DEPARTMENT OF
MINERALS AND ENERGY

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record 1973/83

NOTES ON THE FIRST EDITION CAMOOWEAL GEOLOGICAL SHEET QUEENSLAND, 1961

by

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The information in this Record was compiled between 1961 and 1965, but was not published in the form of Explanatory Notes to accompany the Camooweal 4 mile Geological Series map. Some advances in stratigraphic knowledge since the 4 mile map was published in 1961 are noted in the text but the results of work since about 1967 are omitted.

Öpik compiled the sections on geological investigations, physiography, geomorphology and Cambrian to Recent geology, Carter the sections on Precambrian and economic geology and Randal the section on water resources.

CONTENTS

PREVIOUS INVESTIGATIONS

The earliest geological investigation of the Camooweal Sheet area were carried out by Daintree (1872), and Hodgkinson (1877) soon after the arrival of the first settlers about 1867. The Mount Oxide copper and other prospects of the Cloncurry/Mount Isa Mineral Belt atracted miners to the area and the early investigations were primarily concerned with the mining prospects. Little attention was paid to the geological age of the mineral-bearing strata, which was inferred to be Lower Palaeozoic by analogy with eastern Queensland. Even in 1920 Dunstan regarded the rocks of the Mineral Belt as Silurian and the Cambrian strata as Jurassic. Gregory (1910-1911) presumed a Precambrian age for the mineralized strata and was followed independently by Woolnough (1912). Two decades later Whitehouse (1931, 1936) demonstrated that the rocks of the Mineral Belt were Precambrian and separated by a strong unconformity from the unaltered Cambrian sequence. Whitehouse also discovered and described numerous Cambrian fossils from the area and outlined the stratigraphy of the sequence. In 1947-1948 CSIRO surveyed the area and reported on the nature of the country and its potentialities (Christian et al., 1954) and included geology (Noakes & Traves, 1954) and geomorphology (Stewart, 1954).

Combined field parties of the Bureau of Mineral Resources (BMR) and the Geological Survey of Queensland (GSQ) mapped the Mineral Belt, including part of the Camooweal area, during 1950 to 1957, (Carter et al., 1961, p. 30). The Phanerozoic sequence was studied by Öpik in 1948, 1949 and 1952, and a BMR party led by J.N. Casey with the participation of L.C. Noakes, A.A. Öpik and M.A. Randal, mapped the sequence in 1953. Öpik visited the area once more in 1954, and further information was gathered by de Keyser (1958), Robertson (1960), Randal & Brown (1962), Skwarko (1965) and Lloyd (1967).

The seismic survey (Robertson, 1963) and the drilling of the Morstone No. 1 Well (Stewart & Hoyling, 1963) refer to the oil potentialities of the area. Further geological information is summarised by Carter et al. (1961).

The study of the Camooweal area has contributed significantly to our knowledge of the semi-arid lands, geomorphology of plainlands, geology and life of the Precambrian, ore genesis, life and history of the Cambrian and invertebrate palaeontology.

PHYSIOGRAPHY

The Camooweal Sheet area of some 17 000 km^2 is bounded by latitudes 19°S and 20°S, and longitudes 138°E and 139°30'E. The area is semi-arid; summer rain prevails with 380 mm in the southwest and 500 mm in the northwest. It is pastoral (cattle) country. The vegetation is prairie in the west passing into savannah on the Magenta Plain to the east. Vegetation on the Bagoor Plateau is dry sclerophyll forest and scrub. The Canyon Country on higher ground has spinifex and low trees, but tall forest prevails in the canyons and on the alluvial flats of the West Thornton River. Scrubby woodland dominates the shield area which is diversified by tall trees along the streams. Climate, vegetation, soils and utilization are discussed in Christian et al. (1954).

The altitude is low, with a maximum of about 425 m on the Highland Divide of the shield, and about 365 m on the Bagoor Plateau. The altitude of the plains is about 250 m ± 15 m, with the summits of the outliers reaching over 275 m. In the Ribbed Country some of the crests of the homoclinal ridges of the Age Creek Formation may reach 250 m over a generally depressed elevation of 215-230 m. The streams rise at about 335 m (the headwaters of the O'Shannassy River) and on the Highland Divide at 340 m.

The geographic names of the main physiographic features are of diverse origin. 'Bagoor Plateau' refers to the holding (parish) Bagoor (Queensland Four Mile Series map 4 m 93); 'Canyon Country' was first used by Ball (1911); 'Georgina River Plain' is self-explanatory and has been already used by Öpik, Carter and Noakes (1961); 'Highland Divide' is derived from the name 'Isa Highlands' of Twidale (1958); 'Magenta Plain' is named from Magenta Creek on the Geological Map of Queensland (1953) - a right-hand tributary of Harris Creek or even Harris Creek itself on the Camooweal 4 mile Geological Series Sheet. The intense red colour of the outliers of the Split Rock Sandstone and Cretaceous Polland Waterhole Shale contrasting with the green foliage of the scrub and trees of the plain display the 'magenta' in the landscape. 'Ribbed Country' is descriptive of the low ridge-and-valley landscape developed on the Age Creek Formation where 'Frith wing' and 'Ada wing' refer to creeks of the same names; 'Pilpah Outliers' was already used in Öpik, Carter and Noakes (1961); 'Riversleigh Escarpment' is derived from the station of the same name; 'Wooroona Plain' is taken from Öpik, Carter and Noakes (1961).

<u>Drainage</u>: (Fig. 1). The area is dominated by the Gulf of Carpentaria drainage system, and to a lesser degree by the Lake Eyre interior drainage system, which comprises the intermittent Georgina River and its tributaries. Streams east of the Highland Divide are intermittent tributaries of the Leichhardt River, but west of the divide streams run into the O'Shannassy River drainage system, which is the largest in the area. The main streams (O'Shannassy, Harris and Thornton) converge in the Canyon Country from where the O'Shannassy River develops into a more or less perennial stream. Run-off is supplemented by water stored in the jointed Thorntonia Limestone, whose soil cover is skeletal and permeable. The Gregory and O'Shannassy Rivers converge at the northern edge of the area; within the sheet area the lower reaches of the Gregory are perennial, augmenting O'Shannassy's own supply of water. Past Navery the perennial Symour River flows in a canyon and through the face of the Riversleigh Escarpment.

The converging stream pattern is apparently controlled by a local basin in jointed rocks and karst.

Two perennial springs deserve mentioning; the O'Shannassy River upstream from Morstone (Rivers) where the water flows in a corridor of tall palms within banks of travertine, and Spring Creek, close to Douglas Creek. It is apparent that the activity of these springs depends on the annual rainfall. The Bagoor Plateau has few streams and the creek beds within it are shallow. The heads of the West Thornton, Douglas, and Wooroona Creeks are very small streams forming intermittent waterfalls over the edge of the plateau and rock holes at its foot.

GEOMORPHOLOGY

The Camooweal Sheet area comprises a substantial part of the eastern Barkly Tableland. Geomorphologically the eastern limits of the 'tableland' are the Riversleigh Escarpment (the Cambrian edge) and the minor Cambrian and Cretaceous outliers in the east (fig. 2).

The geomorphology of the Camooweal area has been previously treated in general terms by Christian et al. (1954) as part of the Barkly Region and presented on a map, at a scale of 16 miles to one inch. The results presented in this Record are different in many aspects from those of Christian et al. (1954).

The Riversleigh Escarpment. The Riversleigh Escarpment is topographically developed as the edge of the Thorntonia Limestone of the Canyon Country. Here it is a cliff with a free face of subhorizontal dolomitic limestone resting on basement rocks exposed on the slope below. At Riversleigh the Precambrian slate below the limestone is weathered, but in other places, for example on the Seymour River it is firm and fresh. The Thorntonia Limestone itself is cut by gorges and a maze of short canyons. In the south where the Thorntonia Limestone is absent, the Cambrian edge is still continuous, but it is ill defined owing to the easily disintegrating shale and siltstone of the Inca and Beetle Creek Formations, which are incapable of forming a topographic escarpment. The Riversleigh Escarpment in its present position is a feature of the pre-Cretaceous landscape. In places its edge is covered by outliers of Mesozoic rocks which are also present on the shield and on Middle Cambrian strata of various ages.

Several outliers including the Tarpeian Rock at locality M98, and outliers about 6 km to the north on Verdon Creek, are capped by Tertiary Carl Creek Limestone, see Carter & Öpik (1961, p. 6). These outliers are cutoff spurs and cores of interfluves, vestiges of a canyon landscape, related to and probably a part of the Canyon Country.

Pilpah Inliers. Inliers of Pilpah Sandstone are insignificant in the area (lat. 138°55'E, long. 20°S), but are prominent in the Mount Isa area. Of the three inliers the southernmost is a spur of the Umberella Range. The inliers, sometimes called 'Baraboos' after a hill in Wisconsin, are basement hills emerging through the mantling sediments.

The Georgina River Plain. The Georgina River Plain is an almost perfect plain on durable subhorizontal dolomite. The elevation on the divide is about 170 m and declines in the southwest to 235 m at Camooweal. The pedocalcic, 'black soil' is relatively thick and masks the bedrock; outcrops are therefore rare. Christian et al. (1954) suggest a Tertiary age for these soils; it also seems probable that these soils were formed in the late Cretaceous when erosion of the Cretaceous blanket exposed large surfaces of dolomite. These processes were continuing throughout the Tertiary with the result that gradually younger material was added to the soil-covered plains. It appears that the Georgina River Plain, without its present soil cover, existed well before the Cretaceous.

The Canyon Country. The Canyon Country covers about 4000 km^2 in the Camooweal Sheet area and with its extension into the Lawn Hill Sheet area to the north the total is close to 5000 km^2. The Camooweal Dolomite and Thorntonia Limestone are dissected in a similar manner and therefore the geographic distribution of the canyons cannot be attributed to any particular lithologic and jointing characteristics. The canyons are shallow, most are less than 30 m deep.

The interfluves between the main canyons and their tributaries are lobate and joint controlled; meanders are undeveloped. In general terms the Canyon Country is a dissected plain whose altitude is coincident with the Georgina River Plain and the Magenta Plain. Stream erosion is slow owing to the low grade and small amount of water. Chemical solution of carbonate rocks is active, but its effect cannot be evaluated. The drainage pattern of the Canyon Country was initiated during pre-Mesozoic (pre-Cretaceous) time and probably modified during and after the stripping off of the Cretaceous deposits, whose remnants still occur in the stream beds, e.g. Polland Waterhole Shale (Cretaceous) is present at Thorntonia station and close to locality M128, in West Thorntonia Creek; at locality M95, north of the Seymour River, marine and freshwater Cretaceous beds rest on the dissected Thorntonia Limestone. In the northwest, close to the Herbert Vale O.S. station, plant-bearing Mesozoic sandstone is preserved in a gully which cuts through the dolomite.

The Ribbed Country. The Ribbed Country is defined by the outcrop areas of the Age Creek Formation. The 'ribs' are homoclinal ridges and cuestas, and low ridges running across flat areas. In the Frith wing (about 250 km^2) the ridges are facing northwest and in the Ada wing (about 360 km^2) north-northeast. The streams are transcurrent, but longitudinal tributaries are also present. Gorges are present along the O'Shannassy River and Opal Creek. Relief is low, not exceeding 30-45 m. Sinkholes are frequent and hundreds of lapiez fields are present. The altitude of summits is around 240 m - the same as the plains, but the relief is that of a minor mountain range.

