Environment and Natural Resources Trust Fund
2010 Request for Proposals (RFP)

LCCMR ID: 219-G

Project Title:

CO2 Sequestration (Mineral Carbonation) Potential of Mining Byproducts

LCCMR 2010 Funding Priority:

G. Creative Ideas

Total Project Budget: $ $115,500

Proposed Project Time Period for the Funding Requested: 1 year, 2010 - 2011

Other Non-State Funds: $ $0

Summary:

This project will evaluate the feasibility of sequestering atmospheric CO_2 by conducting bench-scale laboratory testing of a method called “mineral carbonation". Minnesota-based mineral byproducts will be used in the testing.

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Sponsoring Organization: UMD, NRRI

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Location:

Region: Statewide

County Name: St. Louis

City / Township:

_____ Knowledge Base _____ Broad App. _____ Innovation

_____ Leverage _____ Outcomes

_____ Partnerships _____ Urgency _______ TOTAL

PROJECT TITLE: CO_2 Sequestration (Mineral Carbonation) Potential of Mining Byproducts

I. PROJECT STATEMENT

It is accepted that climate change is being driven by ever-increasing levels of atmospheric ***carbon dioxide*** (CO_2). As long as society burns fossil fuels to generate power and drive many of our industrial processes, CO_2 will continue to be released into the atmosphere. Methods for sequestering CO_2 in ways that prevent or reduce its atmospheric release are under intense study worldwide. In response, **this project will evaluate the feasibility of sequestering atmospheric CO_2 by conducting bench-scale laboratory testing of a method called "mineral carbonation"**. Minnesota-based mineral byproducts will be used in the testing.

Magnesium silicate minerals such as ***olivine*** (Mg_2SiO_4) are identified as key CO_2 reactants in the mineral carbonation process, with CO_2 being tied up in the end-product, magnesite ($MgCO_3$), a geologically stable mineral (the accompanying attachment illustrates and presents additional background information about the concept). About 1.6 tons of olivine can theoretically carbonate 1 ton of CO_2, assuming 100% conversion (Gerdemann et al., 2003). Magnesium silicates such as olivine are common non-ore minerals in the Cu-Ni ores of the Duluth Complex, and olivine alone comprises about 25% of typical ore. The proposers believe mineral carbonation is especially relevant to the State of Minnesota, because mining byproducts generated by likely non-ferrous mining activities may very well be a vast source of inexpensive CO_2 - sequestering minerals.

The mineral processing and mineral chemistry emphasis of this study would be the logical and timely step to follow up on the 2008 Minnesota Geological Survey report on CO_2 sequestration potential in Minnesota that was funded by the Legislature, and an anticipated literature review on the potential for application of mineral carbonation in Minnesota proposed for funding by the Minerals Coordinating Committee in the coming biennium. The Minnesota Geological Survey finds the proposed LCCMR study to be fully compatible with its work, and supports the proposal.

Magnesium silicate-bearing byproducts (e.g., mineral tailings) that are representative of future non-ferrous mineral production will be the focus of this investigation.

- A battery of physical, chemical, and mineralogical tests will be performed to guide follow-up bench- and/or pilot scale mineral carbonation testing.
- The carbonation tests will be performed under various physical and chemical operating conditions.
- CO_2 sequestration efficiency and energy consumption will be used as a measure of the overall potential and practicality of this concept.

The proposed work could have a significant impact on how similar CO_2 sequestration systems are approached, developed and applied, not only in Minnesota but worldwide where similar minerals are available. Importantly, it represents an attempt to make a scientifically sound and environmentally beneficial and responsible use of readily available materials that would otherwise be considered a waste or byproduct of an emerging mining industry. As such, the proposal addresses two LCCMR funding priority areas simultaneously with a creative approach (G) to the reduction of carbon and other greenhouse gas emissions (B), and offers a holistic approach to natural resource use and management, a prerequisite to sustainability.

II. DESCRIPTION OF PROJECT RESULTS

Result 1: Characterize byproduct size, chemistry, and mineralogy	**Budget:** $ 7,500
Result 2: Determine byproduct's CO_2 removal from a gas stream	**Budget:** $ 13,000
Result 3: Produce olivine-rich concentrate (ORC) for further testing	**Budget:** $ 8,200
Result 4: Use Result 2 to test ORC	**Budget:** $ 7,800
Result 5: Fluidized bed testing of "as-is" byproduct and ORC, via 2&4	**Budget:** $ 17,800
Result 6: Test "as is" byproduct in an aqueous slurry at various pressures	**Budget:** $ 20,500
Result 7: Test ORC under several of the best conditions, via 5	**Budget:** $ 14,000
Result 8: Ongoing mineralogical characterization and data analysis	**Budget:** $ 12,500
Result 9: Reporting	**Budget:** $ 14,200
Total Budget:	$115,500

