various ways described above, constitutes low grade ore which can be expected in the mineralized zone; however, individual hand specimens of fairly high grade ore can be found. Pyrite is not a common constituent of the sedimentary chlorite schist and is not associated with low grade ore in many places on the surface.

In thin sections of magnetite-bearing chlorite schist, the minerals under the microscope are seen to consist of strongly pleochroic (green → pale green) chlorite containing fine lamellae of a strongly birefringent mineral tentatively identified as biotite. Bands and irregular patchy areas composed of mosaic aggregates of strained quartz and untwinned feldspar (refractive index greater than balsam) are aligned in the schistosity of the rock. Subhedral to euhedral albite porphyroblasts, a few crystals of which are carlbad-twinned and carry inclusions of chlorite, magnetite, feldspar or quartz, are present in the chlorite layers. The parallel lines of inclusions in some of the albite porphyroblasts are slightly rotated in relation to the schistosity of the rock. Magnetite in rounded irregular grains preferentially replaces chlorite areas. Chlorite wisps and shreds in the grain boundaries of the quartz-feldspar aggregate similarly are loci for magnetite deposition. Magnetite grains may replace chlorite around the crystal outlines of an albite porphyroblast (fig. 16). The study of the slides also suggests that quartz and feldspar forming mosaic aggregates were introduced after the porphyroblasts had formed. Magnetite in one thin section is concentrated in chlorite-free areas of quartz and feldspar which it replaces outward from grain boundary fractures.

Summarizing the evidence of microscope and hand specimen study of mineralized rock it may be stated that:—

Magnetite preferentially replaces chlorite, but may also replace quartz and feldspar from open spaces between grains.

Magnetite was introduced after the albite porphyroblasts had formed, and after quartz and feldspar had been introduced.

Quartz and feldspar were probably introduced after albite porphyroblasts had formed. The rock is impregnated with silica and feldspar in places.

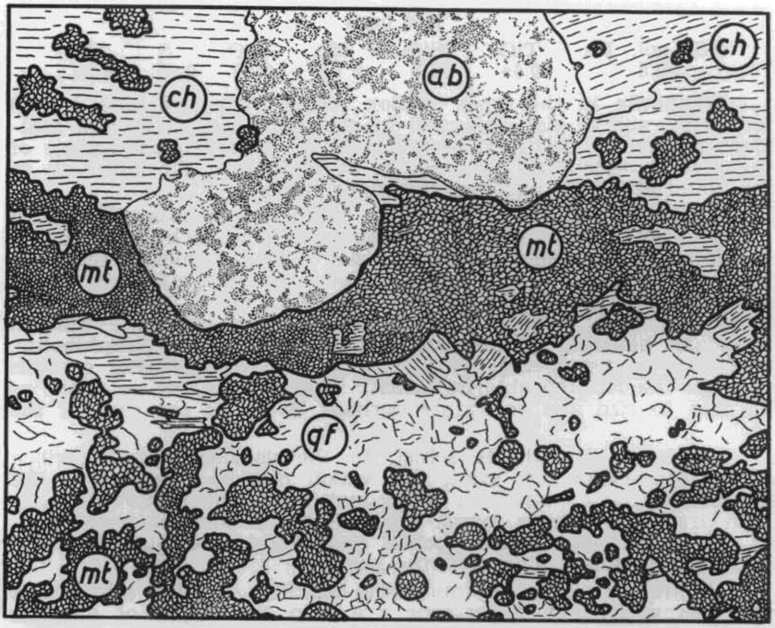


FIGURE 16.—Magnetite (mt) grains in chlorite (ch) formed around albite (ab) porphyroblasts and in quartz-feldspar (qf) aggregate. ×79

No evidence of wall rock alteration to talc, serpentine and epidote was observed. Apatite, the common gangue mineral associated with magnetite elsewhere, has not been observed but barite gangue is present in one place. Carbonate is sparse and was introduced later than gangue feldspar which it partly replaces or rims on the margins of some crystals.

Ore Reserves

SAVAGE RIVER AREA

CENTRAL AREA

Calculation of the total ore reserves in the southern, central and northern areas of the Savage River deposit is not possible at this stage because the length, width and depth of the ore bodies have not been ascertained by drilling in the southern area, and have been indicated only along part of the length in the northern area. Working costs are not sufficiently known at the time of writing to determine the average cut-off grade for mining operations. Knowledge of the cut-off grade would influence the dimensions of the open pit excavation of the ore-bodies and impose a limit to the depth of magnetite that could be profitably mined.

The number of drillholes bored in the central Savage River area is enough to enable some estimates of ore reserves to be made, based on grade of the intersected ore. Symons (1962) calculated the ore reserves from an open pit designed to extract ore to a depth of approximately 400 feet below the surface over a length of approximately one mile. These reserves are:—

82,000,000 tons of ore average 43.8 per cent iron.

17,000,000 tons of low grade ore averaging 17.3 per cent iron.

The writer independently compiled an estimate of ore reserves based on a plan and set of sections supplied by the present licence holders, Pickands, Mather Co. Ltd. to the Department of Mines. The ore reserve thus calculated is given as:—

99,000,000 tons averaging 37.6 per cent iron.

The ratio of waste : ore by weight = 1 : 1.48 } Open pit
The ratio of waste : ore by volume = 1 : 1.09 } extraction

Details of the calculations used in obtaining an overall average grade are listed below:—

ORE SECTIONS

Section	Based on DDH No.	Ore Zone Sq. ft	Total Open Cut Sq. ft	Fe % HCl soluble
2500S	16	94,520	167,965	33.1
2000S	15	143,740	257,000	35
1500S	13	165,800	333,875	39.8
750S	10 and 23	253,640	451,025	41.0
250S	11 and 12	204,150	413,535	44.2
TRAV A	8 and 9	157,475	428,108	38.0
TRAV B	4	195,200	489,175	40.5
TRAV B8	3, 21, and 22	289,975	400,200	35.4
TRAV C0	5 and 6	112,775	203,950	28.5
TRAV C12	7	27,775	48,250	34.1

The overall average grade of the deposit was derived by weighting the average grades of the ore in each drillhole section with their respective areas and the half distances to adjacent drillholes. The average grade of the deposit using this method of calculation was 37.6 per cent Fe.

Average areas and volumes calculated for the derivation of tonnage were:—

Block bounded by Sections	Average Area (sq. ft)		Volume (cu. ft)	
	Ore Block	Open Cut	Ore Block × 1000	Open Cut × 1000
Magnetite Creek—				
DDH 16	47,260	83,982	18,904	33,593
DDH 16-DDH 15	119,130	212,482	55,991	99,866
DDH 15-DDH 13	154,770	295,437	80,480	153,627
DDH 13-DDH 10 and 23	209,720	392,450	136,318	255,093
DDH 10 and 23-DDH 11 and 12	228,895	432,280	82,402	155,621
DDH 11 and 12-DDH 8 and 9	180,812	420,821	65,092	151,495
DDH 8 and 9-DDH 4	176,337	458,641	93,459	243,080
DDH 4-DDH 3, 21 and 22	242,587	444,687	155,256	284,600
DDH 3, 21 and 22-DDH 5 and 6	201,375	302,075	118,825	178,245
DDH 5 and 6-DDH 7	70,275	126,100	61,139	109,707
		Total	867,866	1,665,428

The Specific Gravity of ore grading 37.6 per cent iron was taken to be 4.1 from tests on different grades of ore in the Department of Mines Laboratory, Launceston.

A tonnage factor of 8¾ cubic feet of ore to the long ton was accordingly derived.

Ore dressing tests on Savage River ore by Manson (1959, 1960, 1962) indicated that fine grinding and magnetic separation of 39.8 per cent Fe grade ore yielded a magnetite concentrate assaying 68.3 per cent Fe and weighing 56.6 per cent of the ore.

Ore of grade 37.6 per cent Fe is calculated to yield a magnetite concentrate assaying about 68.0 per cent Fe, and weighing 53.5 per cent of the ore. This magnetic concentrate in the central area may therefore be estimated at 53 million tons. Allowing a loss of 10 per cent due to mining hazard the ore reserve would then be approximately 48 million tons. The calculation of ore reserves is better summarized in figures:—

Specific Gravity of 37.6 per cent Fe grade ore = 4.1.

$$\text{Tonnage factor } \frac{2240}{4.1 \times 62.5} = 8\tfrac{3}{4} \text{ cu.ft/ton}$$

$$\text{Tonnage } \frac{867{,}866{,}500 \text{ cu.ft}}{8.75 \text{ cu.ft/ton}} = 99{,}184{,}692 \text{ tons of grade 37.6 percent Fe.}$$

Ore is oxidized to an average depth of 100 feet below the surface, and enriched to a grade generally between 60 and 66 per cent Fe. The tonnage of enriched ore may range from 20 million tons to about 24 million tons.

Magnetite concentrate of ore reserve $= \frac{53.5}{100} \times 99 \times 10^6$ tons

$= 53 \times 10^6$ tons of grade approx. 68.0 per cent Fe

Less 10 percent mining hazard

$= 47.7 \times 10^6$ tons of approx. 68.0 percent Fe.

Calculation of Waste Tonnage:—

Specific Gravity of amphibolite = 3.0.

$$\text{Tonnage factor} = \frac{2240}{3 \times 62.5} = 11.9 \text{ cu.ft/ton.}$$

$$\text{Tonnage} = \frac{(1,665,427,850-867,866,560) \text{ cu.ft}}{11.9 \text{ cu.ft/ton}}$$

$= 67 \times 10^6$ tons of waste rock.

NORTHERN AREA

Reserves to the date of writing are based on the following drillholes to a maximum depth below surface of 400 feet:—

Section Based On DDH. No.	Ore Zone Sq. ft	HCl Sol Fe %
14	28,800	45
18	72,000	30
19	48,000	35.8
20	12,000	27.0
17	48,000	38.5
Total	208,800	

Overall grade of the ore zone was derived by weighting the average grades of ore in each drillhole section with their respective areas. Overall average grade = 35.3 per cent Fe.

1	68,000	40.6
2	100,000	44.1
Total	168,000	

Average grade of ore zone between DDH 1 and DDH 2 = 42.8 per cent Fe.

The reserve of ore indicated by drilling in the northern area is thus about 16 million tons (see p. 88). An ore reserve of about 14 million tons may be proved by additional drilling, constituting a total reserve of about 30 million tons of ore.

SOUTHERN AREA

The orebody has not yet been drilled, consequently the estimate of 15 million tons of ore to a depth of 400 feet, based mainly on the geophysical anomaly, is liable to modification.

CALCULATION OF TONNAGE IN NORTHERN AREA.

Block bounded by sections	Average Area sq. ft	Volume cu.ft × 1,000	
Savage River—			
DDH 14	14,000	2,800	Tonnage = 93,520,000 cu.ft / 9 cu.ft/ton = 10,391,111 tons @ 35.3 per cent Fe
DDH 14-DDH 18	50,400	27,720	
DDH 18-DDH 19	60,000	30,000	
DDH 19-DDH 20	30,000	15,000	
DDH 20-DDH 17	30,000	18,000	
Total	....	93,520	
DDH 1-DDH 2	84,000	50,400	Tonnage = 5,800,000 tons @ 42.8 per cent Fe

LONG PLAINS SOUTH-BROWN PLAINS AREA

Drillhole R.T.A.E.1, the only one in the area, enables the ore reserve to be estimated roughly by extrapolating the grade and width of ore intersected in the hole along the strike length of the deposit. The ore reserve to a depth of 400 feet below surface is calculated to be 40 to 50 million tons of medium grade ore.

ROCKY RIVER AREA

Magnetometer and geological surveys show low grade mineralization in a zone approximately 200 feet wide, and over a mile long. The corresponding reserve of low grade ore (perhaps no more than 15 per cent Fe) to a depth of 400 feet below surface would possibly be 40 to 50 million tons.

CONCLUSIONS

The estimated ore reserves are summarized as follows:—

Savage River {
Central Area = 99 million tons.
Northern Area = 30 million tons (approx.).
Southern Area = 15 million tons (inferred).

Total 144 million tons of low to medium grade ore.

Long Plains South-Brown Plains = 40 to 50 million tons of low to medium grade ore.

Rocky River area = 40 to 50 million tons of low grade ore.

Magnesite Deposits

MAIN CREEK

Magnesite was first recorded from Main Creek by Rowe (1962) who included an assay of the rock in his report. The writer, accompanied by Geologist D. I. Groves, Department of Mines, examined the magnesite deposit on traverse 18000 N, between 1,350 feet and 1,600 feet west of the baseline. In the course of the investigation a large magnesite body was found in the bed of Main Creek between traverses 18000 N and 19000 N (fig. 17). A subsequent survey of Main Creek south of traverse 18000N indicated lenses and bands of magnesite cropping out in the channel as far as traverse 17000 N, beyond which the country rock becomes arenaceous. Bedded quartzite crops out in the creek about 700 feet downstream from the last magnesite occurrence.

The main body of magnesite is exposed in the channel of Main Creek which is dissected to a depth between 300 feet and 500 feet below the level of the Henty Surface. The bed of the creek in places is a rock channel cut in magnesite to a depth of 10 feet. The small magnesite body to the west of Main Creek, described by Rowe, is situated on the valley side between 20 feet and 90 feet above Main Creek but apart from this all the field

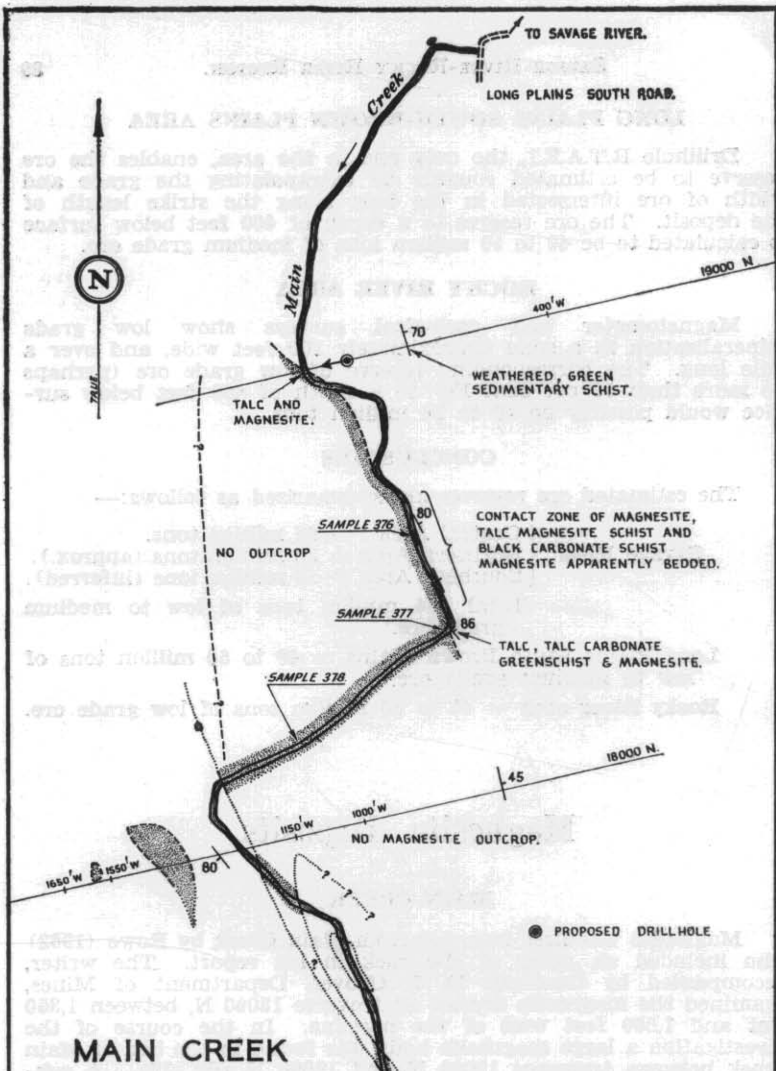


FIGURE 17.

5 cm

exposures of deposits are in deeply dissected tributaries draining to the Savage River. Traverses across the strike of the deposits away from creek beds do not show outcrops of magnesite.

The magnesite in Main Creek is cryptocrystalline; a fresh surface is white, grey or greyish-white and a weathered surface pinkish or flesh-coloured. The surface may be fluted, indented and grooved or it may weather to a form resembling "elephant hide". In one 10 feet long section on the west bank of the creek, a magnesite "conglomerate" is evident, formed by rounded and subangular nodules of pinkish, cryptocrystalline magnesite 2 to 4 inches in size, set in greyish-white, fine- to medium-grained magnesite, less resistant to weathering than the nodules. Elsewhere in the creek channel the texture of the mineral is heterogeneous, formed by irregular blebs and shreds of white or grey, medium-grained magnesite, less than an inch long, in pinkish cryptocrystalline magnesite. The mineral is dense, compact and brittle and breaks with a hackly, subconchoidal fracture.

The structure of the deposit differs across and along strike. In the section across strike, i.e. sub-parallel to the direction of traverse 18000 N, the outcrop is massive and unbedded though joints and crystalline seams give a spurious bedded appearance to the rock.

Main Creek is entrenched approximately along the eastern contact of the magnesite deposit for a distance of 600 feet south of traverse 19000 N. In this section the magnesite is mottled blue and grey, and bands are intercalated with yellowish talc schist and green and black talc-carbonate-chlorite schist. Pyrite is finely disseminated in the talcose zone which appears to be 10 to 20 feet wide, grading eastward into silty talc schist and ultimately into green and grey chlorite-muscovite schist and phyllite of the Whyte Schist pelitic assemblage.

In one section of the rock channel about 100 feet north of the elbow bend in the creek the bedded nature of the magnesite is indicated by a succession of parallel bands of silica up to half an inch thick which form ridges up to 3 inches high in the magnesite host.

In the northern extremity of the deposit near traverse 19000 N, slickensided talc seams up to 6 inches in width ramify through and enclose pods of magnesite.

The relationship of magnesite to country rock is obscure in Main Creek south of traverse 18000 N owing to lack of rock exposure. The magnesite lenses mapped in this section may not represent the true widths of the lodes. Wall rock alteration to black pyrite-bearing schist and yellow talc schist is found adjacent to the most southerly magnesite lens.

In thin section under the microscope the mineral is seen to consist of a granoblastic aggregate of anhedral magnesite grains (average size 0.015 mm) cut by intersecting veinlets of coarser grained carbonate mineral composed of subhedral and, more rarely, euhedral crystals up to 0.1 mm in size. In some hand specimens the veinlets and patches of recrystallized carbonate (magnesite or possibly dolomite) are more coarse-grained.

The analyses of magnesite (analyst, W. St. C. Manson) listed below show the composition of composite samples from localities indicated on the map (fig. 17).

Sample	376	377	378	A
SiO_2	9.4	1.3	0.5	0.80
Al_2O_3	1.1	0.1	Trace	0.23
Fe_2O_3	3.5	3.5	1.7	1.00
MnO	0.2	0.1	Trace	0.11
TiO_2	Trace	Trace	Trace	Nil
CaO	3.6	1.7	1.8	2.65
MgO	40.3	43.4	44.8	44.6
Ignition Loss	42.2	50.0	51.1	50.5
P_2O_5	....	....	....	Trace
SO_2	....	....	....	Nil
S	....	....	....	Nil
	100.3	100.1	99.9	99.89

A. Sample of magnesite on traverse 18000 N, west of Main Creek, collected by S. Rowe (Rowe, 1963).

Structure

Strike and dip attitudes of the magnesite are clearly seen in the bed of Main Creek in the eastern contact zone, which is aligned in a NNW direction parallel to the regional strike and dip of the schist and phyllite country rock. The maximum width of the magnesite body intersected by Main Creek is almost 600 feet; the maximum length between traverses 19000 N and 18000 N is about 800 feet but mineralization extends (probably discontinuously) over a total length of 2,000 feet. The dip of the magnesite body and of the country rock over this distance ranges from 75° in an ENE direction to nearly vertical. Dip and strike attitudes are similar in mica-quartz schist and quartzite on the western side of the deposit. The magnesite deposit is therefore conformable in a horizon at or near the transition from chlorite-muscovite-quartz schist and phyllite into an arenaceous assemblage consisting of mica-quartz schist and quartzite.

The outcrop pattern of magnesite on traverse 18000 N and south in Main Creek to traverse 17000 N strongly suggests that the deposits may be lenticular and irregular in width, length, and depth.

Calculations of ore reserves in the present state of knowledge of the deposits are preliminary estimates subject to alteration after drillholes have been bored. The proposed site of the first drillhole is shown on the map. The result of this drilling will indicate whether the 600 feet width of magnesite exposed in Main Creek is continuous to traverse 19000 N. A preliminary estimate of magnesite reserve, assuming this to be so, is 30,000 short tons/foot depth, allowing a 10 per cent dilution factor. Magnesite is exposed to a depth of 10 feet in places along the creek channel, thus a possible reserve of 300,000 tons is inferred for an area roughly 600 feet square bounded by traverse 19000 N to the north, and by Main Creek to the east and south.

LONG PLAINS SOUTH-BROWN PLAINS AREA

Bowry Creek

A magnesite occurrence very similar to the Main Creek deposit was found in Bowry Creek between traverses 12000 N and 12500 N in the Long Plains South-Brown Plains area (fig. 6). The creek, a small tributary of the Savage River, is deeply dissected exposing pinkish-white, very fine-grained, massive magnesite situated between 550 feet and 850 feet west of the baseline. The deposit is not clearly revealed and magnesite may not be continuous over the 300 feet wide section. The country rock upstream to the baseline consists of dark green chlorite-rich sedimentary schist and phyllite, in places containing lenses of carbonate rock up to 1 foot long in the schistosity. The meta-sediments west of the deposit are greyish and more silty. The country rock on either side of the magnesite body dips steeply (80° to 90°) in an easterly direction. Wall rock alteration to talc and pyrite-bearing schist is not evident and the bedded nature of the massive magnesite can only be inferred.

A chemical analysis of a composite sample (analyst, W. St. C. Manson) gave the following result:—

	%
SiO_2	0.51
Fe	2.17
CaO	1.94
MgO	42.90

Other Occurrences

Magnesium-rich carbonate rock very similar in colour and texture to magnesite was intersected in drillhole R.T.A.E. 1 (11085N 345E), between a depth of 606 feet and 639 feet where it succeeded intersections of magnetite-bearing amphibolite (fig. 21). The contact between amphibolite and carbonate rock is not preserved in the drill core. The hole terminated in carbonate rock and the width is consequently unknown.

