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EXPLANATORY NOTES

HUCKITTA, N.T.

Sheet SF/53—11
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Sheet SF/53—11, International Index

Compiled by K. G. Smith

Issued under the Authority of Senator the Hon. Sir William Spooner,
Minister for National Development

1963
DEPARTMENT OF NATIONAL DEVELOPMENT

Minister: Senator the Hon. Sir William Spooner, K.C.M.G., M.M.
Secretary: Sir Harold Raggatt, C.B.E.

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Director: J. M. Rayner

These notes were prepared in the Geological Branch

Chief Geologist: N. H. Fisher
Explanatory Notes on the Huckitta
Geological Sheet

Compiled by
K. G. Smith

GENERAL

The Huckitta Sheet covers about 7,000 square miles in the south-eastern part of the Northern Territory. The northern half of the Sheet area lies within the Georgina Basin, which contains Upper Proterozoic and Lower Palaeozoic sediments. The southern half contains mainly Precambrian metamorphic and igneous rocks.

Alice Springs, the town nearest the Sheet area, is about 160 miles from Red Tank (on the Plenty River) and about 230 miles from the Jervois copper mines, which are near the eastern boundary of the Sheet and on the main road from Alice Springs to Mount Isa via Tarlton Downs (on the Tobermory Sheet). There are about 50 permanent white residents; most are engaged in raising beef cattle, but some are employed in mining copper and mica; mining activity is sporadic. All roads are unsealed and are often impassable for several days after heavy storms. Most homesteads have landing grounds suitable for light aircraft, which maintain all mail services and provide speedy evacuation in cases of illness.

The average annual rainfall is 10 inches, but most of this comes from sporadic storms in summer months. There is no permanent supply of natural surface water and the pastoral industry depends mainly on underground supplies. Water is available also from a few earth tanks and dams, but these suffer a high loss from evaporation in summer, when temperatures often exceed 100° for several months.

Spinifex and mallee-type scrub grow on the sand plains, and eucalypts along watercourses. Spinifex grows also on areas underlain by carbonate rocks, and gidyea (Acacia georginae) grows in both hilly and plain country.

Maps and air photographs covering the Huckitta Sheet area are—

(i) photo mosaic, at a scale of 4 miles to 1 inch;
(ii) planimetric map, at a scale of 4 miles to 1 inch;
(iii) dye-line maps, at air photograph scale, controlled by slotted template assembly, with principal points, wing points, and topography;
(iv) air photographs, at a scale of 1:46,000 approximately.

The maps have been prepared by, and are available from, the Division of National Mapping, Department of National Development. The air photographs were taken by the Royal Australian Air Force.

C.6632/63.—2.
GEOLOGICAL INVESTIGATIONS

Most of the geological work done on the Huckitta Sheet area has been since 1949, first in the search for metals, and later for petroleum. During the preceding 50 years or so, numerous reconnaissances were made to observe regional geology, and inspections were made of workings in the Jervois area, where copper and lead ores were discovered in 1929.

H. Y. L. Brown (1897) made the first regional reconnaissance; he named Grant Bluff and named and described the Oorabrab Reefs, which he prospected unsuccessfully for gold. Tindale (1931) reported on the geology of the Mopunga and Dulcie Ranges; he measured stratigraphic sections in both areas and named the Mopunga Beds in the sequence exposed in the Mopunga Range. Madigan (1932b) recorded the results of a traverse to the Oorabrab Rockholes area and to the Mopunga and Dulcie Ranges; he considered that some of the sedimentary formations here were the equivalents of some which he had described previously (1932a) in the Western Macdonnell Ranges.

Inspections of the copper lodes at the Jervois area were made by both Gibson and Shepherd in 1929 (In Blanchard, 1940), Hossfeld (1931), Hodge-Smith (1932), and Blanchard (1940); in unpublished reports each condemned the prospects because of the lack of the large visible tonnages of ore which would be required for company operations in such a remote area.

Joklik (1955) reported the results of a detailed study of the Harts Range and Plenty River Mica Fields, which was made from 1949 to 1951; this survey included some regional mapping of the Huckitta Sheet area. Noakes (1956) compiled a composite section of the Mopunga Group, which he named after making a reconnaissance in the Huckitta and Tobermory areas. Casey & Tomlinson (1956) described the geology of part of the Huckitta Sheet area.

To investigate the mineral and petroleum potential of the Huckitta Sheet area, a field party from the Geological Branch of the Bureau of Mineral Resources, Geology and Geophysics systematically mapped the Sheet in 1957 and 1958 (Smith et al., 1960a, b; Smith, in press). Specific investigations made during the general survey were reported by Morgan (1959), Robertson (1959), Vine (1959), and Woolley (1959). Concurrently with the Bureau's survey, geologists of Frome-Broken Hill Co. Pty Ltd mapped the sedimentary areas of the Huckitta Sheet. Geologists from Geosurveys Ltd have made several visits to the area on behalf of Smith Australian Oil Co. Pty Ltd, which has held oil prospecting rights since 1960 over the northern half of the Sheet area.


