SMALL NOTE ON THE COMPOSITION OF BRAZILIAN MANTLE

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ABSTRACT Garnets from concentrate from the Vargem I kimberlite pipe show a long compositional range and reveal long linear trends within the lherzolite field in a Cr_2O_3 – CaO diagram (Sobolev *et al.* 1974) (up to 11% MgO), formed by grains of different dimensions with few deviations to harzburgites. Larger grains (fraction +3) are higher in CaO with less Cr_2O_3 (to 5.5%). The Cr_2O_3 frequency reduces in hyperbolic function for each fraction. Ilmenites reveal 42-56% TiO_2 compositional range with linear FeO – MgO correlations but 3(4) separate groups for Al_2O_3 suggest different proportion of co-precipitated garnet, probably due to polybaric fractionation. Increasing Cr_2O_3 and FeO content (fractionation degree) with reducing TiO_2 is in accord with AFC model.

Garnet xenolith from Indaia II pipe with large Gar- Cpx grains and fine Mica-Carb bearing matrix refer to 60 kbar and 35 mv/m2 geotherm. It displays enriched trace element patterns but not completely equilibrated compositions for Gar and Cpx, suggesting low degree melting of relatively fertile mantle. Studied material may suggest metasomatized, relatively fertile and irregularly heated mantle beneath Southern Brazil as found by (Carvalho & Leonardos 1997).

Keywords: kimberlites, concentrate, garnet, ilmenites, trace elements, PT conditions, Brazil.

INTRODUCTION The composition of Brazilian mantle which is very preliminary studied (Meyer *et al.* 1991, Carvalho & Leonardos 1997, etc.) is of great interest, to compare with other Gondwana blocks that are usually productive in diamonds. Pyropes and garnets from a concentrate from the Vargem I kimberlite pipe (S. Inácio river valley) and a small xenolith and separated xenocryst from the Indaia II kimberlite pipe were analyzed by EPMA and minerals in phlogopite-bearing garnet lherzolite from Indaia II by LAM ICP MS, in the analytical center of UIGGM SD RASc.

RESULTS Pyropes from the Vargem I kimberlite pipe, collected and analyzed by Afanasiev V.P., Pokhilenko N.P. and Sobolev N.V., reveal a linear trend within the lherzolitic field in Cr_2O_3 – CaO diagrams (Sobolev 1977) ranging from 1 to 5% Cr_2O_3 in the fraction +3, while the fraction +0.25-0.5 is more representative and contains more chromium-rich garnets, up to 10% as reported by Meyer *et al.* (1991). Larger garnet grains are less rich in chromium but have slightly higher CaO . The Fe and Ti contents gently decrease with increasing Cr_2O_3 (Fig. 1)(Table.1). Frequency histogram for Cr displays several peaks and generally rapidly falls especially for larger grain sizes. Pyropes often display negative forms after the intergrowths with the phlogopites.

Ilmenites show the common trend of decreasing MgO , Al_2O_3 , NiO with the increase in Cr_2O_3 , FeO , V_2O_5 (Moor *et al.* 1991, Griffin *et al.* 1997) (Fig.2. Table 1) though some elements reveal considerable scattering across the main trend. This is likely the result from the crystallization and interaction with the peridotitic mantle. The reducing of frequency for low- MgO varieties suggests fractional crystallization (Moore *et al.* 1991, Griffin *et al.* 1997). However the increase in Cr_2O_3 content shows that if this is the case ilmenite (KD with melt 3-6) was not the main precipitation phase but crystallized in the

silicate assemblage at least in the initial stage. Al_2O_3 clustering in three groups suggests the different proportion of coeval garnet crystallization. The AFC (De Paolo 1981) may be also suggested to explain Cr_2O_3 increase and Ni scattering, while essential ilmenite precipitation produces the decreasing Cr_2O_3 sub trends visible in middle interval of the trend. The histograms for separate elements do not coincide. Some grouping of the points is possibly explained by the separate capturing intervals of the rising magma or/and polybaric ilmenite fractionation from the same early portion of rising of kimberlite magma in pre-eruption stage.

Cr-spinels display a range from 59 to 30% Cr_2O_3 . As for garnet, the frequency also reduces for the more Cr- rich spinel varieties.

Garnet lherzolite xenolith from INDÁIA II is a partly serpentinized nodule 2 x 1.5 x 2 cm with large rounded garnet and smaller clinopyroxene grains with minor orthopyroxene (mostly altered) and phlogopite. (Table. 2) The rock seems to be partly recrystallized and has porphyroclastic structure. The carbonate grains were determined in fine grained aggregate.

