

Modeling mineral weathering as documented in modern soils developed upon Peoria Loess

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Soils developed along a North-South transect of the Mississippi River Valley document both physical and chemical weathering processes. These Holocene soils span thirteen degrees of latitude and are interpreted to have developed upon Peoria Loess, with pedogenesis commencing between 13-10 ¹⁴C ka BP. Utilizing a published geochemical data set, we investigate both the elemental and mineralogical concentration changes as a function of depth and climate. The mineralogy of these soils reported in the literature was confirmed by XRD analysis of a select subset of samples. For this study, we examine mineral weathering depicted as albite concentration versus depth data (albite depletion profiles). Utilizing a simple equation to describe observed concentration changes as a function of depth, we determine a lumped kinetic parameter for the soils. To interpret our kinetic parameter, we use the GENESIS global climate model to simulate climate at various times throughout the Holocene in order to infer temperature and porefluid flux through the soils over the last 10 ka. By utilizing the GCM-calculated porefluid velocities and our kinetic parameter, we estimate apparent activation energy for albite dissolution as manifested in these soils.

Tracing natural gas migration using boron and lithium isotopes

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Bentonites are layers of altered volcanic ash commonly used as marker beds in sedimentary basins. The ash alters to smectite and illitic clay minerals that record changes in porefluid chemistry during burial diagenesis, as new illite crystals grow.

Boron and lithium contents and isotope ratios were examined in Cretaceous bentonites from the Denver Basin (Wattenberg Gas Field). Different crystal size fractions of I-S separated from these bentonites were analyzed by secondary ion mass spectrometry after removing interlayer contaminants by cation exchange.

During diagenesis, isotopically light B and Li are released from organic matter along with other volatiles (e.g. CH₄) from hydrocarbon (HC) source rocks. Illite incorporates B in tetrahedral sites and Li in octahedral sites of the clay during crystallization, reflecting the distinctly light isotopic signature of the organic source.

Results show light $\delta^{11}\text{B}$ values (-7 to -15‰) with no significant trends observed relative to thermal maturity. B-contents reach 180 ppm in the thermally mature region and decrease radially away from the source region.

Li isotopes vary more than B perhaps due to higher volatility and faster migration away from the heat source. $\delta^7\text{Li}$ ranges from -7 to -17‰ in the gas field and -1 to $+5\text{‰}$ outside the field. One exception is in the thermally mature zone ($R_o = 1.2\%$) where $\delta^7\text{Li}$ is $+10\text{‰}$ in the fine fraction ($<0.125\mu\text{m}$; first nucleated illite) and -17‰ in the coarser ($0.125\text{-}0.5\mu\text{m}$) fraction. We interpret this as a flux of ⁶Li-dominated fluid related to gas generation *after illitization began*. Li-isotopic values generally become heavier away from the gas field, either due to fluid mixing, or by fractionation as clays near the source preferentially incorporate ⁶Li.

We conclude that isotopically light B and Li in authigenic illite reflects the influence of HC related fluids, and that Li follows the pathway of more volatile HC's through water due to its higher mobility relative to B.