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1959/140



## MOUNT ISA 4-MILE GEOLOGICAL SERIES SHEET F54/1

## EXPLANATORY NOTES

Compiled by A.A. Öpik, E.K. Carter, and
L. C. Noakes

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# GEOLOGICAL INVESTIGATIONS

The earliest geological observations in the Mount Isa Sheet area were by Daintree (1872) and by Hodgkinson (1877), who travelled up the Georgina River. Although maps including the Sheet area were produced by Jack (1892), Cameron (1901), Ball (1908) and Dunstan (1920) they do not appear to have visited the area, but they worked in contiguous areas. Woolnough (1912) crossed the area along the Camooweal, Calton Hills, Cloncurry Coach road; he considered the rocks of the Barkly Tableland and around Calton Hills station to be Cambrian and those farther east to be Precambrian.

Saint-Smith (1923) made the first report on the Mount Isa lead-zinc deposits, found that year, and in 1924 recorded trilobites from the Templeton River area. Whitehouse (1936-1940) described the Cambrian fauna and stratigraphy of the region.

From 1925 to 1950 many investigations of mineral deposits were made, notably by Shepherd and by geologists of Mount Isa Mines Ltd. (see Bibliography). Shepherd produced the first subdivision of the Precambrian of the region (see Shepherd, 1946); this was used by David (1932). Officers of the Aerial, Geological and Geophysical Survey of North Australia revised the subdivision of the Precambrian and published several maps of the region (A.G.G.S.N.A. 1936, 1937 and Nye and Rayner, 1940), but appear to have done no field work in the Sheet area. Knight (1953) mapped the Mount Isa Shale and adjoining strata in 1948. In 1947-48 a reconnaissance geological survey was made in the course of a land utilization survey of the Barkly Tableland and adjoining areas by Land Research and Regional Survey section of C.S.I.R.O. (Noakes and Traves, 1954)

From 1950 to 1954 two regional surveys were carried out by the Bureau of Mineral Resources: one, done jointly with the Geological Survey of Queensland, was of the Precambrian of north-western Queensland, the other was of the Post-Precambrian strata between the outcropping Precambrian and the Northern

Territory border. Further check work and detailed mapping was done subsequently: these notes and the accompanying map are based on that field work. Öpik (1956a, b and 1959) and Noakes (1956) have reported some of the results of work on the Cambrian and sub-Cambrian and an account of the Precambrian of north-western Queensland appears in Carter and Brooks (1959). The geology of the region will be fully described in Bulletins in course of preparation by Öpik and by Carter, Brooks and Walker.

In the last decade extensive detailed and regional mapping of the Precambrian strata has been done by Company geologists in the search for base metals and uranium. Very few of the results have been published.

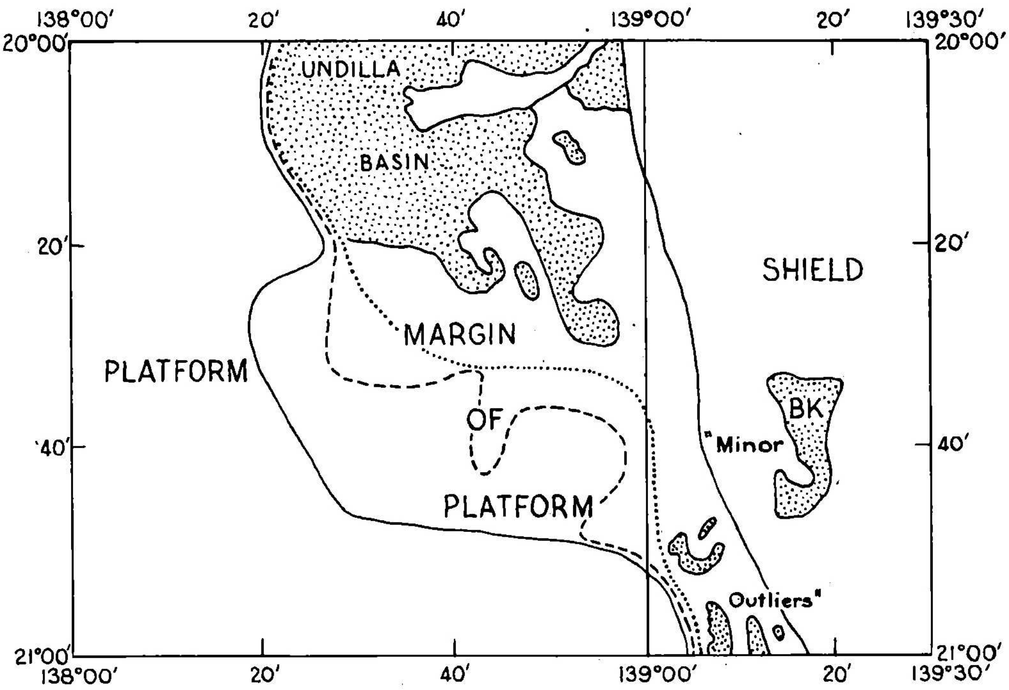
In these Explanatory Notes Carter has written the history of geological investigations, the geology of the Precambrian and economic geology; Noakes has described the water resources, and Öpik is responsible for the remainder - description and history of the land surface and Phanerozoic geology.

## PHYSIOGRAPHY

The climate is subtropical continental, and semiarid. Summer rain prevails, with about 12 inches annually in the south-west, and about 18 inches in the north-east of the area. The average is 15 inches.

It is pastoral land; no agriculture is possible but for irrigated gardens. The vegetation is prairie (semiarid tussock grassland) on the Georgina River Plains with Acacia georginae (gidyea) savannah in places. Grassland prevails also on the alluvial plains. Scrub and low tree savannah, with intervening small grass plains, covers the remaining larger part of the area, whose creeks have fringes of tall trees. For further information on climate, vegetation and soils see C.S.I.R.O. (1954).

Fig. 1. - Major structural divisions, Mt. Isa 4-mile eet area. Dashed line - eastern edge of Camooweal dolomite; BK - Beetle Creek outlier; Dotted line - inferred boundary of distribution of Middle Cambrian sediments: no Cambrian is known south-west of the line within the Mt. Isa Sheet. Dotted areas present distribution of Middle Cambrian.



The streams are intermittent, and no permanent waterholes are known, but for some rock holes in the Isa Highlands.

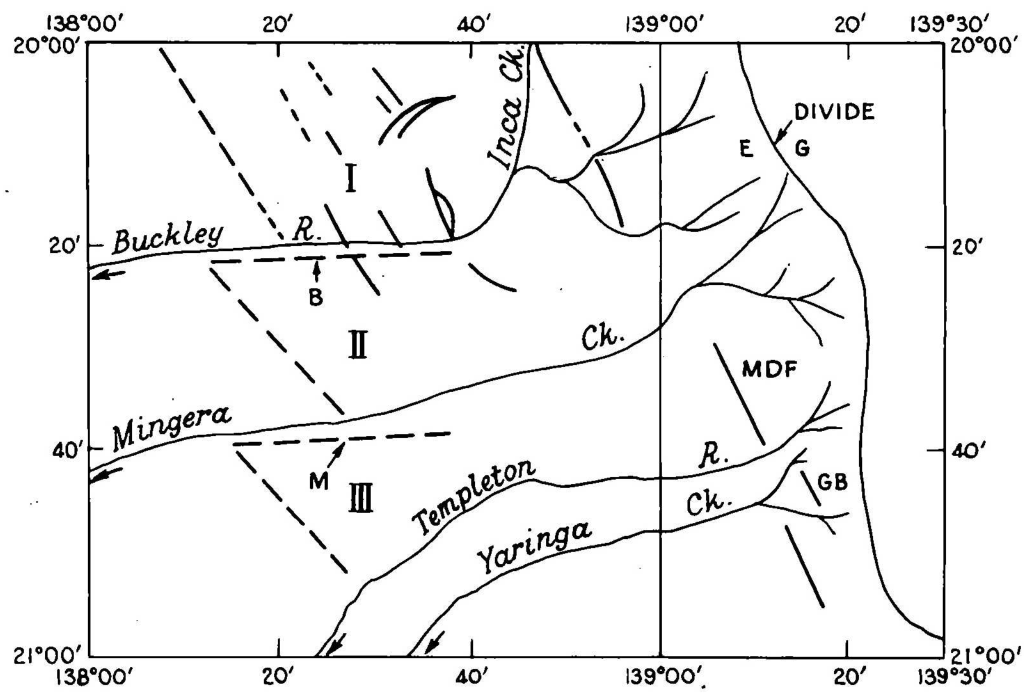
Most of the area (fig. 2) belongs to the interior, Lake Eyre, drainage system and all its streams are tributaries of the Georgina River (in the west, and outside the area). The eastern margin of the area totalling about 650 square miles, however, belongs to the coastal system (Gulf of Carpentaria drainage). The divide is almost meridional with altitudes between 1300-1500 feet. Erosion (down cutting) is present in the headwaters, but it is active only during the short wet seasons, and even then remains intermittent. The river beds are braided, and fringed by wide flood plains and levees.

The four main streams (fig. 2) - the Buckley River, Mingera Creek, the Templeton River and Yaringa Creek follow the general incline of the surface to south-south-west; the slope is about 4 feet in a mile along Mingera Creek, and much less (1-2 feet) along the two southern channelled streams.

The Buckley River and Mingera Creek are deflected from the west-south-west direction in their middle courses and are running almost due west being apparently controlled by the two postulated latitudinal faults in the Pilpah Sandstone (fig. 2).

The topography in general is a plain, flat in the west, rolling in the centre, and hilly and in part precipitous in the east. But in detail two upland areas are indicated: the Isa Highlands in the east, rising to 1500 feet within the Sheet area, and the central ranges of Pilpah Sandstone with altitudes reaching 1200 feet or slightly more. Relevant altitudes are shown in text fig. 3.

