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A Tetrapod Fauna from the Permian of the Sydney Basin

ANNE WARREN

School of Zoology, La Trobe University, Bundoora Victoria 3083, Australia
E-mail: zooaw@zoo.latrobe.edu.au

ABSTRACT. A recent discovery by Bruce Ross of Oceanic Coal Australia Ltd in the roof of the Borehole Seam, West Wallsend Colliery, is the first well documented evidence of a tetrapod fauna from the Permian of Australia. The Borehole Seam (Newcastle Coal Measures, Lambton Subgroup) lies immediately above the Waratah Sandstone which forms the base of the Newcastle Coal Measures and is most likely Kazanian in age. Preliminary study has shown that among the five tetrapod specimens recovered at least temnospondyl amphibians are represented. The only previous tetrapod body fossil from the Australian Permian is a temnospondyl amphibian, *Bothriceps major*, from Airly, to the north-west of Sydney. Tetrapod trace fossils have been known for some time in the southern part of the Sydney Basin where the Illawarra Coal Measures have yielded several sets of reptilian footprints. Tetrapods were therefore living to the north, west and south of the Sydney Basin in the Late Permian of Australia.

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In Australia, records of tetrapod body fossils date from the Late Devonian Cloghnan Shale near Forbes, New South Wales (Campbell & Bell, 1977) and Devonian tetrapod footprints have been described from the Genoa River beds of northern Victoria (Warren & Wakefield, 1972). Most recently the first Early Carboniferous tetrapod fauna from the Southern Hemisphere has been found in Queensland (Thulborn *et al*., 1996). Australia also has a widespread and diverse Early Triassic temnospondyl fauna, especially in the Arcadia Formation of Queensland (Warren, 1991) which is remarkable for the rarity of therapsid reptiles. It is surprising therefore that only a single tetrapod, an amphibian from near the Permo-Triassic boundary of the Sydney Basin (Woodward, 1909), has been recovered from the period between the Early Carboniferous and the Early Triassic. This time interval is important for the emergence of the therapsids which are present in quantity in other continents, especially in the Permian.

The recent discovery of a tetrapod fauna from well below the Permo-Triassic boundary in the Sydney Basin is significant as a first step to filling in this gap. The find was made by Bruce Ross, of Oceanic Coal Australia Ltd, who had previous experience collecting Palaeozoic tetrapods with the legendary Stan Wood of Scotland. Although the state of preservation of the fossils prevents their detailed description and precise identification, the fact that a tetrapod fauna was present is of significance. In this paper I have taken the opportunity to summarise our knowledge of both body and trace fossils from the

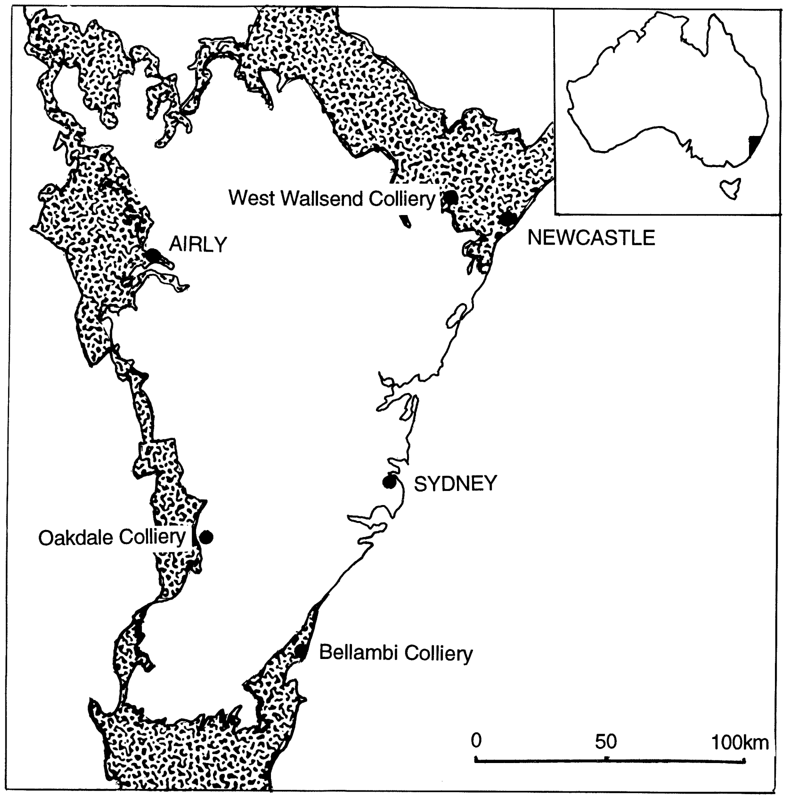

Fig. 1. Map of the central part of the Sydney Basin showing the tetrapod fossil localities in relation to Sydney and Newcastle. Permian outcrop is shaded.

