# BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS



## RECORD

RECORD 1978/17

## STREAM-SEDIMENT GEOCHEMISTRY OF THE FORSAYTH 1:100 000 SHEET AREA, NORTH QUEENSLAND

by

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## Maps - not included (see below)



(Note: The above maps may be purchased from BMR, price $1.50 per sheet).

## SUMMARY

A helicopter-based stream-sediment survey of the Forsayth 1:100 000 Sheet area was undertaken in 1974 to delineate broad areas where subsequent detailed exploration should be concentrated and to establish a sound geochemical framework on which to base any future work.

A total of 1217 minus 180 Um samples were collected at a density of about 1 per 2.5 $km^2$ and analysed for arsenic, barium, beryllium, bismuth, cerium, chromium, cobalt, copper, fluorine, iron, lead, lithium, manganese, nickel, niobium, rubidium, silver, sulphur, thorium, tin, titanium, tungsten, uranium, y trium, and zinc.

The results of the survey can be conveniently presented as a series of 5 computer-drafted maps incorporating the following combinations of elements: copper, cobalt, nickel; copper, lead, zinc; uranium, cerium, thorium; uranium, arsenic, bismuth; tin, niobium, tungsten.

Cobalt and nickel values indicate that the majority of copper anomalies within the area are derived from basic igneous rocks. Very few of the copper, lead, and zinc anomalies discovered are considered worthy of follow-up work, and the presence of large syngenetic base-metal deposits or porphyry copper mineralisation in the Sheet area seems unlikely.

Most high uranium values are associated with anomalous cerium and thorium, and this suggests that detrital monazite is the cause. Enrichments of arsenic and bismuth indicate that some uranium anomalies may have economic potential, however. In the southwest corner of the Sheet area high uranium values are associated with anomalous arsenic, bismuth, tin, and tungsten. Although this area is occupied by Siluro-Devonian Robin Hood Granodiorite, any mineralisation present probably occurs in veins and alteration zones related to Carboniferous igneous activity.

An area of some 40 $km^2$ in the central part of the Newcastle Range is enriched in tin, uranium, bismuth, and to a lesser degree, niobium and tungsten. In addition, there are 3 large areas to the east, north, and northwest of the central zone which are, except for a slight copper enrichment in the eastern area, anomalous only in tin. All 4 zones are associated with rhyolite of the Newcastle Range Volcanics. Clearly large tracts have been permeated by tin and uranium-bearing solutions and the possibility that these have produced large stockwork deposits should not be overlooked.

## INTRODUCTION

### Area of investigation

The Forsayth 1:100 000 Sheet covers an area of slightly less than 3000 km$^2$ bounded by longitudes 143°30' and 144°E and latitudes 18°30' and 19°S (Fig. 1). The town of Forsayth is 300 km southwest of Cairns and lies in the northwest corner of the Sheet area. Gravel roads connect Forsayth with Georgetown 40 km to the north and Einasleigh 70 km to the east. A good bitumen road links Georgetown and Cairns.

### Object of investigation

In 1972 the Bureau of Mineral Resources (BMR) and the Geological Survey of Queensland (GSQ) commenced a detailed investigation of the geology and mineral deposits of the Georgetown Inlier. Geological, geophysical, and geochemical data are being collected so that a better understanding of the distribution, controls, and surface expression of the mineral deposits will facilitate future mineral exploration in the area.

The Forsayth 1:100 000 Sheet area was mapped geologically in 1973-4 (Bain, Withnall & Oversby, 1976) and airborne magnetic and radiometric surveys were carried out during the latter year (Wilson, in preparation). Orientation geochemical studies in 1972-3 (Rossiter, 1975) were the forerunner to the regional stream-sediment survey of the area during 1974. The regional stream-sediment coverage was designed to delineate broad areas where subsequent detailed exploration should be concentrated and to establish a sound framework on which to base any future work.

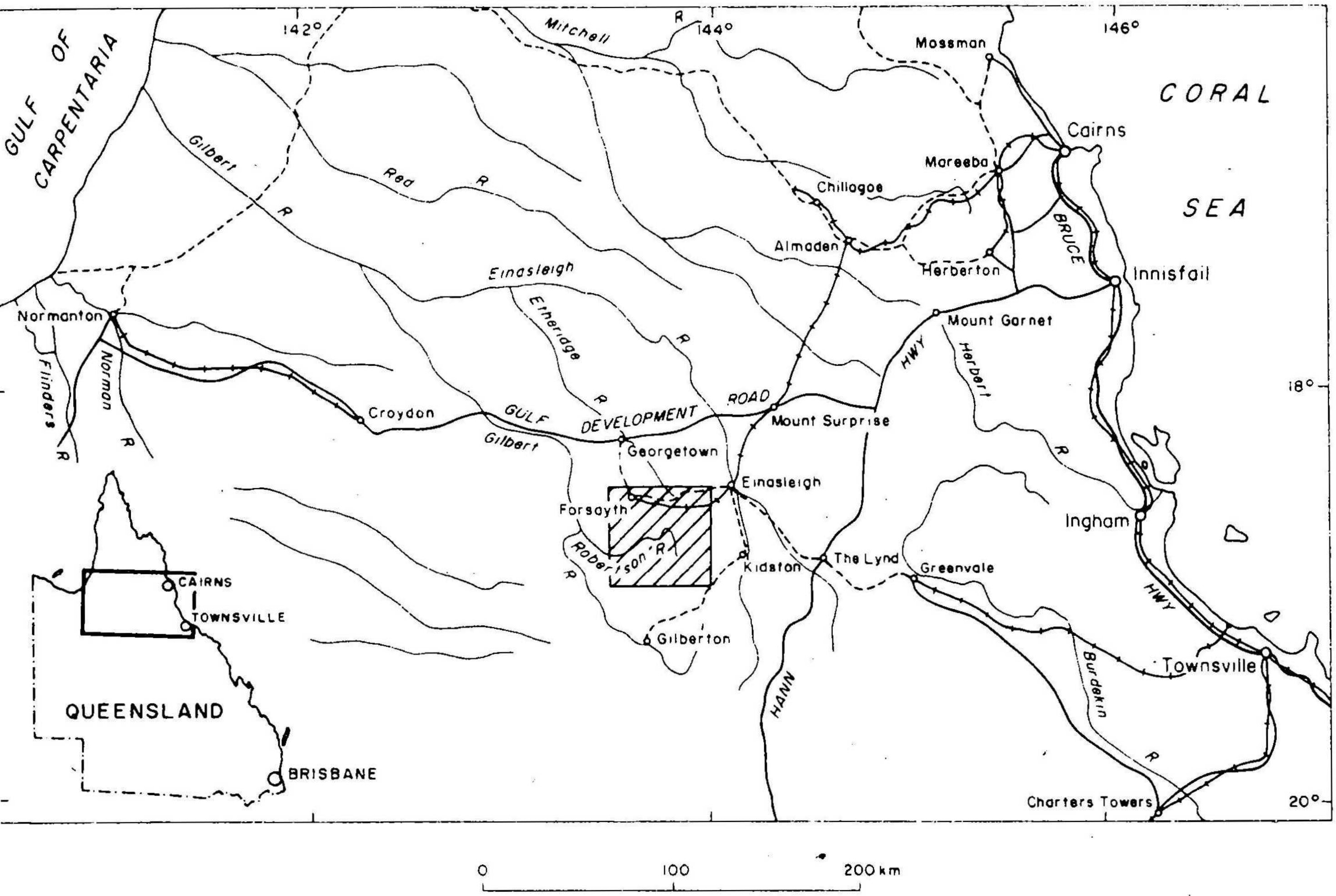
### Climate and vegetation

The region has a semi-arid to subhumid tropical climate. The annual average rainfall is about 700 mm; rain is almost entirely confined to the period November-April. Temperatures are moderate to high all year with an average daily maximum of about 32°C.

Most of the area is covered by a savannah woodland dominated by small eucalypts; large trees are generally found only on Mesozoic sandstone or adjacent to watercourses. Very little land has been cleared or cultivated.

### Relief and drainage

The elevation of the Forsayth 1:100 000 Sheet area varies from




Major road

Secondary road

Railway

Forsayth 1:100 000 sheet area

Fig.1. Location map

340 m to 780 m. The Newcastle Range is the most prominent topographic feature and consists mostly of resistant late Palaeozoic acid volcanic rocks. It increases in height towards the south and the southern part is bounded by sharp escarpments. The range is flanked on either side by moderately hilly country underlain by Precambrian granitic and metamorphic rocks.

In areas of higher relief where erosion is considerable, soils are generally thin and skeletal. Chemical weathering processes assume more importance in the lower country and the soils are consequently deeper, but profile development seldom occurs.

Most of the area is drained by the Robertson River and its tributaries, and lies ultimately within the watershed of the Gilbert River. The northwest corner of the Sheet area is drained by the Etheridge River system, and the eastern edge by tributaries of the Einasleigh River. As a consequence of the seasonal rainfall most of the streams are dry during winter. Permanent waterholes occur almost exclusively on only the largest rivers.

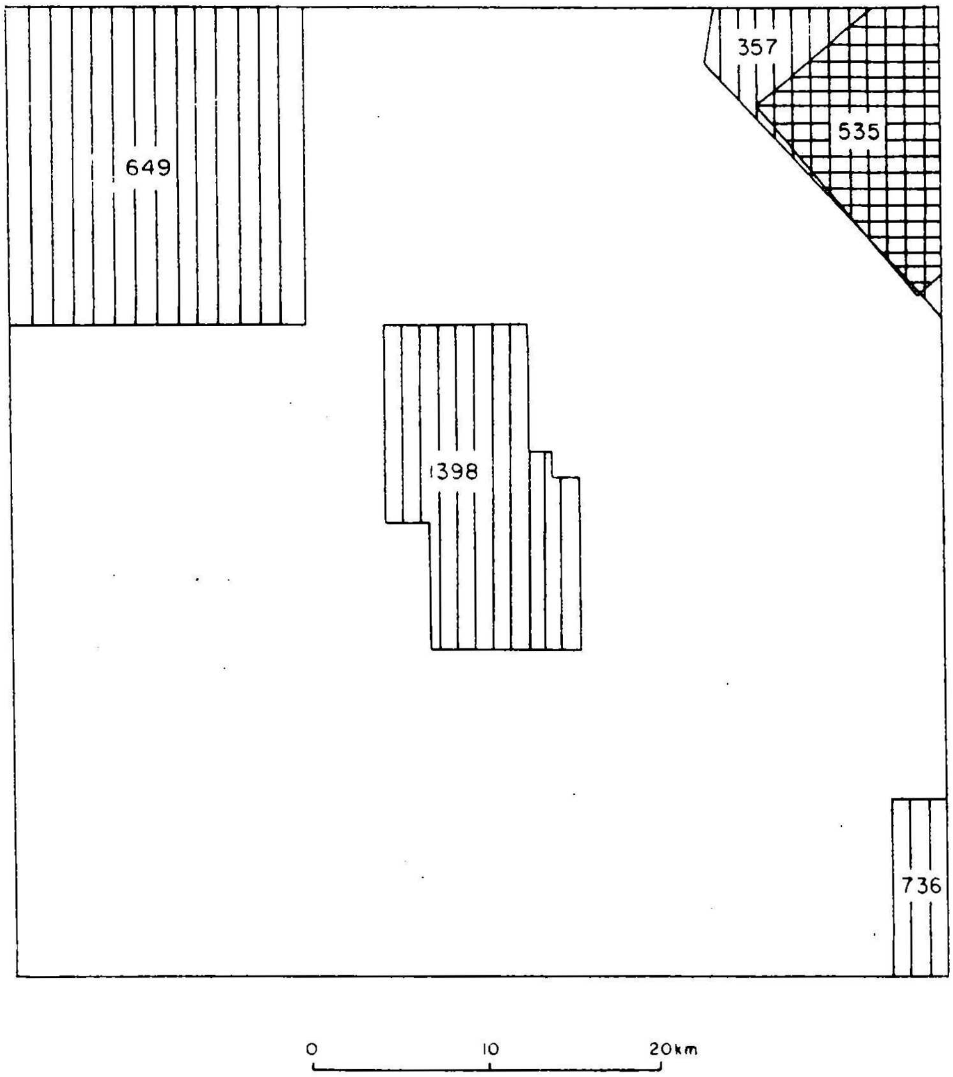
## Previous geochemical investigations

Reports of stream-sediment surveys carried out within the Forsayth 1:100 000 Sheet area by Carpentaria Exploration Co. Pty Ltd (Rawlins & Simpson, 1968), Trans-Australian Exploration Pty Ltd (Perkin, 1971), Forsayth Mineral Explorations NL (Zimmerman, 1970) and Lamadec Exploration Ltd - Laskan Minerals Ltd - Alkane Exploration Ltd (Explorex Pty Ltd, 1971) are on file at the GSQ. The areas covered by these surveys are indicated in Figure 2. Copper, lead, and zinc determinations were made on 'minus 80 mesh' samples in every case, supplemented by cobalt, molybdenum, nickel, and silver analyses in some instances. Many small anomalies were located during this work but follow-up has failed to disclose any significant mineral deposits.

In 1972-73 BMR carried out an extensive geochemical orientation survey over the western half of the Georgetown Inlier (Rossiter, 1975). A darker number of mineralised and unmineralised areas within the Forsayth Sheet area were sampled during the course of this program.

## GEOLOGY

The Georgetown Inlier is an area of Precambrian and Palaeozoic rocks roughly 300 km square (Fig. 3). The inlier is bounded on the east




| A to P | Company | Elements determined |
|---|---|---|
| 357 | Carpentaria Exploration | Ag, Cu, Mo, Pb, Zn |
| 535 | Trans Australian Exploration | Cu, Pb, Zn |
| 649 | Forsayth Mineral Exploration | Co, Cu, Ni, Pb, Zn |
| 736 | Lamadec - Laskan - Alkane | Co, Cu, Mo, Ni, Pb, Zn |
| 1398 | Urangesellschaft | U |

Fig. 2. Forsayth 1:100 000 Sheet area — extent of Authority's to Prospect on which companies carried out stream-sediment sampling before December 1975 (after Withnall, 1976)

by the Palaeozoic Tasman Mobile Belt but the relationship of its Precambrian rocks to those of the Australian Shield to the west is obscured by Mesozoic sediments of the Carpentaria and Eromanga Basins. The first systematic geological investigations within the Forsayth 1:100 000 Sheet area were described by White (1962, 1965). Recently more detailed mapping has been carried out by Bain, Withnall & Oversby (1976) and the following summary is based largely on their work.

The oldest rocks in the Sheet area are the Proterozoic Einasleigh Metamorphics and Robertson River Metamorphics (Fig. 4). The Einasleigh Metamorphics crop out in the northeast and southeast corners of the Sheet area and consist of biotite gneiss, mica schist, amphibolite and minor migmatite, quartzite, and calcsilicate gneiss. The Robertson River Metamorphics are confined to the western half of the Sheet area - mica schist, phyllite, and quartzite are the dominant rock types. White (1965) regarded the Robertson River Metamorphics as younger than the Einasleigh Metamorphics but recent work indicates that metamorphism and deformation of the two units occurred at the same time and they may be of similar stratigraphic age. Soon after their deposition the Robertson River Metamorphics were intruded by numerous small bodies of gabbro and dolerite since metamorphosed to amphibolite and metadolerite (Cobbold 'metadolerite'). At least some of the amphibolite in the Einasleigh Metamorphics is probably related.

The metamorphic rocks are intruded by 3 granites of Proterozoic age - the Forsayth Granite, the Oak River Granodiorite, and the Digger Creek Granite. The Forsayth Granite is confined to the northwest corner of the Sheet area. The dominant lithology is a grey fine to coarse-grained biotite granite containing some secondary muscovite, but widespread variation in both colour and texture occurs. Bain, Withnall & Oversby (1976) recognised 8 variants within the unit mapped as Forsayth Granite*. The Oak River Granodiorite crops out along the eastern margin of the Sheet area and consists of biotite granite and hornblende-biotite tonalite. The Digger Creek Granite forms fairly small bodies scattered throughout the Sheet area. It is a leucocratic muscovite granite varying greatly in grainsize and ranging from grey to white to pink. Most of the pegmatites of the region are probably related to this granite.

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* The rocks originally mapped as Forsayth Granite have recently been subdivided into Forsayth Granite, Ropewalk Granite, Goldsmiths Granite, Delaney Granite, Talbot Creek Granite, and Lighthouse Granite.

