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平成 17 年度活動報告

Institute for Geothermal Sciences

Graduate School of Science

Kyoto University

京都大学

大学院理学研究科

附属地球熱学研究施設

Institute for Geothermal Sciences
Graduate School of Science, Kyoto University

京都大学大学院理学研究科 附属地球熱学研究施設

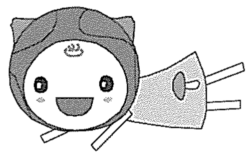
Beppu Geothermal Research Laboratory
Noguchibaru, Beppu, Oita 874-0903
Japan
Telephone: +81-977-22-0713
Facsimile: +81-977-22-0965
別府
〒874-0903 大分県別府市野口原
電話: 0977-22-0713
ファックス: 0977-22-0965
Homepage: http://www.vgs.kyoto-u.ac.jp

Aso Volcanological Laboratory
Minamiaso, Kumamoto 869-1404, Japan
Telephone: +81-9676-7-0022
Facsimile: +81-9676-7-2153

阿蘇（火山研究センター）
〒896-1404 熊本県阿蘇郡南阿蘇村河陽
5280
電話: 0967-67-0022
ファックス: 0967-67-2153
Homepage:
http://www.aso.vgs.kyoto-u.ac.jp/

Front Cover Image:
A strombolian explosion in the 1st crater of Mt. Nakadake, Aso volcano in October 1979.
(Photo by M. Sako)
表紙の写真
1979 年 10 月の阿蘇中岳第一火口のストロンボリ噴火の様子（迫幹夫撮影）

Chinetu-chan designed by Miho Saito
Editional compilation by T. Kawamoto, Printed by Nisshin Insatsu



序

平成 9 年に火山研究施設（阿蘇）と地球物理学研究施設（別府）が現地球熱学研究施設に統合された改組以来早くも 9 年の歳月が経過した．地球熱学研究施設では，地球上で最大規模の火山・地熱温泉活動域のひとつである中部九州地域を巨大な実験装置とみなして，野外観測や室内実験などを中心に，造構運動・火山活動・地熱温泉活動など地球の熱的活動に関する地球熱学の学問体系の構築をめざしている．この基本理念に立脚して，専門分野の異なる研究者が弾力的に協力できるよう，大部門制を採り，以下の 5 つの研究分野が置かれている．地熱流体論研究分野，地熱テクトニクス研究分野，火山構造論研究分野，火山活動論研究分野，地球熱学情報研究分野（外国人客員）である．平成 16 年度には京都大学が法人化され，研究教育の効率化さらには定員削減を余儀なくされる状況にある．遠隔地の課題をみすえながら，阿蘇と別府の有機的な連携を強化する努力がより一層必要となっている．

法人化 2 年目にはいり，施設運営のためには財政的に運営交付金に加えて競争的資金の確保が重要になっている．他方，昨年度設置された施設運営協議会が 6 回開催され，理学研究科との連携が実質化されてきている．このような中で，学内での地球熱学研究施設の研究教育面での位置付けをより明確にすることが必要である．平成 17 年度は，地球熱学研究施設本部（別府）では，懸案の地下の雨漏り対策が当局の支援を得て実施された．

人事面では，9 月末に外国人客員の頼勇氏が離任し，インドネシアバンドン工科大学の Wahyu Srigutomo 氏が阿蘇に着任した．また後藤秀作氏が平成 18 年 3 月 31 日付けで機関研究員を退職し産業技術総合研究所に移動，斎藤武士氏も平成 18 年 3 月 31 日付けで機関研究員を退職し学術振興会特別研究員として，別府での研究を継続することとなった．後任の機関研究員として，平成 18 年 4 月 1 日付けで寺田暁彦氏が阿蘇に，4 月 16 日付けで栗谷豪氏が別府に着任した．また，別府の非常勤事務職員の土屋寿子氏，後藤君子氏が 9 月に退職され，後任として東端歩氏と宮崎奈美氏に勤務をお願いしている．

21 世紀 COE も 3 年目を迎え，研究施設の研究テーマが関係する J2b で成果があがるとともに，あらたに J3b での京都キャンパス・インドネシア ITB との共同研究（鍾乳洞プロジェクト）が開始された．別府・阿蘇をフィールドにした多目的観測サイトの活動も数多く実施され，その内容が COEKAGI21 のホームページに随時掲載された．昨年度設置された地球物理学教室，地質学鉱物学教室，防災研究所，別府，阿蘇を結ぶ TV 会議システムはセミナーや特別講演を中心に活用され，遠隔地からの情報発信に大きな役割をにないはじめている．

平成 18 年 5 月
平成 17 年度地球熱学研究施設長
竹村恵二

Preface

It was passed nine years since the last reorganization of our Institute for Geothermal Sciences from Beppu Geophysical Research Laboratory and Aso Volcanological Laboratory in 1997. We regard central Kyushu, one of the most active volcanic and geothermal fields in the world, as a natural experimental facility. The Institute for Geothermal Sciences is promoting a comprehensive research on thermal structure and the dynamics of the Earth' interior into volcanism, geothermics and tectonics by field work, laboratory experiments, and theory. Based on the fundamental scope of our research, a variety of research works can flexibly cooperate within this interdisciplinary geothermal science research system. We have the following five research units, for geothermal fluids, for geothermal tectonics, for volcanic structure, for volcano-dynamics and geothermal intelligence section (visiting research scholar from abroad). In 2004 fiscal year, Kyoto University was reformed to juridical personalization of national universities. The situation puts us under pressure to do efficient education and research with limited staffs and funds. Taking into consideration on the subjects related to remote institutions from main campus, we need to make effort to intensify cooperative work at Aso and Beppu.

Total revenue decreased and we need to get other competitive fund associated with personalization in 2004. Meetings of the steering committee set in 2004 were held six times in Kyoto campus, and the cooperative relationship between our institute and Graduate School of Science was intensified. We made efforts to clarify a role of the institute in the education and research activity in the Kyoto University. In 2005, the repairing to a rain-leak at Beppu Laboratory building was carried out by the financial support of University.

In personal affairs, Dr. Yong LAI as a visiting faculty left at the end of September from Beppu, and Dr. Wahyu SRIGUTOMO arrived at Aso. As a postdoctoral associate, Dr. Shusaku GOTO left to AIST and Dr. Takeshi SAITO was adopted as a post doctoral fellow of JSPS in March 2006. Dr. Akihiko TERADA at Aso and Dr. Takeshi KURITANI at Beppu replaced in April, 2006. As secretaries at Beppu, Miss Hisako TSUCHIYA and Kimiko GOTO retired in September, and Mrs. Ayumi HIGASHIBATA and Nami MIYAZAKI replaced.

The activity of the KAGI 21 program (Kyoto University Active Geosphere Investigations for the 21st Century Centers of Excellent program) was passed three years, and our institute made a great contribution for scientific activity on water and material circulation at the active geosphere, stalagmite project and as a field station of the multi-purpose field sites for education and research activity. TV meeting systems connecting Kyoto and Uji Campus, Aso and Beppu Laboratory used constantly for seminar and special lectures, and the effective use of these devices contributes to sending information from remote institutions from main campus.

Keiji Takemura, Professor/Director

Beppu, May 2006

目次　Contents

構 成 員　Members

教授　*Professors*

鍵山恒臣　Tsuneomi Kagiyama

竹村恵二（施設長）　Keiji Takemura (Director)

田中良和　Yoshikazu Tanaka

助教授　*Associate Professors*

大倉敬宏　Takahiro Ohkura

大沢信二　Shinji Ohsawa

須藤靖明　Yasuaki Sudo

古川善紹　Yoshitsugu Furukawa

助手　*Assistant Professors*

宇津木充　Mitsuru Utsugi

川本竜彦　Tatsuhiko Kawamoto

柴田知之　Tomoyuki Shibata

山本順司　Junji Yamamoto

外国人客員　*Visiting Faculty*

頼勇　Lai Yong

2005年9月帰国

ワヒュー スリグトモ　Wahyu Srigutomo

2005年10月着任

技術職員　*Technical Professionals*

井上寛之　Hiroyuki Inoue

馬渡秀夫　Hideo Mawatari

吉川慎　Shin Yoshikawa

教務補佐員　*Research Assistant*

芳川雅子　Masako Yoshikawa

研究機関研究員　*Research Associates*

網田和宏　Amita Kazuhiro

2006年5月辞職、秋田大学へ

後藤秀作　Shusaku Goto

2006年3月辞職、産業技術総合研究所へ

齋藤武士　Takeshi Saito

2006年3月辞職、別府でJSPSのPDに

杉本健　Takeshi Sugimoto

研修員　Reseach Fellow

なし

研究生　*Research Student*

なし

COE研究員　*Research Associate (COE)*

西村光史　Koshi Nishimura

大学院生　*Graduate Student*

池田さやか　Ikeda Sayaka

岡本響　Kyo Okamoto

小森省吾　Syogo Komori

三根崇彦　Takahiko Mine

山田誠　Makoto Yamada

2005年10月修了、岡山理科大学へ

研究支援推進員　*Technical Assistant*

藤岡寿美　Hisami Fujioka

事務補佐員　*Secretaries*

今村町子　Matiko Imamura

後藤君子　Kimiko Goto

2005年10月辞職

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2005年10月辞職

東端歩　Ayumi Higashibata

2005年9月着任

宮崎奈美　Nami Miyazaki

2005年11月着任

臨時用務員　*Supply Janitor*

山崎咲代　Sakiyo Yamasaki

研究活動　Research Activities

機関内共同研究　Institution Colaboration

Salinity of fluid inclusions in syn-metamorphic quartz veins, Sanbagawa schists, SW Japan.

***K. Nishimura, S. Ohsawa, K. Amita, Y. Lai, J. Yamamoto,* T. Hirajima (Kyoto)**

Direct investigation of the chemical characteristics of metamorphic fluids (dehydrated fluids) is a key to understand fluid circulation in plate subduction zone. Heating and cooling experiments were conducted with fluid inclusions trapped within syn-metamorphic quartz veins, Sanbagawa schists, to estimate those salinities. The quartz veins are abundant in fluid inclusions, but the main problem arises in identifying fluid inclusions that are truly representative of fluids present during progressive metamorphism. Many fluid inclusions observed in the quartz veins have generally undergone a long history of fracturing, accompanied by trapping of secondary fluid inclusions, during their return to the surface. The fracturing has arrayed the secondary inclusions in the quartz veins. For this study, we have carefully selected large fluid inclusions (>5 m) that are isolated from alignment of the secondary fluid inclusions. The host quartz was doubly polished and cooled and heated under optical microscope using Heating and Cooling Stages (LINKAM LK-600; Fig. 1) at Department of Geology and Mineralogy, Kyoto University. The salinity of chloride-dominated aqueous fluid inclusions can be estimated from the melting temperature of ice during a cycle of freezing and heating (Fig. 2). The determined freezing temperatures range from 3 to 7°C. This temperature range corresponds to the salinities from 5 to 10.5 wt% when using experimental results of Bodnar (1993). It should be noted that the calculated salinities are 'equivalent' concentrations of NaCl, i.e. the salinity of NaCl solution that would yield the same ice melting temperature as the natural fluid measured. The estimated fluid salinities are consistent with the salinity range of metamorphic fluids hosted by sequences of oceanic or accretionary prism origin (Yardley & Graham, 2002).

Recent geochemical works of our group have suggested that fluid inclusions in quartz veins of high-pressure metamorphic rocks (e.g. Sanbagawa schist) are possible candidates of the source of brines along Median Tectonic Line (MTL). The relatively high salinities of the fluid inclusions would support this hypothesis. Trace element analyses of the fluid inclusions are currently carried out using LA-ICP-MS to compare with the trace element patterns of the brines along MTL.

Acknowledgements

We thank K. Otsuka for his support and discussion during the experiments.

References

Bodnar, R. J. (1993) Revised equation and table for determining the freezing point depression of H_2O-NaCl solutions, Geochim. Cosmochim. Acta, 57, 683–684.

Yardley, B. W. D., and Graham, J. T. (2002) The origins of salinity in metamorphic fluids, Geofluids, 2, 249–256.

