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DUCTILE AND BRITTLE TECTONICS IN THE EOPALEOZOIC JAIBARAS BASIN, NORTHEASTERN BRAZIL: IMPLICATIONS ON THE DISTRIBUTION OF FE-CU-RICH FLUIDS

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INTRODUCTION

The final stages of the Brasiliano Cycle (Almeida, 1969) is marked by the occurrence of a series of basins that have been interpreted as molasses settled at the end of the Neoproterozoic III as a result of final continental collision e.g. Camaquã and Itajaí basins, in the south of Brazil, Pouso Alegre, Eleutério, Camarinha, and Castro basins, among others, in the central Brazil, and Iara, Cococi, Catolé, and Jaibaras basins, in the Northeast region (Teixeira *et al.* 2004). Although the use of the term molasse is controversial, the essentially extensional character of the majority of these basins are normally accepted, as well as the close relationship with the end of an orogenic cycle (Brasiliano), notable crustal discontinuities, and the proximity to the main Phanerozoic intracratonic basins. Also the presence of extensive acid- to basic volcanism and granitic bodies are common features.

But for the Camaquã Basin, in which important both disseminated and vein Cu (Au) mineralization have been explored for many years, no significant ore deposits have been reported in these basins. In the Jaibaras Basin (also called Graben, Trough, or Rift), the tectonic contact of the granitic bodies with the volcano-sedimentary sequences is marked by occurrences of iron as hematitic to magnetitic veins and cataclastic breccias associated with hydrothermal alterations in the granite and Cu and Fe sulfides, as well as Cu carbonates (Parente *et al.* 2005a,b, Garcia *et al.* 2006). Recent field research on these occurrences have shown that these features are similar to those found in Fe-Cu-(Au) world-class ore deposits (Hitzman 2000), what makes the region a potential aim for future mineral exploration. A preliminary synthesis of the information regarding the tectonic elements that control the mineralized fluid pathways in the region is exposed in this work.

GEOLOGICAL SETTING

The Jaibaras Basin is included in the Northwestern Ceará Domain (NCD - Arthaud *et al.* 1989) and is limited by the NE-SW Café-Ipueiras, Massapê, Sobral-Pedro II shear zones, which represents a major crustal discontinuity that separates the NCD from the Central Ceará Domain (CCD) the Transbrasiliano Lineament (Figure 1). Following Parente *et al.* (2004) and Costa *et al.* (1979); the sedimentary register can be divided in two sedimentary sequences separated by an erosive discordance: 1) Lower sequence (Vendian-Cambrian) composed by Massapê (normally clast-suported polymitic conglomerates with basement fragments) and Pacujá (reddish, fine- to coarse-grained mostly fluvial sandstones and pelites) formations, from and 2) Upper sequence (Cambrian-Ordovician) represented by Aprazível Formation (polymitic conglomerates with plutonic and/or volcanic fragments). Both intrusive (Mucambo and Meruoca granitic plutons) and extrusive (Parapuí bimodal Suite) magmatic activities occur broadly inside and in the neighborhood of the basin.

STRUCTURAL FRAMEWORK

The main structural feature occurring in the region is a NE-SW-trending regional fault system represented by mostly ductile dextral shear zones normally overprinted by later ductile-brittle reactivation probably related to the opening of the rift. Subsidiary fault and joint systems are widespread especially near the southeast border of the granitic bodies.

Ductile tectonics The southeastern limit of the Jaibaras Basin is marked by a deep, major structural discontinuity, the Sobral-Pedro II Shear Zone, which separates the volcano-sedimentary successions from the nappe stacks that characterize the CCD. Strong, mylonitization occur along the whole structure and affects gneissic-migmatitic basement rocks. The high-angle mylonitic foliation is WNW-ESE-oriented and is associated to subhorizontal stretching lineations defined mainly by secondary muscovite and quartz. The basin is bordered to the northwest by the dextral Café-Ipueiras Shear Zone, of particular importance because it is along its contact with the Meruoca Granite and the volcano-sedimentary sequence that a strong brecciation followed by potassification, propylitization, Fe-metasomatism (hematitization), and sulfidation (pyrite and calcopyrite) occur. It is also in its surroundings that the main occurrences of hematitic bodies were observed. The ductile deformation related to this shear zone affects both basement rocks, such as migmatites, and rhyolites from the Parapuí Suite, giving origin to mylonites to ultramylonites that constitute the host rocks to the main hematitic occurrences. Both shear zones show

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evidence of non-coaxial deformation, with dextral sense of shear given mainly by asymmetric porphyroclasts, S-C surfaces, mica fish, and rotated boudins. Evidence of ductile deformation occur locally in sandstones from the Pacujá Formation, in which southeast-verging, open- to gentle asymmetric folds with southwest-plunging axes are observed. As a result, northwest-dipping, axial-plane small reverse-fault surfaces grow. Very-low metamorphic conditions were commonly reported in sedimentary samples as fine-grained sericite and chlorite, but no secondary penetrative foliations have been observed neither in the sedimentary nor in the volcanic rocks.

