

# **Environment and Natural Resources Trust Fund**

# 2026 Request for Proposal

# **General Information**

Proposal ID: 2026-440

Proposal Title: Biotechnologies for Sustainable Mining of Critical Metals

# **Project Manager Information**

Name: Mikael Elias Organization: U of MN - College of Biological Sciences Office Telephone: (612) 626-1915 Email: mhelias@umn.edu

# **Project Basic Information**

**Project Summary:** This project pioneers protein-based biotechnology to create an eco-friendly "mining-of-the future" in Minnesota, developing engineered proteins to selectively extract critical metals, reducing chemical–based clean-up and minimizing environmental impact.

**ENRTF Funds Requested:** \$280,000

Proposed Project Completion: June 30, 2028

LCCMR Funding Category: Small Projects (G) Secondary Category: Resiliency (A)

# **Project Location**

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

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

When will the work impact occur?

In the Future

# Narrative

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

Minnesota hosts large deposits of strategic metals that include platinum-group metals (PGMs), cobalt, nickel, copper, gold, silver, and even rare earth elements. The Duluth complex in Northern Minnesota is particularly rich: it contains enormous mineral resources, including approximately 5.6 million metric tons of copper ( $\approx$ 12% of domestic copper reserves) and about 280 metric tons of PGMs ( $\approx$ 31% of U.S. PGM reserves). Other important metals are also abundant: nickel, cobalt, gold or silver, and there is even potential for rare earth metals. As global demand rises for various metals due to their critical importance in modern technology (e.g. electric vehicle battery, wind turbine, electronics, electrical infrastructure, defense industry), the pressure to develop mining increases. At the same time, environmental concerns surround conventional mining: the use of energy-intensive machinery and harsh chemicals can create hazardous products such as arsenite that pollute the environment. Novel technologies are needed to safely exploit Minnesota's natural resources and shift to an era of "green mining", maximizing mining efficiency and environmental safeguards.

# 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.

We propose to harness and enhance the native ability of certain proteins to bind metals and hazardous mining byproducts—to increase metal extraction efficiency without the need for harsh chemicals—and capture toxic byproducts. We will improve the affinity and selectivity of metal-binding proteins using a combination of Artificial Intelligence (AI) tools and structure-guided protein engineering. High affinity is essential to improve the extraction efficiency, while selectivity is critical to obtain the purest product possible in this initial step. We will also improve the physical properties of our engineered proteins to ensure that our technology can later be scaled up and used in the field. Improved physical properties include increasing stability and binding capacity as well as resistance to extreme pH, temperature, and high salts/competing metals. Such biological molecules are expected to boost mining efficiency and environmental safety, ultimately making Minnesota a leader in sustainable extraction of critical minerals, which will ensure continued economic growth and resource security while safeguarding its natural resources.

# 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?

We will have tested biotechnologies that are tailored to the mining opportunities in Minnesota. These biologicals will facilitate state-of-the-art methods for the selective, efficient and eco-friendly extraction of target metals to position Minnesota as a leader in biologically enhanced mineral extraction. Through stakeholder engagement, we will also develop a feasible path for implementation. In sum, the project will deliver novel, tailored, eco-friendly technologies to approach mining and help Minnesota access its strategic mineral wealth. A logical follow-up would be to perform testing on real mining samples, benchmarking against existing methods, and optimizing the deployment of the technology.

# Activities and Milestones

# Activity 1: Characterization and engineering of metal-binding proteins

#### Activity Budget: \$131,978

#### **Activity Description:**

We will characterize newly identified and known metal binding proteins relevant to Rare Earth Elements, cobalt, copper, nickel, and arsenate. Using bioinformatics, we will identify candidate proteins (e.g. homologs of Lanmodulin, metallothioneins, NikA, etc.) from organisms living in extreme environments for the high stability of the proteins they encode. We will also work on proteins that can selectively remove common toxic mining byproducts, such as arsenite (e.g. homologs of ArrX). We will produce and purify these proteins recombinantly, and characterize their binding affinity and specificity as measured by isothermal titration calorimetry, spectroscopy, and/or with metal-uptake assays. Next, we will engineer these proteins to improve key properties. We will combine Al-guided approaches (e.g. PROSS, MutCompute, ProteinMPNN) with structure-guided design to enhance stability, metal affinity and specificity. Each "lead" or significantly improved mutant will be verified biochemically and structurally. Protein stability is critical for future implementation of these technologies, potent metal affinity fosters robust recovery of trace metals, while and metal selectivity is essential to achieve high-level extraction purity.

#### **Activity Milestones:**

Description	Approximate Completion Date
Identification and characterization of at least 10 novel metal-binding proteins relevant to MN mining potential	June 30, 2027
Engineering of high-performance binding proteins for key MN metals (>50% binding capacity)	March 31, 2028
Characterization of improved binding proteins for stability, affinity and selectivity	June 30, 2028

# Activity 2: Development and evaluation of protein-based mining formulations

#### Activity Budget: \$148,022

#### **Activity Description:**

The objective is to formulate practical systems for future deployment of improved metal-binding proteins to effectively extract metals and sequester harmful mining byproducts. We will first encapsulate proteins in silica to make functionalized beads in a laboratory setting. These beads will be packed into a filtration column, and metal capture will be evaluated using bench-scale extraction units with a synthetic solution containing defined metal concentrations. The tests will first be conducted with pure solutions, followed by metal solution mixtures to evaluate selectivity. Metal recovery efficiency (% metal captured), throughput (flow rate and volume processed by the technology) and reusability (regeneration, number of cycles) will be measured. Additionally, future field trials and scale-up considerations will be evaluated, in part by collecting input from key local stakeholders (e.g. Glencore, Twin Metals and New Range, Natural Resources Research Institute (NRRI)); this will be key to shape the next steps for this project.

