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. 8, June 30, 2011

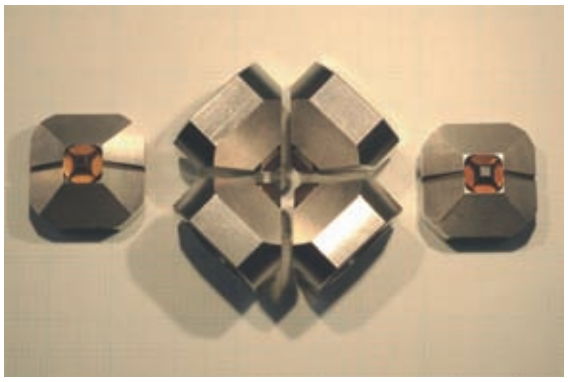
News & Events

Activities of GRC reported on NHK news

The nation-wide TV news program "Ohayo Nippon" of NHK, the Japanese national broadcasting organization, reported activities of GRC and the global COE program on 3rd March 2011. The news started with the comments on the targets and current researches of GRC by the Director, Prof. Tetsuo Irifune, highlighting the nano-polycrystalline diamond (HIME-DIA) of 1 cm produced recently with the world largest Kawai-type apparatus (BOTCHAN-6000). Then the program reported the activities of the Theoretical Mineral Physics Group of GRC in detail, focusing on Prof. Taku Tsuchiya's recent research achievements, who received the JSPS award on the same day, as one of the 24 awardees from all research fields in Japan. Some of the internship students from Peking University studying under the supervision of Prof. Tsuchiya, and Dr. Arnaud Metsue of the TMPG, a global COE Research Fellow from France, were interviewed on their research subjects and impressions on GRC.

HIME-DIA for new high-pressure technology

Efforts have been made to synthesize a number of HIME-DIA rods of 7-8 mm by Dr. Toru Shinmei, the Lab Manager of GRC, which are processed to anvils for multianvil apparatus. Some preliminary tests of the performance of HIME-DIA were made as anvils for diamond anvil cell and the 6-8-2 multianvil cell, which demonstrated this novel material born at GRC is potentially important for new high-pressure technology. The full applications of HIME-DIA anvils have just started with the 6-6 compression system invented by Assoc. Prof. Norimasa Nishiyama of GRC, and Dr. Takehiro Kunimoto of JASRI, who received PhD under the supervision of Prof. Irifune, are currently testing a new cell assembly using HIME-DIA anvils. In addition, application of HIME-DIA anvils to Kawai-type apparatus (multianvil 6-8 system) are also being planned, with which pressures beyond 100 GPa are expected to be realized in the near future. Collaborations using HIME-DIA anvils have been made/started with the researchers in Sumitomo Electric Industries, Osaka University, Hiroshima



University, University of Tokyo, Okayama University, Hyogo University, Japan Atomic Energy Agency, Carnegie Institution, and Yale University.

New studies using MADONNA-II

MADONNA-II, a simplified version of the deformation DIA type apparatus (MADONNA-1500) at GRC, is the new DIA-type apparatus installed at the SOSEKI Lab of GRC in 2010 with the global COE budget for cutting edge research and for training young students relevant to the COE program. This apparatus, which realizes excellent three dimensional alignments of the first-stage anvils, is used mainly by PhD students and COE post-doctoral fellows for studies in 1) lower mantle mineralogy using sintered-diamond anvils, 2) rheological properties of mantle minerals with the 6-6 compression system, and 3) performance tests of new cell assemblages for experiments at SPring-8 and J-PARC, as well as conventional multianvil experiments with Kawai-type assembly. Some new results using this apparatus, such as partitioning of Fe among the coexisting high-pressure phases under the lower mantle conditions, have already been submitted to some international scientific journals.

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

Future directions of GRC

GRC, the core research center of the global COE program, was established in April 2001, and the future directions of GRC have been discussed in the evaluation committee organized in Ehime University. The final report, issued on 9 March 2011, summarizes the great achievements of GRC, highlighting very high successful rate of obtaining external funds (about 2.2 billion Yen = 27.5 million dollars) during this period, over 300 papers in international journals including HIF journals such as Nature, Science and PNAS, 19 major awards such as Alexander von Humboldt Award, JSPS Award, JAMS Award, JSHPST Award, Jamieson Award, Ishikawa Carbon Prize, etc. It is concluded that the activity of GRC should be expanded particularly towards interdisciplinary research fields, such as materials sciences and planetary sciences. It is also recommended that GRC to nominate for a national Joint Usage Research Center in the near future.

