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Preliminary report of a large theropod dinosaur trackway in Clarens Formation sandstone (Early Jurassic) in the Paul Roux district, northeastern Free State, South Africa

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An isolated fallen block of Clarens Formation sandstone near the small northeastern Free State town of Paul Roux preserves part of the trackway of a bipedal dinosaur. Although well known as a local curiosity, this trackway has not previously been formally reported or described. It consists of five successive paces of what is interpreted as a medium-sized to large theropod dinosaur, and represents the largest known theropod trackway in the 'Stormberg' sequence in South Africa. The tracks are assigned to the ichnotaxon *Grallator* sp., and show similarities to North American tracks of comparable age originally described as *Dilophosauripus*. Until now no body fossils of a likely candidate trackmaker were known, but elsewhere in this volume a possible candidate is described by the second author.

Keywords: Dinosauria, tracks, Stormberg, Clarens Formation, Early Jurassic, *Grallator, Kainotrisauropus, Dilophosauripus.*

INTRODUCTION

Unmistakable footprints preserved on a large detached block of sandstone on the farm Uniondale, about nine kilometres southeast of the small northeastern Free State town of Paul Roux (approximate locality coordinates 28°21′47″S, 28°00′05″E), have long been known as a local curiosity. The farmers and townsfolk of the area have long recognized that these markings are the fossilized 'spoor' or tracks of an ancient animal, most accepting the local folklore that the track-maker was 'a dinosaurus'. Although the trackway is well known as a local curiosity and tourist attraction, we are unaware of any formal report or description of these tracks in the scientific literature.

The sandstone block on which the tracks occur (Fig. 1) has come to rest on its side near the base of the adjacent hill from which it has evidently tumbled. It appears to have broken off from a thick, relatively coarse massive sandstone which outcrops near the top of the hill. This sandstone horizon is high in the succession of 'Stormberg' rocks in the area. It is underlain by many metres of coarse, massive sandstone and there can be no doubt that the trackway horizon belongs to the Clarens Formation (Early Jurassic), a conclusion shared by the late James W. Kitching, in whose memory this volume is presented, who visited the site on many occasions over the years.

Dinosaur tracks are known from many localities in 'Stormberg' exposures in Lesotho (Ellenberger 1970) and adjacent areas of South Africa (see e.g. van Dijk 1978; Olsen & Galton 1984; Raath *et al.* 1990; Gow & Latimer 1999), mainly in mudrocks of the Elliot Formation, although Ellenberger (1970) recorded quite a few Lesotho tracksites in what he identified as 'Cave Sandstone', an old name for the Clarens Formation.

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Figure 1. Isolated block of Clarens Formation sandstone on the farm Uniondale, preserving five paces of a dinosaur trackway moving from bottom right to top left.

During a brief field excursion by staff and students of the Bernard Price Institute for Palaeontological Research in June 2003 it was decided to take advantage of a stop on Uniondale farm to measure and photograph the tracks (Fig. 2) and formally place them on record.

Because of the way the block has come to rest, the original surface along which the track-maker moved is now

almost vertical, and therefore rather difficult to measure without some means of climbing the almost vertical five to six metre high face, hence the number of dimensions in Table 1 calculated from scaled photographs, which must therefore be taken as approximations.

DESCRIPTION OF THE UNIONDALE TRACKWAY

The trackway on Uniondale consists of a series of five successive footprints of a large bipedal tridactyl animal (Figs 3 & 4). There is no trace of manus prints associated with any of the pes prints. Because the block is loose and lying on its side, it is no longer possible to determine in which direction the animal originally walked. There are several other scattered, isolated prints of one or more smaller animals on the block, but no clear individual trackways; one such isolated print can be seen slightly below and to the right of R2 in Figure 3a, heading obliquely in the opposite direction to the main trackway.

Each individual print is symmetrically tridactyl, with the central digit (III) the longest (Fig. 4). Each toe print narrows distally, ending in a sharply pointed impression of a narrow claw. Although there has been some weathering of the surface on which the prints are impressed, and no clear details of toe-pad morphology are preserved, their general sharpness and clarity suggests that they are the slightly weathered primary prints impressed directly on the surface on which the animal walked, not underprints.

Table 1 gives the dimensions of the Uniondale trackway, following the methods and terminology of Leonardi (1987) combined with those of Thulborn (1984); where they could not be measured the dimensions were calculated from scaled photographs. Where measurements were physically taken the reference point was the base of the central digit (III).

