Environment and Natural Resources Trust Fund

2026 Request for Proposal

General Information

Proposal ID: 2026-518

Proposal Title: Evaluating Geologic Carbon Storage in the Tamarack Intrusion

Project Manager Information

Name: Joseph Labuz

Organization: U of MN - College of Science and Engineering

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Project Basic Information

Project Summary: An underground deposit of porous olivine rock near Tamarack, MN has the potential to permanently store millions of tons of carbon through natural and safe reactions with CO2.

ENRTF Funds Requested: $509,000

Proposed Project Completion: June 30, 2029

LCCMR Funding Category: Land (F)

Project Location

What is the best scale for describing where your work will take place?

Region(s): NE

What is the best scale to describe the area impacted by your work?

Statewide

When will the work impact occur?

During the Project and In the Future

Narrative

Describe the opportunity or problem your proposal seeks to address. Include any relevant background information.

A promising strategy to reduce anthropogenic CO2 is to permanently store carbon in mafic or ultramafic geologic deposits. These rock masses are advantageous due to their prevalence in the earth's subsurface and their ability to naturally store CO2 through dissolution and mineralization. Successful pilot-scale carbon storage projects in mafic rock, including CarbFix and CarbFix2 in Iceland and the Wallula basalt site in Washington State, have demonstrated storage on a time scale of a few years. By some estimates, engineered geologic storage can far outstrip anthropogenic emissions and it comes with the added advantage of secure storage – dissolution and mineralization "lock" the carbon in the subsurface, overcoming the problems of leakage and loss associated with conventional CO2 sequestration processes. The State of Minnesota has the potential to be a national leader in the geologic storage of CO2, as an underground deposit of olivine-rich dunite/peridotite (feldspathic lherzolite) near Tamarack, MN can theoretically store millions of tons of CO2. The bowl area in the southern portion of the Tamarack Intrusion contains an ultramafic peridotite unit. The significant conductivity and reactivity make this rock mass an attractive target for safe carbon storage.

What is your proposed solution to the problem or opportunity discussed above? Introduce us to the work you are seeking funding to do. You will be asked to expand on this proposed solution in Activities & Milestones.

An underground deposit of porous olivine rock near Tamarack, MN has the potential to permanently store millions of tons of CO2 through natural reactions. Laboratory experiments will be performed to determine chemo-hydro-mechanical properties of the rock using a flow-through apparatus that operates at in situ fluid pressures and temperatures. The experiments will provide datasets necessary to establish the relationship between the geologic and field parameters (e.g. in situ stress, porosity, reaction rates, and flow rates) for successful carbon storage operations, which involve:

(a) preparation of a CO2 charge with sufficient reactivity, e.g. CO2 dissolved in water;
(b) circulation of the CO2 charge through the rock and monitoring of the reactive transport;
(c) sampling of dissolution reactions and control of injection; and
(d) seismic sensing of the processes.

It is important to realize that the mineralogy of the rock will determine the reaction rates, and the porosity and conductivity of the rock mass will govern flow. The resulting efficiency and extent of the dissolution will rest on the ability of the charge to infiltrate into the rock. Note that in all of these considerations, the nature of the rock mass is paramount and thus material characterization is necessary.

What are the specific project outcomes as they relate to the public purpose of protection, conservation, preservation, and enhancement of the state's natural resources?

The research revolves around understanding how the interplay between dissolution and precipitation, and flow and reactive transport phenomena, determines the rate and mass of CO2 stored for given injection pressure and mean stress conditions. Comprehensive datasets will be developed for geochemical, poroelastic, and transport properties of the porous olivine rock from Tamarack, MN. Flow-through experiments will be conducted using CO2-charged water and changes in mineralogy, porosity, conductivity, and poroelastic properties will be determined. Plans will be developed for public engagement with the community, including potentially affected property owners and environmental justice groups.

