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THE RUNTON, W A.
1:250 000 GEOLOGICAL SHEET

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EXPLANATORY NOTES
FOR THE
RUNTON, W.A.
1:250 000 GEOLOGICAL SHEET

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INTRODUCTION

The Runton 1:250 000 Sheet* lies on the tropic of Capricorn just west of the Gibson Desert between latitudes 23° and 24° south, and longitudes 123° and 124°30' east. This area is sometimes referred to as the 'Little Sandy Desert'. Geologically the area is mainly within the Phanerozoic Officer Basin; but part of the Precambrian Paterson Province occurs in the west, and a small portion of the Phanerozoic Canning Basin occurs along the northern margin.

Access may be gained by four-wheel-drive vehicle from Telfer (290 km to the northwest) or Newman (415 km to the west) to an unmaintained track which leads to the northwest corner of the area. This track continues westwards to Windy Corner (72 km east) across the northern half of RUNTON. The disused Canning Stock Route also crosses the northwest corner.

RUNTON receives an average annual rainfall of 200 mm, and experiences an annual evaporation of 2 800 mm (Australian Bureau of Statistics, 1973). Prevailing winds blow from the east and southeast and to a lesser extent from the northeast. The area lies within the Keartland, Canning, and Carnegie Botanical Districts of Beard and Webb (1974), and the flora of the area is described by them.

There are no permanent population centres in the area, although a small group of nomadic Aborigines was sighted during the mapping in 1975.

Available mapping bases include topographic maps at 1:250 000 scale, and aerial photographs at 1:50 000 scale (1953) and 1:80 000 scale, (1970). The maps and photographs

* A name in full capitals (RUNTON) indicates area covered by that 1:250 000 sheet.

are available from the Division of National Mapping, Canberra, and from the Department of Lands and Surveys, Perth.

PHYSIOGRAPHY

The four main physiographic subdivisions on RUNTON are: (a) hills and ridges, (b) undulating lateritic plains, (c) sand plains, and (d) salt lakes. (Fig. 1).

The hills and ridges in the west are composed mainly of Precambrian rocks; many are flanked by areas of colluvium and small alluvial fans. In the central and southeastern parts, the hills are composed of Phanerozoic rocks, and, as they are commonly capped by relatively resistant laterite, they form mesas and buttes.

The undulating lateritic plains in the southeast are characterized by lateritic soils having little or no cover of eolian sand. Small exposures of laterite also occur. A well-developed ancient dendritic drainage can be discerned in the laterite cover of the plains. This is believed to have been formed in the Late Cretaceous or Early Tertiary during a higher rainfall climate than exists in the area today (van de Graaff and others, 1977).

Sand plains are the most widespread physiographic division and they are almost entirely covered by a dense network of longitudinal (seif) sand dunes.

The salt lakes occur mainly in the western and central portions of the area. They mark major fossil drainages, and, while the western ones are mainly connected and still act as lines of ephemeral drainage, the lakes in the central part of the area are separated by sand dunes.

Modern drainages are ephemeral; they consist mainly of small creeks which flow away from the rocky hills and laterite breakaways and disappear in the surrounding plains. Native wells, consisting mainly of natural rock holes, are scattered throughout the area and contain small supplies of water. Old records on the area show that small soaks used to be

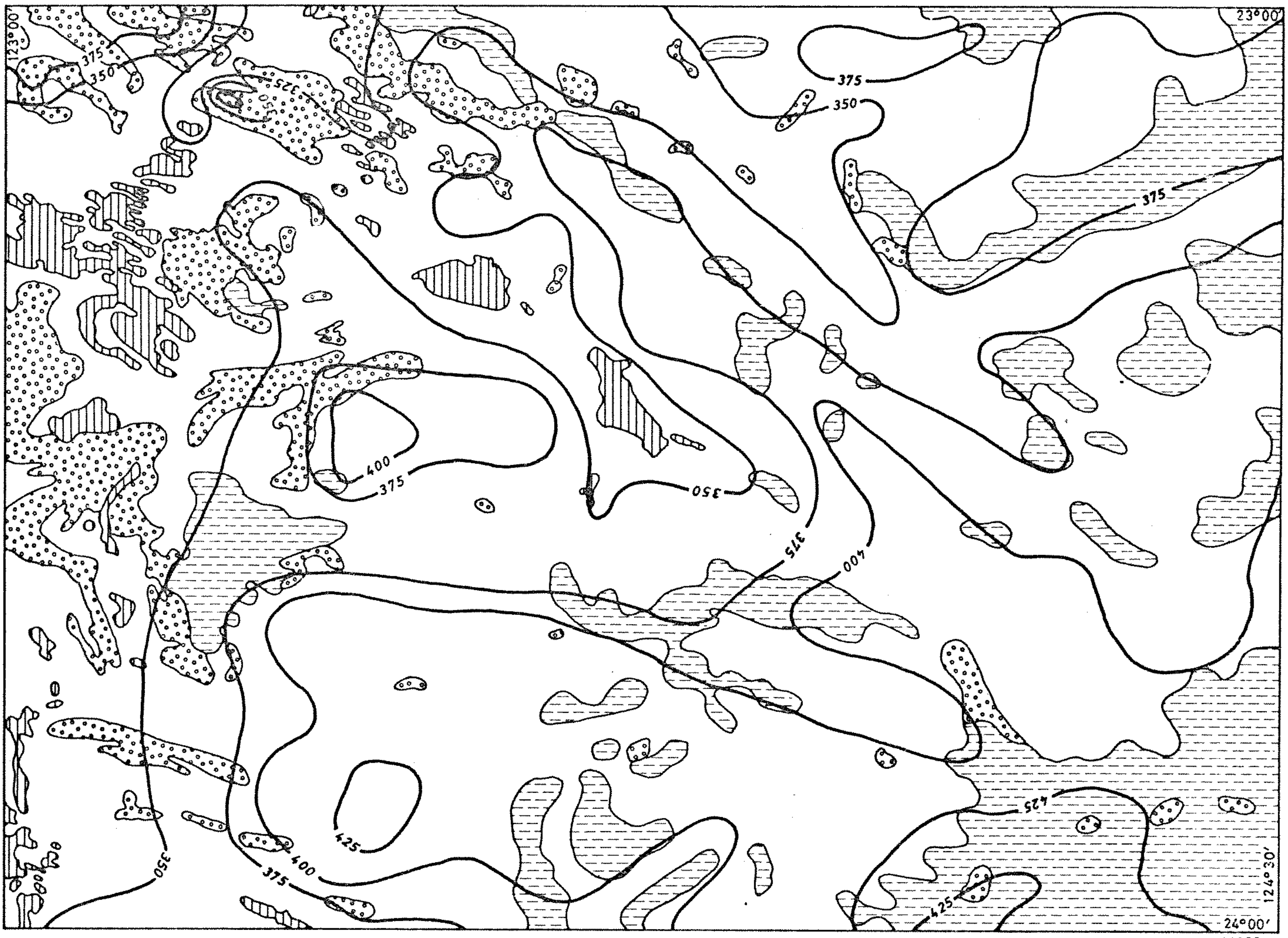

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FIGURE 1.

PHYSIOGRAPHIC SUBDIVISIONS OF RUNTON 1:250 000 SHEET

SCALE

10 0 10 20 30 40 km

Hills and ridges

Undulating laterite plains

Salt lakes

Sand plain

400 Contours in metres above sea level (Information from B.M.R. Gravity Map of Runton)

maintained by Aborigines in or adjacent to the salt lakes, but since the native population of the area has now virtually disappeared, these soaks have become silted up.

