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MOUNT COSTIGAN MINES LIMITED

INTERIM DEVELOPMENT

DATA FOLIO

MOUNT BISCHOFF

TASMANIA

AUGUST 1962

AMG REFERENCE POINTS ADDED

INTRODUCTION

The Mount Bischoff Mine is located in the northwest of Tasmania, Australia, 49 miles by good gravel road from the deep water port of Burnie.

Mount Costigan holds an option to purchase 320 acres of what was formerly the most productive tin mine in Australia. In addition, most of the mineral rights within a 3 mile radius are held by Mount Costigan.

After an examination of the extensive pyrrhotite-cassiterite showings it was decided to conduct an induced potential geophysical survey to indicate additional potential ore. It is felt that a strong east-west anomaly to the south of the old workings indicates the faulted extension of the sulphide-cassiterite zones.

Diamond drilling of the exposed Greisen-Pig Flat sulphide-cassiterite zones has indicated an ore potential, which if limited additional drilling substantiates, will in itself support a 500,000 tons per year operation. Drilling to intersect the faulted extensions is now in progress.

Currently, two research programmes are in progress to ascertain the most economic way to recover the tin and other metals from the ore: 1) the mineral dressing is being investigated, and 2) a new smelting technique requiring only very low grade concentrates is being developed.

For the immediate future limited drilling is planned. Most effort will be placed on mineral dressing and metallurgical research.

Australia is a net importer of tin. This, plus the fact that the world is chronically underproducing tin indicates a strong and ready market for any Bischoff production. There would also appear to be a good possibility for realizing an additional profit from by-products iron powder and sulphur for which there is a ready market in Australia.

Australia is a stable country politically, with a buoyant economy. The country caters to foreign investment and mining taxation laws have been designed to encourage mine development.

EXAMINATION OF THE OLD MOUNT

BISCHOFF TIN MINE, MOUNT

BISCHOFF, TASMANIA

INTRODUCTIONLocation and Access

Waratah is a village in Northwestern Tasmania which once had a population of several thousand, though now there are only some 125 inhabitants. It is about one-half mile south of the old Mount Bischoff Tin Mining Company's workings on Mount Bischoff.

There is a good gravel road from the village to Burnie, a deep water coastal port 49 miles away on the northern side of the island. Guilford Junction is on the railway running between Zeehan and Burnie, and 11 miles east of Waratah by road. Wynyard 12 miles west of Burnie has an airport from which there are scheduled flights to Melbourne.

Purpose and Extent of the Examination

The writer was asked by Dr. W.L. Young of Mount Costigan Mines Limited, Ottawa, Ontario, to examine and evaluate the possible tin producing potential of the ground formerly mined by the Mount Bischoff Tin Mining Company, on Mount Bischoff, near Waratah, Northwestern Tasmania.

The property was visited between the 12th and 16th of June; in all slightly more than four days were taken to go over the geology of the desired locality and the flanks of the mountain. An additional day was spent in Hobart, the state capital, obtaining geological reports, and discussing the property situation at Mount Bischoff, with officials of the Tasmanian Department of Mines.

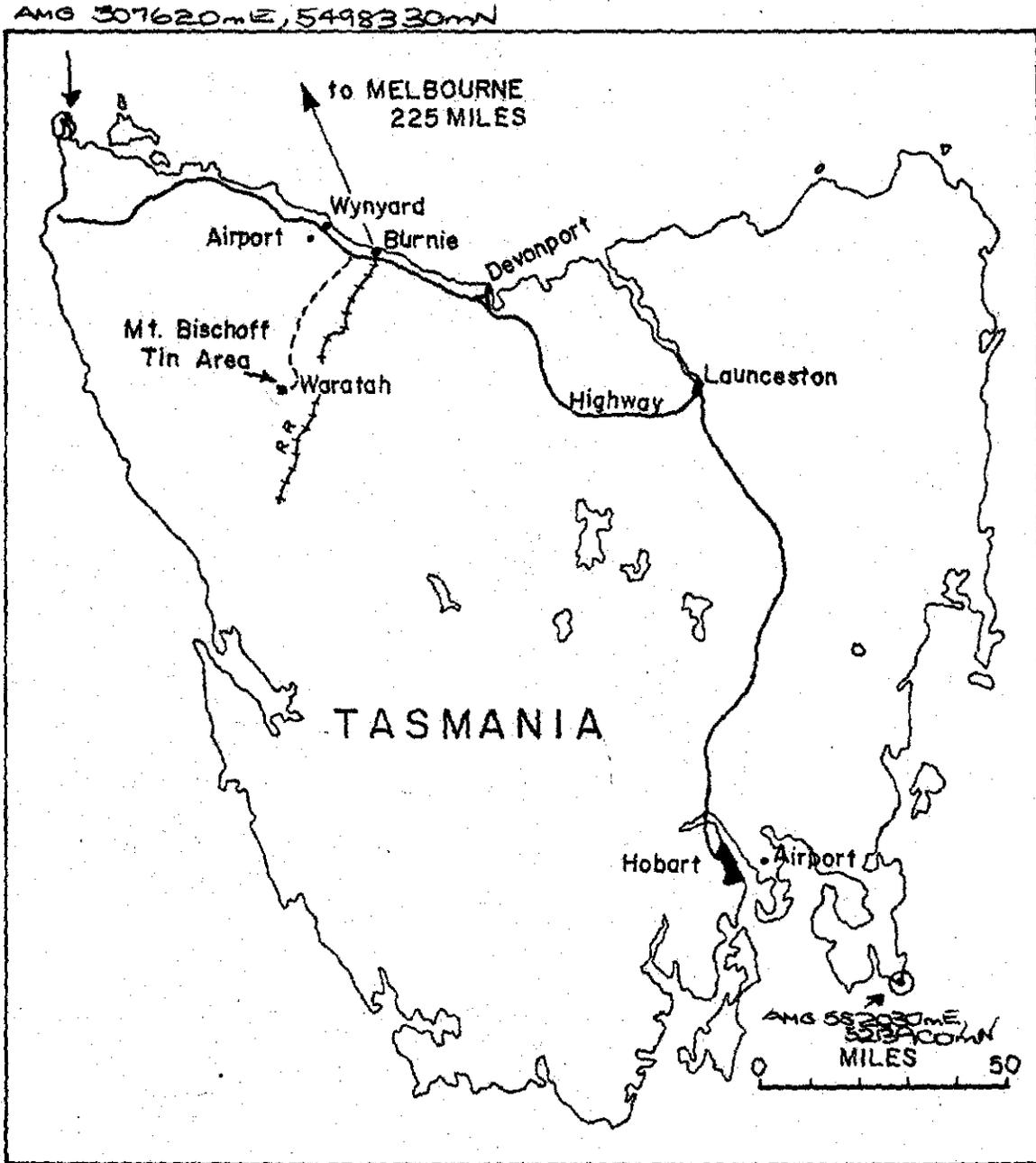
Ownership and Size of the Area

The Tasmanian Government has reserved the mineral rights on a circular area 2 miles in radius centred on Mount Bischoff. Placer leases are let to individual tributors (*) who have the right to mine them to a depth of 100 feet below the surface. Some of the tributors are working the stream gravels, sluicing material on the lower slopes of the mountain, or around the old workings, but a few are engaged in small scale mining of narrow, though at times, rich cassiterite-bearing quartz veins (lodes).

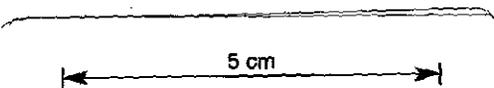
Mr. G. Van de Geer of the Department of Geography, University of Tasmania, Hobart, holds a prospecting lease over 320 acres of what was formerly the most productive ground mined by the now extinct Mount Bischoff Tin Mining Company. The approximate boundaries of this lease are shown on the "Geology Map of the Mount Bischoff Tin Area", which accompanies this report. Mr. Van de Geer holds the lease for Dr. P.A. Hill, of 13 Morris Street, Ottawa, Ontario; and Dr. M. Solomon of 23 Malunna Road South, Lindisfarne, Tasmania. It is in good standing until the 31st of December, 1962.

(*) Small lease holders

AMG REFERENCE POINTS ADDED



LOCATION MAP
MOUNT BISCHOFF
TIN AREA



Dr. Solomon has applied for the prospecting rights over all the ground not yet taken within a three mile radius of Mount Bischoff. His application is now under consideration by the Department of Mines.

The Director of the Tasmanian Department of Mines, Mr. J. Symons, has given assurances that everything possible would be done to help establish new mining ventures in the Mount Bischoff area (*).

History

Tin was discovered on the southwest side of Mount Bischoff in Tinstone Creek during 1873 by James (Philosopher) Smith. The source of the alluvial cassiterite was traced to the mountain, and in 1873 the Mount Bischoff Tin Mining Company was formed to exploit the discovery. After some initial difficulties the property became the most productive tin mine in Australia. "Brown Face", the largest deposit, was exceptionally rich in its upper parts as a result of secondary enrichment, as were several of the other "Faces" (**), though on a smaller scale. Their stratified nature at first led to the belief that they were of alluvial rather than eluvial origin.

Production averaged around 2,200 tons of tin oxide annually until 1898, then it started to drop as the rich ore became exhausted. The beginning of the first world war along with the collapse of the tin market, marked the end of large scale mining. Production continued until 1929, after which the mine was let to tributors. The grade by this time must have been very low for in 1921 it averaged 0.31 per cent (6 - p.1191). The end of the operation was undoubtedly hastened by the onset of the 1929-32 depression, when the price of tin again sagged (8 - p.15). Tributors worked the property in a small way until 1943, when it was taken over by the Commonwealth of Australia, who mined out readily available ore in an attempt to alleviate the tin shortage, caused by the Japanese occupation of Asia. C. L. Knight, geologist with the Commonwealth Bureau of Mineral Resources, was in charge of the exploration and development. There is no clear record of how much was mined, but according to statistics the tonnages removed were not very large (3 - p.5). This operation ceased in 1947, and the tributors again began working the area. Since then their production has been no more than 40 - 50 tons of tin annually (3).

The total production from the Mount Bischoff mine to the end of 1955, was 55,000 tons of tin from 5,500,000 tons of ore (3 - p.25). Since the concentrating process was very ineffcient, it means that the ore averaged a minimum of about 1.4 per cent tin oxide. The bulk of the production came from the "Faces" (open-cuts) on what is now the Van de Geer Lease.

(*) During an interview which the Director was kind enough to accord the writer.

(**) Open-cut or pit.

The only other company on the mountain, the Mount Bischoff Extended Tin Mining Company, operated between 1882-1932, and produced 2,000 tons of tin from the "Giblin Lode" (vein). It was mined to a down-dip depth of 1,000 feet, and averaged about 1 per cent tin. All told there are probably some 40,000 feet of underground workings, most of which occur on the "Giblin" and "Queen Lodes", with only 4,000 to 5,000 feet beneath the other sections.

Mining on Mount Bischoff ceased for a combination of reasons, foremost amongst which were the shortsightedness of management in not doing metallurgical research, and exploration to maintain reserves. Concentrating losses are believed to have been very high, possibly between 30 and 45 per cent.

Climate

Situated on an elevated plateau 2,000 feet above sea level and unprotected by mountain ranges the township of Waratah is exposed to winds from every direction. As a rule winds from the east indicate fine weather, while winds from the west are almost invariably accompanied by boisterous conditions. A short summer extending from December to March is followed by a cool autumn of average duration, a long rigorous winter, distinguished by occasional snowfalls and heavy rainfalls, and a cool spring marked by unsettled weather.

The meteorological record shows an average annual precipitation exceeding 85 inches. There are no periods of drought, but January and February are dry in comparison to June, July and August. Rain falls during 250 days of the year (2 - p.17).

GEOGRAPHY

Mount Bischoff is a monadnock having an elevation of 2,596 feet above sea level. It stands some 500 feet above the adjacent Tertiary basaltic plateau of Northwestern Tasmania. Peneplanation during the Upper Mesozoic and Lower to Middle Tertiary was followed by submergence and deposition of lacustrine sediments. Emergence in conjunction with the extrusion of plateau basalt, commenced a new cycle of erosion. The mountain owes its altitude to a relatively resistant core of quartz porphyry dykes and sills.

Although the sheets of plateau basalt have protected the underlying sedimentary rocks, heavy rainfall, post-Tertiary faulting, and elevation of the plateau to around 2,000 feet above sea level, have rapidly incised deep river valleys along lines of weakness down through the basalts, and into the underlying Palaeozoic and Precambrian rocks. In the area west of

Mount Bischoff, the basalts have almost been removed, but to the south and east, the plateau is still the dominant topographic feature.

The Waratah River drains the east and north sides of the mountain. Its course may reflect faulting modified by weak formations in folded rocks, though the porphyry dykes show no displacement where they cross the river. The Arthur River flows north and drains the western flank of the mountain; its junction with the Waratah River just north of the map sheet, is at an elevation of about 1,100 feet above sea level.

REGIONAL GEOLOGY

Mount Bischoff consists of sedimentary, with some tuffaceous, and possibly flow rocks of the "Bischoff Series", which are considered to be Lower Cambrian or Upper Precambrian, and correlative with part of the Carbine Group (3 - p.1109). They are bounded on the south, west, and north, by the Middle to Upper Cambrian Dundas Group, composed of slates, quartzites, tuffs, breccias, and basic flows; while to the east and south there are Upper Tertiary plateau basalts. These cover a thin series of fresh water sedimentary rocks, which were deposited on an extensive Middle Mesozoic-Upper Tertiary peneplane.

Upper Devonian to Lower Carboniferous ultrabasic to granitic intrusions occur in the area, which were emplaced in conjunction with folding and faulting. A large granite body about four miles south of Mount Bischoff, is probably the surface expression of a much greater mass, extending between the Meredith and Hampshire Range granites, and constituting a tin province. Major tin deposits such as Razorback, Renison Bell, Mount Lindsay, Mount Cleveland, and Mount Bischoff are found in this zone (4 - p.1119). It is thought that the quartz porphyry dykes and the mineralization of Mount Bischoff were derived from a satellitic cupola of this granite occurring beneath the mountain.

Quaternary river gravels and sands are the youngest rocks in the region, and locally have concentrations of cassiterite which are worked by tributors.

GEOLOGY OF MOUNT BISCHOFF

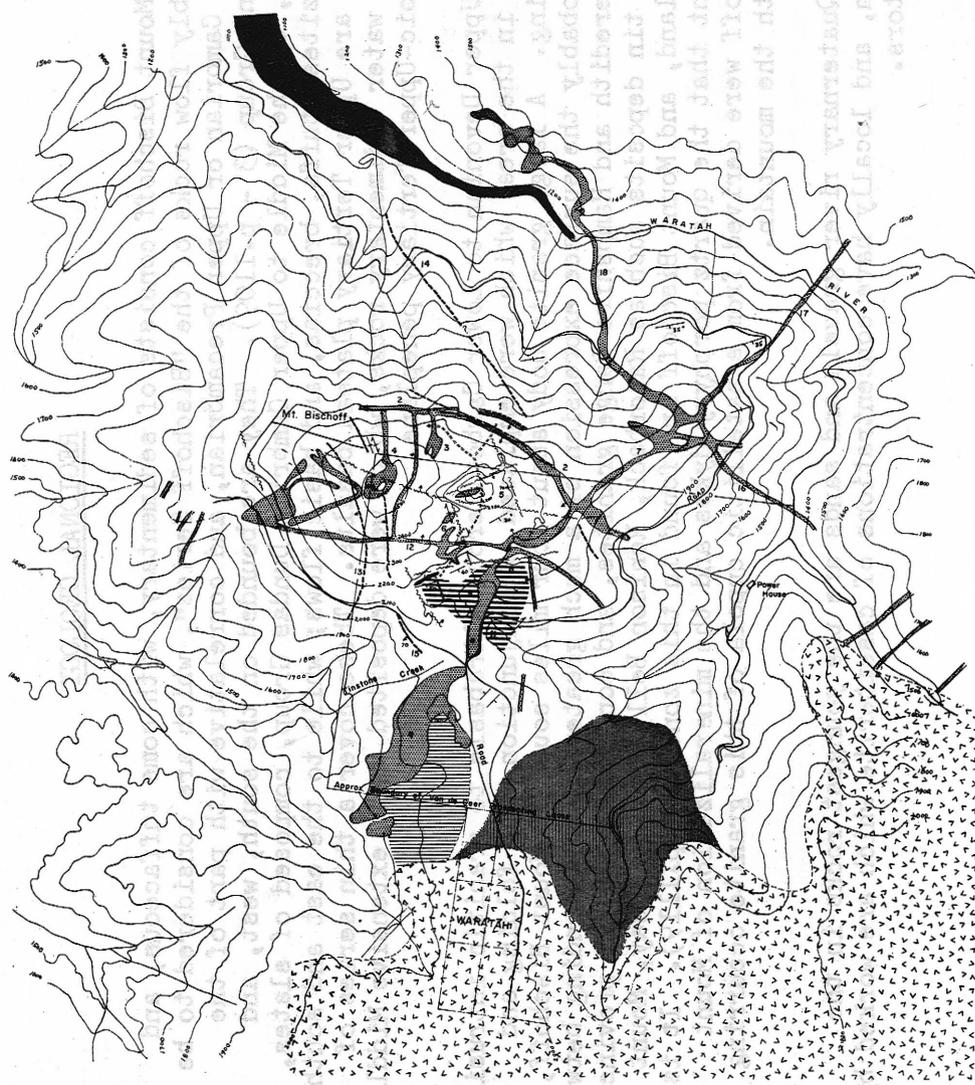
Introduction

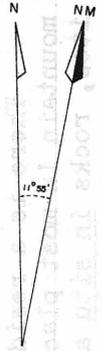
There is a residual mantle of weathered rock or talus covering the mountain in most places. Except for the siliceous porphyries and quartzites, rocks in situ are only seen in the old surface and underground workings, road-cuts and stream beds. In addition there is a dense almost tropical growth of tough shrubs, which prevent freedom of movement.

GEOLOGY MAP OF THE MOUNT BISCHOFF TIN AREA, NORTHWESTERN TASMANIA

LEGEND

- RECENT**
 River Alluvium
 - TERTIARY**
 Basalt flows
 Fresh water Sedimentary Rocks
 - DEVONIAN**
 Quartz Porphyry (Greisen)
 a - Quartz-Feldspar Porphyry
 - MIDDLE TO UPPER CAMBRIAN**
 Dundas Group - Tuff, greywacke, slate, conglomerate, basic flows.
 - UPPER PRECAMBRIAN OR LOWER CAMBRIAN**
 Bischoff Series- Carbine Group - Claystone, siltstone, grey to black shale, conglomerate, slate, quartzite, dolomite, talc, chlorite, and serpentine schists, tuff, possibly some acidic flows.
 Underlain by south to southeast dipping dolomite interbedded with shales and schists, possibly several horizons, or repetition by faulting or folding. In part mineralized, extent not known.
 -  Sulphide replacement body containing tin values
 -  Quartz - cassiterite lode (vein)
 -  Fault suggested
 -  Contact assumed
 -  Strike and dip of bedding, vertical, inclined.
 -  Strike and dip of schistosity, vertical, inclined.
 -  Main adit level
- CONTOUR INTERVAL - 100 FEET



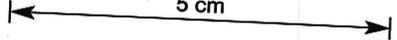
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11° 55'
1. Princess Lode and Dyke.
 2. Queen Lode and Dyke.
 3. North Face open-cut and Dyke.
 4. Summit Face open-cut and Dyke.
 5. Brown Face open-pit and Dyke.
 6. Slaughter Yard Face open-cut and Dyke.
 7. Stanhope Face open-cut and Dyke.
 8. White Face open-cut and Dyke.
 9. Pig Flat Face open-cut.
 10. Greisen Face open-cut.
 11. Happy Valley Face open-cut.
 12. Western Dyke.
 13. Giblin Lode
 14. North Valley Lode
 15. Thompson Lode.
 16. Ringtail Dyke.
 17. North Eastern Dyke.
 18. Northern Dyke.

SCALE: 1 inch = 600 feet



5 cm



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It is regrettable that no geological maps are available, of the extensive underground workings beneath the mountain, since most are now inaccessible. However, the "Greisen Face" pyrrhotite replacement body was seen in the southern part of the "Main Adit Level", though with unwashed walls not much information was obtained. The open-cuts, dykes, and old lodes are listed and indicated by numbers on the accompanying "Geology Map of the Mount Bischoff Tin Area". The geology of the map is based on the work of Reid, with modifications from Knight, and by the writer (2, 5, 6).

Sedimentary and Metasedimentary Rocks

The rocks of sedimentary origin on the mountain are siltstones, claystones, shales, slates, quartzites, conglomerate, dolomite, quartz-mica schists, talc serpentine and chlorite schists. Well bedded quartzites inter-layered with slates and schists predominate on the northern and northeastern flanks of the mountain, while thinly bedded claystones, siltstones and shales are more common on the western flank. Quartzites, or quartz-mica schists along with those composed of talc, serpentine, and more rarely chlorite, occur on the southern and eastern slopes, along with dolomite.

The dolomites are controversial rocks; locally they have been altered to talc and serpentine schists, and have been the host for all the major sulphide replacement ore bodies. Reid (2 - p.37) thinks they are the result of magnesium metasomatism of ultrabasic intrusives; whereas Knight (6) considers them to be of sedimentary origin. The latter view is supported by their sedimentary associations, relict bedding, and chemical analysis. The extent and form of these rocks has still to be determined.

Volcanic Rocks

There are fine grained light green acidic rocks at the bottom of the "Brown Face" open-pit, which contain pumiceous fragments, and lenticular particles of ash. On the south wall, there are fine grained acidic rocks that display what may be flow banding? Examples of suspected tuffs are to be seen on the surface along the eastern margin of "Brown Face", though some are undoubtedly conglomerates. The north wall of this pit has 2-3 inch thick light gray, kaolinized beds, composed of innumerable round to elongated and angular fragments, some of these resemble volcanic shards and lapilli. However, thin sections are reported to show that they are intraformational conglomerates and breccias (*). Furthermore, there are schists in the "Greisen Face" area which may have been in part derived from acidic tuffs or flows.

Intrusive Rocks

Basic and Ultrabasic Rocks

Only one exposure of a basic intrusive rock was found on the mountain. This is in a road-cut on the eastern flank, about 1,800 feet along the road leading east from "Happy Valley". It is fine grained, and occurs at an elevation of approximately 1,800 feet. It is probably a chilled margin or dyke related to the Tertiary plateau basalts.

Chloritic schists seen in the talus near and in the "Greisen Face" might represent sheared and altered basic intrusions or tuffs, but the abundance of chloritic material is not great, and their formation is equally as explicable

(*) personal conversation with Dr. M. Solomon.

by other means. Reid (2 - p.57) in his vertical sections through the mountain, shows large dyke-like bodies of ultrabasic rock beneath "Brown Face" and "Greisen Face". The abundance of pyrrhotite in the old replacement ore bodies, and Reid's unrivaled view of the underground geology, make his interpretation difficult to refute with any certainty. But ultrabasic and basic rocks are not evident at the surface.

Porphyries

The porphyries are most numerous on top of the mountain, where they form conspicuous exposures which stand out as elongated, angular to rounded ridges.

There are two main types of porphyry, the first a quartz porphyry, is the most abundant. It is light to dark gray and very siliceous, and varies from very fine grained almost cherty, to a granular textured rock, composed of fine crystal aggregates of quartz and feldspar, with, in places tourmaline and/or topaz. An increase in the last two minerals is probably at the expense of the feldspar. Increased crystallinity generally goes with an increase in the number of cavities or vugs. These are lined with perfectly formed small crystals of topaz or tourmaline, and quartz, while they contain variable amounts of sulphide, usually pyrite. The cherty porphyry has no cavities, only pyrrhotite with small amounts of chalcopyrite, bornite or covellite. Relatively large rounded blobs of clear to cloudy quartz occur in all varieties, while feldspars though present are rarely seen. The second type is a quartz-feldspar porphyry and consists of numerous well formed, kaolinized feldspar phenocrysts, and less abundant rounded grains of dark quartz, enclosed in a groundmass of the same minerals. Cavities and sulphides are entirely lacking.

Quartz porphyry comprises all the dykes seen on the mountain, except the southern end of the "White Face" dyke, which is the feldspar-rich type.

Reid (2 - p.59) notes that all stages of feldspar replacement can be seen in the "North Face". Unfortunately this was the only "Face" not examined, but the southern part of the "White Face Dyke" exhibits somewhat similar features.