Invited talks in Taiwan, USA, China

The leader of the COE program, Prof. Irifune of GRC, made invited lectures/seminars in National Cheng Kung University in Tainan, Carnegie Institution in Washington D. C., and Sichuan University in Chengdu during the period of late March to early June as a part of the activity of the program and to enhance the mutual collaborations of GRC with the relevant institutions in these organizations. GRC has official agreements with Department of Earth Sciences at Cheng Kung Univ. and Institute of Atomic and Molecular Physics at Sichuan Univ. Ehime Univ. has just concluded an official agreement with Sichuan Univ., and Prof. Irifune visited Chengdu with the President and vice President of Ehime Univ. and delivered a special lecture in Sichuan Univ. Meanwhile, Prof. Irifune gave an invited seminar at the Geophysical Laboratory (GL) of the Carnegie Institution, with which the GRC will have a joint symposium at the GL in September, as a part of the COE program.

Internships and Lectures by the members of SUNY

Some colleagues of the Mineral Physics Institute (MPI) of Stony Brook University, which has official collaboration agreement with GRC and an important partner of the global COE program, visited GRC for internships, lectures, and collaborative researches relevant to the ultrasonic sound velocity measurements at high pressure. Prof. Gabriel Gwanmesia of Delaware University, the former PhD student at Stony Brook University, stayed at GRC from early February for about 2 months and made some experimental studies on the synthesis of polycrystalline garnet for sound velocity measurements. Prof. Baosheng Li of MPI, who is an official member of the global COE program, visited GRC for several days for internships for the basics and application of ultrasonic measurements under high

pressure. Moreover, Prof. Robert C. Liebermann of MPI, who is the former president of COMPRES, visited GRC for about three weeks from early April, and gave a lecture and a seminar, as well as some intensive discussions about the high-pressure mineral physics studies during this period. Prof. Liebermann also enjoyed the cherry blossoms and Hanami parties for the first time, in spite of a number of trips to Japan he made over the past ~40 years.

Completion of a new LVP for neutron studies

A new large volume press ("Atsu-hime") for high-pressure neutron studies has been completed and assembled at the Sumitomo Heavy Industries Techno Fort Co. Ltd. in Niihama city of Ehime prefecture, close to GRC, and an inspection ceremony was held on 18 March 2011 attended by some members of GRC, Prof. Hiroyuki Kagi (an official member of the COE from Univ. Tokyo), and Prof. Takehiko Yagi (the representative of the Grant-in-Aid for Scientific Research on Innovative Areas "Earth Science Based on the High Pressure and Temperature Neutron Experiments"). This apparatus, newly designed by Dr. Takanori Hattori of Japan Atomic Energy Agency and his colleagues, is supposed to move to the new beamline ("PLANET") at the J-PARC. However, because of the earthquake that hit the East Japan on 11 March, some facility of J-PARC was damaged, and the transportation of Atsu-hime to PLANET is forced to be postponed. Meanwhile, a first-beam ceremony was about to be held in the afternoon of 11 March at J-PARC, and many members of the above project, including Prof. Toru Inoue of GRC, gathered at the PLANET and encountered the tragic event. Fortunately, none of them were injured upon the quake, and were able to come back home within a couple of days.

Influence of the earthquake to the COE program

The Great East Japan Earthquake that hit mainly Tohoku and Kanto areas on 11 March 2011 caused casualties of some 16,000 deaths and 5,500 injuries, while nearly 8,000 people are still missing, due mainly to the unexpectedly high tsunami waves. We express our deepest condolence and sympathy to those who suffered from the tragic events and the associated nuclear plant damages in Fukushima. Fortunately, however, the western regions of Japan, including Ehime prefecture in Shikoku island where GRC locates, were not directly affected by the earthquake and the subsequent nuclear plant accident. Our COE program has also been unaffected by these events, except for some delay in the construction of the new high-pressure neutron beamline at J-PARC, where Prof. Kagi of Univ. Tokyo, Prof. Inoue of GRC, and some other members of GRC are heavily involved. We shall make our best efforts toward developing cutting edge studies and mentoring young scientists in the fields relevant to Deep Earth Mineralogy, and contribute to the reconstruction of the Japanese society through the developments of new science and technology.

News & Events

Activities during 2011 JpGU meeting

At the Japan Geoscience Union (JpGU) Meeting 2011 in Makuhari during the period of 22-27 May, two international sessions were organized by the members of the present Global COE program. The first was entitled "Mineral physics and dynamics of deep mantle", which was convened by Dr. Masanori Kameyama, Assoc. Prof. of GRC, together with Dr. Takashi Yoshino at ISEI of Okayama Univ. and Dr. Dapeng Zhao of Tohoku Univ. In this session, twenty-nine (18 for oral and 11 for poster) papers were presented by researchers from various disciplines on mineral physics and geodynamics of the planetary interiors, focusing on (1) thermal/chemical structure, (2) behaviors of fluids and/or hydrous minerals, and (3) rheology of the deep mantle.

The second international session was entitled "Structure, Dynamics & Composition of Earth & Planetary Cores", convened by Dr. Matthew L. Whitaker, Assist. Prof. of the GRC, in collaboration with researchers with seismological and geodynamical basis. The session aimed at a multidisciplinary discussion on the recent research advances and an exchange of new ideas about future directions of the study of the cores, including both solid inner and liquid outer parts of the planetary cores. In this session, twenty-one (14 for oral and 7 for poster) papers were presented by students and researchers from various universities/institutes.