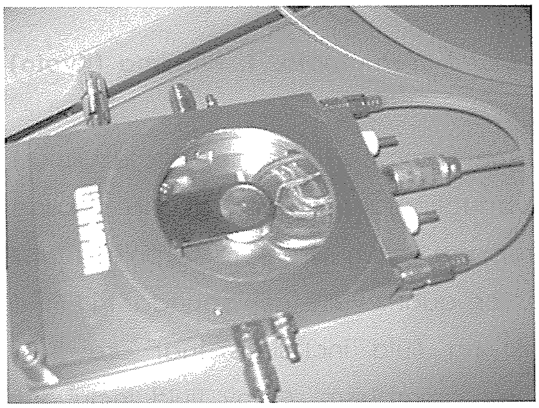

Figure 1. Heating and cooling Stage (LINKAM LK-600)

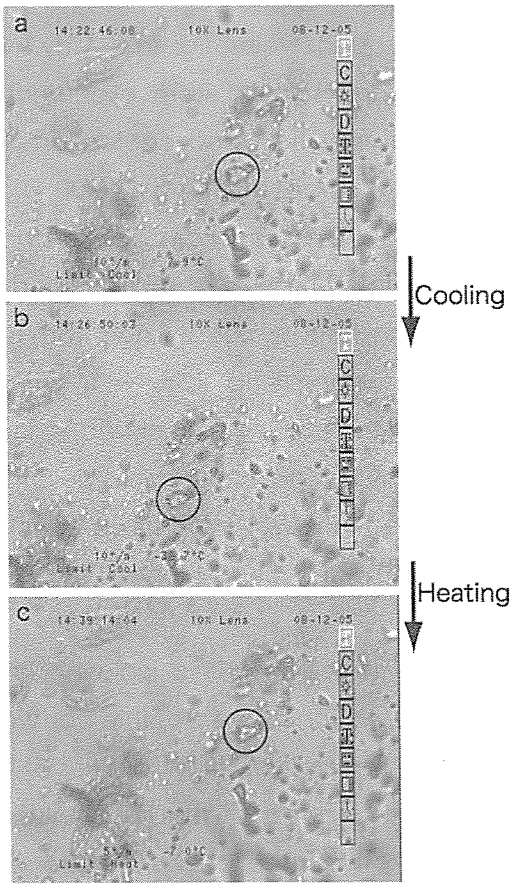

Figure 2. Phase changes of inclusions during cooling and heating. a: liquid + bubble, b: ice, c: liquid + bubble.

Relationship between the distribution of Quaternary adakitic magma on Japanese Island and the geophysical characteristics

T. Shibata*, O. Ujike(Toyama), J. Itoh (GSJ), *T. Sugimoto, K. Takemura

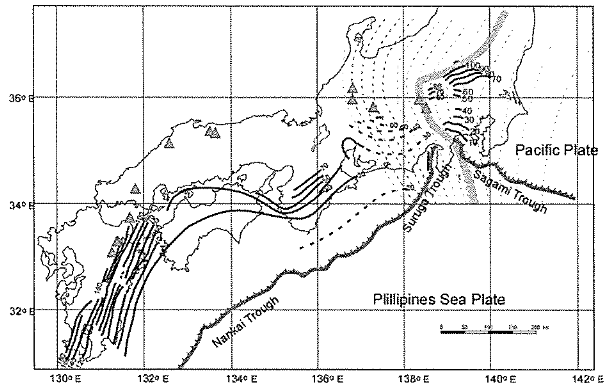

Fig. Distribution of Quaternary adakite in Japanese Islands. Solid lines indicate the depth to the Philipines Sea Plate (Noguchi, 1998: *Bull. Earthq.Res. Inst. Univ. Tokyo*, **73**; Uehira et al., 2001: *Gekkan Chikyu*, Miyoshi and Ishibashi,2002: *Proc. Meeing 13K-7, DPRI, Kyoto Univ.*)

Since Defant and Drummond (1990: *Nature*, **347**) suggested that subducting slab is partial molten when the slab is young and hot, a lot of research about the partial melting of the subducting slab has been accomplished. Because it is important to discuss the material balance at the subduction zone, the genesis of continental crust, and the mantle - crust recycling. However, Yododzinski *et al.* (2001: *Nature*, **409**) reported the adakite magma derived from partial molten of subducting slab, where the old and cold slab is subducting, so that the knowledge about the occurrence condition of the slab melting is thought to be insufficient. It can be considered that comparing the distribution of the adakitic magams and geophysical characteristic of the subducting slab lead us the information about the occurrence condition of the slab melting.

On Japanese Islands, the Philippine Sea plate is subducting at the wide area, from the Kanto district to the Kyushu - Okinwa district. From these districts, Quaternary adakite magmas are reported (Morris, 1995: *Geology*, **23**; Ujike *et al.*, 1999: *J. Min. Petrol. Econ.*, **9**; Kimura *et al*, 2005: *Island Arc*, **14**, Shibata et al., 2005). On the other hand, the geophysical characteristics of the Philippine Sea plate, such as directions and dips of subduction, the shape of the plate and seismicity, changes from place to place. Therefore, it seems that these areas are a very suitable area to discuss the relationship between the distribution of adakitic magma and the geophysical characteristics of the subducting slab. Therefore, we compiled the trace element compositions of Quaternary volcanics reported from that area, and try to discuss the relationship between the distribution of the adakitic magams and geophysical characteristic of the subducting slab.

According to Defant and Drummond (1990: *Nature*, **347**), we discriminated the adakites on the bases of the relationship between Sr/Y ratio and Y concentration. The result is shown in Fig. The eastern and southwestern edges of adakite distribution are at Mt. Kurofuji and Mt. Kujyu, respectively. It can be observed from Fig. that no slab related earthquake is found at just below the occurrence of adakite. Morris (1995: *Geology*, **23**) speculated that no slab earthquake below Daisen volcanoe due to the slab melting. Our observation led his argument to be more generalized.

Trace element and Sr, Nd and Pb Isotopic compositions of Quaternary volcanics from Yufu-Tsurumi volcanic group

Takeshi Sugimoto, Tomoyuki Shibata, Masako Yoshikawa, Keiji Takemura

Yufu-Tsurumi volcano group is located in northeastern Kyushu, Japan. Yufu-Tsurumi volcano group is forming the volcanic front of middle to north Kyushu together with Hime-Shima, Futago-Yama, Kujyu and Aso volcanoes. Yufu-Tsurumi volcano group consists of Yufudake volcano, Tsurumidake volcano and Garandake volcano. They are the stratovolcano which consists mainly of andesitic to dacitic lava domes and lava flows (e.g. Hoshizumi et al., 1988). From the chemical compositions of Yufu-Tsurumi volcanic rocks, it is observed that Nb/Zr ratios (0.06-0.09) are high compared to general island arc magma (<0.03). In the Y versus Sr/Y diagram, the Yufu-Tsurumi volcanic rocks are plotted across the boundary between adakite and island-arc ADR field (Defant et al., 1991). They are also characterised by low HREE relative to felsic volcanic rocks from northeast Japan arc. These chemical characteristics cannot be explained simply by the general model that the origin of island arc magma is MORB-type mantle wedge and fluid derived from subducting slab. Adakites in the SW Japan are considered to be generated by partial melt of subducting Philippine Sea plate (e.g. Morris, 1995; Shibata et al., 2005). The relationship between 87Sr/86Sr and Sr/Y ratios is consistent that partial melt of subducting Philippine Sea plate is one of the source material of Yufu-Tsurumi volcanic rocks. On the other hand, the trends of Pb isotope systematics indicate that the terrigenous sediments from the Nankai Trough (Shimoda et al., 1998) can be another source material of Yufu-Tsurumi volcanic rocks. According to these observations, partial melt of subductiong slab and terrigenous sediments have to be taken account for the genesis of Yufu-Tsurumi volcanic rocks.

(Abstract of Japan Geoscience Union Meeting, 2006)

Environmental change and tephra horizons on the basis of color data of Late Quaternary loam sediments

Takemura, K., Saito, T., Yamamoto, J., Mawatari, H.

Around the Beppu region, thick soil and loam sequences were found including tephra layers. At the south of Mt. Yufudake, the outcrop indicating the tephrostratigraphy of this area is located (Takemura et al., 2005). The tephrostratigraphy during Late Quaternary is summarized since Aso-4 pyroclastic flow deposits erupted at about 90 ka. We collected the continuous drilling core samples behind the cliff observed loam and tephra sequence studied in 2004 (Photo 1).

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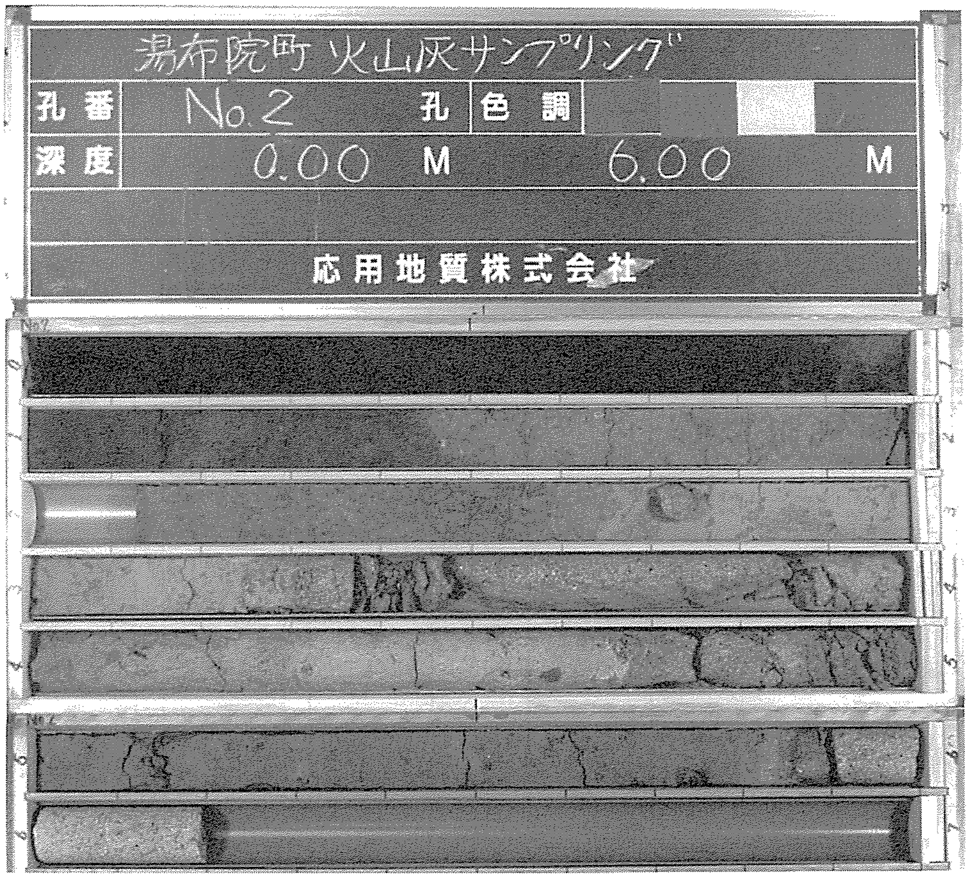

6.

Photo 1. Continuous drilling core samples behind the cliff observed loam and tephra sequence studied in 2004

The core sample has 6 m thick and is composed of black soil and brown soil with volcanic ash layers. Two volcanic ash layers are included in the sequence, and they are K-Ah ash layer and AT ash layer. K-Ah layer which is erupted at 7,300 cal BP, and is found at the 0.85-1.00 m depth. AT ash layer of 26-29 ka eruption is intercalated at 2.3 – 2.4 m depth. Kuju Daiichi tephra layer of about 50 ka and Aso-4 pyroclastic flow deposits are not found in the sequence, and the 6 m loam and soil sequence has the age since 50 ka.

We preliminarily tried to get the continuous color data using the spectrophotometer for understanding the environmental change and volcanic ash horizon recorded in the color change of the sequence. The data are composed of a* (red - green), b* (yellow - blue) and L* (white - black). The distribution of color data is concordant with the stratigraphy of soil sequence. The lower value of L* of sediments upper than 1.45 m is clearly correlated with the black color soil indicating abundance of organic matter. The peak of a* and b* at about 0.9 m depth is correlated with the K-Ah ash horizon with red to yellow color. The continuous measurement of color of soil and loam sequence which was formed at land condition is useful for checking the sequence boundary recorded the environmental change and detecting the tephra horizon with red-yellow color. Stage 1 and Stage 3 in the figure indicate the warmer stages detected by the production of organic matter and the age of tephra horizon.