The Magenta Plain. The Magenta Plain covers an area of about 1000 km^2 between the Ribbed country in the west and north, the shield in the east and the Bagoor Plateau in the south. It is a plain of pediments dissected to a shallow depth by streams. The dissection of the limestone created a bastion topography of low terraced hills, tables and escarpments. At locality M410, in the fork of Harris Creek and V-Creek, and upstream in Harris Creek, gorges with terraced banks are developed to a depth of about 33 to 36 m. Mesas and buttes of Cambrian Split Rock Sandstone and Cretaceous rocks are scattered on the plain. In some places Cretaceous rocks rest on the Split Rock Sandstone and in other places directly on limestone. It can be concluded that the pre-Cretaceous surface already carried erosional residuals of Split Rock Sandstone. The Split Rock Sandstone, being the youngest formation of the Cambrian sequence forms outliers only on divides and interfluves, but the Mesozoic outliers are found resting on strata which are older closer to the Palaeozoic edge. The truncation of the Cambrian as it exists now was accomplished before the Cretaceous. The altitude of the Magenta Plain is about 340 m close to the cliffs of the Bagoor Plateau, and declines to about 215-230 m in the north; summits of some outliers rise to 290 m and 45 m above the top of the Cambrian limestone.

The Bagoor Plateau. The Bagoor Plateau is an area of higher relief rising 60 m - 120 m above the Magenta Plain. On an old map ('Camooweal' L.H.Q., Aust., Cartographic Company, 1943) the southern escarpment of the Bagoor Plateau is referred to as the approximate edge of the Barkly Tableland. The edge of the plateau is lobate with cliffs up to 60 m. In its western part, however, its surface slopes gently westwards. At the heads of Tintæra, Wooroona and Douglas Creeks (Goat and Bucket Rockholes) and West Thornton Creek (Hanging Rock Waterfall) the seasonal rain water runs down the edge in waterfalls and rapids. Polland Rockhole in the southern escarpment refers to a short and narrow marginal gully.

Protected by the Cretaceous Polland Waterhole Shale the pre-Cretaceous land surface is preserved intact, as seen from the inliers of the Split Rock Sandstone, inliers of pre-Split Rock Middle Cambrian limestone, including the Inca Formation cherts and shale, and the Pilpah Sandstone 'baraboos'. The total upland surface of the Bagoor Plateau is about 1500 km^2. Its surface is even and dissected, but the presence of a free face of rubble on the lower slopes and in peripheral stream beds indicates slope erosion supported by marginal gullying; the escarpment is receding and the plateau contracts centripetally leaving residual outliers. In the plains around the plateau skeletal soil with bare rubble-covered pediments on limestone and Split Rock Sandstone are slow in developing deeper soils, slower than the erosion is in liberating the old surface from the drapery of Polland Waterhole Shale.

Karst. The Karst topography of the Camooweal Sheet area was first described by Daneš (1911). About 7 km north of Rocklands at Camooweal are the Ghissons caves; large sinkholes occur immediately east of Camooweal, and south of the town in the Ribbed Country sinkholes and lapiez fields are present. A large sinkhole is shown on the map northeast from New Norfolk station and another has been examined at locality M176, southwest from Thorntonia station.

Laterite. In the Bagoor Plateau and on the larger outliers the surface of the Polland Waterhole Shale is lateritized. Laterite on the Bagoor Plateau is up to 3 m thick. The laterite consists of a topmost ferruginous zone, followed by the mottled and pallid transformation zones. A siliceous zone is not evident in preserved profiles; siliceous billy, however, occurs as a duricrust in places where the ferruginous layer is absent - apparently stripped off. In several surface outcrops the Polland Waterhole Shale is hardened and transformed into a white 'porcellanite'. In surface outcrops and flanks of mesas and buttes the Split Rock Sandstone and the Mesozoic plant-bearing sandstone appear red and in places incrusted by iron oxide, and appear 'lateritic', but no laterite is evident in this material. However, where the Polland Waterhole Shale is exposed, ferruginous laterite is developed. One concludes that quartzose sandstone is unsusceptible to lateritization, but the shale with its Al-minerals is transformable into laterite. Consequently lateritization in the Camooweal area is controlled in the first place by the chemical composition of the rocks. The other condition is climate. The third requisite is palaeogeomorphological; the lateritized surface should be of sufficiently low relief to enable erosion to proceed at a slower pace than lateritization.

In the eastern Barkly Tableland the above-mentioned palaeo-geomorphology became established at the onset of the late Cretaceous time (Cenomanian) after the uplift of the sea floor with its late lower Cretaceous Polland Waterhole Shale forming a subaerial plain.

No accurate geological date for the period of lateritization can be fixed within the span of the late Cretaceous. However, the destruction of the basic material, the Polland Waterhole Shale, with its progressing laterite, continued over a long interval of time, and no evidence is yet available that the process of lateritization itself became extinct. Recent activity is still a possibility in an area of shale as large as the Bagoor Plateau.

The date of leaching and moderate lateritization of the silty and siliceous shale of the Beetle Creek and the Inca Formations is ambiguous. It is either due to pre-Cretaceous events, or to events in the Tertiary in places where the Polland Shale cover was eroded away.

STRUCTURE

The main structural elements (Fig. 3) of the Sheet area are the shield in the east, with relief formed on folded igneous and sedimentary rocks; the Platform in the west, comprising an unmetamorphosed superstructure of predominantly undeformed Cambrian sediments and the Undilla Basin comprising Middle Cambrian sediments. Superimposed on the shield and the superstructure are outliers of a once continuous sheet of Cretaceous strata.

GEOLOGICAL HISTORY

A sub-Cambrian land surface is evident from the great unconformity separating the subhorizontal Cambrian strata from the strongly deformed and truncated Precambrian formations. In general the sub-Cambrian landscape resembled the Mount Isa Highlands and the hilly country of the Pilpah Sandstone. The present landscape around the minor Cambrian outliers resembles the sub-Cambrian surface.

After uplift, Cambrian marine inundation resulted in a depositional plain. The earliest possible date for the uplift is late Middle Cambrian, and possibly the latest is either post-Idmean Upper Cambrian or early Ordovician. The course and events of erosion during the long interval between the Cambrian and the Cretaceous cannot be evaluated. However, it is probable that the Canyon Country originated during this interval, at the end of the cycle of erosion. Before the Cretaceous inundation the land had many lakes receiving sand and some silt and plant remains, e.g. at Yellow and Lee Waterholes. The plant-bearing sandstone around locality M84 is relatively thick.

By the end of the early Cretaceous, land emerged again as a depositional surface. Fossilized, as in the firm laterite, this depositional surface is preserved in the Bagoor Plateau. Erosion, however, continues to remove the Polland Waterhole Shale.

Subsidence about the middle of the Tertiary decelerated the erosion in the uplands and lowlands. A freshwater lake was spread over the Carpentaria lowlands and the valleys at Riversleigh.

In late Tertiary time the land rose again and attained its present altitude; salt water replaced the fresh water in the Carpentaria lake, and erosion accelerated. In the semi-arid climate, however, the effect of the erosion, owing to the low rainfall, remained rather small.

The history of the land surface of the Lawn Hill area (Carter & Öpik, 1961) of the Mount Isa area (Öpik, Carter & Noakes, 1961) and of the Camooweal area together can be regarded as an integrated history of the eastern Barkly Tableland.

PRECAMBRIAN

STRATIGRAPHY

Eight named Lower Proterozoic units, and one Upper Proterozoic unit, have been mapped within the Sheet area. The Lower Proterozoic units form part of the orogenic belt of which the Precambrian of northwestern Queensland is largely composed.

All the stratigraphic names have been approved by the Queensland Stratigraphic Nomenclature Committee. Those which had not appeared in print at the end of 1958 were briefly defined in the Queensland Government Mining Journal (Carter, 1959a).

No age determinations have been made on rocks in the Camooweal Sheet area, but correlation with granite and uranium dates elsewhere suggests that the age of the lower Proterozoic succession is in the range 1800-1500 million years. The Weberra Granite, which intrudes the Ploughed Mountain Beds, has not been dated.

Table 1 shows briefly the lithology, stratigraphic relations, structure, and economic resources of the various Precambrian units in the Sheet area.

Eastern Creek Volcanics

The lava-sediment ratio of this unit decreases southward. Metabasalt is the main rock type in the Camooweal Sheet area and metasediments are thin. Some rhyolite, dacite, and andesite have been recorded at the top of the succession in the Camooweal and Dobbyn Sheet areas. The strata generally have been only slightly altered by regional metamorphism. They are strongly cleaved in places. The volcanics and conglomerates at the top of the Myally Beds are included in the Myally Beds because of the immediately overlying local unconformity. With more detailed mapping they could constitute a separate unit; they are more abundant in the north than in the south. The unit is generally conformable with the Eastern Creek Volcanics, but basal conglomerate and arkose and direct deposition on Ewen Granite in the Dobbyn Sheet area indicate a marked erosional break in the east. Owing to inadequate information the distribution of the Myally Beds has not been accurately delineated in the upper Sandy and Fiery Creeks area.

Judenan Beds

The Judenan Beds are more silty and thinner and have fewer lavas at the top of the succession than the Myally Beds.

Ploughed Mountain Beds

The Ploughed Mountain Beds, which are highly dolomitic in places, are dominantly arenaceous in the east; no dolomite has been recorded east of the Sheet area. Concentric and tubular structures (stromatolites) have been found in the Pandanus Creek area and farther west.

Surprise Creek Beds

The Surprise Creek Beds are confined to the east of the Mount Gordon Fault zone; they differ from the other contemporaneous units in being less dolomitic. A white quartzite marker bed can be followed over a considerable distance.

Paradise Creek Formation

The Paradise Creek Formation is notable for the widespread occurrence of stromatolites, probably of algal origin. The stromatolites occur at several stratigraphic levels from the base of the unit and may extend down into the Gunpowder Creek Formation. They are described and figured by Robertson (1960). The stromatolites in the Ploughed Mountain Beds are similar to several of the forms in the Paradise Creek area.

Lawn Hill Formation

The Lawn Hill Formation crops out in an area about 1.5 km^2 near Riversleigh homestead; exposures are poor and are mainly of siltstone.

Pilpah Sandstone

The Pilpah Sandstone crops out mainly in the Mount Isa Sheet area, but outliers with basal conglomerate unconformably overlie Lower Proterozoic units in the Camooweal Sheet area.

INTRUSIVE IGNEOUS ROCKS

All igneous rocks in the Sheet area are Precambrian. The Weberra Granite in the northeast, has a compact area of outcrop of about 25 km^2, it is well-jointed and has produced a rough topography of moderate relief. It is heterogeneous in appearance, but generally is a red, medium grained, even grained to porphyritic ferromagnesian-poor microcline granite. Numerous granophyric dykes and apophyses, and aplite and quartz veins are associated with it. The granite has not produced strong metamorphism; a narrow zone of silicification is the main contact effect. The granite intrudes the Ploughed Mountain Beds but the exact age of emplacement, and its relation to other granitic rocks of the region, is not known.

Dolerite and amphibolite occur mainly in the Eastern Creek Volcanics, but dykes have been recorded in younger Lower Proterozoic units. They have not been studied in detail, but the basic intrusive history of the region is known to be complex, and probably all the oldest Lower Proterozoic basic intrusives occur in the Camooweal Sheet area. A body, at least 2 km^2 in area, crops out in the Eastern Creek Volcanics in the southeast of the Sheet area. It is varied in texture and may represent a differentiation series.

METAMORPHISM

The Pilpah Sandstone is unmetamorphosed. Most of the cleavage is weakly developed in the least competent strata and the dolomite is extensively recrystallized. The basalt of the Eastern Creek Volcanics has been raised to the green schist metamorphic facies and has been extensively epidotized; the associated sediments have been altered to slate, quartzite and epidote quartzite.

STRUCTURE

The main structural elements are shown in Figure 4.

The Upper Proterozoic Pilpah Sandstone is moderately, but irregularly folded and faulted in places, but the degree of deformation is less than in the Lower Proterozoic strata.

A major structural element, the Mount Gordon Fault zone, divides the Lower Proterozoic area into two. The Mount Gordon fault zone contains a complex of faults and trends 115°. To the east of it sediments are folded into a broad but steeply dipping north-plunging anticline with a tighter syncline farther east (Dobbyn-4 mile Sheet area). Considerable repetition of bedding has resulted from displacement on northeast and east-striking faults. West of the fault zone folding is less regular and fold-axis trends are not so pronounced as to the east. In the north the main structure is a complex broad dome centred near the head of Fiery Creek. It is flanked by narrow synclines that trend parallel to the Mount Gordon Fault and generally plunge north.

