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Using natural gas emission monitoring to assess the hydrogeological mineral springs genesis in non-active zone: example from the Corsica Island

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Deep groundwater circulation increases multiplicity and complexity of groundwater pathways providing a high diversity of intrinsic water properties. Water-rock interactions at depth associated with transit time disparities generate singular mineralisation with high temperature, notable dissolved ions and significant gaseous content. As shown in literature, deep processes involved in gas release can be deduced from fluid gas composition collected at the surface. Widely used as tracers in volcanic areas, seismically- and tectonically-active regions, the gaseous emission monitoring is underused to understand the regional and local groundwater flow patterns that are not linked to an active zone. In order to refine knowledge on complex flow organisation at the origin of diversified mineral springs, this study aims to experiment the use of dissolved gaseous components as a tracer of water up flows interactions.

The oriental plain of Corsica (France) has been chosen for its wide variety of mineral waters (22 springs) emerging at the interface of magmatic (Hercynian orogenesis), metamorphic (Alpine orogenesis) and sedimentary rocks (from the Alpine orogenesis and from Neogene deposits). Dissolved reactive (N_2, CO_2, CH_4, H_2S, H_2, O_2) and noble gases (Ne, Ar, He) on 9 springs have been quarterly sampled (April, July, September & December 2018), and analysed by gas chromatography (µGC).

The first results highlight 3 very contrasted gas abundances:

- (1) N_2-rich thermal waters (54°C), poorly mineralised, with noble gas occurrence as cortege gases. This highlights the influence of deep flow with a long groundwater residence time.
- (2) CO_2-rich cold waters (<20°C), low to highly mineralised, with N_2 as cortege gase. This highlights the occurence of deep flow interacting during his upflow with carbonates of metamophosed rocks.
- (3) CH_4-rich cold waters (<20°C), highly mineralised, with H_2S and CO_2 as cortege gases. This highlights biotic anaerobic activity involvement in gases composition of the mineral waters.

Then, based on the observed abundance of noble gases, theoretical recharge conditions were computed to defined recharge temperature, air- and He-excess. Computation results have stressed out the common origin of these three gas, depending on flow paths, reservoir conditions, biotic and abiotic interaction involvement. The circulation within magmatic reservoir is responsible for the deep N_2-rich flow, which shows during his up flow abiotic interactions with metamorphised carbonates rocks, increasing the CO_2 content in water. Then under anoxic geological confinement in deep sedimentary layers, the CO_2 is reduced into CH_4 and N_2 into NH_4. In the shallowest sedimentary layers, CH_4 formed is degraded, due to the occurrence of rich-organic matter lithology, by biotic activity into H_2S.

This monitoring substantially contributes to improving the complex hydrogeological model of Corsican mineral springs, highlighting the link between deep regional and local groundwater flow; whose even of the non-conventional tools doesn't succeed in clearly testified about the deep escape mechanisms of natural fluids in this non-volcanic regions. In absence of current volcanism, seismic- or tectonic-activity, monitoring the dissolved gases releasing at the surface by thermo-mineral springs provides fundamental information about deep and complex flow paths.