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EXPLANATORY NOTES ON THE CLONCURRY 4-MILE GEOLOGICAL MAP

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INTRODUCTION

Cloncurry was the centre of Australia's largest copper producing mining field for many years: the first deposit was found in 1867; and the area has been the subject of many geological investigations. Most of these were purely local examinations of individual leases, and are listed in the Bibliography on p. More general investigations were made by Jack (1885), Rands (1895), Cameron (1900, 1901), Ball (1905), and Dunstan (1920). Shepherd (1928 unpubl; see Sh pherd, 1946a) subdivided the Precambrian sequence, and his classification was used by David (1932) in his geological Map of Australia. The Aerial, Geological & Geophysical Survey of North Australia used air-photographs to map the four main mineral areas within the Sheet boundaries, between 1935 and 1940. The most comprehensive survey of the area is that by the Bureau of Mineral Resources and the Geological Survey of Queensland (Carter, Brooks & Walker, in preparation), which is the basis for the present map.

Whitehouse (1954) has written a comprehensive report on the palaeogeography of the Great Artesian Basin, portion of which occupies the north-eastern part of the Sheet.

PHYSIOGRAPHY

The area of the Cloncurry Sheet falls into two physiographic units. The Precambrian outcrop area, which occupies about two-thirds of the Sheet, forms the upland division, of moderate relief and extensive rock outcrop; the remaining third, which forms the north-eastern portion of the Sheet, consists dominantly of "black soil" plains with very little relief.

The Selwyn Divide, which forms the watershed between streams which drain into the Gulf of Carpentaria and those which drain into the internal Lake Eyre system, lies only a few miles to the south-west of the Sheet. The two main watercourses are the Cloncurry and Leichhardt Rivers. Neither of these is perennial within the limits of the sheet, but both contain many permanent and near-permanent waterholes.

The geomorphology of the area has been dealt with by Twidale (1956a and c) in papers on north-west and northern Queensland.

<u>Plains Division</u>

The plains lie 400 to 600 feet above sea level and fall gently to the north-east. In the portion adjoining the upland division the almost plane surface is broken by scattered rough outcrops of granite, with some metamorphic rocks, which in places form small groups of hills. Farther to the north-east outcrops are extremely rare and produce very low relief, or none at all.

Water-courses, which may have more or less permanent waterholes, are generally entrenched: some are incised at least 30 feet. They commonly have numerous anabranches, and may be braided; some distributaries connect adjoining watercourses. However, in general, the main water channels are well-defined and the tendency towards distribution of water from the streams (during the short periods of flow) is less pronounced than farther downstream.

Soils are for the most part heavy-textured (black soils) and carry mainly grasses. Sandy soils, including skeletal soils, occur in places near the Precambrian outcrops, and support stunted eucalypts, such as the silver-leaf box. Wide areas of alluvium surround water-courses in places. Water-courses are generally lined by eucalypts.

Uplands Division

The highest point on the Sheet is at about 2,000 feet above sea level and the greatest local relief is 600-700 feet. The larger water-courses have alluviated valleys along which access is relatively easy, but in the headwaters regions of streams access is commonly difficult. Granite, slate, and schist generally have produced topography with the least relief, though in the more elevated parts, such as Mount Burstall, granite may produce high relief. Quartzite, and to a lesser extent, the altered acid lavas, commonly form the ranges with deeply incised, narrow water-courses. Calc-silicate and basaltic rocks give riss to a rough, rocky surface of relatively low relief, although some of the higher grade calc-silicate rocks have formed very high and precipitous ridges. In areas of low relief extensive heavy-textured soils are associated with calc-silicate rocks.

The main water-courses (other than the Leichhardt and Cloncurry Rivers), are parallel to the most prominent fault system. However, as they flow in the same direction in the plains division, known to be underlain by Mesozoic rocks, the drainage pattern may not have been determined by faults. Strike of the strata has exercised a secondary control.

Vegetation in the uplands areas is varied; cover is moderate and consists of fairly low trees (mainly eucalypts), shrubs (mainly acacias) and grasses, notably spinifex. Good timber trees grow only along the larger water-courses.

STRATIGRAPHY

The stratigraphy of the area is set out in Table I.

The age of the Precambrian units is to some extent conjectural. David (1932) showed the Mount Isa Shales and Corella Limestones as "?Older Proterozoic" and the remainder of the succession as Archaeozoic; Nye and Rayner (1940) regarded all but the Mount Isa "Series" and the Mount Quamby Conglomerates as Archaeozoic; Carter, Brooks and Walker (in preparation), on whose work the map is based, consider that most of the Precambrian succession is Lower Proterozoic. The Leichhardt Metamorphics are shown on the map as ?Archaean but they may be Lower Proterozoic. The whole succession may be Archaean, but this is considered unlikely.

Table II shows the probable time-relationships of the Precambrian formations of the region, including those which do not appear in the Cloncurry Sheet area. The correlations have been built up from evidence gathered over the whole Precambrian belt, and not only from the Cloncurry Sheet area.

The small outcrop of Middle Cambrian shales west of Marraba railway siding is the northerly tip of a larger area of such sediments which crop out on the Duchess and other 4-mile Sheet areas to the south and west.

The Mesozoic strata, which lie below the plains and form small outliers on the Precambrian rocks locally form the western limit of the sediments of the Great Artesian Basin.

INTRUSIVE IGNEOUS ROCKS

GRANITE (Joplin, 1955; Carter, Brooks and Walker, in preparation)

Granitic bodies have been named according to distribution and not according to rock type; probably all are composite bodies. In the field four textural types can be recognized in these bodies:

Coarse-grained porphyritic, in part foliated, granite;
Medium-grained to fine-grained massive granite;
A fine white leuco-granite (identified by Joplin, 1955, as albitite and soda granite);
Pegmatite and aplite.