The quartz porphyry is a greisen type alteration which invariably occurs with tin mineralization the world over. It has undoubtedly been formed by the alteration of the feldspar-rich variety.

The "Slaughter Yard Dyke" is the cherty pyrrhotite-bearing variety, whereas the "Stanhope Face Dyke" is a quartz porphyry with abundant green tourmaline, which is so porous (vuggy) that it resembles pumice. It contains only pyrite. The latter dyke must have been a centre of strong gaseous volcanic action. Parts of it which were stockworked with fine quartz veinlets were mined for its tin content.

The quartz-cassiterite veins (lodes) cut the porphyries, therefore they are the youngest known intrusions.

Structure

Interbedded quartzites, slates and schists on the north and northeastern side of the mountain strike between 65 and 80° (*) and have vertical to southerly dips. Except in the northeastern part they are tightly folded; in places the slates give way to schists suggesting strong differential movements between beds amounting to bedded faults. Further south on the eastern

(*) All bearings are magnetic and in azimuth.

flank, schist zones were noted along the road, their attitudes could not be obtained with any certainty, but they are believed to strike in an east or northeasterly direction. In the vicinity of "Happy Valley", the schistosity and the bedding strike northeast. A perfectly formed upright tight symmetrical fold in quartzites and schists is exposed in the old railroad cut, it strikes 40° and displays no plunge.

On the west side of the mountain, just west of "summit Face", there is an excellent schist zone beside a vertical bed of quartzite. A very short distance to the west, the west wall of "Summit Face" displays a nearly vertical fault zone, in which a flat plunging drag-fold adjacent to a porphyry dyke, indicates a movement of west side down. These zones supplement each other and clearly indicate fault movement on a 340° strike. This direction is common to that of faulting, schistosity, and many of the quartz-cassiterite veins. Along the road west of "Summit Face" another 340° vertical fault was found, only here it occurs in gently flexured siltstones and claystones, which locally show weak traces of sulphide mineralization. Their attitudes are in marked contrast to the tightly folded rocks observed elsewhere.

Knight (6) thinks that a north trending syncline formerly extended across the mountain, and that an east striking series of gentle folds were superimposed on the older, by a anticlinorium which covered the mountain. It contained a mineralized dolomite bed or beds, which were entirely eroded in the anticlinal zones, but partly preserved in the synclinal depressions, and on the southern flank. "North Face", "Brown Face" and the "Slaughter Yard Face", ore bodies represent the synclines, and the intervening barren ground the anticlinal zones. The elongated boat-shaped "Brown Face" open-pit has tuff or conglomerate beds in its north wall, which strike 340° and dip 65° west, yet they are unmatched on the south wall. While east and south of the pit, quartzite and tuff, or conglomerate beds, strike northeast and dip southeast at 35° . These attitudes do not support the synclinal theory, unless it is assumed that a very tight fold could develop in otherwise open structure. Evidence based on slickensided and schistose surfaces suggests that the "Old Brown Face" ore body was down-faulted by inward dipping faults.

In the area underlain by the replacement sulphide bodies, Knight (6) found a marker horizon which he calls the "footwall shale". Directly above this rock as in the case of the "Brown Face", or separated by thicknesses of schists, there is the "lower dolomite", in which all the sulphide replacement ore bodies occur. Along the south flank of the mountain the "Greisen", "Pig Flat" and "White Face" zones have an "asbestos horizon" above the "lower dolomite". These are serpentine and talcose rocks, which in their turn are overlain by the "upper dolomite". The "footwall shale" just south of the "Western Dyke" dips steeply south to southeast. Drilling of the "Greisen" ore body encountered two sulphide replacement lenses in dolomite, and near the surface another band of shale. Knight assumes that the repetition of the dolomite beds or lenses results from folding and overturning to the north. However, the possibility that folding may have been accompanied by thrust-faulting in the same direction cannot be disregarded. Reid noted a fault extending between "Greisen Face" and "White Face", which dips at a fairly low angle to the south, and cuts through slates and dolomite (2 - p.106). This fault is on the accompanying Geology Map. The complexity of the structure in this locality is further compounded by the presence of 340° faulting which has displaced or terminated the western end of the "Greisen Face" sulphide body. In view of the evidence it is uncertain how many dolomite beds there are.

Mount Bischoff occupies the axial region of a northeast striking eroded anticlinorium. The crude concentric attitudes of the dyke-cluster on the mountain suggest forceful injection from below; this is supported by evidence

of the gaseous nature of the intrusions. Local structural complexities are to be expected near centres of such activity from heat and stress. The structural problems of Mount Bischoff require further study.

ECONOMIC GEOLOGY

Mineralization

Cassiterite is the only tin mineral, though some stannite may have been present in the "Giblin Lode" (6 p.1192). Marcasite, pyrite and pyrrhotite are the most abundant sulphides; marcasite was very plentiful in the secondary enriched zones formed above the pyrrhotite deposits, and when exposed to the air often ignite spontaneously. Sphalerite, galena, stibnite, wolframite and arsenopyrite, along with many others were in general very minor constituents in the old deposits, though some, especially galena and sphalerite, became increasingly more abundant with depth in the "Giblin Lode" and in parts of the "Queen Lode". Occasionally veins lenses or splashes of the lesser constituents were found in the more massive sulphide deposits. Pyrite is the common sulphide in the veins and the porphyry dykes on the mountain, except in the "Slaughter Yard" porphyry, where it is pyrrhotite.

The gangue minerals are quartz, topaz, tourmaline, fluorite, mica, iron calcium magnesium carbonates, talc, and serpentine. Quartz was and is the most abundant with nearly all occurrences. Talc serpentine and carbonates predominate amongst the massive sulphides in the dolomite horizons, fluorite occurs in the veins, while topaz and tourmaline frequent the quartz porphyries and some veins.

The mineral occurrences on Mount Bischoff can be divided into four classes:

(1) Eluvial (secondary enrichment)

Surface exposures of sulphide replacement deposits were decomposed by weathering, and the soluble materials carried away by ground water, leaving behind cassiterite, silica, and hydrated iron oxides. Marcasite was formed under reducing conditions at depth and grades downward into unaltered sulphides, with a resulting decrease in the average tin content.

(2) Replacement Deposits

Massive pyrrhotite-pyrite lenses replace dolomite, and to a lesser degree other rocks. In the vicinity of the porphyry dykes they are probably more pyritic. The gangue minerals are quartz, iron magnesium and calcium carbonates, talc, mica, occasionally fluorite, and serpentine.

(3) Porphyry Dyke Deposits

Porphyry was emplaced and/or altered under pneumatolytic conditions. It was highly charged with gases and especially rich in boron during the preliminary stages, resulting in the destruction of the feldspars, and the formation of topaz and tourmaline. This was closely followed by deposition of pyrite. There is little tin in this type unless it is stockworked by quartz-cassiterite veins.

(4) Quartz Veins

Fracture fillings by quartz and cassiterite. The best cassiterite veins are characterized by vugs or spaces lined with well formed gangue minerals. They represent the peak period of cassiterite deposition. The gangue minerals

apart from quartz, may be fluorite, topaz, tourmaline, carbonates, a golden mica, pyrite, galena, sphalerite, arsenopyrite, stibnite and jamesonite. However, except for the silicates, the others are rare, though in depth they may increase, as the cassiterite values fall.

Mineral Occurrences and Their Potential

"Brown Face" Open-pit

The pit is about 800 feet long, 500 feet wide, and 150 feet deep. There is a large block of material still in place at the bottom near the southwestern end. It consists of flat-lying slates or hornfels below a sill of porphyry, on top of which there are 20 feet or so of secondary gossaneous material. The porphyry adjacent to the pit wall contains small veins of fine granular dark sulphide and quartz, in places cassiterite is quite conspicuous. The pit wall consists of acidic slickensided rocks and is obviously a fault, which strikes east and dips north at 40° . It also contains some veinlets of cassiterite. Appearances suggest that the cassiterite mineralization may have been distributed by this fault. There are random, quite large blocks of massive pyrrhotite at this end of the pit, and a ledge of fine grained pyrite against the northwestern wall. However this is only an isolated remnant, since behind it, on the north, the wall of the pit is a fault surface which strikes 60° and dips south 55° . Acidic volcanic breccias or agglomerates underlie the bottom of the pit, and a few quartz-cassiterite veinlets occur in these rocks. On the surface east of "Brown Face", there is a well formed narrow shear in tuffs or slates; which strikes 340° and dips west at 70° . It would appear that the former "Brown Face" sulphide deposit was and is "floored" by flat lying dark slates and bounded by inward dipping faults.

There are an estimated 40,000 to 60,000 tons of material remaining in the pit, mainly at its eastern end. It consists of pyrite, pyrrhotite, burnt sulphide and gossan; though the latter two are probably predominant. Grab samples of the first three showed less than 0.1 per cent tin (*), which explains why the material was left. Samples of a yellowish ochre and an adjacent layer of tuff or breccia-conglomerate, from the central part of the north wall 75 feet down from the lip, ran respectively 0.58 and 0.29 per cent tin. This suggests the possibility of finding low grade material around the upper north margin of the pit, which might extend northward in the direction of the "North Face". In addition thin quartz veinlets in the south wall have in places noticeable amounts of cassiterite, which if rich enough might enable sections to be mined.

The intersection at depth of the faults which bound the "Brown Face" pit could have interesting possibilities. It might explain the existence of the worked-out "Brown Face" lode.

If the old "Brown Face" ore body plunged eastwards as suggested by Solomon (7), then more sulphides might be found in that direction, if the movement on the fault at the eastern end has been a reverse movement. However it is feared that the opposite is the case.

"Slaughter Yard Face"

The mineralization in this open-cut is stated to have been similar to that of the other replacement deposits in dolomite. Reid's dimensions for the material removed suggest a production of some 50,000 tons. Only a block of massive pyrrhotite containing around 150 tons, a few pieces of quartz porphyry, and a schist zone trending in a northeasterly direction, are now in

(*) Assayed by the Tasmanian Department of Mines, Launceston.

evidence, beside a considerable amount of waste. There are partings in quartzite waste near a 340° fault along its eastern margin, which if observed with a lens, show occasional surfaces covered with fine cassiterite. Furthermore the "Western Dyke" which bounds it on the south, is intersected at numerous places by quartz-cassiterite veins, and faults which strike 340° , while the schistosity at the northern end of the "Face" has a similar attitude. It is believed that the quartz veins may have "fed" cassiterite to the old sulphide deposit in this locality. There would seem to be a good probability that a stockwork of quartz-cassiterite veins may occur in this vicinity, especially near the intersections between the faults and the veins, with the "Western Dyke".

"Greisen Face"

This area includes the old "Gossan Face" of Reid, it is mostly covered by residual soils: "cuts" show the gradual merging downward from soil into rotten rock. Schists are much in evidence at the north end of the "Face" and amongst the waste, along with partly decomposed sulphide and gossan. Exposures of weathered dolomite have a rusty appearance: crude relict bedding which consists of dolomite, iron carbonates, quartz, and in places talc and serpentine, the last usually in stringers. Underground layered dolomite can be seen in the hanging-wall part of the "Greisen Face" sulphide body. It strikes 70° and dips south at 50° . A drift about 200 feet long extends in a 245° direction from the "Main Adit Tunnel" along the strike of and in the sulphide zone. Both walls over much of their length appear to be in disseminated to massive sulphides. Specimens, magnet, and compass, indicate the predominance of pyrrhotite. A grab sample from the wall, at the entrance of the cross-cut into the old tributors raise, which is north of the drift, assayed 0.06 per cent tin.

The "Greisen Face" sulphide body was investigated by drilling and underground exploration in 1944. The work suggested a possible 91,700 tons of 0.85 to 0.91 per cent tin (5-p.4). Additional tonnages of low grade are believed to exist above and to the north near the "Western Dyke". Massive pyrrhotite and gossan were seen on the surface a few hundred feet on strike and east of the "Main Adit Tunnel", two of Knight's drill holes near the tunnel did not find ore (5-p.5) beneath the exposure. However this could be explained by lensing, plunging or faulting. The west end of the sulphide body is presumably terminated by a fault which strikes 320° - 340° and dips east. The down-dip and lateral extent of the sulphides in this zone have still to be investigated.

A recent article on the tin deposits in this area by Knight, mentions that the remaining "ore" replacing the "lower dolomite" in the "Greisen Face" averages less than 0.4 per cent tin (6-p.1191). It is presumed that this grade includes the area north of the "Greisen Face" massive sulphide zone, around the tributors stope, where there is a considerable amount of untested mineralization.

"Pig Flat Face"

This open-cut displays few identifiable rock exposures other than altered or decomposed porphyry dolomite and eluvium. According to Knight the "upper dolomite" is the underlying rock in this locality, and there may be a 340° fault between here and the "Greisen Face". A gossaniferous pyrrhotite exposure is to be seen at the northwest edge of the "cut", while the floor has a trench some 30 feet long in a northerly direction, which displays abundant fine-grained, dark massive pyrite or marcasite over most of its length. If the sulphides are bedded and strike east to northeast and the dip is south,

then it would suggest a considerable thickness of this material. During the last war some good grade tin ore was removed from this "Face", though in one instance the cassiterite was so fine grained that very little of it was recovered. The down-dip potential of the sulphide occurrences in this locality have not been investigated.

Testing by auger and percussion drilling is reported to have proved the existence of 50,000 tons of 0.18 per cent tin by vaning assay immediately to the west of this "Face", and an additional 25,000 tons of the same grade to the north (chemical assay) (5-p.6). The ground between this locality and "White Face" has not been investigated.

"White Face"

This is a continuation eastwards of "Pig Flat". There are few rock exposures to be seen, only overburden and waste. The residual soils are light-yellow to white and were formed by the decomposition of porphyry, sulphides and crystal quartz "sands". The latter formed beds associated with the ore mined from this "Face". Knight (5-p.7) thinks that there are 50,000 tons in this locality above the "Main Adit Level" in the "upper dolomite", but some shale would have to be removed before it could be mined. The presence of these sulphides is based strictly on correlation between "Pig Flat" and "White Face", and must be considered as purely hypothetical until proven. If the "Happy Valley" dolomite is the southward down-dip extension of the "upper dolomite", it does offer some hope for the locality, since it is mineralized, though only in a patchy manner. The presence of a "lower dolomite" has still to be investigated?

"Happy Valley Face"

Massive pyrite with some pyrrhotite occurs at one place along the northern edge of the cut. While the "upper dolomite" locally has random sporadic stockworks of quartz veins and veinlets, some of which are heavily charged with almost massive pyrite, cassiterite can be seen in some of these under the hand lens. A grab sample of massive pyrite from a one inch thick veinlet was assayed and returned 3.57 per cent tin. If there are sufficient numbers of veinlets such as this throughout sections of the dolomite, there could be potential ore in this horizon, especially near the porphyry on its western side, where the "Happy Valley Lode" occurs. It is said to parallel the wall of the porphyry, and to have carried 1 per cent tin.

An adit driven north from the open-cut "passes through 100 feet of gossaneous material" (2-p.107). Apparently the tin content and the source of this gossan have not been investigated.

If the interpretation of the local stratigraphy is correct, the "happy Valley" dolomite is the "upper dolomite", and there can be a "lower dolomite" or other dolomites at depth, some of which possibly could have sulphide replacement deposits.

Quartz Porphyry Dykes

Certain sections of the "Western Dyke" north of "Greisen Face" are cut by numerous narrow quartz veins, containing sporadic but often abundant cassiterite. In addition, the dyke has disseminations of pyrite, as well as a pyrite vein zone in its margin. It is quite possible that parts of

this dyke and its wall rocks could have modest tin values.

The "Stanhope Face" was mined for the tin in the porphyry, which averaged 0.20 per cent, and in places had better values. The dimensions quoted for this cut of 60 by 60 by 100 feet suggest that it provided about 20,000 tons. The grade quoted is not high, but it was taken because it was cheap to mine, and the cassiterite easy to recover. Underground this grade would not have been acceptable at that time, though now the possibilities of this zone should be investigated.

Reid (2-p.131) mentions that a large number of samples from the dykes on the mountain were assayed, and averaged between 0.09 to 0.17 per cent tin. It is just possible that the prophyry dykes might have large tonnages of low grade yet mineable material.

Lodes (Veins)

No large veins were actually seen during the examination of the workings on the mountain, though the surface excavations of the old "West Bischoff Lode" (?) at the very top, and the "Thompson" near the bottom of the mountain were viewed. Both have certain features in common; they occupy fault fissures, strike 320° - 340° , dip steeply southwest, and are between one and two feet thick.

Tributors are at present working the "Thompson Lode". According to reports the vein is only between an inch to seven inches thick, and strikes northwest and dips steeply southwest. Specimens of the "ore" which were seen, consist of quartz, fluorite, carbonates, golden mica and cassiterite. The latter mineral is not evenly distributed in the veins, but there are some very rich patches, and the cassiterite crystals can be large and well formed.

Many of the veins such as the "Queen", "Giblin", or "Brown Face" (vein), which were formerly mined, or explored and abandoned because of low grade or metallurgical problems, might now under new conditions be profitably worked. The wall rocks of all the old deposits should be searched for stockworks and disseminations of quartz-cassiterite material.

Eluvium

Residual reddish-brown to yellow and gray soils formed by the weathering of sulphides and rock, cover an appreciable area on the southern flank of the mountain; though mostly over the "Greisen" "Pig Flat" and "White Face" sections. They are known to contain some tin values, since periodically the tributors have found and removed thin layers of cassiterite from them. Furthermore, the waste from the old "Faces" is strewn over the area, and contains modest examples of cassiterite. Perhaps both the soil and the waste rock may contain sufficient tin to permit surface mining on a large scale. The operation could grade downward into an open-pit operation, if and when exposures of sulphide zones were encountered.

Dr. Young whom the writer accompanied to Tasmania, has sampled the various materials on the surface. The results of this sampling should give some indication whether further investigation of the eluvium in this zone is warranted.

GEOPHYSICAL SURVEY

An induced polarization and resistivity survey was done to the east and south of the old workings. It was considered of no use to cover the old open-cuts, since sulphides are scattered everywhere over this area.

The results of the survey are shown on the accompanying geophysical map. An easterly striking mineralized zone is suggested beneath, and north of "Happy Valley" extending east as far as the Waratah River. The broad nature of the anomalies, creates suspicion that near surface salts deposited by ground waters may account for most, however these could lie down slope from mineralized zones, or possibly over deposits formed by secondary enrichment.

The anomalous localities along the eastern side of the mountain are over or adjacent to porphyry dykes, and might be attributed to sulphide disseminations in and along side these rocks.

METALLURGY

The ores of the old replacement deposits contained pyrite, pyrrhotite, marcasite and erratically distributed cassiterite; the better grades usually were found in the more siliceous parts of an ore body. The minerals of lead, zinc, arsenic and antimony were present in such small amounts, that there were no metallurgical problems, although periodically small rich splashes or veins containing an abundance of these minerals, were found in the massive sulphide bodies.

The biggest problem faced by the old miners was the fine cassiterite, for the finer it was, the greater were the losses during sluicing and concentrating. Fortunately "Brown Face" the largest and richest tin ore body on the mountain, had a great proportion of coarse cassiterite, whereas in most of the deposits on the south flank, it was and is very fine. This problem had not been solved as late as 1944, when some 12,000 tons of 0.84 per cent tin were treated, and most of the tin was lost because of the fine state of the cassiterite (4 - p.6). It is believed that not more than 70 per cent of the tin was ever recovered from the ores of Mount Bischoff.

The old Cornish vanning assays were used by the miners to test the values of the ores. These assays had three desirable features: they were cheap, quick, and they suggested the recovery grade, not the actual grade.

Bulk samples taken by Dr. Young have been sent to Geo-Met Reactors Limited, of Ottawa. It is hoped that a process will be found which will not only recover most of the tin, but the iron, sulphur, and possibly some of the less abundant metals.

Until a process for treating the mineralization of Mount Bischoff has been developed and its costs are known, no ore can be outlined.

1. The best tin mineralization on Mount Bischoff was and is closely associated with the quartz porphyry dykes clustered at or near the top of the mountain.
2. There are really only two distinct types of tin deposits namely: the replacement of some pre-existing rock usually dolomite by sulphide; and those formed by intrusion of quartz-cassiterite material into fractures. It is suspected that the latter type may be responsible for the tin in the sulphide replacement deposits.
3. Eluvial enrichment of tin-bearing sulphide replacement deposits provided the richest ores in the old mines. The chances of finding another deposit the size and richness of "Brown Face" are remote.
4. Mining of the "Giblin Lode" has shown that cassiterite values can persist to moderate depths, before they decrease and are supplanted by increasing amounts of base metal minerals.
5. The tin-bearing sulphide occurrences beneath the "Greisen", "Pig Flat", "White Face" and "Happy Valley" area, offer considerable promise. There are around 150,000 tons of possible ore probably containing between 0.18 and 0.83 per cent tin, while the lateral, down-dip, and depth potential, of this area has still to be investigated.
6. The tin content in the residual soils on the south side of the mountain might be sufficient to permit them to be mined.
7. Two grab samples from the north wall of "Brown Face" gave 0.58 and 0.29 per cent tin. There could be potential low grade material between this "Face" and "North Face".
8. There might be hypogene and supergene tin mineralization below the induced potential anomalies. Especially in the vicinity of the porphyry dykes.
9. Numerous places of possible interest are to be found on the mountain, such as vein dyke and fault intersections, where stockwork and disseminations of quartz-cassiterite material could occur.
10. There is sufficient tin mineralization on the Van de Geer lease to warrant exploration.

RECOMMENDATIONS

1. Ascertain what grade of tin or tin with other metals will be needed to make ore.
2. Map the geology of the Van de Geer lease and examine all the old underground workings that can be made accessible with little expense.
3. Do a magnetometer survey of the "Greisen", "Pig Flat", "White Face" area, and of the I. P. anomalies. Investigate the possibility

of using a ground E.M. to check the anomalies during dry weather.

4. Investigate the potential around and north of the "Brown Face" north wall.
5. Allow 5,000 feet of diamond drilling with which to investigate the sulphide bodies on the south side of the mountain, and to test any noteworthy geophysical anomalies.
6. Investigate the tin-bearing eluvium on the south flank of the mountain.
7. The planning of any further work would depend upon the results obtained from the above programme.

ESTIMATE OF COST

Geological mapping, underground investigation and supervision....	\$8,000.00
Magnetometer Survey, and E.M. anomaly checks.....	6,000.00
5,000 feet of diamond drilling @ \$6.50.....	32,500.00
Sampling of eluvium by auger, and assaying.....	4,000.00
Metallurgical investigation.....	7,000.00
Administration and office.....	4,000.00
Miscellaneous reserve.....	<u>10,000.00</u>
Total.....	\$71,500.00

1 August, 1962
Arnprior, Ontario

(Signed) N. B. Gillies, Ph.D.
Geologist

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the written permission of the writer.

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CERTIFICATE

I, Norman Bain Gillies, of the Township of McNab, (Arnprior) Renfrew County, in the Province of Ontario, do hereby certify that:

1. I am a Geologist residing in McNab Township, (Arnprior) Ontario;
2. I am a graduate in geology of Dalhousie University, with the degree of Bachelor of Science, and of McGill University with the degree of Master of Science, and Doctor of Philosophy in Geology;
3. I am a member of the Canadian Institute of Mining and Metallurgy, and a fellow of the Geological Society of Canada. I have been practising my profession continuously since by first graduation in 1937, except for five years during the last war;
4. I have no personal interest, either directly or indirectly, in the properties or securities of Mount Costigan Mined Limited, nor in the Van de Geer lease, and do not expect to receive any such interest;
5. The statements made in this report are based on a personal examination of Mount Bischoff, the Van de Geer lease, and reports of previous investigators.

1 August, 1962,
McNab Township, (Arnprior),
Ontario.

(Signed) N.B. Gillies, Ph.D.

(a) The bulk of the past production has come from the sulphide replacement bodies (Brown, Slaughteryard, Greisen and White Faces). These consist of pyrrhotite in a gangue of talc or carbonate, presumably derived from alteration of the dolomite. The carbonate is probably similar to the pistomacate of the Magnet Mine.

Replacement of the dolomite by pyrrhotite was almost complete near the axis of the anticlinorium (in the Brown Face, Slaughteryard Face and Greisen Face orebodies, Fig.1) but south of the Greisen Face it diminished and concentrated near the base of the dolomite. The dolomite north of the Waratah River is unmineralised. A shale bed occurs in the dolomite north of Greisen Face and Knight (1953) described the dolomite above the shale as the Upper Dolomite, and that below as the lower Dolomite.

