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BERYLLIUM TESTING AT TORRINGTON, NEW ENGLAND DISTRICT, NEW SOUTH WALES

by

D.O. Zimmerman and A.D. Haldane

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BERYLLIUM TESTING AT TORRINGTON, NEW ENGLAND DISTRICT, NEW SOUTH WALES

SUMMARY

Soil testing was carried out around three beryllium occurrences in the Torrington District of Northern New South Wales. Auger samples were obtained from the "B" soil horizon and were analysed spectrographically and by a field chemical method. Berylometer testing of the "A" soil horizon was carried out at some of the "B" horizon sample localaties. Beryllium dispersion was found to be fairly uniform in "A" and "B" horizons around Bollinger's deposit which contains the following beryllium minerals: beryl, phenacite, bromellite and milarite. However at Heffernan's deposit and Herbert's Prospect, which contain beryl as the only recorded beryllium mineral, dispersion is best developed in the "A" horizon, and it probably results from movement of discrete particles of beryl. Anomaly contrast was low and ranged from two to four times background.

INTRODUCTION

The increasing worldwide interest in beryllium, and the discovery of new types of beryllium deposits, suggested that beryllium prospecting techniques should be tested under Australian conditions. Most of the world's supply of beryllium has been, and still is, derived from the mineral beryl (14% BeO) typically found as large crystals in pegmatites. The minerals bertrandite and phenacite, both of which contain more than 40% BeO, have recently been found in large tonnage, low grade deposits, better suited to bulk-mining techniques than the beryl-pegmatite deposits (see Rowe, 1961). Phenacite was recognised by W.B. Dallwitz (1954) as one of the main constituents of a radioactive rock sample from Bollinger's Deposit, near Torrington, Northern New South Wales. As Torrington is reasonably close to Sydney and Canberra, and beryl has been reported from several localities in the district (Rayner, 1958), it seemed a good locality in which to test briefly the geochemical prospecting methods which had been developed overseas.

The survey was designed principally to study the dispersion of beryllium around known occurrences in the Torrington District, and to compare the various analytical methods. It was thought that weathering of phenacite and bertrandite might release beryllium in an ionic state which could result in greater geochemical dispersion than has been recorded around occurrences containing only beryl. Beryl is very resistant to weathering, and secondary dispersion by movement of fragments of the mineral might be expected to be found mainly in the upper, or "A", soil horizon. At Torrington, the beryllium content of the "A" horizons was measured using a berylometer, and "B" horizon samples were collected at the same localities. The latter samples were analyzed in the field by a chemical method and spectrographically in the Bureau of Mineral Resources laboratories in Canberra.

The survey was carried out in cooperation with representatives from the New South Wales Mines Department, and the Conzinc Rio Tinto of Australia Ltd.

The BMR survey party comprised A.D. Haldane (chemist), D.O. Zimmerman (geologist) and M.J. Dando (field assistant). It arrived at Torrington on 3rd April and departed on 16th April, 1962. The berylometer and operator, P. Macnamara, were made available through the courtesy of C.R.A. Ltd from 11th to 14th April inclusive. The New South Wales Mines Department was represented by D. Wynn and J. Ringiss, geologists, from 3rd to 11th April inclusive and C. Conaghan and K. Bunch, chemists, from 3rd to 5th April inclusive. The New South Wales Mines Department representatives provided invaluable assistance in locating various deposits in the area and in laying out grids and sampling at the various deposits examined.

PHYSICAL CONDITIONS EXISTING IN THE TORRINGTON DISTRICT

The Torrington District is situated on the south eastern corner of a granitic plateau known as the Mole Tableland, in the northern part of the New England area of New South Wales. The average elevation of the district is between 3000 and 3500 feet above sea level. The Atlas of Australian Resources (1953) classifies the local climate as subtropical highland with appreciable winter rainfall. The average annual rainfall is from 30 to 40 inches and the average temperature range from 85° maximum to 35°F minimum; frosts and light snow may be expected between April and October.

The vegetation is classified as temperate tree savannah and temperate woodland. Small (up to 100 yards square) open swampy areas are common throughout the district and springs and permanent flowing water are plentiful. Slopes in the area are usually quite gentle and streams are mostly swampy and sluggish except during times of flooding. The area is Crown Land, proclaimed as a mineral field.

The overall dense tree and grass cover, combined with the gentle slopes, greatly slows the movement of surface water and this should have a marked effect on the distribution and degree of movement of metals and minerals in the near-surface soils.

Allowance should be made for the rather special physical properties of the Torrington District in applying the results of this investigation to other parts of Australia.

GENERAL GEOLOGY OF THE TORRINGTON DISTRICT

Figure 1, adapted from Carne (1911) shows the generalized geology of the Torrington District. A large roof pendant of claystones, sandstones and conglomerates of Upper Palaeozoic age (Permian?) occurs north-west of Torrington, and this is surrounded entirely by granite of probable Upper Permian age. Small plugs and bosses of granite occur throughout the roof pendant, indicating that the present land surface is close to the roof of the batholith; the abundance of volatile constituents, such as fluorine and rare earths, and the presence of pegmatites and greisens in the area also indicates such a relationship.

The granite occurring throughout the area is medium to coarse grained, commonly porphyritic, and generally crops out as large boulders and as smooth rounded to almost flat slabs. Weathered surfaces are commonly slightly pinkish although when fresh the rocks are grey.

Alteration and mineralization are generally found near granite-sediment contacts, particularly where small bosses of granite intrude the sediments. Coarse topaz, biotite and chlorite are commonly present in these areas. Pegmatites are generally fine grained. Wolfram is probably the most common known ore mineral in the district although tin, molybdenum, fluorine, boron, beryllium, cerium (monazite), uranium and cobalt minerals appear to be widespread in varying amounts. Sulphides are known only in a few isolated localities, e.g., at Bismuth (Fig. 1).

Beryl Occurrences

Beryl was examined at the following localities: Bollinger's Deposit (also known as Blatherarm or Red Terror), Heffernan's Deposit, Wolfram Hill, Carter's Wolfram Deposit, the Bismuth Mine, Fielder's Hill and in the sediments approximately one mile north of Fielder's Hill, the western end of Smith's Mica Lode, and Herbert's Prospect. Beryl is also reported to occur at the Wild Kate Mine (Lawrence, 1961), and on a ridge half a mile south of Carter's Wolfram Deposit. (See Plate 1.)

METHODS OF SAMPLING AND ANALYSIS

Soil Sampling

As one of the aims of the survey was to obtain information on the dispersion of beryllium from the known occurrences, detailed grid sampling was used. The distance between sample points was either 50 or 100 feet depending on the site, and the grid was laid out using a tape and compass to establish the base line, and pace and compass for fixing sample points away from the base line. A total of 283 soil samples were collected from the "B" horizon approximately 12 inches below surface, by means of a 3" diameter soil auger.

Owing to the sluggish nature of the streams in the area, and the results of preliminary analyses which suggested that beryllium did not move far from its source through the soil profile, it was decided that the time available could be more profitably spent in examining the soils rather than stream sediments. Berylometer testing of a stream bed for almost half a mile downstream from Heffernan's lode confirmed this decision.

Berylometer Testing

The berylometer is adequately described in the literature (see Bowie et al, 1960). Briefly the instrument consists of an Sb_{124} gamma ray source and a neutron detecting ratemeter. When irradiated by gamma rays beryllium atoms emit neutrons which are registered on the ratemeter as counts per minute (cpm). The observed count rate is converted to concentration according to the following formulae:

$$\%\ BeO = \frac{(\text{counts per minute} - \text{background count})}{\text{roughness factor} \times \text{source strength}}$$

$$\text{or} \quad \%\ Be = \frac{(\text{counts per minute} - \text{background count})}{\text{roughness factor} \times \text{source strength}} \times \frac{9}{25}$$

The background count represents the number of counts per minute derived from cosmic sources and is measured by making a five minute count before the Sb_{124} source is placed in the instrument each day.

