THE INFLUENCE OF TIDAL, DESPINNING, AND MAGMA OCEAN COOLING STRESSES ON THE MAGNITUDE AND ORIENTATION OF THE MOON'S EARLY GLOBAL STRESS FIELD. R. S. Scott and L. Wilson, Planetary Science Research Group, Environmental Science Dept., Lancaster University, Lancaster LA1 4YQ, UK. (email: r.s.scott@lancaster.ac.uk).

Summary: We address the influence tidal, despinning, and magma ocean cooling stresses have on the global stress field of a growing lunar crust. Surface extensional and strike-slip features are evident. Strike-slip faulting is shown to operate to great depths within the crust.

Introduction: During its lifetime the Moon has been subjected to numerous sources of global, regional and local stresses that have shaped the surface we see today [1-13]. Measurements of the stress field in the crust can provide useful information about the forces responsible for various tectonic processes.

Global processes include reduction in planetary spin rate [14, 15, 16], changes in planetary volume due to thermal evolution [5, 17, 18], and tidal interactions with the Earth [2, 15, 16]. Regional and local stresses appear to be influenced by volcanic and dynamic loading of the lithosphere, topographic variations, and the global processes mentioned previously [4].

There is general consensus among most planetary scientists that the Moon accreted from the debris from a giant impact. According to this hypothesis the Moon was initially much closer to the Earth than now [19, 20, 21]. As a consequence the initial dominant influence on the long term evolution of the Earth-Moon system was tidal exchange of angular momentum between the Earth's spin and the Moon's orbit, thus causing the lunar orbital distance to grow [20].

Counter-intuitively, the effect of the growth in the lunar orbit is to increase the influence of tidally and de-spinning induced stresses on the Moon's overall global stress field [22]. A further consequence of the Moon forming accretion process was the formation of a magma ocean [23]. Solidification of this magma ocean resulted in the build up of global thermal stresses [12, 13]. Because linear stresses are additive, the magnitude and orientation of the Moon's early global stress field was dominated by the superposition of these three stress-inducing processes.

Scott and Wilson [2004a] found a way of relating the growth of the Moon's crust to the evolution of the Moon's orbital distance. This made it possible to determine both the magnitude and orientation of the Moon's tidally induced stress field. The relative merits of each model were determined by comparing the maximum depth at which slippage along existing fractures occurred against thickness of evolving crust.

We have used the same four models proposed by *Scott and Wilson* [2004a], namely models 1 and 2 based on a Moon that evolves to an orbital distance of 13 Re or 16 Re during a crustal growth period of 40 Ma, and models 3 and 4 that consider the same two orbital distances but use a crustal growth period of 60 Ma. We also used the maximum depth of slippage against crustal thickness to determine the relative merits of each.

Allowing the crust to grow in 5 km intervals, we determined the magnitude of the tidal and de-spin membrane stresses and than added isotropic lithospheric and thermal stresses until the crust reached the point at which it began to slide along existing fractures. Where stresses are insufficient to initiate movement, they are allowed to accumulate. By this method we are able to determine not only the type of faulting, but also the depth of that faulting.

A major problem was integrating two different coordinate systems i.e de-spin stresses based on conventional latitude and longitude and tidal stresses based on small and great circles orientated to the sub and anti-Earth points.

To overcome this problem we identified three large circles which are common to each system and also at 90^o to each other. Fig 1 is a cartoon of a segment of the Moon viewed face on. The vertical line, α, is a line that goes from the sub-Earth point through N to the anti-Earth point and returns through the S pole. The horizontal line, β, is the geographical equator, and the circle, γ, relates to the limbs of the Moon. At any point along each line, the three principle stresses for the tidal, despin, lithospheric and thermal stresses, all have the same orientation. The fault type and depth of fault movement applicable to any point on each of the lines, α, β, and γ, can be determined and from this the global distribution deduced.

All four models predict that slippage along pre-existing fractures will favour global strike-slip faulting; however, there is significant differences, between models, in the depth of faulting. We found model 2, a Moon that evolves to an orbital distance of 16 Re in 40 Ma, predicts the greatest depth of faulting. Details for model 2 are shown in Fig. 1.

Faulting at higher latitudes, > 70°, could extend to the base of the crust, if pre-existing fractures exist; however, they are likely to be restricted to the brittle and elastic zones. For a 40 km thick growing crust this will extend down to a depth of 14 km. For latitudes below 70° the depth of faulting will be restricted to the upper 3 km and depths greater than 5 km.

Between the surface and a depth of 1 km, extensional stresses may be present resulting in combined strike-slip and extensional surface features at all latitudes across the globe.

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Figure 1.