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GEOCHEMICAL SAMPLING - MICHELAGO AREA - NEW SOUTH WALES.

by

J.F.Ivanac and N.J.Marshall

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Records 1965/204

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GEOCHEMICAL SAMPLING - MICHELAGO AREA

NEW SOUTH WALES

SUMMARY

During February 1964, geochemical sampling techniques were demonstrated to university students employed during their summer vacation by the Bureau of Mineral Resources. The Michelago area was selected because ferruginous deposits (gossans) are exposed in the area and had been mined in the past for iron ore. Stream sediments, colluvium, gossan and rock samples were collected for geochemical analysis. The results show that the gossans are anomalous in copper, lead and zinc, and suggest that an area extending from Burra to 4 miles south of Michelago should be prospected for base metal deposits.

The gossans are located along a Silurian volcanics/ Ordovician sediments interface particularly where strong shearing, probably associated with the Queanbeyan Fault, has taken place. The gossans, although they appear to be largely pyritic, may directly overlie or may be spatially related to base metal deposits. Consequently attention is drawn to soil covered areas along strike from and for some distance on each side of the volcanics/sediment interface, particularly in areas of structural deformation and disseminated sulphides.

INTRODUCTION

This report briefly sets down the results of geochemical sampling in the Michelago area, New South Wales. During February 1964 stream sediment samples, colluvium, rock chips and gossans were collected from the Michelago area as part of an exercise to show geological students the technique of geochemical sampling. The students were employed during their university vacation and the excursion is an annual event instituted sometime ago.

Several geologists, F. de Keyser, D. Dunnet, A.G.L. Paine, R. Harding, G. Derrick and J.F. Ivanac led individual parties of students. A. Mather, geochemist, assisted for part of the time.

The samples were analysed in the laboratory of the Bureau of Mineral Resources in Canberra. N. Marshall completed analyses for copper, lead and zinc using atomic absorption spectrophotometric techniques; I.R. Pontifex examined several samples of gossan in thin and polished sections. In 1965 G.M. Burton during selection of a site for a water bore on Ponderose sheet station, in the Michelago area, located a limonitic gossan south of the area sampled.

A. D. Haldane completed an emission spectrographic scan of selected samples. Their results are tabulated in appendices to this record.

The ferruginous deposits which excited our interest have been mined in the past for iron ore and umber. They have been prospected unsuccessfully for gold.

PREVIOUS INVESTIGATIONS

The most recent account of the geology is set down on the Canberra 1:250,000 Sheet area which was published in 1963.

Hancock et al during 1962 and 1963 mapped the Michelago 1:50,000 Sheet area and their results are incorporated in the Canberra Sheet area. They recorded the following succession in the Bredbo-Michelago area:-

Lower Devonian - shale and sandstone

unconformity

Browning Orogeny

Silurian - Sandstone near Tharwa
Upper Tuffs
Dacites
Lower Tuffs
Sandstone, Shale
Limestone

unconformity

Benambran Orogeny

Ordovican (a) Siliceous black shale
(b) Thin-bedded sandstone and shale

Australian Iron and Smelting Company hold a small area surrounding the gossans at sample sites 001 and 002. They have mined the gossans for iron ore (J. Harms per.comm) and have completed an aeromagnetic survey over the southernmost ferruginous deposits. Electrolytic Zinc Company of Australasia are currently (1965) exploring the region and hold an Authority to Prospect over most of the region. The complete results of this investigation were discussed with officers of the Electrolytic Zinc Company and any ideas were freely passed on.

In 1961 W. Oldershaw of the Bureau collected samples from the Michelago gossans and showed they contain minor amounts of copper and lead.

SITUATION AND ACCESS

Michelago township is situated on the Monaro Highway 35 miles south of Canberra and in the southern central part of the area sampled. Gossans crop out near a volcanics/sediment interface and occur from 3 miles south-east of, to 10 miles north-east of Michelago and similar deposits are found also at Burra 12 miles north-north-east of Michelago and at Ponderose 2½ miles south of Michelago. They crop out along side a well formed gravel road. A sealed road, the Monaro Highway passes within 1 mile of, and the Sydney-Cooma railway lies within three-quarters of a mile of the gossans.

TOPOGRAPHY

The gossans occur on low undulating hills which have been cleared in some places for grazing and agriculture; in others they are heavily wooded. Although the present erosion surface coincides with outcrops of gossans it is possible that others are concealed beneath transported soils along the volcanic/sediment contact.

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GEOLOGICAL SETTING

The general geology of the area sampled is shown on the geological map of the Canberra 1:250,000 Sheet area and consists of interlayered sediments and volcanics intruded by granites and porphyry.

The oldest rocks are Middle Ordovician sandstones and shales with siliceous black shale occurring near the top of the succession.

Silurian rocks which unconformably overlie Ordovician consist of sandstone, shale and limestone overlain by tuffs which in turn are conformably overlain by dacite flows, bedded and crystal tuffs. A succession of tuffs containing reworked crystal tuffs, dacite flows and thin bedded sandstone overlie the dacitic rocks.

The succession in the Michelago area has been strongly faulted and intruded by igneous rocks.

Ordovician Sediments

Ordovician rocks consist of clean friable quartz sandstones, buff to green fine to medium-grained sandstone, buff to green shale, fine grained yellow ochre and buff tuffs, medium-grained greywacke, yellow grey dolomites, quartzite, chert, and phyllite. They are well bedded and have been strongly folded and sheared. Limonite pseudomorphs after pyrite were observed in several places and may replace sulphides introduced by intrusive rocks. Minor silicification generally accompanies pyritization. Pyritic quartz sandstone and shale are widespread in vicinity of Sample site 109 near the northern end of the area sampled.

Sample 104 was collected from a grey to brown limestone dolomite bed which may be part of either the Ordovician succession or the Silurian volcanics.

The sediments are Upper Ordovician. They have been intruded by the Tinderry and Michelago Granites and possibly by an equivalent of the Mount Painter Porphyry. A gabbro at Sample site 068 appears to intrude Ordovician sediments, which in places, contain up to 5 percent pyrite.

The sediments dip regionally to the west and in the vicinity of the Queanbeyan fault, dip ranges from 75° west to steep east. The pitch of a fold near the Fault appears to be gently north although further work is needed to verify this conclusion.

Silurian

The rocks of Silurian age are shown on the Canberra 1:250,000 Sheet area as Colinton Volcanics and Cooleman Beds and they consist of interlayered tuff, crystal tuff, dacite, shale and sandstone with limestone lenses. Tuffs and limestone are the two most prominent members noted in the Michelago area.

