Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.36271

Geochemical Insights into Metallic (Mo, V) and Metalloid Oxyanions (Se, As, Ge, Si) behavior in Hydrothermal Fluids and Hypersaline Lakes (Asal-Abhé, Djibouti)

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The study of the accumulation of critical elements in the Earth surface is important for both exploration of new resources and the development of environmental management strategies. In this study, we investigated for the first time the (i) metallic and metalloid oxyanions (Se, V, As, Mo) and (ii) germanium/silica (Ge/Si) ratios from hot springs, hypersaline and hyperalkaline lakes, the Asal and Abhé, both located in a continental rift setting (Djibouti). Oxyanion-forming elements such as Se, V, As, and Mo exhibit contrasting mobility that is strongly controlled by pH and redox conditions (Eh), which in turn govern their speciation in surface environments. The Ge/Si ratio is a geochemical tracer widely used to determine the origin of dissolved silicon, contrasting the behavior of Ge and Si during water-rock interaction processes. Three main results are presented : (1) comparison of salinity-normalized concentration profiles from the Lake Asal water column with nearby seawater and hot springs reveals a relative depletion of Se, V, As and Mo in the lake water after correcting for evaporation effects, highlighting significant sequestration in lacustrine sediments; (2) Lake Abhé, which is fed solely by river inflow and groundwater/geothermal springs, exhibits very contrasting patterns with 100 to 1000 fold enrichment of oxyanion forming elements compared to Lake Asal, in particular V (up to 10 mM), As (up to 3 mM) and Mo (up to 26 mM) prompting for further ecotoxicological studies; (3) Compared to typical marine and riverine Ge/Si values ranging below 1 mmol/mol, Lake Asal and Lake Abhé yielded Ge/Si of about 6 and 16 mmol/mol respectively, suggesting significant hydrothermal/geothermal origin of both Ge and Si. This interpretation is further supported by the measured Ge/Si ratios in nearby hot springs, ranging from approximately 11 to 25 µmol/mol. Ongoing Mo, Se, and Ge isotope studies will help to establish a more robust isotopic mass balance of environmentally relevant oxyanions in these extremely arid systems.