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(May 22-27 2011 at Makuhari, Chiba, Japan)

PPS003-P01 Room:Convention Hall Time:May 26 10:30-13:00

Dynamic event recorded in a lunar meteorite NWA 4734

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It is assumed that Late Heavy Bombardment (LHB) occurred in the inner solar system from 4.1 to 3.8 billion years ago. Many planetesimal and/or meteorites collided on the Earth during LHB. The Moon also would experience LHB because many impact craters and thick regolith exist on the Moon. Lunar meteorites would have information about such dynamic events occurred on the Moon. Shock pressure condition could be estimated based on high-pressure mineral assemblages contained in the lunar meteorites.

In this study, we investigated a lunar meteorite, Northwest Africa (NWA) 4734 by scanning electron microscope (SEM), Raman spectroscopy, electron probe micro analyzer (EPMA), X-ray diffraction (XRD) and Cathodoluminescence (CL) spectroscopy. Previous work [1] reports that the high-pressure polymorph of SiO_2 may exist in NWA 4734. Accordingly, we focused our investigation on the high-pressure polymorphs of SiO_2.

NWA 4734 is unbrecciated basalt. Major constituent minerals of NWA 4734 studied here are clinopyroxene, plagioclase (maskelynite), olivine, ilmenite, and SiO_2. Many shock-melt veins and melt pockets exist in the NWA 4734. Raman spectroscopy and SEM observations show that dendritic coesite exists in the SiO_2 gain entrained in the shock-melt vein. Raman spectroscopy indicates that pyroxene-glass was identified in the matrix of the shock-melt vein, which might originate from silicate-perovskite. SiO_2 grains with lamellar textures were observed in a host-rock of NWA 4734. XRD patterns indicate that the SiO_2 grain contains alpha-PbO_2-type SiO_2 seifertite (a = 4.079(2) A, b = 5.030(2) A, c = 4.485(1) A). A small amount of stishovite was identified by XRD, CL and Raman in some SiO_2 grains with lamellar textures. The phase equilibrium diagram of SiO_2 show that cristobalite transforms to seifertite at ~40 GPa at room temperature [2, 3]. It is likely that the SiO_2 grain was originally cristobalite based on several previous studies [e.g., 1, 4]. Accordingly, shock pressure condition recorded in NWA 4734 is at least ~40 GPa.

Reference

[1] H. Chennaoui Aoudjehane, A. Jambon, First evidence of high pressure silica: stishovite and seifertite in lunar meteorite Northwest Africa 4734, 71st Annual Meteoritical Society Meeting (2008) (abstract #5058).

[2] Y. Tsuchida, T. Yagi, New pressure-induced transformations of silica at room temperature, Nature 347 (1990) 267-269.

[3] L. S. Dubrovinsky, N. A. Dubrovinskaia, S. K. Saxena, F. Tutti, S. Rekhi, T. Le Bihan, Guoyin Shen, J. Hu, Pressure-induced transformations of cristobalite, Chemical Physics Letters 333 (2001) 264-270.

[4] J. J. Papike, G. Ryder, C. K. Shearer, Lunar samples, In Planetary Materials, Reviews in Mineralogy & Geochemistry 36, edited by J. J. Papike (1998) 5-1-5-234.

Keywords: moon, silica, coesite, stishovite, seifertite

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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. & Stoffler, 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