Newsletter of the Global COE program

Deep Earth Mineralogy

Center for Advanced Experimental and Theoretical Deep Earth Mineralogy
先進的実験と理論による地球深部物質学拠点

No. 4, January 31, 2010

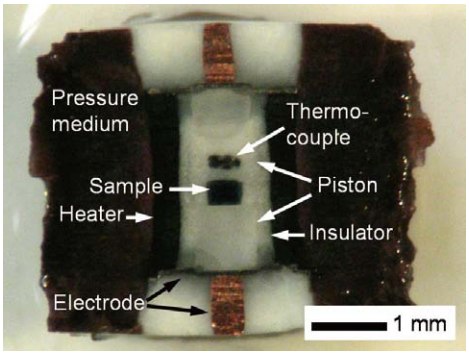
News & Events

New hot papers in Science and PNAS

Research papers by faculty staff members of GRC have been published in highly cited journals, Science and Proc. Natl. Acad. Sci. in December 2009. Prof. Tetsuo Irifune and Dr. T. Shinmei of GRC reported detailed phase transitions in pyrolite at pressures up to about 50 GPa and provided new insights into the chemical composition and density changes in the lower mantle. This study has been conducted in collaboration with the research group (C. A. McCammon, N. Miyajima, D. C. Rubie, D. J. Frost) of Bayerisches Geoinstitut (BGI), University of Bayreuth. Meanwhile, Prof. Taku Tsuchiya of GRC and Dr. Kenji Kawai, a JSPS Postdoctoral Fellow, estimated temperatures of the D" layer near the mantle-core boundary, on the basis of combined ab initio calculations and seismological wave-form inversions. Both studies were reported in some major Japanese newspapers and TV news programs.

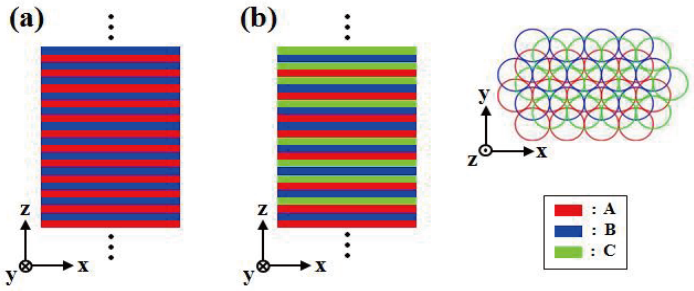
Highest pressure in a cubic anvil apparatus

Dr. Takaaki Kawazoe, a COE postdoctoral fellow at GRC, and his colleagues of the "rheology group" achieved a pressure of ~25 GPa in a DIA-type cubic apparatus (MADONNA-1500), which is the highest pressure recorded in this type of apparatus using tungsten carbide anvils. Dr. Kawazoe developed the "6-6 system", invented by Assoc. Prof. Norimasa Nishiyama of GRC, and succeeded to produce such a high pressure by optimizing the cell assembly. He further applied this technique to deformation experiments, and some preliminary studies have been made on high-pressure forms of olivine at pressures up to 20 GPa, at 1700K, utilizing the D-ram system of MADONNA.



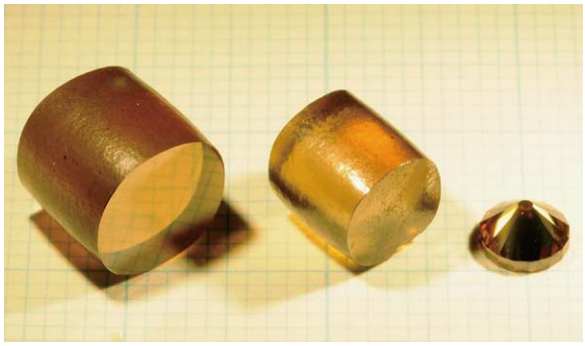
A possible new high-pressure form of Fe

Clarifying the crystal structure of iron at the P, T conditions of the Earth's inner core (>330 GPa, ~5000-6000 K) is one of the major research targets of our global COE program. Simultaneous generation of such extremely high-pressure and temperature conditions, however, has not been realized using static high-pressure vessels, such as multianvil apparatus and diamond anvil cell. Dr. Takahiro Ishikawa, an Assist. Prof. of GRC, found that a stacked disorder structure of hcp and fcc iron becomes more stable at higher temperatures under the inner core pressures, on the basis of ab initio calculations using a new computational algorithm. The disordering at higher temperature was also found to enhance elastic anisotropy of iron, which should have important implications for the structure and dynamics of the core.



Successful synthesis of further larger HIME-DIA

Synthesis of larger ultrahard nano-polycrystalline diamond (NPD = HIME-DIA) is one of important issues in developing new high-pressure technology for deep Earth mineralogy. Mr. Futoshi Isobe, a master course student at GRC, succeeded in synthesizing a flawless HIME-DIA rod of ~8mm in both diameter and length, using a large-volume Kawai-type multianvil apparatus (BOTCHAN-6000) introduced in "SOSEKI LAB" of GRC last year. He used an octahedral pressure medium of 30 mm edge length, and pressurized a graphite rod of about 1 cm, using a set of eight WC anvils with edge length of 65 mm. Thus synthesized rods will be processed and used for new high-pressure vessels.