Activities and Milestones

Activity 1: Task 1. Properties of the rock matrix and the rock-fracture system

Activity Budget: $229,000

Activity Description:
The hydro-mechanical properties and pore structure of a rock dictates how it responds to changes in mean stress and fluid pressure. The pore structure also affects its transport properties and hence controls the rate of chemical reactions, including dissolution and precipitation. Therefore, the selection of a representative sample that reflects in situ pore structure is necessary. We will perform tests to determine mechanical parameters, hydrological properties, mineralogy, and porosity of the rock matrix.

The interactions between fractures, serving as preferential fluid flow paths, and the rock matrix, serving as primary carbon storage space, will exert a dominant control over the storage efficiency. Fracture conductivity is typically orders of magnitude larger than rock matrix conductivity, but storage volume is conversely orders of magnitude larger in the rock matrix. Sustaining fluid flow paths through fractures and fracture-matrix interactions are required for rapid and continued carbon storage. To study the effects of flow rate and fracture geometry on dissolution and precipitation patterns, experiments will be conducted in separate cores containing a single fracture under two different flow regimes. Tracer tests, x-ray CT, and positron emission tomography will be used to quantify flow and transport.

Activity Milestones:

Description	Approximate Completion Date
Work with Talon Metals to obtain representative rock and water samples	September 30, 2026
Develop a testing protocol for measuring hydromechanical properties under in situ conditions	March 31, 2027
Determine mechanical and mineralogical properties of the rock matrix	June 30, 2027
Study the effects of flow rate and fracture geometry on dissolution and precipitation patterns	June 30, 2028

Activity 2: Poroelastic and geochemical analyses of the rock matrix

Activity Budget: $178,000

Activity Description:
The introduction of CO2-charged water to the fluid-saturated rock will result in reaction of Mg rich olivine with the carbonate system (H2CO3*), dissolution and possibly precipitation of thermodynamically stable minerals (e.g. MgCO3). In addition to dissolution and precipitation of MgCO3, additional carbon can be locked as solid minerals (Mg- or Ca-carbonates) as the CO2-charged water is injected into the formation. The presence of high pH groundwater and relatively high concentration of Mg and Ca that have been buffered by Mg-rich silicate rocks favors formation of Mg- or Ca-carbonates.

We will saturate the rock so that the pore fluid will contain an initial water chemistry reflecting activity of various ions that are expected to affect the dissolution and precipitation reactions. These include a representative total inorganic dissolved carbon (H2CO3*, HCO31-, CO32-), Mg2+, Ca2+, Na+, Cl-, SO42-, and K+. The system will be allowed to reach chemical equilibrium, indicated by periodic measurement of fluid chemistry of the specimen. Once equilibrium is achieved, CO2-charged water of various concentrations will be injected. Fluid chemistry changes will be monitored by measuring concentration of various ions in the pore solution using inductively coupled plasma mass spectroscopy (ICP-MS) until a new equilibrium stage is approached.

Activity Milestones:

Description	Approximate Completion Date
Saturate the olivine-rich peridotite and determine poroelastic and transport properties	December 31, 2027
Evaluate pore fluid chemistry to determine changes in concentration of various ions	March 31, 2028
Determine pore filling and sealing by measuring seismic properties and matrix conductivity	March 31, 2029

Activity 3: Community benefits plan

Activity Budget: $102,000

Activity Description:
The project area is located on traditional Anishinaabe lands within the 1854 ceded territory in Carlton County and near the border of the 1855 ceded territory within Aitkin County. The project is proximate to the Fond du Lac Reservation and Mille Lacs Reservation, which are disadvantaged communities according to the Department of Energy's Energy Justice Dashboard Map. In all areas of operations, Talon Metals adheres to its Tribal Engagement and Consultation Statement, and the project team will follow this approach. The Minnesota Department of Transportation lists both Aitkin and Carlton counties as high for social vulnerabilities and disadvantaged for transportation access, cost, and safety. Thus, extensive opportunities exist to expand economic diversification from future carbon storage operations, based on the results of this project.

The team will conduct regular and extensive community engagements in Carlton and Aitkin counties on a quarterly basis. Talon also maintains an open-door policy and community members often drop by the office in the City of Tamarack, MN. As this project moves forward, specific community engagement plans will be developed to maintain transparency on project activities and continue to build trust within the neighboring communities.