#### **Activity Milestones:**

Description	Approximate Completion Date
Prototype formulation and testing of encapsulated for two key metal-binding proteins	February 28, 2028
Measurement of their binding capacity and reusability	April 30, 2028
Development of a future implementation strategy	June 30, 2028

# 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 project will provide new technologies for biological extraction of key MN mining resources, and will position us to scale up protein-based mining technologies from the lab to pilot scale. Integration of these technologies is needed to combine the new opportunities for harvesting critical metals while preserving our environment. The vision is to pivot toward "green mining" via biologically enhanced mineral extraction. The next steps would include lab testing with crude samples, field testing, pilot-scale testing, industrial integration optimization, regulatory approval, and at-scale economic analysis. To support this future work, funding will be sought through the DoD and DoE.

# Project Manager and Organization Qualifications

#### Project Manager Name: Mikael Elias

# Job Title: Associate Professor

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

Mikael Elias holds a Ph.D. in structural enzymology from Université Aix-Marseille (France) and completed his postdoctoral training at the Weizmann Institute of Science (Israel) as a Marie Curie Fellow, specializing in protein evolution and engineering. Since 2014, he is an Associate Professor in the Biochemistry, Molecular Biology and Biophysics department, where he runs a productive laboratory that studies the structure, function, and evolution of proteins and enzymes, with applications in microbiology, human health, and crop and environmental protection. This project builds on his recognized expertise (>75 research articles, 6 patents), including in protein engineering. He also has extensive experience and expertise with high affinity and high selectivity binding proteins. In addition to leading a research laboratory, his past experience as co-founder and former CEO of an enzyme biotechnology company (now acquired) provided him with the network, experience and tools to direct translational research, engage stakeholders and execute this project.

Organization: U of MN - College of Biological Sciences

#### **Organization Description:**

The University of Minnesota is a public land-grant research university. The PI's lab is hosted in the University of Minnesota Biotechnology Institute. This interdisciplinary Institute is located on the Saint Paul campus and hosts a wide range of faculty and labs that apply different aspects of biological, geological and material sciences to address societal challenges. This unique structure creates a cutting-edge, highly collaborative environment to conduct challenging projects that necessitate a wide range of expertise. At the Institute, the PI also has access to extensive lab space to support the proposed research, as well as comprehensive General Administration, Human Resources and accounting to ensure proper project management.

# Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineli	% Bene	# FTE	Class ified	\$ Amount
				gible	fits		Staff?	
Personnel								
Project Pl		Oversee and assist with project research			36.6%	0.16		\$40,053
Lab		to complete research to increase metal extraction			36.6%	2		\$171,925
Researcher		efficiency						
							Sub	\$211,978
							Total	
Contracts and Services								
							Sub	-
							Total	
Equipment, Tools, and Supplies								
	Tools and	Items to include but not limited to: Chemicals, flasks,	Funds are for producing and					\$60,000
	Supplies	pipettes, disposable plasticware, this includes test	optimizing enzymes for lab testing, as					,,
		tubes, gloves and petri plates, as well as media	well as routine lab supplies and DNA					
		needed for production of proteins, molecular biology	sequencing.					
		reagents, electrophoresis gels. Also includes supplies						
		for protein purification (e.g. chromatography						
		columns, resins), characterization supplies such as						
		substrates, mass spectrometry, NMR and ITC usage,						
		and crystallization supplies as well as shipping costs						
		to send samples for structural analysis at national						
		Tabs. Bioreactors and immobilization supplies.					Ck	¢60.000
							Total	<b>300,000</b>
Capital							Total	
Expenditures								
•							Sub	-
							Total	
Acquisitions								
and								
Stewardship								
							Sub	-
							Total	
Travel In								
Minnesota								

					Sub Total	-
Travel Outside Minnesota						
					Sub Total	-
Printing and Publication						
	Publication	Publication of research results	Open-access publication fee. This allows everyone to access the research without the need to pay a subscription to the publisher.			\$5,000
					Sub Total	\$5,000
Other Expenses						
		Repairs and Maintanence	These funds will be used to cover repairs associated with the use of our research instruments for this project.			\$3,022
					Sub Total	\$3,022
					Grand Total	\$280,000

# Classified Staff or Generally Ineligible Expenses

Category/Name Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
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# Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
State				
			State Sub	-
			Total	
Non-State				
In-Kind	Indirect costs for this proposal though not allowed, are listed as in-kind contribution of 54% MTDC which is the Federally Negotiated rate with the U of M. The indirect is proportionate to the awarded funds at a rate of 54% so if the award is reduced the F&A would be reduced	To pay for facility and administrative expenses for this project.	Secured	\$151,200
			Non State Sub Total	\$151,200
			Funds Total	\$151,200

## Total Project Cost: \$431,200

# This amount accurately reflects total project cost?

Yes

# Attachments

# **Required Attachments**

*Visual Component* File: <u>2364187b-c0e.pdf</u>

#### Alternate Text for Visual Component

Metal-Binding Proteins to Sustainably Enhance Critical Metal Extraction....

# Supplemental Attachments

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

Title	File			
SPA approval letter	<u>d49f2752-041.pdf</u>			

# **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?

N/A

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:

Lori Nicol and Amy Angel, University of Minnesota

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

N/A