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GEOCHEMICAL PROSPECTING IN THE VICINITY OF RADIO-ACTIVE DEPOSITS AND PROSPECTS IN THE NORTHERN TERRITORY, AUSTRALIA.

by

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1. INTRODUCTION

During the 1953 field season geochemical prospecting techniques were employed as an additional tool in the search for ore deposits in the Northern Territory. Areas of particular interest were those at which radio-active minerals had already been discovered or at which radiometric anomalies were being investigated. The work thus included the already proved Rum Jungle field as well as the new prospects at Brodribb, Waterhouse, Edith River, and Coronation Hill.

A direct chemical test for uranium in soils was not used, the discovery of the radio-active areas being left to the sensitive ratemeters now in use. The close association between copper and uranium was used to advantage as it is present at many of the uranium prospects in the Northern Territory. It is a logical step to use the geochemical techniques to locate new copper mineralization, and then to carry investigations further by attempting to locate uranium in the vicinity of the copper, particularly in areas covered by deep soils where ratemeters are of no use.

A field test for cobalt, a metal aften closely associated with both copper and uranium, was developed, but of the many samples tested for this element only one gave a positive test. It is possible that the cobalt, an element which is extremely mobile in the oxidized zone, has been completely leached and dispersed from the radio-active minerals.

2. TECHNIQUES

The usual geochemical prospecting techniques, described by Debnam (1953), were applied in the present investigations. Both copper and lead were determined with dithizone, mostly on soil samples, although some rocks were collected where the soil results were disappointing. Filtering procedures were omitted due to contamination by the filter papers. The test solution was decanted after a settling period of 15-30 minutes.

The cobalt test was carried out as follows: 10 ml. of test solution was decanted into a 50 ml. stoppered cylinder and 2 ml. of a 0.1% solution of nitroso-R salt in water added from a burette; this was followed by the addition of 2 gms. of sodium or ammonium acetate and the whole mixture was then shaken. A brown colouration in the liquid indicated the presence of more than 1 p.p.m. of cobalt in the original sample. A red colouration was produced by amounts of cobalt in excess of 20 p.p.m.

3. AREAS INVESTIGATED

		No. of Sample
A. Brodribb	(a) Brodribb Anomalies	102
	(b) Ella Creek Anomalies	73
	(c) Fraser Anomaly	20
	(d) Bynoe Harbour Prospect	63
B. Waterhouse	(a) No.1. Prospect	88
	(b) No.2. Prospect	106
C. Edith River	(a) Tennysons 1F Anomaly	19
	(b) Regional Prospect	16
	(c) Miscellaneous Samples	20
D. South Alligator River	(a) Coronation Hill	164
	(b) Miscellaneous Traverses.	56
E. Rum Jungle	(a) Brown's Deposit	27
	(b) Mt. Fitch	208
	(c) Rum Jungle Creek	42
	(d) Power-Plant Anomaly	26
	(e) Railway Gossan	26
	Total Number of Samples	1056

4. RESULTS AND DISCUSSION

A. Brodribb.

Area	No. of Samples	Cu.	Positive Pb	Co	Negative
Brodribb Anomaly	102	0	0	0	102
Ella Creek Anomalies					
(a) grid	27	0	0	1	26
(b) costeans	46	0	3(rocks)	0	43
Fraser Anomaly	20	0	0	0	20
Bynoe Harbour	63	0	9	0	54
	258	0	12	1	245

The Brodribb area was the most unpromising of all the areas studied. All copper tests were negative and only twelve lead tests were positive. Of these the nine from the Bynoe Harbour Prospect were low and widely dispersed and of little interest. The three positive lead tests at Ella Creek were obtained on rocks from No.2 Costean and in the vicinity of a high radiometric anomaly (6000 counts/min. on a Ratemeter Type PRM 200). The soils, however, were negative. These lead results show some similarity to those obtained at Coronation Hill, although they are somewhat higher. It is possible that the lead is the end product of uranium or thorium disintegration and is not due to common lead minerals. Rock sampling in the Brodribb area may have produced some interesting lead anomalies.

It is probable that all the radiometric anomalies at Brodribb are due to the concentration of uranium or thorium in laterites at the surface. The laterites at the No.1 and No.2 drill sites at Brodribb are the end products of extensive leaching and weathering processes over prominent steeply dipping interbedded hematite slates and quartzites of the Brocks Creek Group, which form the resistant ridges in the area. Relict structures of the slate can be seen in the lateritic end product. The hematized slates contain brecciated quartz fragments and this type of lithology provides easy channels of access for the percolating solutions, which are active under the capillary and gravity forces involved in lateritization.

Sampling was restricted to the type of laterite just described i.e. the high level type, rather than to the extensive low level "laterite". The low level "laterite" is a conglomerate which has been deposited as river terraces by rivers of an earlier cycle and subsequently weathered under the present cycle to give the appearance of the ferruginous or laterite zone of the lateritic profile. Any mineralization found in the low level "secondary laterite" would be associated with the water-worn pebbles in the "laterite" and bear little relationship to the underlying formations.

If copper was originally associated with the extremely low-grade uranium mineralization then it has been removed by weathering processes and not concentrated in the laterites. When compared with the Rum Jungle Creek area, in which laterites exist and where extensive copper and lead anomalies in the soils are present, it is evident that the existence of copper mineralization in the Brodribb area is most unlikely.

In a discussion of the cycle of uranium, Rankama and Sahama (1949) mention that soluble uranium compounds are readily absorbed on the hydroxide gels of iron, aluminium, and manganese. This process would account for the concentration of uranium in laterite. Moreover, in comparing the large amount of secondary hematite at the surface to the small amount of pyrite below the water-table, it is evident that little primary uranium mineralization would have to be present to give high counts in the abundant hematite of the laterite at the surface.

B. Waterhouse.

Area	No. of Samples	Positive Cu	Positive Pb	Negative
No.1 Prospect	88	21	0	67
No.2 Prospect				
(a) grid	79	68	0	11
(b) traverse	27	0	0	27
	194	89	0	105

Two prospects, Nos. 1 and 2, were investigated in the Waterhouse area. The copper-uranium association was present in either case, either directly or indirectly.

The No.1 Prospect, a second order anomaly, consists of steeply dipping quartzites, slates and tuffs of the Brocks Creek Group. The copper mineralization occurs in the quartzites and the radio-activity is in the tuffs. The radio-active tuffs and the copper-bearing quartzites are separated by barren silicified slates. Although these rocks form a prominent ridge, laterites are absent, because of the homogeneous, compact and impervious nature of the beds and their resistance to weathering.

The No.2 Prospect was discovered by G.F. Joklik and it was not recorded as an anomaly by the airborne scintillometer. The copper mineralization is in the carbonaceous slates overlying the Minza Quartzite Breccia (Joklik, 1953a) of the Brocks Creek Group. The high radio-activity is associated with a hard carbonaceous-free section of the slate. No laterites are present over these rock types because they do not form prominent ridges, outcrops are poor, and their lithology is unsuitable for extensive leaching and weathering.

