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1960/86

LAWN HILL 4-MILE GEOLOGICAL SERIES

SHEET E54-9

EXPLANATORY NOTES

Compiled by E.K. Carter and A.A. Öpik

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GEOLOGICAL INVESTIGATIONS

Observations on the geology of the Lawn Hill Sheet area were made by the explorers Landsborough (1862) and Hodgkinson (1877). In 1881 Jack (1885) made numerous and detailed observations.

Cameron (1900) reported on the Lawn Hill silver-lead-zinc field, the first leases on which had been taken up by F.H. Hann of Lawn Hill station in 1887. (Ball (1911) stated that geologist R.A.F. Murray visited the field in 1898 and reported on it. The report apparently was not published and was not available to him.) Cameron also recorded the unconformity between the mineral-bearing strata and the overlying sediments of the Constance Range and the "Dentalium Plateau". The next report on the area was that of Ball (1911), who described the lodes and workings of the Lawn Hill field in considerable detail and also dealt briefly with the geology of the surrounding country. Ball was misled, by incorrect identification of fossils, into believing that the "Dentalium Plateau" (Middle Cambrian) and the "limestones of the Constance Range" (Middle Cambrian, and older), were post-Tertiary. He recorded igneous rocks 20 miles east of the Lawn Hill field, at Mounts Kay and Stawell.

Dunstan (1920) visited the area in the course of a reconnaissance of a wide area of north-western Queensland. Several later inspections of the Lawn Hill deposits were made, but field work did not extend greatly beyond the mineralized area until a party of Aerial, Geological and Geophysical Survey of North Australia geologists, under the leadership of H.I. Jensen, mapped the northern part of the field and northwards to Wollogorang Homestead, 60 miles north of the Nicholson River, in 1939 and 1940 (see A.G.G.S.N.A. 1940a and b, and Jensen, 1941a and b). S.R.L. Shepherd, during an inspection of the field about 1930, recognized that the "Dentalium Plateau" strata are Cambrian (see Ball, 1931). Jensen discovered on the Plateau Middle Cambrian fossils but, like previous workers, correlated it with the Constance Range. The northern limit of the Georgina Basin, which contains Cambrian sediments, had previously been fairly accurately delineated by Whitehouse (1936). He failed, however, to recognize the existence of the Cambrian or Upper Proterozoic Camooweal Dolomite.

In 1948 the area was visited in the course of a survey of the Barkly region, by a land utilization survey team from the Land Research and Regional Survey section of the Commonwealth Scientific and Industrial Research Organization. The geology was reported upon by Noakes and Traves (1954) and the geomorphology by Stewart (1954).

The present map is based on work carried out in the years 1950-54 by two groups. The Precambrian rocks (other than the Camooweal Dolomite) were mapped by joint Bureau of Mineral Resources and Geological Survey of Queensland teams in 1950 and 1954. The Cambrian rocks and the Camooweal Dolomite were mapped by a Bureau party in 1953 and 1954. The geologists who did the field work are named on the map Sheet. The results of this work will be reported by Carter, Brooks and Walker (in preparation) and by Öpik (in preparation).

Mount Isa Mines Ltd. carried out geochemical and geological work on the Lawn Hill mineralized area in 1954. Extensive deposits of low grade sedimentary iron ore, discovered in the course of the regional survey on which this map and notes are based, are at present being tested by Broken Hill Proprietary Company Ltd. The iron-bearing area was mapped in detail by a joint Bureau of Mineral Resources - Geological Survey of Queensland team in 1958 but the results are not incorporated in the map Sheet.

GEOMORPHOLOGY

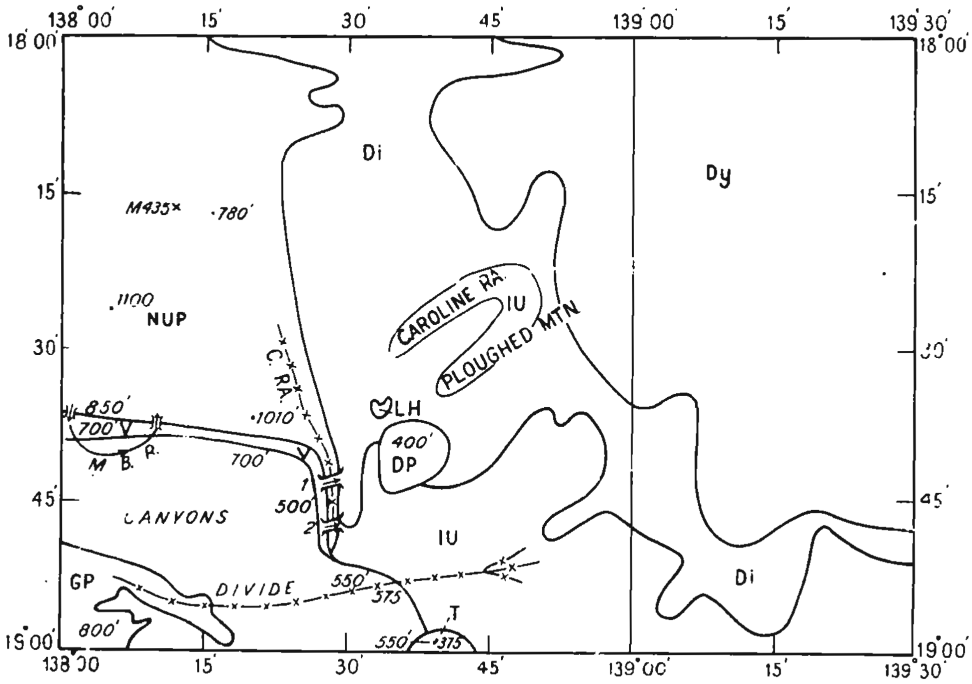
The present surface reflects in the first place the structure and geological history of the region, and in the second place local structures and lithological diversity of the rocks.

Parts of the following regional structural and historical units are present (Fig. 1):

(1) the basement consisting of Precambrian rocks; in the Isa Highlands and in the northern upland it is exposed, and belongs to the shield;

(2) in the south-west Lower Palaeozoic rocks of the Barkly Tableland occur as a superstructure on the basement, and form a platform;

(3) in the north-east the area includes a marginal part of the Great Australian Artesian Basin, known as the Carpentaria Basin. Its rocks are Cretaceous, and outliers of these are present also on the shield and on the platform.



<u>Fig. 1</u>. - Geomorphology Lawn Hill 4-mile sheet. Figures: 575' - altitude in feet; M 435 - marine Lower Cretaceous fossils. Topographic features: CR - Constance Range; "Divide" - divide between Lawn Hill Creek and Gregory River drainage; DP - "Dentalium Plateau" (Cambrian limestone mesa); LH - Lawn Hill (Cambrian limestone mesa); MBR - Musselbrook Creek, with two gorges, and arrows showing stream direction; gorges in Constance Range, 1 - of Lawn Hill Creek, 2 - of Louie Creek, with stream direction. Geomorphological (and topographical) divisions: GP - Georgina River Plain (Barkly Tableland); "Canyons" - dissected slope of Barkly Tableland; Di - Carpentaria Plain, with basement inliers (250' - 350'); Dy - Carpentaria Plain, with inliers (below 250'); IU - Isa Highlands northern hills (summits up to 500'); NUP - northern upland, unnamed; T - Tertiary limestone area, mesa and valley topography; V - fault zone with valley.

