ZIRCON AS A SHOCK INDICATOR IN IMPACTITES OF DRILL CORE YAXCOPOIL-1, CHICXULUB IMPACT STRUCTURE, MEXICO.

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Introduction: We examined zircons in thin sections of suevitic rocks, brecciated impact melt rock, and dike breccias from drill core Yaxcopoil-1 (Yax-1) of the Chicxulub impact structure, Mexico. Zircon was used as an indicator of crystalline host rocks and of the formation conditions of the various types of impact melts formed from crystalline basement rocks in these units. This study presents information about the shock state and spatial distribution of zircon in Chicxulub.

Samples and methods: Samples from the following units [1] were studied: The *Upper Sorted Suevite* (USS) - 803.67 m, the *Upper Suevite* (US) - 823.86 m and 824.01 m, the *Suevitic Breccia with Cataclastic Melt Rock* (SB) - 879.58 m, and an *Impact Breccia Dike* (IBD) - 916.23 m and 916.65 m.

The 6 thin sections were systematically scanned for zircon under the SEM. Optical properties of the zircon grains were investigated by transmitted and reflective optical microscopy and by Raman spectroscopy. Element-concentration mappings were made to check the presence of baddeleyite (bdy).

Preliminary results: A total of 35 zircon grains with an average size of 27 µm were analyzed: of these grains, 27 are included in melt rock clasts, 3 are floating in a clastic matrix, 3 are components of the matrix melt of the SB, and 2 grains are inclusions in feldspar that do not show clear shock features. The zircons indicate a wide range of shock and thermal annealing effects. A major fraction of 25 grains is unshocked and displays a clear to light brown colour.

3 dark brown grains contain bdy (ZrO_2) as < 2 µm sized vermicular to anhedral intergrowths with zircon near the rim: one grain with strongly reduced birefringence from US sample 823.86 m shows the dissociation reaction to bdy and silica (figs. a + b) in a melt rock clast with a perlitic texture. IBD sample 916.23 m hosts a zircon grain with a “granular” [2] texture and patches of bdy near the rim enclosed in a well crystallized melt rock clast. It shows polycrystalline optical properties indicating thermal annealing. IBD sample 916.65 m bears a grain embedded in a sulphide ore bleb within a perlitic textured melt rock clast (fig. c). It displays planar features in the core and regular optical properties.

“Granular” textures [2] were found in 6 brown grains in the thin sections of the USS, the US and IBD 916.23 m: 1 grain occurs in the USS with reduced optical properties enclosed in a poorly crystallized melt rock clast. 2 grains occur in the clastic matrix of the US samples and one grain in the US is mentioned above as an intergrowth with bdy (figs. a + b). All of these 3 grains show reduced birefringence indicating incipient isotropization. 1 additional grain in the US that is embedded in a well crystallized melt clast shows polycrystalline optical properties. 1 grain in the US mentioned above with bdy intergrowths and one in the IBD located in a well crystallized melt rock clast show a granular texture that appears polycrystalline.

Planar deformation features are present in 4 grains: 3 show clear to brown grains of IBD sample 916.65 m in up to three directions with spacings of 1-4 µm. These grains are embedded in a poorly crystallized melt rock clast and one of them is mentioned above with bdy intergrowths (fig. c). 1 grain in sample IBD 916.23 m bears decorated PDFs in two directions and is located in a well crystallized melt rock clast.

Raman spectroscopy confirmed the presence of bdy intergrown with zircon (fig. d) but no reidite spectra. All zircon grains with “granular” textures yielded zircon spectra.

Discussion: The described shock effects in zircon of the Chicxulub impactites represent the full range of known shock features observed in experimentally and naturally shocked zircon and zircon-bearing rocks [2-10]. They cover a pressure range from unshocked (</~5 to >100 GPa) and post-shock secondary annealing conditions with maximum temperatures of more than 1800 °C (breakdown of zircon to bdy). The dissociation of zircon to bdy + silica at 1770°C was reported by [3] in tektites and impact glasses from the Ries impact structure. This dissociation reaction was found to occur at shock pressures of ~94 GPa [4]. Planar deformation features (PDF) in zircon were shown to form as very narrow, nm thick lamellae of amorphous material already at pressures below the transition to the high pressure polymorph reidite between 20 – 40 GPa [5]. PDFs were found to co-exist with a ‘granular’ texture in naturally shocked zircon and reidite [2, 6]. This may be interpreted as a diaplectic and subsequently recrystallized state of zircon [5]. Optical microscopy indicates that the “granular” texture may be produced by two different processes. One type is comparable to strong shock-induced mosacism, while the other type could represent recrystallized isotropic grains.

