Zeitschrift: Eclogae Geologicae Helvetiae
Herausgeber: Schweizerische Geologische Gesellschaft
Band: 83 (1990)
Heft: 2

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DOI: https://doi.org/10.5169/seals-166593

Eclogae geol. Helv. 83/2: 389–397 (1990)

0012-9402/90/020389-9 $ 1.50 + 0.20/0
Birkhäuser Verlag, Basel

Sauropod tracks from the Upper Jurassic Reuchenette Formation (Kimmeridgian; Lommiswil, Kt. Solothurn) of northern Switzerland

By Christian A. Meyer[1])

ABSTRACT

In the vicinity of Solothurn (Swiss Jura mountains) more than two hundred large vertebrate footprints from the Upper Jurassic (Kimmeridgian) have been discovered. At least six different trackways can be recognized attaining up to 60 m in length. According to the morphology and dimensions of the imprints they were produced by large, herbivorous sauropods. The footprints occur on mudcracked, peritidal carbonates which belong to the middle part of the Reuchenette Formation and form the uppermost parts of a regressive tidal flat sequence.

ZUSAMMENFASSUNG

In der Nähe von Solothurn (Schweizer Jura) wurden mehr als zweihundert grosse Sauriertrittsiegel im Oberen Jura (Kimmeridgian) entdeckt. Mindestens sechs verschiedene bis zu 60 m lange Fährten können unterschieden werden. Entsprechend ihrer Dimensionen und ihrer Morphologie stammen sie von grossen sauropoden Dinosauriern. Die Fährten stammen aus intertidalen Karbonaten mit Trockenrissen. Die Gesteinsabfolge gehört in den mittleren Teil der Reuchenette-Formation und bildet den obersten Teil einer regressiven 'tidal flat' Sequenz.

1. Introduction

Sauropod tracks of this age are known from only a limited number of localities. Upper Jurassic trackway sites have been described from Barkhausen (Northern Germany; Kaever & Lapparent 1974), Asturia (Spain; Mensink & Mertman 1984) and from Colorado (USA; Lockley et al. 1986). The sauropod imprints from the High Atlas (Morocco), which have previously been assigned to the Upper Jurassic/Lower Cretaceous (Dutuit & Ouazzou 1980), are now thought to be of Middle Jurassic age (Jenny et al. 1981). Until now, the largest trackway sites are the 'Dinosaur Lake' on Purgatoire River (Colorado, Upper Jurassic), the famous Glen Rose site on Paluxy river (Texas, Lower Cretaceous, Bird 1939) and two other localities of similar age from Northern Germany (Look et al. 1988) and Arkansas (USA; Gillette et al. 1985).

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2. Occurrence of Sauropod tracks

The new sauropod tracksite lies in the southern limb of the Weissenstein-anticline which forms the southernmost part of the Swiss Jura mountain range (Fig. 1). Large bedding plane surfaces of peritidal carbonates (Kimmeridgian/Portlandian), dipping at

