# Rare Earth Elements in crude oil

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Patterns of the entire range of rare earth element (REE) in crude oils and coexisting water, collected from mud volcanoes in Xinjiang Province of China, are recently reported [1]. Crude oils show light REE enriched patterns with flat or depleted patterns in heavy REE, when normalized to chondrite. Surprisingly, the REE concentrations in crude oils are larger than those in coexisting water by a factor of more than one hundred. Considering the hydrophobicity of oil and the high ionic characteristics of REE, it is strongly suggested that REE forms complexes with ligands present in the crude oils. Based on the $^{13}C$ NMR spectroscopy, it was found that small amounts of phenol and carboxyl groups are contained in the crude oil samples, which could possibly provide complexing sites for REE.

On the other hand, the REE concentrations in crude oils collected from Sagara and Nagaoka-Higashiyama oil fields, Japan which have much lesser amounts of carboxyl and phenol groups compared with those in Xinjiang. This fact suggests that REE is released from carboxyl and phenol groups during maturation of crude oil. The important key reaction can be the kerogen decarboxylation. By this reaction, carboxyl groups are decomposed into carbon dioxide gas. Since REE cannot form complexes with gas, it can be released from organic phase during maturation from kerogen to crude oil.

[1] Nakada *et al*. (2010) *Geochem. J*. **44**, 411–418.

# Electron transport across a black smoker chimney

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At deep-sea hydrothermal vent systems, sulfide-rich emissions generate a columnar black-smoker chimney structure, which serves as an ideal habitat for physiologically and phylogenetically diverse extremophiles in the present and ancient deep ocean. Here we report the data that suggest a new form of efficient and robust energy transfer from such hot, sulfur-rich hydrothermal fluids to cold, oxygenated seawater via electrical current generation. Black smoker sulfide chimney was found to display a significant electrical conduction potential owing to the densely interconnected structure of micron and submicron crystalline particles of chalcopyrite and pyrite. The current–voltage characteristics, combined with electrocatalysis measurements, clarified that their metal-like conduction generates an electron transport conduit longer than 10 cm across the chimney wall and converts the spatially discrete redox potential to electrical current. These findings suggest that not only the emitted reductive compounds, but also the high-energy electrons delivered from the inner hydrothermal fluid conduit via conductive sulfide networks, supports primary production at the deep-sea hydrothermal vent systems (Figure 1).

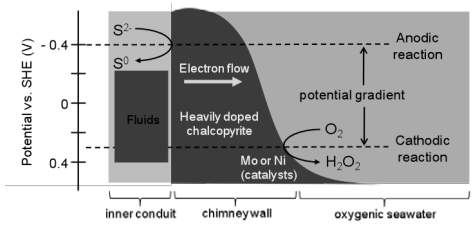


**Figure 1:** An energy diagram for the anodic and cathodic reactions occurring at the inner and outer surfaces, respectively, of the chimney.

[1] Nakamura et al. (2010) *Angew. Chem. Int. Ed*. **49**, 7692-7694.