Newsletter of the Global COE program

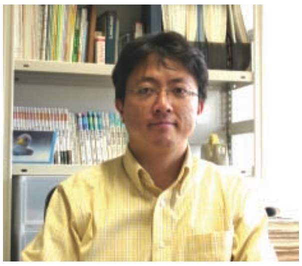
Deep Earth Mineralogy

No. 2, May 30, 2009

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

News & Events

The Young Scientists' Prize to Prof. Tsuchiya



On 14 April in Tokyo, Prof. Taku Tsuchiya, the leader of theoretical mineral physics group of GRC, received the Young Scientists' Prize from the Minister of Ministry of Education, Culture, Sports, Science and Technology (MEXT) for his research achievements in lower mantle mineralogy based on ab initio computations. This prize is awarded to outstanding young scientists below 40 y.o. in all research fields, among which only a couple of scientists are selected in whole Earth science community in Japan. Prof. Tsuchiya plays an important role as the executive committee member of our global COE program, particularly on the advancement of cutting edge researches in deep Earth mineralogy.

Completion of BOTCHAN-6000 and SOSEKI LAB

A 4-floor building, housing a new 6000-ton Kawai-type apparatus and connected to the Integrated Research Building, was completed and an opening ceremony was held on 30 March, attended by the headquarters and the council members of Ehime University, including the president Prof. Komatsu. The name of "BOTCHAN" (Beyond observable Toughness and Conceivable Hardness of Artificial Nano-diamond) is taken from a novel by Soseki Natsume, and the laboratory was named as "SOSEKI LAB" after the writer. Another meaning of SOSEKI in Japanese is "creation of gem stones", and is expected to produce high-quality single crystals and sintered high-pressure phases at high pressure and temperature. With BOTCHAN-6000, HIME-DIA of as large as ~1 cm will also be synthesized and applied for new high-pressure apparatus for higher pressure and temperature generation.

Hot paper picked up by Nature Geoscience

Dr. Dirk Spengler, PD fellow of Ehime University, published his research paper with his colleagues, entitled "Long-lived, cold burial of Baltica to 200 km depth", in Earth and Planetary Science Letters (EPSL, 281, 27-35, 2009). This paper has been picked up in the recent volume of a famous journal of "Nature Geoscience" as one of research highlights (Nature Geosci., vol 2, no. 5). With this outstanding result, now Dr. Spengler proceeds to further step of his research in the current position of Senior Research Fellow Center in Ehime University, which is a collaborative center with the global COE program.

Honorable Guest Professorship to Prof. Irifune from CUG Wuhan

Prof. Tetsuo Irifune, the leader of the global COE program and the director of GRC, was awarded the Honorable Guest Professorship from China University of Geoscience (CUG), Wuhan. Prof. Irifune gave a lecture on the phase transition and constitution of the Earth's mantle and subducting lithologies after the ceremony, and was invited to a banquet with the president of CUG and its headquarters. CUG is one of the major universities in China with more than 40000 students and 22 Schools in broad natural and social sciences, as well as engineering, law, education, etc., and selects some internationally acknowledged and distinguished scientists for the professorship.

Booth at JPGU Meeting

An exibition booth was run by GRC members to advertise the activities of GRC and global COE during the period (16-21 May) of the Japan Geoscience Union (JPGU) meeting held in Makuhari, near Tokyo. The persons in charge of explaining the displays, including nano-polycrystalline diamond (HIME-DIA), wore special Japanese Kimono and attracted many participants and visitors. These costumes for "Botchan" (young master) and "Madonna" are those for main characters in a Japanese novel written by Soseki Natsume, one of the most famous writers in Meiji era in Japan, and used for the names of the new 6000-ton Kawai type and 1500-ton D-DIA type apparatus introduced in GRC.

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

Official agreements with CUG and SCU

To activate and establish the Asian network of deep Earth mineralogy, official agreements for mutual academic exchange of educations and researches have been signed and entered into force between State Key Laboratory of Geological Processes and Mineral Resources, China University of Geosciences (CUG) and GRC, and between Institute of Atomic and Molecular Physics, Sichuan University (SCU) and GRC. Adding to the agreements, the memorandum has also been signed, which prescribes accommodations for active and mutual exchange of students. According to the agreement and memorandum, accommodation for PhD students and internship programs are now planned between these institutes.

Reform of GRC

In association with the global COE program, GRC has been reformed to seven (five experimental and two computational simulation) research/education groups: (1) high-pressure Earth science and technical development, (2) diamond and new materials synthesis, (3) fluid and magma, (4) rheology, (5) applications of diamond anvil cell and quantum beams, (6) mineral physics based on ab initio calculations, and (7) simulation of mantle and core dynamics. In addition to these groups, a new administration office and a COE supporting office have been created to strongly support the activities of GRC and the global COE program (see, TANDEM news for further details).