The roughness factor is a measure of the amount of sample surface in direct contact with the base of the berylometer. The following factors are recommended:-

Soil or sand	- 24
Surface with projections up to one inch high	- 19
Surface with projections up to two inches high	- 15

The base of the instrument is approximately one foot square and the range of detection extends down to about three inches. Thus if the berylometer is not in direct contact with the test surface the observed percentage of beryllium will be reduced.

Sb_{124} has a half life of 60 days, and when fully activated the source strength is 100 millicuries. This gradually decreases by radioactive decay but the strength on any particular date can be calculated provided the date when the source was fully charged is known.

Because of the radiation hazard, the radioactive source for the berylometer must be carried in a special source box, separate from the instrument when it is not in use, e.g., overnight or during long distance transport. Consequently the following stages must be carried out each day by the two man operating team before work commences:-

1. Unpack and assemble the berylometer - 3 to 5 minutes.
2. Switch on and allow to warm up - up to 5 minutes.
3. Take a background count of neutrons due to cosmic activity - 5 minutes.
4. Transfer the radioactive source from the source bod to the berylometer - 1 minute.

5. Transport the instrument to the first sample locality.
6. After arriving at each sample locality at least 30 seconds must be allowed for the instrument to settle down after bumps etc..
7. At each locality a count time of at least two minutes is necessary to obtain a reasonably accurate analysis. If one is concerned with very slight variations in beryllium content a longer count time would be desirable. In reconnaissance work where one is interested only in large variations in the beryllium content, a count time of half a minute could be sufficient. A two minute count was generally used at Torrington.

During the time the berylometer was available at Torrington, it was possible to test about 140 soil sample sites. At each of these a shovel was used to smooth over the soil surface to ensure maximum contact for the instrument. Because of the restricted range of the berylometer it tests only the "A" soil horizon including the humic layer, whereas the soil auger samples came from the "B" horizon at an average depth of 12" below surface.

Other material examined with the berylometer included several outcrops to determine the beryllium background in the country rocks, mine dumps and twelve localities in the drainage downstream from Heffernan's Deposit.

Chemical Analysis

Chemical analysis was carried out in the field. The procedure adopted was briefly as follows. After drying and careful grinding to a fine powder the sample was fused with ammonium fluoride following in detail the method given by Debnam and Webb (1960) up to the preparation of the acid extraction. At the time of the survey neither Beryllon II nor Nervanoid F were available in Australia and curcurmin was used as the colorimetric reagent. Ethylene diamine tetra-acetic acid and tri-ethanolamine were used as complexing agents and the system was buffered to pH = 10 with trisodium phosphate. A suitable aliquot of the acid extract was treated with complexing agent and buffer then curcurmin added and the colour matched immediately against standards prepared at the same time. The useful range was from 0 - 1.6 microgram Be and the detection limit equivalent to 0.5 ppm Be in the original sample.

The method was not particularly satisfactory under the conditions at Torrington. The ammonium fluoride flux had to be dried before use and rapidly absorbed moisture during the period of weighing and mixing with the sample so that considerable care was needed to prevent spattering in the early stages of the fusion. Ammonium fluoride fumes are evolved during the fusion and even in the open air present a considerable health hazard. Removal of the last traces of ammonium fluoride requires careful manipulation as it is thought that it is during this stage beryllium may become fixed in the insoluble residue leading to low results. This is considered to be largely responsible for the consistently low chemical values obtained when compared with the results of spectrographic analysis.

Spectrographic Analysis

The procedure adopted was one based on the visual comparison of spectral line blackening recorded photographically against prepared standard photographic plates. The spectrograph used was a Hilger large quartz Littrow instrument set to cover the wavelength range 3000 - 2300 A°. The spectral lines used and their corresponding detection limits are as follows:-

Be 2348 - 2 ppm, 2650 - 50 ppm.
Sn 2839 - 10 ppm.

Standard samples for the comparison plate were prepared by the addition of beryl and cassiterite to a suitable base, to give standard series containing 0, 2, 5, 10, 20, 50, 100 etc. ppm of beryllium and tin.

Samples were arced to completion in preformed graphite electrodes at 10 amps D.C. anode excitation, and the line intensities recorded photographically using a step weakener to give 100% and 10% transmission. This facilitates comparison of sample and standard line blackening.

The spectrographic technique requires the minimum of sample preparation, grinding and dehydrating at 400°C only, and gives the total metal content irrespective of its mode of occurrence in the sample. It is rapid, completely specific for the element concerned, and is a most satisfactory method of analysis for beryllium.

GEOLOGY AND SAMPLING PATTERN

The localities of the various deposits examined are shown in Fig. 1.

BOLLINGER'S DEPOSIT

Geology

No outcrops of the lode were visible at the time of the survey, but Rayner (1958) describes Bollinger's deposit as a "pegmatitic and greisenous lode", although small isolated outcrops of the typical unaltered granite of the area occur near the mine, and particularly along Blatherarm Creek. The granite exposures in the creek show evidence of deep weathering.

Rayner (op. cit.) notes that the lode contains wolfram, biotite, monazite, beryl, phenacite, bromellite, ?milarite, traces of fluorite, and secondary uranium minerals including torbernite. Small dumps of coarse-grained biotite riddled with beryl crystals were found west of the main shaft. Three areas bordering Blatherarm Creek near the mine have been sluiced for tin and some topaz was found in the alluvium.

Underground mapping by the New South Wales Geological Survey in 1955 showed the strike of the lode as 55°.

Sampling Pattern

Bollinger's deposit was the first area sampled, mainly because it was known to contain phenacite in addition to beryl. A base line was laid out along the strike of the lode and centred on the main shaft. Samples were then taken at intervals of 50 feet on traverses spaced 100 feet apart along the base line. The site was not ideal in some respects as the mine workings, representing the centre of mineralization, are located in the topographically lowest part of the grid. Moreover the dense vegetation and hence stable land surface in the area would also be expected to restrict dispersion.

HEFFERNAN'S DEPOSIT

Geology

Heffernan's wolfram deposit consists of a line of workings about 400 feet long, and striking at 25° across the crest of a low hill. Outcrops of granite and dense siliceous rock occur near the line of lode. Carne (1911, p.58) reports that the southern end of the workings contained "soft decomposed micaceous rock, with vugs containing quartz, felspar and mica crystal aggregates and occasional prisms of beryl"; this rock type was visible in the collapsed workings at the time of the survey. Carne also noted that the bulk of the wolfram won was from the southern end of the workings and it is interesting to note that an inspection of the dumps also showed that beryl crystals are abundant only in the central and southern part of the workings, where they are associated with the softer rock type referred to by Carne. Quartz prisms (rock crystal), muscovite, biotite, felspar, wolfram (ferberite?), beryl, tourmaline, topaz, and fluorite were found in the softer dump material. Much of the beryl is clear and approaches gem quality.

Sampling Pattern

Heffernan's deposit was particularly attractive for dispersion studies because the 'line of lode' occurs near the crest of a gently sloping hill. Furthermore, vegetation was relatively sparse allowing rapid gridding and sampling; beryl was abundant in some of the dumps. A grid was laid out on 50 foot centres with the measured base line corresponding to the principal slope direction, (see topographic section Plate 5).

HERBERT'S PROSPECT

Herbert's prospect was discovered by Mr. W. Herbert, resident of Torrington, in mid 1961. He sank a small pit where he had found some wolfram and small beryl prisms at the surface. The prospecting pit was deepened from 2'6" to 4 feet during the present survey to discover the configuration of the beryl-bearing rock. More beryl crystals were found lying on the surface downslope from the pit and in the soil profile exposed in the south face of the pit.

Geology

Several large rounded outcrops of unaltered porphyritic granite are situated close to Herbert's prospect but no outcrops of lode were found. The nearest known outcrop of sediments is more than a mile distant from the prospect. Beryl apparently occurs in a flat-lying zone of siliceous altered rock enclosed by weathered granite. The observed contacts between the two rock types are quite sharp. Some clay and massive topaz is present with beryl and quartz in the altered zone. Beryl was not found outside the original pit, except where it had been washed downslope along an old vehicle track. The flat zone of altered rock may represent late stage hydrothermal alteration along a flat joint plane near the roof of the batholith.

