1 : 250,000 GEOLOGICAL SERIES—EXPLANATORY NOTES

LAKE AMADEUS

NORTHERN TERRITORY

SG/52—4 INTERNATIONAL INDEX

COMMONWEALTH OF AUSTRALIA

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Compiled by P. J. Cook

Issued under the authority of the Hon. David Fairbairn, Minister for National Development

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS
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COMMONWEALTH OF AUSTRALIA

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Explanatory Notes on the Lake Amadeus Geological Sheet

The Lake Amadeus 1 : 250,000 Sheet area covers about 6500 square miles in the southwest corner of the Northern Territory. It lies in the central part of the Amadeus Basin, which contains Proterozoic and Palaeozoic sediments and superficial Tertiary and Quaternary deposits.

The nearest town, Alice Springs, is about 200 miles by road from Reedy Rockhole in the northeast corner of the Sheet area. Access is poor: the few (unsealed) tracks are mainly restricted to the northeast corner. There is a maintained airfield about 4 miles from King Canyon. Most of the western half is an Aboriginal Reserve. Pastoral leases are held by Tempe Downs, Angas Downs, and Curtin Springs stations in the eastern half, but there are no permanent settlements.

Summers are hot, with temperatures frequently above 100°F, and winters cool with temperatures below 32°F commonly recorded at night. The average annual rainfall is about 10 inches, most of which falls during the summer from sporadic storms.

Topographic maps and air-photographs covering the Sheet area are available from the Division of National Mapping, Department of National Development, and are: photo-mosaic, at a scale of 4 miles to 1 inch; planimetric map, at a scale of 4 miles to 1 inch; dyeline maps at a scale of approximately 1 : 46,500 (air-photograph scale), controlled by slotted template assembly, with principal points, wing points, and topography; air-photographs, flown at 25,000 feet by the R.A.A.F. and at a scale of approximately 1 : 46,500.

Previous geological investigations

The first geologist to visit the Lake Amadeus Sheet area was probably Chewings, who in 1886 investigated the source of the Finke River. Parts of the Sheet area are referred to by Chewings in several publications (Chewings, 1891, 1894, 1896, 1914, 1928, 1931, 1935). Brown visited the George Gill Range and found the first fossils (Brown, 1889, 1890, 1891, 1892, 1895). He subdivided the Amadeus Basin sediments into two groups, but Chewings advocated a threefold division. The Horn Expedition of 1892 (Tate, 1896) also visited the George Hill Range and probably obtained some of their Ordovician fossils from there. Maurice visited the western margin in 1902. He described the conglomerate at Mount Currie and also the mounds of gypsum at Mount Murray (Murray, 1904). George & Murray (1907) described briefly the sandstones of Winnall Ridge and other ridges in the south. Ward, Mawson, and Madigan all discuss briefly the rocks of the George Gill Range (Madigan, 1931, 1932; Mawson & Madigan, 1930; Ward, 1925).

In 1956, the Bureau of Mineral Resources carried out reconnaissance geological work in the Hermannsburg Sheet area and particularly around Ellery Creek (Pritchard & Quinlan, 1962). This has been the basis for most of the subsequent work in the Amadeus Basin. One of the first oil companies to take an interest in the area was Frome Broken Hill Pty Ltd, who in 1959 undertook reconnaissance geological mapping in the eastern half of the Sheet area (Leslie, 1960, unpubl.). Since 1960 Magellan Petroleum (Australia) Pty Ltd have carried out numerous geological and geophysical surveys in the area, particularly in the northeast corner (Stelck & Hopkins, 1962; McNaughton, 1962, unpubl.; Williams, Hopkins, & McNaughton, 1965).

In 1960-64 the Bureau of Mineral Resources systematically mapped the entire Amadeus Basin. As part of this programme the Lake Amadeus Sheet area was mapped in 1962 by Ranford, Cook, and Wells (1966). References to work in the remainder of the Amadeus Basin are listed in the bibliography. In 1960 the Institut Français du Pétrole produced a photo-interpreted geological map of the Lake Amadeus Sheet area for the Bureau of Mineral Resources (Scanvic, 1961, unpubl.).

The first geophysical work was carried out by the Bureau of Mineral Resources in 1960, when two aeromagnetic lines were flown (Goodeve, 1961, unpubl.). The Geophysical Branch of the Bureau of Mineral Resources also completed a helicopter gravity survey in 1962 (Lonsdale & Flavelle, 1963, unpubl.) and an airborne magnetic and radiometric survey in 1965 (Young & Shelley, 1966, unpubl.).

In 1963 two holes were drilled (AP1 and AP4) in the search for phosphate (Barrie, 1964, unpubl.). A regional sedimentological study of the Stairway Sandstone embraced the Sheet area (Crook, 1964, unpubl.; Cook, 1963 and 1966, unpubl.; Pritchard & Cook, 1965). The first exploratory well to be drilled was East Mereenie No. 1, which was drilled on the northern margin in 1963 by a group of companies. Six exploratory wells have been drilled to date (see Table 2).

PHYSIOGRAPHY

The 5 distinct physiographic divisions are shown in Fig. 1.

High mountain ranges and hills. The peaks rise from 200 to 1000 feet above the general level of the plain (up to about 3000 feet above sea level). This physiographic division is almost entirely underlain by gently dipping Mereenie Sandstone and Pertnjara Group (see Fig. 1). Drainage in many parts is dendritic.

