IN HONOR OF DOCTOR ROBERT E. COHENOUR, THE GREAT SALT LAKE ASTROBLEME (GSLA), REVISITED R. Fox[1] and K. Ernstson[2]. [1]Practical Geophysics, 6832 Triumph Lane, West Jordan UT 84084, USA (geofox67@gmail.com) [2]Faculty of Philosophy I, University of Würzburg, D-97074 Würzburg, Germany (kernstson@ernstson.de).

Introduction: Thirty years ago, Dr. Robert E. Cohenour, recipient of a PhD in Geology from the University of Utah in 1957, published a paper titled, "The Great Salt Lake Astrobleme" (GSLA) [1]. His interest in impact geology was initiated by a geologic enigma, introduced during his earlier years as a geologic student, an enigma related to the "Northern Utah Highland", a geologic feature devoid of approximately 10,700 meters of Paleozoic sediments. These sediments occur in the surrounding mountain ranges, but abruptly terminate at the margin of the 'highland', exposing primarily Precambrian rocks overlain by early Tertiary rocks. The missing section of rocks was professed to be the source of heat and pressure that produced the, now exposed, underlying Precambrian Farmington Canyon metamorphic complex. When asked, the professor could give no explanation for the missing 10.7 km sedimentary section. This simple fact was the driving force behind Dr. Cohenour's research into impact geology. His research, initiated in the late 1950's, resulted in a paper titled, "The Asteroidal Impact Theory and Some Geologic Evidence for Asteroidal Impacts on Earth" [2]. This paper presented a logical argument for terrestrial impacts and their associated effects at a time when there was little knowledge about or interest in terrestrial impact geology. This research provided the encouragement for Dr. Cohenour to later postulate the GSLA as the most logical explanation for the missing Paleozoic section and other associated geological enigmas. His 1987 paper was virtually ignored by the local geological community, a community seemingly unfamiliar with and disinterested in impact geology.

Revisitation of the GSLA was induced by an awareness of recent and ongoing geological investigations (e.g., [3]), misguided by a lack of acceptance and appreciation its effects. Over a period of two years, 2016-2017, using the hypothesized GSLA as a guide, field evidence has been collected from in and about its perimeter that consistently supports its validity. Here we report on this new field evidence with a focus on peculiar geologic settings well known from many other impact structures, on mesoscopic deformation features and on microscopic evidence of shock metamorphism as diagnostic of meteorite impact. In light of this, a broader discussion of the conventional geologic models opposing the 30 years old impact model remains undone for now, apart from ascribing the "Northern Utah Highland" Precambrian to the suggested central uplift of the complex impact structure showing some similarity to the Manson (Iowa) impact crater.

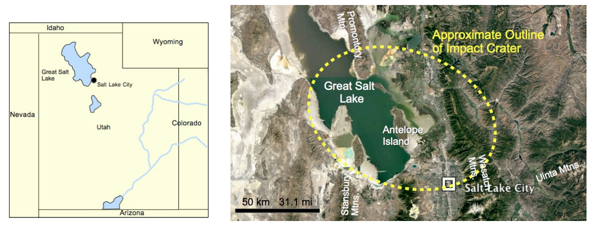

Fig. 1. Map of proposed impact structure. Google Earth. The elliptical shape is attributed to Basin and Range deformation.

Results - Impact deformation from macro- to micro-scale: Breccias are a significant constituent of impact structures due to the established contact/compression, excavation and modification stages of impact cratering. The GSLA is no exception, and the richness of megabreccias, monomictic, polymictic and dike breccias in the field may even be called characteristic.

Megabreccias. In general they are characterized by great extesion and by large-sized components (megablocks), occur at best with gigantic landslides and otherwise are typical for larger impact structures (e.g., [4]). Fig. 2 shows impressive details of megabreccia on Antelope Island belonging to the postulated central uplift.

Fig. 2. Megabreccia in the GSLA. Antelope Island.

Fig. 3. Monomictic breccias in the GSLA.

Monomictic breccias. Due to frequently enormous confining pressures typical voluminous monomictic breccias in impact structures show a grit brecciation, which have been called monomictic movement breccias and in many impact structures are considered diagnostic of impact deformation [5]. Various aspects of GSLA monomictic breccias are shown in Fig. 3.