Figure 1 indicates the broad outlines of the topography and geomorphology: a lowland in the north-east, and uplands in the west and south. The altitudes given were obtained by estimation (1100' on NUP and 500' at the gorges 1 and 2), survey data from a datum established by aircraft altimeter (1010' and 700' on opposed sides of the valley V) and the rest by aneroid barometers.

The broad divisions are (1) the Carpentaria Plain (Twidale, 1956a, b), (2) the Isa Highlands (Twidale, 1956a, b), (3) the northern upland (unnamed), (4) the Barkly Tableland and its dissected slope, and (5) the valley and mesa division with the Tertiary limestone. Stewart (1954) has given a broader division of the area, as part of the Barkly Tableland and surrounds.

The surface of the Carpentaria Plain is essentially depositional, with an alluvial cover, braided stream channels, and an even slope towards the Gulf of Carpentaria. Its substratum consists of Mesozoic (Cretaceous), and probably Tertiary deposits; the presence of Tertiary deposits is indicated by lateritic material on the surface, and in the soil.

The plain is divisible into two parts: one below 250 feet (estimated), without basement inliers (Twidale's Wondoola Plain), and the other (Cloncurry Plain), between 375 and 250 feet, with inliers of basement rocks. The summits of these inliers may reach 500 feet. The inliers can be regarded as buried foothills of the uplands. According to Twidale, the Cloncurry Plain is generally a piedmont plain of erosion, with an essentially stripped or exhumed surface. In the Lawn Hill Sheet area the Isa Highlands plunge towards the depression of the Gulf of Carpentaria, which justifies the description "buried foothills" for this part of the Cloncurry Plain.

The Isa Highlands in the Sheet area have summits up to 700 feet. The topography, already described by Ball (1911), is homoclinal ridges and hogbacks, some with truncated crests, small plateaus, and alluvial deposits in the valleys. The ridges are immature, despite their relief. The present relief pre-dates the Mesozoic inundation (see below).

The northern upland (unnamed) is part of a larger mass of Precambrian rocks that extends beyond the Sheet area to the west-north-west. Immediately north of the Sheet it is cut by the valley of the Nicholson River. The highest altitude is 1100 feet, on a uneven plateau with a radially directed drainage, whose centre is near the Northern Territory border. The topography is homoclinal ridges, some with 200-300 feet high faces, and perched synclines. The Constance Range (up to 1000 feet) is cut by several deep gorges. Cretaceous cappings, generally forming mesas and rubble-covered plateaus, occur as high as 1010'. The Mesozoic subsurface has a relief of up to 250 feet in small areas; its topography is rough and homoclinal, indicating that the whole present topography is essentially exhumed, and pre-Mesozoic in age. Minor streams follow the exhumed old drainage pattern in several places.

Drainage has been controlled largely by the lithology and structure of the Precambrian sediments. The valleys of the main watercourses are generally broad and mature in areas underlain by siltstone and shale, but cliffs up to 100 feet high show that erosion is active. Where sandstone is the surface rock the watercourses are narrow and precipitous. Joints and faults have largely controlled the location of channels and have caused many sharp changes in direction of the watercourse. Musselbrook Creek, within the northern upland, is a very fine example.

The Barkly Tableland (Georgina River Plain) and its dissected slope (Canyons of Fig. 1) are a distinct geomorphological unit in the south-west of the Sheet area. Its frame consists of the Constance Range and low ridges of the Isa Highlands in the east, and the rough ridges of the northern upland in the north. In the south-west the undissected plain

(800 feet) extends west and south as the prairie of the Barkly Tableland. The slope with canyons drops from 800' to 500' over a distance of 30 miles. It is drained by Lawn Hill Creek and the Gregory River (in the south). The low divide between the two watercourses is capped in places by Mesozoic residuals. The divide is traceable for some distance into the Isa Highlands area. The topography of the dissected slope is canyons and steep gullies. The drainage system is well developed and is controlled by joints; karst is absent, but for caves at Louie Creek (Ball, 1911). Watercourses are actively cutting back into the edge of the Tableland, which is otherwise undissected, except for shallow stream beds. Despite the active present-day erosion Mesozoic plant-bearing sandstone has been found in a stream bed in the headwaters area, indicating that the dissection of the slope of the Barkly Tableland was initiated before the Mesozoic inundation. No trace of a second, older, drainage pattern is apparent in the present Lawn Hill Creek stream system, however. It is therefore probable that the present drainage coincides with the main lines of the pre-Mesozoic drainage.

The ranges of the "frame" are cut by gorges. The upper gorge of Musselbrook Creek, at the Border Waterhole, just west of the Northern Territory border, is a cleft a few feet wide, and with a waterfall, and is apparently a subrecent feature, but the lower gorge cuts two homoclinal sandstone ridges and is probably inherited from an earlier drainage system. At the foot of the northern upland a broad shallow valley ("V" of Fig. 1) is present with small Mesozoic residuals on its floor. The valley is eroded into Cambrian sediments, and coincides with the fault zone.

Two outliers of the Thorntonia Limestone - Lawn Hill and Dentalium Plateau (LH and DP of Fig. 1) - are mesas, and residuals of the formerly continuous cover of Cambrian sediments. Lawn Hill is about 100 feet above the plain, with about 15 feet of limestone on its top. Consequently, it is apparent that at this place erosion has removed a layer of rock less than 100 feet thick from the sub-Cambrian surface. The core of the Dentalium Plateau consists of rough ridges of Precambrian rocks.

The geomorphology of the Tertiary limestone area has been discussed by Whitehouse (1940, p. 24-28). He assumes that "since the limestones were formed they have been eroded by the Gregory River and other local streams reducing the once continuous exposure to a main scarp and a number of outliers, separated one from another by the old alluvial plains of these streams".

One author (A.A.Ö.) suggests another explanation, however. The consolidated variety of Carl Creek Limestone (also called Verdon Limestone by Noakes and Traves, 1954)

rests with its top at 550 feet at Verdon Creek, and 660 feet at Riversleigh, perched on hills of basement rocks, with residuals of Cambrian limestone in between, and also abuts against cliffs of the Cambrian limestone, which are slopes of an old valley. The valley, with its floor altitude of 375 feet, predates the deposition of the Carl Creek Limestone. On this valley floor a chalky, friable variety of the limestone occurs.

The Carl Creek Limestone is a freshwater lake deposit, and the lake was over 300 feet deep at Verdon Creek and Riversleigh. It appears that on subaquatic mounds, in warm agitated water, and in reach of sunlight limestone was deposited, while chalky material accumulated on the deep floor. Thus, it is not necessary to assume that the valley was filled originally with the Carl Creek Limestone, and was later eroded, on a formidable scale, by a sub-Recent stream.

HISTORY OF THE LAND SURFACE

1. The oldest sub-Cambrian land surface is seen at the base of the Cambrian and is marked by a great unconformity. It is exposed at Lawn Hill and the Dentalium Plateau and in the Border Waterhole fault zone. Its topography differs

little from the recent topography of the Precambrian uplands although the sub-Cambrian surface has been degraded by subsequent cycles of erosion and the present surface cannot be generally regarded as the "exhumed sub-Cambrian land surface."

2. The sub-Cambrian erosional cycle was interrupted by a lower Palaeozoic transgression, and the land surface was buried, and preserved under the sediments.

3. A depositional land surface, probably with inliers of Precambrian rocks (Constance Range for example), arose from the sea after the Middle Cambrian, and possibly not later than in the second half of the Ordovician, but this event cannot be dated more precisely. It was deformed by faulting and some tilting, probably in the course of the uplift.

