Geophysical Research Abstracts,
Vol. 11, EGU2009-508, 2009
EGU General Assembly 2009

Melting relations of Na-bearing majoritic garnet

A.M. Dymshits (1), A.V. Bobrov (1,2), and Yu.A. Litvin (2)

(1) Geological Faculty, Moscow State University, Russia, (2) Institute of Experimental Mineralogy, Chernogolovka, Russia

Na-bearing majoritic garnets (>0.3 wt% Na_2O) are abundant as inclusions in diamonds from kimberlitic pipes worldwide (Stachel, 2001) providing evidence for a link between high Na concentration and pressure. This is proved by finds of majoritic garnets containing >1 wt% Na_2O. Garnet inclusions with extreme majoritic content were described in diamond from Helam Mine (South Africa). The concentration of Si in these garnets is high and reaches 3.5 f.u.; Na_2O content gains 1.08 wt%. Another E-type Na-bearing majoritic garnet was found in Monastery kimberlite; it contained 3.429 f.u. Si at a very low Al concentration (1.3–1.6 f.u.) (Moore, Gurney, 1985). Of special interest is the find of diamond in Guinea, in which along with garnet inclusion containing 1.37 wt% Na_2O K-rich clinopyroxene (1.44 wt% K_2O) was observed; that is an indicator of pressure above 6 GPa.

Our experiments were aimed on the study of melting relations and compositional range of Na-bearing majoritic garnet in model pyrope $Mg_3Al_2Si_3O_{12}$ (Prp)–$Na_2MgSi_5O_{12}$ (NaGrt) ($\pm$grossular $Ca_3Al_2Si_3O_{12}$), pyrope–jadeite $NaAlSi_2O_6$ (Jd), and pyrope–Na_2CO_3 systems at 7.0–8.5 GPa and 1200–1900˚C using the high-pressure toroidal anvil-with-hole apparatus (Bobrov et al., 2008).

In the pseudo-binary $Mg_3Al_2Si_3O_{12}$–$Na_2MgSi_5O_{12}$system Na-bearing garnet is a liquidus phase up to 60 mol% $Na_2MgSi_5O_{12}$ (NaGrt). At higher content of NaGrt in the system (>80 mol%), enstatite (En) and coesite (Cs) are observed as liquidus phases (Fig. 2). Our experiments provided evidence for a stable sodium incorporation in Grt (0.3-0.6 wt% Na_2O) and its control by temperature and pressure. The highest sodium contents were obtained in experiments at P = 8.5 GPa. Near the liquidus (T = 1840˚C), the equilibrium concentration of Na-component in Grt is 5 mol% $Na_2MgSi_5O_{12}$. With the temperature decrease, Na concentration in Grt increases, and the maximal $Na_2MgSi_5O_{12}$ content of 12 mol% (1.52 wt% Na_2O) is gained at the solidus of the system (T = 1760˚C). Grossular-containing starting materials also produces Na-garnet (up to 1 wt% Na_2O) accompanied by pyroxene and Al-rich phases (kyanite, corundum, and spinel).

$Mg_3Al_2Si_3O_{12}$– $NaAlSi_2O_6$ system should be also considered as pseudo-binary, because Na is incorporated in garnet as $Na_2MgSi_5O_{12}$ (Bobrov et al., 2008) and pyroxene forms jadeite-enstatite (En) solid solutions with Eskola (Esk) $Mg_{0.5}AlSi_2O_6$ component. Main phases obtained in experiments were garnet, pyroxene, kyanite (sometimes corundum) and quenched melt. Liquidus garnet appeared at a temperature < 1800˚[U+FFFD]n a wide range of starting compositions and had a stable Na_2O admixture (up to 0.8 wt.% at 8.5 GPa and up to 0.6 wt.% at 7 GPa) and elevated Si concentration (up to 3.128 f.u.). At near-eutectic temperatures (~1500˚C) garnet becomes progressively enriched in $Na_2MgSi_5O_{12}$and majorite $Mg_4Si_4O_{12}$. Garnets crystallizing from near-eutectic starting materials ($Prp_{20}Jd_{80}$) are the most sodium-rich. This fact indicates the influence of melt alkalinity on the formation of Na-bearing majoritic garnets.

In pyrope–Na_2CO_3 system garnet (a solid solution of pyrope, NaGrt, and Maj) was formed in the range of 15–100 mol% Prp. The highest sodium concentration in garnet (0.8 wt% Na_2O) was registered at 1200˚C. Starting compositions with <15 mol% Prp produce carbonate and pyroxene as liquidus phases.

The results obtained demonstrate that Na is incorporated in garnet as $Na_2MgSi_5O_{12}$component independently on the starting composition of the system. Thus, mechanism of the formation of Na-bearing majoritic garnets suggested by Sobolev and Lavrent'ev (Sobolev, Lavrent'ev, 1971) and experimentally simulated by Bobrov et al. (2008) was confirmed. The crystallization of Na-bearing garnets is mainly controlled by temperature, pressure, and composition of the system. The increase of Na concentration in garnet at constant PT-parameters may result only from the increase of melt alkalinity. The increase of pressure causes only the growth of melting temperature and regular increase of Na content in garnet.

The study was supported by the Russian Foundation for Basic Research (project no. 08-05-00110), grant of the President of Russian Federation (NSh-5367.2008.5).

Program of the Presidium of the Russian Academy of Sciences P9 "Study of matter under extreme conditions", and INTAS grant no. 05-1000008-7927 "Diamond and graphite in carbonate magmas".

Bobrov A.V., Litvin Yu.A., Bindi L., Dymshits A.M. (2008) Phase relations and formation of sodium-rich majoritic garnet in the system $Mg_3Al_2Si_3O_{12}$–$Na_2MgSi_5O_{12}$ at 7.0 and 8.5 GPa. Contrib. Mineral. Petrol. 156, 243–257.

Moore R.O., Gurney J.J. (1985) Pyroxene solid solution in garnets included in diamonds. Nature 318, 553–555.

Sobolev N.V., Lavrent'ev Ju.G. (1971) Isomorphic sodium admixture in garnets formed at high pressures. Contrib. Mineral. Petrol. 31, 1–12.

Stachel T. (2001) Diamonds from the asthenosphere and the transition zone. Eur. J. Mineral. 13, 883–892.