Reidite was first found in distal ejecta from the Chesapeake Bay impact site [6] and in samples from the Ries impact structure [7]. The onset of the displacive transition to the scheelite structured zircon polymorph reidite begins at 20 GPa [8] and is complete at 52 GPa [9]. The lack of reidite in the shocked zircons of Yax-1 could mean that reidite was not stable under the post-impact conditions at Yax-1 since it readily reconverts to zircon at temperatures of 1200°C [4]. Reidite-bearing zircon may have been incorporated into impact melt particles and annealed above some 1500°C. The only natural findings of reidite so far were reported from samples that escaped post impact thermal annealing [6, 7]. In the case of the Ries, this is indicated in reidite-bearing impactites by the presence of stishovite which is instable above 250°C [10].

Conclusions: Zircons at Yax-1 display a wide range of shock effects indicating a pressure range from < 5 to about 100 Gpa. In addition, secondary thermal annealing effects are distinct (e.g., decorated PDF, polycrystalline textures) and have lead to the reconversion of reidite to zircon. The zircon-bearing impactites of YAX-1 have been insufficiently quenched after deposition for retaining high pressure polymorphs such as reidite and stishovite.

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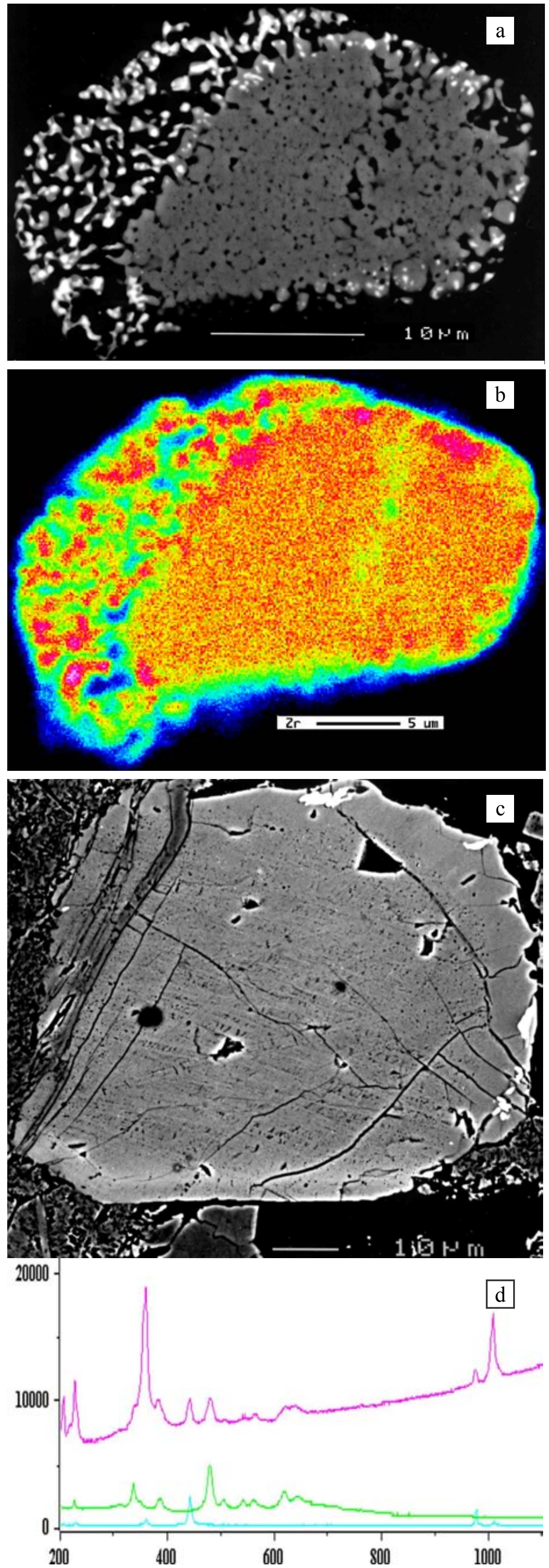

Figs. a - b US sample 823.86 m. Poorly crystallized melt rock clast hosts granular zircon grain which dissociated to baddeleyite (bdy). (a) BSE image, bdy is white, zircon grey. (b) - compositional mapping image showing distribution and relative concentration of Zr in the same grain. Pinkish-red indicates highest, green moderate and blue lowest concentration levels.
Figs. c - d ISB sample 916.65 m. BSE image of Zircon grain embedded in sulphide bleb with PDF in core and bright baddeleyite intergrowths at rim. (d) Raman spectra of a bdy bearing zircon grain in (c) m Plot of frequency [cm^{-1}] vs. intensity. Blue spectrum-unshocked zircon from the Auvergne, green - bdy from Phalaborwa, RSA and pink – bright bdy / zircon intergrowths in (c).