Results for the No.2 Prospect traverse, from which samples were collected along an E-W line situated on the northern side of the creek which crosses the northern end of the anomaly, indicated that the copper mineralization does not extend north of the creek. The copper anomaly appears to continue to the south, but further sampling would be required to indicate its extent.

Plans of the geochemical anomalies for each of these prospects are shown on Plates 1 and 2. The copper mineralization in each case is only low-grade at the surface. The very-high results shown on the plan for No.2 Prospect are due to the very thin soil cover in the vicinity and possible contamination from small pits in which malachite is exposed.

C. Edith River.

Area	No. of Samples	Positive Cu	Positive Pb	Negative
Tennysons 1F	19	0	0	19
Regional Prospect	16	12	0	4
Miscellaneous Samples	20	12	4	4
	55	24	4	27

A short time was spent at Edith River as the geological work was not sufficiently advanced to enable an indication of the areas, in which geochemical prospecting would be desirable. However, the results obtained on the samples tested were of interest to the geologists working in the area.

Tennysons 1F.

At this prospect radio-activity and minor uranium mineralization was present in narrow hematite-apatite breccias and sugary quartz veins, which occupy extensive shears in the Cullen Granite.

All 19 soil samples were negative with respect to copper and lead. A rock sample from the lode gave a medium copper test. The results were not surprising as the soils are derived from an easily weathered and coarse grained granite, and their porous nature would prevent the soluble metal salts being retained.

The area was not sufficiently interesting to warrant further geochemical testing.

Regional Prospect.

This prospect, situated about 2 miles south-east of the Yenberrie lode, consists of a broad N-W trending shear zone in the Cullen Granite and is near the eastern contact with the Brocks Creek sediments. The uranium mineralization (torbernite) and the copper mineralization (malachite-chalcocite) is present in siliceous lodes occupying the numerous shears and joints, especially at their intersections in the granite.

Samples from 4 points, 20 ft. apart, over the outcrop indicated low copper in the soils, but very high copper tests were obtained on the rock samples. Soils both above and below the outcrop, which is situated on the side of a hill, gave negative copper tests.

Many small radio-active anomalies (up to 900 counts/minute) were located in this area. Whenever the counts rose to 2X background, torbernite could be exposed in the rocks. Copper mineralization, in the form of malachite and chalcocite, occurred consistently within a few feet of the torbernite. This is another case of the close uranium-copper association met with in other areas. Unfortunately all the Edith River anomalies were too small to warrant further investigation.

Miscellaneous Samples.

Samples of rocks from outcrops in the country surrounding Edith River were brought in by the regional geologists and tested for copper, lead, and cobalt.

The most interesting samples were those from the Driffield Creek copper pits. A soil sample collected just north of the pit gave a low-medium copper and a medium-high lead test, results which are quite significant when considering a possible extension of the copper-lead lode. An extremely high lead test was obtained on a sample collected by N. Jones in tuffs of the Brock's Creek Group, 1½ miles N.W. of the Mt. Todd Battery. Further investigation and sampling of the area from which the rock was collected has been recommended.

D. South Alligator River.

Area			No. of Samples	Positive Cu	Positive Pb	Negative
Coronation Hill						
Costeans	(a)	soil	49	0	0	49
	(b)	rock	27	4	5	18
Grid	(a)	soil	63	15	0	48
	(b)	rock	18	0	10	8
Miscellaneous	(a)	soil	4	0	1	3
	(b)	rock	3	0	0	3
South Alligator River Traverse			27	2	4	21
South Alligator Hill Traverse			21	6	7	10
South Alligator Gorge Traverse			8	3	0	5
			220	30	27	165

The Coronation Hill investigations occupied most of the time spent at the South Alligator River. The three South Alligator traverses were an attempt at reconnaissance prospecting for copper and lead in the vicinity of Coronation Hill.

Coronation Hill.

The uranium (torbernite and autunite) and copper mineralizations (malachite and chalcocite) occur in separate areas on the steep northern slope of Coronation Hill. Coronation Hill is a prominent peak owing to the resistant nature of the Phillips Creek Sandstone capping and to the extensive silicification after faulting in the area. The abundant secondary uranium mineralization is present in an angular conglomerate and sheared tuff or rhyolites of uncertain age. These rocks outcrop high up the hill-slope and are unconformably overlain by the Phillips Creek Sandstone. At the base of the hill and separate from the uranium mineralization, chalcocite and malachite are associated with a quartz blow filling a shear.

The use of soil as a sampling medium on such a steep slope is rather questionable, there being many adverse factors which may prevent a surface expression of any mineralization which may be present. The most important factor is perhaps the considerable overburden of soil and rubble originating from barren rocks (the Phillips Creek Sandstone) further up the hill. It was considered that sampling of soils within one foot of the surface would be of little use and samples collected at depths below 3-4 feet would be more representative of the bedrock immediately beneath them. Soil samples were taken at all depths in the costeans but unfortunately all the results over the radiometric anomaly were absolutely negative with respect to copper and lead. It is thought, that reasonably extensive or high-grade copper mineralization, in intimate association with the uranium, would have been represented by a copper anomaly, even in the surface soils.

The negative results were rather surprising as it was known that some torbernite occurred with the main radio-active mineral autunite. Rock samples containing torbernite naturally gave positive copper tests with the dithizone, but even these results were not as high as expected. The problem resolves itself into five possibilities, each of which will be considered in turn. They are:

(a) there is insufficient torbernite to give detectable amounts of copper in the soils;

(b) the torbernite does not weather readily and the copper is then held back in the rocks;

(c) the torbernite weathers so rapidly that the copper has been completely removed from the soils;

(d) the dilute hydrochloric acid used for the extractions did not extract the copper from the torbernite; and

(e) too much dilution of soils from mineralized rocks by soil from barren rocks at higher levels.

(a) Insufficient torbernite. This may be the major factor causing the lack of positive tests. Radiometric assay results for the lode material were only in the range 0.1-0.15% U_3O_8. From hand specimens the amount of torbernite is estimated as less than one tenth that of autunite, i.e. there is less than 0.01% torbernite in the rocks. As copper constitutes only 6% of the torbernite the copper percentage of the rock is reduced to less than 0.0006%. During soil forming processes it is not likely that all this available copper would be incorporated in the soil and another 10% reduction is assumed. This leaves less than 0.0001% copper in the soil, provided the soil is derived from bedrock containing over 0.1% U_3O_8. With a maximum copper content of 1 p.p.m. in the soils an efficient extraction procedure would be necessary to indicate a copper anomaly. The "acid soluble" portion of the copper present may not be sufficient to produce positive tests with dithizone.

It is not surprising, from the above discussion, that the soils on Coronation Hill gave negative copper tests. In fact the results tend to indicate the advantages of the dithizone technique, in that it will not detect such low grade copper mineralization.

