IOC-154

EXTENDED ABSTRACTS

sysno=0875350

INTERNATIONAL SYMPOSIUM ON THE PHYSICS AND CHEMISTRY OF THE UPPER MANTLE

AUGUST 14 - 19, 1994
SÃO PAULO - BRAZIL

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FAPESP

sygmo=087 5330

International Symposium on the Physics and Chemistry of the Upper Mantle August 14 - 19, 1994 São Paulo - Brazil

Inferred composition of the parent magma of the mafic ultra-mafic complex of Cana Brava, Goiás, Brazil

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The mafic-ultramafic complex of Cana Brava is about 40 km long and up to 14 km in width in its southern portion, where the stratigraphic sequence is best exposed. It belongs to a 300 km long, discontinuous, north-trending chain of mafic-ultramafic massifs which includes the Barro Alto Complex (in the south) and the Niquelândia body (in its central part, Fig. 1). This chain is part of the Porangatu structural block of Hasui & Haralyi (1986).

The Cana Brava massif is interpreted as an anorogenic, stratiform complex (Girardi & Kurat, 1982; Fuji, 1989 and Correia, 1994), whose layers dip from 30° to 50° NW. The massif is made up of five units, composed of layers containing several associations of cumulus phases and variable amounts of inter-cumulus minerals. Transitions between units are characterized by abrupt changes in the composition of these phases. Stratigraphically, the lowest sequence is composed of amphibolites (PICB1), overlain by serpentinites (PICB2), metawebsterites (PICB3) and metagabbroic rocks (PICB4 and PICB5) at the top. This sequence was originally formed by micrograbbros, peridotites, websterites and gabbroic rocks.

Isotopic data (Ar-Ar and K-Ar, Matsui *et al.*, 1986; K-Ar and Rb-Sr, Girardi *et al.*, 1978; Rb-Sr and Sm-Nd, Fugi, 1989; Rb-Sr and Sm-Nd; Correia, 1994) suggest that the parental magma of the Cana Brava complex evolved as follows:

a)Mantle derivation and sublithospheric or subcrustal settling between 2.25 and 2.62 Ga .

b)Intrusion and crystallization of the body in the country rocks of the Palmeirópolis volcano-sedimentary sequence (Ribeiro Filho & Teixeira, 1986) at about 2.0 Ga .

c)Main metamorphic event and ductile-ruptile deformation (compressive environment) at about 1.3 Ga.

d)Further low-temperature metamorphic reequilibrations (Girardi *et al.*, 1991).

The inferred composition of the parental magma of the Cana Brava Complex was determined by using the composition of mineral phases (Girardi & Kurat, 1982), bulk rock analyses and detailed mapping of the complex (Correia, 1994).

According to Correia (1994), the rock sequence of the complex can be attributed to a single magmatic fractionation. There is no evidence of multiple injections. Metamorphic events affected the different units heterogeneously. The gabbroic rocks (PICB4 and PICB5) were the least transformed; hence their chemical compositions are close to the original ones. Units PICB1 to PICB3 were the most affected by post-magmatic processes.

Geochemical evidence suggests that PICB1 may be the chilled border of the massif. However, due to post-magmatic phenomena, the composition of the parent magma was calculated by using the chemical compositions and inferred volumes of units PICB2 to PICB5. For PICB2 and PICB3 the compositions of mineral phases were utilized (Table 1). Estimated values of PICB4 and PICB5 were obtained through bulk-rock analyses of selected samples having chemical compositions as close as possible to the original liquidus. Samples with signs of cumulitic textures were rejected.

Estimated average modal compositions were: PICB2 - olivine 70%, orthopyroxine 9%, spinel 1%; PICB3 - clinopyroxene 85%, orthopyroxone 10%, plagiodase 5%.

The relative volumes of units PICB2, PICB3, and PICB4 + PICB5 calculated from their average thicknesses in several profiles along the body were: PICB2 = 9.2%, PICB3 = 1.8% and PICB4+PICB5 = 89%.

Table 2 shows the chemical compositions of the units obtained by using the XLFRAC program (Stormer & Nichols, 1978). Compositions 1, 2 and 3 refer, respectively, to PICB2, PICB3 and PICB4 + PICB5. Composition 4 is the average of the units, considering their respective volumes in the body and represents the inferred composition of the Cana Brava parent magma.

Table 3 compares the inferred Cana Brava liquid with supposed parents of similar complexes (Niquelândia, Muskox, Skaergaard, Stillwater and Bushveld). The majority of elements of the Cana Brava magma are within the range of variation of other complexes. Main deviations are not very significant: SiO_2 (47.96 vs. 48.20-50.68), Fe_2O_3 (1.60 vs. 1.02-1.40) and CaO (11.55 vs. 9.78-11.48).

The possible Cana Brava parent magma is olivine-tholeite, similar to the majority of the complexes utilized for comparison. Its amount of normative olivine (8.4%) is within the range (5 to 15%) determined by Green (1971) for liquids derived from 25 to 35% of mantle melting.

