

A new Devonian fish fauna, and revision of post-Ordovician stratigraphy in the Ross River Syncline, Amadeus Basin, central Australia.

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A Devonian microvertebrate fauna from the N'Dahla Member, previously assigned to the Cambro-Ordovician Pacoota Sandstone, has led to a revision of the stratigraphy in the Ross River Syncline. The N'Dahla Member is included in the Devonian Pertnjara Group, and is correlated on faunal evidence with the Deering Siltstone Member of the Parke Siltstone in the central Amadeus Basin. The overlying sandstone, previously mapped as Mereenie Sandstone, is presumed to be equivalent to one of the overlying formations of the Pertnjara Group. The N'Dahla Member rests with angular

unconformity on the underlying Pacoota Sandstone, this break possibly representing both the Rodingan and Pertnjara Movements of other authors. Evidence of the Devonian Pertnjara Movement in the Amadeus Basin is reviewed, and the possibility that the Mereenie Sandstone was never deposited in the Ross River sequence is discussed. The recognition of Mereenie Sandstone in other outcrops and wells in the eastern part of the Amadeus Basin requires re-examination.

Introduction

The N'Dahla Member of the Pacoota Sandstone (Cambro-Ordovician) was defined by Wells & others (1967, p.45) as a thin sequence of clayey and pebbly sandstone, with minor beds of conglomerate and thin beds of limestone, exposed in its type locality at the top of the Pacoota Sandstone at N'Dhala Gorge, in the Ross River Syncline, northeast Amadeus Basin (Fig. 1). Lithology was described as a 'dark red-brown to purple-brown medium to coarse-grained glauconitic poorly sorted friable porous and clayey sandstone'. Minor pebbles, conglomeratic beds of siltstone and limestone fragments, and thin beds of limestone were also recorded. Fossils listed from the N'Dahla Member included trilobites, gastropods, nautiloids, and worm tracks,

indicating an Early Ordovician (late Tremadocian) age, and representing the middle of three informal time units designated for the Pacoota (Wells & others, 1970, p. 66). Some differences in outcrop and lithology were noted between the N'Dhala Gorge type locality, where the member 'weathers recessively and forms the waning slopes beneath a steep scarp of Mereenie Sandstone', and farther west on the northern limb of the Ross River Syncline where it was said to be more resistant, forming 'part of the ridge of Pacoota Sandstone' (Wells & others, 1967, p. 45). As mapped (BMR, 1983) this western part of the member was shown to be overlain by another sandstone of the Pacoota Sandstone, which was in turn overlain with a low-angle unconformity by the Mereenie Sandstone (?Siluro-Devonian). The unconformity was said to be clearly visible on air photos (Wells & others, 1967, p.48).

Fish scales suggesting a Devonian age were first noted in a sample submitted by Pancontinental Petroleum (J.D. Gorter) to R.S. Nicoll for conodont analysis. Further samples were collected by G.C. Young in the 1984 field season, and yielded an abundant microvertebrate fauna, together with reworked Early Palaeozoic microfossils, as summarised below. The vertebrate fauna is distinctively Devonian, and quite different

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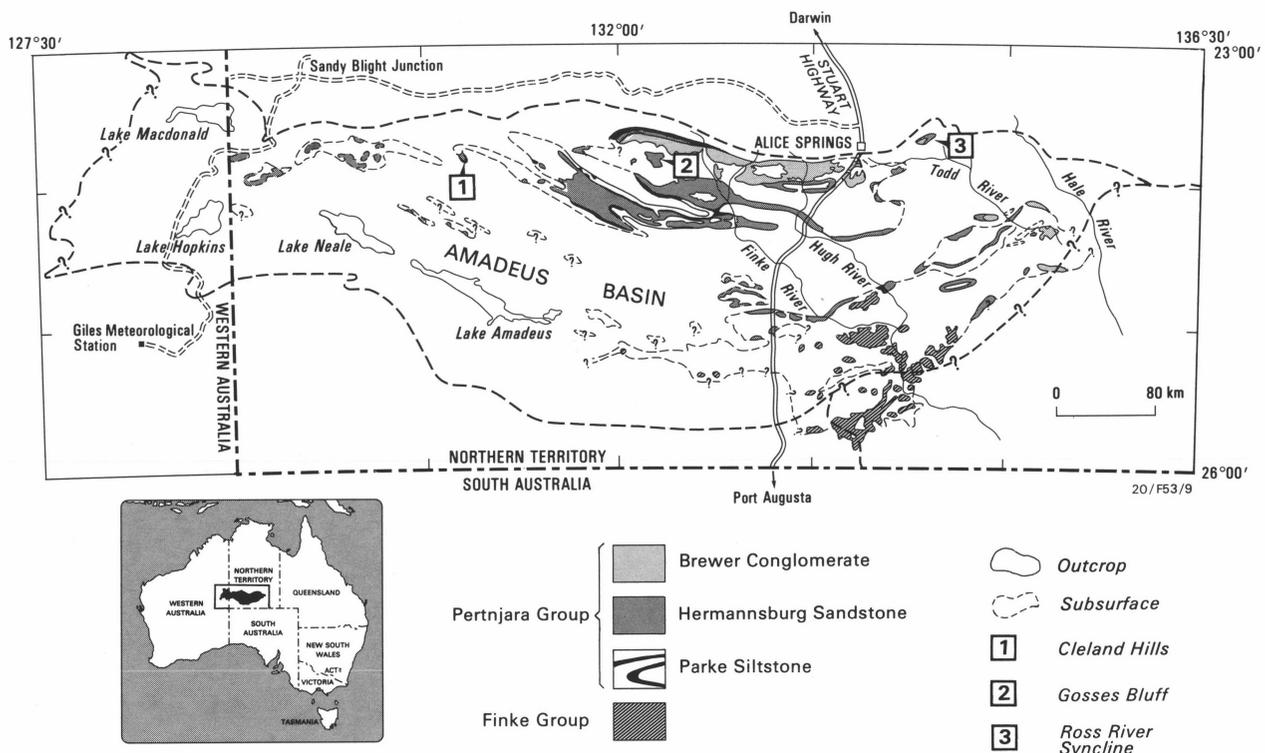


Figure 1. Amadeus Basin, central Australia, showing the distribution of Devonian rocks (Pertnjara and Finke Groups) and the three general localities discussed in this paper.

The new fish fauna reported here comes from the Ross River Syncline (locality 3).

from the vertebrate assemblage of Ordovician age known from elsewhere in the Amadeus Basin (e.g. Ritchie & Gilbert-Tomlinson, 1977). This new fauna has required a reinterpretation of the geology of the N'Dhala Gorge area and the stratigraphy of the sequence in the Ross River Syncline above the Pacoota Sandstone. The N'Dahla Member has been reassigned to the Devonian Pertnjara Group, as a member of its lowermost formation, the Parke Siltstone (Fig. 4).