<table>
<thead>
<tr>
<th>Age</th>
<th>Rock Unit and Symbol</th>
<th>Lithology</th>
<th>Thickness (ft)</th>
<th>Stratigraphical Relationship</th>
<th>Fossils</th>
<th>Structure</th>
<th>Economic Geology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quaternary</td>
<td>Undifferentiated (Oq)</td>
<td>Sand, soil, and alluvion</td>
<td>1-200</td>
<td>Adamant</td>
<td>...</td>
<td>...</td>
<td>Good supplies of potable water where sufficient thickness occurs</td>
</tr>
<tr>
<td></td>
<td>(Ob)</td>
<td>Alluvium</td>
<td></td>
<td>In outcrop, unconformable on Precambrian metamorphic and gneiss rocks</td>
<td>Sponge spicule</td>
<td>Horizontal</td>
<td></td>
</tr>
<tr>
<td>Tertiary</td>
<td>Artunga Beds (Tr)</td>
<td>Silicified limestone, limestone, chert, siltstone, sandstone</td>
<td>5-90</td>
<td>Unconformity</td>
<td></td>
<td>Horizontal</td>
<td></td>
</tr>
<tr>
<td>Triassic</td>
<td>Tarlton Formation (Trt)</td>
<td>Silty sandstone with boulders and cobbles of quartzite; pebble conglomerate</td>
<td>35-200</td>
<td>Unconformable on Paleozoic and Precambrian rocks</td>
<td></td>
<td>Horizontal</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Unconformity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper Devonian</td>
<td>Dulcie Sandstone (Dud)</td>
<td>Brown and white cross-bedded quartz sandstone; and silty calcareous sandstone; pebble conglomerate</td>
<td>2140</td>
<td>Unconformable in Middle and Lower Ordovician sediments</td>
<td></td>
<td>Asymmetric regional syncline with steep dips on southwestern flank; domes and basins within the regional structure</td>
<td>Springs at unconformity with older sediments</td>
</tr>
<tr>
<td>Middle Ordovician</td>
<td>Nora Formation (Omm)</td>
<td>Brown dolomite, brown coquinite, red siltstone, oolitic ironstone, green siltstone, grey sandstone</td>
<td>375</td>
<td>Unconformity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower Ordovician</td>
<td>Tomahawk Beds (C-Ot)</td>
<td>Grey and brown glauconitic sandstone, green siltstone, grey limestone, brown dolomite</td>
<td>650</td>
<td>Conformable on Tomahawk Beds</td>
<td></td>
<td>Dips up to 30°</td>
<td>Oolitic ironstone in Point Spring area</td>
</tr>
<tr>
<td>Upper Cambrian</td>
<td>Arrinthunga Formation (Cua)</td>
<td>Brown, yellow, and purple dolomite; blue oolitic limestone, green siltstone, brown sandstone</td>
<td>3200</td>
<td>Conformable on Arthur Creek Beds</td>
<td></td>
<td>Trilobite at top and bottom, algae widespread</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Eurowie Sandstone Member (Cue)</td>
<td>Brown, ripple-marked, cross-bedded sandstone with halite pseudomorphs</td>
<td>50-100</td>
<td>Folded strongly in central area; faulted severely in north-east</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Middle Cambrian</td>
<td>Arthur Creek Beds (Cma)</td>
<td>Buff shale, blue-black laminated limestone with lenses of calcareous brown sandstone in east; brown and purple dolomite, blue limestones, yellow siltstone, brown sandstone in west</td>
<td>? 1000</td>
<td>May be unconformable on Mount Baldwin Formation</td>
<td></td>
<td>Rich fauna of trilobites and brachiopods; sponge spicules in east; few trilobites and brachiopods in west</td>
<td>Low dips generally, numerous slump structures</td>
</tr>
<tr>
<td>Lower Cambrian</td>
<td>Mount Baldwin Formation (Cbl)</td>
<td>Red glauconitic quartz sandstone, red and grey quartz greywacke, red siltstone, yellow dolomite Grey glauconitic quartz sandstone, red, blue, and green gypsiferous siltstone, brown dolomite</td>
<td>300-2200</td>
<td>Conformable and gradational with the Grant Bluff Formation</td>
<td>Archaeocyathids, brachiopods</td>
<td>Algae</td>
<td>Gentle dips except near faults</td>
</tr>
<tr>
<td></td>
<td>Grant Bluff Formation (P-Cg)</td>
<td>Red and green siltstone, grey quartz sandstone, brown arkose Brown coarse-grained arkose, green siltstone</td>
<td>525</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Elysh Formation (Pue)</td>
<td></td>
<td>420</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Oaraba Arkose Member (Pue)</td>
<td></td>
<td>80</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower Proterozoic</td>
<td>Mount Cornish Formation (Puce)</td>
<td>Boulder beds, green siltstone with “tillitic” texture, cyclic green siltstone and fine sandstone</td>
<td>1250</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower Proterozoic</td>
<td>Duneiper Granite (Pgd)</td>
<td>Medium and coarse-grained quartz-feldspar-muscovite granite</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Jerveon Granite (Pgs)</td>
<td>Quartiz-microcline granite; graphic intergrowths of quartz and feldspar</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Marshall Granite (Pgm)</td>
<td>Quartz-feldspar-biotite granite porphyritic in oriented feldspar</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mount Swan Granite (Pgs)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Archaean</td>
<td>Brady Gneiss (Ab)</td>
<td>Basic rocks, mainly gabbros</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Garnet-mica-feldspar gneiss</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Iridindia Gneiss (Ai)</td>
<td>Garnet-mica-feldspar gneiss</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bundo Gneiss (Ar)</td>
<td>Quartz-feldspar-mica gneiss, porphyroblastic in feldspar</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mica-quartz-feldspar gneiss, locally rich in kyanite</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Entia Gneiss (Ae)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Undifferentiated (Aa)</td>
<td>Gneiss, schist, metaquartzite, marble</td>
<td></td>
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</tbody>
</table>
DRAINAGE AND TOPOGRAPHY

The courses of the Plenty, Marshall, and Bundey Rivers and of Arthur, Lucy, and Ooratippra Creeks illustrate the regional slopes of plains which surround a chain of ranges which roughly bisect the Sheet area diagonally from north-west to south-east. The Jervois Range, in the south-east, trends north-east.

