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GEOLOGY AND MINERAL DEPOSITS OF THE MOSSMAN 1:250,000 SHEET AREA, NORTH QUEENSLAND.

by

F. de Keyser.

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SUMMARY

This report contains the results of regional mapping carried out in the Mossman 1:250,000 Sheet area during the 1960 field season. The data obtained will form part of a Bulletin of the Hodgkinson Basin to be published later, which will incorporate both the Mossman and Cooktown Sheet areas, and probably part of the Atherton and Cape Melville Sheet areas.

The field party consisted of four geologists from the Bureau of Mineral Resources and one geologist from the Geological Survey of Queensland. Mapping was completed except for the rugged, jungle-clad north-eastern corner of the Sheet area. This part was photo-interpreted.

The area is part of the Palaeozoic Tasman Geosynclinal Zone with a shelf environment in the west and a deep-water facies in the east. A Precambrian basement represented by the schist, gneiss, and amphibolite of the Dargalong Metamorphics borders the geosyncline in the extreme west.

The first, pre-orogenic stage in the development of the geosyncline was the deposition of the shelf sediments, mainly reefs, of the Chillagoe Formation, probably late in the Silurian. The Mount Garnet Formation is probably a clastic facies of the Chillagoe Formation, partly of the same age and partly younger. The boundary between the two formations is transitional and arbitrary.

Subsequently many thousands of feet of greywacke and siltstone - the Hodgkinson Formation - were deposited mainly during the Middle and Upper Devonian. Turbidity currents deposited most of the sediments and the currents seem to have flowed chiefly from the south and north.

All these sediments were folded and faulted during the paroxysmal phase of an orogeny, probably early in the Carboniferous. At the end of the ?Carboniferous orogeny, the Mareeba group of granites intruded the folded sediments in the central part of the geosyncline, introducing tin, wolfram, and gold.

After a period of levelling and denudation, tensional fractures were formed and were accompanied, during the Upper Permian, by strong vulcanism and by paralic sedimentation in disconnected shallow basins (Nychum Volcanics, Mount Mulligan Coal Measures); further fracturing formed a cauldron subsidence area, which was subsequently filled by the massive Featherbed Volcanics, possibly in the Lower Triassic. Both volcanic periods were accompanied by, and were probably comagmatic with plutonic igneous activity; the Nychum Volcanics were intruded by the Almaden Granodiorite, and the Featherbed Volcanics by the Elizabeth Creek Granite.

After a period of essentially non-deposition a Lower Cretaceous transgression took place from the west. Two formations are recognized: the terrestrial and littoral Wrotham Park Sandstone (Neocomian or Lower Aptian), conformably overlain by the shaly marine Blackdown Formation (Lower Albian or Upper Aptian).

Remnants of Tertiary gravels and billy breccia overlie the Cretaceous north of Wrotham Park, and in the east of the area some basalts were extruded, probably during the Upper Tertiary or Pleistocene.

Vertical movements persisted until recent times, raising most of the area and rejuvenating most of the drainage system.

There are many deposits and shows of gold, tin, wolfram, copper, lead, antimony, silver, manganese, coal, and limestone in the area, and most of them have been worked intermittently over the years. Among the more important historical fields and mines are the Palmer Goldfield (total production of more than 1,333,000 ounces of fine gold): the Hodgkinson Goldfield (300,000 ounces); the O.K. copper mine; the Mount Mulligan coal mine (nearly 1,000,000 tons of coal mined); and the Mount Carbine wolfram workings. No production of any significance is being obtained from the area at present.

Prospects of a revival of gold mining are not encouraging; the alluvial sources appear exhausted, and the lodes, which are small and discontinuous, have been worked to depths of several hundred feet and are depleted of their richer portions.

The two known larger copper deposits - the O.K. mine and Mount Molloy - have been mined out, and various other smaller shows are low-grade and are unfavourably situated. Repeated attempts to produce from these shows have never been successful.

Tin is concentrated in small alluvial patches on and along the Mareeba Granite, which forms the tablelands in the east of the area. Some of the larger alluvial flats have been tested by private companies, but the results so far have been disappointing. Workable lodes are rare, and the tin is largely derived and concentrated from many thin leaders disseminated in greisenized granite.

Mount Carbine is still a potential wolfram producer, and a rise in the price of wolfram should renew mining activity.

The Mount Mulligan coal mine was closed in 1957, mainly because hydro-electric power became available in these areas formerly supplied with the Mount Mulligan coal. The ash content is rather high.

The antimony andm manganese occurrences are not important because they are small and low-grade. Most of the antimony won in previous years was a by-product of the Hodgkinson gold mines, and, if mined alone, would not have been payable.

INTRODUCTION

The Mossman 1:250,000 Sheet area was mapped during the 1960 field season as part of a programme of systematical regional mapping of North Queensland, which the Bureau of Mineral Resources and the Geological Survey of Queensland began in 1956 to assess the mineral potential of North Queensland.

Members of the 1960 Mossman field party were F. de Keyser (party leader), K.G. Lucas, W.R. Morgan, and B.J. Amos (all geologists of the Bureau of Mineral Resources), and R.M. Tucker (Queensland Geological Survey). During the mapping, K.G. Lucas mainly studied the Hodgkinson Formation; W.R. Morgan the igneous rocks; and R.M. Tucker mapped and B.J. Amos mapped the detailed structures in the Palaeozoic sediments.

Location and Access

The Mossman Sheet area in North Queensland is circumscribed by longitudes 144°E and 145°30'E, and latitudes 16°S and 17°S. The South Pacific Ocean forms part of the eastern boundary.

Mareeba, the main town, is connected with Cairns by railway and bitumen highway. A railway line from Dimbulah to Mount Mulligan was removed in 1959 after the Mount Mulligan coal mine had closed in 1957. Another line, from Mareeba to Mount Molloy and Rumula, has a twice-weekly service.

The Mulligan Highway, still under construction and consolidation, extends from Mareeba across the area to Cooktown, and forms the main access for some station homesteads and many tobacco farms in the Molloy-Mount Carbine area. Mossman and Port Douglas, in the sugar cane district along the coast, are linked with Cairns by a bitumen highway, and with Molloy and Mareeba by an all-weather gravel and dirt road.

The western half of the Sheet area is largely deserted. Four station homesteads in this part of the area or on its western boundary are connected with the Chillagoe-Mareeba road by dirt tracks but apart from these tracks this isolated portion of the area has no access for normal motor vehicles. Four-wheel drive vehicles usually can travel to the abandoned ghost-townships of Palmerville and Maytown on the Palmer River in the north-west, along remnants of old tracks.

Airstrips suitable for light aircraft exist at Wrotham Park, Mount Mulgrave, and Maitland Downs and for medium-sized aircraft at Mareeba. There is a regular air service to Wrotham Park from Cairns.

Climate and Vegetation

Most of the Mossman Sheet area is covered by mixed tropical savannah woodland, which merges rapidly into tropical rain forest near the coast. The coastal belt is one of the wettest parts of Australia, with rainfalls of up to 80 inches per year in the south-east. West of the coastal mountains and table lands ("Great Dividing Range") the annual figures decrease rapidly to between 30 and 40 inches.

The climate is monsoonal, consisting of a dry "winter" and a wet "summer" period. January, February, and March, with rainfall averages of more than five inches per month, are the wettest months; and July, August, and September are the driest with their averages mostly below ¼ inch.

The mean daily temperatures range from 55°-60° (minimum) to 75°-85° (maximum) in July; from 70°-75° (minimum) to 85°-90° (maximum) in January.

The short streams draining into the Pacific Ocean are perennial. In the larger western part of the Mossman Sheet area, which drains into the Gulf of Carpentaria, only the three main streams (Palmer, Mitchell, and Walsh Rivers) are perennial. The larger tributaries, such as Elizabeth Creek, maintain a chain of disconnected waterholes during the dry season, but the rest of the country is parched dry in the winter. A few small springs are found at the base of the arenaceous Mesozoic strata and also in the limestone country of the Chillagoe Formation. Apart from some station water bores in Mesozoic sandstone and river alluvium, no underground water exploitation exists. Mount Mulligan township, now almost deserted, obtained its water from two dams, one of which, built in a gorge on top of the mountain, still provides water to the town's sole survivors by a waterpipe.

PREVIOUS INVESTIGATIONS

The first geological observations in the Mossman Sheet area were probably made by N. Taylor, the geological member of Hann's 1872 expedition. He recorded the agate basalts south-east of Mount Mulgrave homestead, the limestones and "slates" of the Chillagoe Formation, and the mica schist country (Dargalong Metamorphics) between the Mitchell and Palmer Rivers. Because of a find of Glossopteris, the sandstone-capped tableland south of the Mitchell River near Mount Mulgrave homestead was named "Taylor's Carboniferous Range". Apparently he did not notice the unconformity between the fossiliferous formation and the overlying Mesozoic sandstone.

Hann's expedition also found specks of gold in the Palmer River; a discovery that led to a gold rush in the district, promoted in particular by J.V. Mulligan, who in the next few years found payable gold in the Palmer and Hodgkinson districts, and reported traces of gold and tin in many creeks in other areas. The typical gold rushes that followed brought the rapid birth, growth, and death of Palmerville, Maytown, Groganville, Byerstown, Kingsborough, Thornborough, and other townships no longer existing or now in ruins. The Palmer rush also promoted the development of Cooktown, and Port Douglas and Cairns were established as ports of supply for the Hodgkinson District. During these years of feverish gold prospecting other minerals were found and eventually exploited when production from the goldfields declined.

Many articles and papers have been written on localized lodes and deposits, but systematical geological investigation lagged behind. Tenison-Woods (1880), one of the earlier reporters, adhered to the then modernistic view that the Mareeba Granite of Hann's Tableland was the result of an "altering" of the slates, which were seen to "pass gradually into schist, gneiss, and finally granite". He also considered the coarse greywacke at Port Douglas to be a volcanic.

In 1884, Jack described and named the sediments of the Hodgkinson Formation ("Hodgkinson Beds") in their type-area, and he mentioned the discovery of Lepidodendron australe (?) and some corals from the Hodgkinson district. A few years later (1887; 1888; 1897) he gave accounts of the geology in the Palmer River and Limestone gold districts, and correlated the sediments there with those found in the Hodgkinson Field.

In about the first fifteen years of the twentieth century, when the gold rushes had faded, minerals other than gold began to receive attention. Reports were written on tin at China Camp (Saint-Smith, 1915), Mount Holmes (Ball, 1912), Mount Spurgeon (Ball, 1915); on copper at Mount Molloy (Russell, 1903; Weinberg, 1905) and the O.K. Mine (Gibb, 1904; Jack, 1907); on wolfram at Mount Carbine (Ball, 1913); on coal at Mount Mulligan (Ball, 1910; 1912); and on antimony (Saint-Smith, 1917).

Between 1909 and 1921 several articles dealing with physiographic aspects were written by Poole, Danes, Jensen, and Andrews.

A full, detailed treatise on the geology of the Cairns Hinterland was given by Jensen in 1923. Among other problems he discussed the age and relationships of the Featherbed Volcanics, the granites, and the Hodgkinson Formation. Many of his conclusions have been proved incorrect by later discoveries.

Bryan (1925, 1926) summarized the knowledge of earth movements and palaeogeography to that date; and Reid, in 1930, discussed the Palaeozoic stratigraphy of Queensland.

Between 1938 and 1941 the Aerial, Geological and Geophysical Survey of Northern Australia systematically mapped parts of the Mossman Sheet area, and re-appraised and summarized the data on some of the known mineralization, viz. gold, antimony, and manganese. Aerial photographs were used for the first time. Since 1938 also, numerous mines and prospects were inspected by geologists of the Queensland Geological Survey, and some prospects by private companies and syndicates.

Systematic regional mapping began in 1956 by joint field parties of the Bureau of Mineral Resources and of the Queensland Geological Survey and has contributed greatly to the geology of the Mossman Sheet area. This programme of regional mapping of North Queensland will be continued in 1961 in the north-east corner of the Mossman Sheet area and the adjoining Cooktown Sheet area.

PHYSIOGRAPHY

The ill-defined Great Dividing Range, which here contains the Windsor and Mount Carbine Tablelands, trends across the eastern part of the Mossman Sheet area from the vicinity of the Barron River in a north-north-west direction to Racecourse Mountain on the boundary with the Cooktown Sheet area. The Range separates a small coastal area with humid tropical climate from a larger area more inland, which has a semi-arid tropical climate. The eastern slopes of the coastal ranges receive most of the rain from sea-winds; the range rapidly merges to the gentle western slopes of the uplands and tablelands that gradually descend to the plains of the Gulf of Carpentaria.

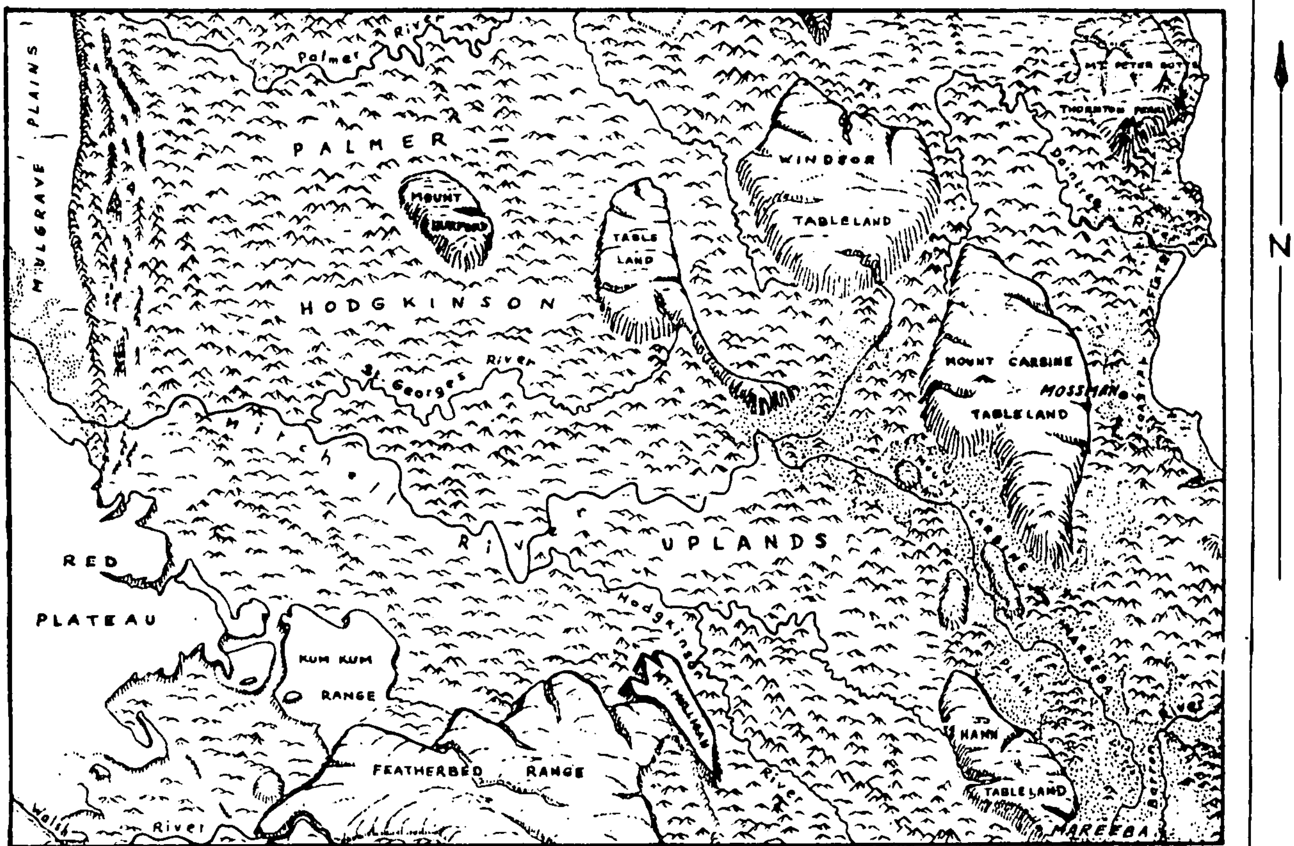

FIG. 1 *Physiography of the Mossman 1:250,000 sheet, North Queensland* Scale 1" = 16 miles

The eastern strip of humid tropical highland, about 10 to 25 miles wide, is almost completely covered with tropical rainforest, except for the populated Mossman Plain where the forests have been cleared for sugarcane fields. The numerous short streams flowing into the ocean are young and have steep gradients along most parts of their courses, knicked by rapids and spectacular waterfalls. They are all perennial.

The larger, semi-arid western area has mainly open savannah woodland, with extensive grasslands on the Mesozoic plains underlain by the Blackdown Formation. Three main rivers - the Palmer, Mitchell, and Walsh Rivers - drain the area into the Gulf of Carpentaria. They have, in the westernmost part of the sheet boundaries, broad flood-plain valleys, entrenched and narrowing in the rough Palmer-Hodgkinson Uplands. The Mitchell River in its upper course flows through the wide, flat alluvial deposits of the Mount Carbine-Mareeba Plains. The three main rivers are probably perennial, but their tributaries stop flowing during the winter months, maintaining a chain of waterholes where they are large enough, but usually completely dry where smaller.

There is a wide diversity of topographic forms within the Mossman Sheet area, ranging from alluvial plains and flat plateau country to rough uplands, dissected tablelands and rugged mountainous highland. The high peaks are found in the east: Thornton Peak (4514 ft.), Mount Spurgeon (4400 ft.), and Mount Lewis (4025 ft.) are the highest peaks. Here also the relief energy is a maximum, which is, for example, more than 4000 feet in the Thornton Peak area, where this difference in altitude occurs within a total distance of two miles or less. Altitudes as well as relief energy decrease towards the west, where at Mount Mulgrave it is a minimum of 500 feet.

The main physiographic units are illustrated in Fig. 1. They are controlled by lithological contrast and structural events.

More than a third of the Mossman Sheet area is occupied by the Palmer-Hodgkinson Uplands, a monotonous, finely textured and dissected, uplifted and rejuvenated Tertiary erosion surface, now constituting a desolate area of stony hills and ridges which are interspersed by the massive granitic tablelands. Many hogbacks, rising above their surroundings, result from the greater resistance against erosion of competent beds of chert and massive greywacke. The Palmer-Hodgkinson Uplands are formed on the Palaeozoic sediments, which, because of their uniform lithology of greywacke and siltstone, erode to form a monotony of the landscape and the dendritic drainage pattern.

The western rim of the Uplands differs slightly from its other parts because of the intercalation of limestone, which forms characteristic dark grey bluffs with karren surface, or lapies. The drainage is here partly subsequent, and follows a north trending valley-and-ridges topography.

West of the Palmer-Hodgkinson Uplands, and separated from them by a large fault (Palmerville Fault) lies the low undulating country of the Mulgrave Plains, formed on the Precambrian Dargalong Metamorphics after the Mesozoic, and which occupy an area of roughly 200 square miles. The topographical contrast between Mulgrave Plains and Palmer-Hodgkinson Uplands may be partly explained by their lithological differences, but it is chiefly the result of young tectonic movements along the Palmerville Fault.

