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Doomed-pioneers bioturbation events related to gravity-flow deposits in marine dysaerobic environments

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Key words: Trace fossils, *Thalassinoides*, sediment-gravity flows, oxygen, doomed pioneers

In a number of localities we have observed discrete horizons with *Thalassinoides* and *Gyrolithes* burrows occurring exclusively at the base of gravity-flow deposits which are intercalated in otherwise non- to poorly bioturbated successions (e.g., Santonian-Maastrich-

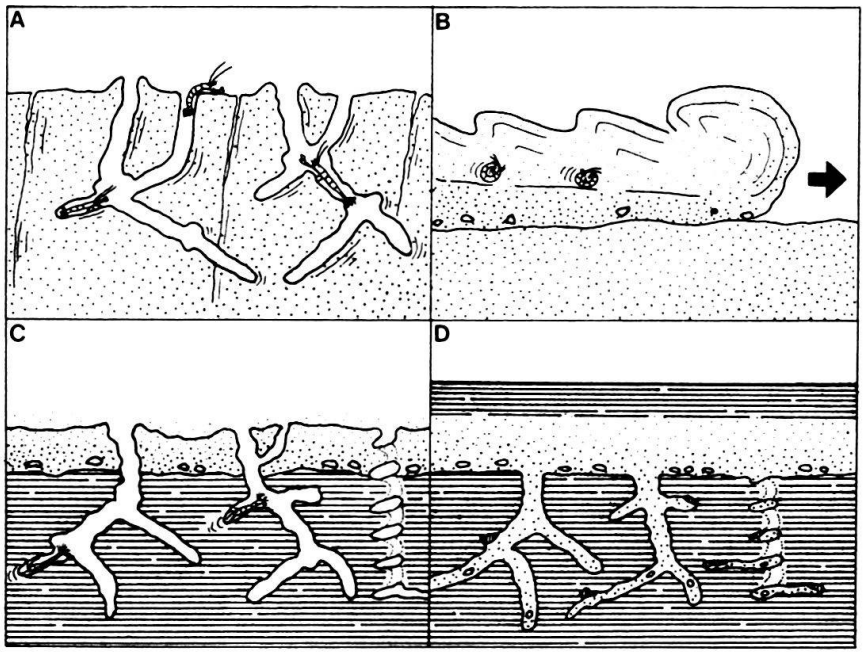

Fig. 1. Genesis of doomed-pioneers burrow assemblages: A. Disruption of original habitat of thalassinidean crustacea by, e.g., a storm event. B. Turbulent transport of thalassinidean crustacea within gravity flows. C. Arrival in oxygen-depleted environment and feeding on organic-rich sediments until dysaerobic bottom-water conditions prevent further burrowing. D. Infill of burrows by active backfilling and passive collapse infill. Return to deposition of laminated sediments (from Föllmi & Grimm, 1990; reproduced with permission from the Geological Society of America).

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tian Guadalupe Formation, Columbia; Campanian Duwi Formation, Egypt; Campanian Mishash Formation, Israel; Oligocene San Gregorio Formation, Baja California; Miocene Monterey Formation, California). These horizons lack burrows of presumably soft-bodied organisms such as *Zoophycus, Planolites,* and *Chondrites.* We attribute a causal relationship between gravity-flow deposition and the presence of *Thalassinoides* and *Gyrolithes* and suggest that these gravity flows have entrained thalassinidean crustacea. Upon deposition in oxygen-deficient environments, the surviving crustacea reworked substantial quantities of laminated, mostly organic-rich sediments in an environment from which they were previously excluded. The persistence of or rapid return to oxygen-depleted conditions limited the survival time and ecological complexity of the imported infaunal dwellers and rendered them doomed pioneers. Ecological and physiological data support this hypothesis: thalassinidean crustacea have the capability to endure turbulent transport and survive upto 5–7 days of anoxia without being severely limited in their biological activities.

For these reasons, isolated horizons with *Thalassinoides* and *Gyrolithes* burrows in otherwise laminated successions are not necessarily indicative of phases of basin-wide oxygenation. Instead, they may represent doomed-pioneer trace-fossil assemblages; i.e., ecologically short-termed phenomena related to the transport of thalassinidean crustacea in gravity flows (Föllmi & Grimm, 1990; Föllmi, 1995; Grimm & Föllmi, 1994).

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