In the south-western corner of the Sheet part of the northern flank of the rugged Harts Ranges rises to about 2000 feet above mean sea level. To the north and east of these Ranges the Plenty and Marshall Rivers drain a sandy plain with a few isolated peaks and mesas. The difference in elevation from west to east across this plain is about 500 feet.

The Dulcie Range forms a plateau, bounded by scarps and rising about 1900 feet above mean sea level. It is the most prominent feature in the central chain of ranges; parts of the narrow Mopunga, Elyuah, and Jervois Ranges are rugged.

The area north of the Dulcie Range and west of Ooratippra Creek is a sand plain which slopes north and north-east towards the Sandover River. The area bounded by Ooratippra and Arthur Creeks, in the north-eastern quadrant of the Sheet, consists of gently-undulating country with numerous ledges of carbonate rocks, some low peaks and a small area of sand plain.

STRATIGRAPHY

The stratigraphy is summarized in Table 1. All rock units are named in accordance with the Australian Code of Stratigraphical Nomenclature and all formation names have been approved by the Territories Committee on Stratigraphical Nomenclature. Many sedimentary formations which are known to crop out over large areas of the Georgina Basin have been named from the Huckitta Sheet area; others have been named from the easterly-adjacning Tobermory Sheet area.

Palaeontological age determinations are incomplete for some fossils obtained from measured sections. Radioactive age determinations are available for three of the granite masses exposed on the Huckitta Sheet area, but no absolute age is available for the Archaean rocks of the Arunta Complex.

The sub-surface geology is known only from the interpretation of data on shallow water bores (which are not everywhere reliable) and from four shallow stratigraphic holes cored by the Bureau of Mineral Resources in 1962.

PRECAMBRIAN

Precambrian rocks crop out sporadically in the southern half of the Huckitta Sheet area. They include metamorphic, and igneous rocks, and younger unmetamorphosed sediments.
Archaean

Precambrian metamorphic rocks, and some igneous rocks, belong to the Arunta Complex, of Archaean age. They include the Entia, Brady, Bruna, and Irindina Gneiss, which crop out prominently in the Harts Range Anticline and are part of the Harts Range Group. These were mapped by Joklik (1955), who named them in areas adjoining Huckitta to the west; they are the only Archaean rocks named on the Huckitta Sheet. Outside the Harts Range area, outcrops of metamorphic rocks are locally prominent, but discontinuous and separated by sand-covered plains. It was impossible to subdivide these metamorphics or to link them with the formations exposed in the Harts Range Anticline; therefore, all metamorphic rocks except those in the Harts Range are undifferentiated within the Arunta Complex.

The undifferentiated metamorphic rocks generally dip at angles exceeding 50° and are strongly folded. Bedding and foliation are commonly almost parallel.

In the western part of the Huckitta Sheet area (excluding the Harts Range) gneiss predominates; other rock types are schist and metaquartzite. The most common gneiss is a coarse-grained quartz-feldspar-biotite-garnet gneiss in which garnets are abundant; a quartz-feldspar-biotite gneiss devoid of garnets is also common. Other common rock types in the western and central area are quartz-feldspar-muscovite gneiss, quartz-feldspar gneiss, hornblendites, biotitites, quartz-sericite schist and metaquartzite. The regional trend of the metamorphic rocks in the western and central parts of the Sheet area is west-north-west.

Schist predominates in the eastern part of the Sheet area; muscovite schist, sericite schist, cordierite schist, and andalusite schist are common, and there are many calc-silicate rocks in the Jervois area, where Morgan (1959) considers the grade of metamorphism to be high in the albite-epidote-amphibolite facies. In the Jervois area the metamorphic rocks are folded into a tight syncline whose axis trends north-east; between the Jervois Range and the Jinka Plains the metamorphic rocks strike north-west: they may be isoclinally folded, but there are no stratigraphic markers to confirm this impression.

Basic rocks, dominantly gabbro (Morgan, 1959), intrude the metamorphic rocks at several localities in the Huckitta Sheet area. They are believed to be older than the granites of the area and are tentatively assigned to the Archaean.

Lower Proterozoic

The only Lower Proterozoic rocks are granites. Joklik (1955) mapped and named the Lower Proterozoic “Sainthill Grit”, but part of this unit has now been traced along strike into quartz-feldspar-biotite gneiss and other parts were mapped and named as the Marshall Granite (Smith et al., 1960b). The Sainthill Grit in the Mount Sainthill area is now considered to be a granitized metamorphic rock, and accordingly it has been included in the undifferentiated Arunta Complex.
Five separate granite bodies have been mapped. Joklik (1955, p. 33) named and described the Jinka Granite, and Smith et al. (1960a, b) named and mapped the remainder. Three, the Jinka, Jervois, and Dnieper Granites, are petrologically similar; they are quartz-feldspar-mica granites. The Marshall Granite consists almost entirely of quartz and feldspar, commonly intergrown; mica is a minor constituent. The Mount Swan Granite is a quartz-feldspar-biotite granite which characteristically has large sub-parallel phenocrysts of feldspar.

The ages of three granite bodies in the Huckitta Sheet area, determined by Hurley et al. (1961) using the Potassium/Argon method, are:—

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Granite</th>
<th>Age (m.y.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F/53/11/1</td>
<td>Jervois</td>
<td>1440</td>
</tr>
<tr>
<td>F/53/11/2</td>
<td>Jinka</td>
<td>1420</td>
</tr>
<tr>
<td>F/53/11/3</td>
<td>Mount Swan</td>
<td>1460</td>
</tr>
</tbody>
</table>

Walpole & Smith (1961) regard these ages as belonging to an upper subdivision of “Lower Proterozoic”. However, Wilson et al. (1960) dated the Jinka Granite by the Rubidium/Strontium method and recorded an age of 1840 m.y. Insufficient age determinations have been made on granites of the Huckitta Sheet area to decide which method indicates the more reliable age.

