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THE GEOLOGY OF THE SELWYN AREA OF NORTH WEST QUEENSLAND

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SUMMARY

Five hundred square miles of mineralized Precambrian rocks in the Selwyn area, 70 miles south of Cloncurry, were mapped at a scale of approximately 1" to 4000 ft. The rocks occupy a broad meridional belt which forms the isoclinally folded western limb of a wide, flat, south-pitching synclinorium. They dip steeply to the east and are extensively strike-faulted.

The Precambrian sequence is subdivided into four formations of which the Mitakoodi Quartzite is the oldest. It is overlain by the Answer Slate which is separated from the succeeding, essentially calcareous, Staveley Formation by a local depositional unconformity. The Kuridala Formation, at the top of the succession, contains two economically important slate members, the Mt. Elliott and the Hampden slates, separated by a thick succession of quartzite and mica schist.

Granite and basic igneous rocks intrude the Precambrian rocks; extensive quartz-hematite bodies, believed to be of metasomatic origin, are associated with the granite.

Scattered outliers of Mesozoic rocks lie unconformably on the Precambrian. There is evidence of deep weathering and supergene alteration of the older rocks before deposition of the Mesozoic strata.

Copper mineralization is widespread, but, with two exceptions, the deposits appear to be small. Nevertheless there is a strong stratigraphic control of mineralization and the possibility of a large low-grade orebody in the Mt. Elliott slate should not be overlooked. In addition, the quartz-hematite replacement bodies are known to be copper-bearing, and may be associated with a major orebody.

Deposits of cobalt, silver and uranium also occur in the area, but, with the possible exception of the low-grade cobalt deposit at Mt. Cobalt, they are not of great economic importance.

INTRODUCTION

The Selwyn-Kuridala area in the Cloncurry Mineral Field was mapped by the Bureau of Mineral Resources during the 1956 field season. The purpose of the survey was to follow up earlier reconnaissance mapping of the North West Queensland Mineral Belt with a detailed investigation of an economically promising region; to assess the economic potentialities of the area; and to construct geological maps to aid prospecting.

Situation

The area investigated comprises some 500 square miles around the rail terminus of Selwyn, 71 miles south of Cloncurry. A dry-weather road connects Selwyn with Cloncurry and continues south of Selwyn to McKinlay and Boulia. The siding of Kuridala lies 18 miles north of Selwyn and 25 miles from Malbon, which is on the main Cloncurry-Mt. Isa line. A weekly train service runs to Selwyn from Cloncurry.

Climate and Water Supply

Annual rainfall is about 15 inches, most of which falls in the summer months. During this period day temperatures are moderate to high. In winter the days are cool and the nights cold, with occasional frosts, and the area is swept by cool southerly winds.

The watercourses flow for only a short period after heavy rain and the water supply in the area is poor. Bores at Kuridala and near Mt. Cobalt provide an adequate supply of brackish water for stock needs and a sufficient supply for mining purposes may be readily available, but good quality water for domestic purposes would be difficult to find.

Vegetation

The vegetation is predominantly spinifex grasses and eucalypts. Stunted shrubs of Acacia occur on many of the basic igneous rocks and groves of lancewood grow on the flat-topped mesas.

Previous Investigations

The Selwyn area is referred to in the reports of Ball (1908), Dunstan (1920), and Reid (1921), but no systematic work seems to have been done until the North Australia Survey entered the area in 1935-36. Broadhurst (1936) reported on the Hampden mines, and Rayner (1938) described the Mt. Cobalt lode in a report on the cobalt deposits of the Cloncurry District. Honman (1938), with Clappison and Dickinson, mapped the area covered by the present survey. Nye and Rayner (1940), in a general report on gold-copper ratios in the Cloncurry field, frequently referred to the Selwyn district.

Sullivan and Matheson (1950) reported on the Kuridala copper field, and their report was amplified and supplemented by Searl (1952a), who mapped a part of the Hampden fold. Sullivan (1952) also speculated on the ore controls at Mt. Elliott, and again his report was supplemented by Searl (1952b), who mapped seven square miles in the vicinity of Mt. Elliott at a scale of 1" to 400 ft. Carter, in various unpublished reports, included most of the Precambrian of this area in his Mort Beds, which he thought to be penecontenporaneous with Marimo Slate and in part contemporaneous with Soldier's Cap Formation and the lower part of the Corella Formation, and which, he recognised, conformably overlay Mitakoodi Quartzite.

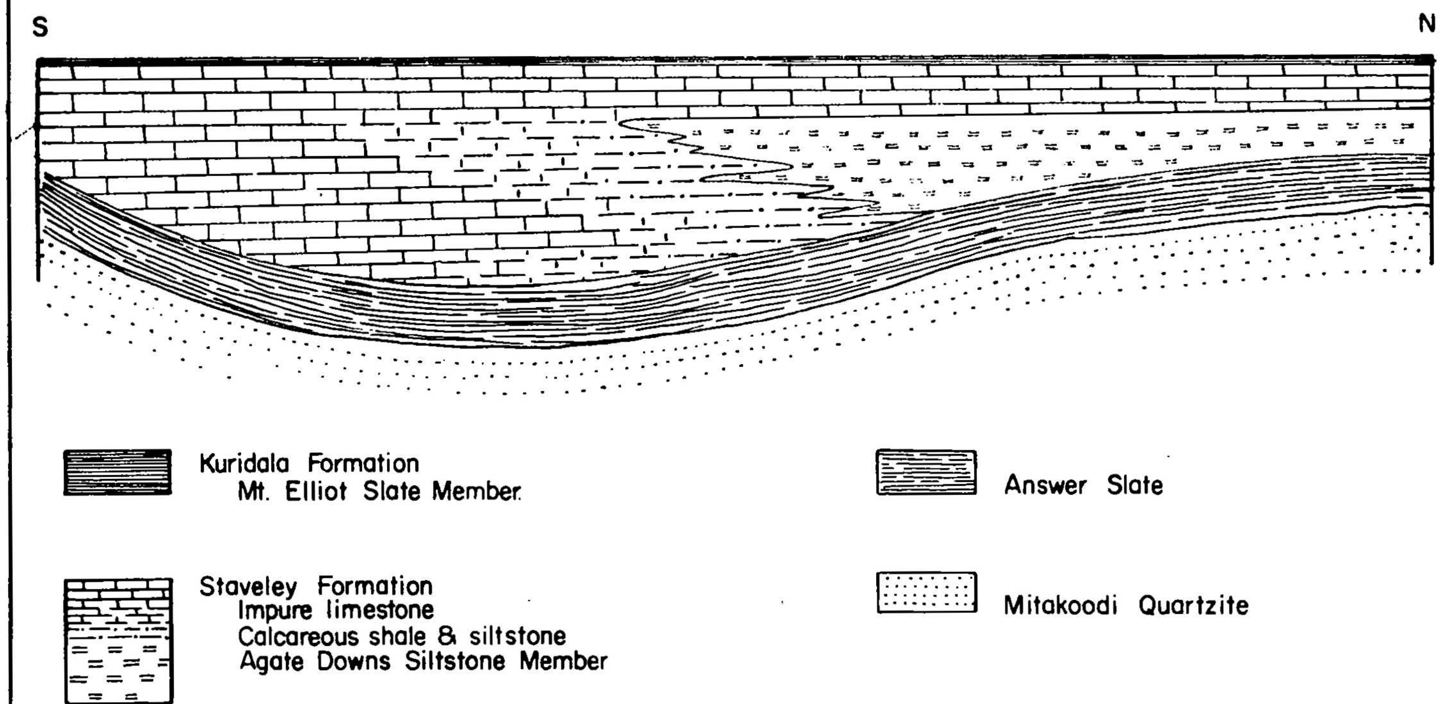
PHYSIOGRAPHY

Selwyn is 1230 ft. above sea level and is situated on the Selwyn Range, a belt of rough country trending east-south-east which forms the watershed between the two principal drainage systems of north-west Queensland, the internal drainage system of the Diamantina and Georgina Rivers to the south and the Gulf of Carpentaria system to the north.

