ABSTRACT

A pervasive NS-EW pattern of structural lineaments on Brazilian terrains has been identified on remote sensing products. Such pattern can be found by cutting and controlling rocks as well as and structures from the Archean to the Paleozoic ages. These rocks have been under several deformation cycles. Those NS and EW structural lineaments exert paleogeographic, sedimentological and tectogenetical control over several litho-structural units. They appear in a subtle way in satellite images, as a direction of maximum density of other fractural patterns. The NS-EW pattern reveals its policyclic character and its influence on the strucutural evolution of the Brazilian craton.

1.0 INTRODUCTION

A research was carried out to analyse remote sensing data on tectonic, structural, paleogeographc and sedimentological control by the NS-EW directions over stratigraphic, litho-structural units of Archean; Lower, Middle and Upper Proterozoic; and Paleozoic ages.

Remote sensing products like MSS-RBV and TM-LANDSAT images at scales ranging from 1:500.000 to 1:100.000; aerial photographs at scales ranging from 1:100.000 to 1:25.000; and magnetometric and gravimetric maps were employed. Besides the interpretation of such data, field work was carried out.

The study areas belong to the following outstanding portions of some Brazilian pre-Cambrian structural provinces (Almeida et alii, 1981), as shown in Figure 1: Sudeste Fold Belt (Mantiqueira Province) which includes Tijucas sequence, Araçuaí Fold Belt (São Francisco Province), Brasília-Tocantins Collision Belt (Brasil Central Shield/Tocantins Province), Tijucas Belt Fold and Joenvile/ Pelotas Massifs.

These structural provinces consist of migmatite-granulitic complex, "greenstone belt" relicts of Archean age, metamorphic vulcano-sedimentary sequences from Archean to Lower Proterozoic ages, metapelites and metapsammites of Lower Proterozoic age, and basic and acidic magmatism. In all these provinces, policyclism, polimetamorphism, tecto-orogenesis, and thermotectonic events were recognized since the Archeozoic age.

2.0 METHODOLOGICAL ASPECTS

The main methodological procedures were, orbital images and pancromatic aerial, photographs visual interpretation based on Veneziani and Anjos (1982), as well as the geometric and statistical analysis of fracturing (Plicka, 1974; Alieyev, 1982; Anjos,1986 and others).

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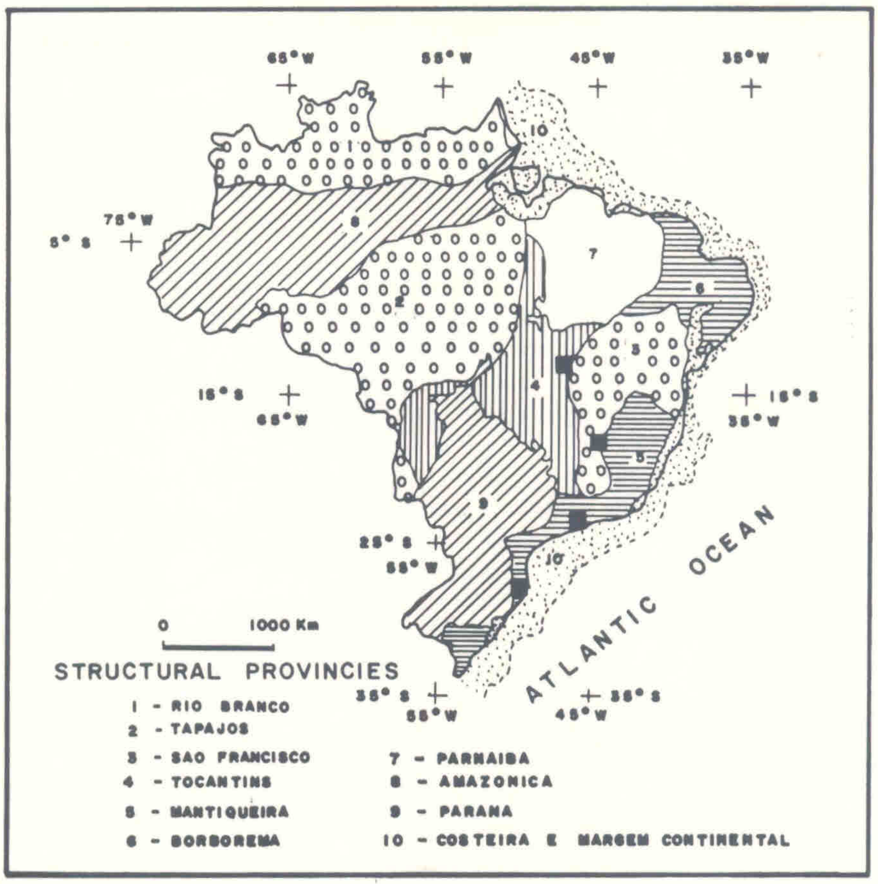

Figure 1 - Map showing Structural Provinces and the research areas. (Modified from Hasui and Almeida, 1984).