Two assays of core section (analyst, W. St. C. Manson) yielded the following information:—

Depth (feet)	606-620	624-639
COMPOSITION	%	%
SiO_2	7.45	7.26
Al_2O_3	0.20	0.04
Fe_2O_3	4.86	4.00
MnO	0.10	0.12
TiO_2	Nil	Nil
CaO	9.79	14.35
MgO	32.16	27.79
Ignition Loss	45.26	46.37
	99.82	99.93

Magnesite is also reported between a depth of 499 feet and 547 feet in drillhole No. 28 (9250N, 200E). Assays of the rock have not yet been made, nor is the core available for inspection. The hole terminated in carbonate rock and the width is unknown. Should the assay prove the rock to be rich in magnesium, carbonate bodies at depth only evident from drillhole core intersections or in deeply eroded creek sections are present over a distance of nearly 10,000 feet extending between traverses 9250 N and 19000 N (fig. 2). If the width of the magnesite bodies revealed in creek sections is maintained along strike a reserve of 300,000 tons/foot depth of magnesite and magnesium-rich carbonate rock may be present.

A small outcrop of carbonate rock, probably magnesite, 10 feet long and 3 feet wide, is exposed in the bed of a creek at approximately 3900 N on the baseline in the Long Plains South-Brown Plains area (fig. 6). Host rocks are amphibolite and greenschist.

ORIGIN OF MAGNESITE

Bain (1924) described the characteristics of types of magnesite deposits listed below:—

Magnesite as a sedimentary rock.
Magnesite as an alteration of serpentine.
Magnesite as a vein filling.
Magnesite as a replacement of limestone and dolomite.

Features which together suggest that magnesite may have been formed by the replacement of sedimentary limestone or dolomite are:—

(i) The concordance of magnesite with the adjacent meta-sediments. Magnesite is stratified with silica layers and talcose zones at one contact. The talcose rocks appear to grade into phyllite and schist.

(ii) Magnesite forming the deposits is massive, and differs from sedimentary magnesite in which the impurity is caused by beds of clastic material.

(iii) The host rocks of the Bowry Creek and Main Creek deposits are meta-sediments. Serpentine rock or altered ultrabasic rock has not been seen.

(iv) Magnesite forming vein-filled deposits is highly ferruginous (Bain, 1924, p. 420). The average iron content of magnesite in Bowry Creek and Main Creek does not indicate this type of deposit.

(v) Talc in the wall rock of contact zones in Main Creek may be an alteration of limestone or dolomite by hydrothermal magnesia solutions. Bain (1924, p. 426) listed a series of reactions involving calcite, dolomite, and magnesia-bearing solutions which produced talc and other ferromagnesian minerals and culminated in the formation of magnesite. The process appears to have been carried to completion in the Main Creek deposit because intermediate minerals of the reactions have not been observed away from the contact zones.

The magnesia-bearing solution required to effect the replacement and enrichment of carbonate rock to magnesite may have been derived from basic magma which formed the amphibolite rock.

The carbonate rock in the core of drillhole R.T.A.E. 1 succeeds intersections of amphibolite and magnetite. The origin of the rock may be similar to that of "dolomite" in the Savage River.

Other Deposits

GOLD AND OSMIRIDIUM

Gold was recovered from the Savage, Whyte and Rocky Rivers, and from Main Creek and its tributaries from 1880 onwards. Adits in magnetite deposits of the Savage River and Rocky River areas were originally driven in the search for gold and silver. Small amounts of nickel, copper and lead sulphides were also reported in these mines. The Specimen Reef, a few miles north of the northern Savage River deposit, carried gold in a narrow quartz-carbonate reef (Smith, 1897).

Osmiridium found with gold in the Savage River was discarded until the turn of the century because of a lack of demand for the metal. Chromite, osmiridium, and magnetite (as fine concentrate and boulders) in the bed of the river both upstream and downstream from the magnetite deposit, can be traced to the serpentinite and ultrabasic body at Bald Hill.

The source of gold, which was also recovered from the weathered detritus overlying Whyte Schist, is more puzzling as the "mother" lode has not been found. Twelvetrees (1903, p. 5) suggested that the gold may be derived from pyritic lodes in Whyte Schist. Black pyrite-graphite lodes in Whyte Schist have been seen in two different localities by the writer. A sample did not assay any gold, and only a trace of copper (0.04 per cent).

TIN

The Tertiary sediments forming Brown Plains and Little Plains have been worked for tin. Scott (1926) reported the presence of a little chromite and gold. Panning of the sediments by W. Pitulej showed that scours 5-10 feet deep in the schist, filled with poorly-sorted gravel, are favourable sites for tin deposition. Much of the tin in bygone days was won from concentrations effected by creeks draining the plains. The economic prospects today are poor unless buried leads can be traced, perhaps by trenching or geophysical prospecting.

DIAMONDS

Most of the very few diamonds found in Tasmania near the turn of the century were recovered from tributaries of Harvey Creek and Badger Creek, streams which rise in the ranges to the west and flow into the Savage River. The diamonds were small and weighed only about one eighth of a carat.

Appendix

CORE ASSAYS AND SECTIONS—DRILL HOLES Nos. 1-25; R.T.A.E. 1

DIAMOND DRILL HOLE No. 1 (see figure 22)

Location: Traverse E00; 300′W

R.L.: 1515′ *Bearing*: 103° *Dip of Hole*: 41°

Depth From ft.	Depth From in.	Depth To ft.	Depth To in.	Inter-section ft.	Inter-section in.	Core Recovery %	Fe (HCl Sol.) %	SiO_2 %	Al_2O_3 %	Ti %	Mn %	P %	S %	V %
400	0	421	0	21			52.2	11.2	..	1.38	0.12	trace	0.98	..
421	0	440	0	19			58.1	6.9	..	1.12	0.12	0.02	0.23	..
440	0	471	0	31			51.9	12.2	..	1.09	0.12	0.02	0.18	..
471	0	487	0	16			28.3	29.5	..	0.76	0.13	0.03	1.61	..
487	0	508	0	21			59.3	14.1	..	1.13	0.12	trace	0.43	..
508	0	515	0	7			13.6	..	..	..	..	..	..	..
515	0	520	0	5		43.5	20.5	29.6	..	0.43	0.08	0.01	0.84	..
520	0	540	0	20			43.1	15.4	..	0.79	0.11	0.01	0.83	..
540	0	563	0	23			41.3	16.5	..	0.82	0.11	0.01	0.69	..
563	0	572	0	9			28.3	23.0	..	0.78	0.09	0.05	1.31	..
572	0	595	0	23			51.1	10.3	..	1.1	0.13	0.03	0.92	..
595	0	611	0	16			46.9	12.6	..	0.96	0.14	0.10	1.21	..
611	0	631	0	20			44.5	14.4	..	0.45	0.14	0.50	0.98	..

Bore depth 668 feet

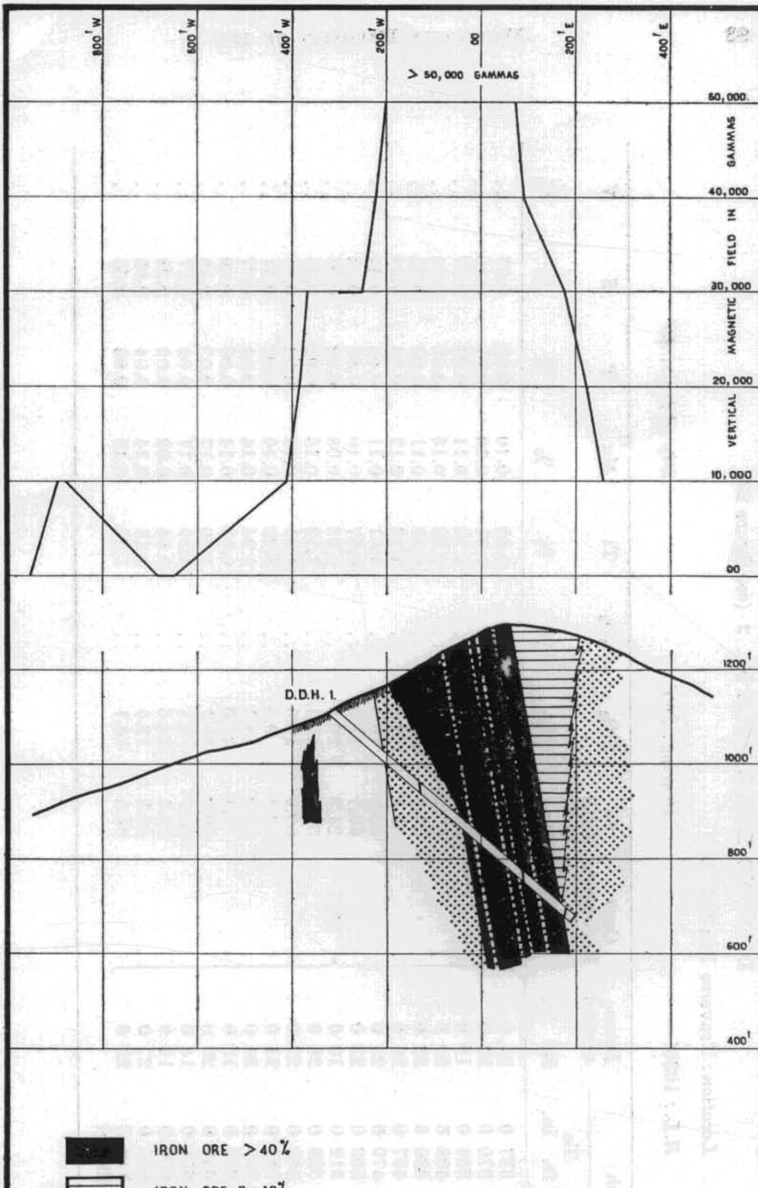


FIGURE 22.

5 cm

DIAMOND DRILL HOLE No. 2 (see figure 23)

Location: Traverse E5; 241′ E

R.L.: 1630′ *Bearing:* 260° *Dip of Hole:* 45°

Depth From ft. in.	Depth To ft. in.	Intersection ft. in.	Core Recovery %	Fe (HCl Sol.) %	SiO_2 %	Al_2O_3 %	Ti %	Mn %	P %	S %	V %
313 0	337 0	24 0		46.6	13.8	..	0.99	0.10	0.02	0.27	..
337 0	370 0	33 0		43.0	16.7	..	1.01	0.10	0.01	0.40	..
370 0	388 0	18 0		56.3	8.1	..	1.12	0.11	0.05	0.57	..
388 0	408 6	20 6		45.2	12.4	..	0.98	0.13	0.09	0.94	..
408 6	430 6	22 0		24.9	25.1	..	0.86	0.11	0.08	0.95	..
430 6	457 0	26 6		53.8	9.6	..	1.13	0.12	0.03	0.38	..
457 0	479 0	22 0		42.2	16.2	..	1.01	0.11	0.05	0.44	..
479 0	502 0	23 0		45.1	13.3	..	0.87	0.10	0.03	0.14	..
502 0	512 0	10 0	93.7	21.8	29.8	..	0.58	0.08	0.02	0.96	..
512 0	538 0	26 0		50.1	11.4	..	1.12	0.15	0.02	0.45	..
538 0	560 0	22 0		50.3	11.0	..	1.01	0.10	0.02	0.21	..
560 0	581 0	21 0		53.1	9.3	..	1.22	0.10	0.02	0.11	..
581 0	605 0	24 0		46.9	13.1	..	1.24	0.14	0.04	0.27	..
605 0	617 0	12 0		9.1	41.6	..	0.93	0.14	0.06	0.46	..
617 0	637 0	20 0		50.2	10.7	..	1.30	0.17	0.03	0.18	..
637 0	651 0	14 0		54.7	8.1	..	1.39	0.17	0.02	0.17	..
651 0	669 0	18 0		27.1	24.5	..	0.88	0.09	0.02	0.28	..
669 0	696 0	27 0		46.3	13.0	..	1.18	0.14	0.04	0.63	..
696 0	718 6	22 6		44.5	14.1	..	1.26	0.16	0.03	0.43	..

Bore depth 863 feet

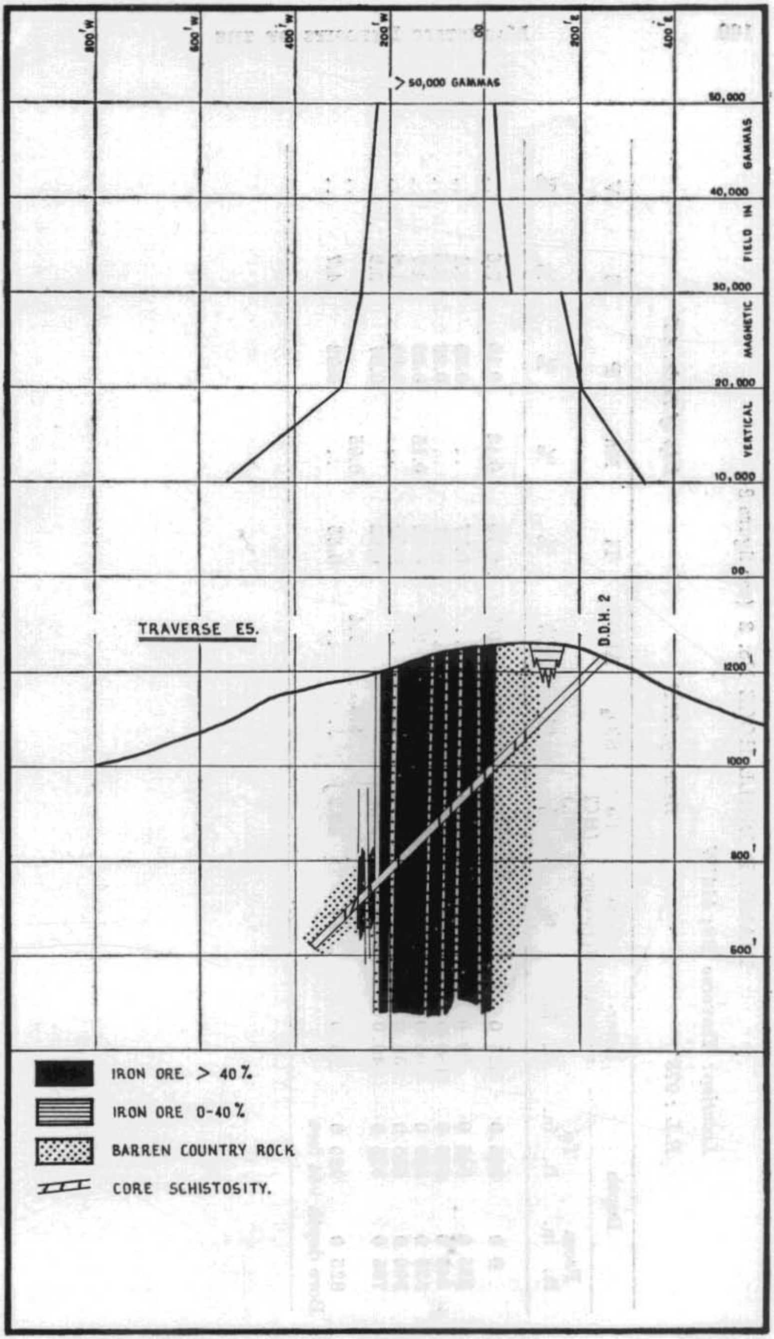


FIGURE 23.

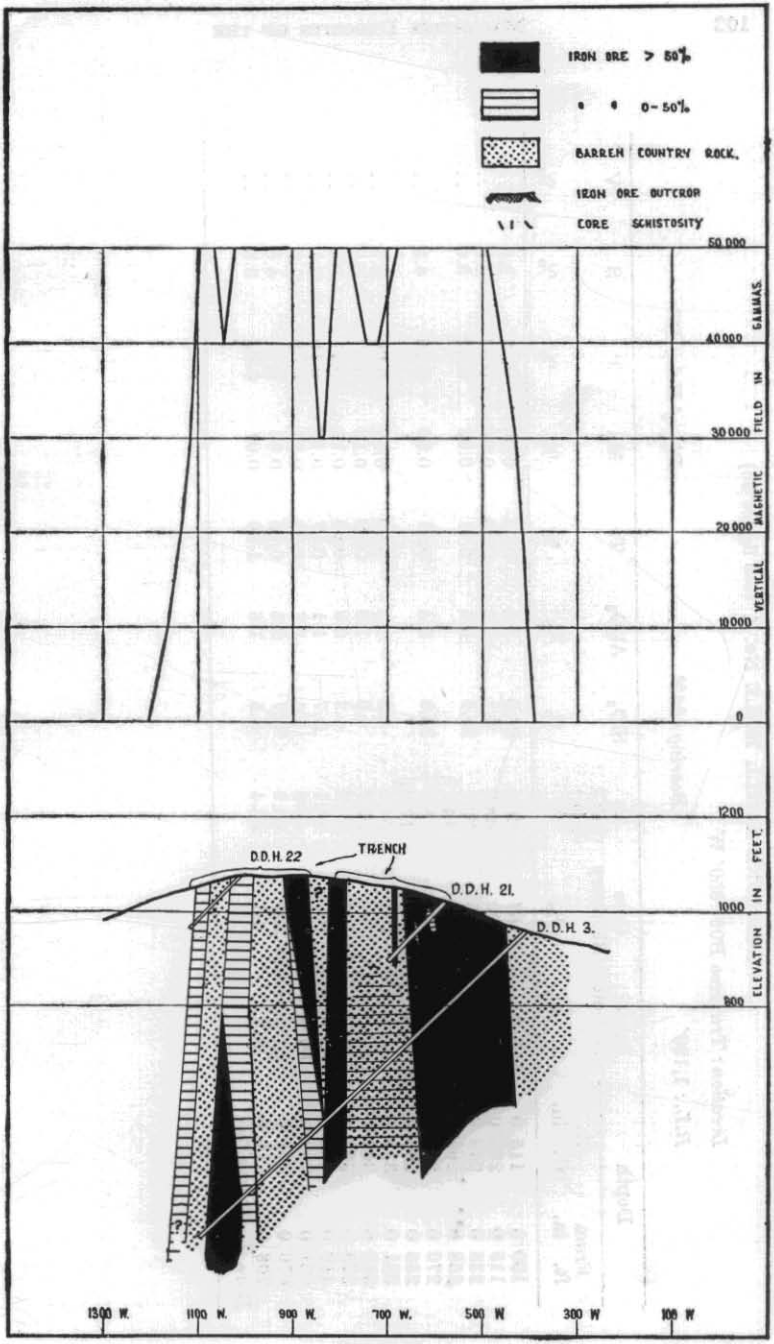
5 cm

DIAMOND DRILL HOLE No. 3 (see figure 24)

Location: Traverse B8; 414′W

R.L : 975′ *Bearing:* 271° *Dip of Hole:* 45°

Depth From ft. in.	Depth To ft. in.	Intersection ft. in.	Core Recovery %	Fe (HCl Sol.) %	SiO_2 %	Al_2O_3 %	Ti %	Mn %	P %	S %	V %
0 0	325 0	325 0	{0-50 = 4 50-325 = 65}	52.0	5.7	0.9	0.19	0.12	0.10	3.6	..
325 0	345 0	20 0	95	32.9	..	..	0.37	..	0.29	8.1	..
345 0	525 0	180 0	83	16.2	..	..	0.31	..	0.22	5.6	..
525 0	590 0	65 0	82	43.1	11.6	2.9	0.65	0.15	0.26	4.7	..
590 0	645 0	55 0	70	15.4	..	..	0.59	..	0.08	1.6	..
785 0	825 0	40 0	85	20.9 }			0.62		0.07	3.9	
				}	8.9	1.4		0.05			..
825 0	920 0	95 0	87	48.3 }	..	..	0.55	..	0.02	4.7	..
Bore depth 944 feet											



IRON ORE > 50%
" " 0-50%
BARREN COUNTRY ROCK.
IRON ORE OUTCROP
CORE SCHISTOSITY
50 000
40 000
30 000
20 000
10 000
0
VERTICAL MAGNETIC FIELD IN GAMMAS.
1200
1000
800
ELEVATION IN FEET.
D.D.H. 22
TRENCH
D.D.H. 21.
D.D.H. 3.
1300 W.
1100 W.
900 W.
700 W.
500 W
300 W
100 W

FIGURE 24.

5 cm

DIAMOND DRILL HOLE No. 4 (see figure 25)

Location: Traverse B00; 850′ W

R.L.: 1,130′ *Bearing:* 263° *Dip of Hole:* 45°

Depth From ft. in.	Depth To ft. in.	Intersection ft. in.	Core Recovery %	Fe (HCl Sol.) %	SiO_2 %	Al_2O_3 %	Ti %	Mn %	P %	S %	V %
100 0	115 0	15 0	67	26.9	27.0	3.1	0.53	0.06	0.02	2.0	..
115 0	235 0	120 0	90	48.9	9.1	2.0	0.30	0.06	0.07	4.3	..
235 0	248 0	13 0	85	20.7	28.3	0.4	0.11	0.03	0.29	3.4	..
258 0	266 6	8 6	100	14.7							
270 0	275 0	5 0	26	8.1	33.8	2.4	0.21	0.09	0.10	4.2	..
285 0	293 0	8 0	73	13.2							
331 0	339 0	8 0	100	54.8	5.3	1.4	0.20	0.08	0.06	4.7	..
343 6	360 6	27 0	97	52.5	6.0	1.3	0.29	0.13	0.07	5.2	..
379 0	392 6	13 6	92	56.7	4.2	0.8	0.29	0.13	0.11	4.3	..
412 0	475 6	63 6	100	43.1	9.7	1.1	0.37	0.19	0.10	7.1	..
521 0	590 9	69 9	97	48.8	5.4	1.7	0.83	0.17	0.09	8.6	..
676 0	688 0	12 0	100	43.9	9.7	2.3	0.76	0.06	0.15	4.6	..
708 6	717 3	8 9	83	55.4	5.5	1.6	1.06	0.07	0.03	3.8	..

