The Economic Potential of Saline Geofluids

Overview
The Net Zero energy transition will place unprecedented demand on natural resources, both as a means of generating renewable energy and as sources of raw materials required for generation, storage and transmission of electricity. The necessary speed of the transition calls for new thinking about where to explore for and how to recover natural resources. One potential new resource, for both renewable energy and critical metals, is saline geofluids, such as those present in geothermal systems, volcanic hot springs and saline aquifers.

Saline geofluids are variably enriched in a very wide variety of elements, from base and precious metals to critical metals and metalloids that are essential for batteries and electric vehicles. The elevated temperatures of these fluids also endow them with geothermal energy that can be co-recovered with the metals either as a local source of green electricity or as a valuable by-product that can be used for metals recovery and processing. To date, commercial co-recovery of metals and energy from geofluids reservoirs is limited to lithium and silica from high-temperature geothermal systems in the USA and New Zealand. However, geothermal fluids are just one category of saline geofluids; others, such as volcanic hot springs, brines from sedimentary basins and saline aquifers, have received much less attention as sources of metals. Ultimately, the economic viability of geofluids is a complex interplay of their metal concentration, fluid production rates, and the cost of recovering their metals. For example, higher fluid production rates and lower processing costs may compensate for lower temperatures and metal endowments; wastewater from seawater desalination plants represents a hypothetical cold, dilute end-member, while magmatic brines from volcanoes represents a hot, metal-rich end-member (see schematic figure). In principle, for each metal there is a potential economic ‘sweetspot’ along the resource continuum. By virtue of their ubiquity and relative ease of discovery and extraction, saline geofluids represent a novel, global opportunity in the drive to Net Zero.

This interdisciplinary, fully industry-funded studentship will explore the saline geofluid resource landscape by integrating information on geofluid chemistry temperature and abundance with technological understanding of how metals can be extracted from fluids. This information will be used to construct geofluid databases that can then be interrogated to identify ‘sweetspots’ in terms of energy and metals production for different types of saline geofluid reservoirs. Extant methods for metals processing will be reviewed, alongside exploration of emergent technologies. An important technical aspect is the optimum strategies for metals recovery; to this end the student will be expected to undertake some exploratory laboratory work in this area in the later stages of the project. Key geopolitical, economic, environmental and local impediments to the extraction of metals from saline geofluids will be considered. The final question is the extent to which different saline geofluid reservoirs have commercial potential, both locally and globally, for co-recovery of metals and energy alongside some preliminary laboratory-tested metals recovery strategies.
Methodology

The project will take a multidisciplinary approach to this complex, ground-breaking new resource frontier. Although there is an emerging recognition of the potential of high temperature geothermal fluids as a source of metals, there has been no assessment of the potential for metals recovery across the entire spectrum of saline geofluids that simultaneously takes account of fluid production rates and metals recovery costs. The first step in undertaking such an assessment is construction of a database of geofluid chemistry, building upon and integrating existing databases of geothermal fluids, saline aquifers and reservoir production fluids.

Review of the state of the art in metals recovery from different types of saline geofluids, including critical assessment of opportunities and impediments is an important step in evaluating economic potential. This technological dimension will require extensive review of the literature and engagement with chemical engineers. A component of laboratory work, looking at specific metals recovery from selected geofluids is expected at this stage, informed by the findings of the first phase of the project.

Finally, the economic potential of saline geofluids will need to be evaluated in a global context that takes into account the distribution of geofluid reservoirs, the relevant capital costs and risks associated with their access, and the competitiveness of this approach relative to conventional mining. The cost benefits of energy co-recovery need also to be considered.

Timeline

**Year 1**: Literature survey and preparatory coursework. Design of database for geothermal fluids and initial database assimilation and construction.

**Year 2**: Completion of geochemical database. Critical assessment of technologies for metals recovery and processing. Assessment of economic opportunities and barriers in a global context.

**Year 3**: Design and execution of preliminary laboratory experiments to recover selected metals from geofluids. Visit to geothermal sites in Japan and/or New Zealand. Presentation of results at World Geothermal Congress or similar international conference.

**Year 4**: Summary of metals recovery strategies for different metals and different types of geofluids. Identification of economic opportunities and risk. Writing up.

Training & Skills

The project requires a wide skill set and an ability to think across disciplines. Although a good knowledge of chemistry, quantitative skills and a familiarity with laboratory work as essential skills, it is unlikely that any potential students will have expertise across this wide area; training will aim to fill gaps in knowledge and skills. For example, the student might take a graduate-level course in database construction. They may follow other courses in earth sciences, chemical engineering (e.g. undergraduate classes in separation or interfacial chemistry) and economics (e.g. final-year undergraduate class in environmental economy or PhD level courses offered by the European Association for Environmental and Resource Economists).

The student will be based in Earth Sciences but will also learn through regular project meetings with the supervisors in all three departments, as well as interaction with the sponsor organisation. A key focus will be on effective integration of scientific thinking across traditional discipline boundaries.

Other courses on professional skills, including scientific writing and illustration for publication, are available through the University. Attendance is encouraged.

Further Reading


Further Information

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