Mining environments – GTK's isotope analytical facilities on dissolved elements in water

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The Geological Survey of Finland (GTK) has been developing methods for the use of new isotopic tracers to monitor the impact of mine water discharge on natural waters, to pinpoint hydraulic connections and interactions within mine environments, as well as to detect possible natural trends and discriminate them from the impacts of mine water. In addition to traditional water isotopes (O and H), S, Li, Mg, Pb, Sr and U isotopes can be now analysed. The method development was carried out in the SUSMIN project funded by Tekes through international ERA-MIN Joint Call (http://projects.gtk.fi/susmin/).

Analytical methods for Fe, Cu, and Zn isotopes are currently under development. While all other elements may be isolated using ion chromatography (IC: Fig. 1) or conventional column methods (Fig. 2), only S is isolated using solely conventional methods and Mg using IC as it is very slow process by conventional methods. The isotope ratios of the purified elemental fractions are then measured using MC-ICPMS (multicollector inductively coupled plasma mass spectrometer: Fig. 3).

The current pilot studies show evidence for mixing of mine waters in recipient surface waters (Figs. 4 & 5) and thereafter introduction of polluted surface waters into ground water (see the Talvivaara case poster). Sr isotopes have been extremely useful to separate the contamination related to the mining process from the natural signature.

These "environmental isotopes" are also applicable to other sample types than water.

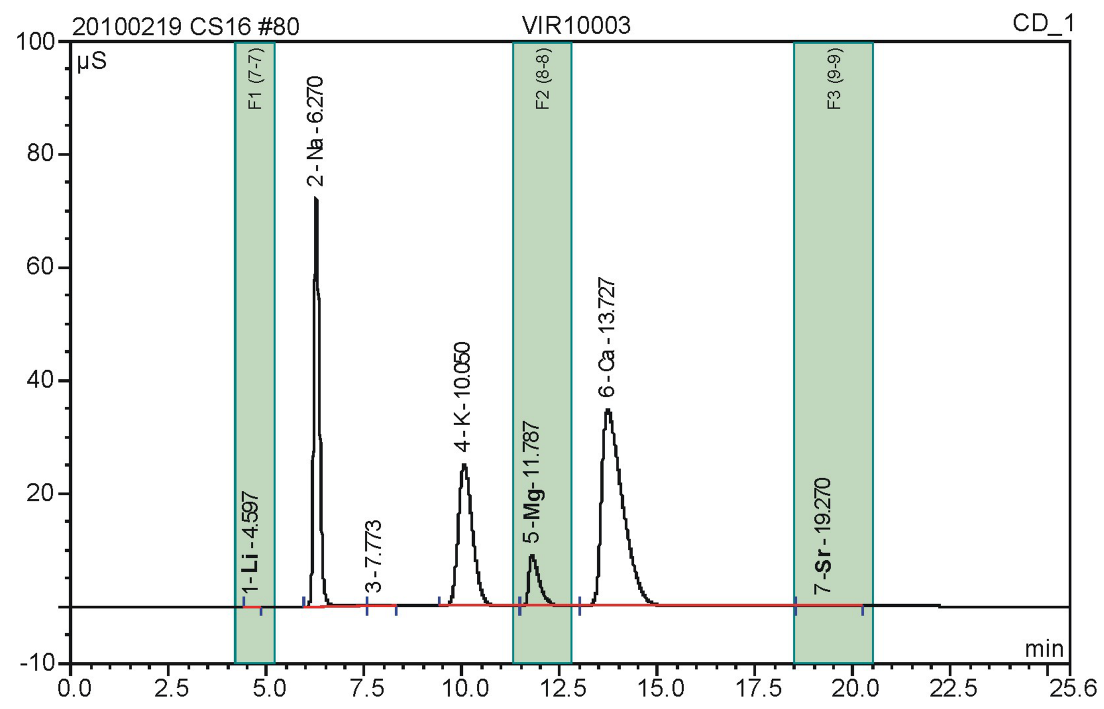

Fig. 1. A cation chromatogram of a river water determined using GTK's ion chromatograph (Dionex, IC-3000). The collected cation fractions are lined with green bars. X-axis refers the duration of the run and the y-axis intensity of the detected ions measured as electrical conductivity (µS). The total area of a peak defines the concentration.

