EVIDENCE FOR AN INITIALLY TOTALLY MOLTEN MOON: YOUNG THRUST FAULT SCARPS IN THE HIGHLANDS. A.B. Binder and H.-C. Gunga, Erde-Mond Forschergruppe, Institut für Mineralogie, Universität Münster, 4400 Münster, W. Germany.

As is previously discussed (1,2), thermal history- and thermoelastic stress models (3) indicate that if the moon was initially totally molten, it should have modest scale (≈10 km), young ($\lesssim$0.5 to 1 x 10^9yr old) thrust fault scarps in the highlands. In contrast, thermoelastic stress calculations for magma ocean models (lunar models initially molten only in the outer few 100 km (4,5)) indicate that the highlands should be free from any global, post-Imbrian, compressional tectonic features. A cursory review of the Apollo high resolution imagry indicated earlier (1,2) that fault scarps with the expected geometry and ages, assuming that the moon was initially totally molten, are found in the highlands. As an extension of this work, we report here the results obtained from an extensive photoselenological study of these highland scarps.

62 thrust fault scarps have been found in the highlands using the Apollo 15 and 16 panoramic imagry. The scarps are visable on images with solar illumination angles (A) between 5^o and 45^o and are best seen at A$\sim$$20^o$. Correcting the data for incompleteness due to illumination effects, we find that about 100 such scarps probably exist in the areas photographed with 5^o<A<45^o. Since this area covers only about 4.4% of the highlands, there must be about 2000 such fault scarps in the highlands. The majority of the observed scarps are members of scarp complexes which are made up of up to 10, but on average 4 to 5 separate scarps. 12 such complexes are observed in the areas investigated, which, from the above, indicates that about 400 complexes are in the highlands.

The individual scarps range in length from 1 to 22 km and have an average length of 9 km, i.e., they are on the 10 km scale as predicted on the basis of the initially totally molten moon model. The complexes are typically 50 km in length, with the largest being 120 km from end to end.

Using the crater morphology-age classification of Trask (6) and the calibration data of Moore et al. (7), most of the scarps could be age dated on the basis of craters which the thrust faults cut or overrun (maximum ages) and craters which are located on the fronts of the scarps (minimum ages). The ages thus determined range from 60±40 million years to 680±250 million years, with younger scarps being much more frequent. Thus this epoch of recent thrust fault activity began about 0.7 x 10^9 years ago and the level of activity has been increasing with time. These ages and this increase in the level of activity are also in accord with the initially totally molten model which predicts that the faulting should have begun at $\lesssim$0.5 to 1 x 10^9years ago in response to the ever increasing thermoelastic stress levels (see Fig. 6 of (2)).

The scarps are of three morphological types; linear, arcuate, and irregular. About 60% of the scarps are linear, 20% are arcuate, and 20% are irregular. Theoretical and experimental data indicate that linear thrust faulting occurs in anisotropic stress fields where, in the horizontal plane, the maximum stress vector is significantly larger (5 to 10%) than the minimum stress vector, while both arcuate and irregular thrust faulting occur in nearly isotropic stress fields. Thus these results lead to the suggestion that the global stress field consists of the isotropic thermoelastic stresses (>>1 kbar range) plus a small (100 bar range) but significant component due to the tidal and rotational stresses which are latitude and longitude dependent (8). If this is the case, then calculations show that the compound global field 1) was significantly anisotropic early in the thrust fault epoch, but became nearly isotropic with time, 2) the degree of anisotropy is and was always greatest at the limbs and least at the sub- and anti-earth points, and 3) the maximum stress vector is and was always in the EW direction in the equatorial regions studied. These results are supported by the following observations concerning the age- and geometric distributions of the scarps: 1) The average age of the arcuate and irregular scarps (190±20 my) is significantly younger than the average age of the linear scarps (270±20 my), 2) the percent of scarps which are linear tends to be greater at the limb than at the sub- and anti-earth points, and 3), allowing for the influence of the ancient lunar grid system on the orientations of the scarps, the maximum stress vector of the fields which caused the thrust faults was and is EW oriented.

In conclusion, the photoselenological results obtained, together with seismological data discussed in an accompanying extended abstract (9), clearly support the concept that the moon was initially totally molten.

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