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PRELIMINARY REPORT ON

THE PRE-CAMBRIAN ROCKS OF THE LAWN HILL, CAMOOWEAL AND DOBBYN SHEETS

by

K.A. Townley, E.M. Bennett, and D.J. Gates.

Canberra

20th June, 1952.

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CONTENTS

TABLE I: CHART OF GEOLOGICAL HISTORY

AGE	ROCK UNIT	PERIODS OF EROSION.	TECTONIC ACTIVITY.	IGNEOUS ACTIVITY	REMARKS
			Slight Tilt?		
Oligocene?	Laterite				Formation of Drainage System
			Rise		
Cretaceous?	Verdon Lst.? Sandstone Relics				
			Epeiric Sinking (L.Cretaceous)		
Cambrian	Cambrian				
		Major			
		Unconformity		L.Cambrian Volcanics	Volcanics apparently not widespread in this area.
U.Proterozoic	Constance Group				
		Major	Intense-Algoman?	Sandy Archie Ck. Granites	Lead-zinc mineralization, Lawn Hill field (and Mt.Isa?).
		Unconformity			
	Lawn Hill Group: Upper (Widallion)	Deduced ? ? ?		Rhyolite.Tuff.	
	Lawn Hill Group: Lower (Ploughed Mt)				
L.Proterozoic			Gentle folding?	EasternCk.Basalt	Eastern Ck.Basalt is related to flows in base of Ploughed Mt. then age is fixed.
	Mt. Isa Group: Upper (Mt.Oxide)				Copper Mineralization (Mt. Isa and Mt. Oxide).
	Mt. Isa Group: Lower (Calton Hills)	Slight ? ? ?	Gentle folding?		
		Major Uncon. postulated	Intense-Laurentian?	Granite	Copper Mineralization (Dobbyn)
Archaeozoic	Kalkadoon Group			Porphyry etc.	

I. SUMMARY

An area of about 12,000 square miles was mapped in the field seasons 1950-51. It contains four Pre-Cambrian rock groups ranging from Archaeozoic to Uppermost Proterozoic. The main groups in the area, the Mt. Isa and Lawn Hill Groups, are shallow-water geosynclinal sediments involved in a Proterozoic orogeny which resulted in fairly intensive folding along dominantly north-south axes, together with much faulting.

The sets of faults are present, one north-south, another north east and north-west, and the third east-west. The orogen was preceded and accompanied by large scale granite intrusions and basalt flows, whose time relationship has not yet been completely worked out. Lead-zinc mineralization took place in Proterozoic times in the Upper Lawn Hill beds, and copper mineralization in the shattered synclines which flank the major intrusives.

Surface water in the area is scanty, but localities exist where reservoirs could be accumulated in the creeks; and sites for small-capacity bores are numerous.

II INTRODUCTION

The area so far mapped of the Cloncurry Pre-Cambrian rocks includes the Lawn Hill, Camooweal and Dobbyn four-mile sheets, and a little of the Mt. Isa sheet, an average of about twelve thousand square miles in all. Mapping was done using aerial photographs as a topographic base; these were on a scale of 1:50,000. Owing to the great area to be covered in a limited time, and to the rugged nature of the terrain, it has not been possible to cover the entire ground in the field; traverses were selected in the field and linked together by photo-geological interpretation. The traverses can be distinguished on the map by dip angles, lithological notes, etc.

Slotted template assemblies of the Lawn Hill and Camooweal sheets had been prepared by the National Mapping Section, Dept. of Interior, and the draft maps have been compiled from them. The only assembly available of the Dobbyn sheet, however, was an uncontrolled photo-mosaic at 4 miles to the inch. When this was enlarged to photo scale, it was found to contain many topographic inaccuracies, which were eliminated as far as possible in the compilation of the draft maps. The latter were produced at photo scale on sheets approximately 30" by 40"; and reductions of these to a scale of 2 miles to one inch have been made.

Previous work in the area has been confined to the mining fields; for a list of the relevant publications of the Queensland Geological Survey, the Aerial, Geological and Geophysical Survey of Northern Australia, and other bodies, see the Bibliography.

