# Ferricrete, surface- and groundwater chemistry as an indicator for concealed mineral deposits

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Handcart Gulch is an alpine watershed within the Montezuma Mining District in the Colorado Front Range, USA. The stream drains hydrothermally altered crystalline rocks, producing acid rock drainage. The stream water is naturally acidic with pH between 3 and 4; thick ferricrete deposits cover the entire streambed and adjacent banks. Previous geophysical and water chemistry studies suggest the presence of a concealed sulfide mineralized zone (possibly a Cu-Mo porphyry deposit of unknown grade and size), but has yet to be identified despite deep borehole drilling. In this study we collected spatially dense groundwater discharge samples adjacent to the stream, ferricrete cores, and stream water samples to better constrain the location of possible mineralization. Stream water samples were collected along 5.4 km of the stream. Using a handheld coring drill, 18 piezometers (<2m deep) were installed over a 4.2-km reach into the ferricrete adjacent to the stream to characterize groundwater from different sub-catchments within the watershed. Water in the piezometers had artesian flow and field parameter values different from stream water, indicating that we were sampling groundwater. Discrete depths from the ferricrete cores were analyzed for major and trace element content. In the ferricretes, Cu concentrations are lowest (mean 75 ppm) upstream, peak ~800 m downstream from our highest sample point (mean 769 ppm), and remain high (mean 459 ppm) for another ~1000 m downstream. Stream- and groundwater show a similar trend of increased Cu concentrations (~400 and 2500 mg/L, respectively) in the same reach. But in the groundwater, the Cu concentration peaks (2670 mg/L) ~200 m upstream from where the stream water and ferricrete Cu highs were identified. As the high-Cu groundwater discharges into the stream water, a lag time and distance is expected for Cu to incorporate into the ferricrete. Specific conductance, $SO_4^{2-}$, Fe, and Zn also peak in groundwater at the same location as the Cu anomaly, supporting the possibility that this water could be sourced from an area of concealed mineralization. Using an integrated approach of stream- and groundwater with solid phase media (ferricrete, stream- or wetland sediment) could be an effective way to constrain the location of concealed deposits.