TABLE OF ROCK UNITS IN THE SELWYN AREA

Age	Formation	Lithology		Remarks
Recent		Alluvial sands and clays		Some alluvial gold
		Erosion and warping		
Tertiary		Laterite		
Mesozoic		Sandstone, conglomerate, shale, siltstone & clay.		Plant fossils
UNCONFORMITY ——		Prolonged erosion and peneplanation		
Cambrian		Limestone, quartzite, shale		
UNCONFORMITY ——		Prolonged erosion	Post-granite basic dykes. Granite emplacement. Folding and faulting. Pre-granite basic intrusives.	Ore deposition
Precambrian (Lower Proterozoic?)	Kuridala Formation			
		Hampden Slate Member	Black calcareous shale & argillaceous limestone.	Copper
		Quartzite and mica schist.		
		Mt. Elliott Slate Member	Carbonaceous slate & silicified slate; some siltstone.	Copper Cobalt
	Staveley Formation	Argillaceous and siliceous limestone, calcareous shale, quartz sandstone calc-silicate granulite and breccia.		
		Agate Downs Siltstone Member	Red and grey siltstone & shale.	
LOCAL UNCONFORMITY ——				
	Answer Slate	Grey slates, (partly silicified) siltstone and albitic chert.		Copper
	Mitakoodi Quartzite	Fine quartzite and quartz sandstone with some siltstone and sheared volcanics.		

FIG I



S
N
Kuridala Formation
Mt. Elliot Slate Member
Answer Slate
Staveley Formation
Impure limestone
Calcareous shale & siltstone
Agate Downs Siltstone Member
Mitakoodi Quartzite

Flat topped residuals of Mesozoic strata are common along the Selwyn Range, particularly east-south-east of Selwyn. To the north and south, where the ground slopes gently away from the watershed, residuals are less numerous. It is clear that the flat Mesozoic beds have played an important part in the moulding of the present topography, and that the drainage system was superimposed, comparatively recently, on the Precambrian rocks as a result of (?)Late Tertiary warping of the land surface (see Twidale, 1956).

To the north the area is drained by the Cloncurry River, which, flowing west-north-west, cuts across the strike of the Precambrian rocks. South of the main watershed, Limestone Creek, Mistake Creek, Gin Creek, and the Mort River drain south into the Burke River without showing any marked relationship to the regional structure.

STRATIGRAPHY

PRECAMBRIAN

Mitakoodi Quartzite

The lowest formation encountered in the Precambrian sequence in this area is the Mitakoodi Quartzite. It crops out in a broad belt stretching from the Wimberu granite near the Young Australia Mine ($1\frac{1}{2}$ miles north of Agate Downs homestead) to Mistake Creek in the south, and dips steeply to the east with little sign of the tight minor folding seen in the overlying formations.

The full thickness of Mitakoodi quartzite was not mapped, but a reconnaissance to the west showed that it overlies basic volcanics, probably Marraba Volcanics (Carter) and that the lower part of the formation is predominantly well-bedded quartzite with subordinate flows of altered basalts. Towards the top of the formation the typical medium grained pink quartzite becomes feldspathic and more argillaceous; cross-bedding becomes more noticeable and thin beds of siltstone, many of them micaceous, are common. Finally, at the top, a thick bed of fine-grained argillaceous sandstone, with lenses of impure limestone, passes abruptly into the shale and slate of the overlying formation, the Answer Slate.

The total thickness of the formation in this area is not known. In the section mapped more than 2,000 ft. of sediment is present, and the full section may measure considerably more.

The type section for the Mitakoodi Quartzite (Carter, brooks and Walker, 1961) is separated from the area mapped by the Wimberu Granite, but there is sufficient similarity in stratigraphic position and lithology, together with evidence of quartzite remnants in the granite, for the correlation to be made with some degree of certainty.

Answer Slate

The Answer Slate conformably overlies the Mitakoodi Quartzite and occupies a long, narrow meridional belt from Kuridala to a point 4 miles south of the Answer copper mine, from which the formation takes its name.

Lithologically the formation is fairly uniform. It is composed chiefly of slate, with subordinate siltstone and impure chert. The slate is a black to grey siliceous rock, locally carbonaceous or sericitic, grading into quartz sericite schist. In many places it has been highly silicified. The siltstone is generally quartz siltstone, although greywacke siltstone occurs locally to the south-west of Agate Downs homestead.

The chert, which is particularly well developed on the north side of Limestone Creek, to the west of Selwyn, is pale brown to grey and cream coloured, faintly banded, and dense-textured. It is commonly pyritic, although in many places the pyrite has been weathered out. The outcrop is generally deeply weathered to form a soft, white, kaolinitic rock spotted with red hematite. Even in relatively fresh rock this alteration can be seen to spread outwards from around the scattered pyrite grains. In thin section the "chert" proves to consist of extremely fine-grained quartz with up to 37% feldspar, accessory biotite, leucoxene, apatite, rare zircon and iron oxides. The feldspar is orthoclase and untwinned oligoclase, and it is its breakdown to kaolin which gives the rock its characteristic appearance in the field.

The origin of the chert is problematical. The presence of orthoclase, plagioclase, and small amounts of biotite would be unusual in a primary chert, but might be explained by reconstitution of clayey material in a limestone which has subsequently been silicified.

Over much of the area the slate is deeply leached and the cleavage is completely obscured. It appears as brown, or yellow to white, soft, shaly rock with kaolinite as flecks and spots, and in the more advanced stages of supergene alteration as a network of fine veinlets.

The Answer Slate is thought to be about 2,000 ft. thick, but the folding is such that an accurate figure cannot be obtained, and the thickness may be considerably less.

The formation is correlated with the lower part of the Marimo Slate. Carter, in a submission to the Queensland Stratigraphic Nomenclature Committee, indicated that the Marimo Slate passed laterally into the Mort Beds, of which the lowermost portion is now named the Answer Slate.

Staveley Formation

This formation which unconformably overlies the Answer Slate, takes its name from the Parish of Staveley, in which most of the outcrop area lies. It occurs in a broad northerly trending belt between Farley outstation in the north and Gin Creek in the south (Plate 1).

A fairly wide variety of sedimentary rocks is included in the Staveley formation; perhaps it should rightly be split into two or more formations. However, all the rock types are closely related in that they are penecontemporaneous, the variation in type of sediment being, broadly speaking, related to position in the depositional area rather than to vertical position in the succession. A single formational name has therefore been adopted, but a prominent portion of the formation has been named as a member, the Agate Downs Siltstone Member.

This member at the base of the Staveley formation forms a prominent flat-topped ridge between Agate Downs homestead and Limestone Creek. North of the Cloncurry River it lenses out abruptly, and south of Limestone Creek it grades laterally into limestone and calcareous shale.

The rock is red and grey thin-bedded siltstone and shale. It is locally silicified along well defined strike shears.

The remainder of the Staveley Formation is essentially calcareous. South of Limestone Creek a succession of thin-bedded impure limestone rests with local unconformity on the Answer Slate. It is well exposed on the south bank of Limestone Creek, 8 miles west of Selwyn, where it forms conspicuous "saw-tooth" outcrops. The rock is pale grey and unaltered and consists of fine calcite with much indeterminate argillaceous material, very fine quartz, and scattered small cubes of pyrite and chalcopyrite. Thin, highly siliceous, bands stand out prominently on the weathered surface. Farther south, near the western margin of the Gin Creek granite, the limestone is thoroughly recrystallized, with the formation of plagioclase feldspar, diopside and other calc-silicate minerals.

Higher in the succession the impure limestone is accompanied by calcareous shale and siltstone with lenses of fine-grained calcareous sandstone. Ripple marking is common in the sandstone, and small-scale slumping, flow-casting, mud cracks, and rain pits are to be seen in the calcareous shale and siltstone, which also contain many pipe-like concretionary structures at right angles to the bedding.

In the narrow "corridor" between the Gin Creek and Williams Granites, the calcareous rocks have suffered fairly intense thermal metamorphism and possibly some metasomatism. Conspicuous pink and dark green, commonly very coarse-grained granulites have been formed. They are composed essentially of plagioclase feldspar and green hornblende, with interstitial calcite and accessory epidote, sphene, apatite, magnetite and, occasionally, scapolite. The hornblende commonly occurs in rough bands. The plagioclase is generally clouded with hematite dust, colouring it a deep red or pink; andesine is the most basic plagioclase recorded in the few thin sections examined, but oligoclase is more common, and a little orthoclase is generally present.

Farther north, in the area between Labour Victory and Twiggie Vous copper mines, a complex succession of calc-silicate granulites and breccias overlies the "Siltstone Member". They belong to approximately the same horizon as the granulite on the east of the Gin Creek granite. Sugary micaceous granulite is overlain by very siliceous fine-grained laminated or "slaty" rock composed of the typical mineral assemblage quartz-hornblende-biotite-plagioclase, with epidote and sphene. Interbedded with these are thin beds of a very tough green epidosite made up of fine-grained granular quartz, epidote, and plagioclase (andesine), with accessory sphene and calcite. These rocks were originally calcareous shale with interbedded siliceous bands, and the alteration is probably due purely to thermal metamorphism with little, if any, metasomatism.

