ON THE DISTRIBUTION OF IMPACT MELT AND BASEMENT CLASTS IN THE CHICXULUB EJECTA BLANKET. F. Schönian, D. Stöffler and T. Kenkmann, Museum für Naturkunde, Humboldt-Universität zu Berlin, Invalidenstrasse 43, D-10115 Berlin, frank.schoenian@museum.hu-berlin.de.

Introduction: The ejecta blanket of the Chicxulub impact crater (Ø 180 km, 65 Ma) was discovered in several wells close to the crater (UNAM 5, 6, and 7 [1]) and mapped over a large area on the southern Yucatán Peninsula, where it covers a preexisting Upper Cretaceous Karst topography [2, 3]. A rough estimate of its content in impact melt, usually altered to clay, was used to calculate melt production during the impact event [4]. However, since the ejecta blanket eroded karst lithologies [5] it was doubted that clay particles generally represent altered melt and assumed that they are at least in part derived from the subsurface by impact-induced erosion. Consequently estimates of the actual amount and the distribution of melt particles as well as crystalline basement clasts are crucial for the understanding of the impact event and the processes of ejecta emplacement.

The proximal ejecta blanket: The drill cores UNAM 5 (U5, 105 km S' of impact center) and UNAM 7 (U7, 126 km SE' of impact center) were described in detail and the amount of melt and basement clast macroscopically determined [6]. The impactites comprise a lower dolomitic megabreccia with large anhydrite megablocks (at 678.1 to 348.8 m in U7) and an upper unit of melt-rich suevites (503.9 to 332 m in U5 and 348.8 to 220.8 m in U7). The breccias can be subdivided into 6 units at U5 and U7 [6].

UNAM 5 suevites (1.17 crater radii – cr). The lower unit of U5 (U5-6) contains abundant impact melt derived from sedimentary rocks (25-40%) and a variable amount of melt derived from crystalline lithologies (5-20%) as well as basement clasts (5-20%). The "sedimentary melt" is absent in units U5-4 and –3 but "crystalline melt" varies between 10 and 30% and crystalline clasts between 0 and 20%. Both, melt and basement clasts, are slightly higher in U5-3 (10-35% and 5-30%). Melt remains high in the fallback suevite of U5-2 (15-40%) but crystalline fragments diminish to 2-10%. The redeposited suevite of U5-1 contains 10-15% of basement clasts and 15-20% of melt.

UNAM 7 megabreccia and contact (1.4 cr). The thick megabreccia sequence (unit U7-6) does not contain any crystalline basement clasts but has a small amount of black or bottle-green melt fragments of 1-3% within the breccia matrix. The contact with the suevites is transitional. In unit U7-5 the first larger melt clasts >3 cm occur well below the base of the lower suevite. The upper part of this unit is an alternating succession of melt-rich, irregular suevitic lenses and the dolomitic, sedimentary breccia. Large melt clasts are present in the lowermost suevites, but dolomitic portions do occur up to 327 m and karstified anhydrite clasts up to m 318 m. The contact should be placed at 348.8 m [6].

UNAM 7 suevites. The lower suevite of U7-4 has a variable but rather high content of green to greenish grey melt clasts (20-40%) but contains only 5-10% of highly shocked crystalline fragments. "Sedimentary melt" is very rare (3-10%). The latter rises in U7-3 to about 15-25%, while "crystalline melt" remains rather constant at 25-30% and basement clasts low at 3-8%. The middle suevite (U7-2) is very heterogeneous and has a high content of dispersed greenish melt particles (35-50%) and contains a slightly higher amount of shocked crystalline fragments (10-15%). Rarely large clasts of "sedimentary melt" are present. In the upper suevite (U7-1) the amount of greenish melt diminishes significantly to 10-20%, but "sedimentary melt" rises slightly to 10-20%. The content of basement clasts is variable, but low (5-10%).

The intermediate ejecta blanket: Outcrops of the ejecta blanket on the central Yucatán Peninsula are rare. The closest unequivocal exposure of the Chicxulub ejecta is a quarry near the village of Ukum in Campeche at 220.5 km from the impact center. Other important outcrops can be found at distances between 283.5 km (Paraiso roadcut) and 298.5 km (Sandoval quarry). Exposures usually display the lower ejecta blanket, since upper parts are removed by erosion.

Ukum quarry (2.45 cr). In the Ukum quarry a thick evaporitic succession (mainly anhydrite) of the Upper Cretaceous Icaiche Formation is overlain by an oligomict breccia of allochthonous limestone and dolomite clasts within a relatively well consolidated dolomitic matrix. Because clasts often display abrasion features such as polish and striations, the breccia could be related to the ejecta blanket [7]. Clasts are probably derived from Upper Cretaceous dolomite and limestone exposures nearby. No crystalline lithologies and no altered melt fragments could be found at this locality.

Paraiso roadcut (3.15 cr). At the outcrop of Paraiso an alternate layering of marls, clays and recrystallized limestones of the Morocoy Formation is overlain by a polymict breccia, composed largely of the underlying lithologies. However, allochthonous dolomite boulders with matrix-coatings are also present. Clay particles are dispersed throughout the matrix, but they resemble the underlaying laminated clays and can not be interpreted as altered impact melt. No basement clasts could be found.

