American Mineralogist, Volume 85, pages 345–353, 2000

Extrapolation of lower mantle properties to zero pressure: Constraints on composition and temperature

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ABSTRACT

The approximation, $(\partial K_S'/\partial T)_{P=0} \approx 0$, where $K_S' = (\partial K_S/\partial P)_S$, K_S is the adiabatic bulk modulus, and P, T, and S represent pressure, temperature, and entropy, is often used, or implicitly assumed, to simplify the interpretation of lower mantle properties when determining plausible mineralogy of that region. This approximation is now found to be unsatisfactory, and a more general treatment gives a positive value which increases strongly with K_S'. We find that $(\partial K_S'/\partial T)_{P=0}$ is $(6 \text{ to } 23) \times 10^{-5} K^{-1}$ for the lower mantle. The behavior of this higher order derivative necessitates a reconsideration of the lower mantle equation-of-state fitting by requiring a higher value of K_{S0}' (K_S' at $P = 0$) than usually considered. The value of $K_{S0}'(T_0)$ where T_0 is the potential temperature, cannot reasonably be less than about 4.2 and may be as high as 4.6, depending on the uncertain value of K_{S0}'(290 K) for silicate perovskite. There is some trade-off between T_0 and composition, but if a simple mixture of perovskite and magnesiowüstite is assumed, the total iron content is found to be Fe/(Fe + Mg) = 0.22, independent of both T_0 and uncertainty in K_{S0}' for perovskite. This implausibly high iron content can be attributed to neglect of the presence of Ca perovskite. We therefore conclude that Ca perovskite is an important constituent of the lower mantle and that it is seismologically conspicuous.