Stillwell (1945) described three types of ore from the Greisen Face: Carbonate-sulphide, massive pyrrhotite, and talc-pyrrhotite. In the first type pyrite, arsenopyrite, and pyrrhotite are cut by later chalcopyrite and galena. Cassiterite occurs as fine grains in pyrite, arsenopyrite and carbonate, and is generally earlier than the sulphides. Colloform pyrite is cut by later sulphides. Cassiterite is rare in massive pyrrhotite but relatively common in the talc of the talc-pyrrhotite ore. Tin distribution in the ore is sporadic and can only be determined by assay; south of the Greisen Face it is concentrated near the base of the orebody.

The dolomite and sulphide ore probably cropped out during erosional phases between the late Mesozoic and the Recent; Limonite gossans developed in places but elsewhere the weathering products were completely removed, leaving residual and detrital cassiterite at the surface. This chemically and mechanically concentrated ore proved to be some of the richest tin ore in the world and enabled the mining company to declare huge profits early in its history.

(b) Zones of pyrite and quartz-pyrite ore occur within the mineralised dolomite. Much of the pyrite may well be secondary, being derived from pyrrhotite by high temperature alteration. Some of the pyrite appears to be primary and confined to dyke margins; leaching of this material leaves a crumbly quartz-pyrite ore, generally rich in cassiterite (e.g. White Face ore). Small quantities of secondary pyrite have been produced during oxidation of the pyrrhotite.

(c) Several fissure lodes occur at Mt. Bischoff and extend beyond the area of dolomite alteration. They vary from a few inches to 10-20 ft. thick and may be steeply dipping or almost horizontal. They display a different mineral assemblage to the pyrrhotite ore, consisting of quartz with sulphides but little pyrrhotite. Displacement has been observed across one lode and several lodes probably occupy faults. The largest body was the Giblin Lode, which was worked by the Mt. Bischoff Extended Company. This lode had an average width of 2 ft. and was worked over a vertical distance of 1000 ft. Tin content averages 1% and the lode consisted of pyrite, sphalerite, arsenopyrite and cassiterite in a gangue of quartz, tourmaline, topaz, etc. Production amounted to over 150,000 tons. Other important bodies were the North Valley and the Queen lodes, each of which contained similar mineral assemblages to the Giblin lode. Stillwell (1943) reported stannite replacing cassiterite in the North Valley Lode.

(d) Portions of the dykes assay 0.3-4% Sn, the cassiterite occurring as a replacement of feldspar or as a joint filling; most of the visible cassiterite found on the mine is of this type.

(e) Late Tertiary lacustrine (?) sands and gravels and Recent soils have been worked for detrital tin south of Mt. Bischoff and there have been extensive alluvial workings in the Waratah River.

Mt. Bischoff is ringed by a number of small mines that form a silver-lead-zinc aureole to the tin mineralisation. Preliminary studies of sphalerite compositions indicate a lower temperature of formation for the aureole deposits than the Bischoff tin ores.

The tin mineralisation is apparently confined to a high-temperature vertical funnel that followed the path of an acid dyke swarm, both dykes and mineralisation probably stemming from a local, cupola-like bulge in the Meredith Granite. The similarity between the Mt. Bischoff and Renison Bell mines is striking, particularly with regard to stratigraphy, structure, mineralogy and igneous activity, and a common mode of origin is indicated.

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- | | |
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NORTH

SOUTH

WARATAH RIVER

BROWN FACE

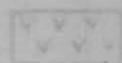
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GREISEN FACE

WARATAH RIVER

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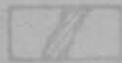
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TERTIARY BASALT



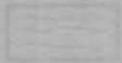
DOLOMITE (PRECAMBRIAN)



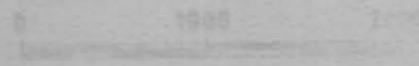
ELVAN DYKES



CAMBRIAN SEDIMENTS



QUARTZITE & SHALES (PRECAMBRIAN)

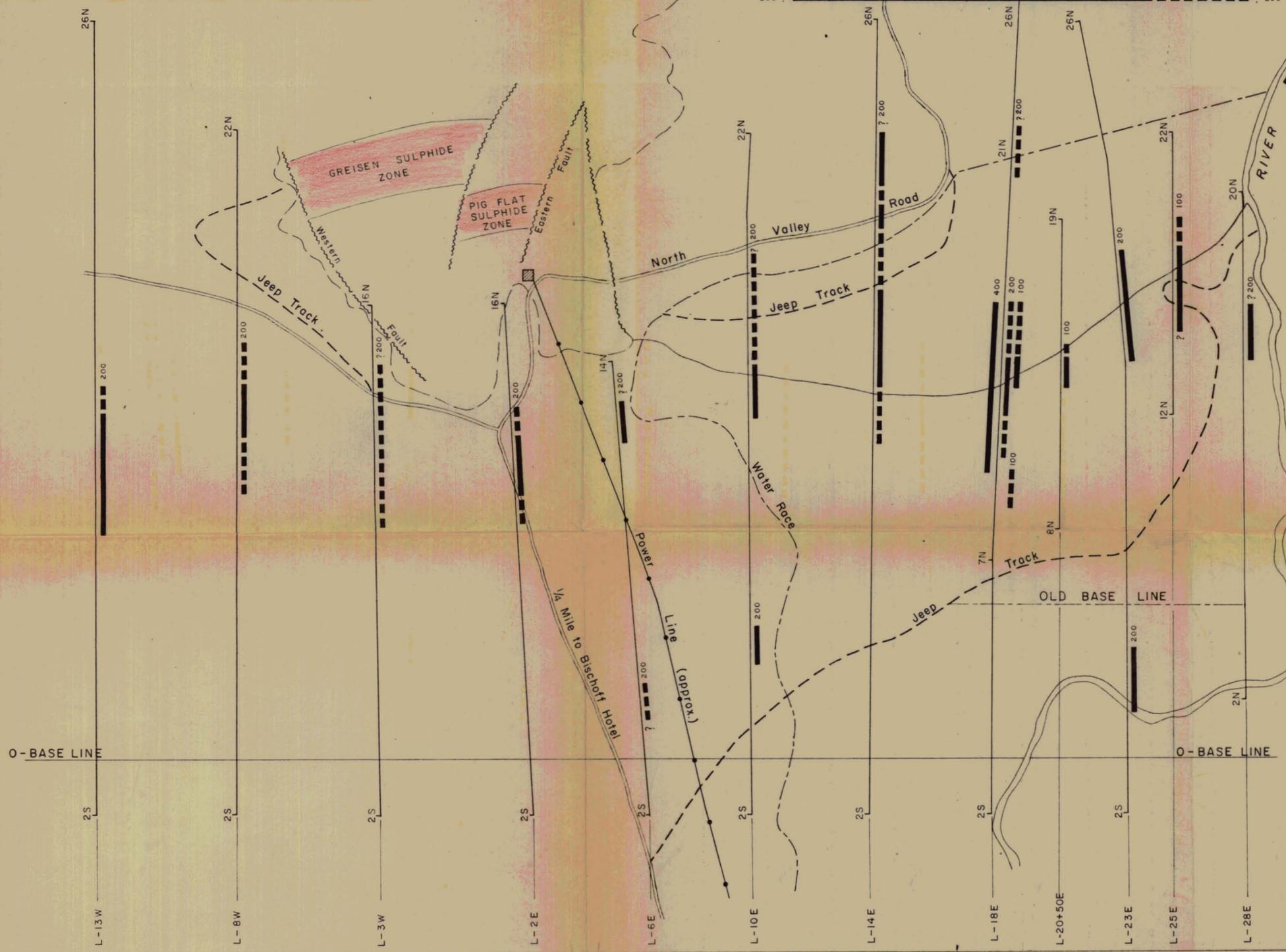
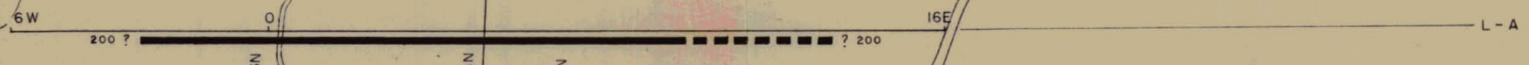
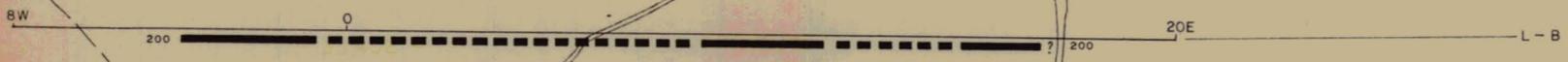
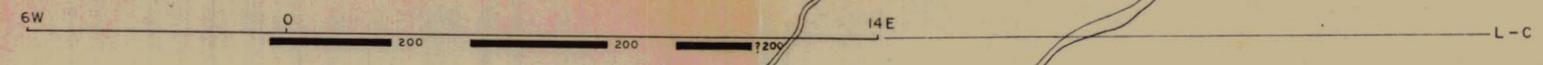
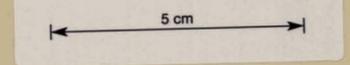


Scale of Feet



292025

25.



LEGEND

ANOMALOUS ZONE

POSSIBLE ANOMALOUS ZONE

NUMBERS AT END OF ANOMALIES INDICATE SPREAD USED.



MOUNT COSTIGAN MINES

MOUNT BISCHOFF OPTION

COMPILATION MAP SHOWING
RELATIONSHIP OF INDUCED POLARIZATION
ANOMALIES TO KNOWN TIN BEARING
SULPHIDE ZONES

APRIL, 1963

025

026

REPORT ON THE
INDUCED POLARIZATION SURVEY
FOR
MOUNT COSTIGAN MINES LIMITED
MOUNT BISCHOFF, TASMANIA
DATED JULY 9, 1962
AND
SUPPLEMENTARY REPORT
DATED SEPTEMBER 5, 1962

NOTES ON THE THEORY OF INDUCED POLARIZATION
AND THE METHOD OF FIELD OPERATION

Induced Polarization as a geophysical measurement refers to the blocking action or polarization of metallic or electronic conductors in a medium of ionic solution conduction.

This electro-chemical phenomenon occurs wherever electrical current is passed through an area which contains metallic minerals such as base metal sulphides. Normally, when current is passed through the ground, as in resistivity measurements, all of the conduction takes place through ions present in the water content of the rock, or soil, i. e. by ionic conduction. This is because almost all minerals have a much higher specific resistivity than ground water. The group of minerals commonly described as "metallic", however, have specific resistivities much lower than ground waters. The induced polarization effect takes place at those interfaces where the mode of conduction changes from ionic in the solutions filling the interstices of the rock to electronic in the metallic minerals present in the rock.

The blocking action or induced polarization mentioned above, which depends upon the chemical energies necessary to allow the ions to give up or receive electrons from the metallic surface, increases with the time that a d. c. current is allowed to flow through

the rock; i. e. as ions pile up against the metallic interface the resistance to current flow increases. Eventually, there is enough polarization in the form of excess ions at the interfaces to effectively stop all current flow through the metallic particle. This polarization takes place at each of the infinite number of solution-metal interfaces in a mineralized rock.

When the d. c. voltage used to create this d. c. current flow is cut off, the Coulomb forces between the charged ions forming the polarization cause them to return to their normal position. This movement of charge creates a small current flow which can be measured on the surface of the ground as a decaying potential difference.

From an alternate viewpoint it can be seen that if the direction of the current through the system is reversed repeatedly before the polarization occurs, the effective resistivity of the system as a whole will change as the frequency of the switching is changed. This is a consequence of the fact that the amount of current flowing through each metallic interface depends upon the length of time that current has been passing through it in one direction.

The values of the "metal factor" or "M. F." are a measure of the amount of polarization present in the rock mass being surveyed. This parameter has been found to be very successful in mapping areas of sulphide mineralization, even those in which all other geophysical methods have been unsuccessful. The induced polarization measurement is more sensitive to sulphide content than other electrical measurements

because it is much more dependent upon the sulphide content. As the sulphide content of a rock is increased, the "metal factor" of the rock increases much more rapidly than the resistivity decreases.

Because of this increased sensitivity, it is possible to locate and outline zones of less than 10% sulphides that can't be located by E. M. Methods. The method has been successful in locating the disseminated "porphyry copper" type mineralization in the South-western United States.

Measurements and experiments also indicate that it should be possible to locate most massive sulphide bodies at a greater depth with induced polarization than with E. M.

Since there is no I. P. effect from any conductor unless it is metallic, the method is useful in checking E. M. anomalies that are suspected of being due to water filled shear zones or other ionic conductors. There is also no effect from conductive overburden, which frequently confuses E. M. results. It would appear from scale model experiments and calculations that the apparent metal factors measured over a mineralized zone are larger if the material overlying the zone is of low resistivity.

Apropos of this, it should be stated that the induced polarization measurements indicate the total amount of metallic constituents in the rock. Thus all of the metallic minerals in the rock, such as pyrite, as well as the ore minerals chalcopyrite, chalcocite, galena, etc. are responsible for the induced polarization effect. Some

oxides such as magnetite, pyrolusite, chromite, and some forms of hematite also conduct by electrons and are metallic. All of the metallic minerals in the rock will contribute to the induced polarization effect measured on the surface.

In the field procedure, measurements on the surface are made in a way that allows the effects of lateral changes in the properties of the ground to be separated from the effects of vertical changes in the properties. Current is applied to the ground at two points a distance (X) apart. The potentials are measured at two other points (X) feet apart, in line with the current electrodes. The distance between the nearest current and potential electrodes is an integer number (N) times the basic distance (X).

The measurements are made along a surveyed line, with a constant distance (NX) between the nearest current and potential electrodes. In most surveys, several traverses are made with various values of (N); i. e. (N) = 1, 2, 3, 4, etc. The kind of survey required (detailed or reconnaissance) decides the number of values of (N) used.

In plotting the results, the values of the apparent resistivity and the apparent metal factor measured for each set of electrode positions are plotted at the intersection of grid lines, one from the center point of the current electrodes and the other from the center point of the potential electrodes. The resistivity values are plotted above the line and the metal factor values below. The lateral displacement of a given value is determined by the location along the survey

line of the center point between the current and potential electrodes. The distance of the value from the line is determined by the distance (NX) between the current and potential electrodes when the measurement was made.

The separation between sender and receiver electrodes is only one factor which determines the depth to which the ground is being sampled in any particular measurement. These plots then, when contoured, are not section maps of the electrical properties of the ground under the survey line. The interpretation of the results from any given survey must be carried out using the combined experience gained from field, model and theoretical investigations. The position of the electrodes when anomalous values are measured must be used in the interpretation.

In the field procedure, the interval over which the potential differences are measured is the same as the interval over which the electrodes are moved after a series of potential readings has been made. One of the advantages of the induced polarization method is that the same equipment can be used for both detailed and reconnaissance surveys merely by changing the distance (X) over which the electrodes are moved each time. In the past, intervals have been used ranging from 100 feet to 1000 feet for (X). In each case, the decision as to the distance (X) and the values of (N) is largely determined by the expected size of the mineral deposit being sought, the size of the expected anomaly and the speed with which it is desired to progress.

The diagram in Figure 1 below demonstrates the method used in plotting the results. Each value of the apparent resistivity and the apparent "Metal factor" is plotted and identified by the position of the four electrodes when the measurement was made. It can be seen that the values measured for the larger values of (n) are plotted farther from the line indicating that the thickness of the layer of the earth that is being tested is greater than for the smaller values of (n); i. e. the depth of the measurement is increased.

METHOD USED IN PLOTTING DIPOLE-DIPOLE
INDUCED POLARIZATION AND RESISTIVITY RESULTS

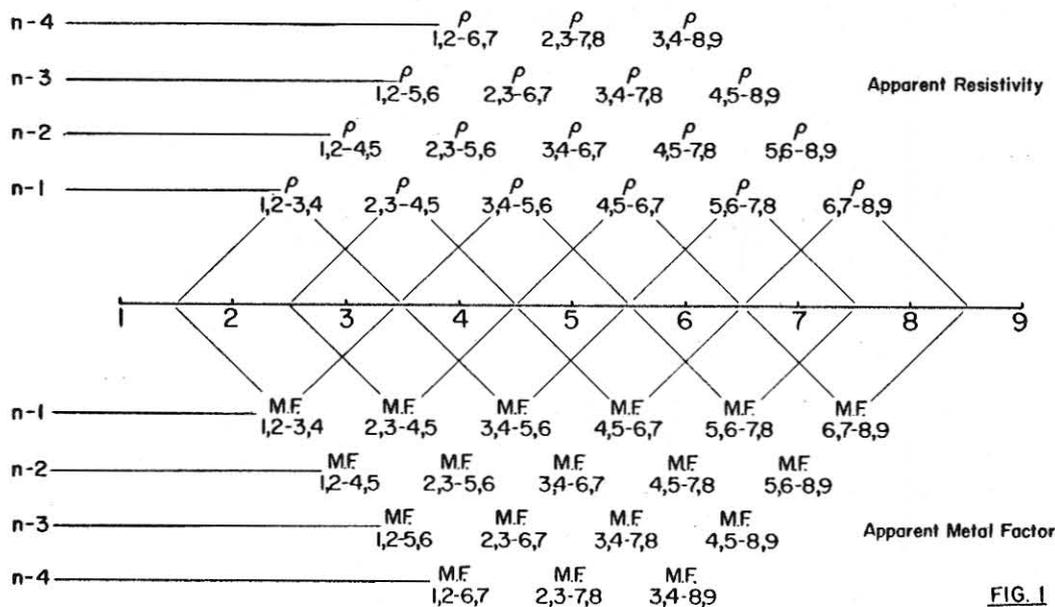
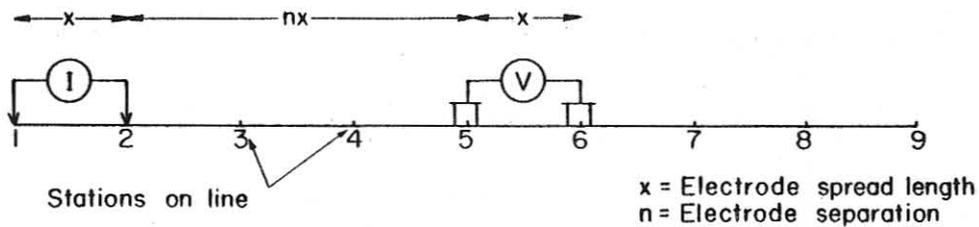


FIG. 1

McPHAR GEOPHYSICS LIMITED**REPORT ON THE
INDUCED POLARIZATION SURVEY****FOR
MOUNT COSTIGAN MINES LIMITED
MOUNT BISCHOFF, TASMANIA**

1. INTRODUCTION

At the request of Dr. W. L. Young we have carried out a combined Induced Polarization-Resistivity survey on the company's property located in the Mount Bischoff tin area near Waratah, north-western Tasmania. This was the leading tin producing district of Australia for 30 years; one company, the Mount Bischoff Tin Mining Company, mined over four and one-half million tons grading 1.17% during the period from 1873 to 1921.

The present survey was carried out in an attempt to locate additional deposits in the immediate vicinity of the old workings. Field work was performed during May and June, 1962, using a McPhar frequency-type I.P. unit. Anomalous results were measured on every traverse and a drilling program is now underway to evaluate the stronger indications.

2. PRESENTATION OF RESULTS

The induced polarization and resistivity results are shown

on the accompanying data plots in the manner described in the notes preceding this report.

<u>Line</u>	<u>Spread</u>	<u>Drawing Number</u>
13W	200-foot	Dwg. I.P. 2897-1
8W	200-foot	Dwg. I.P. 2897-2
3W	200-foot	Dwg. I.P. 2897-3
2E	200-foot	Dwg. I.P. 2897-4
6E	200-foot	Dwg. I.P. 2897-5
10E	200-foot	Dwg. I.P. 2897-6
14E	200-foot	Dwg. I.P. 2897-7
18E	200-foot	Dwg. I.P. 2897-8
18E	100-foot	Dwg. I.P. 2897-9
23E	200-foot	Dwg. I.P. 2897-10
28E	200-foot	Dwg. I.P. 2897-11
"A"	200-foot	Dwg. I.P. 2897-12
"B"	200-foot	Dwg. I.P. 2897-13
"C"	200-foot	Dwg. I.P. 2897-14

Enclosed with this report is Dwg. Misc. 3355, a plan map of the property at a scale of 1" = 300'. The definite and possible induced polarization anomalies are indicated by solid and broken bars respectively on this plan map as well as the data plots. These bars represent the surface projection of the anomalous zones as interpreted from the location of the transmitter and receiver electrodes when the anomalous values were measured.

Since the induced polarization measurement is essentially an averaging process, as are all potential methods, it is frequently difficult to exactly pinpoint the source of an anomaly. Certainly, no anomaly can be located with more accuracy than the spread length; i. e. when using 200' spreads the position of a narrow sulphide body can only be determined to lie between two stations 200' apart. In order to locate sources at some depth, larger spreads must be used, with a corresponding increase in the uncertainties of location. Therefore, while the center of the indicated anomaly probably corresponds fairly well with source, the length of the indicated anomaly along the line should not be taken to represent the exact edges of the anomalous material.

3. GENERAL GEOLOGY

The area is underlain primarily by early Paleozoic clastic sediments, consisting of slate, sandstone and quartzite with beds of volcanic ash. These are intruded by basic dikes, now largely altered to chlorite and dolomite, and by a younger interconnecting series of acid porphyry dikes. The latter group is of particular interest as it is apparently associated with the tin mineralization. The geology and mineral deposits are described in Tasmania Department of Mines G.S.B. #34, The Mount Bischoff Tin Field, published in 1923.

Mineral occurrences are of several types, the two most important being veins and replacement fissures localized in areas of intensely folded and crushed sediments. Replacement fissures were the chief source of ore at Mount Bischoff and consisted of large irregularly

shaped sulphide bodies (pyrite and pyrrhotite) carrying cassiterite.

4. DISCUSSION OF RESULTS

Most of the property was surveyed on north-south lines spaced at 400 or 500 foot intervals, using a 200-foot dipole-dipole electrode configuration. In addition, three east-west lines were run across the northeast corner of the property, extending east from the old workings.

The I.P. results show several anomalies: a narrow, strong zone extending in an easterly direction across the center of the grid; a broad variable zone of anomalous Metal Factors in the northeast section; and two weaker anomalies in the south part of the grid.

The main anomaly across the center of the grid becomes progressively weaker and broader from Line 13W to Line 3W, then becomes stronger again to the east. On Line 28E the anomaly is weaker and the pattern suggests either increasing depth or an off-the-end effect. The strongest effects were obtained on Lines 14E, 18E, and 23E, where the source appears to be shallow, narrow and steeply dipping. Line 18E was resurveyed using 100-foot spreads to provide more detailed information for a drill test. These results indicate that the source is centered at 13-14N and is less than one station wide and one station deep. A drill test is reportedly being carried out on this line.

The results on the east-west lines are suggestive of a broad area of low to moderate metallic mineral content, in contrast to the

narrow, more concentrated source to the south. Line A is anomalous throughout; the results suggest a broad shallow source with somewhat stronger sections at 0-2W, 6E, and 8-10E. Line B is similar except that the source appears to be deeper, with stronger sections at 2W, 10E, and 16E. The effects on Line C are somewhat weaker and the pattern now appears to be breaking up into several discrete sources at 0-2E, 6E, and 10E.

In addition to these two zones, a weak anomaly was noted at the south end of Line 6E correlating with an anomaly at 4N on Line 10E. Also an isolated anomaly was found at 2N on Line 28E. Further surveying would be required to assess the importance of these features.

5. SUMMARY AND RECOMMENDATIONS

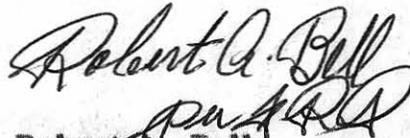
The geophysical survey has indicated two extensive anomalies. One of these trends east-west across the center of the grid and appears to represent a relatively narrow, concentrated, steeply dipping tabular body. The strongest effects were measured on Lines 14E, 18E, and 23E and a drill test is currently underway on Line 18E. The source may be exposed in the southern part of the old workings on Lines 2E and 6E and a detailed geologic investigation is suggested in this area. The anomaly extends west of the grid and may also continue east of the surveyed area, so that further surveying is required if the drill results are favourable.