At Sample site 323 on the banks of the Murrumbidgee River dolomite marble with minor quartz, plagioclase feldspar and muscovite grades into a dolomitic rhyolitic tuff.

The crystal tuff forms bold hills on the western side of Margarets Creek and is a dark green, broadly layered rock.

The Colinton Volcanics dip steeply west and have been strongly sheared. They have been intruded by porphyry and by minor gold-galena quartz veins.

The Colinton Volcanics are Middle Silurian and the Goossoon Beds Upper Silurian. The Colinton Volcanics unconformably overlie Ordovician rocks although this is difficult to observe in the Michelago area where the contact has been faulted.

Intrusive Rocks

Ordovician and Silurian sediments and volcanics are intruded by the Tinderry and Michelago Granites, by porphyry, and by a gabbro at Sample site 068 and by minor sulphide-bearing quartz veins. It is a light to dark grey fine to medium grained quartz felspar porphyry with xenoliths of grey silicified shale. The rock has been sheared and in places is cut by minor quartz veins.

At Sample site 068 a dark fine grained grey green rock has been described by Australian Mineral Development Laboratories as a hydrothermally altered gabbro. Primary iron sulphides are visible in the hand specimen and in country rock intruded by the gabbro. The clinopyroxene has been uralitized and felspars saussuritised to zoisite, epidote, albite and chlorite.

The Tinderry Granite crops out on the eastern margin of the area and forms a bold range of angular mountain peaks rising to a height of 5307 feet above sea level. It is a coarse to medium-grained biotite granite.

The Michelago Granite lies one mile east of the gossans - its western margin parallels the Queanbeyan Fault and its eastern margin abuts, in part on to a spur fault associated with the Queanbeyan Fault. The rock ranges from a coarse grained biotite adamellite to a biotite pyroxene granodiorite.

A porphyry intrudes Silurian rocks between the Michelago township and the Murrumbidgee River.

Structure

The most significant structure in the Michelago area is the southern continuation of the Queanbeyan Fault which virtually extends north-south across the Canberra 1:250,000 Sheet area. Near Spring Valley Homestead the fault bifurcates, one arm tending due south, the other south-west.

The Fault occurs at the Colinton Volcanics-Ordovician sediment interface and is seen either as, a series of left-hand en echelon breaks or as displacements by north-west striking faults now filled in part by quartz veins.

Movement along this fault has contorted the sediments and volcanics into a series of sharp folds sheared along anticlinal and synclinal crests and because of this it is difficult to determine the precise position of the contact between these two rock units.

GEOCHEMICAL SAMPLING

General

Several furruginous deposits some showing well-defined boxwork fabric and in places visible pyrite occurs at irregular intervals along the volcanics/ sediment contact over a distance of 7½ miles. The contact is known to extend to the north through Burra where a large manganiferous gossan similar to the Michelago gossans is reported to contain lead minerals. Ex-sulphide boxworks in Ordovician sediments have been noted some distance east of this contact.

Between the Monaro Highway and the Murrumbidgee river minor quartz veins containing galena and malachite have been prospected in the past.

Most of our attention was paid to the gossans and surrounds as this appeared to be one of the most favourable areas for base metal mineralization.

Geochemical samples were taken from active stream sediments, from colluvium, bank alluvium, gossanous and non-gossanous rock outcrops. Where practicable heavy mineral concentrates were collected from streams.

Active stream sediments were sieved to -80 mesh in the field and placed in Kraft geochemical sample packets. In general the drainage pattern is well-defined and -80 mesh fractions of stream sediments were not difficult to obtain.

Samples of colluvium were taken downslope from the gossans or in areas where the drainage pattern was not particularly well defined.

Bank alluvium was taken in areas where a -80 mesh fraction was difficult to obtain from the streams.

Chips of gossans and rock samples were collected from several points to ensure that the sample was representative and to assist with estimation of primary dispersion patterns. Rock samples were crushed and sieved to -80 mesh before analysis.

Method of Analysis

One gram samples of stream sediment sieved to -80 mesh at the sample site and 0.5 gram samples of gossan crushed to a powder of approximately -100 mesh were used for the analyses.

The samples were weighed into a series of 20 x 150 mm. pyrex tubes contained in a specially constructed rack with a base of 1" thick cast aluminium and depressions to hold the tubes. An aqua regia digestion was carried out by adding 4 ml. of concentrated AR hydrochloric acid and 2 ml. of concentrated AR nitric acid to each tube, then allowing the aqua regia to evaporate slowly to dryness by placing the racks on a hot-plate set to keep the solution simmering gently. This operation was performed under a fume hood and about 6 hours was required to evaporate the samples to dryness, thus ensuring a thorough aqua regia digestion.

Three ml. of conc. hydrochloric acid was then added to the treated residue and the samples allowed to heat to boiling point; then about 10 ml. of water was added and the solutions kept on the hot plate for a further 30 minutes to ensure complete solution of metal chloride residues.

Water was then added to the 50 ml. graduation on each tube, which was then stoppered and inverted to mix the contents. After several hours the insoluble residues consisting mainly of silicates, had settled out and the clear supernatant liquid remaining was aspirated directly into the flame of a Techtron AA-3 Atomic Absorption Spectrophotometer.

An air-acetylene flame was used with a standard 10 cm. burner.

Readings of atomic absorption were taken using the Cu 3247Å, Pb 2833 Å and Zn 2139Å lines. These readings were related to standard calibration graphs prepared by measuring the absorptions of a range of pure metal standards in 0.5 N hydrochloric acid immediately before and after each analytical run, then plotting the average percent absorption value as the logarithm vs. concentration in linear units.

"Non-atomic" absorption, due to loss of light by scattering from particles in the flame can be a source of (positive) error in atomic absorption work where solutions of high salt strength are used. This effect varies inversely as the fourth power of the wavelength but it has been established by tests on purified solutions of AR ferric, aluminium, calcium, sodium, potassium and magnesium salts that "non-atomic" absorption for Cu and Pb is negligible for the wavelengths used and the maximal salt concentrations likely to be encountered in a fifty-fold dilution of stream sediment sample or a 100-fold dilution of gossan.

High salt concentration (e.g. iron) have a more serious effect on the "non-atomic" absorption of the Zn 2139 Å line but the contributions can readily be monitored by checking absorption readings using a tellurium lamp and the 2143 Å line - this is only 4 Å away from the Zn line, and assuming no detectable tellurium is present in the sample, the absorption readings obtained with this lamp can be assigned to "non-atomic" absorption and subtracted from the absorption readings for zinc prior to referring to the calibration graph. Two percent absorption was taken as the detection limit, and readings lower than this are reported as $<$5 ppm. for Cu and $<$30 ppm. for Pb.