The work has so far extended over the 1950 and 1951 field seasons, and the periods worked in the field and the persons taking part were as follows:

August - September 1950:	K.A. Townley
	W.C. Smith
(5 weeks)	D.J. Gates
May - October 1951:	K.A. Townley
	D.J. Gates
(22 weeks)	E.M. Bennett

P. Healy of the Queensland Geological Survey was also a member of both parties for field work only.

Access,to the area: The Barkly highway from Mt. Isa to Camooweal lies just south of the Camooweal sheet in the area mapped: it is the only good road in North-West Queensland. A new highway is being built between Cloncurry and Mt. Isa, but was not finished by the end of 1951.

A vehicle track from Yelvertoft Dip, 45 miles east of Camooweal, to Thorntonia Station follows the Pre-Cambrian - Cambrian contact fairly closely. From Thorntonia northwards a fair track runs to Riversleigh Station, and an old track, now disused, runs to the Lily waterhole, 18 miles east of Riversleigh - Lawn Hill track passes through the Lawn Hill silver-lead field (25 miles north of Riversleigh), and Lawn Hill Station and Gregory Downs are also connected by a good track.

In the south a track leaving the Barkly Highway at the 19 mile bore leads to Calton Hills Homestead, and thence north over the basalt plain to the Mammoth mine. North of the Homestead the track is disused and in bad repair, and Henry's old Mt. Oxide road from the Mammoth to Mt. Oxide is impenetrable to vehicles.

In the east, a good track joins Dobbyn and Kajabbi, running almost parallel to the railway line. From Kajabbi, access to the west is on a fair track for twenty miles to Greta Homestead, which is on Surprise Creek just above its junction with the Leichhardt. From here a rough track runs north-west to Dobbyn, mostly over igneous rocks. From Dobbyn a track runs to Mt. Oxide, ninety miles to the North-west. The first twenty miles are good, but after that it deteriorates and is very rough, with a bad sandy crossing of Mistake Creek. A limited amount only of the country is accessible by jeep from this track. An old dray track used to join Mt. Oxide with Thorntonia Station, but this is now undistinguishable. A track runs north-east from Dobbyn across the Leichhardt to join the main Cloncurry-Burketown road about eight miles north of Coolullah Homestead. A rough track also runs from Dobbyn, via the Orphan mine, to the Crusader mine, and links up at Elsie siding with the Dobbyn-Kajabbi track.

III PHYSIOGRAPHY AND TOPOGRAPHY

i. The Lawn Hill Sheet: Drainage is to the north-east, converging towards Burketown and the Albert River. The Gregory River and Lawn Hill Creek, both arising in the Middle Cambrian Limestones to the west of the area mapped, are perennially flowing streams fed by springs. None of the other creeks, except, for a few miles, Widallion Creek (which bifurcates from Lawn Hill Creek), flow in the dry season. In the alluvial and lateritic plains of the north and east all creeks anastomose, and their channels cover a wide area.

Relief is fairly low, although the hills and ridges of the south central and south-eastern parts of the map are abrupt and steep, and give an impression of high relief: the scarp of the Constance Range, west of Widallion Creek, which rises almost vertically about 300 feet from the alluvial plain, is a prominent feature. Wide areas, including the whole of the north-eastern quarter of the map, are covered by alluvium; and west of this is a broad band of equally featureless laterite.

The topography of the Pre-Cambrian outcrops is determined by the juxtaposition of hard bands of sandstone and quartzite with softer bands of shale, slate and dolomitic limestone, which leaves steep ridges of the harder rock rising from alluvium-covered valleys of the less resistant rocks; and the steeper dips of the older formations accentuate this.,

ii Camooweal Sheet: Drainage is to the north and north-east, all creeks being tributaries of either the Gregory River or the Leichhardt River.. Only the O'Shanassy River, which joins the Gregory just below Riversleigh Station, is perennially flowing.

