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ECHINODERM TAPHONOMY OF THE ZORZINO LIMESTONE (NORIAN, LATE TRIASSIC)

The Zorzino Limestone is well-known among vertebrate paleontologists because of a rich fossil content that includes at least 15 reptilian species and 50 known fish species; in spite of this diversity, the majority of the fish remain to be described. Invertebrates are rare but a diverse fauna has been collected from several horizons; included are corals, a few brachiopods, molluscs (bivalves and gastropods), crustaceans, and echinoderms (echinoids, asteroids, ophiuroids and crinoids). The seafloor during deposition of the Zorzino Limestone was fully anoxic and therefore all fossils, both invertebrate and vertebrate, must be considered allochthonous. Basin margin facies are almost unknown as usually deeply dolomitized; however, the benthic invertebrates must have lived in oxygenated settings, and large bivalve banks had to be present to support the abundant durophagous fish and reptiles that dwelled close to the bottom (Tintori, 1995). Echinoderms are preyed upon by modern durophagous fishes, but at present there is no proof of this behaviour during the Late Triassic. Many coprolites from the Zorzino Limestone are largely formed of crushed molluscan shells, but as yet no coprolite has been discovered that contains echinoderm remains.
Mode of accumulation of the isolate benthic invertebrates in the anoxic Zorzino Limestone remains unresolved. There is no sedimentological evidence of bottom currents, such as scour surfaces or turbidite intervals; further, such currents might be expected to bring oxygenated waters to the depositional setting, and sediments do not suggest presence of oxygen-rich water. The fossils are found largely complete and the echinoderms are still largely articulated; however crinoid arm tips and spinelets of some have been lost, suggesting transport.

Two specimens of an isocrinid crinoid are included among the echinoderms. Preservation indicates that prior to deposition, the crinoids had shed their stems about one cm below the calyx at preformed rupture points of the lower nodal facets; this behavior is typical of isocrinids. An ophiuroid was preserved among the cirri of specimen 1; for improved food gathering, this individual is likely to have climbed the crinoid stem in the echinoderm habitat in order to occupy a position elevated above the sea floor. Crinoid specimen 1 is devoid of its arm tips; certainly, the tips were shed during displacement or transport of the animal because tips would be preserved on the slab if they had been broken after the individual came to rest; this is the manner of preservation of specimen 2, in which tips are scattered and disordered. After burial in the low-energy scavenger-free anoxic

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environment, the crinoid arms partially disarticulated into segments of cm length. Dorsoventrally embedded arms were completely disarticulated; however, the brachials remained in their original arrangement.

Completely preserved isocrinids hitherto have not been reported from Triassic strata. All Triassic isocrinid taxonomic concepts are based on isolated columnals and a few cups, and therefore it is difficult to assign the new crinoids to a known Triassic isocrinid species. However, the stellate proximal stem and the cone-shaped cup with fairly large basals present in the new specimens indicates a close relationship with *Tyrolecrinus,* which was widely distributed over the western Tethys realm during late Ladinian/early Carnian times. The isocrinid clade is a late Ladinian offshoot of the Anisian Holocrinidae. The major isocrinid diagnostic characters are synostosial lower nodal facets (preformed rupture popints), and a cryptosymplectial cone-shaped cup with large radial facets directed outwards. The radial facet arrangement provides space for extensive arm branching and thus a considerable widening of the arm fan relative to ancestral groups. The new isocrinid fits well into a lineage between the Holocrinidae and those Lower Jurassic isocrinids with a single branching of each arm. Certainly, the Zorzino isocrinid was a benthic crinoid such as other isocrinids. Pseudoplanktic lifestyle as it is recorded from the Pentacrinitidae, the other holocrinid offshoot, can be excluded because the stelleroids and echinoids were unequivocally benthic.

The preservation of three echinoid specimens with many of their spines still attached corroborates the taphonomic history inferred for the crinoids. After transport, the echinoids must have been rapidly buried. Their highly flexible tests have been dorsoventrally compressed; however, apical systems, lanterns, and peristomial plates are still in situ. The Zorzino echinoid is an offshoot of the large Anisian/Ladinian *Triadotiaris*, which also has a highly flexible test with wide imbricating interambulacrals bearing crenulate bosses, and a pseudocompound adoral ambulacral plate arrangement. Possibly, this new echinoid was among the ancestors of the echinothurioid clade.

Because of body construction, preservation of the new asteroid specimen reveals relatively little of depositional mode. The asteroid body consists of a large coelomic space that is enclosed by a skeletal-tissue layer of comparatively small, unfused primary skeletal plates (2 or 3 per mm in the present example); the primary plates are more or less densely covered by accessory spinelets and granules. While alive or soon after death, the body of most asteroids is quite tough and resistant to disarticulation, but decay soon begins and the plates rapidly become disassociated.

The present specimen was flattened and the body folded; the interior of the body was not significantly filled with sediment. The life arrangement of plate systems was largely retained; however, plates had begun to separate from their living positions by the time of final entombment, and the delicate mouth frame was strongly disrupted; it is now obscure. Some spines were retained but most were lost. The specimen was not abruptly sealed in sediment as a living or recently dead individual, but it either could have been transported, deposited, and decay began, or alternatively, it could have begun decomposition and

The best preserved isocrinid specimen from the Zorzino Limestone (Zogno-Endenna, Bergamo)

disarticulation at its life site; in either pattern, sediment compaction would contribute to displacement of skeletal elements.

Triassic asteroids are nearly unknown; the new specimen belongs to a new genus and species of the asteroid crown group, and it is of major phylogenetic significance.

The ophiuroids of the Zorzino Limestone were less disturbed than the asteroid, probably because of their small size, closely articulated skeletons, and comparatively small coelom. Arm tips, most spines, and most of the dorsal arm plates were lost, however, and recrystallization has obscured many details of the mouth frame; there also has been some distortion of the disk, but nevertheless these fossils are remarkably intact. The ophiuroids appear to have been buried at or soon after their deaths, but as is true of the asteroid, they provide little evidence for or against a comparatively brief period of transport.

REFERENCE

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