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GEOCHEMICAL PROSPECTING AT MT. ISA.

QUEENSLAND.

by

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SUMMARY

Geochemical anomalies in soils over zones of lead mineralization were studied, both in known mineralized areas and in areas of suspected mineralization. The anomalies were readily detected and outlined by using a dithizone technique on acid extracts of soil samples collected from grid systems.

By assuming the principles of mechanical mixing of the mineralized rock with other material during soil formation, and of downhill migration of soils, the anomalies were correlated with the zones of their origin: the asymmetric anomalies discovered are typical of such conditions.

Applied to areas of suspected mineralization the geochemical prospecting was responsible for the discovery of two new bands of lead mineralization and several large lead and copper anomalies. The method proved to be extremely useful for indicating the most favourable areas for more detailed prospecting such as diamond or churn drilling and geophysical methods.

INTRODUCTION

Geochemical prospecting is one of the newer scientific tools, having been developed over the last fifteen years, and finding its principal application in the search for hidden mineral deposits.

Workers in various countries, in particular Russia (Sergeev, 1941), United States (Huff, 1952), Scandanavia (Rankama, 1940), and Nigeria (Webb and Millman, 1951), have applied the methods with varying degrees of success. Hawkes (1949) gives a summary of the work which had been carried out up to the end of 1949.

The main advantages of the geochemical methods are speed and economy. A team of three men can collect and test up to fifty samples per day. The results are available immediately, and if an anomaly is discovered further sampling can be carried out to define its boundary. Colorimetric analytical methods require only a small quantity of inexpensive chemical materials and equipment which can be transported with ease in suitably packed boxes.

Experienced personnel with high technical qualifications are not necessary for sampling and testing; an assistant of sub-university chemistry standard can be trained to perform the tests satisfactorily in two weeks. One member of the team should be sufficiently qualified in chemistry and geology to enable any unexpected difficulties in procedure to be quickly overcome, and to be able to interpret the results rapidly and correctly.

Soil was the sampling medium used in the Mt. Isa investigations, and the amounts of trace metals, lead and copper, were determined by a colorimetric method using the organic reagent dithizone.

The survey occupied a period of nine weeks, during which time a total of 1334 samples were collected and tested. It was planned to coincide with an extensive prospecting programme being carried out by Mt. Isa Mines Limited embracing two areas of suspected lead mineralization, one north and the other south of Mt. Isa.

Work at the northern area, eleven miles from Mt. Isa, was well advanced when the geochemical studies commenced in October, 1952. Many costeans had been cut to bedrock by bulldozer, several diamond-drill holes were completed or in progress, and five shafts were under construction. High-grade bands of lead mineralization had been uncovered in some of the costeans, and this known mineralization served as an ideal test-area for the geochemical method. Anomalies were established in the sub-surface soils in the vicinity of the known mineralized bands. Thus the results from the test-area served to provide the prospecting criteria for the district as a whole. Further work at the Northern Prospect, in areas not recently investigated, led to the discovery of two new mineralized zones, and the possible rejection as unpromising of other areas.

The Southern Prospecting Area, twelve miles south of Mt. Isa, was then studied in order to determine the most favourable areas for more detailed costeaning and drilling. Previously only one small section had been geologically investigated (Haney's Ridge, Plate 4), and samples assaying over twenty per cent. lead were obtained from one costean. Geological mapping of the area, which covered over three miles length of gossanous outcrop, was being carried out by Mt. Isa geologists whilst the geochemical work was in progress.

The author is indebted to the Commonwealth Bureau of Mineral Resources which made the survey possible and permitted publication of the report, and also to Mt. Isa Mines Limited for the use of laboratory and office space. Thanks are due to S.R. Carter, Chief Geologist of Mt. Isa Mines, for his assistance throughout the project, and to A.A. Gibson of Mt. Isa Mines and K.A. Townley, of the Bureau of Mineral Resources, for their contributions on the geology of the area.

CLIMATE, TOPOGRAPHY, AND VEGETATION

Mt. Isa is situated at 20°40'S latitude and 139°30' longitude. It is at the southern fringe of the monsoonal region, and has a mild dry winter and a hot to very hot summer. The average annual rainfall is 13 inches, most of which falls during the "wet" season between December and March.

Both the Northern and the Southern Prospecting Areas are flanked by prominent quartzite ridges on their western sides. From the foot of the quartzite ridge the Northern Area has a gentle slope to the east with numerous local undulations, but this topographical pattern is rather sharply interrupted by the prominent hills formed by the ferruginous jasper outcrops.

The topography of the Southern Prospect is characterised by a series of sharp ridges with a general north-south trend and a number of quartz "blows". The principal drainage channels run north or south into larger creeks which run west to east through breaks in the ridges at several places.

Vegetation in the area is rather sparse. Trees grow to a height of thirty feet, the most common species being Eucalyptus brevifolia (snappy gum), Eucalyptus pruinosa (silver-leaved box), Eucalyptus argillacea (box), and Acacia spp. (wattles). Acacia lysiphloia (turpentine) is abundant on the alluvial soils. Triodia spp. (spinifex) and Aristida spp. (spear grass) are common.

GEOLOGY OF THE PROSPECTING AREAS.

The geology of Mt. Isa and its immediate surroundings, and the emplacement and paragenesis of the lead-zinc ores, have been summarised in a paper by S.R. Carter (1950).

The lead-zinc mineralization is localised in the western limit of a west-dipping, north-plunging, isoclinal syncline of Mt. Isa shales. These are the uppermost Formation of the Mt. Isa Group, which is Lower Proterozoic in age.

Immediately to the west of the isocline the Mt. Isa shear, a thrust striking north-south and dipping at about 60° to the west, brings the next lower formation, the Eastern Creek Formation, against the shales; and about two miles west of the thrust a region of extensively granitized sediments of the Eastern Creek Formation grades into the Templeton Granite, which is pene-contemporaneous with the pressure from the west.

Sullivan (1952) considers that the Templeton Granite is very significant for the occurrence of ore at Mt. Isa. In the area north and west of Mt. Isa the granite-sedimentary contact forms a north-pitching anticlinal structure along which local reversals of pitch occur. Both the Mt. Isa and the northern prospect deposits are associated with a swing in the granite contact which is convex to the eastward, representing an anticlinal pitch change in the dominantly north-pitching fold. A similar swing in the granite contact south of Mt. Isa led Sullivan to predict the probable occurrence of lead-zinc ore in an area 12-13 miles south of Mt. Isa. He considers that the granite pitches beneath Mt. Isa, and the anticlinal pitch changes in the sediments correspond to the positions of buried cupolas in the granite gneiss.

The Mt. Isa shales consist of brown and grey shales and slates, in part dolomitic and in some places carbonaceous. They are strongly crenulated, and strike faults and cross-fractures provide ore-channels through which the mineralizing solutions had access to the fine-grained shales in which they are emplaced.

The general geology of the Northern Prospecting Area is very similar to that of Mt. Isa and the rock formations are continuous with those of Mt. Isa. The area is bounded in the west by a prominent quartzite ridge. Adjacent and parallel to the eastern margin of this quartzite is the shear-zone which is at least nineteen miles in length and has an average width of five hundred feet at the Northern Prospect. As far as is known the shear-zone is barren throughout its length. It is occupied by phyllite, sericite schist, and some quartzite and shale.

