"ANTISYMMETRIC" SHOCK WAVE DISTRIBUTION AT RIES IMPACT CRATER, GERMANY?:A MICRO-RAMAN SPECTROSCOPICAL STUDY OF SHOCKED ZIRCON. A. Gucsik, Max Planck Institute for Chemistry, Department of Geochemistry,. Joh.-J.-Becherweg 27, D-55128 Mainz, Germany (gucsik@mpch-mainz.mpg.de).

Introduction: Zircon is a highly refractory and weathering-resistant mineral that has proven useful as an indicator of shock metamorphism in the study of impact structures and formations that are old, deeply eroded, and metamorphically overprinted (e.g., [1-3]. Zircon has advantages compared to quartz or other shock-metamorphosed rock-forming minerals that have been widely used as impact indicators, but are far less refractory. Furthermore, U-Pb dating of zircon can provide constraints on the ages of impact events or deposition of impact formations (e.g., [4] and references therein).

Effects of high degrees of shock deformation (>10 GPa) in quartz and other rock-forming minerals (e.g., feldspars), such as planar deformation features (PDFs), were first described from shocked granite inclusions in suevite. Additionally, shock metamorphic indicators, such as high-pressure mineral phases (e.g., coesite, stishovite), diaplectic quartz and feldspar glass, and fused quartz glass (lechatelierite) from suevite were also found in impact breccias from the Ries Crater. The Ries crater is the source of the moldavite tektites of the Central European Strewn Field [5,6].

The extent of shock metamorphism in minerals from the impact formations of the Ries impact crater can be classified into six stages (known as 0, I, II, III, IV, and V) that are characterized by various elastic and plastic deformation phenomena as well as isotropization of minerals, the formation of high-pressure phases and the occurrence of mineral or bulk rock melting [5,6].

The purpose of this investigation is to further investigate the capability of Raman spectroscopy to document shock deformation and to determine whether specific Raman effects in the zircon/scheelite-structure can be utilised to determine particular shock pressure stages.

Samples and Experimental Procedures: For this study, zircon samples were used that had been separated from three rock samples: (1) a glass bomb from suevite from the Aumühle site, which had been classified on the basis of shock metamorphic effects as a Stage IV specimen; (2) a biotite gneiss sample from Appetshofen, classified as Stage II, and (3) crystalline rock fragments from a suevitic sample obtained near Seelbronn, the shock stage of which was given as Stage III. These locations are shown in Figure 1. Crystals from these three zircon separates were cut both parallel and perpendicular to the c-axis, for the purpose of Raman spectrometric analysis.

Raman spectra were obtained with a Renishaw RM1000 confocal micro-Raman spectrometer with a 20 mW, 632 nm He-Ne laser excitation system and a thermo-electrically cooled CCD detector. The power of the laser beam on the sample was approximately 3 mW. Spectra were obtained in the range 100-1200 cm^{-1}, with approximately thirty seconds total exposure time. The spectral resolution (apparatus function) was 4 cm^{-1}. Raman spectra were taken from 3 μm^3 sample volume and CL spectra were obtained from approximately 35 x 45 µm areas.

Further details on the samples and methodology can be found in [7].

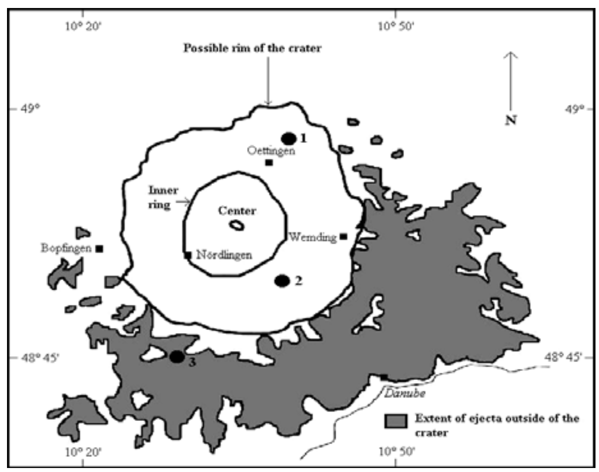

Figure 1. *Locality of the Ries basin in Germany and approximate extent of the Bunte Breccia and suevite breccia. Sample localities are indicated as 1=Aumühle, 2=Appertshofen, 3=Seelbronn. Outline of crater and extent of Bunte Breccia and suevite breccia.* *<u>Scale:</u> the diameter of the possible rim of the crater is approximately 26 km. Map from* [7].