The interpretation method employes the analysis of relief and drainage textural features which can show similar physico-chemical properties for homogeneous lithologic units, regarding their permeability, solubility, deformation and coesion-erosion. This method leads to the recognition of joints, faults, bedding and foliation structures and to the inference of their strikes and dips.

Fracturing analysis was based on the identification of joint zones, which consist of 10 to 30 cm spaced parallel joints, diping from 90 to 70 degrees. These joint zones can extend over distances as long as tens or hundreds of kilometers to form sets of joint zone.

Several researchers, as Veneziani (1987) and others, consider that joint zones have their origins related to the reactivation of narrow tectonic lines, which can be correlated with ancient lines of crustal weakness. These lines of weakness are the main responsible factor for the paleogeographic, sedimentary and tectono-structural control.

Anjos (1986), Santos (1986), Veneziani (1987) and others consider that:

a) Fault tends to follow the sets of joint zones;

b) Sets of joint zones are clearly visible where tectonic activities were increased;

c) The sets of joint zones come from ancient rocks up to the overlying younger ones;

d) Geomorphic features indicate joint zones;

e) The number of sets of joint zones increases around regional faults, which indicates a narrow correlation between these faults and sets of joint zones;

f) The sets of joint zones do not occur regularly everywhere.

The statistical method by Aliyev (1982) was used to analyse different sets of joint zones in a certain area. For each fracturing direction, joint zone density and frequency maps were made and axes of maximum of density and frequency were defined.

For example, a EW axis of maximum density of fracturing in a map of N50E fracturing, shows that the EW direction affected the formation of this NE fracturing. This control shows that the EW axis was a zone of crustal weakness during the formation of the N50E fracturing.

A similar analysis procedure was adopted to carry out the study of the geological sites presented in this paper. Field work was carried out to confirm the structural analysis on the remote sensing data.

3.0 GEOTECTONIC EVOLUTION

Veneziani (1987) and other researchers developed a geotectonic model for the Espinhaço Meridional and Quadrilátero Ferrífero. In this region Lower Proterozoic sediments had originaly a NS direction related to a intracontinental rift formed along the active continental margin of Alpine kind, which was developed in ensialic enviroment. This model agrees with an obduction model confirmed by geophisical data for this region (Haraly et alii, 1984).

For the Sudeste Fold Belt, it is accepted an evolution model during the Upper Proterozoic age, following a global tectonic model (Hasui et alii (1975), Jost (1981), Hasui and Almeida (1984), Anjos (1986), and others). The occurrence of magmatic archs, nodal areas, mafic and ultamafic rocks and the general geometry of the fold region are considered features associated with continental collision and subduction processes..

The Sudeste Fold Belt presents a large area of granite-gnaissic units associated with greenstone belts and high metamorphic grade rocks. Archean and Eoproterozoic units constitute its the regional basement, partially overlain by younger rocks, which were metamorphosed during the Brazilian event in the upper Proterozoic.

The crustal compartimentation of the granite-migmatitic terrains can be attributed to Archean and Lower Proterozoic ages. In the Upper Proterozoic age, this compartimentation is expressed as sharp limits in the meridional portion of the Sudeste Fold Belt.

Is atributed to the Brasil Central region, over the Brasilia-Tocantins Collision Belt an evolutive process considering a primitive sialic protocrust of Archean age (Almeida et alii, 1976; Valente, 1991; and others). In this region, greenstone belts appear associated with arquean rocks. A global tectonic process, is characterized by a transtension process with rifting, differential vulcanism and sedimentation, as well as a transpression phase with subduction, orogenesis, mafic plutonism, deformation and metamorphism.

4.0 DISCUSSION OF RESULTS

The NS direction corresponds to rifting direction of Lower and Middle Proterozoic age, when the meridional Espinhaço sequence was deposited. It is represented by sedimentation control, deformation axis and vergence from E to W of thrust faults (Figure 2).

