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First occurrence of tetrapod footprints from the continental Triassic of the Sidi Said Maachou area (Western Meseta, Morocco)

Abdelkbir Hminna [a,*], Sebastian Voigt [b], Hendrik Klein [c], Hafid Saber [a], Jörg W. Schneider [d], Driss Hmich [a]

[a] Geodynamic and Variscan Geosciences Laboratory, Department of Earth Sciences, Chouaïb Doukkali University, B.P. 20, 24000 El Jadida, Morocco
[b] Urweltmuseum GEOSKOP, Burg Lichtenberg (Pfalz), Burgstr. 19, 66871 Thallichtenberg, Germany
[c] Saurierwelt Paläontologisches Museum, Alte Richt 7, D-92318 Neumarkt, Germany
[d] Geological Institute, TU Bergakademie Freiberg, B.-v.-Cotta-Str. 2, 09596 Freiberg, Germany

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ABSTRACT

The Sidi Said Maachou area in the Moroccan western Meseta preserves a succession, up to 400 m thick, of hitherto poorly studied continental Triassic deposits. Recent detailed geological mapping proposes a lithostratigraphic subdivision of the predominantly red-coloured siliciclastic deposits into three formations. Laminated mudstones and fine-grained sandstones in the upper part of the Oued Oum Er Rbiaa Formation have the most interesting fossil content including plant impressions, rhizoliths, fish scales, and invertebrate and vertebrate traces. These biogenic remains are partially associated with tool marks, microbially induced sedimentary structures, oscillation ripples, desiccation cracks, and halite pseudomorphs, suggesting sedimentation in a playa-like, fluvio-lacustrine system under semiarid conditions. All tetrapod footprints from these beds are assigned to *Brachychirotherium parvum* and indistinguishable from other occurrences of the ichnogenus in Central Europe and North America. Supposed trackmakers are archosaurs of the crocodile stem-group (Crurotarsi) that were widely spread over Triassic Pangaea. Because *Brachychirotherium* is only known from Late Triassic (Carnian–Rhaetian) deposits, the same age is attributed to the footprint horizon of the Oued Oum Er Rbiaa Formation. This is the first record of *Brachychirotherium* on the African continent and the first record of Triassic tetrapod footprints in Morocco outside of the High Atlas.

1. Introduction

Tetrapod footprints from the Triassic of Morocco were first mentioned in the second half of the 20th century from the Argana Basin of the western High Atlas region (Jones, 1975; Dutuit, 1976). Shortly afterwards, Biron and Dutuit (1981) reported on more finds from this area and questionable Middle to Late Triassic footprints of the Ourika Basin in the High Atlas of Marrakech. Recently, diverse assemblages of well-preserved tetrapod footprints were recorded in Early and Middle Triassic red beds of the Argana Basin (Klein et al., 2009, 2010, 2011; Voigt et al., 2011). The only other occurrences of Early Mesozoic tetrapod footprints in North Africa concern supposed Early Triassic deposits in Niger (Ginsburg et al., 1968; Taquet, 1976) and Middle Triassic deposits in Algeria (Kotanski et al., 2004).

Previous studies of the geology of the Sidi Said Maachou area were focused on large-scale lithostratigraphy and volcanic petrography and geochemistry (Gigout, 1951, 1956; El Attari, 2001; Bensalah et al., 2011). Palaeontological data from this region are scarce and are absent for the up to 400 m thick Triassic section. In this paper, we give the first detailed lithostratigraphic description of the Triassic of the Sidi Said Maachou area and report on the discovery of biostratigraphically important tetrapod footprints in these beds. All fossils described herein are housed in the collection of the Department of Earth Sciences, Chouaïb Doukkali University El Jadida, Morocco (CDUE).

2. Geological setting

The approximately 40 km^2 study area, named after its small central village Sidi Said Maachou, is located in the coastal uplift of the Moroccan western Meseta about 45 km southeast of El Jadida (Fig. 1). Geological interest of this domain is based on numerous outcrops of pre-Cenozoic rocks along the valley of the Oued Oum Er Rbiaa that flows from SE to NW through the study area. Along the northern, eastern and south-eastern border of the area Triassic sediments unconformably overlie Palaeozoic (Cambrian and Devo-

* Corresponding author. Tel.: +212 06 69 05 57 50; fax: +212 5 23 34 21 87.
E-mail addresses: hminna_abdelkbir@yahoo.fr (A. Hminna), s.voigt@pfalzmuseum.bv-pfalz.de (S. Voigt), Hendrik.Klein@combyphone.eu (H. Klein), hafidsaber@yahoo.fr (H. Saber), schneidj@geo.tu-freiberg.de (J.W. Schneider), hmich@gmx.net (D. Hmich).

