High resolution magnetic field sensing for geoscientific applications

R. Stolz[1] and the teams at Leibniz-IPHT and Supracon AG[2]

[1] Leibniz Institute of Photonic Technology (Leibniz-IPHT), Research group Magnetometry, Albert-Einstein Str. 9, D-07745 Jena, Germany
[2] Supracon AG, An der Lehmgrube 11, D-07751 Jena, Germany

Quantum magnetometers, magnetic field sensors with quantum limited resolution, have the potential to develop significant impact on applications in geo- and environmental science such as mineral exploration, geo-engineering and technical tasks like pipe or unexploded ordnance detection and archaeometry.
In this work, we will give a short and limited introduction on the methods which make use of highly sensitive magnetometers and the according specific demands on them. In order to make use of their extreme resolution, the magnetometers themselves have to overcome two main challenges – they must be operable at Earth’s magnetic field without degradation of their resolution and, often for active methods, have to be able to track fast changing signals with large amplitude.
There are different ways to extract the information from very weak signals within large-amplitude signals of a disturbed surrounding. We will discuss two methods: one is the well-known gradiometry - the signal extraction is achieved by making use of reference sensors. The second method uses time or frequency domain signal extraction such as averaging for uncovering weak magnetic signals in large amplitude disturbances.
We will introduce instruments which are able to map magnetic field anomalies as well as electromagnetic signals using Superconducting Quantum Interference Devices (SQUID) and Optically Pumped Magnetometers (OPM) in order to derive 3D distributions of magnetization or conductivity of sub-surface geological structures. Examples for the exploration of mineral deposits e.g. [1] or archaeological remainders such as in [2] will be shown.

References

[1] R. Stolz et al., The Leading Edge 25, 178 (2006).
[2] M. Schneider et al., IEEE Trans. Magn. 50, 6000704 (2014).