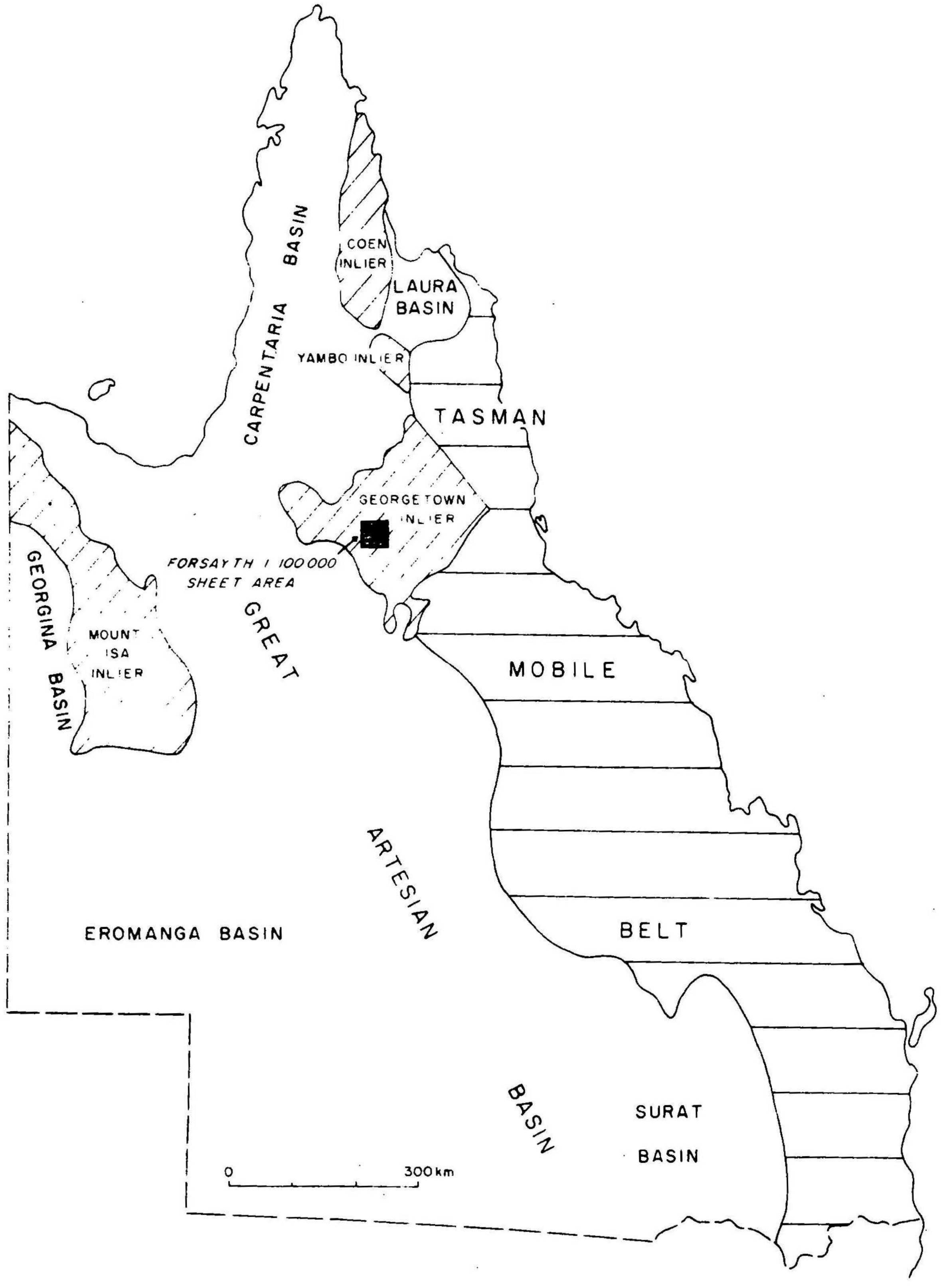


Fig. 3. Regional geology

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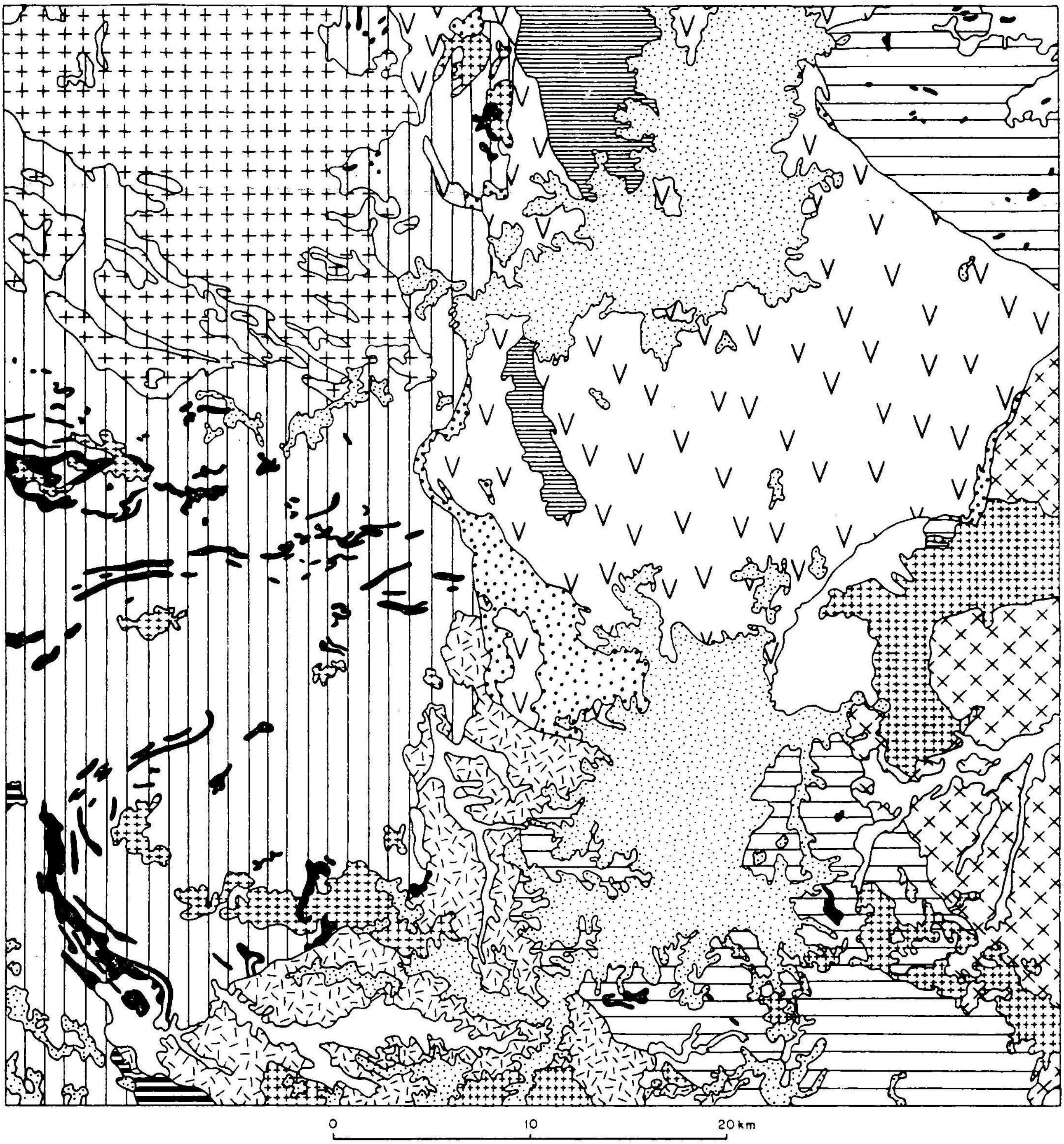


| | | |
|---|---|---|
| QUATERNARY | | Alluvium, colluvium |
| CRETACEOUS | GIL RIV. FM / EULO QUEEN GP | Sandstone, conglomerate |
| PERMIAN | AGATE CREEK VOLCANICS | Rhyolite, basalt, sandstone |
| CARBONIFEROUS | NEWCASTLE RANGE VOLCANICS | Porphyritic microgranite |
| | | Rhyolite, tuff, agglomerate |
| | | Sandstone, conglomerate, andesite |
| SILURO-DEVONIAN | ROBIN HOOD GRANODIORITE | Hornblende-biotite granodiorite |
| PROTEROZOIC | DIGGER CREEK GRANITE | Muscovite granite |
| | OAK RIVER GRANODIORITE | Granodiorite, tonalite |
| | FORSAYTH GRANITE | Biotite granite |
| | COBBOLD 'METADOLERITE' | Metadolerite, amphibolite |
| | ROBERTSON RIV. METAMORPHICS | Schist, phyllite, quartzite |
| | EINASLEIGH METAMORPHICS | Gneiss, schist, migmatite |



 **Fig. 4. Detailed geology of the Forsayth 1:100 000 Sheet area** 

The Robin Hood Granodiorite of probable Siluro-Devonian age occurs in the south-central part of the Sheet area. It is remarkable uniform throughout - the dominant rock type is a grey hornblende biotite granodiorite.

The Carboniferous Newcastle Range Volcanics occupy a downfaulted block possibly formed by cauldron subsidence. Thin discontinuous arkosic sandstone and conglomerate are overlain by a thick volcanic sequence consisting mainly of ignimbritic rhyolite. Large bodies of microgranite intrude the volcanics. In the southwest corner of the Sheet area the Permian Agate Creek Volcanics comprise rhyolite, basalt, agglomerate, and minor sediments. Numerous plugs and dykes of rhyolite and microgranite, presumably related to these two volcanic episodes, are scattered throughout the Forsayth region.

Sandstone and conglomerate of Jurassic to Cretaceous age cover parts of the Sheet area. These belong to the Eulo Queen Group and the Gilbert River Formation.

## MINERAL DEPOSITS

The mines and mineral deposits of the Forsayth 1:100 000 Sheet area have been described in detail by Withnall (1976) and the following summary is based largely on his report. There are basically 5 known mineral districts within the Sheet area (Fig. 5). The Forsayth, Oakville, and Percyville areas are primarily gold-bearing districts, the Upper Mosquito Creek area contains lead-silver mineralisation, whereas copper and lead deposits occur in the Stockman Creek area. Isolated tin, uranium, and fluorine occurrences are also present in the Sheet area. None of the deposits is currently being worked on a significant scale.

### Gold

In the Forsayth district most of the gold deposits occur within the Forsayth Granite but some small deposits are located in metamorphic rocks along the southern margin of the granite or lie across the contact. Usually the deposits consist of a mineralised quartz vein 10 cm to 4 m wide in a steeply dipping fissure or shear zone. The lodes seldom exceed about 200 m in length. The oxidised parts of the deposits consist of ironstained quartz, limonite, hematite, and sometimes cerussite. Below the water-table (about 30 m) the gold is associated with galena, chalcopyrite, and minor sphalerite. Generally only oxidised ore was mined as it could be treated easily by crushing and amalgamation. Only a few of the mines penetrated 12

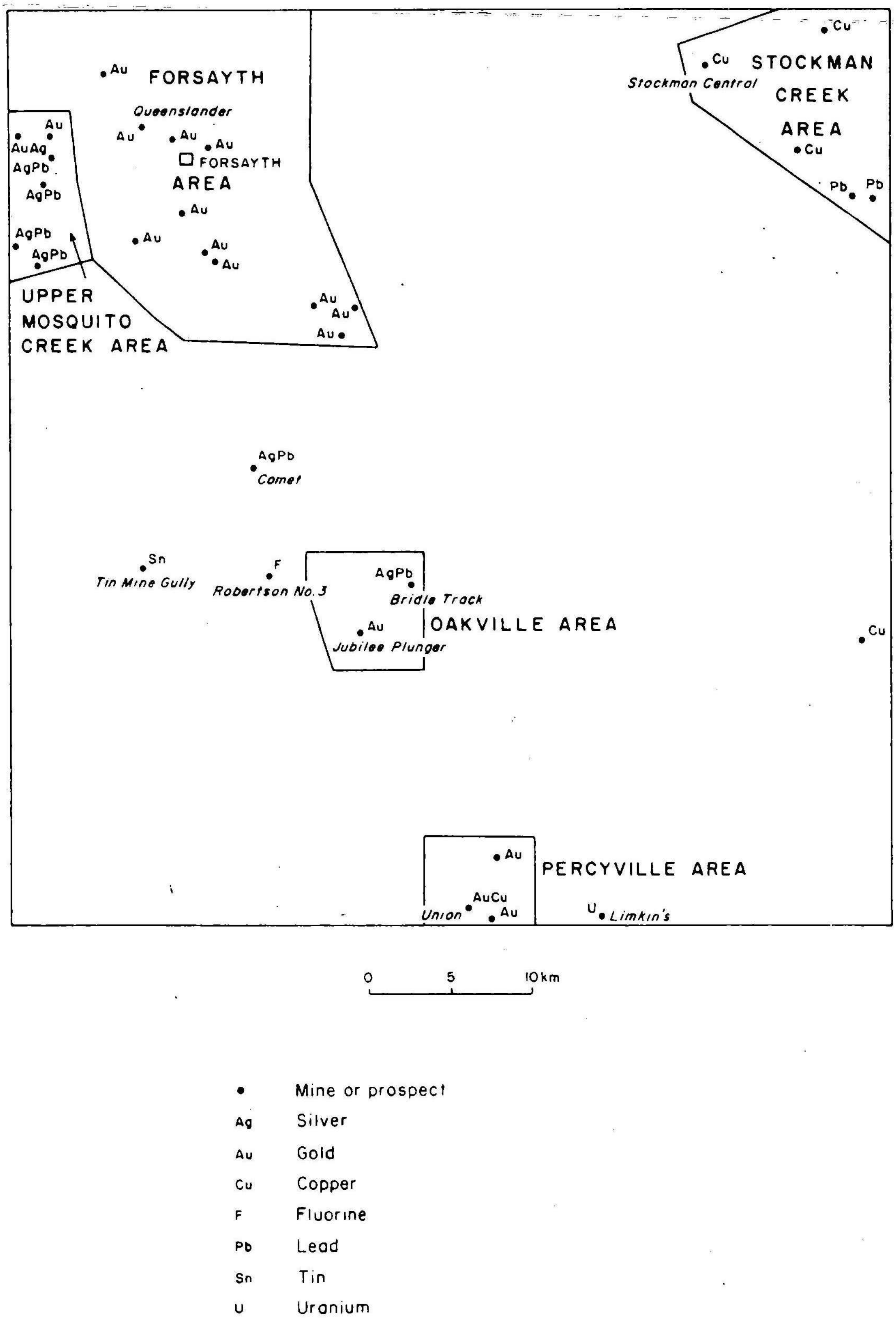


Fig. 5. Main mineral deposits of the Forsayth 1:100 000 Sheet area (after Withnall, 1976)

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sulphide ore and even fewer made an attempt to extract the lead and copper from it. The largest of the Forsayth group of mines was the Queenslander (Fig. 5) where intermittent production between 1878 and 1943 totalled 680.233 kg bullion from 19 854 tonnes of ore and 347.648 kg gold, 718.846 kg silver, 301.7 tonnes lead, and 7.9 tonnes copper from 3590 tonnes of concentrates (Withnall, 1976).

The gold deposits of the Oakville area occur in sericitised shear zones within or adjacent to Robin Hood Granodiorite. The most important deposit is the Jubilee Plunger (Fig. 5) which occupies an alteration zone over 1 km long and up to 100 m wide. It produced 10.096 kg gold-silver bullion from 996 tonnes of ore between 1894 and 1897. Recent drilling, however, indicates the presence of considerable quantities of unworked ore with an average grade of at least 7 g/tonne gold, 86 g/tonne silver, 2.6 percent zinc, 1.1 percent lead, and 0.35 percent copper (Bain, 1976).

The geology of the Percyville area is complex. The dominant rock unit is Digger Creek Granite within which patches of metamorphic rocks and rhyolite dykes occur. Robin Hood Granodiorite crops out nearby.

The gold is present in sericitised shear zones containing discontinuous quartz veins. Most of the lodes contain copper and lead although only a few were worked for these metals. The largest mine was the Union (Fig. 5) with recorded production between 1891 and 1937 of 147.787 kg gold-silver bullion from 4173 tonnes of ore and 61.408 kg gold, 256.762 kg silver, and 59.7 tonnes copper from 322 tonnes of ore and concentrates (Withnall, 1976). The main reef is 150 m long and up to 3.6 m wide.

## Lead-silver

In the Upper Mosquito Creek area there are several small deposits which were worked initially for gold and later for lead and silver. They all occupy fissure quartz reefs in or near Forsayth Granite. Metadolerite often crops out nearby. Mining was confined to the oxidised zone which contains quartz, limonite, hematite, siderite, cerussite, anglesite, and galena. Production from these mines exceeded 100 tonnes of ore in only a few cases.

Small lead-silver deposits also occur in sericitised Robin Hood Granodiorite in the Oakville area. The largest of these is the Bridle Track prospect (Fig. 5) where a vein 0.5 m wide produced a small amount of ore.

The only lead-silver mineralisation of significance lying outside the Upper Mosquito Creek and Oakville areas is the Comet deposit (Fig. 5) which is situated in a shear zone within quartz-muscovite schist of the Robertson River Metamorphics. Total production between 1930 and 1953 was 1.477 kg gold, 518.694 kg silver, and 209 tonnes lead from 410 tonnes of ore (Withnall, 1976).

## Copper

Copper prospects are mostly confined to the Stockman Creek district in the northeast corner of the Sheet area (Fig. 5). The deposits occur in Einasleigh Metamorphics and are associated with gossans containing magnetite, hematite, limonite, cerussite, and malachite. Primary sulphides include pyrite, chalcopyrite, and galena. Production is recorded only from the Stockman-Central mine - 13 tonnes of 7.3 percent copper ore were dispatched for treatment in 1960 and another 200 tonnes of 7 percent ore were 'at grass' (Withnall, 1976).

## Uranium

Uranium mineralisation is present in a quartz reef cutting sericitised Robin Hood Granodiorite at Limkin's prospect (Fig. 5). The ore minerals include metatorbernite, autunite, galena, and pyrite. The prospect produced 10 tonnes of ore containing 1.5 to 4 percent $U_3O_8$ (Wyatt, 1957).

## Tin

Alluvial cassiterite from an unknown source was worked at Tin Mine Gully (Fig. 5). A total of 2.5 tonnes of concentrate averaging 70 percent $SnO_2$ was produced in 1906-7 (Withnall, 1976).

## Fluorine

Fluorite is associated with rhyolite dykes at the Robertson No. 3 prospect (Fig. 5). A number of costeans have been bulldozed in the area but there has been no production.

# SAMPLING AND ANALYTICAL METHODS

## Sampling techniques

It was clear at an early stage that the only feasible way of sampling the Forsayth 1:100 000 Sheet area, with the available time and manpower resources, was to use a helicopter operating from a centrally

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situated base camp, and the program was planned accordingly.

Initially sample points were plotted on Royal Australian Survey Corps 1:50 000 topographic maps so that an even coverage of the Sheet area at a density of about 1 sample per 2.5 $km^2$ was obtained. The orientation work (Rossiter, 1975) showed that anomalies in streams larger than third order are obliterated by dilution so these were rarely sampled during the regional survey. Helicopter loops linking approximately 20 of the sample localities were then designed. Where possible, loops remote from the camp-site at Fish Hole were planned with a lesser number of samples to compensate for the extra weight of fuel that would need to be carried. For ease of navigation the intended path of the aircraft generally followed a major stream with landing sites at points where tributaries entered (Fig. 6). Cross-country flights from one catchment area to another were avoided where possible. Once the helicopter loops had been finalised the sample points were numbered sequentially.

