Application of remote sensing techniques to the lithological characterization of Rocha da Pena (southern Portugal)

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Introduction

Currently, remote sensing techniques are powerful tools for data extraction in Earth Sciences, including Geology, Geomorphology and Soil Science, and are usually applied to map production.
The aim of this study is to show the application of these techniques of remote sensing in the lithological analysis in Rocha da Pena (Loulé, Portugal) using Landsat-TM5 (Figure 1) and Google Earth (Figure 2) images. Lithological discrimination was performed by image fusion techniques and texture analysis.

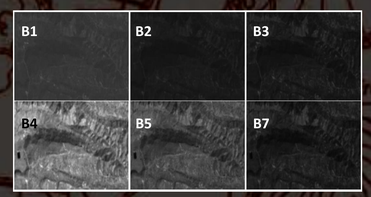

Figure 1. Landsat TM5 bands: B1 B2,B3,B4,B5 and B7 (Rocha da Pena, Loulé, Portugal).

Figure 2. Google Earth image (Rocha da Pena, Loulé, Portugal). (A) Aerial image; (B) NW view.

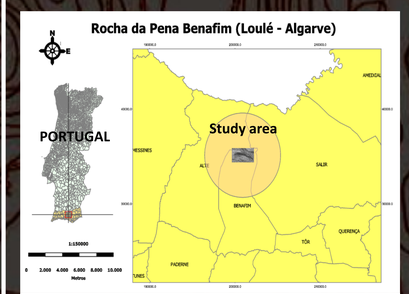

Figure 3. Study area.

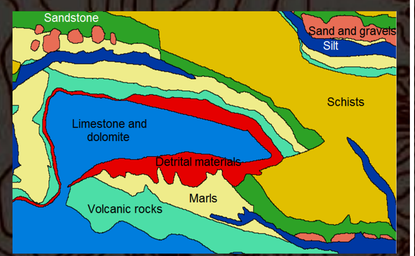

Figure 4. 1:50,000 Portuguese Geological Map (DGM, 1984).

Study Area

The study area (15 km²) includes part of the municipality of Benafim, in the Council of the Loulé (southern Portugal; Figure 3). Rocha da Pena is an isolated limestone massif, covers more than 600 ha reaching its highest point at 479 meters. The steep landscape has a limestone cornice reaching 50 feet high, crowned by a plateau about two kilometers long.

The area is currently protected by Portuguese law (Decreto – Lei 392/91), because of its important geological, geomorphological, biological and cultural features.

The lithological map shows eight different groups (Figure 4), including limestones and dolomites (forming the central massif) as well as schists, volcanic materials, marls, and sandstones in parallel bands around the main unit.

Methodology

The lithological classification was performed by techniques of image fusion and texture analysis. The fusion of images was based on the red-green-blue (RGB) composition of false color images and processing for the system intensity-hue-saturation (IHS), which allowed separating the spectral spatial information to produce a hybrid image, with a better spatial resolution.

Texture analysis was carried out by the geo-statistical analysis method developed by Haralick (1973), known as "Spatial Grey Level Difference Method" (SGLDM), which calculates the probability of a transition between two pixels of the image in grey tones, separated by a specified spatial orientation. This method is commonly known as "Matrixes of co-occurrence".

RGB composit

Is the most simple fusion process that explores the characteristics of the additive color system. Compositions RGB 432 and RGB 754, usually use, were used to obtain RGB images.

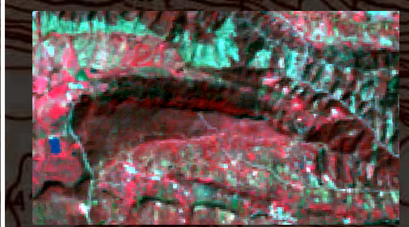

Figure 5. RGB image with Landsat 5 bands: Green (B2), Red (B3) and Near Infrared (B4)

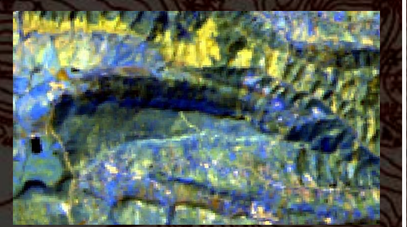

Figure 6. RGB image with Landsat 5 bands: Shortwave infrared (B7), Shortwave Infrared (B5) and Near Infrared (B4)

IHS transformation

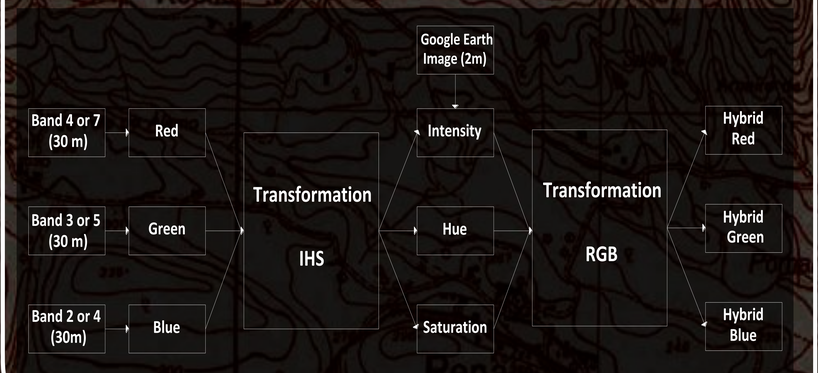

Figure 7. Methodology used for HIS transformation.

Figure 8. Hybrid 432 image.

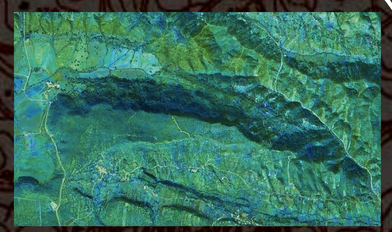

Figure 9. Hybrid 754 image.

Texture analysis

Texture analysis was applied to Google Earth images. The co-occurrence matrix was calculated by analysis windows (9 × 9 pixels), in the direction 0^0. Texture parameters used were: entropy, correlation, contrast, angular second moment and inverse difference moment..

Figure 10. Correlation image.

Results

Both methods could differentiate some of the lithological formations present. The texture analysis method (Figure 11) revealed the presence of the Mira unit, with rough aspect, the Picavessa unit (limestone and dolomite), the Volcano Sedimentary Complex, the Silvex complex (marls-carbonates and evaporites) and water lines on the alluviums.

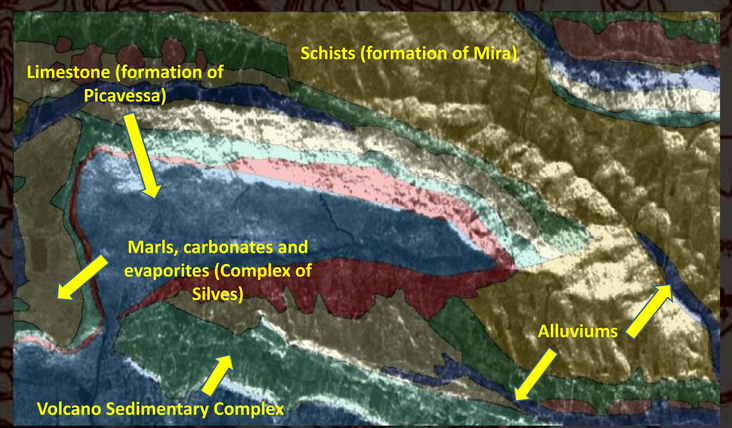

Figure 11. Texture analysis with overlay lithological map.