Global COE
DEEP EARTH MINERALOGY
EHIME UNIVERSITY JASRI, UNIV.TOKYO, SBU

An interdisciplinary workshop by young scientists

The Young Earth Scientist Association (YESA) of the global COE organized the 2nd YESA workshop at GRC on 28-29 September, 2009. The workshop aimed at having extensive discussion on dynamics of the deep Earth, based on high-pressure experimental studies, numerical simulations, and seismological observations. In this workshop, emphasis was made on the interpretation of seismological observations by experimental and theoretical mineral physics studies. Eight young scientists from Hiroshima Univ., JAMSTEC, National Inst. Polar Res., Shizuoka Univ., Tohoku Univ., TiTech., and Univ. Tokyo were invited to give talks, while four speakers were selected from the YESA members of GRC. The interdisciplinary workshop, also attended by about 30 GRC members, was highly successful with extensive discussions among the young scientists, followed by further communication at izakaya restaurants.

Long-term internship students from CUG Wuhan

Two master course students, Mr. Chunyin Zhou and Ms. Cuiping Yang, from Chinese University of Geoscience (Wuhan) have been engaged in high-pressure experimental studies at GRC for about 5 months since September 2009, with financial supports from GRC. GRC and the national key laboratory at CUG Wuhan holds an agreement on the mutual exchange of students and researchers. Mr. Zhou has been working on the phase relations in iron-bearing pyroxene using the quench method, while Ms. Yang focuses her study on in situ observations of serpentine at high pressure and high temperature. Both are expected to finish their internship studies by the end of January, 2010, and write scientific papers on these subjects.

Long-term visiting PhD students from Europe

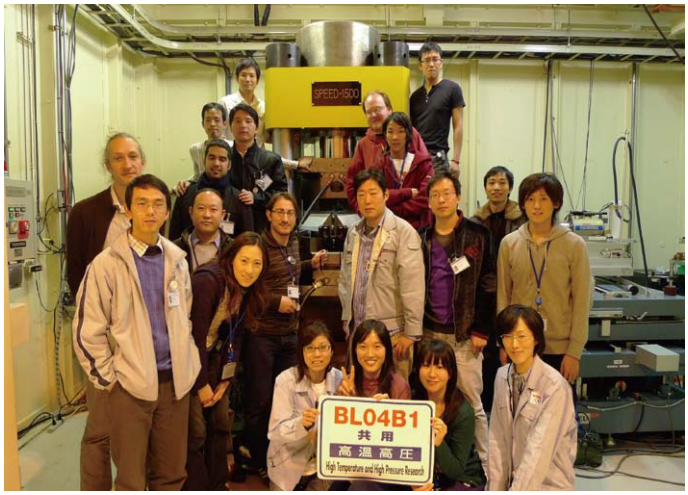
A PhD student from Bayerisches Geoinstitut (BGI), Mr. Stagno Vincenzo, stayed and joined in experimental studies at GRC for four months from September to December 2009, based on an agreement between the two institutes. He made some successful high-pressure runs with sintered diamond anvils operated in MADONNA and also worked with Focused Ion Beam (FIB) for TEM observations of some mineral inclusions in natural diamonds. Meanwhile, another PhD student of Univ. Edinburgh, Mr. Shigeto Hirai, stayed at GRC in November-December 2009, and made a number of high-pressure runs to synthesize new substances with perovskite and post-perovskite structures relevant to materials science. He is planning to visit GRC again in January 2010 for further experimental studies in this direction.

Internship for TEM analysis

An internship for analytical transmission electron microscopy (ATEM) on earth materials was held on October 27-30. The lecturers were Prof. Kiyoshi Fujino and Dr. Hiroaki Ohfuji of GRC, Ehime Univ. The program consisted of lectures and a training course for practical ATEM operation. In the lectures, fundamental crystallography, electron diffraction, and EDS analysis were given, while basics of ATEM operation were taught individually in the training course. Nearly 20 people of the graduate-course students, postdoctoral fellows, and faculty members attended the lectures, and 9 of those people attended the training course. ATEM is now becoming a fundamental tool to study the textures, crystal structures, and compositions of natural and synthetic solid materials, and particularly, important in analyses of high-pressure phases.

Internship for high P-T in situ observation

An internship program "Tutorial for in situ X-ray diffraction experiments under high-pressure and high-temperature using synchrotron radiations" was held on 30 November to 4 December at the BL04B1 beamline at the SPring-8 as a part of the G-COE program by Dr. Funakoshi and Dr. Higo (JASRI). A total of sixteen people, including twelve beginners, participated in the internship program from Ehime Univ., Univ. Tokyo, BGI (Germany), and CUG Wuhan (China). They learned techniques relevant to in situ X-ray observations using a combination of Kawai-type multianvil apparatus and synchrotron radiation. In situ observations of phase transitions in natural olivine were carried out as well as the P-V-T measurements for each phase, followed by the data analyses assisted by the experienced postdoctoral fellows and Ph.D students from GRC. The participants also had an opportunity to visit other beamlines at the SPring-8, including XFEL (a faculty of X-ray Free-Electron Laser at the SPring-8) under construction. A special excursion was organized to visit Nishi-Harima Astronomical Observatory where NAYUTA, the largest telescope in Japan, is open to the public.