Bore depth 954 feet

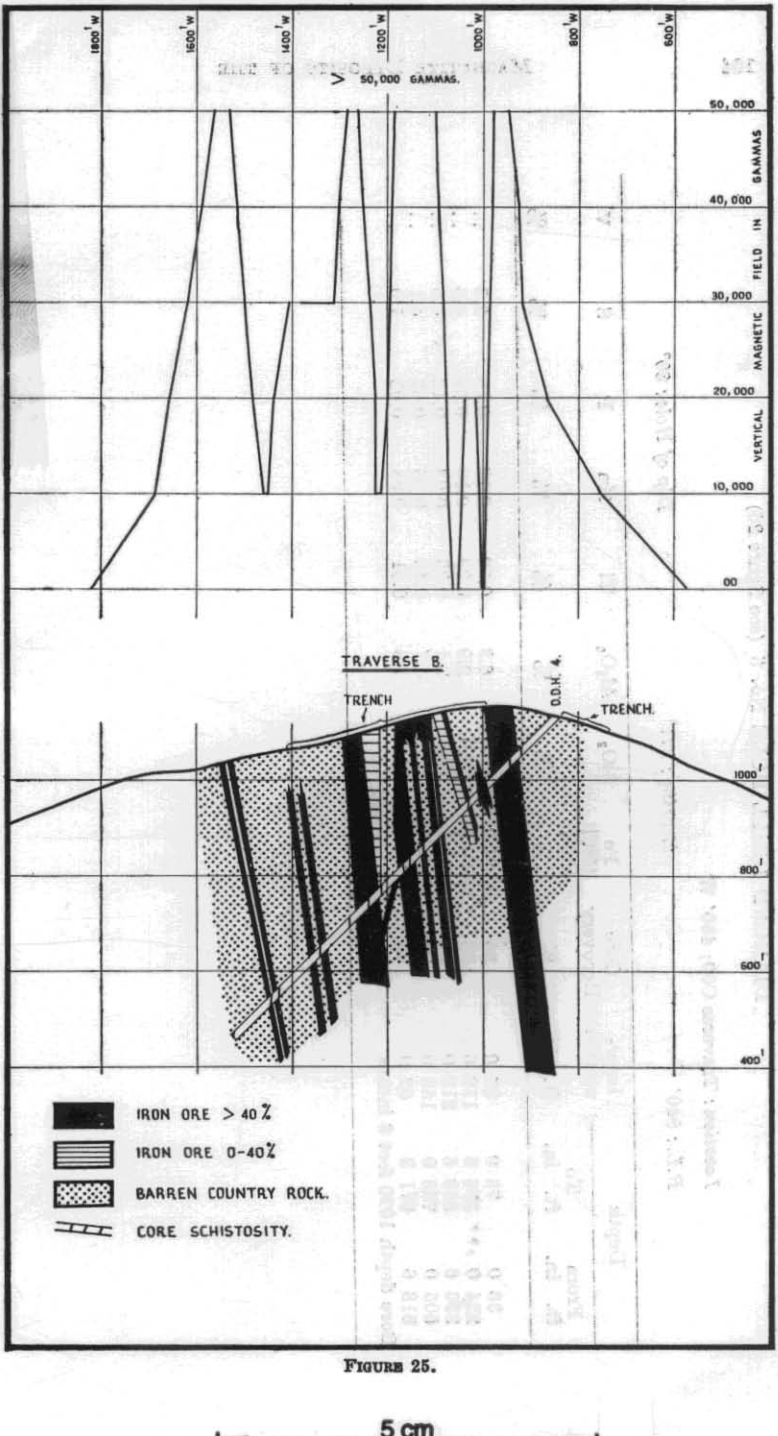


FIGURE 25.

5 cm

DIAMOND DRILL HOLE No. 5 (see figure 26)

Location: Traverse C00; 450′ W

R.L.: 840′ *Bearing:* 271° *Dip of Hole:* 60°

Depth From ft.	Depth From in.	Depth To ft.	Depth To in.	Intersection ft.	Intersection in.	Core Recovery %	Fe (HCl Sol.) %	SiO_2 %	Al_2O_3 %	Ti %	Mn %	P %	S %	V %
36	0	73	0	37	0	55	21.2	27.8	6.3	0.50	0.12	0.18	3.3	..
224	0	336	6	112	6	98	20.9	26.0	2.9	0.29	0.10	0.34	4.6	..
336	6	549	6	213	0	96	46.7	10.3	2.1	0.33	0.08	0.12	4.6	..
605	0	763	0	158	0	89	36.2	17.7	4.7	0.46	0.06	0.07	4.1	..
818	6	871	3	52	9	99	22.8	31.1	7.3	0.61	0.08	0.03	1.0	..

Bore depth 1020 feet 6 inches

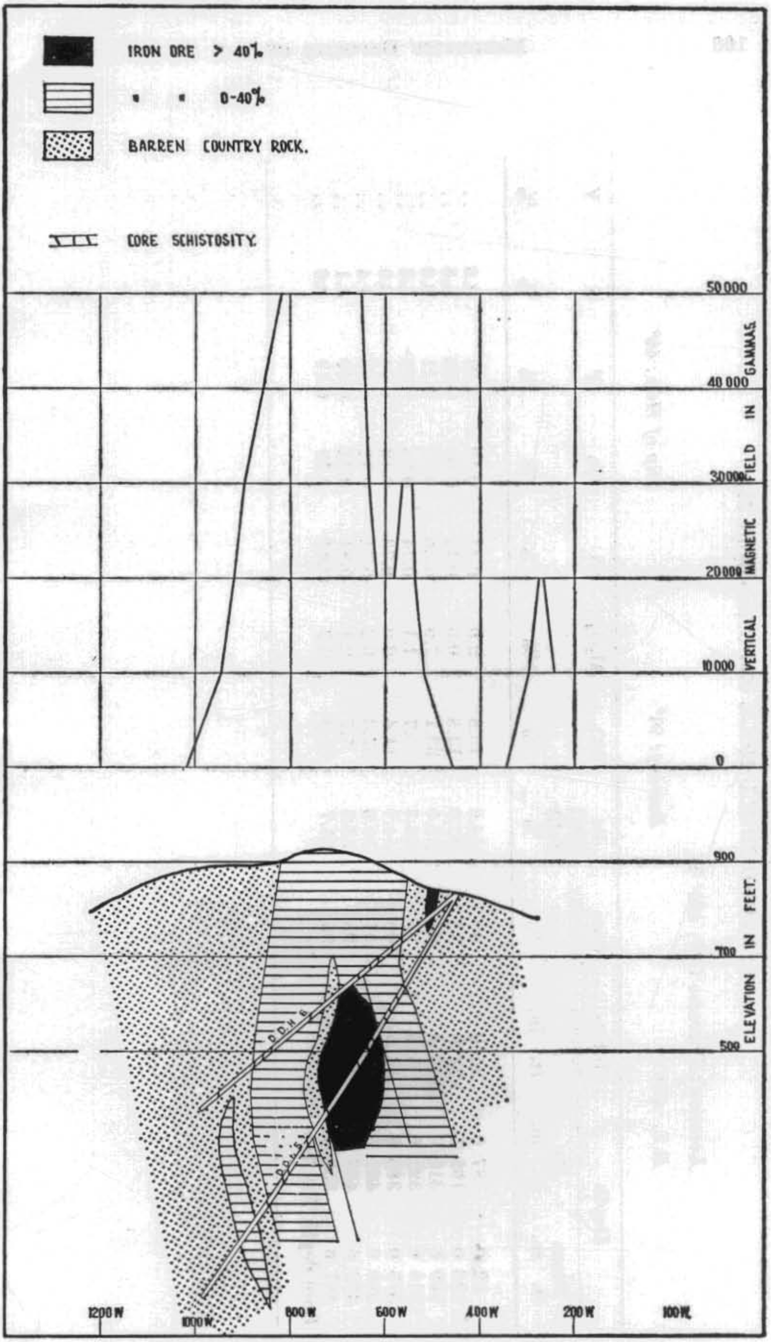


FIGURE 26.

5 cm

DIAMOND DRILL HOLE No. 6 (see figure 26)

Location: Traverse C00; 450′ W

R.L.: 840′ *Bearing*: 91° *Dip of Hole*: 40°

Depth From ft.	in.	Depth To ft.	in.	Inter-section ft.	in.	Core Recovery %	Fe (HCl Sol.) %	SiO_2 %	Al_2O_3 %	Ti %	Mn %	P %	S %	V %
52	0	87	0	35	0	40	44.0	15.8	3.0	0.41	0.10	0.21	4.6	..
146	0	169	6	23	6	79	42.0	14.8	0.5	0.17	0.06	0.23	4.8	..
169	6	316	0	146	6	77	15.0	33.1	7.9	0.56	0.12	0.11	3.0	..
316	0	322	6	6	6	96	56.3	5.7	1.1	0.74	0.05	0.09	3.6	..
373	0	386	6	13	6	100	54.7	11.4	2.0	0.73	0.12	0.04	3.0	..
386	6	462	6	76		97	10.9	37.3	9.2	0.51	0.12	0.06	1.4	..
462	6	487	6	25	0	98	55.3	7.7	2.1	0.81	0.11	0.09	1.1	..
487	6	559	3	71	9	95	26.7	28.9	5.3	0.44	0.10	0.19	3.6	..

Bore depth 704 feet

DIAMOND DRILL HOLE No. 7 (see figure 27)

Location: Traverse C12; 500′ W

R.L.: 580′ *Bearing*: 253° *Dip of Hole*: 0′ = 45°; 400′ = 39°; 800′ = 32°

Depth From ft. in.	Depth To ft. in.	Intersection ft. in.	Core Recovery %	Fe (HCl Sol.) %	SiO_2 %	Al_2O_3 %	Ti %	Mn %	P %	S %	V %
254 0	321 0	67 0	100	26.5	21.5	4.6	0.34	0.08	0.31	4.8	..
343 0	360 0	17 0	100	39.7	13.7	0.4	0.21	0.07	0.22	3.9	..
461 0	477 0	16 0	98	13.4	30.7	5.8	0.25	0.13	0.33	5.9	..
477 0	520 3	43 3	98	48.2	7.3	0.8	0.32	0.11	0.15	5.9	..
520 3	554 6	34 3	100	49.8	6.9	0.7	0.42	0.09	0.03	5.9	..
554 6	579 0	24 6	100	31.6	13.9	1.6	0.26	0.02	0.07	11.6	..
579 0	632 0	53 0	99	10.9	31.1	12.6	0.53	0.08	0.14	3.5	..
632 0	652 0	20 0	100	55.9	4.0	0.9	0.37	0.08	0.20	4.5	..
652 0	680 0	28 0	100	45.0	12.6	5.4	0.55	0.07	0.04	3.1	..
680 0	702 6	22 6	96	48.7	8.8	0.7	0.09	0.06	0.02	4.9	..
702 6	751 0	48 6	100	62.0	1.5	0.4	0.08	0.06	0.05	4.1	..
751 0	782 0	31 0	100	29.5	21.8	7.4	0.60	0.09	0.44	3.8	..

Bore depth 877 feet

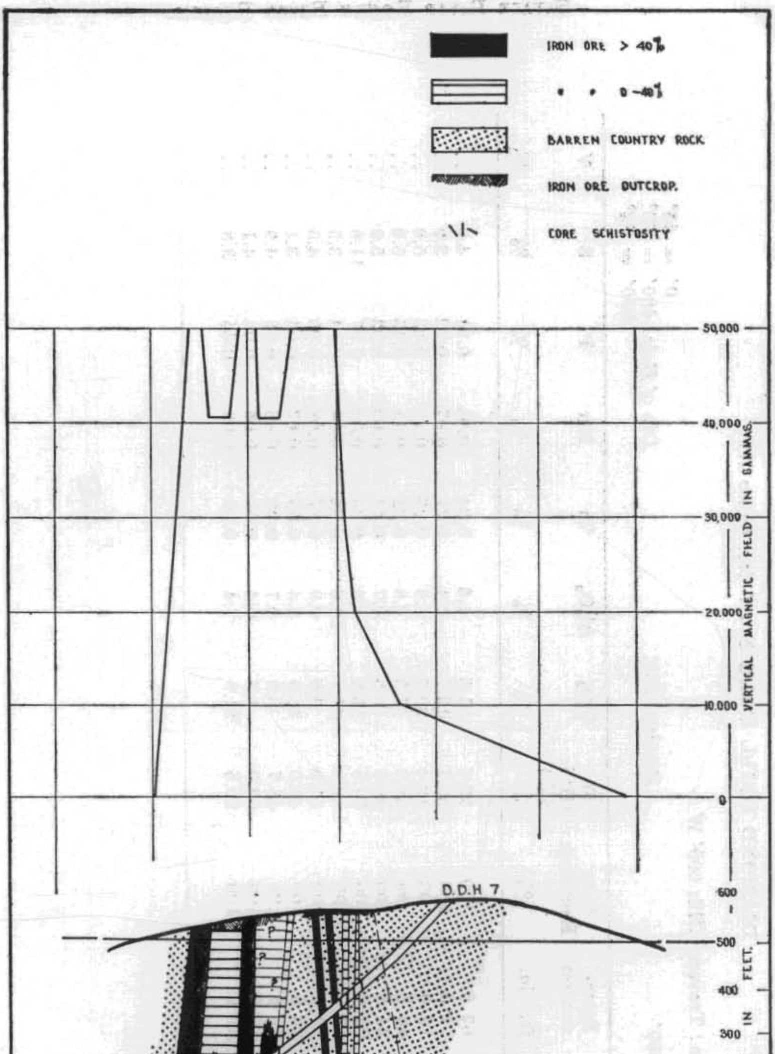
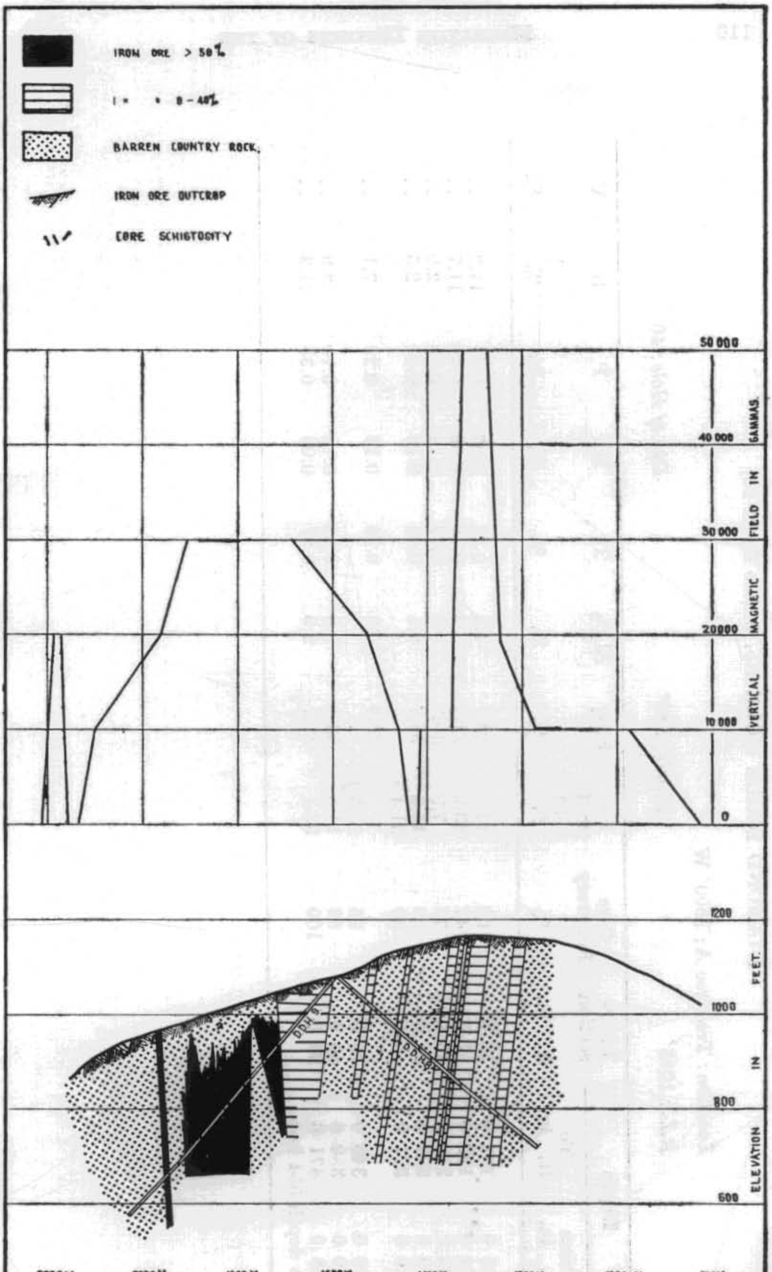


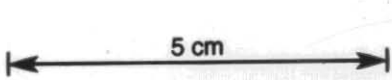
FIGURE 27.

5 cm



IRON ORE > 50%
I " " 0 - 40%
BARREN COUNTRY ROCK.
IRON ORE OUTCROP
CORE SCHISTOSITY
50 000
40 000
30 000
20000
10 000
0
VERTICAL MAGNETIC FIELD IN GAMMAS.
1200
1000
800
600
ELEVATION IN FEET.
2200 W.
2000 W.
1800 W.
1600 W
1400 W.
1200 W.
1000 W.
900 W.

FIGURE 28.



5 cm

DIAMOND DRILL HOLE No. 8 (see figure 28)

Location: Traverse A; 1600′ W

R.L.: 1085′ *Bearing:* 89° *Dip of Hole:* 40°

Depth From ft. in.	Depth To ft. in.	Inter-section ft. in.	Core Recovery %	Fe (HCl Sol.) %	SiO_2 %	Al_2O_3 %	Ti %	Mn %	P %	S %	V %
85 0	101 0	16 0	98	14.2	23.7	4.3	0.15	0.07	0.31	11.3	..
174 6	182 0	7 6	47	23.9	21.7	3.3	0.19	0.06	0.16	11.7	..
233 0	279 6	46 6	75	7.9	40.9	9.0	0.71	0.14	0.09	2.0	..
279 6	307 6	28 0	59	18.6	33.7	9.1	0.84	0.15	0.05	2.5	..
316 0	321 0	5 0	90	31.4 }	23.5	6.8	0.34	0.13	0.29	7.1	..
330 0	340 0	10 0	96	25.5 }							
340 0	380 6	40 6	88	11.5	33.3	9.0	0.33	0.14	0.10	3.9	..
448 0	471 6	23 6	100	35.1	12.7	2.0	0.27	0.05	0.35	11.3	..

Bore depth 554 feet

DIAMOND DRILL HOLE No. 9 (see figure 28)

Location: Traverse A; 1600′ W

R.L.: 1085′ *Bearing:* 269° *Dip of Hole:* 45°

Depth From ft.	in.	Depth To ft.	in.	Intersection ft.	in.	Core Recovery %	Fe (HCl Sol.) %	SiO_2 %	Al_2O_3 %	Ti %	Mn %	P %	S %	V %
0	0	154	0	154	0	1	50.3	19.1	1.8	0.25	0.05	0.06	1.8	..
154	0	178	0	24	0	50	7.0	39.6	13.2	0.53	0.18	0.09	2.5	..
178	0	231	0	53	0	43	54.2	4.9	2.4	0.28	0.07	0.04	6.4	..
268	0	497	0	229	0	88	46.9	8.3	2.0	0.62	0.15	0.14	7.0	..
542	0	548	0	6	0	22	47.7 }							
562	6	563	0	0	6	100	38.7 }	12.6	3.5	1.04	0.16	0.01	2.5	..
582	0	586	0	4	0	63	47.6 }							
603	0	611	0	8	0	55	51.9 }							

Bore depth 665 feet 6 inches

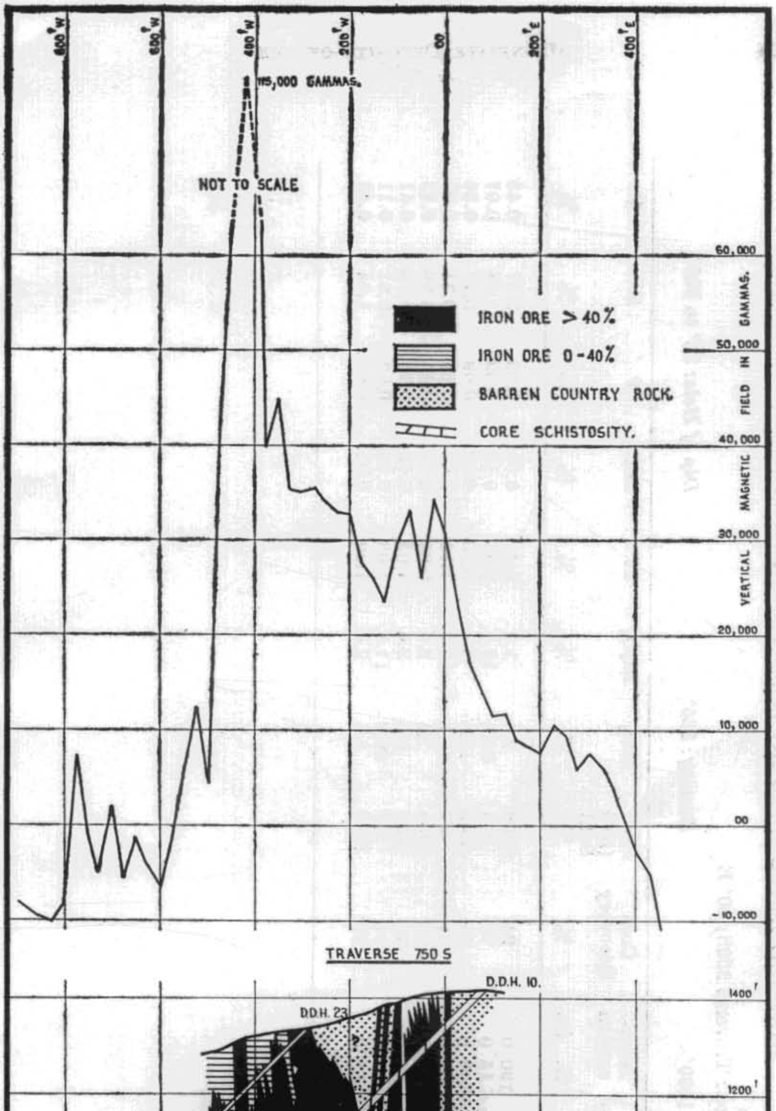
DIAMOND DRILL HOLE No. 10 (see figure 29)

Location: Traverse 750S; 25′ N, 75′ E

R.L.: 1015′ *Bearing:* 269° *Dip of Hole:* 45°

Depth From ft.	in.	Depth To ft.	in.	Intersection ft.	in.	Core Recovery %	Fe (HCl Sol.) %	SiO_2 %	Al_2O_3 %	Ti %	Mn %	P %	S %	V %
95	6	114	0	18	6	34	55.1	6.6	2.3	0.41	0.05	0.08	3.4	..
124	0	276	0	152	0	78	52.0	7.3	2.5	0.30	0.10	0.11	4.7	..
293	6	303	0	9	6	50	53.0	8.7	2.5	0.38	0.11	0.12	2.3	..
318	0	331	0	13	0	83	44.7	12.9	3.0	0.34	0.12	0.16	2.8	..
359	0	438	0	79	0	91	44.6	12.8	3.8	0.40	0.12	0.13	4.0	..

Bore depth 438 feet



800'W
600'W
400'W
200'W
00
200'E
400'E
115,000 GAMMAS.
NOT TO SCALE
IRON ORE > 40%
IRON ORE 0-40%
BARREN COUNTRY ROCK.
CORE SCHISTOSITY.
60,000
50,000
40,000
30,000
20,000
10,000
00
-10,000
VERTICAL MAGNETIC FIELD IN GAMMAS.
TRAVERSE 750 S
D.D.H. 10.
D.D.H. 23
1400'
1200'
1000'

FIGURE 29.

