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NOTES ON THE GEOLOGY OF THE UNIVERSITY OF QUEENSLAND EXPERIMENTAL MINE

INTRODUCTION AND HISTORICAL

Late in 1918 argentiferous cerussite and galena were found at Finney's Hill, Indooroopilly, about 6 miles from the centre of the City of Brisbane and less than 3 miles from the present site of the University of Queensland at St. Lucia. Several leases were quickly taken up.

During the succeeding eleven years over 227,000 oz of silver and nearly 1,800 tons of lead, which realized almost £95,000 were recovered. In 1929, production ceased owing to the low price of lead and the exhaustion of known high-grade silver-lead ore.

It is difficult to arrive at an exact figure for the total tonnage of ore mined and treated, but an indication of the average value of the ore is given in Ball's statement (1926, p.10) that "during the twelve months ending 30th June [1925] a total of 32,491 tons of ore (including 3.033 tons of sulphides) with an assay value of 4.7 oz silver and 3.6 per cent lead, was milled".

Values as high as 24.5 oz silver and 15 per cent lead were encountered in places.

In June 1951 the University of Queensland acquired the mine for undergraduate training in mining; use is also made of it in the training of geology and surveying students, and research into mining and treatment problems has been developed.

GEOLOGY

Summary

The oldest rocks of the Brisbane area consist of two groups of low-grade metamorphics, which are virtually unfossiliferous, but probably of lower Palaeozoic age. They are intruded by granitic plutons and fine-grained acid to intermediate dykes. Resting on these with marked unconformities are freshwater Triassic and Tertiary sediments.

The main structural feature of the area is the Indooroopilly Anticline, an asymmetric fold which plunges gently to the south-southeast beneath the Mesozoic and Cainozoic strata.

In the axial region of the anticline the older group of metamorphics (the Bunya Phyllite or Phyllonite) is exposed; here the dips (of the foliation) are gentle and fluctuating but they steepen both to east and west, the Phyllite being finally separated from the younger group of metamorphics (the Neranleigh-Fernvale Group) by the Kenmore fault to the west and the Normanby fault to the east.

The mine is situated not far to the west of the anticlinal axis near the southern limit of the outcrop of the Phyllite (Fig. 1). About a mile to the west of the mine lies the Green Hill stock of granodiorite, and 2½ miles to the west-northwest is the most southerly outcrop of a much larger pluton, the Enoggera "granite", consisting of granodiorite, adamellite, and related rocks. The mine is in an area of complex minor folds and intense fracturing; the area is also the site of a swarm of rhyolitic dykes.

Bunya Phyllite (Phyllonite)

The earliest event of which there is evidence was deposition of muds and silts which were converted by mild regional metamorphism to quartz-sericite phyllites, the Bunya Phyllite. The metamorphism was produced by regional pressures from the northeast, which at the same time initiated the formation of the Indooroopilly Anticline, the phyllites being pushed against a postulated stable mass to the west and southwest.

The formation comprises rocks consisting essentially of parallel alternating wider bands of dark micaceous material (largely sericite and graphite) and narrower bands of an even-grained mosaic of very small quartz crystals between which are dispersed numerous minute crystals of green chlorite. Foliation is pronounced, but bedding is not apparent.

At some stage much of the phyllite is thought to have undergone structural retrogression, as evidenced by the common completely flattened and even dismembered overfolds of quartz veins, which otherwise follow the foliation, and by the flowing of the foliation around relict crystals of albite. The rocks may therefore be styled phyllonites, although as pointed out by Bryan & Jones (1954, page 29) there is no evidence of mineralogical retrogression; they now present an "even-bedded" appearance with little in the way of puckering or small-scale folding; any of the latter which may have existed was for the most part "ironed-out" during the retrogression.

The force which triggered off this retrogression is not known, but it may have been the same force which brought about the St. Lucia Thrust to which reference is made below.