News & Events

Internship for high-temperature synthesis

Prof. Toshisuke Kawasaki of Graduate School of Science and Technology of Ehime Univ., a member of the global COE program, offered an opportunity for PhD students and postdoctoral fellows to learn high-temperature synthesis techniques on 12-15 January, 2010, as one of the internship programs. Details of the techniques in high-temperature experiments under controlled oxygen fugacities were taught to the young scientists, mostly foreign PhD students of GRC, followed by a practice on electron microprobe analysis of the produced synthetic samples. The COE members of Ehime Univ. outside GRC (Profs. T. Kawasaki, I. Ohno, and A. Yamamoto) greatly contribute to the educational programs on the basic techniques relevant to Deep Earth Mineralogy.

An international session at JpGU 2010 Meeting

An international session entitled "Mineral physics and dynamics of deep mantle" will be held as one of the sessions of the Japan Geoscience Union (JpGU) Meeting 2010 in Makuhari during the period of 23 - 28 May. This session aims at presentations and discussions relevant to mineral physics and geodynamics of the deep mantle, with special emphasis on (1) thermal/chemical structure, (2) behaviours of fluids and/or hydrous minerals, and (3) rheology of the deep mantle. Those who are interested in contributing to this session are encouraged to submit their abstracts by noon of 5 February (JST). We particularly encourage researchers/students of TANDEM laboratories to give talks in this session to enhance mutual communications and collaborations in Asian countries. Dr. M. Kameyama, Assoc. Prof. of GRC, will act as the main convener for this session. For further details, see JpGU website (http://www.jpgu.org/) or directly contact with Dr. Kameyama (kameyama@sci.ehime-u.ac.jp).

International Frontier Seminer

13th (24 September)
"Physical reasons for abandoning plastic deformation measures in plasticity and viscoplasticity theory"
Lecturer : Prof. **Miles B. Rubin** (Israel Institute of Technology, Israel)

14th (5 October)
"Behavior of Xe-SiO_2 and Xe-Fe systems under the condition of the Earth's interior -Application to the "Missing Xenon Problem"
Lecturer : Prof. **Takehiko Yagi** (Institute for Solid State Physics, University of Tokyo, Japan)

15th (14 January)
"Let's creep! - Part II"
Lecturer : Prof. **Yanbin Wang** (Center for Advanced Radiation Sources, The University of Chicago, USA)

Forthcoming Events

The 3rd International Special Lecture

Lecturer: Dr. **Catherine McCammon**
(Staff Scientist, Bayerisches Geoinstitut, Universität Bayreuth, Germany)
Date: 9-10 February, Ehime Univ.

Lecture I (13:00-16:00, 9 February)
"Transition metal chemistry and the Earth's interior"
1. Introduction
2. Crystal field theory
3. Crystal chemistry of transition metal-bearing minerals
4. Trace element geochemistry
5. Mantle geochemistry

16th Internarional Frontier Seminar (17:00-18:00, 9 February)
"Effect of spin transitions on properties and dynamics of the lower mantle"

Lecture II (9:00-12:00. 10 February)
"Oxygen fugacity and the Earth's interior"
1. Introduction
2. Thermodynamics
3. Controlling oxygen fugacity
4. Measuring oxygen fugacity: experiment
5. Measuring oxygen fugacity: natural samples
6. Oxygen fugacity in the Earth's mantle

Global COE activity report meeting

A meeting will be held to review the activity of the global COE program on Deep Earth Mineralogy, attended by the president of Ehime Univ. and four distinguished professors of the evaluation committee outside GRC. The outline of the whole COE activity will be presented by the program leader, Prof. T. Irifune, followed by the reports on the achievements in education and research programs by Profs. T. Inoue and T. Tsuchiya, respectively. Then the leaders of seven major research groups, in five experimental and 2 computational sciences, of GRC will report the activities of the individual groups. The allied members of the global COE program will also give talks on their achievements during the past two years, as follows:

Date: 15 and 16 March, 2010
Venue: 6th floor, Integrated Research Building, Ehime Univ., Matsuyama
Tentative program
(15 March)

9:00-10:40	Outline of the global COE activities
11:10-15:15	Reports from individual groups (I)
15:30-17:50	Poster session
18:00-20:00	Reception
(16 March)	
8:30-15:10	Reports from individual groups (II)
15:30-16:00	Discussion and concluding remarks

New Members

Kazuki KOMATSU (Project Lecturer)

I have joined to COE as a project lecturer at the Univ. of Tokyo from Jan 2009, after finishing a postdoc position in the Univ. of Edinburgh. My scientific specialty is X-ray and neutron crystallography for hydrous minerals, hydrogen bonded material, and molecule crystals. I have a particular interest in the peculiar properties and structure of high pressure polymorphs of ice. I have enthusiastically joined the high pressure neutron research project collaborated with many high pressure or neutron researchers in the world. My current work is the technical developments for high pressure neutron study, especially for installing the Paris-Edinburgh cells at J-PARC. I am also developing high pressure and high/low temperature X-ray diffraction systems in our laboratory using an X-ray focusing mirror, which allows us to take diffraction patterns under pressure without using a synchrotron. It's my pleasure to invite you to collaborate with us if interested in these studies or techniques.

