DINOSAUR TRACKS IN TRIASSIC MOLTENO SEDIMENTS: THE EARLIEST EVIDENCE OF DINOSAURS IN SOUTH AFRICA?

by

M A Raath[1], J W Kitching[2], R W Shone[3], and G J Rossouw[4],

[1]Port Elizabeth Museum and Department of Geology, University of Port Elizabeth; [2]Bernard Price Institute for Palaeontological Research, Johannesburg; [3]Department of Geology, University of Port Elizabeth; [4] Department of Zoology, University of Port Elizabeth

ABSTRACT

A fossil tracksite containing well-preserved tridactyl footprints of bipedal theropod dinosaurs is reported from fluvial overbank deposits of Molteno age (Stormberg Group: Triassic) in the northeastern Cape Province, South Africa. They occur stratigraphically below the mudrocks of the Elliot Formation, in which dinosaur remains are comparatively common, and are taken to represent the earliest evidence for dinosaurs in South Africa. They also represent the earliest unequivocal evidence of tetrapods in Molteno deposits.

INTRODUCTION

Trout anglers working the Pot River near Maclear, a small town in the northeastern Cape Province, South Africa, have long known of peculiar "spoors" (tracks) of some sort preserved in a sandstone ledge on the river bank about 17 km north of the town. Although the occurrence has periodically featured in local newspapers and magazine articles, it seems to have escaped the notice of geologists and palaeontologists. Dr A J Malherbe, a former resident of Maclear, told us that his father reported them to either the university or the museum in Cape Town some time in the 1920s (pers. comm., 1987), but it seems nothing came of this report and we can find no account of it in the scientific literature.

The site was pointed out to one of us (MAR) in June 1987 by Gerald Spilkin of East London. A brief inspection visit at the time confirmed that the marks included vertebrate tracks and that animals of at least two kinds were involved: one smaller and tridactyl, an undoubted bipedal dinosaur; the other larger and possibly quadrupedal, but of uncertain affinity.

Enquiries among local residents about the history of the site established that it has been known as an interesting picnic site for many years, especially amongst trout anglers and their families; Dr A J Malherbe (mentioned earlier) has a particular reason to remember them as far back as 1926 - he recalls that his father took Lord Baden-Powell, founder of the Boy Scout movement, there in that year to show them to him (pers. comm., 1987).

The clearest and best preserved of the assemblage are the plentiful tridactyl tracks of the bipedal dinosaur. Tracks similar to them are well known from other places in southern Africa, especially at localities in neighbouring Lesotho (Ellenberger, 1970; Olsen and Galton, 1984) and generally similar tracks have also been recorded from Zimbabwe further north (Raath, 1972).

The significance of these tracks at Maclear lies largely in the fact that they seem to occur in Molteno rocks, making them the only unmistakable traces of tetrapod vertebrates found thus far in this formation – previous animal fossils recovered from the Molteno have consisted only of a handful of palaeoniscid fish (*Semionotus* sp.) and a variety of invertebrates, mainly insects (e.g. – Anderson and Anderson, 1984: p.40 "Tetrapods – Bone is not preserved in the Molteno Formation").

LOCALITY OF THE MACLEAR TRACK-SITE

The fossil tracks reported here occur on the east bank of the Pot River on the farm "Oakleigh", about 17 km northeast of Maclear on the road to the mountain hamlet of Rhodes (fig. 1).

Approximate co-ordinates for the main site (shown as site 1 in Figure 1) are 30° 58' 34"S; 28°16' 29"E.

A second site preserving isolated tracks (labelled 2 in Figure 1) is situated about 200 m downstream of site 1.