4. The uplift initiated the cycle of erosion, referred to as the "pre-Cretaceous", or "pre-Mesozoic", cycle; considering the probable age of the plant-bearing sandstone, it should be described as "pre-upper Jurassic". Its interval is Ordovician-Jurassic, and has left no record. The Palaeozoic cover was stripped, and reduced to its present extent; the exhumed sub-Cambrian surface was degraded, but its general topographic expression was retained. The exhumed pre-Cretaceous land surface is preserved in the northern upland; and the Carpentaria Plain, including the foothills, is a buried lowland of its topography.

5. Marine Cretaceous transgression interrupted the erosional cycle (4), and the land surface once more became buried under sediments.

6. Uplift at the beginning of the Upper Cretaceous produced a depositional land surface, but this time without inliers; this surface was broadly rolling,

reflecting the contrasts of uplands and lowlands of the substratum.

7. In upper Cretaceous the third major erosional cycle was initiated, and has been active ever since, except for a brief subsidence in the Tertiary, as indicated below (8). Most probably lateritization started also in the Upper Cretaceous and reached its peak, according to the general opinion, in the Miocene. But stripping of the blanket of Cretaceous sediments proceeded consistently on the uplands, with a concurrent exhumation of the old land surface (4). Although the Cretaceous upland residuals are even now in the process of erosion, this surface quite early (8) became a landscape of mesas. The lowland, however, retained its character of a depositional plain.

8. In the Tertiary, presumably after Miocene, and for a geologically brief interval, a subsidence decelerated the erosion in the uplands, and the lowland of Carpentaria contained a freshwater lake.

9. At the end of the Tertiary, uplift intervened (with subsidence in the Torres Strait and the Arafura Sea), and the sea replaced the fresh water in the Gulf of Carpentaria. Erosion gained in force on the land. The present processes are stream erosion in the uplands coupled with slope erosion of the mesas.

STRATIGRAPHY AND LITHOLOGY

The stratigraphic names which appear on the Lawn Hill Sheet and in these notes have been approved by the Queensland Stratigraphic Nomenclature Committee. The Camooweal Dolomite, Carl Creek Limestone, and Cambrian units will be fully defined and described by Öpik (in preparation); the remainder by Carter, Brooks and Walker (in preparation). For certain of the units the term "Beds" has been used in prefer-

TABLE I

PROZOIC GEOLOGY AND HISTORY

System	Series	Rock Unit	Position in the sequence, distribution	Lithology	Thickness	Topography	Structure	Correlation and fossils	Underground water
Quaternary			Surface deposits, (a) on Camooweal Dolomite and Cambrian limestone (lithological control) (b) River channels, flood plains; derived from basement rocks and Mesozoic arenites	(a) Heavy pedocalcic soil (b) Alluvial sandy and pebbly soil and alluvial sand, gravel. (c) Calcareous (dolomitic) rubble.	(a) up to 10 feet (b) over 50 feet in Carpentaria Plain (c) slope scree mainly	(a) Plain, prairie (b) scrubby and timbered plain (c) dissected canyon country with scrub; trees in stream beds.	Horizontal unconsolidated		
Surface of erosion									
Tertiary		Carl Creek Limestone	Rests on basement rocks, and on Thorntonia Limestone: a local unit, extends from the Riversleigh area, Camooweal 4-mile sheet.	Massive and irregularly bedded, white to grey limestone with conglomerate up to 25 feet thick at base; friable white "chalk" on low ground	140 feet, and less	On top of hills of the Precambrian and Cambrian substratum, or "glued" to pre-existing cliffs. "Chalk" in pre-existing valleys in Precambrian rocks.	Horizontal	Age not conclusive (Tertiary, or even Upper Cretaceous); fresh water deposit with gastropods, ostracods and vertebrate bones.	
Surface of erosion									
Cretaceous	Lower	Unnamed sequence in Surprise Creek Bore: Blackdown Formation (above), Wrotham Park Sandstone (below)	Rests on basement rocks, on Camooweal Dolomite, and on Middle Cambrian sediments; probably also on the "plant-bearing sandstone".	Well bedded light grey siltstone, fine grained sandstone, siliceous shale, sporadic conglomerate at base; ferruginous on surface, lateritic colours.	Up to 200 feet on upland; over 400 feet in the Carpentaria Basin, increasing rapidly to east.	Scattered mesas and filling gullies of the substratum, highest elevation about 1000 feet; Carpentaria Basin: plain without outcrops.	Horizontal	At loc. M435 marine fossils (pelecypods); Lower Cretaceous.	Artesian water in the Carpentaria Basin; main aquifer the Wrotham Park Sandstone
Jurrasic	Upper	Unnamed ("plant bearing sandstone") in upland; probably in the Carpentaria Basin	In the upland rests on Middle Cambrian sediments and Camooweal Dolomite, and Precambrian rocks; in the Carpentaria Basin on the basement, but intervening sediments possible.	Quartzose sandstone, very hard in places; slump rolls. "Pipe rock" at loc.M110.	20 feet seen	Small residuals on divide in the south of the sheet; in gullies and valleys in the substratum; scree of "slump roll" blocks.	Horizontal Pipe rock: fractured by joints, low dips (10^{o} and less), but no clear trend	Plants indicate an Upper Jurassic, or Lower Cretaceous age. "Pipe rock", included on lithological and topographic reasons, could be Palaeozoic.	360 feet below surface in Surprise Creek Bore (stock water). Supply 95,000 gallons per day in Watson's Hole Bore.
Probably late in Ordovician			Unconformity, surface of erosion.	Faults along E - W trends; Cambrian sediments folded in places; cleavage, low angle slickensided fractures, and low angle (reverse faults) indicate thrusting from south.					