Faulting is complex, but a well-developed system of conjugate strike-slip faults striking northeast and northwest can be recognised. The sense of the displacement is consistent with east-west compression; displacement is generally fairly small. The Mount Gordon fault system contains some high angle reverse faults and may be partly compressive in origin, but it is thought to be the result of long-continued faulting including normal faulting, which probably started during deposition of the sediments. The faulting of the region is discussed at greater length in Carter, Brooks and Walker (1961).

GEOLOGICAL HISTORY

The Lower Proterozoic rocks of the Camooweal Sheet area together with those in the Lawn Hill Sheet area formed the northwest part of a meridional orogenic belt. The orogenic belt contained at various times two main geosynclinal basins of deposition and for most of the time of its existence a mobile tectonic welt, centred about longitude 139°50'E, separated the two basins. A foreland lay to the west and southwest of the western basin. The western geosynclinal basin developed later than the Eastern Creek Volcanics accumulated in the Camooweal Sheet area. In the Dobbyn Sheet area the Argylla Formation was extruded onto a land surface and the counterpart of the Leander and Mount Guide Quartzites are absent.

Widespread extrusion of the basalt of the Eastern Creek Volcanics is the first event recorded in the Sheet area. A great thickness of lava with thin interbeds of sediments accumulated, which implies subaqueous deposition. The northernmost outcrop is at latitude 19°34'S; it is not known how much farther north the flows extended. The basalt was apparently extruded from the tectonic welt to the east, which had started to rise some time previously and at this time probably resembled a modern volcanic island arc extending from a northern land mass.

Movement of the tectonic welt at the close of the basic vulcanicity produced breaks between the Eastern Creek Volcanics and the Myally Beds in the Dobbyn and Cloncurry Sheet areas, but not elsewhere; it probably was accompanied by an accelerated sinking of the western basin, in which the thick Myally Beds (6000 m or more) and Judenan Beds (2000 m or more) accumulated. Sinking of the basin was probably effected, in part at least, by normal faulting. Sediment was derived from the southwest, north and east (tectonic land); much of the arenaceous material appears to have come from the north.

Toward the close of the Myally-Judenan sedimentation a major orogenic deformation with granite emplacement severely deformed the strata east of the tectonic welt and interrupted sedimentation there, but caused only minor local breaks in the succession west of the welt. No granite was emplaced in the Camooweal Sheet area but the minor vulcanicity at this time may have been associated with the tectonism.

Sedimentation without vulcanicity continued until the final Lower Proterozoic orogenic deformation folded and faulted the region and brought about uplift. The Weberra Granite was probably related to this orogeny.

After an unknown interval the Upper Proterozoic Pilpah Sandstone was formed by the erosion of the mountain chain of Lower Proterozoic rocks and subsequent deposition on a fairly stable shelf or platform. The Pilpah Sandstone, in turn, was moderately folded and faulted before the deposition of the Camooweal Dolomite.

ECONOMIC MINERALS

Copper is the only metal that has been produced from the area. It has come from two main areas - the Mount Oxide area and the Paradise Valley area to the southwest. Mount Oxide has been by far the largest mine; it has yielded very high grade secondary ore, much of it chalcocite. All ore mined is of secondary origin and drilling has not located an economic body of primary ore. The Lady Annie mine has been the second largest producer; its ore has been mainly malachite and cuprite, won by both open cut methods and underground mining. The deposit is a fissure type of lode.

Copper has also been mined from northeast of Thorntonia homestead, e.g. Proxham Part (o.p.) mine, and has been recorded from the Fiery Creek and Sandy Creek areas.

Uranium has been found in several localities in the Eastern Creek Volcanics. The Queen's Gift group of deposits, east of Judenan Creek, appear to be the most promising, but an economic deposit has not yet been found.

Lead-Zinc recorded from north of Thorntonia is uneconomic. Galena in the Camooweal Dolomite on Tott's Creek, 40 km from Camooweal, is of interest as one of the four metal deposits known in the little-disturbed sediments of the region. However, the deposit is uneconomic.

Ferruginous residual soils of the Barkly Tableland and nearby lateritized areas provide excellent road-making material. The meta-basalt of the Eastern Creek Volcanics and arenaceous rocks where not extensively cleaved are also suitable.

PROZOIC

The name Prozoic Era refers to the post-Precambrian life, rocks, and events. In the Camooweal area the strata of the superstructure resting on the basement (the Precambrian of the Mount Isa/Cloncurry Mineral Belt) and separated from that basement by a great unconformity, are prozoic. The Prozoic sequence is presented in Table 2, and also in the map legend.

STRATIGRAPHY

The stratigraphy is discussed in Table 2.

Quaternary

The soil surface is Recent, but the soils themselves were initiated at various times, beginning with the late Cretaceous.

Laterite

Laterite is an extant surface cover on the Cretaceous Polland Waterhole Shale. The age of the lateritization process is Upper Cretaceous to probably Recent.

Tertiary

Carl Creek Limestone

Within the basal conglomerate, pebbles and cobbles of ferruginized and 'billyized' material are present and has been interpreted as clastics derived from laterite. It is too far reaching however, to conclude that the laterite of the source area is of a pre-Miocene or even pre-Oligocene age, but it is correct to say that laterite existed before the deposition of the Carl Creek Limestone.

Mesozoic

Polland Waterhole Shale

Polland Waterhole Shale is named from Pollands Rock Hole, which is described in Table 2, and discussed in the chapter on Geomorphology. Within the area it occurs as remnants of a previous continuous blanket of lower Cretaceous marine strata.

Lee's Waterhole Sandstone

Lee's Waterhole Sandstone (loc. m 88) and other plant-bearing sandstones belong to the pre-Cretaceous land surface and were deposited in seperate lakes each as a separate 'formation'. At the Yellow Waterhole (loc. M 85) north of Lee's Waterhole, sandstone is particularly rich in plant remains. Well exposed sections (about 33 m thick) are present in the mesas at locality M84, resting on the Precambrian and close to the edge of the Cambrian and capped by a lateritic veneer of Polland Waterhole Shale. The sandstone is friable but contains white slump rolls of silicified sandstone ('fresh water quartzite'). Lakes were transient features on the land surface and consequently the relationship of the plant bearing sandstones in the area is problematic. On higher ground the sandstone is as red as the Split Rock Sandstone and both occur in several buttes together - a fact recognised from the plant remains and trilobites found in close proximity to each other.

Undifferentiated Mesozoic deposits

Coarse conglomerate underlying the Polland Waterhole Shale crops out around the 10-Mile Waterhole (M36, M37). It consists predominantly of chert nodules in a friable matrix of sand; presumably it is even older than the plant-bearing Lee's Sandstone.

At locality M95, about 3 km north of the Seymour River, and resting on the uneven old land surface, a cluster of some thirty buttes is marked as Ju (Jurassic?) on the map. The sequence of about 30 m of red sandstone contains plant remains and fresh water shells (Unio) and an interbed containing the marine fossil Rizocorallium (Veevers, 1962, p.6) presumably of a Lower Cretaceous age. This would indicate that the sequence at locality M95 contains the youngest fossils in the area.

Cambrian formations

The Cambrian formations presented in Table 2 and on the map have been described by Öpik (1960, p.99-104). These formations are based on the study of some three hundred localities and sites in the Camooweal area, and about eighty-five localities in the Mount Isa area, and numerous observations made enroute. In drawing the formation boundaries on the map the data from these localities was relied on, especially for interpolation. The upper limit of the Age Creek Formation, and the boundary separating the Currant Bush Limestone from the V-Creek Limestone above it were interpolated on the basis of the intertonguing of the Age Creek Formation with the strata of the other formations, and the gradational passage of the Currant Bush Limestone into the V-Creek Limestone. It should be noted that only the sections across the Age Creek Formation are more or less continuous, the remainder were pieced together from locality data and aerial photographs.

The age of the formations in Table 2 is given in terms of agnostid zones and also by reference to other trilobites Xystridura, Redlichia as published by Öpik (1957, 1960, correlation chart, p.16). The names of the formations have been proposed by Öpik (1956, 1960), and Öpik et al. (1957).

Split Rock Sandstone

The formation is named after the Split Rock rockholes on Wooroona Creek, locality M417, about 48 km east of Camooweal. The strata at this locality consist of a fine-grained silty light grey friable well stratified sandstone, some 3 m thick. Ripple marks are present and some calcareous nodules occur close to the creek bed. On higher ground the sandstone is red (ferrigineous). Upstream the outcrops of the sandstone extend to the edge of the Bagoor Plateau; the total exposed thickness is about 60 m, but the top (under the Polland Waterhole Shale) has been eroded. In some of the outliers sporadic interbeds of brown siltstone are present but otherwise the sandstone is red. The sandstone rests on the Mail Change Limestone, and in the east on V-Creek Limestone, separated by a local hiatus. In the northwest (loc. M299, about 5 km from Morstone ruins) a small remnant of red sandstone rests, with a break at its base, on the Age Creek formation. The Split Rock rockholes were already described and illustrated by Daneš (1911); the stratigraphy and fossils were described by Whitehouse (1936; 1939), who named the rockholes sequence the 'Amphoton Stage' and placed it erroneously at the base of the Middle Cambrian sequence; the Split Rock Sandstone, however, is the youngest Middle Cambrian Formation in the area.

Mail Change Limestone

This limestone formation derives its name from Mail Change site on the old road from Camooweal to Burketown. The main outcrop is seen at locality M1 (longitude 138°30'E, latitude 19°36'S) on Stoney Creek. The rock at this place is a thick bedded well jointed mottled and laminated aphanitic limestone, of which about 3 m is exposed. The total thickness is variable, with an estimated maximum of 15 m. It is absent in the east of the Magenta Plain. The lithology is variable; at locality M19 (northeast of Mail Change) it is sandy, and at locality M389 (at the head of Scrubby Creek) it is marly and friable. Areas of Mail Change Limestone are covered by skeletal soils. Bare outcrops, however, are present in pediments at the foot of several buttes of the Split Rock Sandstone.

At the Wim Well (loc. M413, a few kilometers southeast of Mail Change) a small tabletop is crowned by a residual layer of the Mail Change Limestone resting conformably on grey and marly strata of the V-Creek Limestone. The small thickness of the Mail Change Limestone suggests that it may be the topmost lithological member of the V-Creek Limestone within the Magenta Plain; south of the Bagoor Plateau, however, along the Barkly Highway and in the Mount Isa area (Öpik in Öpik, Carter and Noakes, 1961) it remains a separate formation.

Age Creek Formation

The formation is named after the Age Creek at its junction with the O'Shannassy River, at locality M306 (longitude 138°32'E, latitude 19°28'). This locality is part of a north-facing cuesta with a flanking cliff of the left bank of the O'Shannassy River. The cliff is marked by aboriginal painting of five tall human figures visible only from rocks of the right bank. The whole cuesta is some 6 km long and is cut by five gaps. The sequence in the cuesta at M306 is about 60 m thick, and the dip of the strata is eight degrees south-southwest. The upper part of the sequence consists of a hard and porous thick bedded and banded clastic dolomite; it is externally grey to black, but otherwise off-white and its loose plates ring under the hammer and under the feet. The lower part of the sequence consists of a flaggy, sandy, relatively thin bedded brown, yellow or even light grey dolomite which contains phosphatic brachiopods and trilobites - a fauna similar to that of the Currant Bush Limestone. The Age Creek Formation of the Ada wing is composed of three rock types (1) thin bedded sandy dolomite, in places oolitic friable dolomitic sandstone and even sandstone. They are frequently fossiliferous and are found on lower ground, or under the protection of harder dolomite. These beds are easily eroded and are therefore inconspicuous; (2) sheets of hard clastic dolomite with current bedded sets, conspicuous because of a high resistance to erosion, and forming homoclinal ridges and cuestas; and (3) interbeds of limestone with Currant Bush and V-Creek characteristics. Examples of such interbeds are seen at localities M160, M155 and M156. At M160 a fossiliferous chert layer containing agnostids and other trilobites of an early 'Currant Bush' aspect are found. On Opal Creek at locality M155 a fossiliferous and bituminous interbed of Currant Bush Limestone, about 10 m thick, is sandwiched between two sheets of dolomite; and about 0.3 km south, at locality M156 a fossiliferous interbed of marly V-Creek Limestone is sandwiched between sheets of dolomite. The strata at these sites dip 6-7 degrees south, forming cuestas. The clastic dolomite is everywhere unfossiliferous, but the thin bedded strata, especially in the Ada wing, is fossiliferous at different levels and in many places. Fossils including phosphatic brachiopods and trilobite fragments, are, however, rare in the Frith wing.

