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Methylthiolated arsenic species in geothermal water environments: formation paths and transport properties

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Geothermal systems could be a significant source of environmental arsenic, with methylthiolated arsenates potentially representing a critical yet understudied arsenic species in geothermal water environments. Compared to non-thiolated or non-methylated arsenic species, methylthiolated arsenates generally exhibit higher toxicity and mobility. However, their distribution and behavior in natural water environments, including geothermal waters, remain poorly characterized.

Two pathways are hypothesized for methylthiolated arsenic formation. The first, involving methylation followed by thiolation, is widely accepted. Conversely, the reverse sequence (thiolation preceding methylation) lacks validation, primarily due to analytical challenges in quantifying thioarsenites. Intriguingly, the detection of methylthiolated arsenates in neutral-to-alkaline hot springs, rapidly recharged by shallow, high-temperature reservoirs, supports the feasibility of the second pathway in these settings.

Once released into hot spring ecosystems, methylthiolated arsenates demonstrate reduced adsorption to sediments compared to other arsenic species. This low affinity may enable their long-distance transport via fluvial systems, potentially driving large-scale arsenic cycling. To address knowledge gaps, future research in arsenic geochemistry should prioritize quantifying the environmental transport, fate, and regional-to-global ecological impacts of methylthiolated arsenic species.