Reactive transport modeling of coupled feldspar dissolution and secondary mineral precipitation and its implication for diagenetic interaction in sandstones

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Dissolution of feldspars and precipitation of secondary minerals (kaolinite, illite and quartz) are significant diagenetic processes in arkosic sandstones. Three types of mineral assemblages were identified in subsurface arkose: extensively leached feldspars with a large amount of authigenic kaolinite and quartz cement (MA-1), extensively leached feldspars with a large amount of kaolinite and minor quartz cement (MA-2), and extensively leached feldspars with a small amountof both kaolinite and quartz cement (MA-3).

Reactive transport modeling using Geochemist's Workbench 9.0 were conducted to decipher the origin of the different mineral assemblages. Results suggest that a dissolution zone, a transitional zone, and a precipitation zone can be formed in a sandstone unit with suitable constraints of temperature, flow rate, fluid composition and mineral reaction rate, with the development of MA-3, MA-2, and MA-1 assemblages respectively. Higher $SiO_{2(aq)}$ concentration required for saturation of quartz than for kaolinite and low Al^{3+} concentration needed for saturation of kaolinite lead to the precipitation of only kaolinite in the transitional zone.

Comparisons between modeling results and natural sandstone diagenesis suggest that an MA-1 assemblage is likely to occur in buried sandstones at high temperatures (>70–80°C) and low flow rates. An MA-2 assemblage may occur in moderately buried sandstones at moderate temperatures (40–70°C), in deeply buried sandstones with faults and fractures serving as conduits of meteoric freshwater, or in shallow sandstones where meteoric water is not abundant. An MA-3 assemblage tends to occur in shallow sandstones at low temperatures (<40–50°C) and high flow rates, or in buried sandstones where faults and fractures develop widely and serve as freshwater conduits. These proposals are valid in natural arkosic sandstones and of great significance in deciphering the diagenetic environments where the feldspar dissolution and secondary mineral precipitation have occurred.