Result (1-9) and associated Deliverables *(1-n)*	**Completion Date**
1. Byproduct size distribution(1), chemistry(2), mineralogy(3)	*9-1-2010*
2. Determination of variables such as temperature, gas flow rate and gas composition on byproduct's ability to absorb CO_2 (1)	*10-1-2010*
3. An olivine- rich concentrate (ORC) for further testing (1)	*12-1-2010*
4. Test results using olivine concentrate (1)	*1-1-2011*
5. The effect of improved gas-solid contact on the absorption of CO_2 (1)	*2-1-2011*
6. Determination of the effect of variables on the ability of byproduct to absorb CO_2 (1)	*3-15-2011*
7. Determination of the effect of variables on the ability of byproduct to absorb CO_2 (1)	*4-15-2011*
8. X-ray diffraction patterns, mineral images, and chemistry (1) and data analysis (2)	*5-15-2011*
9. Final report including all results and recommendations (1)	*6-30-2011*

III. PROJECT STRATEGY

A. Project Team/Partners

NRRI's Coleraine Minerals Research Laboratory (CMRL) and the Duluth-based Economic Geology Group (EGG) will conduct the research. CMRL will perform the majority of the laboratory testing outlined above; the EGG will be responsible for performing the mineral characterization work required for assessing any changes imparted by the various carbonation process steps. Engineers, scientists, and technicians from both CMRL and EGG will collaborate on experimental design, laboratory work, data interpretation, and report writing. Key personnel include: Lawrence Zanko, EGG – will be the project's Principal Investigator (PI), and Blair Benner, CMRL – will be co-PI, and manage and oversee the mineral carbonation process. John Heine, EGG – will be project geologist/scientist responsible for mineral characterization studies. Harvey Thorleifson, Ph.D., Director, Minnesota Geological Survey (MGS), will be a project cooperator/advisor.

B. Timeline Requirements

One year (12 months): For this concept to be practical, mineral carbonation reactions should be measurable and quantifiable within relatively short time periods. This will allow the tests outlined above to be performed within a one year period.

C. Long-Term Strategy

Should the results of the proposed project show promise, especially within the context of previous and ongoing MGS investigations, the logical next step would be to conduct a pilot-scale study. Longer-term investments to support a pilot-scale study would be proportional to the current request. The goal would be to leverage additional funding via sources such as the United States Department of Energy (DOE) or Environmental Protection Agency (EPA).

Project Budget

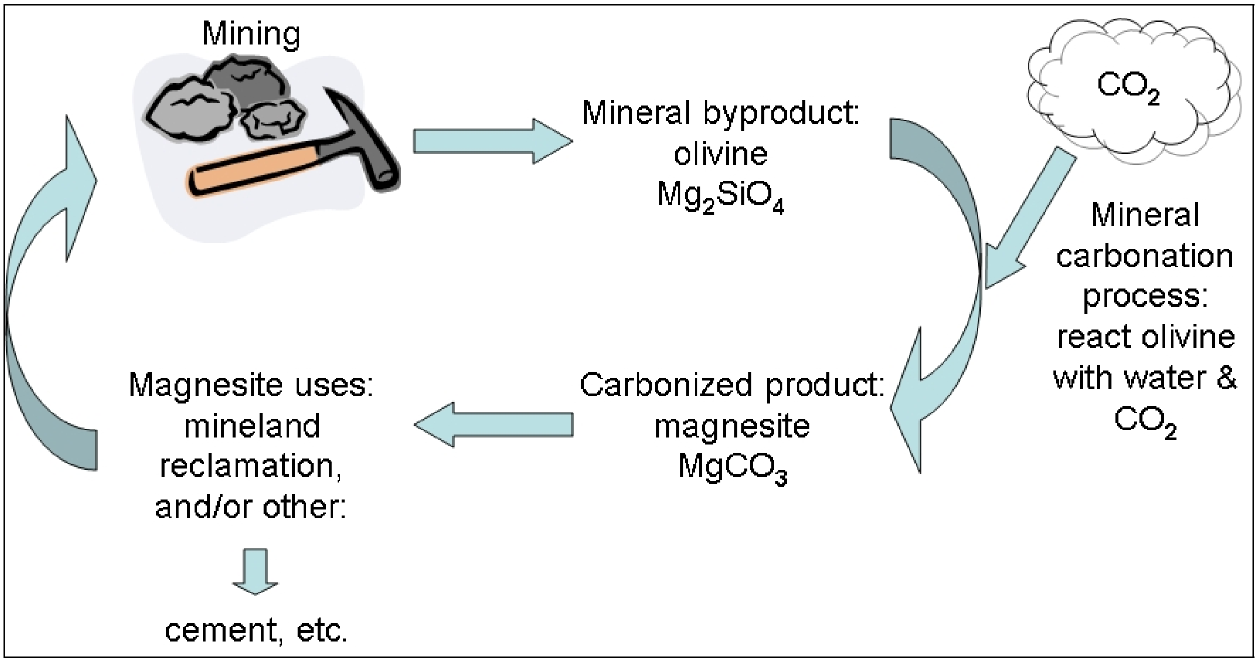
IV. TOTAL PROJECT REQUEST BUDGET (*1* year)

