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Record 1980/54

PALAEOZOIC ROCKS OF THE HARDMAN, ROSEWOOD, AND ARGYLE BASINS, EAST KIMBERLEY REGION, WESTERN AUSTRALIA

by

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CONTENTS

FOREWORD

This Record presents the results of an investigation of the Palaeozoic rocks of the Hardman, Rosewood and Argyle basins, in the East Kimberley region of Western Australia. The results of the fieldwork, carried out in 1962-63, were published in map form by Dow & Gemuts (1967) but this Record, which describes the formations mapped, was not issued.

The Record proposes some changes to the stratigraphic nomenclature used by previous workers, and presents new field data. The results of mapping the Palaeozoic sequence in the eastern part of the Hardman Basin (in the Northern Territory) were presented in map form by Mendum (1972) and were discussed by Sweet, Mendum, Bultitude & Morgan (1974). Those workers' interpretation of the stratigraphy differs from that of Dow's (this work) for the western part of the basin and may ultimately lead to a remapping of the basin. The field data presented in this Record are made available so that future workers in the region will be better able to study the areas critical to resolving the stratigraphic problems.

The original manuscript has been modified as little as possible, and imperial units have therefore been retained for both thickness and distance measurements. Some references have been added to the text, but editorial comments, where they have been made, are shown in italics in order to distinguish them from the original text.

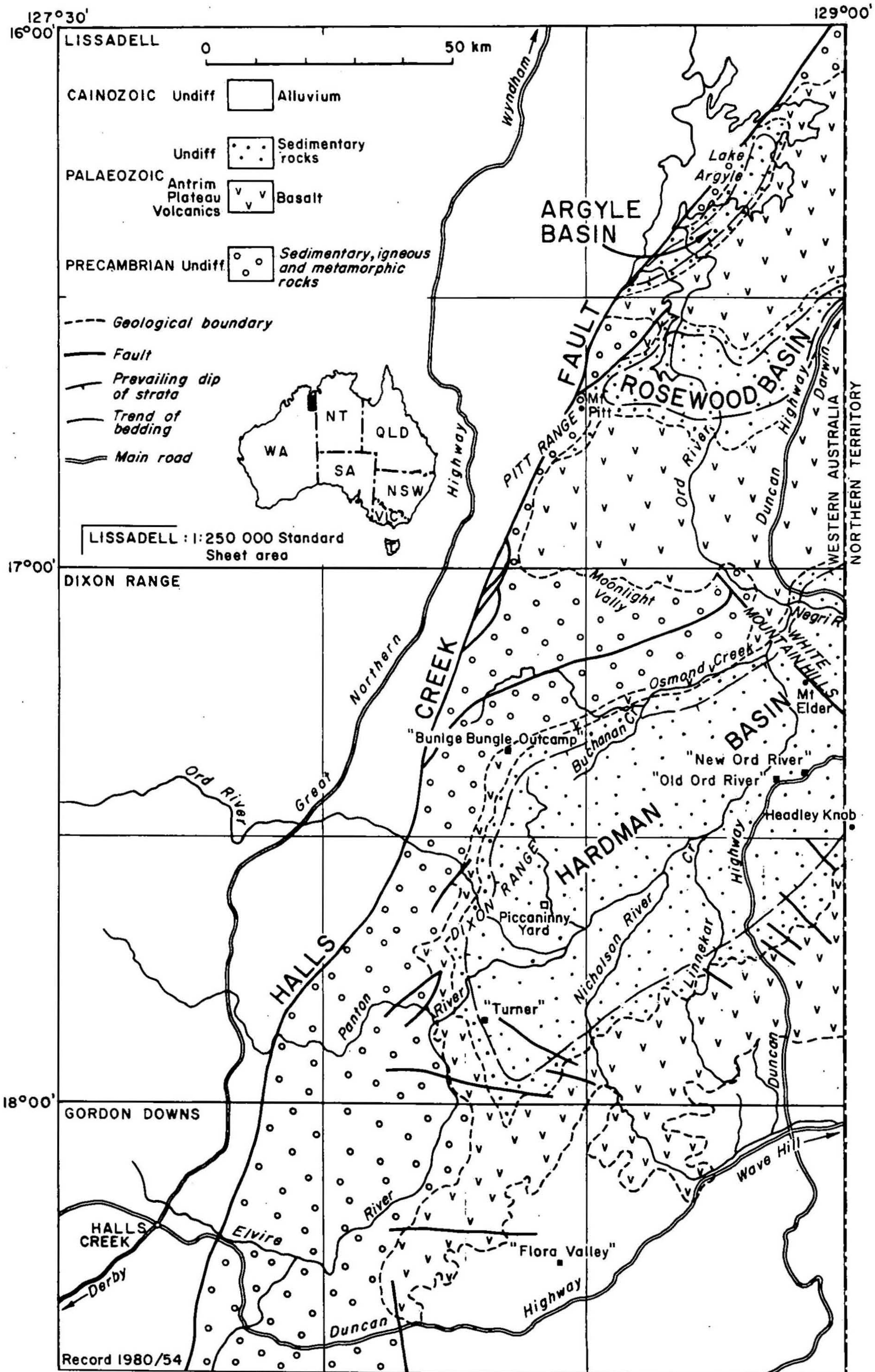

Fig. 1 Locality map, East Kimberley Region, Western Australia

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INTRODUCTION

During 1963 the Dixon Range and Lissadell 1:250 000 Sheet areas in the northeast corner of Western Australia were mapped jointly by the Geological Survey of Western Australia and the Commonwealth Bureau of Mineral Resources (see locality map, figure 1). Although the survey concentrated on the Precambrian rocks, the Palaeozoic rocks east of the Halls Creek Fault were mapped in broad reconnaissance detail, and as a result it was found necessary to change some of the stratigraphic nomenclature used by Traves (1955).

The purpose of this report is to present the information gathered on the Palaeozoic rocks, and to re-define some of the rock units. The Palaeozoic rocks of the Bonaparte Gulf Basin to the north are described by Veevers & Roberts (1968).

The 1963 mapping was done by D.B. Dow, J.H. Latter, K.A. Plumb and D. Dunnet, of the Bureau of Mineral Resources, and R. Passmore and I. Gemuts of the Geological Survey of Western Australia; the southern part of the Hardman Basin was mapped in 1962 by J.W. Smith (Bureau of Mineral Resources) and I. Gemuts.

PREVIOUS INVESTIGATIONS

Hardman (1886) carried out the first geological investigation on the Palaeozoic rocks of this region. His was a very broad reconnaissance, and although he did not recognise the Cambrian age of the rocks, his geological boundaries need very little alteration.

Surveys were later carried out by Jack (1906), Blatchford (1921, 1927), and Mahony (1922), but the first real advance on Hardman's work was made by Wade (1924), who assessed the petroleum prospects of the region and corrected many of the earlier misconceptions on the age of the rocks. In 1923 a bore was drilled to a depth of 408 feet (the Okes-Durack bore) near White Mountain in an unsuccessful bid to find oil.

Matheson & Teichert (1948) made probably the greatest contribution to our knowledge of the Palaeozoic rocks of the area, and their work was considerably amplified by Traves (1955). Öpik (1967) described the Cambrian faunas collected from the region during Traves's and earlier surveys.