South of the Mulgrave Plains, the Dargalong Metamorphics are overlain by a cover of Mesozoic sediments forming part of the Red Plateau, as named by Twidale (1956). The plateau extends to the adjoining Atherton, Walsh, and Red River Sheet areas, and also it overlaps a portion of the Palmer-Hodgkinson Uplands. A cliff 100 to 400 feet high forms the eastern boundary, whereas in the north the boundary is more gradational. The Red Plateau slopes gently westwards, and is exposed for about 400 square miles in the south-west of the Mossman Sheet area.

Massive Permian volcanics make up the Featherbed Range, which is an incised tableland-like structure covering about 350 square miles on the southern edge of the Sheet area, and rising up to 1000 feet above its surroundings. The Walsh River has cut a superimposed gorge through the range, partly re-adjusted to the joints. The drainage system is angular and strongly controlled by these joints.

Other Permian volcanics (the Nychum Volcanics), which are better stratified than the volcanics in the Featherbed Range, form the Kum-Kum Range, essentially a plateau north-west of the Featherbed Range, and representing an exhumed Upper Permian land surface, which was re-exposed after the erosion of the protecting cover of Mesozoic sandstone. The process of ex-humation is still continuing westwards.

The Featherbed Range is bounded in the north-east by Mount Mulligan which is an obsequent rift-block mountain with an area of 30 square miles, and composed of Mesozoic sandstone and conglomerate. The mountain is dissected on nearly all sides to form vertical cliffs up to 1000 feet high. Mount Mulligan is one of the most conspicuous landmarks in the Mossman Sheet area, and can be seen from the Red Hill copper prospect, 50 miles to the north-west.

A number of granite batholiths in the Palmer-Hodgkinson Uplands have resisted levelling by erosion during the Cainozoic, and forms the granite Tablelands of Mount Windsor, Mount Carbine (each with an area of about 200 square miles), Hann, Mount Hurford, and some smaller masses. The Tablelands are sharply defined, rise steeply above their surroundings, and normally have a reasonably flat upper surface, which is generally deeply incised and sculptured at the edges. The drainage is in part radial, in part joint-controlled and angular.

The Mount Carbine-Mareeba Plain contains the upper reaches of the Mitchell River, which is here clearly a captured part of a pre-existing larger stream running through a flood-plain that is much too large in proportion to the Mitchell River.

A narrow strip of alluviated flat country along the coast forms the Coastal Plain.

REGIONAL GEOLOGY

The regional geology of the Mossman Sheet area contains the complete history of development of part of the Tasman Geosynclinal Zone. In the far west of the area, the Shield area bordering the geosynclinal zone is represented by the Precambrian Dargalong Metamorphics. The folded and faulted Palaeozoic geosynclinal sediments form most of the rock formations in the area mapped, and they are represented by Upper Silurian-Lower Devonian Shelf deposits of the Chillagoe and Mount Garnet Formations, and the Middle Devonian to ?Lower Carboniferous trough deposits of the Hodgkinson Formations. The Palaeozoic sediments were intruded, first by the late-orogenic Mareeba and Cannibal Creek Granites in the east and north of the area, later by the post-orogenic, Permian to Triassic Almaden Granodiorite and Elizabeth Creek Granite, which are exposed in the south-western part of the Sheet area. This post-orogenic Permian-Triassic plutonism was accompanied by volcanic activity, resulting in the outpour of the Nychum and Featherbed Volcanics in Almaden and Elizabeth Creek Granitic areas. The landscape during the Permian and Triassic was one of low relief, favourable for the formation of coal fields, as for example the Mount Mulligan Coal Measures. During Mesozoic times epeirogenic transgressions from the west or north-west deposited a blanket of sandstone (Wrotham Park Sandstone) and shale (Blackdown Formation) over the levelled older formations. Their eroded remnants now form the Red Plateau, fringed with mesas and buttes, in the south-western border area. The latest deposits were Cainozoic gravels and olivine basalt, small relicts of which are found on the western and on the northern sheet boundaries respectively; they are more widespread in the adjoining Walsh River and Cooktown Sheet areas.

Many of these formations and units have been described in previous Bureau reports (de Keyser et al., 1959; Best, 1961; Morgan, 1961). Where possible in the next pages, their characteristics will be briefly summarized, and one is referred to the literature for further details.

Precambrian

The Dargalong Metamorphics consist of quartz-mica schist, gneiss, augen gneiss, quartzite, "granulite", and amphibolite, occupying the undulating plain west of the Palmerville Fault, north of the Mitchell River. South of the river the metamorphics are mostly concealed by cover of Mesozoic sandstone and Permian volcanics. The metamorphics were referred to as the "Frome Series" by A.G.G.S.N.A. geologists (1940a), but they are the same metamorphics as the Dargalong Metamorphics in the type-area around Dargalong in the Chillagoe district, and there is therefore no need for another metamorphic name.

The faulted boundary against the Palaeozoic Chillagoe Formation is sharp and abrupt, and easily discernible on aerial photographs. The lithologies grade into each other. Outcrops are scarce and generally very weathered, which allows for little or no structural aerial photo interpretation except where a resistant quartzite band outlines a sharp, steep-limbed fold.

TABLE I

STRATIGRAPHY OF THE MOSSMAN 1:250,000 SHEET

ERA	PERIOD	ROCK UNIT	THICKNESS	DESCRIPTION	DISTRIBUTION	TOPOGRAPHY	STRUCTURE	AGE PALAEONTOLOGY CORRELATION	RELATIONSHIPS	ECONOMIC INTEREST	PRINCIPAL REFERENCES
CAINOZOIC	QUATERNARY	Alluvium, soil (Qa)	Up to 75 feet in Molloy-Mt. Carbine area.	Sand, Gravel, thick soil	Mt. Carbine-Mareeba Plain; coastal plains; parts of Mulgrave plains	Level Plains	-	Recent, grading back into Tertiary	Unconformable veneer on older formations.	Alluvial gold and tin; sugarcane, tobacco.	-
		Coastal swamps (Qa)	Unknown	Saltwater silts and muds	Along mouth of the Daintree River; between Port Douglas and Mossman coast; north of Bayly Point.	Low swamps with stagnant water arms.	-	Recent	-	-	-
		Old beach sand (Qr)	Unknown	Clean white sand with pumice drift.	Narrow coastal strip from Daintree River 6 miles to the south.	Low sandy strip	Old shore lines visible on aerial photographs	Recent	-	-	-
	TERTIARY	Olivine basalt (Czb)	About 200 ft. in the north; 40 ft. near Mareeba	Olivine basalt, scoraceous in part.	Scattered flow remnants and vents along northern edge of Sheet area; buried under alluvium around Mareeba	Flat cappings on eroded Hodgkinson topography: inverted relief.	Horizontal, with probable vent remains.	Pliocene or Pleistocene	Unconformably overlying Hodgkinson Formation	-	-
		Gravel, billy (Czy)	Up to 180 ft.	Well-rounded quartz gravel, in places overlain by billy breccia	Veneer and scattered patches along road between Wrotham Park and Mt. Mulgrave; also probably the gravel banks of Mitchell River near Mt. Mulgrave, and of Elizabeth Creek near Wrotham Park.	Flat gravel surface and low mounds on Cretaceous plain; river banks.	-	Possibly Miocene	Unconformably overlying Hodgkinson Formation	-	-
MESOZOIC	APTIAN OR ALBIAN	Blackdown Formation (Klb)	Up to 100 ft. in Sheet area, but thickening to the west.	Shale, siltstone, sandy shale, some lenticular sandstone. Calcareous concretions	Along the road between Wrotham Park and Mt. Mulgrave.	Flat grassy plains, generally with thin veneer of Cainozoic gravel.	Horizontal	(Upper) Aptian to (lower) Albian. *Panope* sp., *Mytilus* sp., *Gari* sp., *Maccoyella* sp., *Pinna* sp., *Tatella* sp., *Dentalium* sp., *Malletia* sp., *Australiceras* sp., *Toxoceratoides* sp., *Sanmartinoceras* sp., *Foraminifera*, [illegible]	Conformably overlying Wrotham Park Sandstone. Unconformably overlain by Cainozoic gravels and "billy" breccia.	Cattle country	Laing & Power (195[illegible]) [illegible]ds (1960)

ERA	PERIOD	ROCK UNIT	THICKNESS	DESCRIPTION	DISTRIBUTION	TOPOGRAPHY	STRUCTURE	AGE PALAEONTOLOGY CORRELATION	RELATIONSHIPS	ECONOMIC INTEREST	PRINCIPAL REFERENCES
MESOZOIC	NEOCOMIAN OR APTIAN	Wrotham Park Sandstone (Klw)	Up to 400 feet.	Conglomerate and sandstones, with in places glauconitic horizon on top.	South-west corner of sheet area.	Low plateau bounded by scarps and fringed by buttes and mesas.	Sub-horizontal with slight (less than 5°) regional dip towards the west.	Neocomian or Aptian. Fossils rare: *Maccoyella barklyi*, *Terebratulid brachiopods*, indeterminable plant stems. Probably to be correlated with Gilbert Formation.	Unconformably overlying Precambrian and the Palaeozoic Formations. Conformably overlain by Blackdown Formation.	–	Laing & Power (1959) Woods (1960)
	JURASSIC?	Laura Sandstone (Jl)	100 feet	Sandstone, with conglomerate at the base.	Three or four very small outliers north of Palmer River	Small cappings on hills.	Horizontal	Jurassic ? No fossils in area mapped.	Unconformably overlies the Hodgkinson Formation	–	Whitehouse (1952)
	TRIASSIC?	Pepperpot Sandstone (Rp)	1000 feet	Current-bedded red conglomerate and sandstone and some tuff-shale; grading upwards into white flaggy argillaceous sandstone and siltstone.	Forms the 30 square miles of Mount Mulligan.	Small plateau or tableland bounded by tiers of cliffs totalling 1000 feet.	Flat, with dips generally less than 15° except where adjoining faults. Represents fill-in of rift valley.	Triassic ? Plant fossils. *Taeniopteris* sp. *Odontopteris* sp. *Phyllotheca* sp. *Ginko* sp.	Overlies Mt. Mulligan Coal Measures with slight unconformity. Faulted boundary against Featherbed Volcanics.	–	Ball (1912) (1917)
PALAEOZOIC - MESOZOIC	UPPER PERMIAN - LOWER TRIASSIC	Elizabeth Creek Granite (Pgz)	–	Pink leucocratic biotite granite, poor in mafics, and commonly porphyritic	One or two stocks in south-west portion of Sheet area.	Bare bouldery hills, rougher than Almaden Granodiorite	Massive. Joint pattern on aerial photographs.	Probably Lower (?) Triassic.	Intruding and co-magmatic with the Featherbed Volcanics. Intruding the Hodgkinson and older Formations.	Introducer of tin.	Branch (1961) Morgan (1961)
		Featherbed Volcanics (Pf)	At least 2000 ft.	Massive acid ignimbrites; sub-ordinate flows and pyroclasts. Some sediments at base.	About 350 square miles along southern edge of Sheet area.	Incised tableland.	Massive. Joint pattern on aerial photographs; some broad, gentle folding with dips generally not exceeding 20° except near faults.	Upper Permian or Lower-Triassic	Faulted boundary all around. Probably younger than Nychum Volcanics, older than Pepperpot Sandstone.	–	Morgan (1961) Branch (1960) de Keyser et. al. (1959)
		Almaden Granodiorite (Pga)	–	Grey hornblende-biotite granodiorite, commonly [illegible]	Several stocks in south-western portion of the Sheet [illegible]	Bouldery, hilly outcrops, with "metal hills"	Massive	Upper Permian ?	Intrudes the folded Palaeozoic formations and also seems to intrude the [illegible]	Introducer of copper silver-lead (?), some [illegible]	Branch (1960) Morgan (1961)

ERA	PERIOD	ROCK UNIT	THICKNESS	DESCRIPTION	DISTRIBUTION	TOPOGRAPHY	STRUCTURE	AGE PALAEONTOLOGY CORRELATION	RELATIONSHIPS	ECONOMIC INTEREST	PRINCIPAL REFERENCES
PALAEOZOIC	UPPER PERMIAN	Mount Mulligan Coal Measures (Ptm)	0-800 (?) feet	Conglomerate, sandstone, siltstone, shale, coal. In places volcanic breccia at base.	Forms the base of Mount Mulligan.	-	Flat, with dips generally less than 15° except where adjoining faults.	Upper Permian (-lower Triassic?) Plant fossils: Glossopteris spp. Sphenophyllum sp. Sphenopteris (?) sp. Vertebraria. Micro-flora: spores and pollen	Unconformably overlies Hodgkinson Formation. Unconformably overlain by Pepperpot Sandstone.	Coal	Ball (1912, 1917) Morton (1945) Shepherd (1945) Connah (1953)
		Nychum Volcanics (Pny)	Up to 500 ft.	Mainly acid flows, ignimbrites and pyroclasts; minor andesites and basalts. Near the base: tuffs, arkose, conglomerate, siltstone, shale, impure coal.	In the south-western part of the Sheet area, south of Mitchell River. Isolated occurrence north-west of Mount Mulligan.	Plateaux (Kum Kum Range) or low undulating country.	Essentially horizontal, with faulting and some gentle broad folding; dips generally less than 30°	Upper Permian (-Lower Triassic?). Glossopteris spp. abundant, Rare Taeniopteris sp. Equisitalean, pollen and spores. Probably time-equivalent of Mt. Mulligan Coal Measures.	Unconformably overlies folded Precambrian and Palaeozoic formations. Unconformably overlain by Wrotham Park Sandstone. Probably intruded by Almaden Granodiorite.	-	Morgan (1961)
	CARBONIFEROUS	Montalbion Sandstone (Cm)	Thin rubbly remnants	Quartzose sandstone.	Along Northcote-Thornborough road, as dwindled northern extension of main outcrop in Atherton Sheet area.	Rubbly remnants on top of hills.	Rubbly remnants, attitudes unknown.	Carboniferous	Would be unconformably overlying Hodgkinson Formation.	-	Best (1961)
		Cannibal Creek Granite (Cgc)	-	Cream biotite-microcline granite ± muscovite.	Mountain massif east and south-east of Cannibal Creek.	Incised tableland	Massive jointed.	Carboniferous	Intrudes the Hodgkinson Formation	Introducer of gold and tin.	Morgan (1961)
		Mareeba Granite (Cgm)	-	Grey biotite-microcline granite ± muscovite. Commonly strongly porphyritic.	Batholiths in the eastern and central-northern parts of the Sheet area.	Forms the tablelands of Windsor, Mount Carbine, Hann, etc.	Massive, jointed. Some foliation in places.	Carboniferous	Intrudes the Hodgkinson Formation and Barron River Metamorphics	Introducer of gold, tin, wolfram, antimony. Some copper.	Morgan (1961)
	DEVONIAN	Barron River Metamor-phics (Pzb)	Unknown	Low-grade metamorphic greywacke, siltstone, phyllite, micaceous schist.	Zone along the coast, from Mareeba to the North.	Indefinite and varied, from jungle-clad hills and mountains to coastal plains.	Steeply folded, faulted.	Penecontemporaneous with Hodgkinson Formation.	Largely a metamorphic facies of the Hodgkinson Formation. Intruded by Mareeba Granite.	-	-

ERA	PERIOD	ROCK UNIT	THICKNESS	DESCRIPTION	DISTRIBUTION	TOPOGRAPHY	STRUCTURE	AGE PALAEONTOLOGY CORRELATION	RELATIONSHIPS	ECONOMIC INTEREST	PRINCIPAL REFERENCES
PALAEOZOIC	MIDDLE DEVONIAN - LOWER CARBONIFEROUS	Hodgkinson Formation (D-Ch)	At least 20,000 ft., possibly 40,000 feet.	Micaceous greywacke and quartz greywacke, siltstone, slate; intercalations of chert, basic volcanics, conglomerate. Rare lenses of limestone.	Occupies the larger part of the Mossman Sheet area.	Monotonous hills and ridges; fine-textured drenditic drainage pattern.	Faulted and steeply folded, regional strike north-north-west.	Middle Devonian to possibly Lower Carboniferous. *Lepidodendron australe* (?) or *Leptophloeum australe* (McCoy). *Retzia* sp., *Pachypora* sp. *Cyathophyllum helianthoides* *Favosites* sp., *Grypophyllum* sp. Indeterminable plant stems.	Younger than Chillagoe and Mt. Garnet Formations, possibly with unconformable contact. Unconformably overlain by Nychum Volcanics, Mt. Mulligan Coal Measures, Cainozoic basalt.	Host rock for gold, tin, wolfram, antimony and copper mineralization. Some manganese limestone.	Jack (1884) Jensen (1923) Reid (1930) ACGSNA (1940, 1941) [illegible] (196[illegible] White (1960, 1961b)
	UPPER SILURIAN - LOWER DEVONIAN	Mount Garnet Formation (S-Dg)	Unknown	Quartz greywacke, feldspathic sandstone, arkose, siltstone, bedded chert; subordinate conglomerate, rare lenses of limestone, interbedded basalt.	Chiefly between Big Watson Creek and Wrotham Park road. Disappears north of Mitchell River.	Generally low ridges; more pronounced ridges formed by massive dust. Siltstones occupy the valleys.	Faulted and steeply folded.	Upper Silurian-Lower Devonian.	Partly penecontemporaneous with, partly younger than, the Chillagoe Formation, the boundary with which is transitional. Unconformably overlain by Nychum Volcanics. Wrotham Park Sandstone. Intruded by the Permian granites.	Host rock for copper	Best (1961) de Keyser et. al. (1959). (Koorboora and Red Cap Beds)
		Chillagoe Formation (S-Dh)	Thickness estimated at roughly 5000-10,000 feet.	Fossiliferous reef limestone, bedded chert, quartz greywacke, siltstone, conglomerate lenses, interbedded basalt. Quartzose sandstone and siltstone at the base.	North-south trending belt 2 to 8 miles wide from Palmerville-Maytown in the north to the Walsh River in the south, and beyond.	Limestone forms typical bluffs with lapies; chert forms smooth, rounded, rubbly ridges; the arenites somewhat rougher ridges; siltstones occupy the flats and valleys. Drainage tends to be subsequent north of Mitchell River	Faulted and steeply folded, regional strike north-south.	Upper Silurian, possibly ranging into Lower Devonian. Many corals: *Favosites*, *Heliolites*, *Halysites*, *Tryplasma*, *Cyathophyllum*, *Spongophyllum*, *Xystriphyllum*, *Pseudamplexus*, etc. Also *crinoids*, *brachiopods*, *gastropods*, *Desmospongea*.	Faulted boundary against older Dargalong Metamorphics. Reef facies of Mt. Garnet Formation. Unconformably overlain by Nychum Volcanics and Wrotham Park Sandstone. Intruded by Almaden Granodiorite.	Host Rock for copper	de Keyser et. al. (1959) (1960) Jensen (1941) Broadhurst (1952)
PRECAMBRIAN	ARCHAEAN(?)	Dargalong Metamorphics (Ad)	Unknown	Micaceous schist, gneiss, quartzite, augengneiss, amphibolite, granulite. Garnet-amphibolite facies of regional metamorphism.	Occupies the Mulgrave Plains. South of the Mitchell River largely covered by Permian volcanics and Cretaceous sandstone.	Generally undulating plains and lowlands. Outcrops rare, and much weathered.	Faulted and strongly folded, regional strike north-south.	Pre-Silurian possibly Archaean because of high-grade metamorphic aspect.	Faulted boundary against the younger and probably unconformable Chillagoe Formation. Unconformably overlain by Nychum Volcanics and Wrotham Park Sandstone.	No known mineralization in Mossman Sheet area; elsewhere: gold, copper, fluorspar (?).	Ball (1917) de Keyser et. al. (1959).

