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Artikel: Depositional trends in the Valdorbia Section (central Italy) during the Early Jurassic, as revealed by micropaleontology, sedimentology and geochemistry

Autor: Monaco, P. / Nocchi, M. / Ortega-Huertas, M.

Kapitel: 7: Trace fossil assemblages

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the previously semi-lithified mud and buried shells. The strong oscillatory-flow regime at the sea-floor induced a winnowing of finer sediment (the matrix is moved away) and formed a sequence with a characteristic upward trend: a wackestone, a packstone and then a grainstone in the upper part (Brenner & Davies 1973; Specht & Brenner 1979; Kreisa 1981). In other cases due to continuous oscillatory flow on the sea floor, variable periods of non-sedimentation and/or erosion occurred (hiatus), with the exhumation of firmground (or hardground) during the Middle Toarcian (Monaco in press c).

Wavy laminites, interbedded with graded rhythmites, are described also in the Toarcian black shales of NW-Greece and are interpreted as storm deposits formed by direct wave action (see Walzebuck 1982).

6.4 A vertical trend from turbidites to HCS and WB deposits

In the studied section some different trends are recognized:

a The first is present in the COR unit from the Carixian to the lower part of the Lower Toarcian. Meter-scale cycles of fine-grained calcareous turbidites, due to low-density flows, evolve gradually in coarse-grained, m-thick turbidites and gravity flow deposits (Fig. 14). Amalgamated, high-density turbidites contain reworked skeletal grains of a carbonate platform environment. This detrital sedimentation represents an increase in supply in the Valdorbia area, probably related to local tectonics that influenced the M. Catria-Valdorbia area. A tectonic elevation in the M. Catria area probably involved a deepening in the Valdorbia one in the upper part of the Early Jurassic when the bottom of the Valdorbia basin reached the maximum depth (Monaco 1992, Tab. 1). Another interpretation is that the thickening and coarsening up during the Domerian (Fig. 14) could be related to a sea-level fall (Farinacci et al., 1981; Hallam 1988).

b Coarse-grained calcarenitic turbidites in the COR/MS units transition are overlain by fine-grained calcisiltitic turbidites in the upper part of the MS Fm. (Lower Toarcian, Tenuicostatum – Serpentinus Zones, Fig. 14). The thickness and the grain size of detritic beds decrease going upward. This fining-upward trend seems to indicate a reduction of a local tectonic activity and a uniform depth of the sea-floor.

c A shallowing-upward trend characterizes the Lower Toarcian – Middle/Upper Toarcian interval. Fine-grained turbidites, abundant in the MS Formation are overlain by sharp-based HCS deposits and WB beds in the RAUM unit (Fig. 14). This shallowing-upward trend may be related to a progressive sea-level fall in the Middle/Late Toarcian (Hallam 1988) that is general in the Umbria-Marche area. Microfaunal assemblages reflect this progressive shallowing-upward trend and indicate a transition from a sea-floor comparable to an upper bathyal/outer shelf environment in the Early Toarcian, to an outer- middle shelf in the Middle/Late Toarcian.

7. Trace fossil assemblages

7.1 Burrowing during authigenic sedimentation

a COR Unit. The lower part of the COR unit is very weakly bioturbated by small horizontal traces and Chondrites forms are common. During the Late Domerian, in contrast, the nodular sediments of the COR are pervasively bioturbated. Here the penetration depth reaches 7–10 mm and the maximum burrow diameter reaches 15 mm (in reddish nodular facies). Chondrites, Planolites, Thalassinoides and composite burrows represent the most important trace fossils (Fig. 17).

b MS Formation. At the beginning of the Toarcian, when medium to poorly oxygenated "Marne del M. Serrone" shales were deposited ("Toarcian Anoxic Event"), trace fossils are rare and poorly diversified. Chondrites and rare Planolites are present in laminated marly levels. The penetration depth in general is low, 3–5 mm (exceptionally 12 mm). Maximum burrow diameters reach 2–6 mm in the lower part of MS; in this interval nodular facies are absent, and, therefore, small and rare horizontal burrows are predominant (Fig. 17). Ornate burrow-systems (geometrically patterned agrichnia, mainly referred to Protopaleodictyon), of 3–8 mm in diameter, are locally present on the lower surface of such turbidite beds as "semirelief" casts (Seilacher, 1964) (Fig. 18). Planolites, Gyrochorte and Thalassinoides are also present, specially above the black shales interval (at the MS – RAUM transition) where these forms can reach 10–25 mm in diameter.