Structural direction NW, is associated to shear belt orientation, with mylonitic foliation, cataclasites, and also correlated structures.

The fracturing density map shows that these three directions NS, EW, and NW control all other fracturing directions, what confirms their policyclic character and their status of crustal weakness zones (Figure 3).

The fracture analysis leads to the understanding of the geologic and tectonic strain.

Over the meridional portion of Espinhaço, where the regional control is NNE (Figure 2), (Veneziani, 1987), five fracturing patterns were recognized: N10-30W, N15-30E, N45-60E, N50-60W and EW directions.

In the Sudeste Fold Belt, over the Tijucas Fold sequence and the Joenville and Pelotas massif, the main fracturing directions recognized were NNE, ENE, NNW, NW and EW (Anjos, 1986) and a geologic control of these features was exerted by ENE-EW and NS-NNW directions.

Sedimentation, fold axes, tectonic and transcurrences in the granulite-gnaissic rocks of Archean age and rocks of lower Proterozoic age were controled by ENE direction. This control probably remained until Paleozoic times, as shown by rifting, sedimentation and vulcanism in the Upper Proterozoic and was responsible for the deposition of schists of Brusque Group, molasses of Itajaí Group and sediments of Paraná Basin, structured by ENE dextral transcurrences and thrusts with vergence from SE to NW.

Paleozoic sedimentation control was determined by NS and NNW structural directions, showing that both distensive and compressive characters of these directions remained until Paleozoic times (Figure 4).

Analysis of fracturing density maps leads to the definition of axes of maximum of fracturing, which show that zones of crustal weakness are pervasive and control the formation of younger fracturing systems in any direction. Such analysis also confirms their reactivations during younger tectonic cycles.

Tectonic and geologic control along EW, NS and NW directions were also recognized from the analysis of fracturing density maps. The EW direction is related to the deposition of Arquean age sequences, which show foliation, fracturing and thrusts faults with vergence from N to S.

Also on the Sudeste Fold Belt, in its central zone, where São Paulo Shear Zone was described by Hasui (1978), seven directions of fracturing were identified: N45W, N45E, N50-60E, N20-30W, EW, N20-30E and NS. The main ones are EW, NS and N50-60E directions (Figure 5).

