COMMONWEALTH OF AUSTRALIA.

DEPARTMENT OF NATIONAL DEVELOPMENT.

BUREAU OF MINERAL RESOURCES GEOLOGY AND GEOPHYSICS.

RECORDS:

1964/78

GEOLOGY OF THE INGHAM 1:250,000 GEOLOGICAL SHEET AREA SE.55/10, QUEENSLAND

by

F. de Keyser, R.S.H. Fardon (B.M.R.)
and L.G. Cuttler, (G.S.Q.)

GEOLOGY OF THE INGHAM 1:250,000 GEOLOGICAL SHEET AREA, SE.55/10, QUEENSLAND.

by

F.de Keyser, R.S.H.Fardon, and L.G.Cuttler*
(*Queensland Geological Survey).

RECORDS 1964/78

CONTENTS

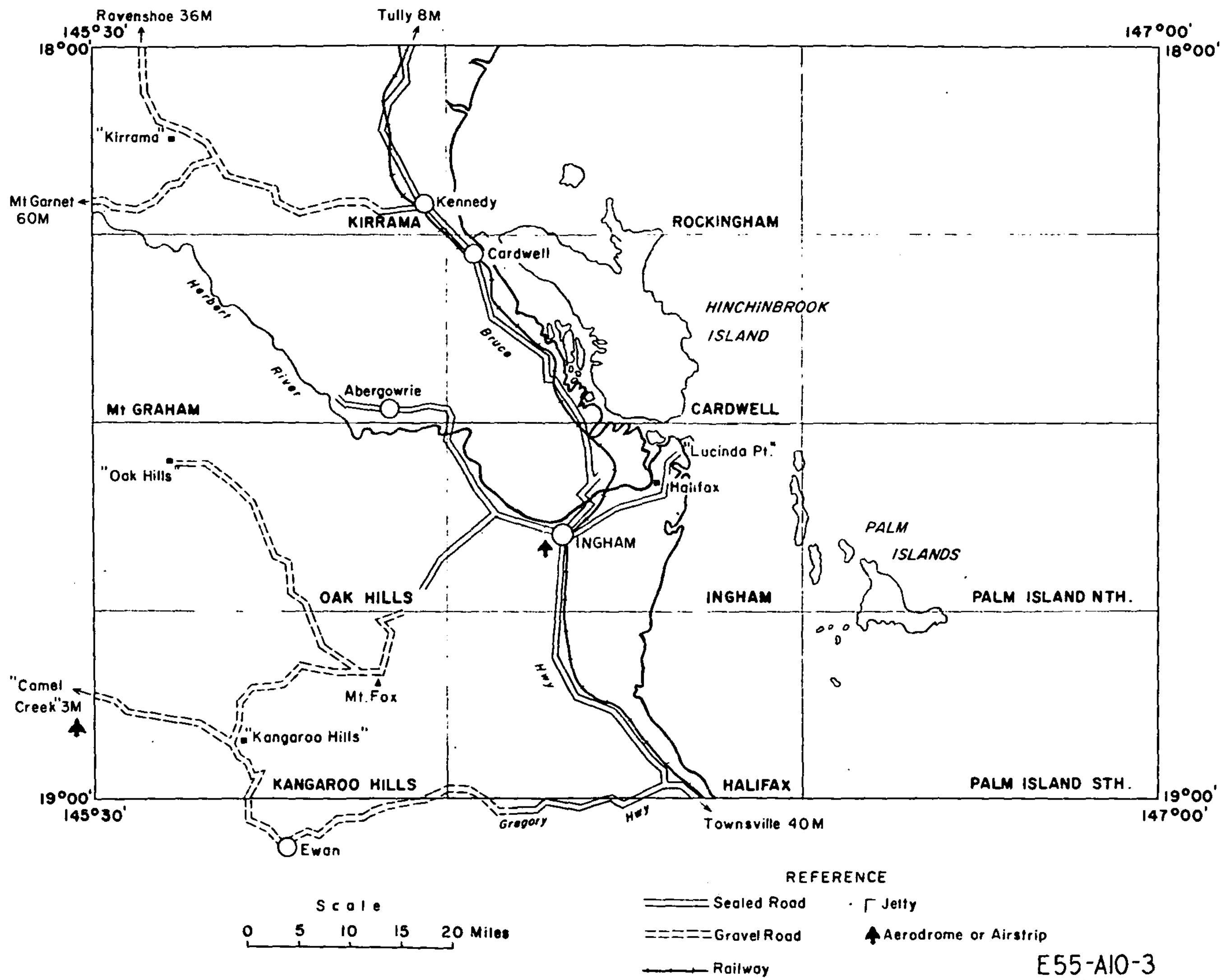


FIG 1- INGHAM 1:250,000 SHEET SHOWING 1 MILE SHEETS, TOWNS AND COMMUNICATIONS

Bureau of Mineral Resources, Geology and Geophysics, June 1964. To accompany Record No 1964/78

GEOLOGY OF THE INGHAM 1:250,000 GEOLOGICAL SHEET AREA

SE. 55/10 QUEENSLAND

SUMMARY

This report covers the work of combined field parties of the Bureau of Mineral Resources and the Geological Survey of Queensland, which spent several months mapping the Ingham 1:250,000 Sheet area during 1962 and 1963, as part of a continuing program of the regional mapping of North Queensland that started in 1956.

Portions of succeeding depositional environments of the Tasman Geosyncline are represented in the Ingham sheet area: they are the Lower Silurian Wairuna depositional area, the Upper Silurian Kangaroo Hills Trough, the Devonian Hodgkinson Basin, and the Carboniferous Clarke River Basin. A Precambrian environment may also be preserved. The formations contained in these basins were folded and faulted during a number of orogenies, the last one of which took place during the Carboniferous and was accompanied by large-scale igneous activity. As a result, the area is now largely occupied by granite, volcanic rocks and numerous dykes, whereas the original sedimentary deposits are preserved only sporadically within the limits of the Sheet area. Our knowledge of the geological history is therefore very incomplete.

The granites are divided into several lithological groups, and appear to have had a complex history. They intrude the volcanics and are intruded by the acid and basic dykes. The inferred range of their ages is from Upper Carboniferous to Permian.

All these Palaeozoic rocks are unconformably overlain by flat-lying Cainozoic sediments and basalt, remnants of which now form the Lucy Tableland and its fringe of mesas and buttes, and are generally lateritized. Probably by the end of the Pliocene or the beginning of the Pleistocene, the old Tertiary surface was broken up by differential vertical movements. Its western part was elevated and now forms a somewhat dissected plateau; its eastern part foundered and is represented by the coastal plain with its Quaternary alluvial deposits, and farther east by the submerged continental shelf.

Tin (as cassiterite) and tungsten (as wolframite) are the only metals produced in any quantity from the Ingham Sheet area; the tin occurs in alluvial deposits, deep leads and in lodes. The workings are mainly concentrated in the Kangaroo Hills Mineral Field, most of which lies in the adjoining Townsville Sheet area to the south. Antimony, bismuth, molhbdenum, copper, lead, zinc, gold, and silver are also known from the Ingham Sheet area, but their occurrences are either unpayable, or have yielded insignificant amounts of ore only, mostly as a by-product from the wolfram mines. Industrial materials being produced are clay and road metal or aggregate.

GEOLOGY OF THE INGHAM 1:250,000 GEOLOGICAL SHEET AREA, SE 55/10, QUEENSLAND.

INTRODUCTION

The Ingham 1:250,000 Sheet area lies in North Queensland, bounded by longitudes 145°30' and 147° east, and latitudes 18° and 19° south. It is 400 miles north of the Tropic of Capricorn. More than half of the area is occupied by the continental shelf with its Great Barrier Reef and continental islands; the mainland consists of a flat coastal plain, ranges, and a plateau in the west.

Much of the following climatological information is taken from the Atlas of Australian Resources (1954): the average monthly maximum and minimum temperatures in the area are of the order of 85° and 70° in January, 75° and 55° in July. The high country is cooler and has frosts every winter. Humidity averages 80 percent in summer, 40 percent in winter. The main ranges receive more than 80 inches of rain a year, and this amount decreases towards the south-west to about 30 inches. The rain is concentrated in the period January to March inclusive, during which the monthly rainfall ranges from 14 to 19 inches; less than 2 inches is usually recorded during each of the months July, August, and September, except in the ranges.

The low plain is covered by mixed coastal woodlands, swamp vegetation, and mangroves; the ranges and eastern part of the plateau carry dense tropical rain forest, which gives way slowly or abruptly to high-rainfall eucalypt forest and then to savannah woodland to the west. Most of Hinchinbrook Island is covered with dense, stunted scrub. All the high-rainfall areas grow rank grasses from four to eight feet high, and much of the drier western plateau is covered with spear grass.

Figure 1 shows the main settlements and lines of communication, as well as the subdivision of the Ingham Sheet into 1-Mile Sheet areas. Ingham, with a population of about 5000, is the only town of any size; Halifax and Cardwell are small townships, and other settlements consist of only a few houses. The area is linked to north and south by the sealed Bruce Highway and a 3 foot 6 inch railway. Gravel roads shown on Figure 1 are trafficable in all but the worst weather, but other roads and tracks are usually passable only to four-wheel drive vehicles. Ingham, with the only commercial airstrip in the area, has two scheduled flights daily to the north and south. A non-commercial airstrip for light aircraft exists at Camel Creek Homestead (which, strictly speaking, is just outside the Sheet area). The Lucinda jetty handles coastal freighters, and launches have access to Hinchinbrook Island up the tidal creeks on the western side; landing on the eastern beaches is commonly made difficult by heavy seas. The coastal plain has established sugar and dairy industries, and beef cattle are raised in the drier western part of the tableland. A small amount of timber is taken from the rain forest.

The area is covered by a sketchy 4-mile military map of 1943, and partly by more accurate, contoured 1-mile military maps. More detailed are the Queensland Lands Department maps at 4-mile and 2-mile scale. The Army Survey Corps in 1963 produced accurate, contoured photo-scale (1:80,000) planimetric maps. Complete air-photo coverage is given by 1:80,000 scale vertical photos flown by Adastra Airways Ltd. in 1961, and from these the Division of National Mapping has prepared uncontrolled photo-mosaics at scales 1:250,000 and 1:63,000. Older, larger-scale air-photo series are listed in Table 1.

PREVIOUS INVESTIGATIONS

Since the first investigations by early explorers of the Great Barrier Reef - Jukes in 1847 and Agassiz in 1898 - the question of the origin of the continental shelf, coastal plain, ranges, and plateau of North Queensland, and their relationships, has been discussed in many geomorphological papers written especially in the years 1909 to 1911, by Andrews (1910), Danes (1911), David (1911), Davis (1917), Jensen (1911), Poole (1909), Süssmilch (1938), Griffith Taylor (1911), and others. All, except Agassiz, agreed that the features were due to Late Tertiary vertical movements. Most thought that differential faulting was the main factor (Süssmilch,1938; David,1950; Twidale,1956b); others sought the answer in warping and bending (Davis,1917; King,1962). Bryan (1925) allowed the possibility of faulting . though he believes that most of the landforms of east Queensland are due to differential erosion by consequent drainage.

Compared with the interest shown in the physiographic problems, investigations of the regional geology lagged behind. General geological reports on North Queensland, written by Daintree (1872), Maitland (1891), and Jack and Etheridge (1892), include a sketchy account of the Ingham Sheet area. More detailed though rather incidental and local geological descriptions were made during investigations of the mining areas, mainly in the Kangaroo Hills Mineral Field (Cameron, Jack, Keid, Morton, Reid, Saint Smith, Shepherd, and others). After the early general reports little progress was made in the regional geology of north-east Queensland until mapping by combined Bureau of Mineral Resources and Geological Survey of Queensland field parties began in 1956. The basis of our present understanding of the region was laid by these surveys, which were carried out in the adjoining Sheet areas to the west and north. The results are summarized in various papers by White, Wyatt, Branch, and Bush in the "Geology of Queensland" (J.Geol.Soc.Aust.,7,1960), in Explanatory Notes on the Sheet areas adjoining the Ingham area, and in unpublished progress reports. A summary of the regional geological history of the Cairns Hinterland was given by White (1961). Branch (1962) exhaustively discussed the Late Palaeozoic igneous rocks and their origin.

Papers on laterites and soils in North Queensland are those by Simonett (1957) and Connah and Hubble (1960). The Great Barrier Reef and continental shelf were treated in great detail by Fairbridge (1950).

Work done within the limits of the Ingham Sheet includes a survey of the Blencoe Creek - Herbert Falls area (Wolff,1959), and a reconnaissance of the Kangaroo Hills area (Tweedale and Bush,1957). The Bureau of Mineral Resources carried out aeromagnetic surveys over the continental shelf (1959), a gravity survey (1961), and seismic surveys in the Herbert River area (1962). Finally, this report and the accompanying map are the result of field work carried out by a joint party of the Bureau of Mineral Resources and the Geological Survey of Queensland during September, 1962, and from May to July, 1963.

PHYSIOGRAPHY (see Plate 2)

From west to east, the area may be divided into five physiographic units:

a. the plateau, with remnants of the Lucy Tableland
b. the ranges
c. the coastal plain
d. the continental shelf
e. the islands

The general trend of the major physiographic units is north-west.

The plateau, which occupies the western part of

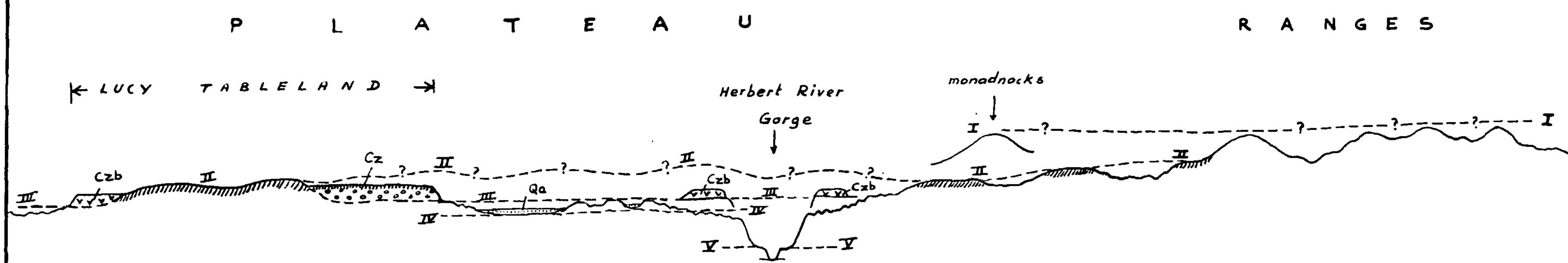


Figure 2 — DIAGRAMMATIC SECTION ACROSS PLATEAU AND RANGES, SHOWING OBSERVED AND INFERRED EROSION SURFACES *(not to scale)*.

V ? Recent level near bottom of gorge, showing renewed incision to present-day level.

IV ? Plio-Pleistocene surface, with some aggradation (Qa), for example in Upper Burdekin valley.

III ? Early Pliocene surface, covered by Cz and Czb. ? Pliocene diatomite near top of section. Formation of duricrust.

II ? Miocene surface, undulating and lateritized. ////// laterite

I ? Mesozoic surface? Possibly represented by monadnocks and accordant summit levels.

Bureau of Mineral Resources, Geology and Geophysics. To accompany Record No 1964/78

E55/A10/4

the area, is from 1200 feet to 2200 feet high. It slopes gently south-west, and its highest parts lie along the steep scarp rising from the coastal plain. The plateau represents an uplifted and variously dissected, composite surface (Fig. 2), which had been covered by a thick blanketing soil profile, parts of which might be termed lateritic. Undissected remnants of the original and deeply weathered surface are seen in buttes and smooth mesas (Lucy Tableland), mainly in the central-west of the plateau. The Lucy Tableland has erosional as well as aggradational components (Fig. 2) which are of somewhat different age, as can be observed in the area west of the Ingham Sheet boundary.

For the most part the plateau has been dissected just below the level of the old surface to an intricate pattern of hills and ridges with accordant summits and dendritic drainage and, in many places, still with remnants of the deep weathering profile on hill tops. In detail the texture of dissection shows several forms, from generally undulating country in the sedimentary Kangaroo Hills Formation to steep hills and V-shaped valley topography between Blencoe Creek and Smoko Creek; hornfelsed or indurated sediments along granite contacts have been imprinted with a fine dendritic drainage pattern. The level of the old surface is broken by granitic monadnocks.

The original, Tertiary erosion surface (II in Figure 2) had broad, gentle elevations and depressions corresponding roughly with the present divides and catchment areas. The mean depth of subsequent erosion has been of the order of 150 to 200 feet, and 400 feet is a maximum. If the main uplift began at the end of the Pliocene, the average rate of erosion must have been in the vicinity of 1/5 to 1/10 inch per century. Great differences in altitude, within a short distance, of flat-lying soil remnants are suggestive of post-Tertiary fault movements, for example in the area west of Dingo Mountain near Kirrama Homestead.

The plateau is bounded on the north-east and south-east by, and merges with, a belt of <u>ranges</u>, all of which rise to above 3000 feet. They are rugged and youthful, displaying steep cliffs, gorges, and waterfalls, such as are also found along the scarp of the plateau. These ranges may be the remnants of one or more uplifted, older erosion surfaces (I in Figure 2): the highest points throughout the area appear to form an accordant summit level 3000 to 3500 feet high.

There is some evidence that the ranges are in places bounded by faults - e.g. the presence of clean, curved lineaments along the steep scarps, with triangular facets on spurs against the lineament; and the existence of straight-lined geological boundaries along some of the postulated faults in places where straightness would not normally be expected. These inferred faults trend generally north-west and east, giving the ranges a blocky outline especially from the Cardwell Range northwards, with rectilinear embayments such as the one along Kennedy Creek. That the embayments are essentially down-faulted areas is also suggested by the lack of water-courses large enough to account for their formation by erosion.

