

Monitoring of mining impact on natural waters using isotopic tracers (S, U and Sr) – a pilot study from Talvivaara, northeastern Finland

I. Mänttari¹, Y. Lahaye¹, R. Kietäväinen¹, A. Pasanen², A. Eskelinen², M-L. Räisänen² and P. Forsman²
¹Geological Survey of Finland, P.O.Box 96, 02151 Espoo, FINLAND
²Geological Survey of Finland, P.O.Box 1237, 70211 Kuopio, FINLAND

This study aimed to identify the possible effects of the acidic, metal-bearing waste water leakage from the gypsum pond on natural waters at the Talvivaara mining area (Fig. 1), northeastern Finland (Fig. 2) by using and testing the applicability of isotopic tracers. As a pilot study, only a few mining related water samples and samples from nearby surface- and groundwaters were selected for S, U, and Sr isotope analyses. Research was carried out in the Tekes Green Mining funded Closedure project (<http://mineclosure.gtk.fi>).

For S and U isotope analysis, S was eluted using cation exchange resin and U using TRU-Spec resin. Sr was eluted using Dionex ICS-3000 ion chromatography system. The isotope ratios were measured using MC-ICPMS at the Geological Survey of Finland, Espoo.

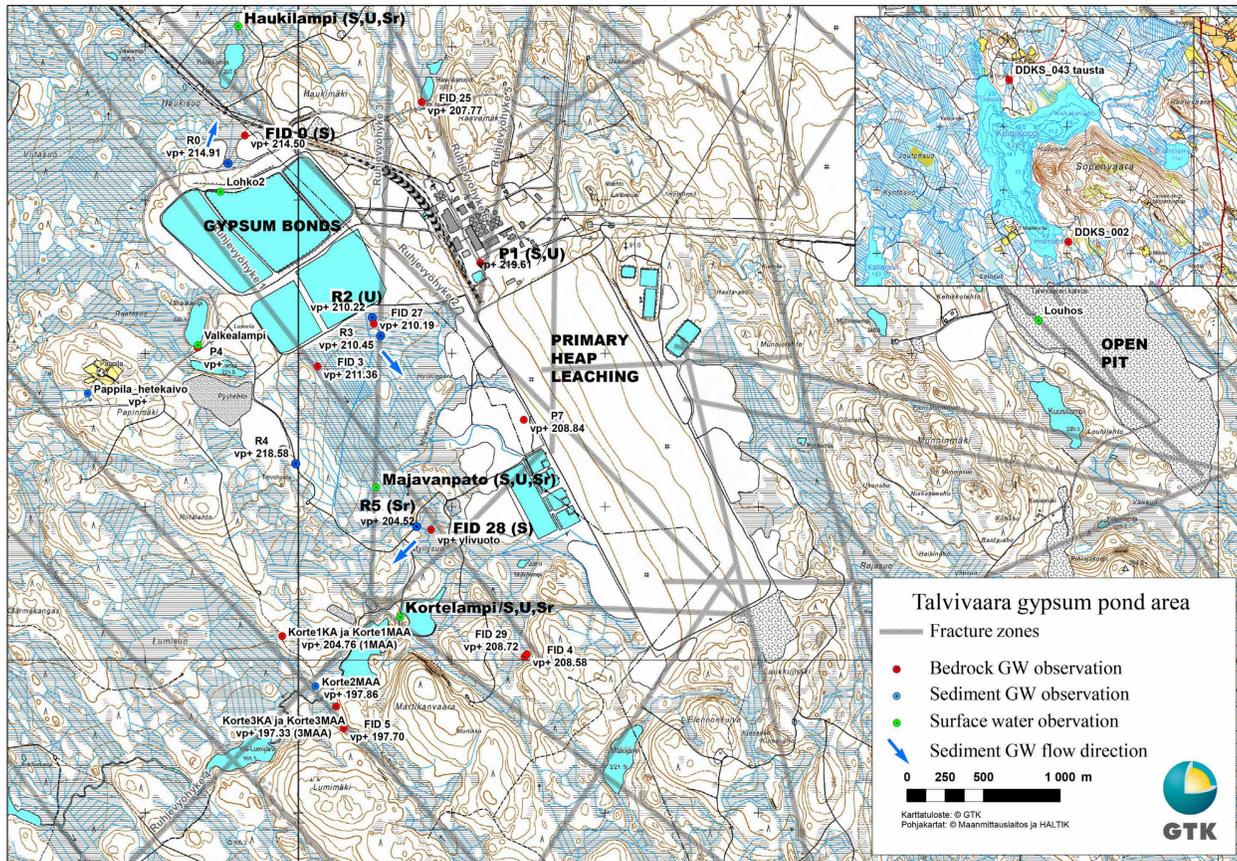


Fig 1. Talvivaara mining area, ground water (GW) and surface water observation points are indicated. Bold and larger text means an observation point where S, U and/or Sr contamination was detected/suspected. In diagrams, "nearby lakes" refer Kortelampi, Majavanpato and Haukilampi.



