1:250 000 GEOLOGICAL SERIES—EXPLANATORY NOTES

McLARTY HILLS
WESTERN AUSTRALIA

SHEET SE/51-15 INTERNATIONAL INDEX

DEPARTMENT OF NATIONAL DEVELOPMENT & ENERGY
BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

DEPARTMENT OF MINES, WESTERN AUSTRALIA
GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

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COMPILED BY D. L. GIBSON

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Explanatory Notes on the McLarty Hills Geological Sheet

Compiled by D. L. Gibson

The McLarty Hills 1:250 000 Sheet area lies in northern Western Australia between latitudes 19° and 20°S and longitudes 123° and 124°30'E. The Sheet area, which is situated in the north of the Great Sandy Desert, contains scattered outcrops of Mesozoic rocks protruding through a widespread cover of Cainozoic aeolian sand. Geologically, it is part of the Phanerozoic Canning Basin.

The area is uninhabited, and there is no industry. Vehicular access is limited to petroleum exploration tracks and seismic lines constructed before 1968; they were in poor condition in 1977, when the field work for this map and Notes was carried out.

The climate in the Sheet area is hot and dry. The average annual rainfall is about 330 mm, but most of this is cyclonic, and occurs mainly between December and March. The average daily maximum and minimum temperatures are about 38°C and 25°C in January, and 28°C and 11°C in July. Frosts may occasionally occur in winter. Average annual evaporation is probably 2550 mm. All climatic figures have been estimated from Bureau of Meteorology contour maps.

Vegetation on the sand dunes is simple in species and structure, and differs from that of the interdune flats. The dune flanks are normally vegetated with *Plectrachne* spinifex, and *Grevillea* and *Acacia* shrubs; scattered pockets of small *Eucalyptus* trees may be present. The dune crests are often bare and subject to wind action. The extent of vegetation of the interdune areas is primarily influenced by the amount of sand present, and is commonly composed of shrubs (mainly *Acacia, Grevillea,* and *Hakea*), and spinifex (*Plectrachne* and *Triodia*). Claypans are generally sparsely vegetated with small succulents ('samphire').

History of investigations

Colonel P. E. Warburton was the first explorer to enter the Sheet area, during a journey between Alice Springs and the Oakover River (in the Yarrie 1:250 000 Sheet area) in 1873. L. A. Wells crossed the Sheet area from south to north in 1896 (Feekin & others, 1970).

Geological. The first geologist to work in the area was F. G. Clapp, who traversed by tractor from Broome to the McLarty Hills (Clapp, 1925). Geologists of West Australian Petroleum Pty Ltd (WAPET) visited the McLarty Hills in 1954, and collected fossils, which were later identified by Dickins (Appendix 4 *in* Veevers & Wells, 1961). Photo-interpretation of the surface geology of the Sheet area was incorporated into a map of Canning Basin at a scale of 20 miles to 1 inch, which accompanies a synthesis of the geology of the Canning Basin by Veevers & Wells (1961). Surface geological mapping was carried out by French Petroleum Company (Australia) Pty Ltd (French Petroleum) in 1967, and is reported by Leslie (1967).

The Sheet area was geologically mapped in 1977 by a combined Bureau of Mineral Resources (BMR)/Geological Survey of Western Australia (GSWA) team, as part of a project to map the entire Canning Basin at 1:250 000 scale (Towner & Gibson, 1980). The mapping consisted of three helicopter-assisted traverses across the Sheet area and subsequent photo-interpretation.

Geophysical. The first geophysical surveys that covered part of the Sheet area began in the early 1950's with reconnaissance aeromagnetics flown by BMR (Quilty, 1960); further aeromagnetics were flown by WAPET in 1962 (WAPET, 1966a). The earliest gravity survey was conducted by BMR (Flavelle & Goodspeed, 1962). Later, more-detailed gravity work was carried out by WAPET in 1963–4 (WAPET, 1964) and French Petroleum in 1967 (French Petroleum, 1967a, 1967b). The areomagnetic surveys and the gravity surveys showed that the basement of the Canning Basin in the Sheet area is quite shallow compared with areas to the north and south.

The gravity contours displayed on the map are those of the BMR helicopter gravity survey, commenced in 1952 and completed in 1960, together with the later company data, which has been partly processed by Darby & Fraser (1969) and then by Fraser (1974). The nomenclature of gravity provinces has been revised by Fraser (1976). A synthesis of all the available pre-1962 gravity information in the Canning Basin, relating it to the known surface geology and the borehole stratigraphy, was published in 1974 (Flavelle, 1974).

Two seismic surveys have been carried out partly within the Sheet area: the McLarty survey of French Petroleum (1976b) and the Munro D–2 survey of WAPET (1971). The Munro D–2 survey only just came onto the southwestern corner of the Sheet area, but the McLarty survey covered much of the Sheet area. The McLarty survey showed that the Canning Basin rocks generally dip gently to the south and southwest, and that there is a west-northwesterly trending anticline and syncline in Ordovician rocks of the Canning Basin in the central-northern part of the Sheet area. Structural closure was mapped on the anticline, and subsequently the Total McLarty 1 well was drilled to near basement in this area of closure (Total, 1968a). Fluorescence and bituminous material were the only shows of hydrocarbons in this well.

Aerial photographs and maps. Vertical aerial photographs of the Sheet area, at a nominal scale of 1:85 000 (RC–9 series), were flown in 1967 and were used to prepare the accompanying geological map; 1:50 000 scale photos (K–17 series) were flown in 1949. 1:250 000 topographic maps were compiled in 1962 by the Western Australian Department of Lands and Surveys, and in 1977 by the Division of National Mapping. Photomosaic maps at an approximate scale of 1:100 000 were produced by the Division of National Mapping in 1970. Six 1:100 000 contoured topographic maps were produced by the Commonwealth Division of National Mapping in 1973, using the 1967 photography. Photos and maps are available from the Division of National Mapping, Canberra, and the Department of Lands and Surveys, Perth.

PHYSIOGRAPHY

The physiography of the Sheet area is summarised in Figure 1.

The form lines shown on the physiographic map have been compiled using the widely spaced information from BMR gravity survey station heights.