The Kalkadoon Granite is largely a biotite granodiorite of similar conposition to the metadacite it intrudes. The main rock type is coarse-grained and porphyritic, with pink microcline phenocrysts set in a hypidiomorphic granular groundmass of oligoclase-andesine, microcline and quartz. As mapped, part is older than the Surprise Creek Beds, and part is younger. Numerous metamorphic remnants occur in the Kalkadoon Granite.

The Wonga Granite is generally a coarsely porphyritic, foliated microcline granite. It is a roughly concordant body, with widespread, but possibly local, granitization. It contains numerous, commonly dyke-like, intrusions of a finer grained granite, and of microcline pegmatite.

The Naraku Granite is a medium-grained to fine-grained, pink micro-adamellite to micro-granodiorite, and has a hypidiomorphic granular texture. It contains less mafic minerals than the other two granites and is generally massive. The main mineral constituents are microcline, andesine, quartz, and biotite.

The age, or ages, of the various granitic rocks has not bean definitely established: the region has been deformed by two main Precambrian orogenies and granite probably accompanied each. Finer grained granite may also have followed each orogeny. Dr. G.A. Joplin has suggested that the granodiorite of the Kalkadoon Granite may be related to the metadacites of the Leichhardt Metamorphics.

DOLERITE

Four categories (based on field work) of basic intrusive rocks are shown on the Cloncurry Map Sheet. All are dolerite, gabbro, or metamorphic derivatives of these (amphibolite). K.R. Walker, as a result of detailed petrological and field work in the region, has classified the basic igneous rocks in the Precambrian terrain into at least seven groups. Some of the groups may be contemporaneous and genetically related, and not all are represented in the Cloncurry Sheet area.

The dyke swarms, shown in the map without a symbol, mainly in the Leichhardt Metamorphics and Argylla Formation, consist of intrusives of more than one age. Some in the Leichhardt Metamorphics may be older than the Argylla Formation. Some may be related to the Eastern Creek and contemporaneous vulcanicity; others may be older or younger.

The group of basic rocks marked db may contain both lavas and intrusives; the latter are probably of more than one age. Some of the metadolerites may be related to the Eastern Creek vulcanicity.

Those dykes and stocks marked dl generally occupy fault lines or thenoses of pitching folds; some are affected by granite and are metamorphosed. They must therefore be younger than one period of folding and older than some, at least, of the granitic rocks.

The dolerites of the fourth category of dykes, marked do, intrudes granite, e.g. at Mount Burstall. It is not re-crystallized, as the other types are, and is only locally sheared. Evidence does not suffice to establish the age of this intrusion relative to the final Lower Proterozoic granitic activity. Dolerite do may generally be recognised in the field by its spheroidal weathering.

Numerous amphibolitic rocks occur in the Corella Formation but are not shown in the Map Sheet because Walker (1956, unpubl.) has demonstrated that some, at least, are highly metamorphosed sediments. Basic igneous sills and lavas may also be present.

METAMORPHISM

The rocks of the Sheet area have been deformed and metamorphosed in several ways; regional metamorphism is wide-spread, whereas contact metamorphism predominates locally. More-over, except in the strata of the western geosynclines, the effects of regional metasomatism mask those of metamorphism in many places. Furthermore, the intensity of metamorphism differed considerably on either side of the tectonic land (vide p. and Fig.1).

Strata on the eastern side of the tectonic land are in the biotite or higher grades of metamorphism. In the eastern Snake Creek area, south-south-east of Cloncurry, andalusite-garnet-mica schist occurs and in the Upper Cattle Creek area, staurolite-garnet-mica schist is found. The Leichhardt Metamorphics appear overall to be more highly metamorphosed than most of the strata to the east, and contrast sharply with the rocks to the west. West of the Leichhardt Metamorphics the Eastern Creek Volcanics show only slight regional metamorphism. Slaty and fracture cleavage has developed parallel to local fold-axis planes in some strata, and locally dislocation metamorphism is important.

Examples of contact metamorphism recognized occur close to granite contacts. The sequence of granitic events is insufficiently known to relate these contact effects to any particular granitic body or event. However, cordierite-anthophyllite-, and some of the andalusite-, bearing rocks are thought to be products of strong contact effects. West of the Leichhardt Metamorphics contact metamorphism is negligible, but widespread hydrothermal activity has produced low temperature mineral assemblages in many rocks, and particularly in the basaltic rocks.

STRUCTURE

The major structural features of the Cloncurry Sheet area are shown in Fig.1. There are four major anticlinoria. Faulting is dominated by two elements - the north-east-striking components of a conjugate shear-fault system, and the zone of reverse faulting south from Cloncurry.

Folding. At least two periods of folding have affected the older strata. Folding is strong to isoclinal with extensive overturning of fold axes, but, except for the intricate plastic deformation of the calc-silicate rocks and of the quartzites of the Mitakoodi Quartzite (see below), is relatively simple. The strata west of the tectonic land are folded less strongly than those to the east; very few rocks are overturned but dips of 70° and more are usual.

Fold axes in general strike within a few degrees of north-south, except in the south-east of the Sheet area. In the western half of the Sheet fold axes in the older units commonly dip west.

Both east and west of Cloncurry, the major fold axes trend roughly east-west. South-west of Cloncurry, in the area enclosed by the Mitakoodi Quartzite, fold axes strike north-east toughly parallel to the direction of the main faults in the area. Intricate folding of the Mitakoodi Quartzite, also on north-east to east-north-east axes, is attributed to shear-folding of the competent strata which lie between the incompetent strate of the Marraba Volcanics and the Marimo Slate.

Faulting. The history of faulting inthe area is complex. Much of the vulcanicity and sedimentation is believed to have been accompanied by tensional faulting. The major north-east-striking faults in the area are believed to have been formed during the first compressive orogenic deformation, although later movement undoubtedly occurred. These faults are quartz-filled and form prominent topographic features. Extensive conjugate shear faults which generally strike north-east and north-west have also affected the strata laid down after the first orogeny was comlete.