For Pb, a somewhat fuel-rich flame was used for optimum sensitivity, whereas oxidizing ("normal")flames were used for Cu and Zn.

Sensitivity for zinc is very high by atomic absorption methods, and in a 10 cm. flame, and upper limit of about 2.5 ppm. Zn in solution applies. This corresponds to an absorption of 80 percent, and because of the logarithmic nature of the absorption vs. concentration curve, readings above 80 percent absorption cannot be regarded as being precise.

For this reason, high zinc samples (over 250 ppm for gossans, or 125 ppm for stream sediments) which gave off-scale readings or extreme scale readings were re-run with the burner rotated at an angle to reduce the effective path length of the flame, thereby reducing sensitivity. A corresponding calibration graph was drawn up for this condition. This avoided the necessity for large numbers of dilutions, which can introduce further errors. In some cases, however, the highest zinc samples still had to be diluted, despite burner rotation which increased the useful upper limit of detection to about 15 ppm Zn in solution. Sample 330 was observed to give a strong green colouration in the flame, due to a high content of barium. Values below 100 ppm are expressed to the nearest 5 ppm, while values above 100 ppm are expressed to 2 significant figures.

Igneous Rocks

Chip samples from the various types of rocks of igneous origin in the area yielded the following results:-

TABLE I - IGNEOUS ROCKS, GEOCHEMICAL RESULTS.

Sample Number	Military Grid* Reference	Cu ppm	Pb ppm	Zn ppm	Rock type
068	224075, 594050	60	40	55	pyritic gabbro
308	223000, 600600	25	80	120	schistose porphyritic rhyolite
320	220250 91675	10	40	170	crystal tuff, euhedral quartz and felspar metacrysts.
324	220550 592550	30	20	20	porphyry - near Ordovician/Silurian interface
312	215550, 589800	5	40	15	chilled porphyry on limestone contact
317	217150 598600	10	80	25	quartz felspar porphyry
300	221550, 590700	5	25	40	medium to coarse grained biotite adamellite.
306	226500 593525	5	25	25	pink, leucocratic, fine grained granite.
307	222200 586700	5	25	25	pyritic granitic rock
327	222800, 590125	15	25	55	biotite granodiorite
328	224200, 590125	5	50	5	pyroxene granodiorite
329	225650, 601175	5	20	5	granophyre
108	215675, 593975	10	30	40	Quartz vein 4 inches wide with brecciated porphyry on hanging wall.

* Military Grid Reference shows Easting and Northing.

Comparison shows that the granitic rocks are lower in copper, lead and zinc than porphyries and tuffs. Analysis of the gabbro and the pyrite content suggests it could be a source of Cu, Pb, Zn although trace element content is not necessarily anomalous for this particular rock. Further geochemical sampling is needed.

The high lead and zinc content of the rhyolite and crystal tuff is of interest but further sampling may show that the results are either anomalous or represent a specific horizon in the volcanics.

SEDIMENTS AND METASEDIMENTS

Analyses of rock samples collected from Ordovician sediments and Silurian limestones are listed in Table 2.

TABLE 2 - SEDIMENTS AND METASEDIMENTS, GEOCHEMICAL RESULTS

Sample Number	Military Grid Reference	Cu ppm	Pb ppm	Zn ppm	Rock type
009	219800 589700	15	30	25	composite - sandstone and slate, minor quartz veins, hematite and manganese oxide
063	223650 598000	20	40	75	phyllite
069	224300 599000	10	40	25	composite quartzite, pyrite veinlets near contact with diorite
119	225350 591650	15	30	45	hornfels (micaceous quartzite)
306	224900 595850	20	35	100	phyllite (micaceous siltstone)
309	224050 595700	10	25	95	micaceous phyllite
313	219950 597700	20	25	40	ferruginous and pyritic quartz sandstone
314	221100 591200	25	25	70	silicified siltstone
316	215750 589400	5	70	35	composite chip sample of porphyry and marble
318	224175 596350	15	25	40	phyllite
323	215650 589975	50	20	135	composite - greenish white medium grained dolomite, dolomite marble and rhyolite tuff, pale green talc, near limestone/porphyry contact.
325	225050 594100	10	20	75	grey phyllitic siltstone
326	221000 593050	-5	-20	5	micaceous siltstone

Ordovician sandstones, slates, siltstone and phyllites average 13 ppm Cu, 28 ppm Pb and 54 ppm Zn.

Dolomitic marble sample 323 collected from Silurian sediments on the Murrumbidgee River is anomalous in copper and zinc suggesting that nearby intrusive porphyry might have introduced mineralization into the area.

GOSSANS

The gossans range in size from a few feet to 580 feet long and up to 70 feet wide. They are lenticular with irregular margins in places, in others they are sub-parallel to the strike of Ordovician sediments. Boxworks, mostly after pyrite, are common and occur in layers parallel to the bedding or as lenses within the gossans. Considerable reworking and redeposition of the limonites contributes to the irregular shape and make it difficult to determine the original outlines of the lodes.

They range in colour from dark blackish brown through umber to purple brown, and yellow ochre. Leached remnants of sedimentary rocks are white to pale pink and purple. Manganiferous staining is common particularly on the gossans at Burra.

Pontifex, Appendix 2, has examined typical specimens of the gossans and has observed goethite, lepidocrocite, pyrite, magnetite, titaniferous magnetite, martite and hematite.

Pyrite (Specimen 407) occurs as irregular lenticular aggregates parallel to the layering. It is euhedral and subhedral and is set in a limonite matrix with irregular veins of quartz. The pyrite has been brecciated. Cubic boxworks, up to 4 mm across, after pyrite now partly filled with limonite are common and in general are parallel to subparallel to the layering (Specimen 405). Specimen 400 contains several discrete grains of pyrite in an earthy limonite matrix.

Pyrite was recorded from other places in the area mapped and probably occurs as haloes around intrusive igneous rock.

Magnetite (Specimen 404) occurs as loosely-packed aggregates in a speckled light grey and dark grey rock. In some places it shows a mottled intergrowth with titaniferous magnetite.

Sample 406 consists of irregularly shaped grains and aggregates of hematite set in a white to pinkish white clayey sericite matrix. Pontifex notes that the hematite may replace magnetite. Sample 404 from the same gossan is strongly magnetic and also contains skeletal grains of pyrite within the magnetite aggregate. Pyrite veinlets intrude magnetite.

Sample 304 analysed 1.8% Zn and contains sub-circular cavities which may be derived in part from sphalerite.

