

Asteriacites lumbricalis von Schlotheim, 1820 from the Coste dell'Anglone Lower Jurassic (Sinemurian) dinosaur ichnosite (Valle del Sarca, Trentino, NE Italy)

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ABSTRACT - Here we report the first finding of *Asteriacites lumbricalis* in the Lower Jurassic of the Trento Platform. Palaeoenvironmental indications given by the presence of this trace fossil are added to the stratigraphical and sedimentological data for the Coste dell'Anglone dinosaur ichnosite. We suggest that during the middle-late Sinemurian this geographical sector was occupied by marginal-marine, tidal flat embayments with possible presence of a not too far fresh water source. This would have been necessary to sustain the existence of sedentary populations of dinosaurs recorded in the deposits that directly overlie those preserving the trace fossil described herein.

RIASSUNTO - [*Asteriacites lumbricalis* dall'ichnosito ad orme di dinosauri di Coste dell'Anglone (Sinemuriano; Valle del Sarca, Trentino, NE Italy)] - Il presente lavoro riporta della prima scoperta della traccia fossile *Asteriacites lumbricalis* nel Giurassico Inferiore della Piattaforma di Trento. Le indicazioni paleoambientali fornite dalla presenza di questa traccia vengono integrate ai dati stratigrafici e sedimentologici noti per l'ichnosito ad orme di dinosauro di Coste dell'Anglone. Si propone che durante il Sinemuriano medio-superiore questo settore geografico fosse occupato da un ambiente marino marginale di piattaforma tidale alla quale giungevano apporti di acque dolci. Tale presenza sarebbe stata necessaria per garantire la sussistenza delle popolazioni stanziali di dinosauri documentate nei depositi immediatamente soprastanti a quelli descritti.

INTRODUCTION

The Coste dell'Anglone dinosaur ichnosite is located along the eastern slope of Monte Brento (Dro, Trentino Alto-Adige; Fig. 1), in the central sector of the Southern Alps, slightly north of the Garda Lake. In this site, hundreds of dinosaur tracks, mostly arranged in long trackways and currently under study, were recognized on a wide monoclinical surface dipping about 30° SE (Petti et al., 2008). At the top of a shallowing-thickening-upward cycle, about 1 m below the dinosaur trampled bed (that forms the top of a successive cycle) several *Asteriacites lumbricalis* traces were found.

Asteriacites von Schlotheim, 1820 is a well known star-shaped resting trace (cubichnia) that belongs to the *Cruziana* ichnofacies (Seilacher, 1964, 1967). This ichnofacies characterizes the sublittoral, offshore and inner shelf environments between daily wave base and storm wave base as well as lagoons (Frey & Pemberton, 1985). *Asteriacites* has a long temporal range extending from Cambrian to recent shallow- to deep-marine facies (see Mikulás, 1992 and references therein). In the Eastern sector of the Southern Alps *Asteriacites* has been documented several times (Broglia Loriga et al., 1983, 1990), its occurrence has in particular been investigated in the study of the Permo-Triassic aftermath (e.g., Twitchett & Wignall, 1996; Wilson & Rigby, 2000).

Seilacher (1953) suggested that *Asteriacites lumbricalis* was probably made by ophiuroids but most subsequent papers did not provide any discussion about

the possible producer of the trace (but see Spencer & Wright, 1966; Lawrence, 1987). The tracemaker was generally intuitively indicated as a member of the Asterozoa without distinguishing between asteroids and ophiuroids (e.g., Santos & Campanha, 1970; Brito, 1977; Crimes & Jiang, 1986). However Mángano et al. (1999) convincingly showed that an ophiuroid tracemaker is the most reliable interpretation in the majority of cases (see also Seilacher, 2007). Mikulás (1990) and West & Ward (1990) have also provided evidence of *Asteriacites lumbricalis* preserved with ophiuroids remains *in situ*.