Sampling Pattern

A grid was laid out on 50 foot centres around the immediate area of the prospect. Berylometer testing was carried out and "B" horizon soil samples were analyzed spectrographically in Canberra. The results are plotted in Plate 8.

DISCUSSION OF RESULTS

The analytical results are summarised in Table 1, and are plotted on Plates 2 - 8. The results obtained by each analytical method have been classified into various concentration ranges and then expressed as a percentage of the total number of analyses for the deposit in question. This facilitates selection of background, threshold (upper limit of background), and anomalous values. At Bollinger's and Heffernan's deposits these values for the berylometer could be biased towards the anomalous side as a shortage of time demanded that the berylometer be used over areas which had given anomalous results by chemical analysis, e.g., at Bollinger's deposit, and over probably anomalous areas, i.e., downslope from known beryl occurrences at Heffernan's deposit. Despite this bias, the percentage of anomalous berylometer results at Herbert's prospect is much higher than at either of the other two localities tested. A similar distribution is not shown by the spectrographic results at Herbert's prospect, and this suggests that the anomalies occur mainly in the "A" soil horizon at this locality.

Whatever the method of analysis, the results have one feature in common in that the anomalies are all of very low contrast. Most of the anomalous results are from two to four times background, and several of the high results are on samples of dump material rather than soil. Another common feature is that the anomalous patterns are very irregular in shape and distribution around known beryllium occurrences; this could be caused by unequal distribution of beryllium minerals in the lode.

TABLE 1 - SUMMARY OF ANALYTICAL RESULTS

(a) Chemical analysis of "B" horizon soils

Deposit	No. of Analyses	Percentage frequency distribution				
		1-*	1	2	3-4	5+* ppm Be
Bollinger's	64	48.5	28	15.5	6	2
Heffernan's	74	31	47	14	5	3
		Background	Threshold		Anomalous	

* 1- less than 1
5+ 5 or greater than 5

(b) Spectrographic analysis of "B" horizon soils

Deposit	No. of Analyses	Percentage frequency distribution				
		10-	10	15-20	30	30+ ppm Be
Bollinger's	65	48	20	15.5	12.5	4
Heffernan's	188	44	30	23	2.5	0.5
Herbert's	36	56	36	8	-	-
		Background	Threshold		Anomalous	

(c) Berylometer analysis of "A" horizon soils

Deposit	No. of Analyses	Percentage frequency distribution			
		21-	21-30	31-50	51+ ppm Be
Bollinger's	42	41	45	12	2
Heffernan's	98	33	40	20	7
Herbert's	33	12	45.5	36.5	6
		Background	Threshold	Anomalous	

(d) Berylometer analysis of outcrops

Deposit	Average Be background	Range
Bollinger's	14.5 ppm.	12-18 ppm.
Heffernan's	16 ppm.	5-25 ppm.
Herbert's	18 ppm.	14-21 ppm.

(e) Spectrographic analysis of soil profile at Herbert's Prospect.

Sample interval and depth	Beryllium ppm.	Tin ppm.
2 - 5 in.	7	10
5 - 8 in.	10	10
8 -11 in.	20	n.d.
11-14 in.	20	10
14-17 in.	10	10
17-20 in.	5	n.d.
Average	12	

n.d. - not detected

Another feature is the difference between results obtained on the same samples by the spectrographic and chemical methods of analysis. This may be due to incomplete extraction of beryllium during the ammonium fluoride fusion used in the chemical method. If so these results may be worthless because the extraction may be inconsistent. However, at Bollinger's deposit, the anomalous area outlined by wet analysis corresponds roughly with that outlined by spectrographic analyses. Some of the differences in the results obtained by the two methods may be due to the nature of the distribution of beryllium in the samples. In all of the areas sampled, beryllium occurs in fragments of the mineral beryl; distribution of this mineral through the soil profile, and through a soil sample, might be quite haphazard. This situation may exist at Heffernan's deposit where the only recorded beryllium mineral is beryl. However, at Bollinger's deposit, several beryllium minerals are known to occur in addition to beryl. Weathering of these minerals may release BeO or Be into the soil profile, in which case there would be a much greater chance of the beryllium becoming fairly evenly distributed through the profile.

Another interesting feature is that at Bollinger's deposit analyses by all three methods revealed anomalous areas which are practically coincident. This implies that the dispersion pattern is roughly the same in the "A" and "B" soil horizons, which could be due to beryllium being present in a more mobile state than usual (see preceding paragraph).

The haphazard patterns and the low contrast of the beryllium anomalies suggest that a closely spaced grid pattern would be necessary in prospecting for beryllium in virgin areas. Moreover, in reconnaissance prospecting, even a small anomaly may be worth checking.

The results obtained at the individual deposits are discussed in turn below.

Bollinger's Deposit

The principal anomalous area is spread asymmetrically around the mine workings. The anomalous patterns in the "B" horizon are elongated in the direction of the strike of the lode whereas the berylometer anomaly ("A" horizon) is elongate slightly across the strike. Of the grid samples the highest results were obtained on a sample collected at the eastern end of the mine dump. A berylometer test on one of the dumps west of the main shaft recorded one percent Be. Most of the measurements on the western dumps ranged between 700 and 1800 ppm Be, whereas the dumps east of the shaft were of much lower grade and contain between 60 and 450 ppm Be. A small anomaly is outlined in the extreme south west corner of the grid by chemical analysis but it was not confirmed by spectrographic analysis. However berylometer analysis shows a slight high in this area and it warrants checking in any future work on the district.

The tin content of the "B" horizon samples was determined concurrently with beryllium by the spectrographic method, and the results are plotted in Plate 4. They show an anomalous area along the strike of the lode and marginal to the beryllium anomaly found in the centre of the grid. The tin distribution together with the old tin workings suggest a stanniferous zone surrounding Bollinger's lode. Thus tin may be useful as an indicator metal in geochemical prospecting in this area.

Heffernan's Deposit

The anomalous areas are outlined in Plates 5, 6 and 7. The principal anomalous areas are located around the central and southern portions of the workings on the line of lode. The berylometer also revealed a highly anomalous area in the alluvium along the creek north west of the workings. However this anomaly may be artificial as numerous crystals of quartz, topaz and beryl were found near the present surface of the alluvium bordering the creek; it is thought that this material was transported from the mine dumps to the creek for washing and screening during searches for gems. The distribution of the threshold and anomalous values determined by berylometer downslope from the central and southern parts of the line of lode show a broad and relatively even dispersion pattern which is considered to be due to the movement of particles of beryl in the "A" horizon. The anomaly patterns determined spectrographically are more scattered, but show little dispersion of beryllium away from the main lode. Chemical analyses of samples from Heffernan's deposit are incomplete but those available show some anomalies which do not correspond to anomalies found by spectrographic analysis. Berylometer analyses along the creek downstream from the grid area (see inset - Plate 5) show that there is practically no dispersion downstream. Berylometer analyses were made on all of the mine dumps along the line of lode. They showed that the central portion is richest in beryllium and that the northern group of workings contain little more than background quantities of beryllium. The highest value of 4100 ppm Be was recorded a few feet south of the sample locality containing 2450 ppm (see Plate 5).

The tin content of the samples from Heffernan's deposit was determined spectrographically but the results show no direct relation to the beryllium distribution in the area. Most of the area sampled showed less than 10 ppm of tin.

Herbert's Prospect

The spectrographic analyses show a low level of beryllium in the "B" horizon at Herbert's prospect, in contrast to the berylometer results which show anomalous values over much of the area tested, including downslope from the pits. This difference is also shown in the results obtained on soil samples from the south face of the pit (Table 1 (e)). At the surface immediately adjacent to the pit the berylometer gave a reading of 200 ppm Be and beryl crystals (excluded from soil profile samples) could be seen at the surface and in the upper soil profile. Yet the soil sample at 12" immediately below the site of the high berylometer reading gave only 15 ppm Be and the average value for the soil profile from 2" to 20" was 12 ppm Be. It is apparent that while the berylometer readily detects the beryl near the surface these crystals are not releasing beryllium to the surrounding soil either by mechanical or chemical weathering. Consequently soil samples show little or no evidence of the presence of beryl unless one or more of these relatively coarse crystals are included by chance in the samples.

