Shock effects in quartz: compression versus shear deformation – An example from the Rochechouart impact structure, France

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The effects of the shock wave-associated stress resulting from a large meteorite impact are recorded in the microstructures of naturally shocked rocks. Quartz is especially useful to provide information on the stress conditions during shock, given the widespread occurrence of this mineral in the Earth's crust and its comprehensive experimental calibration. This study compiles effects in quartz resulting from compression due the high shock pressure, which is as a first approximation the mean stress of the shock wave-associated stress tensor, and from shear deformation due the high differential stresses during shock in target rocks and impact breccias from the Rochechouart impact structure. Micrustructures that result from compression/decompression are pockets of new quartz grains surrounded by intensely shocked quartz (Fig. 1) that shows intense mosaicism, as indicated by TEM analysis. This microstructure suggests that it formed by annealing of diaplectic glass. A high density of very fine rhombohedral planar deformation features (PDFs) that can merge into a mosaicism structure in TEM is common in shocked quartz from the Rochechouart impact breccia. These features indicate high shock pressures (20-35 GPa). Shock effects in quartz that record shear deformation are mechanical Brazil twins and planar fractures. These shock effects indicate high differential stresses on the order of a few GPa. Shock effects indicating high differential stress never occur together with those indicating high shock pressure. This suggests that the differential stresses at high shock pressure (>20 GPa), i.e. at high mean stress, are ineffective to cause shear deformation. Whereas at attenuated mean stress (<20 GPa) the differential stress gets relatively more effective.

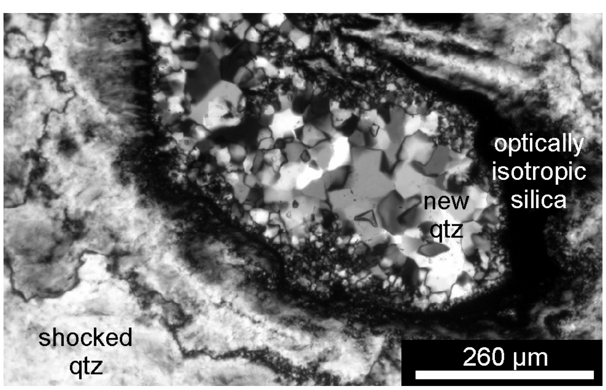

Figure 1: Pockets of newly crystallised quartz surrounded by intensely shocked quartz.

Sediment-microbe interactions in permeable sediments at hydrocarbon seeps in the Santa Barbara Channel, California

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Sediments of marine cold-seep areas exhibit high rates of hydrocarbon discharge and are unique dynamic systems with specific microbial communities connected to methane and/or oil degradation processes. Microbial activity in such systems is in general tightly coupled to advective transport mechanisms of fluids and hydrocarbons as well as to geochemical gradients in the sediment. Seeps in coastal shallow-water areas are, in contrast to deep-sea mud, characterized by sandy permeable sediments, thus enabling enhanced substrate exchange due to accelerated pore water transport processes. We investigated sandy sediments off Coal Oil Point (Santa Barbara Channel, California), one of the world's largest hydrocarbon-seep area, to study the effect of pore water transport processes on microbial methane and sulfur turnover, biogeochemical gradients as well as microbial community structure. Our results show accelerated microbial activity of anaerobic oxidation of methane and sulfate reduction in areas where reduced fluids, rich in hydrocarbons, are seeping through highly permeable surface sediments. Vertical and horizontal biogeochemical parameters such as sulfide, oxygen, methane, and sulfate reveal gradients and small-scale distribution patterns that differ from cold-seep systems of the deeper oceans. We suggest that these gradients and the resulting microbial activity are a result of pore water transport processes, where the supply of substrates is not limited to diffusion. Our data indicate that fast substrate supply and removal of inhibitory end products is an important factor enabling efficient microbial consumption of methane in marine sediments.