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## New discoveries of archosaur and other tetrapod footprints from the Timezgadiouine Formation (Irohalene Member, Upper Triassic) of the Argana Basin, western High Atlas, Morocco – Ichnotaxonomic implications



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## ABSTRACT

New discoveries of tetrapod footprints from the Irohalene Member (T5, Upper Triassic, Carnian) of the Timezgadiouine Formation near Irohalene (Argana Basin, Morocco) are assigned to *Parachirotherium* isp., *Atreipus-Grallator* isp. (Dinosauromorpha), *Brachychirotherium* isp. (crocodilian-stem archosaurs), *Apatopus lineatus* (phytosaur) and *Rhynchosauroides* (lepidosauromorphs/archosauromorphs). *Parachirotherium* is present on the surfaces with different tetradactyl–pentadactyl extramorphological variations, similar to the preservation mode observed at the type locality of the ichnogenus in the Middle Triassic of the European Germanic Basin. Described specimens permit a re-evaluation of footprints described earlier from the Irohalene locality that are synonymized here with *Parachirotherium* and *Atreipus-Grallator*. The presence of *Brachychirotherium* is the second record in North Africa and Morocco. The assemblage is similar in composition to other T5 localities and to some ichnofaunas in North America and central Europe. Biostratigraphically, the occurrence of *Brachychirotherium* indicates the respective biochron that can be cross-correlated with the Carnian–Rhaetian interval.

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## 1. Introduction

In recent years, the Argana Basin of Morocco became an important region for the discovery of Palaeozoic–Mesozoic tetrapod footprints and a rich source for ichnological research. Several ichnotaxa, previously unknown from North Africa or even the African continent, were described for the first time (Hminna, 2013; Hminna et al., 2012, 2013; Klein et al., 2010, 2011, 2013; Lagnaoui, 2014a, 2014b; Lagnaoui et al., 2012; Voigt et al., 2010, 2011). The Irohalene Member (T5) of the Timezgadiouine Formation (Upper Triassic, Carnian) in the Argana Basin is essentially known for its rich vertebrate fauna (Jalil, 1999; Jalil and Peyer, 2007; Kammerer et al., 2011). Tetrapod footprints were described from this unit by Biron and Dutuit (1981) and recently by Lagnaoui et al. (2012). The latter paper was essentially based on

material from 2011 field work, when diverse tetrapod track assemblages together with abundant *Scoyenia* invertebrate traces were discovered in the Triassic Timezgadiouine and Bigoudine formations. The footprints were assigned to *Apatopus*, *Atreipus-Grallator*, *Eubrontes* isp., *Parachirotherium*, cf. *Parachirotherium postchirotherioides*, *Rhynchosauroides* isp., and *Synaptichnium* isp. (Lagnaoui et al., 2012).

Recently, during further fieldwork in the Argana Basin following the First International Congress on Continental Ichnology (ICCI) in El Jadida, 2015, the authors documented numerous new finds of footprints, mostly those of archosaurs. These are preserved on the lower and upper surfaces of loose sandstone blocks scattered around localities near Irohalene village in the northern part of the Argana Basin (Fig. 1). Preservation of the footprints and co-occurrence of abundant invertebrate trace fossils on the surfaces is similar to that of specimens figured and described from Irohalene by Biron and Dutuit (1981). Even if the exact position of locations mentioned by the latter authors is vague, it is likely that the new discoveries come from same or nearby spots. Moreover, the partly well-preserved imprints and morphological details permit a

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