

IGEM Grant Report

☐ Progress (due January 1) ☒ Annual (due July 31) ☐ Final (due August 31)

IGEM Grant # IGM26-007

Principal Investigator: Amin Mirkouei

Name/Full Title of Project: SONO-MSE Process for Permanent Magnets Manufacturing from Idaho-Sourced Minerals"

Submission Date: 07/24/2026

Primary Institution: University of Idaho

Instructions: Complete each section of this report directly on this template. Completed reports must be limited to 1 page for Progress Reports and 2 pages for Annual or Final Reports in 12 pt Arial or similar font, excluding the expenditure report. Simple and concise answers will be appreciated, and even bullet lists of information will be sufficient. Reports that do not follow these requirements will be returned for revision. Submit reports by the appropriate due date to HERC@edu.idaho.gov.

Section 1: Project and its goals

This project aims to advance the extraction and processing of Idaho-sourced rare earth elements (REEs) to enable low-cost rare earth metal (REM) production. The primary objective is to validate neodymium-rich mischmetal (Nd-rich MM) as a viable commercial pathway for permanent magnet manufacturing. To achieve this goal, we will both produce initial samples of Nd-rich MM alloy to use for Nd-rich MM-Fe-B permanent magnets and perform initial techno-economic analysis (TEA) and life cycle assessment (LCA) of the proposed SONO-MSE pathway.

Section 2: Summary of accomplishments and future plans

Initial characterization of the Lemhi Pass samples confirmed high neodymium (Nd) concentrations, supporting their potential for producing Nd-rich MM alloys and magnets. The samples also contained elevated thorium concentrations, consistent with previous USGS studies. Two experimental approaches were pursued: (1) top-down approach: microwave- and ultrasound-assisted leaching of REE-rich samples was conducted using organic acids, e.g., food-grade citric acid. The resulting leachate was centrifuged and either dried and calcined directly, or precipitated, dried, and calcined to produce REE oxides for later conversion into mixed REE-rich metals via molten salt electrolysis; and (2) bottom-up approach: pure-metal charges were prepared to replicate REE composition of samples and melted under an inert atmosphere. Initial experiments showed that graphite crucibles introduced undesirable carbon contamination. Carbon can react with Nd, reduce the Nd-rich phase needed for grain-boundary pinning, and form iron-carbon phases that negatively affect magnet performance. Based on these findings, graphite components were replaced with inert boron nitride crucibles and a water-cooled copper mold. The resulting alloys will be characterized to verify their composition and assess their suitability for magnet production. These results will also guide optimization of the top-down extraction process. Collaboration with Hydrova Inc. enabled the team to establish a customized vacuum induction melting system while substantially reducing development time and cost. Hydrova's expertise and infrastructure eliminated the need to design and construct the furnace entirely from the ground up. The furnace was delivered in November 2025, and the processing system, including the machined copper mold assembly, was subsequently completed. The project has several potential commercial pathways. Nd-rich MM alloys could be supplied to magnet manufacturers, while continued research could support domestic production of Nd-rich MM permanent magnets. We are also pursuing DOE funding opportunities

and collaborations with national laboratories and industry partners, including INL, Oak Ridge National Laboratory, Hydrova, and Idaho Strategic Resources (IDR). Once alloy characterization is complete, collaborators at DOE, INL, and Ames Lab/CMI will be consulted regarding magnet-production feasibility. Future work will focus on thorium separation, alloy characterization, molten salt electrolysis, process optimization, and pilot-scale demonstration. Please check the attached files (Supplementary Information and accepted ASME conference paper) for additional results.