The western limit of the mineralized zone is approximately one thousand feet east of the quartzite ridge. The area between is occupied by various groups of shales. The rocks which contain the mineralized zone are predominantly thinly-bedded, slightly dolomitic to dolomitic, shales, hundreds of feet in width. They have a general north-south strike, and have large gentle flexures and some tight folding. Dips average about 60° to the west. The mineralized zone has a heavily pyritic hanging-wall section averaging fifty feet in width, and carrying numerous narrow sphalerite-galena seams. This section is represented at the surface by prominent but discontinuous ferruginous jasper outcrops. At Offset Hill, however, the ferruginous jasper occurs in the footwall beds. To the east more mineralized and pyritic beds occur with intercalated barren beds but the mineralized bands decrease in width and eight hundred feet east of the jasper ridges the shales are completely barren.

Diamond drilling has proved that the main section of the mineralized zone has a length of at least two thousand five hundred feet and an average width of four hundred and forty feet; the mean depth of the drillhole intersections is about one thousand feet below the surface. Although the overall grade is low, there are several lodes of commercial grade and of minable width within the zone. Some of the mineralized beds are galena rich, but in most of them sphalerite predominates.

There are a few points of similarity between the Southern and Northern Prospecting Areas. Each is bounded on the west by a prominent quartzite ridge, in both the mineralization occurs in shales, prominent ferrugincus jaspers mark the mineralized zones of each, and in each area the shales have a general north-south strike and steep westerly dip. Here, however, the similarity ends.

At the southern end of the Southern Area, Window Ridge is three hundred feet east of a large ridge of quartzite which runs parallel to the Window Ridge and Mt. Novit outcrops, but swings to the north-west from the northern end of Mt. Novit, so that it is two thousand feet west of Gouger Ridge. The quartzite thereafter resumes its north-south strike. The area between the western quartzite and the jasper ridges is temporarily designated as siliceous shale.

The mineralized beds are contained in shales and are represented by the sharp, rough ferruginous jasper ridges, namely Window Ridge, Mt. Novit, Cork Ridge, Haney's Ridge and Bradshaw's Ridge. The ferruginous jaspers are closely associated with beds that have obviously contained a high percentage of pyrite. Another belt of siliceous shales forms the footwall of this group and immediately below this is the so-called "footwall quartzite". This gradually transgresses the shales in a manner which suggests that it has been formed by silicification along a strike-fault zone. This impression is heightened by the fact that prominent quartz "blows" occur at intervals throughout its length.

The ferruginous shales and jaspers of Cork Ridge are cut off against the footwall "quartzite" at the southern end of Gouger Ridge, and the remainder of Gouger Ridge and the whole of Smoko Ridge represent part of the "footwall quartzite" group. Geological study of these two ridges yielded no indications of mineralization, and they were considered to be barren. The geochemical results indicated that they are favourable for lead mineralization.

SAMPLING PROCEDURES:

All testing was carried out on soil samples. Surface waters were not available; rocks, although easy to sample, require crushing which is a time-consuming operation; mainly because of shortage of time the sampling of vegetation was not attempted.

The presence of costeans greatly facilitated the establishment of the prospecting criteria in the early part of the survey. The chief problem was to decide on the minimum depth at which samples could be collected and still give a true representation of the conditions at bedrock. Tests on samples from the sides of the costeans, in soils up to eight feet deep, revealed that for each sampling position uniform results were obtained irrespective of the depths at which the samples were taken. As the humus layer was not sampled, the depth of 9-15 inches was used for sampling throughout the project, except in special cases. In one case, for example, the topsoil, to a depth of 18 inches, consisted of very recent alluvium which gave negative results, whereas deeper soils at the same point gave high results. To obtain truly representative samples it was necessary to penetrate the upper alluvium with a post-hole digger before collecting the sample.

Most of the samples were collected from traverses laid out by compass and tape, survey pegs being used as positioning points. Pick and shovel were used as sampling tools, but the post-hole digger was found to be more convenient for soils free of large rock fragments.

TESTING PROCEDURES:

The testing procedures used throughout the project were similar to those introduced to Australia in 1948 by Dr. V.P. Sokoloff (Sokoloff et al, 1953) of the United States Geological Survey. These methods seem to have lost popularity during the last few years, preference being given to those which seek total amounts of the metals in question and which present the results in numerical form. However the writer's experience in other Australian studies has shown that acid-soluble forms of the metals are quite useful in establishing, more rapidly than and as accurately as the other methods, the geochemical expression of mineralization. Testing procedures differ considerably, and depend on the forms of the metals being investigated. Acid-soluble forms include "free", "exchangeable", "occluded", and perhaps some "organic" forms (Sokoloff, 1951). Metals present in the crystal structures of the soil components are not as useful in establishing the geochemical expression, and, in any case, time-consuming operations such as prolonged aqua-regia extractions or fusions are required to release these forms as soluble compounds.

Colorimetric analytical methods have invariably been used in Australian studies, and this practice was continued at Mt. Isa. The colorimetric reagent, diphenylthiocarbazone (dithizone) has been thoroughly investigated by Sandell (1944) and others. The chief advantages of colorimetric methods for field prospecting are speed, small apparatus requirements, and economy. A two-man team can test up to eighty samples per day. The equipment required at Mt. Isa consisted of : balance, 200 ml beakers, filter funnels and stands, filter papers, "Hydrion" pH papers, 500 ml. and 25 ml. burettes, burette stands and clamps, clock glasses, 50 ml. graduated glass-stoppered cylinders, reagent bottles, and spatulas. Chemicals used were hydrochloric acid, carbon tetrachloride, dithizone, ammonium hydroxide, and potassium cyanide.

Distilled water was not required as the Mt. Isa tap water was entirely free of copper and lead. Zinc did not have to be removed as it did not interfere with the tests. If required, suitable metal-free water could be produced in aluminium stills (glass has proved unsatisfactory in the field) or with ion-exchange resins (Lakin, Stephens, and Almond, 1949).

The testing procedures were both simple and rapid. Ten grams of soil, selected with a spatula from the finer portion of the sample (grain size up to 0.5 mm.), were weighed on a rough balance, and transferred to a 200 ml. beaker; 50 mls. of 0.01N hydrochloric acid were added, and the mixture swirled at intervals for two minutes to allow extraction of the acid-soluble forms of the metals. If the pH increased above three during the extraction, a suitable adjustment was made with hydrochloric acid. Failure to adjust the pH when extracting alkaline soils would cause incomplete extraction of the "acid-soluble" forms of the metals with consequent low results. After filtration, the filtrate (called the test solution) was ready for the colorimetric determinations.

The reactions of the reagent dithizone, as applied to geochemical prospecting, have been fully described by Sokoloff et al (1953).

Thirty millilitres of the test solution at pH3 were transferred to a 50 ml. cylinder, and 5 ml. of 0.01 per cent dithizone solution (in carbon tetrachloride) added. A change of colour in the dithizone layer to grey or purple after shaking for thirty seconds was attributed to copper. Without removing the copper by replacing the dithizone in the cylinder two drops of concentrated ammonium hydroxide were added to bring the solution to a pH of 8-9. At this stage shaking for two seconds revealed intense pink colours in the organic layer, caused by the large amounts of zinc present. However, all copper and zinc colours were removed by the addition of 0.5 ml. of a ten per cent potassium cyanide solution. Any pink colours remaining in the organic layer after shaking for fifteen seconds were considered as being due to lead, the only possible interfering elements being divalent tin, monovalent thallium, and bismuth (Sandell, 1944), all of which could be disregarded in the area under investigation. If large amounts of lead were indicated in the 30 ml. test the aliquot of test solution was reduced to 5 ml. or even to 1 ml. to give a more accurate semi-quantitative appraisal of the results.

