INTEGRATION OF REMOTE SENSING AND GEOPHYSICAL DATA: AN APPROACH FOR GEOLOGICAL STUDIES IN THE TROPICAL RAINFOREST OF EASTERN AMAZONIA (CARAJAS DISTRICT)

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ABSTRACT:

The complexity of the Amazon environment causes many difficulties to the implementation of geological programs. One alternative to these problems is based on the use of indirect information obtained from orbital remote sensing data. This paper discusses aspects related to an implementation of à long term research project in the Pojuca area (Carajás Region), focussing on Digital Image Processing techniques (IHS Transformation), based on Landsat TM and aerogeophysical data.

KEY WORDS: Digital Image Processing, Geology, IHS.

1. INTRODUCTION

The Amazon region has very few geological surveys, in spite of having several mineral districts. The relationship between geology, relief, soils and vegetation cover is poorly known. This lack of knowledge is caused by many factors, such as the non-accessibility to the area, its environmental complexity, the absence of systematic and integrated multidisciplinary studies, etc. These problems can be partially solved by the use of remote sensing and geophysical data.

In this context, a large research project is running, based on the extraction of geological information with data obtained from remote sensing (Landsat TM images and aerial photographs), geophysics (aereomagnetometry and gamma spectrometry), topography, geology and botany.

Part of this study consists on the analysis and correlation between vegetation cover (plant communities) and geological units in a tropical rainforest environment, using geobotanical models (Paradella, 1989). In order to perform this work, a digital database was implemented for a test area, in the Carajas Mineral Province (Paradella et al., 1990a), where several geological and geobotanical investigations are conducted (Paradella et al., 1990b; Rolim and Paradella, 1991 and Paradella, 1992).

The objective of this paper is to present first results of a study on remote sensing and geophysical data integration.

2. STUDY AREA

The area under study is located at the Northern border of the Carajás Mountain Range, Pará State, centered on the Pojuca Cu-Zn deposits (Figure 1).

According to DOCEGEO (1988), the basement of the Pojuca area is named "Xingu Complex". It is a sequence of gnaissic rocks, originated from medium to high metamorphism in Archean granitic terrains. This unit is bordered by a discordant Archean volcanic sequence to NW, with intercalated clastic/chemical sediments, denominated "Igarape Pojuca Group". These rocks are at a greenschist-anphibolite metamorphic grade and present a trend to N70° N, as part of a wide shear zone, characterized by a ductile/brittle deformation. Furthermore, this sequence presents several Cu and Cu (Zn) deposits, associated with Au and Mo. Overlying these rocks, there is a transgressive clastic sedimentary unit of Early Proterozoic age, known as "Rio Fresco Group". This sequence shows a sharp boundary with the Igarape Pojuca Group and presents low metamorphism. Several anorogenic granites of 1.8 b.y. age are identified in this mineral Province. In the area under study, these granites are intrusive only in the Igarape Pojuca Group. Finally, Tertiary lateritic crusts have been preserved and are exposed over the Rio Fresco metasediments.

Another important feature of this area, is its environmental complexity, characterized by heterogeneous topography, deep chemical weathering profiles of thick latosols, almost total absence of outcrops and dense vegetation cover (tropical rainforest), composed by numerous species (Paradella, 1990a).

3. DATASET USED

The characteristics of the dataset used are presented in Table 1.

4. IHS TRANSFORMATION

There are many digital processing techniques to enhance the information presented on the satellite remote sensing data. In many cases, the final product is a color composition, as a result of the Red-Green-Blue combination (RGB). The visual interpretation of this product presents good results, because the human eye is able to discriminate much more colors than grey tones. Figure 2 shows a geometrical representation of the RGB space, where one color can be specified by its three-dimensional coordinates.

However, the color display coordinate system can also be defined by three independent and orthogonal parameters, named Intensity (I), Hue (H) and Saturation (S). In this case, Intensity considers the total energy of the image (brightness); hue is the color sensation (average wavelength) and saturation is the relative index of the color purity (percentage of white light). The attributes of IHS express another type of color perception, since they can be manipulated in a controlled way, providing a quantitative image interpretation. Being so, it is necessary to decompose the IHS attributes of the image, considering them individually, in opposition to the RGB space, which allows only simultaneous changes at the IHS parameters.

In this paper, the triangular coordinates were used (Haydn et al., 1982) to test the usefulness of the IHS transformation (Figure 3).