About 350 pegmatites in Precambrian metamorphic and igneous rocks were mapped by the Bureau party; many more are probably concealed. Some of the pegmatites are discordant, but most are concordant with metamorphic rocks. Their dominant trend is west, and there are strong subsidiary trends to the north-west and north-east. Some pegmatites have been mined for muscovite on the Plenty River Mica Field.

Wilson et al. (1960) have recorded an age of about 400 m.y. for a pegmatite from the nearby Harts Range area. This age agrees closely with one of 420 for a samarskite-bearing pegmatite from the same area, and is also in general agreement with an age of 357 m.y. which Hurley et al. (1961) determined for the Archaean Irindina Gneiss. This cannot represent the age of the Arunta Complex, but Walpole & Smith (1961) consider that stress in the basement, which caused the formation and subsequent deformation of the Amadeus Basin, may have been sufficient to effect recrystallization of mica in basement rocks. In the Huckitta Sheet area, similar tectonic conditions could have caused mobilization of mica in Palaeozoic time; none of the pegmatites have been dated in this area and in many places Upper Proterozoic sediments rest unconformably on pegmatites. On this field evidence the pegmatites of the Huckitta Sheet area are tentatively regarded as Lower Proterozoic.

Upper Proterozoic

All Upper Proterozoic rocks on the Huckitta Sheet are sediments exposed on the south-western margin of the Georgina Basin. They are not metamorphosed and have not been intruded by igneous rocks. The basal unit is the Mount Cornish Formation; it is succeeded with slight disconformity by the Elyuah Formation, the oldest formation of the Upper Proterozoic–Lower Cambrian Mopunga Group.
The *Mount Cornish Formation* has been named from Mount Cornish (22° 48' S., 136° 28' 30" E.), the type locality. Outcrops of the Formation are small and discontinuous and have also been mapped in the Jervois, Elyuah, and Mopunga Ranges. The Formation unconformably overlies Precambrian metamorphic and igneous rocks. The thickness in the type section is 1250 feet, but in the Jervois and Elyuah Ranges it is less than 100 feet and in the Mopunga Range it is 150 feet. The presence of soled, faceted, and striated boulders in some beds of the Mount Cornish Formation suggests glacial abrasion. No polished surfaces have been observed, but one ground moraine, about 2 miles north-east of the Oorabra Rockholes, has been recorded (Condon, 1958). The Mount Cornish Formation may be correlated with the glacial Are Yonga Formation of the Western Macdonnell Ranges, which was mapped and named by Prichard & Quinlan (1962).

**Upper Proterozoic to Middle Palaeozoic**

*Upper Proterozoic (?) and Lower Cambrian*

The Elyuah, Grant Bluff, and Mount Baldwin Formations constitute the Mopunga Group. The Mount Baldwin Formation, the youngest unit, contains archaeocyathids and brachiopods near its top; no diagnostic fossils have been found in the Elyuah and Grant Bluff Formations and they are therefore regarded as Upper Proterozoic, although one or both of them could be Lower Cambrian.

The *Elyuah Formation* rests on the Mount Cornish Formation with a slight disconformity, and also lies unconformably on Precambrian metamorphic and igneous rocks. The name is taken from the Elyuah Range, in the northern and eastern parts of which the formation crops out. The Elyuah Formation consists of a basal arkose and an overlying shale. Both arkose and shale are found in the Jervois, Elyuah, and Mopunga Ranges and in a few isolated localities between the Jervois and Elyuah Ranges. Arkose outcrops are prominent though small; the shale crops out poorly but almost continuously in the scarp.

The arkose member includes the Oorabra Arkose, named by Joklik (1955) from outcrops near Grant Bluff, where it interfingers with shale of the Elyuah Formation. The name Oorabra Arkose is restricted to the arkose in the north-western end of the Elyuah Range. The Elyuah Formation contains other arkose beds which may be correlated in part with the Oorabra Arkose. The type section of the Oorabra Arkose, established by the 1957–58 Bureau survey, is ½ mile north of Grant Bluff; here it is 83 feet thick, but the thickness changes markedly over short distances and it is 550 feet thick in its north-western outcrops.

The type section of the Elyuah Formation is located about 10 miles east of Grant Bluff and contains about 300 feet of arkose and 120 feet of shale. The arkose ranges from 50 to 3500 feet thick in the Sheet area, but the thickness of the shale is more uniform and is usually about 300 feet.
The *Grant Bluff Formation* caps Grant Bluff, from which the name is taken. The type section is located in the Elyuah Range, about 10 miles south-east of Grant Bluff at about 22° 45' 30" S., 135° 53' E. The Formation crops out in each of the Jervois, Elyuah, and Mopunga Ranges and extends north-west from the Mopunga Range to the western boundary of the Sheet area. The Formation includes some distinctive sandstone beds which are useful stratigraphic markers in many places both east and west of the Huckitta Sheet area.

In the type section the Grant Bluff Formation is 525 feet thick and is succeeded conformably by the Mount Baldwin Formation. In the Jervois Range the Grant Bluff Formation is also about 525 feet thick, but its thickness in the Mopunga Range is only 400 feet and to the north-west of this Range only about 200 feet is exposed. Algae are the only fossils yet found in the Grant Bluff Formation, and it is therefore referred tentatively to the Upper Proterozoic.