During the meeting, an exhibition booth was run by GRC members to advertise the activities of the GRC and global COE. At the booth, hot research products by the GRC were also displayed, including the nano-polycrystalline diamond (HIME-DIA) and facilities recently installed at the GRC. The materials displayed in the booth successfully attracted many participants/visitors from broad ranges of interests in the meeting.

International Frontier Seminar

20th (23rd February)
"The elasticity of synthetic polycrystalline almandine, grossular and CMNF garnet at high pressures and high temperatures"
Lecturer: **Prof. Gabriel Gwanmesia** (Delaware State University)

21st (1st March)
"Fe-bearing perovskite and post-perovskite: phase stability, spin transitions, and the consequences for the lower mantle"
Lecturer: **Dr. Razvan Caracas** (CNRS, ENS de Lyon, Lab. Sciences de la Terre)

22nd (15th April)
"Indoor vs. Outdoor geophysics"
Lecturer: **Prof. Robert C. Liebermann** (Dept. Geosci., Stony Brook University)

Forthcoming Events

GL-GRC inter-institutional Science Symposium

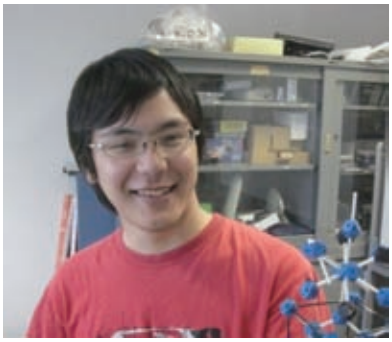
As a part of the global COE program, GRC and Geophysical Laboratory of Carnegie Institution will have a joint inter-institutional symposium in September for three days. About 30 oral presentations by young scientists from both institutions and related laboratories are scheduled, as well as several keynote talks by the relatively senior members and poster presentations from the both sides. The symposium is held to highlight the forefront research at these institutions and foster scientific exchange between them. For further details, please see the website of the symposium.
(http://people.gl.ciw.edu/grc/)

4th YESA workshop

The 4th YESA (Young Earth Scientist Association) workshop will be held on 1st and 2nd September, 2011, at GRC. This workshop focuses on the effects of the heterogeneous materials on the mantle dynamics, estimated by using various methods, such as geodynamics simulations, seismology, mineral physics, and petrochemistry under the deep mantle conditions. One of the major scientific goals of this workshop is to propose a new model based on the interpretation of dynamics and evolution of the Earth's and planetary deep interiors in the light of the heterogeneity in the mantle. For further details: Please see global COE website (http://deep-earth-mineralogy.jp) or contact Dr. Ichikawa at GRC (h-ichikawa@sci.ehime-u.ac.jp).

New Members

Youhei Kojima (PhD Student, GRC)



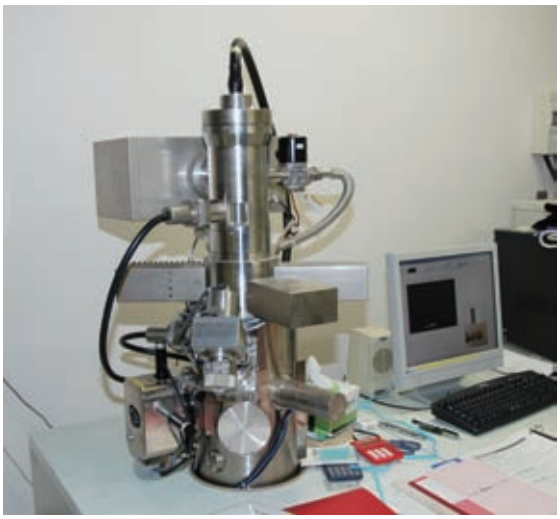
I am a new Ph.D. student who joined the GCOE program at GRC this April. My research interest is carbon nitride (C_3N_4) which is theoretically predicted to be harder than diamond. Throughout my undergraduate and master thesis works, I have been studying whether the predicted superhard C_3N_4 phase can be obtained via high-pressure and high-temperature experiments. I performed a series of experiments using a laser-heated diamond anvil cell combined with in-situ X-ray diffraction at BL10XU, SPring-8 and found that graphitic-C_3N_4 (starting material) transforms to an orthorhombic phase above 30 GPa and 1600 K. The unit cell of the orthorhombic phase is similar to that of the hydrogen-bearing phase, $C_2N_2(NH)$, although its composition was measured to be close to stoichiometric C_3N_4, suggesting a flexible adaptation of the structure in the C-N-H system under high pressure.

I am currently investigating the stability of this phase at pressures above 100 GPa and also exploring the possibility of whether superhard carbon nitride with a pure C_3N_4 composition can really be synthesized. I hope to obtain the new hardest material in my PhD. project.

