Trace element fractionation during exsolution of garnet from clinopyroxene in an eclogite xenolith from Obnazhennaya (Siberia)

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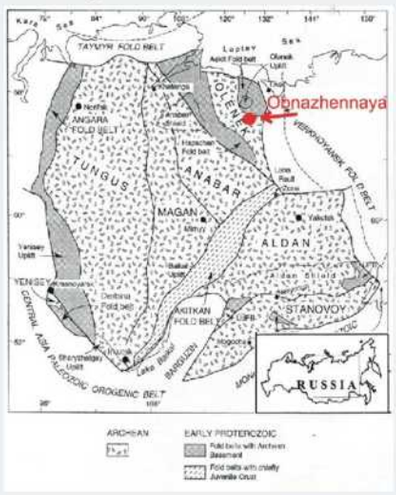
Geological setting

The Late Jurassic Obnazhennaya kimberlite pipe located in the Olenek province at the northern Siberian Craton. It contains a great variety of mantle xenoliths including garnet and spinel peridotites, pyroxenites and eclogites.



Petrography

The Obna 006 xenolith is a bimineralic garnet pyroxenite (eclogitic composition) which contains a large clinopyroxene megacryst with multiple lamellae of exsolved garnet.

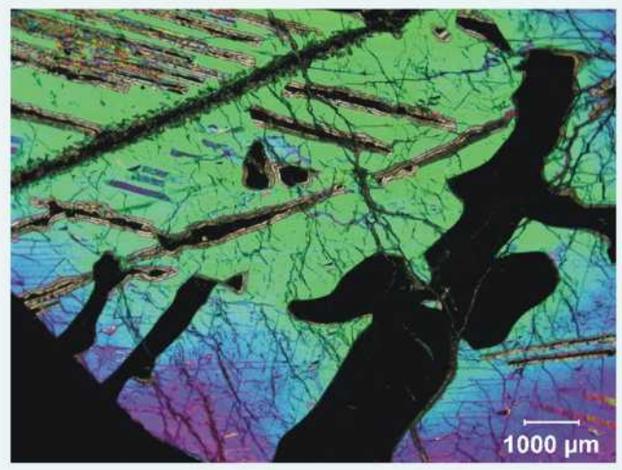
The following sets of exsolved garnet can be distinguished:

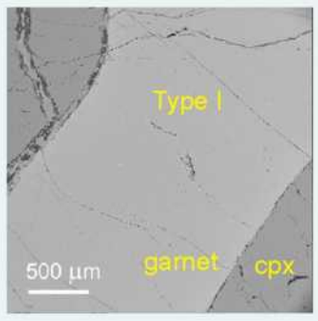
Type I. Vermicular intersticial garnet segregation with maximum thicknesses of 1500-2000 μm

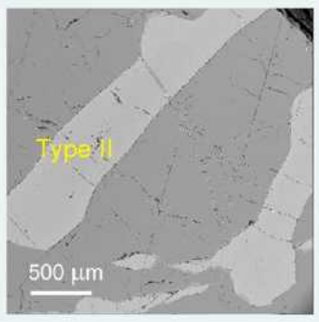
Type II. Elongated discontinuous garnet layers with average thicknesses of 500 μm

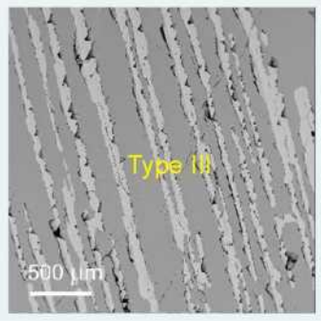
Type III. Oriented continuous layers of garnet 50-200 μm across

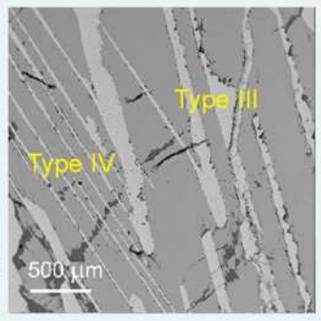
Type IV. Thin oriented garnet lamellae about 10-20 μm across