Sample 409 consists of a spongy mass of fibrous limonite, with thin cell walls, yellow to yellow brown and dispersed through brecciated argillaceous schist. The boxworks are columnar and are suggestive of migration and redeposition of limonite.

TABLE 3 - GOSSANS, GEOCHEMICAL RESULTS
(1)

Sample Number	Grid Reference	Cu ppm	Pb ppm	Zn ppm	Description
001	219750 587425	155	240	500	
002	219800 587600	105	<30	200	
021	221300 594075	95	30	380	
022	221200 594100	55	<30	130	
029	220675 592675	510	30	480	pit, quartz, gypsum, serpentine in part replaced by quartz.
032	220625 592675	250	<30	65	
035	220550 592475	225	310	1800	botryoidal goethite
037	220525 592400	305	110	1300	
040	220250 591675	350	<30	50	about 300 feet long
118	216475 591450	2,600	42,000	35	galena, quartz vein minor malachite, minor prospect.
302	220650 592900	470	40	270	Iron-rich material with siliceous coating; rock sample.
303	221000 593050	190	100	300	hematite, limonite, quartz.
304	222450 546200	60	35	17,500	
310	223200 599950	10	25	170	
321	220250 591675	420	40	45	Approximately 300 feet long; ex-pyrite boxworks.
322		5	40	15	360 feet long; averages 3 feet wide manganese oxide; strong banding strike 167 degrees.
330	220750 593150	280	20	2550	barite, hematite; exposed in stream
331	223250 599100	170	40	65	120 feet long, about 8 feet wide, dip 80°W.

SEMI-QUANTITATIVE EMISSION SPECTROGRAPH ANALYSES* OF SELECTED SAMPLES

	Ni	Co	Cu	Pb	Mo	V	Zn	Note
400	5	20	350	350	6	6	600	Same locality as sample 001 and 002
401	5	20	350	5	2	20	250	
402	35	50	350	250	2-	60	800	
404	5	15	150	5	2-	6	200	Same locality as Sample 040
405	10	60	250	20	2-	60	250	
406	5	2	150	5	2-	4	150	
407	20	30	500	250	2-	40	1600	Same locality as Sample 304
408	80	60	25	5	2-	20	10000+	
409	5	2	200	50	2-	4	1000	Brief description - e.g. cellular fibrous limonite dispersed through brecciated argillaceous schist.

* Analyses by A.D. Haldane

Table 3 shows that the gossans are anomalous in copper, lead and zinc. The copper content ranges from 5 to 510 p.p.m.; lead <30 to 310 p.p.m., and zinc 15 p.p.m. to 17,500 p.p.m. The wide range in analytical values may be due to intense leaching of the gossans or to inherent variations in grade of the original mineral deposit.

The general conclusion from a study of the gossans is that they represent a heavily oxidised base metal sulphide deposit with pyrite as the most significant sulphide present. Some textures e.g. the circular pits, may be derived from sphalerite.

Stream Sediments, Colluvium and Heavy Mineral Concentrates

Stream sediments, soil and alluvium were collected at a density of about 1 sample per half square mile over the area shown on Plate I; the results are listed in Appendix 1. The sample density was increased near the gossans to determine the influence, if any, of material shed from them.

Colluvium was collected more by way of experiment to determine the influence of material shed downslope from the gossans.

The technique of collecting heavy mineral concentrates by panning of stream sediments was demonstrated to the students and a few samples taken, although in general such concentrates were difficult to obtain.

Stream sediment samples average 13 p.p.m. copper; 29 p.p.m. lead (several values have been listed as <30 p.p.m. and have not been included in this average; it is probable that the lead content of drainage samples is less than 29 p.p.m.) and 43 p.p.m. zinc.

Samples of colluvium average 15 p.p.m. copper and 38 p.p.m. zinc. Most analyses for lead are listed at <30 p.p.m. and it is best to show lead as ranging from <30 p.p.m. to 70 p.p.m.

The results show that streams draining the gossans do not appear to reflect the higher metal content of the gossans. Sample 039 (20 p.p.m. Cu, < 30 p.p.m. Pb, 40 p.p.m. Zn) and 023 (20 p.p.m. Cu, < 30 p.p.m. Pb, 30 p.p.m. Zn) and others were taken from streams cutting directly across the volcanics/sediment interface.

Samples 140 and 042 are anomalous in zinc (90 p.p.m. Zn) and were collected from streams draining Ordovician sediments only. A gabbro intrusion one mile north of 042 could have donated zinc to the sediments or it may be obtained from weathering of disseminated pyrite and associated mineralisation in the sediments in that area.

Sediments from a gully draining limestone and marble near Spring Valley homestead yielded 60 p.p.m. Cu, 50 p.p.m. Pb and 265 p.p.m. Zn. The limestone occurs at the volcanics/sediment interface and may be anomalous. However it has been suggested that the alkaline soils provided a suitable site for trace element accumulation. Sample 073 - residual soil over ferruginous limestone gave similar results 130 p.p.m. Cu, 80 p.p.m. Pb and 220 p.p.m. Zn.

The trace element content of streams draining Colinton Volcanics and porphyry intruding the Volcanics is generally higher than the trace element content of streams draining other rocks.

A heavy mineral concentrate from a stream draining a porphyry which intrudes Colinton Volcanics and Gossoon Beds analysed 20 pp.m. Cu, 100 p.p.m. Pb and 155 p.p.m. Zn. Further trace element investigation is needed to show whether porphyry may have introduced the mineral deposits.

Colluvium samples taken down slope from gossans are anomalous in some places and not in others, and the results should be interpreted with caution. On the one hand sample 036 downslope from a gossan analysed 60 p.p.m. Cu, 70 p.p.m. Pb and 190 p.p.m. Zn and is anomalous; on the other hand sample 030 gave 25 p.p.m. Cu, <30 p.p.m. Pb and 45 p.p.m. Zn whereas the gossan 029 analysed 510 p.p.m. Cu, 30 p.p.m. Pb and 480 p.p.m. Zn..

Residual soils appear to reflect the trace element content of the host. Sample 073, a dark brown soil overlying dolomitic limestone, analysed 130 p.p.m. Cu, 80 p.p.m. Pb and 220 p.p.m. Zn; the anomalous result might be due to the inherent metal content of the dolomite.

DISCUSSION

The gossans are anomalous in copper, lead and zinc and include one which assays up to 1.8 percent zinc. Chip samples and (selected) specimens from the gossans appear to be more reliable as a guide to mineralization than drainage samples although a more extensive investigation of the province may show that some stream sediments are anomalous.

