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Advanced SQUID instruments for mineral exploration

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Quantum magnetometers, say 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 geo-technical tasks like pipe line detection or unexploded ordnance detection and archaeometry. Especially, mineral exploration has a high social priority to enable a sustainable and affordable supply of the high technology industry with the required materials.

Within this talk, we will give a short and limited introduction on the geophysical methods which make use of highly sensitive magnetometers, herein Superconducting Quantum Interference Devices (SQUIDs), and the according specific demands on them. In order to make use of their extreme resolution in mineral exploration, the magnetometers themselves have to overcome two main challenges – they must be operable at Earth's magnetic field without degradation of their performance especially in terms of signal resolution and, often for active methods, have to be able to track fast changing signals with large amplitude.

The two main methods in geophysics for SQUID magnetometers, namely magnetics and electromagnetics will be discussed in more detail. We will introduce instruments which are able to map magnetic field anomalies with utmost resolution in order to derive 3D distributions of magnetization or conductivity of sub-surface geological structures. We will provide examples form mineral exploration and archaeology.

Within the second method, a secondary magnetic field induced from currents in the sub-surface has to be recorded with high resolution and bandwidth for determining the conductivity and polarization effects of the according geological structures under investigation. We will provide examples of ground based transient electromagnetics and will discuss the future prospects of SQUIDs in this context.

Finally, we will discuss which research topics have to be addressed to widen the range of applications for SQUIDs in geophysics.

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