In detail the frequency distribution of the spectrographic results at Herbert's Prospect is bimodal with modes of 5 and 10 ppm Be so that values of 20 and 15 ppm can be regarded as anomalous. However these values are extraordinarily small in relation to the obvious abundance of beryl.

Under the climatic and topographic conditions at Herbert's Prospect it can be stated that dispersion from beryl mineralization is negligible in the residual soil and only occurs by surface wash from outcropping sources. The berylometer results suggest that there may be several as yet undiscovered occurrences nearby which are similar to the one which has been tested by pitting.

CONCLUSIONS AND RECOMMENDATIONS

1. Beryllium dispersion is more uniform, and it may be more extensive, around complex beryllium deposits, i.e., those which contain complex Be minerals in addition to beryl.

2. Dispersion in soils around beryllium occurrences containing mainly beryl occurs mainly in the "A" soil horizon.

3. The three methods of analysis for beryllium in soils, viz., chemical, spectrographic and berylometer, all revealed beryllium anomalies in the vicinity of beryllium occurrences. The chemical method was not satisfactory and could not be recommended without further trials. The

spectrographic technique is simple, rapid and reliable but requires that samples be sent to a central laboratory for analysis. Because of the geochemical behaviour of beryl, sampling error could be significant where small samples are collected, as is usual for spectrographic analysis. The berylometer has the advantage of analysing a large sample (approximately 12" x 12" x 3") in situ, and thus it is not greatly affected by irregular distribution of beryllium in soils as small particles of beryl.

4. Beryllium anomalies in the Torrington District are of low contrast and values seldom exceed two to four times background values. Primary and dispersion haloes are limited, and a closely spaced grid (centres less than 200 feet apart) is necessary to locate them.

5. Soil sampling of the "A" horizon should be carried out at localities in the Torrington District which have already been tested by berylometer. These samples should be analysed spectrographically to provide a direct comparison with the berylometer results already obtained.

ACKNOWLEDGEMENTS

The authors would like to express their thanks to local residents who provided information about beryl occurrences in the district, and in some cases acted as guides; in particular W. Herbert, T. Toy, G. Gilbey, P. Finnigan and A. Potter deserve thanks.

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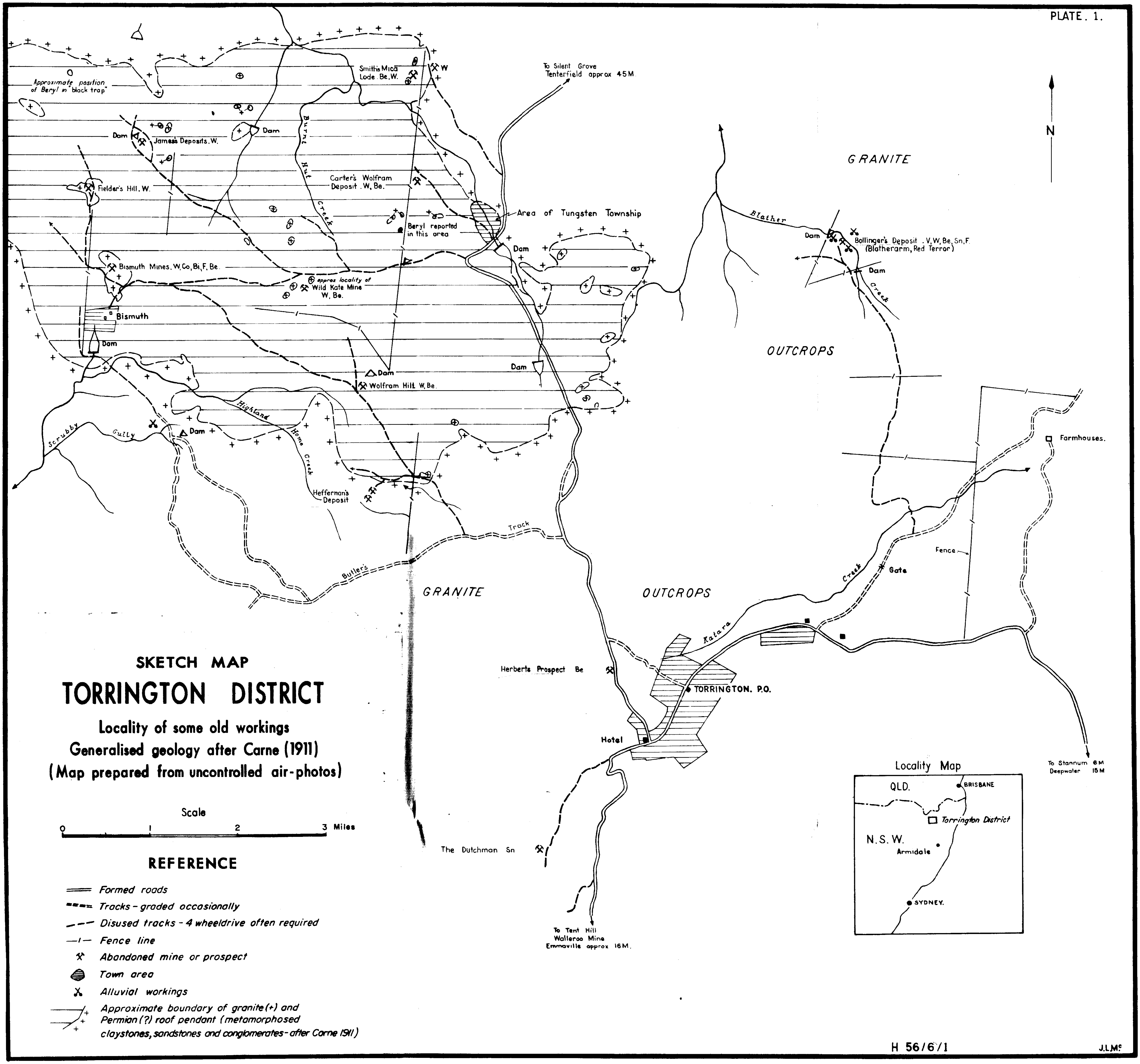
Fig. 1. Sluiced area at Bollinger's deposit, Blatherarm Creek, showing dense vegetation and small dumps of biotite-beryl rock near 44-gallon drum.

Fig. 2. Berylometer on dump beside pit at Herbert's Prospect.



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To accompany Record No.