The sample points and numbers and the helicopter flight-lines were then transferred to overlays on 1:25 000 colour aerial photographs. For convenience, points belonging to different loops were plotted on different photos wherever possible. Numbering of field data sheets and plastic sample bags completed the pre-field phase of the program.

The bulk of the sampling was carried out during July 1974 with a Hughes 500 helicopter carrying a 3-man crew (pilot, geochemist/navigator, and field hand). At each locality the aircraft remained on the ground for 2-5 min while 1 or 2 samples weighing 5-10 kg were taken. Active sediment from near the centre of the stream channel was collected where this was possible. Each sample was a composite of 3 or 4 scoops of material from points a few metres apart. Eighty samples (4 loops) could be collected in a day using a total of about 4 hours flying time and 4 hours idling time.

The helicopter was able to maintain vertical performance carrying 3 persons, about 150 kg of samples, and sufficient fuel for the return to camp; however, it was found advantageous to complete loops in difficult terrain in the cool of the morning when the aircraft performed best. Normally little difficulty was experienced in landing close to the predetermined sample site and fewer than 5 percent of points had to be moved closer to a clearing.

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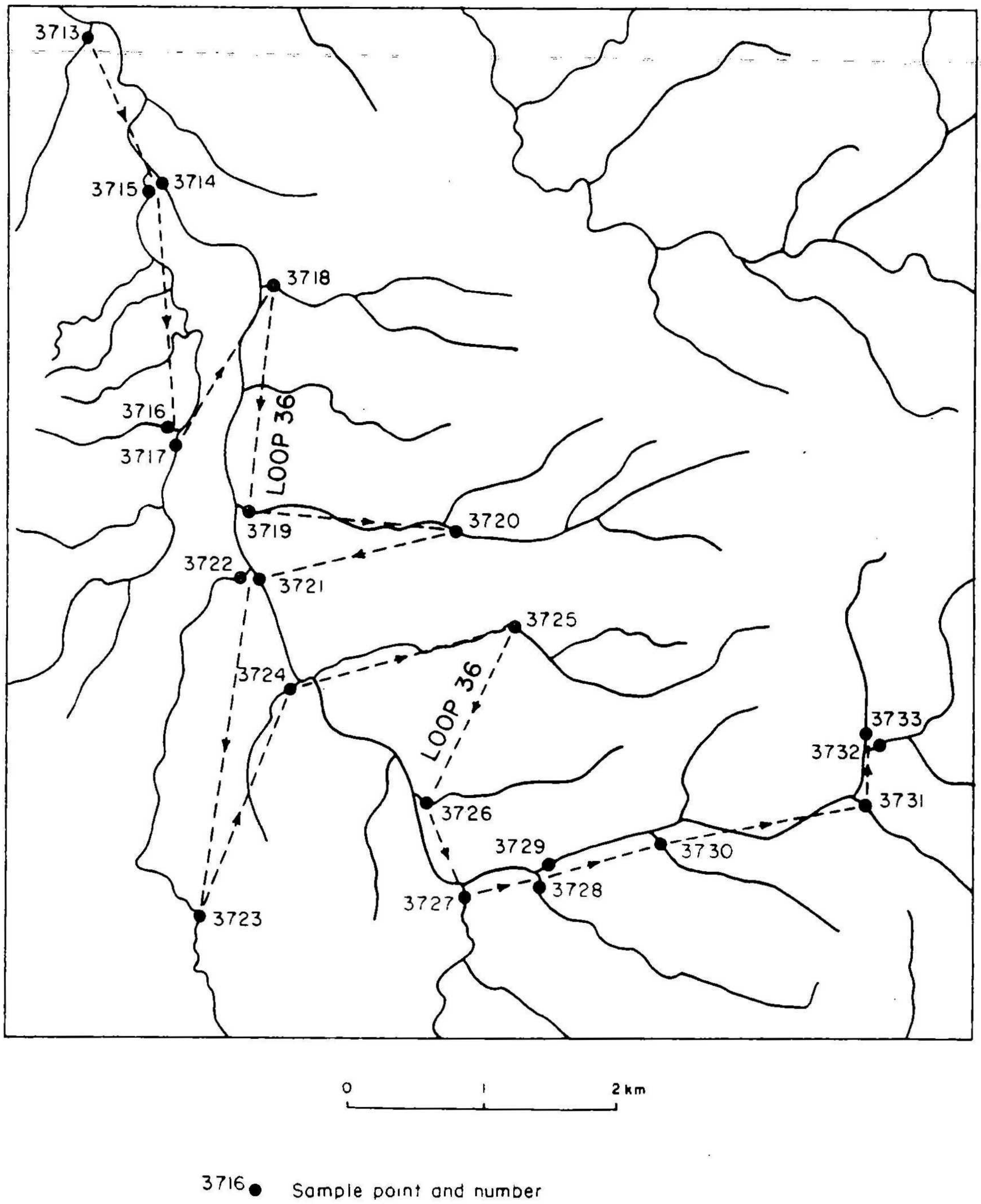


Fig. 6. Typical helicopter loop

Only in rare instances was it necessary to return to a sample site by ground traverse in order to maintain adequate sampling coverage.

On return to the base camp each sample was sieved and panned as detailed in Figure 7. The final products obtained were 20-50 g of material sieved to minus 180 m (85 mesh BSS, the optimum grainsize as indicated by the 1972-3 orientation survey) and a heavy-mineral concentrate weighing approximately 100 g. The methodology and results of the heavy-mineral studies will be reported on at a later date.

## Analytical techniques

The sieved stream-sediment samples were analysed for beryllium, chromium, cobalt, copper, iron, lead, lithium, manganese, nickel, silver, and zinc by atomic absorption spectrophotometry, and for arsenic, barium, bismuth, cerium, fluorine, niobium, rubidium, sulphur, thorium, tin, titanium, tungsten, uranium, and yttrium by X-ray fluorescence spectrometry. All analytical work was carried out in the BMR laboratories.

### Atomic absorption

A 1 g portion of each minus 180 m sample was treated with 1:1 perchloric acid (6 ml) and 40 percent hydrofluoric acid (10 ml) in a platinum basin and heated on a waterbath until fuming. The basin was then transferred to a hot-plate and further heated until a 'dry' cake formed. Hydrochloric acid (5 ml, 1:1) was added and the cake dissolved by gentle heating. After cooling, the contents of the basin were transferred to a 25 ml volumetric flask and made up to volume.

The sample solutions were analysed using a Varian AA6 spectrophotometer interfaced with a Hewlett-Packard 2100A computer and a teletype output. The instrumental conditions employed and the detection limits obtained are shown in Table 1.

Where a low concentration of cobalt, lead, nickel, or zinc was encountered, a non-atomic absorption correction was made using a hydrogen-continuum lamp at the analytical wavelength. Construction of calibration curves from instrument responses to standard solutions and all subsequent calculations were performed by the computer.

### X-ray fluorescence

All samples were ground for 90 seconds in a Siebtechnik vibratory

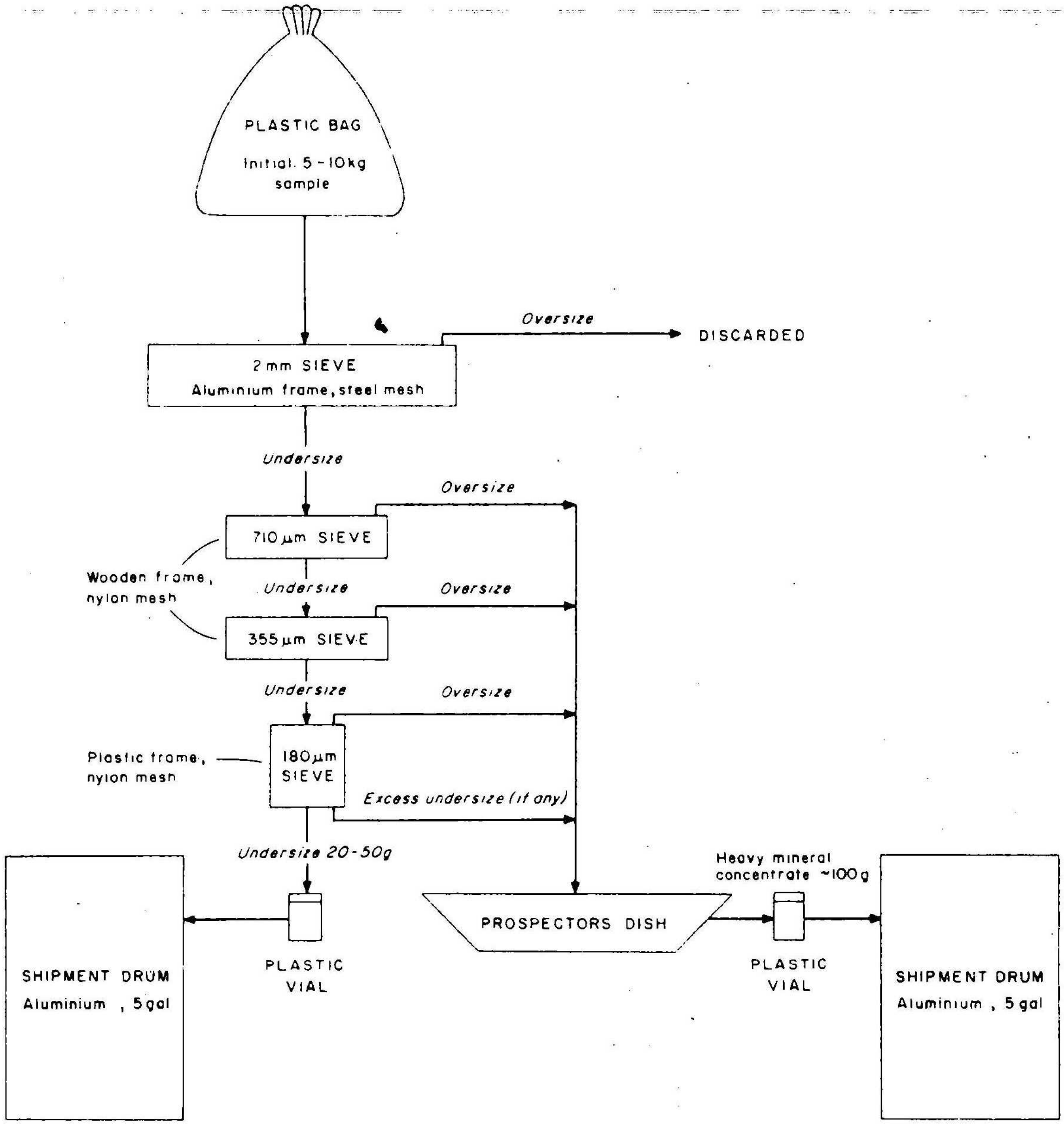


Fig. 7. Sample preparation flowchart

Table 1: Instrumental conditions employed for atomic absorption analysis

| Element | Line (nm) | Spectral Bandpass (nm) | Lamp current (mA) | Flame type* | Flame stoichiometry | Detection limit (ppm)** |
|---|---|---|---|---|---|---|
| Ag | 328.1 | 0.50 | 4 | A/A | Oxidising | 1 |
| Be | 234.9 | 0.50 | 8 | NO/A | Reducing | 1 |
| Co | 240.7 | 0.20 | 8 | A/A | Oxidising | 2 |
| Cr | 357.9 | 0.20 | 5 | NO/A | Reducing | 4 |
| Cu | 324.8 | 0.50 | 3 | A/A | Oxidising | 2 |
| Fe | 372.0 | 0.20 | 6 | A/A | Oxidising | 1000 |
| Li | 670.8 | 0.20 | 5 | A/A | Oxidising | 1 |
| Mn | 279.5 | 0.20 | 5 | A/A | Oxidising | 10 |
| Mi | 232.0 | 0.20 | 8 | A/A | Oxidising | 2 |
| Pb | 217.0 | 1.00 | 6 | A/A | Oxidising | 4 |
| Zn | 213.9 | 0.50 | 6 | A/A | Oxidising | 1 |

* A/A - air/acetylene; NO/A = nitrous oxide/acetylene

** Detection limit defined as ppm in solid equivalent to 0.004 A in solution (1g/25 ml) mill using an agate vessel. A 12 g portion of each was then pressed into a pellet using Mowiol as the binding agent.

The samples were analysed using a Philips PW1450 X-ray spectrometer fitted with a 60-position automatic sample changer. The operating conditions employed and the detection limits obtained are shown in Table 2.

The method outlined by Norrish & Chappell (1967) was used for converting count-rates to element concentrations. In the main, artificially prepared standards were used, but occasional checks were made against United States Geological Survey rock standards. Dead-time corrections were made automatically by the spectrometer. Empirical corrections for interfering elements were made for arsenic (corrected for lead interference), barium (for cerium and titanium), bismuth (for arsenic and lead), thorium (for bismuth and lead), uranium (for rubidium), and yttrium (for lead, rubidium, and thorium). An attempt was made to analyse for molybdenum but the large interference effects due to zirconium rendered the results of dubious values. The analytical method has since been refined and it is hoped that acceptable molybdenum values will be obtained during future surveys. Mass absorption coefficient corrections were of two types. For barium and cerium determinations an iron mass absorption coefficient calculated from the atomic absorption values for iron was used. For all other elements Compton scattered tube line measurements were made and mass absorption coefficients calculated for the rubidium K-alpha wavelength. Non-linear background corrections were made using 'spec' pure silica.

## DATA PRESENTATION METHODS

### Choice or presentation system

The data display system for the Forsayth 1:100 000 Sheet stream-sediment results was designed according to the following specifications:

1. The data should be presented in map rather than tabulated form so as to be easily assimilable.

2. Actual analytical values rather than statistically manipulated data should be displayed, leaving users free to perform their own preferred interpretation procedures.

3. The maps should have a visual impact; that is, the eye should 21

Table 2: Instrumental conditions employed for X-ray fluorescence analysis. Vacuum was used throughout. The gas used in the flow counter was 10 percent v/v methane in argon.

| Element | Line | Peak 2θ | Peak count time(s) | Background 2θ's | Background count time(s) | Tube | Tube voltage (kV) | Tube current (mA) | Primary collimator | Crystal | Counter | Theoretical detection limit (ppm) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| As | K-alpha | 33.98 | 40 | ±0.44 | 20 | Mo | 90 | 30 | Fine | LiF 200 | Flow + scint. | 0.4 |
| Ba | L-beta | 128.99 | 100 | ±2.30 | 40 | Au | 60 | 45 | Coarse | LiF 220 | Flow | 2.1 |
| Bi | L-alpha | 33.00 | 40 | ±0.60 | 20 | Mo | 90 | 30 | Fine | LiF 200 | Flow + scint. | 0.8 |
| Ce | L-beta | 111.78 | 100 | +2.20<br>−1.60 | 40 | Au | 60 | 45 | Coarse | LiF 220 | Flow | 2.3 |
| F | K-alpha | 90.93 | 100 | ±1.75 | 40 | Cr | 50 | 40 | Coarse | TlAP | Flow | 650 |
| Nb | K-alpha | 21.37 | 40 | ±0.37 | 20 | Au | 90 | 30 | Fine | LiF 200 | Scint. | 0.8 |
| Rb | K-alpha | 26.58 | 20 | ±0.30 | 10 | Mo | 90 | 30 | Fine | LiF 200 | Scint. | 0.5 |
| S | K-alpha | 75.83 | 40 | ±1.20 | 20 | Cr | 50 | 40 | Coarse | PE | Flow | 5 |
| Sn | K-alpha | 19.84 | 100 | ±0.45 | 40 | Au | 90 | 30 | Fine | LiF 220 | Scint. | 1.0 |
| Th | L-alpha | 27.46 | 40 | ±0.20 | 20 | Mo | 90 | 30 | Fine | LiF 200 | Scint. | 0.9 |
| Ti | K-alpha | 86.20 | 40 | −1.00 | 20 | Au | 50 | 20 | Fine | LiF 200 | Flow | 3 |
| U | L-alpha | 37.30 | 100 | ±0.25 | 40 | Mo | 90 | 30 | Fine | LiF 220 | Scint. | 0.6 |
| W | L-alpha | 62.49 | 100 | ±0.75 | 40 | Mo | 90 | 30 | Fine | LiF 220 | Flow + scint. | 1.8 |
| Y | K-alpha | 33.84 | 20 | ±0.43 | 10 | Mo | 90 | 30 | Fine | LiF 220 | Scint. | 0.6 |

be attracted to high values.

4. Without sacrificing clarity it should be possible to present the results for a number of elements on the one map, thereby facilitating comparisons between related elements and avoiding a cumbersome number of maps.

5. The system should be amenable to computerised drafting to expedite publication.

The system adopted is based on a circular symbol incorporating the results for 3 elements. Each of the 3 variables is assigned a 120$^{\circ}$ sector of the symbol circle and the portion of the segment blocked out is proportional, via a class-interval graduation scheme, to the actual element concentration. Analytical values in parts per million are shown adjacent to the appropriate sector. The position of the geochemical symbol for each sample point could be specified so that overprinting, a serious problem with many computer-based plotting systems, was avoided.

The class intervals used in constructing the symbol were chosen so that, as far as possible, normal values for a particular element fall within the lowermost class for that element. The setting of the upper limits of the background classes was given much thought. The usual statistical methods of defining geochemical thresholds using combinations of mean and standard deviation were rejected as they make assumptions concerning the normality or lognormality of the data, which are rarely justified. Cumulative frequency curves on probability paper were also considered but the use of these is somewhat subjective. Instead simple manageable figures (generally multiples of 10 or 25) tried and proven by practical experience in the study area were decided upon. These correspond fairly closely for several of the elements with results obtained using the mean and standard deviation methods (Table 3). Values occupying the 3 upper class intervals are termed slightly, moderately, and strongly anomalous in the following discussion.

