Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.35923

A novel DNA extraction method reveals previously inaccessible subsurface microbial communities

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Microbial communities in subsurface environments influence mineral transformation, redox processes, and long-term biogeochemical cycling [1]. In clay-rich environments, these microbial processes are particularly relevant due to the strong physicochemical interactions between clay minerals, fluids, and microorganisms. However, characterizing subsurface microbial communities in clay-bearing materials remains technically challenging. Clay has very low permeability, high surface reactivity, and strong DNA adsorption capacity. Its plasticity makes mechanical disaggregation difficult, making conventional extraction protocols inefficient, time-consuming, or reliant on highly toxic reagents. As a result, the recovery of high-quality environmental DNA from clay-rich soils, sediments, and clay rock formations is frequently insufficient for downstream molecular applications such as metagenomics and microbial community analyses. This methodological limitation restricts our ability to assess microbial diversity and evaluate its role in subsurface biogeochemical processes.

To address this issue, we developed a DNA extraction method, compatible with available commercial kits and based on a double mechanical and chemical action, destroying clay structure and desorbing DNA from clay surfaces. We tested the protocol on a range of environmental and engineered clay materials. These include a mixture (80/20 w) of quartz sand and MX-80 bentonite and crushed Opalinus Clay, both candidate backfill materials for the Swiss deep geological nuclear waste repository. The method successfully recovered high-quality DNA resulting in a hundred-fold increase in DNA yield compared to the standard procedure and enabled the characterization of hydrogenotrophic microbial communities in these systems [2]. Additionally, we applied the protocol to deltaic aquifer sediments, where conventional kits failed to yield DNA suitable for metagenomic analysis. This optimized DNA extraction method substantially improved access to previously under-characterized subsurface microbial communities in clay-rich systems, thereby advancing our understanding of mineral–microbe interactions and their implications for subsurface biogeochemistry.

References:

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[2] C. Rolland *et al.*, “Impact of Water Saturation on Microbial Hydrogen Consumption in Porous Media,” *Environ. Sci. Technol.*, acs.est.5c08683, Dec. 2025