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THE GEOLOGY OF THE ORD BASIN: A REVIEW

by

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SUMMARY

The Ord Basin straddles the border between Western Australia and Northern Territory in the area drained by the middle and lower reaches of the Ord River. It contains about 570 m of shales and fossiliferous marine limestones (the Negri Group) of early Middle Cambrian (Ordian) age, which were probably originally continuous, but now occur in three main structural basins (the Hardman, Rosewood, and Argyle Basins; a total area of about 8,400 km^2). The depositional basin developed over about 31,000 km^2 of the Antrim Plateau Volcanics (Upper Adelaidean - ?Lower Cambrian) in the southern half of the Victoria River Basin, and is itself overlain by residuals of ?Devonian and Cainozoic sediments.

The exploration, and tectonic setting of the basin are briefly discussed. A short outline of its Phanerozoic history leads to the conclusion that its petroleum possibilities are minimal. The gentle synclinal structure of the basin, the erosional periods between the Cambrian and the Devonian, and after the Devonian, could have permitted any possible accumulation of hydrocarbons to escape.

INTRODUCTION

The Ord Basin lies directly south of the Bonaparte Gulf Basin, from which it is separated by a narrow belt of intensely deformed metamorphic and igneous Precambrian rocks (the Halls Creek Mobile Zone of Traves, 1955). The name was originally used by Gentilli & Fairbridge (1951) to delineate the physiographic province drained by the middle and lower reaches of the Ord River, and was adopted by McWhae et al., (1958) for the depositional basin. It contains about 570 m of dominantly marine Middle Cambrian sediments, which were probably originally continuous, but now occur in three main structural basins (the Hardman, Rosewood, and Argyle Basins of Matheson & Teichert, 1948; Fig. 1).

The basin developed over the Upper Adelaidean-?Lower Cambrian Antrim Plateau Volcanics in the southern half of the Victoria River Basin (G.S.A., 1971), and is itself overlain by residuals of Devonian and Cainozoic sediments (Fig. 2); (these are briefly described in this paper, in order to complete the account of the Phanerozoic history of the region). The margin of the basin, as shown by Traves (1955, fig. 6), defines a physiographic province (which includes the Antrim Plateau Volcanics), roughly triangular, covering an area of about 31,000 km^2, and distributed about equally on each side of the border between Western Australia and the Northern Territory. The sedimentary sequence, however, covers only about 8,400 km^2, and lies mostly in Western Australia.

PREVIOUS INVESTIGATIONS

The earliest geological work in the Ord River was by Hardman (1885), whose widespread investigations included the mapping of the Hardman Basin. Jack (1906) reported on the hydrology of the southwestern part of the region, but little was added to the knowledge of the geology until the discovery of asphaltite near the junction of the Ord and Negri Rivers in 1920 (Maitland, 1920; Blatchford, 1922) initiated interest in petroleum prospects in the area (Mahony, 1922).

Wade (1924) made a valuable contribution to the stratigraphic knowledge of the East Kimberley region, and reported on the prospects of finding commercial quantities of petroleum in the area.

Matheson & Teichert (1948) made a major contribution to the geological knowledge of the Ord Basin in their report and reconnaissance maps of the Cambrian rocks in the structural basins. Their report contains an excellent summary and bibliography of the literature up to 1945, and assesses the petroleum potential of the region. Geological knowledge of the region was further advanced by Traves (1955), who is responsible for many of the formation names used at the present time.

In 1963, the Western Australian side of the Ord Basin, which is contained within the Dixon Range (Dow & Gemuts, 1967) and Lissadell (Plumb, 1968) 1:250 000 Sheets, was mapped by the Bureau of Mineral Resources and the Geological Survey of Western Australia. During the same year, the Palaeozoic rocks of the Ragged Range Outlier, south of the Bonaparte Gulf Basin and west of the Ord Basin, were mapped by Kaulback & Veevers (1969). In 1969, the Northern Territory side of the basin was mapped by the Bureau of Mineral Resources in the areas covered by the Limbunya (Mendum, 1972) and Waterloo (Sweet, 1973) 1:250 000 Sheets. The geology of the southern Victoria River region has been described by Sweet, Mendum, Bultitude, & Morgan (in prep.). Öpik (1958, 1967, 1970), who took part in the earlier survey by Traves, has produced palaeontological data of considerable biostratigraphic importance, based on his collections and those of later surveys. These suggest that some revision of the mapping is required.