Low ranges and hills with intervening sand dunes. Strike ridges generally rise from 50 to 200 feet above the plain; they are generally composed of fairly steeply dipping Mereenie Sandstone, Larapinta Group or Winnall Beds. The dunes are of the braided type.

Sand plain with some dunes and low outcrop. Outcrops in this Division rise only a few feet above the sand plain and are generally composed of very steeply dipping Winnall Beds. Dunes are generally braided, but there are some longitudinal dunes.

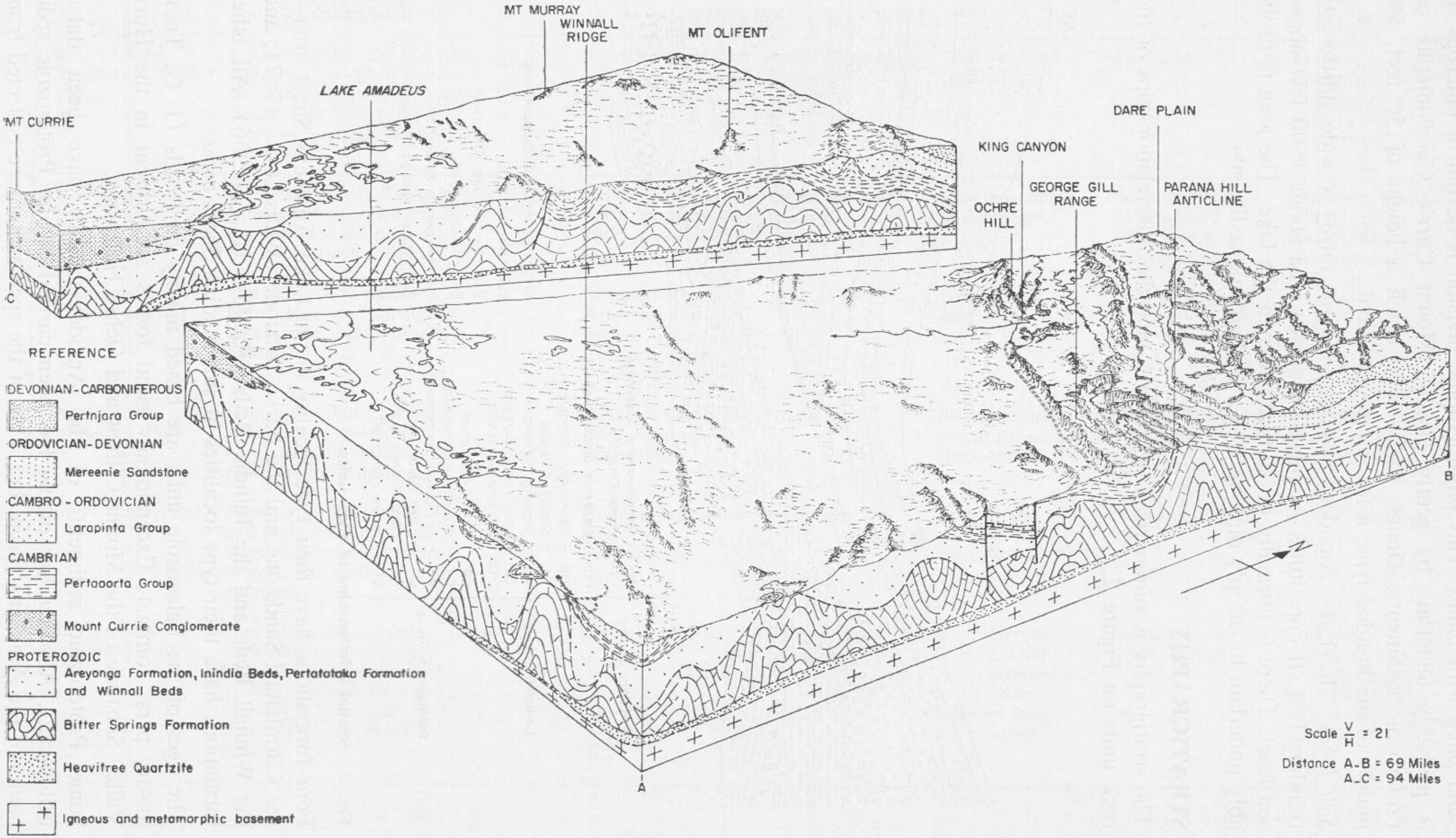

Fig. 1. Physiography in relation to geology.

Sand plain with dunes. This physiographic division is devoid of outcrops; it is probably underlain by gently dipping Mount Currie Conglomerate or Proterozoic sediments. Dunes, which may reach a height of 50 feet, are mainly of the braided type; a few are longitudinal.

Salt lakes. The Lake Amadeus salt lake system forms a wide northwest-trending belt. It constitutes an inland drainage area about 1500 feet above sea level. There is normally no surface water in the lake. The area is probably underlain by steeply dipping Upper Proterozoic sediments.

STRATIGRAPHY

The stratigraphy is summarized in Table 1, and the interrelationships of the rock units on Figure 2.

