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Tetrapod Footprints from the Alpine Buntsandstein (Lower Triassic) of the Drau Range (Eastern Alps, Austria)

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Tetrapod footprints
Lower Triassic
Olenekian
Austria
Protochirotherium
Rhynchosauroides
Synaptichnium
Protochirotherium biochron

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Tetrapodenfährten aus dem Alpinen Buntsandstein (Untertrias) des Drauzuges (Ostalpen, Österreich)

Zusammenfassung

Wir dokumentieren Tetrapodenfährten aus dem oberen Teil des Oberen Alpinen Buntsandsteins (unteres Olenekium) des Drauzuges (Kärnten, Südösterreich). Die Tetrapodenfährten stammen aus einer dünnen Lage aus roten Silt- und Tonsteinen, eingeschaltet in einer Sandsteinabfolge, die Ablagerungen breiter, flacher Rinnen eines verzweigten Flusssystems darstellen. Drei Ichnotaxa wurden bestimmt: aff. *Protochirotherium* ichnosp., *Rhynchosauroides* ichnosp. und cf. *Synaptichnium* ichnosp. Diese Fährtenfauna ist das dritte Vorkommen der bislang relativ wenig bekannten Fährtenvergesellschaftung des *Protochirotherium* Biochrons und stellt das älteste bekannte, gut datierte Vorkommen von Tetrapodenfährten dar, das dem *Protochirotherium* Biochron zugeordnet werden kann. Es bestätigt das Vorkommen von *Synaptichnium* in dieser Zeit und zeigt, dass dieses Biochron einen Großteil des Olenekium repräsentiert.

Abstract

We document tetrapod footprints from the upper part of the Upper Alpine Buntsandstein (lower Olenekian) of the Drau Range (Carinthia, Southern Austria). The tetrapod footprints occur in thin red siltstone and shale intercalated in superimposed sandstone sheets deposited in broad shallow channels of a distal braidplain environment. Three ichnotaxa are present: aff. *Protochirotherium* ichnosp., *Rhynchosauroides* ichnosp. and cf. *Synaptichnium* ichnosp. The Austrian footprint assemblage adds a third datapoint to the relatively little known footprint assemblages of the *Protochirotherium* biochron, and is the oldest known, precisely-dated record of tetrapod footprints that can be assigned to the *Protochirotherium* biochron. It confirms the presence of *Synaptichnium* in this time interval and it establishes that the biochron is equivalent to most of Olenekian time.

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Introduction

Tetrapod footprints have been known from the Lower and Middle Triassic Buntsandstein of the Germanic Basin since KAUP (1835) described *Chirotherium* from the Buntsandstein ("Thüringer Chirotheriensandstein") of southern Thuringia. Tetrapod footprints of late Early and/or Middle Triassic age are also known from England, France, Italy and Poland in western Europe, northern Africa, southern China, the western USA and Argentina (e.g., HAUBOLD, 1984; KLEIN & HAUBOLD, 2007; LUCAS, 2007; KLEIN & LUCAS, 2010a, b; KLEIN et al., 2010; TOURANI et al., 2010). From the Alpine Buntsandstein of the Eastern Alps in Austria, which represents the lower part of the Lower Triassic in the Tethyan realm and is composed of mostly nonmarine red beds, tetrapod footprints have not been previously documented, although the facies is quite similar to that of the Buntsandstein in the Germanic Basin. KRAINER (1985) first mentioned the occurrence of tetrapod footprints from the upper part of the Alpine Buntsandstein of the Drau Range, but without any description or identifications. The purpose of this paper is to provide a first description and documentation of tetrapod footprints from the Alpine Buntsandstein and to comment on their biostratigraphic significance.

