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 herzolite field in a Cr2O3 - CaO diagram (Sobolev et al. 1974) (up to 11% Cr2O3), formed by grains of different dimensions with few deviations to harzburgites. Larger grains (fraction +3) are higher in CaO with less Cr2O3 (to 5.3%). The Cr2O3 frequency reduces in hyperbolic function for each fraction. Ilmenites reveal 42-56% TiO2 compositional range with linear FeO - MgO correlations but 3(4) separate groups for Al2O3 suggest different proportion of co-crystallized garnet, probably due to polybaric fractionation. Increasing Cr2O3 and FeO% content (fractionation degree) with reducing TiO2 is in accord with AFC model.

Garnet xenolith from Idaia II pipe with large Garnet-Cpx grains and fine Mica-Carb-bearing matrix refer to 60 kilobar and 35 mm/m2 geotherm. It displays enriched trace element patterns but not completely equilibrated compositions for Garnet 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 & Leonaridos 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 & Leonaridos 1997, etc.) is of great interest, to compare with other Gondwana blocks that are usually productive in diamonds. Pyrope and garnets from a concentrate from the Vargem I kimberlite pipe (S. Inácio river valley) and a small xenolith and separated xenocryst from the Indaiá II kimberlite pipe were analyzed by EPMA and minerals in phlogopite-bearing garnet lherzolite from Indaiá II by LAM ICP MS, in the analytical center of UIGGM SD RSC.

RESULTS Pyrope 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 herzolite field in Cr2O3 - CaO diagrams (Sobolev 1977) ranging from 1 to 5% Cr2O3 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 increase with increasing Cr2O3 (Fig. 1)(Table.1). Frequency histogram for Cr displays several peaks and generally rapidly falls especially for larger grain sizes. Pyrope often display negative forms after the intergrowths with the phlogopites.

Ilmenites show the common trend of decreasing MgO, Al2O3, NiO with the increase in Cr2O3, FeO, V2O5 (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 Cr2O3 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. Al2O3 clustering in three groups suggests the different proportion of coeval garnet crystallization. The AFC (De Paolo 1981) may be also suggested to explain Cr2O3 increase and Ni scattering, while essential ilmenite precipitation produces the decreasing Cr2O3 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 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% Cr2O3. As for garnet, the frequency also reduces for the more Cr-rich spinel varieties.

Garnet lherzolite xenolith from INDÁIA II is a partly serpentinitized 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 Achterbergh 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 & Leonards (1997). Clinopyroxene thermobarometry (Nimis and Taylor, 2000). (Ashchepekov 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 & Leonards (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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**References**


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.
**Small note on the composition of Brazilian mantle**

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

<table>
<thead>
<tr>
<th>Oxide</th>
<th>Garnets</th>
<th>Ilmenites</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO2</td>
<td>41.35</td>
<td>50.95</td>
</tr>
<tr>
<td>TiO2</td>
<td>0.11</td>
<td>0.45</td>
</tr>
<tr>
<td>Al2O3</td>
<td>19.97</td>
<td>0.45</td>
</tr>
<tr>
<td>Cr2O3</td>
<td>4.56</td>
<td>4.43</td>
</tr>
<tr>
<td>FeO</td>
<td>9.36</td>
<td>5.59</td>
</tr>
<tr>
<td>MnO</td>
<td>0.46</td>
<td>0.51</td>
</tr>
<tr>
<td>MgO</td>
<td>19.52</td>
<td>12.18</td>
</tr>
<tr>
<td>CaO</td>
<td>5.59</td>
<td>3.40</td>
</tr>
<tr>
<td>Total</td>
<td>100.91</td>
<td>100.91</td>
</tr>
<tr>
<td>Fe/(Fe+Mg)%</td>
<td>21.21</td>
<td>21.01</td>
</tr>
</tbody>
</table>

**Table 2 - Composition of minerals from the garnet-lherzolite xenolith, Indaiá II pipe**

<table>
<thead>
<tr>
<th>Oxides</th>
<th>Cr-Diopside</th>
<th>Enstatite</th>
<th>Garnets</th>
<th>Olivine</th>
<th>Phlogopite</th>
<th>Carbonatite</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO2</td>
<td>54.82</td>
<td>57.90</td>
<td>41.50</td>
<td>40.79</td>
<td>40.74</td>
<td>0.00</td>
</tr>
<tr>
<td>TiO2</td>
<td>0.10</td>
<td>0.02</td>
<td>0.23</td>
<td>0.16</td>
<td>0.00</td>
<td>0.87</td>
</tr>
<tr>
<td>Al2O3</td>
<td>1.64</td>
<td>0.23</td>
<td>19.94</td>
<td>0.04</td>
<td>13.15</td>
<td>0.07</td>
</tr>
<tr>
<td>Cr2O3</td>
<td>1.71</td>
<td>0.15</td>
<td>5.11</td>
<td>0.03</td>
<td>0.74</td>
<td>0.00</td>
</tr>
<tr>
<td>FeO</td>
<td>2.55</td>
<td>4.65</td>
<td>8.02</td>
<td>7.98</td>
<td>4.09</td>
<td>1.02</td>
</tr>
<tr>
<td>MnO</td>
<td>0.09</td>
<td>0.11</td>
<td>0.44</td>
<td>0.09</td>
<td>0.02</td>
<td>0.69</td>
</tr>
<tr>
<td>MgO</td>
<td>17.10</td>
<td>35.94</td>
<td>19.17</td>
<td>50.08</td>
<td>25.55</td>
<td>3.58</td>
</tr>
<tr>
<td>CaO</td>
<td>18.93</td>
<td>0.38</td>
<td>5.09</td>
<td>0.14</td>
<td>0.02</td>
<td>54.07</td>
</tr>
<tr>
<td>Na2O</td>
<td>1.83</td>
<td>0.13</td>
<td>0.03</td>
<td>0.20</td>
<td>0.16</td>
<td>0.00</td>
</tr>
<tr>
<td>K2O</td>
<td>0.07</td>
<td>0.01</td>
<td>0.01</td>
<td>0.10</td>
<td>11.58</td>
<td>0.01</td>
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<tr>
<td>NiO</td>
<td>0.057</td>
<td>0.117</td>
<td>0.018</td>
<td>0.359</td>
<td>0.104</td>
<td>59.44</td>
</tr>
<tr>
<td>Total</td>
<td>98.85</td>
<td>99.52</td>
<td>99.46</td>
<td>99.44</td>
<td>96.92</td>
<td>59.44</td>
</tr>
<tr>
<td>Fe/(Fe+Mg)%</td>
<td>7.72</td>
<td>6.77</td>
<td>19.01</td>
<td>8.21</td>
<td>8.24</td>
<td>13.78</td>
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</table>

