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腾冲地热区高温热水中稀土元素特征

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摘要:

腾冲地热区位于印度-欧亚板块碰撞带东北缘, 构造和岩浆活动频繁, 地热作用明显, 热泉广泛分布, 是现代热泉研究的天然实验室。热水中的稀土元素特征是指示浅层水岩反应的重要指标。由于热水中稀土元素含量较低且变化范围大, 腾冲地区热泉稀土元素组成的报道比较罕见。本文尝试研究了腾冲高温热水中稀土元素组成特征, 并与美国内华达州贝奥沃韦地热田和加利福尼亚希伯地热田热水的稀土元素特征进行了对比。本文选取腾冲地区的高温热泉, 应用ICP-MS, 测试了热水中稀土元素。分析结果表明热水中稀土元素含量相对较低且变化范围较大, 其变化范围为球粒陨石的 $<10^{-5} \sim 10^{-2}$ 倍。稀土元素球粒陨石标准化配分模式整体为轻微右倾型或平坦型, 显示轻重稀土分异不明显; δEu 既有正异常也有负异常; 各热泉点热水稀土配分模式之间存在差异。虽然腾冲地热区热水的REE含量比美国贝奥沃韦地热田和希伯地热田热水的高10倍, 两者之间的稀土元素分布特征具有一致性。热水中的 δEu 负异常为深循环的大气降水与具有负铕异常火山岩水岩反应的结果, 正铕异常可能是由快速上返的大气降水与蒸发岩中的石膏反应导致。

英文摘要:

The Tengchong geothermal area, located on the northeast edge of the Indian-Eurasian plate collision zone, is characterized by frequent tectonic and magmatic activities and widely spread hot springs, serving as a natural laboratory for the geothermal system study. By far, the concentrations of REE in hot springs are barely reported owing to the low concentrations, although it is an important parameter reflecting the rock-water reactions in shallow crust. The concentrations of REE and pattern in the Tengchong hot springs with high temperature waters are studied in this paper, and further compared to those in the geothermal fields in American Nevada and California states. The REE are testing via ICP-MS. The results show that the concentrations of REE range from $< 10^{-5}$ to approximately 10^{-2} times chondrite. Most samples show little fractionation between LREE and HREE, exhibiting slight LREE-enriched or flat shapes in chondrite-normalized REE patterns, and display both positive and negative Eu anomaly. And the chondrite-normalized REE patterns vary from one hot spring to another. Although the concentrations of REE in the Tengchong hot spring waters are ten times higher than those in the hot spring waters in American geothermal fields, they display similar distribution characteristics with the American hot spring waters. The negative Eu anomaly in the spring waters is induced by the water-rock reaction between the deep-cycle meteoric water and ingenious rocks with negative Eu anomaly; alternatively, positive Eu anomaly was possibly resulted from the reaction between the meteoric water and Ca-bearing phases such as gypsum occurring in the evaporites.

关键词: [稀土元素](#) [热泉水](#) [ICP-MS](#) [腾冲地热区](#)

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