System	Series	Rock Unit	Position in the sequence, distribution	Lithology	Thickness	Topography	Structure	Correlation and Fossils	Underground Water
		(Lancewood Shale; present only in Northern Territory)	(Rests on Currant Bush Limestone conformably; small area immediately west from the Northern Territory boundary; overlain in places by Mesozoic "plant-bearing sandstone" with diffuse contact)	(Shale, leached, lateritic colours; original rock probably calcareous, but cannot be established because of leaching and lateritisation)	(70 feet seen)	(Cluster of dissected hills)	(Horizontal to sub-horizontal)	(Fuchonia, Peronopsis, Ptychagnostus, cystids. Apparently equivalent of a part of Currant Bush Limestone)	
Cambrian	Middle	Currant Bush Limestone. Name extended from Camooweal 4-mile Sheet area.	Rests conformably on Border Waterhole Formation.	Limestone, variable in appearance: dark bituminous bedded; soft, grey and flaggy, with [illegible] in places; nodular, hard; dolomite, dolomite with chert grit. Siltstone lenses.	about 60-100 feet in the west; about 500 feet on section line, but duplication possible.	Pediments with ribbed surface; low cuestas facing north; terraced slopes; low bastions.	Near vertical proximity of faults; dip 5-10 degrees away from faults; isoclinal folding in some places possible.	New species of Fuchonia, ptychopariid, and nepeid trilobites; Anomocaridae; Ptychagnostus gibbus, P.atavus (Zone species).	In fault zone probable; no bores
		Border Waterhole Formation	Known only in the sheet area and nearby N.T. Rests on Precambrian rocks, and immediately west of the N.T. boundary on Camooweal Dolomite. Thorntonia Limestone is absent in the fault area	Upper: thick bedded dolomitic blue-grey limestone with chert which may exceed 50% of sequence; interbeds of chert layers; a layer of siliceous shale is present; lower: siliceous shale with chert rubble on surface	100-150 feet	Low rubbly ridges; rough limestone faces with open joints	Steep dips (up to 80 degrees) in fault zones	Xystridura, Lyriaspis, Peronopsis, Helcionella; correlates: Beeble Ck. Formation, Alexandria Beds (N.T.)	As above
		Thorntonia Limestone	Rests on basement rocks at Lawn Hill, and Verdon Ck.; or Camooweal Dolomite at Ixion Ck.; not present (not deposited) in the Border Waterhole fault zone.	Dolomitic limestone with chert and Girvanella ("Girvanella puddings")	About 100 feet seen	Low, rubble covered hills; cliffs	Sub-horizontal	Girvanella, Redlichia, Pagetia; Xystridura (high in sequence) at Lawn Hill only.	No data
		Unnamed Cambrian Informally referred to as "Louie Creek limestones"	Rests apparently above Camooweal Dolomite; relationship with other units not clear; parts of it are apparently not separable from Camooweal Dolomite by lithology.	Probable lithology: thin-bedded, non-bituminous limestone, with chert.	"several hundred feet"	Canyons, low terraced escarpments.	Horizontal	Position in sequence and correlation uncertain. Fossiliferous?	Springs at eastern edge (elevation 500 feet or less; indicates a shallow aquifer.
		Disconformity; surface of erosion.							
	Cambrian, possibly older	Camooweal Dolomite	Rests on basement rocks; extends from Camooweal-Morstone area (lithological continuity). Includes some similar rocks of younger age.	Dolomite, dolomitic limestone, with sand, and sandy interbeds, and with chert nodules ("ribbonstone")	Of the order of 500 feet	Plateau dissected by canyons	Horizontal	Unfossiliferous; at Ixion Creek rests below "Girvanella puddings"; detritus contributed to Currant Bush Limestone.	

TABLE II

PRECAMBRIAN STRATIGRAPHY AND TECTONIC HISTORY

Era	Period	Stratigraphic Unit	Symbol	Lithology	Max. Thick.	Tectonic History and Comments
CAMBRIAN OF UPPER PROTEROZOIC	UNCONFORMITY					Uplift and erosion
		Camooweal Dolomite	B/Є			Sagging of land surface to south-west of Sheet area, to form shallow basin. Sedimentation extended into Lawn Hill Sheet area. Minor extrusion of lava, along fault line at S. of Constance Ra. Relationship to Camooweal Dolomite not certain.
		Colless Volcanics	B/Є	Vesicular basalt, and other lavas	200+ feet	
	UNCONFORMITY					Uplift
PROTEROZOIC	Upper				?	Moderate folding on east-west axis, to give basin and dome type of structure; faulting.
		Mullera Formation	Bul	Fine-grained sandstone, siltstone and shale, including ferruginous sediments in lower part	7,000'	Sedimentation occurred in a basin centred south of the Nicholson River. The Constance Sandstone overlaps the Peters Creek Volcanics and Wollogorang Formation in the Westmoreland Sheet area but lies with major unconformity on the Lawn Hill Formation in the Lawn Hill Sheet area. The Mullera Formation also lenses out to the north.
		Constance Sandstone	Bua	Coarse- to fine-grained sandstone; some pebble beds and conglomerate; siltstone lens north of Elizabeth Creek	3,600'+	
	UNCONFORMITY					Uplift and erosion.
	Lower	Weberra Granite	Bgb	Red, medium-grained granite, with granophyre and pegmatite; muscovite-rich in part.		Strong folding, on meridional to east-west axes, and faulting, followed by granite intrusion; age of intrusion unknown.
		Lawn Hill Formation	Blf	Impure sandstone, shale, siltstone and felsite (?including chert, tuff and rhyolite?)	5,000'	Sedimentation more or less continuous, at shallow to moderate depths. A local unconformity has been observed between the Ploughed Mountain and Myally Beds in the Camooweal Sheet area. Sediments reflect miogeosynclinal or unstable shelf environments; attain geosynclinal thickness.
		Ploughed Mountain Beds	Blz	Impure arenaceous beds, dolomite, siltstone and shale	10,000 - 15,000'	
		Myally Beds	Bly	Sandstone, quartzite, conglomerate; acid to basic lavas and agglomerate	20,000'	

ence to "Formation" because the geology of the unit is imperfectly known.

The stratigraphy, lithology and tectonic history are tabulated in Tables I and II.

PRECAMBRIAN UNITS

Age of the Precambrian Units of North-western Queensland

David (1932), in his geological map of Australia, showed the Mount Isa Shales and Corella Limestones as (?) Older Proterozoic and the remainder of the Precambrian of north-western Queensland as Archaeozoic. Nye and Rayner (1940) regarded the Kalkadoon-Argylla series as Archaeozoic, the Soldiers Cap series as probably Upper Archaeozoic, and the Mount Isa series as Lower Proterozoic. Carter, Brooks and Walker (in preparation) have shown that the metamorphics and sediments described by Nye and Rayner belong, with a few possible exceptions, to the one general period of sedimentation and mountain building (which involved two orogenies).

Holmes and Smales (1948) have determined the age of a crystal of monazite from pegmatite at Mica Creek, near Mount Isa, to be between 1,000 and 1,200 million years. Recent preliminary age determinations obtained by isotope measurements, indicate that the metamorphic rocks of the region (and therefore contemporaneous sediments) are more than 1,600 million years old. The classification of the strata therefore becomes a matter of definition of Archaean and Proterozoic.

The oldest strata in north-western Queensland which have been dated by fossils are Lower Cambrian; the oldest in the Lawn Hill Sheet area is the Middle Cambrian Thorntonia Limestone. Unconformably or disconformably, below the Thorntonia Limestone are the Colless Volcanics and probably the Camooweal Dolomite both of which are unconformably underlain by the Mullera Formation and the Constance Sandstone. A major angular unconformity separates the Constance Sandstone from the Lawn Hill Formation. Farther north, a lengthy period of vulcanicity and sedimentation is represented by units more or less conformably below the Constance Sandstone. The Camooweal Dolomite may be Cambrian or Upper Proterozoic (see Öpik, 1956a). The successions between the Lawn Hill Formation and the Camooweal Dolomite are therefore probably all Upper Proterozoic. This view is substantiated by correlations in the Northern Territory (see Carter, Brooks and Walker, in preparation).

None of the metamorphic rocks referred to above crop out in the Lawn Hill Sheet area, but the Myally Beds are regarded as contemporaneous with the Corella Formation.

Myally Beds. Only the uppermost few thousand feet of the succession crops out in the Lawn Hill Sheet area. No lavas occur in the lower part, which is exposed in the Camooweal and Dobbyn Sheet areas. The arenaceous sediments are coarse-to medium-grained, generally well bedded, moderately well sorted and commonly ripple-marked and cross-bedded. Sediments, including heavy conglomerate, are associated with lavas at the top of the formation.

Ploughed Mountain Beds. East of the Lawn Hill mineral field the uppermost strata are dominantly quartz greywacke. The bulk of the unit consists of thinly-interbedded dolomite, siltstone, shale and sandstone, but in the east of the Sheet area the lower part is arenaceous sandstone and quartzite, with some conglomerate. Concentric and tubular structures, of organic origin, occur in some of the dolomitic strata.