Examination of three thin sections, of an amphibolite and two gneisses, revealed a mineral assemblage including quartz, plagioclase, hornblende, biotite, and garnet as the main minerals. Since the plagioclase is a basic andesine-labradorite, and the hornblende is greenish-brown, it has been deducted that the regional metamorphism of the rocks is in the upper range of the garnet-amphibolite facies. Albite, reported by Jensen in 1941, could not be found in the thin sections examined.

The age of the Dargalong Metamorphics is unknown, apart from the fact that they are pre-Silurian. White (1961) considered the metamorphics as Archaean, mainly because of their high grade regional metamorphism.

Palaeozoic

Upper Silurian-Lower Devonian

The Chillagoe Formation ("Palmerville Series" of A.G.G.S.N.A., 1940a) occupies a meridional belt 3 to 8 miles wide, and is an extension from the type-area in the Chillagoe district. To the north the formation continues into the Cooktown Sheet area. It is bounded in the west by the Palmerville Fault, in the east by the Mount Garnet and Hodgkinson Formations. The eastern (upper) boundary in all probability transgresses time boundaries, and particularly its boundary against the Mount Garnet Formation is transitional and arbitrary. The Chillagoe formation overlies the Dargalong Metamorphics probably unconformably, since its un-metamorphosed conglomerate lenses contain pebbles and boulders of amphibolite and gneiss of the Dargalong Metamorphics.

The main rock types are fossiliferous limestone, chert, quartz-greywacke, and siltstone, with intercalated basalts and some lenses of conglomerate. The base of the Chillagoe Formation is formed by quartz siltstone or fine-grained quartz sandstone, which near the Palmerville Fault is commonly transformed by shearing into sericitic quartz schist.

On aerial photographs the dark jagged limestone bluffs with their karren surface are easily interpreted, and the bluffs show definite trends owing to the alternation of beds of different chemical and mechanical composition

The limestone contains fossils, which include species of tabulate and rugose corals, crinoids, brachiopods, and some gastropods (de Keyser et al, 1959), suggesting an Upper Silurian age and probably extending into the Lower Devonian.

The name of Mount Garnet Formation was proposed by Best (1961) for greywacke, siltstone, and reef sediments near Mount Garnet in the Atherton Sheet area, which he considered to be off-shore equivalents of the Chillagoe Formation. These sediments can be mapped as far north as just north of the Mitchell River, via Almaden and Mungana, to the Mossman Sheet area, where they either lens out or are overlapped by the Hodgkinson Formation.

Quartz greywacke, arkose, chert, siltstone, feldspathic sandstone, some conglomerate, and small isolated lenses of limestone are the composing sediments, and they contain intercalated basic lavas. The Mt. Garnet Formation differs from the Chillagoe Formation by a paucity of limestone and a predominance of clastic sediments, and the boundary between the two formations is therefore transitional and arbitrary.

The Mount Garnet Formation is in part penecontemporaneous with, in part younger than, the Chillagoe Formation, and it may be regarded as a clastic facies of the Chillagoe Formation, which thickens considerably where the Chillagoe reef-facies thins, and vice-versa. The depth of deposition was probably shallow, as for the Chillagoe Formation. White (1961) has compared the shelf area of the Mt. Garnet Formation to a 'Continental Borderland' (Wiseman & Ovey, 1953), which is a continental shelf area containing irregular deep and shallow parts.

The boundary of the Mt. Garnet Formation with the overlying Hodgkinson Formation is better defined in the south than north of the Mitchell River, where the unit merges with the facies of the Hodgkinson sediments, so that here the boundary is arbitrary.

White (1961) postulated the rise of a tectonic land during the early Palaeozoic, which continued to rise in the Upper Silurian-Lower Devonian in the region south of the Mossman Sheet area, and he presented evidence for an unconformity between the Mount Garnet and Hodgkinson Formations there. It seems doubtful whether an unconformity can be proved in the Mossman Sheet area and in the north. The absence of an unconformity here would, however, support the tectonic land concept, and explain the large thickness of the Mount Garnet Formation in the south:- the rise of land in the south would supply abundant detritus, diminishing to the north (thinning of Mount Garnet Formation), and, with continuing rise during Devonian times, a definite unconformity between Mount Garnet and Hodgkinson Formations would be formed, changing into a disconformity or possibly into an uninterrupted sequence farther north.

Middle Devonian to ?Lower Carboniferous

The Hodgkinson Formation occupies an area at least as large as that covered by all other geological units together. The bulk of the formation consists of greywacke, quartz greywacke, and siltstone, with radiolarian chert, intercalated basic volcanics, and some conglomerate locally abundant. Rare lenses of limestone and some interbeds of acid lava also occur.

Most of the greywacke and siltstone are rhythmically and uniformly thin-bedded, forming thick monotonous sequences with ample evidence of being deposited by turbidity currents. In the type area - the Hodgkinson Goldfield - the sediments are mainly massive, structureless micaceous greywacke with thinner shale and siltstone beds commonly containing abundant plant-fragments, and a few fossiliferous limestone lenses and conglomerates. The reef sediments, probably formed in shallow water or at least close inshore, are not the most common sediments of the formation.

Bedded and massive cherts are locally abundant, especially north of the Daintree River, where they are associated with black cherty shale or siltstone and with basic volcanics. South of the Daintree River cherty siltstone and large areas of black slates seem to predominate over greywackes. A general decrease in grain size from south (Barron River area) to north (across the Daintree River) and current transport from south to north in these areas suggest increasing distances from the source area, probably accompanied by an increase in depth.

The conglomerate and greywacke contain pebbles and fragments of penecontemporaneous sediments as well as metamorphic Precambrian (?) material. Their distribution suggests that the source lands were probably situated at short distances beyond the southern and northern boundaries of the Mossman Sheet area.

Microscopic examination of the arenites shows most of them as greywacke with typical immature mineralogical composition and texture, poor sorting, and more than 15 per cent matrix. With slight variations in the matrix content and relative abundance of minerals, gradations into quartz greywackes and feldspathic sandstones occur.

In many places it is difficult to distinguish between Hodgkinson Formation and Mount Garnet Formation. Generally the Hodgkinson sediments are more uniformly bedded, with less variety, and have greenish, brown, buff, or ochre weathering colours in many places with red or pink edges; they have a larger proportion of greywacke, which form blocky, jointed outcrops. The Mount Garnet sediments are more poorly sorted, more massive and irregular, with a greater amount of arkosic and feldspathic sandstones and quartz greywacke. Their outcrops are either dirty dark or very light weathered and show rounded, bouldery surfaces.

The age of the Hodgkinson Formation is probably Middle Devonian to Lower Carboniferous. Prof. Hill (pers. comm.) determined Middle Devonian corals from two localities on the Thornborough-Northcote road (Plate 1). The corals consist of _Favosites_ sp. cf. _nitidus_, _Favosites_ sp. ?_goldfussi_, ?_Hexagonaria_ sp., _Grypophyllum_ sp., _Fasciphyllum_ ?sp. small-celled, _Xystriphyllum_ ? sp. small-celled. Mary White (1960, 1961b) determined plants referable to _Leptophloeum australe_ (M'Coy) from near Stannary Hills (Atherton Sheet area), 12 miles north-north-west of Dimbulah (Atherton Sheet area), and in the Dessily Range (Mossman Sheet area), all from the Hodgkinson Formation. She states that _Leptophloeum australe_ (M'Coy) is a reliable indicator of Upper Devonian in Eastern Australia, and it is possible that it persisted into Lower Carboniferous in some areas. It may be that the eastern part of the Hodgkinson Formation, which includes large areas of slate, chert, cherty siltstone, basic volcanic, and some ultrabasic rock, may represent either the earliest Hodgkinson deposits or the time-equivalents of the Mount Garnet and Chillagoe Formations, which have been deposited as a pelagic facies at some distance from the shelf areas to the east and south, and conformably overlain by the younger Hodgkinson Formation.

The Hodgkinson Formation is overlain with an angular unconformity by the Permian Nychum Volcanics, the Mesozoic Laura Sandstone, and by Cainozoic basalt, and it is intruded by the granites, acid and basic dykes. A total thickness of several tens of thousands of feet can be estimated for the Hodgkinson Formation.

Towards the east of the arch the sediments are metamorphosed, and the formation grades into the Barron River Metamorphics. The basic volcanics are first affected and are converted into greenschists composed of albite, epidote, actinolite, chlorite, calcite, and sphene. In the sediments, clastic biotite is regenerated and a scattering of newly-formed minute euhedral biotite flakes appears before a macroscopic change is noticeable. (It is not always evident, however, whether metamorphic effects are due to regional processes or to thermal influence of granite intrusions). The boundary with the Barron River Metamorphics therefore is arbitrary, gradational, and ill-defined.

Within the limits of the Mossman Sheet area, the Barron River Metamorphics consist of low-grade micaceous schist, phyllite, slate, metamorphosed greywacke, siltstone, and very rare limestone lenses. The grade of metamorphism does not exceed the biotite-chlorite sub-facies of the greenschist facies. Only the phyllite and micaceous schist have a metamorphic appearance in outcrop; the more competent and coarse-grained greywacke-siltstone sequences generally retain an unaltered appearance, though thin sections clearly reveal recrystallization, formation of biotite, etc. In zones of intense shearing and crushing, greywackes may resemble banded high-grade 'gneiss', which would be unstable in this greenschist metamorphic environment; but under the microscope the sedimentary origin of the 'gneiss' is clearly recognizable, and the metamorphic grade is not higher than in the surrounding beds. The difference between the 'gneiss' and the other low grade metamorphics is mainly in the mobilization and re-grouping of minerals as quartz and biotite and the stronger recrystallization. 'Crush-gneiss' would probably be a suitable term for the 'gneiss'.

The boundary of the Barron River Metamorphics with the Hodgkinson Formation as drawn on the map (Plate 1) represents roughly the limit of those exposures where evidence of regional metamorphism is visible in outcrop. The Geological Map of Queensland (1953) shows a wide belt of Barron River Metamorphics along the coast, but in the field little difference is noticeable between these rocks and the Hodgkinson sediments, and as the grade of metamorphism increases only gradually from west to east, and the metamorphic boundary cuts across different lithologies, it seems justified to conclude that the Barron River Metamorphics in the Sheet area represent a metamorphic facies of the Hodgkinson Formation, probably including time-equivalents of the Chillagoe and Mount Garnet Formations.

Carboniferous

The Mount Albion Sandstone is a Carboniferous formation exposed in the adjoining Atherton ~~4-mile~~ Sheet area, where it consists of light-grey sandstone. A few patches of rubbly sandstone on hill tops in the Northcote-Thornborough area may be remnants of the Mount Albion Sandstone within the Mossman Sheet area, but attitudes or relationship with the Hodgkinson Formation were not observed.

Permian-Lower Triassic

The Upper Permian-Lower Triassic Nychum Volcanics and Mount Mulligan Coal Measures overlie the steeply dipping older Palaeozoic formations with a strong angular unconformity. They are lavas and sediments laid down in disconnected, shallow, probably continental basins and are only slightly folded. A third Upper Permian to Lower Triassic formation, the Featherbed Volcanics, was emplaced during a period of cauldron subsidence.

The Nychum Volcanics are exposed in the south-western part of the Mossman Sheet area, with a probable minor occurrence north-west of Mount Mulligan, and are fully described by Morgan (1961), together with all the other Palaeozoic igneous rocks of the Sheet area.

The volcanics consist mostly of acid lavas and pyroclasts, with sub-ordinate basic and intermediate flows, and contain some sediments near the base. Several remnants of eroded volcanic necks were recognized, and possible centres of vulcanicity were inferred from the outcrop of large volumes of volcanic breccia. Strong lateral variations are common so that no two sections are alike. Total thicknesses range up to 500 feet. Folding is gentle and broad, with dips rarely exceeding 30°. The Nychum Volcanics are overlain with a small angular unconformity by the Cretaceous Wrotham Park Sandstone, and probably by Featherbed Volcanics.

Basic and intermediate flows of basalt and andesite are extruded early in the succession in most areas. Some flows are amygdaloidal, with agate, quartz, calcite, chlorite, and zeolite (?) filling the amygdales. The pyroclastic rocks are composed of ignimbrite, crystal tuffs, and volcanic breccias. Rhyolite and dacite are the most common acid flows, and in many they are flow-banded. Sediments are exposed mostly at or near the base of the formation, and include quartz conglomerate, arkose, coarse micaceous sandstone, siltstone, some mudstone, and coaly shale. Fossil stream-channels and wash-outs suggest a shallow, continental environment.

Plant fossils are common in the coaly shale and in some of the siltstone. Samples collected in 1960 were identified by Mary White (1961) and include: Glossopteris indica Sch., G. angustifolia Brong., a fragment of Taeniopteris cf. T. elongata Walk., a fragment of Taeniopteris cf. T.avianamattae, small herbaceous Equisitalean, and many seeds. Mary White suggests that the associations indicate an Uppermost Permian or Lower Triassic age.

Spores and pollen grains in samples collected by Broken Hill Pty Co Ltd in 1957 were examined by Balme, University of Western Australia, and assigned to genera such as Lunatisporites, Striatopodocarpidites, Pityosporites, etc. (personal communication). The microflora closely compares the Upper Bowen, Newcastle Coal Measures, and other formations elsewhere in Queensland, and Balme placed the B.H.P. samples in the Upper Permian. Dr. Evans (pers. comm.) of the Bureau of Mineral Resources supports this view after examining material collected during the 1960 field season.

Probably equivalent in age to the coaly shales of the Nychum Volcanics are the Mount Mulligan Coal Measures, which form the base of Mount Mulligan. They consist of coarse conglomerate, arkose and pebbly sandstone, siltstone, shale, and coal, and they are unconformably overlain by Triassic (?) conglomerate and sandstone. In the north-west and east the base is formed by reworked Nychum Volcanics. The total thickness of the formation increases from a few feet in the south to 120 feet at the State Mine, to more than 300 feet 2½ miles farther to the north, and to a maximum of possibly 800 feet in the conglomerates in the north-east of the Mount Mulligan area.

The conglomerates are massive, chaotic, and show few bedding structures. Pebbles are well-rounded, and more than about 70 per cent is rhyolite, with minor amounts of chert, quartz, and some slate of the Hodgkinson Formation. Owing to the great amount of rhyolite pebbles in the conglomerate, seen from a distance, it is yellowish to greenish, in strong contrast to the more vivid red of the overlying Triassic (?) conglomerate and sandstone.

Coal seams are associated with thin, bedded and laminated grey siltstone and shale and fine sandstone, which swell and pinch irregularly, and display fine bedding structures. The three main coal horizons are composite coal-shale beds 12 to 25 feet thick.

Plant fossils collected in 1960 from the coal and shale interbeds were identified by Mary White (1961) as: Glossopteris indica Sch. and G.angustifolia Brong., and the age given as Permian or Lower Triassic. Dr. Evans (pers. comm.) found Upper Permian micro-flora in these samples. The Mount Mulligan Coal Measures are therefore probably penecontemporaneous with the Nychum Volcanics.

Between Mount Mulligan and the main outcrops of Nychum Volcanics in the west of the Sheet area, an area of about 400 square miles is occupied by the Featherbed Volcanics, which is composed mostly of massive ignimbrite and acid crystal tuffs with some volcanic breccias and a few rare lavas (Morgan, 1961). No basic extrusives were observed.

In outcrop and hand-specimen, the Featherbed Volcanics closely resemble the Nychum Volcanics. Differences in the field are the paucity of basic lavas in the Featherbed Volcanics, their massive texture as compared with the well bedded Nychum Volcanics, and above all their geological occurrence within an area formed by cauldron subsidence, bounded on all sides by large faults. Their total thickness of more than 2000 feet also greatly exceeds that of the Nychum Volcanics. In places, however, it is not easy to assign outcrops to either the Featherbed or the Nychum Volcanics, and in such places the geological setting is the guiding factor.

There is evidence that the Featherbed Volcanics are younger than the Nychum Volcanics, and they are considered to be older than the Triassic (?) Pepperpot Sandstone of Mount Mulligan for reasons to be discussed later. Their age is thus possibly Lower Triassic.

Intrusive Rocks

The Palaeozoic formations described in the previous sections are intruded by three different granites and many acid and basic dykes (Morgan, 1961).

The Mareeba Granite is the oldest of the three granites, and intrudes the Hodgkinson Formation and Barron River Metamorphics in the central and eastern parts of the Mossman Sheet area. It is a commonly strongly porphyritic, grey, medium- to coarse-grained, two-mica granite in which microcline is common and forms the large phenocrysts, and in which biotite is generally more abundant than muscovite. Some isolated outcrops of diorite are tentatively regarded as related to the Mareeba Granite.

The granite forms the Tablelands of Windsor, Mount Carbine, Hann, and other geographical masses. Its texture is generally xenomorphic and inequigranular, and appears to be protoclastic. Patches of greisen, tourmaline-bearing varieties, pegmatite and aplite veins, porphyritic and granitic dykes are common in and around the intrusives, and are probably the main source of the alluvial tin worked in these areas.

An aureole of thermal metamorphism surrounds the intrusive bodies and has converted the sediments to 'spotted' schists, biotite-quartz hornfels, and andalusite schist. West of Mossman feldspar porphyroblasts similar to those in the granite occur in hornfels near the contact, and indicate a metasomatic origin for the feldspar. Also this may suggest that potassium-metasomatism formed microcline within the granite.

The Mareeba Granite was intruded after the main phase of shearing and cleavage, but some tight folding of the cleavage and 'plastic' folding in places suggest continuation of movements during, and probably caused by, the emplacement of the granite.

The <u>Cannibal Creek Granite</u> is medium- to coarse-grained, slightly foliated, and sparsely porphyritic. The mineralogical composition is similar to that of the Mareeba Granite: quartz, microcline, biotite, muscovite. The granite belongs to the Mareeba group of granites.

Thornton Peak, north of the Daintree River, consists of a pink-yellow granite poor in mafics, in which the feldspar is mainly perthitic alkali feldspar, and granophyric structures are very common.

The emplacement of these granites was probably in the Lower Carboniferous during the final stages of orogeny. Evidence for this late-orogenic emplacement is found in the local foliation, the protoclastic texture, the presence of microcline (Morgan, 1961), and some of the contact phenomena.