The St. Lucia Thrust Zone

Increase of the pressure from the northeast resulted in the production of very numerous thrust faults within a zone to which the name St. Lucia Thrust has been applied (Bryan & Jones, 1954). This very complex thrusting produced rocks similar to the Bunya Phyllite in most respects but showing abundant evidence of very severe

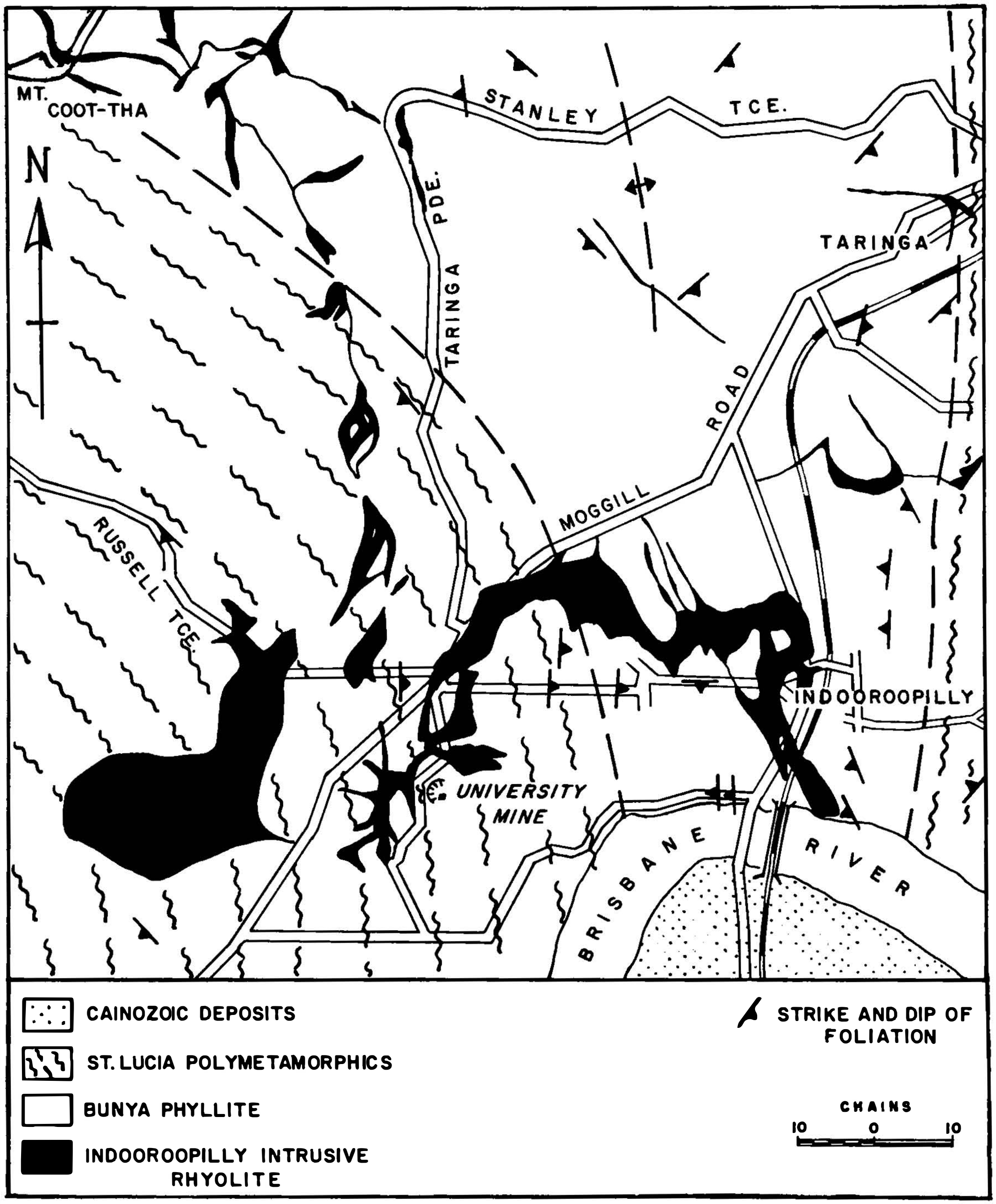

FIG. 1.—Geological map of the area surrounding the University Mine (intrusive rhyolite outcrops from a map by L. C. Ball, 1920*a*).

deformation. These rocks, which might be termed "regional mylonites", were named by Bryan & Jones (1954) the St. Lucia Polymetamorphics. Mineralogically, they are similar to the Bunya Phyllite, but the micaceous layers are highly contorted and flow around knots and lunules of a dark-coloured quartz, and the whole is riddled with highly contorted light-coloured quartz veins. The quartz knots and lunules owe their dark colour to the inclusion of very numerous needles of green chlorite. Like the Phyllite, the Polymetamorphics do not show bedding, which however can usually be found in the succeeding Neranleigh-Fernvale Group.

