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Thermodiffusion (Ludwig-Soret Effect) in Geological Systems¹

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Since its discovery more than a century and a half ago, the Ludwig-Soret effect (development of concentration gradients in response to a temperature gradient) has been documented in a large variety of inorganic and organic solutions, and exploited as an industrial tool for chemical and isotopic refinement. Theoretical treatments are numerous based on kinetic and thermodynamic principles, but none adequately explains the phenomenon operating in complex naturally occurring fluids. In the geological sciences, the Ludwig-Soret effect has received extraordinary attention as an agent for small (and large) scale chemical differentiation and a probe of fundamental fluid properties of the Earth's hydrosphere, and silicate (crust-mantle) and alloy (core) interior. In particular, silicate liquids show significant isotope fractionation by thermodiffusion at temperatures greatly exceeding those where equilibrium fractionation effects are vanishingly small, and this can persist to lower temperatures even with concomitant crystallization. We review these recent findings and present new experimental work on silicate and Fe(FeS) melts, considering the underlying causes towards reconciling observed mass-dependent isotope and mass-independent chemical effects.

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