The *Mount Baldwin Formation* is named from Mount Baldwin at the south-eastern tip of the Elyuah Range. The type section of the Formation continues from the type section of the underlying Grant Bluff Formation. The Mount Baldwin Formation contains a high proportion of dark red sediments and these give a distinctive dark pattern on air photographs.

The Mount Baldwin Formation crops out in the Jervois, Elyuah, and Mopunga Ranges, and in small areas between these; a few outcrops of the Formation have been found near MacDonald Downs homestead, and on the west bank of the Bundey River. The thickness in the type section is 1375 feet, but in the Sheet area a range from 300 feet to 2200 feet is known.

In the type section a bed of dolomite about 960 feet above the base contains archaeocyathids and brachiopods, which have been determined by A. A. Opik (pers. comm.) as Lower Cambrian. Similar Lower Cambrian fossils have been collected from the Formation at several localities in the Mopunga Range. The stratigraphical range of the Mount Baldwin Formation within the Lower Cambrian is not known yet.

*Middle Cambrian*

The Middle Cambrian sediments in the Huckitta Sheet area are named the *Arthur Creek Beds*. The name is taken from Arthur Creek, which drains part of the outcrop area of the Middle Cambrian sediments. The Arthur Creek Beds crop out discontinuously from Lucy Creek Landing Ground to the Mopunga Range; they are not known to crop out west of Mount Ultim, but may be present below the surface.

East of Point Spring the Arthur Creek Beds consist of three richly fossiliferous units; in ascending order these are:

(i) siltstone and shale;
(ii) blue limestone;
(iii) dolomite, and limestone with lenses of calcareous sandstone.
The basal unit overlies the Mount Baldwin Formation with apparent conformity. The thickness of the Arthur Creek Beds in the eastern part of the Huckitta Sheet area is about 1000 feet, but no complete section can be measured there. Fossil assemblages ranging in age from lower to upper Middle Cambrian (A. A. Opik and J. G. Tomlinson, pers. comm.) have been collected from the Arthur Creek Beds exposed in the eastern area, and many of the limestone beds have a petrolierous odour when freshly struck.

West of Point Spring, the Arthur Creek Beds consist of dolomite and limestone, and non-outcropping soft siltstone and fine sandstone which are seen in samples from water bores. Fossils are rare and have been found in only three localities, all about 6 miles west of Huckitta Homestead. The oldest of these collections was obtained 40 feet stratigraphically above an archaeocyathid-bearing bed of the Mount Baldwin Formation. In this western area the thickness of the Arthur Creek Beds is estimated to be 1000 feet, but the boundary with the overlying Arrinthurunga Formation is not lithologically distinct.

**Upper Cambrian**

The Arrinthurunga Formation and the lower part of the overlying Tomahawk Beds are of Upper Cambrian age. The *Arrinthurunga Formation* crops out over a large part of the north-eastern quadrant of the Huckitta Sheet area, and also in the flanks of the Dulcie Range. The Formation has not been observed west of Mount Ultim on the southern flank of the Dulcie Range; on the northern flank it has not been observed west of Ooratippra Creek.

The Arrinthurunga Formation has been named from Arrinthurunga Creek. The type section is located at 22° 41' 15" S., 135° 40' E., near the north-western end of the Elyuah Range; here the sequence is incomplete but it adequately demonstrates the lithology of carbonate rocks and interbedded siltstone and sandstone, which are typical of the unit in the central and western parts of the Sheet area.

In the eastern part of the Sheet area, the Formation may be locally subdivided, and the following units are present (in descending order):—

(i) light brown dolomite, with some thin sandstone lenses;
(ii) a prominent sandstone lens—the *Eurowie Sandstone Member*;
(iii) blue algal and oolitic limestone, buff dolomite, and thin siltstone beds;
(iv) dark brown, thick-beded dolomite.

The Eurowie Sandstone Member has been named from Eurowie Yard (22° 29' S., 135° 54' 50" E.); it is 50–100 feet thick and contains abundant halite casts, ripple marks and mud cracks. The Member does not occur in the type section of the Formation, and where it does crop out the remainder of the Formation is usually poorly exposed.
The Arrinhrunga Formation is 3200 feet thick near the Marshall River, where the only fossil collections have been made; fossil trilobites were collected at one locality near the base of the Formation and at another location near the top. Fragments of hyolithids and brachiopods were observed near the middle of the same sequence, but could not be removed undamaged.

Upper Cambrian/Lower Ordovician

The richly-fossiliferous Tomahawk Beds crop out in the northern and southern foothills of the Dulcie Range and also in the north-eastern part of the Sheet area. They are named from Tomahawk Yard (22° 26' S., 135° 48' 45" E.), where sandstone in the lower part of the unit forms prominent outcrops. A section of 650 feet has been measured near Point Spring; west of Derry Downs Homestead the unit is 750 feet thick. In the Huckitta Homestead/Point Spring area the Tomahawk Beds appear to be conformable on, and gradational into, the Arrinhrunga Formation, but in the area south-east of Lucy Creek Homestead a reduced thickness of dolomite at the top of the Arrinhrunga Formation suggests erosion before the Tomahawk Beds were laid down. In the north-western part of the Sheet area the Tomahawk Beds may be transgressive on to much older rocks; the Beds here consist almost entirely of sandstone, but lack of outcrop between the Grant Bluff Formation and the Tomahawk Beds prevents proof of the transition. The Bureau's core-hole Grg 1 (22° 19' 45" S., 135° 3' E.) was sited to show proof of the transition, but did not penetrate rocks older than Upper Cambrian.