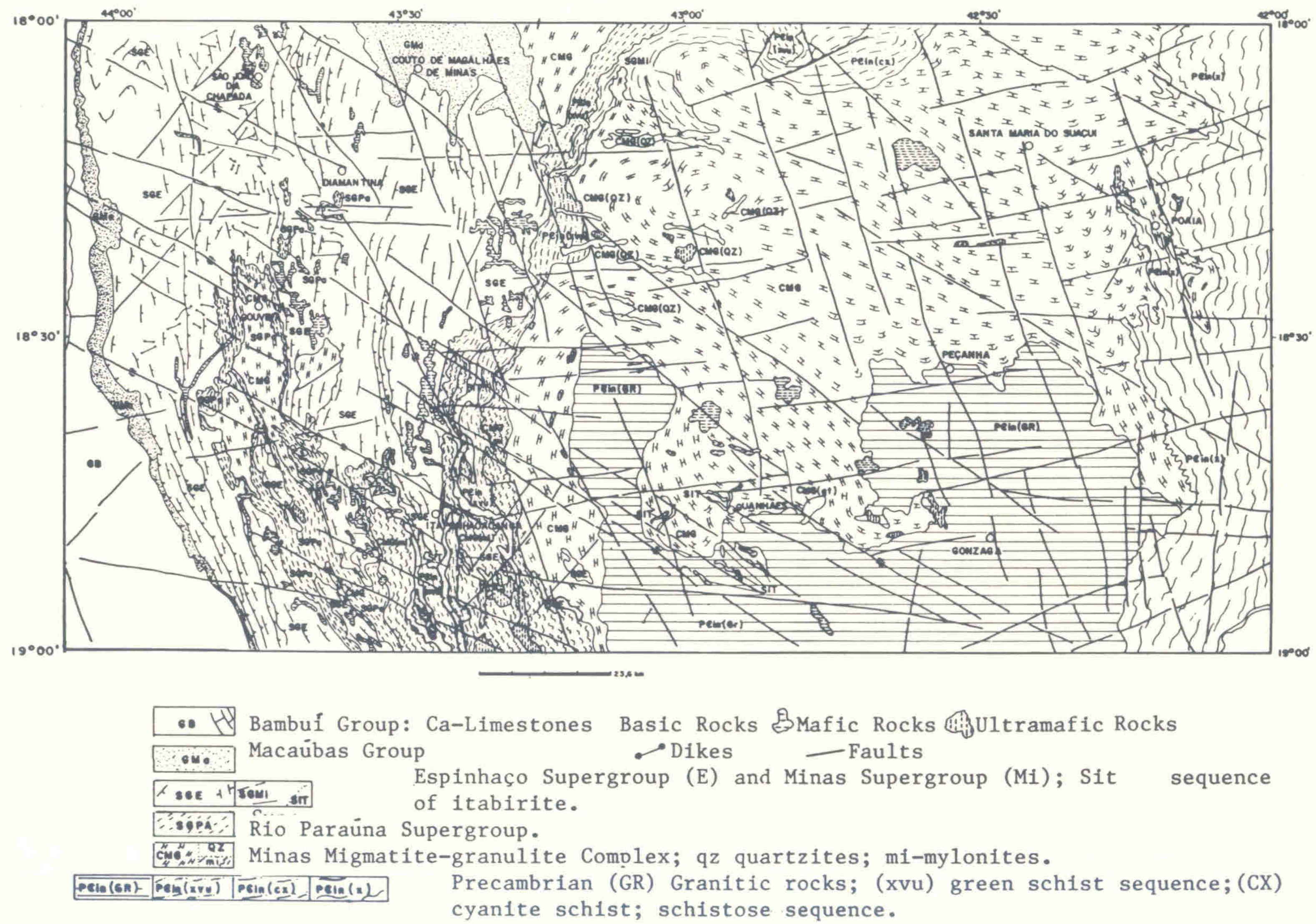

Figure 2 . Geologic Structural Map of Meridional Espinhaco Showing the NS and EW control.

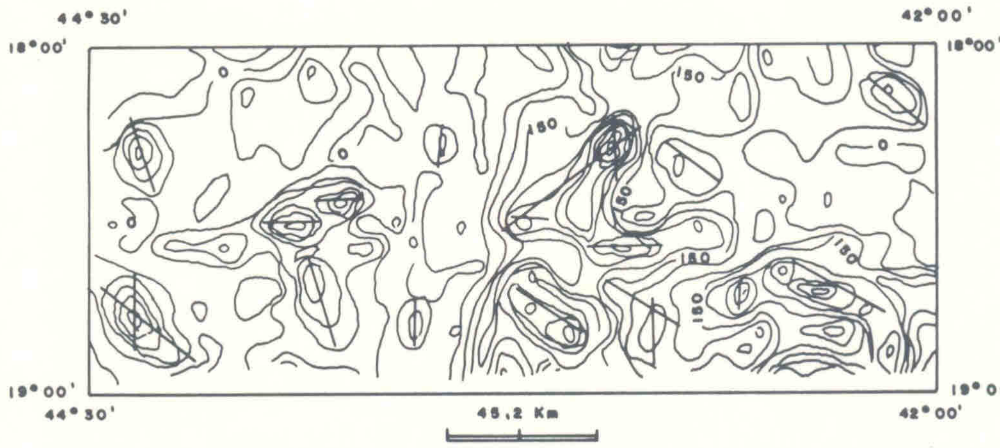

Figure 3- Fracturing density map of Meridional Espinhaço with maximun areas of fracturing following NS and EW axes.