Our results support, insofar as this project has gone, Zimmerman (1965) who studied Mt. Isa gossans and showed that they may be regarded as visible geochemical anomalies which can be appraised initially by trace element analyses of a few random samples. Previous experience in gossan interpretation is not essential.

The gossans at Michelago may be directly related to or overlying sulphide lodes. Any exploration programme should not overlook the possibility that economic deposits may be found some distance from the outcrops of the gossans. Sample 307 is a pyrite-bearing granite and shows that sulphide minerals can be found some distance from the volcanic/sediment contact. There are several soil-covered areas between sample 001 and the most northerly part of the area sampled which may conceal mineral deposits.

Origin of Gossans

The gossans are located on or close to Ordovician sediment/Silurian volcanics contact. They are stratiform in part and consist of sulphide-bearing fine tuffs, shales and argillaceous and calcareous siltstones. Dolomitic rocks may be more extensive than are obvious on the surface. Intrusives, porphyry, gabbro and grainite post date the bedded rocks and in all cases have a minor halo of pyrite mineralization associated with them.

Before any definite conclusion can be drawn further detailed mapping and trace element studies needs.to be carried out.

CONCLUSIONS

The results of the Michelago geochemical investigation have shown definite mineral exploration targets in an area extending from Burra to four miles south of Michelago.

The gossans are anomalous in copper, lead and zinc and should be geologically mapped in detail and prospected by geophysical methods. The area for immediate study extends from Ponderose, 2½ miles south of Michelago to Burra 12 miles north northeast of Michelago along the volcanics/sediment contact. Gossans at Ponderose and Burra should be sampled.

Geophysics will have particular application in transported soil-covered areas which could conceal sulphide deposits. It is suggested that prospecting along selected traverses should extend for at least one mile on each side of the contact to cover areas where pyrite boxworks are known.

The presence of sulphides and magnetite in some gossans suggests that a combination of induced polarization and magnetic methods should be the most useful geophysical techniques.

Geochemical sampling along the Queanbeyan Fault and its branches (see Canberra 1:250,000 Sheet area) and of the country between the Murrumbidgee River and the eastern boundary of the Michelago and Bredbo 1 mile sheet areas should continue.

The Silurian volcanics gave a higher geochemical background than other rocks in the area and should be prospected in more detail. Some possibly anomalous results were obtained in Ordovician sediments where sulphide minerals, in the form of pyrite casts, were noted. Such results suggest that more attention should be given to Ordovician rocks but interpretation of any anomalies found should be assisted by detailed geological mapping and geophysics.

The Burra and Michelago gossans are situated on or close to the Queanbeyan Fault (Canberra 1:250,000 Sheet area) a major north-striking fault. The Queanbeyan Fault could be an important feature in the history of mineralization in the region. Near Queanbeyan, a minor copper occurrence is noted close to it.

The occurrence of anomalous copper lead and zinc in the gossans, the possibility of sulphide mineralization some distance from the volcanic/sediment interface and in particular the broad similarity of the geology of the region to other mineral-bearing areas suggests that detailed exploration using geochemistry as the tool should be carried out over the whole sequence of Ordovician and Silurian rocks.

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APPENDIX I

STREAM SEDIMENT SAMPLES, ALLUVIUM, SOIL COLLUVIUM, HEAVY MINERAL CONCENTRATES, MICHELAGO AREA

Stream Sediment Samples, Alluvium and Soil

Sample No.	Grid Reference	ppm Cu	ppm Pb	ppm Zn	
005	220700 590025	20	<30	25	stream sediment
006	220500 589975	10	"	15	"
010	219750 589350	20	"	30	"
012	220075 588825	10	"	15	"
014	220600 587950	25	"	30	"
018	220825 586850	15	"	35	"
019	221450 586050	10	"	20	"
020	222225 586050	5	"	20	"
023	221100 593900	20	"	30	"
024	220900 593500	15	"	25	"
025	220775 593325	40	"	45	minor colluvial material
026	220675 593150	30	30	75	50 feet west and downstream from creek cutting across gossan.
027	221000 593050	45	30	55	magnetite in stream sediment.
028	220675 593025	20	<30	55	stream sediment
031	220750 592800	25	"	40	"
034	220525 592575	20	"	40	"
039	220350 591900	20	"	40	"
042	223750 597200	20	"	90	"
044	223550 596950	10	"	35	"
045	223225 597375	15	"	35	"
046	223050 597050	25	"	30	"

Sample No.	Grid Reference	ppm Cu	ppm Pb	ppm Zn	
050	222350 596000	15	30	40	stream sediment
051	222350 595800	10	"	35	"
053	222175 595525	15	40	45	soil
054	222075 595300	25	50	60	"
055	221850 595150	10	-40	60	"
056	221650 594800	15	-40	75	"
057	221600 594675	20	-40	50	"
061	223450 598150	15	-40	40	stream sediment draining grey, white tuff
063	223650 598000	20	"	75	stream sediment
064	224400 598300	10	"	25	"
067	224050 599250	10	"	25	"
070	224100 599450	5	"	65	stream transects tuff, quartzite, shale with pyrite casts.
074	223250 600200	20	-40	55	
076	223300 600500	20	"	55	"
077	223300 600650	10	-40	50	"
078	223150 600550	10	-40	65	draining Silurian porphyry porphyry
079	225700 600925	10	-40	35	stream sediment
080	226250 600800	10	-40	35	"
081	222200 586750	10	-40	30	alluvium, centre of stream stream
082	222050 589800	15	"	50	alluvium, centre of stream stream in granite
084	222725 589775	20	"	50	alluvium in granite
085	224000 589750	10	40	80	alluvium - drains granite-sediment contact. contact
086	224175 589750	10	40	30	alluvium - from main stream draining west side of Tinderry Mountains.