The nature of the uplift that led to the formation of the plateau and ranges of north-east Queensland remains disputable. Most of the earlier physiographers presented the ranges and plateau as uplifted faultblocks, and the coastal plain and continental shelf as foundered areas (Andrews,1910; Danes,1911; Süssmilch,1938; David,1950; Twidale,1956). Davis (1917), however, explained the physiography by warping or flexuring and contended that successive axes of flexure gradually shifted westwards; and King (1962) states that "...in the modern view the numerous scarps of the eastern region are erosional in origin, and recent faulting is negligible in Australia". He explained the scarp as a pediplanation phenomenon, and as due to parallel retreat of a scarped hillslope during pedimentation after warping. Marks (1924) and in part also Bryan (1930) were adherents of differential erosion as the major factor in the genesis of the ranges, but this cannot be upheld for the Ingham area, where the participating rock units are of fairly uniform or non-contrasting lithology.

Although it is true that differential erosion may have accentuated some of the landforms, and that scarp retreat has taken place (irregularly in places, and therefore obscuring original faultlines), faulting is here still considered to have been the fundamental cause of the uplift. Reasons are:

1. The rectilinear, blocky outline of ranges and embayments and straight formational contacts in places. Actual field and microscopic evidence has been found, for example along the eastern side of the Cardwell Range, though the age of this faulting is not known.
2. The altitude of Hinchinbrook and Palm Islands, and the westward slope of the plateau, are arguments against flexuring or down-warping to the east.
3. The coastal plain is an area of Quaternary shallow-

water sedimentation on a basement that is now well below sea level, whereas the drainage and topography of the adjacent plateau and ranges show strong rejuvenation and some indication of stages of uplift. These points suggest (repeated or continuous?) subsidence in the coastal plain area, and repeated uplift of the plateau area, whereby a possible hinge zone, in case of flexuring, would be non-existent or would have to be very narrow.

The age of the main uplift has variously been estimated as Miocene and Pliocene (David, 1950), post-Miocene (Süssmilch, 1938), mainly end of Pliocene (Andrews, 1910), "Late Tertiary" by most authors, and Pleistocene by Bryan (1925). The uplift seems to fit in well with the Plio-Pleistocene 'cymatogenic' movements[1] of the Gondwana continents, as described by King (1962, pp.224-227), but appears to have taken place in stages (Fig. 2).

Whereas the plateau is a surface of erosion and denudation, the coastal plain is an aggradational feature. Its deposits attain a known thickness of as much as 316 feet in the Herbert River delta (Calvert, 1959). The plain is flat, and very little above the present sea level; an alternation of marine and freshwater sediments may be expected in the stratigraphic column because of fluctuating sea levels during the Quaternary, and possibly also because of different rates of subsidence of the basement.

The present cycle is one of slight erosion, following a Recent 15-foot drop of sea level estimated by Browne (1945) to have occurred 3000 to 4000 years ago. The streams are cutting down in their terraces and outwash fans at the foot of the hills.

The coastal plain is mainly a large floodplain, swampy in many places. Natural levees border the Herbert River. Talus and scree slopes and outwash fans are spread out along the foot of the mountains. In many places the sediments in these outwash fans are partly cemented, and are mottled with iron oxide. Nearer the sea are strips of old, vegetated beach sands, on air-photos displaying old shoreline trends; north of Cardwell in particular they are interspersed with lagoonal deposits (mud and salt pans) and man-

---

1) 'Cymatogeny' is defined by King as a mode of crustal deformation between epeirogeny and orogeny in which the earth's surface is thrown into great waves or undulations commonly hundreds of miles across and thousands of feet high.

grove swamps. Broad fringes of mangrove swamps with a confusing maze of tidal inlets and saltwater creeks are common along the coast, especially along either side of Hinchinbrook Channel.

The coastline shows two north-west trending sections (conformable with the regional structural trend) joined by transverse north-north-east sections. This is characteristic of much of the North Queensland coast.

The <u>continental shelf</u> is apparently continuous with the coastal plain: the present coastline would shift many miles either way on a rise or fall of sea level of a few tens of feet. The sea depth is generally between 100 feet and 200 feet. The shelf basement is covered by terrigenous sediments containing lenses and tongues of reef detritus. Borings on Heron Island and at Michaelmas Cay, outside the Ingham Sheet area, show that the thickness of Quaternary sediments is at least 400 feet to 500 feet (Fairbridge, 1950). Little is known about the form of the basement. David (1911) thought that it was affected by a series of faults, and concluded that the continental island groups represent horsts. Fairbridge (1950) considers the shelf margin to be the location of a hinge fault.

Though the longshore currents during the south-east trade winds are northerly, their effect in the Ingham Sheet area is partly countered by tidal movements (in Hinchinbrook Channel) and by eddy currents (in Rockingham Bay). The resulting current movements are imprinted on the sand configurations in the shallow water along the coast, as seen on air photographs.

The Great Barrier Reef was not investigated; it has, however, been described in detail by Fairbridge (1950).

The <u>continental islands</u>, including Hinchinbrook Island, the Family Group of islands, the Palm Islands, and the islands in Rockingham Bay, may be considered as separated parts of the ranges. They generally have a drowned topography, owing to a post-glacial rise of sea level of about 200 feet. A more Recent 15-foot relative fall of the sea level is indicated by raised beaches and some emerged alluvial flats, and was responsible for the connection of Cape Richards and Cape Sandwich with the main mass of Hinchinbrook Island. Since then, longshore currents have been depositing sand against the connecting mudflat area between Mount Bowen and Cape Sandwich, and on the resulting strip of sand, 1700 feet wide, the trade winds have built a series of U-dunes that have grown together into an irregular toothcomb pattern in which the "teeth" are facing south-east.

The drainage merits separate discussion. It is worthy of note that the Herbert River, the main stream in the area, runs east against the general south-westerly tilt of the plateau. The same feature is found in many other places along the North Queensland plateau, and it has been shown (Taylor, 1911) that such rivers were originally consequent streams flowing west, but were deflected to the east during the Late Cainozoic following warping or tilting along north-south axes to the west of the old main divide, which is represented by the zone of ranges along the edge of the plateau. The Herbert River is no exception, and further evidence for its original westerly flow direction may be sought in the tendency shown by a few of its tributary junctions to head upstreams.

Before its deflection, the Herbert River may have been part of any of the principal west-draining river systems in the vicinity: the Einasleigh River (via the Upper Burdekin), or the Mitchell River (via the Millstream and Barron River). The area of widespread (?)Pliocene aggradation (Cz), west of the Ingham Sheet area, between the Herbert and Upper Burdekin Rivers perhaps denotes a former connection between the two systems.

The time of deflection is not precisely known, but may be inferred from the following. The Lucy Tableland is composed of two components, which are best recognized in the region immediately west of the Ingham Sheet area: they are an older, undulating, lateritized erosion surface, merging with a flat, younger, aggradational surface which was formed over parts of the older surface (cf. Fig. 2). The sediments of the younger surface were probably deposited during a period when the original upper reaches of the Herbert River and the Upper Burdekin River (hence including the parts now within the Ingham Sheet area) became sluggish, meandering streams as a result of rising intermediate base levels to the west, following upwarp and damming by basalt flows (Taylor, 1911; Best, 1962b). By the end of this period the rivers became completely dammed, as suggested by beds of diatomite at the top of these deposits, and the rivers subsequently found an outlet to the east, through the divide, either by capture or by overflow in passes. The period of deflection was probably Pliocene, as the diatomite is thought to be of about that age (Best, 1959). As soon as this break-through occurred, a start could be made with the cutting of a gorge through the old divide. A pronounced uplift at the end of the Pliocene or the beginning of the Pleistocene strongly rejuvenated the drainage, and deepened the gorge, which has since then cut back about 35 miles. Renewed uplift, or, possibly, climatic changes during the Holocene are indicated by remnants of a shoulder low down in the gorge, near the Herbert Falls west of the Ingham Sheet area; by two nick-points in the river profile below the falls, in the same general locality; and possibly by terraces in the alluvium along Garrawalt Creek and other streams on the plateau.

The plain traversed by the lower part of the Herbert River is a large delta, across which the river perpetually shifts. Old channels of the Herbert River in this deltaic region are represented by the Cattle, Trebonne, Palm, and Victoria Creeks, which are partly dry and swampy, but whose meandering loops and old ox-bow lakes are still clearly recognizable from the air. The Herbert River has probably gradually migrated to the north as a result of sandbars and spits continuously building northwards under the influence of the longshore currents. Levee deposits south of the river have spilled over the deserted upper channels of Trebonne and Palm Creeks.

STRATIGRAPHY (see Table 2)

Within the Ingham Sheet area, several depositional environments of the Tasman geosynclinal system are represented, each of a different age. They are the Hodgkinson Basin, the Kangaroo Hills Trough, the Clarke River Basin, the Wairuna depositional area, and possibly a Precambrian sedimentary environment. The formations in these basins were folded and faulted during a number of orogenies, the last one of which took place during the Carboniferous and was accompanied and followed by large-scale igneous activity. As a result, the area is now largely occupied by granites, volcanics, and dyke rocks, whereas the older sedimentary deposits are, within the limits of the Sheet area, only sporadically preserved, chiefly in the western and southern border areas. Unconformably overlying all these rock units are remnants of Cainozoic laterites and sediments and a few basalt flows.

The stratigraphy is summarized in Table 2, and the geological history on page 27.

PRECAMBRIAN (?).

The Running River Metamorphics, named by Wyatt in 1964, occur in the Hidden Valley area in a north-east trending belt which forms an extension from their type area in the adjoining Townsville 1:250,000 Sheet area. Prior to this survey they had been regarded as part of the Silurian "Ewan Metamorphics" (Informal name - Tweedale and Bush, 1957; and Bush, 1960), but mapping in the type area seems to suggest a structural and metamorphic unconformity with the lower-grade "Ewan Metamorphics" (Wyatt, personal communication). The Running River Metamorphics are thought by Wyatt to be possibly Precambrian because of their degree of metamorphism, but an Early Palaeozoic age is by no means excluded.

In the Ingham Sheet area, the formation consists of amphibolites and coarse mica schists. The former comprise a variety of massive as well as banded and foliated rocks composed of combinations of amphibole, clinopyroxene, plagioclase, apatite, sphene, biotite, alkali feldspar, and some quartz. In some thin sections, the effects of post-metamorphic or para-metamorphic shearing are obvious, and include, apart from the usual physical deformation, also the breaking-down of monoclinic pyroxene (?diopside) into hornblende, actinolite, uralite, epidote minerals, and pale-brown biotite, either directly or in stages. In extreme cases pyroxene-rich rocks are seen to be transformed into foliated rocks with hornblende-rich and biotite-rich layers. In other foliated rocks, layers may be composed entirely of either pyroxene, plagioclase, or pale-brown biotite, a result at least in part of metamorphic differentiation. The colour of the amphiboles ranges from green-blue to darker green or brown-green. In some specimens the feldspars include an alkali feldspar, most probably and commonly albite. Sphene and apatite are abundant in several specimens.

Although most of the normal plagioclase amphibolites were probably derived from basic igneous rocks, some of the specimens rich in diopside and variable of texture are most likely calc-silicate rocks.

The Running River Metamorphics are intruded by Upper Palaeozoic granite and dykes, and along most of their eastern margin are faulted against the granite. Locally, sheared and granitized rocks and a little biotite-quartz hornfels occur against the granite boundary.

PALAEOZOIC.

A small area of weathered, grey-green sandstone, siltstone, and black shale on the western margin of the Ingham Sheet area has been correlated lithologically with the Wairuna Formation mapped in the adjoining Einasleigh Sheet area (White and Wyatt, 1960), and originally called "Wairuna Beds" by Maitland in 1891. They were tightly folded, probably during more than one episode, and have a north-north-easterly regional strike. No fossils were found, but in their type area they are reported to contain graptolites, trilobites, brachiopods, pelecypods, corals, and bryozoa of Late Lower Silurian age, and to have been deposited in an unstable shelf or shallow basin environment. The formation is intruded by the Upper Palaeozoic granites and dyke rocks, though some dark, fine-grained porphyries may represent interbedded volcanics. The boundary with the Kangaroo Hills Formation has been drawn quite arbitrarily, as the rare and very weathered outcrops do not permit a satisfactory distinction.

The Upper Silurian to Lower Devonian Kangaroo Hills Formation (originally the "Kangaroo Hills Series" of Saint-Smith, 1922), which occupies the south-western corner of the Sheet area, consists of interbedded micaceous greywacke, quartz greywacke, siltstone, shale, and subordinate sandstone or quartzite, mudstone, and lithic conglomerate. Beds are commonly between one inch and six inches thick, but massive greywacke and thinly laminated siltstone also occur. Graded bedding and bedding structures such as sole marks, fluting, and load casts, are common, and small-scale current bedding is found locally. Current directions can be determined in many places, but the complex structure precluded the reconstruction, during this survey, of palaeocurrent systems. The beds are isoclinally folded and commonly overturned and faulted. Near the boundary with the adjoining Einasleigh 1:250,000 Sheet area the regional trend is east, but towards the east of the outcrop area it changes to north-east. Individual bedding strikes, however, are highly variable, and may deviate much from the generalized, regional trend. A second phase of folding can be recognized north-east of Camel Creek Homestead, where a system of more open, similar, monoclinal folds plunging steeply south-west was imposed on the earlier isoclinal folds with mainly horizontal axes.

Tweedale and Bush (1957) give the age of the formation as Middle Silurian to Lower Devonian, whereas White and Wyatt (1960) show an age of Upper Silurian to Lower Devonian.

In the adjoining Einasleigh area, White and Wyatt (1960) distinguished between a Greenvale Formation and an (unconformably overlying?) Kangaroo Hills Formation. This distinction could not be carried over into the Ingham Sheet area - either lithologically or structurally - and the rocks in the Ingham area that are continuous with the two units in the Einasleigh area were therefore all included in the Kangaroo Hills Formation.

A small, down-faulted wedge of gently folded sediments and some volcanics, nine miles north of Kangaroo Hills Homestead, was correlated by Tweedale and Bush (1957) with the Clarke River Formation, the type area of which is along the Clarke River some 30 miles south-west of Camel Creek Homestead. This formation was originally described by Saint Smith in 1922 under the name "Clarke River Series". In the Ingham Sheet area the formation comprises siltstone, shale, sandstone, coarse conglomerate, and acid tuffs and flows. Dips are generally less than 30°, though along the faulted margins they may be almost vertical. Lepidodendron fragments are abundant in some of the shale, and Tweedale and Bush record marine fossils from limestone floaters of unknown source near the southern margin of the wedge.

The age of the formation in its type area ranges from Lower Carboniferous (Tournaisian) to possibly Middle Carboniferous; in the Ingham Sheet area the upper part of the section has probably been eroded away.

Sediments classified as undifferentiated Palaeozoic crop out on Mount Helen and other small, isolated hills in the coastal plain south of Ingham. They consist of massive impure quartzite, current-bedded in places, and generally weathered grey or brown. They are intruded by Upper Palaeozoic granite, but otherwise their relationships are unknown. White (1961) shows the Kangaroo Hills Trough as continuing through this area, and it is possible that these quartzites represent shelf sediments of that trough, preserved as roof pendants in the granite. On the other hand, the Running River Metamorphics crop out in closer vicinity, and a correlation with these cannot be rejected on present knowledge.

Small inclusions of schist several feet long have been found in the granite, and Thomson (1950) recorded schist and greywacke just south of Smoko Creek gorge.

White kaolinized, possibly tuffaceous "sandstone" occurs on the southern Cardwell Range, about 8 miles north of Ingham, and is perhaps genetically associated with the (?)Upper Carboniferous volcanics (C1) exposed around it.

The major group of rocks in the Ingham Sheet area is an Upper Palaeozoic igneous complex which was emplaced over a prolonged period and comprises porphyritic volcancis, various granitoid rocks, and acid and basic dykes. As similar granites in adjoining Sheet areas have been shown to be Late Carboniferous to Lower Permian by radioactive dating, the igneous rocks in the Ingham Sheet area are tentatively assigned to the same period, pending the results of age determinations.

The compositions and textures of the rocks differ widely, but some order can be introduced by making the following, partly arbitrary, groups, listed in what appears to be their order of emplacement:

1. Volcanic porphyries (Cl)
2. Diorite and granodiorite (Cg_1)
3. Coarse quartz-feldspar porphyry (Cg_2)
4. "Granites", sensu lato (Cg_3)
5. Microgranite (Cg_4)
6. Acid dykes
7. Basic dykes

Some of these groups are transitional, and members in one group commonly have affinities with those in other groups. This applies mainly to the groups 2 and 4.

1. The volcanic porphyries (Cl) comprise acid as well as intermediate rock types, and include pink feldspar porphyries, flinty quartz porphyries, rhyolite, rhyolitic tuff and breccia, spherulitic rhyolite, glassy rhyolite, rhyodacite, dacite, micro-adamellite porphyry, green-grey dacite porphyry, and many other modifications and variants. These rocks are generally massive and structureless; flowbanding, - - [illegible], where present, dips at various angles but is usually steep. Most of the rhyolitic types contain phenocrysts of quartz, potash-feldspar (commonly perthitic), and soda-rich plagioclase, in a matrix that may be fine-grained, xenomorphic, felsitic, devitrified, glassy, spherulitic, or recrystallized. The mafic minerals are biotite and less commonly hornblende, commonly altered in part to chlorite and epidote. In some thin sections the amphibole is rather blue and may be alkalic. The presence of microcline in some thin sections is interesting. Dacites, which are also wide-spread, contain white plagioclase and clear quartz phenocrysts in a fine, dark matrix, and have biotite and hornblende as mafic constituents. Feldspar porphyry is well exposed along the Wallaman Falls in Stony Creek, from where it was described by Branch (1962) as welded tuff with a composition grading from trachyandesite at the bottom of the gorge, through rhyodacite, to rhyolite at the top. Spherulitic rhyolites are common west of Garrawalt Creek, and in the hills

north and south of Ingham. Tuff and breccias occur on Orpheus Island, the northern part of Hinchinbrook Island, the Cardwell Range, and west of Mount Lee. Micro-adamellite porphyry is exposed mainly in the north-west, south of Cameron Creek. Small areas of andesite occur in the vicinity of Tomlin Creek and the Murray River, and some of these outcrops are perhaps plugs or dykes.

