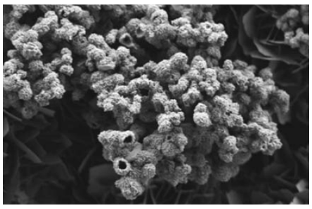
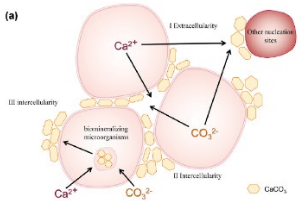


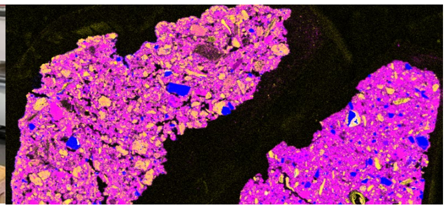

The ARTificial Soil [ARTS] Project: exploring bacterial biomineralization as the future of sustainable construction

Imagine Architecture That Lives: Structures that adapt to their environment, solidify through microbial processes, support plant growth, and ultimately return to the earth at the end of their lifecycle. The project ARTificial Soil brings this vision to life by developing a new, living, earth-based monomaterial that integrates microbiological activity, geotechnical performance, and digital formability into a single material system.

Many microorganisms naturally produce natural cement in soil and marine environments through **microbially induced calcium carbonate precipitation** (**MICP**), also known as biocementation or biomineralization. This is a natural biological process in which microbes generate inorganic materials as part of their fundamental metabolic activities.

We explore two approaches to microbial biomineralization that have been largely overlooked in architecture:
-**Aerobic Organic Conversion:** This is an environmentally friendly process that produces no toxic byproducts. Its reaction substrates, derived from compost components, are already integrated into the material. Our goal is to make this process precisely controllable. While organic conversion is highly efficient in surface layers, it is less effective in deeper layers due to oxygen limitations.
- **Denitrification:** To address the limitations of aerobic processes, we combine them with denitrification, an anaerobic MICP process that can function effectively in deeper layers, and produces harmless molecular nitrogen as the only byproduct.

The microorganisms capable of facilitating both processes - *heterotrophic, facultatively denitrifying bacteria* - are naturally present in many environmental materials, such as soil and compost. With adequate nutrient supply, they can multiply directly within the building material under the specified conditions, eliminating the need for separate cultivation and addition.

Experimental Design & Hypothesis

1) **Development of a Printable Soil Mixture:** The goal is to develop a soil formulation, whose mechanical and biological properties can be precisely controlled by varying substrate components (e.g., clay, rock flour, compost), microbial process management, and adjustments to soil moisture, pH value, and nutrient content. This material mixture will be optimized for robotic 3D printing in terms of flow behaviour, viscosity, and ductility.
   Hypothesis: *MICP (microbially induced calcium carbonate precipitation) enables binding agent free solidification of humus-rich soils and that load-bearing capacity and microbial environment can be controlled through targeted material composition.*
2) **Microbial Monitoring:** This monitoring will document the temporal changes in microbial communities during the material's solidification process. This includes tracking the abundance and activity of relevant microorganisms as well as their metabolic pathways (*metagenomics, metatranscriptomics*), and correlating these factors with the mechanical and biological development of the material.
   Hypothesis: Structural consolidation through MICP can be related to microbial taxa and their activity to establish a long-term biological functionality.

Earliest starting date is **December 2025**, a start in **February/March 2026** is also possible. Experience in molecular biology (e.g. DNA extractions) are required, knowledge of microbial genomics (e.g. UE Env. Omics) and competency in microbiology wet lab skills (e.g. culturing) are strongly recommended. Experience in nutrient (HPLC) and element (ICP-OES) analysis are a plus, however, expert training will be provided. *Please inquire by emailing Prof. Chris Rinke.*