Activity report by young scientists for FY2008

16 March, 2009, Ehime University

Takaaki KAWAZOE (PD Fellow, GRC)
Rheological properties of deep mantle minerals under high-pressure and temperature based on deformation and melting experiments

Yoshio KONO (PD Fellow, present: Research Fellow, GRC)
Elastic wave velocity measurements of minerals, rocks, and melts at high pressures and high temperatures

Akihiro YAMADA (PD Fellow, GRC)
Relaxation of $MgSiO_3$ glass

Yusuke USUI (PD Fellow, GRC)
Anisotropy and velocity heterogeneity in the deep Earth's mantle: cross study combined with seismic observations and numerical modeling

Steeve Gréaux (PD Fellow, GRC)
Impact of 3+ cations hosting on properties of minerals of the Earth's deep mantle

Yoshinori TANGE (PD Fellow, present: Assistant Professor, GRC)
Developments in high-pressure experiments for precise determination of the bulk composition of the lower mantle

Leiming FANG (PhD student, GRC)
High pressure and high temperature synthesis of novel crystalline C-N materials

Takehiro KUNIMOTO (PhD student, GRC)
Development of a 6-8-2 type multi-anvil apparatus and its applications

Yu NISHIHARA (Senior Research Fellow, Ehime Univ.)
The phase transformation in $MgSiO_3$ pyroxenes at high-pressure and -temperature determined by in-situ X-ray diffraction: Implications for nature of the X-discontinuity

Jun TSUCHIYA (Senior Research Fellow, Ehime Univ.)
First principles investigations on hydrous systems -Brief reports of our recent works and future plans-

Shoko ODAKE (PhD student, Univ. Tokyo)
Laser processing of Nano-polycrystalline diamond

Hiroaki OHFUJI (Assistant Professor, GRC)
Laser Heating in "nano-polycrystalline" diamond anvil cell -Application for melting experiments of iron-

Yuji HIGO (Research Scientist, SPring-8)
Development of the elastic wave velocity measurement technique which can be adapted for soft material -a preliminary experimental result

5th International Frontier Seminar

"Effects of Hydration on the elastic properties of transition zone minerals"
Lecturer : Prof. **Steven D. Jacobsen**
(Department of Earth and Planetary Sciences, Northwestern University, USA)
Date: 3 March 2009

6th International Frontier Seminar

"Laboratory-based Interpretation of Upper-mantle Seismic Tomograms : Progress and Prospects"
Lecturer : Prof. **Ian Jackson**
(Research School of Earth Sciences, Australian National University, Australia)
Date: 3 March 2009

7th International Frontier Seminar

"Some Remaining Problems in the Mantle"
Lecturer : Prof. **Craig R.Bina**
(Department of Earth and Planetary Sciences, Northwestern University, USA)
Date: 4 March 2009

The 2nd International Special Lecture

"Water Distribution Across the Mantle Transition Zone in Earth and Its Implications for the Evolution of Ocean"

Lecturer: Shun-ichiro Karato
(Yale University, Department of Geology and Geophysics)
Date: 2-3 September 2009, Venue: Ehime University, Japan

The transition zone of Earth's mantle (MTZ; ~410 to ~660 km depth) can store a large amount of water up to ~ten times of the current ocean mass. Consequently, this layer may play an important role in the circulation of water in Earth. However, the role of MTZ in water circulation has been poorly understood because of the difficulties in determining the water distribution in the deep mantle. Various geochemical and geophysical observations are reviewed including the water contents in various basalts as well as electrical conductivity and seismological observations in order to infer the water distribution in the deep mantle of Earth at present. It is concluded that the MTZ has a range of water content but is ~ 0.1-0.3 wt% in the Pacific. This value is about ten times higher than the water content in the asthenosphere and is close to the critical water content for partial melting at above the 410-km discontinuity. This suggests that the water content in MTZ is self-regulated by partial melting that would in turn stabilize the ocean mass during the geological history.

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GRC-BGI Workshop

Date: 17-19 June, 2009, Venue: Bayreuth, Germany

The joint workshop by BGI (Bayerishes Geoinstitut, University of Bayreuth) and GRC will be held at Bayreuth, Germany, on June 17-19, 2009. The workshop is aiming at training young scientists to become international researchers with high presentation and dicussion abilities. Another objective is to share and exchange information on the researches and experimental and computational techniques between GRC and BGI on deep Earth mineralogy (GRC and BGI have the offiical agreement for mutual academic exchange of educations and researches).

Program (Session title)

17 June
11:15-14:45 Phase Equilibria and Phase Transformations in the Earth's mantle
14:45-15:25 Mineral Physics I
15:30- Lab Tours

18 June
9:00-10:10 Silicate Metlts and Fluids
10:45-12:20 Mineral Physics II
14:00-15:35 New Experimental Methods
15:35- Poster Session

19 June
9:00-10:20 Deformation and Rheology
10:45-12:20 Earth's core

Internship Program

"Tutorial for Crystal Structure Analysis"

Date: 19-21 August, 2009, Venue: Ehime University
Lecturer: Kazuki Komatsu
(Geochemical Laboratory, The Univ. of Tokyo)

This is a practical internship program focused on a basic procedure for crystal structure analysis. It would be particularly suitable for Ph.D. students, Post-Doc and young scientists who are beginners for Rietveld refinements and structure solving. Anyone who would like to improve their knowledge and skills for crystal structure analysis or anyone who is interested in the experiments in spallation neutron sources like J-PARC will be also welcome.

