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Commercial demonstration of carbon dioxide removal and mineralization with modified ultramafic mine residues

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The greenhouse gas carbon dioxide (CO_2) can be removed from the atmosphere using alkaline industrial waste, such as ultramafic mine tailings, as a reactive feedstock. The captured CO_2 is stored durably in carbonate minerals. Mine residues derived from serpentinized ultramafic ore passively capture CO_2 at very slow rates, but the rate of capture can be enhanced through the activation of the feedstock during material processing and the manipulation of waste after deposition in the tailings storage facility.

Arca Climate Technologies Inc. is a start-up company based in Vancouver, Canada that is built on more than 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 both Mineral Activation and Smart Churning technologies. Smart Churning is integrated with continuous monitoring of CO_2 capture. The tailings surface is physically manipulated by autonomous robots to increase the rate of CO_2 capture from air. Key parameters that impact the CO_2 capture rate include surface area, water content, and pH, all of which can be optimized by Smart Churning. Carbon removal is directly monitored at a point-scale using commercially available dynamic closed chambers, and at a larger-scale with eddy covariance systems deployed. The two independent methods measure similar CO_2 removal rates both in undisturbed baseline plots and on churned tailings. Results demonstrate that the rate of capture from Smart Churning is increased over baseline passive air capture rates by 5 to 10-fold and is sustained for months. Mineral trapping is confirmed with electron microscopy imaging of the carbonate mineral cements that bind milled tailings grains. The reactivity of serpentine to CO_2 increases substantially after microwave activation. Laboratory air capture tests using activated serpentine demonstrate a 250-fold increase in CO_2 capture capacity over capture rates of unactivated serpentine. The rate of CO_2 capture is similarly increased. Together, Mineral Activation and Smart Churning deployed at mine sites globally could remove CO_2 from the atmosphere at a gigatonne scale.