Sample No.	Grid Reference	ppm Cu	ppm Pb	ppm Zn	
087	223950 588650	10	-30	45	alluvium - granite
088	224350 588000	10	"	55	" "
089	224950 588250	-5	"	20	alluvium
090	225400 588650	15	"	20	alluvium in creek which parallels granite-quartz sandstone contact
091	225400 589125	10	-30	55	alluvium - granite boulders on sediments
092	225300 589550	15	"	55	alluvium - creek drains Tinderry Mountains
093	217575 589775	5	"	25	alluvium - Porphyry intruding Colinton Volcanics.
094	217550 589650	10	"	55	drains rocks east of Murrumbidgee River.
097	215875 589350	5	"	15	alluvial fan draining Colinton Volcanics.
098	215600 589825	10	"	45	silt; drains porphyry intruding Colinton Volcanics
099	215600 589825	20	"	70	stream sediments; drains porphyry intruding Colinton Volcanics.
101	224100 600500	5	"	-	stream sediments
102	223100 599900	10	"	60	drains Colinton Volcanics
103	223550 598250	10	"	25	clay
104	223000 598350	60	50	265	sediment in gully draining limestone and marble.
106	215900 594950	5	<30	20	heavy mineral concentrate
107	215900 594950	10	"	30	Porphyry intruding Colinton Volcanics
110	216100 593300	15	"	30	soil
111	216200 593150	10	"	30	"
112	224800 595850	10	"	40	organic material; drains Ordovician sediments
113	225050 594100	10	"	55	stream sediment
114	226050 594000	20	"	50	fine granitic material
115	226075 593350	15	40	50	granite material on phyllite bedrock

Sample No.	Grid Reference	ppm Cu	ppm Pb	ppm Zn	
121	223575 594900	20	10	55	stream sediment
122	222950 595025	15	10	50	" "
139	225900 594050	10	10	45	" "
140	224025 595700	25	25	90	stream sediments; drains Ordovician sediments
141	215850 592450	10	35	45	alluvium
142	215925 592150	25	35	55	"
146	225075 591750	20	15	60	"
147	225700 590975	15	25	60	stream sediments
148	223400 590675	15	25	60	" "
150	224400 590000	20	35	55	" "
151	224450 590100	10	25	35	alluvium
152	224650 591600	20	25	50	stream sediment
153	224200 592150	10	25	40	" "
154	223350 592000	8	25	30	" "
155	222850 591200	20	25	60	alluvium
156	222200 591575	8	25	20	stream sediment, granite
157	221700 591025	5	10	20	stream sediment;granite-sediment contact
160	220700 590950	10	10	20	stream sediment
176	215425 596825	5	10	40	stream sediment; Porphyry intruding Colinton Volcanics and Gossan Beds
177	215350 59765 0	10	25	45	stream sediment; Porphyry intruding Colinton Volcanics and Gossan Beds.
178	215525 599350	20	100	155	Concentrate· Porphyry intruding Colinton Volcanics and Gossan Beds
179	215525 599350	5	35	50	stream sediment; Porphyry intruding Colinton Volcanics and Gossan Beds
180	215425 599450	10	35	50	stream sediment; Porphyry intruding Colinton Volcanics and Gossan Beds
181	222100 599525	30	40	80	drains Colinton Volcanics

Sample No.	Grid Reference	ppm Cu	ppm Pb	ppm Zn	
182	222050 595700	15	40	75	drains Colinton Volcanics
183	221550 595225	25	10	125	" " "
184	218550 597950	5	25	35	drains Porphyry intruding Colinton Volcanics
185	218250 596850	10	25	65	drains Porphyry intruding Colinton Volcanics
186	218250 596000	10	25	40	drains Porphyry intruding Colinton Volcanics
187	218500 594500	5	25	40	" " "
189	220400 593425	5	40	35	drains Colinton Volcanics
190	221025 594300	15	70	80	" "
191	217300 602175	15	35	55	drains Porphyry intruding Colinton Volcanics
192	217500 601975	5	25	35	" "
194	218025 601650	10	35	70	" "
195	218225 601400	10	35	55	" "
196	218575 600850	15	35	65	" "
197	218550 599300	5	25	30	" "
198	218550 598800	10	25	40	" "
199	218600 598300	10	35	50	" "
333	223875 603600	5	40	30	stream sediments; drains Silurian Porphyry
334	223800 603850	10	40	40	" "
335	224550	10	20	15	stream sediments; drains Ordovician sediments
336	224575 604200	5	20	20	" "
337	224700 603950	5	20	25	" "
338	224500 606600	10	20	25	" "

Colluvium and Heavy Mineral Concentrates

Sample No.	Grid Reference	ppm Cu	ppm Pb	ppm Zn	
003	219400 588050	10	<30	20	colluvium, centre of gully draining gossanous area.
004	219150 589175	10	<30	20	colluvium
007	219950 590350	25	<30	25	colluvium
008	219800 589825	15	<30	10	alluvium on deltaic fan at gully inter-section
011	220050 588925	10	"	15	bank alluvium
013	220300 588525	10	"	10	concentrate
015	221300 188250	-5	"	15	colluvium, granite soil
016	221700 589100	10	"	20	colluvium from plowed field in granite
017	229950 587700	15	<30	20	colluvium below out-crops of gossan
030	220750 592950	25	<30	45	"
033	220600 592775	15	30	40	"
036	220475 592400	60	70	190	colluvium near gossan
038	220475 592225	30	<30	50	bank alluvium
047	222750 596800	20	"	35	colluvium
048	222250 595950	15	"	30	colluvium
052	222350 595700	10	<40	30	"
066	224550 598350	10	<40	30	bank alluvium
072	223225 599800	10	<40	65	colluvium below gossan lenses
073	223225 599975	130	80	220	residual soil, colluvium, dark brown over ferruginous limestone.
075	223300 600500	20	<40	35	clay, limonitic
083	222200 589650	10	<40	35	colluvium - in leucocratic granite
100	215575 289825				black sand
105	223275 598800	20	<30	80	colluvium

Sample No.	Grid Reference	ppm Cu	ppm Pb	ppm Zn	
109	216025 593375	5	30	35	colluvium
149	223500 590600	10	25	35	"
158	221400 590475	50	10	45	"
159	220950 590375	10	10	20	"

APPENDIX 2

A MINERALOGICAL STUDY OF NINE SAMPLES OF GOSSAN FROM MICHELAGO, N.S.W.

by

I. R. Pontifex

The following samples were submitted by J. Ivanac; all are located on the Michelago 1:50,000 sheet (No. 8726 - IV).

Regst. No.		Military Grid Reference
64.03.0400	E.21972	N. 058742
64.03.0401	"	"
64.03.0402	"	"
64.03.0404	E.22024	N. 059167
64.03.0405	"	"
64.03.0406	"	"
64.03.0407	E.22247	N. 59622
64.03.0408	"	"
64.03.0409	"	"

Spectrochemical Analysis

A spectrochemical analysis of part of each rock described was analysed by A.D. Haldane on the large quartz spectrograph. The results, in ppm., are as follows:

Sample No.	Ni	Co	Cu	Pb	Mo	V	Zn	Others
64.03.0400	5	20	350	350	6	6	600	
0401	5	20	350	5	2	20	250	
0402	35	50	350	250	2-	60	800	Be (2)
0404	5	15	150	5	2-	6	200	
0405	10	60	250	20	2-	60	250	
0406	5	2	150	5	2-	4	150	
0407	20	30	500	250	2-	40	1600	
0408	80	60	25	5	2-	20	10000+	
64.03.0409	5	2	200	50	2-	4	1000	

Au and Ag sought but not detected

2-   -   less than 2 ppm.

