SYMPLECTITES IN UPPER MANTLE HARZBURGITES AND GARNET HARZBURGITES

Field, S.W.

Stockton State College, Pomona New Jersey, 08240

Symplectites are complex mineral intergrowths commonly found in upper mantle peridotites recovered from kimberlite pipes (Exley et.al., 1982; Dawson and Smith, 1975). Symplectites are abundant in harzburgites and garnet harzburgites found in the Cretaceous Jagersfontein kimberlite in South Africa. Symplectites in harzburgites are composed of either enstatite, diopside, and spinel or diopside and spinel. Symplectites in garnet harzburgites are composed of either diopside, garnet, and spinel or garnet and spinel. Amphibole is found in a few symplectites and is thought to be of metasomatic origin. Temperature estimates for the garnet harzburgites obtained from Lindsley and Andersons (1983) two pyroxene geothermometer range from 650 to 1300 c with most falling between 850 and 1000 c. Pressure estimates from garnet-diopside geobarometry (Brey et.al., 1986) range from 12 to 47 kilobars with most estimates falling between 20 and 35 kilobars. Temperature estimates for symplectite-bearing harzburgites range from a low of 775 c to a high of 1300 c.

Petrography: Harzburgites containing symplectites are composed dominantly of medium-grained olivines (0.5-2.0mm) surrounding cluster of enstatites. Symplectites, generally less than 0.5 mm in diameter, make up less than 1 modal percent of the peridotites. Symplectites are constructed of a single or small number of optically homogeneous pyroxene crystals embedded with tens to hundreds of small, wavy, spinel lamellae. The symplectites are located adjacent to discrete enstatite and are generally triangular or arcuate in shape. Spinel lamellae are crystallographically oriented in the pyroxene and radiate outward away from the enstatite.

Garnet harzburgites are composed of clusters of large discrete enstatites surrounded by olivines. Within the enstatite clusters are small interstitial garnets, spinels, and diopsides. Enstatites contain abundant planar lamellae of spinel, diopside and in some samples garnet. Symplectites are located within enstatite clusters adjacent to lamellae-bearing pyroxenes. Symplectite structure consists of either small spinel blebs within large garnets or commonly a central core of diopside crystals embedded with tens to hundreds of wavy spinel lamellae surrounded by a rim or partial rim of garnet.

Mineral Chemistry: Olivines in harzburgites and garnet harzburgites have identical chemistries and range from Fo_{92} to Fo_{94}. Diopsides in harzburgites, present dominantly in symplectites, have a lower Na content (.02-.08 cat./6 oxy) and slightly higher Mg content (.93-.96 cat./6 oxy) than diopsides in

garnet harzburgites (Na .03-.13, Mg .90-.96 cat./6 oxy). Discrete enstatite in harzburgites differ compositionally from enstatites in garnet harzburgites. Harzburgite enstatite Al contents (.03-.14 cat./6 oxy), Ca contents (.01 .04 cat./6 oxy) and Cr contents are higher than Al (.03-.05 cat./6 oxy), Ca (<.01 cat./6 oxy), and Cr contents in garnet harzburgite enstatites. Silicon and magnesium contents in harzburgite enstatites are distinctly lower than Si and Mg contents in garnet harzburgite enstatites. In addition discrete harzburgite enstatites are enriched in Ca, Al, and Cr contents with respect to enstatites in symplectites (Al .04-.09, Ca .01-.02 cat./6 oxy). Symplectite enstatites in harzburgites are intermediate in chemistry to discrete harzburgite enstatites and discrete garnet harzburgite enstatites.

Symplectite spinels in harzburgites are Mg (5.3-6.1 cat./32 oxy) and Al rich (6.8-11.2 cat./32 oxy) and Cr (4.8-8.5 cat./32 oxy) and Fe_T poor (2.0-2.8 cat./32 oxy). Spinels in garnet harzburgites are found as lamellae in enstatite, as small discrete interstitial grains, and as lamellae in symplectites. All the garnet harzburgite spinels are rich in Fe_T (3.2-4.4 cat./32 oxy) and Cr (9.7-10.9 cat./32 oxy) and poor in Mg (4.6-5.2 cat./32 oxy) and Al (4.1-6.2 cat./32 oxy). Although spinels in harzburgites and garnet harzburgites have generally different compositons the compositions form a continuous trend from Mg and Al rich to Fe and Cr poor. Garnets found only in garnet harzburgites, are found as lamellae in enstatites, discrete interstial grains, and as rims or partial rims around symplectites. Garnets have a limited range in composition (Py_{67-73} Alm_{12-19} $Sp_{0.5-1.5}$) in all morphological forms.

Discussion: The petrography and chemistry of minerals in symplectites and symplectite-bearing peridotites indicate that intergrowth formation was complex and involved exsolution, diffusion, metamorphism, and in some cases metasomatism and that symplectites in harzburgites and garnet harzburgites may be genetically related. Lamellae in enstatite and the position of symplectites adjacent to lamellae-bearing enstatites indicates symplectite diopside diffussed out of enstatite. The optical orientation of spinel in symplectites and the textural relationship of spinel to pyroxene suggest that spinel unmixed from diopside after the pyroxene diffused from enstatite. Garnet appears to have formed by a reaction between olivine or enstatite, spinel, and diopside after formation of the symplectite core. Metasomatic reactions formed amphibole by replacement of garnet, diopside, enstatite, and spinel in some peridotites. Harzburgites which contain high Al discrete enstatites and modally minor symplectites may be precursors to garnet harzburgites containing low Al enstatites and a modally higher percentage of spinel, diopside, and garnet.

Table 1. Mineral Chemistry

	1	2	3	4	5	6	7	8
Si	.996	2.992	1.977	1.926	1.935	1.993	0	0
Ti	0	0	.001	.001	0	0	0	0
Al	0	1.856	.076	.138	.097	.029	8.158	4.708
Cr	0	.170	.030	.020	.021	.005	7.548	10.575
Fe^{3+}	0	-	-	-	-	-	.294	.717
Fe^{2+}	.139	.490	.044	.129	.129	.139	2.404	2.817
Mn	0	.029	-	0	0	.004	.045	.051
Mg	1.860	2.080	.946	1.736	1.810	1.820	5.552	5.133
Ca	0	.389	.881	.027	.024	.006	-	-
Na	.006	-	.035		.001	0	.002	-
Total	3.001	8.006	3.990	3.978	4.016	3.998	24.001	24.001

1. Olivine - cat./4 oxy
2. Garnet - cat./12 oxy
3. Diopside cat./6 oxy
4. Enstatite (Discrete, Harzburgite) cat./6 oxy
5. Enstatite (symplectite, Harzburgite) cat./6 oxy.
6. Enstatite (Discrete, Garnet Harzburgite) cat./6 oxy.
7. Spinel (Symplectite, Harzburgite) cat./32 oxy.
8. Spinel (Symplectite, Garnet Harzburgite) cat./32 oxy.

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