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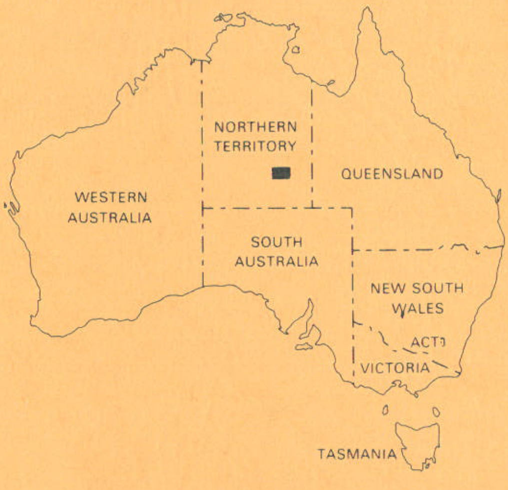
ILLOGWA CREEK
NORTHERN TERRITORY



INTERNATIONAL INDEX

DEPARTMENT OF RESOURCES & ENERGY
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DEPARTMENT OF MINES AND ENERGY, NORTHERN TERRITORY
NORTHERN TERRITORY GEOLOGICAL SURVEY

1:250 000 GEOLOGICAL SERIES—EXPLANATORY NOTES

ILLOGWA CREEK
NORTHERN TERRITORY
(Second Edition)

SHEET SF/53-15 INTERNATIONAL INDEX

COMPILED BY R. D. SHAW & M. J. FREEMAN*

*Northern Territory Geological Survey

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Explanatory Notes on the Illogwa Creek Geological Sheet (Second Edition)

*Compiled by R. D. Shaw & M. J. Freeman**

The Illogwa Creek 1:250 000 Sheet area is situated between latitudes 23°00′ and 24°00′ south, and longitudes 135°00′ and 136°30′ east, in the southern part of the Northern Territory. The area is occupied by several pastoral leases (Mount Riddock, Ambalindum, Indiana, Atula, Loves Creek, Numery, Ringwood), where beef cattle are grazed.

Access to the Sheet area is provided by the largely unsealed Plenty Highway, in the north, which connects the Stuart Highway from Alice Springs with Boulia and Mount Isa in Queensland, and the track from Alice Springs through Ringwood, Numery, and Limbla homesteads in the south; the track through Ringwood homestead is a sealed road for half the way to Ross River Tourist Chalet in the Alice Springs 1:250 000 Sheet area. Most roads and tracks are usable all year, except after heavy rain. Access is very difficult away from the main station tracks in the ranges and in the areas marginal to the Simpson Desert. A licensed landing strip suitable for light aircraft is located at Indiana, and an authorised landing area suitable for light aircraft is available at Atula homestead. Limbla, Numery, Indiana, and Atula homesteads operate transceivers connected with the Royal Flying Doctor base at Alice Springs, and radio telephones are located at Indiana, Atula, and Numery.

The climate is one of long hot summers, when temperatures can exceed 40°C, and short mild winters with some frosts. The average rainfall is about 230 mm, most of which generally falls between October and March, but both frequency and amount are erratic. Water is available from numerous bores and wells, but many of the bores yield stock-quality water only. Several small earth dams collect surface water after wet weather. Several waterholes along Hale River and Pulya Pulya Creek are semipermanent.

The accompanying map is based on contributions from a number of BMR geological mapping groups. The original stratigraphy in the northwest of the Sheet area was erected by Joklik and co-workers (Joklik, 1955a) based on earlier work by Hodge-Smith (1932) and Jensen (1943, 1944c, 1947). Stratigraphic mapping of the Amadeus Basin sedimentary rocks, reported on by Wells & others (1967) and partly revised by Preiss & others (1978), was used as a basis for mapping in the southwest of the Sheet area; boundaries of these sedimentary rocks have been revised, and one unit has been subdivided. Structural features established in the adjacent Alice Springs 1:250 000 Sheet area (Forman & others, 1967) were extrapolated into the Sheet area (Shaw & Milligan, 1969). More recent structural geological research is in progress by the University of Adelaide near the western margin of the Sheet area (Ding & others, 1983).

The Sheet area was completely remapped and revised during combined BMR/NTGS field research in 1979-80 (Shaw & others, 1982). Geological data were plotted on overlays of (1) 1:25 000 colour airphotos of the western third of the Sheet area (Quartz

*Northern Territory Geological Survey.

and Limbla 1:100 000 Sheet areas), and (2) 1:80 000 black and white airphotos (RC9) in the eastern two-thirds of the Sheet area. These data were transferred to enlarged transparent overlays prepared from orthophotomaps. The data in the Quartz and Limbla 1:100 000 Sheet areas were reduced to 1:100 000 scale, and printed as preliminary 1:100 000 geological sheets. These were generalised, reduced, and combined with reduced 1:80 000 compilation sheets (of the eastern two-thirds of the Sheet area) at a common scale of 1:250 000.

Previous investigations

The main recent accounts of geological research and investigations in the Sheet area are listed in the references; a more exhaustive compilation of references is listed in Shaw & others (1979, 1982). Early geological reports of the Sheet area concentrated on mica-mining activity. Brown (1889, 1890, 1897) visited the Lindsay mica mine and commented on its economic potential. Jensen (1943, 1944a, b) and Joklik (1955a, b) recorded detailed investigations of the mica deposits. Other studies of the mica fields include those of Armstrong (1954), Tomich (1952), and Daly & Dyson (1956).

Regional geophysical investigations include total magnetic intensity surveys of the southern half of the Sheet area in 1962 (Quilty & Milsom, 1964) and of the northern half in 1963-64 (Wells, Milsom & Tipper, 1966); and gravity surveys in 1961 (Langron, 1962) and 1962 (Barlow, 1965, 1966).

Company activity between 1964 and 1979 was concerned principally with base-metal exploration in the Amadeus Basin sequence (Youles, 1964; Australian Geophysical Pty Ltd, 1967; McIntyre Mines (Aust.) Pty Ltd, 1968; Plumridge & MacDonald, 1970; and Sullivan, 1970), and to a lesser extent in the Arunta Block (Tham, 1971). Companies have also been active in the search for either uranium or rare-earth minerals in the Harts Range (Morrison & Matheson, 1968; Corbett, 1970; Faulkner, 1971; Flack, 1970; Miller, 1971; Clarke, 1978a). Cainozoic sediments have also been explored for uranium—along Illogwa Creek (Agip Nucleare Australia Pty Ltd, 1977, 1979; Afmeco 1980a) and along the Plenty River (Afmeco, 1980b). Traces of nickel and chromium accompanying small siliceous ironstone bodies east of the Harts Range were briefly investigated by Barraclough (1978) and Howland (1971). The recently discovered ruby locality in the Harts Range has been briefly described by McColl & Warren (1979) and Katz (1981).

PHYSIOGRAPHY

Perry & others (1962) have given a comprehensive account of the land systems of the Sheet area.

Mabbutt (*in* Perry & others, 1962) subdivided the region into gross physical units, and described in detail a number of land systems. The topography and drainage, and their relationship to the geology, are shown in Figure 1. The *crystalline central ranges* of the Harts Range are steep-sided, and rise to over 300 m above the valleys, which are 400 to 600 m above sea level. The *folded central ranges* occur in the southwest sector of the Sheet area. They comprise high quartzite ridges and intervening narrow valleys. To the east the ridges become lower, and to the southeast are separated by sand plains. The *Plenty River plains* cover most of the *Simpson Desert*, and comprise broad flat sand plains with a few low flat-topped hills. The *inner dune field* has north-northwesterly longitudinal dunes separated by broad sand plains scattered with very low mesas and hills.

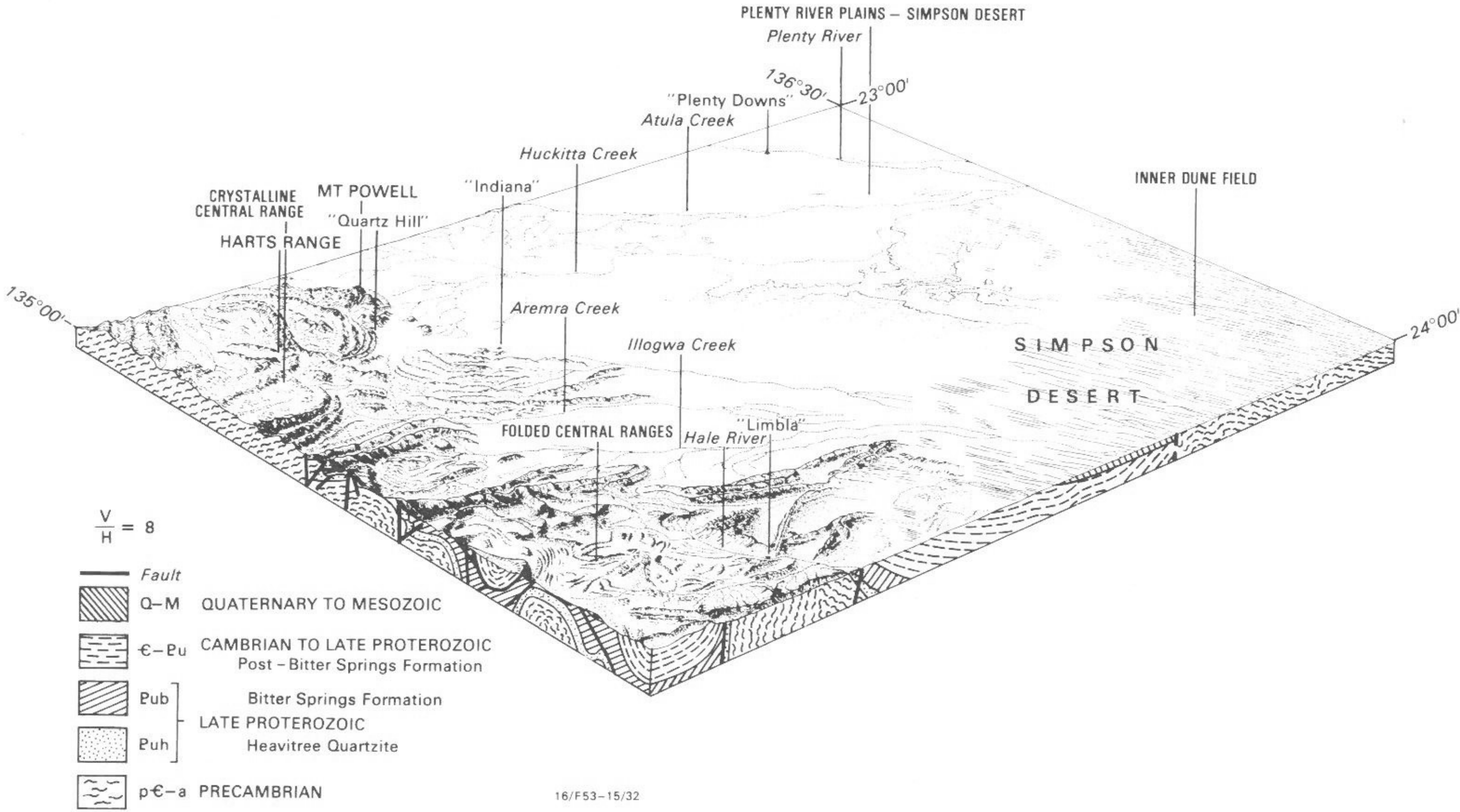

Fig. 1. Physiography and its relationship to geology.

