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Water radiolysis leads to a fun geochemistry

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Water radiolysis is a key process for hydrogen (H_2) and abiotic organic molecules generation in the Earth's crust. The aim of this presentation is to provide some insight into this process from a radiochemist viewpoint. We will transpose the knowledge we gain from water radiolysis in the context of radioactive waste disposal to natural geological settings and draw important conclusions for deep microbial ecosystems development and abiotic organic synthesis. Some examples will be given about: (i) the relationship between H_2 production and the nature of the emitted particle (α/β/Î³) considered for water radiolysis, (ii) the boosted production of H_2 observed when aqueous solutions are in contact with some mineral surfaces such as rutile (TiO_2) and calcite (Costagliola et al., 2017), (iii) the scavenging role of carbonate anions onto hydroxyl radical and the amplified yield of H_2, (Vandenborre et al., 2021), and (iv) the switch from an inorganic world to an organic one through the carboxylate anions production from carbonate radiolysis.

Radiation chemistry is often overlooked by geologists who consider the process as anecdotic (apart for the thermal budget of Earth) in term of mass balance. However, water radiolysis is both a large-scale and widespread process in the crust and it does not need specific conditions to occur (e.g. temperature, pressure, salinity, catalysis), even if porosity, availability of water, dose rate, and surface catalysis are key parameters to be accounted for. We will show that at geological time scale, water radiolysis leads to a very diverse, reactive, and fun chemistry able to sustain life and even to create the condition for its emergence.

Costagliola et al., 2017. Radiolytic dissolution of calcite under gamma and helium ion irradiation. *The Journal of Physical Chemistry C*, *121*(44), pp.24548-24556.

Vandenborre et al., 2021. Carboxylate anion generation in aqueous solution from carbonate radiolysis, a potential route for abiotic organic acid synthesis on Earth and beyond. *EPSL*, *564*, p.116892.