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Lead Contents and Lead Isotopes in the Labile Fraction of Sediments in Silicate-Drained Rocks: Evidence in Small Watersheds in the Massif Central (France)

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Introduction

It is generally agreed that heavy metals associated with Fe-Mn oxides are the main forms in the non residual part of river sediments. The early study of Carpenter et al. (1975) has demonstrated the exceptional tendency of Fe-Mn oxides, and particularly Mn oxides, to scavenge certain metals (Cu, Zn, Ni, Pb.) from solution to form coatings on river sediments. Relationships between Mn and metals have been investigated on catchments to constrain the coupled behaviour of these species. Among the heavy metals, lead is a highly toxic contaminant that has been delivered in large quantities to ecosystems worldwide via atmospheric deposition. The study of Wang et al. (1995) has evidenced that mineral soil horizons act as a sink for atmospheric lead as it passes through ecosystem. Therefore, the ecosystem appears to be an excellent filtering machine that completely retains contaminant lead in its soil profiles. Based on heavy metal concentrations and lead isotopes in the labile fraction from sediments and soils from small watersheds in the Massif Central (France), this study investigates the sources and behaviour of heavy metals in a non anthropogenic aquatic environment. Furthermore, mobilisation and spatial repartition of these metals are investigated in areas where ore mineralisations may produce "natural" heavy metals input to the environment.

Sampling site

The investigated areas, which concern two small watershed, forms part of the French Massif Central. The Allanche watershed covers around 160 km^2 located in the Cézallier (west of Massif Central) underlain by alkaline basalt bedrock. Along the watershed, the Allanche river flows through the volcanic terrains of the lava plateau and divides the Cantal stratified volcano and the Cézallier volcano. The Desges watershed covers 89 km^2 in the Margeride mountains, south of Massif Central. Half of the watershed of the Desges river is formed of granite-gneiss plateaus, the other of gorges. The bedrock of the upper Desges watershed consists of three main units: granite, gneiss and mica schist. The lower part of the Desges watershed is composed of mica schist and rocks of the leptyno-amphibolite group (gneiss, amphibolite). The Desges River drains an area of known ore mineralisations deposits and some mining activities are well known during more than thirty years. Conversely, there is no evidence of ore deposits on the Allanche river, covered by basalt bedrocks. At the outlet of the river in the Allagnon river, Sb-Pb deposits were evidenced in the leptyno-amphibolite group.

Results and discussion

Large fluctuations in trace element contents are observed both in sediments and soils. The relationships between the labile fraction and trace elements and among trace elements evidenced that Fe-Mn oxyhydroxides act as the principal transport medium for trace elements in the labile fraction. Th, an indicator of crustal weathering, is well correlated with Mn. The relationships between Th and Pb show two trends. On the Allanche watershed, Th increase largely associated with a slight increase in the lead contents. Conversely, on the Desges watershed, a huge increase of lead is associated with a slight increase in Th contents. Lead present in the Desges watershed is considered to have been introduced mainly by natural processes of weathering and erosion from ore mineralisations that may be reflected at a greater degree by the coatings in the sediments and soils. This is confirmed by the lead isotopes that fall in the range of measured ore mineralisations, themselves in the range of granitic basements. On the Allanche watershed, lead cannot be linked with the presence of ore mineralisations and lead isotopes point out that lead may originate from anthropogenic inputs (gasoline). Previous work on sediments (Négrel & Deschamps, 1996) suggested an external input for lead linked to atmospheric deposition on this watershed and this study, coupled with investigations in rainwaters (Négrel & Roy, 1998), confirms this atmospheric origin for lead.

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