Takehiko TANAKA (PhD student)

I started studying at Ehime University as a PhD student in October 2009. Usually, I work at a senior high school of Mie-prefecture as a physics teacher. I have continued studying the high-pressure properties of methane hydrate by using a diamond anvil cell. The high pressure phase of methane hydrate called "filled ice" is expected to exhibit symmetrization of the framework of hydrogen bonds. In my PhD study, I am going to try to confirm this experimentally. Also, I am interested in the pedagogy of science as I have tried to foster scientific interest for the youth at the high school where I am working.

Fulong WANG (PhD student)

I moved to GRC in September 2009 after finishing my Master's Degree in high pressure and high temperature science at Sichuan University in July 2009. I majored in developing technology for large volume high pressure and high temperature (LVHPHT) experiments. I have an extensive experimental background, and my Master's dissertation research focused on developing a new type of two-stage LVHPHT apparatus based on the hinge-type cubic-anvil press. The pressure can be taken up to 20 GPa using the phase transitions of Bi, Ba, Ge, Si, ZnS, and GaAs, and the temperature can be up to 2000 K. This is the first time to achieve such conditions in China. I'd like to continue this interesting research at GRC. In addition, the system MgO-FeO-SiO_2 is fundamental to our understanding of its constituents and dynamics because the total amounts of MgO, FeO, and SiO_2 make up more than 90 wt % of the bulk silicate Earth. Researching the MgO-FeO-SiO_2 system, therefore, is also my current research interest.

Yongtao ZOU (PhD student)

After graduating from Sichuan University in June 2009, I have been a GRC student of the Novel Material Synthesis Group for my PhD courses study. I majored in High Pressure Science and Technology with the guidance of Prof. Duanwei He, one of the TANDEM members, on investigation of the high pressure behaviors of $MgAl_2O_4$ nanoceramics and/or high-pressure synthesis and characterization of superhard/hard materials of the B-C-N-O system. My current interests are focused on the study of high pressure behaviors of such mantle materials as $Mg_3Al_2Si_3O_{12}$-$Mg_3Cr_2Si_3O_{12}$ system. In the coming years, I will devote myself to studying this system with the guidance of Prof. Irifune and Dr. Shinmei.

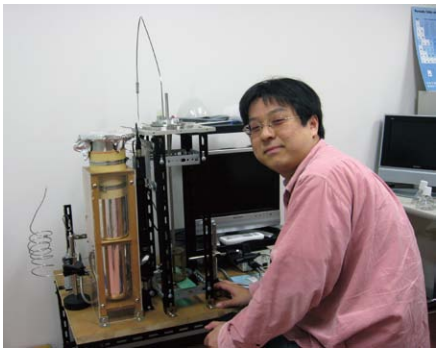
Internship Report

Akihiro Yamada (COE postdoctoral fellow)

I visited Advanced Photon Source in Argonne National Laboratory, which is a third generation synchrotron radiation source in the US, on October 20th to 27th. We are working on a in-situ observation of silicate melt structure at high pressure and temperature with a Paris-Edinburgh press using X-ray diffraction. The present experiment has been performed at sector 16 BMB beamline, which is operated by HPCAT, Geophysical Laboratory, Carnegie institution of Washington. Members from GSECars, University of Chicago have also been collaborating with us. A Paris-Edinburgh press has a large advantage in the wide accessibility of 2θ angle due to the simple geometry of the device. At that beamtime, we successfully obtained X-ray diffraction patterns of $NaAlSi_3O_8$ melt up to 5.5 GPa and 1600 ºC. Very few experiments under such high temperature conditions using a Paris-Edinburgh press have been reported, so far. In particular, there is no work on the structure of silicate melt, which consists of low Z elements (requires large-volume sample). The present technique is promising for the neutron diffraction of silicate melt at high pressure and temperature as well. At last, I would like to say thank the faculty at GRC very much for their kind consideration in supporting my travel to Argonne National Laboratory.

Intermolecular interactions in hydrogen hydrate under high pressure

Shinichi MACHIDA
(COE Postdoctoral Fellow)



Hydrogen hydrate is made of hydrogen-bonded water molecules forming cages or frameworks that include hydrogen molecules. In planetary sciences, hydrogen hydrate is thought to play an important role. Hydrogen hydrate has attracted attention as a material to trap hydrogen molecules into ice in interstellar space (Mao et al., 2002). Thus, hydrogen hydrate would help to store hydrogen in the planets, from which it could be a reservoir of hydrogen molecules proposed for formation and evolution. To understand the behavior of hydrogen hydrate in planets, the properties of hydrogen hydrate under high-pressure are very important.

