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Source and mobility of Rare Earth Elements in a sedimentary aquifer system: Aquitaine basin (Southern France)

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The study of rare earth elements (REEs) in natural waters initially involved an examination of their occurrence and behavior in seawater and coastal waters such as estuaries. Since the 1990s, REE geochemistry has been applied to continental waters such as rivers and lakes and groundwaters. Rare earth elements are of great interest because of their unique characteristics and have been used in the study of many geological processes like weathering and water–rock interaction processes, provenance of sediments, etc... With the evolution of analytical techniques like new generation ICP-MS, much attention had been paid towards the water geochemistry of REEs. However, there is a need of more investigations devoted to REEs in large groundwater systems, especially on the understanding of the distribution of REEs and their evolution in such systems. In this frame, large sedimentary aquifer systems often constitute strategic water resources for drinking water supply, agriculture irrigation and industry, but can also represent an energetic resource for geothermal power. Large water abstractions can induce complete modification of the natural functioning of such aquifer systems. These large aquifer systems thus require water management at the basin scale in order to preserve both water quantity and quality.

The large Eocene Sand aquifer system of the Aquitaine sedimentary basin was studied through various hydrological, chemical and isotopic tools. This system extends over 116,000 km² in the South west part of the French territory. The aquifer being artesian in the west of the district and confined with piezometric levels around 250-m depth in the east. The 'Eocene Sands', composed of sandy Tertiary sediments alternating with carbonate deposits, is a multi-layer system with high permeability and a thickness of several tens of metres to a hundred metres. The Eocene Sand aquifer system comprises at least five aquifers: Paleocene, Eocene infra-molassic sands (IMS), early Eocene, middle Eocene, and late Eocene. One important feature, in these confined systems isolated from anthropogenic influence, is the range in salinities by a factor of 10, from 250 mg/L up to 2.5 g/L. The Σ REE, in the range 2-54 ng/L, with a dependence on salinity when expressed in % HCO₃ or SO₄, reflect the carbonate or evaporite source of REEs. The UCC normalized-REE patterns show a large variability as exemplified by the REE flat patterns-low SREE associated with salinity controlled by HCO₃.

In the present work, the REEs are investigated in terms of saturation indices, speciation modelling, REE patterns in order to recognize the aquifer type hosting groundwater and decipher the origin of the salinity of the groundwater as some part of the aquifer display in the groundwater concentration of chemical element exceeding the drinking water standard (SO₄, F...). Such high concentrations of naturally-occurring substances (e.g. unaffected by human activities) can have negative impacts on groundwater thresholds and deciphering their origin by means of geochemical tools like REE is a remaining challenge.