GEOLOGIC AND GEOMORPHOLOGIC FEATURES APPLIED FOR IDENTIFICATION OF WINE TERROIR UNITS BY DIGITAL IMAGE PROCESSING, SPECTRORADIOMETRIC AND GIS TECHNIQUES IN ENCRUZILHADA DO SUL, RS, BRAZIL

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ABSTRACT

Results in the characterization of a new wine terroir unit in south Brazil are reported. Presently, several areas in Brazil are being studied, in an effort to define new wine terroirs and improve the quality of Brazilian wines. This paper reports what is being done, by Embrapa (Brazilian Agricultural Research Corporation) and its partners Remote Sensing and Meteorological Research Center (CEPSRM/UFRGS) and Brazilian Geological Survey (CPRM), in the Encruzilhada do Sul region, at Rio Grande do Sul State, that is part of the Serra do Sudeste viticultural region. Satellite images from several sources (SRTM, ASTER, ALOS) were used, together with field data (rock samples). Digital elevation models were built and used to define areas with slopes and solar expositions adequate to vine growing, with altitudes above 350 m. Spectroradiometry of rock samples was performed, to identify several minerals (montmorilonite, illite, pyrophilite and kaolinite). Geologic maps were used to locate rock types to collected in field trips; those rocks had their spectral response extracted from radiometry, and fitted to the six bands of ASTER SWIR subsystem, resulting in a map of the distribution of these rocks in some areas of interest. Two wineries were more closely studied. The first area produces wine from 35 hectares of Cabernet Sauvignon, Merlot, Nebbiolo, Pinot Noir and Chardonnay. The other winery has 61 hectares and produces Pinot Noir and Chardonnay grapes for sparkling wines. The study concludes that the use of remote sensing resources and associated geotechnologies are effective to terroir studies.

KEYWORD

Brazilian wines; geology; geomorphology; spectroradiometry; geographical information system.

INTRODUCTION

In Brazil, spectroradiometric studies have been developed to characterize new viticultural geographic appellations, and for this effort, geotechnologies have been used by Embrapa and Embrapa Grape and Wine Research Center (Centro Nacional de Pesquisas em Uva e

Vinho/CNPUV) is located in Bento Gonçalves, at Rio Grande do Sul State, at the main Brazilian wine production region. One of the more promising new studied areas is located near Encruzilhada do Sul city, in Serra do Sudeste viticultural region (Figure 1). This area is dominated by extensive grasslands with minor forest patches developed over old Precambrian terrains represented mainly by granitic-gnaissic rocks. Soils are mainly cambisolos and argisolos, poor in organic matter, well drained and occasionally gravely. The whole region is part of the Pampa Biome (Embrapa 2008), which also covers large areas in neighboring Uruguay and Argentina.

