

HYDROUS MINERALS AND CARBONATES IN PERIDOTITE INCLUSIONS FROM THE GREEN KNOBS AND BUELL PARK KIMBERLITIC DIATREMES ON THE COLORADO PLATEAU.

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Over 90% of the peridotite inclusions in kimberlitic tuff at these diatremes contain hydrous phases which appear to have formed before the inclusions were incorporated in the erupting kimberlite, and a few percent contain carbonate of similar origin. Such "primary" phases are distinguished from "secondary" phases formed during or after incorporation in kimberlite by the following criteria: primary phases were deformed together with anhydrous silicates, they occur locally in relatively large crystals in apparent equilibrium metamorphic textures, and they show systematic compositional variations together with anhydrous silicates. The "primary" hydrous phases -- amphibole, chlorite, titanoclinohumite, and probably antigorite -- comprise from trace amounts to 90% of the hydrated inclusions. Antigorite also formed as a late "secondary" phase, and many antigorite textures cannot be interpreted unambiguously.

Mineral compositions in Table 1 are from three rocks (N53, N23, N51) with relatively homogeneous hydrous phases; the rocks are arranged in order of increasing abundance of hydrous minerals (N51 most hydrated). Amphiboles and pyroxenes become less aluminous, and orthopyroxene becomes less calcic with increased rock hydration. Textures, compositional differences between grains, and zoning indicate chemical disequilibrium: in an extreme example, one rock contains amphibole with a range of over 8% Al_2O_3 . Several assemblages (e.g. ol-opx-cpx-sp-amph; ol-cpx-antig) may represent local equilibrium, as judged from experimental data and assemblages in ultramafic rocks metamorphosed in the crust (e.g. Evans, 1977). Neither talc nor anthophyllite is present, and orthopyroxene occurs together with antigorite in many rocks. This pair most likely indicates disequilibrium even on a local scale; high water pressure and high Al plus Cr may relatively stabilize antigorite, however (e.g. Hemley and others, 1977), and equilibrium in the uppermost mantle is conceivable. Titanoclinohumite is likely stabilized by Ti; it has very similar compositions in different assemblages (Table 1). Magnesite, a likely "primary" carbonate, has been analyzed in five inclusions and has a systematic Fe/Mg partition with associated olivine. Dolomite, of debatable origin, is a rare phase, and late, secondary calcite is common.

The solid-fluid reactions may have occurred over ranges of temperature and water fugacity. Magnesite and recrystallized diopside occur in near contact but may not have been in equilibrium; the lower-pressure pair dolomite-enstatite was not observed. Consideration of the phases present and the study of anhydrous reactions of Smith and Levy (1976) suggest reactions at less than 700°C and less than 18 kb. Fe is partitioned into relict and recrystallized olivine as hydrous phases with lower Fe/Mg ratios are formed; observed olivine zoning (Fig. 1) is most compatible with some hydration preceding kimberlite eruption by less than tens of millions of years.

Peridotite hydration may be directly related to the genesis of kimberlite and associated rocks. The Defiance uplift has been a persistent Phanerozoic high (Hunt, 1956). Hydration may have begun along zones of weakness in the mantle associated with the high even before Laramide monocline formation. Three analyzed peridotite inclusions with possible primary antigorite contain

$\leq 0.03\%$ Na₂O, while 5 inclusions without "primary" antigorite contain 0.18 - 0.49%. Na may have been released during hydration in the stability field of antigorite, and it may have contributed to the formation of the unusually sodic Plateau eclogites found primarily in kimberlite diatremes to the north. Subsequent intrusion of minette magma into the hydrated peridotite may have caused dehydration reactions and provided the volatiles for disaggregation and eruption of non-magmatic Plateau kimberlite.

