

## **DRA-12. PORE WATER CHARACTERIZATION**

A. Campbell, V.T. McLemore, G. Graf, April 29, 2007, revised November 6, 2008, December 8, 2008 (reviewed by K. Soloman)

### **Hydrological and Geochemical insights from stable isotope study of precipitation and soil water at Questa**

#### **1. STATEMENT OF THE PROBLEM**

Can stable isotope compositions of precipitation and soil waters help to understand hydrological processes in the rock piles?

#### **2. PREVIOUS WORK**

- Campbell and Hendrickx (2008)
- There is a vast amount of work on stable isotopes in precipitation, and the effects of evaporation in the geochemical and hydrological literature (see Campbell and Larsen, 1998; Drakos et al., 2004; Shurbaji and Campbell, 1997).

#### **3. TECHNICAL APPROACH**

Quarterly samples of precipitation have been collected to develop an understanding of the stable isotopic composition of local meteoric water for comparison purposes. Water from soil samples from various environments, extracted using a vacuum distillation method, have been analyzed for hydrogen and oxygen isotopes. Samples collected from near surface pits reveal evaporation near the pile surface. Several water samples from water draining from the rock piles were also sampled and analyzed. We had hoped to collect more water samples from the trench sampling as well. Those waters might have shown “deep” evaporation from vapor flow through course zones of the pile. However those samples would have needed to be collected immediately after the trench was opened and proved logistically difficult.

#### **4. CONCEPTUAL MODEL**

To model the hydrological response of a rock pile, the water input at the upper boundary needs to be specified. This is dependant on the amounts of precipitation, infiltration, evaporation and runoff. Evaporation will first be active near the top of the rock pile. Due to isotopic fractionation between liquid and vapor phases, stable isotopic compositions of the residual (infiltrating) precipitation will be isotopically different from the precipitation. The residual (infiltrating) precipitation isotopic composition serves not only as a measure of the degree of evaporation, but also provides potentially unique tracers spikes of infiltration. Additional evaporation can occur deeper within the rock piles due to adjacency to preferred pathways of air flow. The more evaporated stable isotope compositions of these samples could confirm air movement within the piles.

#### **5. STATUS OF COMPONENT INVESTIGATION**

The stable isotope data has been collected and discussed in Campbell and Hendrickx (2008).