In the south-western sector of the Sheet area, outcrops of two post-orogenic, high-level granites occur: the <u>Almaden Granodiorite</u>, which is probably genetically associated with the Nychum Volcanics; and the <u>Elizabeth Creek Granite</u>, genetically associated with the Featherbed Volcanics. Both are different from the late-orogenic Mareeba Granite: their potassium feldspar, for instance, is orthoclase instead of microcline, their thermal metamorphism of the surrounding sediments is only slight, and pneumatolytic effects are less intense.

The Almaden Granodiorite is a grey, often porphyritic hornblende-biotite granodiorite outcropping with the Nychum Volcanics north of the Walsh River. According to Branch (pers. comm.) it is probably a more basic phase of the Herbert River Granite (White, 1961), which is here contaminated by the assimilation of the limestones of the Chillagoe Formation. Quartz, orthoclase, calcic plagioclase, biotite, and hornblende are the rock-forming components. The granite is probably genetically related to the Nychum Volcanics, which it appears to intrude in a locality at Nolan's Creek (Morgan, 1961).

The Elizabeth Creek Granite is a leucocratic, mafic-poor, porphyritic pink granite, and is exposed north-east of the Night-flower Mine, along the northern boundary of the Featherbed Range. Its bouldery outcrops are generally more rugged than those of the Almaden Granodiorite which tend to be smoother, lower, and more rounded. The Elizabeth Creek Granite is comagmatic with the Featherbed Volcanics, which it intrudes in places (Branch, pers. comm.).

Other intrusive rocks in the Mossman Sheet area include acid to intermediate dykes (particularly in the Maytown area), and doleritic or dioritic dykes. A large composite dyke south-west of Mount Mulligan is nearly a mile wide, and passes into a fault into the adjoining Atherton Sheet area. Its northern part consists of mottled fine-grained hornblende granodiorite with some biotite; the southern portion is a fine-grained 'rhyolite'. Inclusions of leucocratic granophyric aplites and granites are exposed in both parts, and may be derived from a granite older than the Herbert River Granite as seen by Branch (pers. comm.) in the Herbert River Gorge area. The dyke's relationship to the Featherbed and Nychum Volcanics is not known, but it is thought that the dyke may be genetically related to the Nychum Volcanics.

Mesozoic

The Pepperpot Sandstone, which forms the high cliffs of Mount Mulligan and overlies the Mount Mulligan Coal Measures, is a formation (name not yet approved by the Queensland Stratigraphic Nomenclature Committee) composed of current-bedded, massive, red, micaceous and arkosic sandstone and conglomerate near the base, grading upwards into more flaggy, white, argillaceous sandstone and siltstone. According to Ball (1917) red tuff-shales are intercalated in this section. The conglomerate contains well-rounded pebbles of quartz and chert, with some quartzite and quartz greywacke; volcanic pebbles, if they occur, are very rare. Bedding and cross-bedding structures are well-developed, in contrast with the more chaotic structure of the underlying Permian conglomerate. Lenses of conglomerate and grits filling wash-outs, the coarse torrential-type current-bedding, and the plant fossils suggest mainly a terrestrial deposition, probably in a subsiding rift-valley.

The Pepperpot Sandstone overlies the Mount Mulligan Coal Measures with ... 'a slight unconformity' (Ball, 1917), ... 'conformably' (Morton, 1945), with a ... 'marked angular unconformity' (Dixon, 1957). The beds appear conformable, but as they wedge out south of King Cole colliery, Ball is probably right. A total thickness of 1000 feet was estimated by Dixon (1957) and was also measured by us on aerial photos.

The relationship of the Pepperpot Sandstone to the adjoining Featherbed Volcanics is not known. Most probably the sandstone is younger than the volcanics, and the absence of volcanic pebbles is explained by the fact that the source of sediments lay to the south-east and thus away from volcanic regions, as is indicated by the direction of the current-bedding. Another argument for the younger volcanic age is the absence of dykes through the sandstone.

Plant fossils were not found during the 1960 survey, but Ball (1917) recorded impressions of Taeniopteris, Odontopteris, Phyllotheca, and Ginko, and decided upon a Triassic age for the formation. Dixon (1957) was impressed by its resemblance to the 'Blythesdale' (=Wrotham Park) Sandstone in the west, and regarded the formation as Cretaceous. Whitehouse (1952) was of the same opinion. However, Triassic arenaceous deposits with red tuff-shales are being found in more and more places near the base of the Artesian Basin, Bowen Basin, etc. (Dr. Evans, pers. comm.), and there is an increasing possibility that the Pepperpot Sandstone, too, may be Triassic.

The Laura Sandstone occupies large areas of the Cooktown Sheet area immediately north of the Palmer River, but is in the Mossman Sheet area only represented by three or four very small outliers. North of Palmerville its most common sediment type seems to be a white, friable quartz sandstone with associated conglomerate at the base. The formation, originally called the Dalrymple Sandstone by Tenison-Woods, was re-named by Dunstan (1913b) and Jensen (A.G.G.S.N.A., 1940a). Whitehouse (1952) regarded the formation as Cretaceous and rejected the commonly held opinion of a Jurassic age, which, according to him, was based on chemical analyses of coal, and therefore not sufficiently substantiated. However, fossils found in the Cooktown Sheet area appear to indicate a Jurassic age.

The Wrotham Park Sandstone (named by Laing and Power, 1959) transgresses the folded Precambrian and Palaeozoic formations as a blanket of sandstone and conglomerate in the south-western portion of the Mossman Sheet area. The ratio of conglomerate to sandstone increases eastwards in the direction of the old shore-line. A fine glauconitic sandstone of uneven texture forms the top horizon in many places. Current-bedding generally indicates a direction of transport from the east. The formation shows a low regional dip of less than 5^{o} to the west.

Fossils are scarce. Terebratulid brachiopods were found by Morgan at the top of a small mesa 3 miles south-east of the road-crossing over Nolan Creek, and from the same locality Maccoyella barklyi (Moore) was later identified by Woods (1960). Rare impressions of indeterminable plant stems and some fossil wood were noticed in other outcrops. Woods (1960) extrapolated a basal Cretaceous age (Neocomian) for the formation, since it underlies the Blackdown Formation, which he regards as Aptian. It is possible, however, that the Blackdown Formation is Albian, and the Wrotham Park Sandstone may therefore be Aptian.

The pre-Mesozoic surface was undulating, with relief differences of up to a few hundred feet. The thickness of the formation is therefore variable, and is a maximum of about 400 feet within the boundaries of the area mapped. The base was probably dominantly a fresh-water deposit, transgressed by a littoral-marine facies.

Conformably overlying the Wrotham Park Sandstone are the shale, siltstone, sandy shale, and marl of the Blackdown Formation, which crops out along the road between Wrotham Park and Mount Mulgrave. The formation is about 100 feet thick within the limits of the Mossman Sheet area, and it thickens to the west. Calcareous concretions, found in both shales and sandstone members, are possibly syngenetic (Woods, 1960). Mr. Woods, of the Queensland Geological Survey, during a visit to the 1960 field party collected a rich fauna of pelecypods and ammonites from several localities (Fig. 3). The most common fossils as identified by Woods (1960) are: Panope rugosa Moore, Mytilus palmerensis Etheridge fil, Gari elliptica Whitehouse, and Maccoyella barklyi (Moore), 'Mactra' trigonalis Moore, Australiceras aff. jacki (Etheridge fil), and species of Pinna, Tatella, Dentalium, Malletia, Turritella. Common in localities just outside the Sheet area are furthermore Toxoceratoides taylori, Australiceras irregulare Sanmartinoceras olene, and others. According to Woods the ammonites suggest an Aptian age, and the formation can be correlated with at least part of the Roma Formation.

Dr. Irene Crespin examined arenaceous and calcareous foraminifera and some radiolaria and ostracoda from a sample taken from Elizabeth Creek, 3.3 miles from the Walsh River

Telegraphic Office on the road to Wrotham Park, and at first assigned an Aptian age to the assemblages (Crespin, 1956). Dr. Crespin, however, now considers them to be Albian (pers. comm.). Possibly the sample locality does not belong to the Blackdown Formation proper, but to a slightly younger stage: Woods, too, mentions the presence of Albian sediments west of the Mossman Sheet area.

Cainozoic

Cainozoic deposits, though widespread in the adjoining Atherton Sheet area, are preserved as a few scattered remnants on the western and northern fringes of the Mossman Sheet area, and as alluvial flats in the Mount Carbine - Mareeba Plain and the coastal plains.

Residual patches of possibly Middle or Lower Tertiary gravel and billy occur along the road between Wrotham Park and Mount Mulgrave. The largest outcrop is a 180-foot hill just east of the road: a thick mantle of billy-breccia here is underlain by well-rounded quartz gravels with a sandy matrix. The thick gravels forming the high banks of Elizabeth Creek and the Mitchell River may also be Tertiary.

Cainozoic olivine basalt is exposed as a few flow remnants on the northern edge of the Sheet area, mainly east of the Mulligan Highway. The flows lie as irregular horizontal caps on deeply incised sediments of the Hodgkinson Formation, thus forming a good example of inverted topography. The age is not precisely known at present, but it is not older than Pliocene, and is probably younger, on account of the state of preservation of several volcanic vents in the adjoining Cooktown area to the north.

Basalt is also present 15 to 60 feet below the surface of the alluvium cover around Mareeba, as revealed by bores, but it is not exposed in outcrop. It forms here the most northern end of the Atherton Basalt Province. A thickness of 40 feet was traversed by a bore near the bacon factory just north of Mareeba.

The youngest deposits are the alluvial sands and gravels in the Mount Carbine-Mareeba and coastal plains. They are up to 75 feet thick in places between Mount Molloy and Mount Carbine. Parts of the coastal plains are occupied by salt-water marshes, and a belt of old beach sands extends from near Mossman to the mouth of the Daintree River.

STRUCTURE

The structural history of the folded Palaeozoic formations has been described by Amos (1961), and the following summary is mainly taken from his report.

The structure of the geosynclinal Palaeozoic formations is dominated by steeply dipping beds and steeply plunging folds of varying magnitudes. The regional strike is north-north-west, and most of the beds dip more than 60°.

The earliest formed folds - termed First Folds - were tight, with steep limbs and sub-horizontal axes trending north-north-west, thus establishing the regional strike. Later folds - termed Second Folds - formed under a different stress system, were mostly broad with predominantly steep plunges, which were determined by the intersection of their axial planes and the steeply dipping limbs of the first generation of folds. The direction of plunge is variable.

A third phase of deformation resulted in the formation of slaty cleavage throughout the area, accompanied by some cleavage folding (as termed by de Sitter). This cleavage cuts incongruently across folds of earlier deformation periods. The intensity of deformation varied according to metamorphic conditions: in the east of the Sheet area the deformation was plastic in places, and cleavage formed uniformly in all the rocks; in the west of the area deformation was more brittle, and was largely confined to the less competent sediments, locally forming so-called 'shear-zones' along which beds were not greatly displaced.

Faulting was very intense, and included strike-faulting and wrench-faulting. Most of the major faults are strike-faults, and are later than the last cleavage. Wrench-faults of uncertain age are well-developed in the north-western part of the Sheet area. The main fault system trends north-west or west-north-west, and it is generally sinistral; a less developed system trends north-east and is dextral.

Tectonically, the First Folds were the result of a horizontal compression normal to the margin of the Hodgkinson Basin. During the second stage a lateral movement of sedimentary material predominated from farther south - where the sediments had been strongly compressed between the eastwards protruding Precambrian basement and a relatively rigid eastern block - to the north-west into an area of less stress, thus forming the steeply plunging cross-folds. Vertical movements at this stage were restricted, probably by the load of the overlying folded sediment pile. Renewed lateral compression was not transmitted into folds because the sediments were already strongly folded, and as a result a widespread slaty cleavage was superimposed on the previous folds.

It may be asked what was the 'rigid eastern block' which provided the necessary compressional stress-field, and where might this eastern basement(?) be found at present? Experiments particularly in Russia during recent years seem to show that a great variety of defor.ation types, including the lateral squeezing that formed the cross-folds in our area, can be produced by essentially vertical movements. Applying this idea to the Mossman Sheet area, we may expect to find early orogenic vertical uplift in the east as a result of granitization processes followed by intrusive updoming. The Precambrian basement provided a western rigid block, probably up-faulted. Strongest squeezing then should have taken place where the two rigid regions approach each other most closely, as in the Hodgkinson district.

In the periods following the deformations described above - which constitute the Lower Carboniferous orogeny - folding was no longer significant, but faulting remained important. The Permian sediments and volcanics show some broad, shallow folding, which, however, may have been a drag-effect caused by faults. Faulting was predominant and ultimately resulted in the cauldron subsidence of an area accompanied by the outpour of the Featherbed Volcanics.

Vertical movements have continued up to the present time, and many old faults were rejuvenated: there is proof, for example, that the old Palmerville Fault (extending from Princess Charlotte Bay in the north to Almaden in the south) was active again in late-Tertiary or even younger times. Its original vertical movement - west block up - was reversed into east block up. Other faults, in the Hodgkinson district for instance, have also known recent re-activity, as it is suggested by the very different morphology on either side of the fault planes.

The recent faulting has been the controlling factor in the sculpturing of the present-day landscape.

NOTES ON THE GEOMORPHOLOGY

The present-day topography and drainage have already been described in the chapter on Physiography (p. 5); they have been formed by the erosion of recently uplifted Tertiary denudation surfaces. Remnants of a post-Permian denudation surface are being exhumed in the south-west of the Sheet area, where they had been protected by the Mesozoic cover.

Remnants of Tertiary erosion surfaces are represented by the Mulgrave Plains and the Mount Carbine-Mareeba Plains, and are also indicated by 'gipfelfluhrs' (accordant crests) in the Hodgkinson - Palmer Uplands. The flat surfaces of the tablelands probably represent an older, possibly Cretaceous, erosion surface.

Originally the Tertiary denudation surface covered the whole of the Mossman Sheet area. Then faulting and upwarping raised a central block bounded on the west by the Palmerville Fault, on the east by the coastal plains. The drainage system was re-incised in this central block: incised meander loops still suggest the original maturity or old age of the streams. Maturity has been preserved in the south-eastern part of the block (Mount Carbine-Mareeba Plains) as it lay upstream of the axis of culmination.

The 'Great Divide', which was formed by this uplift, moved slowly westwards owing to the very rapid erosion by the youthful coastal streams, and several streams were captured. A well-known example of cover capture is the Barron River, the upper reaches of which originally were part of the Mitchell River system. The river was not captured at the sharp bend north of Biboohra, as one might expect, but farther to the east, and the Clohesy River must therefore also be regarded as a former tributary of the Mitchell River. Another probable capture occurred at the Daintree River. Rivers were also captured between the Mitchell River and Palmer River systems: the branches of the Mitchell River erode stronger headward than those of the Palmer River; one fine example of headward erosion is the capture of a tributary of Sandy Creek by Fine Gold Creek.

The gradual removal of the Mesozoic and Cainozoic cover from the Hodgkinson area superimposed the drainage system upon the underlying Palaeozoic formations. This is most strikingly visible in the Featherbed Range, where the Walsh River has cut a gorge through the resistant volcanics. The streams later adapted themselves to the joint pattern of the volcanics.

GEOLOGICAL HISTORY

Figure 2 shows the major events of the geological history, which consists of:

Stage 1 - Precambrian. Orogeny and metamorphism of Precambrian sediments to form the Dargalong Metamorphics.

Stage 2 - Upper Silurian - Upper Devonian. Substage a): Upper Silurian to Lower Devonian. Subsidence of the Precambrian Shield; development of the Tasman Geosyncline in the Sheet area by a transgression of a shallow sea, and deposition in a shelf zone of Chillagoe and Mount Garnet Formations, which may be represented by pelagic sediments deposited farther to the east.

Substage b): Middle Devonian-Upper Devonian. Accelaration of subsidence to form the Hodgkinson Basin which was filled with turbidites.

Stage 3 - Lower Carboniferous. Orogeny. Folding and faulting, then regional uplift and erosion. Intrusion of the Mareeba and Cannibal Creek Granites at the end of the orogeny. Formation of the Palmerville Fault ?

Stage 4 - Upper Permian. Deposition of coals of Nychum Volcanics and Mount Mulligan Coal Measures and extrusion of Nychum Volcanics on surface of low relief. At Mount Mulligan a rift-valley began to form. Intrusion of Almaden Granodiorite.

Stage 5 - (Upper Permian?-) Lower Triassic. Cauldron subsidence, and outpour of Featherbed Volcanics accompanied by intrusion of Elizabeth Creek Granite. Triassic (?) fill-in of Mount Mulligan rift-valley, with bulk of the sediments from the south-east. Acid dykes.

Stage 6 - Lower Cretaceous. Regional transgression from the west and north. Deposition of littoral and terrestrial Wrotham Park Sandstone, and later deposition of marine Blackdown Formation.

Stage 7 - Cainozoic. Erosion of Mesozoic, deposition of Tertiary gravels, and extrusion of olivine basalt. Recent vertical movement of Tertiary denudation surfaces. Central upwarping and block-faulting, superimposition of originally consequent drainage.

