MINERALOGY OF THE MONTE SANTO ALKALINE PEGMATITES WITH PARTICULAR REFERENCE TO CANCRINITE MINERAL

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INTRODUCTION

The alkaline rocks are known in all continents from the Proterozoic to the Cenozoic age. Alkaline suites are generated by magmas sub-saturated in silica that occur in a wide variety of tectonic settings, including rifting centers (bimodal associations), subduction zones (continental margin and island arc), oceanic islands, strike-slip (transform) and, within Proterozoic stable cratons, independent of orogenic activity. Genetically these magmas are commonly interpreted as a product of shallow rate of the partial melting in the mantle (Lumbers 1978). So, alkaline rocks are derived from specific magmas, whose parental magma was generated somewhere in the asthenospheric or lithospheric mantle, and that this magma differentiates to form derivative magmas from which crystallize the spectrum of alkaline rocks found in plutonic, hypabissal and volcanics environments (Mitchell 1996). Magmas formed in this way are often silica-undersaturated and characterized by high concentrations of the alkali metals, K and Na.

Nepheline syenites occur as integral components of relatively shallow complex of subvolcanic origin and may contain both, felsic silica-saturated and oversaturated syenites and granites, direct or indirect evidence for the mafic rocks (Plat 1996). Normally, it is common the presence of pegmatites in large intrusions of feldspathoid syenites.

In Brazil there are several alkaline complexes; those related to pegmatites are found in (a) the nepheline syenite complexes as Boca Nova (Pará), Canaã (Rio de Janeiro), and (b) the alkaline provinces of the South Bahia and Tocantins Monte Santo Suite. The pegmatites studies in this work are those related to Monte Santo Suite present in the southern segments of the Araguaia Belt. This region was selected for two reasons: i) the scarce scientific research done in the area, and ii) due to an expected economic potential.

GEOLOGICAL SETTING

Geotectonically, the research area comprises the northern portion of the Paraguai-Araguaia belt and is located at the north of the Tocantins Province. The Araguaia Belt has Neoproterozoic age and is1200 km long and more than 100 km wide and a general N-S orientation. To the west the area is in contact with the Amazonian Craton and is covered by Quaternary sediments. In the north, northeast and east, the belt is covered by phanerozoic sediments of the Parnaiba. To the south and southeast it is bordered by the Goias Median Massif (Almeida 1974, Alvarenga et al. 2000).

According to Alvarenga et al. (2000) the evolution of the Araguaia Belt started with the rift opening during the Neoproterozoic age, which in the early stages was marked by the alkaline magma intrusion.

In the southern segment of the Araguaia Belt, the basement sequences include metavolcanic-sedimentary rocks, gneisses tonalitic, calco-silicates, alkaline rocks, and granitic rocks. The metavolcanic-sedimentary rocks are represented by the Rio Coco Group and the granitic rocks by the Serrote e Matança granitoids. The tonalitic gneisses and calco-silicate rocks comprise the Rio dos Mangues complex, whereas the alkaline gneisses represent the Suite Monte Santo.

Geologically, the Monte Santo alkaline Suite (Hasui et al. 1984) is positioned in the southern portion of the Araguaia Belt (Almeida 1974). This alkaline suite corresponds to a folded belt of N-S direction, structured during the Brasiliano cycle (Moura & Gaudette 1993) and it is represented for few small bodies of nepheline syenite gneiss intruded in the Estrondo Group.

There is some pegmatite bodies intruded in these nepheline syenitic rocks and their mineralogy is very close to the hosted rocks.