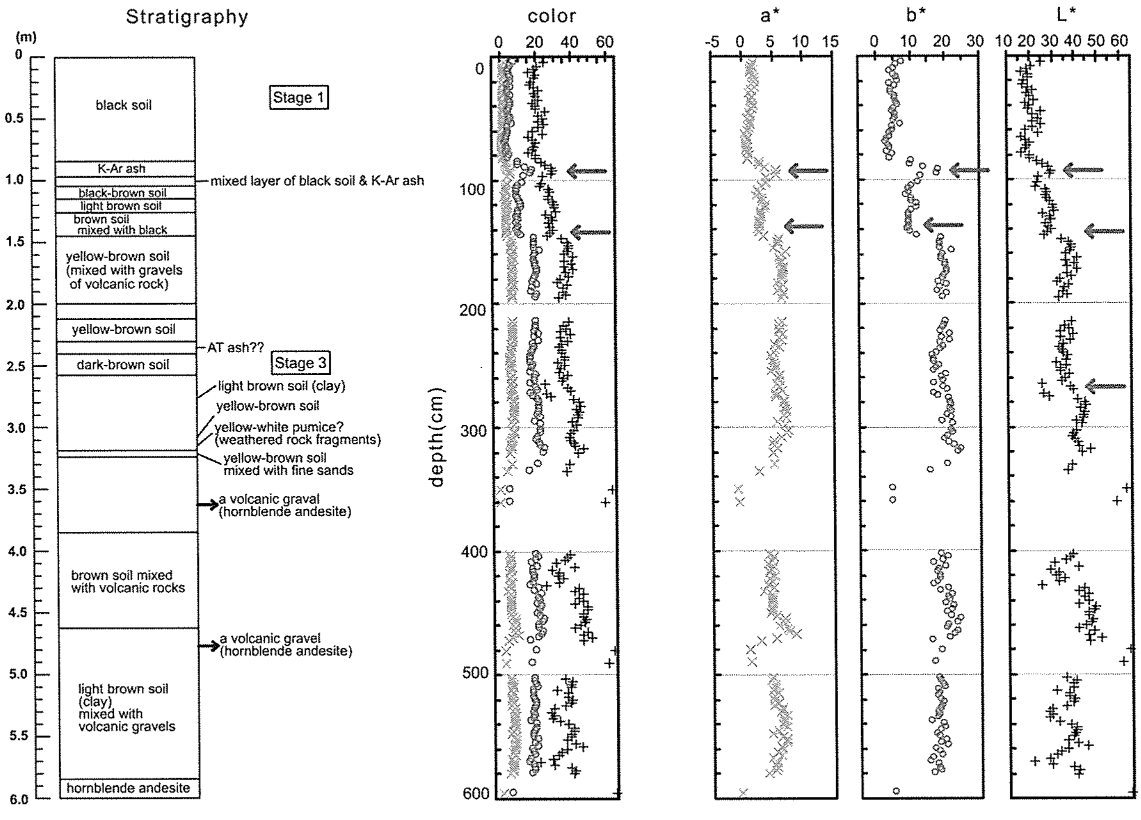

Fig. 1 Stratigraphy of soil sequence and color data (a*, b* and L*).

Trace elements in grain-boundary component in mantle xenoliths analyzed by LA-ICP-MS: Implications for mantle occurrence of subduction-related fluid

***Junji Yamamoto, Yong Lai, Koshi Nishimura,* Shun'ichi Nakai (ERI, Tokyo)**
Vladimir S. Prikhod'ko (Far-Eastern Branch, Russian Academy of Science)
Shoji Arai (Kanazawa)

Abstract

Based on trace element chemistry, we have constrained the occurrence of grain-boundary component in mantle wedge-derived xenoliths from Far Eastern Russia. Mineral separates and whole rock of the xenoliths were washed using hot nitric acid for extraction of grain-boundary components. The whole rock of one xenolith shows an apparent negative Ce anomaly and large depletion in high-field-strength elements (HFSE) with the W-type lanthanide tetrad effect. The trace element pattern of the whole rock is not correlated with those of constituent minerals, but rather the leachate. That fact suggests that the lanthanide tetrad effect and negative anomaly in Ce and HFSE in the whole rock are attributable to the presence of the grain-boundary component.

In order to distinguish these signatures, we analyzed trace element compositions of the grain-boundary component using laser ablation ICP-MS. The grain-boundary component apparently included negative Ce anomaly. Also some kinds of melt inclusions show negative Ce anomaly. The negative anomaly in Ce and HFSE in mantle rocks are generally regarded to be mantle metasomatism related to the specific subduction environments such as infiltration of aqueous fluid dehydrated from subducted slab. Because the Far Eastern Russia area was located at the subduction zone in the Jurassic - early Cretaceous Period, the present mantle rocks would have been infiltrated by fluid dehydrated from the subducted slab.

1. Introduction

At an active margin of a continent or an island arc, several kinds of fluids infiltrate into the mantle wedge. For example, aqueous fluids released from the descending oceanic lithosphere trigger partial melting of the mantle wedge. Then, the melt ascends through the mantle wedge leading to the subduction-related volcanism. In that case, part of the melt would remain in the mantle wedge as a grain-boundary component or as a melt inclusion.

We intend to reveal the occurrence of subduction-related fluids in rocks derived from the mantle wedge. For this purpose, incompatible trace elements in the mantle xenoliths from the active margin of a continent or an island arc are effective for identifying mantle processes, including partial melting and metasomatism, in the mantle wedge. In that case, the grain-boundary component should be treated carefully because it is an important factor in controlling the trace element budget of the mantle (Hiraga et al., 2004). Many trace elements are incompatible in mantle rocks. For example, in the lithospheric mantle, large ion lithophile elements (LILE: e.g., K, Rb, Cs and Ba) and high-field-strength elements (HFSE: Ti, Nb, Ta, Zr and Hf) are concentrated in accessory minerals such as feldspar, amphibole, phlogopite, apatite and titanites or grain-boundary components. Fluid inclusions trapped in mantle minerals differ compositionally from whole rocks and the grain-boundary component. This study is intended to elucidate the origin of the grain-boundary components by comparing the trace element patterns of whole rocks with those of acid-leached major minerals for a mantle xenolith from Far Eastern Russia. The solutions obtained by leaching and laser ablation ICP-MS analysis were effective to characterize the grain-boundary components.

2. Sample and experimental method

Extensive tholeiitic and alkaline basaltic volcanism took place in northeastern China and Far Eastern Russia in the Cenozoic. The alkaline basalts locally contain abundant upper mantle-derived ultramafic xenoliths. According to a recent geodynamic reconstruction, the region is regarded to be an active margin of the Eurasian continent in the Mesozoic to Paleogene. Further, environs of sampling points of the xenoliths used in this study are covered over with accretionary complexes. Therefore, the xenoliths from Far Eastern Russia were affected by subduction in the Mesozoic to Early Cenozoic and were entrained to the Earth's surface by Late Cenozoic basalt volcanism. The basalts erupted long after the plate subduction in the Far Eastern Russia area. It confers considerable advantages on the study of subduction-related fluids in mantle xenolith. The mantle xenoliths sampled at active convergent margin could inherit subduction-related features from their host magma. Thus, the present mantle xenoliths are suitable for the study on the subduction-related subcontinental lithospheric mantle. One xenolith (Sv-1) used in this study was sampled from Far Eastern Russia, which comprises spinel-lherzolite. The xenolith was taken from a volcanic body with eruption age of about 9-13 Ma (e.g., Sato, 2000). The xenolith contains 61.3 vol% olivine, 22.3 vol% orthopyroxene, 13.1 vol% clinopyroxene, and 3.3 vol% spinel.

Trace elements in solutions were analyzed by inductively coupled plasma-mass spectrometry (ICP-MS, PQ3; Thermo Elemental, U.K.) at the Earthquake Research Institute, University of Tokyo for olivine, orthopyroxene and clinopyroxene and whole rocks for a xenolith. Rocks were cut into slabs of about 2 mm thick, which were used as samples representing whole rocks. Residual rock specimens were roughly crushed; minerals were carefully selected manually. The mineral separates and the slabs of whole rocks were washed with 70°C 2 N HNO_3 for half an hour for extraction of the grain-boundary components, then washed ultrasonically in distilled water. Treatment reduced the weight by ca. 2%. Leachates were also analyzed separately to characterize the leached grain-boundary components. After treatment, 20 mg of each powdered sample was weighed in a Teflon beaker (or 10 mg for orthopyroxene and clinopyroxene), 0.3 ml of both 11.5 N $HClO_4$ and 30 N HF were added to the samples for decomposition. The precisions of the abundance data are 10% for most elements and 20% for Sr and those with low abundances.

Trace element compositions of the grain-boundary components and melt inclusions were determined using a Laser Ablation microsampler coupled to an Inductively Coupled Plasma Mass Spectrometer (LA-ICP-MS). For these analyses, a UV (266 nm) laser beam is focused onto the surface of a solid sample. The laser used for this study is a Q-switched Nd-YAG laser operated at 4 Hz and 7 mJ per pulse. Spot sizes for these analyses are 25-100 microns, and average drill rates are ~ 1 micron/sec. The ICP-MS is a PQ3 (Thermo Elemental, U.K.) installed at the Institute for Geothermal Sciences, Kyoto University. Peak and background regions were selected from the time-resolved spectra of each sample, and the selected replicates averaged to determine the net count rate for each mass. Relative element sensitivities were calibrated against the NIST 610 glass, with values cross-checked against other well-characterized natural material including mantle-derived pyroxenes. Detection limits ranged from ~ 1 ppm for a variety of elements including rare earth elements, Th and U. Replicate analyses of the NIST 610 glass indicate an analytical precision of less than 10 %.

3. Results

Incompatible trace elements tend to occur mostly in clinopyroxene in spinel peridotites (e.g., Bedini & Bodinier, 1999). Thus, the primitive mantle-normalized trace element patterns of clinopyroxene from spinel peridotites usually mimic those of the whole rock, especially for less incompatible elements. The trace element pattern of the whole rock is not correlated with those of the constituent minerals, especially for more incompatible elements (Rb-Sr, Fig. 1). Particularly, the whole-rock pattern shows a concave-upward curve in normalized REE pattern and a clear negative Ce anomaly. It is noteworthy that the Ce anomaly is not detected in the constituent minerals. The pattern of the clinopyroxene shows a slight depletion in light-REE (LREE), but such a convex-downward curve without the Ce anomaly is typical of clinopyroxene from mantle peridotites (e.g., Bedini & Bodinier, 1999). The whole-rock pattern of sample Sv-1 shows clear depletions in Hf and Zr. Negative anomalies for the analyzed whole rock are too large compared with the calculated whole-rock values (Fig. 1). Such HFSE depletion is probably ascribable to the occurrence of the other host phase for incompatible elements in the xenolith, such as accessory minerals or grain-boundary component that are poor in Ce, Hf and Zr.

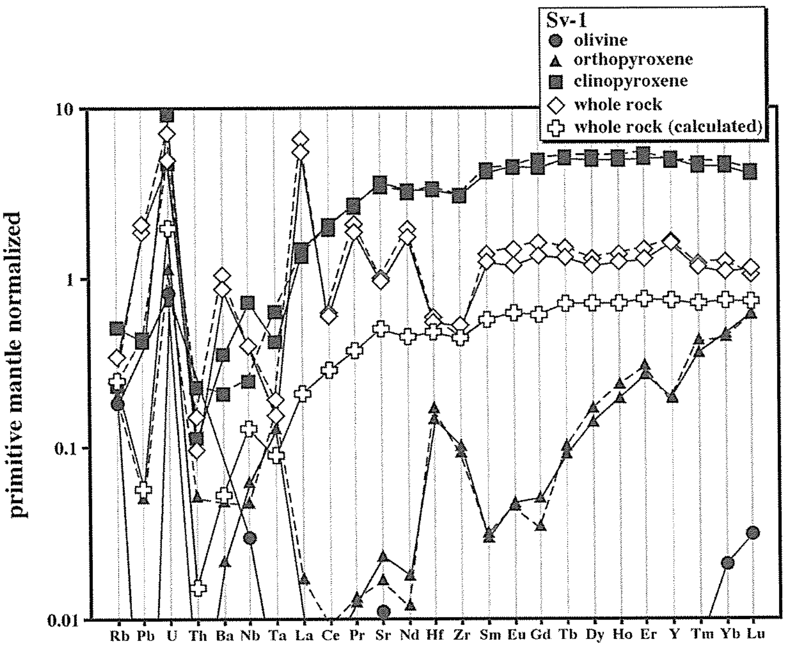

Figure 1. Normalized trace element patterns for constituent minerals and the whole rock of a xenolith of sample Sv-1. Analyses were duplicated separately for orthopyroxene, clinopyroxene and whole rock. The trace element pattern for the whole rock calculated by modal proportion and trace element compositions of the constituent minerals is also plotted.

4. Discussion

4.1. Distribution of the material depleted in HFSE and Ce

The grain-boundary component of the mantle xenoliths was extracted through chemical treatment using hot nitric acid (e.g., Bedini & Bodinier, 1999). Many mantle xenoliths are known to contain veins and patches of glass. Suzuki (1987) assumed that the grain-boundary component is a thin quenched glass with thickness of a few tens of nm at most. Hiraga et al. (2004) reported thin intergranular amorphous films with thickness of 0.5 - 10 nm in some polycrystalline oxides using high-resolution electron microscopy. The present grain-boundary component would be also thin amorphous film, because the grain-boundary enrichment of the incompatible elements was removed easily by washing in mild acid as observed in figure 2, which show trace element patterns of leachates. The patterns of the leachates of orthopyroxene and clinopyroxene resemble the whole-rock patterns, in particular in spikes of U, Ba and La and depletion in Rb, Th, Ce and HFSE. Such anomalies were not observed in the constituent minerals leached with hot nitric acid (Fig. 1). Therefore, we infer that the anomalies result from the existence of grain-boundary component. This inference suggests that the trace element content of the xenolith is controlled strongly by that of the grain-boundary component. Here is figure 3, which shows comparison of trace element compositions between the whole rocks and the calculated whole rocks. It is helpful to show trace element composition of the grain-boundary component. The contents of highly incompatible elements of the analyzed whole rocks tend to be higher than those of the calculated whole rocks. Hiraga et al. (2004) predicted that elements of their ionic radius (or incompatibility) larger than Sr will mainly stay at grain boundaries and this seems to appear in figure 3. Enrichment of incompatible elements at the grain boundaries relative to the grain matrices does not, however, occur parallel to the incompatibility of the elements. Particularly, the analyzed whole rock of sample Sv-1 shows spikes of Pb, Ba and La, and depletions in Rb, U, Ce, Sr and HFSE. This indicates that, though the grain-boundary component had been in the process establishing approximate equilibrium in trace element partition with grain matrices, the anomalies are initial properties of the grain-boundary component.

