



SMRI Request for Proposal (RFP2023-02) **“Research on Microbial Induced Reactions in Hydrogen Salt Caverns”**

1. Background

With the increasing demand for hydrogen storage, it is necessary to anticipate the risks associated with microbial activity and the induced chemical reactions in underground hydrogen storage. While hydrogen may provide an effective energy carrier for use by mankind, it can also serve as an accessible energy source for microbial metabolism. In salt caverns, the reactions catalyzed by microorganisms such as sulfate-reducers can induce risks of loss of stored hydrogen, risks of gas pollution by hydrogen sulfide (H₂S) or risks of corrosion. To confirm the suitability of salt caverns as viable hydrogen storage sites, the expected proposal will investigate the microorganism’s population in salt caverns, measure the consumption of hydrogen and the production of H₂S by these microorganisms in brines under representative conditions, develop models that replicate this reactivity and predict the effect of hydrogen storage in a salt cavern and if possible, measure the gas quality at the outlet of existing H₂ caverns.

2. Scope of Work

Hydrogen is an electron donor used by various microorganisms living in anoxic subsurface environments. This microbial activity catalyzes the reduction of carbonates or carbon dioxide, sulfates or other sulfur species and ferric iron to produce acetate or methane, sulfides and hydrogen sulfide and ferrous iron. The reactions are called acetogenesis, methanogenesis, sulfate reduction and ferri-reduction. Our understanding of microbial hydrogen-consuming activities in salt caverns is currently limited and appears to vary depending on the site. However, initial findings indicate that sulfide-producing microorganisms are likely to be the primary active microorganisms in such environments. Given the presence of ample sulfate sources, the production of hydrogen sulfide is considered the main risk. The high salinity prevalent in salt caverns, nearing halite saturation, restricts the proliferation of microorganisms to rare and specific halophile species.

Studies investigating microbial communities in salt caverns have revealed their presence, and issues related to sulfur contamination of stored hydrocarbon products encountered in some instances suggest that microorganisms can pose a risk during storage. However, the extent of actual hydrogen consumption by these microorganisms at cavern scale remains unclear, and the impact, or lack thereof, of microbial activity in salt caverns is yet to be established. The main challenges lie in characterizing these microorganisms and quantifying their hydrogen consumption, as well as extrapolating laboratory-scale observations to real-world salt cavern conditions.

The scope of the work could include:

- Sample and characterize the microorganisms present in salt caverns. This including consideration of the potential origin of these microorganisms (e.g. imported via leaching fluid) and how does this change at different locations.
- Determine the location within the cavern (e.g. in the sump fluid or exposed on the cavern walls) where the microorganisms exist.
- Conduct hydrogen consumption & H₂S production experiments by the identified microorganisms under conditions representative of salt caverns. These experiments would be designed to monitor the chemical mass balance in the gas and brine and the evolutionary trends of bacterial populations over time.

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- Consideration should be given to the different temperature and pressure ranges which will occur in the cavern over its operating cycle to determine the impact of different operating ranges.
- If possible, the research could also be validated by observations in one or several of the existing Hydrogen storage caverns. This would be decisive to prove the validity of the proposed models and would give the salt cavern community reference examples of the impacts, or lack of, at cavern scale.
- Develop a reactive model, calibrated using data obtained from laboratory experiments and field scale data, and subsequently employed to predict the microbial and chemical effects of hydrogen within a salt cavern. Notably, the model would account for the scaling effects between laboratory-derived rates and the rates representative of the actual conditions prevailing in a salt cavern.

3. Proposal Instructions

Responses to this RFP should be reasonably brief (less than 10 pages), describe the proposed effort and offer a succinct discussion of the technical approach.

This RFP anticipates that a fixed-sum contract will be used, and a project schedule and cost plan will be submitted.

The qualifications and experience of the proposed researcher(s) in the technical field described within the Scope of Work are likely the most significant proposal-evaluation criteria.

Teaming and subcontracting to bolster qualifications are encouraged, but a strong lead researcher (project manager) must be identified in the proposal and will be named in the research contract as key personnel. The level of commitment of the lead researcher to the research effort must be itemized in the proposal.

Proposals should be submitted in electronic form via email to Tim Bauer, SMRI Research Coordinator, (tbauer@solutionmining.org), by 31 January 2024. Please email a statement of your interest or intentions to respond to this RFP before 29 December 2023, so you can receive any updates or modifications to this RFP. Questions relating to this RFP should be directed in writing (via email) to the Research Coordinator. Answers to questions that apply to all potential proposers will be forwarded to all identified proposers.

4. Contract Award and Contract Specifics

Proposals will be evaluated solely based on information contained in the proposal. The proposer selected for negotiation of a contract will be the one that best meets SMRI’s needs and is economically sound. SMRI has the right to select or reject any or all proposals.