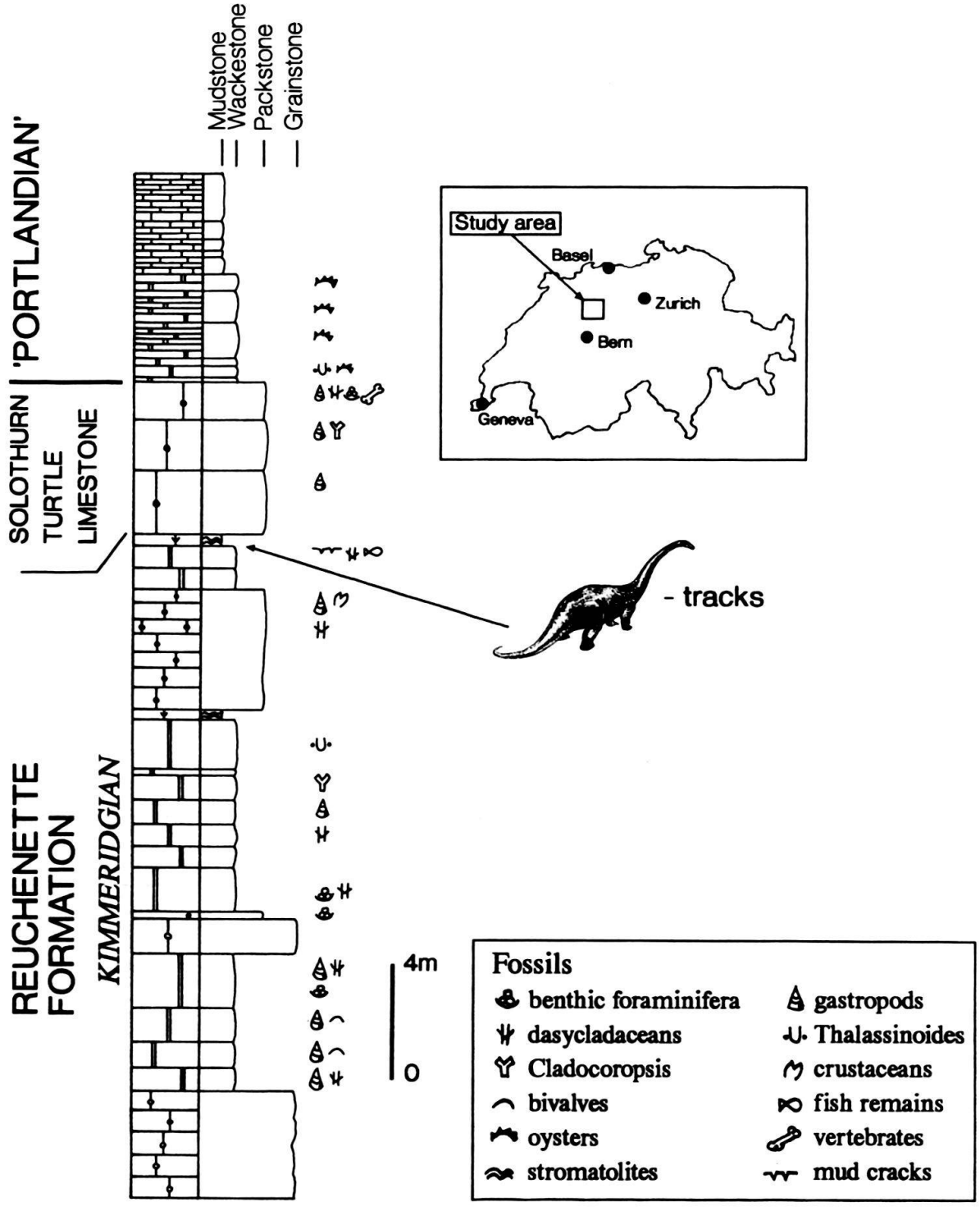

Fig. 1. Location and sedimentological section of the trackway locality.

45°–70° to the south, can be observed in a limestone quarry 1 km north of the small village Lommiswil (Koord.: 602 900/231 675) some 5 km north of the town Solothurn. On a surface of nearly 10 000 m^2 more than two hundred single vertebrate imprints were discovered in February 1987. Whereas the lower part of the steeply inclined wall (70°) is accessible at the quarry bottom, the upper part of the surface can only be reached by climbing.

A second occurrence was found in winter 1989 in the vicinity of Grenchen, about 5 km to the east of the main locality (Koord.: 596 050/228 800). This site consists of a steeply inclined surface of approximatively 20 m^2. The partially eroded prints (9 single prints) do not differ significantly from the tracks at Lommiswil and they occur at the same stratigraphic level.

At present six trackways of 25 to 60 m length are visible at the main locality. 213 single prints can be observed on the whole surface (Fig. 2). In the center of the quarry another trackway with a set of twelve imprints can be seen, however, due to erosion they are not as visible (Fig. 2).