MAJOR AND TRACE ELEMENTS The trace-element composition of the minerals (garnet and pyroxenes) is close to that of such minerals for South Africa (van Achterbergergh *et al.* 1998). They possibly were not in complete equilibrium judging by the KD-reconstructed trace element distributions (Table.3) (Fig.3). Trace elements suggest lower degree of melting for the clinopyroxenes then for garnets and slightly different melting associations. The melting assemblage for clinopyroxene possibly includes some amount of metasomatic minerals including phlogopite (elevated Ba, Sr). High Nb, Ta, U, Th concentrations suggest melting of a nearly primitive source. Comparing with the minerals from Aldan craton keel these are more enriched in incompatible elements suggesting

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a lower melting degree of more hydrous and fertile mantle peridotites.

THERMOBAROMETRY Calculated TP conditions for the described xenolith plots on the 35mv/m² geotherm as reported by Carvalho & Leonardos (1997). Clinopyroxene thermobarometry (Nimis and Taylor, 2000), (Ashchepkov 2001) for pyroxene xenocrysts found in the kimberlite matrix reveals more scattering but also yields values in 50-65 kbar interval (Fig.4). It should be noted that in the examined xenolith the Cr₂O₃ content of garnet (5%) is close to the maximal values for grains in fraction +3 in the concentrate. Thus at pressure 60-65 kbar the garnets may still be relatively low in Cr, which is explained by a fertile mantle composition.

CONCLUSION Judging from the studied mineral concentrate and xenolith the mantle keel beneath S. Brazil is layered as proved by Carvalho & Leonardos (1997). The megacrystalline ilmenite nodules display long probably polybaric fractionation trend according to AFC model at least in final stages. The abundant phlogopite metasomatism probably results from the ancient processes of continental collision.

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Figure 1 - Garnet compositions in different fractions from concentrate of kimberlite Vargem I, Santo Inácio River valley and their frequency histograms. Data for the garnets are collected and analyzed by Afanasiev V.P., Pokhilenko N.P., Sobolev N.V. during the field trip of the 5th IKC.

Table 1 - Composition of the selected minerals from the concentrate from the Vargem I intrusion, Santo Inácio River valley

Oxide	Garnets									
SiO ₂	41.35	41.38	40.92	41.59	40.12	39.54	40.78	40.15	40.12	40.2
TiO ₂	0.11	0.12	0.35	0.35	0.09	0.12	0.1	0.085	0.08	0.7
Al ₂ O ₃	19.97	20.34	21.10	21.62	18.40	19.01	17.99	17.14	16.97	17.10
Cr ₂ O ₃	4.56	3.26	2.55	1.56	7.44	8.54	8.99	9.45	10.16	10.26
FeO	9.36	8.70	9.68	9.99	9.13	8.31	8.33	8.49	8.01	8.29
MnO	0.46	0.45	0.47	0.43	0.44	0.43	0.42	0.46	0.42	0.4
MgO	19.52	19.52	19.80	19.86	19.84	17.85	16.97	17.02	18.68	16.72
CaO	5.59	5.14	4.63	4.41	4.83	6.61	7.01	6.72	5.23	7.42
Total	100.91	100.91	100.91	100.91	100.29	100.41	100.59	99.52	99.67	101.09
Fe/(Fe+Mg)%	21.21	20.01	21.53	22.02	20.52	20.71	21.60	21.87	19.40	21.77

Oxide	Ilmenites									
TiO ₂	50.95	52.01	50.02	52.72	48.72	47.32	44.31	45.17	53.07	
Al ₂ O ₃	0.45	0.46	0.51	0.20	0.13	0.04	0.04	0.008	3.68	
Cr ₂ O ₃	4.43	3.40	3.03	0.89	1.58	1.15	2.90	2.65	0.607	
FeO	31.55	31.00	35.63	36.07	39.58	44.57	44.74	44.73	33.33	
MnO	0.32	0.41	0.38	0.36	0.43	0.33	0.40	0.408	0.296	
MgO	12.18	11.85	9.80	9.78	8.89	6.44	5.99	5.98	9.6	
NiO	0.13	0.26	0.14	0.18	0.22	0.12	0.12	0.061	0.162	
V ₂ O ₅	0.37	0.29	0.32	0.18	0.44	0.44	0.45	0.327	0.402	
Total	100.37	99.67	99.83	100.39	99.98	100.41	98.94	99.334	101.147	