Overlying this calcareous shale sequence is a thick succession of coarsely crystalline hornblende-plagioclase granulite and breccia-conglomerate with lenses or "pods" of crystalline limestone. The breccia-conglomerate consists of very angular to perfectly rounded fragments, ranging in diameter from a fraction of an inch to several inches, set in a medium-grained granular matrix of quartz, calcite, plagioclase (oligoclase), biotite and microcline, with, in many specimens, hornblende. The fragments show a wide range of composition, but the different types are rarely mixed. Many of the larger, more angular fragments are identical with the groundmass and distinguishable from it only on the weathered surface where the outline is clearly marked. The well rounded fragments and some of the irregular ones stand out clearly as fresh pink material which, in thin section, is a very fine-grained quartz-microcline rock clouded with dusty hematite and with a little interstitial calcite. The outline of the pebbles varies from sharp to gradational. The rock originally was a very impure limestone -conglomerate or calcareous greywacke conglomerate, but the original nature of the pebbles is obscure. Probably they, too, were calcareous rocks. The microcline may be reconstituted feldspathic material or may have arisen from the thermal metamorphism of dolomite with micaceous impurities.

The crystalline limestone associated with the breccia-conglomerate occurs in "pods" or lenses. It is generally light coloured and coarsely crystalline, containing some quartz and plagioclase feldspar and, in places, biotite, hornblende or diopside, with apatite and sphene. Large cubes of chalcopyrite, surrounded by a wide cuprite-malachite halo, are scattered throughout the rock.

Both the calc-silicate granulite and breccia-conglomerate continue north of Twiggie Vous copper mine, the former being predominant north of the Kuridala-Malbon railway line. Along the margin of the Wimberu granite, north-west of Kuridala, pyroxene is developed instead of amphibole and some of the plagioclase is replaced by scapolite. North-east of Farley Outstation impure scapolite limestone, consisting of calcite with quartz, scapolite, hornblende, chlorite, biotite, magnetite and epidote, is developed.

The metamorphism of this suite of calcareous rocks can be attributed, to a very great extent, to simple thermal metamorphism. There is no evidence that they were recrystallized under great pressure, and the distribution of the calc-silicate granulite and associated rocks bears a close relationship to that of the granites, both the larger masses and the smaller intrusions such as occur near Twiggie Vous mine. The typical mineral assemblage found in these rocks is consistent with thermal metamorphism of calcareous shale, slate and sandstone. The alkali feldspars may have been produced at the expense of micaceous material, or much of the albite may represent recrystallization of the finely divided albite present in many argillaceous limestones; the orthoclase and microcline could result from the dissociation of sericite. Many of these rocks, and the un-metamorphosed calcareous rocks, have however been altered by later supergene processes, probably in the early Mesozoic and in the Palaeozoic. The resulting leached rocks are discussed elsewhere.

The distribution of rock types in the Staveley Formation and their relationship to the underlying Answer Slate seems to indicate that this series of impure limestones, calcareous shales and siltstones was deposited in shallow water on an irregular, warped surface, giving rise to local depositional unconformities.

The relationships suggested for the lithological units within the formation at the time of deposition are shown in the diagram (Fig.1). Similar relationships have been observed elsewhere in northwest Queensland between the Corella Formation and underlying rocks.

The total thickness of the Staveley Formation is difficult to ascertain owing to the tight folding and the strike faulting. In addition, the thickness increases rapidly from north to south. It is probably less than 2,000 ft. west of Kuridala, increasing to more than 8,000 ft. south of Limestone Creek.

Kuridala Formation

The Kuridala Formation is the youngest of the four Precambrian formations mapped. It is best exposed in the Hampden fold at Kuridala. The formation is dominantly arenaceous, with a thin, but conspicuous, black slate bed at the base and another at the top. These slates have been named the Mt. Elliott Slate Member and Hampden Slate Member respectively. The thick quartzite and mica schist succession between them has not been named.

The total thickness of the formation is approximately 7000 feet in the Kuridala section, but may be greater farther south.

The Mt. Elliott Slate Member is the basal member of the Kuridala Formation. It occurs in a rather sinuous, tightly folded outcrop from the Cloncurry River, through Mt. Elliott, to south of Mt. Cobalt. North of the Cloncurry River it is absent or is represented by only a few inches of black slate. The slate on the north-east of the True Blue fault is, however, correlated with the Mt. Elliott Slate.

The lithology is generally very uniform. It is a typical black slate, commonly carbonaceous and pyritic. At the top it grades upwards through micaceous slate and phyllite into the overlying mica schist. The lower contact with the Staveley Formation is generally sharp and well-defined, but conformable.

To the west of Selwyn the Member thickens considerably and becomes lithologically more diverse. With the incoming of more clastic material, lenses of siltstone and greywacke siltstone, and even greywacke, are to be found interbedded with the more normal slate. South-west of Selwyn a thick, red, glossy phyllite, with interbedded siltstone, takes the place of the slate.

The slate is commonly silicified, generally along narrow shear zones; but south of Mt. Doré the entire unit is highly silicified for a distance of nearly $1\frac{1}{2}$ miles. North of Mt. Doré, where it is in contact with Williams Granite, small chiastolite crystals are developed, but in general the degree of metamorphism of the slate is low. It was not, apparently, as susceptible to the metamorphic processes as other rocks in the area, possibly because of the presence of carbon, which, as Harker (1932) suggests "tends to inhibit or delay the normal (metamorphic) reactions".

Spectacular showings of secondary copper minerals are found throughout the Mt. Elliott Slate and several important orebodies are located in it.

Maximum thickness, south of Selwyn, is 800 feet; average thickness is of the order of 500 feet.

<u>Quartzite Mica Schist</u>. The bulk of the Kuridala Formation is made up of the quartzite and interbedded mica schist which occur between the two slate members. The full sequence of quartzite and mica schist is exposed in the Hampden fold near Kuridala, but elsewhere the top of the succession is not seen. The thickness at Kuridala is probably 6,000 feet. East of Mt. Cobalt the full succession has not been mapped in detail, but tightly folded quartzite and mica schist are known to occur for several miles in this direction.

At the base of the succession the rock is predominantly mica schist. Thin micaceous and feldspathic quartzite beds appear a short distance above the base; overlying these, quartzite with thin (6 inches to 2 ft.) interbedded mica schist is the dominant rock type. Near the top of the succession mica schist again becomes predominant. Of the total of 6,000 feet exposed in the Kuridala area, some 500 ft. at the base and a further 500 ft. at the top is predominantly mica-schist. The lower zone may, however, be rather thicker (possibly over 1,000 ft.) in the Mt. Cobalt area.

The mica schist is a highly foliated rock of reddish to silvery appearance, sometimes studded with large black porphyroblasts. In thin section, the muscovite mica appears as thin tabular books and flakes with a parallel orientation. Quartz occurs in slender prisms with the mica and also in rough bands and lenses, in which it is only partly recrystallized. Some biotite is scattered through the rocks in small flakes. Porphyroblasts, which are very irregularly distributed through the rock, consist of large masses of highly altered staurolite, up to ½ inch long and showing the characteristic crystal outline. A core of pale-yellow strongly pleochroic staurolite generally remains, but the crystals are very largely altered to a fine scaly micaceous aggregate. Muscovite and quartz, including some relatively large quartz-rich bands, are strongly deflected around the borders of the staurolite crystals. There is no doubt, therefore, that the staurolite grew in place.

Near Mt. Cobalt the mica schist crops out on long, prominent, glistening ridges. In places it is puckered, but more commonly foliation is wavy or undulating. It appears to be, generally speaking, parallel to the bedding, of which traces can be seen. In the closed structure north of the Labour Victory copper mine, where there are many thin quartzite beds with the mica schist, the relationship between bedding and schistosity is fairly clear.

The quartzite is a normal medium-grained sedimentary quartzite, ranging from a clean well sorted rock, with rounded grains of glassy quartz cemented by secondary silicification, to coarser feldspathic and micaceous types. It is generally a massive to thick-bedded rock with thin mica schist intercalations. It is rarely ripple-marked; cross-bedding was not recorded.

<u>The Hampden Slate Member</u> is found only in the core of the Hampden fold at Kuridala. Although the top of the slate is not seen, it is probably of the order of 500 ft. thick. The rock is a thin-bedded black carbonaceous and calcareous slate, locally grading into a dark argillaceous limestone or carbonaceous "slaty" limestone. It is micaceous at the base of the unit.

