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ELECTRICAL CONDUCTIVITY OF CHONDRITIC METEORITES*

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The electrical conductivity of samples of the Murchison and Allende carbonaceous chondrites is 4 to 6 orders of magnitude greater than rock forming minerals such as olivine for temperatures up to 700° C. The remarkably high electrical conductivity of these meteorites is attributed to carbon at grain boundaries. Much of this carbon is produced by pyrolyzation of hydrocarbons at temperatures in excess of 150° C. As temperature increases, light hydrocarbons are driven off and a carbon-rich residue or char migrates to the grain boundaries enhancing electrical conductivity.

Assuming that carbon was present at grain boundaries in material which comprised the meteorite parent bodies, we have calculated the electrical heating of such bodies as a function of body size and solar distance during a hypothetical T-Tauri phase of the sun. Input conductivity data for the meteorite parent body were the present carbonaceous chondrite values for temperatures up to 840° C and the electrical conductivity values for olivine above 840° C.

Results of these calculations indicate that bodies up to 500 km in diameter would be heated to 1100° C (melting point of basalt) out to about 4 AU in times of one million years or less, which is the hypothesized duration of the T-Tauri phase of the sun. The distribution of asteroid types as a result of these calculations is consistent with the distribution of asteroid compositional types inferred from remote sensing: carbonaceous chondrite asteroids peak at about 3 AU, more siliceous asteroids peak at about 2.3 AU.

One concern with these calculations is the use of olivine conductivity data at temperatures in excess of 840° C. We were required to use olivine conductivity at these temperatures because the conductivity of all carbonaceous chondrite samples decreased perciptiously toward the olivine values. Two factors could be responsible for this decrease: oxidation of carbon in the CO_2/CO gas mixture or volatility of carbon. We are unable to separate these effects in gas mixing systems, vacuums, or inert gases because of the extremely low oxygen fugacity- less or equal to about 10^{-15} Pa- required to prevent the oxidation of carbon at 840°C. In addition, the precipation of carbon from the more reducing CO/CO_2 gas mixes required to produce this low oxygen fugacity interferes with the conductivity measurement.

The environment in the wake of the shuttle or space station can be exploited to produce oxygen fugacities less than 10^{-15} Pa using a molecular shield. Such an environment would be ideally suited to perform electrical conductivity measurements at high temperature in an atmosphere which would not interfere with that measurement.

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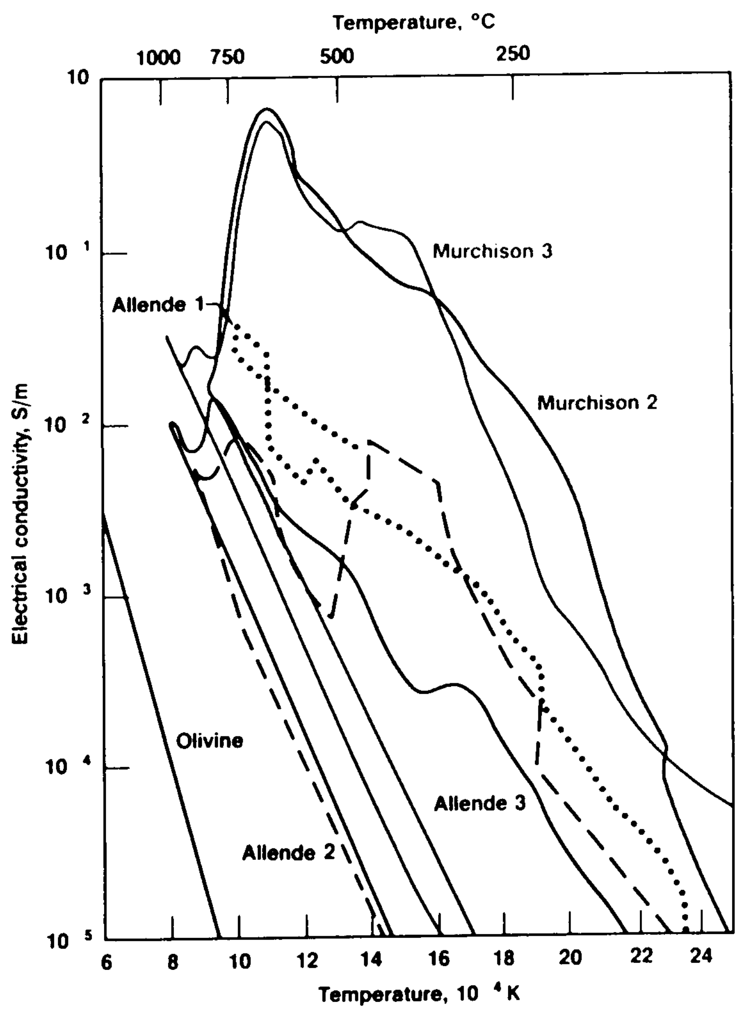

Fig. 1

Comparison of electrical conductivity as a function of temperature for samples of two carbonaceous meteorites (Murchison and Allende) and for terrestrial olivine. Note that all carbonaceous chondrites show very high electrical conductivity, compared to olivine, at temperatures below about 800°C. Above this temperature, loss of carbon causes conductivity to decrease with time toward values observed for single-crystal olivine.