DIAMOND DRILL HOLE No. 11 (see figures 30 and 31)

Location: Traverse 250S; 80′ E

R.L.: 1030′ *Bearing:* 265° *Dip of Hole:* 55° to 200′

Depth From ft. in.	Depth To ft. in.	Intersection ft. in.	Core Recovery %	Fe (HCl Sol.) %	SiO_2 %	Al_2O_3 %	Ti %	Mn %	P %	S %	V %
0 0	190 0	190 0	24	59.6	2.4	1.5	0.41	0.09	0.06	3.07	0.43
190 0	205 0	15 0	70	8.3	35.8	12.4	0.84	0.12	0.09	1.04	0.07
205 0	307 0	102 0	80	45.3	10.5	3.4	0.56	0.12	0.09	5.79	0.34
307 0	358 0	51 0	74	4.7	46.6	15.2	1.14	0.13	0.06	0.31	0.07
358 0	362 0	4 0	25	56.0	7.4	2.0	0.94	0.14	0.15	4.96	0.42
375 0	450 0	75 0	85	53.9	5.4	2.0	1.03	0.13	0.13	5.26	0.41
450 0	473 0	23 0	87	8.9	46.2	11.8	1.03	0.14	0.09	0.81	0.11
473 0	526 0	53 0	37	53.5	8.5	2.4	1.29	0.07	0.08	1.84	0.43

Bore depth 577 feet 6 inches

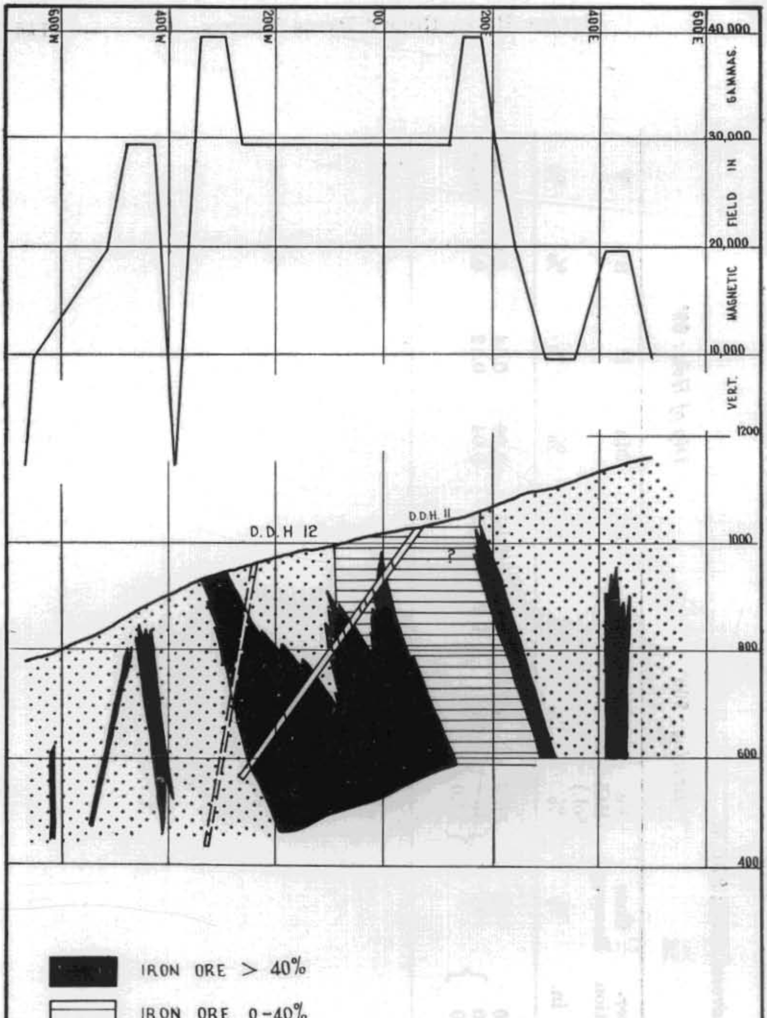
DIAMOND DRILL HOLE No. 12 (see figures 30 and 31)

Location: Traverse 250S; 270′ W

R.L.: 960′ *Bearing:* 266° *Dip of Hole:* 82°

Depth From ft. in.	Depth To ft. in.	Intersection ft. in.	Core Recovery %	Fe (HCl Sol.) %	SiO_2 %	Al_2O_3 %	Ti %	Mn %	P %	S %	V %
0 0	261 0	261 0	62	56.6	3.4	2.1	0.25	0.09	0.14	3.8	0.42
334 0	338 0	4 0 }	90	{ 36.6 }	36.6	9.2	1.02	0.04	0.12	0.7	0.16
340 0	350 0	10 0 }		{ 14.0 }							

Bore depth 526 feet 6 inches



600N
400N
200N
00
200E
400E
600E
40,000
30,000
20,000
10,000
VERT. MAGNETIC FIELD IN GAMMAS.
1200
1000
800
600
400
D. D. H 12
D.D.H. 11
?
IRON ORE > 40%
IRON ORE 0-40%
BARREN COUNTRY ROCK.
CORE SCHISTOSITY.

FIGURE 30.

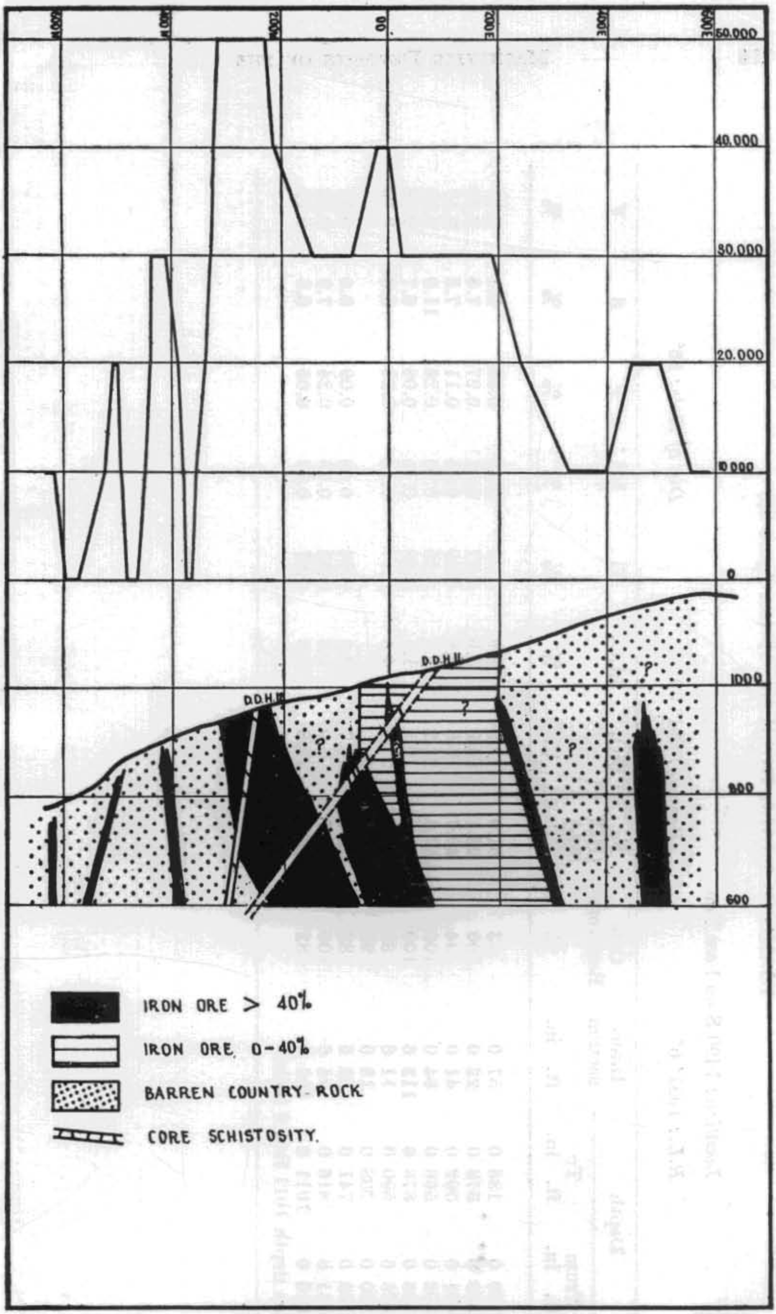


FIGURE 31.

5 cm

DIAMOND DRILL HOLE No. 13 (see figure 32)

Location: 1490 S on base line

R.L.: 1031′ 6″ *Bearing:* 291° 50′ *Dip of Hole:* 65°

Depth				Inter-section		Core Recovery	Fe (HCl Sol.)	SiO_2	Al_2O_3	Ti	Mn	P	S	V
From		To												
ft.	in.	ft.	in.	ft.	in.	%	%	%	%	%	%	%	%	%
129	0	186	0	57	0	43	61.0	2.9	1.9	0.32	0.10	0.25	3.1	0.37
350	0	372	0	22	0	100	33.1	15.9	3.6	0.27	0.07	0.27	7.8	0.19
461	0	502	0	41	0	94	40.7	13.8	3.9	0.40	0.05	0.11	7.3	0.17
502	0	566	0	64	0	100	16.6	22.2	5.4	0.25	0.05	0.26	11.9	0.06
566	0	678	6	112	6	100	51.2	6.1	1.5	0.48	0.14	0.08	6.7	0.38
678	6	690	0	11	6	83	3.7 }	22.0	4.4	0.67	0.14	0.20	5.8	0.19
690	0	708	0	18	0	95	43.1 }							
708	0	741	6	33	6	83	5.8	44.7	12.5	0.94	0.08	0.09	0.6	0.07
741	6	816	0	74	6	100	49.7	5.0	1.2	0.83	0.15	0.24	7.9	0.32
816	0	1011	0	195	0	82	40.7	12.8	2.8	0.87	0.13	0.05	6.6	0.25

Bore depth 1011 feet 6 inches

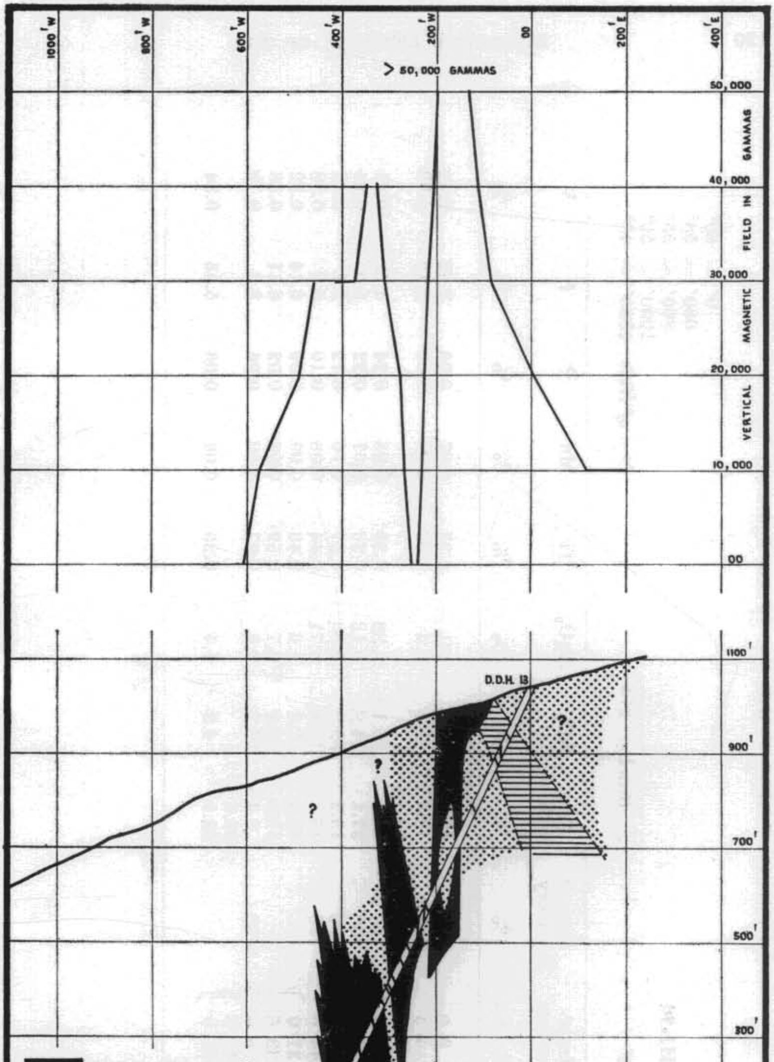

> 50,000 GAMMAS
1000' W
800' W
600' W
400' W
200' W
00
200' E
400' E
50,000
40,000
30,000
20,000
10,000
00
VERTICAL MAGNETIC FIELD IN GAMMAS
1100'
900'
700'
500'
300'
100'
D.D.H. 13
IRON ORE > 40%
IRON ORE 0-40%
BARREN COUNTRY ROCK.
CORE SCHISTOSITY

FIGURE 32.

DIAMOND DRILL HOLE No. 14 (see figure 33)

Location: H1·00

R.L.: 475′ *Bearing:* 274° *Dip of Hole:* 0′ = 60°, 600′ = 58°, 800′ = 55°, 1000′ = 50°, 1200′ = 43°

Depth From ft.	in.	Depth To ft.	in.	Intersection ft.	in.	Core Recovery %	Fe (HCl Sol.) %	SiO_2 %	Al_2O_3 %	Ti %	Mn %	P %	S %	V %
50	0	59	0	9	0	< 2	52	5.0	2.1	0.37	0.07	0.06	2.42	0.44
279	0	283	3	4	3	100	49.5 }	5.8	0.4	0.02	0.09	0.06	3.19	0.02
291	0	300	6	9	6	100	50.6 }							
848	0	955	0	107	0	100	32.5	16.1	1.99	0.29	0.08	0.24	4.52	0.21
1,004	0	1,145	0	141	0	100	37.1	14.9	1.12	0.30	0.07	0.22	5.0	0.24
1,145	0	1,169	0	24	0	92	15.2	33.0	9.60	0.57	0.10	0.12	2.2	0.12
1,210	0	1,254	6	44	6	95	45	10.8	2.71	0.44	0.08	0.10	5.2	0.28
1,254	6	1,285	6	31	0		48.6	7.4	1.6	0.49	0.09	0.09	6.14	0.32
1,285	6	1,319	0	33	6		51.5	5.9	3.7	0.59	0.09	0.02	6.11	0.36
1,319	0	1,327	6	8	6	> 90 (1,254 6 to 1,370 0)	5.4 }	27.7	3.3	0.67	0.06	0.06	3.3	0.19
1,327	6	1,339	0	11	6		38.6 }							
1,339	0	1,370	0	31	0		52.8	4.5	1.4	0.25	0.06	0.06	5.45	0.34

Bore depth 1,541 feet

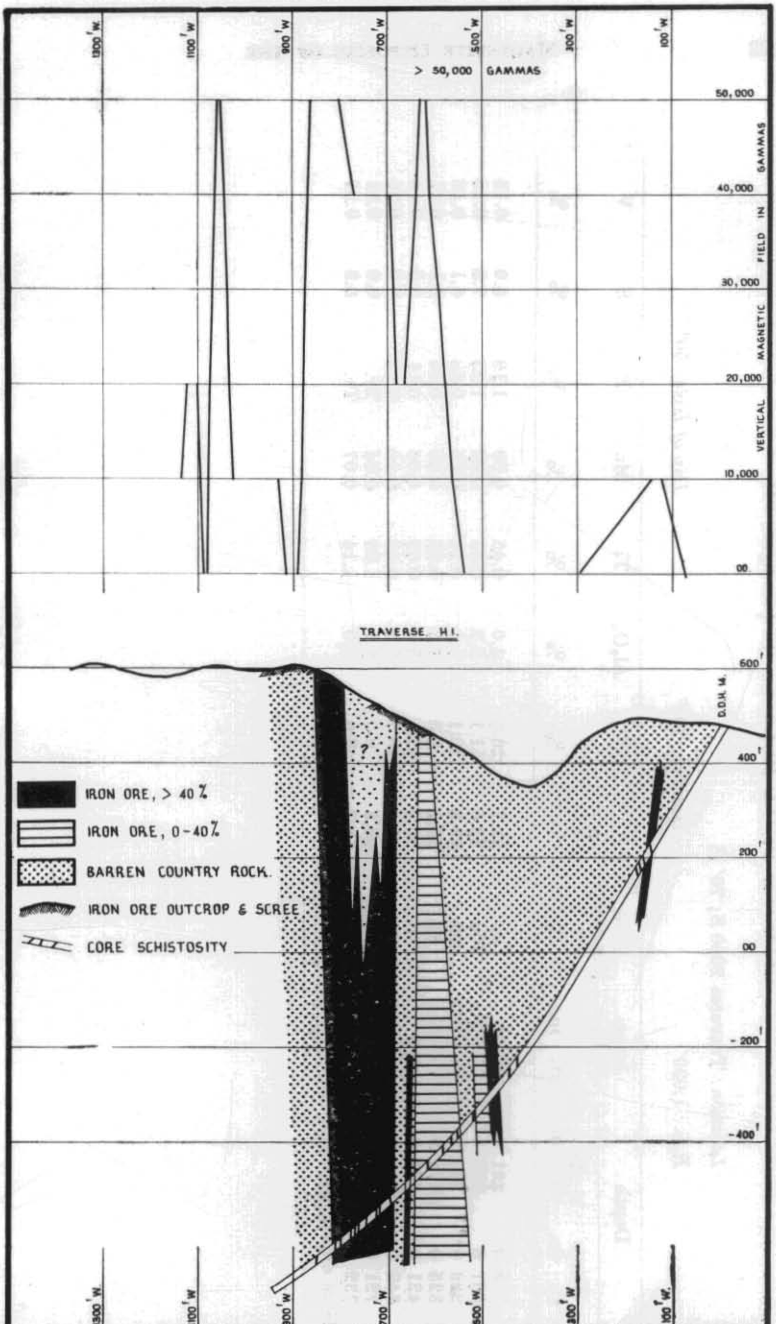


FIGURE 33.

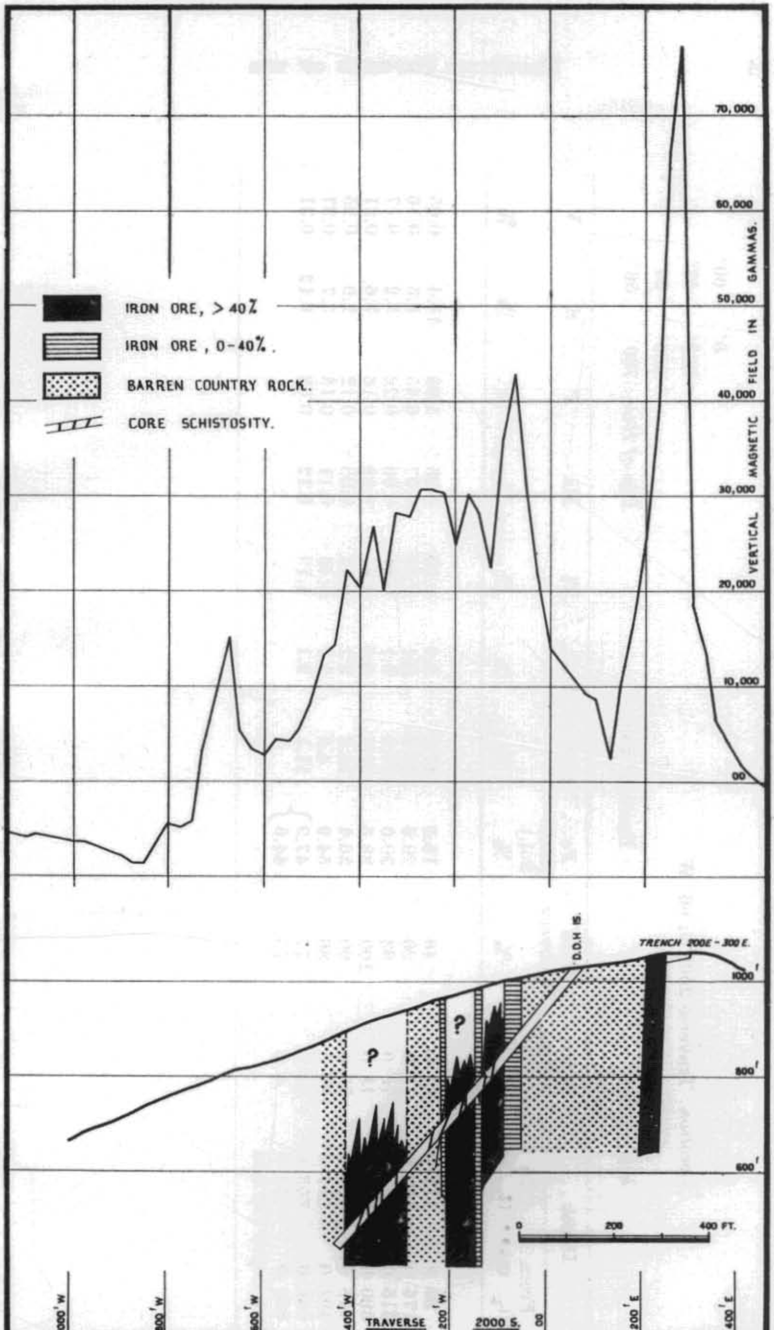
5 cm

DIAMOND DRILL HOLE No. 15 (see figure 34)

Location: Traverse 2000 S; 70′ E

R.L.: 1,030′ *Bearing:* 293° *Dip of Hole:* 50°

Depth From ft.	Depth From in.	Depth To ft.	Depth To in.	Inter-section ft.	Inter-section in.	Core Recovery %	Fe (HCl Sol.) %	SiO_2 %	Al_2O_3 %	Ti %	Mn %	P %	S %	V %
173	0	261	0	88	0	93	23.7	20.5	4.0	0.45	0.09	1.19	5.9	0.15
261	0	286	0	25	0	100	32.6	11.1	3.2	0.25	0.06	1.23	7.3	0.16
286	0	325	0	39	0	99	35.8	20.1	1.2	0.14	0.05	0.58	6.1	0.18
325	0	415	0	90	0	78	56.4	3.8	1.3	0.24	0.08	0.14	5.1	0.41
421	0	435	0	14	0	46	28.3	17.1	3.4	0.63	0.06	0.11	8.3	0.15
540	0	708	0	168	0	93	32.5	10.7	3.3	0.58	0.10	0.08	5.0	0.34
721	0	725	0	4	0	86	48.3	9.0	2.1	1.08	0.04	Tr.	6.8	0.31
732	6	734	0	1	6	86	53.7	7.0	2.0	1.14	0.07	Tr.	5.3	0.35
Bore depth 781 feet														



IRON ORE, > 40%
IRON ORE, 0-40%.
BARREN COUNTRY ROCK.
CORE SCHISTOSITY.
VERTICAL MAGNETIC FIELD IN GAMMAS.
70,000
60,000
50,000
40,000
30,000
20,000
10,000
00
D.D.H. 15.
TRENCH 200E - 300E.
1000'
800'
600'
0
200
400 FT.
1000' W
800' W
600' W
400' W
TRAVERSE
200' W
2000 S.
00
200' E
400' E

FIGURE 34.

