Clay Mineral Diagenesis in Core KM-3 of Searles Lake, California

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Abstract: Core KM-3 at Searles Lake, California, comprises 693.4 m of lacustrine sediments deposited over the past 3.2 m.y. The lake water evolved from moderately saline, slightly alkaline, and dominated by Na, Ca, Cl, SO_4, and $HCO_3 + CO_3$ to a highly alkaline brine dominated by Na and CO_3 ions. Sediments are chiefly muds and evaporites. Montmorillonite and illite are the principal detrital clay minerals supplied to Searles Lake at present and probably during the late Pliocene and Pleistocene.

The drill core is divided into three diagenetic zones on the basis of clay-mineral reactions. The upper zone (0 – 291.1 m) contains authigenic Fe-illite, Mg-smectite, K-feldspar, and analcime, which average 60 – 70% of the <2-μm silicate fraction of mud samples. The principal silicate reactants are detrital montmorillonite and kaolinite, which have been largely consumed. The middle zone (291.1 – 541.6 m) also contains authigenic Fe-illite, Mg-smectite, K-feldspar, and analcime, but they form only 20 to 30% of the <2-μm silicate fraction, and considerable detrital montmorillonite and kaolinite remain unaltered. In muds of the lower zone (541.6 – 693.4 m), a small amount of clinoptilolite is the only authigenic silicate mineral identified, although authigenie montmorillonite probably coexists here as well. Vitric ash is the silicate reactant, and detrital clay minerals apparently remain unaltered in the lower zone.

Diagenetic zoning reflects the pore-water chemistry, in which pH may have been the most important parameter. Sediments of the upper zone were deposited in highly alkaline lakes of variable salinity, and sinking brines with a pH of 9.0 – 10.0 have saturated all sediments. Sediments of the middle zone were deposited in lakes of moderate to high salinity. The pH was overall lower than in the upper zone, although it probably exceeded 9.0, at least locally, during silicate diagenesis. Moderate salinity and a slightly alkaline pH (~7.5 – 8.0) are inferred for both the lake and pore water of the lower zone.

Oxygen-isotope values of authigenic Fe-illite, Mg-smectite, and K-feldspar, and phillipsite in the upper diagenetic zone reflect a high degree of evaporative concentration and presumably of salinity. Equilibrium water values calculated for 22 ° C from the oxygen-isotopic composition of authigenic phyllosilicates range from -3.5 to + 1.9‰, averaging -1.2‰, (SMOW). Higher salinities are suggested for K-feldspar, for which water values range from + 1.8 to + 4.8‰, averaging + 3.4‰. The water value for phillipsite is +0.3‰. By comparison, rainfall at Searles Lake has an average $\delta^{18}O$ value of about -9.8‰, and a brine sample has a value of +4.0‰.

Mud samples of the middle and upper diagenetic zones tend to be rich in Fe-illite or Mg-smectite, but not in both, indicating that the two minerals are favored to some extent by different environments. Fe-illite seems to be generally favored by oxidizing conditions and probably by a playa environment, and Mg-smectite seems to be favored by reducing conditions and an open-water environment. One stratigraphic unit of the upper zone does not fit this pattern and contains abundant Fe-illite in sediments of a deep perennial lake.

Key Words: Analcime • Diagenesis • Fe-illite • K-feldspar • Mg-smectite • Montmorillonite • Oxygen isotopes • Phillipsite • Searles Lake

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