## Plotting techniques

Field and analytical data for all samples collected during the Forsayth 1:100 000 Sheet stream-sediment survey are stored in the form

Table 3: Summary statistics for all elements determined during the Forsayth stream-sediment survey. All values are in parts per million

| Element | Arithmetic mean | Standard deviation | 2 x Mean | Mean + 2 standard deviations | Threshold used on maps |
|---|---|---|---|---|---|
| Cu | 21 | 18 | 42 | 57 | 50 |
| Zn | 61 | 111 | 122 | 283 | 150 |
| Pb | 39 | 107 | 78 | 253 | 100 |
| S | 491 | 3150 | 982 | 6790 | - |
| Ag | 1 | 1 | 2 | 3 | - |
| Sn | 7 | 21 | 14 | 49 | 25 |
| W* | 3 | 4 | 6 | 11 | 10 |
| Bi* | 1 | 2 | 2 | 5 | 4 |
| Nb | 19 | 10 | 38 | 39 | 50 |
| Li | 11 | 6 | 22 | 23 | - |
| Be | 2 | 1 | 4 | 4 | - |
| Rb | 126 | 56 | 252 | 238 | - |
| U | 8 | 8 | 16 | 24 | 10 |
| As | 5 | 5 | 10 | 15 | 10 |
| F* | 111 | 367 | 222 | 845 | - |
| Th | 57 | 94 | 114 | 245 | 75 |
| Ce | 167 | 203 | 334 | 573 | 200 |
| Y | 68 | 57 | 136 | 182 | - |
| Ba | 705 | 290 | 1410 | 1290 | - |
| Mn | 671 | 546 | 1340 | 1760 | - |
| Co | 12 | 10 | 24 | 32 | 25 |
| Ni | 14 | 9 | 28 | 32 | 30 |
| Cr | 56 | 46 | 112 | 148 | - |
| Fe | 33000 | 27000 | 66000 | 87000 | - |
| Ti | 7140 | 5400 | 14300 | 18000 | - |

No. of samples = 1217

* Figures for tungsten, bismuth, and fluorine are artificially low as a value of zero was arbitrarily assigned in any instance in which these elements could not be detected.

shown in Figure 8 using the INFOL information storage/retrieval system. The most useful aspects of INFOL are the update and interrogation phases. The update option allows new data to be added to the file (if, say, additional sampling were carried out in the Sheet area) or data already present to be modified (this might be desirable, for example, if a superior analytical technique were developed and the samples reanalysed for a particular element). During the interrogation phase, data for each sample can be tested against retrieval criteria (for example, copper content greater than 100 ppm, catchment formation = Einasleigh Metamorphics) and all or a specified part of the data for samples satisfying the criteria are extracted and either copied to another file for attaching to a post-processing program or printed out in a report. The format of the printout can be controlled by the user (Fig. 9).

As the first stage of the drafting process, INFOL was used to generate 2 files on magnetic tape - one comprising registered numbers, the other registered numbers and analytical data. Both files were split into blocks which corresponded with the helicopter loops used during the sampling. These blocks were retained throughout the various stages of the plotting procedure to facilitate checking and editing.

Next all sample locations and the intended positions of the centres of all geochemical symbols were digitised using a Gradicon digitising table. The maps used for digitising were National Mapping 1:100 000 topographic sheets printed on stable base film. The digitised information was transferred to magnetic tapes using program GRADI, a part of BMR's Hewlett-Packard 2100A system.

The 4 files generated by INFOL and digitising were merged on the CSIRO Cyber 76 computer using programs from the BMR Airborne Geophysics Reductions Group library. Program DIGDIS converted digitised sample position data to latitudes and longitudes and created a sequential file comprising registered numbers and sample latitudes and longitudes. The sequential file generated by DIGSEG combined registered numbers, symbol latitudes and longitudes, and analytical data. The DIGDIS and DIGSEG files were then accessed by program PLANPL to create a plotting tape. A subroutine of PLANPL called KEMSYM placed the analytical values into the appropriate class intervals and generated the geochemical symbols.

NAME | | | DATE | SHEET OF

INPUT FORMAT –

```
 11-80 (card columns)
*1*Registered Number*2*Samp.Type*Mesh Size (um)**3*1:1ØØ ØØØ Sheet Name *  Easting (°E)  *  Northing (°S+9Ø)  * Air Photo Reference *
*4*Flow*Stream Width (m)*Order*Texture*Posn**5*Relief*Banks*Veg.*Min*Cont.**6*Lithology*Formation*
*7*  Cu*  Zn*  Pb*  S*  Ag**8*  Sn*  W*  Mo*  Bi*  Nb*  Li*  Be*  Rb*
*9*  U*  As*  F*  Th*  Ce*  Y*  Ba**1Ø*  Mn*  Co*  Ni*  Cr*  Fe*  Ti**
```

CODES USED –

Sample Type

S C – sieved channel sample
B C – bulk channel sample
S B – sieved bank sample
H M – heavy mineral sample

Stream Flow

F – flowing
D – dry or with unconnected waterholes

Stream Bed Material

B O U L – mainly boulders
G R A V – mainly gravel
S A N D – mainly sand
S I L T – mainly silt

Sample Position in Stream

S M – centre of straight section of stream
S E – edge of straight section of stream
B M – centre of stream on bend
B I – inside of bend in stream
B O – outside of bend in stream

Relief of Surrounding Area

H – high (mountainous)
M – moderate (hilly)
L – low

Bank Type

A – alluvial
C – one or both banks colluvial

Vegetation

F – forest
G – natural grassland
C – cleared, cultivated

Signs of Mineralisation

Ø – no evidence
S – copper staining
G – gossan

Contamination

Ø – no evidence
U – urban or domestic
R – road
X – railway
A – agricultural
M – mining

Catchment Lithology

W – wholly
M – mainly
P – partly +

G N S S – gneiss
S C S T – schist
P H Y T – phyllite
Q R T Z – quartzite
G R D R – granodiorite
G R N T – granite
M D L T – metadolerite (amphibolite)
R Y L T – rhyolite
S N D S – sandstone

Catchment Rock Formation

W – wholly
M – mainly

E N M M – Einasleigh Metamorphics
R R M M – Robertson R. Metamorphics
O R G D – Oak River Granodiorite
F S G R – Forsayth Granite
D C G R – Digger Creek Granite
C B M D – Cobbold Metadolerite
R H G D – Robin Hood Granodiorite
N R V C – Newcastle Range Volcanics
A C V C – Agate Creek Volcanics
M E S O – Mesozoic

EXAMPLE –

```
*1*7430401Ø*2*SC*18Ø**3*FORSAYTH        *143558188 *1Ø85Ø9342 *FS/ 1/566Ø*
*4*D*  7*1*GRAV*SM**5*L*C*F*Ø*Ø**6*WGRNT*WFSGR*
*7*   1Ø*  41*  66*  246*  Ø**8*  6*  4*  -Ø*  Ø*  22*  13*  3*  282*
*9* 19*  1*  Ø*  181*  295*  8Ø*  567**1Ø*  2Ø8*  6*  18*  39*  16ØØØ*  36ØØ**
```

Ø = not detected
–Ø = not determined

\+ Used when rock types of exceptional geochemistry (metadolerite, amphibolite or sandstone) are present

Fig. 8. INFOL input

Record No. 1978/17



```
REG'D NO: 74303007       FLOW:      D      RELIEF:       M      CU:   35    SN:   2    U:   10    MN:   705
SAMP.TYPE: SC            WIDTH:     12     BANK TYPE:    L      ZN:   66    W:    4    AS:  20    CO:    16
MESH SIZE: 180           ORDER:     3      VEGETATION:   F      PB:   34    MO:   0    F: 1000    NI:    25
SHEET:     FORSAYTH      TEXTURE:   BOUL   MINERAL'N:    0      S:  1200    BI:   0    TH:  70    CR:    71
EASTING:   143690082     POSITION:  SM     CONTAM'N:     0      AG:    0    NB:  17    CE: 226    FE: 29000
NORTHING:  108707017                       LITHOLOGY:    PMESU              LI:  21    Y:   82    TI:  5990
AIR PHOTO: FS/06/4772                      FORMATION:    MRRMM              BE:   3    BA: 695
                                                                            RB: 168

REG'D NO: 74303008       FLOW:      D      RELIEF:       M      CU:   37    SN:   2    U:   11    MN:  1030
SAMP.TYPE: SC            WIDTH:     8      BANK TYPE:    C      ZN:   89    W:    6    AS:   5    CO:    19
MESH SIZE: 180           ORDER:     2      VEGETATION:   F      PB:   36    MO:   0    F: 1000    NI:    27
SHEET:     FORSAYTH      TEXTURE:   BOUL   MINERAL'N:    0      S:  1480    BI:   0    TH:  85    CR:    71
EASTING:   143698217     POSITION:  SM     CONTAM'N:     0      AG:    0    NB:  16    CE: 280    FE: 33000
NORTHING:  108691690                       LITHOLOGY:    PMESU              LI:  17    Y:  114    TI:  6280
AIR PHOTO: FS/06/4772                      FORMATION:    MRRMM              BE:   3    BA: 696
                                                                            RB: 161

REG'D NO: 74303009       FLOW:      D      RELIEF:       M      CU:   26    SN:   5    U:    6    MN:   800
SAMP.TYPE: SC            WIDTH:     8      BANK TYPE:    C      ZN:   79    W:    6    AS:  54    CO:    17
MESH SIZE: 180           ORDER:     2      VEGETATION:   F      PB:   31    MO:   0    F:    0    NI:    23
SHEET:     FORSAYTH      TEXTURE:   BOUL   MINERAL'N:    0      S:  2200    BI:   0    TH:  39    CR:    50
EASTING:   143700354     POSITION:  SE     CONTAM'N:     0      AG:    0    NB:  21    CE: 136    FE: 30000
NORTHING:  108692154                       LITHOLOGY:    MSCST              LI:  25    Y:   81    TI:  7460
AIR PHOTO: FS/06/4772                      FORMATION:    MRRMM              BE:   3    BA: 619
                                                                            RB: 173

REG'D NO: 74303010       FLOW:      F      RELIEF:       L      CU:   21    SN:   2    U:   15    MN:   860
SAMP.TYPE: SC            WIDTH:     8      BANK TYPE:    L      ZN:   60    W:    3    AS:   1    CO:    13
MESH SIZE: 180           ORDER:     2      VEGETATION:   F      PB:   35    MO:   0    F:    0    NI:    20
SHEET:     FORSAYTH      TEXTURE:   BOUL   MINERAL'N:    0      S:   220    BI:   0    TH: 134    CR:    43
EASTING:   143679372     POSITION:  SM     CONTAM'N:     0      AG:    0    NB:  13    CE: 380    FE: 28000
NORTHING:  108719310                       LITHOLOGY:    MSCST              LI:  11    Y:  115    TI:  7840
AIR PHOTO: FS/06/4772                      FORMATION:    MRRMM              BE:   2    BA: 678
                                                                            RB: 139

REG'D NO: 74303011       FLOW:      F      RELIEF:       M      CU:   24    SN:   2    U:   11    MN:   665
SAMP.TYPE: SC            WIDTH:     9      BANK TYPE:    L      ZN:   56    W:    3    AS:   0    CO:    14
MESH SIZE: 180           ORDER:     3      VEGETATION:   F      PB:   30    MO:   0    F:    0    NI:    33
SHEET:     FORSAYTH      TEXTURE:   BOUL   MINERAL'N:    0      S:   170    BI:   0    TH:  79    CR:    45
EASTING:   143670449     POSITION:  BU     CONTAM'N:     0      AG:    0    NB:   9    CE: 235    FE: 26000
NORTHING:  108715145                       LITHOLOGY:    PMULT              LI:  12    Y:   96    TI:  3760
AIR PHOTO: FS/06/4772                      FORMATION:    MRRMM              BE:   2    BA: 670
                                                                            RB: 109

REG'D NO: 74303012       FLOW:      F      RELIEF:       M      CU:   35    SN:   4    U:   17    MN:   930
SAMP.TYPE: SC            WIDTH:     9      BANK TYPE:    L      ZN:   80    W:    4    AS:   1    CO:    16
MESH SIZE: 180           ORDER:     3      VEGETATION:   F      PB:   39    MO:   0    F:    0    NI:    32
SHEET:     FORSAYTH      TEXTURE:   GRAV   MINERAL'N:    0      S:   380    BI:   0    TH: 150    CR:    83
EASTING:   143669096     POSITION:  SM     CONTAM'N:     0      AG:    0    NB:  19    CE: 406    FE: 37000
NORTHING:  108716156                       LITHOLOGY:    MSCST              LI:  14    Y:  121    TI:  9090
AIR PHOTO: FS/06/4772                      FORMATION:    MRRMM              BE:   2    BA: 731
                                                                            RB: 132
```

Fig. 9. INFOL report

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E54/A12-59

Test runs were made by attaching the plotting tape to a Calcomp 939 Drum Plotter. Sample point, symbol outline, analytical values, and coloured sectors for each group of 3 elements were combined on the one plot during testing. When all editing to eliminate problems such as symbol overlap was completed, a Calcomp 745 Flatbed Plotter was used for the final map production. Features of each map to be printed in different colours were scribed on 4 separate masks. The first of these comprised sample point, symbol outline, and analytical values - arrows linking the sample points with the relevant symbols were added to this mask manually. The coloured sectors for one of each of the 3 elements were scribed onto the other 3 masks. The fifth mask used in printing each map was the National Mapping 1:100 000 topographic base to which the positions and names of all the mines in the Sheet area had been added by hand. Most of the drafting of the map surrounds was done manually although plotting of the geochemical legend was automated. A flowchart summarising the plotting procedure is shown in Figure 10.

## DISCUSSION OF RESULTS

All geochemical values of economic significance encountered during the Forsayth 1:100 000 stream-sediment survey can be conveniently presented for discussion as a series of 5 maps incorporating the following combinations of elements:

Map 1 - Copper, cobalt, nickel
Map 2 - Copper, lead, zinc
Map 3 - Uranium, cerium, thorium
Map 4 - Uranium, arsenic, bismuth
Map 5 - Tin, niobium, tungsten

The data for chromium, fluorine, iron, manganese, silver, sulphur, titanium, and yttrium were considered for presentation in map form but were rejected for reasons given in the following sections. Barium, beryllium, lithium, and rubidium showed background levels over the entire Sheet area and so their inclusion in the maps was not seriously contemplated. Summary statistics for all the elements determined are shown in Table 3.

### Map 1 (Copper, cobalt, nickel) and Map 2 (Copper, lead, zinc)

The copper background is considerably higher in stream sediments from catchments containing significant amounts of metadolerite and amphibolite 28

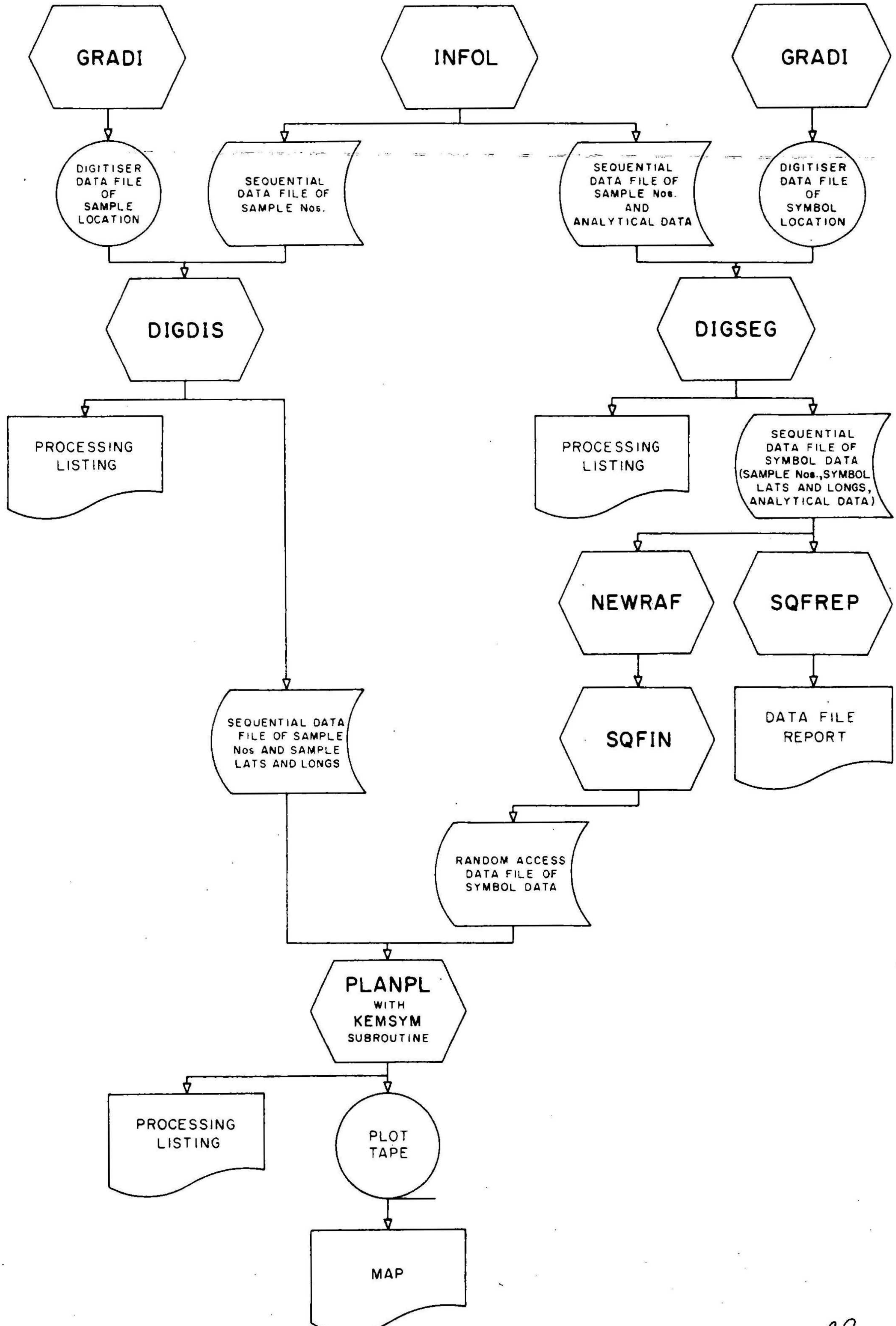


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Fig. 10. Plotting procedures flowchart

than it is in samples from streams draining the other rock types of the Forsayth 1:100 000 Sheet area. An average copper content of 58 ppm in samples from areas where Cobbold 'metadolerite' predominates, compares with means of 7-30 ppm for the other rock units (Table 4). It is important during any appraisal of the distribution of copper in the stream sediments to be able to distinguish the high copper values related to basic igneous rocks from those which might indicate mineralisation. One way to do this is to consider the abundances of other elements in the copper-rich samples.

