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

PPS003-01 Room:202 Time:May 26 14:15-14:45

Dissociation of olivine to silicate-perovskite and magesiowustite in the shocked Martian meteorite DaG 735

Masaaki Miyahara[1*], Eiji Ohtani[1], Shin Ozawa[1], Makoto Kimura[2], Ahmed El Goresy[3], Takeshi Sakai[1], Toshiro Nagase[1], Kenji Hiraga[4], Naohisa Hirao[5], Yasuo Ohishi[5]

[1]Graduate School of Science, Tohoku Univ., [2]Faculty of Science, Ibaraki Univ., [3]Universitat Bayreuth, [4]IMR, Tohoku Univ., [5]JASRI

Equilibrium high-pressure and -temperature experiments indicate that olivine dissociates to (Mg,Fe)SiO_3-perovskite (Pv) + magnesiowustite (Mw) around and below the transition zone of the Earth. The dissociation of olivine has never been reported from any natural samples so far. Therefore, the dissociation mechanism of olivine in natural samples may be unclear. We report first evidence for the natural dissociation of olivine in the shergottite Dar al Gani (DaG) 735 at high-pressure and -temperature condition induced by a dynamic event on Mars. Olivine (Fa_{34-41}) adjacent to or entrained in the shock vein and melt pockets of Martian meteorite, olivine-phyric shergottite Dar al Gani 735 dissociated to (Mg,Fe)SiO_3-perovskite (Pv) + magnesiowustite (Mw), whereby perovskite partially vitrified during decompression. Transmission electron microscopy (TEM) observations reveal that micro-texture of olivine dissociation products evolve from lamellar to equigranular with increasing temperature at the same pressure conditions. This is in accord with the observations of synthetic samples recovered from high-pressure and temperature experiments leading to equigranular (Mg,Fe)SiO_3-Pv and Mw have 50-100 nm in thickness and lamellar (Mg,Fe)SiO_3-Pv and Mw have ~20 and ~10 nm in diameter, respectively. The measured partitioning coefficient, $K^{Pv/Mw}$ = $[FeO/MgO]_{Pv}/[FeO/MgO]_{Mw}$, between (Mg,Fe)$SiO_3$-Pv and Mw in equigranular and lamellar textures are ~0.15 and ~0.78, respectively. The dissociation of olivine implies that the pressure and temperature conditions recorded in the shock vein and melt pockets during the dynamic event were ~25 GPa but 700 degree at least.

Keywords: olivine, decomposition, silicate-perovskite, magnesiowustite, TEM, FIB

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

PPS003-02 Room:202 Time:May 26 14:45-15:00

Petrology and Mineralogy of the RBT 04261 Shergottite

Takafumi Niihara[1*], Hiroshi Kaiden[2], Keiji Misawa[2]

[1]SOKENDAI, [2]NIPR

Ages from cratering analysis of image data on the Martian surface [1] and radiometric ages of Martian meteorites [2] provide important insights into the crustal evolution of Mars. These ages, however, have come under great debate recently. Bouvier et al., [3. 4] reported Pb-Pb ages of ˜4100 Ma for the Martian meteorites, Zagami, Shergotty, and Los Angeles, and concluded that the lithosphere of Mars is extremely old, and furthermore that the young Rb-Sr and Sm-Nd ages of ˜180 Ma so far reported for Martian meteorite shergottites [2] represent resetting of the isotopic systems by shock metamorphism or by aqueous fluid activities on Mars.

The U-Pb isotopic system for baddeleyite (ZrO_2) has several advantages for resolving this age conflict. First, baddeleyite occurs in shergottites as an accessory mineral and retains some uranium but excludes thorium and common lead during its crystallization. Second, baddeleyite is known to be highly durable in aqueous fluids [5]. Finally, the thermal diffusivities of uranium and lead in baddeleyite are considered to be much smaller than those of strontium and rare earth elements in pyroxene, plagioclase, and phosphates, making the U-Pb system of baddeleyite more resistant to resetting during reheating events. To determine robust crystallization ages of shergottites, we have undertaken petrological and mineralogical study of RBT 04261, enriched lherzolitic shergottite, to determine shock effect on baddeleyite.