STRATIGRAPHY

Precambrian igneous and metamorphic rocks of the Arunta Block crop out throughout most of the Sheet area. The Upper Proterozoic to Palaeozoic sedimentary rocks of the Amadeus Basin crop out in the southwestern part. Thin Cainozoic sediments conceal much of the outcrop in the eastern two-thirds of the Sheet area.

PRECAMBRIAN ARUNTA BLOCK

Full descriptions and discussion of rock relationships for the Arunta Block units are set out in Shaw & others (1982). These units in the Sheet area are grouped into two of the three stratigraphic divisions that Shaw & Stewart (1975) and Stewart & others (1984) have erected for the metamorphic rocks of the Arunta Block.

Division 1, presumed to be the oldest, is characterised by mafic and felsic rocks metamorphosed to the granulite facies. Only metamorphically retrogressed equivalents of Division 1 rocks are present in the Sheet area, where they occupy a small outcrop area on the western edge near Mount Ruby. These rocks, presumed to be Early Proterozoic, are tentatively assigned to the Bungitina metamorphics (p€sb) of the Strangways Metamorphic Complex and to unnamed unit p€x.

Division 2 in the Sheet area is represented by the Harts Range Group, a mixed metamorphosed igneous–sedimentary sequence, comprising the quartzofeldspathic Entia and Bruna Gneisses (p€he and p€ha) and the concordantly overlying pelitic and partly calcareous Irindina and Brady Gneisses (p€hi and p€hb). Recent work by Ding & others (1983) suggests that the Bruna Gneiss may have been originally an extensive porphyritic granite sill, whereas the Entia Gneiss may represent a mixed sequence of volcanic, volcaniclastic, and sedimentary rocks. The Irindina and Brady Gneisses are substantially metasediments. Scattered outcrops on the plains east of the Harts Range are mapped as undivided Harts Range Group (p€h) because they interfinger with the Irindina Gneiss to the north (in the Huckitta 1:250 000 Sheet area) and because they include calc-silicate rocks lithologically like those of the Brady Gneiss. In the northeastern part of the adjacent Alice Springs 1:250 000 Sheet area, the Harts Range Group overlies the Strangways Metamorphic Complex with a discordant boundary which is presumed to be a deformed unconformity (Shaw & others, 1979) now represented by a tectonic slide.

The Irindina Gneiss includes an amphibolite member (Riddock Amphibolite Member) and a composite member consisting of a calcareous component and a gneissic component with feldspar megacrysts (Stanovos Gneiss Member). The formal name, Riddock Amphibolite Member (p€hr), is applied only to those outcrops that are unequivocally continuous with the type area in the Alice Springs 1:250 000 Sheet area. Lenses of amphibolite (p€hi^a) at Mount Ruby, southeast of Oodnarta waterhole, south of Mount George, and southwest of Spriggs Creek Bore may not all be at the same stratigraphic level as the principal occurrence, and are therefore not included within the member. Ding & others (1983), however, included amphibolite lenses southwest of Spriggs Creek Bore and near and south of Mount George in the Riddock Amphibolite Member because they regarded these units as continuous; they considered that their distribution partly outlines the axial trace of F2 (or F3) folds.

In the southwest of the Sheet area, the Illogwa Schist Zone (Pzr) separates the Harts Range Group from well-layered quartzofeldspathic gneiss, amphibolite, and metasediments (Albarta Metamorphics, p€a; and unit p€f). These rocks have lithological features like the Cavenagh and Tommys Gap metamorphics, units in the Alice Springs 1:250 000 Sheet area which are thought to be transitional between Divisions 1 and 2 (Stewart & others, 1984).

Scattered outcrops of metamorphic rocks (p€) at the margin of the Simpson Desert, south of Huckitta Creek and east of Illogwa Creek, may be a facies equivalent of undivided Harts Range Group (p€h). They are left unassigned because contacts with the surrounding units are not exposed. They are typical of the pelitic rocks generally assigned to Division 2 elsewhere in the Arunta Block.

Metamorphic rocks (p€s), forming small scattered hills in a basement inlier in the southwest, have been described by Leitch & others (1970) as gneiss, migmatite, and mafic schist.

Igneous rocks

The Harts Range Group is intruded by granodiorite (e.g., Huckitta and Inkamulla Granodiorites, Ꝑgh and Ꝑgk) and basic and minor ultrabasic rocks (e.g. units Ꝑdx, Ꝑgb, and Ꝑp); these are metamorphosed to varying degrees.

The Albarta Metamorphics and unit p€f are intruded by the Atneequa Granitic Complex (Ꝑgq), and by granodiorite, tonalite, and diorite tentatively assigned to the Aremra Granodiorite (Ꝑgl).

Late Proterozoic and Palaeozoic Amadeus Basin

The Amadeus Basin is an intracratonic structural basin containing Upper Proterozoic and Palaeozoic sandstone, shale, and carbonate deposited in a mainly shallow-marine environment. The stratigraphy of the basin is described by Wells & others (1970), and a more detailed description of the northeastern Amadeus Basin including the Sheet area is given by Wells & others (1967). Preiss & others (1978) have presented more recent revisions to the stratigraphy. During the 1979 mapping survey the Gillen Member of the Bitter Springs Formation was further divided into five subunits (Shaw & others, 1982). The stratigraphy of the Amadeus Basin is summarised in Table 1; lithologies and ages of stratigraphic units are annotated in the legend of the accompanying map.

TABLE 1. SUMMARY OF STRATIGRAPHY, AMADEUS BASIN SEQUENCE

Rock unit and map symbol	*Relations*	*Remarks*
Pz?		Flat-lying unit unlike any formation known in Amadeus Basin sequence; forms isolated outcrop in SE of Sheet area
Arumbera Sandstone Ꝑ€a	Conformable on Julie Formation	About 400 m thick. Late Proterozoic metazoans in lower part (Glaessner & Walter, 1975) and Early Cambrian trace fossils in middle part (Daily, 1972) in Alice Springs Sheet area
Julie Formation Ꝑuj	Conformable between Pertatataka Formation and Arumbera Sandstone	Thickness estimated to be 200 m
Pertatataka Formation Ꝑup	Conformably overlies Pioneer Sandstone	Up to 1400 m thick

Rock unit and map symbol	*Relations*	*Remarks*
Waldo Pedlar Member Ꝑul	Conformable member of Pertatataka Formation. Inferred to overlie Limbla Member of Aralka Formation in far SW	60 m thick
Pioneer Sandstone Ꝑux	Disconformably and locally unconformably overlies Bitter Springs Formation. Conformably overlies Olympic Formation, and may interfinger with it (Preiss & others, 1978)	
Olympic Formation Ꝑuf	Disconformably overlies Aralka Formation with very local angular discordance at base (2 km W of Dead Horse Waterhole)	Thickness very variable—roughly 100 m. Represents the younger of two Proterozoic tillites.
Aralka Formation Ꝑuk	Conformably overlies Areyonga Formation. Disconformable below Olympic Formation	
Limbla Member Ꝑum	Conformable member at top of Aralka Formation. Disconformable below Olympic Formation in Alice Springs Sheet area	Possibly 150 m thick
Ringwood Member Ꝑur	Conformable member within lower part of Aralka Formation	Possibly 150 m thick
Areyonga Formation Ꝑua	Inferred to disconformably overlie Bitter Springs Formation. Conformable below Aralka Formation	About 600 m thick in Limbla Syncline. The diamictite is regarded as an expression of the older of two Proterozoic tillites
Bitter Springs Formation Ꝑub	Everywhere subdivided into two members	
Loves Creek Member Ꝑue	Conformable on Gillen Member. Inferred to be disconformable below Areyonga Formation. Overlain disconformably and locally unconformably by Pioneer Sandstone.	Spilite forms lenses a few metres thick in dark red ferruginous siltstone at top of unit
Gillen Member Ꝑug	Conformable on Heavitree Quartzite. Conformable below Loves Creek Member. Locally overlain disconformably by Pioneer Sandstone.	Divided into five subunits (see Shaw & others, 1982)
Heavitree Quartzite Ꝑuh	Nonconformable on rocks of the Arunta Block. Conformable below Gillen Member	Thickness 300 to 400 m in Coulthards Gap area and 188 m ESE of Waldo Pedlar Bore. Coarser and more conglomeratic than in Alice Springs Sheet area, to W, perhaps owing to thickening of Fenn Gap Conglomerate Member (see Clarke *in* Stewart & others, 1980)

Mesozoic and Cainozoic units

The stratigraphy of Mesozoic and Cainozoic units is outlined in Table 2.

The Jurassic–Cretaceous Hooray Sandstone (JKh), a correlative of the De Souza Sandstone of Wells & others (1970), overlies the unnamed schist unit (pϵ) in the southeastern part of the Sheet area. It is coarse to fine-grained, poorly sorted, and ferruginised. In much of the eastern two-thirds of the Sheet area its outcrops were deeply weathered in the early Tertiary.

A number of highly ferruginous and silicified cappings (Tls) in the northern central part of the Sheet area are thought to have formed on small, non-outcropping ultrabasic and basic bodies, the presence of which can only be inferred from the weathered remnants. Some of these show local surface enrichment in chrome and nickel.

A Tertiary sedimentary basin known only in the subsurface extends to the southeast from just west of Gidgee Bore along the margin of the main ranges of metamorphic rocks. The sequence is similar to that in the Ti Tree and Waite Basins (Alcoota and Napperby 1:250 000 Sheet areas). The oldest sediments in the basin (Ta), known only from drill core, are claystones and interbedded sandstones. The homogeneity of the claystones indicates quiet-water deposition coupled with low input of terrigenous detritus from the nearby Harts and MacDonnell Ranges. The mudstones pass abruptly into overlying poorly sorted clastics, which were probably deposited rapidly in a series of piedmont fans. These sediments are intensely weathered, and contain abundant iron oxide pisoliths.

This sequence is capped by a thin veneer of chalcedonic limestone (Tw), which has a more extensive distribution to the east where it caps highly weathered metamorphic rocks.

STRUCTURE

The geological structure of the Sheet area is shown in the 1:1 000 000-scale tectonic sketch on the geological map sheet, and is generalised from bedrock exposures and interpretation of the results of aeromagnetic surveys flown by BMR in 1962-1964 and by the Northern Territory Department of Mines and Energy in 1981. The Sheet area comprises two major structural entities: (1) crystalline basement belonging to the Arunta Block, and (2) sedimentary rocks of the overlying Amadeus Basin sequence, which occupies a belt in the southwest corner of the Sheet area.