GEOLOGICAL SETTING

The trace-bearing level belongs to the lower portion of the Rotzo Formation (Sinemurian-Pliensbachian; Calcarei Grigi Group see Avanzini et al., 2007 and references therein; Fig. 1a) represented in this geographical sector by a shallowing upward peritidal sequence composed of cycles, each characterized by the transition from a low energy subtidal unit (bioturbated nodular limestone) to high energy subtidal deposits (oolitic grainstone with intraclasts and bioclasts) up to inter- and supra-tidal deposits (stromatolitic and finely laminated layers) (see Monaco & Giannetti, 2002; Giannetti & Monaco, 2004). Microfossils analysis of these basal layers has allowed the recognition of a microassemblage that indicates a middle-late Sinemurian age (Petti et al., 2009a).

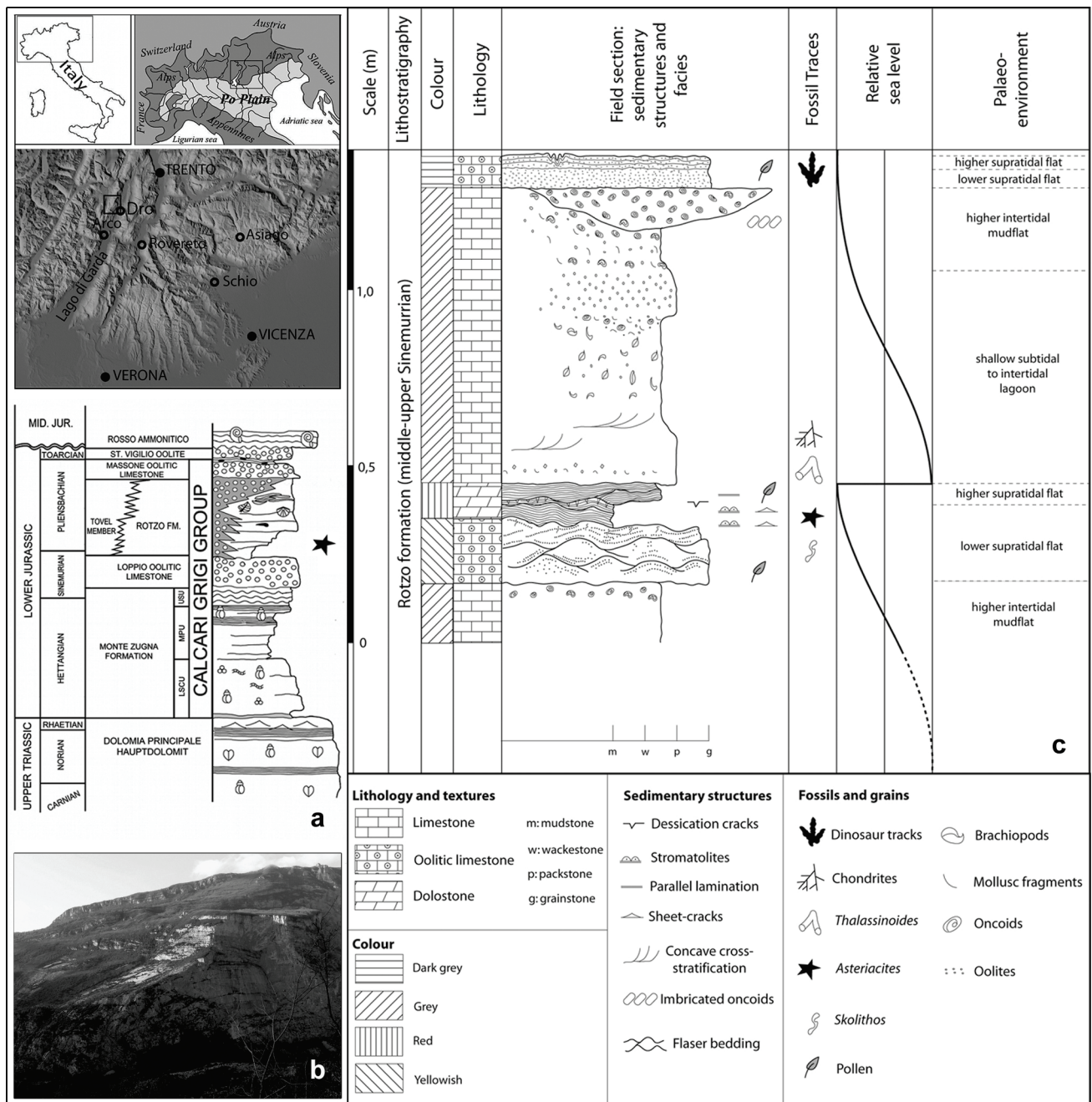


Fig. 1 - The Coste dell' Anglone ichnosite, Trentino Alto-Adige, NE Italy; a) stratigraphical section of the Lower Jurassic deposits. Trace fossils bearing levels belong to the lower portion of the Rotzo Formation (Sinemurian-Pliensbachian, Calcarei Grigi Group); b) panoramic view of the site located along the eastern slope of Monte Brento; c) detail of the studied section constituted of two shallowing upward cycles including both *Asteriacites lumbricalis* and dinosaur traces.

The traces are preserved at the top of the peritidal cycle in a finely laminated dolostone yellow/red in colour with evidences of supratidal exposure (mud cracks and laminar fenestrae).

The base of this sedimentary portion is represented by a peloidal mud followed by sandy layers with parallel to slightly irregular upper and lower contacts and internal laminae varying from parallel to undulatory. This heterolithic stratification (*sensu* Damico & Hardie 1994), or flaser lenticular bedding (*sensu* Rieneck 1960) was considered by Rieneck & Wunderlich (1968) as quite common in shallow water carbonate platform deposits. When tidal flats are covered during ebbing or flooding

tides, currents or waves produce irregularly rippled sands and silts. During slack tides or calm seas, mud suspended in the water column settles out, burying the ripples to various degrees.

The mud compacts and is thus not easily eroded during the next current cycle. Alternatively, as appears in the Coste dell' Anglone dinosaur ichnosite, such interlaminated structures can be produced by the preferential trapping of mud by microbial mats during storm flooding and then deposition of sand as the current wane (Damico & Hardie, 1994). The top of the peritidal cycle shows a 30 cm thick inter to supratidal sequence made of a interlaying of fine laminated dark peloidal