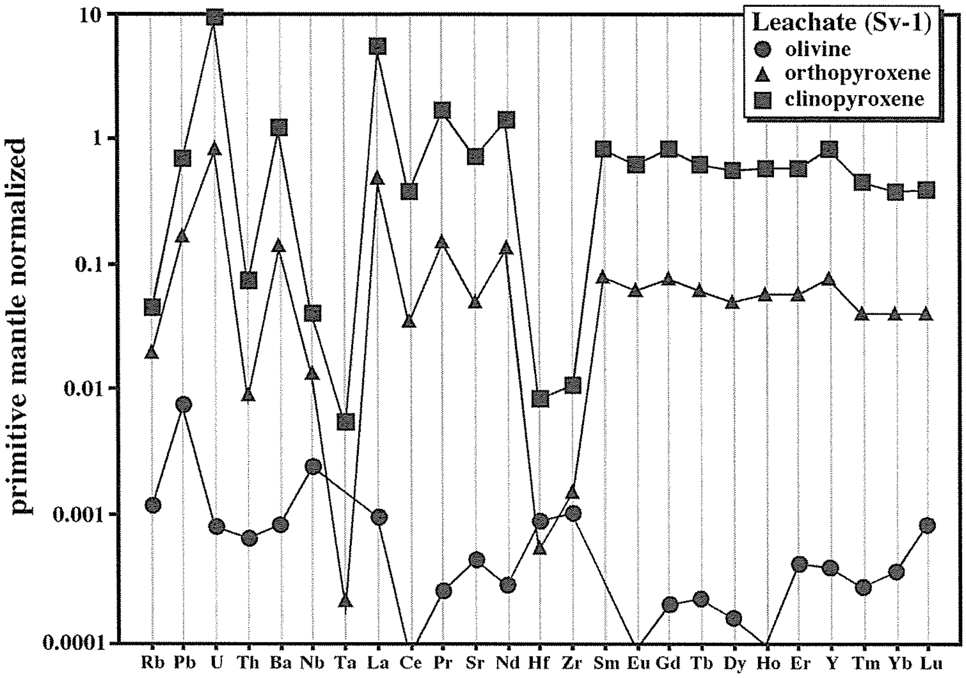

Figure 2. Normalized trace element patterns for leachates of constituent minerals of a xenolith of sample Sv-1. Values of the y-axis were calculated by the weight of trace elements in the leachates; it was divided by the weight of its host mineral used for

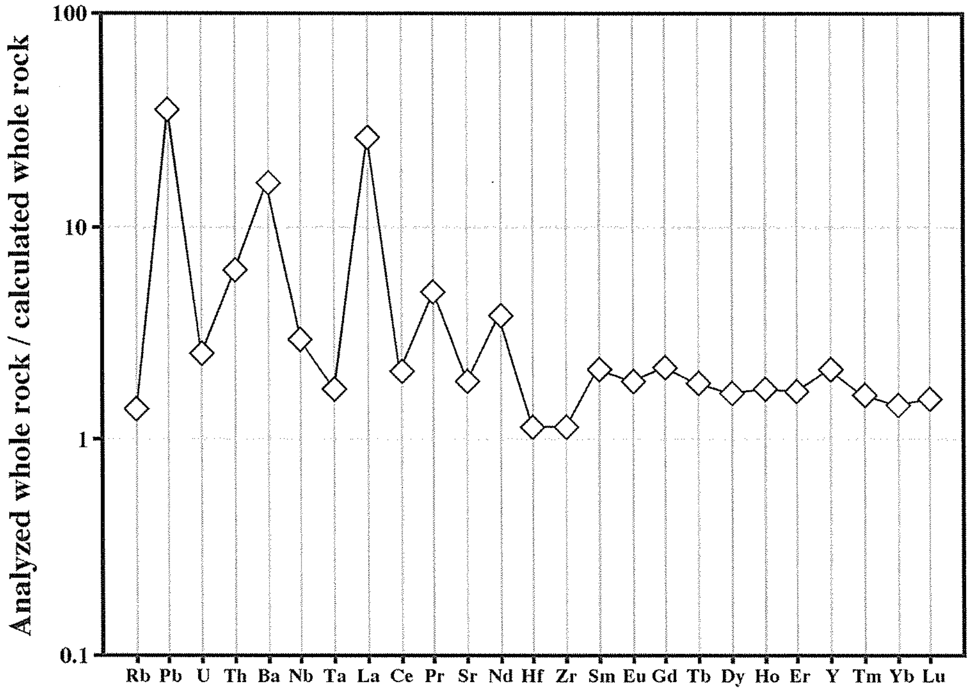

Figure 3. Trace element patterns for the analyzed whole rock normalized by the calculated whole

In order to distinguish distribution of the material depleted in HFSE and Ce, we analyzed rare earth element compositions of the grain-boundary components using LA-ICP-MS. Figure 4 shows rare earth element patterns of the grain-boundary components accompanied by the pattern of the whole rock. The grain-boundary components apparently included negative Ce anomaly. Also some kinds of melt inclusions show negative Ce anomaly. This study represents the first finding of the negative Ce anomaly in the melt inclusions.

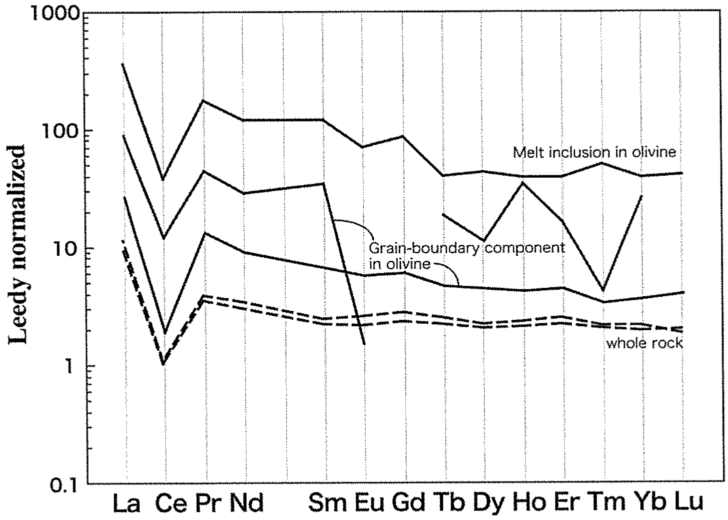

Figure 4. Leedy-normalized rare earth element patterns for grain-boundary component and melt inclusion analyzed by LA-ICP-MS accompanied by the analyzed whole rock.

4.2. Negative Ce anomaly in mantle rocks

Cerium is the only REE that is oxidized in nature. The change in ionic charge and radius engenders decoupling of Ce^{4+} from the trivalent REE (except for Eu) because of the unique configuration of the 4f electron shell. Hence, this element has valuable information about geochemical processes, reflecting such processes as redox reactions. The Ce anomalies found in the present study indicate that Ce has undergone reactions involving Ce^{4+} under oxidizing conditions or the anomalies have incorporated source materials originally having the negative Ce anomaly (e.g., natural aquatic solution). The negative Ce anomaly in the grain-boundary component and the melt inclusion must therefore be inherent from the source region. The negative Ce anomalies in mantle-derived peridotites were conspicuously reported from several island arc. We shall outline here only briefly fluid in the mantle wedge. In the mantle wedge, the silicate melt generated by partial melting of mantle rock would have ascended through the grain boundary of mantle minerals. The melt is generated by reaction of mantle minerals with aqueous fluid dehydrated from descending slab. Thus, trace elements of the aqueous fluid are partly inherited from those in the descending slab. It is interesting to note that oceanic sediments generally show negative Ce anomaly. Furthermore, Ce may not be dissolved much in the aqueous fluid derived from the descending slab due to generation of Ce^{4+} in an oxidizing condition. The grain-boundary component and the melt inclusion are therefore inferred to originate from subduction-related components.

4.3. Positive anomalies among some highly incompatible elements

The whole rock of sample Sv-1 reveals a nearly flat REE pattern with depletion in Rb, Th, Ce, Sr and HFSE, and spikes of U, Ba and La (Fig. 1). This possibly indicates at least a two-stage history for the xenolith. The depletions in incompatible elements can be induced by the loss of a partial melt enriched in incompatible elements. Spikes of U, Ba and La in the whole rock pattern suggest that the depletion event was followed by an enrichment episode caused by a material that is rich in U, Ba and La, but very poor in Rb, Th, Ce, Sr and HFSE. That conjecture is plausible. Although the constituent minerals of the Sv-1 sample are markedly enriched in U, they have depleted patterns with a gradual decrease in LREE and low values of highly incompatible elements. On the other hand, the leachates have spikes of U, Ba and La. These spikes are consistent with an interpretation that the relatively high contents of U, Ba and La in the whole rock exist largely because of a depletion event and a subsequent enrichment event.

4.4. Respective origins of the grain-boundary component and melt inclusion

Beneath the continental active margin or island arc, aqueous fluid derived from the subducted slab ascends into the mantle wedge. Hydrated peridotite was formed by the addition of slab-derived H_2O. Hydrous minerals such as amphibole, chlorite and phlogopite in the hydrated peridotite broke down in downward flow of the mantle wedge and release H_2O. Interconnection of the aqueous fluid in the hydrated peridotite is controlled by dihedral angles of mineral grains. At low pressure and temperature, most aqueous fluids generated by successive decomposition of the hydrous minerals in downdragged hydrous peridotite could not segregate from solids and would be transported to greater depths as free fluid in isolated pores among crystals. If such downdragged hydrous peridotite reaches a region where the dihedral angle is less than 60°, aqueous fluid is supplied continuously from the downdragged hydrous peridotite. When the aqueous fluid reached the region with the solidus temperature of hydrous peridotite, partial melting in the mantle wedge took place to produce initial magma. Melt was extracted upwards, ascending through the mantle wedge, engendering subduction-related volcanism if melt segregation occurred. Incidentally, if the aqueous fluid took a detour, avoiding the partial melting zone, it directly infiltrated into the mantle located above the partial-melting zone. It eventually emerges to the Earth's surface as hydrothermal fluid. Part of both the melt and fluid should remain in the mantle wedge as a grain-boundary component and melt inclusion, or as fluid inclusion, containing features of depletion in HFSE and Ce with the lanthanide tetrad effect as mentioned before. In this respect, the HFSE depletion in the grain-boundary components of the present xenoliths is related to subduction processes. In the Jurassic - Early Cretaceous Period, a subduction zone was formed in Far

Eastern Russia. The aqueous fluid released from the descending oceanic lithosphere would trigger partial melting of the mantle wedge at the depth of *ca*. 60 km. The melt therefore ascend through the mantle wedge, and engender subduction-related volcanism. The present mantle xenoliths were derived from the uppermost part of the mantle wedge (35-40 km) beneath Far Eastern Russia (Yamamoto *et al.*, 2002). Such a region must be infiltrated by the melt that had ascended from the partial melting zone. Consequently, both the grain-boundary component and the melt inclusion, which have a relation to the aqueous fluid in their generation, are fluids related to the subduction system.

5. Summary

(1) Trace element pattern of the whole rock shows large depletion in HFSE and Ce. Such anomalies are not well identified in the acid-leached constituent minerals. Trace element patterns of the leachates of the constituent minerals are similar to the whole-rock pattern. These results suggest the contribution of the grain-boundary component. The application of LA-ICP-MS to in-situ analyses of rare earth elements in the grain-boundary component and melt inclusion revealed that the negative Ce anomaly were originated from both the grain-boundary component and the melt inclusion.

(2) The depletion in HFSE and Ce in the trace element pattern of the grain-boundary component and the melt inclusion indicate a relationship with aqueous fluid. Because the Far Eastern Russia area was located at the subduction zone in the Jurassic - Early Cretaceous Periods, the present mantle xenoliths, which are located immediately above the partial melting zone, had been infiltrated by the melt derived from the partial melting zone or the aqueous fluid derived directly from subducted slab. Therefore, several anomalies observed in both the grain-boundary component and the melt inclusion are common features of the mantle wedge.