c RAUM Unit. During the deposition of well-oxygenated and nodular sediments of the RAUM unit, trace fossils increase progressively in abundance. Horizontal and vertical trace-fossils are large, diversified and fairly common in autochthonous mudstones and wackestones (Fig. 17). Thalassinoides, of 2 to 4 cm in diameter, and Planolites represent the dominant burrow systems of reddish marly deposits. These traces, and also ammonites, are reworked by Chondrites and Helminthopsis. The maximum burrow diameter rarely exceeds 30 mm and penetration depths can reach 50 – 60 mm in the reddish nodular limestones of Late Toarcian age (Fig. 17 and 18d). Subelliptical concentrations of bivalve and/or echinoderm fragments due to vertical burrowing activity are very common in this interval. In the Bifrons and lower part of Erbaense Zones (Middle Toarcian) 20 to 60 cm thick calcisiltite beds, showing HCS and oscillatory ripples, are interbedded with marls (Monaco in press c). Burrows on the lower surface of HCS beds are common. Horizontal Thalassinoides and Ophiomorpha are prevalent with diameters about 30–50 mm and Planolites is also present (Fig. 18b and c). At the top of HCS beds, oscillatory ripples become increasingly burrowed upwards by vertical traces, and Skolithos and Chondrites are the traces of the dominant firmground-burrowers (Fig. 18d). In fine-grained deposits (silts) Chondrites is represented by darker vertical traces showing upside-down Y-shaped development (Ekdale 1985). The penetration depth locally can reach 50–60 mm. Paleophycus, and Planolites, are very common when the upper part of HCS deposit is formed by a coarse-grained fraction (sand).

7.2 The significance of burrowing during turbiditic deposition (Early Toarcian)

In the turbiditic environment of the Lower Toarcian the trace fossil associations are higly diversified and burrow densities are very low (K-selected endobenthos, Ekdale 1985). Trace fossils are essentially pre-depositional traces and are produced in an equilibrium situation in the hemipelagic mud that was deposited slowly in between turbidite events (Seilacher 1962). Ornate burrow systems (e.g. geometrically patterned agrichnia such as Protopaleodictyon) that are present on the lower surface of turbiditic beds, probably reflect very specialized feeding behaviour (Bromley 1990).