Geology of the N'Dhala Gorge area

The first samples containing Devonian thelodont fish scales were collected (J.D.G.) adjacent to the car-park at N'Dhala Gorge (locality 1, Fig. 2), close to the site of earlier samples (AS257-259, collected in the 1960s) on which an Ordovician age for the N'Dahla Member was based. Much of the N'Dahla Member in this area is covered by scree, and a detailed re-assessment, assisted by the aerial photographs used in the original mapping, has led to a revision of the geology.

It is apparent that the contact between the N'Dahla Member and the underlying Pacoota Sandstone was placed too low in the sequence in the original mapping, and that samples

AS257-259 were not collected from a horizon well within the N'Dahla Member, but came either from the basal part of the member or from the quartz arenite developed at the top of the underlying Pacoota Sandstone. This arenite forms a prominent dip slope around the closure of the Ross River Syncline, and is the highest horizon in the area in which macrofossils, apart from trace fossils, were observed during the 1984 field work. A re-examination of the original samples supports a mixed source. AS257 contains abundant fossil fragments, too incomplete for identification, but similar in appearance to those in the Pacoota, but which may have been reworked, since the lithology suggests that this specimen came from the N'Dahla Member. AS258 is of typical Pacoota lithology, with *Cruziana* and *Skolithos* type trace fossils. Its atypical red coloration could indicate derivation from the Palaeozoic weathered surface forming the top of the Pacoota Sandstone beneath the unconformity. Sample AS259 could not be located, but two further samples collected during the original mapping from near the westernmost exposure of the N'Dahla Member, about 3.5 km east of Williams Bore, were also examined. One of these (AS230) is of typical N'Dahla lithology, and contains abundant moulds of a small gastropod, which are too poorly preserved for identification. AS231 contains trilobite fragments and, together with

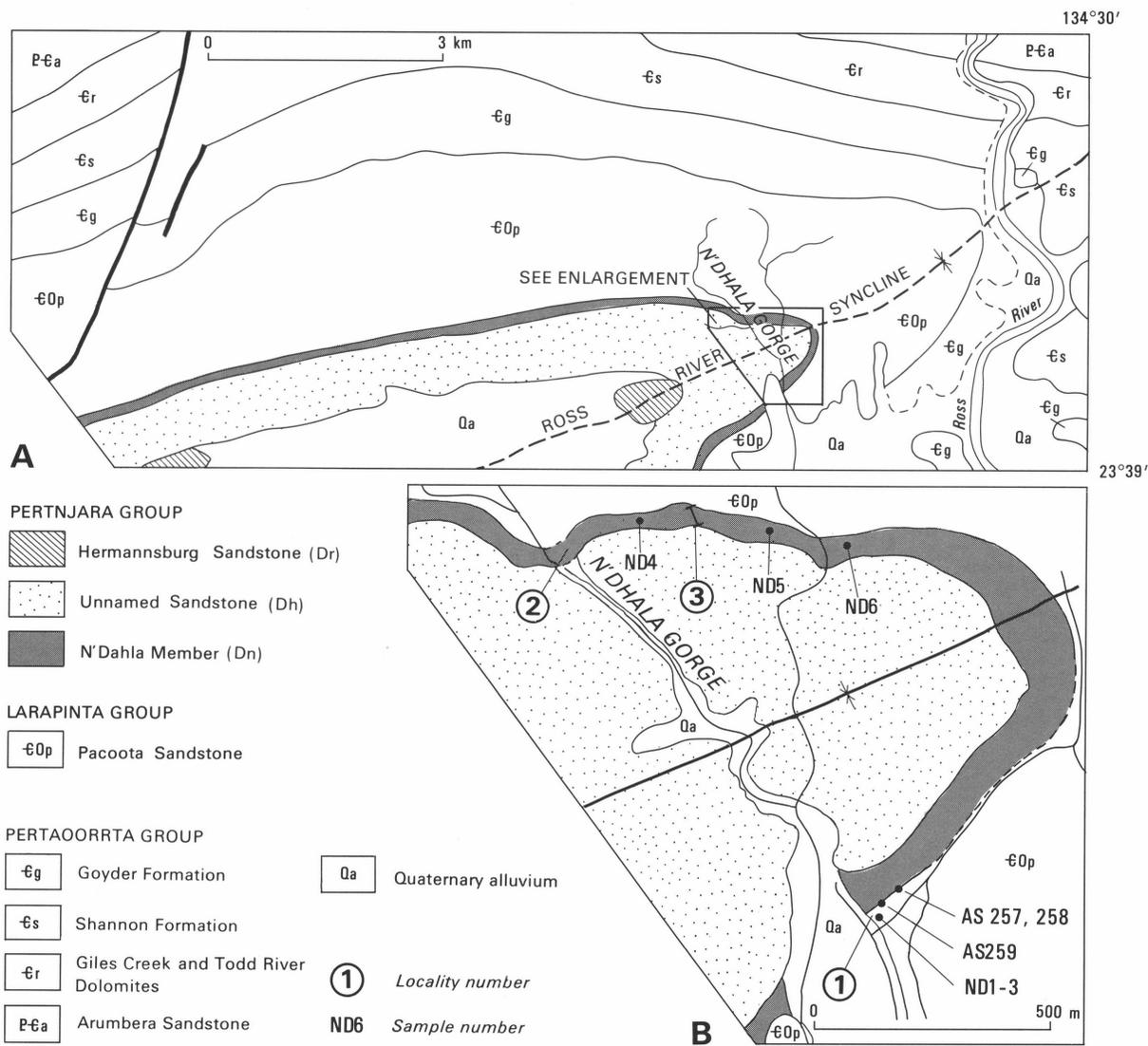


Figure 2. A — Geology of the Ross River-N'Dhala Gorge area, modified after the 1:100 000 Geological Special Sheet, Geology of the Alice Springs Region (BMR, 1983); B — N'Dhala Gorge area, showing field localities (1-3), and collecting sites for the original palaeontological samples (AS257-259), and the new samples reported here (ND1-6).

lithology, clearly indicates derivation from the underlying Pacoota Sandstone. Thus, the mixed derivation of these samples and the problem of reworked fossils (see below) render them unreliable for dating purposes. New samples (ND 1-3) collected in 1984 from the vicinity of the original fish samples contained conodonts indicating an Ordovician age, but no fish remains. Reference to the original aerial photographs indicates that these samples come from a horizon just below that of samples AS257-259.

On the published map (BMR, 1983), the N'Dahla Member on the northwestern limb of the Ross River Syncline is shown as overlain by another sandstone of the Pacoota, which extends as far east as the northwestern opening of N'Dhala Gorge (locality 2, Fig. 2). Here it is truncated by a low-angle unconformity at the base of the overlying Mereenie Sandstone. This interpretation was based on a study of aerial photographs, so this area was also examined in the 1984 field season, and further samples were collected for microfossils.

