A METHOD FOR U-Th ISOTOPIC ANALYSIS OF SALINE AND GEOTHERMAL WATERS

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U-Th activity ratios are widely used to constrain the chronology of recent (i.e.; Quaternary) events and processes. Considering natural waters, these activity ratios may help to derive groundwater residence times in an aquifer, or to investigate water-rock interaction processes.

For this purpose, large quantities of water (at least 15 l) are necessary, especially when the analysis of Th isotopic composition is required.

Classically, the isolation of U and Th from the water (previously acidified to prevent the development of bacterial flora, as well as the adsorption of cations on the walls of the container) includes a preliminary step of co-precipitation at pH ≥ 7 of transition metals, using a Fe carrier.

However, in the case of saline and geothermal waters, some other elements may also precipitate with transition metals, resulting in an important residue. Furthermore, in case of Si-rich water, hydrated silica also precipitates as a gel that cannot further redissolve unless using large quantities of hydrofluoric acid. This problem could be theoretically overcome if using soda (instead of ammonia) as base to get a basic pH. In this case, water-soluble water glass (Na_2SiO_3) is formed that prevents silica precipitation.

Alternatively, U and Th may be isolated from natural water using a chelating resin (Greenberg and Kingston, 1983). A procedure allowing for efficient chemical extraction of U and Th has been performed at BRGM Orléans. The water sample is collected in a jerrycan equipped with a tap, then the pH of the water is adjusted to a value close to 3.5 (± 0.5). A column filled with Chelex 100® resin, previously adjusted at the same pH (~ 3.5), is directly fitted on the tap to allow for a continuous flow of the water through the column. As no additionnal overpressure system is involved, this operation may take some time, but the experience shows that the process is generally achieved within a few days in the case of high water volumes. This oepration can be processed either in a cleanlab or even directly in the field depending on pollution requirements (and also on the time !).

At such a pH, U and Th are quantitatively retained on the chelating resin, whereas most cations, like alkalis and most of the alkaline earths are removed. In addition, silica is not retained under such conditions. Finally, U and Th are eluted, with some transition metals, using dilute nitric acid.

A further step of chemical isolation of U and Th involves a specific UTEVA® resin. Such a resin is designed for U elution, but it may be also utilized for Th (Douville et al.,2010). Both elements are retained on the resin in dilute (2N or 3N) nitric acid, and U may be eluted either with very dilute nitric acid or dilute (1N) hydrochloric acid. Now, the high affinity of Th for hydrochloric acid allows to elute it in such a media, whatever its normality. Hence, it is possible to collect specifically both U and Th in the same fraction using dilute (1N) HCl if these two elements are wanted to be further analyzed together, as is the case for the standard MC-ICP/MS U-Th analysis technique utilized at BRGM.

This method has been successfully tested on a sample of the geothermal waters from the Bouillante area (French Guadalupe), whose Si content averages 500 mg/l (Sanjuan, 2001). A second test carried out on the high-temperature geothermal fluids from Iceland has also allowed to remove silica efficiently. In this latter case, an extended UTEVA® purification step may be required, depending on the chemical characteristics of the fluids.

Finally, this method has revealed very successful for saline, low temperature geothermal waters from the Vendée area (France). U-Th results obtained on these waters are presented and discussed.

References

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