Stabilizing a cliff using biomineral binders

November 20 2019, by Cécilia Carron

Credit: Ecole Polytechnique Federale de Lausanne

EPFL spin-off Medusoil has successfully tested its ground-stabilization process on cliffs subject to surface erosion. The company's biomineral-based solution can be used to stabilize sandy and gravelly subsoils to safeguard surrounding infrastructure. It is a long-lasting and easy-to-use alternative to industrial fluids—the production and use of which can be harmful to the environment. The startup is now ready to scale up production.

Soil erosion, landslides, rising sea levels and other consequences of extreme weather conditions can weaken the ground which surrounds infrastructure. In order to maintain their structural integrity, the subsoil often has to be stabilized. Existing solutions, which commonly use cement, lime or industrial resins, do not necessarily provide with long-term stability and have often a hazardous effect on the soil quality with microplastics and toxic substances or by raising groundwater alkalinity above acceptable levels.

Medusoil, an EPFL spin-off, is the first company in the world to develop a soil-stabilization solution that harnesses—and accelerates—a natural process: it generates mineral calcite, a powerful binder that hardens soil at the microscopic level. The solution is fast, inexpensive and consumes little energy. The company has successfully tested its technique on eroding cliffs in the Vaud Canton. It has also set up a facility to mass-produce its soil-stabilization agent as well as a mobile injection unit that can be dispatched to construction sites.

Using microorganisms as the triggering agent

Taking its cue from nature, the mineralization process creates calcite crystals, which firmly bind the gravel or sand particles together. For the triggering agent, the researchers used Sporosarcina pasteurii microorganisms, which they freeze-dried for easier handling. When combined with urea molecules, the microorganisms release carbonate, which binds to the calcium to form crystals. The crystals attach to particles in the ground and grow in number and size—in some cases reaching several hundred micrometers across. Urease, an enzyme released as part of the microorganism's digestive process, accelerates the reaction, making it 1,000 times faster than in nature. And the end product is achieved in a matter of days or even hours.

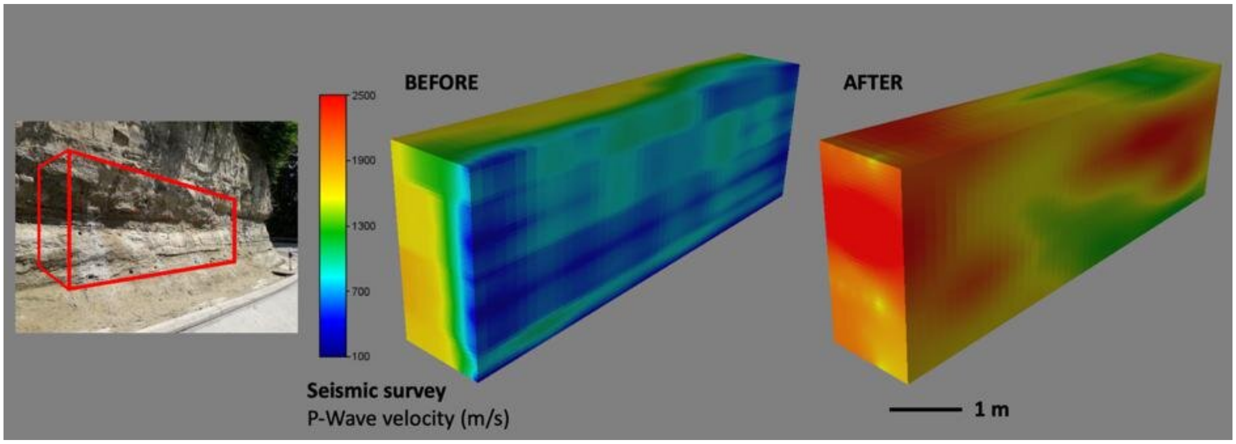

Figure 1 Results of the pilot application where $CaCO_3$ biominerals were produced in an unstable cliff. Credit: Ecole Polytechnique Federale de Lausanne

Real-world testing

The Medusoil team came up with the most promising fluid compositions at EPFL's Laboratory of Soil Mechanics and then began testing them under real-life conditions in 2018. One of the pilot projects was to reinforce a sandstone cliff that had become unstable as a result of surface erosion caused by wind and by rain runoff that affected the fine soil particles. "During these tests, we were able to consolidate the soil in the target zone and make it denser, thereby improving its stability," says Dimitrios Terzis, the firm's CEO. The test results were corroborated by geophysical measurements, including seismic surveys, where shock waves sent through the ground traveled nearly twice as fast following the mineralization process (see figure 1). That is a clear indication that the soil is more compact and less susceptible to damage in the event of an earthquake.

Medusoil's solution is easy to apply. The mineralization mixture is injected into the ground at regular intervals through tubes. It reacts when it comes into contact with calcium to form calcite, the main component of many types of sedimentary rocks, below the surface. The results are already apparent just a few hours later. The process can also be scaled to the needs of soil-reinforcement and construction projects. Small quantities of calcite generate enough particle resilience to withstand the shear stresses caused by a major earthquake; they can also stabilize slopes or shore up existing foundations. With higher levels of calcite, the biominerals can serve as a construction material or be used for soil sealing.

Provided by Ecole Polytechnique Federale de Lausanne