ANALYTICAL PROCEDURES

All the analyses were carried out at the Analytical Technical Laboratory of the Mineral Resource Department, of the Federal University of Mato Grosso, Brazil. Powder X-ray diffraction patterns (XRD) of the original and heated samples (1100^{o}C) were collected between 10^{o} and 90^{o} (2theta) in a Shimadzu diffractometer, XRD-6000 model, with Cu-Ka radiation and a graphite monochromator. Chemical analyses were obtained by energy dispersive spectrometry (EDS) using a Shimadzu EDX-700HS Fluorescence and Quali-Quant FP method. Thermogravimetric analyses (TGA) were performed on a Shimadzu DTG-60 module. The equipment temperature range is 25 to 1200^{o}C, and a heating rate of 10^{o}C min $^{-1}$ was used.

MINERALOGY OF THE PEGMATITES

The alkaline pegmatite group comprises some sodalite-bearing dikes which outcrop the nepheline syenite rocks. These pegmatite bodies commonly occur as dikes of few centimeters to 1.5 meters wide with maximal strike lengths of 3 meters, concordant or crosscutting the structural fabric of the alkaline rocks (Fig. 1).

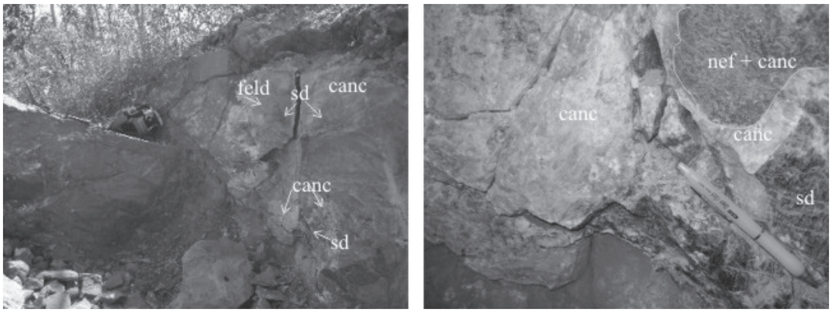

Figure 1- Alkaline pegmatite outcrop sometime concordant or discordant to the foliation of the host-rock (a) detail showing a fragment of the host-rock (delimited with solid line) alterated to cancrinite (b).

Most of the pegmatoid veins show irregular geometry and are composed predominantly for sodalite, alkaline feldspar, cancrinite and biotite. Some veins contain also calcite associated with biotite and K-feldspar. The biotite occurs as subhedral to euhedral crystals of 0.3 to 5.0 centimeters in size, being the major crystals, they frequently occur in clusters and along the edges of the dikes, whereas the small crystals are disseminated inside the bodies. The sodalite, cancrinite and K-feldspar commonly appear as large massive crystals. The K-feldspar is white and the cancrinite yellow, both are concentrated in the edge of the vein. Sodalite shows dark blue color and present two sets of fractures, normally filled by zeolite, which is a product of hydrothermal activity. In some pegmatitic bodies is common the presence of angular fragments of the host rocks, indicating a late emplacement. One of the fracture sets observed in the sodalite is concurrent with the direction and dip of the foliation of the host rock, suggesting that a deformational phase occurred after the pegmatite formation.

CANCRINITE MINERAL

Table 1 lists the major and trace element composition for the cancrinite of the Monte Santo alkaline pegmatites. The chemical analyses were difficulty to by performed due to the unknown amount of molecular water, carbonate, and hydroxyl. Ca and Na elements are deficient in all samples (i.e., considering 2 and 6 cations respectively for Ca and Na, per 24 oxygen atoms) suggesting the presence of vacancies in the large channel as observed by Hassan & Busseck (1992) for natural cancrinite of Bancroft, Canada. This same interpretation can be given for Si and Al, but considering for each 6 cations per 24 oxygen atoms, probably due to isomorphic substitution.