The topography is shown in Figure 1. The contours show the distribution of the major valleys which formed part of the ancient drainage system referred to above.

PREVIOUS INVESTIGATIONS

L.A. Wells (1902) was the first explorer to enter the area when he travelled from Wiluna to the Fitzroy River, passing by Separation Well. In 1906-7 Canning surveyed the stock route which now bears his name and which crosses the northwestern corner of the area. A geologist, H.W.B. Talbot, accompanied Canning during a later well-sinking trip begun in 1908, and recorded the geology and groundwater prospects of the area (Talbot, 1910). Kidson (1921) recorded magnetic observations along the stock route.

The area was not geologically mapped until 1956 when Stinear and Wells of the Bureau of Mineral Resources (BMR) mapped the southern part of the Canning Basin. Compilations of the geology were made and incorporated in a map of the whole of the basin (1:1 267 200 scale) by Veevers and Wells (1961). The early mapping established the Phanerozoic units that are present in the area, although the reconnaissance nature of the mapping did not enable their distribution to be accurately plotted.

Gravity investigations were also commenced by the BMR during the 1950's, and by 1960 part of RUNTON had been covered (Flavelle and Goodspeed, 1962).

During geological surveys of the Gibson Desert, parts of the area were described by Leslie (1961) for Frome-Broken Hill Company and by Mack and Herrmann (1965) for Union Oil Corporation.

During exploration under the Petroleum Search Subsidy Acts 1959-1969, only one survey, the South Canning Basin Aeromagnetic Survey, flown by Aero Services Limited for

West Australian Petroleum Pty Ltd (1966) extended into the area.

In 1971 a joint Geological Survey of Western Australia (GSWA) and Bureau of Mineral Resources (BMR) partly mapped the area to the south (Kennewell, 1975) as part of a reconnaissance geological survey of the Officer Basin (Lowry and others, 1972).

The present survey was carried out in 1975 by a joint GSWA-BMR party mapping the Phanerozoic rocks in the area (Towner and others, 1976), and a GSWA party mapping the Precambrian rocks. Precambrian rocks in the northwestern part of the area were mapped on the ground, but the rest was completed by helicopter traverses.

STRATIGRAPHY

The stratigraphy is summarized in Table 1 and additional notes are given below.

PROTEROZOIC

Rudall Metamorphic Complex

The southeasterly extension of the Rudall Metamorphic Complex (Williams and others, 1976) occurs in the northwest part of RUNTON. It consists of two interfoliated sequences which have undergone complex deformation and metamorphism. The first sequence contains gneissic and granitic rocks that have been retrograded by greenschist metamorphism. The second sequence, dominantly quartzite and schist, was formed by prograde metamorphism of a sedimentary sequence younger than the gneiss.

The dominant gneissic rock is retrograded quartz-feldspar-biotite-muscovite gneiss (Ɇnb). It contains various proportions of microcline and plagioclase which give a range in composition from granite to tonalite. Quartz and feldspar have been cataclastically deformed, and are enclosed in a finely granulated matrix of biotite, lesser muscovite, and

TABLE 1 Stratigraphic Table, Runton Sheet

Age		Thick-ness (m)	Lithology	Stratigraphic relationships	Fossils	Remarks
QUATERNARY	Alluvium (Qa)	3±	Clay, silt sand, and gravel	Surficial deposit		Occurs in creeks and as alluvial fans adjacent to hills.
	Mixed alluvial and eolian deposits (Qs)	10±	Mixed sand and silt; minor gravel	Surficial deposit		Characterized by mixed grass and spinifex growth. Occurs mainly in depressions.
	Eolian deposits (Qz)	15±	Red sand; minor silt and gravel	Surficial deposit		Characterized by spinifex growth without grass. Occurs as sand plains and dune fields.
	Lacustrine deposits (QI)	0-?100	Clay, silt, minor sand gypsum and halite	Surficial deposit		Occurs in claypans and salt lakes.
	Colluvial deposits (Qc)	5±	Gravel, sand, minor	Surficial deposit		Occurs on flanks of outcrops and as gravel plains

Age		Thick-ness (m)	Lithology	Stratigraphic relationships	Fossils	Remarks
UNDIVIDED CAINOZOIC	Lateritic soil (<u>Czs</u>)	5±	Gravel, pisoliths of laterite sand, silt and mud	Overlies <u>Czl</u>		Occurs as undulating plains and hills.
	Laterite (<u>Czl</u>)	10±	Laterite, pisolitic or massive	Overlies clayey bedrock		Overlies all Phanerozoic units and some Precambrian rocks
	Calcrete (<u>Czk</u>)	10±	Limestone, arenaceous chalcedony	Commonly interfingers with lacustrine deposits		Includes kankar, caliche and travertine good aquifer
	Silcrete (<u>Czt</u>)	2±	Silicified sandstone	Overlain by eolian sand		
EARLY CRETACEOUS TO EARLY TERTIARY	Lampe Beds (<u>KTl</u>)	?5±	Silicified sandstone and conglom-erate	Overlies Bejah Claystone, Samuel Formation and Paterson Formation unconformably; overlies and underlies laterite		Occurs as capping to hills of Phanerozoic rocks

Age		Thickness (m)	Lithology	Stratigraphic relationships	Fossils	Remarks
	Lake George Beds (KTg)	10±	Sandstone, coarse to very coarse grained; pebble conglomerate poorly sorted; unbedded, partly silicified	Unconformably overlies Anketell Sandstone to north of area; overlain by laterite; probably equivalent to Lampe Beds	?fossil roots	Only exposed at and around Winnecke Rock in the area
EARLY CRETACEOUS	Bejah Claystone (Ke)	5±	Claystone; minor siltstone, and very fine-grained sandstone; massive to poorly bedded; porcellanized.	Unconformably overlain by Lampe Beds; conformably overlies Samuel Formation	Radiolaria; *Lithocyclia exilis*; bivalves found outside the area (Skwarko, 1967)	Only occurs in southeastern part of RUNTON. Type section at Bejah Hill.

Age		Thickness (m)	Lithology	Stratigraphic relationships	Fossils	Remarks
	Samuel Formation (Ks)	30±	Sandstone, fine-grained and very fine-grained; interbedded with mudstone; thin-bedded, ripple cross-bedded, bioturbated	Unconformably overlain by Lampe Beds; conformably overlain by Bejah Claystone; ?laterally equivalent to Anketell Sandstone; ?overlies Cronin Sandstone, probably disconformably; overlies Paterson Formation	Bivalves	Relatively well exposed in southeast of area.
	Anketell Sandstone (Ka)	?100±	Sandstone, fine-grained to coarse-grained, conglomeratic, bioturbated, cross-bedded,	Overlies Precambrian and Paterson Formation unconformably; probably overlies and may be partly equivalent to Cronin Sandstone;	*Rhizocorallium*	Possibly a good aquifer

Age		Thickness (m)	Lithology	Stratigraphic relationships	Fossils	Remarks
			mainly thin-bedded; minor inter-bedded mudstone, bioturbated	? equivalent to Samuel Formation		
MESOZOIC UNDIVIDED	Cronin Sandstone (Mr)	?75±	Sandstone, fine to coarse-grained, bioturbated, large-scale cross-bedding, moderately sorted; minor mudstone and pebble conglomerate	Unconformably overlies Paterson Formation; may be partly equivalent to and overlain by Anketell Sandstone; may be correlative of Callawa Formation to north	Plant fossils	Previously only recognized at Cronin Hills, the type section. Now traced throughout most of RUNTON. Possibly a good aquifer.