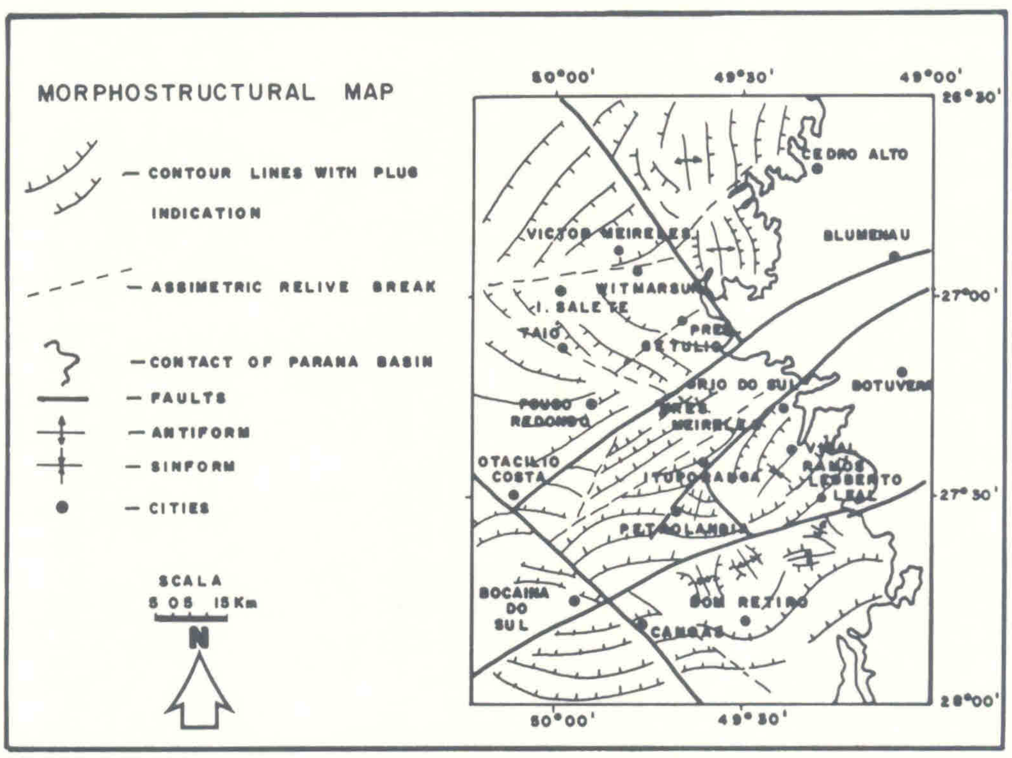

Figure 4 - Morphostructural map showing the influence of structural lines of Precambrian age over the Parana Basin (Anjos, 1986).