The stridelength varies from 220 to 250 cm and the average gait is 170 cm; the maximum width of the track is 180 cm. Due to the overlapping of the manus by the pes, most trackways display only alternating pes imprints. They occur as epichnia (negative epirelief) throughout the whole surface. In rare instances manus and pes imprints can be distinguished (Figs. 3 and 4). The prints of the manus show a crescent outline with a length of 40 cm and approximatively the same width. The pes imprints have a circular to triangular outline (max. length: 80 cm, width: 50–60 cm) and are surrounded by a collar-like convolution of the sediment (Fig. 3). In some trackways even the pes impressions are only partially preserved. They are horseshoe shaped and can only be distinguished from manus impressions by their larger size.

The depth of the imprints varies from 10 to 25 cm. Most of the prints are filled by dasycladaean wackestones with a dense network of *Thalassinoides*-tubes. The imprint medium consists of a partially mudcracked wackestone with birdseyes, dasycladacean fragments and miliolid foraminifera (Fig. 1).

3. Sedimentology and Stratigraphy

The section in the Steingrueben-quarry is composed of medium to thick bedded shallow water limestones of the Reuchenette Formation which are overlain by thinly bedded limestones of the 'Portlandian' (sensu Bläsi 1980). In the western part of the quarry, which is now abandoned, the middle part of the Reuchenette Formation can be observed. It consists of dasycladacean wackestones, pelletal packstones and laminated mudstones with keystone vugs. The uppermost part of the Reuchenette Formation is visible in the eastern, active part of the quarry. Here it comprises dasycladacean wackestones, stromatolithic boundstones and massive nerineid packstones. The latter are being quarried for their excellent building stone quality, leaving a large south dipping surface where the dinosaur trackways are visible.

The middle and upper part of the Reuchenette Formation display two sedimentary sequences. The lower one is a regressive sequence ending with a stromatolithic boundstone with dessication features, mud pebbles and strong bioturbation. The dinosaur-track bed lies just below this boundstone. The upper part of the Formation starts with a