(b and c) Torbernite weathering. Uranium is generally considered to be a very mobile element in the weathering zone. It is not likely that torbernite would be so resistant to weathering, that it would be incorporated in the soil as the mineral, without decomposition taking place. Under some weathering conditions this could perhaps happen, but as acid conditions probably prevail at Coronation Hill it is more likely that weathering of the radio-active minerals has been extremely rapid, and with the heavy deluges of rain in summer the products have been quickly washed downhill. Most of the copper from the torbernite would thus be rapidly dispersed, making its detection in the soil almost impossible with the use of present field methods.

(d) Extraction medium. The geochemical tests were all carried out using 0.01N hydrochloric acid as extraction medium. This may not have been the most desirable acid and strength, and it was found that only traces of torbernite would dissolve in it. Better solution was obtained with 1N and concentrated hydrochloric acid, but even with these strengths positive copper tests were not obtained for the soils. Nitric acid, in which torbernite is more soluble, would have been more suitable. This acid, however, was not available.

Recent trends in geochemical prospecting techniques in America have been towards more vigorous extraction procedures than those used in the present survey. Owing to the insolubility of torbernite in dilute hydrochloric acid, it is evident that such procedures should also be adopted in some of the N.T. uranium areas. The simple acid extraction is particularly suitable for mineralization in which carbonates are predominant but inadequate when the mineralization is phosphate-rich (as at parts of Coronation Hill). This does not necessarily invalidate the present work in such areas as when the copper-uranium association occurs (other than as torbernite) the copper is normally present as carbonate and the dilute acid extraction procedure is applicable.

(e) Dilution by barren soils. Whenever mineralization occurs on the side of a hill there is dilution of the ore minerals in the soil derived from the mineralized rock by soil from the barren rocks (Phillips Creek Sandstone) above the mineralization. This dilution would be extensive at Coronation Hill, where the slope is very steep and where the barren rocks tend to form more soil than do the mineralized rocks. The negative copper tests at the surface may be due to this dilution factor, but it does not extirely account for the negative results for samples from deeper horizons.

Summarizing the above discussion, it is possible that the negative copper results obtained over the radiometric anomaly at

Coronation Hill were due, firstly to no copper minerals and insufficient torbernite in the zone of uranium mineralization, secondly to the rapid leaching of the small traces of copper, which may have reached the soils, and thirdly to the extensive dilution of soil from mineralized rock by soil from higher barren Phillips Creek Sandstone.

It must not be forgotten, however, that copper mineralization is present in the area, only 300 feet north of the known radioactive mineralization. Malachite exists at the surface in the vicinity of the quartz blow down-hill from the uranium deposit. This is another example of the persistent copper-uranium association, which occurs at most of the Northern Territory radio-active deposits. In this case the uranium and copper are not intimately associated at the surface as at White's Deposit, Rum Jungle.

The absence of an intimate copper-uranium association in the secondary mineralization may indicate the absence of a primary zone in the immediate vicinity. If the assumption that copper and uranium do accompany each other at the uranium deposits in the Northern Territory is correct, then the two deposits, Coronation Hill and Dyson's, may be explained by this theory. Drilling at each deposit has not revealed primary mineralization.

During the weathering of the primary copper-uranium orebody there will be a certain amount of fractionation of the copper and uranium minerals, but whilst primary mineralization is still present, the process will not be sufficiently selective to produce a complete separation. However, as soon as the original primary deposit has been completely weathered the secondary minerals will continue to separate and eventually a complete separation of uranium from copper minerals should be effected, due to their different behaviour to solvents and other weathering agents. Thus it could be possible to get a secondary uranium deposit in which copper minerals are absent even though they were present in the primary deposit.

The copper mineralization at Coronation Hill could have originated from the same primary sources as the uranium and have been concentrated by later processes. Plate 3 shows the position of the copper anomaly, which extends down-hill from the quartz-blow where copper minerals are exposed, and its relation to the costeans and shaft in which uranium mineralization was discovered.

When soil sampling failed to reveal the presence of a geochemical anomaly over the uranium deposit the sampling of rocks was undertaken. This was confined to the eastern side of the hill where the rocks, mainly tuffs or rhyolites and slates, have no soil cover. Of the 45 samples, 4 gave positive copper tests and 15 gave positive lead results. The weak lead anomaly which was indicated is shown on Plate 4. Whether this lead is related to any primary or secondary uranium mineralization, or neither, is a matter for conjecture. Molecular weight determinations may indicate that the lead is present in the form of the Pb206 and Pb207 isotopes, which are the end products of U238 and U235 disintegrations respectively. Rankama and Sahama (1949) state that these two lead isotopes are formed in the uranium disintegration and accumulate in the uraniferous minerals. If the lead were due to the mineral kasolite, $Pb. UO_2. SiO_4. H_2O$ or more common lead minerals, higher lead results would have been expected, although minute amounts of these minerals could be present.

Radiometric assays with a very sensitive type of Beta-Gamma Ratemeter were carried out on many of the Coronation Hill soil samples by geophysicist I.A. Mumme. Of the 46 samples tested 30 assayed less than 0.01% eU_3O_8, 8 were 0.01%, 6 were 0.02%, and one 0.04%. In every case the results greater than 0.01% were obtained on samples from the lower horizons of the costeans. These results tend to confirm the previous observations regarding dilution near the surface by barren soil from above and of rapid leaching of the minerals in the soil near the surface.

Lack of equipment and reagents prevented the development of a rapid field test for uranium. If necessary, laboratory work will be carried out on such a test before the next field season.

Soil sampling along three traverses was carried out in the vicinity of Coronation Hill, firstly as a test for reconnaissance geochemical prospecting and secondly, as an attempt to locate any extension or recurrence of the Coronation Hill mineralization.

South Alligator River Traverse. Twenty seven samples were collected at 100 ft. intervals from a traverse bearing 280° and along the northern flank of the western extension of Coronation Hill. The only two positive copper results were at the eastern end of the traverse and associated with the Coronation Hill copper mineralization. Four dispersed low lead results were not sufficiently interesting to warrant further investigation.

South Alligator Hill Traverse. This traverse was along the northern slopes of the ridges to the south-east of Coronation Hill. Twenty-one samples were collected at 100-200 ft. intervals. Six gave low copper tests and five gave low lead tests. The results indicate that mineralization near the tops of the ridges (fault rocks and slates) is unlikely.

South Alligator Gorge Samples. Eight grab samples were collected in a short gorge south-east of the eastern end of the Alligator Hill traverse, where extensive faulting occurs along the same trend as the faulting on Coronation Hill. Three low copper tests were obtained and further sampling was not warranted.

Although no significant results were obtained from these three traverses, they supplied some useful information on the method of approach for regional geochemical prospecting in this type of country.

E. Rum Jungle.

Area	No. of Samples	Positive Cu	Positive Pb	Negative
Brown's Deposit	27	19	24	3
Mt. Fitch	208	129	11	79
Rum Jungle Creek	42	29	25	11
Power Plant Anomaly	26	0	0	26
Railway Gossans	26	15	13	6
	329	192	73	125

Brown's Deposit.