Naoki Noguchi
(Postdoctoral Fellow, The University of Tokyo)

See next page for a detailed.

Facility at GRC (II): Focused Ion Beam (FIB) system



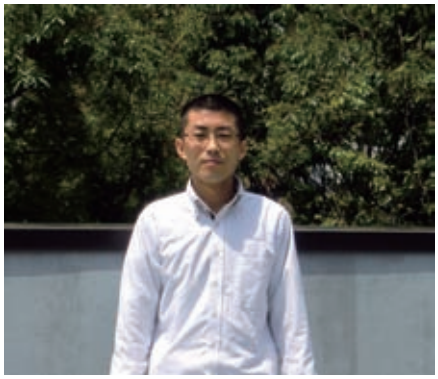
The FIB technique was developed in the late 1980s, and has been used mostly in the fields relevant to nano-technology and semiconductor industries. Applications of this technique to Earth sciences started in early 2000s to make thin foils for TEM observations. A combination of this technique and a sample-retrieval system with a micro manipulator enables to make a site-specific thin foil. GRC introduced an FIB system (JEOL JEM-9310FIB) in 2003, for the first time in high-pressure mineral physics field, and successfully applied this system for the sample subjected to a pressure of 115 GPa at 2200K in a laser heated diamond anvil cell (Irifune, Isshiki, and Sakamoto, EPSL, 2005). Using this system, a thin film of the sample with typical dimensions of ~10 × 5 × 0.1μm can be easily made and picked up with the micro manipulator, and used for TEM observations, which is now a quite popular technique in high-pressure mineral physics studies, particularly those using LHDAC. This system is open to the visiting and guest researchers at GRC, and has been used for the processing various natural and synthetic samples.

COLUMN: The world of Three Kingdoms

"Sanguo Zhi" ("Sangoku-shi" 三 国 志 or "Records of Three Kingdoms") is a famous historical book on the Three kingdoms period of China (AD 189-280), which describes the histories of the rival States of Wei (Gi, 魏), Shu (Shoku, 蜀), and Wu (Go, 呉). The original author is thought to be Chen Shou, born in the present Sichuan, which is the Kingdom of Shu (Shoku). On the other hand, "Sangoku-shi", written by a Japanese writer Eiji Yoshikawa, is kind of long novel based on "Sangue Zhi", which is quite popular in Japan but may be more closely related to the "Sanguoyani" ("Romance of Three Kingdoms") written in China later in the 14th century. GRC made an official agreement on the mutual collaborations and exchange of people with the Institute of Atomic and Molecular Physics of Sichuan University in 2008, and some members of both institutes hold strong mutual relations. Chengdu, where Sichuan University locates, was the ancient capital of the state of Shu. Zhuge Lian (諸葛亮 or 諸葛孔明) played an important role as a chancellor of Shu, who helped the emperor Liu Bei (劉 備) and is one of the most popular and favorite characters for Japanese. Although Shu was the smallest state with the lowest population, it survived and even sometimes dominated other countries over the period of the Three kingdoms, because of the presence of Zhuge Lian. Lian emphasizes in his famous document "Chu Shi Biao" (出師表) that it is most important to adopt and use best persons for the right positions for the Kingdom to survive and develop, particularly for the small kingdom like Shu. This may also be true for GRC, which is a small "kingdom" and locates in the southwestern country side of Japan, similar to Shu, and perhaps should be taken into considerations for its survival and development in the next 10 years.

The behavior of OH groups of antigorite under high pressure and high temperature

Naoki Noguchi
(Postdoctoral Fellow,
The University of Tokyo)



Serpentine minerals are formed by hydrothermal alteration of mafic and ultramafic rocks. In particular, the serpentine minerals resulting from alteration of oceanic crusts play a role in carrying water to the depths of subduction zones. Stabilities and physico-chemical properties of serpentine minerals under high pressure (HP) and high temperature (HT) conditions are essential for constructing a comprehensive model on the dehydration processes in subduction zones. Previous experimental studies on serpentine minerals have revealed that antigorite has the largest stability field in serpentine minerals under HT condition (e.g., Evans et al. 1976), and antigorite must be abundant in the altered oceanic crusts. However, in spite of the importance for the fundamental properties of antigorite, the crystal structure including the geometry of OH groups under HP-HT conditions remains unclear.