DIAMOND DRILL HOLE No. 16 (see figure 35)

Location: Traverse 2500 S; 66′ W

R.L.: 940 ′

Bearing: 289°

Dip of Hole:

0′	60°
500′	57°
600′	57°
700′	56°

Depth From ft.	in.	Depth To ft.	in.	Intersection ft.	in.	Core Recovery %	Fe (HCl Sol.) %	SiO_2 %	Al_2O_3 %	Ti %	Mn %	P %	S %	V %
80	0	117	0	37	0	40	18.3	17.6	2.8	0.20	0.05	1.03	15.4	0.05
176	0	190	0	14	0	20	29.6	21.8	3.1	0.65	0.07	0.45	5.5	0.16
215	0	291	0	76	0	63	30.0	17.8	3.1	0.34	0.09	0.22	5.2	0.17
380	0	398	0	18	0	100	28.5	22.3	6.5	0.84	0.09	0.16	3.6	0.21
418	0	494	0	76	0	90	36.4	15.9	3.1	0.42	0.08	0.12	2.9	0.25
494	0	617	0	123	0	86	54.9	4.5	1.1	0.45	0.11	0.13	5.7	0.37
640	0	653	0	13	0	77	47.9 }	11.1	3.1	1.19	0.12	0.02	6.12	0.31
669	0	673	0	4	0	75	44.6 }							

Bore depth 703 feet

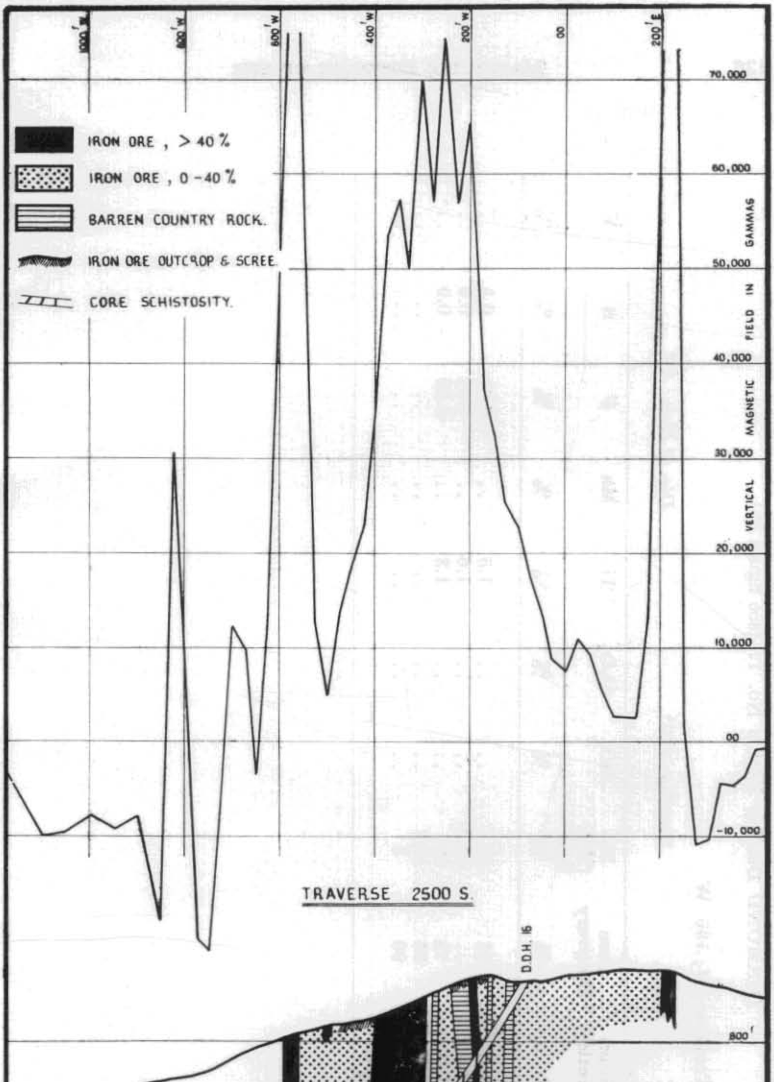


FIGURE 35.

5 cm

DIAMOND DRILL HOLE No. 17 (see figure 36)

Location: Traverse D7; 190′ W

R.L.: 670′ *Bearing:* 270° *Dip of Hole:* 67°

Depth		Inter-section	Core Recovery	Fe (HCl Sol.)	SiO_2	Al_2O_3	Ti	Mn	P	S	V
From ft. in.	To ft. in.	ft. in.	%	%	%	%	%	%	%	%	%
4 0	60 0	56 0	21	63	..	..	1.5	..	0.01	0.3	..
70 0	79 0	9 0	..	63.4	..	..	1.6	..	0.02	0.3	..
120 0	183 0	63 0	73	50	..	..	1.3	..	0.02	0.9	..
183 0	203 0	20 0	88	19.7	..	..	..	..	..	..	..
203 0	215 0	12 0	90	5	..	..	..	..	..	..	..

Bore depth 215 feet

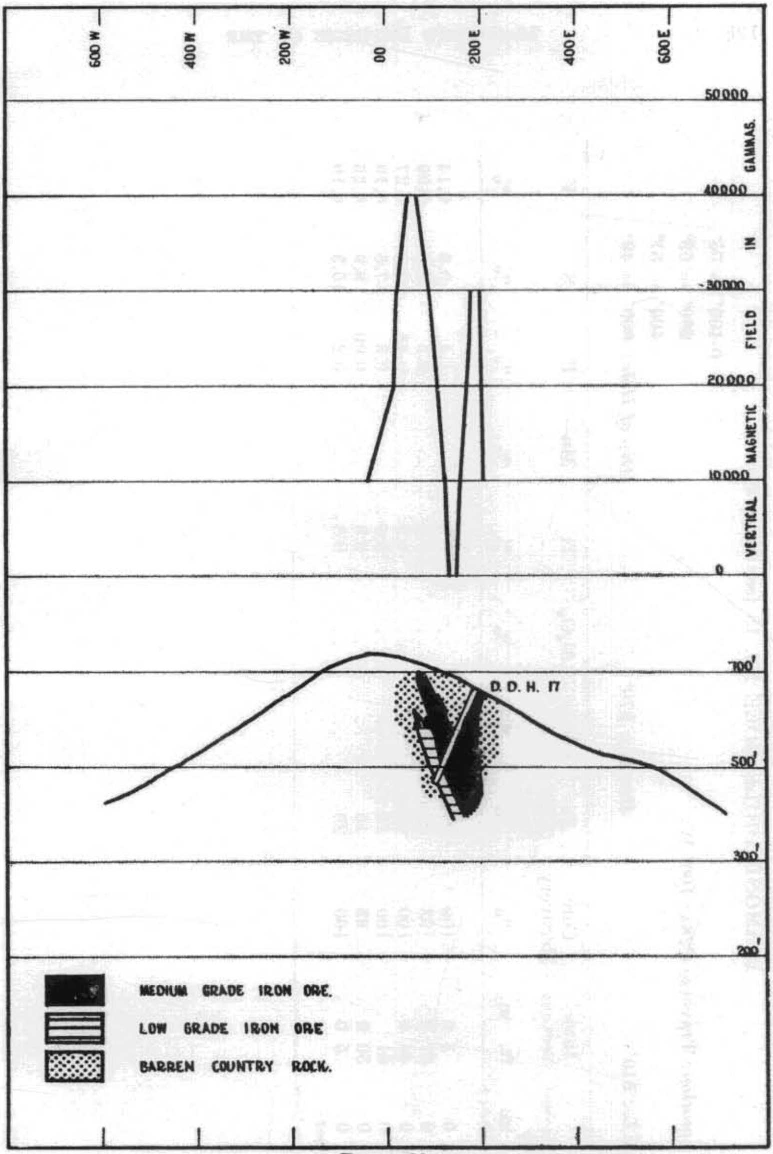


FIGURE 36.

5 cm

DIAMOND DRILL HOLE No. 18 (see figure 37)

Location: Traverse C28A; 100′ W

R.L.: 510′ *Bearing:* 270° *Dip of Hole:* 0-100′ = 55°; 200′ = 53°; 400′ = 51°; 600′ = 49°

Depth From ft. in.	Depth To ft. in.	Inter-section ft. in.	Core Recovery %	Fe (HCl Sol.) %	SiO_2 %	Al_2O_3 %	Ti %	Mn %	P %	S %	V %
257 0	262 0	5 0	100	27.6	..	..	0.3	..	1.4	9.6	0.14
325 0	382 0	57 0	93	25.0	..	..	0.3	..	0.2	3.8	0.09
382 0	426 0	44 0	100	43.0	..	..	0.3	..	0.46	8.1	0.27
426 0	507 0	81	100	13.2	..	..	0.5	..	0.3	7.5	0.19
507 0	557 0	50 0	88	45	..	..	0.6	..	0.09	8.9	0.26
557 0	562 0	5 0	100	20	..	..	0.3	..	0.2	15.3	0.10

Bore depth 634 feet

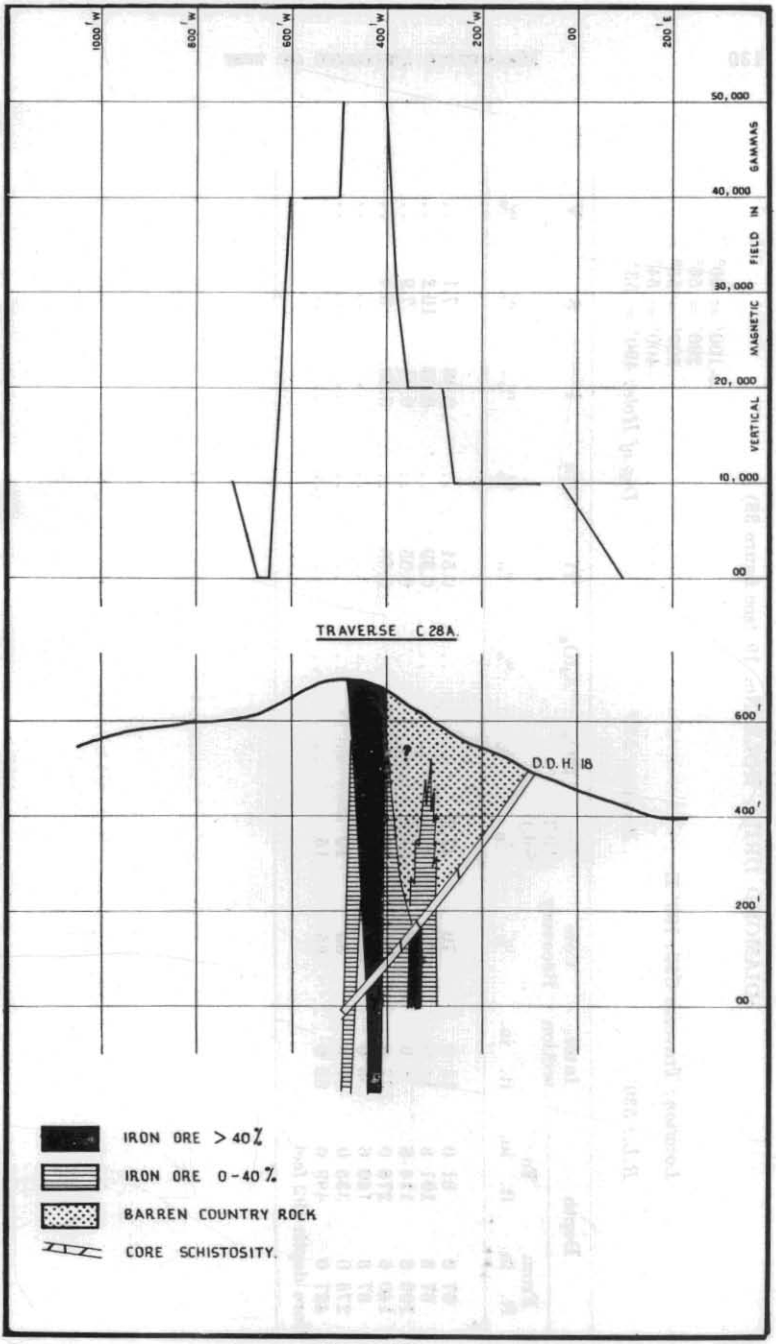


FIGURE 37.

5 cm

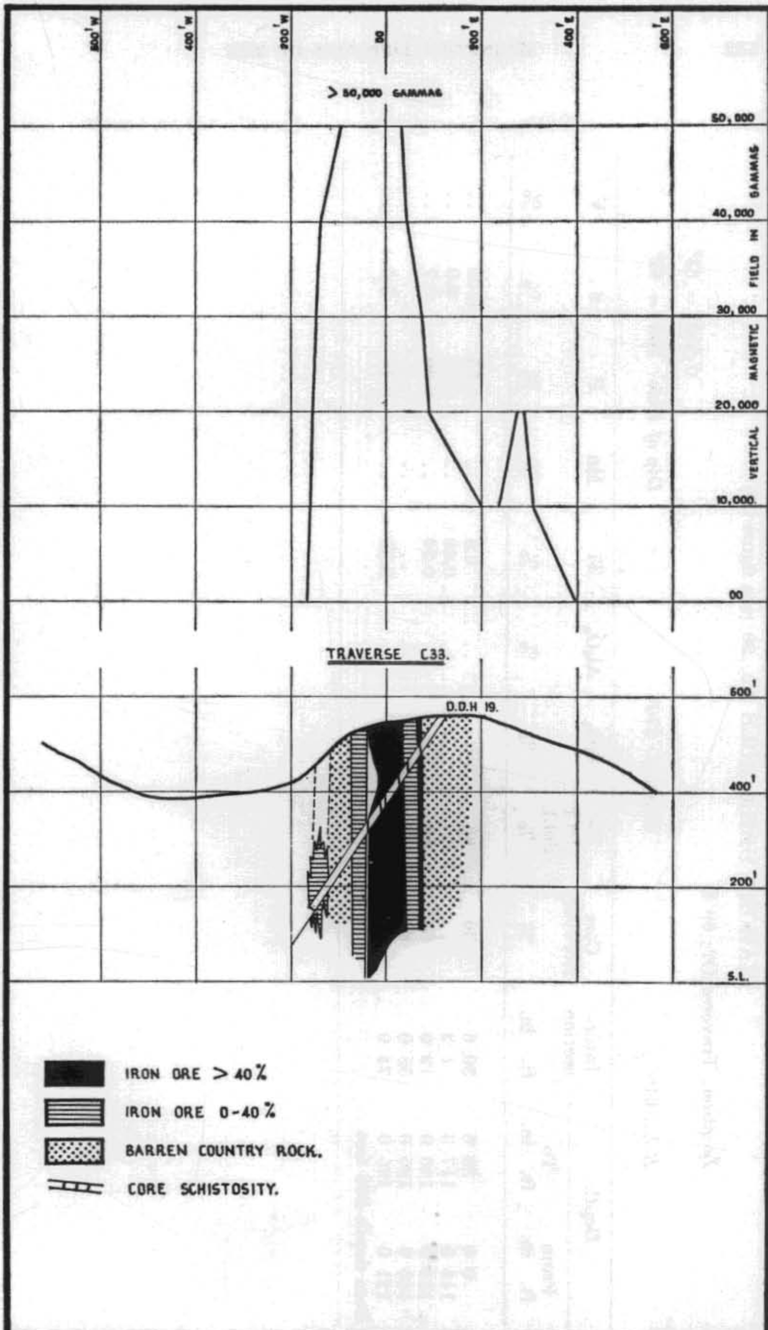
DIAMOND DRILL HOLE No. 19 (see figure 38)

Location: Traverse C33; 100′ E

R.L.: 530′   *Bearing:* 270°   *Dip of Hole:* 0-100′ = 60°; 200′ = 56°; 300′ = 55°; 400′ = 54°; 490′ = 53°

Depth From ft.	in.	To ft.	in.	Intersection ft.	in.	Core Recovery %	Fe (HCl Sol.) %	SiO_2 %	A_2lO_3 %	Ti %	Mn %	P %	S %	V %
67	0	81	0	14	0	70	47.3	..	..	0.51	..	0.56	7.1	..
87	8	101	8	14	0	99	30.7	..	..	0.39	..	0.03	10.2	..
106	8	114	8	8	0	100	35.9	..	..	0.55	..	0.04	7.9	..
140	6	278	0	137	6	97	43.0	..	..	0.68	..	0.09	8.4	..
87	6	140	6	53	0	100	20	..	..	..	..	..	..	..
278	0	335	0	57	0	85	10	..	..	..	..	..	..	..
427	0	489	0	62	0	65	15	..	..	..	..	..	..	

Bore depth 492 feet



600' W
400' W
200' W
00
200' E
400' E
600' E
> 50,000 GAMMAS
50,000
40,000
30,000
20,000
10,000.
00
VERTICAL MAGNETIC FIELD IN GAMMAS
TRAVERSE C33.
D.D.H 19.
600'
400'
200'
S.L.
IRON ORE > 40 %
IRON ORE 0-40 %
BARREN COUNTRY ROCK.
CORE SCHISTOSITY.

FIGURE 38.

DIAMOND DRILL HOLE No. 20 (see figure 39)

Location: Traverse D2; 60′E

R.L.: 610′ *Bearing:* 270° *Dip of Hole:* 0-200′ = 63°; 298′ = 62°

Depth From ft. in.	Depth To ft. in.	Inter-section ft. in.	Core Recovery %	Fe (HCl Sol.) %	SiO_2 %	Al_2O_3 %	Ti %	Mn %	P %	S %	V %
0 0	30 6	30 6	± 30	63	..	..	0.5	..	0.55	0.06	..
116 0	117 3	1 3	..	45	..	..	0.48	..	0.02	6.0	..
121 0	140 0	19 0	95	40	..	..	0.36	..	0.90	5.7	..
140 0	195 0	55 0	69	22	..	..	..	..	..	..	..
121 0	195 0	74 0	75	27	..	..	0.30	..	0.75	5.5	..
Bore depth 298 feet											

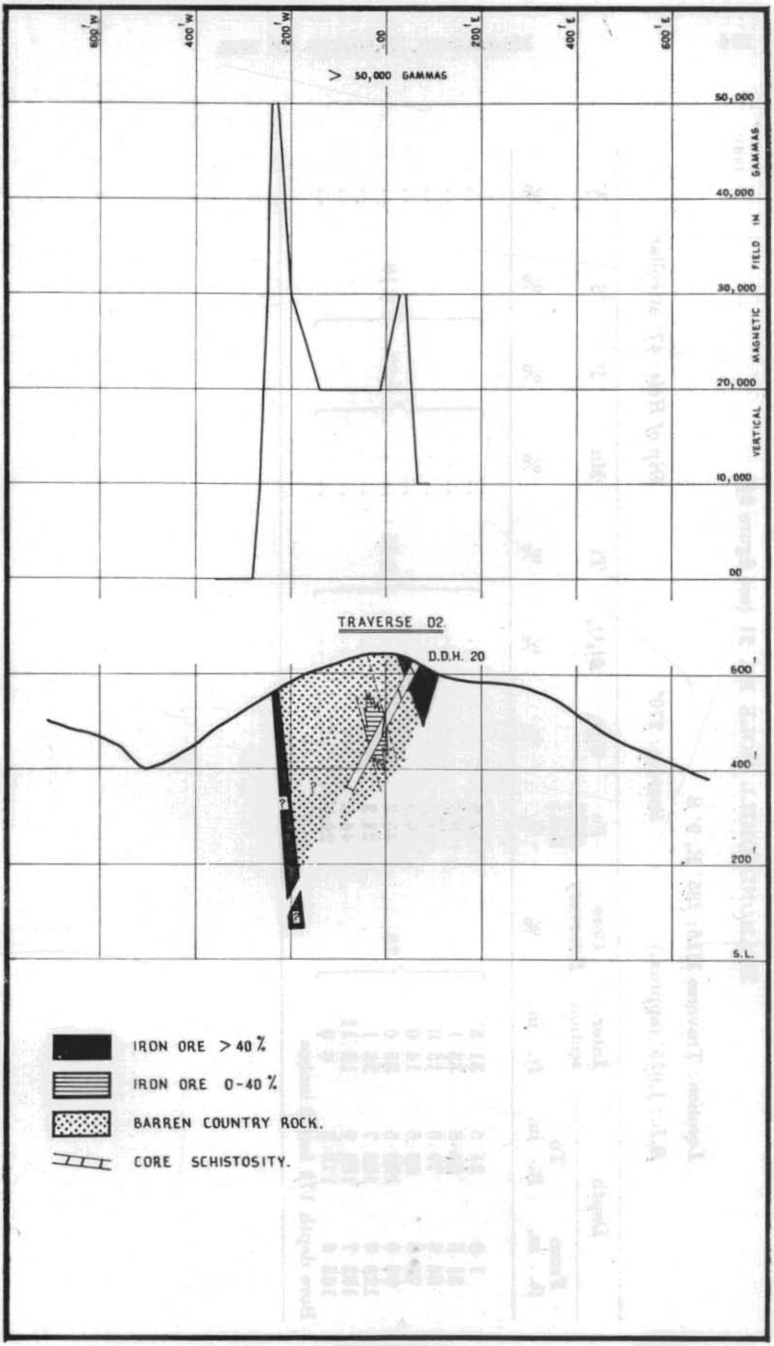


FIGURE 39.

5 cm

DIAMOND DRILL HOLE No. 21 (see figure 24)

Location: Traverse H16; 285′ E, 9′ S

R.L.: 1,025′ (approx.) *Bearing:* 270° *Dip of Hole:* 47° at collar

Depth From ft. in.	Depth To ft. in.	Intersection ft. in.	Core Recovery %	Fe (HCl Sol.) %	SiO_2 %	Al_2O_3 %	Ti %	Mn %	P %	S %	V %
1 0	31 5	31 5		51.6	..	..		..			..
31 5	64 6	33 1		9.6	..	..		..			..
64 6	79 6	15 0		47.9	..	..		..			..
79 6	93 6	14 0		6.9	..	..		..			..
93 6	128 6	35 0	75	45.2	..	..	0.55	..	0.09	4.18	..
128 6	152 7	24 1		24.2	..	..		..			..
152 7	165 6	12 11		44.3	..	..		..			..
165 6	172 2	6 8		25.9	..	..		..			..