Twenty-seven samples were collected from a traverse over this deposit to obtain some data on the prospecting criteria for the Rum Jungle area. The traverse was made approximately at right angles to the strike of the slate and limestone of the Brocks Creek Group embayment into the Rum Jungle Granite. Brown's Deposit is situated near the slate and limestone junction. Outcrops are poor at Brown's Deposit and the shale and limestone yield a thick red soil, which is ideal for geochemical sampling. The traverse was commenced at the point, where the old Rum Jungle road crosses the East Finnis River, bearing was 190° Mag., and sampling points were at 100 ft. intervals. Where possible two or more samples were collected from each hole, especially where the soils changed colour at depth.

As expected, large strong copper and lead anomalies were located. Although the surface is almost flat, with only a very gentle grade from the deposit to the East Finnis River, the copper anomaly extends for over 700 feet towards the river and the lead anomaly for over 800 feet. Such an extensive dispersion over a flat surface with deep soil cover could only indicate a large, reasonably high-grade copper-lead deposit. The lead results were consistently very-high in the anomalous zone, being of the same order as those obtained at Mt. Isa in 1952 (Debnam, 1953).

Mt. Fitch.

This area had already been thoroughly investigated by Territory Enterprises Pty. Ltd. and costeaning had been carried out along the limestone-slate contact (Brocks Creek Group), 600 feet west of the Mt. Fitch Granite contact. Laterites were absent over the slates and limestones which yield a thick deep chocolate coloured soil. Secondary detrital "laterite" occurs at a lower level to the west of the slates as a river terrace conglomerate. Once again sampling over this type of laterite was avoided, because they have no relationship with the underlying formations.

The costeans permitted easy and rapid sampling and samples could be collected from any level between the surface and bedrock (except in some limestone soils where costeans up to 17'6" deep did not expose bedrock).

The copper results, which are presented on Plate 5, are of particular interest. The positive tests extend around the limestone-slate contact and are at their maximum in the western section of the area.

The mineralization was thought to have been confined to the area between the slate-limestone contact and a silicified marker horizon not far from the contact, but the geochemical results indicate that copper mineralization may also occur in the vicinity of the low ridge to the west, which was not covered by the survey. Soils in this area are not very deep and the importance of the high copper results should not be over-estimated.

Copper mineralization may also occur outside the limestone in the eastern portion of the area. Malachite has been exposed in a shallow pit in the limestone soils. A traverse was proposed for this sector, but no time was available for the collection of the samples.

The few positive lead results were low and widely dispersed and of no interest in the interpretation.

Surface samples collected before costeaning over a newly discovered radiometric anomaly in silicified carbonaceous slates, gave negative copper tests, except for one low result 150 ft. south of the anomaly. However a rock sample taken from bedrock in No.9 costean gave a very-high copper result. Further work in costeans 7, 9 and 14 may prove of interest.

In general it was found that copper tended to concentrate near the surface of the deep brown soils derived from limestone, whereas over slates the copper results decreased from bedrock to the surface. However the decrease was not sufficient to prevent the use of surface samples for outlining the geochemical anomalies.

Rum Jungle Creek.

The anomaly at Rum Jungle Creek was first indicated by the airborne scintillometer, and in 1952 it was inspected by N.H. Fisher and R.S. Matheson, geologists of the Bureau of Mineral Resources.

The area, approximately 3 miles south of Mt. Fitch, is characterised by flat topography, with only one very low quartzite ridge standing above the general surface level. This ridge extends E-W just south of the E-W base line. Laterite was present at the lower levels in the area. The area was covered by a 100 ft. grid and detailed geophysical prospecting had disclosed three radiometric anomalies. Only one costean had been bull-dozed and the geochemical prospecting was carried out before further costeaning, so that samples could be collected from undisturbed soil.

Sampling was carried out along 3 traverses, all running E-W, along the 100N, 500S, and 1800S lines respectively, and passing over the previously discovered radiometric anomalies.

The results were most encouraging. Samples from the 100N traverse, along the northern side of the low ridge, gave both very-high copper and lead results. Copper tests varied from high at the eastern end, to very-high for 300 ft. west, then medium for another 300 ft. and very-high over the next 400 ft. west. The most western sample, at the N-S base line, gave only a trace of copper.

In the costean, which crossed the traverse at right angles east of the 100E peg, the copper results were somewhat lower, varying from medium to very-high. A sample of a mottled green rock from the costean and on the 100N line gave an extremely high copper test. Although green in colour, this rock was not expected to be the main source of the copper tests in the soil.

The lead results for the 100N traverse were consistently very-high along the entire 900 ft. of the traverse, and also in the costean. Both copper and lead results for this area are shown on Plate 6. No positive cobalt tests were obtained.

In general the results for the 100N traverse are of the same order as those obtained at Brown's Deposit, although there is no visible mineralization in the Rum Jungle Creek area. This may mean a more extensive high-grade deposit at depth and even if no surface indications are discovered, diamond drilling in this area should be warranted. However, with such high and consistent lead tests it should be possible to locate the source of the lead in the soils by costeaning.

The 500S traverse, on the southern slope of the low ridge already mentioned, extended from the N-S base line to the 700E peg. The positive copper and lead results did not persist as in the 100N traverse. Two very-high copper tests at the 300E and 700E pegs indicated the presence of copper, but all other samples were either low or negative. A weak lead anomaly was discovered at the western end of the traverse over a length of 300 feet, but all other lead tests were negative.

Samples from the 1800S traverse, from the N-S base line to 600W were entirely negative with respect to both copper and lead.

The area as a whole is of interest. There are three separate radiometric anomalies, one with which there is a definite copper and lead association, another with which some copper and lead may be associated, and the other at which both copper and lead are entirely absent. Results of costeaning and other work by T.E.P. geologists will be of geochemical interest.

Further geochemical prospecting should be carried out in this area to ascertain the extent of the copper and lead anomalies. This work should include a continuation of the 100N traverse both to the east and the west, an extension of the 500S traverse to the east, and at least one traverse bearing N-S, preferably through the 300E peg of the E-W base line.

Power-Plant Anomaly.

A strong self potential anomaly was discovered over the Finniss River, north of Brown's Deposit by the geophysicists, and geochemical testing was carried out to discover, whether the mineralization contained copper or lead. All 26 samples were negative with respect to these two metals on the SP anomaly was apparently due to the massive ferruginous outcrops in the area. The homogeneous, compact structure of the iron and the relict structures in the iron outcrop, probably represent extensive leaching and replacement of limestone.

Railway Gossan.

Twenty-six soil and rock samples were collected from a grid over a small outcrop of boxwork-type gossan situated on the west side of the road from Rum Jungle Siding to Mt. Fitch, about one mile from the siding. The area was recommended for testing by F. Frankovich.

The boxworks outcrop between sandy quartzites to the west and quartzites with interbedded brecciated hematized slates to the east. The boxworks are rhomb shaped and apparently represent the silicified relics of a calcite mosaic in a coarse, recrystallized limestone, interbedded with the predominant quartzite horizon.