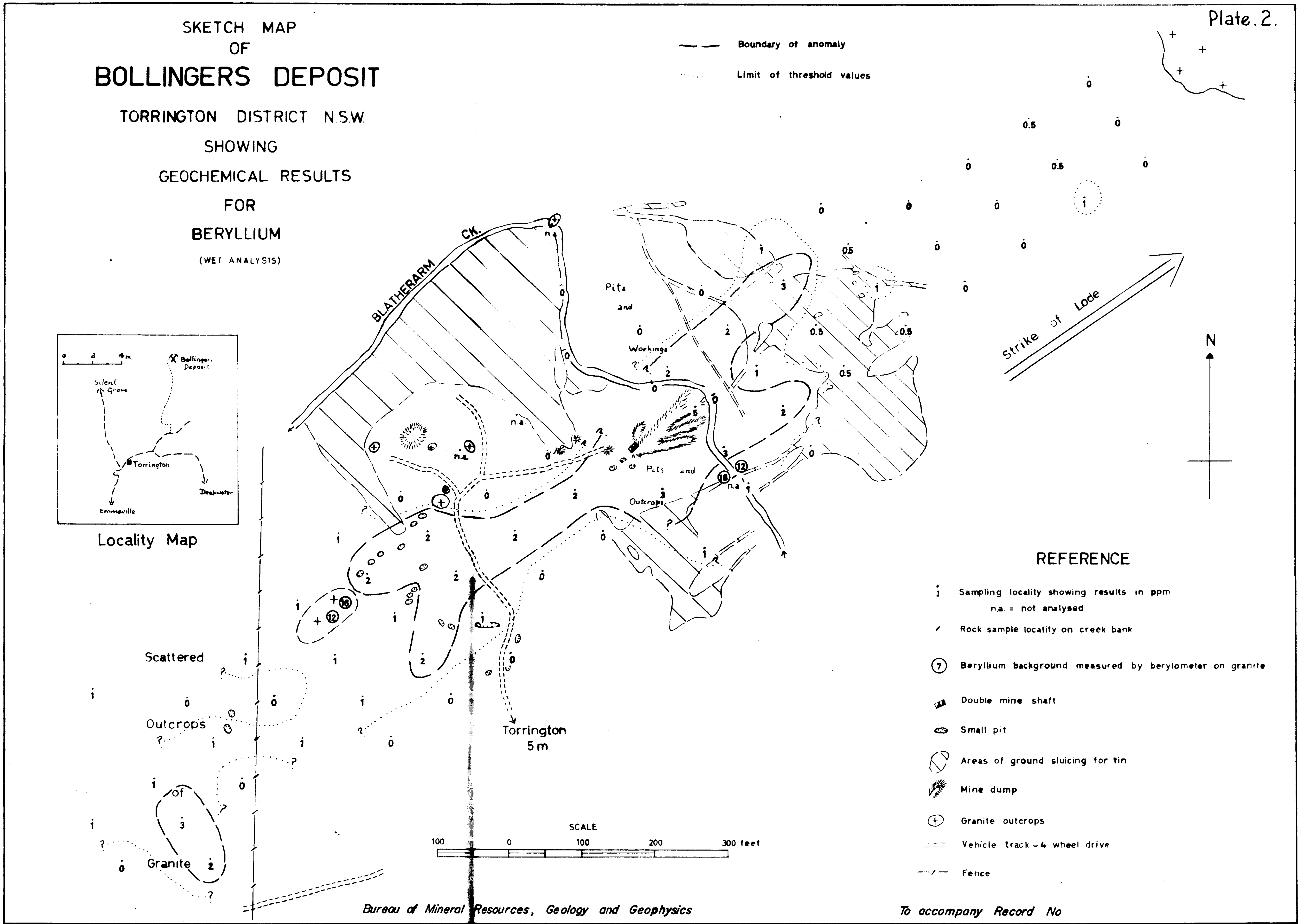


Plate. 2.
SKETCH MAP
OF
BOLLINGERS DEPOSIT
TORRINGTON DISTRICT N.S.W.
SHOWING
GEOCHEMICAL RESULTS
FOR
BERYLLIUM
(WET ANALYSIS)
Boundary of anomaly
Limit of threshold values
BLATHERARM CK.
Pits and Workings
Pits and Outcrops
Strike of Lode
N
Locality Map
Bollinger Deposit
Torrington
Emmaville
Deepwater
Scattered
Outcrops
of
Granite
Torrington 5 m.
SCALE
100 0 100 200 300 feet
REFERENCE
Sampling locality showing results in ppm.
n.a. = not analysed.
Rock sample locality on creek bank
Beryllium background measured by berylometer on granite
Double mine shaft
Small pit
Areas of ground sluicing for tin
Mine dump
Granite outcrops
Vehicle track - 4 wheel drive
Fence
Bureau of Mineral Resources, Geology and Geophysics
To accompany Record No

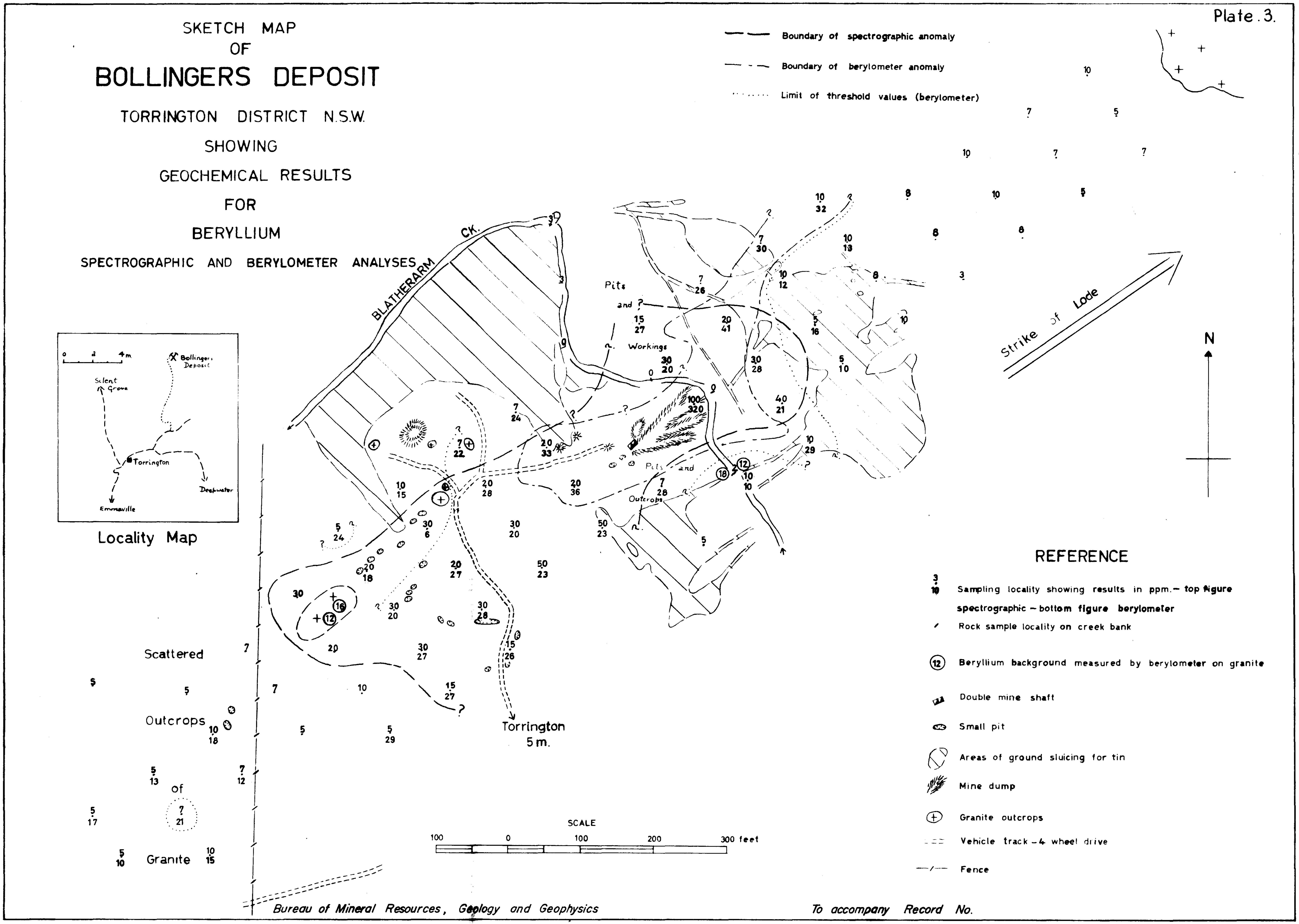


Plate. 3.
SKETCH MAP OF
BOLLINGERS DEPOSIT
TORRINGTON DISTRICT N.S.W.
SHOWING
GEOCHEMICAL RESULTS
FOR
BERYLLIUM
SPECTROGRAPHIC AND BERYLOMETER ANALYSES
Boundary of spectrographic anomaly
Boundary of berylometer anomaly
Limit of threshold values (berylometer)
BLATHERARM CK.
Pits and
Workings
Pits and
Outcrops
Strike of Lode
N
Locality Map
Bollingers Deposit
Silent Grove
Torrington
Deepwater
Emmaville
Scattered
Outcrops
of
Granite
Torrington 5 m.
SCALE
100 0 100 200 300 feet
REFERENCE
Sampling locality showing results in ppm.– top figure spectrographic – bottom figure berylometer
Rock sample locality on creek bank
Beryllium background measured by berylometer on granite
Double mine shaft
Small pit
Areas of ground sluicing for tin
Mine dump
Granite outcrops
Vehicle track – 4 wheel drive
Fence
Bureau of Mineral Resources, Geology and Geophysics
To accompany Record No.

