NEMESIS: diffusion of dissolved neon in the HADES URL

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Over the last decade, SCK CEN obtained a large set of diffusion coefficients for various gases in the Boom Clay Formation. These diffusion experiments were performed in the lab on Boom Clay samples with diameter of 80 mm and a length of 30 mm [1, 2]. Around a geological disposal facility, diffusion of gas is assumed to take place over the whole formation, i.e. an approximate range of up to several hundred meters. This led to the question: is the lab-scale diffusion coefficient still valid on a larger (meters) scale? Hence, SCK CEN, EURIDICE and ONDRAF/NIRAS are now performing a new in situ diffusion experiment with dissolved neon in the HADES URL, with main objective to confirm and improve the current knowledge on diffusion of dissolved gas at a large scale.

Four piezometers in a 3D configuration of the MEGAS setup (drilled in the 1990's) are selected. Dissolved gas (neon) is circulated through filter A17 (Figure 1). Monitoring takes place in filters A18, C9 and B22, which allows the anisotropy of diffusion to be assessed.

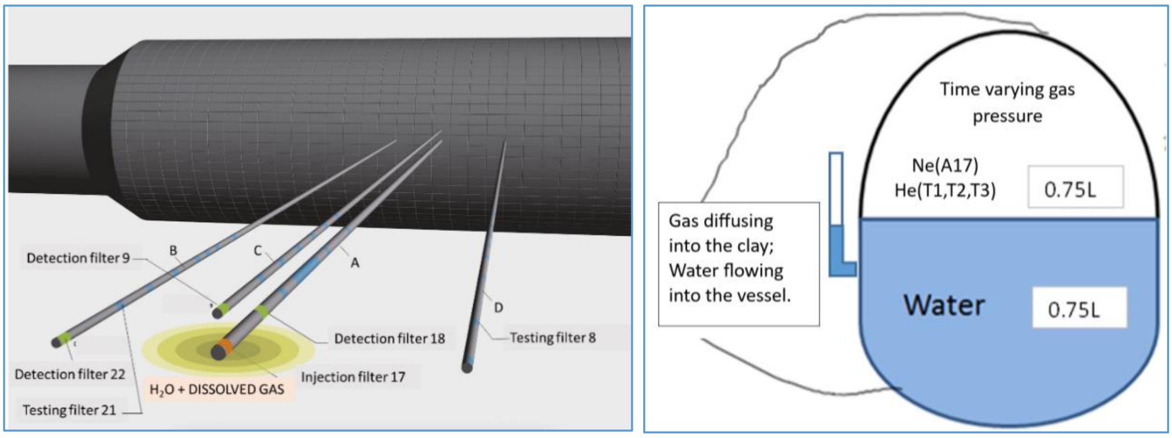

Figure 1: Left: Schematic view of the location of the boreholes and different filters. Right: schematic view of the vessel in the monitoring (target 1, 2 and 3) circuits

The principle of this in situ gas diffusion experiment is similar to the experiments in the lab [3]: a gas (neon) is dissolved in water in a source vessel (S, in a circuit involving filter A17), and the water with dissolved neon is circulated through filter A17 which is in contact with the clay. Dissolved neon will start to diffuse in the clay around A17. After some time, dissolved neon will be present in the water in three monitoring vessels (T1 - filter C9, T2 - filter A18, T3 - filter B22). By measuring the concentration increase of neon over time in the monitoring vessels using online gas analysis, the diffusion parameters can be determined.

Prior to the start of the diffusion experiment with neon, and in order to better understand the performance of the setup and the processes in the host formation, trial in-diffusion tests with helium were performed in filters 8 and 21 which are not involved in the neon through-diffusion test. Model results and field measurements were in good agreement with the lab-scale test results, confirming lab-scale values of diffusion coefficients and validating the good understanding of the in situ experimental system.

The NEMESIS through-diffusion experiment was launched on September 5, 2023. Since the start, the pressure in the vessels has been monitored. At first, the pressure decreased in all the vessels, leading to a steady-state after 150 days. This first phase of the NEMESIS experiment can be analysed as an in-diffusion of gas.

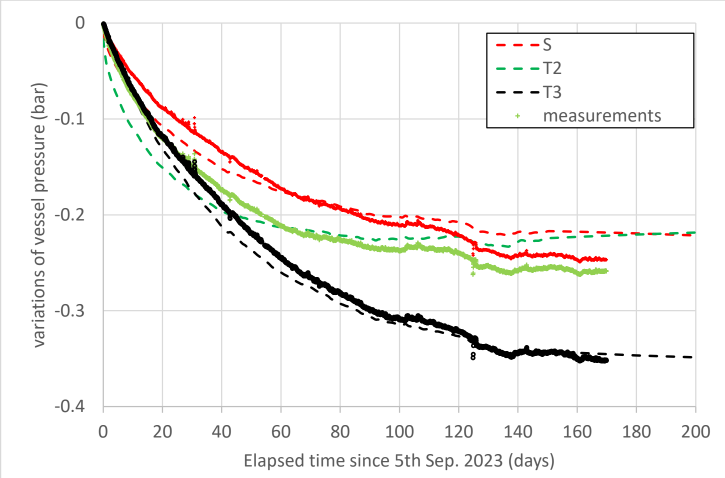

Figure 2: The comparison between the measurements (dots) and modeling results (dashes) for the pressure drop in the vessels T2 (A18) and T3 (B22) and Source (A17).

The commercial software COMSOL V6.1 is used to simulate the pressure variations in the vessels. The pressure inside the vessels changes over time as a combined result of gas diffusing out of the vessel, into the clay and water entering the vessel. In the model, the water pressure and concentration boundary conditions at each filter are provided by that within the vessels.

Numerical modelling reveals that the amount of water that enters the vessel has a significant impact on the pressure variation in the vessel. Consequently, any factor that can possibly cause a change of water pressure in the vicinity of the filter, such as the initial water pressure in the vessel, pressure changes brought on by pumping and temperature fluctuations needs to be accounted for in the model.

Figure 2 presents the comparison of the pressure drop in the vessels between the measurements and modeling (blind predictions) results. It can be seen that, with a set of parameters estimated from previous in situ and lab experiments, pressure drop in the vessel can be well captured, confirming the transferability of diffusion coefficients to larger scale. Nevertheless, this still has to be validated thanks to a through-diffusion test that should be more accurate and able to capture anisotropy. Results are expected only after 5 years.

References

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