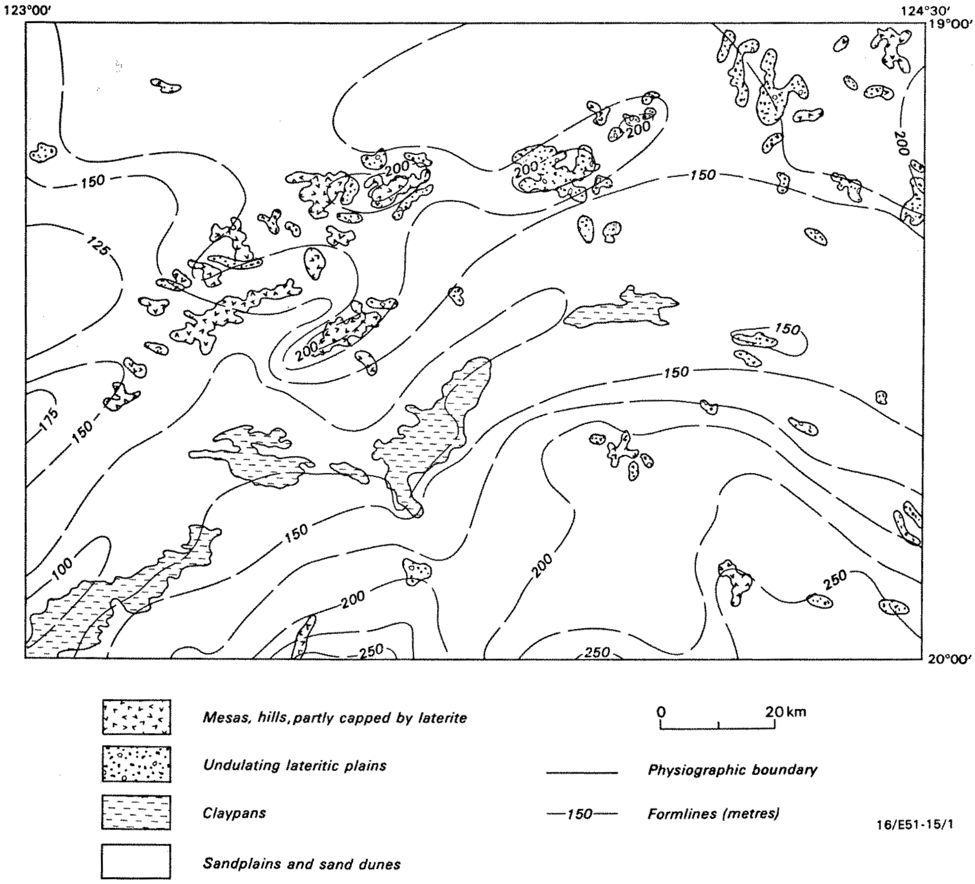

Fig. 1. Physiography.

Mesas and hills

Small rocky hills and breakaways, up to 30 m in height, project through the sand cover, especially in the central western and northeastern parts of the Sheet area. Some of the mesas and hills are capped by laterite.

Undulating lateritic plains

Small areas of lateritic plain occur scattered throughout the Sheet area; more extensive areas of laterite are probably hidden under the aeolian sand plain. The lateritic plains are low, and the surfaces are covered by pisoliths and, in places, by a thin blanket of red sand or longitudinal sand dunes.

Claypans

Numerous small claypans are present along the floor of a broad shallow valley which runs from the central eastern side of the Sheet area to the southwestern corner. This valley is thought to represent an ancient drainage course.

Sand plains and sand dunes

The Sheet area is dominated by an aeolian dunefield, with westerly to north-westerly-trending seif dunes of an average height of 8–13 m. The dunes are of simple and chain type (terms of Crowe, 1975) and were deposited by easterly to east-southeasterly winds. Calcrete floors some interdune areas in low-lying parts of the Sheet area.

STRATIGRAPHY

The stratigraphy of the Sheet area is summarised in Table 1 and described briefly below. Units older than the Late Jurassic Alexander Formation are not known to crop out in the area. Most have been intersected by the Total McLarty 1 well; three more units (Tandalgoo Red Beds, Poole Sandstone, and Noonkanbah Formation) are predicted to be present in the subsurface in the south of the Sheet area—see geological cross-section on the accompanying map and on the map accompanying the Joanna Spring Explanatory Notes (Towner, in press a).

PRECAMBRIAN

The nature of the basement rocks shown in the geological cross-section is unknown. Total Edgar Range 1 (27 km north of the Sheet area) bottomed in pelitic schist (Total, 1968b) and WAPET Munro 1 (55 km west of the Sheet area) bottomed in granite (WAPET, 1972).

PALAEOZOIC

Early to Middle Ordovician

The presence of Ordovician rocks in the Sheet area is confirmed in Total McLarty 1. The following units have been recognised (Gorter & others, 1979; Towner & Gibson, 1980; McTavish & Legg, 1976)—these units are present across much of the Canning Basin, and probably extend across the whole Sheet area:

The *Nambeet Formation* (Ot; Johnstone *in* WAPET, 1961a; Koop, 1966) is the oldest known unit in the Canning Basin. It contains an Early Ordovician or Late Cambrian fauna in the Mandora Sheet area to the west (Gilbert-Tomlinson, *in* WAPET, 1961a), but is of Early Ordovician age in Mount Anderson Sheet area to the north (Gibson & Crowe, in press). The *Wilson Cliffs Sandstone* (Oi; McTavish & Legg, 1976), intersected in Total McLarty 1, is a facies equivalent of the Nambeet Formation in this area. The overlying *Willara Formation* (Ow; McTavish, *in* Playford & others, 1975), is probably also of Early Ordovician age. The *Goldwyer Formation* (Oo; Elliott, *in* WAPET, 1961b) overlies the Willara Formation, and is of Middle Ordovician age (Combaz, *in* Total, 1968a). The overlying *Nita Formation* (On; McTavish, *in* Playford & others, 1975), is probably of late Middle Ordovician age (Balme, *in* Total, 1968a).