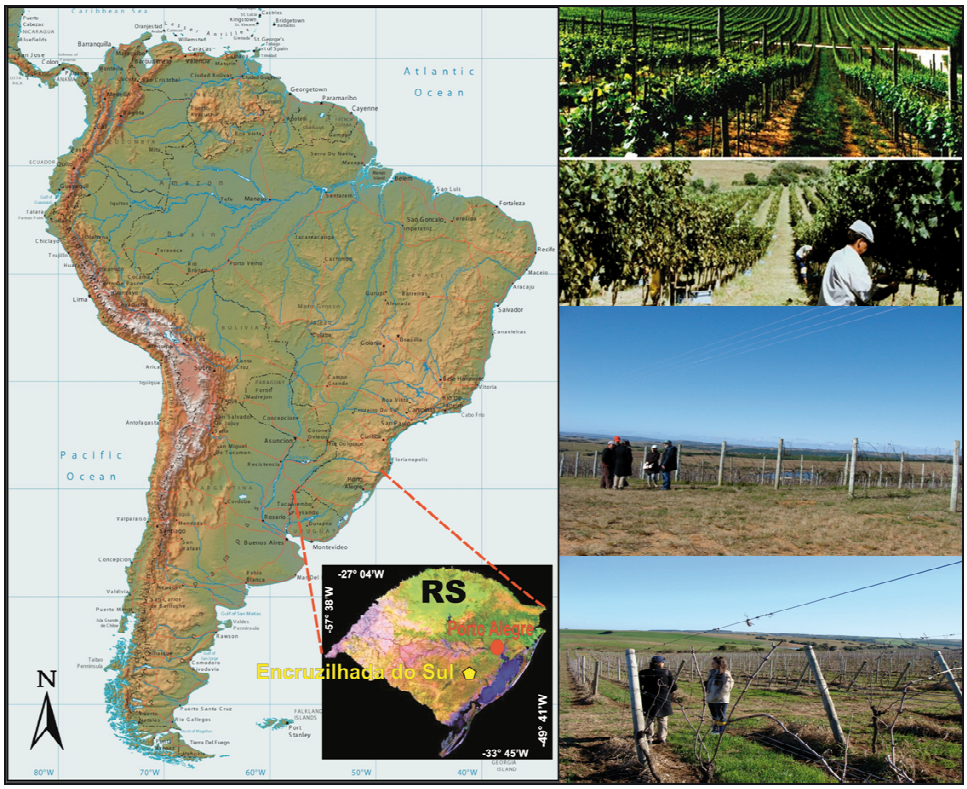

Figure 1. Location and vineyards in Encruzilhada do Sul, Brazil.

Vineyards for fine wines (Vitis vinifera) were first introduced around 1970, and presently there are more than 300 hectares with grapes such as Barbera, Cabernet Franc, Cabernet Sauvignon, Merlot, Periquita, Teroldego, Marselan, Pinot Noir, Ancelota, Malbec, Touriga Nacional, Gamay, Arinarnoa, Alicante Bouschet, Chardonnay, Gewürztraminer, Malvasia de Cândia, Sauvignon Blanc, Riesling, and others. Such a large diversity of vineyards proves an ongoing search for grape varieties that leads to a terroir identity. This identity, in fact, is already suggested by Cemin and Ducati (2008), which detected spectral differences between grape varieties in Encruzilhada do Sul, when compared with French and Chilean vineyards. Further studies on the area were performed by Hoff et al. (2007), comparing geology and relief units in the region, while Hoff et al. (2009) studied relief from two sets of orbital data; Bergmann et al. (2009) linked digital elevation models (DEM) and geological surveys to vineyards data. This work presents additional studies on this region, relating physical data as rock and landscape, which give specificity to wines, and thus define a potential terroir.

MATERIALS AND METHODS

Cartography was based on SH-22-Y-A-VI-2 map 1:50,000 scale, from the Brazilian Army. Digital elevation models (DEM) were generated from three orbital sources: the Space Shuttle DEM (SRTM 2008) to characterize regional features on low resolution; the ASTER imager (Abrams and Hook 2002) to study the areas on medium resolution; and ALOS satellite (ALOS 2009) to characterize the vineyards on high resolution. Soil and geological maps were produced by Embrapa and CPRM, respectively.

Thematic relief and landscape maps providing information were produced by CEPSRM/UFRGS through digital image processing. Those products were grouped in a Geographic Information System (GIS) environment, using ground and satellite data, to produce a suitable agricultural zoning, searching for potential terroir units.

Digital elevation models produced slope, elevation, and solar orientation maps, which were integrated, to be used in wine production planning.

Rock samples were collected in field trips, and analyzed with spectroradiometric techniques by POSAM - Portable Spectroradiometer for Mineral identification and MISO - Mineral Identification Software (Dowa, 2003) at CPRM. The spectral signatures lead to the identification of the main species of minerals and their spectra was degraded to match the six bands of ASTER SWIR subsystem, thus allowing a comparison with satellite data, leading to the identification of rock types on images.

RESULTS AND DISCUSSION

Figure 2A shows the elevation map. Geomorphologic features like areas above 350 m are highlighted, since these higher places tend to yield better wines. Relief features as slope and solar orientation are important factors to wine quality. These features were crossed with areas above than 350 m to show the best places to grape cropping (Figure 2B).

