TRACING LOWER CRUST AND UPPER MANTLE ON THE SURFACE OF THE MOON. Katarina Miljkovic[1] and Mark A. Wieczorek[1], [1]Univ Paris Diderot, Sorbonne Paris Cité, Institut de Physique du Globe de Paris, 75013 Paris, France (miljkovic@ipgp.fr).

Introduction: The global crustal thickness map of the Moon derived from GRAIL gravity measurements shows that the lunar crust is thinner than previously thought. The nearside crust is on average 30 km thick. The crustal thickness on the farside varies from about 30 km in the South Pole-Aitken (SPA) basin up to 60 km in the highlands [1]. Previous studies suggest that during basin formation, the amount of excavated mantle depends on the target material rheology [2,3]. This work investigates whether these crustal thicknesses, together with different target properties could have caused the excavation of the underlying mantle material during impact basin formation, how much and where would that material be located within the impact site.

Method: Numerical modeling of lunar impact basins was made using iSALE-2D, a multi-material, multi-rheology shock physics hydrocode [4,5]. An infinite-half space target mesh in 2-D was divided into crust and mantle layers, represented by basaltic and dunite rock, respectively. The material parameters: ANEOS, strength and failure model were used from [6,7]. Thickness of the pre-impact crustal layer was fixed at 30 or 60 km. Impactor size ranged from 15 to 90 km and impact speed was 17 km/s, which covered a range of impact basins from small peak-ring to large multi-ring basins. Lunar nearside and farside were represented by vertical temperature profiles derived from lunar 3-D thermal evolution models [8] with variations that correspond to the location on the surface (i.e. PKT, highlands) and the time basins formed (~4.0 Ga ago).

Results: Impact basins form via the growth of a deep, bowl-shaped transient cavity that is gravitationally unstable and is followed by a complex collapse into final morphology. The collapse of the transient crater is combined of inward motion of the cavity walls and prominent uplift of the cavity floor [2,6], both of which depend sensitively on the shear strength and temperature of the crust and upper mantle [9]. The uplift of the transient crater floor brings up the underlying layers of lower crust and upper mantle closer to the surface, where surface exposure is possible, depending on target properties and impact size.

Numerical modeling shows that in a 30-km-thick crust, the formation of peak ring and multi-ring basins is accompanied by exposures of upper mantle on the surface, with highest concentrations of mantle material in regions between the peak (or inner) ring and topographic rim. Depending on the size of the melt pool formed within the basin center, these exposures mostly concentrate at the melt pool edge, where the melt pool is also the shallowest. Similarly in a 60-km-thick crust, the lower crust becomes mostly exposed, with little or no upper mantle involved. Materal uplifted and deposited on the surface is heavily mixed in with the upper crust layers. In addition, depending on the crustal properties, during final stages of crater modification a fine layer of fractured crust could cover up the exposed underlying material.

Comparison with observations: The hyper-spectral mapping obtained by the Spectral Profiler (SP) onboard SELENE/Kaguya shows global distribution of olivine-rich [10] and pure anorthosite (PAN)-rich [11] sites on the Moon. Olivine is associated with the upper mantle, and PAN with lower crust [10,11]. The olivine-rich exposures are found mainly on the nearside, where crust is globally thinner than on the farside. Some olivine was found in the SPA and Moscoviense basins, which are the regions of the thinnest crust on the farside. Furthermore, those olivine exposures are distributed along the concentric regions within the basins, mainly along the mare or crater rims [10]. Similar patterns are found in the highland region with the PAN exposures being concentrated along the crater rims [11].

Conclusions: Numerical modeling of lunar impact basin formation, for basins ranging from peak-ring to multi-ring showed that uncovering and excavation of the lower crust and upped mantle material are likely products of basin formation in the thin crust, and for larger basins in the thick crust. If the observed exposures of olivine and PAN are indeed the highest concentrations of the underlying material exposed to the surface, then our numerical modeling is in agreement with the observations.

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