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IAS
INTERNATIONAL ASSOCIATION OF SEDIMENTOLOGISTS

IPA International Palaeontological Association

SPG
Société Paléontologique Suisse
Schweizerische Paläontologische Gesellschaft
Società Paleontologica Svizzera

EAVP
European Association of Vertebrate Palaeontologists

Formation and preservation of Late Jurassic dinosaur track-bearing tidal-flat laminites (Canton Jura, NW Switzerland) through microbial mats

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Recently, an increasing number of investigations comparing fossil and modern microorganisms highlighted the role of microbial mats in the formation of minerals and diagenetic processes leading to the development of sedimentary rocks including lithographic limestones and trace fossils. More specifically, on recent tidal flats, the sporadic growth of microbial mats alternating with carbonate precipitation may lead to the formation of biolaminated sediments, where vertebrate tracks (true tracks, undertracks, overtracks) are easily preserved (Marty et al. 2009). However, because microbial mats are mainly composed of extracellular polymeric substances (EPS) containing over 70% of water, the former presence of microbial mats in the fossil record can only with electron microscopy be proven unambiguously (Pacton et al. 2007).

This study is based on Late Jurassic (Kimmeridgian) dinosaur track-bearing laminites from NW Switzerland near Porrentruy, which formed on tidal flats of the Jura carbonate platform (Marty 2008). Macrosedimentary structures (i.e., dinosaur tracks, desiccation cracks, ripple & wrinkle marks) of superimposed palaeosurfaces were documented and analysed and a high-resolution microfacies analysis was carried out. Of selected samples the total organic carbon content was determined by Rock-Eval pyrolysis, and mineralogical (including clay minerals) analyses were performed by standard X-ray diffraction. The organic matter (OM) was then isolated from the mineral fraction using a standard palynological preparation technique in order to analyse it on thin sections with optical microscopy using natural light and blue-light fluorescence, and on ultrathin sections with transmission electron microscopy (TEM).

The former presence of microbial mats is suggested by the stromatolithic appearance of the laminites in the field; crypt microbial lamination and fenestrae in thin sections (i.e., a laminated alternation of OM and minerals); polygonal desiccation cracks, pustular nodules, and wrinkle marks on palaeosurfaces; and by associated track features such as (internal) overtracks.

TEM observations show heterogeneous OM mainly composed of a more or less fluffy alveolar network corresponding to exopolymeric substances (EPS), sometimes of "curly" and ovoid bodies with thick membranes corresponding to bacterial and algal cell walls, and accessorily of complex fibrous structures with a strong contrast and characteristic lamellae indicating terrestrial fragments (plants). Further, ultralaminae displaying diffuse outlines and a relatively small thickness (80 nm) have also been observed. According to the classification of Pacton et al. (2008) they can be attributed to bacterial cell walls indicating a low degradation level in the OM cycle. This evidence suggests that the laminites were mainly formed by the sporadic growth of photosynthetic microbial mats occasionally incorporating terrestrial plants.

We conclude that the studied laminite intervals formed in a tidal flat environment subjected to desiccation and rehydration (due to a regularly or episodically covering with shallow water) allowing the growth of microbial mats and hence the formation and preservation of dinosaur tracks. Today, such conditions are typically observed on higher intertidal to supratidal flats. Consequently, the palaeoenvironment of the laminites from NW Switzerland was clearly more terrestrial (i.e., characterized by a higher exposure index) when compared with the Kimmeridgian to Tithonian (sub)lithographic limestones from Cerin (shallow lagoon to intertidal; Gaillard et al. 1994), Orbagnoux (shallow lagoon; Tribovillard et al. 1999), and Solnhofen (deeper lagoon; Seilacher 2008).

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