The slate is intruded by a great many doleritic sills from a few feet to several hundred feet thick, commonly separated from each other by only a few feet of country rock. For the most part metamorphism at the contact of these intrusives is negligible or is confined to a very narrow zone of silicification. Where they intrude limestone, however, a thin band of dense calc-silicate rocks composed of diopside, actinolite, and oligoclase is generally formed.

The adjacent slate is, however, seldom altered. Even in the calcareous slates the presence of carbon seems to have inhibited metamorphic reaction.

CAMBRIAN

No sediments of proven Cambrian age have been identified within the area mapped. The flat-lying red siltstone and sandstone, in part conglomeratic, which rest unconformably on Answer Slate south of the Answer Mine are probably Mesozoic, but may be Cambrian. Cambrian siltstone and limestone, with chert, and containing halite pseudomorphs, occur to the south and west outside the boundaries of the area described. In the west they are faulted against the Precambrian.

MESOZOIC

Remnants of a widespread cover of flat-lying Mesozoic strata occur throughout the area as scattered mesas. In addition there are many prominent flat-topped hills from which the Mesozoic cover has been removed by erosion, leaving a surface which approximates to the ancient, early Mesozoic land surface. The Precambrian rocks exposed on this surface are leached and silicified to a great depth.

The Mesozoic sediments comprise loosely cemented basal conglomerate, pebbly and coarse sandstone, friable, white quartz sandstone, shale, claystone, siltstone, and, in a few localities, a ferruginous basal breccia containing angular shale fragments. They appear to be partly terrestrial and partly lacustrine and were laid down on a mildly dissected peneplain.

Well preserved plant remains were recovered from claystone and shale deposited in an ancient valley four miles west-north-west of Selwyn. The two species were identified as *Pterophyllum (Nilsonia) princeps*, which is a Triassic-Jurassic form, and *Aspleniopterus* sp., which is post-Triassic (White, 1957). Elsewhere plant remains were fragmentary and not determinable.

TERTIARY

The early Tertiary lateritization of north-west Queensland (Twidale, 1956) is probably not represented in the Selwyn area. Honman (1938) and Searl (1952a) suggested that the rocks exposed on the old Mesozoic land surface in the vicinity of Selwyn had subsequently been altered by lateritic processes, but there seem to be no reasonable grounds for supposing that this lateritization is not part of the early Mesozoic profile.

IGNEOUS ROCKS

Basic Intrusives.

The basic igneous rocks intruding the Precambrian sequence are of two ages, separated by a period of granitic activity.

Pre-granite Metadolerites: Slightly altered dolerites are present throughout the area. They occur mainly as sills, commonly many hundreds of feet thick and of great extent. In addition, two plug-like masses occur, on Horse Creek and 4 miles north-west of Selwyn, and there is a complex intrusion north of Twiggie Vous mine. The sill phase is particularly well developed in the Hampden fold at Kuridala, where many sills, from a few feet to several hundred feet thick, can be traced right around the closed fold structure.

Honman (1938) and Searl (1952b) believed that many, if not all, of the basic igneous rocks in the Kuridala area were extrusive flows on the grounds of their fine grain-size and the occurrence of doubtful flow vesicles. During the present survey, however, intrusive contacts and slight contact metamorphism were found at the top of most sills and vesicles were not recorded.

These intrusives form rough "blocky" outcrops of tough, fresh rock. The doleritic texture is generally well preserved. In one example (4 miles north-west of Selwyn), feldspar laths are aligned at 030°, almost at right angles to the strike of the enclosing sediments. Much of the pyroxene is altered to green hornblende, and scapolite in a few rocks replaces the feldspar. Locally, shearing has formed a hornblende schist, as at Mt. Cobalt, but in general the grade of metamorphism shown by these rocks is low.

These intrusives are clearly older than the granite, as shown by the intrusive granite contacts and assimilation of the basic rock by the granite. That they were emplaced before the folding is suggested by the remarkable concordance of the sills with the intricately folded sedimentary beds and by the almost complete absence of cross-cutting intrusions. In addition, crushing and micro-brecciation at the margins of the sills and, in places, the tight drag-folding and crushing of the adjacent country rock seem to be due to the greater competency of the sills during folding. On the other hand, the dolerite generally shows very little shearing or textural alteration due to the folding other than a rather linear jointing parallel to the strike, and it is possible that intrusion was contemporaneous with folding.

Post-granite Dolerite: Post-granite basic igneous activity is represented by two large dolerite dykes, one near the Hampden Queen copper mine and the other south-east to Mt. Doré mine; both run east-west. The fresh rock is a normal coarse-grained dolerite, in which pyroxene is only slightly altered to amphibole. It weathers in a characteristic spheroidal manner in contrast to the "slabby" weathering of the pre-granite dolerites.

Granite

Three granite masses are represented: the Wimberu Granite to the north-west of Kuridala; the Williams Granite in the east; and the Gin Creek Granite west of Mt. Cobalt. None of these has been examined in detail in the present survey.

The Wimberu Granite, in this area, is a coarse porphyritic granite containing many large inclusions and "rafts" of altered dolerite and limestone, highly altered quartzose sediments and migmatite. The contact is marked by a broad zone of highly altered sediments and contaminated granite.

The Williams Granite, at least along its western margin, is a more uniformly coarse-grained, non-porphyritic granite, and contains few inclusions of country rock. The contact is sharp and cleancut, though often intricate. To the north of Mt. Doré a slightly finer grained selvage occurs on the margin of the granite, and chiastolite is developed in a narrow zone in the slate. Elsewhere little evidence of contact metamorphism is associated with this granite.

The Gin Creek Granite, an oval outcrop 8 to 9 miles wide lies to the west of Mt. Cobalt. Although separated from the Williams granite by only a narrow strip of country rock, it is more closely akin to the Wimberu granite. It is a coarse porphyritic autochthonous granite with many basic xenoliths. Migmatites are developed round the margin of the body and contact metamorphism is marked.

In addition to the three major granites there are several small acid stocks and dykes. The largest of these, near the Mort River 3 miles south-east of Mt. Doré, is $\frac{3}{4}$ mile across and is surrounded by a wide zone of hornfels. A small elongate body of leucocratic granite about 200 ft. wide occurs near Tip Top mine and is associated with crystalline limestone and calc-silicate granulite. Other small granite stocks occur in the Horse Creek and Limestone Creek areas.

Other Acid Intrusives

A peculiar acid dyke cuts the eastern limb of the Hampden syncline north of Farley homestead. It is composed of fairly coarse-grained granular feldspar (oligoclase) and biotite. It may represent a highly contaminated aplite.

A small quartz-feldspar porphyry dyke occurs near the Wimberu granite south-west of Agate Downs homestead.

QUARTZ-HEMATITE ROCK

Quartz-hematite rock occurs in a series of long dyke-like bodies confined, generally, to the Staveley Formation. They crop out near Twiggie Vous and Labour Victory mines and in the area south of Limestone Creek, and are well developed in the broad valley west of the Mariposa uranium prospect, along the eastern margin of the Gin Creek granite.

The quartz-hematite bodies are everywhere parallel to the dip and strike of the tightly folded sedimentary beds. They form prominent red-brown to black "wall-like" outcrops and in the Mariposa area can be traced for more than 11 miles, although individual bodies are seldom continuous for more than one mile. Many of them occur in groups of up to five or six parallel, closely spaced, "veins"; in one place at least they seem to follow round the nose of a tight fold.

In the field the deposits appear to consist essentially of quartz and fine to medium grained granular hematite. No other minerals are visible, but the rock is weakly magnetic and drilling has shown that magnetite largely takes the place of hematite at depth. In the more quartzose types a rough foliation, possibly the trace of original bedding, is apparent and, in extreme cases, the rock closely resembles a coarse "banded ironstone". The hematite is commonly specular in the more iron-rich rocks.

The walls of the quartz-hematite bodies are usually sharp and cleancut; but a few have gradational boundaries. Gradational walls are seen near the Labour Victory copper mine and lateral gradation is clearly visible near the Mariposa mine. East of this mine a thick bed of impure crystalline limestone passes into massive quartz-hematite rock, and a thick lens of calcareous sedimentary breccia south-west of the mine is converted to quartz-hematite rock for several hundred feet along the strike. In both cases the transformation appears to have been effected by the introduction of thin, often microscopic, ramifying veinlets of quartz and hematite, the latter in relatively large, platy crystals. The veinlets coalesce and generally become richer in iron to form massive quartz-hematite rock.