Field examination indicates that the sequence here is the same as at the southeastern end of N'Dhala Gorge. The sandstone previously interpreted as overlying the N'Dahla Member in fact underlies it and corresponds to the previously mentioned uppermost quartzitic strata of the Pacoota Sandstone, which crop out around the northeastern closure of the syncline. The underlying strata, which crop out on the southern slope of the valley immediately to the north of the gorge, were previously interpreted from aerial photographs as the recessive N'Dahla Member. However, this valley, which is formed by the creek that flows through N'Dhala Gorge, is in fact developed within a recessive shaly part of the Pacoota

Sandstone. Looking west from the northwestern opening of the gorge, the upper part of the Pacoota can be seen to form a prominent strike ridge, overlain by the more recessive beds of the N'Dahla Member. The more resistant uppermost Pacoota Sandstone can be traced along strike across the opening of the gorge to the eastern side (locality 2, Fig. 2), where it can be seen to lie stratigraphically immediately beneath the N'Dahla Member. Lithology of the uppermost Pacoota Sandstone at this locality comprises interbeds 100-300 mm thick of sandstone and mudstone, with abundant vertical burrows and desiccation crack impressions, and some layers with numerous mud clast impressions. Poorly preserved gastropods (probably *Lecanospira* Butts 1926) are common in some beds.

The overlying N'Dahla Member at locality 2 is largely obscured by scree, and crops out poorly as a micaceous red siltstone, which may be very gritty, with small pebbles and pieces of limestone. Spot samples collected along strike to the east (ND4-6, Fig. 2) contained an abundant microvertebrate fauna (see below). The member was followed along strike around the closure of the syncline and back to the southeastern entrance of N'Dhala Gorge at the car park. Good exposures were only encountered in the gullies adjacent to the two northern openings of the gorge, and in small washouts on the eastern and southern scree slopes. The only locality where the sequence from the Pacoota Sandstone through the N'Dahla Member to the overlying sandstone is reasonably exposed is on the saddle between the two northern openings of the gorge. An approximate section measured through the N'Dahla Member at this locality (3, Fig. 2), is given in Fig. 3A. This is designated the type section for the N'Dahla Member.

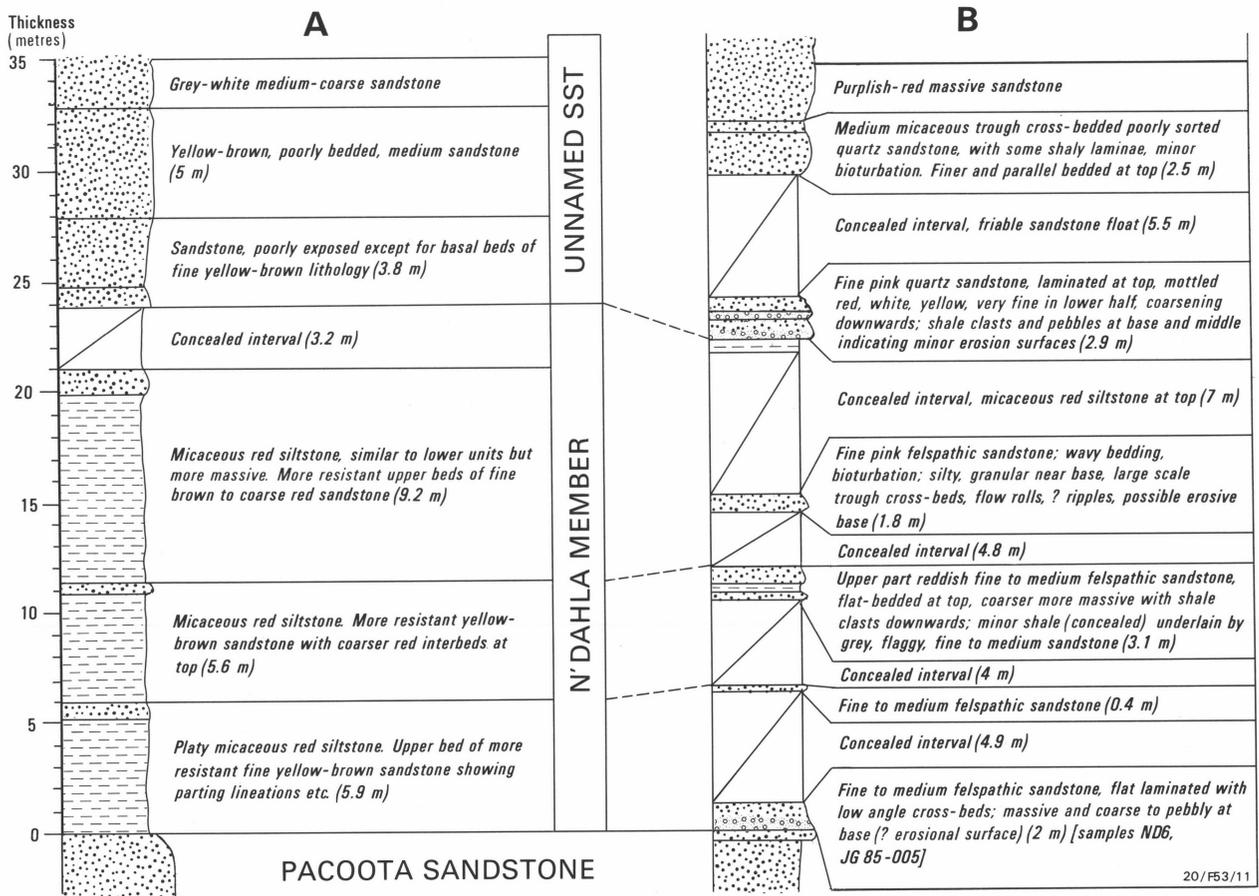


Figure 3. A — Proposed type section for the N'Dahla Member of the Pertnjara Group at N'Dhala Gorge (locality 3, Fig. 2). B — Section measured through the N'Dahla Member at the site of original palaeontological samples (locality 1, Fig. 2). Suggested correlations between beds indicated by dashed lines.

The base of the N'Dahla Member is taken as the first red siltstone above the silicified fossiliferous sandstone of the Pacoota Sandstone. Interpretation of aerial photographs shows this contact to be a low-angle unconformity, as noted by Wells & others (1967, p. 48). The N'Dahla Member in the type section comprises four fining-upward cycles of interbedded micaceous red siltstone and yellow-brown fine lithic feldspathic quartz sandstone, the latter generally less than a metre thick. The red siltstone weathers recessively, and is poorly exposed. The top of the member is placed at the top of the highest red siltstone bed beneath the overlying sandstone. In the type section this is identified by its recessive exposure. The upper contact of the N'Dahla Member with the overlying sandstone may be unconformable, and is marked by a decrease in lithic and feldspathic content of the sandstone. The lower 10 m of section above the N'Dahla, and beneath the more massive bluff-forming sandstone unit previously identified as Mereenie Sandstone (Fig. 3A), comprises thin-bedded, poorly sorted quartz sandstone with local pebbly interbeds. Wells & others (1970) recorded a thickness of about 15 m for the N'Dahla Member, which is somewhat less than the measured type section of about 24 m (Fig. 3A).