IDENTITY OF THE UNIONDALE TRACK-MAKER

The symmetrically tridactyl prints of the Uniondale trackway agree most closely in shape and size with tracks from beds of comparable age in Lesotho which Ellenberger (1970) named *Kainotrisauropus* spp. Olsen & Galton (1984) referred *Kainotrisauropus* to the ubiquitous



Figure 2. Measuring stride length from L1 (obscured by bush) to L2 (stride = 2.80 m).

tridactyl ichnotaxon *Grallator* (*Eubrontes*), which is generally attributed to bipedal saurischian dinosaurs, notably the theropods (Olsen & Galton, 1984).

The Uniondale track-maker is tentatively identified as a theropod on the grounds that its footprints are longer than broad, that each toe tapers distally, and the toe prints each end in a sharp claw imprint; ornithischian prints in general would be expected to be broader than long, with the toe prints having roughly parallel sides and each ending in a rounded ungual impression rather than the sharply tapering imprint of a claw (Thulborn 1984). The

Table 1. Dimensions of dinosaur tracks.

Dimension	Uniondale trackway	Ntumbe River trackway**	*Dilophosauripus****
Print length	~397 mm (L2*)	400	230
Print width	~323 mm (L2*)	300	280
Ratio of print width to print length	0.81	1.33	0.82
Divarication angle between digits II and III	37 degrees	31	20
Divarication angle between digits III and IV	34 degrees	26	28
Pace length	1.44 m (L1–R1) ~1.50 m (L2–R2*)	1.27 m (ave)	1.06 (isolated print)
Pace angulation	136 degrees (R1–L2–R2) 140 degrees (L2–R2–L3)	135 degrees (ave)	
Stride length	2.80 m (L1 to L2)	1.26–2.62	
Ratio pes length:pace	3.6	3.2	~3

*Measured from scaled photographs.
**Broderick 1984; Munyikwa 1996.
***Welles 1971.

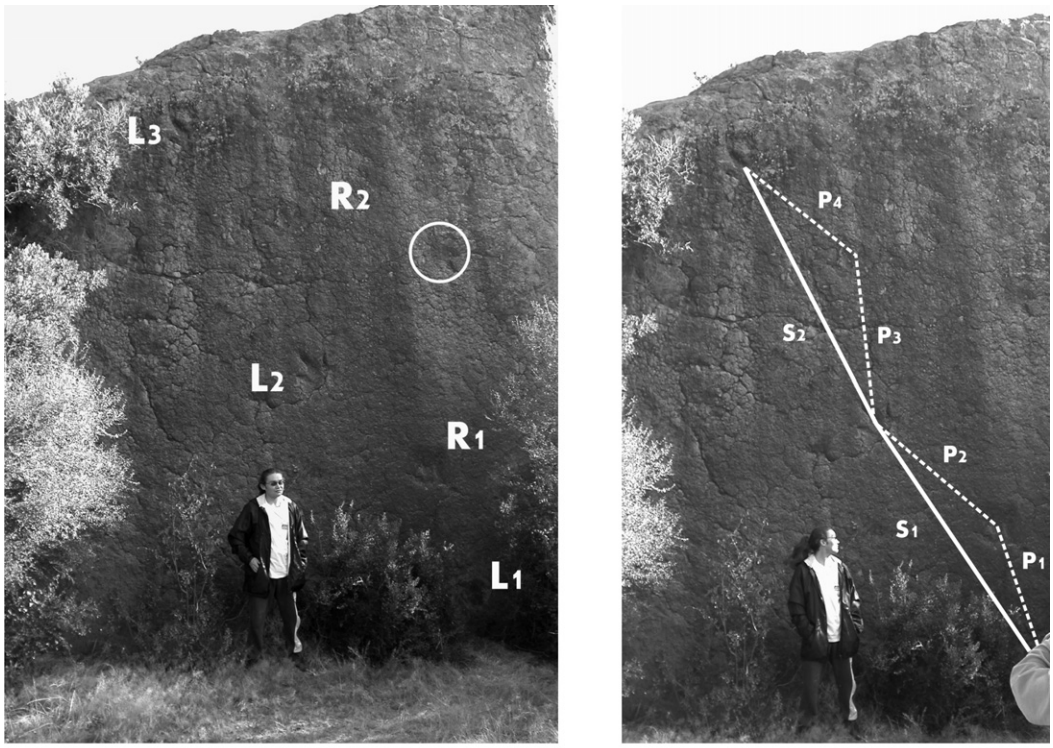

Figure 3. **a**, The full trackway, with figure for scale, and individual prints labelled (note the isolated smaller print [circled] below and to the right of R2, heading in the opposite direction to the main trackway). **b**, Same as (a), with successive strides (S1, S2) and paces (P1–P4) indicated.

lack of manual prints also rules out any quadrupedal dinosaurs such as the prosauropods that dominate the dinosaur fauna of the Elliot and Clarens formations (see e.g. Kitching & Raath 1984), and therefore also rules out attribution of these tracks to the quadrupedal ichnotaxon *Atreipus*.

