BASAL REFLECTIONS OF A STABLE ISOTOPIST: REVEALING THE SECRETS OF FLUIDS, CLIMATE & CRYSTAL CHEMISTRY FROM THE CLAY ARCHIVE

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The use of stable hydrogen and oxygen isotopic analysis to determine the origin and evolution of clay minerals was revealed in seminal papers by Savin & Epstein, Lawrence & Taylor, and Sheppard *et al.* in the late1960s and early 1970s. They taught us about the relationships among temperature and the isotopic compositions of clay minerals and water. My research group has exploited this elegant foundation ever since.

H- and O-isotope results for diagenetic illite, smectite and kaolinite record the basin-wide Eocene influx of meteoric water into sandstones of the Western Canada sedimentary basin, and its impact on hydrocarbon distribution. H- and O-isotope analyses of secondary chlorite and illite mark multiple episodes of rock-water interaction along the Precambrian-Paleozoic unconformity in the Appalachian basin. Hot basinal brines, driven westward by Taconic orogenic events, controlled chlorite formation. Illitic clays formed later from local meteoric water during basement reactivation related to distal Acadian and Alleghanian orogenic activity. We have also used the H- and O-isotopic compositions of pedogenic clay minerals from Cretaceous paleosols as a climate archive. These values are a proxy for paleo-precipitation, whose isotopic compositions, in turn, can be related to temperature. In Holocene systems, grass phytoliths (opal-A) also preserve O-isotope compositions that can be related to humidity. There have also been practical applications. For example, steam is injected into oil sands to facilitate hydrocarbon recovery. Changes in the H- and O-isotope compositions of reservoir clays can be used to trace the extent and temperature of contact with the injected fluid.

Isolation of clay minerals without changing their stable isotopic compositions is a practical challenge to the analyst. The classic ‘Red’ and ‘Blue’ texts of Professor Jackson describe most common methods used in clay separation. We have evaluated most these procedures for their isotopic consequences. Stable isotopic study of clays also depends upon reliable knowledge of clay-water fractionation factors. Patience is a virtue in measurement of clay-water fractionation factors at low temperatures. Our studies of gibbsite, for example, produced reliable O- and H-isotope fractionation factors only after years of growth. Post-formational isotopic exchange of clays with ambient fluids is also of concern. It affects different clays differently, in ways still being discovered. For example, 1.0nm halloysite demonstrated significant oxygen (in addition to hydrogen) isotopic exchange at room temperature, a feature largely absent from the 0.7nm variety. A still greater challenge to interpreting clay stable isotopic results is the chance that some clay minerals inherit part of their compositions from precursors. Experiments involving transformation of berthierine (1:1) to saponite (2:1) suggest that the prudent clay isotopist no longer can ignore the possibility of such behaviour.