Fig. 2. Location of the Talvivaara mine that utilizes polymetallic black schist ore. Metal extraction is done by bioheapleaching. The main product is nickel and by products are zinc, copper and cobalt.

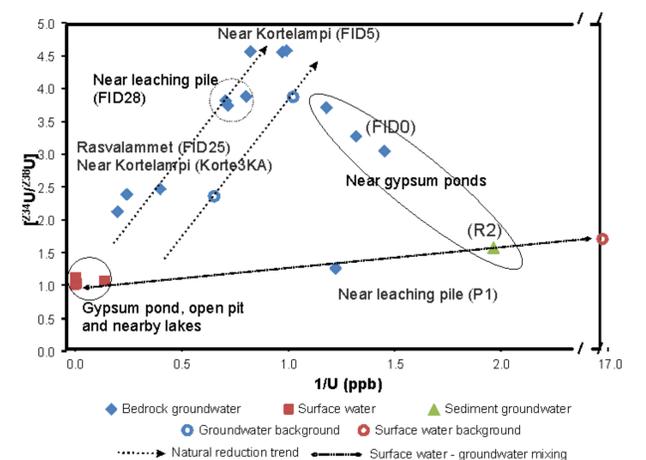
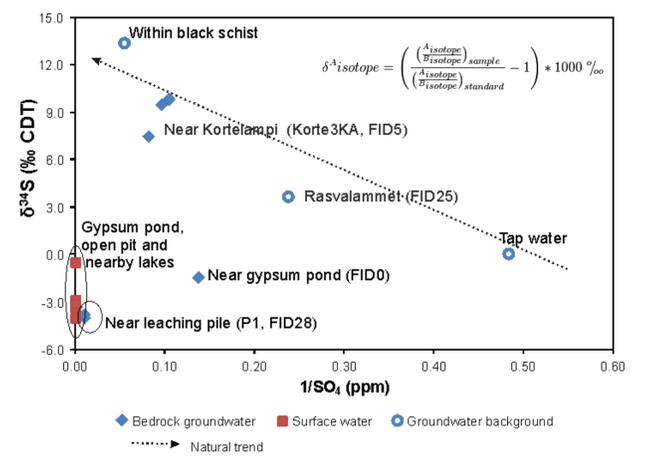


Fig. 3. S (upper) and U (lower) isotope data plots. These indicate contamination of nearby lakes by the waste water leakage from the gypsum ponds and thereafter introduction of polluted surface waters into some ground water samples (P1 & R2 and probably also FID28 & FID0). In the figure below, the activity ratio of uranium is defined by $[^{234}\text{U}/^{238}\text{U}] = \frac{(^{234}\text{U}/^{238}\text{U})_{\text{sample}}}{(^{234}\text{U}/^{238}\text{U})_{\text{secular equilibrium}}}$ (0.00005472)

Since individual isotopic systems may solve different type of questions, it is essential to familiarize well to surrounding geology and all the mining processes before making the sampling plan and selecting the used isotope systems. It would also be important to select enough mining process related samples and background samples to solve possible natural trends and finally discriminate them from the mining waste water pollutions.

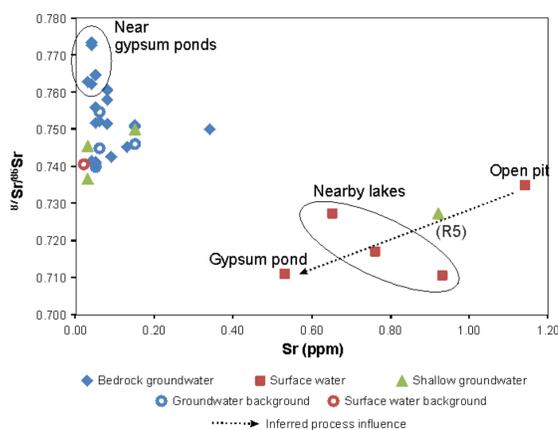


Fig. 4 (LEFT). ⁸⁷Sr/⁸⁶Sr vs. Sr (ppm) (upper) and Ca/K (lower) plots. Contamination of nearby lakes by the waste waters from the gypsum pond is evident. A clear mixing trend is seen in the lower diagram.

From the available restricted S, U and Sr isotope data, we can conclude that the mining waste waters were leaked into the surrounding lakes and some ground water samples seemed to be mixed with the polluted surface waters (Figs 3 and 4). Especially in case of S and U isotopes, it was not always clear whether the isotope signatures were (partially) controlled by natural redox processes.

In the Talvivaara case, Sr isotopes evidence a clear influence of the mining processes (chemicals and/or their selective leaching of minerals/rock types) to nearby lakes and one sediment groundwater sample.

The fact that the sample sets for individual isotope measurements were not totally parallel, a full comparison of the results from different isotope tracers was defective. Moreover, for identifying bedrock ground water flow paths, the sample set was insufficient.