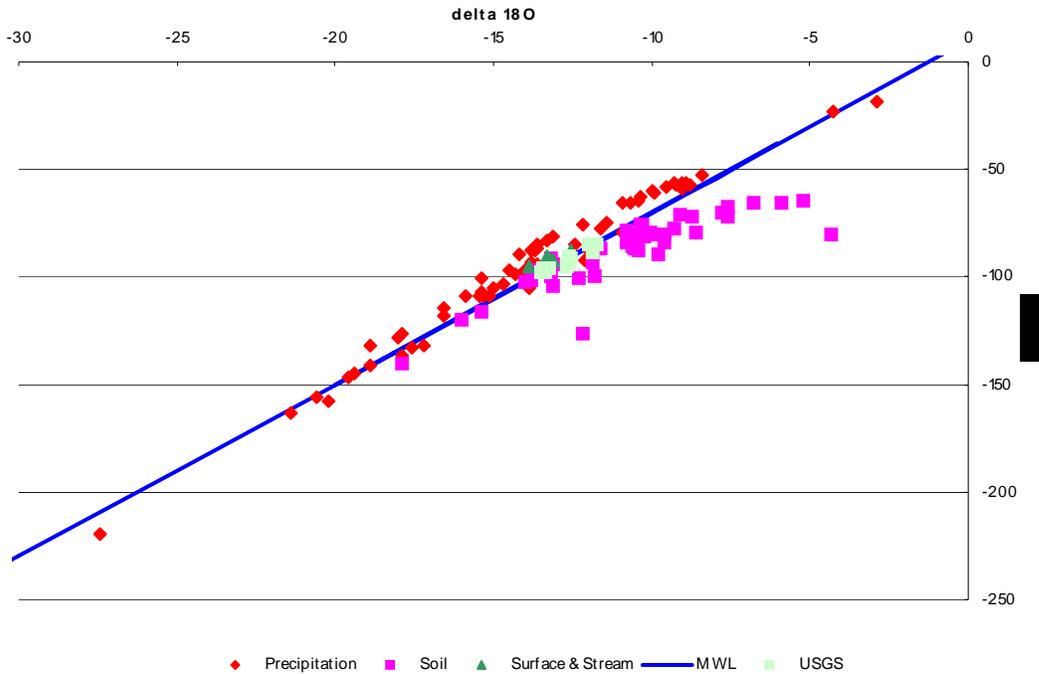


FIGURE 1. Meteoric and soil waters from the Questa area. The red symbols are from precipitation collectors and define a local meteoric water line. The local stream and surface waters (green triangles) plot with in the range of meteoric waters. The pink squares are all from waters extracted from the pile soils. They plot to the right of the precipitation indicating some degree of evaporation. See Figure 2 for the detail of evaporated samples from the shallow soil pits.

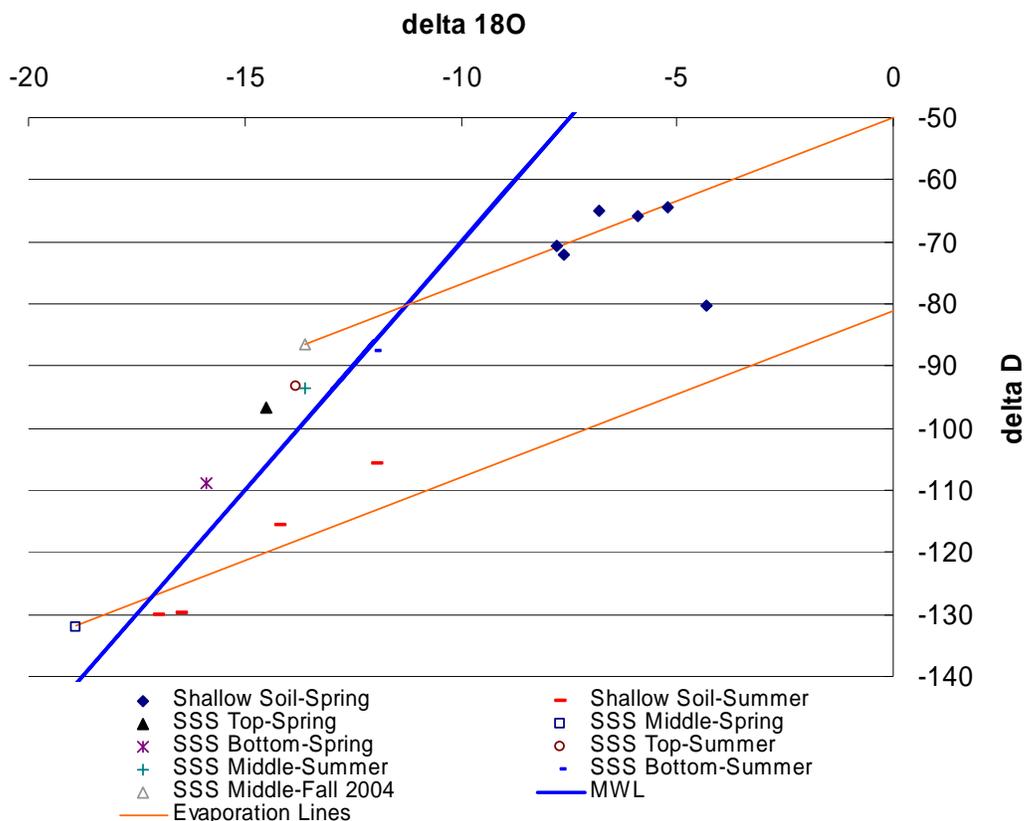


FIGURE 2. Shallow surface soil samples and precipitation samples collected on 4/7/2005 (spring) and 6/16/2005 (summer) from Sugar Shack South. All shallow soil samples were taken at the location of the SSS Middle precipitation collector. The graph indicates the shallow soil samples taken in April 2005 possibly evaporated from precipitation similar to Fall 2004 rainfall and the June 2005 shallow soil samples possibly evaporated from precipitation similar to Spring 2005 rainfall.