BUDGET ITEM *(See list of Eligible & Non-Eligible Costs, p. 13)*	**AMOUNT**
PI and Engineer(s) (includes salary and fringe)	$ 43,860
Scientist(s) and Technician(s) (includes salary and fringe)	$ 65,540
Equipment/Tools/Supplies: includes fluidized bed reactor tube, fittings, piping, tubing, gases, reagents and glassware	$ 5,000
Travel: Mileage Duluth-Coleraine, meeting attendance, etc.	$ 1,100
Additional Budget Items:	$ -
TOTAL PROJECT BUDGET REQUEST TO LCCMR	$ 115,500

V. OTHER FUNDS

SOURCE OF FUNDS	**AMOUNT**	**Status**
Other Non-State $ Being Applied to Project During Project Period:		
Other State $ Being Applied to Project During Project Period:	$ -	
In-kind Services During Project Period:	$ -	
Remaining $ from Current Trust Fund Appropriation (if applicable):		
Funding History:	$ -	

Mineral Carbonation Conceptualization



Example of Potential Magnitude

- **540,000 tons:** Annual CO_2 sequestration potential for byproduct olivine at 25% carbonation efficiency for a typical-size, Minnesota-based, mining operation. Even at 5% efficiency, over 100,000 tons of CO_2 could be sequestered.
- **150,000 tons**: The inherent annual reduction in CO_2 attributable to the energy savings of incidental grinding. This value is based on: 1) the estimated 15 kWh/ton energy-saving advantage the concept has over "virgin" olivine sources, because the crushing and fine grinding required for increasing the reactivity of the olivine for mineral carbonation will have already been done during ore processing; and 2) a typical coal-fired power plant produces 1.5lbs of CO_2 per kWh of electricity.
- **10 tons:** A conservative estimate of the amount of CO_2 a single person generates every year based on typical living activities (transportation, heating/cooling, eating, etc.)

2010 LCCMR Project Manager Qualifications

Lawrence Zanko, NRRI

Mr. Zanko is a Research Fellow and Group Leader for By-Product Reuse and Remediation within the Minerals Division of the Center for Applied Research and Technology Development of the Natural Resources Research Institute (NRRI), University of Minnesota Duluth. He has worked in the minerals field and has conducted geological, mineral resource and minerals industry-related applied research for most of his 26-year career. Since his start with NRRI in 1988, he has participated in or led a broad spectrum of research projects – often conducted in cooperation with private industry – dealing with non-ferrous minerals, ferrous minerals, industrial minerals (most recently focusing on construction aggregates), contaminated sediment remediation and reuse, and related policy issues. He regularly interacts and collaborates with public and private sector professionals and academicians in the geological, minerals, transportation, and environmental fields, inside and outside Minnesota. He is a graduate of the University of Minnesota – Twin Cities, where he received bachelor degrees in Geological Engineering and Microbiology, and a Masters degree in Geological Engineering.

Blair Benner, NRRI-CMRL

Blair Benner is director of the Minerals Beneficiation Program within the Minerals Division at the Coleraine Minerals Research Laboratory. He has over 30 years of research and development experience in mineral processing and extractive metallurgy: 10 years with emphasis on base metals and 20 years of primarily iron ore processing research and development. His research has been carried from the bench scale and applied to commercial operations. Most recently his focus has been directed toward the application of mineral processing techniques for environmental clean up.

Background

M.S. Extractive and Chemical Metallurgy, Stanford University, 1971
B.S. Metallurgy, Penn State, 1969

Organization Description

NRRI was established in 1983 to encourage economic growth for Minnesota's natural resources-based industries while keeping watch over that growth's impact on the environment.

http://www.nrri.umn.edu/default/about.htm