

PRELIMINARY ICHNOLOGICAL RESULTS ON THE STEIERDORF FORMATION IN ANINA, ROMANIA

Mihai E. POPA¹ and Arthur KEDZIOR²

Abstract: New preliminary ichnological results regarding the Lower Jurassic Steierdorf Formation of the Resita Basin (South Carpathians) are discussed in this paper, with emphasis on structures considered as tunnels dug by vertebrates in the basalmost sequences of this formation in Anina, the Czech Colony open cast mine respectively, an exceptional locality for its geological heritage. The basalmost sequence of the Steierdorf Formation belongs to the Doman Member (lowermost Hettangian), where red beds and coarse sediments were described. In these sequences, two types of structures were described, a linear type and a spiral type, such structures being assigned to tunnels dug by Early Jurassic vertebrates, most probably reptiles. The features of the tunnels include typical morphology and architecture, both in length and in cross section, different petrology and granulometry of the tunnel infillings, oxidic coating of the contact between the infill and the matrix, and possible claw marks,

Keywords: Hettangian, Lower Jurassic, Steierdorf Formation, Doman Member, ichnology, tunnels, Early Jurassic vertebrates, Anina, South Carpathians, Romania.

Rezumat: Prezenta contribuție discută rezultate ichnologice noi, preliminare, provenind din Formațiunea Steierdorf, Jurassic inferioară, din Bazinul Resita (Carpații Meridionali), cu accent pe structuri considerate tunele săpate de vertebrate, descoperite în secvențele bazale ale formațiunii, la Anina, în cariera Colonia Cehă, o localitate importantă în patrimoniul geologic al zonei. Partea bazală a Formațiunii de Steierdorf aparține Membrului de Doman (Hettangian bazal), și include depozite roșii, grosiere. Două tipuri de structuri sunt descrise din aceste depozite: de tip linear și de tip spiral, fiind considerate tunele săpate de vertebrate jurasice, cel mai probabil reptile. Trăsăturile caracteristice ale structurilor includ morfologia și arhitectura tipică în secțiune și în lungime, petrologia și granulometria tipică a matricii ce formează umplutura tunelelor, prezența unei cruste oxidice la contactul dintre umplutură și sedimentul înconjurător, și, posibil, urme de gheare.

Cuvinte cheie: Hettangian, Jurassic inferior, Formațiunea de Steierdorf, Membrul de Doman, ichnologie, tunele, vertebrate Jurassic timpurii, Anina, Carpații Meridionali, România.

INTRODUCTION

The Steierdorf Formation (Bucur 1991, 1997) occurs in the Getic Nappe of the South Carpathians, in the Reșița Basin. It is a continental formation deposited in an intramountain depression, Lower Jurassic in age (Hettangian – Pliensbachian), with three members: the Doman Member (lowermost Hettangian), the Valea Tereziei Member (Hettangian – Sinemurian) and the Uteris Member (Pliensbachian – Middle Toarcian). It includes fluvial, marsh and alluvial sequences in which a well preserved and highly diverse flora was recorded (Popa, 2000a, Popa & Van Konijnenburg – Van Cittert, 2006). Stratigraphical and nomenclatural details regarding the Steierdorf Formation have been discussed in previous papers (Popa, 2000a, b).

The ichnological data regarding the Steierdorf Formation are scarce, as this type of

studies began rather late (Popa, 2000a, b). Popa (2000b) described *Batrachopus* cf. *deweyi* from the Doman Member, as the first Mesozoic tetrapod tracks in Romania.

SEDIMENTOLOGY

The Lower Jurassic (Hettangian-Sinemurian) coal-bearing strata overlie the studied red coloured sediments. This red bed facies consist of interbedded conglomeratic, sandstone and mudstone layers. The thickness of individual layers changes from tens of centimetres up to several meters. Due to vertical arrangement of the strata lateral variations in thickness have not been observed in detail.