In 1969 the eastern part of the Hardman basin, in the Victoria River region of the Northern Territory, was mapped by BMR (Mendum, 1972; Sweet & others, 1974). Mendum re-interpreted some of the boundaries published by Dow & Gemuts (1967). Öpik (1970) published further results of his work on the trilobite faunas collected from the Hardman basin during the earlier surveys. Jones (1976) reviewed much of the previous work on the Ord Basin (the sedimentary basin of which the Hardman, Rosewood and Argyle structural basins are remnants; McWhae & others, 1958) but did not have access to this Record.

STRATIGRAPHY

Introduction

The Palaeozoic rocks of the East Kimberley region were laid down on a basement of Precambrian rocks which include late Adelaidean glacial rocks (Dow & Gemuts, 1969). After the deposition of the late Adelaidean glacial rocks there was a long period of erosion during which most of the glacial rocks were stripped away. There followed in early Cambrian time a vast outpouring of tholeiitic basalt which gave rise to the Antrim Plateau Volcanics; these basalts cover a large area in northern Australia (Bultitude, 1976).

A short period of erosion followed during which soil profiles were formed on the Antrim Plateau Volcanics. A marine transgression in the early Middle Cambrian resulted in deposition of fossiliferous marine sediments called the Negri Group by Traves (1955). Traves subdivided the Negri Group into eight formations (Table 1), but in this Record four of those formations are combined into the Panton Formation. The Negri Group extends over much of the eastern half of the East Kimberley region, and at one time it probably formed a continuous cover east of the Halls Creek Fault. The Group is now preserved in three contiguous structural basins which are called the Hardman, Rosewood, and Argyle Basins.

The youngest Palaeozoic rocks in the map area belong to the Elder Sandstone. Field relations between this unit and the Negri Group are uncertain, but the two units appear to be separated by an unconformity. The Elder Sandstone is a correlative of the fossiliferous Ragged Range Conglomerate Member of the Cockatoo Formation, which is preserved north of the map area (Veevers & Roberts, 1968).

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DETAILED DESCRIPTION OF THE ROCK UNITS

Antrim Plateau Volcanics

Lithology - Tholeiitic basalt lava flows, and rare, thin, beds of basalt agglomerate, and quartz sandstone. The main area of outcrop is east of the Halls Creek Mobile Zone, but the volcanics crop out over much of the northern part of the zone; there is a large outlier to the west of the map area in the middle reaches of the Margaret River.

Derivation of Name - Hardman (1885) named the country underlain by basaltic volcanics south of the Ord River the Great Antrim Plateau, after the Antrim Plateau of Ireland, and therefore by inference named the Volcanics. David (1932) first used the name Antrim Plateau Basalts, but this was changed by Traves (1955) to Antrim Plateau Volcanics, because the unit contains tuff and agglomerate.

Type section - The type area is the dissected volcanic country south of the Hardman Basin, named by Hardman the Great Antrim Plateau. No type section has been designated, although two sections were measured on the western margin of the Hardman Basin. These sections have been shown, incorrectly, as type sections on the Dixon Range 1:250 000 Sheet.

Stratigraphic Relations - The Volcanics unconformably overlie the late Adelaidean Albert Edward Group and the Louisa Downs Group, and are overlain in the south by the Cambrian Headleys Limestone. In the north the Volcanics are overlain by the early Middle Cambrian Blatchford Formation and the Devonian Ragged Range Conglomerate Member. The surface of the Volcanics immediately beneath the Limestone is deeply weathered and ferruginised in places and probably represents an erosion interval.

Thickness - The greatest thickness measured in the map area east of the Halls Creek Mobile Zone is 3280 feet near Bungle Bungle outcamp.

Age - Probably early Cambrian.

The Antrim Plateau Volcanics have been described by Traves (1955) and the following remarks are intended to amplify his description.

Most of the formation is made up of fine to medium-grained basalt, but it also contains some prominent beds of sandstone and some minor agglomerate.

The basalt occurs as massive, concordant flows generally less than 100 feet thick. Some can be traced in escarpments for several miles. Many of the flows are vesicular and contain amygdales of agate, chalcedony, calcite, and prehnite. The upper parts of most flows are more highly vesicular than their central parts, and there appears to be an increase in the proportion of amygdaloidal basalt towards the top of the formation. Geodes up to 2 feet in diameter, lined with amethyst crystals up to 3 inches across, were found in basalt near Bungle Bungle outcamp, but they are rare.

The section of the Volcanics described in Table 1 was measured by chain and compass near Bungle Bungle outcamp.

Five thin-sections of basalt from the type area were described by Joyce (1965). They are all fine, even-grained augite basalt consisting of augite, labradorite (An_{58-59}), chlorite, iron oxides, and kaolin. In one specimen the augite has lamellae of exsolved orthopyroxene, and rare pigeonite, and two others contain interstitial quartz. Joyce stated (p. 127) "In general, therefore, the Antrim Plateau basalts possess the characteristics of tholeiitic basalts. The apparent lack of pigeonite or orthopyroxene in four out of the five specimens examined is contrary to the generalisation of Kennedy (1933) and Turner and Verhoogen (1960), but the remaining characteristics are far more compatible with the tholeiitic suite than with the alkaline olivine basalt suite."

The findings of Edwards & Clarke (1940), who described 21 specimens of basalt from the Antrim Plateau Volcanics from widely scattered localities in the Ord River region, support this conclusion. They stated that the basalts form a homogeneous petrographic province, intermediate in composition between undersaturated olivine basalt and oversaturated tholeiitic basalt. However, they stated that the affinities of the basalts are with the tholeiitic magma type.

Red-brown feldspathic sandstone forms prominent marker beds in some localities in the northern part of the region. One bed near the base of the formation is about 30 to 40 feet thick and is a very persistent marker bed. It consists of friable, cross-bedded sandstone and contains interbeds of a massive breccia consisting of angular fragments of underlying sandstone bedrock in a ferruginous matrix.

A sandstone bed at the base of the Antrim Plateau Volcanics near Horse Creek Well in the Moonlight Valley is made up of quartz grains of probably aeolian origin. The rock is friable, and consists of spherical or ovoid grains of quartz and chert which are remarkably well sorted; they are all about 0.08 mm in diameter and most are frosted.

Agglomerate is a minor constituent of the succession in the map area. A band of agglomerate was seen in the formation in a creek 11 miles north-northwest of Turner Homestead: it is about 30 feet thick and consists of sub-rounded fragments of vesicular (almost scoriaceous) basalt up to 8 inches across in a highly indurated basaltic matrix. The andesite breccia near the top of the measured section at Bungle Bungle outcamp is probably a volcanic breccia, though it could possibly be a weathering feature.

Agglomerate is more common in the north, and in the Glenhill Valley, north of the map area, there are several bands of basaltic agglomerate.

In places, especially in the northern part of the East Kimberley region, the volcanics were laid down on a surface of quite high relief, possibly similar to that of the present day. This is exemplified in the Glenhill area where flat-lying basalt fills a small valley and abuts against a near-vertical cliff.

The thickness of the volcanics was measured in 3 places: north-northwest of Turner Homestead it is 3200 feet as measured on the airphotos; near Bungle Bungle Outcamp it was measured by chain and compass as at least 3280 feet (Table 2); and near Mount Pitt it is about 2800 feet thick (measured on the airphotos).

