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A new Triassic vertebrate fauna from Antarctica and its depositional setting

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Abstract: A new fauna of late Early to early Middle Triassic vertebrates has been found in the upper member of the Fremouw Formation in the Beardmore Glacier area of Antarctica. It includes *Cynognathus*, a kannmeyeriid, and other therapsid (mammal-like) reptiles representing new, more derived genera of carnivorous and gomphodont cynodonts. New genera of temnospondyl amphibians belonging to the capitosauroid evolutionary complex also occur. The unusual abundance of well-preserved amphibians may offer new insights concerning the evolution and distribution patterns of early Mesozoic temnospondyls. These fossils represent only the second terrestrial vertebrate fauna from the mainland of Antarctica. The fossils occur on a prominent sandstone platform, which represents part of the exhumed channel of a braided stream deposit. The platform is over 200 metres above the well-known *Lystrosaurus* fauna of the lower Fremouw Formation. The locality is near the axis of a major foreland basin that paralleled the present trend of the Transantarctic Mountains. Conditions of rapid subsidence and aggradation of fluvial units were ideal for the preservation of vertebrate faunas.

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Introduction

Since the identification of *Lystrosaurus* Zone (earliest Triassic) fossil tetrapods in 1969 (Elliot *et al.* 1970), several localities in the central Transantarctic Mountains have produced vertebrates of comparable age (Hammer *et al.* 1987). Now a new and younger fauna has been found that is equivalent in age to or, perhaps, slightly younger than the *Kannemeyeria* Assemblage Zone (Keyser & Smith 1978 – late Early Triassic, equivalent to the *Cynognathus* Zone) of South Africa. The fossils occur in the deglaciated Gordon Valley near Beardmore Glacier (Fig. 1).

The stratigraphic position of the fossils in the upper member of the Fremouw Formation is considerably higher (200 m) than the *Lystrosaurus* Zone faunas, all of which are from the lower member (Colbert 1982, Hammer *et al.* 1987) (Fig. 2). Approximate age-equivalence with the *Kannemeyeria (Cynognathus)* Zone is indicated by specimens referable to both the cynodont genus *Cynognathus* and the dicynodont family Kannemeyeriidae, although two new genera of therapsids may indicate a slightly younger age.

During the twenty years since the first temnospondyl amphibian jaw fragment in Antarctica was found on Graphite Peak (Barrett *et al.* 1968; this report), four other expeditions have searched for terrestrial vertebrate remains in the Permian and Triassic of Antarctica. Only *Lystrosaurus* Zone localities in areas near the Beardmore and Shackleton glaciers in the Central Transantarctic Mountains yielded terrestrial vertebrates of any kind. Northern parts of the range, in Victoria Land, offered no stratigraphic equivalent to much of the Fremouw Formation and hence attempts to recover terrestrial vertebrates there proved unsuccessful (Hammer 1986). Thus, this new assemblage represents only the second terrestrial vertebrate fauna from the mainland of Antarctica.

Because this assemblage was discovered near the end of the 1985–1986 austral field season, less than two weeks of excavation was possible by a field party of four. Nearly 50 specimens were recovered from Gordon Valley (many more remain uncollected), approximately half of which should be identifiable to genus. Over 200 additional specimens of *Lystrosaurus* Zone fossils were collected at other localities earlier in the season.

The fauna

The vertebrate assemblage from the upper Fremouw Formation mainly consists of large disarticulated cranial fragments, although some postcranial material also occurs. *Cynognathus* is represented by a partial mandible, which consists of the central portion of the left dentary (American Museum of Natural History – AMNH No.24422, Fig. 3a, 3b). Although the teeth on this specimen are broken, much of the tooth row is evident from the roots. The size of the jaw and the general nature of the teeth and the adductor fossa indicate that it belongs to a large advanced cynodont reptile. The shape of the teeth aligns it with carnivores such as *Cynognathus*

rather than the omnivorous to herbivorous diademodontids. What can be seen of the teeth and the size of the jaw do not exclude the possibility that it belongs to a large chiniquodontid. However, the Antarctic mandible is relatively deeper than that of the chiniquodontids and the size and shape of the adductor fossa is very similar to that of *Cynognathus*. This jaw apparently pertains to either *Cynognathus* or a new, very similar, genus. Because the specimen shows no unique features, it is here referred to *Cynognathus* sp. A species determination is not possible because of the incompleteness of the fossil.