In spite of the mineralogical similarity of the "Phyllites" and the Polymetamorphics and the not infrequent difficulty in deciding in which formation a particular outcrop should be placed, there is no certainty that the latter are simply an overthrust portion of the former. In particular the increase in abundance and complexity of the white quartz veins eastwards from the axial region to Milton constitutes an unsolved problem.

The Neranleigh-Fernvale Group

Resting unconformably on the older formation is the Neranleigh-Fernvale Group, psammitic and pelitic sediments, sandstones, greywackes, shales, slates, cherts, and some basic volcanics, which were subjected to very mild regional metamorphism. The pressure from the northeast continuing, the Indooroopilly Anticline continued to grow and a second culmination was reached with the formation of the *Hamilton Thrust,* which deformed the northeasterly part of the Neranleigh-Fernvale Group of cataclasites which now appear as an overthrust sheet resting on the only slightly deformed Neranleigh-Fernvale rocks.

The Enoggera Pluton

In late Permian times the Enoggera and the nearby small Green Hill plutons of adamellite and granodiorite were intruded into the axial region of the Anticline, and it was probably at this time that doming and associated heavy fracturing was added to the already existing deformation of the mine area. The minimum age of the Enoggera Pluton has been determined by the potassium-argon method (using biotite) as 219×10^6 years—late Permian or early Triassic (Evernden & Richards, 1962).

The Indooroopilly Intrusive Rhyolites

These rocks are best developed in the axial region of the anticline, between Mt. Coot-tha and the University Mine, in which area the intrusives are so numerous as to constitute a dyke swarm (Fig. 1). Many of the intrusions parallel the gently dipping foliation of the phyllites, thus giving wide outcrops, but they are somewhat irregular in shape and exhibit some transgressive boundaries.

The intrusive rhyolites have been correlated in age with the Brookfield Volcanics (Bryan & Jones, 1954, page 44), which are intruded by the Kholo Creek quartz diorite (Gradwell, 1958), presumed to be little different in age from the Enoggera and Green Hill masses. The intrusive rhyolites were therefore placed by Bryan & Jones as older than the Enoggera pluton.

The above correlation depends on supposed similarities between the rhyolites of the mine area and rhyolite dykes near Upper Brookfield, which latter were probably feeders to the rhyolitic members of the Brookfield volcanics. Examination of a greater range of thin sections of the dykes near Upper Brookfield and the dykes in the mine area shows little similarity in texture between the two groups of rocks. On the other hand, recent field work has confirmed that there are, in the Mt. Coot-tha area, dyke-rocks which appear to be gradational between the Indooroopilly Intrusive Rhyolites and quartz porphyries. Bryan (1914) found that quartz porphyry dykes intrude the Enoggera pluton and also that the quartz porphyries intrude dykes of rhyolite, but noted that there are also gradational types; thus there may not be a long time-break between intrusion of rhyolites and porphyries. If this is so, the intrusive rhyolites may be later than the Enoggera pluton, belonging either to the same intrusive epoch as the pluton, or to the slightly later Middle Triassic period of vulcanicity which produced the ignimbrite of the Brisbane Tuff. The latter view has been supported by Briggs (1929) and Richards & Bryan (1934), and evidence for it has been summarized by Jones (1947, page 52).

