EXHUMED PALEOZOIC IMPACT CRATER STREWN FIELD NEAR DOUGLAS, WYOMING, USA: EVIDENCE FROM MICROSTRUCTURAL ANALYSIS, SATELLITE, AND DRONE IMAGERY.

Thomas Kenkmann[1], Kent A. Sundell[2], Douglas Cook[3], [1]Institut für Geo- und Umweltnaturwissenschaften, Albert-Ludwigs-Universität Freiburg, Germany; [2]Casper College, Casper, WY, USA; [3]Independent Consultant, Colorado Springs, CO USA.

Introduction: During hypervelocity collisions a large amount of energy is coupled to the Earth's atmosphere [1]. Even for crater-forming impact events, such as the Meteor Crater event, the atmosphere plays an important role and leads to the disruption of projectiles [2]. Catastrophic disruption and the subsequent deceleration of fragment clouds were investigated with numerical models, e.g. [3], and results were tested against natural occurrences. Disruption of meteoroids is documented from a number of witnessed falls, meteorite strewn fields, and impact crater strewn fields, e.g., Sikhote-Alin [4] or Henbury [5]. All currently known strewn fields have a Quarternary age. Here we present a new impact crater strewn field that is exceptional in both size and age.

Observation and Regional Geology: More than thirty circular and ellipsoidal possible impact craters have been identified on the northeast facing flank of the Sheep Mountain anticline near Douglas, Wyoming, USA centered on 42°40'00"N, 105°27'16"W. The crater structures are exposed in the uppermost quartz-cemented sandstone (fluvial festoon to shoreface cross-bedded quartz arenite) of the Permo-Carboniferous Casper Formation. Rim-to-rim diameters of the crater pits range from 16 meters to 66 meters. The exposed strewn field on Sheep Mountain has a minimum length of 6.4 km in SE-NW direction. Satellite and drone imagery has revealed crater shape, orientation, and size. Some have resistant crescent shaped morphologies, with lowest spill point to NE caused by strata tilting and erosional processes (Fig.1). Eight of the craters have the compelling geomorphology of a simple impact crater with a raised rim and overturned flap, an apparent continuous ejecta blanket, and an ovoid shape oriented SE to NW coincident with the strike of the strewn field. Based on crater structure and ejecta distribution an impact from SE towards NW is inferred. The other craters exhibit a lesser quality of these features and are rated as possible to probable.

The craters are exhumed from beneath Permo-Triassic Goose Egg Formation Opeche Shale Member red beds (paralic mudstones) on a very resistant Casper sandstone surface. Strata were tilted by 15° E-NE during the Laramide Orogeny during the Upper Cretaceous and Paleogene. Satellite imagery shows that the craters are only in this narrow stratigraphic band along strike at the top of the Casper Formation. It is assumed there was originally an elliptical strewn field pattern but possible additional craters on the west side of the ellipse are eroded away and additional ones on the east side of the ellipse may lie below the Goose Egg Formation. More crater structures have been found on satellite imagery up to 14 km SW and 19 km NW of Sheep Mountain. These also are on the uppermost

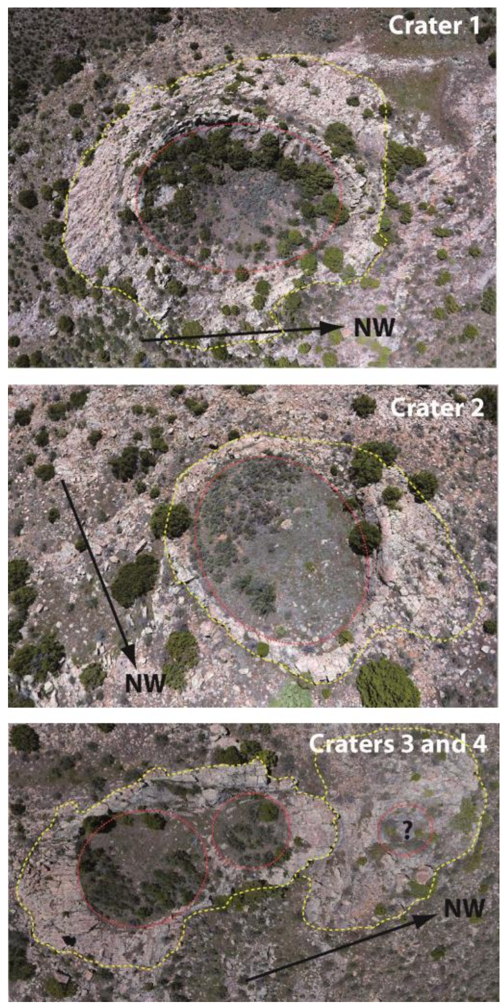

Fig. 1 (a) Crater 1 is 60 m in diameter along the NW-SE trajectory. Its NE flank is eroded. The crater was intensely sampled and contain shocked quartz grains. b) Crater 2 has a 31 m long axis and shows preferred ejecta downrange. c) Crater 3 and 4 are not fully separated with a 35 m long axis and a well-developed overturned flap downrange. Dotted red and yellow lines outline the crater cavity and preserved ejecta blanket, respectively.