Fig. 2. - Drainage and lineament, Mt. Isa 4-mile Sheet area. E - Lake Eyre (interior) drainage; G - Gulf of Carpentaria drainage; MDF - May Downs Fault, and Quartz reef; GB - Gidyea Bore (434), Cambrian (in the west) faulted down against granite; B - Buckley River Fault; M - Mingera Creek Fault; I - Umberella Block; II Saint-Smith Block; III Polygonum Block.

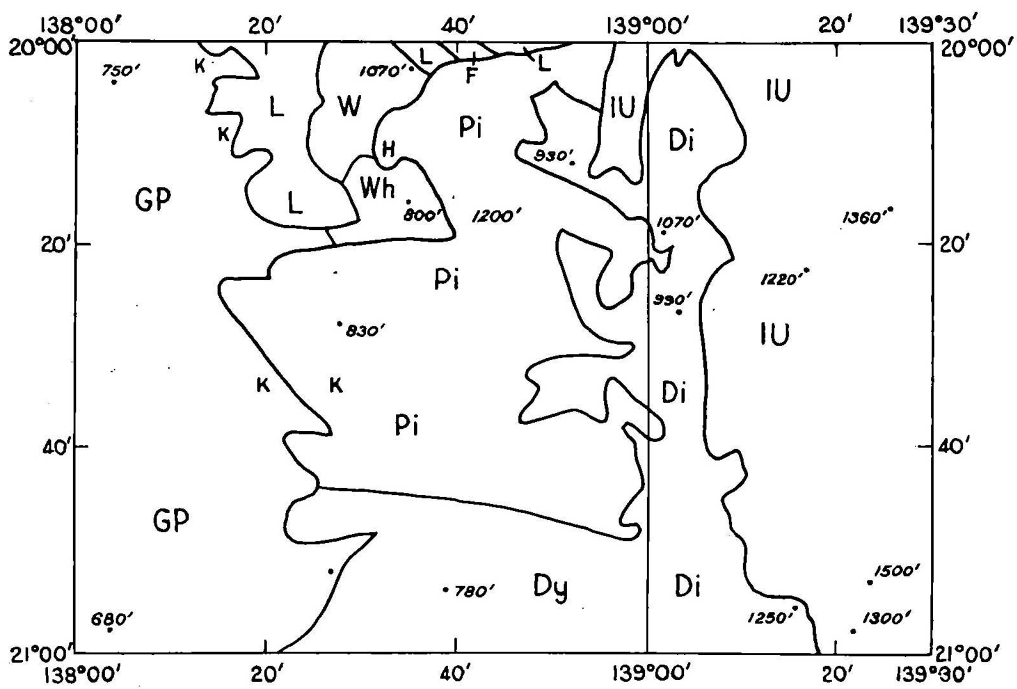


GEOMORPHOLOGY

The present surface reflects the regional and local structures and the lithological diversity of the rocks. In fig. 3 are shown the morphological subdivisions, which are an amplification from Öpik (1959).

The Georgina River Plain (eastern Barkly Tableland) is most probably a pediplane, stripped completely of cover rocks. The lateritic plateau, is within the map area, a lobate extension of the large plateau in the Camooweal area. The edges of the lobes are in places steep slopes and even cliffs 100-200 feet high. The Forty Mile Plain is a small pediplane with pediments of Cambrian limestone and Cretaceous shale at the foot of the Umberella Range. Wooroona Plain, extending from the Camooweal area, has a floor of limestone and sandstone pediments with tabletops and buttes of Polland Shale and Split Rock Sandstone. It is relatively high, with elevations of pediments of 1030-1070 feet. Whistler Plain (grass plain) is a limestone pediment; its elevation is only 800 feet. The Pilpah Inliers area is a landscape of hills and ridges. South of the Buckley River the valleys between the hills are filled with horizontal Camooweal Dolomite forming grass plains - an extension of the Georgina River Plain. North of the Buckley River, and around the Ogilvie Range the mantle of the hills consists of the Inca formation with a rolling and scrubby surface. Hence, the Pilpah Inliers are a rough mountain land buried under the rocks of the superstructure. Bore data in the plain, combined with the present elevation of the main ridges, indicate an amplitude of the original precambrian topography of not less than 1000 feet. The eastern part of the Ogilvie Range is a 10 miles long cuesta with the cliff facing south-west and rising about 200 feet above its foot. The topography, except the truncated crest of the cuesta, is essentially Precambrian, with Cambrian preserved in the valley (Ogilvie Range Outlier).

Fig. 3. - Geomorphological divisions, Mt. Isa 4-mile Sheet. Figures refer to altitudes at bores (in plains, valley floors). Only the 1200' and 1500' refer to summit. GP - Georgina River Plain; K - Sinkhole clusters (Karst); Pi - Pilpah Inliers area; H - "Horseshoe" (Loc. 229-230), L - lateritic plateau (Polland Shale); F - Forty Mile Plain; W - Wooroona Plain; Wh - Whistler Plain; D - depositional alluvial plains (Di - with basement inliers; Dy - Creek Channel Plain); IU - Isa Highlands.



The smaller inliers around Barkly Downs Homestead are also cuestas or cuestas truncated almost to the level of the plain. "The Horseshoe" (Loc. 230, see below under loc. 226) is an anticline with its core eroded and filled with Cambrian sediments. Inside the amphitheatre the shale of the Inca formation is preserved in the gullies of its slope indicating that although the Pilpah Sandstone here was exposed during the whole of the Tertiary the ridge still preserves its Precambrian land topography.

The Isa Highlands are described by Twidale (1956) as "a succession of ridges and hills, which are part of an immature dissected plateau averaging 1200-1500 feet above sea level, and in places 1600 feet or higher."

The alluvial plain in the north (Di) abounds with inliers of basement rocks and merges into the broad and very shallow stream valleys; and in the south (Dy) it is a "channel country", almost horizontal, and a flood plain in the wet seasons.

The present conditions of denudation and deposition within the map area are as follows: the Isa Highlands are the site of slow erosion and slope erosion and deliver waste to the depositional plains. The main contributors are the headwaters of the Templeton River and Yaringa Creek which arise in higher parts of the upland and in easily eroded granite country. The central portion of the area - Pilpah Inliers and the lateritic plateau - is the site of predominant slope erosion and pedimentation. Slope erosion is most active in the Wooroona Plain, and the lateritic plateau (L in fig. 3) is a geologically rapidly vanishing feature. The Georgina River Plain is a potential depositional surface, but it is remote from the uplands and receives little, and only fine grained, material distributed by seasonal floods.

## HISTORY OF THE LAND SURFACE

The present land surface has been formed during the interval beginning with the regression of the Lower Cretaceous sea. Erosion started at the beginning of the Upper Cretaceous and most of the Cretaceous sediments were stripped off in early Tertiary. Lateritization also started, presumably, in late Cretaceous time and continued as long as large enough surfaces of Polland Shale were standing as plateaus. The erosion was mainly slope erosion without dissection of the depositional surface of Cretaceous sediments. In Tertiary a temporary subsidence delayed the pace of erosion; lakes with limestone sedimentation established themselves for a while, and the destruction of residual Polland Shale plateaus with the already present laterite was delayed also. Chemical weathering and lateritization prevailed for a while over mechanical erosion. By this time Split Rock Sandstone and shale of the Inca Formation were already exposed and subjected to lateritization as well. Towards the end of the Tertiary an uplift eliminated the lakes and accelerated the reduction of the plateaus. Isa Highlands were standing up during the whole of the post-Lower Cretaceous interval and were consistently and slowly eroded without attaining yet a mature topography. The erosional history of the Highlands started at the end of the Ordovician and was initiated by the rise of the Smoky Anticline (see Öpik, 1959). In effect, that part of the Isa Highlands within the area represents the western flank of this anticlinal uplift. This uplift resulted in the exhumation of a Precambrian erosional surface, temporarily covered by Cambrian sediments. Probably a shedding area persisted farther east throughout Upper Proterozoic and Palaeozoic time.

The Precambrian history is outlined on pp. 16-17.

The possibility of a former cover of Upper Cambrian and Ordovician sediments is apparent.

The Middle Cambrian Split Rock Sandstone has lost its upper beds to Pre-Mesozoic erosion and no indication exists that this Sandstone is the last Cambrian deposit. There were, probably, uppermost Middle Cambrian and lower Upper Cambrian sediments present also. In the Urandangi Sheet area Ordovician (Tremadocian) is represented by the Ninmaroo Formation, whose present northern edge shows no indication of shore line deposits, and it can be assumed that these rocks were spread also over the Camooweal Dolomite of the Mt. Isa Sheet area. It is probable that Mt. Michael (Lat. 20°52', Long. 138°3'), Loc. 432, is a small residual of the Ninmaroo. The rocks here are hard dolomite bands with thicker sandy and marly interbeds - a lithology characteristic for the Ninmaroo Formation and unknown in Camooweal Dolomite. The Ordovician was stripped off the platform also in pre-Mesozoic times. Some more of it may be still preserved under the concealing cover of the "black soil."

## GEOLOGY

### PRECAMBRIAN

#### Stratigraphy

The stratigraphy, including mutual superpositional relationships of units and correlations, lithologies, thicknesses and distribution are summarized in Table 1. The time relationships of all Precambrian units of north-western Queensland are presented schematically in the chart opposite p. 16. Since the chart was printed further field work has clarified some of the relationships shown. The Mingera Beds have been shown to lie in the same stratigraphic position as the Gunpowder Creek Formation and the Mount Isa Shale is now thought most likely to be of the same age. The Leichhardt Metamorphics, which had been considered to be possibly Archaean, largely on petrological grounds, are now thought to be generally conformable with the Argylla Formation. The view of Joplin and Walker (in press) that the oldest element of the Kalkadoon Granite is probably co-magmatic with the dacite of the Leichhardt Metamorphics is subscribed to. In addition a granite has been found (Ewen Granite - Dobbyn 4-mile Sheet area) which is younger than the Argylla Formation and older than the Eastern Creek Volcanics.