U N C O N F O R M I T Y

Age		Thickness (m)	Lithology	Stratigraphic relationships	Fossils	Remarks
PERMIAN	Paterson Formation Undivided (Pa)	450	Sandstone; mudstone, poorly bedded with dropstones	Unconformably overlies Precambrian rocks. Unconformably overlain by Cronin Sandstone, Samuel Formation and Anketell Sandstone	Palynomorphs outside area (Kemp, 1976)	Exposure too poor (or not visited) to enable identification of facies.
	Fluvio-glacial facies (Paf)	?200±	Sandstone, fine to coarse-grained, poorly sorted, contains dropstones, cross-bedded minor mudstone and conglomerate	As above. Relationships with glacio-lacustrine facies not known		Possibly a good aquifer, however, to south contains saline water. Not common on RUNTON.
	Glacio-lacustrine facies (Pal)	?200±	Mudstone, abundant dropstones massive to poorly	As above. Relationships with fluvio-glacial facies not known.		Very poor aquifer. Is characteristically leached white and purple. Forms distinctive

Age		Thickness (m)	Lithology	Stratigraphic relationships	Fossils	Remarks
			bedded, very poorly sorted, grading to sandstone in places			White air-photo pattern.
U N C O N F O R M I T Y						
PROTEROZOIC	Karara Formation (Ekl, Eka, Ekg)	2000	Conglomerate quartz sandstone, siltstone shale and dolomite	Unconformably overlies Yeneena Group and Rudall Metamorphic Complex		Deformed by D4 only
U N C O N F O R M I T Y						
	Yeneena Group (Ey)	5000	Sandstone with minor interbeds of shale siltstone and dolomite	Unconformably overlies Rudall Metamorphic Complex		Deformed by D3 and D4.
U N C O N F O R M I T Y						

Age		Thick-ness (m)	Lithology	Stratigraphic relationships	Fossils	Remarks
	Bqm Bqq		Quartzite and quartz-mica schist	Interfoliated with older gneissic rocks		Deformed and metamorphosed by D2, D3 and D4.
Rudall Metamorphic Complex	Bgg, Bnb, Bnx		Retrograded interfoliated gneissic rocks	Oldest recognised basement rocks		Deformed and metamorphosed by D1, D2, D3 and D4.

accessory garnet, amphibole, and magnetite. In some areas, biotite is partly altered to chlorite. The more homogeneous gneisses have been derived from granitic rocks, but the more aluminous types having less uniform gneissic banding, possibly derive from sedimentary rocks.

Strongly foliated and schistose biotite granite and adamellite (Egg) is texturally and mineralogically similar to the retrograded granitic gneiss, but was emplaced during or after the first period of deformation (D1).

Undivided gneiss (Enx) is a heterogeneous unit that occurs interfoliated with the Enb gneiss. Rock types include mafic gneiss and amphibolite, retrograded ultramafic schist and gneiss, quartz-magnetite-grunerite gneiss, paragneiss, quartzite, and migmatite. Mafic amphibolite, composed of feldspar, hornblende, and garnet, is similar to the mafic gneiss, but lacks gneissic foliation. Hornblende and plagioclase may be retrogressed to tremolite and epidote respectively. Tremolite schist, foliated serpentinite, and talc schist are derived from pyroxenite and peridotite. Paragneiss includes quartz-feldspar gneiss and garnet-chlorite-mica schist. Similar paragneiss on TABLETOP (Yeates and Chin, in press) contains relict staurolite and kyanite which indicate a middle amphibolite-facies metamorphism during the D1 period of deformation. Migmatite developed in some areas by sweating-out and veining of leucocratic granite phases.

The Rudall Metamorphic Complex also contains quartzite and quartz-mica schist, which are thought to have formed from sedimentary rocks deposited on the gneissic basement. Relict bedding is outlined by textural and compositional differences. Foliated quartzite (Eqq) includes fine to coarse granular quartzite, which is commonly micaceous and rarely feldspathic. Muscovite and sparse biotite are oriented along the foliation planes. Quartz-mica schist (Eqm) contains more than ten per cent muscovite or sericite and sparse biotite, feldspar, and magnetite.

No ages have yet been determined for the events that shaped the Rudall Metamorphic Complex. The lithological association of banded iron-formation, ultramafic, mafic, sedimentary, and granitic rocks suggests that the original terrain was Archaean. The development of the gneissic foliation took place either during the Archaean -- by analogy with the model for similar rocks on ROBINSON RANGE (Elias and Williams, 1977) -- or during the Proterozoic in a mobile zone marginal to the Pilbara and Yilgarn Blocks. The metamorphism of the quartzite and quartz-mica schist predates the Yeneena and Bangemall Groups, and a Proterozoic age is inferred. Since this is the last metamorphic event to have affected the Rudall Metamorphic Complex, the complex is shown on the map as Proterozoic in age.

Even-grained biotite adamellite

Isolated outcrops of even-grained biotite adamellite (Bgb) occur 35 km east-northeast of Karara Well. The adamellite consists of two phases; a weakly foliated medium-grained phase, and a fine-grained to medium-grained dyke phase. Both are petrologically similar and contain microcline slightly in excess of oligoclase. Both feldspars are more extensively sericitized in the foliated adamellite than in the dyke phase. The latter phase contains scattered euhedral microcline phenocrysts which are flow-aligned parallel to dyke margins.

The texture of the foliated adamellite is distinguished by slightly flattened and partially polygonized quartz; this suggests that annealing has taken place during overprinting of the foliation. The flattening is possibly a result of forceful intrusion of the later adamellite. The relationahips and similarities between the two phases suggest that they represent two distinct pulses of the same intrusion.

The relative age of the adamellite is not precisely known. The lack of D3 cleavage, which is widely imprinted on rocks of the Paterson Province, suggests that intrusion postdated this deformation. Its even-grained texture and post-tectonic nature resemble the Late Proterozoic Mount Crofton Granite on PATERSON RANGE (Chin and Hickman, 1977) although the petrology does not suggest a genetic relationship.

Yeneena Group

Subdivisions of the Yeneena Group (Ey) (Williams and others, 1976) are mapped lithologically because of the difficulty in assigning formation names across intervening regions of poor exposure. The basal unconformity with the Rudall Metamorphic Complex is exposed at one point 5.5 km west of Karara Well, and nowhere is there a complete section of the group exposed. The age of the group is uncertain but is probably Early or Middle Proterozoic.

The (stratigraphically) lowest exposed rocks occur northwest of Well 23 and consist of at least 1 000 m of massive and cross-bedded, medium-grained quartz sandstone with minor interbeds of poorly sorted, coarse-grained sandstone, and granule and pebble conglomerate. This sequence probably correlates with the Coolbro Sandstone on RUDALL (Chin and others, in prep).

The sweeping ridges and cuestas of the Runton Range and adjacent areas are composed of cyclic sequences of sandstone siltstone and shale. These rocks are probably stratigraphically higher than the sandstone northwest of Well 23. Underlying the lowermost cycle are flaggy micaceous sandstone, siltstones, and purple-brown and green mudstone beds. Laminated dolomite (Eyd) at this level consists of brown dolomite sandstone interbedded with light-grey, fine-grained dolomite.

