

PPS003-P02

Room:Convention Hall

Time:May 26 10:30-13:00

Microstructural analyses of shocked quartz from Dhala impact structure in India

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Dhala impact structure, northern India was newly discovered with ~11-km-wide ring structure, and its stratigraphical age is estimated to be between ca. 2.5 Ga and ca. 1.7 Ga [1]. Although this structure has been largely eroded, abundant shock-metamorphic signatures are evidence for an impact shock. However, there has been no quantitative estimate for shock pressure and no crystallographic orientation studies yet. Here we show a quantitative estimate for shock pressure of the Dhala structure through the analysis of shocked quartz microstructures (PDF: Planar Deformation Feature and ballen texture).

Shocked quartz from terrestrial impact craters shows characteristic microstructures, such as planar deformation features (PDFs) and ballen textures. PDFs are one of shock-produced microstructures that are intracrystalline lamella with optical and crystallographic contrast from host crystal. Individual PDFs show a width of typically 2-3 micrometers, which closely spaced in typically 2-10 micrometers within grains. They occur parallel to certain rational crystallographic planes in quartz lattice, and the common plane families for PDFs are formed along {10-13}, {10-12} and (0001). The shock experiments and natural examples confirmed that different sets of PDFs crystallographic planes are changed in term of progressive shock stages, determining a shock pressure from the PDFs [2]. Using this relation, we can quantitatively determine a shock pressure for the Dhala structure.

Ballen texture in shocked quartz is characterized by a fish-scale like texture under the optical microscope. It was suggested that the ballen texture represented pseudomorphs as a result of volume shrinkage after cristobalite had replaced lechatelierite initially formed by shock-induced thermal transformation of quartz [3] or recrystallized diaplectic quartz glass initially formed by shock wave [4]. There are five categories of ballen textures [5]:

- I. alpha-cristobalite ballen with homogeneous extinction.
- II. alpha-quartz ballen with homogeneous extinction.
- III. alpha-quartz ballen with heterogeneous extinction.
- IV. alpha-quartz with intraballen recrystallization.
- V. chert-like recrystallized ballen alpha-quartz.

Previous studies have focused on the mineralogy and formation mechanism, but there is no crystallographic orientation analysis for their five categories. Therefore, we conducted an electron back scattered diffraction (EBSD) analysis to discriminate these category.

U-stage analysis of PDFs showed the development of PDFs in a few rhombohedral planes in quartz, most frequently parallel to planes of {10-13} and {10-12} forms. This suggests that these quartz grains were suffered from shock wave-associated stress of 20-25GPa without the involvement of shear. Because shock experiments suggested ballen quartz forms under the pressure exceeding 30GPa [4], these quartz clasts underwent a shock pressure of 20-30GPa. EBSD patterns reveal correlation between crystallographic orientation and fish-scale like textures of type II and III ballen quartz, suggesting that they preserved initial formation process. However, many of IV and V have no such correlation likely reflecting signature of late recrystallization. In the presentation, in addition to the result of the U-stage and EBSD analyses, we report TEM observations of PDFs in detail.

References: [1] Pati, J.K., Reimold, W.U., Koeberl, C. and Pati, P., 2008, *Meteor. & Planet. Sci.*, **43**, p. 1383-1398. [2] Langenhorst, F. & Deutsch, A., 1994, *Earth and Planet. Sci. Lett.*, **125**, p.407-420. [3] Carstens, H., 1975, *Contrib. Miner. Petrol.*, **50**, p.145-155. [4] Bischoff, A. & Stoffer, D., 1984, *J. Geophys. Res.*, **89**, B645-B656. [5] Ferriere, L., Koeberl, C., and Reimold, W.U., 2009, *Eur. J. Miner.*, **21**, p.203-217.

Keywords: shocked quartz, PDFs, ballen, Dhala