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Three-component Magnetic Logging in the Outokumpu Borehole

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Magnetic measurements in boreholes are normally used for the interpretation of total field anomalies or for tool orientation. Some more sophisticated tools may use inclinometers to obtain the vertical and the horizontal field components and estimate magnetic field inclination. However, in particular in ore exploration, the declination of the magnetic field is of interest for reducing the ambiguity of the interpretation. Another possible application is the reorientation of borehole cores. With the knowledge of the declination one can easily combine the results of magnetic laboratory measurements with other logging results.
To determine the declination of the rock magnetisation, it is critical to obtain the inclination as well as the azimuthal position with a high accuracy. In our tool, the "Göttinger Bohrloch Magnetometer" (GBM), the rotation along the x-, y- and z-axis is recorded by three fibre-optic gyros. These instruments have the benefit of a very small drift per hour (approx. 1 deg/h) in combination with a high resolution ($9 \cdot 10^{-5}$degrees per increment). The small drift is critical due to the measuring time of several hours in deep boreholes. The hardware and processing schemes of the GBM are continuously being modified and tested to improve the accuracy of the reorientation. The declination of magnetization was successfully determined in the HSDP borehole, but a systematic evaluation of the accuracy was not carried out. Here, we discuss data from the Outokumpu borehole in Finland, acquired in September 2008.
The aim was to obtain an understanding of the deep structure of the Cu-Co-Zn ore deposits as well as their formation process. The ore is hosted in the so-called Outokumpu assemblage, consisting of black shales, serpentinite and skarn rock.
After various steps of data processing we obtained several down- and uplogs of the magnetic field in three components. We used these data to derive a model of homogenously magnetised layers along the borehole. The repeatability of the declination of the rock magnetization between the individual measurements lies between 10 and 20 degrees. This accuracy might be sufficient for some applications, e.g. ore exploration. Further improvement is expected from refined processing schemes and remeasuring of calibration parameters, e.g. the orientation of the sensors with respect to the housing.
The integrated interpretation of our results with data from laboratory investigations will enable us to test various hypotheses on the tectonic evolution of the Outokumpu assemblage.