The basal part of each cycle is massive and cross-bedded, medium-grained to coarse-grained sandstone, commonly containing clay balls, and minor granule conglomerate. Mudstone laminae define bedding planes with asymmetrical and symmetrical shallow-water ripples. The cycle fines upwards through a 100-m interval of well-bedded abundantly ripple-marked, fine-grained and medium-grained sandstone, to interbedded flaggy siltstone and shale (Eys) containing a few thin beds of fine-grained micaceous sandstone marked with current lineations. Opposing foresets at this level suggest deposition by tidal currents. This cycle is repreated upwards.

The stratigraphically highest beds in the Yeneena Group occur in the Cromer Cone- Cronin Hills area. They are mostly massive sandstone, similar to that in the Runton Range sequence. However, grains tend to be more angular and less well sorted, and feldspar is more abundant. Conglomerate, commonly containing intraformational mudstone clasts, occurs as lenses at the base of large cross-sets and in scour channels. Beds of yellow-brown and pink dolomite are interbedded with pink mudstone and cross-bedded sandstone.

The sequence in the Runton Range area is thought to result from near-shore deposition, as indicated by the occurrence of shallow-water ripples, cross-bedding of possible tidal origin, dolomite of tidal flat or lagoonal origin, and mudcracks in adjacent areas. The sequence in the Cromer Cone-Cronin Hills area is less mature, coarser grained, more poorly sorted, and contains conglomerate and scour-and-fill structures. The overall upward-coarsening of the succession in both areas, and the cyclicity in parts of the sequence suggest deposition in a deltaic environment.

The sequence in the Runton Range and Cromer Cone-Cronin Hills areas correlates best with the Choorun Formation (Chin and others, in prep.).

Karara Formation

The Karara Formation -- defined herein and referred to as 'Karara Beds' by Williams and others (1976) -- unconformably overlies the Yeneena Group and Rudall Metamorphic Complex in the Karara Well area. Deposition postdates the first deformation of the Yeneena Group (D3) and predates the second folding (D4). Although the age of the Karara Formation is not known, it is possible that the sequence is a near-shore facies of the Middle Proterozoic Bangemall Group. The type locality lies in the hills between Well 23 and Karara Well (Lat. 23°05'S, Long. 123°18'E), where the unit is approximately 1 800 m thick.

The unconformity with the Yeneena Group is exposed at localities 11 km and 14 km west-northwest of Well 23. The underlying sandstone is intensely silicified close to the unconformity, and has fractured into columnar blocks and spherical boulders, which have been reworked into the residual and fluviatile conglomerate that forms the basal beds of the Karara Formation. The silicification of the Yeneena Group is thus a palaeo-weathering effect.

The basal unit of the Karara Formation is interbedded conglomerate, sandstone, siltstone and shale (Ēg), and is up to 500 m thick. The conglomerate occurs in crudely bedded and cross-bedded lenses throughout the unit. Clasts range up to 1 m in diameter at the base of lenses, but elsewhere average 0.1 m in diameter. They include silicified sandstone of the Yeneena Group, intraformational mudstone, and a variety of lithologies from the Rudall Metamorphic Complex. The conglomerate commonly grades vertically and laterally into poorly sorted feldspathic sandstone. Interbedded shale, laminated, micaceous siltstone and fine-grained sandstone are common in beds up to 5 m thick which characteristically contain symmetrical, shallow-water ripples and load casts.

The boundary with the overlying unit of sandstone and minor siltstone (Ēka) is gradational through interbedded coarse-grained sandstone, fine micaceous sandstone and laminated siltstone. The Ēka unit is up to 1 500 m thick, and consists dominantly of medium-grained, well-sorted sandstone. It is well bedded (up to 1 m thick), and contains slump and flame structures, ripples and cross-bedding. Near the top are thin interbeds of siltstone and conglomerate.

The topmost unit of the Karara Formation is interbedded dolomite and laminated shale (Ēk1). The dolomite is composed of thin, pink, buff, and light-grey beds, some of which are arenaceous or argillaceous and contain poorly developed cross-bedding.

Dolerite Intrusions

Dolerite in the Yeneena Group is characteristically fine grained, and relates to two periods of intrusion. The first forms sills and dykes which were intruded prior to the principal deformation (D3). The second is a suite of subvertical, north-northeasterly trending dykes which also intrude the Bangemall Group on GUNANYA (Williams and Williams, 1977). Although discontinuous at the surface, they lie in straight lines for distances in excess of 50 km.

PERMIAN

Paterson Formation

The Paterson Formation (Pa) (Talbot, 1920; Traves and others, 1956) is considered to be a facies equivalent of parts of the Grant Group (Crowe and Towner, 1977), and occurs in the southern Canning Basin and the Officer Basin. The unit is widespread on RUNTON and contains a glacio-lacustrine facies (Pal) and a fluvio-glacial facies (Paf). Paterson Formation undivided (Pa) refers to outcrops in which the facies could not be determined.

The most characteristic feature of the Paterson Formation is that it contains glacially derived dropstones of various Precambrian rock types, some of which are facet ed and striated. In the glacio-lacustrine facies these dropstones are randomly set in a massive mudstone matrix the erosion of which is responsible for the low, rounded cliffs bounding the outcrop. Such exposures commonly contain purple, red, and white liesegang banding. In the fluvio-glacial facies, the dropstones occur throughout the sequence together with lenses of fluvially derived conglomerate.

A glaciated pavement with overlying tillite occurs 11 km west-southwest of Cronin Hills.

Apart from bioturbation structures, no macrofossils are recorded from the Paterson Formation. However, microfossil evidence from father south indicates an Early Sakmarian age (sensu stricto) for the unit (Kemp, 1976).

Grant Group

Undivided Grant Group (Pg) (Guppy and others, 1952; Crowe and Towner, 1977) may extend into the northeasterncorner of the area, but it is not exposed. The group consists of sandstone with minor shale, and is thought to be a basinal equivalent of at least part of the Paterson Formation (Crowe and Towner, 1977). It is only shown on the rock relationship diagram on the map.

UNDIVIDED MESOZOIC

Cronin Sandstone

The Cronin Sandstone (Mr) (Veevers and Wells, 1961) was previously only recognised in the northwestern Officer Basin at Cronin Hills, its type locality. The unit is now mapped throughout the west-central part of RUNTON, and it has tentatively been identified near Bejah Hill in the southeast.

Plant fossils in the lower part of the Cronin Sandstone have been dated as Late Triassic or Jurassic by White (1961) suggesting that the unit is older than the Cretaceous Anketell Sandstone. However, the two units are lithologically similar, and Towner and others (1976) have suggested that they may be partly equivalent and that the age of the Cronin Sandstone may range from Late Triassic to Early Cretaceous.

Towner and others (1976) have also suggested that the Cronin Sandstone may be a correlative of the Callawa Formation of the southern Canning Basin.

LOWER CRETACEOUS

Anketell Sandstone

The Anketell Sandstone (Ka) (Traves and others, 1956) was previously not recognized on RUNTON (Veevers and Wells, 1961), but it is now mapped in the north-central and northeastern parts of the area. The unit disconformably overlies Paterson Formation, and overlaps it to lie unconformably on Precambrian rocks. To the east of RUNTON, Towner and others (1976) believe that the Anketell Sandstone has an interfingering contact with the Samuel Formation.

The Anketell Sandstone is believed by Crespin (1956) to be Early Cretaceous because it contains Early Cretaceous foraminifers and occupies a similar topographic position to the Early Cretaceous Samuel Formation. The trace fossil, *Rhizocorallium*, which is common in the Anketell Sandstone, is no longer considered diagnostic of the Lower Cretaceous as it was by Traves and others (1956) and Veevers (1962).