RBT 04261 is mainly composed of pyroxene, olivine, and plagioclase glass (maskelynite) and shows poikilitic and non-poikilitic lithologies. Melt pockets (˜100 micrometer in size) are found in pyroxene and maskelynite in non-poikilitic area. Baddeleyite grains are found in the non-poikilitic lithology, and most of them are associate with ilmenite. A few baddeleyite grains showed euhedral in shape and occurred with maskelynite. The baddeleyite does not convert from monoclinic to any high-pressure and -temperature polymorph of ZrO_2 in RBT 04261. There is no SiO_2glass, which is associate with baddeleyite, suggesting that the baddeleyite is not a decompositional product of $ZrSiO_4$ by shock metamorphism [6]. Baddeleyite surrounded by melt pocket was rarely observed. Baddeleyite is not melted even in melt pocket.

The U-Pb age for baddeleyite in RBT 04261 [7] thus is consistent with the radiometric ages (˜180 Ma) previously reported for Zagami, Shergotty, Los Angeles, and RBT 04262 [2, 8]. The implication from petrology, mineralogy, and isotopic study [7] of baddeleyite in Martian meteorites is that volcanic activity on Mars continued to the resent past, at least to a few hundred million years.

References: [1] Hartmann W.K. and Neukum G. 2001. Space Sci. Rev. 96: 165. [2] Nyquist L.E. et al. 2001. Space Sci. Rev. 96: 105. [3] Bouvier A. et al. 2005. Earth Planet. Sci. Lett. 240: 221. [4] Bouvier A. et al. 2008. Earth Planet. Sci. Lett. 266: 105. [5] Lumpkin G.R. 1999. J. Nucl. Mater. 274: 206. [6] El Goresy A. 1965. J. Geophys. Res. 70: 3453. [7] Niihara T. et al. (2010) Meteorit. Planet. Sci. 45: A152. [8] Shih C.-Y. et al. 2009. 40th Lunar Planet. Sci. Conf.: Abstract #1360.

Keywords: Shergottite, Crystallization age, Baddeleyite, Shock

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

PPS003-03 Room:202 Time:May 26 15:00-15:15

On the formation of nano-particles in olivine from Martian meteorites by shock metamorphism

Takashi Mikouchi[1]*, Taichi Kurihara[1], Takeshi Kasama[2]

[1]Dept. Earth & Planet. Sci., U. of Tokyo, [2]Technical University of Denmark

Recent recovery of many Martian meteorites from hot and cold deserts has revealed that olivine shows dark color in many samples unlike other extraterrestrial olivines. Especially, olivine in the NWA2737 chassignite is completely black and has lead to the discovery of nano-particles of Fe-Ni metal (10-20 nm) in olivine which is responsible for the dark color [e.g., 1,2]. The formation of such nano-particles is important to properly interpret the remote sensing data and their magnetic signatures [e.g., 3,4]. Then, the question is whether similar nano-particles are pervasively present in other Martian meteorites with dark-colored olivine. We analyzed these Martian meteorites (powder) by transmission electron microscopes (TEM) and found that nano-particles are present in all samples we studied (ALH77005, LEW88516, Y000097, NWA1950, Dhofar 019, and LAR06319) [5,6]. Their abundance appears related to the degree of darkening. ALH77005 and Y000097 contain Fe-Ni metal nano-particles similar to NWA2737. However, magnetite nano-particles were found in LEW88516, NWA1950, Dhofar 019, and LAR06319. The presence of magnetite nano-particles would be also responsible for the dark color of olivine as is the case for Fe-Ni metal nano-particles. We further analyzed olivine in NWA1950 by advanced TEM because this sample has been reported to contain Fe-Ni metal nano-particles [1] although we found magnetite. The sample prepared by focused ion beam (FIB) technique contained Fe metal nano-particles (15-20 nm) as reported by [1]. However, we also found small amounts of hematite that is most likely to be formed during sample preparation by FIB [7]. In our FIB sample, we could not find magnetite nano-particles. The EDS line analysis across nano-particles showed clear increase of Fe and slight decrease of Si and Mg within the nano-particles. The olivine host often showed Moire fringes with polycrystalline textures that may be also due to re-deposited crystalline phases by FIB sample preparation.