The topography of the western half of the sheet is one of very little relief except for occasional mesas: this is on the flat-lying Cambrian limestone, which develops a karst topography towards its margin. The Pre-Cambrian rocks are weathered much as in the Lawn Hill sheet; that is, the more resistant sandstones and quartzites stand out as ridges separated by valleys in the dolomitic limestone, shale, etc. The Sandy Creek granite forms a slightly dissected plateau, and the Eastern Creek basalt gives rise to a large flat area in the south-east. The most elevated and rugged area is that in the east and north-east, where tight folds in quartzites have given rise to numbers of parallel and sub-parallel ridges rising abruptly from the valley of Sandy Creek.

iii. Dobbyn Sheet: west of the Leichhardt all drainage is to the north-east; all creeks are tributaries of the Leichhardt. The three main creeks draining the western area are Surprise, Mistake, and Gunpowder Creeks. East of the Leichhardt the drainage is to the north-west, and creeks generally are much smaller than the major ones in the west. The area west of Dobbyn is of low relief, but rough owing to the rugged ridges of quartzite which are the remnants of an old land surface. North of Dobbyn and east of the Leichhardt the country is uniformly level, and covered mainly by alluvium and Cretaceous rocks.

In general, the drainage pattern of the area is considered to be antecedent to the present topography: it is suggested that the pattern was developed during the period of lateritic peneplanation or after the Cretaceous transgression had covered the area with flat sandstones, (of which occasional remnants are found capping hills,) and has been superimposed onto - and is partly responsible for - the present topography.

IV. STRATIGRAPHY.

Table I shows the stratigraphic column as far as it has been established.

i. The Kalkadoon Group.

Around Dobbyn a small area of the oldest rocks so far encountered has been mapped. These are named by AGGSNA the Kalkadoon series (Ann. Rept, AGGSNA, 1936). It is not possible in this area to define its age relationships with other sedimentary rocks because it is now here in contact with them; but the Kalkadoon group has been involved in an earlier orogeny than the Mt. Isa Group, and as this orogeny is probably of Laurentian age, the group can be assigned to the Archaeozoic.

Kalkadoon rocks are in consequence considerably more metamorphosed then those met with elsewhere in the area. The uppermost beds are quartzites and sandstones; below these are limestones now transformed into calcite marble with chalcopyrite. Under these again are epidotoised quartzites and schists; and the oldest rocks yet mapped are altered porphyries (see section IV (iii) below). Several copper mines occur within the area occupied by this group, in the Dobbyn area, and a detailed description of the country rocks encountered will be found in Iten and Searl (1952).

The group extends southwards beyond the mapped area.

ii. The Mt. Isa Group.

This group is so named because AGGSNA (Honman, 1939) in mapping the Mt. Oxide area, named the rocks Mt. Isa series: as the present survey has not yet reached Mt. Isa, there is no certain link-up with the rocks exposed there, but

they are probably of the same age. The group has been divided into Upper and Lower formations on tectonic and lithological grounds and on the presence of an unconformity on Gunpowder Creek north-east of the Mammoth mine, which has, however, only been traced for a few miles. These are referred to in this report as Upper and Lower Mt. Isa Formations, but will be given correct formal names when more field work has been done.

(a). The Lower Mt. Isa Formation (Calton Hills Formation?)

In the core of the anticline whose axis runs north-south practically along the eastern margin of the Camooweal sheet, there are extensive basalt flows (The Eastern Creek basalt) projecting through these are blocks of quartzite whose bedding and surface characteristics are almost entirely lost; there are also - north of Eastern Creek - remnant beds of sandstones and quartzite which retain their bedding and reflect the anticlinal structure. These may conveniently be classed together as the Lower Mt. Isa Formation, for which the name Calton Hills Formation is tentatively proposed. There are no direct field criteria for dividing the known Mt. Isa beds in this way other than the unconformity mentioned above; as far as can be seen no slates or shales occur in the succession other than the thin band immediately below the unconformity. Honman (1939) includes a dolomitic band in the crest of the anticline east of the Mammoth mine, but no trace of this was found by the present investigators.

(b) The Upper Mt. Isa Formation (The Mt. Oxide Formation?)