In the Frith wing part of the Age Creek Formation, sheets of detrital and oolitic dolomite, which are often current-bedded, are also numerous. They form conspicuous northwest-facing cuestas and homoclinal ridges. At localities M324 and M325, the dips of the strata are 15 to 25 degrees. Numerous lapies fields are present on these dolomites, for example, along the lower reach of the Stoney Creek and along the O'Shannassey River close to the Totts Creek junction. In the bed of the O'Shannassey River at locality M14, a detrital dolomite (dipping 12 degrees east-southeast) is exposed; it is comparable with the rock in the upper part of the cuesta at locality M306. However, the strata at the heads of Bauhinia Creek, at the southern end of the continuous outcrops of the formation are different. They are minutely laminated current bedded dolomite, with alternating sandy and sandless laminae, dipping about 5 degrees to the southeast in low cuestas (at M34) and interbedded flaggy white fine-grained sandstone and dolomite in the creek bed at locality M35. Included in the Age Creek Formation is some stratified sandy limestone exposed along, and in, the bed of Stoney Creek, (loc. M6) some 8 km from Wim Well and about 2 km downstream in an old well. These beds contain slumped lenses of Age Creek material. The strata presumably represent a large contaminated tongue of V-Creek Limestone, comparable with the nearby limestone at Wim Well, and even in the Morstone No. 1 Well. No interbeds identifiable as Currant Bush have been found in the Frith wing.

The Age Creek Formation was deposited on the slopes of the Undilla Basin which was gradually sinking over a long period of time.

The possibility of the Age Creek Formation extending into the subsurface of the Magenta Plain (see sections on the map) has been concluded from the presence of numerous small scattered inliers of dolomite, oolitic material, current bedded sandy dolomite, and clastic dolomite. These may represent sheets, tongues and detrital lenses of Age Creek Formation indicating the presence of a larger mass of that formation at subsurface.

According to Randal and Brown (1962) 'the Age Creek Formation appears to interfinger with rocks which have previously been regarded as Camooweal Dolomite in Ada Creek, west of Marion Bore and in Frith and Labortion Creeks, near Morstone'. The interfingering strata in such a case should be of the same Ordian age as the Camooweal Dolomite and older than the mass of the Age Creek Formation. This accepted, one may conclude that along its western fringe the Age Creek Formation rests on the subsurface part of the Camooweal Dolomite which may, or may not have participated in the subsidence of the basin. Camooweal Dolomite is absent in the Morstone No. 1 Well.

V-Creek Limestone

The name V-Creek Limestone is self-explanatory, it refers in the first place to the outcrops in the canyon at the creek's crossing, locality M409 (long. 138°30'E; lat. 19°36'S). The outcrops are continuous in terraced bastions and cliffs along V-Creek and Harris Creek. The sequence consists of flaggy fissile laminated grey marly limestone, with some subordinate harder beds and occasional oolitic bands; the total exposed thickness is about 40 m. The sequence is more accessible at locality M410 (Patchwork Water Hole). At locality M411, Harris Waterhole on Harris Creek, the V-Creek Limestone sequence, which is about 35 m thick, is completely exposed in the canyon and in bastions on higher ground. At its base, in vertical walls, 10 m of crumbly laminated marly beds contain numerous agnostids. At locality M130 northeast of V-Creek Crossing, the V-Creek Limestone sequence is reduced to a thin ferruginous or even iron ore layer. At locality M65, on the right bank of the O'Shannassy River, in a gully about 5 km downstream from Morstone ruins, V-Creek Limestone and Mail Change Limestone (together about 6 m thick) are exposed at a longitudinal fault on the southern side of the fault wall. The occurrence is remarkable because the Age Creek Formation north (M306) as well as south (M71) contains older Currant Bush fossils.

The V-Creek Limestone was deposited simultaneously with the upper part of the Age Creek Formation.

Currant Bush Limestone

The formation is named after Currant Bush Creek, Longitude 138°49'E, Latitude 19°32'S. Strata of diverse rock types constitute the formation: bituminous flaggy limestone, which predominates; interbeds of pale aphanitic limestone; sporadic shale layers; chert in layers and biscuits; oolitic beds; sporadic interbeds of laminated marly limestone; grey sandy limestone; interformational breccia and even dolomitic limestone. In places the outcrops are covered with a mass of chert fragments leached out of the limestone. About 150 m is exposed in the Currant Bush Creek area. The lowermost part of the formation, of some 18 m, rests on the Thorntonia Limestone at locality M150 (long. 138°56'E, lat. 19°34'S). Dark bituminous shelly limestone (with some phosphate), aphanatic banded limestone, and intra-formational breccia are exposed; no shale attributable to the Inca Formation is present. West of locality M150, the same sequence is present at locality M176 (a sinkhole), but with some 3 m of shale (Inca Formation). The large middle part of the formation consisting of flaggy bituminous limestone with chert, and interbeds of aphanitic limestone is exposed in the ribbed pediments and low bastions around locality M64 (some 13 km southwest of Thorntonia; longitude 138°52'E, latitude 19°32'S). The uppermost part is exposed around a butte about 18-20 m high, at locality M130. It consists of grey bituminous limestone topped by a siliceous shale with chert biscuits - the uppermost stratum of the Currant Bush Limestone; on it rests a thin layer of iron ore with several species of V-Creek trilobites. The butte is crowned by red sandstone of the Split Rock Sandstone.

Intertonguing connects the Currant Bush Limestone with the larger part of the Age Creek Formation. The contact of the Currant Bush Limestone with the Inca Formation is diachronous (Öpik, 1954; 1960): the contact dips northward resulting in the complete elimination of the Currant Bush Limestone in the Mount Isa area. Nevertheless in individual sections Currant Bush Limestone rests above the Inca Formation.

Inca Formation

The lithological composition of the Inca Formation is summarized in Table 2.

The formation was named after Inca Creek, longitude 138°54'E, latitude 20°00'S. It crops out on the low slopes of the creek valley over a distance of some 20 km. The formation covers a larger area in the Mount Isa Sheet area than in the Camooweal Sheet area. In the Camooweal Sheet area it increases in thickness southwards. It is absent in the north, except for erratic lenses below the Currant Bush Limestone; a 3 m lense of shale with some chert occurs in a sinkhole at locality M176; at locality M412, west of Thorntonia, rocks of the Inca Formation are mostly covered by rubble, and are remarkable for the occurrence of polymerid trilobites, which also occur in the Currant Bush Limestone, but never in the rest of the Inca Formation farther south. In a cluster of buttes at Gum Lagoon at locality M149 about 11 km south from Thorntonia some 20 m of shale of the Inca Formation rests on the Thorntonia Limestone. South of latitude 19°36'S strata of the Inca Formation are developed as a coherent sheet, about 30 m thick in the butte at locality M144 and some 60 m thick on Inca Creek. In this part of the formation the sequence carries a number of scattered limestone lentils and layers of chert (spongiolite). In the butte at locality M169, some 34 km south of Thorntonia and about 22 km north of Inca Creek, a 3 m-thick limestone bed occurs in lateritic shale; the laterization has circumvened this limestone. In the subsurface south of the Bagoor Plateau, the Inca shale is petroliferous (Shepherd, 1945).

Fossils indicate that the Inca Formation and the Currant Bush Limestone were deposited in different marine environments. In both formations pelagic agnostids of the same genera and species are present; the Inca rocks, however, are devoid of other trilobites. Currant Bush Limestone contains a diversified population of pliomerid trilobites. Consequently, only pelagic animals could live in the Inca seaways whose waters were inhospitable to life. The water in which Currant Bush Limestone was deposited was able to support all kinds of life at any depth and place.

Beetle Creek Formation

The name of the formation has been derived from a locality in the Mount Isa area (Öpik, 1960; Öpik, Carter & Noakes, 1961). In the Camooweal area rocks of this formation (shale, siltstone and chert) crop out in several sites along the southern edge of the Cambrian, and in minor outliers in the Paradise Area Valley, (de Keyser, 1968). At locality M61 (long. 138°55'E; lat. 19°47'S) the sequence rests on a conglomerate 12 m thick. At M267 (longitude 138°58', latitude 19°55') in the bed of Dingo Creek a sequence of shale with chert and fine grained sandstone is exposed. It appears that the Beetle Creek strata and the Thorntonia Limestone, being synchronous deposits, replace each other in space. The most southern outcrops of the Thorntonia Limestone disappear at localities M149 and M146 (latitude 19°38') and the northern most outcrop of the Beetle Creek, some 13 km southward, is locality M175 at the Deep Creek fault.

Thorntonia Limestone

The Thorntonia Limestone was named after Thorntonia homestead. Formal use of this name was introduced by Öpik (1956, 1957). The stratigraphic concept, however, is attributable to the work of Whitehouse (op. cit., p.3). The formation consists of dolomitic limestone and limestone; chert concretions are abundant, constituting in places more than half of the volume of strata, as for example in the escarpment at locality M101, at the entrance to the canyon of the Gregory River. In the same place limestone and even bituminous limestone is present in the lower part of the section, which itself is some 30 m thick. The topography at the site consists of rough hills, and the sequence is some 40 m thick; the lower part, exposed in isolated pillars on the river bank, consists of a shale with a conglomerate at its base. In the bed of the river, however, remnants of the Cretaceous Polland Waterhole Share are exposed.

The lower part of the Thorntonia Limestone in the whole of its distribution area consists of the 'Girvanella pudding'; Girvanella, a globular calcareous algae is very abundant, and is a major constituent of the rock; the algal globes are often silicified as well as dolomitized.

The contact of the Thorntonia Limestone against the basement, in the unconformity at locality M94, is illustrated in Figure 5.

The contact with the Current Bush Limestone (at loc.M150) or the Inca Formation (loc. M149) is well defined lithologically. The boundary of the Thorntonia Limestone against the Age Creek Formation above, as shown on the map, has been interpolated with the aid of aerial photographs, with the result that some of the marginal outcrops of the Thorntonia sequence became included in the basal part of the Age Creek Formation, as for example locality M73; it is, presumably, an inlier exposed in the lenses of a canyon. The most western occurrence of Girvanella is locality M358 (at the western fringe of the Ada Wing); the Girvanella bed is included here in the Age Creek Formation. The western limit of the Girvanella puddings of the Thorntonia Limestone against the Camooweal Dolomite has been interpreted from aerial photographs. In Morstone No. 1 Well a phanerocrystalline limestone with chert, between 250 and 285 m represents the Thorntonia Limestone (Gatehouse, 1963; Gilbert-Tomlinson, 1963). The relationship of the Thorntonia Limestone with the Beetle Creek Formation is discussed below.

Camooweal Dolomite

The lithological composition of the Camooweal dolomite is given in Table 2 together with data regarding its thickness; the ground water supply is described in the chapter on Water Resources. Its geological age is discussed and references to recent papers are given, under the heading 'Amendments to the legend of the map'. Vertical sections of the dolomite occur in the canyon of the Goonoma Creek (localities M50A and M51) with thicknesses up to 30 m; some sections are also accessible in the sinkholes east of Camooweal.