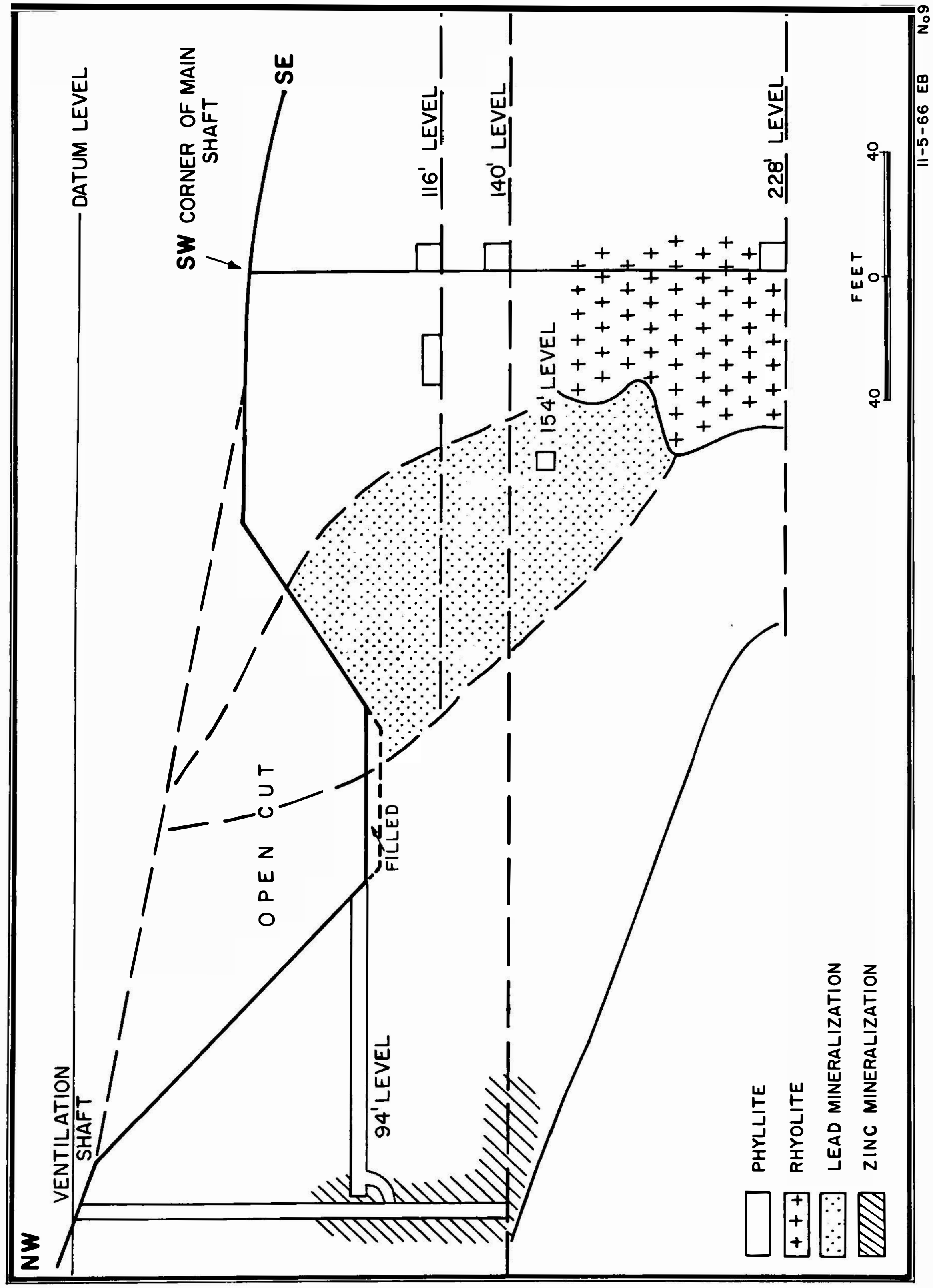

FIG. 2.—Section N.W.-S.E. from the ventilation shaft (Cox's shaft) to the S.W. corner of the main shaft. Some of the information is taken from a section by L. C. Ball (1926).

As will be shown below, the ore bodies are intimately associated with the dykes.

The geological sequence (earliest first) then may be summarized as follows:

Growth of the Indooroopilly Anticline (stages 1–7):

1. Formation of Bunya Phyllite
2. Moderate regional metamorphism
3. St. Lucia Thrusts and ?Phyllonitization
4. Erosion
5. Deposition of Neranleigh-Fernvale Group
6. Very mild regional metamorphism
7. Hamilton Thrust
8. Erosion (long interval)
9. Intrusion of Enoggera and Green Hill granites
10. Erosion?
11. Intrusion of Indooroopilly Rhyolites, heavy fracturing in the mine area, mineralization
12. Erosion?
13. Deposition of Brisbane Tuff and Triassic strata

Structure in the mine area

The mine is situated in the St. Lucia Polymetamorphics not far to the west of the outcrop of the St. Lucia Thrust Zone, which is draped over the Indooroopilly Anticline. Bryan & Jones (1954) considered that the workings penetrated into Bunya Phyllite beneath the Polymetamorphics, but our recent work and re-examination of material collected earlier has shown that the whole of the mine workings down to the deepest (228-foot) level are in Polymetamorphics or rhyolite.

The chemical analysis of a specimen from the bottom of the open cut, set out in Bryan & Jones (1954, page 30), was therefore wrongly stated to be of Bunya Phyllite; it is in fact an analysis of St. Lucia Polymetamorphics.

The mine is situated on the western limb of the Indooroopilly Anticline but not far removed from the broad axial region. Although it is on the western limb, most dips recorded in the mine are to the east, and this is the case also between the mine and the Green Hill granite; elsewhere, however, dips are consistent with the anticlinal structure. This local reversal of dips may be interpreted as originating from forcible injection of the small Green Hill granite mass and the rhyolites close to the axial region of the structure, which resulted in the formation of a local dome and tilted the strata at the mine to the east and south.