A high-pressure structure of hydrogen hydrate, filled ice Ic structure (FIIcS), was reported to be maintained up to 60 GPa (Vos et al. 1996). The filled ice structures of many other gas-hydrates decompose below 6.5 GPa, thus, the FIIcS of hydrogen hydrate shows remarkable stability. But, the reasons for the stability of the FIIcS under higher pressures have not yet been explained. In my research, high-pressure experiments of the FIIcS for hydrogen hydrate were performed by using a diamond anvil cell. Then, the reasons for the stability were examined with regard to the intermolecular interactions between hydrogen and water molecules.

In the Raman measurements, a roton (rotation mode) revealed that the rotation of the hydrogen molecules seemed to be suppressed at around 20 GPa (Fig. 1). In the case of solid hydrogen, ordering of the rotation for hydrogen molecules was considered to require low temperatures, below 85K, and high pressures, above 110 GPa (Mao and Hemley 1994). Therefore, suppression of the rotation of hydrogen molecules observed in the FIIcS under low pressure indicated that the intermolecular interactions in the FIIcS were very remarkable. And, these intermolecular interactions might induce the stability of the FIIcS for hydrogen hydrate.

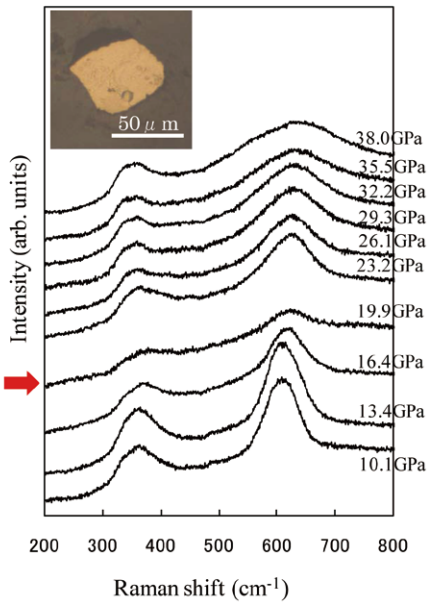


Fig. 1. The representative photograph of the hydrogen hydrate in the diamond anvil cell at 27.0 GPa, and the Raman spectra of the roton (rotation mode) of the hydrogen molecules for hydrogen hydrate. The intensity of the roton decreased at 19.9 GPa.

Study on the silicate melt structure using Paris-Edinburgh press

Akihiro YAMADA
(COE Postdoctoral Fellow)

We have been working on silicate melt structure at high pressure and temperature using synchrotron X-rays. I'm currently pursuing simultaneous measurement of the structure and physical properties (density) of silicate melt at high pressure. To achieve this project a Paris-Edinburgh press, which has simple geometry and the capacity for a large volume sample, is being used as the high pressure device. As the first stage of this project, we tried to establish the system for the melt(glass)-structure experiment. The present experiment has been performing at Sector 16 BMB beamline, which is operated at HPCAT (Carnegie institution of Washington) at Advanced Photon Source of Argonne National Laboratory in the US. Members from GSECars, University of Chicago are also collaborating with us. Polychromatic X-rays from a bending magnet with the energy range between 20-150 keV is available at this beamline. Also, a very accurate stage for the solid state detector which can be set 2θ widely in the horizontal direction is available at this beamline. A Paris-Edinburgh press, which has been installed by GSECars, is put in the center of the stage. Despite the wide accessibility of the device, very few experiments under high temperature conditions such as the melting point of silicate have been reported, so far. Particularly, there is no report of the work on the silicate melt structure due to the difficulties of the experiment. Specifically, not only the refractory property but light elements make the experiment challenging because it requires a large volume sample to get a good X-ray diffraction signal from the sample.

One of the results of the present experiment, the radial distribution function (G(r)) of $NaAlSi_3O_8$ melt collected at 5.5 GPa and 1600 °C, is shown in the Fig. 1. By taking advantage of the Paris-Edinburgh press, we successfully extended 2θ up to 37°, which allows us to get diffraction data up to ~22 $Å^{-1}$. This is very effective for the improvement of the resolution of the radial distribution function, which can be derived by transformation of the structure factor. Previously, we obtained diffraction patterns up to 25° with DIA-type multianvil press (e.g., Yamada et al., 2007). A sharp peak at ~1.63 Å corresponds to the local structure of aluminum silicate melt which consists of a tetrahedral unit of SiO_4 and AlO_4 (shown in the Fig. 1). We cannot distinguish the peak position of Al-O from Si-O because both distances are very close to each other (Si-O=~1.6 Å, Al-O=~1.7 Å). If the coordination number of the Al atom changes at a lower pressure than Si as previous studies have indicated, the we could see a splitting of the T-O peak because the highly coordinated Al has a longer bond length (~1.9 Å). In order to investigate this structural change in the melt, I will try to obtain structural data at higher pressure conditions.