The results indicated both weak copper and lead anomalies, which coincided with the outcrop. It is not likely that any of the boxworks are due to copper or lead sulphides in the original calcite.

CONCLUSIONS

Although the results of the geochemical prospecting were negative in some areas, they were far from disappointing, and in other areas they were most encouraging. It is interesting to observe that, wherever the geochemical results were entirely negative (e.g. Brodribb and Fraser Anomalies), no uranium minerals have yet been discovered, even after much intensive work by the geologists.

The copper-uranium association occurred at all the prospects where uranium had been discovered. In places, the association between copper and uranium minerals was intimate, whereas in others, several hundreds of feet separated the two types of mineralization. The theory is advanced by A.H. Debnam, that where an intimate association (other than as torbernite) is present, primary mineralization will be found to exist, but where several hundreds of feet separate the different occurrences only secondary uranium mineralization is present.

All known and newly discovered areas containing copper mineralization should be tested for radio-activity with ratemeters.

The results in the Rum Jungle area were particularly encouraging and the geologists of T.E.P. showed great interest in them. It was generally considered that this type of prospecting would be extremely useful for regional prospecting for copper, lead and uranium in this district.

A more suitable method of classifying the results should be developed to give them more of a quantitative significance. The system of denoting a result as a multiple of background (e.g. 8X) would be useful. It would then be possible to distinguish between two results at present designated as very-high, although one may be only 100X and the other 1000X background. A neater plan of the results, showing X background contours, would be evolved.

A direct method for uranium was not used in the present investigations, due mainly to lack of equipment, the copper-uranium-lead associations being relied upon to give the required uranium indications.

However, future work should include direct uranium methods. A fusion and fluorescence technique could be used for minute traces of uranium in soils or plants (Guttag and Grimaldi, 1951). Geobotanical techniques have recently been developed in the U.S.A. (Condon, 1953), and they show great promise.

Geochemical and geobotanical methods of uranium prospecting have two distinct advantages over the ratemeters, which are in use at present. Firstly, a thick soil cover, which is sufficient to prevent radio-activity reaching the surface, is ideally suited for geochemical prospecting. Secondly, the ratemeters cannot distinguish between uranium and thorium radiations, whereas the chemical methods identify the radioactive substance.

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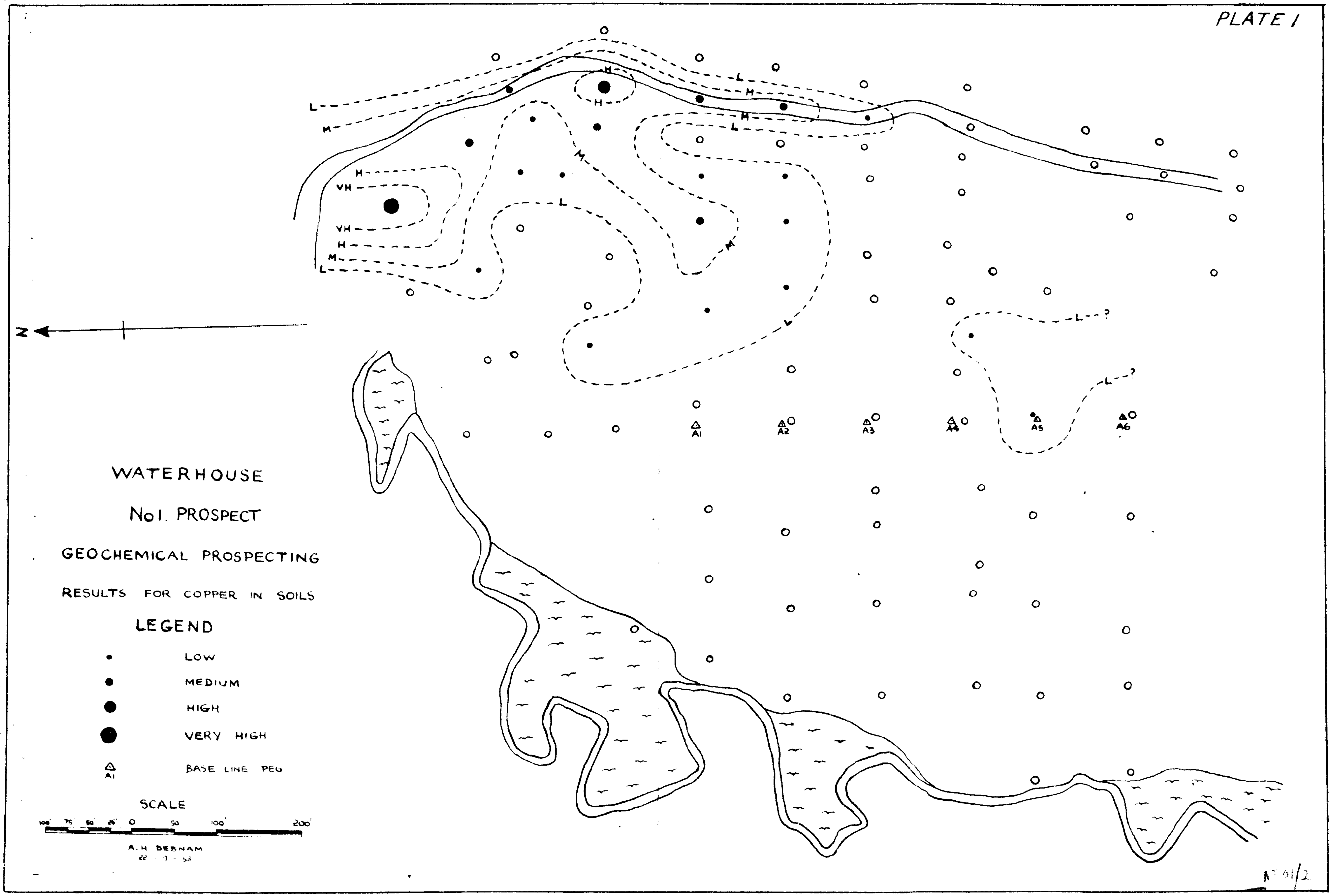


PLATE I
N
WATERHOUSE
No1. PROSPECT
GEOCHEMICAL PROSPECTING
RESULTS FOR COPPER IN SOILS
LEGEND
LOW
MEDIUM
HIGH
VERY HIGH
BASE LINE PEG
A1
SCALE
100' 75 50 25' 0 50 100' 200'
A. H. DEBNAM
L
M
H
VH
L-?
A1
A2
A3
A4
A5
A6

