# Developing Deep Exploration Concepts and Technologies

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## Introduction

**The project Developing Mine Camp Exploration Concepts and Technologies — 'Brownfield exploration' focuses on developing deep exploration concepts and technologies for previously rather shallow (depth usually not over 500 m) explored crystalline bedrock areas. The Outokumpu Cu-Co-Zn ore belt (Figures 1 and 2), Finland, as a case history demonstrates the exploration concept development and novel applications of deep data acquisition and modeling.**

**This deep exploration research project is funded by Tekes Green Mining funding program and coordinated by Geological Survey of Finland (GTK), Eastern Finland Office and co-operated by University of Helsinki (UH). Besides the aforementioned public funding, private financing for the project comes via three exploration companies - FinnAust Mining Management Oy, Kylylahti Copper Oy (Boliden Kylylahti) and Mondo Minerals B.V. Branch Finland - and Joensuu Regional Development Company JOSEK Ltd. They all have long-running activities in Eastern Finland regions. The project collaborates internationally with similar research projects in Canada, Greece and Sweden and networks also e.g. with top 3D geomodeling oriented research parties in EU. The project is scheduled for 2013-2015 with a total budget of 833 thousand euro.**

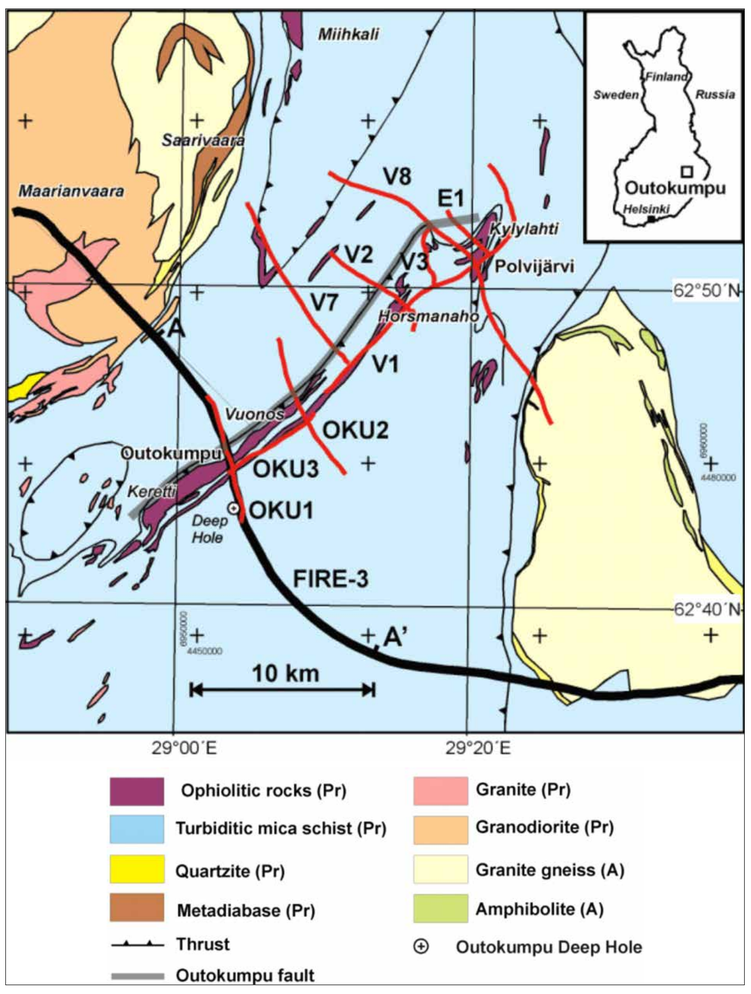


Figure 1. Geological map of the Outokumpu ore belt with locations of the most important mining camps and FIRE and HIRE seismic reflection lines (adopted from Kukkonen et al. 2012).

## Deep exploration concepts and technologies

The deep exploration methods are being improved by an iterative multi-disciplinary approach of integrating geophysical and geological modeling of the subsurface properties in 3D. We use several deep geophysical and modeling methods and multiple sources of extensive digital GIS-referenced geodatasets and interpretive models to compile and further develop Common Earth Models (CEM) of the subsurface varying from deposit to regional scale.

The Outokumpu Mining Camp CEM will consist of more than one software platform. The techniques are being developed and regularly updated according to new information obtained on this classical, yet still enterprising, ore province. The project aims at evaluating deep situated mineral potential in the Outokumpu Mining Camp area (depth of interest from surface to 2 km, optimally 5 km).