In 1985 another section was measured at locality 1 (J.D.G. and B. Jakeman), to include the site of the first thelodont samples. Although the N'Dahla Member here is less well exposed, several fining-upward cycles can again be recognised. The basal beds are trough cross-bedded and conglomeratic quartz sandstones, a lithology not represented at the base of the type section. At locality 1 these represent an abrupt lithological change from the underlying white quartzite of the Pacoota Sandstone. Pebbles of quartzite, chert, and limestone up to 40 mm in size were seen, but no thin beds of limestone (cf. Wells & others, 1967). The conglomerate grades upwards into parallel-bedded fine-grained quartz sandstones, followed by a covered interval, assumed to be micaceous red siltstone. As in the type section, this cycle is repeated several times through the sequence (Fig. 3B).

Revised stratigraphy above the Pacoota Sandstone in the Ross River Syncline

According to previous interpretations, the Pacoota Sandstone in the Ross River Syncline was unconformably overlain by the Mereenie Sandstone (Silurian or Devonian), and this in turn was unconformably overlain by the Devonian Pertnjara Group.

A Middle to Late Devonian age for the Pertnjara Group elsewhere in the Amadeus Basin is given by placoderm fish remains (Gilbert-Tomlinson, 1968; Young, 1985) and spores (Hodgson, 1968; Playford & others, 1976). However, the age of the Mereenie Sandstone is less well constrained. As discussed by Young (1985), the precise stratigraphic horizon of some fish remains from Gosses Bluff, previously used to determine a Devonian age for the Mereenie Sandstone, is uncertain. Two alternative interpretations of Gosses Bluff stratigraphy were proposed (Young, 1985, fig. 2), with the Devonian fish fauna being derived either from near the Mereenie-Pertnjara contact or from an uppermost sandstone of the Larapinta Group underlying the Mereenie Sandstone.

The discovery of the new Devonian fish fauna reported here, apparently from beneath the Mereenie Sandstone in the Ross River Syncline, would appear to support the second alternative, thereby indicating a Devonian age for the Mereenie Sandstone. However, some samples collected (M.O.) in the 1985 field season from the Cleland Hills in the northwestern part of the Amadeus Basin (Fig. 1) suggest an alternative interpretation. These have yielded fragmentary

thelodont scales and a single impression of a fish spine in sandstone. They come from calcareous sandstone beds that overlie the Mereenie Sandstone at Mount Winter (see Wells & others, 1965, p. 29). These were referred by Jones (1972, fig. 6) to the lowermost Deering Siltstone Member of the Parke Siltstone, the basal formation of the Pertnjara Group. This new Devonian vertebrate locality will be dealt with in more detail elsewhere, but there is little doubt that it is equivalent to the thelodont fauna from the N'Dahla Member, which must therefore represent a stratigraphic horizon approximately equivalent to the lowermost Pertnjara Group. This is consistent with recent field-work at Gosses Bluff (M.O.) suggesting that the fish fauna there comes from just above the top of the Mereenie Sandstone.

Thus, we suggest that the Mereenie Sandstone previously mapped in the Ross River Syncline was incorrectly identified, and instead represents an unnamed sandstone formation belonging to the Pertnjara Group. It is noteworthy that the occurrence of Mereenie Sandstone as previously mapped in this region is a small outlier of the main Mereenie outcrop in the Amadeus Basin (e.g. Wells & others, 1970, fig. 34). The difficulty of distinguishing the Mereenie Sandstone from overlying sandstones of the Pertnjara Group in areas to the south, where the Parke Siltstone is missing from the sequence, was noted by Wells & others (1967, p. 49). The new interpretation proposed here necessitates a revision of the stratigraphy of the overlying Pertnjara Group.

Jones (1972) identified three units in the Pertnjara Group in the Ross River Syncline: a lower member about 200 m thick identified as the basal Ooraminna Sandstone Member of the Hermannsburg Sandstone; an upper Ljiltera Member of the Hermannsburg Sandstone, about 300 m thick; and a thin sequence of Brewer Conglomerate at the top of the section (thicknesses after Jones, 1972, figs 7, 9, 10). The conglomerate occurs only as isolated outcrops (Jones, 1972, p. 243), which Wells & others (1967, p. 49) recorded as unconformable on underlying formations. Although an unconformity was also mapped between the Pertnjara and the underlying 'Mereenie' (BMR, 1983), this presumably was based on the apparent absence of lower formations of the Pertnjara Group. There is no clear evidence of an unconformity in the field, and both Wells & others (1970) and Jones (1972, p. 231) regarded the contact between the Parke Siltstone of the Pertnjara Group and Mereenie Sandstone throughout the Amadeus Basin as generally conformable. Jones also suggested (p. 240) that the distribution of the Ooraminna Sandstone Member coincided with the area where the Hermannsburg Sandstone lies directly on Mereenie Sandstone, but this generalisation no longer applies in the Ross River area.

Reconnaissance examination of the post-N'Dahla Member units in the Ross River Syncline by one of us (M.O.) has shown that both the Ljiltera Member of the Hermannsburg Sandstone and the Brewer Conglomerate can be recognised, but that the sandstone occurring above the type section between the N'Dahla Member and the Ljiltera Member cannot be directly correlated, on lithological grounds, with any existing Pertnjara Group formation. This unnamed sandstone unit is composed of dominantly fine quartz sandstone with minor feldspar, and appears to have been deposited mainly in an aeolian environment. Much more detailed work is necessary before the unit can be formally described.

On the faunal evidence presented below, we suggest that the N'Dahla Member is equivalent to the Deering Siltstone Member of the Parke Siltstone as defined in Jones (1972), and that the sandstone formation previously mapped as Mereenie Sandstone in the Ross River Syncline broadly

correlates with that part of the Pertnjara Group between the Harajica Sandstone of the Parke Siltstone and Ljiltera Member of the Hermannsburg Sandstone (Fig. 4).

Preliminary description of the new fauna

Vertebrates

Fish remains from the first sample (NDG from locality 1) are fragmentary and few in number, and the best material comes from samples ND4-6 on the northern limb of the syncline (Fig. 2B). The following forms have so far been identified in the N'Dahla fish fauna:

turiniid thelodont scales (abundant)

- nikoliviid thelodont scales (rare)
- acanthodian scales in two morphologies (very rare)
- crossopterygian tooth (one specimen)
- cosmoid bone pieces (uncommon)
- indeterminate bone fragments (uncommon)
- fragments ornamented with bifurcating ridges (very rare)

The turiniid scales are variable in size and shape (Fig. 5A-J), but generally show striations or grooves on the ridges of the crown (e.g. Fig. 5A, E, H, J), and lateral wings or lappets on these ridges (e.g. Fig. 5C, D). Both are features observed in *Turinia* scales from the Cravens Peak Beds in the Georgina Basin (e.g. Turner & others, 1981), in *Turinia hutkensis* and

