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The lithological and hydrochemical controls on the heterogeneity in magnesium isotope of groundwater in a sandstone aquifer

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Abstract

As a major element in water, Mg isotope is an ideal proxy for studying the geochemical processes of water cycle because of the significant fractionation of Mg isotope affected by low temperature geochemical processes (Teng et al., 2007). There are numerous studies on the Mg isotope of river water and soil water, but little on the behavior of Mg isotope in groundwater. In a sandstone aquifer in the Ordos Basin, China, the δ^{26}Mg values of shallow groundwater in recharge areas range between -1.29‰ and -1.07‰, which is within the range of widely values in groundwater (Jacobson et al.,2010; Immenhauser et al.,2010; Tipper et al., 2012a,b; Geske et al.,2015; Ma et al.,2015), while the δ^{26}Mg values of deep groundwater in discharge areas ranges between -2.13‰ and -3.3‰, which are much lower than frequently observed δ^{26}Mg values of water. This phenomenon implies that there are complicated geochemical processes in deep groundwater in discharge areas, which are different from shallow groundwater in recharge areas. With the aid of $^{87}Sr/^{86}Sr$ ratios, it has been found that dissolution of calcite in the sandstone contributes partly to the lower δ^{26}Mg values. The significant negative correlation between δ^{26}Mg values and Mg^{2+} indicates the adsorption by clay minerals in deep groundwater with long residence times also contributes to the lower δ^{26}Mg values. For 8 deep groundwater samples, the relationship between δ^{26}Mg values and Mg^{2+} has been quantitatively explained by the superposition of dissolution of calcite and adsorption by clay minerals. However, for the other 4 deep groundwater samples, in addition to the controls by dissolution and adsorption, the process of decarbonation during the upward flow of deep groundwater, which causes precipitation of carbonate, leads to rises in δ^{26}Mg values and further decreases in Mg^{2+}. This study suggests strong lithological and hydrochemical controls on the Mg isotopic composition of groundwater, which leads to heterogeneity of magnesium isotope of groundwater.

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