Lawn Hill Formation. The Lawn Hill Formation contains practically all the known silver-lead-zinc deposits of the area. In addition to the rock types listed in Table II quartz greywacke and carbonaceous shale are present; some beds within the mineral field are probably calcareous or dolomitic. Extensive limestone beds crop out in the westerly inlier of Lawn Hill Formation in the Constance Sandstone.

Constance Sandstone is generally well-bedded; sediments tend to be coarser and less well sorted in the north than in the south, particularly near the base of the unit. In the north they are also commonly poorly cemented. Cross-bedding and ripple-marking are common. Jointing is well developed in the coarser sandstones. The joints have been eroded out to form steep gullies in places. Siltstone also occurs in the Constance Sandstone north of Elizabeth Creek, and a thin-bedded calcareous greywacke - sandstone succession forms the base of the formation in the southern part of the Constance scarp.

Mullera Formation. Sediments are generally thin-bedded. In places they are cross-bedded and ripple-marked; mud cracks and other shallow water sedimentary structures are abundant. Most of the sediments are micaceous.

Colless Volcanics consist of amygdaloidal basalt and probably other basic and intermediate lavas. The unit crops out over only a few square miles at the south end of the Constance Range, where it unconformably overlies the Mullera Formation and Constance Sandstone and is unconformably overlain by Middle Cambrian Thorntonia Limestone. A contact with the Camooweal Dolomite has not been observed, because of poor exposure.

Camooweal Dolomite. The name "Camooweal Dolomite" denotes the great dolomite body of the Barkly Tableland, and especially that part of it which is overlain by the basal Middle Cambrian of the Undilla Basin in the Camooweal 4-mile Sheet area. In the Lawn Hill area, on Ixion Creek, the Thorntonia Limestone (locally the lowermost Middle Cambrian) rests above a dolomite which is lithologically similar to the Camooweal Dolomite. The continuity of the formation between Camooweal in the south and the drainage areas of the Gregory River and Lawn Hill Creek in the north is assumed from the invariable repetition of the lithology (dolomite with chert) in all examined outcrops in between. Circumstantial evidence of a pre-Middle Cambrian age of the dolomite is provided by the presence of detrital dolomite in the Middle Cambrian of the Undilla Basin in the south, and in the Currant Bush Limestone in the north. The detritus is presumably derived from a dolomite formation which lies between these places and is situated in the drainage area of the Gregory River and the Lawn Hill Creek. The area, however, contains undefined outliers of unfossiliferous dolomite and dolomitic limestone, as indicated above under "Louie Creek limestones", and Currant Bush Limestone. For this reason lithological boundaries, such as that between "dolomite and bituminous fossiliferous limestone" are not necessarily formation boundaries.

CAMBRIAN

The Cambrian sequence of the Lawn Hill Sheet area has been discussed previously by Öpik (1956, 1960). Cambrian sediments occur in three separate areas: (1) the outliers at Lawn Hill homestead and the Dentalium Plateau, (2) on Verdon Creek and Ixion Creek, as an extension from the Undilla Basin in the south, and (3) in the fault zone along the Musselbrook and Colless Creeks. Further, a large area of doubtful Cambrian limestone occurs on Louie Creek and is discussed separately.

The two outliers, Lawn Hill and Dentalium Plateau, consist of Thorntonia Limestone, which in the Plateau is in part a "*Girvanella* pudding" (the rock is full of spherical algae); some chert with *Xystridura* also occurs on Dentalium Plateau, but is not mapped separately.

The occurrence on Verdon Creek is also of Thorntonia Limestone (*Girvanella* pudding) and dolomite limestone with *Redlichia* (in chert nodules). In western outcrops the "*Girvanella* pudding" is a current-bedded dolomitic limestone, which apparently was deposited near a shore.

In the fault zone Thorntonia Limestone and its time equivalents are absent by reason of non-deposition. The sequence present covers the lower part (less than half) of the Middle Cambrian (part of the *Xystridura* Zone, and the Zones of *Ptychagnostus gibbus*, and *P. atavus*; see correlation chart, Öpik, 1960). The lowermost unit is the Border Waterhole Formation, which is contemporaneous with the Beetle Creek Formation in Queensland, and the Alexandria beds in the Northern Territory; lithology of the Border Waterhole Formation is, however, distinctive (see Table 1). The nearest outcrop of the Beetle Creek Formation is about 90 miles to the south, and that of the Alexandria beds 100 miles to the west. The three units should therefore retain their individual names.

The name "Currant Bush" refers primarily to a limestone sequence in the Undilla Basin, 60 miles to the south. It is applied in the Lawn Hill area (1) to reserve the formal naming for the future, and (2) on the assumption that this formation is a marine deposit of regional significance, consisting predominantly of bituminous limestone. No meridional connexion existed, however, between the Undilla Basin and the fault zone, as the Age Creek Formation intervenes along the northern slope of the Basin; but sediments of a sea way existed along the present Isa Highlands as a communication between the two depositional areas of the Currant Bush Limestone, suggesting their original spatial continuity.

The Currant Bush Limestone in the fault zone is not lithologically uniform, as can be seen from the stratigraphic table. The unifying characters are the predominance of bituminous varieties of fossiliferous limestone and continuity of outcrop.

Massive, thick-bedded dolomitic limestone constitutes the upper part of the sequence in the south, at the Northern Territory border; non-bituminous dolomitic limestone and dolomite beds occur also on top of, and in sequence with, the Currant Bush Limestone (at locality M 398). On the map such rocks are included in the Currant Bush Limestone wherever the superposition was visible. They are similar to rocks of the Age Creek Formation, in the Undilla Basin, which interfinger with the Currant Bush Limestone; but some of the dolomitic beds of the "Age Creek type" are very similar to the Camooweal Dolomite. They can only be differentiated where clear contacts can be seen. Therefore, in places where the superposition was not clear the limit of the "bituminous and fossiliferous limestone" was taken as the southern boundary of the Currant Bush Limestone.

The Lancewood Shale is included in the stratigraphic table, although this unit occurs only across the Northern Territory Border. Probably the Lancewood Shale is the equivalent of an undefined upper part of the Currant Bush Limestone which in the fault zone contains lenses of calcareous siltstone, and some shale. The area of outcrop of the Lancewood Shale has numerous sandstone residuals, of which some are Mesozoic (with poor plant remains), and some are apparently in sequence with the shale below.

The name "Louie Creek limestones" ("Cambrian, queried", in the legend of the map, and in the stratigraphic table) has no formal status. Ball (1911) included it in his "recent limestones", which also contain the Thorntonia Limestone. According to Ball, the thin bedded limestone at Louie Creek has a thickness of several hundred feet; "the limestones along Louie Creek on certain horizons contain small shells, possibly Tellina" (p. 18). He was, however, unable to collect these fossils. Consequently, reasons are apparent why the "Louie Creek limestones" cannot be included safely in the Cambrian sequence. The queried boundary on the map encloses an area with a distinctive airphoto pattern; the pattern is believed to be characteristic of the Louie Creek limestones and different from that of other limestones and dolomites in its vicinity. Apparently the Louie Creek limestones rest on the Camooweal Dolomite, and parts of them may have been included in that Dolomite. Their air photo pattern is that of a thin bedded and jointed limestone with a tendency to form low bastions. It is certainly not Recent, or Tertiary.