Acknowledgements

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Equilibrium temperature and pressure conditions of the peridotite xenoliths in the French Massif Central

Yoshikawa Masako, Kawamoto Tatsuhiko, Yamamoto Junji

Cenozoic volcanoes in the Central Massif, France, brought peridotite xenoliths to the surface. Extensive studies were carried out with those peridotite samples by the use of petrography, trace element chemistry and isotopic compositions. Mercier and Nicolas (J. Petrol., 1975) suggested that the Puy Beaunit xenoliths were recrystallized and brought up from the shallower upper mantle, near the depth for the Moho discontinuity based on (1) the presence of spherical spinel and (2) the existence of transitional rock type from ultramafic to charnockitic with increasing silica contents. Also, clinopyroxenes of the Puy Beaunit xenoliths were characterized by (1) higher Sr and lower Nd isotopic compositions than those of the other peridotite xenoliths of the French Massif Central and (2) isotopic compositions similar to the granulite xenoliths derived from the lower crust underneath the French Massif Central (e.g. Downes and Dupuy, Earth Planet. Sci. Lett., 1987). On the basis of these isotopic and textural signatures of the Puy Beaunit peridotite xenoliths, Downes and Dupuy (Earth Planet. Sci. Lett., 1987) and Downes et al (Chem. Geol., 2003) also inferred that these peridotite xenoliths experienced with mechanical mixing between peridotite and enriched pyroxenite in the Moho region. In order to assess this hypothesis,

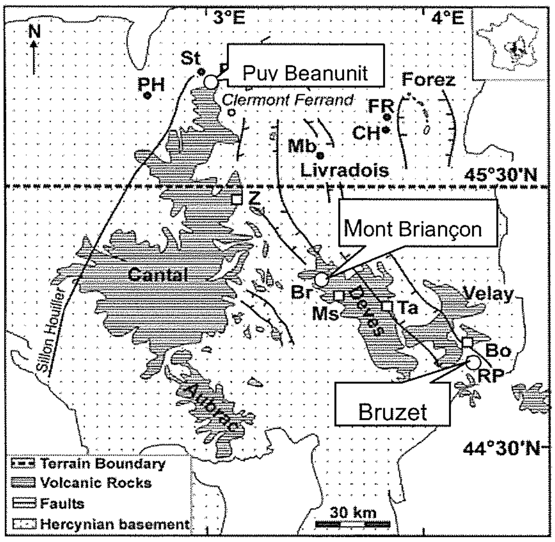

Fig. 1. Sketch map of Massif Central modified from Downes et al. (Chem. Geol., 2003) showing localities of the analyzed peridotite xenoliths and of the peridotite xenoliths studied by Downes and Dupuy (Earth Planet. Sci. Lett., 1987) and Zanga et al., (Contrib. Mineral Petrol., 1997).

we should know the pressure and temperature conditions of the peridotite xenoliths before the eruptions.

The xenoliths of Puy Beaunit show secondary equigranular and protogranular textures and the other xenoliths are protogranular and protogranular-to-porphyroclastic textures according to the definition of Mecier and Nicolas (J. Petrol., 1975). We examined the PT conditions of 10 peridotite xenoliths in scoria deposits from Puy Beaunit and Mont Briançon, and in Bruzet lava flow erupted at the Ray Pic crater, in the Massif Central, France (Fig. 1). We determined the equilibrium temperatures based on the two-pyroxene geothermometer using chemical compositions of Ca-rich and Ca-poor pyroxenes (Wells, Contrib. Mineral. Petrol., 1977). A promising depth scale for the peridotites is the residual pressure of CO_2 fluid inclusions. If the residual pressure, and consequently the density, of CO_2 was determined, extrapolation of the pressure to the equilibrium temperature estimated from the mineral thermometer indicates the pressure of CO_2 when the fluid inclusions were thermally equilibrated with the surrounding host mineral in the deep Earth. Micro-Raman spectroscopy is highly effective for determining density of CO_2 in CO_2 fluid inclusions (Yamamoto and Kagi, Chem. Lett., 2006). The estimated ranges of equilibrium temperatures and pressures are 860-940°C and 0.47-0.68 GPa for Puy Beaunit, 920-1000°C and 0.95-1.1 GPa for Mont Briançon and 960-990°C and 0.91-1.1 GPa for Bruzet, respectively (Fig. 2). These results indicate that the Puy Beaunit xenoliths were derived from obviously shallower depths (around 17-25 km) than the other localities (around 32-42 km). We conclude that the peridotite xenoliths of Puy Beaunit were brought up from the slightly shallower depth than the present Moho depth (around 27km, Zanga et al., Contrib. Mineral Petrol., 1997), and this is consistent with the hypothesis by the previous studies on the basis of petrography (Mercier and Nicolas, J. Petrol., 1975) and isotopic compositions (Downes and Dupuy, Earth Planet. Sci. Lett., 1987; Downes et al (Chem. Geol., 2003).

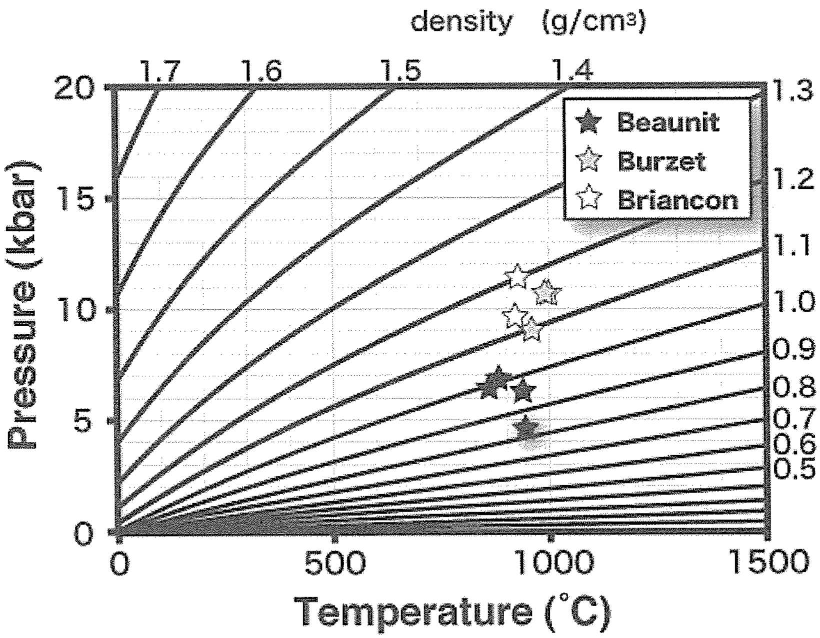

Fig. 2. P-T phase diagram of CO_2 in the high temperature and pressure range with data of CO_2 fulid inclusions of the French Massif Central peridotite xenoliths. Data of the equation of state for CO_2 is after Pizer and Sterner (J. Chem. Phys., 1994). Contours represent density, in g/cm^3 (i.e. isochores).

研究報告　Scientific Reports

Reconstruction of ground surface temperature history in the southeastern part of the Republic of Korea over the last 300 years

Shusaku Goto, Hyoung Chan Kim (Korea Inst Geosci Mineral Resour, Korea)
Youhei Uchida, Yasukuni Okubo (AIST, Tsukuba)

1. Introduction

Past changes in temperature at the earth surface have penetrated into the subsurface and have been recorded as transient temperature perturbations to the background thermal field. In the absence of fluid moving, changes in ground surface temperature (GST) slowly propagate downward by heat conduction. Depth of the perturbation and time at which GST changes have occurred is linked nonlinearly by thermal diffusivity of rock. Subsurface temperature perturbations attenuate with increasing depth due to the diffusive process. The attenuation depends on frequency of GST variations: higher frequency components are diffused out at shallower depth. Thus, subsurface temperature perturbations indicate signals of long-term trend of GST variations.

Northeast Asia is geographically important to study global and hemispheric climate trend. The purpose of this study is to infer a change in GST over the last 300 years in Ulsan (Fig. 1) by inversion of borehole temperature logs. Here, we report outline of this study. See Goto et al. (2005) for the detailed discussion.

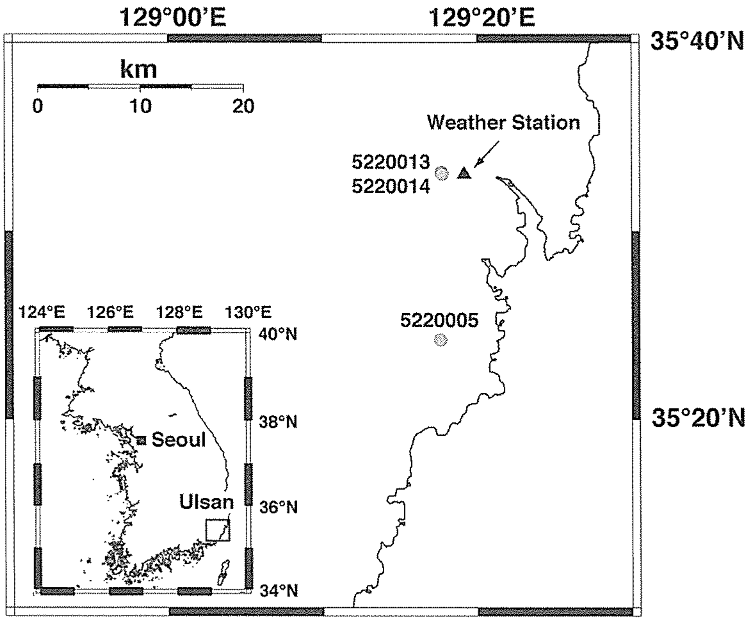

Fig.1 Locations of boreholes and weather station (Ulsan Gauging station of Korea Meteorological administration) in Ulsan, southeast of the Republic of Korea. Index map of the location of Ulsan is inserted.

2. Borehole temperature data in Ulsan, southeast of the Republic of Korea

In Ulsan, nineteen borehole temperature logs have been carried out for geothermal and hydrological surveys since 1986. To avoid non-climatic distortions (heterogeneity of the earth material and advection due to groundwater) to the GST history reconstruction, we selected three boreholes (5220005, 5220013 and 5220014) in Fig.1.

Fig.2 shows temperature profiles of the selected boreholes measured (thin solid line). Temperatures shallower than 30 m are not plotted in the figure because the effects of annual temperature change at the ground surface are seen. Background thermal regime for each borehole, calculated by a linear fitting from the temperatures deeper than 180 m, is also shown as a dashed line in Fig.2. The temperature gradients are 24–30 mK/m (K/km). Fig.3(a) shows the reduced temperature profiles that represent departures from their background thermal regimes (Fig.2). All of these reduced temperature profiles show positive temperature anomalies with amplitude of ~0.8 K at a depth of 30 m, indicating the recent warming at the surface.

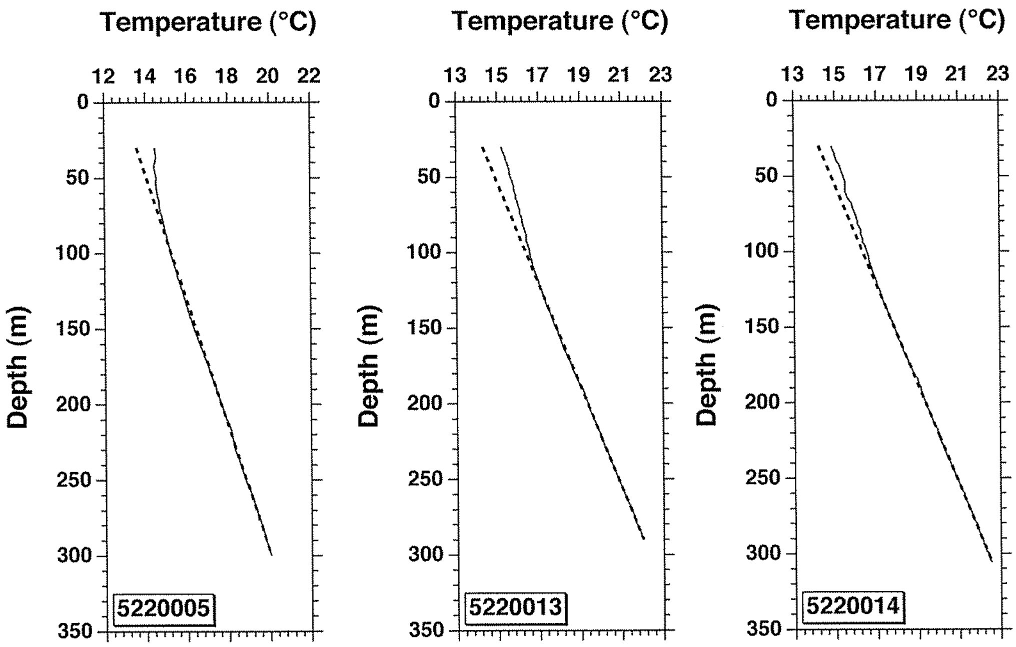

Fig.2 Temperature profiles in boreholes in Ulsan. Thin solid lines indicate measured temperatures. Dashed lines are the background thermal regimes.

3. Results and discussion

Fig.3(b) shows the result of GST history reconstruction from the three reduced temperature profiles in Fig.3(a). In the reconstructed GST history, a cold period is seen in the late 19th century. After the cold period, the GST shows an increase of 1.5 K by 1980. The synthetic temperature profile calculated from the GST history explains the long wavelength trends of the reduced temperature profiles (Fig.3(a)).

In Ulsan, surface air temperature (SAT) measurement has begun since 1946. In Fig.3(b), the mean annual SAT records from 1946 to 1988 are plotted. The GST history in Ulsan agrees with the long wavelength trend of the SAT records. Since 1962, Ulsan has developed as one of the major industrial cities in the Republic of Korea and major industrial plants and factories have been built. Thus, the increase in SAT in Ulsan suggests local warming due to the industrial activities in the area, along with global warming.

