THE EFFECT OF ROTATION ON THE DEPOSITION OF TERRESTRIAL IMPACT EJECTA.

K.E. Wrobel and P.H. Schultz, Department of Geological Sciences, Brown University, Box 1846, Providence, RI 02912-1846 (Kelly_Wrobel@brown.edu).

Introduction: The distribution of distal ejecta on the Earth differs from that of the Moon due to the presence of an atmosphere and rapid rotation. Previous studies demonstrated the significant effects of planetary rotation on ejecta deposition with application to Mars [1] and Earth [2-3]. The effects of rotation on ejecta emplacement on the Earth differ slightly from the effects observed on Mars due to the much larger size of the Earth.

Background and Approach: The present study describes the consequences of the Coriolis force on ejecta deposition on the Earth. On Mars, the most prominent rotational effects were observed for ejecta launched at velocities in the range of 3 to 5 km/s. Due to the size of the Earth, much greater launch velocities (less than the escape velocity of ~11.2 km/s) are required for the distal components most sensitive to rotational effects.

The effect of planetary rotation is applied to the spherical ballistic equations. Ejecta-scaling models [4] allow estimating deposit thickness values and mapping ejecta contributions to particular regions. Ejecta trajectories and distributions were modeled for launch angles of 45° and 70° (from the horizontal). The first case represents gravity-controlled excavation. The second provides a first-order approximation for higher angle trajectories from plume driven/entrained ejecta.

Ejecta trajectories were plotted on surface projections of the Earth for three different impact sites. The Chesapeake Bay crater, ~80 km in diameter, is located at 37°17'N, 76°1'W and the Popigai crater, ~100km in diameter, is found at 71°39'N, 111°11'E. Both craters are estimated to be ~35Ma in age [5]. The 100-km diameter Manicouagan crater (located at 51°23'N, 68°42'W) is one of the largest known Phanerozoic impacts (estimated to be ~210 Ma in age) [5].

Results: Figures 1-3 display the mapped ejecta trajectories for the three craters listed above. These figures are paleogeographic maps [6] displaying plate tectonic reconstructions representative of 35 Ma ago (Figures 1 and 2) and 200 Ma ago (Figure 3).

The Coriolis force dramatically modifies both the high-angle and 45° ejecta trajectories. Ejecta launched at 45° result in a distinct wrapping in the hemisphere opposite from the initial impact. For high-latitude impacts such as Popigai (Figure 2), this wrapping of ejecta occurs around the pole opposite of the impact. Ejecta delivered to such high latitudes will exhibit high entry velocities and small quantities. Low-latitude impacts, such as Chesapeake Bay (Figure 1), can result in significant depositional enhancements (10-fold increase) relative to expectations from simple exponential decay.

The trajectories representing deposition from early-time plume-driven products (70° data) are severely limited immediately east of the crater. Depositional enhancement occurs to the west as a direct result of the wrapping of the trajectories.

Discussion: The focus of many studies [7-9] has been the discovery of impact ejecta and/or spherule layers and their correlation with other well-established ejecta deposits. Other studies infer the size of a yet-discovered primary crater from the quantity of ejecta at a particular site.

The Chesapeake Bay structure is the source crater for a specific type of tektites classified as the North American (N.A.) microtektites [10]. Liu and Glass [7] recently reported new distant sites for impact ejecta/spherule layers that they believe to be related to N.A. microtektites based on their geochemical similarity and stratigraphic placement. One particular location discussed by Liu and Glass [7] is Site 709C, located in the W. Indian Ocean. This site coincides with the band of enhanced ejecta deposition (where the 45° trajectories "wrap") as shown in Figure 1. A launch velocity of ~8.5 km/s would be necessary to deliver ejecta from the Chesapeake Bay crater to Site 709C. The enhanced deposition occurring in this region would result in ejecta accumulations of ~20 cm (at the top of the atmosphere).

Other studies [8-9] have identified sites of impact ejecta layers that do not resemble the North American microtektites. Whitehead *et al.* [8] discuss the discovery of melanocratic microkrystites in the Indian and Pacific Oceans. Due to the distinctive geochemistry, they suggest that the microkrystites are associated with the Popigai impact structure. Launch velocities ranging from ~6.5 km/s to ~8 km/s would then be required to deliver ejecta to these marine sites. The results of our study predict that sufficient ejecta (~ .1–1 cm) would arrive in the upper atmosphere at these particular locations.

Lastly, Walkden *et al*. [9] recently described ejecta deposits in Southwestern Britain that are consistent with Manicouagan as the source crater. These deposits range from 0 to 15 cm thick with an average thickness of 2.5 cm. Figure 3 reveals that a substantial amount (~5 cm) of ejecta deposition from Manicouagan should be expected in the region of Southwestern Britain due to its proximity at the time of crater formation (~2000 km from the crater), In addition, wrapping of distal trajectories (analogous to the Chesapeake Bay impact) would indicate other potential sites in unexpected localities today.

