Geophysical Study of a Potential Source of Secondary Raw Materials – the Aijala Mine Tailings Area Southern Finland

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SMART GROUND PROJECT

The SMART GROUND project funded by the EU's Horizon 2020 program improves the availability of information of the secondary raw material in the EU. The consortium will create a single EU database that integrates all the data from existing sources and new information retrieved with time progress. SMART GROUND database will enable the exchange of contacts and information among the relevant stakeholders, which are interested in providing or obtaining secondary raw materials. The project produces detailed information of secondary raw materials pilot landfills of partner countries. The tailings of Aijala closed mine is one of the Finnish pilots. In the SMART GROUND project, the integrated use of geophysics and geochemistry was tested to estimate the volumes of mineral resources of the tailings pond.

AIJALA TAILINGS POND

The Aijala tailings pond consists of material from Metsämonttu and Aijala mines and the layers of the them can be distinguished from the geochemical data. The composition of Aijala tailings has been studied already in 1982. It contains around 2 million tons of waste which average metal content is as follows: 0.12 % copper, 0.5 % lead, 0.11 % silver and 0.69 ppm gold. Thickness of the tailings layer is on average 8.7 m and at the deepest part 12 m. (Sipilä, 1994, Kokkola, 1982).

SOIL DRILLING AND GEOCHEMISTRY

In summer 2016 Geological Survey of Finland made additional drill holes and the samples were analysed in 1 m intervals, 48 samples in total and a vast geochemical analysis was carried out. The geochemical assays of the samples revealed the interface of the tailings material from Metsämonttu and Aijala mines. The top part which contained tailings from Metsämonttu mine was rich in lead and the bottom part containing tailings from Aijala, was rich in copper (Figure 1).