This doming was accompanied by heavy fracturing. On some of the faults there seems to have been repeated movement, for on the 228-foot level, where the drives are mostly through rhyolite, every clearly observable junction between rhyolite and phyllonite suggests that rhyolite was forced in along faults; but at other points, as in the drive towards the ventilation shaft on the 140-foot level, both phyllonite and rhyolite are heavily brecciated (Plate I (1)). Brecciation is also well shown in an old quarry off Moggill Road about 300 yards to the west of the Mine, where the greater part of the quarry is occupied either by rhyolite breccia or by a breccia of rhyolite and phyllonite.

In the mine workings innumerable faults, both normal and reverse, are to be seen. Most of these are small, though in many cases it is impossible to determine either the amount of throw or indeed which is the downthrow side. In spite of the major effects of several of the faults, none can be correlated from one level to another.

Intrusive rhyolite of the mine area

The intrusive rhyolite in the University Mine is light-coloured, non-porphyritic, and aphanitic. It shows flow-layering only close to the phyllonite contacts, where

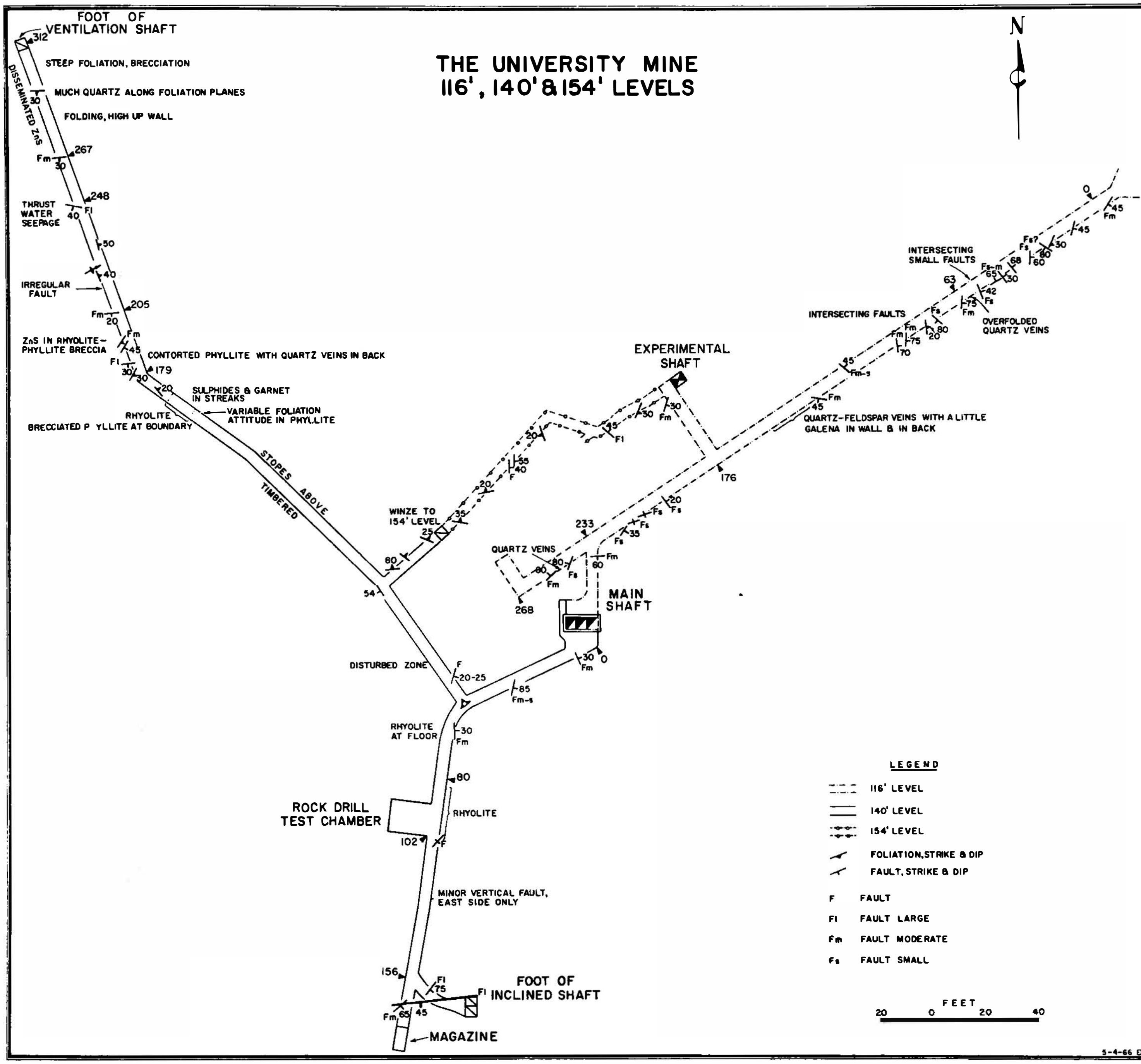

FIG. 3.—Plan of the 116-foot, 140-foot and 154-foot levels.

it is, in some places, amygdaloidal. Minor veining by quartz and sulphide minerals is also present.

Under the microscope, the rock consists largely of a granular mosaic of potash feldspar and quartz in irregular grains with an average diameter of about 0.15 mm. Smaller laths of albitic plagioclase. more or less sericitized, are included in the potash feldspar and the quartz. Calcite and chlorite occur in minor amounts as products of hydrothermal alteration. Opaque minerals are mostly confined to thin veins and amygdules.

Garnet occurs with quartz and sulphides in amygdules in the rhyolite midway along the ventilation shaft drive on the 140-foot level. The garnet, which is almost colourless or slightly tinged with brown in thin section, is an almandine-spessartine with refractive index between 1.79 and 1.81. A little fine-grained granular carbonate (?siderite) is usually present at the margins of the amygdules. A similar occurrence of garnet in amygdules in the rhyolite has been noted in a surface exposure outside the Indooroopilly State School, a quarter of a mile north of the mine.