Middle Ordovician

The Nora Formation conformably overlies the Tomahawk Beds; on the Huckitta Sheet area, because of pre-Devonian erosion, it is limited to a narrow area of outcrop occurring for 25 miles along the south-western scarp of the Dulcie Range. The Formation has been named from Nora Gap (22° 43' S., 137° 56' E.) on the adjoining Tobermory area. There is no continuity of outcrop between the Tobermory and Huckitta areas, but similar lithologies and fossils permit confident correlation. The Nora Formation is about 375 feet thick near Point Spring, but elsewhere it is generally thinner. In all places, scree from the overlying Dulcie Sandstone obscures much of the Formation.

Devonian

The Dulcie Sandstone has been named from the Dulcie Range, which is capped by this sandstone, resting unconformably on both the Nora Formation and the Tomahawk Beds. The type section is located at 22° 35' S., 135° 41' E., where the formation is 2140 feet thick and contains, in its upper part, the Upper Devonian fresh-water placoderms Bothriocephalus sp. and Phyllolepis sp. (Hills, 1959). The Dulcie Sandstone in the Point Spring area is 1700 feet thick and contains fragments of placoderms. The thickness near Derry Downs Homestead is 1500 feet.
MESOZOIC

?Triassic

In the Huckitta Sheet area there are two small outcrops of sediments of probable Triassic age. One of these caps Mount Sainthill and consists of 35 feet of pebble conglomerate and silty sandstone; the other crops out in a valley about 5 miles north of Point Spring, and consists of about 200 feet of silty sandstone with pebbles and cobbles of quartz and angular blocks of silicified quartz sandstone.

At Mount Sainthill these beds contain a few sponge spicules, but fossils have not been found in the other outcrop. Both outcrops are correlated with the Tarlton Formation, named by Condon & Smith (1959) in the Tarlton Range area on the easterly-adjoining Tobermory Sheet, whose upper beds contain plant fossils of Triassic age (White, 1961).

CAINOZOIC

Tertiary

The Arltunga Beds crop out in the western and south-central parts of the Sheet area. They have been recognized in the core from the Bureau's hole No. Grg 1 and may extend under much of the sand cover in the north-central part of the Sheet area.

Madigan (1932b) named similar sediments the ‘Arltungan Beds’, in the Arltunga area to the south-west of the Huckitta area. This name has now been modified to ‘Arltunga Beds’, to conform to the Australian Code of Stratigraphic Nomenclature. Madigan reported freshwater gastropods, of either Pliocene or Pleistocene age, from the Beds in the Arltunga area, but none have been found in the Huckitta Sheet area. Thickness in the Sheet area ranges from 35 to 90 feet.

Quaternary

Sand and alluvium cover large areas. The alluvium consists mainly of sandy soil derived from Precambrian metamorphic and igneous rocks, and calcareous soil derived from Palaeozoic carbonate rocks. Bore records show that alluvium along the banks of the Marshall River can attain a thickness of 200 feet; elsewhere, sand and alluvium are less than 30 feet thick.

CORE-DRILLING

Between February and December 1962, the Geological Branch of the Bureau conducted a programme of coring in various parts of the Georgina Basin. The programme was designed to obtain stratigraphic information in sand-covered areas and areas of poor exposure and to obtain unweathered samples of known formations.
Four holes were cored on the Huckitta Sheet area. Hole No. Grg 1 was sited to investigate stratigraphy beneath the sand cover north-west of New MacDonald Downs Homestead, and holes Nos. Grg 6, 7, and 8 were sited to obtain fresh samples of Cambrian formations. The results of the whole programme will be published by E. N. Milligan*; preliminary results of the four holes on the Huckitta Sheet area are:—

<table>
<thead>
<tr>
<th>Hole No.</th>
<th>Total Depth (feet)</th>
<th>Strata (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grg 1</td>
<td>210</td>
<td>0–30, Quaternary sand; 30–116, Arltunga Beds; 116–210, Fossiliferous oolitic limestone, and sandstone of Upper Cambrian age.</td>
</tr>
<tr>
<td>Grg 6</td>
<td>682</td>
<td>0–23, Quaternary sand; 23–682, Fossiliferous limestone and shale of the Arthur Creek Beds.</td>
</tr>
<tr>
<td>Grg 7</td>
<td>755</td>
<td>0–755, Limestone, siltstone and dolomite of the Arrinthrunga Formation.</td>
</tr>
<tr>
<td>Grg 8</td>
<td>295</td>
<td>0–295, Limestone of the Arrinthrunga Formation.</td>
</tr>
</tbody>
</table>

**STRUCTURAL GEOLOGY AND GEOLOGICAL HISTORY**

Nothing is known of Archaean history and little is known of the regional structure in the Archaean rocks; they have been highly metamorphosed and strongly folded, probably by many orogenies. Disconnected outcrops of the undifferentiated Archaean rocks indicate a regional strike to the west and north-west except in the Jervois area, where it is north-east. Dips in these rocks generally exceed 50°, but structure cannot be mapped, except in the extreme south-west corner of the Sheet.

Granite bodies were intruded during the Lower Proterozoic (Walpole & Smith, 1961), and pegmatites may have been emplaced in fractures during the final stages of intrusion. The pegmatites trend dominantly west (Woolley, 1959). There is no record of geological events between the intrusion of granite and late Upper Proterozoic sedimentation.

