Multispectral Imagery: Remote Sensing in Mining (Part 1)

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Remote sensing and satellite image interpretation techniques are a fundamental part of mineral exploration programmes. The applications of remote sensing in the mining sector, however, are manifold, particularly with the commercial availability of Unmanned Aerial Vehicles (UAVs). In this first part of ***Remote Sensing in Mining Series***, we would like to outline three common examples multispectral imagery can be used for.

1. Logistics & Infastructure planning

Dwindling prices of metals, 'not-in-my-backyard' attitude of western societies, and other factors require companies to explore for mineral resources in remote or poorly-developed areas. Every exploration programme starts with a geographical reconnaissance of an area. Key questions to be answered are: infrastructure, access, best camp site locations, communities and residential areas, water supplies, drainage networks and topography etc. This information can be acquired at low cost through the analysis of satellite imagery, such as ASTER or Sentinel-2 products that have better resolution than Landsat.

2. Lithological & mineral identification and discrimination

The capability of determining the composition of a geological material or product is based on spectral information, which is contained in a set of bands. A ***band***, or ***channel***, is a defined range (also ***bandwidth***) of the electromagnetic spectrum in which a sensor collects light. For example, the third band of Landsat-7 (B3) represents an image in the range of 0.63 – 0.69 micrometer wavelength, which is close to how a human being perceives red light. Spectral information can be visualised by ternary RGB (Red-Green-Blue) colour composite or classified by advanced algorithms.

Amongst many others, a popular Landsat- 7 band combination for geological interpretation is RGB 7-4-2, which is particularly useful in arid areas. By combining bands from different spectral ranges (7 – short-wave infrared, 4 - near-infrared 2 – green) the use of spectral information is maximized, so that differing mineralogy will produce a variety of colours supporting lithological discrimination. The combination resembles a natural colour image. Vegetation appears as bright green, barren soil as pink and water is dark blue.

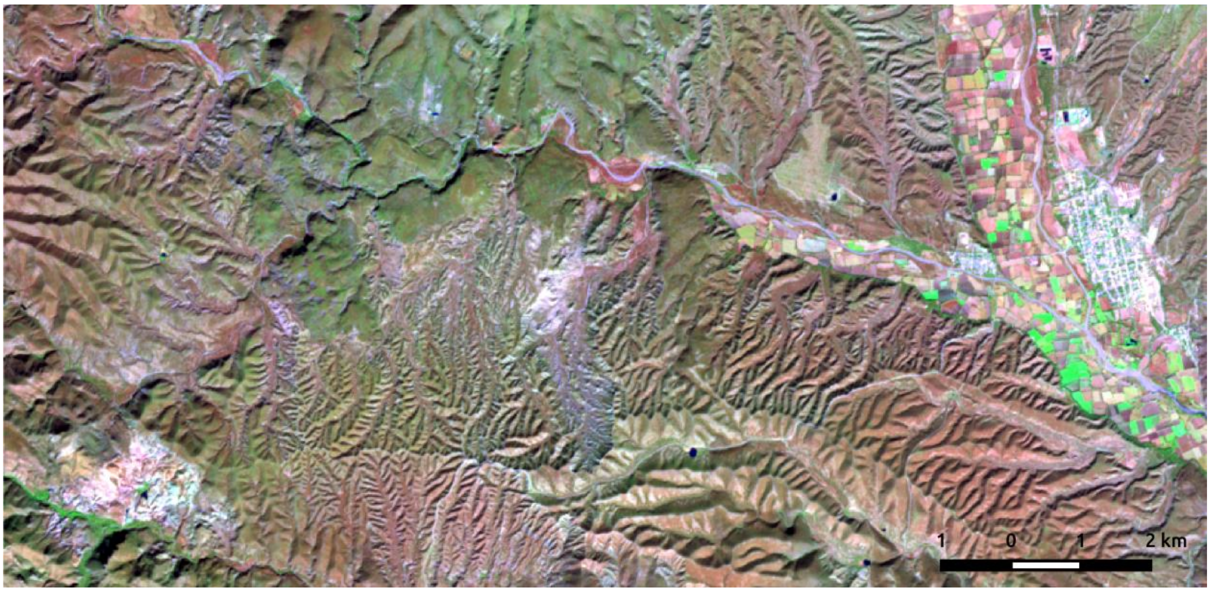

Figure 1. Sentinel-2 RGB 12-8-3 color composite of the Sonora Desert near Cumpas, Mexico. Sentinel-2 12-8-3 roughly corresponds to Landsat-7 7-4-2. The image presents sparsely vegetated terrain, with cultivation and agriculture visible in the valley to the right. The different types of soils are clearly visible due to varying tones of brownish pink, and it is straightforward to spot vegetated patches of land. Most of the image is covered with quaternary conglomerate – it shows brown colour with pink or green tones depending on the slope orientation and other factors. Note the outcrops of basalt in the top centre (greyish-green colour). In the left bottom of the picture there are layers of volcano-sedimentary rocks. Most probably they host hydrothermal alteration suggested by highly variable colours (pink to yellow and blue). Note that geomorphology can make it easier to distinguish lithology (differing rock structure and resistance to weathering will produce a different 'texture' in the image).

