Development of Remote Sensing Workflow applied to Mineral Exploration

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Introduction

Mineral Exploration is an expensive task both financially and timely. Also, it endangers the employees that are exposed to field activities, which are fundamental to the development of projects, but with a high risk to health and safety. By understanding this scenario, it becomes possible to realize the usefulness of remote sensing applications in mineral exploration, saving money and time, as well as avoiding unnecessary exposure of employees to risks. With literature studies and an extensive understanding of the regional geology, it is feasible to determine specific targets with the help of satellites, then move on to field confirmation.

The Australian start-up OreFox understood the importance of remote sensing for the mining industry, and so from this internship period, which spanned from March to July 2023, the development of a workflow for hydrothermal anomaly detection began. This workflow will be part of the platform called GeoDesk, which aims to help junior mining companies extract the maximum information from their data, such as geochemistry and drilling, thus allowing the most accurate determination of a target for the development of a mineral exploration.

In this report, the whole development process for hydrothermal anomaly detection will be described starting from a validation example. More specific procedures will not be reported due to the confidentiality terms present in the contract.

Methodology

The development of the application of remote sensing in the identification of hydrothermal alterations has three main parts: methodological research, pre-processing and results. Based on these results, a decision can be made to carry out further geological research in situ, and finally to apply for exploration of the area.

(1.0) Bibliographic review

The field of remote sensing is very vast, so there are many applications in many areas. One of these is mining, where the aim is to identify the spectral response of minerals using multispectral and hyperspectral satellite images. In general, multispectral images are more readily available and free of charge, unlike hyperspectral images, which are more expensive to obtain - in proportion to the amount of data they can provide.

For the application of remote sensing in mineral exploration, there are many methodologies developed from the voluminous public Sentinel-2 and Landsat Series data. Many of these methodologies focus on hydrothermal alterations, using mainly the red, near infrared and short-wave infrared bands, as well as, of course, other bands that help to better highlight the information present in the pixels.

(1.1) Band Ratio

One method of identifying minerals is through the band ratio. It involves the calculation of the ratio of the digital values of two different bands in a multispectral or hyperspectral image. This technique helps enhance certain features and characteristics of the surface being observed, making it easier to distinguish and identify specific minerals. In the context of mineral exploration, different minerals have unique spectral signatures, which means they reflect and absorb electromagnetic radiation in distinctive ways across various wavelengths. By analyzing the reflectance patterns of minerals in different bands of the electromagnetic spectrum, geologists and remote sensing experts can identify and map the presence of minerals on the Earth's surface.

Some very widespread band ratios in remote sensing for mineral exploration are the Sabin Ratio (Sabin, 1999) and the Kaufmann Ratio (Mia and Fujimitsu, 2012). Both band ratios were used together with other methodologies to delimit the areas of interest. The workflow was based on the research developed by Frutoso et al (2021), where the results of various operations are combined to obtain a well-defined result.

(1.2) Principal Component Analysis

The other methodology used to identify areas with hydrothermal alteration was principal component analysis (PCA). The Crósta technique (Loughlin, 1991) applies dimension reduction to extract the most important details from the blue, red, near infrared, SWIR-1 and SWIR-2 bands. The methodology performs two PCAs for two different types of minerals: iron oxides, with the blue, red, near infrared and SWIR-1 bands; and also hydroxyl-clay minerals, with the blue, near infrared, SWIR-1 and 2 bands. These bands are the ones with the greatest reflection/absorption by these groups of minerals, which leads to the need to reduce the dimensions and then finally identify the areas with the greatest concentration of these minerals. Finally, an RGB composition is generated with the PCA of hydroxyls in the R channel, hydroxyls plus iron in the G channel and iron in the B channel.

Results

The application of the methodologies was successful due to the discovery of a promising vanadium region, leading to an application for mineral exploration in the state of Queensland, Australia. In image 1, we can see the band ratios, both Sabin ratio and Kaufmann Ratio, and the principal components for iron and clays.