MESOZOIC

Data regarding the Mesozoic deposits of the upland are given in the chart and under "Geomorphology". The plant-bearing sandstone at the base of the Mesozoic succession is dated as Upper Jurassic, which is the oldest age possible for it; it could be Lower Cretaceous. At the locality M 435, in a siltstone, members of the staff of Mount Isa Mines Ltd collected marine pelecypods which, according to J.M. Dickins (this Bureau), are Upper Jurassic to Lower Cretaceous.

In the part of the Carpentaria Basin that lies within the Lawn Hill Sheet area the uppermost Lower Cretaceous deposit is the Blackdown Formation (Laing and Power, 1959a), which is 355 feet thick and is underlain by the Wrotham Park Sandstone (same authors), up to 80 feet thick (my information supplied by M.A. Reynolds, this Bureau). These are equivalents of the lower part of the Cretaceous sequence of the Great Artesian Basin. Younger strata are not present in the Lawn Hill area.

CAINOZOIC

Quaternary deposits - non calcareous alluvium and soil, calcareous alluvium and soil, lateritic and sandy soils - are classified in the first place according to their pedological aspects (Stewart, 1954); but their relative age is not obvious. The laterite is older than the soils (Upper Cretaceous-Tertiary). The "residual and alluvial black soil" on dolomite, the black soil of the Barkly Tableland, is recent, but formation of the soil began in the Tertiary.

Carl Creek Limestone is adequately described in the chart, and in the section on geomorphology. Possibly more Tertiary deposits will be discovered in the lowland of the Carpentaria Basin. At the base of the Carl Creek Limestone a ferruginous conglomerate with fossiliferous Cambrian chert pebbles is present in several places and at loc.M105 a white sandstone, 25 feet thick, occurs. Whitehouse (1940) observed also angular fragments of limonite and chert, and interpreted the occurrence as a "fossil soil (?lateritic)."

DESCRIPTIONS OF SELECTED LOCALITIES

M103 (Long. 138°41', lat. 19°00') - 1 mile south of Verdon Creek. Cliff (elevation at top 510 feet). Carl Creek Limestone, with vertebrate bones, and gastropods (upper beds), about 90 feet: ferruginous conglomerate at base, resting on a rough surface of Precambrian rocks.

M104 (Long. 138°39', lat. 19°00') - rectangular valley cliffs. Spectacular Cambrian/Precambrian unconformity.

M105 (Long. 138°41', lat. 18°59') - cliff facing Verdon Creek. Pebbly white sandstone and conglomerate, 25 feet thick, at the base of, and in sequence with, Carl Creek Limestone.

M106 (Long. 138°34', lat. 18°53', elevation 575 feet)- outcrops of Thorntonia Limestone with Redlichia (in chert).

M107 (Long. 138°30', lat. 18°54'; elevation 670 feet on track, 730 feet on top of outcrop) - Thorntonia Limestone; over 60 feet: top part cystid limestone with brachiopods (silicified) thick bedded, current bedded Girvanella limestone in lower part of outcrop, Camooweal Dolomite on lower ground.

M110 (Long. 138°22', lat. 18°55') - friable red sandstone with vertical pipes, jointed, not horizontal. It is included in Upper Jurassic, but the age is not certain.

M376 (Long. 138°01', lat. 18°37') - in banks and bed of a small creek. Contorted but generally south dipping (20° - 30°), variegated, friable siliceous shale with ptychopariids, agnostids and stenotheca. See under loc. M 397.

M396 (Long. 138°16', 18°40') - low hills, steep gullies. Non-bituminous flaggy limestone with chert layers, dipping south about 10° and flattening rapidly. Cannot be assigned to Currant Bush Limestone, and is probably an outlier or inlier of Ball's "Louie Creek limestones". Contact with the Camooweal Dolomite is apparently a rubble-covered fault.

M398 (Long. 138°10', lat. 18°38'), on E - D section line. Currant Bush Limestone, of several lithologies, including calcareous sandstone; dip south-south-west from near vertical in the north to 25° and less in the south. Total thickness about

500 feet, but isoclinal folding possible.

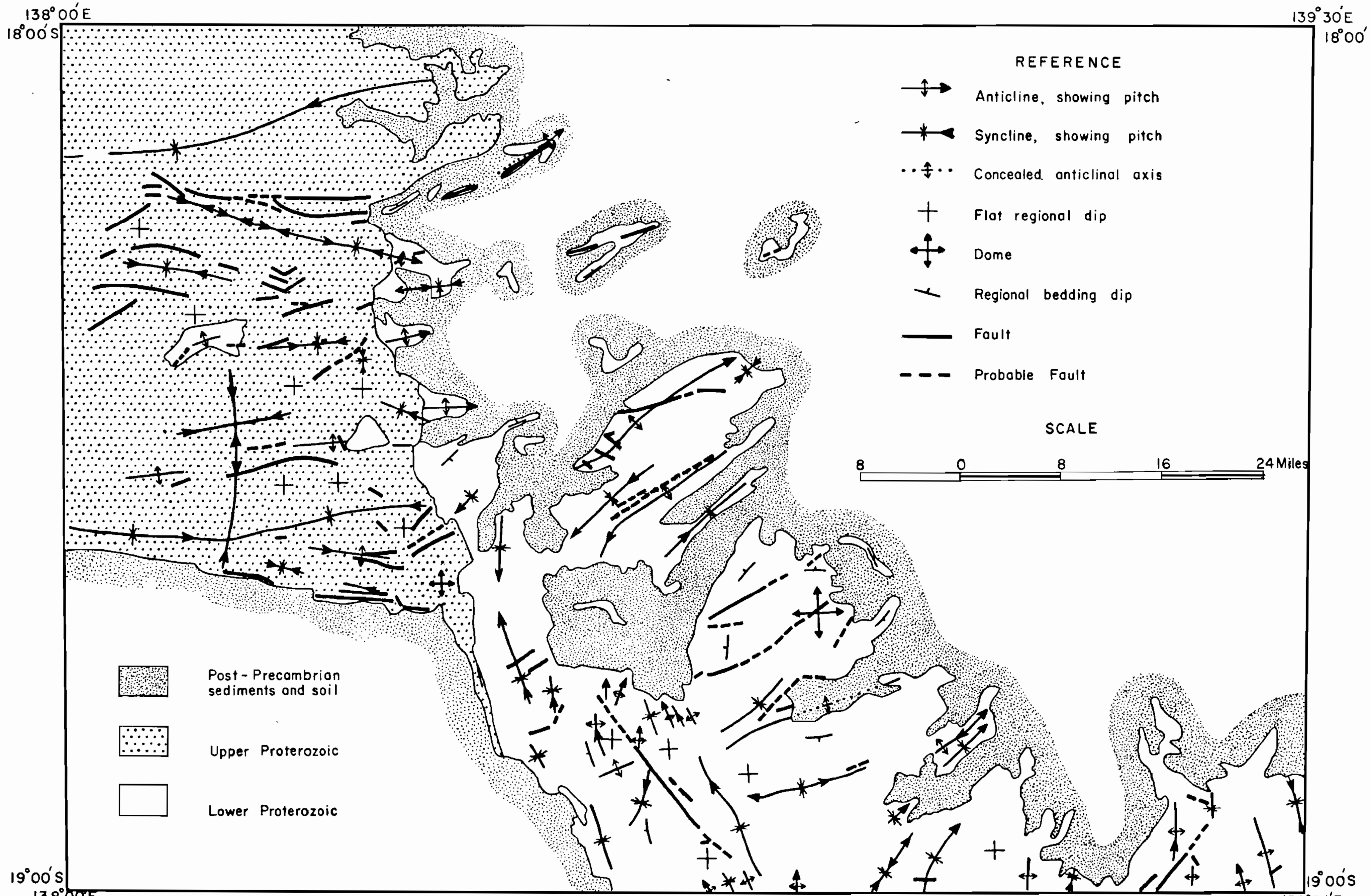
The highest bed (about 100 feet thick) is a detrital dolomite "gritty with chert fragments". Contact with Camooweal Dolomite is a fault; the Dolomite is shattered and fractured. Blocks and small residuals of Mesozoic sandstone occur on the limestone pediment.