Bore depth 172 feet 2 inches

DIAMOND DRILL HOLE No. 22 (see figure 24)

Location: Traverse B8; 570′ W of DDH3

R.L.: 1,075′ *Bearing:* 270° *Dip of Hole:* 45°

Depth From ft. in.	Depth To ft. in.	Inter-section ft. in.	Core Recovery %	Fe (HCl Sol.) %	SiO_2 %	Al_2O_3 %	Ti %	Mn %	P %	S %	V %
0 0	30 0	30 0	30	47	..	..	} 1.53	..	} 0.03	} 0.15	..
10 0	69 0	59 0	20	20	..	..					..
112 9	131 3	18 6	..	..	..	..	0.55	..	0.21	4.1	..
131 3	147 0	15 9	..	..	..	..	0.55	..	0.05	1.5	..
114 6	154 4	..	..	18	..	..	..	..	..	..	..
Bore depth 159 feet 7 inches											

DIAMOND DRILL HOLE No. 23 (see figure 29)

Location: Traverse 750S; 275′ W, 25′ N

R.L.: 925′ *Bearing:* West *Dip of Hole:* 47°

Depth From ft. in.	Depth To ft. in.	Inter-section ft. in.	Core Recovery %	Fe (HCl Sol.) %	SiO_2 %	Al_2O_3 %	Ti %	Mn %	P %	S %	V %
2 0	53 0	51 0	58	58.7	..	..	0.26	..	0.12	1.84	..
53 0	72 3	19 3	..	8.39	..	..	..	..	..	..	..
72 3	105 3	33 0	44	49.8	..	..	0.19	..	0.12	6.51	..
105 3	221 6	116 3	}	28.6	..	..	..	..	..	..	..
221 6	239 0	17 6	} 62	22.1	..	..	..	..	..	..	..
106 0	223 6	117 6	..	..	..	..	0.55	..	0.08	4.5	..
227 0	292 6	65 6	..	..	..	..	0.63	..	0.07	4.0	..
239 0	292 6	53 6	56	43.4	..	..	..	..	..	..	..
Bore depth 297 feet											

DIAMOND DRILL HOLE No. 24

Location: Traverse B08; 20′ E, 70′ S

R.L.: 1,125′ *Bearing:*— *Dip of Hole:* Vertical

Depth				Intersection		Core Recovery	Fe (HCl Sol.)	SiO_2	Al_2O_3	Ti	Mn	P	S	V
From		To												
ft.	in.	ft.	in.	ft.	in.	%	%	%	%	%	%	%	%	%
0	0	73	0	73	0	94	55.5	..	..	0.15	..	0.14	0.47	..

Bore depth 73 feet

DIAMOND DRILL HOLE No. 25 (see figure 40)

Location: Traverse 18D; 460′ E, 20′ S

R.L.: 710′ *Bearing:* 270° *Dip of Hole:* 0-500′ = 65°; 600′ = 64°; 700′ = 64°

Depth From ft. in.	Depth To ft. in.	Intersection ft. in.	Core Recovery %	Fe (HCl Sol.) %	SiO_2 %	Al_2O_3 %	Ti %	Mn %	P %	S %	V %
0 0	19 6	19 6	56	60.8	..	..	..	..	..	..	..
19 6	310 9	291 3	71	9.48	..	..	..	..	..	..	..
0 0	85 0	85 0	..	..	..	..	0.53	..	0.09	0.93	..
142 6	169 6	27 0	..	..	..	..	0.16	..	0.17	2.68	..
215 6	258 0	42 6	..	..	..	..	0.42	..	0.12	0.97	..
310 9	336 0	25 3	96	56.2	..	..	1.53	..	Nil	0.31	..
641 0	646 6	5 6	80	32.8	..	..	..	..	..	..	..
661 0	662 0	1 0	..	27.0	..	..	..	..	..	..	..
682 0	684 0	2 0	..	33.7	..	..	..	..	..	..	..
731 0	733 0	2 0	..	21.6	..	..	..	..	..	..	..
Bore depth 749 feet											

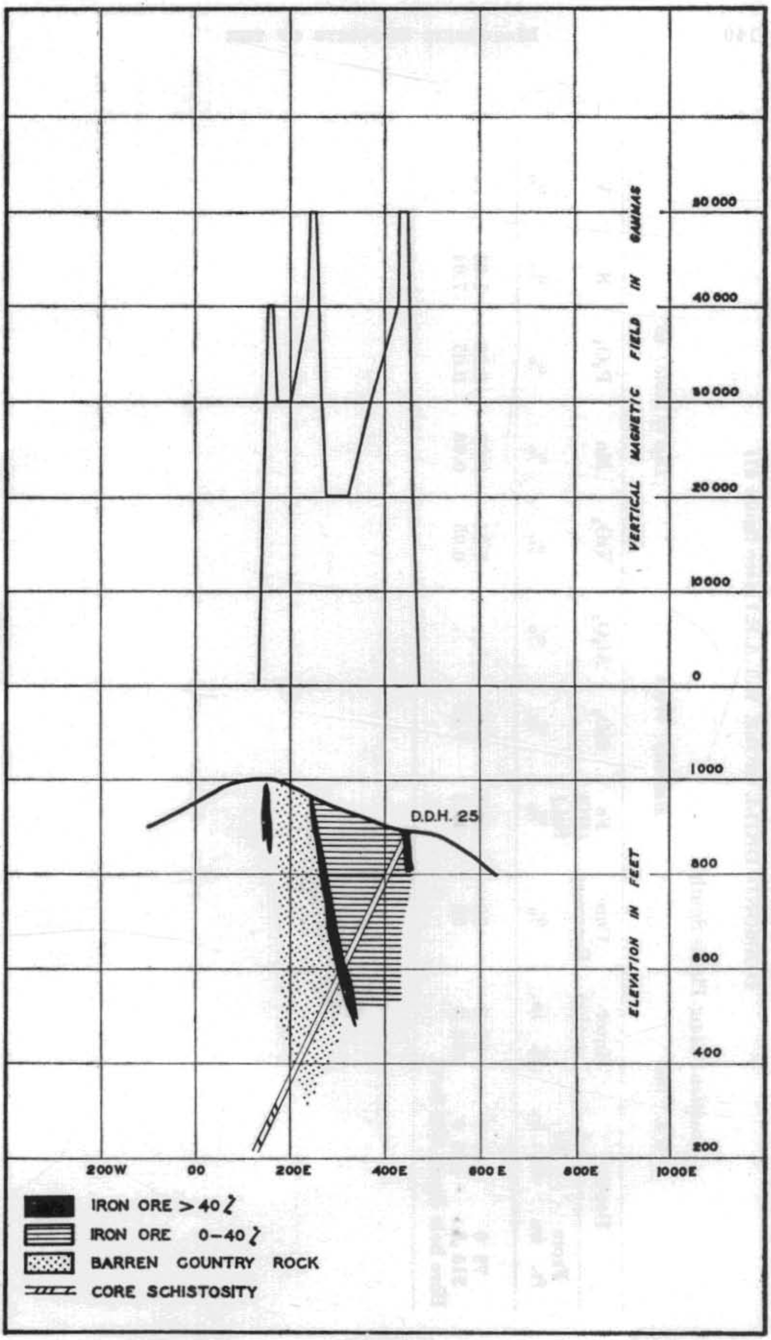


FIGURE 40.

5 cm

DIAMOND DRILL HOLE R.T.A.E.1 (see figure 41)

Location: Long Plains South

R.L.: 905 ′ *Bearing:* West *Dip of Hole:* 45°

Depth From ft. in.	Depth To ft. in.	Inter-section ft. in.	Core Recovery %	Fe (HCl Sol.) %	SiO_2 %	Al_2O_3 %	TiO_2 %	Mn %	P_2O_5 %	S %	V %
79 0	116 0	37 0	50	56.6	6.07	..	1.54	0.09	0.08	1.64	..
315 3	498 0	182 9	53	49.1	7.57	..	0.95	0.06	0.07	7.64	..

Bore hole depth 639 feet

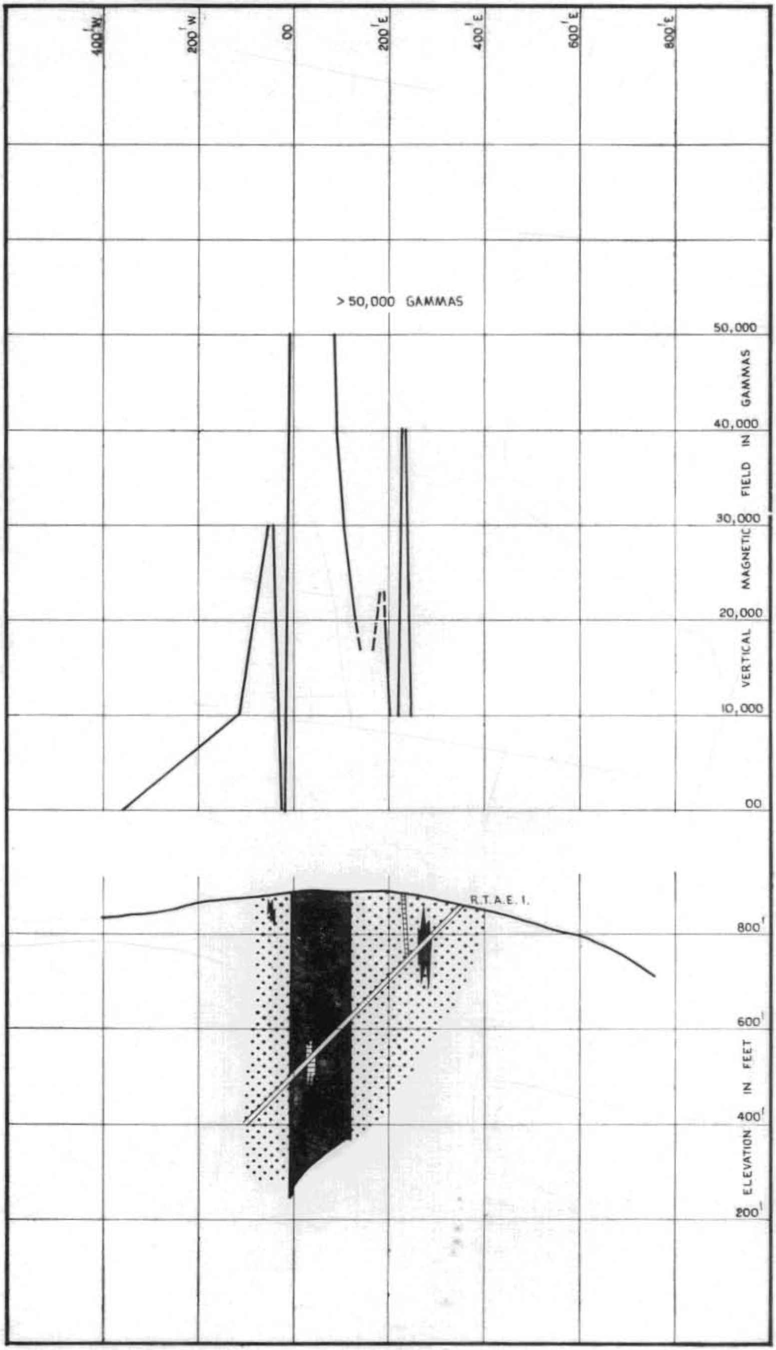


FIGURE 41.

5 cm

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Explanation of Plates

PLATE 1.

Faulted (F) pelitic and psammitic Whyte Schist contact. Long Plains South area.

PLATE 2.

Graphitic schist and phyllite belonging to Whyte Schist. Waratah-Corinna road.

PLATE 3.

Quartz-feldspar porphyroblasts, lenses and bands in schist. Incident light × 100.

PLATE 4.

Flat-lying Tertiary conglomerate overlying vertical Precambrian Whyte Schist. Waratah-Corinna road.

PLATE 5.

Dolomite (d)-greenschist contact. Savage River.

PLATE 6.

Plunging chevron-folded Whyte Schist. Waratah-Corinna road.

PLATE 7.

Magnetite (mt) peripheral to pyrite (py) and internally replacing pyrite. Chalcopyrite (cp) in grain boundaries. Gangue (g) indicated. Reflected light × 60.

PLATE 8.

Chalcopyrite (cp) in contact between pyrite (py) and magnetite (mt), bordered by blue chalocite (cc) adjacent to magnetite. Gangue (g) indicated. Reflected light × 112.

PLATE 9.

Pyrite (py) replacing gangue (g) around magnetite crystals (mt). Reflected light × 104.

PLATE 10.

Chalcopyrite (cp) in pyrite (py). Bladed gangue (g) intergrown with magnetite (mt) and pyrite. Reflected light × 66.

PLATE 11.

Bladed gangue (g) ophitically intergrown with pyrite (py) and less markedly with magnetite (mt). Reflected light × 102.

PLATE 12.

Sparsely metallized (magnetite and pyrite) propylitized amphibolite. Varnished core section.

PLATE 13.

Magnetite needles aligned in asbestos fibres. Varnished core section.

PLATE 14.

Primary magnetite and pyrite crystals in amphibolite. Incident light × 110.

PLATE 15.

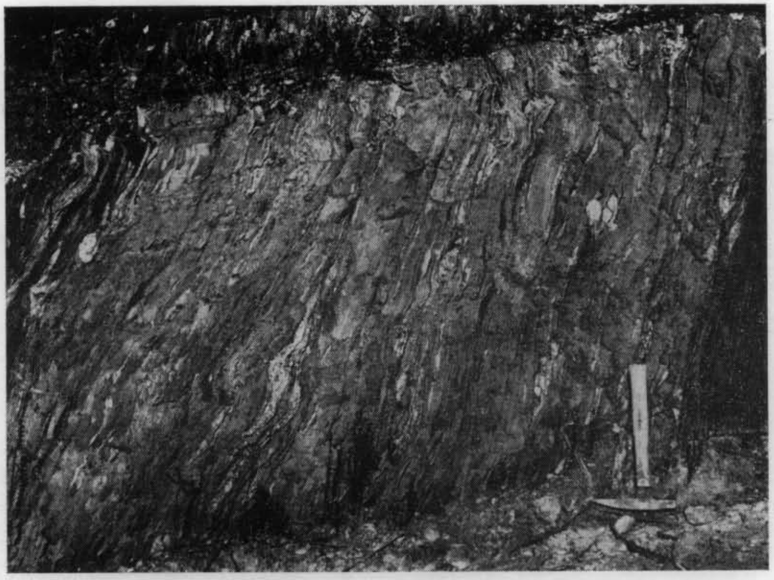
Magnetite (mt) preferentially replacing greenschist band in amphibolite. Incident light × 120.

PLATE 16.

Chlorite (ch), talc (t), serpentine (s) alteration intergrown with apatite (ap) and opaque magnetite and pyrite. Incident light, crossed nicols × 83.

5 cm

PLATE 1.



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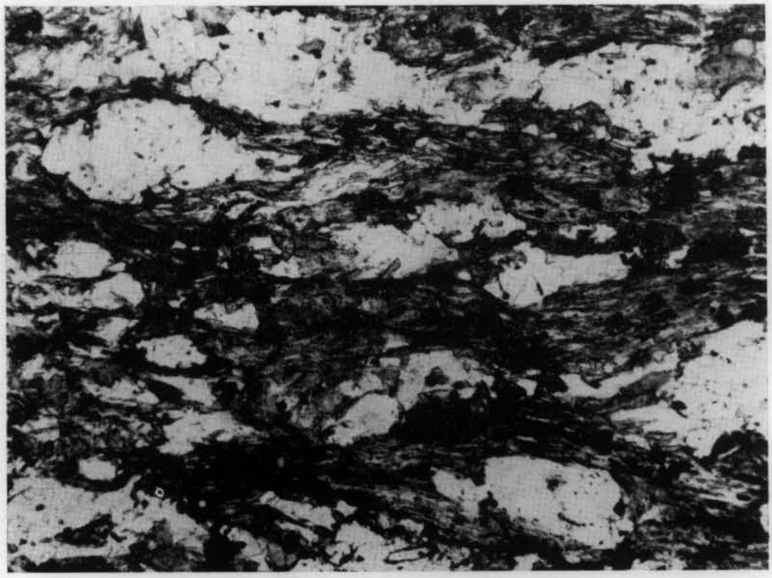


PLATE 3.

PLATE 4.

5 cm

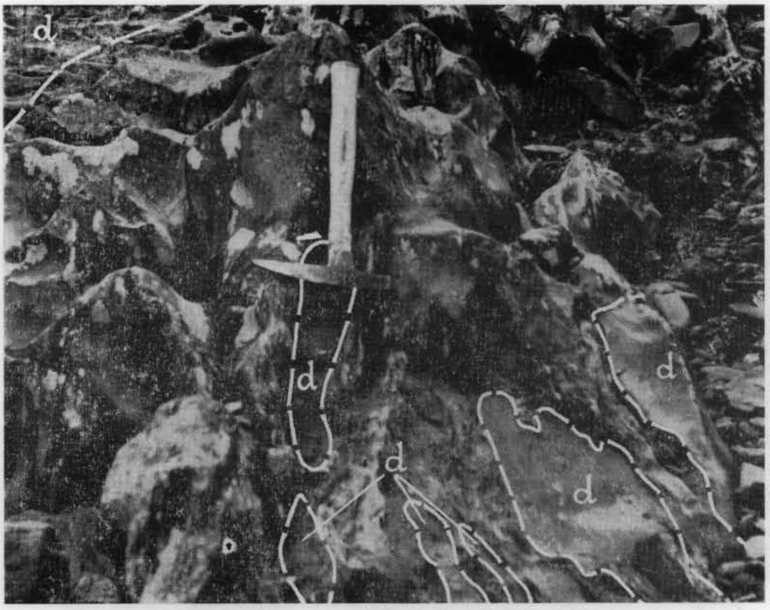
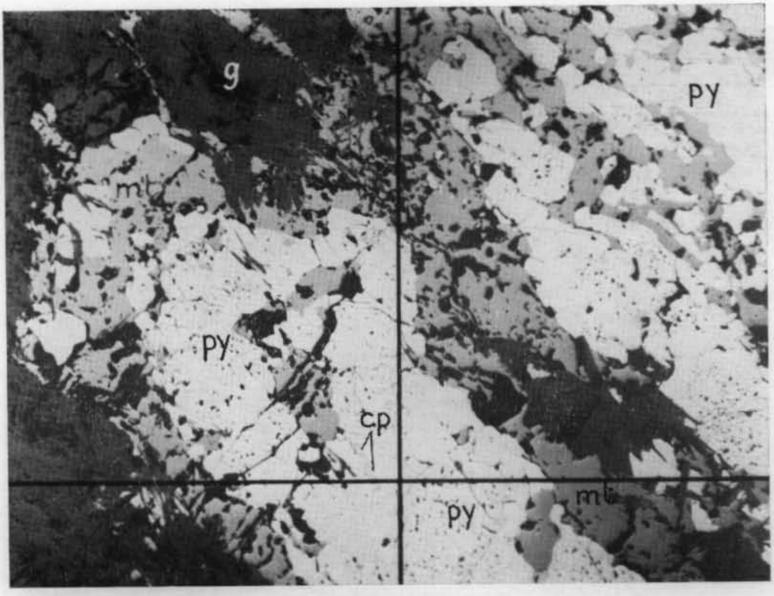


PLATE 5.

PLATE 6.

5 cm



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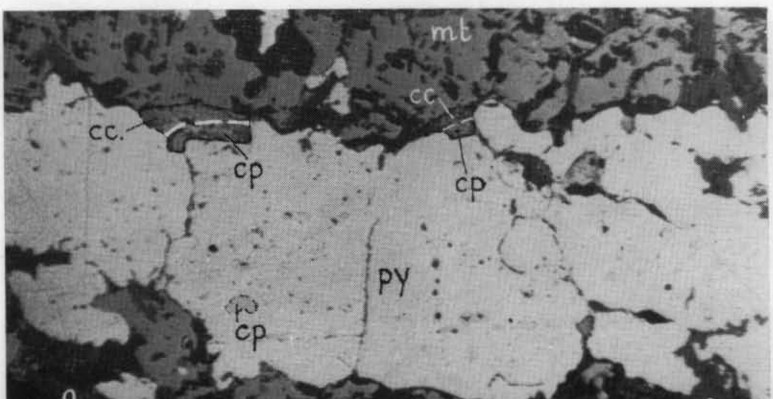
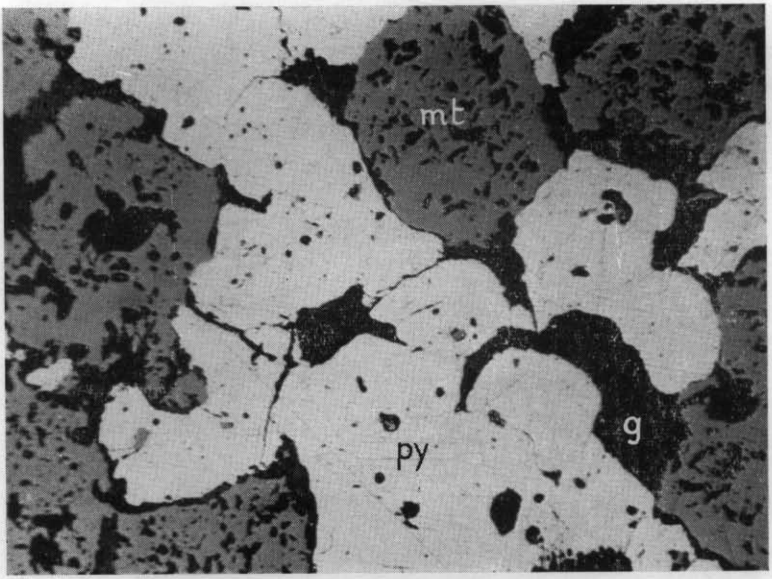


PLATE 8.

5 cm



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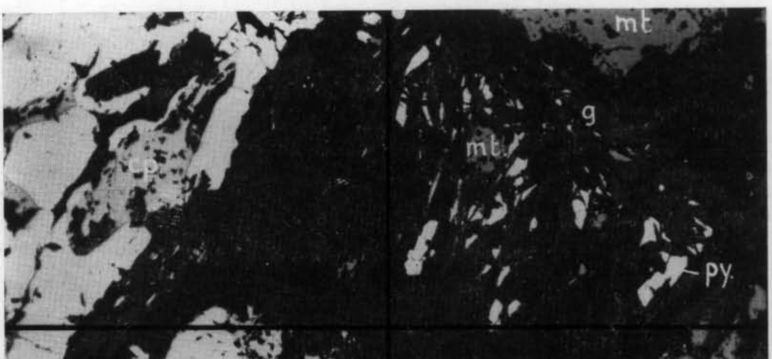


PLATE. 10.