Samuel Formation

The Samuel Formation (Ks) (Lowry and others, 1972) occurs in the southeastern part of RUNTON where it is believed to overlie Cronin Sandstone and where it is conformably overlain by Bejah Claystone. The unit is exposed in sporadic small cliffs, and it is commonly capped by a thick laterite profile. Fossils from the Samuel Formation in the area are listed by Skwarko (1976) and indicate an Aptian age for the unit.

Bejah Claystone

The Bejah Claystone (Ke) (Veevers and Wells, 1961; Lowry and others, 1972) consists almost entirely of claystone with only minor siltstone and sandstone. The unit is recognised only at Bejah Hill, the type section, and a few other isolated exposures in the southeastern part of the RUNTON. It is massive or very poorly bedded and there are no sedimentary structures, apart from some mottled patterns which may indicate bioturbation.

According to Crespin the Bejah Claystone contains the Radiolaria *Lithocyclia exilis* and *Cenosphaera* sp. which indicate an Albian age (Veevers and Wells, 1961), and outside the area the unit contains an Aptian pelecypod fauna (Skwarko, 1967). The age of the Bejah Claystone is therefore considered to be Aptian-Albian.

LOWER CRETACEOUS TO TERTIARY

Lake George Beds

The Lake George Beds (KTg) (Crowe and Towner, 1977) only occur in a small area around Winnecke Rock in the northeastern part of RUNTON. No contacts with other units are exposed in the area, but to the north on TABLETOP the

Lake George Beds rest unconformably on the Anketell Sandstone (Towner and others, 1976) and a similar relationship is believed to exist in the Winnecke Rock area. Towner and others (1976) have suggested that the Lake George Beds correlate with the Lampe Beds and they are, therefore, assigneda?Late Cretaceous to Early Tertiary age.

Lampe Beds

The Lampe Beds (KTl) (Lowry and others, 1972) cap clayey exposures of the Bejah Claystone and the Samuel and Paterson Formations, and can be distinguished on aerial photographs by their light tone. Laterite appears mainly to overlie the Lampe Beds, but it is also known to underlie them (Crowe, in press). Lowry and others (1972) believed the Lampe Beds are Late Cretaceous to Early Tertiary in age as they overlie the Aptian-Albian Bejah Claystone and are mainly overlain by laterite which they believed was no younger than Miocene.

UNDIVIDED CAINOZOIC

Lateritic soil (Czs) is particularly extensive in the east; it is mainly sandy, but contains abundant lateritic pisoliths, which give it a distinctive dark tone on aerial photographs. Many of the areas shown as lateritic soil, flank valleys of an ancient drainage system described by van de Graaff and others (1977) and summarized in Towner and others (1976).

Associated with areas of lateritic soil are exposures of laterite (Czl) which commonly occurs as a thick (5-10 m) pisolitic crust overlying the more clayey formations. Laterite is also present as a capping on the sandier formations, where it is much thinner. Van de Graaff and others (1977) believe the laterite in the desert areas of Western Australia is mainly Tertiary, but, since older and younger laterites are also known, the broader age term of undivided Cainozoic is preferred for the unit.

Calcrete (Czk) is not widespread on RUNTON, and is mainly confined to areas adjacent to the major drainages. The calcrete commonly contains chalcedony, and crops out as low rugged rises around margins of salt lakes and claypans.

QUATERNARY

The most widespread Pleistocene to Holocene deposits are eolian deposits (Qz) consisting mainly of fine-grained and very fine-grained red quartz sand. In the eastern part of the area, the sand occurs as a sand plain without dunes, but elsewhere the eolian sand forms longitudinal or seif dunes. Simple and chain dunes are the most common, but net-like dunes also occur in depressions - terms of Crowe (1975).

Mixed alluvial and eolian deposits (Qs) are also common and occur in relict depressions of paleodrainages and around hills. On aerial photographs, the unit can be distinguished from pure eolian deposits by a mottled tone resulting from the floral variety that it supports. Pure eolian deposits normally only support spinifex, and therefore, have an even tone on the air-photographs.

Lacustrine deposits (Ql) occur in and adjacent to claypans and salt lakes in the area. The more extensive lacustrine deposits are probably underlain by older alluvium which was laid down when the fossil drainages were active.

Alluvium (Qa) is present in the few small creeks that drain the larger hills. Colluvial deposits (Qc) flank many of the hills in the western and northwestern parts of the area and cover the low rises around Bejah Hill in the southeast.

STRUCTURE

There are three tectonic subdivisions on RUNTON: the Precambrian Paterson Province in the west, a small part of the Phanerozoic Canning Basin in the north, and the mainly Phanerozoic Officer Basin in the remainder (Fig. 2).