The Arunta Block consists chiefly of a layered sequence of metamorphic rocks intruded in the south by large bodies of granite. Ding & others (1983) recognised several phases of folding in the Irindina Gneiss at the western margin of the Sheet area. The first three phases formed roughly coaxial recumbent folds with shallow northerly plunges. Extensive blastomylonite, developed early in the folding history, is localised in decollement zones at or near both the upper and lower contacts of the Bruna Gneiss in the northwest of the Sheet area. Towards the south, much of the porphyroblastic-feldspar gneiss that makes up the Bruna Gneiss has developed into an intense L–S tectonite with a high-grade fabric which is mylonitic in part.

The largest fold structure is the Huckitta Anticline, a north-northeast-trending arch extending across the northwestern part of the Sheet area and ending in a major domal structure, Entia Domal Structure, which makes up the central part of the Harts Range. Granite and granitic gneiss occur in the core of two minor domes (Huckitta and Inkamulla Domes) within the main domal structure, and the upward rise of these

TABLE 2. MESOZOIC AND CAINOZOIC STRATIGRAPHY

Age	*Rock unit and map symbol*	*Lithology/type of deposit*	*Thickness*	*Tectonic events*	*Environment, fossils, and age*
QUATERNARY	Qa	Fine and coarse clay–quartz sand, silt, and minor gravel (lacking a marked soil profile); claypans; alluvium in part in and along creeks; flood-out plains		Possible uplift in the area of the Harts Range, or rejuvenation due to subsidence within the Lake Eyre Basin	Channels date from latest pluvial period—either Holocene or latest Pleistocene
	Qc	Colluvium eluvium, scree			
	Qr	Red earth; sand, silt, clay, gravel; more fine sand and silt than in Qa			Underlies alluvium around ranges
	Qs	Aeolian quartz sand		Region tectonically stable	Humid oxidising conditions followed by aridity and aeolian activity. Development of broad sandplains with minor dune fields. Cementation of porous surface sediments and colluvium forming calcareous crusts
CAINOZOIC	Cz	Slightly weathered rock related to Czc			Flat to slightly undulating peneplain, possibly Pleistocene surface, commonly partly dissected by ?Holocene erosion
	Czc	Fanglomerate: dissected alluvium and colluvium	20 m	Movement on some faults suspected	Period of extensive erosion and development of outwash plains during or immediately preceding sand dune formation

Age	*Rock unit and map symbol*	*Lithology/type of deposit*	*Thickness*	*Tectonic events*	*Environment, fossils, and age*
TERTIARY	Waite Formation equivalent, Tw	Greenish grey siltstone, chalcedony and limestone	20 m	Region tectonically stable	Argillaceous sediments and chemical precipitates in very quiet, lacustrine environment. Age probably Late Miocene or Early Pliocene (Woodburne, 1967)
	Ta (in subsurface)	Red-brown and yellowish claystones interbedded with reddish sandstone (20 m); overlain by green claystone and interbeds of sandstone (144 m); followed by red-brown silty and clayey sandstone (20–100 m); then coarse clean quartz-lithic sandstone (20 m); capped by red-brown silty sandstone (4–15 m) intersected in BMR Illogwa Creek Nos. 1, 2, and 3	Up to 250 m	Tectonic activity may have caused the development of intermontane fans, which may instead reflect a climatic change (possibly expressed as increased erosion through a reduction in vegetation cover)	Mainly lacustrine in early stages; intermontane piedmont fans in middle part; becoming fluviatile in upper part
	T	Poorly developed weathering profile. Calcrete on dissected peneplain on Ꞓuh (3 km W of Coulthards Gap waterhole (GR NP0688)			Flat peneplain surface; commonly elevated with respect to Cz. Age uncertain, possibly Miocene
	Tls	Highly siliceous and ferruginous rock. Forms cap over ultramafic? rock			

TABLE 2 *(continued)*

Age	*Rock unit and map symbol*	*Lithology/type of deposit*	*Thickness*	*Tectonic events*	*Environment, fossils, and age*
TERTIARY OR OLDER	Tl	Laterite profile with well developed ferruginous, mottled, and leached zones; in places grading down into unweathered rocks. Best developed on coarsely crystalline rocks; ferricrete present.	+20 m	Region tectonically stable; widespread peneplanation	Trizonal laterite profile produced by deep weathering under humid conditions, seasonal precipitation, and fluctuating water-table
	Tla	Undifferentiated deeply weathered rock		As above	As above
MESOZOIC Upper Jurassic to Lower Cretaceous	Hooray Sandstone, JKh	Medium to coarse quartz sandstone with kaolinitic cement. Upper part altered to ironstone	1–40 m	Downwarping of the axis of the Eromanga Basin	Fluviatile. Age determined by palynomorphs from elsewhere in the Eromanga Basin (Exon & others, 1972)

granites may have been the cause of the doming. An earlier phase of folding, commonly with northerly trends, preceded the doming event; it is represented by many small overturned to reclined folds.

James & others (1984) have argued that the Harts Range Group has been affected by six major thrusting episodes, of which the earlier ones generated complex thrust structures separated by decollement surfaces. Scales & others (1984) have studied strain and petrofabric patterns on the eastern flank of the Entia Domal Structure.

At the southwestern limit of Arunta Block exposures, faulting in the Oolera Fault Zone has repeated exposures of Heavitree Quartzite, the Gillen Member of the Bitter Springs Formation, and rocks of the underlying Arunta Block in numerous fault blocks. Several shallow-dipping overturned sequences in this zone suggest that the major faults are reverse faults or high-angle overthrust faults, and that granitoid rocks mantled by Upper Proterozoic sedimentary rocks (Heavitree Quartzite and Bitter Springs Formation) at two localities (Oolera Spring and 8 km northeast of Dead Horse Waterhole) are the noses of small nappes preserved as klippen.

A second major zone of overthrust faults farther north coincides with the Illogwa Schist Zone. This zone is the eastern extension of the root zone of the Ruby Gap Nappe, the lowest thrust-nappe in the Arltunga Nappe Complex (Forman, 1971; Shaw & others, 1971). Slivers of Upper Proterozoic sedimentary rock (Heavitree Quartzite) have been overridden by the schist zone along a major overthrust fault on its southern margin. The Illogwa Schist Zone is regarded as a major shear zone, and can be traced into the adjacent Alice Springs Sheet area, where it corresponds to the base of the White Range Nappe. It was formed during the Alice Springs Orogeny between 300 and 400 m.y. ago.

The northern margin of the Amadeus Basin outside the Sheet area to the west is marked by either a steep homocline or by thrust-faults. A similar pattern is repeated in the Oolera Fault Zone within the Sheet area. In the southwest corner of the Sheet area, the general pattern is interrupted by a broad northwest-trending arch outlined by the distribution of the Bitter Springs Formation. The arch is probably the surface expression of a transverse block of underlying Arunta Block rocks. Major cover-nappes evident in the adjacent Alice Springs Sheet area encroach into the Sheet area west of the arch. The limits of the N'Dhala and Olympic Nappes are based on extrapolation of these features from the Alice Springs Sheet area, and require additional field checking.

In the eastern part of the preserved Upper Proterozoic cover sequence, thrust-faults have developed, presumably in response to gravity sliding during uplift of the basement to the west and north. The Limbla Syncline may be surrounded by thrust-faults that outline a cover-nappe formed during this uplift. In the far southwestern part of the Sheet area, numerous decollements were formed within the Bitter Springs Formation at a level where gypsum has been observed, and these evaporites are likely to have facilitated the formation of planes of detachment, some of which have become thrust-faults.

METAMORPHISM

Much of the Arunta Block metamorphic sequence in the northwest part of the Sheet area has been metamorphosed to the upper part of the amphibolite facies bordering the granulite facies (Fig. 2). Granulite facies assemblages include orthopyroxene–clinopyroxene–plagioclase and rare cordierite–spinel–gedrite–kyanite. P–T conditions for the granulite facies assemblages have been estimated by Dobos (1978) at 7–9 kb and

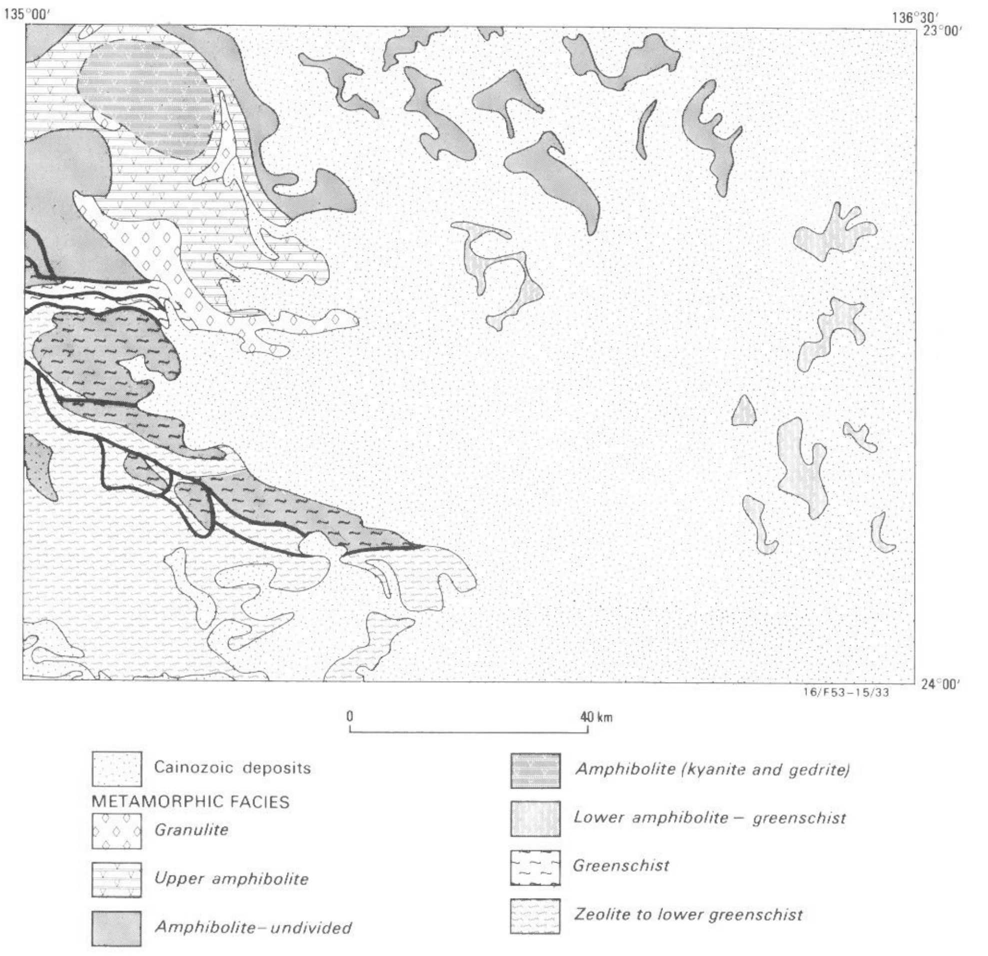

Fig. 2. Metamorphic map (modified after Forman & Shaw, 1973).