Polymictic breccias. In impact stuctures they characteristically originate in the rapidly proceeding stages of cratering - excavation, ejection, landing of ejecta and their heighly energetic mixing with the local target material. This is the reason for the formation of breccias-within-breccias right up to multiple breccia generations normally not observed in geological processes. The abundant breccia generations (e.g., Fig. 4) encountered in the GSLA are strong evidence for the postulated impact event.

Fig. 4. Polymictic breccias in the GSLA (Harkers Canyon).

Dike breccias (or breccia dikes). They are a prominent feature in impact structures [6] frequently allowing detailed reconstruction of the cratering process. Fig. 5 compiles a few examples of monomictic and polymictic dikes and dike systems exposed in the GSLA emphasizing a probable impact signature.

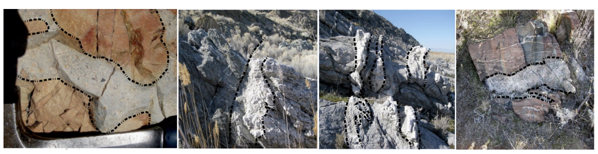

Fig. 5. Delineation of breccia dikes in the GSLA.

Mesoscopic deformation. The Mountain Dell Canyon deposit (Fig. 6) is interpreted as part of an ejecta blanket that reasonably is expected to exist around a big and relatively young impact structure. High confining pressures acting within very short times during excavation, ejection and landing of target rocks leads to high-pressure/short-term deformations in particular observed with hard components embedded in a soft matrix. Impressive examples have been described for the Ries impact crater and the large Spanish Azuara and Rubielos de la Cérida impacts (e.g. [4]) pointing out that such extreme deformations, nevertheless, leave the affected cobbles and boulders coherent, factors incompatible with slow tectonic stress.

Fig. 6. Typical high-pressure/short-term deformation from the Mountain Dell Canyon suggested impact ejecta deposit.

Shock metamorphism. So far, the investigations of the GSLA have mainly focused on the field evidence for the proposed giant impact event as exemplified before. In contrast lab analyses and polarizing microscopy for shock identification are still preliminary. Typical planar deformation features (PDF) in quartz are widespread and in part extremely abundant and tightly packed in the quartzite rocks (Fig. 7). Multiple sets of PDF in a grain are common, and in thin sections more than 80 % of all quartz grains may show PDF. Very often, sets of closely spaced planar features are markedly bent or kinked, which may be interpreted as tectonically produced. Since they are closely linked to undulatory extinction and kink banding in the quartz grains (Fig. 7) a crystallographic orientation is indicated pointing to primary PDF shock deformation and a later deformation of the quartz grains in the ongoing cratering process. Multiple sets of planar fractures (PF) in quartz meanwhile considered as diagnostic of impact shock [8], are also abundant.

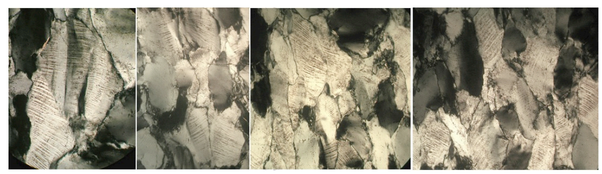

Fig. 7. Multiple sets of PDF in quartz. To the left: Kink bands in quartz grains with linked PDF orientation.

Conclusion: Dr. Cohenour's original idea of the GSLA was solely (but convincingly) based on topographic, structural and stratigraphical considerations. His 30 years old model, using textbook knowledge of meteorite impact cratering as an established geologic process, is an unerring guide to geologic characteristics uniquely associated with impacts. There is little doubt that the GSLA should be considered a probable large impact structure that formed around the K-Pg boundary.

References:

[1] Cohenour, R.E. (1987) *Utah Geol. Ass. Publ.*, *16*, 133-150. [2] Cohenour, R.E. and Sharp, B.J. (1987) *Utah Geol. Ass. Publ., 16*, 105-132. [3] King, J.K. and Willis, G.C. (2000) *Misc. Publ. 00-1, Utah Geol. Surv*. [4] Ernstson, K., et al. (2002). *Treballs del Museu de Geologia de Barcelona, 11*, 5-65. [5] Reiff, W. (1978) *Meteoritics, 13*, 605-609. [6] Lambert, P. (1981) In: R.B. Merrill, P H. Schultz (eds.) *Lunar Planet. Sci. Proc. 12A*, 59-78. [7] French B.M. (1998) *Traces of catastrophe,* 120 p., Houston (LPI). [8] French, B.M. and Koeberl, C (2010) *Earth-Sci. Rev., 98*, 123-170.