Late Ordovician? to Early Devonian

Disconformably(?) overlying the Nita Formation is the *Carribuddy Formation* (Sc; Koop, *in* WAPET, 1966b). It is conformably overlain by the Tandalgoo Red Beds of Early Devonian age, and is therefore considered to be Late Ordovician(?) to Early Devonian on stratigraphic grounds. Halite predominates in the Carribuddy Formation in Total McLarty 1; massive halite in the Formation in the Mount Anderson Sheet area to the north is considered to be the source for a salt dome penetrated by WAPET Frome Rocks 1 (WAPET, 1962). Several closed anticlines in the Munro Sheet area to the west are also probably associated with salt diapirism in the Carribuddy Formation (Gorter & others, 1979).

The *Tandalgoo Red Beds* (Dt; Koop, *in* WAPET, 1966b) conformably overlie the Carribuddy Formation. The unit is not present in Total McLarty 1, but is predicted to be present in the southern part of the Sheet area where it has not been eroded by the pre-Permian erosion cycle. The unit is poorly dated, but is probably of Early Devonian age (Gross, 1971). The fine-grained clastic rocks and minor limestone of the unit were probably deposited in an arid, terrestrial environment.

Early Permian

The *Grant Group* (Pg; Guppy & others, 1958; Crowe & Towner, 1976) unconformably overlies the Carribuddy Formation and Tandalgoo Red Beds. Crowe & Towner (1976) defined three formations within the Grant Group, namely the Betty, Winifred, and Carolyn Formations. Total McLarty 1 intersected rocks which probably belong to the lower unit, the Betty Formation (fine to coarse sandstone with basal conglomerate), and the middle unit, the Winifred Formation (mudstone). It is probable that the upper unit, the Carolyn Formation (sandstone), is present in the south of the Sheet area, as the overlying Poole Sandstone is also thought to be present there. The Betty and Carolyn Formations are thought to have been deposited under cold water or glacial conditions.

The *Poole Sandstone* (Pp; Guppy & others, 1952) overlies the Grant Group. Crowe & others (1978) showed that the boundary between the Poole Sandstone and the Grant Group is an angular unconformity in the Grant Range (Mount Anderson 1:250 000 Sheet area to the north), but this angularity has not been demonstrated in the McLarty Hills Sheet area. The Carolyn Formation and the lower part of the Poole Sandstone are Sakmarian in age (Crowe & others, 1978).

The *Noonkanbah Formation* (Pn; Wade, 1938; Guppy & others, 1952) was not penetrated in Total McLarty 1, but was encountered between 103.8 m and 157.9 m in Total Kemp Field 1 in the adjacent Joanna Spring Sheet area to the south; hence the unit is thought to be present in the south of the McLarty Hills Sheet area. The unit is of Artinskian age, based on palynomorphs recovered from cores and cuttings in wells outside the Sheet area (WAPET, 1966b).

MESOZOIC

Jurassic to Early Cretaceous

Since most of the Mesozoic sequences are flat-lying or very shallow dipping, and in general not very thick, it is not possible to represent each of the Mesozoic units individually on a cross section at a scale of V/H = 1. Therefore, the Mesozoic units have been shown on the cross-section as *JK undivided.*

The *Wallal Sandstone* (J1; McWhae, *in* WAPET, 1961a) was intersected in Total McLarty 1, and is probably of continental to shallow-marine origin. This sandstone unit is known to crop out only in the Mount Anderson and Derby 1:250 000 Sheet areas to the north, but data from petroleum exploration wells outside the McLarty Hills Sheet area indicate that it is present over much of the west Canning Basin. It is thought to be of Middle to Late Jurassic age in the Sheet area, but to the east of that area it may range into the Early Jurassic (Towner &

TABLE 1. STRATIGRAPHY OF McLARTY HILLS SHEET AREA

	Age	*Rock unit & map symbol*	*Estimated thickness (m)*	*Lithology*	*Stratigraphic relations*	*Fossils*	*Remarks*
CAINOZOIC	Quaternary	Qa	2	Sand, silt; minor gravel	Superficial		Alluvial deposits
		Ql	5	Silt, fine sand	Superficial		Lacustrine deposits
		Qs	5	Sand, silt; minor gravel	Superficial		Mixed alluvial and aeolian deposits
		Qz	20	Fine to medium-grained red sand; minor silt	Superficial		Aeolian deposits — seif dunes and sand sheets
		Czk	5	Calcrete, minor chalcedony	Superficial		Carbonate deposits developed in-situ in soils
		Czs	2	Sand, silt, and ferruginous gravel and pisoliths; minor clay	Superficial; overlies Czl		Ferruginous gravel plains
		Czl	5	Pisolitic and massive laterite (ferruginous duricrust)	Superficial; overlain by all other Cainozoic units		Pedogenic deposit
MESOZOIC	Early Cretaceous	Frezier Sandstone Kf	50	Fine to coarse, poorly sorted, feldspathic sandstone; cross-bedded; minor mudstone	Possibily disconformably overlies Kb, JKr, Ja; possibly laterally equivalent to JKo	Rare bivalves outside the Sheet area	Fluvial to deltaic
		Broome Sandstone Kb	50	Sandstone, mudstone	Conformably(?) overlies JKr; disconformably(?) overlain by Kf	Bivalves, plant fossils, and palynomorphs outside the Sheet area	Interpreted to be present in the far west of the Sheet area; does not crop out; shallow marine
	Late Jurassic to Early Cretaceous	Mowla Sandstone JKo	10	Poorly sorted, coarse sandstone with granules and clay pellets; cross-bedded	Overlies JKr, probably conformably to disconformably; possibly laterally equivalent to Kf; top eroded	Plant fossils outside the Sheet area	Fluvial to deltaic
		Jarlemai Siltstone JKr	50	Very fine to fine sandstone, inter-bedded mudstone; ripple-marked, cross-bedded; bioturbated in part	Conformably overlies Ja; overlain probably conformably to disconformably by JKo, disconformably(?) by Kf, conformably(?) by Kb	Bivalves, ammonites, gastropods, and palynomorphs outside the Sheet area	Shallow marine

TABLE 1. STRATIGRAPHY OF McLARTY HILLS SHEET AREA (*continued*)