The Yaringa Metamorphics have been mapped as possibly Archaean because of a striking dissimilarity in metamorphic grade between them and the nearest outcropping Lower Proterozoic rocks, which have been mapped as Mingera Beds. These two units are not in contact at the surface. The metamorphic grade of the Yaringa Metamorphics is not higher than that of some schists, gneisses and amphibolite west of Mount Isa, which have been mapped as Eastern Creek Volcanics. Possibly, therefore, the Yaringa Metamorphics are not Archaean but are of the same age as one of the older Lower Proterozoic units. Alternatively the high grade metamorphics may not form part of the Eastern Creek Volcanics but may be much older. The oldest part of the Sybella Granite, which is a composite granitic body, may also be Archaean.

The only published age for rocks of the region, based on the ratios of radioactive isotopes, is that for monazite in pegmatite from the Mica Creek area, about 8 miles south-west of Mount Isa. The pegmatite is probably associated with one of the phases of the Sybella Granite that intrude the adjacent Lower Proterozoic sediments. Holmes and Smales (1948) obtained an age of 1,000 to 1,200 million years, by recalculation of the data of Nier et al (1941). Owing to weathering, and consequent loss of uranium, the determination may not be very accurate.

The contemporaneous Mount Guide Quartzite and Leander Quartzite are the oldest units of the conformable Lower Proterozoic succession on the Mount Isa Sheet. Mount Guide Quartzite is underlain by acid lavas of the Leichhardt Metamorphics and Argylla Formation farther east, where it has a basal boulder conglomerate with acid lava and granite cobbles. The base of the Leander Quartzite is not exposed. The two quartzitic formations are characterized by a pronounced meridional jointing.

In the Mount Isa Sheet area the transition to the Eastern Creek Volcanics is remarkably abrupt. Throughout most of the area metabasalt flows and metasediments are thinly interbedded and are roughly equal in amounts but thick quartzite lenses are common near the top of the formation. Flows are generally fine-grained, some are vesicular, amygdaloidal or scoriaceous. Very little tuff has been recognised. The succession generally is in the greenschist facies of metamorphism.

The main difference between the Myally Beds and Judenan Beds is the greater proportion of silty material in the latter. Acid to basic lavas are also better developed at the top of the Myally Beds north of the Sheet area. The passage from Eastern Creek Volcanics to the overlying sediments is generally conformable but conglomerate, basal arkose and unconformity indicate local interruptions to sedimentation in the Cloncurry and Dobbyn Sheet areas.

The Surprise Creek Beds (which hardly appear in the Mount Isa 4-mile Sheet) are regarded as contemporaneous with the Gunpowder Creek Formation and the Paradise Creek Formation jointly. The Paradise Creek Formation is much more dolomite-rich than contemporaneous strata of the Surprise Creek Beds or the underlying Gunpowder Creek Formation. A striking feature of the Paradise Creek Formation is the widespread occurrence of stromatolites, probably of algal origin. They are described and figured by Robertson (in press), but are not known in the Mount Isa 4-mile Sheet area.

Siltstone in the Mingera Beds, similar to some in the Gunpowder Creek Formation, conformably overlies the Judenan Beds east of Wilfred Creek but in the Mine Creek area the basal beds appear to be conglomerate, pebble beds and coarse impure sandstone. Apparently a sharp near-shore facies change is responsible for the difference in lithology.

Lithologically the Mount Isa Shale is similar to portions of the Gunpowder Creek and Paradise Creek Formations and the Mingera Beds. The ore-bearing group of rocks resembles portions of the Paradise Creek Formation. However the Mount Isa Shale appears to have occupied a special, tectonically active position between the foreland and a tectonic well to the east. Large-scale sedimentary slump breccias have recently been recognised in siliceous dolomite near Spear Creek.

The Upper Proterozoic Pilpah Sandstone is generally a fairly well-sorted, medium-grained, quartz sandstone, but is feldspathic and cross-bedded in parts and has some conglomerate near its eastern margin.

## Igneous Rocks

Igneous activity of the region was confined to the Precambrian; probably all that recorded in the Sheet area is Lower Proterozoic or older.

Granite: All the granite has been mapped as Sybella Granite ("Templeton Granite" of Shepherd, 1952, p. 377), but several ages and types of granitic rocks are known. The Sybella Granite extends from near the Barkly Highway to Smoky Creek, 80 miles south of the Mount Isa Sheet. The oldest granite has been recognised on Mingera Creek. It is coarse-grained, cream to pink, and appears to have been weathered in place before intrusion of the next granite (Joplin, 1955, p.42; Carter, Brooks and Walker, in preparation). The ?oldest Lower Proterozoic granite is a red, foliated, porphyritic, microcline-biotite granite. It is intruded by a finer-grained, pink, microcline granite, with very little dark mineral. Later minor intrusions of soda aplite, albitite, and mica and feldspar pegmatites cut the main granite bodies. Some of the granite intrudes the Judenan Beds. The Mingera Beds and Mount Isa Shale are not intruded by granite at the surface but as they were involved in the final orogenic deformation of the region are probably older than the youngest of the granites.

Dolerite and Amphibolite: The basic intrusive history of the region is complex. At least three ages of intrusion are recorded in the Sheet area. The oldest are amphibolites in the Yaringa Metamorphics, and the ?Eastern Creek Volcanics north-west of Mount Isa. They have been strongly metamorphosed and deformed. North-west of Mount Isa the amphibolites are cut by contact-altered metadolerites which have suffered little regional metamorphism. This type also occurs elsewhere and clearly post-dates the first Lower Proterozoic orogenic deformation of the region. Near the aerodrome, north of Mt. Isa, two east-striking, unmetamorphosed, dolerite dykes cut the Mount Isa Shale. Several types of "greenstone" occur near the Mount Isa orebodies but the origins and relationships have not yet been resolved.

## Metamorphism

The Pilpah Sandstone is unmetamorphosed. Most of the Lower Proterozoic sediments are only slightly altered; fracture cleavage is weakly developed in the least competent strata and the older arenaceous strata are quartzitic. The Eastern Creek Volcanics have been raised to the greenschist metamorphic facies and have been extensively epidotised.

Along the eastern margin of the Sybella Granite (particularly the area mapped as Eastern Creek Volcanics) and the Yaringa Metamorphics, however, the general grade of metamorphism is rather higher. Schist, gneiss, amphibolite and, locally, migmatite have formed. The highest grade is a cordierite-sillimanite-mica schist, 6 to 8 miles north-west of Mount Isa.

Joplin (1955, pp. 38, 39) has suggested that these rocks may be inliers of ?Archaean. Also near the margin of the Sybella Granite some rocks have been extensively greisenized. There is a wide zone of dislocation metamorphism west of the Mount Isa Fault and in a zone of pitch change north of the Barkly Highway, 16-20 miles north of Mount Isa.

## Structure

Generally the intensity and strongly directional nature of deformation of the Precambrian diminishes from east to west. The Leander Quartzite and the Mount Isa Shale are steeply folded (and faulted) on meridional axes, the one anticlinal, the other synclinal. West of the Mount Isa Shale is a zone of intense faulting and shearing, and overturning of strata, bounded on the east by the Mount Isa Fault. The Sybella Granite occupies a complex north-pitching dome, to the north and west of which the strata are more irregularly, though steeply, folded. The Upper Proterozoic Pilpah Sandstone is very irregularly folded. Folds are open and dips average less than 25°, but some exceed 45°.

The main faults in the Sheet area are the Mount Isa and Leichhardt Faults (meridional), the May Downs Fault (strike 340°), and the southern extremity of the Mount Gordon Fault system (strike 015°-030°). There is considerable undeciphered faulting north of the Mount Isa Fault, and north-west and north-east striking shear, or transcurrent, faults are common. The Mount Isa Fault is a high angle reverse fault, with a considerable-horizontal component of movement; the others, except for the transcurrent faults, all appear to be normal faults.

Faulting was probably active during much of Lower Proterozoic time: the history of faulting largely remains to be unravelled; it is discussed at greater length in Carter, Brooks and Walker (in preparation).

History

The Precambrian of the Mount Isa Sheet area formed part of a meridional orogenic belt whose axis lay a few miles to the east. There were two main periods of orogenic deformation but the earlier of the two left little impress on the rocks of the Sheet area, although elements of the Sybella Granite may have been emplaced then.

Nothing is known of the Archaean history of the region; the extent, or even existence, of Archaean outcrops has not been finally resolved. The oldest Lower Proterozoic rocks are acid lavas, partly terrestrial and partly sub-marine in extrusion. It is doubtful whether they ever extended as far west as the Mount Isa Sheet area. They were followed, with a time break in the Sheet area, but not east of the tectonic welt (see below) by an arenaceous succession - the Mount Guide and Leander Quartzites. During this time a meridional tectonic welt started to rise about long. 139°50'E. Basaltic vulcanicity supervened to give the vast Eastern Creek Volcanics, which were deposited subaqueously in the Sheet area, apparently pouring from the vicinity of the tectonic welt. Sediment up to this time was being contributed from land to the south-west, west and north, with some contribution from the "tectonic land".

Movement of the tectonic land at the close of the basic vulcanicity produced breaks between the Eastern Creek Volcanics and the Myally Beds on the Cloncurry and Dobbyn Sheets but elsewhere the passage to the Myally and Judenan Beds was conformable.

A major orogenic deformation, with granite emplacement, about the close of the Myally-Judenan sedimentation produced only local unconformity and interruption of sedimentation west of the tectonic land and may have produced the minor vulcanicity at that time, but east of the tectonic land cuased strong folding and complete interruption of sedimentation.

Sedimentation, without vulcanicity, continued until the final Lower Proterozoic orogeny, granite intrusion and uplift some time after the Lawn Hill Formation had been laid down (see Time Relationships of Precambrian Units chart).