Anomalous copper values occurring in combination with high chromium, cobalt, iron, manganese, nickel, and titanium might be expected to indicate metadolerites and amphibolites as these elements are generally enriched in such rocks (Table 4). Of these, cobalt and nickel show the strongest correlation with copper in the stream sediments of the Forsayth area (Table 5) and so were considered the best pointers as to whether a particular copper enrichment could be attributed to basic igneous rocks*. Copper, cobalt, and nickel results are presented in Map 1. Chromium, iron, manganese, and titanium show high values not only in association with basic rocks but also where ilmenite and magnetite segregations occur - these are especially common in areas of Einasleigh Metamorphics and Robin Hood Granodiorite.

On the other hand, copper, lead, and zinc frequently accompany one another in the mineral deposits of the Forsayth area (see 'Mineral Deposits', p.4) and it is reasonable to suspect that any high copper level associated with high lead and zinc is related to mineralisation. Map 2 combines the results for these 3 elements. Fortunately there is no evidence, in the region, of false zinc anomalies caused by manganese scavenging.

Orientation studies during 1972-73 suggested that silver and sulphur values might also be useful in detecting gold and silver-lead deposits (Rossiter, 1975). However, during the regional survey silver levels gave so little information additional to that provided by copper, lead and zinc figures, that the effort and expense of presenting silver values in map form was not considered justified. Sulphur was excluded

*Cobalt and nickel are enriched in metalliferous veins in some parts of the world but this is not the case in the Forsayth region.

Table 4: Background values for sediments derived from the different rock units of the Forsayth 1:100 000 Sheet area. For the purposes of this discussion the background is defined as the arithmetic mean. All values are in parts per million. The means for tungsten, bismuth, and fluorine do little more than indicate which units the elements were detected in. Samples showing obvious signs of contamination were excluded from the calculations.

| Rock unit | Einasleigh Metamorphics | Robertson R Metamorphics | Oak R Granodiorite | Forsayth Granite | Digger Ck Granite | Cobbold 'metadolerite' | Robin Hood Granodiorite | Newcastle R rhyolites | Newcastle R granites | Newcastle R sandstones | Agate Ck Volcanics | Mesozoic sandstones |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. samples | 16 | 49 | 25 | 50 | 15 | 11* | 28* | 93 | 10* | 13* | 3* | 15* |
| Cu | 30 | 25 | 11 | 17 | 8 | 58 | 14 | 13 | 7 | 8 | 16 | 11 |
| Zn | 86 | 59 | 43 | 42 | 34 | 79 | 54 | 71 | 67 | 51 | 98 | 28 |
| Pb | 26 | 27 | 36 | 48 | 54 | 14 | 33 | 54 | 31 | 27 | 43 | 17 |
| S | 213 | 380 | 148 | 372 | 145 | 268 | 155 | 275 | 241 | 213 | 412 | 208 |
| Ag | 1 | ND | 1 | 1 | 1 | 1 | 1 | 1 | 1 | ND | 1 | ND |
| Sn | 5 | 2 | 2 | 4 | ND | ND | 3 | 17 | 3 | 3 | 10 | 23 |
| W | ND | ND | ND | 6 | 4 | ND | 3 | 4 | ND | 6 | 6 | 4 |
| Bi | ND | ND | 2 | ND | ND | ND | ND | ND | ND | ND | 2 | ND |
| Nb | 20 | 15 | 12 | 25 | 10 | 14 | 17 | 22 | 23 | 19 | 28 | 16 |
| Li | 8 | 18 | 6 | 11 | 7 | 14 | 13 | 8 | 8 | 18 | 20 | 9 |
| Be | 2 | 2 | 2 | 4 | 2 | 2 | 3 | 3 | 2 | 3 | 3 | 1 |
| Rb | 99 | 116 | 104 | 205 | 150 | 63 | 109 | 199 | 137 | 145 | 173 | 56 |
| U | 7 | 6 | 5 | 24 | 4 | 3 | 7 | 6 | 3 | 6 | 6 | 6 |
| As | 3 | 4 | 7 | 3 | 5 | 3 | 6 | 4 | 4 | 13 | 5 | 6 |
| F | ND | 70 | ND | 600 | ND | ND | 50 | ND | ND | 400 | ND | ND |
| Th | 56 | 31 | 22 | 231 | 26 | 12 | 22 | 26 | 18 | 27 | 30 | 28 |
| Ce | 172 | 106 | 86 | 485 | 77 | 59 | 79 | 124 | 124 | 96 | 82 | 109 |
| Y | 52 | 48 | 48 | 147 | 87 | 31 | 62 | 57 | 38 | 52 | 64 | 53 |
| Ba | 667 | 611 | 1150 | 773 | 1210 | 411 | 884 | 862 | 1340 | 723 | 543 | 294 |
| Mn | 1380 | 855 | 646 | 439 | 644 | 1620 | 560 | 292 | 551 | 313 | 555 | 158 |
| Co | 21 | 13 | 12 | 10 | 8 | 26 | 13 | 6 | 5 | 8 | 14 | 6 |
| Ni | 25 | 18 | 12 | 13 | 6 | 31 | 16 | 4 | 4 | 4 | 20 | 8 |
| Cr | 97 | 50 | 66 | 52 | 26 | 60 | 118 | 14 | 18 | 15 | 64 | 59 |
| Fe | 66000 | 29000 | 36000 | 24000 | 18000 | 64000 | 60000 | 15000 | 24000 | 17000 | 29000 | 21000 |
| Ti | 13600 | 7080 | 4590 | 5340 | 2240 | 16700 | 5030 | 3400 | 8060 | 3250 | 9400 | 6630 |

ND - not detected.

* So that a reasonable number of values was available for calculation of the means it was necessary for these rock units to include samples from catchment areas containing minor amounts of other rocks with similar geochemistry.

3

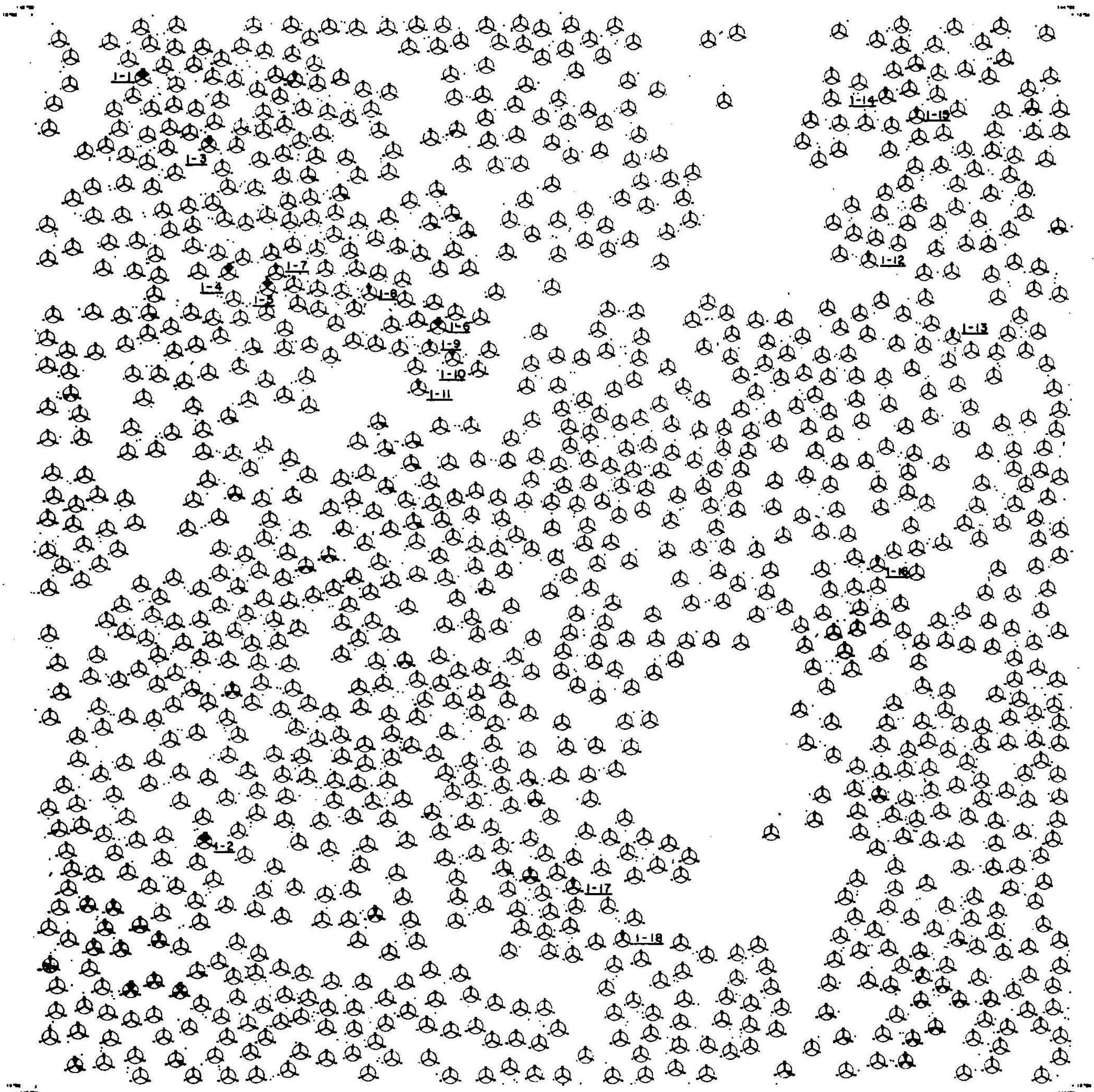
| Cu | Zn | Pb | S | Ag | Sn | W | Bi | Nb | Li | Be | Rb | U | As | F | Th | Ce | Y | Ba | Mn | Co | Ni | Cr | Fe | Ti | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.00 | 0.69 | -0.03 | 0.27 | * | -0.13 | * | * | 0.08 | 0.36 | 0.11 | -0.01 | 0.15 | -0.04 | * | 0.18 | 0.19 | -0.05 | -0.09 | 0.64 | 0.74 | 0.73 | 0.49 | 0.63 | 0.59 | Cu |
| | 1.00 | 0.27 | 0.33 | * | -0.15 | * | * | 0.21 | 0.37 | 0.25 | 0.22 | 0.13 | 0.03 | * | 0.16 | 0.25 | 0.07 | 0.07 | 0.59 | 0.59 | 0.53 | 0.27 | 0.54 | 0.39 | Zn |
| | | 1.00 | 0.06 | * | 0.04 | * | * | 0.21 | -0.06 | 0.48 | 0.64 | 0.31 | 0.08 | * | 0.37 | 0.38 | 0.48 | 0.48 | -0.02 | -0.15 | -0.20 | -0.17 | -0.16 | -0.32 | Pb |
| | | | 1.00 | * | -0.10 | * | * | 0.24 | 0.42 | 0.30 | 0.26 | 0.15 | 0.04 | * | 0.09 | 0.23 | 0.07 | -0.02 | 0.07 | 0.11 | 0.15 | 0.00 | -0.02 | 0.01 | S |
| | | | | 1.00 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | Ag |
| | | | | | 1.00 | * | * | 0.08 | -0.29 | -0.04 | -0.05 | 0.04 | 0.03 | * | 0.09 | 0.04 | 0.13 | -0.10 | -0.16 | -0.17 | -0.19 | -0.10 | -0.15 | -0.03 | Sn |
| | | | | | | 1.00 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | W |
| | | | | | | | 1.00 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | Bi |
| | | | | | | | | 1.00 | 0.09 | 0.41 | 0.33 | 0.61 | 0.07 | * | 0.59 | 0.60 | 0.58 | -0.03 | -0.06 | 0.03 | 0.03 | 0.17 | 0.06 | 0.24 | Nb |
| | | | | | | | | | 1.00 | 0.37 | 0.19 | 0.20 | 0.03 | * | 0.03 | 0.04 | -0.01 | -0.13 | 0.25 | 0.36 | 0.39 | 0.18 | 0.20 | 0.14 | Li |
| | | | | | | | | | | 1.00 | 0.71 | 0.41 | 0.09 | * | 0.37 | 0.39 | 0.41 | 0.36 | 0.02 | 0.09 | 0.07 | 0.03 | -0.04 | -0.17 | Be |
| | | | | | | | | | | | 1.00 | 0.32 | 0.05 | * | 0.39 | 0.41 | 0.40 | 0.49 | -0.11 | -0.15 | -0.17 | -0.26 | -0.30 | -0.37 | Rb |
| | | | | | | | | | | | | 1.00 | 0.05 | * | 0.84 | 0.74 | 0.79 | 0.01 | 0.14 | 0.16 | 0.16 | 0.29 | 0.16 | 0.24 | U |
| | | | | | | | | | | | | | 1.00 | * | 0.00 | -0.01 | 0.08 | 0.17 | -0.01 | 0.01 | -0.03 | 0.08 | 0.08 | 0.04 | As |
| | | | | | | | | | | | | | | 1.00 | * | * | * | * | * | * | * | * | * | * | F |
| | | | | | | | | | | | | | | | 1.00 | 0.89 | 0.31 | 0.11 | 0.16 | 0.16 | 0.15 | 0.25 | 0.10 | 0.26 | Th |
| | | | | | | | | | | | | | | | | 1.00 | 0.76 | 0.20 | 0.13 | 0.15 | 0.15 | 0.21 | 0.09 | 0.22 | Ce |
| | | | | | | | | | | | | | | | | | 1.00 | 0.20 | 0.04 | 0.00 | -0.02 | 0.13 | 0.01 | 0.06 | Y |
| | | | | | | | | | | | | | | | | | | 1.00 | 0.04 | -0.02 | -0.06 | 0.01 | -0.04 | -0.28 | Ba |
| | | | | | | | | | | | | | | | | | | | 1.00 | 0.80 | 0.69 | 0.46 | 0.75 | 0.65 | Mn |
| | | | | | | | | | | | | | | | | | | | | 1.00 | 0.86 | 0.67 | 0.83 | 0.69 | Co |
| | | | | | | | | | | | | | | | | | | | | | 1.00 | 0.70 | 0.76 | 0.63 | Ni |
| | | | | | | | | | | | | | | | | | | | | | | 1.00 | 0.76 | 0.56 | Cr |
| | | | | | | | | | | | | | | | | | | | | | | | 1.00 | 0.73 | Fe |
| | | | | | | | | | | | | | | | | | | | | | | | | 1.00 | Ti |

Table 5: Spearman rank correlation co-efficients for the Forsayth stream-sediment data (1217 samples). The mid-rank method was used in the case of ties. As silver, tungsten, bismuth, and fluorine were not detected in many samples nonsensical co-efficients for these elements resulted. Spearman's method was preferred as it makes no assumption of normality for the data population.

because of its rather erratic behaviour. While it is anomalously high in sediments downstream from some lead-rich deposits, very high levels (up to 88700 ppm) occur in areas where there is no good reason to suspect the presence of mineralisation. X-ray diffraction studies indicate that precipitation of thenardite ($Na_2SO_4$) in the stream sediments is the cause of these spurious values.

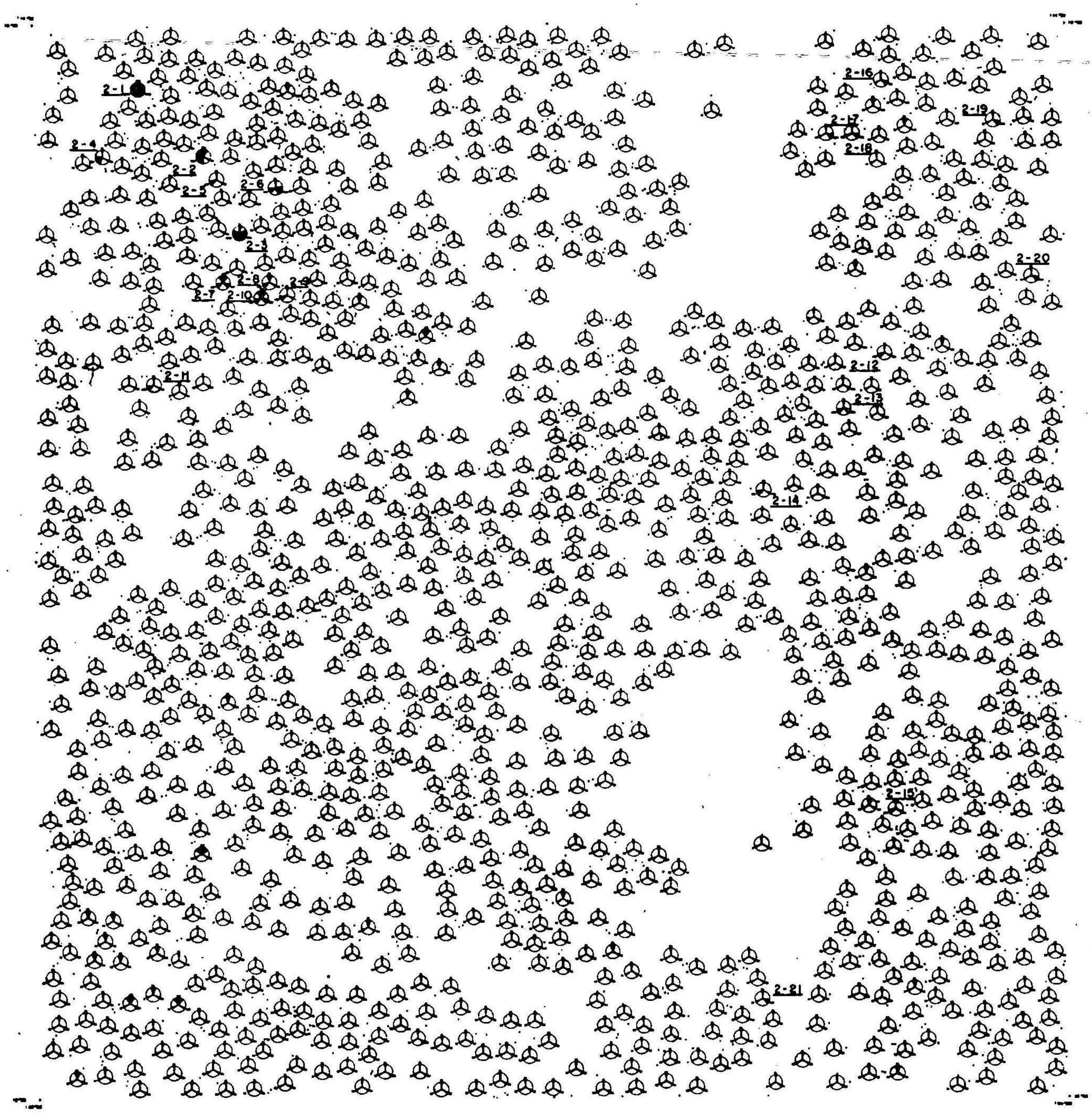
Map 1 discloses 17 copper values exceeding 50 ppm that are accompanied by high cobalt and/or nickel; in all but 6 cases basic igneous rocks have been noted in the catchment area. In addition there are 18 anomalous copper values which are not accompanied by enrichments of cobalt and/or nickel. These are numbered 1-1 to 1-18 in Figure 11. Two values (1-1 and 1-2) are strongly anomalous. The former occurs in a stream draining tailings from the Dry Hash gold mine. The latter is remote from known mineralisation in an area underlain by Robertson River Metamorphics, and probably warrants follow-up. Moderately anomalous levels (1-3 to 1-6) occur near the Nil Desperandum, Havelock, Big Reef, and Caledonia gold mines respectively. The mines of the Forsayth goldfields are also responsible for 5 slightly anomalous values (1-7 to 1-11). Slightly anomalous copper occurs in two streams draining Newcastle Range Volcanics (1-12 and 1-13). Anomaly 1-13 is located in an area enriched in tin (Map 5). The remaining slightly anomalous samples (1-14 to 1-18) are all from streams whose catchments consist partly of Einasleigh Metamorphics and these anomalies are more probably the expression of higher background copper in these rocks (Table 4) rather than mineral deposits. No sample used in the calculation of the Einasleigh Metamorphics background values combined high copper with high cobalt or nickel so that bias of the mean by unmapped basic rocks is unlikely.