700–800°C. An age of granulite metamorphism of about 1800 m.y. in the Sheet area is inferred from the regional distribution of granulite facies rocks of established metamorphic age outside the Sheet area (Black & others, 1983). The peak of the granulite metamorphism is considered to have followed the main episode of north-plunging recumbent folding. The rocks in the Sheet area were extensively retrogressed under amphibolite facies conditions.

The upper unit of the Harts Range Group (Brady Gneiss) contains mineral assemblages typical of the middle part of the amphibolite facies: sillimanite–cordierite–muscovite–biotite–plagioclase–quartz and clinopyroxene–scapolite–hornblende–clinozoisite–plagioclase–quartz. East of the Harts Range, assemblages such as clinopyroxene–scapolite–plagioclase–hornblende–clinozoisite and sillimanite–muscovite–biotite–plagioclase–quartz in the undivided Harts Range Group reflect a similar grade of metamorphism. Farther southeast, in the unnamed schists and gneisses mapped as pϵ bordering the Simpson Desert, metamorphic assemblages such as sillimanite–muscovite–biotite–quartz still persist, but index minerals such as sillimanite are absent from these rocks in the far southeast. These rocks to the east and southeast are thought to have been metamorphosed at about 1800 m.y., during the same event that metamorphosed the rocks in the Harts Range to the northwest.

South of the Illogwa Schist Zone, the Arunta Block rocks are metamorphosed to about the middle of the amphibolite facies. Syntectonic granites intruding these rocks are correlated with the Atnarpa Igneous Complex to the west, which has an Rb-Sr age of 1650 m.y. (Black & others, 1983).

Widespread retrograde metamorphism has affected the rocks in and south of the Illogwa Schist Zone; for example, in the schists of the Illogwa Schist Zone, common mineral assemblages are albite–epidote–sericite–chlorite. This retrograde metamorphism is considered to have accompanied shearing and overthrusting during the Alice Springs Orogeny.

Biotite altered to chlorite, and saussuritised plagioclase and polygonised quartz, are minor to marked common features in rocks adjacent to major faults, particularly in the Oolera Fault Zone. As the Bitter Springs Formation exhibits these features, the metamorphic event responsible for them may also have affected the lower part of the Amadeus Basin sequence.

The Harts Range pegmatites may also have been emplaced during the Alice Springs Orogeny in the Devonian or Carboniferous (Riley, 1968; Forman & others, 1967), although further age determination work is needed to clarify this age. These pegmatites are generally surrounded by a zone of retrogression and possible metasomatism up to 100 m wide in which muscovite is common.

GEOPHYSICS

Magnetics

Generalised aeromagnetic zones based on the work of Quilty & Milsom (1964) and Wells & others (1966), modified by recent data obtained by the Northern Territory Department of Mines and Energy (1982), are shown in Figure 3. Zone boundaries are designed to give a general picture, and do not necessarily coincide with changes in magnetic basement.

Zone 1 represents areas with a high degree of magnetic disturbance, consistent with shallow basement consisting mainly of Division 1 of the Arunta Block or units transitional between Divisions 1 and 2. Many steep anomalies within these areas suggest near-surface magnetic bodies. In area 1a, marked anomalies have north-northwest trends and partly correspond to the Harts Range Group. In areas 1c and 1d a distinct magnetic lineation trends north-northwest. The southwestern part of area 1b corresponds to the Albarta Metamorphics, and the northern part corresponds to the Harts Range Group. The anomalies in area 1c are considered to be due to deeper sources than the outcropping rock units. Elsewhere in the Arunta Block, Division 1 rocks commonly correspond to a highly disturbed magnetic pattern such as in area 1c.

Zone 2 represents magnetically quiet areas interspersed with minor north-trending anomalies. The zone corresponds to rocks of the Harts Range Group.

Zone 3 is an area of low magnetic values, has relatively smooth magnetic profiles, and corresponds to Division 2 rocks. It therefore seems probable that metamorphic rock or granite of relatively low magnetic susceptibility is present in zone 1.

Zone 4 is an area of moderate magnetic susceptibility where up to about 4600 m of Upper Proterozoic and Tertiary sedimentary rocks overlie crystalline basement.

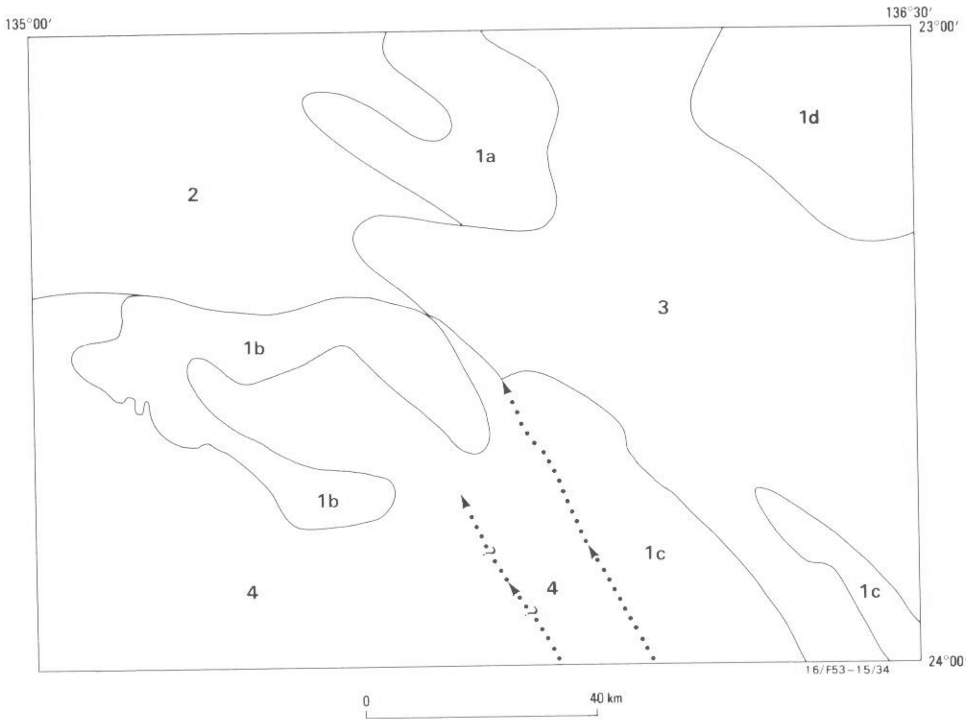

Fig. 3. Aeromagnetic zones.

Northwest-trending linear magnetic features evident on the total magnetic intensity map in the south (Quilty & Milsom, 1964) are interpreted as faults.

Gravity

The greater part of the Sheet area is occupied by part of the Illogwa Regional Gravity High (Fig. 4), a gravity province corresponding to shallow Arunta basement and separating the Amadeus Regional Gravity Low (corresponding to the Amadeus Basin) from the Georgina Regional Gravity Shelf (corresponding to the Georgina Basin; Vale, 1965; Barlow, 1966).

Generally northwest-trending relative high and low Bouguer anomalies in this gravity high are likely to reflect deeper sources than the anomalies recorded by variations in aeromagnetic response. The gravity high comprises three subprovinces, all of which cross the Sheet area. The Hale River Gravity Platform shelves westerly and southwesterly from highest values in the east to the low gravity depression of the Amadeus Basin; a minor gravity high (1a in Fig. 4) is superimposed on the gravity platform near the centre of the Sheet area (Barlow, 1966). The Lake Caroline Gravity

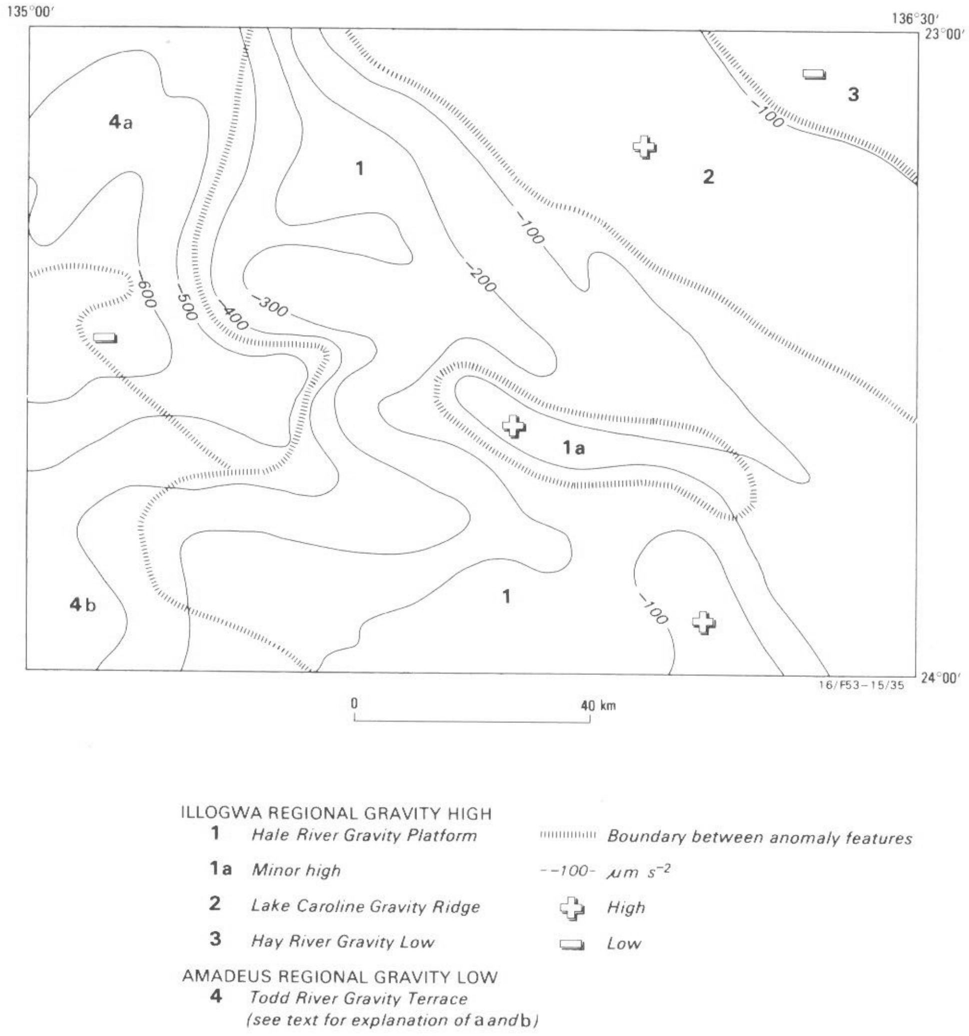

Fig. 4. Bouguer anomaly contours and gravity features (mainly from Vale, 1965; Barlow, 1966).

