Form B:IGEM-HERC Full Proposal Cover Sheet
Idaho State Board of Education

Proposal Number

Total Amount Requested: 90 K over 1 year

Proposal Track: Proof of Concept

NSF I-Corps participation: Have you participated in, or plan to participate in the NSF I-Corps Program? Is so, when did you or will you?

I participated in the NSF I-Corps program previously but not for this project. I plan to participate in the NSF I-Corps program if our project was chosen for award.

Project title:

Single-Step Molten Salt Electrochemical Process for Direct Lithium Extraction from Clay-Type Lithium Ore

Specific Project Focus: Critical materials Recovery Technologies

Project Start Date: 7/1/2026	**Project End date: 6/30/2027**
The Regents of University of Idaho	**Chemical and Biological Engineering**

Address: 995 MK Simpson Blvd
Idaho Falls, ID 83401

Email Adress: Haiyanz@uidaho.edu	**Phone Number 2085338123**

	Name	Title	Signature
Principal Investigator:	**Haiyan Zhao**	**Associate Professor**	
Co Investigators:	**Travis McLing**	**Group lead**	
Name of Partnering Company:	**Lithium Americas**	**Technical Director**	Representative Name: Ryan Ravenell ryan.ravenelle@lithiumamericas.com

Authorized Organizational Representative	**Name** **Sarah Martonick** ee 2/24/26	**Signature** Digitally signed by Sarah S Martonick Date: 2026.02.24 16:40:26 -08'00'

1. **The Regents of University of Idaho**
2. **Single-Step Molten Salt Process for Direct Lithium Extraction from Clay-Type Lithium Ore**
3. **PI:** Haiyan Zhao**; Co-PI:** Travis McLing
4. **Total amount requested:** $90 K
5. **Significance of project and project objective(s):**

The rapid electrification of transportation and expansion of grid-scale energy storage have placed lithium carbonate (Li_2CO_3) at the center of the clean energy economy. Global lithium demand is projected to increase several-fold over the next decade, driven primarily by lithium-ion battery production for electric vehicles and stationary energy storage systems.[1] As a result, securing reliable domestic lithium supply has become a strategic national priority under U.S. critical materials policy frameworks.[2] While lithium brines and hard-rock spodumene currently dominate global production, clay-type lithium deposits represent a vast but underutilized domestic resource, particularly in the western United States.[3] Unlocking these deposits is essential to building a resilient and geographically diversified U.S. lithium supply chain.

Clay-type lithium ores differ fundamentally from spodumene. Instead of occurring in discrete lithium silicate crystals, lithium in clay deposits is structurally embedded within layered aluminosilicate minerals such as illite and cookeite-derived phases, or distributed within clay interlayers (Fig.1).[4] Lithium is tightly associated with aluminum-, silicon-, iron-, and magnesium-bearing frameworks, making selective extraction significantly more complex. Conventional industrial processing relies on high-temperature roasting followed by sulfuric acid or alkaline leaching.[5] Although moderate lithium recovery can be achieved, these methods require multiple energy-intensive unit operations, large volumes of reagents, and extensive downstream purification. Acid leaching, in particular, dissolves substantial quantities of impurities alongside lithium, increasing operational cost and environmental burden.[6] Even alkaline routes require sequential roasting, leaching, solvent extraction, and precipitation steps.