Fe-Ni metal nano-particles have been suggested to be formed by reduction of Fe^{2+} in olivine by shock metamorphism [e.g., 1,2]. In contrast, the formation of magnetite requires oxidation of Fe^{2+}, but similar shock metamorphism should be responsible for the formation. In order to re-produce the formation of nano-particles by shock, we performed shock experiments on San Carlos olivine (powder) at 20, 30, 40, and 46 GPa. We found that shock pressure at 40 and 46 GPa produced magnetite nano-particles in olivine [8]. These shock pressures are in accordance with the estimated shock pressure of Martian meteorites that contain dark olivine. The formation of different species of nano-particles (Fe-Ni metal or magnetite) would be explained by the different redox state during shock on Mars. Since it is unlikely to consider large difference of fO_2, temperature difference during shock could be controlling the formation of these species. Indeed, we could reproduce Fe-Ni metal nano-particles instead of magnetite by heating shock experiment (400 and 800 ^{o}C) on San Carlos olivine at 40 GPa [9]. Thus, NWA1950 may be a sample containing both Fe metal and magnetite because of heterogeneous increase of temperature within the sample. It is still unexplained why such dark color olivine is seen exclusively in Martian meteorites although such strong shock metamorphism is seen other meteorite types. Because Mars is the only possible parent body with water, water may play an important role for the formation of nano-particles by shock metamorphism.

References: [1] Van de Moortele B. et al. (2007) EPSL, 262, 37-49. [2] Treiman A. H. (2007) JGR, 112, E4, E04002. [3] Pieters C. M. et al. (2008) JGR, 113, E06004. [4] Hoffmann V. et al. (2009) LPS XL, #2194. [5] Kurihara T. et al. (2008) LPS XXXIX, #2478. [6] Kurihara T. et al. (2009) LPS XL, #1049. [7] Mikouchi T. et al. (2011) LPS XLII, #1689. [8] Kurihara T. (2008) LPS XXXIX, #2505. [9] Kurihara T. et al. (2010) LPS XLI, #1655.

Keywords: olivine, nano-particle, shock metamorphism, martian meteorites

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

PPS003-04 Room:202 Time:May 26 15:15-15:30

Effects of meteoroid impacts on lunar crust

Tomoko Arai[1*]

[1]Chiba Institute of Technology

Lunar feldspathic crust is considered to be a product of a primordial magma ocean crystallization. Mineral distribution and chemical composition of the lunar crust provides us with keys to understand the composition and the mode of crystallization of a magma ocean. Rock types and compositions of the lunar crust have been understood by Apollo samples, lunar meteorites and remote sensing. Most of the rock samples originated from the lunar feldspathic rust are brecciated and thermally altered to the variable extent due to the multiple meteoroid impacts on the lunar surface. Since mineral distribution and composition of the primary crust is critical to discuss the magma ocean composition, the effect of meteoroid impacts on the petrology, mineralogy and chemistry of the primary lunar crust should be properly evaluated.

Mineralogical studies of lunar feldspathic meteorites indicate that fragments of the possible primary crust are preserved in some, but many are thermally altered. The thermally metamorphism on the lunar crust tends to occur in a local extent around the target sites of the meteoroid impacts. The mode and degree of the thermal metamorphism are variable, resulting mainly in the change in mineral distribution and composition, but less likely in the bulk-rock chemical composition. Some paired meteorites, which are blasted off the moon by a single meteoroid impact, are geochemically identical, but mineralogically distinct.

Recent lunar remote sensing, such as Kaguya enable us to understand the mineralogy of the lunar crust with a high spatial resolution (20m/pixel). These data reveal that the lunar crustal mineralogy is diverse with a variable proportion of low-Ca pyroxene and olivine plus dominant plagioclase. Such apparent mineralogical diversity may be resulted from the secondary metamorphism by the meteoroid impacts, rather than the initial crystallization from a magma ocean.

Keywords: Meteoroid impact, Moon, Lunar crust, Thermal metamorphism

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

PPS003-05 Room:202 Time:May 26 15:30-15:45

Formation analyses of terrestrial and extraterrestrial materials by carbon-bearing textures at various impact events

Yasunori Miura[1]*

[1]Yamaguchi University

The present study is summarized as follows:

1) Carbon element is related with material changing driving force at any impact and shock wave processes on the solar system bodies of the Earth, the Moon, Mars and Asteroids.

2) Carbon-bearing materials can be found impact craters on the dry lands and water-bearing ocean impacts on the Earth.

3) Multi-events of the Earth, Mars and the Moon can be analyzed by formation of carbon-bearing textures, which are characteristic material indicators of impact growth reaction with various conditions.

4) Meteorites formed at airless asteroids show various carbon-bearing textures by impacts on vacuum extraterrestrial locations.