Ridge (Lonsdale & Flavelle, 1968), at the northeastern margin of the Hale River Gravity Platform, has a distinct northwest trend, and is tentatively interpreted as a major tectonic lineament. In the Sheet area the gravity ridge is located over scattered outcrops of the Harts Range Group and undivided Arunta Block. These do not have sufficient mass to account for the gravity ridge, which must reflect a deeper source. The Hay River Gravity Low is an elongate depression north of and parallel to the Lake Caroline Gravity Ridge; the linear boundary is interpreted as a deep fault in the tectonic sketch on the map sheet. Barlow (1966) suggested that there is evidence that granite has intruded the feature. However, new aeromagnetic data released by NTGS as a total magnetic intensity map of the Plenty River 1:100 000 Sheet area (northwestern portion of the Hay River 1:250 000 Sheet area, east of the Illogwa Creek Sheet area) indicate that rocks with a marked linear magnetic fabric correspond to this gravity low, and overlap onto the Lake Caroline Gravity Ridge. The gravity patterns are presumably due to much deeper geological features than those controlling the magnetic pattern.

The western quarter of the Sheet area falls within the Todd River Gravity Terrace, which is part of the Amadeus Regional Gravity Low. The gravity terrace is characterised by northeasterly and easterly trends. Area 4a is a region of crystalline basement; area 4b is a region of crystalline basement overlain by the Upper Proterozoic Amadeus Basin sequence.

GEOLOGICAL HISTORY

The sequence of events in the Illogwa Creek Sheet area is interpreted as follows:

(1) Lower Proterozoic mafic and felsic volcanic rocks and intercalated minor sediments (Division 1) were deposited.

(2) Arkosic sand derived from the Division 1 terrane, and possible acid volcanics, followed by sand, silt, clay, and impure carbonate, accompanied by basic flows and sills—the Harts Range Group (Division 2)—accumulated.

(3) A major ductile strain event affecting the lower and upper parts of the Bruna Gneiss in particular; three episodes of northerly trending recumbent folding; and the intrusion of several small gabbro and norite bodies and sills, and numerous very small basic bodies—are presumed to have preceded metamorphism to upper amphibolite–transitional granulite at 1800 m.y. in the northwest part of the area. In the central-west (south of the Illogwa Schist Zone) folding and metamorphism to amphibolite facies possibly occurred at or before about 1700 m.y. Granites were emplaced in the central-west and southwestern parts of the Arunta Block at about 1650 m.y.

(4) Quartz sand and mud (Division 3), possibly reworked Division 2 rocks, probably accumulated; though not preserved in the Sheet area, they are represented by quartzite, schist, and slate 13 km south-southeast of Limbla homestead (Leitch & others, 1970).

(5) Widespread uplift and erosion in the Sheet area followed regional metamorphism and migmatisation at about 1100-1000 m.y. west of the Sheet area (Shaw & others, 1979; Shaw & Wells, 1983).

(6) Dolerite dykes and rare small unmetamorphosed gabbro bodies may have been introduced at about 900 m.y.—at the same time as the Stuart Dyke Swarm was emplaced in the Alice Springs Sheet area, to the west (Black & others, 1980).

(7) Episodic deposition from Late Proterozoic to at least Early Cambrian times resulted initially in the accumulation of the Heavitree Quartzite and Bitter Springs Formation, followed in the next episode by the Areyonga and Aralka Formations, then in the final episode by the Olympic Formation, Pioneer Sandstone, Pertatataka Formation, Julie Formation, and Arumbera Sandstone. Each episode was preceded by regional uplift, resulting in a disconformity between depositional groups. Each of the last two depositional episodes began with a unit showing evidence of a period of glacial activity (Areyonga Formation and Olympic Formation). Deposition of the Bitter Springs Formation was accompanied by minor basic volcanism.

(8) The final tectonism (Alice Springs Orogeny) in the Carboniferous or Late Devonian caused thrust-faulting, retrograde metamorphism, and disturbance of mineral isotopes in the Arunta Block. The Illogwa Schist Zone was formed during this event, and so too probably were thrust-faults in the Upper Proterozoic sedimentary sequence.

(9) The post-Carboniferous to Jurassic period was one of continued erosion, epeirogenic uplifts, and some rejuvenation of older faults.

(10) A thin unit of labile sandstone (Hooray Sandstone) was deposited in a fluvial environment over a wide area extending into the Eromanga Basin.

(11) Deep weathering in the early Tertiary or, less likely, in the Late Cretaceous resulted in a laterite profile and the formation of ferricrete (Tl).

(12) Localised tectonic activity produced intermontane basins into which were deposited lacustrine clay, silt, and sand, followed by piedmont-fan silty and clayey sand, then fluviatile silty sand.

(13) Renewed deposition of argillaceous sediments and calcareous and siliceous precipitates probably in the Late Miocene or Early Pliocene (Waite Formation) in very quiet lacustrine environments was concurrent with or followed by further peneplanation.

(14) Further mild tectonic activity, possibly in the Late Pliocene, resulted in extensive erosion and development of outwash plains (Czc), deposition of some alluvium (Qa), and formation of red-earth soils (Qr), all possibly under humid conditions immediately preceding sand dune formation (Qs) in an arid environment.

(15) Deposition of Quaternary red-earth soil (Qr) and alluvium (Qa) from uplifted areas continued, and colluvium (Qc) formed on present-day hillslopes.

(16) Renewed erosion coincided with the formation of drainage channels and deposition of further alluvium (Qa) in the Holocene or latest Pleistocene during the latest pluvial period.

MINERAL RESOURCES

Table 3 lists all known occurrences of minerals of economic interest in the Illogwa Creek Sheet area. Some of these have been summarised by Warren & others (1974) and Stewart & Warren (1977), and Shaw & others (1982) have presented additional details. Ruby and pink corundum of cabochon-grade are currently being mined intermittently on a small scale north of Spriggs Creek Bore. The Sheet area is prospective for base-metals, gemstones, tungsten, and uranium.

Base-metals (copper, lead, and zinc)

Prominent magnetic anomalies in the Albarta Metamorphics south of the Illogwa Schist Zone correspond to banded iron-rich fine-grained banded metasediments containing 3–5 per cent magnetite (Tham, 1971). These have been geochemically sampled for Pb, Zn, Cu, Ni, Co, and Cr with disappointing results. Although there are no known base-metal deposits within the Sheet area the Albarta Metamorphics lithologically resemble the Mascotte Gneiss Complex–Bonya Schist sequence, which in the Huckitta 1:250 000 Sheet area (to the north) includes the Jervois Cu–Pb–Zn–Ag orebody, and, for this reason, warrant further attention.

A number of companies have explored for base-metals in the Upper Proterozoic sedimentary rocks near both Ringwood and Limbla homesteads (Australian Geophysical Pty Ltd, 1967; Sullivan, 1970; Plumridge & MacDonald, 1970). This sedimentary sequence shows some similarities to sequences in the African copper-belt, but exploration results in the Sheet area to date have been disappointing.

Beryllium

Beryl has been recorded at the Atrichs, Delma, Valiant Sister (no. 26 on accompanying map), Leprechaun, Eastern Chief, and Mount Ruby (nos. 37 and 38) mica mines, and at an unnamed mine (no. 48), located about 5 km east of Oodnarta waterhole (NQ2514). Beryl localities in the Harts Range have been examined by Jones (1957).

TABLE 3. MINERAL OCCURRENCES

Map no.	*Name (and number NTGS file)*	*Grid reference*	*Commodity, minerals*	*Lode rock*	*Country rock*	*Remarks*	*References*
1	Eastern Chief (M1)	NQ0355	Mi, Be	Pegmatite (muscovite)	Garnet and sillimanite-bearing muscovite–biotite gneiss	Production 20 tonnes (est.) in 1924–43; 2174 kg (4788 lb) in 1944–51; accessory beryl	Sullivan (1942a); Jensen (1944a, b; p. 205, p. 125); Daly & Dyson (1956, p. 3); Jones (1957)
2	Ophir (M61)	NQ7456	Mi	Pegmatite	Unknown	Abundant ruby mica. Production 9.1 tonnes (9.0 tons) in 1954–59. Location not field-checked.	NTGS Mineral File; Rochow (1962)
3	Valley Bore	NQ1550	W	Scheelite in calc-silicate rock cut by quartz veins	Quartzofeldspathic gneiss, muscovite–biotite schist, calc-silicate rock	Production nil. Bulldozer-cuts up to 1.5 m deep and 10–30 m long	Faulks (1967); Corbett (1970); Barraclough (1978) Cogar & Felderhof (1973)
4	Hillrise (M81)	NQ0446	Ruby, corundum	Hornblende-bearing plagioclase-rich rock mantled by and containing lenses of hornblende and phlogopite-rich gneiss	Phlogopite–plagioclase-rich schist intercalated with sillimanite-bearing garnet–biotite–quartz–plagioclase rock	Series of costeans and bulldozer pits. Blue, pink, and clear corundum forms tabular hexagonal crystals up to 5 cm diameter. Some corundum is ruby of cabochon grade	Clarke (1978b); McColl & Warren (1979); Katz (1981)
6	Spriggs Camp	NQ0244	Mi	Pegmatite	Biotite gneiss, garnet–biotite gneiss	Production unknown	Matthews (1905)
7	Moonlight (M20)	NQ3742	Mi	Pegmatite	Garnet-bearing schistose muscovite–biotite gneiss	Production 533 kg (1175 lb) in 1950	NTGS Mineral File

Map no.	Name (and number NTGS file)	Grid reference	Commodity, minerals	Lode rock	Country rock	Remarks	References
8	Mirror Finish (M17)	NQ3843	Mi	Pegmatite	Garnet-bearing schistose muscovite–biotite gneiss	Open-cut over a vertical range of about 30 m	Joklik (1955a, p. 219); Daly & Dyson (1956); Jensen (1944b); Armstrong (1954)
10	Flying Fox (M52)	NQ3741	Mi	Pegmatite (muscovite)	Garnet-bearing muscovite–biotite schistose gneiss	Production 272 kg (600 lb) in 1957	NTGS Mineral File; Rochow (1962)
11	Desperate	NQ3840	Mi, Cu	Pegmatite (muscovite) with large irregular quartz core	Garnet-bearing muscovite-biotite schistose gneiss	Production 1800 kg (3964 lb) in 1949–51; traces of chalcopyrite and pyrite in quartz-rich pegmatite	Joklik (1955a, pp. 119 194); Daly & Dyson (1956, p. 10)
12	(M21, M32)	NQ3839	Mi	Pegmatite	Garnet-bearing muscovite–biotite gneiss	Production unknown. M32 is 2 km SE Mount Powell	NTGS Mineral File
14	Delma (M23)	NQ4139	Mi, Be	Pegmatite (muscovite)	Exposure rare at mine; nearby, garnet-bearing muscovite-biotite schistose gneiss, biotite gneiss, calc-silicate rock	Production 5.0 tonnes (4.9 tons) in 1948–51, 5 tonnes in 1954–59; accessory minerals: beryl, apatite, tourmaline	Joklik (1955a, p. 196); Daly & Dyson (1956, p. 10); Armstrong (1954); Jones (1957); Rochow (1962)
16	Atrichs (M67)	NQ1139	Mi, Be	Pegmatite (muscovite)	Sillimanite–garnet–biotite gneiss	Accessory beryl. Production unknown	Corbett (1970)
17		NQ1339	Mi	Pegmatite	Porphyroblastic gneiss	Unknown	Shaw & others (1982)
18	Lone Pine (Cone Hill)	NQ3137	Mi, U, Nb, Ta, Ce	Pegmatite	Coarse-grained amphibolite	3 m trench. Accessory samarskite, bismuthinite	Joklik (1955a, p. 175); Daly & Dyson (1956, p. 78); Shaw & others (1982)
20	Solo	NQ3636	Mi	Pegmatite	Garnet–biotite gneiss, hornblende gneiss	Minor	Daly & Dyson (1956, p. 9)