The only record of Upper Proterozoic sedimentation in the Sheet area is that of the Pilpah Sandstone, a fairly normal stable-shelf or basin type of deposit, which was derived from the mountain chain of Lower Proterozoic rocks, formed by the final Lower Proterozoic orogeny. The ranges, lying mainly to the east and north, but at times within the Sheet area, provided a shedding area not only during Upper Proterozoic, but also through most of the subsequent history of the area (see pp. 9-10).

<u>CAMBRIAN</u>

Table II describes adequately the Cambrian sequence, to which some notes are added here.

The lowermost formation is the Camooweal Dolomite the age of which remains doubtful. It could represent the uppermost Proterozoic, or have a low position in the Lower Cambrian, as indicated by Öpik (1959). Its position below Middle Cambrian is evident in the Camooweal 4-mile Sheet area.

The distribution of Middle Cambrian within the Mt. Isa 4-mile Sheet area is indicated in fig. 1. The rocks are preserved as outliers ("Minor Outliers") in the south-east, and as an extension of the Undilla Basin (the largest outlier) in the north. Here the Cambrian sequence is faulted down against the Camooweal Dolomite (Loc. 240, Long. 138°26', Long. 20°18'), but the northern extension of the fault is obscured by Cretaceous cover.

Age Creek Formation (Ꞓma) and the "Post-Precambrian" dark limestone, gypsum (C) are not included in Table I.

The Age Creek Formation is represented by a single small outcrop, Loc. 236, on Rocky Waterhole (Lat. 20°11', Long. 138° 21'), within a lateritic plain. The Age Creek Formation is an equivalent of most of the Middle Cambrian sequence except for the

Split Rock Sandstone and Beetle Creek Formation, and it is impossible to assign the occurrence at Rocky Waterhole to a definite position in the sequence. The position given in the map reference is probable but not definite. The rock is massive and platy, detrital, and sandy, oolitic dolomite. It is unfossiliferous. The dip is three degrees east.

The "Post-Precambrian" (Cma) dark limestone and gypsum (Loc. 190) occur on Cattle Creek, (Lat. 20°10', Long. 139°1'), at elevation 1075 feet, and about 50 feet of limestone is present, all above that height. The limestone is bituminous, unfossiliferous, and horizontal. It cannot be dated, but is quite distinct from the Tertiary white limestone (Tl) with chalcedony which occurs seven miles south, on the Barkly Highway and which has a much lower topographic position (elevation of 1016 feet). In the same outlier of Cattle Creek white platy limestone is also present.

The total thickness of the Cambrian preserved in the area is 800 feet. In the bore No. 79 on the Forty Mile Plain (Long. 138°40', lat. 20°2') 750 feet is present, to which the preserved part of the Split Rock Sandstone (about 50 feet) should be added. No sections exist that permit the measuring of the Cambrian sequence on the surface in one spot; but by piecing together information from all observed outcrops the same figure (800 feet) was found.

<u>MESOZOIC AND CAINOZOIC</u>

Terrestrial conglomerates and a plant-bearing sandstone, and the marine Polland Waterhole Shale represent the Mesozoic sequence in the area.

Only two small outcrops of the plant-bearing sandstone are known: 1) Loc. 235 (Long. 138°24', lat. 20°8'), at Rocky Waterhole, and 2) Loc. 197 (Long. 138°36', lat. 20°5'), on the western slope of the Umberella Range, preserved in a gully in Pilpah Sandstone. The fossils belong to the "<u>Otozamites</u> - flora" which ranges from about the middle of the Jurassic to Lower Cretaceous. The unfossiliferous conglomerates are regarded as being of the same age because they appear in the same position in the sequence as the plant-bearing sandstone.

The Cretaceous marine Polland Waterhole Shale rests on any of the older sediments, including the Jurassic. Its original thickness is unknown because its surface is eroded. The lithology is uniform in all outcrops indicating that it represents a significant marine event.

The Cainozoic is adequately discussed in Table II.

## POST-PRECAMBRIAN STRUCTURE

Within the Mt. Isa Sheet area the following historical structural divisions are present: 1) a superstructure consisting of unmetamorphosed horizontal and sub-horizontal Palaeozoic (including Camooweal Dolomite), Mesozoic and Cainozoic strata; 2) a metamorphozed Precambrian basement and 3) an intermediate unit ("storey") of the mildly folded Pilpah Sandstone, which is in relation to the basement (2) a superstructure itself. These three vertical subdivisions correspond to major structural subdivision on the surface, as shown in fig. 1: 1) the platform, 2) the margin of the platform, and 3) the shield. The structure of the shield area is discussed under "Precambrian" by E.K. Carter. The platform's superstructure is horizontal and without any signs of deformation.

The margin of the platform shows a fracture lineament trending north-west (Georgina Lineament, Hills, 1955), which is manifest in faults cutting the Cambrian rocks. The Cambrian itself is mildly and locally folded and trends north-west south and west from the Umberella Range. The most prominent post-Cambrian structure is the reverse fault between Whistlers Creek and Buckley River. Near Gidyea Bore, 10 miles due west from Mt. Isa (fig. 2), the Cambrian sequence is faulted down against granite, in the west.

The eastern edge of the platform against its margin is shattered and numerous sink holes (fig. 3) are present, arranged in the north-west lineament. The distribution of residuals of Cambrian rocks (fig. 1) indicates the same trend and the rocks themselves are confined to the marginal belt of the platform. The age of these structures is Ordovician, according to Öpik (1959) and so is the anticlinal uplift of the Mt. Isa Highlands.

Similar structural trends are evident in the Precambrian Pilpah Sandstone and some of its particular structures are pre-Middle Cambrian. For example, the May Downs Fault (fig. 2), a quartz reef and a Precambrian (?) fault, follows the trend of post-Cambrian faults east of the Inca Creek, and the same trend is apparent in the Ogilvie Range which is much more folded than the Cambrian.

The Pilpah Sandstone is also cut by two pre-Middle Cambrian latitudinal faults into three separate blocks; presumably the Polygonum Block is the most elevated and the Umberella Block the most depressed unit. The Saint-Smith and the Polygonum Block may have been islands or a barrier during the deposition of the Cambrian (Öpik, 1956, p. 10). The age of these structures within the Pilpah Sandstone is late Precambrian, or even Lower Cambrian, corresponding to the "Unconformity 5" in Öpik's chart (1959).

## DESCRIPTIONS OF SELECTED LOCALITIES

Localities are marked by red numbers. In the card register these numbers carry the letter M (e.g. M 434) which is omitted on the map.

Beetle Creek Outlier (Loc. 263 and 433).

Abundantly fossiliferous outcrops of Beetle Creek Formation (siliceous shale and chert with _Xystridura_ fauna) and lower part of Inca Formation (laminated silty shale with agnostids, including _Ptychagnostus gibbus_ and _P. atavus_). Loc. 263 (Long. $139^{o}20'$, lat. $20^{o}36'$) - fossiliferous Inca shale, as for example immediately west from the turn-off to Beetle Creek from the track to Moss Bore. Loc. 433 - Beetle Creek area proper, a mesa capped by Inca shale. The "type locality" of Beetle Creek, is in the creek bed itself. Within the outlier, and at Beetle Creek itself the basement protrudes the superstructure in several places (unconformity).

Hall's Memorial; Loc. 426, on Yelvertoft, and on Barkly Highway, Bore 61 (dismantled). (Long. 138°53', lat. 20°11'). The original locality of "Yelvertoft Bed", with Redlichia idonea Whitehouse. In places the rock has been quarried away for road metal, but fossils still can be collected on the surface north west from the Memorial and on slope toward the Buckly River.

"Flora Downs", Loc. 425 and 191: a grass plain west from Yelvertoft Homestead. Loc. 425 (Long. 138°52', lat. 20°13'). Immediately west from gate - very fossiliferous Inca shale in pediment outcrops; east of gate - Pilpah Sandstone. The whole "Flora Downs" plain abounds with outcrops of Inca shale. In the centre a limestone member is exposed (Loc. 191) which contains agnostids (Ptychagnostus gibbus, P. Atavus, Diplagnostus) in its eastern outcrops.

Loc. 196, about 1.5 m south from Barkly Highway on track to Whistlers Bore (Long. 138°36', lat. 20°2'). Mail change Limestone, a terraced hill; about 20' exposed. Polland Shale outcrops also present.

Whistler's Bore, Loc. 462, about 3 miles south from Barkly Highway (Long. 138°36', lat. 20°3'). A grass plain with pediment outcrops of Vee Creek Limestone: marly beds with harder interbeds. Well-preserved and abundant agnostids.

Barkly Downs, Bore No. 7, on Whistlers Creek, Loc. 247 (Long. 138°34', lat. 20°15'). Vee Creek Limestone in creek bed.

Grey laminated, even shaly, limestone with limestone ellipsoids and thin interbeds of harder limestone. Papyriaspis lanceola Whitehouse, Asthenopsis sp., Amphoton sp., Mapania augusta (Whitehouse), Daryagnostus incertus (Brögger).

Loc. 226, (Long. 138°31', lat. 20°10'). Split Rock Sandstone. Low bald hills with cliffs facing west. 1) Pink friable soft micaceous shale, followed above by 2) yellow fine-grained, almost silty, sandstone with 3) hard creamy silica bed on top. Ferruginous crust on top. Total thickness 50'. The bed (3) - the silica bed abounds with well-preserved fossils (Nepea Narinosa Whitehouse, Amphoton spinigerum Whitehouse and agnostids). Lateritization is evident. The locality is off tracks and the access is difficult. South east is the "Horse Shoe", an eroded anticline of Pilpah sandstone displaying the $\text{Є}/p\text{Є}$ unconformity (Loc. 230). There is also a local break in the Cambrian sequence (Split Rock rests directly on shale of the Inca Formation; not well exposed); immediately south of the "Horse Shoe" (Loc. 231) Vee Creek limestone is present. Access to these localities is difficult.