The volcanic porphyries are intruded by associated granites and granodiorite. This may be inferred from the following points of evidence:

a. porphyry is intruded by pink granite in Little Crystal Creek (not shown on the map), a tributary of Crystal Creek on the south-eastern boundary of the Sheet area;

b. the pink leucocratic granite in the area east of Oak Hills Homestead generally has a chilled border of microgranite against the porphyry;

c. thin sections of porphyries from the vicinity of granites commonly show recrystallization and some probable thermal metamorphism (formation of fresh, decussate biotite clusters probably after hornblende). In places recrystallization has been so intensive that the porphyries seem to grade into the intruding adamellite, for instance in the area north of Oak Hills homestead.

The general mode of occurrence of the porphyries is that of huge, slab-like roof pendants in the sub-horizontal roof area of the granites. Because of this, the boundary between granite and porphyry in many places follows the scarp bounding the ranges and plateau, thus creating the false impression that the porphyries have been laid down on the granite.

The porphyries north of Kirrama Homestead are continuous with the Glen Gordon Volcanics and possibly with the Sunday Creek Volcanics of the Atherton 1:250,000 Sheet area (Best, 1962). As the porphyries in the other parts of the Ingham Sheet area strongly resemble the northern members, they are, for lack of evidence to the contrary, all correlated with the Glen Gordon Volcanics. Their age is given as Permian by Best (1962), but Branch considers them Upper Carboniferous, which is more likely because they are intruded by granites that are probably Upper Carboniferous to Permian.

2. The group designated diorite and granodiorite (Cg_1) is named after its most typical rock types, but the actual range in composition is from olivine gabbro to hornblende-biotite adamellite. This purely lithological grouping is made for the practical purpose of field mapping only, and

does not necessarily imply genetic relationships; it is possible, for example, that the gabbro represents a separate intrusive phase, or that the more acid adamellites should be included with the granites (Cg_3) into which they appear to grade.

Only the larger outcrop areas are shown on the map; numerous smaller and unmapped outcrops are scattered throughout the Sheet area. The largest body is an irregular stock in the headwater region of Douglas Creek in the south-west. This was mapped as syenite by Tweedale and Bush (1957), but consists mainly of coarse to fine-grained hornblende-biotite and hypersthene-hornblende-biotite diorites and some quartz diorite.

Olivine gabbro was found at Mount Dora, 4 miles west of Kangaroo Hills Homestead.

South of Mount Fox are two irregular intrusions of hornblende diorite, hornblende-quartz diorite, and tonalite.

Most of the other outcrops consist of hornblende-biotite granodiorite and, especially along Gowrie Creek, of hornblende-biotite adamellite. In all the diorites and granodiorites studied, sphene, apatite, iron oxides, and pyrite are abundant accessories.

A characteristic of the diorites and granodiorites is the presence of xonoliths, which are quite abundant in places. They are darker than the host rock, have a high percentage of hornblende and biotite, and generally have sharp outlines, although in some outcrops they become more shadowy and tend towards complete assimilation. Most contain feldspar porphyroblasts which are probably metasomatic. In Gowrie Creek, xenoliths in granodiorite are so numerous and large that the granodiorite merely forms veins between them. Along the Murray River, a hornblende andesite outcrop was seen to be cut by a trellise of fine north-westerly veins of granodiorite; further into the granodiorite the blocks thus formed become a series of closely-packed, rounded lozenges, and grade further still into small, sparse, rounded xenoliths. Along the Burdekin River in the west, granodiorites are contaminated with andesite, and a grey biotite adamellite grades through granodiorite into dacitic or andesitic porphyry.

These examples suggest that much of the diorite and granodiorite was produced by assimilation of basic material by a more acid magma. However, primary basic magma may have existed side by side with this more acid magma, as suggested by the presence of olivine gabbro, and we may expect that some of the granodiorites are normal differentiation products.

Although normally the granites (Cg_3) are seen to intrude the rocks of this group (Cg_1), in at least one outcrop granodiorite seems to intrude granite; hence their periods of intrusion probably overlapped.

3. Intrusive coarse quartz-feldspar porphyries (Cg_2) of a characteristic appearance occur in several places in the Ingham Sheet area, but are sufficiently developed to be mapped as a separate unit only in the Cardwell Range, about 16 miles north-north-west of Ingham. Here they occur as rocks of variable texture and composition, and are intimately associated with other rock types, mainly altered dacites, which in places seem to grade into the porphyry. The porphyry (Cg_2) is easily distinguishable from the other igneous rocks in the Sheet area by its large, idiomorphic phenocrysts of feldspar and quartz, commonly 1 cm. to 2 cm. across. Its composition ranges from micro-granodiorite to micro-granite. The feldspars are plagioclase and orthoclase; in places pink orthoclase is rimmed by white albite or oligoclase. The groundmass is a more or less altered, fine-grained, equigranular, xenomorphic aggregate of mainly quartz and alkali feldspar with hornblende, biotite, apatite, and secondary sericite, chlorite, epidote, and calcite. There are indications of strong recrystallization in the groundmass, and the phenocrysts are much altered and locally crushed or strained.

The complex is surrounded by pink granite, against which it is faulted on the eastern side and possibly also on all other sides. The time relationships between the coarse porphyries and the surrounding granite (Cg_3) are not known because of the faulted contacts. Possibly the porphyries are older than the granite in view of their association with (volcanic?) dacite, and their recrystallization. However, similar porphyries occur elsewhere in the Cairns hinterland as broad dykes cutting through the youngest granites; furthermore the dacite need not necessarily be volcanic but could be a dyke rock, and the recrystallization may also be interpreted as a protoclastic effect caused by emplacement of the porphyry during the faulting and shearing that affected the granite. It is therefore equally possible that the porphyry is later than the granite.

4. Under the heading of Granite (sensu lato, Cg_3) are brought together granitoid rocks of various compositions and textures which apparently grade into one another: grey to

light-pink biotite granite and adamellite; pink leucocratic granite and alaskite; grey hornblende-biotite adamellite; peralkalic riebeckite granite; micro-granite, micro-adamellite, aplite, and pegmatite. The colour of these rocks ranges from grey, creamy or soft pink in the adamellites to pink and red in the more alkalic members; the leucocratic alkali granites and alaskites especially are generally deep pink to red. Most of the rocks are porphyritic in varying degrees. The microperthitic potash-feldspar is microcline-perthite in places, but the typical microcline twinning is commonly only faintly discernible, and it is probable that some of the untwinned potash-feldspar in other specimens is untwinned microcline rather than orthoclase. Microperthite of the lamellar vein, film, or string perthite type is especially well developed in the leucocratic alkali granites and alaskites. Granophyric quartz-feldspar intergrowths are common in the most acid and leucocratic rocks.

The predominant type of Cg_3 granite south of the Herbert River Gorge is a coarse, pink alaskite, whereas north of the river a far greater range of rock types exists. The alaskite is composed of quartz, microperthite, albite or albite-oligoclase, and a little brown biotite which is commonly chloritized in part. Epidote-zoisite minerals are common as an alteration product of plagioclase and biotite, and zoned orthite is an uncommon but persistent accessory. North of the Herbert River are variants of light-pink or grey, hornblende-carrying biotite granites and adamellites. Near the bridge at Blencoe Creek in the north-west, a small outcrop of micro-adamellite with randomly oriented acicular hornblende resembles the micro-adamellite of Mount Stuart, near Townsville. Muscovite-biotite granite was seen in one place only, namely on Goddard Creek, where it crosses the Kirrama Range road.

Micro-granite, aplite, small granite pegmatite, and fine-grained porphyritic marginal granite are local modifications. Boundaries between the fine-grained marginal granite and similar-looking volcanic porphyries are transitional in places, and are therefore arbitrarily drawn on the map, for example in the area north of Oak Hills Homestead. This is probably a textural convergence between a chilled and contaminated granite border on the one hand and recrystallized, granite-intruded porphyry on the other. Micrognanite very commonly occurs as a chilled border of granite in contact with volcanic porphyries; where they are present in the middle of intrusions they probably indicate roof areas of the granite.

An interesting rock is the riebeckite granite of Hinchinbrook Island (de Keyser, 1964). This granite is similar to the alaskite with which it is associated, being composed of quartz and microperthite, but with a little interstitial soda-amphibole. The rock is somewhat drusy; pegmatitic schlieren are common, and in these riebeckite may attain dimensions of more than 6 cm.. Chemically the mineral is an arfvedsonitic riebeckite, but it has some unusual optical properties. The drusy character of the rock, the formation of pegmatite, the late formation of the interstitial riebeckite, the strong alteration of original biotite, and the wide-spread formation of deuteric albite seem to point to a late-stage alteration of the rock by hot, sodic solutions or vapors.

Most granites are weathered and altered to varying degree: feldspars are sericitized and kaolinized, and mafic minerals chloritized and epidotized. Epidotization is particularly common in many alaskites and in the faulted granite south-west of Kangaroo Hills Homestead, which also contains some tourmaline and is intruded by thick veins and stringers of quartz.

The granites have indurated the Palaeozoic sediments they intrude, and biotite or garnet hornfels is developed locally. They have recrystallized the volcanic porphyries in their vicinity, and in the Fungus Creek area the porphyry appears to have become granitized by the development of potash-feldspar porphyroblasts.

Field relationships show that the granites were not intruded in one single phase. In general the more acid rocks are later than the less acid, as might be expected, but this does not necessarily mean that all similar phases are of the same age.

No absolute age determinations have yet been made on the granites of the Ingham Sheet area. Age determinations on granites elsewhere in the Cairns hinterland indicate a spread from Middle Carboniferous to Lower Permian; the later granites occur in the Cooktown area in the far north, and the earlier in the Atherton and Einasleigh 1:250,000 Sheet areas to the west. In the Townsville Sheet area, Permo-Carboniferous volcanics are intruded by granite similar to that occurring on the Palm Islands. Hence, the age range of the granites (Cg_3) in the Ingham Sheet area may be tentatively put as Upper (?)Carboniferous to Permian.

5. The Gorge Range south of the Herbert River consists of

two stocks of a pink, leucocratic micro-granite and porphyrytic micro-granite (Cg_4) which are elongated in a north-westerly direction. The southern stock tails off into a narrow dyke to the south-east, which in turn leads into an inferred fault. The rock consists of quartz, perthite, and microcline, with a little biotite, iron oxides, sphene, tourmaline, and rare blue soda-amphibole. Granophyric textures are common, and the rock is somewhat drusy.

Although the micro-granite (Cg_4) is very similar to the micro-granites associated with the granites (Cg_3), it is thought to be younger than these (see page 18) and is therefore shown as a separate unit on the geological map.

6. The geological map gives only a sketchy picture of the many swarms of acid dykes in the Ingham Sheet area: all the large swarms shown are in open country where they can be detected on airphotos, but more are known to occur in heavily timbered country where photo-interpretation is hardly possible. The numbers of individual dykes in the swarms is far greater than shown, to the extent that in places they obscure the granite country rock.

These acid dykes consist of rhyolite, felsite, aplite, trachyte, and, near the western boundary of the sheet area, a few riebeckite micro-adamellites. Coarse, pink feldspar porphyry dykes are found mainly in the Hidden Valley area, but are also known at Mount Farquharson and in the Cardwell Range. Most of the dykes are weathered pink or mauve, but where fresh their groundmass may be light or dark grey, black, mauve, cream, or pink, and their texture finely crystalline to dense and flinty.

The dykes cut all the igneous rocks so far described. Most are only a few feet to a few yards wide, but owing to their enormous number the total dilatation of their country rock must have been considerable. Almost all acid dykes trend north-west, parallel to the direction of the Palmerville Fault.

7. Although basic dykes are found throughout the area, they are far less numerous than the acid dykes, and their trend, though generally north to north-west, shows a wider range of deviations. Most are hornblende, augite, or olivine dolerites or quartz dolerites; some are andesite or andesite porphyry. In the Hidden Valley area a few altered diorite dykes were found.

The basic dykes were, on the whole, formed later than the acid dykes, but several phases of intrusion do exist, and their emplacement overlaps that of the acid dykes.

The age of the dykes is not known, but in general they appear to represent the last phase of the late Palaeozoic period of igneous activity. It is possible, however, that the olivine dolerites may be associated with the Late Cainozoic vulcanism.

Relationships and genesis of the Upper Palaeozoic igneous rocks.

The igneous rocks in the Ingham Sheet area have a complex history. Contacts between related rocks of one type, and intrusive relationships between different types, indicate a multi-phase emplacement of the igneous complex, and although the granite masses appear to form a coherent batholith, they are in fact composite bodies, as is shown in the following examples, which are only a few of many.

Small textural and compositional variations in the Palm Island granite, as well as its photo pattern, suggest that the rock was emplaced as a series of sheets.

Older granite may be metasomatically or thermally affected by later granite, as is indicated in an exposure on the Gregory Highway on the southern boundary of the Sheet area, where grey biotite micro-adamellite is intruded by pink leucocratic granite, and, probably as a result of this, porphyroblasts of microcline have been formed in the adamellite. The leucogranite has a horizontal margin of pegmatite and aplite in contact with the grey micro-adamellite.

In the Gorge Range, the microgranite Cg_4 is thought to be later than the granite Cg_3 because it appears to be intruded along, and to pass into, a fault traversing the granite; furthermore, the microgranite Cg_4 carries some tourmaline, and the mylonite zone along the Palmerville Fault through the granite at Smoko Creek is intensively tourmalinized. These observations suggest that there was a post-(Cg_3)granite magma phase enriched in boron and intruded along faults as microgranite.

Apart from sharp intrusive contacts between different granites, there also appears to be a continuous gradational range of Cg_3 granite types from grey hornblende-biotite adamellite through grey and pink biotite granite to leucogranite, and from fine-grained to coarse-grained varieties. The changes take place by:

change in type of ferromagnesian mineral from hornblende to biotite;

decrease in proportion of ferromagnesian minerals;

decrease in plagioclase content;
increasing tendency to form granophyric textures and exsolution microperthites.

Because in the granodiorite group (Cg_1) complete gradation was seen between hornblende-biotite adamellite and basic hornblende diorite, a continuous compositional range may exist in the two groups Cg_1 and Cg_3, hornblende-biotite adamellite forming the common link. This should be regarded as a lithological range only, as it is quite possible that two magmas-one basic, one acid-have participated. In other words, it is considered likely that the igneous sequence resulted not only from fractionation differentiation but also from assimilation and hybridization. For example, the abundance of basic xenoliths and associated digestive features in the hornblende-biotite granodiorites and quartz diorites is sufficient evidence to suggest that these rocks were produced by assimilation of, most probably, basic igneous rocks by a granitic melt. It is also shown that where intrusive contacts are exposed the more acid members are later than the more basic rock. This does not mean that all members of identical lithology are of the same age: elsewhere in the Cairns hinterland it has been shown by K-Ar age determination that identical rock types may have different ages in different areas, so that there is a widespread chronological overlap between the various rock types.

Although no modal or normative data are available for the granites in the Ingham Sheet area, nor their trace element distribution or absolute ages, an attempt is made to sketch the igneous history along the following lines:

Primary basic magma, assumed to have existed at a certain level in the upper mantle, was intruded during the Late Palaeozoic orogeny. At the same time granitic magma was being generated by differential melting and anatexis owing to the increased temperature and pressure. After the orogeny had passed its climax, and stress release had set in, both acid and basic magmas could find their way quickly to the surface and be emplaced as volcanic sheets and dykes. During this process intermingling of the two magmas probably took place. The main part of the acid magmas or migmas, however, slowly made its way upward as diapiric masses, which on their way intersected much basic material of the earlier-intruded primary magma. Contamination and assimilation followed on a large scale, giving rise to the xenolithic diorites and granodiorites. Later waves of granite intrusions were less contaminated, for the chemical differences between them and the traversed rocks, which were largely composed of contaminated granites of the previous phase, had decreased considerably. Hence the normal processes of fractionation-differentiation could become of increasingly greater importance. Plutonic igneous activity finally declined, but fractures caused by continuing post-orogenic tensional stresses provided channelways along which rest-magma and primary basic magma could rapidly surge upwards and form dykes. The emplacement of basic dykes was more prolonged because of the availability of primary magma after all the acid rest-magma had solidified.

The scarcity of outcrops of basic igneous rocks such as gabbro and diorite is perhaps due to their not having the "buoyancy" of the acid melts which, because of their lower specific gravity, could rise higher in the rock pile by diapirism.

Correlation of the Late Palaeozoic igneous rocks.

The reasons for correlating the volcanic porphyries in the Ingham Sheet area with the Glen Gordon Volcanics have been set out on page 14 . Time correlations of the various granites with named and defined granites in adjoining areas are not yet possible. The bodies of granitic rocks are continuous with undifferentiated pink leucogranite (de Keyser, 1963b) to the north; with Herbert River Granite (Branch, 1962) to the west; and with Oweenee Granite (Wyatt, in White, Stewart, Branch, Green, and Wyatt, 1959) to the south. Parts of the granite are lithologically similar to each of these, and also to the Elizabeth Creek Granite (Branch, 1962), to the pink Castle Hill granite in Townsville, and to the Tully Granite Complex at Tully on the Innisfail 1:250,000 Sheet area. Much of the rock shown as Herbert River Granite along the eastern border of the adjoining Einasleigh Sheet area resembles more strongly the Elizabeth Creek Granite, especially south of the Herbert River. In general then, previous definitions of granite types, which may have held farther to the west, do not apply in the Ingham Sheet area; types occurring in distinct masses elsewhere here appear to be only parts of a continuous series, and a lithological type has no absolute age significance.

Generalizations about the Herbert River Batholith (White, 1961; Branch, 1962) to which the Ingham granites geographically belong, do not apply in this area. Such generalizations presented, for example, in Branch's summary of his study of the area to the west, state that the batholith is an essentially homogeneous biotite adamellite to hornblende-biotite granodiorite; that xenoliths are rare or absent; and that roof pendants appear to be rare. Rather the opposite seems true in the Ingham Sheet area.

The relative ages of the granites tend to follow an order from basic to acid, as discussed above. However, in this respect the leucocratic alaskites south of the Herbert River may present a problem, for on the one hand they strongly resemble the Castle Hill granite in Townsville, thought to be one of the older granites in the area (personal communication by Dr. P.J. Stephenson); on the other hand they also resemble typical Elizabeth Creek Granite, known as a late-stage granite type elsewhere in the Cairns hinterland (which is as might be expected in the event of magmatic differentiation). It is possible that the abundance of dyke swarms in the alaskite as compared with their relative scarcity in other granite types, points to a greater age for the alaskite; on the other hand the distribution of the dyke swarms may well be structurally controlled only, as they appear to be concentrated south of the Palmerville Fault, being scarce north of it, and this happens to coincide more or less with the distribution of the alaskite.

