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Integration of UAS-borne hyperspectral remote-sensing and geophysics in mineral exploration under sub-polar conditions in Finland.

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The EIT Raw Materials project Mulsedro (MultiSensorDrones) started 2017 and aims to combine different types of UAS (Unmanned Aerial Systems) with comparable sensor systems for geological mapping. The ultimate goal is to develop/apply specific geoscientific tools and workflows for the mineral exploration geologist, therefore boost these disruptive technologies. The applied techniques include multi- and hyperspectral remote-sensing as well as geophysical measurements of the earth's magnetic field. Our work is centered on UAS-borne data acquired by commercial and custom fixed-wing and multicopter UAS. The UAS-borne data is, in parallel, validated by traditional field techniques (spectroradiometry, X-ray fluorescence, magnetic susceptibility, geological mapping and sampling). All validation points are located by post-processing relative GNSS positioning to ensure precise location on the UAS-borne data.

We present results of last year's major field campaign of late September 2018, conducted in Finland's central region ∼200 km SE of Oulu. We surveyed a bedrock outcrop (2.8 ha) belonging to a currently non-operating Fe-Ti-V mine in Otanmäki. The local geology comprises Archean basement host-rocks, featuring a gabbroic suite with massive ore cumulates made of illmenite, magnetite and secondary iron minerals. We processed an UAS-borne digital surface model and both true-color RGB and 4-band multispectral orthomosaics with an industry standard fixed-wing system. Additionally, we acquired a hyperspectral surface mosaic (504 – 900 nm, 50 bands) with a multicopter. The data were automatically pre-processed, geo-referenced and topographically corrected using a in-house python-based toolbox.

In addition, the geomagnetic field was measured at different altitudes above ground (a.g.l.: 15 m, 40 m, 65 m) with UAS-based fluxgate magnetometers. Magnetic data was processed according to standards of aeromagnetic exploration (diurnal changes, heading effects, levelling). The fixed-wing UAS magnetic maps cover the regional field over the whole former mining area. Data quality is good within industry standards. We find multicopter data (e.g. 15 m a.g.l.) being similar to ground magnetics. Image classifications reveal the distribution of host rocks, specific alteration zones and ores. By using upscaled geomagnetic maps, we identify anomalies and field patterns, that can be correlated to detailed surface magnetic susceptibility profiles.

Both remote sensing and geophysical techniques are combined and the advantages of UAS methods for mineral exploration are illustrated. UAS are prominent in providing high resolution data within fast turn-around times. In particular, fixed-wing data shows the potential to surrogate helicopter surveys in the future, providing a reduction of costs and investment risks. Multicopter surveys augment ground inspection in areas with perilous or limited accessibility (e.g., slopes, waste heaps, cliffs). In summary, we propose these methods to be fully applicable in multiple related research fields, e.g., active mine monitoring, hydrogeology, geotechnics, agriculture, archaeology and mine legacy monitoring.