Soil profiles in the measured section near Bungle Bungle outcamp indicate that there may have been 3 distinct periods of basalt outpourings, and that the formation was probably extruded over a considerable period of time. On the western side of the Hardman Basin the basalt immediately beneath Headleys Limestone is in places highly ferruginous to a depth of 20 feet. Thus, though the contact between the two units appears to be conformable (Harms, 1959; Traves,1955), this ferruginous layer may be the result of a long period of weathering before Headleys Limestone was deposited.

The basalt was extruded either in uppermost Adelaidean or in early Cambrian times. It lies unconformably between the Albert Edward Group, which has been radiometrically dated at about 650 million years (Bofinger, personal communication), and the basal Negri Group which is early Middle Cambrian.

NEGRI GROUP

Constituent Formations and Lithologies -

Hudson Formation: Ferruginous micaceous quartz siltstone and sandstone; uppermost unit.

Panton Formation: Grey and brown siltstone and shale; rare thin beds of grey limestone.

Linnekar Limestone: Flaggy, grey, fine-grained limestone.

Nelson Shale: Grey to reddish-brown shale and fine-grained quartz sandstone.

Headleys Limestone: Grey, fine-grained limestone containing chert nodules. Lowermost unit.

Distribution -

Sediments of the Negri Group have been down-folded into the Antrim Plateau Volcanics in three separate areas east of the Halls Creek Fault; these structural basins were called by Matheson & Teichert (1948) the Hardman, Rosewood, and Argyle Basins (Fig. 1). The original sedimentary basin, presumably covering a larger area than the three remnants, was called the Ord Basin by McWhae & others (1958).

Derivation of Name -

The group takes its name from the Negri River, which joins the Ord River at 128°52'E, 17°04'S, near the northern margin of the Hardman Basin.

Previous Nomenclature -

The sediments were first named by Mahony (1922) who divided them into two series, the Negri Series and the Mount Elder Series, names which were later used by Matheson & Teichert (1948), (see Table 1). Traves (1955) subdivided the Negri Series into eight formations, and changed the name to Negri Group to conform to the Australian Code of Stratigraphic Nomenclature. He included in the Negri Group the lowermost part of the Elder Series of Matheson & Teichert, and named the rest of the Elder Series the Elder Sandstone.

Of Traves's 8 formations listed in Table 1, the Corby and Shady Camp limestones are thin and discontinuous and cannot be recognised away from the type area; the Negri and Panton Shales are alike, and in the absence of the two limestone beds cannot be distinguished. Hence in this report the formations have been combined into one unit called the Panton Formation. The Hudson Shale of Traves is almost entirely sandstone and siltstone, so we have named it the Hudson Formation.

Stratigraphic Relations - The Group overlies the Antrim Plateau Volcanics with probable erosional unconformity, and is overlain unconformably by the Elder Sandstone.

Thickness - About 1750 feet.

Age - Earliest Middle Cambrian (Ordian Stage of Öpik, 1967).

Öpik (1967) discussed the fauna from the Negri Group and its role in the erection of a formal stage (the Ordian stage) representing the earliest part of the Middle Cambrian. The part of the Negri Group below, and including most of, the Panton Formation is definitely Ordian (Öpik, 1967), but the Hudson Formation does not contain diagnostic fossils; it could include younger Middle Cambrian strata.

Headleys Limestone

Lithology - Massive or laminated fine-grained grey limestone containing chert nodules in the lower part.

Distribution - In the Hardman, Rosewood, and Argyle Basins.

Derivation of Name - The Headleys Limestone was named by Traves (1955) after Headleys Knob, 11 miles south-east of Ord River Homestead. (129°00'E, 17°28'S approx.).

Type section - The type section was measured on the western side of the Hardman Basin three miles south of Dixon Range, at 128°14'E, 17°41'S.

Stratigraphic Relations - Overlies the Antrim Plateau Volcanics with possible erosional unconformity, and is conformably overlain by the Nelson Shale.

Thickness - Between 120 feet and 180 feet.

Age - Probably early Middle Cambrian.

The Headleys Limestone is resistant to weathering, and where it is gently dipping it forms cuestas, which in places on the south side of the Hardman Basin have an almost impenetrable karst topography. On the western and northern sides of the Hardman and Rosewood Basins the Limestone is nearly vertical, and forms parallel-sided "walls" up to 50 feet high.

The four sections measured on the western side of the Hardman Basin are similar, and consist of 30 feet of massive, fine-grained grey limestone containing chert nodules, overlain by 120 feet of laminated and thin-bedded fine-grained grey limestone. Stromatolite domes between two and four inches across are common in the upper parts of the limestone, but are rare in the lower part. Beds of "two-tone" limestone were seen in the lower part: these are composed of fine-grained grey limestone containing blebs, lenses, and thin beds of yellow, probably dolomitic limestone.

The limestone is between 120 feet and 180 feet thick in most outcrops and invariably is more massive and contains chert nodules near the base. It lenses out in the eastern Argyle Basin, and the Nelson Shale rests directly on the Antrim Plateau Volcanics (Plumb, 1967).

Contacts with the underlying Antrim Plateau Volcanics were seen only on the western and northern margins of the Hardman Basin. In most places the basalt has been ferruginised and silicified for 20 feet below the contact with the limestone, and this is taken as evidence of a period of weathering and possibly erosion before the deposition of the Headleys Limestone. No fossils have been found in Headleys Limestone, but it is part of a conformable sequence which contains early Middle Cambrian fossils in its upper part; its age is therefore probably early Middle Cambrian.

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Nelson Shale

Lithology -	Mostly grey, brown, or red shale and siltstone. Gypsiferous and pyritic in places.
Distribution -	In the Hardman, Rosewood, and Argyle Basins.
Derivation of Name -	Nelson Shale was named by Traves (1955) after Nelson Creek (east of the map area), 26 miles east-northeast of Ord River homestead. (at about 129°08'E, 17°20'S).
Type area -	The Hardman Basin. No type section has been designated.
Stratigraphic Relations -	The formation lies conformably between the Headleys and Linnekar Limestones, except in the eastern Argyle Basin, where it unconformably overlies the Antrim Plateau Volcanics.
Thickness -	Between 500 feet and 600 feet thick.
Age -	No fossils other than <u>Girvanella</u> have been found in the shale, but as it conformably underlies Linnekar Limestone it is regarded as early Middle Cambrian.

The formation weathers readily, and forms rolling blacksoil plains. Exposures are confined to creek beds, and no sections are completely exposed. Matheson & Teichert (1948) measured 525 feet of calcareous shale south of the junction of the Ord and Negri Rivers, but exposures in this area are poor. Probably the most complete section, of 591 feet, is given by the Okes-Durack Bore, drilled near White Mountain in about 1923 (Hobson, 1936); the log is quoted in Table 3.

Linnekar Limestone

Lithology -	Fine-grained fossiliferous grey limestone and minor marl.
Distribution -	Hardman, Rosewood, and Argyle Basins.
Derivation of Name -	Named by Traves (1955) after Linnekar Creek, which joins the Ord River about 12 miles southwest of Ord River Homestead (128°44'E, 17°30'S).
Type section -	The type section was measured along Linnekar Creek.
Stratigraphic relations -	The limestone lies conformably between the Nelson Shale and the Panton Formation.
Thickness -	Generally between 50 feet and 70 feet thick, but ranges up to 130 feet on the western side of the Hardman Basin and is only 30 feet in the Rosewood and Argyle Basins.
Age -	Early Middle Cambrian (Ordian).