5. METHODOLOGY

Table 2 shows a diagram of the methodology used in this study.

6. RESULTS

Plate 1 is a color composition of Landsat TM imagery (TM bands 5, 4, and 1), selected by the optimal index factor (Chavez et al., 1982). The contrast enhancement applied at this composition (RGB space) does not expand the range of colors displayed, because the spectral data are highly correlated from channel to channel.

Plate 2 shows the final product of the IHS-transform in the previous color composition. Both the color hue and intensity are enhanced, in order to improve the range and lightness of the picture, as suggested by Gillespie et al. (1986). This combination provides a better visual discrimination of geological and structural features.

Another procedure to improve the visual interpretation is shown by plate 3, where the IHS transform combines the first principal component of the six reflective Landsat bands (intensity channel) and the total magnetic field (hue channel). This product provides additional information on the textural and topographycal features (principal components) "colored" by the magnetic patterns. This IHS transform is, such as the previous approach (Plate 2), a better visual discriminator of geological and structural information.

Plate 4 is the geological map analysed, based on the information obtained by the IHS transforms and the geological map of DOCEGEO (1988).

An alternative to improve the extraction of geological information in the tropical rainforest environment, is the digital integration of multidisciplinary data. In order to perform this integration, one must consider the potencial information obtained from the geophysical surveys. In Brazil, data from these surveys should be better integrated with other variables,such as data from remote sensing, topography, geochemistry and geology.

This paper is the first step of an investigation. Many efforts have been made to improve the data processing quality for high density information (geophysical) in order to work at continously larger areas.

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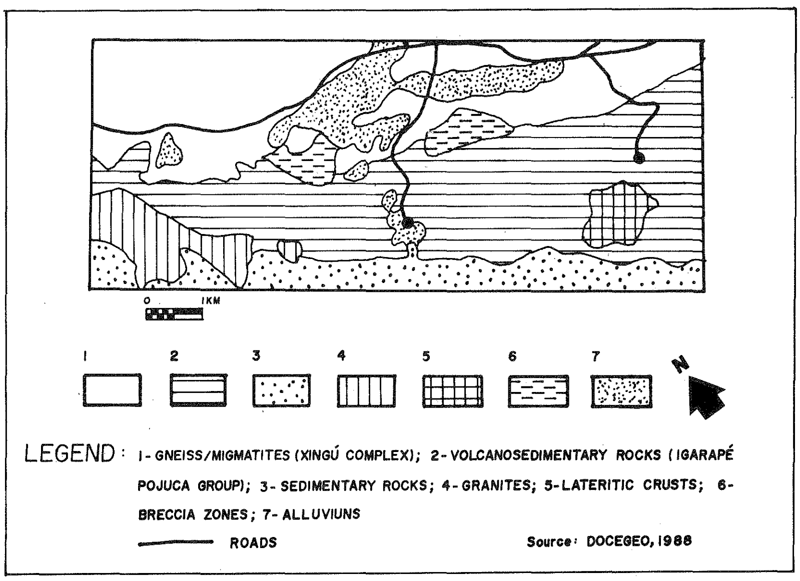


FIGURE 01: GEOLOGICAL MAP

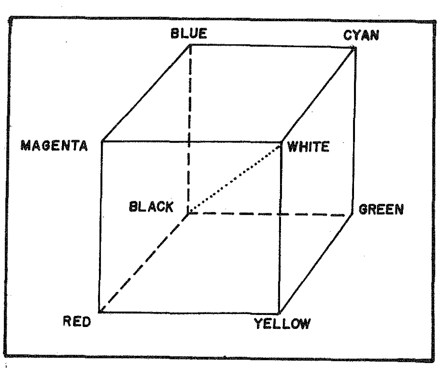


FIGURE 02: Geometrical representation of the RGB space

SOURCE: Mather (1987)