Knowledge of Currant Bush Limestone west of the Northern Territory Border is helpful in understanding the sequence. Very fossiliferous beds crop out on Lancewood Creek, at latitude 18°39'. M 187 (longitude 137°57'), south of the stream bed, has the contact of the limestone and Lancewood Shale exposed. The shale (50-60 feet visible) forms hills, and one has a patch of conglomerate, and sandstone with indistinct plant remains, as capping. M 186 (longitude 137°58'), in creek beds - marly limestone with harder ellipsoids contains a prolific fauna, including complete specimens of Fuchonia. Dip about 10 degrees south.

M379 (Long. 138°00', lat. 18°38') - Marble Creek. Massive, thick bedded limestone, dips 10° to 80° south. In the stream bed soft marly beds are contorted and are apparently overridden by less deformed thick bedded limestone. M382 (Long. 137°59', 18°38') - massive, thick bedded dolomitic limestone ("Age Creek" lithology), dips south 5° - 10°. M383 (Long. 137°59', lat. 18°41') - heads of Marble Creek, and west from disused boundary cairns. Small, inconspicuous outcrops of fractured Camooweal Dolomite in scrub; on top of the Dolomite are small residuals of Mesozoic sandstone, and soft siliceous shale (Border Waterhole Formation; see M376); rubble of Cambrian chert, and chert from the Dolomite.

GRANITE

The few, small, poorly exposed outcrops of granite have been grouped with the Weberra Granite, which crops out in the Camooweal Sheet area. The granite in the Lawn Hill Sheet



Bureau of Mineral Resources, Geology and Geophysics, March 1960.

KC Q 42-20

area is essentially a massive, fine to coarse-grained muscovite granite with which are associated muscovite and tourmaline pegmatites. The age relationship of the Weberra Granite to others in north-western Queensland has not been established; all are Precambrian. Petrologically, it differs from the other granites.

METAMORPHISM

Metamorphic effects in the Lawn Hill Sheet area are slight. The Lower Proterozoic strata generally have not been raised beyond the sericite metamorphic grade. Fracture cleavage is locally well developed but nowhere does it mask the bedding. Those quartzites which are exposed may be largely the product of superficial weathering processes, but local silicification by hypogene processes has occurred in the vicinity of some faults and mineral-bearing lodes. The effect of the Weberra Granite is not apparent because of poor exposure, but any metamorphic aureole probably does not extend more than a few hundred feet. Both mica schist and hornfels have been recorded.

The Upper Protoerozic and younger strata display no metamorphic effects.

STRUCTURE

The structural elements of the Precambrian of the Lawn Hill sheet area are shown in Fig.2.

FOLDING

The Lower Proterozoic strata are moderately to strongly folded, with a tendency towards basin and dome structures. Synclines are generally more nearly linear and are narrower than the domes. A striking feature is the swing in the direction of the major fold axes from meridional in the south-east to east-west between Musselbrook and Elizabeth Creeks, in the north-west.

The Upper Proterozoic sediments of the Constance Range are moderately folded; dips in excess of 30° are not common. Basin and dome structure is well-developed but the east-west axis of folding is the stronger.

FAULTING:

A north-east/south-east system of strike-slip faults forms the main fracture pattern in the Lower Prtoerozoic. The faults are commonly quartz filled; some are mineralized by silver-lead-zinc or copper. In the Upper Proterozoic sediments east-west normal faults are the most prominent. They occur mainly in anticlinal zones and displacements of up to 4,000 feet have been recorded. Quartz stringers are associated with them in places, but otherwise they are unmineralized. Some strike-slip and high angle reverse faults are present.

Along the southern margin of the Constance Sandstone two periods of faulting can be recognized (the Little's Range fault zone). One fault movement locally severely deformed the Constance Sandstone but did not disturb the Camooweal Dolomite; the other produced vertical dips in Middle Cambrian strata. The second faulting was older than Lower Cretaceous, it was probably late Ordovician (Öpik, 1956, 1960), and resulted from thrusting from the south. Two lines of faulting, representing the two periods of movement, are apparent in the fault zone.

Some Mesozoic outcrops have been slightly dislocated by minor faulting.

ECONOMIC GEOLOGY

Silver and lead are the only metals which have been mined in important quantities. The ore deposits are confined almost entirely to the Lawn Hill Formation, where they occur as fissure lodes in north-east and north-west trending faults. A small vein of galena has also been found in the Mullera Formwation, in the upper Elizabeth Creek area. Total recorded production to the end of 1958 is 4,953 long tons of lead and 152,245 ounces of silver. Both carbonate and sulphide ores have been mined. The main mines are listed in Table III. Production from individual mines is given from 1948 only. No metal was obtained from 1928-1947 and the analysis of mine production before 1928 has not been made. Zinc also occurs in association with the silver-lead but is not recovered, as production of zinc from the locality is not economic. Ore is carted by road to Mount Isa.

TABLE III

Production from Principal Silver-Lead Mines, Burketown Mineral Field* 1948-1959

	Ore Long tons	Lead Produced tons	Silver oz.	%Pb	Oz.Ag per ton
Silver King	2,599	1,356.4	47,152	52	18.1
East Star (Star of the East)	717	433.0	3,384	60	4.7
Mended Hill	673	413.5	15,557	61	23.1
Lilydale	175	74.8	769	43	4.4
Lucky Dollar	143	75.0	458	52	3.2
Anglo-American	127	57.0	833	45	6.6
Western King	97	49.2	1,650	51	17.1
Axis (Axis Ridge)	89	52.8	636	59	7.1
Greater Britain	68	35.3	342	52	5.0

* The Burketown Mineral Field has an area of 317 square miles, and contains only the Lawn Hill field. The two copper mines in the area lie outside its boundaries. The Field is now administered in conjunction with the Cloncurry and Mount Isa Mineral Fields.

Copper has been produced from two mines in the Sheet area. One mine is the Waanyee, 6 miles east-north-east from Lawn Hill homestead, from a fault in the Ploughed Mountain Beds. Recorded production is 84 tons of copper, from ore of average grade 28% Cu. The other mine is a small show (Ridgepole) associated with the Colless Volcanics, from which hand-picked ore has been mined.

No significant radiometric anomalies are known to occur in the Sheet area.

Huge deposits of low-grade sedimentary iron ore form a distinctive feature of the near-basal beds of the Mullera Formation, in the Constance Range. Specimens containing more than 55% Fe have been assayed, but the average grade is probably less than 40% Fe. The deposits are at present being tested for grade and extent.

Minor quantities of manganese are associated with cappings over the Colless Volcanics.