The Linnekar Limestone is slightly more resistant to erosion than the overlying and underlying formations, and it forms low cuestas around the southern and eastern parts of the Hardman Basin. On the western and northern margins of the basin it dips more steeply, and is generally covered by soil or alluvium, but sufficient outcrop was found to prove that the formation continues around the basin. It also crops out around the Rosewood and Argyle Basins, although poorly.

The Linnekar Limestone consists of 10 to 20 feet of flaggy grey limestone overlain by 50 to 60 feet of platy grey or brown, fine-grained limestone containing thin marl interbeds. Ripple marks are common near the top of the formation. Six sections of the formation have been measured in the Hardman Basin; the maximum thickness measured was 130 feet in an excellent exposure west of the Dixon Range, but in other localities the formation is between 50 and 70 feet thick (Traves, 1955). In the Rosewood and Argyle Basins the formation appears to be almost identical with that of the Hardman Basin.

Figure 2: Probable algal growths exposed near the Elvire - Ord River junction in Linnekar Limestone. (G6072)

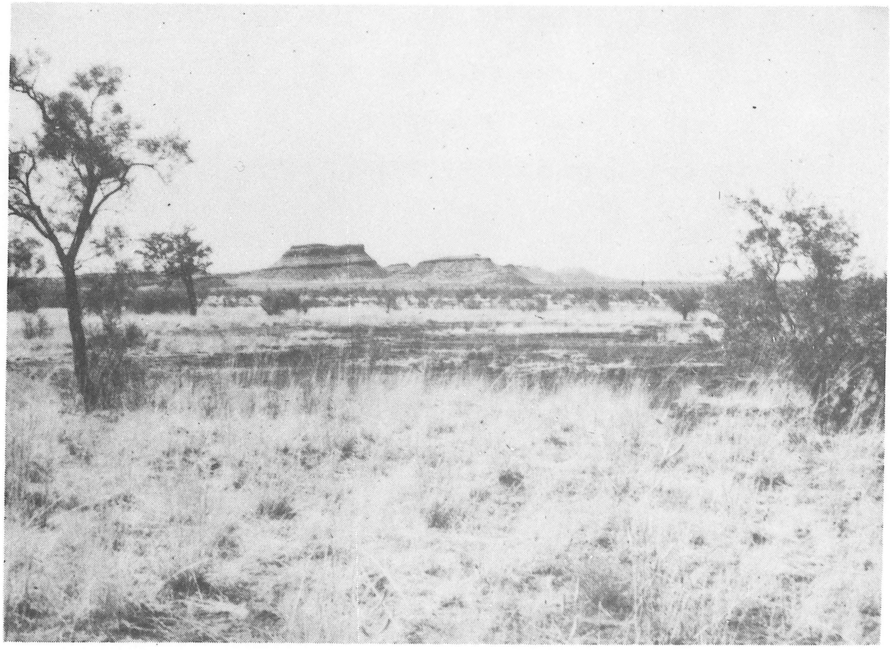

Figure 3: Mount Elder photographed from the north. Resistant Elder Sandstone forms mesas up to 500 feet above the Ord Plains. (G6800).

The formation is richly fossiliferous in places, particularly near its top. Abundant Redlichia and Biconulites species were found where the road joining Ord River and Turner Homestead crosses Linnekar Creek. The formation is also richly fossiliferous in the Nicholson River, near the mouth of the Negri River, and in the Elvire River three miles upstream from its junction with the Ord River, where stromatolites are well exposed. In the other localities shown on the 1:250 000 geological maps only fragmentary fossils have been found. The fossil assemblage comprises Redlichia forresti, Biconulites hardmani, and Girvanella, and belongs to the Ordian stage of Öpik (1967), i.e. earliest Middle Cambrian.

Panton Formation

Lithology - Predominantly brown, red, and grey micaceous siltstone, which is commonly calcareous. Rare thin beds of limestone and fine-grained calcareous siltstone.

Distribution - Throughout the Hardman Basin. Poorly exposed fine-grained sediments and thin limestone beds in the Rosewood and Argyle Basins probably belong to the Panton Formation.

Derivation of Name - From Mount Panton, which is 30 miles southeast of the Ord-Negri Rivers junction, east of the map area.

Type section - Immediately west of White Mountain (128°56'E, 17°16'S). The type section was measured by chain and compass in a small creek draining the north-western flank of White Mountain.

Stratigraphic relations - The formation lies conformably between the Linnekar Limestone and the Hudson Formation. The contact with the Linnekar Limestone is gradational over about 20 feet, and the boundary is arbitrarily placed where the siltstone becomes predominant. In the type section the upper boundary is the top of a massive limestone (the Corby Limestone of Traves, 1955), but where this is absent the boundary is placed at the change from platy red-brown micaceous siltstone to thinly flaggy chocolate-brown sandstone.

Thickness - The type section is 535 feet thick.

Age - Early Middle Cambrian (Ordian).

Most of the Panton Formation weathers readily and forms sandy blacksoil plains in which outcrop is generally found only in the banks of creeks incised below plain level. The two limestone members are more resistant, and generally crop out as subdued cuestas.

The rocks of the Panton Formation overlying the Linnekar Limestone on the eastern side of the Hardman Basin (east of the map area) contain a greater proportion of thin flaggy limestone. The sequence measured at Mount Panton by Matheson & Teichert (1948) is typical of this more calcareous facies (see Table 4).

The correlation of the sequence at Mount Panton with that in the type area is not certain. Traves correlated the two ten-feet-thick beds of massive limestone and the intervening 125 feet of sediments at Mount Panton with the lowermost massive limestone of the type area (Shady Camp Limestone). Such a marked thinning to the west appears unlikely, and from a study of airphotos, the Mount Panton sequence seems to correlate with the upper part of the type area as shown in Figure 4, a correlation originally suggested by Matheson & Teichert (1948).

The change eastwards to a more calcareous facies is accompanied by a marked decrease in thickness. The eastern margin of the basin of deposition of the Panton Formation was therefore probably not far east of Mount Panton.

On the western side of the Hardman Basin the massive limestone beds are absent, but otherwise the formation is indistinguishable from the type section. Unfortunately exposures are poor and the thickness of the formation could not be measured, but it does not appear to be markedly different from the type section. West of Dixon Range red-brown micaceous shale and siltstone in the lower part of the formation contains spherical or ovoid green zones reminiscent of the 'zebra stone' (Blatchford, 1928) of the Adelaidean Ranford Formation (Dow & Gemuts, 1969). In this locality there is a one-foot-thick bed of algal limestone which is possibly the lateral equivalent of the ten-foot bed of massive limestone near the middle of the formation in the type area.

