Petrology and Geochemistry of Peridotite Inclusions from the Mir kimberlite, Siberia

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The Mir kimberlite of Siberia contains a diverse suite of mantle-derived xenoliths including coarse and sheared garnet lherzolites, eclogites, ilmenite-garnet wehrlites and a heterogeneous group of garnet pyroxenites. We have focussed on the mineral chemistry of a suite of lherzolites, wehrlites and pyroxenites (Table 1). All these rocks contain garnet with CaO contents indicative of saturation with diopside and are relatively Mg-rich with the exception of the wehrlites. The latter rocks contain relatively Fa-rich olivine (Fo_{84-85}) in contrast to the coarse and sheared lherzolites which contain Fo-rich olivines: Fo_{91-93} and Fo_{90-92} respectively. Only one garnet pyroxenite in the sample suite contains olivine, Fo_{94}, but most other pyroxenites contain Mg-rich pyroxenes (diopside Mg # 89-96) and thus these rocks are mineralogically distinct from eclogites and similar to the coarse garnet lherzolites. The pyroxenites are typically coarse-grained and have relatively unstrained minerals. Most of these pyroxenites equilibrated within a pressure and temperature range (21-39 kb and 700-900°C, after Brey and Kohler, 1990; Ellis and Green, 1979) similar to that estimated for the the coarse garnet lherzolites (29-42 kb, 700-900°C) at Mir, as well as the coarse garnet peridotites from another Siberian kimberlite, Udachnaya (Boyd et al., 1997). In contrast, the deformed or sheared garnet lherzolites equilibrated at much higher pressures and temperatures (56-62 kb and 1170-1250°C). A similar dichotomy in equilibration conditions and texture exists for lherzolites from Udachnaya. Sheared ilmenite-garnet wehrlites from Mir also equilibrated at relatively high temperatures (>1150°C based on garnet-clinopyroxene equilibria) and although the mineral assemblage is not sensitive to pressure, we infer that these deformed, high temperature wehrlites are probably derived from the same depths as the sheared lherzolites based on similar textures as well as the high calculated equilibration temperatures.

Nd isotopic data confirm the thermobarometric calculations: high temperature lherzolites have diopside and garnet which were in approximate isotopic equilibrium at the time of eruption whereas low temperature lherzolites and pyroxenites contain garnet and diopside which were not in equilibrium at the time of eruption.

The garnet pyroxenites are a particularly diverse group lithologically and include orthopyroxenites, websterites and clinopyroxenites. At least one pyroxenite contains garnet with exsolved diopside and in this sense is similar to the ultradeep inclusions (Haggerty and Sautter, 1990). However the garnet also contains exsolved rutile which appears to balance the excess Si contained in the exsolved diopside and no original majorite component in the garnet is required (Roden et al., ms.) . Moreover, isotopic disequilibrium between garnet and diopside, and thermobarometric calculations all suggest that this inclusion originated from within the lithosphere and no previous high pressure history is required. As a group the pyroxenites probably represent reequilibrated cumulates from intrusive magmas into the lithsophere.

The ilmenite-garnet wehrlites are a particularly fascinating lithology because their sheared textures and high temperatures of equilibration suggest an origin from the same source region as the sheared lherzolites. The ilmenite is MgO-rich (Table 1) and has a peculiar texture characterized by elongate grains which occupy interstices between silicate grains as if the ilmenite records the texture of a melt with very low surface tension. Garnets are relatively Ti-rich and Cr and Mn are zoned in the two examples we studied (Table 1). Tentatively we attribute the origin of these rocks to intrusion and metasomatism of continental lithosphere by an Fe-rich, Si-poor melt.

Table 1. Mineral Compositions

Sample	A239 - Coarse Gt Lherz				TM-184 - Sheared Gt Lherz			
Mineral	oliv	gt	cpx	opx	oliv	gt	cpx	opx
SiO_2	41.06	42.11	55.05	58.13	40.52	41.88	55.33	57.34
TiO_2	---	0.05	0.05	0.03	---	0.86	0.45	0.21
Al_2O_3	---	22.51	2.42	0.48	---	20.16	2.62	0.74
Cr_2O_3	---	1.56	1.21	0.12	---	2.93	0.87	0.20
CaO	nd	4.45	21.45	0.18	0.06	4.59	16.41	0.78
MgO	50.99	20.18	16.11	36.21	48.77	20.42	17.41	34.08
FeO	7.87	8.83	1.90	5.00	10.13	8.23	4.10	6.09
MnO	0.09	0.28	nd	0.07	0.09	0.15	0.06	0.12
NiO	0.32	---	---	---	0.25	---	---	---
Na_2O	---	nd	1.84	0.03	---	nd	2.41	0.24
Total	100.33	99.97	100.03	100.25	99.86	99.22	99.66	99.80

Sample	TM-71 - Sheared Ilmenite-Garnet Wehrlite				
Mineral	oliv	gt core	gt rim	cpx	ilm
SiO_2	41.05	41.15	41.38	54.73	nd
TiO_2	---	0.95	0.95	0.38	49.94
Al_2O_3	---	19.29	20.05	2.41	0.64
Cr_2O_3	---	2.77	1.59	0.57	0.86
CaO	0.05	4.66	4.65	16.61	nd
MgO	45.14	18.41	18.49	17.24	9.71
FeO	14.49	11.99	11.88	5.69	40.74
MnO	0.17	0.17	0.28	0.09	0.15
NiO	0.13	---	---	---	0.08
Na_2O	---	nd	nd	2.30	---
Total	99.90	99.39	99.27	100.02	101.13

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