West of the Gorge Creek-Quilalar Fault system (see map faulting has produced three repetitions of outcrop of the north-pitching Eastern Creek Volcanics. Between the Mitakoodi Quartzit and the Soldiers Cap Formation, south of Cloncurry, extensive high-angle thrust-faulting with east-dipping fault planes has severely deformed the area. Few displacements are believed to be very large.

Strike-faulting is very widespread, but its effect cannot be readily evaluated.

GEOLOGICAL HISTORY

The Precambrian history of the area is one of continued instability. The Leichhardt Metamorphics were intruded by a granodiorite believed to be older than the other granites in the area, and lie probably unconformably below the Lower Proterozoic succession, but may be part of it. The earliest Lower Proterozoic rocks are acid lavas, poured out in vast quantities, mainly on land; as activity proceeded, transgression of the sea from the east gave rise to sediments interbedded with, and overlying, the flows. During the period of arenaceous sedimentation that succeeded the vulcanicity (Leander, Ballara and Mount Guide Quartzites), a ridge, roughly along the line of outcrop of the Leichhardt Metamorphics, rose to form 'tectonic land' and separate the basin into two portions.

A period of even more extensive vulcanicity followed: basalts, mostly submarine, accumulated in both eastern and western geosynclinal belts, interbedded with sediments (Soldiers Cap Formation, Marraba Volcanics, and Mitakoodi Quartzite in the east, Eastern Creek Volcanics in the west). Some of the swarms of dolerite dykes in the underlying formations are probably related to this vulcanicity. The tectonic land continued to rise, giving rise to marginal unconformities, and a regional unconformity in the east.

Deposition of thin-bedded dolomite (Corella Formation) waning vulcanicity (Mount Philp Agglomerate), and sandy sediments (Myally Beds in west, possibly Knapdale and Roxmere Quartzites in east) closed the first Lower Proterozoic episode.

A major orogeny with east-west compression, followed in the eastern geosynclinal belt and was probably accompanied by the emplacement of granite. It was weakly reflected in the western geosyncline and was succeeded by the deposition of the Surprise Creek Beds and Mount Isa Shale in the west and Deighton Quartzite in the east. The subsidence in the western geosyncline that allowed the accumulation of a thick pile of shallow to moderately deep-water sediments was accompanied, and perhaps effected, by north-south and east-west faulting.

A second major orogeny, with east-west compression, deformed the whole Lower Proterozoic sequence in both geosynclines. It was accompanied by granite, and preceded and accompanied by dolerite. The final uplift was followed by extensive erosion before the Quamby Conglomerate was laid down.

Of Cambrian time no record remains except for the northern-most tip of a Middle Cambrian basin which developed over a wide area south of the Sheet. Some faulting may be younver than this: such faults are known in the adjoining Duchess Sheet area.

The Cretaceous, and perhaps Jurassic, sedimentation is the next episode of which any record remains. The lowest beds are fresh-water, and the sea later transgressed over, probably most of the area, though only occasional thin residual cappings are left in the Precambrian belt.

In Cainozoic times the drainage system has been by epeiric uplift that gently warped the land-surface and, locally, laterite and riverine deposits were formed.

ECONOMIC GEOLOGY

Within the Cloncurry Sheet area production of economic minerals has come almost exclusively from the metamorphic rocks. The only exception is gold from the Quamby Conglomerate and from the Myally and Surprise Creek Beds. However, from beyond the Sheet boundaries important production of lead-zinc-silver and copper has come from little-metamorphosed strata, notably the production from Mount Isa Mines.

The main metals that have been produced are copper and gold; other metals known to occur are uranium, lead, zinc, silver, cobalt, tungsten, rare earths, iron, manganese, bismuth. Non-metallic resources include "limestone" (calcite), and road-building materials.

Copper. Copper has been produced from the field for over eighty years. Several hundred leases have been worked from time to time, most of them were small shows from which only secondary minerals were mined and from which production was commonly less than 10 tons of copper. Total production of copper from the Sheet area to the end of 1954 is about 13,000 long tons. This was won from 135,000 tons of ore giving an average grade of 9.66% Cu. The Great Australia and Wee McGregor mines are the only mines to have produced more than 1,000 tons of copper. The ore of many of the mines, particularly in the eastern part of the Sheet area, was gold-bearing. Production of the main mines is tabulated below:

Mine	Ore (long tons)	%Cu	Copper content (long tons)
Wee MacGregor	44,411	6	2,731
Great Australia	33,965	8	2,693
Rosebud	19,761	7	517 *
Magnet	6,764	12	728 *
Mt.McNamara	4,849	13	609
Federal	3,977	24	966 *
Blockade (Argylla)	2,867	9	258 *
Referee (Ruth)	1,505	19	287
Edna May (Willsbrough)	1,403	14	195
Mt.Olive	1,065	12	123
Sunset	526	19	102
Timberoo	386	34	132
Success	303	36	107

* Returns incomplete

Gold. The chief sources of gold have been from small reef workings in the Soldiers Cap area, south-east of Cloncurry, and from copper-gold ores. Reef gold has been mined also in the Bower Bird Sunday Gully area (in the north-west of the Sheet area); and gold has been won from the ?Upper Proterozoic Quamby Conglomerate, near Mount Quamby. This gold is probably of hydrothermal origin, but may be detrital. Alluvial gold has been won from each ofthe localities referred to above and also from an area nine miles west-south-west of Cloncurry.

The total recorded production of gold from the Cloncurry Mineral Field to the end of 1954 is 102,043 ounces. Of this amount over 60,000 ounces was obtained from the ores of the main copper mines outside the Cloncurry Sheet area. Probably the greater part of the remainder was mined from the Cloncurry Sheet area. It includes 3,277 ounces of gold obtained from copper ores (average grade of recovery 0.48 dwt/ton). In the period 1931-1942 3,061 ounces of gold were obtained from 3,021 tons of gold ore, other than copper-gold ore; this represents 90% of the total production from such ore for the whole of the field.

