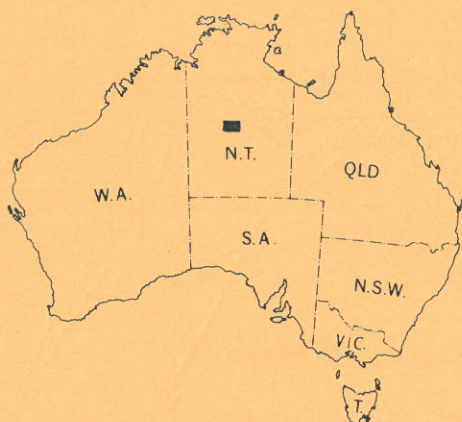


1:250 000 GEOLOGICAL SERIES—EXPLANATORY NOTES

LANDER RIVER

NORTHERN TERRITORY



SHEET SF/53-1 INTERNATIONAL INDEX

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

1:250 000 GEOLOGICAL SERIES—EXPLANATORY NOTES

LANDER RIVER

NORTHERN TERRITORY

SHEET SF/53-1 INTERNATIONAL INDEX

COMPILED BY P. J. KENNEWELL & L. A. OFFE



AUSTRALIAN GOVERNMENT PUBLISHING SERVICE
CANBERRA 1979

DEPARTMENT OF NATIONAL DEVELOPMENT

MINISTER: THE HON. K. E. NEWMAN, M.P.

SECRETARY: A. J. WOODS

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

DIRECTOR: L. C. NOAKES, O.B.E.

ASSISTANT DIRECTOR, GEOLOGICAL BRANCH: J. N. CASEY

ISBN 0 642 04008 7

© Commonwealth of Australia, 1979

*Published for the Bureau of Mineral Resources, Geology and Geophysics
by the Australian Government Publishing Service*

Printed by Graphic Services Pty Ltd, 516-518 Grand Junction Road, Northfield, S.A. 5085

Explanatory Notes on the Lander River Geological Sheet

Compiled by P. J. Kennewell and L. A. Offe

The Lander River Sheet area is in the southeast part of the Tanami Desert, Northern Territory. It includes parts of the Wiso Basin and the Arunta Block, and is between latitudes 20° and 21°S, and longitudes 132° and 133°30'E.

There are no permanent settlements in the area, and access is poor. Station tracks extend along the Lander River and Hanson River floodouts, and a track graded by BMR in 1974 provides access to the eastern edge of the Sheet area. Cross-country travel with a four-wheel-drive vehicle is possible, but is difficult owing to sand dunes, scrub, spinifex and, in places, a lack of landmarks for navigation.

The climate is arid, with an annual rainfall of 250 mm and an annual evaporation of 2800 mm. Mean temperatures range from a maximum of 37°C to a minimum of 23°C in January, and from a maximum of 23°C to a minimum of 8°C in July (Australia, Bureau of Census and Statistics, 1970).

Vegetation is typically xerophytic, with spinifex dominant on sand plains, light eucalypt and mulga scrub on river floodouts and gentle rises, and saltbush on some claypans. Waterholes in the floodouts of the Lander and Hanson Rivers contain water most of the time, drying up during periods of drought. Claypans in many parts of the Sheet area commonly contain water after heavy rains. Cattle are grazed on the river floodouts.

Previous investigations

Davidson (1905) led a prospecting expedition across the southwest part of the Sheet area in 1900, and recorded outcrops of granite, quartz, and ironstone.

In 1909 Chewings (1928, 1931) sank a series of wells for a proposed stock route across the eastern part of the Sheet area and commented on the Lake Surprise Sandstone.

Aero Service Limited flew an aeromagnetic survey over the Wiso Basin in 1964, covering most of the Sheet area, and indicating magnetic basement at less than 1000 m in the northern part, but deepening in the central part, with shallow magnetic basement over the Arunta Block (Zarzavatjian & Hartman, 1964).

Photo-interpretation of the Sheet area (Rivereau & Perry, 1965), and a gravity survey showing a large gravity minimum trending west-northwest across the Sheet area (Flavelle, 1965; Fraser, Darby, & Vale, in press) were both completed in 1965.

Reconnaissance geological mapping by BMR (Milligan, Smith, Nichols, & Douch, 1966) was also completed using a helicopter in 1965, and revealed crystalline rocks of the Arunta Block in the south, and sediments of the Wiso Basin in the central and northern parts of the Sheet area.

A reflection and refraction seismic survey was carried out over the Lander Trough in 1967, showing bedded rocks thickening southwards to over 2000 m and faulted against the Arunta Block (Ray Geophysics, 1967; Kennewell, Mathur, & Wilkes, 1977).

American Overseas Petroleum Ltd (1967) compiled a report on the Wiso Basin which included part of the Sheet area, and carried out an aeromagnetic survey which included the north and central parts of the Sheet area (Adastra Hunting Geophysics Pty Ltd, 1967).

Aerial photographs were taken at a nominal scale of 1:50 000 in 1950, and 1:80 000 in 1971, and a 1:250 000 topographic map was produced in 1963. All are available from the Division of National Mapping, Canberra.

Present investigations

In 1974 a series of shallow stratigraphic holes was drilled across the northern part of the Lander Trough by BMR. The holes penetrated weathered rocks of the Lake Surprise Sandstone and Hanson River Beds (Kennewell & Huleatt, in prep.). Offe visited outcrops near the southern margin of the Sheet area in 1974.

The Lander River Sheet area was mapped in 1975 by BMR using a helicopter, as part of a reconnaissance geological survey of the southern Wiso Basin and adjoining parts of the Arunta Block (Kennewell & Huleatt, in prep.). Although 1:80 000 scale aerial photographs were used for navigation, the geological Sheet was prepared by amending the 1:250 000 photo-interpretation map, prepared from 1:50 000 scale photographs.

The Hanson River seismic survey results and the known geological, aeromagnetic, and gravity data were synthesised, and the nature of the rocks of the Lander Trough was postulated (Kennewell et al., 1977).

Physiography

Most landforms developed are typical of an arid environment. The Sheet area is a flat plain crossed by two north-flowing rivers, the Lander and the Hanson, which dissipate in floodouts in the Tanami Desert which covers the central and northern part of the Sheet area. The plain ranges in elevation from 475 m in the south, to 275 m in the north, and the area forms part of the Tennant Creek Surface of Hays (1967). The formlines shown on the map were compiled by the authors from spot elevations obtained at 7-km spacings by the 1965 gravity survey, and give only a broad indication of relief. Seven physiographic units are recognised (Fig. 1).