Brittle tectonics Field data on the geometrical aspects of brittle deformation are described here using information taken from extension and shear joints, dykes and veins, and faults. For the whole basin, the most prominent joint sets are WNW- and ENE-trending, compatible with the directions for conjugate *en echelon* joints found locally in conglomerates from the Aprazível Formation. Chronological relationship between these families is not well-defined, but preliminary detailed studies in the surroundings of the main hematitic breccias and blocks occurrences reveal a general rule in which hematite-filled WNW joints are crosscut by ENE joints. However, the most recurrent pattern is a stockwork-like geometry associated with well-developed brecciation especially in the Meruoca Granite and in rhyolites. Both Meruoca and Mucambo plutons are crosscut by leucocratic, decimetric to centimetric microgranite dykes showing an average trend ENE. Data on fault surfaces show that two main sets of faults are identified in the area: *i)* Southeast- to south-dipping, medium-angle normal faults; and *ii)* Northeast-trending, high-angle dextral faults parallel to sub parallel to the main trend of the basin and to the major shear zones.

DISCUSSION AND CONCLUSIONS

The preliminary data presented in this paper suggest that the formation of the Jaibaras Basin is closely linked to the major lineaments that compound the NE-SW- fault system in the region. Both ductile Sobral-Pedro II and Café-Ipueiras shear zones show evidence of medium- to low-grade mylonitization affecting rocks from the basement and from the basin, as well as a dextral sense of shear. Later reactivation in higher crustal levels can be identified from dextral brittle faults parallel to the major shear zones. The main structural elements that can be associated with this movement are: a) Local asymmetric folds with SW-verging axes; b) Conjugate WNW- and ESE-trending joints and *en echelon* fractures; 3) Southeast- to south-dipping normal faults and 4) ENE-trending dykes in the granitic bodies. The orientation of these structures is compatible with a general paleostress field with horizontal E-ENEσ_1 compatible with NE-SW right-lateral movements. The orientation of the microgranitic dykes indicate that the same stress regime seems to have continued until the last stages of magma crystallization in the granites.

The main structural features controlling the Fe occurrences along the southeastern border of the Meruoca Pluton are second-order structures related to the Café-Ipueiras Shear Zone such as WNW joints and some of the intersections with the ENE joints. The extensive tectonics along the main fault surfaces generated thick brecciation zones normally better-developed in granites and in rhyolites sometimes related to stockwork-like veins. In the Mucambo Pluton specularite-rich breccias were observed along the southeastern limit of the body, being the main structural control related to dextral, E-W-trending faults, normally crosscut by conjugate, WNW-ESE joints. Both in the Meruoca and Mucambo bodies, these structures are subsidiary of the main NE-SW first-order regional shear zones, implying possibly in deep paths for the Fe-Cu-rich fluids that gave origin to the mineral occurrences. More detailed structural and isotopic studies are being currently carried out in order to determine these relationships.

REFERENCES

Almeida F.F.M. 1969. Diferenciação tectônica da Plataforma Brasileira. *In*: SBG, Congr. Bras. Geol., 23, Salvador, 1969. *Anais...*, Salvador, p. 29-46.

Arthaud, M.H., Vasconcelos, A.M., Nogueira Neto, J.A., Oliveira, F.V.C., Parente, C.V., Monié, P., Liégeois, J.P., Caby, R., Fetter, A., 1998. Main structural features of Precambrian domains from Ceará (NE Brazil). In: 14th *International Conference on Basement Tectonics, Ouro Preto, MG*: 84-85.

Costa M.J., França J.B., Lins C.A.C., Bacchiega I.F., Habekost C.R., Cruz W.B. 1979. *Geologia da Bacia Jaibaras: Ceará, Piauí e Maranhão Projeto Jaibaras*. DNPM/MME, Geologia 14, Seção Geologia Básica 11, 106p.

Garcia M.G.M., Parente C.V., Souza R.R., Albuquerque Júnior I.F., 2006. Controle estrutural de depósitos tipo *IOCG*: Dados preliminares da Bacia do Jaibaras-CE, Província Borborema. *In*: Congresso Brasileiro de Geologia, 43, Aracaju-SE. *Anais...*, p.353.

Hitzman, M.W. 2000. Iron oxide-Cu-Au Deposits: What, where, when, and why. In Porter, T.M. (ed.) *Hydrothermal Iron Oxide Copper-Gold & Related Deposits: A Global Perspective*. Australian Mineral Foundation, Adelaide, pp. 9-25.

Novais, F.R.G., Neves, B.B.B, Kawashita, K. 1979. Reconhecimento cronoestratigráfico da região nordeste do Estado do Ceará. *In*: Simpósio de Geologia do Nordeste, 7, Natal-RN, 1979. *Atas*. Natal, SBG. p. 93-110.