5 cm

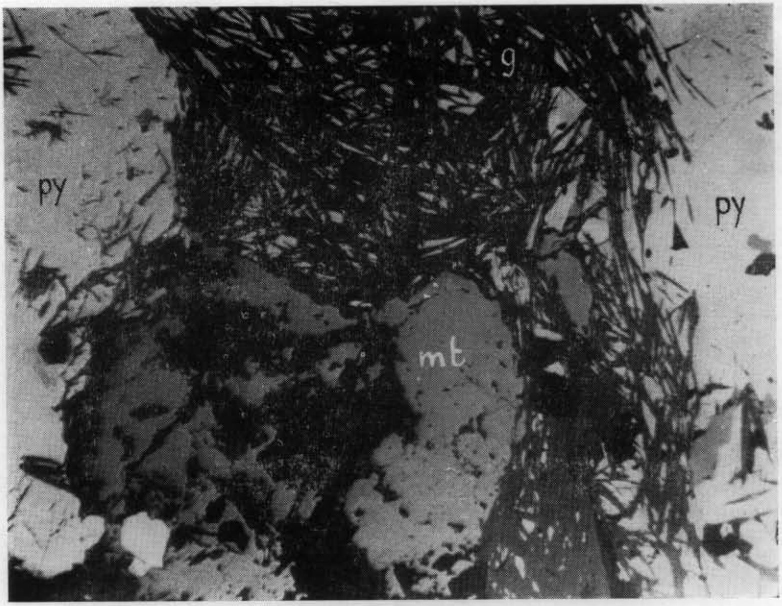


PLATE 11.

PLATE 12.

5 cm

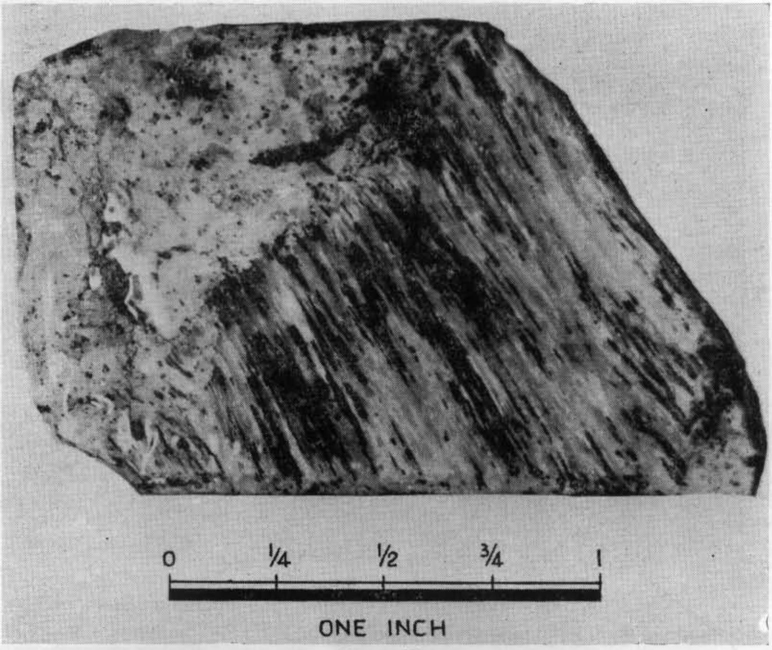


PLATE 13.

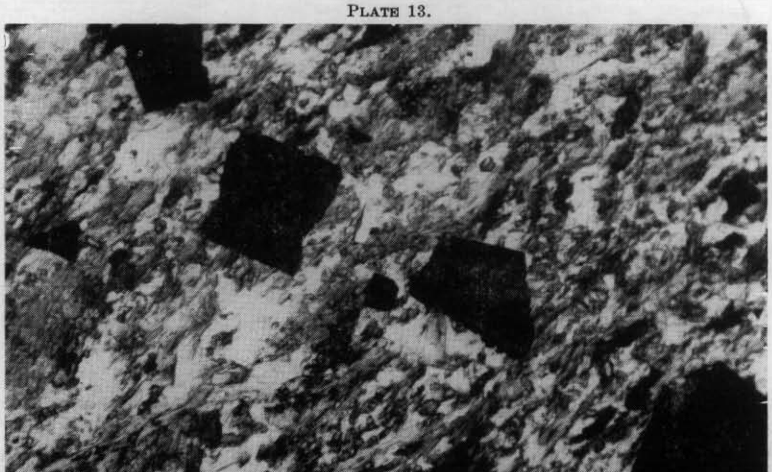


PLATE 14.

5 cm

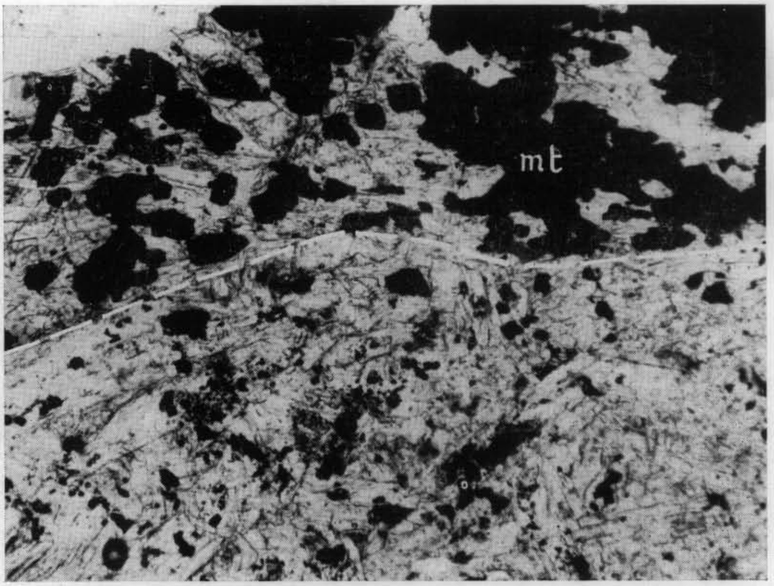


PLATE 15.

PLATE 16.

FIG. 2 GSB48

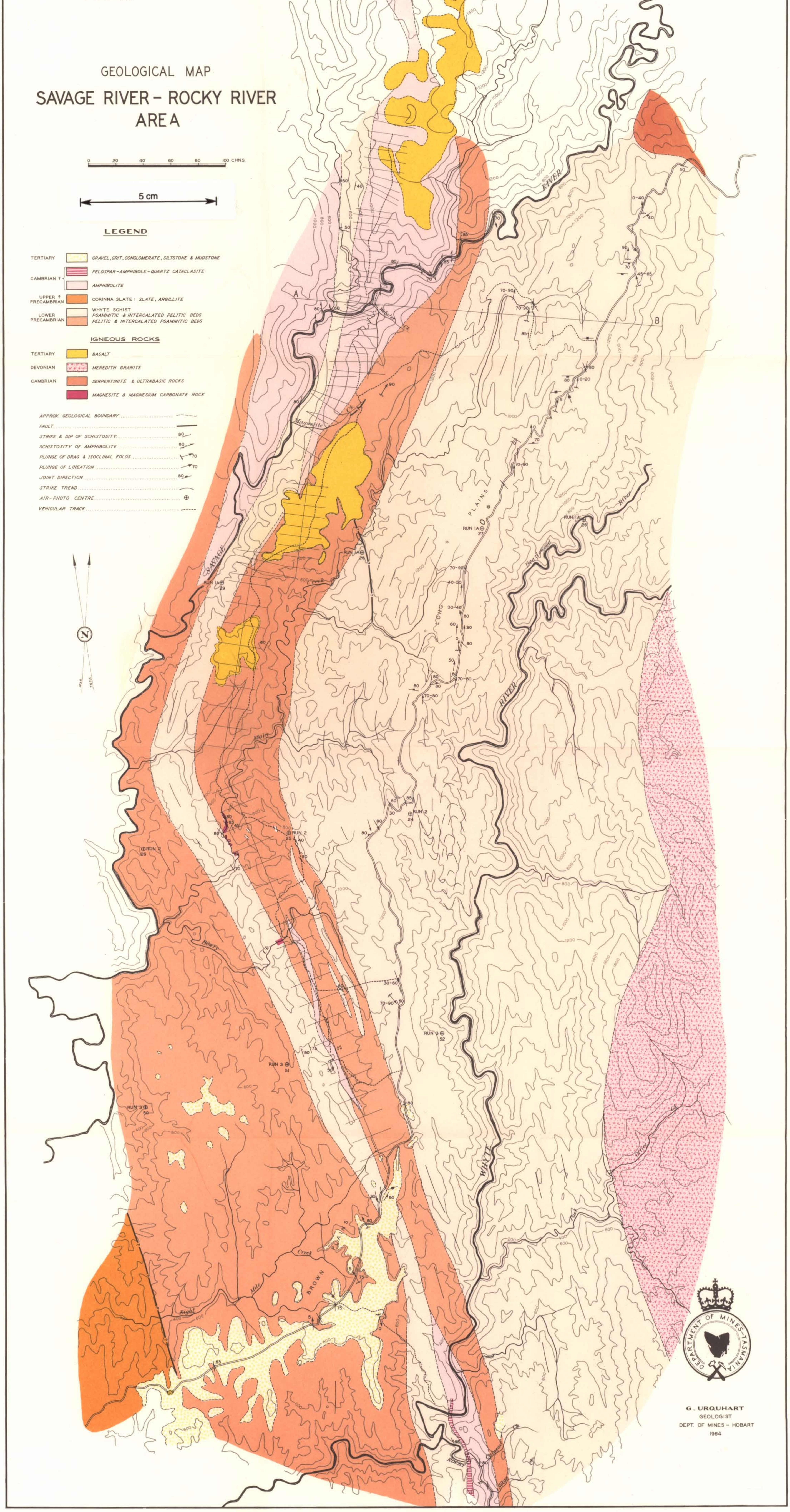
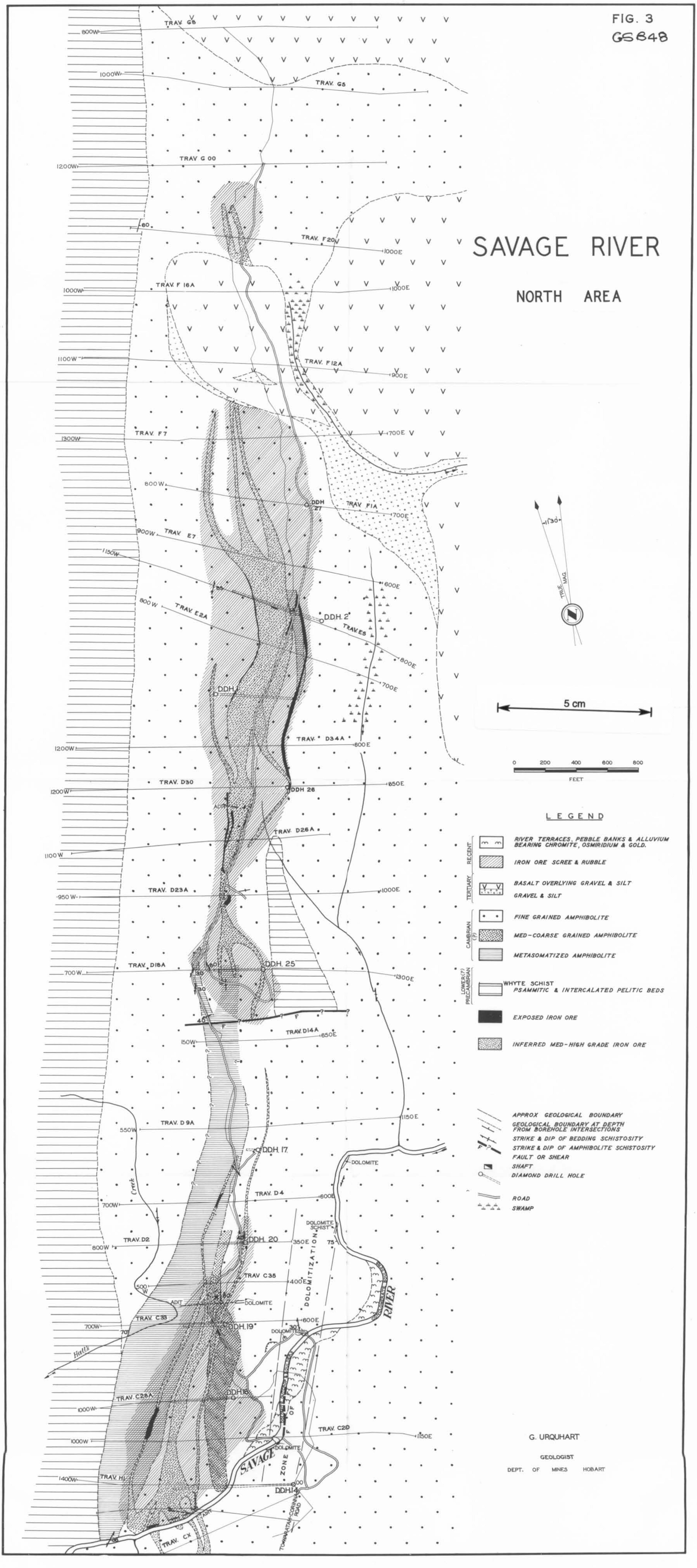

GEOLOGICAL MAP
SAVAGE RIVER - ROCKY RIVER AREA
0 20 40 60 80 100 CHNS.
5 cm
LEGEND
TERTIARY
GRAVEL, GRIT, CONGLOMERATE, SILTSTONE & MUDSTONE
CAMBRIAN ?
FELDSPAR-AMPHIBOLE-QUARTZ CATACLASITE
AMPHIBOLITE
UPPER ? PRECAMBRIAN
CORINNA SLATE: SLATE, ARGILLITE
LOWER PRECAMBRIAN
WHYTE SCHIST
PSAMMITIC & INTERCALATED PELITIC BEDS
PELITIC & INTERCALATED PSAMMITIC BEDS
IGNEOUS ROCKS
TERTIARY
BASALT
DEVONIAN
MEREDITH GRANITE
CAMBRIAN
SERPENTINITE & ULTRABASIC ROCKS
MAGNESITE & MAGNESIUM CARBONATE ROCK
APPROX. GEOLOGICAL BOUNDARY
FAULT
STRIKE & DIP OF SCHISTOSITY
SCHISTOSITY OF AMPHIBOLITE
PLUNGE OF DRAG & ISOCLINAL FOLDS
PLUNGE OF LINEATION
JOINT DIRECTION
STRIKE TREND
AIR-PHOTO CENTRE
VEHICULAR TRACK
SAVAGE
RIVER
WHYTE
RIVER
LONG PLAINS
ROCKY
A
B
DEPARTMENT OF MINES - TASMANIA
G. URQUHART
GEOLOGIST
DEPT. OF MINES - HOBART
1964

FIG. 3
GS848


SAVAGE RIVER
NORTH AREA
5 cm
0 200 400 600 800
FEET
LEGEND
RECENT
RIVER TERRACES, PEBBLE BANKS & ALLUVIUM BEARING CHROMITE, OSMIRIDIUM & GOLD.
IRON ORE SCREE & RUBBLE
TERTIARY
BASALT OVERLYING GRAVEL & SILT
GRAVEL & SILT
CAMBRIAN (?)
FINE GRAINED AMPHIBOLITE
MED-COARSE GRAINED AMPHIBOLITE
METASOMATIZED AMPHIBOLITE
LOWER (?) PRECAMBRIAN
WHYTE SCHIST
PSAMMITIC & INTERCALATED PELITIC BEDS
EXPOSED IRON ORE
INFERRED MED-HIGH GRADE IRON ORE
APPROX GEOLOGICAL BOUNDARY
GEOLOGICAL BOUNDARY AT DEPTH FROM BOREHOLE INTERSECTIONS
STRIKE & DIP OF BEDDING SCHISTOSITY
STRIKE & DIP OF AMPHIBOLITE SCHISTOSITY
FAULT OR SHEAR
SHAFT
DIAMOND DRILL HOLE
ROAD
SWAMP
TRUE
MAG
SAVAGE RIVER
DOLOMITIZATION
ZONE OF
TOWN - CORINNA ROAD
Halls Creek
G. URQUHART
GEOLOGIST
DEPT. OF MINES HOBART

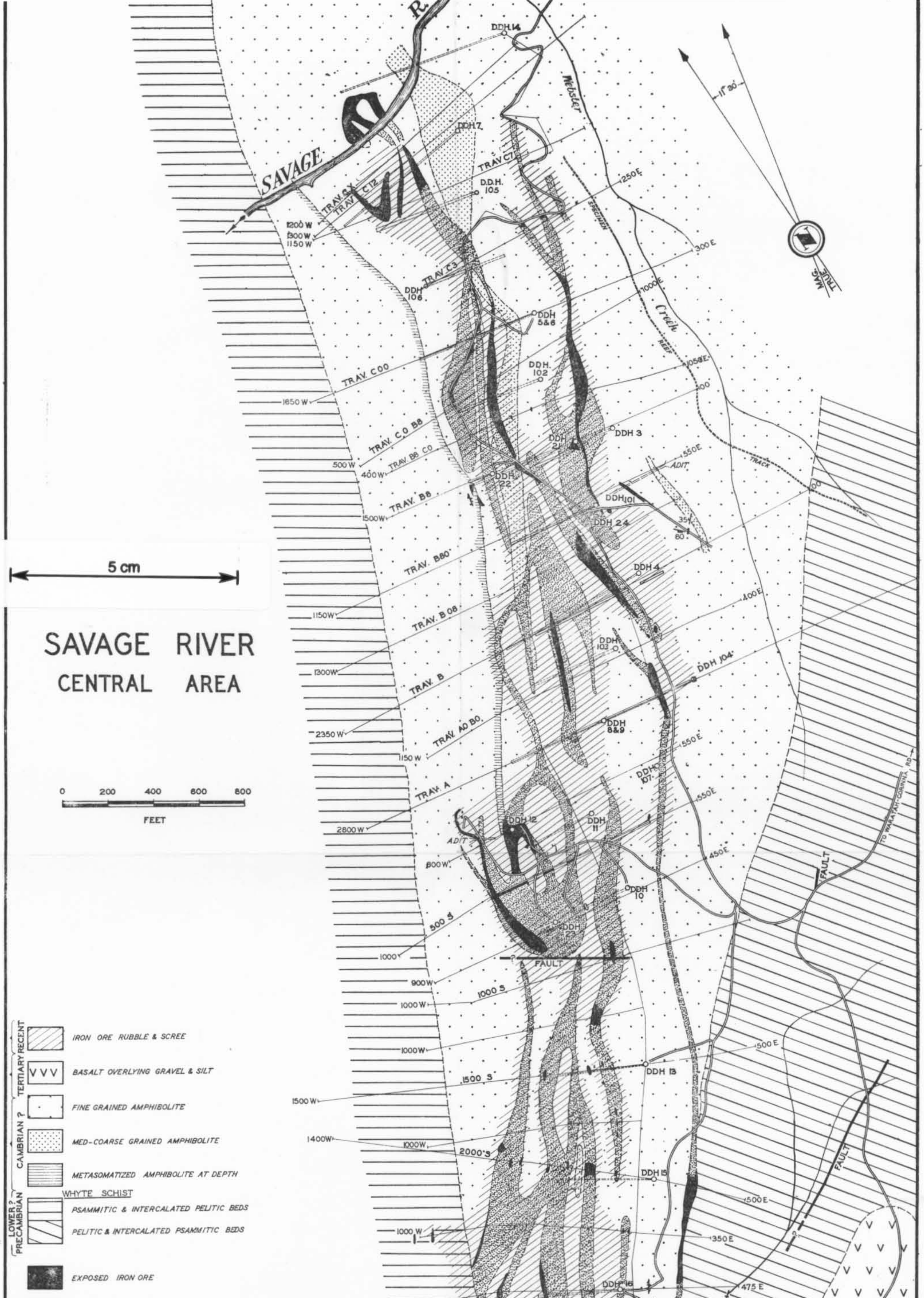

SAVAGE RIVER
CENTRAL AREA
5 cm
0 200 400 600 800
FEET
SAVAGE
R.
Webster
Creek
Magnetite
Creek
FAULT
ADIT
DDH 14
DDH 7
D.D.H. 105
DDH 106
DDH 5&6
DDH 102
DDH 3
DDH 21
DDH 22
DDH 101
DDH 24
DDH 4
DDH 103
DDH 104
DDH 8&9
DDH 107
DDH 12
DDH 11
DDH 10
DDH 23
DDH 13
DDH 15
DDH 16
TRAV. C00
TRAV. C0 B8
TRAV. B8 C0
TRAV. B8
TRAV. B80
TRAV. B 08
TRAV. B
TRAV. A0 B0
TRAV. A
TRAV. C3
TRAV. C7
TRAV. C12
MAG.
TRUE
11° 30'
TERTIARY RECENT
CAMBRIAN ?
LOWER ? PRECAMBRIAN
IRON ORE RUBBLE & SCREE
BASALT OVERLYING GRAVEL & SILT
FINE GRAINED AMPHIBOLITE
MED-COARSE GRAINED AMPHIBOLITE
METASOMATIZED AMPHIBOLITE AT DEPTH
WHYTE SCHIST
PSAMMITIC & INTERCALATED PELITIC BEDS
PELITIC & INTERCALATED PSAMMITIC BEDS
EXPOSED IRON ORE
INFERRED MED-HIGH GRADE ORE LODE
APPROX GEOLOGICAL BOUNDARY
GEOLOGICAL BOUNDARY AT DEPTH FROM BOREHOLE INTERSECTIONS
STRIKE & DIP OF BEDDING SCHISTOSITY
STRIKE & DIP OF AMPHIBOLITE SCHISTOSITY
DIAMOND DRILL HOLE
TRENCH
G. URQUHART
GEOLOGIST
DEPT OF MINES
HOBART

Figure 4.