TABLE 3 *(continued)*

Map no.	*Name (and number NTGS file)*	*Grid reference*	*Commodity, minerals*	*Lode rock*	*Country rock*	*Remarks*	*References*
21	Last Hope (24)	NQ3734	Mi, U, Nb, Ta, Ce	Pegmatite (muscovite)	Garnet–biotite gneiss, layered amphibolite	Production 1362 kg (3000 lb) in 1944–50; accessory betafite, monazite	Joklik (1955a, p. 175); Daly & Dyson (1956, p. 8)
22		NQ0136	Mi	Pegmatite	Garnet–biotite gneiss	Production unknown	
23		NQ0732	Mi	Pegmatite	Garnet–biotite gneiss	Production unknown	Shaw & others (1982)
24	Carrara group	NQ1030	Mi	Pegmatite	Biotite gneiss		
25	Eastern Belle (M38) (Carrara group)	NQ1131	Mi, Cu	Pegmatite (muscovite)	Biotite gneiss, sillimanite–biotite gneiss, garnet–biotite gneiss	Production 590 kg (1300 lb) in 1957	Joklik (1955a, p. 205, pl. 25); Jensen, (1944a, b); Shaw & others (1982); NTGS Mineral File
26	Little Sister (M40) (Carrara group)	NQ1231	Mi, Be	Pegmatite	Garnet–biotite gneiss	Abundant garnet 200 m to S, at Valiant Sister (part of deposit 26 on map)	Shaw & others (1982)
26	Valiant Sister (Carrara group)	NQ1231 (200 m N of Little Sister)	Mi, Be	Pegmatite	Garnet–biotite gneiss	Production 1680 kg (3700 lb) in 1957. Accessory beryl, enstatite, spodumene	Daly & Dyson (1956); Shaw & others (1982)
27	Carrara Group	NQ1231	Mi	Pegmatite	Muscovite pegmatite		
28	Lower Mine (Carrara group)	NQ1331	Mi	Pegmatite	Garnet–biotite gneiss	Accessory garnet, aegirine	NTGS Mineral File; Flack (1970)
29	Ragonesis (M37)	NQ2928	Mi	Pegmatite	Garnet–biotite gneiss	Operating in 1944	Daly & Dyson (1956, p. 9)

Map no.	*Name (and number NTGS file)*	*Grid reference*	*Commodity, minerals*	*Lode rock*	*Country rock*	*Remarks*	*References*
30	Last Chance	NQ3329	Mi, Be	Pegmatite (muscovite, beryl)	Garnet–biotite gneiss, rarely containing sillimanite	Production 22.6 tonnes (22.2 tons) in 1946–53; accessory biotite, apatite, garnet, diopside. Blanket Reef, Flat Dyke, and Big Reef (M34, M35) occur NE and SW of main mine	Joklik (1955a, p. 191, pls. 17, 18); Daly & Dyson (1956, p. 9); Shaw & others (1982)
31		NQ3429	Mi	Pegmatite	Miscellaneous pegmatites containing minor muscovite (31–34)		
32		NQ3429	Mi	Pegmatite			
33		NQ3529	Mi	Pegmatite			
34		NQ4527	Mi	Pegmatite			
35	Crespins	NQ4727	Mi	Pegmatite (muscovite), some graphic	Schistose quartzofeldspathic muscovite gneiss, biotite gneiss	Production unknown	Joklik (1955a, p. 15); Shaw & others (1982)
36	Leprechaun (M78)	NQ0323	Mi, Be	Quartz-rich pegmatite (muscovite, beryl)	Garnet–biotite gneiss	Accessory chrysoberyl, sphene. Several extensive drives and pits	NTGS Mineral File
37		NQ0522	Mi	Pegmatite	Miscellaneous pegmatites containing minor muscovite (37–40)		
38		NQ0422	Mi	Pegmatite			
39		NQ0521	Mi	Pegmatite			
40		NQ0521	Mi	Pegmatite			

TABLE 3 *(continued)*

Map no.	*Name (and number NTGS file)*	*Grid reference*	*Commodity, minerals*	*Lode rock*	*Country rock*	*Remarks*	*References*
41, 42	Lindsay West group of mines (M33, M44, M51)	NQ0520	Mi, Be	Pegmatite	Schistose biotite gneiss, garnet–biotite gneiss, sillimanite gneiss, quartzo-feldspathic gneiss	Beryl, rutile, tourmaline, hydroxyapatite	Daly & Dyson (1956); NTGS Mineral File; Shaw & others (1982)
43	Lindsay	NQ0720	Mi	Well-zoned pegmatite with quartz-rich core (muscovite)	Garnet–biotite gneiss	Accessory tourmaline. Small open cut 25 × 2 m, and 15 m deep	Brown (1889, 1890); Joklik (1955a, p. 15); Daly & Dyson (1956, p. 10)
44		NQ2422	Mi	Pegmatite	Muscovite pegmatite		
45		NQ2924	Mi	Pegmatite	Garnet–biotite gneiss	Production unknown	
46, 47	Rockhole Bore	NQ3118	Mi	Pegmatite	Garnet–biotite gneiss	Production unknown	Shaw & others (1982)
48		NQ2814	Mi, Be	Pegmatite	In alluvium surrounded by garnet–biotite gneiss, biotite gneiss	Production unknown, Pit 3 m diameter, 2 m deep. Accessory beryl, tourmaline	Shaw & others (1982)
49		NQ3514	Mi	Pegmatite	Garnet–biotite gneiss, biotite gneiss	Production unknown	Shaw & others (1982)
50	Hale River	NQ0110	Au, Cu	ENE-striking quartz veins	Quartzofeldspathic schist	Traces of copper carbonate, rarer chalcopyrite, rare Au in assay. Production nil	Ruxton (1963); Shaw & Milligan (1969); Warren & others (1974)
51	Black Diamond (M28)	NQ4806	Mi, Ap	Pegmatite containing muscovite, garnet, apatite	Quartzofeldspathic gneiss with traces of biotite and garnet; biotite gneiss, thin layers of amphibolite	Production 191 kg (420 lb) 1948–52; trench 20 × 3 m, and 2 m deep	Joklik (1955a, p. 15); Shaw & others (1982)

TABLE 3 *(continued)*

Map no.	*Name (and number NTGS file)*	*Grid reference*	*Commodity, minerals*	*Lode rock*	*Country rock*	*Remarks*	*References*
52	Albarta (M94)	NP0796	U	Brecciated quartz filling tensional fault flanked to W by fractured muscovite-chlorite quartzofeldspathic schist containing up to 5% pyrite	Quartzofeldspathic gneiss and chlorite-muscovite schist	Grab-rock-chip samples of schist assayed 80-140 ppm U. U concentrated in structural features of high porosity	Frazer (1977); Craven (1978); Shaw & others (1982)
53	Albarta Copper (M56)	NP3189	Cu	Vein quartz and porphyritic basic rock	Quartzite, schist	Malachite, chalcocite, chalcopyrite over 30x10 m	NTGS Mineral File
54	Tourmaline Gorge (M94)	NP0497	U	Flakes of an unidentified uranium-bearing metamorphic mineral similar to torbernite in microfractures in narrow deformed zone	Granite containing tourmaline (3-5%) and traces of garnet and altered beryl	Production nil	Craven (1978); Shaw & others (1982)

TABLE 3 *(continued)*

Map no.	*Name (and number NTGS file)*	*Grid reference*	*Commodity, minerals*	*Lode rock*	*Country rock*	*Remarks*	*References*
55	Hammer Hill (M80)	NQ4555	Ni, Cr	Siliceous rock formed by alteration of serpentinised rock, which is possibly a quartz–plagioclase–amphibole rock	Unknown, some pale brownish carbonate in drill core	Siliceous body; contains patches of pale green translucent nickeliferous silcrete; composite rock chip samples (7) at 10 m intervals across body averaged 2317 ppm Ni, 483 ppm Cr, and 43 ppm Co; one sample contained 1.01% Ni; DDH by NTGS	Howland (1971); Barraclough (1978); Flack (1970); Shaw & others (1982; DDH7 on map)
	Walter Smiths (M66)	NQ1652 NQ1551	U, Nb, Ce	Patch of calc-silicate rock containing samarskite and allanite cut by E–W pegmatite with magnesite, actinolite, fluorspar, calcite, and microcline at margins	Quartzofeldspathic gneiss, calc-silicate rock, muscovite–biotite schist	Bulldozer-cut 0.5 m deep at NQ1651; allanite and sepiolite possibly present	Corbett (1970); Shaw & others (1982)
		NQ1751	Tourmaline	Quartz vein	Quartzofeldspathic gneiss	Crystals	Shaw & others (1982)
	(M10)	NQ2353	Corundum, cordierite (iolite)	Kyanite–cordierite–gedrite–biotite schist	Quartzofeldspathic gneiss	Fossickers locality, rare pink corundum	Dobos (1978)
	(M6, M14, M15, M16)	NQ2848, NQ1046, NQ1047, NQ1245, NQ1842	Kyanite	Lenses of biotite schist	Quartzofeldspathic gneiss	Some blue	Joklik (1955a); Jensen (1943)

TABLE 3 *(continued)*

Map no.	*Name (and number NTGS file)*	*Grid reference*	*Commodity, minerals*	*Lode rock*	*Country rock*	*Remarks*	*References*
		NQ0534	Pb, Zn	Calc-silicate rock	Garnet-bearing quartzofeldspathic rock, garnet–biotite gneiss	Host rock contains galena and smithsonite	Shaw & others (1982)
		NQ2835	Cu	Ferruginous coarse-grained quartzite	Quartzofeldspathic gneiss	100 ppm Cu in grab-sample	Shaw & others (1982)
		NQ3251	Mo	Conformable pegmatite	Garnet-bearing muscovite–biotite schistose gneiss	Slight trace of molybdenite only	Warren & others (1974)
		NQ2212	W, Cu	Biotite schist	In Illogwa Schist Zone		Shaw & others (1982)
	Junction	NP6272	Cu	Quartz-goethite rock forms low circular rise, 75 m across, cut in places by minute veins of malachite	Calc-silicate rock, quartzofeldspathic gneiss	3 samples averaged 4250 ppm Cu, 30 ppm Pb, 12 ppm Ni. Traces of gold (0.05–2.0 ppm) in analysis by Agip Nucleare	Agip Nucleare Australia Pty Ltd (1979)
		NP2462	Cu	Fine disseminated bornite, chalcopyrite, chalcocite, and a trace of malachite in spilite	In intercalated spilite and dolomite, in Loves Creek Member (Bitter Springs Formation)	Chip sample from a mineralised zone 5 m wide in spilite assayed 1900 ppm Cu	Shaw & others (1982)
	(M90)	NP3268 NP3062	Zn	Finely disseminated sphalerite	Calcarenite and siltstone in Ringwood Member (Aralka Formation)		Australian Geophysical Pty Ltd (1967); NTGS Mineral File
	(M82, M85) (M52)	NP3355 NP3356	Cu	Trace of chrysocolla	Limbla Member (Aralka Formation)	Trace mineralisation only	McIntyre Mines (Australia) Pty Ltd (1968); Faulkner (1971); NTGS Mineral File
	Illogwa Creek (M53)	Unlocated	Cu	Quartz reef	Schist, gneiss, granite	Malachite with hematite	NTGS Mineral File

