CAIMAN

CharActerization of the mIneral weathering Mechanisms, genes and regulAtions according to miNeralogical and geochemical factors

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Summary

Context — Our planet is characterised by a wide range of rocks and minerals that shape landscapes and play an essential role in soil structure and fertility, carbon sequestration and biosphere nutrition. At the environmental level, minerals represent important sources of nutrients such as K, Mg, or P, especially for forests developed on poor soil. At the industrial level, they represent a reserve of strategic elements such as rare earths (REE) or metals, and a source of toxic elements to manage such as arsenic. The chemical elements contained in minerals are released through a weathering process that combines biotic and abiotic factors. Apart from the action of rain, water circulation and erosion, plants, fungi and bacteria contribute physically and chemically to the weathering of minerals. While the general mechanisms used by bacteria to weather minerals have been known for a long time and correspond to proton-promoted dissolution (acidolysis), chelation (complexolysis) and redox reactions, the molecular mechanisms and genes involved remain largely unknown, as do the possible regulatory mechanisms linked to the minerals or chemical elements available.

Objectives — In this context, the CAIMAN project is a multi-disciplinary and multi-method project focused on the study of interactions between bacteria and minerals and involving functional genomics, chemistry, biogeochemistry and mineralogy. The project aims to decipher the genes and metabolites used by bacteria to weather minerals and to identify the factors controlling this function (ionic strength of the environment, stoichiometry, nutrient availability). While the role of bacteria in mineral weathering has been extensively studied for chemolithotrophic organisms and those able to breathe these minerals in the absence of oxygen, the molecular mechanisms used by aerobic heterotrophic bacteria as well as the biogeochemical and mineralogical determinants have, on the contrary, been little studied. Since soil bacteria represent a major component of the functioning of biogeochemical cycles, understanding and identifying their role in the mobilisation of nutrients and the genes involved is a real scientific front and a challenge for maintaining or even controlling the fertility of low-input ecosystems and plant growth in a context of global change. These developments are also of industrial interest because many minerals contain strategic elements such as rare earths.

Approaches — The general hypothesis tested in this project is that soil bacteria are able to alter minerals by different mechanisms and depending on nutrient availability, environmental conditions and chemical content of the minerals. In this context, the CAIMAN project aims to identify the molecular and biogeochemical basis allowing bacteria to weather soil minerals and rocks and/or controlling the bacterial/mineral interaction, by combining expertise in mineralogy, pedology, chemistry, microbiology and environmental genomics. The proposed work will be carried out on bacterial strains with different weathering effectiveness and/or suspected of preferentially using acidification or chelation mechanisms. Representatives of bacterial genera frequently found in soils and the rhizosphere of trees (e.g. *Caballeronia, Pseudomonas*) will be considered. A large collection of bacterial strains already characterised for their ability to alter minerals is available in the laboratory and some of them have their genome already sequenced.

Expected results and impacts — This work will provide new insight into the diversity of genes and metabolites used by bacteria to weather and/or interact with minerals and rocks. The CAIMAN project should also make it possible to identify the factors regulating the weathering function. These results will be used to analyse the genomes of bacterial strains that are effective at weathering and develop potential biondicators.