The Palm Island granite and adamellite closely resemble the granite on Magnetic Island in the Townsville area, which probably belongs to a late phase of intrusion, according to Dr. P.J. Stephenson (personal communication).

CAINOZOIC.

Cainozoic rocks are divided as follows: an undifferentiated group (Cz) of sediments, laterite, lateritic soil, billy, and diatomite; (undifferentiated) basalt (Czb); Quaternary alluvium (Qa); talus and scree (Qt); and beach sand and dunes (Qr).

The undifferentiated group constitutes the main part of the Lucy Tableland and its outliers. The sediments comprise pebble conglomerate, sandstone and secondary quartzite, granite "wash", clay, and diatomite. They are commonly current-bedded and generally not well sorted, and are white, cream, brown, or red. The total thickness in the Ingham Sheet area is about 150 feet, but owing to a rather undulating and uneven basement they lens out in many places, and merge with surfaces of lateritized basement.

The diatomite crops out mainly in the Flaggy Creek area, where it lies at, or close to, the top of the section. It is white, porous, and light, but impure and of poor quality (White and Crespin, 1959); its age may be Pliocene (Best, 1959). The diatomites in North Queensland are thought to have been deposited in lakes formed by the damming of streams by basalt flows (Best, 1959).

All these sediments, and the exposed erosion surface that forms their basement, were subjected to prolonged weathering during the Tertiary, and acquired a deep soil profile which locally may be called a laterite (although much of what is loosely called "laterite" in the area would not strictly fit the definition of true laterite). Six samples from a 16-foot soil section south-east of Princess Hills Homestead were analyzed by the Australian Mineral Development Laboratory (analyst: C.R. Edmond) in Adelaide. The results show that in the upper two or three feet the content of SiO_2 decreases sharply downwards, whereas Al_2O_3 and K_2O, and to a lesser degree Fe_2O_3, increase. Below this level, SiO_2 gradually increases again, and Al_2O_3 decreases slowly. K_2O and Fe_2O_3 remain virtually constant or increase only slightly.

In the weathering profile, red ferruginous grits and nodular ferruginous crusts are widespread. North of Kangaroo Hills Homestead, mammillar or broken "ironstone" and billy crusts are formed on the Cainozoic sediments, and for such formations "duricrust" is a better term than laterite. "Billy" or silicified sandstone is widespread on mesas in the south-west of the area. On a hill 5½ miles north-north-east of Kangaroo Hills Homestead billy is formed by cementation towards the top of 150 feet of current-bedded, pure white Cainozoic sandstone. At the 15-Mile Mine, a similar billy 2 to 30 feet thick, is underlain by gravels which rest on granite. Possibly the silica necessary for the cementation was derived from the weathering of feldspar and other impurities in the original sandstone, because the sandstone is now extremely pure and quartzose.

The undifferentiated basalt (Czb) includes basalt of more than one age. An older, vesicular, fine-grained olivine basalt occurs in the north-west of the area, and has been tentatively correlated with the Wallaroo Basalt which covers about fifty square miles along the Herbert River west of the Ingham Sheet area, and is considered to be Upper Miocene or Lower Pliocene (Best, 1959). This basalt is cut by the Herbert River gorge, and seems to be associated with the ?Pliocene sediments of the Lucy Tableland. A basalt of much later age is represented by the Recent flows around Mount Fox, filling valleys formed in the original tableland. The perfect cone shape of Mount Fox and its general lack of vegetation, apart from grass, indicate that the last eruptive phases must have been in Recent or even sub-historic times. Deeply-weathered remnants of much older Mount Fox basalt occur on a somewhat higher level on the north-east side of the cone.

Boring for water in the coastal plain along the Herbert River has shown the alluvium (Qa) in this delta region to consist of clay, sandy clay, sand, gravel, and some conglomerate; mangrove mud is intercalated at depths between 10 feet and 35 feet below the surface, a few miles inward from the present coast (Calvert, 1959). The total thickness of sediment penetrated by the bores reaches a maximum in the Palm Creek area, where granitic basement occurs at depths of more than 315 feet. Fluviatile, lagoonal, and shelf sediments are probably interbedded under the coastal plain and continental shelf because of oscillations of the sea level, actual or relative. The age of the alluvium probably ranges back to Pleistocene or perhaps even Late Tertiary at the base. The alluvial deposits, excepting the most recent ones, are commonly mottled and cemented.

Boulder conglomerate and gravel are perched beside creeks on the sides of some of the ranges, especially among the headwaters of Broadwater Creek. They may be Pleistocene.

In parts of the ranges, large areas of colluvial to alluvial scree and talus (Qt) composed of unsorted boulder and gravel deposits have been deposited by both fluviatile and gravitational transport.

Old beach sand (Qr) remains in strips and patches separated from the present coast by swamps and lagoonal deposits. Their former strand lines are still recognizable on airphotos. Dunes have been formed in a narrow strip along the north-east shore of Hinchinbrook Island (see page 7). Beach rock, which is hard, carbonate-cemented beach gravel, is found on several of the continental islands above sea level. According to most investigators (Russell, 1962; and others), beach rock is formed in those places where seeping, fresh groundwater mixes with seawater, particularly where the average temperatures are high. Also found on raised beaches on many of the islands are considerable quantities of pumice.

Shelf deposits, though not exposed, are described by Fairbridge (1950), and are at least 400 to 500 feet thick (see page 7).

STRUCTURAL GEOLOGY

Large tracts of igneous rocks separate several geologically different regions in the Ingham Sheet area: the (?)Precambrian Running River Metamorphics in the south; segments of the Early Palaeozoic Broken River Embayment (Hill, 1960), including the Kangaroo Hills Trough (White, 1961) in the west; and the trough of the Barron River Metamorphics, now considered part of the Hodgkinson Basin (de Keyser, 1963b), to the north (contrary to what is shown on the 1963 Geological Map of Queensland the Barron River Metamorphics do not crop out in the Ingham Sheet area). Owing to the large volume of igneous rocks, no coherent structural picture encompassing the various folded sedimentary regions was obtained.

Little is known of the structural regime of the Running River Metamorphics, apart from the fact that they are steeply folded, and have a north-easterly regional trend.

In the Kangaroo Hills Trough, bedding trends generally range from north-east to east. Folding is tight, steep, and apparently complex, and its pattern was not unravelled during the survey. Two stages of folding were recognized north-east of Camel Creek Homestead, where the fold-axes of the second stage plunge steeply south-west.

From the Late Palaeozoic, the regional structural trend has been mainly north-west. This is expressed in the trends of dyke swarms, faults, and shear-zones, not only in the Ingham Sheet area but also, and even more so, in the regions of the Hodgkinson Trough farther north. Faulting has been active on several occasions, and its effects can be demonstrated in the field (shearing, mylonitization) as well as under the microscope. Undoubtedly many more faults exist than are shown on the map, having escaped detection because of the thick forest cover and the lithological uniformity. One of the main features, the Palmerville Fault, which runs from Cape York to Townsville, and is regarded as defining the western boundary of the Hodgkinson Basin (de Keyser, 1963a), can be traced on recent photomosaics of the Ingham Sheet as a continuous lineament. Tourmalinized mylonite zones were found along this line in Smoko Creek; otherwise, however, its expression in the field is unobtrusive, and there is no evidence for any recurrence of movement along the fault during the Cainozoic such as did take place in its northern extension in the Chillagoe district and beyond.

Significantly, the many dyke swarms run parallel with this north-westerly trend of the Palmerville Fault, and were probably formed in response to the same stress field. Doming along an axis parallel to, and south-west of, the Palmerville Fault may have played a part in the formation of open fractures along which acid magma could rise as dykes.

Besides the dominant north-westerly fault trends, other trends present are easterly and north-easterly, especially in the Kangaroo Hills-Hidden Valley area. In places block faulting resulted, an example of which is preserved in the downfaulted outcrop area of Carboniferous sediment 9 miles north of Kangaroo Hills Homestead.

Jointing is well developed and widespread in most granites and volcanics, and commonly extends into the adjoining hornfels and indurated sediments.

GEOLOGICAL HISTORY

The area contains only small parts of a number of depositional environments that have been dealt with in separate reports to which the reader is referred for more detailed information (White, 1961; White, Best, Branch, 1959; White and Wyatt, 1960; Wyatt and White, 1960).

The earliest history of the region is not well known. Traces of a possible Precambrian sedimentation and volcanic period are represented by the schists and amphibolites of the Running River Metamorphics.

Palaeozoic sediments were deposited during the Lower Silurian in a shallow-water environment (Wairuna Formation), and later, during the Upper Silurian to Lower Devonian, in a somewhat deeper, geosynclinal environment (Kangaroo Hills Formation). These periods are reported to have been separated by an early Upper Silurian orogeny, evidence for which can be found in the type areas of the formations. A major orogeny occurred in the Lower or Middle Devonian, when the greywacke and siltstone sequence of the Kangaroo Hills Formation was folded by stresses whose components were apparently directed north or north-west.

Another major orogeny, with its paroxysmal phase in the Early Carboniferous, made itself felt mainly in the Hodgkinson Basin farther north, where it was responsible for the folding of the Devonian sediments. Its effects are not obvious in the Ingham area, where older formations had already been strongly folded and had largely become landmasses surrounded by a shallow, epineritic sea, in which the Clarke River Formation was laid down in a littoral environment. The gentle folding of this formation is probably due to aftereffects of the Carboniferous orogeny.

The orogeny was immediately followed by a period of igneous activity-extrusive as well as intrusive-which lasted from the Middle Carboniferous to the Permian, and which closed with the intrusion of acid and basic dykes.

There is no record from the Mesozoic, during which the Ingham Sheet area was probably eroded down to a low, inert, mature or old landmass not far above sea level. This situation continued into the Tertiary. The main water divide at that time must have been close to the present-day ranges bounding the plateau in the east, and the Herbert River and Burdekin River were consequent, west-flowing systems.

During the Middle Tertiary, some uplift and warping set in, along an axis west of the Ingham Sheet area. Owing to the stronger uplift of the middle river courses, their upper courses became old, meandering streams which deposited their load mainly between the eastern main divide and the ultimately established divide in the west, possibly in a series of lakes. When eventually their middle courses were totally disrupted by continued warping and by extrusions of basalt in the region of the new divide, probably during the Pliocene, new outlets were found to the east through the lower gaps in the eastern divide, possibly helped by capture in some places. Uplift or warping continued, perhaps in several stages, during the Late Cainozoic. The strongest of these vertical movements, probably at the end of the Pliocene or the beginning of the Pleistocene, elevated the plateau region to approximately its present position.

ECONOMIC GEOLOGY

by

L.G. Cuttler

INTRODUCTION.

Mining in the area began with the discovery of alluvial cassiterite at the junction of Prospector and Oaky Creeks, following original finds in 1875, at Running Creek, a tributary of the Star River about 25 miles south of the southern boundary of the Ingham Sheet area. Subsequent working of the upper tributaries of Running River (Ingham Sheet) led to the establishment of the (now abandoned) township of Benham (not shown) on Hermit Creek. Alluvial tin was discovered and worked at Dingo Creek, a small tributary of Garrawalt Creek, in about 1888; at Five Mile Creek, near Cardwell, in 1895; in deep leads at Fifteen Mile Creek and Mount Fox in 1905 and 1936, respectively; and in the headwaters of Broadwater Creek in 1939 (though the presence of

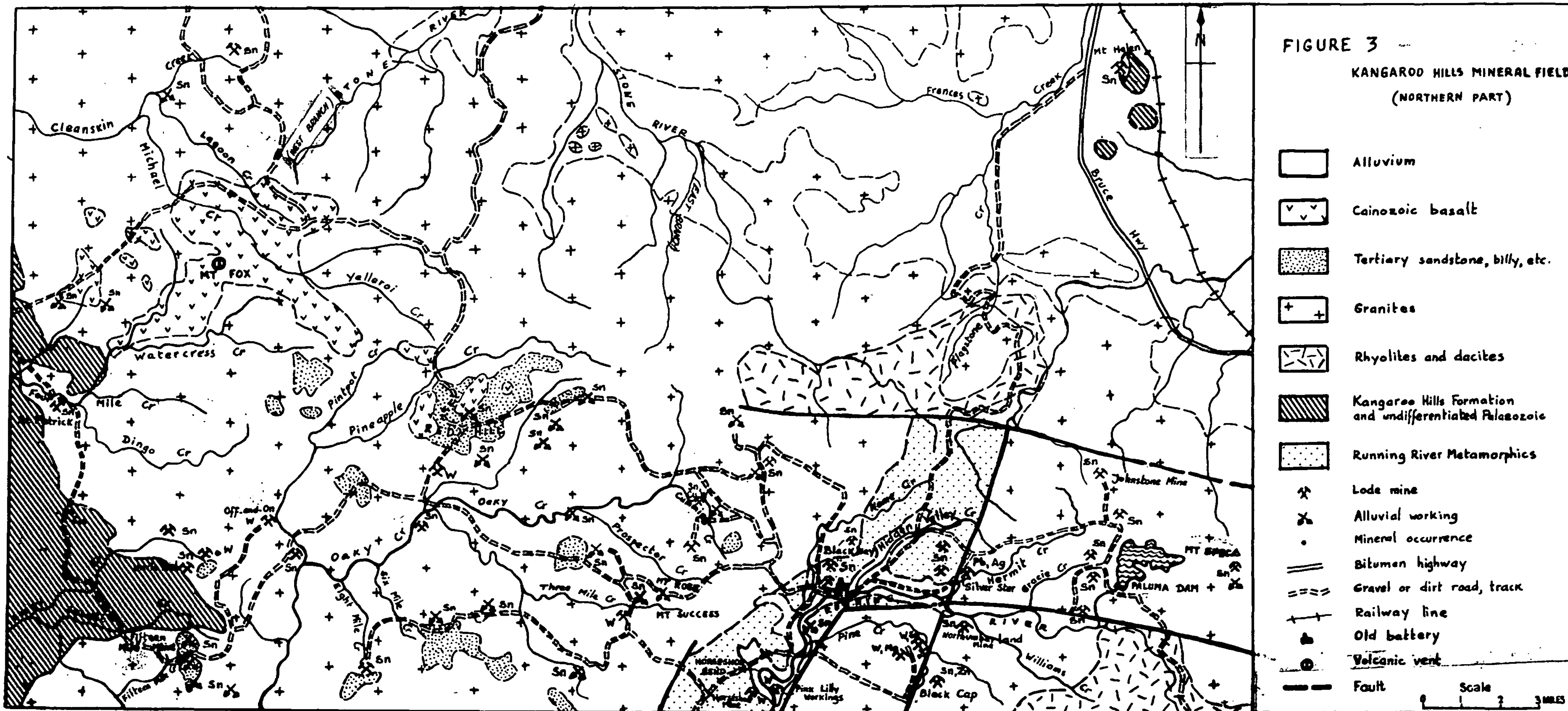


FIGURE 3

KANGAROO HILLS MINERAL FIELD (NORTHERN PART)

Bureau of Mineral Resources, Geology and Geophysics. To accompany Record No 1964/78 tin in that area had been known since 1905).

Many small lode deposits were worked, especially in the Hidden Valley area, by 1883; at Mount Spec before 1896 and in 1901; at Watercress in 1912; and at Mount Helen in 1939.

Wolframite was first mined at Ollera Creek in 1895, and also occurs in a few other localities.

Apart from tin and tungsten, which are the only metals produced in any quantity from the Ingham Sheet area, a number of other metals is known to be present, but production of these has been negligible. They include antimony, bismuth, molybdenum, copper, lead, zinc, gold, and silver.

Non-metallic materials produced in the Ingham Sheet area are aggregate and road metal, and clay; a few beach sands were tested for heavy minerals, but no economic concentrations were found.

TIN.

Tin, in the form of cassiterite, occurs:

a- in Recent stream alluvium,

b- in Tertiary deep leads,

c- in lodes in granite and adjoining contact zones.

In the Ingham Sheet area, alluvial tin was first found at the junction of Prospector and Oaky Creeks, and since then the production has been mainly from alluvial deposits, including deep leads. Lode mining came to the fore after 1914 in the Kangaroo Hills Mineral Field, most of which lies within the adjoining Townsville 1:250,000 Sheet area, and is officially credited with a total yield, between 1885 and 1962, of 8281 tons of cassiterite concentrate (valued at £1,050,574); about 3605 tons of this were from alluvial sources.

Separate returns for the individual workings in the Ingham Sheet area were usually not prepared, nor are the few official figures complete. However, it is estimated that more than 1365 tons of cassiterite concentrate (of which 1155 tons were from alluvial deposits) have been produced in the Sheet area.

a) Recent alluvial deposits.

The deposits first worked were in Recent alluvium in the beds, banks, and small flats along Running River, Hermit Creek, the upper part of Oaky Creek (sometimes referred to as Sandy Creek), Prospector Creek, Three Mile Creek, Six Mile Creek, Eight Mile Creek, Pineapple Creek, and a few smaller creeks and gullies. Later, cassiterite concentrations were found elsewhere in Cleanskin Creek, Garrawalt Creek, Broadwater Creek, and Five Mile Creek. Most of these areas are largely worked out, though a little tin can still be recovered after each wet season. Commonly the cassiterite in the alluvial deposits is accompanied by other heavy minerals such as ilmenite, magnetite, zircon, garnet, topaz, wolframite, and in places also gold.

The workings along Garrawalt Creek (Keid, 1937) and one of its tributeries, Dingo Creek, extend for about 12 miles. Cassiterite has been recovered intermittently ever since its first discovery in 1888. It occurs in granite-derived alluvium forming terraces and flats that may be up to 30 chains wide owing to the meandering course of the creek. At least two terraces are recognized, the older of which is up to about 30 feet above the present stream level. The alluvium ranges from clayey sand to coarse, bouldery gravel, and is interspersed with granite cobbles and quartz pebbles. Lenses of coarse sediment commonly occur throughout the finer material. The average thickness of the alluvium is 35 feet or more; that of the "wash" proper is 6 to 7 feet and increases to 15 to 20 feet close to the main channel. The overburden generally consists of red and white mottled clay. Commonly the wash itself is similarly mottled, and is locally cemented by iron oxides.