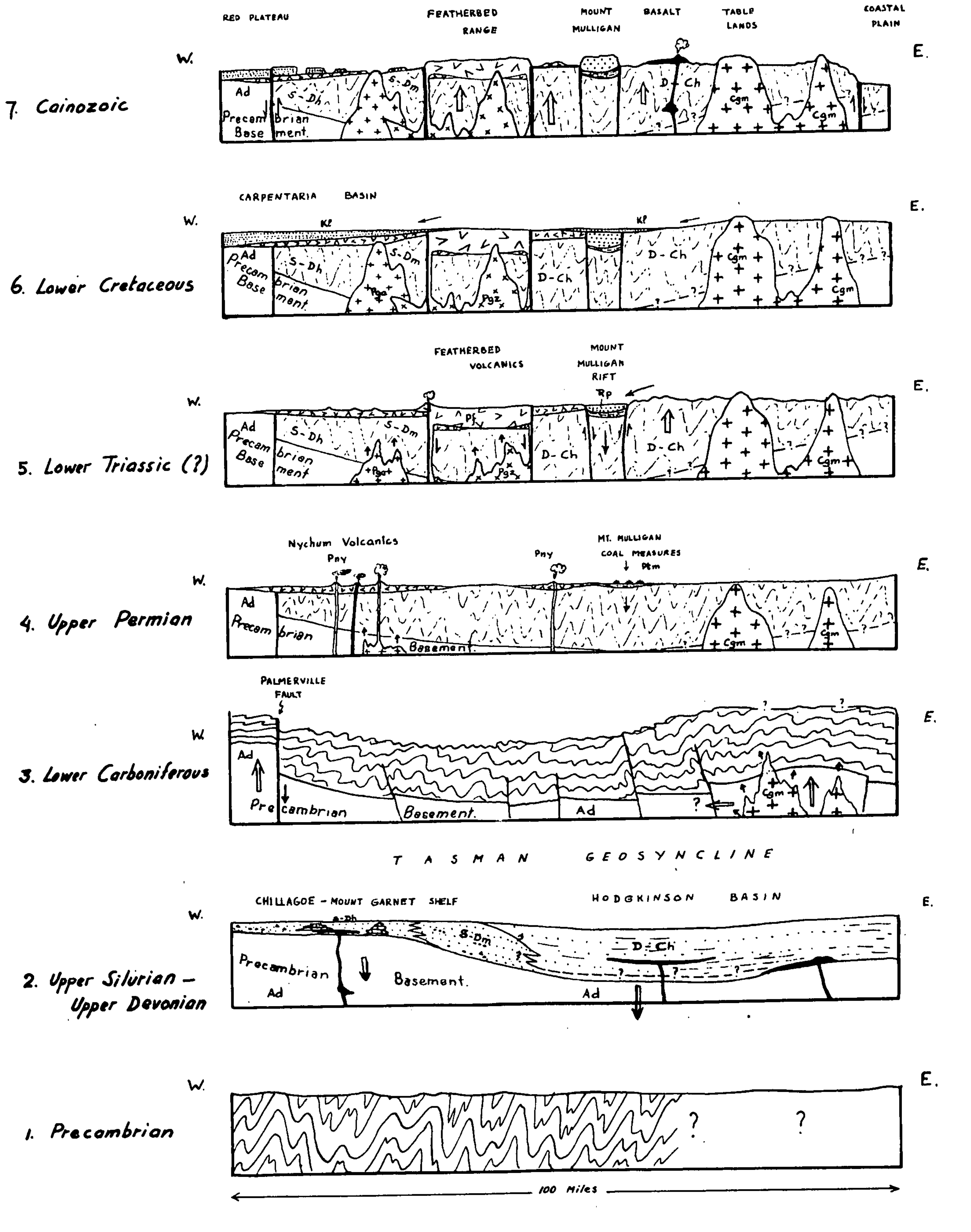

FIGURE 2 - GEOLOGICAL HISTORY, MOSSMAN 1:250,000 SHEET AREA

⇑ Regional movements

↓ Local movements

Basic volcanics

ECONOMIC GEOLOGY

Historical Introduction

In 1872 the Queensland Government sponsored an expedition led by William Hann to find gold in North Queensland, and Hann succeeded by discovering gold but in unpayable quantities. The few specks that Frederick Warner, a member of the expedition, obtained over a distance of 45 miles along the Palmer River, were enough, however, for Mulligan to organize an expedition the next year. His party found rich gold near what became the township of Maytown. The first parcel of 102 oz. was taken to Georgetown; later a further 5058 oz. were brought to Cardwell, and a gold rush quickly followed. The Palmer has been the most prolific alluvial goldfield in Queensland, and ranks fourth in the production list of Queensland Goldfields, with a total production estimated at 1,334,500 oz. of fine gold, of which more than 90% came from alluvial sources. The peak of 250,000 oz. was reached in 1875, and some 26,000 people were then living in the area, thirty percent of whom were Chinese. The yield fell sharply during the next few years, apart from a temporary increase in 1888-1889, when the Maytown reefs were in full development. Later attempts at dredging, sluicing, and mining produced negligible results only and were soon abandoned and only a few ounces per year were being produced up to World War II.

Encouraged by his Palmer success, Mulligan set out on five more expeditions, during which he reported gold and tin in streams, including the Hodgkinson River. Payable gold, however, was not found in this area until 1876, during his last journey, and soon the Hodgkinson district was the target for thousands of prospectors. Estimates of the total production vary considerably - the highest figure given is some 300,000 ounces of gold up to 1951. The peak year was 1878 with a yield of about 44,000 ounces. After that production declined rapidly to 655 ounces in 1891, when most of the mines were closed. Since then a fairly constant annual production of between 2000 and 5000 ounces was maintained until the advent of World War II, when production virtually stopped. Some scattered work is being done from time to time by small parties.

The attention given to the region after the initial gold finds led to the discovery of other minerals besides gold. Antimony was found to be associated with gold in the Hodgkinson district. Tin had already been reported by Mulligan, and when the gold deposits were becoming depleted the prospectors turned to the less rewarding tin deposits. Most of the tin has been won from small patches of alluvium in the Palmer area and on and around the granitic tablelands of Mount Spurgeon, Mount Windsor, etc. The fairly large Mareeba-Mount Carbine alluvial flats, which seem to be the most obvious place where substantial alluvial tin deposits may be concealed, have been partly tested by drilling carried out by private companies in the post-war years. A few small lodes are known as well, for example at Cannibal Creek, China Camp, and Mount Holmes, but these deposits are small in comparison with the rich tin deposits in the adjoining Atherton Sheet area.

Wolfram was probably the first metal found at Mount Carbine in 1895, but was then mistaken for manganese ("Manganese Creek"). The locality has been the best producer in the Mossman Sheet area, although with its total of 2,800 tons of concentrates it cannot be called a big mine. It still has production potentiality, should the price of wolfram improve again. Mount Perseverance, discovered in 1917, is a smaller wolfram field, and there are many other insignificant prospects scattered over the eastern part of the Sheet area.

Copper was discovered in 1883 at the Mount Molloy deposit, and in 1904 the O.K. Mine in the western part of the area began production. The combined output of these two mines was probably less than 10,000 tons of copper. A number of small prospects elsewhere in the area have yielded only token amounts of copper.

Silver-lead was discovered in 1923 from the Nightflower Mine, ten miles east of Nychum homestead; this mine is the only known silver-lead mine in the area.

Manganese occurs in many low-grade pockets and lodes in the eastern part of the area, but it cannot be worked economically.

Coal, found at the base of Mount Mulligan in 1907, was first produced in 1914, and up to 1957, when the mine closed due to the advent of hydro-electric power from the Tully scheme nearly 1,000,000 tons had been won.

Limestone was quarried from the Chillagoe Formation west of the O.K. mine, and from an outcrop east of Southedge railway siding for use as flux and from Mowbray for fertiliser for the sugar cane industry.

Cobalt and bismuth (Nolan's Creek), cinnabar (O.K.-Mitchell River area), and tantalite (branch of the Mossman River) are of mineralogical interest only.

There is little mining activity in the Mossman Sheet area at present except for sporadic development work carried out by small groups of men in the Mount Perseverance area and at the Southern Cross mine in the Hodgkinson district. A few bags of tin were obtained by hydraulic sluicing at Mount Spurgeon in 1960.

The known data for each of the minerals won in the Mossman Sheet area are summarized in the following pages. The location of the mines and mineral occurrences is given on Figure 3.

Gold

The two gold producing areas were the Palmer River Goldfield (including the Limestone district) and the Hodgkinson Goldfield. Gold has also been reported from a large number of creeks and lodes elsewhere, but not in economical grade or quantities, or with only very small production.

Fig. 3

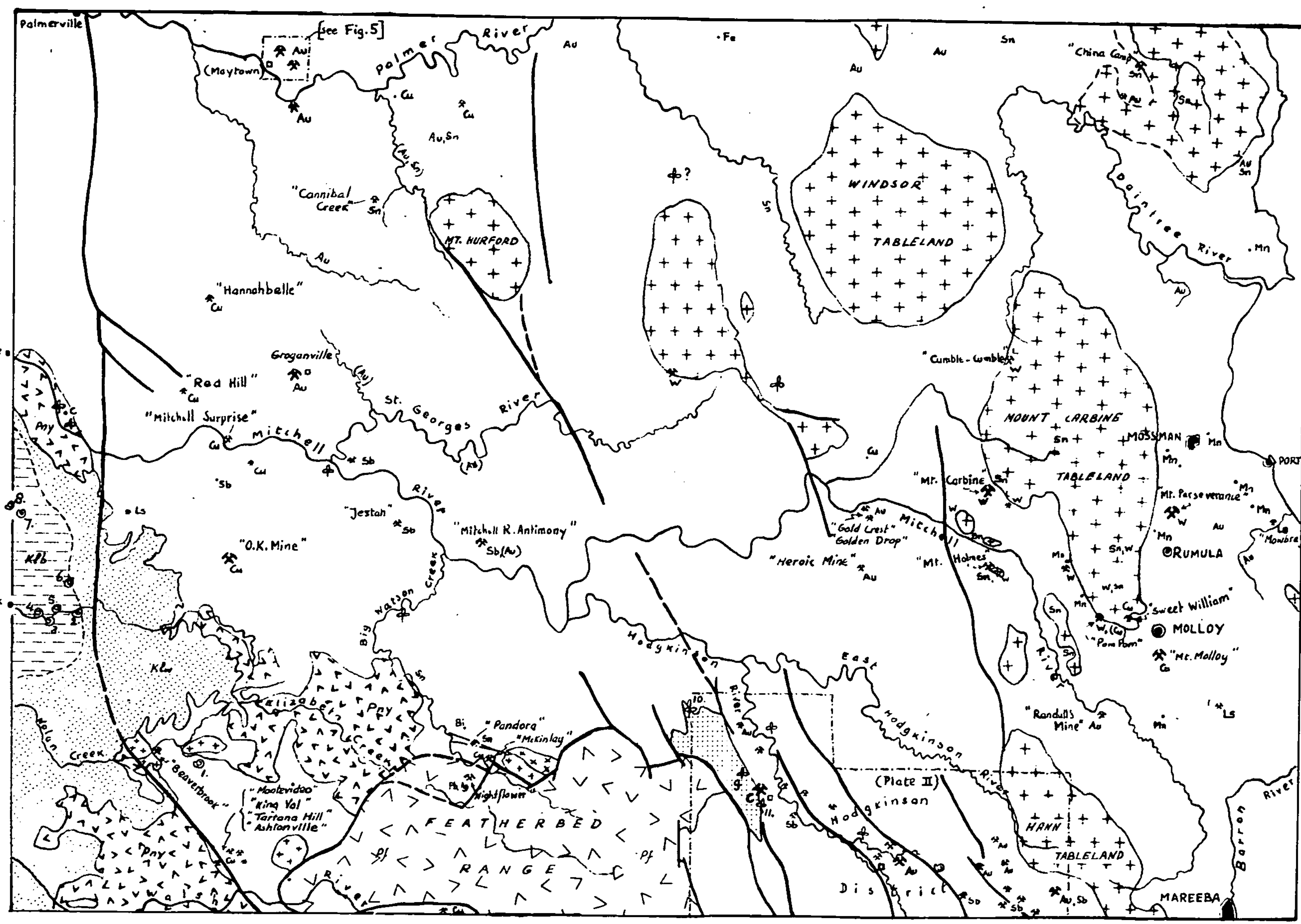

FIGURE 3 — Location of mines and mining districts ; fossil localities ; reported mineral occurrences.

Scale 1 inch to 10 miles.

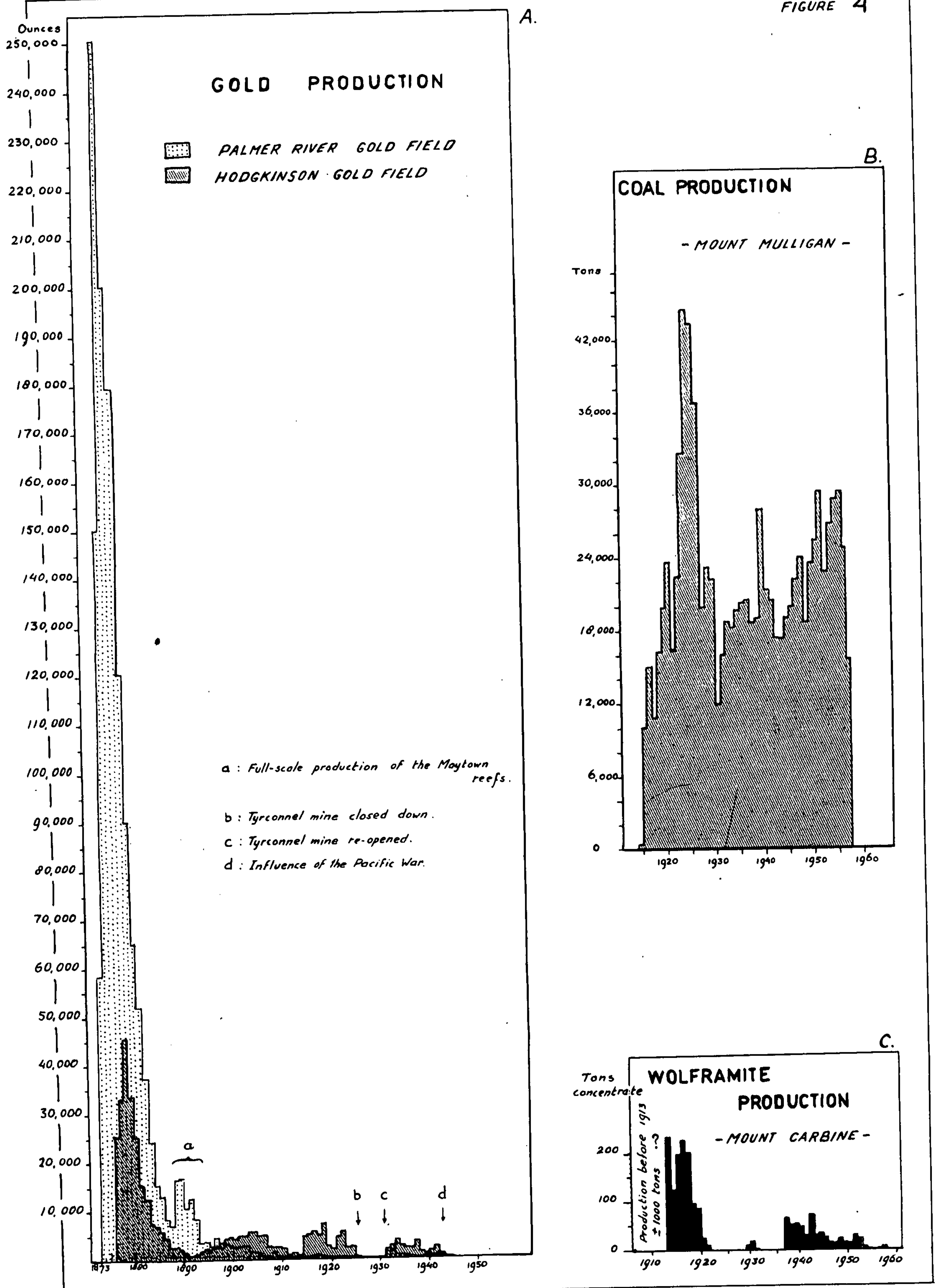
A.
GOLD PRODUCTION
PALMER RIVER GOLD FIELD
HODGKINSON GOLD FIELD
Ounces
a : Full-scale production of the Maytown reefs.
b : Tyrconnel mine closed down.
c : Tyrconnel mine re-opened.
d : Influence of the Pacific War.
B.
COAL PRODUCTION
- MOUNT MULLIGAN -
Tons
C.
WOLFRAMITE PRODUCTION
- MOUNT CARBINE -
Tons concentrate
Production before 1913 ± 1000 tons ?

FIGURE 4

Palmer River Goldfield - (Jack 1888, 1896, 1897, 1899; Jackson 1913; A.G.G.S.N.A. 1940).

More than ninety percent of the production was from alluvial sources along the river and its branches, mainly between Fish Creek junction (5 miles east of Palmerville) and Byerstown, although gold was worked over a total distance of 120 miles from Strathleven to Campbell Creek (about 35 miles upstream from Maytown). The total yield was undoubtedly higher than the estimated 1,334,500 ounces, because of the large number of Chinese miners who worked on the field and the then common practice of evading the official channels for the sale of gold.

The alluvial production soared to a peak of more than 250,000 ounces in 1875 (Figure 4A), whereafter the annual yield declined rapidly. In 1926 the "Palmer River Gold-dredging Company" was formed to work the Strathleven, Glenroy, and Bonanza areas downstream from Palmerville (and outside the Mossman Sheet area), although the reported values obtained by boring were not very encouraging, being only about 1/1 per cubic yard. Work was halted in 1935 when the recovery grade became very low (about 4d per cubic yard), because of the extreme fine comminution of the gold and the abundance of non-commercial heavy minerals which packed the riffles. Some 3600 ounces of gold were won in four years dredging. Between 1934 and 1938 hydraulic sluicing was tried on a small area 6 miles upstream from Palmerville by the "Commonwealth Preliminary Mining Syndicate", but again operations were unprofitable.

Gold-bearing quartz reefs were soon found, and although their total yield cannot compare with the production from placers, there were many mines and workings concentrated north and east of Maytown and at Limestone Creek, a tributary of the Mitchell River, 23 miles south of Maytown. The biggest and most productive of these mines was the Anglo-Saxon in the Limestone group, which with its total gold yield of 30,892 ounces provided nearly one third of the production of all the Maytown reefs. The Anglo-Saxon was worked to a depth of about 600 feet, had seven levels, and was sunk on a north-east trending fissure-vein which ranged up to 6 feet in width. The ore shoot was 300 to 400 feet long, and the ore was arsenical in the lower levels. The grade averaged 1.64 oz Au per ton, but some very rich patches assayed as high as 78 oz per ton.

The Maytown reefs include several groups: the Ida-Comet, the Louisa, the Queen, and the Alexander groups, and a few smaller groups outside the area mapped. The first ore parcels were crushed in 1876, and about 137,000 oz of fine gold were obtained from 80,000 tons of ore, in which is included the production of the Limestone group. The average grade generally ranged between one and two ounces per ton. Most of the Maytown mines closed after 1893 and were not reopened. An effort to revive the Louisa mine in 1939-1940 was not successful, as the mine made a great deal of water, and pyrite and arsenopyrite in the ore made treatment difficult.

