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How do ore deposits form? NEXT uses mineral systems modeling to improve our understanding

In this write-up, we invited Tobias Bauer, Associate Professor at Luleå University of Technology (LTU) in Sweden, to fill us in on how ore deposits are formed and how mineral systems modeling can help to advance our understanding.

How do ore deposits form?

Ore deposits require a whole series of ingredients to form. The vast majority of metals sit in minerals that formed in geological processes over a very long period of time. Geologists try to reconstruct these processes based on available observations. Most ore deposits formed from hot fluids that circulated through the Earth's crust and carried metals with them on the way. Once these fluids get focused along certain pathways, they might reach conditions where they are no longer stable and metals can precipitate.

What is mineral system modeling?

Mineral system modeling attempts to simulate these processes on multiple scales. The modeling effort considers the following ingredients that are necessary for forming an ore deposit:

- **Fluid source:** this could be infiltrating rain or seawater, water that is pressed out from sediments or fluids from an intrusion, such as a magma chamber.
- **Energy source** that can drive circulation of fluids: this could be the heat from an intrusion or heat and pressure from burial under overlying rocks or heat and pressure from colliding continents.
- **Metal source:** this could be surrounding rocks that are leached by circulating fluids, yet metals can also come directly from intrusions.
- **Fluid pathway:** dense rocks usually do not allow fluids to circulate, so fluid pathways are required to focus the fluid flow. Such pathways can be fracture zones related to geological structures such as faults.
- **Trap:** a chemical or mechanical trap that favours the precipitation of metals. This can be a drop in pressure or temperature, mixing with other fluids or the contact with reactive rocks.
- **Preservation of the deposit:** was the deposit preserved over time or was it modified afterwards, for example if it became overprinted by later metamorphic events.

The important aspect to consider is that an ore deposit can form only if all these ingredients are present!

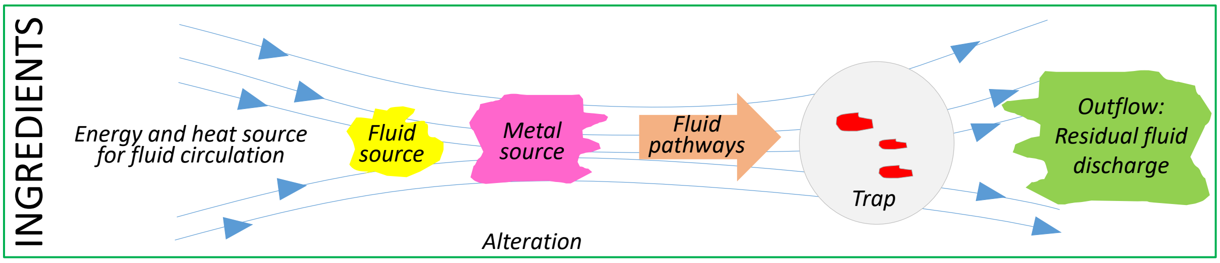

Figure 1. Ingredients of a mineral system (from Knox-Robinson and Wyborn, 1997)

What is required to advance our understanding of how these ore deposits are formed?

In order to improve our understanding of all these ingredients, we need to study rocks on different scales and in different areas. Fluid and energy sources for mineral systems are typically affecting large areas, typically in the magnitude of hundreds of kilometres. On the other hand, traps for mineral precipitation are localized to small areas, such as just tens or hundreds of metres. The latter areas bring target sites in the NEXT project for detailed investigation.

However, it should be borne in mind that all of these ingredients are uniquely different which explains why a wide range of different analytical techniques is needed to understand them.

The EU funding permits us to bring together a highly interdisciplinary team of researchers that includes geologists, geophysicists, geochemistry and ore geology experts, which is really crucial if we are to improve our understanding of how ore deposits are formed.

Where is mineral systems modeling being applied in the NEXT project?

In the NEXT project all these ingredients are being reconstructed for specific types of ore deposits.

These comprise copper-gold deposits that formed from orogenic processes, such as through the collision of continents and the consequent formation of mountain chains. Our target areas comprise both the northern Fennoscandian Shield (Finland and Sweden) and the Iberian Peninsula. The latter is also a target area for massive sulphide deposits that formed on the seafloor in volcanic environments and tungsten-tin deposits that formed on top of intrusions.

European Commission

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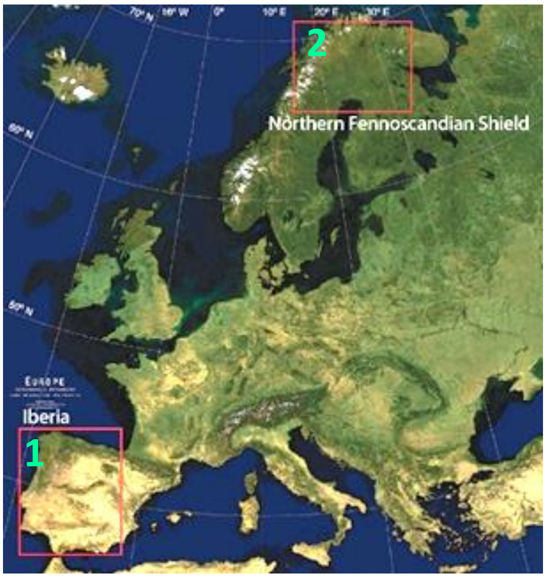

Figure 2. NEXT brings a focus on distinct ore deposit types in: (1) the Iberian Peninsula and (2) the Northern Fennoscandian Shield

How would you describe your ultimate goal?

Our ultimate goal is not only to define conceptual and regional guidelines for targeting orebodies, but also to significantly reduce the cost of mineral exploration and consequently to reduce on the social and environmental impact of mineral exploration activities. For this purpose, our research outcomes are being shared with other research colleagues in the NEXT project who are looking at the economic, social and environmental aspects of mineral exploration.

More about NEXT: www.new-exploration.tech

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