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Geochemical characterisation of porewater from poorly indurated Neogene and Paleogene clays in the Netherlands

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Argillaceous formations of low permeability have been selected in several countries as geological host rock formation for the disposal of radioactive waste. The general barrier function of the host rock is to retard and attenuate the migration of radionuclides to the biosphere. In this context, understanding porewater chemistry and water-rock interactions in clayey formations is important for the safety assessment of repository systems in clay-rich formations. Porewater chemical conditions and buffering abilities of the rock will control radionuclides concentration in the geological barrier over time.

In the Netherlands, poorly indurated clays are viewed as potential host formations in COVRA's research programme for the disposal of radioactive waste. The properties of these clay layers are poorly characterised, and currently largely inferred from material at shallower depths in Belgium (e.g. 220 m at HADES URL). In Spring 2022, high-quality cores and sediment samples were obtained from the multi-purpose research borehole DAPGEO-02 [1]. The Smet Coring System (SCS), previously applied in Belgium, was employed to extract cores of adequate mechanical quality. 64 cores were extracted at depths between 362 and 415 m beneath Delft, in either PVC or Shelby tube core barrels. The cores were air/light-tight sealed in aluminium bags, and then stored at 4°C. The cored succession belongs to the Miocene age (interval 364.10-390.5 m) and late Paleogene, Thanetian-early Eocene, Ypresian age range (interval 390.5-414.0 m). The lithological stratigraphy fits with four formations: the Diessen formation (364.1-382.95 m), the Groote Heide formation (382.95-390.5 m), the Ieper Member from the Dongen formation (390.5-393.9 m), as well as the Oosteind Member (393.9-402.0 m); and the Liessel Member of the Landen formation (402.0-414.0 m).

The mineralogy, geochemistry, and porewater chemistry were analysed from core samples of each formation: DAPGEO-02-C27, DAPGEO-02-C49, DAPGEO-02-C55, DAPGEO-02-C62 and DAPGEO-02-C71. The dry density and water content ranged from 1.54 to 1.62 g/cm3 and 21.5 to 28.1 %, respectively. The porewater was extracted using the squeezing technique at a pressure of 5 MPa, with the water collected inside septum vials to avoid exposure to air. In addition, the porewater was analysed as a function of squeezing pressure up to 50 MPa. The obtained porewater samples were very highly saline waters, with concentrations higher than seawater (SW), and salinity increasing with depth from 0.65 to 0.88 M, except in a transition zone with a sandy layer where the porewater is similar to SW. Br/Cl ratio is similar to SW, but a depletion of sulfate with respect to SW is observed, probably due to sulfate reduction and formation of pyrite, as observed in the rock samples, and according to the reducing conditions of the environment. Mg is also depleted probably due to its involvement in water-rock reactions and formation of smectite clay-rich mineral layers. Anion accessible porosity value is 0.8 for all samples, except in the sandy layer, where the value is 1.

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[1] Vardon et al. (2022) https://doi.org/10.4233/uuid:fde70c00-cf65-4174-9cd3-89585a5e61bd

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