TECTONIC SETTING

Tectonically, the Ord Basin is the uppermost part of the Sturt Block - a relatively stable mass of mostly unaltered Adelaidean sedimentary rocks, situated on the eastern side of the Halls Creek Mobile Zone. Its western margin is marked by the Halls Creek Fault, and by fault wedges of Precambrian rocks between it and its north-easterly splay faults. Both the Antrim Plateau Volcanics and Middle Cambrian sediments have been faulted and eroded to a level where the sediments are preserved in three structural basins. These are from north to south:

(a) The Argyle Basin, about 40 km long and 11 km wide; its long axis trends northeast, parallel to the Halls Creek Fault.

(b) The Rosewood Basin, about 64 km long and 18 km wide, with its long axis trending east-northeast.

(c) The Hardman Basin, 120 km long and 56 km wide, originally referred to by Wade (1924, p.26) as the Ord River Basin. Its long axis trends northeast in Western Australia and swings southeast in the Northern Territory.

STRATIGRAPHY

LATE ADELAIDEAN-CAMBRIAN

In Late Adelaidean to possibly Early Cambrian time, basaltic lavas of the Antrim Plateau Volcanics were extruded over a wide, deeply eroded surface of Adelaidean rocks (the Albert Edward Group), with a marked regional angular unconformity. The volcanics, described by Edwards & Clarke (1940) as a single province of tholeiitic basalts, are about 915 m thick. They consist of several lava flows of amygdaloidal and massive basalts, and thin lenses of sandstone, siltstone, limestone, and chert. The latter contains the stromatolites _Conophyton basalticum_ and _C._ cf. _gaubitza_; in the U.S.S.R., _Conophyton_ is restricted to the Precambrian and _C. gaubitza_ is probably Vendian (Walter, 1972). Lava flow thicknesses range from less than 15 m up to about 110 m; most flows are less than 50 m thick, and many are traceable for several kilometres. Locally, agglomerate and about 9 m of red-brown cherty quartz sandstone occur at the base. The sandstone, which contains quartz grains of probable aeolian origin, may have been deposited in lakes on the Adelaidean land surface. Weathering profiles within the basalts suggest that there may have been three distinct periods of subaerial extrusion. One such highly ferruginous profile at the top of the Antrim Plateau Volcanics may represent a smaller hiatus than the angular unconformity at its base. For other accounts of the Antrim Plateau Volcanics the reader is referred to Dunn & Brown (1969), Prider (1969), Bultitude (1971), and Walter (1972).

In early Middle Cambrian time, alternating limestones and shales with gypsum (the Negri Group), probably representing cycles of marine and non-marine evaporitic conditions (Öpik, 1956, p. 262), were deposited over the Ord River area and beyond the present accepted limits of the basin itself. The oldest sediments of the Negri Group (_sensu_

Traves, 1955) are preserved in the Ragged Range Outlier as the Blatchford Formation. They contain the trilobite Onaraspis adusta and the pteropod Biconulites hardmani, the oldest faunal assemblage of the Ordian Stage - the basal stage of the Middle Cambrian (Öpik, 1967, 1970). The formation, at least 120 m thick, consists of dolomitic siltstone with fossiliferous interbeds of glauconitic dolomite, overlain by dolomitic quartz sandstone. It unconformably overlies the Antrim Plateau Volcanics, and is unconformably overlain by the Devonian Ragged Range Conglomerate (Kaulback & Veevers, 1969).