5) The Moon show carbon-bearing compositions and features on polymict breccias during impacts on the airless Moon and asteroids, together with solar wind activity.

6) Germany Ries crater with carbon-bearing data also in drilled samples are relicts of limestone rock by impact.

7) Ocean-impacts on active Earth planet can be analyzed by carbon- or chlorine (halite-like)-bearing grains on impact samples of the KT and PT geological boundaries (Europe and China), impact glass (Libyan LDSG glasses) and broken Congo diamonds.

8) The present data of multi-events indicator can be applied unknown multi-event drilled samples of the Takamatsu (Kagawa) buried broken crater by near-crater bottom samples, and the Akiyoshi (Yamaguchi) breccias limestone blocks transported by buried blocks under the continents at ocean-impact remnants at southern separated places.

Keywords: carbon-bearing texture, impacts, material indicator of growth, meteorite impact, ocean-impact, carbon and chlorine

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

PPS003-06 Room:202 Time:May 26 15:45-16:15

Physical condition produced by high-velocity impacts

Toshimori Sekine[1*]

[1]DEPSS, Hiroshima University

It has been generally recognized that impact phenomena occurred more frequently in LHB than the present time. Impact-induced compression waves and the associated rarefaction waves change the state and shape of matters in both of impactor and target. We can observe part of such materials after the dynamic process as meteorites or impactites. As well as three basic parameters of pressure, temperature, and duration, there are several critical factors to control the impact-induced physical sate such as the impact speed and angle, the initial state of matter, the size of impactor and so on. Recent studies provide estimation methods of pressure based on the experimental data but temperature is not so easy to be estimated because the initial state (especially porosity, its distribution, grains size, thermal conductivity, etc) affects greatly temperature rise even if compressed at a pressure. Pressure will be equilibrated faster, but temperature will be relatively slower. High-pressure minerals in meteorites are observed in the shock veins that display higher temperature than the surrounding host rock and that are not always equilibrated thermally. Therefore it is important to understand the mechanism of shock vein formation and local heating. We need to investigate how shock veins are formed through not only shock recovery experiments but also in-situ measurements of physical condition in the process of high-velocity impacts. I address importance to check temperature profile spatially and time-resolvedly to understand the formation mechanism.

Keywords: Physics and chemistry of impacts, Shock metamorphism, Experimental study, Shock temperature

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

PPS003-07 Room:202 Time:May 26 16:30-16:45

Asteroidal collision inferred from meteorites: A preliminary results on the systematic survey for NIPR collection

Makoto Kimura[1*], Yamaguchi Akira[2], Kojima Hideyasu[2]

[1]Faculty of Science, Ibaraki University, [2]National Institute of Polar Research

Collision is one of the most important processes for the evolution of asteroid. Meteorites, mostly originated from asteroids, show the evidence for asteroidal collision, such as breccia, shock-induced vein, and the occurrence of exotic clast. These features were already documented for many meteorites [e.g., 1, 2]. However, the relative abundance of meteorites subjected to collisional process has been rarely reported, in spite of its significance. Systematic study is necessary to explore the collisional process based on a large collection. One of the best collection is a great number of Antarctic meteorites in NIPR. We have started such study on this collection, and here present the preliminary results.

According to the published data for chondrites in NIPR collection, 86 show distinct breccia texture. 145 chondrites include some kinds of clast, such as shock-darkened, granular, igneous and foreign clasts. 75 chondrites contain shock vein and melted area. An ultrahigh pressure mineral, ringwoodite, is often encountered in such vein under optical microscope. As noticed by Lin and Kimura [3], melt rock and breccia are common in these enstatite chondrite collection. Thus, brecciation and other shock features induced by asteroidal collision are commonly observed in NIPR collection.

References: [1] Keil K. (1994) Planet. Space Sci., 42, 1109-1122, [2] Bridges J.C. and Hutchison R. (1997) MAPS, 32, 389-394. [3] Lin Y. and Kimura M. (1998) MAPS, 33, 501-511.