Provenance

Tetrapod footprints were collected from a red micaceous siltstone and shale horizon in the upper part of the Upper Alpine Buntsandstein of the Drau Range, which is exposed along the road from Aichach to Ried, approximately 5 km SW of Paternion in the northern Gailtal Alps (Carinthia, southern Austria: Text-Fig. 1). The first specimens were collected in 1983; additional collections were obtained in 2009 and 2010. The specimens are stored in the paleontological collection of the Institute of Geology and Paleontology of the University of Innsbruck (catalogue numbers P-10123–P-10128).

In the Drau Range, the Alpine Buntsandstein is up to 150 m thick and composed of two fining-upward megasequences termed Lower and Upper Alpine Buntsandstein (KRAINER, 1985, 1987). Tetrapod footprints documented in this paper occur in a 20 cm thick red siltstone and shale intercalated in sandstone. The siltstone and shale is laminated, thins out laterally and is intercalated in superimposed sandstone sheets deposited in broad shallow channels of a distal braidplain environment (KRAINER, 1985, 1987, 2010).

The Upper Alpine Buntsandstein approximately correlates to the Volpriehausen- and Detfurth-Folge of the Buntsandstein in the Germanic Basin (KRAINER, 2010) (Text-Fig. 1). This indicates an Induan age of the Lower Alpine Buntsandstein and an Early Olenekian age of the Upper Alpine Buntsandstein of the Drau Range (KRAINER, 2010).

Ichnology

We have collected eight specimens with tetrapod footprints of relatively poor preservation from the locality in the Drau Range. From the collection, we can tentatively identify three ichnogenera of tetrapod footprints.

Aff. *Protochirotherium* ichnosp.

P-10128 (Text-Fig. 2 A–B) is an incomplete pes imprint preserved in convex hyporelief. It is the largest track in the assemblage, measuring approximately 100 mm in total length. Longer than wide, it has a sole that is broad and plantigrade. The digits are relatively thick, with evident digital pads, and have pointed tips. Digit I is much shorter than digit II, which is shorter than digits III–IV, and digit III is longest. The location of digit V is not certain due to breakage, but it appears to be set well posterior to the other digits.

This specimen is clearly the footprint of a chirothere, but is incomplete and not well enough preserved to allow a definite ichnogeneric assignment. The following features support possible assignment to *Protochirotherium*: relatively large size and plantigrade; long, thick digits I–IV; digit lengths III > IV > II > I; and digit IV slightly shorter than digit III (cf. HAUBOLD, 1971a, b; KLEIN & HAUBOLD, 2003, 2004; KING et al., 2005; KLEIN & LUCAS, 2010a, b). However, this footprint is not well enough preserved to be identified with certainty at the ichnogeneric level. Clearly it is chirothere, and we tentatively identify it as aff. *Protochirotherium*.

Rhynchosauroides isp.

P-10127 (Text-Fig. 3 A–B) is a small (total length = 10 mm), lacertoid, digitigrade and tridactyl imprint. It has three thin, curved (toward the midline) digits pointing in one direction (here identified as digits II–IV), and a fourth imprint (digit or sole imprint?) pointing in the other direction. The three digits increase in length from II to III to IV, and digit IV diverges more than III does from II. P-10123 is another small, tridactyl track, but is much less well preserved than P-10127. We identify P-10127 as a pes track of *Rhynchosauroides*.