Permian of the Sydney Basin as well as to describe the new finds. A map of the fossil localities is presented in Figure 1 and a chart of their temporal relationships is presented in Figure 2.

		Northern Sydney Basin	Southern & Western Sydney Basin
Early Triassic	Scythian	NARRABEEN GROUP ?	NARRABEEN GROUP ?
Late Permian	Tatarian	NEWCASTLE COAL MEASURES	**BULLI COAL**
			ILLAWARRA COAL MEASURES
		BOREHOLE SEAM	
		TOMAGO COAL MEASURES	**GLEN DAVIS FMN**
	Kazanian		ILLAWARRA COAL MEASURES

Fig. 2. Stratigraphic relationships between the tetrapod-bearing strata which are shown in bold type. The new West Wallsend fauna is from the Borehole Seam, the temnospondyl *Bothriceps major* from the Glen Davis Formation, and both sets of footprints from the Bulli Coal.

Tetrapod body fossils

Bothriceps australis Huxley, 1859—BM(NH) R23110

According to Watson (1956) this specimen was bought by the British Museum in 1948 from a person of whom nothing is known and was said to have been found in "Australia". Watson considered that the structure of *Bothriceps australis* suggested that it was as early as, or earlier than, *Bothriceps major* (discussed below) and subsequent authors have followed Watson in assigning it a Late Permian age. The evidence for this conclusion is tenuous and an Early Triassic age is more likely than Permian. The specimen shows several grade characters common to Mesozoic temnospondyls, such as the loss of the supraoccipital, basioccipital and opisthotic from the occiput, and the presence of a firm suture between the pterygoid and the parasphenoid.

Stratigraphic position. Unknown. A label associated with the specimen says it is from the "Hawkesbury Beds (Permian)". This was probably an educated guess but could well be correct except that the Hawkesbury Sandstone of the Sydney Basin is now early Middle Triassic.

Fig. 3. The temnospondyl amphibian *Bothriceps major*; head MMF12697a, body AM F50977.

Bothriceps major Woodward, 1909

This specimen (Fig. 3) which was recovered from the Commonwealth Oil Corporation's shale mine at Airly, near Capertee in the west of the Sydney Basin is preserved in three pieces distributed in three different repositories as follows: head, Geological Survey of New South Wales, Sydney, MMF 12697a; body, Australian Museum, Sydney, AM F 50977; counterpart head and body, Natural History Museum, London, BM(NH) R3728.

Woodward (1909) recognised the specimen as a brachyopid amphibian, placing it in the same genus as *B. australis*, presumably because they were both Australian, but decided to separate it specifically because of a difference in the size of its orbits, those of *B. major* being relatively smaller.

Watson (1956) transferred the specimen to a new genus, *Trucheosaurus*, largely because " in the few structures clearly shown in the only known specimen it differs from the type of the genus *Bothriceps* and indeed from all other known genera of the family" and also because "the specimen is important as showing the occurrence of a typical brachyopid at an early horizon". The name *Trucheosaurus*, from the Greek for rags and tatters, reflects Watson's opinion of the state of preservation of the specimen. It was returned to *Bothriceps* by Welles and Estes (1969). All three blocks of *B. major* are currently being restudied by Dr C. A. Marsicano and myself; we intend removing *B. major* from the family Brachyopidae.

Stratigraphic position. The torbanite from which *B. major* originated is in the Glen Davis Formation of the Charbon Subgroup, a lower deltaic facies of the Late Permian Illawarra Coal Measures (Eui Kyoo Yoo pers. com., 1995). Palynological evidence indicates that the Glen Davis Formation is older than Tatarian but not older than Kazanian (McMinn, 1985; Foster pers. com., 1995). Thus *B. major* is indeed Permian and stratigraphically the earliest recorded member of the stereospondyl radiation.

