The influence of faults on groundwater flow and transport dynamics: the raw fault in the Neogene aquifer, Belgium.

Alberto Casillas-Trasvina\textsuperscript{1,2}, Bart Rogiers\textsuperscript{3}, Koen Beerten\textsuperscript{2}, Laurent Wouters\textsuperscript{3}, and Kristine Walraevens\textsuperscript{1}

\textsuperscript{1}Gent University, Faculty of Sciences, Laboratory for Applied Geology and Hydrogeology, Belgium (jesusalberto.casillastrasvina@ugent.be)
\textsuperscript{2}SCK•CEN, Belgian Nuclear Research Centre, Engineered and Geosystems Analysis, Belgium
\textsuperscript{3}ONDRAF/NIRAS, Belgian Agency for Radioactive Waste and Enriched Fissile Materials, Belgium

Faults play an important role in flow and transport in regional groundwater systems. The inclusion of faults during the conceptualization of regional groundwater systems and their incorporation during the construction of groundwater models is crucial, particularly during performance assessments of radioactive waste repositories as well as risk assessment for other deep subsurface activities. Faults can act as: i) barriers slowing down groundwater flow, ii) conduits speeding up groundwater flow, or iii) a combination of both. Determining flow and transport behaviors across these structures is difficult since they are rarely exposed on the surface and their hydraulic behavior vary spatially. Environmental tracers may provide valuable information potentially useful to determine flow pathways, travel times, and groundwater age. If these latter are affected by the presence of fault zones, and they can yield important information for the parameterization of faults in groundwater models. For the Neogene aquifer in Flanders, groundwater flow and solute transport models have been developed in the framework of safety and feasibility studies for the underlying Boom Clay Formation as potential host rock for geological disposal of radioactive waste. However, the simulated fluxes and transport parameters of these models are still subject to large uncertainties, as they are typically constrained by hydraulic heads only and their current conceptualization does not differentiate the fault zones from the undisturbed aquifer materials. This study investigates how groundwater flow and solute transport in the sedimentary Neogene aquifer are disturbed by the Rauw fault – a 55 km long normal fault – across the Nete catchment, in Belgium. To this end, we use a combination of hydraulic head observations and several environmental tracers: hydrochemical analyses, stable isotopes, carbon-14 (\textsuperscript{14}C), helium-tritium (\textsuperscript{3}He-\textsuperscript{3}H), helium-4 (\textsuperscript{4}He) and temperature-depth (TD) profiles. This will allow us to: i) test our current understanding of the system as well as the corresponding model performance, and ii) decrease the uncertainties on forward model outcomes for future scenarios and inverse models by including an advanced conceptualization. The Rauw fault has a displacement of >7 meters which increases with depth. The observed hydraulic gradient across the fault zone appears significant, with head differences of 1.8-2.0 meters over an horizontal distance of 60 meters. Two sampling campaigns have taken place, in 2016 and 2019, for collection of \textsuperscript{3}He-\textsuperscript{3}H, \textsuperscript{4}He, \textsuperscript{14}C, and TD data at a total of 38 selected wells across the Nete river catchment.
These will be further used as observations points for the transport modelling. Here, we will present the first results and interpretations of the gathered temperature and environmental tracer data in complementation with hydraulic head levels to evaluate the effects of the Rauw Fault on the hydrogeological system and the implications future conceptualization and numerical modelling.