

## Characterizing multiple sources and interaction in the critical zone through Sr-isotope tracing of surface and groundwater

Philippe Negrel and Hélène Pauwels  
BRGM, Orleans, France

The Critical Zone (CZ) is the lithosphere-atmosphere boundary where complex physical, chemical and biological processes occurs and control the transfer and storage of water and chemical elements. This is the place where life-sustaining resources are, where nutrients are being released from the rocks. Because it is the place where we are living, this is a fragile zone, a critical zone as a perturbed natural ecosystem. Water resources in hard-rocks commonly involve different hydrogeological compartments such as overlying sediments, weathered rock, the weathered-fissured zone, and fractured bedrock. Streams, lakes and wetlands that drain such environments can drain groundwater, recharge groundwater, or do both. Groundwater resources in many countries are increasingly threatened by growing demand, wasteful use, and contamination. Surface water and shallow groundwater are particularly vulnerable to pollution, while deeper resources are more protected from contamination.

Here, we first report on Sr isotope data as well as major ions, from shallow and deep groundwater in several granite and schist areas over France with intensive agriculture covering large parts of these catchments. In three granite and Brioveryan 'schist' areas of the Armorican Massif, the range in Sr contents in groundwater from different catchments agrees with previous work on groundwater sampled from granites in France. The Sr content is well correlated with Mg and both are partly related to agricultural practices and water rock interaction. The relationship between Sr- isotope and Mg/Sr ratios allow defining the different end-members, mainly rain, agricultural practice and water-rock interaction. The data from the Armorican Massif and other surface and groundwater for catchment draining silicate bedrocks (300-450Ma) like the Hérault, Seine, Moselle, Garonne, Morvan, Margeride, Cantal, Pyrénées and Vosges are scattered between at least three geochemical signatures. These include fertilizer and manure, water originating in the upper compartment of the aquifer in weathered rock (alterite) and water from the lower compartment of the aquifer, mainly comprising fissured fresh rock. The interaction with alterite thus led to higher Sr- isotope ratios (around 0.730) in the water because of the weathering of residual minerals whereas interaction in the fissured part implies that the Sr-isotope characteristics of waters are more related to the weathering of whole rock with a lower value.

Secondly, an extensive approach was done by enlarging to Africa (granite-gneiss and schists 2200 – 700 Ma of the Congo Basin), French Guiana (Archaen gneiss 3400–2700Ma and granite-gneiss rocks 2300–1900Ma) and India (Archean granites 2500Ma and Palaeoproterozoic granodiorite and schists 3100 – 1600Ma) considering both surface and groundwater. Here, the weathering processes concern older silicate environments and such weathered silicates yield to clearly higher Sr- isotope ratios (up to 0.745). The Sr-isotope tracing defines and identifies the relative signature of water origin between alterite and rain or agricultural practice (India), between alterite and underlying weathered-fissured and fractured bedrock (Africa) and between the three end-members in French Guiana.