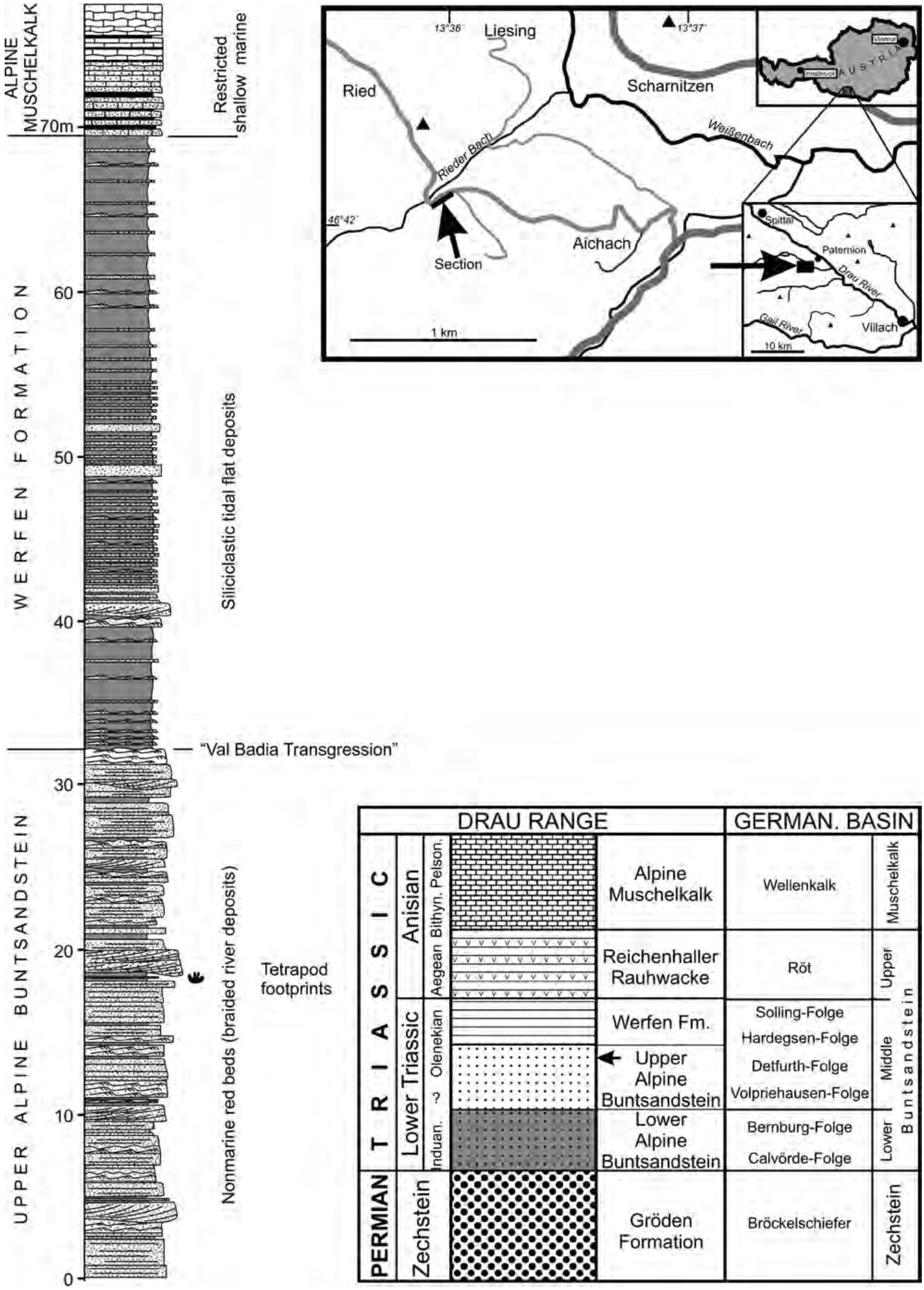
P-10126 (Text-Fig. 3 C–D) is a small (14.5 mm long) pentadactyl print that is relatively broad (length/width = 1.3). Digits II–IV are forward directed and increase in length from I to IV. Digit V is posterior to the digit row formed by digits I–IV and projects laterally. We identify P-10126 as a manus track of *Rhynchosauroides*.

The small size of the pes, the lacertoid and medially curved digits and the increase in digit length from II to IV and the relatively small plantigrade manus are characteristic of *Rhynchosauroides* (e.g., HAUBOLD, 1971b; KLEIN & LUCAS, 2010b; LUCAS et al., 2010). Tridactyl pes tracks are common in *Rhynchosauroides* (for example, see DEMATHIEU & DEMATHIEU, 2004: Fig. 5 and LUCAS et al., 2010: Figs. 45–46). The Austrian specimens are few and not well preserved, and the ichnogenus *Rhynchosauroides* is badly in need of revision, so we make no ichnospecific assignment. Small lepidosauromorphs are the most likely trackmakers of *Rhynchosauroides* (HAUBOLD, 1971a, b, 1984; LUCAS et al., 2010).