The conglomeratic layers contain quartz pebbles up to 5 cm in diameter and lithic grains, poorly sorted and rounded. The clasts are supported by a matrix of sand. Sedimentary

¹ University of Bucharest, Faculty of Geology and Geophysics, Laboratory of Palaeontology, 1, N. Balcescu Ave., 010041, Bucharest, Romania, mihai@mepopa.com

² Institute for Geological Sciences, Polish Academy of Sciences, Krakow Research Centre, Senacka 1, 31-002, Krakow, Poland, ndkedzio@cyf-kr.edu.pl

structures are invisible, but sometimes fining upward features and traces of the clasts imbrications can be observed.

The sandstones seem to be massive, without visible sedimentary structures. Only in the northern part of Czech Colony Quarry, in the thick packages, large scale cross stratification is present. The layers of the massive sandstone use to contain dispersed quartz grains up to 2 cm in diameter. The majority of the sandstones are coarse to very coarse-grained, only sometimes the topmost parts of individual packages contain medium grained sandstones. The thin sandstone layers (up to 1 m), which are interbedded within fine-grained sediments, show finer fraction (fine to medium-grained). On the upper surfaces of almost all sandstone layers, oval blocks with secondary ferrooxide crusts are visible, showing evidence of desiccation.

The fine-grained sediments consist of mainly horizontally laminated coarse-grained mudstones. The boundaries between fine-grained and coarse-grained facies are usually sharp and erosional. Only subordinately gradual change has been observed to fine-grained sandstones. The colours of the mudstone are red brown, almost violet, with only a few dark grey layers.

The presence of the layers of massive, mainly matrix supported type, coarse-grained sediments with dispersed pebbles, in the Czech Colony Quarry are indicative for high viscosity flow, typical for alluvial fans. The high viscosity prevents sediments from sorting as flow decelerates. All clasts sizes are dumped together, giving a very poorly sorted deposit with larger clasts 'floating' in the finer matrix. The sedimentary structures visible in the sandstone layers are indicative for low viscosity flow. Such flow would carry both bedload and suspension. Large scale cross stratification and clast imbrication suggest sheet flood deposits or stream channel deposits. Assuming all these features, an alluvial fan environment has been reconstructed. Although the red colour of the rocks cannot be conclusive for the paleoclimatic conditions, the presence of abundant decimetre to a few metres thick sheet sandstone deposits with abundant evidences of desiccation, interbedded with fine-grained playa deposits can be considered as ephemeral, flash-flood sedimentation in arid to semi-arid conditions.

NEW ICHNOLOGICAL RESULTS

The basal sequence of the Doman Member, in which the tetrapod tracks *Batrachopus* cf. *deweyi* were previously described (Popa, 2000b), includes a series of unusual traces

which were discovered by the authors in 2005, in the Colonia Cehă (Czech Colony) Quarry, north of the Ponor Quarry. Both of these quarries are proposed to become Sites of Special Scientific Interest (SSSI) for paleobotanical, paleozoological and geological reasons, together with the sterile dumps of the Pit no. 1 in Anina.

The unusual structures include two types: a linear type and a spiral type, both of them confined to the lower sequence of the Doman Member.

The linear type is represented by cast structures variable in length, between 150 cm and 550 cm, with a width varying between 20 cm and 40 cm (Plate 1, Figs. 1, 2, 3). The shape of these burrows is strongly elongated, linear, with a circular or elliptical cross section, sometimes with a flat surface downwards and rounded upwards. Sometimes, they are divided dichotomously (Plate 1, Fig. 2). On one structure, lateral striations, sharp and elongated are present, as an indicator for digging with claws (Plate 1, Fig. 3). The cast clearly shows these linear striations. The sediment filling these structures is white, with a different granulometry of that in which they are included (red beds). The casts are always within the bedding plane of the redbeds, rarely crossing it slightly.

The spiral type is recorded as one isolated occurrence, towards the southern end of the Czech Colony Quarry (Plate 1, Fig. 4). It consists of a circular burrow dug spirally downwards, perpendicular to the bedding plane, with a white sediment filling containing variable quartzitic clasts. An iron oxide coating occurs at the contact with the surrounding, in situ sediments. As it outcrops, only the cross section of this structure can be observed.