Keywords: asteroid, collision, meteorite

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

PPS003-08 Room:202 Time:May 26 16:45-17:15

Approach to asteroidal impacts by static high-pressure experiments

Naotaka Tomioka[1]*

[1]ISEI, Okayama University

Impact event is one of the important processes for accretion and evolution of the planetary system. The event is recorded in petrographic features such as deformation, recrystallization, melting, and phase transformations of meteoritic minerals. Shock pressures in meteorites have been estimated only on the basis of shock recovery experiments [1]. However, the shock pressure duration should be significantly different between laboratory shock and natural shock because the pressure duration in shock compression is proportional to the size of target materials. In the case of laboratory shock experiments, the target size and pressure duration are 10^{-3} m and 10^{-6} seconds, respectively. The large parent bodies of chondrites result in much longer timescales for shock pressures resulting from natural impact compared with laboratory shock experiments. In fact, several researchers claimed that the peak pressure of natural impact persists from tens of milliseconds to several seconds in terms of the ultrahigh-pressure mineralogy and cation-diffusion profiles in shock-induced veins [2-4]. Therefore, if the kinetics of phase transformations are sluggish enough relative to the timescale of shock experiments, shock pressures of heavily shocked meteorites could be overestimated.

As an attempt to reevaluate the present shock-pressure scale, we focused on the formation pressure of diaplectic feldspar glass that is called maskelynite in heavily shocked meteorites. Static compression experiments of albitic plagioclase (Ab_{99}) have been demonstrated under moderately high temperature using an externally heated diamond anvil cell with pressure duration of tens of minutes. The temperature and time dependence of the amorphization pressure of albitic plagioclase and its mechanism of amorphization were investigated on the basis of the Raman spectroscopy and transmission electron microscopy (TEM) of recovered specimens. Combining the data of the in situ X-ray diffraction study of Ab_{98} plagioclase [5] and those of the present study [6], we find a clear trend where the amorphization pressure decreases with increasing temperature. In addition, the results of the present study suggest that shorter pressure duration results in a lower degree of amorphization in plagioclase. The formation of maskelynite in shocked meteorites does not necessarily require the very high shock pressure (30-90 GPa) that was previously estimated on the basis of shock recovery experiments [1]. The shock pressure calibration, especially for high shock stages, needs further reevaluation.

References:
[1] Stoffler, D., K. Keil, and E. R. D. Scott (1991) *Geochim. Cosmochim. Acta* 55, 3845?3867.
[2] Beck, P., P. Gillet, A. El Goresy, and S. Mostefaoui (2005) *Nature* , 435, 1071-1074.
[3] Ohtani, E., Y. Kimura, M. Kimura, T. Takata, T. Kondo, and T. Kubo T. (2004) *Earth Planet. Sci. Lett.*, 227, 505-515.
[4] Xie, Z., and T. Sharp (2007) *Earth Planet. Sci. Lett.*, 254, 433-445.
[5] Kubo, T., M. Kimura, T. Kato, M. Nishi, A. Tominaga, T. Kikegawa, and K. Funakoshi (2010) *Nature Geosci.* , 3, 41-45.
[6] Tomioka, N., H. Kondo, A. Kunikata, T. Nagai (2010) *Geophy. Res. Lett.*, 37, doi:10.1029/2010GL044221

Keywords: shock metamorphism, maskelynite, plagioclase, diamond anvil cell

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

PPS003-09 Room:202 Time:May 26 17:15-17:45

Shock metamorphism in shock induced melt veins of L chondrites: Constrain shock pressure and duration.

Zhidong Xie[1*], Thomas Sharp[2], Paul DeCarli[3]

[1]Nanjing University, [2]Arizona State University, [3]SRI International

Shock metamorphism resulting from hypervelocity collisions between planetary bodies, is a fundamental processes in the solar system. The term "shock metamorphism" is used to describe all changes in rocks and minerals resulting from the passage of shock waves. Most meteorites have experienced collisions and have a record of shock metamorphism, which include brecciation, deformation, phase transformation, local melting and crystallization. The key to reading this record is to use the shock features to estimate the pressure and duration of shock event, which can be related back to velocity and size of the impacting bodies. A widely used shock-classification scheme for chondrites was proposed by Stoffler et al. 1991. This shock classification system is easy to apply and correctly represents the progressive shock-pressure sequence from weak to strong. However, pressure calibration based on shock recovery experiments is problematic for some shock features, such as phase transformations, which depend on reaction kinetics.