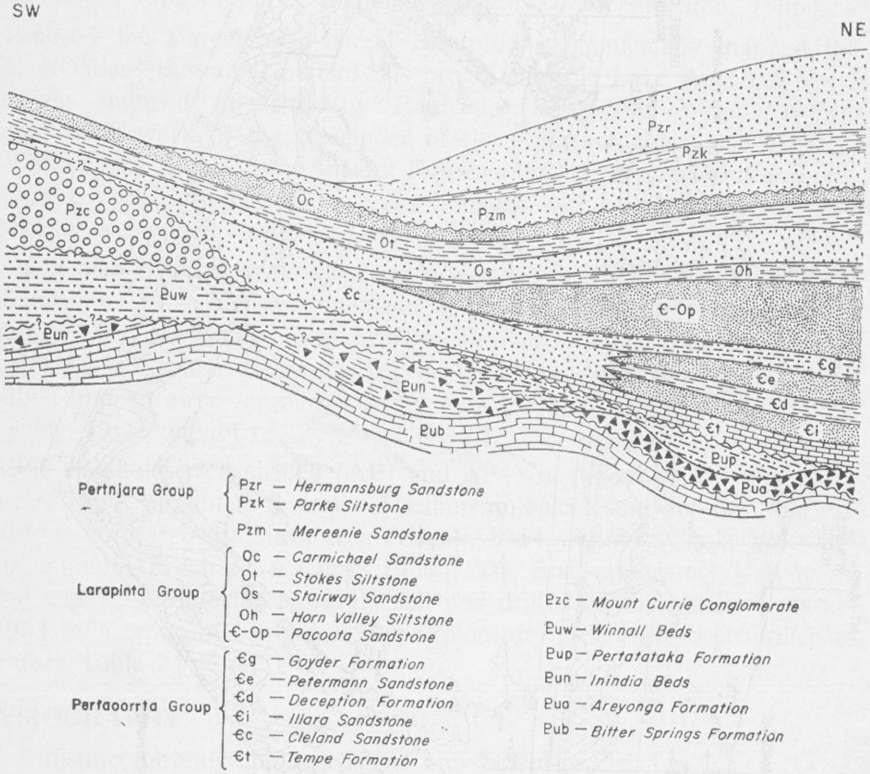

Fig. 2. Spatial relationships of rock units.

Four formations have their type locality in the Lake Amadeus Sheet area—the Carmichael Sandstone and the Parke Siltstone (Wells et al., 1967); and the Winnall Beds and the Inindia Beds (Ranford et al., 1966). All other formations have their type localities in surrounding Sheet areas.

The ages of the Palaeozoic units are based mainly on fossils (J. G. Tomlinson, pers. comm.). Exceptionally good fossils are present in the Horn Valley Siltstone of the Mount Olifent and Ochre Hill areas.

Some Proterozoic sediments of the Amadeus Basin have been dated isotopically. Absolute age dating has been carried out on Proterozoic sediments of the Amadeus Basin, but none of the specimens were collected from the Lake Amadeus Sheet area. Figure 2 shows diagrammatically the relation of the various rock units.

GEOPHYSICAL DATA

Gravity

Lonsdale & Flavelle (1963, unpubl.) recognized two gravity features within the Sheet area; they termed them the Amadeus Gravity Depression and the Angas Downs Gravity Ridge. There is a gravity gradient across the Sheet area, from –50 mgals in the south to –125 mgals in the north. This gradient corresponds to an increasing thickness of Proterozoic and Palaeozoic rocks (particularly the latter) from south to north. In the Angas Downs Gravity Ridge there is a maximum of 1000 feet of Palaeozoic sediments, whereas in the northeast corner there are over 10,000 feet of Palaeozoic sediments. Folding of the sediments in the Angas Downs Gravity Ridge area also appears to be more severe than that in the Amadeus Gravity Depression.

Diapirs do not appear to be related to the gravity lows; but this may be because gravity stations are too widely spaced for such a relationship to be reflected. Anticlinal structures in the northern half of the Sheet area are not gravity highs; so there is presumably a décollement in the section, and basement is not involved in the folding of the sediments.

Aeromagnetic

The aeromagnetic work of Young & Shelley (1966, unpubl.) has indicated that the greatest depth to magnetic basement is 34,000 feet; this depth occurs in the centre of the Sheet area in a northwest-trending trough. The lineament of diapiric structures which crosses the Sheet area is situated approximately along the axis of the trough (see Fig. 3), in the area of maximum overburdened sediments.

Considerable depths to magnetic basement (greater than 30,000 feet) also occur in the northeast and northwest margins. The minimum depth to magnetic basement occurs in the southwest corner, where the depth is estimated at less than 12,000 feet.

Radiometric

The Sheet area can be divided into three radiometric divisions—northern and southern radiometric maxima separated by an east-west radiometric minimum.

The highest radiometric anomaly (100 counts per second) occurs in the northeast corner, over Johnny Creek Anticline. It may be significant that this is also the area with the largest known outcrop area of Stairway Sandstone phosphorites (phosphorites are found to be slightly radioactive in many parts of the world). Most of the anomalies cannot be correlated with any feature of the surface geology, although it is suspected that the lutites of the Pertaoorrta and Larapinta Groups may be responsible for some of the radiometric maxima. Many of the radiometric minima correspond to areas covered by aeolian sand or underlain by Mereenie Sandstone, or Hermannsburg Sandstone.