The cassiterite has been derived from the weathering of numerous stanniferous quartz and quartz-mica veins filling north-westerly to north trending joints in the granite. The granite close to these joints is generally slightly greisenized and somewhat stanniferous.

The limited water supply and the accumulation of tailings prevent continuous sluicing. Production figures for the early (and most productive) years are not known. Between 1936 and 1962 the area yielded about 81 tons of concentrate, and some mining is still going on. The average recovery is about one or two pounds of concentrate per cubic yard; rich patches may carry as much as 8 to 10 lb. per yard. The grade of the concentrates ranges from 53 to 74 percent cassiterite.

During 1959-1960 Mount Isa Mines Limited carried out a detailed prospecting and drilling programme for alluvial tin at Black Adder Flat on Garrawalt Creek, about 3 miles south of Garrawalt Falls. A total of 22 holes were sunk in the flats and terraces on either side of the creek, over a distance of 60 chain, and these revealed thicknesses of alluvium ranging from 25 to 51 feet. The wash proper was from 2 to 20 feet thick, and was overlain by 12 to 35 feet of overburden. In only four boreholdes were values of ½lb. or more of concentrate to the yard obtained, and most of the wash drilled contained less than 2 oz. per yard. The best value---4¾lb. per cubic yard---was found in 5 feet of wash at a depth of 30 feet, in a high terrace about 6 chains west of Garrawalt Creek (Foord, 1960).

Although cassiterite was known to be present in the B r o a d w a t e r C r e e k area since 1905, it was not until 1939 that economic deposits were found in the headwaters of Broadwater Creek, 5½ miles south-west of Cardwell. The deposits are situated on a dissected, jungle-covered plateau of medium-grained, pink to grey granite, 2000 to 2200 feet high. The principal workings have been along Francis Creek and Paddy's Gully (not shown on the map). The cassiterite occurs in flats of Recent alluvium up to 2½ chains wide along the creeks and also in the creek beds. The stanniferous wash is up to 4½ feet thick and is covered with overburden up to 8 feet thick (Cribb, 1940). The alluvium grades from coarse, pebbly wash to sandy clay, and in places contains large scattered boulders of granite. The cassiterite content may be as high as 37½ lb. per cubic yard (Cribb, 1940), and the average value is about 5 to 7 lb. per yard. Along Francis Creek, tin is concentrated in well defined lines which mark old stream courses. Blocks of an older, cemented wash contained 4 to 5 lb. of cassiterite per cubic yard, and were probably a source for some of the Recent deposits. The cassiterite is generally fine-grained and quite angular. Traces of gold and wolframite accompany the cassiterite.

The cassiterite in P r o s p e c t o r C r e e k, a tributary of Oaky Creek, ranges from coarse slugs more than 1½ inch across, to fine sand-sized particles. Assays of up to 76 percent Sn indicate that the cassiterite is of very high grade. Local sources put the total production of tin concentrates at about 100 tons.

In 1939, the Adelaide Tin Exploration Company test-drilled their dredging claim along R u n n i n g R i v e r, including the alluvial flats on both sides of the river extending upstreams from the Gregory Highway crossing. Nine bore holes were sunk to depths of 40 to 50 feet, but the values found were all less than ¼ lb. of concentrates per yard (Lee, 1939).

In 1960, Mount Isa Mines Limited test-drilled a two-mile section of alluvium along C l e a n s k i n C r e e k east of its junction with Lagoon Creek, about 5 miles north of Mount Fox. The alluvium was 19 to 35 feet thick and contained from 2 to 9 feet of stanniferous wash. It forms flats and terraces with widths ranging from 100 feet to 1300 feet. In only two of the 16 holes drilled were values of more than ½ lb. of concentrates per yard found, the maximum value being 14 oz. per yard at a depth between 26 and 35 feet (Foord, 1960).

b) Tertiary deep leads and high-level gravels.

When the richer Recent deposits of alluvial tin became exhausted, the attention of the prospectors was turned to the areas of high-level, stanniferous gravels capping many of the ridges and hills, especially in the headwater region of Oaky Creek (Cameron, 1906). These gravels are overlain by discontinuous remnants of a horizontal Tertiary sandstone cover, extending south from Mount Fox to the head of Eight Mile Creek, and east to Prospector Creek. In some localities the sandstone is capped by small remnants of basalt. Around Fifteen Mile Creek, at the southern border of the area, the sandstone is up to 100 feet thick, but along the divide from Eight Mile Creek to Three Mile Creek its thickness is only about 20 feet (Cameron, 1906). The rock consists mainly of white, friable quartz sandstone with minor intercalations of grit and conglomerate, and it must originally have formed an almost continuous cover over the old Tertiary land surface in the western and south-western part of the Sheet area before being eroded by the present stream systems. Probably where the sandstone was previously overlain by basalt, a "billy" crust or silicified cap has been developed.

The gravels have proved to be tin-bearing over a considerable area, although few of them are of economic grade. At the Mount Rose and Mount Success localities (Fig. 3), one to two acres of wash contained up to 7 lb. of tin concentrates per cubic yard, enough to allow treatment at Three Mile Creek (Cameron, 1906). At the head of Eight Mile Creek, 1½ feet of wash at the base of a sandstone cap contained 13 lb. of concentrates per yard.

Richer deposits are located in the "deep leads", which represent old stream channel deposits in the gravels on the old land surface and are buried beneath the later sandstone cap. The deep leads at F i f t e e n M i l e C r e e k, which are estimated to have yielded 140 tons of concentrates (valued at £37,530) to the end of 1962, have produced most of the tin from this type of deposit. They have been worked, since 1905, over a length of 1¼ mile. Four adjacent but distinct deep lead areas can be recognized (Shepherd, 1943b). Three of these are south of Fifteen Mile Creek; one, the most important, extends north of this creek, has a general north-south trend, and has been worked intermittently over about ¼ mile in its northern section. Shepherd mapped its probable course for a further 30 chains south of its known position to its most likely outlet at Fifteen Mile Creek, and his location of the outlet area was supported by the findings of Ridgway (1944d) after a levelling survey around the granite-sandstone contact. However, during attempts to trace the lead south of its last known positinn, wash was detected in only one of a number of test shafts and pits, and Ridgway (1945a) concluded that the lead probably existed farther to the west of the shafts as a very narrow channel.

The stanniferous wash in the main lead has a maximum width of 100 feet, the best values occurring in a deep gutter 45 feet wide (Shepherd, 1943b). The overlying sandstone cap is 40 to 50 feet thick, on the average. The wash grades from coarse and pebbly gravel to fine, cemented sand with a few bands of kaolinitic clay, and has a maximum thickness of 7 feet and an average thickness of 2 or 3 feet. The best tin values are in the coarse material at the base of the wash, but higher lenses of coarse material were worked occasionally. Values of 40 to 50 lb. per cubic yard were not uncommon, and in places increased to as high as 1½ to 3 cwt of concentrates per cubic yard (Shepherd, 1943b). The average tin content is probably about 10 to 15 lb. per cubic yard. The cassiterite was most likely derived from numerous small tin-bearing veins in the granite. The deposits were worked mainly by underground methods, in the course of which numerous shafts were sunk to depths of more than 60 feet, and from these a network of tunnels followed the stanniferous leads. In recent years a little sluicing and dry-blowing has been carried out. Large-scale sluicing attempts between 1924 and 1927 by the Castle Dredging Company failed mainly because of an inadequate water supply, and poor tin values in the actual area sluiced were a contributing factor. Only about 16½ tons of tin concentrates were recovered from some 40,000 cubic yards of overburden sluiced.

The deep lead workings south of Fifteen Mile Creek were probably at one time joined with the main lead north of the creek. Values of up to 40 lb. per cubic yard were obtained locally from some of these workings (Ridgway, 1944d; 1947b; Shepherd, 1943b).

A large tonnage of relatively low-grade stanniferous wash ideally suited for sluicing still remains at Fifteen Mile Creek, but although the deep leads are the most attractive mining proposition in the Ingham Sheet area, large-scale sluicing is not possible because of an inadequate water supply.

Elsewhere, in the Red Hill (Fig. 3) or Allingham area, about 7 miles east-south-east of Mount Fox, a deep lead has been worked intermittently since the beginning of the century. Here, compact, current-bedded, and variously coloured sands and wash up to 20 feet thick and dipping to the west, are overlain by some 30 feet of basalt. The wash contained up to 12 lb. of tin concentrates per cubic yard. Parts of the wash were cemented and had to be crushed to free the tin. An attempt at large-scale sluicing, between 1914 and 1918, failed, again because of insufficient water and the generally low average tin values.

In another deep lead deposit, trending east-west at the southern edge of a small basalt remnant about three miles west-south-west of Mount Fox, workings comprised a number of adits, shafts, and tunnels (Morton, 1946). The alluvium is only about 7 feet thick and consists of loose sand and some fine wash with interspersed granite boulders. Morton found that the values locally occurred in the upper section of the wash. Production from the Mount Fox lead was approximately 18¼ tons of concentrates between 1936 and 1962.

A further area of deep leads occurs about 16 miles west-north-west of Mount Fox, outside the main area of stanniferous Tertiary gravels. Here, at the head of Black Cow Creek, and against a tongue of basalt, are two sub-parallel leads of apparently different age (Andrews, 1962). The course of the (uneconomic) southern lead is represented by a series of isolated hills of silicified conglomerate and sandstone. The younger lead is composed of conglomerate, ferruginous grit and sandstone, and has stanniferous gravels at the base. The sediments are exposed only along the southern edge of the basalt flow, and have a maximum width of ¼ mile. The lead trends east-west, and is slightly more than two miles long. Its possible north-western extension was mapped by New Consolidated Goldfields for a further 2½ miles (Andrews, 1962). Drilling by Mount Isa Mines Ltd in 1960 penetrated an average of 43 feet of basalt and 27 feet of sediment, including wash with thicknesses between 1 foot and

$21\frac{1}{2}$ feet. Only two holes showed values of more than $\frac{1}{2}$ lb. of tin concentrates per cubic yard in their richer sections (Foord, 1960). Three holes put down by New Consolidated Goldfields in 1962 in the same area gave an average value of 0.14 lb., of concentrates per cubic yard (Andrews, 1962).

c) Lode tin.

The tin lodes in the Ingham Sheet area are characteristically small, rich, shallow lenses and pipes, rarely persisting to depths of more than 70 feet, and generally associated with pink, leucocratic (biotite) granite. The formation of the lodes has been controlled by vertical or nearly vertical, east and north-east trending joints and fissures, in granite as well as in adjoining slate. Although the more important lodes in the Kangaroo Hills Mineral Field are in altered sediments, as at the Sardine and the Shrimp tin mines (outside the Ingham Sheet area), the majority of mines in the Sheet area are within the granite, generally close to its periphery. The ore shoots are irregularly distributed throughout the lodes, which range from chloritic veins with little quartz to highly siliceous lodes containing various proportions of chlorite (Morton, 1940). Cassiterite also occurs in quartz veins associated with greisen patches, and disseminated throughout slightly altered granite, but such occurrences are uncommon. Magnetite, garnet, fluorspar, and pyrite are commonly associated with the cassiterite in the lodes, and in many lodes copper minerals are also present. In the Blackboy or Mount Eva mine, about 1 mile north of the old Northumberland Battery, the cassiterite gave way to copper and lead at a depth of 12 feet. From a few lodes, sphalerite and scheelite have been recorded.

Shepherd (1943a) nowhere found cassiterite and wolframite associated in the same shoot, nor with certainty in the same lode, on the Kangaroo Hills Mineral Field, whereas from the Garrawalt Creek-Dingo Creek area traces of wolframite, molybdenite, and cassiterite were found associated in a single specimen. In some areas the tin and tungsten mineralization appears to be associated with a series of quartz porphyry dykes intruding the granite (Connah, 1952b; Morton, 1940; Saint-Smith, 1916; Shepherd, 1943a).

Most of the mines have produced only a few tons of concentrate, even where sunk on lodes that were rich at the surface. The largest single recent producer in the Ingham Sheet area has been the N o r t h u m b e r l a n d mine, situated near the junction of Williams Creek and Running River; since 1960 it has yielded more than 25 tons of tin concentrate (valued at £13,315). Nevertheless, this is insignificant when compared with the 1550 tons raised from the Sardine mine near Ewan (outside the Sheet area), the biggest lode mine on the Kangaroo Hills Mineral Field. The Northumberland mine is situated on two intersecting, altered and greisenized lodes in granite, the main one of which is up to 8 feet wide and has a north-north-westerly trend. Enrichment took place at the intersection of the lodes, where coarse cassiterite crystals occurred in quartz veins. The average cassiterite content was 5 percent, but increased to a maximum of 30 percent in some parts of the lode.

Some of the earlier mines may have produced more tin than the Northumberland mine, as for example the Uncle Ned mine, about 2 miles north of the Fifteen Mile Creek alluvial workings. However, its reputed production of 170 tons of concentrate cannot be officially confirmed, as the records are incomplete.

At M o u n t S p e c, stanniferous quartz-chlorite lodes in pink leucocratic granite on the southern mountain slopes were being worked before 1896, and especially in 1901 and 1902, when a 5 head stamp battery was installed. Notwithstanding a production of 22½ tons of concentrate for the year 1902, mining stopped because of high costs of development, stores, and wages (Newman, 1903). The lodes strike north to north-east in general; the main lode, which was up to 4 feet wide, contained very rich ore, but the others were not very profitable. Much water below a depth of 70 feet prevented further work on the main lode.

In the W a t e r c r e s s area, about 5 miles south-west of Mount Fox, several lodes, rich at the surface, were found during prospecting following the discovery of alluvial deposits there in 1911. Cassiterite occurs in small quartz leaders, as well as disseminated in areas of slightly altered granite and porphyry which is locally crushed and chloritized (Marks, 1913; Saint-Smith, 1916). Although the mineralized zones within the lodes may be up to 50 feet wide, the ore shoots, which are irregularly distributed, are small though very rich, showing an average grade of 5 to 10 percent, and maximum values of 30 percent cassiterite. The lodes strike east-west, conforming in attitude with the major joints in the granite (Saint-Smith, 1916). The richest ore shows copper staining along cleavage planes. Some 30.5 tons of concentrates (valued at £3,660) represent the officially recorded production.

At Mount Helen, 8 miles south of Ingham, cassiterite occurs in quartz-chlorite lodes discovered in 1939 along the western slopes of a hill (Morton, 1939b). The lodes occupy east-north-easterly to east-south-easterly trending joints in pink, coarse-grained granite near its contact with blue-grey quartzite of uncertain age. The ore was high-grade, averaging 12 percent, and hand-picked material contained up to 33½ percent cassiterite; however, after the richer ore had been exhausted, values dropped to about 2 or 3 percent. Recovery of the cassiterite was hampered by its close association with iron oxides, which led to losses during the normal gravity separation in water. The production has been approximately 13.5 tons of concentrate.

TUNGSTEN.

Tungsten is the only metal other than tin that has been produced in any quantity from the Ingham Sheet area, mainly as wolframite, though a little scheelite also occurs.

Production has come mainly from the Ollera Creek workings, Horseshoe Bend, and Dingo Mountain; small workings are located at Five Mile Creek near Cardwell, at Quartpot Creek, Pine Creek, and in the Red Hill or Allingham area. The rate of production has varied widely in reflection of the fluctuating market prices. The officially recorded production, to the end of 1962, from the Ingham Sheet area (exclusive of Ollera) has been 42 tons (valued at £24,923). Production from the Ollera Field, most of which is situated in the adjoining Townsville Sheet area, has been 217 tons of wolfram concentrate (valued at £25,244).

The wolframite is contained in short, irregular, high-grade shoots in chloritic lodes and quartz reefs forming fissure veins or joint fillings and pipes (Ball, 1911; Connah, 1952b; Levingston, 1957; Morton, 1940; Ridgway, 1948; Shepherd, 1943a). Only rarely do the lodes occur in rocks other than granite, which is commonly sericitized and chloritized adjacent the lodes. The veins are generally up to 5 feet wide, are vertical or nearly so, and have rarely been worked to depths of more than 50 feet, except at Ollera Creek and Dingo Mountain. Amongst the accessory minerals that may accompany the wolframite are pyrite, fluorite, molybdenite, bismuthinite, topaz, chalcopyrite, arsenopyrite, scheelite, calcite, cassiterite, and hematite.

In the hills at Ollera Creek (just outside the southern Sheet boundary), wolframite occurs in quartz pipes in granite, and in lesser quantity as bunches of ore along joints in greisen and silicified granite (Ball, 1911; Ridgway, 1948). Most of the veins dip steeply and trend north and east; some trend north-east or north-west. Enrichment is common at joint intersections. The quartz pipes are generally in granite, although, in the extreme north-eastern tip of the field, shafts have been sunk on quartz veins in rhyolite. Mineralization in the Ollera Field persists to greater depths than anywhere else in the Sheet area, and some shafts reached depths of 120 feet to 200 feet (Connah, 1952a; Laun, 1917; Lee, 1938). Apart from wolframite, the lodes also carry molybdenite, which locally is more abundant than wolframite (Ball, 1911). Bismutite and bismuthinite are also commonly associated with the wolframite, and some workings have even been worked for bismuth alone (Laun, 1917).

The official production figures from the early period of the field, since its discovery in 1895, probably accounted for only about one quarter of the actual yield which may have been of the order of £50,000 worth of wolfram (Ball, 1911). In addition, 10 cwt of molybdenite-wolfram concentrate and 6½ tons of bismuth-wolfram concentrate have been produced. Eluvial and alluvial wolframite contributed most to the output in the early years, and a little was still being won in 1951.

The H o r s e s h o e wolfram mine, on the western bank of Running River at "Horseshoe Bend", about 1½ miles south-west of its crossing of the Gregory Highway, has probably been the major single wolfram producer in the Sheet area. Fine-grained, disseminated wolframite was here mined from a crushed, chloritic zone in quartz porphyry (Connah, 1952b; Morton, 1940; Shepherd, 1943a). This north-west trending lode was 5 feet wide at the surface, and was worked intermittently to a depth of 62 feet. Production since 1940 has been about 11 tons of wolframite, valued at £7,611.