Low rises, pediments, and rock outcrops are present throughout the Sheet area rising almost imperceptibly from the surrounding sandplain. Most rises are covered by rubble of ferricrete and weathered rock, although low outcrops, small scarps, and a few prominent hills are present. Vegetation is commonly sparse and short creeks may incise the gently sloping surface. Pediments surrounding many rises consist of clayey sand with a few pebbles of ferricrete and weathered rock, and are commonly covered by scrub. Rock outcrops generally form small scarps produced by erosion of low rises, but some very resistant rocks, such as amphibolite, granite, and silicified sandstone, crop out as prominent mesas, or rounded hills with exfoliation.

Quartz ridges are prominent features of the landscape in the south of the Sheet area, where they have near-vertical sides flanked by scree slopes. Some are up to 25 m high and 10 km long.

Sandplains are present throughout the Sheet area, and are characteristically flat and featureless, with a monotonous cover of spinifex and small shrubs.

Dunefields extend over a large part of the Sheet area, where wind has formed the sand into dunes up to 20 m high and 10 km long. Their orientation is west-

northwest, parallel to the prevailing winds. Spinifex growth has stabilised the dunes to a large extent.

Calcrete areas and claypans are present mainly in the northern half of the Sheet area. Calcrete areas are rubbly plains with calcrete mounds up to 1 m high separated by sand. In the northern part of the Sheet area they are commonly developed over dolomite of the Hanson River Beds. The flat, rounded claypans are commonly dry with a sun-cracked surface, but contain water after heavy rains.

Floodouts are present in the eastern and southwestern parts of the Sheet area, where the Hanson and Lander Rivers flow northwards from the Arunta Block, depositing reworked sand and alluvium on the almost featureless sand-plains of the Sheet area.

Red earth plains are commonly found marginal to low rises and pediments, and include recent colluvial fans and gentle red soil slopes. Arcuate groves of scrubby mulga generally outline the surface extent of the red soil.

Relict drainage channels are shown on the Sheet near the Lander River floodout, and probably represent earlier channels of the river.

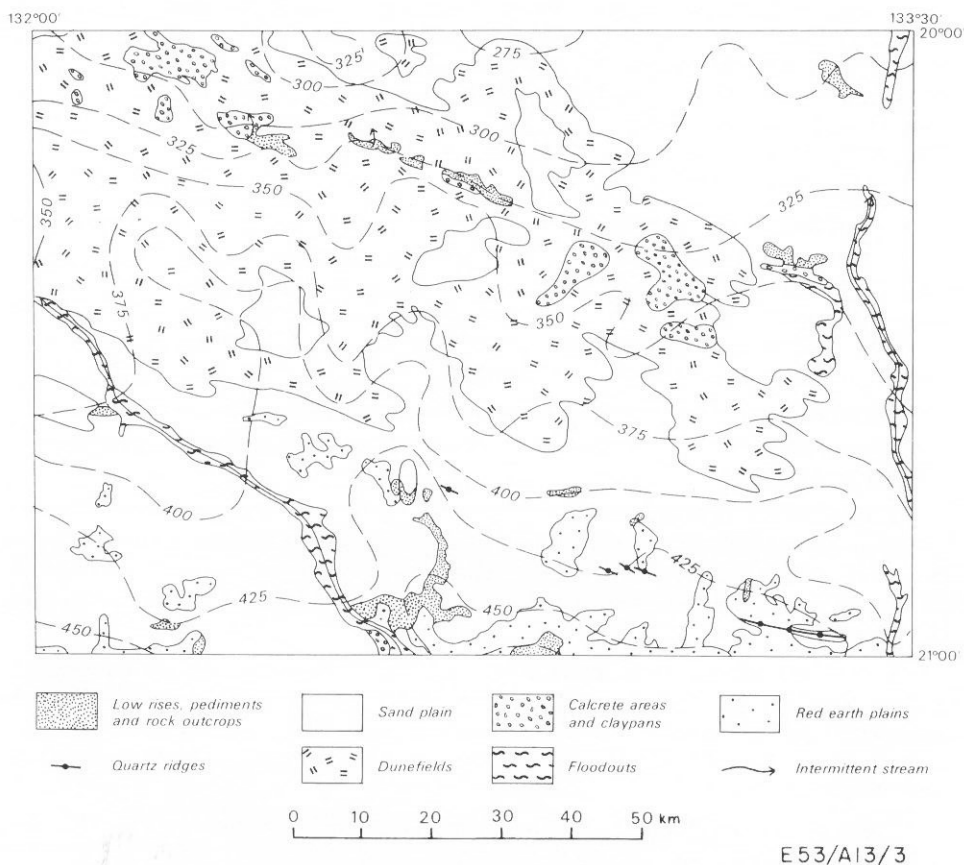


Fig. 1. Physiography.

STRATIGRAPHY

The oldest rocks in the Sheet area, of the crystalline Arunta Block, are faulted against a bedded sequence of Proterozoic and Palaeozoic rocks, including sediments of the Wiso Basin, which underlies the central and northern parts of the Sheet area. A thick veneer of Cainozoic sediments reduces outcrop to a few low areas of commonly weathered rock. The stratigraphy is summarised in Table 1.

Early Proterozoic

The *Lander Rock Beds* (P11) are the oldest exposed rocks in the Sheet area, and crop out as small, low rises in the south. Metaquartzite, schistose metasandstone, and mica schist of greenschist facies are typical; at locality 74110185A in the extreme central south, tourmaline-biotite-muscovite-quartz schist is intruded by granite veins. At localities 620 and 625, intrusions of mafic rock and granite have thermally metamorphosed the Lander Rock Beds, producing sillimanite-cordierite hornfels and garnet-sillimanite-cordierite-hornfels respectively. Because most rock types in the unit weather readily, exposures are generally found adjacent to resistant igneous intrusions or quartz veins and in the dissected slopes of ferricrete mounds. In the adjoining Mount Solitaire Sheet area the Lander Rock Beds are intruded by an unnamed granite which, in turn, is probably intruded by the 1780 \pm 24 m.y. The Granites Granite (Offe & Kennewell, 1978). Therefore the Lander Rock Beds are Early Proterozoic or older. This age is supported by the age of 1640 \pm 100 m.y. (Dr L. P. Black, BMR, pers. comm., 1975) obtained for an aplite dyke in granite which intrudes a facies variant of the Lander Rock Beds in the Mount Peake Sheet area (Offe, 1978).