Loc. 233, (Long. 138°28', lat. 20°11'). Elevation of pediment 1040 feet. A cluster of hills of Split Rock Sandstone (with siltstone) with small pediments of Mail Change Limestone in between; it appears that the contact is an interformational erosional surface. East of it (Loc. 232) - a Mail Change pediment; west of Loc. 233 is a grass plain and savannah with pediment outcrops of platy limestone attributed to Vee Creek Limestone (lowermost part of it, with Ptychagnostus punctuosus. It appears that in this whole area a break (disconformity) is present at the base of Split Rock Sandstone, as seen in some other places, for example in the "Horse Shoe" and in the Ogilvie Range. Rapid slope erosion is in progress.

Ogilvie Range, Ogilvie Outlier, Loc. 428, 429, heads of Lily Creek. (Long. 138°47', lat. 20°22'). Cambrian preserved in a valley of the pre-Cambrian surface (unconformity against Pilpah Sandstone). Split Rock Sandstone rests disconformably on Beetle Creek Formation. Lower part of the formation is the "Yelvertoft bed"(chert and siliceous shale). Access is difficult (along right bank of Lily Creek). In the creek - at Loc. 205 - pebbles and cobbles of Beetle Creek shale with numerous fossils (*Xystridura*, *Pagetia*).

## ECONOMIC GEOLOGY

The huge Mount Isa silver-lead-zinc and copper orebodies occur in the Mount Isa Shale in the east of the area. Present rate of production makes Mount Isa Mines Ltd's mine the largest in Australia. To 31st December, 1958, 75,773,391 ounces of silver (valued at £17,423,389), 969,746 long tons of lead (£67,336,811), 459,019 tons of zinc (£33,188,431) and 196,361 tons of copper (£56,101,911) had been produced. Estimated reserves of silver-lead-zinc ore were 24,200,000 tons, of grade 7.8% Pb, 5.8% Zn, and 5.6 oz/ton Ag, and 16,650,000 tons of 3.75% Cu. Resources are known to be much greater than the indicated reserves. In addition substantial tonnages of silver-lead-zinc have been revealed in the Company's northern leases, 10 to 12 miles north of Mount Isa. Minor amounts of silver-lead-zinc have been mined from the Mount Isa Shale south of Mount Isa.

There are a few other small copper deposits, mainly in the Eastern Creek Volcanics, from which a few tons of ore have been obtained.

Uranium occurs widely, and almost exclusively, in Eastern Creek Volcanics, including the Quartz Blow-Spear Creek belt of mineralization a few miles north-west of Mount Isa (Carter, 1955). Although several deposits have been tested by drilling, shaft-sinking and costeaning none has proved of economic size and grade so far.

Gold has been worked in one area only - the May Downs deposits, near Mine Creek. Total production from 242 tons was 100.3 oz. The Mount Isa ores contain no recoverable gold.

Cadmium was recovered as a by-product from Mount Isa Mines' lead smelter between 1951 and 1954. Recovery was 15.2 tons Cd metal.

About 13 tons of beryl have been mined from pegmatite in, and west of, the Big Beryl mine. Half the beryl has come from the Big Beryl. Small quantities of mica, tantalum and tin have been won from the Mica Creek area, 8 miles south-west of Mount Isa. Monazite has been recorded from the same area.

Abundant road metal is available from the Eastern Creek Volcanics, and the ferruginous residual soils which are common throughout the area make excellent road-making material. Most of the larger creeks have extensive deposits of sand and gravel, though those draining from the Sybella Granite have a lot of feldspar in their gravels.

Crystalline quartz near Mount Isa has been mined as smelter flux. Feldspar (albite and microcline) is abundant near Mica Creek but is not economic owing to the remoteness of the region.

## UNDERGROUND WATER RESOURCES

Underground water is one of the main factors controlling the development of the pastoral industry within the region because rainfall is low and seasonal, and provides no perennial stream. Supplies of sub-surface water are directly dependent on the capacity of the various rock formations to store water in porous beds or in fractures, from which it may be recovered by bores. Sub-divisions of the region, based on underground water supplies, are shown in figure 4.

The downs country of the western portion of the region, forming the eastern margin of the Barkly Tableland, overlies sub-horizontal dolomite and other sediments of late Proterozoic and Cambrian age; these support a comparatively high cattle population by providing both reliable underground water supplies and fertile pedocalcic soils.

Farther east, Precambrian metamorphic and igneous rocks give rise to upland ridge country in which soils are generally poorer, vegetation is more sparse, and underground water supplies are less reliable and harder to find. Probably more than 50 bores have been sunk in the region, for the most part in the downs, but bore records are too few to provide any detailed account of underground water resources.

The most reliable supplies come from the Camooweal Dolomite which underlies the downs towards the western boundary of the region (figure 4); water is stored in sandy beds or in fractures in the dolomite and in most places major supplies are tapped between 100 and 350 feet from the surface. Yields are comparatively high; they probably average more than a thousand gallons per hour, and some bores have been tested to the capacity of the pumping equipment, about 2,000 gallons per hour. In some places sub-artesian conditions have been proved; in the vicinity of Barkly Downs, for example, water in some bores rose more than 60 feet on penetration, owing to hydro-static pressure in a local basin in Camooweal Dolomite which is almost completely surrounded by ridges of Precambrian sandstone. In other places, ground water gives little evidence of pressure, although sub-artesian conditions may be dominant.

Recharge comes mainly from outcrops of the Camooweal Dolomite, particularly along its eastern edge, from sandy creek channels and from areas of sandy soils. Few details of salinity are available, but all known bores are suitable for stock and most of them are suitable for human consumption.

North easterly from the outcrop from the Camooweal Dolomite, an area underlain by the flatly-bedded Cambrian sediments of the Undilla B asin provides fairly reliable supplies, particularly in Cambrian limestone, although not as large as those furnished by the Camooweal Dolomite· towards the western margin of Cambrian outcrop bores may penetrate the underlying Camooweal Dolomite and tap this more reliable source. The Inca Formation contains some water in cracks but has less potential than other Cambrian rocks. Water from the Cambrian sediments is commonly more saline than that from the Camooweal Dolomite.

In much of this sub-division, however, the Cambrian sediments are overlain by mesas of Cretaceous siliceous shale which contain no water.

A broad ridge of Pilpah Sandstone also offers little chance of reliable supplies.

To the south of this sub-division lies an area of ridges and intervening broad alluviated valleys which is almost entirely underlain by the late Precambrian Pilpah Sandstone. This formation provides poor cattle country and there are few records of bores from which the underground water potential might be assessed; two bores drilled in the sandstone were reported as unsuccessful. In general, sandstone beds have not retained sufficient pore spaces to function as aquifers, nor has jointing been sufficiently consistent to provide storage in fractures. There may be, in some localities, sufficient local catchment and fracturing to warrant boring, but in general the Pilpah Sandstone has little potential.

The eastern portion of the region is occupied by stony ridges and broad valleys underlain by Precambrian metamorphic and igneous rocks. Supplies of sub-surface waters are limited to comparatively shallow soaks along some of the streams and to relatively small supplies from crystalline rocks where fractures have been consistent enough to provide storage; in places water is also stored along bedding planes. Substantial volumes of water have been obtained from fractures in the Mount Isa Shale, and soaks, along the Leichhardt River valley, to supplement the Mount Isa town supply. Areas underlain by granite have perhaps the least potential, although where deep weathering has taken place water may be stored in weathered material above the interface with fresh rock. The expected yield from a bore suitably sited in metamorphic rock would lie between 100 and 400 gallons per hour, although higher yields are known. Salinity is generally low in soaks but notably higher where water is tapped from crystallised rocks, although in most places it is within the range of human consumption. The yield from both soaks and bores is likely to be unreliable in drought.

