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NEXT advances mineral exploration in glaciated terrains

In this cover picture, Pertti Sarala, Research Professor in geochemical exploration at the Geological Survey of Finland (GTK) and the Oulu Mining School, is seen sampling upper soil. Upper soil geochemical sampling is one of the advanced, environmentally friendly surface geochemical exploration techniques that has been successfully tested in the **EU funded Horizon 2020 New Exploration Technologies (NEXT)** project. For this write-up, we invited Pertti to explain in more detail the advances of mineral exploration in glaciated terrains brought by the NEXT project.

Could you give us a brief history of mineral exploration in glaciated terrains?

For over a hundred years already, studies of surficial geology, surface boulders and heavy minerals are used in mineral exploration of glaciated terrains. Geochemical methods also have been at the basis of mineral potential mapping in these terrains for more than 50 years. Since the 1950s, the development of chemical analyses techniques has been continuous, allowing for the determination of increasingly lower concentrations and for an ever-growing group of elements. Starting from base metals, i.e. copper, lead, nickel and zinc, explored in the 1960s, the mining industry moved from precious metals such as gold and platinum in the 1980s to high technology metals such as gallium, indium and scandium. Rare earth elements and battery technology metals have been under intensive exploration and mining since the 1990s. These analytical development steps have in fact been a boosting factor for mineral exploration around the world.

How do these advances relate to our understanding of mineral exploration processes?

Particularly in glaciated terrains, our understanding about transport and deposition processes increased through the use of surface geological research techniques. The development of what is known as morphological interpretation and our improved understanding of formation processes in relation to subglacial conditions and glacial dynamics have brought important contributions to widening our knowledge. As an example, reference can be made to the use of the remote sensing method, known as LiDAR, that is used to examine the surface of the Earth. LiDAR-based elevation models have completely renewed the process of morphological mapping as the increased amount of detail of glacial features supports a much more advanced interpretation. This has brought a wealth of information, which permits us to delve into aspects such as the secondary dispersion of mineralized materials in glaciated terrains.

Which features would you consider as being of the foremost importance in the context of mineral exploration of glaciated terrains?

A key feature for mineral exploration is brought by **till** or **glacial till**, which can be described as unsorted glacial sediment, derived from the erosion and entrainment of material by the moving ice of a glacier. As a consequence of this process, till represents a mixture of fresh bedrock, pre-glacial weathered bedrock and other pre-existing sediments. Till debris and rock fragments are always found some distance away from the source or sources from which they were derived. As they disperse in the direction of the ice-flow, they give a larger and more homogenized indication of the source(s) than of the bedrock itself. However, this dispersion is influenced by many different factors, i.e. geology, topography and subglacial conditions with ice-mass variations, and is highly dependent on glaciogenic deposition environments composed of glacial erosion, debris transportation and deposition.

Thick glaciogenic deposits, large mire areas and **pre-glacial weathered bedrock** are challenging for mineral exploration and require expensive research methods. These geological environments are typical of large areas in the Northern Hemisphere and are very sensitive to climate and environmental changes and actions of any kind which can disturb the vegetation and soils.

How is sampling traditionally conducted in these glaciated terrains?

Till samples have traditionally been collected using hand-made test pits but more often heavier sampling methods such as tractor excavator, percussion drilling and soil drilling are needed to get more representative samples deeper from the transported cover. Specific till size fractions such as less than 0.063 mm are used in geochemical analyses using partial leaching. To determine the elemental composition of the samples requires methods that are based on atomic emission spectroscopy and atomic absorption spectroscopy. This explains why this traditional sampling procedure is typically both expensive and time-consuming.

It should also be borne in mind that different land-use interests and large conserved areas can restrict the mineral exploration field work using traditional geochemical sampling and analysis methods. For example, the northern, sub-Arctic areas in Fennoscandia and Finland, are typically vulnerable and belong widely to Natura 2000 or other nature conservation programmes. Despite the relatively high current activity of mineral exploration in our part of the world, vast areas in Finland and the Fennoscandian shield are poorly studied for exploration.

Could you describe the advances in mineral exploration of glaciated terrains brought by the NEXT project?

Our goal is to assess the effectiveness of geochemical research methods which offer an easy way to collect samples with low-to-negligible impact on nature and would also be cost-efficient. To move away from the use of heavy sampling beneath the transported cover of glaciated terrains, new sampling and analytical methods are required that will give us a geochemical signal directly from the underlying bedrock.

Our use of **advanced surface geochemical exploration methods** is based on **metal ions migration through the sediment deposits**. As my research colleague in the EU funded Horizon 2020 NEXT project, Maarit Middleton explained in her earlier write-up (Link), upper soils, plants and snow provide relatively easy, fast and cost-effective sampling media with a very low environmental impact. In fact, traces of such sampling are hard to even spot in the field.

Moreover, with only minor pre-processing requirements, supported by numerous weak or partial leaching techniques, these methods are highly cost-effective for many ore types in different terrains. In addition, new on-site geochemical analysis techniques such as a field electrochemical probe instrument that is being developed in the NEXT project as well as other modern field analysers, such as portable XRF, can support surface geochemical exploration by giving element concentrations directly in the field. This is a huge benefit as it offers the possibility of obtaining sampling results in real-time instead of first having to send the samples to a laboratory and having to wait for several days to obtain the results.

How would you describe the benefits of the new surface geochemical methods in NEXT?

The development of new sampling techniques and analysis methods using upper soil layers, plants and snow enables cost-effective and nature-friendly mineral exploration in environmentally sensitive areas like the Arctic. In these areas, the transported cover typically consists of thick glaciogenic overburden and large, peat-covered areas that present a challenge to traditional exploration methods. Furthermore, large areas have restricted access due to large uninhabited expanses. There are also many nature reservation areas, which makes the use of heavy machinery for mineral exploration highly inappropriate.

It is also worthwhile to note that thick transported cover can be found frequently and these techniques are perfectly suitable also in these terrains. The surface geochemical methods have been proven to be effective in recognizing many types of buried ore bodies or mineralized lithological units and structures from the bedrock. This is a significant benefit when it comes to the selection of targets for further exploration studies. In addition, I do believe that the reduced environmental impact and exploration footprint by using these technologies can help to increase the social acceptance of mineral exploration in these terrains.

More about NEXT: www.new-exploration.tech

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