Section 3: Summary of budget expenditures (7/1/2025-6/30/2026)

Description	Total allocated budget	Total expenses
Salary	52,654	42,859
Fringe	7,927	6,739
Travel	2,493	971
Op exp	20,579	10,029
Capital	31,633	31,633
Tuition	8,318	8,318
Total	123,606	106,736

Section 4: Economic development/impact

The project will assess the technical, environmental, and economic feasibility of producing Nd-rich MM-Fe-B magnets via an integrated extraction process. TEA and LCA studies will evaluate potential energy savings, reduced environmental impacts, and decreased reliance on foreign rare earth supplies. Hydrova and IDR have expressed interest in REE-rich magnet manufacturing. IDR 2025 drilling at Lemhi Pass identified zones with elevated REEs and phosphorus, potentially associated with monazite and xenotime, as well as thorium-rich zones that may contain thorite. IDR plans to conduct SEM mineralogical analysis to confirm the ore minerals. Our goal is to advance the SONO-MSE process to pilot scale and pursue DOE Loan Programs Office (LPO) funding for a full-scale U.S. production facility. One of our DOE proposals was also selected for funding in early summer 2026, and is currently under initial negotiation.

Section 5: Participants

The project team includes Dr. Amin Mirkouei (PI), Dr. Alex Vakanski (co-PI), and three graduate students. Sneha Pradhananga (MSc in Nuclear Engineering) has led experimental work, reporting, machine learning model development, and preparation of an ASME conference paper. Jonathan Alvarez (MSc in Technology Management) supported sample preparation, furnace installation, and copper mold integration. Kundan Kumar (PhD in Environmental Science) has contributed to organic acid leaching, induction melting, REE extraction pathway development, and machine learning modeling.

Section 6: Long-term sustainability plan

We plan to submit proposals to NSF SBIR and DOE ARPA-E. Upon successful completion of project milestones, our goal is to advance the technology to pilot-scale demonstration, positioning the project to qualify for DOE LPO funding to construct a full-scale production facility capable of performing the SONO-MSE process for extracting and refining rare earth metals from Idaho-sourced minerals.

Section 7: Expenditure Report

Please check the attached file.

University of Idaho
Itemized Expenditures
From 7/1/2025 through 6/30/2026

Grant: UI8619 - ISBOE HERC: SONO-MSE (ml)

Index: 855864 - ISBOE HERC: SONO-MSE (ml)

Fund: 228619 - ISBOE HERC: SONO-MSE (ml)

Salaries					
E4108 Summer Salary		Mirkouei, Amin	216	Hours	\$15,868.08
		Vakanski, Aleksandar	65	Hours	\$4,537.65
E4109 IA/GA Salary		Pradhananga, Sneha	780	Hours	\$19,032.00
					\$39,437.73
Temporary Help					
E4135 Temporary Student		Kumar, Kundan	60	Hours	\$1,470.00
		Pradhananga, Sneha	80	Hours	\$1,952.00
					\$3,422.00
Fringe Benefits					
		E4280 Faculty CFR Benefit Expense			\$6,019.69
		E4282 Student CFR Fringe Expense			\$718.50
					\$6,738.19
Travel					
E5360 Personal Vehicle - In-State					
8/15/2025	I2341384	Mirkouei, Amin			\$219.69
E5381 Airfare - Out-of-State					
6/29/2026	Z1119674	Airfare 06042026	Doc Ref: 53032472		\$319.40
E5396 Lodging & Per Diem – In State					
8/4/2025	I2341018	Pradhananga, Sneha			\$58.00
8/15/2025	I2341384	Mirkouei, Amin			\$58.00
8/18/2025	I2341531	Richardson, Kathryn A.			\$58.00
E5397 Lodging & Per Diem – Out of State					
6/29/2026	Z1119674	Hotel 06042026	Doc Ref: 53032472		\$258.57
					\$971.66
Operating Expenses					
E5020 Postage & Mailing					
1/27/2026	Z1109732	UPS shipping samples to Analytial S	Doc Ref:		\$13.67
E5070 Conference/Registration Fees					
6/29/2026	Z1119674	Conference Registration 05192026	Doc Ref: 53032472		\$550.00
E5152 All Other Services					

