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Unbroken dinosaur eggs accumulated together do not guarantee autochthony of the fossil assemblage

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In situ dinosaur clutches have been considered autochthonous remains, due to the relative fragility of complete eggs, and to the presence of egg-to-egg contacts that suggest a single, biologically-induced, depositional event -the egg laying by female dinosaurs. This has led to consider dinosaur clutches as good indicators of sedimentary discontinuities and paleosoil presence, even in massive mud deposits, and to consider them as good proxies of the environmental conditions in the moment of clutch laying. Here we re-visit the "Paimogo clutch", a one hundred, multi-oospecific egg assemblage from the Late Jurassic (Late Kimmeridgian) recovered from the Lourinhã Formation (Lusitanian basin, W Portugal). Theropod eggs are relatively large (13 x 10 cm) and some of them contain embryos, which are compatible with the coeval allosauroid Lourinhanosaurus. They have angustiprismatoolithic eggshells and smooth outer surfaces. The presence of wide pore openings and thin eggshells results in high water vapor conductance, which suggests they were

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covered with either soil or plant debris to avoid desiccation. In addition, three crocodylomorph eggs (*Krokolithes dinophilus*) have been recovered from the same assemblage. The egg assemblage is included in a paleosoil characterized by a massive to poorly laminated, highly bioturbated silt with carbonate nodules. Isotopic and elemental geochemical analysis groups the theropod eggs in two categories, suggesting at least two independent laying events. Sedimentological analysis, coupled with a study of the Anisotropy of Magnetic Susceptibility, indicate that the eggs were transported by a low energy flow and accumulated by a sedimentary trap. The unequal distribution of bioturbation in the area suggests this trap was caused by a vegetal barrier. Thus, the Paimogo clutch should be regarded as a reworked, or at least as a parautochthonous assemblage. Actualistic taphonomy experiments are needed to determine if this type of low-energy flow can transport the eggs outside of the nesting ground, rendering them allochthonous remains. Our results emphasize that detailed sedimentary and taphonomic analysis are needed to determine if egg assemblages represent autochthonous fossils before identifying them as clutches. This is particularly relevant for geochemical studies commonly using eggs from a clutch to establish paleoenvironmental conditions.

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