aspects of the upper mantle. Firstly, the determination of the pyrolite solidus in the presence of small amounts of water (water-undersaturated, p_{H_2O} determined by equilibrium between pargasitic amphibole and its breakdown products) establishes a firm petrological model for the low velocity zone (LVZ) of the upper mantle. If the water content of the upper mantle is < 0.4% approximately, the petrological model predicts a relatively stable location of the roof to the low velocity zone at depths equivalent to 27−29 kb load pressure (85−95 km approx.) due to intersection of the local geothermal gradient with the pyrolite solidus. Variation in the local geothermal gradient would cause variation in the degree of partial melting (and thus the magnitude of the seismic attenuation) within the LVZ and possibly considerable variation in the depth to the floor of the LVZ, with little change in the depth to the roof of the LVZ (base of the lithosphere). The data on subsolidus mineralogy for (pyrolite + 0.2% H_2O) also show that the appearance of garnet would occur along an oceanic geotherm at load pressures of approximately 17−19 kb (55−66 km). This mineralogical change would cause a small increase in density and possibly in seismic velocity in the lower part of the lithosphere; similar mineralogical zoning for an anhydrous mantle has been discussed previously [5, 6].

The data illustrating the position of the pyrolite solidus for water-saturated melting show that the base of the lithosphere, if located by the intersection of the geotherm with the pyrolite solidus, may move abruptly from depths of 85−95 km to depths of 60−70 km, without change in the local geothermal gradient, *if* the water content of the lower part of the lithosphere is increased to exceed ~0.4% H_2O. Addition of water to previously immobile lithosphere may occur from underthrust lithosphere of a subduction zone, and may lead to rather high degrees of partial melting and mantle diapirism from depths of 60−70 km, the degree of partial melting increasing as the diapirs moved towards the surface.

The experimental data provide an explicit model for two different tectonic regimes (fig. 3). The water-undersaturated melting data are applied to yield a model of a relatively stable lithosphere and LVZ, either in oceanic or continental regions, in which volcanism may occur either by simple fracturing of the lithosphere and direct tapping of the small melt fraction in the LVZ, or by tensional thinning of the lithosphere with
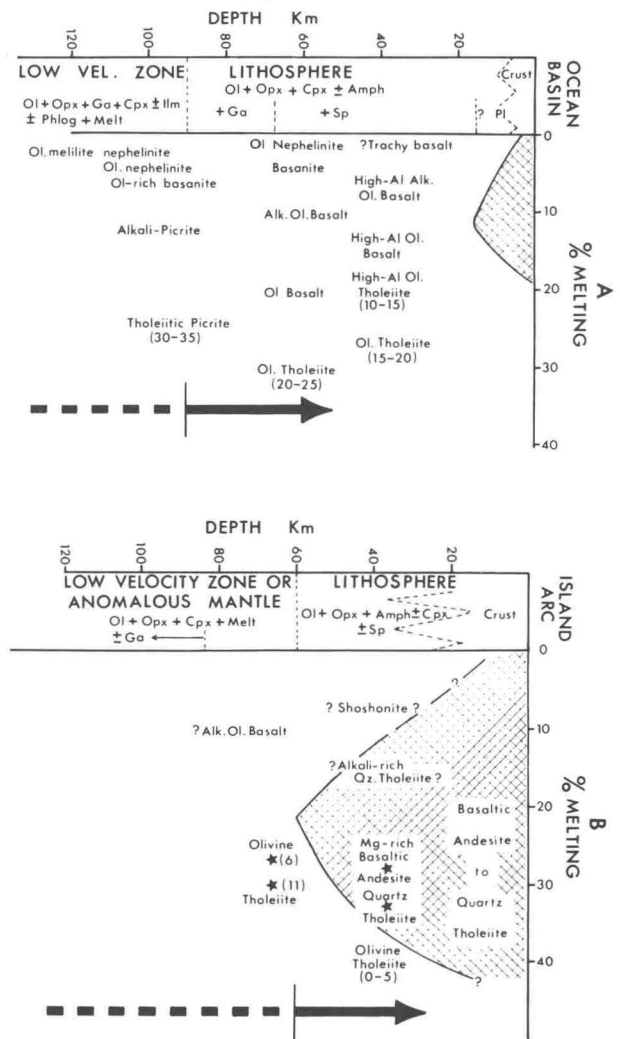