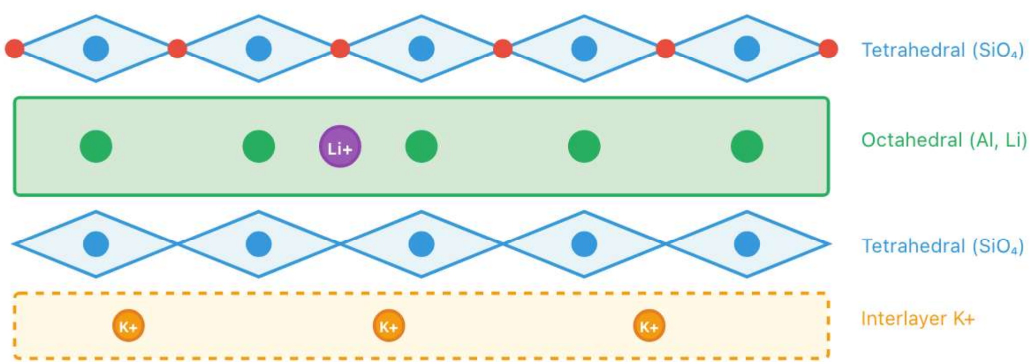

Fig.1 Lithium binding structure in Illite clay structure

This project proposes a fundamentally different processing paradigm: a single-step molten salt electrochemical system that integrates thermal activation and selective lithium separation within one reactor. In this approach, molten salts function simultaneously as high-temperature reaction media and electrochemical electrolytes. Elevated temperature induces partial dehydroxylation and structural rearrangement of clay frameworks, weakening lithium–oxygen interactions and rendering lithium electrochemically accessible.[7] Instead of relying solely on chemical dissolution, applied electrochemical potential provides thermodynamic selectivity, enabling targeted lithium recovery while suppressing co-extraction of multivalent impurities such as Al^{3+}, Fe^{3+}, and Mg^{2+}.[8]

The scientific basis of this concept rests on three principles. First, clay minerals undergo structural modification at elevated temperature, increasing cation mobility.[7] Second, molten chloride and carbonate salts provide highly conductive ionic environments with well-defined electrochemical windows, in which Li^+ exhibits high mobility relative to multivalent cations.[9] Third, electrochemical potential enables precise thermodynamic control of reduction reactions, allowing lithium to be selectively transported or reduced while aluminosilicate matrices remain stable.[10] The central hypothesis is that, under optimized molten salt conditions, clay frameworks partially destabilize, lithium becomes weakly bound and electrochemically accessible, applied potential selectively drives Li^+ transport, and aluminosilicate impurities remain in the solid residue. By coupling thermochemical activation with electrochemical selectivity, this approach eliminates multiple conventional unit operations and introduces a transformative pathway for clay-type lithium extraction.

Successful validation will position Idaho as a leader in sustainable lithium extraction and align directly with HERC priorities in critical materials recovery, advanced manufacturing, and clean energy innovation.

6. Specific project plan and timeline

This proof-of-concept effort begins at Technology Readiness Level (TRL) 0–1, where individual phenomena are understood but have not yet been integrated. The objective of this project is to experimentally validate the integrated concept and advance it to TRL 2.

The project unfolds in four coordinated phases.

Phase 1: Thermodynamic and Electrochemical Feasibility

The first phase establishes thermodynamic viability. Using established modeling tools, we will calculate Gibbs free energy changes for lithium liberation reactions within molten salt systems. Electrochemical windows will be defined to identify potential ranges that favor lithium transport while suppressing impurity reduction. This phase determines optimal salt compositions and operating temperatures.

Phase 2: Structural Behavior of Clay Ore in Molten Salts

The second phase investigates how clay-type ore behaves when exposed to molten salt environments. Through X-ray diffraction and electron microscopy, we will track mineral structural evolution and identify the conditions under which lithium becomes electrochemically accessible. These experiments provide mechanistic understanding of lithium activation.

Phase 3: Electrochemical Lithium Extraction

In the third phase, a laboratory-scale molten salt electrochemical cell will be constructed. Cyclic voltammetry and controlled-potential experiments will quantify lithium extraction efficiency and impurity suppression. This phase directly tests the hypothesis of selective electrochemical lithium transport.

The target performance metrics include:

- ≥70% lithium extraction efficiency
- ≤1% aluminum and iron co-extraction

Phase 4: Lithium Carbonate Production

Recovered lithium will be converted to lithium carbonate, and purity will be assessed. Achieving ≥99.5% purity will demonstrate compatibility with battery-grade standards and confirm the commercial relevance of the process. Completion of these phases advances the technology to TRL 2 and establishes the foundation for laboratory-scale prototype development (TRL 3–4).