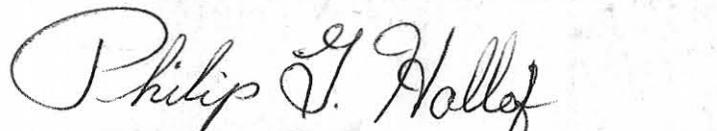
The second zone appears to represent a broad, variable source of lower metallic mineral content and presumably is an extension of the

mineralization encountered in the open cut. It would be desirable to extend the N-S lines farther north in order to select specific drilling locations on this zone, but since this is not practical at present the zone could be tested by a series of short vertical holes on the stronger sections of the anomaly as described above.

The T.D.M. report indicates the highest tin values do not occur in the highest sulphide concentrations. This suggests that if any encouragement is obtained from the initial drill test on the main zone that a hole should also be drilled on the weaker section near the west side of the grid.

McPHAR GEOPHYSICS LIMITED


Robert A. Bell,
Geologist.


Philip G. Hallof,
Geophysicist. *Per. S.H.*

Dated: July 9, 1962.

McPHAR GEOPHYSICS LIMITED

**SUPPLEMENTARY REPORT ON THE
INDUCED POLARIZATION SURVEY**

FOR

MOUNT COSTIGAN MINES LIMITED

MOUNT BISCHOFF, TASMANIA

1. INTRODUCTION

In May and June of 1962 an induced polarization-resistivity survey was carried out on the Company's tin property in the Mount Bischoff Area of Tasmania. The geophysical results were presented in a report dated July 9, 1962, entitled "Report on the Induced Polarization Survey for Mount Costigan Mines Limited, Mount Bischoff, Tasmania". Subsequently three additional traverses were run to assist in detailing an interesting anomaly. These results are embodied in the present report.

2. PRESENTATION OF RESULTS

The induced polarization and resistivity results are shown on the enclosed data plots in the manner described in the notes preceding this report.

<u>Line</u>	<u>Spread</u>	<u>Dwg. No.</u>
18E	400-foot	Dwg. I.P. 2897-15
20-1/2E	100-foot	Dwg. I.P. 2897-16
25E	100-foot	Dwg. I.P. 2897-17

Dwg. Misc. 3355, the plan map of the grid at a scale of 1" = 300', has been revised to show the additional traverses and is also enclosed with this report.

3. DISCUSSION OF RESULTS

Line 18E

This line was resurveyed using a 400-foot station interval. The I.P. results confirm the earlier work using smaller spreads and indicate a relatively shallow, strong source between stations 10N and 14N.

Line 20-1/2E

This is a new line, intermediate between original Lines 18E and 23E, and was surveyed with 100-foot spreads. There is a relatively shallow anomaly (less than 100 feet) at 13-14N with a possible weak extension to the north. This correlates with the shallow zone at 13-14N, Line 18E and at 16N, Line 23E.

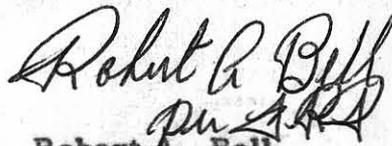
Line 25E

This traverse using 100-foot spreads is also a fill-in line, between original Lines 23E and 28E. It shows a deep anomaly (100 feet or more) at 15-18N with a possible weak extension to 19N. This correlates with the feature at 16N on Lines 23E and 28E. The source now appears to be wide, probably greater than 100 feet and possibly 200 feet, or else is composed of two or more closely spaced sources.

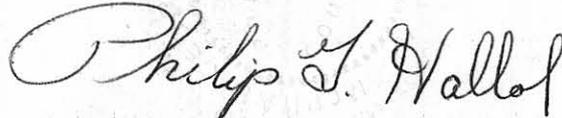
4. SUMMARY AND RECOMMENDATIONS

Three additional traverses have been run across the main anomaly, described in the earlier report, to provide additional control for the drill test. Further geophysical work is not warranted until the results of this drilling program are available.

McPHAR GEOPHYSICS LIMITED



Robert A. Bell,
Geologist.



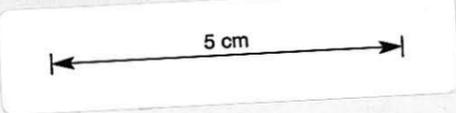
Philip G. Hallof,
Geophysicist.

Per. J. W.

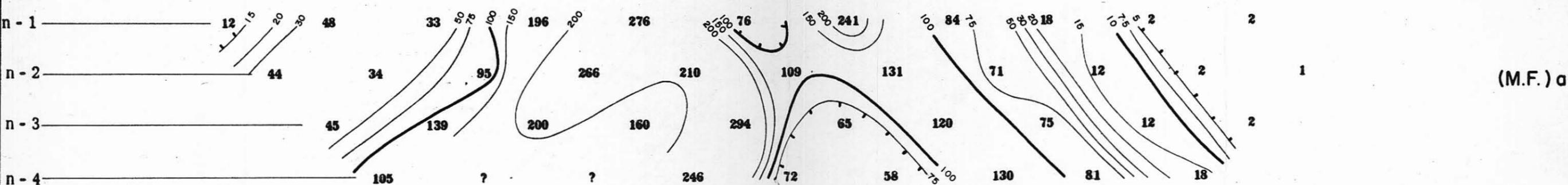
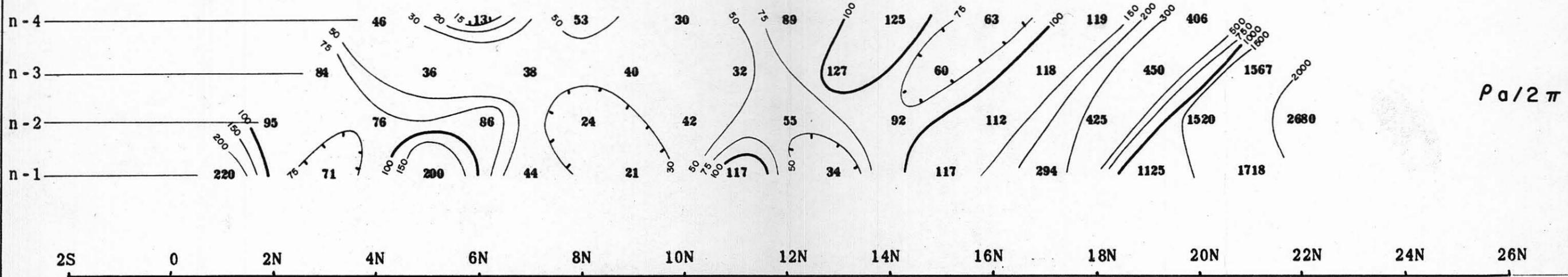
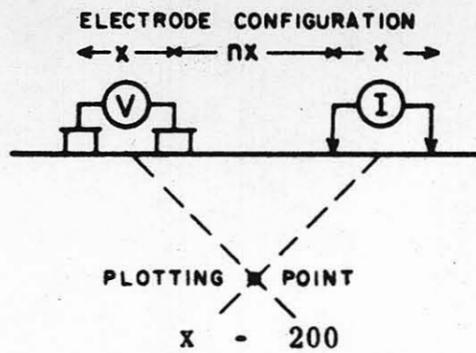
Dated: September 5, 1962.

McPHAR GEOPHYSICS LIMITED

INDUCED POLARIZATION AND RESISTIVITY SURVEY



292043



LINE NO.13 W

042

MOUNT COSTIGAN MINES LIMITED

MT. BISCHOFF AREA-TASMANIA.

Scale - One inch = 200 Feet

ANOMALOUS ZONE

POSSIBLE ANOMALOUS ZONE

NOTE
LOGARITHMIC CONTOUR INTERVAL

FREQUENCY 31-25CPS

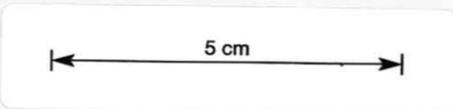
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APPROVED *R.B.B.*

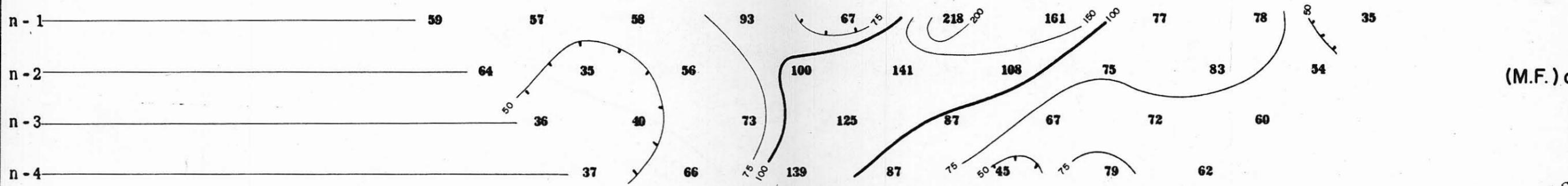
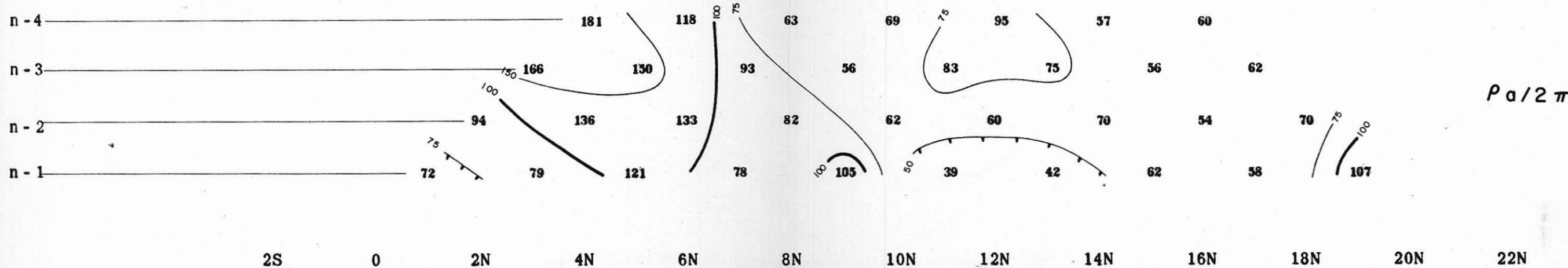
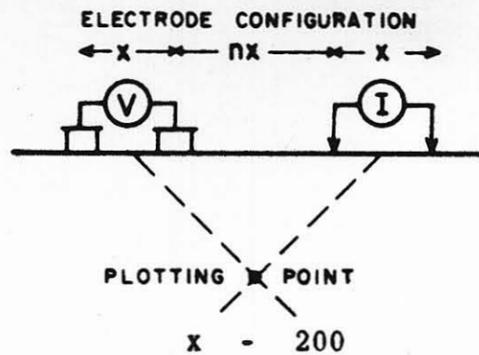
DATE *Jul 10/62*

McPHAR GEOPHYSICS LIMITED

INDUCED POLARIZATION AND RESISTIVITY SURVEY



292044



LINE NO. 8 W

043

MOUNT COSTIGAN MINES LIMITED

MT. BISCHOFF AREA—TASMANIA.

Scale—One inch= 200 Feet

ANOMALOUS ZONE

POSSIBLE ANOMALOUS ZONE

NOTE
LOGARITHMIC CONTOUR INTERVAL

FREQUENCY 31—25CPS

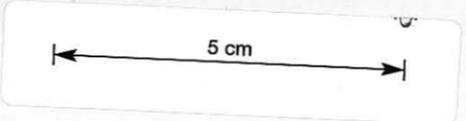
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APPROVED *RAB.*

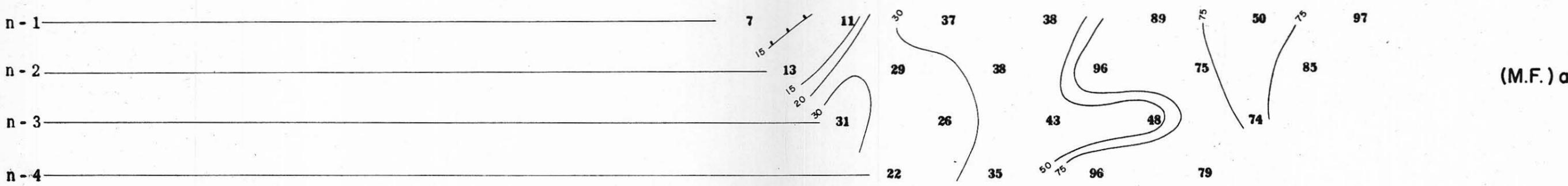
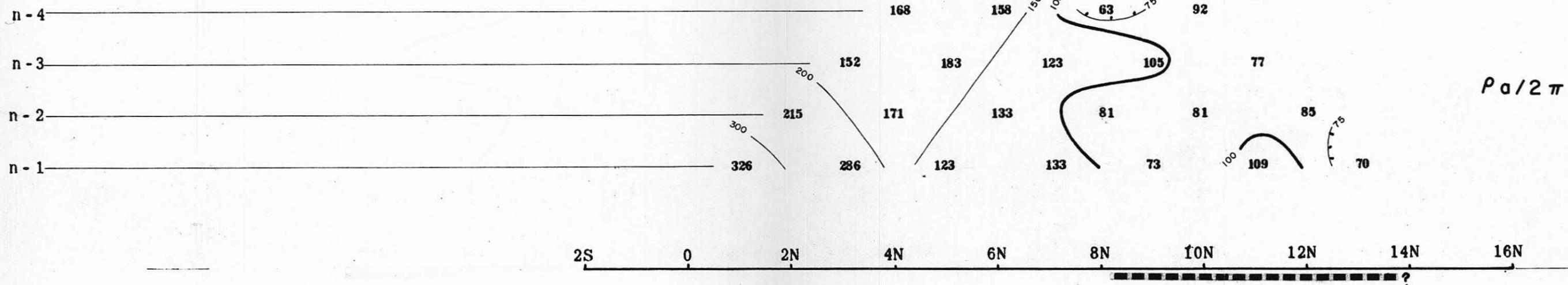
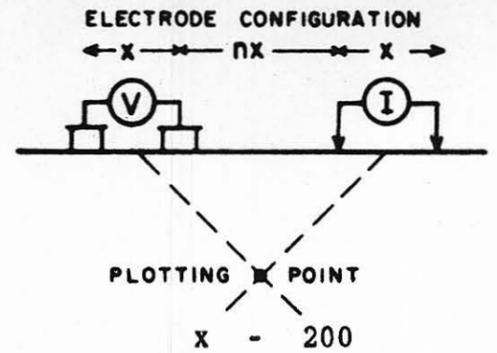
DATE *July 10/62.*

McPHAR GEOPHYSICS LIMITED

INDUCED POLARIZATION AND RESISTIVITY SURVEY



292045



LINE NO. 3 W

044

MOUNT COSTIGAN MINES LIMITED

MT. BISCHOFF AREA—TASMANIA.

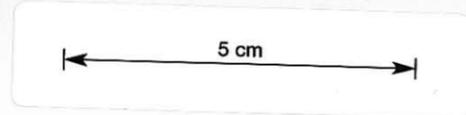
Scale—One inch= 200 Feet

ANOMALOUS ZONE
 POSSIBLE ANOMALOUS ZONE
 NOTE LOGARITHMIC CONTOUR INTERVAL

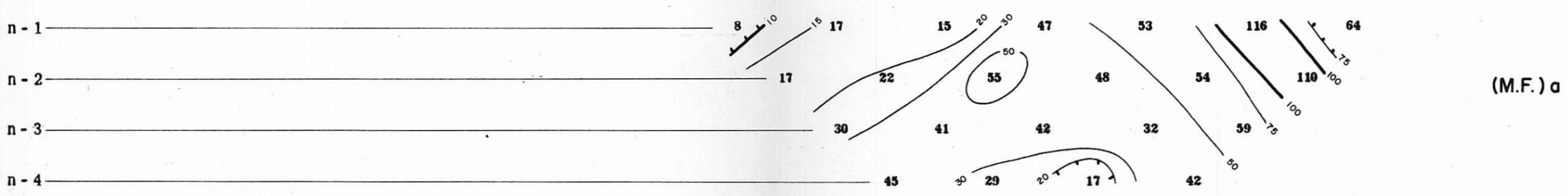
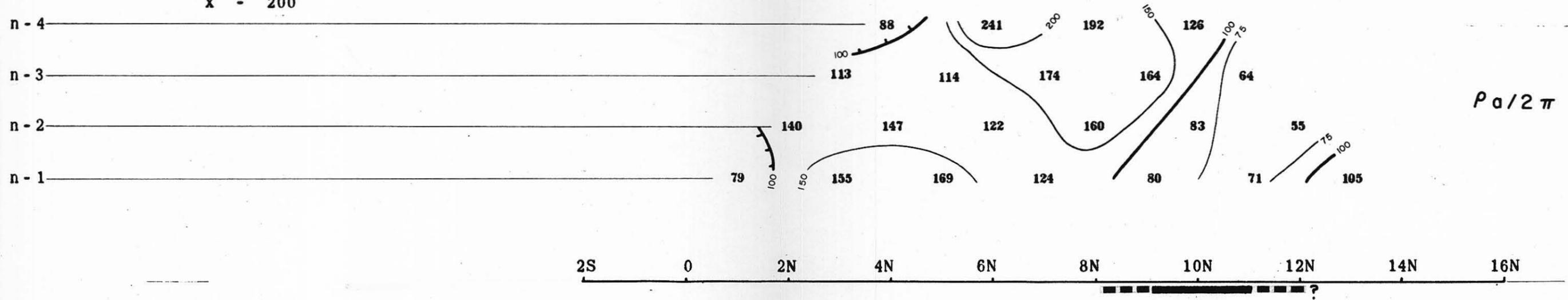
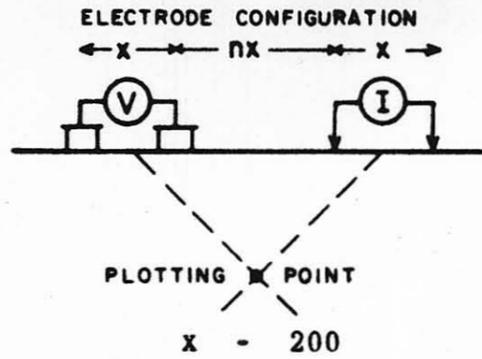
FREQUENCY 31-2.5CPS
 DATE SURVEYED MAY 1962
 APPROVED
 DATE

McPHAR GEOPHYSICS LIMITED

INDUCED POLARIZATION AND RESISTIVITY SURVEY



292046



LINE NO. 2E

045

MOUNT COSTIGAN MINES LIMITED

MT. BISCHOFF AREA-TASMANIA.

Scale - One inch = 200 Feet

ANOMALOUS ZONE
 POSSIBLE ANOMALOUS ZONE
 NOTE
 LOGARITHMIC CONTOUR INTERVAL

FREQUENCY 31-2.5CPS

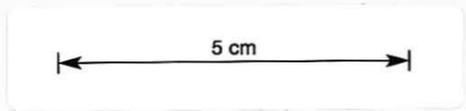
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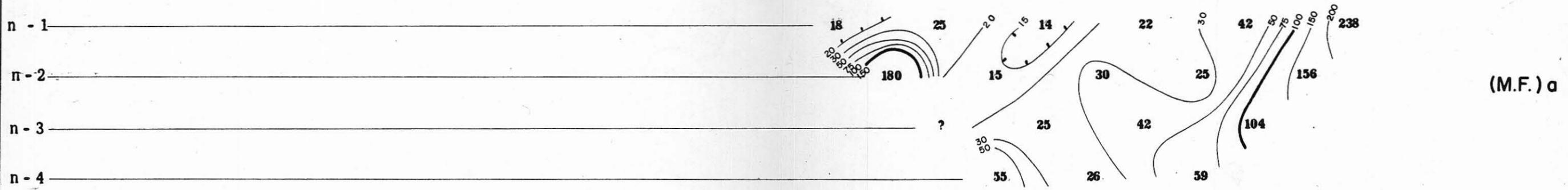
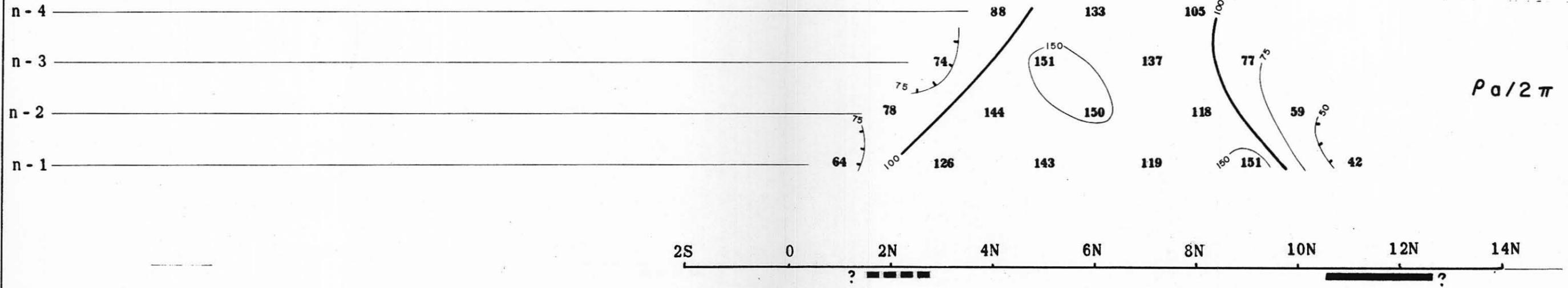
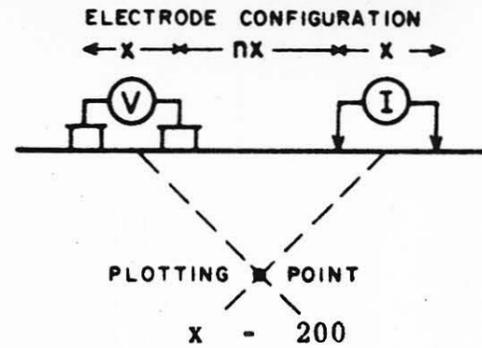
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McPHAR GEOPHYSICS LIMITED

INDUCED POLARIZATION AND RESISTIVITY SURVEY



292047



LINE NO. 6E

046

MOUNT COSTIGAN MINES LIMITED

MT. BISCHOFF AREA-TASMANIA.

Scale - One inch = 200 Feet

ANOMALOUS ZONE

POSSIBLE ANOMALOUS ZONE

NOTE
LOGARITHMIC CONTOUR INTERVAL

FREQUENCY 31-25CPS

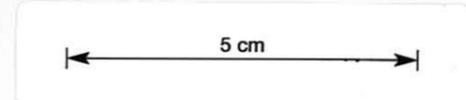
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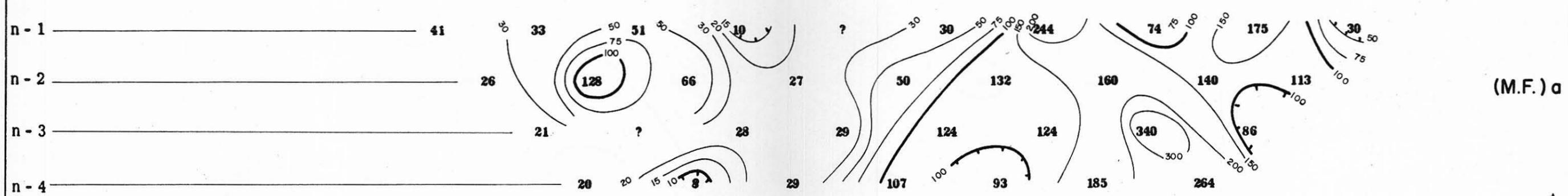
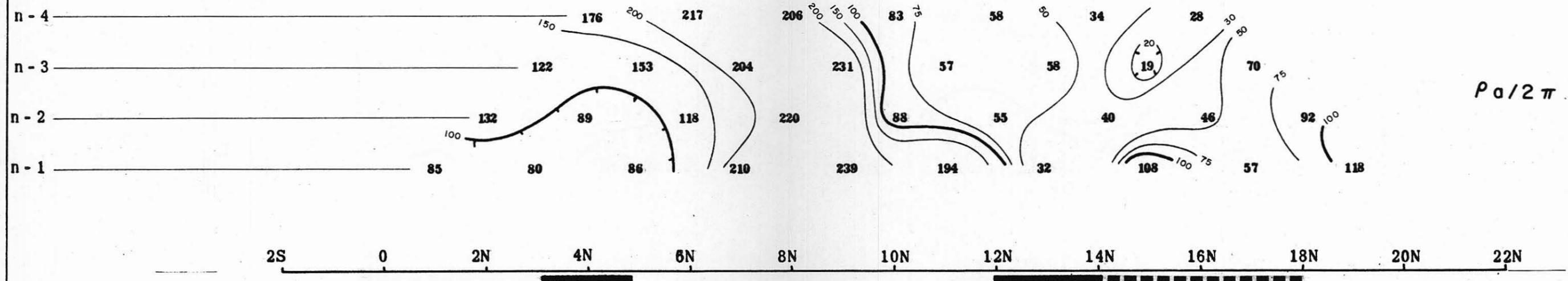
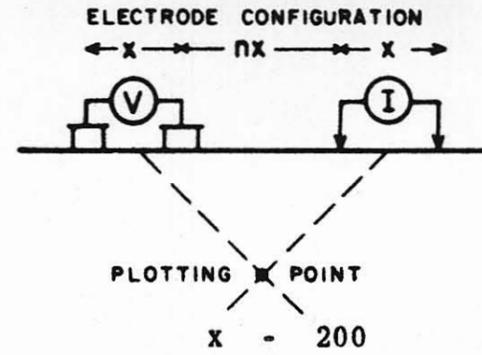
DATE *Jul 10/62.*

McPHAR GEOPHYSICS LIMITED

INDUCED POLARIZATION AND RESISTIVITY SURVEY



292048



LINE NO. 10E

047

MOUNT COSTIGAN MINES LIMITED

MT. BISCHOFF AREA-TASMANIA.