New material from West Wallsend

A rock fall in 1984 from the roof of the Borehole Seam at the West Wallsend Colliery owned by Oceanic Coal Australia Ltd. was recognised by mining engineer, Bruce Ross, as containing fossil vertebrates. These are preserved in concretions within a highly carbonaceous shale and have been dorsoventrally compressed and partially metamorphosed so that little detail of their anatomy remains. All appear to have been split through the centre of the specimen so that none present a dorsal or ventral aspect. While the majority of the specimens are fish, as indicated by the presence of lepidotrichia and scales, four concretions appear to contain tetrapod remains.

AM F95421, AM F95122. These specimens (Figs 4, 5) are part and counterpart of a boomerang shaped concretion which contains most of a tetrapod vertebral column with attached ribs. It is possible to count

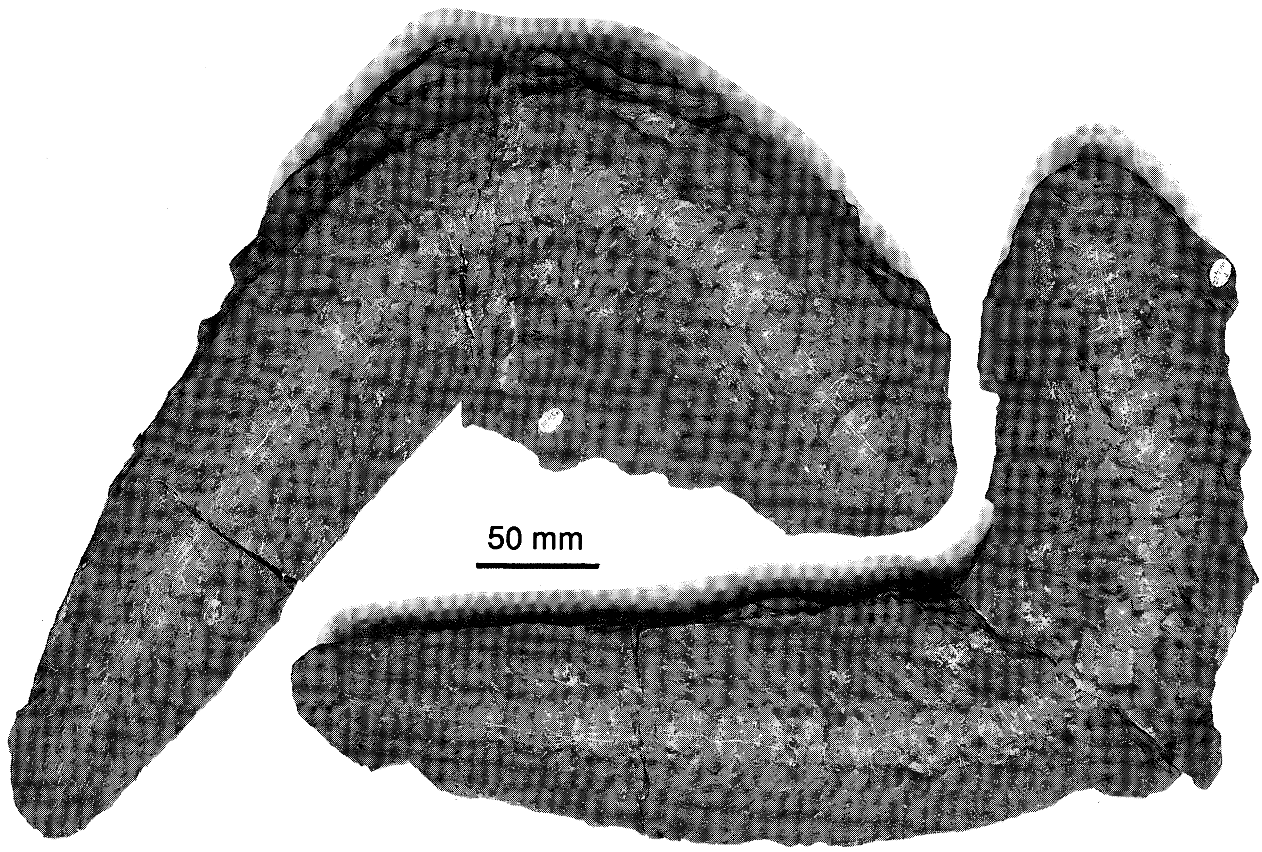

Fig. 4. Temnospondyl vertebral column from West Wallsend: AM F95421, AM F95422.

approximately 24 presacral vertebrae and about ten caudals. A count of between 23 and 26 is typical of the few temnospondyls in which an articulated column is preserved and a similar range is found in early reptiles (Romer, 1956).