The internship will include the following program.

- Procedure of analysis for powder x-ray/neutron diffraction using GSAS
- An introduction to crystallography (the definition of crystal, the diffraction process, concept of reciprocal lattice, Bragg's law, space group etc…)
- What profile patterns tells us. (lattice constants, atomic coordinates, atomic displacements, crystalline size, preferred orientation, residual stress, etc…)

It is preferable that participants will bring their own laptop computer to install some crystallographic software. GRC can prepare several laptop PCs, if participants do not have it. The number of participants would be limited up to 15.

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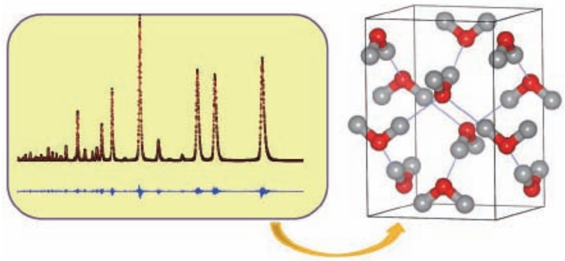

International Summer School

"P-V-T equations of state of materials"

Date: 3-5 August, 2009, Venue: Ehime University

T. Tsuchiya and Y. Tange from GRC are in charge of a G-COE international summer school "P-V-T equations of state of materials" to be held on August 3-5 at GRC as a satellite meeting of the forthcoming AIRAPT 22. Uncertainty in pressure standards and accurate measurement of P-V-T EoS of materials is long been a critical issue in high-pressure science and technology. Several important progresses can however be seen in these years in experimental techniques, analytical and calculation methods and theory. Now it is a nice timing to meet researchers from several research areas and discuss the topics comprehensively to take a next step. The workshop will be composed of reviews of cutting-edge research results and discussion. Talks will be given by top-level world-wide scientists from (i) theory and modelling, (ii) shock experiment, and (iii) static experiment. We are also planning to have a special lecture to be given by Prof. Holzapfel accompanied with the workshop. People involved in the high-pressure science and technology of course including students are most welcome.

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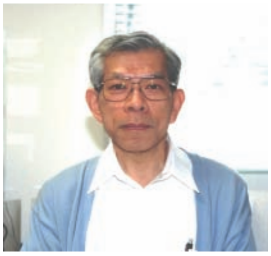
New Members

Kiyoshi FUJINO (Professor)

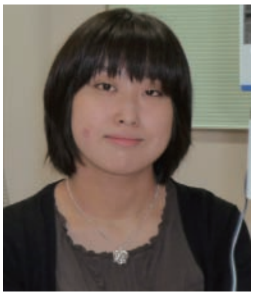


My name is Kiyoshi Fujino. I came from Hokkaido University. Actually, I had been a faculty member of the Department of Earth Sciences at Ehime-University until 16 years ago. My speciality covers a wide range of phase equilibria, crystal structures, phase transitions and rheology of minerals at high pressure and high temperature, using X-ray diffraction, analytical electron microscopy and high pressure and high temperature experiments including a laser-heated diamond anvil cell. Currently, I am interested in the experimental measurement of spin states of iron in the lower mantle minerals. I would like to deeply contribute to the succession of the fundamental methods of studying minerals such as crystallography and thermodynamics along with the basic experimental methods in the international cooperation of the Global COE program.

Yasuhiro KUWAYAMA (Assistant Professor)

My name is Yasuhiro Kuwayama and I have moved here from Tokyo Institute of Technology. I received my Ph.D from Tokyo Tech. in 2007, working with Prof. Kei Hirose on phase relations of iron alloys based on laser-heated diamond-anvil cell (LH-DAC) experiments. My current research interests are focused mainly on the structure, composition, dynamics and evolution of the Earth's central core. Achieving high pressure and temperature conditions equivalent to the center of the Earth is a major experimental challenge. I will make efforts to successfully achieve accurate measurements under such extreme conditions, in order to understand the whole range structure of the deep Earth interior from mantle to core. It is my great pleasure to work at GRC.

Ayako SHINOZAKI (PhD student)



I graduated master course from University of Tsukuba in this spring. I research for relationship between C-O-H fluid mantle minerals using laser heated diamond anvil cell. Mantle dynamics considerably depends on these fluids. Thus, existence and states of the fluids in the Earth's mantle are important issues to be understood. Methane and water fluids are stable in the lower part of mantle. I'd like to reveal about stability of methane in the mantle condition, the effect of methane and hydrogen on stability and crystal structure of olivine.

