Geochemical investigations on the Mbuji-Mayi and Kundelungu megacryst suites (Democratic Republic of Congo)

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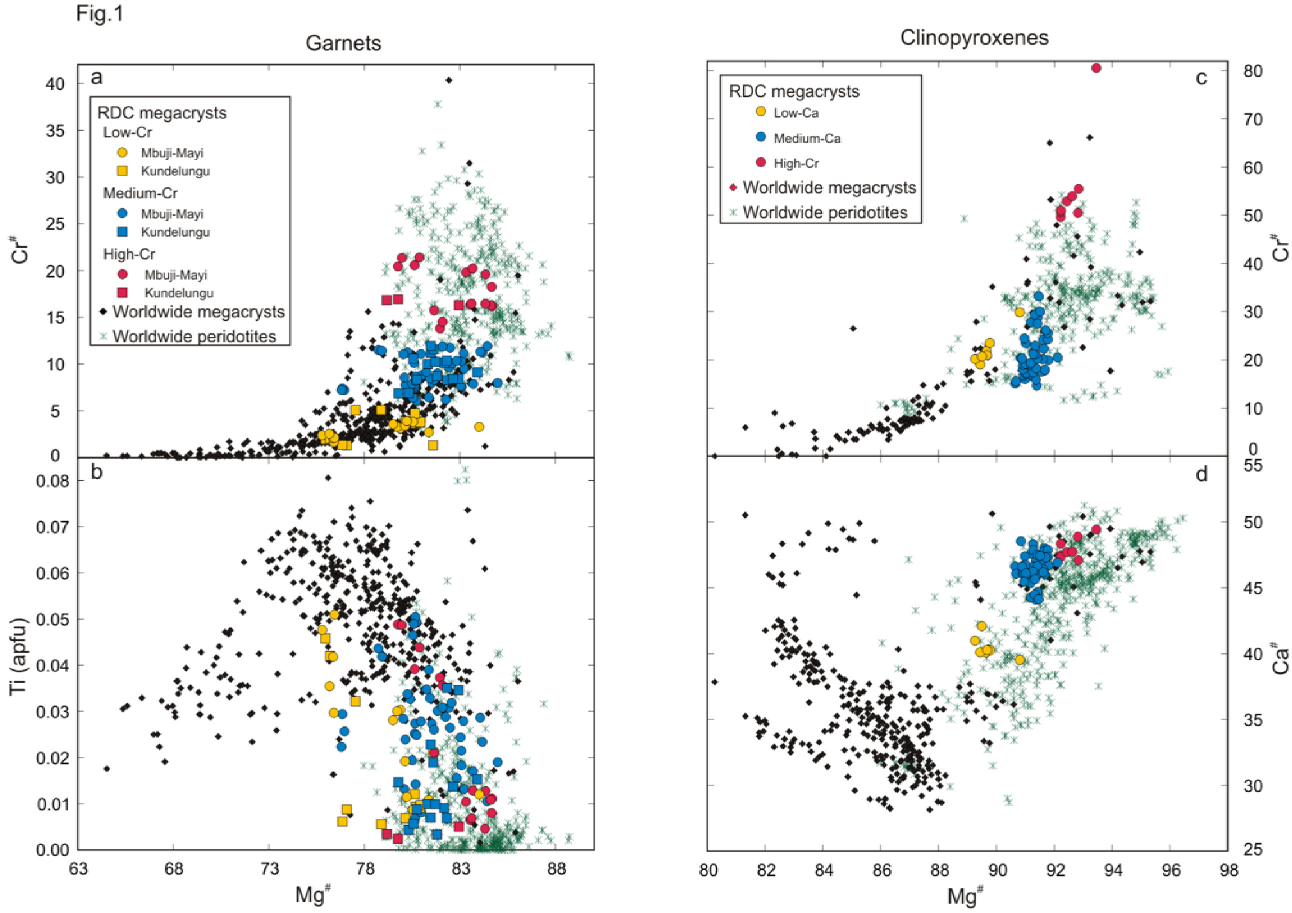
Two kimberlite fields are known in Democratic Republic of Congo. The Mbuji-Mayi kimberlites are diamond-rich, they are located in the East Kasaï province and intrude the Archean (>2.7Ga) Congo-Kasaï craton. The diamond-poor Kundelungu kimberlites are situated on the Kundelungu Plateau (Shaba region) and crosscut a Paleoproterozoic basement (~1.9Ga) belonging to the south-western extension of the Bangweulu block. These two kimberlite fields have been largely studied (Demaiffe et al, 1991) as well as the Mbuji-Mayi eclogite nodules (El Fadili & Demaiffe, 1999) but their respective megacryst suites are still poorly known. The discrete nodule suites of both localities comprise typical pyrope, diopside and Mg-ilmenite megacrysts. Moreover, zircon, corundum, baddeleyite and chlorite megacrysts and rutile-silicate intergrowths have been found at Mbuji-Mayi and olivine, orthopyroxene and phlogopite megacrysts at Kundelungu.