Unnamed Granite (Pg) crops out in the south as pavements with spheroidal boulders of fresh rock, and as weathered exposures in dissected scarps, and adjacent to quartz ridges. Quartz, perthitic microcline, plagioclase with deformed twin lamellae, coarse muscovite flakes, biotite, and apatite are typical. At some localities feldspar phenocrysts are up to 3 cm long, quartz grains are fractured, plagioclase is partly saussuritised and sericitised, and the biotite chloritised. Contact metamorphic rocks adjoin the granite at localities 621 and 626.

Schistose granite crops out adjacent to the Jarrah Jarrah Range. In an outcrop 1 km south of the range, gneissic muscovite granite contains feldspar augen up to 2 cm long.

The relations between the many granites in the Sheet area are not known, but all are deformed, and retrogressive metamorphism is evident in unweathered specimens. This suggests that they are related to and of similar age to granites in the Mount Solitaire Sheet area to the west, and in the Mount Peake Sheet area to the south.

The unnamed granite is inferred to be Early Proterozoic, as similar granites in the adjoining Mount Solitaire Sheet area are intruded by the earliest Carpentarian The Granites Granite.

PROTEROZOIC

Plugs of *unnamed mafic rocks* (dl, amph) occur at localities 619, 625, and 627, where dolerite, amphibolitised dolerite, and medium-grained amphibolite crop out respectively. The mafic rocks are even-textured and may therefore be younger than the foliated unnamed granite.

Brecciated vein quartz (q) forms prominent ridges up to 10 km long in the south. Fragments of coarsely crystalline quartz are enclosed in a matrix of secondary quartz, and several phases of brecciation are apparent. The brecciation indicates that the quartz fills fault zones that have been subjected to several episodes of movement. In the Mount Peake Sheet area to the south, similar fault zones cut the Late Adelaidean to Early Cambrian Central Mount Stuart Formation (Offe, 1978); the faults may, however, have been active before this time. The major faults at the southwestern margin of the Lander Trough (see sections ABC and DEF on Sheet) trend parallel to many of the brecciated vein quartz ridges and may be earlier fault zones reactivated. Thus some of these fault zones may have been active until Ordovician time.

Rocks interpreted as *Hatches Creek Group* (Eh) and *Central Mount Stuart Formation* (Es) do not crop out in the Sheet area, but are thought to be present at depth beneath seismic lines R-1 and R-2 (Kennewell et al., 1977). Near the southern end of the seismic traverses they form a south-dipping sequence faulted against the Arunta Block by a series of west-northwesterly-trending faults. Their extent throughout the Sheet area is unknown, but seismic data suggest that they form basement to the Lander Trough, and gravity and aeromagnetic data together with the regional geology suggest that the trough extends west-northwesterly across the Sheet area. The seismic survey (Ray Geophysics, 1967) indicates that these rocks are bedded, but have high seismic velocities (5790 to 6460 m/s) typical of recrystallised rocks. A poor-quality reflector is interpreted as the boundary between the two rock units, with discontinuous but conformable reflections above this horizon originating from within the Central Mount Stuart Formation.

The Hatches Creek Group in the Sheet area has been assumed, on the basis of high seismic velocities, to be recrystallised, but in the adjoining Bonney Well Sheet area it crops out as silicified quartz and feldspathic sandstone, pebble conglomerate, siltstone, and shale, with acid and basic lavas. Magnetic anomalies similar to those produced by these basic lavas in the Bonney Well Sheet area are present in the Lander River Sheet area, indicating that lavas are present in this group in the Sheet area (Kennewell et al., 1977). Thickness of the group is at least several thousand metres in the Bonney Well Sheet area, and its age is Early Proterozoic or Carpentarian (Smith, 1970).

The Central Mount Stuart Formation is inferred to unconformably overlie the Hatches Creek Group, and to form the upper part of the high-velocity sequence underlying the Lander Trough. It does not crop out in the Sheet area, but is exposed 65 km to the southeast in the Barrow Creek Sheet area, where it is up to 250 m thick and contains sandstone, arkose, and greywacke, with minor conglomerate and dolomite (Smith & Milligan, 1964). It is Late Adelaidean to Early Cambrian (Offe, 1978).

Palaeozoic

The *Antrim Plateau Volcanics* (included in unit Pz) do not crop out in the Sheet area, but are indicated to be present beneath the Palaeozoic rocks in the northeastern part of the Sheet area by magnetic anomalies similar to those due to the Antrim Plateau Volcanics on the western margin of the Wiso Basin (Kennewell et al., 1977). The volcanics in this area are tholeiitic basalts, with a few thin interbeds of sedimentary rocks. They form part of a widespread series of flows cropping out in many areas of northern Australia.

TABLE 1. STRATIGRAPHY OF LANDER RIVER SHEET AREA

<i>Era</i>	<i>Period</i>	<i>Rock unit and symbol</i>	<i>Lithology</i>	<i>Est. max. thickness (m)</i>	<i>Distribution in Sheet area</i>	<i>Remarks</i>
CAINOZOIC	TERTIARY	Qc	Cobbles, boulders, sand silt, clay: col-luvial	5	S part	Unconsolidated; formed around quartz ridges and prominent hills
		Qa	Poorly sorted sand, granule conglom-erate, few iron oxide concretions: fluvial	9	E and SW parts	Poorly consolidated; weathered; underlies floodouts and former river channels
		Qs	Fine to coarse quartz sand: aeolian	20	Throughout	Unconsolidated; forms thin veneer over most of Sheet area; dunes developed in places
		Qr	Sand, silt, clay, rock fragments; red soil	3	S part	Unconsolidated; covers very gentle slopes around rises
		Ql	Sand, silt, clay, evaporites: lacustrine	5	Throughout	Unconsolidated; floors salt lakes and claypans
		Czt	Siliceous calcite and dolomite; a few quartz grains and fragments of under-lying rock: calcrete	13	NW, N, E, and far S parts	Caps outcrops of dolomite, underlies Lander R. alluvium
	TER-TIARY	Czg	Gravel; ironstone and quartz fragments, sand, silt, clay	2	Throughout, common in S part	Unconsolidated; covers low rises, forms outwash fans
		Tlf	Ferricrete; platy, nodular or honeycomb-textured sandy ironstone, quartz veinlets	3	S part	Crops out as low mounds; results from chemical weathering
		Tld	Deeply weathered rock, uncertain rock type	—	S part	Bedrock outcrop too weathered to be recognised
		Buchanan Hills Beds KTb	Fine to coarse, poorly sorted, angular to rounded sandstone: ?fluvial	5	Central-E part	Consolidated, weathered, unconform-ably overlies older rocks
PALAEO-ZOIC		Lake Surprise Sandstone Pzl	Well-sorted well-rounded medium to coarse sandstone: fluvial or shallow marine	350	E, SE, central, and WNW parts	Unconformable on Oh