Casper Formation on analogous structural and erosional settings to Sheep Mountain. The additional craters extend the length of the Douglas Strewn Field to at least 33 km. The impact age is inferred to be immediately after Casper Formation deposition (lithostratigraphic age +/-280 Mya), as there is no crater filling with younger Casper sandstone. The original craters would have been eroded away in a short time without fast transgression and burial by Opeche muds.

Microstructure: Samples from Crater 1 [6] were investigated microstructurally. So far we found one grain with cross-cutting PDF lamellae in various crystallographic directions (Fig. 2a, b) and several grains with PDFs along (0001) in samples from Crater 1 (Fig. 2c). Quartz grains exhibit Boehm lamellae and intensive fracturing (Fig. 2d). Hertzian-type fractures form along stress chains and grain-to-grain contacts. Deformation affected rounded quartz grains but not the quartzitic overgrowth seams (Fig. 2d). This implies that the impact occurred in unconsolidated sand prior to diagenesis. Fractures, Boehm lamellae, and PDF are massively decorated with fluid inclusions suggesting that pore space was filled with water during impact. Shock lithification [7] possibly made craters more resistant to erosion. Some partly became pedestal craters.

Discussion: The inferred lithostratigraphic age date of +/-280 Mya and a possible impact crater strewn field size of 33 km make the Douglas Strewn Field potentially the oldest and one of the largest strewn fields on Earth. The regional geology context discount other mechanism for creating circular crater pit structures such as volcanism, halokinesis, fluid or gas escape, or karst collapse. This is an ongoing study. Further studies will focus on (i) the microstructural proof of shock metamorphism of the other, more eroded possible crater structures of the strewn field and its outliers, (ii) search for projectile relics, (iii) constraining the strewn field size, (iv) testing other potential scenarios including multiple airbursts/strewnfields, secondary cratering and a connection to large impact events.

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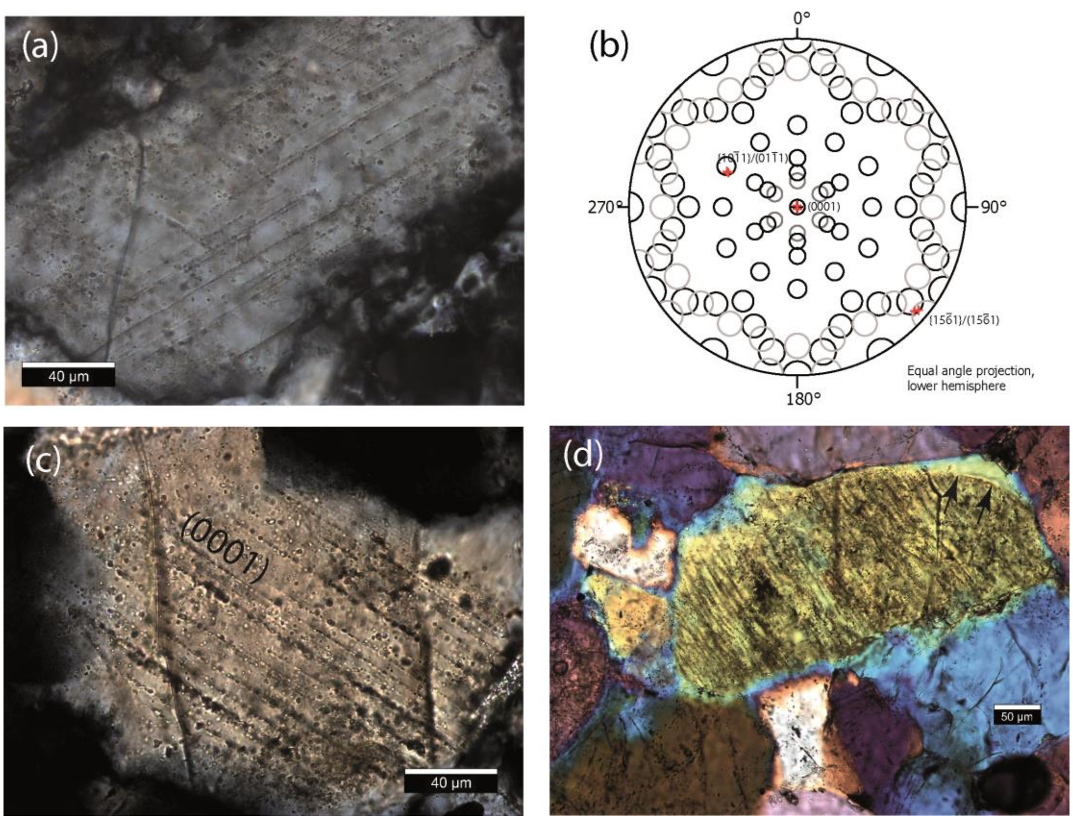

Fig. 1 (a) Cross-cutting planar deformation features (PDFs) in quartz grain of crater 1. (b) Crystallographic orientation of lamellae of (a). (c) Quartz grains with fluid-decorated basal PDF lamellae along (0001). (d) Grain with high density of Boehm lamellae and fractures. Note that the deformations ends at the round shaped original grain surface (arrows) and does not extend into the syntactic overgrowth seam.