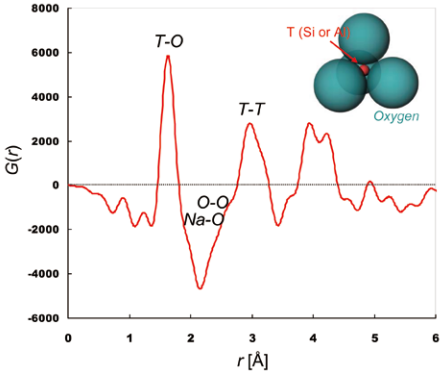


Fig. 1. Radial distribution function, G(r), of $NaAlSi_3O_8$ melt collected at 5.5 GPa and 1600 °C. a picture in the figure is a schematic illustration of TO_4 tetrahedron (T= Si, Al), which is the local structure of aluminous silicate melt.

Message from COMPRES to TANDEM

Robert C. Liebermann
(Former President of COMPRES)
Distinguished Service Professor,
Department of Geosciences,
Stony Brook University

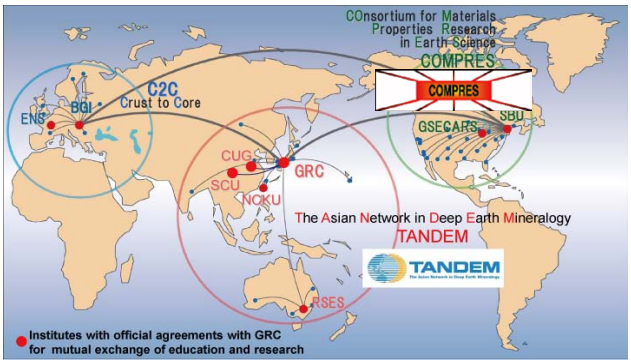
For the past 6 ½ years [from August 2003 to January 2010], I have had the privilege of serving as President of the COnsortium for Materials Properties Research in Earth Sciences [COMPRES]. COMPRES is a community-based consortium whose goal is to enable Earth Science researchers to conduct the next generation of high-pressure science on world-class equipment and facilities. It facilitates the operation of beam lines, the development of new technologies for high pressure research, and advocates for science and educational programs to the various funding agencies.

Established in 2001 as the result of a proposal to the National Science Foundation Division of Earth Sciences by representatives of 18 academic institutions in the U. S., COMPRES has grown to be an international organization with 55 U. S. institutional members and 34 foreign affiliate members. See details at the website: www.compres.us.

One of the most remarkable signs of progress and expansion of the field of mineral physics has been the large number of faculty-level appointments in major academic institutions in the U. S. and the world during the COMPRES era. For example, from 2007-2009, there were 11 such appointments in U. S. universities and 23 in foreign universities [including 8 at Ehime University in Matsuyama]. This is the clearest signal of the vitality of this scientific field.

We in COMPRES took special note of the formation of TANDEM, the Asian Network in Deep Earth Mineralogy, as an international network in the Asian region for the advancement of experimental and computational studies on the physical properties, structures, dynamics, and evolution of the Earth's deep interior. Of the 20 TANDEM laboratories, 8 are foreign affiliate members of COMPRES; additional members are welcome to apply, using the procedures found at: http://www.compres.us/index.php?option=com_content&task=view&id=2&Itemid=60.

COMPRES looks forward to increased cooperation and exchanges with the faculty, staff and students of the TANDEM laboratories in the future.



News & Events

A mineral physics session for WPGM at Taipei

A session related to Deep Earth Mineralogy, entitled "Structure and Composition of the Earth's Interior" will be held during the Western Pacific Geophysical Meeting (WPGM) in Taipei on 22-25 June. This session is convened mainly by the representative persons of TANDEM members (i.e. Baosheng Li, SUNY; Jennifer Kung, NCKU; Tetsuo Irifune, GRC; Ian Jackson, ANU; Eiji Ohtani, Tohoku U.), and solicits presentations from experimental and computational studies on physical and chemical processes inside the Earth's mantle and the core. We encourage the scientists of TANDEM members to submit papers to this session. The deadline for abstract submission is 25 February. For further details: http://www.agu.org/meetings/wp10/.

Special volume of Journal of Earth Sciences

A special volume of Journal of Earth Sciences (Springer) will be published for celebration of the career contribution of Prof. Zhenmin Jin of China University of Geosciences (Wuhan). Zhenmin published over 110 scientific papers which highlight melt topology in partially molten mantle peridotite during ductile deformation, microfabrics in peridotite xenoliths of Eastern China, eclogite rheology, and physical properties of ultrahigh-pressure metamorphic rocks from China. He is a leading figure in high pressure Earth sciences of China, who contributes to broader scientific issues through his role as a senior CUG professor, member of the Chinese Academy of Science, and China NSF Advisory Committee. Zhenmin also plays as the representative of the TANDEM members in China, and will convene the second TANDEM symposium to be held in Wuhan in this Autumn. The deadline for article submission is 15 March 2010.