Sandoval quarry (3.32 cr). Sandoval is a medium sized quarry where a polymict breccia composed of limestone and dolomite clasts within a poorly consolidated carbonate-rich matrix are exposed. The variable clasts display different source areas and do rarely show abrasion features. A shocked quartz grain from the insoluble residue of the matrix confirms the impact origin of this breccia. Clay clasts that probably can be interpreted as altered impact melt occur with amounts of 1-2% within the matrix. Again, no crystalline basement clasts are present.

The distal ejecta blanket: Beyond 300 km distance from the impact center (3.33 cr) the Chicxulub ejecta blanket is widely distributed and easily accessible across the southern Yucatán Peninsula. The best known examples are the outcrops in the Rio-Hondo-area along the border between Mexico and Belize.

Sarabia quarry (3.6). At Sarabia, a large quarry in the Chetumal area, clay particles are dispersed at an amount of ~5% throughout the matrix of the ejecta blanket and can at least in part be interpreted as altered impact melt. Large melt fragments were found as well as shocked crystalline clasts. Both occur close to the base of the ejecta rather than at its top. They are not enriched in any layer, but mixed with the bulk ejecta material composed of dolomite clasts floting in a well consolidated dolomitic matrix. The basal contact with the Upper Cretaceous Barton Creek dolomites is heavily sheared and no basal ejecta layer is present.

Ramonal roadcut (3.73 cr). At the Ramonal roadcut a lower layer rich in spheroids and vesiculated clay particles is filling a karst depression (Ramonal N) and overlying heavily karstified bedrock of the Barton Creek formation (Ramonal S) [2, 3]. Here clay clasts form 10 to 15% of the bulk material and can be interpreted as altered melt. Small vesiculated glass shards are present within the ejecta matrix. Larger melt clasts are very rare, but shocked crystalline fragments could be recovered from this basal layer.

Rio Hondo region (3.7-3.86 cr). Farther south the ejecta blanket is highly heterogeneous and does contain a variable amount of clay particles (5-20%, in local pockets to 40-50%). However, these clays can not unequivocally be interpreted as altered melt. The basal layer of Ramonal is not present, but crystalline basement clasts could be found at two localities. Again, these clasts are mixed within the bulk ejecta material and occur close to the base of the ejecta blanket.

Southcentral Yucatán Peninsula (3.3-3.8 cr). The Chicxulub ejecta blanket is widely distributed on the southcentral Yucatán Peninsula, but yet poorly studied. At many localities clay particles, that in part can be interpreted as altered melt, are distributed to various amounts within the ejecta matrix. Shocked quartz was found in the insoluble residue of the matrix at at least one locality. However, crystalline basement clasts where not found at any of these localities. Their occurence seem to be restricted to the Rio Hondo region.

Discussion and conclusions: Due to the uncertainties in interpreting clay particles either as altered impact melt or as clasts derived from subsurface erosion it appears to be difficult to estimate the amount of melt distributed within the ejecta at the present state of knowledge. Nevertheless, several important observations could be made:

1. Melt particles do rarely occur within the Bunte-Breccia-like unit (megabreccia) of U7.
2. The transition from the megabreccia to the suevites of U7 with breccia-in-breccia textures and intact large melt fragments indicates a turbulent mixing between vapor plume and ejecta curtain material.
3. The absence of crystalline basement clasts and the scarcity of (possible) melt fragments at intermediate distances from the crater indicates ejecta curtain material, also if the breccias are largely composed of locally eroded materials.
4. The occurrence of basement and melt clasts at low levels within the ejecta blanket beyond 3.5 cr indicates an ‘inverse stratigraphy’ compared to the sequence of the U7 drill core.
5. The absence of such crystalline lithologies and large melt clasts at localities on the southcentral Peninsula might bear information on the impact angle.

The observed ‘inverse stratigraphy’ and the mixing with the bulk ejecta material implies that impact melt and basement clasts arrived first at the distal localities and were subsequently eroded by the evolving secondary ejecta flow that followed ballistic emplacement [3]. At few localities (e.g. Ramonal N) this primary ejecta is still preserved in paleodepressions of the Upper Cretaceous topography. The primary ejecta flow might be driven by atmospheric turbulences (ring vortices) that mixed curtain and plume material close to the crater and overran the ballistic ejecta [cf.8].

References: [1] Urrutia-Fucugauchi J. et al. (1996) *Geophys. Res. Let. 23(13)*, 1565-1568. [2] Pope K. O. et al. (2005) *GSA Spec. Pap. 384*, 171–190. [3] Kenkmann T. and Schönian F. (2006) *Meteoritics & Planet. Sci. 41(10)*, 1587-1603. [4] Pope K.O. et al. (2004) *Meteoritics & Planet. Sci. 39(1)*, 97-116. [5] Schönian F. et al. (2003) *3rd Int. Conf. Large Met. Impacts*, Abstract #4128. [6] Schönian F. et al. (2006) *LPS XXXVII*, Abstract #2229. [7] Schönian F. et al. (2005) *LPS XXXVI*, Abstract #2389. [8] Barnouin-Jha O. et al. (2005) *JGR 110*, E04010, 1-22.