	Age	*Rock unit & map symbol*	*Estimated thickness (m)*	*Lithology*	*Stratigraphic relations*	*Fossils*	*Remarks*
MESOZOIC	Jurassic	Alexander Formation Ja	50	Fine to coarse sandstone, inter-bedded mudstone, rare conglomerate; ripple-marked, cross-bedded	Conformably overlies J1; conformably overlain by JKr, disconformably(?) by Kf	Bivalves and fossil wood (ammonites, stelleroids, brachiopods, and microfossils outside the Sheet area)	Shallow marine (tidal)
		Wallal Sandstone J1	103 in Total McLarty 1	Sandstone; minor siltstone, conglomerate	Unconformably overlies Pn, Pp, Pg; conformably overlain by Ja	Palynomorphs	Continental to shallow marine
				UNCONFORMITY			
PALAEOZOIC	Early Permian	Noonkanbah Formation Pn	30	Calcareous, micaceous mudstone; interbeds of fine sandstone and limestone	Conformably ovelies Pp; overlain unconformably by J1	Brachiopods, bryozoans, corals, crinoids, forams, bivalves, gastropods, ostracods, and palynomorphs outside the Sheet area	Predicted to be present in sub-surface in the south of Sheet area; marine
		Poole Sandstone Pp	20	Very fine to fine sandstone; interbedded mudstone	Disconformably(?) overlies Pg; overlain conformably by Pn, unconformably by J1	Plant fossils, brachiopods, bryozoans, forams, ammonoids, molluscs, conodonts, crinoids, and ostracods outside the Sheet area	Predicted to be present in sub-surface in the south of Sheet area; marine to lagoonal
		Grant Group Pg	326 in Total McLarty 1, 400? max.	Fine to coarse sandstone; mudstone; basal conglomerate	Unconformably overlies Dt, Sc; overlain disconformably(?) by Pp, unconformably by J1	Palynomorphs, bivalves, gastropods, brachiopods, bryozoans, and crinoids outside the Sheet area	Sandstone of Carolyn Formation at top; mudstone of Winifred Formation in middle; sandstone and conglomerate of Betty Formation at base; marine, partly glacial marine
				UNCONFORMITY			
	Early Devonian	Tandalgoo Red Beds Dt	300	Fine, reddish-bown sandstone; minor shale, limestone, and siltstone	Conformably overlies Sc; unconformably overlain by Pg	Palynomorphs and fish scales outside Sheet area	Predicted to be present in the south of Sheet area; an arid-climate, terrestrial deposit

TABLE 1. STRATIGRAPHY OF McLARTY HILLS SHEET AREA (*continued*)

	Age	*Rock unit & map symbol*	*Estimated thickness (m)*	*Lithology*	*Stratigraphic relations*	*Fossils*	*Remarks*
PALAEOZOIC	Late Ordovician to Early Devonian	Carribuddy Formation Sc	1197 in Total McLarty 1	Halite, dolomite, siltstone, shale and anhydrite	Disconformably(?) overlies On; overlain conformably by Dt, unconformably by Pg		Evaporitic shallow marine deposit
	Middle Ordovician	Nita Formation On	57 in Total McLarty 1	Limestone, dolomite and minor interbedded shale	Conformably overlies Oo; disconformably(?) overlain by Sc	Chitinozoans, acritarchs, and brachiopods; palynomorphs, conodonts, molluscs, and crinoids outside the Sheet area	Shallow marine
		Goldwyer Formation Oo	373 in Total McLarty 1	Black shale, interbedded limestone; calcareous, pyritic	Conformable between Ow and On	Chitinozoans, graptolites, echinoderms, bryozoans, brachiopods, and trilobites; condonts, ostracods, and nautiloids outside the Sheet area	Shallow marine
	Early Ordovician	Willara Formation Ow	280 in Total McLarty 1	Limestone, dolomite, interbedded shale and sandstone	Conformable between Ot and Oo	Echinoderms, trilobites, ostracods, gastropods, algae, brachiopods, and bryozoans; graptolites, conodonts, and nautiloids outside the Sheet area	Shallow marine
		Wilson Cliffs Sandstone Oi	250+	Fine to very fine well-sorted calcareous sandstone; minor shale	Unconformably overlies p€; conformably overlain by Ow; facies equivalent of Ot	Trilobites, graptolites, bivalves, brachiopods, conodonts, and microflora	Shallow marine
		Nambeet Formation Ot	300	Shale, grey to green; interbedded fine sandstone	Unconformably overlies p€; conformably overlain by Ow; facies equivalent of Oi	Echinoderms, trilobites, algae, and brachipods; graptolites and gastropods outside the Sheet area	Shallow marine
				UNCONFORMITY			
PRECAMBRIAN		Undivided p€		Igneous, metamorphic and sedimentary rocks	Unconformably overlain by Ot		Basement to the Canning Basin

Gibson, 1980). The formation unconformably overlies the Permian Noonkanbah Formation, Poole Sandstone, and Grant Group; an angular discordance is recognisable on many of the seismic sections. The top of the sandstone is conformable with the overlying Alexander Formation.

The *Alexander Formation* (Ja; Brunnschweiler, 1954) is present in numerous small hills and rises, mainly in the northwestern quarter of the Sheet area; it is the oldest unit which crops out in the Sheet area, and the youngest unit intersected in Total McLarty 1. In outcrop, it consists of medium to coarse-grained sandstone, with some mudstone and rare conglomerate beds. Cross-bedding and ripples are common, and the rocks are commonly strongly ferruginised. Shelly fossil casts are common in places. Outcrops of fine to medium sandstone and mudstone in the far southeastern corner of the Sheet area may belong to the Alexander Formation, and have been labelled Ja? on the accompanying map. The unit has been dated as Late Jurassic (Oxfordian) by a rich macrofauna in exposures to the north in the adjacent Mount Anderson Sheet area (Crowe & others, 1978).

The overlying *Jarlemai Siltstone* (JKr; Brunnschweiler, 1954) is finer grained than the Alexander Formation and generally not ferruginised. White, massive to thin-bedded fine sandstone and mudstone with ripple marks and cross-bedding is the normal lithology of outcrops of this unit in the Sheet area. It is bioturbated in places.