GEOCHEMICAL PLAN
WATERHOUSE URANIUM PROSPECT № 2

SCALE

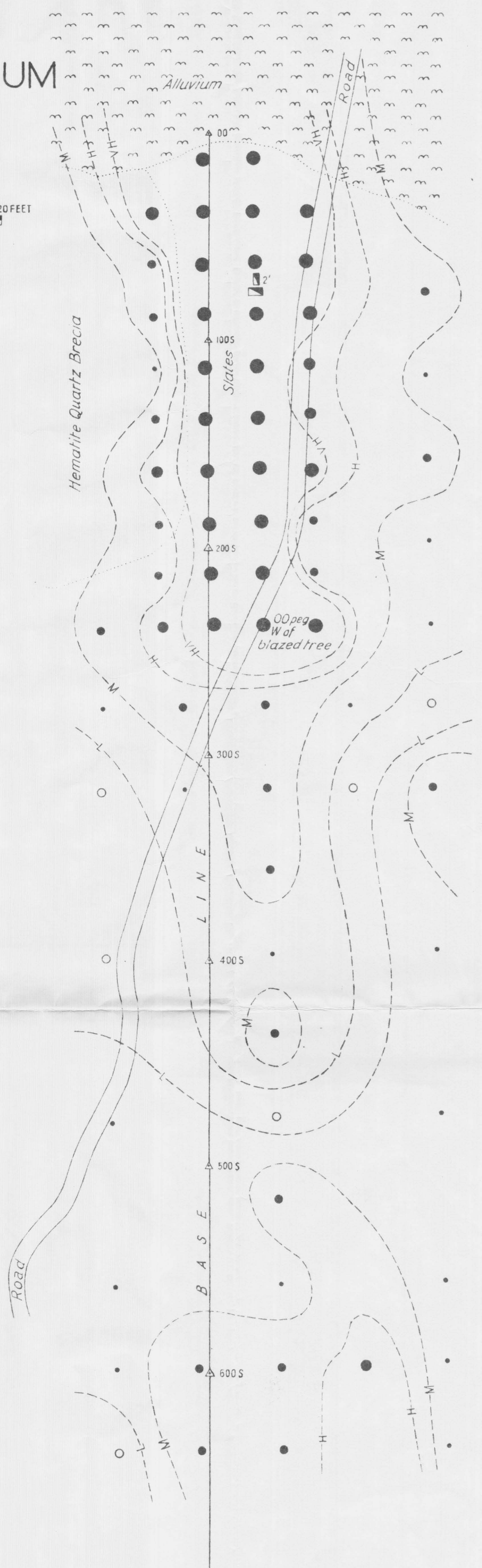
40 20 0 40 80 120 FEET

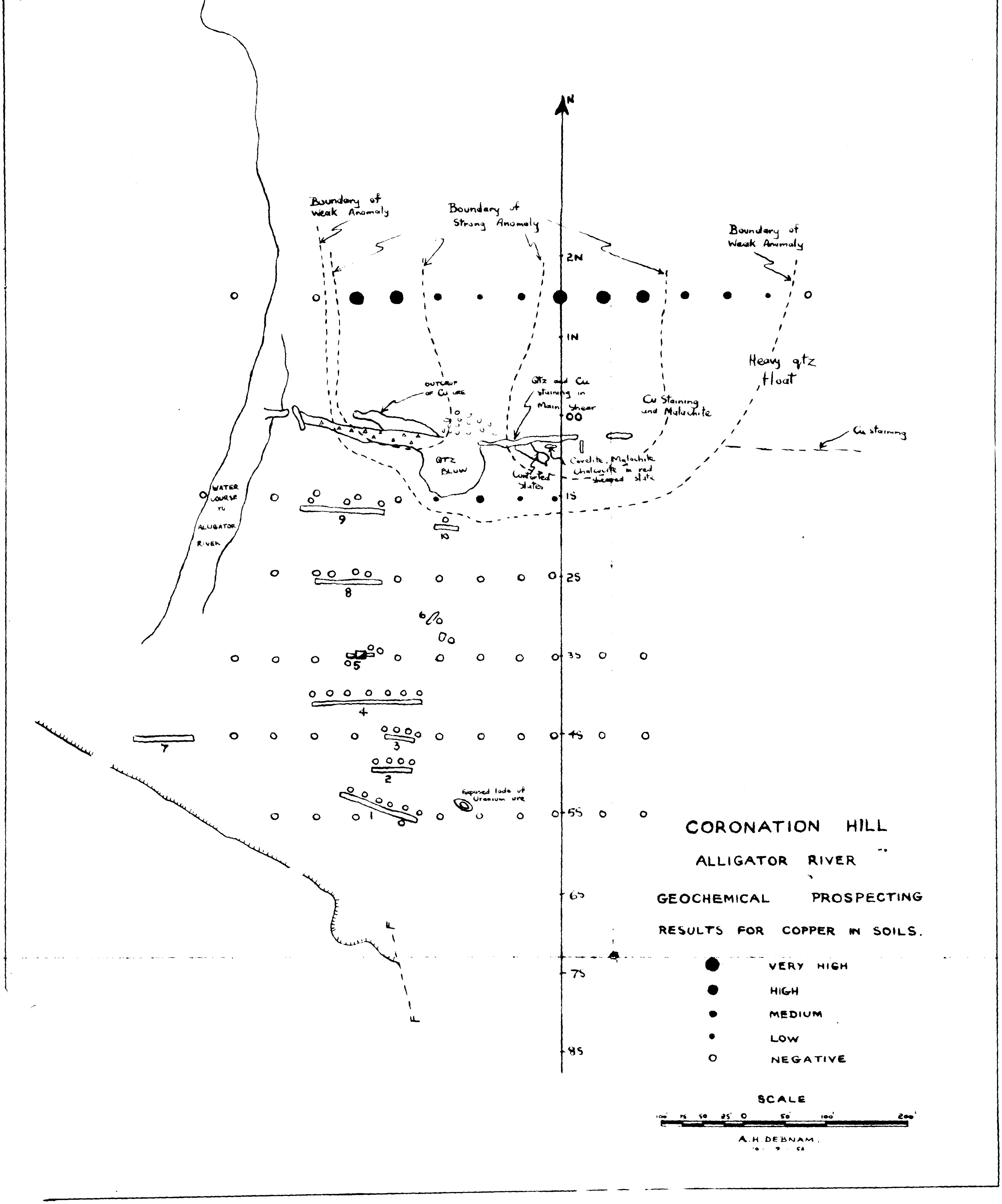
REFERENCE

Copper Results

○	O	*Negative*
•	L	*Low*
●	M	*Medium*
●	H	*High*
●	VH	*Very High*

True
4°30' Mag.





Boundary of Weak Anomaly
Boundary of Strong Anomaly
Boundary of Weak Anomaly
N
2N
1N
Heavy qtz float
OUTCROP OF Cu ORE
Qtz and Cu staining in Main Shear
Cu Staining and Malachite
00
Cu staining
QTZ BLOW
Contorted Slates
Covelite, Malachite Chalcocite in red sheared slate
WATER COURSE TO ALLIGATOR RIVER
1S
9
10
2S
8
6
3S
5
4
4S
7
3
2
Exposed lode of Uranium ore
1
5S
6S
7S
8S
CORONATION HILL
ALLIGATOR RIVER
GEOCHEMICAL PROSPECTING
RESULTS FOR COPPER IN SOILS.
VERY HIGH
HIGH
MEDIUM
LOW
NEGATIVE
SCALE
A.H. DEBNAM.