The country rock is commonly a heavily leached calcareous shale or impure limestone, but, in the Mariposa area particularly, the true nature of the original sediment is difficult to determine owing to the deep weathering.

These quartz-hematite bodies are very similar in nature and in setting to the Mt. Philp deposits (Carter and Brooks, 1955) and bear a strong resemblance to the magnetic skarn ores of New Jersey (e.g. Hotz, 1954) and of Scandinavia, etc., in which the magnetite is believed to have originated from an acid magma by interaction with carbonate rocks (Rankama and Sakama, 1950).

STRUCTURE

Structurally the Selwyn area presents a picture of tight isoclinal folding, overturned toward the west, with extensive strike faulting. The folding probably occurs on the western limb of a broad, flat, south-pitching synclinorium, the axis of which coincides with the axis of the Hampden Syncline and from there runs south-south-east to the east of Mt. Cobalt.

The Hampden Syncline, the keel or axial portion of the major synclinorium, is a simple syncline, overturned to the west and showing only minor plications on the limbs. It pitches to the south at the north end and to the north farther south, forming an elongated closed structure. The overturned eastern limb is thrown down to the east by the north-south Hampden fault.

Further pitch changes give rise to another closed synclinal axis east of Mt. Cobalt.

The major part of the area, however, lies on the west limb of the synclinorium; where the tight isoclinal folding is difficult to interpret. The folds are overturned to the west and the beds dip uniformly east at a high angle. The cleavage is parallel to the bedding (except on the apex of folds) and there are numerous sudden reversals of pitch throughout the area. It is only in deeply cut creek sections or where ripple marks or other sedimentary structures are present, or where drag-folds and the bedding-cleavage relationships are apparent, that the fold pattern can be unravelled at all.

Faulting is almost entirely strike faulting. Only a very few cross-faults are known, and they, with the exception of the True Blue Fault north of Kuridala, probably represents no more than local adjustment to the strike faulting. The great majority of the strike faults dip steeply to the east, parallel to bedding and cleavage, and are dip-slip reverse faults. Many of the faults may have originated as shear thrusts on the axial planes of extremely tight isoclinal folds (see section 1, Plate 6).

PRE-MESOZOIC WEATHERING

Over much of the Selwyn area the exposed Precambrian rocks, particularly the calcareous rocks, are so highly leached and altered that their original nature is not always apparent. The process by which they have reached their present state is, however, reasonably clear. They are the product of the deep and intensive weathering to which the Precambrian rocks were subjected before the Mesozoic/strata were laid down.

This alteration is most intense close to the base of the Mesozoic cover and, although the depth of weathering probably was far from uniform, the degree of alteration is in general closely related to the distance below the old land surface. All stages of weathering can be seen from, for example, slightly leached limestone to red "terra rossa" earths and slickensided clays. The weathered material has subsequently been compacted and compressed by the weight of the overlying Mesozoic sediments.

The rocks so formed vary considerably in appearance, depending on the nature of the parent rock and the stage of weathering. In addition to the terra rossas and clays they include a great variety of leached limestones, scaly, grey sericitic and chloritic schists and phyllites, "kaolinised" slates, clayey siltstones, tourmalinised "siltstones", speckled and streaky kaolinitic rocks and many varieties of micaceous, clayey and ferruginous rocks.

Many of these rocks are indistinguishable from rocks described by Sorotchinsky (1954) who showed that limestone could be replaced during weathering by quartz, albite, chlorite, sericite, etc., giving rise to rocks with the appearance of schists, phyllites and even granitoid rocks. Quartz and feldspars, micas, zircon, tourmaline, rutile, and ilmenite were observed forming "dans les tissues" of fossils. Kaisin (1956) also found that siltstone, schist, quartzite "gres argilleux riche en fer" etc. could be formed during weathering of limestone so that it was often impossible to retrace their calcareous origin.

In the Selwyn area these "leached" rocks consist mainly of quartz, amorphous clay minerals, some of which have been determined as kaolinite, and sericite. In addition, muscovite and biotite, sodic plagioclase, and small amounts of tourmaline (commonly euhedral), leucoxene, hematite, black iron oxide, chalcedony, rare rutile and zircon, and possibly brookite and anatase are present in many of the rocks.

Where the parent rock is granite, the weathered product is a pale pink kaolinitic mass with clots of sericite and scattered quartz grains. This material is seen underlying Mesozoic outcrops north of Selwyn, and on flat-topped hills, from which the later sediments have been eroded, in the Gin Creek granite.

The Answer Slate, near Limestone Creek and south of the Answer Mine, has been extensively kaolinized and generally all trace of cleavage has been obliterated. The altered rocks are streaked and flecked with kaolin. South of the Answer Mine they are criss-crossed with fine veinlets of kaolin.

The carbonaceous Mt. Elliott and Hampden slates seem to have been more resistant to chemical weathering and oxidation, and only in the country close to Selwyn, where a thin layer of Mesozoic still remains, is any notable alteration found. Here the Mt. Elliott Slate is kaolinized and ferruginized and it is often difficult to establish within 15 or 20 feet, where the base of the Mesozoic lies. The numerous doleritic intrusions also seem to have resisted weathering, and outcrops are generally comparatively fresh even when, as is the case 4 miles North west of Selwyn, outcrops of very highly altered rocks occur close to the intrusions. A few dolerites, however, are highly altered.

The calcareous Staveley Formation is the most widely affected and shows the greatest diversity of weathered material. The parent rock ranges from argillaceous limestone to calcareous shale and calcareous sandstone, although it must be admitted few of these rocks crop out in a completely fresh state. The sandstone, for example, contains very little lime and much of the shale is decalcified, and in many outcrops the calcareous nature of the parent rock can only be inferred from the form and appearance, texture and composition of the weathered material which has been compacted and compressed by the weight of overlying Mesozoic rocks.

The grey scaly phyllite and schist such as those found near the head of Limestone Creek were originally impure thin-bedded limestones, and contain many thin bands of porous "terra rossa". Interbedded with these, in Limestone Creek and to the south, towards the granite, are red and brown banded "siltstones" and "claystones" flecked or streaked with kaolin and in places showing ovoid structures and liesegang banding. They consist of fine detrital quartz, with secondary outgrowths, embedded in an iron-stained clay matrix with clots and patches of kaolin and thin layers of platy sericite. Small amounts of authigenic tourmaline, leucoxene and black iron oxide are present, and rarely zircon and colloform chalcedony. The more sericite-rich layers are conspicuously banded in pink and white, and in some exposures have a decidedly schistose appearance. These rocks are believed to represent the mantle of insoluble material left after leaching and decalcification of calcareous shale, marl and argillaceous limestone.

Very similar rocks containing muscovite in varying amounts are found in the Mariposa valley, at the north end of the Gin Creek Granite, and at several other localities. These rocks in the hand specimen have the appearance of a micaceous siltstone, but one in which the relatively large mica flakes are oriented completely at random, unlike most normal micaceous sediments. In thin section they are seen to contain equidimensional angular quartz grains about 0.04 mm. in diameter, evenly distributed through a matrix of platy kaolin which may constitute as much as 50% of the total volume of the rock. Accessory minerals are hydrated iron oxide occurring as streaks and granules, leucoxene, and euhedral tourmaline. Muscovite is scattered through the rock in amounts ranging from 2 or 3% up to 15% or even 20% of the total. It is "porphyroblastic" in habit, consisting of large flakes (up to 0.5 mm.) with rather ragged edges and random orientation. The rock is cut by tiny veinlets of kaolin, and commonly contains flattened, chalcedony-lined cavities.

These rocks also are probably the insoluble residues of a calcareous shale or similar rock, but the origin of the muscovite is problematical. It may represent the fine sericitic material present in some of the argillaceous limestones, reconstituted during emplacement of the granites to form muscovite which has survived the subsequent leaching. In general, muscovite occurs where the leached rocks are near the granite; only fine sericite is present elsewhere. But muscovite-bearing limestone has not been recorded, nor is muscovite a common constituent of the calc-silicate granulites.

The calc-silicate rocks, where they have been subjected to this intense leaching, are more difficult to recognise, and generally there is nothing whatever about them to suggest that they were ever calcareous. In the hand specimen the rock is generally a porous, red, more or less silicified granulite, and even in thin section it cannot always be distinguished from an igneous rock . It commonly resembles, quite strongly, a granite aplite, consisting of microcline and albite, quartz and a little chlorite, with hydrated iron oxides and leucoxene and occasionally tourmaline. In most cases the rock is heavily stained red by dusty hematite.

Their sedimentary origin is, however, apparent in the field and it can be traced into normal calc-silicate granulites.