Fig. 4

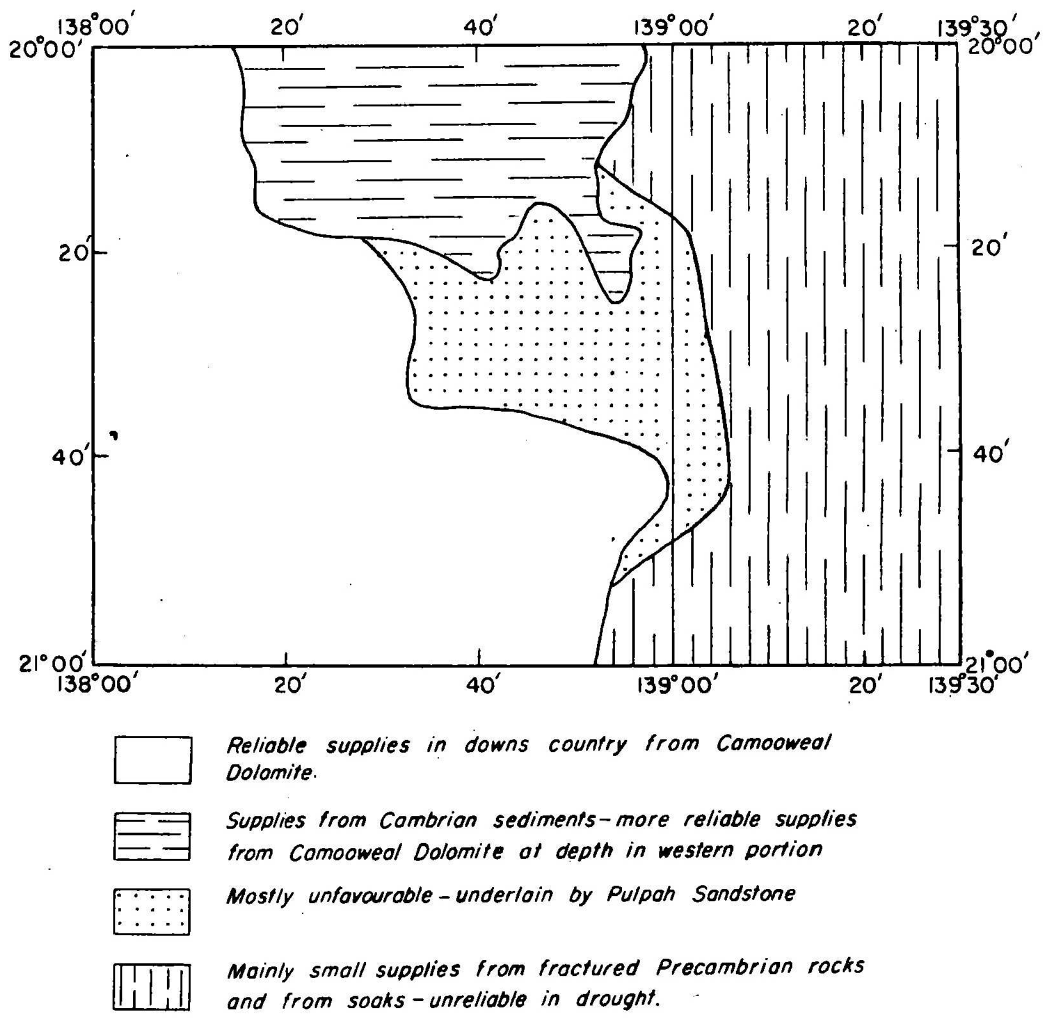


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TABLE I

STRATIGRAPHY OF MT. ISA 4-MILE SHEET AREA

PRECAMBRIAN

| SYSTEM | SERIES | ROCK UNIT | POSITION IN THE SEQUENCE, DISTRIBUTION | LITHOLOGY | THICK-NESS | TOPOGRAPHY | STRUCTURE | CORRELATIONS AND FOSSILS | UNDER-GROUND WATER | MINERAL DEPOSITS |
|---|---|---|---|---|---|---|---|---|---|---|
| PRECAMBRIAN | UPPER PROTER-OZOIC | Pilpah Sandstone | Unconformably below Camooweal Dolomite; unconformably above Mingera Beds. Centre of Sheet. | Medium-grained quartz sandstone; some conglomerate. | 1,000? ft. | Hilly, fair relief. | Some dips exceed 40°; folding irregular; faulted. | Possibly equivalent to Constance Sandstone. | Poor supplies | None |
| | UNCONFORMITY - Granite Intrusion | | | | | | | | | |
| | LOWER PROTEROZOIC | Paradise Creek Formation | Unconformably under Pilpah Sandstone; conformably over Gunpowder Creek Formation. North-east of Sheet; Camooweal Sheet. | Dolomite, siltstone, sandstone. | 10,000 to 15,000 ft. | Generally fair to moderate relief; hilly. | Irregularly strongly folded; faulted. | Upper Surprise Ck. and Ploughed Mt. Beds. Possibly with upper Mt.Isa Shale. Extensive stromatolites. | Poor; obtainable in favourable loci. | Copper |
| | | Gunpowder Creek Formation | Conformably under Paradise Creek Formation, local unconformity with Myally Beds. N.E. of Sheet; Camooweal Sheet. | Siltstone, shale, sandstone; some dolomite. | 2,000? ft. | Generally hilly; fair to moderate relief. | Irregularly, strongly folded; faulted. | Lower Surprise Creek and Ploughed Mt. Beds, Mingera Beds ?Mount Isa Shale. | Poor; obtainable in favourable loci. | Copper |
| | | Mount Isa Shale | Locally unconformably over Myally Beds. E. of Sheet; W. of Cloncurry Sheet. | Clay shale, siliceous shale, siltstone, dolomitic and carbonaceous shale; siliceous dolomite, quartzite, breccia. | 10,000+ ft. | Low to moderate relief - mainly along Leichhardt R. Valley. | Faulted, steeply dipping E limb of syncline. | Probably equiv. to all, or part of Gunpowder Ck. Formation(? together with Paradise Ck.Fm.), Surprise Creek Beds, Ploughed Mt. Beds, Mingera Beds. | Moderate supplies along Leichhardt R.; some brackish. | Lead-zinc-silver, copper. |
| | | Surprise Creek Beds | Extreme N.E. of Sheet; Camooweal, Dobbyn and Cloncurry Sheets. | Siltstone and sandstone in Sheet area. | 20,000? ft. Unknown in Sheet area. | Moderate to strong relief. Strike ridges. | Strongly folded; faulted. | Ploughed Mt. Beds; Paradise Ck. and Gunpowder Ck. Formations jointly. Partly with Mingera Beds and ?Mount Isa Shale. | Poor. Obtainable in favourable loci. | Sparse gold and copper; possibly other base metals. No mineralization known on Mt. Isa Sheet. |
| | | Mingera Beds | Conformably between Paradise Creek Formation and Judenan Beds west of Sybella Granite. | Shale, siltstone, sandstone, pebble beds, conglomerate. | 5,000? ft. | Hilly; fair to moderate relief. | Moderately to strongly folded; faulted. | Gunpowder Ck. Formation; lower Surprise Ck. & Ploughed Mt. Beds; ?Mount Isa Shale. | Poor. Obtainable in favourable loci. | Gold. |
| | | LOCAL UNCONFORMITY - Probable Granite Intrusion | | | | | | | | |

| SYSTEM | SERIES | ROCK UNIT | POSITION IN THE SEQUENCE, DISTRIBUTION | LITHOLOGY | THICK-NESS | TOPOGRAPHY | STRUCTURE | CORRELATIONS AND FOSSILS | UNDER-GROUND WATER | MINERAL DEPOSITS |
|---|---|---|---|---|---|---|---|---|---|---|
| PRECAMBRIAN | LOWER PROTEROZOIC | Judenan Beds | Conformably over Eastern Creek Volcanics; local unconformity with Gunpowder Creek Formation. N.E. and ?E. of Sheet; S.E. Camooweal Sheet. | Sandstone, siltstone, shale, generally impure; some acid tuff. | 6,000+? ft. | Hilly. Moderate to strong relief. Strike ridges. | Strongly folded; faulted. | Myally Beds. | Local supplies in joints & faults. | Probably poor base metal mineralization. Sub-economic uranium. Beryl, mica, tin, tantalite, monazite probably in this formation(Mica Creek). |
| | | Myally Beds | Local unconformity with Mt. Isa Shale and Eastern Creek Volcanics. One square mile extreme E. of Sheet; extends E, N, and N.W. | Sandstone, quartzite, quartz greywacke, siltstone, conglomerate, basic and acid lavas. Sandstone in Sheet area. | 20,000+ ft. Unknown in Sheet area. | Very rough hills. Strong relief; strike ridges. | Strongly folded; faulted. | Judenan Beds. | Local supplies in bedding plane; joints & faults. | Poorly mineralized. Gold and base metals? |
| | | LOCAL UNCONFORMITY AND EROSIONAL BREAKS (not in Sheet Area) | | | | | | | | |
| | | Eastern Creek Volcanics | Conformably over Mt. Guide and Leander Quartzites; local unconformity with Myally Beds; Judenan Beds conformable. E of Sheets; extends S, E and N. | Quartzite, feldspathic quartzite, quartz greywacke, conglomerate. | 8,000? ft. | Very rough hills, strong relief, with meridional ridges. | Strongly folded, faulted, jointed. N-S fold axis. | Leander Quartzite, probably Ballara Quartzite. | Local supplies in joints, faults, bedding planes. | None known. |
| | | Mount Guide Quartzite | Disconformably or conformably above Argylla Formation; conformably below Eastern Creek Volcanics. Extreme S.E. of Sheet; extends S & E. | Quartzite, feldspathic quartzite, quartz greywacke, conglomerate. | 8,000? ft. | Very rough hills; strong relief, with meridional ridges. | Strongly folded, faulted, jointed, N-S fold axis. | Leander Quartzite, probably Ballara Quartzite. | Local supplies in joints, faults, bedding planes. | None known. |
| | | Leander Quartzite | Conformably below Eastern Creek Volcanics. N.E. of Sheet; extends slightly into Cloncurry and Camooweal Sheets. | Quartzite; some metabasalt, tuff and slate. | 5,000+ ft. Base not exposed. | Very rough hills; strong relief. | Strongly folded; faulted, jointed. N-S fold axis. | Mount Guide Quartzite; probably Ballara Quartzite. | Local supplies in joints, faults, bedding planes. | None known. |
| | | ? UNCONFORMITY AT TOP OF ARCHAEAN | | Possibly Two Lower Proterozoic Granite Intrusions (not recognized in Sheet area) | | | | | | |
| | ?ARCHAEAN | Yaringa Metamorphics. | Unconformably overlain by Mingera Beds? May lie within Lower Proterozoic succession. Small area mid south-east of Sheet. | Migmatite, gneiss, schist, quartzite, conglomerate. | ? | Low relief. Alluviated in part, rough terrain in part. | Highly deformed. | - | Poor | None known. |