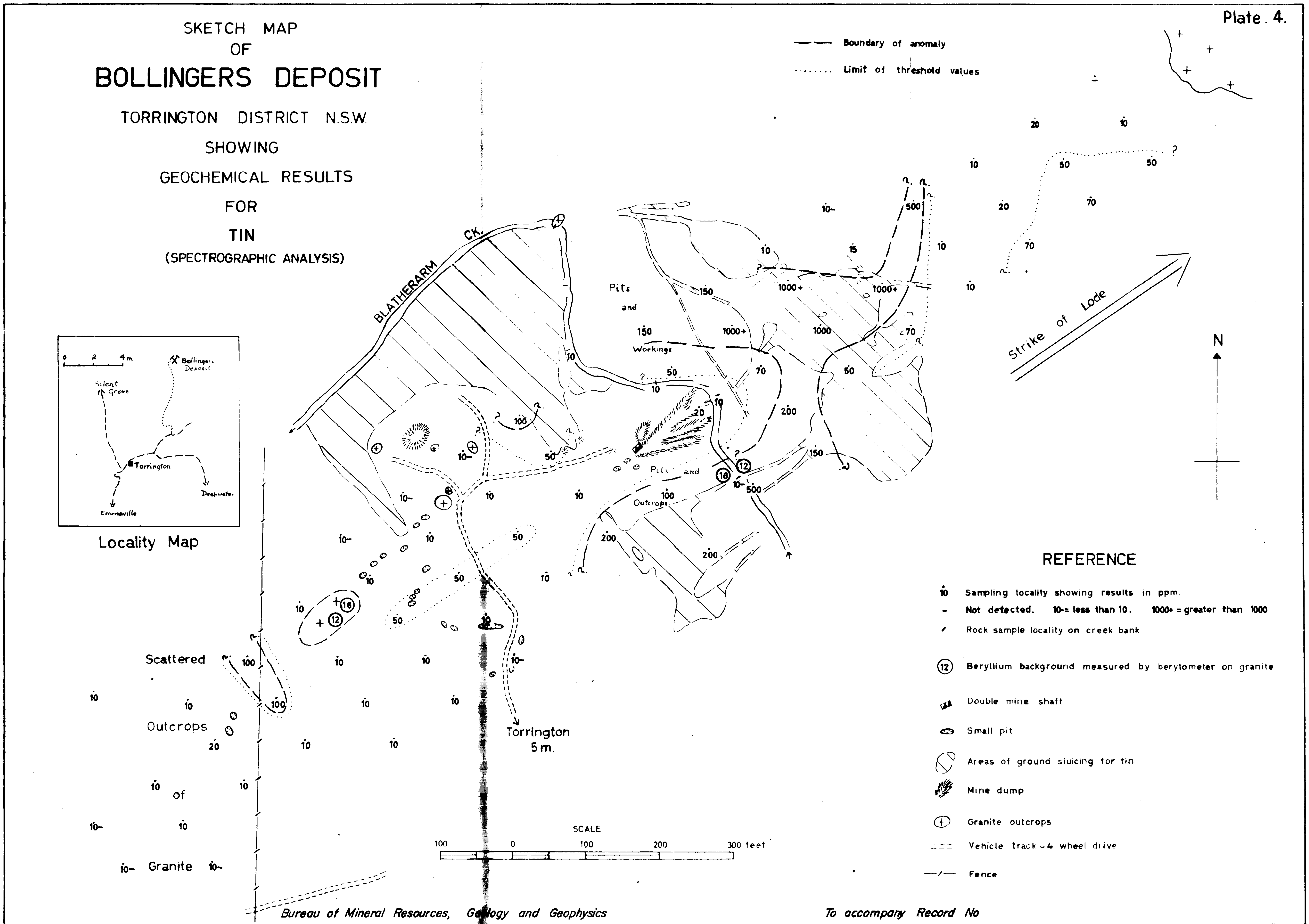


Plate. 4.
SKETCH MAP
OF
BOLLINGERS DEPOSIT
TORRINGTON DISTRICT N.S.W.
SHOWING
GEOCHEMICAL RESULTS
FOR
TIN
(SPECTROGRAPHIC ANALYSIS)
Boundary of anomaly
Limit of threshold values
BLATHERARM CK.
Pits and Workings
Pits and Outcrops
Strike of Lode
N
Locality Map
Bollingers Deposit
Silent Grove
Torrington
Deepwater
Emmaville
Scattered Outcrops of Granite
Torrington 5 m.
SCALE
100 0 100 200 300 feet
REFERENCE
Sampling locality showing results in ppm.
Not detected. 10- = less than 10. 1000+ = greater than 1000
Rock sample locality on creek bank
Beryllium background measured by berylometer on granite
Double mine shaft
Small pit
Areas of ground sluicing for tin
Mine dump
Granite outcrops
Vehicle track - 4 wheel drive
Fence
Bureau of Mineral Resources, Geology and Geophysics
To accompany Record No