For further details, please contact following guest editors:
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Tetsuo Irifune (irifune@dpc.ehime-u.ac.jp)
Junfeng Zhang (jfzhang@cug.edu.cn).

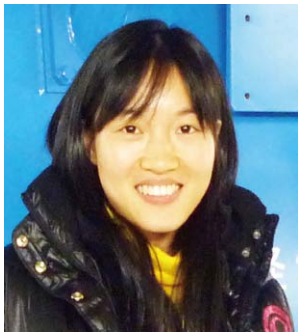
A visit to CHINA

I visited China University of Geosciences (Beijing) (CUGB), Peking University, China University of Geosciences (Wuhan) (CUGW), and Guangzhou Institute of Geochemistry (GIG) with an invitation from the State Key Laboratory of Geological Processes and Mineral Resources from November 7 to 16. This invitation was arranged by Prof. Shengrong Li of CUGB and Prof. Zhenmin Jin of CUGW. At these 4 organizations, I introduced GRC and the Global COE program of the GRC, and gave a talk on the two topics, "Discovery of natural silicate ilmenite and perovskite in the shocked meteorite" and "$FeAlO_3$ substitution in $MgSiO_3$ perovskite in the Earth's lower mantle - why is ferric iron more dominant than ferrous in the lower mantle?-". About 30 to 60 people, both students and researchers attended the presentations. It was impressive to me that the students gave me straightforward questions about the issues which might not be familiar to them. I also discussed with the researchers and the students various issues.

Although CUGB and CUGW are now a comprehensive university, their geosciences schools are still at a higher level than the other schools. CUGB seems to have a strong background in the traditional geoscience areas, while at CUGW the new areas such as mineral physics and rheology are also active. Geochemistry is also active at CUGW. At Peking University, Profs Xi Lie (having been in Matsuyama) and Xiang Wu (having been in Misasa) are setting up a high pressure laboratory in the School of Earth and Space Sciences. At GIG, Prof. Hongping He arranged my stay, and here I met Prof. Xiande Xie who was once a president of IMA (International Mineralogical Association) after several years' absence. GIG belongs to the Chinese Academy of Science and has graduate-course students. It was equipped with new apparatuses related to geochemistry.

This was my first trip to China, and my impression is 'In China, everything is changing so rapidly'. (article by K. Fujino)

Internship Reports at GRC



Cuiping YANG

I came here in the middle of September from China University of Geosciences (Wuhan), and I study here as an internship student. I am glad that I have the chance to study at the GRC and meet so many kind people. My research topic here is "Equation of state of antigorite and chlorite under high pressure and high temperature (HPHT) determined by in-situ X-ray diffraction", and Prof. Inoue is my supervisor.

During this internship, I went to the Photon Factory (PF) to do my in-situ X-ray diffraction experiments for one week, and collected many diffraction data about antigorite and chlorite to draw the P-V-T path of these minerals, which is important because antigorite and chlorite are main hydrous minerals in subduction zones, and their equation of state controls their stability field at HPHT. Previous data on P-V-T of antigorite and chlorite were measured at room temperature and high pressure, which cannot represent the real situation in the earth's interior. This is my first experiment, and fortunately, with the help of Inoue-sensei, Yamada-san and Sogabe-san the result was quite successful.

After the experiment at PF, I attended the special internship program at SPring-8, to learn how to do synchrotron in situ X-ray diffraction experiments under high pressure and high temperature. From this program I learned a lot, about the synchrotron X-ray system, about the way to conduct an experiment well, and about team work and communication. I am proud to be one member of Team 3. During this internship, Funakoshi-san arranged sightseeing at the astronomical observatory in Harima, which is really interesting, and after that, we had a small party to celebrate this internship, every one of us had a lot of fun with that, and we appreciate this special internship indeed.

I like this beautiful and clean city, and my life here is enjoyable and the people here are kind and helpful. I hope next year I can come here and start my PhD course with these lovely people.

Chunyin ZHOU

I'm very honored to have this opportunity to study high-pressure and -temperature technology at the GRC from September (2009) to January (2010). There are developed facilities for me to carry out experiments in phase transitions of $(Mg_{0.93},Fe_{0.07})SiO_3$, which is a representative composition of pyroxene in harzburgite of subducted oceanic slabs. It will help to advance our knowledge of the mineralogy of the mantle transition zone and geodynamics. So far I have obtained some high quality experimental results with multi-anvil apparatus of ORANGE 2000 in the ultra high pressure laboratory. And I've also learned many experimental skills in the laboratory. In addition, their teamwork at GRC impressed me very much. Young scientists from France, Germany, USA, and China cooperate and communicate with each other as an international scientific group.

Fortunately, I had a chance to take part in the beamtime at SPring-8 as part of the Global COE internship program. We visited the world famous scientific facilities and conducted in-situ X-ray diffraction experiments with synchrotron radiation at the BL04B1. The experience at SPring-8 is wonderful and very important to my career.