Map 2 shows 15 lead values greater than 100 ppm (labelled 2-1 to 2-15 in Figure 12). The 3 strongly anomalous values (2-1 to 2-3) are situated near the Dry Hash, Nil Desperandum, and Forget-me-not/Settler mines respectively. The Marquis gold mine is responsible for the only moderately anomalous lead level (2-4). Slightly anomalous lead occurs downstream from the Forget-me-not/Settler (2-5), Struggle (2-6), Havelock (2-7), Big Reef (2-8 to 2-10), and Tweedside (2-11) mines. Three (2-12 to 2-14) of the remaining 4 slightly anomalous levels occur in sediments derived from Newcastle Range rhyolites and these appear, on the average, to be slightly enriched in lead relative to most of the other rock units in the area (Table 4). As 93 samples were used to calculate the Newcastle Range rhyolite background values, the incorporation of 3 slightly anomalous figures did not bias the mean noticeably.




1-1 *Anomaly referred to in text*

Fig. 11. Key to Map 1 (Copper, cobalt, nickel)




2-1 *Anomaly referred to in text*

Fig. 12. Key to Map 2 (Copper, lead, zinc)

Map 2 also indicates 12 zinc values exceeding 150 ppm. Strongly anomalous values occur near the Dry Hash (2-1) and Forget-me-not/Settler (2-3) mines. The Struggle mine is reflected in a moderately anomalous zinc level (2-6) and the Havelock and Big Reef mines give rise to slightly anomalous values (2-7 and 2-8 respectively). Six (numbered 2-16 to 2-21 in Figure 12) out of the 7 remaining slightly anomalous zinc values occur in areas of Einasleigh Metamorphics, again probably reflecting a higher background level in these rocks (Table 4).

Map 3 (Uranium, cerium, thorium) and Map 4 (Uranium, arsenic, bismuth)

As is the case for copper, high uranium values do not necessarily indicate mineralisation. The presence of detrital uraniferous minerals, principally monazite ((Ce, La, Y, Th) $PO_4$), can give rise to stream-sediment uranium values of up to 93 ppm. Such anomalies have no economic significance. Monazite occurs in many parts of the Sheet area; it is especially associated with Forsayth Granite, Einasleigh Metamorphics, and, to a lesser degree, Robertson River Metamorphics or dyke rocks intruding this unit (Fig. 13). To distinguish high uranium levels caused by monazite from those which might indicate mineralisation, the abundances of other elements need to be considered.

Samples enriched in uranium but low in cerium and thorium are less likely to contain monazite and therefore tend to be more interesting from an economic viewpoint. Results for these 3 elements are shown in Map 3. Yttrium is anomalously high in monazite-bearing rocks but also appears to be slightly enriched in the uranium deposits of the area - consequently it sheds less light than cerium or thorium on the problem of interpreting uranium values. The same comment applies to tungsten.

Arsenic and bismuth are commonly associated with uranium mineralisation in the Forsayth area and these elements appear in Map 4. Fluorine and molybdenum were also considered as pathfinders for uranium deposits as both are anomalously high at the Maureen uranium prospect 70 km north-northwest of Forsayth (O'Rourke, 1975). The X-ray fluorescence technique used for fluorine is rather insensitive (theoretical detection limit 650 ppm) and this element was seldom detected in samples whose uranium, arsenic, and bismuth contents suggested proximity to mineralisation. This is not to say that slight fluorine enrichments do not occur, however. As fluorine was

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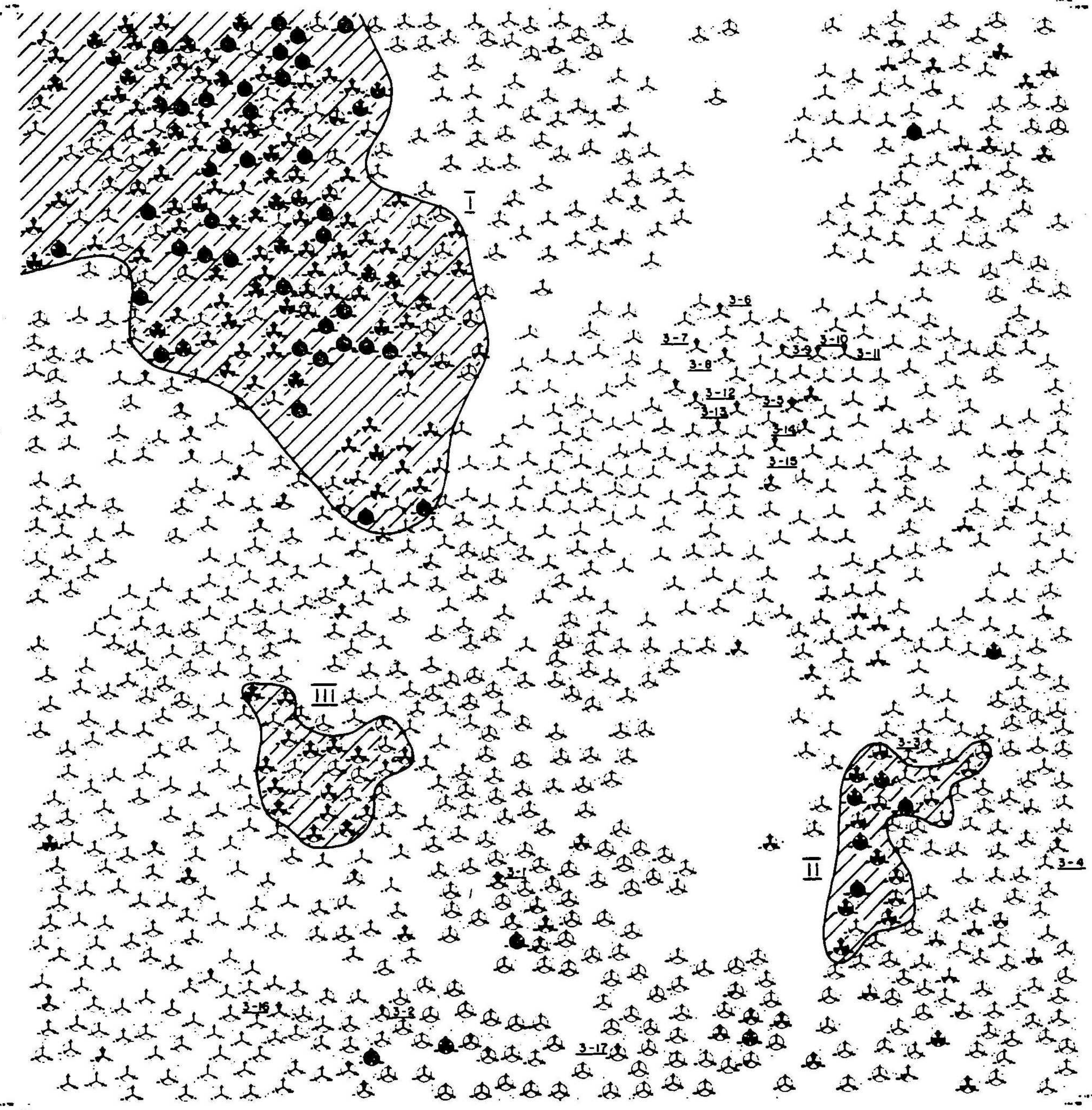
detected almost exclusively in streams draining areas of Forsayth Granite or Newcastle Range sandstones, a higher background level in thses rock units is suggested (Table 4). Analytical problems (p. 9) also precluded the use of molybdenum as a pathfinder for uranium deposits.

The bewildering array of uranium anomalies located by the survey can only be interpreted by using Maps 3 and 4 in close collaboration.

The samples most likely to indicate mineralisation combine anomalous uranium values with low cerium and thorium and high arsenic and bismuth. There are 4 of these, labelled 3-1 to 3-4 in Figure 13. One value (3-1) is moderately anomalous. Field observations show that this anomaly is associated with an alteration zone in Robin Hood Granodiorite. The alteration may be of Carboniferous age (Bain, 1977); its extent is obscured by a veneer of hill-wash. It is encouraging to note that gold-uranium mineralisation occurs in a similar geological setting at the Mount Hogan prospect about 30 km to the south-southeast. Central Coast Exploration NL have recently carried out extensive drilling at Mount Hogan (O'Rourke & Bennell, 1977). One of the slightly anomalous values (3-2) is also in an area underlain by Robin Hood Granodiorite while the others occur in areas of Digger Creek Granite (3-3) and Oak River Granodiorite (3-4). All may be related to mineralisation of Carboniferous age.

Slightly less promising from an economic viewpoint but nevertheless possibly associated with mineral deposits are the 13 samples (numbered 3-5 to 3-17 in Figure 13) anomalous in uranium, low in cerium and thorium, and enriched in one of the pathfinder elements (arsenic or bismuth). The one moderately anomalous value (3-5) is in an area of the Newcastle Range Volcanics mapped as ignimbritic rhyolite. The potential of this zone is enhanced by the fact that 10 slightly anomalous values (3-6 to 3-15) also occur in the vicinity. The anomaly in its entirety covers an area of some 40 $km^2$ and the uranium is accompanied by high levels of bismuth (Map 4), niobium, tin, and tungsten (Map 5). Clearly a large tract within the Newcastle Range has been permeated by mineralising solutions - whether or not concentration to economic grade has occurred at any point within this zone remains to be seen. The other 2 slightly anomalous values (3-16 and 3-17) are both situated in areas of Robin Hood Granodiorite.

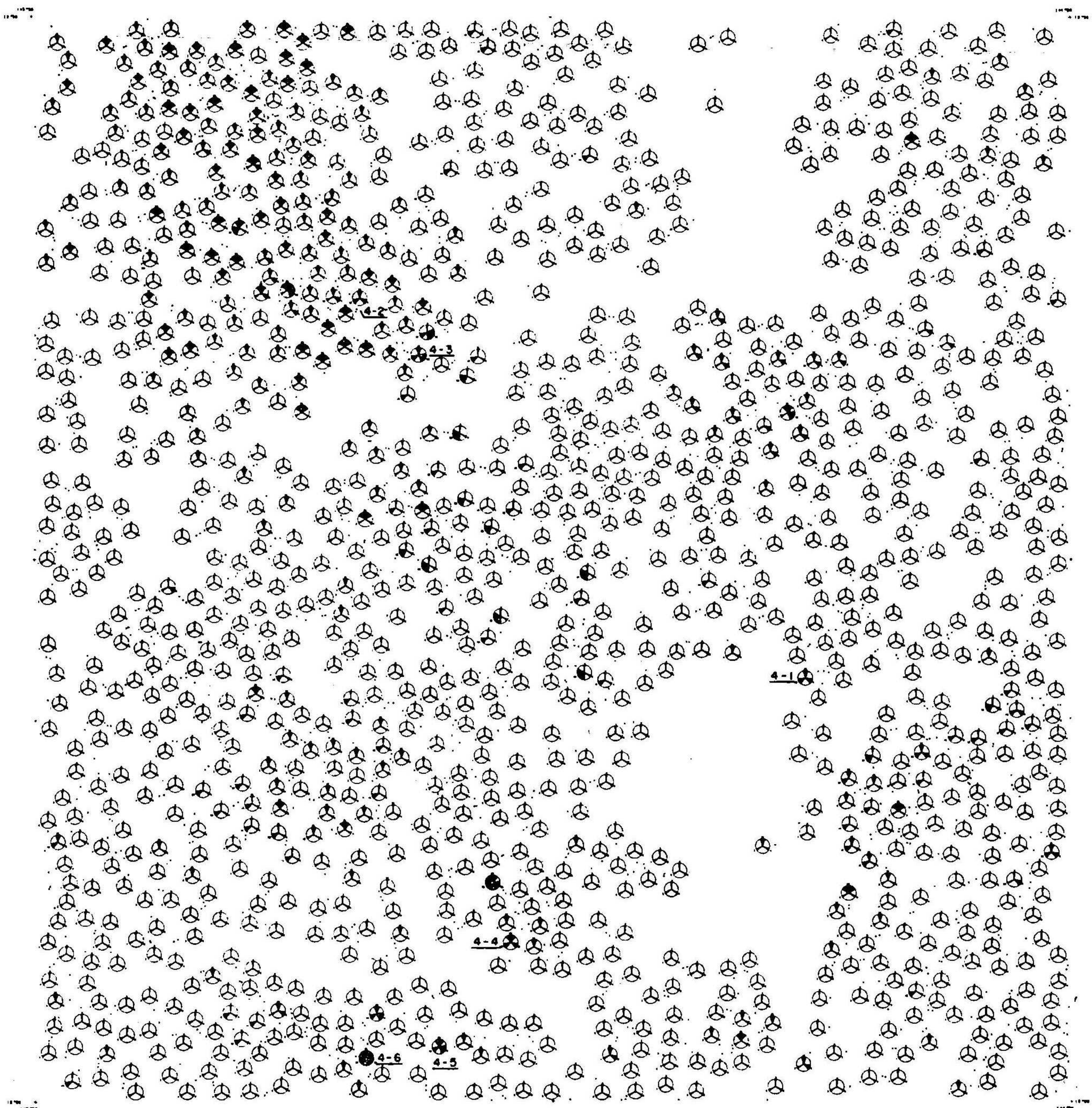
Also having some economic potential is the one sample (4-1 in Figure 14) combining slightly anomalous uranium with high arsenic, bismuth,




3-1 *Anomaly referred to in text*

*Main concentrations of detrital monazite in the area. Zones I, II and III are underlain by Forsayth Granite, Einasleigh Metamorphics and Robertson River Metamorphics intruded by acid dykes, respectively*

**Fig. 13. Key to Map 3 (Uranium, cerium, thorium)**




4-1 *Anomaly referred to in text*

Fig. 14. Key to Map 4 (Uranium, arsenic, bismuth)

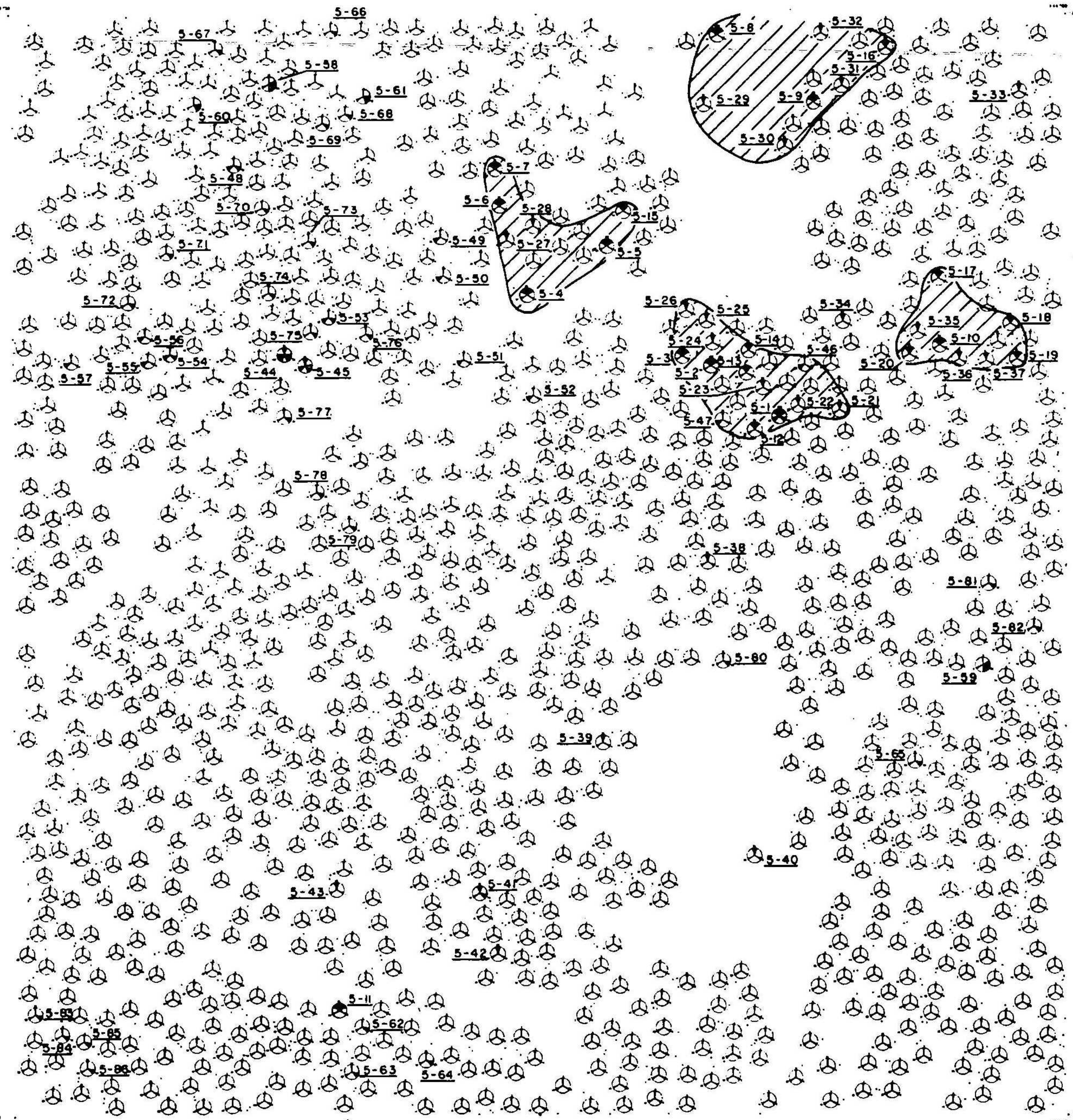
and only one of the monazite indicators (cerium). This anomaly occurs within tuffaceous rocks of the Newcastle Range Volcanics. Follow-up work in this area has revealed an interesting problem. When resampling was carried out during 1976 no high uranium values were found although high arsenic levels (up to 91 ppm in soils) were still present. The reason for this is not clear but a possible explanation is that a drop in the water-table, caused by decreased rainfall during the 1974-5 and 1975-6 wet seasons, in some way disrupted the migration of uranium into the stream via the groundwater system. Until this problem is resolved the area cannot be written off as being of no economic interest. Fortunately this is an isolated instance and all other uranium anomalies followed-up during 1976 could be relocated.

