

Mineralogy of weathering at the Questa Mo Mine, NM: 2. Stable isotopes and geochemical modeling

A.R. CAMPBELL^{1*}, V.W. LUETH², G.J. GRAF¹,
AND M.J. LOGSDON³

¹E&ES Dept. New Mexico Tech, Socorro, NM 87801
(*correspondence: campbell@nmt.edu)

²NMBGMR, New Mexico Tech, Socorro, NM 87801

³Geochemica, Inc., 9045 Soquel Dr., Ste 2, Aptos, CA 95003

Chemical weathering and hydrothermal alteration typically involves the hydrolysis of feldspars to produce clay minerals by incongruent dissolution. A detailed study of weathering of mine rock piles and hydrothermal alteration scars at the Questa Mo mine, New Mexico revealed no authigenic clay. Although clay minerals are abundant in these rocks, there is a distinct lack of authigenic clay formation during the past ~40 years of rock pile weathering and longer (up to 4 million years in the scars). Stable isotope analysis of treated bulk clay mineral samples indicates a solely hydrothermal origin.

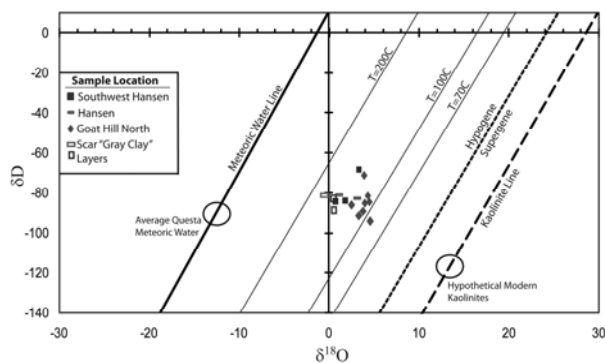


Figure 1: δD - $\delta^{18}O$ for rock pile and alteration scar clays.

The mineralogy and stable-isotope results are consistent with modeled results for clay mineral stability in low pH solutions. Standard mineral-stability and solubility diagrams used in studies of hydrothermal alteration imply formation of clay minerals during hydrolysis. However, when the mineral stabilities are re-evaluated using water chemistry typical of waters from within the rock piles, complexation of Al^{3+} , primarily by F^- and SO_4^{2-} , limits the activity of Al^{3+}_{aq} , and therefore solid aluminous phases, including clays, are undersaturated in waters. New clays will not form from the hydrolysis of feldspars. Instead, earlier-formed hydrothermal clays will dissolve.

Characterizing the extent and role of natural subsurface bioreduction in a uranium-contaminated aquifer

K.M. CAMPBELL¹, N.P. QAFOKU², R. KUKKADAPU²,
K.H. WILLIAMS³, E. LESHER⁴, L. FIGUEROA⁴,
A. PEACOCK⁶, M.J. WILKINS⁵, J.A. DAVIS¹,
J. ICENHOWER² AND P.E. LONG²

¹USGS, Menlo Park, CA 94025 (kcampbell@usgs.gov)

²Pacific Northwest National Lab., Richland, WA 98816

³Lawrence Berkeley National Lab., Berkeley, CA 94720

⁴Colorado School of Mines, Golden, CO 80401

⁵University of California, Berkeley, Berkeley, CA 94720

⁶Haley & Aldrich, Inc., Oak Ridge, TN 37830

Bioremediation is a promising strategy for the long-term treatment of uranium (U)-contaminated groundwater. Dissolved U(VI) is reduced to insoluble U(IV) by stimulating indigenous metal-reducing bacteria *in situ* at the field-scale by the addition of low concentrations of acetate. Several cores were drilled in a region of naturally-occurring U(VI) bioreduction at Rifle, CO, USA. Characterization of the naturally bioreduced sediment provides 1) an understanding of the natural processes that occur in the sediment under reducing conditions, and 2) assistance in optimizing strategies for the bioremediation.

Sediment samples from the cores that range from minimally reduced to naturally bioreduced aquifer sediment were analyzed for labile U(VI), acid-extractable and total U, and were characterized with XRD, μ -XRD, XRF, SEM/EDS, TEM, EMP, XMP, EXAFS, and XANES. Size fractions of selected samples were analyzed for BET surface area, bicarbonate/carbonate and acid extractable U content, and mineralogical composition. The acid volatile sulfide (AVS), Fe(II), and bioavailable Fe(III) content of the bulk sediment were also determined. Phospholipid fatty acid (PLFA) and qPCR were used to identify the sediment microbial community.

Solid-phase U concentrations were higher in the naturally bioreduced zone, with evidence for a significant amount of U(IV) present. U was detected in high concentrations in framboidal pyrite and magnetite grains. The samples from this zone were elevated in AVS and depleted in bioavailable Fe(III), indicating that Fe(III) and sulfate reduction have occurred naturally in the sediment. Increased concentrations of solid phase organic carbon in this region also suggest that natural bioreduction is stimulated by zones of high organic carbon content. Microbial biomass and community composition varied along the bioreduction gradient. As a result of the elevated sulfide mineral content, the zone of bioreduction was detectable at the field scale using an induced polarization geophysical method.