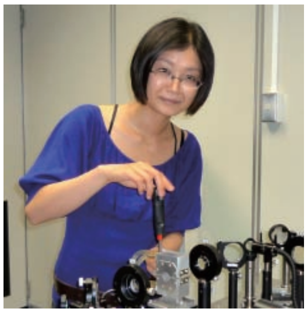
Hisako HIRAI (Professor)

I moved to GRC from Tsukuba University on this April. My major is high-pressure material science and Earth-planetary science. I study high-pressure properties of gas hydrates, e.g. methane, hydrogen and carbon dioxide hydrates, and planetary ices, e.g. solid methane and ethane by using diamond anvil cell in wide temperature range from 77K to 2500K. On the basis of the experimental results, I try to understand the nature of these materials and also to infer interiors of the icy planets and their moons. Besides, I'm interested in synthesis of diamond and ultra-hard materials, especially in the transition mechanisms from starting materials.

Shinichi MACHIDA (COE Postdoctoral Fellow)

My research is high pressure study for gas hydrates. Gas hydrates are inclusion compounds which are made of hydrogen-bonded water molecules forming cages or frameworks and of including gas molecules. Methane hydrate is expected to become a promising natural resource. Also, hydrogen has attracted attention as a new energy resource, and hydrogen hydrate is expected to be the storage of hydrogen molecules. In the icy planets of the solar system, methane hydrate and hydrogen hydrate are considered to be the major constituents of outer planets and their moons. To estimate the formation and evolution process and the interiors in icy planets, high pressure experiments of gas hydrate are important.

Sayaka MURAKAMI (PhD student)



I start from this April on experiments under the condition at the Earth's core-mantle boundary (CMB) using diamond anvil cell. The objective of my research is to determine melting temperature of major minerals in the lower mantle, which is importnt issue to understand Ultra-Low Velocity Zone (ULVZ) suggested to exist just above the CMB. The origins of ULVZ are suggested to be due to partial melting of mantle materials. However, the melting temperature for lower mantle minerals are not well determined. Through the experiments in my PhD student life, I'd like to investigate the origins of heterogeneous structures at CMB and to study the dynamics at the CMB.

Internship Report

Akihiro YAMADA (COE Postdoctoral Fellow)

I visited Department of geology, University of California Davis (UCDavis) as an internship scholar from January to mid March. I studied about structure and density of dense silicate glass with students and researchers there. They are investigating silicate melt structure and the physical properties (e.g., density and viscosity) at high pressure through the relaxation process of the glass, which reflects the structure of super-cooled liquid at the conditions where it is synthesized. In particular, they have excellent facility of solid state Nuclear Magnetic Resonance (NMR), which focuses on structural analysis of dense amorphous materials including silicates synthesized at high pressure and temperature. They gave me a chance to collect the data of dense $MgSiO_3$ glasses synthesized at high pressures and temperatures. In addition, I had a chance to participate in the beamtime of UCDavis group at Advanced Photon Source (APS). The group at UCDavis and GSECars have been working on the volumetric properties of silicate melt with pressure using high-pressure micro X-ray computed tomography, which is unique technique developed at GSECarse (Sector 13). In this method, we can get 3D image of sample by taking 2D sample image with rotating 180 degree (e.g., every 0.5 degrees). This method is useful for many kinds of experiment.

I am so grateful to GRC faculties, secretary and colleagues at UCDavis, Prof. C.E. Lesher and his students, for giving me great opportunity and their kind helps during this internship program

Preliminary Experiments using the Deformation-DIA Apparatus "MADONNA"

Takaaki KAWAZOE
(COE Postdoctral Fellow)

It is important to study rheological properties of mantle minerals (e.g., olivine, wadsleyite, ringwoodite and Mg-perovskite) at high pressure for understanding mantle dynamics. Pressure range of the traditional deformation experiments had been limited up to a few GPa using a gas apparatus and a Griggs apparatus. The situation was changed by developments of two types of new high-pressure deformation apparatus, namely deformation-DIA apparatus (D-DIA; Wang et al., 2003) and rotational Drickamer apparatus (RDA; Yamazaki and Karato, 2001). Both apparatus have capability to generate pressure of 18 GPa at high temperatures (Nishiyama et al., 2007; Nishihara et al., 2008). The D-DIA apparatus has simpler deformation geometry compared with that of the RDA. This makes it easier to interpret a lattice preferred orientation (LPO) of a deformed sample. This advantage of the D-DIA apparatus motivated us to conduct deformation experiment of mantle minerals with large strain at high pressure to study their LPO. Here we will report results of preliminary experiments using a D-DIA apparatus "MADONNA".

Preliminary experiments were performed using "MADONNA" with a 6-6 type compression system (Nishiyama et al., 2008). We employed tungsten carbide anvils for pressure-generation and deformation tests. The relationship between sample pressure and press load was calibrated at room temperature by measuring electrical resistance change of ZnTe (12.0 GPa), ZnS (16.2 GPa), GaAs (19.3 GPa) and GaP (24 GPa). Calibration of the relationship at high temperature (1900-2000 K) was conducted by the quench method using phase transitions in Mg_2SiO_4. Pressure generation was observed up to 20 and 24 GPa (Figure) at 1900-2000 K and room temperature, respectively. Preliminary deformation experiments were performed using a deformation cell at 19 GPa and room temperature. Deformation of a pressure medium was monitored as advancement of upper and lower anvils using displacement sensors.