The tracks reported here agree in general features with unnamed tracks in beds of approximately similar age on the Ntumbe River in northeastern Zimbabwe (Broderick 1984, 1985; Munyikwa 1996) (Table 1), although these prints do not seem to show distinct impressions of narrow, trenchant claws (Raath, pers. obs.). They also agree quite well with tracks recorded by Welles (1971) from the approximately coeval Kayenta Formation of the southwestern U.S.A. (Table 1), which he named *Dilophosauripus*, suggesting possibly another instance of close resemblance between the faunas of the 'Stormberg' of southern Africa and the Kayenta Formation of North America (see e.g.

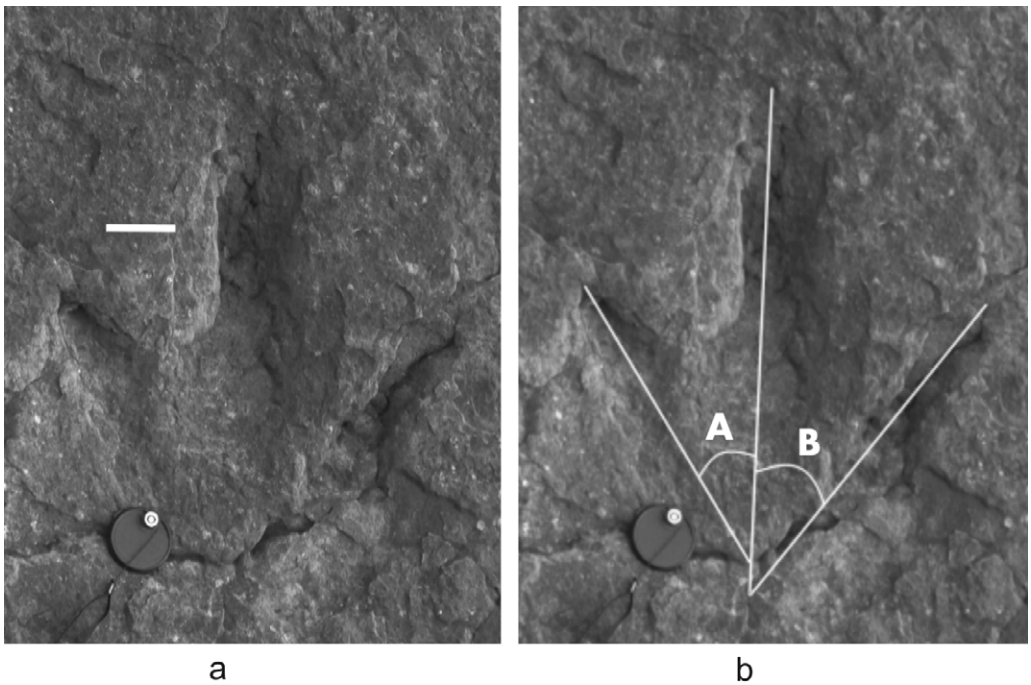

Figure 4. **a**, Individual print (L2) (scale bar = 60 mm). **b**, Same as (a) with lines on which divarication angles were measured between digits II and III (angle B) and between III and IV (angle A). See Table 1 for values.

Olsen & Galton 1984: 92–93).

The animal that made the Uniondale track is considerably larger than any theropod dinosaur known to date by body fossils from either the Elliot or Clarens formations; until now the only theropod represented by bony remains from these deposits is the small form originally named *Syntarsus* (now considered a synonym of *Coelophysis*) (Raath 1980; Paul 1993; Bristowe & Raath 2004). Two footprints attributed to this Gondwana species of *Coelophysis* are known from rocks of Upper Elliot age in Zimbabwe (Raath 1972) and these, together with the abundant, well-preserved foot bones of this animal, make it clear that *Coelophysis* is far too small to have been the Uniondale track-maker. However, elsewhere in this volume, Yates (2005) describes a new large coelophysoid theropod of comparable geological age whose fragmentary remains indicate an animal of the right order of size to have made tracks like those at Uniondale.

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