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Goto, S., H.C. Kim, Y. Uchida, Y. Okubo (2005): Reconstruction of ground surface temperature history from borehole temperature data in the southeastern part of the Republic of Korea. J. Geophys. Eng., 2, 312–319.

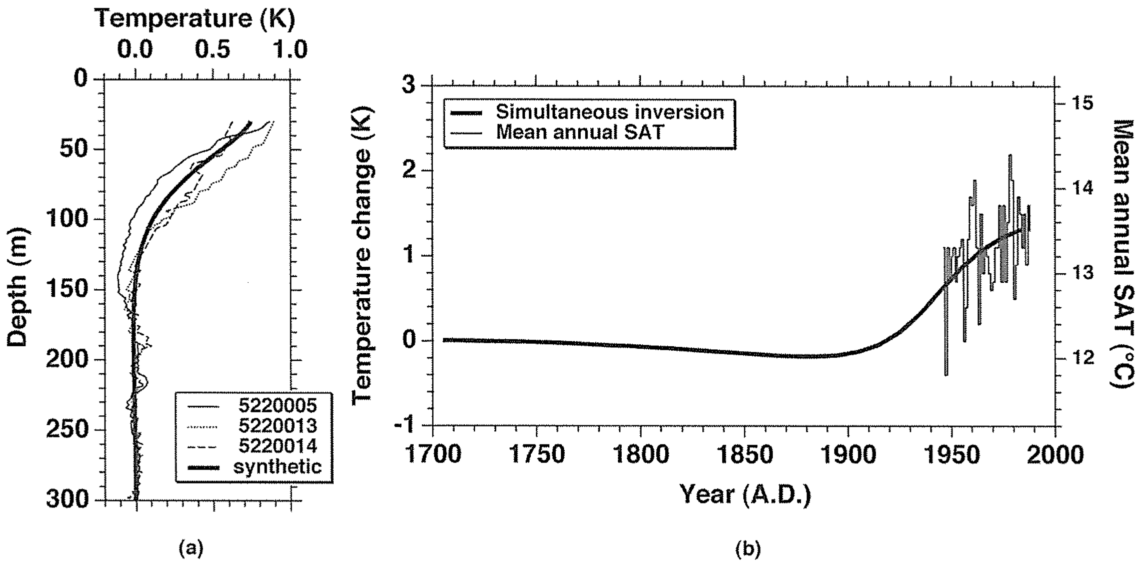


Fig.3 Results of GST history reconstruction. (a) Comparison of reduced temperature profiles and synthetic temperature profile calculated from the reconstructed GST history in the right figure. (b) Plots of GST history and SAT records in Ulsan.

A review of hydrous phases and water transport in the subducting slab

Kawamoto, T.

Arc volcanoes are typically located 90-180 km above the surface of downgoing slabs, as shown by Wadati-Benioff deep seismic foci (Gill 1981; Tatsumi 1989). The intimate relationship between the dip angles of the subducting slab and the locations of volcanic arcs indicates that subduction zone magmatism is triggered by material input from the subducting slab (Tatsumi and Eggins 1995). The slab-derived components are thought to be aqueous fluids or H_2O-rich partial melts of subducted oceanic crust. Therefore, knowledge of the stability of hydrous phases and the chemical and physical properties of aqueous fluids in downgoing slabs is essential to understand the material transport in subduction zones. In this section, I will review the stability of hydrous phases in downgoing peridotite, basalt and sediment systems, and the chemical and the wetting properties of aqueous fluids.

Recent experimental studies indicate that 3 – 4 GPa, equivalent to 90 – 120 km depth, is a key pressure, where (1) the chemical compositions of silicate components dissolved in aqueous fluids equilibrated with mantle minerals approach the composition of mantle peridotite itself (Stalder et al. 2001; Mibe et al. 2002; Kawamoto et al. 2004), (2) the dihedral angle between olivine and aqueous fluids starts becoming smaller than 60° (Watson et al. 1990; Mibe et al. 1998; 1999), and (3) the immisciblity gap between peridotitic melts and aqueous fluids disappears and consequently hydrous minerals liberate supercritical aqueous fluids (Mibe et al. 2004; 2006). The similarity between these pressures and the depths of downgoing slab underneath volcanic fronts, where the maximum numbers of volcanoes are formed, 124 +/- 38 km (Gill 1981) or 112 +/- 19 km (Tatsumi 1986), suggests that subduction zone magmatism can be triggered by the input of supercritical fluids from the downgoing peridotite and basalt.

Both the change of chemical composition and of wetting properties of mantle fluids with pressure may be related to the onset of complete miscibility between silicate melt and aqueous fluids as the pressure and temperature conditions approach the critical endpoint.

(Reviews in Mineralogy and Geochemistry, Volume 62, in press)

Direct observation of crtical behavior between aqueous fluids and and andesitic melt: major element chemistry of supercritical fluids in mantle wedge

***Kawamoto, T*, Kanzaki, M (ISEI, Misasa), Mibe, K (ERI, Tokyo), Matsukage, K, N (Ibaraki), Ono, S (JAMSTEC, IFREE)**

Aqueous fluids dissolve significant amounts of silicates under high-temperature and high-pressure conditions. Silicate components dissolved in aqueous fluids coexisting with mantle peridotite change their major element chemistry from silisic at 1-2 GPa to peridotitic at 3 GPa and higher pressures (Ayers et al. 1997 EPSL; Stalder et al. 2001CMP; Mibe et al. 2002 GCA; Kawamoto et al 2004 Am Min). In the present study, we show direct observations of complete mixing between aqueous fluids and a calc-alkaline andesitic melt (61.5 weight percent SiO_2) at around 1 GPa by use of Bassett type externally heated diamond anvil cell (Bassett et al 1993, Rev Sci Instrum). Aqueous fluids and andesitic melts can mix completely around at 3 GPa. Mibe et al. (2004 Fall Meeting) reported a possible second critical endpoint between aqueous fluids and a peridotitic melt at 3.8 GPa by use of synchrotron X-ray radiography using multi-anvil type high-T and high-P apparatus at SPring-8. These experiments suggest that the slab-derived component can be under supercritical conditions. Whether the component has chemical characteristics like a partial melt or an aqueous fluid depends on temperature. In wedge mantle, such supercritical fluids can lose water by forming hydrous minerals as reactions with mantle minerals, and get rich in silicate components. In this case, those fluids can become gradually water-rich melts. Critical temperature, which is a boundary between two-fluids and a single supercritical fluid regions, increases as decreasing pressure (Shen and Keppler, 1997 Nature; Bureau and Keppler 2001 EPSL). Therefore, supercritical fluids separate into silicate melts and aqueous fluids along its migration to the surface. In this case, an elemental fractionation should occur between an aqueous fluid and a silicate melt.

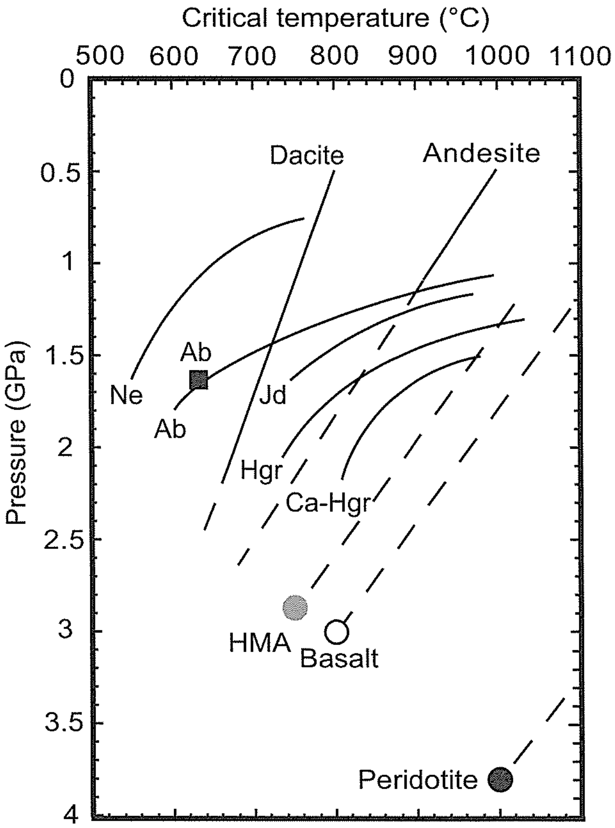


Figure Critical temperatures observed between aqueous fluids and albite (Ab, Shen and Keppler 1997 Nature), nepheline (Ne), jadeite (Jd), and haplogranitic (Hgr) melts, Ca bearing haplogranitic melts (Ca-Hgr) and dacite (Bureau and Keppler 1999 EPSL), and natural calc-alkaline andesite/dacite (Kawamoto 2004 Rev High Pressure Sci Tech). The estimated second critical endpoints between albite (Stalder et al. 2000 Am Mineral), basalt (Mibe et al. 2006 AGU Fall meet), and peridotite (Mibe et al. 2005 AGU Fall meet) and aqueous fluids are also plotted.

Slip rates and late Quaternary activity of the Unzen active faults in western Kyushu

Matsuoka, A. (Nippon Koei), Tsutsumi, H.(Kyoto Univ), *Takemura, K.*
Hoshizumi, H., Matsumoto, A. (GSJ, Tsukuba),

The Unzen Graben, which is bounded by normal faults to the north and south, is located at the western end of the Beppu-Shimabara Graben. The faults in the Unzen Graben have developed in association with the growth of the Unzen volcanoes and deformed volcanic materials such as lavas and pyroclastic deposits. The detailed location and vertical offsets of the active faults have been reported by previous studies, but the timing of faulting was poorly costrained. In this study, we calculate vertical slip rates of the faults based on recently obtained radiometric ages of volcanic rocks and sediments. The active faults in the Unzen Graben can be divided into five groups, based on the slip rates and the timing of faulting. The faults located on the northwestern and southeastern margins of the Unzen Graben have vertical slip rates as high as 0.12 to 1.0 mm/yr. However, the faults located on the northeastern margin of the graven are less active and have slip rates of 0.28 to 0.38 mm/yr. The faults inside the graben have slip rates of 0.085 to 0.46 mm/yr, except for the Akamatsudani fault which has a slip rate of 0.91 to 1.7 mm/yr. These faults show cumulative vertical offsets and their slip rates tend to be higher closer to the Fugen Volcano. On the other hand, the faults outside of the Unzen Graben have considerably lower slip rates of 0.026 to 0.068 mm/yr.

(Active Fault Reseach, vol 25, 2005)

Second critical endpoint in the basalt-H_2O system

Mibe, K (ERI, Tokyo), Kanzaki, M (ISEI, Misasa), *Kawamoto, T,*
Matsukage, K, N (Ibaraki), Fei, Y (Gephys Lab), Ono, S (JAMSTEC, IFREE)

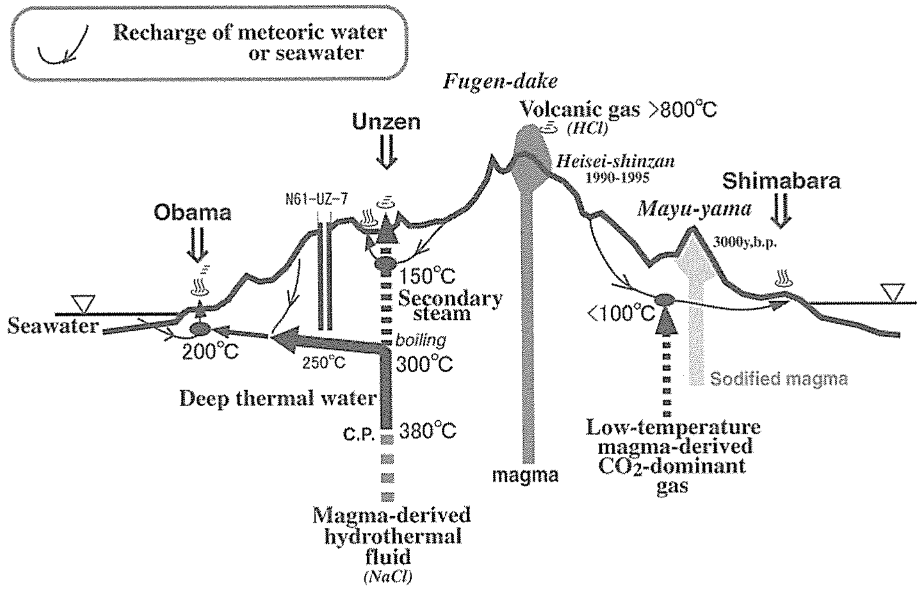
The water released from subducting slab plays an important role in mass transport within subduction zones. Therefore, understanding the phase relations in the basalt-H_2O system is fundamental for clarifying the subduction zone magmatgism. In order to determine the second critical endpoint in the basalt (MORB)-H_2O system, experiments were conducted using X-ray radiography technique together with Kawai-type double-stage multi-anvil high pressure apparatus (SPEED-1500) installed at SPring-8, Japan. Direct X-ray beam, which passes through the anvil gaps of SPEED-1500 and sample under high pressure, is observed with an X-ray camera. The sample container should not react with hydrous samples, but should be x-ray transparent. We, therefore, developed a new sample container, which is composed of a metal tube and a pair of single crystal diamond lids put on both ends of metal tube. The sample in the metal container can directly be observed through the diamond lids with X-ray radiography. The experimental conditions are at pressures from 1.8 to 4.0 GPa and at temperatures up to about 1400 deg. C. Pressure is applied first, and then temperature is increased. In the experiments at pressures below the second critical endpoint, the experimental P-T path encounters the stability field of aqueous fluid + silicate melt. In this case, one phase (either aqueous fluid or silicate melt) forms spheres in the other phase because of their differences in the interfacial tension. Therefore, round shape is expected to be observed in the radiographic images. On the other hand, in experiments beyond the second critical endpoint, round shape should not be observed because supercritical fluid is the only phase existing at high temperature. In the experiments up to 3 GPa, two phases (fluid and melt) were observed. Above 3 GPa, however, we could not distinguish two phases in the radiographic images, indicating that aqueous fluid and silicate melt can coexist up to 3 GPa and there is no difference between these two phases above 3 GPa. It could be concluded that the second critical endpoint in the system basalt (MORB)-H_2O occurs at around 3 GPa. Our experimental results suggest that the aqueous fluid and silicate becomes indistinguishable at the depths deeper than 90 km in subducting hydrous slab. The fluid released from the slab in the for-arc region could be one phase (aqueous fluid) or two phases (aqueous fluid + hydrous silicate melt) depending on the slab temperature, whereas the released fluid beneath the volcanic front and in the back-arc side should be the only one supercritical fluid phase.