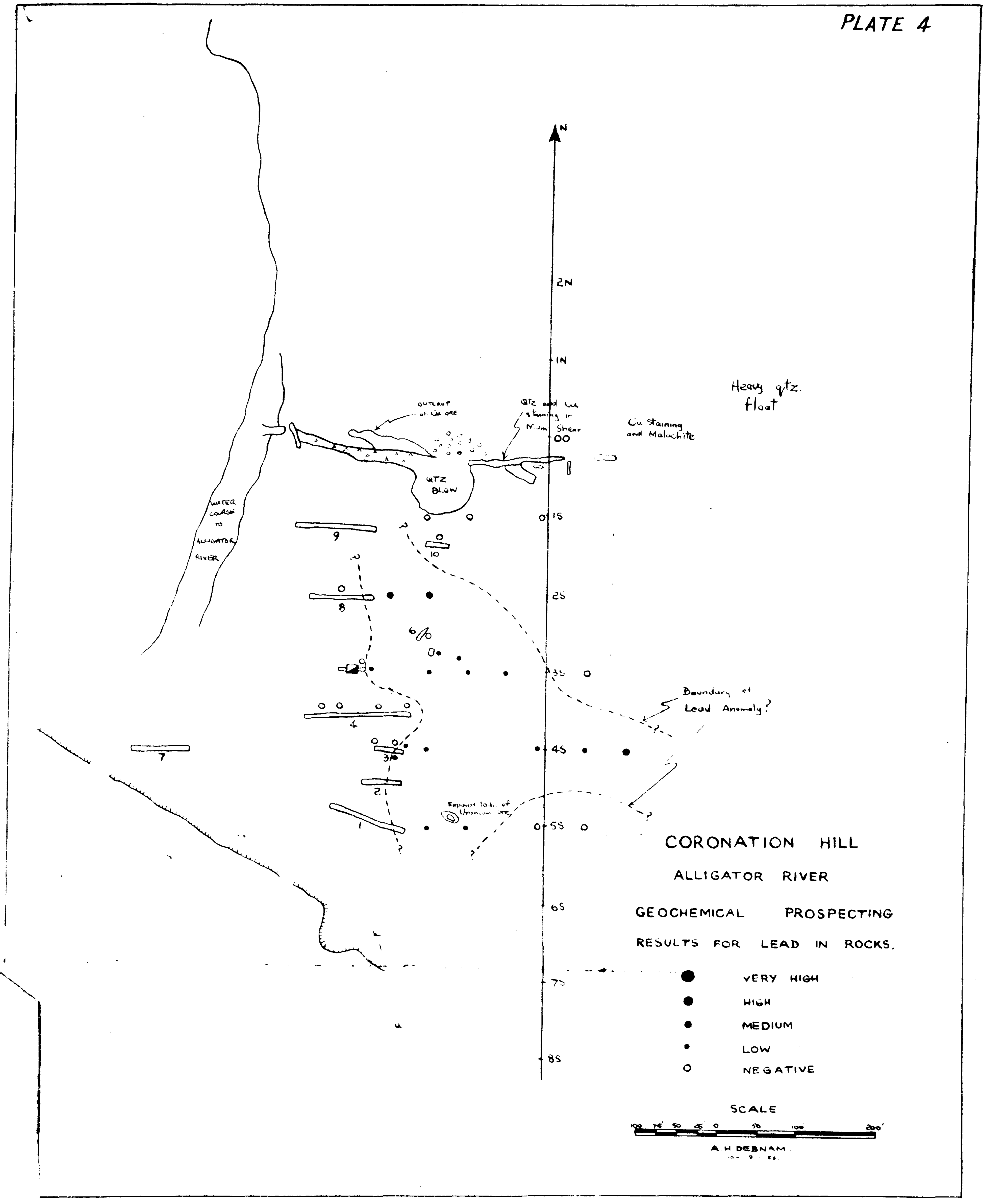


PLATE 4
N
2N
1N
00
1S
2S
3S
4S
5S
6S
7S
8S
OUTCROP of Cu ORE
QTZ and Cu staining in Mum. Shear
Cu Staining and Malachite
Heavy qtz. float
QTZ BLOW
WATER COURSE TO ALLIGATOR RIVER
Boundary of Lead Anomaly?
Exposed lode of Uranium ore
CORONATION HILL
ALLIGATOR RIVER
GEOCHEMICAL PROSPECTING
RESULTS FOR LEAD IN ROCKS.
VERY HIGH
HIGH
MEDIUM
LOW
NEGATIVE
SCALE
100 75 50 25 0 50 100 200'
A. H. DEBNAM.

