SHATTER CONE AND ITS SURFACE MESH-STRUCTURE FORMED BY IMPACT MELT-GASIFICATION IN XISHAN TAIHU LAKE CHINA. H.N. Wang[1], Y. Chen[1], X.F. Shen[1], L.Y. Zhou[1], Y.W. Wang[2] , [1]Department of Earth & Planetary Sciences, Nanjing University, Nanjing, China 210093 (wanghn@nju.edu.cn), [2] Department of Natural Resources and Environmental Sciences, University of Illinois at Urbana-Champaign, Champaign, IL, US 61820 (nsfzwyw@gmail.com)

Introduction: Shatter cones are represented by a range of curved to curvilinear fractures decorated with a varying degree of divergent striations. Striations radiate from an apex of a conical feature or from a narrow apical area. Shatter cones are the only distinct meso-to macroscopic recognition criterion for impact structures. Despite being known for 110 yr, the formation mechanism of shatter cone remains unclear. Different hypotheses for their formation exist in the literature, but none of them account for all the current field observations of shatter cones. [1], [2], [3], [4]

In addition, it is noticeable that the microstructures (smears and fibres, melt splats and spherules) were produced by melting-vaporization on the surface of shatter cones. [5], [6], [7], [8]

This paper reports our finding of a new type of shatter cone in Xishan Island, Taihu (Jiangsu, China), where shatter cone clustered in limestone target rocks. The cone surface develops a mesh-structure formed by melting-gasification and a variety of corrugated, scaly, honeycombed impressions. The discovery of this new type of shatter cones could contribute to the discussion of the formation mechanism of shatter cones.

I. Geological setting: Xishan is the largest island in the Taihu Lake. The strata in the island are reversed and formed as thrust nappe. The eastern part of the island is the newer Carboniferous-Permian limestone. The west is the older Silurian - Devonian quartz sandstone. At eastern areas around Yuan Shan - Linwu Shan - Shek Kip Shan, the rock of Limestone hills, which are taller than a hundred meters and near the lake, almost completely fragmented from top to bottom. Limestone fractured breccia and melting phenomenon for the breccia (that is, the famous “Taihu stone”). In the distribution area of the “Taihu stone”, shatter cone clusters were found to have developed amongst them.

II. The characteristics of Xishan shatter cone: Xishan shatter cone clusters rich in development. By size (height): miniature at centimeter scale (Fig.a), medium-sized between 50-70 cm (Fig.b), to large-sized at 1.5 meters. There are completely developed straight conicals, but also underdeveloped part conicals. There are common types of shatter cone fit in conventional definitions (Fig.a, Fig.b), which conical striation possess bifurcated. But also new type of shatter cone unique to this area (Fig.c, Fig.d), which conical surface with mesh-structures and multiple impressions (or air imprint)

III. Mesh-structure and a variety of imprints of shatter cone surface

1. Mesh-structure: In the Xishan shatter cone population, the shatter cone, which conical surface presents mesh-structures, has the genetic significance for the reason that explains the formation mechanism. Such cones of this type are associated with conventional cones and appear in the same area. The height of these cones is generally 50 to 70 cm. As shown in the Fig.c, the conical triations radiate from the original point at apex of cone.it is similar to the longitude meridian of Earth--theodolite. Meanwhile, cone surface presents hoop--line around the cone. The grid (cell) on cone surface is generally in centimeter scale (2-4cm x 2-3cm), latitude and longitude lines form a grid mesh-structure. This is an important and unique phenomenon never reported in any literature in the past. It could contribute to the discussion and explanation of the theory of the formation of shatter cone. In addition, there are complex cone (Fig.d), formed by multiple cones, which has the plurality of cone top. It also has a mesh-structure on the surface.

2. Other kinds of imprints (or gas imprints): In addition to the mesh-structure, the surface of the cone is often marked with ripples, fish scales, honeycomb and scoop-like imprints.

Imprint pit developed on cone surface: Shallow ones develop into ripples, fish scales structure; deep pits develop into a honeycomb, spoon-shaped structures.

IV. Discussion:

1. Characteristics of Xishan shatter cone:

Cataclasis and melting phenomenon is well developed. Whether inside the cone or cone surface, it is visible that they are all composited by limestone granules. Petrographic studies show that they are mainly fine limestones granule welded by Caco3-melt. Calcite twins-crystal, planar deformation features (PDFs), planar features (PFs) are visible in fine granules. The melting phenomenon of calcite granule is very obvious. In the early stages of melting, the granules become cloudy and gloomy. twins-crystal, PDFs and PFs gradually become shorter and eventually disappear, granules edge melt and gradually become brighter. When multiple granules edge melts and polymerized, it will form irregular veinlets or reticular. Even residual calcite granules are visible embedded in the bright yellow melt.

2, similar to the digital model: The conical fracture in Xishan limestone target rock is very **similar to** the model in article "The formation of shatter cones by shock wave interference during impacting". [3] Otherwise, the mesh-structure of the conical surface, formed by the longitudinal wave and the annular (hoop) shaped wave is presumed to be similar to the shock wave lattice unit (cell) and therefore contributing to the explanation of the formation of the shatter cone.

3. The formation model of the Xishan shatter cone: mesh-structure are related to the melt-gasification of carbonatites target rock. Compared to Sudbury, which target rock is igneous and metamorphic rocks, both of which have different physical-chemical properties. Carbonates are brittle, fusible and volatile. Under shock wave effect, it is brittle and easy granulitization, melting point as low as 500-600°C. Under the conditions of instantaneous decompression, it is fusible and volatile. Thus, when the shock wave pass through, it melts instantly and form atherosclerotic fluid. Impress marks and relics when the shock wave passes. Then, it is quenched instantly, leaving the mesh-structure and gas imprint structure. In the melt and boiling process of carbonatite melting-fluid, the bubble rupture and formed honeycomb gas imprint structure.

Conclusion:

1.Xishan shatter cone created clusters. The existence of shatter cones with both complete and incomplete development, different size, and different types indicate that the Taihu Lake experienced a meteorite impact event.

2. The conical fracture and the mesh-structure of conical surfaces is similar to Baratoux's digital simulation and theoretical interpretation. This new type could serve a valuable field evidence to validate the hypothesis of the shatter cones formation.

3. Formation model of mesh-structure and gas imprint on conical surface:

At early stage of meteorite impact----, pressure dropped immediately after pressing. It forms conical fractures and accompanied by granularization➜ impact caused high temperature with an instantaneous decompression ➜ carbonate rock melting-gasification and formed atherosclerotic fluid ➜ shock wave pass through and left imprint ➜ instantly quench cooling forms mesh-structure and a variety of imprints (or gas imprints).

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