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Lake algal-rafted lithic and biotic debris and the origin of insect Lagerstätten

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Deep-water, microlaminated facies of early Mesozoic eastern North American rift lakes contain well-preserved fossil fishes, reptiles, and continental arthropods, notably spinocaudatans (clam shrimp) and insects, some occurrences of which qualify as Konservat-Lagerstätten(1). Also abundant are distinctive 0.3-1.0 cm clusters of mm-scale lithic clasts (colloquially termed "blebs"). These were first noted in fish-bearing strata in Connecticut and Massachusetts, USA(2), but now they have been found in all of these Triassic-Jurassic basins. Blebs occur globally in strata of various ages and tectonic environments: the Devonian Caithness Flagstones (Scotland), Mississippian Albert Shale (Canada), and the Eocene Green River Formation (western USA). In the Late Triassic "Solite" Lagerstätte (North Carolina, USA) and in the Early Jurassic East Berlin Formation (Connecticut and Massachusetts) there are similar clusters of small, complete spinocaudatans, and at "Solite", insect clusters. These arthropod clusters are often mono-specific. Insect clusters involve complete individuals that are in very close proximity, but often not in contact with each other. Possible explanations for the lithic clast blebs include root- or ice-rafting, but ice-rafting must be dismissed for the Green River Formation in which blebs are associated with palms, other subtropical vegetation, and crocodilians. "Solite" occurrences were deposited at the equator along with plants and large non-dinosaurian reptiles intolerant of freezing temperatures. Root-rafting is not impossible as an origin for the lithic clast blebs, but not plausible for the arthropod clusters. Gastric or oral ejections and coprolites of fish are excluded because the invertebrates are not comminuted. A particularly informative specimen from the "Solite" Lagerstätte consists of multiple growth stages of water bugs (Triassonepa solensis)(3) that surround a plant stem but have no apparent physical connections. A mechanism that parsimoniously explains all of these observations is algal-mat rafting. Floating filamentous cyanobacterial or green algal mats (e.g., Oscillatoria, Lyngbya, Spirogyra, Cladophora, etc.) are reported to trap and transport small lithic clasts(4), plant material(5) and various other debris, including complete insects. When the mats sink, they carry debris with them. We hypothesize that disseminated, heavier debris, such as mm-scale lithic clasts, condenses as the mat containing them founders and is drawn together, forming blebs. The algal mat itself leaves no visible trace. Movement of debris-filled algal rafts away from the shoreline, and their subsequent sinking, explains the occurrences of clusters of objects, such as insects or lithic clasts, and also explains the occurrence of complete insects in deep lake sediments(6). Despite the propensity of dead insects to float and disarticulate(7), algal rafting thus provides a mechanism for the creation of complete-insect Lagerstätten.

1) Fraser, N.C., et al. (1996) Nature 380:615. 2) McDonald, N.G. (1975) Fossil Fishes from the Newark Group of the Connecticut Valley, MA thesis, Wesleyan University, Middletown, CT, 230 p. 3) Criscione, J. & Grimaldi, D. (2017) J. Paleo. 91(6):1166. 4) Mendoza-Lera, C. et al. (2016) Water Res. 52(1):108. 5) Szymczyk, A. (2016) J. Paleolim. 55(4):303. 6) We thank Jean-Claude Gall for suggesting this origin to PEO in the 1970s. 7) Furth, D.G. (1983) Hydrobiologia 102(1):3.