In the Huckitta Sheet area, formations equivalent to either the Heavitree Quartzite or the Bitter Springs Limestone (Joklik, 1955, Prichard & Quinlan, 1962) of the Eastern and Western Macdonnell Ranges are not represented. The Mount Cornish Formation, in the south-western part of the Georgina Basin, is here correlated with the glacial Areyonga Formation (Prichard & Quinlan, 1962) of the Amadeus Basin. The deposition of the Mount Cornish

Formation marked the beginning of sedimentation in the south-western part of the Georgina Basin; in this area the basin was probably initiated by down-warping of blocks of basement rocks along north-east and north-west fractures.

The sedimentation which began in late Upper Proterozoic time persisted, without major tectonic breaks, until at least Middle Ordovician time. The greatest thicknesses of preserved sediments are in the Huckitta Homestead/Point Spring area, which may correspond to the site of thickest deposition in a local depression by relatively greater down-warping of blocks of Precambrian basement. This depression is suggested by the abrupt termination of outcropping Arthur Creek Beds and Arrinthrungra Formation near Mount Ultim, and the probable transgression of these units by the Tomahawk Beds in the same area.

The extent of Middle Ordovician sedimentation is unknown; most of the Nora Formation was eroded before the Dulcie Sandstone was laid down, but the dips in the Nora Formation indicate that there was little, if any, folding of Ordovician rocks in pre-Devonian time.

A major Palaeozoic orogeny took place in post-Devonian time; folding and faulting were severe in the southern flank of the Dulcie Range, and strong north-westerly faults cut the Arrinthrungra Formation and the Tomahawk Beds in the north-east. The effects of this orogeny were much milder on the northern flank of the Dulcie Range, where dips in the Dulcie Sandstone and the Tomahawk Beds are very low.

The Triassic and Tertiary sediments have not been folded or faulted. Very low surface slopes on some Tertiary beds in the south-west are more likely to be of erosional or depositional than of structural origin.

**ECONOMIC GEOLOGY**

The only minerals of economic importance which have been mined in the Huckitta Sheet area are: mica in the Plenty River area, and copper, with associated lead and silver, in the Jervois and Bonya Bore areas. Occurrences of barytes, bismuth, iron, and lead have been noted elsewhere and some have been investigated, but apart from superficial gouging they have not been mined.

*Barytes.*—Numerous thin veins of barytes occur in the Jinda Granite and there are a few veins in metamorphic rocks of the Arunta Complex. None of the veins has been mined and all are too small to warrant further investigation.

*Bismuth.*—The ore from all of the Jervois copper mines except the ‘Bellbird’ contains bismuth in small amounts; concentration occasionally reaches 9%.

*Copper.*—A belt of discontinuous copper mineralization about 6 miles long over an average width of 2000 feet occurs in the Jervois area. It has been mapped and sampled by Blanchard (1940), Robertson (1959), and geologists of New Consolidated Goldfields (Aust.) Ltd, who tested the deposits by drilling in 1961 and 1962.
Secondary copper ores in the area persist to about 100 feet, but primary mineralization below this depth has not been mined. The copper minerals occur predominantly in skarn lenses and garnetiferous granulite phases in Precambrian metamorphic rocks which have been folded into a syncline plunging north-north-east beneath Upper Proterozoic sediments in the Jervois Range. The copper lodes are associated with shearing; there are also lead lodes, which are confined to calcic bands in the metamorphic rocks.

Six lodes have been worked. The first ore was won in 1929, and from that time until 1939 about 200 tons of hand-picked ore, including 33% copper ore, and lead ore containing 64% lead and 100 ounces of silver to the ton, was sold. There was little or no production between 1939 and 1948, but from 1948 until 1956 about 2800 tons of secondary copper ore was won. Much of this ore came from the Bellbird Mine, and most of it was transported to Mount Isa for treatment.

In 1957 the operator (Mr K. Johanesen) erected an acid leaching plant at the Jervois mines, with the object of producing copper sulphate for the fertilizer market. The planned daily capacity was one ton of sulphate from seven tons of ore. A trial parcel of ore was treated and this experiment showed that some modifications to the plant were necessary. The modifications were made in 1958, and the plant’s capacity was trebled at the same time. The project was then temporarily abandoned until 1962, when preparations were made to mine more ore for treatment.

Other deposits of copper have been mined in the area west and north-west of Bonya Bore (22° 46’ 12” S., 136° 8’ 30” E.). Here secondary copper ores and a little chalcopyrite have been won from quartz veins which cut Precambrian metamorphic and basic igneous rocks. Several shafts were sunk, but the workings have been idle since 1957.

Iron.—The Cambro-Ordovician Tomahawk Beds contain ferruginous sandstone and the Middle Ordovician Nora Formation contains oolitic ironstone and ferruginous sandstone. The oolitic ironstone occurs only in the Point Spring area, where thin beds totalling 6 feet in thickness have been recorded in an interval of 32 feet of the Nora Formation (Vine, 1959). Ferruginous sandstone beds, ranging in thickness from 5 to 50 feet, are known in the Tomahawk Beds in the Mount Ultim area, and can be traced over a distance of about 2 miles.

An analysis of oolitic ironstone from the Point Spring area showed 39-6% Fe₂O₃, and a sandstone from the Mount Ultim area contained 25-7% Fe₂O₃ (Vine, 1959). The deposits have not been adequately sampled and they warrant further investigation.

Lead.—Apart from the lead ores in the Jervois area there is only one occurrence worthy of note. This is about 3 miles south of Box Hole Bore (22° 16’ 23” S., 135° 51’ E.) and was discovered by a prospector in 1960.
This deposit has fairly extensive showings of galena in beds of dolomite of the Upper Cambrian Arrinthrunga Formation. The prospect was mapped and drilled by Zinc Corporation Pty Ltd, who subsequently relinquished their option on it. Woolley & Rochow (1961) examined the area for the Bureau.