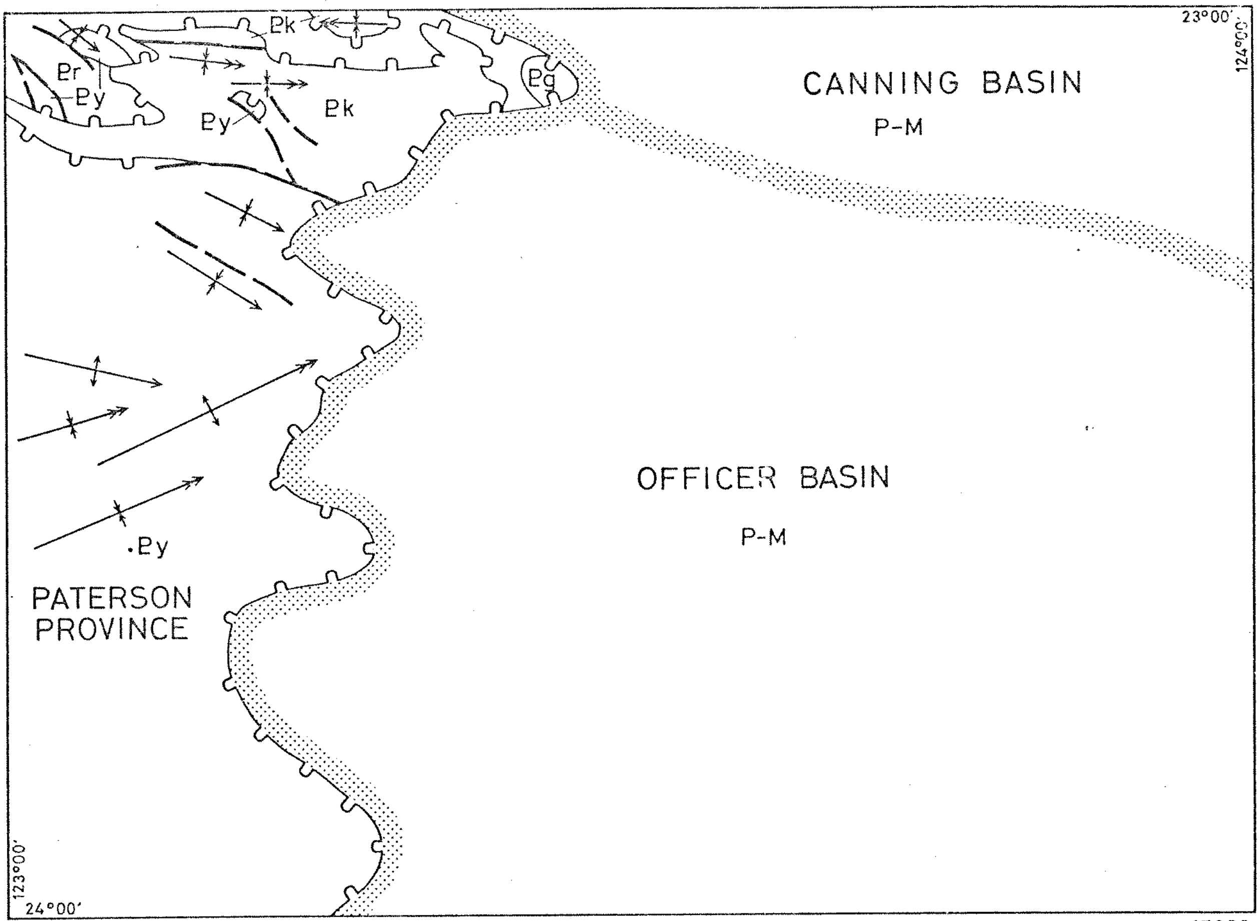
PATERSON PROVINCE

All the exposed Proterozoic rocks occur within the Paterson Province (Daniels and Horwitz, 1969). The eastern and southeastern boundaries are defined as the unconformities with rocks of the Canning and Officer Basins.

Four major periods of deformation are recognized, the first two of which were accompanied by metamorphism. The first deformation (D1) and associated regional metamorphism produced gneissic foliation in the Rudall Metamorphic Complex. Despite subsequent deformation, metamorphically differentiated bands, augen, porphyroblasts and mineral alignments related to the first deformation, are still recognizable. Relict staurolite and kyanite indicate that at least middle amphibolite-facies metamorphism was attained.

The overprinting second deformation (D2) was accompanied by a pervasive upper greenschist-facies metamorphism. This was the first event to affect the quartzite and quartz-mica schist sequence (Bqq, Bqm), and resulted in tight folding, transposition of bedding, and the development of strong metamorphic foliation (defined by recrystallization of quartz and planar orientation of mica). The D1 gneissic foliation was also strongly folded and transposed. Metmorphic minerals, such as garnet, epidote, and biotite indicate metamorphism to the biotite zone of the greenschist facies, but, in some areas, regression of biotite to chlorite indicates that metamorphism was lower grade.

The first folding of the Yeneena Group (D3) was accompanied, in the northern part of the area, by recrystallization of clay to sericite in cleavage planes. Cleavage is largely absent in the south, except in the cores of tight folds. In the south, folds are mainly broad and upright, and have axes that plunge shallowly to the southeast. Some folds have axial-plane faults. The D2 schistosity of the metamorphic rocks was crenulated in the D3 folding. On adjacent RUDALL Chin and others (in prep.) believe that the D3 folding was caused by the thrusting of rocks which now form the basement of the Canning Basin, over rocks to the southwest.



17068

FIGURE 2

STRUCTURAL SKETCH OF RUNTON SHEET SF51-15

10 0 10 20 30 40 km

REFERENCE

P-M	Undivided Canning and Officer Basin Sediments
Ꝑk	Karara Formation
Ꝑy	Yeneena Group
Ꝑg	Adamellite
Ꝑr	Rudall Metamorphic Complex

- Geological boundary
- Fault
- D_3 Syncline showing plunge
- D_3 Anticline showing plunge
- D_4 Syncline showing plunge
- D_4 Anticline showing plunge
- Unconformity
- Province boundary

The fourth deformation (D4) produced cleavage and folding which trends easterly and east-northeasterly and has a style similar to the preceding D3 deformation, but is restricted to distinct zones. Major folds of this generation occur in the Yeneena Group in the Runton Range and in the Karara Formation near Karara Well.

CANNING BASIN

Only a small portion of the Canning Basin occurs along the northern margin of RUNTON. The only structures known in this area are two faults 25 km east of Karara Well. Subsurface folds are known in the Canning Basin to the north of the area, but probably do not occur on RUNTON.

The boundary between the Canning and Officer Basins has been arbitrarily taken as the axial region of the Anketell Regional Gravity High — Warri Gravity Ridge (Lowry and others, 1972; Towner and others, 1976) - and surface information does not allow any more precise definition than this.

OFFICER BASIN

The Officer Basin on RUNTON contains a thin sequence of Phanerozoic rocks, probably less than 600 m thick. No folds are known in the sequence, and only one fault was mapped at Cromer Cone. However, from adjoining areas (van de Graaff, 1974; Crowe, in press) indicates the possibility that diapiric structures, resulting from the intrusion of Proterozoic evaporites (Wells and Kennewell, 1974; van de Graaff, 1974) may also occur in the area.

GEOLOGICAL HISTORY

The earliest geological event recorded on RUNTON is ?Early Proterozoic high-grade metamorphism of possible Archaean granitic, layered igneous, and sedimentary rocks. Arenaceous and pelitic rocks were deposited unconformably on the resulting gneisses, then folded (D2) and metamorphosed.

This tectonism also resulted in reworking of the basement gneiss. Stabilization of the metamorphic complex was followed by a period of erosion. A shallow sea then transgressed the area; and sand, mud, and gravel were deposited in a near shore environment (Yeneena Group). A delta may have formed as the sea retreated during the Early or Middle Proterozoic. Dolerite sills and dykes intruded the Yeneena Group, and a third period of folding (D3) followed.

After the folding (D3), the area was exposed to subaerial erosion and surface silicification. Gravel, sand, clay and dolomite accumulated on this land-surface, possibly in rivers and in a shallow sea (Karara Formation). A final period of folding (D4) during the Proterozoic affected the area before the intrusion of mafic dykes.

During the Early Palaeozoic, the area was subjected to uplift and erosion. If any deposition occurred, the deposits were removed and reworked when the area was glaciated during Early Permian times. The glacial deposits were laid down in rivers in the western part of the area but mainly in lakes in the Canning and Officer Basin parts (Paterson Formation). The presence of dropstones in the glacio-lacustrine facies of the Paterson Formation indicates that the lakes contained floating ice. In the northeastern corner of RUNTON, in the Canning Basin, there may have been some marine deposition during the Early Permian (Grant Group).

After the Early Permian glaciation, the area was again subjected to erosion until maybe in Late Triassic or Early Cretaceous times, rivers deposited sand, mud, and gravel in the Officer Basin part of the area (Cronin Sandstone). The basinal areas were inundated in Early Cretaceous times by a shallow sea which deposited sand and mud (Samuel Formation) over much of RUNTON, and sand and gravel (Anketell Sandstone) in a near-shore environment in the north. Quiet conditions then prevailed, and clay was deposited in the south (Bejah Claystone) before the sea retreated from the area.

After the Cretaceous sea receded, subaerial conditions prevailed until rivers deposited sand and gravel (Lampe

Beds) which in the north were weathered into soil (Lake George Beds). The same rivers probably developed into the dendritic drainage system which is preserved in parts of the area and which probably reached maturity in Early Tertiary times (van de Graaff and others, 1977). Laterite formed on this land surface, and then, as the climate became drier, the drainages became dammed, and calcrete was deposited in alluvium adjacent to the salt lakes that formed. Sedimentation in these playas has continued to the present, despite the onset of arid conditions which have resulted in the formation of eolian landforms such as mesas, buttes, and sand dunes. Minor eolian and alluvial deposition is occurring in the area today.

ECONOMIC GEOLOGY

GROUNDWATER

The groundwater resources of the area are poorly known. The only wells in the area are two on the Canning Stock Route, both in Cainozoic sediments. Salinities (total dissolved solids) recorded from the two wells in the winter of 1975 were 5 400 mg/l in Well 23 and 3 960 mg/l in Well 24.