I'm so grateful to GRC faculties, particularly Prof. Irifune and Nishiyama-san for their creative advice and guidance. Yano-san and Wada-san taught me how to operate the machines and make parts for the cells. And Shinmei-san helped me a lot with my experiments. Thanks are given to all the people above.

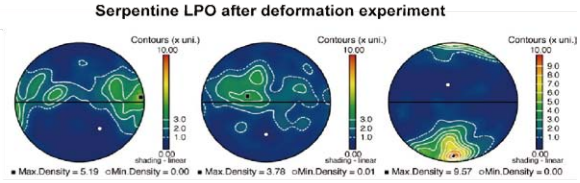
Department of Earth and Planetary Systems Science, Hiroshima University

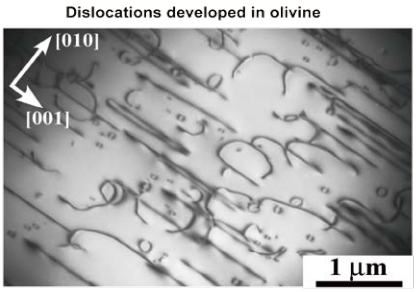
Hiroshima University was established in 1949 by combining the various preexisted higher educational institutions. It now has 11 faculties, 12 graduate schools, a research institute, a university hospital, and 11 attached schools. The numbers of students are ca. 10,980 and ca. 4,520 in undergraduate and graduate courses, respectively. Academic staffs are ca. 1,800. Hiroshima University has 2 campuses which are located in Hiroshima city, known as the International City of Peace and Culture, and Higashi-Hiroshima city. The latter is the main campus, covering 252 hectares in the verdant area, where we are located.

The main members of TANDEM at Hiroshima University are Drs. J. Ando and I. Katayama who are also visiting researchers at the Geodynamic Research Center of Ehime University. They belong to the Department of Earth and Planetary Systems Science at Hiroshima University. This department currently has 14 faculty members, 5 post-docs, 13 PhD students, and 26 master-course students in addition to 25 x 4 undergraduate students. These members include a Chinese graduate student and a Korean post-doc. The department organizes 3 research/education groups named "Evolution of Earth and Planetary System", "Geodynamics", and "Environmental and Resource Science". The research/education activities of these groups cover a wide range of Earth sciences including sedimentology, paleontology, petrology, structural geology, mineralogy, geodynamics, seismology, geochemistry, cosmochemistry, and economic geology. In 2007, our department was selected for the program for improving graduate school education by JSPS. This educational program is designed to raise the academic level of our students through incorporation of the research results achieved in the field of basic science and those achieved in the field of science offering natural hazards.

"Rheology of the crust/mantle minerals" is a key term in our research. We have studied plasticity of olivine and garnet so far and recently focused on serpentine. To proceed with these interesting topics, we emphasize two research methods which are deformation experiments and microstructural observations. For the deformation experiments, we usually use a solid medium deformation apparatus which was designed to be able to generate up to 4 GPa pressure and 1400 ºC temperature conditions. This apparatus can conduct two types of deformation experiments, namely constant strain rate and creep tests. The microstructural observations of recovered samples and naturally deformed mantle rocks (peridotite and eclogite) are very important to clarify the deformation mechanism and deformation process in the real mantle. An important technique for the observation is TEM with 200 kV accelerating voltage. SEM, FTIR, and Laser-RAMAN are also useful analytical instruments for these experiments. These instruments are all installed in our department.

In addition to the solid medium deformation apparatus, our department has the following rigs; 1) High temperature biaxial frictional testing machine, 2) Rotary shear high velocity frictional testing machine, 3) High temperature high pressure deformation and fluid flow gas apparatus and 4) Intra vessel deformation and fluid flow apparatus. All these rigs are developed by Prof. Shimamoto who is one of our faculty members. The first machine is equipped with a furnace which can heat up to ca. 1000 ºC and a gear train loading system with 0.03 mm/yr to 1.5 mm/s in slip rate.





The second machine allows the reproduction of seismic slip rates of up to a few m/s and simultaneously measuring mechanical properties of simulated faults. The third machine is a standard gas apparatus with 220 MPa maximum pressure, but equipped with a good servo-controlling system for pore pressure of either gas or liquid, which has been used for permeability measurements. The final machine is a high quality triaxial apparatus for deformation and fluid flow studies with 200 MPa maximum pressure.

Using these apparatuses, we can now conduct the various rheological studies of crust and mantle constituent rocks/minerals here. Moreover, our department focuses on the study of tectonics of the East Asia combined with a chronological study using Sensitive High Resolution Ion Micro-Probe (SHRIMP). This high quality instrument is also installed in our department. We'd like to welcome any members of TANDEM who are interested in the research areas of our department, not only "Rheology of the mantle minerals", to make future collaborations.

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TANDEM
The Asian Network in Deep Earth Mineralogy

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Global COE Newsletter, issued Jan., May and Sep.
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