Fig. 5 GSB48

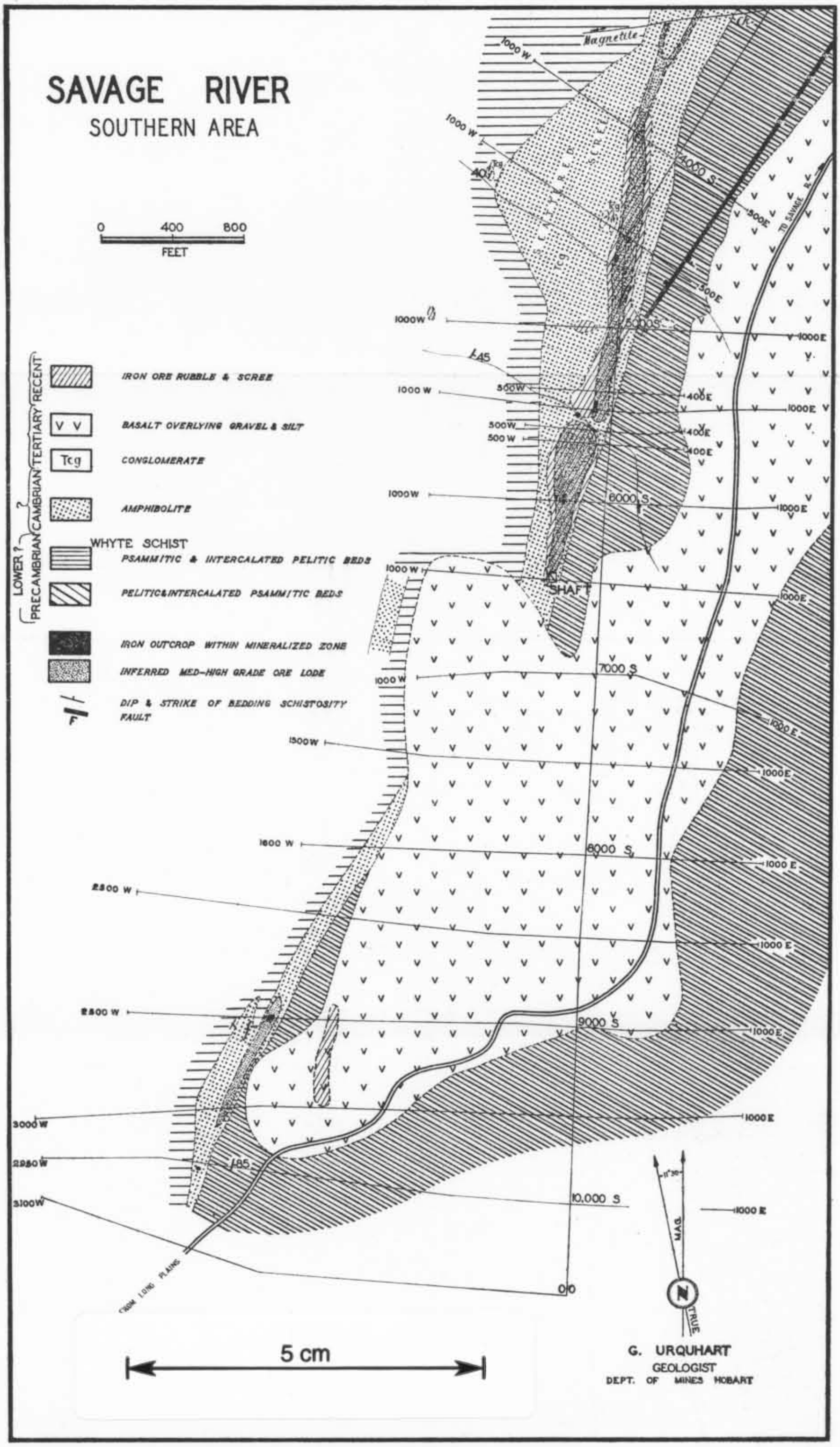


FIGURE 5.

Fig. 6 GSB48

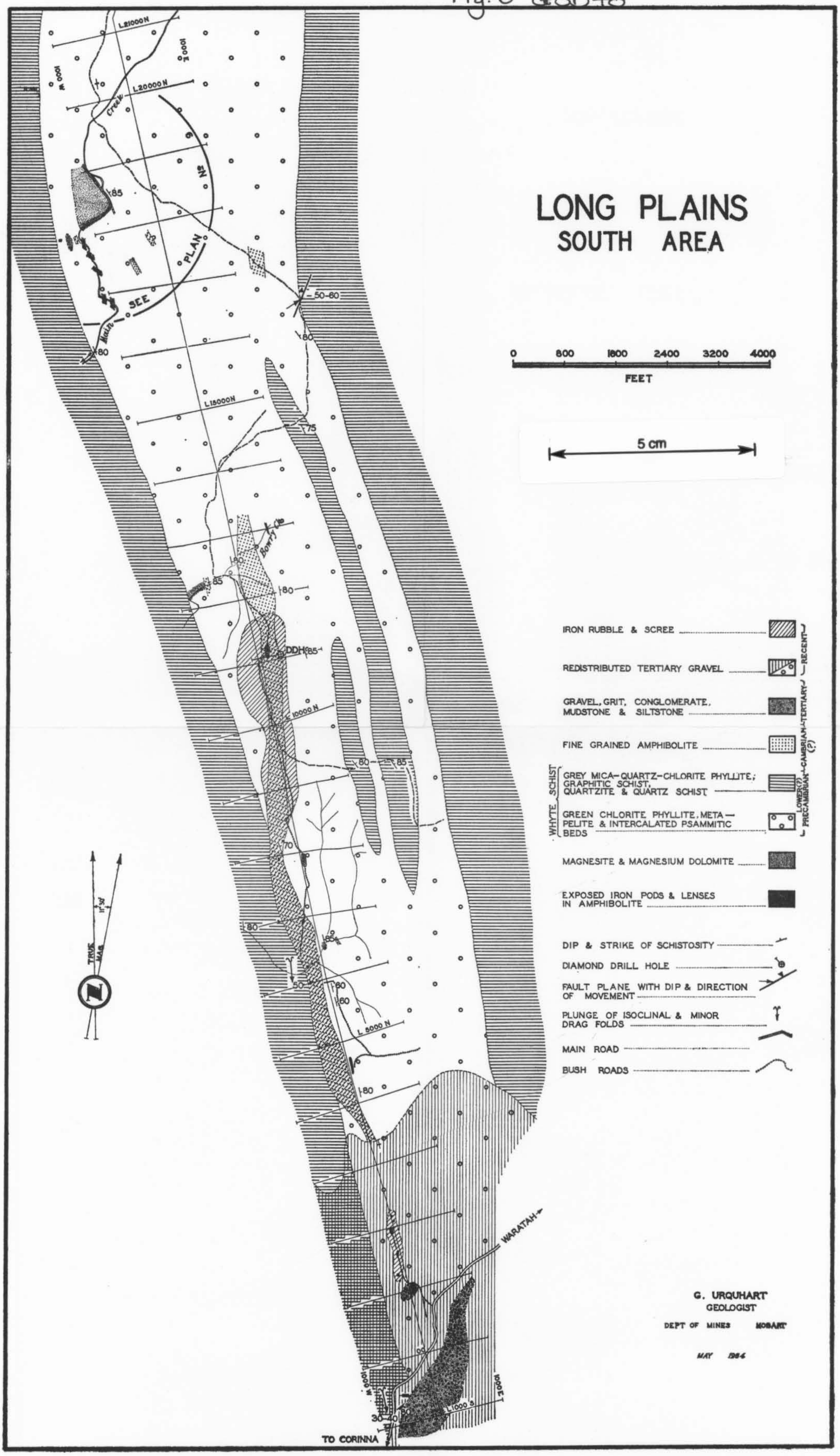


Figure 6.

GS848

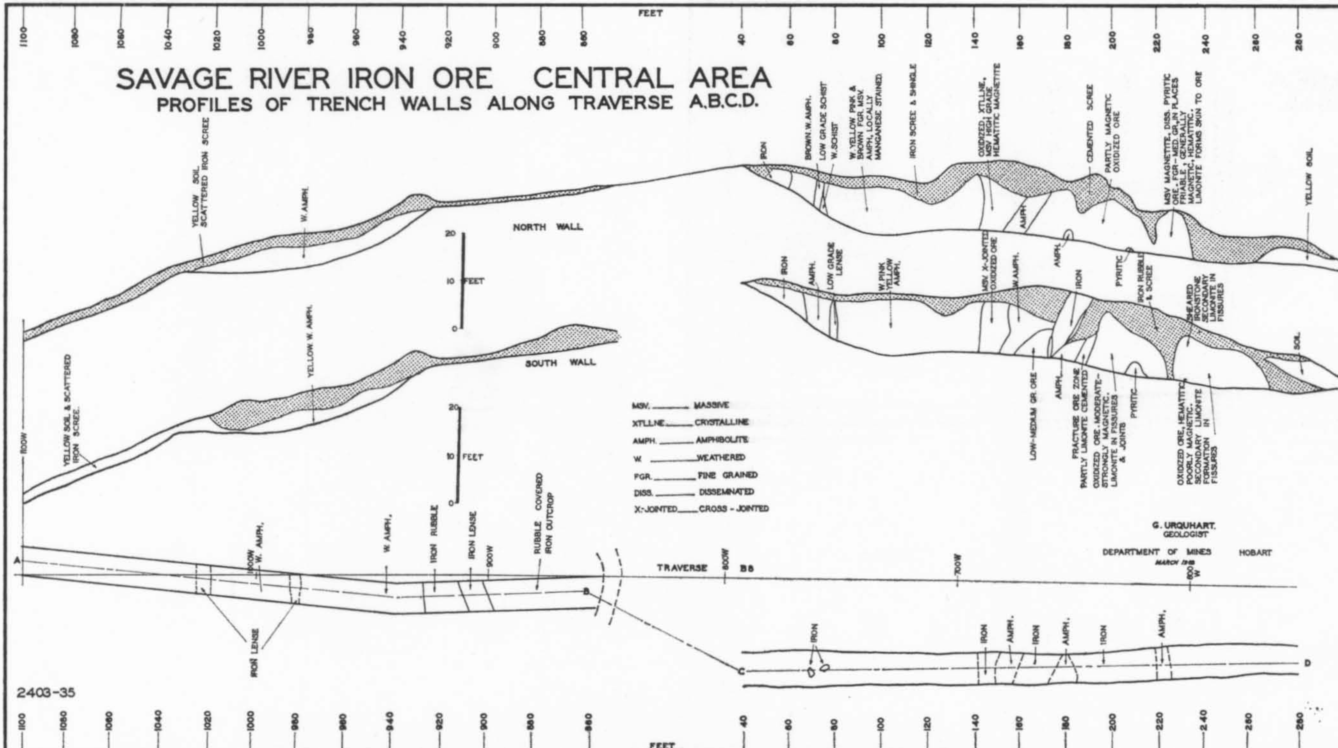


FIGURE 18.

5 cm

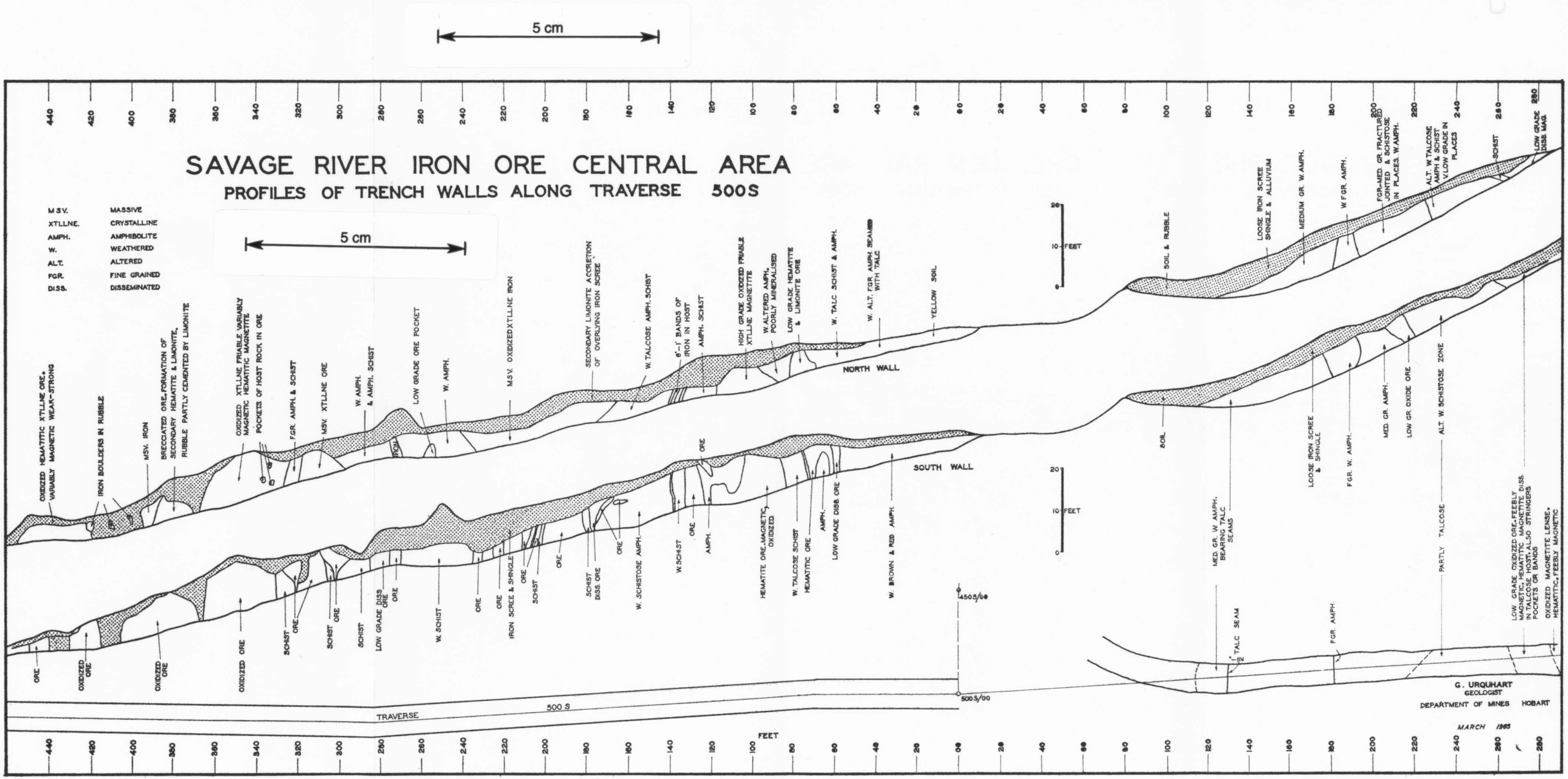
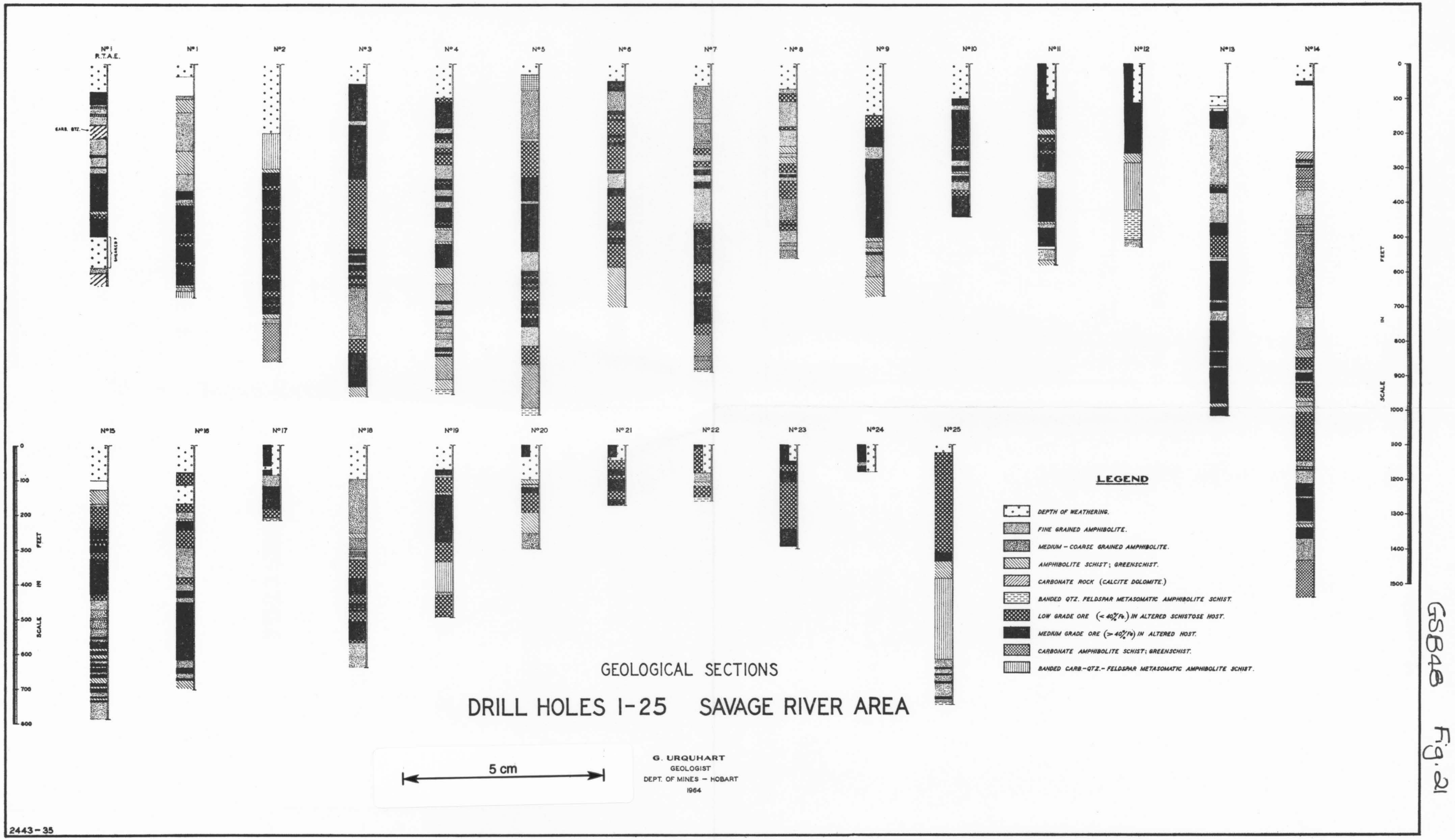

SAVAGE RIVER IRON ORE CENTRAL AREA
PROFILES OF TRENCH WALLS ALONG TRAVERSE 500S
M SV. MASSIVE
XTLLNE. CRYSTALLINE
AMPH. AMPHIBOLITE
W. WEATHERED
ALT. ALTERED
FGR. FINE GRAINED
DISS. DISSEMINATED
5 cm
OXIDIZED HEMATITIC XTLLNE ORE. VARIABLY MAGNETIC WEAK-STRONG
IRON BOULDERS IN RUBBLE
MSV. IRON
BRECCIATED ORE. FORMATION OF SECONDARY HEMATITE & LIMONITE. RUBBLE PARTLY CEMENTED BY LIMONITE
OXIDIZED XTLLNE FRIABLE VARIABLY MAGNETIC HEMATITIC MAGNETITE
POCKETS OF HOST ROCK IN ORE
F.GR. AMPH. & SCHIST
MSV. XTLLNE ORE
W. AMPH. & AMPH. SCHIST
IRON
LOW GRADE ORE POCKET
W. AMPH.
MSV. OXIDIZED XTLLNE IRON
SECONDARY LIMONITE ACCRETION OF OVERLYING IRON SCREE
W. TALCOSE AMPH. SCHIST
6"-1' BANDS OF IRON IN HOST
AMPH. SCHIST
HIGH GRADE OXIDIZED FRIABLE XTLLNE MAGNETITE
W. ALTERED AMPH. POORLY MINERALISED
LOW GRADE HEMATITE & LIMONITE ORE
W. TALC SCHIST & AMPH.
W. ALT. F.GR. AMPH. SEAMED WITH TALC
YELLOW SOIL
NORTH WALL
SOUTH WALL
SOIL & RUBBLE
LOOSE IRON SCREE SHINGLE & ALLUVIUM
MEDIUM GR. W. AMPH.
W. F.GR. AMPH.
F.GR.-MED. GR. FRACTURED JOINTED & SCHISTOSE IN PLACES. W. AMPH.
ALT. W. TALCOSE AMPH & SCHIST V. LOW GRADE IN PLACES
SCHIST
LOW GRADE DISS. MAG.
ORE
OXIDIZED ORE
OXIDIZED ORE
OXIDIZED ORE
SCHIST
ORE
SCHIST
ORE
SCHIST
LOW GRADE DISS ORE
ORE
W. SCHIST
ORE
ORE
IRON SCREE & SHINGLE
ORE
SCHIST
ORE
SCHIST
DISS. ORE
ORE
W. SCHISTOSE AMPH.
W. SCHIST
ORE
AMPH.
ORE
HEMATITE ORE. MAGNETIC, OXIDIZED.
W. TALCOSE SCHIST
HEMATITIC ORE
AMPH.
LOW GRADE DISS. ORE
W. BROWN & RED AMPH.
SOIL
MED. GR. W. AMPH. BEARING TALC SEAMS
TALC SEAM
LOOSE IRON SCREE & SHINGLE
F.GR. W. AMPH.
F.GR. AMPH.
MED. GR. AMPH.
LOW GR. OXIDE ORE
PARTLY TALCOSE
ALT. W. SCHISTOSE ZONE
LOW GRADE OXIDIZED ORE - FEEBLY MAGNETIC. HEMATITIC MAGNETITE DISS. IN TALCOSE HOST. ALSO STRINGERS POCKETS OR BANDS
OXIDIZED MAGNETITE LENSE. HEMATITIC, FEEBLY MAGNETIC
0 10 FEET 20
450S/00
500S/00
TRAVERSE
500 S
FEET
G. URQUHART
GEOLOGIST
DEPARTMENT OF MINES HOBART
MARCH 1965

FIGURE 20.



N°1 R.T.A.E.
N°1
N°2
N°3
N°4
N°5
N°6
N°7
N°8
N°9
N°10
N°11
N°12
N°13
N°14
N°15
N°16
N°17
N°18
N°19
N°20
N°21
N°22
N°23
N°24
N°25
SCALE IN FEET
LEGEND
DEPTH OF WEATHERING.
FINE GRAINED AMPHIBOLITE.
MEDIUM – COARSE GRAINED AMPHIBOLITE.
AMPHIBOLITE SCHIST; GREENSCHIST.
CARBONATE ROCK (CALCITE DOLOMITE.)
BANDED QTZ. FELDSPAR METASOMATIC AMPHIBOLITE SCHIST.
LOW GRADE ORE (< 40% Fe) IN ALTERED SCHISTOSE HOST.
MEDIUM GRADE ORE (> 40% Fe) IN ALTERED HOST.
CARBONATE AMPHIBOLITE SCHIST; GREENSCHIST.
BANDED CARB.-QTZ.- FELDSPAR METASOMATIC AMPHIBOLITE SCHIST.
GEOLOGICAL SECTIONS
DRILL HOLES 1-25 SAVAGE RIVER AREA
5 cm
G. URQUHART
GEOLOGIST
DEPT. OF MINES – HOBART
1964
2443-35
GSB48 Fig. 21

FIGURE 21.