The interferences referred to by Sokoloff et al. (1953) for testing at pH8 did not appear to be operative in the lead tests carried out at Mt. Isa. The intensities of the pink colours given by standard lead solutions increased in proportion to the amount of lead in the solution. It was found that if the pH was raised above nine the lead colours were suppressed, and low results were obtained. Large amounts of copper caused a mixture of the yellow oxidation product of dithizone and the brown enol copper dithizenate to form in alkaline solution, and these colours were not completely removed by the potassium cyanide. In such cases the copper had to be removed before the lead test could be carried out.

The only troublesome interference encountered in the testing procedures was caused by dust which contained a high proportion of copper and lead minerals, presumably derived from the mine crushing plant which was only 200 yards from the laboratory. On windy days it was difficult to keep dust out of the solutions during extraction and filtering operations. However, a blank test run concurrently with each batch of tests gave warning of this interference.

METHOD OF REPORTING THE RESULTS:

When assessing the value of a test, it is necessary to emphasize that the search is for prospecting indications and not for exact quantitative results. Colour intensities were most conveniently recorded as negative, low, medium, high, and very high. For copper estimations the results were assessed from the time taken for the purple colours to appear and from the intensities of the colours after thirty seconds agitation. The values for lead tests were assigned according to the aliquots of test solutions used and the resulting colours after shaking for fifteen seconds, as shown in Table 1.

TABLE 1.

Values Assigned to Colours in Lead Tests.

Aliquot of Test Solution Mls.	Colour observed in Carbon tetrachloride Layer	Value Assigned to the Test.	Approx. p.p.m. Acid Soluble Lead.
30	Colourless	Negative	less than 0.2
30	Faint pink	Low	0.2 - 1.0
30	Intense pink)	Medium	1.0 - 6.0
5	Faint pink)		
5	Intense pink }	High	6.0 - 30
1	Faint Pink }		
1	Intense pink	Very high	greater than 30

From Table 1 it is seen that a very high percentage error can be tolerated without appreciably affecting the final result. In the case of borderline results, it is of no real consequence into which of two adjacent brackets they are placed.

Under such circumstances nothing is gained by introducing refinements into the method, which at first may have appeared a little rough to the analytical chemist.

The results obtained in an extensive survey, such as that carried out at Mt. Isa, are of little use in tabular form, and are best presented on plans. The original plans were on a scale of one hundred feet to the inch, but these were reduced to four hundred feet to the inch to facilitate drafting and handling. Each circle and dot on the plans represents a sampling point, the size of the dot increasing with the strength of the test.

Two grades of geochemical anomalies have been outlined. In general, the strong anomalies embrace all the very high results, and the weak anomalies include the high and medium tests.

Results:

Of the 1334 samples collected and tested during the nine weeks of the survey, 744 were from the Northern Prospect, and 590 were from the Southern Prospect.

NORTHERN PROSPECTING AREA

The locations of the areas studied at the Northern Prospect are shown in Fig. 1.

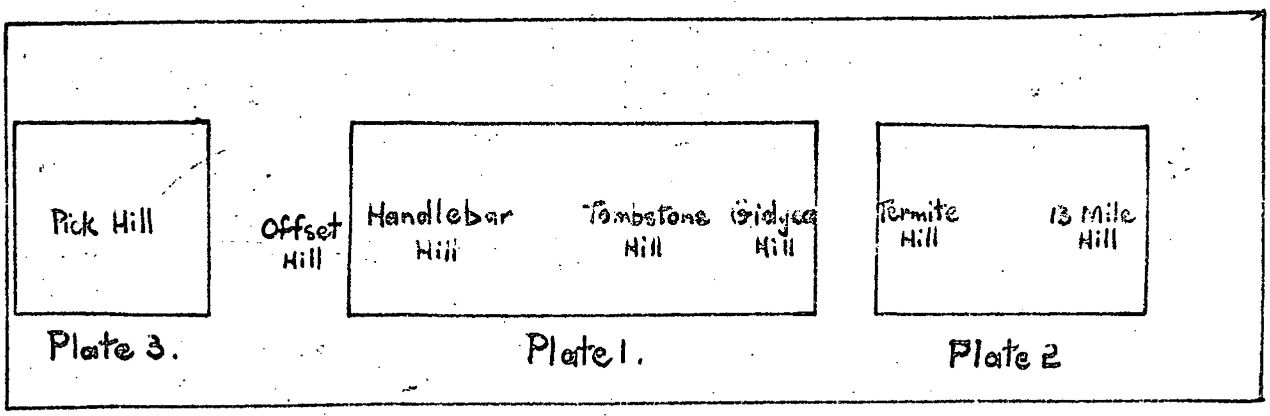

Fig. 1. Localities of Areas Studied at the Northern Prospect

The preliminary prospecting criteria were obtained from samples collected in No. 4 costean, situated between Handlebar and Tombstone Hills (Plate 1). The results are shown diagrammatically in Fig. 2.

It is seen from Fig. 2 that the bands of high-grade mineralization are represented by a distinct geochemical anomaly in the overlying soils. The anomaly is asymmetric, the highest values being over

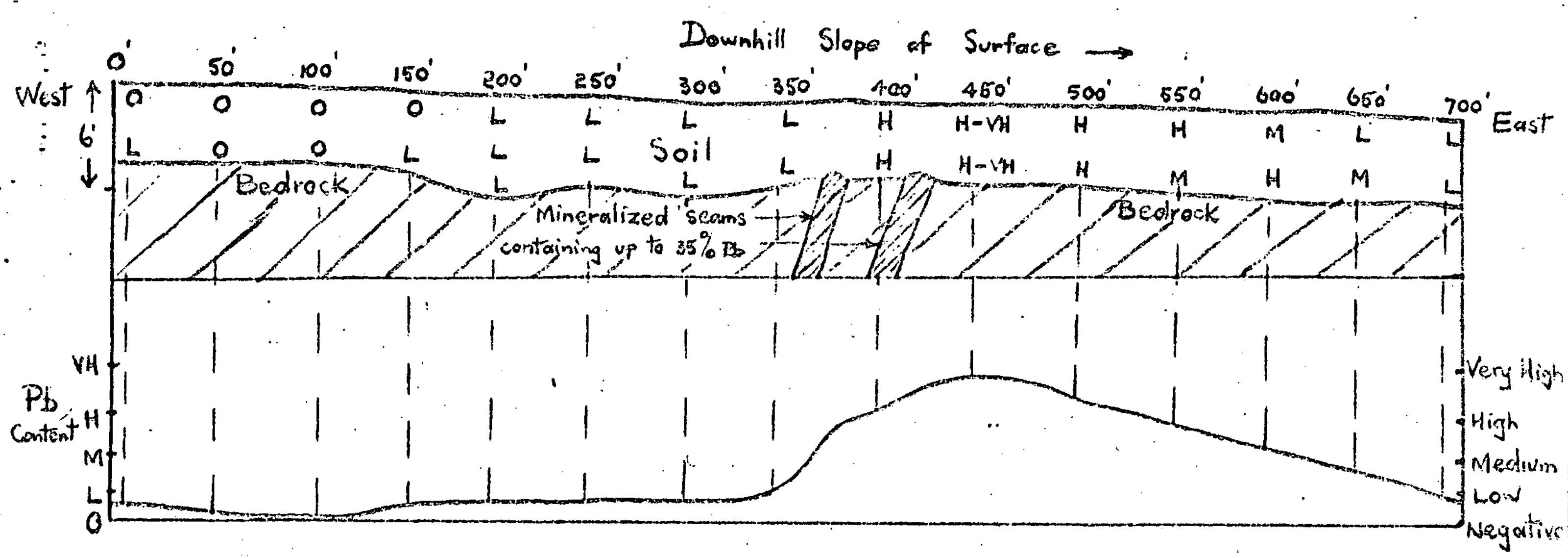

Fig. 2. Lead Results in No. 4 Costean, showing Lateral and Vertical Distribution of

and immediately downhill from the mineralized bands; downslope the values steadily decrease, so that within three hundred feet of the seams they have almost returned to the normal background value.