As a rule of thumb, the greater the number of bands and narrower their bandwidth (finer spectral resolution), the better the capability to distinguish between different materials. Data from several multispectral sensors are available at no charge to the general public as well as business enterprises (visit www.earthexplorer.com for more information). Those include Aster, Sentinel-2, and the entire 40+ year archive of Landsat imagery. However, it is important to be aware of the limitations of using coarse (15-30m resolution) multispectral satellite images for geological analysis. Geological features can easily be obscured by vegetation (including lichens and moss), soil or regolith cover, or may be undetectable because of the coarse resolution of the imaging system. In summary, Landsat-type imagery is a great tool for characterising regional scale features, detecting moderate size outcrops (larger than 50x50m) for fieldwork planning purposes, and interpreting lithological and alteration features emphasised by colour variations.

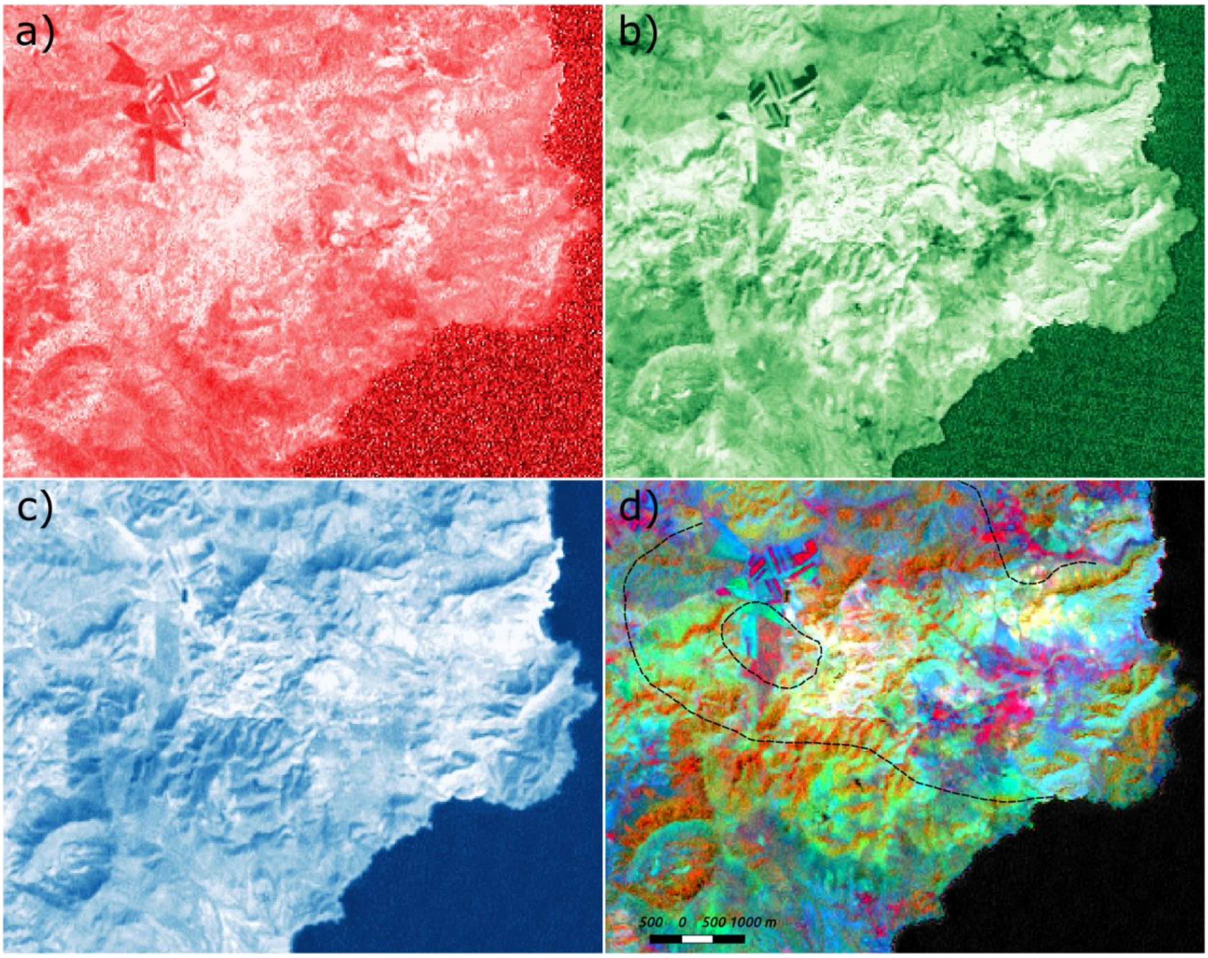

Figure 2. Montage of Landsat-7 scenes showing the Rodalquilar caldera (SE Spain). The caldera (outlined by the dashed line in d) hosts one of the best exposed epithermal alunite gold deposits in the World. Band ratios a), b), c) are shown in their respective filters used for producing colour composition d). A) 5/7 band ratio enhancing the signal from clay minerals and healthy vegetation (bright pixels shows high value). B) 5/4 band ratio emphasizing ferrous minerals – it is useful for mapping dark volcanic rocks. C) 3/1 band ratio capturing areas with high Fe^{3+} content that in this particular area characterizes volcanic rocks weathered in oxidized environment. d) RGB 5/7-5/4-3/1 color composition showing argillic alteration in yellow and white (Arribas Jr et al., 1995).

