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Arsenic enrichment in geothermal groundwater: an insight from lithium and boron isotopes

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Naturally occurring high arsenic (As) groundwater (>10 μg/L) distributes around the world, which is a threat to human health. Geothermal groundwater is generally enriched with high As induced by geothermal conduction. However, contribution of geothermal conduction to dissolved As concentrations in groundwater still keeps poorly understood. To quantify the contribution of geothermal conduction to As enrichment, isotopic compositions of boron ($\delta^{11}B$) and lithium ($\delta^{7}Li$) in groundwater from the middle-Pliocene aquifer (Pliocene-GW) were investigated in Guide Basin. Results turned out that As concentration in Pliocene-GW varied from 11.6 to 356 μg/L, and $\delta^{11}B$ values and $\delta^{7}Li$ values in Pliocene-GW ranged from -8.03‰ to 12.9‰ and from 16.3‰ to 19.3‰, respectively. Most of $\delta^{11}B$ values in Pliocene-GW were in the range of $\delta^{11}B$ values in groundwater affected by silicates weathering, and $\delta^{11}B$ values in Pliocene-GW was negatively correlated with the calculated reservoir temperature. $\delta^{7}Li$ values in Pliocene-GW was negatively correlated with Li/Na^{+}, and increased along with Pliocene-GW flow path, both of which suggest that long Pliocene-GW residence time in aquifer is responsible for high $\delta^{7}Li$ due to adsorption and precipitation of ^{6}Li. Elevated As concentration was observed along the Pliocene-GW flow path, implying that the long Pliocene-GW residence time in aquifer is conducive to dissolved As accumulation in groundwater. Additionally, higher concentration of As was observed with lower $\delta^{11}B$ values in Pliocene-GW, indicating that elevated reservoir temperature is responsible for high As in groundwater. Pliocene-GW samples with similar $\delta^{7}Li$ values, referring to about the same residence time of Pliocene-GW in aquifer, were divided into three groups, including Group I, Group II and Group III, according the reservoir temperature ($\delta^{11}B$ values). Arsenic of samples in Group III with high $\delta^{11}B$ values was assumed to be released from original groundwater-rock interactions without the affection of geothermal conduction. There were averagely 86.9% and 51.5% As released from the groundwater-rock interactions induced by geothermal conduction in samples of Group I and Group II, respectively. This study quantified the contribution of geothermal conduction to As accumulation in groundwater based on isotopic method.