TABLE 1. STRATIGRAPHY OF LANDER RIVER SHEET AREA—(Cont.)

<i>Era</i>	<i>Period</i>	<i>Rock unit and symbol</i>	<i>Lithology</i>	<i>Est. max. thickness (m)</i>	<i>Distribution in Sheet area</i>	<i>Remarks</i>
PALAEOZOIC	ORDOVICIAN	Hanson River Beds Oh	Well to poorly sorted fine sandstone, glauconitic and micaceous in parts; white claystone, laminated and silty in parts; green glauconitic, micaceous claystone; medium to coarsely crystalline dolomite with silty laminae in parts; marine or intertidal and possible fluvial	800	N part; may extend into Lander Trough, concealed by Lake Surprise Sandstone	Probably unconformable on older rocks; probably contains several rock units; weathered to over 100 m depth in places, silicified in places, poorly outcropping; contains faunas of two different Ordovician ages
		Early Palaeozoic rocks Pz	Siltstone, sandstone, claystone, dolomite, chert, and basalt	800	Does not crop out, extends into Lander Trough concealed by younger rocks	Unconformable on older rocks. Section only
PROTEROZOIC	LATE ADELAIDEAN TO EARLY CAMBRIAN	Central Mount Stuart Formation P Gs	Sandstone, arkose, greywacke, mica conglomerate and dolomite	600	Does not crop out, underlies at least central-W part; probably extends under Lander Trough	Presence inferred from seismic survey; includes glacial rocks Section only
	EARLY PROTEROZOIC OR CARBONIFEROUS	Hatches Creek Group Ph	Silicified quartzose and feldspathic sandstone, pebble conglomerate, siltstone, shale, acid and basic lavas	Several thousand	Does not crop out, underlies at least central-W part; probably extends under most of N and central parts	Presence inferred from seismic and aeromagnetic surveys
	EARLY PROTEROZOIC	Brecciated vein quartz q	Quartz fragments in matrix of secondary quartz	—	S part	Probably fills fault zones subjected to several episodes of movement
		dl and amph	Dolerite, amphibolitised dolerite, amphibolite	—	Central-S part	Intrudes Lander Rock Beds; relations with other rocks uncertain
		P g	Fine and medium-grained, foliated, commonly porphyritic granite, schistose or gneissic at some localities	—	S part	Intrudes Lander Rock Beds; probably includes many separate granite intrusions
	EARLY PROTEROZOIC	Lander Rock Beds P ll	Metaquartzite, schistose metasandstone, mica schist, granite veins, hornfels	—	S part	Oldest known rock unit in Sheet area; greenschist facies metamorphic rocks; thermally metamorphosed in places

The *Montejinni Limestone*, *Hooker Creek Formation*, and *Lothari Hill Sandstone* (Kennewell & Huleatt, in prep.) do not crop out in the Sheet area, but probably extend under the north and central parts, concealed beneath younger sedimentary rocks. They are included in the Early Palaeozoic rocks (Pz) on the cross-section. The Montejinni Limestone is the basal formation of the Wiso Basin sequence. It crops out extensively in the northwest part of the basin, and is at least 157 m thick in BMR Green Swamp Well No. 6 drill hole, 73 km north of the Sheet area, where grey, fine to medium-grained dolomite and minor red, grey, and green dolomitic siltstone and siltstone beds were penetrated. Fossils indicate an early Middle Cambrian age (Huleatt, 1978) and, together with the lithologies, suggest a shallow marine to supratidal origin. The Hooker Creek Formation crops out in the neighbouring Tanami East Sheet area (Huleatt, 1978) and a complete section was penetrated by BMR Green Swamp Well No. 6 drill hole, where it is 165 m thick and consists of red-brown dolomitic siltstone with interbeds of brown, grey, and white fine-grained dolomite and calcareous sandstone; it has a gradational contact with the underlying Montejinni Limestone. A fauna including the trilobite *Redlichia* indicates an early Middle Cambrian (Ordian) age, and the formation was probably laid down in a tidal to shallow marine environment. A red-brown poorly sorted fine-grained sandstone, the Lothari Hill Sandstone, conformably overlies the Hooker Creek Formation in the neighbouring Tanami East Sheet area with a gradational contact. The thickest section penetrated by drilling, BMR Green Swamp Well No. 4, 82 km north of the Sheet area, was 94 m thick and consisted of sandstone with rare beds of claystone, chert, and dolomite. Although no fossils have been found, a Middle Cambrian age is inferred as its contact with the underlying Hooker Creek Formation is gradational, and it is unconformably overlain by Middle Cambrian (Templetonian) Point Wakefield Beds. A supratidal to intertidal depositional environment, possibly with marine deposition in the basal part of the unit, is inferred (Huleatt, 1978).

The *Point Wakefield Beds* (Kennewell & Huleatt, in prep.) form a poorly known sequence which covers large areas to the north of the Sheet area, and is probably present beneath a thin cover of aeolian sand and alluvium in the extreme northeast of the Sheet area. It is included in the unit Pz and probably dips southwards under younger rocks beneath the north and central parts of the Sheet area into the Lander Trough. Two lithologies, possibly belonging to distinct rock units, are recognised in the Beds. Calcareous siltstone, clayey in parts, exposed only as small fragments in calcrete, possibly forms the lower part; similar sediments contain Middle Cambrian (Templetonian) trilobites in the neighbouring Tennant Creek Sheet area (Kennewell, in press). Interbedded red to white, fine-grained well-sorted angular micaceous sandstone, and red-brown micaceous sandy siltstone and silty claystone, laminated and bioturbated in parts, underlie the northeast corner of the Sheet area, and possibly form the upper part of the Beds. Their age is in the range Middle Cambrian to Ordovician.