North of the Labour Victory mine a long ridge of calc-silicate breccia is exposed. At the north end of the outcrop the rock has a typical granular quartz-calcite-plagioclase-hornblende-biotite groundmass with pink quartz-microcline-calcite fragments. Towards the south, however, where there is abundant evidence of pre-Mesozoic leaching in the adjacent rocks, the breccia appears as a very porous red feldspathic rock with fine-grained fragments. This rock was originally mapped as an agglomerate, with which it is easily confused in the field. In thin section the matrix is seen to consist of microcline and quartz with iron oxides, leucoxene, and some spherulitic chalcedony. In one specimen, clots of black tourmaline crystals and rhombic pseudomorphs outlined by iron oxides and consisting mainly of chalcedony are present. The fragments consist of fine-grained acid plagioclase and microcline with small amounts of quartz, iron oxides, biotite, chalcedony, and a varying amount of tourmaline.

ECONOMIC GEOLOGY

Introduction

Mining activity in the Selwyn area is now almost at a standstill. A little rich silver ore is being produced from a small mine west of Kuridala and some copper is still being won from the old dumps and from surface workings.

At one time, however, this was one of the more important copper-producing fields in north west-Queensland. Copper appears to have been discovered in the area before 1883. In 1898 some 10 tons of ore from the Hampden Mine at Kuridala were smelted. At this stage, the ore was carried to the rail head at Winton and only very rich ore could be exploited.

Mt. Elliott deposit and several smaller deposits were prospected in the eighteen-nineties, but development only began with the formation of Mt. Elliott Ltd. in 1905. The erection of smelters at Mt. Elliott in 1909 and Hampden in 1911 greatly stimulated the development of many smaller mines in the field, and in the next ten or twelve years close on half a million tons of rich secondary copper ore were mined and treated.

By 1920 most of the secondary ores had been worked out and the price of copper was too low for the very considerable reserves of low-grade primary ores to be worked profitably. The smelters were closed down and even small-scale production was much reduced.

The Mt. Cobalt deposit had been discovered in 1919 and came into production in 1921. By 1934 approximately 766 tons of hand-picked ore and concentrates had been shipped out, making this the largest cobalt producer in Australia, but shortage of water proved a formidable obstacle to mining and treatment and the mine closed down in that year.

Most of the bigger mines are now totally inaccessible.

Copper

Copper is by far the most important metal to have been mined in Selwyn area. More than 500,000 tons of ore averaging 6-12% Cu have been produced, and Mt. Elliott and Hampden mines are each reported to have reserves of over 100,000 tons of 3-4% Cu ore. The principal deposits and their mining history have been described elsewhere (Carter et al., 1961 ; Nye and Rayner, 1940; Rayner, 1938; Broadhurst, 1936; Honman 1938, etc.) and little can be added now except to describe the occurrences in relation to the stratigraphy and structure. None of the workings is now accessible and they were not examined during the present survey.

The Hampden group of mines at Kuridala, Hampden, Hampden Consuls, Hampden Central and Hampden Queen, are located in the Hampden Slate at the top of the Kuridala Formation. The mineralization occurs on a strike shear which cuts the eastern overfolded limb of the Hampden Syncline. Sullivan and Matheson (1950) considered that the ore was localized on the fault where the slate was brought up against the resistant dolerite (amphibolite), and suggested that this was a reverse fault on which a second syncline, lying to the east, was thrust over the westerly Hampden syncline. This idea is not confirmed by the present work; it is believed that the fault is normal and that the eastern (overturned) limb of the syncline has been thrown down (see section 2).

At its northern end the Hampden fault is in slate, but intersects a thick overturned dolerite sill not far below the surface (see transverse sections in Broadhurst, 1936). The available evidence suggests that ore is localized on this intersection. There is, therefore, an overall flat southerly pitch at this point and the ore may pitch under the Hampden Central and Hampden Queen mines, which were not developed below the 300 ft. level. At the southern end of the fault, which continues strongly for roughly five miles south of Hampden Central, the pitch would be northerly and ore repetition might be expected at this point, where there are traces of copper at the surface. In addition, ore repetitions might be expected to occur down the dip of the fault at the intersection with other dolerite sills.

Mt. Elliott mine lies about one mile south of the railhead at Selwyn. The ore occurs in crushed material associated with a tight shear fold in Mt. Elliott Slate, adjacent to an intrusive dolerite sill. Very little information has been recorded concerning the underground workings, which are now inaccessible, but the mineralization appears to be confined to the Mt. Elliott Slate (Group III rocks of Searl, 1952a) and may have occurred in a series of en echelon lenses. The oxidized ore is mainly malachite. The primary ore (from dump material) contained chalcopyrite, pyrite, magnetite, and pyrrhotite, with a gangue of diopside, scapolite, calcite, sphene, and prehnite, showing a metamorphic texture, which suggests that the ore was deposited, or at least redeposited, during the thermal metamorphism which converted much of the underlying Staveley Formation to calc-silicate rocks.

The Answer Mine occurs in Answer Slate 13 miles south-west of Selwyn. The quartz lode follows a strike shear in sericite schist at the contact of the slate with granite.

The Young Australia, also in Answer Slate, lies 1½ miles north of Agate Downs homestead. The ore is chalcocite-malachite in a quartz lode along a strike fault.

West Hampden, 3 miles west of Kuridala, is also in silicified Answer Slate close to the contact with the Wimberu Granite and, like a number of small prospects near-by, consists of malachite veins and staining on cleavage and shear planes in the slate, with narrow jaspery gossans showing patches of boxwork.

The Belgium Mine, at the northern end of the Gin Creek Granite, has a recorded production of 88 tons of copper from 353 tons of ore, a return of 25%. The deposit occurs in a thick north-south vein of glassy quartz at the contact of the granite and calcareous shale. From dump material the ore appears to be a quartz-pyrite rock with chalcopyrite.

Labour Victory, Tip Top, Mt. Doré, No Hope, and True Blue, each of which has produced more than one ton of metallic copper, all occur in Mt. Elliott Slate. They consist essentially of malachite in thin veins and as "paint" on cleavage planes and small cross-fractures in the black slate, generally associated with a small shear and fold structure. At Mt. Doré azurite also occurs, associated with a granitic vein in the slate, and sooty chalcocite is found in No Hope, 3 miles south of Mt. Cobalt.

A great many other small mines and prospects occur in the Mt. Elliott Slate. To the north of Mt. Doré, in a narrow band of slate along the granite contact, and in the area south-west of Mt. Elliott, where the slate is repeated by folding, a large number of small secondary copper deposits have been opened up by trenching and pitting, or by stoping from the surface. These deposits are all similar; soft black carbonaceous slate carries thin parallel stringers of malachite on cleavage planes and in cross-fractures with, in places, small patches of sooty chalcocite. The mineralized zone is rarely more than 2 to 3 feet wide and is generally associated with drag-folding or shearing. Many of the mineralized zones are capped by siliceous, jaspery gossans, which commonly display boxwork with malachite staining; a few carry native copper and chalcopyrite. Some of the gossans are 6 to 10 feet wide and 300 to 400 ft. long.

South of Mt. Doré the Mt. Elliott Slate is, for a distance of 1½ miles, completely silicified and is extensively stained with, or cut by, thin veins of malachite, and spotted with thin "rosettes" of turquoise. Farther south the normal black slate contains many small copper showings, similar to those north of Mt. Doré.

On the Mt. Cobalt track, three miles north of Mt. Cobalt, reddish-brown, jaspery gossans with malachite staining occur in the black slates. They form a zone some 300 to 400 ft. wide and more than half a mile long in which gossans up to 10 feet wide abound. Boxwork, copper staining, and traces of bornite, chalcopyrite, cuprite, and native copper can be seen in the gossans.

Another prominent ferruginous capping occurs on a strike-shear zone about $\frac{1}{4}$ x $\frac{3}{4}$ mile west of Mt. Cobalt. It is about 40 feet wide and can be traced for more than three miles in tightly folded and sheared silicified slate. Although there is no visible copper mineralization, geochemical sampling showed that 5 to 10 parts per million of copper could be detected throughout the outcrop; in two sections of four or five hundred feet this figure rises to 150 to 200 p.p.m.

Cobalt

Mt. Cobalt is 18 miles south of Selwyn and is the largest deposit in Australia to have been mined primarily for cobalt. The mineralization occurs at the sheared contact between metadolerite and quartzite near the base of the Kuridala Formation. The deposit has been described by Rayner (1938) and others.