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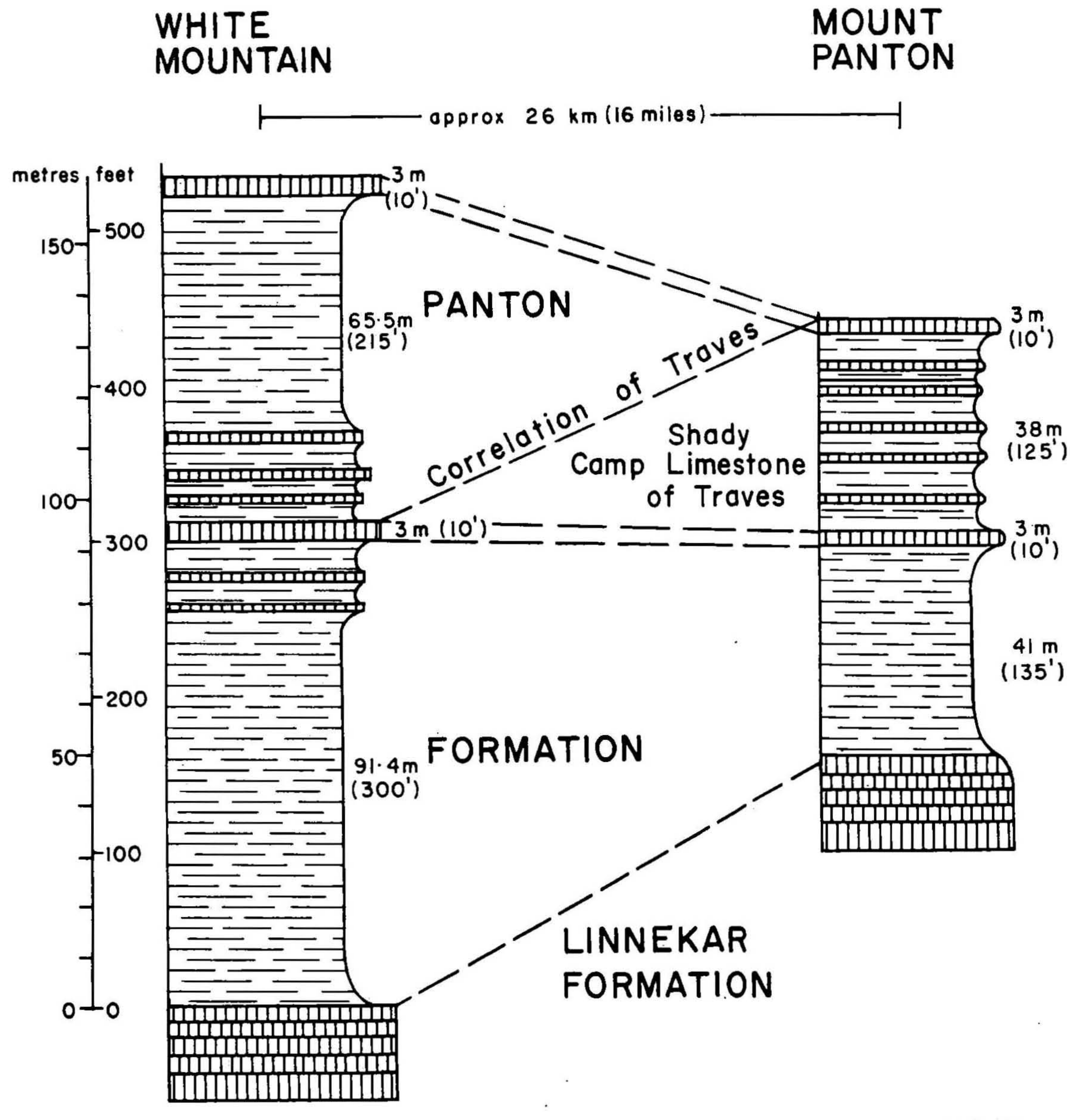

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Fig. 4 Correlation of the section at Mount Panton with the type section at White Mountain

Little is known of the Panton Formation in the Rosewood and Argyle Basins because it is covered by soil and only thin beds of limestone and rare, small outcrops of shale and siltstone were found.

The fossil assemblage shows that the age of the formation is early Middle Cambrian (Traves, 1955).

Hudson Formation

Lithology -	Mostly flaggy, chocolate-brown, micaceous, quartz siltstone and sandstone.
Distribution -	Known only in the Hardman and Argyle Basins.
Derivation of Name -	After Hudson Creek, which drains the southwestern slopes of White Mountain (Traves, 1955). This formation was originally included in the base of the Elder Series by Matheson & Teichert (1948), but Traves (1955) rightly considered that it was deposited in the same sedimentary cycle as the rest of the Negri Group. He therefore included it in the Negri Group. The rocks of the formation are almost entirely siltstone and sandstone, so we prefer the name Hudson Formation.
Type area -	The type area is the White Mountain region, and the type section was measured in Hudson Creek (128°58'E, 17°15'S).

There appears to be an error in the figures given for the type section locality, which plots within Elder Sandstone north of White Mountain. A more feasible locality, in outcrop of Hudson Formation southwest of the mountain, is at 128°57'30"E, 17°16'S. In the light of the changes made by Mendum (1972), discussed below, this type locality may not be suitable at all.

Stratigraphic relations - The Hudson Formation conformably overlies the Panton Formation. For the definition of the lower boundary see Panton Formation. In the type area the Elder Sandstone appears to be conformable on the Hudson Formation, but regional mapping shows the contact to be a very slight angular unconformity. The upper boundary is therefore placed where thinly-flaggy, fine-grained, quartz sandstone of the Hudson Formation changes to massive, cross-bedded Elder Sandstone. Elsewhere in the Hardman Basin colluvium derived from the Elder Sandstone obscures the boundary.

Mendum (1972) and Sweet, Mendum, Bultitude & Morgan (1974) included the Hudson Shale of Traves (1955) in the Panton Formation, not in the Hudson Formation (in the sense of this Record). However, they recognised a unit, which they mapped as Hudson Formation, within the Elder Sandstone as mapped by Dow & Gemuts (1967). This was done without knowledge of the definitions contained in this Record. Sweet & others (1974) argued that Dow & Gemuts had not placed the boundary of the Elder Sandstone at the same stratigraphic level as the unconformity recognised at the base of the sandstone in the western Hardman basin, and that some Cambrian rocks had mistakenly been included with the sandstone.

Thickness - The type section is 477 feet thick.

Age - The only fossil species found in the formation is Biconulites hardmani; the stratigraphic position of the formation indicates an early Middle Cambrian age.

Over most of the Hardman Basin the only outcrop is very subdued structural benches of more resistant sandstone; the rest of the formation is covered by sand or soil.