The age of Manicouagan makes it a unique crater for ejecta studies. Deposits of significant quantities could have settled on landmasses and sedimentary basins that have since moved far away from the location of the crater. Any site that was initially within ~30° of Manicouagan would have received ejecta deposits of 5 cm or greater. Such locations would include the northern parts of South America, all of North America, northwest portions of Africa, and Western Europe. A region of enhanced deposition would also be expected due to rotational effects. Velocities required to launch ejecta to this region of greater deposition range from ~8 km/s to ~9.5 km/s. Australia, falling in the middle of this particular area of enhanced accumulations, may have received ~10-15 cm of ejecta (launched at ~8 km/s) from the Manicouagan crater.

Conclusions: The Coriolis force created by the rotation of the Earth significantly modifies the deposition of ejecta. Consequently, radial decay laws will not provide completely accurate predictions of the distributions of ejecta from a crater or, conversely, the scale of the impact based on distal ejecta thicknesses. Nevertheless, incorporation of the Coriolis effect can aid in the discovery of new sites.

References: [1] Wilbur K.E. and Schultz P.H. (2002) LPSC XXXIII, #1728. [2] Kring D. and Durda D. (2002) *JGR*, 107, 10,1029/2001JE001532. [3] Alvarez W., Claeys P. and Kieffer S. (1995) *Science*, 269, 930-935. [4] Housen K.R., Schmidt R.M. and Holsapple K.A. (1983) *JGR*, 88, 2485-2499. [5] Whitehead J. (2003) Earth Impact Database, http://www.unb.ca/passc/ImpactDatabase. [6] Schettino A. (2001) Plate Tectonic Reconstructions, http://www.itis-molinari.mi.it/Reconstructions.htm. [7] Liu S. and Glass B.P. (2001) LPSC XXXII, #2027. [8] Whitehead J. et al. (2000) *Earth Planet. Sci. Lett.*, 181, 473-487. [9] Walkden G., Parker J. and Kelley S. (2002) *Science*, 298, 2185-2188. [10] Koeberl C. et al. (1996) *Science*, 271, 1263-1266.

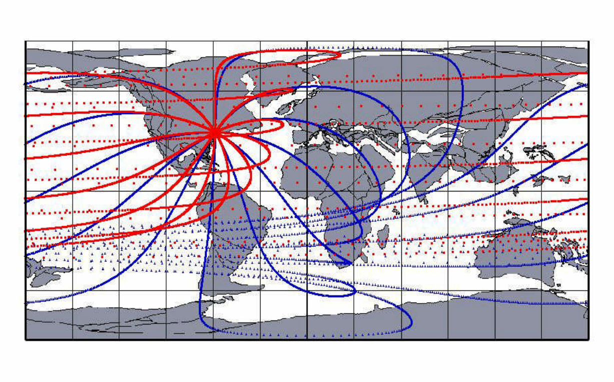

Figure 1. The trajectories trace the paths of ejecta launched from the Chesapeake Bay crater.

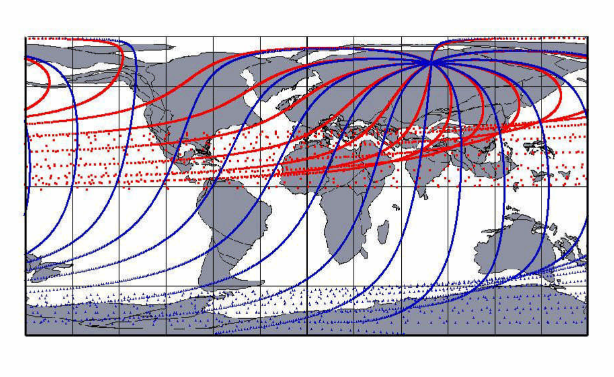

Figure 2. The trajectories trace the paths of ejecta launched from the Popigai crater.

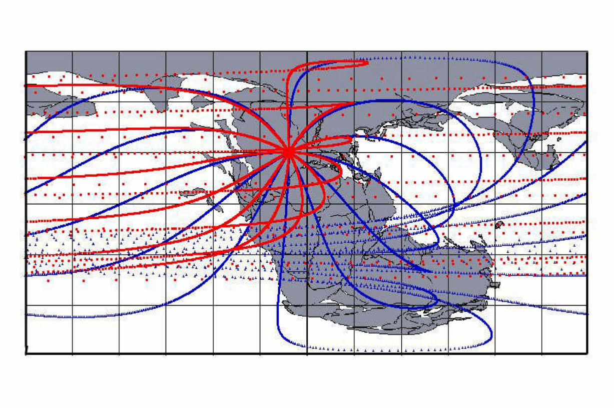

Figure 3. The trajectories trace the paths of ejecta launched from the Manicouagan crater.

Figures 1-3: Paleogeographic maps displaying plate tectonic reconstructions representative of the Earth 35 Ma ago (figures 1 and 2) and 200 Ma ago (figure 3). The blue triangles mark the landing positions of ejecta launched with an ejection angle of 45°. The red squares indicate the landing positions of ejecta launched at 70° (representing plume-driven products).