Some silver occurred with the gold, but the total yield has been slight. Silver content of gold ores rarely exceeded 1 oz/ton.

Uranium. A large number of radioactive deposits were discovered in 1954 and 1955. Of these only one is now being developed - the Mary Kathleen mine, from which production began in 1958. This mine should produce a large tonnage of medium grade ore. In 1955 a trial parcel of 10 tons of hand-picked secondary uranium ore was transported from the Milo lease to Rum Jungle, but further significant production is not likely under present conditions.

Of the other prospects the most promising appears to be the Counter lease, 10 miles east-north-east of Mount Isa, but the ore cannot be won and treated economically at present.

Cobalt. Cobalt has been recorded from nine mines and localities in the Cloncurry Sheet area (see Rayner, 1938). In addition to those recorded by Rayner, a small deposit was recently reported from near the Federal copper mine. Only two mines have yielded any commercial production: the Success, from which 25 tons of ore averaging 22% Co was produced, and the Queen Sally, 26 tons averaging 10.2%. An unknown amount of cobalt was contained in early copper shipments from the Success mine.

Lead-Zinc-Silver. No significant productiin of lead-zinc-silver has been recorded from the Cloncurry sheet area. Denmead (1937) reports that a small parcel of silver-lead ore was shipped from a deposit near Doughboy Creek, in the north-west of the area. A large low-grade deposit is known to occur in the Dugald River area. Honman (1937) suggested that there might be 133,000 tons of 9.5% lead and 2-3 oz/ton silver per 100 feet of depth and a considerably greater tonnage of 4.5% lead, and that zinc would probably be found in the primary zone. Subsequent work by a private company confirmed the existence of a large low-grade deposit of silver-lead-zinc, but grade and size do not warrant development under present conditions.

Weak lead-zinc mineralization is common in the carbonaceous slates in the Corella Formation and the Marimo Slate.

Iron. Mount Philp, in the Ballara district, forms a prominent range of quartz-hematite-magnetite rock. The deposit contains about 105,000 tons per vertical foot, averaging 41.8% Fe and 38.2% silica, including 71,000 tons per vertical foot averaging 48.5% Fe and 28.7% SiO_2 (see Carter and Brooks, 1955). Considerably smaller deposits of iron form Mount Leviathan (Black Mountain) and Mount Pisa, near Cloncurry.

Rare Earth Minerals. Minerals containing the rare earth elements cerium, yttrium, lanthanum, and erbium form an important proportion of the Mary Kathleen uranium lode, but the rare earths are not being recovered during treatment of the ore.

The same mineral assemblage has been recorded from 4 miles south of the Mary Kathleen lease, and allanite (which contains rare earths) is a widespread metamorphic mineral in small quantities throughout the more highly metamorphosed rocks of the Corella Formation.

Manganese. Throughout the Marimo Slate numerous prominent strike faults bear manganese and iron. The manganese in these outcrops undoubtedly is concentrated at the surface, and grade generally is low. In the course of reconnaissance sampling, the highest-grade sample assayed 43.6%Mn. Manganese from some of these deposits is being used in the Mary Kathleen treatment plant.

Other Metals. Minerals containing tungsten, bismuth, molybdenum, and nickel have also been recorded in the Sheet area. The first two metals have been mined, but only a few tons have been produced. The nickel occurs as an impurity in some copper ores.

"Limestone". The most important non-metallic mineral mined is calcite (described locally as limestone), which is used extensively as flux in the processing of Mount Isa ore. Some dolomite is also used. The deposits are of coarsely crystalline calcite, which occurs as lenses in the calc-silicate rocks of the Corella Formation; a few deposits also occur in the Leichhardt Metamorphics. Some of the deposits are very pure; some, e.g. Dolomite quarries, have been mineralized and contain 1-2% copper in parts of the body.

Calcite has been quarried from near Quamby, Cloncurry, Marimo, Dolomite, and Chumvale. Total productinn is about 466,000 tons. Other known deposits of sufficient size for exploitation are shown on the map. Lenses of calcite are extremely common throughout the Corella Formation and many more workable deposits certainly occur.

Coal. Coaliferous seams have been recorded and tested in the Mesozoic in the Cabbage Tree Creek area (Annual Report for 1926, Queensland Department of Mines, p.103), but they appear to have been only 2-3 inches wide and are of no commercial value.

WATER SUPPLY

Surface Water. Permanent or near-permanent surface water occurs both in the plains and the hill country of the Sheet area in water-holes in the larger water-courses. Smaller bodies of water also persist throughout the year in sheltered rock-holes in the upper reaches of the river systems. Most of the rock-holes are of little use to pastoralists because they are small and inaccessible, and not close to good feed. To the prospector and small-scale miner they are invaluable.

Springs occur in places throughout the outcropping Precambrian strata. They are most abundant in the upper Corella River area andin the headwaters area of some water-courses in the Soldiers Cap area.

Pastoralists have undertaken a certain amount of surface water storage by erecting earth barriers across small water-courses.

Large dams have been constructed to serve centres of population. The Rifle Creek Dam (in the south-west of the Sheet area), with a capacity of 2,200 million gallons, supplies Mount Isa township and mine. A second, larger, dam has recently been constructed for the same purpose on the Leichhardt River, near its junction with Spring Creek. A dam has also been built on the Upper Corella River to serve Mary Kathleen township and mine. In earlier years a smaller dam higher on the same water-course supplied the Rosebud copper mine. Cloncurry draws its water supply (which is barely adequate) from a waterhole and bores on the Cloncurry River, near the town.