The groundwater potential of the Precambriah rocks in the area is thought to be poor because the rocks are generally impermeable. However, zones of intense fracture may have some potential for limited supplies.

Parts of the fluvio-glacial facies of the Paterson Formation and the Cronin Sandstone may also contain potable water. The rest of the Permian and Mesozoic rocks contain high proportions of clay, and could be expected to produce only small supplies of groundwater.

Potable groundwater may also occur in areas where there are thick deposits of sand or colluvium, and larger supplies could be found in calcrete. However, where the calcrete bodies are near salt lakes, any water they contain would probably be saline.

PETROLEUM

The petroleum potential of the area is negligible as there are no known source rocks in the area, and the Phanerozoic rocks have probably not undergone sufficient thermal maturation to have generated petroleum.

METALS

The Rudall Metamorphic Complex and the Yeneena Group have some potential for copper, lead, zinc, and associated silver, because these metals have been recorded from the same units outside the area (Chin and others, in prep.). Commercial quantities of gold are also known to occur in the Yeneena Group to the northwest of the area at Telfer (Blockley, 1974; Chin and Hickman, 1977).

CONSTRUCTION MATERIALS

Laterite and lateritic soils in the area are useful road-construction materials. The isolated exposures of weathered Phanerozoic rocks in the eastern part of the area could also be used for road building. Colluvial deposits around exposures of Precambrian rocks in the western part of the area could be used for the same purpose.

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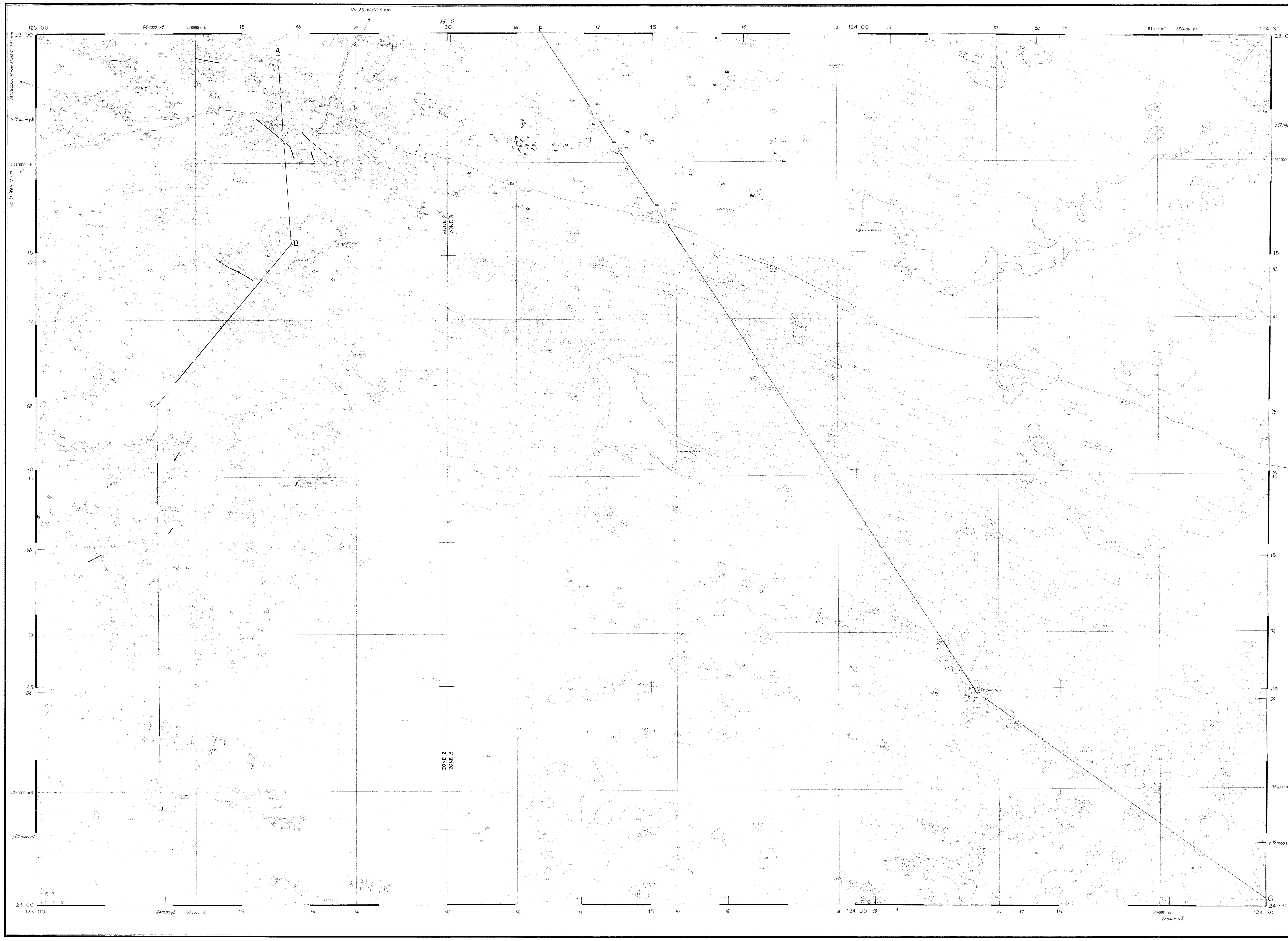
AUSTRALIA 1:250 000 GEOLOGICAL SERIES

RUNTON

WESTERN AUSTRALIA

SHEET SF 51-15



Reference

Geological boundary
- Accurate
- Approximate
- Inferred

Fault
- Accurate
- Approximate
- Inferred

Fold
- Syncline showing plunge of fold axis

Bedding
- Strike and dip measured
- Top of bed indicated by cross-bedding
- Air-photo lineament
- Air-photo interpretation of bedding; dip <15°

Cleavage and Foliation
- Strike and dip of fracture cleavage; crenulation cleavage overprinting metamorphic foliation
- Vertical cleavage
- Strike and dip of metamorphic foliation overprinting gneiss and related rock
- Vertical foliation

Lineation
- Direction and plunge

- Type section locality
- Macrofossil locality
- Microfossil locality
- Plant fossil
- Glacial striae

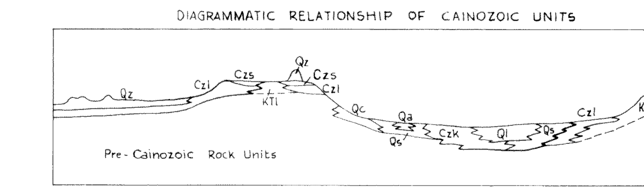
- Track
- Horizontal control, minor
- FX2 350m Bench mark, height accurate
- Sand dune

