Geochemical and Mineralogic Effects of Flow of Reduced Fluids Through Oxidized Red Sandstones

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Extensive regions of bleached and chemically altered sandstone within terrestrial red-bed deposits of the Colorado Plateau reflect widespread interaction with subsurface reduced fluids. Although bleaching likely results from dissolution of early diagenetic hematite grain coatings by reduced aqueous fluids or hydrocarbons, little is known about the fate of the reduced iron, when it was mobilized, what other chemical changes occurred in the bleached and downstream parts of the flow systems, and how timing and drivers of fluid flow relate to basin- and regional-scale forcings such as deformation or exhumation. We present findings from geochemical and petrographic analyses, mass balance calculations, and reactive transport modelling focused primarily on a bleached paleo-hydrocarbon reservoir in the Jurassic Entrada Sandstone. Fluid-rock reactions in this unit include dissolution of hematite, feldspar, and early calcite and precipitation of quartz overgrowths, clays, and a late calcite cement with an isotopic signature reflecting a mixture of hydrocarbons and meteoric water. Abundant pyrite concretions, now mostly oxidized to iron oxide, are present near boundaries between bleached and unbleached sandstones but only account for less than half of the mobilized iron. Fluids carrying dissolved iron may be discharged at the surface, forming iron-oxide deposits or iron-rich claystones in lacustrine deposits. Other elements that are depleted in the bleached sandstone include Ti, Al, K, Pb, Rb, Sr, and Th. In contrast, Cu, U, Ni, and V are enriched in the bleached sandstone, likely due to later addition of oxidized fluids to the reservoir. Using results from geochemical analyses and petrographic observations, we also modelled fluid-rock reactions and changes in fluid chemistry downstream.