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Detection of chromite minerals using Spectral Linear Unmixing on Sentinel-2 imagery. Case study: Ingessana Hills, Blue Nile Province,Sudan.

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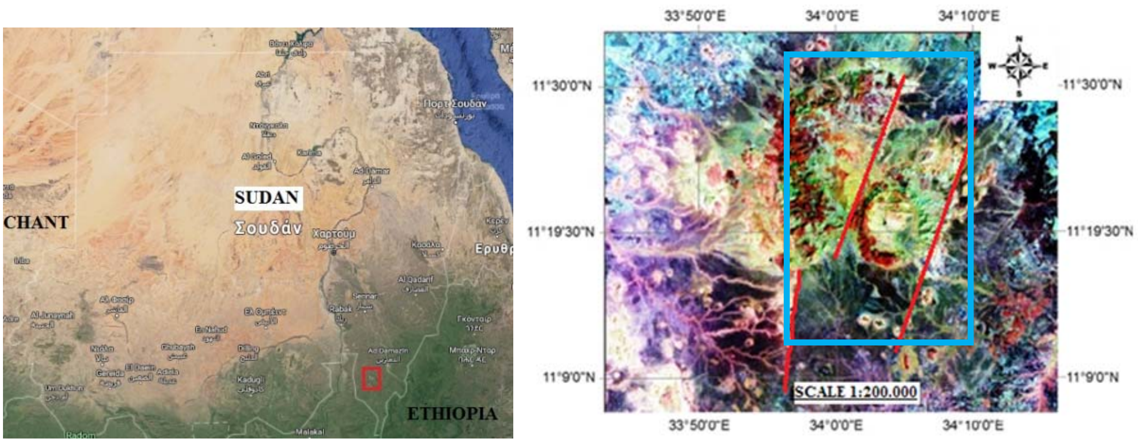
Introduction

The Ingessana hills in the southern Blue Nile of Sudan consist of serpentinised and highly silicified dunites in contact with the intruding Bau granite. The observed chromite mineralization zones are associated with NE-SW trending shear-zones. The mineralization associated with ophiolitic belts includes podiform chromite, asbestos, talc, and base metal (Cu, Ni, Co) mineralization. We applied Linear Spectral Unmixing algorithmon a 10m spatial resolution Sentinel-2 images in ordertodetect and map the chromite mineralization and the associated mineralization of ophiolitic belts. The resulting abundance maps show the capabilityof Sentinel-2 for detailed mineral mapping and detection of potential chromite ore depositlocations.

Background and Object

The study area is located at the Ingessana Hills, in Blue Nile Province of Sudan (Fig. 1). The dominant basement rocks consist of serpentinised hartzburgites and dunites with metadolerite, epidiorite and gabbro surrounded by psammopelitic metamorphic rocks and cropping out around the hill (Fig.1). The chromite mineralization is mainly concentrated in the western side of the Ingessana Hills as lenses, veins, in irregular patches and disseminated deposits, in the serpentinites and talc carbonate rocks of the dunite –peridotite gabbro (Ibrahim, 2003). The lenses and the veins generally strike NNW with steep dips.



(a) (b)

Figure 1. (a) The red box indicates the location of the study area in Sudan. (b) Colour composite of the mosaic Sentinel-2 image after equalization stretching of the study area [R:12 (2,19μm), G:8A (0,86μm), B:3 (0,56μm)]. The red lines correspond to the main faulting. The cyan box represents the area of the abundance images that are shown in fig.2.

Methodology

In this study, we used two adjacent Sentinel 2 (S2B) images Level 1C, acquired on19/02/2019 and on 29/02/2019. After atmospheric correction, the two images were mosaicked (Fig.1). The output reflectance image has 12 spectral bands and 10m spatial resolution.We then performed Linear Spectral Unmixing (LUN). The LUN approach assumes that the reflectance of each pixel is a linear combination of the spectral signature of each material (endmember) present in the pixel (Keshava & Mustard, 2002) and determines its relative abundance, based on its spectral characteristics. Compliant to the geology of the area, the spectral signatures of talc, chlorite, chromite, limonite, hematite, antigorite, epidote, quartz, tremolite, chrysotile and dolomite were retrieved from the USGS Spectral Library. We applied a Least Squares LUN with a positivity constraint. The abundance map for each endmember was calculated (Fig. 2). The abundance values were then normalized between 0 and 1.