The *Hanson River Beds* (Oh) (Milligan, 1976) underlie the northern part of the Sheet area, but are very poorly exposed, cropping out discontinuously in a northwest-trending area extending from the central east to the northwest corner of the Sheet area. Their lithology is poorly known, as calcrete covers large low rises underlain by the Beds, and the few scarps in which they do crop out are covered by scree of the more resistant rock types which obscures the softer rocks. The upper contact of the formation is unconformable, and the uppermost part of

the Beds may be obscured in the Lander Trough by the overlying Lake Surprise Sandstone. The youngest exposed beds, of late Arenig or Llanvirnian age (Dr E. Druce, BMR, pers. comm., 1977), crop out in the northwestern and central part of the Sheet area as medium to coarsely crystalline dolomite, well-sorted sub-angular and rounded fine-grained sandstone and white laminated claystone. Older rocks, of middle Arenigian age, crop out in the eastern part of the Sheet area, where both well sorted and rounded, and poorly sorted and angular to rounded fine sandstone, medium crystalline dolomite, white sandy siltstone, and rare chert are exposed. BMR drilling in the eastern part of the Sheet area additionally penetrated laminated silty dolomite, interbedded well-rounded well-sorted glauconitic sandstone, green, highly micaceous glauconitic claystone, and finely crystalline white dolomite. The drill holes shown on section DEF have been extrapolated along lines parallel to the northward limits of the Lake Surprise Sandstone. The conodonts used for dating were found only in the upper part of this sequence; the possibility of disconformities or unconformities within the Hanson River Beds cannot be dismissed, and some of the rocks mentioned may be older than the conodont-bearing dated dolomites. Quartz overgrowths have formed on sand grains at some localities, producing quartzites, and although it is possible that some of the outcrops belong to the Proterozoic Hatches Creek Group, K. G. Smith (pers. comm.) has reported Palaeozoic fossils from some quartzites, suggesting that the overgrowths were formed during shallow burial or weathering. The BMR drilling showed that the Hanson River Beds are intensely weathered to more than 100 m below the surface in most places, and the appearance of the drill core suggests that the weathering has altered the sorting and texture of rocks in places (Kennewell & Huleatt, in prep.). This weathering has decomposed the near-surface rocks, and they weather readily to sand and clay; hence the Hanson River Beds do not crop out in most areas but are overlain by sand plain.

Poor exposure and the probable presence of several rock units make difficult the determination of the environments in which the Beds were deposited; most exposed rocks are of shallow marine or intertidal origin, although some of the poorly sorted sediments could be of fluvial origin. Thickness of the Beds is difficult to determine, but the seismic survey across the Lander Trough indicated that they are part of a sequence which is 300 m thick on the northern end of seismic line R-2, and thickens to 800 m in the Lander Trough.

The *Lake Surprise Sandstone* (Pzl) (Kennewell & Huleatt, in prep.) underlies a northwest-trending area extending across the Sheet area and overlies the southern part of the Lander Trough. Well sorted and rounded, medium to coarse-grained sandstone, containing a white claystone matrix in parts, is ubiquitous, and is typically cross-bedded at low angles. The sand was deposited under fluvial or shallow marine conditions, and extensive deformation, resulting in low-amplitude folds at locality 53, and overturning of beds at locality 46 may be due to contemporaneous slumping or soft sand deformation. The seismic survey indicates that the sandstone thickens to about 250 m in the central part of seismic line R-1 and to about 100 m beneath parts of R-2 (Kennewell et al., 1977).

The age of the formation is post-Ordovician, as it unconformably overlies the Hanson River Beds, which contain late Arenig or early Llanvirnian (Ordovician) fossils. As its tectonic setting is similar to that of the Devonian Dulcie Sandstone of the Georgina Basin, and the Late Devonian to Carboniferous Pertnjara Group of the Amadeus Basin, a Late Palaeozoic age is inferred.

Cretaceous or Tertiary

The *Buchanan Hills Beds* (KTb) (Kennewell & Huleatt, in prep.) crop out as thin cappings on outcrops of Hanson River Beds, and as rubble on low rises in the northeast of the Sheet area. They consist of fine to coarse-grained, poorly sorted, angular to rounded quartz sandstone, and their lithology suggests a fluvial origin. The unit is extensive in Sheet areas to the north, and is interpreted as extending into this Sheet area as a surficial deposit probably no more than 5 m thick. As similar rocks have been penetrated in the Hanson River Beds by BMR drilling in the Sheet area (Kennewell & Huleatt, in prep.) these outcrops could belong to that unit. The Buchanan Hills Beds have pre-Miocene laterite developed on them in the neighbouring Tanami East Sheet area, indicating an age older than Miocene; their flat-lying attitude and unconformable contact on older rocks suggest a Cretaceous or Early Tertiary age.

Deeply weathered rock (Tld) has been mapped where exposed bedrock is extremely weathered, and the original rock type is not identifiable.

Ferricrete (Tlf) crops out as low, rubbly, flat-topped mounds of flaky, nodular or honeycomb-textured purple, brown, and black ironstone. Quartz veinlets occur locally, and the ironstone commonly contains angular quartz grains.

The deeply weathered rock and ferricrete both formed during periods of intense weathering, probably during development of the laterite soil profile which is well exposed in the neighbouring Tanami East Sheet area. The time of formation is uncertain; the laterite soil profile is pre-Miocene (Huleatt, 1978), and although an Early Tertiary age is most likely, a Late Cretaceous age cannot be disproved.

Cainozoic

Gravel (Czg) covers low rises and forms outwash fans from ferricrete mounds, and consists of angular to rounded, locally polished ironstone fragments and minor quartz scree in a matrix of sand, silt, and clay.

