Implications of Convection in the Moon and the Terrestrial Planets

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During the past year we have worked on two principle lines of research:

1) The early thermal and chemical evolution of the moon. The work on the evolution of isotopic systems on the moon has now been published (1). The rubidium-strontium, neodymium-samarium, and uranium-thorium-lead systems were studied. The relation of source region heterogeneity to the mixing associated with mantle convection was considered. We are continuing this line of research by studying the chemical evolution of the moon and terrestrial planets by means of parameterized convection. One aspect of our studies is the concentration of trace elements including the heat producing elements into the crust thus influencing the rate of mantle convection. A second aspect of our studies is the delamination of planetary lithospheres as a cooling mechanism and as a means of returning trace elements to the planetary interior.

2) Fractals. Our group is the only group working on the application of fractal concepts to planetary geology and geophysics. With the current explosion of interest in and research on fractals this promises to be a most rewarding line of research. Our initial results have been quite exciting. Our first application of the fractal concept was to fragmentation including the frequency-size distribution of meteorites, asteroids, and particulate matter produced by impacts. This work has now been published (2). We have continued our fractal research on geophysical spectra. Global spectra are available for topography and geoid on the Earth, Venus, Mars, and the moon. If the spectral energy density has a power law dependence on wave number a fractal is defined. The topography spectra for the earth is a well-defined fractal with D = 1.5; this corresponds to Brown noise with the amplitude proportional to the wave length. Although there is more scatter for the other planetary bodies, the data for Mars and the moon correlate well with the data for the earth. Venus also exhibits a Brown noise behavior but with a smaller amplitude. The power law dependence of the Earth's geoid is known as Kaula's law. We show that uncompensated Brownian topography gives a power law dependence that is in good agreement with Kaula's law. However, the required amplitude is only 8% of the observed topography. This ratio increases to 72% for the moon. This work was presented at the 17th Lunar and Planetary Science Conference, Houston, Texas, March 17-21, 1986 (3) and has been written up and accepted for publication in the Proceedings (4).

(1) D.L. Turcotte and L.H. Kellogg, Implications of isotope data for the origin of the Moon, in Origin of the Moon, W.K. Hartmann, R.J. Phillips and G.L. Taylor, eds., Lunar and Planetary Institute, 311-330 (1986).

(2) D.L. Turcotte, Fractals and fragmentation, J. Geophys. Res., 91, 1921-1926 (1986).

(3) D.L. Turcotte, A fractal approach to planetary spectra, Lunar Planet. Sci. XVII, 905-906 (1986).

(4) D.L. Turcotte, A fractal interpretation of topography and geoid spectra on the earth, moon, Venus, and Mars, J. Geophys. Res., in press (1986).