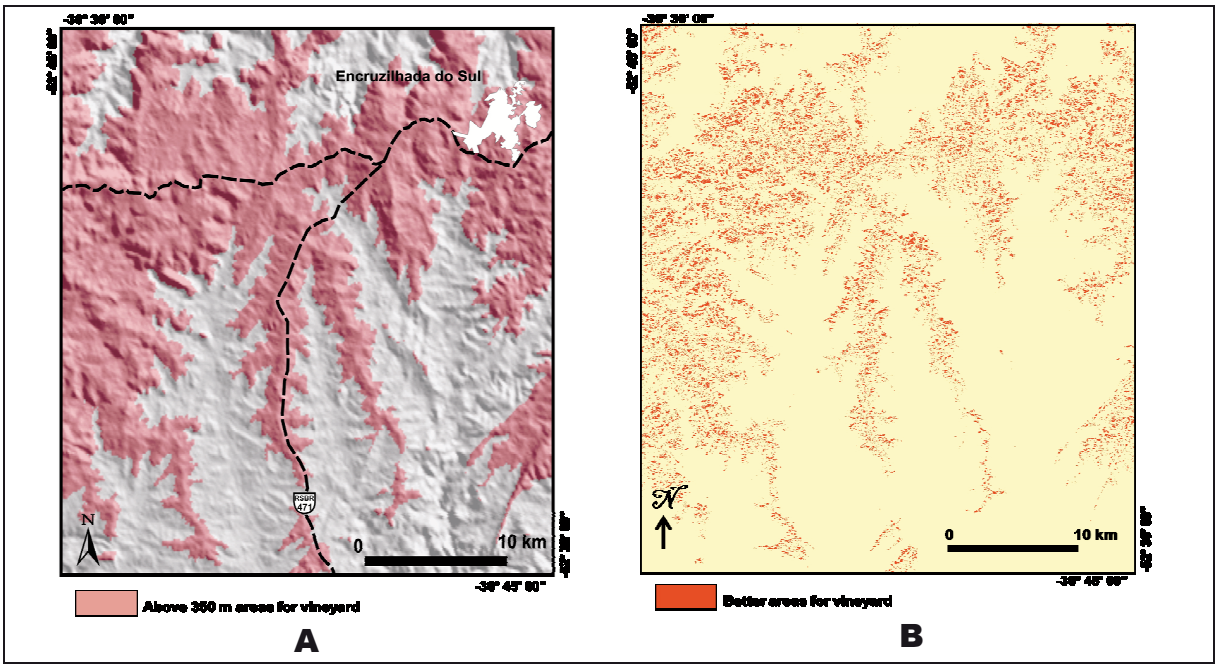

Figure 2. A: DEM generated from SRTM data, where shaded relief shows areas above 350 m; B: from ASTER data, areas above 350 m, flat relief and northern exposition (Hoff et al. 2007). Dashed lines are roads.

Figure 3A shows the geologic map of the region. Figure 3B shows the reflectance spectra of five rock types, expressed in the six bands of ASTER SWIR subsystem. These signatures were used to detect these five rocks in the terrain imaged by ASTER, producing a classified image for areas above 350 m (Figure 3C). Spectral radiometric techniques identified minerals such as montmorilonite, illite, pyrophilite and kaolinite.