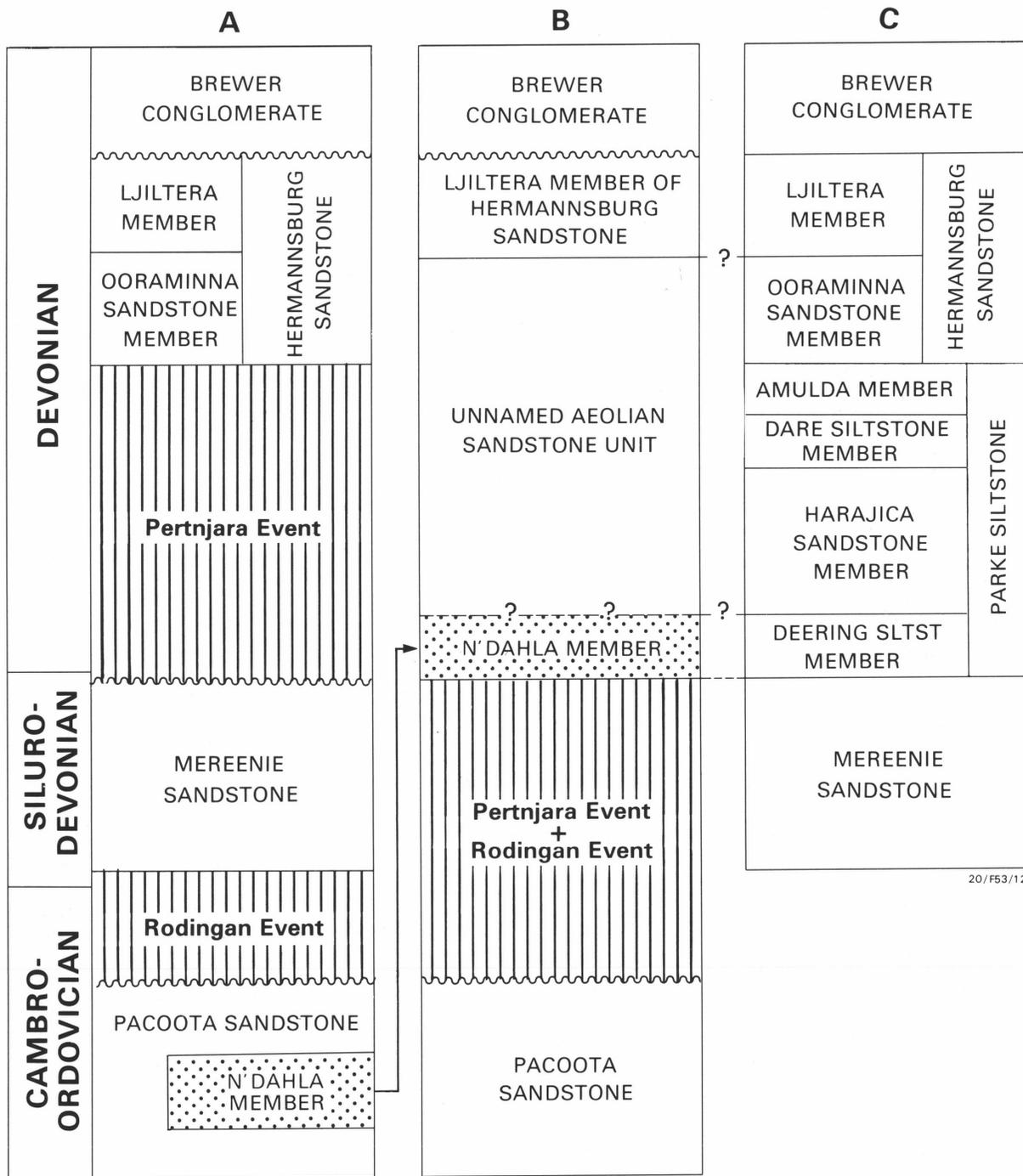


Figure 4. A — Original stratigraphic interpretation of the N'Dahla Member of the Pacoota Sandstone and overlying formations in the Ross River sequence (after Wells & others, 1970; Alice Springs Region, 1:100 000 Geological Special Sheet). B — revised stratigraphy based on the new Devonian vertebrate fauna described here. C — suggested broad correlation with subdivisions of the Pertnjara Group defined by Jones (1972).

T. cf. hutkensis from Iran and southeastern Australia (Bleck & Goujet, 1978; Young & Gorter, 1981), and in *Australolepis* from the Carnarvon basin (Turner & Dring, 1981). These forms are provisionally regarded as ranging in age from late Early Devonian (Emsian) to early Late Devonian (Frasnian). In the present sample, several scales show the elongate anterior basal process typical of *Turinia* body scales (Fig. 5A, E). The head scales closely resemble corresponding scales of

T. pagei from Europe (e.g. Fig. 5G, H; cf. Ørvig, 1969) or *T. australiensis* from the Cravens Peak fauna (e.g. Fig. 5J; cf. Turner & others, 1981). Turiniid scales of post-Emsian age are not known from Europe, and appear to be a Gondwanan group. They have also recently been reported from South America (Goujet & others, 1984), China (Wang & others, 1986), and many localities in southeastern Australia (Pickett & others, 1985).