The Jarlemai Siltstone is also interpreted to underlie low ferruginous gravel plains (Czs) which exhibit poorly-defined sinous trend lines in the northeastern portion of the Sheet area. These gravel plains were previously interpreted by Veevers & Wells, (1961) as being underlain by Permian rocks, as similar airphoto patterns are seen in the Permian rocks in Sheet areas to the north and east. However, Veevers & Wells interpretation is now considered to be unlikely as these areas are close to known outcrops of Jarlemai Siltstone. The Jarlemai Siltstone has been dated as Kimmeridgian to Tithonian outside the Sheet area, but may extend into the Early Cretaceous (Crowe & others, 1978).

The *Mowla Sandstone* (JKo; Brunnschweiler, 1954; Guppy & others, 1958) is interpreted to be a deltaic-to-fluvial deposit which overlies the shallow-marine Jarlemai Siltstone. All outcrops are strongly ferruginised. The age of the Mowla Sandstone is considered to be latest Jurassic or Early Cretaceous on stratigraphic grounds. It overlies the Jarlemai Siltstone in the Mount Anderson Sheet area to the north conformably to disconformably (Gibson & Crowe, in press); this relationship is probably also true in the McLarty Hills Sheet area.

The *Broome Sandstone* (Kb; Reeves, 1949) is interpreted to be present in the far western portion of the Sheet area, though it is not known to crop out there; possible outcrops of Broome Sandstone occur within a few kilometres of the eastern edge of the adjoining Munro Sheet area (Towner, in press b). The Broome Sandstone is considered to be Early Cretaceous (Neocomian) in age (Towner & Gibson, 1980), mainly on stratigraphic grounds. It is considered to be partly equivalent to the Mowla Sandstone.

The *Frezier Sandstone* (Kf; Lindner & Drew, *in* McWhae & others, 1958) crops out near the southern edge of the Sheet area, south of the McLarty Hills. The Frezier Sandstone is a continental (fluvial) sandstone deposit characterised by tabular cross-bedding. It has tentatively been dated as Aptian by Dickins (*in*

Veevers & Wells, 1961) on the basis of rare bivalves present in the unit outside the Sheet area. Its relationship with the Mowla Sandstone is not known, although it is possible that they might be partly laterally equivalent. The Frezier Sandstone possibly disconformity overlies the Broome Sandstone, Jarlemai Siltstone, and Alexander Formation in the Sheet area (see Simplified Geology sketch on the accompanying map), but poor outcrop renders these relationships hypothetical.

CAINOZOIC

A thin veneer of Cainozoic sediments covers most of the Sheet area. The oldest preserved unit is *Laterite* (Czl) or ferruginous duricrust, which forms low rises and breakaways; it is common over the fine-grained rocks of the Jarlemai Siltstone because they are readily susceptible to lateritisation.

Ferruginous gravel plains (Czs) overlie the laterite, and form low rises. *Calcrete* (Czk) is exposed between sand dunes in some areas. The calcrete is thought to have resulted from water-table movements, associated with the wet and dry seasons, that resulted in the precipitation of calcium carbonate.

The most widespread Quaternary unit is *aeolian sand* (Qz), which occurs as longitudinal seif dunes and sand sheets composed of well-sorted, fine to medium-grained, reddish-brown and yellow quartzose sand, with minor reddish-brown silt. *Mixed aeolian and alluvial deposits* (Qs) are recognised by their distinctive pattern on aerial photographs; the deposits occur between dunes in restricted areas in the northern half of the Sheet area. *Lake deposits* (Q1) of silt and fine sand fill claypans along the floor of a broad valley which runs across the Sheet area. Minor *alluvium* (Qa) occurs within watercourses near the McLarty Hills.

STRUCTURE

The Sheet area lies mainly on the Broome Arch structural subdivision of the Canning Basin. The southwestern portion of the Sheet area is part of the Willara Sub-Basin and the southern area is part of the Kidson Sub-Basin (see the Simplified Geology sketch on the accompanying map). The boundaries between these three sub-divisions are gradational, and are based on basement configuration.

Only two possible faults (in the northeast and southeast) have been recognised at the surface in the Sheet area. A dip of 4° in the Mowla Sandstone and Jarlemai Siltstone at the northeast locality is the steepest seen at the surface; subsurface information suggests that dips at depth are generally less than 2°. Seismic work has delineated only minor faults in the subsurface.

A slight angular unconformity at the base of the Grant Group indicates that mild deformation and consequent erosion probably occurred in the Devonian or Carboniferous; similarly, the unconformity at the base of the Wallal Sandstone points to deformation and erosion, probably in the Triassic or Early Jurassic.

In the Mount Anderson 1:250 000 Sheet area to the north, the Poole Sandstone unconformably overlies the Grant Group (Gibson & Crowe, in press) but there is insufficient data available in the McLarty Hills Sheet area to determine whether the boundary is an unconformity or disconformity, and hence, whether there was any deformation at that time (Sakmarian).

GEOLOGICAL HISTORY

In Precambrian times, sediments were laid down, and then intruded by igneous rocks. These rocks were subsequently deformed and metamorphosed to form the basement of the Canning Basin. A long period of erosion was followed by sedimentation in the Early Ordovician when a shallow epicontinental sea covered the area. Clay, carbonates, sand, and silt (Nambeet Formation, Wilson Cliffs Sandstone, and the Willara, Goldwyer, and Nita Formations) were deposited in this shallow sea in Early to Middle Ordovician times.

The sea then regressed from the area, and returned, possibly as early as Late Ordovician, after a period of minor erosion. Again, water depths were shallow, and carbonates, evaporites (halite and anhydrite), silt, and clay (Carribuddy Formation) were deposited. The sea then withdrew from the area and continental sand with minor silt, mud, and carbonate (Tandalgoo Red Beds) were deposited under arid continental conditions in the Early Devonian.

The area was then uplifted and eroded till Early Permian (Sakmarian) times when the sea again invaded the area. Sand, mud, and gravel (Grant Group) were laid down in this sea, possibly partly under glacial or cold water conditions. After a short regression, the sea re-entered the area and sand, mud, and carbonates (Poole Sandstone and Noonkanbah Formation) were deposited during Early Permian (late Sakmarian to Artinskian) times.