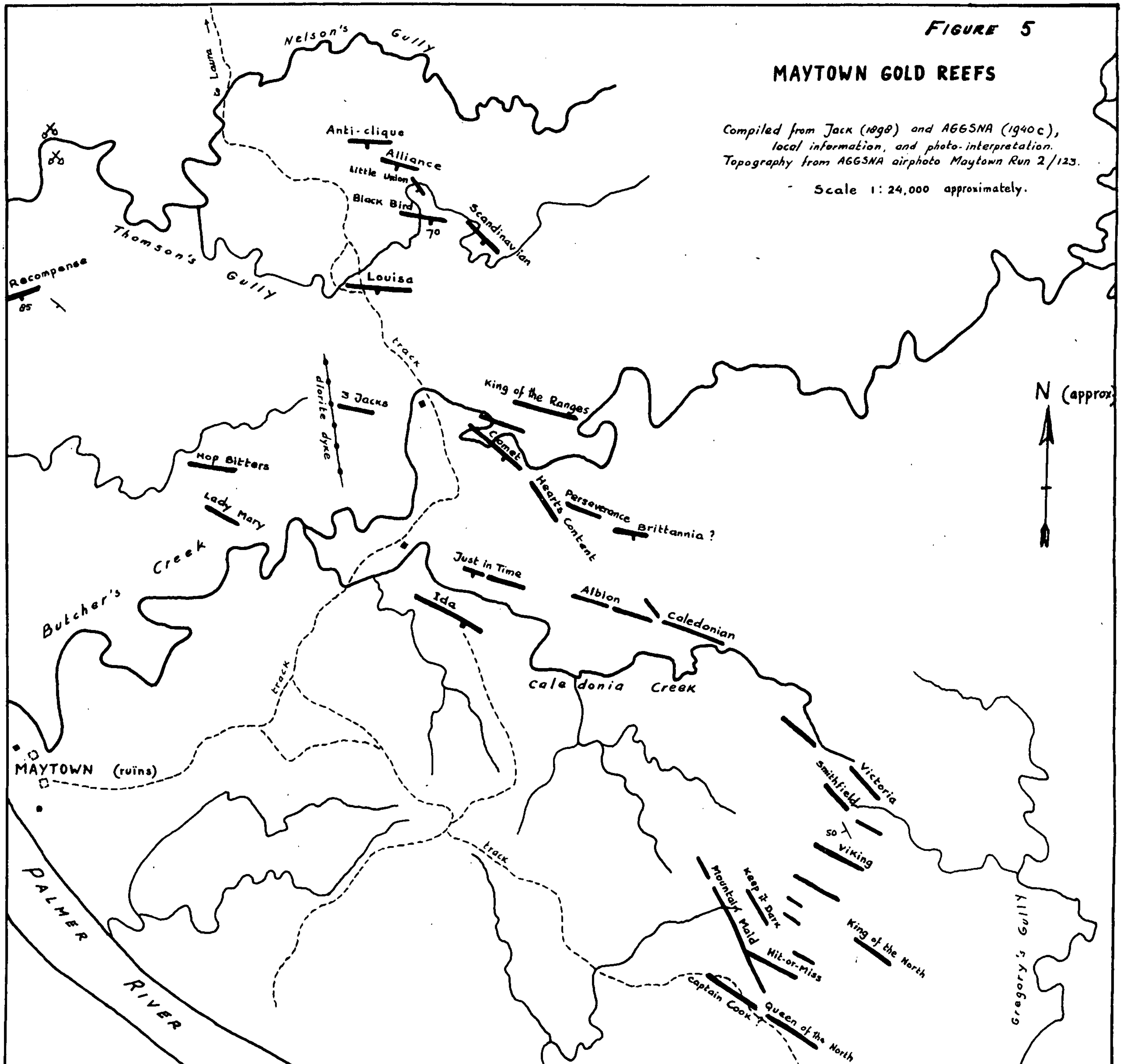

FIGURE 5

MAYTOWN GOLD REEFS

Compiled from Jack (1898) and AGGSNA (1940c), local information, and photo-interpretation. Topography from AGGSNA airphoto Maytown Run 2/123.

Scale 1:24,000 approximately.

Mining operations on the Maytown lodes met with many difficulties. Timber was scarce and its quality was poor; transport was very expensive, and the cost of living extremely high because of the isolation of the area. Jack (1899) quoted prices of £20 for a bag of flour, the price of horse shoe nails was equal to their weight in gold, and freight from Cooktown was £40 per ton. Mining methods were concentrated on richest portions without giving attention to development work. Reefs were small and, very rich on top, but generally with depth the lodes became poor and the abundance of water difficult to cope with. Jackson (1913), contrary to other opinions then current, concluded that most of the payable ore was exhausted and re-opening of closed mines was not warranted, but that, should reopening be considered, more reefs should be mined at once, using modern equipment, electric power, and cheap oil fuel.

The auriferous reefs are thin, small, and lenticular quartz-filled fissure veins within a belt of sheared dark phyllite and greywacke. Thicknesses range from a few inches up to two feet, and commonly average one foot or less. Apart from the reefs mined there are many thin leaders throughout the country that cannot be mined economically. For example, Mt. Bennett is a silicified fault zone with gossanous outcrops, containing gold and some copper.

The quartz contains native gold, with some pyrite, arsenopyrite, and a little stibnite. There is less admixture of base metals in the Palmer River gold reef, generally, than in the lodes on the Hodgkinson Field. The reefs strike north-west or north-north-west and dip steeply to the south-west.

Jack (1888) and others noticed that bends in the reefs are favourable loci for ore enrichment. It also appears that the grade rapidly decreases with depth, particularly in some reefs of the Queen group of lodes, but it is uncertain whether this decrease is due to secondary surface enrichment.

A third, and interesting, mode of occurrence of gold is in the basal conglomerate of the Mesozoic Laura Sandstone, north of the Palmer River and outside the area mapped (A.G.G.S.N.A., 1940d). The conglomerate forms an interrupted layer up to 4 or 5 feet thick and filling old stream courses running north on the pre-Mesozoic surface of erosion. The gold, where present, is concentrated near the bottom of the conglomerate, and is free, water-worn, and of high fineness. No production figures are available, but quite an amount of work was done locally in tunnelling and raising. The deposits were probed in the early days, and tested again in the 1936-1938 period using diesel-engine power, a five-head stamper battery, and other machinery. Test-mining appeared to give the only reliable figures as normal sampling showed only traces of gold. However, the best grades of 2.5 to 5 dwt per ton were not satisfactory, as this alluvial deposit can only be exploited by hard-rock mining methods, the ore volumes are small, the gold content erratic, and many buried leads are ill-defined and branching.

Conclusions - It appears that the alluvial sources and the known reefs are exhausted in the Palmer River Goldfield. It is considered there is little chance of further economic deposits of alluvial gold west of Palmerville, because the comminution of the gold there suggests a great distance from the source area; and because the geological history might have consisted of the following stages.

i) distribution of gold mainly to the north (A.G.G.S.N.A., 1940d) on a mature pre-Mesozoic surface of erosion, and concentration of gold in the basal Mesozoic conglomerates.

ii) upwarping and tilting caused partial erosion of the Mesozoic cover, and a change in the direction of drainage flow to the west. A post-Mesozoic surface of erosion was formed on which some of the gold in the Maytown area was redistributed. The finer gold fractions were deposited west of Palmerville.

iii) renewed movement along the old Palmerville Fault rejuvenated the Maytown block, and formed excellent traps for the redistributed gold in this area, and supplied more gold from the rapidly eroding reefs. Rejuvenation was a major process in the concentration of alluvial gold. During stages of maturity in the geomorphological cycle, gold would probably be redistributed over larger surfaces and thus diluted to low-grade blanket deposits. The metal tends to concentrate in narrow bands in a young topography. On entering the Palmerville plains the stream energy was largely dissipated and the river was therefore not depositing large quantities of gold in that area, nor was it capable of concentrating gold into one new channel from gold previously distributed in several old channels.

Hodgkinson Goldfield (Tenison-Woods 1880; Jack 1884, 1896; A.G.G.S.N.A. 1938, 1939; Morton 1944).

The total yield of the Hodgkinson Field is estimated at about 300,000 oz of gold, of which 12,000 to 40,000 oz were from alluvial mining mostly in the year 1876. Hence the Hodgkinson district, though a smaller gold producing field than the Palmer, was a richer lode-mining area. In 1878, a year after the first gold was won from lodes, there were 492 mines on 330 claims, and twelve crushing plants totalling 121 stampheads were operating. Most claims were relinquished within about a dozen years, and only a handful of mines were intermittently productive until all activities stopped during the war in the Pacific area. The post-war years saw only sporadic interest, and production was insignificant.

Two lodes, the Tyrconnel and the General Grant groups, have jointly produced probably more than 50 percent of the total yield of the field. The average grade was about 17.8 dwt per ton for the General Grant, 21.7 dwt per ton for the Tyrconnel. The Tyrconnel was the largest lode worked in the district, and was in practically continuous production until 1924; the bottom level is at 430 feet where the grade was uneconomic. From 1933 to 1937 attempts were made to extract 14,000 tons of ore remaining, but the grade of 4.17 dwt per ton proved to be below expectation and work was stopped.

The General Grant was worked till 1910 for 23,119 oz of bullion. At 500 feet depth the ore body is 600 feet long, and sampling in 1934-1937 proved about 8000 tons of reserves with a grade of 8 dwt per ton, which was not economic, although a slight improvement of grade is noticeable in the bottom level. The deepest workings were 715 feet below the surface.

Prior to 1905, the Flying Pig Mine was the most important producer and yielded 14,929 oz of bullion, from 8,099 tons of ore.

One of the few persistently producing mines was the Minnie Moxham, later known as the New Minnie Moxham. It was the only mine with some production after World War II and yielded about 450 oz of fine gold between 1947 and 1950.

Jack (1884) noted two main groups of lodes in the Hodgkinson district:

lodes parallel to the strike, but cutting across the dip;

lodes (mainly north-south) at right angles across the strike, and dipping to the west.

The lodes, particularly the first group, must not be confused with the conspicuous chert ridges that form prominent landmarks in the area, and which usually were considered to be siliceous dykes or veins without gold.

In the lodes, the gangue consists of sheared country rock interleaved with quartz stringers, or of quartz veins ranging from a few inches to several feet in width. The best gold values seem to occur in white platy quartz with dark slaty seams, as in the Tyrconnel mine (and as also found in the Maytown lodes). Massive, rubbly or blocky quartz appears to contain relatively little gold.

Ore minerals are: native gold, varying amounts of stibnite, some pyrite, arsenopyrite, and minor quantities of chalcopyrite, sphalerite, and galena. Stibnite is plentiful in some shoots and in these both gold and antimony were mined. Some of these mines changed production from gold to antimony in later years, depending on market conditions. The veins rich in stibnite appear to belong to a younger phase of hydrothermal activity. Galena and sphalerite were very noticeable in the Leviathan mine, and in a few mines such as the Southern Cross and the Tyrconnel, scheelite was found. In the Southern Cross, scheelite was first noticed at 90 ft depth and was from then on a constant constituent of the quartz gangue, particularly in the portions rich in gold. This mine was at times worked for scheelite. Molybdenite is a rare mineral found in the Southern Cross, and barytes occurs in the gangue of the Minnie Moxham mine. Appreciable amounts of tourmaline are present in the Southern Cross lode.

There is little evidence for structural or stratigraphical control of the ore shoots. Jensen (1923) stated that the Tyrconnel shoot is located in a strong bend of the lode; and occasionally a carbonaceous slate is a more favourable host-rock than other kinds of sediments, as observed in the Flying Pig. Here the ore shoot pitches parallel to the lineation formed by the intersection of the lode with certain kaolinized or carbonaceous slates.

In places there is little surface indication of a reef. The best example is the Tyrconnel, where black shale contains thin quartz stringers which widen from a few inches at the surface to several feet at depth.

The literature suggests that the reefs are probably worked out. The lodes are small and broken, the ore shoots commonly deeper than long, and the grade of any ore remaining at depth too low to allow a profitable reopening. The reason why the Hodgkinson Goldfield, with its better lode production, had so little alluvial gold as compared with the Palmer River area may be because the Hodgkinson lodes possibly represent the upper portion of a mineralized vein system, not sufficiently eroded to provide a prolific supply of free gold. The lack of surface indications at the Tyrconnel reef seems to support this. Possibly also the gold was distributed over a large area, because the drainage radiated from the lode area, in contrast to the Palmer district where all streams from the lode outcrops converged into the Palmer River.

Other Gold Occurrences.

There are few deposits outside the Palmer and Hodgkinson Goldfields and these are of no importance.

Randall's Mine, or the "Freedom", is a quartz lode six miles north-east of Southedge station homestead. It was worked between 1939 and 1941, producing about 650 oz of gold and 100 oz of silver, and was then abandoned.

Three small quartz lodes are reported from the Mitchell River area south of Curraghmore station homestead (Reid, 1932). The quartz is iron-stained in places, and contains some free gold, pyrite, and galena. A parcel of $4\frac{3}{4}$ tons of this ore sent to Chillagoe yielded 8.56 oz of fine gold.

Other minor gold veins are reported from the China Camp area (the "Enterprise"); from around Racecourse Mountain between Diggers Creek and the West Normanby River; and at Nolan's Creek (Morton 1939) where some gold is associated with cobalt, bismuth, and arsenopyrite in low-grade pipe-like bodies.

Small quantities of gold have been found in most streams over most of the Sheet area: from the St. Georges River, with its tributaries Fine Gold Creek and Hurrican Creek, to the coastal streams of Noah Creek and Cooper Creek; in Diggers Creek, Barratt Creek, and many of the creeks south of Mossman; and in most of the Palmer River tributaries - Sandy Creek, Granite Creek, Tin Creek, and Doughboy Creek. Some of these were worked, particularly by the Chinese, but generally the deposits were small.

Copper

Copper was mined almost exclusively from two centres: Mount Molloy in the east of the area, and the O.K. Mines in the west. Apart from these there is a scattering of minor, commonly uneconomic prospects, mainly in a north trending belt in the west.

Mount Molloy (Weinberg, 1905; Edwards, 1943).

The lode, discovered in 1883 and situated 4 miles south of Mount Molloy township, is emplaced along a north-north-west trending shear zone. It dips 50° to 70° west and is 6 to 8 feet wide on the average and up to 20 feet in places. Footwall and hangingwall are well-defined slickenside surfaces.

The oxidation zone penetrates to a depth of 90 feet, contains azurite, malachite, and other secondary copper minerals in a gossanous, siliceous or kaolinized gangue, and had an average grade of 10 percent copper.

Between the 93 foot and 142 foot levels there was a 12 foot wide zone with numerous chalcopyrite veins. The grades here increased to 30 percent copper. Below the 142 foot level the ore contains pyrite, chalcopyrite, and some sphalerite, in sheared black phyllitic siltstone and fine quartz greywacke.

The lode has been worked over a length of more than 800 feet, and up to 1905 7,109 tons of ore containing 15.9 percent copper were produced. Much of the earlier output, however, was not officially recorded. The reserves in 1905 were estimated at 42,000 tons of 12 percent ore, or about 5000 tons of copper. Since that year, production has been intermittent, and figures are not known.

<u>The O.K. Mines</u> - (Gibb, 1904; Jack, 1907; Morton, 1938, 1939; Edwards, 1943).

The O.K. group, situated about 7 miles south-east of Belleview station homestead, includes the O.K., North O.K., and South O.K. mines, of which the O.K. is the most important.

The O.K. lode consists of many pipe-like ore bodies enveloped within a north-west striking belt of low-grade kaolinic material. It produced more than 30,000 tons of ore with a yield of 4,500 tons of copper between 1904 and 1911, and it was during that period the chief copper producing mine in the Chillagoe district despite its unfavourable situation in isolated rough country. The mine was abandoned in 1910.

The grade in the pipe-like bodies ranged from 8 percent to 18 percent and was less than 8 percent in the surrounding kaolinic mantle. The ore minerals in the oxidized zone - copper carbonates, cuprite, and some chalcopyrite - were replaced by siliceous chalcopyrite-pyrite mixtures between 15 ft and 80 ft depth. Between the 45 foot and 115 foot levels the ore was enriched, but below the 115 foot level the grade decreased with increasing pyrite content of the primary sulphide zone.

The same conditions were experienced at the smaller North O.K. lode, where a gossanous oxidation cap passed down into an enrichment zone 10 to 20 ft thick, with a copper content of 10-20 percent; the grade decreased with depth and at the 140 foot level, the ore consisted mainly of pyrite and assayed 5 to 6 percent of copper. The mine was originally worked by the O.K. Company between 1908 and 1912, and later in 1937-1938 when 1100 tons of ore averaging 6 percent copper were obtained. Copper reserves of the North O.K. lode are very small; they are estimated as 700 to 800 tons, compared with the 20,000 tons estimated at the O.K. mine.

Small amounts of copper were won from the "Sweet William" a narrow vein three miles north-west of Molloy in and near the contact of granite of the Mount Frazer mass.

Other prospects, with little or no production, are the McKinlay on Big Watson Creek; the Mitchell Surprise, Red Hill, and Hannahbelle workings north of the Mitchell River; Keddy's copper show south of the Palmer River; the Tartana, Montevideo, and King Vol workings at Bowler Creek, north of the Walsh River;

and the Peninsular prospect at Curraghmore Station. Low grade and small reserves combined with isolated position have deterred successful operations, although some efforts were made to open up these shows. The latest attempt was made during 1960, by a small party headed by Mr. Bethel, who used a bulldozer on the Hannahbelle prospect, but failed to discover good grade ore.

Tungsten

The main centres for the production of tungsten in the Mossman Sheet area have been Mount Carbine and Mount Perseverance; small amounts were won from other prospects around the edges of the granite massifs between Mareeba and the Windsor Tableland. Some scheelite came from Mount Carbine, Mount Perseverance, and the Hodgkinson district.

Mount Carbine - (Ball, 1913; Morton, 1945; Ridgeway, 1946; Connah, 1953).

Wolframite was known from the Mount Carbine area before 1895, but the black shoads were thought to be manganese ("Manganese Creek"). Since then exploitation progressed slowly, and gradually Mount Carbine developed into the best wolfram producer in the area, and it is classed among the top three sources of wolframite and scheelite in Queensland. By 1911 a battery had been installed followed by development work in 1918.

The lodes consist of numerous roughly parallel veins which branch and anastomose, and thin out again. They are grouped into a number of overlapping and slightly radiating zones. Similar, but barren veins, also occur in the granite about ½ mile north-east and east of the workings. They are commonly less than 2 feet wide but may in places widen to 6 feet. The ore zone is about 1½ miles long by ¼ mile wide, and trends north-west.

The veins are composed of milky quartz with variable quantities of potash-feldspar, in many places coarsely pegmatitic in form. Muscovite occurs in a few veins, and a micaceous film on the vein walls is common. Tourmaline is distributed as very fine needles throughout the lodes; beryl is a rare constituent.

The ore mineral is high-grade wolframite containing 70 to 73 percent WO_3, 18 percent FeO, and 6 percent MnO. The largest single block found weighed 6 tons. In places, particularly in the eastern workings, it is associated with some scheelite, which does not persist in depth and is perhaps secondary. Scheelite has also been mined from isolated lodes east of the township.

Other metallic minerals in the veins are: pyrite, traces of chalcopyrite and molybdenite, and cassiterite. The cassiterite is in places rich enough to be mined separately, as at the Vera mine north-east of Carbine Hill. Faulting, both pre-ore and post-ore, has cut off and displaced veins up to 2 or 3 feet and in one case 10 feet.

Total production up to the end of 1958, when mining had stopped, was more than 2,800 tons of concentrate (Fig. 4C), 1000 tons of which were obtained before 1912, according to unofficial estimates. The average grade in the 1911 and 1913 period was about 1½ percent wolframite. Main periods of activity were from 1910 to 1920, a short recovery in 1929 to 1930, and from 1937 to 1952. The market price has been the dominant influence on production, and since the average values in the lowest levels, though low, show no marked decline, it is probable that a rise in wolfram price will be followed by renewed mining activity.

Mount Perseverance - (Morton, 1938; Levingstone & Carruthers, 1953).

Precise production figures for the Mount Perseverance workings are unobtainable, but the total was probably about 115 tons of concentrate. As at Mount Carbine, the shoots are quartz-feldspar veins less than 2 feet thick, which commonly branch and rejoin, and have a selvedge of yellow mica several inches thick along their walls. An increase of mica, and also heavy iron staining of the quartz, are considered favourable indications for wolfram. The veins are faulted, and are not arranged in a predictable pattern, probably partly owing to intense soil-creep on the steep slopes against which the workings are nestled.