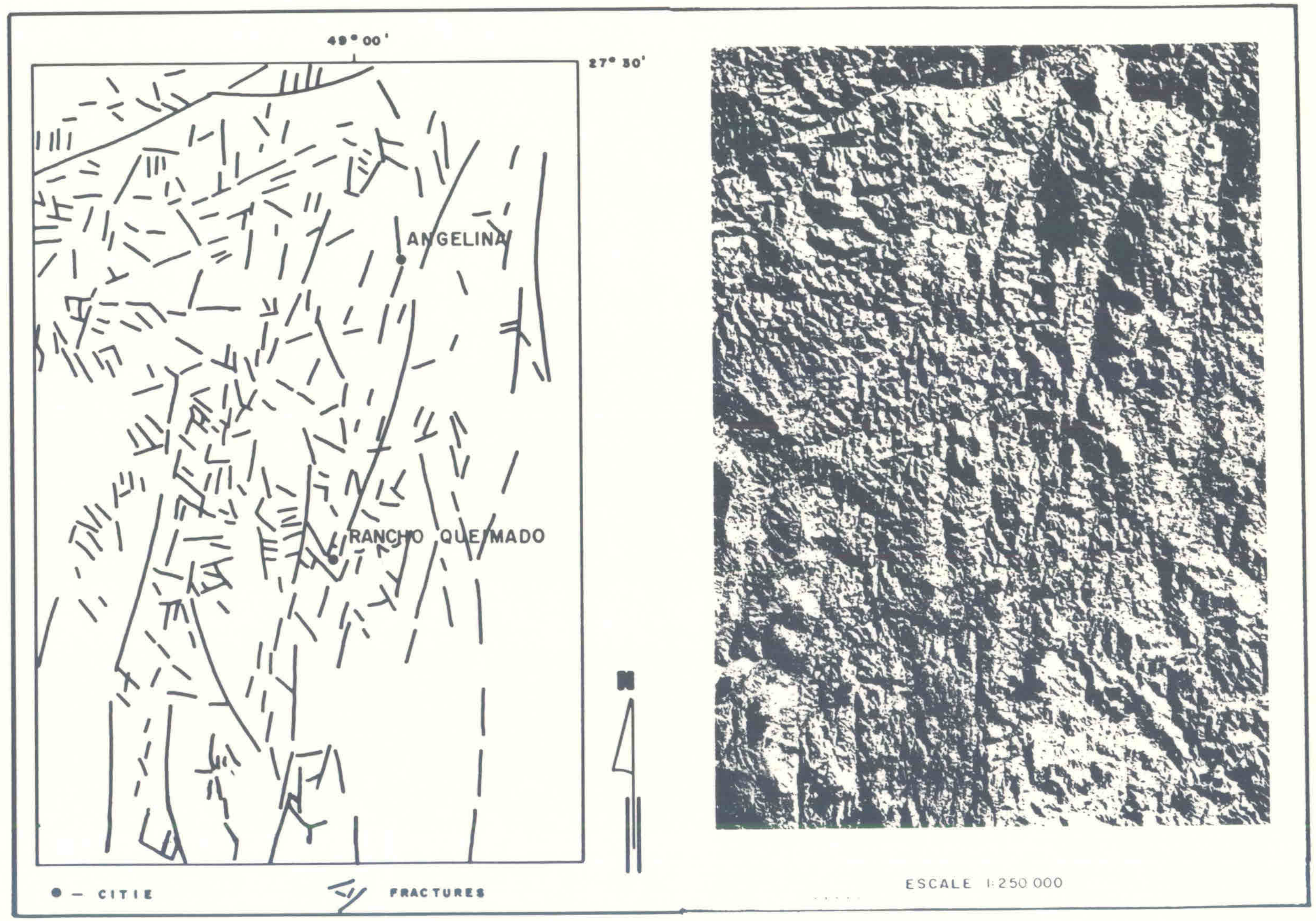

Figure 5 - Image TM/LANDSAT and its structural interpretation over the Pelotas Massif showing strong NS fracture pattern cutting the ENE foliation.

The tectonic sedimentary control during the Lower Proterozoic age is mainly due to EW direction, that is observed within vertical shear zones and mylonitic belts, which promotes sharp geologic contact between different metassedimentary sequences of the embasement.

The N50-60E direction is related to a main regional shear belt that is found in this area. Besides this N50-60E direction, Riedel's fractures are associated with it.

NS and EW-N80E directions also control the installation of other fracturing directions (Figure 6 and 7).

In the Brasilia-Tocantins Collision Belt, the principal structural orientation can be observed on Figure 5. The main ones are N5-30E, EW, NW, NNW, and NE. NS and EW directions were correlated to transpression and transtension tectonics respectively (Valente, 1991). Deep faults, chacterized by rifts and magnetic anomalies of Archean to Lower Proterozoic age with NS direction, exert tectonic control over sedimentation, vulcanism, plutonism and the structuration of Palmeirópis sequence.

Flux and locally mylonitic foliations, thrust faults, fold axes and vertical shear belts are controlled by EW direction (Figure 8).

The third and more important structural direction is the N20-30E dextral shear belt, reactivated up to recent times, as observed by Valente (1991), in Paraná and Maranhão Basins.