Fig. 3. Diagram summarizing the petrogenetic applications of the melting studies on pyrolite composition. The column to the left illustrates the mineralogical character of the lithosphere and depth to the onset of partial melting in the island arc situation and the normal oceanic crust-mantle situation. In the right side of the diagrams, the character of magma derived by partial melting of pyrolite is plotted as a function of depth of magma segregation and degree of partial melting. Numbers in parentheses adjacent to basalt names refer to the normative olivine content of the partial melt. The hatched areas illustrate the range of conditions over which *quartz-normative* magmas may be derived by direct partial melting and magma segregation from pyrolite. (A) is compiled for melting under water-undersaturated conditions, with a water content in the source pyrolite of about 0.2%. (B) is compiled for melting under water-saturated conditions. The asterisks denote the specific liquid compositions calculated at 10 kb and 20 kb in this paper.

consequent upwelling and diapirism from the LVZ leading to higher degrees of partial melting and shallower depths of magma segregation. If the latter process develops into large-scale rifting apart of lithospheric plates, then the deeper parts of the LVZ become involved in the upwelling at the rift axis and act as major magma sources. The data of fig. 2 may in this way, be applied to quantify the specific models of basaltic volcanism of mid-oceanic ridge, rift valley, island chain and oceanic island situations which were developed previously [12, 15—17].

In contrast to this tectonic setting, the data on water-saturated melting is applied to yield a model of an unstable situation in which the base of the lithosphere moves to depths of 60—70 km due to access of water (to exceed about 0.4% H_2O) and the higher water contents produce higher degrees of partial melting at depths > 60 km. This setting is one in which mantle diapirism, in some cases from reactivated lithosphere, would lead to high degrees of melting under water-saturated or near-saturated conditions and to magma segregation at rather shallow depths. The tectonic conditions described would occur if there were access of proportionately large amounts of water to the upper 60—150 km of the mantle. Such conditions may occur in the wedge of mantle overlying the Benioff zone in oceanic trench-island arc situations where the source of proportionately large and rapidly released amounts of water can be attributed to dehydration reactions in subducted lithosphere [2, 3, 12, 13, 18, 20].

6.2. Magma genesis in island arcs

As well as defining the *P, T* conditions of melting of a pyrolite upper mantle under water-saturated conditions, the data presented establish the nature of the magmas produced by partial melting under these conditions. It has been shown that with sufficiently high degrees of melting of pyrolite at 10 kb such that olivine (+ accessory chromite) is the only residual phase ($\sim 32\%$ melting), the melt is of magnesian quartz tholeiite character. For lower degrees of melting (28%) of pyrolite under these conditions, liquids with $\sim 10\%$ normative quartz and $\sim 56\%$ SiO_2 are produced at temperatures of $\sim 1100°C$, leaving residual wehrlite (olivine + clinopyroxene ± accessory chromite). For $<$

25% melting, at 10 kb and $T < 1100°C$, the magma composition cannot as yet be clearly specified but the evidence presented suggests that liquids will have higher alkali-content but retain SiO_2 contents of around 55%. Magmas such as the highly magnesian, low-calcium, quartz-rich "andesites" (56—58% SiO_2) of Cape Vogel, Papua [28, 31] might be products of high degrees of melting of pyrolite under water-saturated conditions with magma segregation occurring at < 10 kb [29].

The data presented in this paper on the experimental melting of pyrolite show that water-saturated, magnesian quartz tholeiites and basaltic andesites may be derived by direct partial melting of *pyrolite* at ~ 10 kb but that water-saturated olivine tholeiites are the least undersaturated magmas which may be derived by partial melting of pyrolite at ~ 20 kb. These conclusions support those of Nicholls and Ringwood [2, 3] who have carried out the necessary complementary study, i.e. the determination of the liquidus phases of olivine tholeiite, quartz tholeiite and basaltic andesite under water-saturated conditions. These studies [2, 3] defined the expansion of the field of olivine as a liquidus phase in quartz-normative natural rock compositions under water-saturated conditions and demonstrated that such liquids could be equilibrium melt products of a peridotite source, leaving residual olivine. The data presented in this paper do not support the conclusion that andesitic or dacitic magmas can be derived by direct partial melting of peridotite at pressures up to 25 or 30 kb [1,7—9, 29]. More importantly, the data provide clear evidence that the presence of highly siliceous glasses in quenched high-pressure runs containing a large proportion of primary crystals (either with or without readily identifiable quench phases) is a result of metastable fractionation of liquid during quenching, caused by the outgrowth of rims on primary phases and/or nucleation of quench clinopyroxene, amphibole and mica. The compositions of such glasses are not consistent with equilibrium between liquid and primary olivine and pyroxenes of the peridotite source rock and do not constitute evidence for the genesis of siliceous ($> 55\%$ SiO_2) liquids by partial melting of peridotite under water-saturated conditions at $P > 10$ kb.