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Autor:	Föllmi, Karl B. / Grimm, Kurt A.
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Doomed-pioneers bioturbation events related to gravity-flow deposits in marine dysaerobic environments

KARL B. FÖLLMI¹ & KURT A. GRIMM²

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-

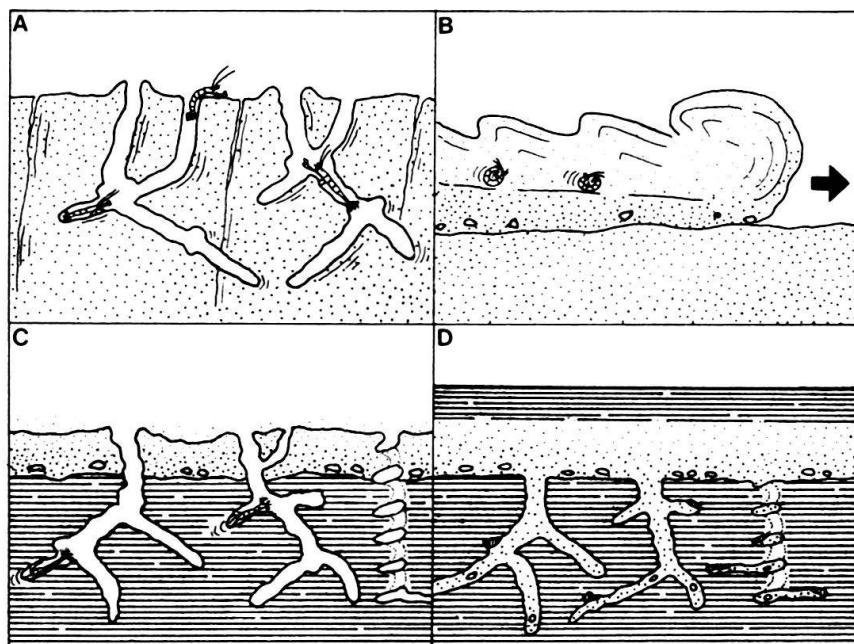


Fig. 1. Genesis of doomed-pioneers burrow assemblages: A. Disruption of original habitat of thalassinidean crustacea by, e.g., a storm event. B. Turbulent transport of thalassinidean crustacea within gravity flows. C. Arrival in oxygen-depleted environment and feeding on organic-rich sediments until 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).

¹ Geological Institute, ETH Centre, CH-8092 Zürich

² Department of Geological Sciences, Univ. of British Columbia, Vancouver, BC V6T 1Z4, Canada

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 up to 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-term phenomena related to the transport of thalassinidean crustacea in gravity flows (Föllmi & Grimm, 1990; Föllmi, 1995; Grimm & Föllmi, 1994).

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