5/12/2026	Q0174099	Amazon Capital Pure Citric Acid, 10 Pound - Food Grade	\$37.19
6/1/2026	!0622367	Amazon Capital Services Inc	\$0.00
E5307 Analytical Services			
1/5/2026	J1392249	AHR IDG SDEC25-003	\$1,312.50
6/15/2026	J1403539	IDG/JH from 855864 to 771954	\$3,600.00
E5724 Research Supplies			
9/10/2025	Z1101822	Purchase of buckets and lids relate Doc Ref:	\$155.99
9/10/2025	Z1101822	Refund related to return of one lid Doc Ref: 45950961	(\$12.71)
9/24/2025	Q0137240	McMaster-Carr S Tight tolerance hard wear-resistant	\$136.35
9/24/2025	Q0137240	McMaster-Carr S Tight-Tolerance Hard Wear-Resistant	\$25.34
9/24/2025	Q0137240	McMaster-Carr S Tight-Tolerance Hard Wear-Resistant	\$45.00
9/24/2025	Q0137240	McMaster-Carr S shipping minus discount \$4.43	\$17.36
9/24/2025	Q0137240	McMaster-Carr S tight-tolerance hard wear-resistant	\$15.00
9/29/2025	!0596745	McMaster-Carr Supply Co.	\$0.00
9/29/2025	!0596745	McMaster-Carr Supply Co.	\$0.00
9/29/2025	!0596745	McMaster-Carr Supply Co.	\$0.00
9/29/2025	!0596745	McMaster-Carr Supply Co.	\$0.00
10/1/2025	Q0138093	McMaster-Carr S Tight-Tolerance Hard Wear-Resistant	\$156.80
10/1/2025	Q0138093	McMaster-Carr S shipping minus discount \$3.14	\$10.79
10/2/2025	!0597204	McMaster-Carr Supply Co.	\$0.00
11/26/2025	Q0147319	McMaster-Carr S Multipurpose 110 copper Bar, 2" Thick,	\$284.31
11/26/2025	Q0147319	McMaster-Carr S Shipping	\$17.19
12/3/2025	!0603414	McMaster-Carr Supply Co.	\$0.00
12/17/2025	Q0150158	McMaster-Carr S Solder-connect fitting for copper	\$40.38
12/17/2025	Q0150158	McMaster-Carr S shipping	\$11.43
12/17/2025	!0604418	McMaster-Carr Supply Co.	\$0.00
2/21/2026	Q0159893	Amazon Capital Bonsenkitchen Precut Vacuum Sealer	\$6.79
2/23/2026	Q0160043	McMaster-Carr S Glove Box Clamps, worm drive, 8"	\$20.45
2/23/2026	Q0160043	McMaster-Carr S shipping minus discount	\$13.86
2/23/2026	!0614042	McMaster-Carr Supply Co.	\$0.00
2/28/2026	Q0161249	Amazon Capital Alliance Rubber Company Inc. Can	\$4.88
3/4/2026	Q0161643	Amazon Capital EesTeck 2Pcs 10" (Diameter)	\$6.99
3/13/2026	!0615932	Amazon Capital Services Inc	\$0.00
3/20/2026	!0616565	Amazon Capital Services Inc	\$0.00
3/23/2026	!0616645	Amazon Capital Services Inc	\$0.00
4/8/2026	Q0168165	MSE Supplies LL MSE Pro High Purity Boron Nitride	\$195.80
4/8/2026	Q0168165	MSE Supplies LL shipping	\$32.33
4/8/2026	Q0168225	Amazon Capital OTOOLWORLD High Frequency Heater	\$26.00
4/14/2026	Q0169012	Amazon Capital Heating Coil of 15KW High Frequency	\$55.00
4/17/2026	B1968763	MSE Supplies LLC	\$0.00
4/28/2026	!0619659	Amazon Capital Services Inc	\$0.00
5/4/2026	!0620208	Amazon Capital Services Inc	\$0.00
5/19/2026	Q0175218	Amazon Capital K-Type Thermocouple Block Ceramic	\$13.99
5/27/2026	Q0176739	Amazon Capital Heating Coil of 15KW High Frequency	\$120.00
6/8/2026	!0623062	Amazon Capital Services Inc	\$0.00
6/10/2026	Q0179322	Fisher Scientif FILTER HOLDER W/REC PSF 250ML	\$158.39
6/10/2026	Q0179322	Fisher Scientif FISHERBRAND ELITE PIPETTE KIT	\$1,057.15
6/10/2026	Q0179445	Amazon Capital Mini Ice Cube Tray for Freezer: FDDBI	\$54.36
6/10/2026	Q0179511	Amazon Capital Cadbibe 50ml Clear Glass Vials with	\$16.96
6/10/2026	Q0179511	Amazon Capital LEMENT 50pcs KN95 Face Mask Black	\$27.14
6/10/2026	Q0179511	Amazon Capital Supmedic Medical Nitrile Exam Gloves,	\$17.96
6/11/2026	Q0179674	Amazon Capital Cadbibe 50ml Clear Glass Vials with	\$50.88
6/12/2026	Q0180010	Amazon Capital Mini Ice Cube Tray for Freezer: FDDBI	\$95.94
6/16/2026	Q0180388	Amazon Capital Membrane Filter Papers 100 pcs, 0.45	\$92.64
6/16/2026	Q0180399	Amazon Capital The Pharma-C Company -70%	\$28.13
6/16/2026	!0623749	Amazon Capital Services Inc	\$0.00