Anteriorly the column is twisted so that neural arches are visible as well as ribs. Here several vertebrae appear typically rhachitomous; neural arches articulate with large pleurocentra separated by smaller intercentra. Posterior to the eighth neural spine the column twists so that it is seen in frontal section, with symmetrically arranged ribs. At centrum twenty four the column again twists revealing two neural arches in the same section as ribs. This part of the column may be immediately postsacral; tetrapods typically have a postsacral area which is rib bearing before the haemal arches begin and the ribs are lost. The final two centra preserved appear to bear haemal arches as well as neural arches.

Beneath vertebrae five and six three bones may be parts of the anterior limb or they could be expanded pectoral ribs.

This specimen appears to be a temnospondyl amphibian as evidenced by the rhachitomous appearance of several of its more anterior vertebrae.

AM F97240 (Fig. 6A). Unfortunately the counterpart of this small concretion was not recovered. An articulated but buckled section of vertebral column is represented by approximately fifteen centra at least five of which are associated with ribs. It is not possible to tell whether these represent rhachitomous or stereospondylous centra, or whether they are from temnospondyls or amniotes.

AM F97241 (Figs 6B, 7). Potentially the most complete of the collection, this specimen, which is preserved in part and counterpart, includes what appear to be cranial and mandibular remains as well as centra, ribs, and possible skin impressions.

A single tooth associated with the mandible is longitudinally infolded in its lower half indicating probable temnospondyl affinity. Although the bones associated with this tooth together define the shape of a mandible none can be positively identified as individual mandibular elements.

Some of the presumed cranial bones are ornamented, with fine ridges radiating from the centres of ossification. No midline symmetry can be found among these elements and none can be named. Individual bones are larger than expected if they are considered to belong to a skull associated with the

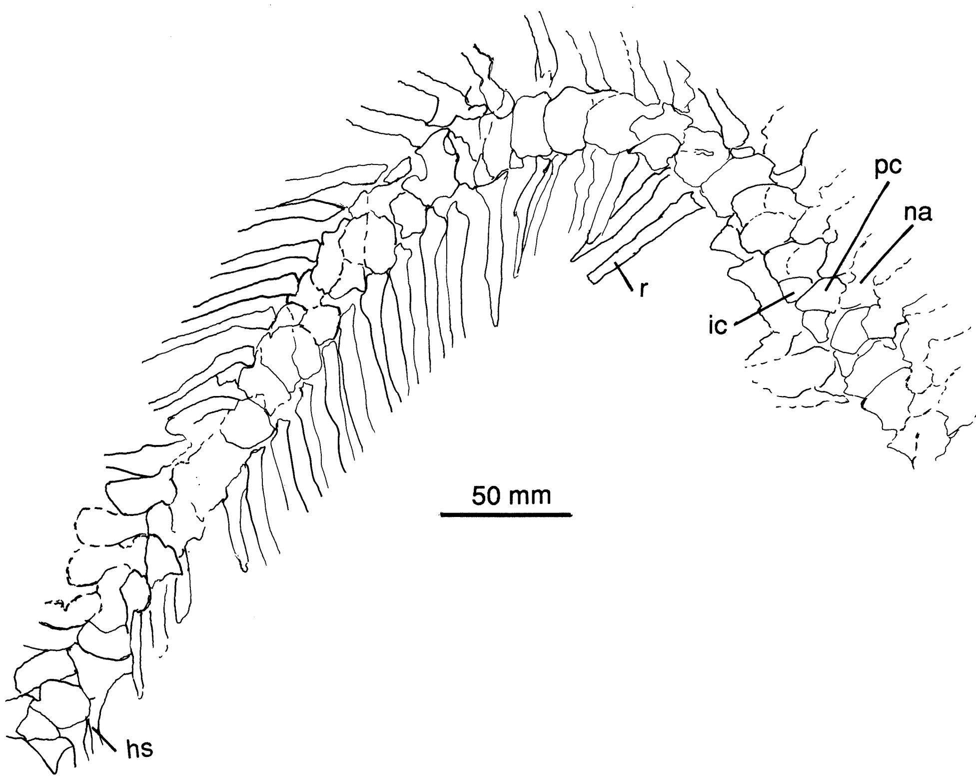

Fig. 5. Outline of bones of temnospondyl vertebral column AM F95421. Abbreviations used in this and subsequent figures are as follows: c—centrum, hs—haemal spine, ic—intercentrum, l—limb element, m—mandible, pc—pleurocentrum, r—rib, s—?skin impression, t—tooth.

mandible and together they occupy too large an area for such a skull. Therefore it is likely that elements of the pectoral girdle are also present.

