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# The critical role of bacteria in mineral carbonation of kimberlite.

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The breakdown of ultramafic rock during natural weathering captures carbon dioxide from the atmosphere to form carbonate minerals. Kimberlite, an ultramafic rock that can produce diamond weathers when exposed to water. These water-rock interactions also contribute to the growth of bacteria, which accelerate the weathering process. Yellow ground (oxidized Kimberlite found at the surface) samples from the South African Voorspoed and Kareevlei mines contained both molecular signatures (16SrDNA) and viable bacteria. Our molecular analyses highlighted a bacterial population consistent with serpentinite soils and demonstrated that bacteria play a role in yellow ground formation. These yellow ground cultures can grow using only kimberlite as a substrate, promoting weathering in order to live, and providing cultures that are important to natural weathering, yellow ground formation and subsequent mineral carbonation.

In order to demonstrate the importance of biology in mineral carbonation of kimberlite, we performed X-Ray Fluorescent Microscopy (XFM) at the Australian Synchrotron to obtain structural and compositional analysis of the South African Venetia mine's massive volcaniclastic kimberlite (MVK) Coarse Residue Deposit (CRD) with and without biofilm (weathering), 50-year-old Cullinan CRD and definitive, friable Kareevlei yellow ground. These analyses demonstrated that calcium, potassium and iron can be used as tracers for weathering and mineral carbonation.

Our small laboratory and larger (1000 L) field-based mineral carbonation experiments both demonstrated the importance of photosynthetic biofilms in the carbonation of kimberlite residue. All of our experiments produced intergranular cements, which stabilised the CRD residue, providing a strategy to increase mine safety while sequestering carbon. We observed continued mineral carbonation with depth demonstrating that carbonation will continue as the kimberlite is buried on the mine site, which will achieve even greater carbon offsets than anticipated.

Our pilot scale field experiment demonstrated that we offset 20% (on a mass equivalent) of the annual mine emissions in one year using bacterial carbonation, with the likelihood of continued carbonation ensuring that we will have the capacity to produce a carbon neutral mine.