The Upper Mt. Isa Formation is exposed along, and west of, the Mt. Gordon Fault system. Its boundary with the Ploughed Mt. Formation is still in doubt in places, because the conglomerate at the base of the Ploughed Mt. Formation disappears under laterite near the Johnson River, and has not yet been identified farther south and east. The formation consists mainly of sandstones and quartzites with subordinate dolomitic limestones and shales.

iii. The Lawn Hill Group

The name is after Jensen (1941b); it has been found possible to subdivide the group into two formations.

(a) The Ploughed Mt. Formation

The Ploughed Mt. Formation can be traced from the Caroline Range north of Lawn Hill homestead to Paradise Valley in the south, though the affinities of the Paradise Valley rocks themselves are still in doubt. The name is taken from The Ploughed Mountain, a range five miles east of Lawn Hill homestead, where the uppermost quartzites and dolomitic limestones crop out.

The formation consists of alternating bands of quartzite or solicified sandstone, and dolomitic limestone; with the latter are interbedded thin flaggy sandstones and a few shales, which become thicker and more numerous towards the south. At the base of the formation is a thick conglomerate divided into three by thin quartzite bands. The middle band of conglomerate contains thin sills or flows of vesicular basalt, and is partly agglomeratic.

(b) The Widallion Formation

The uppermost rocks of the Lawn Hill Group are exposed in a belt some ten miles wide, and extending from Mt. Oscar in the North to the Seymour river in the south. They are named from Widallion Creek, east of the Constance Range, and the type section is from the Edith Range to the Ploughed Mountain.

The Rocks consist, as exposed, of shales and slates with sandstone and quartzite. Fairly high in the formation are a few thin rhyolites and tuffs, and a shaly limestone is exposed at White Crossing, ten miles north of Lawn Hill.

The mineralization of the Lawn Hill field is in this formation.

iv. Sedimentation in the Proterozoic.

From the base of the Mt. Isa Group upwards, all the Pre-Cambrian sediments are of shallow water origin. Ripple marks and current bedding are common in the sandstones and quartzites throughout; and the flaggy beds in the dolomitic limestone of the Ploughed Mt. Formation are similarly ripple-marked.

There is a constant repetition of similar types: sandstones intercalated with shales gradually decrease in shale content, are replaced by sandstones with limestones, and then give way again to sandstones and shales; but no major lateral change in facies has been found, and the shaly beds contain dolomites and the dolomites shales. Two conglomerates have been mapped, one in the Sandy Creek syncline which occur without angular unconformity relative to the rocks below them.

These conglomerates tend to confirm the theory suggested by the rhythmic sedimentation that the sequence is the result of cyclic depostiion in very shallow water, infilling a gradually sinking geosyncline. They indicate that there were periods when, without horizontal movement, the surface rose above water for a short time and then sank again. (Probably more conglomerates of the same type would be found by more intensive mapping.)

The total thickness of rock in the combined Mt. Isa - Lawn Hill Groups can only be guessed because of the repeated dislocations, but may be of the order of 20,000-25,000 feet.

It is considered that deposition continued almost uninterruptedly throughout the whole period: though if the Eastern Creek basalt was expanded at the end of Mt. Isa where there must have been a considerable erosion, even the great conglomerate which is used to divide the Mt. Isa from the Lawn Hill Group generally lies only slightly unconformably on the Mt. Isa rocks, and in many places seems to be entirely conformable. It is therefore not possible except by extremely detailed work to subdivide the series by age, since no criteria are available for the identification of any isolated outcrops.

v. The Constance Group

The group is named from the Constance Range east of Lawn Hill homestead, where the unconformity between the basal sandstone and the underlying Widallion beds is clearly shown.

Jensen (1914b) applied the name "Constance Range Series" to the Cambrian limestones "and quartzites". It has been found necessary to split this series into Cambrian limestones and Pre-Cambrian Constance Group on account of the major unconformity between them.

The thickness of the group within the limits of the area mapped is small--about 1000 feet. The basal bed is a fairly coarse, ripple-marked, silicified sandstone, below which are some thin and discontinuous lenses of conglomerate. Above it are slates and shales followed by sandstone and quartzite.