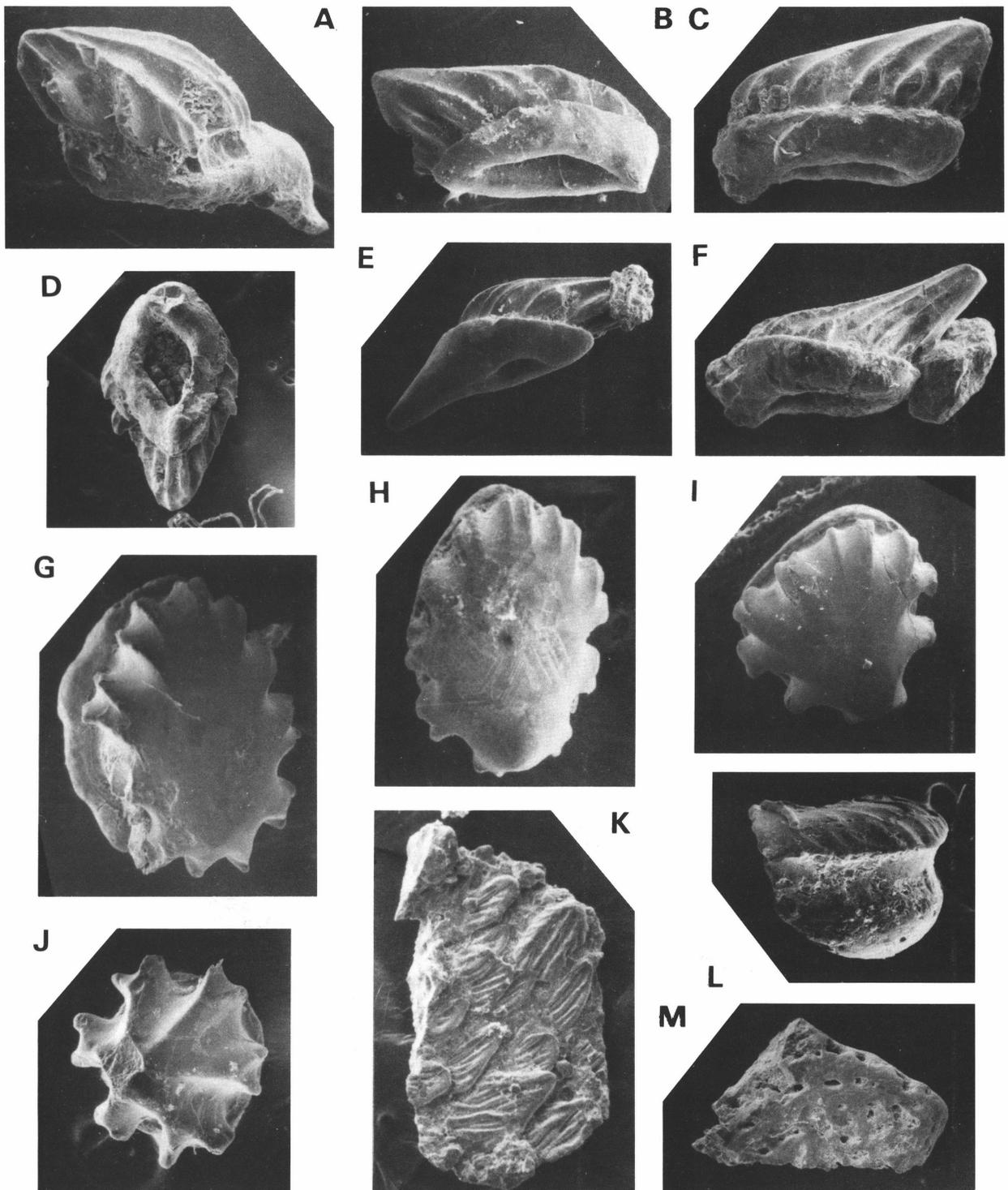


Figure 5. Devonian vertebrate fossils from the N'Dahla Member of the Pertnjara Group, Ross River Syncline, eastern Amadeus Basin. A–J, *Turinia* sp. (CPC 25768–25777 respectively), body scales in approximate lateral (A–C, E, F) and ventral (D) views, and head scales (G–J) in dorsal view (all $\times 50$ except A, J, $\times 100$, and E, F, $\times 35$). K, ornamented bone fragment (CPC 25778), possibly acanthodian, in external view ($\times 50$). L, acanthodian scale (CPC 25779), cf. *Cheiracanthoides*, in anterolateral view ($\times 75$). M, cosmoid bone fragment (CPC 25780) in external view ($\times 35$). C, D, E, H, J, from sample ND4, others from sample ND6. (All specimens deposited in the Commonwealth Palaeontological Collection, Bureau of Mineral Resources, Canberra.)

The ornamented acanthodian scales have a flat crown with faint, widely spaced ridges converging posteriorly (Fig. 5L). There is a slightly constricted neck and a convex base. They resemble the form genera *Cheiracanthoides* (e.g. Gross, 1973, pl. 27, fig. 6) or *Homalacanthus* (e.g. Denison, 1979), which are similar in the rounded anterior and bluntly pointed posterior margins of the crown, and the widely spaced ridges. *Cheiracanthoides* scales were described from the Eifelian limestones of the eastern United States (Wells, 1944), and are abundant in Emsian limestones at Taemas (Giffin, 1980), and other eastern Australian localities. In Germany similar scales occur in faunas near the Emsian-Eifelian boundary (e.g. Vieth-Schreiner, 1983; Poltnig, 1984), but they are not associated with thelodontids. However, *Cheiracanthoides* scales and thelodont scales do occur together in the late Emsian-Eifelian Broken River Formation of Queensland (S.T., personal observation).

The only examples of ornamented bone in the sample may also belong to acanthodians. Only two fragments less than 1 mm across have been found. They are ornamented with curved ridges flanked by radiating striations (Fig. 5K), and show some resemblance to tesseræ of the acanthodian *Nostolepis striata* (e.g. Gross, 1971a, pl. 3, figs. 15, 21, 25), but also the *Onychodus* remains illustrated by Wells (1944, pl. 3). Until better material becomes available these fragments are tentatively referred to the Acanthodii.

The crossopterygian tooth has a fluted base, and fine longitudinal striations. The distal end is missing. The preserved part is 7 mm long and 2.5×3.5 mm in diameter at the narrow end. It could belong to a rhipidistian, onychodontid, or coelacanth fish. Histological sections show a very distinct enamel layer with fan-shaped radial striations, a feature typical of sarcopterygian fishes and higher vertebrate groups (M. M. Smith, personal communication). The absence of infolding of the dentine suggests that the tooth belongs either to an early osteolepid or an onychodontid fish. The latter group is associated with thelodontid scales in the Cravens Peak Beds of the Georgina Basin (Turner & others, 1981; Young, 1984).

Cosmoid bone fragments show the typical pores and shiny surface of the tissue cosmine (Fig. 5M). They could belong to rhipidistians or dipnoans.

A few bone fragments were sectioned to see if other groups could be identified, particularly placoderms, which are normally well represented in Devonian fish assemblages. However, in none of the thin sections was the bone well enough preserved to show diagnostic tissues.

Conodonts

Samples ND and JG85-005 (collected by J.D.G.), ND1-3 (collected by G.C.Y.), and 84-2011/1 (collected by R.S.N.) from locality 1 (Fig. 2) yielded conodonts indicating an Ordovician (Tremadocian) age, and presumably came from the uppermost beds of the Pacoota Sandstone. As noted above, these beds were previously mapped erroneously as part of the N'Dahla Member. Sample ND from this locality (collected by J.D.G.) also contained fragments of Devonian fish scales, suggesting reworking of the older faunal component. However, no conodonts were found in samples ND4-6 from the northern limb of the syncline, which are clearly within the N'Dahla Member (Fig. 2), and it is possible that the first samples from locality 1 were from several horizons near the Pacoota-N'Dahla contact and included pieces from both formations. Of earlier palaeontological samples collected from this locality, AS257 has yielded a rich conodont

assemblage typical of the P2 horizon, the second highest of four subdivisions recognised in the Pacoota Sandstone.

Gastropods

Poorly preserved gastropods in sample AS230 mentioned above are indeterminable, so whether they are part of the Devonian fauna or of the reworked component is at present unknown. Sample ND6 produced two phosphatic steinkerns, probably belonging to the mollusc *Pelagiella deltoides*, a species first described by Runnegar & Jell (1976) from the post-Templetonian part of the Currant Bush Limestone in the Georgina Basin, western Queensland. Forms of similar morphology and preservation are also known from the Middle Cambrian Giles Creek Dolomite in the Amadeus Basin (J.R.L. unpublished) and from the lowermost carbonates in the Arthur Creek Formation of the western Georgina Basin, Northern Territory (Freeman, 1986). In the latter fauna they are associated with the mollusc *Protowenella* sp. and the trilobites *Xystridura* sp., *Pagetia* sp., and *?Peronopsis* sp., which also indicate a Templetonian age.

