DUBA, A., Heard, H. C., Piwinskii, A. J., and Schock, R. N., Electrical conductivity and the geotherm, Intern. Conf. Geothermometry and Geobarometry, University Park, Penn., October 5-10, 1975. [UCRL-77272, Abstract]

A temperature profile for the earth may be inferred from laboratory electrical-conductivity (σ) studies using analyses of geomagnetic and magnetotelluric data for the σ distribution as a function of depth. Since olivine ($Fo_{90}Fa_{10}$) is probably the dominant constituent in the earth's upper mantle, the earth's σ in this region should be similar to that of olivine. The σ of olivine as a function of temperature up to 1660°C was measured at a pressure of 0.1 MPa with a 30:1 CO_2/H_2 mixture that yields an oxygen fugacity, $f(O_2)$, of 10^{-3} Pa at 1200°C. This $f(O_2)$ is within the olivine stability field and is a reasonable approximation of mantle $f(O_2)$. Both H_2/CO_2 and CO/CO_2 mixes were used in measuring the σ of olivine as a function of $f(O_2)$. At any temperature, these σ data vary less than 0.3 of an order of magnitude with 5 orders of magnitude change in $f(O_2)$. The $f(O_2)$ variation studied here, 10^{-8} to 10^{-3} Pa at 1200°C, spans olivine stability from reduction to within 3 orders of magnitude of oxidation.

If we thus assume that the σ of the mantle is controlled by olivine, we can use the laboratory σ data and magnetotelluric and geomagnetic data on σ distribution with depth to calculate the earth's temperature profile to ~400 km, where olivine undergoes a phase change.

At depths less than 300 km, the geomagnetic technique cannot provide a reliable σ-versus-depth profile because lateral variations in σ at these depths invalidate the assumption of spherical symmetry required for analysis. Therefore, for depths shallower than 300 km, we have chosen magnetotelluric data from the western United States.

Between the base of the crust and 100 km, unreasonably high temperatures are calculated using the olivine σ data, which indicate that olivine does not control the σ of the mantle at these depths. A highly conductive interstitial phase could be responsible for the observed σ. This interstitial phase cannot be orthopyroxene since its conductivity is similar to that of olivine.

The geomagnetic and magnetotelluric σ-versus-depth data yield consistent temperature profiles for the earth to 400 km. There is good agreement between these temperature profiles and other geotherms. The broad consistency of the mantle temperatures inferred from geochemical and geophysical studies is encouraging and indicates that the temperature at 250 km is between 1675 and 1775°C.