Plates 1, 2, and 3 present the results obtained at the Northern Prospect. Plate 1 shows two large and three small anomalies outlined in the Handlebar-Tombstone area. Most of the mineralization was already known before the geochemical prospecting commenced, and the anomalies demonstrated the correlation between the traces of lead minerals in the soils and the underlying mineralized material from which the soils were derived.

The northern boundary only of the large anomaly on the eastern slope of Handlebar Hill has been outlined. Further sampling to the south was not possible owing to the presence of dumps near the prospecting shafts. However, the anomaly would certainly continue to the south, over and down-hill from the high-grade mineralized bands shown on Plate 1. An unexpected strong anomaly crosses the eastern end of No. 2 costean on Handlebar Hill; further investigation revealed mineralized bands which previously were not known to exist.

The two weak anomalies over Nos. 4 and 5 costeans between Handlebar and Tombstone Hills were discovered during the preliminary testing at the beginning of the survey. The small western anomaly may be due to weak lead mineralization associated with pyrite. The soil cover was very thin, and substantial mineralization should have produced higher results. The other anomaly, seven hundred feet in length, is more important, as it represents seams of high-grade mineralization (2 feet of 35.8%, and 8.5 feet of 21.3% lead). The reasons for the presence of only a weak anomaly over these seams and the existence of apparently negative areas on either side are discussed in the interpretation (Page ~~10~~ 11).

The large strong anomalies at Tombstone Hill bear a striking resemblance to those at Handlebar Hill (Plate 1). Mineralized seams were known to be present and the geochemical results give a guide to their extent. A southern extension of the mineralized bands to No. 3 costean was first indicated by the geochemical prospecting. Later assay results proved that a one-foot band of 7% lead mineralization existed in No. 3 costean a short distance uphill from the place where very high geochemical results were obtained. Soils were only two feet deep over this band.

The weak and dispersed results obtained at Gidyea Hill suggest either that the mineralized bands do not extend north of Tombstone Hill, or that they do not reach the surface in that area.

The Termite Flat - 13 Mile Hill area (Plate 2) had been prospected many years previously, apparently without success, and the old costeans, with supplementary traverses, were used for sampling. The geochemical prospecting showed no more success, although many weak anomalies were established. Closer and deeper sampling, due to the deep soils encountered, would be necessary before more conclusive results for the area could be obtained.

Pick Hill was the most southerly portion of the Northern Prospect to be studied. The area was untouched except for two hand-dug costeans which had been prepared many years previously. An anomaly over sixteen hundred feet inlength (Plate 3) was discovered; the northern boundary has not been established due to the presence of a creek bed. The strong anomaly was over eight hundred feet long, and at its northern end a small costean was cut in an attempt to discover the source of the anomaly. A costean less than ten feet long was required to reveal a mineralized band which contained crystallized cerussite in the decomposed bedrock. Further geological work has traced the band for many hundreds of feet to the north, almost to Offset Hill. This was the second discovery made solely by geochemical prospecting methods of lead mineralization in the Northern Prospecting Area.

SOUTHERN PROSPECTING AREA.

The lead results for this area are presented on Plate 4 which represents the $3\frac{1}{2}$ miles of almost continuous gossanous outcrops covered by the survey. Several areas, for example, Bradshaw's Ridge, Mt. Novit, and Window Ridge, were considered as being geologically favourable, because of structure or the presence of favourable types of gossans, for the discovery of ore-bearing seams. Contrary to expectations, these areas gave only small weak anomalies which appear to indicate an almost complete lack of surface lead mineralization.

However, on Smoko Ridge a large and strong geochemical lead anomaly was discovered. This ridge and the northern part of Gouger Ridge fall into the "footwall quartzite" group, and have the appearance of a non-ferruginous jasper. The anomaly differs from all the other lead anomalies in that it extends to both sides of the ridge; the mineralization must occur at the top of the ridge or on both sides, being more extensive on the western side where the strong anomaly occurs.

Another lead anomaly, possibly associated with that on Smoko Ridge, was outlined on Haney's Ridge, north of Smoko Ridge; the two ridges are separated by Sybella Creek. The surface indications of mineralization thus extend over a length of five thousand feet. A seam containing payable lead ore had been discovered in one of the costeans at Haney's Ridge before the geochemical work commenced.

Although the Mt. Isa work was chiefly an investigation of lead mineralization, the possibility of detecting copper anomalies was not overlooked, and all-lead tests were preceded by an examination for copper.

At the southern section of the Southern Prospect, from Gouger Ridge to Window Ridge, the number and intensity of positive copper tests increased considerably, and they have been recorded separately on Plate 5. Three separate strong copper anomalies were outlined, each at least sixteen hundred feet in length. It is interesting to note that they occur in areas in which the lead results were lower than expected on geological grounds. Some reasonably high, but very dispersed, copper tests at Bradshaw's Ridge have not been recorded on the plans.

INTERPRETATION OF THE RESULTS

The preliminary investigations were carried out in the area of known mineralization chiefly to establish a correlation between the geochemical anomalies located in the soils and the ore occurrences from which they originated. In each of the areas studied the mineralization occurs in bands which are usually parallel or almost parallel to the ridges. Abnormal amounts of lead are found in the residual soils associated with the seams containing oxidized lead minerals, and the ratio of acid-soluble lead in these soils to that in soils derived from barren rock is as high as 200:1. In a few exceptional cases the ratio exceeded 1000:1. This is a much higher ratio than that of 170:1 given by Huff (1952) who used strong acids and fusions to extract the metals. It may indicate that the acid-soluble forms of the metals, extracted by dilute acid, give a much sharper geochemical anomaly than the corresponding total amounts of the metals, as extracted by aqua-regia or fusion.

There is little doubt that the lead anomalies discovered in the Mt. Isa study are similar to those originally described by Sergeev (1941), and discussed by Huff (1952). They are the typical asymmetric anomalies produced by mechanical dispersion and downhill creep in soil over a seam parallel to the topographic contours. The seam must be present at bedrock for the anomaly to exist as solutions play no part in the formation of the anomaly. The detection of a previously unknown band of mineralization (for example at Pick Hill) is relatively simple, as the upper topographic boundary of a strong anomaly is almost certain to be directly over the band under investigation.

The width and strength of the anomalies are influenced by the following factors: the width and grade of the mineralized seams, the topographical relief and depth of soil over the seams, the relative proportions of residual and alluvial soils in the anomalous areas, and the mobilities of the metals in the soil horizons.

It is obvious that a wide high-grade seam will introduce more mineral into the soil than a narrow low-grade seam, thus producing a larger and stronger anomaly. That the acid-soluble forms of the metals are correspondingly increased is probably a reasonable assumption. Webb and Millman (1951) also suggest, from the results of a biogeochemical reconnaissance in Nigeria, that an increase in the total amount of an element in the soil will increase the available portion of that element. The acid-soluble forms of the metals are equivalent to the available portions which are taken up by vegetation (Hawkes, 1950).

Owing to the shallow residual soil cover, seams at or near the tops of ridges should produce anomalies of maximum strength. A seam of similar dimensions and grade, but further downslope, would produce a weaker anomaly, because much soil from barren rocks above the band would be mixed with that derived from the band itself, with consequent dilution of the seam mineral dispersed in the soil. In general, soils increase in depth on passing down a slope, causing further dilution of the ore minerals.

At Haney's Ridge (Plate 4), the strongly mineralized seam occurs in an almost flat outcrop with very little soil cover. The anomaly is very strong, but narrow. Had several feet of soil overlain this seam the anomaly would have been weaker but much wider owing to increased mechanical dispersion.

