COMPUTER SIMULATION MODEL FOR EARLY POST-CAPTURE LUNAR ORBITAL EVOLUTION: IMPLICATIONS FOR THERMAL HISTORY OF MOON AND EARTH; R. J. Malcuit, Dept. of Geology and Geography, and R. R. Winters, Dept. of Physics and Astronomy, Denison University, Granville, Ohio 43023.

Gravitational capture of a lunar-like body by an earth-like planet entails the dissipation of about 2.0 x 10^{35} ergs within the interacting bodies during a close gravitational encounter (1). The deformation constants (Love numbers) of the two bodies must be sufficiently high and the Q's (effective dissipation factors) must be sufficiently low for capture to occur. To simulate the post-capture orbital evolution, orbital and deformational parameters for the interacting bodies were chosen to be consistent with gravitational capture because the early post-capture orbital evolution would necessarily commence immediately after the capture event (episode). For simplification, the simulation is restricted to two bodies undergoing mutual radial tidal deformations only (i.e., the effects of solar and other planetary perturbations as well as the tangential tidal effects of body rotation are neglected). Furthermore, an impulse approximation is used in the transferal of orbital energy to the bodies. When the Love numbers are held constant, the time scale of orbital evolution is controlled by the Q factors. For the case of displacement Love numbers for the earth-like planet (h_e) = 0.9 and for the lunar-like body (h_m) = 0.5 and for the post-capture orbital parameters, apogee = 270 R_e (Earth radii), perigee = 20 R_e, and semi-minor axis = 73.5 R_e (Fig. 1), the time scale for circularization of the originally highly elliptical orbit to 4% eccentricity (T_{cir}) = 1.1 x 10^5 years for Q_{system} (Q for each body) = 20, T_{cir} = 5.5 x 10^5 years for Q_{system} = 100, and T_{cir} = 2.75 x 10^6 years for Q_{system} = 500 (Fig. 2). Since a minimum of 6.3 x 10^{35} ergs must be dissipated during the capture and subsequent early post-capture orbital circularization, the bodies of the earth-like planet and the lunar-like body are heated considerably during this era. Using the displacement Love numbers given above, about 15% of the energy goes to the earth-like planet and about 85% goes into the lunar-like body. Although the 15% allocated to the earth-like body would be sufficient to melt only a 3.0 km thick zone of mantle material, the combination of energy dissipation and tidal action during such an orbital circularization scenario could lead to enhanced rates of crustal spreading and subduction on an already warm earth-like planet. We think that such a tidally induced thermal episode may be sufficient to cause widespread destruction and/or metamorphism of the ancient crust of an earth-like planet (a major global thermal-tectonic episode (2,3,4). The energy dissipated within the lunar-like body would be sufficient to melt a zone over 200 km thick within the magma ocean zone during the time scale of orbital circularization, an episode that could result in widespread flooding of basaltic lava into basins on the surface of the lunar-like body. We suggest that such simultaneous thermal events may have effected the Earth-Moon system about 3.9 billion years ago and may be related to the initiation of mare-type

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basaltic volcanism at about that time (5).

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Figure 1. Composite diagram showing various stages in the evolution of the early post-capture geocentric orbit of a lunar-like body. Note that angular momentum is conserved (i.e., the angular momentum of orbital state 5 is equal to that of orbital state 1). However, the total energy of the two orbits differs by 4.6 x 10^{35} ergs. The orbital periods are as follows: orbit 1 = 102 days (day = 24 hr.), orbit 2 = 81 days, orbit 3 = 58 days, orbit 4 = 39 days, orbit 5 (circular orbit) = 13.2 days.

Figure 2. Plot of energy dissipation vs. time for circularization of early post-capture geocentric orbit of a lunar-like body. For all cases, h_m = 0.5 and h_e = 0.9. Curve a: Q_{system} = 20; curve b: Q_{system} = 100; curve c: Q_{system} = 500. Broken horizontal line shows heat flow for a lunar-like body with a 20 km thick anorthositic crust and a thermal gradient of 8.00 x 10^{-4} °C/cm, a value which should relate to a "warm" lunar-like body.

Fig. 1

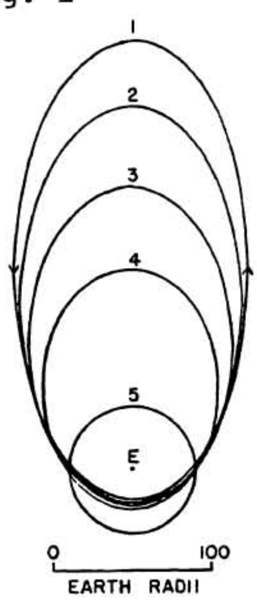

Fig. 2