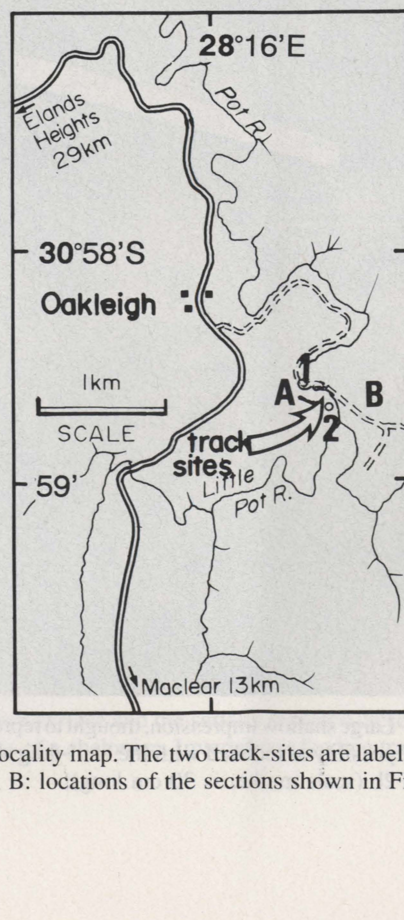

Figure 1. Locality map. The two track-sites are labelled 1 and 2. A, B: locations of the sections shown in Figure 7.

DESCRIPTION OF THE TRACKS

The most prominent trace exposed in the Maclear site is a straight groove ploughed into the mud (fig. 2 a,b), with several other less clear similar traces nearby. These grooves are tentatively interpreted as tail drags, but no absolutely unequivocal footprints can be associated

Figure 2. The prominent groove in the surface presumed to have been caused by a dragging tail. Numerous tridactyl tracks and desiccation cracks can be seen covering the surface (scale marker in each case is 30 cm long).
a - general view;
b - close-up of groove to show rolled edges of mud ploughed by the ?dragging tail.

Figure 3. Large shallow impression, thought to represent a footprint possibly associated with the ?tail-drag shown in Figure 2b (scale marker is 30 cm long);

with them. One indistinct large impression (fig. 3) may be associated with the groove, but no association can be demonstrated beyond doubt, and no unequivocal repeats of this impression have been located on the exposure. About 200 metres downstream of the main track-site, evidently on or near the same bedding plane, is another exposure of some isolated footprints including the tridactyl type, but also another less distinct, larger, shallow impression which could conceivably be a better-preserved and more complete example of the one we associate with the presumed tail-drag groove. Although details of the morphology of this latter trace are not very clear, it is not unlike the sort of track identified by Ellenberger (1970) as *Tetrasauropus* and attributed to a prosauropod dinosaur (see e.g. Olsen and Galton, 1984: fig. 3e). tridactyl prints show that the tracks of several animals (at least seven in the group as presently exposed) are aligned together in a trackway. Other tracks of the same kind heading in the opposite direction are superimposed on some of them. This phenomenon of "doubling back" is fairly commonly observed in tracksites elsewhere, and is sometimes interpreted as indicating a shoreline which shepherded animals along its edge (see e.g. Farlow, Hawthorne and Langston, 1986; Lockley, 1986; Morales, 1986).

One well preserved tridactyl print in the assemblage has the following dimensions:

digit II: 160 mm (83% of digit III length)
digit III: 195 mm
digit IV: 170 mm (87% of digit III length)

Stride lengths, defined as "the distance between corresponding points on successive prints of the same foot" (Farlow, 1981), in the tridactyl trackways vary between 1,72 m and 1,92 m, giving a stride/footprint length ratio of *ca*. 8,8 to 9,8 compared with a ratio of 12,7 to 18,2 calculated from the track of a walking ostrich (Farlow, 1986).

A smaller isolated tridactyl print found on a ripple marked surface at site 2 (fig. 4) has the following dimensions:

digit II:	120 mm (75% of III)
digit III:	160 mm
digit IV:	140 mm (87% of III)

Although this print is nearly 20% smaller than those at site 1, its morphology is similar and it is presumed to belong to the same or a very closely related taxon of maker. At this site on the same ripple marked surface as the tridactyl pes print are other paired crescentic tool marks which might also be ichnites of some kind (?chelonian) as well as invertebrate feeding traces (fig. 4).

GEOLOGY AND AGE OF THE TRACKS

The rock in which the tracks are preserved forms a narrow ledge in the bank of the Pot river bed (fig. 5), and consists of a medium - to fine-grained cross-bedded silty sandstone which was covered by a thin drape of mud before the dinosaurs walked across the surface. That the mud-covered surface was still damp when the track-makers passed is shown by the coherence of the overturned and rolled edges of the "ploughed" shallow groove which we presume was caused by a dragging tail (fig. 2b).