As the ferruginous jasper outcrops at the Northern Prospect represent the western margin (hangingwall) of the mineralized zone, it follows that positive lead tests can be expected only on the eastern slopes,and not on the western slopes, of the hills. This was proved to be the case. The jasper ridges, where they occur, effectively protect the metalliferous soils in their vicinity from dilution by barren soil from the west, and ensure that the soil on their eastern slopes is derived wholly from the mineralized zone. In the gap between Handlebar and Tombstone Hills, and that between Pick and Offset Hills, the diluting effect of soils from the west is very extensive. At Offset Hill, where the ferruginous jasper occurs in the footwall, the strong geochemical anomaly could be expected on the western side of the hill. Five samples were collected from a costean on the western side of Offset Hill and they gave very high results. The remainder of the hill was not sampled.

The Smoko Ridge anomaly occurs on both sides of the ridge, although the strong anomaly is confined to the western side (Plate 4). At Window Ridge two low lead values were given by samples taken one hundred feet north of survey peg No. 57. These samples were collected from residual soil on the top of the ridge; this soil is only a few inches deep, but covers mineralized rock which assayed 0.25 to 0.5% lead. If soils representing mineralization of this grade are favourably placed at the top of a ridge, and give only a low result, it is reasonable to assume that the very high results at Smoko Ridge represent relatively high-grade mineralization, possibly in the order of 5 to 20%

lead, also situated close to the top of the ridge.

It is possible that the geochemical results not only indicate the mineralized areas, but also the grade, in general terms, of the mineralization. If this assumption is correct, the only areas in the Southern Prospect where commercial-grade lead mineralization is likely to be found near the surface are Smoko Ridge and Haney's Ridge, and possibly at the southern end of Window Ridge.

The results at Smoko and Haney's Ridges suggest that the footwall quartzite is in some way associated with mineralization; whether it has a local concentrating effect on the mineralization in the shales, or whether it indicates that the postulated strike-fault zone is mineralized, can only be conjectured at this stage of our knowledge. (A.A. Gibson, personal communication).

The weak lead anomalies at Window Ridge, Mt. Novit, Cork Ridge, and Bradshaw's Ridge cannot be overlooked completely. It is safe to conclude that substantial surface mineralization will not be found in these areas but the possibility of the presence of commercial grade ore at depth still remains. Unfortunately the geochemical prospecting at its present stage of development cannot assist in the solution of this problem.

The strong anomaly on the eastern side of Handlebar Hill (Plate 1), where new mineralized seams were discovered, need not necessarily be due to high-grade mineralization. Thus, it is seen from the plan that the soils uphill from the anomaly already give high results, and that the mineralization in the newly discovered band merely increases the values to very high. The increase, however, is sufficiently well defined to allow detection of the band; but it may be below commercial grade.

At the Northern Prospect, the presence of only a weak anomaly over the two high-grade seams (up to 35% lead) which cross Nos. 4 and 5 costeans (Plate 1) is readily explained when the nature of the soils in the anomalous area is considered. A large proportion of eluvial material, characterized by angular and some rounded pebbles and obviously derived from barren rocks to the west, has been intermixed with the soils derived from the seams, causing dilution of the lead minerals in the soils. What would have been a strong anomaly, in residual soil only, is thus reduced to a weak anomaly.

The negative areas north and south of this anomaly were unexpected as deep drilling revealed that the seams were continuous at depth and similar conditions were expected at the surface. The lack of positive tests was later found to be due to the presence of old deep water-channels, now completely concealed beneath the eluvium. At a churndrill hole on the northern side of No. 3 costean the depth of soil is 27 feet. The resulting decrease in concentration of the lead minerals in the deep soils over the veins was sufficient to cause negative geochemical results in these areas. Before the correct results could be obtained for such cases a new sampling technique would have to be adopted, the depth of 9-15 inches as in the present survey being obviously inadequate.

It is possible that the old drainage channels, filled as they are with a large percentage of coarse material, still contribute largely to the drainage of the area, and they would tend to drain to a reasonably dry state after rains. This combination of deep alluvial cover with leaching by fresh water each rainy season and rapid drying out of the soil might tend to prevent indications of mineralization from reaching the shallower layers of the soil. The rate of soil shift is also likely to be more rapid in such channels.

Groundwaters, even when they are present for short periods during the summer, appear to play little or no part in the solution and dispersion of the lead ore minerals. The stability of oxidized lead minerals in the zone of weathering is well known, and even for other minerals Huff (1952) suggests that after incorporation in the soil the ore metals are practically insoluble in soil moisture.

The sphalerite and galena in the seams at the Northern Prospect are ultra-fine-grained and intimately mixed. Very few of the mineralized beds show visible signs of mineralization at the surface and it is probable that when the sulphides were oxidized at the surface the sphalerite was rapidly leached out, leaving the lead minerals in a finely divided state which allowed them to be easily dispersed.

The interpretation of the copper anomalies is more difficult than that of lead anomalies, because of the greater mobility of copper in the weathering zone. Copper minerals would have to be present at bedrock to allow mechanical dispersion; visible traces, as oxidized copper minerals, would be present in the soil; and no such traces were observed. On the other hand, without circulating groundwater, copper would not rise from a non-outcropping orebody at depth. Earlier extensive leaching of a sulphide orebody, in a more humid climate, might have left sufficient vestigial copper above the water table to produce a geochemical anomaly at the present surface. Alkaline conditions in the present soils, as noted in many samples from the copper anomalous areas, would help to hold the copper in an immobile form.

In a study of the dispersion of copper from the San Manuel Copper Deposit, Arizona, in a climate similar to that of Mt. Isa, Lovering, Huff and Almond (1950) state that wherever the soil is derived from the immediately underlying rocks, as on ridges, the copper content of the soil bears an especially close relationship to the copper content of the parent rock. Whether or not this is true at Mt. Isa can not be proved until more prospecting has been carried out.

CONCLUSION

The survey was a test case for the prospecting for lead by geochemical methods; as far as is known it was the first time they had been applied successfully in Australia to lead mineralization.

The chief use of the geochemical prospecting was to separate a large area into smaller favourable and unfavourable areas. Advanced prospecting could then be carried out with less expense and with an increased possibility of locating commercial grade mineralization.

Thus at the Southern Prospect, of the 3½ miles length of probably mineralized outcrops, only Smoko and Haney's Ridges were shown by the geochemical work to be suitable for more advanced prospecting. The results are more surprising when it is remembered that at Smoko Ridge the geologists considered that mineralization of any type would be most unlikely. On these grounds the ridge would probably have been overlooked during the costeaning and drilling programme.

The weak lead anomalies in the other parts of the Southern Prospect indicate that mineralization is not present at the surface in commercial quantities and that examination of the bedrock by costeaning would be of no avail.

Interpretation of the three copper anomalies in the Southern Prospect proved rather difficult as an anomlay over known copper mineralization, with which a comparison could be drawn, was not available. The value of the results can only be assessed when the drilling results are known.

At Pick Hill, in the Northern Prospect, the discovery of a mineralized seam demonstrated the rapidity of the method and its advantage of day-to-day planning of the work. In less than three days a team of three was able to sample the area (86 samples), test the samples in the laboratory, indicate the lateral extent of the mineralization and locate the mineralized seam by digging a short costean.

The success of this project should encourage further work of this type, both in the Mt. Isa area and in other areas of similar climate and topography.