In the Hardman Basin, the Negri Group has a maximum thickness of 573 m, and overlies the Antrim Plateau Volcanics with only slight angular unconformity. There are no unconformities within the Group. Each formation is considerably thinner on the eastern side of the Hardman Basin than on the western side. This indicates that although the basin is preserved for structural reasons, its origin is depositional (D.B. Dow, pers. comm.). The base of the Negri Group in the Hardman Basin - the Headleys Limestone - consists of 46 m of massive grey limestone with chert nodules, overlain by laminated and thin-bedded grey limestone. Its age is Ordian (Öpik, 1967, p. 148; see reference to the Mount Panton sequence, below), and according to Traves (1955, p. 38), may be equivalent to that of the Montejinni Limestone, which overlies the Antrim Plateau Volcanics to the east, in the Wave Hill and Victoria River Downs areas.

The Nelson Shale contains a maximum thickness of 180 m of shale and siltstone with gypsum and pyrite, and minor thin lenses of limestone and sandstone. No fossils have been found; its age, by intrapolation, is Ordian.

The Linnekar Limestone consists of 18-40 m of fossiliferous grey limestone, medium-bedded for the lowest 3-6 m, and thin-bedded with thin marl interbeds for the remainder. Redlichia forresti and Biconulites hardmani occur in the marly interbeds at the junction of Linnekar Creek and Brook Creek (Wade, 1924; Matheson & Teichert, 1948; Öpik, 1958). This is Öpik's (1970) Assemblage 4 of the Ordian Stage.

The Panton Formation (sensu Dow & Gemuts, 1967) is the name applied to 157 m of shale and subordinate interbedded limestone between the Linnekar Limestone and the Hudson Formation. Dow & Gemuts combined four of Traves' (1955) formations - in ascending order the Panton Shale, Shady Camp Limestone, Negri River Shale, and Corby Limestone, into the one unit. Biostratigraphic studies and detailed mapping are required to elucidate this sequence, and for this purpose, Traves' formations still provide a framework for any revisions. For example, the limestone and shale sequence at Mount Panton, identified by Traves (1955, p. 41) as Shady Camp Limestone, is placed by Öpik (1967) below the Linnekar Limestone, and below the beds with Redlichia forresti. The Mount Panton strata contain the oldest species of Redlichia so far known in the Ordian - R. amadeana - which is associated with an undescribed new species of Xystridura (Öpik, 1970); this is Öpik's (1970) Assemblage 5 of the Ordian stage. Other fossils include the much cited Biconulites hardmani, Wimanella, and Girvanella (Matheson & Teichert, 1948; Traves, 1955; McWhae et al., 1958). The Shady Camp Limestone, on the other hand, contains the Redlichia forresti fauna. The top of the Panton Formation is marked by the Corby Limestone of Traves (i.e., the fourth limestone unit of Matheson & Teichert, 1948). It consists of 3 m of hard, laminated dolomite and limestone with small chert nodules. Biconulites is present.

The Hudson Formation is the name given to the top unit of the Negri Group. As defined by Dow, Gemuts, Plumb, & Dunnet (1964), the Hudson Formation includes both the Hudson Shale and the lower part of the Elder Sandstone of Traves (1955). It consists of about 150 m of red and grey siltstone and marl with some thin beds of glauconitic limestone, grading upwards into brown micaceous sandstone. Thus, the Hudson Formation marks the transition from the cyclic deposition of limestones and shales to the deposition of sandstone. The only fossils known are the remains of probable jellyfish collected from the Dixon Range. (These are erroneously reported from the Elder Sandstone by Dow & Gemuts, 1967, table 4).

DEVONIAN

After Ordian time, the area was probably a land surface during most of Cambrian, Ordovician, and Silurian time, for no sediments remain. The next marine transgression probably took place in the Devonian, when the Elder Sandstone was deposited on the Negri Group with an erosional unconformity, and in places overlap on to the Antrim Plateau Volcanics. It was the recognition of this unconformity in the Dixon Range area which led Dow et al., (1964) to restrict the name Elder Sandstone to the upper part of the Elder Sandstone of Traves (1955). In the north-eastern part of the Hardman Basin, this unconformity is more difficult to recognize, because there the contact between the Hudson Formation and the Elder Sandstone is paraconformable. The Elder Sandstone is about 200 m thick, and consists of 18 m of basal conglomerate, overlain by massive and cross-bedded quartz sandstone. No fossils have been found, but the discovery of probable Upper Devonian pelecypods and gastropods in the Ragged Range Conglomerate, point to the possibility that the Elder Sandstone (sensu Dow & Gemuts, 1967), with which Reeves (1948) and

Traves (1955) identified the Conglomerate, is itself Devonian (Kaulback & Veevers, 1969, p. 30).