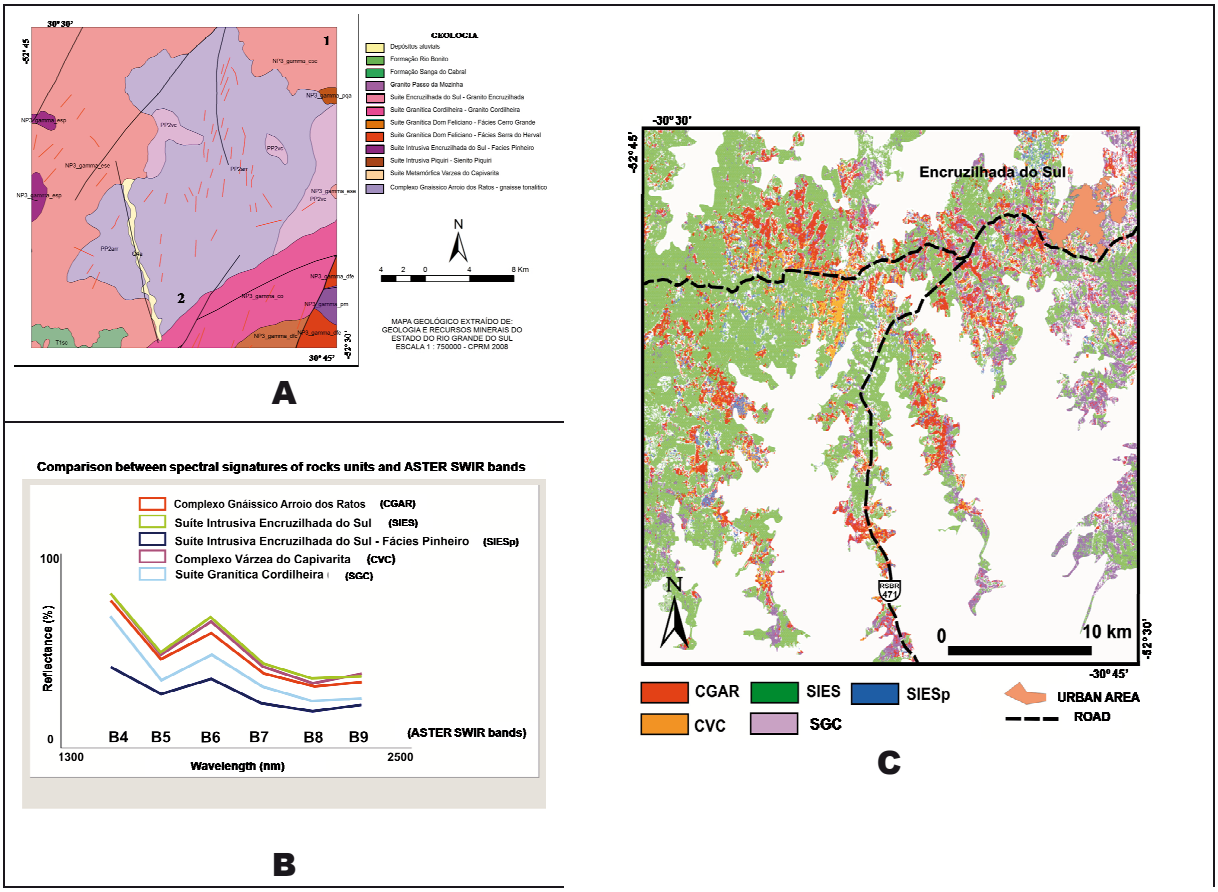

Figure 3. Geological map (A), adapted from CPRM (2008), showing location of wineries Lídio Carraro (1) and Chandon do Brasil (2) in Encruzilhada do Sul; spectral signature of rocks (B); classified image for geology (C), from Hoff et al. (2009).

Two vineyard areas were more closely studied. Figure 4 shows the Lidio Carraro winery, with 35 ha of Cabernet Sauvignon, Merlot, Nebbiolo, Pinot Noir and Chardonnay grapes . The digital elevation model showed maximum elevation of 360 m, and slopes mainly in 3-8% and 8-30% classes; solar exposition is mostly North and Northeast.

The second area is Chandon do Brasil winery, which produces sparkling wine from Pinot Noir and Chardonnay cropped over 61 ha. DEM indicated an elevation varying from 350 to 380 m, slopes from 3-8% to 8-30%, and aspect (solar exposition) between North, Northwest and West (Figure 5).