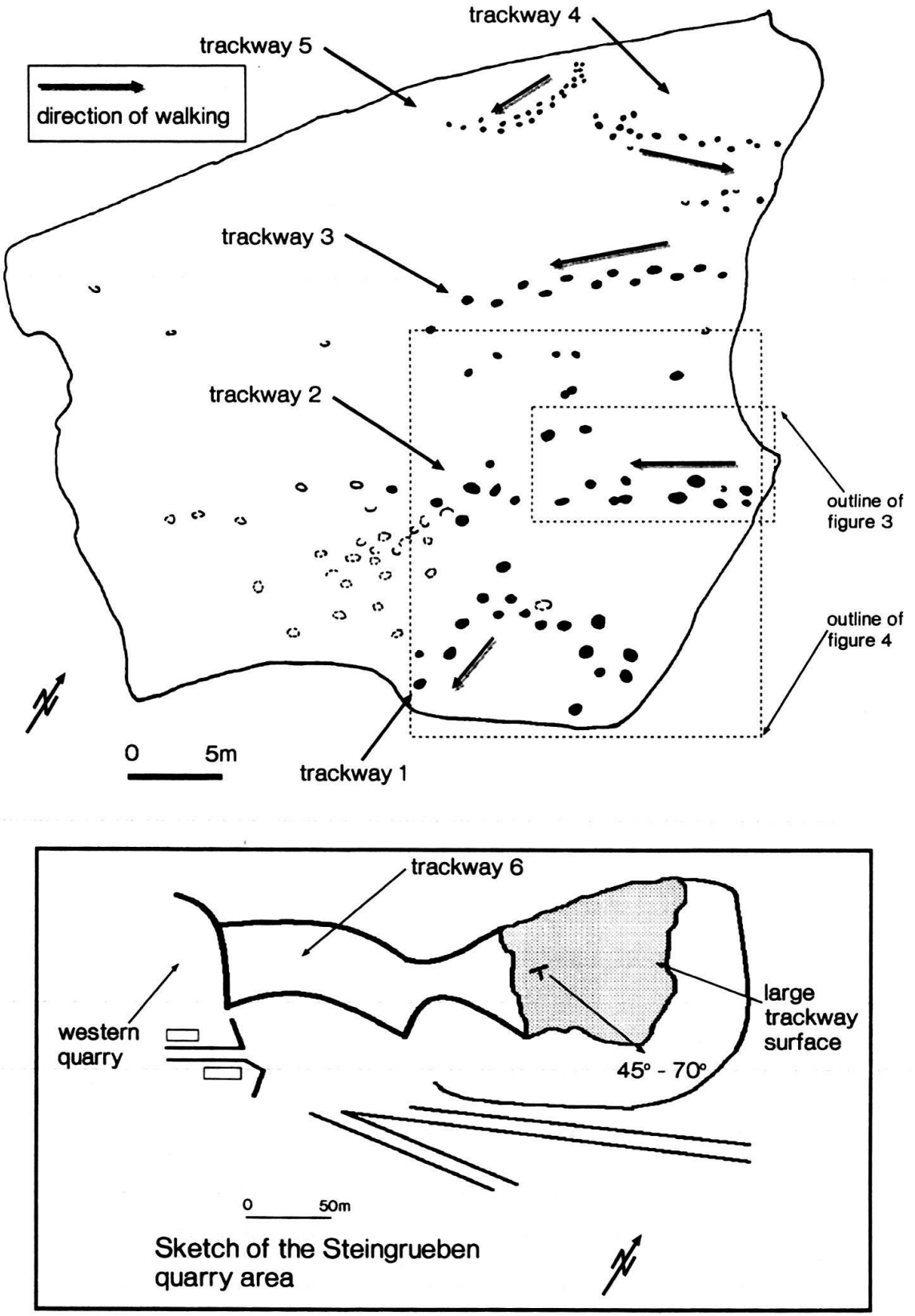

Fig. 2. Frontal view of the trackway surface at Steingrueben quarry, Lommiswil. Due to the oblique view the lower part of the surface appears larger than the upper portion (maximal height: 110 m; maximal width: 85 m). The right margin of sketch outline is the active quarry front (Sketch drawn from slide). Lower part: situation plan of the quarry.