Activity Milestones:

Description	Approximate Completion Date
Explore ways to connect carbon storage with the interests of Native American communities	June 30, 2027
Facilitate meetings to promote economic development and protect cultural values	June 30, 2028
Develop an effective field operation for safe carbon storage at the Tamarack Intrusion	June 30, 2029

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Emmanuel Detournay	University of Minnesota	Senior Investigator	Yes
Bojan Guzina	University of Minnesota	Senior Investigator	Yes
Peter Kang	University of Minnesota	Senior Investigator	Yes
Vaughan Voller	University of Minnesota	Senior Investigator	Yes
Heather Arends	Minnesota Department of Natural Resources	Stakeholder and land manager of the Tamarack Intrusion	No
Brian Goldner	Talon Metals	Consultant, Tamarack geology and geophysics	Yes
Jessica Johnson	Talon Metals	Consultant, external engagement	Yes

Long-Term Implementation and Funding

Describe how the results will be implemented and how any ongoing effort will be funded. If not already addressed as part of the project, how will findings, results, and products developed be implemented after project completion? If additional work is needed, how will this work be funded?

The results will be used as preliminary data for a DOE proposal supporting a feasibility study at the Tamarack, MN site. The goal of the proposal will be to develop the engineering that will lead to realizing the potential for large-scale subsurface storage of CO2. Arriving at an effective operation for carbon storage requires that reaction and flow work in a positive feedback loop, and material characterization is a key step. The proposed site, the Tamarack intrusion, is an ideal location due to the estimated total volume of fresh olivine that can be easily reacted with CO2.

Project Manager and Organization Qualifications

Project Manager Name: Joseph Labuz

Job Title: Professor

Provide description of the project manager's qualifications to manage the proposed project.

The project will be directed by Professor Joseph Labuz, University of Minnesota (UMN), who has considerable experience in leadership and project management, (i) managing a $5M/year operation as Department Head of Civil, Environmental, and Geo- Engineering from July 1, 2012 – June 30, 2022, and (ii) serving as co-director of the US Department of Energy funded Energy Frontier Research Center on Geo-processes in Mineral Carbon Storage (GMCS), a multi-million dollar award (2022-26). Labuz has more than 30 years of experience in the experimental investigation of fluid-saturated rock. Team members include Emmanuel Detournay, Bojan Guzina, Peter Kang, and Vaughan Voller. Detournay is Bennett Professor of Rock Mechanics and a member of the National Academy of Engineering; he has devoted a major component of his career to the poromechanics of rock. Guzina is an international authority on imaging and inverse modeling of geological systems. Kang is an expert in physical experiments and numerical modeling of subsurface flow and reactive transport. Voller is international leader on forecasting flow and transport in realistic fracture networks at the rock-mass scale. The geomechanics and earth science laboratories at the University of Minnesota are well equipped for determining hydro-mechanical properties of rock, including under realistic conditions of temperature and pressure. Basic instrumentation and apparatus associated with a rock mechanics laboratory are available. Supporting equipment to monitor flow and seismic velocities include appropriate pumps, sensors, and high speed data acquisition systems. The Talon technical contact is Brian Goldner, with support provided by Jess Johnson.

Goldner is Chief Exploration and Operating Officer and Johnson is Vice President of External Affairs. The project will be established within UMN's financial system and managed as a standard project within the University's sponsored project administration with strict oversight functions.