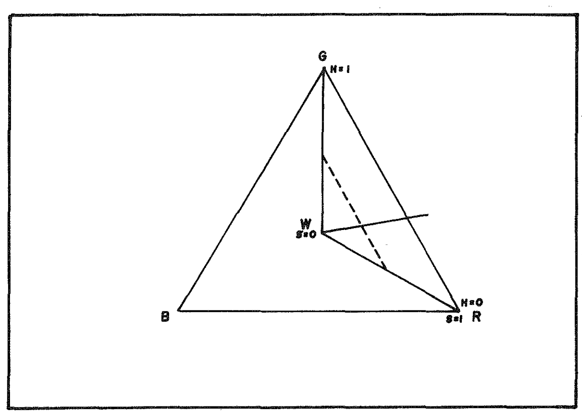
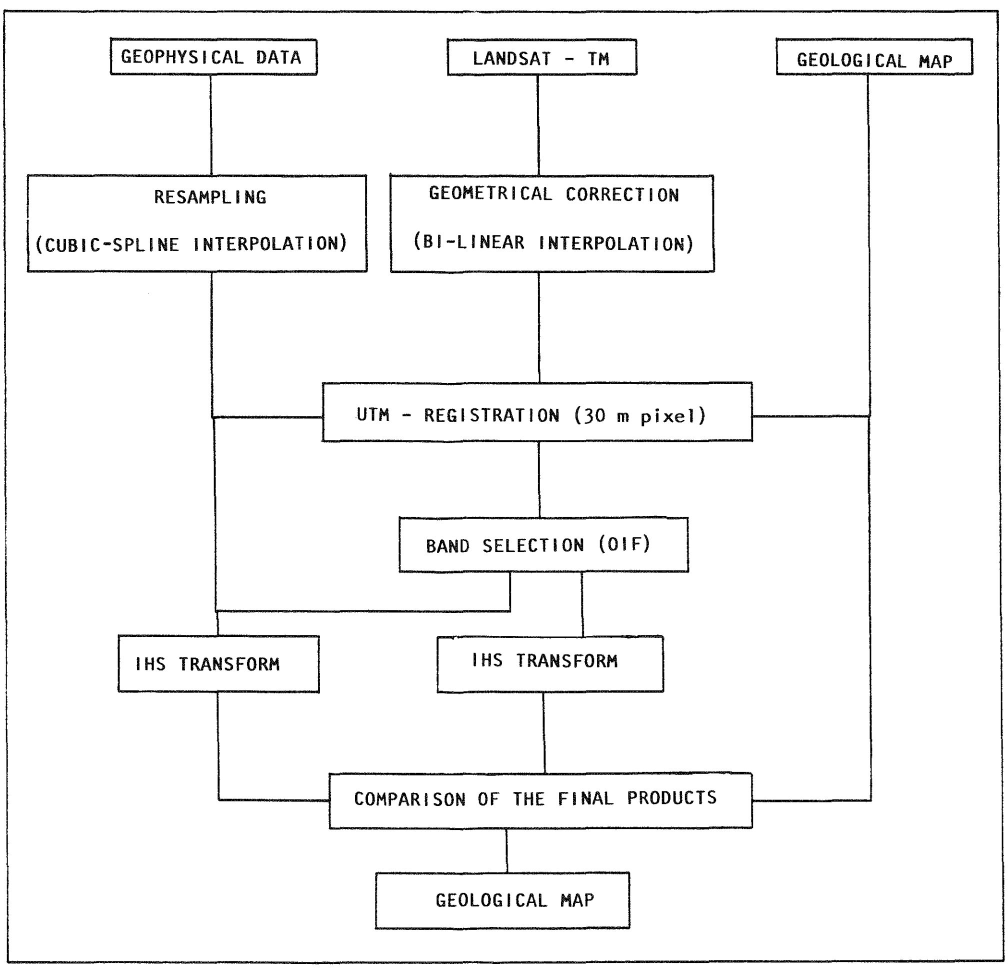


FIGURE 03: Simplified IHS representation

SOURCE: Haydn et al (1982)

Data	Caracteristics
Landsat TM	TM-5 Date: 05/31/1984 Spatial resolution: 30 m UTM - registered
Total Magnetic field profile (Brazil/Canada Project)	Regular grid Original grid spacing: N-S: 61 m E-W: 1000 m Flight height: 150 m Resampled grid spacing: 30 m Interpolation method: cubic spline
Geological Map	Scale: 1:10000 (covering 30% of the the study area)

Table 1: Characteristics of the data.



OIF= Optimal Index Factor (Chavez et al., 1982).

Table 2: Methodology.

Plate 1: Color composition of Landsat TM (bands 5, 4 and 1).