DISCUSSIONS

Vertebrate burrow complexes were described by Groenewald *et al.* (2001) from the Lower Triassic Beaufort Group, Karoo Basin. There, these burrows are associated in complexes, different in architecture than those of Anina, and they were produced by reptiles (*Trirachodon*). Taken individually, however, these burrows resemble strongly in shape the structures found in Anina, but in Romania they are simple, not associated in complexes. Hasiotis *et al.* (2004) described both linear and circular types from Triassic deposits of South Africa and Jurassic sediments of North America. The linear type described by Hasiotis *et al.* (2004) are even more similar with the Romanian structures, while the spiral type from

Arizona is the only similar structure to the spiral type in Czech Colony.

The linear structures are simpler to be interpreted as burrows, when considering the petrology of the whitish infilling, the shape of the burrows, their cross section and lateral linear marks resembling scratches. For this kind of structures, alternate explanations are difficult to find.

The only alternate explanation for the spiral structure is linked to sideritic concretions which can show red crusts inside the main concretionary bodies, but in their cases, the general shape is spherical or ellipsoidal, with highly irregular inner crust geometry. In the case of the spiral structures from the Czech Colony Quarry, the shape is clearly different of the irregular pattern of the sideric crusts.

For the Romanian structures, the reptiles remain the only possible group responsible for digging such burrows, but the precise group of reptiles excavating such burrows remains to be identified in the future.

CONCLUSIONS

The Steierdorf Formation in Anina yielded a rich floral assemblage, as well as a very interesting ichnological assemblage with tetrapod tracks and tunnels dug by vertebrates, this time recorded in the Czech Colony open cast mine. The tunnels described in this paper are the first of their type in Europe, and they include two morphologies: a linear morphology and a spiral morphology. The vertebrates are the only possible contributor for ichnological structures of this type, taking in consideration the size and shape of the diggings, their architecture, the claw marks and depositional context. Most probably, reptiles were the ones producing such structures in the Czech Colony.

ACKNOWLEDGEMENTS

One author (MEP) wishes to dedicate this paper to Professor Dan I. Grigorescu, an eminent personality in the field of vertebrate paleontology, as homage to his scientific and educational achievements. Also MEP wishes to thank Dr. Jesper Milan, from the Geological Institute in Copenhagen, for fruitful discussions and for literature help during his studies within the framework of the Synthesis scheme at the Geological Museum in Copenhagen.

REFERENCES

- Bucur, I. I., 1991. Proposition pour une nomenclature formelle des depots paléozoïques et mésozoïques de la zone de Resița-Moldova Nouă (Carpathes Meridionales, Roumanie). *Studia Universitatis Babeș-Bolyai, Geologie*, XXXVI, 2, 3-14.
- Bucur, I. I., 1997. Formațiunile mesozoice din zona Resița-Moldova Nouă. Cluj-Napoca, 214 pp.
- Groenewald, G., Welman, J. & MacEachern, J., 2001. Vertebrate burrow complexes from the Early Triassic *Cynognathus* Zone (Driekoppen Formation, Beaufort Group) of the Karoo Basin, South Africa. *Palaïos*, 16, 148-160.
- Hasiotis, S., Wellner, R., Martin, A. & Demko, T., 2004. Vertebrate burrows from Triassic and Jurassic continental deposits of North America and Antarctica: their paleoenvironmental and paleoecological significance. *Ichnos*, 11, 103-124.
- Popa, M. E., 2000a. Early Jurassic land flora of the Getic Nappe. University of Bucharest, Bucharest, 258 pp.
- Popa, M. E., 2000b. Aspects of Romanian Early Jurassic palaeobotany and palynology. Part III. Phytostратigraphy of the Getic Nappe. *Acta Palaeontologica Romaniaae*, 2, 377-386.
- Popa, M. E., 2000c. First find of Mesozoic tetrapod tracks in Romania. *Acta Palaeontologica Romaniaae*, 2, 387-390.

PLATE 1

Fig. 1. Linear burrow in the Czech Colony's eastern flank, in the red beds of the Doman Member. The filling is represented by white sandstone.

Fig. 2. Linear burrow divided dichotomously, Doman Member, Czech Colony, also in red beds.

Fig. 3. Linear burrow of large size, in red beds, Czech Colony, Doman Member.

Fig. 4. Spiral burrow in cross section, with coarse sediment infill and iron oxidic coating, Doman Member, southern end of the Czech Colony quarry.

PLATE 1