It is still a possibility that within the area attributed to the Camooweal Dolomite and covered by the 'black soil' rocks of a different composition and age from Camooweal Dolomite may be present.

Unnamed clastics

The unnamed clastics (see Table 2) below the 335 m level (1100 ft) in the Morstone No. 1 Well (Stewart & Hoyling, 1963) are unaltered and even friable and only slightly deformed; Steward and Hoyling regard them tentatively as Proterozoic, and Öpik as Lower Cambrian.

AMENDMENTS TO MAP LEGEND

In Table 2, information is included that became available during the decade following the preparation of the map and its legend. The legend is therefore in need of amendment.

Laterite: In the legend Laterite is included in the Cainozoic, but it is known to have existed since Upper Cretaceous time.

Tertiary: According to Lloyd (pers. comm.) and Tedford (pers. comm.) the age of the Carl Creek Limestone is late Oligocene to early Miocene.

Mesozoic: Skwarko (1965) suggests an early Cretaceous age for the plant-bearing sandstone shown as Upper Jurassic? in the legend. I prefer the general form in the legend because the flora has not been described, and it represents a vegetation that existed for a long time on the pre-Cretaceous land.

Middle Cambrian: The Age Creek Formation is shown in the legend resting above the Currant Bush Limestone. However, palaeontological evidence shows that it is synchronous with the sequence beginning with the Beetle Creek Formation and ending with the V-Creek Limestone. The middle part of the Age Creek Formation is of the same age as the Currant Bush Limestone. The evidence is palaeontological.

Camooweal Dolomite: In the legend the phrase 'or Upper Proterozoic' must be deleted because Johnson, Nichols and Bell (1964) recorded a '*Lingula* sp.' (presumably *Lingulella*) at a depth of 1195-1272 feet in the core of BMR No. 11 Well; the Prozoic age of the sequence is thus established. As shown in Table 2, the age of the Camooweal Dolomite is 'Ordian (= early Middle Cambrian) passing into Lower Cambrian'. The Ordian is a stage introduced by Öpik (1967), and in terms of Australian stratigraphy is lowermost Middle Cambrian. Another standard which became popular in the Soviet Union and France regards the temporal equivalents of the Ordian as the uppermost Lower Cambrian. Fossils recently discovered in wells (Traves & Wolf, 1963; Jones & Gatehouse, 1963; Johnson, Nichols, & Bell, 1964) in upper portions of the Camooweal Dolomite, down to 70 m (Johnson et al., op. cit.) and on the surface (the Ranken Limestone of Öpik, 1956) (see also Randal & Brown, 1962) are Ordian. A trilobite was also found in the Camooweal Sheet area on Labortion Creek (G.A. Brown, pers. comm.) belonging to the genus *Parapollilla* which, according to the standard of the Soviet Union, is Lower Cambrian, but in Australian terms Ordian. The extrapolation of the Ordian age down the sequence being unsafe the lower part of the Camooweal Dolomite is presumably Lower Cambrian (in terms of any standard). The fauna of the lower part of the Thorntonia Limestone, with *Redlichia* is late Ordian passing upwards into Middle Cambrian (in everybody's sense).

Changes in the position of homesteads and roads

After completion of the map the position of Morstone homestead was moved from the O'Shannassy River to its present site at the A-Bore on Frith Creek; the old site is referred to in these notes as 'Morstone' (ruins on O'Shannassy); in the literature Morstone refers to the old site.

The position of the main road from Camooweal to Burketown via Thorntonia was also changed; on the map it refers to the position up to October 1960.

The position of the lead deposit at locality M414 shown on the map is approximate, the error being 00°1' of latitude and longitude; the co-ordinates are 138°16.75'E and 19°37'S (M.A. Randal, pers. comm.).

STRUCTURE

Orogenic plication, igneous activity, and metamorphism are absent in the Sheet area. Epeirogenetic movements causing uplifts and subsidences are discussed in the history of the land surface. Subsidence of the Undilla Basin in the Middle Cambrian was epeirogenetic. The two diagrammatic sections on the map are based on the attitude of the strata on the surface, and on the thickness of the Age Creek Formation in excess of 1200 m along the O'Shannessy River, (Agus Creek) and Ada Creek (Randal and Brown, 1962), and decreasing to the south and east southeast, where it peters out at the Redbank Bore, close to Battle Creek (loc. MY19). The deepest part of the Undilla Basin probably lies some 6 to 7 km south of Morstone (ruins on O'Shannassy) but the thickness of the rocks in it remains a matter of further enquiry. A seismic survey was conducted in the area and Robertson (1963) states that 'it is possible to conclude with reasonable certainty that the maximum thickness of the Cambrian limestone sequence in the Undilla Basin is about 1350 m'.

The topography of the floor of the basin is unknown, but by analogy with the Mount Isa area, a hilly landscape should be expected. The Morstone No. 1 Well (Stewart and Hoyling, 1963) penetrated at 33 m an unconformity below the Middle Cambrian sequence, about 8 km south from the inferred deepest part of the basin. It may be the crest of a hill, or ridge of basement buried under the Middle Cambrian strata.

During sedimentation gravitational sliding in several places and on several levels resulted in slumping. The largest slumped area, in the V-Creek Limestone sequence, is east of Harris Creek, longitude 138°46'. Minor faulting occurred also during the Middle Cambrian, and local hiatuses, and intraformational breccias are apparent at localities M130, M150 and M176.

Some faults cut through the whole of the Middle Cambrian sequence, and are therefore post-Cambrian and pre-Cretaceous. Of these faults the largest is that on Deep Creek (longitude 138°55' and latitude 19°47') and some 25 km to the south of the map. The Middle Cambrian sequence is displaced in a syncline against the conglomerate resting below the Beetle Creek strata (locality M175). The 'Timberline fault' south of Morstone is of a similar age; it is so named because it separates the grassland south of the fault from the savannah and forest to the north.

Post-Cretaceous structures are present but insignificant. Rare fractures and failures, having a ferruginous and opaline gouge, and draping (flexures) of Polland Waterhole Shale over edges of Split Rock Sandstone inliers have been recognised.

LOCALITIES REFERRED TO IN THE TEXT

On the map the localities are marked with a cross (X) and a number in red ink. In the text the letter 'M' is the symbol used in the card catalogue designating the sites of the region.

In the list that follows reference is given to headings under which the particular sites are discussed, or mentioned.

M1	Mail Change Limestone
M6	Age Creek Formation
M14	Age Creek Formation
M34	Age Creek Formation
M35	Age Creek Formation
M36	Mesozoic
M37	Mesozoic
M41	Geomorphology (Bagoor Plateau)
M50A	Camooweal Dolomite
M51	Camooweal Dolomite
M64	Currant Bush Limestone
M65	V-Creek Limestone
M71	V-Creek Limestone
M73	Thorntonia Limestone
M84	History of the land surface; Mesozoic
M85	Mesozoic
M88	Mesozoic
M94	Thorntonia Limestone; Text figure 4
M95	Geomorphology (Canyon Country); Mesozoic, undifferentiated
M98	Geomorphology
M101	Thorntonia Limestone
M115	Geomorphology (Canyon Country)
M117	V-Creek Limestone
M130	Geomorphology. Prozoic structures; Currant Bush Limestone; V-Creek Limestone
M114	Inca Formation
M146	Beetle Creek Formation
M149	Inca Formation; Beetle Creek Formation; Thorntonia Limestone
M150	Prozoic structures; Currant Bush Limestone; Thorntonia Limestone
M155	Age Creek Formation
M156	Age Creek Formation
M160	Age Creek Formation
M175	Prozoic structures; Beetle Creek Formation
M176	Currant Bush Limestone; Inca Formation Prozoic Structures; Karst
M178	Thorntonia Formation; Geomorphology (Canyon Country)
M267	Beetle Creek Formation
M299	Split Rock Sandstone
M306	Age Creek Formation
M324	Age Creek Formation
M325	Age Creek Formation
M358	Thorntonia Formation
M409	V-Creek Limestone
M410	V-Creek Limestone; Magenta Plain
M411	V-Creek Limestone
M412	Inca Formation
M413	Mail Change Limestone; V-Creek Limestone
M414	'Change in the position etc'
M417	Split Rock Sandstone
M419	Prozoic Structure

WATER RESOURCES

The Camooweal Sheet area receives an annual rainfall of 380 mm in the southwest ranging to over 500 mm in the northeast. The central and western parts of the area contain good cattle-grazing lands, but the industry is hampered by inadequate surface water caused by the low seasonal rainfall and the high evaporation (annual evaporation in the Ranken Sheet area to the west is greater than 1.5 m). The downs country in the west is the best grazing area, but because of the low relief there are few features to provide many permanent billabongs. Consequently the cattle industry is dependent on the availability of groundwater. Figure 6 shows subdivisions of the area based on the availability of surface water and groundwater.

In the north and northwest of province I carbonate rocks of the Thorntonia Limestone and the Camooweal Dolomite are extensively dissected by numerous rocky water-courses, which in places have deeply incised themselves, thus forming a large area of canyon topography. The major water courses - the Gregory and O'Shannassy Rivers - are perennial in their lower courses, although late in the dry season the flow is small and in severe drought years may cease for a few weeks. The streams are fed by numerous springs issuing from joints, fissures, and porous rocks in the canyon walls; in places the springs are hidden by large billabongs. All the streams contain large deep permanent waterholes. Few bores are located in this canyon area as the surface water is adequate for the few head of stock: the country is very rugged and difficult for stock work, and the rocky ground provides only sparse feed. However, near Thorntonia homestead surface waters are inadequate or unreliable because of the low accumulated run-off in the upper reaches of the Thorntonia River and the concentration of cattle in the less rugged parts of the holding. Five bores on Thorntonia station obtain water from the Thorntonia Limestone at depths between 30 and 40 m; supplies are fair and the water is sub-artesian.

The western and southwestern part of the Camooweal Sheet area (Province II) consists of gently rolling downs of Mitchell and Flinders grass on black soil developed over the Camooweal Dolomite. It contains the best cattle-grazing land of the entire Sheet area, but because of the low relief, permanent waterholes are few, and though large, are inadequate for the large stock population in the area. Twenty-one working bores occur in this area, and provide good supplies ranging from 1.88 to 3.75. Most bores are sub-artesian and obtain water from fissures and cavities in the Camooweal Dolomite at depths between 55 and 110 m.

It appears that bores in the Camooweal Dolomite are reasonably certain of success; however, since the depth and efficiency of an aquifer are controlled by the occurrence of fissures in the dolomite or by sandy lenses contained in it, the risk of missing an aquifer, though slight, is always present. A bore northwest of Morstone homestead was drilled to about 300 m and it was reported to be completely dry; the site was moved 5 km north onto the headwaters of Nankivel Creek and there the bore provides a good supply from an unknown depth. It is uncertain if a dry bore on Bauhinia Creek was drilled in Camooweal Dolomite or the Age Creek Formation. No unsuccessful bores are definitely known in the Camooweal Dolomite on the adjoining Ranken Sheet area.

Province III, in the central part of the Sheet area, is approximately co-extensive with the exposed part of the Undilla Basin, and is generally dificient in water. Province IIIa contains the dissected rocks of the Age Creek Formation and some grassy downs developed over these rocks. The outcrops of the Age Creek Formation are rugged, and like the canyon areas to the north are little used for grazing; permanent and semi-permanent water-holes are in places spring fed and are just adequate for stock purposes. However, the grassy down developed in the southern part of this area are good grazing, but are poor in both surface and sub-surface water. Four bores drilled in this area provided little or no supply.

