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The chemical character of fluids forming diagenetic illite in the Southern Appalachian Basin

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ABSTRACT

Diagenetic illite (mixed layer illite-smectite, I-S) from Ordovician and Devonian potassium bentonite (K-bentonite) and shales was studied in the proximal southern Appalachian Basin (Alabama through Virginia) to understand in more detail the timing of illite formation as well as attempt to describe the chemistry of the fluids that formed illite during the Alleghanian Orogeny through combined K/Rb and oxygen isotope analyses. The clay fraction of the K-bentonites is composed predominantly of illite-smectite (I-S) and chlorite. Most I-S exhibited Kalkberg order (IISI) with >85% illite layers. The K-Ar dates of I-S from Ordovician K-bentonites and Devonian K-bentonites mostly range from 260–310 Ma and indicate I-S formed during the Alleghanian Orogeny. Internally concordant dates and similar percentages of illite layers of I-S are measured from several samples collected within a thick (1 m) Ordovician K-bentonite at Fort Payne, Alabama.

The oxygen isotopic values ($\delta^{18}O$) of I-S range from 18–23‰ SMOW. At lowest levels of thermal maturity and burial, as seen by conodont alteration index values (CAI) of 1.5–2.0, the range in $\delta^{18}O$ values of water in equilibrium with I-S is 2.5–3.5‰. At higher thermal maturity (CAI = 2.5–4.5), the $\delta^{18}O$ of water in equilibrium with I-S is from 4.5 to 12‰. The $\delta^{18}O$ analyses are mostly consistent with I-S having formed in the presence of orogenic (i.e., saline) waters. The mean K/Rb of the Appalachian illites from this study is 325 (N = 20). This mean K/Rb is also consistent with the formation of diagenetic I-S in the presence of a saline fluids having higher K activities than meteoric waters. The combined data indicate these diagenetic illites in K-bentonites formed from saline/orogenic waters during the Alleghanian Orogeny along the Valley and Ridge Province in the southern Appalachian Basin. Although the data rule out formation of diagenetic illite in the presence of meteoric water or long-term reaction with connate formation waters, the combined data cannot distinguish the source and the mechanism (tectonic push or flush from tectonic highlands) for the movement of saline fluids in the Appalachian Basin.