Using high-resolution streambank groundwater discharge sampling to locate concealed mineral deposits

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Groundwater chemistry data have been widely used for geochemical exploration, but this method is often limited by a scarcity of springs and wells, and by uncertainty in the flowpath history of sampled water. We present a study demonstrating a novel approach that combines sampling of streambank groundwater discharge from hand-installed piezometers and the collection of environmental tracer data which provide recharge source and residence time information. Samples were collected from Handcart Gulch, an alpine watershed in the Montezuma Mining District, Colorado Front Range, USA. Previous geophysical and water chemistry data suggested a potential zone of concealed sulfide mineralization (possible Cu-Mo porphyry deposit of unknown grade). Eighteen piezometers were installed next to the trunk stream along a 4.2 km reach at locations strategically chosen to intercept groundwater flow originating from different sections of adjacent ridges with the objective of confirming and refining the location of the suspected mineralized zone. Piezometers were drilled to depths of 1-2 m with a hand-held power core drill in zones of iron-oxide cemented colluvium (ferricrete) indicative of iron-rich groundwater discharge. Piezometer waters had specific conductance, pH, and dissolved oxygen values distinctly different from adjacent stream water, and most were artesian, confirming that water in the piezometers was discharging groundwater. Samples were analyzed for major and trace elements; stable isotopes of water; and tritium, noble gas isotopes, and sulfur hexafluoride (SF_6) for dating. Specific conductance, sulfate, and most metal concentrations (including Cu) all display a well-defined peak at Site 4, located about 800 m downstream from the highest-elevation site. Sulfate and Cu concentrations are also higher on the northeast side of the stream than the southwest side. Preliminary stable isotope and SF_6 age results display no anomaly near Site 4, suggesting that the chemical anomaly is unlikely due to a unique recharge source or flowpath type (e.g., more deeply-circulating, older water). Available results thus provide new evidence for the presence of a concealed mineralized zone, constrain its possible location, and generally support the method's utility.