Integration of drone-borne hyperspectral and geomagnetic data. A combined approach in geologic remote sensing. A test from the Siilinjärvi carbonatite, Finland.

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Introduction

The worlds need for critical materials sees a surge since the last two decades. Most of Europe's larger mineral deposits have been discovered and exploited by now. A rising need to include formerly unattractive or inaccessible prospects is apparent. Here, using drones for detailed prospecting of small areas comes in handy. Drones have the advantage of being cost-efficient, easily deployable and having a short turn-around time for high resolution data. We integrate several remote sensing applications. In particular, we combine the advantage of light-weight drone technology with a snapshot hyperspectral camera and a magnetometer. The project name, **MULSEDRO**, stands for ***MULtiSEnsorDROnes.***

Fig.1 Principle of unmanned aerial system surface scanning with a hyperspectral camera system in Siilinjärvi, Finland.

Methods and Test area

Tholeg – "THO-R-PX8" Octocopter
- 5 kg payload
- 30 min max. flight time
- Vapor-Magnetometer
- Hyperspectral camera (HS)

Radai Oy – "Albatros" Fixed wing
- 2 kg payload
- 2.5 m wingspan
- 90 min flight time
- Fluxgate magnetometer

DMT Pilot 3D Positioning system
- 2 kg weight
- Integrated positioning system
- Inertial measurement unit and stereo camera for orientation under GPS loss

Implementation in progress

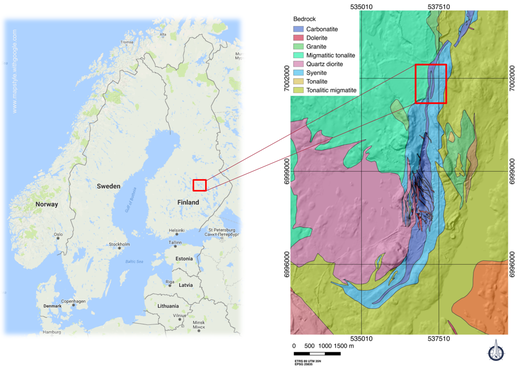

Fig. 2 Left – Location of the test site in Finland. Right – Overview of the target area

Ground validation

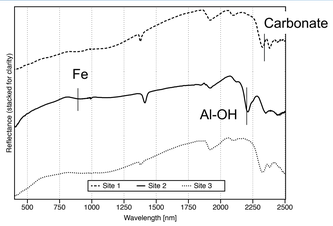

Fig. 3 Spectroscopic validation of in-situ samples from field sites.

Fig. 4 Field site conditions during sampling and measuring in Finland.

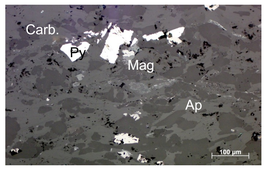

Fig. 5 Polarized microscopy image of a thin section of sample GU8, used to identify minerals which indicate the presence of a mineral with high magnetic susceptibility.

We expect to identify surficial rock formations using HSI data and estimate their subsurface proportions with magnetics. The data sets are processed through a framework of dedicated correction tools.

Validation of the data sets follows a workflow by a combination of in-situ and laboratory measurements to characterize rock forming minerals.. (X-ray fluorescence, X-ray diffraction, near-field spectroscopy (350 – 2500 nm) and optical microscopy)

Results

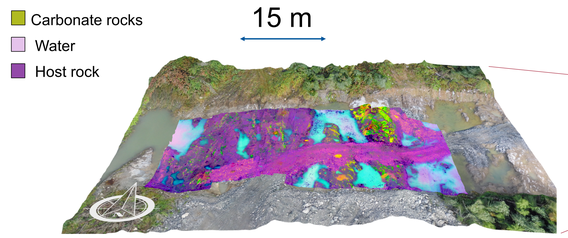

Fig. 6 Principal components analysis display of a drone–borne hyperspectral image mosaic: projected onto digital elevation model.

- Digital elevation models (Structure-from-Motion Multi-View-Stereo photogrammetry)
- Corrected hyperspectral data (MEPHySTo toolbox; Jakob et al. 2017)
- Calibrated Magnetic data (e.g. orientation , diurnal and external induced field fluctuations)

We delineate carbonate dykes and associated fenitisation in hyperspectral data. We observe a trend with similar orientation in magnetic readings. We interpret the results as an enrichment of magnetite, among other iron minerals, in the carbonate host rocks.

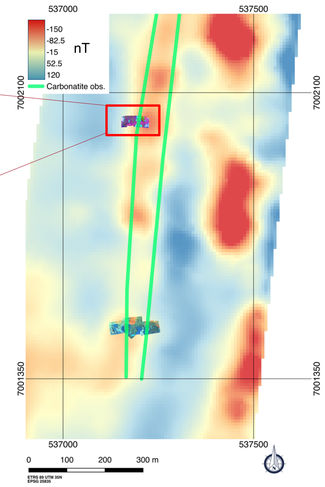

Fig. 7 The figure illustrates UAS borne magnetic measurements from Radai Oy (2016), superimposed by UAS borne hyperspectral images from the 2017 field campaign. The anomaly in the data follows the mapped carbonate dyke.

Outlook

The results are promising and we demonstrate that drone-based exploration becomes more accurate, affordable, intuitive and accessible to the mining sector and the geoscientific community.

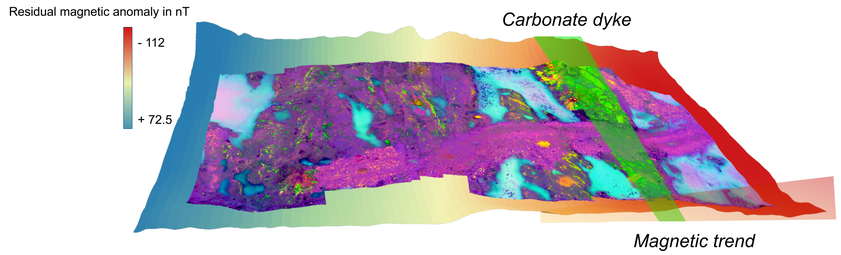

Fig. 8 Residual magnetic field combined with the hyperspectral surface information. In particular, the mineralogical or structural information are used as constraints for the up-following inversion of the data.

Open questions:

1. ***The acceptable resolution difference between the magnetic data and hyperspectral surface information?***
2. ***How to decrease the engine noise without limiting the flight performance?***
3. ***Sufficient spectral range of hyperspectral sensors?***

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