Scale - One inch = 200 Feet

ANOMALOUS ZONE

POSSIBLE ANOMALOUS ZONE

NOTE
LOGARITHMIC CONTOUR INTERVAL

FREQUENCY - 31 - 2.5CPS

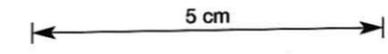
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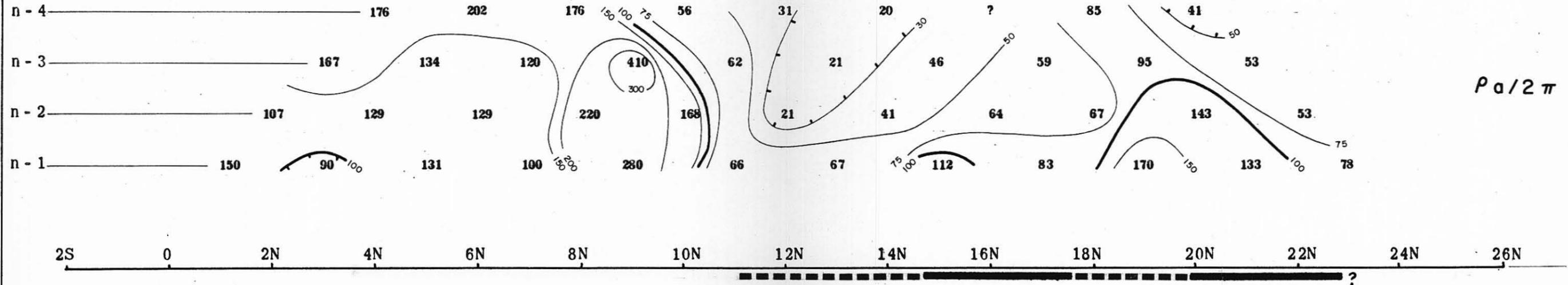
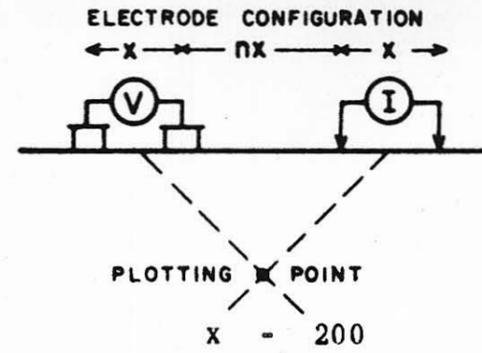
DATE *Jul 10/62*

McPHAR GEOPHYSICS LIMITED

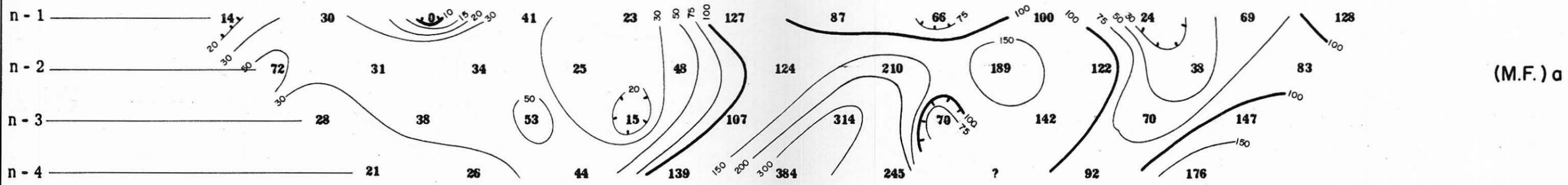
INDUCED POLARIZATION AND RESISTIVITY SURVEY



292049



$P a / 2 \pi$



(M.F.) a

048

MOUNT COSTIGAN MINES LIMITED

MT. BISCHOFF AREA-TASMANIA.

Scale - One inch = 200 Feet

ANOMALOUS ZONE

POSSIBLE ANOMALOUS ZONE

NOTE
LOGARITHMIC CONTOUR INTERVAL

FREQUENCY 31-2.5CPS

DATE SURVEYED MAY 1962

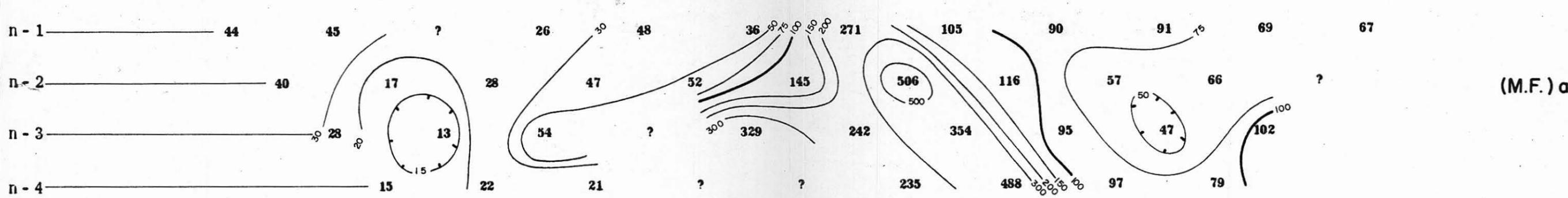
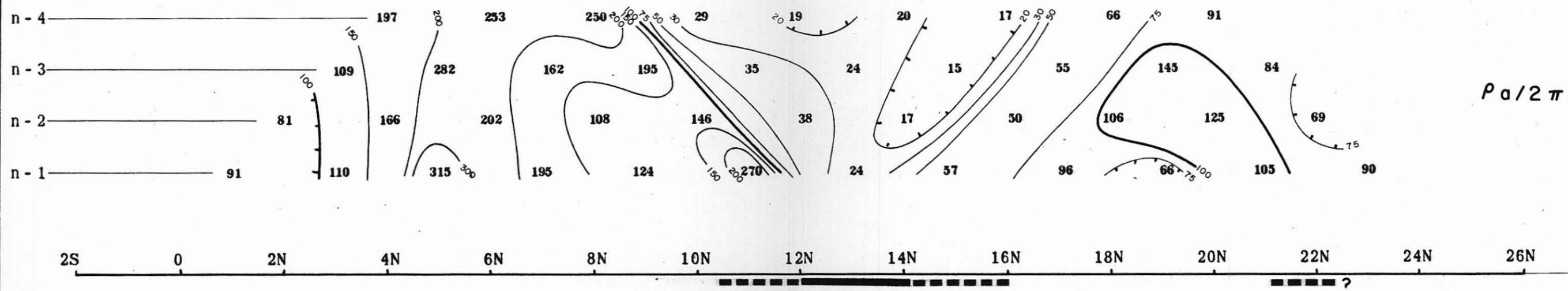
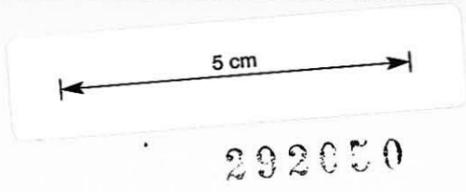
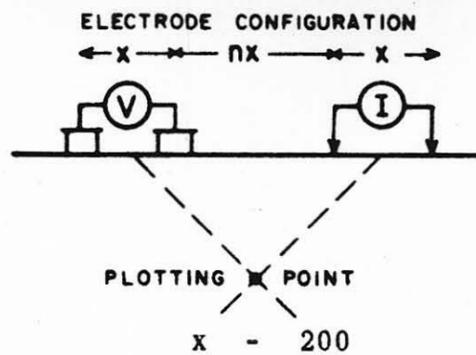
APPROVED *R.A.B.*

DATE *Jul 10/62*

LINE NO. 14 E

McPHAR GEOPHYSICS LIMITED

INDUCED POLARIZATION AND RESISTIVITY SURVEY



LINE NO. 18 E

MOUNT COSTIGAN MINES LIMITED

MT. BISCHOFF AREA—TASMANIA.

Scale—One inch = 200 Feet

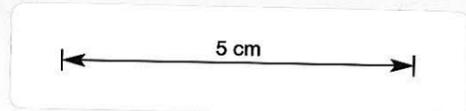
ANOMALOUS ZONE
 POSSIBLE ANOMALOUS ZONE
 NOTE
 LOGARITHMIC CONTOUR INTERVAL

FREQUENCY 31—2.5CPS
 DATE SURVEYED MAY 1962
 APPROVED *KAB.*
 DATE *Jul 10/62*

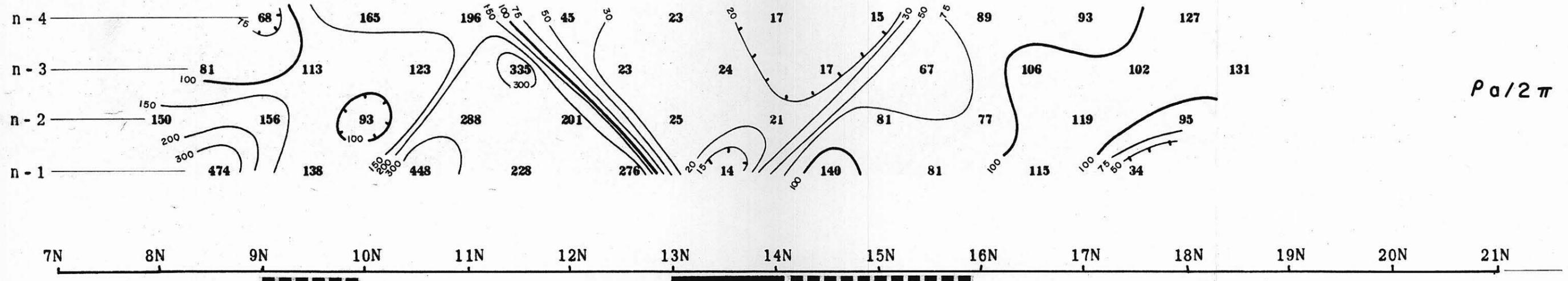
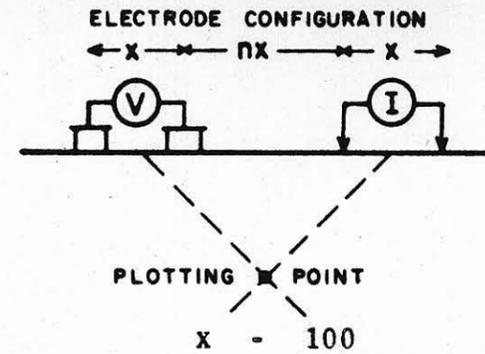
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McPHAR GEOPHYSICS LIMITED

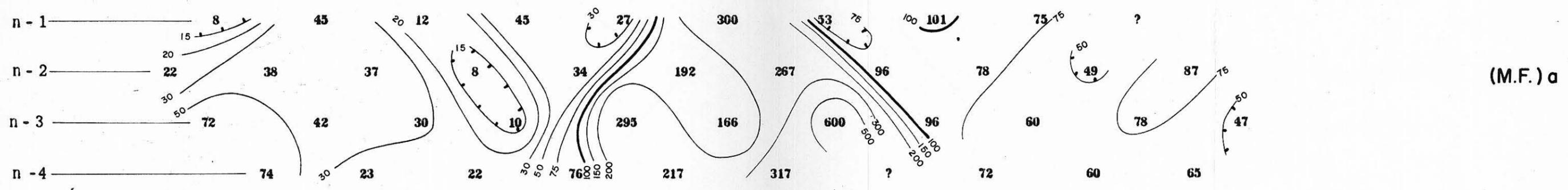
INDUCED POLARIZATION AND RESISTIVITY SURVEY



292051



$P a / 2 \pi$



(M.F.) a

LINE NO. 18E

050

MOUNT COSTIGAN MINES LIMITED

MT. BISCHOFF AREA-TASMANIA.

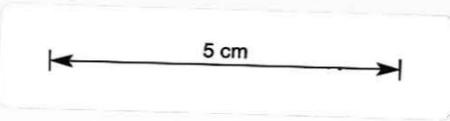
Scale - One inch = 100 Feet

ANOMALOUS ZONE
 POSSIBLE ANOMALOUS ZONE
 NOTE LOGARITHMIC CONTOUR INTERVAL

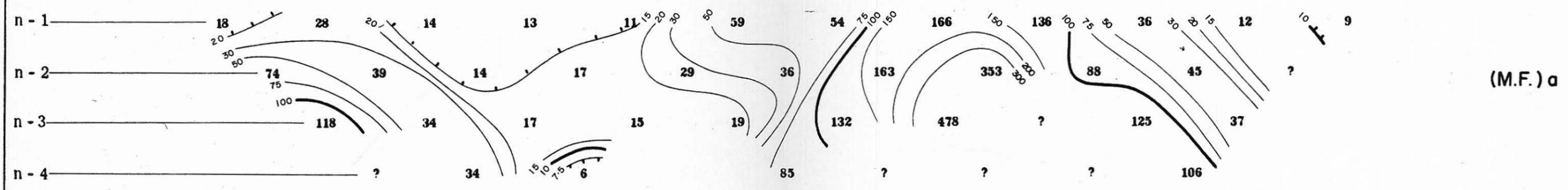
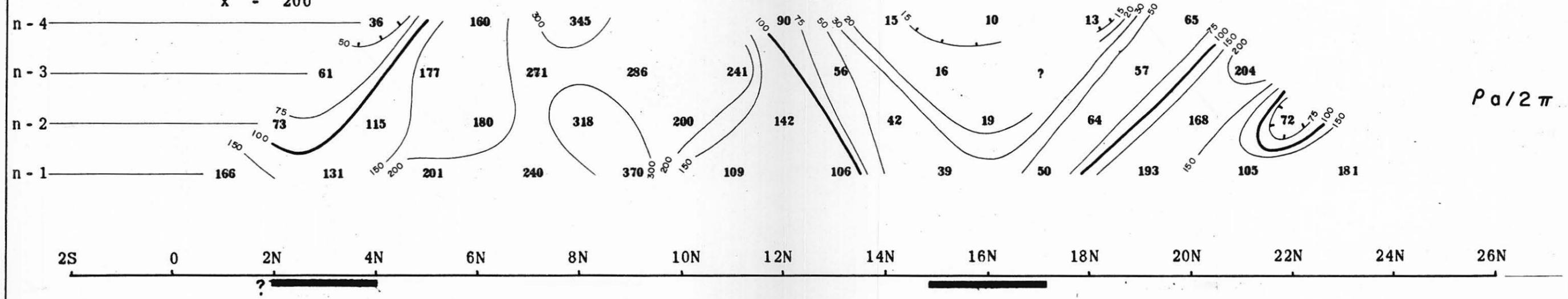
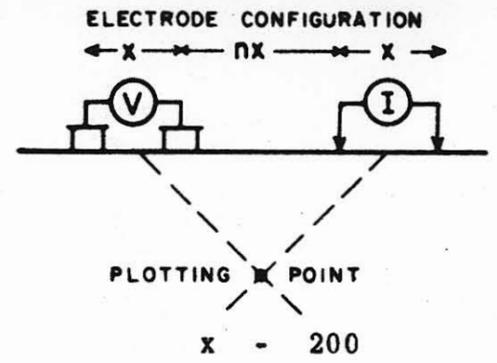
FREQUENCY 31-25CPS
 DATE SURVEYED MAY 1962
 APPROVED RAB
 DATE Jul 10/62

McPHAR GEOPHYSICS LIMITED

INDUCED POLARIZATION AND RESISTIVITY SURVEY



292052



LINE NO. 23E

051

MOUNT COSTIGAN MINES LIMITED

MT. BISCHOFF AREA—TASMANIA.

Scale—One inch = 200 Feet

ANOMALOUS ZONE

POSSIBLE ANOMALOUS ZONE

NOTE
LOGARITHMIC CONTOUR INTERVAL

FREQUENCY—31—2.5CPS

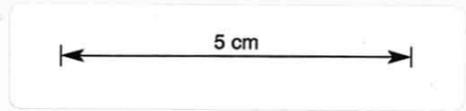
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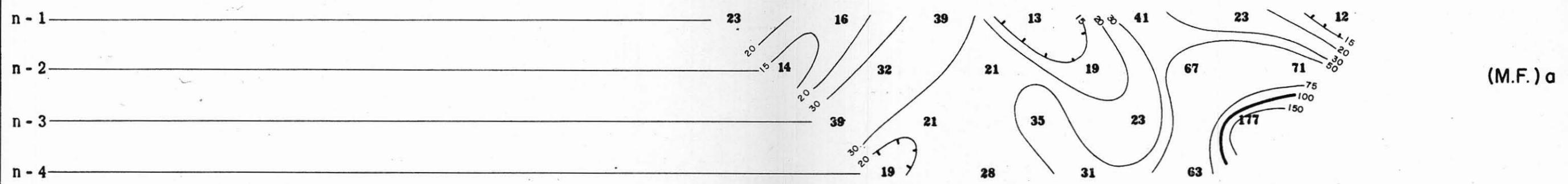
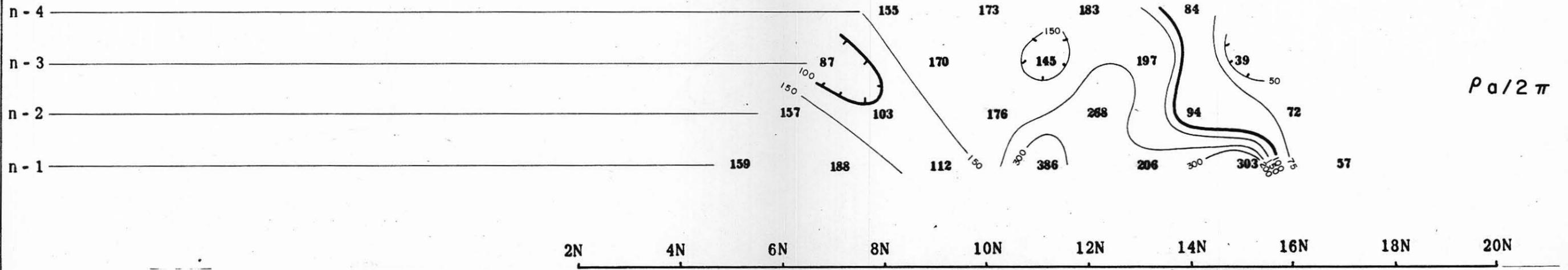
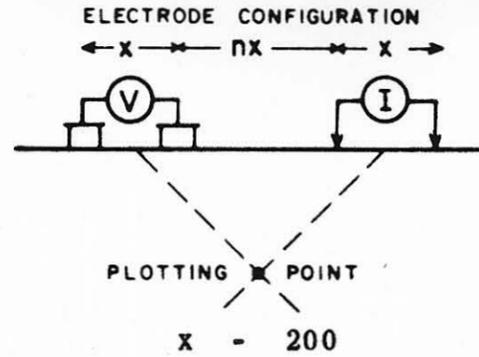
DATE *Jul 10/62*

McPHAR GEOPHYSICS LIMITED

INDUCED POLARIZATION AND RESISTIVITY SURVEY



292053



052

MOUNT COSTIGAN MINES LIMITED

MT. BISCHOFF AREA-TASMANIA.

Scale - One inch = 200 Feet

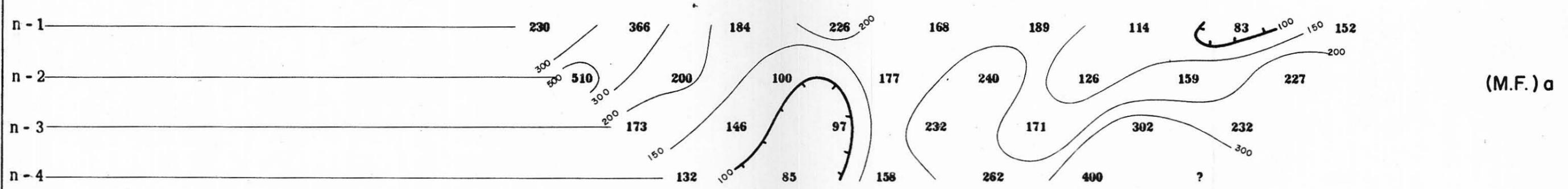
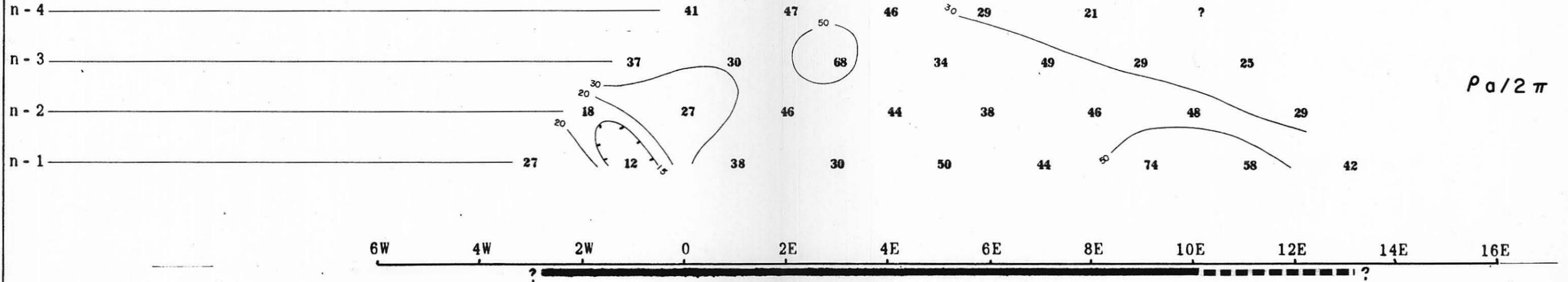
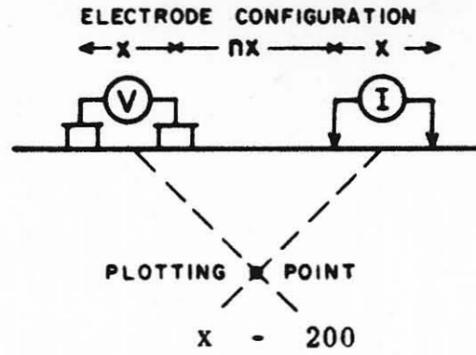
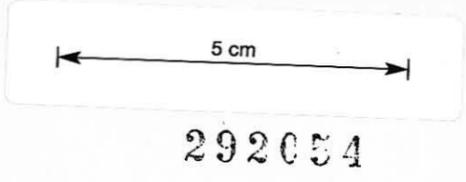
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 POSSIBLE ANOMALOUS ZONE **- - - -**
 NOTE
 LOGARITHMIC CONTOUR INTERVAL

FREQUENCY - 31 - 2.5CPS
 DATE SURVEYED MAY 1962
 APPROVED RAB.
 DATE Jul 10/62

LINE NO. 28 E

McPHAR GEOPHYSICS LIMITED

INDUCED POLARIZATION AND RESISTIVITY SURVEY



LINE NO. "A"

053

MOUNT COSTIGAN MINES LIMITED

MT. BISCHOFF AREA—TASMANIA.