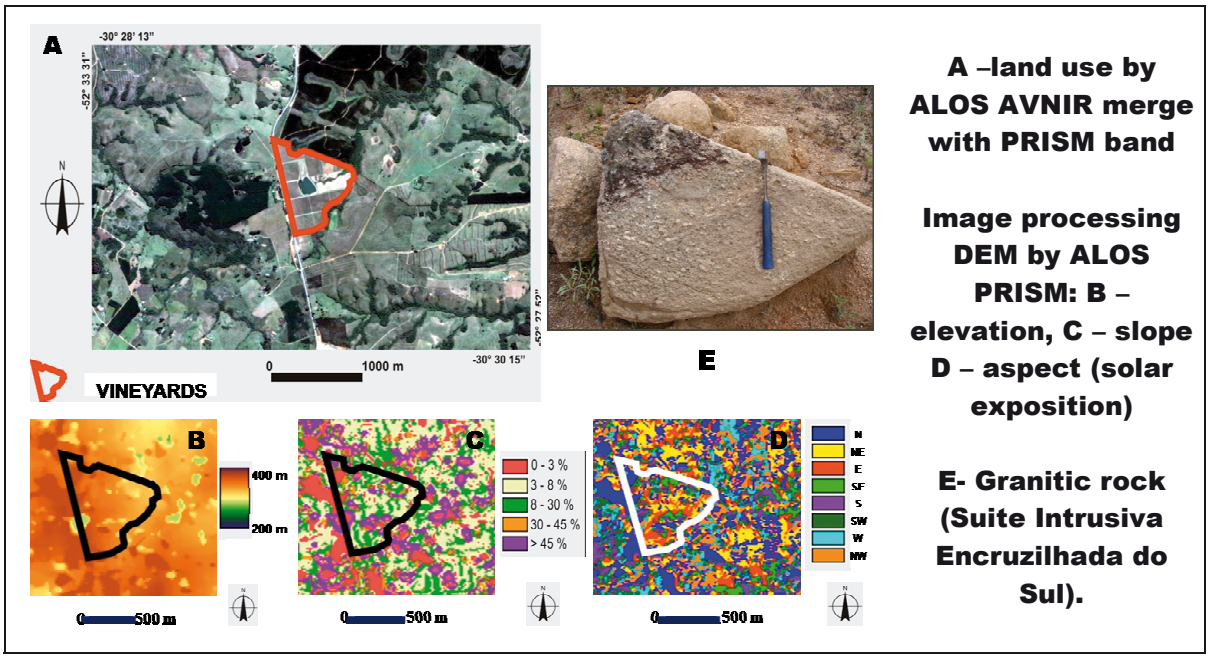

Figure 4 – Vinícola Lídio Carraro, Encruzilhada do Sul, Brazil.

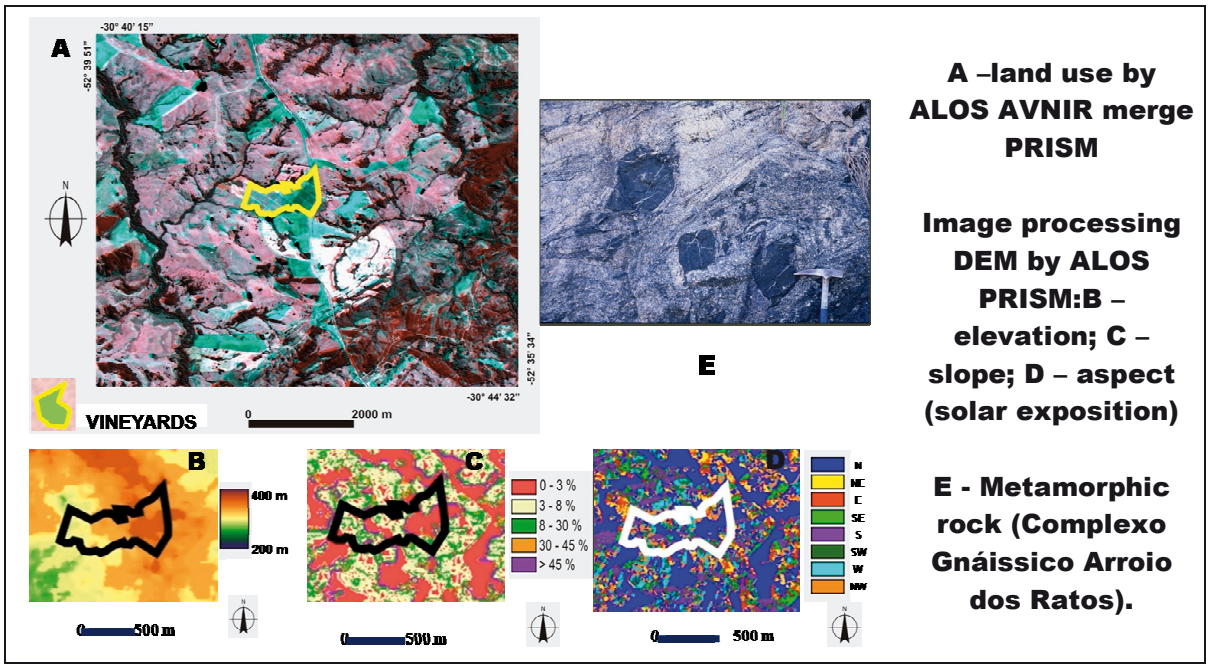

Figure 5 – Chandon do Brasil, Encruzilhada do Sul, Brazil.

CONCLUSIONS

This study showed how the integrated use of geotechnologies and spectral analysis from radiometry, supported by field data, can contribute effectively to viticulture studies aiming to terroir characterization. Satellite images from several sources, such as low (SRTM), medium (ASTER) and high (ALOS) resolutions, are effective to produce information on geological,

topographical, and solar orientation data, important to establish criteria to identify potential terroir units, to agricultural zoning, and to strategies in vineyard and wine production.

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