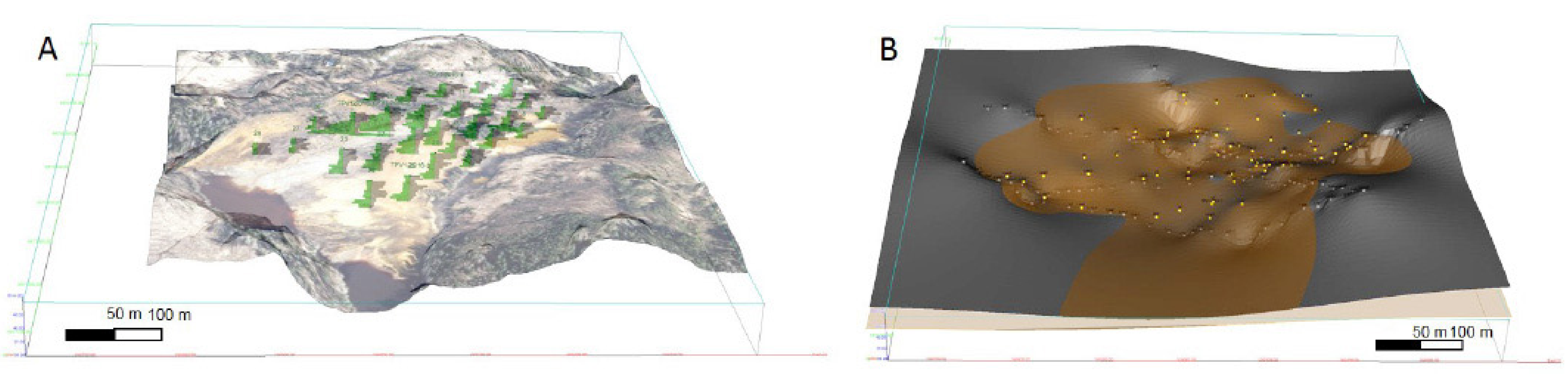


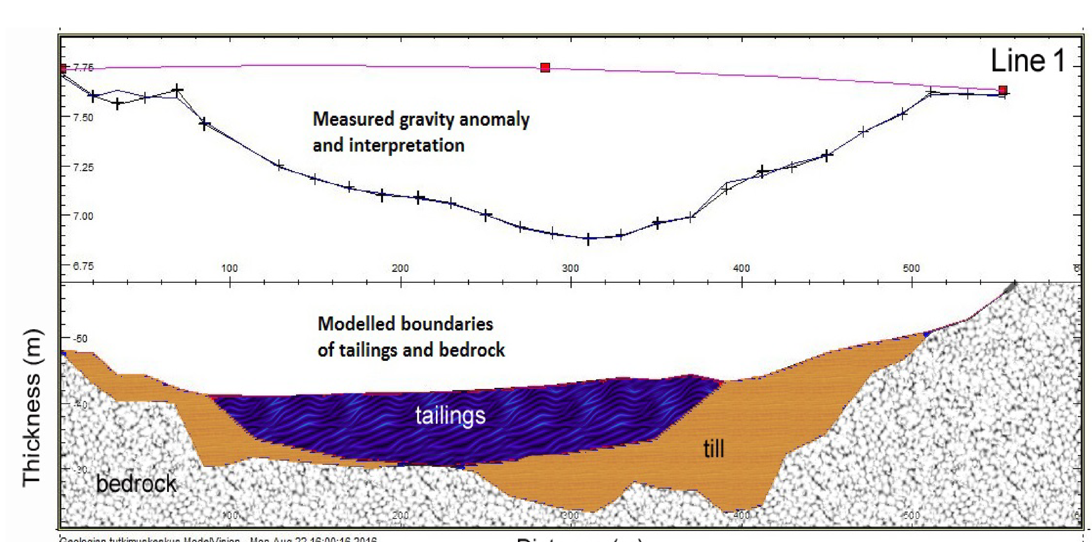
Figure 1. A) LiDAR topography with an aerial photograph of the Aijala tailings pond and the drill holes with copper (green) and lead (grey) contents. B) Bedrock as grey surface and bottom of the tailings as brown surface.

GEOPHYSICAL STUDIES

Geophysics was used to study the inner structure and dimensions of the tailings pond. Magnetic and electromagnetic GEM-2 surveys were carried out over the whole tailings area. Gravity, Electrical Resistivity Tomography (ERT) and Induced Polarization Tomography (IPT) profiles were measured in selected places nearby the new drilling points.

Results of the gravity survey were used to interpret the thickness of the tailings pond and depth of bedrock surface (Figure 2). The bottom of the tailings pond could be defined fairly reliably by using in situ densities and drill hole data as reference. The bedrock outcrops at the ends of the measured profiles were used as reference in interpreting the bedrock topography (Valli & Mattsson, 1998).

Figure 2. Gravity model showing the thickness of tailings and the under laying till layer. The density 1950 kg/m^3 of the tailings material has been determined from in situ samples. For the lower till layer we used density of 1.9 kg/m^3.



GEM-2 method (Won et al., 1996) was utilised to map electrical conductivity of the tailings ponds top surface layers. Apparent conductivity and susceptibility were calculated from the responses of four frequencies. The conductivity varies quite much in the area. 2-layer inversion was calculated to find out the suitability of GEM-2 to this kind of geological situation and possible to get the thickness variations of tailings pond (Figure 3). Magnetics was used to locate the high suskeptibility contained material. These areas are situated roughly at the same areas as the most conductive areas. Apparently due to small coil spacing (low penetration depth) the GEM-2 results were not fully comparable with other data.