The contact between rhyolite and phyllonite on the 140-foot level is generally sharp, but at one point there is an apparent graduation over an inch or so, as the flow-layering in the rhyolite becomes more pronounced and the colour becomes darker as the phyllonite contact is approached. Under the microscope, a variety of fine-grained flow textures are exhibited, and in most zones a marked "spotting" is developed. Some of the spots appear to be microphenocrysts replaced by quartz. Several small crystals of green tourmaline are present in one zone. Close to the phyllonite contact, xenoliths are more abundant; some are quartzite, others flakes of bleached mica from the phyllonite.

A chemical analysis of the intrusive rhyolite (Table 1) shows that the rock has relatively high alumina and potash for a rhyolite, which is explained by the presence of sericite formed by hydrothermal alteration. The unaltered rock would have had higher silica and perhaps higher soda, and, with lower alumina and potash, may have been comparable to the Enoggera granite (adamellite) or to ignimbrite of the Brisbane Tuff. The low lime and magnesia of the intrusive rhyolite are more closely comparable to the ignimbrite than to the adamellite.

TABLE 1

CHEMICAL ANALYSES OF SOME IGNEOUS ROCKS FROM THE BRISBANE DISTRICT

	1	2	3	4	
SiO_2	72.40	73.52	75.52	Q	37.0
Al_2O_3	16.17	11.05	12.73	Cor	5.9
Fe_2O_3	0.32	abs.	2.18	Or	25.6
FeO	1.16	3.15	1.43	Ab	24.1
MgO	0.31	1.03	0.27	An	2.2
CaO	0.45	1.70	0.28	Hy	2.6
Na_2O	2.86	4.08	2.30	Il	0.3
K_2O	4.30	3.99	3.47	Mt	0.5
H_2O +	1.35	0.44	1.20	Ap	0.1
H_2O −	0.10	0.16	0.48		
TiO_2	0.17	0.20	0.30		
P_2O_5	0.06	0.15	0.16		
MnO	0.18	—	0.01		
	99.83	99.47	100.57		

1. Indooroopilly Intrusive Rhyolite (13118), rock drill test chamber, 140-foot level, University Mine, Indooroopilly. Anal. L. J. Sutherland.
2. Enoggera "Granite" (adamellite), Enoggera. Anal. G. R. Patten. (Bryan, 1922).
3. Rhyolitic ignimbrite, Brisbane Tuff, Bowser and Lever's Quarry, Windsor. Anal. G. R. Patten (Briggs, 1929).
4. C.I.P.W. Weight Norm of 1.

