RESEARCH NOTE

First evidence of a tetrapod footprint from the Triassic of northern Victoria Land, Antarctica

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Abstract

Here, we report on a tetrapod footprint from the Transantarctic Basin in the far north of Victoria Land, which marks the first record of terrestrial vertebrates for this region. The single specimen derives from a previously unknown lithological unit of Middle or Late Triassic age of the Beacon Supergroup in the Helliwell Hills in the central Rennick Glacier area. It differs in both size and morphology clearly from Middle Triassic trackway types from the upper Fremouw Formation of the Queen Alexandra Range in southern Victoria Land, and likely represents a primitive amniote, procolophonid or therapsid. The footprint is the third evidence of fossil vertebrate trackways in Antarctica.

Keywords

Beacon Supergroup; Helliwell Hills; ichnotaxon; *Procolophonichnium*; Rennick Glacier; Transantarctic Basin

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Introduction

Since the first terrestrial tetrapod fossil was described from the central Transantarctic Mountains in Antarctica (Barrett et al. 1968), three distinct early Mesozoic tetrapod faunas have been recognized from the lower Fremouw Formation (Lower Triassic), the upper Fremouw Formation (lower Middle Triassic) and the Hanson Formation (Lower Jurassic) (Smith 2013). In addition, a few tetrapod specimens are known from the Lashly Formation (Upper Triassic) in southern Victoria Land (Hammer et al. 2004). Most of the early Mesozoic Antarctic tetrapods, that is, temnospondyl amphibians, therapsids, archosauromorphs, pterosaurs and dinosaurs, are documented by body fossils, that is, skulls, jaws, teeth, bones and even entire skeletons (Smith et al. 2011; Stilwell & Long 2011; Smith 2013). Tetrapod trace fossils have also been found in the central Transantarctic Mountains: burrows of therapsids and parareptiles have been found in the lower Fremouw Formation in the Beardmore Glacier region (Miller et al. 2001; Sidor et al. 2008) and trackways, perhaps made by the therapsid *Lystrosaurus*, have been discovered in the upper Fremouw Formation of the Queen Alexandra Range (Macdonald et al. 1991). Together with avian tracks from the Eocene Fossil Hill Formation at Fildes Peninsula on King George Island, South Shetland Islands (Covacevich & Rich 1982; Mansilla et al. 2012), these were the only known vertebrate trace fossils from Antarctica.

Here, we describe an isolated tetrapod footprint from the Transantarctic Basin in the far north of Victoria Land, which represents the first evidence of terrestrial vertebrates for this region. Our specimen derives from a previously unknown lithological unit of the Beacon Supergroup in the northern Helliwell Hills in the central Rennick Glacier area (Fig. 1). The unit has a thickness of 250+ m and consists of greenish-weathering, fine-grained sandstone and thick overbank mudstone with thin coal seams, locally containing abundant silicified wood, silicified peat and occasional occurrences of plant compressions. The occurrences of *Kykloxylon*, *Agathoxylon*, *Heidiphyllum* and *Lepacyclotes* indicate a Middle or Late Triassic age (Bomfleur & Mörs 2016; Bomfleur et al. 2018).

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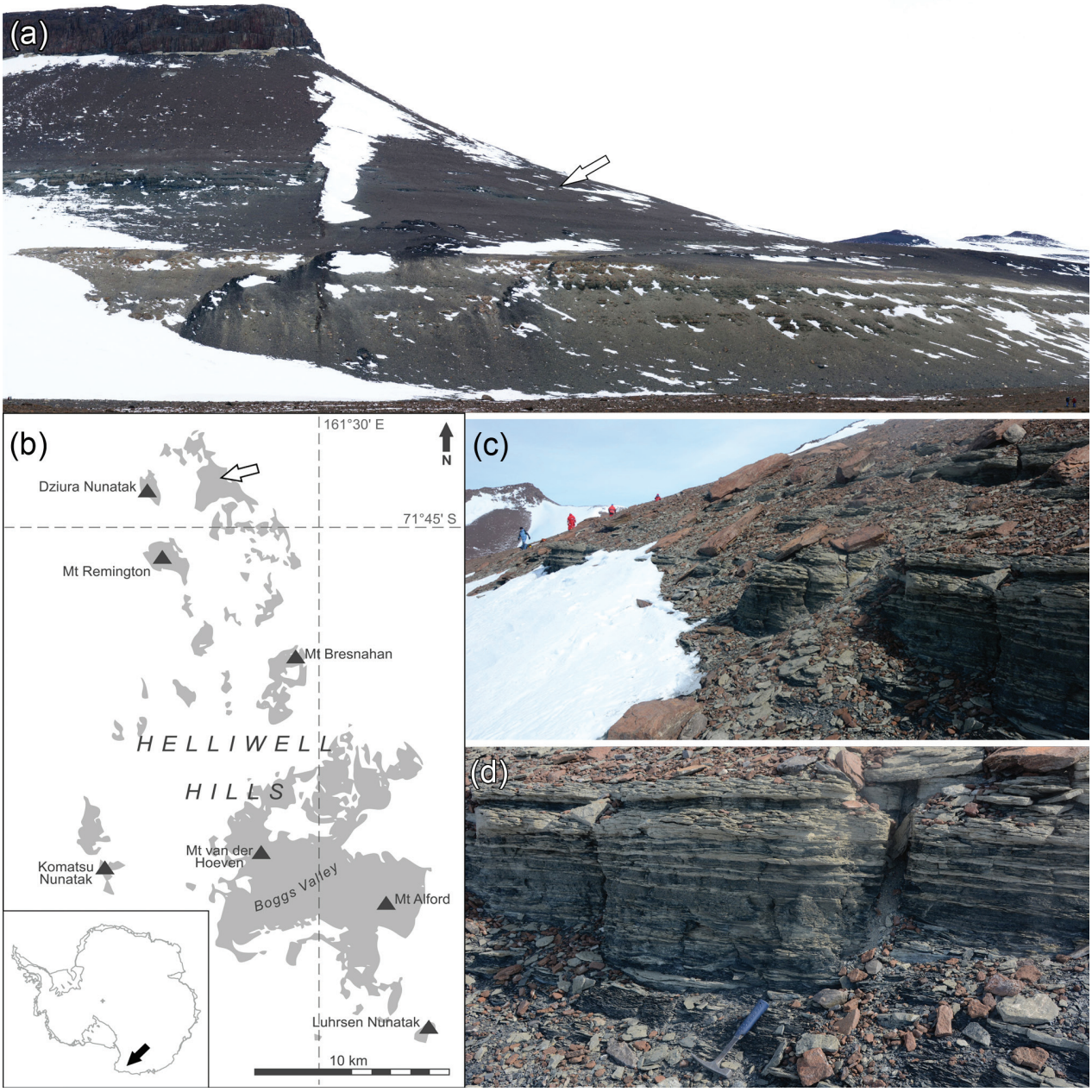