A small maxillary fragment containing a broken canine tusk is referable to the Kannemeyeriidae (AMNH No.24403, Fig. 4a, 4b). Although the specimen is a small fragment of the whole, its size is indicative of a large dicynodont. The curvature of the ventral edge of the maxilla relative to the position of the tusk suggests that this animal did not have the deep skull typical of the lystrosaurids. The face was longer relative to height, a general feature typical of most Permian dicynodonts and the large Triassic kannemeyeriids. The specimen may actually pertain to *Kannemeyeria* from South Africa. However, it is too small a fragment to show features that necessarily align it with this genus within the family and hence it is regarded *incertae sedis* within the Kannemeyeriidae.

At least two other cranial fragments represent new genera of therapsids. The anterior two thirds of a right dentary (AMNH No. 24407) belongs to a large carnivorous cynodont that has a much deeper and larger adductor fossa than that of *Cynognathus*. In fact, this specimen shows a more derived state for this feature than any of the typical *Kannemeyeria* (*Cynognathus*) Zone animals.

A fairly complete right maxilla (AMNH No.24421) from Gordon Valley represents a new gomphodont cynodont. This animal is equivalent in size to the large diademodontids of the *Kannemeyeria (Cynognathus)* Zone. However, unlike *Diademodon* it has no simple postcanine teeth, leaving a large diastema between the canines and the gomphodont teeth. Also, the postcanine teeth are offset medially leaving a lateral overhang of the maxilla above the tooth row. Both of these features are more typical of the Middle Triassic traversodontids of South America or, perhaps, *Cricodon* of the Manda Formation of Tanzania, although this specimen differs in other ways from these forms.

The occurence of these two new cynodonts with derived features atypical of the *Kannemeyeria (Cynognathus)* Zone genera suggests either a slightly younger age, perhaps early Middle Triassic, for this portion of the upper Fremouw Formation, or, that a more progressive fauna evolved independently in Antarctica during the late Early Triassic. In either case the cynodonts include typical Late Scythian Gondwana forms mixed with genera showing more derived features.

Temnospondyl amphibian material is abundant in Gordon Valley. In contrast to all of the lower Fremouw Formation localities (Hammer 1989), most of the amphibian specimens

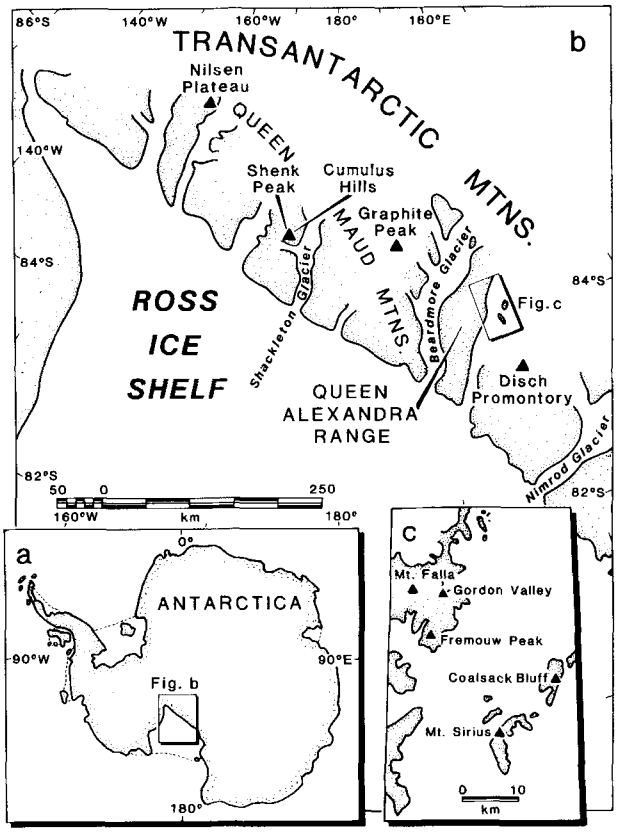

Fig. 1 Location maps of Triassic vertebrate localities in the central Transantarctic Mountains

there are larger and better preserved than the reptilian fragments. This maybe due to taphonomic influences; the amphibians were aquatic and lived in the channels, while the reptilian material was washed into streams directly or by the erosion of flood-plain sediments.

Most of the temnospondyls identified to date appear to represent new genera. A large, nearly complete skull of a capitosaurid shows an open otic notch, a feature typical of more primitive members of the family, such as *Parotosuchus*. This animal could be a large parotosuchid, but its size and shape differs from many of the specimens referred to this poorly defined genus, which seem to be linked largely by the plesiomorphic open notch character. The current state of capitosaurid taxonomy will make it difficult to determine the exact affinities of this animal without a family revision.