I have measured infrared (IR) absorption spectra of antigorite under HP-HT conditions in order to obtain insights about the behavior of OH groups under HP-HT conditions. IR absorption spectra of antigorite were measured up to 27 GPa and 320 ºC with an external heating diamond anvil cell (DAC) using the synchrotron IR source at BL43IR, SPring-8 (Fig. 1). The absorption bands assignable to the OH stretching modes of outer-OH and inner-OH groups shifted to higher frequencies with increasing pressure. The shift rate of the inner-OH band is almost constant at all pressure ranges, while that of the outer-OH band increases slightly at about 6 GPa. This discontinuous change of the shift rate is consistent with the anomalous behavior of the outer-OH group upon compression previously predicted in the first principle calculation study (Mookherjee and Stixrude 2009). Specifically, the pressure dependence of the outer-OH band indicates that the hydrogen ion of an outer-OH group interacts not only with the nearest basal oxygen ion of the SiO_4 tetrahedron but the second nearest two basal oxygen ions upon compression. My study demonstrates that the latter interaction overcomes the former interaction at about 6 GPa.

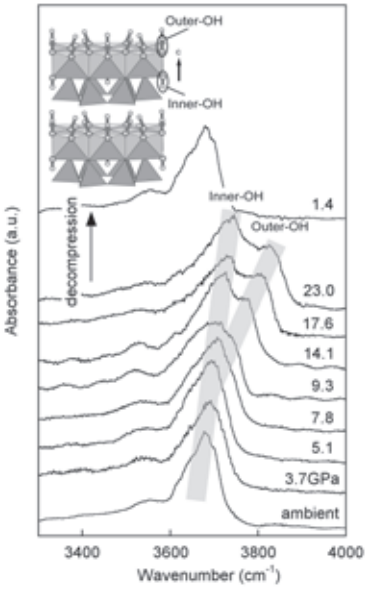


Fig.1. Selected IR absorption spectra of antigorite obtained from the isothermal compression experiment at 20 ºC. The inset shows basic crystal structure of serpentine minerals.

Experimental study on the stability of graphitic C_3N_4 under high pressure and high temperature

Leiming Fang
(PhD Student)

Since β-C_3N_4, a carbon nitride phase, was theoretically predicted to have an extreme bulk modulus equivalent to or greater than that of diamond, many efforts have been devoted to studying this potential superhard material and related phases through theoretical and experimental approaches. In recent years, many efforts were made to study the stability and potential phase transition of graphitic C_3N_4 (g-C_3N_4) at high pressure and high temperature conditions. However, exploring a reproducible method for obtaining low-compressible bulk C_3N_4 materials is still a challenging task.

In this work, we investigated the stability and decomposition of g-C_3N_4 in the pressure and temperature range of 10-25 GPa and up to 2000 ºC by multi-anvil experiments and phase characterization of the quenched products. The result showed that g-C_3N_4 was found to remain stable at relatively mild temperatures, but decomposes to graphite and nitrogen at temperatures above 600-700 ºC and up to 15 GPa, while it decomposes directly to diamond (plus nitrogen) above 800-900 ºC and between 22-25 GPa (Fig. 1). The estimated decomposition curve for g-C_3N_4 has a positive slope (~0.05 GPa/K) up to ~22 GPa, but becomes inverted (negative) above this pressure. The diamond formed through decomposition is characterized by euhedral crystals which are not sintered to each other, but loosely aggregated, suggesting the crystallization in a liquid (nitrogen) medium. The nitrogen release from the graphitic C-N framework may also play an important role in lowering the activation energy required for diamond formation and enhancing the grain growth rate. No phase transition of g-C_3N_4 was observed at P-T conditions up to 25 GPa and 2000 ºC, and the theoretically predicted, low-compressible superhard C_3N_4 phases could not be obtained. Further studies, for example at higher pressures and/or using well-crystalline g-C_3N_4 with a stoichiometric composition as a starting material, are needed to investigate whether such superhard C_3N_4 can really be synthesized in the laboratory.

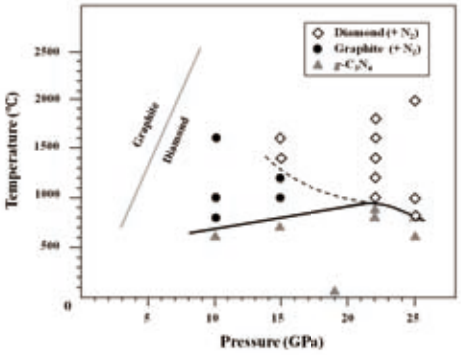


Fig. 1. P-T diagram showing the stability of g-C_3N_4. The solid black line indicates the decomposition boundary for g-C_3N_4, determined from the results of our quench experiments (not a thermodynamic boundary). The broken line indicates the reaction (kinetic) boundary between graphite and diamond observed in the present study.

News & Events

Internship students from Peking Univ. to GRC

Our global COE is making efforts on the education not only of students at Ehime Univ. but also of interinstitutional and international students. The short course internship program at GRC accepted foreign graduate students from the late February 2011. Two Peking Univ. graduate students visited the Theoretical Mineral Physics group for a month in February and worked with Prof. Tsuchiya with the support of the COE. They learned some latest ab initio computation techniques on the finite temperature thermodynamics and studied high-P,T behaviors of some sesquioxide and fluoroperovskite. Another Peking Univ. graduate student visited GRC in March and performed theoretical search for potential high-pressure phase transitions in iron phosphide and successfully found some new phenomena.