Fig 1 (a) Location of the fossil locality on the north-west slope of an unnamed mesa in the northern Helliwell Hills (white arrow). (b) Map of the Helliwell Hills with the fossil locality at the Helliwell Hills Camp (white arrow) and of the Helliwell Hills in Antarctica (inset, black arrow). (c) Fossil locality with exposed Triassic sediments. (d) Close-up showing the greenish-weathered, fine-grained sandstone and mudstone layers, hammer for scale. (Photos by B. Bomfleur.)

Material and methods

The specimen described here was collected by some of the authors (TM, LC, AL and BB) during the 11th German Antarctic North Victoria Land Expedition (GANOVEX XI) in the austral summer of 2015/16. This specimen was found while surface collecting in the active layer on the north-west slope of an unnamed mesa in the northern Helliwell Hills, close to the field camp, GPS data 71°43.844'S, 161°21.413'E (Fig. 1). The specimen is preserved as a cast in a light-coloured, fine-grained sandstone slab of ca. 3 cm thickness. It was mechanically cleansed, documented photographically and cast.

The specimen is housed in the polar sample collections of the Federal Institute for Geosciences and Natural

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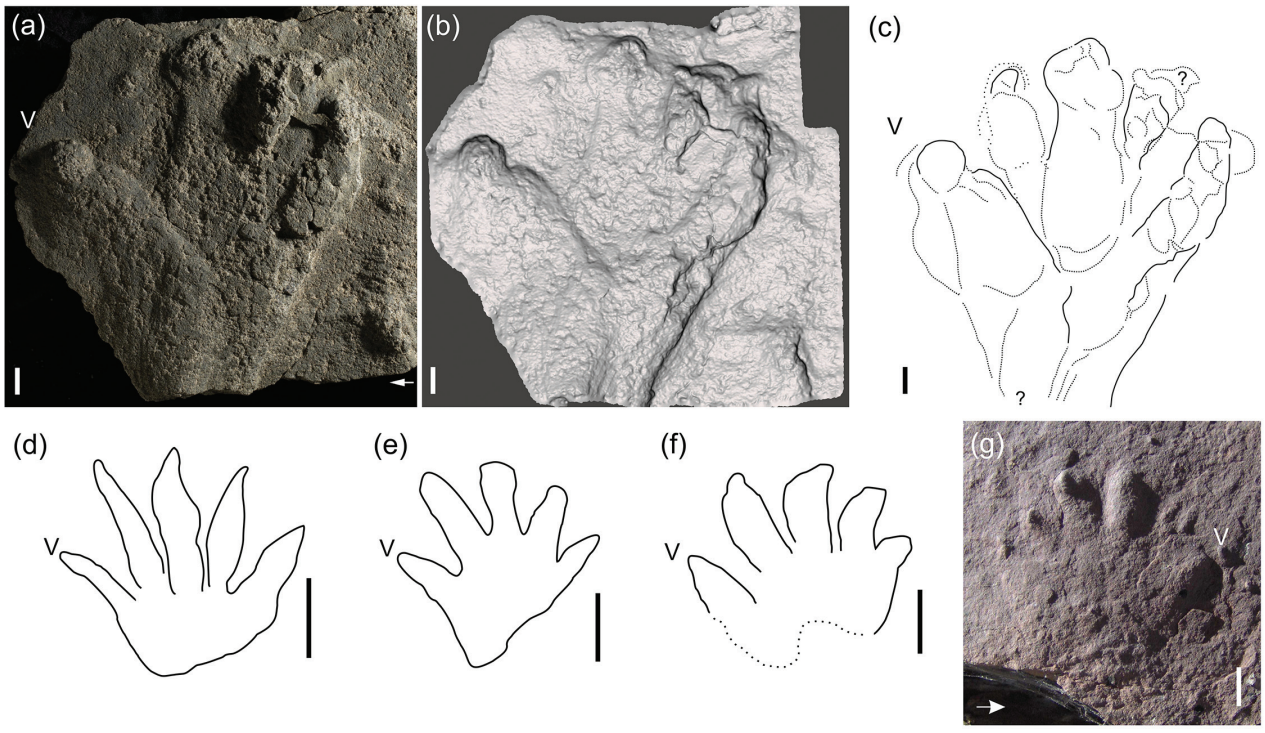