7. Potential economic viability and Idaho impact

Clay-type lithium deposits represent a large and strategically significant resource in the western United States.[3] A cleaner, electrochemically controlled extraction pathway would provide competitive advantage by reducing reagent consumption, minimizing waste generation, and simplifying process design. The project leverages the University of Idaho's expertise in molten salt chemistry and high-temperature electrochemistry, supported by collaboration with Idaho National Laboratory. Beyond primary ore processing, the technology may enable value recovery from legacy mine tailings, addressing environmental liabilities while generating economic opportunity.

The path to commercialization is staged:

- Year 1: Proof-of-concept validation (TRL 2)
- Years 2–3: Laboratory-scale prototype (TRL 3–4)
- Years 4–6: Pilot demonstration
- Years 6–8: Commercial deployment

Intellectual property generated during this effort will form the basis for licensing or industry partnerships, strengthening Idaho's innovation ecosystem.

8. Criteria for measuring success

Include metrics by which project success and economic impact will be measured. Progress towards these measures will be required as part of awarded proposals reporting requirements. Metrics must be specific, objective, measurable, and realistic. Each metric must be measurable during the annual reporting period.

Project success will be measured through clearly defined outcomes:

- Demonstrated selective lithium extraction ≥70%
- Impurity co-extraction ≤1%
- Lithium carbonate purity ≥99.5%
- Submission of at least one invention disclosure
- Submission of at least one federal proposal
- Draft of one peer-reviewed manuscript

These metrics are achievable within the proposed 12-month period and provide objective indicators of advancement along the TRL continuum.

9. Briefly describe anticipated development challenges/barriers

Technical challenges include mineralogical complexity, electrochemical selectivity, mass transport limitations, and electrode stability under high-temperature molten salt conditions. Lithium must be liberated without mobilizing Al-, Si-, or Fe-bearing species. Selective Li^+ recovery requires operation within a narrow electrochemical window. Diffusion and interfacial kinetics may limit efficiency, and electrode materials must resist corrosion. These challenges primarily involve process optimization rather than fundamental feasibility. Systematic thermodynamic modeling, electrochemical mapping, and materials characterization will define operational boundaries and mitigate technical risk.

10. Budget Table

LINE ITEM REQUEST	JUSTIFICATION	TOTAL REQUEST
Personnel (salary and fringe)	200 hours summer salary for PI; Graduate student regular semester and summer hours	52,000
Equipment	Molten Salt reactor	12,000
Travel	Conference Travel	5,000
Participant Support		0
Other Direct Costs	Materials, shipping, analysis, publication	21,000
		90,000

11. Budget Justification

The explanation of costs indicated in the budget above is as follows: Personnel Costs (salary and fringe): PI Haiyan Zhao will spend 200 hours exclusively on this project. One graduate student will execute the project tasks for 12 months. The student's salary is calculated at $26 per hour for 20 h/week during the fall and spring semesters (a total of 39 weeks). The students will work 40 h/week for 13 weeks in the summer. Therefore, $33,800 is requested for the student. FY26 fringe rates are as follows: Faculty: 29.5%; and Students: 3.2%. Funding is requested to purchase a 1000C Molten Salt Reactor with Three-electrode system at a cost of approximately $12,000 for the lab scale testing. Travel funding $5000 is requested for the PI and graduate student to attend one domestic-based conference to disseminate research outcomes best related to research – mining, chemistry. Other direct costs include supply costs of $4,500, publication costs of $1000, graduate students' tuition ($11577 per student per year), and health insurance ($1206 per semester per student, total $ 2412) for 1 student over 2 semesters.

12. Project Management Structure

The project will be led by PI: Haiyan Zhao**,** who will provide overall scientific leadership, budget oversight, reporting to HERC, and coordination of laboratory activities. The PI will supervise graduate students and work on all thermodynamic modeling, molten salt experimentation, and electrochemical testing. Co-PI: Travis McLing will consult for clay ore geochemistry, and Idaho-relevant resource evaluation. The Co-PI will oversee ore selection, mineralogical analysis, interpretation of phase transformation behavior and mentor students. Lithium Americas will provide carbonate rich ore samples for proof-of-concept testing.