The specimens in sample ND6 must have been reworked and, because of their excellent preservation (Fig. 6), they either underwent little water transport or, more probably, were transported within clasts, presumably derived from the Giles Creek Dolomite, since a different species of *Pelagiella* occurs in the Todd River Dolomite (Laurie, 1986).

Age and correlation of the N'Dahla fish fauna

The closest thelodont locality is that from the Toko Syncline in the Georgina Basin, where the Cravens Peak Beds contain turiniid scales similar to those from the N'Dahla Member. The Cravens Peak fauna also contains onychodontid and dipnoan remains (Young, 1984), which would account for the osteichthyan fragments occurring here. However, it is a more diverse fauna, and notable absences from the N'Dahla assemblage are *Machaeracanthus* spines and scales, smooth ischnacanthid scales, chondrichthyan scales and teeth (Turner & Young, in press), and placoderms (antiarchs).

Young (1985, p. 245) suggested that the fragmentary fish fauna from Gosses Bluff in the north central part of the Amadeus Basin was probably equivalent to the Cravens Peak fauna of the Georgina Basin. The same fauna occurs in the lower Dulcie Sandstone of the Georgina Basin and, as noted above, is also represented in basal beds of the Pertnara Group in the Cleland Hills, about 140 km to the west of Gosses Bluff (Fig. 1). Gross (1971b) described turiniid scales from the Canning Basin of Western Australia, and similar scales have recently been recognised in the subsurface in the Officer Basin. Thus it seems that this fauna was widespread across the Australian craton during Early to Middle Devonian time. Much the same fauna also occurs in the Mulga Downs Group of western New South Wales, where a maximum age of Emsian is provided by a marine invertebrate fauna in the underlying Buckambool Sandstone (see Turner & others, 1981, p. 64; Young, 1984, p. 75). Although a lower biostratigraphic limit to turiniid occurrences in the Australian Devonian is not yet established, an age near the Early to Middle Devonian boundary is indicated for the N'Dahla fauna.

Environment and provenance

Both thelodont scales and bone fragments are excellently preserved, although the latter are badly broken. There is little evidence of significant transportation of the material. A

noteworthy feature is the variable colour of the thelodont scales, ranging from very dark grey, to pink, to translucent. This is an unusual feature, possibly indicating multiple provenance.

Marss & Einasto (1978) studied Siluro-Devonian microvertebrate assemblages in the Baltic region of the Russian Platform in relation to other palaeoenvironmental indicators. A high ratio of thelodonts to acanthodians characterised shallow lagoonal or littoral deposits. However, there is as yet no evidence that Australian assemblages show corresponding proportions. Turner & others (1981) interpreted the thelodont fauna from the Cravens Peak Beds in the Georgina Basin as a marine or marginal marine assemblage, on the evidence of the crustacean *Cryptophyllus*. Abundant glauconite in one N'Dahla sample (JG85-005; Amdel, 1985) was probably derived or reworked from the underlying Pacoota (cf. Wells & others, 1967), and other sedimentological evidence from the member suggests a fluvial depositional environment.

The occurrence of reworked limestone clasts of Cambrian age unconformably above Ordovician strata in the N'Dhala

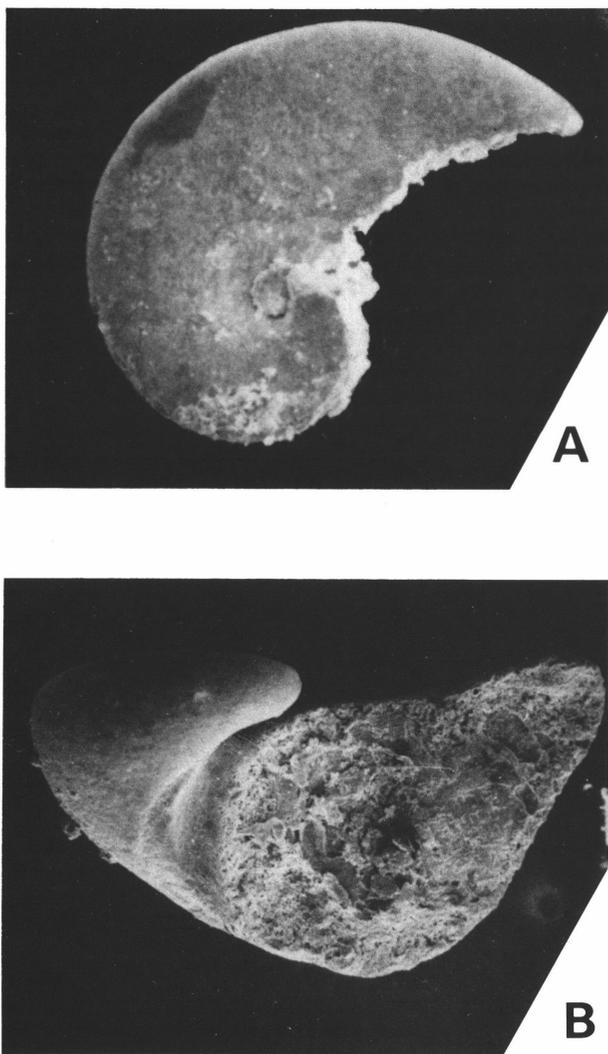


Figure 6. Reworked Cambrian molluscs (*Pelagiella deltoides* Runnegar & Jell 1976) from the N'Dahla Member of the Pertnjara Group, Ross River Syncline, eastern Amadeus Basin.

A — dorsal view (CPC 25781); B — apertural view (CPC 25782). (Both $\times 50$, from sample ND6; specimens deposited in the Commonwealth Palaeontological Collection, Bureau of Mineral Resources, Canberra.)

section implies an adjacent source which was tectonically active in post-Cambrian time and subject to erosion into both Larapinta and Pertaoorra Groups during the Early to Middle Devonian. The inferred 'pre-Mereenie' erosional surface illustrated by Wells & others (1970, fig. 35) shows a boundary between the Pacoota Sandstone and the Pertaoorra Group at least 25 km to the southeast of the N'Dhala Gorge locality.

Discussion

A reinterpretation of the post-Ordovician stratigraphy of the Ross River sequence based on this new Devonian fish fauna has important implications for the interpretation of the depositional history, tectonics, and hydrocarbon potential of the northeastern part of the Amadeus Basin. Many outcrops of Mereenie Sandstone have been mapped in the region, in spite of the difficulties in distinguishing field occurrences in the eastern part of the basin from sandstones of the overlying Pertnjara Group (Wells & others, 1967). The Mereenie has also been widely recognised in the subsurface in petroleum wells (e.g. Schroder & Gorter, 1984, fig. 12), but it now seems likely, at least in the northeastern area, that some correlations based on identification of Mereenie Sandstone may be erroneous, the sandstones so identified belonging instead to the Pertnjara Group. The thickness of the Pertnjara Group is thought to have played a major role in the timing of hydrocarbon generation in the Amadeus Basin (Gorter, 1984; Jackson & others, 1984), so documentation of thickness variation is important. Moreover, thermal maturation levels of Early Palaeozoic source rocks may have been influenced by the amount of sedimentary unloading and reduced depths of burial during the various phases of post-Ordovician tectonism (Gorter, 1984).