An invited talk at NCKU

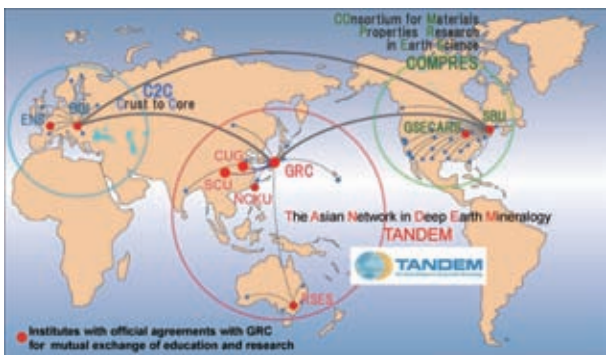
Prof. Irifune gave an invited talk at the Department of Earth Science, National Cheng Kung University, in Tainan on 24 March 2011, which has official agreement on the collaborations and exchange of people with GRC. Assist. Prof. Jennifer Kung of NCKU, who hosted Prof. Irifune, received PhD at the Research School of Earth Sciences, Australian National University, which also holds a similar agreement with GRC. Prof. Kung moved to the Mineral Physics Institute (MPI) of Stony Brook University and worked with Prof. Li, who is an official member of the COE. Prof. Irifune gave a talk about the activities of GRC and the global COE program, and also on the topics relevant to HIME-DIA. As this visit was right after the earthquake that hit eastern Japan on 11 March, he also lectured some aspects of the geological settings around the Japan islands and the status of the nuclear plant damages in Fukushima.

Official agreement between Ehime Univ. and Sichuan Univ.

A ceremony for concluding the official agreement on the research collaborations and exchange of students/researchers between Ehime University and Sichuan University was held on 31 May 2011, at the latter University in Chengdu, China. The presidents of both universities attended the ceremony, and vice president Prof. Ryuichi Yatabe, Prof. Irifune of GRC, and Prof. Yasuyuki Murakami of Research Center of Ancient East Asian Iron Culture (RCAEAI), gave special lectures prior to the ceremony. GRC holds an official agreement of inter-institutional level with the Institute of Atomic and Molecular Physics (IAMP) and RCAEAI has strong relations with the researchers of College of History and Culture of Sichuan University, and the mutual collaborations are to be expanded to the university level. Prof. Irifune and Dr. Li Lei of the global COE post-doctoral fellow also visited IAMP on the following day, and gave a seminar on the synthesis and properties of HIME-DIA, followed by a lab tour and a reception lunch, hosted by Prof. Duanwei He and his colleagues of IAMP. Dr. Zhi Wang, who is a former PhD student at GRC and now a professor of Chengdu University of Technology, also attended the seminar. Chengdu is the capital city of Sichuan province, and known as the ancient capital of Shu in the Three Kingdoms (see, the Column page). The party of Ehime University actually visited Wuhouci Temple, which is dedicated to the memory of both the emperor Liu Bei and the prime minister Zhuge Liang of the Shu kingdom during the visit to Chengdu.

AIRAPT-23 to be held in Mumbai, India

The 23rd meeting of the International Association for the Advancement of High Pressure Science and Technology (AIRAPT-23) will be held in Mumbai during the period of 25-30 September, where Prof. Irifune of GRC will deliver a plenary lecture on the synthesis, properties, and applications of ultrahard nano-polycrystalline diamond (HIME-DIA). GRC and the global COE program are planning to open a booth at the venue, where Dr. Akira Yamada, the Research Administrator at GRC, will attend and explain the activities of GRC and the COE program, as well as the details of the special PhD course on Deep Earth Mineralogy of Ehime University.



Research Group for Earth and Planetary Materials Science in the Department of Natural History Science, Hokkaido University

The main Campus of Hokkaido University is located in Sapporo, Japan. Sapporo is the political and economic center for Hokkaido, an island in northernmost Japan and is characterized by four beautiful seasons, including a cool summer and cold, snowy winter. Since there are many attractions such as various sceneries, activities and foods, a lot of domestic and international visitors, particularly from Asian countries, have repeatedly visited the island. Hokkaido University started its history in 1876 as Sapporo Agricultural College. The phrase "Boys, be ambitious!" by Dr. Williams S. Clark, the first Vice-President of the College, is well known for Japanese and is recognized as the Frontier Spirit that young students should have. Now, Hokkaido University has 12 undergraduate schools with about 11,000 students, 18 graduate schools with about 6,000 students (incl. about 900 international students) and numerous research and education facilities. We are very proud of Emeritus Professor Akira Suzuki winning the Nobel Prize in Chemistry in 2010.