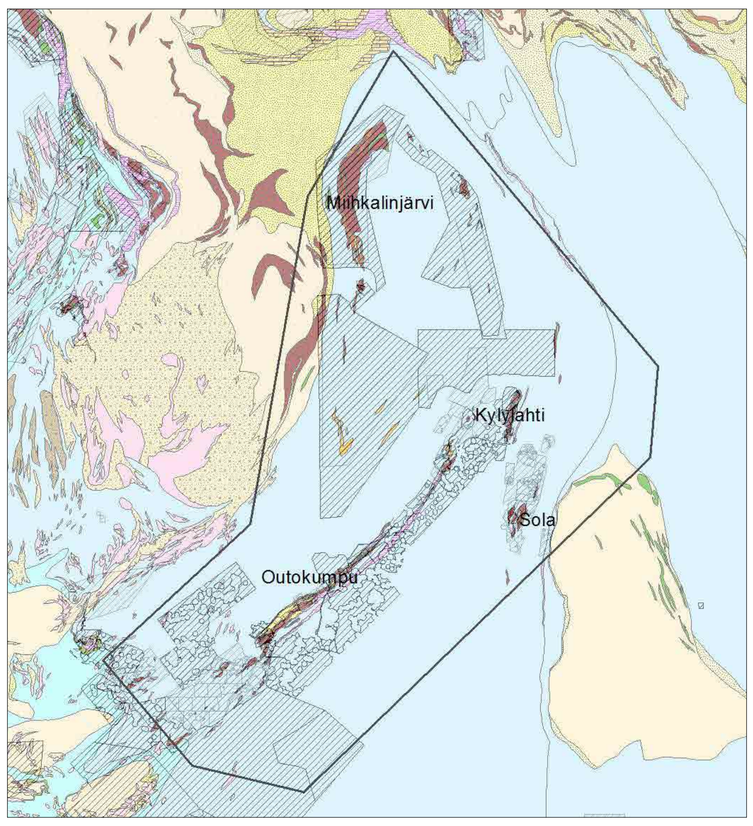


Figure 2. Outokumpu mining camp area has several ongoing mining activites, e.g. copper and nickel exploration and mining and talc production (active areas with permission process = hatched areas, Finnish mining registry; bedrock map DigiKP 2013).

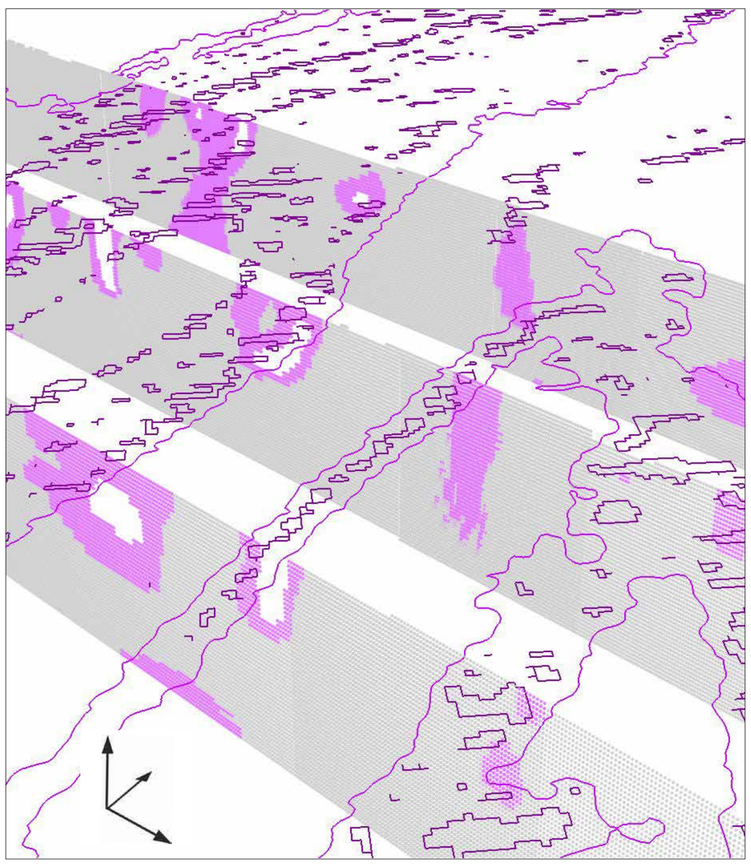

Figure 3. An example of visualizing old and new electromagnetic interpretive 2D data together in 3D in a common GIS application graphic user interphase (GTK, Geotech Airborne Limited).

## References

Kukkonen, I.T., Heinonen, S., Heikkinen, P. and Sorjonen-Ward, P., 2012. Delineating ophiolite-derived host rocks of massive sulfide Cu-Co-Zn deposits with 2D high-resolution seismic reflection data in Outokumpu, Finland. Geophysics, 77( 5), P. WC213–WC222, doi 10.1190/GEO2012-0029.1.

Bedrock of Finland - DigiKP, 2013. Digital map database [Electronic resource]. Espoo: Geological Survey of Finland [referred 15.10.2013]. Version 1.0.

## AFMAG Z-axis Tipper ElectroMagnetic (ZTEM) airborne data acquisition

Linked with the Tekes Green Mining project, GTK has financed an individual helicopter flight operation in the project research area for acquiring deep geophysical, regional scale audio frequency magnetotelluric (AFMAG) Z-axis Tipper ElectroMagnetic (ZTEM) data systematically (Figures 4, 5 and 6).