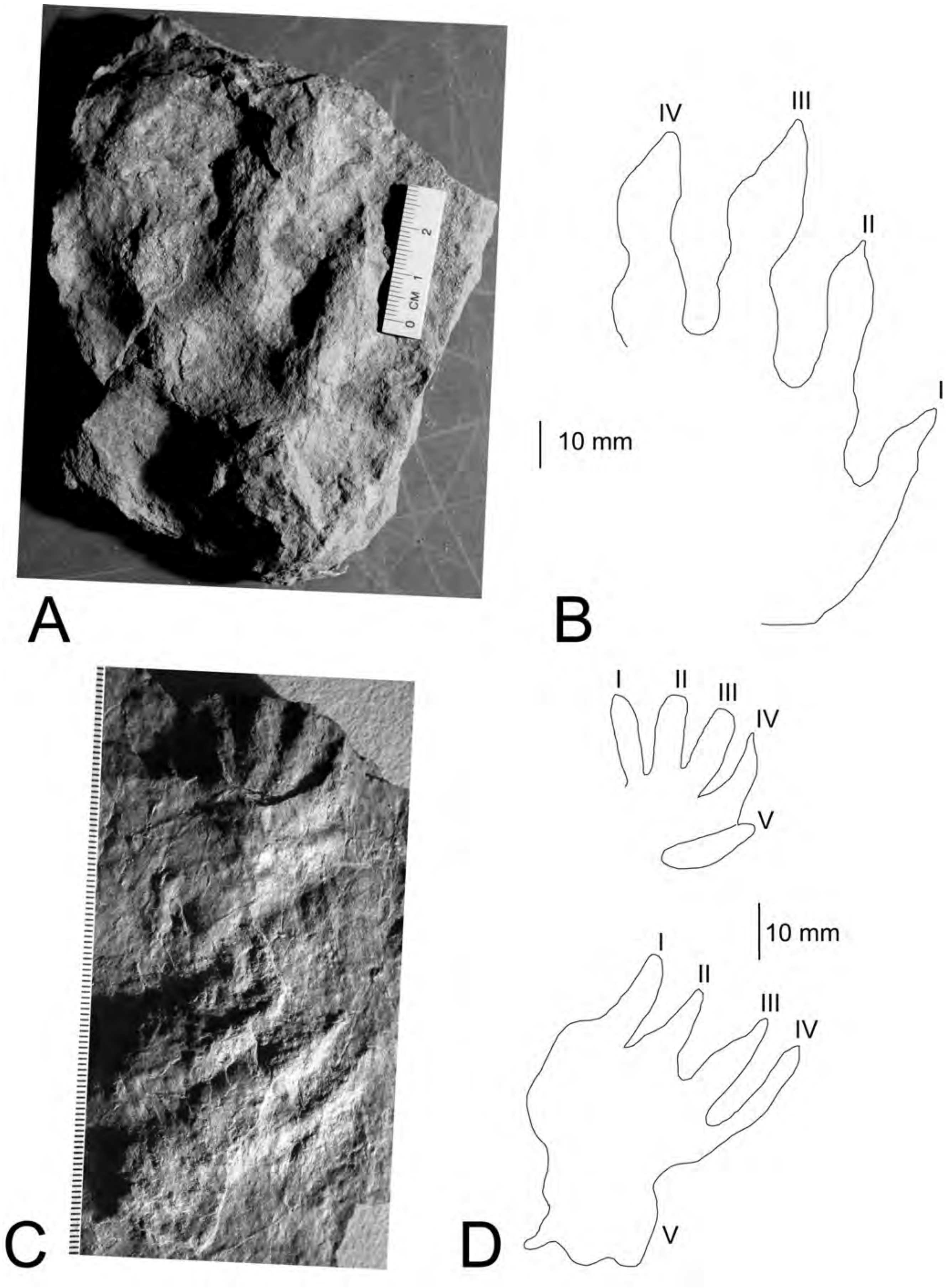
Cf. *Synaptichnium* ichnosp.