Management approach includes:

- Biweekly internal meetings to track experimental progress.
- Quarterly milestone reviews aligned with TRL advancement.
- Data management plan with centralized documentation of modeling, electrochemical, and characterization results.

- Risk mitigation checkpoints at the end of each phase to refine operating parameters.

The PI retains primary authority for technical and budgetary decisions, ensuring streamlined coordination and accountability.

Table 1: Gantt chart for the project timeline

Tasks	**Months 1–3**	**4–6**	**7–9**	**10–12**	**Milestone**
Thermodynamic Modeling	■				**Feasible salt window defined**
Electrochemical Window Mapping	■				**Selective Li potential range**
Clay–Salt Structural Studies		■			**Lithium activation confirmed**
Cell Construction		■			**Lab cell operational**
Lithium Extraction Testing			■		**≥70% extraction**
Impurity Suppression Optimization			■		**≤1% co-extraction**
Li_2CO_3 Conversion & Purity Testing				■	**≥99.5% purity**
Invention Disclosure				■	**Disclosure submitted**
Federal Proposal Submission				■	**Proposal submitted**

Key Development Milestones

- **Month 3:** Defined thermodynamic feasibility
- **Month 6:** Lithium activation confirmed in molten salt
- **Month 9:** Demonstrated selective electrochemical lithium extraction
- **Month 12:** Produced ≥99.5% Li_2CO_3 and submitted invention disclosure

This structured management plan ensures measurable progress toward TRL 2 within 12 months.

13. Additional institutional and other sector support

Institutional Support – University of Idaho

The University of Idaho provides substantial in-kind infrastructure support, including:

- Access to high-temperature furnaces and molten salt handling systems
- Electrochemical workstations for cyclic voltammetry and controlled-potential studies
- X-ray diffraction (XRD) and SEM/EDS facilities
- Graduate research assistant support infrastructure
- Laboratory space within Chemical and Biological Engineering

No new building construction is required. Existing facilities are fully capable of supporting proof-of-concept validation.

The university also provides:

- Proposal development assistance
- Technology transfer and patent support through the Office of Research and Economic Development
- Industry partnership facilitation

National Laboratory Collaboration

Collaboration with **Idaho National Laboratory (INL)** provides:

- Technical consultation in high-temperature electrochemical systems
- Potential access to advanced characterization tools
- Strategic alignment with DOE Critical Materials priorities

This collaboration strengthens scalability and federal funding competitiveness.

Industry Engagement

Preliminary discussions with lithium sector stakeholders (including Lithium Americas) support:

- Access to representative clay ore samples
- Industrial feedback on scalability
- Guidance on impurity tolerance limits for battery-grade materials

External partners will serve as technical advisors and future pilot-scale collaborators.

14. Future funding

Upon successful TRL 2 validation, applications will be submitted to:

- DOE–EERE (Battery Materials Processing, Critical Materials Innovation)
- DOE Critical Materials Institute
- ARPA-E transformational mineral processing programs
- NSF EPSCoR Research Infrastructure Improvement
- Industry cost-share partnerships for pilot-scale development

REFERENCE:

1. International Energy Agency. *Global EV Outlook 2023: Catching Up with Climate Ambitions*; International Energy Agency: Paris, France, 2023.
2. U.S. Department of Energy. *Critical Materials Assessment 2023*; U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy: Washington, DC, 2023.
3. U.S. Geological Survey. *Mineral Commodity Summaries 2024: Lithium*; U.S. Geological Survey: Reston, VA, 2024.
4. Kesler, S. E.; Gruber, P. W.; Medina, P. A.; Keoleian, G. A.; Everson, M. P.; Wallington, T. J. Global Lithium Resources: Relative Importance of Pegmatite, Brine and Other Deposits. *Ore Geology Reviews* **2012**, *48*, 55–69. https://doi.org/10.1016/j.oregeorev.2012.05.006.
5. Meshram, P.; Pandey, B. D.; Mankhand, T. R. Extraction of Lithium from Primary and Secondary Sources by Pre-Treatment, Leaching and Separation: A Comprehensive Review. *Hydrometallurgy* **2014**, *150*, 192–208. https://doi.org/10.1016/j.hydromet.2014.10.012.
6. Swain, B. Recovery and Recycling of Lithium: A Review. *Separation and Purification Technology* **2017**, *172*, 388–403. https://doi.org/10.1016/j.seppur.2016.08.031.
7. Guggenheim, S.; Martin, R. T. Definition of Clay and Clay Mineral: Joint Report of the AIPEA Nomenclature and CMS Nomenclature Committees. *Clays and Clay Minerals* **1995**, *43*, 255–256. https://doi.org/10.1346/CCMN.1995.0430213.
8. Bard, A. J.; Faulkner, L. R. *Electrochemical Methods: Fundamentals and Applications*, 2nd ed.; John Wiley & Sons: New York, 2001.
9. Sundheim, B. R., Ed. *Fused Salts*; McGraw-Hill: New York, 1964.
10. White, R. E.; Botte, G. G. Electrochemical Engineering in Molten Salt Systems. *Electrochimica Acta* **2005**, *50*, 5198–5208. https://doi.org/10.1016/j.electacta.2005.02.099.

Appendix A: Facilities and Equipment

University of Idaho, Idaho Falls

The 5,000 m^2 Critical Minerals and Energy Systems Innovation Center (CMESIC) supports characterization, laboratory-scale experimentation, modeling, and analytical validation. Key capabilities include advanced visualization and data interpretation through the Applied Visualization Laboratory (AVL); high-resolution mineralogical and microstructural characterization via the Microscopy and Characterization Suite (MaCS) and UI Electron Microscopy Center. Three-electrode electrochemical cells within argon atmosphere gloveboxes (MBraun, Labmaster 200G) both regular and radiological work are available for molten salts handling, and electrochemical measurements at Radiochemistry Laboratory CMESIC. A Kerr lab electric furnace (Auto Electro Melt Maxi) was used for heating up and keeping the high temperature molten salt over 1000 °C. One potentiostat (Princeton Applied Research models) is available to interface with experiments in the argon glovebox for electrochemistry measurement with up to 2 A current. The current can be boosted up to 10 A with the booster from PAR. This equipment has been used recently for electrolytic reduction of metal oxides in molten $LiCl-Li_2O$. The same setup within normal air has been used for the corrosion study in molten $K_2CO_3-Li_2CO_3$ using AC and DC electrochemistry techniques. A Gamry potentiostat is available for normal atmosphere electrochemistry measurement.

In addition, UI has more than 500 ft^2 office space available equipped with more than 40 computers. Dr. Zhao also runs the chemistry and materials lab in University of Idaho, Idaho Falls campus which has more 3000 ft^2 lab space, where Dr. Zhao has a TGA/DSC3+ from Mettler Toledo for high temperature measurement up to 1600 °C with gas delivery system for in situ studies, interfaced with the infrared equipment (PerkinElmer, Frontier) for gas phase monitoring.

Appendix B: Biographical Sketches

IDENTIFYING INFORMATION:

NAME: Zhao, Haiyan

ORCID iD: https://orcid.org/0000-0002-8585-0113

POSITION TITLE: Associate Professor

PRIMARY ORGANIZATION AND LOCATION: University of Idaho, IDAHO FALLS, ID, United States

Professional Preparation:

ORGANIZATION AND LOCATION	DEGREE (if applicable)	RECEIPT DATE	FIELD OF STUDY
Argonne National Laboratory, Lemont, Illinois, United States	Postdoctoral Fellow	07/2010 - 07/2013	X-ray Science Division
Virginia Tech, Blacksburg, VA, United States	PHD	05/2009	Chemical Engineering
Tsinghua University, Beijing, Beijing, China	MS	07/2003	Chemical Engineering
Tianjin University, Tianjin, Tianjin, China	BS	07/2000	Chemistry