The succession above this has not been mapped. The whole has been laid down on an irregular surface of upturned and eroded Lawn Hill Beds.

vi. Cambrian and Later.

The Cambrian and later rocks of the area are dealt with by Noakes and Traves (1952) and O'pik (1952).

Only two points need to be added here:

(a) A single outcrop of vesicular basalt was discovered between the Constance Group and the Middle Cambrian Limestone.

This may be a representative of the Lower Cambrian Volcanics, hitherto unrecorded from the Eastern edge of the Barkly Tableland.

(b) Occasional hill cappings of ?Cretaceous, unfossiliferous sandstone are found at scattered points throughout the area.

These appear to be indications of a widespread ?Cretaceous transgression.

V. ASSOCIATED IGNEOUS ACTIVITY

Igneous activity is widespread throughout the area; its suggested stratigraphic relationships can be seen from Table 1.

Petrographic examination of the specimens collected in the field is far from complete, and no clear account of most of the rocks mentioned can therefore be given.

i. The Granites

(a) The Dobbyn Granites

Two masses of granite are exposed on the Dobbyn sheet. They appear to be sodic granites or granodiorites, and are intruded into porphyries. Basic dykes are found intruding the granite and the porphyry but none have been found in the surrounding sediments, nor are there any acid dykes or quartz reefs in the latter which can be assigned to the granitic intrusions.

The "Granitised sediments" mapped at the northern end of the more westerly granite are schists which are thought to be a roof pendant of Kalkadoon age.

There are two possibilities to be considered when estimating the age of the Dobbyn granites: (i) that they are post-Kalkadoon and Pre-Mt. Isa; and (ii) that they are post Mt. Isa and pre-Constance. Their role in the structural history of the area is discussed below; but they must have been emplaced before the orogeny which deformed the Proterozoic rocks, since their stabilising influence on the anticlines is well marked, as is the increased complexity of the folding at a distance from that influence but there is not much evidence to show whether they were a basement for the Mt. Isa beds or were emplaced in the folds before the major effect of the compressive force was felt. It is noteworthy that there are no dykes or quartz reefs in the Mt. Isa sediments bordering the granite (so far discovered) and that at only one place was there any evidence found of contact metamorphism; and that was rather disputable.

Until evidence to disprove it is found, the supposition is advanced that the Dobbyn granites are pre-Mt. Isa in age, and were emplaced during the orogeny (probably Laurentian) which metamorphosed the Kalkadoon group.

(b) The Sandy Creek Granite

Between Sandy and Fiery Creeks is an area of some 15 sq. miles of granite. It is not possible accurately to define its boundaries, because they take the form of increasingly granitised sediments - mostly sandstones - until towards the centre there is apparently true granite. The appearance in fact is that of a purely metasomatic replacement. The age of the Sandy Creek granite is post-Ploughed Mt., because it transgresses the Ploughed Mt. - Mt. Isa contact.

(c) The Archie Creek Granite

There is a similar area of granitization just east of Archie Creek (runs 11 and 12, Lawn Hill sheet). It lies about

40 miles north-west of the Sandy Creek granite, and it may fairly be assumed that the two are contemporaneous. The Archie Creek Granite is entirely contained in Ploughed Mt. sediments.

It is inherently probable that the Archie Creek granite is related to the Lawn Hill lead-zinc-silver mineralization, though there is no evidence for this: the ploughed Mt. rocks which lie between the visible granite and the mineralized Widallion rocks are barren of minerals. But it is practically certain that the Sandy Creek and Archie Creek granites are a phase of the (Algoman?) orogeny which affected the Mt. Isa and Lawn Hill groups; and the mineralization is certainly post-Widallion and pre-Constance.

ii. <u>The Basalts</u>

(a) The Eastern Creek Basalt.

Most of the south-eastern corner of the Camooweal sheet, and the south-western corner of the Dobbyn Sheet, are occupied by a large exposure of basalt, which also continues many miles south towards Mt. Isa. It occupies the core of a large anticline and its thickness is unknown, though probably not great because in many places thin bands of sediment are exposed within the basalt. The basalt consists of a number of flows, and the thickness of one of them was measured at 90 feet.