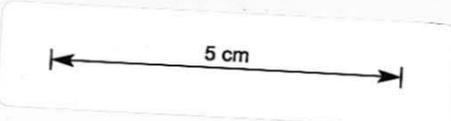
Scale—One inch= 200 Feet

ANOMALOUS ZONE
 POSSIBLE ANOMALOUS ZONE
 NOTE LOGARITHMIC CONTOUR INTERVAL

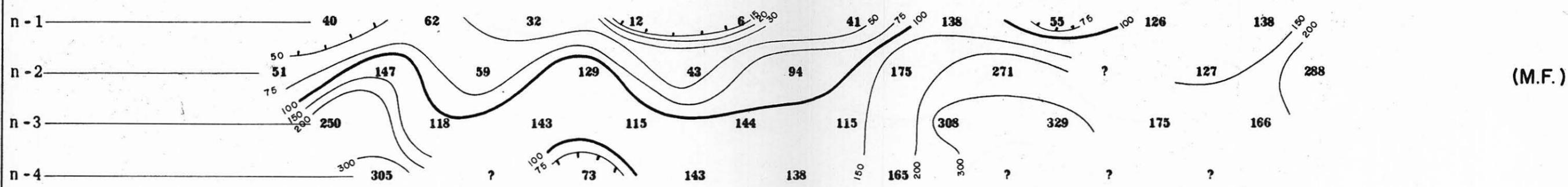
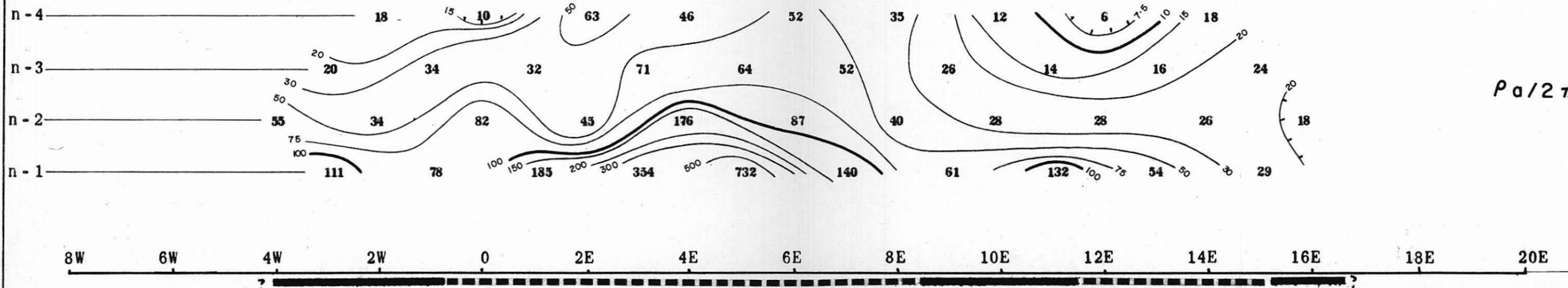
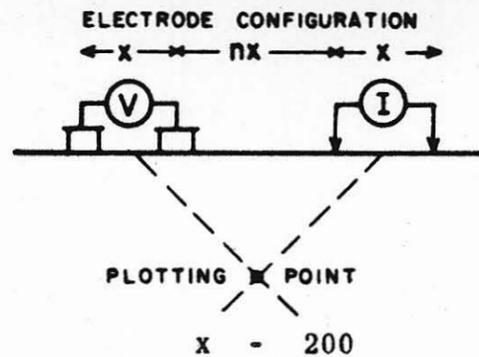
FREQUENCY 31-25CPS
 DATE SURVEYED MAY 1962
 APPROVED *RAB*
 DATE *Jul 10/62*

McPHAR GEOPHYSICS LIMITED

INDUCED POLARIZATION AND RESISTIVITY SURVEY



292055



LINE NO. "B"

054

MOUNT COSTIGAN MINES LIMITED

MT. BISCHOFF AREA—TASMANIA.

Scale—One inch= 200 Feet

ANOMALOUS ZONE

POSSIBLE ANOMALOUS ZONE

NOTE
 LOGARITHMIC CONTOUR INTERVAL

FREQUENCY - 31 - 2.5CPS

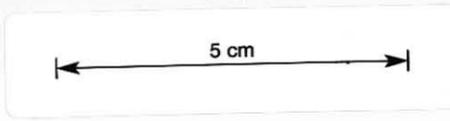
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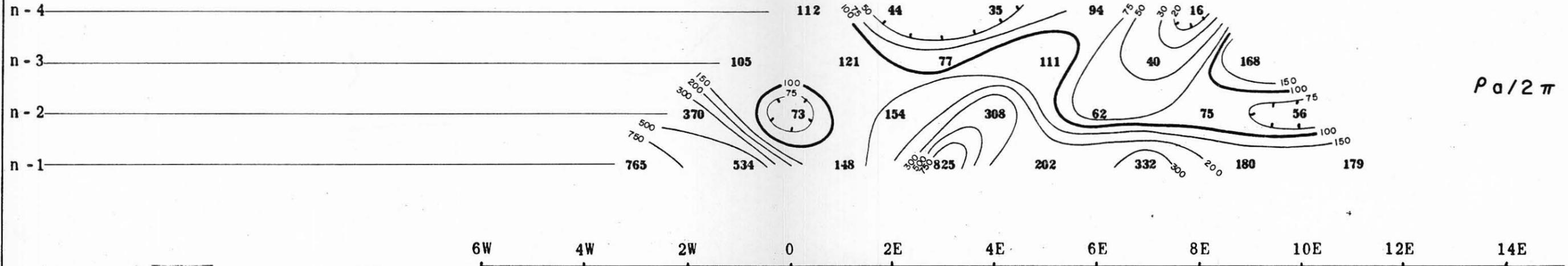
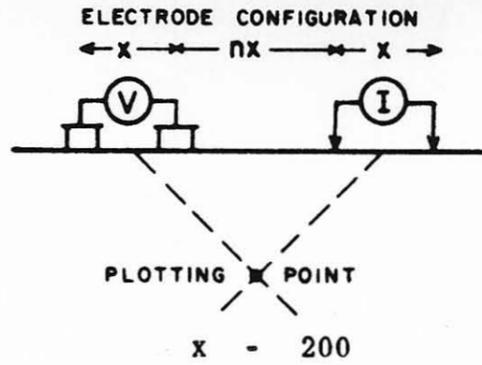
DATE *Jul 10/62*

McPHAR GEOPHYSICS LIMITED

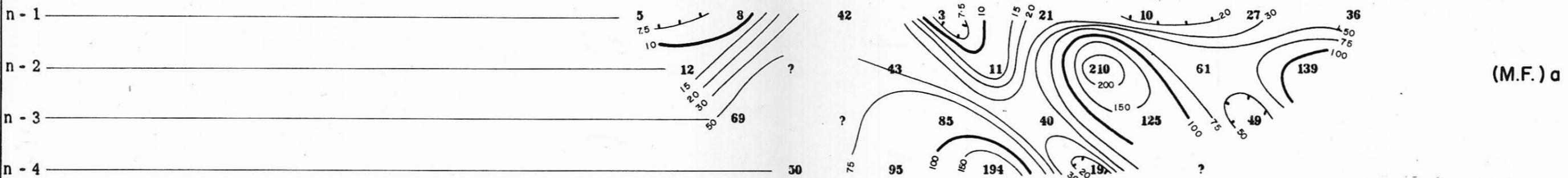
INDUCED POLARIZATION AND RESISTIVITY SURVEY



292056



$P a / 2 \pi$



(M.F.) a

055

MOUNT COSTIGAN MINES LIMITED

MT. BISCHOFF AREA-TASMANIA.

Scale - One inch = 200 Feet

ANOMALOUS ZONE
 POSSIBLE ANOMALOUS ZONE
 NOTE
 LOGARITHMIC CONTOUR INTERVAL

FREQUENCY 31-25CPS

DATE SURVEYED MAY 1962

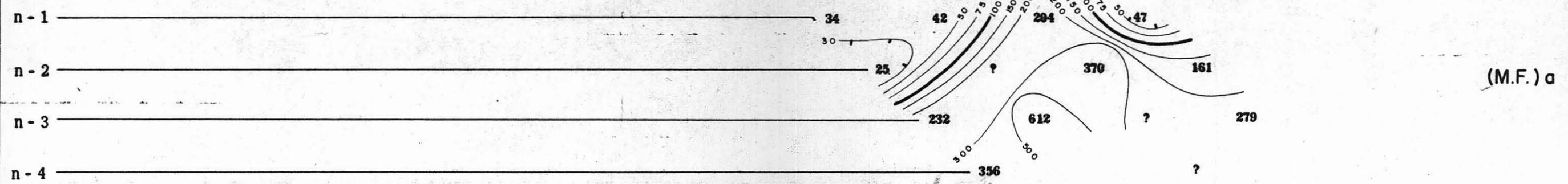
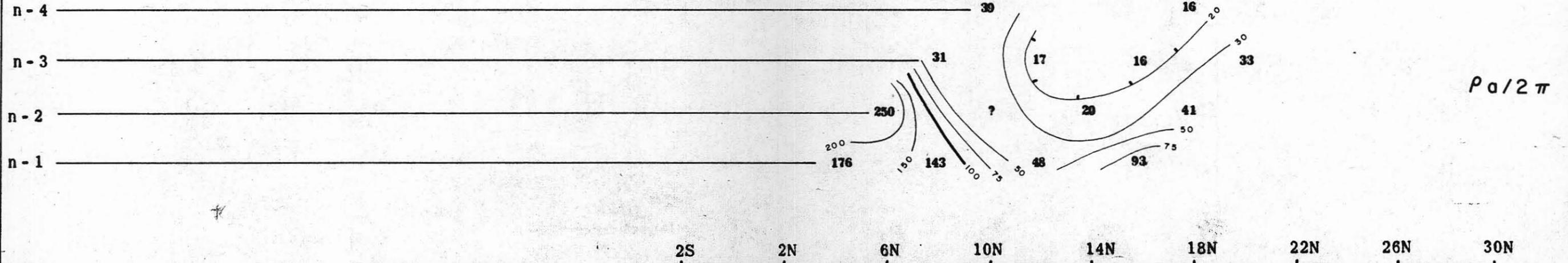
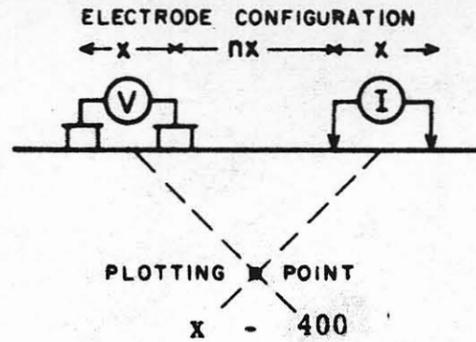
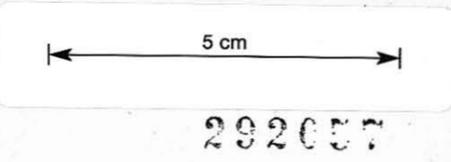
APPROVED

DATE

LINE NO. "C"

McPHAR GEOPHYSICS LIMITED

INDUCED POLARIZATION AND RESISTIVITY SURVEY



LINE NO.-18E

056

MOUNT COSTIGAN MINES LIMITED

MT. BISCHOFF AREA—TASMANIA.

Scale—One inch = 400 Feet

ANOMALOUS ZONE
POSSIBLE ANOMALOUS ZONE
NOTE
LOGARITHMIC CONTOUR INTERVAL

FREQUENCY-31-25CPS

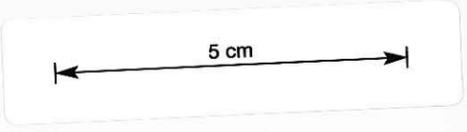
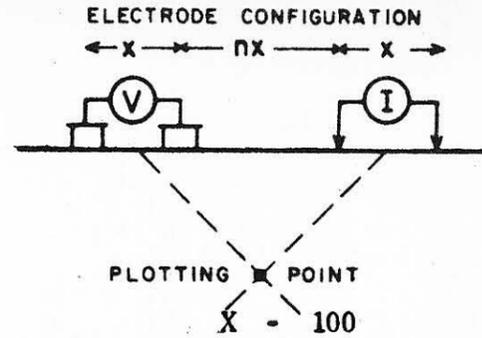
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APPROVED *LAB.*

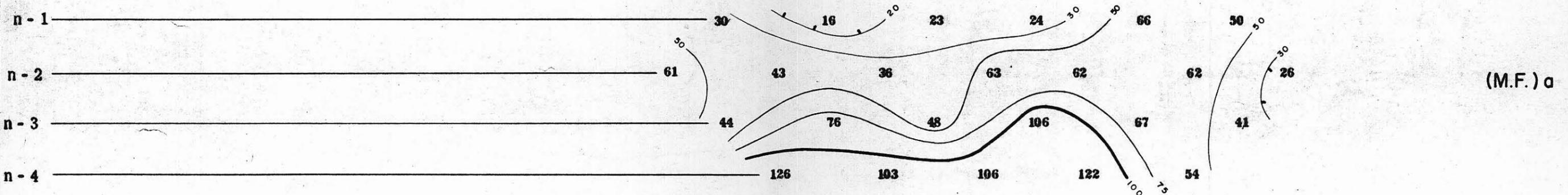
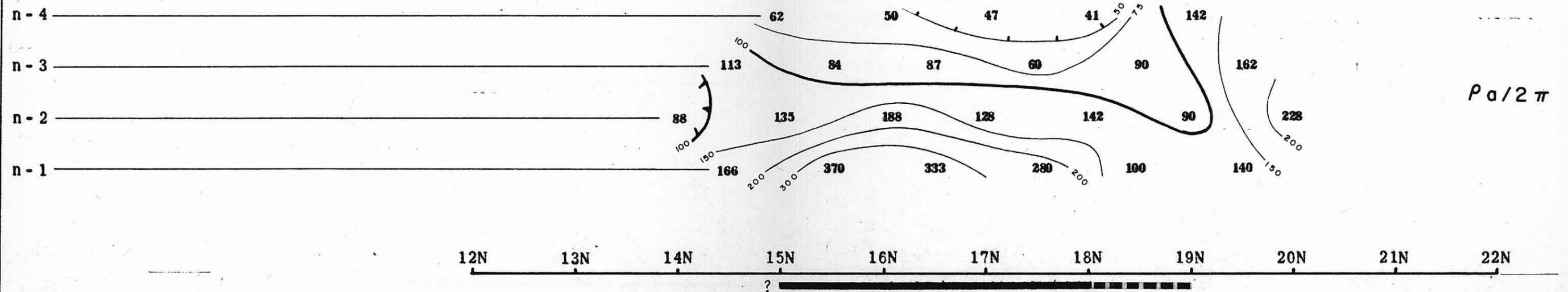
DATE *Sep. 7/62.*

McPHAR GEOPHYSICS LIMITED

INDUCED POLARIZATION AND RESISTIVITY SURVEY



292059



058

MOUNT COSTIGAN MINES LIMITED

MT. BISCHOFF AREA—TASMANIA.

Scale—One inch = 100 Feet

ANOMALOUS ZONE **—————**
 POSSIBLE ANOMALOUS ZONE **- - - - -**
 NOTE
 LOGARITHMIC CONTOUR INTERVAL

FREQUENCY 31-25CPS
 DATE SURVEYED AUG. 1962
 APPROVED Alb.
 DATE Sep. 7/62

LINE NO. 25E

DIAMOND DRILLING

A diamond drill programme was commenced in December 1962. The purpose of this programme was to test the Griesen-Pig Flat area as a potential tin ore body, and to test the east-west I.P. anomaly as a possible faulted extension of the Griesen-Pig Flat zones.

The Griesen-Pig Flat drilling, now finished, consisted of seven drill holes for a total of 1418 feet. The drilling of the I.P. anomaly is still in progress.

A geologic plan showing the sulphide-cassiterite zones and the location of diamond drill holes #1 to 7, together with diamond drill section "B", "E" and "J + 25 lt.E" are included. Photostats of core and sludge analyses by the Tasmanian Department of Mines are also enclosed.

Summary of Drilling Results*

D.D.H. No.	Width of Intersection (ft)	Av. Grade Sn	G x I
1	57	0.99	56.43
2	60	0.74	44.40
3	55	0.40	22.00
4	40	0.59	23.60
5	55	0.30	16.50
6	170	0.45	76.50
** 7 (1)	75	0.35	26.25
7 (2)	75	0.64	48.00
	Σ 512		Σ 265.68 (1)
			Σ 287.43 (2)

$$\text{Average Width of Intersection} = \frac{\Sigma I}{\text{No.}} = \frac{512}{7} = 73 \text{ ft.}$$

$$\text{Average Grade} = \frac{\Sigma G \times I}{\Sigma I}$$

$$(1) = \frac{265.68}{512} = 0.52\% \text{ Sn}$$

$$(2) = \frac{287.43}{512} = 0.56\% \text{ Sn}$$

* The tin bearing zones shown here were chosen by assay boundaries. Higher grade ore can be obtained at the expense of widths.

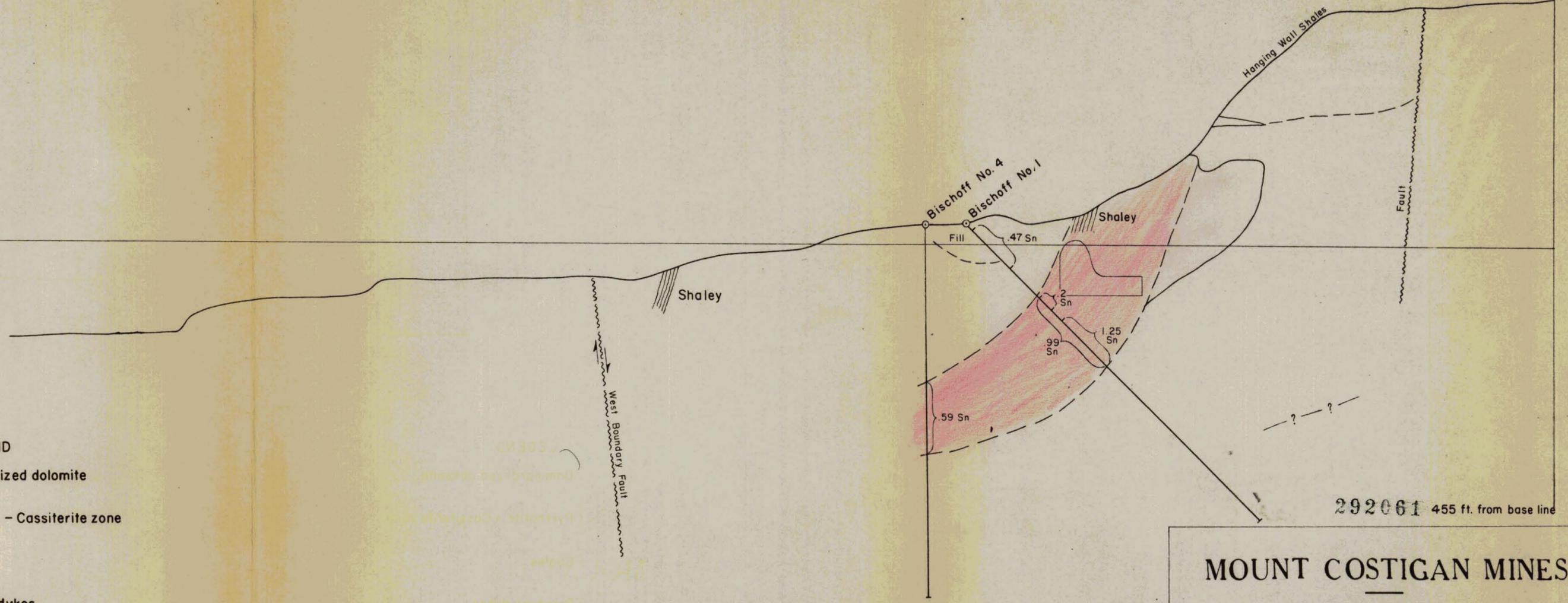
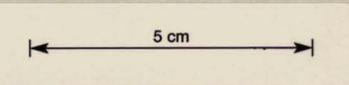
** Core recovery from D.D.H. 7 was poor. (1) is the average using core only; (2) is the average grade using core and sludge analyses.

S

N

255 R.L.

- LEGEND**
-  Unmineralized dolomite
 -  Pyrrhotite - Cassiterite zone
 -  Shales
 -  Porphyry dykes



MOUNT COSTIGAN MINES
MOUNT BISCHOFF OPTION
 — DIAMOND DRILL SECTION B —
 D.D.H. No's. 1,4
 April 1963 Scale: 1 inch to 50 feet

060

S

N

255 R.L.

Shales

LEGEND

-  Unmineralized dolomite
-  Pyrrhotite - Cassiterite zone
-  Shales
-  Porphyry dykes

5 cm

Bischoff No. 5

Bischoff No. 3

Bischoff No. 2

Fault

Fault

.3 Sn

.38 Sn

.74 Sn

.19 Sn

.29 Sn

.80 Sn

.74 Sn

455 ft. from base line

292062

MOUNT COSTIGAN MINES

MOUNT BISCHOFF OPTION

061

— DIAMOND DRILL SECTION E —

D. D. H. No's. 2, 3, 5

April 1963

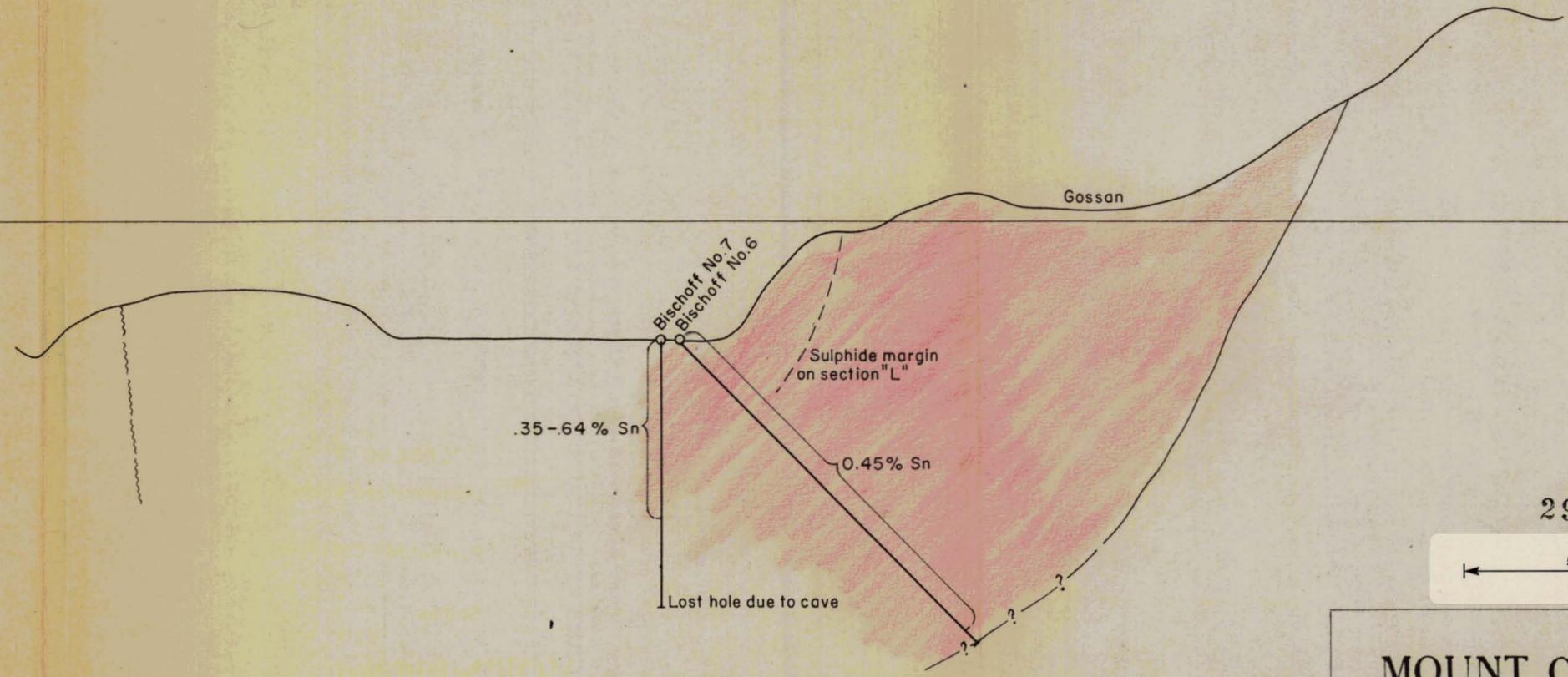
Scale: 1 inch to 50 feet

S

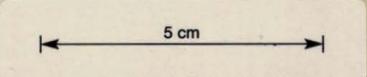
N

255 R.L.

- LEGEND**
-  Unmineralized dolomite
 -  Pyrrhotite - Cassiterite zone
 -  Shales
 -  Porphyry dykes



292063



455 feet from base line

MOUNT COSTIGAN MINES
MOUNT BISCHOFF OPTION
DIAMOND DRILL SECTION J+25'E
 D.D.H. No's. 6,7
 April 1963 Scale: 1 inch to 50 feet

063

ORE POTENTIAL

T.R. CLARKE & ASSOCIATES
CONSULTING ENGINEERS
TORONTO, ONTARIO

May 3, 1963

Dr. W.L. Young
President
Mount Costigan Mines Limited
30 The Driveway
Ottawa, Ontario

Dear Sir:

I have examined the data supplied on the Mount Bischoff option which consisted of three cross sections of the deposit showing D.D. Hole 1 to 7 inclusive and surface topography and contour plans.