References

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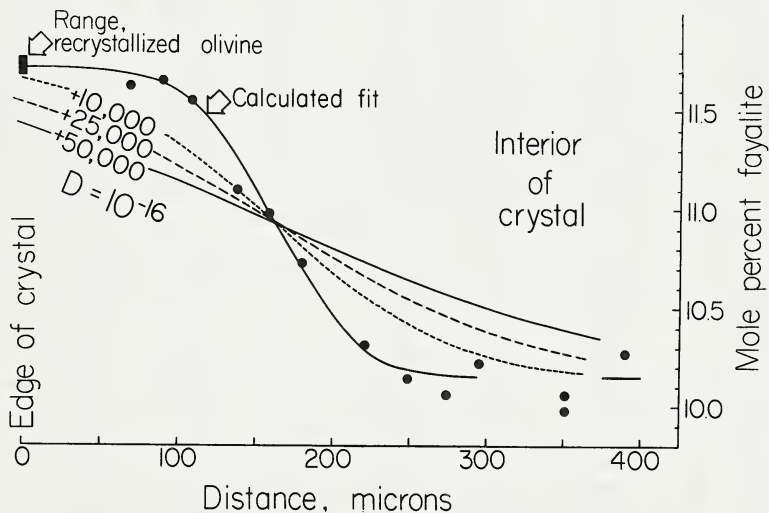


Figure 1: Observed compositional profile in olivine. The recrystallized olivine is in Fe/Mg exchange equilibrium with amphibole, chlorite, and titanoclinohumite: the crystal interior is typical of rock olivine before hydration. D , the diffusion coefficient, is an estimate for 700°C. Times for the calculated fit to decay are in years. A decrease in D by any factor results in an increase in time by the same factor.

Table 1: Mineral compositions in peridotites with increasing amounts of hydration (N51 most hydrated).

Rock N53							
	Opx	Cpx	Ol	Amph	Spinel		
SiO ₂	54.3	52.6	na	42.6	nd		
TiO ₂	.08	.22	na	.28	nd		
Al ₂ O ₃	5.22	6.40	na	15.7	56.9		
Cr ₂ O ₃	.47	.87	na	.80	11.9		
Fe as FeO	6.07	2.20	9.45	3.91	12.2		
MnO	.16	.10	na	.06	.13		
MgO	32.8	15.9	50.4	18.3	19.1		
CaO	.77	20.2	.01	12.0	.02		
Na ₂ O	.07	1.67	na	3.49	nd		
K ₂ O	nd	nd	na	.03	nd		
	100.0	100.2		97.2	100.2		
Rock N23							
	Opx	Cpx	Ol	Amph	Chlor	Clinoh	Magnesite
SiO ₂	57.3	54.7	40.4	55.6	31.8	35.6	na
TiO ₂	.06	.08	.01	.05	nd	5.55	na
Al ₂ O ₃	1.47	1.73	.00	1.64	12.4	.00	na
Cr ₂ O ₃	.29	1.24	.00	.18	2.05	.02	na
Fe as FeO	6.24	2.03	11.6	2.85	4.28	11.7	5.28
MnO	.12	.06	.20	.08	.01	.18	na
MgO	35.6	16.8	49.1	23.2	34.2	46.2	42.0
CaO	.24	22.6	.00	9.23	na	.01	.17
Na ₂ O	nd	1.19	.00	3.83	na	na	na
K ₂ O	na	na	na	.84	na	na	na
	101.3	100.4	101.2	97.4	84.8	99.2	
Rock N51							
	Opx	Cpx	Ol	Antig	Chlor	Clinoh	
SiO ₂	57.2	54.8	42.1	41.1	32.9	36.3	
TiO ₂	.03	.02	nd	.03	.02	5.57	
Al ₂ O ₃	1.09	.33	nd	2.82	12.3	nd	
Cr ₂ O ₃	na	.18	na	.79	1.95	na	
Fe as FeO	5.81	1.94	9.26	3.64	3.47	9.20	
MnO	na	.08	.18	.04	nd	.19	
MgO	35.1	17.4	49.1	37.5	34.9	46.5	
CaO	.11	24.4	nd	.03	.04	.03	
Na ₂ O	na	.59	na	na	na	na	
NiO	na	na	.36	.16	.19	.29	
	99.3	99.8	101.1	86.2	85.7	98.1	