TERTIARY

Tertiary sediments, which rest directly on the older rocks already described, include veneers of terrestrial gravel, sandstone, siltstone, and some laterite. The main record is preserved as small residual outliers at White Mountain, and is no older than Miocene (Lloyd, 1968). Here, the White Mountain Formation consists of 113 m of chert, shale, marl, siltstone, and a little quartz sandstone. The chert contains freshwater gastropods and ostracods (Chapman, 1937; McMichael, 1968), and the marine foraminifer Ammonia beccarii (Lloyd, 1968a b). This anomalous association suggests to Lloyd (1968 a, b) a brief incursion of the sea into a lacustrine environment, perhaps during the latest Miocene or Pliocene, and perhaps at the time when parts of surface III (of Van Andel & Veevers, 1967) possibly became a marine depositional surface, after the mid-Miocene diastrophism of the Timor Sea region (Veevers, 1969).

STRUCTURE

Over the greater parts of the Hardman, Rosewood, and Argyle Basins, the rocks have a gentle regional dip to the northwest. The markedly asymmetrical structure of these basins is the result of upward drag along faults on their western and northwestern margins. The northeastern end of the Hardman Basin has been deformed by a north-westerly faulted monocline - the 'Kelly Creek Anticline' of Matheson & Teichert (1948, p. 79). This lies on the line of a large shear-zone which affects the Halls Creek Group (Archaean or Lower Proterozoic) near the junction of the Ord and Negri Rivers. The White Mountain Formation, which has been slightly tilted and buckled, probably owes its elevated position to Tertiary movement on the fault. Minor northwesterly faults along the southern margin of the Hardman Basin affect both the Headleys Limestone and the Antrim Plateau Volcanics.

PETROLEUM POSSIBILITIES

Asphaltite has been reported from several localities in the Antrim Plateau Volcanics as a black shiny residue in vesicles and cavities in basalt (Simpson, 1921; Blatchford, 1922; Farquharson, 1922; Mahony, 1922; Wade, 1924; Matheson & Teichert, 1948; Traves, 1955). After its discovery in 1920 near the junction of the Ord and Negri Rivers, the Okes-Durack Kimberley Oil Company drilled on the Kelly Creek Anticline, in the Negri Group near White Mountain. The bore began in Linnekar Limestone, passed through Nelson Shale and Headleys Limestone, and penetrated 122 m into Antrim Plateau Volcanics. Although traces of gas and possibly oily matter were found, Wade (1924) concluded that it was impossible that oil was present in commercial quantities in the Ord River area. Blatchford (1927), Hobson (1936), and Reeves (1951) also reported unfavourably on the prospects of finding oil accumulations.

The source of the asphaltite is not known. Wade (1924) is of the opinion that it is an oil residue from the Negri Group; Matheson & Teichert (1948) thought that the source rocks were in the Upper Palaeozoic sequence to the north, now known as the Bonaparte Gulf Basin; whereas Traves (1955) suggests that the dark shales of his Victoria River Group with more than 600 m of sediments, including algal limestones, is a more likely source. Dow & Gemuts (1969) also tentatively suggest a Precambrian source, possibly the Albert Edward Group of the Victoria River Basin.

The possibility of finding petroleum in commercial quantities in the Ord Basin is remote, mainly because the sedimentary sequence lacks suitable traps. The gentle synclinal structure of the basin, the erosional periods between the Cambrian and the Devonian, and after the Devonian, could all have permitted the escape of hydrocarbons.