The ore

The ore can be regarded as forming two separate ore-bodies. One of these, that consisting of silver-lead with only minor zinc, was fairly well-defined. It was developed in fault breccia, often of dyke material and phyllonite, but in part of phyllonite only. The ore occurred close to the rhyolite-phyllonite contact, the host rock being in most cases phyllonite with rhyolite apophyses, but to a minor extent the host was rhyolite itself. This silver-lead ore appears to be almost completely stoped out.

The other "ore-body" has not been mined; it contains largely sphalerite, with

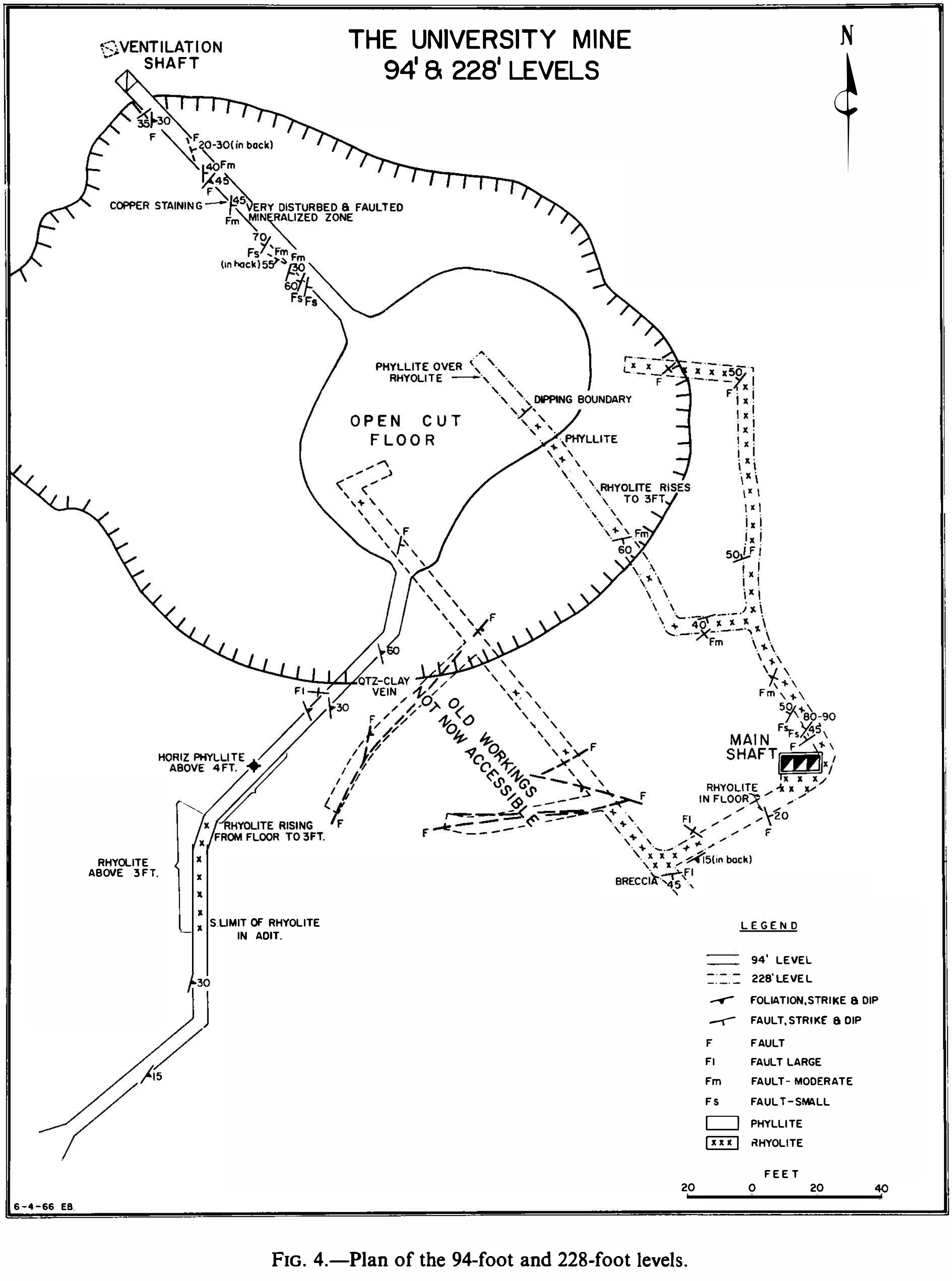

FIG. 4.—Plan of the 94-foot and 228-foot levels.

minor galena, and is much less well defined than was the galena ore-body. It is best developed in proximity to the present ventilation shaft (Cox's shaft), but the recent extension of the 140-foot level to connect with this shaft revealed intermittent disseminated sphalerite for some 40 feet to the southeast along the drive.

