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Origins of the Mg/Li ratio in closed-basin brines of the Lithium Triangle: the relative importance of high- and low-temperature water-rock interactions

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The Mg/Li ratio is commonly applied as a screening metric for lithium-brine development, yet the geochemical processes responsible for its wide variability remain incompletely understood. In the Lithium Triangle of the Central Andes, Mg/Li ratios in closed-basin brines range from <1 to >500, even among basins with broadly similar lithology, geochemical evolution, and major-ion compositions. Here we consider the origins of the Mg/Li ratio in inflow waters and what processes modify this ratio as waters evolve into hypersaline brines. We synthesize geochemical data from 577 spring waters and 1,078 brine samples spanning more than 100 closed basins to evaluate the origin of this variability. Our results indicate that Mg/Li ratios in inflow waters are fundamentally established by the temperature of water-rock interaction. High-temperature geothermal systems preferentially remove Mg into secondary minerals, generating low Mg/Li fluids, a well known process, whereas low-temperature near-surface interactions produce higher Mg/Li ratios that approximate source-rock compositions. At the basin scale, brine Mg/Li values represent mixing-weighted integration of these distinct thermal endmembers. Although evaporation and mineral precipitation strongly increase solute concentrations, they typically exert limited control on Mg/Li ratios under the circumneutral conditions characteristic of most Lithium Triangle brines. In contrast, alkaline systems constitute important exceptions: Mg-silicate precipitation selectively removes Mg, overprinting the original inflow signature. These findings demonstrate that Mg/Li ratios primarily record the integrated thermal history of solute sources rather than evaporative evolution alone. This framework improves interpretation of Mg/Li as an exploration indicator and provides broader insight into the geochemical evolution of continental brine systems.