3. Environmental auditing

In many countries environmental and land management policies require mine site operators to remediate any damages to the environment, whether they were caused during exploration/exploitation activities, or happened before the company acquired the land. Satellite data can considerably assist monitoring temporal changes of land use and historical contamination before, during and after field activities (4D modelling). A number of algorithms have been developed to assist the determination of various biophysical parameters. For example, the NDVI (Normalised Difference Vegetation Index) can detect healthy vegetation and support the mapping of possible contamination.

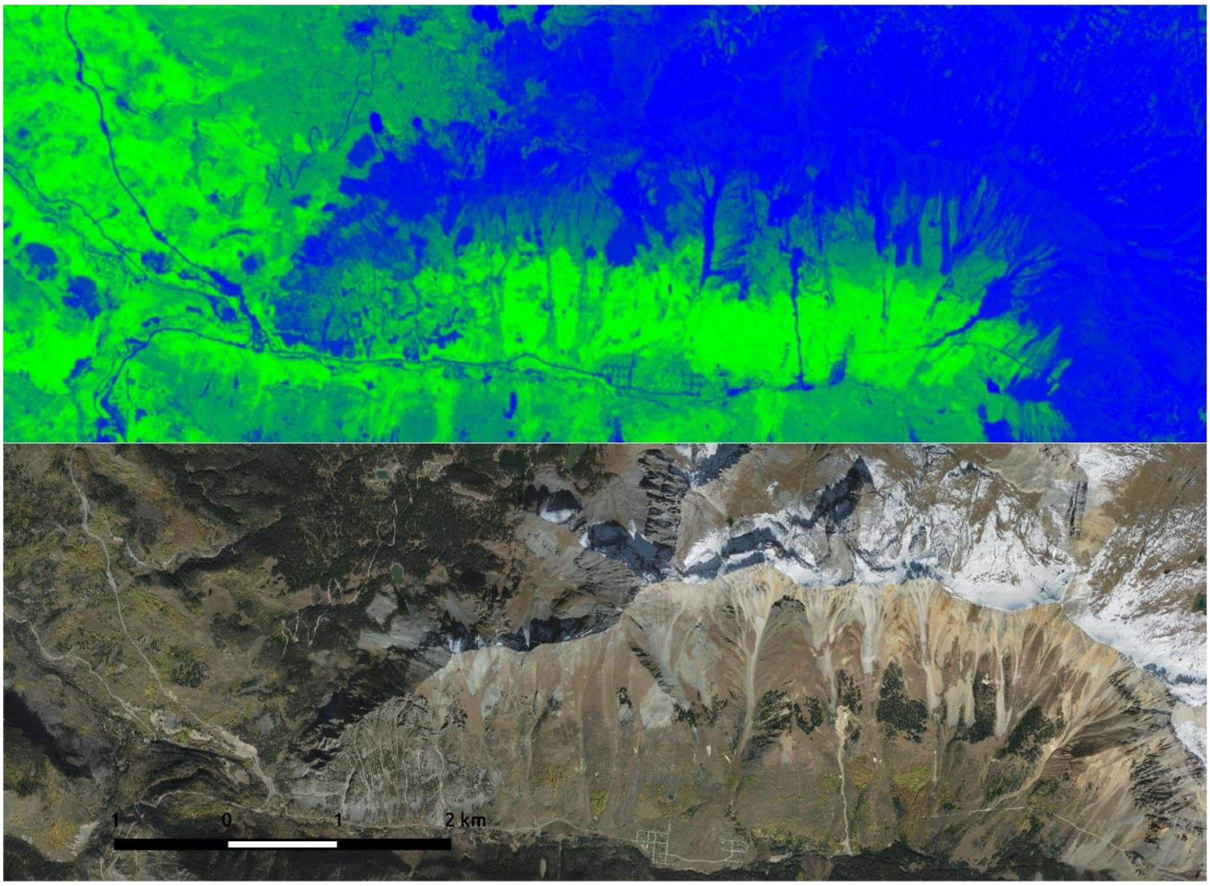

Figure 3. Normalized Difference Vegetation Index (NDVI) produced from Sentinel-2 imagery, San Juan Mts., Colorado, USA (above). NDVI is a popular tool for studying the general health of vegetation. It is directly related to the photosynthetic capacity of plants. Bright green shows areas covered with healthy vegetation, and blue signifies areas with other materials like rocks, water, soil and concrete. Google Earth image of the location is provided for comparison (below).

Literature

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