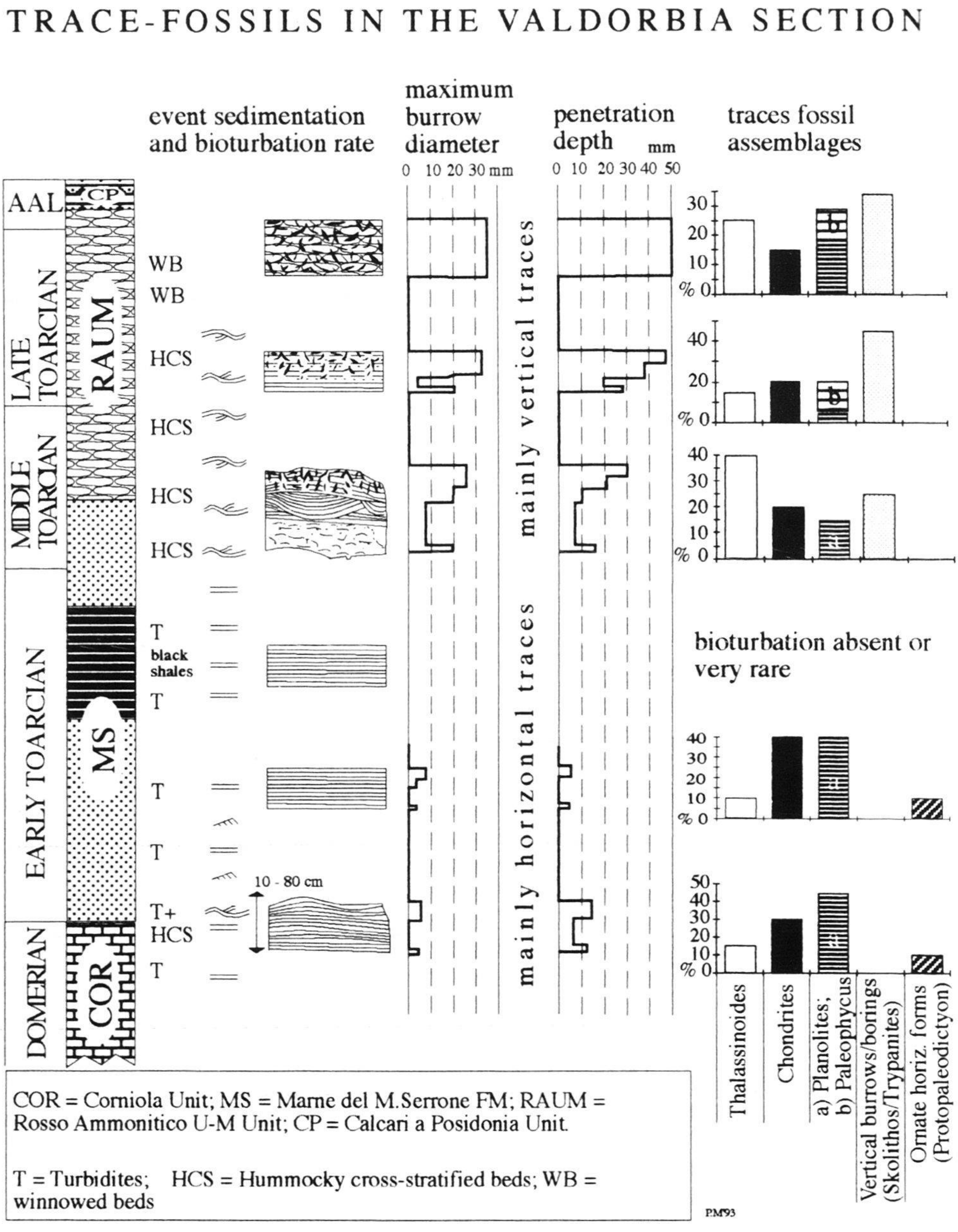
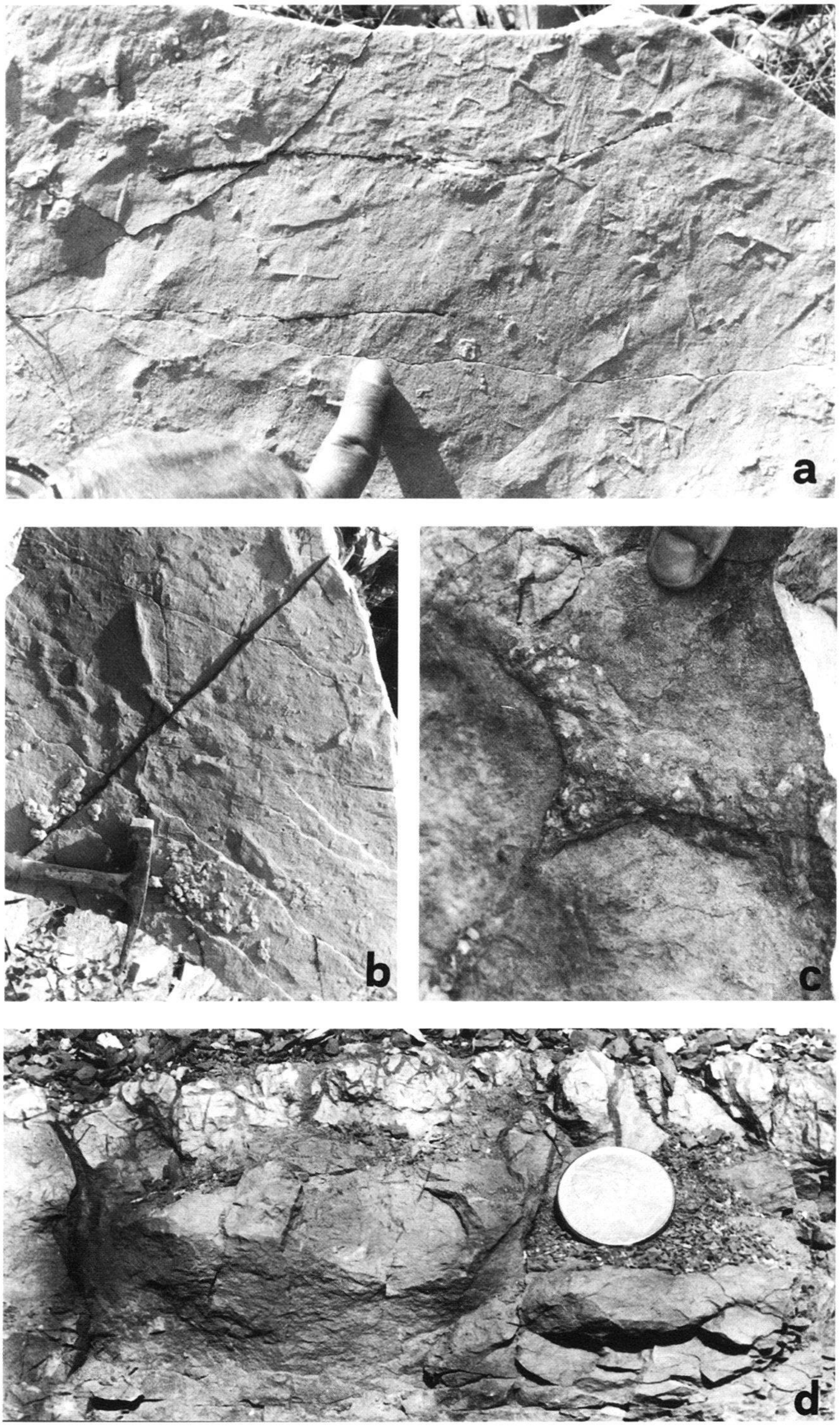