Results and Discussion: The Raman spectra of the naturally shock-deformed zircon samples from the Ries crater (Stage-II: 35-45 GPa, Stage-III: 45-50 GPa, Stage-IV: >50 GPa) cut parallel and perpendicular to their crystallographic c-axes do not exhibit significant differences from each other. The fluorescence background and widths of the Raman bands in all samples are considerably larger than for the experimentally shock-deformed samples, which indicates lower crystallinity with major zoning and defects.

Both Stage-II (35-45 GPa) samples are characterized by five peaks at 224, 356, 439, 974 and 1007 cm^{-1}, indicating zircon-type structure as reidite (Figs. 2a,b). Additionally, a weak peak at 210 cm^{-1} appears in the Raman spectra of the Stage-II (parallel) sample (Fig. 2a). The peak intensities of the (perpendicular) sample are higher than those of the parallel-samples. The peak at 1007 cm^{-1} is relatively strong in the (perpendicular) sample (Fig. 2b).

The Raman spectrum of the Stage-III (45-50 GPa) sample (parallel) shows eleven peaks at 202, 224, 327, 356, 404, 439, 465, 558, 845, 974 and 1007 cm^{-1}, which indicate the presence of the scheelite-type phase among predominant zircon-type material (Fig. 2c). In contrast, the Stage-III perpendicular-sample contains only eight peaks at 202, 214, 224, 356, 404, 439, 974 and 1007 cm^{-1} showing pure zircon-type structure (Fig. 2d). A peak at 1007 cm^{-1} is relatively strong in the perpendicular-sample (Fig. 2d). In general, the fluorescence background in the parallel-sample is considerably higher than in the perpendicular-sample. In both cases, the peak intensities are similar [7,8].

The spectra of the Stage-IV samples (60-80 GPa, parallel- and perpendicular-samples) are characterized by seven peaks at 202, 215, 225, 356, 439, 974 and 1007 cm^{-1}, indicating zircon-type phase [7,8] (Figs. 2e,f). In both cases, a peak at 1007 cm^{-1} is relatively strong. The peak intensities of the perpendicular-sample are higher than those of the parallel-sample (Fig. 2f).

Conclusion: Whilst these three zircon fractions were obtained from three crystalline rock samples from the Ries crater, which, on the basis of the respective variation of shock metamorphic effects had been classified to belong to different shock stages (II-IV), the overall variation of deformation effects noted in this Raman investigation is not compatible with these shock classifications. A highly shocked rock was affected by a heterogeneous shock wave distribution, which causes different shock effects, such as e.g., microdeformations in the mineral content of whole rock. This also a wide range of shock stages in the various minerals that are present in such a rock, including unshocked fragments or clasts to partially or completely melted phases. Consequently, the shock-deformed zircons might be related to the low-shock regime (<30 GPa), and do not represent the same shock stages as indicated by whole-rock petrography indicating the anti-symmetric distribution of shock waves during the Ries impact event. The results show a clear dependence of the Raman properties of zircon with shock pressure, which confirms the possible use of this results in method as a shock indicator.

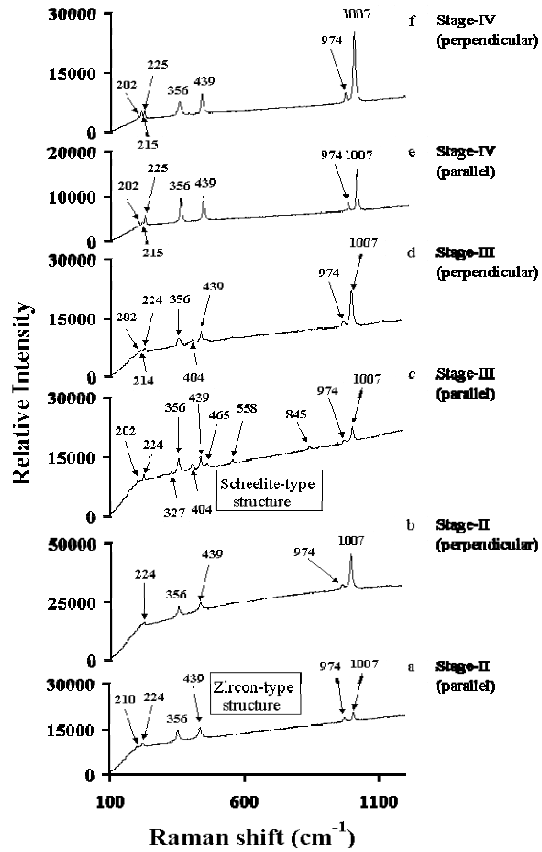

Figure 2. *Raman spectra of shock deformed zircon specimens from the Ries impact crater (Germany). Numbers denote peak positions in [cm^{-1}]. Data from* [7].

References:

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