A Hydro-geochemical Study on Hydrothermal System and Formation Processes of Hot Springs in Unzen Graben of the Shimabara Peninsula, Kyushu, Japan

S. Ohsawa

In this study, a model for hydrothermal system and formation processes of hot springs (Obama, Unzen and Shimabara hot springs) in Unzen Graben of the Shimabara Peninsula was constructed on the basis of a detailed analysis of hydro-geochemical data obtained by Ohsawa et al. (2002) and NEDO (1988). Both of Obama and Unzen hot springs at the western part of the graben, which are located at the southwest side of the volcanic center of Unzen Volcano, are generated by one active liquid-dominant hydrothermal fluid of Na-Cl type. Fumarolic area adjoining Unzen hot spring being on the uplands is developed by a steam separated from the hydrothermal fluid at some 300℃, and hot water of H-SO_4 type of Unzen hot spring is formed by mixing of the secondary steam into shallow groundwater at about 150℃. Heat and material source of the liquid-dominant hydrothermal fluid is a high-pressure magma-derived hydrothermal fluid in which chloride is contained in Na-form. The "residual" deep thermal water migrates laterally toward the western coast while conductively cooled, and finally the mixing of seawater into the thermal water results in the formation of boiling or hot water of Obama hot spring at approximately 200℃. Warm water of HCO_3 type of Shimabara hot spring at the eastern part of the graben, which is located at the east side of the volcanic center of Unzen Volcano, is formed at less than 100℃ by mixing of a low-temperature magma-derived CO_2-dominant gas into shallow groundwater of meteoric origin. This low-temperature gas might be derived from a solidified magma relevant to a monogenetic volcano, Mt. Mayu-yama formed 3000 year before present, but the formation mechanism of such gas is still unaccounted for. This hydro-geochemical study cannot pinpoint the precise location of the primary magma chamber of Unzen Vocalno which is still hotly argued, however the conclusion of this study for the aspect of geochemical formation mechanism of hot spring waters agrees to the previous model (Ohta, 1973; 1975) on the whole.

(Journal of Geothermal Society of Japan, Vol.28, No.3, in press)



A hydro-geochemical model for hydrothermal system and formation processes of hot springs in Unzen graben.

Seismicity within the Philippine Sea Slab in the Central and Southern Kyushu, Japan

***Kyo Okamoto, Takahiro Ohkura,* Tetsuzo Seno (ERI, Tokyo)**

In order to determine where (within the oceanic crust or mantle alone, or within both of them) intraslab earthquakes occur in the Central and Southern Kyushu, Japan, we analyzed the waveform data observed in the Chugoku-Shikoku region, and determined whether they have P- and S-waves guided by the oceanic crust of the Philippine Sea (PHS) slab or not.

Secondly, with a view to locate hypocenters of the intraslab earthquakes with a high accuracy, we relocated them using Double-Difference hypocenter determination method. The results are as follows: (1) In the north part of the study area, several intraslab earthquakes occurred within the oceanic crust, and in the south part, they occurred within the oceanic mantle. (2) It is not clear whether earthquakes occurred also within the oceanic mantle in the north part and within the oceanic crust in the south part. (3) We recognized the double structure of seismicity at several cross-sections in the study area. Submitted to ZISIN 2

Isotope Compositions of Submarine Hana Ridge Lavas, Haleakala Volcano, Hawaii: Implications for Source Compositions, Melting Process and the Structure of the Hawaiian Plume

Ren, Z.-Y. (TITECH), *Shibata, T., Yoshikawa, M.,* Johnson, K.T.M. (University of Hawaii)
Takahashi, E. (TITECH)

We report Sr, Nd, and Pb isotope compositions for 17 bulk-rock samples from the submarine Hana Ridge, Haleakala volcano, Hawaii, collected by three dives by ROV *Kaiko* during a joint Japan–US Hawaiian cruise in 2001. The Sr, Nd, and Pb isotope ratios for the submarine Hana Ridge lavas are similar to those of Kilauea lavas. This contrasts with the isotope ratios from the subaerial Honomanu lavas of the Haleakala shield, which are similar to Mauna Loa lavas or intermediate between the Kilauea and Mauna Loa fields. The observation that both the Kea and Loa components coexist in individual shields is inconsistent with the interpretation that the location of volcanoes within the Hawaiian chain controls the geographical distribution of the Loa and Kea trend geochemical characteristics. Isotopic and trace element ratios in Haleakala shield lavas suggest that a recycled oceanic crustal gabbroic component is present in the mantle source. The geochemical characteristics of the lavas combined with petrological modeling calculations using trace element inversion and pMELTS suggest that the melting depth progressively decreases in the mantle source during shield growth, and that the proportion of the recycled oceanic gabbroic component sampled by the melt is higher in the later stages of Hawaiian shields as the volcanoes migrate away from the central axis of the plume.

(Journal of Petrology, 47, 255-275, 2006)

Magnetic petrology: applications to volcanology

Takeshi Saito

Magnetic petrology is the science of magnetic minerals, mainly iron-titanium oxide minerals (figure). It aims to identify the magnetic carriers and to determine the factors that control the occurrence and abundance of these phases by using two traditional fields of study, rock magnetism and petrology. By rock magnetic analyses, we can find the magnetic properties that give us information about magnetic minerals. By petrological analyses, we can find the occurrence of oxide minerals. By integrating both types of information, the origin of magnetization and the evolution of oxide minerals can be considered. In volcanic materials, there are abundant iron-titanium oxide minerals and they show a wide variation in a single lava dome, a single lava flow and one sequence of tephra. Therefore, by magnetic petrological analyses, we can estimate the genesis and evolution of magma. In this paper, I describe three studies about magnetic petrology. 1) Oxides can be frequently oxidized during initial cooling between the magma reservoir and a deposit. According to the difference of temperature, cooling rate and oxygen fugacity, various oxide minerals are produced in lava dome eruptions. 2) In many volcanic materials, like lava flows or tephra, fine-grained oxides can be crystallized in a matrix during the cooling process. This process is important in considering the genesis of the magma or the materials. 3) Heating experiments indicate that exsolution titanohematite lamellas in titanomagnetite can be an indicator of heating temperature and duration. (Journal of Geography. 114, 296-308, 2005.)

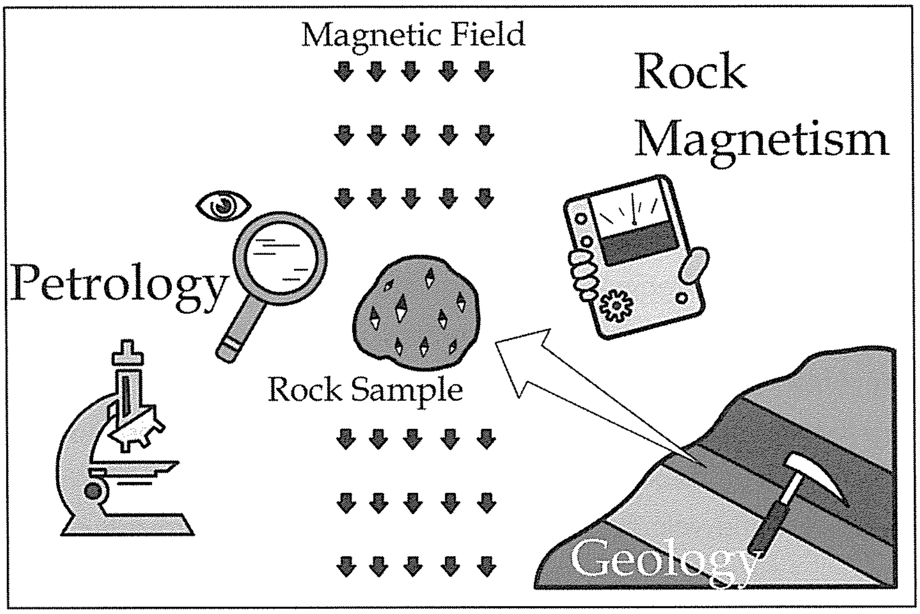


Figure Sketch of the world of magnetic petrology. Magnetic petrology is based of rock magnetism, petrology and geology.

Characteristic magnetic petrological behavior of historical lavas of Unzen volcano

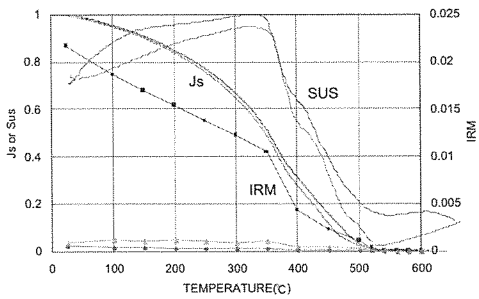
Takeshi Saito, **Hiroki Kamata, Naoto Ishikawa (IHS, Kyoto)**

Recently, studying magnetic behavior and petrology of iron-titanium oxide minerals have achieved steady results and such a method of study have been known as magnetic petrology or magneto-petrology (e.g. Frost, 1991). Magnetic petrology is an effective method for studying the genesis or evolution of volcanic materials because they contain abundant iron-titanium oxides which show wide variation according to the difference of eruptive and cooling processes (e.g. Gromme et al., 1969; Audunsson et al., 1992; Kontny et al., 2003; Saito et al., 2004). I have been working on understanding the mode of eruption in various volcanoes by using magnetic petrological methods (e.g. Saito et al., 2003, 2004, JVGR). In this presentation, I will report about characteristic magnetic properties and petrology of iron-titanium oxides in lavas from Unzen volcano, Japan, indicating the difference of eruptive conditions.

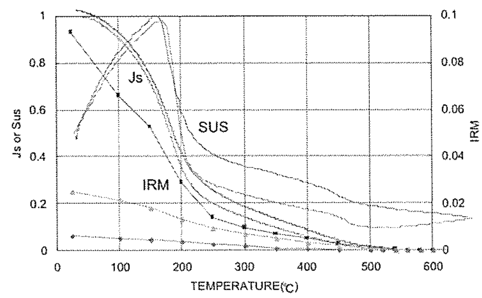
Unzen volcano is one of the most active volcanoes in Japan. Historical eruptions occurred in 1663, 1792 and 1990-1995. Andesite lava (57.5 wt.% SiO_2) flowed out in 1663 and dacite lava flow (66.5 wt.% SiO_2) was effused in 1792 (Ohta, 1984). The most recent activity is the 1990-1995 eruption, which is characterized by the effusions of dacite lava domes (64.5-66.0 wt.% SiO_2) and the generations of abundant block-and-ash flows of dome collapse origin (Nakada et al., 1999). Although the 1792 lava showed the highest SiO_2 bulk rock composition in these three lavas and it would be expected that the 1792 lava showed the lowest fluidity, the 1990-1995 lava formed lava domes and showed the lowest fluidity. Nakatani and Sato (2002) tried to explain this discrepancy by petrological analyses, but they did not get consistent results.

