it is essentially a surface characteristic of the oceanic mantle and extends at most a few tens of kilometres beneath the Mohorovicic discontinuity. It may, however, be sufficiently extensive to affect surface wave propagation across oceans and introduces a further source of variation in models required to satisfy both Love and Raleigh wave dispersion curves. Unfortunately, to judge by measurements on both a single crystal[4] and whole rock samples[23], the shear velocity anisotropy of olivine-rich rocks appears to be less marked than that of the compressional velocity, and the effect on surface wave propagation might be undetectable. Nevertheless, it is worth asking whether the horizontally laminated, alternately hard and soft, mantle Aki has proposed[24] to account for both Love and Raleigh wave dispersion in Japan could not be alternatively described as an essentially homogeneous mantle with anisotropic properties.

In conclusion, it has been suggested that the anisotropy of the oceanic upper mantle is generated beneath the mid-oceanic ridges and results from the tendency of the *a* crystallographic axes of olivine crystals to lie perpendicular to the trend of the ridge.

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Worldwide Distribution of Earthquakes

A COMPILATION by Barazangi and Dorman[1] of the worldwide epicentres of earthquakes reported by the US Coast and Geodetic Survey for the years 1961 to 1967 strikingly demonstrates the limited extent of seismically active areas. Almost all earthquakes occur in very narrow bands along oceanic ridges and transform faults, along continental transcurrent faults, or in broader zones below and behind island arcs. The depth distribution of earthquakes is also very limited. Almost all seismic energy is released in the crust[2]. Intermediate and deep focus earthquakes occur almost without exception in narrow planar zones which dip at angles of about 45° below island arcs[2,3]. Apart from minor seismicity associated with volcanic activity, seismic activity decreases to a very low level at quite shallow depths in all other regions. In California, for example, no earthquakes have been observed below about 15–20 km. This remarkably non-uniform geographical distribution implies that the occurrence of earthquakes requires very special conditions. It is the purpose of this communication to suggest that a necessary condition is the presence of relatively acidic rock.

Earthquakes result in differential movements between major blocks of the crust and on a worldwide scale there is a consistent pattern of movements[3,4], so it is necessary to suppose that the deviatoric stresses which are directly responsible for earthquakes must occur quite widely and cannot be restricted to seismic zones. Much of the mantle must flow aseismically. What then are the conditions required for deep focus earthquakes ?

Oliver and Isacks[3,5] have suggested that the deep earthquake zones behind island arcs delineate the upper surface of a slab of lithosphere which has plunged into the mantle. If this is so, it seems that deep focus earthquakes occur in rocks of crustal or uppermost mantle types. This is a feature shared with all other earthquakes, which suggests that earthquakes are characteristic of the rheology of only certain rock types.

Earthquakes associated with continental transcurrent faults such as the San Andreas are almost always above the Conrad discontinuity. This can be understood from field and laboratory studies (ref. 6 and my unpublished results with M. Wyss and S. W. Smith) which indicate that stick-slip friction is not likely to occur in basic or ultrabasic rock. Below the Conrad, frictional sliding, if it occurs, seems to be stable and does not result in earthquakes. This demonstrates the strong effect of chemical composition in the one case where the earthquake mechanism is fairly well understood.

The primary difference between crustal and mantle materials is in their silica contents. The Si–O bond has been found to play a vital part in the rheological behaviour of silicates, for it is this strong bond which gives these minerals their generally high strength. For example, cleavage almost always occurs in planes which do not cut Si–O bonds. Laboratory studies at high temperatures and pressures have shown that dislocations are not mobile on such planes[7]. Consequently the ease with which continual plastic flow can be maintained by dislocation motion without rupture should increase with decreasing silica content. The same generalization can be made for viscous deformation: the high strength of the Si–O bond would result in a very high activation energy for self-diffusion of either of these atomic species or for activated mobilization of dislocations which cut those bonds. Even in the liquid state this generalization seems to hold: basaltic magmas have lower viscosities than rhyolitic ones[8]. Consequently we should expect a discontinuity in rheological properties towards higher ductility at the *M* as well as the Conrad discontinuity if these discontinuities represent a sharp compositional change towards lower silica content.

Necessary conditions for the generation of earthquakes seem to be the presence of high differential motion and that such motion takes place in crustal or uppermost mantle rock. Any hypothesis of the mechanism of earthquakes, whether involving rupture or a phase transformation, must take into account both these conditions.

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