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Biofilm development in a hotspot of mixing between shallow and deep groundwater in a fractured aquifer: field evidence from joint flow, chemical and microbiological characterization

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Biofilms play a major role in controlling the fluxes and reactivity of chemical species transported in hydrological systems. Their development can have either positive impacts on groundwater quality
(e.g. attenuation of contaminants under natural or stimulated conditions), or possible negative effects on subsurface operations (e.g. bio-clogging of geothermal dipoles or artificial recharge systems). Micro-organisms require both electron donors and electron acceptors for cellular growth, proliferation and maintenance of their metabolic functions. The mechanisms controlling these reactions derive from the interactions occurring at the micro-scale that depend on
mineral compositions, the biota of subsurface environment, but also fluid mixing, which
determines the local concentrations of nutriments, electron donors and electron acceptors.
Hence, mixing zones between oxygen and nutriment rich shallow groundwater and mineralized deep groundwater are often considered as potential hotspots of microbial activity, although relatively few field data document flow distributions, transport properties, chemical gradients and micro-organisms distributions across these mixing interfaces.

Here we investigate the origin of a localized biofilm development observed in the fractured granite aquifer at the Ploemeur observatory (H+ network hplus.ore.fr).This biofilm composed of ferro-oxidizing bacteria is observed in an 130m deep artesian well. Borehole video logs show an important colonization of the well by the biofilm in the shallower part (0 to 60m), while it is inexistent in the deeper part (60 to 130m). As flow is localized in a few deep and shallow fractures, we presume that
the spatial distribution of biofilm is controlled by mixing between shallow and deep groundwater. To verify this hypothesis we conducted a field campaign with joint characterization of the flow and chemical composition of water flowing from the different fractures, as well as the microbiological composition of the biofilm at different depth, using pyrosequencing techniques. We will discuss
in this presentation the results of this interdisciplinary dataset and their implications for the occurrence of hotspots of microbiological activity in the subsurface.