An alternative means of estimating shock pressure is to use the mineralogy of melt veins to estimate crystallization conditions based on phase relations determined in static high-pressure experiments. Shock-induced melt veins contain two lithologies. One consists of polycrystalline grains that transformed from host rock fragments by solid-state mechanisms. The other consists of quenched silicate and metal-sulfide grains that crystallized from shock-induced melts. The crystallized mineral assemblages can be used to constrain the crystallization pressure of the melt based on phase equilibrium data, and then infer the shock pressure. The shock duration can be constrained by using transformation kinetics, such as the crystallization rate of the melt-vein matrix, or growth rate of the high-pressure minerals, or using elements diffusion rate between two minerals.

Here we report the TEM observations of the mineral assemblages in the shock-induced melt veins in several L chondrites of shock stages S3 to S6. The mineral assemblages combined with phase equilibrium data are used to constrain the crystallization pressures. The goal is to see how crystallization pressures are related to the shock pressures inferred from Stoffler's shock classification. Based upon the assemblages observed, crystallization of shock veins can occur before, during or after pressure release. When the assemblage consists of high-pressure minerals and that assemblage is constant across a melt vein or pocket, the crystallization pressure corresponds to the equilibrium shock pressure. Equilibrium shock pressures inferred from the mineralogy of shock-induced melt veins suggest that the pressure calibration of Stoffler et al. is too high by a factor of at least two for highly shocked (S5-S6) chondrites.

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

PPS003-10 Room:202 Time:May 26 17:45-18:00

Shock Conditions and Formation Mechanism of Akimotoite-Pyroxene Glass Assemblages in the Grove Mountains (GRV) 052082

Lu Feng[1*], Masaaki Miyahara[2], Toshiro Nagase[2], Eiji Ohtani[2], Sen Hu[1], Ahmed El Goresy[3], Yangting Lin[1]

[1]Institute of Geology and Geophysics, CAS, [2]Tohoku University, [3]Bayerisches Geoinstitut

Introduction: Aggregates of high-pressure minerals in heavily shocked meteorites were generally considered to have formed via solid-solid phase transformation [e.g., 1]. On the other hand, several previous studies demonstrated that some high-pressure minerals were formed from a chondritic or mono-mineralic melt induced by a dynamic event [e.g., 2, 3].

Grove Mountains (GRV) 052082 is an L6 chondrite found in Grove Mountains, Antarctica. GRV 052082 was severely shocked, producing melt veins up to 2 mm wide intersecting the whole studied section. The shock-induced melt veins were studied to estimate the pressure-temperature conditions of the natural shock event, and to clarify formation mechanisms of the high-pressure minerals.

Results: The matrix of the melt veins mainly consists of fine-grained majorite-pyrope solid solution and ringwoodite. The host-rock clasts entrained in the veins are mostly rounded or ovoid. Ringwoodite, majorite, akimotoite, pyroxene glass, jadeite, lingunite and maskelynite were identified by Raman in the clasts.

Most low-Ca pyroxene in the clasts has been partially or totally replaced by akimotoite-pyroxene glass assemblages, which contains micron-sized areas with variable brightness in the back-scattered electron images. This is in contrast to the homogeneous grains in the host-rock ($Fs_{20.5-21.3}$). FIB-TEM investigation of areas depicting different brightness reveals that they are composed of idiomorphic akimotoite (Fs_{15-17}) grains (ranging from 100 nm to 400 nm) scattered in pyroxene glass (Fs_{31-39}). The CaO contents of pyroxene glass (0.4-4.5 wt%) are slightly higher than those of akimotoite (0.1-3.1 wt%) and the pyroxene grains in the host (0.8-1.0 wt%). However, the Al_2O_3 contents of them are almost identical.

Discussion: The existence of majorite-pyrope solid solution and ringwoodite in the melt veins is similar to those reported in other shocked L6 meteorites[4-6], suggestive of crystal-liquid origin at a peak shock pressure and temperature of 18-23 GPa and $>$ 2,000^o C, respectively, based on phase diagrams obtained by high-pressure and -temperature melting experiments of Allende meteorite and KLB-1peridotite [e.g., 7]. The euhedral habit, and heterogeneous compositions of akimotoite that is different from the parental unmelted pyroxene suggest crystallization of akimotoite from a shock-induced pyroxene melt rather than by solid-solid state phase transformation. The inherited shapes and low bulk concentrations of Al_2O_3, CaO and Na_2O of these akimotoite?pyroxene glass assemblages suggest that the surrounding chondritic materials did not contaminate the pyroxene melt. The FeO content of the pyroxene glass is significantly higher than the maximum solubility of FeO in $MgSiO_3$ perovskite at 18-23 GPa [8], thus negating a back-transformation from preexisting silicate-perovskite. As crystallization of akimotoite with high Mg# proceeded, the residual melt became richer in Fe and Ca, which quenched to pyroxene glass under high pressure.