The age of the Eastern Creek basalt is doubtful: it was extruded before the major tectonism of the area, as shown by the fact that faults normal to the Mt. Gordon fault zone affect it, and that trends of folding are occasionally discernible in it. Also, further south, tuffs and chloritic schists are associated with it which conform to the attitude of the country rock. Provisionally it has been put at the top of the Mt. Isa Group; but as it is certainly younger than the Dobbyn granites, a closer estimate can only be made when they have been re-examined.

The basalt carried traces of copper in places, and may be associated with the origin of some of the copper deposits of the area: it is very probable that it is closely connected with the altered dolerite at Mt. Isa Mines, which is considered as the probable source of the Mt. Isa copper lode. (S.R. Carter, personal communication.)

Five miles north of the Eastern Creek stockyard is a small plug of diorite: it is possible that this is an indication of an underlying pluton. (See section V(1) below).

Generally the basalt does not seem to have suffered much metamorphism, but in places bands of chloritic schist are found in it. Thin streaks of a whitish alteration product looking like magnesite can also be found in the basalt, and on the aerial photographs they can be seen to have a trend akin to that of the nearest country rock. It seems probable, therefore, that the basalt has been caught up in the folding, and, though resistant, has been partly moulded and altered in the course of the movements.

(b) The flows in the Ploughed Mt. Conglomerate.

Two thin but persistent flows of vesicular basalt are found in the Ploughed Mt. conglomerate. They may be of an age with the Eastern Creek basalt. In the lower part of this conglomerate, too, there is a thick band of agglomerate whose affinities are unknown.

(c) The Northern Basalt.

A small and perplexing exposure of basalt was mapped on the Lawn Hill sheet (run 11 photo 5216) unconformably overlying Ploughed Mt. sediments. Two distinct basalts - an amygdaloidal one and a uralitized ?dolerite - are found, associated with tuffs, in a section of about 50 feet vertical thickness. Laterite immediately to the east and south hides any clue as to their age and affinities.

iii. The Porphyries

There are two main outcrops of porphyry in the Dobbyn area, both intruded by granite. That near Dobbyn is a quartz porphyry, highly sheared and altered by granite intrusion.

That near Gunpowder Creek is a quartz-orthoclase porphyry, with inclusions of mafic minerals which give it a darker appearance. Notwithstanding the mineralogical difference between the two, it is possible that they are of the same stock: the effect of the granite intrusion would be sufficient to mask their identity.

iv. Other igneous rocks

Basic dykes intrude both granite and porphyry. They vary considerably in type, and range from diorites and dolerites to a possible augitite.

VI. THE STRUCTURE OF THE AREA

(a) Folding

In general the folding has a north-south or NNE-SSW trend, though there are many local variation.

The south-eastern part of the area centres on two great anticlines with igneous cores: the more easterly of these has an exposed core of Dobbyn granite extending for 50 miles north-south. The western anticline has no exposed plutonic core, except possibly the plug of diorite mentioned above, and is covered by an extensive basalt flow; but it is considered that the similarity in behaviour of the two anticlines indicates that a granitic core underlies this one also.

The flanks of these anticlines are occupied by heavily folded and faulted synclines whose axes run north-south, veering to NNE to the north. The age of the granite cores is discussed in section IV; but whatever the age it seems likely that they were emplaced before the major orogenic forces built up, because the anticlines are much less disturbed than their concomitant synclines, as would be the case if their resistance were strengthened by igneous cores. In the north, the western anticline is crumpled and contorted: it is suggested that the batholith plunges northwards, and has here plunged so deep that it is no longer effective as a massif against the folding.

West of the Mt. Gordon fault system, which is the western syncline, the folding loses its regularity and becomes less intense; minor folds are developed, with varying pitch and divergent axes - although the general disposition of the axial trends is still NNE; and some dome-and-basin structures are found. The rocks of this zone are largely arenaceous. Farther west still the folding again becomes more intense, and the majority of fold axes are north-south, but there is some development of irregular NW-trending folds. These rocks are comparatively thin quartzites and sandstones interbedded with thicker dolomitic limestones (which are highly contorted,) and the incompetency of the latter may have contributed to the tighter folding.