Calcrete (Czt) forms a capping on outcrops of the dolomites of the Hanson River Beds in the northwest, north, and east of the Sheet area, and underlies the alluvium of the Lander River in the far south. The finely crystalline siliceous calcite and dolomite contain a few quartz grains, and fragments of recrystallised dolomite near the contact with the underlying bedrock. Elongate mounds of calcrete up to 10 m high occur on outcrops of Hanson River Beds, accentuating the joint patterns. They may form by groundwater moving upwards along joints or faults, dissolving dolomite and silica, and depositing them on the surface as calcrete after evaporation of the water. The greatest observed thickness of the calcrete capping in outcrop is 3 m which, combined with the thickness in the elongate mounds, indicates a maximum thickness of about 13 m. Austerity Well, near the southern margin of the Sheet area, penetrated 9 m of calcrete.

Lacustrine deposits (Ql) of sand, silt, clay, and evaporites, probably only several metres thick, have formed throughout the Sheet area in small playa lakes that periodically hold water. The clastic sediments are transported and deposited by stream, slope wash, and wind action. The evaporites are formed by concentration of salts by rapid evaporation of the water.

Red soil (Qr) containing poorly sorted rock fragments, sand, silt, and clay covers very gentle slopes around rises in the south. Soil creep and sheet flow with minor stream action probably cause the deposits to move slowly downhill, and

give rise to the arcuate mulga groves which are typical. The deposits are probably no more than several metres thick.

Aeolian sand (Qs) forms a veneer several metres thick over most of the Sheet area. It is typically quartzose, moderately sorted, well-rounded, and fine to coarse-grained; staining by iron oxides has produced a red-brown colour. Dunes up to 15 m high have developed in the north and central parts of the Sheet area but most are stabilised by the growth of spinifex and other vegetation.

Alluvium (Qa) underlies the Hanson and Lander River floodouts, and several elongate areas which may represent former river channels. BMR stratigraphic drilling showed that the alluvium underlies some areas of sand plain in the eastern part of the Sheet area. The alluvium is a fine-grained sand with a few medium and coarse grains, angular to rounded, poorly sorted, poorly consolidated, weathered, and contains a few iron oxide concretions. A well-sorted bed of angular to rounded granule conglomerate is present at the base of the alluvium in places. The greatest thickness penetrated is 9 m in BMR Lander River No. 7.

Colluvium (Qc) is of very limited extent in the Sheet area, forming scree slopes surrounding prominent hills and quartz ridges in the southern part of the Sheet area. Cobbles and boulders of quartz and bedrock are enclosed in a poorly sorted matrix of sand, silt, and clay, forming a deposit several metres thick.

STRUCTURE

Sedimentary rocks of the Wiso Basin overlie bedded Proterozoic rocks in the north and central parts of the Sheet area. The Ordovician and older rocks are faulted against the igneous and metamorphic rocks of the Arunta Block which crop out in the southern part of the Sheet area.

The sediments of the Arunta Block have been tightly folded on a mesoscale, regionally metamorphosed to greenschist facies mineral assemblages, and locally thermally metamorphosed to hornblende hornfels facies assemblages. Axial plane foliation commonly parallels lithologic layers.

Brecciated and resilicified quartz veins form west-northwesterly-trending ridges throughout the Arunta Block, and represent reactivated fault zones. Lineaments in both the Arunta Block and in outcrops of the Hanson River Beds probably represent fractures which are roughly parallel to these fault zones, and were probably formed by the same stress. Faults are indicated by the Hanson River seismic survey (American Overseas Petroleum, 1967) as forming the southern margin of the Lander Trough. Because their nature is still speculative, they are shown as vertical in the cross-section. The fault lines are parallel to the prominent quartz-filled fault zones within the Arunta Block.

The presence of a poorly defined trough of sediments extending west-northwesterly across the Sheet area is indicated by seismic, aeromagnetic, and gravity surveys (Kennewell et al., 1977). The trough is a crustal downwarp in which Palaeozoic sediments have been preserved, and forms the southern part of the otherwise flat-lying Wiso Basin. Two rock sequences are distinguished in the trough, overlying a south-dipping sequence, probably of Proterozoic age, forming its basement and containing poorly bedded rocks with high seismic velocities. As previously discussed, the lower part of these basement rocks may be the Hatches Creek Group, and the upper part a lateral equivalent of the Central Mount Stuart Formation.

The lower sequence of the trough has medium seismic velocities and probably consists of Cambrian and Ordovician rocks. It thickens from 350 m at the northern end of seismic line R-2 to 800 m at its southern end, where it is faulted against the Arunta Block.

The upper sequence is up to 250 m thick, has relatively low seismic velocities, and probably consists of the Lake Surprise Sandstone. This sequence is virtually flat-lying, and extends across one of the faults on the southern edge of the trough. Although the faulting took place after Ordovician time, it must have occurred before deposition, possibly during Late Palaeozoic time, of the Lake Surprise Sandstone.

The structure of the northern part of the Sheet area is poorly known, but is probably simple, with flat-lying Palaeozoic sediments overlying Proterozoic basement rocks.

GEOLOGICAL HISTORY

During Early Proterozoic time, sea covered the Sheet area, depositing clay, silt, and sand of the Arunta Block. These were buried, metamorphosed to green-schist facies mineral assemblages, and tightly folded. Many granite masses (Unnamed Granite) intruded the rocks during this time and were deformed and partly retrogressed to lower metamorphic facies assemblages. Cooling of the rocks, uplift, and erosion followed.

A marine transgression then took place, during either Early Proterozoic or Carpentarian time, and sand, conglomerate, silt, and clay were deposited, while volcanoes erupted flows of acid and basic lava (Hatches Creek Group). Mafic intrusions (Unnamed Mafic Rocks) may have resulted from the crystallisation of the basic vents, or may have formed during a separate period of igneous activity.

Uplift and erosion preceded deposition of sand, dolomite, and conglomerate, possibly partly under glacial conditions, during Late Adelaidean to earliest Cambrian time (Central Mount Stuart Formation).

Basalt flows covered at least the northeast part of the Sheet area during Early Cambrian time before seas transgressed the area in the Middle Cambrian depositing the basal dolomite, silt, and sand of the Wiso Basin as they retreated. The history of the Sheet area in the Late Cambrian and Ordovician is not clear, but was probably typified by transgressions and regressions depositing carbonates and clastic sediments (Point Wakefield Beds and Hanson River Beds).

