LUNAR STRESS HISTORY, PART 1: GLOBAL THERMOELASTIC, TIDAL, AND SYNCHRONOUS ROTATIONAL STRESSES. A.B. Binder, Erde-Mond Forschergruppe, Institut für Mineralogie, Universität Münster, 4400 Münster, W. Germany.

This paper is the first in a series which will be used to discuss, first theoretically and then empirically, the stress history of the moon. In this paper I discuss the global stress history of the moon on the basis of the following concepts and assumptions. 1) As is indicated in (1) and in two accompanying abstracts (2,3), the moon was initially totally molten. 2) The earth-moon distance as a function of time is that given by (4). 3) The moon achieved synchronous rotation (5) in such a short period of time ($<10^4$ years) after its formation that the potential stresses caused by nonsynchronous rotational effects are of no importance. 4) The body of the moon has not undergone any reorientation (6,7) with respect to its rotational axes since the crust became sufficiently stable to record tectonic events, i.e. since about 4.3 to 4.4×10^9 years ago (4). Neither fluid convection in the earliest history of the moon nor solid state convection later in its history have been important in developing stresses in the lithosphere (8). On the basis of these considerations, the only stresses which have affected the moon on a global scale are the thermoelastic stresses, the stresses caused by tidal and synchronous rotational effects as the moon moved away from the earth, and the stresses caused by large basin forming impacts. In this paper I do not consider the stresses due to the basin forming impacts. The stresses due to basin impacts, reorientation of the body of the moon (6,7), mare fill loading (9), etc., as well as new photoselenological observations will be discussed in the following papers.

The basic lunar global stress field consists of the stresses caused by the thermoelastic-, tidal-, and synchronous rotational effects. Representative thermoelastic stresses for an initially totally molten moon, as functions of time and depth in the moon, are taken from (8). The tidal and synchronous rotational stresses are calculated following (10, 11) and using the time evolution model of the lunar orbit radius vector of (4). The tidal and synchronous rotational stresses are calculated on the basis of the observations (4) that the moon behaved like a hydrostatic body with a thin lithosphere (thickness = 0 to 0.03 x lunar radius) at all times before $3.0\pm0.5 \times 10^9$ years ago and that it behaved like a hydrostatic body with a very thick lithosphere (thickness >0.5 x lunar radius) or like an elastic, but incompressible body at all times after $3.0\pm0.5 \times 10^9$ years ago. The calculated tensor, stress vectors formed in the lithosphere under these model considerations, as functions of time, latitude, longitude, and depth in the lithosphere are vectorially added for different time intervals throughout lunar history.

The resulting stress fields and the equations developed by (12) are used to define 1) the selenographical regions in which normal-, strike-slip-, and thrust faults should have occurred, 2) the orientation of these faults, and 3) the intensity of faulting as a function of time throughout lunar history.

The results obtained indicate that the magnitude of the global stresses were large enough to produce deep seated (several 10's of km or more deep) crustal/lithospheric faults of the type which were apparently responsible for the formation of the ancient lunar grid system (which most probably formed by 4.0 to 4.3×10^9 years ago), only if the earth-moon distance increased from a few (3-5) earth radii to about 15 earth radii during the first few $\times 10^8$ years of lunar history. Further the global stresses were sufficiently weak after the period of formation of the lunar grid system so that only normal faulting at high latitudes would have been possible during the period between about 4×10^9 to about 3.5×10^9 years ago. After about 3.5×10^9 years ago, the global stresses became compressional and began to build up in magnitude as the thermoelastic stress component became dominant and ever stronger. However these stresses were initially sufficiently weak, so that global thrust faulting could not begin until <0.5 to 1 x 10^9 years ago, a prediction which has been confirmed by photoselenological and seismic observations as discussed by (1) and in two accompanying abstracts (2,3).

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Forschergruppe Contribution No. 40.