The ore minerals are wolframite with some scheelite, tungstite or ochre, Pyrite, arsenopyrite, and traces of copper carbonate and chalcopyrite are also found. Cassiterite occurs in places, not necessarily associated with the wolframite.

Neither Morton nor Levingstone were impressed with the wolfram potential of Mount Perseverance because of the patchy distribution of the ore, the smallness of the veins, and the fact that much non-productive work must be done at each revival of mining activities, which are, as for Mount Carbine, dependant upon the market price.

Small pockets and lenses of wolfram ore have been mined from near granite dykes in the Rumula-Julatten area; from a pegmatite and greisen vein at Pom Pom Creek and other gullies at the western margin of the Mount Frazer-Mount Spurgeon granite batholith; and from a quartz-muscovite vein at the Cumble Cumble prospect on Reedy Creek. Scheelite was mined for short periods from the Southern Cross and Tyrconnel mines in the Hodgkinson district.

Tin (Jack, 1888a; Ball, 1912a, 1915; Saint-Smith, 1915; Jensen, 1927; Morton, 1931; Reid 1932a; A.G.G.S.N.A., 1938a).

Tin is another widely distributed mineral in the Mossman Sheet area. The total production has been at least 3,550 tons of concentrate.

Alluvial tin is known from practically all creeks running off the granite tablelands north of Molloy, and has been worked in most of these. The eastern slopes are reported to contain the richer accumulations, which is understandable in view of the greater concentrating energy induced by the very young topography. The better known areas are on and around Mount Spurgeon, Mount Frazer, Mount Lewis, Lighthouse Mountain, Mount Windsor, and Mount Alto. Alluvial tin was also won from many creeks in the western part of the Sheet area, e.g. Cannibal Creek and Granite Creek in the Palmer district: the latter is the most prolific producer with 2,373 tons of concentrate up to the end of 1884.

All these alluvial deposits are small and localized and do not offer much scope for large-scale operations. The large alluvial flats extending from Mareeba to Mount Carbine are a first logical target to be tested with such operations in mind. In 1958 New Consolidated Goldfields (Clark 1959) carried out a programme of test-drilling in the Mount Carbine-Molloy area, where the alluvial sands and gravels are 40 to 60 feet thick and in places over 75 feet thick. The results of this drilling did not encourage further work.

The source of these placer deposits is probably numerous greisenous, pegmatitic, and aplitic dykes, and quartz veins and which are in themselves too low-grade to be worked as mines. There are only very few workable lodes: Cannibal Creek, China Camp, Mount Holmes, the Pandora mine, and the Vera prospect at Mount Carbine are the known examples.

The Cannibal Creek lodes consist of a series of parallel quartz veins within a belt 200 feet wide of the Hodgkinson Formation, trending west-north-west, and cut off in the west by a fault. The quartz is white to nearly black, and is commonly micaceous in the tin-rich portions. The lodes were worked over a distance of more than a mile, the main zone being 800 feet long, 3 to 4 feet wide. The lodes, irregular of shape, contain erratic and patchy concentrations of cassiterite.

The lode at China Camp was discovered in 1908. It consists of weathered greisenized granite, which contains disseminated cassiterite and is traversed by tin-bearing quartz-tourmaline veins and ferruginous leaders. Because of its strong decomposition the granite was soft enough to be worked profitably to an average depth of 80 feet by hydraulic sluicing. The area was favourably recommended by Saint-Smith (1916) because of the extent of the area of greisenized granite, the depth and extent of decomposition, and the satisfactory water supply.

There are many small stanniferous, north-east trending quartz veins, on the crest of Mount Holmes, which are cut by north-north-west trending dykes of intermediate composition. The ore veins are commonly less than one foot thick. Some veins carry wolframite. Production has been negligible.

In the Big Watson Creek area, the Pandora lode is situated on a west-north-west trending shear zone. The main body is probably a pipe on the intersection of this shear and the projected northern extension of the nearby Nightflower line of faulting. 2.45 tons of tin concentrate were obtained from about 20 tons of ore in 1928.

<u>Antimony</u> - (A.G.G.S.N.A. 1940b, 1941d).

Antimony is a common associate of gold in quartz lodes in parts of the Hodgkinson district and along the Mitchell River, and many mines have produced both metals. The main production centres were the Northcote and Woodville areas in the Hodgkinson district, and the Mitchell River Antimony Mine (or Peter Pan).

The first discoveries in the Northcote area were made in 1877 immediately after the discovery of gold. Three lines of north-west trending lodes were developed in this area: the Ethel, the Emily, and the Black Bess. The ratio of gold to antimony was not constant. Intergrowth of quartz and stibnite are probably due to replacement of an older gold-quartz phase by younger antimony-bearing solutions. Up to 1941 approximately 1500 tons had been produced from the Northcote area.

In the Woodville area there are about six groups of lodes. The main mine was the Jackson.

The total output of antimony from the whole of the Hodgkinson district is quoted by Clark (1959a) as 3,104 tons.

The Mitchell River Antimony Mine, also known as Peter Pan, had a treatment plant. It is located on a quartz lode nearly ½ mile long. The grade of ore was low and did not persist in depth. Assays of various samples range between 4 percent and 29 percent antimony (the latter only in an exceptional case), with gold values between 2 dwt and 3 oz per ton.

There are other similar lodes, such as the Jestah and King Pin, and on the north side of the Mitchell River near its junction with St. Georges River. These are small low-grade deposits. In the King Pin mine, stibnite appears to be the latest mineral precipitated after arsenopyrite, pyrite, sphalerite, and chalcopyrite. Cervantite occurs as an alteration product of stibnite in many of the lodes.

Some antimony mineralization is known from as far west as Belleview Homestead, and in the Palmer area.

Lead and Silver - (Saint-Smith, 1923)

The Nightflower Mine, situated at about ten miles east of Nychum Homestead, was discovered in 1923, and is the only known occurrence of lead-silver ore in the Mossman Sheet area. The lode is a north-north-east trending silicified fault zone within Permian volcanics, and contains galena and fine-grained stibnite with some pyrite, chalcopyrite, and rare sphalerite. Secondary minerals are cerussite and pyromorphite. The silver content is reported to be high. The lode is up to 15 feet wide in places, carrying ore-seams up to 3 feet wide. Analyses of good lead ore commonly showed between 30 percent and 40 percent Pb, with between 40 and 50 oz of silver per ton. A specimen of pure galena assayed 78.6 percent Pb and 109.1 oz of silver per ton.

The output in 1923 was estimated at about 20 tons of high-grade ore per week. No production figures are known for about the first three years of mining activity. In 1929 only 32 tons were obtained, and all work probably stopped after 1930, probably because the values became inconsistent and the richest portions had been mined. The average grade of ore actually mined in the first few years was 30 percent Pb with 35 to 40 oz of silver per ton.

Silver was also obtained as a by-product of the gold mines, and Dunstan (1913a) mentioned a yield of 86,271 ounces from the Hodgkinson Goldfield, and 1,059 ounces from the Palmer Goldfield, up to the end of 1912.

Manganese - (A.G.G.S.N.A., 1941e; White & Wyatt, 1957).

Small shows of low-grade manganese are widespread over the eastern part of the Mossman Sheet area, between the Daintree River and Mona Mona mission station south of Black Mountain, and around Molloy.

The best manganese ore was obtained from the Cassowary Range west of Port Douglas: assay figures here range between 17 percent and 51 percent Mn, and 30 tons of ore were mined, but not treated. The ore reserves are too small to allow profitable mining.

A hand-picked sample from the forestry road towards Bayly Creek, north of the Daintree River, collected during the 1960 field season, assayed 46.3 percent Mn, but the average grade of the small pockets noticed here is undoubtedly lower.

The ore minerals cited in the literature are psilomelane and pyrolusite, but laboratory investigations reveal the existence of cryptomelane and gamma-MnO_2. (Casey, 1956).

Other Metals

At Nolan Creek (Morton, 1939a) there are low-grade deposits of gold and silver, some bismuth and cobalt. Bismuthite was also noticed during the 1960 field season in a quartz vein north-west of the Pandora mine.

Cinnabar was reported from the O.K. Mine and from the area between the O.K. and the Mitchell River antimony mines.

Some tantalite has been found amongst the tin wash of Platypus Creek, a branch of the Mossman River, and may also be present in the Dargalong Metamorphics area, according to a local source of information.

Coal - (Ball 1912c, 1917; Morton, 1945b; Shepherd, 1945; Connah, 1953).

Coal was found at the base of Mount Mulligan in 1907, and was mined continuously from 1914 to 1957 when the mine closed down following the completion of the Tully Falls Hydro-electric scheme. Up till then the mine provided fuel for power plants, for the surrounding mining districts. An aggregate of about one million tons of coal was produced from the State Mine, and, (since 1941), from the King Cole Colliery, which was owned by Tableland Tin Dredging N.L.

At the State Mine, four composite coal horizons are interbedded with sand shale sequences. The total thickness of the Permian coal measures increases from zero about 9 chains south of the King Cole colliery, to 120 feet at the State Mine, to more than 300 feet, 2½ miles farther to the north, and to a maximum thickness of possibly over 800 feet in the conglomerates at the north-eastern extremity. Similarly the number of coal seams increases from one (at King Cole mine) to four (State Mine), but farther north the quality deteriorates rapidly.

In the mine workings it appears that the interleaved shale bands within the coal horizons thin out uniformly towards the west, and the coal layers maintain a fairly constant thickness.

Dunstan (1913b) estimated that the coal reserves possibly amounted to 60,000,000 tons, of which 15,000,000 tons were "actual". Ball (1917) gave a figure of 19,500,000 tons. Facies changes to the west and north however caused later estimates to shrink considerably, and the last figure available is 1,175,000 tons for the two main seams of the three seams mined, (Powell Duffryn, 1949).

The coals are classed by De Jersey (1949) as sub-hydrous high-volatile bituminous, with a calorific value between 14,000 and 14,600. The predominant type consists of sub-hydrous durain with some clarain bands. A high ash content of 15 to 17 percent makes the coal unsuitable for coking purposes. An analysis of typical Mount Mulligan coal gave:

Moisture	2.3%
Volatile matter	27.5%
fixed carbon	52.5%
ash	17.7%

In the Mitchell River area south-east of Mount Mulgrave homestead, about 4 feet of highly impure coal are exposed in a gully near Jug Waterhole, in Permian sediments and volcanics of probably the same age as the Mount Mulligan Coal Measures.

Limestone

Limestone, used as flux in the mining industry and as agricultural fertilizer, has been mined from limestone bluffs of the Chillagoe Formation north-west of the O.K. mine; from a bluff 5 miles north-east of Southedge railway siding; and from Mowbray, south of Port Douglas.

The Mowbray deposit (Denmead, 1949) is a lens of coarsely recrystallized white limestone (with bands and laminae of dark impure limestone) with low-grade metamorphic phyllite and greywacke. The quarry has been productive since 1940, and the rate of output in 1949 was less than 1000 tons per year. The estimated reserves amount to 17,500 tons above the quarry floor, with an additional 35,000 tons to 100 feet below the floor. The quarry was idle in 1960.

Control and environment of the Mineralization

The main minerals in the Sheet area - gold, tin, and wolfram - are all associated with the Mareeba and Cannibal Creek Granites and are arranged according to the principle of zoning of ore deposits: the tin generally being found in pneumatolytic to hydrothermal veins well within, or at the contacts, of the granite masses; the wolfram slightly farther out, at the contact, or in the country rock not very far from the granites; and the gold in mesothermal and epithermal veins at distances of several to many miles from known granite outcrops. A few exceptions to this "rule" (Mount Cannibal Creek tin lodes) may perhaps be explained by assuming the presence of granite at shallow depths below the surface. This possibility is illustrated at Mount Holmes where granite has been exposed in Recent times.

The Mareeba and Cannibal Creek Granites are leucocratic alkali granites, in which microcline, perthitic alkali feldspar, and sodic plagioclase predominate over more basic plagioclase, and in which the mafic constituent is biotite, in places accompanied by muscovite. This is in accordance with the findings of Serebryakov (1961)* that tin is normally associated with acid granites with high $\frac{K + Na}{Ca + Mg}$ ratio. A similar high ratio may be present in the Elizabeth Creek Granite, which appears to be the main tin-bearing granite in the adjoining Atherton Sheet. The Pandora Mine, the only known tin lode in the Mossman area which is not associated with the Mareeba granites, is associated with an outcrop of Elizabeth Creek Granite. The Almaden Granodiorite which has a lower K, Na/Ca, Mg ratio, does not appear to be associated with much tin mineralization. The distribution of copper is less easily explained. It commonly occurs within or near the boundaries of the Chillagoe and Mount Garnet Formations, with the exception of the Mount Molloy deposit and two or three small isolated prospects. Association with a granite is not evident, although we can perhaps again assume the presence of granite at not too great a depth below the surface. Four miles north-east of Belleview homestead, for example, a small outcrop of granite was unexpectedly found amidst a vast extent of greywackes and siltstones.

A third point is that most of the deposits are, geographically at least, associated with basic lavas of the same age as the enclosing sediments, as at the O.K. and Mitchell Surprise mines, and at Mungana in the Chillagoe district; the Hannahbelle prospect is also near basic volcanics.

Without discussing other possibilities, it is suggested, in an attempt to combine all these points in one scheme, that copper and iron compounds were first introduced into a shelf or near-shelf environment by basic extrusions during the deposition of the Lower Palaeozoic formations; and that they were then at a later stage concentrated in suitable structural traps by hydrothermal solutions originating from granites, which were stoping their way upwards into the shelf area. The copper at Mount Molloy may have originally been formed in a black shale environment, and later concentrated in a shear zone under the influence of plutonic activity and faulting.

The manganese mineralization in the eastern part of the Mossman Sheet area is commonly associated with chert and basic volcanics, an association well-known from many other geosynclinal areas in the world. The current trend of geological thought is to consider such manganese deposits as syngenetic and introduced, together with silica, from sub-marine lavas, to form manganese precipitates and bedded cherts. In the Mossman area, the manganese has then presumably undergone redistribution and concentration by plutonic activity combined with shearing and some metamorphism. Afterwards it had undergone secondary enrichment and accumulated in small pockets during the present weathering cycle.

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* Serebryakov concluded from a study of certain granites in Russia that "all shows of tin mineralization (in that area) are spatially located in the zone of sodium-potassium metasomatism, independently of the position of this zone with respect to the contacts of the massif". In this zone the later feldspars have replaced the earlier ones with preservation of the crystalline lattice orientation.

PLANS AND SECTIONS

(Held by the Queensland Geological Survey)

At Brisbane:

Mine	Ref. No.	Description	Scale
Mitchell Surprise	1/4	Plan of 170 ft level	1" to 20'
	1/24	Plan and section of workings.	1" to 20'
General Grant	1/50	Assay Plan	
Mount Carbine	1/50	Mining tenements, based on Irvinebank Comp. and Thermo-Electric Comp.'s Records.	1" to 2 ch.
	1/50	Sections prepared by Thermo-Electric Comp.	1" to 25'
Mount Molloy	1/6	Plan and sections of workings, based on 1907 Comp. map, with additions.	1" to 20'
O.K. mine	1/34	Plan of Mineral leases	1" to 8 ch.
		Plans of mine workings, 150 ft level.	1" to 10'
		Plans of mine workings No. 1 level.	1" to 10'
		Plan from 1908 blueprint, by the O.K. Syndicate, with additions.	1" to 20'

At Charters Towers:

Mine	Ref. No.	Description	Scale
Mount Carbine	117/1	Sketch Map	1" to 25'
	117/2	Plan	"
	117/3	Cross-section	"
	117/4	Long. sections	"
	117/5		
	117/6	Plan	"
	117/7	Traverse plan	"
	117/8	Section	"
	117/9	Sections	"
	117/10	Plans	"
	117/11	Plans	"
	117/12	Plans	"
	117/13	Plans	"
	117/14	Plans	"
	117/15	Plans	"
Mount Molloy	130/1	Plan	1" to 40'
	130/2	Plan	1" to 30'
	130/3	Section	1" to 30'
	130/4	Section	1" to 20'
	130/5	Section	"
	130/6	Plan and section	"
	130/7	Section	"

Mine	Ref. No.	Description	Scale
General Grant	193/1	Lease plan	1" to 4 ch.
	193/2	Homeward Bound group	1" to 33'
	193/3	General Grant group	1" to 50'
	193/4	Lizzie Redmond Group	"
	193/5	Section, General Grant	"
	193/6	Long. section	"
	193/7	Assay plan	1" to 20'
	193/8	Plan	"
	193/9	Section	1" to 10'
	193/10	Portion of assay plan	"
Tyrconnel	194/1	Assay plan	1" to 20'
	194/2	Long. section	1" to 25'
	194/3	Surface plan	"
	194/4	Plan 6	"
	194/5	Plan 3	"
	194/6	Plan 2	"
	194/7	Plan 5	"
	194/8	Plan 4½	"
	194/9	Plan 1	"
	194/10	Plan 4	"
	194/11	Assay plan	
	194/12	No. 6 level	"
	194/13	No. 5 and No. 6 level	1" to 30'

At Redbank: Plans and Sections of Mount Mulligan.

Description	Scale
Plan of State Colliery, from Mine Plan, with additions	1" to 2 ch.
Section along main tunnel, State Colliery	1" to 100'
Sections of No. 1 seam, State Colliery	1" to 1'
" " " 2 " " "	"
Diagrammatic section tunnel workings, State mine	(H: 1" to 100' (V: 1" to 5'
Section of No. 3 seam	1" to 1'
King Cole section, lower portion main dip	1" to 5'
King Cole plan	1" to 2 ch.
Uncontrolled map, from air photos, Mt. Mulligan area	
Bore hole sections N 54/1951	1" to 10'
N 55/1951	"
NS 3/1951	1" to 20'
NS 4/1951	"
Boring, location of bores 1-5/1951 in relation to King Cole and State Collieries	1" to 5 ch.

