CHICXULUB EJECTA DISTRIBUTION: PATCHY OR CONTINUOUS? T. J. Goldin[1] and H. J. Melosh[2], [1]Department of Geosciences, University of Arizona, Tucson, Arizona 85721 (tgoldin@email.arizona.edu), [2]Lunar and Planetary Lab, University of Arizona, Tucson, AZ 85721 (jmelosh@lpl.arizona.edu).

Introduction: A discrepancy exists between the seemingly uniform ejecta layer found globally at the K/T boundary and the nonuniform distribution of spherules by the expanding impact plume. For craters on planetary bodies with no atmospheres, such as the lunar crater Tycho [1], the distal impact ejecta is concentrated in rays rather than evenly distributed. Models of ballistically traveling Chicxulub vapor plume material [2] also suggest an asymmetric distribution of ejecta. However, in distal localities, the thickness of the K/T ejecta layer is a fairly constant 2-3 mm [3]. We propose that the nonuniform input of ejecta from the impact plume can be reconciled with the observed uniform deposit on the ground if interactions between falling Chicxulub ejecta and the atmosphere are considered. Such interactions can lead to redistribution of ejecta in the atmosphere prior to sedimentation.

Modeling: We model deposition of Chicxulub distal ejecta through the Earth's atmosphere using the two-dimensional, two-phase fluid flow code KFIX-LPL, which has been modified from the KFIX code [4] to suit the problem of impact ejecta sedimentation. KFIX is based on the original KACHINA code [5]. Our models allow us to examine the interactions of falling impact spherules with the atmosphere, including both the mechanics and style of particle settling and induced pressure and temperature changes in the atmosphere.

In order to test to what extent ejecta of initially nonuniform distribution is redistributed laterally in the atmosphere, we model a simple scenario in which 250-μm impact spherules are injected into half of a rectangular mesh representing the Earth's atmosphere, whereas the other half receives no flux of material from the impact plume. The initial mesh approximates the Earth's atmosphere with an exponential pressure gradient, constant temperature, standard gravity and properties of air (assuming ideal gas behavior). The spherules, modeled as a simple compressible fluid with the properties of basaltic glass, are injected into the upper atmosphere at 8 km/s, at an altitude of 200 km, and with a flux and duration comparable with the volume of spherules observed in outcrops and impact theory. The spherules are injected vertically such that any observed horizontal velocities must be the product of interactions with the atmosphere.

The spherules fall through the thin upper atmosphere, decelerating due to drag and increasing atmospheric density and accumulating in a band at an altitude of ~50 km. The deceleration of spherules heats the particles (~1400 K) and the surrounding atmosphere, heat which can then dissipate as thermal radiation.

Initially, the spherules fall vertically, settling through the atmosphere as individual particles at terminal fall velocity and are contained within the half of the mesh into which they were injected. After ~10 minutes, the base of the spherule layer becomes unstable and density currents form, transporting the spherules collectively in plumes. Some of these plumes propagate downwards; however, the increased density of the atmosphere at lower altitudes contributes to a preference for lateral growth of the density currents and the hot impact spherules are smeared laterally across the mesh.

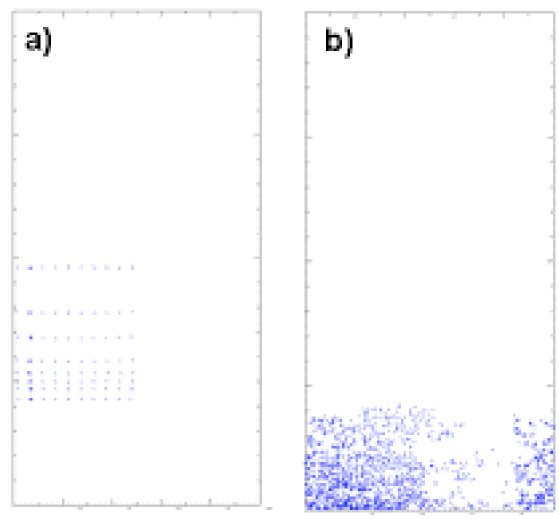

Fig. 1. The position of spherule tracer particles for the scenario of vertical spherule injection into the left half of the mesh only. The tracer particles track the movement of the spherule phase through the mesh and do not represent actual spherules. (a) After 5 minutes, the spherules fall individually and are restricted to their original horizontal positions. Shortly after this, the layer becomes unstable and density currents form that propagate laterally as well as vertically. (b) After 2 hours, deposition of spherules on the Earth's surface is occurring across the width of the mesh. Although the spherule distribution is uneven, the patchiness introduced into the top of the mesh has been reduced. The mesh is 200 km high and 100 km wide and left and right mesh boundaries are periodic.

Density Current Analysis: The modeled instabilities are real density currents and not numerical artifacts, as confirmed by models of an analogous (but simpler) scenario of tephra fall in water. We modeled a series of experiments [] using KFIX-LPL and instability formation was evaluated using a criterion yielded by the ratio between turbulent instability growth rate and the Stokes settling velocity of individual particles. Our models agree with both experimental observations and the analytical criterion. Density currents caused by loading of the atmosphere by Chicxulub ejecta are harder to evaluate due to the compressibility of air and the heating generated by decelerating spherules and require a complex criterion.

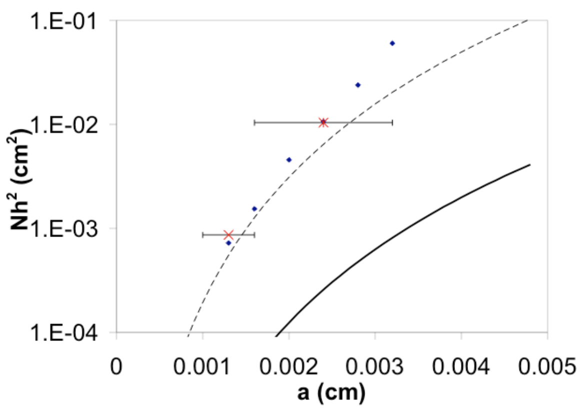

Fig. 2. Evaluation of instability onset for small particles of various sizes falling through water. KFIX-LPL model results (blue) match well with the Carey tephrafall experiments (red) and lie along the trend of our instability criterion, *B*, where any point below *B*=1 (black line) is expected to be stable. *B*=5 is also plotted (dashed line). *N* is volume fraction of particles, *h* is layer thickness and *a* is particle radius.

Conclusions: KFIX-LPL model results support redistribution of distal Chicxulub ejecta in the atmosphere via laterally propagating density currents. Thus the asymmetrical distribution of impact spherules injected into the upper atmosphere from the expanding impact plume may not reflect deposition patterns on the ground. The lateral migration of the spherules during descent would have reduced patchiness and led to more uniform coverage of the K/T boundary layer. Although our models do not show uniform mixing of the spherules across the atmosphere, additional lateral transport by winds in the lower atmosphere and waves (in marine depositional environments) would lead to increasing uniformity of thickness and distribution of the K/T boundary deposit. Lateral transport of impact spherules also has important implications for the distribution of environmental effects of Chicxulub. The lateral spread of hot spherules and atmospheric heating would lead to increased coverage of thermal radiation-induced wildfires and other biologic consequences.

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