Specimen P-10125 (Text-Fig. 2 C–D) preserves associated manus and pes imprints in convex hyporelief. The pes preserves digits I–IV, which has pointed tips, are slightly curved and relatively slender. Digits increase in length from I to IV, with digits I and II approximately the same length, and III and IV approximately the same length. Digit V, much the shortest digit, is well separated and posterior to digit IV. There is a large, plantigrade sole imprint. Total length of the pes imprint is approximately 55 mm.

The manus imprint has a total length of approximately 28 mm and is rotated medially with respect to the pes imprint. It preserves five digits, and digit V is impressed as a long, oblique print posterior to the other digits and



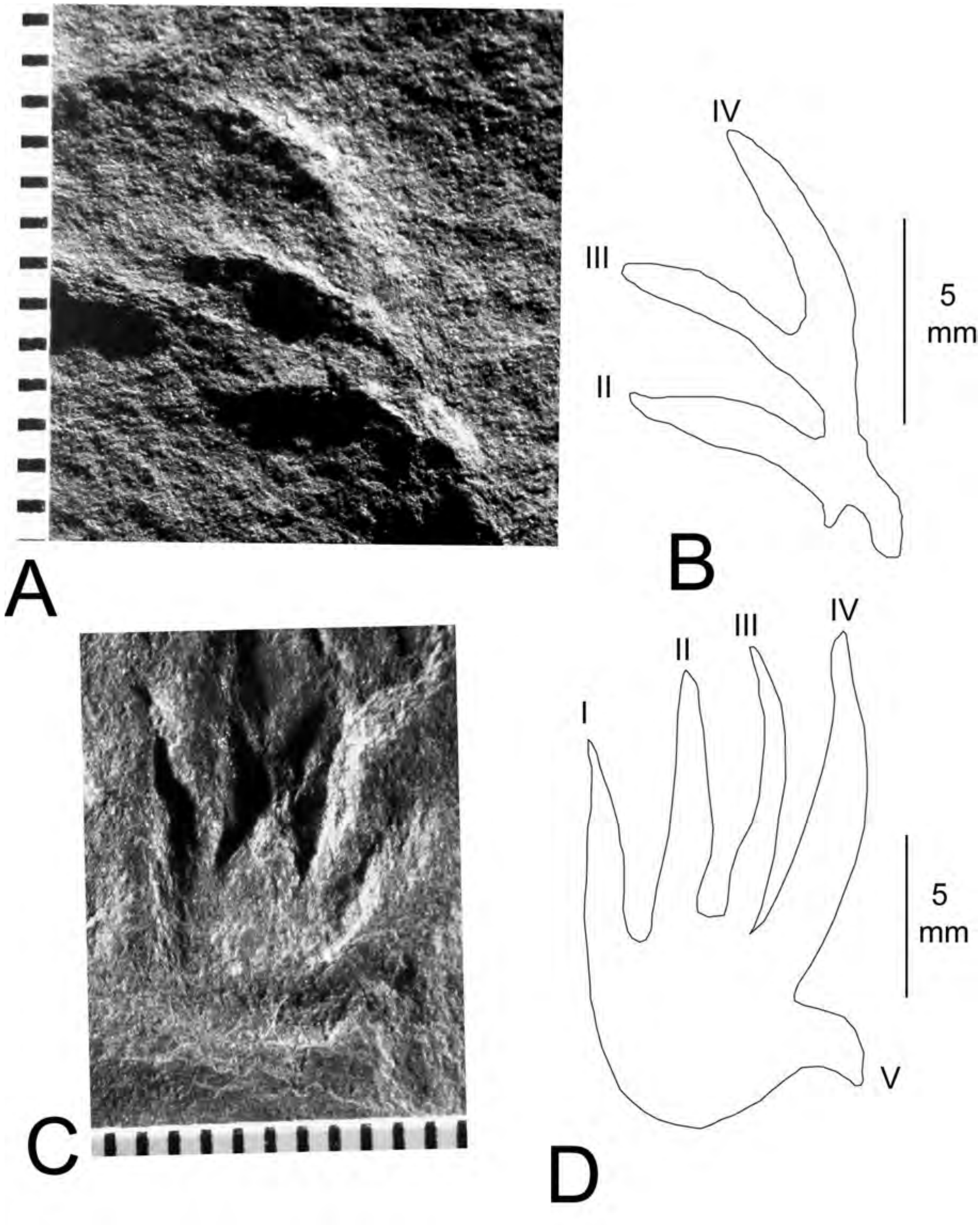
Text-Fig. 1.
Location map (upper right), detailed stratigraphic section (left) through the uppermost Alpine Buntsandstein, Werfen Formation and lowermost Alpine Muschelkalk with position of the horizon containing the tetrapod footprints and generalized stratigraphy of the Lower Triassic of the Drau Range and correlation with the Lower Triassic of the Germanic Basin (lower right).