Probable fossil jellyfish found by R. Passmore during regional mapping in 1963 were collected from Piccanniny Creek, about two miles southeast of Piccanniny Yard. The fossils probably occur in the upper part of the Hudson

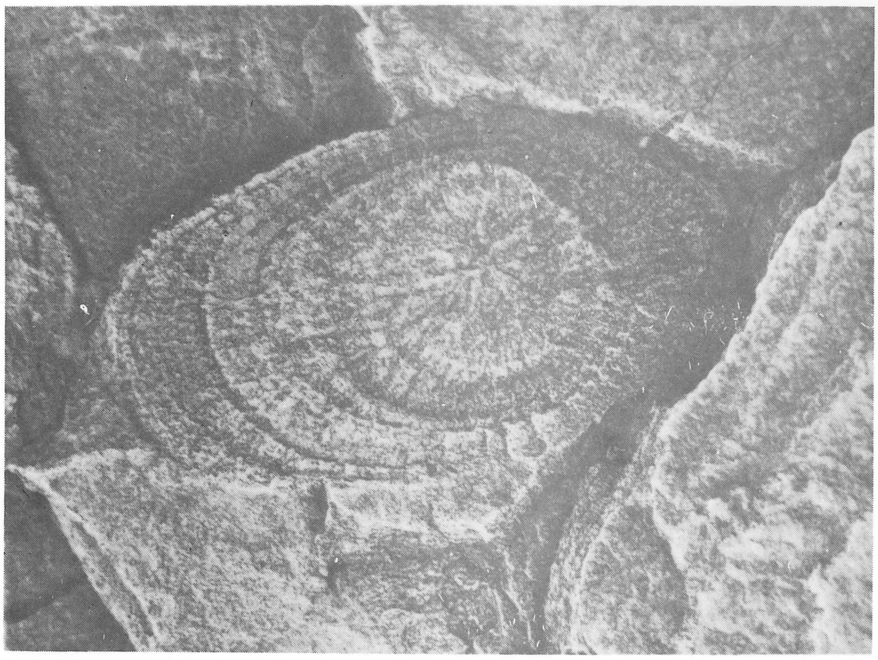

Figure 5: Fossil "jellyfish" from the Hudson Formation. (X5). (F3840)

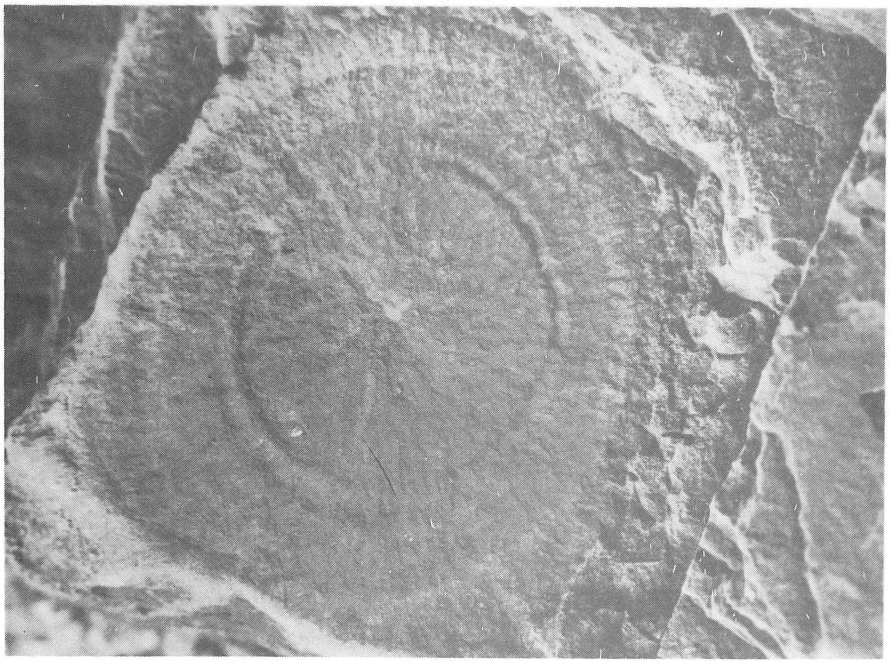

Figure 6: Fossil "jellyfish" from the Hudson Formation. (X4). (GB2245)

Formation, but there is some doubt as to the exact locality, and it could not be found on a subsequent visit to the area. Two types of 'fossil jellyfish' were found (Figs. 5 and 6), one of which is almost identical with a form collected from the Adelaidean Ranford Formation near Mount Brooking 116 miles to the north-northeast (Dunnet, 1965). The specimen illustrated in Figure 5 is smaller than average, and most of the individuals collected are between one and two inches across.

Some of the 'fossil jellyfish' in the Ranford Formation near Mount Brooking appear to be crystal casts, i.e. they are inorganic, (M. Walter, BMR, personal communication). However, there are several forms present at Mount Brooking (Dunnet, 1965), and some of them do appear to be impressions of organisms.

The Hudson Formation conformably overlies the Panton Formation and is therefore probably Middle Cambrian.

Elder Sandstone

Lithology -	The formation is composed of massive cross-bedded sandstone.
Distribution -	It crops out in the northwestern and northeastern Hardman Basin, and also forms the Hardman Range in the southwestern corner of the basin. A small outlier of quartz sandstone 22 miles east-north-east of Flora Valley Homestead is also referred to the Elder Sandstone.
Derivation of name -	The name Elder Series was proposed by Mahony (in Hobson, 1936), and used by Matheson & Teichert (1948) for the shale and sandstone overlying the fourth limestone unit of their Negri Series in the White Mountain region. Traves (1955) included the lower finer-grained part of the Elder Series in the Negri Group, and renamed the upper unit Elder Sandstone, to conform with the Australian Code of

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Stratigraphic Nomenclature. The name is derived from Mount Elder, six miles northwest of White Mountain (128°55'E, 17°13'S).

Type area - The type area is the White Mountain region. No type section was measured.

Stratigraphic relations - The sandstone rests unconformably on the Negri Group in the western part of the Hardman Basin, and is also probably unconformable in the eastern part.

Thickness - The Elder Sandstone is about 1300 feet thick in the east. A section measured near Bungle Bungle outcamp is 650 feet thick, and although this was incomplete, the total thickness in the area probably does not exceed 800 feet.

Age and correlatives - No fossils have been found in the Elder Sandstone, but it is probably a correlative of the Ragged Range Conglomerate Member of the Cockatoo Formation, of upper Devonian age (Veevers & Roberts, 1968).

The Elder Sandstone forms rugged flat-topped mountains which are bounded by steep cliffs (Fig. 7). Closely-spaced joints in some places form deep chasms, or, more commonly, are silicified and stand out as prominent ribs. Scrub-covered sand plains have been formed by erosion of the sandstone.

The formation is composed almost entirely of medium-grained quartz sandstone, which is red or pink on weathered surfaces, but white when broken. It consists of well rounded to sub-rounded, well sorted quartz grains and small amounts of ferruginous or sericitic matrix. It is massive or thick-bedded, ubiquitously cross-bedded, and friable. Outcrops generally have a silicified surface and the sandstone weathers with a characteristic cavernous outcrop. In the type area the upper parts of the sandstone contain pebbles of chert and agate which were probably derived from the Antrim Plateau Volcanics.

Figure 7: Mesa of Elder Sandstone taken from south of Bungle Bungle outcamp looking eastwards. (GB2246)

In the type area, about 160 feet above its base there are three thin (two to four inches thick) beds of very highly ferruginous, fine-grained, quartz sandstone. The beds are either dark red-brown, and probably hematitic, or chocolate-brown and probably limonitic; the limonitic beds commonly have a distinctive botryoidal surface. Similar beds were noted throughout the basin in the lower part of the Elder Sandstone, and with more detailed mapping they could prove to be valuable markers.

On the western margin of the Hardman Basin the base of the Elder Sandstone is generally marked by a lenticular basal conglomeratic sandstone 40 to 60 feet thick. It consists of cross-bedded sandstone, identical to the bulk of the Elder Sandstone, and contains scattered pebbles and cobbles of quartz, quartzite, and rare chert. The conglomeratic beds rest on an irregular surface eroded on the Hudson Formation.

