River/groundwater mixing study using major and trace elements

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As a part of a hydrogeochemical study of the watershed of the Var River (southeastern France), we focused on groundwaters on the downstream alluvial area providing tools for water management. This resource concerns more than 600 000 inhabitants of the Côte d'Azur.

In order to detect and estimate proportions of water mixing, we use a simple graphical method to plot in a same diagram several major and trace elements. For a single mixing of two components, concentrations ratios of conservative elements fit along a linear plot in a C_1/C_3 vs. C_2/C_3 diagram where C_i is the concentration in the component i, #1 and 2 are the origin waters and #3 is the mixture. The intercepts with X and Y-axis give proportions of mixing. By using both major and trace elements, we generally obtain a more precise linear regression than with major data only, because of higher variations of trace elements concentrations. On the given example, Cs and As do not fit at all, suggesting their non-conservative behavior. Very low Pb level induces analytical problems, which can explain its shift from the linear plot.

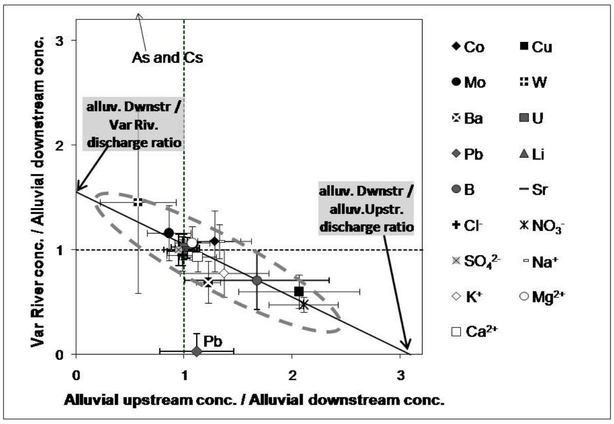

Figure 1: Plot of concentration ratios to study the local infiltration of the Var River into the alluvial aquifer.

This method (i) allows to elucidate recharge processes of the alluvial reservoir from the river or a deeper aquifer when concentrations did not give enough information to define the origin and (ii) gives an example of useful utilization of trace elements in groundwater studies.

Lead isotope variations and tectonic terranes in southern Mexico

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New TIMS (Thermal Ionization Mass Spectrometry) Pb isotope analyses of various crustal units and ores from distinct subterranes of the Guerrero terrane are presented in order to trace metal sources in these deposits and infer source reservoirs. Lead isotope data for ores and the associated igneous rocks from deposits located in the Sierra Madre terrane are also presented to examine whether ore metal sources differ among the proposed tectonostratigraphic exotic terranes of Mexico.

Ores from La Verde and La Esmeralda porphyry copper deposits (Guerrero terrane) yield isotopic ratios between 18.678 and 18.723 for $^{206}Pb/^{204}Pb$, 15.569 and 15.618 for $^{207}Pb/^{204}Pb$, and 38.423 and 38.602 for $^{208}Pb/^{204}Pb$, defining a narrow field just below the average Pb crust evolution curve of Stacey and Kramers [1]. Minerals from Zimapan and La Negra skarn mines (Sierra Madre terrane) yield values varying from 18.775 to 18.975 for $^{206}Pb/^{204}Pb$, 15.593 to 15.844 for $^{207}Pb/^{204}Pb$, and 38.553 to 39.404 for $^{208}Pb/^{204}$, plotting above the Stacey-Kramers reference line. The current and previously published [2, 3, 4] data support the hypothesis that subducted crustal material, which might represent pelagic sediment, supplied substantial amounts of Pb to porphyry copper deposits situated in the Zihuatanejo-Huetamo subterrane. The trend is not similar for epithermal deposits situated further inland (Teloloapan and Zacatecas subterranes), where ores show higher radiogenenity; this pattern is compatible with assimilation of radiogenic compositions of Mesozoic metamorphic rocks of the Guerrero terrane by magmas derived from a MORB-type mantle. Comparison between the isotopic signatures of ores from the Sierra Madre terrane and distinct subterranes of the Guerrero terrane supports the idea that there is no direct correlation between the distinct suspect terranes of Mexico and the isotopic signatures of the associated ores. Rather, these Pb isotope patterns are interpreted to reflect increasing crustal contribution to mantle-derived magmas as the arc advanced onto a progressively thicker continental crust toward the east.

[1] Stacey and Kramers (1975) *EPSL* **26**, 207-221. [2] Hosler and Macfarlane (1996) *Science* **273**, 1819-1824. [3] Cumming *et al.* (1979) *Economic Geology* **74**, 1395-1407. [4] Miranda-Gasca (1995) *PhD Dissertation*, 294 pp.