It is my opinion that

- (1) The deposit can be mined by open pit method to a depth of 125 feet above datum or 125 R.L.
- (2) To this depth there should be an ore potential of 2,100,000 tons grading 0.46% Sn.
- (3) At a mining rate of 500,000 tons a year your pit operating costs should approximate \$1.36 a short ton.
- (4) The capital cost to equip the pit for this operation would be \$950,000.00. If a contractor is to be used instead of a Company operation add \$0.65 to the operating cost or \$2.01 a ton.

The above figures are based on Canadian practice. Ideal weather and ground water conditions and size of the primary crusher could materially reduce the operating costs per ton.

Respectfully submitted,

T.R. Clarke, B.Eng., P.Eng.

Mineral dressing research on the Mount Bischoff ores is now in progress to: (a) produce a smelter acceptable concentrate, and (b) to produce a 1.5 - 2.0% Sn concentrate which is considered as a satisfactory feed for the chlorination process now under development by Geo-Met Reactors Limited (please see next chapter).

Two groups, the Mineral Dressing Laboratory of the Tasmanian Department of Mines, and Geo-Met Reactors Limited are engaged in this research. Final reports have not yet been received.

At the Renison Bell and Mount Cleveland, where the ore is similar to the Bischoff, 65% recoveries to a 50% + tin concentrate, acceptable to the Sydney smelter, are obtained without difficulty using normal gravity milling practices.

Geo-Met Report No. 14 is attached.

METALLURGICAL RESEARCH

Preliminary metallurgical research has been done by Geo-Met Reactors Limited of Ottawa.

This company has conducted a series of experiments in an attempt to recover the tin by means of a chlorination process utilizing run-of-mine to low-grade tin concentrates, thus eliminating the heavy losses of tin inherent in obtaining a high grade smelter concentrate.

These requirements have shown that better than 90% of the tin can be recovered as tin Chloride (low in iron); that under certain conditions the iron in the pyrrhotite can be recovered as elemental powdered iron; and that much of the sulphur can be recovered as elemental sulphur. There is sufficient sulphur present in the ore to make the reaction exothermic.

Geo-Met Reports No. 6 and 17 are attached.

27 February 1963.

GEO-MET RESEARCH PROGRESS REPORT #6THE RECOVERY OF TIN FROM MT. BISCHOFF ORE1. INTRODUCTION

Conventional methods of extracting tin by means of concentration and smelting of a high grade concentrate is not a very suitable proposition for the Mt. Bischoff ore, because of low recoveries and the high iron content. Selective chloridising of tin in the run of mine ore, if possible, could be advantageously adopted. It would be advantageous to carry out the chloridisation at low temperatures and relatively rapid rates of reaction in order to limit corrosion problems and fuel requirements.

2. NATURE OF THE ORE

The Mt. Bischoff tin ore is characterised by a high percentage of sulphur. A typical analysis of the ore is as follows:

<u>Constituents</u>	<u>% Composition</u>
Total tin	1.34
Iron	36.26
Sulphur	21.84
Al ₂ O ₃	Medium High
SiO ₂	Medium High
MgO	Medium High

(Medium High: 5 to 50% approximately by semi-quantitative spectrographic analysis).

3. THEORETICAL CONSIDERATIONS

Whether a proposed chemical process is feasible or not in actual practice, depends on two major properties of the chemical reaction involved. These are the free energy change and the rate of reaction. Consideration of free energy values makes possible certain predictions of the direction and extent of a given reaction, as well as the effect of temperature, pressure and composition upon the result. If the free energy change ΔF of the reaction is negative, then the reaction is favourable. Whereas reactions having a positive value of free energy change, render the reaction unlikely to occur.

Reaction rate cannot be predicted from the free energy data and has to be obtained by actual experiment. However, at the elevated temperatures generally used in metallurgical technology, the rates of chemical reactions are usually sufficiently high; and hence the diffusion of the reactants and products to and from the zone of reaction determines the actual rate.

Thus, if the free energy change is favourable (i.e. ΔF is positive) the chances are good that a metallurgical reaction at elevated temperature will proceed at a reasonable rate, if adequate provision for rapid diffusion has been made.

In the literature it is the usual practice to give the values of standard free energy change, ΔF° , instead of the free energy change, ΔF . For the reaction $bB + cC \rightarrow dD + eE$ these two are related by the reaction

$$\Delta F + \Delta F^\circ + RT \ln \frac{A_D^d A_E^e}{A_B^b A_C^c}$$

where A_i = activity of constituent (i)
 T = absolute temperature, $^\circ K$
 R = gas constant

However, under ordinary practice of high temperature and moderate pressure the second term on the right hand side of the above equation is very small compared to the other two terms. And the value of ΔF° is very nearly equal to ΔF .

4. CHOICE FOR THE APPROPRIATE CHLORIDISING AGENT FOR MT. BISCHOFF ORE

The most important factor in the chloridising process is the selective chloridisation of the valuable mineral. Thus in the present case, the prime consideration is the chloridisation of the tin mineral and avoidance of chloridisation of other unwanted minerals. Not all chloridising agents will be suitable for this specific purpose; hence a judicious choice of the chloridising agents is warranted.

The standard free energy change values for chlorination of the possible constituents of Mt. Bischoff ore with chlorine gas are given in Table I. Alumina and silica are very stable compounds and would not be chlorinated by ordinary means; hence they are not considered.

TABLE I - Chlorination of Mt. Bischoff ore constituents by chlorine alone

No.	Reaction	Standard free energy change ΔF° , K.Cals.	
		500 $^\circ K$ (227 $^\circ C$)	1000 $^\circ K$ (727 $^\circ C$)
1	$SnO_2 + Cl_2 \rightarrow Sn Cl_2 + O_2$	+ 46.7	+ 23.3
2	$SnO_2 + 2 Cl_2 \rightarrow Sn Cl_4 + O_2$	+ 12.0	+ 4.1
3	$Fe_2O_3 + 2 Cl_2 \rightarrow 2 Fe Cl_2 + 3/2 O_2$	+ 27.8	+ 28.4
4	$Fe_3O_4 + 3 Cl_2 \rightarrow 3 FeCl_2 + 2 O_2$	+ 20.2	+ 28.1
5	$FeS_2 + Cl_2 \rightarrow Fe Cl_2 + 2S \text{ or } S_2 (g)^*$	+ 22.4	- 33.3
6	$FeS + Cl_2 \rightarrow FeCl_2 + S \text{ or } 1/2 S_2(g)^*$	- 9.0	- 29.9

* At 500 $^\circ K$ sulphur will be present in the molten state, whereas at 1000 $^\circ K$ sulphur gas will be present: M.P. of sulphur - 329 $^\circ K$ (56 $^\circ C$)
 B.P. of sulphur - 717 $^\circ K$ (444 $^\circ C$)

From Table I it is seen that by Chlorine Fe S₂ will be chlorinated whereas SnO₂ will not react, whereas the exactly opposite situation is being looked for. Thus Chlorine could not be selected as a suitable reagent.

It is to be noted here that for oxide minerals it is generally required to have a reducing agent together with the chloridising agent. This reducing agent can be used separately as H₂, CO, C, etc. or in the combined form already present in the chloridising agents like CCl₄, COCl₂, HCl, etc.

The free energy change values for the chloridising reactions with hydrochloric acid gas are given in Table II.

TABLE II - Chloridisation reactions with hydrogen chloride gas

No.	Reaction	Standard free energy change ΔF° , K.Cals.	
		500°K(227°C)	1000°K(727°C)
1	$\text{SnO}_2 + 2 \text{HCl} \rightarrow \text{SnCl}_2 + \text{H}_2\text{O} + 1/2 \text{O}_2$	+ 40.7	+ 35.3
2	$\text{SnO}_2 + 4 \text{HCl} \rightarrow \text{SnCl}_4 + 2 \text{H}_2\text{O}$	0.0	+ 8.1
3	$\text{Fe}_2\text{O}_3 + 4 \text{HCl} \rightarrow 2 \text{FeCl}_2 + 2 \text{H}_2\text{O} + 1/2 \text{O}_2$	+ 15.8	+ 32.4
4	$\text{Fe}_3\text{O}_4 + 6 \text{HCl} \rightarrow 3 \text{FeCl}_2 + 3 \text{H}_2\text{O} + 1/2 \text{O}_2$	+ 2.2	+ 34.1
5	$\text{FeS}_2 + 2 \text{HCl} \rightarrow \text{FeCl}_2 + \text{H}_2\text{S} + \text{S}$ or $1/2 \text{S}_2$ (g)	+ 23.3	+ 4.8
6	$\text{FeS} + 2 \text{HCl} \rightarrow \text{FeCl}_2 + \text{H}_2\text{S}$	- 8.1	+ 7.2

From this table it is seen that hydrogen chloride gas alone may be a suitable chloridising agent for recovering tin as SnCl₄. However, this reagent has one main disadvantage. The reaction of cassiterite (SnO₂) with hydrogen chloride gas is endothermic at temperatures below 1200°K (927°C). This would demand the additional supply of fuel to keep up the proper temperature for the reaction. Also a ΔF° value of 0.0 K.Cals at 500°K, gives only a fifty-fifty chance for the success of reaction and at that temperature of 500°K the rate of the reaction may not be high enough. At higher temperatures, on the other hand the reaction has a positive value of ΔF° .

This unfavourable situation of chloridisation reaction of cassiterite with hydrogen chloride gas alone can be remedied by the use of an additional reducing agent such as H₂, CO, or C. The elemental carbon used with hydrogen chloride will favour the chloridisation of the iron compounds together with cassiterite. In other work at Geo-Met Reactors Limited hydrogen has been mentioned as a better reducing agent than carbon monoxide for the reduction of SnO₂ to Sn; hydrogen can penetrate the crystal lattice of SnO₂ more easily than CO. Hence, the chloridisation experiment of Mt. Bischoff tin ore is proposed to be carried out at first with a mixture of hydrogen and hydrogen chloride gas.

The standard free energy change values of chloridisation with hydrogen and hydrogen chloride gas are given in Table III.

TABLE III - Chloridisation reactions with hydrogen and hydrogen chloride gas

No.	Reaction	Standard free energy change ΔF° , K. Cals	
		500°K(227°C)	1000°K(727°C)
1	$\text{SnO}_2 + \text{H}_2 + 2 \text{HCl} \rightarrow \text{SnCl}_2 + 2 \text{H}_2\text{O}$	- 11.7	- 10.7
2	$\text{SnO}_2 + \text{H}_2 + 4\text{HCl} \rightarrow \text{SnCl}_4 + 2 \text{H}_2\text{O} + \text{H}_2$	0.0	+ 8.2
3	$\text{Fe}_2\text{O}_3 + \text{H}_2 + 4\text{HCl} \rightarrow 2 \text{FeCl}_2 + 3 \text{H}_2\text{O}$	- 36.6	- 13.6
4	$\text{Fe}_3\text{O}_4 + \text{H}_2 + 6\text{HCl} \rightarrow 3 \text{FeCl}_2 + 4 \text{H}_2\text{O}$	- 50.2	- 11.9
5	$\text{FeS}_2 + \text{H}_2 + 2 \text{HCl} \rightarrow \text{FeCl}_2 + 2 \text{H}_2\text{S}$	+ 7.8	- 4.0
6	$\text{FeS} + \text{H}_2 + 2 \text{HCl} \rightarrow \text{FeCl}_2 + \text{H}_2\text{S} + \text{H}_2$	- 8.1	+ 7.2

From Table III it is seen that the chloridisation of cassiterite to SnCl_2 in Reaction No.1 is highly favourable at both 500°K and 1000°K. Also most of the iron in Mt. Bischoff ore is probably in the form of FeS_2 and FeS . If FeS_2 is present then to avoid chloridisation lower temperatures should be used. (Reaction 5). On the other hand if FeS is present then for the same reason, higher temperatures would be used. A mineralogical examination of the constituents of Mt. Bischoff ore is under investigation. Another favourable point with reaction No. 1 ($\text{SnO}_2 + \text{H}_2 + 2 \text{HCl} \rightarrow \text{SnCl}_2 + 2 \text{H}_2\text{O}$) is that it is exothermic. Hence the process can be carried out with its own heat of reaction.

5. EXPERIMENTAL WORK

The experimental arrangement is shown in Fig.1. A series of five tests with various gas mixtures of H_2 and HCl (commercial grade) was performed on 50 gm - samples of ore in a 1000 - watt furnace fitted with a Vycor reaction tube. The total gas flow rate was 460 millilitre per minute at a temperature of 600°C. While raising the temperature to 600°C, N_2 was passed to expel the air from the Vycor tube. The volatilised product which condensed in the cooler part of the Vycor tube was collected by washing with dilute hydrochloric acid. Both the hydrochloric acid solutions in the gas scrubbing train and the Vycor tube solution were analysed for tin and iron. Table IV shows the results obtained.

In Table IV, the percent tin volatilisation is calculated on the basis of 1.34% tin in the mine-run ore. In Table V, the percent tin volatilisation based on the analysis of residue and volatilised products in each test, is shown. On this basis of calculation a much higher recovery of tin chloride is obtained. However, in this method of calculation, the tin percent in the ore varied from 0.76% to 1.34% as compared

to 1.34% tin assumed in the previous basis of calculation. An analysis of the unchloridised ore in each test could have been very helpful in checking the material balance in each case. Unfortunately, this analysis was not done. Proper care of this point is being taken in current tests.

It may, however, be pointed out that the 1.31 and 1.34% tin obtained from the raw ore, based on the analysis of chloridised residue and volatilised products, in the first two tests, check well with the assumed figure of 1.34% tin in the raw ore. No other results of percent tin in the present case are as close as the first two. This lends some support to the basis of calculation employed in Table I.

Percentage tin volatilisation as a function of the gas mixture composition from the results of Table IV is shown in Fig.2.

TABLE IV - Volatilisation of tin and iron chlorides from 50 gm samples of mine-run ore.

Test No.	Gas ratio		Time mins.	Distribution of tin						Total tin volatilised gms	Percent tin volatiliz'n	Total iron volatilised gms	Percent iron volatiliz'n
	Volume percent			Percent of tin in sample									
	H ₂	HCl		gms			gms						
			Vycor tube	1st wash bottle	2nd wash bottle	Vycor tube	1st wash bottle	2nd wash bottle					
1	70	30	45	0.4513	0.0176	0.0176	67.36	10.62	2.63	0.540	80.60	Nil	Nil
2	50	50	45	0.4374	0.0626	0.0050	65.28	9.34	0.93	0.505	75.35	Nil	Nil
3	25	75	45	0.3480	0.0585	0.0045	52.00	8.73	0.61	0.411	61.34	0.053	0.30
4	85	15	45	0.4210	0.0092	0.0092	62.83	1.37	1.37	0.439	65.58	0.004	0.02
5	0	100	45	0.2808	0.0282	0.0094	41.91	4.21	1.40	0.318	47.52	0.069	0.38

The values for iron volatilisation are based on 36.26% of iron in the ore.

072

- 6 -

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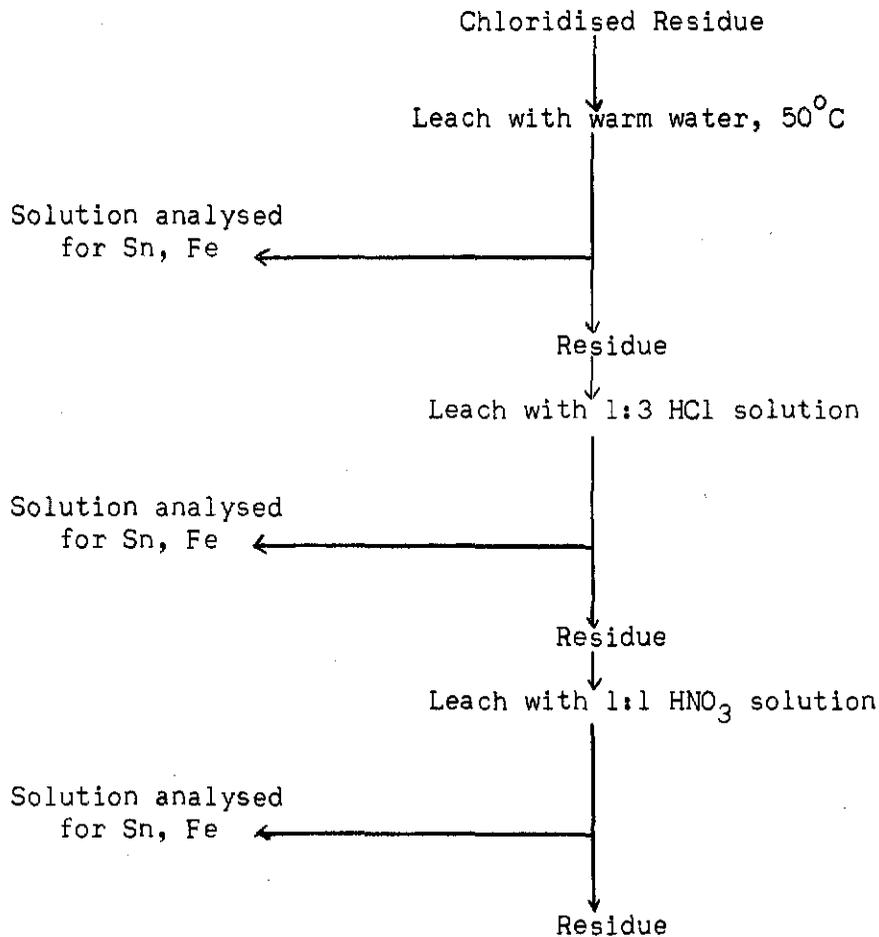
TABLE V - Tin volatilisation based on the analysis of chloridised residue and volatilised products.

Test No.	Gas ratio volume		Time mins.	Total tin volatilised (A), gms.	Total tin in the chlorinated residue (B), gms.	Total tin in 50 gm sample (A+B), gms.	Percent tin volatiliz'n $\frac{A}{A+B} \times 100$	Percent tin in 50 gm sample $\frac{A+B}{50} \times 100$
	H ₂	HCl						
1	70	30	45	0.540	0.117	0.657	82.20	1.31
2	50	50	45	0.505	0.165	0.670	75.35	1.34
3	25	75	45	0.411	0.118	0.529	77.54	1.06
4	85	15	45	0.439	0.012	0.458	96.00	0.92
5	0	100	45	0.318	0.060	0.378	84.14	0.76

073

5.1 Leaching Tests

To determine the nature of tin and iron compound in the chloridised product, the residue from Test No.1 was leached according to the following scheme.



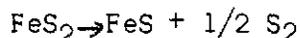
Water should dissolve FeCl_2 , FeCl_3 , SnCl_2 and SnCl_4 ; FeS , Fe_2O_3 and SnS should be dissolved in the HCl solution; and FeS_2 and SnO_2 are soluble in HNO_3 solution.

The results of the analysis of the leach products are given in table VI.

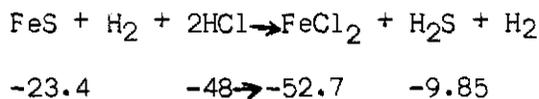
TABLE VI - Results of leaching test on 30 gms of chloridised ore.

Water leach solution, gms.		HCl leach solution, gms.		HNO ₃ leach solution, gms.	
Fe	Sn	Fe	Sn	Fe	Sn
0.0088	0.0064	9.1424	0.0080	1.6000	0.0128

Thus, from the leaching test, it is seen that about 90% of the iron in the chlorinated residue is present as FeS and Fe₂O₃. If it is assumed that FeS₂ is present in the mine-run ore then during the heating up of the ore to 600°C, FeS₂ is favoured to be decomposed to FeS and elemental sulphur according to the following reaction:



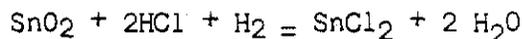
The presence of FeS in the chlorinated residue can thus be explained. The reaction of FeS with HCl proceeds only to a limited extent because of the positive ΔF .



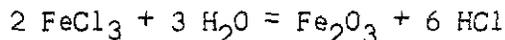
For the above reaction ΔF° at 727°C = +8.95 K.Cals.

The above reaction has a positive value for the standard free energy change, and hence in all probability the reaction would not take place. These considerations apply also to the FeS originally present in the mine-run ore.

Another factor of importance is that any water vapour formed in the reaction



will decompose any FeCl₃ formed as follows:



5.2 Chloridising Experiments at Low Temperature

The ΔF° of the reaction, $\text{SnO}_2 + \text{H}_2 + 2\text{HCl} \rightarrow \text{SnCl}_2 + 2\text{H}_2\text{O}$, as a function of temperature is given in Table VII.

TABLE VII - Standard free energy change for the reaction
 $\text{SnO}_2 + \text{H}_2 + 2\text{HCl} \rightarrow \text{SnCl}_2 + 2\text{H}_2\text{O}$

$^{\circ}\text{F}$	440.6	800.6	1340.6	1700.6
$^{\circ}\text{C}$	227	427	727	1027
$^{\circ}\text{K}$	500	700	1000	1300
ΔF°	-11.7 K.Cals	-5.0 K.Cals	-10.7 K.Cals	-15.0 K.Cals

Hence at a temperature of 350°C (623°K) ΔF° for the above reaction is about -6.0K.Cals . At this temperature SnCl_2 will be formed but will not vapourise. Leaching with water would separate it. With this idea in mind, 50 gm sample of the ore was spread evenly on about 6" length on the Vycor tube, and an unspecified mixture of H_2 and HCl was passed at a reaction temperature of 350°C for a period of 20 minutes. The experiment has to be stopped due to gas leakage in the experimental set up. The chloridised residue was leached with hot water. Some tin chloride also vapourised into the HCl solution in the gas train. Percent tin chloridisation in this experiment was 12%.

No comparison could be made due to the very short time of the experiment. Another experiment with longer reaction time and at slightly higher temperature will be made.

6. DISCUSSION OF RESULTS

Substantial quantities of tin were chloridised and volatilised (75 to 96%) at a temperature of 600°C with a gas mixture of H_2 and HCl containing 15 to 50% HCl . Iron in the residue was present as ferrous sulphide and not as iron chloride. Negligible amount of iron was found in the volatilised product. Most of the sulphur remained in the residue. Elemental sulphur was also collected during the reaction.

The preliminary investigations done, so far, on the chloridisation of Mt. Bischoff ore are promising. It is hoped that by investigating all the process variables, recoveries of tin as chlorides could further be improved.

7. RECOMMENDATIONS

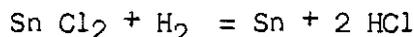
A knowledge of the mineralogical constituents of the mine-run ore would throw more light on the thermodynamic considerations of the different chloridisation reactions by various reagents. This would help to select the proper chloridising reagents for the selective chloridisation of tin.

A more extensive analysis on the reactants and products should be carried out to check the metallurgical balances on each individual experiment.

8. ECONOMIC CONSIDERATIONS

It is difficult at this stage of the work to give accurate costs of recovering tin from Mt. Bischoff ore by chloridising. However, an assessment of the economic feasibility is possible.

Assuming recirculation of the HCl gas and recovery from the SnCl₂ and SnCl₄ by hydrogen reduction



The following consumption of reagents and thermal energy will be required per pound of tin produced.

H cl-0.1 lb	\$0.01
H ₂ -7 cu.ft	\$0.01
Heat Requirements	<u>\$0.05</u>
Total	<u>\$0.07</u>

Labour, overhead and capital depreciation costs of course will have to be added. However, with an ore value of about \$10/ton and no complicated milling circuit the process should prove to be economically feasible.

9. FUTURE WORK

Future work will be carried out along the following lines:

- (a) Further investigation of the optimum temperatures and particles size for reaction of the ore with hydrochloric acid gas.
- (b) The possibility of burning H₂ + Cl₂ in the reaction zone to utilise the exothermic heat produced in this reaction.
- (c) The possibility of a bulk flotation of the sulphides to reduce the quantity of ore to be handled.
- (d) Studies on the optimum conditions for the recovery of tin by hydrogen reduction of Sn Cl₂ and Sn Cl₄.
- (e) Studies on the fused salt electrolysis of Sn Cl₂ and Sn Cl₄.
- (f) Pilot-plant studies.