It is possible that at least one benthosuchid occurs, if, as Jupp & Warren (1986) have suggested, they are the only temnospondyl family to lack an anterior meckelian foramen on the mandible. A single partial mandible from Gordon Valley does show this feature, although, it otherwise looks very capitosaurid. In general, fossils of the Family Benthosuchidae are rare in Gondwana and are previously unknown from Antarctica.

A large snout fragment (indicating a total skull length of

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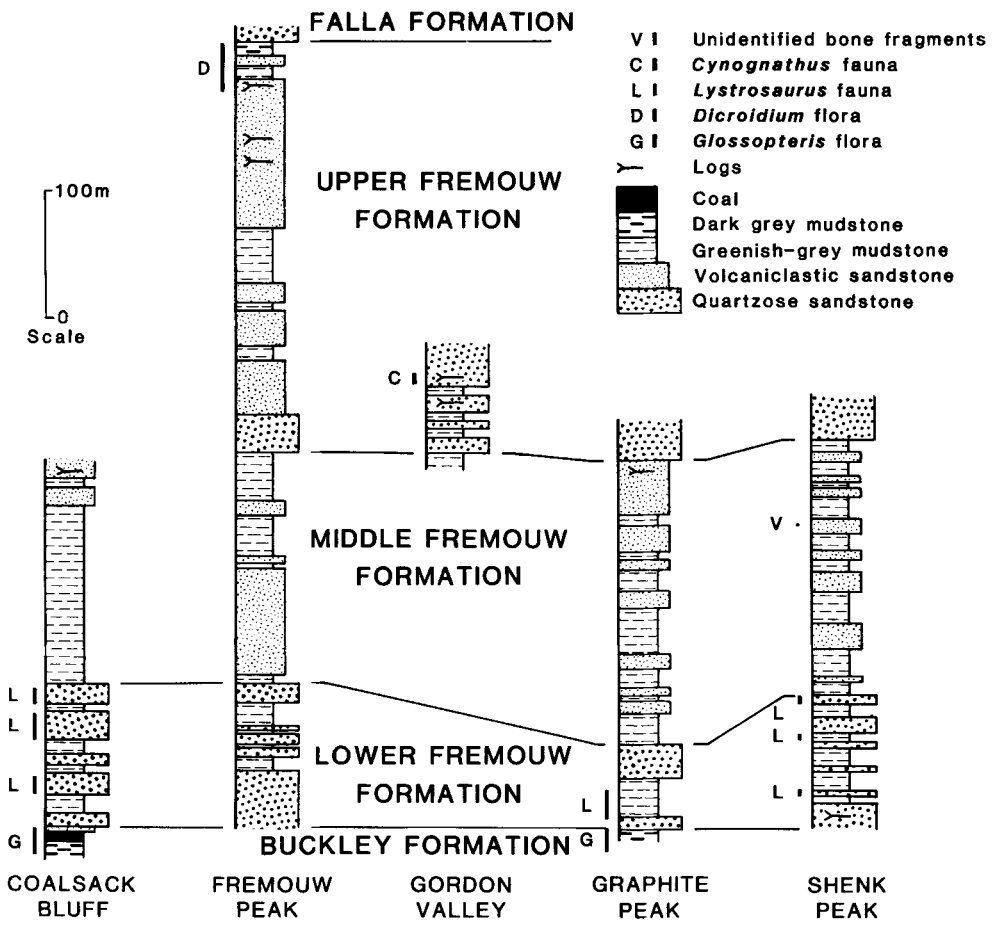

Fig. 2 Correlative stratigraphic sequences of the primary vertebrate-bearing outcrops of the central Transantarctic Mountains.

over 1 m) pertains to a third genus of the capitosaurid-benthosuchid complex (i.e. Superfamily Capitosauroidea). Whereas the general nature of this animal appears to be capitosaurid, the single anterior palatal vacuity has a narrow central region with larger "pockets" laterally, very similar to some specimens of *Benthosuchus*. The unique feature of this specimen is a row of extremely large palatal tusks directly behind this vacuity.

The unusual abundance of well-preserved temnospondyl material in this fauna is of particular interest, considering the fact that faunas of similar age from South Africa, India and South America show a much greater relative abundance of reptiles. Early Triassic faunas of Tasmania and certain areas of Australia are similarly rich in temnospondyl material, but no genera appear to be common to both the Antarctic and Australian communities. Because of this situation, further collection and study of this new Antarctic fauna should reveal important information about the distribution and evolution of early Mesozoic temnospondyls, particularlythose belonging to the widely distributed capitosaurid complex.

