MICRO-RAMAN PROPERTIES OF QUARTZ IN SUEVITE BRECCIA FROM RIES IMPACT CRATER, GERMANY.
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Introduction: Suevite is a shock-methamorphosed breccia (impactite) [1], which is formed by large impact events and can be found in many complex meteorite craters around the world. In general, most of the impact site's minerals have gone through sintering and melting during the impact event, but since suevite could contain various stages of shock metamorphism simultaneously, several grains of the original materials (quartz) can still be identified within the molten, or fragmented matrix material [2].

These grains can be used as indicators for the shock wave barometry [3], since their deformed lattice structure can be analyzed with micro-Raman spectroscopy enabling us to determine the shock encountered by this sample during the impact event. The purpose of this study is to investigate the stages of shock metamorphism of quartz from the suevite breccias using micro- Raman spectroscopy.

Experimental procedure: Our sample (Fig.1) has been collected in the Nördlinger-Ries crater (Aumühle carry), which is situated in Bavaria, Germany. It was formed approximately 14.4 million years ago and is one of the well-investigated impact craters around the world providing a great variety of the shock-metamorphosed minerals [5]. Two representative thin sections (designated as 49-4030 and 49-4036) were prepared for the present study.

Figure 1. *The suevite sample used in our study*

During our analysis, we worked with three thin sections of the same sample taken from different areas.

For the optical observations preceding the micro-Raman analysis, we used a NIKON Eclipse E200 microscope and the possible locations of the Raman spectra have also been determined.

We used a Reinshaw Rm-2000 Raman spectrometer and a Leica DM/LM microscope at the Research Institute for Solid State Physics and Optics in Budapest (SZFKI) to record the Raman spectra. The laser wavelength was 785 nm, and the spot site was focused to the sample with 1 µm (effective energy was 8 mW). Some micro-Raman spectra of two different grains 30/A and 36/B have been recorded, as well as the spectra of the matrix material and the epoxy coating.

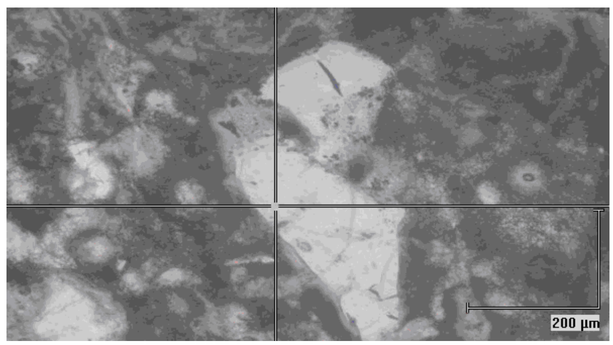

Figure 2. *The quartz clast 30/A located in the 49-4030 sample*

The 30/A (Fig.2.) fragment shows several fractures as well as a larger fractured piece at the upper side of the picture. It also posesses clear edges, however, the thin fracture lines inside indicate, that the grain did not went through a melting period.

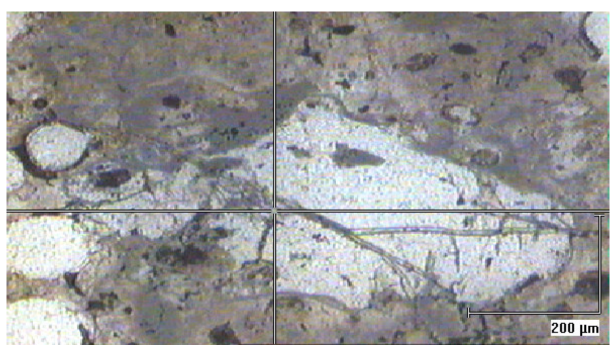

Figure 3. *The quartz clast 36/B located in the 49-4036 sample,*

The triangular quartz fragment of 36/B (Fig.3.) sample shows several inner fractures. This grain also lacks signs of melting. This grain also exhibits several inclusions, as well as a heavily fragmented area. With larger magnification several small planar deformation features (PDFs) are observable, (one of the most important mineralogical indicator of shock metamorphism). These features discernible in both the 30/A and the 36/B quartz grains

Results: The micro-Raman spectra of the selected quartz grains and Epoxy material were recorded in spectral wavelength ranging from 100 to 1000 cm^{-1}. (Fig. 4).