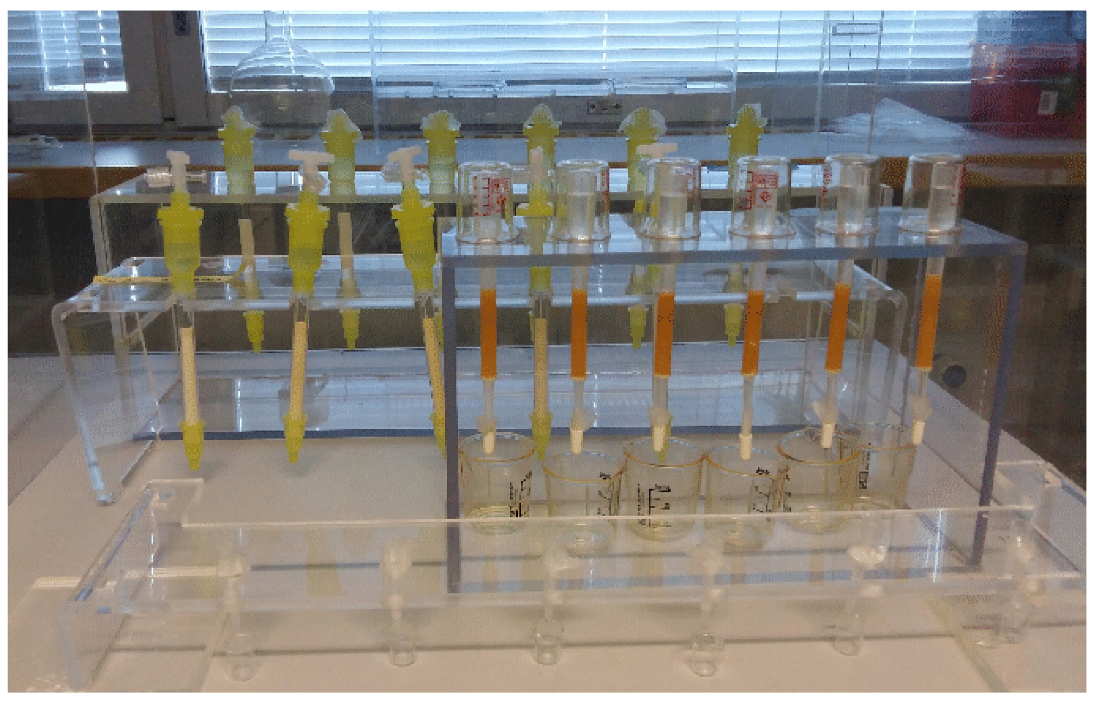

Fig. 2. Different types of columns and resins. S, U, Sr+Pb are eluted using tiny pipette columns in front (cation exchange resin, Tru-spec resin, Sr specific resin). Larger pipette columns for Li separation using cation exchange resin and BioRad columns for transition metal separation and for Fe only.

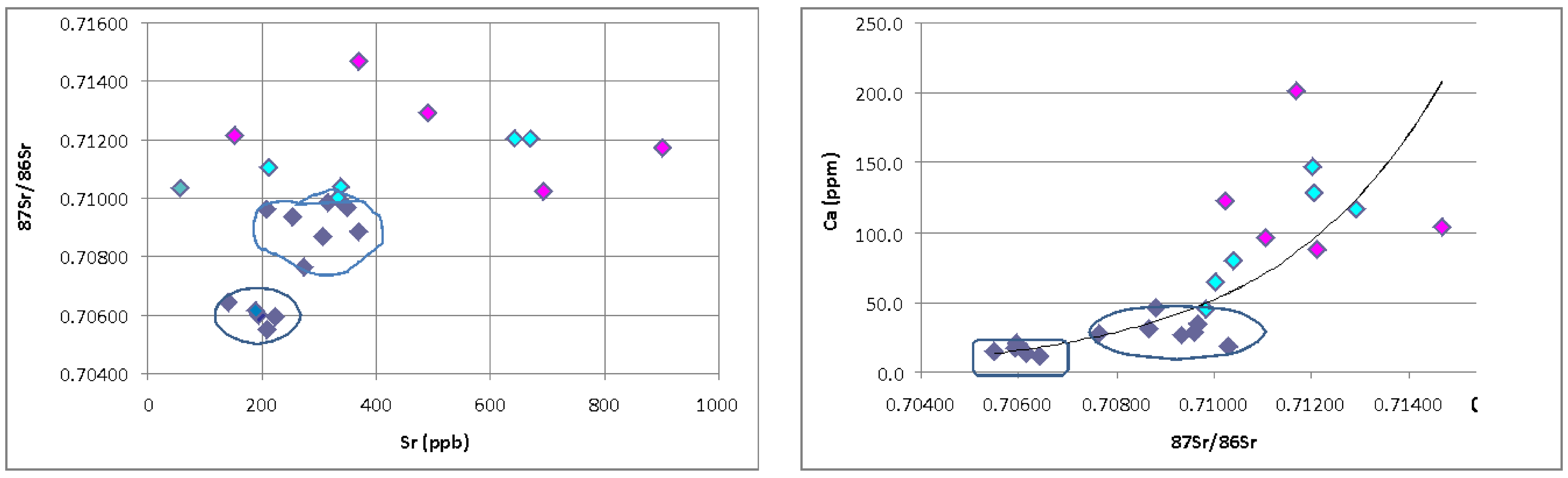

Fig. 4. $^{87}Sr/^{86}Sr$ vs. Sr concentration and $^{87}Sr/^{86}Sr$ vs. Ca concentration plots. Acid mine waters (lilac), contaminated surface waters (turquoise) and uncontaminated surface and ground waters (grey-blue). A coherent group of water samples cosisting of low $^{87}Sr/^{86}Sr$ and low Sr + Ca concentrations from diverse type of waters (ground, surface and artifical lakes) representing typical background values. The acid mine waters and contaminated surface water samples have higher $^{87}Sr/^{86}Sr$ and Ca concentrations. The diagram in right, shows a mixing curve that passes throught the other sample group (grey-blue) with slightly elevated $^{87}Sr/^{86}Sr$ ratios. However, it is unclear whether these samples show slight contamination with the mine waters or do they have a different natural Sr source. The higher $^{87}Sr/^{86}Sr$ and Ca in acid mine waters and contaminated water samples indicate either that they use higher $^{87}Sr/^{86}Sr$ lime in neutralization processes and/or, that the acid waters dissolve selectively Ca-rich minerals/rock types with higer Sr isotope ratios.