Regression, and possible uplift followed, and the Permian deposits were eroded. Sedimentation recommenced in Early(?) Jurassic times and continental to shallow-marine sand, and minor silt and gravel (Wallal Sandstone) were deposited. In Late Jurassic (Oxfordian) times the sea had transgressed the area and sand and mud (Alexander Formation) were deposited in a shallow marine (tidal) environment. Continued transgression in late Oxfordian or Kimmeridgian times led to deposition of very-fine to fine sand and mud (Jarlemai Siltstone), still in a shallow marine environment.

The sea regressed from the area, probably in latest Jurassic times, and continental to deltaic sand and gravel of the Mowla and Frezier Sandstones were deposited over most of the Sheet area, except in the far west, where the shallow-marine sand and mud of the Broome Sandstone were probably deposited over the Jarlemai Siltstone as the sea regressed.

The area has been extensively eroded and weathered since Early Cretaceous times. By Early Tertiary(?) times, a broad valley had been eroded across the Sheet area and a lateritic duricrust had formed under the influence of a moist warm seasonal climate. An increase in aridity in the Late Tertiary initiated the choking of the valley with eroded material. In the Quaternary, extensive aeolian sand deposits were laid down over most of the Sheet area by easterly to east-southeasterly winds. Calcrete developed in the soils in areas of shallow fluctuating water-table, and lacustrine silt and fine sand were deposited in a chain of claypans that developed along the floor of the broad valley across the Sheet area. Mixed aeolian and alluvial sand, silt, and minor gravel accumulated in some interdune areas, and alluvium was deposited in minor watercourses.

ECONOMIC RESOURCES

Petroleum

The only petroleum exploration well drilled in the Sheet area, Total McLarty 1 (Total, 1968a), encountered no significant hydrocarbon shows. Burne & Kantsler (1977) imply that the Ordovician rocks and part of the Carribuddy Formation are mature for oil generation in the Sheet area, and that current temperatures are the highest that the rocks have encountered. However, Burne & others (1979) conclude that, although there is evidence favouring oil accumulation in the Ordovician rocks on the Broome Arch, the Ordovician formations tested so far in the general area have low permeability and lack seals (Total McLarty 1 encountered no reservoir rocks below the Permian) and the Carribuddy Formation has no source rock potential. In addition, Gorter & others (1979) recognise only one other closed structure, apart from the dome on which Total McLarty 1 was drilled, in the Sheet area. The prospects for finding petroleum in the Sheet area are therefore considered very low.

Water

There are no station water-bores in the Sheet area. However, 19 or 20 bores have been drilled in the Sheet area for water supplies for geophysical teams and petroleum exploration drilling; of these, 10 were dry. The remainder encountered potable water in Jurassic rocks at depths between 6 and 64 m (French Petroleum, 1967a, 1967b; Total, 1968a).

Claypans and rockholes may contain water after heavy rainfall in the wet season. About 22 km southwest of the McLarty Hills, a small pool at one end of a claypan is surrounded by bullrushes and a thick stand of acacias. This pool represents an area where the water table comes to the surface, and is probably a permanent source of good quality water.

Evaporites

A thick sequence of evaporites (halite with minor anhydrite) were intersected at depth in the Carribuddy Formation in Total McLarty No. 1 well (Total, 1968a; Glover, 1973; Wells, 1980).

Construction materials

Supplies of pisolitic laterite and ferruginised sandstone, suitable for road construction, are available in the Sheet area.

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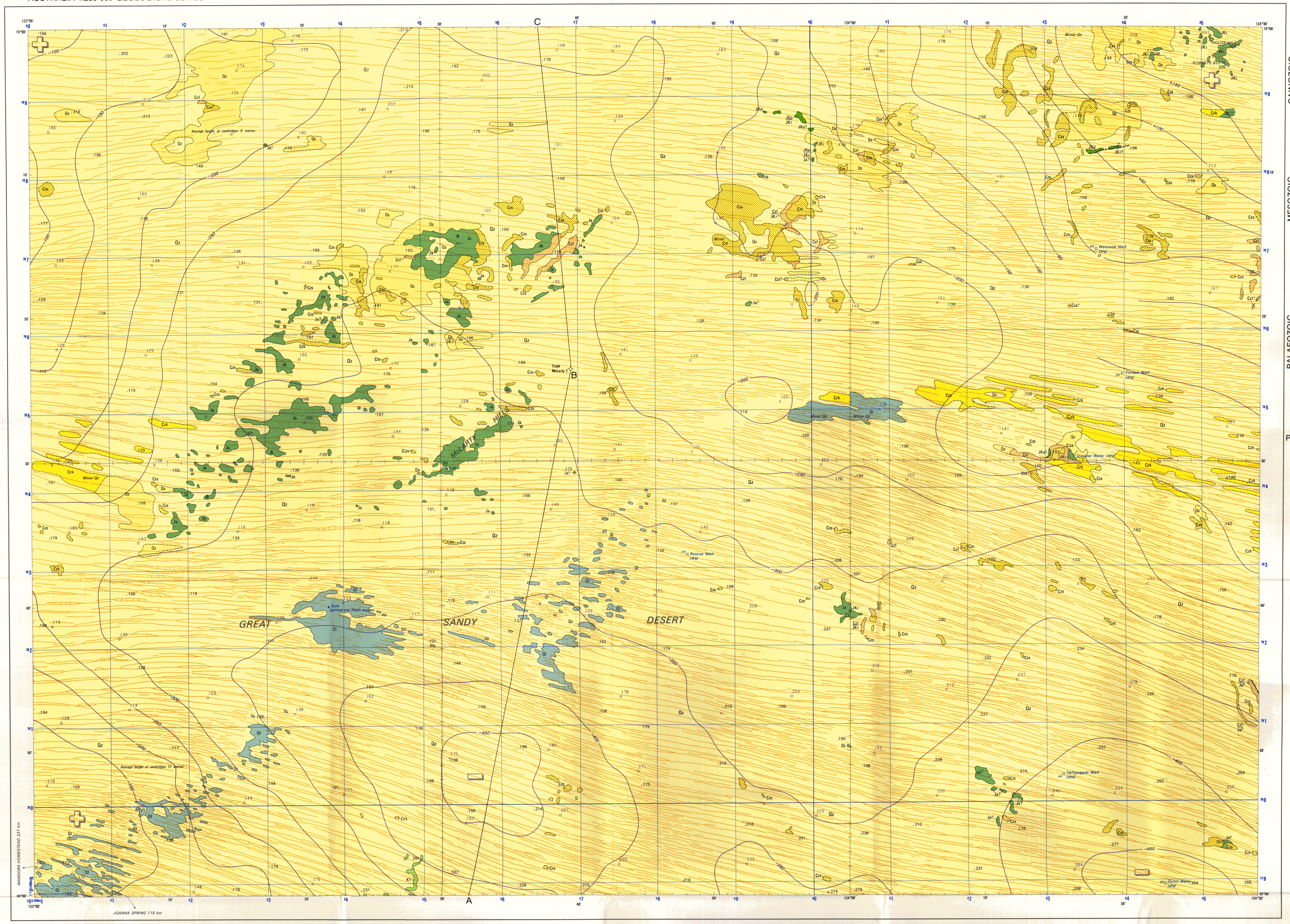
AUSTRALIA 1:250 000 GEOLOGICAL SERIES