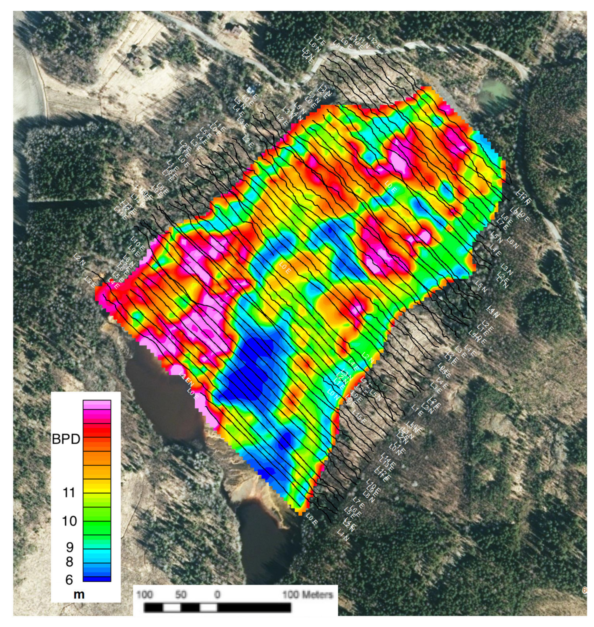


Figure 3. Thickness of conductive tailings from 2-layer inversion of GEM-2 data. BPD= below the penetration depth (>11m).

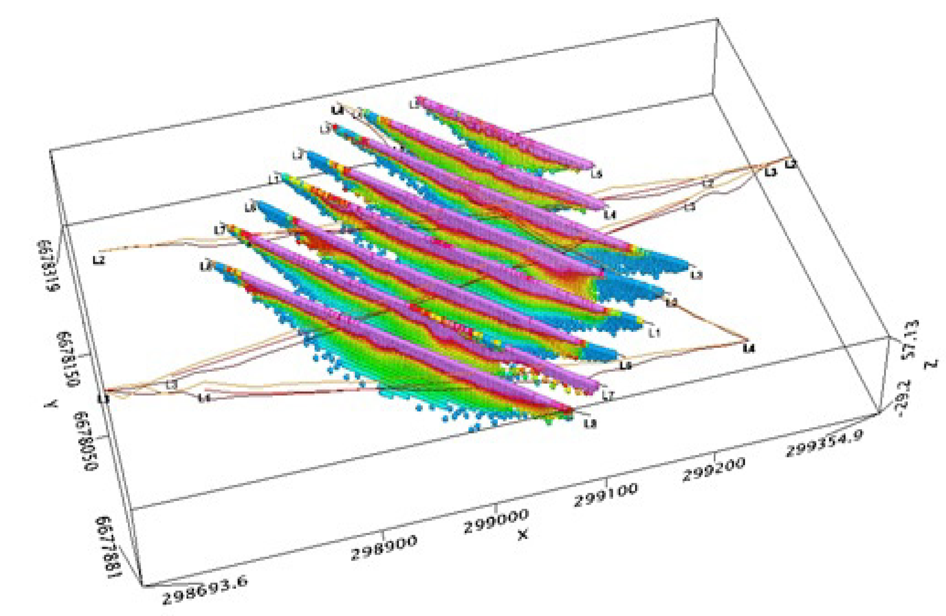


Figure 4. ERT model together with boundaries between tailings and till and between till and bedrock (interpreted form gravity results, see figure 2).

ERT and IPT were used to study changes in the electrical conductivity of the tailings material. The tailings with highest conductivity parts can be detected easily from the resistivity results. The IPT anomalies were typically weak and the highest values appeared in top layer. More detailed interpretation of the results were made after integrating the interpretations with another data (Figure 4). The results were utilised in 3D modelling of the structure of the tailings pond (Figure 5).