The cost of the programme including pilot-plant construction and studies will be approximately \$200,000.

10. CONCLUSIONS

Initial experimental work on the chloridisation of Mt. Bischoff mine-run ores has shown that high recoveries of tin (80-96%) can be obtained. The tin is recovered as tin chloride which is only slightly contaminated with iron.

(Sgd) S. Ghosh, M.Sc.

(Sgd) W.A.Morgan, B.Sc., Ph.D.P.Eng.

8 April 1963

A PRELIMINARY STUDY OF MINERAL PROCESSING PROBLEMS
OF MOUNT BISCHOFF TIN ORE

A series of 6 lab scale test was carried out on a sample of ore, marked Mt. Bischoff Tin Ore, Tasmania.

This work was of a preliminary nature, the object being to study some of the characteristics and problems which might be encountered if this ore is to be treated on a commercial scale.

The sample of ore consisted chiefly of serpentine and pyrrhotite. The serpentine was of a "talcy" nature, and floated very readily with a minimum amount of light frother, fed stagewise. In this step a considerable amount of cassiterite reported with the gangue or talc. Some of this tin could be dropped out of the talc flotation concentrate by cleaning. In laboratory test No. D-2 a total of 46% of the mill heads by weight consisted of talc and contained some 40.0% of the total tin. By one-stage cleaning of the talc fraction (Lab test No.D-5), 25.51% containing 12.15% of the total cassiterite was rejected. In test No. D-2 the talc product assayed 0.98% Sn, against an assay of 0.57% Sn in test No. D-5. This would lead one to believe that the cassiterite is very fine-grained and to a large extent free.

Of the pyrrhotite present in the ore, some is magnetic and some non-magnetic. In lab test No.D-4, the crockett magnetic separator recovered 22.12% of the total heads, or 60.58% of the total pyrrhotite in the sample. The pyrrhotite can be recovered from the Bischoff ore by means of a wet permanent magnet (Crockett type) and a high intensity wet magnetic separator (Jones type). An effective way of recovering the pyrrhotite is by either a combination of a crockett magnetic separation followed by flotation, or by straight flotation. The natural pH of the pulp after grinding is 6.8 and is quite satisfactory for a pyrrhotite float with a low consumption of reagents.

In the following table are figures to show weight loss of total heads against the assay content of the cassiterite in the pyrrhotite concentrates.

Test Number	Total wt.of pyrrhotite	Assay % Sn
Lab test D-2	40.23	0.32
Lab test D-3	45.32	0.38
Lab test D-4	22.12	0.11
Lab test D-4	14.38	1.04
Lab test D-5	38.14	0.41
Lab test D-6	57.72	0.57

In lab test D-6, in which the Jones high intensity wet magnetic separator was used, the highest weight loss and the highest tin assay was obtained. This could be accounted for in several ways; the cassiterite may be present as true middlings with the pyrrhotite, or as fine grains in gangue particles containing sufficient pyrrhotite to make them magnetic.

In the mineralogical examination conducted by the Swastika Laboratories Ltd., on this sample, they found some of the cassiterite occurring with titanite. It is felt that this titanite was concentrated with the Jones high intensity separator and that this accounts for the higher weight content and higher Sn content in the magnetic fraction.

In the following table are figures representing the total cassiterite locked or lost in the talc and pyrrhotite products. It is evident that the talc and pyrrhotite must be removed from this ore in the first stages of mineral dressing, and, due to the fact these two fractions carry some 50 to 60 percent of the cassiterite, it is clear that better recovery of the tin from these fractions of the ore is the first major problem.

Lab test number	Conc.	Weight %	% Sn in fraction	Total Sn lost in test
Lab test D-1	1	83.08	61.57	
" "	2	7.91	6.45	68.02
" D-2	1	33.42	30.92	
" "	2	14.74	9.47	
" "	3	40.23	11.03	51.42
" D-3	1	34.93	41.86	
" "	2	45.32	11.35	53.21
" D-4	1	53.00	49.87	
" "	2	22.12	2.13	
" "	3	14.38	13.09	65.09
" D-5	1	25.51	12.15	
" "	2	38.14	13.06	25.21
" D-6	1	57.72	25.56	25.56

(Sgd) A. C. King

GEO-MET REACTORS LIMITED

GEO-MET PROGRESS REPORT

#17

10 April 1963.

MT. BISCHOFF CHLORIDISATION EXPERIMENTSINTRODUCTION

In a previous series of tests (Research Progress Report No. 6), it has been confirmed that high percentages of tin chlorides are volatilised from Mt. Bischoff tin ore, when it is chloridised with a mixture of HCl and H₂ gases at a temperature of 600°C. In this present series of tests it was decided to study the effect of other variables, mainly the flow speed of gas mixture, on the recovery of tin chlorides.

EXPERIMENTAL DETAILS

The experimental apparatus was the same as before (Report No.6), the only difference being that this time a 1" I.D. silica tube was used while the I.D. of the Vycor tube in the previous tests was 2". The flow rate of the chloridising agents was the same, i.e. 460 ml/min. Hence in the present series of tests the gas flow speed was approximately four times that of the previous tests (neglecting the effect of the area of the boats).

RESULTS

The results of tin and iron chlorides recovery, together with the analyses of the test samples and the chloridised products are given in Table I.

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SAMPLE CALCULATIONS (Test No. 3 Table I)

(a) % Sn volatilisation based on the analysis of chloridised residue

Wt. of chloridised ore	=	41.63 gms
% Sn in the chloridised ore	=	.14%) average .21%) Sn % = $\frac{.35}{2} = .175\%$
Wt. of Sn chlorides volatilised	=	.639 gms
Wt. of Sn in the chloridised ore	=	(.175 x .4163) = .071 gm
Total wt. of Sn = (.639 + .071)	=	.710 gm.

$$\text{Hence \% Sn volatilisation} = \frac{.639}{.71} \times 100 = \underline{\underline{90\%}}$$

(b) Metallurgical balance based on the analysis of the products

Wt. of the unchloridised sample	=	46.24 gms
% Sn in the unchloridised sample	=	1.2%) Average Sn % 1.5%) = $\frac{2.7}{2} = 1.35\%$
Wt. of Sn in the unchloridised residue	=	.4624 x 1.35 = .6237 gms
Wt. of Sn in the products (chloridised residue + volatilised chlorides)	=	.710 gms

Hence

$$\begin{aligned} \text{Metallurgical balance \%} &= \frac{\text{Wt. of Sn in the products}}{\text{Wt. of Sn in the raw sample}} \times 100 \\ &= \frac{.710}{.6237} \times 100 = \underline{\underline{112\%}} \end{aligned}$$

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(c) % Sn from analytical results

Total wt. of Sn in the products	=	.710	gms
Wt. of the sample	=	46.24	gms
% Sn in the sample	=	$\frac{.710}{46.24} \times 100$	= <u>1.53%</u>

DISCUSSION OF RESULTS

Although the analytical results of tin are not very consistent, probably due to the sampling error (although sampling was performed on a small riffle), certain general observations can be drawn from the results of Table I.

- Higher gas flow speed increases the Sn volatilisation.
- The maximum amount of Sn chlorides volatilised from 50 gm sample in previous tests was .540 gm (see Report No. 6), whereas the maximum amount of tin chlorides volatilised from a 45 gm sample in the present series of tests is .680 gms at a higher (approximately four times) flow speed. Thus the percentage increase in maximum Sn volatilisation with the present higher speed of flow is given as:

$$\frac{0.680}{0.540} \times \frac{50}{45} = \underline{140\%}$$
- The chloridisation reaction rate is very high at a temperature of 600°C. Thus even within 5 minutes 84% of Sn recovery is obtained (test No. 7).
- The chloridisation reaction rate is considerably low at temperatures below 600°C. Thus even at a higher flow rate of 690 ml/min the percentage recovery of Sn chlorides at 500°C is only 30% for a test run for 6 minute period (test No. 8).
- A very high recovery of tin chlorides can be obtained with HCl gas only, at a high flow speed (test No. 5). The reaction rate with HCl gas only is quite high.
- Very little amount of iron is volatilised.
- Most of the sulphur stays behind in the chloridised residue.

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RESULTS FOR CHLORIDISATION WITH 100% HCl GAS

The properties of the chloridised product with 100% HCl gas are found to be somewhat different from the rest of the chloridised products with H₂ and HCl gases. The chloridisation with 100% HCl gas gives a residue with about 35% metallic iron, which means that all the iron in the Mt. Bischoff tin ore is being transformed to metallic iron (% iron in raw ore = 36%). The chloridisation experiments with H₂ and HCl mixtures, on the other hand, do not give any metallic iron in the chloridised product. However, this finding is being further investigated, and confirmation of this result would be given at a future date.

(Signed)

S. Ghosh, M.Sc.(Chem),
Project Engineer.

Approved

(Signed)

W. A. Morgan,
President & Managing Director.

SG:jmt

PROJECTED CASH REQUIREMENTS

The financing of the Mount Bischoff tin prospect should proceed through three logical stages:

- I. Junior risk capital equity financing;
- II. Senior risk capital equity financing; and
- III. Senior debt financing.

STAGE I.

The junior risk capital equity financing has been completed by Mount Costigan Mines Limited. Mount Costigan has demonstrated:

- (a) the probable existence of 2,100,000 tons grading 0.46% tin which can be mined at a rate of 500,000 tons per year by open pit methods for \$1.36 per ton;
- (b) through geophysical surveys, the probable extension of the tin bearing sulphides;
- (c) the feasibility of using a chloridisation process for smelting which would effect high recoveries of tin from very low grade (2%) concentrates at a cost of 25¢ per pound. There is a good possibility that by-products iron powder and sulphur can be recovered and sold at a profit.

STAGE II.

Senior risk capital equity financing is required to complete:

(a)	Property development	\$ 97,500.00
(b)	Mineral dressing research	50,000.00
(c)	Metallurgical research	200,000.00
(d)	Working capital	65,000.00
	Total	<u>\$412,500.00</u>

STAGE III.

Senior debt financing requirements are estimated to be:

(a)	Capital cost of pit equipment	\$950,000.00
(b)	Capital cost of mill equipment	1,500,000.00
(c)	Capital cost of smelting unit	1,000,000.00
(d)	Working capital	<u>1,000,000.00</u>
	Total	<u>\$4,450,000.00</u>

PROJECTED CASH FLOW

The estimated annual net profit, before taxes and amortization of the funded debt, is calculated to be \$1,990,000:

Mine operation	500,000 tons/year	
Grade	0.46% Sn	
Recoverable 90%	0.41% Sn	
Annual tin production	4,100,000 lbs	
Gross annual profit @ \$1.20 lb.		<u>\$4,920,000.00</u>

Projected Costs:

Mining @ \$1.36/ton	\$680,000.00	
Milling @ \$2.00/ton	1,000,000.00	
Smelting @ \$2.50/ton	1,250,000.00	
	<u> </u>	
	\$2,930,000.00	
Annual Net Profit		<u>\$1,990,000.00</u>

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Plan in Drafting Room folder 62-346

Comstaff.EXPLANATION OF MOUNT BISCHOFF GEOLOGY MAP.

Location of open-casting mining faces and glory-holes:-

Brown Face:	2,694,000N - 1,069,750E to 2,693,875N - 1,069,125E
Slaughteryard Face:	2,693,750N - 1,069,125E to 2,693,500N - 1,069,000E
White Face:	2,693,125N - 1,069,875E to 2,693,000N - 1,069,500E
Greisen Face:	2,693,000N - 1,068,500E to 2,693,250N - 1,069,500E
Pig Flat:	centres on 2,692,625N - 1,069,125E
Happy Valley:	centres on 2,692,875N - 1,069,750E
Don Hill:	mapped area south of 2,691,600N

1. MAPPING PROCESSES

A grid was laid by compass and tape traverses to the north and south of a base line from points 100 feet apart and each line pegged at 50 foot intervals. Spot heights were calculated from clinometer readings and the whole grid surveyed in relation to the Mount Bischoff trig. point by theodolite. Points at observations were offset by tape.

A clear distinction was made between bedding planes and foliation planes, the former were measured for fold information and the latter for shear, fault and thrust directions only.

Highly sheared folds adjacent to fault planes, concertina folds in the immediate vicinity of boudins and warped beds within boudin were rejected in terms of overall structural significance. Certain well developed joint planes were

/2. barely distinguishable....

barely distinguishable from beds and bedding measurements in these circumstances were recorded as doubtful.

Fold measurements comprised the determinations of plunge (angle and direction), axial plane (strike and dip) and limb orientations (strike and dip). Folds were classified according to their size (major and minor), amplitudes being estimated in the main and not measured.

Fault and thrust plane determinations and orientation of slickenside, where found, were recorded and drag against fault planes noted to infer relative movement of each side. Actual throw on faults was seldom measurable,

Structural rolling on bedding planes (Mullion structures) has tended to obscure sedimentary sole structures so inverted "drag" was the main criterion for deciding on the reversal of a stratigraphic sequence (upside down beds).

2. STRATIGRAPHIC COLUMN.

Late Proterozoic - Early Cambrian Sediments:-

Top:-	Grey shale and Argillite with interbedded siltstone and quartzite. Grey shale and siltstone (thinly bedded) with little quartzite. Narrow zone of black carbonaceous shale - not continuous. Dolomite with interbedded black shale.
Bottom:-	Black carbonaceous shale (very thinly bedded) with siltstones.
Intrusives:-	Quartz veins.
Devonian (?)	Quartz porphyry.

There is some evidence to suggest that the dolomite is a single horizon though not always continuous and definite evidence for its sedimentary character and similarly the replaced dolomite - essentially a quartz-pyrrhotite-cassiterite rock which may take the form of a gossan in part.

Numerous inverted sequences were encountered; a good example being Don Hill.

The "rheomorphic" argillite is not a stratigraphic unit but seems to be genetically related to structural and metasomatic disturbance. The rock is highly contorted, brecciated, recrystallised and veined by numerous quartz-tourmaline-cassiterite stringers which carry a little sulphide.

The mudstone formation to the south of Don Hill is problematical for although the rocks dip beneath the black shales, the contact is sheared and large blocks of black shale lie within it.

The quartz porphyry dykes were emplaced prior to the cassiterite quartz veinlets. They have been partially greisenized and appear to be controlled structurally viz. the large southern dyke which N.E. - S.W. is aligned along the edge of a refolded nappe and the disjointed E-W dykes are parallel to the axis of a fundamental asymmetrical anticline in part. In Brown Face the porphyry is a sill and there is much evidence of a sheet-like mode of occurrence elsewhere on the Mount.

3. STRUCTURAL GEOLOGY

Of faults, few major dislocations have been observed and there appears to be a dearth of décollement structures. The most common faults are small-throw faults aligned parallel to the steep limbs of asymmetrical folds adjacent to the hinge giving rise to "keel" structures.

Three types of folding, subdivided into two styles of folding were recognised; the types trend N-S, E-W and NE-SW and the styles are fundamental folds which comprise the two former types and nappe folds.

(i) Fundamental folds:- These structures tend to have steep axial planes and are mainly asymmetrical folds. Axial plane and plunge variations are common and bent hinges were recorded even in microfolds. Certain unusual changes in the trend of beds, without dislocation, may be ascribed to sharply hinged kinks (the variation may amount to 20°).

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Examples - asymmetrical anticline (E - W) between Brown Face and White Face; plunge changes from east to west are 25° W, 37° W.

anticlinal warp at White Face north (E - W); plunge changes from east to west are 35° E, 11° W.

anticline west of Pig Flat (NNW - SSE); plunge changes from north to south are 52° N, 26° S.

(ii) Nappes:- The overfolds without exception have been moved from the south-east to the north-west and invariably trend NE - SW.

Refolded folds of this type are recumbant structures with the fold axis at about 60° to the fundamental isoclinal fold axis (probably N - S).

Examples - anticlinal overfold at Brown Face; plunge changes from east to west are 30° SW, 15° SW.

recumbant anticlinal refolded fold from Happy Valley to White Face; plunge changes from east to west are 40° SW, 4° SW.

inverted sequence at Don Hill; plunge changes from east to west are 30° SW, 4° SW, 12° NE, 50° NE, 16° SW and 20° SW.

Complicated structural zones develop at the junctions of fundamental and nappe structures as exemplified at the eastern edge of White Face (recumbant anticline abuts against a fundamental E-W anticlinorium) and Greisen Face where a fundamental N-S anticline plunges toward the probable extension of the Brown Face - Slaughteryard Face overfold.

It would seem that the fundamental structures are older relative to the nappe structures but it is possible that the deformation of the Mount Bischoff rocks occurred in a single major epoch comprised of varying dominant phases viz. E - W stress, N - S stress and resultant overfolding from SE to NW.

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5.

4. ECONOMIC GEOLOGY:

Our two prime interests at Mount Bischoff are the discrete replacement deposits of cassiterite and various sulphides in dolomite (these should exceed 1% Sn.) and the reconstituted argillite breccia (rheomorphic) with anastomosing veinlets of quartz-cassiterite (expect about 0.5% Sn.) which could well represent a very large tonnage of relatively low-grade ore.

So far, both the discrete hydrothermal quartz veins remaining for exploitation and the minor irregular replacement zones in quartz porphyry (greisen) do not appear to warrant particular attention.

5. GEOLOGICAL SECTIONS

These will be drawn up when the underground mapping and bore-hole re-logging programme has been completed.

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Dr. J. F. Lambert 30.10.1969.

COSTYGAN

Greisen

— Big Flat Area — Mt. Bischoff.

50'-1"

180 m²

085

interpret by reference to other maps?

292091

08585

used as locality map for Borehole Sites.

COMSTAFF

① 1970 Winter Field Season (black folder)

Report
to accompany:—

An evaluation of the ore Reserves of Mt. Bischoff

② Grid Plan.

③ Mt. Bischoff — Underground workings — tin values.

④ Mt. Bischoff — Surface Geol. Plan.

⑤ S.W. Dolomite SECTIONS 1-1 Jan 70

⑥ W. Greisen SECTION 2-2 " "

⑦ Slaughtered SECTION 3-3 " "

⑧ Happy Valley SECTIONS 4-4 " "

⑨ Mt. Bischoff Dolomite Bodies.

⑩ " " Survey of Main Tunnel + Air Photo control

⑪ Mt. Bischoff Mine Area.
Geol. Outcrop Map Colour Crayon.

⑫ Mt. Bischoff Geol. Interpret. Mine Area.

⑬ " " Surface Geological Plan.

Mt. Bischoff

Aug. 1962.

292092

Introduction — 1

Geology — 14

Geol Section — (no hope)

Ind. Polarisation results (✓) tin/sulphide lodes. $4 \times \frac{1}{4}$

Ind. Polarisation (text) — 15

Report Ind. Polarisation maps — x1.

Ind. Polarisation electrode patterns
+ results — x17

Drilling — x1

Drilling Section — 3 (— $6 \times \frac{1}{2}$).

Ore Calculat x1

Mineral Dressing x19

Cost Flow x1

Expl. of Maps x5 — seems to be by J.F. Lambert
reference. Comstaff.
30-10-1969.

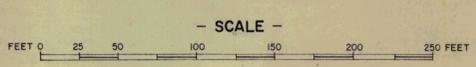


LEGEND

- HANGING-WALL SHALES
- STRONGLY MINERALIZED DOLOMITE
- MINERALIZED DOLOMITE
- MINERALIZED DOLOMITE BOULDERS
- DOLOMITIC SHALES
- FOOTWALL SHALES
- GOSSAN
- PYRITIC LODS
- SHEARED TALC HORIZON
- ALTERED QUARTZ PORPHYRY



- REFERENCE**
- Mine Railway
 - Fault
 - Plane Table Station
 - BISCHOFF NO.4 Diamond Drill Hole



292093

MOUNT COSTIGAN MINES
MOUNT BISCHOFF OPTION

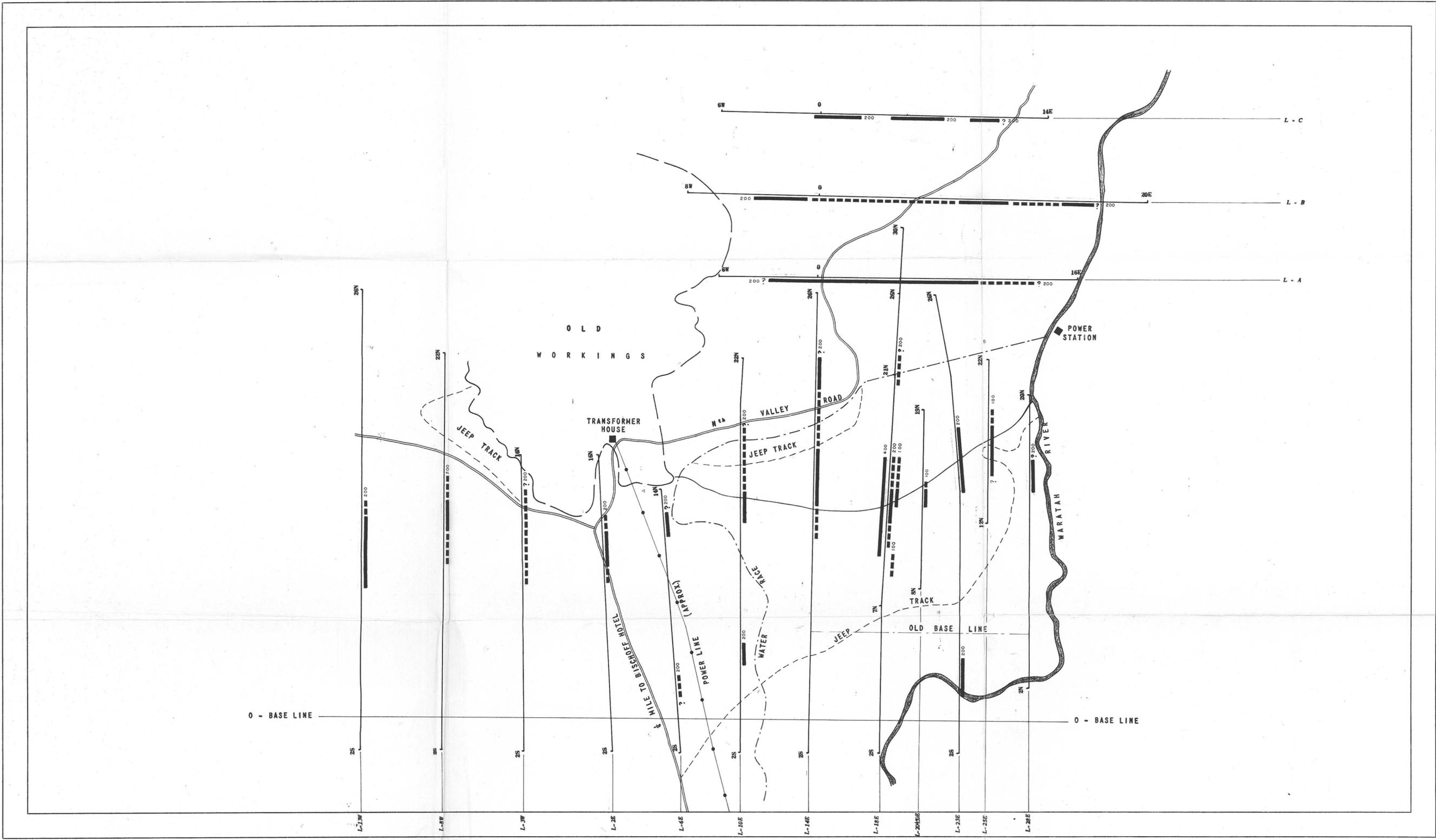
— GEOLOGICAL PLAN —

DATE: JAN. 1963 GEOLOGY BY: M. SOLOMON
W. YOUNG

5 cm

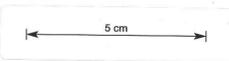
62-346

McPHAR GEOPHYSICS LIMITED
INDUCED POLARIZATION AND RESISTIVITY SURVEY
LOCATION MAP



ANOMALOUS ZONE ———
 POSSIBLE ANOMALOUS ZONE - - - - -
 NUMBERS AT END OF ANOMALIES
 INDICATE SPREAD USED

MOUNT COSTIGAN MINES LIMITED
 MT. BISCHOFF AREA—TASMANIA.



091
 292094
 62-346
 DRAWN: F.R.P.
 DATE: JULY 1962
 REVISED: *reB.*
 DATE: Sept. 7/62.
 APPROVED: *R.B.B.*
 DATE: July 10/62.