**3-D BALLISTIC MODEL FOR THE DISTRIBUTION OF ANTIPODAL EJECTA FROM THE TYCHO IMPACT.** D. A. Paige¹, P. S. Russell¹, P. Jögi², I. S. Curren², ¹University of California, Los Angeles, Los Angeles, CA 90095, USA, ²Weizmann Institute for Science, Israel.

**Introduction:** LRO Diviner [1] and LROC [2] observations have revealed a ~100 km diameter region of anomalous rock abundance and melt features in the antipodal region of Tycho impact crater. The region is offset to the west of Tycho’s antipode (Fig. 1), and exhibits a range unusual geomorphic features that include rubble, rock fences, veneers and ponds [3]. Crater count age dating suggests that the emplacement of these features were contemporaneous with the Tycho impact [2,4]. The global emplacement of ballistic ejecta has been previously modeled in a range of solar system contexts [5,6], including for the case of Tycho [7,8]. We have developed a new global Tycho ejecta emplacement model that includes the effects of topographic shadowing of low-angle ejecta which can be compared to maps of ejecta and energy deposition in the Tycho antipode region.

**Methodology:** The model launches ~1 billion ejecta particles from Tycho at a wide range of azimuth and elevation angles and velocities. Trajectories are calculated under the influence of the Moon’s gravity and rotation. The resulting ejecta impact locations, velocities and times are determined relative to a 60-meter resolution global topographic DEM [9] based on LOLA laser altimeter [10] and Selene Terrain Camera [11] measurements. The mapped densities of ejecta particles can be compared with geomorphic maps and rock abundance data and the source regions for ejecta accumulations can be traced back to their launch points at Tycho.

**Results:** Consistent with the results of previous studies [7], the effects of the Moon’s rotation during the ~1-2 hour time of flight results in the point of ejecta convergence being offset to the west of the antipodal point (Fig. 2).
The effects of the Coriolis force [5] become more significant for longer flight times, but much smaller than the basic effects of planetary rotation for the simulations performed here. Lower-angle ejecta (with shorter flight-times) tends to converge on the eastern edge of the antipodal deposit, whereas higher-angle ejecta (with longer flight-times) tends to converge in an extended “tail” that extends to the west (Fig. 3). Topographic shadowing has significant effects on the distribution of low-angle ejecta, which is consistent with analyses of Diviner rock abundance measurements [1,3].

**Comparison with Observations:** The model produces a time-dependent picture of the “rain” of ejecta particles in the antipodal region. Both data and models suggest that a significant fraction of the antipodal ejecta was emplaced at very low angles at non-uniform azimuths [1]. Several lines of evidence point to Tycho being an oblique impact [12], which is potentially consistent with this general notion. The model predicts that low-angle ejecta was emplaced early during the event, but were subsequently covered by higher-energy high-angle ejecta that extended over a wider area to the west. The current model predicts a much higher degree of geographic focusing of the antipodal ejecta than can be inferred from observations. This is likely due deviations from pure ballistic ejecta behavior, either near the impact event or en-route to the antipode. The fact that crater rays are not observed to emanate along purely radial lines from their source craters [15] may be related to this phenomenon.

Diviner only observes high rock abundances in steeply sloping areas of the antipodal region, whereas the areas covered by veneer and ponds are much more extensive [3]. We are examining all available datasets to form a clearer picture of the distribution and energy of the Tycho antipodal ejecta and its interaction with the underlying topography in order to form a clearer picture of the processes responsible for this distinctive recent event that is recorded on the Moon’s surface.