Stratigraphy and pyrite geochemistry of the Lower–Upper Ordovician in the Lerhamn and Fågelsång-3 drill cores, Scania, Sweden

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A pilot study at Lund University, using XRF-analysis, have shown an As-anomaly with elevated concentrations in an Ordovician shale from a drill core obtained in the Lerhamn area, northwestern Scania, southern Sweden. In this follow-up study a deeper geochemical analysis with focus on arsenic in pyrite from the Lerhamn drill core is done using LA-ICP-MS, for high precision and accurate results. A second drill core (Fågelsång-3) retrieved from Ordovician shales in the Fågelsång area, south-west Scania, is also investigated for a comparison of the result.

Introduction

The Ordovician Period (485.4–443.8 Ma) lasted for about 42 million years and is characterized by warm climate, intense tectonic activity and high sea levels. In combination with low O_2-levels this resulted in anoxia in the marine environment. Anoxic conditions promotes the formation of sulfide minerals like pyrite (FeS_2). Pyrite formed at high rates during the Ordovician and is commonly found in shale.

Pyrite is known to incorporate different trace-elements like arsenic and heavy metals. However, arsenic in particular may accumulate in high concentrations in pyrite. Arsenic is a very toxic element and may cause serious health effects at low concentrations. These effects include e.g. cellular injury and DNA damage, a number of diseases and disorders and several types of cancer. Arsenic poisoning has therefore led to a cause for concern by the World Health Organization (WHO).

Aim

The main objectives of this study are:

- To describe the stratigraphy of two Ordovician drill cores from Lerhamn and Fågelsång.
- To analyze the concentration of arsenic and heavy metals in pyrite in the Lerhamn and Fågelsång-3 drill cores.
- If high concentrations of arsenic are also present in the Fågelsång-3 drill core, is there a correlation between the Ordovician successions in the Lerhamn and Fågelsång-3 drill cores?
- If high-arsenic rocks are exposed for weathering what are then the potential risks and health effects of arsenic?

Method

Pyrite was extracted from two drill cores, the Lerhamn and the Fågelsång-3 drill cores. A total of 388 samples (269 from Lerhamn and 119 from Fågelsång-3) were extracted for analysis. The analysis was done using Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS).

Results

The analytical results from the LA-ICP-MS confirm high concentrations of arsenic, including some of the heavy metals (V, Cr, Co, Mo, Cd, Sb, W, Hg, Pb), in both drill cores. However, a single significant As-anomaly is only observed in the Lerhamn drill core peaking at around 40 m depth (Fig. 1). The average arsenic concentration is approximately 736 ppm in the Lerhamn drill core and 268 ppm in the Fågelsång-3 drill core, with highest values ranging up to 17660 ppm and 2295 ppm, respectively.

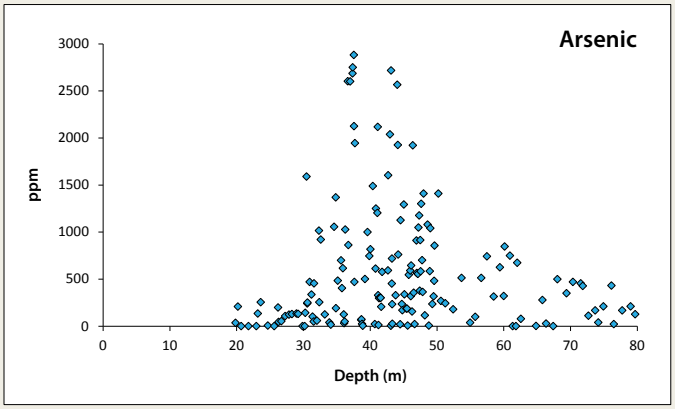

Fig. 1. Diagram showing arsenic concentrations in pyrite from the Lerhamn drill core. Highest concentration measures 17660 ppm and lowest 0.04 ppm (Excluded points: 17660 ppm, 6129 ppm and 5504 ppm).

Conclusions

The Lerhamn and Fågelsång-3 drill cores are dominated by grey to black Ordovician shales. Carbonates in the shale units are largely restricted to fractures. Pyrite of varying size are common throughout the entire succession in both drill cores.

The analytical results show high concentrations of arsenic and some of the heavy metals. The high concentration of arsenic in both drill cores is a result of dysoxic to anoxic (bottom or pore) water, caused by e.g. climatic conditions during the Ordovician.

The upper part (ca. 20.5 m) of the Lerhamn drill core is represented by a short overlapping interval in the lower part (ca. 6.5 m) of the Fågelsång-3 drill core.

In its present location the arsenic-rich shales pose no threat. However, there is a potential risk for local arsenic contamination if the shale/pyrite is exposed to surface conditions.

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