Plate 2: Final product of the IHS transform

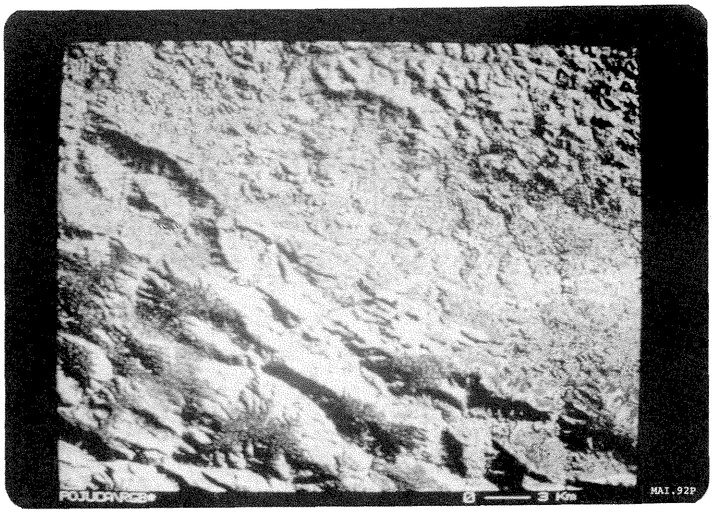


Plate 3: Final product of the IHS transform(I: PC1;
H: magnetics and S: bands 5, 4 and 1).

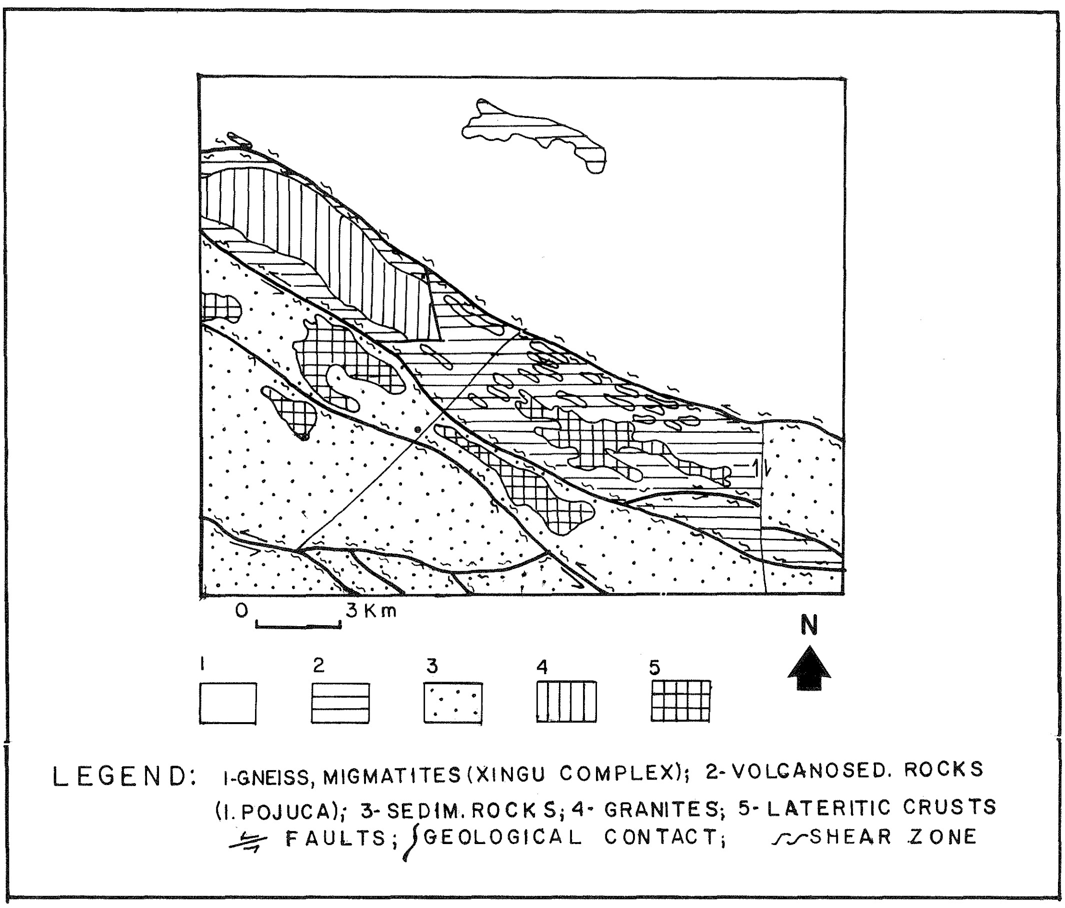


Figure 04: Final geological map.