

### **Carbon Dioxide Removal Using Serpentine-Rich Mine Residues**

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The greenhouse gas carbon dioxide (CO<sub>2</sub>) is removed from the atmosphere using alkaline industrial waste, such as ultramafic mine tailings, as a reactive feedstock. The captured CO<sub>2</sub> is stored durably in carbonate minerals. Mine tailings derived from serpentinized ultramafic ore passively capture CO<sub>2</sub> at slow rates, but the rate of capture can be enhanced through the activation of the feedstock during mineral processing and the manipulation of tailings after deposition in the tailings storage facility.

Arca Climate Technologies Inc. is a start-up company based in Vancouver, Canada that is built on 20 years of research from the Mineral Deposit Research Unit at The University of British Columbia. Here we present results from Arca laboratory and field pilots of activation and Smart Churning technologies. Smart Churning is integrated with continuous monitoring of CO<sub>2</sub> capture. The tailings surface is roughened using physical manipulation techniques to increase the rate of CO<sub>2</sub> capture from air. Key parameters that impact the CO<sub>2</sub> capture rate are the surface area, water content, and pH of the tailings, all of which can be modified by Smart Churning. CO<sub>2</sub> removal is directly monitored at a point-scale using commercially available dynamic closed chambers, and at a larger-scale with eddy covariance monitoring. The two independent methods measure similar CO<sub>2</sub> removal rates. Results demonstrate that the rate of capture from Smart Churning is significantly increased over baseline passive air capture rates. Mineral trapping is confirmed with electron microscopy imaging of carbonate mineral cements that bind milled tailings grains. The reactivity of serpentine to CO<sub>2</sub> increases substantially after thermal, mechanical, and chemical activation. Laboratory air capture tests using activated serpentine demonstrate a 150-fold increase in CO<sub>2</sub> capture capacity, and similar enhancement of capture rate. Together, activation and Smart Churning deployed at mine sites globally could remove CO<sub>2</sub> from the atmosphere at gigatonne scale.