Our research group for Earth and Planetary Materials Science belongs to the Department of Natural History Sciences in the Faculty of Science, a unique department covering a wide range of research fields such as Geology, Geophysics, Geo/Cosmochemistry, Geodesy, Hydrology, Oceanography, Biodiversity and Science Communication. There are about 200 graduate students and the approximately 80 staff members engage not only in educational programs but also in their own research projects. High pressure mineral science studies in our research group started with Hydrothermal test tubes and Piston cylinder type high pressure apparatuses in the 1960s. The Transmission Electron Microscopic technique has been applied to high pressure mineral sciences by Prof. K. Fujino since the 1990s. The first discovery of natural silicate ilmenite (akimotoite) and perovskite in a meteorite in 1997 was one of the most exciting research results. Since T. Nagai has joined the group, various in-situ high pressure and high temperature experiments by using laser heated diamond anvil cells combined with synchrotron X-ray diffraction have been performed in order to understand the mineral physics in the Earth's lower mantle. We hope some of you are interested in our recent results such as the nature of the $Fe^{3+}AlO_3$ substitution in $MgSiO_3$-perovskite at lower mantle conditions, spin transition of Fe^{3+} in $Fe^{3+}AlO_3$-bearing $MgSiO_3$-perovskite, discovery of $MnSiO_3$-perovskite, diamond formation from carbonate minerals at lower mantle conditions, and so on.

Currently, our group is interested in two main research fields, one is mineral physics at high pressure and high temperature, led by T. Nagai and the other is crystallography of minerals, led by H. Miura. Two PhD, three master course and four undergraduate students now work hard on these subjects. Thesis themes are crystal chemistry of silicate perovskites and/or perovskite-related materials and dehydration processes of hydrous minerals, for example. In addition, T. Nagai has worked hard to construct a new beam line for high pressure and high temperature neutron diffraction measurements at J-PARC, Tokai, Japan, in order to understand the behavior of hydrogen in minerals from the upper mantle to the uppermost lower mantle. Since, obtaining neutron diffraction data at high pressure and high temperature is at the forefront of the experimental frontier, and we are greatly expecting to open a new window in the world of mineral physics.

Major high pressure facilities in our group are diamond anvil cells with a YLF laser and Piston cylinder and hydrothermal apparatuses. We also have Analytical TEM, SEM, XRD, TG, Raman and infrared micro-spectroscopy system for sample characterization. In addition to the above apparatuses, we have access to other instruments such as FE-SEM, FIB and STEM in Open Facilities shared by the Creative Research Institution, Hokkaido University and we often visit synchrotron facilities (PF and SPring8) in order to carry out *in-situ* X-ray diffraction experiments at high pressure and high temperature.

Finally, we are looking forward to your coming visit to our lab and collaborating with the TANDEM members with great pleasure.

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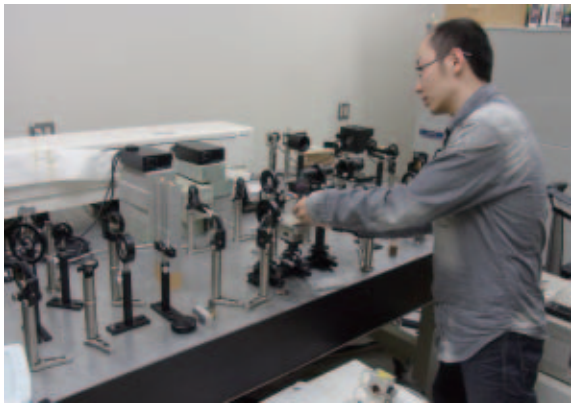
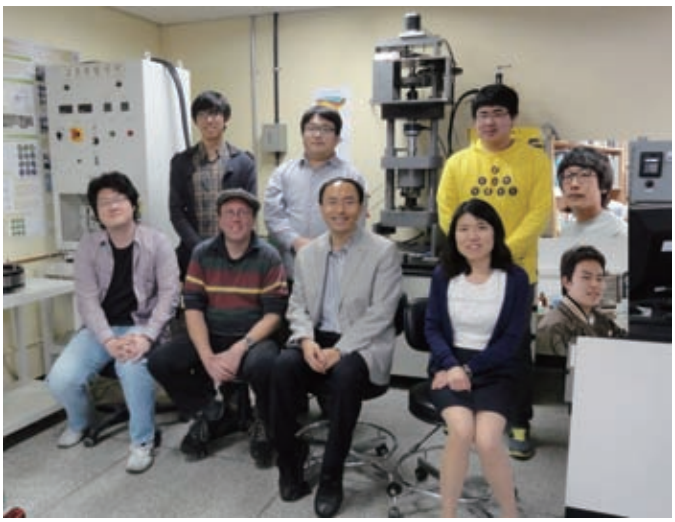


TANDEM Laboratories:

