Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.33809

From molecular-scale interfaces to engineered barriers: a geochemical trajectory inspired by Laurent Charlet

BIN MA

North China Electric Power University, China Nuclear Power Engineering Co., Ltd.

My scientific trajectory has been deeply shaped by the intellectual framework developed during my PhD under the supervision of Laurent Charlet, Alejandro Fernández-Martínez, and Yongguan Zhu, where environmental geochemistry was approached through a tight coupling of molecular-scale mechanisms, redox processes, and their implications at the system scale. Our joint work focused on the fate of redox-sensitive contaminants and radionuclides at mineral-water interfaces, with particular emphasis on iron-bearing phases in cementitious and geological environments. By combining synchrotron-based spectroscopies with thermodynamic modelling, we demonstrated how surface composition, Fe(II)/Fe(III) redox buffering, and interfacial speciation govern contaminant retention, transformation, and long-term stability in multi-barrier systems relevant to nuclear waste disposal.

This interface-centered and redox-explicit approach has continued to guide my research beyond the PhD, first during my postdoctoral and tenure-track years in Switzerland (Empa and PSI), and more recently after establishing my research group at North China Electric Power University (NCEPU). In Switzerland, this framework was extended to the thermodynamic description of cement-rock interactions, Fe-doped layered double hydroxides, and zeolites formed under repository-relevant conditions, linking experimental solubility data with predictive geochemical models. These studies reinforced the idea that macroscopic barrier performance emerges from nanoscale structural and redox processes.

Since returning to NCEPU, I have further expanded this legacy toward engineered low-carbon cementitious systems for radioactive waste immobilization, integrating iron redox chemistry, mineral reactivity, and long-term evolution into materials design. While the systems have evolved from natural minerals to engineered binders, the underlying philosophy remains the same: understanding and controlling environmental and health-relevant processes requires bridging molecular-scale interfacial geochemistry with long-term, field-scale behavior. This contribution is both a continuation of, and a tribute to, the scientific vision exemplified by Laurent Charlet.