Besides galena, sphalerite, and their oxidation products, L. C. Ball (1920*a*, *b*; 1921) has reported pyrite, chalcopyrite, arsenopyrite, and pyrrhotite. Of these the latter two sulphides and the oxidation products have not been observed by the writers. Ball also noted that the bulk of the ore stoped was "oxidised", largely cerussite.

The shape of the galena ore-body is revealed only by Ball's reports and especially by that of 1926. It could be described as a pipe-like mass of irregularly shaped cross-section of maximum dimensions of about 150 feet in an east-west direction and of 80 feet in a north-south direction; but the shape and size varied greatly at different depths. It plunged to the east at about 45° (Fig. 2).

Polished surfaces (Plate I (3), (4)) of slightly mineralized rhyolite from the rhyolite-phyllonite contact 150 feet along the northwest drive on the 140-foot level are instructive: small stretched cavities in the rhyolite are filled with quartz, garnet, and sulphides; quartz and garnet form an outer layer with galena and sphalerite filling the centre. The sphalerite contains blebs of exsolved chalcopyrite, suggesting cooling of the ore-solutions to below 350°-400°C before crystallization. Whereas the cavities are deformed, the cavity fillings are undeformed except that a very few crystals of galena show slightly curved cleavages; a few knife-edge thin veins connect at least some cavities to the rhyolite-phyllonite contact.

It would appear that the sequence of events was:

(1) faulting, movements continuing until the end of (3) below;
(2) intrusion of rhyolite with movement continuing when the rhyolite was in a pasty condition so that the cavities were drawn out;
(3) continued movements on faults to cause brecciation of rhyolite and phyllonite near the contact;
(4) immediate introduction of garnet, quartz, and sulphides in that order with just sufficient local movement of the rhyolite to deform some galena crystals.

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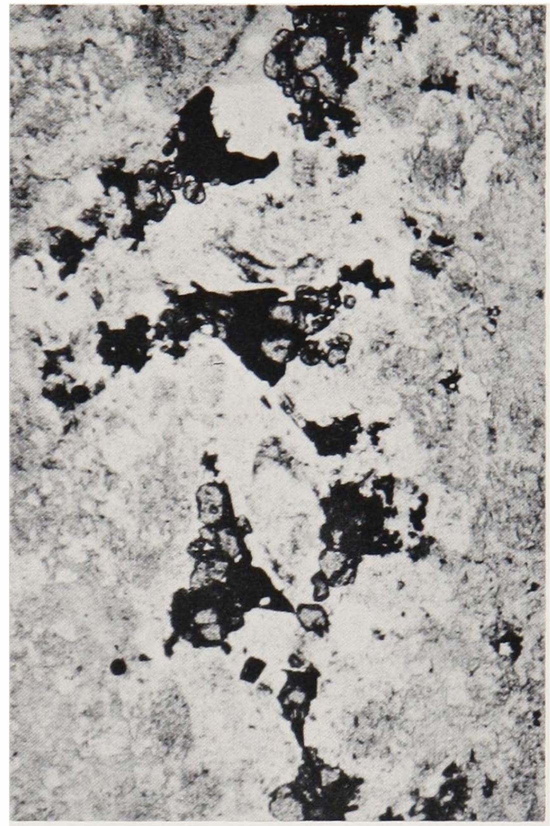
PLATE I.—Rhyolite and ore minerals from approximately half-way along the ventilation shaft drive, 140-foot level, University Mine.

1. Sawn hand-specimen of a brecciated rhyolite (2805). Spaces between the rhyolite fragments are filled with sphalerite. A fragment of phyllite is in the top left-hand corner. The scale is 10 mm long.
2. Photomicrograph, plane polarized light, of a thin section of rhyolite (7844), containing an amygdule filled with quartz (almost white), garnet (dark grey, high relief), and sulphides (black). Field of view is 4.5 mm × 3 mm.
3. Photomicrograph, reflected light, of a polished surface of ore minerals (7844). Galena (white with triangular black markings), sphalerite (medium grey), and chalcopyrite (small pale grey blebs exsolved from sphalerite) are the sulphides; the dark grey mineral is largely garnet. Field of view is 1.8 mm × 1.2 mm.
4. Same as 3, except that chalcopyrite is absent. Shows slightly curved cleavages in the galena. Field of view is 1.8 mm × 1.2 mm.

1



2

3

4

Plate I