These results show capability of "MADONNA" to conduct deformation experiments up to 20 GPa and 2000 K. Further technical development is to be done toward deformation experiments of mantle minerals and rocks under pressure-temperature conditions of the mantle transition zone and the lower mantle.

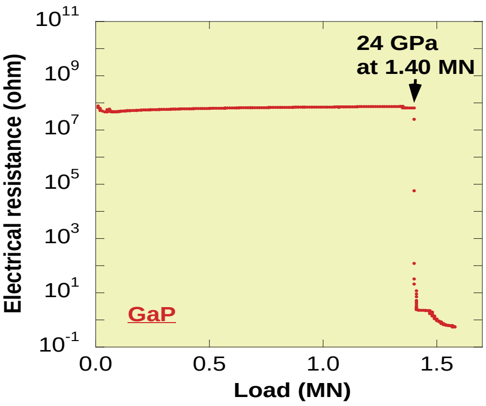


Figure 1 . Electrical resistance of GaP with applied press load during compression process. The generated pressure is the highest record using a cubic-anvil apparatus (including the D-DIA apparatus).

Elastic properties of $MgGeO_3$ postperovskite by first principles calculations

Yusuke USUI
(COE Postdoctral Fellow)

Now the relationship between the seismic velocity heterogeneity observed in the deep mantle and the properties of postperovskite phase of $MgSiO_3$ is being discussed extensively. Since the $MgSiO_3$ has quite high transition pressure, study of low-pressure analogs is also important. Although the high-P,T phase relation of $MgGeO_3$ is predicted to be quite similar to those of $MgSiO_3$ including the Clapeyron slope, it is still not well understood how similar the elastic properties of analogs to those of $MgSiO_3$. We show the elasticity of $MgGeO_3$ perovskite (pv) and postperovskite (ppv) calculated based on the density functional first principles methods, and compare them to those reported for $MgSiO_3$.

The behavior of elastic property of $MgGeO_3$ ppv is generally the same as those of $MgSiO_3$. The small c_{22} means that the [010] direction parallel to the stacking direction of GeO_3 layers is significantly compressible. The large c_{66} indicates that a lateral shift of layers ((010) planes) parallel to the edge sharing octahedral columns (along [100]) faces the greatest resistance. These are also found in $MgSiO_3$ ppv. On the other hand, c_{55} is clearly smaller than other shear elastic constants. This means the resistance very weak for shear deformation of GeO_3 plane itself. In comparison with $MgGeO_3$ and $MgSiO_3$, c_{55} of $MgGeO_3$ is remarkably smaller than that of $MgSiO_3$. This indicates that the shear elasticity of ppv is more distinct in $MgGeO_3$ than in $MgSiO_3$.

The isotropic averaged compressional (P), shear (S) and bulk (φ) wave velocities show negative jumps of -1.09%, -1.02% and -1.12% across the static transition pressure, respectively. These are very different from the case of $MgSiO_3$, where the S wave of ppv shows a distinct positive jump of +1.5%, being consistent with the typical character of the D" discontinuity. In this point, the elasticity of $MgGeO_3$ ppv is not completely analogous to that of $MgSiO_3$. For transverse anisotropy (A_S^T), both phases have the same anisotropy trend at relevant pressures, though the anisotropy in $MgGeO_3$ has somewhat larger pressure dependences in all three directions. A_S^T of $MgGeO_3$ for [100], [010], [001] aligned vertically are +1.0%, +2.8% and +26.9%, respectively. Those of $MgSiO_3$ are quite similar and -6.7%, +3.4%, and +16.8%, respectively. Unlike $CaIrO_3$, distinctive $V_{SV}<V_{SH}$ type transverse anisotropy, that is typically observable in the D" layer, is achieved only when [001] is oriented vertically at relevant pressures. Finally we conclude that $MgGeO_3$ are not fully comparable to those of $MgSiO_3$, in particular for the velocity contrasts across the phase change, though we may consider $MgGeO_3$ as one of good low-pressure analogs of $MgSiO_3$.