Subsurface Water. The Mesozoic sediments which underlie the plains country, in the north-east of the Sheet area, form part of the Great Artesian Basin. Artesian or sub-artesian water is generally available throughout this area at depths ranging from 100 feet or less near the outcropping Precambrian rocks to about 1,000 feet in the north-eastern corner. According to Whitehouse (1954) the aquifers of the Euroka Shelf, which extends on to the Cloncurry area, are mainly sandstones of the Blythesdale Group.

Within the Precambrian block there are no continuous aquifers. Most of the subsurface water is obtained from the sands of present day water-courses. Along the major streams permanent supplies of water may generally be obtained readily from wells or bores on the river flats, and on the smaller streams, upstream of local traps such as "bars" of impervious rock cutting across the valley. The rate of flow from such bores generally does not exceed 1,000 gallons per hour.

The crystalline Precambrian rocks generally do not provide good reservoirs for underground water. This applies particularly to the altered acid lavas of the Leichhardt Metamorphics and to the granites. Deeply weathered granite, however, may provide good supplies of water. Jointing and solution cavities in the calc-silicate rocks provide considerable water storage space, as is evidenced by the numerous springs in the upper Corella River.

Faults and joints in the quartzites and in the interbedded metabasalts and metasediments generally contain a supply of water in the areas of outcrop of such rocks. Underground water should generally he obtainable from suitable structures in slates and shales.

Most water so far obtained from underground sources has proved to be sufficiently pure for stock and domestic purposes, although a few bores have yielded saline water.

BIBLIOGRAPHY

A.G.G.S.N.A., 1935 - Report for period ended 30th June, 1935. Aer.Surv.N.Aust.

__________, 1936a- Report for period ended 31st December, 1935. Ibid.

__________, 1936b- Report for period ended 30th June, 1936. Ibid.

__________, 1937 - Report for period ended 31st December, 1936. Ibid.

__________, 1939a- Report for period ended 31st December, 1938. Ibid.

__________, 1939b- Report for period ended 30th June, 1939. Ibid.

BALL, L.C., 1908 - Cloncurry copper mining district, parts. 1 and 2. Publ.Geol.Surv.Qld.215.

__________, 1921 - Gold at Mt.Quamby, N.G. Qld Govt Min.J., 22, 8-12.

BROOKS, J.H., 1956a- Copper mining in the Cloncurry Mineral Field. Qld Govt Min.J., 57, 891-921, also as Publ. 255, 1957.

__________, 1956b- Developments in the exploration of uranium deposits, Cloncurry Mineral Field, north-western Queensland, 1955. Ibid., 57, 618-625.

__________, 1956c- Iron ore deposits of Queensland. Summary report. Ibid., 57, 837-843, also as Publ. 283, 1957.

__________, 1957a- "Joy" cobalt prospect, Cloncurry. Qld Govt Min.J., 58, 605-6.

__________, 1957b- Copper Blonde, calcite-copper deposit, Cloncurry Mineral Field. Qld Govt Min.J., 58, 606.

__________, 1957c- King Solomon, copper deposit, Cloncurry Mineral Field. Qld Govt Min.J., 58, 606-7.

BROWNE, W.R., and JONES, O.A., 1944 - A revised glossary of Queensland stratigraphy. Univ.Qld Dep. Geol.Pap. 2(11).

CAMERON, W.E., 1900 - Recent developments in the copper mining in the Cloncurry district. Publ.geol.Surv. Qld, 153.

CAMERON, W.E., 1901 - Geological observations in north-western Queensland. Ann.Rep.Qld Dep.Min.,(1900-2) (Geol.Surv.Qld Publ. 159), 186-191.

__________, 1903 - Iron ores in Queensland. Qld Govt Min.J., 4, 126.

CARTER, E.K., 1955a- Cloncurry uranium. Min.Mag.Nov.1955.

__________, 1955b- Radioactive occurrences, Cloncurry Mineral Field, Queensland. Qld Govt Min.J.,56, 644.

CARTER, E.K., and BROOKS, J.H., 1955 - Mt.Philp iron deposit, Cloncurry district, Queensland. Bur.Min.Resour.Aust.Rep.17.

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

CHERRY, F.J., 1905 - Copper mining in the Corella River, Cloncurry. Qld Govt Min.J.,6, 139.

CLARKE, W.B., 1868 - On the auriferous and other metalliferous districts of northern Queensland. Trans.Roy.Soc.N.S.W. (1867), 42-57.

DAINTREE, R., 1868 - Report on the Cape River diggings and the latest mineral discoveries in North Queensland. By Authority. Brisbane.

__________, 1870 - General report upon the Northern District. By Authority. Brisbane.

__________, 1872 - Notes on the Geology of the Colony of Queensland. Quart.J.geol.Soc.Lond., 28(3), 271-360.

DAVID, T.W.E., 1932 - EXPLANATORY NOTES TO ACCOMPANY A NEW GEOLOGICAL MAP OF THE COMMONWEALTH OF AUSTRALIA. Australasian Medical Publishing Co., Sydney.

DAVID, T.W.E.,(ed.W.R. Browne), 1950 - THE GEOLOGY OF THE COMMONWEALTH OF AUSTRALIA. London, Arnold.

DENMEAD, A.K., 1937 - Silver prospect near Doughboy Creek, Kajabbi District. Qld Govt Min.J.,38, 354 (corrig. 428).

DUNSTAN, B., 1904 - The iron bonus commission - evidence taken in Queensland. Geol.Surv.Qld Publ.190(4) 12-25.

DUNSTAN, B., 1913 - Queensland Mineral Index. Ibid.241.

__________, 1920 - North-western Queensland. Geological notes on the Cloncurry-Camooweal-Burketown-Boulia area. Ibid. 265

EDWARDS, A.B., 1938 - Some ilmenite micro-structures and their interpretation. Proc.Aust.Inst.Min.metall. n.s. 110, 43.

