IMPACT-RELATED DEFORMATION FEATURES IN CHERTS FROM TERRESTRIAL IMPACT STRUCTURES.

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Introduction: Cherts, rocks predominantly made up of micro- to cryptocrystalline silica that formed during the diagenetic SiO_2 replacement of the sedimentary host rock, are commonly found associated with limestones and sulfates [1;2]. Among the micro- to cryptocrystalline, microfibrous varieties of silica, chalcedony *sensu stricto* ('length-fast chalcedony') and quartzine ('length-slow chalcedony') [3;4] are widespread in sedimentary-diagenetic cherts. Impacts into limestone targets might, therefore, cause specific impact-related deformation in chert. However, with the exception of the report of shocked recrystallized chert from the Slate Islands impact structure (Canada) [5], there is sparse data on the petrography and shock-metamorphic behavior of such rocks at terrestrial impact sites. A preliminary review of impact-induced and potentially impact-related microdeformation features in cherts from a number of sedimentary-hosted terrestrial impact structures is presented.

Cherts from Terrestrial Impact Structures and Associated Microdeformation Features:

Jebel Waqf as Suwwan, Jordan. The investigation of a shocked, chalcedony-, quartzine-, and quartz-bearing allochthonous (Upper Cretaceous) chert nodule recovered from wadi gravels in the central uplift of the ~6 km Jebel Waqf as Suwwan impact structure [6] revealed new potential shock indicators in microfibrous-spherulitic silica, in addition to well-defined shock-metamorphic effects [7] in coarser-crystalline quartz. Apart from the macroscopic overall brecciation of the chert, the microcrystalline silica groundmass exhibits a dendritic-suborthogonal fracture pattern (Fig. 1) commonly associated with thin silica 'recrystallization bands' that intersect the diagenetic chert fabric. Fibrous aggregates of quartzine spherulites in chalcedony-quartzine-quartz veinlets locally have shattered appearance and show conspicuous microscopic 'curved fractures' perpendicular to the quartzine fiber direction (parallel to the basal plane; Fig. 2); the curved fractures commonly trend subparallel to planar fractures (PFs) in neighboring shocked quartz. Quartz exhibits PFs, feather features [8], and mainly single sets of planar deformation features (PDFs) parallel to the basal plane (0001) (Brazil twins) [7;9] with rare additional PDFs parallel to $\{10\bar{1}3\}$. In contrast, autochthonous Eocene cherts from the weakly shocked uplifted rim of the Jebel Waqf as Suwwan impact structure lack PFs and PDFs in quartz, as well as quartzine and curved fractures therein [10].

Fig. 1: Polished section of shocked chert from the Jebel Waqf as Suwwan impact structure, Jordan, showing a distinct dendritic-suborthogonal fracture network.

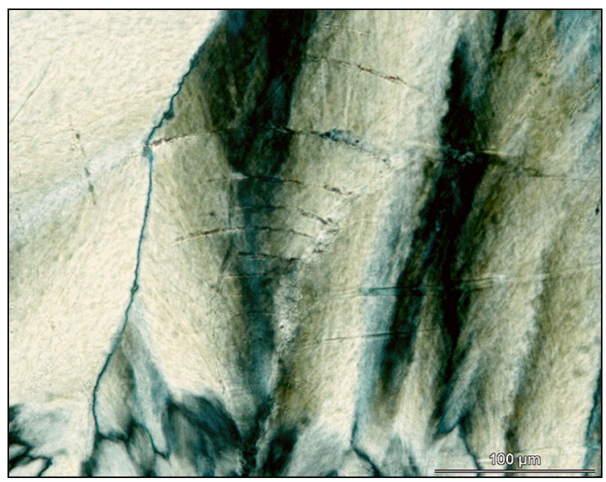

Fig. 2: 'Curved fractures' in spherulitic quartzine within chert from Jebel Waqf as Suwwan as potential shock-metamorphic features in microfibrous silica; note silica 're-crystallizaton bands' (cross-polarized light).