Text-Fig. 2.
Chirothere footprints from the Upper Alpine Buntsandstein in the Drau Range, Austria.
A–B, aff. *Protochirotherium* ichnosp., P-10128, incomplete pes imprint in convex hyporelief.
C–D, cf. *Synaptichnium* ichnosp., P-10125, pes and manus imprints in convex hyporelief.
Scales are in mm.

directed outward from the trackway midline. Digits I–IV are in a group oriented antero-medially, with digits II and III slightly longer than digit I and longer than digit IV. Digit tips of II and III are not preserved.

Diagnostic features of *Synaptichnium* seen in the Austrian specimen are: manus about one third smaller than pes, manus digit III longest, pes digit IV longest, pes digits slightly curved inward with short and acute claws and no digital pads (cf. HAUBOLD, 1971a, b; KLEIN & HAUBOLD, 2003, 2004; DEMATHIEU & DEMATHIEU, 2004). However, given the limited nature of the material available to us, we only identify this specimen as cf. *Synaptichnium*. There are at least four valid ichnospecies of *Synaptichnium*, and the North American ichnospecies *S. cameronense* and *S. diabloense* have very short and splayed pes digits I and II, quite different from the Austrian specimen. However, given the limited extent of our material, we also make no ichnospecific assignment.

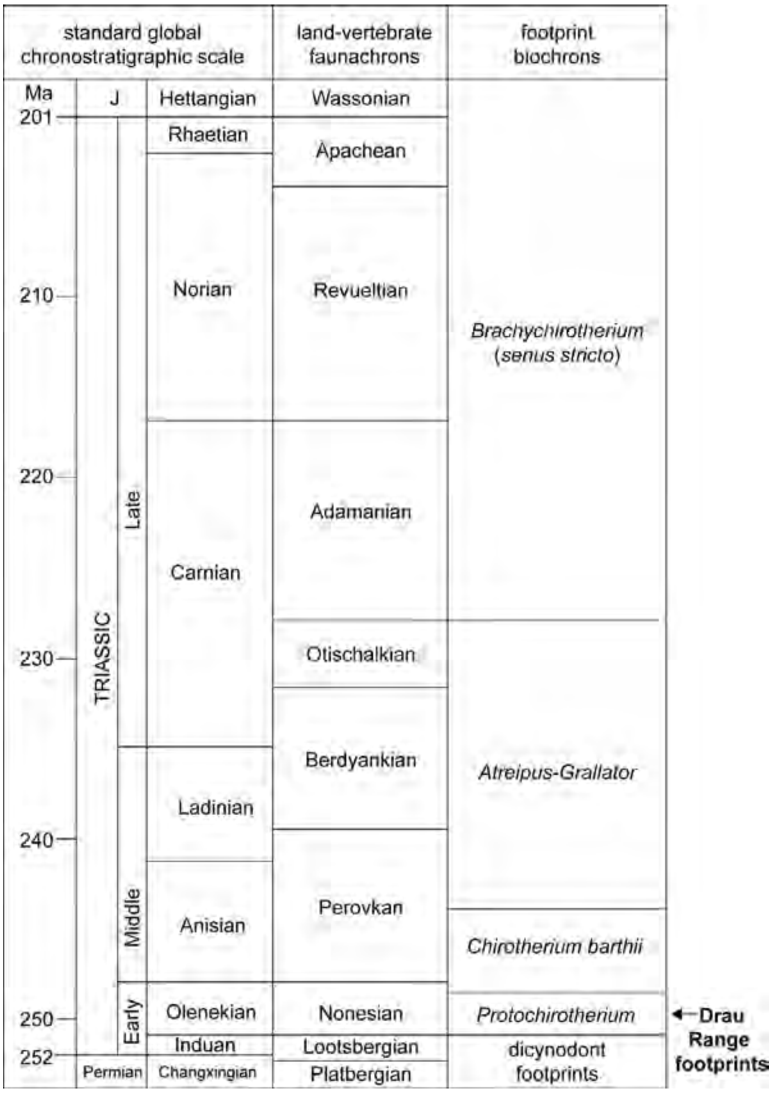


Text-Fig. 3.
Rhynchosauroides ichnosp. footprints from the Upper Alpine Buntsandstein in the Drau Range, Austria.
A–B, Pes imprint in convex hyporelief, P-10127.
C–D, Manus imprint in concave epirelief, P-10126.
Scales are in mm.

Biostratigraphic Significance