EDWARDS, A.B. and BAKER, G., 1954 - Scapolitisation in the Cloncurry district of North-western Queensland. J.geol.Soc.Aust.,1, 1-33.

FISHER, N.H., 1947a - Lead. Bur.Miner.Resour.Aust.Summ.Rep. 23, 10-11.

__________, 1947b - Zinc. Ibid., 33, 8-9.

GIBB, T., 1904 - The Cloncurry copper field, Queensland. Qld Govt Min.J.,5, 554-558.

HARRIS, S., 1918-19 - Resources of Cloncurry copper field,N.Q. Chem.Eng.Min.Rev.,10 (112-123) and 11(124).

HODGKINSON, W.O. 1877 - Exploration in North-western Queensland, 1875-76, Votes & Proc.Legislative Assembly, Qld, Sess. 1876, 3, 352-386.

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

HONMAN, C.S., 1936a- The Mt.Freda-Canteen area, Soldiers Cap, Cloncurry district. Aer.Surv.N.Aust.Qld Rep.1.

__________, 1936b- The Gilded rose area, Cloncurry district. Ibid., 2.

__________, 1937a- The Dugald River silver-lead lodes, Cloncurry district. Ibid., 8.

__________, 1937b- The Bower Bird auriferous area, Cloncurry district. Ibid.,19.

__________, 1938 - Mt.Elliott-Hampden area, Cloncurry district. Ibid., 22.

__________, 1939 - The Soldiers Cap area, Cloncurry district. (with portions by R.J.S.Clappison andE.O. Rayner, and appendix by A.O Booth).Ibid., 18.

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

JACKSON, A., 1862 - ROBERT O'HARA BOURKE AND THE AUSTRALIAN EXPLORING EXPEDITION OF 1860, London Smith Elder.

JENSEN, H.J., 1940 - The eastern portion of the Bower Bird district, Cloncurry district. Aer.Surv. N.Aust.Qld Rep. 48.

JONES, O.A., 1953 - The structural geology of the Precambrian in Queensland in relation to mineralization. In GEOLOGY OF AUSTRALIAN ORE DEPOSITS. Fifth Emp.Min.metall.Cong., 1,344-351.

JOPLIN, G.A., 1955 - A preliminary account of the petrology of the Cloncurry Mineral Field. Proc.Roy.Soc. Qld, 66(4), 33-67.

__________, 1956 - On the association of albitites and soda aplites with potash granites in the Pre-cambrian and older Palaeozoic of Australia. J.Roy.Soc. N.S.W., 90(2), 80-86.

JOPLIN, G.A., and WALKER, K.R., (In preparation). Precambrian granites of north-western Queensland.

KNIGHT, C.L., 1953 - Regional Geology of Mt.Isa. In GEOLOGY OF AUSTRALIAN ORE DEPOSITS. Fifth Emp.Min. metall. Cong., 1, 352-360.

LAWRENCE, J.W., 1955 - Uranium mineralization in the Cloncurry-Mt.Isa area. Proc.Roy.Soc.Qld.66.

LEES, W., 1899 - THE GOLDFIELDS OF QUEENSLAND. Brisbane, Outridge Printing Co.

LEES, W., 1907 - THE COPPER MINES AND MINERAL FIELDS OF QUEENSLAND. Queensland Country Life Press, 45-60.

LINDEN, E.B., 1887 - A catalogue of such minerals as are at present known in Queensland with their principal associations and places of occurrence. Proc.Roy.Soc.Qld.4, 32-78.

McANDREW, J., and EDWARDS, A.B., 1953 - Specimens from Gereta zinc prospect. Sci.ind.Res.Org.,Melb., Mineragr. Rep.553.

McANDREW, J., and EDWARDS, A.B., 1954a- Radioactive ore from Mt. Isa, Queensland. Ibid., 590.

__________, 1954b- Radioactive ore from Mt.Isa, Queensland. Ibid., 603.

__________, 1954c- Radioactive ore from Mary Kathleen lease, Mt.Isa district, Queensland. Ibid.,604.

__________, 1955a- Radioactive ore, "Counter" (Anderson's lode), Cloncurry district, Queensland. Ibid.,609.

__________, 1955b- Stillwellite, a near rare-earth mineral from the Mary Kathleen lease. Ibid.,617.

__________, 1957a- Radioactive specimens from the Cloncurry district Queensland. Ibid., 677.

__________, 1957b- Radioactive ore from Milestone, North-western Queensland. Ibid., 680.

McANDREWS, J., and SCOTT, J.R., 1955 - Stillwellite, a new rare-earth mineral from Queensland. Nature, 176 (No.509).

McKINLAY, J., circa 1863 - McKINLAY'S JOURNAL OF EXPLORATION IN THE INTERIOR OF AUSTRALIA. Melbourne, F.Bailliere.

MARSHALL, C.E., and NARAIN, H., 1954 - Regional gravity investigations in the eastern and central Commonwealth. Uni.Sydney.Dep.Geol.Geophys.Mem. 1954/2.

MATHESON, R.S., and SEARL, R.A., 1956 - Mary Kathleen uranium deposit. Econ.Geol., 31(6).

MORLEY, I.W., 1950 - The copper industry of Queensland. Qld Govt Min.J., 51, 530-533.

MOTT, W.D., 1952 - Oil in Queensland. Ibid.,53, 848-861.

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.

NYE, P.B., 1947 - Cobalt.Bur.Min.Resour.Aust.Summ.Rep.32, 7-9.

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.

PHILLIPS, 1909 - Advisability of constructing railways and ports connecting therewith in the Gulf of Carpentaria. By Authority. A.J.Cumming, Govt.Printer, Brisbane. (Parl.Pap. printed during 1st sess. 18th Parliament, 2, 591-632).

QUEENSLAND DEPARTMENT OF MINES - Annual reports 1878 -.

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.