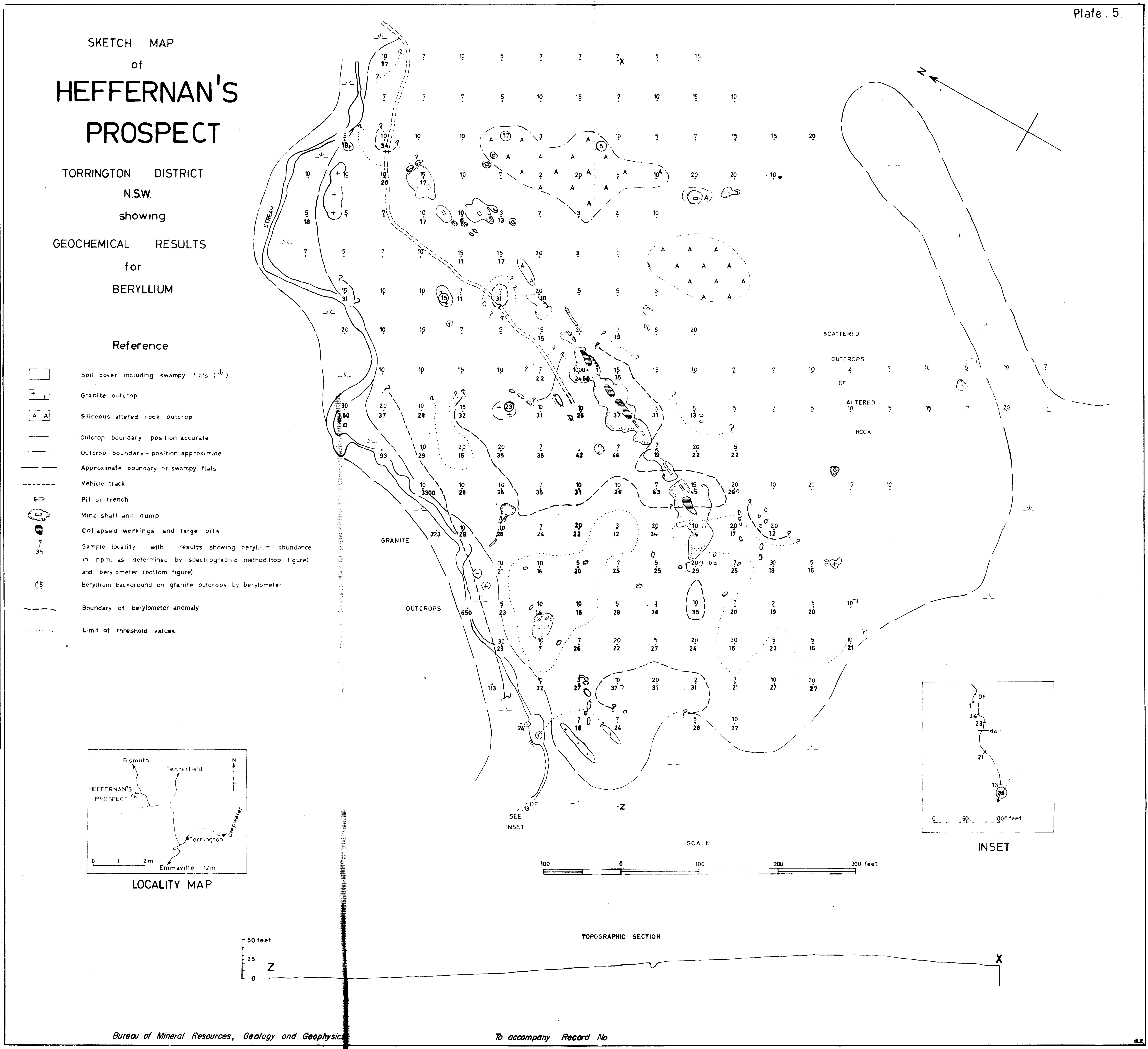
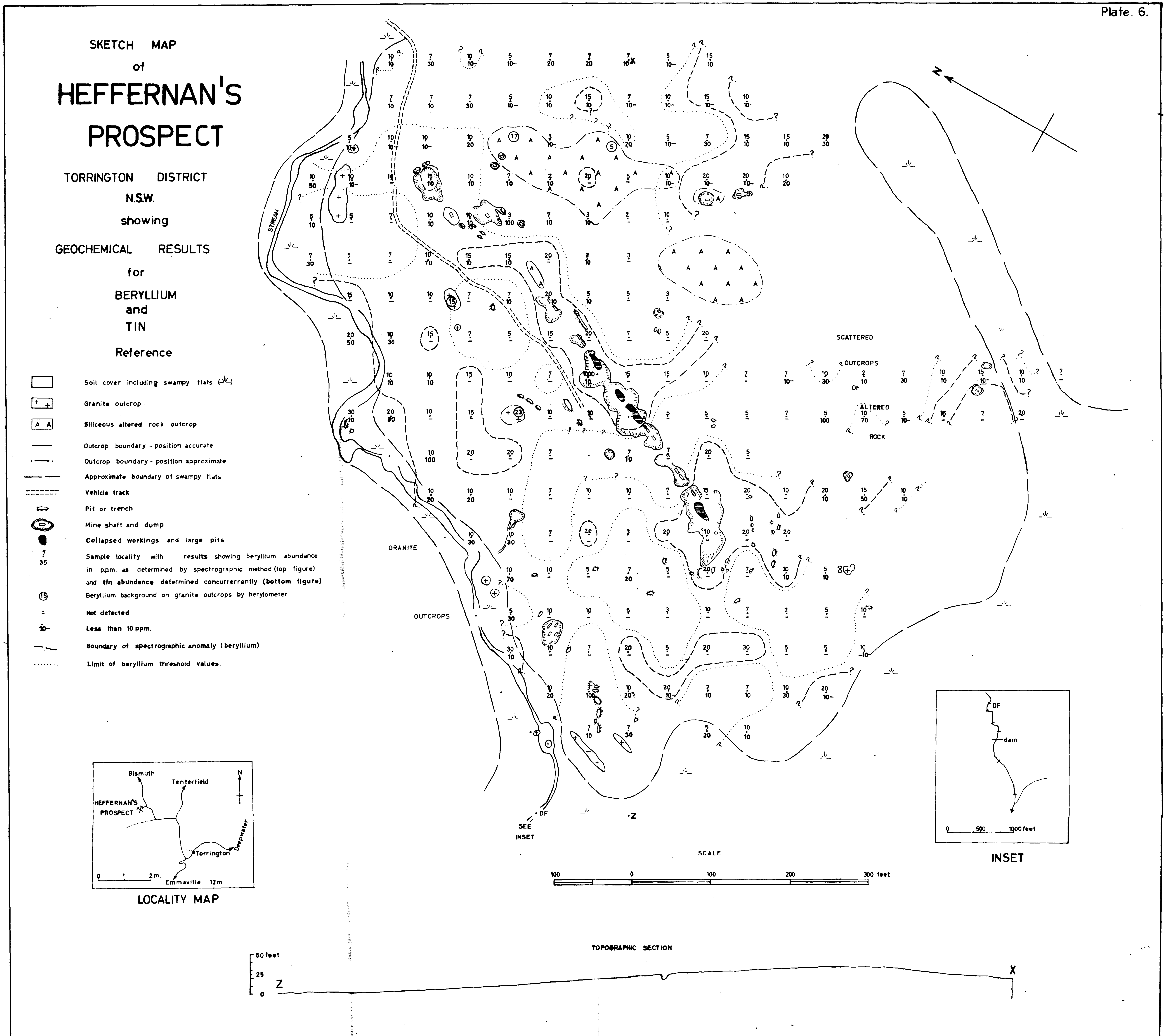


Plate . 5.
SKETCH MAP
of
HEFFERNAN'S
PROSPECT
TORRINGTON DISTRICT
N.S.W.
showing
GEOCHEMICAL RESULTS
for
BERYLLIUM
Reference
Soil cover including swampy flats
Granite outcrop
Siliceous altered rock outcrop
Outcrop boundary - position accurate
Outcrop boundary - position approximate
Approximate boundary of swampy flats
Vehicle track
Pit or trench
Mine shaft and dump
Collapsed workings and large pits
Sample locality with results showing beryllium abundance in ppm. as determined by spectrographic method (top figure) and berylometer (bottom figure)
Beryllium background on granite outcrops by berylometer
Boundary of berylometer anomaly
Limit of threshold values
STREAM
GRANITE
OUTCROPS
SCATTERED OUTCROPS OF ALTERED ROCK
SEE INSET
SCALE
100 0 100 200 300 feet
INSET
DF
dam
0 500 1000 feet
Bismuth
Tenterfield
HEFFERNAN'S PROSPECT
Torrington
Deepwater
Emmaville 12m.
0 1 2m
LOCALITY MAP
TOPOGRAPHIC SECTION
50 feet
25
0
Z
X
Bureau of Mineral Resources, Geology and Geophysics
To accompany Record No

Plate. 6.