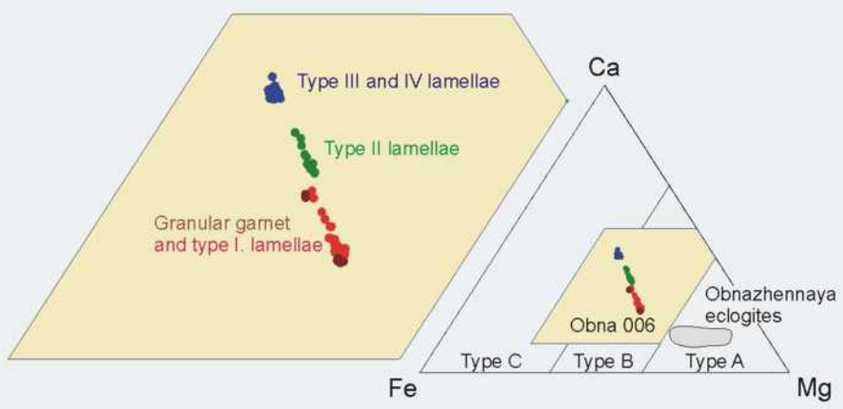


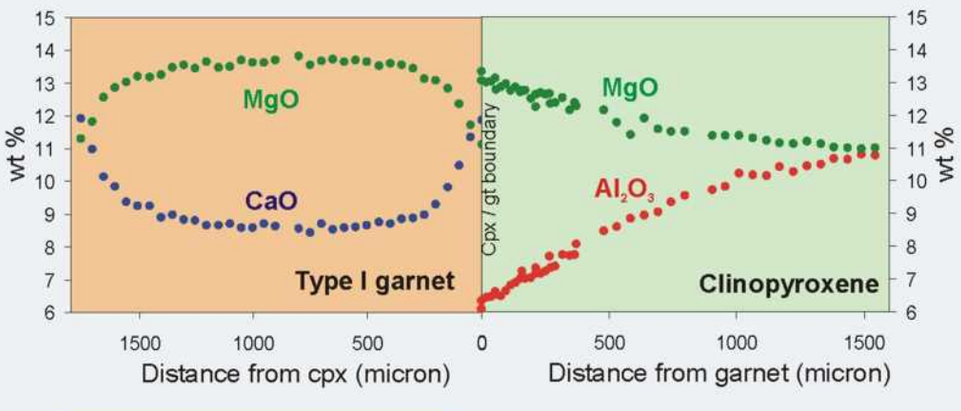


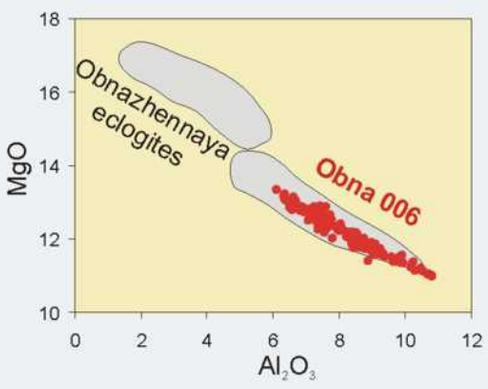
Major elements

Garnet composition

The CaO content of garnets increases as the thickness of the exsolution lamellae decreases. The thick Type I. lamellae show significant compositional zoning with increasing CaO and decreasing MgO contents towards the rims. All kinds of garnets plot mainly into the field of Group B eclogite garnets.







Clinopyroxene composition

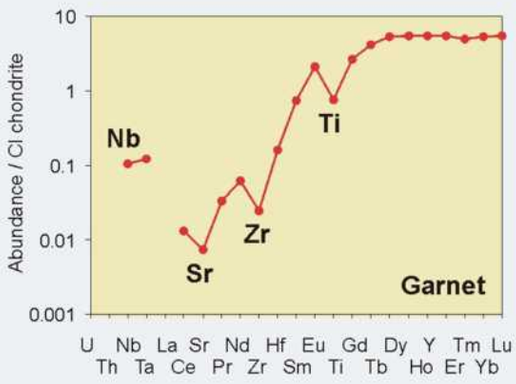
The clinopyroxene is heterogeneous especially in its Al_2O_3, MgO and Na_2O contents. In the lamellae-free parts it has high (almost 11 wt%) Al_2O_3 content, but its Al_2O_3 and Na_2O content decreases, MgO content increases towards the large garnet lamellae as a result of incomplete diffusion.