TABLE 1. STRATIGRAPHY OF THE LAKE AMADEUS SHEET AREA

Period	Rock unit and symbol	Lithology	Thickness (maximum)	Stratigraphic relationships	Palaeontology and age	Topographic expression	Water supply	Remarks
Quaternary	Alluvium (Qa)	Alluvial sand and river gravel.				Stream deposits and alluvial flats.	Good potential for high quality water.	Mainly in north-east corner.
	Sand (Qs)	Fine aeolian sands.				Dunes.		
	Travertine (Ql)	Grey and white vuggy concretionary masses.		Unconformable on older sediments.		Low mounds.		Over limestone and dolomite.
	Evaporites (Qt)	Thin interbeds of evaporites (gypsum) and silt.				Beds of salt lakes.	Poor prospects.	Lake Amadeus salt lake system.
	Gypsum (Qg)	Grey and white soft friable gypsum.				Low mounds.		Commonly present over diapirs.
Tertiary	Limestone, chert (Tl)	Fine grey limestone and chert, thin interbeds sandstone and siltstone.	20′+		Similar Tertiary sediments farther east are fossiliferous.	Low mesas and mounds.		Only in southeast corner.
	Conglomerate (Tc)	Poorly consolidated moderately to well rounded conglomerate.	20′+	Unconformable on older sediments.		Capping on mesas.	Very poor prospects.	Only in northeast corner.
	Sandstone, siltstone (Ts)	Kaolinitic sandstone, sandy siltstone, some pisolitic ironstone.	40′+			Prominent mesas.		Only in northeast corner.
Devonian to Carboniferous — Pertnjara Group	Hermannsburg Sandstone (Pzr)	Red-brown medium to coarse poorly sorted thick-bedded sandstone, pebbly sandstone, minor siltstone.	500′+	Conformable on Parke Siltstone.	Barren. Dated by fossils elsewhere.	High prominent escarpments.	Large potential supply of moderate water.	Top an erosional surface.
	Parke Siltstone (Pzk)	Brown, green, and grey siltstone and calcareous siltstone, pseudomorphs after halite. Some thin silty sandstone and limestone interbeds.	2000′	Conformable on Mereenie Sandstone.	Barren. Dated by spores elsewhere.	Wide alluvium-covered valleys.	No potential.	
Silurian to Devonian	Mereenie Sandstone (Pzm)	White fine to medium well sorted cross-bedded sandstone.	2000′	Regionally unconformable on Carmichael Sandstone.	Problematica.	High prominent escarpments.	Large quantities of excellent water.	Extremely uniform.
Cambrian to Ordovician — Larapinta Group	Carmichael Sandstone (Oc)	Red-brown fine to medium sandstone, some thin siltstone interbeds.	300′	Conformable on Stokes Siltstone.	*Cruziana.*	Scree-covered slopes.	Moderate quantities of good water.	Halite pseudomorphs fairly common.
	Stokes Siltstone (Ot)	Grey, green, and red-brown thin-bedded siltstone, pseudomorphs after halite. Some thin-bedded grey and pink limestones.	1180′	Conformable on Stairway Sandstone.	Early Upper Ordovician fossils.	Alluvium-covered strike valleys.	Mostly impermeable.	Limestones almost coquinites. Halite pseudomorphs common.
	Stairway Sandstone (Os)	Fine to medium white quartz sandstone, interbedded green siltstone, rare limestone and thin phosphorite bands.	780′	Conformable on Horn Valley Siltstone in north; unconformable on Proterozoic in south.	Middle Ordovician fossils.	Strike ridges.	Water generally saline.	Pelletal phosphorites.
	Horn Valley Siltstone (Oh)	Grey-green calcareous siltstone and grey thinly bedded limestone.	285′	Conformable on Pacoota Sandstone.	Very rich Lower Ordovician fauna.	Narrow strike valleys.	Prospects very poor.	Distinctive band of oolitic ironstone near top.
	Pacoota Sandstone (Є-Op)	Medium to coarse thick-bedded white sandstone, some conglomeratic sandstone, minor thin interbeds of siltstone.	1060′	?Conformable on Goyder Formation and Cleland Sandstone.	*Scolithus.* Rare, Upper Cambrian to Lower Ordovician fossils.	Prominent strike ridges and scarps.	Large potential supply of good water.	Piperock very common.