Steinheim, Germany. Chert nodules in brecciated Upper Jurassic target limestone from the ~3.8 km Steinheim impact crater [11], largely composed of chalcedony, display intense macroscopic brecciation and revealed a dendritic-suborthogonal fracture pattern associated with microscopic silica recrystallization bands (Fig. 3). The latter also occur in chert clasts within the Steinheim impact breccia drill cores. No microscopic effects suggestive of higher levels of shock, such as PFs or PDFs in quartz, have so far been found in the Steinheim cherts.

Fig. 3: Dendritic-suborthogonal fracture pattern and silica recrystallization bands in impact-brecciated chert from the Steinheim Basin, Germany (plane-polarized light).

Kentland, Indiana, USA. Carbonate-dominated polymictic lithic impact breccias from the central uplift of the ~13 km Kentland impact structure [12] contain clasts of partially recrystallized Paleozoic chalcedonic chert that show mainly single sets of PDFs in coarser-crystalline quartz domains (Fig. 4), similar to the Jebel Waqf as Suwwan cherts. Chert clasts in the impact breccia, moreover, commonly exhibit suborthogonal fracturing and silica recrystallization bands.

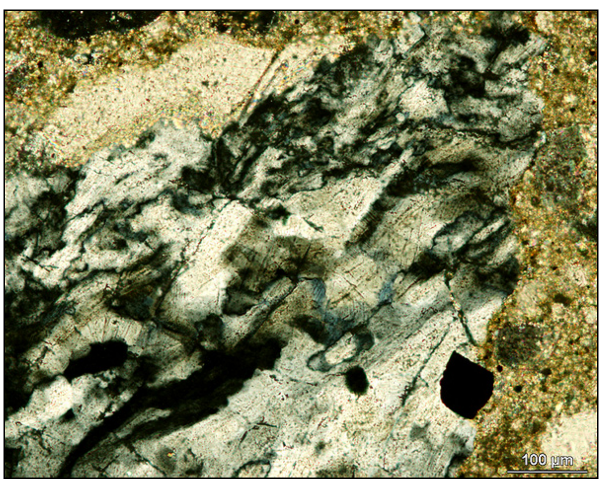

Fig. 4: Clast of recrystallized chert in carbonate-dominated impact breccia from Kentland Dome, USA; coarser-crystalline quartz domains (center) exhibit mainly single sets of PDFs (cross-polarized light).

Crooked Creek, Missouri, USA. Cherts from the central uplift region of the ~7 km Paleozoic Crooked Creek impact structure [13] are similar in composition to the Jebel Waqf as Suwwan samples and contain chalcedony, quartzine, and coarser-crystalline quartz. Quartz neither exhibits PFs nor PDFs, and spherulitic quartzine shows no curved fracture patterns like those observed at Jebel Waqf as Suwwan. However, silica recrystallization bands have been encountered in the Crooked Creek chert.

Interpretation and Summary: Cherts may exhibit various specific microdeformation features generated during an impact event. As a prime example, shocked chert nodules from the Jebel Waqf as Suwwan impact structure exhibit a wealth of features suggestive of impact-triggered deformation. Shock petrography of coarser-crystalline quartz in the Jebel Waqf as Suwwan and Kentland cherts indicates minimum shock pressures of ~8-10 GPa and high shock-induced differential stresses required for the formation of mechanical Brazil twins [7]. The internal crosscutting relationships of primary diagenetic and impact-related deformational features in the Jebel Waqf as Suwwan chert nodules, combined with shock pressure estimates, suggest that the 'curved fractures' across quartzine spherulites might represent specific (low- to medium-pressure) shock-metamorphic features, maybe in structural analogy to basal PFs in quartz [10]. The dendritic-orthogonal fracture network in the Jebel Waqf as Suwwan and Steinheim chert groundmass, as well as silica recrystallization bands (likely healed fractures), are probably related to impact-induced shear deformation and recrystallization, respectively, and cannot be considered as definite shock indicators. In summary, cherts might be of particular interest and promising in the search for shock-metamorphic microfeatures at proven and putative impact structures hosted by mainly carbonatic sedimentary target rocks.

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