Fig. 3. MC-ICPMS for isotope ratio measurements.

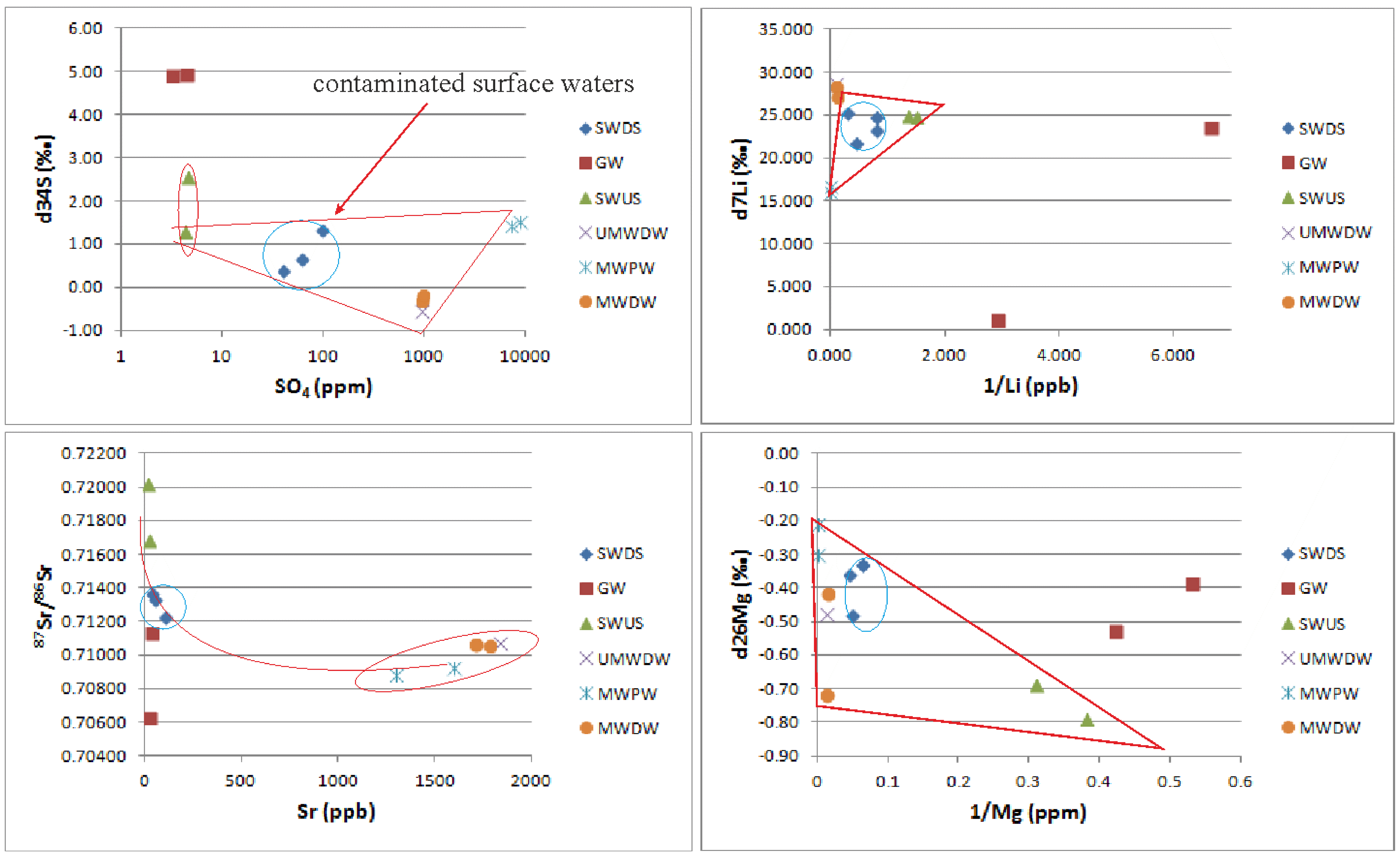

Fig. 5 (RIGHT). Approximate mixing triangels with end members of uncontaminated surface water, process waters, and mine dewatering waters for S, Li and Mg isotopes. For Sr, a mixing curve has been suggested. Blue diamonds refer surface water samples showing contamination from mine water discharge.

Legend:

GW: Groundwater (background): believed to not be influenced by mine waters
MWDW + UMWDW: Mine water dewatering water + Underground mine water dewatering water
MWPW: Mine water process water, surface waters discharged from process water settling pond
SWDS: Surface water, downstream of mine water discharge

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