H17 PETROLOGY OF THE CRUST/MANTLE BOUNDARY BENEATH SOUTHWEST JAPAN

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Ultramafic and mafic xenoliths in Cenozoic alkali basalt lavas from Oki-Dogo island in the Japan Sea have been studied.   Relative proportion of rock types of the xenoliths in 10 eruptive units was determined in situ (Fig.1) and following systematics were discovered: 1)lavas which contain spinel lherzolite xenoliths always contain all other rock types; 2)proportion of dunite, wehrlite and pyroxenite increases as proportion of spinel lherzolite decreases; 3) there are lavas which contain only gabbros and granulite xenoliths.   Spinel lherzolites and other peridotite and pyroxenite xenoliths are distinct in that (1)the latter frequently show mineralogical bandings whereas spinel lherzolites are always massive; and (2)spinel lherzolites show a narrow range of compositional variation (e.g. Fo=90-86, NiO in olivine 3500-4000 ppm) whereas the latter rocks exhibit a wide range of variation (e.g. Fo=87-75, NiO in olivine 3000-500 ppm) (Fig.2).
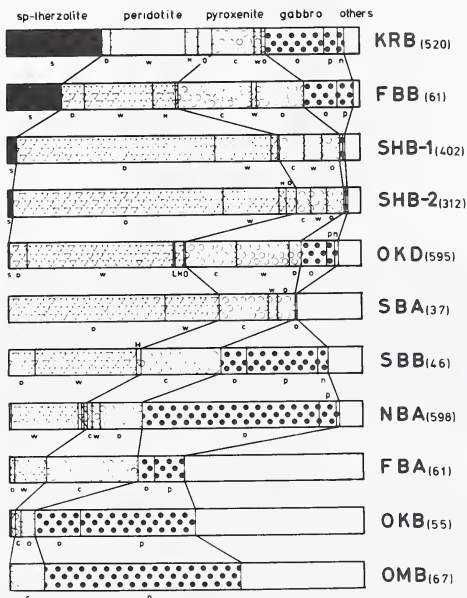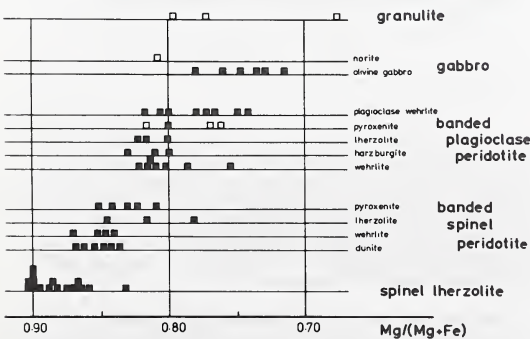
From mineral assemblages the banded peridotites and pyroxenites are classified into two categories: 1)banded spinel peridotite group, represented by the four phase assemblage ol+opx+cpx+sp equivalent to the spinel lherzolites; 2)banded plagioclase peridotite group, comprises the ol+opx+cpx+pl assemblage. Equilibration temperatures by the geothermometer of Wood & Banno (1973) are in the range spinel lherzolite 1100-1200°C, banded spinel peridotite 1050-1100°C, banded plagioclase peridotite 1000-1100°C, gabbro 1000-1100°C and granulite 900-1000°C (Fig.3).   The rocks of the banded spinel peridotite group and the banded plagioclase peridotite group are considered to be cumulates from basaltic magmas at pressures above about 10 kbar and below that pressure, respectively.   Judging from their metamorphic textures and the relatively low equilibration temperatures, however, those rocks can not be cognate inclusions precipitated from the host magma.

Based on these results a perologic model of the crust and upper mantle beneath Oki-Dogo island is constructed (Fig.4).   The lower crust is composed mainly
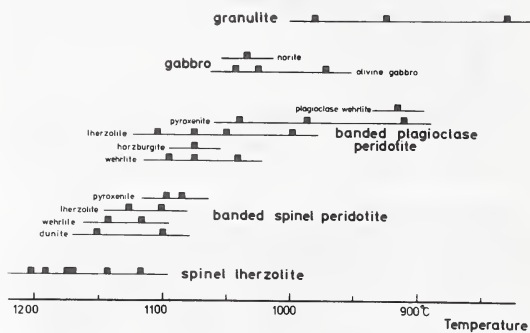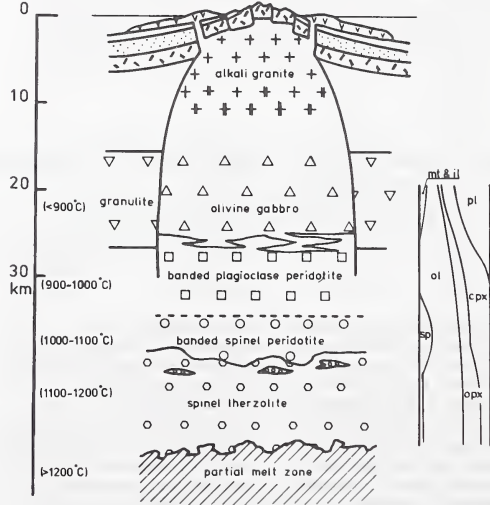
Fig. 1

Fig. 3

Fig. 2

Fig. 4

of olivine gabbro and granulite, and the uppermost mantle is composed of thick layers of banded perido-tite and pyroxenite underlaid by a zone of massive spinel lherzolite. The depth from which the host magmas have derived may be different among the erupt-ive units considering the variety and the systematics in the xenolith associations shown in Fig.l. The lavas which contain spinel lherzolites, however, must have derived from the deepest zone of the strata.

