EGU2020-10719
https://doi.org/10.5194/egusphere-egu2020-10719
EGU General Assembly 2020

Sentinel-2 as a tool for mapping iron-bearing alteration minerals: a case study from the Iberian Pyrite Belt (Southern Spain)

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Satellite-based remote sensing offers a time-saving and cost-effective way of exploring mineral resources in support of mineral exploration and monitoring of mining activities. On one hand, the newest generation of non-commercial optical satellite sensors, such as Sentinel-2, provides data with improved spectral, spatial and temporal resolution. One of the main advantages of Sentinel-2 with respect to other sensors is that it has several bands that cover the 900 nm iron absorption feature. On the other hand, this unique feature still remains underrated as suggested by the lack of applications in the mining sector. We explored the potential of Sentinel-2 for regional-scale mapping of iron-bearing alteration minerals using several approaches commonly used in Earth Observation. We focused on the Iberian pyrite belt, which hosts several of the largest massive sulfide deposits on Earth and has been extensively mined for copper, manganese, iron and gold since the Bronze Age.

First, we attempted to characterize the part of the spectrum between 704 and 945 nm (bands 5 to 9), which is associated to the iron absorption feature, using normalized indices and curve-fitting techniques. These approaches do not require inputs and allow to easily and quickly produce a map of alterations zones revealing mineral prospects and mining sites, but at the cost of a lack of differentiation between the different mineral assemblages. The second approach used was to map specific mineral assemblages using the Spectral Angle Mapper algorithm, which determines the spectral similarity between a known reference spectrum and another unknown spectrum. Relevant mineral assemblages were defined using the mineral composition and resampled spectral signatures from field samples. The focus was mainly set on assemblages containing sericite, chlorite and goethite, which are closely associated to volcanic hosted massive sulfides. Despite known difficulties, related to the low spectral resolution and pixel mixing, several assemblages such as those containing chlorite and sericite could be successfully mapped and their overall distribution appeared consistent with field sampling and hyperspectral imaging from existing studies. Finally, we attempted to map specific mineral assemblages using classification methods based on state of the art machine learning algorithms such as Support Vector Machine, Multi-Layer Perceptron and Random Forrest. Training pixels for mineral assemblages were carefully selected based on field observations and existing hyperspectral data. Each classification method was assessed using a stratified K-fold cross-validation and all four classifications perform

well if we consider the average accuracies for alterations, which range from 93.9 to 96.2%.

Sentinel-2 proves to be a powerful tool for mapping iron-bearing minerals. The different approaches we tested (from the simple ones requiring no inputs to the more complex ones requiring field data and knowledge) allow to efficiently map iron-bearing alteration minerals with an increasing degree of details and can find applications not only in mineral exploration but also in monitoring of mining activities.