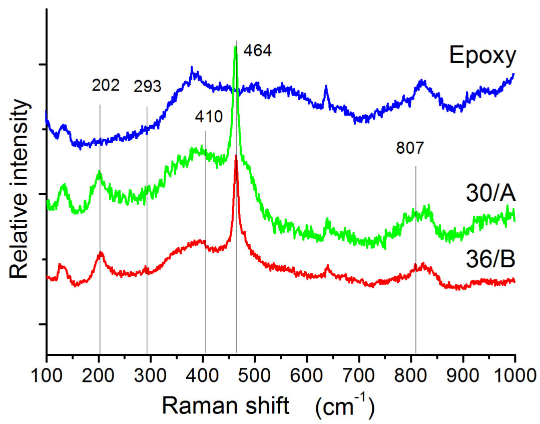

Figure 4. *Representative spectra of the epoxy coating, and of the 36/A and 30/B quartz grains.*

The measured peaks of the quartz in the 30/A grain were at 134, 202, 294, 410 cm^{-1} a very strong peak at 464 and 638 cm^{-1}, and a double peak at 805 cm^{-1}. in the 36/B grain we observed peaks at 137, 202, 293, and 410 cm^{-1}, also a very strong peak at 464, 640 cm^{-1}. and also a double peak at 805 cm^{-1}. We observed epoxy peaks at 137, 380, 500, 550, 636 and 820 cm^{-1}.

In the case when we neglect the matching peaks (possible epoxy peaks), we get the peaks at 202, 293, 410, and 464 and 807 cm^{-1} for the quartz observed.

Discussion: In previous systematic studies shock-deformed quartz in experiment and nature [1,3], it has been demonstrated that the micro-Raman spectroscopy is a powerful technique to determine the shock pressure-related characteristic structural properties of quartz from the impactites at different shock stages.

12GP	206	264	354	464	809
This study	202	293	410	464	807
25GP	-	-	-	486	820

Table 1. *The location of characteristic peaks (numbers correspond to cm^{-1}) at different shock pressures. Data from Gucsik et al. [3]*

Furthermore, we could denote that our sample's spectra show more similarities with the spectra of the quartz shocked at 12GPa. Also the peak at 202 cm^{-1} is a symmetric vibrational peak, which disappears at higher shock pressures (>25 GPa). It shows the very strong 464 cm^{-1} peak characteristic for regular unshocked quartz, as well as the peak in the 260-290 cm^{-1} intervall.

While the peak recorded at 820 cm^{-1} is without doubt an epoxy peak, a less intense peak is also observable in both grains at 805-807 cm^{-1} which could indicate the presence of another maximum, masked by the more intense epoxy peak.

It is also important to note, that the peaks observable in all spectra at 134-137 cm^{-1} are in fact not epoxy peaks, but maximums characteristic for the micro-Raman spectrometer utilized by this study.

In general, a slight shift is observable in the peak positions of our sample, when compared to lower pressures. This and the mild increase in background intensity indicates pressuers higher than 12 GPa.

Conclusion: In a comparison with the reference spectra and with other data collected by previous studies [6]. We can conclude that the given sample of suevit has gone trough shock events with a magnitude of about 15 ± 3GPa.

For the further investigations, it is also planned to obtain Scanning Electron Microscope-Cathodoluminescence (SEM-CL) data on quartz grains from suevite to understand more about the microelement migration due to the increasing shock pressure.

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References: [1] Gucsik et al. (2004) Meteoritics & Planetary Science 39, 1273-1285 [2] Okumura et al. (2007) Lunar and Planetary Science XXXVIII, abstract, abstract#1062. [3] Gucsik et al. (2003) Meteoritics & Planetary Science 38, 1187-1197. [4] Mihályi et al., (2009) Lunar and Planetary Science Conference, abstract#1542. [5] Engelhardt et al. (1995) Meteoritics 30, 279-293. [6] Kayama et al. (2010) Meteoritics and Planetary Science Supplement, abstract#5192. [7] Okumura et al. (2006) Meteoritics and Planetary Science Supplement, abstract#5189.