mudstone and reddish millimetre-thick sandy-dolostone layers. The presence of thin stromatolite layers with subaerial exposure evidence, makes reasonable that in our case the tidal flat, after the accumulation of the peloidal mud, became exposed to the subaerial environment with pedogenetic rubefaction, mud cracking, and dolomitisation. Among this finely laminated layers and immediately below the supratidal interval a monospecific *Asteriacites lumbricalis* assemblage was recognised (Fig. 1c).

The lower part of the subsequent cycle (deposited in the lower-middle subtidal environment of a carbonate lagoon) is abundantly reworked and burrowing can be recognised as a primary factor in the nodularity of this basal part of the cycles. The middle and upper part of the cycle is much less burrowed: small fossil traces (0.5 to 1 cm in diameter) include *Chondrites* and *Skolitos*. These traces are associated to reworked bivalve and brachiopod skeletal fragments. Dinosaur tracks are slightly impressed on the top of the cycle consisting of alternating stromatolitic laminae and dark gray bioclastic grainstone covering a set of meandering shallow tidal channels infilled by coarse grained and embriated oncoidal floatstones/rudstones.

TRACE FOSSIL DESCRIPTION

About 30 star-shaped traces have been analysed. All specimens resemble the typical morphology of *Asteriacites lumbricalis* von Schlotheim, 1820 (Fig. 2). Quality of preservation is highly variable. Most traces are represented by poorly preserved convex hyporeliefs (as in Savrda, 2007, p. 100 Fig. 6.8). It is however always possible to identify 4-5 rays tapering towards the tip. Rays originate from a central structure (average diameter 4 mm) that in majority of the specimens is undifferentiated. The most informative traces show morphological details such as delicate transversal or V-shaped annulations on the rays. Those are produced by the regular digging action of the tube feet moving sediment outward from beneath the arms and are generally recorded in the undertrace only (Seilacher, 1953, 2007). Occasionally, a shallow impression is visible in the central area. The few traces preserved as concave epireliefs did not provide any further detail. Trace diameters (arm tip to arm tip) range from 5 to 21 mm with more than half having a diameter of less than 13 mm. The arms are moderately long in relation to the central structure with lengths ranging from 3 to 18 mm. Arm thickness ranges from 1 to 7 mm. In the here considered horizon, *Asteriacites* constitutes a monospecific assemblage.