Parente C.V., Silva Filho W.F., Almeida A.R. 2004. *Bacias do Estágio de Transição do Domínio Setentrional da Província Borborema*. In: Mantesso-Neto V., Bartorelli A., Carneiro C.D.R., Brito Neves B.B. (Org.). Geologia do Continente

Sul-Americano: Evolução da obra de Fernando Flávio Marques de Almeida. Editora Beca, p. 525-536.

Parente C.V., Silva Filho W.F., Fernandes N.H., Almeida A.R., Gouveia C., Garcia M.G.M., 2005a. Geologia e tipologia da ocorrência de ferro da bacia eoproterozóica Jaibaras, CE. I Simpósio de Metalogenia, Gramado-RS, *CD ROM Volume*.

Parente C.V., Garcia M.G.M., Botelho N.F., Souza R.R., Albuquerque Júnior I.F. 2005b. Aspectos geológicos e tipológicos das ocorrências de Fe-Cu da bacia eo-paleozóica Jaibaras-CE. In: Simp. Geol. do Nordeste, 21, Recife-PE, 1995. *Bol. Resumos*: 168-172.

Teixeira A.L., Gaucher C., Paim P.S.G., Fonseca M.M., Parente C.V., Silva Filho W.F., Almeida A.R. 2004. *Bacias do estágio da transição da Plataforma Sul-Americana*. In: Mantesso-Neto V., Bartorelli A., Carneiro C.D.R., Brito Neves B.B. (Org.). *Geologia do Continente Sul-Americano: Evolução da obra de Fernando Flávio Marques de Almeida*. Editora Beca, p. 487-536.

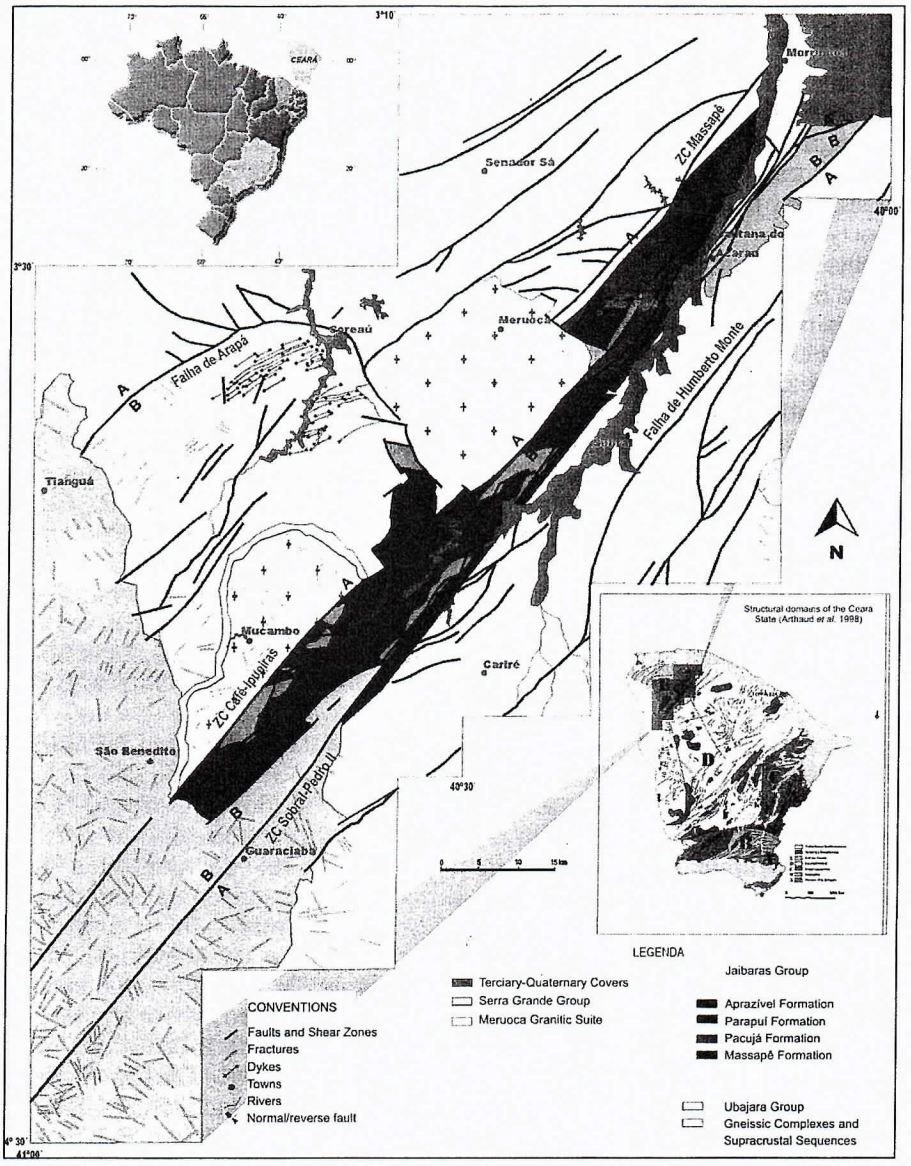

Figure 1 – Simplified geological map of the Jaibaras Basin (modified from Costa et al. 1979 and CPRM 2003).