Organization: U of MN - College of Science and Engineering

Organization Description:
The US Department of Energy (DOE) funded center on Geo-processes in Mineral Carbon Storage (GMCS) deals with the scientific fundamentals of interacting thermo-hydro-mechanical-chemical processes underpinning mineral carbon storage. The research performed under the auspices of GMCS focuses on two "end" members in terms of relevant rock properties: (i) conventional ultramafic rocks endowed with high reactivity but low permeability and (ii) mafic rocks that are characterized by low reactivity and higher permeability. In light of their respective foci, the LCCMR and GMCS efforts are synergistic in that (i) the granular olivine at the Tamarack site falls outside of the range of rock parameters that are considered by GMCS and (ii) the fundamental science stemming from GMCS will facilitate investigation of the potential of the Tamarack complex for carbon storage.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Joseph Labuz		Project manager			36.6%	0.06		$25,083
Emmanuel Detournay		Senior investigator			36.6%	0.09		$25,083
Bojan Guzina		Senior investigator			36.6%	0.09		$25,083
Peter Kang		Senior investigator			36.6%	0.12		$25,083
Vaughan Voller		Senior investigator			36.6%	0.09		$25,083
TBD		Research scientist 2			25.9%	1.9		$158,634
TBD		Graduate student			48%	1.35		$164,151
							Sub Total	**$448,200**
Contracts and Services								
Talon Metals	Service Contract	Talon has been exploring the Tamarack site for nearly 20 years and has extensive experience working in the area and innovating best practice methods for protecting the environment while executing drilling operations. Talon will provide rock cores, knowledge of the Tamarack geology, and lead the community and tribal engagement.				0.3		$45,906
							Sub Total	**$45,906**
Equipment, Tools, and Supplies								
							Sub Total	-
Capital Expenditures								
							Sub Total	-
Acquisitions and Stewardship								

							Sub Total	**-**
Travel In Minnesota								
	Miles/ Meals/ Lodging	Two trips per year to the Tamarack site, 290 miles round trip, two people, $0.55 per mile, $!78 per diem	Visit site to sample rock and meet with geologists to discuss results					$5,894
							Sub Total	**$5,894**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
							Sub Total	**-**
Other Expenses								
		Lab supplies and services ($3000 per yr)	To determine fluid chemistry and dissolution/precipitation minerals (e.g. x-ray CT, positron emission tomography, inductively coupled plasma mass spectroscopy)					$9,000
							Sub Total	**$9,000**
							Grand Total	**$509,000**

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request

Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
State				
			State Sub Total	**-**
Non-State				
			Non State Sub Total	**-**
			Funds Total	**-**

Total Project Cost: $509,000

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: e051301e-529.pdf

Alternate Text for Visual Component

Figure 1 shows the Tamarack Intrusion, which is composed of a dunite/peridotite deposit. Figure 2 is a schematic of natural geologic storage of CO2....

Supplemental Attachments

Capital Project Questionnaire, Budget Supplements, Support Letter, Photos, Media, Other

Title	File
UMN letter authorizing submission of the proposal	8ce8f0f8-ed8.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

Do you understand that travel expenses are only approved if they follow the "Commissioner's Plan" promulgated by the Commissioner of Management of Budget or, for University of Minnesota projects, the University of Minnesota plan?

Yes, I understand the UMN Policy on travel applies.

Does your project have potential for royalties, copyrights, patents, sale of products and assets, or revenue generation?

Yes

Do you understand and acknowledge IP and revenue-return and sharing requirements in 116P.10?

Yes

Do you wish to request reinvestment of any revenues into your project instead of returning revenue to the ENRTF?

No

Does your project include original, hypothesis-driven research?

Yes

Does the organization have a fiscal agent for this project?

Yes, Sponsored Projects Administration

Does your project include the pre-design, design, construction, or renovation of a building, trail, campground, or other fixed capital asset costing $10,000 or more or large-scale stream or wetland restoration?

No

Do you propose using an appropriation from the Environment and Natural Resources Trust Fund to conduct a project that provides children's services (as defined in Minnesota Statutes section 299C.61 Subd.7 as "the provision of care, treatment, education, training, instruction, or recreation to children")?

No

Provide the name(s) and organization(s) of additional individuals assisting in the completion of this proposal:

Christina Doherty, Sponsored Projects Administration

Do you understand that a named service contract does not constitute a funder-designated subrecipient or approval of a sole-source contract? In other words, a service contract entity is only approved if it has been selected according to the contracting rules identified in state law and policy for organizations that receive ENRTF funds through direct appropriations, or in the DNR's reimbursement manual for non-state organizations. These rules may include competitive bidding and prevailing wage requirements

Yes, I understand