The ZTEM flight has been successfully operated in the Outokumpu Mining Camp area by Geotech Ltd in June 2013. The final results of the airborne ZTEM measurements have been modeled to get 2D inversions for each of the flown profile lines (Figures 3 and 6), and are presently being processed for further 3D inversion. The ZTEM data act as one of the background datasets for the Tekes Green Mining program funded research project.

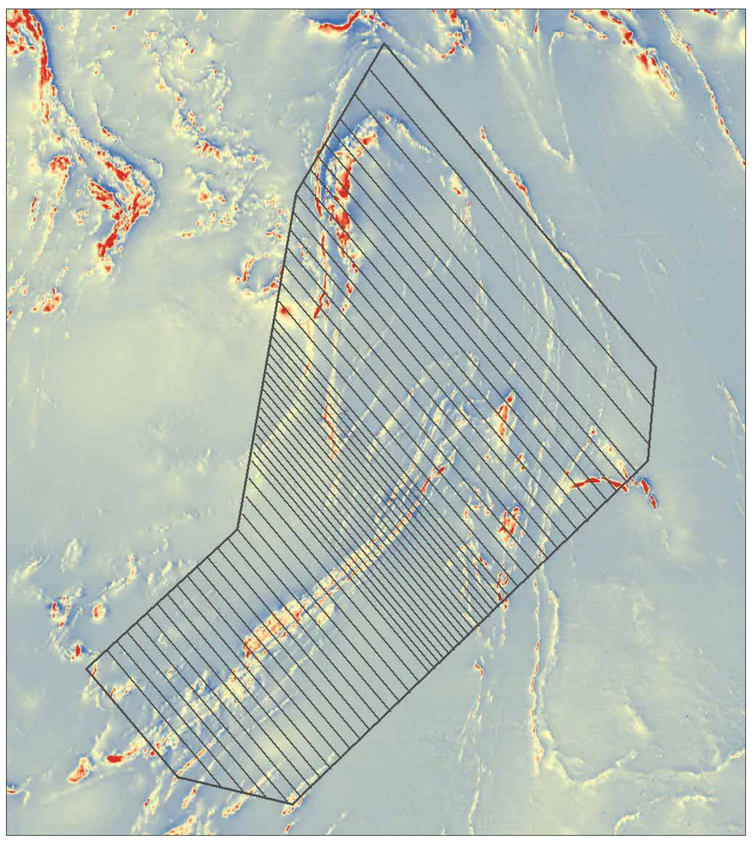

Figure 4. ZTEM airborne helicopter measurement in the Outokumpu project research area (black delineation) consisted of 51 profiles and ca. 1200 line-kilometres in total (black lines inside the research area delineation). The line spacing was 500, 1000, and 2000 metres. The aeromagnetic data in the background has been compiled by GTK.

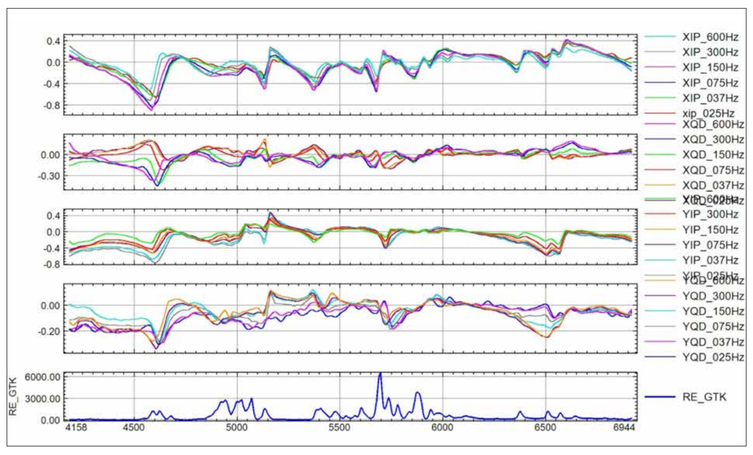


Figure 5. ZTEM results of a single measurement profile compared to airborne electromagnetic (3 kHz, real component) data of GTK (AFMAG ZTEM data by Geotech Airborne Limited, data comparison by GTK).

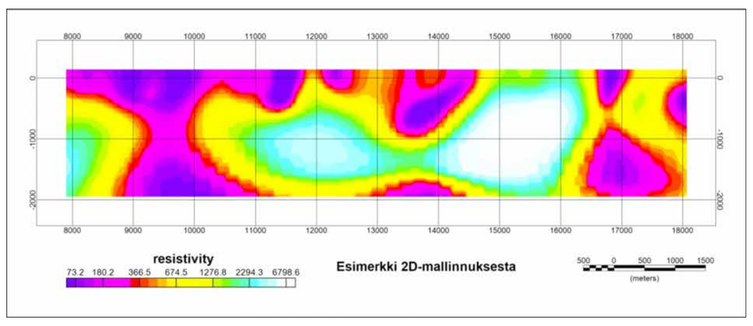


Figure 6. One example of 2D inversion of the ZTEM data by Geotech Airborne Limited.

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