Province IIIb, though largely stony and hilly, contains large expanses of grassy downs well suited for grazing, but like Province IIIa, it is deficient in both surface and sub-surface waters. Permanent water holes are few since the streams are not well entrenched in their upper reaches. Four bores (up to 180 m deep) in the area were abandoned because of inadequate supply. A few wells were constructed but have also been abandoned, presumably because of inadequate supply. The only working bore in this area is Wim Well, which supplies less than 0.68 from between 45 and 90 m in the Currant Bush Limestone. Bull Creek Bore also in the Currant Bush Limestone, provided about 0.89 l/s but was abandoned, presumably because the supply was considered inadequate. Wooroona Bore on the Barkly Highway is in a geologically similar area; it supplies only 1.25 l/s from a depth between 130 and 188 m.

No bores have been drilled in the Cretaceous rocks (Province IV) in the southern part of the Sheet area; consequently, its groundwater resources are unknown. The rock is mainly a silicified shale but local sandy beds may provide restricted supplies. The thickness of the Cretaceous rocks is probably not large and if water is not obtained within the shale or at the unconformity with the Cambrian rocks, water might be available in the Cambrian rocks themselves. However, the Cambrian sequence here is similar to the outcropping Cambrian to the north (Province III) which has yielded only poor supplies and contains many unsuccessful bores. The western outcrop of the Cretaceous rocks is underlain by the Camooweal Dolomite; bores drilled to below the unconformity will probably obtain good supplies from cavities and fissures in the dolomite.

The area of Cretaceous rocks contains few streams, but a number of rock-holes (notably Pollards, east of Wooroona Bore) contain some water for most of the year. The catchment is restricted, however, and the holes may dry up in drought years. Waterholes occur in the upper reaches of the O'Shannassy River in Plain Creek.

The eastern part of the Camooweal Sheet area (Province V) contains the folded and sheared rocks of the Precambrian Shield area of Mount Isa. The area contains permanent and semi-permanent waterholes. One bore on Thorntonia station provides adequate supplies of the sub-artesian water from a depth of 40 m in the Ploughed Mountain Beds. Groundwater supplies in this area could be obtained from shallow wells or spears in the alluvium along the major watercourses. Bores and wells might obtain local supplies from cleavage planes, fissures, fractures, joints, and bedding planes in the folded Precambrian rocks. Supplies in this area will probably be less than 0.68 l/s and may be unreliable in times of drought.

There is little information available concerning the relationship of the groundwater of the Camooweal Sheet area to that on the Barkly Tableland to the west. Inadequate levelling has prevented the construction of piezometric contours which may indicate the direction of groundwater flow. It is not known if the groundwater of the Camooweal Sheet area is contained in the one system or in several independent systems. Anomalous values for the standing water levels in Province III and the generally poor supplies in this area suggest it may be an independent system sealed off from the western areas by some geological cause such as a change in lithology producing a change in porosity and transmissibility. The little available data in the western part suggests that the groundwater flow conforms to the pattern established in the west on the Barkly Tableland. In the eastern parts of the Ranken and Avon Downs Sheet area groundwater flow appears to coincide with surface drainage i.e. along the Georgina River (Randal, 1962). More recent work (Randal, in prep.) indicates an additional direction of flow towards the Gulf Drainage System with a high in the piezometric surface corresponding to the surface divide between the inland waters and the streams flowing to the north; this high probably continues eastwards into the Camooweal Sheet area.

The quality of the water in the Camooweal Sheet area is variable but in the main is fit for human consumption. No detailed analyses are available but future studies of water quality and supplies on the Barkly Tableland will probably extend into the Camooweal Sheet area (Randal, in prep.).

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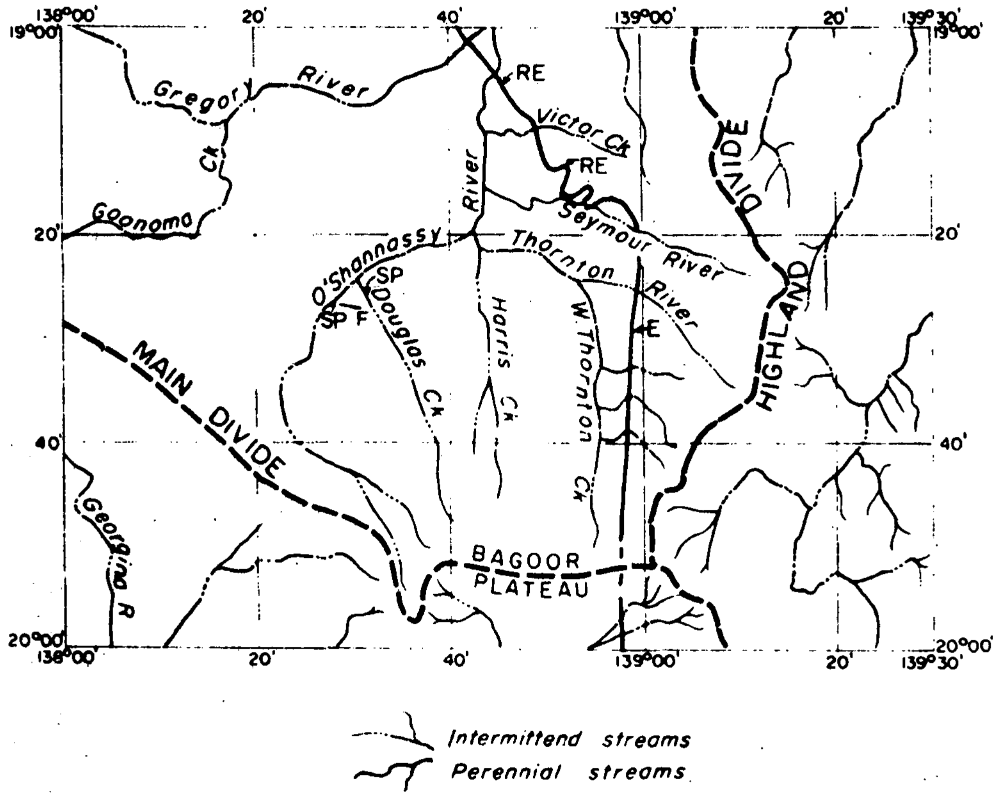

Figure 1: Drainage, Camooweal 4-mile sheet F- fault; Sp- springs; RE- Riversleigh Escarpment (eastern edge of the Cambrian); E- eastern edge of the Cambrian (low relief).

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To accompany Record 1973/83

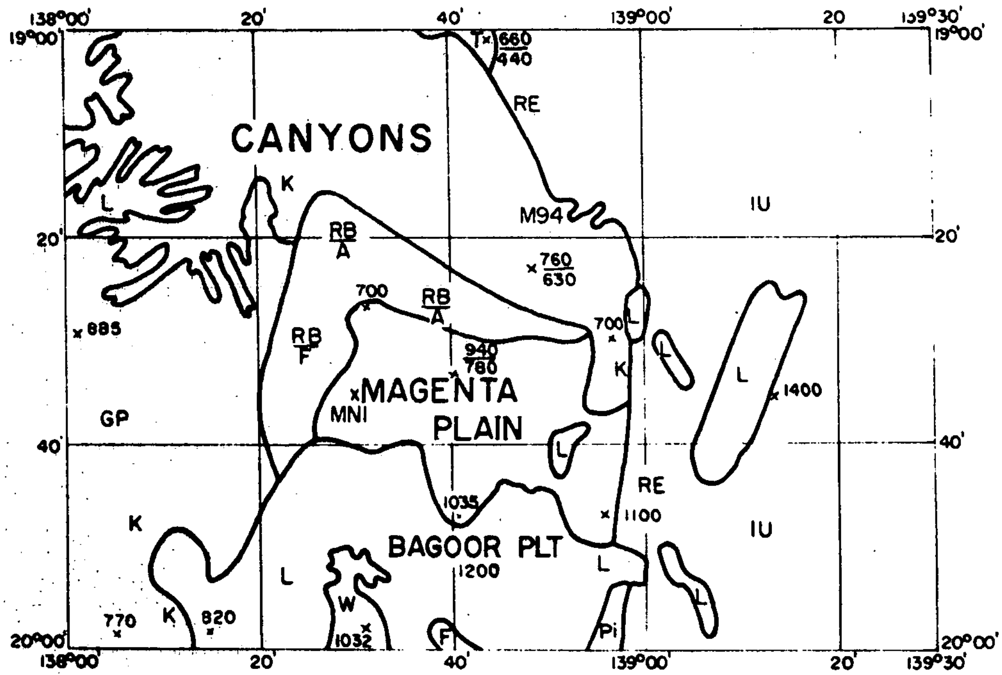

Figure 2: Geomorphological divisions, Camooweal 4-mile sheet. IH- Mount Isa Highlands; L- plateaus, mesas and residual Cretaceous; GP- Georgina River Plain; RB- the ribbed country; RB/ F- Frith Way; RBA- Ada Wings; F- Forty Mile Plain; W- Wooroona Plain; Pi- Pilpha inliers; K- Karst; RE- Riversleigh Escarpment; T- Tertiary limestone; Altitudes (e.g. 885) in feet; two figures (e g. 940/780) are altitudes of pediment and summit at the same feature; MNI- Morstone No. 1 Well

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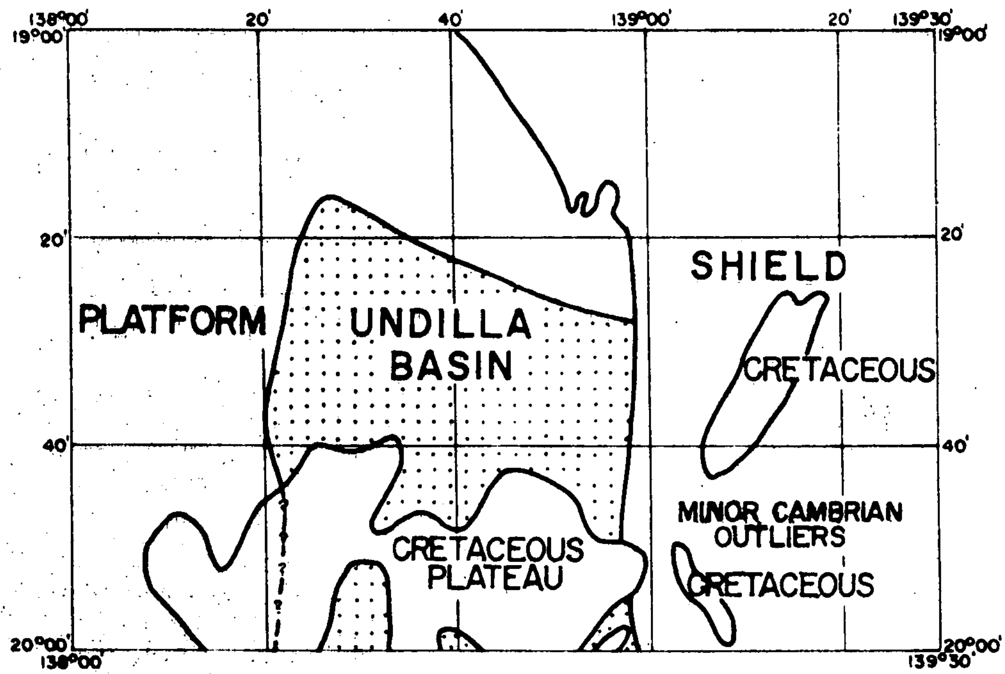

Figure 3: Major structural divisions, Camooweal 4-mile sheet. The queried(?) line indicates the inferred sub-Cretaceous limit of the Undilla Basin. The minor Cambrian outliers are not shown on the diagram