Sub-aerial drying has caused polygonal desiccation cracking in the surface (fig. 6).

The track-bearing ledge lies in the thalweg of the Pot River, just a few centimetres above normal flow level. Although there is usually little more than a steady gentle flow in the river, it is prone to periodic flooding as a result of summer thunderstorms and the melting of winter snow in its mountain catchment. Despite this repeated inundation and scouring by torrential flood waters, the tracks have survived remarkably well - presumably mainly because of "case-hardening" by diagenetic induration of the ancient mud-drape.

The Maclear tracks are preserved near the base of the Stormberg Group, a geological succession whose constituents nearly all have their formal stratotypes located in the general vicinity of the northeastern Cape; the name "Stormberg" itself derives from the range of mountains of that name about 200 km west-southwest of Maclear. The Stormberg clastic wedge is thickest in this region in the south, and thins rapidly northwards (Visser,

Figure 4. Isolated tridactyl footprint at Site 2 shown in Figure 1. Note the ripple marked surface and the serially repeated crescentic traces to the right of and behind the tridactyl footprint, possibly representing tracks of a chelonian. Invertebrate feeding traces are also present (scale marker is 15 cm long).

1980, 1984; Turner, 1970, 1984; and references in those cited). The basal Stormberg layers are the thick, coarse fluvial sandstones and finer shales of the Molteno Formation, named after a village in the foothills of the Stormberg mountains. Above the Molteno Formation sandstones lie the brick-red mudrocks and sandstones of the Elliot Formation, named after a town 40 km southwest of Maclear. Pale, finer-grained, mainly aeolian sandstones of the Clarens Formation overlie the Elliot mudrocks and are the youngest of the Stormberg sediments. The thick Drakensberg lavas cap the sequence. This entire sequence is exposed in the Barkly Pass about 50 km west

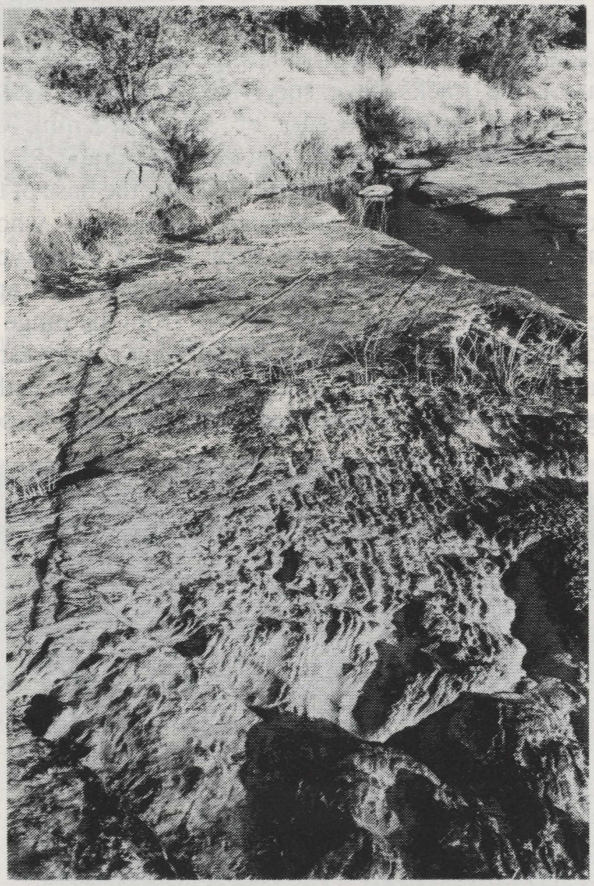

Figure 5. General view of the track-bearing ledge in the Pot River, Maclear district, viewed from the south and showing truncated cross-laminated silts in foreground and "case-hardened" mud-draped surface in mid- and background on which the tracks are preserved; note the well marked ?tail-drag along the entire exposure.

of Maclear on the main road between Elliot and the north, with Molteno right at the base of the pass and Drakensberg lavas right on top.