Preliminary investigations focus on major (WDS electron microprobe) and rare earth elements (LA-ICP-MS) compositions of garnet megacrysts from both regions and clinopyroxene megacrysts from Mbuji-Mayi.

Major element compositions

Three groups of pyrope are identified on the basis of their Cr content (fig.1a): low-Cr (0.43-1.79 wt%Cr_2O_3; $Mg^\#$: 75.8-84.0); medium-Cr (1.93-4.12 wt%Cr_2O_3; $Mg^\#$: 77.0-84.9) and high-Cr (4.44-6.89 wt%Cr_2O_3; $Mg^\#$: 79.2-84.6). The three groups are recognized in both localities. There is no obvious geochemical difference between the compositions of the garnets of Mbuji-Mayi and Kundelungu.

Fig.1



Moreover, many garnets, whatever their origin, size and/or composition, contain polymineral inclusions, principally K-rich hydrated minerals (phlogopite and amphibole) and Cr-spinels. These inclusions are commonly associated with a radial network of fractures. The presence of these inclusions in most garnets suggests a common process of formation.
Three diopside groups are distinguished at Mbuji-Mayi on the basis of their Cr and Ca contents (fig.1c-d): low-Ca ($Ca^{\#}$: 39.5-42.1; 0.61-0.92 wt%Cr_2O_3); medium-Ca ($Ca^{\#}$: 44.1-48.5; 0.41-1.09 wt%Cr_2O_3) and high-Cr ($Ca^{\#}$: 47.1-49.4; 1.31-2.77 wt%Cr_2O_3).

The comparison of the RDC megacrysts with other megacryst suites worldwide (South Africa, Lesotho, Russia, USA for garnets and clinopyroxene and Australia, Canada, Siberia, Botswana and Namibia for garnets only; see *references), shows that RDC megacrysts display some peculiar major element features.

The RDC garnet megacrysts (fig.1a-b) do not show the usually observed trends of simultaneously decreasing $Cr^{\#}$ [=Cr/(Cr+Al)] and $Mg^{\#}$ [=Mg/(Mg+Fe)] or of inversely correlated Ti and $Mg^{\#}$, which are commonly interpreted as typical fractional crystallisation trends (Garrison & Taylor, 1980; Hops et al., 1992). The garnets from RDC are richer in Cr but poorer in Ti and Fe than those from other suites. The RDC clinopyroxene megacrysts (fig.1c-d) are enriched in Mg and Cr but depleted in Ti and Fe by comparison to others and they do not display the $Mg^{\#}$-$Cr^{\#}$ trend commonly seen in other localities. Furthermore, the negative correlation between $Ca^{\#}$ [=Ca/(Mg+Ca)] and $Mg^{\#}$, widely observed in other suites (Bell et al., 2004), is absent from the RDC clinopyroxenes.

