N89-15011

ELECTRICAL CONDUCTIVITY OF CARBONACEOUS CHONDRITES AND ELECTRIC HEATING OF METEORITE PARENT BODIES*

Duba, A., Lawrence Livermore National Laboratory
P.O. Box 880, I-201, Livermore, CA 94550

Electromagnetic heating of rock-forming materials most probably was an important process in the early history of the solar system. Electrical conductivity experiments of representative materials such as carbonaceous chondrites are necessary to obtain data for use in electromagnetic heating models.

The electrical conductivity of samples of the Murchison and Allende carbonaceous chondrites is 4 to 6 orders of magnitude greater than that of rock forming minerals (e.g., olivine) 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 pyrolyzing hydrocarbons at temperatures in excess of 200°C. As the temperature increases, light hydrocarbons are driven off and a carbon-rich residue, or char, migrates to the grain boundaries thus enhancing the electrical conductivity.

With the assumption that carbon was present at grain boundaries in the material that comprised the meteorite parent bodies, we have calculated the electrical heating of such bodies as a function of body size and solar distance using the T-Tauri model of Sonett and Herbert (1977). Input conductivity data for

*Work performed under the auspices of the U.S. Department of Energy by the Lawrence Livermore National under contract number W-7405-ENG-48.

the meteorite parent body were the present carbonaceous chondrite values up to about 800°C and the electrical conductivity of olivine above 800°C. The results indicate that bodies up to 500 km in diameter would be heated to 1100°C (melting point of basalt) out to about 3 AU in times of one million years or less. The distribution of asteroid types as a result of these calculations is consistent with the distribution of asteroid compositional types inferred from remote sensing (Gradie and Tedesco, 1982); carbonaceous chondrite asteroids peak at about 3 AU, more siliceous asteroids peak at about 2.4 AU.

One concern with these calculations is the use of olivine conductivity data at temperatures in excess of 800°C. We were required to use olivine conductivity at these temperatures because the conductivity of all carbonaceous chondrite samples decreased precipitously toward the olivine values. Two factors could be responsible for this decrease. These are 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 800°C. In addition, the precipitation 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 Space Station can be exploited to produce oxygen fugacities less than 10^{-15} Pa (Oran et al., 1977). An experimental package consisting of a one square meter shield attached to a 15 cm diameter by 40 cm long furnace and tied to a conductance bridge, furnace controller, and digital voltmeter inside the Space Station via umbilical cable could make the required measurements. Because heating rates as low as 0.1°C/hour are required to study kinetics of the pyrolysis reactions which are the cause of the high conductivity of the carbonaceous chondrites, experimental times up to 3 months will be needed.

Gradie, J. and E. Tedesco, "Compositional structure of the asteriod belt," Science 216, 1405-1407, 1982.

Oran, W.A. and R.J. Naumann, "Utilization of vacuum developed in the wake zone of space vehicles in the LDEF class," J. Vac. Sci. Tech. 14, 1276-1977.

Sonett, C.P. and F.L. Herbert, "Pre-main sequence heating of planetoids," in Comets, Asteroids and Meteorites: Interactions, Evolution and Origins. A.H. Delsemme, ed., U. of Toledo Press, Toledo, Ohio, 429-437, 1977.