Using culture experiments to investigate carbonate/clay-mineral associations in natural environments and the geological record

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Carbonate and clay minerals are commonly found associated in ancient lacustrine formations. Specific examples of this association have been recorded for the Cretaceous Codó Formation, NE Brazil [1], a Tertiary lacustrine sequence, Jbel Rhassoul, Morocco [2] and a mid-Eocene lacustrine succession at Gebel El-Goza El-Hamra, NE Egypt, [3]. Some studies have related this association to a diagenetic transformation of clay minerals to dolomite, but the exact formation process remains a debatable matter. In order to understand this association in the geological record, we have undertaken a comparative study of laboratory experiments and modern environments where clay minerals have been shown to precipitate together with carbonate minerals. Two modern dolomite-forming environments, the Coorong lakes, South Australia and Brejo do Espinho Rio de Janeiro, Brazil, were selected for this investigation. In addition, enrichment microbial culture experiments, using natural pore water from Brejo do Espinho as the growth medium, were performed. To establish the environmental parameters and biological processes facilitating the dual mineral association, the experimental and natural samples have been compared and analyzed by high-resolution TEM. The results demonstrate that the carbonate and clay minerals apparently do not co-precipitate, but the precipitation of the different minerals has probably occurred under different environmental conditions with variable chemistries, e.g., hypersalinity versus normal salinity resulting from the changing ratio of evaporation versus precipitation. Thus, the investigated mineral association is not a product of a diagenetic process but represents an environmental phenomenon related to changes in solution chemistry.

[1] Bahniuk et al. (2015) Sedimentology, 62, 155-181. [2] Chahi et al. (1999) J. Sedim. Res., 69, 1123-1135. [3] Wanas & Sallan (2016) Sed. Geol., 343, 132-140.