Cambrian — Pertaoorrta Group	Goyder Formation (Єg)	Yellow-brown and white medium thin-bedded calcareous sandstone, yellow siltstone, lenses of grey-brown sandy dolomite and limestone.	850′	Conformable on Petermann Sandstone or Cleland Sandstone.	Stromatolites in upper part.	Alluvium-covered valleys.	Upper part may provide a small supply.	Irregular lenses of manganese-rich rock.
	Petermann Sandstone (Єe)	Red-brown and white, fine to medium micaceous sandstone and silty sandstone. A little siltstone.	640′	Conformable on Deception Formation.	Unfossiliferous.	Prominent strike ridges.	Possibly some supply.	Only recognized in Parana Hill Anticline.
	Deception Formation (Єd)	Red-brown siltstone and shale, minor thin beds red-brown sandstone. Slumping and clay pellets.	460′	Conformable on Illara Sandstone.	Unfossiliferous.	Strike valleys.	Poor potential.	Only recognized in Parana Hill Anticline.
	Illara Sandstone (Єi)	Red-brown fine to medium micaceous sandstone, minor thin interbeds of calcareous sandstone and siltstone, cross-bedded and slumped.	420′	Conformable on Tempe Formation.	No fossils found.	Prominent strike ridges.	Possibly some supply from 'cleaner' sandstone.	Only recognized in Parana Hill Anticline.
	Cleland Sandstone (Єc)	White and red-brown silty sandstone, fine to coarse, pebbly in places. Strongly cross-bedded and slumped.	1570′+	Conformable under Goyder Formation and Pacoota Sandstone. Unconformable on Proterozoic rocks; conformable on Tempe Formation.	Lower Middle Cambrian trilobites, gastropods and brachiopods.	Strike valley.	Some horizons may give small supply.	Only recognized in northeast corner.
Cambrian	Tempe Formation (Єt)	Red and green siltstone, brown sandy dolomite, glauconitic dolomites, limestone, and sandstone. Some thin chert bands.	400′	Unconformable on Proterozoic formations.	No fossils found.	Mainly poorly exposed, some low strike ridges.	Prospects poor.	Only recognized in western half.
Proterozoic to Cambrian	Mount Currie Conglomerate (Pzc)	Pebble, cobble, and boulder conglomerate. Phenoclasts of quartz-feldspar porphyry, basalt, vein quartz, metamorphic quartzite, silicified sandstone.		Unconformable on Winnall Beds.	Unfossiliferous. Probably Cambrian	Well rounded inselbergs.	No potential.	Massive. Epidotization very common. Only in south-west corner.
Proterozoic	Winnall Beds (Puw)	White and brown fine to very coarse thickly bedded cross-bedded sandstone, white and green siltstones.	5700′+	Unconformable under younger rocks. Lower contact badly exposed.	Indeterminate tracks and trails.	Very prominent strike ridges.	Some beds likely to give good quantities of moderate water.	Slumping, scour and fill, mud cracks, etc., very characteristic.
	Pertatataka Formation (Pup)	Grey-green and purple-brown shale and siltstone, thin interbeds limestone or dolomite.		?Conformable on Areyonga Formation; unconformable below Pertaoorrta Group.	Algae.	Only present subsurface.	No potential.	
	Areyonga Formation (Pua)	Grey-green tillitic pebbly siltstone and claystone, lenses of medium to coarse cross-bedded sandstone.	750′	Disconformable on Bitter Springs Formation.	No fossils.	Poorly exposed except for sandstone lenses.	Moderate potential from porous sands.	Only recognized in core of Parana Hill Anticline.
	Inindia Beds (Pun)	Brown and yellow siltstone and shale, medium sandstone, bedded chert, chert breccia, thin beds of dolomite.	?	Disconformable on Bitter Springs Formation.	No fossils.	Very poorly exposed; low mounds.	No potential.	Only in southern half.
	Bitter Springs Formation (Pub)	Grey dolomite and dolomitic limestone with chert lenses, limestone. Interbeds of red-brown siltstone and sandstone. Masses of sheared and contorted gypsum.	1660′	Base not exposed.	*Collenia* very common.	Siltstone recessive. Some dolomite forms prominent strike ridges. Gypsum forms low mounds.	Moderate supply, generally highly saline.	Commonly associated with possible diapirs. Gypsum exposed only in cores of diapirs.