Water Supply

The Gregory River is the largest permanent stream in the area. It is reported to have a dry-season flow in excess of 100 cusecs near its junction with the O'Shanassy River (Whitehouse, 1940), but the surface flow diminishes downstream. If circumstances should warrant it the Gregory River could readily be dammed above the point where it enters the plains. Lawn Hill and Widdallion Creeks also are permanently flowing streams in their upper courses. They, in addition to Musselbrook and Elizabeth Creeks, could be dammed near the points at which they emerge from the Constance Range. Some earth tanks and dams have been constructed in the plains country.

There are a large number of permanent waterholes on other watercourses. Because the better pasture land is reasonably well-watered, very few bores have been put down. However, underground water should be available under the soil and alluvium of the plains country. Water has been obtained in the central portion of the Sheet area at depths ranging from 85 to 360 feet.

Information regarding the water resources of the various Pro zoic formations is given in Table I.

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BIBLIOGRAPHY

A.G.G.S.N.A., 1940a - Report for period ended 31st December, 1939. Aer.Surv.N.Aust.

__________, 1940b - Report for period ended 30th June, 1940. Ibid.

BALL, L.C., 1911 - The Burketown Mineral Field (silver lead and zinc mines). Pub.Geol.Surv.Qld. No.232.

__________, 1931 - The Lawn Hill mineral field. Qld.Govt.Min.J., 32, 263.

BLASKETT, K.S., 1959 - Concentration of iron ores from Constance Range, Queensland. Sci.ind.Res.org.Melb.Ore dressing Invest., 568.

BROOKS, J.H., 1956 - Iron ore deposits of Queensland. Summary Report. Qld.Govt.Min.J., 57, 837-843

BRYAN, W.H. and JONES, O.A., 1944 - A revised glossary of Queensland stratigraphy. Univ.of Qld.Pap., Dept. of Geol., 2 (11).

CAMERON, W.E., 1900 - On the Lawn Hill silver-lead company's properties, Mended Hill. Pub.Geol.Surv.Qld. No. 138.

__________, 1901 - Geological observations in north-western Queensland. Qld.Dept.Mines Ann.Rep. 1900-1902 (Pub. Geol.Surv.Qld. No.159), 186-191.

CARTER, E.K., 1959 - New stratigraphic units in the Precambrian of north-western Queensland. Qld.Govt Min.J., 60, 437-441.

__________, and BROOKS, J.H., 1960 - The Precambrian of north-western Queensland. J.geol.Soc.Aust., 6(2).

__________, and WALKER, K.R., (in preparation) - The Precambrian mineral belt of north-western Queensland. Bur.Min.Resour.Aust.Bull. 51

C.S.I.R.O., 1954 - Survey of Barkly region, 1947-48. Sci.Ind. Res.org., Land Res.Ser. 3.

DAVID, T.W.E., 1932 - EXPLANATORY NOTES TO ACCOMPANY A NEW GEOLOGICAL MAP OF THE COMMONWEALTH OF AUSTRALIA. C.S.I.R., Melbourne.

DUNSTAN, B., 1913 - Queensland mineral index.Pub.Qld Geol.Surv. No. 241.

DUNSTAN, B., 1920 - North-western Queensland. Geological notes on the Cloncurry-Camooweal-Burketown-Boulia area. Ibid., No. 265.

EDWARDS, A.B., 1953 - The Lawn Hill silver-lead field. In GEOLOGY OF AUSTRALIANORE DEPOSITS. Fifth Emp.Min. Metall.Congr., 1, 378-383.

__________, 1957a-c - Constance Range iron formation, I-III. Sci.ind.Res.Org.Mineragr.Rep. 716,718 and 719.

__________, 1959a - Oolitic iron formation at Constance Range, IV: DDH42B. Ibid. 770.

__________, 1959b - Oolitic iron formations from Constance Range, V: Analysed specimens, Ibid., 776.

HODGKINSON, W.O., 1877 - Exploration in north-western Queensland, 1875-76. Votes and Proc. Legis. Ass. Qld Session of 1876, 3, 352-386.

HOLMES, A., and SMALES, A.A., 1948 - Monazite from Bodmin Moor, Cornwall: A study in geochronology. Roy.Soc.Edinburgh Proc. Sec. B, 63(2), 115-129.

JACK, R.L., 1885 - Six reports on the geological features of part of the district to be traverses by the proposed trans-continental railway. Parl.Pap. reprinted with revisionary notes in 1898 as Geol.Surv.Qld Bull. 10 (Pub. 136).

JENSEN, H.I., 1941a - The Lawn Hill silver-lead-zinc field, Lawn Hill-Wollogorang district. Aer.Surv.N.Aust.Qld Rep. 46.

__________, 1941b - Report on portion of North-western Queensland adjacent to Northern Territory border. Ibid., 47 (unpub.).

LANDSBOROUGH, W., 1862 - JOURNAL OF LANDSBOROUGH'S EXPEDITION FROM CARPENTARIA, IN SEARCH OF BURKE AND WILLS. Melbourne, Wilson and McKinnon.

NIER, A.A., THOMPSON, R.W. and MURPHEY, B.F., 1941 - The isotopic composition of lead and the measurement of geological time. III. Phys.Rev., 60, 112-116.

NOAKES, L.C., 1956 - Upper Proterozoic and Sub-Cambrian rocks in Australia. In EL SISTEMA CAMBRICO, SU PALEOGEOGRAFIA Y EL PROBLEMA DE SU BASE, 2, 213-238. 20th Inter.Geol. Congr., Mexico.

__________, and TRAVES, D.M., 1954 - Outline of the geology of the Barkly region. In SURVEY OF BARKLY REGION, 1947-48. Sci.ind.Res.Org.Land Res. Ser. 3.

NYE, P.B., and RAYNER, E.O., 1940 - The Cloncurry copper deposits with special reference to the gold-copper ratios of the ores. Aer.Surv.N.Aust.Qld Rep. 35.

ÖPIK, A.A., 1956a - Cambrian geology of Queensland. In EL SISTEMA CAMBRICO, SU PALEOGEOGRAFIA Y EL PROBLEMA DE SU BASE, 2, 1-24, 20th Inter.Geol.Congr.,Mexico.

__________, 1956b - Cambrian palaeogeography of Australia. Ibid. 2, 239-284.

QUEENSLAND GOVERNMENT MINING JOURNAL, 1954 - Geological and geophysical survey of the Lawn Hill, Mt. Isa, Cloncurry region, north-western Queensland. Qld Govt Min.J., 55, 910-916.

SAINT-SMITH, E.C., 1925a - Lawn Hill silver-lead-zinc field, Burketown Mineral Field. Ibid., 26, 91-92 and 303-307.

STEWART, G.A., 1954 - Geomorphology of the Barkly region. In SURVEY OF BARKLY REGION, 1947-48. Sci.ind.Res.Org. Land Res.Ser. 3, 42-58.

TWIDALE, C.R., 1956a - The physiography of north-west Queensland. Geogr.Stud. 3, 1.

__________, 1956b - Chronology of denudation in north-west Queensland. Bull.geol.Soc.Amer., 67, 867.

WHITEHOUSE, F.W., 1936 - The Cambrian faunas of Eastern Australia. Part I. Stratigraphic outline. Qld Mus.Mem. 11(1), 59-112, Reprinted as Univ. of Qld Dep.of Geol.Pub.82.

__________, 1940 - Studies in the late geological history of Queensland. Univ. of Qld Pap. Dep. of Geol.n.s.2(1).