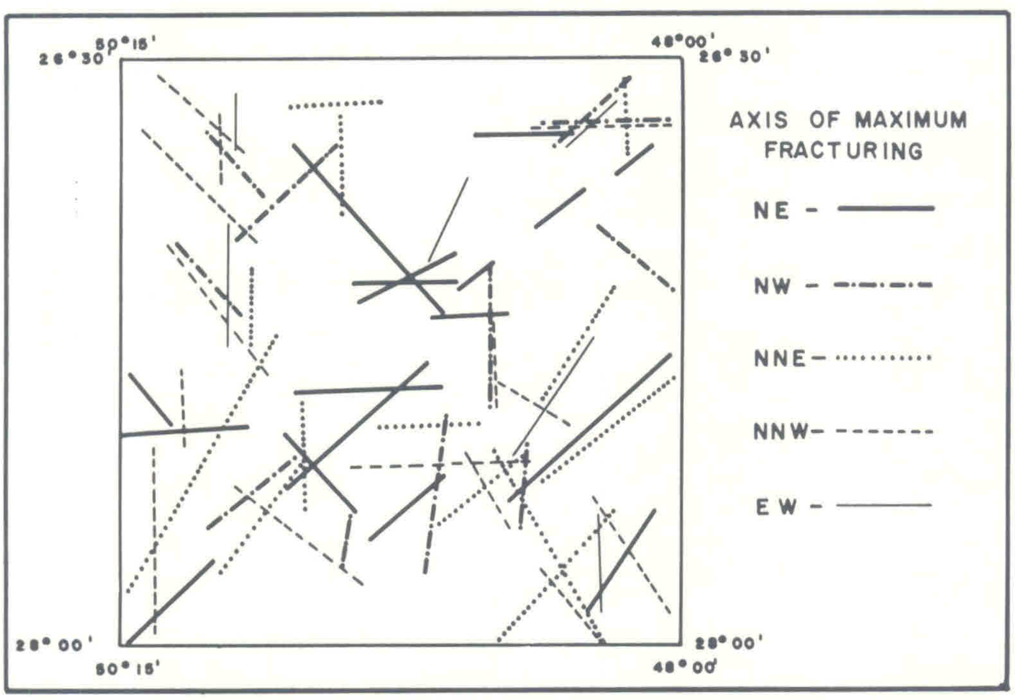

Figure 6 - Axes of maximum fracturing over Tijucas Sequence Pelotas and Joenvile Massifs - Sudeste Fold Belt - show the control of EW-NS direction over other directions.

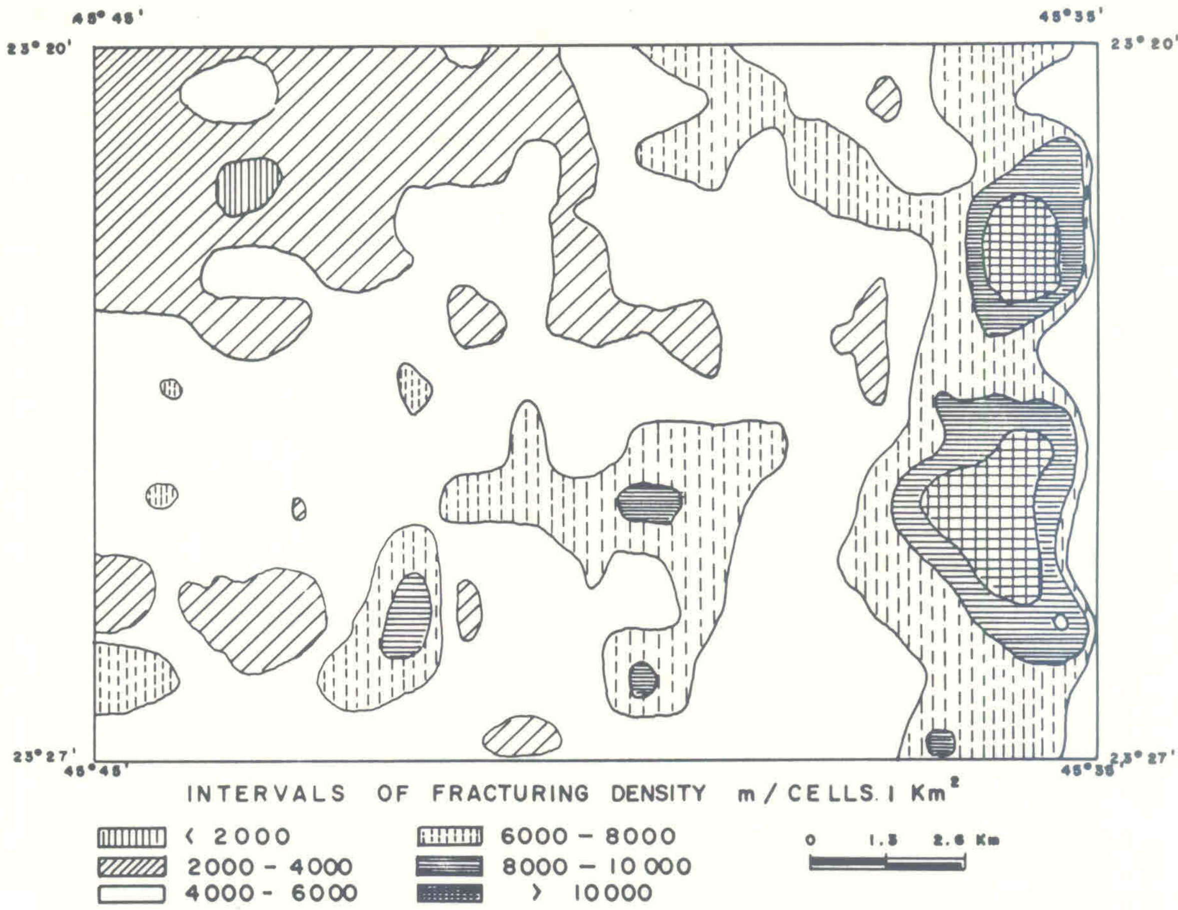

Figure 7 - Fracturing density map, over Shear Belt São Paulo, Sudeste Fold Belt. The areas of maximum fracturing are oriented preferentially to NS and EW. (Modifield of Rocio (1993))