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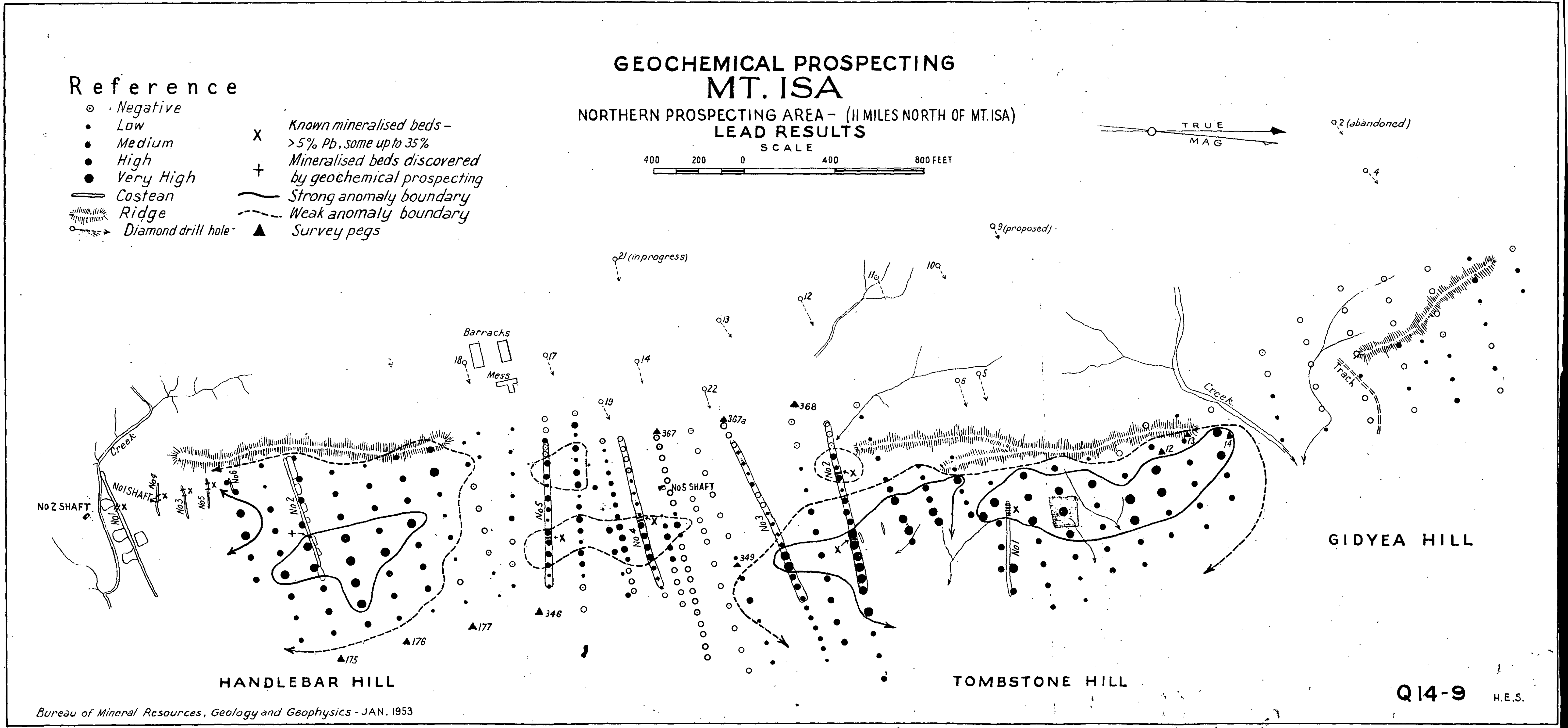

GEOCHEMICAL PROSPECTING
MT. ISA
NORTHERN PROSPECTING AREA - (11 MILES NORTH OF MT. ISA)
LEAD RESULTS
SCALE
400 200 0 400 800 FEET
TRUE
MAG
Reference
Negative
Low
Medium
High
Very High
Costean
Ridge
Diamond drill hole
Known mineralised beds - >5% Pb, some up to 35%
Mineralised beds discovered by geochemical prospecting
Strong anomaly boundary
Weak anomaly boundary
Survey pegs
2 (abandoned)
4
9 (proposed)
21 (in progress)
10
11
12
13
14
17
18
19
22
5
6
Barracks
Mess
Creek
Track
No 2 SHAFT
No 1 SHAFT
No 5 SHAFT
No 1
No 2
No 3
No 4
No 5
No 6
367
367a
368
349
346
177
176
175
HANDLEBAR HILL
TOMBSTONE HILL
GIDYEA HILL
Bureau of Mineral Resources, Geology and Geophysics - JAN. 1953
Q14-9
H.E.S.

PLATE 2.

