SEG 2024 Conference: Sustainable Mineral Exploration and Development

Hard Rock-Hosted Lithium Deposits: A Process-Centric Review

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Secure lithium supply is critical to meeting the energy storage demands of the energy transition. Lithium exploration has ramped up over the past decade in response to surging demand and has prompted exploration and development of lithium resources in various geological settings, including granites, pegmatites, clays, salars, and unconventional brine aquifers.

Despite the diversity of environments in which lithium accumulates, salars and hard-rock systems (such as pegmatites) remain the principal sources of commercial lithium concentrate. Hard-rock systems are likely to remain a key source of lithium, as they are widely distributed within permissive jurisdictions to mining. Hard-rock mining also utilises conventional mining and processing techniques, offering relatively low risk to explorers and investors.

Lithium exploration concepts have needed to evolve rapidly in recent years in response to increased interest from explorers. To date, a limited sample set of hard-rock lithium deposits have been studied in detail, many of which were originally investigated with an emphasis on other commodities such as tin. This historical research base, which has underpinned the understanding of hard-rock systems until recently, leads to a risk of bias within geological interpretations and exploration approaches.

Here, we review a range of hard-rock lithium deposits, including those currently being mined and others under development. We present a process-focused analysis of lithium systems that is driven by a mineral systems approach and review each system within this context. We consider three critical processes that lead to lithium concentration within the crust: partial melting, assimilation of crustal material, and fractional crystallisation. All deposits reviewed in this study involve at least one of these processes within their formation, but most represent a hybrid case. This work offers a holistic lens through which to view lithium mineral systems and introduces novel concepts with which to explore hard-rock lithium systems.