The two vertebral centra associated with AM F97241 could be rhachitomous or stereospondylous.

Dimpled areas of sediment (Fig. 7) adjacent to the bone in this and AM F97243 may be impressions of soft body parts but equally could be cleavage patterning. They are not present elsewhere on the block of sediment or in the other specimens. Their indentations are too irregular in arrangement to be marks left by small scales and they may be skin impressions.

This specimen is identified as most likely to be a temnospondyl amphibian on the basis of its infolded teeth. Some fish, notably some sarcopterygians, shared folded teeth with early tetrapods, but the last known of these was *Ectosteorachis* from the Early Permian. Rarely, actinopterygians may have folded teeth. The absence of lepidotrichia or fish-like scales associated with the specimen suggests that it is not an actinopterygian, and the vertebral centra are rather large and heavily ossified for a fish.

AM F97242 (Fig. 6C). While this concretion did not split cleanly through the specimen, so that it is fragmented into five main blocks, the colour differentiation is better. Possible cranial material, vertebrae, ribs and limb elements are present. The cranial segment is traversed by a groove which could be a sensory canal and has a raised area which may be a centre of ossification adjacent to the groove. Two slightly curved lateral margins could be the posterolateral borders of interpterygoid vacuities if the element is a parasphenoid. On the other hand they could define the stem of an interclavicle!

The centra look more reptilian than amphibian, being spool-shaped with one or both ends concave as some sections are solid and others bear a central perforation of varying diameter. Mesozoic temnospondyls sometimes have such centra but Palaeozoic temnospondyls do not, and reptiliomorph amphibians, which do have spool-shaped centra, have not been found in the Southern Hemisphere.

All limb remains, except one, have flattened rather than rounded ends and could be temnospondyl or reptile.

