Oxygen Isotope Compositions of Mixed-Layer Serpentine-Chlorite and Illite-Smectite in the Tuscaloosa Formation (U.S. Gulf Coast): Implications for Pore Fluids and Mineralogic Reactions

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Abstract: Oxygen isotopic compositions were determined for coexisting mixed-layer serpentine-chlorite (Sp-Ch) and illite-smectite (I-S) from 5 Tuscaloosa Formation sandstone cores sampled between 1937 and 5470 m burial depth. High gradient magnetic separation (HGMS) was used to concentrate Sp-Ch and I-S from the <0.5 μm fraction of each core sample into fractions with a range in the Sp-Ch : I-S ratio, and end-member $\delta^{18}O$ compositions were determined by extrapolation. The Sp-Ch $\delta^{18}O$ values range from +10.4 to 13.7‰ and increase with burial between 3509 and 5470 m. The only exception is Sp-Ch from 1937 m, which has an anomalously high $\delta^{18}O$ value of +12.6‰ The I-S $\delta^{18}O$ values range from +16.1 to 17.3‰ and do not change significantly between 3509 and 5470 m burial depth.

Pore water $\delta^{18}O$ compositions calculated from Sp-Ch and I-S values and measured borehole temperatures range from −2.6 to +10.3‰. The isotopically light values indicate that Sp-Ch formed at shallow burial depths in the presence of brackish to marine water and/or meteoric water. The depth-related increase in $\delta^{18}O$ of Sp-Ch is attributed to oxygen exchange between mineral and pore water during diagenetic mineral reactions. Increasing $\delta^{18}O$ values, in conjunction with XRD and SEM data, indicate that transformation of serpentine layers to chlorite layers and *Ibb* polytype layers to *Iaa* polytype layers occurred on a layer-by-layer basis when individual layers dissolved and recrystallized within the confines of coherent crystals. Possible explanations for the variation in I-S $\delta^{18}O$ values include depth-related differences in pore water $\delta^{18}O$ values present at the time of I-S crystallization, contamination by detrital $2M_1$ mica and 1*M* polytype rotations that facilitated oxygen exchange.

Key Words: Diagenesis • Illite-Smectite • Oxygen Isotopes • Sandstone • Serpentine-Chlorite • Tuscaloosa Formation

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