GEOLOGICAL AND HYDROGEOLOGICAL FEATURES CONTROLLING MECHANISMS OF FLUORIDE ENRICHMENT IN GROUNDWATER IN THE EAST AFRICAN RIFT SYSTEM

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The H2020 FLOWERED project (de-FLuoridation technologies for imprOving quality of WatEr and agRo-animal products along the East African Rift Valley in the context of aDaptation to climate change) aims to address environmental and health (human/animal) issues associated with fluoride contamination in the East African Rift System (EARS), in three case study areas in Ethiopia, Tanzania and Kenya.
A regional review of geology and structural geology was performed to define the hydrogeological features along the EARS and the geological/geochemical conditions associated with the presence of fluoride in groundwater. The results of this research will address future investigations for the assessment of the processes controlling the natural enrichment of fluoride in groundwater of the three target areas.
The EARS, being an active continental rift, is characterized by widespread volcanism and tectonic extension. The rift architecture controls the regional fault pattern, it can be subdivided into orthogonal rifting (which produces long, extension-orthogonal boundary faults) and oblique rifting (yielding general en-echelon arrangement of faults, relay zones and basins with less subsidence).
The regional fault pattern and the volcanism are strongly associated also to rifting maturity stages. Early stages of rifting infer widely-spaced faults, volcanism and hydrothermal fluids ascent localised on the rift border, while mature stages express closely-spaced fault pattern, diffuse volcanism and hydrothermal fluids ascent in the rift floor. An intermediate stage between these two end-members implies an incipient internal faulting.
The orientation of faults strongly influences the recharge area, the geometry and relationship between aquifers and groundwater flow direction.
The hydrogeochemical evidence indicated that fluoride concentration in EARS aquifers reaches up to 70 mg/L and is related to different factors. These include temperature, pH, solubility of fluorine-bearing minerals, anion exchange between hydroxyl and fluoride ions, water residence time. Water-acidic rocks interaction, exacerbated by heat anomaly generated along regional faults or from recent hot eruption centres, favor high fluoride incorporation into groundwater. Safe fluoride groundwater also occurs, mainly related to basaltic or phonolitic unaltered lava-flow fractured or autobrecciated.

The results of this review showed that fluoride circulation in groundwater of the EARS is strongly conditioned by the volcano-tectonic processes, in terms of the interplay between characteristics of faults and lithology, degree of tectonic segmentation and displacement, and volcanism. The aforementioned features are governed by the rift architecture and stage of maturity. In central Ethiopia (oblique rifting in an intermediate stage of maturity) and in central Kenya (orthogonal rifting in a mature stage), fluoride concentration mainly increases from border towards the centre of the rift, and its concentration in groundwater is strongly controlled by the diffuse volcanism in the rift axis and the high degree of fracturing and tectonic segmentation. In the rift centres of this areas, axial and/or transverse groundwater circulation can be strongly influenced by the arrangement of fault pattern. Conversely, in northern Tanzania (early stage of maturity), fluoride occurrence in groundwater, even though of volcano-tectonic origin, may be controlled by lithological and mineralogical features and hydrothermal deep circulation more than the degree of tectonic segmentation.