The above discussion illustrates the principle that both mineralogical changes and P,T effects on V_s are of prime importance in determining the seismic velocity distribution within the upper mantle. Even without any effects of chemical zoning within the upper mantle it is apparent that variations in geothermal gradients will considerably affect the velocity distributions, particularly the depth of velocity minima, the magnitude of velocity differences and the presence of one or two low velocity channels in the upper mantle. Assuming a critical gradient of 4.5°C/km for V_s a broad low velocity channel at about 150-170 km depth might be expected along the shield geotherm of fig. 2. Similar models may be set up from fig. 2 by assuming various geothermal gradients and also including the additional complexity of chemical variation from pyrolite to refractory peridotite and dunite.

6. CONCLUSIONS

An experimental study of the equilibrium relations between pyroxene pyrolite and garnet pyrolite demonstrates that pyroxene + spinel pyrolite is stable in the sub-oceanic mantle to depths of 60-70 km. At this depth spinel and pyroxene react to form garnet and olivine. The amount of garnet formed from this reaction depends sensitively upon the temperature at which the geotherm intersects the spinel + pyroxene ⇌ garnet + olivine boundary. At temperatures in excess of 1000°C, less than half the potential garnet in the pyrolite composition forms by this reaction, the rest remaining in solid solution in aluminous orthopyroxene (> 3% Al_2O_3) and aluminous clinopyroxene. At depths between 60-70 km and about 120 km, the garnet content of the pyrolite remains roughly constant or may decrease slightly as more Al_2O_3 goes into solid solution in the pyroxenes. At depths greater than 120-130 km the geothermal gradient enters a region in which, with increasing depth, the amount of garnet gradually increases as $(Ca,Mg)Al_2SiO_6$ solid solution in the pyroxenes decreases.

It is demonstrated that mineralogical variation along geothermal gradients, particularly in oceanic regions, may be expected to strongly influence the seismic velocity distribution in the upper mantle. In particular, mineralogical zoning of the upper mantle may yield two low velocity channels (for V_s) at depths of about 65 km and between 100 and 150 km respectively. No unique model of mineralogical or seismic velocity distribution in the upper mantle is presented, rather it is argued that regional variations in chemical composition (from pyrolite to refractory peridotite), and in geothermal gradients will produce significant, regional differences in seismic velocity distributions.

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