North of the Gregory River is a considerable development of dome-and-basin structure, and the axial trend generally veers easterly, until, east of Lawn Hill homestead, two ranges striking north-east are found.

Two hypotheses are suggested to account for this north-easterly swing. It may be a local irregularity which is caused by the smaller load on the upper rocks of the series when pressure was exerted; or it may be the result of a complexing of two forces. More or less contemporaneously with the force from the east which has caused the main orogeny in this area, a compressive force was exerted from the north, which had its greatest effect in the rocks

of the Calvert Hills Area. (A reconnaissance traverse was run through this area in 1950). Here the strike is east-west, and the folding fairly intense. A complex of the two forces at their meeting point would give rise to a north-east strike and to a good deal of irregularity, leading to dome-and-basin and similar phenomena.

The Widallion formation, found in the south-central part of the Lawn Hill sheet, is more gently folded than the lower formations, and an unconformity has been deduced between it and the Ploughed Mt. Formation; but as it is in the "cusp" zone between the two forces postulated above, and as it is also the highest formation affected by the orogeny, the gentler folding and irregularity may be caused by a diminution of pressure rather than a prolonged time lapse followed by further pressure.

The Constance Group is still more gently folded, and no pattern of folding is discernible; certain areas (Lawn Hill, runs 7 and 8) show unmistakable evidence of slumping on an irregular platform. For these reasons it is considered that the folding was superficial and was not connected with the geosynclinal orogeny; and that the Constance beds are epicontinental.

The Cambrian Limestone, apart from some local slumping in the "Dentalium Plateau" and north of Yelvertoft Dip, is sub-horizontal, dipping gently and continuously to the west.

(b) Faulting

The fault pattern resolves itself readily into three groups:

(i) The north-south complex of the Mt. Gordon fault system. This is the earliest of the groups, and appears to be a thrust system relieving the pressure on the more westerly beds.

(ii) A consistent pattern of NE and NW tear faults which are compression faults acting in accordance with the hypothesis of a compressive force from the east.

(iii) More or less contemporaneous with these is a rather less regular pattern of East-west faults. These are apparently normal faults.

(c) The Tectonic History of the Area

Much of the tectonic history given below is highly speculative; the course of events, if the hypotheses outlined above are accepted, was probably as follows.

(a) An early intense tectonism (Laurentian?) resulting in the folding and metamorphism of the Archaeozoic Kalkadoon group.

(b) Major intrusions of granite.

(c) Deposition of Mt. Isa Group, followed by gentle folding.

(d) Period of erosion.

(e) Infilling of the eroded cores of the major anticlines by basalt.

(f) Deposition of Lawn Hill Group.

(g) Intense pressure from the east (and from the north?) causing the major (Algoman?) orogenic movement.

(h) Metasomatic emplacement of Sandy and Archie Creek granites.

(i) Period of erosion.

(j) Deposition of Constance Group and superficial folding thereof.

(k), Period of erosion.

(l) Flow of Lower Cambrian Basalt.

(m) Deposition of Middle Cambrian limestone.

(n) No further ascertainable movements until the epeiric sinking during Cretaceous time, wherein part or all of the area was covered by a Cretaceous transgression.

(O) Lateritization, with development of, effectively, the present drainage system.

(p) Post-Miocene erosion of laterite, with, possibly, all slight epeiric tilt downwards to the NE.

Table I gives a tentative correlation between stratigraphy, igneous activity, and tectonism along the lines discussed above.

If the two main orogenies are accepted as Laurentian and Algoman in age, which seems likely by analogy with other Pre-Cambrian geosynclines in Northern Australia (Noakes, 1952) then the upper and lower limits of the Mt. Isa - Lawn Hill deposition can be fairly closely located, and the age of the Constance Group fixed as Upper Proterozoic (Nullagine). The ages of the two granites can also be specified within fairly narrow limits.

VII. MINERAL DEPOSITS

The mineral wealth of the area mapped lies in three zones: the Lawn Hill silver-lead-zinc field, the Mt. Oxide copper group, and the Dobbyn copper group. The last is best left for consideration with the Cloncurry area, to which it is allied.