The research contract will be negotiated between the selected contractor and SMRI. The contractor will be solely responsible for coordination of any subcontracted work and for all payments to any sub-contractor(s).

1. SMRI contract for this Work will be fixed sum for the defined statement of work. The proposed fixed-sum payment must be clearly defined in the proposal. Payment will be made upon acceptance by the Research Committee of the final research report. No other progress or interim payments would normally be made.
2. SMRI’s Project Sponsor will be named after contractor selection. The Project Sponsor will be the contact for any project-related communications.
3. The research project is to be completed within the time frame agreed on for the project.
4. The contractor shall present progress reports at each SMRI Research Committee meeting during the project and an oral research report at the end of the project. The costs for these presentations, if

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any, are to be included in the fixed-sum cost of the project. The Project Sponsor or Research Coordinator may present one of the two required progress reports per year to the Research Committee using materials (text and PowerPoint) prepared by the project team.

5. A final research report is required in the form of a standard scientific or technical report. The research report will provide standard information such as background and purpose for the research, theoretical basis and methods, data collected, analysis, references, and research conclusions. Depending on the amount of information used, either lists of information in appendices or separate electronic files of the information, or both, might be required. All report submittals (drafts-for-review and final) will be as electronic files, both MS-WORD (*.doc) and PDF (*.pdf). SMRI will supply formats/contents for its standardized report covers, title pages, and forward/disclaimer for its research reports. The research report will be reviewed by the Project Sponsor, the Research Coordinator, and the Research Committee. Before final report acceptance, the researchers must satisfactorily address all review comments.
6. The enclosed Standard Terms and Conditions for SMRI Research Contracts, dated 3 January 2023, shall apply. Additional limitations or modifications are possible before contract negotiation.
7. SMRI retains ownership and copyright of the work products resulting from this research. Limitations on publishing and release of information are listed in the Terms and Conditions.

Tim Bauer
Research Coordinator

Enclosures:

Standard Terms and Conditions for SMRI Research Contracts, dated 3 January 2023

Cc: John Nadeau, Executive Director
Andreas Reitze, 2023 SMRI President
Daniel Noack, 2023 SMRI Research Chairman
Members of the SMRI Research Committee

SMRI RFP2023-02_Microbial Induced Reactions in H2 Salt Caverns.pdf

ATTACHMENT
STANDARD TERMS AND CONDITIONS



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Standard Terms and Conditions for SMRI Research Contracts **3 January 2023**

1. The contractor shall perform the scope of work and submit the contract deliverables specified in the Request for Proposals (RFP) and the contractor's proposal. If differences exist between the RFP and the contractor's proposal, the RFP shall govern, unless otherwise specified in the contract. All written or electronic communication regarding the research is to be in English.
2. The SMRI Project Sponsor(s) will provide technical oversight to include review of project plans, will assist in resolution of any technical issues which might impact the project or research results, will approve contractor progress reports, and will review all invoices for accuracy.
3. During the project, progress reports may be given by the contractor during Research Committee meetings generally on the Saturday before SMRI conferences begin, or the brief progress reports must be given to the Project Sponsor prior to the Research Committee meetings for informing the Committee.
4. After the first draft report is approved by SMRI's Research Committee, SMRI will provide a report number, a cover page, a disclaimer regarding the report contents, and a copyright notice which will become part of the final report. A filename and format will then be designated for the final report. All draft and final versions of the research report must include the date at the end of the filename
5. The final report shall be provided in electronic format in Adobe Acrobat word searchable (.pdf) format. The electronic report may consist of text, figures, tables, maps, data files, etc. Reports in electronic format may contain color, (such that colors will print visibly in black and white). Files too large for email attachment may be sent to SMRI via an FTP site.
6. The final results of the research shall be presented in a 30-minute oral report at an SMRI meeting. The report may, at the discretion of SMRI, be at a members-only meeting, or as part of a technical conference. Any and all costs associated with the presentation are part of the contract and included in the contractor's proposal.
7. Upon SMRI acceptance of the final report, the Contractor shall send an invoice electronically to the SMRI Executive Director, Assistant Executive Director, Research Coordinator, Project Sponsor, and copy to accounting@solutionmining.org for approval and payment.
8. SMRI owns the copyright and has the sole right to distribute the report and research products in all versions and formats, including the right to charge for it. The Contractor may distribute the report without charge within the Contractor's organization.
9. SMRI has the right to cancel the contract for any reason and at any time. Should SMRI elect to do so, it shall reimburse the contractor for all costs incurred through the cancellation, unless the cancellation is due to inadequate or late performance.
10. SMRI will not pay any costs or reimburse any expenses not specifically included in the contract. Any changes to the contract must be approved in writing by SMRI and the researcher prior to such additional work or expense. Full costs of the project will be paid by SMRI upon acceptance of the final report by the Research Committee, unless partial payments are specified in the proposal and contract.