STRUCTURE (Fig. 3)

Folding

There were apparently two main periods of folding in the Lake Amadeus Sheet area; the first occurred during the Petermann Ranges Orogeny (Forman, 1966) and the second during the Alice Springs Orogeny (Forman et al., 1967).

The Petermann Ranges Orogeny (late Proterozoic or early Cambrian) folded Proterozoic sediments in the southern half of the Sheet area. In particular, the Winnall Beds were folded into tight west or west-northwest synclines, as may be seen at Winnall Ridge. The area most strongly affected by this movement corresponds to the Angas Downs Gravity Ridge. To the north, there was only very minor folding during this orogeny.

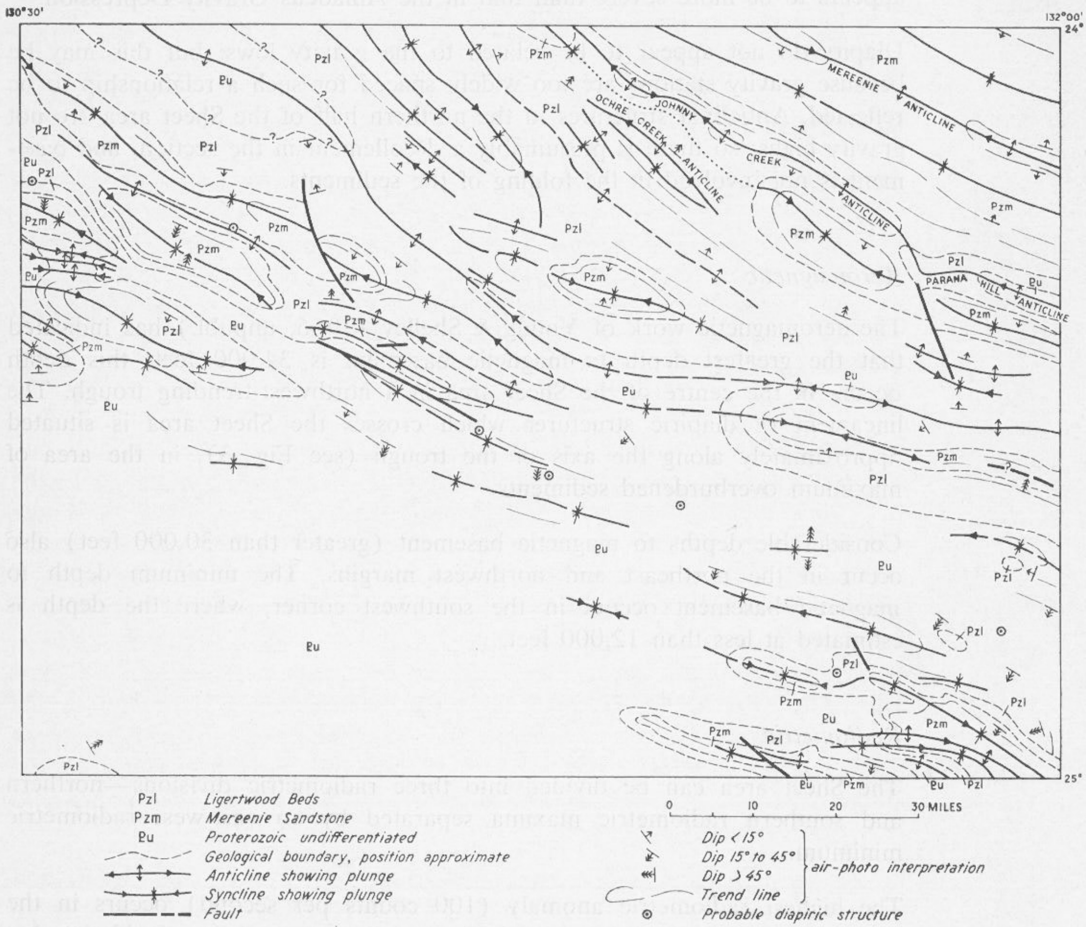

Fig. 3. Structure of Lake Amadeus Sheet.

The Alice Springs Orogeny (Upper Devonian—Carboniferous) produced major folding in the north along northwest-trending axes subparallel to the older trend. All the main anticlines—Mereenie, Johnny Creek, Parana Hill, and Ochre Hill Anticlines—formed during this folding episode. Some of the anticlines may have been further modified by the movement of salt into the folds of the Bitter Springs Formation.

Epeirogenic movement known as the Rodingan (?Silurian) Movement took place between the two main orogenies (Wells et al., 1967). Some minor folding may have been associated with this epeirogenesis, but the main movement was probably an uplift or tilting. Minor epeirogenic movement may have occurred after the Areyonga and before the Pertatataka Formation was laid down.

Faulting

The two main types of faults in the Lake Amadeus Sheet area are strike faults and transverse faults.

The strike faults have west-northwest trends. The amount of displacement is uncertain, but may be up to several thousand feet.

The transverse faults generally trend north-northwest and their displacement is probably only small.

GEOLOGICAL HISTORY

The oldest unit exposed in the Lake Amadeus Sheet area is the *Bitter Springs Formation*—a carbonate lutite sequence (with some evaporites) probably laid down in fairly warm shallow water on a shelf. Temperatures gradually dropped, and during *Areyonga Formation* time marine glacial sediments were deposited in the north while finer-grained sediments (the *Inindia Beds*) were deposited in the south. This suggests that the main source area for the sediments lay to the north. There may have been a minor epeirogeny at the close of Areyonga-Inindia time.

By *Pertatataka Formation* time the climate was probably warmer, and thin limestone, dolomite, and lutite were deposited in the north; to the south the very thick arenitic sequence (with some lutites) of the *Winnall Beds* was deposited in a fairly vigorous sea. The source area for these sediments probably lay to the south. In the late Proterozoic or Lower Cambrian, a major orogeny took place southwest of the Sheet area. This produced tight folding in the Proterozoic sediments and formed a landmass (corresponding approximately to the Angas Downs Gravity high) in the southern half of the Sheet area. The synorogenic *Mount Currie Conglomerate* was deposited in the southwest corner. In the southeast, the conglomerates of the *Pertaoorrta Group* may also have been deposited contemporaneously. Much of the southern part of the Sheet area remained land from the lower Cambrian to the Upper Ordovician.

In the north, sedimentation continued throughout Pertaoorrta Group and Larapinta Group times with no major breaks. Palaeozoic sedimentation in this area commenced in the lower middle Cambrian with the *Tempe Formation,* a shallow-water marine carbonate facies of considerable extent. This was followed by a more arenitic phase, particularly in the west, where the *Cleland Sandstone* was deposited, possibly in a delta, but grading laterally to the east into shallow marine conditions in which the *Illara Sandstone,* the *Deception Formation,* and the *Petermann Sandstone* were laid down. A uniform shallow sea spread over most of the northern part of the Sheet area during *Goyder Formation* (Upper Cambrian) time, and lutites and reef limestones were deposited.

In the southeastern part of the Sheet area, south of the George Gill Range, the Cambrian sediments consist of nearshore conglomerate, silty sandstone, and shale. Most of these outcrops cannot be identified with the Cambrian formations exposed farther north and are mapped as undifferentiated Pertaoorrta Group.