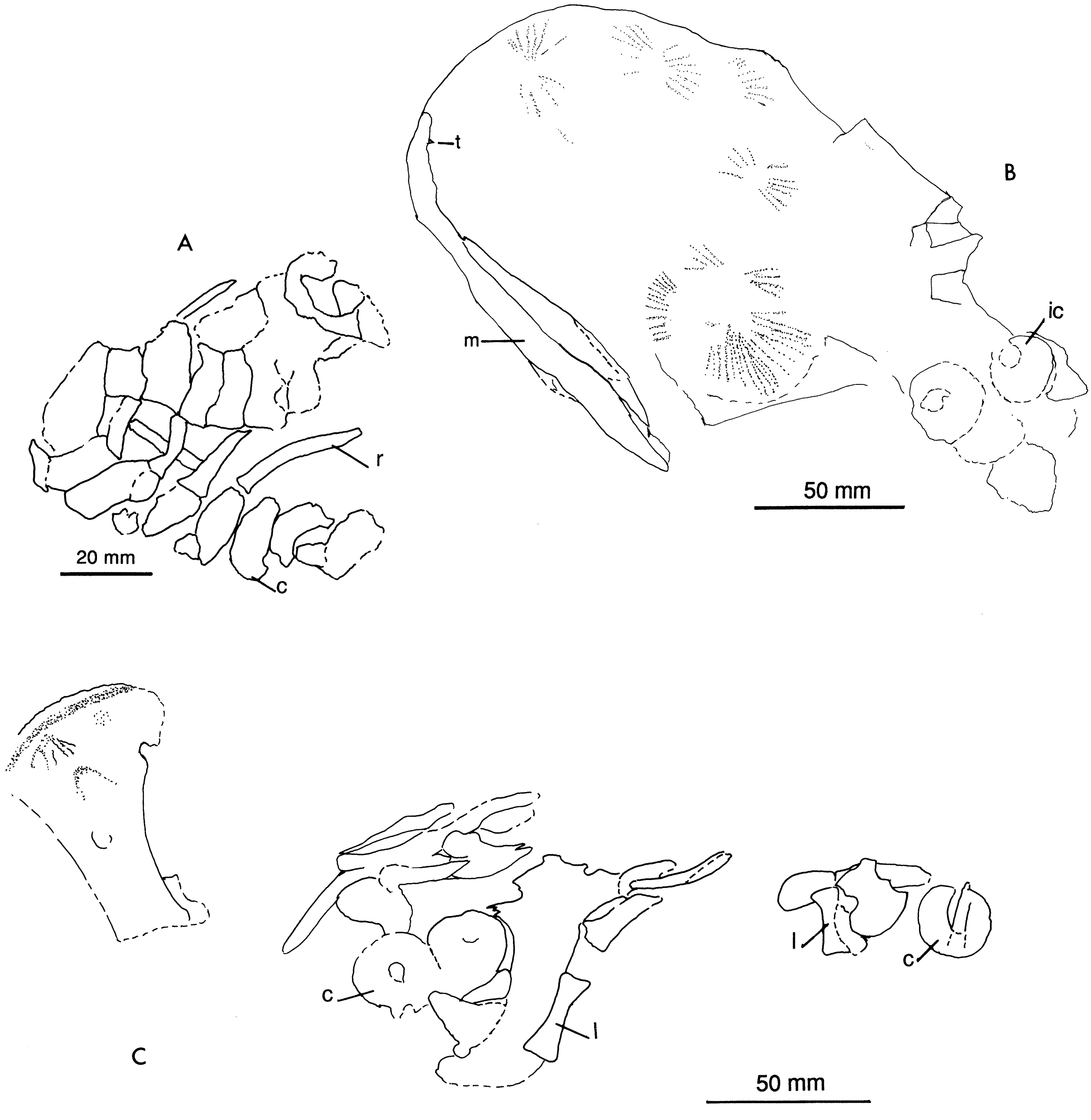

Fig. 6. Outline drawings of bones discernible on **A**—AM F97240, tetrapod vertebral column; **B**—AM F97241, ? temnospondyl remains; **C**—AM F97242, tetrapod ? cranial (left) and postcranial (centre and right) elements. In B the tooth is transposed from the counterpart. Photographs of specimens A and C are not provided as too little colour differentiation exists between bone and sediment. The three areas of bone depicted in C are shown in their natural relationship.

Their size indicates that they are distal limb elements or metapodials.

AM F97243. All remains on this fragmented block are carbonised and difficult to differentiate from the matrix. It appears to be a partial articulated vertebral column with associated ribs.

Stratigraphic position. The Borehole Seam is the lowermost part of the Lambton Subgroup and lies immediately above the Waratah Sandstone which forms the base of the Newcastle Coal Measures in the Newcastle area (McMinn, 1985). The Borehole Seam is Kazanian in age (Diessel, 1980). On McMinn's palynostratigraphic correlation of the Upper Permian of the Sydney Basin (1985, fig. 3) it is a little younger than the Glen Davis Formation from which the temnospondyl, *Bothriceps major*, was recovered.