Appointments and Positions

2020 - present Associate Professor, University of Idaho, IDAHO FALLS, ID, United States
2014 - 2020 Assistant Professor, University of Idaho, Idaho Falls, ID, United States
2013 - 2014 Assistant Chemist, Argonne National Laboratory, Lemont, IL, United States
2003 - 2004 R&D Engineering, Wison Chemical Engineering Company, Shanghai, Not Applicable, N/A, China

Products

Products Most Closely Related to the Proposed Project

1. Engmann E, Diaz L, Lister T, Zhao H. Aqueous Electrochemical Processing Of Rare Earth Elements. In: Karamalidis A, Eggert R, editors. Rare Earth Elements [Internet] 111 River Street, Hoboken, NJ 07030, USA: WILEY; 2024. Chapter 7 Available from: https://doi.org/10.1002/9781119515005.ch7
2. Engmann E, Diaz L, Lister T, Atifi A, Palasyuk O, Zhao H. Selective pseudocapacitive immobilization of REE elements on carbon-based electrodes. Electrochimica Acta. 2024; 478:143860. Available from: https://doi.org/10.1016/j.electacta.2024.143860
3. Engmann E, Diaz L, Lister T, Palasyuk O, Zhao H. Electrochemistry of Praseodymium in Aqueous Solution Using a Liquid Gallium Cathode. Journal of electrochemical Society. 2022; 169:63519. Available from: DOI: 10.1149/1945-7111/ ac76e3
4. Herrmann S, Zhao H, Shi M, Jones M, Patterson M. Halogenation of used aluminum matrix test reactor fuel – a bench-scale demonstration with surrogate materials. Journal of nuclear science

and technology. 2022; 59(3):395-406. Available from: DOI: 10.1080/00223131.2021.1974595

5. Herrmann S, Westphal B, Li S, Zhao H. Parametric Study of Used Nuclear Oxide Fuel Constituent Dissolution in Molten LiCl-KCl-UCl3. Nuclear Technology. 2022; 208(5):871-891. Available from: DOI: 10.1080/00295450.2021.1973180

Other Significant Products, Whether or Not Related to the Proposed Project

1. Shi M, Li S, Zhao H. High-Temperature Reference Electrodes for Electrochemical Measurements in Molten Li2O/LiCl Salts. Electrochimica Acta. 2025; 541. Available from: https://doi.org/10.1016/j.electacta.2025.147377
2. Shi M, Li S, Zhao H. Electrolytic Reduction of Titanium Dioxide in Molten Li2O/ LiCl. Electrochem. 2021; 2(2):224-235. Available from: https://doi.org/10.3390/electrochem2020016
3. Shi M, Jiang J, Zhao H. Electrodeposition of Aluminum in the 1-Ethyl-3-Methylimidazolium Tetrachloroaluminate Ionic Liquid. Electrochem. 2021 February; 2(2):189. Available from: https://doi.org/10.3390/electrochem2020013
4. Shi M, Li S, Zhao H. High Current Efficiency of NiO Electro - reduction in Molten Salt. J. Electrochem. Soc.. 2018; 165(14):E768. Available from: doi: 10.1149/2.0781814jes
5. Li R, Wang L, Li L, Yu T, Zhao H, Chapman KW, Wang Y, Rivers ML, Chupas PJ, Mao HK, Liu H. Local structure of liquid gallium under pressure. Sci Rep. 2017 Jul 18;7(1):5666. PubMed Central PMCID: PMC5515953.

Certification:

I certify that the information provided is current, accurate, and complete. This includes but is not limited to information related to domestic and foreign appointments and positions.

I also certify that, at the time of submission, I am not a party to a malign foreign talent recruitment program.

Misrepresentations and/or omissions may be subject to prosecution and liability pursuant to, but not limited to, 18 U.S.C. §§ 287, 1001, 1031 and 31 U.S.C. §§ 3729-3733 and 3802.