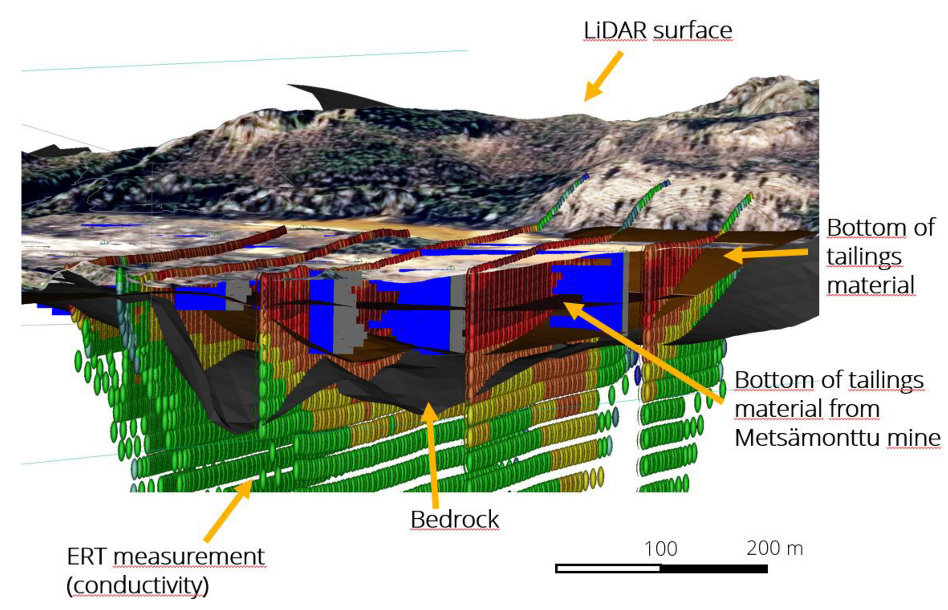


Figure 5. 3D modelling of the structure of Aijala tailings pond with tailings from Aijala Cu-mine and Metsämonttu Zn-Pb mine. Integrated use of ERT and gravity, drilling and geochemical analysis.

MINERAL RESOURCES ESTIMATION

The mineral resources were estimated by interpolating the metal contents in the old and new drill cores into a 1 m^3 resolution block model separately to the Metsämonttu and the Aijala mine tailings layers (Valjus & all, 2016). The blocks were determined by the layers generated according to the gravity interpretations of the tailings bottom and bedrock surface.
Inverse Distance method was used to interpolate the metals contents. As the changes in metal content are more likely to be in vertical direction, the used search ellipsoid was horizontal and it was 200 m in length and in width and 2 m in depth.
Figure 6 shows as an example the interpolated copper content in the Metsämonttu mine tailings layers. The total volume of the layer is 852 399 m^3, and it contains approximately 678 tons of copper.

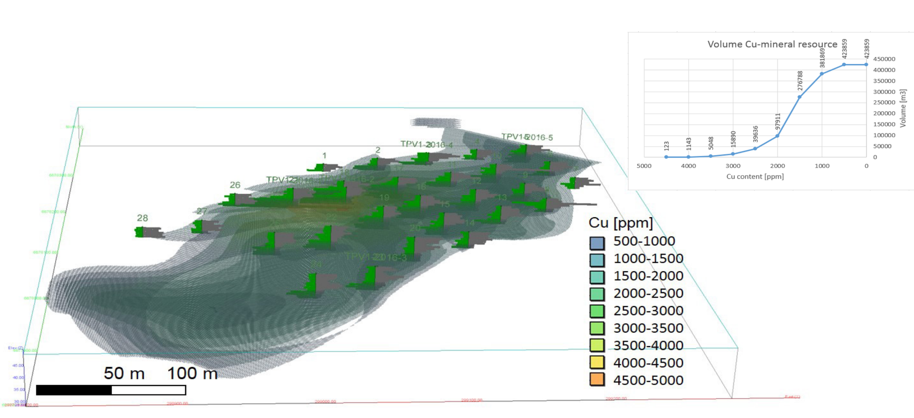


Figure 6. Block model showing the interpolated copper content in Aijala mine tailings layer.

CONCLUSIONS

The tailings pond of the closed Aijala mine was studied as an example of a source of secondary raw materials in EU. The use of detailed geophysical interpretations integrated to the geochemical sampling proved to be a profitable way in defining the inner structures of the mine tailings and they also gave more information of the variation of the tailings ponds bottom and bedrock surface. The results were utilised in 3D model of the structure and volumes of mineral resources of the tailings pond. The information concerning the tailings pond can be found later in the standardised EU landfill database, and it can be utilised by the possible re-user of the raw material to make feasibility study and planning the operations.

References

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