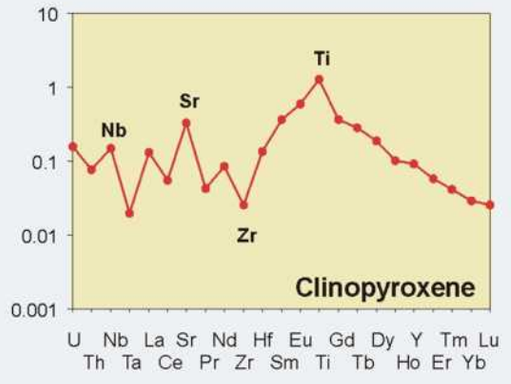
Representative composition of garnet and clinopyroxene

	Garnet				Clinopyroxene	
	Granular	Type I	Type II	Type III	Clean	At garnet
SiO_2	40.64	40.16	40.25	39.64	51.27	53.27
TiO_2	0.05	0.04	0.05	0.05	0.08	0.09
Al_2O_3	22.97	22.59	22.65	22.06	10.80	6.10
Cr_2O_3	0.15	0.14	0.14	0.16	0.13	0.13
FeO	14.19	14.56	13.31	12.67	3.42	3.13
MnO	0.41	0.39	0.35	0.29	0.03	0.04
MgO	14.11	13.60	11.42	9.36	11.00	13.35
CaO	7.98	8.52	12.56	15.50	19.53	20.75
Na_2O	0.05	0.02	0.03	0.09	3.46	2.89
Total	100.54	100.02	100.74	99.83	99.70	99.74

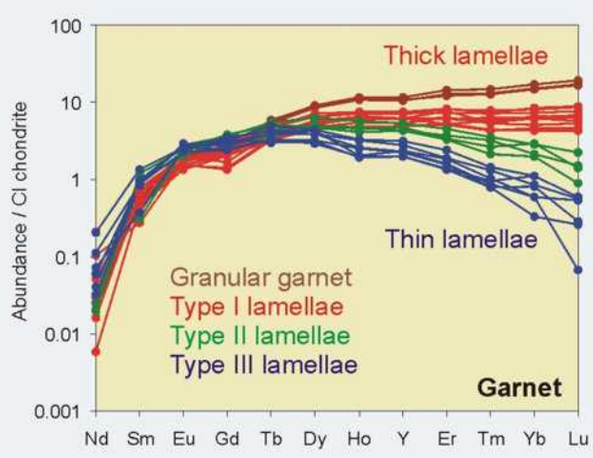
Trace elements

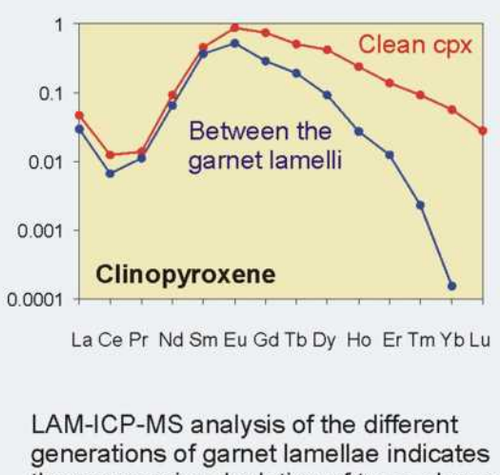
Trace elements were analysed using a laser ablation ICP-MS at the Natural History Museum in London.



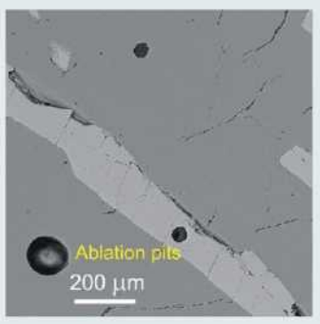


Both clinopyroxene and garnet have low incompatible trace element contents. The positive Sr anomaly in the normalised trace element pattern of the clinopyroxene may suggest a feldspar-bearing precursor.





LAM-ICP-MS analysis of the different generations of garnet lamellae indicates the progressive depletion of trace elements compatible with garnet (HREE, Y, Sc) during the course of exsolution.



Acknowledgements
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Discussion

The different sets of garnet exsolution lamellae crystallized from the large Al-rich clinopyroxene megacryst in sequence appearently as a result of pressure release and slow cooling at depth. Variation of trace elements in the garnet lamellae and their host clinopyroxene suggests a diffusion-controlled trace element fractionation during cooling and garnet exsolution. The preservation of the fractionated trace element patterns in the exsolved garnets, as well as the diffusion gradients in the host clinopyroxene indicate that cooling and exsolution occurred shortly before the xenolith was entrained by the kimberlite melt. Cooling and release of pressure appearently were too fast for the system to attain chemical equilibrium - a feature very commonly observed with alkali basalt and kimberlitic volcanism, indicating widespread short-term disturbances in the mantle shortly before eruption took place.