The 5 samples (labelled 4-2 to 4-6 in Figure 14) which combine anomalous uranium with high arsenic and bismuth and with high cerium and thorium are an enigma. The first two elements suggest that mineralisation might be the cause of these anomalies, the last two imply the presence of monazite. It seems likely that the high arsenic and bismuth values in the Goldsmiths Creek area (4-2 and 4-3) are related to gold mineralisation and that uranium is, in fact, present in monazite. However, anomalies 4-4 to 4-6 cannot be disregarded entirely as they occur in close proximity to some of the economically promising uranium anomalies (3-1, 3-2, 3-16, 3-17) discussed above.

Map 5 (Tin, niobium, tungsten)

Map 5 presents results for tin, niobium, and tungsten as all 3 show anomalous values and there is some possibility of the existence of economic concentrations of these metals in the Forsayth 1:100 000 Sheet area.

A total of 45 samples contain tin in excess of 25 ppm. These are numbered 5-1 to 5-45 in Figure 15. Three strongly anomalous values (5-1 to 5-3) occur within the previously-mentioned uranium-rich area of the central Newcastle Range (p.16). A further 7 strongly anomalous values (5-4 to 5-10), also associated with Newcastle Range Volcanics, cluster in 3 areas to the east, north, and northwest of the central uranium-rich zone (Fig. 15). The only other strongly anomalous value (5-11) occurs in an area underlain by Robin Hood Granodiorite. Many moderately anomalous (5-12 to 5-20)




5-1 *Anomaly referred to in text*

*The 4 stanniferous zones of the Newcastle Range discussed in the text*

Fig. 15. Key to Map 5 (Tin, niobium, tungsten)

and slightly anomalous (5-21 to 5-37) samples occur in streams draining the 4 main stanniferous zones of the Newcastle Range - a further 3 slightly anomalous values (5-38 to 5-40) are situated in the southern parts of the range. Slightly anomalous levels occur in areas of Robin Hood Granodiorite (5-41 to 5-43), where they are usually associated with economically interesting uranium concentrations, and in one stream draining Forsayth Granite (5-44 and 5-45).

The niobium contents of 15 samples are greater than 50 ppm. Moderately anomalous (5-44) and slightly anomalous (5-45) values occur in the area of Forsayth Granite enriched in tin. Three slightly anomalous values (5-1, 5-46, and 5-47) are in the uranium-tin province of the central Newcastle Range. The remaining 10 slightly anomalous values (5-48 to 5-57) occur mainly in catchment areas containing outcrops of Forsayth Granite and probably reflect a higher background niobium level in this rock unit (Table 4).

The survey recorded 36 tungsten values exceeding 10 ppm. Most of these anomalies are unlikely to be of economic significance as they are associated with high cerium and thorium and this suggests that the tungsten is present either in monazite or a mineral of similar provenance and specific gravity. The 2 strong anomalies (5-58 and 5-59) fall into this category as do 2 of the moderately anomalous values (5-60 and 5-61). The other 2 moderately anomalous tungsten values (5-44 and 5-45) also occur in samples rich in cerium and thorium but the presence of tin and niobium indicates that perhaps these anomalies should not be overlooked. There are 6 slightly anomalous values (5-1, 5-41, 5-62 to 5-65) of economic importance. The first occurs in the uranium-tin zone of the central Newcastle Range, the other 5 in uranium-rich areas of Robin Hood Granodiorite and Digger Creek Granite. All but 4 of the remaining 24 slightly anomalous tungsten levels (5-48, 5-53, 5-54, 5-66 to 5-86) are associated with high cerium and/or thorium. Fifteen of these are from streams draining areas of Forsayth Granite - a rock unit which contains abundant monazite (p.15).

## CONCLUSIONS AND RECOMMENDATIONS

Stream-sediment sampling of the Forsayth 1:100 000 Sheet suggests that the area's greatest economic potential lies in the possibility of tin and uranium deposits.

An area of some 40 km$^2$ in the central part of the Newcastle Range

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is enriched in tin, uranium, bismuth and, to a lesser degree, niobium and tungsten. The absence of any beryllium, lithium, or rubidium anomaly suggests that the mineralisation is not of pegmatitic type. In addition, there are 3 large areas to the east, north, and northwest of the central zone which are, except for a slight copper enrichment in the eastern area, anomalous only in tin. Again, these 3 anomalous zones all occur in Newcastle Range rhyolites. Clearly, large tracts of the Newcastle Range have been permeated by tin- and uranium-bearing solutions, and the possibility that these may have produced large stockwork deposits should not be overlooked.

Another interesting group of anomalies occurs towards the southwest corner of the Sheet area; here uranium enrichments are associated with high arsenic, bismuth, tin, and tungsten. Although this area is occupied by Robin Hood Granodiorite any mineralisation associated with the anomalies is probably related to Carboniferous igneous activity. At the Mount Hogan uranium-gold prospect about 20 km from the southern margin of the Forsayth 1:100 000 Sheet, an alteration zone within Mount Hogan Granite attains sufficient dimensions for Central Coast Exploration NL to have carried out extensive drilling in recent years.

Indications of uranium mineralisation have also been discovered in streams draining areas of Digger Creek Granite and Oak River Granodiorite as well as Newcastle Range Volcanics and Robin Hood Granodiorite. The fact that this metal occurs in a number of geological settings should be taken into account during future exploration of the area. If geochemical surveys for uranium are contemplated the possibility of anomalies caused by detrital monazite should be remembered. The determination of arsenic, bismuth, cerium, and thorium, can help distinguish uranium enrichments due to this cause from those more likely to indicate mineralisation.

The survey brought to light only one strongly anomalous copper value which was not associated with basic igneous rocks or known mineralisation. Although this anomaly is worthy of follow-up work the presence of large syngenetic copper-lead-zinc deposits within the Sheet area is unlikely. Porphyry copper deposits occur west of Georgetown at Mount Turner and Mount Darcy but the possibility that such mineralisation will be found here is remote.

## ACKNOWLEDGEMENTS

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AUSTRALIA 1:100 000 STREAM—SEDIMENT GEOCHEMISTRY SERIES

# FORSAYTH

## COPPER - COBALT - NICKEL

SCALE 1:100000

1 0 1 2 3 4 5 6 7 8 9 10 Kilometres

Sample collection 1974 by
A.Rossiter, M.Shackleton, K.Armstrong, A.Hoey, F.Stevenson, T.Fletcher
Chemical analysis of samples 1975–76 by
B.Cruikshank, P.Swan, J.Weekes, G.Willcocks(AAS), J.Pyke, K.Ellingsen, J.Fitzsimmons, J.Sheraton(XRF)
Compilation and coding of geochemical information by
A.Rossiter, P.Scott, K.Armstrong
Computer programming for automated cartography by
J.Rees, K.Long, P.Scott, R.Macduff, T.Luyendyk

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Base map compiled by the Division of National Mapping


| | | | | |
|---|---|---|---|---|
| COPPER AAS, 2 | 0-50 | 51-100 | 101-150 | >150 |
| COBALT AAS, 2 | 0-25 | 26-50 | 51-75 | >75 |
| NICKEL AAS, 2 | 0-30 | 31-60 | 61-90 | >90 |

The analytical technique used and the detection limit obtained are indicated below each element
AAS = atomic absorption spectrophotometry
XRF = X-ray fluorescence spectrometry
All values are parts per million in samples sieved to minus 180 micrometres (85 mesh BSS)

| | | | |
|---|---|---|---|
| • | Stream-sediment sample locality | | Road |
| | | | Vehicle track |
| | Abandoned mine | | Railway |
| | Abandoned prospect | | Fence |
| | Abandoned alluvial workings | | Building |
| | Mill and treatment plant | Yd | Yard |
| | Site of former battery | | Spring |
| Cu | Copper | | Dam on stream |
| F | Fluorine | E | Earth dam |
| Au | Gold | | Windpump |
| Pb | Lead | | Waterbore |
| Ag | Silver | | |
| Sn | Tin | | |
| U | Uranium | | |

INDEX TO 1:100 000 MAPS

| | | | |
|---|---|---|---|
| FOREST HOME 756 | GEORGETOWN 7661 | MOUNT SURPRISE 7761 | 18°00' |
| NORTH HEAD 7560 | FORSAYTH 7660 | EINASLEIGH 7760 | 18°30' |
| BELLFIELD 7559 | GILBERTON 7659 | LYNDHURST 7759 | 19°00' |
| 143°00' | 143°30' | 144°00' | 144°30' / 19°30' |

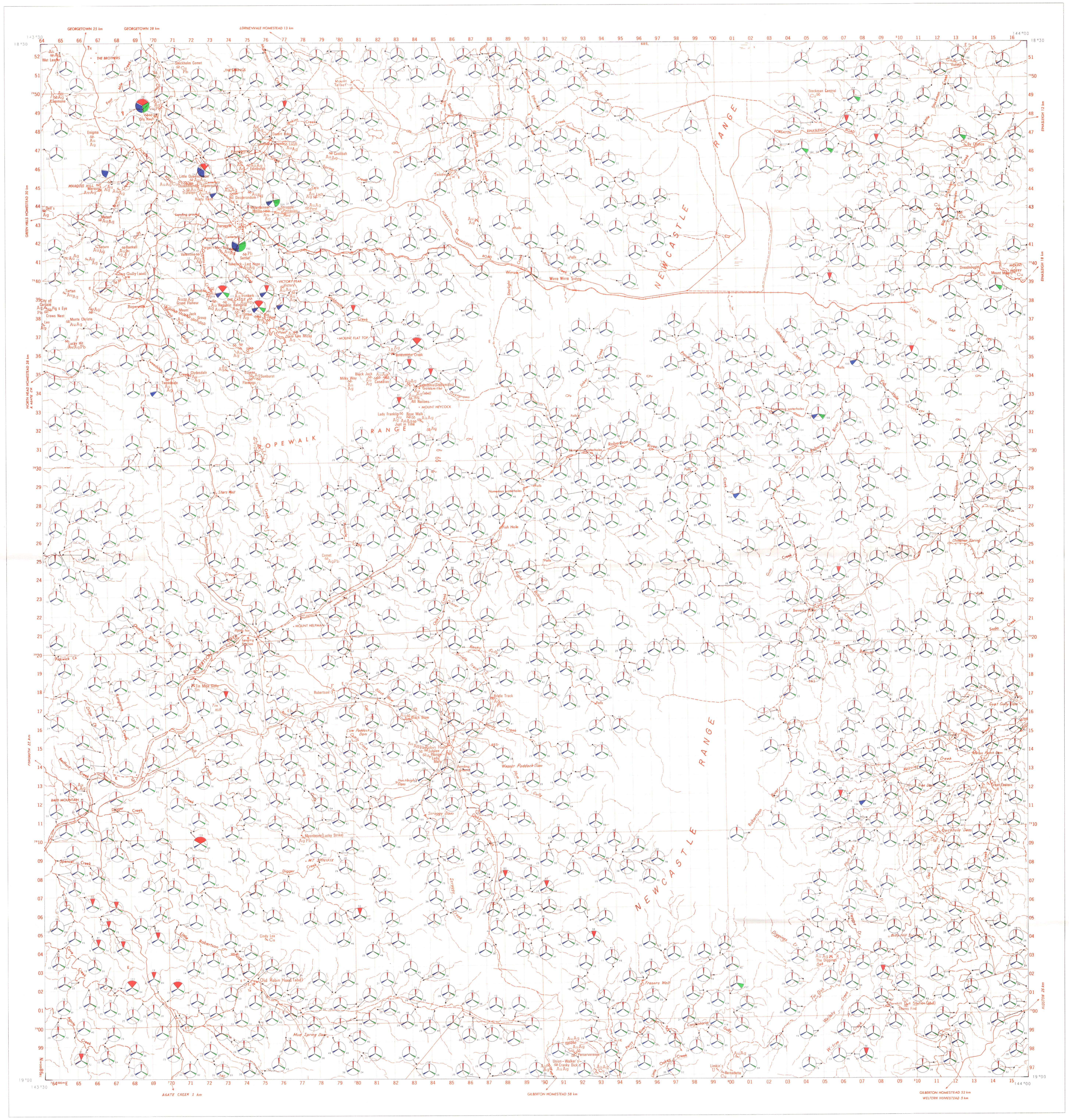

AUSTRALIA 1:100 000 STREAM - SEDIMENT GEOCHEMISTRY SERIES
FORSAYTH
QUEENSLAND-SHEET NO 7660
COPPER-COBALT-NICKEL

R76/1334 (1)
Cat. No. 7766 956

# AUSTRALIA 1:100 000 STREAM–SEDIMENT GEOCHEMISTRY SERIES

# FORSAYTH

## COPPER – LEAD – ZINC




SCALE 1:100000

1 0 1 2 3 4 5 6 7 8 9 10 Kilometres


Sample collection 1974 by
A. Rossiter, M. Shackleton, K. Armstrong, A. Hoey, F. Stevenson, T. Fletcher
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Compilation and coding of geochemical information by
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Computer programming for automated cartography by
J. Rees, K. Long, P. Scott, R. Macduff, T. Luyendyk

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Design and drafting by Cartography Section, BMR
Base map compiled by the Division of National Mapping



| | | | | |
|---|---|---|---|---|
| COPPER AAS, 2 | 0-50 | 51-100 | 101-150 | >150 |
| LEAD AAS, 4 | 0-100 | 101-200 | 201-300 | >300 |
| ZINC AAS, 1 | 0-150 | 151-300 | 301-450 | >450 |

The analytical technique used and the detection limit obtained are indicated below each element
AAS = atomic absorption spectrophotometry
XRF = X-ray fluorescence spectrometry
All values are parts per million in samples sieved to minus 180 micrometres (85 mesh BSS).

| | |
|---|---|
| • | *Stream-sediment sample locality* |
| | *Abandoned mine* |
| | *Abandoned prospect* |
| | *Abandoned alluvial workings* |
| | *Mill and treatment plant* |
| | *Site of former battery* |
| Cu | *Copper* |
| F | *Fluorine* |
| Au | *Gold* |
| Pb | *Lead* |
| Ag | *Silver* |
| Sn | *Tin* |
| U | *Uranium* |

| | |
|---|---|
| | *Road* |
| | *Vehicle track* |
| | *Railway* |
| | *Fence* |
| | *Building* |
| Yd | *Yard* |
| | *Spring* |
| | *Dam on stream* |
| E | *Earth dam* |
| | *Windpump* |
| | *Waterbore* |

