Geophysics and mineralogy of the Earth's interior

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Seismic data indicate that the internal structure of the earth is layered. The crust extends down to the Moho discontinuity, which occurs as deep as 70 km (44 mi) beneath the continents and 8 km (5 mi) beneath the oceans. Below the crust the mantle is composed of ferromagnesian silicates and extends down to 2900 km (1800 mi). Below that is the core, which is liquid down to 5100 km (3170 mi) and solid down to the center of the Earth. Above 900 km (562.5 mi), the mantle is not homogeneous. The inhomogeneity is due to: 1) Difference in composition for various layers. 2) If the composition is constant, the difference must be due to different phases. 3) Inhomogeneity may be due to both polymorphic and transitional phases of material.

Which is most likely? What is the nature of polymorphic transitions? Under the high temperature and pressure conditicns of the Earth's mantle, silicate minerals such as olivine undergo phase transitions due to polymorphism. What kind of polymorphic transitions are tbere? The only kind which has been demonstrated is the transition from olivine (Mg_2SiO_4) to spinel (Mg_2SiO_4). Other possible transitions are corundum and stishovite transitions, and are of the same type. All are normal type transitions and are endothermic (heat is absorbed). Even though we assume the transitions in the Earth are normal, the olivine–spinel types, we still must recognize that there is the possibility of the abnornal type (Fig. 1).

From the Clausius-Clapeyron equation, for the transition reaction:

$$\frac{dT}{dP_{A \rightarrow B}} = T_K\left(\frac{V_B - V_A}{\Delta H}\right)$$

T_K = °Kelvin, V_A and V_B = molecular volumes related to density. ΔH = molecular heat of the reaction.Will convections operate through the 900 kmm transition boundary? Mantle convection simulations in the fields of experimental geophysics indicate that polymorphic transitions may play an important role in promoting or inhibiting layered thermal convection between the upper and lower mantle. The magnitude of the driving force for promoting layered convection is critically dependent on the value of the Clapeyron slope.

In closing, physical inhomogeneity in the mantle favours convection currents, while chemical inhomogeneity argues against convection. The goal is to link the high pressure and temperature research on the Earth's interior to studies on the phases and properties of iron and its alloys in the Earth's core and also to studies of other planets both in nature and in the laboratory by spectroscopic probes and electron microscopy.

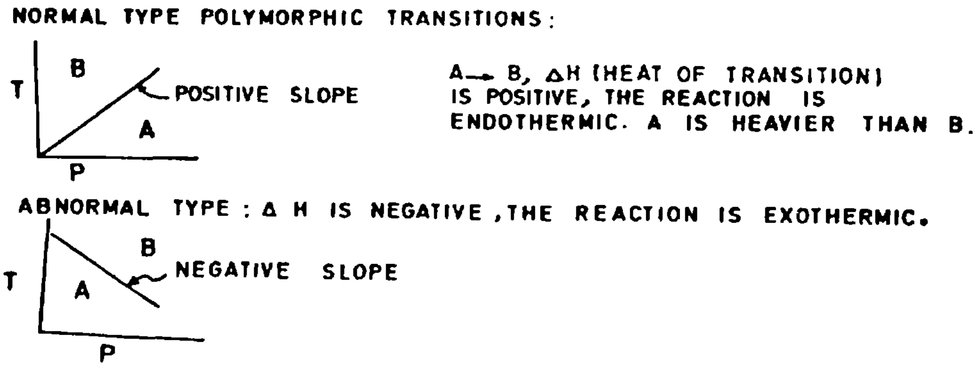

FIG. 1. Normal (A) and abnormal (B) types of polymorphic transitions in the mantle of the Earth.