Bureau of Mineral Resources, Geology and Geophysics *To accompany Record No.*

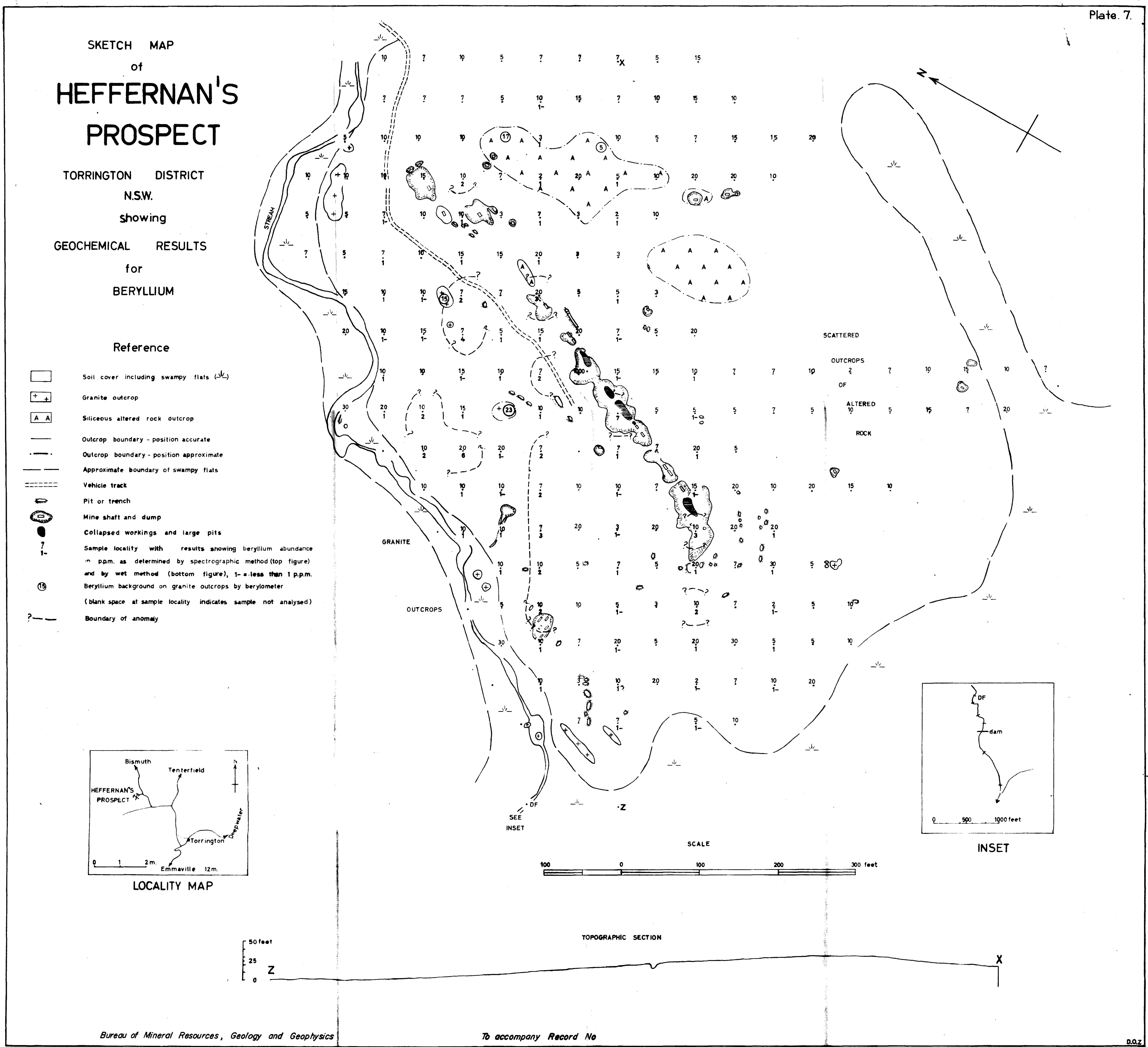
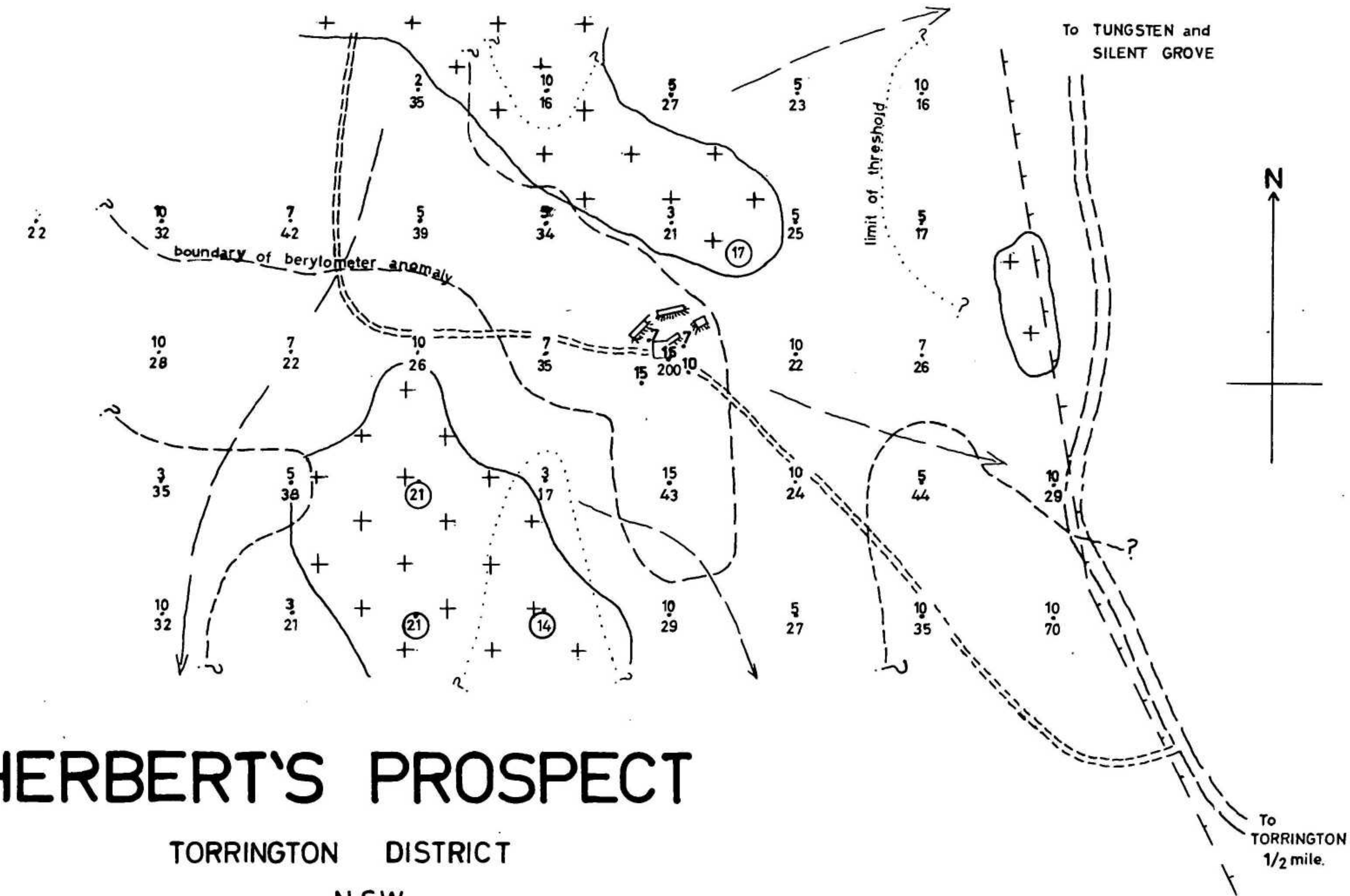


Plate. 7.
SKETCH MAP
of
HEFFERNAN'S
PROSPECT
TORRINGTON DISTRICT
N.S.W.
showing
GEOCHEMICAL RESULTS
for
BERYLLIUM
Reference
Soil cover including swampy flats
Granite outcrop
Siliceous altered rock outcrop
Outcrop boundary - position accurate
Outcrop boundary - position approximate
Approximate boundary of swampy flats
Vehicle track
Pit or trench
Mine shaft and dump
Collapsed workings and large pits
Sample locality with results showing beryllium abundance in p.p.m. as determined by spectrographic method (top figure) and by wet method (bottom figure), 1- = less than 1 p.p.m.
Beryllium background on granite outcrops by berylometer
(blank space at sample locality indicates sample not analysed)
Boundary of anomaly
STREAM
GRANITE
OUTCROPS
SCATTERED
OUTCROPS
OF
ALTERED
ROCK
N
SEE
INSET
DF
Z
X
SCALE
100 0 100 200 300 feet
INSET
DF
dam
0 500 1000 feet
LOCALITY MAP
Bismuth
Tenterfield
HEFFERNAN'S
PROSPECT
Torrington
Deepwater
Emmaville 12m.
0 1 2 m.
N
TOPOGRAPHIC SECTION
50 feet
25
0
Bureau of Mineral Resources, Geology and Geophysics
To accompany Record No
D.O.Z.

Plate. 8.



HERBERT'S PROSPECT

TORRINGTON DISTRICT

N.S.W.

showing

GEOCHEMICAL RESULTS

for

BERYLLIUM

SCALE

50 0 50 100 150 200 feet

Reference

5 / 10 — Geochemical sample locality showing spectrographic analysis (top) and berylometer analysis (bottom)

(24) — Beryllium background in ppm as determined by berylometer on granite outcrops

Granite outcrop with boundary

Pits

Road

Vehicle track

Telegraph line

Drainage direction

Bureau of Mineral Resources, Geology and Geophysics

To accompany Record No

d.o.z.