6/22/2026	Q0181177	Amazon Capital Digital Thermometer Pyrometer -400°F	\$24.99
6/26/2026	Q0182321	Airgas Inc 2 argon gas tanks plus delivery and hazmat	\$1,065.66
6/27/2026	Q0182413	Amazon Capital Heating Coil of 15KW High Frequency	\$120.00
6/29/2026	!0625168	Airgas Inc	\$0.00
6/29/2026	!0625179	Fisher Scientific Co.	\$0.00
6/29/2026	!0625179	Fisher Scientific Co.	\$0.00
6/30/2026	Q0182602	Amazon Capital MXBAOHENG Heat Resistant Gloves	\$169.00
6/30/2026	!0625225	Amazon Capital Services Inc	\$0.00
6/30/2026	!0625225	Amazon Capital Services Inc	\$0.00
6/30/2026	!0625225	Amazon Capital Services Inc	\$0.00
6/30/2026	!0625225	Amazon Capital Services Inc	\$0.00
6/30/2026	Q0183730	Amazon Capital Oxalic Acid [C2H2O4] 99.8% ACS	\$137.95
			\$10,029.83

\$5K or > Capital Outlay

E6850 >5K Medical/Surgery/Lab Equipment

9/22/2025	Q0136712	Hydrova Inc Custom Inert Induction Furnace	\$28,133.81
9/22/2025	Q0136712	Hydrova Inc shipping	\$3,500.00
9/24/2025	B1957893	Hydrova Inc	\$0.00
9/24/2025	B1957893	Hydrova Inc	\$0.00
			\$31,633.81

Trustee/Benefits

E7140 Tuition and Fees - Grad Assistants

8/21/2025	J1384452	AWA1 for V00944992	\$35.00
8/21/2025	J1384452	GRFT for V00944992	\$866.00
8/21/2025	J1384452	MG1I for V00944992	\$105.00
8/21/2025	J1384452	SHI1 for V00944992	\$1,206.00
8/21/2025	J1384452	TFGR for V00944992	\$4,700.00
8/21/2025	J1384452	VVSF for V00944992	\$100.00
2/17/2026	J1395569	V00944992 PAYMENT term 202520	\$1,006.00
4/6/2026	J1398498	V00944992 PAYMENT term 202520	\$300.00
			\$8,318.00

Totals for 228619

\$100,551.22

Totals for UI8619

\$100,551.22