Deformation then occurred, possibly contemporaneously with the Alice Springs Orogeny which took place during the Late Devonian or Early Carboniferous in the Amadeus Basin to the south. Downwarping of the Lander Trough relative to the remainder of the Wiso Basin resulted in the preservation of both a greater thickness of Palaeozoic sediments, and of a thick sequence of the underlying Proterozoic rocks. Large faults developed on the southwestern margin of the trough, faulting crystalline rocks of the Arunta Block against these sediments. A later marine transgression or river system deposited sands in the Lander Trough area, covering the large faults (Lake Surprise Sandstone).

The history from Late Palaeozoic time to the present has been relatively quiet with deposition of sands by rivers (Buchanan Hills Beds), followed by a period of intense weathering which resulted in development of a laterite soil profile during Late Cretaceous or Early Tertiary time. Erosion has since probably removed

the upper zone of the laterite soil profile (ferricrete), reducing most of the Sheet area to an almost featureless plain on which calcrete formed, alluvium from the Lander and Hanson Rivers, colluvium, gravel, lake deposits, and windblown sand were deposited, and red soils developed.

MINERALS

Water

Crystalline rocks of the Arunta Block are generally poor aquifers and have not yielded water in the bores which penetrated them on the Lander River floodout. In the adjoining Mount Peake Sheet area highly weathered rocks of the Arunta Block produce poor-quality water in quantities dependent on the permeability of the weathered zone (Offe, 1978).

The Hatches Creek Group and Central Mount Stuart Formation may be too deep to be a useful source of water.

The Montejinni Limestone provides good water in the north Wiso Basin (Randal, 1973) but is probably present only at depth beneath the Sheet area and is untested. The Hooker Creek Formation and Lothari Hill Sandstone are poor aquifers and are unlikely to contain water, and the Point Wakefield Beds are untested.

The Hanson River Beds were penetrated by BMR Lander River Nos. 2 to 5 and BMR Bonney Well Nos. 1 and 2 and, with the exception of BMR Lander River No. 4 which only penetrated several metres below the water-table, yielded flows between 3000 and 6000 litres per hour of generally good stock-quality water.

The Lake Surprise Sandstone produced 6000 litres per hour of good stock-quality water in BMR Lander River Nos. 1, 6, and 7.

The Buchanan Hills Beds are probably too thin to be present below the water-table. A flow of 6000 litres per hour of poor stock-quality water from river alluvium was obtained in Parklands Bore, and during BMR drilling seepages occurred where the alluvium was below the water-table. Water was obtained from calcrete in Austerity Well, near the southern edge of the Sheet area (Milligan et al., 1966).

Cainozoic basins up to 100 m thick have been drilled in the neighbouring Mount Peake and Mount Theo Sheet areas (Offe, 1978; Stewart, 1976). Parts of these basins yield good supplies of water suitable for stock or human consumption from Late Tertiary and Quaternary fluvial sediments, and similar basins may be present in the Sheet area, underlying areas with no bedrock outcrops such as the Lander and Hanson River Floodouts.

Depth to the water-table ranges from 2 m in BMR Lander River No. 1 to 20 m in BMR Lander River No. 4.

Petroleum

The petroleum potential of the Sheet area is untested, but the Hanson River seismic survey (Ray Geophysics, 1967) indicated that up to 1000 m of Palaeozoic bedded rocks are present in the Lander Trough in the eastern part of the Sheet area; the extent and thickness of these rocks in other parts of the Sheet area is not known (Kennewell et al., 1977). The rocks include marine sediments of Cambrian and Ordovician age; sediments of similar age contain gas and condensate in the Amadeus Basin to the south, and gas in the Georgina Basin to the east. Well-sorted sandstone and claystone of the Hanson River Beds may provide reservoir rocks and caprocks, respectively. The seismic survey indicates slight folding of the base of the Lake Surprise Sandstone, and very gentle structural traps could be present.

Phosphate

Two samples of quartzose pellet dolomite collected from the Hanson River Beds at localities 8 km apart in the north-central part of the Sheet area contained 10.6% and 3.2% P_2O_5 , respectively. The phosphate occurs as rolled pellets which may be clasts or pellets concentrated by winnowing of finer material (Milligan et al., 1966).

Gold

Waldrons Hill gold prospect consists of a gold-bearing carbonate-veined quartz vein filling a shear zone. The country rock consists of amphibolitised dolerite and medium-grained biotite granite surrounded by garnet-sillimanite-cordierite hornfels.

Samples collected by the Aerial Geological and Geophysical Survey of Northern Australia from the mine dump contained 5 g/tonne of gold (Anonymous, 1941). A sample of the carbonate-veined quartz collected during this survey contained 0.4 g/tonne of gold (see Table 2).

Ironstone

Many outcrops of ferricrete contain a high proportion of iron, and could be classified as ironstone. Table 2 includes an analysis of ironstone sample 603, which caps an outcrop of granite and metasediment.

TABLE 2. RESULTS OF ANALYSES OF SAMPLES 603 AND 623

<i>Sample No.*</i>	<i>Remarks</i>	<i>Grid reference</i>	<i>Cu</i>	<i>Pb</i>	<i>Zn</i>	<i>Ni</i>	<i>Bi</i>	<i>Mn</i>	<i>Au</i>	<i>Ag</i>	<i>Se</i>	<i>Hg</i>	<i>Fe</i>
603	Ironstone capping granite and metasediment	24916820	40	38	180	42	<10	440	0.10	<1	5	4	50.9%
623	Carbonate-veined quartz (Waldrons Hill Gold Prospect)	23887097	25	5	130	15	<10	1900	0.40	<1	<2	<4	14.5%

* Preceded by 75110. Results in ppm unless otherwise shown. Method: AAS except for Se and Hg (both XRF).
 Analysts: Australian Mineral Development Laboratories, Report AN 3566/76.

