



Fig. 2. K in relation to d_1 . The numbers are those of the minerals in Table 1.

such as the degree of filling of holes of a given sort (tetrahedral, octahedral, etc.). The energy of a cation is [2] dependent on whether it is in a tetrahedral hole or an octahedral one, because of the effects of the surrounding electric field on the electron distribution in the ion.

Figures 3 and 4 show the entropy S and Gibbs free energy Z as functions of v_0 , the abscissa in Fig. 3 being the entropy per g-atom. There is some dependence of S on volume, as minerals with low volumes (bromellite, stishovite, corundum, kyanite) tend to have low S . There is a clearer relation of S to the properties of the cations; Fig. 3 shows the cation series in order of increasing S , which is also the order of increasing atomic weight.

Figure 4 shows that the mean Gibbs free energy $\Delta Z/n$ has no clear relation to v_0 but is related to the properties of the cations, being anomalously low for compounds of Fe, Mn, Zn, and Sn but high for Ti, Al, and Zr. The corresponding cation series is shown. The corresponding enthalpy has a similar relation to v_0 (graph not shown).

Recently, \bar{v} and ΔZ have been used to elucidate the depth distribution of paragenetic mineral associations [8, 24, 26]. If the mean mineral composition of a metamorphic facies is considered from the viewpoint of the mean atomic volume [24], there is no clear division of minerals into groups, but \bar{v} tends to fall as the depth increases (some uncertainty is introduced by the wide stability ranges of quartz and the plagioclases). The significance of \bar{v} for the depth distribution of minerals should be considered over a wider range with due allowance for the effects of T , which makes fairly clear the crystallochemical nature of the Mohorovičić discontinuity, M , which coincides approximately with $\bar{v} = 7$ and separates two regions of occurrence of oxides and silicates. Above M we find typical crustal minerals with a fairly open structure, which contain large cations such as Na, K, and Ca; below M we find minerals with close packing of the oxygen ions (olivine, spinel, garnets, etc.). This shows that below M , in the upper and lower parts of the mantle, we should find geospheres differing primarily in oxygen packing density. We may say roughly that differences in v_0 characterize major geospheres, while differences in ΔZ make themselves felt within each such sphere.