Comment on mineral terminology.

The term limonite is considered by some authors to have a definite formula (Fe O. OH. n H_2O), but it has been shown to consist of cryptocrystalline goethite and/or lepidocrocite, along with adsorbed water. Some hematite may also be present.

Theoreti ally, pure crystalline lepidocrocite (Fe O.OH) and goethite (Fe O.OH) have distinctive optical properties. In most naturally occurring material however, their properties are similar since variations of their mode of occurrence (e.g. crystalline, amorphous, colloform etc. and combinations of these) give varying optical properties, which overlap.

In this study hematite was readily identified (although in 64.03.0406 some of its properties are similar to goethite) but the varied mode of occurrence of the hydrated-iron-oxides prevented a definite distinction between goethite and lepidocrocite in most sections.

Therefore, in the following descriptions the gossanous material will generally be referred to as limonite although most of it is almost certainly goethite.

In the samples containing limonite box-works, but no sulphides, no attempt was made to relate the box-works to pre-existent sulphides. This will be dealt with in future work on these by J. Ivanac.

64.03.0400

This is a sample of massive gossan which consists of yellow-brown earthy limonite and dark brown semi-consolidated limonite within skeletal cavities, defined by veins and walls of siliceous, iron-rich material.

This is a difficult rock to polish; however a suitable section for reflected light examination was prepared of the more resistant parts but the earthy pockets of limonite tend to be lost during polishing. The hydrated oxides seen in the hand specimen consist almost entirely of irregular skeletal, cellular masses of amorphous goethite. Colloform and spherolitic aggregate textures are rare.

Small blebs, rod-like, and curved inclusions of lepidocrocite have a random distribution through goethite masses. These have an average size of 0.02 mm. and together they form about 3% of the section. Rarely, an extremely fine rim of lepidocrocite surrounds small cavities within goethite.

Several discrete grains of pyrite occur in the iron-oxide matrix. One grain in earthy limonite measures 0.5 mm. across, others which occur both in the earthy and the more consolidated parts of the specimen have an average size of 0.03 mm. All grains of pyrite have well defined margins and these appear to be remnant cores of pre-existent pyrite which has been almost completely replaced by iron-hydroxides.

64.03.0401

This sample consists of a skeletal intergrowth of long narrow cavities, oriented more-or-less perpendicular to the weathered surface, and filled with earthy yellow, and brown limonite. The cavities are enclosed by a diversified system of thin walls of relatively hard, silica-rich limonite.

Fragments of quartz occur at random through the limonite matrix.

In polished section the limonite walls are seen to consist of cryptocrystalline goethite and minor silica. These form an intricate lace pattern which encloses cavities which are elongated in a generalised common direction. The average thickness of the walls is 0.03 mm.

Although some of the walls have slightly scalloped margins no colloform structures are obvious. Observations through crossed nicols indicate that the crystal growth in the walls is generally transverse across the full width of the wall rather than in a series of layers conformable to the wall margins.

No sulphides were found in the section.

64.03.402 (Thin-section)

About 60% of this rock consists of a loosely packed aggregate of subangular, more-or-less equi-sized quartz grains and minor amounts of chert. The average grain size is 0.05 mm.

Interstices between the grains are filled with fine grained chlorite and minor sericite which are generally lightly stained by hydrated-iron-oxide.

Narrow quartz veins, 0.75 mm. wide, cut through the rock, these are cut by fine veinlets of hydrated-iron-oxides and intruding patches and stringers of chlorite.

Part of the weathered surface of the rock is encrusted by iron-silica rich material which appears to have been derived from the rock and concentrated by processes related to "case hardening".

The rock is classified as a weathered, slightly ferruginised, argillaceous siltstone.

64.03.0404

This is a grey, fine-grained weathered rock; it is strongly magnetic.

In thin-section it is seen to consist of a loosely packed aggregate of opaque minerals (45% of the section) the interstices between which are filled with sericite and clay. The average size of the opaque grains is 0.06 mm. across.

In polished-section the opaque mineral was identified as magnetite. It typically occurs in single euhedral grains and as aggregates of these. In some grains magnetite shows a mottled intergrowth with titaniferous magnetite.

Almost all magnetite grains are replaced to a small extent by hematite (variety martite) around their boundaries and along crystallographic planes.

Extremely fine skeletal grains of pyrite occur in some interstices within the magnetite aggregate and veinlets of pyrite rarely intrude magnetite grains.

64.03.0405

This sample consists of highly weathered, ferruginised schist which contains abundant limonite-filled cavities and pseudomorphs of limonite after pyrite. The pseudomorphs have an average size of 1.5 mm. across and they are concentrated in a poorly defined band which is generally conformable with the schistocity planes in the rock.

In polished-section, euhedral cubic forms (of pre-existing pyrite) are made up of cellular masses of goethite. The goethite exhibits irregular zonal textures but commonly it occurs in a regular lattice pattern, which indicates that it is indigneous limonite which has replaced pyrite along its cleavage planes. In some places the zonal textures are colloform.

Sections of the goethite walls are optically and physically discontinuous which indicates that they formed by progressive alteration of pyrite under variations of chemical conditions.

Several small grains of pyrite (0.01 mm.) occur more or less in the centre of some pseudomorphs, their margins are well defined and do not show any transitional state of alteration to goethite.

64.03.0406

About 70% of this sample consists of a white, clay-sericite matrix which contains disseminated, fractured grains of iron-oxide. The average size of the grains is 3 mm. The rock is weakly magnetic and highly leached.

In polished-section the opaque grains seen in hand-specimen were identified as hematite which has completely replaced magnetite, presumably by supergene oxidation.

The color of the hematite is whiter than usual, it does however show characteristic anisotropic properties which distinguish it from maghemite. At X480 magnification the hematite is seen to form fine, intricate, triangular net-works which indicate that it has replaced magnetite along octahedral crystallographic direction.

The margins of most grains have altered to hydrated-iron-oxides and veins and stringers of this material have extensively invaded hematite in some places.

No remnant patches of magnetite were recognised and it is evident that the hematite has retained some degree of magnetism of the original magnetite.

This sample is possibly a coarse grained, leached equivalent of 64.03.0404.

64.03.0407

This is a weathered ferruginised schist. A band in the rock, up to 5 cm. side, and conformable to the schistocity, contains disseminated pyrite and limonitic cellular cavities.

In polished-section the limonite is seen to form irregularly shaped cellular patterns and mottled intergrowths which show variations in zonal textures indicating slight variations in the composition of the limonite.