The Austrian footprint assemblage can be characterized as chirothere dominated and includes lacertoid footprints. Thus it resembles chirothere-dominated tetrapod footprint assemblages found in many Lower-Middle Triassic strata across Pangea. KLEIN & LUCAS (2010a) most recently reviewed the stratigraphic distribution of Triassic tetrapod footprint assemblages (also see LUCAS, 2003, 2007; HUNT & LUCAS, 2007 and KLEIN & HAUBOLD, 2007). They assigned the classic chirothere assemblages to their *Chirotherium barthii* biochron, which is of latest Olenekian–Anisian age (Text-Fig. 4). KLEIN & LUCAS (2010a) also identified an older footprint biochron, the *Protochirotherium* biochron of Olenekian age (Text-Fig. 4).

The age of the upper part of the Alpine Buntsandstein is early Olenekian, so the footprints described here are within the age of KLEIN & LUCAS's (2010a) *Protochirotherium* biochron. The assemblages of the biochron previously documented are from the Wióry-Formation of the Holy Cross Mountains of Poland (FUGLEWICZ et al., 1990; PTASZYNSKI, 2000; NIEDZWIEDZKI & PTASZYNSKI, 2007) and from the Detfurth-Formation of eastern Hessen, Germany (FICHTER & KUNZ, 2004) and these are of late Olenekian (early Spathian) age (KLEIN & LUCAS, 2010a). So the Drau Range assemblage is the oldest known, precisely dated record of tetrapod footprints that can be assigned to the *Protochirotherium* biochron. The Austrian footprint assemblage documented here thus adds a third datapoint to the relatively little known footprint assemblages of the *Protochirotherium* biochron. It confirms the likely presence of *Synaptichnium* in this time interval and it establishes that the biochron is equivalent to most of Olenekian time.



Text-Fig. 4.
Triassic tetrapod footprint biochronology of KLEIN & LUCAS (2010a), showing temporal position of Drau Range footprint assemblage.

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