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	1	2	3	4	5	6	7
Mineral-Rock	ol.-perid.	opx.-perid.	cpx.-perid	sp.-perid.	opx.-pyrox.	cpx.-pyrox.	plag.-pyrox.
Unit	PICB2	PICB2	PICB2	PICB2	PICB3	PICB3	PICB3
SiO_2	41.48	56.90	54.10	0.09	55.40	52.65	52.96
TiO_2	0.02	0.07	0.23	0.05	0.07	0.36	0.00
Al_2O_3	0.02	2.50	2.90	47.00	3.18	3.86	29.72
FeO	9.94	5.70	1.90	14.00	8.65	2.16	0.00
Fe_2O_3	1.05	1.48	0.49	4.66	0.92	0.56	0.59
MnO	0.17	0.20	0.07	0.20	0.23	0.10	0.00
MgO	46.20	32.50	16.10	12.50	30.94	15.20	0.00
CaO	0.02	0.31	22.60	0.02	0.24	23.40	12.28
Na_2O	0.02	0.02	0.58	0.00	0.02	0.28	4.21
K_2O	0.02	0.02	0.02	0.00	0.02	0.31	0.13
P_2O_5	0.00	0.00	0.00	0.00	0.00	0.00	0.00

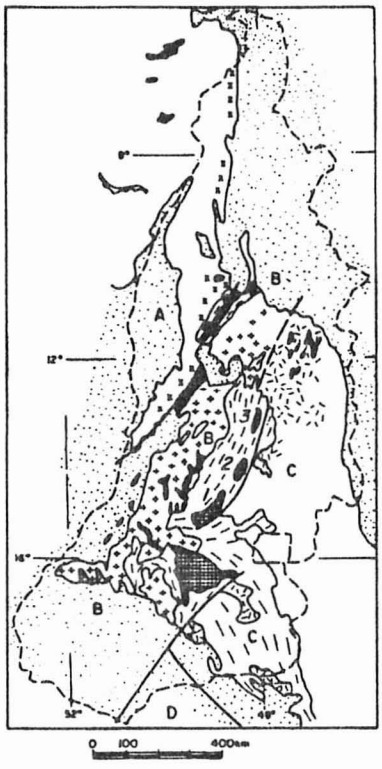
Table 1 - Compositions of mineral phases from units PICB2 and PICB3 of the Cana Brava Complex. Analyses 1, 2 and 3 refer to averages of several mineral phases of sample G-24. Analyses 5, 6 and 7 refer to averages of several mineral phases belonging to the samples CBAK15-GA, MCB-920 and G-23. In the spinel-peridotite sample (analysis 4) the spinel phase has 19% Cr_2O_3. Data from Girardi & Kurat, 1982.

	1	2	3	4
	perid.	pyrox.	gabbro	par. liq.
	PICB2	PICB3	PICB4 + PICB5	PICB
SiO_2	45.29	52.94	48.05	47.96
TiO_2	0.05	0.31	0.86	0.77
Al_2O_3	1.25	5.09	19.92	17.04
FeO	8.41	2.70	8.35	9.22
Fe_2O_3	1.12	0.60	1.62	1.60
MnO	0.17	0.11	0.22	0.22
MgO	40.41	16.01	7.66	10.88
CaO	2.11	20.53	12.30	11.55
Na_2O	0.07	0.45	1.27	1.15
K_2O	0.02	0.27	0.11	0.10
P_2O_5	0.00	0.00	0.08	0.07
mg mol	0.89	0.91	0.62	0.67
NE	0.0	0.0	0.0	0.0
Q	0.0	0.0	0.0	0.0
PL	3.8	16.6	59.5	51.1
CPX	5.9	72.1	9.9	12.8
OPX	26.6	7.5	24.9	23.9
OL	62.0	2.4	1.6	8.4

Table 2 - Bulk rock compositions calculated for the units of the Cana Brava Complex (analyses 1, 2 and 3). Analyses 4 refers to the inferred parent liquid. mg mol calculated using $Fe_2O_3/FeO = 0.15$.

	1	2	3	4	5	6
Complex	Cana Brava	Niquelândia	Muskox	Skaergaard	Stillwater	Bushveld
SiO_2	47.96	49.15	48.20	48.55	50.68	50.55
TiO_2	0.77	0.43	0.93	1.18	0.45	0.66
Al_2O_3	17.04	15.09	11.98	17.39	17.64	15.23
FeO	9.22	7.41	9.13	8.71	8.79	10.17
Fe_2O_3	1.60	1.02	1.25	1.20	1.21	1.40
MnO	0.22	0.16	0.18	0.16	0.15	0.23
MgO	10.88	14.08	14.88	8.70	7.67	8.30
CaO	11.55	11.03	9.78	11.48	10.47	11.30
Na_2O	1.15	1.20	1.56	2.39	1.87	2.24
K_2O	0.10	0.09	0.56	0.25	0.24	0.19
P_2O_5	0.07	0.04	0.08	0.10	0.09	—
mg mol	0.67	0.77	0.74	0.64	0.61	0.59
NE	0.0	0.0	0.0	0.0	0.0	0.0
Q	0.0	0.0	0.0	0.0	1.3	0.0
PL	51.1	46.3	41.2	57.6	56.7	51.8
CPX	12.8	15.2	19.6	16.6	10.2	19.6
OPX	23.9	25.2	16.2	7.5	29.0	19.2
OL	8.4	10.8	19.3	14.2	0.0	6.2

Table 3 - Comparison among chemical and normative composition of the inferred parent liquid of the Cana Brava massif and similar magmas of mafic-ultramafic complexes: Niquelândia (Girardi *et al.*, 1986); Muskox (Irvine, 1979); Stillwater (Hess, 1960) and Bushveld (Wagner & Brown, 1968). mg mol calculated using $Fe_2O_3/FeO = 0.15$.



A — Araguacema Block
B — Porangatu Block
C — Brasília Block
D — Paraná Block
— Block boundary
— — Inferred Block boundary
Supracrustal volcano-sedimentary rocks
Greenstone Belts
Colmeia Complex
Goiano Complex
Baixo Paraná Complex
Metamorphic belts: Médio Tocantins (N), Ceres (C) and Alfenas (S)
1,2e3 Barro Alto, Niquelândia and Cana Brava Complexes, respectively

Figure 1 - Structural organization of Goiás and Tocantins states (modified from Hasui & Haralyi, 1988)