Depositional setting

The Fremouw Formation, which is about 600 m thick, crops out along the Transantarctic Mountains from Disch Promontory to Nilsen Plateau, a distance of 475 km (Fig. 1). Throughout its extent, three informal members have been noted (Collinson & Elliot 1984, Barrett *et al.* 1986). The lower member, which contains the *Lystrosaurus* fauna, consists of a 75 to 125 m-thick sequence of quartzose sandstone. The middle member, about 200 m thick, is dominated by greenish-grey, siltstones and mudstones with subsidiary sandstone. A few indeterminate vertebrate fossils have been found in the middle member in the Cumulus Hills along Shackleton Glacier. The upper member is a 300 m-thick cross-bedded, volcaniclastic sandstone. The *Kannemeyeria* (*Cynognathus*) fauna occurs near the top of an 8 m-thick, resistant, quartzose sandstone at the base of the upper member (Fig. 2). This sandstone forms a prominent platform for several km along the south side of Gordon Valley and also occurs at the nearby type-section of the Fremouw Formation at Fremouw Peak (Collinson & Elliot 1984). The surface of this platform represents an exhumed river channel. Abundant siltstone clasts and compressed fossil logs occur with the bones. The

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Fig. 3a *Cynognathus sp.* mandible (AMNH No.24422) from the Gordon Valley (scale in cm).

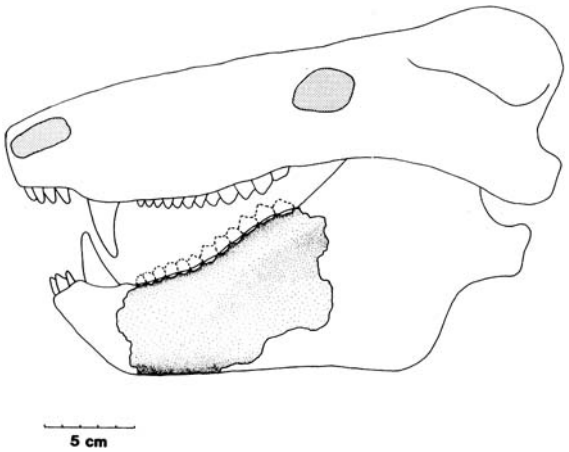

Fig. 3b Reconstructed skull of *Cynognathus* showing position of partial mandible.

bones, including an abundance of cranial material, are disarticulated, but not greatly abraded by transport. A well preserved *Dicroidium* flora, some of which is preserved as silicified peat, has been described from near the top of the formation in the immediate area (Smoot *et al.* 1987).

The Fremouw Formation was deposited in a foreland basin between the Antarctic craton and a fold-thrust belt in West Antarctica (Collinson *et al.* 1987). Major streams flowed longitudinally along the axis of this basin parallel to the fold-thrust belt. Lower Fremouw sandstones in the Beardmore Glacier area are more quartzose and thicker than in other areas, suggesting that it was near the axis of the basin. The formation was deposited by low-sinuosity, braided streams on a broad, low-gradient flood plain. Channel-form sandstones were deposited as the bed load of major

Fig. 4a Kannemeyeriid maxillary fragment showing canine tusk (AMNH No.24403,scale in cm).

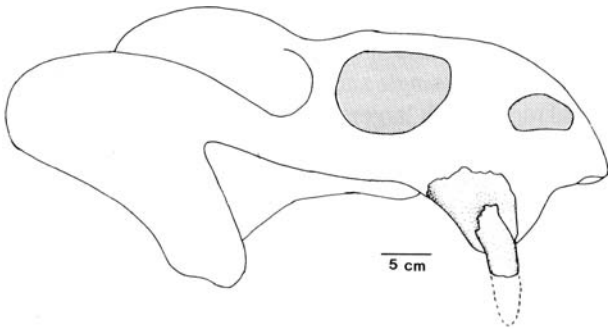

Fig. 4b Reconstructed skull of *Kannemeyeria* showing position of maxillary fragment.

channels and tributaries and fine-grained sandstone, siltstone and mudstone were the overbank deposits. Conditions of rapid subsidence and aggradation of fluvial units were ideal for the preservation of vertebrate faunas. Little forest cover probably existed, but abundance of small roots in flood-plain facies suggests some local plant cover. However, the occurrence of fossil logs in sandstone channel deposits

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suggests that wooded areas existed locally within the drainage basin, possibly in highland areas.

The existence of a diverse reptilian and amphibian fauna strongly indicates a climate characterized by mild, seldom freezing temperatures. The sandy, low-sinuosity braided streams of the Fremouw are similar to streams in semi-arid areas today. Major flooding appears to have dominated the fluvial regime. The area was located in a subpolar region; spring snow-melt on highlands between the palaeo-Pacific ocean and East Antarctica could have produced the major floods and kept the lowlands well-watered despite general aridity.

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