(a) The Lawn Hill Silver-lead-zinc field.

The field consists of a large number of small fissure deposits in or associated with the NE-SW faults which are numerous between Lilydale Springs and Lawn Hill Creek. No detailed mapping of the mines has been attempted by the present survey. They are described in Cameron (1900a), Ball(1911), Saint-Smith(1926) and Jensen (1941b).

The ore consists of galena and sphalerite in a sideritic or manganiferous gangue. Galena and sphalerite commonly occur separately. The country rock is shale and thin sandstone with an occasional rhyolite and tuff band. The galena occurs as small but rich veins, and carries a high silver content (up to 40 oz. per ton). At the present time there are some half-dozen gougers on the field, producing a little high-grade lead ore, which is sold to Mt. Isa Mines Ltd. Owing to the expense of haulage and the small quantities produced, the operable cut-off is about 35%, and large quantities of poorer ore are being dumped, which could be recovered is a small battery were available in the area. There is no sale for zinc which is therefore all dumped.

The only known possible source for the mineralization is the Archie Creek granite, about 25 miles ESE of the field.

Mineralization is confined to faults in the Widallion beds, those in the neighbouring Ploughed Mt. rocks being barren, except for the Waanyee copper mine, a very small malachite show in a fault in The Ploughed Mountain beds.

(b) The Mt. Oxide Group

For a description of the Mt. Oxide and adjoining mines see Honman (1939) and earlier reports by Ball (1908) Cameron (1900b) and Dunstan (1920). South Broken Hill Ltd. have recently re-examined and drilled the Mt. Oxide lode.

The copper deposits occur in or near the Mt. Gordon fault system. The country rocks are sandstones and shales with subordinate dolomitic limestone, and the ore-shoot at Mt. Oxide is in slates, generally graphitic, in the zone of influence of Mt. Oxide fault which is en echelon fault of the Mt. Goroow System.

The source of the ore i s not definitely known: it is fairly certain that the fault system formed the channel for the incoming of the ore, and deposits seem to be localised in cross- and echelon-shears rather than in the main NNE system.

Small copper occurrences are found also in the eastern syncline, between the Eastern Creek basalt and the Dobbyn granite.

(c) The Loch Ness field (Jensen, 1941a) occupies an area astride Surprise Creek at the south-eastern edge of the granite. This field has not yet been visited during the present investigation.

It contains a large haematite deposit as well as small copper-gold deposits.

VIII. WATER SUPPLIES

(a) Flowing Streams

The Gregory and O'Shanassy Rivers and Lawn H ill Creek, with its offshoot Widallion Creek, ate the only perennially flowing streams in the area. They are fed by springs from the limestone of the Barkly Group. The flow of the Gregory River below Riversleigh has been measured (Dunstan,1920) at 83,000,000 gallons per day, and that of the O'Shanassy at 24,000,000 gallons per day. No value for the average flow of Lawn Hill Creek has been found, but it is much smaller than the other two.

(b) Waterholes

Most of the larger creeks in the area contain numbers of permanent and semi-permanent waterholes. Owing to the nature of the country these are generally inaccessible to cattle, though some are in continuous use. Much wider use of static water could be made, however, because it is considered that it would be simple to locate positions for artificial dams on all the main and many of the minor creeks at such sites that cattle could use them.

(c) Bore Prospects

There is little chance of siting large capacity bores anywhere in the area, owing to the high dips and frequent dislocations of the country rocks; but there are numerous places where small pockets of water could be tapped at fairly shallow depths. Bores have been sited on Riversleigh and Calton Hills stations, but results of boring are not yet to hand, except for one bore at Riversleigh, where a good supply was struck at 80 feet. Unfortunately the water had too high a mineral content to be usable for stock.

Records of existing bores are rather scanty. Complete logs of five Lawn Hill bores have been obtained; and there is an interesting record of granite having been struck below the alluvium on Kamilaroi Station, at a place which has previously been mapped as alluvium-covered Cretaceous.

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