Recent exploration on the property has shown that the orebody extends well to north and south of the old workings, but the overall grade is low. Limited geochemical testing of soils to the north of the Mt. Cobalt lode proved the presence of cobalt, but results were inconclusive.

Traces of cobalt mineralization, in the form of erythrite, were recorded in the Mt. Elliott slate adjacent to a long north-south gossan $\frac{3}{4}$ mile west of Mt. Cobalt.

Silver

The Silver Phantom deposit, in 1956 held by J. Tunny, is the only silver deposit and the only producing mine in the area. It is a hydrothermal deposit, situated 7 miles south-west of Kuridala in a fissure in highly altered sediments near the margin of the Wimberu granite.

The ore consists of cerargyrite and native silver in a gangue of barytes and limonitic jasper. Distribution of the ore is controlled by the intersection of vertical joints with the main fissure. At present only ore expected, on visual examination, to yield more than 1,000 oz. silver to the ton is being dispatched for treatment at Port Kembla.

Uranium

The Mariposa and Utah uranium prospects have been described by Brooks (1956). The Mariposa occurs in bleached and kaolinised Mt. Elliott Slate carrying scattered torbernite on the cleavage planes, and the Utah is in calc-silicate rocks belonging to the Staveley Formation, and the radioactivity is apparently due to davidite. Small quantities of davidite have also been recorded elsewhere in these rocks.

Radiometric prospecting of the area showed that, in general, the radioactive background level of the Mt. Elliott Slate was two to three times higher than in the other sedimentary formations, but no activity of any economic significance was detected.

Barytes

A small deposit of good quality barytes occurs in the Answer Slate near Limestone Creek, 9 miles west of Selwyn. It crops out as a lens-shaped body of crystalline barytes, about 20 feet thick, surrounded by a zone of siliceous limonite. The whole deposit is 450 feet long and occurs in chert and silicified slate close to a doleritic intrusion.

Barytes also forms the gangue at the Silver Phantom mine.

Manganese

Superficial staining is widespread and a small patch of wad occurs south-west of Agate Downs Homestead.

Limestone

Good quality limestone for fluxing purposes is not common in the area: most of the crystalline limestones are very impure. Veins and pods of pure calcite occur in the dolerite mass east of Twiggie Vous copper mine and in some of the larger sills in the Kuridala area. Most of these have been worked for lime at some time, but it is doubtful if any are big enough to make their exploitation worth while.

<u>Tungsten</u>.

Scheelite is associated with the mineralization at Mt. Cobalt and a few tons of ore have been mined from a small deposit on the Mt. Cobalt shear.

GEOCHEMICAL PROSPECTING

The quartz-hematite bodies in the Mariposa area were selected as the primary target for geochemical prospecting for a number of reasons, viz: (1) their apparent replacement origin; (2) the obviously favourable position in calcareous shale and limestone close to a granite contact; (3) their similarity to quartz-hematite bodies at Tennant Creek; and (4) the favourable results of preliminary testing. Chip samples were taken across the outcrop at 150-foot intervals throughout the area. Altogether about 15 miles of quartz-hematite outcrop was sampled. The samples were crushed mechanically and, using a hot acid extraction and the dithizone technique, copper was detected in amounts ranging from 2 or 3 to 600 p.p.m. The higher values form two well defined anomalies, each 700 to 800 feet long (see plate 5).

A few soil and stream gravel samples were collected on the slopes below the hematite outcrops. These demonstrated quite clearly that cupriferous material was being shed from the outcrop.

In addition, the long gossan lying three-quarters of a mile to the west of Mt. Cobalt was chip-sampled at 150-foot intervals. This showed a background copper content of approximately 20 p.p.m. and, in the southern portions, two anomalously high sections giving values of up to 200 p.p.m.

A few soil samples and several drill core specimens from Mt. Cobalt area were tested for cobalt, but the results were inconclusive.

THE DISTRIBUTION AND CONTROL OF MINERALIZATION

The distribution of the copper mineralization suggests strong lithological and stratigraphical control of ore deposition. Except for a few small quartz-vein type deposits such as the Belgium deposit, the known copper occurrences are confined to the three slate horizons. Of these the Mt. Elliott Slate is undoubtedly the most important.

In the Hampden area ore is localized on a fault cutting the Hampden Slate, which was apparently a favourable rock for ore deposition. Similarly, in the Answer Slate, copper mineralization is confined to the true slates, particularly where they are carbonaceous, and is rarely found in the other rocks. The deposits in this formation are small, however, and widely scattered and are probably of little importance.

The Mt. Elliott orebody is the only large copper deposit in the Mt. Elliott Slate, but, as has been shown in the preceeding section, very many small deposits of secondary copper minerals are located on this horizon, and few have been adequately tested. Further, the Mt. Elliott slate is generally extensively copper-stained; traces of secondary copper mineralization are visible almost anywhere along the line of outcrop; and there are a great many small copper-bearing gossans. Generally, mineralization is localized on a small shear or crush zone associated with tight folding, and there is an obvious structural control at least of the deposition of the secondary carbonate minerals.

The occurrence of the copper mineralization in the carbonaceous and pyritic Mt. Elliott Slate and not in the underlying calcareous rocks, which are generally believed to be most favourable for the deposition of copper and other ores, is a little difficult to explain if a hydrothermal origin for the ores is postulated. The main concentration of copper mineralization may occur at the top of the Staveley Formation, where the overlying dense and relatively impervious slate forms a stratigraphic trap. The widespread small secondary deposits in the Mt. Elliott slate may then be nothing more than "leakage" past the main ore horizon. However, it is not impossible that the mineralization is syngenetic and confined to the slate horizon, and that a large low-grade orebody may be present within the slate.

Of the other rocks in the area, the Mitakoodi Quartzite and the quartzite and mica schist of the Kuridala Formation are barren of significant mineralization. In the Staveley Formation, traces of copper or other mineralization, and limonite gossans and other possible indications of sulphide mineralization, are rarely seen. Some of the unweathered argillaceous limestone, however, carries widely scattered small grains of chalcopyrite, and the crystalline limestone near Tip Top mine contains rare large cubes of chalcopyrite surrounded by cuprite and malachite.

The quartz-hematite bodies, which have been shown by geochemical testing and by drilling to be associated with copper mineralization, occur in the Staveley Formation. They are believed to be skarn rocks related to the Gin Creek granite intrusion and to have replaced calcareous shales and argillaceous limestones.

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AGE	FORMATION		LITHOLOGY	MINERALIZATION
Recent			Alluvial sands and clays	Some alluvial gold.
	UNCONFORMITY		Erosion and warping	
Tertiary			Laterite	
Mesozoic			Sandstone, conglomerate. shale, siltstone and clay. Plant fossils	
UNCONFORMITY ——— Prolonged erosion and peneplanation				
Cambrian			Limestone, quartzite, shale.	
UNCONFORMITY ——— Prolonged erosion.			Post-granite basic dykes. Granite emplacement. Folding and faulting Pregranite basic intrusives.	Ore deposition.
Precambrian	Kuridala Formation	Hampden Slate Member	Black calcareous shale and argillaceous limestone	Copper
			quartzite and mica schist	
(Lower Proterozoic?)		Mt. Elliott Slate Member	Carbonaceous slate and silicified slate; some siltstone	Copper Cobalt
	Staveley Formation		Argillaceous and siliceous limestone, calcareous shale, quartz sandstone calc-silicate granulite and breccia	
		Agate Downs Siltstone Member	Red and grey siltstone and shale.	
LOCAL UNCONFORMITY				
		Answer Slate	Grey slates (partly silicified), siltstone and albitic chert. etc.	copper
		Mitakoodi Quartzite		

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PLATE I

GEOLOGY OF THE SELWYN AREA
CLONCURRY
QUEENSLAND

Approximate Scale

Based on photoscale compilation by the National Mapping Office

FIELD SHEET ONLY

LEGEND

MESOZOIC

Conglomerate, sandstone, siltstone, shale

LOWER PROTEROZOIC

Mort Group — KURIDALA FORMATION:
- Black calcareous slate : Hampden Slate Member
- Mica schist
- Quartzite
- Interbedded quartzite and micaschist
- Black carbonaceous and silicified slate : Selwyn Slate Member

LOWER PROTEROZOIC

Mort Group — STAVELEY FORMATION:
- Red and grey siltstones and shales
- Fine quartz sandstones, in part calcareous
- Calcareous shales (often deeply leached)
- Calcareous siltstone and shaly siltstone
- Limestone and argillaceous limestone
  Idem, where leached
- Metamorphic limestone
- Calc-silicate granulites & epidote granulite
- Calc-silicate breccia

