THE CHICXULUB CONTINUOUS EJECTA BLANKET AND ITS IMPLICATIONS FOR FLUIDIZED EJECTA BLANKETS ON MARS. Kevin O. Pope[1] and Adriana C. Ocampo[2]. [1]Geo Eco Arc Research, 3220 N St. NW, Suite 132, Washington, DC 20007, kpope@primenet.com, [2]Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA 91109, aocampo@hq.nasa.gov.

Introduction: The relative importance of crustal volatiles and atmospheres in the emplacement of ejecta blankets forms the central part of the debate on the origin of fluidized ejecta blankets on Mars. One hypothesis is that fluidized ejecta are a product of volatiles (most likely water) in the Martian crust, which when mixed with the solid ejecta caused it to flow like a terrestrial debris flow [1]. Another hypothesis is that on planets with atmospheres much of the fine-grained ejecta is winnowed out of the ejecta curtain by atmospheric drag, thus producing a turbulent cloud of debris that flows with fluid-like properties [2]. The existence of fluidized ejecta blankets on Mars is used in arguments for abundant water in the Martian subsurface [1]. If atmospheric effects alone can produce these fluidized features, then this argument is weakened. If the atmosphere is responsible for the formation of fluidized ejecta blankets, then these features on Mars may provide information on past atmospheric conditions [2].

In this paper we examine the evidence for fluidized ejecta emplacement by the Chicxulub impact in the Yucatan Peninsula of Mexico. Target rocks at Chicxulub were rich in volatiles, including water. Earth has a thick atmosphere and therefore ejecta emplacement, especially in the outer parts of the ejecta blanket, was affected by atmospheric drag. The Chicxulub impact had conditions that match both hypotheses for the formation of fluidized ejecta blankets, therefore its ejecta blanket may provide insights into ejecta fluidization mechanisms.

Extent and Thickness of the Chicxulub Ejecta Blanket: The Chicxulub ejecta blanket has been cored close to the rim of the crater where the maximum thickness is about 500 m [3]. The only known exposures of the ejecta blanket come from the Albion Formation, which is exposed 360 km from the center of Chicxulub on Albion Island in northern Belize [4], and in recently discovered outcrops directly across the Mexican border in Quintana Roo. The maximum observed thickness of these deposits is 16 m, but may have been more. Geological reconnaissance further south in Belize has not located additional exposures and it appears that the ejecta on Albion Island lie near the outer edge of the continuous ejecta blanket.

These geological data indicate that the continuous ejecta blanket of the Chicxulub crater extends not much more than 360 km from the center of impact. Recent geophysical studies place the final Chicxulub crater diameter at about 200 km, with a transient crater diameter of 100 km [5]. Ejecta blanket scaling relationships have been developed for the moon and are widely applicable to other terrestrial planets for craters up to 436 km in diameter [6]. Scaling relationships [7] predict that the Chicxulub continuous ejecta blanket should extend about 185-288 km, considerably less than the 364 km noted. McGetchin et al. developed a semi-empirical scaling relationship for ejecta thickness of large craters based in part on data from lunar craters [8]. When this scaling is applied to the Chicxulub continuous ejecta blanket, it predicts thicknesses about an order of magnitude less than observed.

Composition of the Chicxulub Ejecta Blanket: Recent studies of the Albion Formation demonstrate that the Chicxulub continuous ejecta blanket is composed of multiple flows of debris [4]. Foliation and basal shear planes between some flows indicate laminar flow regimes. Lack of these features and of size grading in other flows suggests turbulent flow. Some outcrops produced evidence of alternating laminar and turbulent flow, typical of distal pyroclastic flows where loss of volatiles (deflation) causes a shift from turbulent to laminar flow.

The basal one to two meters of the Albion Formation (spheroid bed) is composed of up to four flows containing 10-30% carbonate accretionary lapilli. The lapilli range is size from 1-30 mm and many have angular cores of dolomite and rarely altered glass. Altered glass spheroids are abundant in the basal flow. The upper 15 m of the Albion Formation (diamictite bed) contains large carbonate blocks and about 10% altered glass supported in a dolomite and calcite silt matrix. Grain size analyses of the coarse fraction suggests there are two populations of clasts: one containing large blocks 2-8 m in diameter and another dominated by clasts <25 cm in diameter. The diamictite bed also contains accretionary blocks, up to 4.5 m in diameter. The base of the diamictite bed only rarely exhibits evidence of shear and appears to have been mostly emplaced by a turbulent flow over the spheroid bed. One location in Mexico exposes an ~100 m long horizontal shear plane separating two flows within the diamictite bed.

Conclusions: Comparisons of the Chicxulub continuous ejecta blanket with crater scaling relationships clearly show that the thickness and extent of ejecta blankets from large lunar craters do not compare well with Chicxulub. The Chicxulub ejecta blanket extends farther and contains more material than ejecta blankets from comparable sized craters on the moon. These findings argue against simple ballistic emplacement of the Chicxulub ejecta and are consistent with atmospheric drag concentration of ejecta and extensive surface flow. Such flow is indicated by structures in the ejecta deposits of the Albion Formation in Belize and Mexico. Atmospheric drag sorting may be responsible for the crude sorting into two populations, where the <25 cm population is dominated by material stripped from the ejecta curtain by the atmosphere. Finally, the abundance of accretionary lapilli and blocks indicates that much of the ejecta is derived from a dense, turbulent cloud of debris and was not emplaced ballistically nor solely by a combination of ballistic and surface transport.

We conclude that the Albion Formation is part of a fluidized ejecta blanket and that its formation best fits the atmospheric drag hypothesis. Fluidized ejecta blankets on Mars commonly have multiple, crossing flow lobes that extend twice as far as typical ballistic ejecta blankets [6]. The Albion Formation may be a good terrestrial analog of such flow lobes. Future studies of Chicxulub are needed to confirm the relative importance of atmospheres versus crustal volatiles in the formation of fluidized ejecta blankets. Such studies promise to provide important information for the interpretation of past environments on Mars.

References: [1] Carr, M.H., Crumpler, L.S., Cuuts, J.A., Greeley, R., Guest, J.E., and Masursky, H., 1977, Journal of Geophysical Research, v. 82, p. 4055-4065. [2] Schultz, P.H., and D.E. Gault, 1979, Journal of Geophysical Research, v. 84, 7669-7687. [3] Ward, W.C., Keller, G., Stinnesbeck, W., and Adatte, T., 1995, Geology v. 23, p. 873-876. [4] Ocampo, A.C., Pope, K.O., and Fischer, A.G., 1996, Geological Society of America Special Paper v. 307, p. 75-88. [5] Morgan, J., et al. 1997, Nature, v. 390, p. 472-476. [6] Melosh, H.J., 1989, Impact cratering: A Geologic Process: New York, Oxford University Press, 245 p. [7] Moore, H.J., Hodges, C.A., and Scott, D.H., 1974, Proceedings of the Fifth Lunar Conference, v. 1, p. 71-100. [8] McGetchin, T.R., Settle, M., and Head, J.W., 1973, Earth and Planetary Science Letters, v. 20, p. 226-236.