TABLE II

STRATIGRAPHY OF MT. ISA 4-MILE SHEET AREA

PALAEOZOIC TO QUATERNARY

| SYSTEM | SERIES | ROCK UNIT | POSITION IN THE SEQUENCE, DISTRIBUTION | LITHOLOGY | THICK-NESS | TOPOGRAPHY | STRUCTURE | CORRELATION AND FOSSILS | UNDER-GROUND WATER | MINERAL DEPOSITS |
|---|---|---|---|---|---|---|---|---|---|---|
| QUATER-NARY | | | Surface deposits, a) on Camooweal Dolomite and Cambrian limestone (lithological control). Widespread. b) River channels, flood-plains; derived mainly from basement rocks. | a) Heavy ped-calcic soil with dissemin-ated gypsum in deeper level; b) Alluvial sandy and pebbly soil and alluvial sand, gravel; clay pans; some aeolian soil. | a) Up to 15 ft. b) Up to 50 ft. | a) Plain, prairie. b) Scrubby plain. | Horizontal, unconsol-idated. | | a) Imper-meable. b) Small local. | |
| SURFACE OF EROSION | | | | | | | | | | |
| TERTIARY | Not defin-able | /Water-hole | Chemically weathered sur-face of Polland /Shale and undissected shale of Inca Formation, silty beds of Split Rock Sandstone, Pediments of Pilpah Sandstone. | Laterite; on Pilpah Sandstone thin ferruginous crust only. | Up to 10 ft. | On plateau and table-tops. | Topograph-ically sub-horizontal. | | | Road metal; quarries along Barkly H'way. |
| | | Austral Downs Limestone "Lacustrine limestone" | Rests on Camooweal Dolomite. On basement rocks at Johnson Lagoon. | White limestone with flints. | Small. (first tens of feet). | Plain; stream bed. | Horizontal. | | | |
| SURFACE OF EROSION | | | | | | | | | | |
| CRET-ACEOUS | Lower | Polland Waterhole Shale | Rests on basement rocks, on Cambrian, and on sandstone with plant fossils. | Siliceous friable shale white, pale grey, bluish grey; lateritized on surface. | Up to 100 ft. seen, but top eroded. | Plateau, tabletops, buttes. | Horizontal; slumping rare, joint-ing developed. | Radiolaria; Lower Cret-aceous by analogy with other occurrences. | | |
| DISCONFORMITY (EROSIONAL BREAK) APPARENT | | | | | | | | | | |
| JUR-ASSIC | Upper | Unnamed | On basement rocks and on Cambrian; small outcrops; presumably discontinuous. | Sandstone with plant fossils. Conglomerate (undiff-erentiated). | 10-15 ft. or less. | Outcrops in plain and on slope of Umberella Ra; valley fill. | Slumping only. | Flora indicates Upper Jurassic to Lower Cretaceous. | | |
| UNCONFORMITY; SURFACE OF EROSION; PRECEDING FAULTING AND MODERATE FOLDING | | | | | | | | | | |

TABLE II (Cont'd).



| SYSTEM | SERIES | ROCK UNITS | POSITION IN THE SEQUENCE, DISTRIBUTION | LITHOLOGY | THICKNESS | TOPOGRAPHY | STRUCTURE | CORRELATION AND FOSSILS | UNDERGROUND WATER | MINERAL DEPOSITS |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Split Rock Sandstone | Rests on Mail Change Limestone or on V-Creek Limestone; in Ogilvie Range on Beetle Creek Formation (local disconformity). | Quartzose fine-grained sandstone with siltstone interbeds. | Up to 70 ft. seen; top eroded. | Tabletops and buttes; pediments; similar topography under Polland Waterhole Shale cover. | Subhorizontal; locally low dip (up to ten degrees). | Low in Leiopyge laevigata zone. Nepea narinosa, Amphoton spinigerum, Darypyge, agnostids. | | |
| | | Mail Change Limestone | Rests on V-Creek Limestone; well-developed in northern outcrops; thin and pinching out in southern outcrop. Confined to Undilla Basin. | Two-toned mottled lutitic limestone; thick bedded; in some places nodular and sandy. | 20 ft. seen in a single outcrop. | Pediments; small low terraced hills (bastions). | Horizontal to sub-horizontal. | The same zone as Split Rock Sandstone. Brachiopods abundant. | | Good building stone used in bridges of the H'way. |
| | | V-Creek Limestone | Rests on Inca Formation; confined to Undilla Basin, where it rests on Currant Bush Limestone. | Impure sandy and marly limestone with widely spaced harder interbeds. In places chert biscuits in upper beds. | About 10 ft. seen; estimated 100 ft. | Pediments; low outcrops in creek banks. | Subhorizontal; at faults dips from 18° to vertical. | Ptychagnostus nathorsti zone and overlaps with P. punctuosus z. Papyriaspis, Mapania, agnostids. | | |
| CAMBRIAN | Middle | Currant Bush Limestone | Rests on Inca Formation; only one outcrop area north of Umberella Range (Forty Mile Plain). | Bituminous flaggy limestone with silty partitions; calcilutite interbeds. | ? | Pediment with pedocalcic soil, grass plain. | Horizontal. | Same as V-Creek Limestone, corresponding to its lower half. | | |
| | | Inca Formation | Rests on Beetle Creek F. or direct on Pilpah Sandstone; widespread from north-west to south-east. | Siliceous laminated shale and siltstone with spongiolite chert layers and large lenses (members) of impure flaggy and ellipsoidal limestone. | 500 ft. | Pediments; low rolling hills, cliffs in creek banks, tabletops; thin veneer on Precambrian. | Horizontal to moderately folded; in Pilpah Inliers area the trend is north-west. | Ptychagnostus gibbus, P. atavus and up to P. punctuosus zone; agnostids, sponges. | In fractures and joints in limestone. Small supply. | |
| | | Beetle Creek Formation, including "Yelvertoft Bed" | Below Inca Formation; in Ogilvie Range below Split Rock Sandstone (disconformity). Lenticular in Pilpah Inliers area, otherwise widespread. | Siliceous sandy shale and siltstone, solid chert layers, silicified limestone interbeds, conglomerate at base. | 50 ft. at Beetle Ck; "Yelvertoft Bed" in Ogilvie Ra; 15 ft. | Tabletops and pediments (rare). | Horizontal or locally folded; vertical at faults. | Several species of Xystridura; Pagetia; Peronopsis, Lyriaspis, Fuchonia, etc. | | In conglomerate. |
| | | Unnamed and not mapped. | Below Beetle Creek Formation at Gidyea Bore, 10 miles west from Mt. Isa. | Friable sandstone with a polymict pebble conglomerate at base, as a "valley fill". | 10-15 ft. | Low rise. | Horizontal continuity with Beetle Creek not evident; a break in between probable. | Pipe rock. Probably an erosional residual of Lower Cambrian. | | |
| | Middle and Lower | MILD UNCONFORMITY OR DISCONFORMITY | | | | | | | | |
| | Lower? | Camooweal Dolomite | In the Camooweal 4-mile Sheet area rests below Middle Cambrian. In the west and south-west rests on basement rocks. | Dolomite and calcareous dolomite with chert nodules. | 800 ft. | Plain, prairie. | Horizontal. | Unfossiliferous. | Good supplies. | Monolithic building material. |
| | | UNCONFORMITY (SUPERSTRUCTURE/BASEMENT) | | | | | | | | |

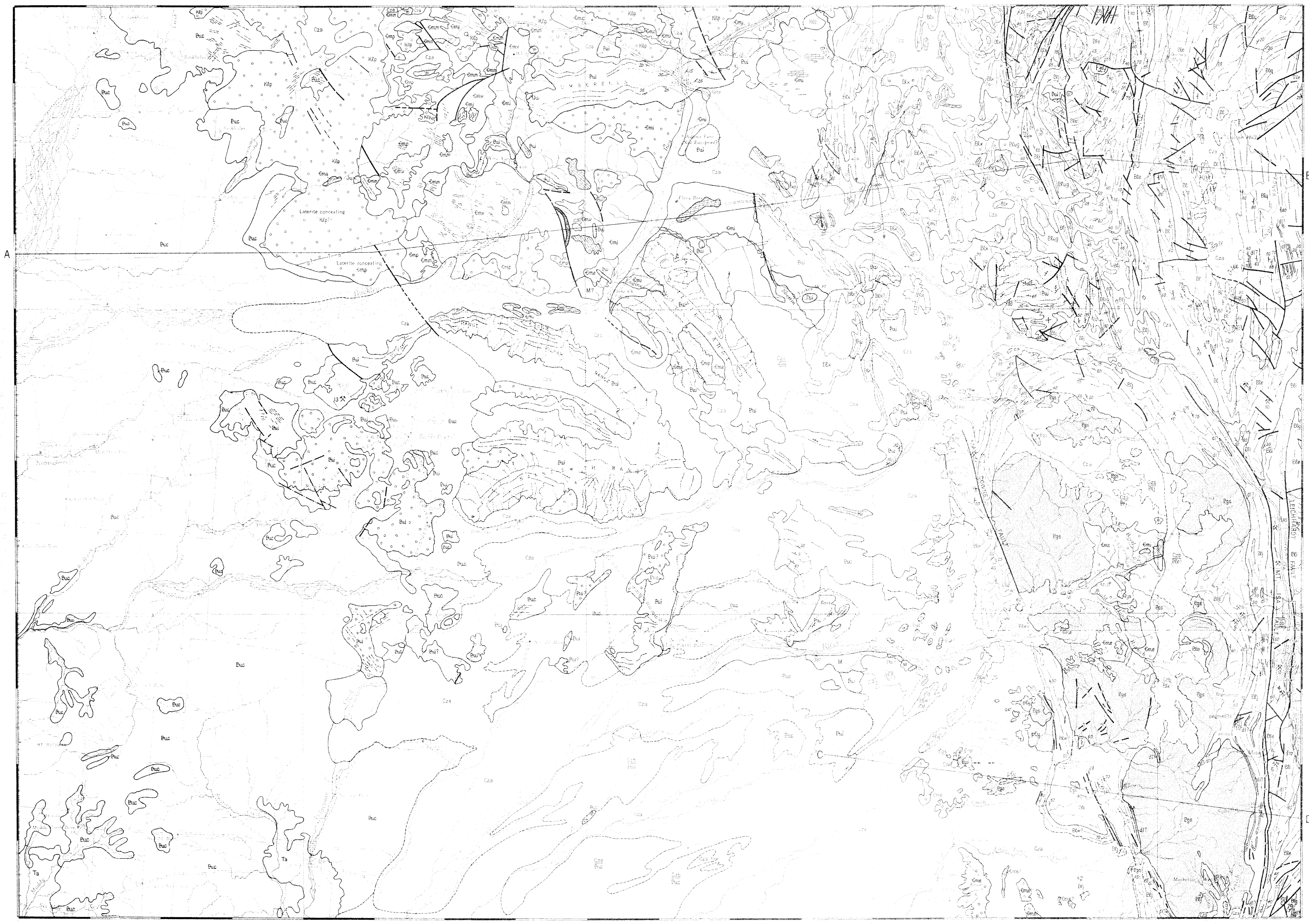
AUSTRALIA 1:253,440

# MT ISA

QUEENSLAND

4 MILE GEOLOGICAL SERIES SHEET F 54 - 1

FIRST EDITION 1959




## Reference

Geological boundaries

- Established boundary, position accurate
- Established boundary, position approximate
- Inferred, probable or indefinite boundary

