Formation of barite chimneys in hydrothermal systems

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Two recently discovered hydrothermal systems at the slow-spreading Arctic Mid-Ocean Ridge system, the Jan Mayen (JMVF) and the Loki's Castle vent fields (LCVF) contain barite chimneys of variable composition. Both hydrothermal systems consists of two active vent sites, which is confirmed by elevated hydrogen sulphide concentrations and discharge of high-temperature fluids, reaching 270°C in the JMVF and 317°C in the LCVF.

In contrast to the high-temperature vent sites, areas of diffuse venting with emanating clear fluids at slightly elevated temperatures (~20°C) have been found to harbour numerous barite chimneys. The barite chimneys in the JMVF are composed of barite, silica and abundant iron, zinc and lead-sulphide minerals, with pyrite representing the dominant sulphides. In contrast, the barite chimneys of the LCVF consist mainly of pure barite with lesser amounts of sulphide minerals.

In additon to oxygen isotopes, this study presents the first multiple sulphur isotope data on barite chimneys in hydrothermal systems. $\delta^{34}S_{sulphate}$ and $\delta^{18}O_{sulphate}$ values of the JMVF barite chimneys are lower than $\delta^{34}S$ of seawater sulphate and $\delta^{34}S$ values of extracted sulphides point to a magmatic source. This indicates that these barite chimneys have been precipitated from a mixture of seawater and hydrothermal fluids. $\delta^{34}S_{sulphate}$ and $\delta^{18}O_{sulphate}$ values for the barite chimneys in the LCVF are higher than $\delta^{34}S$ values for contemporaneous seawater, and show remarkable differences between the surface and the interior. The highest $\delta^{34}S_{sulphate}$ values have been found in the chimney interior, reaching $\delta^{34}S_{sulphate}$ values up to +34.9‰. Negative $\Delta^{33}S_{sulphate}$ values in combination with positive $\delta^{34}S_{sulphate}$ and $\delta^{18}O_{sulphate}$ values strongly point to biological sulfate reduction processes, most likely in the sub surface of the LCVF. The presence of filaments within the chimneys (revealed by SEM) and the finding of framboidal pyite in barite chimneys and underlying sediments in the LCVF indicates that biologic processes caused the observed sulfur and oxygen isotope fractionation.

Sorption of lanthanide ions to mineral surfaces monitored by luminescence spectroscopy techniques

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The distribution of metal ions in the environment is a crucial issue which needs fundamental understanding of the processes involved, e.g., for predicting the safety of repositories for radioactive or chemotoxic waste. In general, the distribution of metal ions is governed by processes like adsorption, desorption, and/or incorporation into inorganic or organic phases, respectively, precipitation from and transport in the aqueous phase. The toxicity of metal ions is not only reflected by its appearance in an environmental compartment, but is determined by its chemical speciation. Therefore, experimental techniques are utile, which allow to monitor the presence and chemical environment of a metal ion at the same time.

The sorption of lanthanide ions on mineral phases, like kaolinite, was investigated by luminescence techniques. As lanthanide ions Europium(III) and Terbium(III) were used because of their outstanding luminescence properties. The influence of salinity and/or the presence of potentially complexing agents on the lanthanide ion's sorption (strength, etc.) was further investigated. As complexing agents low molecular weight organic substances (LMWOS), such as formic and acetic acid, but also potentially chelating agents, like hydroxy propionic acids, were used. Such LMWOS had been identified as constituents of Kerogen isolated from clay minerals and may here distinctly determine the speciation of metal ions. From the luminescence characteristics of the lanthanide ions conclusions concerning their coordination were deduced. Going down to cryogenic temperatures allowed to distinguish between different complex species. Taking advantage of the inter-lanthanide energy transfer made it possible to calculate averaged distances (in the Å to nm range, which extends the observable interionic distance range beyond the first coordination sphere) between sorbed lanthanide ions. Combining the results of the different luminescence techniques deepens the understanding of metal ion sorption on mineral phases, which is a key aspect for understanding transport phenomena of ions (e.g., actinides) in host rock formations.