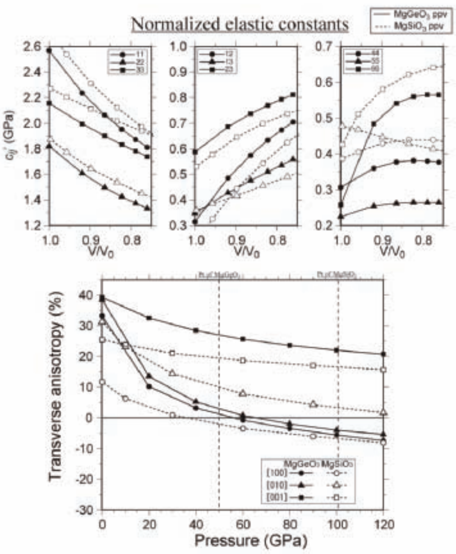


Figure 1 . (top) Volume dependence of the normalized elastic constants of $MgGeO_3$ and $MgSiO_3$ post perovskite (bottom) Pressure dependence of the elastic anisotropy of $MgGeO_3$ and $MgSiO_3$ post perovskite. Polarization anisotropy of S waves in transversely isotropic media with the three possible orientations of the major crystalline axes: a, b, and c oriented vertically.

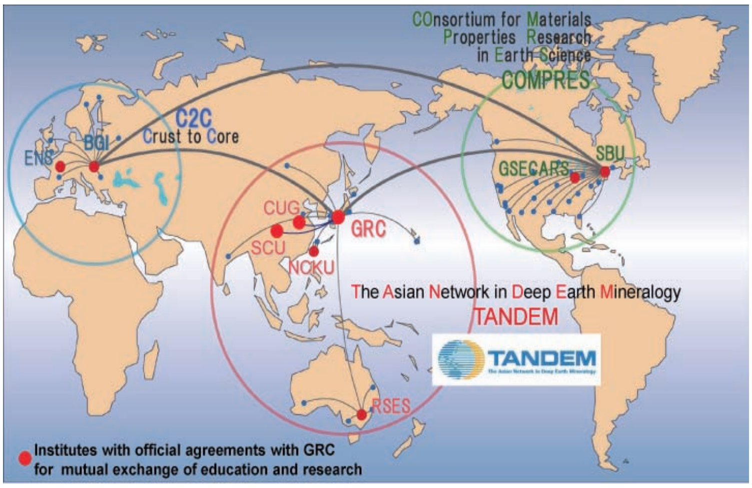
TANDEM

The Asian Network in Deep Earth Mineralogy

News & Events

International session in JPGU meeting

An international session relevant to deep Earth mineralogy was held during the period of the annual meeting of Japan Geoscience Union (16-21 May). This session was run for three days, entitled as "Dynamics and Evolution of the deep Earth", convened by T. Katsura (Okayama Univ.), D. Zhao (Tohoku Univ.), and M. Kameyama (Ehime Univ.), in order to enhance international communications and collaborations in deep Earth mineralogy, particularly in the Asian region. Our global COE program contributed to invite some foreign researchers, including Dr. Yingwei Fei of Geophysical Laboratory, CIW, and Nadege Hilairet of GSECARS, Univ. Chicago, and will continue to play major roles in the corresponding international sessions in forthcoming years. Contributions of papers from TANDEM laboratories are to be most welcome in these sessions of the JPGU meeting held every May in Makuhari, near Tokyo.



TANDEM Laboratories (2009 May)

Ehime University	Japan
University of Tokyo (Geochem. Lab.)	Japan
University of Tokyo (Inst. Solid State Phys.)	Japan
Japan Synchrotron Research Institute	Japan
Hokkaido University	Japan
Kyushu University	Japan
Hiroshima University	Japan
National Institute for Materials Science	Japan
Gakushuin University	Japan
Okayama University	Japan
Tokyo Institute of Technology	Japan
Osaka University	Japan
Kyoto University	Japan
University of Hyogo	Japan
Japan Agency for Marine-Earth Science Technology (IFREE)	Japan
China University of Geosciences	China
Jiling University	China
Peking University	China
Chinese Academy of Science (Inst. Geochem.)	China
Chinese Academy of Science (Inst. Geol. Geophys.)	China
Yanshan University	China
Sichuan University	China
Seoul National University	Korea
National Chen Kung University	Taiwan
Australian National University	Australia

Advisors:
Yanbin Wang, GSECARS, Univ. Chicago
Baosheng Li, MPI, Stony Brook Univ.
Juhua Chen, Florida Int. Univ.
Yingwei Fei, Carnegie Inst. Washington

Brief Communications

A visit to CUG in Wuhan

I had an opportunity to visit China University of Geoscience (CUG) in Wuhan briefly in April and communicate with the headquarters, including the President of CUG (Prof. Jingao Zhang), Dean of Faculty of Earth Sciences (Prof. Xiulong Lai), Director of State Key Laboratory of Geological Processes and Mineral Resources (GPMR, Prof. Shan Gao), and Prof. Zhenmin Jin, a member of Chinese Academy of Science. I also enjoyed talking with the faculty staff members and students at GPMR and a campus/lab tour organized by Prof. Jin. I found staff members of GPMR are of world-level and the laboratories there are very well equipped and organized, particularly those related to experimental geochemistry and petrology. I was also impressed by the students of GPMR, who are highly motivated and prepared to step into new research fields, in addition to their high ability to communicate in English. Wuhan is the capital of Hubei province with a population of about 10 million, and consists of a mixture of urban high-rise buildings and traditional Chinese downtown areas. Although I did not have time to explore the city on this visit, I do hope to see some famous spots, such as Yellow Crane Tower, in my next trip to Wuhan. Finally, I would like to thank Profs. Jin and Junfeng Zhang of GPMR for their warm hospitality during my stay (article by T. Irifune).