LOWER PROTEROZOIC

Mort Group — ANSWER SLATE:
- Black and grey slates, often silicified
- Chert, often pyritic
- Siltstone

MITTAKOODI QUARTZITE:
- Quartzite
- Silty sandstone
- Sheared volcanics

IGNEOUS ROCKS

- Metadolerite and amphibolite
- Postgranite dolerite
- Granite : William-, Wimberu- and Gin Creek Granite

MIGMATITES

- Migmatite

SYMBOLS

- a) Quartz-filled vein or fracture
  b) Zone of extreme silification
- Quartz-haematite and haematite rock
- Breccia
- Gossan
- Mine or prospect
- Strike and dip of bed, with plunge of lineation
- Vertical beds
- Generalised strike and dip of crumpled or undulating beds
- Strike and dip of overturned beds
- Plunge or pitch of minor anticline
- Plunge or pitch of minor syncline
- Established fault, position accurate
- Inferred, probable or indefinite fault
- Shear zone
- Strike and dip of cleavage
- Vertical cleavage
- Waterbore
- Railway line
- Track
- Homestead

THE KURIDALA AREA

PLATE 2

Cloncurry, Queensland

FIELD SHEET ONLY

Based on radial line plot on A.G.G.S.N.A. aerial photographs

THE SELWYN - MT. COBALT AREA

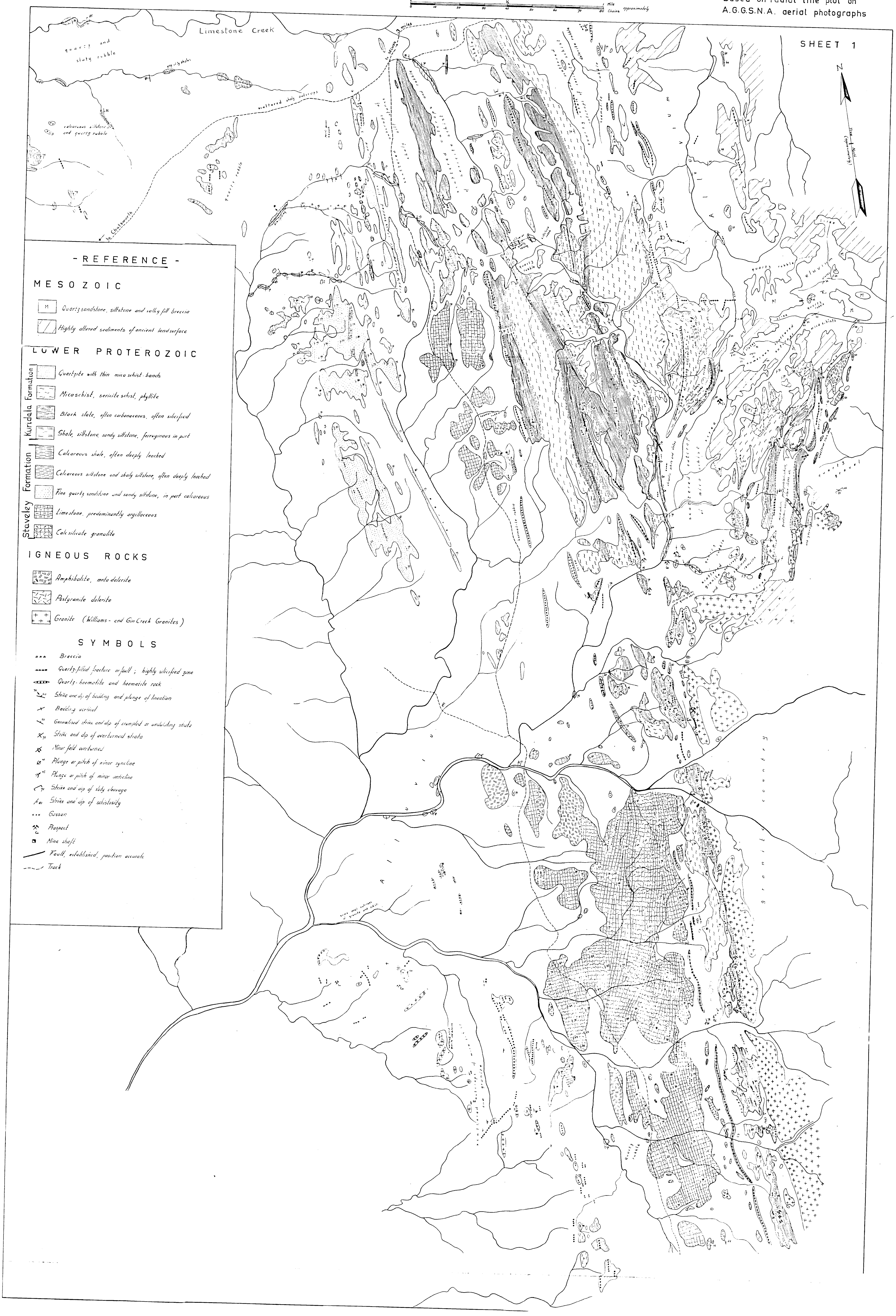
PLATE 3

Cloncurry, Queensland

FIELD SHEET ONLY

Scale

Based on radial line plot on A.G.G.S.N.A. aerial photographs



SHEET 2 JOINS

SELWYN - MT. COBALT AREA

Sheet 1 joins

SHEET 2

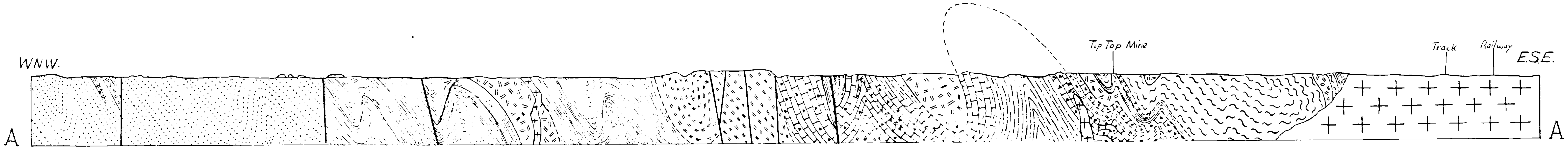
PLATE 4


PLATE 5
GEOCHEMICAL PROSPECTING SURVEY
FOR COPPER
MARIPOSA VALLEY
SELWYN AREA
QUEENSLAND
N
TO SELWYN
12 MILES
TO McKINLAY
"Mariposa"
Mariposa Creek
Mt Cobalt
Reference
Hematite outcrop
Limonite gossan
Copper value of hematite sample
Copper value of limonite sample
Copper value of soil sample
Copper value of river gravel sample
Figures represent parts per million
Prospect
Track
SCALE OF FEET
0
1000
2000
3000
4000
5000

Plate 6

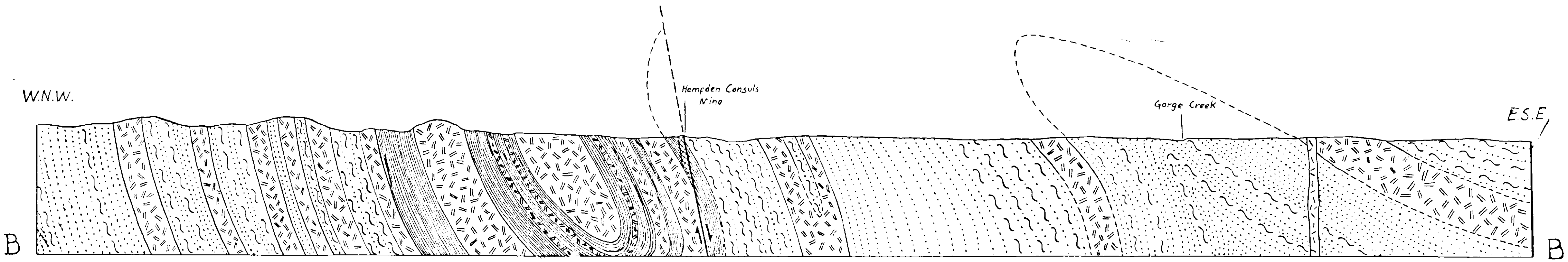
PLATE 6

GEOLOGICAL SECTIONS SELWYN AREA



FOR LEGEND SEE PLATE 1.

HORIZONTAL SCALE 1 INCH = 1½ MILES
VERTICAL SCALE APPROX. 3 x HORIZONTAL



FOR LEGEND SEE PLATE 2.

HORIZONTAL SCALE 1100 feet = 1 inch
VERTICAL SCALE 1100 feet = 1 inch