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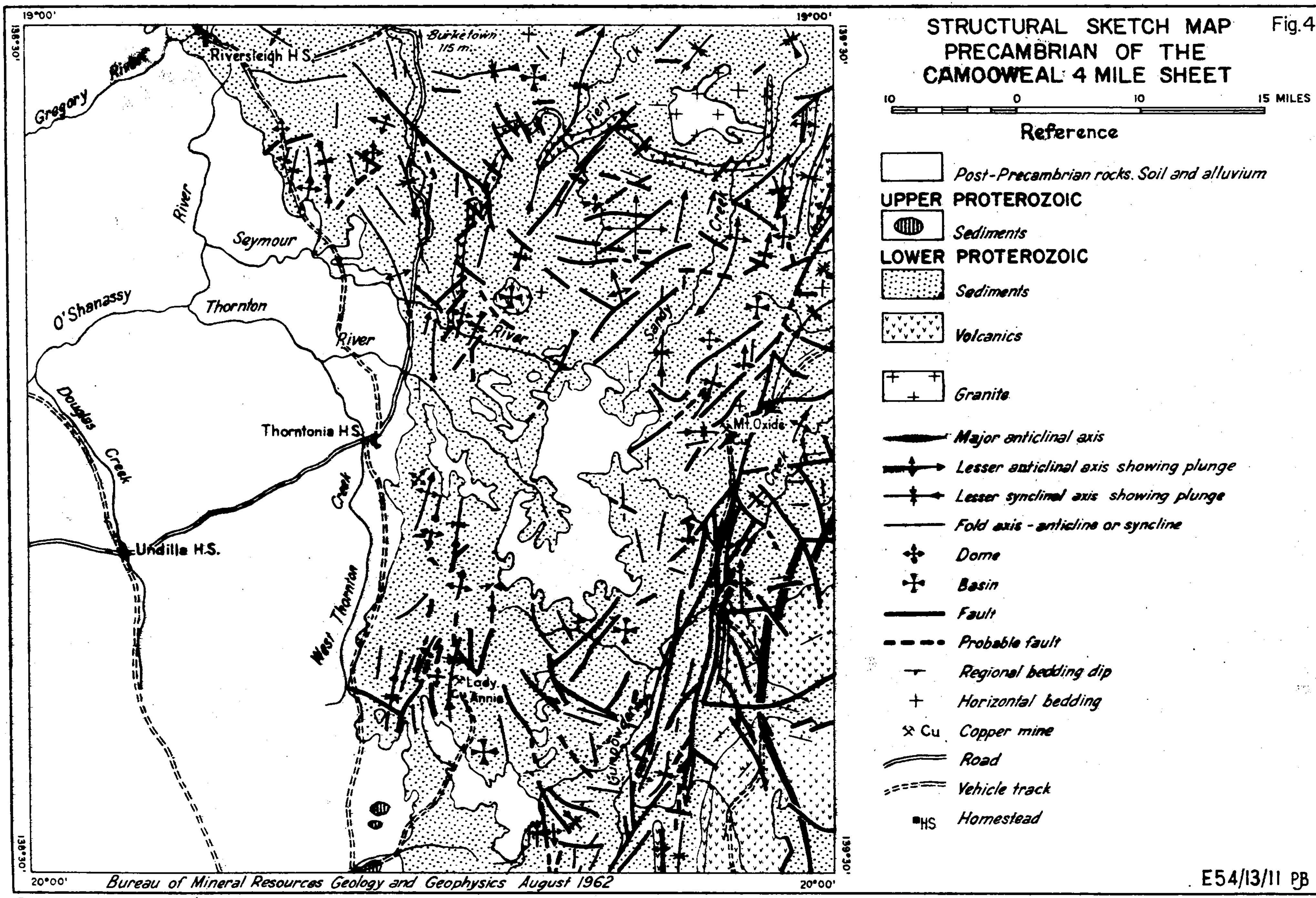

To accompany Record 1973/83

Figure 5: The unconformity in the Riversleigh Escarpment at the Seymour River, locality M94 (See text-fig.2).
Top: the lowermost part of the horizontal Thorntonian Limestone (dolomitic), about three to four feet high, gritty and with a pebble conglomerate at its base Below the unconformity: Lower Proterozoic Ploughed Mountain Beds, dipping 60 degrees northeast.

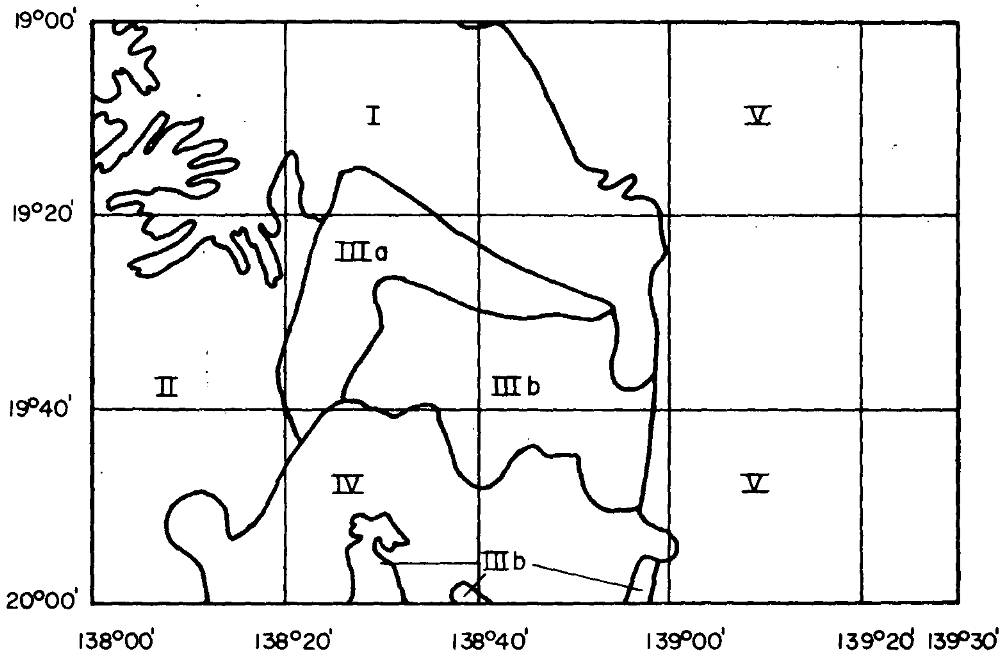

Fig.6

WATER PROVINCES —— CAMOOWEAL AREA

To accompany Record 1973/83

E54/A13/24

TABLE 1 STRATIGRAPHY OF THE CAMOOWEAL 4-MILE SHEET AREA - PRECAMBRIAN

System	Series	Rock Unit	Position in the Sequence-Distribution	Lithology	Thickness (m)	Topography	Structure	Correlations and fossils	Underground Water	Mineral Deposits
PRECAMBRIAN	UPPER PROTEROZOIC	Pilpah Sandstone	Unconformably below Camooweal Dolomite; unconformably above Lower Prot. units. Extreme S centre of Sheet. Mt Isa and Urandangi Sheets	Medium-grained quartz sandstone and conglomerate	300?	Hilly, fair relief	Some dips exceed 40°, folding irregular, faulted	Possibly equivalent to Constance Sandstone	Poor supplies	None
		U N C O N F O R M I T Y - GRANITE INTRUSION								
	LOWER PROTEROZOIC	Lawn Hill Formation	Conformably(?) above Ploughed Mountain Beds. Overlain with major unconformity by Upper Proterozoic Constance Sandstone (Lawn Hill Sheet). One square mile centre of N margin of Sheet. Centre Lawn Hill Sheet	Siltstone on Camooweal Sheet; elsewhere included sandstone, shale, aphanitic volcanics	600-1500	Generally low relief, poor exposure; some low hills on Lawn Hill Sheet	Strongly folded and faulted	-	Poor; local supplies available	Cooper, uranium (no economic deposits in Sheet area). Other metals elsewhere
		Paradise Ck. Formation	Unconformably under Pilpah SS (Mt Isa Sheet); conformably over Gunpowder Ck F. SE of Sheet, NE of Mt Isa Sheet	Dolomite, siltstone, shale, sandstone, some carbonaceous slate	3000-4500?	Generally hilly, fair to moderate relief	Irregularly strongly folded, faulted	Upper Suprise Ck and Ploughed Mountain Beds, possibly upper Mt Isa Shale. Extensive stromatolites	Poor; obtainable in favourable localities	Copper
		Gunpowder Ck Formation	Conformably under Paradise Ck F., local unconformity with Myally Beds. SE of Sheet NE of Mt Isa Sheet	Siltstone, shale, sandstone, some dolomite	600?	•	•	Lower Surprise Ck and Ploughed Mtn Beds; ?Mt Isa Shale	•	•
		Surprise Ck Beds	Conformably above Myally and Judenan Beds. Extreme E of Sheet; Mt Isa, Dobbyn and Cloncurry Sheets	Siltstone, sandstone, dolomite	6000? Unknown in Sheet area	Moderate to strong relief; strike ridges	Strong N-S folding; faulted	Ploughed Mtn Beds; Paradise Ck and Gunpowder Ck F's jointly; Partly with Mingera Beds and Mt Isa Shale	•	Sparse gold and copper on other Sheets
		Ploughed Mtn Beds	Conformably(?) under Lawn Hill F, overlies Myally Beds with local unconformity. NE of Sheet; Lawn Hill and Dobbyn Sheets	Impure araneous beds, dolomite, siltstone	300-4500	Strong to moderate relief; strike ridges	Irregularly strongly folded; faulted	As for Surprise Creek Beds	•	Some copper, possibly lead-zinc
		L O C A L U N C O N F O R M I T Y - Probable Granite Intrusion								
		Judenan Beds	Conformably above Eastern Ck Volcanics. Local unconformity with Gunpowder Creek F. SE of Sheet, E Mt Isa Sheet	Quartzitic sandstone, siltstone, shale generally impure, some acid tuff	1800+?	Hilly, strong to moderate relief. Strike ridges	Strongly folded; faulted	Myally Beds	Poor; local supplies in joints and faults	Sub-economic deposits of base metals and uranium
		Myally Beds	Local unconformity with Mt Isa Shale and Eastern Ck Volcanics (to E and SE of Camooweal Sheet; conformable in Sheet area). Local unconformity with Ploughed Mountain Beds NE of Sheet. Lawn Hill, Dobbyn and Cloncurry Sheets	Sandstone, quartzite quartz greywacke, siltstone, conglomerate; basic and acid lavas and agglomerate at top of succession	6000+	Very rough hills; strong relief, strike ridges	Strongly folded and faulted	Judenan Beds	Local supplies in bedding, joints and faults	Poorly mineralized Base metals and gold
		Eastern Ck Volcanics	Conformably over Mt Guide Q. (Mt Isa Sheet), disconformably over Argylla F. (Dobbyn Sheet?. Conformably under Judenan and Myally Beds in Sheet area; local unconformity with Myally Beds and Mount Isa Shale (Cloncurry Sheet). SE of Sheet, extends widely to SSE and E of Sheet	Interbedded metabasalt and metasediments - quartzite, slate and epidote quartzite	6000? Unknown in Sheet area	Rough terrain but low relief	Strongly folded and faulted	Marraba Volcs., part Soldiers Cap F. (Cloncurry and Duchess Sheets)	Local supplies available	Copper, uranium (no economic deposits in Sheet area). Other metal elsewhere