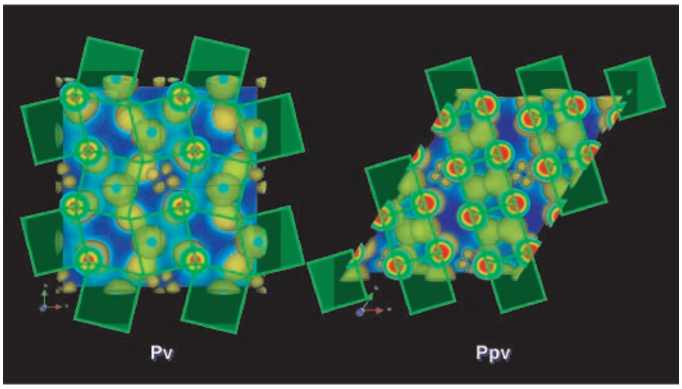
Geodynamics Research Center, Ehime University

Geodynamics Research Center (GRC) of Ehime University is the core institute of the global COE program on Deep Earth Mineralogy, which is one of three COE programs selected in Earth and planetary science field among all Japanese universities. GRC focuses its studies on structures, physical properties, dynamics and evolution of deep Earth, based on experimental and theoretical grounds. GRC now has 15 faculty members (including tenure-track positions and COE professor positions) and more than 10 post-docs and research fellows, as well as ~15 graduate and ~10 undergraduate students. The activities of GRC and global COE are strongly supported by about 15 technical, administrative, and official staff members, such as "Research Administrator" and "Lab Manager", which have been firstly introduced to GRC as entirely new positions in Japanese universities. These figures of the GRC members are increasing year by year, and we expect the total number will soon reach ~80.

Experimental branch of GRC is made of 5 major research/education groups, focusing on (1) high-pressure Earth science and technical development, (2) diamond and new materials synthesis, (3) fluid and magma, (4) rheology, and (5) applications of diamond anvil cell and quantum beams, while theoretical study groups are (6) mineral physics based on ab initio calculations and (7) simulation of mantle and core dynamics. All of these groups organize their own seminars, in addition to the "Geodynamics Seminar" given in English regularly held on Friday for whole GRC members. In addition to these seminars, we invite world-leading scientists for "International Lecture" and "International Frontier Seminar" series open to researchers/students outside GRC.

Experimental groups share rich high-pressure experimental and analytical facility at GRC. GRC has three conventional Kawai-type multianvil apparatus (ORAGNGE-1000, 2000, 3000) for high-pressure phase equilibrium and physical measurement studies, as well as new world-largest D-DIA (MADONNA-1500) and 6000-ton Kawai-type apparatus (BOTCHAN-6000) for deformation and materials synthesis experiments, respectively. Moreover, a new version of MADONNA (MADONNA-II) for operation of sintered-diamond cell will be introduced within this year.

GRC also has more than 10 diamond anvil cells with a YAG laser heating system, in addition to a Drickamer and a piston-cylinder apparatus. The analytical instruments available include 200keV analytical TEM, SEM-EDX combined with micro-Raman spectroscopy, FE-SEM with EBSD and EDX, high-power X-ray with high-temperature furnace and micro-focus attachment, FIB, micro FT-IR, etc. Utilizing these apparatus and instruments, as well as synchrotron X-ray source of SPring-8 which is easily accessible from GRC, experimental groups have greatly contributed to the precise determinations of phase transitions in deep mantle and subducted slabs, elastic wave velocity measurement under the mantle transition region, behavior of water in deep mantle, etc. Synthesis of new materials have also been conducted in collaboration with related laboratories in physics, chemistry, materials science, using high-pressure facility at GRC. One such successful example is the nano-polycrystalline diamond (NPD=HIME-DIA) invented by GRC, which was found to be the hardest material ever synthesized, and industrial and scientific applications of this novel material has been pursued at GRC and related laboratories.



Theoretical mineral physics group is pursuing investigations of ultra-high pressure and high-temperature behaviors of Earth and planetary materials and also related materials based primarily on the first principles computation techniques. Major interests are 1. density functional computation of complex minerals and related materials and their physiscal properties (structural property, thermodynamics, elasticity, etc. of major lower mantle and core phases). 2. development of fundamental methods for calculation techniques, 3. theory of materials at extreme condition, 4. Earth's structure and dynamics. The group's recent achievements include quite important post-perovskite transition in $MgSiO_3$, pressure-induced spin transition of iron in ferropericlase, P-V-T equations of state of major materials, dense structures, melt, iron alloy, etc. The method is now extended to solid-solution thermodynamics, and these studies have drastically advanced our understanding of the Earth's deep mantle mineralogy. This group is now updating the GRC parallel computing system. New cluster system has approximately 400 cores and 400 GB memory in total with quad-core Xeon processors. See web site for further information on the research activity of the group (http://www.sci.ehime-u.ac.jp/~takut/index_e.html).