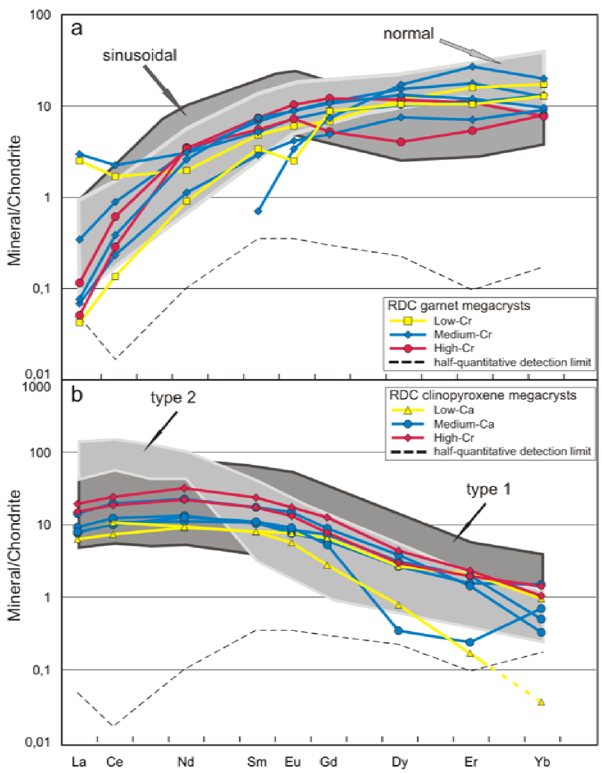
The comparison of the major element compositions of the RDC megacrysts with the minerals of peridotite xenoliths from kimberlites worldwide (Lesotho, Canada, USA, RDC, South Africa, see *references) brings some more features to light. The garnets from RDC are quite richer in Fe and Ti but poorer in Cr than those from the peridotite xenoliths (fig.1a-b). The Mbuji-Mayi clinopyroxenes are also enriched in Fe and Ti; some of them are enriched in Ca and Mg by comparison to peridotitic clinopyroxene (fig.1c-d).

The RDC megacrysts appear thus to be intermediate between the megacrysts from other kimberlites and the kimberlite-derived peridotite xenoliths. They do not display the fractional crystallisation trends commonly observed in other megacryst suites and are enriched in Fe and Ti by comparison to peridotitic minerals.

Trace element (REE) compositions

Garnet megacrysts from RDC are quite poor in REE (ΣREE: 7.8-16.6ppm). There is no relation between Cr and REE contents. Most pyropes analysed display a "normal" pattern ($(La/Yb)_N$ = 0.003-0.027) although some crystals are LREE enriched ($La_N \sim 2.5$-3) and/or display positive ($Eu/Eu^* \sim 1.35$) or negative ($Eu/Eu^* \sim 0.46$) Eu anomalies (fig.2a). Similar anomalies have been observed in garnets from peridotite xenoliths and have been interpreted as resulting from variations in redox conditions during a metasomatic event (Griffin & O'Reilly, 2007).
It is interesting to note that the patterns of the RDC garnet megacrysts are similar to those reported by Hoal et al. (1994) in the garnets from peridotite xenoliths of South Africa (fig.2a). The normal and sinusoidal REE profiles respectively represent garnets that were, or were not, reequilibrated with a LREE-enriched metasomatic agent (mantle fluid or melt ?).

Fig.2



The RDC clinopyroxene megacrysts are also REE poor (ΣREE: 15.3-45.5ppm) and display relative LREE enrichment ($(La/Yb)_N$ = 5.1-43.2). There is a positive correlation between the REE and Cr contents of the diopsides. Again, the REE profiles of the diopside megacrysts are similar to those of the peridotitic clinopyroxenes (fig.2b).
In their study of the REE contents of the diopsides of garnet lherzolites from different Kaapvaal kimberlites, Gregoire et al. (2003) identified two types of profile: the types 1 and 2 (fig.2b).

These two types of clinopyroxene are LREE enriched (type 2 is more enriched than type 1) and interpreted as minerals having crystallized from, or been completely equilibrated with, highly alkaline mafic silicate melts. For the type 1, which shows more similarities with the RDC diopsides, the melt is believed to be related to Group I kimberlite magmas. It has been shown that RDC kimberlites indeed belong to the Group I kimberlites (Weis & Demaiffe, 1985).

The REE patterns of the RDC garnet and diopside megacrysts show similarities with some of the profiles recorded in the minerals of metasomatically modified peridotite xenoliths.

Discussion and conclusions

The differences in compositions between RDC megacrysts and those from other occurrences could be related to different modes of formation. Some megacryst suites could be associated to fractional crystallisation processes while the RDC megacrysts, which display chemical similarities with mantle-derived minerals, could result from metasomatic transformation of deep mantle rocks. This assumption is strengthened by the probable two mantle metasomatisms observed in the RDC megacrysts: 1) the modal K-metasomatism represented by the presence of K-rich hydrated inclusions in garnets and 2) the cryptic Fe-Ti metasomatism.

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