Fig. 17. Trace fossil assemblages and relationship with turbidites and HCS deposits.


a
b
c
d

During the black shale interval trace fossils became rare. In this oxygen-depleted environment the nature of the bioturbation is episodic, superficial (diameters in the range of one to few millimeters, Fig. 17) and dominated by the highly branched fodinichnial burrow Chondrites, which is characteristic of oxygen-poor interstitial conditions (Bromley & Ekdale 1984). Probably, as the concentration of dissolved oxygen in bottom waters decreases, the size of organisms capable of inhabiting underlying substrates also decreases (Rhoads & Morse 1971). Nevertheless, a very rapid and erosive sedimentation such as turbidite deposition may considerably disturb the trace-fossil record and complicate the interpretation of paleo-oxygenation (Savrda & Bottjer 1986; 1989).

7.3 The significance of burrowing during HCS deposition (Middle-Late Toarcian)

A sea-level fall during the Middle-Late Toarcian (Hallam 1988) probably favoured a sea bottom depth very close to the major storm wave base (approximately 80–100 m deep). Consequently, HCS beds may be diagnostic of an agitated, highly-oxygenated environment (Dam 1990). Trace fossils in the lower part of HCS beds are mainly monospecific and often with high burrow density (r- selected ichnotaxa of Ekdale 1985). Sedimentary structures indicate that the burrows were produced over a fairly short period of time and that the environment was inhospitable due to very uneven sediment accumulation rates and oscillatory currents. Therefore, the typical ichnocoenosis of storm-derived sediments comprises traces produced by opportunistic organisms in an unstable, high-stress, physically-controlled environment, where food supplies were abundant for short periods of time. When erosion strips away a soft and/or soupy superficial layer to expose a firmground, the sea floor can be occupied by characteristic groups of firmground-burrowers (Ekdale 1985). A progressive intensification of bioturbation levels from the MS to the RAUM units indicate that oxygen availability in bottom waters increased gradually through time (from the Lower to the Upper Toarcian) and dwelling organisms increased their penetration depth and occupied progressively deeper levels in the sediment column. Consequently, the organisms inhabiting the reddish and autochthonous nodular facies inter-HCS beds of the RAUM are large, diverse and very abundant, corresponding with the well-oxygenated conditions of Savrda & Bottjer (1986; 1989).

Fig. 18. **a** Trace fossils formed in turbiditic conditions, Lower Toarcian (Tenuicostatum Zone). A geometrically patterned burrow system (ornate horizontal forms mainly referred to Protopaleodictyon) is present as "semirelief" on the lower surface of a calcarenitic turbidite. **b** Other horizontal traces (mainly Thalassinoides) in the same turbiditic bed. **c** Ophiomorpha, Middle/Upper Toarcian transition. **d** Trace fossils formed during the waning phase of HCS event when continuous and strong oscillatory mouvements on the sea floor, involved variable periods of non-sedimentation and/or erosion, with exhumation of firmgrounds (Middle/Upper Toarcian transition, Erbaense Zone). The increasing penetration depth reflects a low sedimentation rate and testifies a favourable condition for several opportunistic firmground burrowers (mainly Skolithos, Chondrites, Planolites and Paleophycus).