Results and Conclusions

Chromite is detected west and east of the Ingessana Hills (Fig. 3). The easternmost outcrops of chromite are accompanied by high limonite abundances, indicating that they are rich in iron (Fig. 2a, b). Limonite has also been detected at an extended area aligned to the NE - SW faulting of the Ingessana Hills. Antigorite, seems to have the same spatial extentwith chromite (fig.2c), while chrysotile (fig.2d) is detected at the fringes of serpentinised rocks in contact with meta-sediments. The proposed areas for further investigationare presented in fig.3.The results are in a good agreement with literature, unpublished reports and with the geological map, including locations of current mining sites.

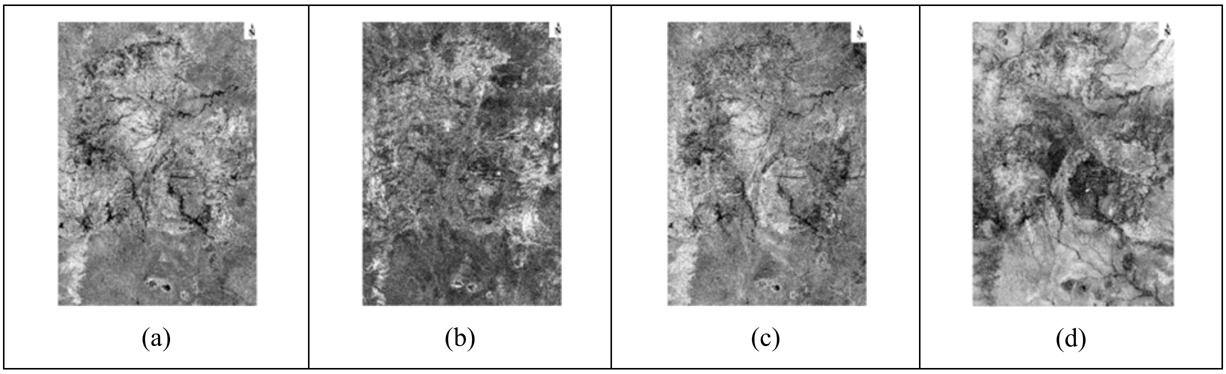


Figure 2.**Spectral Linear Unmixing (LUN) result. Abundance images of (a) chromite, (b)limonite, (c) antigorite, (d) chrysotile. Black and white areas correspond to low and high mineral abundances correspondingly.**

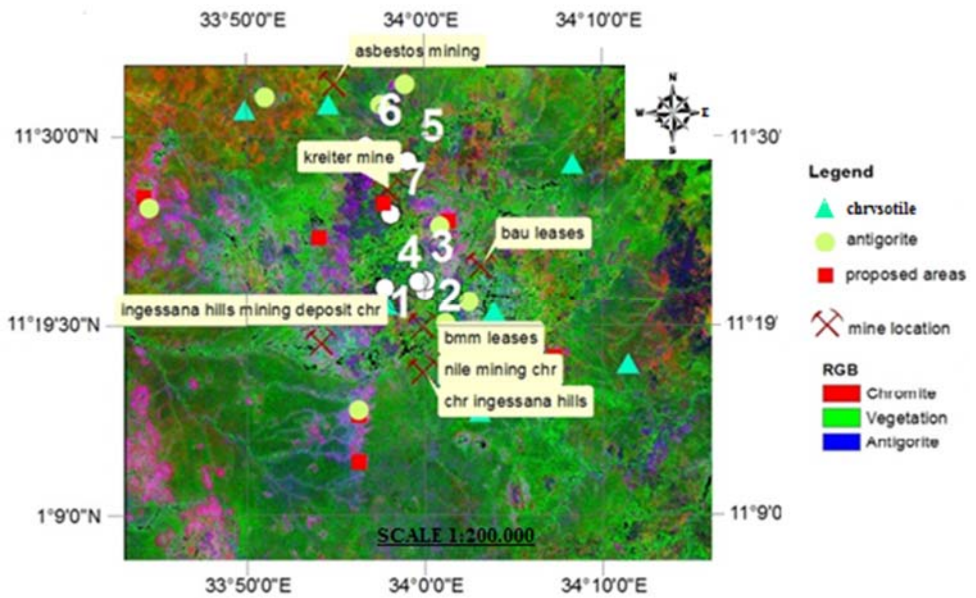


Figure 3.CCF image of the abundances of: R: Chromite G:Vegetation B:Antigorite. The proposed locations for further investigation are shown (red squares).

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