Stratigraphically, the tracks seem to occur in the Molteno - making them perhaps the earliest evidence of dinosaurs in South Africa, but the time-transgressive nature of the Molteno-Elliot contact (see e.g. Visser, 1980, 1984; Olsen and Galton, 1984) leaves this point somewhat moot. As Visser (1984) notes, the Molteno Formation in this area makes up the valley floor at the foot of the surrounding Drakensberg mountains, which are built of Elliot Formation mudrocks from the base, overlain by the crags of Clarens Formation sandstones, and capped by the lavas. Visser (pers. comm., in litt., 1987) informed us that, on the basis of his recent eight years of sedimentological fieldwork in the area, he locates the Molteno-Elliot contact "right at the foot of the (Barkly) pass in the Tsomo River and this position agrees with the boundary defined by (A.L.) du Toit on his map (?1910) of the area."

The tracks occur in beds well below the level of this contact (although the actual stratigraphic interval was not measured or even estimated in this preliminary study); they are even below beds which might be described as "uppermost Molteno" through which the Pot River has cut its deep valley.

This stratigraphic conclusion is supported by the observation that the lip of the high ground overlooking the tracksite, itself a result of the river's deep incision into the valley floor, is composed of a thick, very coarse sandstone (fig. 7) bearing the hallmarks of the Indwe Sandstone Member of the Molteno. The distinctively coarse and widely persistent Indwe Sandstone represents the second of six upward-fining megacycles identified in the deposition of the Molteno (Turner, 1975, 1984; Visser, 1984).

Within a kilometre of the track-site, a shale outcrop exposed in a quarry contains abundant plant fossils including the characteristic Molteno genus, *Dicroidium* (fig. 8). This same stratum can be traced laterally to the vicinity of the tracksite, where it outcrops under a thin sandstone roughly 50 metres above the horizon of the tracks.

The conclusion therefore seems inescapable that the tracks are indeed deep in Molteno sediments, that they are therefore mid- to late Triassic in age.

DISCUSSION

Identity of the Track-makers

Because of uncertainty over what produced the long straight grooves at site 1, we see little point in discussing them further in this preliminary report. We speculate that they might be the tail drags of quadrupedal prosauropod dinosaurs, but have no hard evidence to offer in support other than the indistinct probable footprint shown in Figure 3.

As far as the tridactyl tracks are concerned, the most likely makers are surely dinosaurs, more specifically small to medium-sized theropods ("coelurosaurs"). Based on their shape, these pes prints are assignable either to the ichnogenus *Grallator* (see Olsen and Galton, 1984: fig. 3H) or to *Atreipus* (Olsen and Baird, 1986: figs 6.3, 6.4). However, since *Atreipus* is defined as "habitually quadrupedal ichnites" (Olsen and Baird, 1986: 62), and since no manus impressions have been found associated with any of the tridactyl pes impressions in the Maclear tracks, this ichnogenus can be eliminated.

Figure 6. Desiccation cracks and tridactyl ichnites on the exposed surface (scale marker is 30 cm long).

There is a measure of consensus that *Grallator*-like tracks were "almost certainly made by small theropod dinosaurs" (Olsen and Galton, 1984: 97). Bony remains of dinosaurs are plentiful in Stormberg and equivalent sediments from several sites in southern Africa (see Raath, 1980; Cooper, 1981; Kitching and Raath, 1984 and references therein). Indeed, bones of dinosaurs have been found as close by as the Barkly Pass, not far from the tracksite but never below rocks which are clearly recognisable as belonging to the Elliot Formation; i.e. never in rocks of "Molteno aspect". Until now they have invariably been found well above even the base of the Elliot Formation and their apparently consistent stratigraphic distribution led Kitching and Raath (1984) to propose two biozones in the Elliot Formation – the *Euskelosaurus* Range Zone in the lower parts and the *Massospondylus* Range Zone in the middle and upper parts.

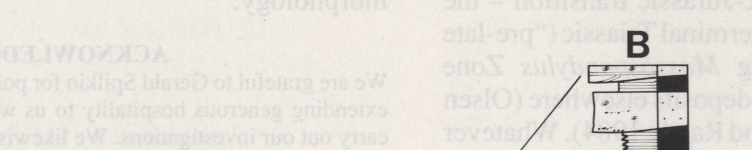

Figure 7. Semi-schematic lithostratigraphic interpretations of sections at A and B (see fig. 1), also showing general topography of the tracksite.