BIBLIOGRAPHY

- *ADASIRA HUNTING GEOPHYSICS PTY LTD, 1967—An airborne magnetometer survey, Wiso Basin, N.T. *For American Overseas Petroleum Ltd. Bur. Miner. Resour. Aust. file 66/4624* (unpubl.).
- *AMERICAN OVERSEAS PETROLEUM LTD, 1967—Wiso-Dulcie photogeological report, March 1967. *Company Report* (unpubl.).
- ANONYMOUS, 1941—Delny wolfram discovery. *Aer. geol. geophys. Surv. N. Aust., Ann. Rep.* to 31st December 1940, 56.
- AUSTRALIA BUREAU OF CENSUS AND STATISTICS, 1970—Official year book of the Commonwealth of Australia No. 65. *Canberra, Govt Printer*.
- CHEWINGS, C., 1928—A journey from Barrow Creek to Victoria River. *Geogr. J.* 76, 316-38.
- CHEWINGS, C., 1931—A delineation of the Precambrian plateau in central and north Australia with notes on the impingent sedimentary formations. *Trans. Roy. Soc. S. Aust.*, 55, 1-11.
- DAVIDSON, A. A., 1905—Journal of explorations in central Australia by the Central Australian Exploration Syndicate Limited, 1898-1900. *S. Aust. parl. Paper* 27.
- FLAVELLE, A. J., 1965—Helicopter survey by contract, N.T. & Qld, 1965, Part I. *Bur. Miner. Resour. Aust. Rec.* 1965/212 (unpubl.).
- FRASER, A. R., DARBY, F., & VALE, K. R., in press—A qualitative analysis of the results of the reconnaissance gravity survey of Australia. *Bur. Miner. Resour. Aust. Rep.* 198.
- †GEOPEKO, 1977—Annual and final report, EL 982. *Peko-Wallsend Ltd. CR 77/25* (unpubl.).
- †GEOPEKO, 1977—Annual and final report, EL 983. *Peko-Wallsend Ltd. CR 77/26* (unpubl.).
- †GEOPEKO, 1977—Final report area relinquished, EL 981. *Peko-Wallsend Ltd. CR 77/86* (unpubl.).
- HAYS, J., 1967—Land surfaces and laterites in the north of the Northern Territory. In JENNINGS, J. N., & MABBUTT, J. A.—LANDFORM STUDIES FROM AUSTRALIA AND NEW GUINEA. *Canberra, ANU Press*.
- HULEATT, M. B., 1978—Tanami East, N.T.—1:250 000 Geological Series. *Bur. Miner. Resour. Aust. explan. Notes* SE/52-16.
- KENNEWELL, P. J., in press—Green Swamp Well, N.T.—1:250 000 Geological Series. *Bur. Miner. Resour. Aust. explan. notes* SE/53-13.
- KENNEWELL, P. J., & HULEATT, M. B., in prep.—Geology of the Wiso Basin. *Bur. Miner. Resour. Aust. Bull.*
- KENNEWELL, P. J., MATHUR, S. P., & WILKES, P. G., 1977—The Lander Trough, southern Wiso Basin, N.T. *BMR J. Aust. Geol. Geophys.*, 2(2), 131-6.
- †KEWANEE, 1973—Final report Jarrah Jarrah, EL 806. *Kewanee Australia Pty Ltd. CR 73/30* (unpubl.).
- †KEWANEE, 1973—Final report geochemistry and geophysical mapping data, AP 2753, 2643. *Kewanee Australia Pty Ltd. CR 73/59* (unpubl.).
- †KEWANEE, 1973—Final report Hanson River, EL 381. *Kewanee Australia Pty Ltd. CR 73/165* (unpubl.).
- †KEWANEE, 1973—Final report Jarrah Jarrah, EL 806. *Kewanee Australia Pty Ltd. CR 73/168* (unpubl.).
- †KEWANEE, 1973—Annual report Lander River 1, EL 115. *Kewanee Australia Pty Ltd. CR 73/178* (unpubl.).
- †KEWANEE, 1973—Annual report Lander River 3, EL 117. *Kewanee Australia Pty Ltd. CR 73/179* (unpubl.).
- †KEWANEE, 1973—Annual report Lander River 2, EL 116. *Kewanee Australia Pty Ltd. CR 73/180* (unpubl.).
- MILLIGAN, E. N., 1976—Wiso Basin. In LESLIE, R. B., EVANS, H. J., & KNIGHT, C. L. (eds)—Economic geology of Australia and Papua New Guinea—3. *Petroleum. Australas. Inst. Min. Metall. Monogr.*, 7, 237-8.
- MILLIGAN, E. N., SMITH, K. G., NICHOLS, R. A. H., & DOUTCH, H. F., 1966—The geology of the Wiso Basin, N.T. *Bur. Miner. Resour. Aust. Rec.* 1966/47 (unpubl.).
- OFFE, L. A., 1978—Mount Peake, N.T.—1:250 000 Geological Series. *Bur. Miner. Resour. Aust. explan. Notes* SF/53-5.

- OFFE, L. A., & KENNEWELL, P. J., 1978—Mount Solitaire, N.T.—1:250 000 Geological Series. *Bur. Miner. Resour. Aust. explan. Notes SF/52-4*.
- RANDAL, M. A., 1973—Groundwater in the northern Wiso Basin and environs, Northern Territory. *Bur. Miner. Resour. Aust. Bull.* 123.
- *RAY GEOPHYSICS (AUSTRALIA) PTY LTD, 1967—Geograph seismic survey of the Hanson River area, Northern Territory, OP119. PSSA final report for *American Overseas Petroleum Limited* (unpubl.).
- RIVIEREAU, J. C., & PERRY, W. J., 1965—Report on photo-interpretation in the Wiso Basin, Northern Territory. *Bur. Miner. Resour. Aust. Rec.* 1965/115 (unpubl.)
- SMITH, K. G., 1970—Bonney Well, N.T.—1:250 000 Geological Series. *Bur. Miner. Resour. Aust. explan. Notes SF/53-2*.
- SMITH, K. G., & MILLIGAN, E. N., 1964—Barrow Creek, N.T.—1:250 000 Geological Series. *Bur. Miner. Resour. Aust. explan. Notes SF/53-6*
- STEWART, A. J., 1976—Mount Theo, N.T.—1:250 000 Geological Series. *Bur. Miner. Resour. Aust. explan. Notes SF/52-8*.
- STEWART, A. J., OFFE, L. A., GLIKSON, A. Y., & WARREN, R. G., in prep.—Geology of the northwestern part of the Arunta Block. *Bur. Miner. Resour. Aust. Rec.* (unpubl.).
- ZARZAVATJIAN, P. A., & HARTMAN, R. R., 1964—Interpretation report of airborne magnetometer survey over Tanami area, Northern Territory. *Aero Service Ltd, for Exoil Oil Co. Pty Ltd* (unpubl.).

* Available in BMR Library, Canberra.

† Available on open file, Department of Mines, Darwin.