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Weathering processes in the Gault Clay formation, Paris Basin

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The Lower Cretaceous Gault marine clay formation outcrops in the area of Brienne-le-Chateau (north-eastern France) currently investigated in the context of a sub-surface repository for low-level radioactive waste. This work aimed at investigating weathering processes (depth variations, chemical reactions) and water transfers in the Gault Clay from present-day to millennial timescale. In this framework, we applied a multi-disciplinary approach to rock and water samples collected in 5 m- deep pits and deep boreholes including the critical zone developed in the Gault clay. The pits were dug along transect on the eastern side of the Aube river that crosscut two successive hillslopes probably corresponding to two alluvial layers; the boreholes were drilled on the ridgetops and in the valleys (Lerouge et al., 2018).

Field work provided evidence of Quaternary surficial formations ranging between ~5 m in valleys and on lower parts of the slopes, 5m to 10 m in filled paleo valleys localized under ridgetops, and less than 1 m on the upper part of the slopes. Slides of surficial formations and of Gault clay moved downslopes. Water comings at different depths in the surficial formations were observed during the dug of the pits. Some waters come also above slide plans at the top of Gault Clay, rather suggesting lateral water transfers. Stable isotopes (^{18}O, D) of the ground waters and pore waters in Gault clay show evaporation processes down to ~10 m depth.

Powder X-ray diffraction performed on bulk rock and clay fractions, and cation exchange capacity measurements of Gault clay and slide plans in contact with surficial formations give evidence of levels rich in swelling clay and of dissolution of pristine marine carbonates. Some secondary carbonate concretions result from precipitation of recent fluids.

Degassing of samples conditioned under He atmosphere provided evidence of a very high CO_2 production in soil (0-30 cm), and a high CO_2 degassing associated to oxygen peak in the first 2-10 m Gault Clay. The CO_2 degassing increase in weathered Gault clay relative to preserved one results from calcite dissolution due to pyrite oxidation and to organic matter degradation. The $\delta^{13}C$ of CO_2 indicates that the organic matter degradation is a major source of CO_2 down to 10-12 m, maximum depth at which we observed fossil roots. Then the CO_2 degassing decreases down to a constant value in preserved Gault Clay, where the carbonate system and the mineral assemblage control dissolved carbonates in pore waters.

Strontium ($^{87}Sr/^{86}Sr$) and lithium ($\delta^{7}Li$) isotopic data of the exchangeable fraction allow well distinguishing surficial formations (~2-5 m) from Gault clay, and altered (~2-20 m) from unaltered Gault Clay (>~15 m).

Combined data rather indicate that weathering processes are occurring as deep as 20 m below the surface with maximum intensity of alteration in the ~2-10 m zone.

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