About ¾ mile east of the Horseshoe mine, on the eastern bank of Running River, the P i n k L i l l y wolfram workings produced wolframite from quartz-chlorite veins along east-west joints in quartzite and hornfels close to their contact with granite. Veins of greisenized granite also contain wolframite. The workings extend over a distance of 7 chains, and have yielded about 9 or 10 tons of concentrate.

At D i n g o M o u n t a i n, 4½ miles west of Kirrama Homestead in the north-western corner of the Sheet area, wolframite is disseminated through a north-westerly trending quartz vein in coarse-grained granite which, near the vein, is greisenized and chloritized (Levingston, 1957). The vein, 2½ feet wide on the average, has been mined to a depth of more than 80 feet, and commonly showed enrichment at intersections with small cross-veins.

In the Red Hill or Allingham area, north of Oaky Creek, various workings have produced a total of at least 16 tons of wolframite since their successive discoveries since 1910. The maximum depth of workings is 110 feet.

Scheelite accompanies wolframite in quartz veins in granite in the Lucky Seven mine at the Upper Stone River (position on the map unknown). The official production figure is only a few hundredweights.

A little scheelite is also present in mixed tin-copper ore in a north-easterly trending granite lode at the Patterson tin mine on Cummins Creek .

Scheelite has been recorded to be associated with arsenopyrite, chalcopyrite, and fluorspar in a wolfram lode about 10 chain south-west of the Horseshoe wolfram mine (Morton, 1940).

OTHER METALS

Metals other than tin and tungsten have not been produced in any quantity from the Ingham Sheet area.

Antimony is present as cervantite and stibnite in quartz veins in the Kangaroo Hills Formation on a spur of Mount Dora, 4 miles west of Kangaroo Hills Homestead. The veins have been worked occasionally since 1893, but production has been negligible. Antimony has also been recorded from an area about 7 miles north of Kangaroo Hills Homestead, one mile west of Michael Creek (Geol. Survey of Queensland records).

Bismuth minerals accompany the tungsten and molybdenum mineralization at Ollera Creek, where a few lodes have at times been worked solely for their bismuth content (Ball, 1911; Cusack, 1904; Laun, 1917). Production was 3½ tons of concentrate, valued at £1,252. The main bismuth minerals were bismutite and bismuthinite (Laun, 1917).

Bismutite was also reported from alluvial gravels in the Kangaroo Hills area (Maitland, 1891), and bismuthinite in the wolfram workings at Dingo Mountain and Five Mile Creek, and in the Pink Lilly workings. Traces of bismuth and molybdenite are associated with the wolfram-bearing quartz vein in granite at the Upper Stone River.

M o l y b d e n u m was generally won as a by-product from wolfram workings, as at Ollera Creek (Ball, 1911), Dingo Mountain (Levingston, 1957), and the Pink Lilly workings. At Ollera Creek, production of molybdenite was about 22 tons, valued at £2,610, and 10 cwt of mixed molybdenite-wolfram concentrate, valued at £54. Recovery was difficult because of the fine size of the molybdenite flakes.

C o p p e r mineralization is widespread throughout the area, but is of little economic significance. At Flaggy Creek, about a mile south of its entrace into the Herbert River gorge, a number of small, lenticular deposits along joints in silicified and chloritized granodiorite have been worked from time to time, but Cameron (1914) considered them too small and discontinuous to support even a small mining venture, although small patches show values of up to 35 percent copper. The joints trend north-west, and are filled with quartz containing malachite, azurite, cuprite, chalcopyrite, and pyrite (Cameron, 1914; Knight, 1949). The length of the ore bodies rarely exceeds 50 feet, and their width 6 feet. Other copper shows occur in the upper Douglas Creek area in the form of small, north-westerly trending lodes of copper carbonate and chrysocolla in hornblende granite (Saint-Smith, 1916), or as short quartzose lodes in quartzite close to the granite contact. Grades in the quartz lodes ranged up to 11 percent copper and 9 oz. of silver per ton (Saint-Smith, 1916). A small lens of copper ore in a lode in granite in the Watercress area was not rich enough to be worked. In the Hidden Valley - Red Hill (or Allingham) area, some of the tin lodes carry accessory copper minerals which in a few workings increase with depth. At the Blackboy or Mount Eva mine, about 1 mile north-east of the junction of Home Creek and Running River, for example, the tin ore at the surface gave way to a shoot of copper and lead ore at a depth of 12 feet. At Rocky Creek, a small western tributary in the headwater region of Smoko Creek, a shallow, narrow shoot in vitreous quartz contains a complex auriferous sulphide ore of pyrite, galena, sphalerite, chalcopyrite, and wolframite. The shoot trends north-north-east along a joint in greisenized granite (Morton, 1928).

L e a d is present as galena in the Rocky Creek locality mentioned above, and in a number of small, shallow, rich, lenticular bodies in north-west trending quartz veins in joints traversing chloritized and sericitized granodiorite at Flaggy Creek (Knight, 1949), in the vicinity of the copper lodes already described, though not in the same shoots. The shoots may be up to 100 feet long and 30 feet wide, and in places contain some pyrite and manganese oxides. Three tons of argentiferous galena and cerussite, won from these lodes in 1914, contained 43 percent lead and 10 oz of silver per ton (Cameron, 1914). At the Silver Star workings, on the western bank of Hermit Creek, a tunnel has been driven 12 feet on a flat reef of galena, about 2 feet wide, in granite. Galena is also reported from a hill some 10 miles south-west of Ingham.

Z i n c , in the form of sphalerite, is found in minor amounts in the Black Cap tin mine in the Hidden Valley area, and in the complex sulphide ore at Rocky Creek.

Alluvial g o l d is found in the headwaters of Yamanie Creek and Smoko Creek, and in some of the alluvial tin deposits, especially at Broadwater Creek and in the deep leads at Mount Fox and at Black Cow Creek. Lode gold occurs in the quartz veins at Rocky Creek (Morton, 1928); assay values ranged from a trace of gold and 6 dwt of silver per ton to 19 gr. of gold and 7 oz. of silver per ton. A picked sample from the dump contained 1 dwt 14 gr. of gold and 40 oz. 8 dwt of silver per ton. Morton considered the lode as a typical example of lodes carrying wolframite, molybdenite, bismuth, or tin ores, and hence did not think it likely that it would be highly auriferous.

There is no record of any s i l v e r production from the Ingham Sheet area, although the numerous small deposits of lead ore are argentiferous. A parcel of lead ore from Flaggy Creek assayed 10 oz. of silver per ton (Cameron, 1914), and silver values at Rocky Creek ranged from 6 dwt to 6 oz. per ton.

INDUSTRIAL MATERIALS.

A g g r e g a t e and road metal have been produced from a number of quarries in Palaeozoic granite, volcanics, hornfels, and quartzite.

C l a y has been obtained from a Pleistocene to Recent deposit at Ingham. The clay is of a brown, plastic type, and contains some small patches of silt and sand. It has been used in the manufacture of bricks, pipes, and common pottery (Hosking, 1951), and it is also suitable for the manufacture of roofing tiles and dry-pressed bricks. The official total production to the end of 1962 has been 22,389 tons, valued at £4,910, at an average annual production rate, since 1952, of about 2000 tons. White kaolin clay, suitable for ceramic purposes, is reported to occur close to the shore line on the southern end of Hinchinbrook Island

(Connah, 1952c).

Some testing of beach sands for heavy minerals was carried out during the late fifties at various places along the coast and on Hinchinbrook Island. Test boring at Ramsay Bay on the eastern side of the island in 1956-57 revealed only low percentages of rutile (0.8%, 1.8%, and 2%) and zircon (4.5%, 6.7%, and 8%) in the heavy mineral fraction, which consisted largely of ilmenite (Connah, 1961, and Geol. Survey of Queensland records). In 1954, Dowsett Engineering Limited tested ten beaches between Ollera Creek in the south to the Tully River in the north, but found no significant concentrations of heavy minerals.

BIBLIOGRAPHY

AGASSIZ, A., 1898 - A visit to the Great Barrier Reef of Australia in the steamer Croydon. Bull.Mus.Comp.Zool.Harv., 28(4), 95-148.

ANDREWS, E.C., 1902 - Preliminary note on the geology of the Queensland coast with reference to the geography of the Queensland and New South Wales plateau. Proc.Linn.Soc.N.S.W., 27, 146-185.

ANDREWS, E.C., 1910 - Geographical unity of eastern Australia in Late and Post-Tertiary time. J.Roy.Soc.N.S.W., 44, 419-480.

ANDREWS, P.B., 1962 - Report on Camel Creek project, Queensland, in Authority to Prospect 188M New Consolidated Gold Fields (A'asia.) Pty.Ltd., unpubl. rep.

BALL, L.C., 1911 - Wolfram and molybdenite in Queensland. Extracts from progress reports, II. Qld.Govt.Min.J., 12, 564-565.

BEST, J.G., 1959 - Cainozoic basalts of the Einasleigh 4-mile Sheet, North Queensland. Bur.Min.Resour.Aust.Rec., 1959/117 (unpubl.)

BEST, J.G., 1960 - Some Cainozoic basaltic volcanoes in North Queensland. Ibid. 1960/78 (unpubl.)

BEST, J.G., 1962a- Atherton, Queensland - 1:250,000 Geological Series. Bur.Min.Resour., explan.Notes, E/55-5

BEST, J.G., 1962b- Alluvial tin prospects in North Queensland. Bur.Min.Resour.Aust., Records 1962/12 (unpubl.)

B.M.R., 1959 - Commonwealth of Australia, Bureau of Mineral Resources, Geology and Geophysics: Great Barrier Reef aeromagnetic surveys. Bur.Min.Resour. Aust.Rec. 1959/68, 69, 70 (unpubl.)

BRANCH, C.D., 1962 - The structural and magmatic relationships between acid lavas, pyroclastic flows, and granite of the Georgetown Inlier , North Queensland. Ph.D. Thesis, University of Sydney (umpubl.)

BRANCH, C.D., WHITE, D.A., and WYATT, D.H., 1960 - Terrestrial volcanics and related porphyries and granites North Queensland. In - THE GEOLOGY OF QUEENSLAND J.geol.Soc.Aust., 7, 237-244.

BROOKS, J.H., 1960 - Northern coastal Queensland. In - THE GEOLOGY OF QUEENSLAND, J.geol. Soc.Aust., 7, 130-131.

BROWNE, W.R., 1945 - An attempted post-Tertiary chronology for Australia (presidential Address) Proc.Linn.Soc.N.S.W., 70, V-XX

BRYAN, W.H., 1925 - Earth movements in Queensland (Presidential Address). Proc.Roy.Soc. Qld., 37, 1-82.

BRYAN, W.H., 1926 - Earlier palaeogeography of Queensland. Ibid., 38, 79-114.

BRYAN, W.H., 1928 - The Queensland continental shelf, Rep.Great Barrier Reef Comm., 2(4), 58-69.

BRYAN, W.H., 1930 - The physiography of Queensland. In - HANDBOOK FOR QUEENSLAND, Aust.Ass. Adv.Sci., Meeting 1930, 17-20

BRYAN, W.H., and JONES, O.A., 1946 - The geological history of Queensland - a stratigraphical outline. Pap.Univ. Qld.,Dept.Geol., 2(12)

BUSH, W.E., 1960 - The Kangaroo Hills Mineral Field (Ewan). In - THE GEOLOGY OF QUEENSLAND. J.geol.Soc.Aust., 7, 128-129.

CALVERT, F.J., 1959 - Notes on groundwater investigations, Herbert River delta. Qld.Irrigation Water Supply Comm., unpubl.Rep.

CAMERON, W.E., 1901 - The Kangaroo Hills Mineral Field. Publ.geol.Surv.Qld., 167, 2-4, 5-6 Also in: Qld.Govt Min.J., 3, 21-23 (1902).

CAMERON, W.E., 1906 - The Kangaroo Hills Mineral Field. Second report. Qld.Govt.Min.J., 7, 241.

CAMERON, W.E., 1914 - Copper and silver-lead lodes, Wairuna Station, Herberton District. Ibid. 15, 464-5.

CARTER, F.J., 1959 - Preliminary geological traverse of Blencoe Creek - location of dam site. Co-ordinator General's Dept.unpubl. Rep.

CONNAH. T.H., 1952a- Ollera Wolfram Field. Qld.Govt.Min. J., 53, 56.

CONNAH, T.H., 1952b- "Horseshoe" and "Bower Bird" wolfram mines, Kangaroo Hills. Ibid. 53, 141.

CONNAH, T.H., 1952c- Re white clay. Unpublished report to Chief Government Geologist of Queensland.

CONNAH, T.H., 1954 - Fifteen Mile Diggings, Kallanda. Unpublished report to Chief Government Geologist of Queensland.

CONNAH, T.H., 1961 - Beach sand heavy mineral deposits of Queensland. Publ.geol.Surv.Qld , 302.

CONNAH, T.H., and HUBBLE, G.D., 1960 - Laterites. In - THE GEOLOGY OF QUEENSLAND. J.geol.Soc.Aust., 7, 373-386.

COTTON, C.A., 1949 - A review of tectonic relief in Australia. J.Geol., 57 (3), 280-296.

COTTON, L.A., 1946 - The pulse of the Pacific. J.Roy.Soc. N.S.W., 80, 41-76.

CRIBB, H.G.C., 1940 - Alluvial tin - Upper Broadwater Creek - Cardwell. (Unpubl.rep. to Chief Govt.Geologist of Queensland).

CURRUTHERS, D.S., 1953 - Notes on present mining activities in the Ewan-Hidden Valley area. Unpubl. Rep. to Chief Government Geologist of Queensland.

CUSACK, W.G.K., 1904 - Ollera Creek Wolfram Field. Visit by the Warden. Qld.Govt Min.J., 5, 517-519.

DAINTREE, R., 1872 - Notes on the geology of the colony of Queensland. Quart.J.geol.Soc.Lond., 28, 271-317.

DANES, J.V., 1911 - On the physiography of north-east Australia. Vestnik Kral. Ceske Spol. Nauk, Trida II, Prague, 1912.

DAVID, T.W.E., 1911 - Notes on some of the chief tectonic lines of Australia. (Presidential Address). J.Roy.Soc.N.S.W. 45, 1-60.

DAVID, T.W.E., 1932 - Explanatory notes to accompany a new Geological Map of the Commonwealth of Australia. Sydney, Australasian Medical Publishing Co.Ltd.

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

DAVIS, W.M., 1917 - The Great Barrier Reef of Australia. Amer.J.Sci., 44, 339-351.

DOOLEY, J.C., 1963 - Gravity surveys of the Great Barrier Reef and adjacent coast, North Qld, 1954-1960, Bur.Min.Resour.Aust.Rec. 1963/163 (unpubl.)

DENMEAD, A.K., 1949 - Fifteen Mile diggings, Kallanda, Kangaroo Hills, M.F. Qld Govt Min.J., 50, 143-144.

DUNSTAN, B., 1913 - Queensland Mineral Index. Publ.geol. Surv. Qld., 241.

DUNSTAN, B., 1917 - Queensland mineral deposits. Ibid., 268.

FAIRBRIDGE, R.W., 1950 - Recent and Pleystocene coral reefs of Australia. J.Geol. 58(4), 330-401.

FOORD, H., 1960 - Blue Range Authority to Prospect No. 129M. Alluvial tin sampling. Mount Isa Mines Limited, unpubl. Rep.

GEORGE, A.E., 1939 - Report of Warden for Ingham District; in Ann.Rep.Dep.Min.Qld., 1938, 94.

HEDLEY, C., 1911 - A study of marginal drainage (Presidential Address). Proc.Linn.Soc.N.S.W., 36(1), 1-38.

HEDLEY, C., 1926 - Recent studies on the Great Barrier Reef of Queensland. Amer.J.Sci., 11, 187-193.

HEDLEY, C. and TAYLOR, T. Griffith, 1907 - Coral reefs of the Great Barrier, Queensland: a study of their structure, life-distribution, and relation to mainland physiography. Rep.Aust. Ass.Adv.Sci. 11, 397-413.

HILL, Dorothy, 1951 - Geology. In - HANDBOOK FOR QUEENSLAND. Aust.Ass.Adv.Sci., Brisbane, 13-24.

HILL, Dorothy, 1960a- Geological structure. In - THE GEOLOGY OF QUEENSLAND. J.geol.Soc.Aust., 7, 1-19.

HILL, Dorothy, 1960b- The Great Barrier Reefs. Ibid., 412-413.

HILLS, E.S., 1955 - A contribution to the morphotectonics of Australia. J.geol.Soc.Aust., 3, 1-15.

HOSKING, J.S., 1951 - The clay resources of Australia. Sci.ind.Res.Org.Unpubl.rep.

JACK, R.L., 1886 - Handbook of Queensland Geology. Publ.geol.Surv.Qld., 31.

JACK, R.L., 1888 - The mineral wealth of Queensland. Ibid., 48.

JACK, R.L., 1892 - The Kangaroo Hills silver and tin mines. Ibid., 82.

JACK, R.L., and ETHERIDGE, R., Jr., 1892 - The geology and palaeontology of Queensland and New Guinea. Ibid., 92.

JACKSON, C.F.V., 1905 - Ollera Creek Wolfram Field. Notes by Chief Inspector of Mines. Qld Govt Min.J. 6, 486.

JARDINE, F., 1928 - The topography of the Townsville littoral. Rep. Great Barrier Reef Comm., 2(5), 141-148.

JENSEN, H.I., 1911 - The building of eastern Australia. Proc. Roy. Soc. Qld 23, 149-196.

JENSEN, H.I., 1919 - The Castle Dredging Company. Unpubl. rep. to Chief Govt Geologist of Queensland.

JENSEN, H.I., 1923 - The geology of the Cairns Hinterland and other parts of North Queensland. Publ.geol.Surv.Qld., 274.

JONES, O.A., 1947 - Ore genesis in Queensland (Presidential Address). Proc.Roy.Soc.Qld., 59(1), 1-91.