In one area, limonite walls in a regular rhomb-shaped lattice form acute angles of 65°.

Euhedral and subhedral grains of pyrite occur in the limonite matrix and in irregular veins of quartz. The pyrite in quartz is generally not associated with iron-hydroxides.

The pyrite in the limonite matrix are relic cores of the original pyrite grains which have been extensively replaced by limonite.

Much of the pyrite is severely brecciated. Some grains have comb-like margins where limonite is replacing them along closely spaced cleavage planes.

In many places the zonal textures of limonite around pyrite grains have no relationship to the shape of these grains and although the major walls of limonite in most cavities give some suggestion of cubic crystal-system forms, minor ramifying veins of limonite tend to obliterate these.

Thin stringers of limonite are common along the rock foliation.

64.03.0408

This specimen consists largely of a botryoidal cellular mass of dark-brown and steel-grey bands of limonite, some silica rich, which enclose zoned cavities of light-brown and maroon, earthy, finely cellular limonite. Some cavities have a poorly defined quadrangular, rhomb and triangular shape although generally they have a highly irregular shape.

The regular shaped box works with spongy cores suggest that the limonite is indigenous, derived from pre-existing sulphides, but the botryoidal walled, irregular cavities which make up the majority of the specimen suggest that it is transported limonite, deposited from a colloidal state by supergene agencies.

In polished section the limonite within the cavities is distinctly spongy; most of the limonite is strongly mottled. The limonite surrounding the cavities is zoned in a way which indicates colloform deposition of this material. Most wall surfaces are finely mamillary.

No sulphides were observed in the polished section.

In view of the high zinc content of this sample (1.5%) this gossan may have formed by the replacement of sphalerite. However the excessive amount of iron in the sample and the probability that much of it is transported suggests that the zinc may also have been introduced from an external source.

64.03.0409

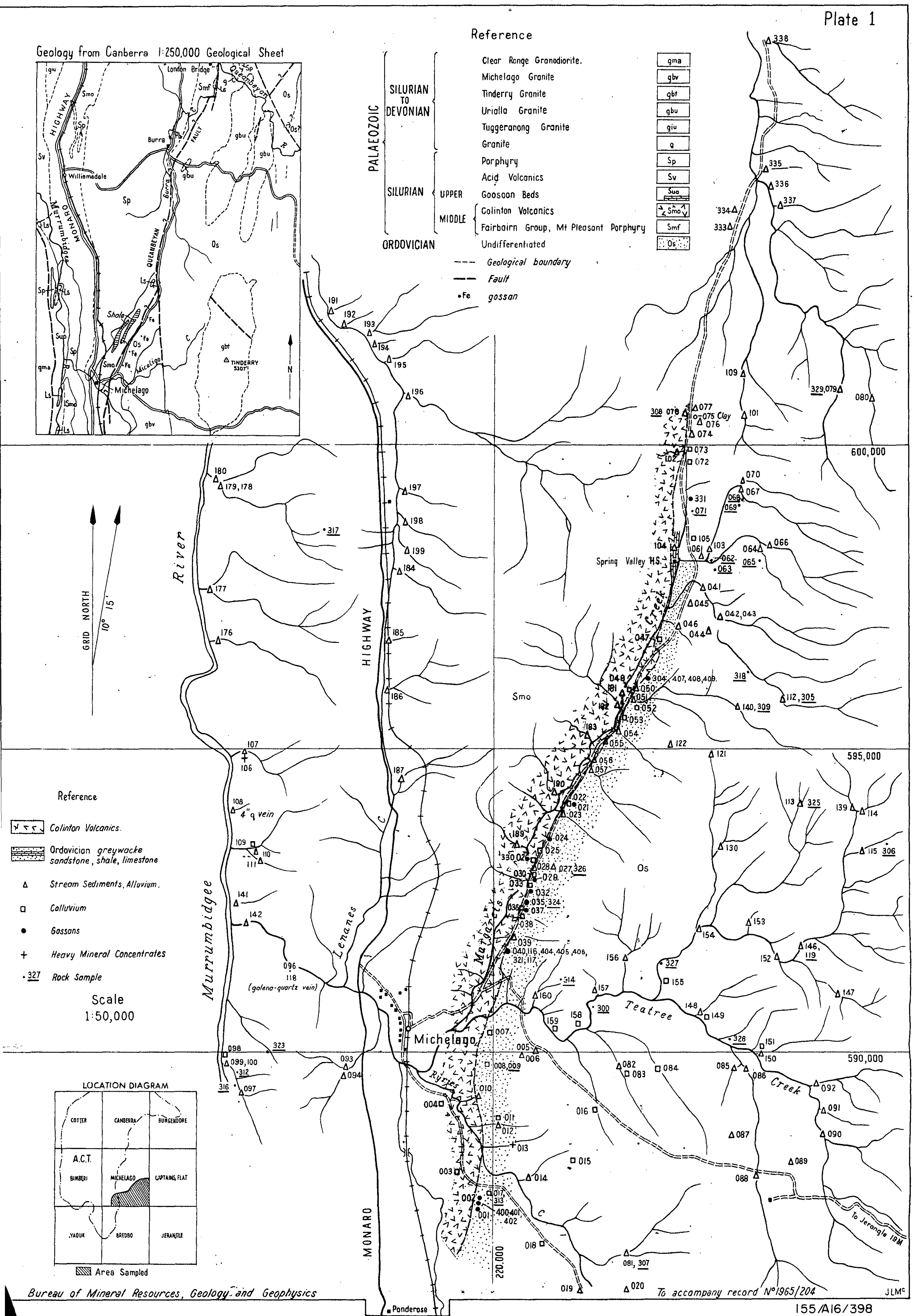
This specimen consists of a spongy mass of limonite which encrusts a weathered, ferruginous schist. In a section cut across the rock, randomly oriented fragments of schist are incorporated in, and invaded by limonite which indicates that the schist is replaced by the gossan,

Cellular cavities in part of the gossan tend to be elongated and commonly oriented perpendicular to the limonite-schist contact. Other parts of the gossan consist of sheaf-like aggregates of limonite foliae.

In polished-section the limonite is seen to form botryoidal shaped cavities, the walls of which consist of colloform, zoned, silica-rich limonite. The dimensions and shape of the cavities are irregular and there is no indication of the forms of pre-existing sulphides.

It seems likely that most of the limonite in this specimen has been transported to its present site; here it accumulated as a gossan by the related processes of colloidal deposition and replacement of the schist.

MICHELAGO GOSSANS N.S.W. GEOCHEMICAL SAMPLE LOCALITIES



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