Between Dixon Range and Buchanan Creek, on the western and northwestern margins of the Hardman Basin, the Elder Sandstone rests unconformably on the Negri Group, and in Red Rock Creek it overlaps steeply dipping and eroded Headleys Limestone, on to Antrim Plateau Volcanics.

On the eastern side of the Hardman Basin, the relationship of the Elder Sandstone to the Hudson Formation is less well known. Traves (1955) stated that sedimentation was continuous during the deposition of the Negri Group and the Elder Sandstone in the Middle Cambrian. If the Elder Sandstone is Devonian, as suspected, it is most unlikely that sedimentation was continuous. In the type area the contact between the two formations appears to be conformable, but is probably paraconformable: 210 feet of Hudson Formation is present between the two-feet-thick cavernous limestone bed (Table 5) and the base of the Elder Sandstone, while near Mistake Creek Homestead, about 12 miles to the northeast, there is only 30 feet of sediments between what is probably the same limestone and the Elder Sandstone. The difference in thickness was probably caused by erosion before the deposition of the Elder Sandstone.

In view of the discussion on the Hudson Formation (see previous italics) it seems likely that the contact described above is a contact within the Negri Group, i.e. between the Panton and Hudson Formations as mapped by Mendum (1972), and not between the Hudson Formation and Elder Sandstone. A re-examination of aerial photographs confirms that the major change in photopattern and topography is at a higher stratigraphic level than that suggested in this Record (and by Dow & Gemuts, 1967).

The thinning of the sequence above the cavernous limestone in the Hudson Formation could be due to either stratigraphic thinning or erosion. Further mapping and a continued search for diagnostic fossils is recommended.

No fossils have been found in the Elder Sandstone, but it is very similar to the Upper Devonian Cockatoo Formation found to the north, with which it is tentatively correlated.

REFERENCES

BLATCHFORD, T., 1922 - Interim report on the occurrence of glance pitch near the junction of the Negri and Ord Rivers, known as "Oakes Find". Geological Survey of Western Australia, Annual Report for 1921, 90-92.

BLATCHFORD, T., 1928 - Geological observations made while travelling in west Kimberley up the valleys lying between the Pentecost and Kings Rivers, and eastward across the Denham and Ord Rivers as far as Argyle station on the Behn River. Geological Survey of Western Australia, Annual Report for 1927, 10-15.

BULTITUDE, R.J., 1976 - Flood basalts of probable Early Cambrian age in northern Australia. In JOHNSON, R.W., editor - VOLCANISM IN AUSTRALASIA. Elsevier, Amsterdam, 1-20.

DAVID, T.W.E., 1932 - Explanatory notes to accompany a new geological map of the Commonwealth of Australia. The Commonwealth Council for Scientific and Industrial Research, Sydney.

DOW, D.B., & GEMUTS, I., 1967 - Dixon Range, Western Australia - 1:250 000 geological series. Bureau of Mineral Resources, Australia, Explanatory Notes SE/52-6.

DOW, D.B., & GEMUTS, I., 1969 - Geology of the Kimberley Region, Western Australia: The East Kimberley. Bureau of Mineral Resources, Australia, Bulletin 106.

DUNNET, D., 1965 - A new occurrence of Proterozoic 'Jellyfish' from the Kimberley region, Western Australia. Bureau of Mineral Resources, Australia, Record 1965/134 (unpublished).

EDWARDS, A.B., & CLARKE, E. de C., 1940 - Some Cambrian basalts from the East Kimberleys, Western Australia. Journal of the Royal Society of Western Australia, 26, 77-101.

GEMUTS, I., & SMITH, J.W., 1967 - Gordon Downs, Western Australia - 1:250 000 geological series. Bureau of Mineral Resources, Australia, Explanatory Notes SE/52-10.

27

HARMS, J.E., 1959 - The geology of the Kimberley Division, Western Australia, and of an adjacent area of the Northern Territory. M.Sc. Thesis, Adelaide University (unpublished).

HARDMAN, E.T., 1885 - Report on the geology of the Kimberley District, Western Australia. Western Australia Parliamentary Paper 34.

HOBSON, R.A., 1936 - Summary of petroleum exploration in Western Australia to January 1935. Geological Survey of Western Australia, Annual Report for 1935, 22-34.

JACK, R.L., 1906 - The prospects of obtaining artesian water in the Kimberley District. Geological Survey of Western Australia, Bulletin 25.

JONES, P.J., 1976 - Ord Basin. In LESLIE, R.B., EVANS, H.J., & KNIGHT, C.L., editors - ECONOMIC GEOLOGY OF AUSTRALIA AND PAPUA NEW GUINEA. PART 3: PETROLEUM. Australasian Institute of Mining and Metallurgy, Monograph Series 7, 242-6.

JOYCE, A.S., 1965 - Petrography and petrology of selected rock specimens from the Ord River Region, Western Australia. Bureau of Mineral Resources, Australia, Record 1965/209 (unpublished).

KENNEDY, W.Q., 1933 - Trends of differentiation in basaltic magmas. American Journal of Science, 25, 239-56.

McWHAE, J.R.H., PLAYFORD, P.E., LINDNER, A.W., GLENISTER, B.F., & BALME, B.E., 1958 - The stratigraphy of Western Australia. Journal of the Geological Society of Australia, 4(2).

MAHONY, D.J., 1922 - Report on oil prospects near Ord - Negri River Junction, East Kimberley District. Geological Survey of Western Australia File 290/22 (unpublished).

MATHESON, R.S., & TEICHERT, C., 1948 - Geological reconnaissance in the eastern portion of the Kimberley Division, Western Australia. Geological Survey of Western Australia, Annual Report for 1945, 27-41.

28

MENDUM, J.R., 1972 - Limbunya, Northern Territory - 1:250 000 geological series. Bureau of Mineral Resources, Australia, Explanatory Notes SE/52-7.

OPIK, A.A., 1967 - The Ordian stage of the Cambrian and its Australian metadoxididae. Bureau of Mineral Resources, Australia, Bulletin 92, 133-65.

OPIK, A.A., 1970 - Redlichia of the Ordian (Cambrian) of northern Australia and New South Wales. Bureau of Mineral Resources, Australia, Bulletin 114.

PLUMB, K.A., 1967 - Lissadell, Western Australia - 1:250 000 geological series. Bureau of Mineral Resources, Australia, Explanatory Notes SE/52-2.

SWEET, I.P., MENDUM, J.R., BULTITUDE, R.J., & MORGAN, C.M., 1974 - The geology of the southern Victoria River region, Northern Territory. Bureau of Mineral Resources, Australia, Report 167.

TRAVES, D.M., 1955 - The geology of the Ord-Victoria Region, Northern Australia. Bureau of Mineral Resources, Australia, Bulletin 27.

TURNER, F.J., & VERHOOGEN, J., 1960 - IGNEOUS AND METAMORPHIC PETROLOGY. Second edition. McGraw-Hill, New York.

VEEVERS, J.J., & ROBERTS, J., 1968 - Upper Palaeozoic rocks, Bonaparte Gulf Basin of northwestern Australia. Bureau of Mineral Resources, Australia, Bulletin 97.

WADE, A., 1924 - Petroleum prospects, Kimberley District of Western Australia and Northern Territory. Commonwealth of Australia Parliamentary Paper, 142.