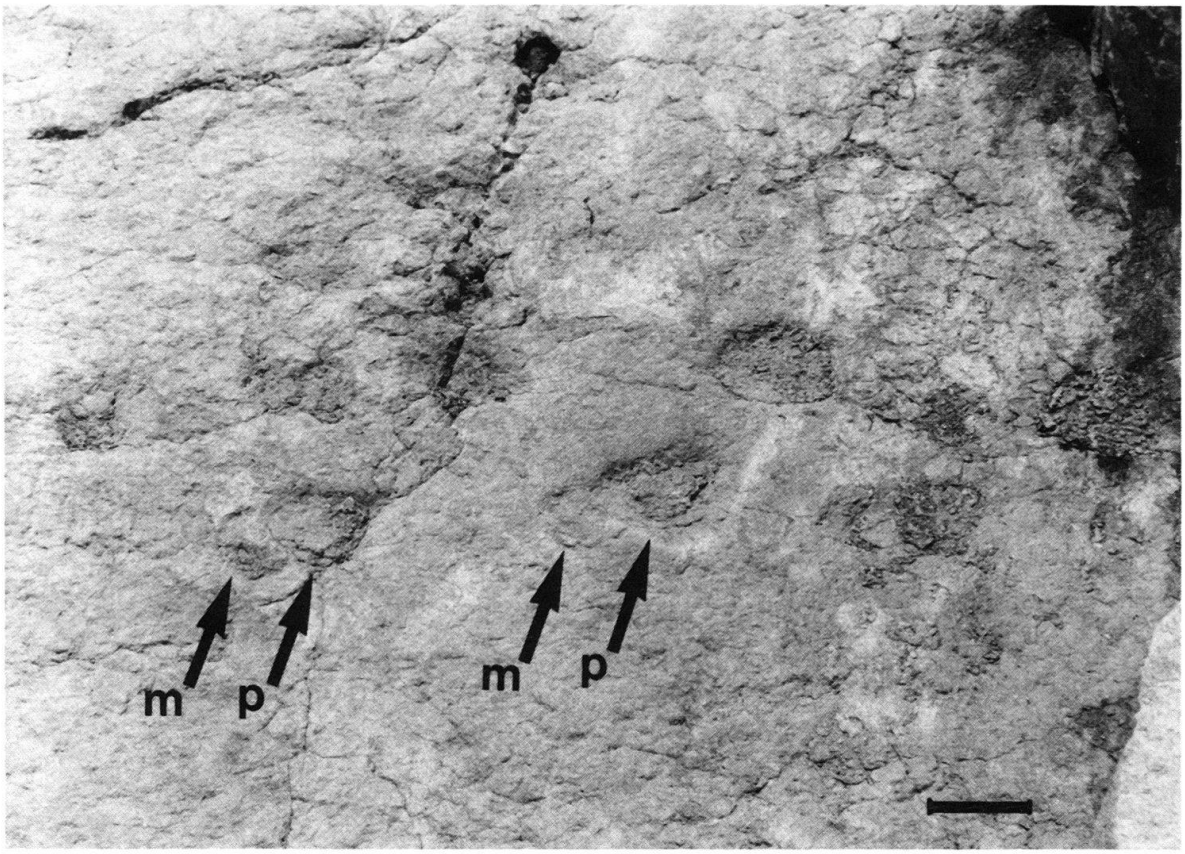

Fig. 3. Detail of trackway nr. 2. Note imprint of left manus (m) and pes (p, arrow). The animal moved from the right to the left; scalebar is 1 m.

transgression of shallow marine nerineid packstones grading into the thinly bedded coquinoid mudstones of the 'Portlandian'. This stromatolithic boundstone layer can be traced for more than 5 km to the southeast into the Verena-anticline where it forms the base of the Solothurn turtle limestone. This member of the Reuchenette Formation contains a very fossiliferous layer where hundreds of marine turtles, shark- and other fish remains and a diverse benthic invertebrate fauna have been found (MEYER 1988, 1989a).

Apart from nerineid gastropods, macrofossils are scarce in the Steingrueben-quarry. Below the track bed a chela of a hermit crab *(Orhomalus virgulinus* ETALLON) has been found and on the surface of the trackbed an isolated tooth of the pycnodontid fish *Macrodon* sp. has been observed. The uppermost nerineid-layer, called 'Grenz-nerineenbank' (e.g. THALMANN 1966) contains scattered carapace fragments of marine turtles *(Plesiochelys* sp.) and tooth-plates of a shark *(Asteracanthus* sp.). Recently a complete lower jaw, a partial skull and fragments of the postcranial skeleton of a meso-suchian crocodile *(Steneosaurus* sp.) were found.

4. Discussion

The enormous size and the overall morphology, as well as the character of the different trackways and traces, are typical for sauropod dinosaurs. Although many dif-

Fig. 4. Detail of lower right part of trackway surface with trackway nr. 1 (lower left) and trackway nr. 2 (upper right); scalebar is 1 m.

ferences in print preservation can be observed, I believe that they have been produced by the same species. Apart from missing claw impressions, they can be compared with the famous Upper Jurassic sauropod tracks from the Purgatoire site of the Colorado plateau (Lockley et al. 1986) and the Lower Cretaceous Briar site of Arkansas (Pittman & Gillette 1989). The sauropod imprints from the lower Kimmeridgian of Germany (Kaever & Lapparent 1974) are smaller in size and possess an indistinct outline. The described prints from Lommiswil also share many similarities with the track of *Breviparopus* from the Middle Jurassic of Morocco (Dutuit & Ouazzou 1980).