DISCUSSION: PALAEOENVIRONMENTAL INTERPRETATION

Integration of sedimentologic and ichnologic data for the Coste dell' Anglone dinosaur ichnosite is of particular interest not only for its bearing on the palaeogeographic reconstruction of this restricted setting but, more importantly, for its possible contribution to the ongoing debate on the palaeogeography of the Trento Platform during the Early Jurassic (e.g., Petti et al., 2009b).

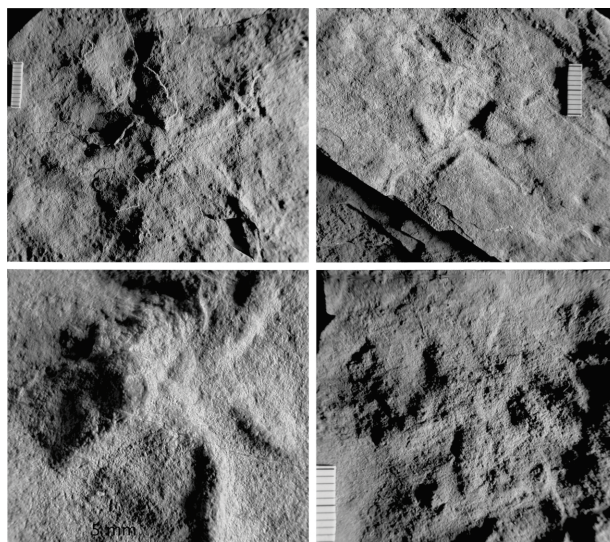


Fig. 2 - Examples of *Asteriacites lumbricalis* von Schlotheim, 1820 as preserved at the Coste dell' Anglone ichnosite. Where not otherwise indicated, scale bar = 10 mm.

Asteriacites is recorded in marginal-marine, tidal-flat facies, and, as shown by Mángano et al. (1999) is common in brackish-water conditions. In this type of environments *Asteriacites* are usually smaller than those living in a fully marine environment. The average small size of our specimens in comparison to the commonly reported size for *Asteriacites* (up to 31 mm; Mángano et al., 1999) seems a clue in favour of the interpretation of an environment with depressed salinity. Miniaturization of the organisms (Segerstrale, 1957; Hakes, 1985), and ophiuroids in particular (Remane & Schlieper, 1972; Spaargaren, 1995; Gingras et al., 1999), has been widely documented in relation to salinity stress. *Asteriacites* is generally considered as indicative of fully oxygenated (Müller, 1980; Mikuláš, 1992; Twitchett & Wignall, 1996) and clear waters (Kilbourne et al., 1998). Facies analysis indicates sedimentation in sand, mixed sand-mud, intertidal flats. Sedimentary structures are indicative of shallow water tidal environment and the observed heterolithic stratification indicates the presence of steady flows at low current velocities.

Those data are consistent with an environment of deposition formed by restricted bay settings protected by a sea (the Lombardy pelagic basin) located westward.

Having found a marked difference in the size of the individuals we can also suggest the presence of both juvenile and adult ophiuroids. This indicates that the area was inhabited by a stable population of ophiuroids thus suggesting fairly constant environmental conditions.

CONCLUSIONS

This discovery represents the first report of *Asteriacites* in the Lower Jurassic Trento Platform. *A. lumbricalis* can be used as a palaeoenvironmental marker. This ophiuroid trace can be considered indicative of fully oxygenated brackish environments with clear waters. These elements can be added to the stratigraphical and sedimentological data for the Coste dell' Anglone

dinosaur ichnosite in order to better reconstruct its palaeoenvironment. The presence of *Asteriacites* and its possible role as brackish water indicator can be considered as a clue in favour of the possible presence of a fresh water source in a nearby area. This would have been necessary to sustain the existence of sedentary populations of dinosaurs recorded in the deposits that overlie those preserving the here described traces.

We suggest that during the middle-late Sinemurian this area was occupied by marginal-marine, tidal-flat embayments with a possible fresh water source in a nearby area.

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