TABLE 1 - SUMMARY OF PALAEOZOIC STRATIGRAPHY

EAST KIMBERLEY REGION

AGE	NAME OF UNIT					LITHOLOGY	FOSSILS
	Matheson & Teichert (1948)	Traves (1955)		This Record			
DEVONIAN	Elder Series	Elder Sandstone		Elder Sandstone		White and pink cavernous sandstone, basal quartz conglomerate in places	
		Unconformity					
LOWER MIDDLE CAMBRIAN		Negri Group	Hudson Shale	Negri Group	Hudson Formation	Ferruginous micaceous sandstone and subordinate red siltstone. Rare flaggy limestone.	Fossil "jellyfish", *Biconulites hardmani*
	Negri Series		Corby Limestone Negri River Shale Shady Camp Lmst. Panton Shale		Panton Formation	Interbedded grey siltstone, shale, and subordinate limestone	*Girvanella* sp., *B. hardmani*, *Redlichia* sp., *Xystridura* sp., *Wimanella* sp., *Billingsella* cf. *humboldti*
			Linnekar Limestone		Linnekar Limestone	Limestone and marl.	*Redlichia forresti*, *B. hardmani*, *Girvanella* sp.
			Nelson Shale		Nelson Shale	Shale and siltstone, partly gypsiferous and calcareous rare thin limestone beds	
			Headleys Limestone		Headleys Limestone	Fine-grained grey limestone	
		Possible unconformity					
PROBABLE LOWER CAMBRIAN	Basaltic Rocks	Antrim Plateau Volcanics		Antrim Plateau Volcanics		tholeiitic basalt, minor basalt agglomerate, andesite and some dolerite.	

TABLE 2

Section of Antrim Plateau Volcanics measured near Bungle Bungle outcamp

Thickness in feet	Apparently conformable contact with Headleys Limestone
200	fine-grained greenish basalt
200	amygdaloidal basalt
400	purple vesicular basalt breccia
280	purplish, green non-vesicular basalt
265	amygdaloidal basalt
soil profile	
150	olivine basalt
320	purplish-grey basalt
170	green basalt
110	very vesicular basalt
210	grey basalt
110	medium-grained purplish-green pyroxene basalt
250	purple scoriaceous basalt
30	purple basalt with chilled margins
soil profile	
75	purple vesicular basalt
310	purplish-green basalt
200	purplish-grey vesicular basalt containing many green zeolites
Total 3280	Base not seen

TABLE 3 - Lithological log of the Okes-Durack bore (after Hobson, 1936)

Formation	Thickness (feet)	Lithology
Panton Formation	7	Reddish brown mudstone
Linnekar Limestone	27	Blue flaggy limestone, with nodular fossils (Girvanella)
	24	Blue calcareous shale with thin seams of gypsum and thin bands of hard crystalline limestone and some pyrites. Fossils between 45 and 55 feet.
	8	Blue to grey limestone with nodular fossils
Nelson Shale	49	Grey, brown, and blue shale, with gypsum and hard streaks
	140	Brown mudstone with patches of blue crystals of gypsum (looks like a flaggy sandstone in places)
	12	Grey shale with patches of blue
	204	Brown to reddish sandy mudstone with bands of grit, veins of crystalline gypsum and small crystals of pyrites
	24	Blue-grey shale
	139	Brown sandy mudstone, calcareous in places
	2	Grey limestone, water rose to within 9 feet of the surface
	21	Brown mudstone
Headleys Limestone	6	Thin limestone cap covering hard banded chert
	125	Grey limestone, crystalline, hard and massive. Gas noticeable in sludge. Petroliferous odour. Slightly foetid from presence of sulphur; brecciated chert in lower few feet
Antrim Plateau Volcanics	408	Light blue to grey basalt

TABLE 4 - Type section of the Panton Formation

Formation	Thickness (feet)	Lithology
Hudson Formation	-	Thinly flaggy to platy chocolate-brown sandstone and interbedded greenish-cream micaceous quartz siltstone.
		conformable contact
Panton Formation	10	Fine-grained, grey limestone. Massive in the lower part, grading to platy at the top; wavy laminations are characteristic of the massive beds where chert nodules are common.
	170	Platy green and red-brown micaceous siltstone, which grades into very fine-grained micaceous sandstone. Both are commonly calcareous.
	45	Greenish-cream micaceous siltstone, which crops out very poorly. Thin plates of limestone crowded with Biconulites hardmani and containing rare trilobite fragments.
	10	Massive fine-grained grey limestone four feet thick, which grades upwards into platy limestone crowded with B. hardmani.
	300	Brown, red, and grey, siltstone and shale, which are generally micaceous. Commonly calcareous and rarely gypsiferous. Rare thin beds of fine-grained limestone.
	Total:535	
		conformable contact
Linnekar Limestone	-	Flaggy to platy, blue to grey fine-grained limestone

TABLE 5 - Section of the Panton Formation measured at Mount Panton by Matheson & Teichert (1948)

Thickness in feet	Lithology
10	Hard, massive limestone with *Girvanella* and *Biconulites hardmani*
16	Grey shale, unfossilifeous
12	Flaggy limestone with rich trilobite layers (*Redlichia* and *Xystridura*)
12	Grey shale
6	Flaggy limestone with abundant *Xystridura*
19	Grey shale with *Redlichia* and *Xystridura*
5	Flaggy limestone
24	Grey shale
1	Limestone with *Biconulites hardmani* and *Wimanella* sp.
9	Grey shale
1	Limestone with *Biconulites hardmani* and *Wimanella* sp.
20	Grey shale with *Redlichia* sp.
10	Hard massive limestone with *Girvanella* and *Biconulites hardmani*
135+	Red and grey shales, unfossiliferous
Total 280+	

TABLE 6 - Type section of the Hudson Formation

Formation	Thickness in feet	Lithology
Elder Sandstone	-	Medium-grained quartz sandstone which is massive to thick-bedded and contains ubiquitous cross-bedding
		probable unconformity
Hudson Formation	25	Thinly flaggy, fine-grained, red, micaceous quartz sandstone with some red shale partings. Some ripple marks, worm tracks, and rare shale pebbles are found in the sandstone. There are some interbeds, six inches thick, of green ferruginous quartz sandstone.
	60	Thinly flaggy to laminated, red, micaceous, siltstone and shale grading into predominantly flaggy quartz sandstone at the top. Swash ripple marks common. Beds of green fine-grained quartz sandstone between one inch and six inches thick are common.
	80	Thinly flaggy to platy, red, micaceous siltstone with very thin red shale partings. Some beds up to six inches thick of medium-grained quartz sandstone. Ripple marks common.
	45	Laminated green to lilac micaceous siltstone. Partings of subordinate red shale.
	2	Greenish-grey, cavernous limestone, which is slumped in places. Copper staining and cavity fillings common. Abundant Biconulites hardmani.
	75	Thinly flaggy, purple-brown micaceous quartz sandstone. Consists of medium-sized well-rounded grains of quartz in a ferruginous argillaceous matrix.
	165	Thinly flaggy to platy chocolate-brown micaceous quartz sandstone which grades into siltstone.
	25	Thinly flaggy to platy chocolate-brown sandstone similar to above. Interbedded with greenish-cream micaceous quartz siltstone.
	Total 477	
		conformable contact
Panton Formation	10	Massive grey fine-grained limestone.