Gemstones and specimen material

The Sheet area has yielded numerous and valuable specimens held in museums and private collections, and some material is sold as part of the tourist trade in Alice Springs. *Chrome spinel* has been reported from a metamorphosed ultramafic body (Ꞓp) at GR NQ1951. Similar metamorphosed mafic to ultramafic bodies near Mount Mary also contain chrome spinel, but have not been delineated on the map because of their small size. *Kyanite* and *cordierite* have been excavated by fossickers from schist lenses in the Entia Gneiss 9 km north-northeast of Inkamulla Bore. *Corundum* and *gedrite* are also present at this locality. Kyanite occurs in a number of other schist lenses in the Entia Gneiss. *Ruby* is being mined on a small scale at the Hillrise mine (GR NQ0446) in a plagioclase-rich variant of the Riddock Amphibolite Member 4 km northwest of Spriggs Creek Bore. *Tourmaline* crystals occur in a quartz vein just east of Valley Bore. Accessory minerals in the mica-bearing Harts Range pegmatites (see Table 3) include *tourmaline, apatite, beryl,* and *spodumene. Epidote, plagioclase,* and *sphene* crystals occur in dykes of plagioclase-rich rock in the Riddock Amphibolite Member 2–3 km south of Spriggs Creek Bore.

Gold

In the Alice Springs 1:250 000 Sheet area, many small gold lodes at Arltunga and Winnecke in the Arltunga Nappe Complex lie in or close to zones of severe deformation due to the Alice Springs Orogeny. Information on these lodes has been summarised by Warren (1980). The Oolera Fault Zone (see tectonic sketch on map sheet) and the Illogwa Schist Zone represent extensions of these tectonic features into the Illogwa Creek Sheet area, where the Albarta Metamorphics—which resemble the Cavenagh metamorphics at Arltunga—are intruded by an extensive igneous complex of granite to diorite very similar to the Atnarpa Igneous Complex at Arltunga. Thus, the geological setting in the southern Arunta Block in the Sheet area is similar to that of the historic Arltunga Goldfield, 50 km to the west. The only gold deposit known in the Illogwa Creek Sheet area is the Hale River prospect (GR NQ0110).

Phosphate

Forman & others (1967) reported on a single specimen of magnetite–apatite metaquartzite containing 15% apatite from the upper reaches of Illogwa Creek. The extent and exact location of the apatite-bearing rock is unknown.

Mica

Mica deposits occur in large undeformed bodies of cross-cutting pegmatites. Zoned very coarse-grained bodies, particularly those containing oligoclase, have been the most productive. Previously productive mica mines are most abundant in the Irindina and Brady Gneisses. The mica deposits of the Harts Range have been extensively described by Joklik (1955a, b). Earlier, more general descriptions have been given by Hodge-Smith (1932) and Jensen (1947). Muscovite was mined between 1888 and 1961, and a total of 1660 t was produced (Gourlay, 1965). The last mines could not compete with imported mica, and were abandoned in 1961, when the Commonwealth Mica Pool ceased operation. Other reports on the mica mines include those of Sullivan (1942a, b), Dunn (1947), Tomich (1952), and Rochow (1962). Many of the mines are now in a dangerous condition.

Molybdenum

Molybdenite occurs as coarse flakes at one stratigraphic level of the Entia Gneiss in the Inkamulla Dome at the eastern end of the Harts Range (L.A. Johannsen, personal communication *in* Warren & others, 1974).

Nickel

A small nickeliferous laterite deposit (Hammer Hill) has been examined and drilled by the Northern Territory Geological Survey (Barraclough, 1978); Howland (1971) has also noted this deposit. Several other similar ferruginous siliceous bodies have been located southeast of Hammer Hill. Analyses of these show similar Ni and Cr values (appendix 2A *in* Shaw & others, 1982).

Rare-earth minerals

Betafite has been recorded from the Last Hope mica mine, and samarskite from the Lone Pine mica mine. Rare-earth minerals reported from the Mount Mary area (Morrison & Matheson, 1968) could not be relocated during a field check by Shaw & others (1982).

Salts

The Bitter Springs Formation has been prospected for economic salt deposits (Banks, 1964), but sodium chloride and calcium sulphate are the only salts found in quantity. Gypsum occurrences appear to be most common in unit 3 of the Gillen Member.

Tungsten

Traces of scheelite and rare-earth minerals occur in quartz veins cutting a calc-silicate marker unit 2 km west of Valley Bore. Alluvial scheelite with traces of molybdenite and a bismuth mineral have been reported from the centre of the Inkamulla Dome and at a locality about 5 km east of there (L.A. Johannsen, personal communication *in* Warren & others, 1974).

A concentration of 200 ppm W was detected by semi-quantitative emission spectrometry in a biotite schist containing 0.8% Cu (Shaw & others, 1982) at GR NQ2212 in the Illogwa Schist Zone.

Calc-silicate rocks in the Albarta Metamorphics and undivided Harts Range Group near Atula Bore (GR NQ8241) may be prospective for scheelite, especially near granite bodies, because scheelite deposits in the Bonya–Jervois area in the Huckitta 1:250 000 Sheet area are located in a similar rock association.

Uranium

Uranium in the Harts Range is commonly in the form of betafite or samarskite. Betafite containing 0.01 to 0.02% U_3O_8 has been reported from the Last Hope mica mine, and samarskite is recorded at the Lone Pine mica mine. Uranium has been explored for in the Albarta Metamorphics (Frazer, 1977; Craven, 1978). Rare uranium concentrations appear to be in zones of fracture and faulting, and in schist zones of high permeability.

Agip Nucleare Australia Pty Ltd (1979) and Afmeco (1980a) have explored for uranium in Tertiary sediments near Junction Bore, and Afmeco (1980b) explored in unconsolidated Cainozoic sediments along the Plenty River and Illogwa Creek.

GROUNDWATER

The average annual rainfall in the Sheet area is about 230 mm, and the average annual evaporation is about ten times that value (Slatyer *in* Perry & others, 1962).

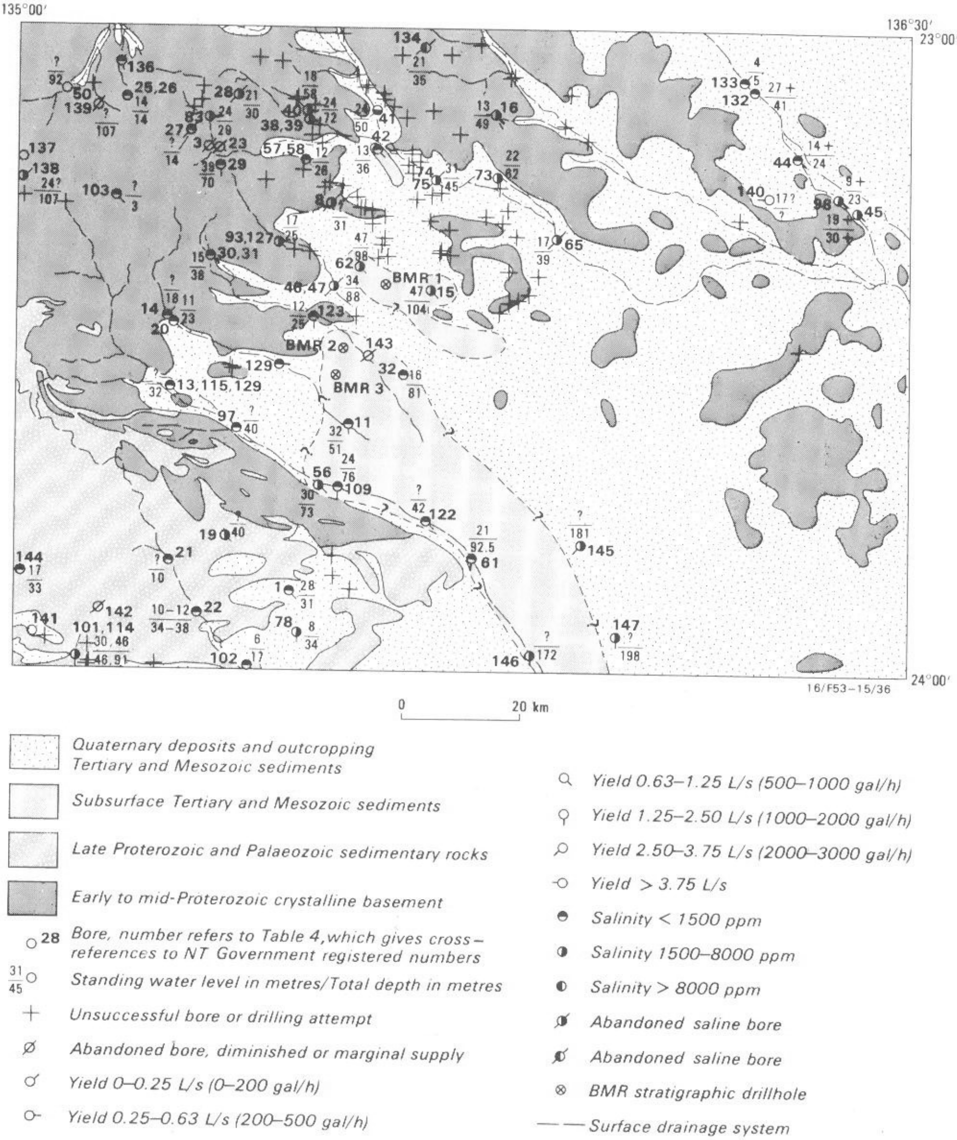

Fig. 5. Water-bores, and yield and quality of water.

Hence, groundwater is the principal source of water supply, and is tapped by numerous bores and wells, most of which yield stock-quality water only.

The groundwater resources of the area have been discussed in regional terms by Jones & Quinlan (*in* Perry & others, 1962) and Woolley & Quinlan (*in* Wells & others, 1970). Woolley (1963) has outlined the groundwater potential on Atula station (previously Plenty River station). A list of productive and marginal bores—compiled from Shaw & Milligan (1969), word-of-mouth information obtained from the local pastoralists in 1979, and records in the Water Investigation Division of the Northern Territory Department of Mines & Energy—is presented in Table 4, and the distribution of water-bores is given in Figure 5.