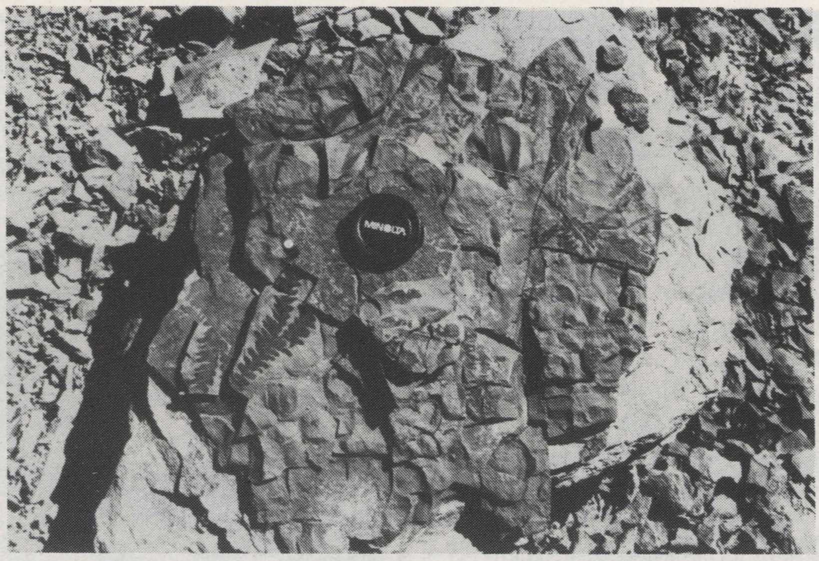

Figure 8. Slab of shale from a quarry approximately 0,5 km northeast of the tracksite, showing leaf impressions of *Dicroidium*, amongst other plant fossils. This same fossiliferous shale occurs under a prominent thin sandtone which outcrops part-way up the slope in the immediate vicinity of the tracksite.

So far, no theropod bones have been found in the *Euskelosaurus* Range Zone, but at least one taxon, *Syntarsus*, is not uncommon in the overlying *Massospondylus* Range Zone (Raath, 1980; Kitching and Raath, 1984). Ichnites attributed to *Syntarsus* have been found in Zimbabwe in beds which, on palaeontological grounds, correlate with the upper parts of the Elliot Formation (Raath, 1972).

Quite what span of time is represented by the accumulated sediments of the Molteno, Elliot and Clarens formations is unknown, but it is probably not much – Visser (1980: 61) suggests that the whole sequence was deposited in a period of less than 10 myr. The age of the Molteno itself is far from settled; recent work suggests that it is at least middle to late Triassic (Lower Carnian – Anderson and Anderson, 1984: 40), whereas the Elliot Formation spans the Triassic-Jurassic transition – the *Euskelosaurus* Zone may be terminal Triassic ("pre-late Norian"), and the overlying *Massospondylus* Zone correlates with early Jurassic deposits elsewhere (Olsen and Galton, 1984; Kitching and Raath, 1984). Whatever the case, it certainly seems that the Maclear dinosaur tracks are stratigraphically the lowest, and therefore the earliest, authenticated evidence of dinosaurs in South Africa, and as such they are significant. Ellenberger (1970) assigned several of the tracksites he investigated to the Molteno, but gave no stratigraphic reasons for this assigment and it has not been generally accepted by other authors. The Maclear find reopens the question of whether Ellenberger's attribution was not in fact correct.

Tridactyl theropod-like tracks have been found elsewhere in rocks as early as the Anisian stage of the Late Triassic, as in the "gres inferieur" of France (Demathieu, 1986), so it is certainly conceivable that theropods were walking around in this part of the Gondwana hinterland before the fluvial mudrocks of the Elliot Formation were laid down. The size of the Maclear tridactyl prints rules out *Syntarsus rhodesiensis* as the maker; its footprints are about half the size of the Maclear tracks, but they are otherwise very similar in morphology.

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