Mantle and core dynamics group also uses parallel computing system, as well as super computers such as Earth Simulator, to simulate dynamics of the whole mantle, mantle-core boundary, and outer core of the Earth, based on fluid dynamics and other physics disciplines. Development of cutting-edge computational techniques relevant to dynamics and evolution of the Earth is also a major research subject of this group. Physical parameters obtained by both experimental and theoretical mineral physics groups are used to simulate various phenomena in Earth's and planetary deep interiors.

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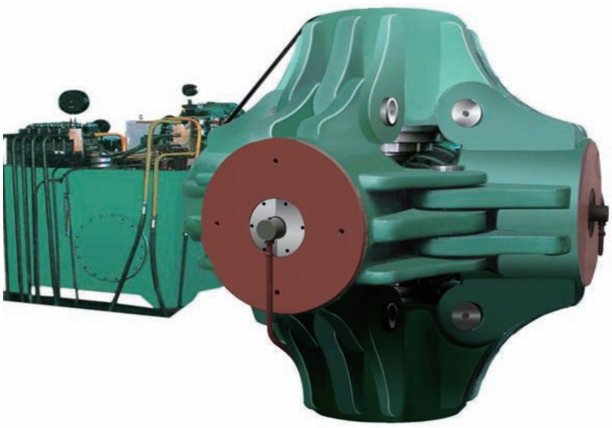
Laboratory of High Pressure Science & Technology (HPST) , Sichuan University

Sichuan University (SCU) is a national key university directly under the State Ministry of Education. As the largest university in the west of China, SCU has a history of more than 110 years and enjoys a deep cultural background and eminent scholarly research tradition. It has 2 national key labs, 6 national engineering centers, 5 ministerial key labs, 35 provincial key labs, 10 ministerial and provincial centers, 4 key research bases for humanities and social sciences, and 4 clinical research bases at the national level. Besides, it has 12 first-class disciplines to grant Doctor's degree and Master's degree, 111 second-class disciplines to grant Doctor's degree, 178 Master programs, 6 specialized degree programs, and 16 post-doctor stations. The 109 bachelor programs cover the major fields in liberal arts, sciences, engineering, medicine and agriculture. SCU has a current student population of more than 70 thousands.

The Laboratory of High Pressure Science & Technology (HPST) was supported by the Atomic and Molecular Physics Institute of SCU. The predecessor of the HPST laboratory was the High Temperature and High Pressure Physics Institute, which was established by Chengdu University of Science and Technology (now is SCU) and Fluid Physics Institute of China Academy of Engineering Physics in 1983. The HPST began to recruit graduate students for master and doctoral degree majored in Atomic and Molecular Physics since 1985. In 2006, it began to recruit graduate students for master and doctoral degree majored in High Pressure & Technology, which is the earliest specialty in China.

The HPST original main purpose was to provide a platform on the research and application of the dynamic and static high pressure. It is one of the earliest labs to perform the research on the synthesis of made-made diamond and cBN. Currently, its researches are mainly focusing on novel superhard materials, solidification and crystal growth at high pressure, non-crystalline materials and new energy materials, elastic moduli and strength of strong materials under high pressure as well as development of technology for large volume press.



The laboratory currently houses a two-stage gas gun, 6×800 ton cubic press, and 6×2500 ton cubic press. The two-stage gas gun can generate the pressure up to 300 GPa, the 6×800 ton cubic press equipped with self-designed 6-8 two-stage apparatus can enhance the P/T condition up to 25 GPa/2000°C, and the 6×2500 ton cubic press is currently the largest tonnage high-pressure apparatus in laboratories of the world. In addition to those high P/T apparatus, the HPST is also equipped with X-ray diffraction apparatus (DX2500), Vickers hardness tester (FV700), and high vacuum furnace system (WZB-20), Numerical Control Machine, etc.

Professor Duanwei He is the head of the HPST. There are currently 5 faculties, 6 PhD students and about 20 master students in the group. The HPST has a weekly seminar on a regular basis, and always welcomes speakers and audience from outside the laboratory.

The laboratory always contributes zealously to the international corporations. Last century, Professor Masao Wakatsuki, the first person to successfully grow the synthetic diamond in Japan, has been invited as the visiting professor of the HPST laboratory. The two laboratories have exchange scholar programs and also accomplished two joint projects sponsored by Japan Ministry of Education, Science and Culture. At present, the laboratory is collaborating actively with many other international research laboratories in high-pressure fields including Geodynamics Research Center (GRC) at Ehime University, Geosciences department at Princeton University, LANSCE division at Los Alamos National Laboratory, etc. We look forward to establishing close and sustained collaborations with any interested individual or laboratories of the TANDEM on high-pressure researches and training of young scientists and graduate students.

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