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## Why and when does cobalt form and why does it matter?

Cobalt and all the nasty problems associated with it, prominently featured in the news during the past few years, but what is it exactly? Cobalt is a relatively rare metal that is used, among other things, in batteries for cellphones, cars and other electronics. With more and more electric cars being used worldwide, cobalt has become the new popular metal in town, together with lithium. Unfortunately, the ugly truth is that cobalt is mostly extracted in countries of conflict, such as the Democratic Republic of Congo, where either child or forced labor is used for their extraction. The good news, on the other hand, is that cobalt can be found in other places around the world, even here in Sweden!

So how do we find this elusive metal? Well, it is key to understand at what time of the Earth's history and how cobalt formed. To find this out we can study known deposits. The Vena-Dampetorp deposit is a small group of mining pits, located within the Bergslagen mining region, where copper and cobalt were mined up to the XIX century. The rocks in this area represent ash and lava which erupted from volcanoes in an ancient sea around 1,890 million years ago. From those times till today they experienced a tough road where the rocks were pushed in different directions and cooked at very high temperatures, changing the minerals and the structures in them.

Using detailed observations of the rocks under the microscope together with chemical analyses, the origin, location and evolution of cobalt can be investigated. Similarly, one can discover when this happened through analysis of individual crystals of a mineral called titanite. This mineral is special as it contains uranium, a radioactive element that through time transforms into lead, a non-radioactive element, due to its radioactive decomposition. This acts as an hourglass where on the top we have "grains" of uranium that over time turns into lead "grains" in the bottom of the hourglass. By counting the "grains" of each element in individual grains it is possible to know how much time has passed these crystals formed.



*Figure 1. Crystal of cobaltite, the main mineral containing cobalt in the Vena-Dampetorp deposit.*

### Where does cobalt come from?

The results suggest that the mineral deposit formed in the bottom of an ancient sea in a similar way as modern sea-floor chimneys operate. In these chimneys hot fluids carry metals from the rocks underneath through these chimneys and deposit them on the seabed or in the rocks immediately beneath it. In addition, it was also found that the cobalt, which probably comes from a magma source, was transported and concentrated during the high temperature cooking of these rocks. Cobalt was either squeezed, dissolved or melted and migrated to other parts of the deposit. So, when did this happened? The mineral clocks analysed tell us that these crystals formed around 1,882 million years ago. This means that the first appearance of cobalt in this area of Sweden happened before this date and that it was transported later.

In summary, cobalt in the Bergslagen region is associated to ancient underwater chimneys. By finding rocks that share similar geological characteristics and age in the region, while considering the effects that high temperatures have in the transport that late, it is possible to find more cobalt deposits in the region.

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