WESTERN AUSTRALIA

SHEET SE 51-15



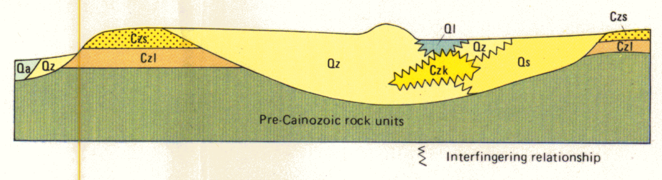
CAINOZOIC	QUATERNARY		Qa	Sand, silt; minor gravel : alluvial
			Ql	Silt, fine sand: lacustrine
			Qs	Sand, silt; minor gravel : mixed alluvial and aeolian
			Qz	Red sand, fine to medium; minor silt : aeolian
			Czk	Calcrete; minor chalcedony : pedogenic
			Czs	Sand, silt, ferruginous gravel and pisoliths; minor clay : gravel plains overlying Czl
			Czl	Laterite, pisolitic or massive : pedogenic
MESOZOIC	JURASSIC TO EARLY CRETACEOUS		JK	Undivided. Section only
	EARLY CRETACEOUS	Frezier Sandstone	Kf	Sandstone, fine to coarse, poorly sorted, feldspathic, cross-bedded; very minor mudstone : fluvial to deltaic
		Broome Sandstone	Kb	Sandstone, mudstone : shallow marine. Diagrams only
	LATE JURASSIC TO EARLY CRETACEOUS	Mowla Sandstone	JKo	Sandstone, coarse with granules, clay pellets, poorly sorted, cross-bedded : fluvial to deltaic
		Jarlemai Siltstone	JKr	Sandstone, very fine to fine : interbedded mudstone; ripple-marked, cross-bedded; bioturbated in part : shallow marine
	LATE JURASSIC	Alexander Formation	Ja	Sandstone, fine to coarse, interbedded with mudstone; rare conglomerate; ripple-marked, cross-bedded, fossiliferous : shallow marine
	EARLY? TO LATE JURASSIC	Wallal Sandstone	Jl	Sandstone; minor siltstone, conglomerate
PALAEOZOIC	EARLY PERMIAN	Noonkanbah Formation	Pn	Mudstone, calcareous, micaceous; fine sandstone, limestone interbeds; fossiliferous
		Poole Sandstone	Pp	Sandstone, very fine to fine; interbedded mudstone
		Grant Group	Pg	Sandstone, fine to coarse; mudstone; basal conglomerate
	EARLY DEVONIAN	Tandalgoo Red Beds	Dt	Fine sandstone, reddish brown, shale; minor limestone
	LATE ORDOVICIAN? TO EARLY DEVONIAN	Carribuddy Formation	Sc	Halite, dolomite, siltstone, shale, anhydrite
	MIDDLE ORDOVICIAN	Nita Formation	On	Limestone, dolomite, interbedded shale
		Goldwyer Formation	Oo	Shale, black, fossiliferous, calcareous, pyritic; interbedded limestone
	EARLY ORDOVICIAN	Willara Formation	Ow	Limestone, dolomite, fossiliferous, interbedded shale and sandstone
		Nambeet Formation	Ot	Shale, grey to green, fine sandstone
		Wilson Cliffs Sandstone	Oi	Sandstone, fine to very fine, well sorted, calcareous; minor shale
PRECAMBRIAN			p€	Igneous, metamorphic, and sedimentary rocks

Section and rock relationship diagram only (applies to Jl to p€)

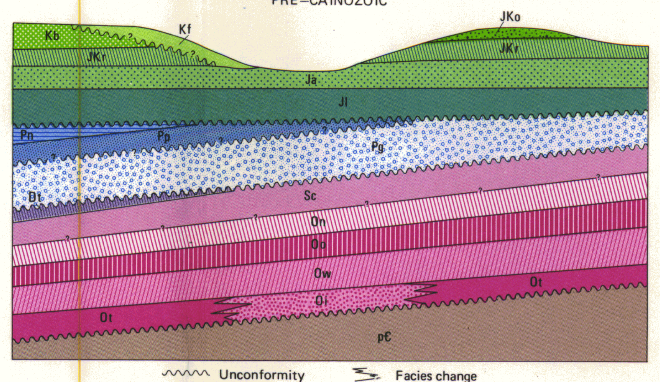
- Geological boundary
- Fault
- Where location of boundaries and faults is approximate, line is broken; where inferred, queried; where concealed, faults are shown by short dashes.
- Strike and dip of strata
- Trend-line. Airphoto interpretation
- Macrofossil locality
- Fossil wood locality
- Petroleum exploration well, dry, abandoned
- Well
- Sand dunes
- Vehicle track
- Trigonometrical station
- ·176 Elevation in metres
- pa Position approximate
- 182 Selected gravity station with elevation in metres
- —300— Bouguer gravity anomaly (micrometres sec^{-2}), computer-plotter produced
- Gravity anomaly — relative high
- Gravity anomaly — relative low