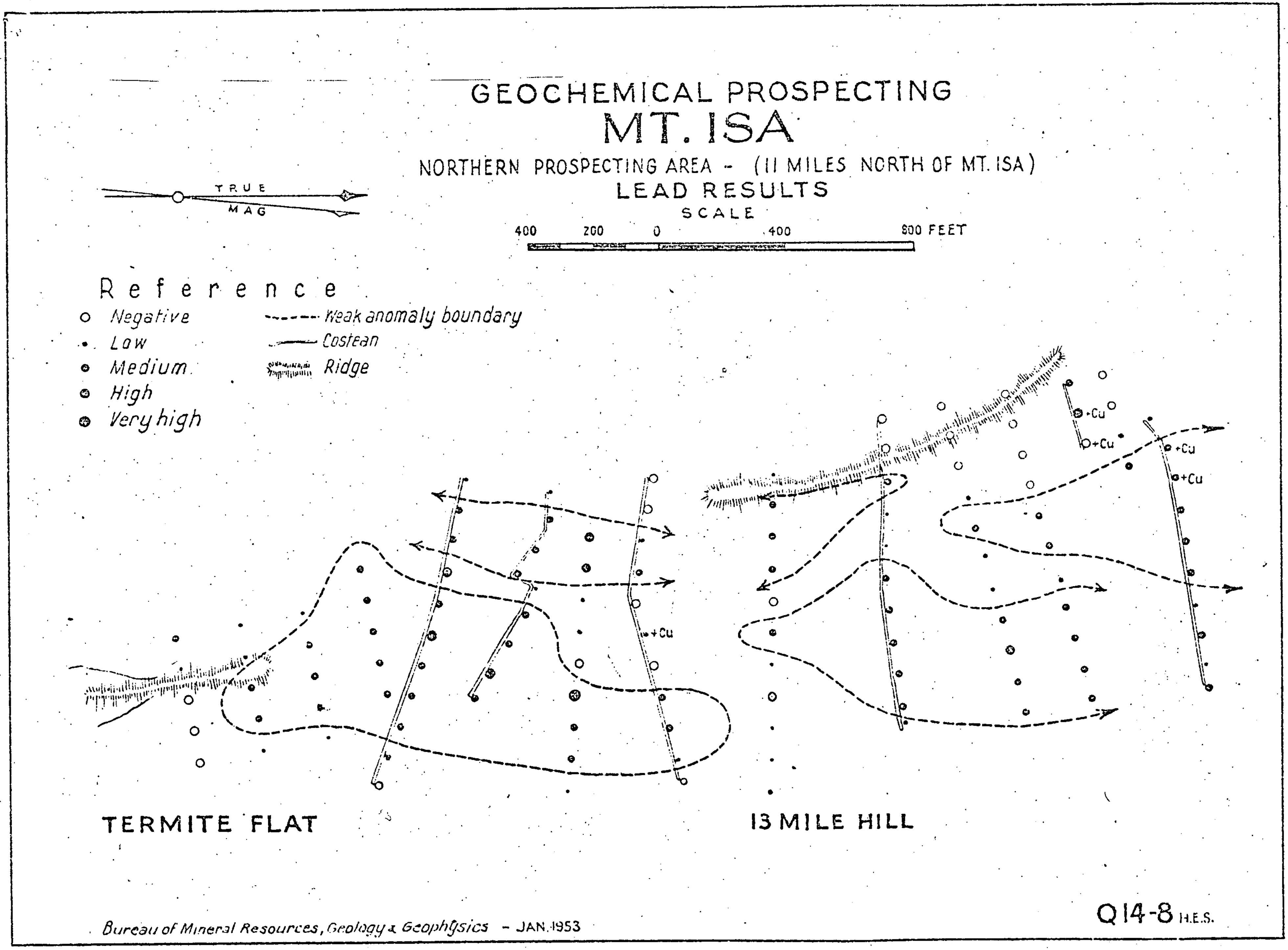
GEOCHEMICAL PROSPECTING
MT. ISA
NORTHERN PROSPECTING AREA - (11 MILES NORTH OF MT. ISA)
LEAD RESULTS
SCALE
400 200 0 400 800 FEET
TRUE
MAG
Reference
Negative
Low
Medium
High
Very high
Weak anomaly boundary
Costean
Ridge
+Cu
TERMITE FLAT
13 MILE HILL
Q14-8 H.E.S.
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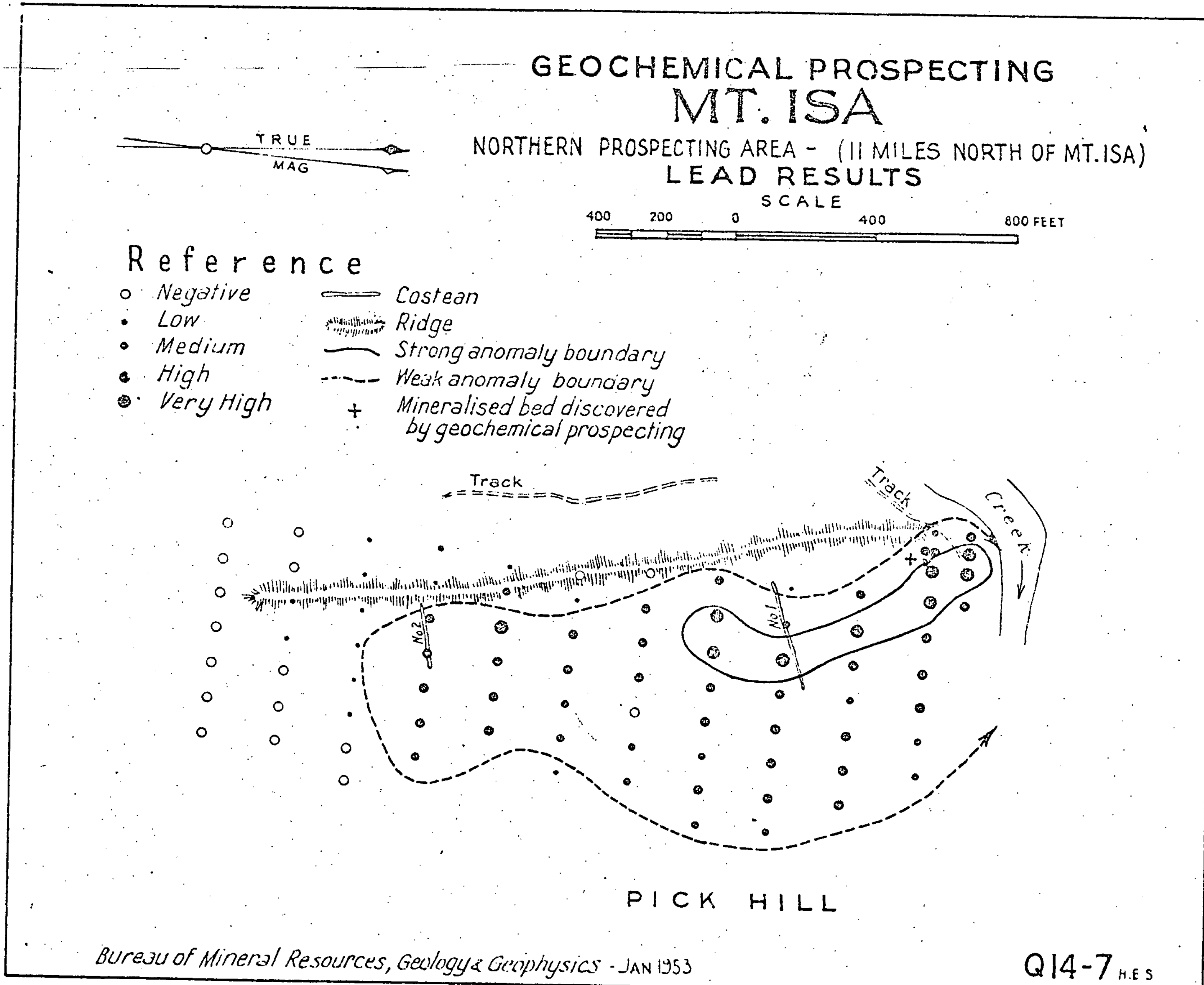
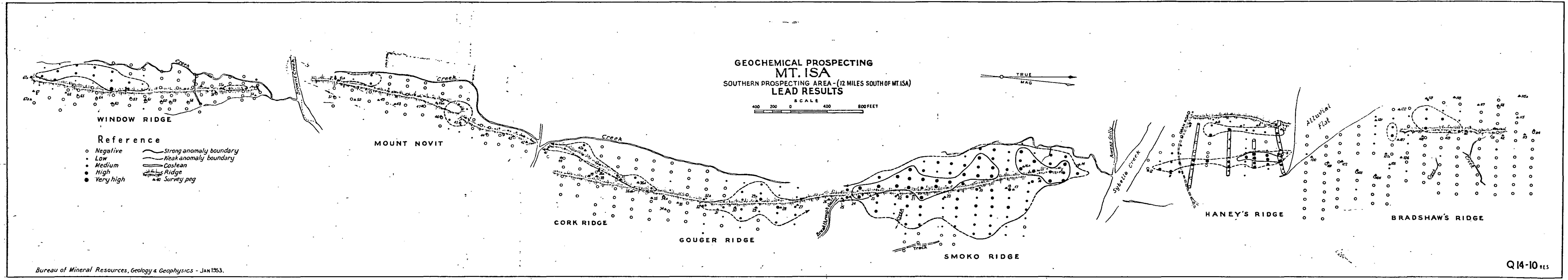
PLATE 3


GEOCHEMICAL PROSPECTING
MT. ISA
NORTHERN PROSPECTING AREA - (11 MILES NORTH OF MT. ISA)
LEAD RESULTS
SCALE
400 200 0 400 800 FEET
TRUE
MAG
Reference
Negative
Low
Medium
High
Very High
Costean
Ridge
Strong anomaly boundary
Weak anomaly boundary
Mineralised bed discovered by geochemical prospecting
Track
Track
Creek
No.2
No.1
PICK HILL
Bureau of Mineral Resources, Geology & Geophysics - JAN 1953
Q14-7 H.E.S



GEOCHEMICAL PROSPECTING
MT. ISA
SOUTHERN PROSPECTING AREA - (12 MILES SOUTH OF MT. ISA)
LEAD RESULTS
SCALE
400 200 0 400 800 FEET
TRUE
MAG
Reference
Negative
Low
Medium
High
Very high
Strong anomaly boundary
Weak anomaly boundary
Costean
Ridge
Survey peg
WINDOW RIDGE
MOUNT NOVIT
CORK RIDGE
GOUGER RIDGE
SMOKO RIDGE
HANEY'S RIDGE
BRADSHAW'S RIDGE
Creek
Sybella Creek
Alluvial Flat
Track
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Q14-10 RES