Ehime Univ.	Japan	Osaka Univ.	Japan	Sichuan Univ.	China
Univ. Tokyo (Geochem. Lab.)	Japan	Kyoto Univ.	Japan	Seoul Natl.Univ.	Korea
Univ. Tokyo (Inst. Solid State Phys.)	Japan	Univ. Hyogo	Japan	Natl. Chen Kung Univ.	Taiwan
Japan Synchrotron Res. Inst.	Japan	JAMSTEC (Inst. Res. Earth Evol.)	Japan	Australian Natl. Univ.	Australia
Hokkaido Univ.	Japan	Tohoku Univ.	Japan		
Kyushu Univ.	Japan	China Univ. Geosci., Wuhan	China	**Advisors:**	
Hiroshima Univ.	Japan	Jilin Univ.	China	Yanbin WANG (GSECARS, Univ. Chicago)	
Natl. Inst. Mater. Sci.	Japan	Peking Univ.	China	Baosheng LI (MPI, Stony Brook Univ.)	
Gakushuin Univ.	Japan	Chin. Acad. Sci. (Inst. Geochem.)	China	Jiuhua CHEN (Florida Int. Univ.)	
Okayama Univ.	Japan	Chin. Acad. Sci. (Inst. Geol. Geophys.)	China	Yingwei FEI (Carnegie Inst. Washington)	
Tokyo Inst. Tech.	Japan	Yanshan Univ.	China	Tomoo KATSURA (BGI, Univ. Bayreuth)	

Tectonophysics Laboratory
Seoul National University, South Korea



Seoul National University (SNU) was founded in 1946 as the first national university of Korea. Currently it is comprised of 16 colleges with 83 departments for undergraduates, 1 graduate School with 99 programs, 9 professional graduate schools with 16,325 undergraduate and 10,616 graduate students. The mission of Seoul National University in the twenty-first century is to create a vibrant intellectual community where students and scholars join together in building the future. As Korea's leading research university, Seoul National University is committed to diversifying its student body and faculty, fostering global exchange, and promoting path-breaking research in all fields of knowledge.

The School of Earth and Environmental Sciences (SEES) is advancing into the world scene with continued cooperation from the government and industrial enterprise. All of the professors, researchers, and students are putting all of our efforts towards one goal; becoming a world-leading institution for education and research in the important field of earth and environmental sciences. SEES has 36 professors, 150 undergraduate students and 200 graduate students. SEES has brought the formation of 6 research groups comprised of the Crust Mantle Research group, the Ocean-Atmospheric Research group, the Ecology and Biological Resources group, the Climate Change Research group, the Natural Disaster Research group, and the Environmental Monitoring Research group in the fields of pure research, application development and technology development. Through the integrated research of each of these groups, SEES strives to grow into a world-class education/research institution in the field of earth and environmental science research.

Tectonophysics Laboratory led by Prof. Haemyeong Jung belongs to the Crust Mantle Research group in SEES at the Seoul National University. Prof. Haemyeong Jung is a representative person of TANDEM at SNU and is interested in studying physical properties, deformation mechanisms of minerals and rocks, and seismic anisotropy in the crust and mantle. To conduct deformation experiments of minerals and rocks at high pressure and high temperature, a conventional Griggs apparatus was installed at the Tectonophysics Laboratory in 2007. Pressure and temperature can be reached to P = 2 GPa and T = 1773 K. Shear strain can be achieved up to $\gamma \sim 7$ and strain rate is in the range of $10^{-3} - 10^{-7}$/s. Currently, we are also making a modified Griggs apparatus which can be reached up to the pressure of 5 GPa and temperature of 1873 K. We are now conducting P- and T-calibration of the new deformation apparatus. We are also interested in studying naturally deformed minerals and rocks and we have been collecting mantle xenoliths, peridotites, eclogites, kimberlites over the world. Combining experimental studies and field work, we want to understand deformation mechanisms of rocks in our planet Earth.

We have modern analytical instruments in the Tectonophysics Laboratory for studying physical and chemical environments and deformation microstructures. JEOL JSM-6380 SEM/HKL Electron Back-Scattered Diffraction system with Channel 5 software was installed at the Tectonophysics Laboratory in 2007 to determine lattice preferred orientation (LPO) of minerals such as olivine, enstatite, diopside, and sperpentine, etc. To measure water content in various minerals in experimental samples and rock specimen, Nicolete 6700 Fourier transformation infrared (FTIR) and IR microscope was installed at the Tectonophysics Laboratory in 2007. The FTIR was equipped with automatic stage for mapping an area to measure O-H concentration. We normally use an IR beam size of 30 × 30 μm. In addition, DXR Micro-Raman spectroscopy with automatic stage was installed in 2009 for identifying tiny minerals. The Raman microscope consists of a 532 nm laser, nominal resolution of 5 cm^{-1} and wave number in the ranges of 50 ~ 5000 cm^{-1}. The auto-stage makes us mapping in XY and XZ plane with 1 μm step size.

We welcome researchers and students in TANDEM laboratories to visit our Tectonophysics Laboratory and hope to conduct collaborative research together. Activities of our lab can be found in our website below:
(http://plaza.snu.ac.kr/~hjung/)

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