Due to dangerous working conditions (permanent likelihood of rock fall) the complete mapping of the new site (air photographs etc.) and the detailed trackway analysis is not yet finished.

Nevertheless, the observed sedimentological context of the prints clearly demonstrates, that they have been produced on an intertidal substrate that was at least temporarily emergent. The environment was a large carbonate tidal flat limited in the southeast by shallow lagoonal sediments (MEYER 1989b).

Further to the east the Kimmeridgian strata grade into deeper marine sediments with corals and ammonites (see GYGI 1987) and to the north shallow marine conditions prevail. Supratidal sediments have been reported only in the western part of the Swiss and French Jura (BERNIER 1984; CHEVALLIER 1989). We therefore suggest that large parts of the western part of the Swiss Jura were at least temporarily emergent to allow the sauropod dinosaurs to reach the region around Solothurn.

Although the Kimmeridgian strata in Northern Switzerland are mostly marine carbonates, remains of terrestrial dinosaurs are known from several localities. A partial skeleton of *Cetiosauriscus greppini* v. HUENE has been found in the Upper Kimmeridgian near Moutier; this locality lies about 10 km north of the new trackway sites (GREPPIN 1870; HUENE 1922).

Cetiosauriscus greppini v. HUENE is one of the smallest members of the genus and attained a length of 10 m, with a hip height of about 2 m; however, the material is too incomplete for a reasonable reconstruction of the animal. Nevertheless, at the present state of knowledge, it seems unlikely that *Cetiosauriscus* produced the present trackways. These sauropod remains were found together with fragments of mesosuchian crocodiles *(Dakosaurus)* and a tooth of *Labrosaurus meriani.* Previously GRESSLY (1841) had recognized the occurrence of megalosaurid teeth in the Solothurn Turtle Limestone and this fragmentary material was revised by HUENE (1925). It contains three teeth of carnivorous theropods and two fibulae and an ischium of uncertain affinity.

In this context it is interesting that a similar fossil association from the Oxfordian of Damparis, France (a partial sauropod skeleton and theropod teeth: LAPPARENT de 1943) have been interpreted by BUFFETAUT (1988) as a result from the in situ disarticulation of sauropod bones by theropods; he postulated a vast carbonate platform which could provide suitable habitats for dinosaur communities. Remains of land plants and tree trunks from the Solothurn Turtle Limestone (MEYER 1989b) and the presence of sauropods and theropods around Solothurn and Moutier strongly supports this hypothesis.

5. Conclusions

These sauropod tracks are the most southeasterly occurrence on the european shore of tethys and represent the largest known Upper Jurassic trackway site of Europe. Their presence at the end of a regressive sedimentary sequence is in accordance with many reported tracksites. Their preservation in peritidal carbonate sediments suggests that the habitat of the reported sauropods was similar to most of the known occurrences. In addition to the sedimentological evidence, these sauropod

traces are a useful indicator for the partial emergence of 'Kimmeridgian' tidal flat environment.

Acknowledgments

We thank Dr. H. Haubold (Halle) and Dr. H. Furrer (Zürich) for the review of the manuscript and for helpful suggestions. Continuous access to the site was made possible by the quarry-authorities Mr. Karli (Bargetzi & Biberstein, Solothurn), Dr. C. Meyer, R. Brunner (Keller AG, Frick) and the quarry men R. Aeby, H. and K. Aeby (Lommiswil), their help in various ways is kindly acknowledged. I also thank Jacky Platt (Bern) for the correction of the English manuscript. Fieldwork was partly sponsored by the Government of the Canton of Solothurn through a lototo credit. The authors work forms part of a Swiss national foundation project (Nr. 20-26549.89).

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Manuscript received 15 January 1990
Revision accepted 7 March 1990