INDEX TO 1:100 000 MAPS

| | 143°00'–143°30' | 143°30'–144°00' | 144°00'–144°30' |
|---|---|---|---|
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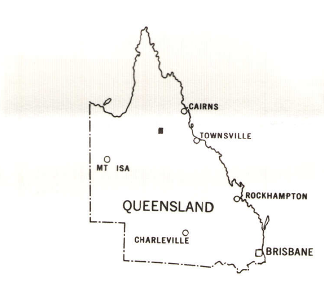
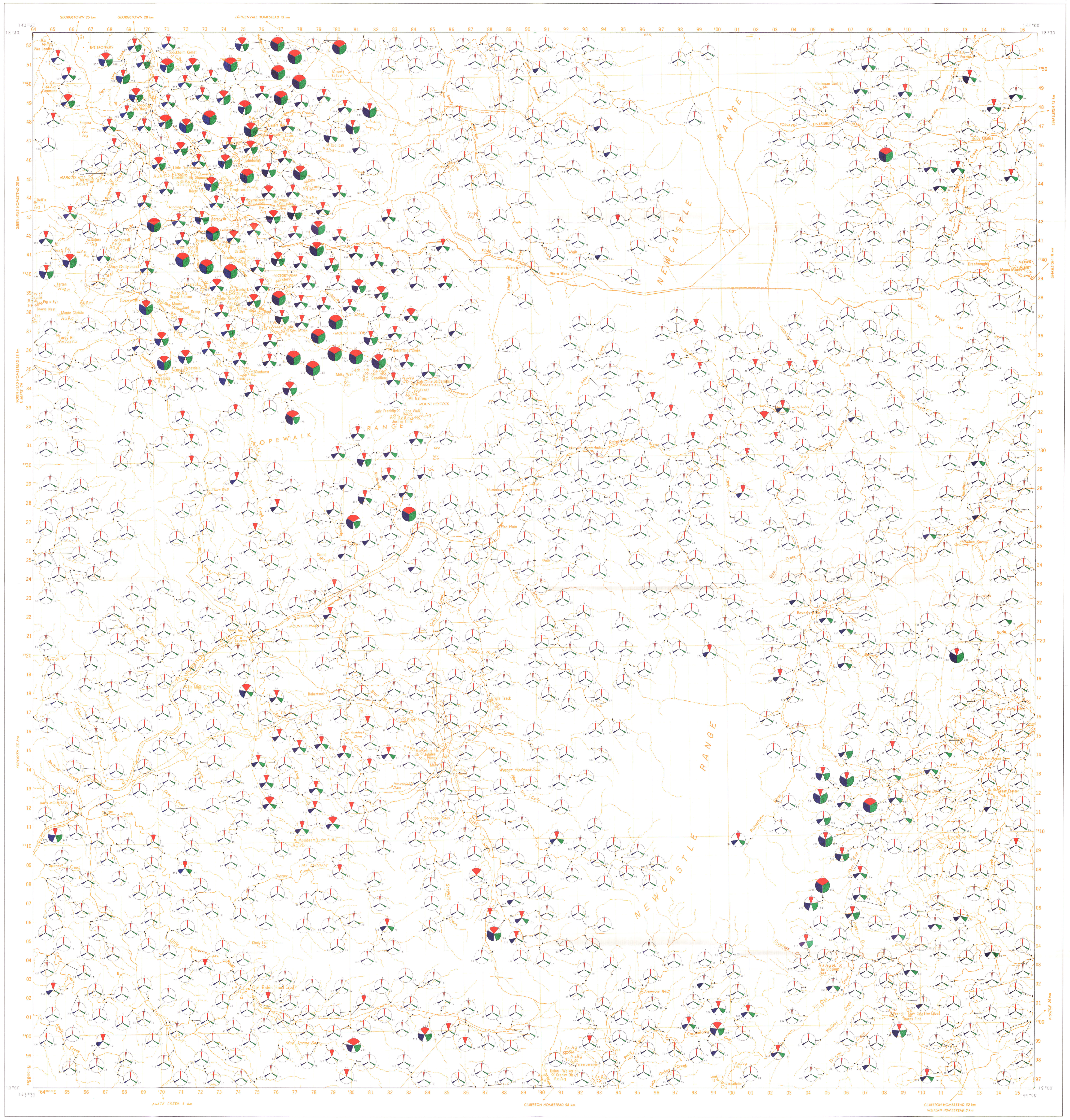
| 18°30'–19°00' | NORTH HEAD 7560 | FORSAYTH 7660 | EINASLEIGH 7760 |
| 19°00'–19°30' | BELLFIELD 7559 | GILBERTON 7659 | LYNDHURST 7759 |




AUSTRALIA 1:100 000 STREAM-SEDIMENT GEOCHEMISTRY SERIES
FORSAYTH
QUEENSLAND-SHEET NO 7660
COPPER-LEAD-ZINC



# AUSTRALIA 1:100 000 STREAM—SEDIMENT GEOCHEMISTRY SERIES

# FORSAYTH

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SCALE 1:100000

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Sample collection 1974 by
A.Rossiter, M.Shackleton, K.Armstrong, A.Hoey, F.Stevenson, T.Fletcher
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under the authority of the Minister for National Development
Design and drafting by Cartography Section, BMR
Base map compiled by the Division of National Mapping


| | | | | |
|---|---|---|---|---|
| URANIUM XRF, 1 | 0-10 | 11-20 | 21-30 | >30 |
| CERIUM XRF, 3 | 0-200 | 201-400 | 401-600 | >600 |
| THORIUM XRF, 2 | 0-75 | 76-150 | 151-225 | >225 |

The analytical technique used and the detection limit obtained are indicated below each element
AAS = atomic absorption spectrophotometry
XRF = X-ray fluorescence spectrometry
All values are parts per million in samples sieved to minus 180 micrometres (85 mesh BSS)

| | |
|---|---|
| Stream-sediment sample locality | Road |
| Abandoned mine | Vehicle track |
| Abandoned prospect | Railway |
| Abandoned alluvial workings | Fence |
| Mill and treatment plant | Building |
| Site of former battery | Yard |
| Cu Copper | Spring |
| F Fluorine | Dam on stream |
| Au Gold | Earth dam |
| Pb Lead | Windpump |
| Ag Silver | Waterbore |
| Sn Tin | |
| U Uranium | |

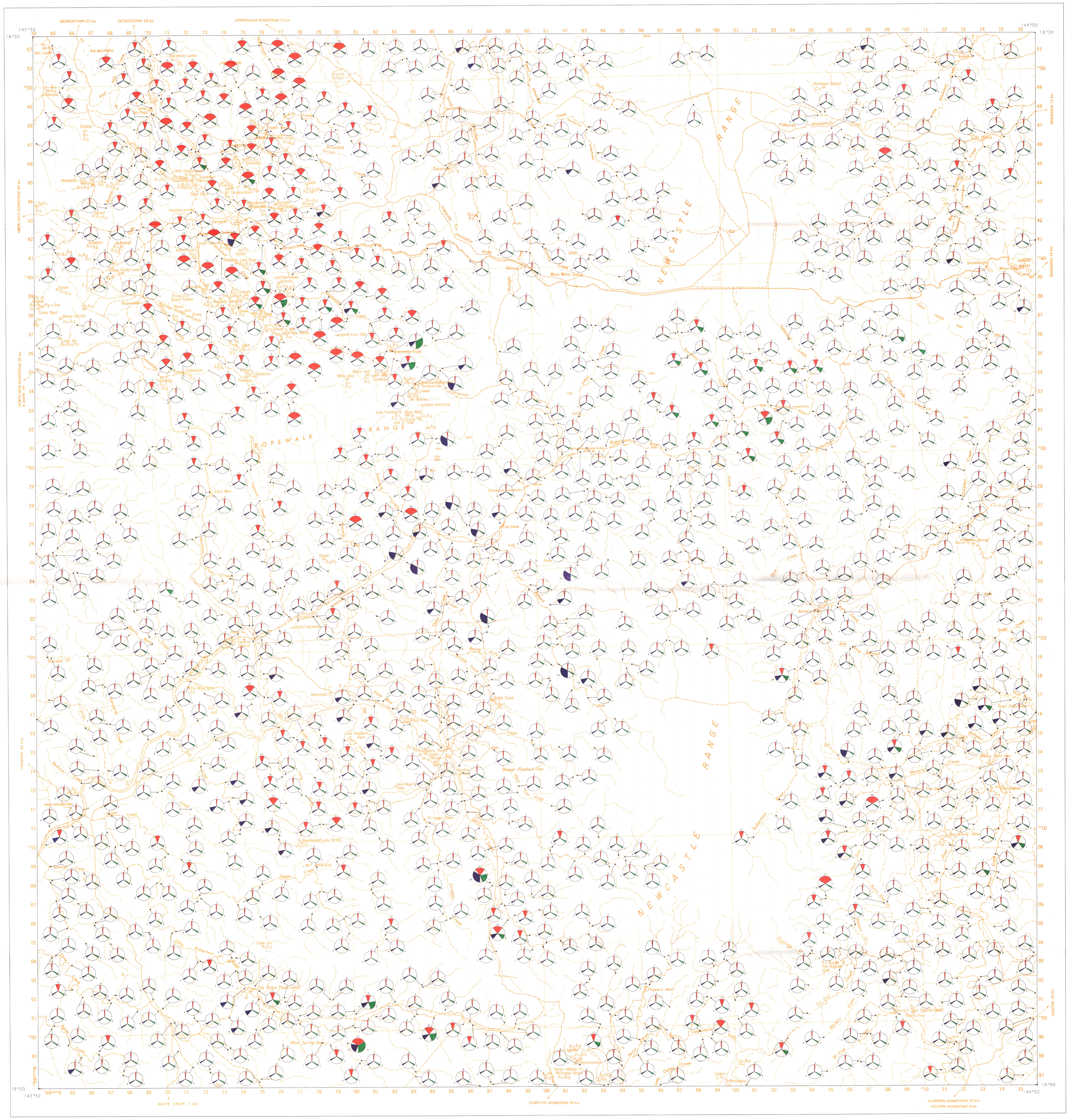
INDEX TO 1:100 000 MAPS

| | | |
|---|---|---|
| FOREST HOME 7561 | GEORGETOWN 7661 | MOUNT SURPRISE 7761 |
| NORTH HEAD 7560 | FORSAYTH 7660 | EINASLEIGH 7760 |
| BELLFIELD 7559 | GILBERTON 7659 | LYNDHURST 7759 |

143°00' 143°30' 144°00' 144°30' — 18°00' 18°30' 19°00' 19°30'


AUSTRALIA 1:100 000 STREAM-SEDIMENT GEOCHEMISTRY SERIES
FORSAYTH
QUEENSLAND-SHEET NO 7660
URANIUM — CERIUM — THORIUM

R76/1334 (1)
Cat. No. 7766 956




# AUSTRALIA 1:100 000 STREAM–SEDIMENT GEOCHEMISTRY SERIES

# FORSAYTH

## URANIUM – ARSENIC – BISMUTH

SCALE 1:100000

1 0 1 2 3 4 5 6 7 8 9 10 Kilometres


Sample collection 1974 by
A. Rossiter, M. Shackleton, K. Armstrong, A. Hoey, F. Stevenson, T. Fletcher

Chemical analysis of samples 1975–76 by
B. Cruikshank, P. Swan, J. Weekes, G. Willcocks (AAS), J. Pyke, K. Ellingsen, J. Fitzsimmons, J. Sheraton (XRF)

Compilation and coding of geochemical information by
A. Rossiter, P. Scott, K. Armstrong

Computer programming for automated cartography by
J. Rees, K. Long, P. Scott, R. Macduff, T. Luyendyk

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under the authority of the Minister for National Development
Design and drafting by Cartography Section, BMR
Base map compiled by the Division of National Mapping



URANIUM
XRF, 1

0-10 | 11-20 | 21-30 | >30

ARSENIC
XRF, 1

0-10 | 11-20 | 21-30 | >30

BISMUTH
XRF, 2

0-4 | 5-8 | 9-12 | >12

The analytical technique used and the detection limit obtained are indicated below each element
AAS = atomic absorption spectrophotometry
XRF = X-ray fluorescence spectrometry
All values are parts per million in samples sieved to minus 180 micrometres (85 mesh BSS)

Stream-sediment sample locality
Abandoned mine
Abandoned prospect
Abandoned alluvial workings
Mill and treatment plant
Site of former battery
Cu Copper
F Fluorine
Au Gold
Pb Lead
Ag Silver
Sn Tin
U Uranium

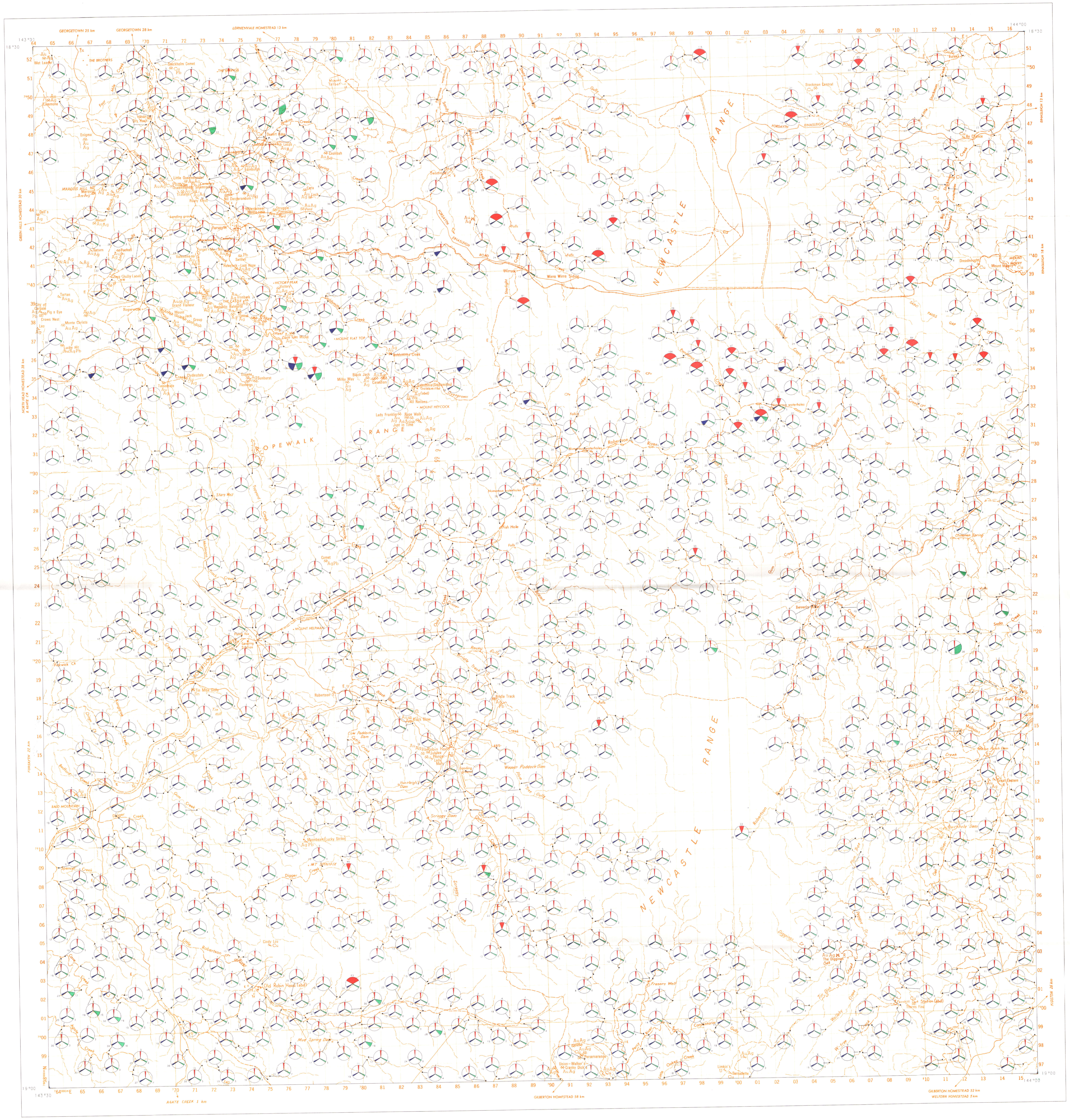
Road
Vehicle track
Railway
Fence
Building
Yd Yard
Spring
Dam on stream
E Earth dam
Windpump
Waterbore

INDEX TO 1:100 000 MAPS

| | | | |
|---|---|---|---|
| FOREST HOME 7561 | GEORGETOWN 7661 | MOUNT SURPRISE 7761 | 18°00' |
| NORTH HEAD 7560 | FORSAYTH 7660 | EINASLEIGH 7760 | 18°30' |
| BELLFIELD 7559 | GILBERTON 7659 | LYNDHURST 7759 | 19°00' |
| 143°00' | 143°30' | 144°00' | 144°30' / 19°30' |


AUSTRALIA 1:100 000 STREAM-SEDIMENT GEOCHEMISTRY SERIES
FORSAYTH
QUEENSLAND-SHEET NO 7660
URANIUM – ARSENIC – BISMUTH

R76/1334 (1)
Cat. No. 7766 956



# AUSTRALIA 1:100 000 STREAM–SEDIMENT GEOCHEMISTRY SERIES

# FORSAYTH

## TIN – NIOBIUM – TUNGSTEN

SCALE 1:100000

1 0 1 2 3 4 5 6 7 8 9 10 Kilometres

Sample collection 1974 by
A.Rossiter, M.Shackleton, K.Armstrong, A.Hoey, F.Stevenson, T.Fletcher

Chemical analysis of samples 1975–76 by
B.Cruikshank, P.Swan, J.Weekes, G.Willcocks(AAS), J.Pyke, K.Ellingsen, J.Fitzsimmons, J.Sheraton(XRF)

Compilation and coding of geochemical information by
A.Rossiter, P.Scott, K.Armstrong

Computer programming for automated cartography by
J.Rees, K.Long, P.Scott, R.Macduff, T.Luyendyk

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| | | | | |
|---|---|---|---|---|
| TIN XRF, 2 | 0-25 | 26-50 | 51-75 | >75 |
| NIOBIUM XRF, 2 | 0-50 | 51-100 | 101-150 | >150 |
| TUNGSTEN XRF, 3 | 0-10 | 11-20 | 21-30 | >30 |

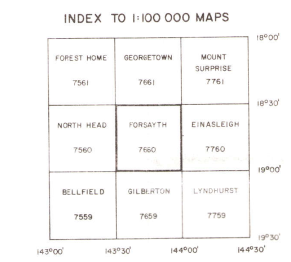
The analytical technique used and the detection limit obtained are indicated below each element
AAS = atomic absorption spectrophotometry
XRF = X-ray fluorescence spectrometry
All values are parts per million in samples sieved to minus 180 micrometres (85 mesh BSS)

*Stream-sediment sample locality*

*Abandoned mine*
*Abandoned prospect*
*Abandoned alluvial workings*
*Mill and treatment plant*
*Site of former battery*
Cu *Copper*
F *Fluorine*
Au *Gold*
Pb *Lead*
Ag *Silver*
Sn *Tin*
U *Uranium*

*Road*
*Vehicle track*
*Railway*
*Fence*
*Building*
Yd *Yard*
*Spring*
*Dam on stream*
E *Earth dam*
*Windpump*
*Waterbore*

INDEX TO 1:100 000 MAPS





AUSTRALIA 1:100 000 STREAM–SEDIMENT GEOCHEMISTRY SERIES
FORSAYTH
QUEENSLAND–SHEET NO 7660
TIN – NIOBIUM – TUNGSTEN

R76/1334 (1)
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