Featured Project:  
Carbon Mineralization in Mine Waste

Research could lead to carbon-neutral mining operations

Mineralization reactions in hard rock mine waste consume carbon dioxide, converting it from a mobile gas into relatively inert solid mineral form. This research may offer a long-term, stable strategy of storing atmospheric CO₂. In natural settings, this process stabilizes the concentration of atmospheric CO₂ over geological time scales. Carbon mineralization in industrial mine wastes is much faster and if accelerated could consume more CO₂ than is emitted during mine operations.

Prof. Greg Dipple and his research team are accelerating carbon mineralization processes. One area of investigation involves increasing the concentration of CO₂ supplied to a slurry similar in chemical composition to trailing process water. Results show a 200 fold rate of increase over atmospheric weathering just by increasing the concentration of CO₂ in the air passed through the slurry to 10%.

A second approach is using an enzyme, carbonic anhydrase, to catalyse the hydration of aqueous CO₂ to a form that is more easily mineralized. Finally, both methods will be combined - higher concentrations of CO₂ will be used with the enzyme.

The research is also comparing major Canadian industrial emitters of CO₂ with bedrock occurrences and mine sites for mafic to ultramafic rocks to access proximities of sources and sinks. Results show there are significant opportunities for CO₂ storage in ultramafic rock-hosted mines and bedrock occurrences outside of the sedimentary basins that are optimal for more conventional carbon capture and storage.

Benefits to Canada and beyond

The technology can be transported to countries with mining operations. There is potential to securely store CO₂ from mining operations for thousands to millions of years.

Industrial Applications

This research has applications for the mining industry. Carbon could be sequestered in tailings and waste rock. Some large mines could operate as net carbon sinks, turning their mine waste into a resource by absorbing the carbon dioxide emissions of other industries.

Project Partners

None at this time.

In September 2011, a preliminary research proposal was circulated to approximately three dozen international mining companies to solicit participation in the next phase of this project.

Research Grant: $120,000 / 2 years

Research Team:
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Focus on Research provides summaries of CMC’s research projects.
Project Description

Goal: Some mine waste has an inherent but untapped capacity to absorb and trap the greenhouse gas carbon dioxide. In mine waste rock and tailings that are rich in magnesium silicate minerals, carbon fixation capacity is much larger than total greenhouse gas production from mine operations. The carbon mineralization project will develop processes for capturing carbon dioxide in mine wastes and fixing the carbon within mineral precipitates for safe long-term storage.

Activities: The project will examine the chemical reactions by which carbon dioxide is trapped and fixed in mineral form through controlled laboratory experiments so that they can be accelerated for enhanced carbon dioxide uptake. The role of biologically mediated reactions in carbon fixation, and the potential for microbially mediated acceleration of carbon uptake will be examined experimentally. The experiments will also be used to calibrate a geochemical model for predicting rates of carbon mineralization at a wide range of reaction conditions and for subsurface reaction in existing mine waste accumulations.

Milestone 1: Experimental work has demonstrated that uptake of CO$_2$ into solution is rate limiting for carbon mineralization in mine tailings. Gas streams ranging in composition from atmospheric (~0.04%) to 100% CO$_2$ were sparged into alkaline slurries containing brucite, a tailings mineral. Brucite was completely replaced by the magnesium carbonate mineral, nesquehonite, within 75, 12 and 7 hours with 10%, 50% and 100% CO$_2$ gas respectively. Experimental carbon mineralization rates were accelerated by a factor of up to 2200, and exceed that required to carbonate all the brucite produced annually at the Mount Keith Nickel Mine (MKM) in Western Australia.

Milestone 2: Major Canadian industrial emitters of CO$_2$ were compared with bedrock occurrences and mine sites for mafic to ultramafic rocks to access proximities of sources and sinks. Results show there are significant opportunities for CO$_2$ storage in ultramafic rock-hosted mines and bedrock occurrences outside of the sedimentary basins that are optimal for more conventional carbon capture and storage.

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About CMC-NCE
Carbon Management Canada CMC-NCE is a national network that funds academic research and promotes the transfer to practice of knowledge and technologies to reduce CO$_2$ emissions in the fossil energy industry and other large stationary emitters. CMC and its investigators work closely with experts in the fossil energy sector, government and the not-for-profit sector to develop cutting-edge technologies, train tomorrow’s professionals and contribute to policy development.

The Network has over 150 investigators at 27 Canadian academic institutions and one American university. We also have close to 200 graduate students and postdoctoral fellows working with investigators. CMC supports 36 research projects for a total of $18 million and is funding new projects in 2012.