QUEENSLAND GOVERNMENT MINING JOURNAL, 1956 - The Mary Kathleen project will hasten development of Queensland's uranium field. Ibid., 57.

RAGGATT, H.G., 1950 - Stratigraphic nomenclature. Aust.J.Sci., 12(5).

RANDS, W.H., 1895 - Report on the Leichhardt goldfield and other mining centres in the Cloncurry district. Geol.Surv.Qld Publ.104.

RAYNER, E.O., 1938 - Cobalt deposits of the Cloncurry district. Aer.Surv.N.Aust.Qld Rep.10.

RAYNER, E.O., 1953 - Cobalt mineralization in the Cloncurry district. In GEOLOGY OF AUSTRALIAN ORE DEPOSITS. Fifth Emp.Min.metall.Congr.,1, 417-425.

RAYNER, J.M., and NYE, P.B., 1956 - Geophysical report on the Soldiers Cap area, Cloncurry district. Aer.Surv.N.Aust.Qld Rep.4.

RAYNER, J.M., and NYE, P.B., 1937 - Geophysical report on the Trekelano area, Cloncurry district. (Supplementary to Qld Rep.5) Ibid.,Qld,17.

RUTHERFORD, W.P., and KITCHENER, 1904 - COPY OF REPORT OF THE PRINCIPAL COPPER PROPERTIES AT CLONCURRY, NORTHERN QUEENSLAND. London, Moreton & Birt.

SAINT-SMITH, E.C.,1925- Queen Sally cobalt mine, Koolamarra, Cloncurry Gold and Mineral Field. Qld Govt Min.J., 26, 281.

SHEPHERD, S.R.L.,1928 - Notes and maps prepared as a result of a geological traverse from the Templeton River through Mount Isa,West Leichhardt and Argylla to Cloncurry, made in 1927, with petrological descriptions by A.K.Denmead. Geol.Surv.Qld (Unpublished).

SHEPHERD, R.S.L.,1931a- Cloncurry Mineral Field. Qld Govt Min.J., 32, 226.

SHEPHERD, R.S.L.,1931b- Gilded Rose and Pinnacles areas, Cloncurry district. Ibid., 32, 482.

__________, 1931c- Top Camp and Pumpkin Gully, Cloncurry Mineral Field. Ibid., 32, 226.

__________, 1932a- Notes on the Cloncurry Mineral Field. Ibid., 33, 77-79.

__________, 1932b- The Gilded Rose area at Cloncurry. Ibid., 33, 48.

__________, 1933a- Comstock mine, Soldiers Cap, Cloncurry district. Ibid., 34, 162-163.

__________, 1933b- Mount Freda, Soldiers Cap, Cloncurry district. Ibid., 34, 160-162.

__________, 1945 - Cloncurry water supply. Ibid.,46, 267.

__________, 1946a- Geological sketch map, Cloncurry area, Ibid., 47, 144-146.

__________, 1946b- Mt.Oxide copper mine, Cloncurry Field. Ibid., 47, 110-113.

__________, 1946c- Some mines in the Cloncurry Field.Ibid., 47, 45-52.

__________, 1953 - Geology of Cloncurry district. In GEOLOGY OF AUSTRALIAN ORE DEPOSITS. Fifth Emp.Min. metall.Cong., 1, 384-390.

STILLWELL, F.L., 1938 - Copper-cobalt ore from the Success mine, near Cloncurry, Queensland. Sci.ind.Res. Org.Melb., Mineragr.Rep.122.

__________, 1947 - Zinc-lead ore from Dugald River, North Queensland. Ibid. 375.

TWIDALE, C.R., 1956a- Chronology of denudation in north-west Queensland. Bull.Geol.Soc.Amer.67(7), 867- 882.

__________, 1956b - Pediments at Naraku. The Aust.Geogr.Nov. 1956.

__________, 1956c- The physiography of north-western Queensland. Geogr.Studies, 3(1).

UHR, R.C.H., 1879-1886 - Annual reports of the Queensland Department of Mines for the years 1878-1885.

WALLER, G.A., 1906 - Report on John Moffat's optims at Cloncurry (see Ball, L.C. 1908, 8).

WALKER, K.R., 1956 - An attempt to distinguish between calc-silicate and basic igneous rocks in the Mary Kathleen mine area, north-west Queensland. Bur.Min.Resour.Aust.Rec. 1956/107 (Unpublished).

WHITEHOUSE, F.W., 1954 - Geology of the Queensland portion of the Great Australian Basin. Appendix G. Artesian water supplies in Queensland. Dep.of Co-ordinator of Public Works, Queensland.

WOOLNOUGH, W.G., 1912 - Report on the geology of the Northern Territory. Bull.N.Terr.Aust.,4.

