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Synergies of Drone-Borne and Satellite Data for Noninvasive Mineral Exploration in Namibia

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The transition toward a net zero energy economy has led to an increased demand for the critical raw materials required for green technologies. Recycling alone is not capable of compensating the requirements for the foreseeable future. At the same time, the extractive sector is facing increasing difficulties in getting stakeholder support to develop new projects. Therefore, our goal is to adopt exploration techniques that minimize environmental impact and prioritize non-invasive methods. For this, we use innovative remote sensing methods to not only improve mineral detection and mapping, but also foster social acceptability for the mining and exploration industry. Hyperspectral imaging (HSI) is a rapidly developing technology that allows for fast and systematic identification of key minerals at the Earth's surface and provides information about mineral abundances and associations. Several recently launched satellites and the rapid rise of NewSpace (commercial providers) are also opening new opportunities. In this contribution, we illustrate a process including joint drone-borne HSI and satellite-based HSI. We leverage the potential of the different platforms and imaging systems, taking into account their respective advantages and disadvantages. We suggest a vertical integration of drone-borne high spatial and spectral resolution but with limited coverage, and large-scale imaging with 30 m ground sampling provided by satellites such as EnMAP, PRISMA, and the soon to be launched Planet (Tanager) and CHIME. We argue that a combination of machine learning and spectroscopy, accompanied by a structural analysis provides an ideal solution to map potential targets accurately. The processing chain includes radiometric and geometric corrections, coregistration, and spectral and structural mapping. We showcase this approach at two study sites in Namibia: The Marinkas Quellen Carbonatite Complex and the Uis pegmatite-hosted tin mine. Both of these deposits host CRMs used in today's green technology, i.e., REEs and lithium, respectively.