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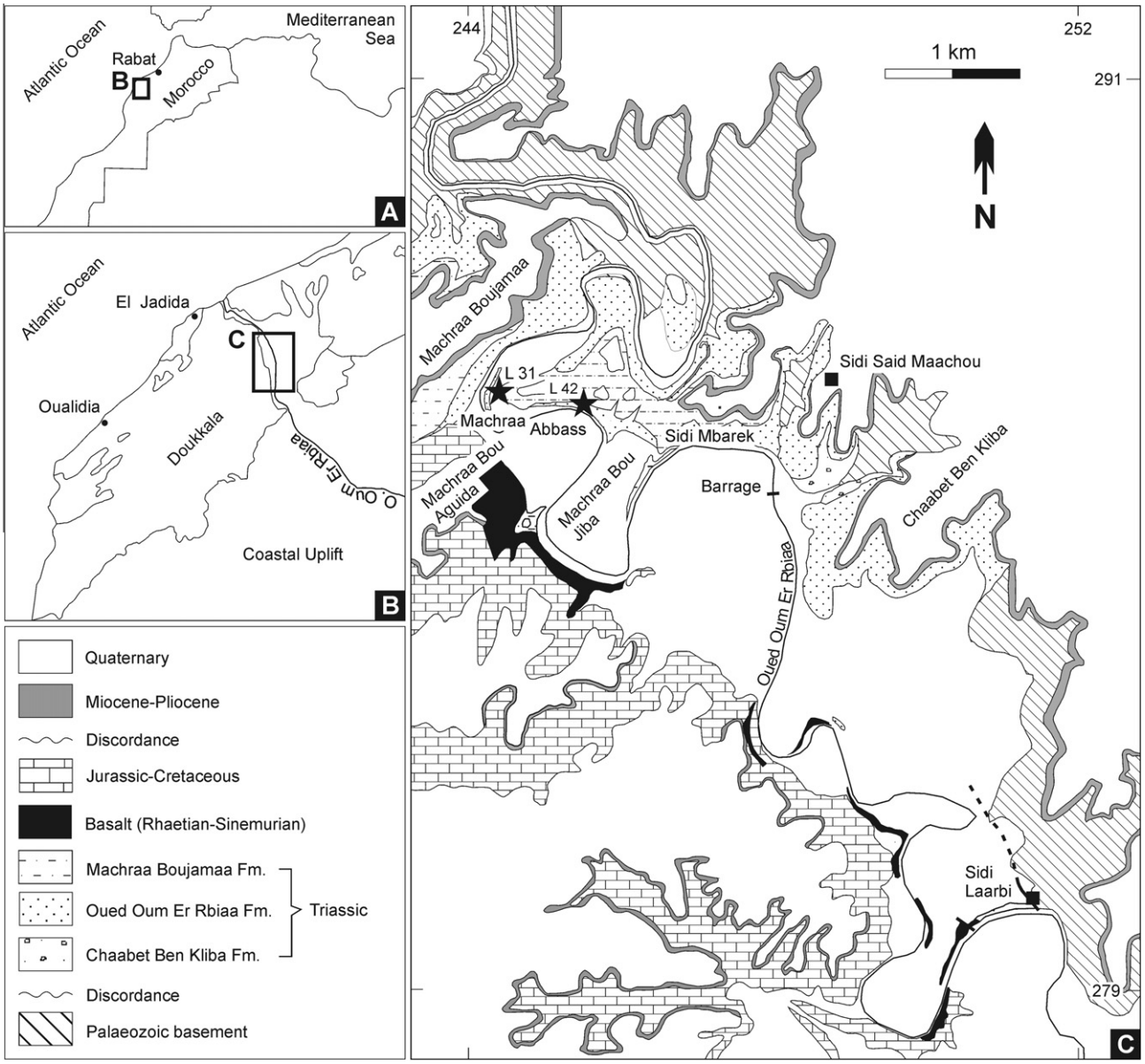

Fig. 1. Location and geological overview of the study area. (A and B) Position of the Sidi Said Maachou area in Morocco and the western Meseta. (C) Simplified geological map of the Sidi Said Maachou area (after Hminna, 2005) and tetrapod track sites (CDUE localities 31 and 42).

nian) basement. To the west and southwest, Triassic sediments are overlain by Rhaetian–Sinemurian tholeiitic basalts and Jurassic–Cretaceous sedimentary rocks (Gigout, 1956; Ouadia, 1998; Hminna, 2005; Bensalah et al., 2011).

During the Early Mesozoic, accumulation of continental deposits took place in the Sidi Said Maachou area due to local subsidence most likely triggered by reactivated Late Palaeozoic (Hercynian) structures such as the Sidi Laarbi fault. This fault reaches from the SE into the study area (Fig. 1C) and might continue to the north-western corner, but there it is covered by Mesozoic and Cenozoic deposits. Subsurface data are required to more precisely assess the dimension and tectonic structure of the Triassic strata in the Sidi Said Maachou area.

2.1. Lithostratigraphy and sedimentology

Based on detailed mapping, the Triassic succession of the study area is subdivided into three formations with several members (Hminna, 2005; Fig. 2). The basal Chaabet Ben Kliba Formation is composed of interbedded conglomerates, sandstones and siltstones, that crop out northwest of the Chaabet Ben Kliba cliffs (Fig. 1). The thickness of the unit ranges from 10 to 100 m with systematic increase to the east and southeast. Its base is formed by reddish-brown or grey, massive, 1–2 m thick conglomerates that rest with an angular unconformity on folded and metamorphosed Cambrian pelitic sediments. Individual beds form decametre-wide lenticular bodies of matrix-supported, poorly sorted, randomly oriented, pebble-sized conglomerate. Components are dominated by quartzite and shale, subangular, subrounded or rounded in shape, and 1–10 cm in maximum length. Intercalated sandstones are dominantly medium- to fine-grained, rarely coarse-grained, reddish-brown in colour, and a few centimetres to up to 2 m thick. Coarse-grained sandstones consist of carbonate-cemented, subrounded to subangular detrital quartz grains and rock fragments. Most sandstones are massive in appearance, but, locally, indistinct horizontal stratification or planar cross-bedding may also occur. Siltstone beds are several centimetres to several metres thick, and reddish-brown to whitish grey in colour, and often laterally