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Figure 2 - Variation diagram for the ilmenites from the same Vargem II kimberlite. Small dots are the partial analyses of small grains made by Afanastiev 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-herzolite xenolith, Indaiá pipe.

<table>
<thead>
<tr>
<th>Component</th>
<th>Ini Cpx</th>
<th>Ini-Gar</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO₂</td>
<td>54.82</td>
<td>41.50</td>
</tr>
<tr>
<td>TiO₂</td>
<td>0.10</td>
<td>0.16</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>1.64</td>
<td>19.94</td>
</tr>
<tr>
<td>Cr₂O₃</td>
<td>1.71</td>
<td>5.11</td>
</tr>
<tr>
<td>FeO</td>
<td>2.55</td>
<td>8.02</td>
</tr>
<tr>
<td>MnO</td>
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<td>0.44</td>
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<tr>
<td>MgO</td>
<td>17.10</td>
<td>19.17</td>
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<tr>
<td>CaO</td>
<td>18.93</td>
<td>5.09</td>
</tr>
<tr>
<td>Na₂O</td>
<td>1.83</td>
<td>0.03</td>
</tr>
<tr>
<td>K₂O</td>
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<td>0.007</td>
</tr>
<tr>
<td>NiO</td>
<td>0.057</td>
<td>0.018</td>
</tr>
<tr>
<td>Total</td>
<td>98.86</td>
<td>100.32</td>
</tr>
<tr>
<td>mg'</td>
<td>0.077</td>
<td>0.190</td>
</tr>
<tr>
<td>Ba</td>
<td>38.68</td>
<td></td>
</tr>
<tr>
<td>La</td>
<td>8.87</td>
<td>0.02</td>
</tr>
<tr>
<td>Ce</td>
<td>29.34</td>
<td>0.14</td>
</tr>
<tr>
<td>Pr</td>
<td>4.61</td>
<td>0.04</td>
</tr>
<tr>
<td>Nd</td>
<td>17.66</td>
<td>0.35</td>
</tr>
<tr>
<td>Eu</td>
<td>0.73</td>
<td>0.10</td>
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<tr>
<td>Sm</td>
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<tr>
<td>Gd</td>
<td>1.74</td>
<td>0.38</td>
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<tr>
<td>Tb</td>
<td>0.19</td>
<td>0.08</td>
</tr>
<tr>
<td>Dy</td>
<td>0.80</td>
<td>0.53</td>
</tr>
<tr>
<td>Ho</td>
<td>0.10</td>
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<tr>
<td>Er</td>
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<td>0.40</td>
</tr>
<tr>
<td>Tm</td>
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<td>0.06</td>
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<tr>
<td>Yb</td>
<td>0.15</td>
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<tr>
<td>Lu</td>
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<td>0.09</td>
</tr>
<tr>
<td>Hf</td>
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<tr>
<td>Zr</td>
<td>79.84</td>
<td>9.28</td>
</tr>
<tr>
<td>Y</td>
<td>3.46</td>
<td>4.19</td>
</tr>
<tr>
<td>Ta</td>
<td>0.06</td>
<td>0.01</td>
</tr>
<tr>
<td>Nb</td>
<td>3.47</td>
<td>0.53</td>
</tr>
<tr>
<td>Th</td>
<td>0.13</td>
<td>0.06</td>
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<tr>
<td>U</td>
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</tr>
<tr>
<td>Sr</td>
<td>576.36</td>
<td>28.89</td>
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<tr>
<td>Rb</td>
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<tr>
<td>Cs</td>
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<td>0.19</td>
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<tr>
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<tr>
<td>Co</td>
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<td>43.21</td>
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<td>Cu</td>
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<td>91.87</td>
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<td>Zn</td>
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<td>4.75</td>
</tr>
<tr>
<td>Au</td>
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<td>0.02</td>
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</table>

Note. The EMPA analyses were done in UIGGM SD RAS, Novosibirsk on CamecaMicro, 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.
Figure 3 - Trace elements for the clinopyroxene and garnet from garnet lherzolite, Indaiá II pipe.
Figure 4 - PT plot for the xenoliths from Indiáí 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 Indiáí II kimberlite pipe using Opx thermobarometry (Brey, Kohler 1990) – (McGregor 1973). 3. TP estimate for the Cr-Diopside xenocrysts from the kimberlite Indiáí II using (Nimis and Taylor, 2000) thermobarometry. 4. TP estimates on the Cr-Diopside xenocrysts from the kimberlite Indiáí II using (Nimis & Taylor 2000) thermometer and (Ashchevpov 2001) barometer.