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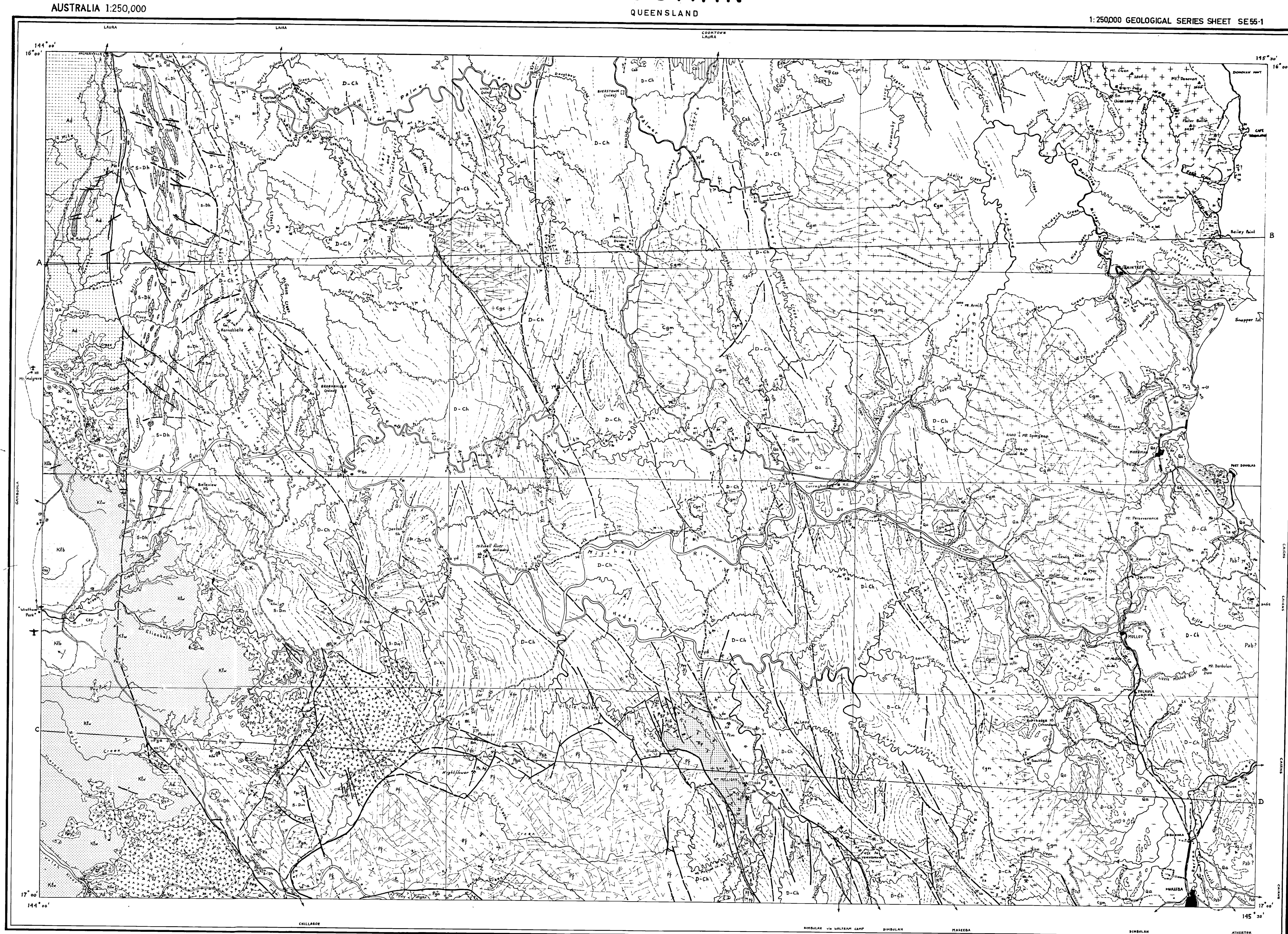

REFERENCE

CAINOZOIC	QUATERNARY		Qa	Alluvium, soil.
			Qa	Coastal marsh.
			Qr	Old beach sand.
		Unconformity		
			Czb	Olivine basalt.
			Czy	Billy breccia, gravel.
		Unconformity		
MESOZOIC	LOWER CRETACEOUS	Blackdown Formation	Klb	Grey shale, siltstone, sandy shale; some lenticular sandstone. Calcareous concretions in places. Fossiliferous.
		Wrotham Park Sandstone	Klw	Pebble conglomerate, feldspathic sandstone, pebbly sandstone. Glauconitic horizon on top.
	JURASSIC (?)	Laura Sandstone	Jl	Conglomerate, sandstone.
	TRIASSIC (?)	"Pepperpot Sandstone" *	Rp	Red, white pebble conglomerate and massive pebbly sandstone at the base. Flaggy argillaceous and silty sandstone towards the top. Cross-bedding common.
		Unconformity		
PALAEOZOIC	PERMIAN to TRIASSIC	Elizabeth Creek Granite	Pgz	Pink biotite granite, leucocratic.
		Featherbed Volcanics	Pf	Acid lavas and pyroclasts, generally massive.
		Unconformity		
		Almaden Granodiorite	Pga	Grey hornblende-biotite granodiorite.
		Herbert River Granite	Pgh	Grey hornblende-biotite granite.
		"Mt. Mulligan Coal Measures" *	Pm	Massive pebble conglomerate, sandy shale, shale, sandstone, arkose, mudstone, coal bands.
		Nychum Volcanics	Pny	Mainly acid lavas and pyroclasts; some intermediate and basic lavas, amygdaloidal lavas. – Tuffaceous sediment, arkose, siltstone, impure coal.
		Unconformity		
	CARBONIFEROUS	Montalbion Sandstone	Cm	Quartzose sandstone.
		Unconformity		
		Cannibal Creek Granite	Cgc	Cream biotite-microcline granite ± muscovite.
		Mareeba Granite	Cgm	Grey biotite-microcline granite ± muscovite. Commonly strongly porphyritic.
		"Thornton Granite" *	Cgt	Cream leucocratic granophyric granite.
	M. DEVONIAN to L. CARBONIFEROUS	Hodgkinson Formation	D-Ch	Well-bedded micaceous (quartz) greywacke, siltstone, slate; intercalations of basic volcanics, chert, sedimentary breccia, conglomerate. – Main conglomerate horizon.
		Unconformity ?		
	U. SILURIAN to L. DEVONIAN	Mt. Garnet Formation	S-Dm	Quartz 'greywacke', arkose, feldspathic sandstone, siltstone, breccia, conglomerate lenses; intercalations of basic volcanics and chert. Small limestone lenses.
		Chillagoe Formation	S-Dh	Fossiliferous limestone, bedded chert, quartz 'greywacke', siltstone, breccia, conglomerate lenses, intercalations of basic volcanics. At the base: quartz sandstone and quartz siltstone. – Main outcrop of limestone.
	Undifferentiated	Barron River Metamorphics	Pzb	Low-grade metamorphic phyllite, schist, quartz 'greywacke', and siltstone
		Unconformity		
PRE-CAMBRIAN	ARCHAEAN (?)	Dargalong Metamorphics	Ad	Quartz-mica schist, augen gneiss, granulite, quartzite, amphibolite.

* Note: Formation name not yet approved by Queensland Stratigraphic Nomenclature Committee.

- Trend of bedding
- Geological boundary
- Fault
  - Relative horizontal movement
  - Relative vertical movement: U = up, D = down
- Anticline, showing plunge
- Syncline, showing plunge
  - Where location of boundaries, folds, and faults is approximate line is broken; where inferred, queried; where concealed, boundaries and folds are dotted, faults are shown by short dashes.
- 75 Strike and dip of strata
- 80 Overturned strata
- Vertical strata
- Horizontal strata
- Generalized strike and dip of folded strata
- Top of strata
- Direction of sediment transport
- Dip < 15° } from air-photo interpretation
- Dip 15°–45° } from air-photo interpretation
- Dip > 45° } from air-photo interpretation
- Joint pattern and possible faults } from air-photo interpretation
- 50 Strike and dip of foliation (metamorphic rocks) and flow layering (igneous rocks)
- Vertical foliation
- 60 Strike and dip of cleavage
- Vertical cleavage
- 45 Plunge of lineation
- Horizontal lineation
- Dyke or vein: q = quartz; d = dolerite, or other basic or intermediate dyke rock; r = rhyolite, or other acid dyke rock; gr = granite, or related rock
- Volcanic vent, extinct
- Macro fossil locality
- Micro fossil locality
- Plant fossil locality
- Minor mineral occurrence, of mineralogical interest only
- Prospect; little or no production
- Mine, quarry, large open cut, or group of mines and prospects
- P.D. Prospect, position doubtful or approximate
- Old battery, smelter, or treatment plant

Ag = Silver	Mn = Manganese		
Au = Gold	Pb = Lead		
Bi = Bismuth	Sb = Antimony		
C = Coal	Sn = Tin		
Cu = Copper	W = Tungsten		
Ls = Limestone			

- 5400 Trigonometric station, height in feet above sealevel
- 1400 Spotheight, taken from Queensland 4-Mile Series maps
- Highway or main connecting road
- Secondary road, in general use and usually in fair condition
- Vehicle track no longer in use, in very poor condition, suitable for 4-wheel drive vehicles only
- W.H. Water hole
- B Water bore with windpump
- T Water tank
- Dwelling
- HS Brooklyn Homestead
- MOSSMAN Larger town
- Site of former village, now abandoned or in ruins
- yd Yard
- Fence
- Telephone or telegraph line
- Railway line
- Landing strip
- Dam

Geology and topographic base compiled by the Bureau of Mineral Resources, Geology and Geophysics, using slotted template assemblies prepared by the Army Survey Corps. Aerial photography by Adastra, scale 1:80,000, vertical coverage complete except for north-east corner.

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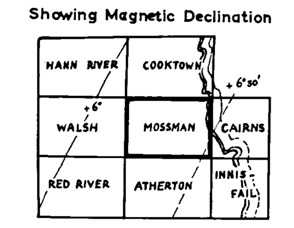

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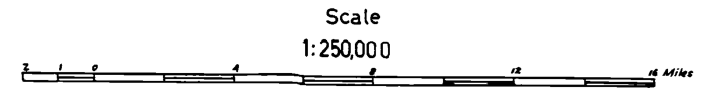

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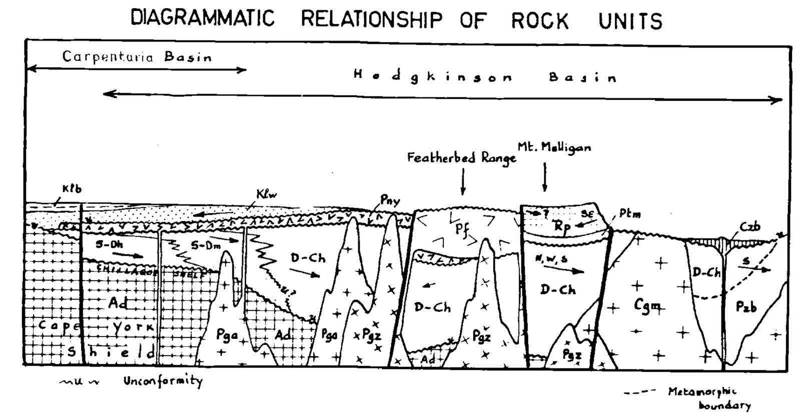
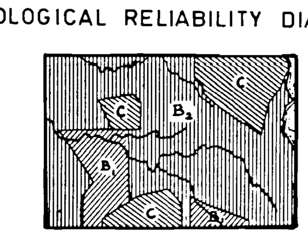
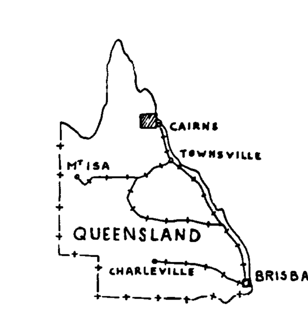


GEOLOGICAL RELIABILITY DIAGRAM



- B_1 Detailed reconnaissance: numerous traverses and photo-interpretation
- B_2 Reconnaissance: traverses and photo-interpretation
- C Air-photo interpretation only

Geology by: F. de Keyser, K.G. Lucas, W.R. Morgan, B.J. Amos, R.M. Tucker.
Compiled and drawn by: F. de Keyser, May 1961.



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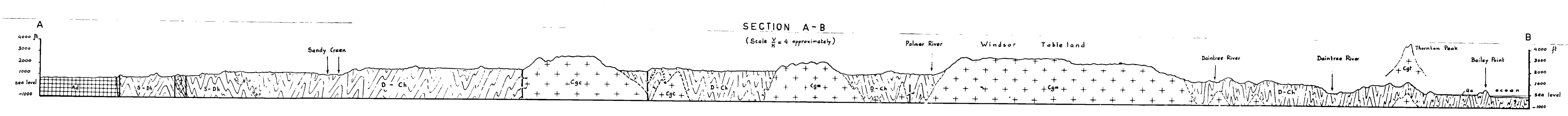
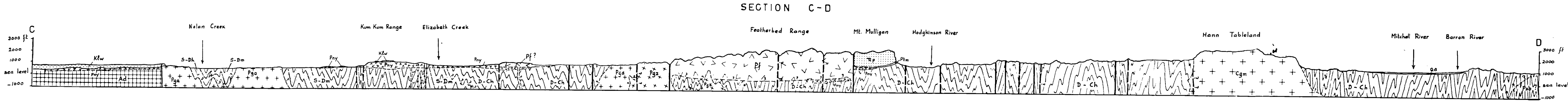


SECTION C–D



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SHEET SE 55-1

(PRELIMINARY EDITION)

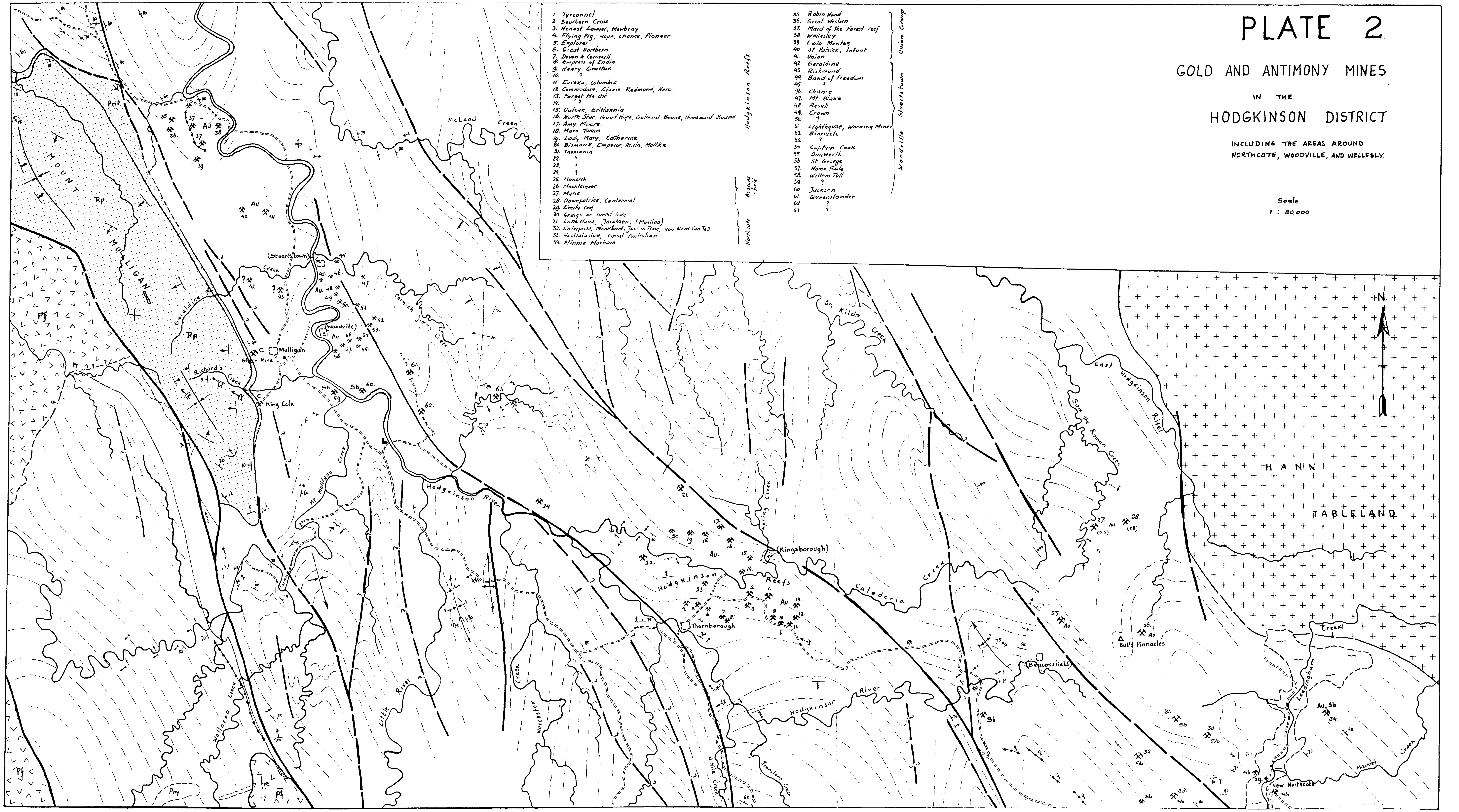
PLATE 2
GOLD AND ANTIMONY MINES
IN THE
HODGKINSON DISTRICT
INCLUDING THE AREAS AROUND
NORTHCOTE, WOODVILLE, AND WELLESLY.
Scale
1 : 80,000
1. Tyrconnel
2. Southern Cross
3. Honest Lawyer, Mowbray
4. Flying Pig, Hope, Chance, Pioneer
5. Explorer
6. Great Northern
7. Devon & Cornwall
8. Empress of India
9. Henry Grattan
10. ?
11 Eureka, Columbia
12. Commodore, Lizzie Redmond, Hero.
13. Forget Me Not
14. ?
15. Vulcan, Brittannia
16. North Star, Good Hope, Outward Bound, Homeward Bound
17. Amy Moore.
18. Mark Twain
19. Lady Mary, Catherine
20. Bismarck, Emperor, Atilla, Moltke
21. Tasmania
22. ?
23. ?
24 ?
Hodgkinson Reefs
25. Monarch
26. Mountaineer
27. Maria
28. Downpatrick, Centennial.
Beaconsfield
29. Emily reef
30. Graigs or Tunnel lode
31. Lone Hand, Jacobsen, (Matilda)
32. Enterprise, Monkland, Just in Time, You Never Can Tell
33. Australasian, Great Australian
34. Minnie Moxham
Northcote
35. Robin Hood
36. Great Western
37. Maid of the Forest reef
38. Wellesley
39. Lola Montez
40. St Patrick, Infant
41. Union
Union Group
42. Geraldine
43. Richmond
44 Band of Freedom
45. ?
46. Chance
47. Mt. Blake
48. Result
49. Crown
50. ?
51 Lighthouse, Working Miner
52. Binnacle
53. ?
54 Captain Cook
55. Dagworth
56. St. George
57. Home Rule
58. Willem Toll
59 ?
60. Jackson
61. Queenslander
62. ?
63 ?
Woodville - Stuartstown
N
MOUNT MULLIGAN
Rp
Pmt
Pf
Pny
McLeod Creek
(Stuartstown)
(Woodville)
Mulligan
State Mine
Richard's Creek
King Cole
Geraldine Creek
Cornish Jimmy Creek
Mt Mulligan Creek
Hodgkinson River
Little River
Worcester Creek
Wallaroo Creek
St. Kilda Creek
Spring Creek
(Kingsborough)
Hodgkinson Reefs
Thornborough
Caledonia Creek
4 Mile Creek
Tinstone Creek
East Hodgkinson River
Sam the Roman Creek
(Beaconsfield)
Bull's Pinnacles
HANN TABLELAND
Leadingham Creek
Mackie's Creek
New Northcote
Au
Sb
Au, Sb