Table 1: X-ray fluorescence analyses of cancrinite from alkaline pegmatites of the Monte Santo Complex.
Analyses by TG; oxides in wt% and trace elements in ppm, # peace of same samples

	Canc1	Canc2	Canc3#	Canc4#
SiO_2	34.900	34.994	35.366	35.153
Al_2O_3	30.903	30.883	30.672	30.563
Na_2O	15.547	15.807	15.359	15.840
CaO	7.698	7.629	7.803	7.659
Fe_2O_3	0.070	0.067	0.068	0.068
MnO	0.072	0.075	0.067	0.065
K_2O	0.012	0.034	0.019	0.010
* LOSS	10.670	10.446	10.590	10.580
Total	99.718	99.759	99.790	99.795
Sr	176	191	187	196
Cu	1067	711	1067	800
Rb	2850	2138	1425	2138
As	nd	nd	2500	2500
Ga	nd	nd	3500	nd
Zr	nd	9100	nd	4550
Y	8900	8900	8900	nd
W	449	nd	nd	nd
Co	219	nd	nd	nd
Cation numbers per 24 O atoms for Na, Al, and Si				
Si	5.67	5.67	5.73	5.70
Al	5.92	5.90	5.85	5.85
Na	4.90	4.97	4.82	4.98
Ca	1.34	1.32	1.35	1.33
Si+Al	11.585	11.571	11.581	11.550

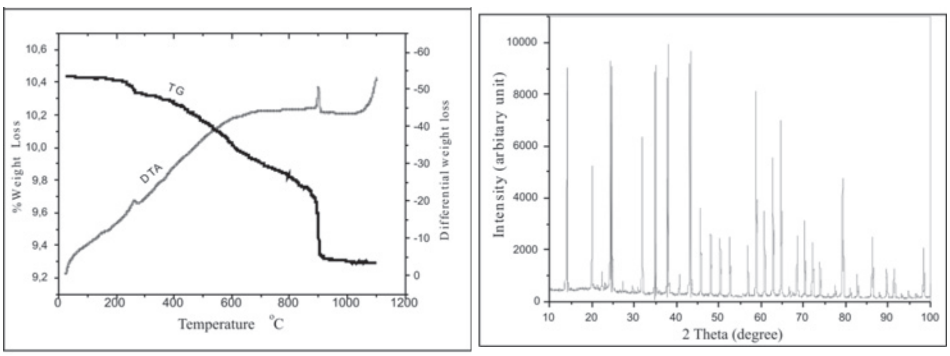

Figure 2: Thermogravimetric curves (a) and X-ray Diffraction powder patterns (b) of the canc2 sample

The performed thermal analysis shows similar behavior in all samples. In Figure 2 (Canc2 samples) is possible to observe a four-stage loss in weight. The first step, between 20 and 130^{o}C was interpreted as the moisture loss, with 0.12 wt%. The second step with about 3.00 wt%, occur between 131^{o}C and 540^{o}C and is attributed to loss of water molecules located in the channel and the combustion of organic residuals At temperatures up to 540^{o}C until near 860^{o}C (third step) the weight loss was assigned to decomposition and reaction of the hydroxyl anion to formation of the new phase with 3.31 wt% of lost. Above 860^{o}C the cancrinite is completely decomposed to a nepheline-like phase, identified by diffractometry. The total loss is showed in Table 1. In Figure 2 is observed the diffractogram of the cancrinite, whose reflections are consistent with space group *P*63, and the cell parameter obtained by indexing the main peaks scanned in the 2θ interval of 10–80° were a = 12,605 (0,004)Å, c = 5,118 (0,002) Å, with a cell volume of 704. 238(0,82)Å^{3}. There are indications of other phases present which were identified as zeolite (natrolite) and nepheline.

CONCLUSIONS

The pegmatites intruding the alkaline granite complex of Monte Santo Suite occur as lenses or sometimes as unzoned dikes.The emplacement them probably occurred in the transition from the ductile to the brittle regime, which resulted in the presence of the host-rock fragments spread within them The geochemistry of cancrinite shows deficiency in Ca and Na, Al and Si, probably resulting from the alteration of the cancrinite to zeolite that was detected by the X-ray diffraction patterns.

The study concerning to origin of the Monte Santo alkaline pegmatites and mineralogical characterization of its constituents is under investigation.

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