

An account of the Chernobyl Pilot Site studies: 25 years later

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Introduction

25 years have passed since the accident at the Chernobyl NPP, but up to now scientists are still working on answering the question “what are the consequences of the accident?”, and in particular, can we define radionuclide (RN) migration processes today and for the future in soils, vegetation and possibly air re-suspension?. Following the Chernobyl accident (26/04/1986), the contaminated topsoil layers containing fuel particles and contaminated organic matter, coming from the Red forest, were buried in trenches only a few meters deep in the Chernobyl exclusion zone in order to prevent RN dispersion and especially to diminish the exposure dose to workers (liquidators) on site in 1987. Since 1999, the French Institute of Radioprotection and Nuclear Safety (IRSN), in collaboration with the Ukrainian Institute of Agricultural Radiology (UIAR/NUBiP) and the Ukrainian Institute of GeoSciences (IGS), has been studying the impact of the contaminated waste trench T-22, located 2.5 km South-West from Chernobyl NPP, on the aquifers below. The Chernobyl Pilot Site (CPS), which includes the trench T-22, was equipped to carry out in situ radioecological and hydrogeological investigations. The objectives of the research are devoted to the characterization of RN migration both upward into the vegetation and downward to the aquifer, in order to validate RN's transfer models in the environment.

Results and Conclusion

To this end, flow and transport mechanisms were first decoupled. Water flow only studies are still carried out in the different soil layers and in the aquifer. Soil –RN interactions are still studied first in the laboratory (especially for Cs-137 and Sr-90) and analogues were/are also studied on the field. In a second step, these processes were re-coupled by calculating, the reactive transport of RN both at the laboratory scale, under well controlled conditions, and in the CPS where the Sr-90 migration's plume is surveyed for 20 years. In connection to the dynamic of RN migration, our studies also addressed: (i) the nature of the waste material in order to better estimate the amount of the RN stock and its release properties over time; (ii) the possible evidence of enhanced transport down to the aquifer and in the saturated zone due to specific and stable aqueous species of RN and/or to the presence of colloidal substances, and (iii) the upward migration of RN due to the root system of the plants that grow mainly over the trench as such export fluxes from the trench probably constitute one of the main hazards for the near future. The future investigation at CPS and extended to the larger Chernobyl Exclusion Zone include a better understanding of the joint biogeochemical, radioecological and hydrological processes.

Local structure and crystallization pathways of amorphous calcium carbonate

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We compare local structures of synthetic amorphous calcium carbonate (ACC) by ⁴³Ca- and ²⁵Mg-nuclear magnetic resonance (NMR) to long-range order by low-angle and conventional x-ray diffraction and to characterization by thermal gravimetric analysis, scanning electron microscopy, and energy dispersive spectroscopy. The range of parent solution compositions, temperatures, and Na₂CO_{3(s)} induced precipitation yields ACC compositions of 10-40 weight percent water and 0-50% Mg. Subsequent crystallization can yield all anhydrous and hydrous polymorphs of CaCO₃, mixed assemblages, and dolomite. In spite of this variability, the ⁴³Ca NMR spectra of ACC collected immediately after synthesis consist of broad, featureless resonances with Gaussian line shapes (mean chemical shift = -0.4±0.5ppm, FWHH = 27.6±1ppm) that do not depend on Mg²⁺ or H₂O content. We derive indistinguishable maximum mean Ca-O bond distances of 2.45 Å for all samples and our analysis suggest that spectral widths are dominated by chemical shift dispersion that arises from local disorder. Preliminary ²⁵Mg-NMR suggests the presence of rigid and mobile ²⁵Mg populations. [Mg] of the parent solution correlates with ACC stability, though our data suggest Mg²⁺ incorporation in the solid phase is not responsible for the observed stabilization. Within experimental ranges we also observe ACC mesocrystallization, ikaite (CaCO₃•6H₂O) decomposition to monohydrocalcite (CaCO₃•H₂O), and low-temperature proto-dolomite.