- Watercourse, intermittent
- W Well
- (Abd) Abandoned
- (PD) Position doubtful

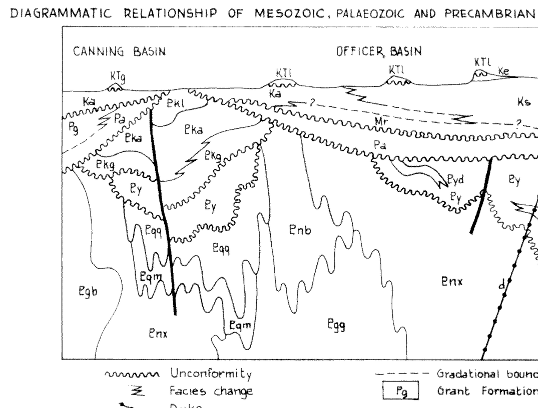
Reference

CAINOZOIC	QUATERNARY		Qa	Clay, silt, sand, gravel; alluvial
			Qs	Sand, silt; alluvial and eolian, mainly in depressions
			Qz	Sand; eolian
			Ql	Clay, silt, minor sand, gypsum, minor halite; lacustrine
			Qc	Gravel, sand, minor silt; colluvial
			Czs	Lateritic soil; pisolith gravel on surface; pedogenic
			Czl	Laterite, pisolitic or massive; pedogenic
			Czk	Calcrete, kankar, chalcedony; fluvio-lacustrine and pedogenic
			Czt	Silcrete; weathering product
MESOZOIC	CRETACEOUS TO TERTIARY	Lampe Beds	KTl	Silicified sandstone, fine to coarse-grained, conglomeratic; fluviatile
		Lake George Beds	KTg	Sandstone, partly silicified, medium to coarse-grained, conglomeratic, ? bioturbated, un-bedded; ? pedogenic
	CRETACEOUS	Bejah Claystone	Ke	Claystone, minor siltstone, rare sandstone, massive; radiolaria; marine
		Samuel Formation	Ks	Sandstone, fine-grained, interbedded with mudstone, ripple marks, glauconite; fossiliferous; marine
		Anketell Sandstone	Ka	Sandstone, fine to coarse-grained, and mudstone, thin to medium-bedded, wavy bedded, ripple marked, bioturbated, cross-bedded near top; ? paralic
	MESOZOIC UNDIVIDED	Cronin Sandstone	Mr	Sandstone, fine to coarse-grained, minor mudstone and conglomerate, cross-bedded; plant fossils; continental
PALAEOZOIC	PERMIAN	Paterson Formation	Pa	Undivided. Sandstone and mudstone, dropstones; glacial
			Paf	Fluvio-glacial facies. Sandstone and mudstone, cross-bedded, conglomeratic, dropstones
			Pal	Glacial-lacustrine facies. Mudstone, poorly sorted, dropstones, minor sandstone
PROTEROZOIC			d, q	Minor intrusion; q - quartz, d - dolerite
		Karara Beds	Ꝑkl	Shale and laminated dolomite, interbedded
			Ꝑka	Quartz sandstone, cream to purple; minor siltstone, well-bedded
			Ꝑkg	Conglomerate, polymictic; minor sandstone, siltstone, shale, interbedded
		Yeneena Group	Ꝑy	Sandstone and quartzite, fine to medium-grained, well-bedded; minor interbeds of siltstone and shale
			Ꝑys	Shale and fissile siltstone
			Ꝑyd	Laminated dolomite
			Ꝑgb	Biotite adamellite, medium-grained, not foliated
		Rudall Metamorphic Complex	Ꝑqm	Quartz-muscovite schist
			Ꝑqq	Quartzite, foliated
			Ꝑgg	Biotite granite to adamellite, strongly foliated
			Ꝑnb	Retrograded quartz-feldspar-biotite gneiss, strong overprinted foliation
			Ꝑnx	Retrograded gneiss; interfoliated with amphibolite, quartzite and ultramafic schist

DIAGRAMMATIC RELATIONSHIP OF CAINOZOIC UNITS



DIAGRAMMATIC RELATIONSHIP OF MESOZOIC, PALAEOZOIC AND PRECAMBRIAN ROCK UNITS



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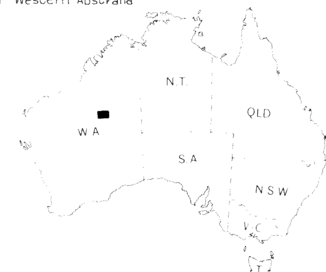
Topographic base from compilations by the Lands and Survey Department of Western Australia



INDEX TO ADJOINING SHEETS

Showing Magnetic Declination

NULLAGINE SF 51-5	PATERSON RANGE SF 51-6	SAHARA SF 51-7	PERCIVAL SF 51-8	HELENA SF 52-5
BALFOUR DOWNS SF 51-9	RUDALL SF 51-10	TABLE TOP SF 51-11	URAL SF 51-12	WILSON SF 52-9
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NABBERU SG 51-5	STANLEY SG 51-6	HERBERT SG 51-7	BROWNE SG 51-8	BENTLEY SG 52-5

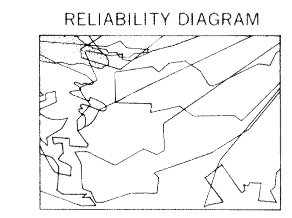
Scale 1:250 000

5 0 5 10 15 20 25 KILOMETRES

5 0 5 10 MILES

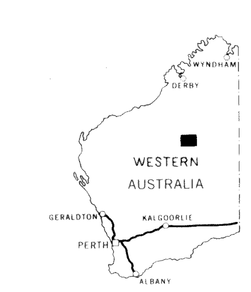
BROWN NUMBERED LINES ARE 20 000 METRE INTERVALS OF THE AUSTRALIAN MAP GRID. ZONE 51
BROWN TICKS WITH ITALIC NUMBERS INDICATE THE 20 000 YARD GRID. ZONE 2 & 3 (AUSTRALIA SERIES)
TRANSVERSE MERCATOR PROJECTION

RELIABILITY DIAGRAM



- Semi-detailed ground mapping and air-photo interpretation
- Reconnaissance mapping with helicopter traverses and air-photo interpretation
- Helicopter traverse line

Geology by R. J. Chin, R. W. A. Crowe, I. R. Williams, S. J. Williams (Geological Survey of Western Australia) and M. J. Jackson, R. R. Towner, A. N. Yeates (Bureau of Mineral Resources) 1975
Cartography by Geological Drafting Section, Department of Mines, Western Australia

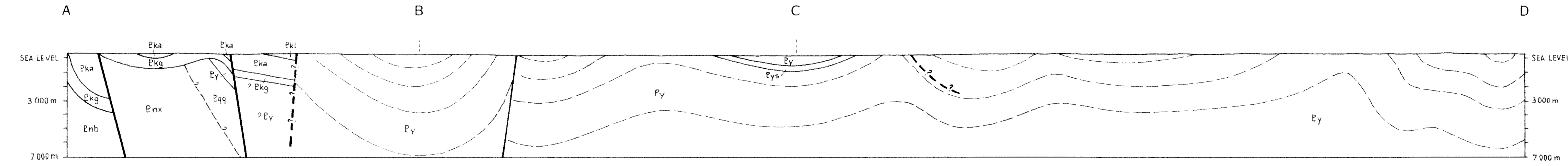


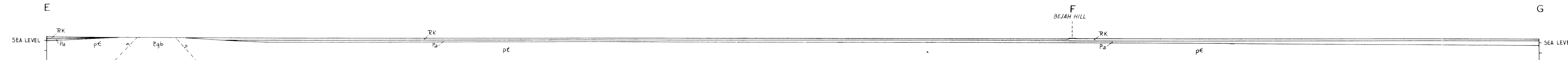
Sections

Cainozoic sediments omitted

Scale: V/H = 1

Depth in metres





TRK Undivided Triassic-Cretaceous Rocks

pЄ Undivided Precambrian including probable Karrara Beds, Yeneena Group and Rudall Metamorphic Complex

PRELIMINARY EDITION 1977

SUBJECT TO AMENDMENT

RUNTON

SHEET SF 51-15