## 6. RELIABILITY ANALYSIS

**Assumptions**—none

### **Technical and data uncertainties:**

Although the effects of evaporation on the stable isotopic composition are quite noticeable, the degree of evaporation can be determined. Using a simple Rayleigh distillation model, the data presented in Figure 2 revealed that about 20 to 30 percent of the precipitation has been evaporated. However given the natural variability of samples, the variability of the precipitation and textural effects on evaporation, that result is considered semi-quantitative. Sampling soils for isotope analysis near suspected vapor flow pathways deeper in the piles was unsuccessful due to logistical difficulties in obtaining a sample soon after the trenches were dug. After exposure to the atmosphere the isotopic composition would change due to further evaporation.

## 7. CONCLUSIONS OF THE COMPONENT

- Yes, stable isotopes can help understand the hydrology of the rock piles in the following ways.
- The precipitation results describe a stable isotope baseline, which can be as a basis of comparison for stable isotope measurements of pore waters collected from within the rock piles.
- Most of the pore waters extracted from pile soils plot to the right of the precipitation samples and show some isotopic enrichment with respect the meteoric water. This is interpreted as being caused by evaporation, most likely in the near surface as recent precipitation began to infiltrate.
- In several instances near surface pore waters seemingly reflect the seasonality of the precipitation.
- The isotopic composition of water flowing from the toe of GHN is closer in isotopic composition to pristine precipitation than the slightly evaporated pore waters. This suggests that there is a fast recharge pathway for some precipitation. The fast recharge implies only that the water enters the pile and infiltrates to a depth below the evaporation front in the vadose zone, before much evaporation takes place. Presumably this happens by some preferential flow path. It does not imply that the waters move quickly through the pile. The chemical composition of these waters do show some equilibration with rock, which could be used to imply considerable residence time.
- Stable isotope results reveal clear seasonality of isotopic signatures. This is not shown in Figure 1, but is in Campbell and Hendrickx (2008).
- The shallow pore waters show a maximum of 20 to 30 % evaporation. This is seen only in the pore waters from the shallow pits, and the maximum evaporation is seen at the evaporation front. Our deepest shallow profile extended down three feet and exhibited enrichment to the bottom, implying that evaporation was effective to at least this depth. Pore waters from deeper in the rock piles (i.e. from the trench sampling) show much less evaporation. This information can be used to compare with the amount of evaporation needed in the hydrological models to achieve a water balance.

## 8. REFERENCES

- Campbell, A. and Hendrickx, J., 2008, Final report on the stable isotopic composition of precipitation and soil samples at the Questa mine: revised unpublished report to Molycorp Tasks 1.12.3 and 1.12.4, 21 p.
- Campbell, A.R. and Larsen, P., 1998, Introduction to stable isotope applications in hydrothermal systems; *in* J. Richardson and P. Larsen, eds., *Techniques in Hydrothermal Ore Deposit Geology: Reviews in Economic Geology*, v. 10, p. 173-193.
- Drakos, P., Sims K., Reisterer, Blusztajn, J. and Lazarus, J., 2004, Chemical and isotopic constraints on source-waters and connectivity of basin-fill aquifers in the southern San Luis Basin, New Mexico: *New Mexico Geological Society, Guidebook 55*, p. 405-414.
- Shurbaji, A.R. and Campbell, A.R., 1997, Study of Evaporation and Recharge in Desert Soil Using Environmental Tracers, New Mexico, USA: *Environmental Geology*, v. 29, no. 3/4, p. 147-151.

**9. TECHNICAL APPENDICES**

Campbell, A. and Hendrickx, J., 2008, Final report on the stable isotopic composition of precipitation and soil samples at the Questa mine: revised unpublished report to Molycorp Tasks 1.12.3 and 1.12.4, 21 p.