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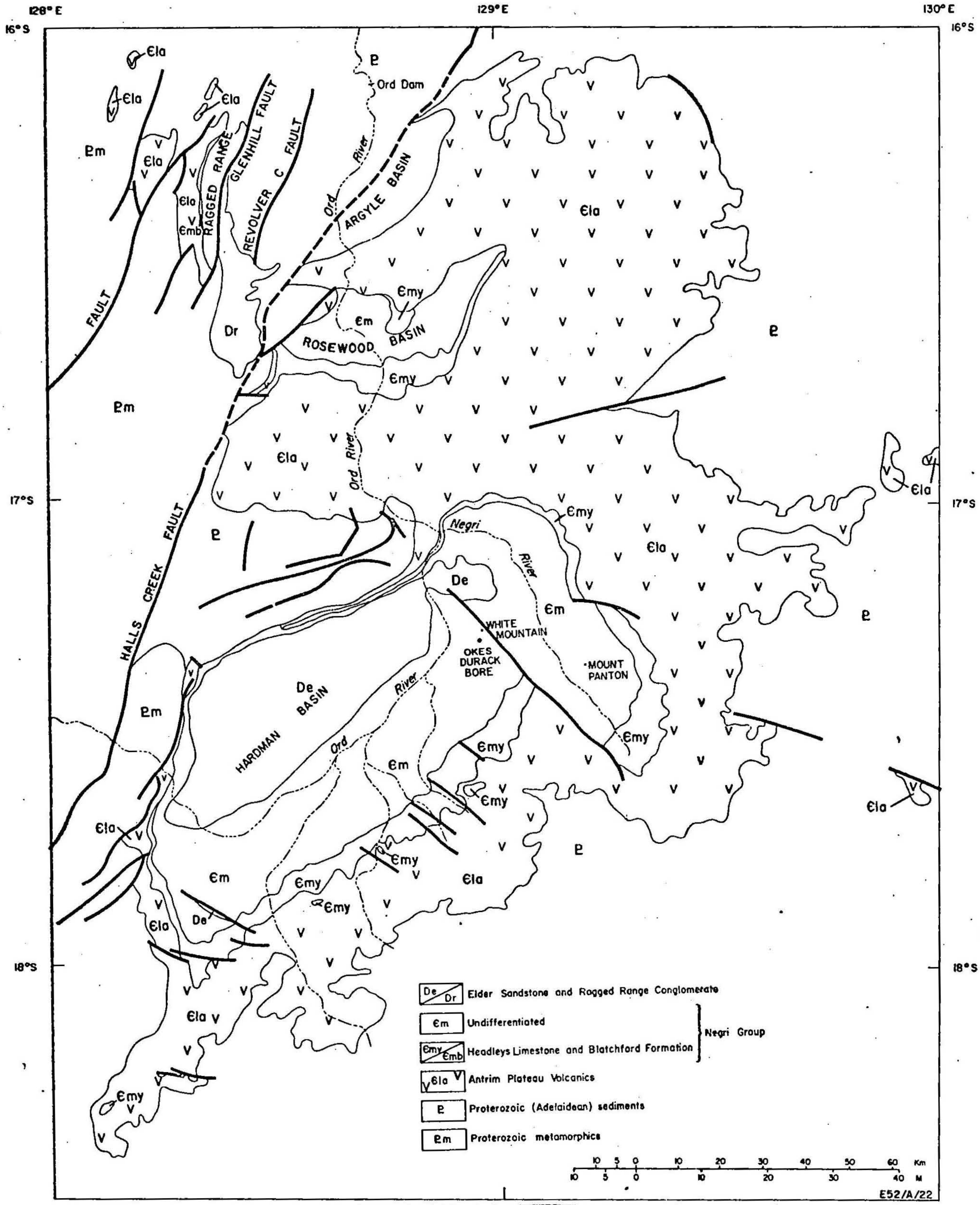

Fig. 1 Geological sketch-map of the Ord Basin.

