THE FLUIDIZED CHICXULUB EJECTA BLANKET, MEXICO: IMPLICATIONS FOR MARS. F. Schönian[1], D. Stöffler[1], T. Kenkmann[1] and A. Wittmann[1], Humboldt-University of Berlin, Invalidenstr. 43, D-10115 Berlin, Germany, e-mail: frank.schoenian@museum.hu-berlin.de

Introduction: Fluidized ejecta blankets have been a principal argument for the existence of water or ice on Mars [1,2]. Some authors suggested that these ejecta morphologies might be produced by turbulent atmospheric flows induced by ring vortices developing behind the advancing ejecta curtain and compare them to the ejecta outflows on Venus [3,4]. The only known example of an ejecta blanket on Earth reaching runout distances similar to Mars and Venus (~3 and >9 crater radii respectively) is that of the Chicxulub impact structure (Ø 180 km, 65 Ma). Its ejecta blanket could be traced up to distances of 5 crater radii [5]. Since both a dense atmosphere and volatiles (water), are present on Earth, the Chicxulub ejecta blanket can provide field control on the processes of ejecta fluidization.

Previous observations and models: The Chicxulub ejecta blanket has been described in detail from Albion Island (363 km from the impact center; [6,7], fig. 1) and from the Cayo district (460 km from the center; [5,6]). The large runout distance, the apparent horizontal bedding, the absence of erosion and secondary cratering and two clast populations have been attributed to a non-cohesive behaviour of the flow after collapse from a dense atmospheric ejecta cloud [7]. Matrix coatings around large boulders ('accretionary blocks') and particle abrasion features on dolomite clasts ('high altitude ballistic ejecta') were thought to having been formed within the atmosphere. Clay particles within the ejecta blanket have been exclusively interpreted as altered impact glasses [6,7]. Consequently, the atmospheric drag hypothesis has been favoured as a model for the formation of fluidized ejecta blankets on Earth and Mars [7,8]. New results from adjacent Quintana Roo (Mexico) suggest different mechanisms for the deposition of the Albion Fm.

Fig. 1: Ejecta blanket localities W of the Rio-Hondo / Laguna-Bacalar fault. Localities cited in the text are underlined. Radial distance from Chicxulub Pto. on the right.

Properties of the Albion Formation in Mexico: The ejecta blanket was mapped continuously west of the Rio-Hondo-Laguna-Bacalar fault within a radial range of 295 to 320 km (3.2 to 3.9 crater radii) from the impact center (fig. 1). The Albion Fm. in Quintana Roo fills a pre-existing karstified paleorelief and is discordantly overlain either by Lower Tertiary (south) or Upper Tertiary (north) strata [9]. The sediment characteristics suggest that internal friction rises significantly from north to south and that the ejecta blanket is largely composed of material derived by erosion of the subsurface and very small amounts of crater derived material are present. The features previously related to atmospheric processes can be better explained by subsurface erosion and internal shearing [9]: The large boulders become incorporated within the flow by erosion of topographic highs of the Barton Creek Fm. Coatings around boulders develop by adhesion of clay rich matrix material during a rolling transport. Surface abrasion features like striations, polish and pits were formed by internal shearing at high confining pressures. Shear planes in the ejecta matrix and abraded clasts become more abundant towards the south [9, 7].

Distribution of clay particles within the matrix. A crucial point in the understanding of the processes that acted during the deposition of the Albion Fm. is the origin and amount of clay particles within the matrix. Clays are very rare (< 2%) at the northern localities between a radial distance of 295 to 300 km from the impact center. At a distance of 320-330 km (Chetumal area, fig. 1) the amount of clay particles rises approximately up to 5%. Clay rich breccia dikes related to shear zones crosscut the dolomitic matrix of the ejecta blanket. Towards the south (330-350 km, fig. 1) the clay content rises up to 10 or locally even more than 20%. However, the clays are very inhomogeneously distributed within the Albion Fm. and related to distinct sedimentological features. Only at some localities (e.g.

basal ejecta at Ramonal, fig. 1) do clays show characteristics of altered melt particles.