JONES, O.A., and JONES, J.B., 1956 - Notes on the geology of some North Queensland Islands, Part II. Rep. Great Barrier Reef Comm., 6(3), 45-54.

JUKES, J.B., 1847 - NARRATIVE OF THE SURVEYING VOYAGE OF H.M.S. FLY. T. and W. Boone, London.

KEID, H.G.W., 1937 - Garrawalt Creek tin field. Qld Govt. Min.J. 38. 195-198.

DE KEYSER, F., 1963a- The Palmerville Fault - a "fundamental" structure in North Queensland. J.geol.Soc.Aust., 10(2), 273-278.

DE KEYSER, F., 1963b- Explanatory Notes on the Innisfail 1:250,000 Geological Sheet, S.E. 55-6. Bur.Min.Resour.Aust.Rec., 1963/79 (unpubl.)

DE KEYSER, F.,(in prep.)- Arfvedso-riebeckite in a granite on Hinchinbrook Island, North Queensland. J.geol.Soc.Aust.

KING, L.C., 1962 - THE MORPHOLOGY OF THE EARTH Oliver and Boyd, Edinburgh.

KNIGHT, C.L., 1949 - Herbert River Gorge prospects, North Queensland, Enterprise Exploration Company Pty. Ltd., umpubl.Rep.

LAUN, E.J., 1917 - Inspector of Mines for Charters Towers Report for November. Qld.Govt Min.J., 18, 624.

LEE, J.W., 1938 - Wolfram at Ollera. Interesting historical survey. Notable revival of interest. Qld Govt.Min.J., 39, 142-3.

LEE, J.W., 1939 - Kangaroo Hills. Ibid. 40, 344.

LEVINGSTON, K.R., 1952 - Fifteen Mile Diggings, Kallanda. Unpubl. Rep. to Chief Government Geologist of Queensland.

LEVINGSTON, K.R., 1954 - Fifteen Mile Diggings, Kallanda. *Ibid*.

LEVINGSTON, K.R., 1956 - Fifteen Mile Diggings (D.C. Becke). *Ibid*.

LEVINGSTON, K.R., 1957 - "Red Hill" Wolfram Workings, Dingo Mountain, Kirrama Range. *Ibid*.

MacGILLVRAY, J., 1852 - NARRATIVE OF THE VOYAGE OF H.M.S. RATTLESNAKE. *T. and W.Boone, London*.

MAITLAND, A.G., 1891 - On the geology and mineral resources of the Upper Burdekin. *Publ.geol. Surv. Qld*, 71.

MARKS, E.O., 1913 - Kangaroo Hills. *Qld Govt Min.J.* 14, 60-62.

MARKS, E.O., 1924 - Some doubts in Queensland physiography (Presidential Address). *Proc.Roy.Soc.Qld*, 36, 1-18

MORTON, C.C., 1928 - A reported auriferous deposit - Kirrama holding - Cardwell district. *Unpubl.Rep. to the Chief Government Geologist of Queensland*.

MORTON, C.C., 1935 - Re application for assistance by J. Rosendahl and party, Hidden Valley. *Ibid*.

MORTON, C.C., 1936 - Granite Bar Claim - Station Creek-Hidden Valley. *Ibid*.

MORTON, C.C., 1939a- Tin lode at Garrawalt Creek. *Qld. Govt.Min. J.*, 40, 184-185.

MORTON, C.C., 1939b- Tin discovery at Mount Helen, Ingham. *Ibid*., 40, 185-186.

MORTON, C.C., 1940 - Hidden Valley District. *Ibid*. 41, 310-12.

MORTON, C.C., 1945a- Subsidy application, T.P. Dickseen, Mt. Fox. *Unpubl.Rep to Chief Government Geologist of Queensland*.

MORTON, C.C., 1945b- Re proposed State Forest - parishes of Ashton, Stone and Ryeburn. *Ibid*.

MORTON, C.C., 1946 - Mount Fox Lead, Kangaroo Hills. *Qld Govt Min. J.*, 47, 77-8

NEWMAN, G.H., 1903 - Kangaroo Hills Field. Report of Warden; in *Ann. Rep. Dep. Min. Qld*, 1902, 84-86.

PARLIAMENTARY PAPERS QLD, 1949 - Water resources of the Tully-Herbert Rivers region; report of the committee appointed by the Co-ordinator General of Public Works to investigate the utilisation of water resources from the Tully River to the Herbert River. *Govt.Printer, Brisbane*.

POOLE, Wm., 1909 - Notes on the physiography of North Queensland. *Aust.Ass.Adv.Sci.*, 12th Meeting, 316-317.

PRESCOTT, J.A., 1931 - The soils of Australia in relation to vegetation and climate. *Bull Coun. Sci.ind. Res. Aust.*, No. 52.

PRESCOTT, J.A., and PENDLETON, R.L., 1952 - Laterite and lateritic soils. *Tech. Commun. Bur. Soil. Sci.*, Harpenden, 47, 1-51.

QUEENSLAND DEPT. OF MINES,	1912 -	Sketchmap of Kangaroo Hills, Star River, Charters Towers and Ravenswood Gold and Mineral Fields. Ann. Rep. to Under Secr. for Mines for the year 1911.
REID, J.H.,	1919 -	Iron ore. Hinchinbrook Island. Letter Book, Geol. Surv. Qld, 20, 379-380. (unpublished).
REID, J.H.,	1931 -	The Running River silver-lead lodes, Kangaroo Hills Mineral Field. Qld Govt Min. J. 32, 263-268.
REID, J.H.,	1932a-	A cardwell Range Show. Unpubl. Rep. to Chief Government Geologist of Queensland (Also in Qld Govt.Min. J., 33, 114).
REID, J.H.,	1932b-	"Elenbora". Ibid. (Also in Qld Govt Min. J. 33, 114).
REID, J.H.,	1933 -	Hidden Valley Extended, Running River District Qld Govt.Min.J., 34, 32-3.
RICHARDS, H.C.,	1924 -	Volcanic activity in Queensland. Rep. Aust. Ass. Adv. Sci, 17, 275-299.
RICHARDS, H.C. and HEDLEY, C.,	1923 -	Report submitted to the Great Barrier Reef Committee, 13th July, 1923. Qld geogr. J. 38.
RICHARDS, H.C. and HEDLEY, C.,	1925 -	A geological reconnaissance in North Queensland. Trans. Roy.geog. Soc. Aust.(Qld), 1, NS, 1-28.
RICHARDS, H.C., and HILL, Dorothy,	1942 -	Great Barrier Reef Bores, 1926 and 1937 - descriptions, analyses and interpretations. Rep. Great Barrier Reef Comm., 5, 76-110.
RIDGWAY, J.E.,	1944a-	Re subsidised driving of 250 feet adit. A.J. and C.E. Castles Merry Widow Extended alluvial tin claim No. 1317, Kangaroo Hills. Unpubl. Rep. to Chief Government Geologist of Queensland.
RIDGWAY, J.E.,	1944b-	Re application for subsidy by Neale Bros. to drive adit from Sawpit Creek to cut Wild Cat lead. Ibid.
RIDGWAY, J.E.,	1944c-	Re subsidy application, G.A. Bessell, Wild Cat South, Kallanda. Ibid.
RIDGWAY, J.E.,	1944d-	Kallanda (Fifteen Mile Creek) tin deep leads, Kangaroo Hills. Qld. Govt.Min.J., 45, 270-272.
RIDGWAY, J.E.,	1945a-	Application for subsidy, G.A. Bessell, Wild Cat South (Claim No. 1382), Kallanda. Unpubl. Rep. to Chief Government Geologist of Queensland.
RIDGWAY, J.E.,	1945b-	Subsidy application, W.J. and R.E. Bird, Mocking Bird (Claim No. 1374). Ibid.
RIDGWAY, J.E.,	1945c-	Subsidy application, Wild Cat South (Claim No. 1382). Ibid.
RIDGWAY, J.E.,	1946a-	Subsidy application, F.J. Jansen and V. Erga, Kallanda. Ibid.

RIDGWAY, J.E., 1946b- Application for subsidy to sink a shaft on Wild Cat Claim No. 850 (Old No. 784), Kallanda. Ibid.

RIDGWAY, J.E., 1947a- Kallanda. Progress Report 1944-1946. Qld Govt Min.J. 48, 127-129.

RIDGWAY, J.E., 1947b- Kallanda, Kangaroo Hills Field. Ibid. 48, 231-233.

RIDGWAY, J.E., 1948 - Ollera Wolfram Field, North Queensland. Ibid., 49, 13-14

RUSSELL, R.J., 1962 - Origin of beach rock. Ann.Geomorph., 6(i), 1-16.

SAINT-SMITH, E.C., 1921 - Castle Tin Mine (Fifteen Mile). Unpubl. rep. to Chief Govt. Geologist of Queensland.

SAINT-SMITH, E.C., 1916 - Kangaroo Hills Mineral Field, North Queensland. Qld. Govt Min.J., 17, 534-539.

x SHEPHERD, S.R.L., 1943a- Notes on some wolfram and tin occurrences in the Hidden Valley - Waverley section of the Kangaroo Hills Mineral Field. Qld. Govt Min. J. 44, 120-124.

SHEPHERD, S.R.L., 1943b- Tin deep leads at 15 Mile Creek and Kallanda, Kangaroo Hills M.F. Ibid., 44, 124-129.

SIMONETT, D.S., 1957 - Observations on laterite and other ironstone soils in North Queensland. J.Roy.Soc.N.S.W., 91, 23-35.

SUSSMILCH, C.A., 1938 - The geomorphology of Eastern Queensland. Rep. Great Barrier Reef Comm., 4(3), 105-134.

TAYLOR, T. GRIFFITH, 1911 - Physiography of Eastern Australia. Commonwealth Bur.Meteorology, Bull.8.

TENISON-WOODS, J.E., 1888 - The Desert Sandstone. J.Roy.Soc. N.S.W., 22, 290-335.

TENISON-WOODS, J.E., 1880 - Geology of Northern Queensland. Phil. Soc. Qld Trans. 3, 16.

THORNBURY, W.D., 1954 - PRINCIPLES OF GEOMORPHOLOGY. New York, Wiley.

TRENDALL, A.F., 1962 - The formation of "Apparent Peneplains" by a process of combined lateritisation and surface wash. Ann. Geomorph., 6(2), 183-197.

TWEEDALE, G.W. and BUSH, W.E., 1957 - Geological reconnaissance in the Kangaroo Hills - Ewan area. Geol.Surv.Qld, unpubl. Rep.

TWIDALE, C.R., 1956a- A physiographic reconnaissance of some volcanic provinces in North Queensland, Australia. Bull.volcan., 2(18), 3-23.

TWIDALE, C.R., 1956b- Chronology of denudation in north-west Queensland. Bull.geol.Soc.Amer., 67, 867-882.

WHITE, D.A., 1959a- Geology of the Herbert River area, North Queensland. Bur.Min.Resour. Aust., unpubl.memo.

x SAINT-SMITH, E.C. 1922 - Geology and mineral resources of portion of the southern section of Oaky Creek district, Kangaroo Hills mineral Field. Ibid., 23, 309-314.

WHITE, D.A., 1959b- New stratigraphic units in North Queensland geology. Qld Govt Min.J., 60, 442-447.

WHITE, D.A., 1959c- Explanatory Notes to the Einasleigh 4-mile Sheet. Bur.Min.Resour.Aust. Rec. 1959/129 (unpubl.)

WHITE, D.A., 1960 - Explanatory Notes to the Clarke River 4-mile Sheet. Bur.Min.Resour.Aust. Rec. 1960/82 (unpubl.)

WHITE, D.A., 1961 - Geological history of the Cairns-Townsville hinterland, North Queensland. Bur.Min.Resour.Aust.Rep. 59.

WHITE, D.A. and CRESPIN, Irene, 1959 - Some diatomite deposits, North Queensland. Qld.Govt.Min.J., 60, 191-193.

WHITE, D.A., and HUGHES, K.K., 1957 - Progress report on regional mapping in North Queensland. Bur.Min.Resour. Aust.Rec. 1957/38 (unpubl.)

WHITE, D.A., and WYATT, D.H., 1960 - The Upper Burdekin River Valley. In: THE GEOLOGY OF QUEENSLAND. J.geol. Soc.Aust. 7, 123-128.

WHITE, D.A., BEST, J.G. and BRANCH, C.D., 1959 - Progress report on regional geological mapping, North Queensland, 1958. Bur.Min.Resour.Aust.Rec. 1959/115 (unpubl.)

WHITE, D.A., STEWART, J.R., BRANCH, C.D., GREEN, D.H., and WYATT, D.H., 1959 - Progress report on the regional geological mapping of North Queensland, 1957; Gray Creek, Broken River, and Clarke River area. Ibid. 1959/114 (unpubl.)

WHITE, D.A., WYATT, D.H., and BUSH, W.E., 1960 - Upper Burdekin valley. In: THE GEOLOGY OF QUEENSLAND. J.geol.Soc. Aust., 7, 149-154.

WHITEHOUSE, F.W., 1930 - The geology of Queensland; in HANDBOOK FOR QUEENSLAND. Aust.Ass.Adv. Sci., Handbook 20, 23-39.

WHITEHOUSE, F.W., 1940 - Studies in the late geological history of Queensland. Pap. Univ. Qld. Dep. Geol., 2(i), 62-72.

WOLFF, K.W., 1962 - Appendix H: Geology. In: REPORT ON THE PROPOSED DEVELOPMENT OF THE HERBERT RIVER FOR HYDRO-ELECTRIC POWER GENERATION. Geol.Surv. Qld.unpubl. Rep.

WOOLNOUGH, W.G., 1927 - The chemical criteria of peneplanation (Presidential Address). J.Roy.Soc. N.S.W., 61, 17-24.

WYATT, D.H., and WHITE, D.A., 1960 - Upper Burdekin valley. In: THE GEOLOGY OF QUEENSLAND. J.geol.Soc. Aust., 7, 177-180

Table 1 - AIR PHOTO COVERAGE INGHAM 1:250,000 SHEET AREA

Ingham 4 mile.

Flown by Adastra 7/6/61. Scale 1:85,000.

Kirrama-Rockingham 1 mile areas.

Flown by Adastra 21/7/56. Scale 1 inch to 30 chains or 1:26,000.

Halifax 1 mile area.

Flown by Adastra August 1951. Scale 1 inch to 30 chains or 1:26,000.

Ingham 1 mile area.

Flown by Adastra 1/10/60. Scale 1 inch to 30 chains or 1:26,000.

Flown by R.A.A.F. 1942. Scale 1:23,270.

Cardwell 1 mile area.

Flown by Adastra 2/6/56. Scale 1 inch to 30 chains or 1:26,000.

Flown by R.A.A.F. August, 1943. Scale 1:23,270.

Mt. Graham 1 mile area.

Flown by Adastra 2/6/56. Scale 1 inch to 30 chains or 1:26,000.

Flown by R.A.A.F. Date when flown not known, but probably 1942 or 1943. Scale also not known but most likely 1:23,270.

Oak Hills 1 mile area.

Flown by R.A.A.F. 12/6/45. Scale 1:33,779.

Kangaroo Hills 1 mile area.

Flown by R.A.A.F. 13/6/45. Scale 1:33,779.

Herbert River Gorge area.

Flown by Adastra 4/6/56. Scale 1:16,000.

Townsville-Cowley Main Road area.

Flown by Adastra 5/12/60. Scale 1 inch to 15 chains or 1:13,000.

TABLE 2 - STRATIGRAPHY OF THE INGHAM 1:250,000 SHEET AREA

ERA	PERIOD	ROCK UNIT AND SYMBOL	LITHOLOGY	STRATIGRAPHIC RELATIONS, TOPOGRAPHY	REMARKS	PRINCIPAL REFERENCES	ECONOMIC GEOLOGY
CAINOZOIC	RECENT	Alluvium and soil (Qa)	Gravel, sand, silt, clay, mud; residual soil; lagoonal deposits.	Forms the flat coastal plain. Swamps and mangroves are common.	Greatest thickness known is 316 feet in bore hole, Herbert River delta area.	Calvert (1959); Simonett (1957).	Alluvial tin deposits along stream courses
		Talus and scree (Qt)	Unsorted boulder conglomerate and gravel	At the foot and lower slopes of scarps.	Colluvial	-	-
		Dunes and beach sand (Qr)	Sand; locally some beach rock.	Old beaches and sand spits; U-dunes.	Old strand lines recognizable on airphotos	-	-
	?PLIOCENE - RECENT	Shelf deposits (not exposed)	Terrigenous sediments with lenses of reef sand; coral reefs; glauconitic quartz sand near base of Quaternary section.	Continental shelf and Great Barrier Reef.	Thickness more than 500 feet.	Fairbridge (1950); Richards and Hill (1942).	-
		Undifferentiated basalt (Czb)	Vesicular olivine basalt; mainly flows, some pyroclastic material.	Older basalts may be lateritized; younger basalts overlie billy and Cainozoic gravel deposits. All basalts unconformably overlie the Palaeozoic rock units.	Outcrops of older basalt along Herbert River correlated with Wallaroo Basalt (Best, 1959); younger Mt. Fox basalt grades up into Recent.	Best (1959).	-
	?PLIOCENE	Undifferentiated Cainozoic (Cz)	Pebble conglomerate, gravel, sandstone, siltstone; granite "wash"; billy, laterite, ferruginous soil; diatomite.	Unconformably overlie Palaeozoic rock units. Are probably penecontemporaneous with undifferentiated basalt (Czb.)	Thickness ranges to about 150 feet. Includes "Cameron Creek Formation" (Wolff, 1962). Diatomite may be Pliocene.	White and Crespin (1959); Wolff (1962).	Stanniferous gravels and deep leads.
PALAEOZOIC	UPPER CARBONIFEROUS TO PERMIAN	Basic dykes	Dark-green, fine-grained dolerite and andesite.	Intrude all other Palaeozoic igneous rocks. Basic dykes younger than acid dykes, in general.	A few dykes on the Burdekin River contain riebeckite.	-	-
		Acid dykes	Generally pink or creamy weathered rhyolites and some trachyte. Flow-banding and spherulitic structures common.				
		Pink microgranite (Cg_4)	Somewhat vughy, pink, leucocratic microgranite and porphyritic microgranite.	Intrudes the volcanics (Cl), and is probably younger than the other granites (Cg_1 - Cg_3).	Forms the Gorge Range.	-	-
		Granite undifferentiated (Cg_3)	Wide range of granitoid rocks, including biotite granite, hornblende-biotite granite and adamellite, alaskite, microgranite and microadamellite, riebeckite granite, aplite, pegmatite.	Intrude the Running River Metamorphics, Wairuna Formation, Kangaroo Hills Formation, the granodiorites (Cg_1), and the volcanics (Cl).	Rock types resemble Herbert River Granite, Elizabeth Creek Granite, Tully Granite Complex, Almaden Granite.	Branch (1962); White (1959b); de Keyser (1963).	Tin mineralization, mainly associated with the pink, leucocratic, alaskitic varieties. Tungsten mineralization. (Copper, lead, zinc, silver, gold, bismuth, molybdenum and antimony in uneconomic quantities).
		Coarse quartz-feldspar porphyry complex (Cg_2)	Pink porphyry with coarse (ca: ½ inch), idiomorphic phenocrysts of pink or white feldspar and quartz in dense, microcrystalline matrix. Associated with altered dacite and rhyodacite.	Relative time position uncertain. Younger than volcanics (Cl), possibly also Granite (Cg_3)	Faulted against surrounding Granite (Cg_3)	-	-