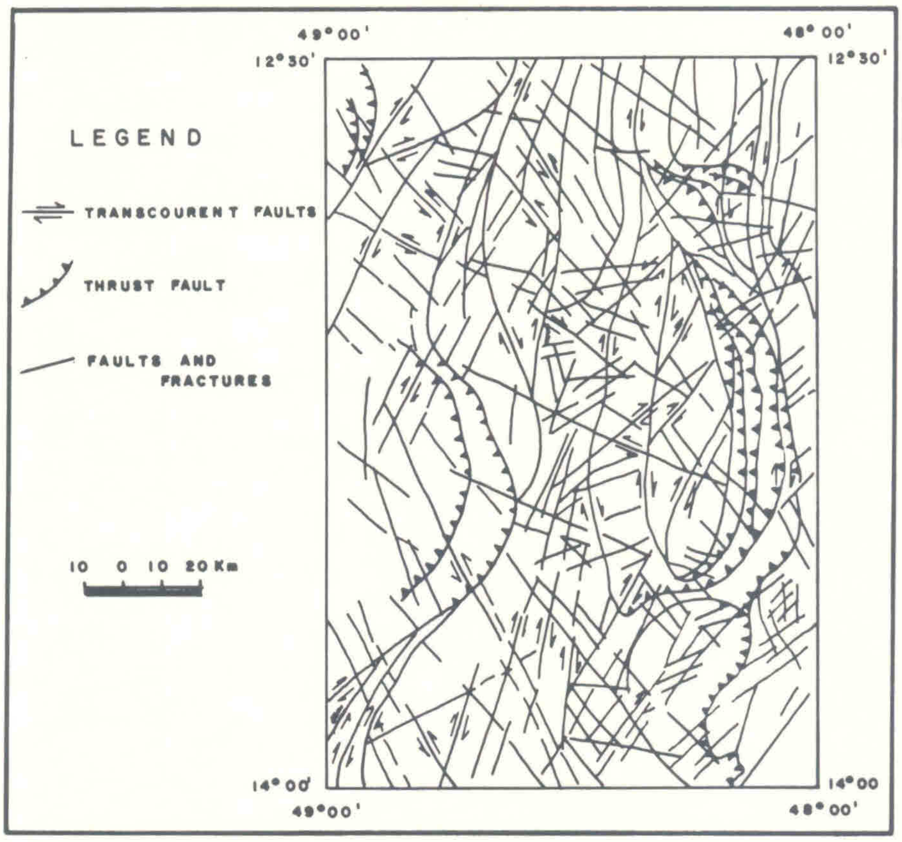

Figura 8 - Structural lineament map obtained with TM/LANDSAT image Brasília-Tocantins Collision Belt (Valente, 1991).

5.0 CONCLUSIONS

The thorough analysis of geological, structural, tectonic, and morphological data from remote sensing data allows some preliminary conclusions about the geologic evolution.

a) A tectonic control of ancient fracturing over younger ones. Can be observed However, the EW and NS control are common to all study areas, as it is demonstrated by the axes of maximum fracturing density;

b) Over the Meridional Espinhaço and Brasília- Tocantins Collision Belt, NS and EW directions exerted a paleogeographic, sedimentary and tectogenetic control on the Archean and Proterozoic units;

c) For the two areas located on the Sudeste Fold Belt, the control by NS and EW directions is tectogenetic. The paleogeographic and sedimentological controls during Middle-Upper Proterozic times of Tijucas-Itajaí sequences were determined by EW direction;

d) To the Paleozoic-Mesozoic times, the sedimentation control is tectogenic by EW direction, as seen on Paraná Basin, in Santa Catarina state, and on Taubaté Basin, in São Paulo state;

e) The influence of EW-NS directions determines the flexural deformation with NS and EW axes. This is observed in morphostructural maps, with topographic highs and depositional lows;

f) The aquisition of furthe data is necessary in order to determine the sedimentation control during Archean age in the Sudeste Fold Belt and during Lower-Middle Proterozoic age in the São Paulo Shear Belt. However, field data, has shown NS direction in Archean and Proterozoic terrains.

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