Subsurface erosion of clays. Clay interbeds are present within the upper parts of the underlying Barton Creek Fm. Subsurface erosion is evident by the incorporation of large boulders of the Upper Barton Creek Fm. within the flow [10]. At the basal contact of Sarabia (327 km from the center, fig. 1) the Barton Creek formation is exhibit 3-4 m of a monomict clay rich dolomite breccia at its top which is overlain by a heterogeneous 2 m thick basal diamictite, heavily comminuted and sheared. Atop this unit a lenticular body (max. 1.5 m) of sheared clays derived from the Barton Creek Fm. can be observed. In the basal part of the diamictite that overlies these clays, an irregular, up to 1 m thick, lense of clay breccia composed of the same clays is present. Meter sized dolomite bolders derived from the uppermost Barton Creek Fm. exhibit sheared coatings with clays enriched along the shear planes.

At the basal contact at Ramonal (335 km from Chicxulub Pto., fig. 1) a polymict, spheroid rich diamictite that fills in a paleovalley, becomes heavily sheared around an obstacle of Upper Cretaceous dolomites towards the south [9]. The up to 2 m thick basal shear bed is bounded by clay rich shear zones that incorporate clays from the subsurface. Large boulders slide on clays and clay breccias that acted as lubricants within the shear zones. These results suggest that two distinct populations of clays (altered glass and locally eroded clays) are present within the Albion diamictite.

Internal structures. Internal shear planes and shear zones become a predominant sedimentological feature at distances of >3.5 crater radii from the impact center [9]. Shearing is more pronounced at the base, around obstacles and within carbonate-rich, clay-poor portions of the ejecta blanket. If the matrix contains more clays shearing is less prominent and normal sedimentary structures prevail.

The relation of sedimentary structures to clay and carbonate content can be studied at the Sabidos/Alvaro Obregon locality (344 km from the center, fig. 1) where a lower carbonate-rich, clay-poor (2-10 %) ejecta bed is seperated from an upper marly and clay rich (10-40 %) layer by a > 90 m long subhorizontal, irregular shear plane. While in the lower unit curved conjugated shear planes are dominant features, shearing is almost absent in the upper part and horizontal bedding planes and slump structures developed. The principal shear zone is in part composed of comminuted matrix material, with clay particles that show a shaped preferred orientation, and in part by clays enriched in lenticular pockets along the shear plane.

A depositional model: A preliminary depositional model for the Albion Diamictite in Quintana Roo can be deduced from the data obtained so far: At the northern localities shear zones, coated boulders and striated clasts are absent. The amount of clays within the diamictite is low and faint laminations and bedding structures are present. This indicates that after initial ballistic emplacement at distances <<3 radii the flow was still non-cohesive and turbulent up to 3.5 crater radii from the impact center. It was most likely driven by the water content within the flow. At a distances of about 320 km it evolved from a less cohesive, turbulent, to a cohesive, complex debris flow by detrainment of volatiles (water). Local clays are eroded and incorporated within highly mobile shear zones and entrained within the flow. This process is most likely responsible for the large runout distance observed. Frictional forces indicated by shear planes within clay-poor parts of the ejecta blanket are suggesting that without the entrainment of clays the secondary ejecta flow already might have ceased at distances of around 4 crater radii from the impact center.

Conclusions: The properties of the Albion diamictite favor the role of volatiles in the target rocks and eroded bedrock lithologies for the development of the secondary ejecta flow. Atmospheric processes are probably of minor importance for the deposition of the ejecta blanket on the Southeastern Yucatan Peninsula.

Consequently, it is unlikely that atmospheric processes contributed to the formation of the fluidized rampart ejecta on Mars, where the atmospheric density and pressure were significantly lower than on Earth throughout most of its geologic history [10]. The smaller runout, the ramparts and multiple lobes observed on Mars may be related to a 'freezing' of the flow at lower radial distances. The observations from the Chicxulub ejecta blanket support the hypothesis that on Mars water or ice in the subsurface accounts for the fluidization of ejecta blankets [1,2].

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