PLATE 5

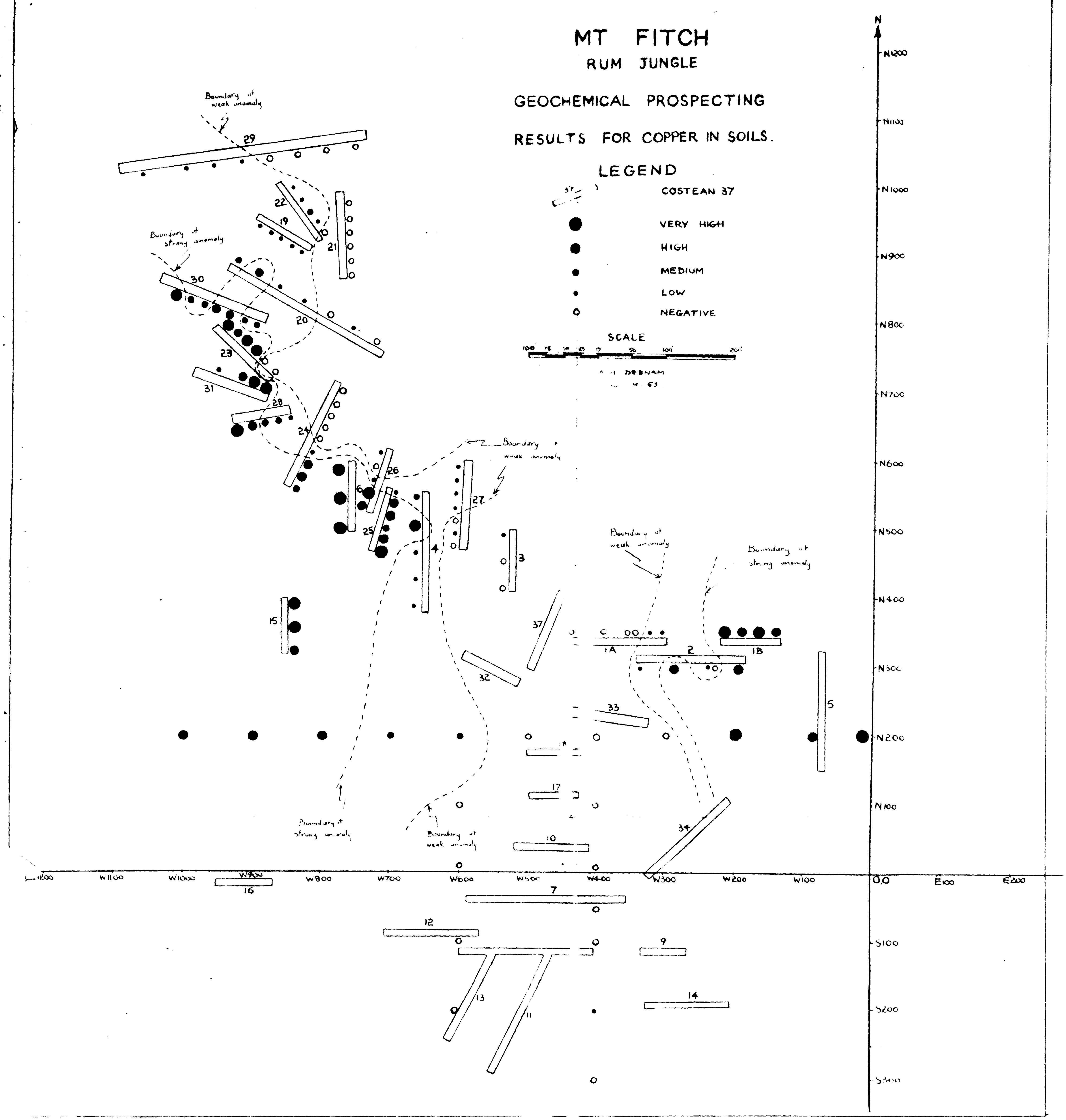
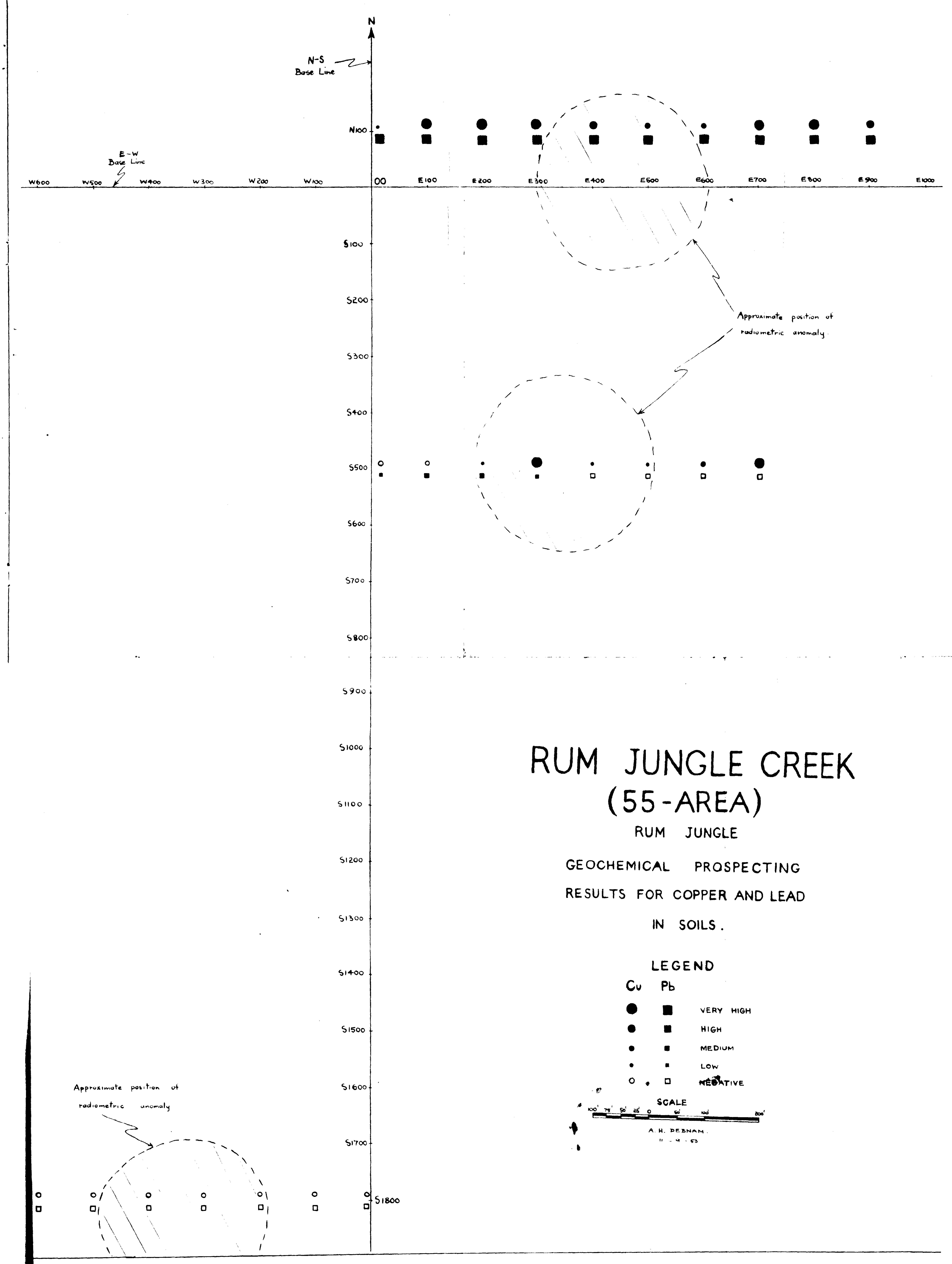

MT FITCH
RUM JUNGLE
GEOCHEMICAL PROSPECTING
RESULTS FOR COPPER IN SOILS.
LEGEND
COSTEAN 37
VERY HIGH
HIGH
MEDIUM
LOW
NEGATIVE
SCALE
Boundary of weak anomaly
Boundary of strong anomaly
N
N1200
N1100
N1000
N900
N800
N700
N600
N500
N400
N300
N200
N100
S100
S200
S300
W1100
W1000
W900
W800
W700
W600
W500
W400
W300
W200
W100
0,0
E100
E200

PLATE 6


N
N-S Base Line
E-W Base Line
N100
W600 W500 W400 W300 W200 W100 00 E100 E200 E300 E400 E500 E600 E700 E800 E900 E1000
S100
S200
S300
S400
S500
S600
S700
S800
S900
S1000
S1100
S1200
S1300
S1400
S1500
S1600
S1700
S1800
Approximate position of radiometric anomaly.
Approximate position of radiometric anomaly
RUM JUNGLE CREEK
(55-AREA)
RUM JUNGLE
GEOCHEMICAL PROSPECTING
RESULTS FOR COPPER AND LEAD
IN SOILS.
LEGEND
Cu Pb
VERY HIGH
HIGH
MEDIUM
LOW
NEGATIVE
SCALE
A. H. DEBNAM.