TABLE I : STRATIGRAPHY OF CLONCURRY SHEET AREA

AGE	ROCK UNIT	DOMINANT LITHOLOGY	THICKNESS IN FEET	DISTRIBUTION	TOPOGRAPHY	REMARKS	ECONOMIC GEOLOGY
CAINOZOIC	Cza	Soil and alluvium					
	M	Sandstone and limestone	?	Probably underlies large part of plain	Very low rises	Flat-lying Marine: Inoceramus found. Prob.Tambo Formation.	Artesian water
MESOZOIC		Sandstone and siltstone		Mt.Table Top, and Cabbage Creek and Soldiers Cap areas.	Mesas on Pre-cambrian rocks.	Flat-lying Fresh-water: perhaps correlable with Blythesdale Group	
		Sandstone-siltstone under quartz-greywacke and porcellanite.		Mesa at Soldiers Cap (90' of fresh-water and marine sediments)	Flat-topped mesa	Flat-lying L.Cretaceous foraminifera & pelecypoda in basal 10 ft.	
MIDDLE CAMBRIAN	Roaring Siltstone? (Cm)	Laminated shale	?	Outlier on Argylla Form. 4½miles west of Marraba Rly.Stn.	Low relief	Dips gentle Not fossiliferous. Tentatively equated with Roaring Siltstone of Duchess Sheet.	
UPPER PROTEROZOIC	Quamby Conglomerate (Bug)	Conglomerate, arkosic sandstone	1,000?	22 to 33 miles NW of Cloncurry	Rough, steep hills.	Synclinal: Faulted Major unconformity over older rocks. Age not established	Au
	Mount Isa Shale (Bli)	Shale, dolomitic shale, siltstone, quartzite.	10,000?	N-S belt extreme west centre of map	Low relief open valley.	Faulted north-pitching syncline - pitch reversals	Pb, Zn, Ag, Cu. Water
	Surprise Creek (Blu) Beds	Interbedded impure pelites and psammites	20,000?	N-S belt from Mt.Isa-Cloncurry Rd.through Leichhardt Valley to NW edge of map.	Rough, hilly; lower than outcropping Myally Beds	Tight N-S folds, some overturned locally	Au,probably other metals, Water?
LOWER	Deighton Quartzite (Bld)	Quartzite	7,000	Near western edge of Corella F.exposures, north and south of Cloncurry-Mt.Isa Rd.	Rough, hilly, high relief.	Major unconformity over older rocks. Each outlier and steeply folded basin.	
	Chumvale Breccia (Blv)	Schistose breccia and sericite schist	1,000	Small outcrops 12-16 miles W.of Cloncurry	Rough,hilly	Folded, Stratigraphic relationships unknown	
	Charley Creek Formation (Blh)	Quartzite and calc-silicate interbedded	4,000+	Charley Creek	Hilly,high relief strike ridges	Open folding,extensive faulting. Stratigraphic relationships not clear.	Calcite ("Limestone")
	Knapdale Quartzite (Blk)	Quartzite	6,000?	Between Dugald River & Cabbage Tree Creek	Prominent range in plain country	Steeply folded N-S axis. Faulted.	
PROTEROZOIC	Roxmere Quartzite (Blr)	Quartzite	4,000?	Three outcrops SE of Cloncurry and E. of Cloncurry River.	Hilly	Steeply folded, faulted probably overlies Corella F.conformably.	
	Myally Beds (Bly)	Sandstone and quartz siltstone	20,000+	N.W.corner of map	Very rough and hilly. Steep strike ridges.	Strong but open N.S. folds; synclines lighter than anticlines.	Au? Poor in other metals. Water?
	Corella Formation (Blc)	Calc-silicate and other moderate to high-grade meta-morphics.	10,000?	Broad N.S.belt in centre of map: bifurcates at N & S: Kajabbi to Cloncurry and Corella Rivers.	Open plains to very rough, steep hills.	Intricately folded and plastically deformed.	U, Cu, Au,Pb, Zn, Ag, Co. Water,Calcite ("limestone")

AGE	ROCK UNIT	DOMINANT LITHOLOGY	THICKNESS IN FEET	DISTRIBUTION	TOPOGRAPHY	REMARKS	ECONOMIC GEOLOGY
	Mt.Philp Agglomerate (Blp)	Feldspathized agglomerate	?	Small outcrop east and south of Ballara	Hilly	Domal? Intruded by basic and igneous rocks.	
LOWER	Marimo Slate (Blm)	Sandy slate, siltstone, quartz greywacke	8,000+?	S. of Cloncurry, east of Mitakoodi Quartzite	Open valleys: some rough, steep ridges.	Intricate N. pitching folds. Extensive faulting. Some beds overturned.	Cu, Au, Mn, some U.
	Mitakoodi Quartzite (Blt)	Quartzite, little meta-basalt.	4,000+	Flanks Marraba Volcanics	Strike ridges, steep valleys	as Marraba Volcanics	
	Marraba Volcanics (Bla)	Quartzite and meta-basalt, schist.	10,000?	SW of Cloncurry - arcuate belt.	Low relief, rough in places.	Strongly and intricately folded. General pitch NE.	Cu, Au, Co.
	Eastern Creek Volcanics (Ble)	Interbedded quartzite and metabasalt.	20,000?	N-S belt on western edge of Sheet	Rough, but low relief.	In places fractured-sheared; north pitching folds; metamorphosed.	Some Cu, U.
PROTEROZOIC	Soldiers Cap Formation (Bls)	Schists lowest member; quartzite and meta-basalt; slate, quartzite, metabasalt, chert, top member.	25,000+	Cloncurry-Kaampa-Soldiers Cap.	Rough, Moderate to high relief, strike ridges	Steep pitching folds, cross folds; faulted.	Cu, Au, Co, W, U.
	Ballara Quartzite (Blb)	Quartzite, some metabasalt	2,000+	N-S belt between Fountain Range and Cameron Faults.	Rugged hills: little soil.	Tight N-S folds; faulted	Cu
	Leander Quartzite (Blg)	Quartzite, some metabasalt	5,000+	Extreme western edge (most outcrop on Mt.Isa Sheet Area)	Abrupt hills, plane-topped; little or no soil	Domal	
	Mount Guide Quartzite (Blg)	Quartzite, some meta-basalt near top.	8,000+	South-western corner of map area.	Steep ridges; forms watershed of many minor creeks.	Steeply folded; strongly faulted.	
	Argylla Formation (Bln)	Altered acid volcanics; metabasalt and meta-sediments near top.	?10,000	On eastern edge of outcrop of Leichhardt Metamorphics and Duck Creek area.	Very rough, moderate relief	Steeply folded; faulted.	Cu
? ARCHAEAN	Leichhardt Metamorphics (P (pGl)	Gneiss, schist, amphibolite	Unknown	N-S belt in or E of Leichhardt R. valley.	Rough, hummocky, but low relief.	Highly folded and faulted; intruded by Kalkadoon Granodiorite and dolerites.	Cu. Calcite ("limestone").