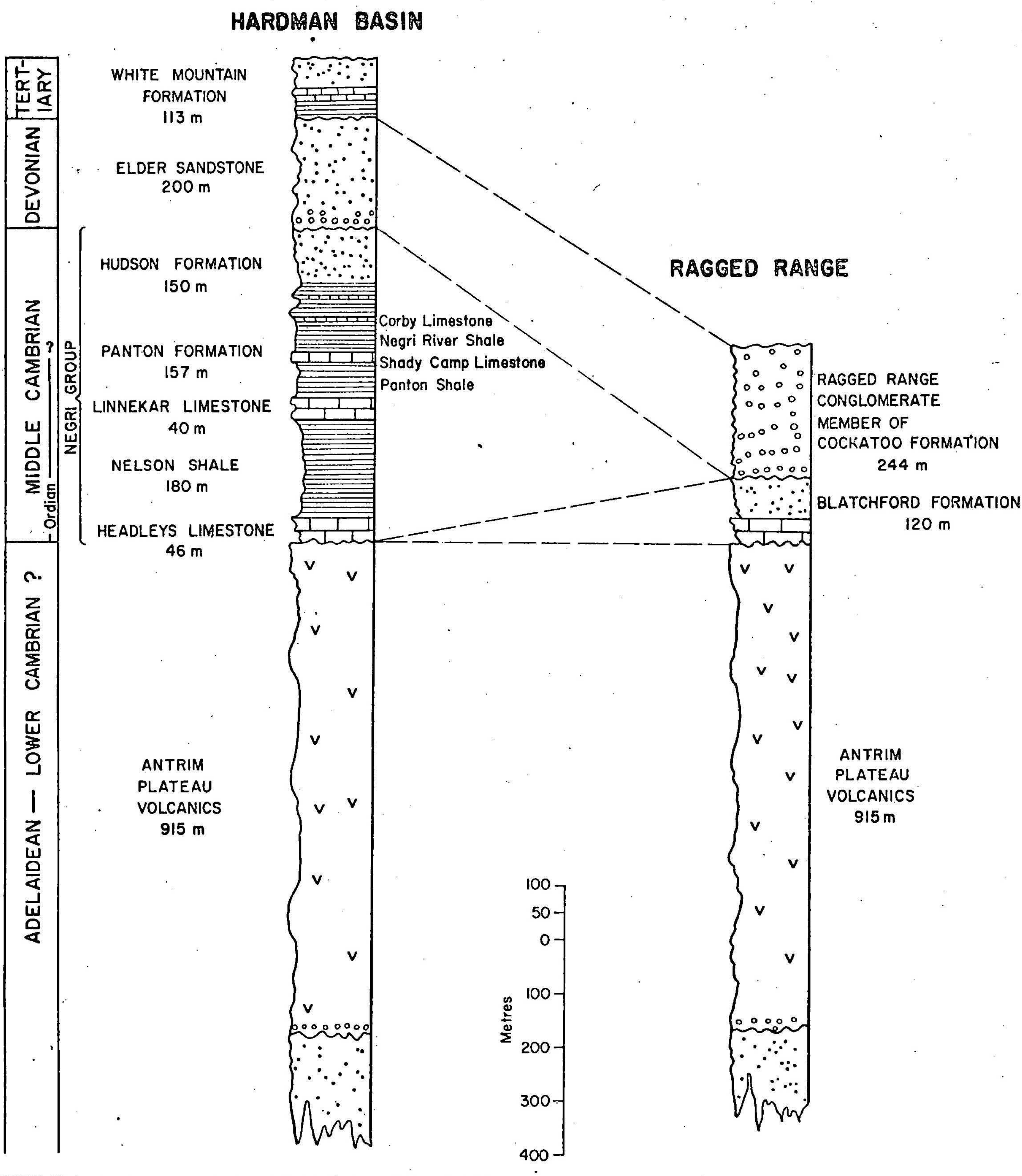

Fig. 2 Composite section of uppermost Adelaidean-Middle Cambrian, Devonian and Tertiary rocks in the Hardman Basin and the Ragged Range Outlier.

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