TABLE 2. STRATIGRAPHY OF CAMOOWEAL 4-MILE SHEET AREA - PROZOIC

System	Series	Rock Unit Name	Position in the Sequence, Distribution	Lithology	Thickness (m)	Topography	Structure	Correlation & fossils	Underground water	Mineral Deposits
QUATERNARY			Surface deposits (a) on undissected Camooweal Dolomite and locally on Cambrian dolomite and limestone	(a) Heavy pedocalcic soil with gypsum in deeper levels; pebbly surfaces locally	(a) Up to 3 m	(a) Plain, prairie; locally savannah	Horizontal unconsol-idated	(a) Age: recent soil, but originated in Tertiary, and possibly initiated in late Cretaceous in the course of stripping of Lower Cretaceous cover	(a) impermeable	
			(b) Stream channels, valleys, flood plains, derived from local rocks	(b) Alluvial sandy and pebbly soil; alluvial sand and gravel; red sand dunes on eastern part of Bagoar Plateau	(b) Up to 6 m in stream banks	Savannah; flood plains with tall forrest	Horizontal, unconsolidated	(b) Age: recent and sub-recent	(b) Small supply intermittent	
			Surfaces of progressing erosion 4: bald outcrops of substratum widespread (exhumed pre-Cretaceous relief) Cretaceous cappings diminishing in size and numbers							
TERTIARY			Chemically weathered surface of pre-Tertiary parent rock (Polland Waterhole). Shale, silty Upper Jurassic sandstone, and Split Rock Sandstone)	Laterite (ferruginous mottled and pallid zones). Siliceous billy replacing locally the destroyed ferruginous zone; ferruginous siliceous rubble	4.5 m	Plateau with forest; scrubby to bare outliers; pediments (exceptionally)	Topographically subhorizontal	Age of the event of latertization: Tertiary but began in late Cretaceous and probably extends into Recent in the Bagoor Plateau		Road metal quarries along Barkly Highway
			Laterite passes into parent rock; no structural surface intervenes but for change in lithology (buried rocks incapable of lateritization)							
TERTIARY	Early Miocene to late Oligocene	Carl Ck. Limestone	Rests on basement rocks and Thorntonia Limestone; only in the Riversleigh area and extends into the Lawn Hill 4-mile sheet area (Verdon Creek)	Massive and irregularly bedded, white to grey limestone with conglomerate at base; friable chalk on low ground. The conglomerate is ferruginous	42 m in the free face of Tarpeian Rock	Valley fill, mesas and masking the escarpment of Thorntonia Limestone	Horizontal, but rests on a rather uneven relief (130-200 m)	Depositional after the stripping of Lower Cretaceous. Fossils: gastropods, estracods, foraminifera; reptiles, birds, marsupials		
CRETACEOUS	UPPER (LATE)		Surface of progressive erosion; plateaus of Lower Cretaceous sediments; exhumed pediments on the sedimentary superstructure; stripped ridge and valley relief on the shield emerging from under the Lower Cretaceous cover General uplift followed by erosion (stripping) and lateritization. Local fracturing and small scale faulting							
CRETACEOUS	LOWER	Pollard Waterhole Shale	Rests on basement rocks, on Cambrian, on Camooweal Dolomite and sandstone with fossil plants	Siliceous friable shale, white, pale, grey, bluish grey; lateritized on surface. Marine	In excess of 60 m	Plateau and outliers (mesas, buttes)	Horizontal, gently tilted in places; jointing developed; locally small faults	Radiolaria; Lower Cretaceous by analogy with other occurrences		Opal in fractures; not commercial
			Disconformity (erosional break) against the Upper Jurassic; Unconformity against the basement, and the truncated surface of Cambrian rocks. Subsidence indicating the Cretaceous inundation							
JURASSIC	UPPER	Lee's Waterhole Sandstone and several unnamed sandstones	On basement rocks, on Camooweal Dolomite, and on Cambrian; disconnected occurrences of lacustrine deposits, representing several geographically separate rock units	Friable sandstone with silicified slump rolls; interbedded pebble conglomerate; siltstone	Up to 33 m (east of Thorntonia; unnamed)	Rolling surface with boulders; mesas and clusters of mesas	Horizontal; locally slightly tilted	Fossil flora of ferns and conifers; age: Lower Cretaceous to Upper Jurassic		

System	Series	Rock Unit Name	Position in the Sequence, Distribution	Lithology	Thickness (m)	Topography	Structure	Correlation & fossils	Underground water	Remarks
URASSIC?	Upper	Unnamed conglomerate	(a) At 10-mile Waterhole on O'Shannassy and south and south west under laterite and lateritic. Polland Waterhole Shale; Harris Creek/Thornton River interfluves on Thorntonia Limestone; south of Seymour River on Thorntonia Limestone? north-east of Thorntonia Limestone and basement	Conglomerate with sandstone matrix. In the west (O'Shannassey), it is a chert boulder conglomerate, chert derived from Camooweal Dolomite; sandstone pebbles to boulders east of Harris Creek; Precambrian material at Thorntonia	Total not exposed; over 15 m seen east of Thorntonia	Dissected rugged, rolling surface; mesa, buttes and pediment east of Thorntonia	Horizontal; slumping	Age inconclusive; post-Cambrian, and older than sandstone with plants and Polland Waterhole Shale	Soaks (intermittent)	
		Mesozoic undifferentiated	(b) Outliers on Precambrian	Slate, sandstone, conglomerate	Variable (veneer to over 30 m	Mesas	Horizontal	Includes Polland Waterhole Shale, plant sandstone and unnamed conglomerate as above		
			Unconformity as above the Jurassic; geographic distribution of Cambrian outcrops (superstructure) and basement rocks(shield) and relief of the surface the same as in the present time; long interval (from Upper Cambrian to Upper Jurassic)							
RIAN	MIDDLE	Split Rock Sandstone	Rests on Mail Change Limestone, on Age Creek Formation; in the north-east of Undilla Basin on V-Creek Limestone and Currant Bush Limestone; also concealed under Polland Waterhole Shale	Quartzose friable fine grained sandstone with siltstone interbeds; at Split Rock Waterhole calcareous nodules in lowermost beds	Over 30 m in Vooroona Ck exposed; pediments and escarpments fringing the plateau	Mesas, buttes and clusters of hills; inliers, in Bagoar Plateau; pediments and escarpments fringing the plateau	Sub[illegible]izontal, ofte[illegible] tilted and cut by small pre-Mesozoic faults; gently folded in the Bagoor Plateau	Age: just reaching the lowermost Leiopyge laevigata Zone; Nepea Narinosa, Anphoton spinigerum Dorypyge agnostids.	Soaks at the fringes of Bagoor Plateau	
		Mail Change Limestone	Rests on V-Creek Limestone and on parts of Age Creek Formation; peters out in the east	Two-toned mottled lutite limestone; thick bedded; in some places nodular and sandy	About 15 m and less	Level plain; small bastrons when dissected; pediments	Subhorizontal faults as above	Same fauna as Split Rock Sandstone; abundance of Acrothele	Soaks and Springs at its base	Building ston used locally
		V-Creek Limestone AGE CREEK FORMATION	V-Creek Limestone rests on Currant Bush Limestone; interbedded with dolomite of Age Creek Formation. Very thin, or absent at M130, or replaced by siltstone	Impure marly limestone, often nodular, with several harder intervals	33-36 m single sections exposed; may reach 60 m or more	Relief of low bastions, ribbed surfaces (pediment dissected by streams)	Faults as above; dip up to 5°, flattening to horizontal towards Undilla	Ptychagn[illegible]us nathorsti zone and overlap of P. nathorsti and P. punctuosus; Papyriaspis Nepea, Anohoton, Mapania agnostids	Small supply locally	
		Currant Bush Limestone	Interfiner with Age Ck. Formation; rests on Thorntonia Limestone near Thorntonia station, and on Inca Formation in the south	Bituminous, flaggy limestone with chert; oolitic, aphanite and shaly interbeds; marly interbeds. Intraformational breccias, up to 3 m thick	Variable decreasing to south; 30 m in single section; total estimated; over 150 m in the north	Escarpments, low angle cuestas, ribbed surfaces, (pediments); low bastion relief	Faults as above; dips from 2° to 5° toward the basin; reversal of dip locally	Ptychagnostus nathorsti Zone (in Mount Isa area); Ptychagnostus punctuosus Euagnostus opimus Ptychagnostus atavus Ptychagnostus gibbus Zones	No data	
		Inca Formation	Inca Formation rests on Thorntonia Limestone in the north, and on Beetle Creek Formation in the south; gradually replaces Currant Bush Limestone; no contact with Age Creek Formation	Siliceous laminated shale and siltstone with spongiolite chert layers, interbeds of fine-grained sandstone, members (lenses) of limestone. Apparently bitimunous when fresh	Variable 3 m-60 m	Mesas, buttes, rubble covered pediments; creek bands	As above, but often contorted, with brecciated chert layers		None; salt licks on sandstone interbeds	

System	Series	Name	Position in the Sequence Distribution	Lithology	Thickness	Topography	Structure	Correlation and Fossils	Underground Water	Remarks
CAMBRIAN	MIDDLE	Age Creek Formation	Age Creek Formation rests on Thorntonia Limestone and represents the western and northern fringe of the Undilla Basin; interfingers with the limestone sequence of the Basin; See text for relations with Camooweal dolomite	Flaggy to thick bedded sandy dolomite and calcareous dolomite and oolitic limestone; interbeds of fine grained calcareous sandstone (up to 60 m); thick bedded, banded porous dolomite; interbeds (up to 30 m thick) of current bedded detrital dolomite; with chert fragments in places; limestone interbeds (very fossiliferous) up to 15 m thick	Cumulative thickness on O'Shannassey about 1200 m south of M420	Dissected strike ridges; long linear cuestas facing north west and northeast; ribbed pediments; sink-holes and lapiez fields	Dips southeast and southwest commonly 5-12 degrees present; large slumped dolomite bodies; strike faults	Same age as the whole sequence from *Ptychagnostus gibbus* Zone (below) to the top of *P. nathorsti* zone. Lowermost beds west of O'Shannassey are probably equivalents of upper part of Thorntonia Limestone	None to the depth of 270 m (depth of dud bores)	
		Beetle Creek Formation	Not well represented south of Deep Creek, in the minor Cambrian outliers and between Dingo and Inca Creeks. No contact with the Thorntonia Limestone	Siliceous shale with chert, siltstone and fine grained sandstone; rests on conglomerate, or direct on the basement	Preserved is a veneer, 1-5 m thick; at Dingo Creek much more, but base not exposed	Veneer on mes [illegible] valley full at Dingo Creek	Locally contorted and adjusted to Sub-Cambrian relief	*Xystridura* fauna (abundant) the lowermost 1-2 feet with *Redlichia*; contemporaneous with the upper half of Thorntonia Limestone		
	Passing below into Ordian (Earliest Middle Cambrian)	Thorntonia Limestone	North of Deep Creek, rests on basement; overlain by Inca Formation, and in the north by Currant Bush Limestone and Age Creek Formation	Dolomitic limestone with chert; grey shaly limestone; surface silicification of rock and fossils	33 m seen in Riversleigh escarpment; total over 75 m (bores)	Canyon country with hilly rough inter-fluvia; cliffs, escarpments. Sinkholes	Dips along Riversleigh escarpment 2-3 degrees west; at Thorntonia up to 5 degrees. Strongly jointed	Same age as Beetle Creek Formation. (*Xystridura* above, *Redlichia* below); its lower part is developed to a great extent as *Girvanella* 'puddings'	Numerous springs ample supply of bore water	
			Unconformity against the Precambrian; classical outcrop at Seymour River where the hiatus covers the lower part of the Middle Cambrian, the Lower Cambrian and a part of the Upper Proterozoic sequence							
	Ordian (Earliest Middle Cambrian) passing into Lower Cambrian	Camooweal Dolomite	Absent in the Undilla Basin (Morstone No.1 Well); older than the Thorntonia Limestone and its *Girvanella* pudding	Thickbedded laminated dolomite (and subordinate calcareous dolomite) with ribbon stone (chert nodules, stringers and layers); oolitic and pellety dolomite; aphanatic dolomite	240-300 m in bores	Soil covered plain; Canyons in the north	Almost horizontal; regionally dips to west-southwest; the dip is of the order of 1:1000	Sparsely fossiliferous; sphosphatic brachiopods (*Linguella*, *"Acrotreta"*) rather rare, but through out the section in some bores; trilobite remains in chert (on surface) indicate a late Lower to earliest Middle Cambrian age of the upper part of sequence	Good supply	Galena, insignificant deposit
	Lower Cambrian or Proterozoic	Unnamed clastics	Subsurface, in Morstone No. 1 Well; unconformably overlain by the Thorntonia Limestone at about 335 m below surface	Claystone, siltstone, shale - with glauconitic layers; sandstone	430 m	-	Shallow dip (5 to 10 degrees) west	None		