

## **Content and Patterns of Rare Earth Elements in Groundwater, Surface Soil and Carbonate Rocks from Karst Underground River System**

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### **Methods**

The REEs of groundwater, surface soil and Carbonate Rocks, by Inductively Coupled Plasma Mass Spectrometry (ICP-MS) have been analysed.

### **Discussion of Results**

The results indicate that the total rare earth elements ( REEs ) contents of soil ranged from 117.82 to 451.98 $\mu\text{g/g}$ , averaging 312.30 $\mu\text{g/g}$ . The spatial distribution of REE had medium differentiation. The mean value of LREE/HREE was 7.86, which was close to 7.47 of the North American Shale. The shale Northern American Shale Composite ( NASC )-normalized REEs patterns display light rare earth element is enriched relative to heavy rare earth element, with negative Ce anomalies and negative Eu anomalies. The negative Ce, Eu anomalies and parent rocks have a certain correlation. Although the mother rock decides the initial content of rare earth elements in soil, but the content is also affected by other factors. Water chemistry indicators and rare earth elements (REEs) analysis had been carried out for groundwater from Zhaidi underground river. The results indicate that the total rare earth element ( REE ) contents of groundwater are low, most of the water point enriches in HREEs relative to LREEs. The low concentration of  $\Sigma\text{REE}$  are unrelated to pH and Eh,  $\text{HCO}_3^-$  and  $\text{Ca}^{2+}$  have the same effect on the total REE concentration. The enrichment of HREEs can be attributed to the pH of groundwater. The data normalized according to Northern American Shale Composite ( NASC ) exhibit a REE pattern with negative Ce anomalies and positive Eu anomalies for most of groundwater samples. The negative Ce anomalies and Mn, Fe have a certain correlation, the positive Eu anomalies are related to oxidation-reduction condition. There are differences in the enrichment and fractionation of rare earth elements between underground river subsystem and karst spring subsystem in the underground river system. The results indicate that the total rare earth elements ( REEs ) contents of carbonate rock are low, There are differences in the concentrations of rare earth elements between carbonate rocks of different strata. The shale Northern American Shale Composite ( NASC )-normalized REEs patterns display heavy rare earth element is enriched relative to light rare earth element, with negative Ce anomalies and no Eu anomalies.