The new stratigraphic scheme proposed above excludes the possibility that the lithostratigraphic units recognised are largely diachronous. Thus, we consider it most unlikely that the Mereenie Sandstone, with a thickness in excess of 700 m, can be completely diachronous, such that the top of the formation in the west was deposited at the same time as the base of the formation in the Ross River area. An alternative interpretation is that the base of the Parke Siltstone is diachronous, with the relatively thin sequences of Parke Siltstone containing datable fossils in the west (Cleland Hills), and some 380 km to the east at N'Dhala Gorge, correlating not with the base of the formation in the central northern part of the basin, where it reaches maximum thickness, but somewhere near its top. Evidence against both hypotheses is provided by the fish fauna at Gosses Bluff, which lies approximately midway between the western and eastern fossil localities. According to the first hypothesis, the Gosses Bluff fish fauna should lie in the middle of the Mereenie Sandstone, and according to the second it should lie at the top of the Parke Siltstone or the base of the Hermannsburg Sandstone. Although the sequence at Gosses Bluff is highly disturbed and difficult to interpret, the fish fauna occurs in a red siltstone bed that is apparently resting on immediately underlying sandstones of Mereenie lithology (Young, 1985, p. 242). This lithological association has not been observed elsewhere either at a level within the Mereenie or at a level at the top of the Parke Siltstone or the base of the Hermannsburg Sandstone. We suggest that the Gosses Bluff occurrence is entirely consistent with the interpretation that the basal part of the Parke Siltstone containing the fish fauna in the west and the east is essentially synchronous.

It follows that either the Mereenie Sandstone was never deposited in the Ross River area or, if it was, it was completely eroded before deposition of the N'Dahla Member. Jones (1972) discussed tectonic events identified by earlier workers

that were manifested in the depositional history of the Pertnjara Group. Two separate orogenic events were proposed by Wells & others (1970), before and after deposition of the Mereenie Sandstone. They regarded the Early Palaeozoic Rodingan Movement as an epeirogenic pre-Mereenie uplift of a large part of the Amadeus Basin, including the northeastern portion. The Middle to Late Devonian Pertnjara Movement was defined (Wells & others, 1970, p. 133) as the event that produced unconformity between the Mereenie Sandstone and the Pertnjara Group in the central-northern and northeastern parts of the basin. It was noted that this movement apparently had little effect in the central to southwestern Amadeus Basin, where the Parke Siltstone appears conformable on the Mereenie Sandstone. They suggested the possibility that the unconformity lay above and not beneath the Parke Siltstone.

According to Jones (1972, p. 246), the Pertnjara Movement produced a disconformity between the Mereenie Sandstone and the Pertnjara Group in the northeast, but the stratigraphy as revised above (Fig. 4B) now places the unconformity in the Ross River sequence between the Ordovician Pacoota Sandstone and the Devonian Pertnjara Group. Elsewhere in the basin the Mereenie is clearly seen to thin towards the east along the MacDonnell Ranges, as the erosional surface representing the Pertnjara Movement cuts down through older formations. East of Ellery Creek the Mereenie Sandstone has been completely removed, with Pertnjara Group sediments progressively lying unconformably on older sediments of the Larapinta and Pertaoorrta Groups. In the Waterhouse Range, the James Ranges, and the Ooraminna Anticline and Camel Flat Syncline to the south and east, the Hermannsburg Sandstone of the Pertnjara Group directly overlies the Mereenie Sandstone.

However, as noted above, where the basal Parke Siltstone of the Pertnjara Group is developed, it is generally conformable on the Mereenie Sandstone (Wells & others, 1970; Jones, 1972). Exceptions to this recorded in the literature are in the Illamurta Springs-Seymour Range area (Ranford & others, 1965, p. 31) and in the Deering Hills (Wells & others, 1965, p.29; Jones, 1972, p.234), but the former may be a local feature and the latter is probably an onlap of basal Parke Siltstone on a Mereenie palaeoslope. Thus, it seems that, if the Mereenie Sandstone was deposited in the Ross River sequence, and was subsequently eroded, the latter erosional event may have been somewhat older than the erosional events that produced the unconformity between the Pertnjara Group and Mereenie Sandstone as recorded elsewhere in the basin. Alternatively, the Mereenie Sandstone may never have been deposited in the Ross River sequence.

A similar depositional and erosional history is recorded in the Georgina Basin sequence, over 200 km to the north, where the basal part of the Dulcie Sandstone in the northwestern Dulcie Syncline, which contains an equivalent fish fauna to that of the N'Dahla Member, lies unconformably on the Tomahawk Beds, which are comparable in fauna, lithology, and age to the Pacoota Sandstone (J. H. Shergold, personal communication). It is therefore of interest that the Ross River sequence is interpreted as part of an allochthonous sheet (the N'Dhala Nappe), with a displacement from the north, recently estimated at between 30 and 60 km (Stewart & Oakes, in press).

To summarise, there is evidence of at least one depositional break in the Palaeozoic sequence of the Ross River syncline (Fig. 4B): an Early Palaeozoic event corresponding to the Rodingan Movement. If the Mereenie Sandstone was ever deposited in the Ross River area, it was removed by another

erosional event (Pertnjara Event) older than Parke Siltstone time, and probably not of basin-wide significance. The N'Dahla sequence resembles that of the Georgina Basin to the north, where the same fish fauna occurs unconformably above Early Palaeozoic sediments equivalent to the underlying Pacoota Sandstone of the Ross River sequence.

From the Ross River sequence a palaeomagnetic reading of presumed Devonian age has recently been cited for the Australian craton (e.g. Goleby, 1980; Livermore & others, 1985). This is the 'Ross River overprint', to which an age of 374 Ma has been ascribed, based on Kirschvink's (1978) analysis of palaeomagnetic directions in Late Precambrian to Early Cambrian sediments from the Amadeus Basin. A secondary component in samples from the Ross River area, when corrected for structure, was found to lie between results for the Mereenie Sandstone (Embleton, 1973a) and the Paterson Toscanite (Carboniferous), according to the apparent polar wander curve of Embleton (1973b). Uncertainties about the age of the Mereenie Sandstone magnetisation (interpreted as Silurian or Devonian) have been discussed previously (Young, 1985). In view of the various alternative interpretations placed on palaeomagnetic data for the Middle Palaeozoic of Gondwana (e.g. Schmidt & Morris, 1977; Goleby, 1980; Livermore & others, 1985), a Devonian age for the Ross River overprint is at present unsupported. The status of these data should be clarified when new palaeomagnetic investigations of Devonian strata in the Ross River area are completed (C. Klootwijk, personal communication).

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