Larapinta Group sedimentation opened with conditions very similar to those prevailing in Pertaoorrta Group time; the *Pacoota Sandstone* was, however, deposited in rather more turbulent water, with a considerable flow of terrigenous sediments from the west. The Amadeus Basin at the time was a broad shallow embayment with the open sea lying to the east. The sea became very much deeper during *Horn Valley Siltstone* time, and there may also have been a considerable decrease in the inflow of terrigenous sediments. At the same time circulation of bottom water was restricted, pelagic fauna abounded, and a strongly reducing environment in the bottom water developed. The environment became less reducing during lower *Stairway Sandstone* time, and conditions similar to those of Pacoota Sandstone time returned to the area; the main source area was now to the southeast, and the open ocean to the northwest, with only very restricted connexion to the east. In middle Stairway Sandstone time the environment again became more restricted, and black siltstones and shales and pelletal phophorites were deposited over much of the northern part of the Sheet area. The upper Stairway Sandstone sedimentation was accompanied by a major transgression of an Upper Ordovician sea across the entire area. This concept is illustrated in Figure 4, which shows the Stairway Sandstone overlapping older formations of the Larapinta Group and resting on the Cleland Sandstone and Mount Currie conglomerate. These contacts are not exposed on the Lake Amadeus Sheet area. The main source area still lay to the southeast, but connexions wih the open sea now lay to both the east and the west. This broad epeiric sea became more saline in *Stokes Siltstone* time—in some instances sufficiently saline for the crystallization of halite. At this time, the main connexion to the open sea lay to the east. Larapinta Group sedimentation closed with the deposition of the *Carmichael Sandstone* over the entire Sheet area; conditions were probably deltaic, the connexion to the open sea still lay to the east; the main source area of the terrigenous sediments was probably to the south. The Rodingan Movement probably took place early in the Silurian and the area was raised above sea level. How much rock was eroded after this movement is uncertain, but it may have been a considerable thickness.

It was not until late Silurian or Devonian times that sedimentation began again with the deposition of the *Mereenie Sandstone*. The depositional environment of this formation is problematical, but it is thought that it may be predominantly continental with associated lacustrine, aeolian, and fluviatile sands.

The Mereenie Sandstone is succeeded (probably conformably) by the *Parke Siltstone* unit of the Pertnjara Group, which was almost certainly laid down in a lacustrine environment. The overlying sandstone and pebbly sandstone of the Hermannsburg Sandstone are continental synorogenic sediments deposited during the Alice Springs Orogeny. Major folding and faulting occurred during the orogeny, but since that time the area appears to have been stable, remaining continental throughout the Permian, Mesozoic, and Cainozoic.

During the Permian the Sheet area may have been glaciated, as there are Permian tillitic deposits to the northwest and west. There are no known Mesozoic sediments in the Sheet area. During the Tertiary, the climate of the region was fairly wet and lakes formed in several places; fluvial deposits (conglomerates and sands) were also deposited in places. Much of the area was also subjected to severe tropical weathering at times during the Tertiary.

During the Quaternary the climate became more arid, leading to the drying up of the Tertiary lake system and the development of salt lakes. Sand dunes formed and moved across much of the area. In most recent times, rainfall may have increased slightly, allowing a sparse cover of vegetation to grow, and fix most of the dunes.

ECONOMIC GEOLOGY

Surface Water

There are a number of permanent rockholes and springs in the northeast. All the rockholes contain good-quality water and are within the Mereenie Sandstone. There are two lines of rockholes and springs—those along the southern margin of the George Gill Range (such as Reedy Rockhole) and those along the southern margin of Shakes Plain (such as Grantham Rockhole).

Within the ranges there are also a number of semipermanent waterholes, which may hold water for several months after rain.

Away from the northeast corner, there is no permanent surface water. Some of the rockholes (such as Kulpi and Nonane Rockholes) may be semipermanent.

Underground Water

Little is known of the hydrology: only twelve holes have so far been drilled in the search for underground water. Salinities range from 500 parts per million in the waterbore for East Mereenie No. 3 Well to 7500 parts per million in Inindia Bore. The water table is 410 feet in East Mereenie No. 3 and 179 feet in Indindia Bore.

The depth of the water table appears generally to decrease and the salinity of the water to increase to the south. In most areas, however, these regional trends are probably minor compared with the influence of local geology. Areas underlain by Mereenie Sandstone have the deepest water table. This is probably because the permeability of the Mereenie Sandstone is high, and thus the regional gradient on the piezometric surface is low (T. Quinlan, pers. comm.)

Petroleum

Only the northeast corner of the Sheet area can be regarded as having petroleum potential at the present time. Elsewhere all visible anticlinal structures have been breached to the Proterozoic. In the northeast corner there are several anticlines with closure in Palaeozoic sediments. They have all now been tested, except the anticline to the north of Ochre Hill No. 1, the section in which is likely to be almost identical with that encountered in East Johnny Creek No. 1. The results of the six wells drilled are summarized in Table 2.