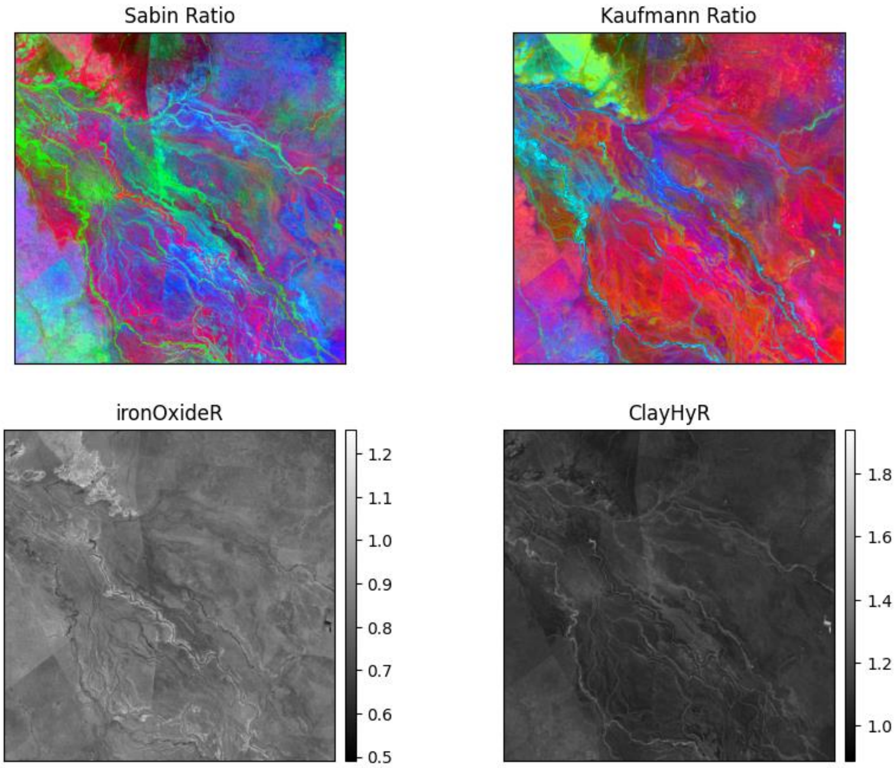

Figure 1: Visualization of the AOI in Sabin and Kaufmann ratio on the first line; Iron Oxide and Clay Hydroxide on the second line.

Figure 2 shows the color composition result of PCA, where the white and yellowish portions indicate hydrothermal alteration, and consequently the presence of ore, where the exploration application was made, as shown in Figure 3.

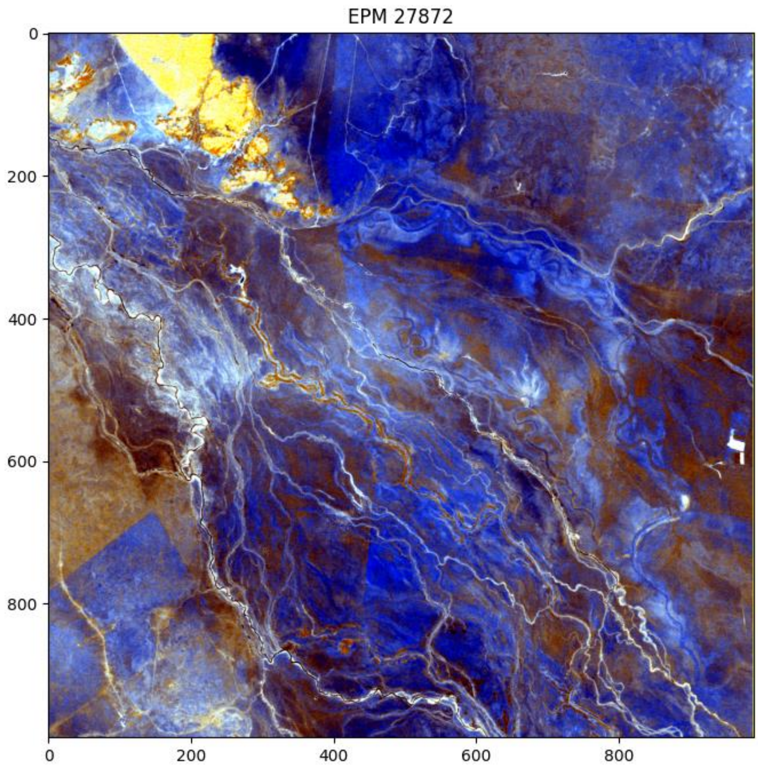

Figure 2: RGB composition for the PCA. R: Clay Hydroxyl PCA, G: Iron + Clay Hydroxil, B: Iron Oxide.

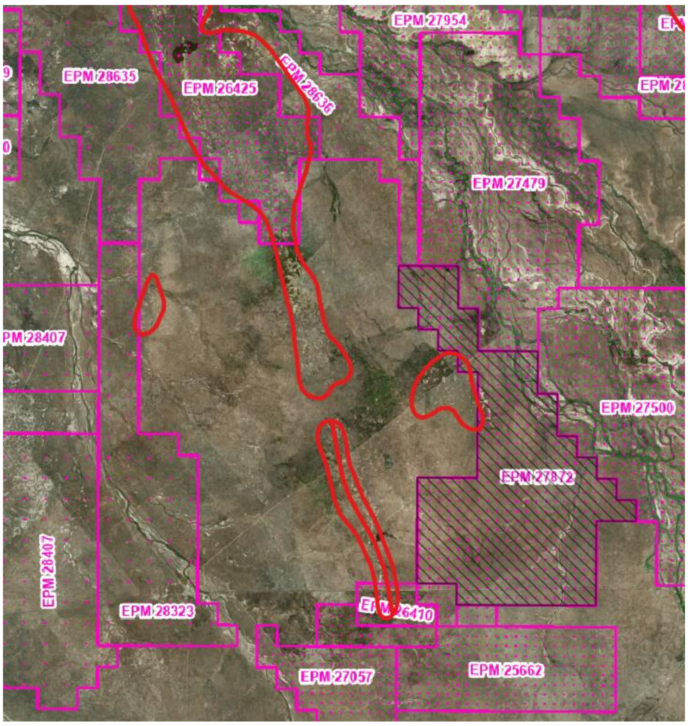

Figure 3: In red, the lithology rich in vanadium, where there is no mining requirement. Place that OreFox will develop its operation.

Recommendations

For the next intake, I strongly recommend building a strong network on your LinkedIn. As you make yourself active there, creating a lot of technical posts with a certain frequency, you reach more people from different parts of the world – who can also be potential investors or contractors. Personally, I started looking for internships in January, so I could have more time to schedule my activities and find a company where I could fit all my purposes.

Therefore, to be successful in finding an internship, in my opinion, you have to: set your goals of the area you are interested in to work with; search companies that fit this purpose and send them your CV – it is important to adapt your CV according to the company you are sending to; meanwhile waiting for answers, develop your LinkedIn profile.

References

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