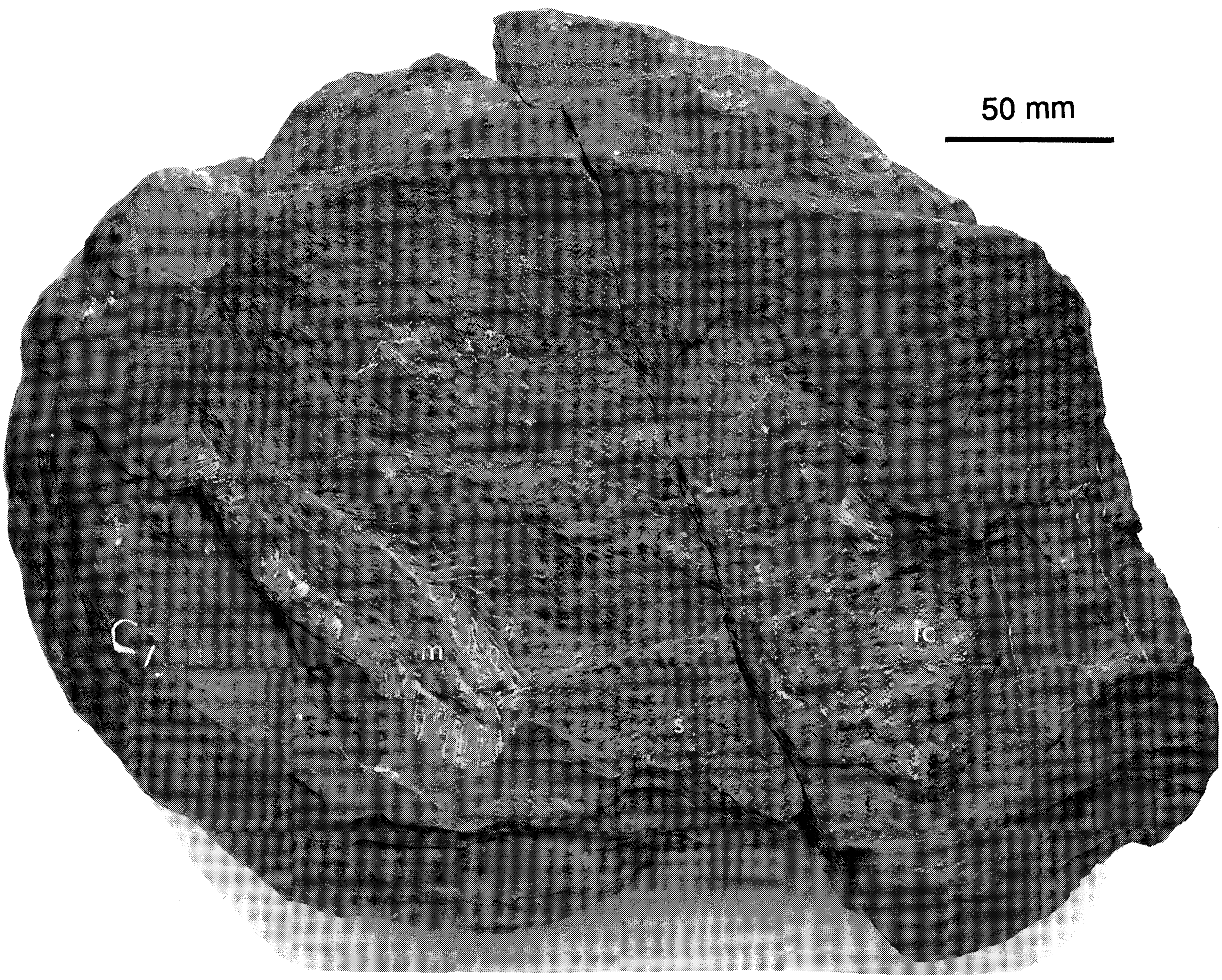

Fig. 7. Photograph of AM F97241, ? temnospondyl remains.

Footprints

Bellambi Colliery

The Bellambi track was discovered following a rock fall from the roof of the Bulli Seam in 1913. It was identified by Dun, who was paleontologist to the New South Wales Geological Survey at the time, as comparable to the reptilian footprints described as *Ichnium gampsodactylum* found in Permian rocks in Germany and the English midlands, and was illustrated by Harper (1915, Plate XXIV) and Herbert & Helby (1980, p. 116). A formal description of these tracks as an ichnotaxon, *Dicynodontipus bellambiensis*, has now appeared (Retallack, 1996). They are argued to have been made by a dicynodont, most likely *Lystrosaurus*, but part of the evidence for this generic identification rests on Retallack's acceptance of a Triassic age for the trackway (see below).

Oakdale Colliery

A second tetrapod trackway (AM F97129, Fig. 8), also from the roof of the Bulli Seam, but this time from the Oakdale Colliery, was donated to the Australian Museum in 1995 by A. Wright. Like the Bellambi track, the Oakdale specimen has a five digit manus with a five digit pes and is therefore also reptilian in origin. The tapered digits suggest claws were present, thus reinforcing the identification of the trackmaker as reptilian. The prints are considerably smaller than those from Bellambi but otherwise are similar in having fore and hind prints of equal size with equally expressed digits. A greater pace angulation and a slightly more digitigrade stance indicate that, although the tracks were made by a similar but smaller animal to the one at Bellambi, it was moving at a faster pace. A small dicynodont or procolophonid are most likely to have made the tracks, although tracks attributed to procolophonids (Haubold, 1971) do not have claw marks.

