

Influence of early diagenesis on the sedimentary archives of the modern volcanic Lake Specchio di Venere, Italy

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Interpreting the paleoenvironments of ancient sediments and rocks relies on our understanding of how modern sediments and rocks form and how their signatures, including their mineralogy, are preserved or transformed over time. Yet, the different transformations affecting sediments during early diagenesis are still poorly understood. In this study, we investigate the formation and transformation of sediments in the modern volcanic Lake Specchio di Venere, Pantelleria Island, Italy. The lake is affected by intense hydrothermal activity emitting mainly CO₂ and is characterised by a high pH (~9.0), an elevated alkalinity (63 mM) and a salinity of ~26 psu. This lake hosts microbialites, organo-sedimentary rocks formed by the activity of microorganisms, creating an ideal ecosystem to tease apart the respective roles of biological activity and physico-chemical conditions in the formation and transformation of sediment constituents and microbialites.

The mineralogy and chemistry of a 1.5 m long sediment core sampled at the deepest point of the lake were determined along with the pore-water chemistry, providing insights on the biogeochemical processes occurring during early diagenesis. The upper ~50 cm of the core shows alternating dark, pink and white laminae of ~1 mm thickness, with the transition into a massive, ~45 cm thick layer characterized by higher porosity and marked by an increase in Mn, P and S contents. Volcanic ash layers are present at different depths, marking episodes of past volcanic eruptions. Mineralogical analyses reveal a decrease in the contents of hydromagnesite and dolomite and an increase in poorly crystalline Mg-silicate phases with depth indicating active reverse weathering processes. In contrast, aragonite and calcite persist throughout the core. Sediment pore waters show a downcore decrease in pH from 9.1 to 8.5 and an increase in alkalinity from 63 mM to 77 mM along with an abrupt decrease in (Si)_{aq} and (Ca)_{aq} concentrations in the first 2 cm followed by a gradual increasing trend. The presence of goethite near the surface and pyrite at depth, along with the downcore decrease in (SO₄²⁻)_{aq} porewater concentrations, highlight redox-driven transformations. Detailed microscopic analyses and geochemical