High pressure phase relations of a basalt taken from the unit KRB (which contains the largest amount of spinel lherzolites among the 10 units in Fig.l) have been determined (Fig.5) with a piston-cylinder apparatus under dry conditions (Takahashi, 1980). The lava KRB is considered to have last equilibrated with the spinel lherzolite upper mantle at about 40 to 50 km depth and may have ascended without chemical modi-fication, because it coexists with ol+opx+cpx on its liquidus at 14 kbar (Fig.5).

Fig. 6

Southwest Honshū Arc

Fig. 5

Fig. 7
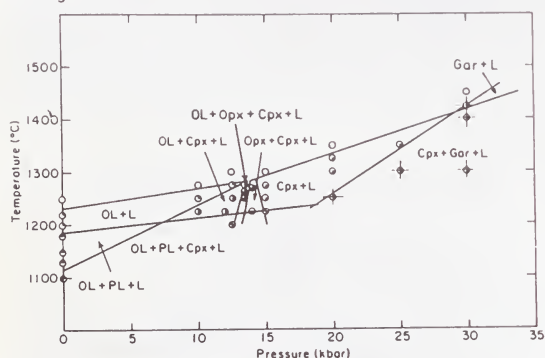
Spinel lherzolite is considered to be the major constituent of the earth's uppermost mantle and the xenoliths of that rock type predominate over other peridotite and pyroxenite in most of the alkali basalt localities in the world (Forbes & Kuno, 1967). How-ever, paucity of spinel lherzolite xenoliths and ex-istence of the large amount of cumulative peridotite and pyroxenite xenoliths are common natures in alkali basalt localities in the Southwest Japan (e.g. Yama-guchi,1964; Aoki,1968; Takahashi,1978). The upper-most part of the mantle beneath this area may be oc-cupied with a large amount of peridotite and pyroxe-nite cumulates (Fig.6).

According to Hashizume & Matsui (1979), no sharp reflections from the Moho discontinuity have been observed from this area, and their best fit velocity model (Fig.7) suggests that the crust/mantle boundary beneath this area comprises numerous alterations of mafic and ultramafic rocks such as in layered intru-sive bodies. The crust and upper mantle beneath the
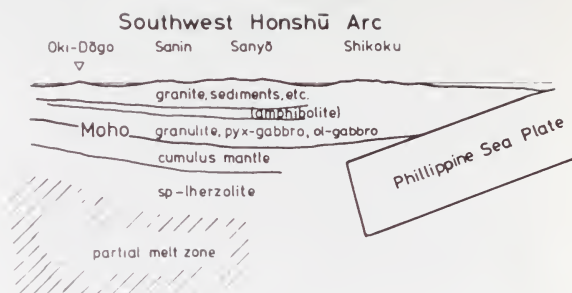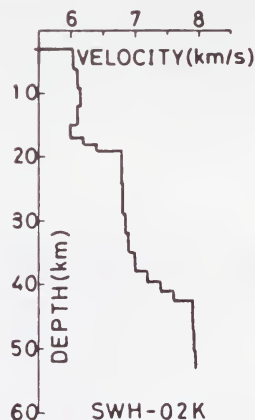
Southwest Japan may have been chemically differenti-ated due to a large flux of magmas during the last 100 Ma period, where and when extensive andesite vol-canisms and granitic batholith formation took place. The bulk chemical composition of the crust above the petrologic Moho (the boundary between the spinel lherzolite layer and the cumulative peridotite/pyro-xenite layer in Fig.4 and Fig.6) could be basaltic rather than andesitic.

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H18 THEORETICAL PREDICTION OF SUBSOLIDUS PHASE RELATIONSHIPS IN PERIDOTITES AND BASALTS

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A considerable amount of experimental and calorimetric data on the thermodynamic properties of pure minerals and solid solutions have been obtained in recent years. These data have been used to calibrate geothermometers and geobarometers (e.g. $CaMgSi_2O_6$ orthopyroxene-clinopyroxene) in an attempt to determine the physical conditions of formation of crustal and mantle rocks. Thus far, however, such approaches have used only a few of the possible components present in multiphase assemblages and, with the exception of the work of Nicholls (1977)

there has been no attempt to calculate the total compositions and stabilities of all possible phases. The object of this study is to predict both phase relationships and mineral compositions as functions of pressure, temperature, and bulk rock composition by integrating available thermodynamic and phase equilibrium data.

The method used to calculate equilibrium assemblages at given P, T and composition is that of free energy minimisation using steepest descent.