



Fig 1 High pressures tend to produce densely packed structures. Top drawing shows the low pressure form of quartz: each silicon atom has four close oxygen atoms, each oxygen has two silicons—thus the structure has 4:2 co-ordination. At pressures over 100,000 atmospheres this changes to 6:3 co-ordination: each silicon now has six oxygen neighbours, each oxygen has three silicon. High pressure form is known as stishovite, low pressure form as low quartz

The increased density, hardness and refractive index and the reduced chemical reactivity are typical of high-pressure stabilised forms.

This behaviour is general in non-metallic solids in which the atoms show a progressive increase in co-ordination from 2 to 3, 3 to 4, 4 to 6, and 6 to 8 as pressure increases. On this basis one can predict that at some higher pressure the 6:3 co-ordinated SiO_2 should change to an 8:4 co-ordinated structure—but this has not yet been observed. Higher co-ordination than eight is usually found only in metals, so that materials would be expected to become metals when high pressures had raised their co-ordination sufficiently.

Looked at from the point of view of the bonding electrons a pressure-induced decrease in volume is associated with a progressive broadening of energy level structure, which leads to narrowing, and eventual elimination, of forbidden energy ranges characteristic of non-metals. Indeed non-metal to metal transitions at high pressures have been observed experimentally for a considerable number of materials, among them the elements phosphorus, selenium, tellurium and iodine. Using explosively-generated high-pressure shock waves, workers in the United States have shown that diamond itself probably transforms to a metal at about 600,000 atmospheres.

Since packing arrangements and electronic structure are affected by pressure, it is not surprising to find that compounds can be formed at pressure between elements which do not normally combine—for example, a new super-conducting compound Nb_3In has recently been prepared at Lincoln Laboratories at about 45,000 atmospheres.

Preserving high-pressure structures

Transformations where a change of co-ordination occurs can be of two different types, 'diffusionless' and 'reconstructive,' depending on the ease with which the lattice of the material passes from one structure to the other. Where a simple path exists, involving, for example, a shear of the lattice requiring only small displacements of the atoms, rapid transformation usually takes place as soon as the stabilising pressure is reached. Such 'diffusionless' transformations reverse rapidly when the pressure is removed, so that there is