Fig 2 (a–c) Footprint of cf. *Procolophonichnium* isp., Triassic, northern Victoria Land, Antarctica: (a) photograph, arrow indicates direction of light; (b) image from laser scanner; (c) simple interpretative drawing. (d–f) Simplified drawings of *Procolophonichnium* specimens from other locations: (d) *Procolophonichnium nopcsai* (Kuhn, 1963), Lower Triassic near Middelburg, Karoo Basin, South Africa; (e) *Procolophonichnium winterswijkense* (Demathieu & Oosterink, 1983), Lower–Middle Triassic (Olenekian–Anisian), Buntsandstein and Muschelkalk of the Germanic Basin; (f) *Procolophonichnium polonicum* (Ptaszyński 2000), Lower Triassic, Wióry, Holy Cross Mountains, Poland); (g) cf. *Procolophonichnium* isp. (unpublished specimen), Lower Triassic, Wióry, Holy Cross Mountains, Poland. The digit V imprint is indicated with the letter V. Scale bars are 1 cm long.

Resources, Hannover. Additional casts, photographs and 3D-scans are housed there and also in the GEOSKOP museum in Thallichtenberg, Germany.

Results and discussion

Ichnogenus *Procolophonichnium* Nopcsa, 1923
cf. *Procolophonichnium* isp.
Fig. 2a, b, c

Material. Poorly preserved, isolated left pes imprint; specimen preserved as natural cast.

Description. Medium-sized pentadactyl pes imprint, characterized by a long digit V imprint situated close to the digit group I-IV. Digit group I-IV short and wide. Tip of digit V on the level of half the length of digit IV and tip of digit I. Digits moderately broad and curved outwards, increasing in length from I to V. Digit V positioned posterolaterally to digit group I-IV. Digit IV subequal in length with digit III.

Remarks and comparisons. This specimen should be included in the ichnogenus *Procolophonichnium* because of the presence of a long digit V imprint situated close to the digit group I-IV. *Procolophonichnium* ichnites are relatively rare components of Late Permian/Early Triassic through Late Triassic ichnofaunas (see Klein & Niedźwiedzki 2012; Klein et al. 2015). *Procolophonichnium* is well-known from Lower–Middle Triassic strata in central Europe, especially from the Buntsandstein and some marginal marine Muschelkalk deposits in the Netherlands and Germany (Haubold 1971a, b; Demathieu & Müller 1978; Demathieu & Oosterink 1983, 1988). In recent years, several new species of *Procolophonichnium* have been found in the Lower, Middle and Upper Triassic of Europe (Ptaszyński 2000; Diedrich 2002a, b; Klein et al. 2015). Almost all of these species are characterized by relatively small sizes (Fig. 2d, e, f) and by a long digit V, which is positioned posterolaterally to digit group I-IV (Klein et al. 2015). There are, however, exceptions, and some findings from the upper Lower Triassic (Olenekian) of Poland (Fig. 2g; for more about locality, see Ptaszyński 2000; Klein & Niedźwiedzki 2012) indicate that *Procolophonichnium* can also be represented by ichnites of medium size (ongoing study). The specimen

from Antarctica represents one of the largest known ichnites of this ichnogenus.

Procolophonichnium tracks and trackways were originally attributed to procolophonids (Seeley 1904, 1905; Nopcsa 1923; Haubold 1971a, b; Baird 1986), "Cotylosauria" and turtles (Kuhn 1958, 1963), and/or captorhinids (Haubold 1984). More recent interpretations consider "primitive amniotes" (Klein & Lucas 2010) or procolophonids and therapsids (Klein et al. 2011; Klein et al. 2015) as track-maker candidates.

The morphology of the Helliwell Hill specimen differs clearly from the three previously described types of trackways from the upper Fremouw Formation of the Queen Alexandra Range, both in size and morphology (see figure 3 in Macdonald et al. 1991). The Helliwell Hill specimen further highlights the largely untapped potential of Beacon Supergroup rocks of northern Victoria Land for the study of the vertebrates that inhabited Antarctica in the Mesozoic.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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