

Linking sediment-hosted and groundwater-mobile mineral nanoparticles in the Central Oklahoma Aquifer

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The sands and muds of the Permian-age Central Oklahoma Aquifer (COA) experienced a rich depositional and diagenetic history of fluid-rock interactions, leading to the formation of abundant nanoparticulate iron oxides and clays. Paleo fluid-rock interactions were also responsible for distributing potentially toxic elements such as arsenic, chromium, and uranium. Extracted groundwater from these rock units frequently contains concentrations of these elements considered unsafe for public consumption. Deeper understanding of both diagenetic paleo-hematite nanoparticle precipitation and present-day mineral-water interactions remain key to development of strategies for the efficient and safe use of COA groundwater.

To this end, we combined studies of samples from the USGS/EPA Norman Arsenic Test Hole core, outcrop samples, and mineral colloids collected from groundwater wells using custom-designed subsurface colloid collectors. Core and outcrop materials were investigated by bulk and clay powder XRD, bulk chemistry, selective extractions, optical microscopy, and SEM. Additionally, selected core samples with clear evidence of localized bleaching and iron mobilization were selected for further investigations of diagenetic processes, including thin section petrography and electron probe microanalysis. Results indicate that As dominantly associates with hematite and goethite nanoparticles and Cr more strongly associates with clays.

Colloidally transported minerals collected in monitoring wells directly onto TEM grids varied significantly with well screen depth. TEM and SEM imaging, electron diffraction, and EDS analyses demonstrated clays and nanoparticulate iron oxides were most abundant, although the most shallow well included Fe-Cr rich nanoparticles associated with micron-scale elemental sulfur grains. In experiments with outcrop samples, abundant clays were released as colloids at all pH values, but goethite was preferentially released for pH>8. Ongoing research seeks to link lab and field studies of mineral/colloid distribution and chemistry to determine the processes responsible for trace element sequestration and transport.