GEODETIC SIGNATURES OF ACTIVE LUNAR TECTONICS

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Introduction: The lunar surface is often assumed to be entirely static, except for tidal deformations and meteorite impact; a recent study using Lunar Laser Ranging (LLR) constrains the relative motion of the Apollo 11 and 14 retroreflector arrays to be no more than 4 mm/yr over a 14-year period [1]. However, the seimometers left on the Moon by the Apollo astronauts as part of the Apollo Lunar Surface Experiments Package (ALSEP) arrays revealed that there were relatively strong surface or near-surface lunar moonquakes [2], which must be associated with ground motions. Twenty-eight such Earthquakes were detected in eight years of observation, and the largest were energetic enough to present a possible risk to Astronauts on the surface in the seismic zone [3].

Active Thrust Faults on the Moon: Recent work has shown a connection between at least some of the surface moonquakes and geologically young thrust faults on the Moon, with 7 of the 28 ALSEP events been within 60 km of an apparently young lobate scarp. Conventional crater-size / frequency dating indicates that these lobate scarps are <50 Myr old [4]. Another study [5] shows that geologically young lobate scarps and wrinke ridges are assocated with fresh boulder fields (Figure 1), with large numbers of 1 to 10 meter boulders on top of or beside ridges in the fault area. The rapid destruction of such boulder fields by meteorite impacts indicates that these areas must be very young (< 10 million years in some cases). The combination of fresh faults with the apparent creation of boulder fields strong suggests that at least some surface moonquakes are associated with meter level surface motions (as multiple small motions would not unearth or create large numbers of meter sized boulders on top of ridges). A veritical or horizontal displacement of such a size on the near side of the Moon could be easily observed by either LLR of retroreflectors, or Very Long Baseline Interfermetry (VLBI) of suitable radio beacons [6], respectively, assuming that a suitable geodetic network was placed in the seismically active area.

Penetrator Deployed Geodetic Arrays: Ballistic penetrators can support lunar science by allowing for the rapid creation of instrument and communications arrays on the lunar surface, including deployement of a geodetic network together with seismometers in a tectonically active area [7, 8, 9, 10].

Space Initiatives Inc (SII) is developing a standard instrument package including a three axis accelerometer, three axis magnetometers, geophones and COMPASS VLBI Beacons to enable their accurate global positioning on the lunar near-side [6]. Such an array, with current deployment mechanisms, would allow instrumentation of roughly a 1 km wide section of an active thrust fault in a single mission, possibly in conjunction with a NASA CLPS lander. By providing cm-level determinations of local fault motions, the fault could be monitored (and fault motions compared to local seismology) even in the absense of large moonquakes on the instrumented fault. Such a mission would also be able to better constrain the seismic risk of such areas.

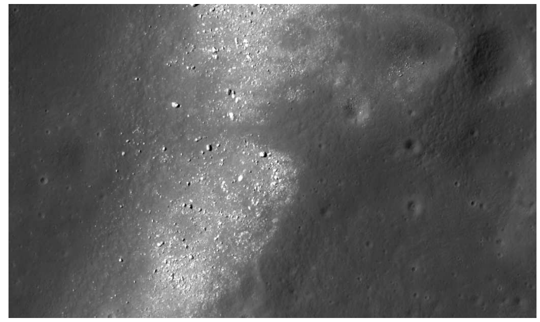

Figure 1: Boulders in a candidate area for recent lunar tectonics in Mare Nubium. Portion of LROC NAC image M1144863959L; North is up.

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