TABLE 2. DRILLING OPERATIONS IN THE LAKE AMADEUS SHEET AREA (to April 1966)

Well	*Date drilled*	*Total depth (feet)*	*Bottomed in*	*Status*	*Remarks*
East Johnny Creek No. 1	May 1965	6342	Bitter Springs Formation	Dry abandoned	
East Mereenie No. 1	April to July 1964	4705	Goyder Formation	Gas producer	Large quantities of gas and condensate encountered in the Pacoota Sandstone.
East Mereenie No. 2	Sept. to Nov. 1964	5175	Goyder Formation	Gas producer	
East Mereenie No. 3	Nov. 1965 to Jan. 1966		Goyder Formation		1400 feet of high gravity oil recovered in a drill stem test.
Johnny Creek No. 1		877	Goyder Formation	Dry abandoned	
Ochre Hill No. 1	June 1965	3761	Bitter Springs Formation	Dry abandoned	Possibly some residual hydrocarbons.

The only wells to encounter large quantities of hydrocarbons (gas plus condensate) have been on the Mereenie Anticline, where large quantities of gas were produced from the Pacoota Sandstone and smaller quantities in the Stairway Sandstone. Oil-saturated sand was also intersected between 657 and 661 feet in the basal sand of the Stairway Sandstone in diamond drill hole AP1 at the eastern end of Johnny Creek Anticline.

The results of the drilling suggest that only the Larapinta Group can be regarded as having petroleum potential. The Cambrian Cleland Sandstone proved to be disappointing as a potential reservoir rock in the Ochre Hill No. 1 and East Johnny Creek No. 1 wells. Further test drilling of the Mereenie anticline should confirm that the structure is a large gas-condensate field.

Phosphate

Phosphorites were first found in the Sheet area in 1962 (Cook, 1963). Pelletal phosphorites occur in all formations of the Larapinta Group and in the Tempe Formation, but only the Stairway Sandstone contains large quantities. These phosphorites have been drilled at two places—AP1 and AP4 (Barrie, 1964, unpubl.).

Stairway Sandstone phosphorites occur in bands from 1 to 12 inches thick which contain up to 22 percent P_2O_5. Individual pellets contain up to 27 percent P_2O_5. On the present rather sparse evidence phosphorite bands appear to be most concentrated on the southern margin, but so far no concentration is of commercial importance. Trace elements are associated with the phosphorites; for instance, up to 50 parts per million of lead occur in phosphorites of the Johnny Creek area. It is unlikely that any are in commercial concentrations. Ranford et al. (1966) record the presence of a 1 foot bed of a complex lead arsenophosphate (corkite) in the Inindia Bore area.

Cook (1966, unpubl.) has shown that winnowing was probably the major sedimentary process which concentrated the phosphate, and suggests that commercial concentrations may occur in the areas of greatest winnowing, such as the southern margin.

Barytes

Thin veins of barytes occur in the Bitter Springs Formation in the core of Parana Hill Anticline, but are too small for commercial exploitation.

Building Stone

Some of the Palaeozoic sandstones may be sufficiently fissile and resistant to weathering to make a useful building stone, but the distance of the area from potential markets make it most unlikely that they will be used, except by local cattle stations.

Brick making

Some of the Palaeozoic and Proterozoic lutite sequences may contain clays which would be suitable for the making of shale bricks.

Dolomite

Dolomite occurs in the Bitter Springs Formation. No areas are sufficiently accessible to enable it to be exploited commercially.

Gypsum

Large quantities of gypsum are present in Lake Amadeus and also in the cores of the diapiric structures in the central part of the Sheet area. The gypsum could be readily extracted from Lake Amadeus.

Jasper

Jasper occurs in the Areyonga Formation and the Inindia Beds. When polished it makes an attractive stone which is used in jewellery.

Limestone

Limestones are common in the northeast corner in the Bitter Springs Formation, the Stokes Siltstone, the Horn Valley Siltstone, and the Tempe Formation. It is unikely that the limestone will be commercially exploited in the foreseeable future.

Ochre

Some poor quality ochre occurs in the Goyder Formation of the Ochre Hill (Ulbanalli) area. It has been worked by aboriginals, but probably has no economic potential.

Potash

No potash has been found. The most likely place for potash to occur is in the bed of Lake Amadeus in association with other evaporites. It may also occur in some of the diapiric structures. Glauconite, which may be used for the manufacture of potash, occurs in the Tempe Formation and in the Larapinta Group. Only the Pacoota Sandstone contains sufficient glauconite to be regarded as possibly of commercial interest.

Salt

Halite occurs as a thin encrustation on the surface of Lake Amadeus. It has been worked commercially to the southeast of Inindia Bore. Halite also occurs within the Bitter Springs Formation.

Iron

A thin band (up to 1 foot thick) of oolitic ironstone occurs near the top of the Horn Valley Siltstone. Superficial encrustations of ironstone associated with the lateritized zone of the Tertiary weathering profile are commonly found on sandstones, e.g. the Mereenie Sandstone of the King Canyon area. Pisolitic ironstone also occurs in the Tertiary in the vicinity of the Vale of Tempe. Currently none of these occurrences have potential for commercial exploitation, as the quantities of ore are small and the area remote.

Manganese

Beds and lenses of iron and manganese-rich rock occur in the upper part of the Goyder Formation. Ranford et al. (1966) record a sample from near Ochre Hill which contained 56 percent of manganese. The manganese is present only as a thin superficial encrustation on sandstone or limestone. Further work on the Goyder Formation may reveal more significant quantities of manganese.

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