Table 2 - Composition of minerals from the garnet- ilherzolite xenolith, Indaia II pipe

Oxides	Cr-Diopside	Enstatite	Garnets	Olivine	Phlogopite	Carbonatite
SiO ₂	54.82	57.90	41.50	40.79	40.74	0.00
TiO ₂	0.10	0.02	0.16	0.00	0.87	0.00
Al ₂ O ₃	1.64	0.23	19.94	0.04	13.15	0.07
Cr ₂ O ₃	1.71	0.15	5.11	0.03	0.74	0.00
FeO	2.55	4.65	8.02	7.98	4.09	1.02
MnO	0.09	0.11	0.44	0.09	0.02	0.69
MgO	17.10	35.94	19.17	50.08	25.55	3.58
CaO	18.93	0.38	5.09	0.14	0.02	54.07
Na ₂ O	1.83	0.13	0.03	0.20	0.16	0.00
K ₂ O	0.07	0.01	0.01	0.10	11.58	0.01
NiO	0.057	0.117	0.018	0.359		0.104
Total	98.85	99.52	99.46	99.44	96.92	59.44
Fe/(Fe+Mg)%	7.72	6.77	19.01	8.21	8.24	13.78

Figure 2 - Variation diagram for the ilmenites from the same Vargem II kimberlite. Small dots are the partial analyses of small grains made by Afanasiev V.P., Pokhilenko N.P., Sobolev N.V. Large dots analyses of fraction +3 ilmenite nodules, made by Ashchepkov I.V.

Table 3 - Compositions of the major and trace elements in minerals from garnet- lherzolite xenolith, Indaiá pipe.

N Sample Component	lnl Cpx	lnl-Gar
SiO ₂	54.82	41.50
TiO ₂	0.10	0.16
Al ₂ O ₃	1.64	19.94
Cr ₂ O ₃	1.71	5.11
FeO	2.55	8.02
MnO	0.09	0.44
MgO	17.10	19.17
CaO	18.93	5.09
Na ₂ O	1.83	0.03
K ₂ O	0.074	0.007
NiO	0.057	0.018
Total	98.86	100.32
mg [†]	0.077	0.190
Ba	38.68	-
La	8.87	0.02
Ce	29.34	0.14
Pr	4.61	0.04
Nd	17.66	0.35
Eu	0.73	0.10
Sm	3.12	0.21
Gd	1.74	0.38
Tb	0.19	0.08
Dy	0.80	0.53
Ho	0.10	0.14
Er	0.24	0.40
Tm	0.03	0.06
Yb	0.15	0.50
Lu	0.02	0.09
Hf	2.30	0.23
Zr	79.84	9.28
Y	3.46	4.19
Ta	0.06	0.01
Nb	3.47	0.53
Th	0.13	0.06
U	0.17	0.04
Sr	576.36	28.89
Rb	2.28	1.75
Cs	0.13	0.19
Pb	1.90	2.57
Co	52.08	43.21
Cu	130.54	91.87
Zn	9.69	4.75
Au	0.01	0.02

Note. The EMPA analyses were done in UIGGM SD RAS, Novosibirsk on ComebaxMicro, operator Khmelnikova O.S. Trace elements are done by LA-ICP MS on "Finigan Element" in analytic center of UIGGM SD RASc with the laser "UV LaserProbe", the operators – P.A.Gerasimov, A.I.Saprykin

Trace element patterns for Pyrope and Cr-Diopside from Indaia II Garnet lherzolite xenolith

Figure 3 - Trace elements for the clinopyroxene and garnet from garnet lherzolite, Indaia II pipe.

Figure 4 - PT plot for the xenoliths from Indaiá comparing with those from Três Ranchos IV pipe. 1. TP estimates for Três Ranchos IV (Carvalho & Leonardos 1997). 2. TP estimates for the xenolith from Indaiá II kimberlite pipe using Opx thermobarometry (Brey, Kohler 1990) – (McGregor 1973). 3. TP estimate for the Cr-Diopside xenocrysts from the kimberlite Indaiá II using (Nimis and Taylor, 2000) thermobarometry. 4. TP estimates on the Cr-Diopside xenocrysts from the kimberlite Indaiá II using (Nimis & Taylor 2000) thermometer and (Ashchepkov 2001) barometer.