Certified by Zhao, Haiyan in SciENcv on 2025-11-29 17:15:07

NSF BIOGRAPHICAL SKETCH **OMB-3145-0058**

NAME: Travis McLing

NSF ID:

POSITION TITLE & INSTITUTION: Chief Geologist & Directorate Fellow&Idaho National Laboratory

A. PROFESSIONAL PREPARATION

List undergraduate and graduate education and postdoctoral training. List the year the degree was received as well as inclusive dates of postdoctoral training. Institution name, Location, Major/Area of Study, Degree (if applicable), Year

INSTITUTION	LOCATION	MAJOR/AREA OF STUDY	DEGREE (if applicable)	YEAR (YYYY)
Idaho State University	Pocatello	Geology	B.S.	
Idaho State University	Pocatello	Geology	M.S.	
University of Idaho	Moscow	Geology	Ph.D	2017

B. APPOINTMENTS

List, in reverse chronological order, all academic/professional appointments beginning with the current appointment. Start/End Year of Appointment, Position Title, Organization, City, State, Country

From - To	Position Title, Organization and Location
1992-present	Research Scientist in Geology& Geochemistry, Idaho National Laboratory, Idaho Falls, ID
2017-2020	Carbon Storage Lead, Idaho National Laboratory, Idaho Falls, Idaho
2020-present	Chief Geologist & Directorate Fellow, Idaho National Laboratory, Idaho Falls, Idaho

C. PRODUCTS

Acceptable products must be citable and accessible including but not limited to publications, data sets, software, patents, and copyrights. Unacceptable products are unpublished documents not yet submitted for publication, invited lectures, and additional lists of products. Each product must include full citation information including (where applicable and practicable) names of all authors, date of publication or release, title, title of enclosing work such as journal or book, volume, issue, pages, website and Uniform Resource Locator (URL) or other Persistent Identifier.

Products Most Closely Related to the Proposed Project

1) McLing, T.L., Smith, R.W., & Johnson, T.M. "Chemical characteristics of thermal water beneath the eastern Snake River Plain." Special Paper of the Geological Society of America, 353: 205–211 (2002). 2) McLing, T.L., et al. "Decarbonizing aluminum production: Integrating high-temperature modular nuclear reactors for sustainable energy supply." Energy Conversion and Management: X, 28:101313 (2025).EGS Collab Team; 3) McLing, T.L., et al. "Characterizing hydraulic fracture formation during enhanced geothermal system experiments using coda waves." Leading Edge, 44(3):163–169 (2025).Neupane, G., 4) McLing, T.L., et al. "Estimating mineral scaling and porosity alterations during the circulation test at Utah-FORGE site using reactive transport modeling." Conference contribution (2025).Dobson, P., McLing, T.L., et al. "High-Temperature Aquifer Thermal Energy Storage (HT-ATES) Projects in Germany and the Netherlands—Review and Lessons Learned." Energies, 18(23):6

Other Significant Products, Whether or Not Related to the Proposed Project

McLing, T.L., et al. "Utilizing Rare Earth Elements as Tracers in High-TDS Reservoir Brines in CCS Applications." Energy Procedia (conference publication).McLing, T.L., et al. Groundwater tracers and subsurface characterization publications (various hydrogeology and geochemistry topics).

D. SYNERGISTIC ACTIVITIES

List up to five distinct examples that demonstrate the broader impact of the individual's professional and scholarly activities that focus on the integration and transfer of knowledge as well as its creation.

1.Leadership in Carbon Storage Research — Chair, Idaho Carbon Issues Task Force as part of the Idaho Governor's Carbon Sequestration Advisory Committee, guiding policy and technical strategy for carbon capture and storage in the region.
2. Program Development & National Partnerships — Leads geochemical modeling and field studies in carbon dioxide transport, mineralization, and natural analogue sites for carbon sequestration, in collaboration with DOE, Shell International Exploration, NETL, and regional energy alliances.

3. Geothermal Energy Innovation — Principal investigator on geothermal and subsurface energy storage research designed to integrate geological heat storage with power systems; programs funded by U.S. DOE Geothermal Technologies Office.

4. Workforce Mentorship — Engages with graduate students, postdoctoral researchers, and early career scientists through institutional research activities and professional collaborations (INL, CAES, university partners).
5. Professional Engagement — Member of professional societies including the American Geophysical Union (AGU), Geochemical Society, and Geothermal Research Council, supporting scientific community exchange and standards.