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Pb Isotopes as Tracers of Anthropogenic Inputs and Weathering Process (Strengbach Catchment, Vosges Mountains, France)

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Study area

Since 1985 hydrochemical investigations have been performed in the Strengbach catchment (Vosges mountains, NE of France) in order to study the effects of acid atmospheric inputs in a sensitive silicate forested area. The aim of the present study is to understand the behavior of lead in this silicate environment and particularly to identify the anthropogenic and lithologic inputs, and to characterise the weathering processes. For that purpose surface waters, soils, granite and separated mineral phases have been analyzed both for Pb isotopic compositions and abundances.

Results

The main isotopic results are summarized on figure 1. - Rainwater and throughfall display the lowest Pb isotopic ratios found in the catchment ($^{206}\text{Pb}/^{204}\text{Pb} = 17.8$), close to known anthropogenic lead values ($^{206}\text{Pb}/^{204}\text{Pb} = 16.83$) (Monna et al., 1997). Among the rock forming minerals (HPT granite), the highest isotopic ratio is found in biotite ($^{206}\text{Pb}/^{204}\text{Pb} = 26.78$) whereas the lowest one is for orthoclase ($^{206}\text{Pb}/^{204}\text{Pb} = 18.11$). Muscovite and albite present intermediate Pb isotopic ratio: $^{206}\text{Pb}/^{204}\text{Pb} = 20.02$. Orthoclase is the most Pb enriched mineral (66 ppm). The Pb isotopic ratios of the fine earth fractions are decreasing with increasing depth in the two soil profiles (HP, PP). Moreover Pb content increases significantly with decreasing depth in the upper soil layers by 80 cm whereas deeper lead content remains almost constant.

- The Pb isotopic composition of surface waters falls in between the precipitation and the soil profile field compositions. Surface waters (streams and shallow soil solution) display Pb isotopic ratios close to that of the upper soil layers, on the opposite to deep surface waters (spring waters and deep soil solutions) which are closer to K-feldspar and precipitation. The Pb isotopic ratio of the soil solution increases with decreasing depth in relation to the increase of DOC content. However, surprisingly as shown on figure 1 the Pb isotopic trend of the surface waters with decreasing depth is contrary to that expected by a simple mixing process between lithological end-member (deep soil profiles) and anthropogenic end-member (precipitation).

Discussion

The decrease of Pb isotopic composition with decreasing depth in soil and the strong increase in Pb content in surface layers can be interpreted as a combination of two processes: the input of anthropogenic Pb bound to organic matter from surface horizons and the output of lithological lead by weathering of isotopic rich minerals (i.e. albite). The unexpected Pb isotopic composition of the spring waters and deep soil solutions can be interpreted by a geochemical control by K-Feldspar. This mineral holds 58% of the Pb of the granite and is a major remaining phase in the saprolite and in the soil profile whereas albite and biotite have been weathered. However, the isotopic disequilibrium between these surface waters and the surrounding mineral phases needs further investigations, particularly those concerning secondary mineral-phases and exchanges processes.

Monna F, Lancelot J, Croudace IW, Cundy AB & Lexis JT, *Environ. Sci. Technol.*, **31**, 2277-2286, (1997).

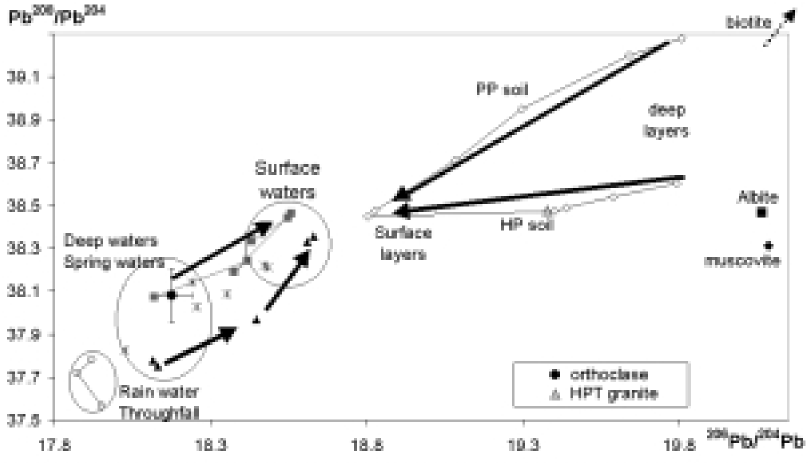

Figure 1 : $^{208}\text{Pb}/^{204}\text{Pb}$ vs $^{206}\text{Pb}/^{204}\text{Pb}$ in the water, the soils, the minerals and the granite of the Strengbach catchment. The arrows represent the trends with decreasing depth