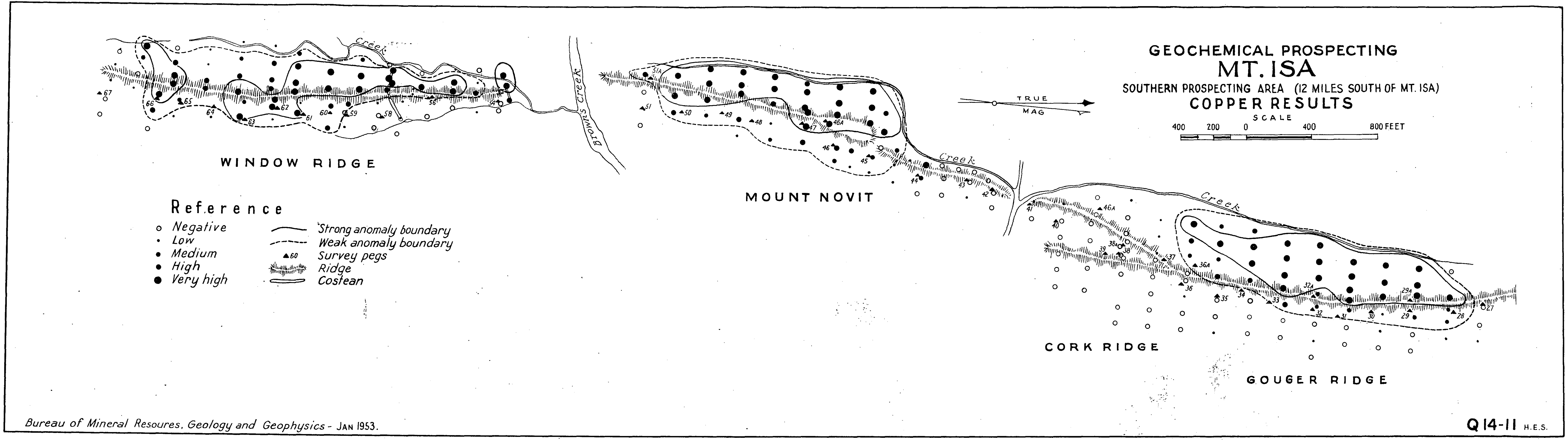
GEOCHEMICAL PROSPECTING
MT. ISA
SOUTHERN PROSPECTING AREA (12 MILES SOUTH OF MT. ISA)
COPPER RESULTS
TRUE
MAG
SCALE
400 200 0 400 800 FEET
WINDOW RIDGE
MOUNT NOVIT
CORK RIDGE
GOUGER RIDGE
Browns Creek
Creek
Reference
Negative
Low
Medium
High
Very high
Strong anomaly boundary
Weak anomaly boundary
Survey pegs
Ridge
Costean
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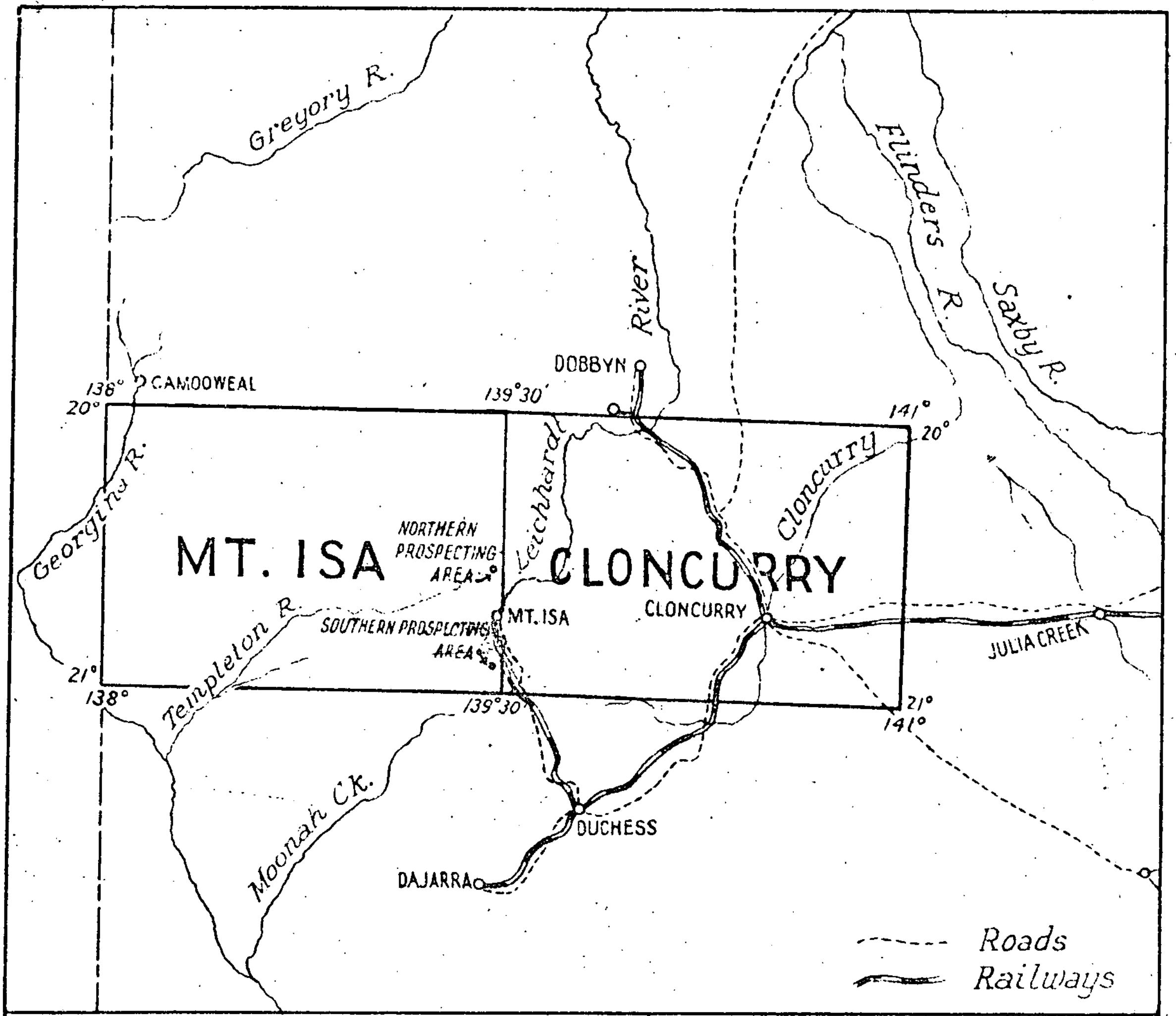
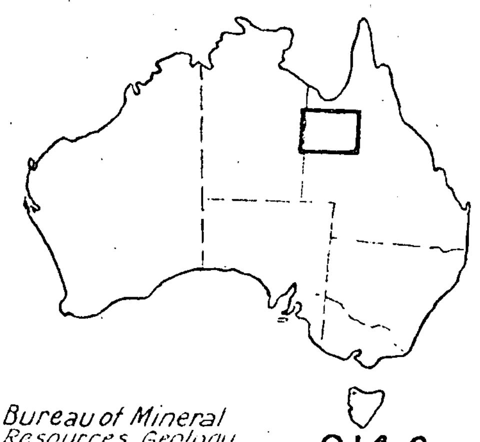
PLATE 6



MAP SHOWING AREA DEALT WITH IN REPORT AND REFERENCE TO AUSTRALIAN FOUR MILE MAP SERIES



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