References:[1] Xie et al. (2007) EPSL, 254, 433-445. [2] Miyahara et al.(2008) PNAS, 105, 8542-8547. [3] Miyahara et al. (2009) PEPI, 177, 116-121. [4] Xie et al. (2006) GCA, 70, 504-515. [5] Chen et al. (1996) Science, 271, 1570-1573.[6] Ohtani et al.(2004) EPSL, 227, 505-515. [7] Agee et al. (1995) JGR, 100, 17725-17740. [8] Ohtani et al. (1991) EPSL, 102, 158-166.

Keywords: meteorite, ordinary chondrite, shock, high-pressure polymorph, pyrxoene, transformation mechanism

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

PPS003-11 Room:202 Time:May 26 18:00-18:30

HIGH PRESSURE MINERAL ASSEMBLAGES IN THE LHERZOLITIC SHERGOTTITE GROVE MOUNTAINS (GRV) 020090

YT Lin[1*], Lu Feng[1], Sen Hu[1]

[1]Institute of Geology and Geophysics, CAS

Introduction: Shergottites commonly experienced heavy shock metamorphism that could be significantly different from that took place in the parent bodies of ordinary chondrites [1]. As a subgroup, most lherzolitic shergottites share similar petrography, geochemistry, radiometric ages and ejection ages, probably ejected from the same or similar igneous units on Mars. The main difference among them is various degree of post-shock thermal metamorphism [2]. GRV 020090 was recently found in Antarctica. It was classified as an lherzolitic shergottite [3], but highly enriched in REEs and other incompatible elements [4]. Hence, GRV 020090 supplies us with another probe of shock metamorphism on Mars.

Results: GRV 020090 contains poikilitic and interstitial lithologies. Olivine and pyroxenes show mosaic extinction, and are highly fractured. Plagioclase is characteristic of smooth surface and complete extinction under the crossed Nicol, indicative of transformation to glass. However, in high-contrast BSE images, assemblages of plagioclase grains with various brightness can be noted. Towards ferromagnesiam silicates, plagioclase becomes more Ab-, Or-rich, and K-feldspar was usually found at the rims of plagioclase.

Shock-induced melt veinlets (up to 100 micrometers wide) were found in the poikilitic lithology. They are usually zoned, from assemblages of tiny granular or needle grains of low-Ca pyroxene at the cores to pyroxene glass layers in contact with the host rock, which were confirmed by Raman. Chromite grains close to the veinlets show dark-bright lamellae with three directions of orientation. Presence of $FeCr_2O_4$-structured chromite was confirmed by Raman, similar to those reported in ordinary chondrites [5]. EPMA reveals no significant chemical variation in both of them. Olivine inside or in contact with the veinlets was transformed to assemblages of ring-woodite and glass, and then surrounded by an another layer of olivine glass. Coexisting with ringwoodite, low-Ca pyroxene was transformed to lamellae of akimotoite with interstitial glass. Merrillite in the veinlet was partially melted and mixed with chromite. The relict grains were transformed into the high-pressure polymorph.

Discussion and Summary: The complete extinction of maskelynite in the host rock and clear glass of olivine and pyroxene in the shock-induced melt veinlets indicate that GRV 020090 was quenched from the shock-induced melt and experienced little post-shock thermal metamor-phism. The coexistence of ringwoodite, majorite, akimotoite, and tuite suggests a P-T condition of 18-20GPa, ˜1800^{o}C. The pyroxene glass may be vitrified perovskite, indicative of a pressure $>$22 GPa. Plagioclase in the host rock of GRV 020090 was shocked to diaplectic glass, but not melted.

References: [1] Beck P., et al. 2005. Nature 435: 1071-1074. [2] Lin Y., et al. 2005. Meteoritics & Planetary Science 40: 1599-1619. [3] Miao B., et al. 2004. Acta Geologica Sinica 78: 1034-1041. [4] Lin Y., et al. 2008. Meteoritics & Planetary Science 43: A86. [5] Chen M., et al. 2003. Geochimica et Cosmochimica Acta 67: 3937-3942.

Keywords: meteorite, Mars, lherzolitic shergottite, shock, high-pressure polymorph