The lead mineralization can be traced for about 2 miles. The occurrence is of academic interest as a syngenetic deposit, but it is probably too small for company operations and too remote to be economically attractive to gougers. The sedimentary host formation crops out over large areas and prospecting, particularly by geochemical means, might reveal other similar deposits.

*Mica.*—Most of the Plenty River Mica Field lies within the confines of the Huckitta Sheet area. The field was mapped by Joklik (1955). The mines have always been worked either by individuals or small syndicates. The mica occurs in shoots in pegmatites and a relatively high proportion of ruby mica has been won from the Plenty River Field. Most of the rich deposits of surface mica have been discovered; very few new mines have been opened since the time of Joklik’s survey, and none of these is large. The field is now idle because of lack of readily available payable mica.

The best mica comes from coarse-grained, zoned, discordant pegmatites (Joklik, 1955, p. 178). Very many pegmatites are exposed in the Huckitta Sheet area; about 350 were mapped during the 1957–1958 survey, but most of them were fine-grained and concordant. Only eight were considered worthy of further examination; these have been reported by Woolley (1959, unpubl.). Because the surface search for additional mica deposits has not been very rewarding other methods of prospecting need consideration. Earth-moving machinery could be used to strip soil from areas riddled with pegmatites; and extensions of known deposits could be sought by drilling. The Geophysical Branch of the Bureau tried resistivity tests at two mines on the Plenty River Field, but the results were inconclusive (Tate, 1958, unpubl.) and the method has not been tried again in this area.

*Petroleum prospects.*—No seepages of petroleum are known in the Sheet area and no wells have been drilled for petroleum. In 1962 the Bureau of Mineral Resources cored four shallow holes in the area to obtain stratigraphic and lithological information.

The richly fossiliferous dense limestone of the Arthur Creek Beds often emits a petriferous odour when freshly broken. Such an odour was detected in most of the core from the Bureau’s hole No. Grg 6, in these Beds, and they may contain source beds for petroleum. The overlying Arrinthrunga Formation could provide reservoir and cap rocks. The Tomahawk Beds contain sandstone aquifers, and the Nora Formation may contain suitable cap rocks. However, most of the Tomahawk Beds and Nora Formation are structurally low, beneath the Dulcie Range, and this limits preliminary search to the Cambrian Arthur Creek Beds and Arrinthrunga Formation.
The total thickness of the two Cambrian units is about 4500 feet; but the subsurface extent of the Middle Cambrian sediments is unknown. Some domes and anticlines are exposed in the Arrinhrunga Formation and many beds of this sequence may have developed secondary porosity during dolomitization. Fault traps in the Arrinhrunga Formation may also be present. It may be very difficult to obtain adequate seismic data through the Cambrian carbonate sequences and assessment of the petroleum potential may depend largely on structural and stratigraphic drilling and on gravity and aeromagnetic surveys.

Underground Water Resources

The pastoral industry depends mainly on supplies of underground water, because of the almost total lack of natural surface water and the high rate of evaporation from earth tanks and dams. The general requirements for a bore in this area are that it will produce a regular supply of at least 600 gallons per hour and that the pump depth does not exceed 600 feet.

About 70 successful bores and at least 30 unsuccessful ones have been drilled in the Sheet area. The records of many bores are inadequate and are of little value geologically, but more recent drilling operations are better documented because of increased geological supervision and of stricter enforcement of Northern Territory Administration Ordinances governing the drilling and logging of water bores.

About one-third of the area of the Huckitta Sheet is underlain by Precambrian metamorphic and igneous rocks, and many unsuccessful bores (highly saline and/or low yields) have been drilled in these. However, careful selection of sites to intersect fractured quartz veins, fault planes, or shear zones can improve the chances of success. Good supplies may be obtained from aquifers within thick alluvium over the Precambrian rocks.

The majority of successful bores have been drilled into Palaeozoic sediments, but in many instances Palaeozoic outcrop areas are too stony or inaccessible for the grazing of cattle, and water is not required where it is readily available. The Arrinhrunga Formation contains thin sandstone beds which yield at least 1000 gallons per hour, and greater yields are often obtained from porous carbonate rocks of the formation. The Upper Cambrian sandstone at the base of the Tomahawk Beds usually produces excellent supplies of potable water, but is often in the wrong place to be exploited. Underground water could be produced from the Dulcie Sandstone, but most of its surface is unsuitable for grazing. There are several springs at the unconformity between the Dulcie Sandstone and underlying formations.

The Arthur Creek Beds in the Lucy Creek area are not good aquifers, but two successful bores have been drilled fortuitously into solution cavities in a blue limestone member. West of Huckitta Homestead, successful bores have been drilled into soft silty sediments and into fractured chert of the Arthur Creek Beds.
There has been little drilling in either the Mount Baldwin or Grant Bluff Formations; this is due in part to the topography and in part to unfavourable lithologies; both formations contain considerable amounts of siltstone and very precise siting is usually required to drill the more favourable sandstone and dolomite beds.

The Elyuah Formation has not been drilled because of its unfavourable lithology, but the basal arkose beds may produce water, which would be expected to be saline. Only one bore has been drilled into the Mount Cornish Formation; it produced 1200 gallons per hour from arkose but the water, although usable, was saline.

The Arltunga Beds have not been proved to contain water, but the drill may have penetrated them in a few bores on MacDonald Downs Station. On the Huckitta Sheet area the base of the Beds is usually exposed, where they cap older rocks. Hence they are virtually useless for water supplies, but if they could be tapped below the water table they should be very good aquifers, and are known to be good on the westerly-adjoining Alcoota Sheet area.

CORRIGENDUM

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