Strike and dip of strata

- Inclined
- Horizontal
- Prevailing direction of dip } by air-photo interpretation
- Trend line

Folds

- Established anticlinal crest - position approximate (Showing direction of plunge)
- Established synclinal trough - position approximate (Showing direction of plunge)
- Plunge of minor anticline

Faults

- Established fault - position accurate
- Established fault - position approximate
- Inferred, probable or indefinite fault
- Established fault - concealed
- Fault zone
- Fracture lineation } by air-photo interpretation
- Joints

Mineral deposits

- Mine, quarry or prospect
- 1 & 2 Northern Leases Pb Zn Ag
- 3 Mt Isa Cu Pb Zn Ag
- 4 Bernborough Pb Zn Ag
- 5 Native Bee Cu
- 6 Flat Tyre U
- 7 Mothers Day U
- 8 Easter Egg U
- 9 The Pile U
- 10 Skal U
- 11 Big Beryl Be
- 12 May Downs Au
- 13 Bs

- Ag Silver
- Au Gold
- Be Beryl
- Bs Building stone
- Cu Copper
- Pb Lead
- U Uranium
- Zn Zinc

Miscellaneous

- Reference numbers to localities
- State boundary
- Railway
- Highway
- Vehicle track
- Fence
- Telephone line
- Homestead
- Bore or well
- Water hole
- Airfield
- Spot height in feet ( Datum: mean sea level )

## Reference

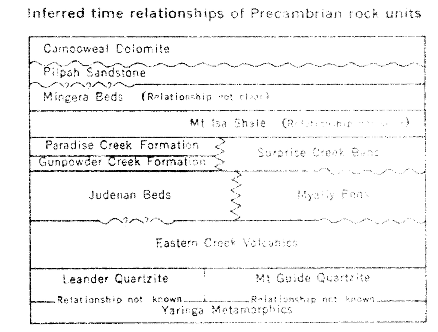
| | | | | |
|---|---|---|---|---|
| CAINOZOIC | | | Cza | Soil and alluvium |
| | | | Czb | Alluvial black soil |
| | TERTIARY | Austral Downs Limestone | Ta | Lacustrine limestone with flint nodules |
| | | | T | Lacustrine limestone |
| MESOZOIC | LOWER CRETACEOUS | Polland Waterhole Shale | Klp | Siliceous shale with radiolaria |
| | UPPER JURASSIC | | Ju | Sandstone with plant fossils |
| | UNDIFFERENTIATED | | M | Conglomerate |
| PALAEOZOIC | MIDDLE CAMBRIAN | Split Rock Sandstone | Ꞓmp | Sandstone, siltstone. |
| | | Mail Change Limestone | Ꞓmm | (Residual and alluvial black soil over) two-toned calcilutite. Main outcrops shown darker |
| | | V-Creek Limestone | Ꞓmv | Laminated impure limestone |
| | | Age Creek Formation | Ꞓma | Dolomitic limestone |
| | | Currant Bush Limestone | Ꞓmc | Limestone |
| | | Inca Formation | Ꞓmi | Siliceous shale and chert. Limestone interbeds |
| | | Beetle Creek Formation | Ꞓme | Basal conglomerate, chert, siliceous shale |
| | | Undifferentiated | Ꞓm | Conglomerate |
| | POST PRECAMBRIAN | | c | Dark limestone; gypsum |
| | UPPER PROTEROZOIC OR CAMBRIAN | Camooweal Dolomite | Puc | (Residual and alluvial black soil over) dolomite with chert nodules. Main outcrops shown darker |
| PRECAMBRIAN | UPPER PROTEROZOIC | Pilpah Sandstone | Pui | Sandstone, some conglomerate |
| | | | do | Dolerite |
| | | Possible | | |
| | LOWER PROTEROZOIC | | dl | Metadolerite and gabbro |
| | | Mingera Beds | Plw | Shale, sandstone, pebble beds, conglomerate |
| | | Mount Isa Shale | Pli | Shale, siltstone, dolomite. |
| | | Paradise Creek Formation | Plx | Dolomite, siltstone, sandstone |
| | | Gunpowder Creek Formation | Plug | Siltstone, shale, sandstone |
| | | Surprise Creek Beds | Plu | Shale, siltstone, sandstone, dolomite, conglomerate |
| | | Judenan Beds | Plj | Sandstone, siltstone, shale, some acid tuff |
| | | Myally Beds | Ply | Sandstone, quartzite, siltstone conglomerate, basic and acid lavas |
| | | Probably | | |
| | | Eastern Creek Volcanics | Ple | Interbedded metabasalt, quartzite and epidote quartzite, some limestone, siltstone, tuff |
| | | Mount Guide Quartzite | Plg | Quartzite, generally feldspathic, conglomerate |
| | | Leander Quartzite | Plq | Quartzite, some metabasalt and tuff |
| | | Undifferentiated | Pl | Quartzite, siltstone, shale, conglomerate |
| | | Yaringa Metamorphics | pPy | Migmatite, gneiss, schist, conglomerate |
| | | | | Laterite |

Granite

Sybella ("Templeton") Granite — Pgs — Coarse porphyritic and fine grained granodiorite and granite

A composite body : may include granitic basement rocks and intrusives of two ages within the Lower Proterozoic

Inferred time relationships of Precambrian rock units

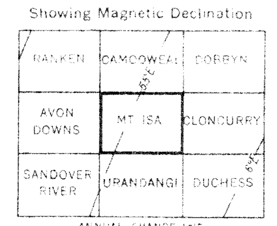



Unconformity

Compiled and published by the Bureau of Mineral Resources, Geology and Geophysics, Department of National Development, in conjunction with the Geological Survey of Queensland. Topographic base compiled and drawn by the Division of National Mapping, Department of National Development. Aerial photography by the Royal Australian Air Force; complete vertical coverage at 1:50,000 scale. Transverse Mercator Projection.

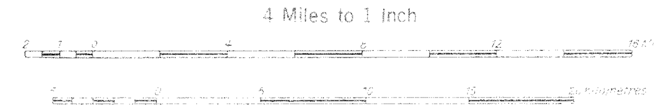
INDEX TO ADJOINING SHEETS

Showing Magnetic Declination

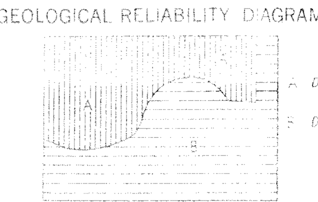



Scale

4 Miles to 1 Inch




GEOLOGICAL RELIABILITY DIAGRAM




A. Detailed mapping

B. Detailed reconnaissance - numerous traverses with air-photo interpretation

Geology by : A. A. Öpik, K. A. Townley, E. K. Carter, J. N. Casey, W. M. Roberts, B. W. Hawkins, M. A. Randal, F. de Keyser

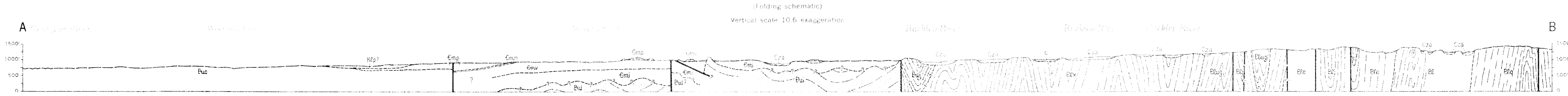
Compiled Jan. 1958 by : A. A. Öpik, E. K. Carter, G. M. Burton

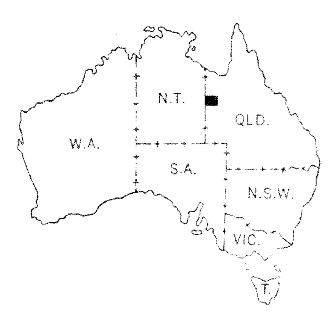
Drawn by: H. F. Joechel

Section A-B

(Folding schematic)

Vertical scale 10.6 exaggeration

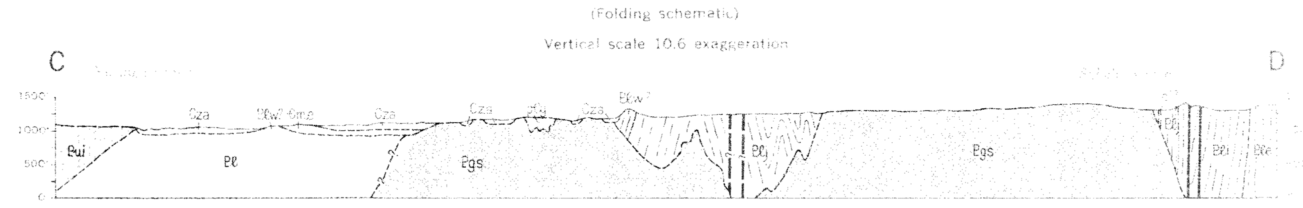


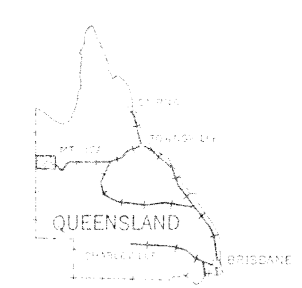




Section C-D

(Folding schematic)

Vertical scale 10.6 exaggeration




Copies of this map may be obtained from the Bureau of Mineral Resources, Geology and Geophysics, Canberra, A.C.T., or the Geological Survey of Queensland, Brisbane, Queensland.

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