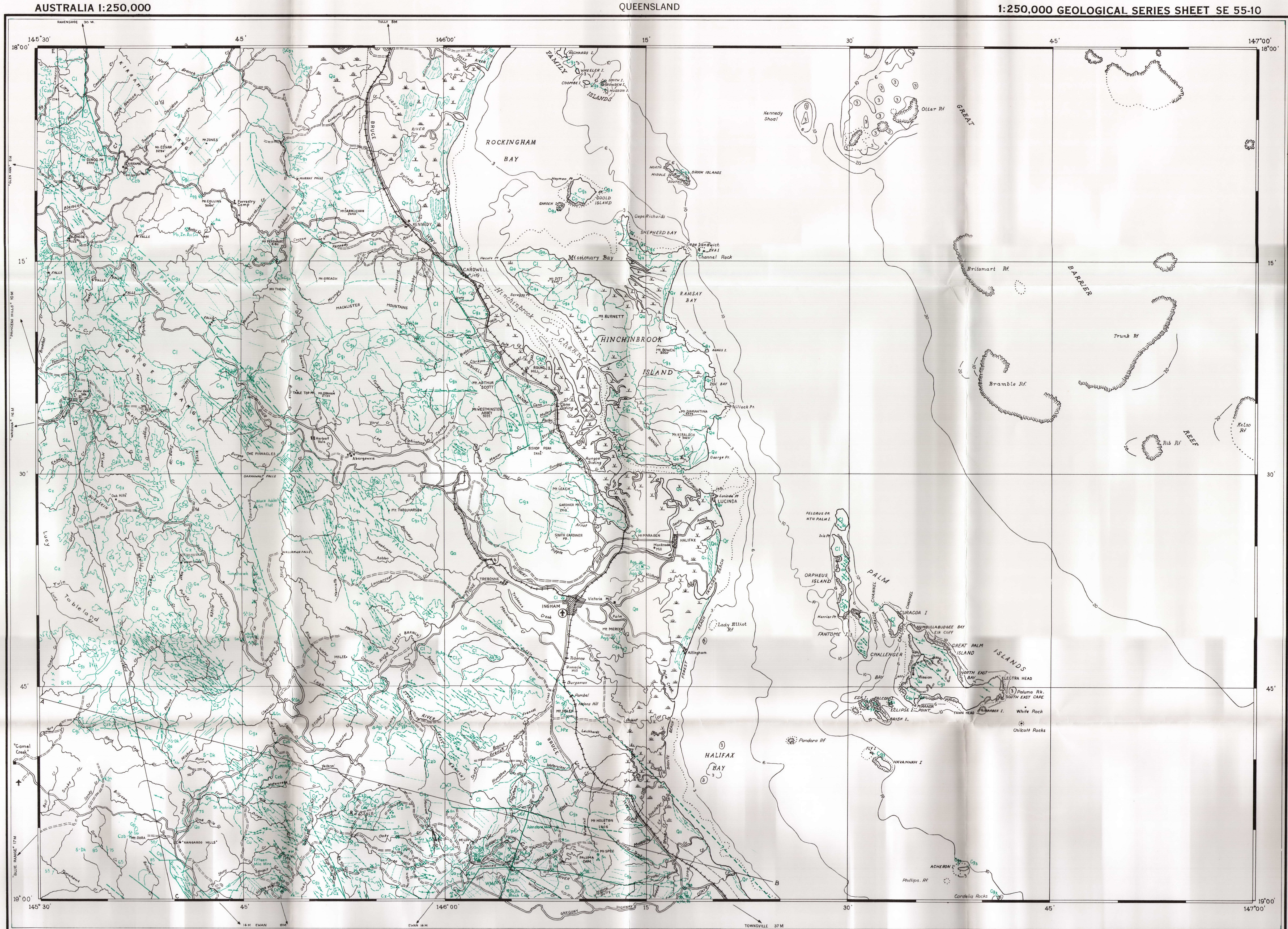
ERA	PERIOD	ROCK UNIT AND SYMBOL	LITHOLOGY	STRATIGRAPHIC RELATIONS, TOPOGRAPHY	REMARKS	PRINCIPAL REFERENCES	ECONOMIC GEOLOGY
	Upper Carboniferous to Permian	Diorite-Granodiorite group (Cg_1)	Biotite-hornblende granodiorite, quartz diorite, adamellite, diorite. Some olivine gabbro and hypersthene-biotite-hornblende diorite.	Intrude the Kangaroo Hills Formation and the volcanics (Cl). Intruded by granites (Cg_3).	Commonly contain numerous xenoliths.	-	-
	Upper (?) Carboniferous	?Glen Gordon Volcanics (Cl)	Massive rhyolitic to dacitic porphyries, and a few volcanic breccias and tuffs; some andesite. Phenocrysts or phenoclasts of quartz, pink feldspar and white feldspar in dense, microcrystalline groundmass which is light or dark-grey, mauve, pink, or grey-green.	Intruded by the igneous rocks (Cg_1, Cg_3, Cg_4).	Thickness at least 1500 feet in Wallaman Falls area. Correlation with type Glen Gordon volcanics highly probable. Possibly largely ignimbritic in origin. Recrystallization of groundmass common.	Best (1962); Branch (1962); White (1959b); de Keyser (1963b).	-
	Lower Carboniferous	Clarke River Formation (Cc)	Basal conglomerate; sandstone, mudstone, siltstone, shale.	Unconformably overlies Kangaroo Hills Formation.	Occurs in small, downfaulted block. Abundant plant fossils.	Tweedale and Bush (1957); Wyatt and White (1960).	-
PALAEOZOIC	Upper Silurian - Lower Devonian	Kangaroo Hills Formation (S-Dk)	Greywacke, siltstone, sandstone, shale, pebbly greywacke, quartz greywacke, conglomerate.	Intruded by Cg_1 and Cg_3 granodiorites and granites, and overlain by Cz and Czb.	May include the Greenvale Formation of the adjoining Einasleigh 1:250,000 Sheet area.	Tweedale and Bush (1957); White and Wyatt (1960).	-
	Lower Silurian	Wairuna Formation (Slw)	Massive sandstone, black shale, siltstone, greywacke.	Intruded by granite Cg_3 and overlain by Cl and Cz.	Outcrops very weathered.	White (1959b); White and Wyatt (1960).	-
		Undifferentiated (Pz)	Quartzite, commonly current-bedded; white tuffaceous(?) sandstone.	Intruded by granite Cg_3. Otherwise age relationships unknown, as only isolated outcrops occur in coastal plain alluvial area.	The white (?) tuffaceous sandstone may be genetically associated with the Glen Gordon Volcanics (Cl).	-	-
PRECAMBRIAN		Running River Metamorphics (pCr)	Amphibolite and calc-silicate rocks; mica schist.	Possibly Precambrian because of degree of metamorphism. Intruded by granite Cg_3.	Formerly included with the Silurian Ewan Metamorphics.	Named by Wyatt (1964)	-

PRELIMINARY EDITION, 1964
SUBJECT TO AMENDMENT

AUSTRALIA 1:250,000

INGHAM
QUEENSLAND

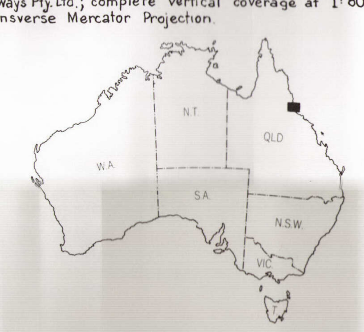
1:250,000 GEOLOGICAL SERIES SHEET SE 55-10



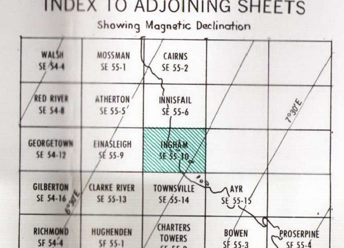
Scale 1 : 250,000

Compiled and issued by the Bureau of Mineral Resources, Geology and Geophysics, Department of National Development, in conjunction with the Geological Survey of Queensland. Topographic base compiled by the Royal Australian Survey Corps. Aerial photography by Adastra Airways Pty. Ltd.; complete vertical coverage at 1:60,000 scale. Transverse Mercator Projection.

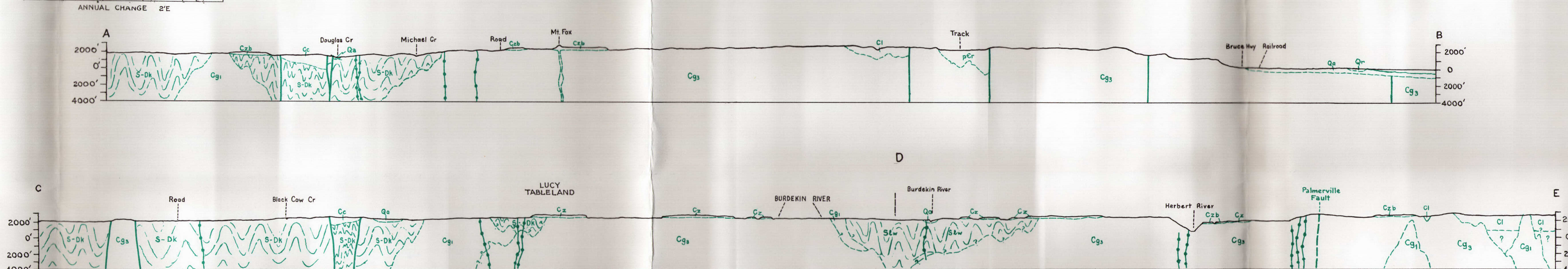
Geology, 1962-63, by: R.S.H. Fardon, F. de Keyser, L.G. Cuttler, R.Z. de Ferranti, U Kyaw Nyein.
Compiled, 1963, by: R.S.H. Fardon, R.Z. de Ferranti, F.H. Peniguel. Jr.
Drawn by: F.H. Peniguel. Jr.



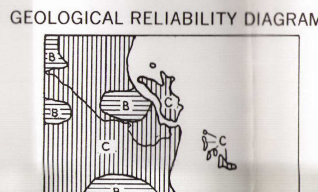
INDEX TO ADJOINING SHEETS



Sections
(folding diagrammatic)



GEOLOGICAL RELIABILITY DIAGRAM



B Detailed reconnaissance—traverses and air-photo interpretation
C Reconnaissance—mainly air-photo interpretation, few traverses

Reference

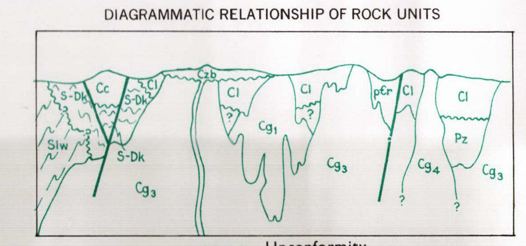
CAINOZOIC	QUATERNARY		Qa	Alluvium, soil, lagoonal deposits
			Qt	Scree, talus
			Qr	Dunes and beach sand, showing trend of old shore lines
	UNDIFFERENTIATED		Czb	Olivine basalt
			Cz	Conglomerate, sandstone, siltstone, laterite and lateritic soil, silcrete, diatomite
PALAEOZOIC	UPPER CARBONIFEROUS TO PERMIAN		Cg4	Pink microgranite
			Cg3	Hornblende-biotite adamellite, biotite granite, riebeckite granite, microgranite, alaskite
			Cg2	Coarse pink quartz-feldspar porphyry complex
			Cg1	Grey biotite-hornblende granodiorite, some diorite and olivine gabbro
	UPPER(?) CARBONIFEROUS	Glen Gordon Volcanics	Cl	Massive rhyolitic to dacitic volcanics, some andesite
	LOWER CARBONIFEROUS	Clarke River Formation	Cc	Conglomerate, mudstone, siltstone, shale, sandstone
	LOWER DEVONIAN TO UPPER SILURIAN	Kangaroo Hills Formation	S-Dk	Greywacke, quartz greywacke, siltstone, slate, conglomerate
	LOWER SILURIAN	Wairuna Formation	Slw	Siltstone, greywacke, massive sandstone, black shale
	UNDIFFERENTIATED		Pz	Blue grey quartzite
PRECAMBRIAN		Running River Metamorphics	pЄr	Amphibolite, mica schist, calcsilicate rock.

- Geological boundary
- Fault
  Where location of boundaries and faults is approximate, line is broken; where inferred, queried; where concealed, boundaries and faults are shown by short dashes.
- Strike and dip of strata
- Vertical strata
- Trend of bedding, Joints, Dip > 45° — Air-photo interpretation
- Vertical foliation
- Shear-zone.
- Platy flow, inclined
- Basic volcanic vent, extinct
- Plant fossil locality
- Dyke or vein, mainly by air-photo interpretation, mostly rhyolite; do - dolerite, q - quartz, r - rhyolite, rg - riebeckite micro-adamellite
- Battery
- Mine
- Open cut
- Alluvial workings
- Minor mineral occurrence

Agg	Aggregate, road metal, etc.,	Mo	Molybdenum
Au	Gold	Pb	Lead
Bi	Bismuth	Sn	Tin
Cl	Clay	W	Tungsten
Cu	Copper	Zn	Zinc
Di	Diatomite		

- Road
- Vehicle track
- Railway with siding
- Power transmission line
- "Oak Hills" Homestead
- Landing ground
- Airport
- Yd Yard
- Falls
- Swamp
- Mangrove
- Coral reef
- Fathom line
- Shoal
- •2113′ Height in feet, barometric; datum, mean sea level
- Trend of dunes

DIAGRAMMATIC RELATIONSHIP OF ROCK UNITS



Unconformity

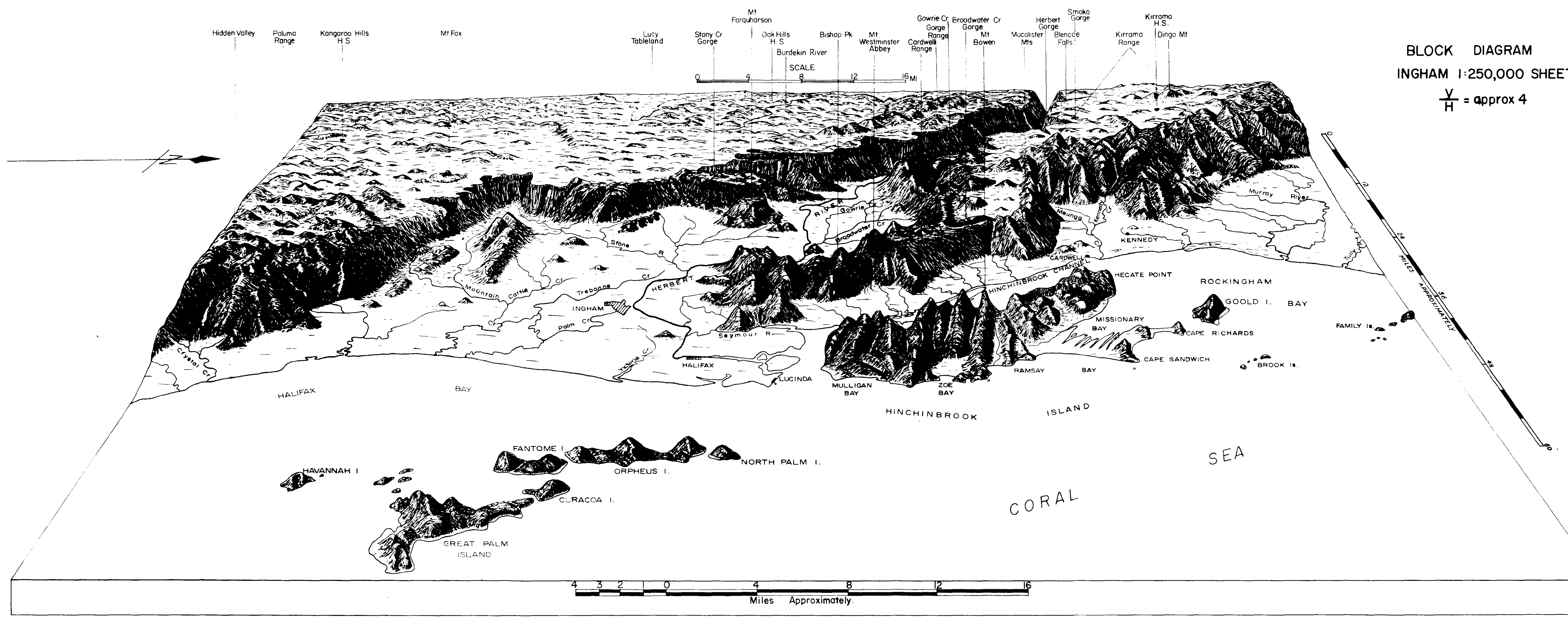
INGHAM
SHEET SE 55-10

PLATE 2

BLOCK DIAGRAM

INGHAM 1:250,000 SHEET

$\frac{V}{H}$ = approx 4



Bureau of Mineral Resources, Geology and Geophysics. To accompany Record No 1964/78

FP28