DIAGRAMMATIC RELATIONSHIP OF ROCK UNITS

CAINOZOIC



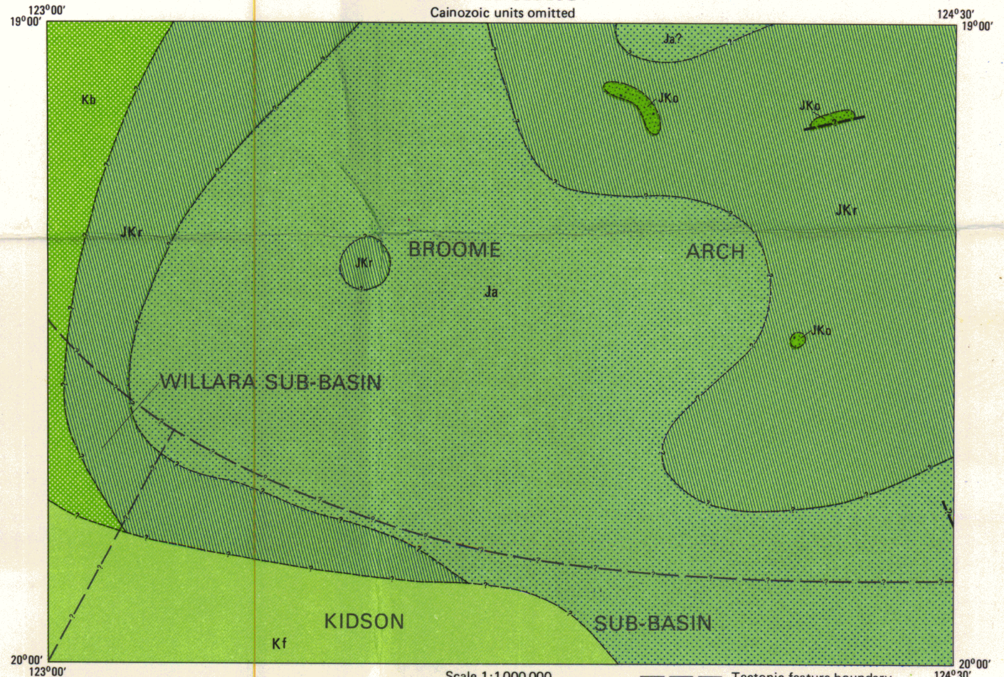
PRE-CAINOZOIC



Unconformity   Facies change

SIMPLIFIED GEOLOGY

Cainozoic units omitted



Scale 1:1 000 000   Tectonic feature boundary

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UNIVERSAL GRID REFERENCE

GRID ZONE DESIGNATION: 51K

100,000 METRE SQUARE IDENTIFICATION

VU WU XU / VT WT XT (78 0; 50, 60)

IGNORE the SMALLER figures of any grid number; these are for finding the full co ordinates. Use ONLY the LARGER figures of the grid number; example: 500000mE

TO GIVE A STANDARD REFERENCE ON THIS SHEET TO NEAREST 1000 METRES

SAMPLE POINT: Disaster Water

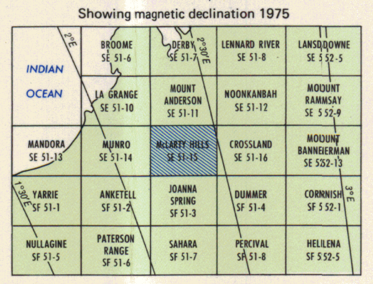
1. Read letters identifying 100 000 metre square in which the point lies: XU
2. Locate first VERTICAL grid line to LEFT of point and read LARGE figure labelling the line either in the top or bottom margin, or on the line itself: 3
3. Estimate tenths from grid line to point: 3
4. Locate first HORIZONTAL grid line BELOW point and read LARGE figure labelling the line in either the left or right margin, or on the line itself: 4
5. Estimate tenths from grid line to point: 4

SAMPLE REFERENCE: XU3344

If reporting beyond 18° in any direction, prefix Grid Zone Designation, as: 51KXU3344

INDEX TO ADJOINING SHEETS

Showing magnetic declination 1975



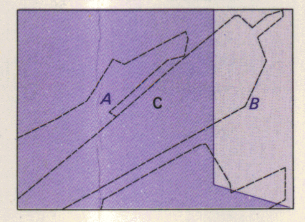
SCALE 1:250 000

0 5 10 15 20 25 Kilometres

BLUE NUMBERED LINES ARE 10 000 METRE INTERVALS OF THE AUSTRALIAN MAP GRID, ZONE 51

TRANSVERSE MERCATOR PROJECTION

RELIABILITY DIAGRAM



Geology C General reconnaissance: few traverses, mainly airphoto interpretation

Helicopter traverse

Gravity A Detailed survey

B Reconnaissance

Geology 1977 by D.L.Gibson, R.R.Towner BMR; R.W.A.Crowe GSWA
Compiled 1978 by D.L.Gibson, D.G.Walton
Gravimetry 1960-67 by BMR and private companies
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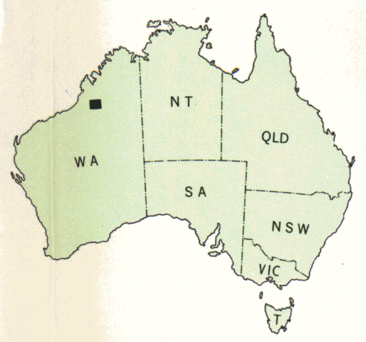
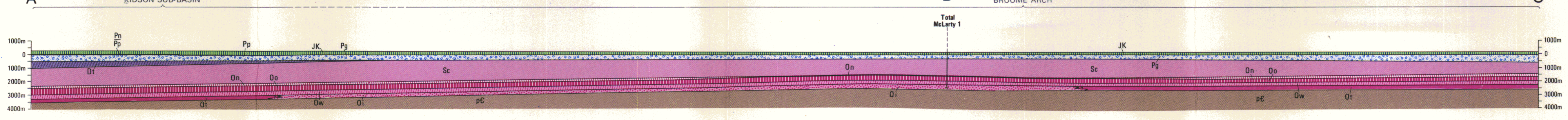


SCHEMATIC SECTION

Cainozoic sediments omitted

Scale V/H = 1



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