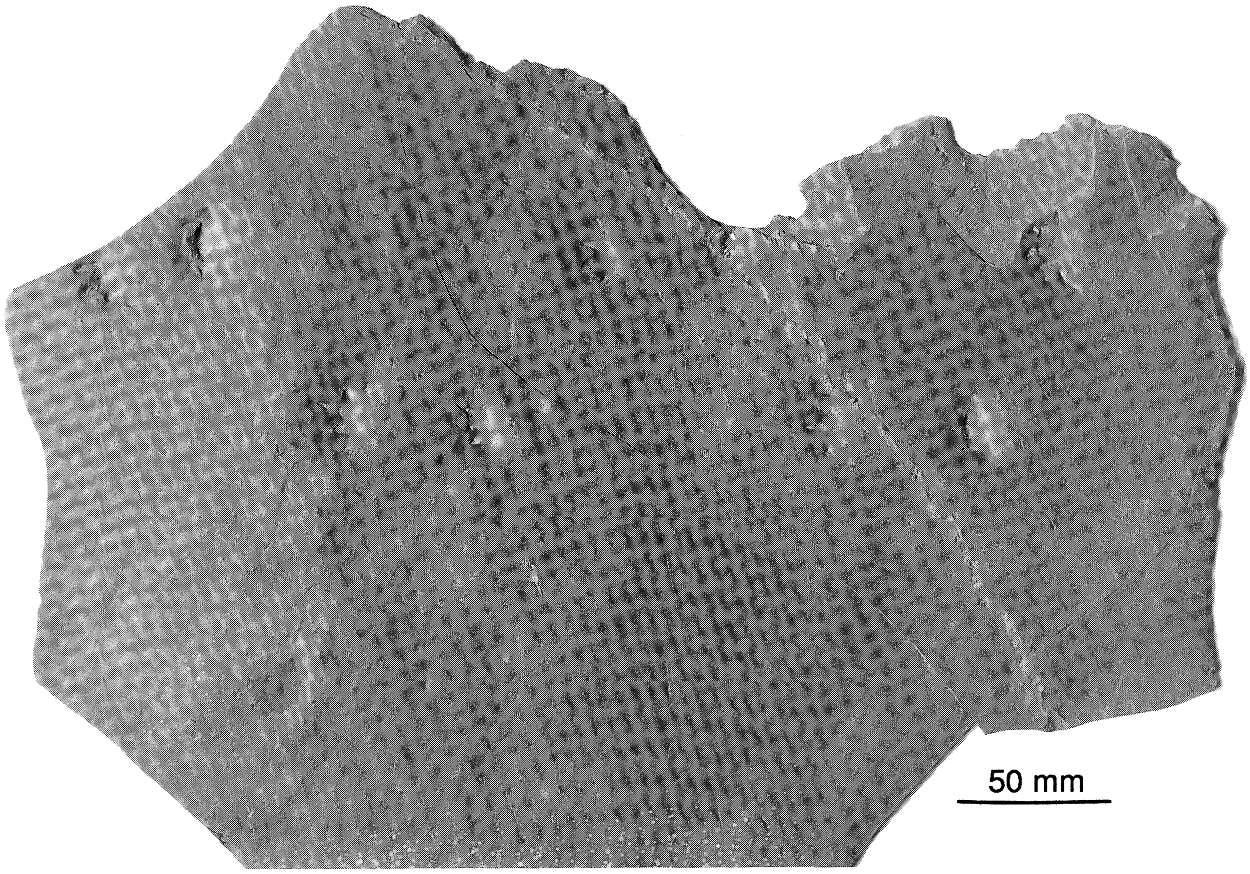

Fig. 8. Amniote trackway (natural mould) from the Oakdale Colliery. AM F97129.

Both the Bellambi and Oakdale footprints are associated with arthropod tracks.

Stratigraphic position. In the southern part of the Sydney Basin, near Wollongong, the Coal Cliff Sandstone, which preserved both the Bellambi and Oakdale trackways, is the lowermost unit of the Narrabeen Group. The Coal Cliff sandstone forms the roof of the Bulli Seam and thus marks the top of the Illawarra Coal Measures (Bowman, 1980), a stratigraphic position close to the Permo-Triassic boundary. The exact position of this boundary in the Sydney Basin is debatable. Palynological evidence indicates that the Narrabeen Group, which overlies the coal measures, extends downwards into the Permian (Retallack, 1980; Archbold & Dickens, 1996) and that the trackways were made before the Late Tatarian. On the other hand, Retallack (1996) argued that the facies change from coal measures to alluvial shales and sandstones at the base of the Narrabeen Group marks the Permo-Triassic boundary. He additionally cites a lightening of the 13 C isotopic ratio of kerogen in sediments at the base of the Coal Cliff Sandstone which he correlates with various marine sequences worldwide where the isotope ratio falls at the Permo-Triassic boundary. The tracks thus lie close to the Permo-Triassic boundary; evidence for them being latest Permian or earliest Triassic is equivocal.

Conclusions

Evidence of tetrapod occupation of the Sydney Basin in the Late Permian is widespread with body fossils to the north and west and trackways to the south-east. Both amphibians and early amniotes are represented but apart from the temnospondyl from Airly none of the material is further identifiable. The new material from the West Wallsend Colliery constitutes the second oldest vertebrate record from the Permian of Australia.

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