The crystalline rocks of the Arunta Block have poor prospects for good water supplies. The water-table lies close to the surface under a large part of these rocks. Aquifers in the Arunta Block are generally restricted to zones of fracturing or areas of extensive weathering, both of which are comparatively small and hence carry little water. Only about one-third of the bores for which complete records are available have yielded adequate supplies (i.e., greater than 0.5 L/s, 400 gal/h), and half of these were too saline for use. Only Brumby No. 2 Bore has a capacity in excess of 0.76 L/s (600 gal/h). Most successful bores are located along creeks, where they are recharged by creek flow. Because storage is limited, the supplies of several bores diminish considerably after extended use during a series of dry years (e.g. bores 3, 23, 47, and 138 in Fig. 5). A few bores (e.g., Atula and Gidyee) are reserved for use during drought years.

Of the two major groundwater provinces within the Arunta Block, the Harts Range area between Mount Brady and Mount George is characterised by low-capacity bores with salt contents of 500 to 1500 ppm; and the area between Huckitta and Atula Creeks, east of Brahma Bore, contains bores with low to moderate capacity and salt contents of 4000 to 20 000 ppm, of which sodium chloride makes up roughly 60%.

Only Bullhole Bore is thought to intersect the Bitter Springs Formation; water from this bore has a moderate salt content of 3000 ppm. In the Areyonga and Aralka Formations and Pioneer Sandstone, prospects are fair in the permeable sandstone beds where permeability is not restricted by a kaolinitic matrix or calcareous cement. Elsewhere in the Amadeus Basin the Julie Formation is potentially a moderately good aquifer. Sandy parts of the Arumbera Sandstone are moderate to good aquifers in both quantity and quality, but have not been tested in the Illogwa Creek Sheet area.

Prospects in the Tertiary rocks are usually good, with a success rate of about one in two. Two types of aquifer are present: one fills old stream channels which generally underlie the Quaternary deposits; the second comprises lacustrine and fluviatile sediments laid down outside the present drainage system. Within the low-prospect area of the Arunta Block, the second type is perhaps the better prospect wherever the Tertiary sediments extend below the piezometric surface.

A similar success rate has been obtained from bores in Quaternary drainage channels. The most productive aquifers are lenses of sand within the channels. Most of this water is of good quality and is suitable for human consumption. However, water in Atula Creek and Huckitta Creek east of Brahma Bore is salty to very salty (3000 to 8000 ppm), reflecting the high salt content of the rocks in the catchment area between these two creeks.

TABLE 4. PRODUCTIVE AND MARGINAL WATER-BORES

No. (Fig. 5)	*Name of bore*	*Capacity L/s (gal/h)*	*Depth m (feet)*	*Standing water-level m (feet)*	*Aquifer*	*Old BMR bore no.*	*Registered no. of NT Water Investigation Division*
1	Moonlight	1.26-1.01 (1000-800)	31 (103)	28 (93)	Qa or Ꝑuk	67	1325
8	Newmarket (abandoned)	poor	31 (103)	—	pЄhb	—	unknown
11	No. 3 (Numery)	1.51 (1200)	51 (167)	32 (106)	Qa (sand)	118	2299
13, 115	Albarta	2.27, 0.38 (1800), (300)	30, 32 (98), (105)	unknown	Qa or pЄa	113	2358, 12390
14	Aremra (see also Leaky (20) below)	0.13 (100 in '63)	18 (60)	unknown	Qa or ?Pzr	74	2534
15	Gidyea	1.26 (1000)	104 (340)	47 (153)	Ta	62	2490
16	Atula (drought use only)	0.96 (760 or less)	49 (162)	12.5 (41)	pЄh	73	2491
19	Bullhole	1.01 (800)	40 (130)	unknown	Qa or Ꝑue	115	2533
20	Leaky	1.21 (960)	23 (77)	10.5 (35)	Qa or ?Pzr	99	4084
21	Bronco	unknown	10 (34)	unknown	Qa or ?Ꝑuk	114	2535
22	Limbla homestead (4 holes)	unknown	10-12 (34-38)	unknown	Qa	54, 116	2536
25, 26	Inkamulla Bore	unknown	14 (46)	14 (46)	Qa or Ꝑgk	44	2561, 2562
27	Huckitta Well (abandoned)	unknown	14 (46)	unknown	Qa or Ꝑgh	48	2563

No. (Fig. 5)	Name of bore	Capacity L/s (gal/h)	Depth m (feet)	Standing water-level m (feet)	Aquifer	Old BMR bore no.	Registered no. of NT Water Investigation Division
28	Mirror Finish (abandoned)	0.38 (300)	30 (98)	21 (70)	pꞒhb	28	2564
29	Coggan	1.51 (1200)	70 (228)	39 (84)	Qa or pꞒh	29	2365
30, 31	Rockhole (replacement)	1.90+ (1500+)	38, 28 (125), (92)	15 (50)	Qa or pꞒh	42	2466, 2567
32	Allans (Numery)	0.88-0.38 (700-300)	81 (265)	16 (52)	Qa and Ta	—	2724
38, 39	Epsom No. 2 (replacement)	0.50 (400)	41 (135)	24 (80)	pꞒhb	8	1322
40	Epsom No. 1	1.13 (900)	58 (191)	18 (60)	pꞒhb	7	unknown
41	Crossing	1.51 (1200)	50 (164)	24 (79)	Qa or pꞒh	4	3255
42	Brahma (abandoned)	1.20 (950)	36 (117)	13 (43)	pꞒh	13	3254
44	No. 2 (Atula)	1.26 (1000)	24 (80)	18, 14 (59), (45)	Qa	57	2495
45	No. 3 (Atula)	1.51-0.88 (1200-750)	30 (100)	20, 18 (64), (58)	Qa	78	2496
46, 47	Black Diamond or No. 10 (Indiana)	0.35 (275 in '59)	88 (289)	34 (112)	pꞒhs	24	1763, 1764
50	Spriggs Creek	0.25 (200 in '65)	91 (300 in '65)	uncertain	pꞒha	63	3690 (several attempts include 2560, 3769)
56	Illogwa	1.26 (1000 in '57)	85 (280)	unknown	Qa or Ta	32	3378

No. (Fig. 5)	*Name of bore*	*Capacity L/s (gal/h)*	*Depth m (feet)*	*Standing water-level m (feet)*	*Aquifer*	*Old BMR bore no.*	*Registered no. of NT Water Investigation Division*
57	Brumby No. 2	1.26+ (1000+)	26 (86)	13 (43)	Qa	1100	4161
58, 59	Brumby	0.95 (750)	20 (65)	?12 (?40)	pЄhb	12	4144, 4120
61	Second Attempt	1.90 (1500)	49, 92.5 (161), (303)	?21 (?69)	Ta	—	12717
62	New Black Diamond or New No. 10	1.26 (1000)	98 (322)	47 (155)	Ta	92	4090
65	Ascot (abandoned, salty)	2.27 (1800)	39 (128)	16.5 (54)	Qa Ta	93	4030
73	Phillipson Stock Route (Badens)	0.30 (240)	60, 62 (198), (202)	27, 22 (90), (71)	Weathered schist, pЄh	49	4516
74, 75	Noll (abandoned)	1.51 (1200)	45, 7 (148), (22)	31 (103)	Weathered schist, pЄh	—	4551, 4552
78	No. 8, Perseverance	1.26 (1000 in '55)	34 (110)	8 (27)	Qa (sand)	33	1729
83	Huckitta	0.63-0.25 (480 in '65, 180 in '71)	29 (95)	24 (78)	pЄhe	83	?4705
93, 127	Indiana homestead (or Butterfly)	1.50 (1200 in '61)	26-25 (84-81)	17-15 (55-50)	pЄhs	30	7213, 7539, 7537
97	Atneequa	3.78 (3000)	40 (130)	unknown	Qa or ?Ta	—	10210
98	Atula homestead	1.01-0.63 (800-500)	23 (75)	9+ (30+)	Qa	—	10218

No. (Fig. 5)	Name of bore	Capacity L/s (gal/h)	Depth m (feet)	Standing water-level m (feet)	Aquifer	Old BMR bore no.	Registered no. of NT Water Investigation Division
101, 114	Waldo Pedlar (replacements)	2.50-2.13 (2000+)	46, 91 (150), (300)	30, 46 (100), (150)	Ꝑuk	68	3942 12051
102	No. 7 (Phillipson Stock Route)	2.27 (1800 in '57)	17 (57)	6 (19)	Qa	36	1284
103	Harding Springs	2.27-1.26 (18609 in '51, 1000 in '71)	3 (10)	unknown	Fault, pꞒhe	103	2667
109	No. 9 (Numery) (periodic use)	3.02-2.52 (2400 in '57, 2000)	76 (249)	24 (80)	Qa or Ta	35	11869
122	Junction	1.26-0.63 (1000-500)	42 (138)	unknown	Qa or Ta	119	4777
123	Acacia	3.53 (2800 in '59)	25 (81)	12 (40)	pꞒhi	38	7538
129	Atnarta	0.4 (300-400 in '79)	unknown	unknown	Qa	112	—
132	No. 1 (Atula)	0.76-0.95+ (600-750+)	41 (136)	27, 37 (90), (120)	Qa	55	—
133	Soakage (Atula)	?0.13 (?100)	4.6 (15)	3.5 (12)	Qa	56	—
134	Table Top, Atula West (Jinka) (marginal, salty)	?0.76 (?600)	35 (114)	21 (70)	pꞒh	90	—
136	Valley	No data	—	—	Qa or pꞒhe	—	—
137	New Lizzie Bore	No data	—	—	pꞒhi	—	—

No. (Fig. 5)	Name of bore	Capacity L/s (gal/h)	Depth m (feet)	Standing water-level m (feet)	Aquifer	Old BMR bore no.	Registered no. of NT Water Investigation Division
138	Lizzie Bore No. 2	0.2 (160)	107 (350)	?24 (?80)	pЄhi	—	—
139	Haddicks (abandoned)	0.10 (80)	107 (350)	unknown	pЄhe	—	—
140	Ilumba (Atula)	5.0 (4000)	unknown	?17 (?55)	pЄ	—	—
141	Allen (Ringwood)	No data	—	—	Ꝑuk	—	unknown
142	Salt Hole	Soakage	—	waterhole	Ꝑug	—	—
143	No. 4 (Numery) (posn approx.)	1.26 (1000)	81 (265)	60 (200)	Qa and Ta	81	unknown
144	—	5.0 (4000)	33 (108)	17 (56)	Qa or Ꝑug	—	12049
145	—	2.5 (2000)	181 (594)	?	JKh	—	12767
146	—	1.9 (1500)	172 (564)	?	?Ta	—	12716
147	—	1.9 (1500)	198 (649)	?	JKh	—	12768

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