In order to clarify the eruptive condition of the last three eruptions at Unzen volcano and to explain the above-mentioned discrepancy, I carried out magnetic petrological analyses on the 1663, 1792 and 1990-1995 lava samples. High-temperature susceptibility and the orthogonal IRM experiments revealed that three kinds of lava samples show distinct magnetic behavior and iron-titanium oxide mineral assemblages (figure). All samples contain two kinds of titanomagnetite with different Ti content. Ti-poor titanomagnetite whose Tc is about 450 degrees C is commonly found in three lava samples. However, each lava shows another Ti-rich titanomagnetite with distinct Ti content. Ti-rich titanomagnetite in the 1990-1995 lava shows the highest Tc of about 350-400 degrees C. The 1792 lava shows lower Tc of about 300 degrees C and the 1663 lava shows the lowest Tc of about 200 degrees C. Generally speaking, Ti-rich titanomagnetite shows high equilibrium temperature (Ghiorso and Sack, 1991). This indicates that Unzen samples are derived from two magmas with different temperature and temperature of the high-T magma in the 1990-1995 lava is lower than that of the 1663 and 1792 lava. In addition, IRM experiments indicate that the remanence carried by Ti-rich titanomagnetite shows greater contribution to the total remanence than Ti-poor titanomagnetite. This character is more apparent in the 1663 and 1792 samples than in the 1990-1995 lava. This indicates that supplied high-T magma during 1663 and 1792 eruption is greater in amount than in the 1990-1995 eruption. This is consistent with the microscopic observations, which indicate that the 1990-1995 lava shows higher groundmass crystallinity and richer in phenocrysts than the 1663 and 1792 lava. These results suggest that temperature of the 1990-1995 magma is lower than the 1663 and 1792 magma. This difference of magma temperature probably causes the different mode of eruption and the different fluidity of three lavas. (Earth Monthly, 2006, in press)

1990-1995 lava



1663 lava



1792 lava

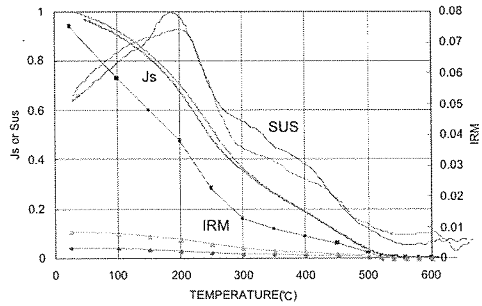
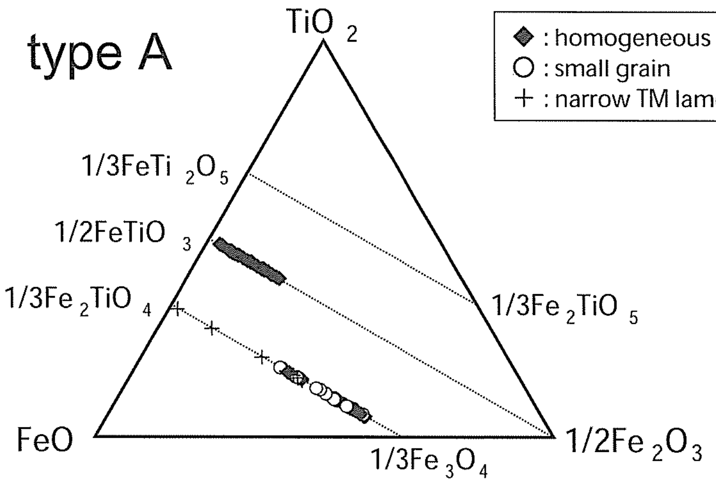


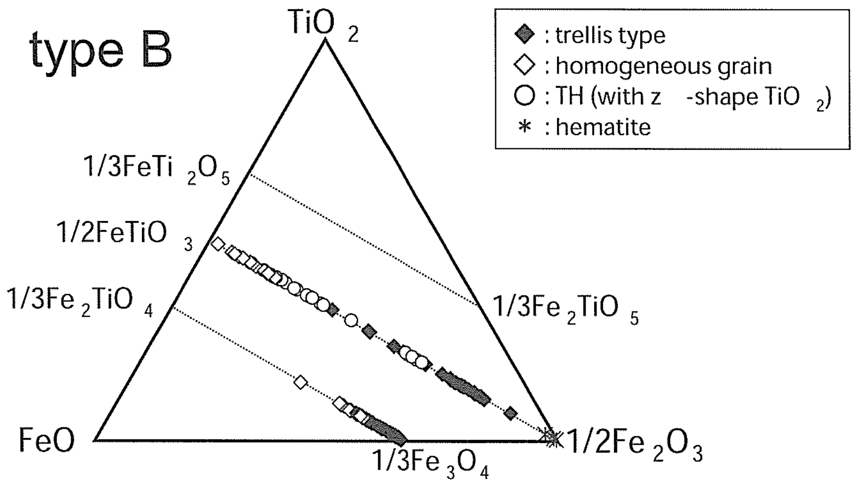
Figure Thermal changes of susceptibility, strong-field magnetization and orthogonal IRM of three historical Unzen lavas.

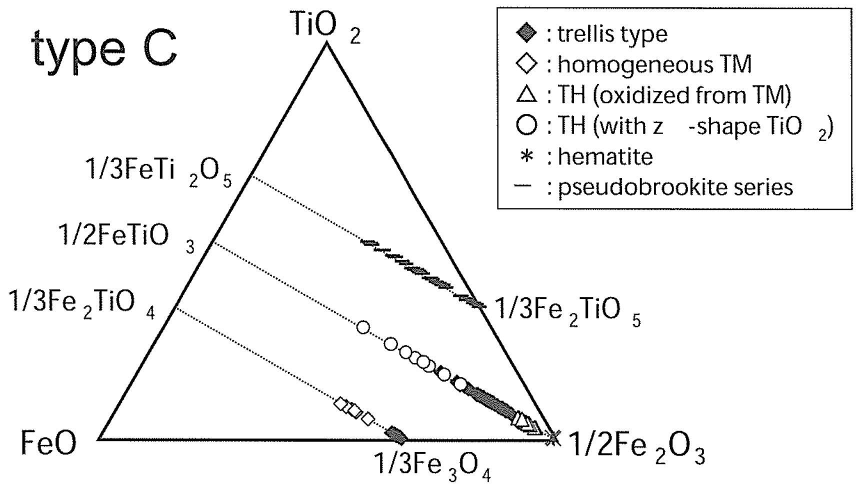
Magnetic petrology of the 1990-1995 dacite lava of Unzen volcano, Japan: degree of oxidation and its implications for lava dome growth

***Takeshi Saito*, Naoto Ishikawa, Hiroki Kamata (IHS, Kyoto)**

In order to understand the oxidation state and process in lava dome, magnetic petrological analyses were carried out on lava samples from the lava domes and block-and-ash-flow deposits of the 1990-1995 eruption of Unzen volcano, Japan. As a result, three different types of magnetic petrology are recognized in our samples related to the redox reaction during initial cooling (figure). Type A oxides are characterized by homogenous titanomagnetite and titanohematite with low coercivity, indicating low oxidation state. Type B oxides are weakly exsolved and titanohematite laths and rutile lenses develop. They have higher coercivity with a small quantity of hematite, indicating higher oxidation state. Type C oxides, the highest oxidation state, are completely exsolved and composed of multiphase; Ti-poor titanomagnetite, titanohematite, rutile and pseudobrookite. Considering with geological occurrences, we found that the oxidation processes is quite different between endogenous dome and exogenous dome and the position of the sample and the process of dome growth is the important factor in oxidation. Lava samples from endogenous dome were oxidized concentrically and classified into the three types according to the sample position; samples from surface are strongly oxidized and reached to type C, while inner part are unoxidized and classified to type A. Samples from the vent of exogenous dome were not oxidized and classified to type A. In block-and-ash-flow deposits, which were generated from exogenous dome, many oxidized lavas classified to type B or C were contained, suggesting flow front or distal parts can be oxidized in varying degrees. This implies that horizontal oxidation is dominant process in exogenous dome. (submitted to J. Volcanol. Geotherm. Res.)







Observations of red glow at Aso volcano, Japan, using a consumer digital camcorder

Takeshi Saito, Takahiro Ohkura, **Satoshi Sakai (IHS, Kyoto)**

Aso volcano in central Kyushu, Japan, had shown the activity of red glow again during last summer. Fukuoka center of Japan Meteorological Agency issued volcanic observation report no. 28 on Aso volcano stating that red glow was observed at the first crater in Naka-dake at Aso volcano on 31 May 2005. Red glow is high temperature spots at surface of crater, which can be seen glowing red with the naked eye at night. Red glow have been observed in many volcanoes around the world because it sometimes indicates the rising magma.

Recent activity at Naka-dake is characterized as a cycle of hot water pool (dormant period), mud eruption, dry-up of the pool, red glow, and Strombolian eruption. Red glow have been carefully monitored as a precursor of the next eruption. Recently, red glow had been observed at the southern wall of the first crater between November 2000 and August 2004. Since August 2004 red glow had not been seen in the first crater.

This activity had been observed between May 2005 and September 2005. Since 8 September water in the crater had been increased and glowing region had been submerged below the surface.

We conducted a field survey on 7 June and 29 July and observed red glow inside the crater. We adopted near-infrared image system using a Sony's consumer digital camcorder, which was summarized in Saito et al. (2005, Earth Planets Space). Our system shows better performance in observation and thermometry of high temperature spots than previous infrared thermometers or thermal infrared cameras.

As a result, we observed some high temperature spots around the hot water pool inside the first crater (figure). There was a largest region of about 10 meters, named spot A, at the western bank. In this region, a number of high temperature spots were observed. A large lava block in the pool, named spot B, glowed red. The temperature of red glow was estimated by using ThermoShot, the software which converts a bitmap image into a thermal image. We found that the high temperature region had a temperature of more than 600°C and the maximum temperature reached about 730°C. There was no high temperature spot in southern wall, indicating the temperature was less than 300°C.

While red glow was observed, hot water level in the crater decreased by about 20% of usual and pool was boiling violently. These facts show signs of volcanic activity. Heat supplied to the crater may be increasing, compared with dormant period from 1993 to 2000. However, no abnormal is found in seismicity (volcanic earthquakes and tremors) and the other monitoring data. In addition, glowing region was submerged after September because of increasing rainfall and water. They indicate that Aso is not so active as eruption occur immediately. Anyway, we must pay attention to the volcanic activity of Aso volcano. (2005 fall meeting, the Volcanological Society of Japan)

ThermoShot
The software which converts a bitmap image into a thermal image, developed at School of Earth Sciences, Kyoto University. You can download from the following website.
http://www.gaia.h.kyoto-u.ac.jp/~thermoshot/index_e.htm

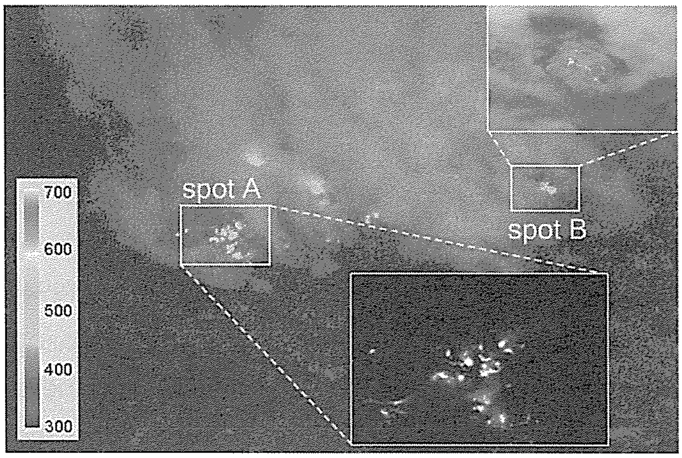


Figure The thermal image of the crater bottom at the first crater in Naka-dake at Aso volcano. Two near-infrared images of two spots are also shown.

Resistivity structure of Unzen Volcano derived from Time Domain Electromagnetic (TDEM) survey

Wahyu Srigutomo, Tsuneomi Kagiyama, **Wataru Kanda (DPRI, Kyoto)**
Hiroshi Munekane (Gepgrphy Survey Inst), Takeshi Hashimoto (Hokkaido)
Yoshikazu Tanaka, **Hisashi Utada (ERI, Tokyo),** ***Mitsuru Utsugi***

Time-domain electromagnetic (TDEM) surveys were carried out around Unzen Volcano, Shimabara Peninsula, South-west Japan in 2001 and 2002 in the eastern part of the peninsula. The surveys were the completion of the previously interpreted TDEM data collected from 1995 surveys conducted in the western part of the peninsula (Fig. 1).

The most prominent results from both TDEM measurements in the western and eastern part of Unzen is the existence of the conductive layer beneath a resistive surface layer in most of the sites. The resistivity structure roughly can be estimated by a 3 layer model: i.e., a resistive or moderately resistive surface layer (several tens to several hundreds Ω.m) followed by a low resistive layer (< 10 Ω.m) and third resistive layer. The conductive layer is located at about depths of 300 m to 3 km below the surface. They are equivalent to depths of sea level to 2.5 km below sea level depending on the altitude of each site. At several sites to the west of Fugen-dake and in the eastern part of Unzen the minimum resistivity values attain 1Ω.m.

Around the northeastern part of the peninsula, which is near from the coast, the low resistive layer appears almost at the same as the sea level. On the other hand, this layer appears at deeper depth along the western part of Chijiwa Fault, and at shallower depth along some other normal faults within the western part of Unzen Graben. At several sites to the west of Fugen-dake and in the eastern part of Unzen the minimum resistivity values attain 1Ω.m. (Fig. 2). The low resistive shallow layer is interpreted to be a complex of water saturated and altered layers, which spreads widely beneath Shimabara Peninsula.

Distribution of spatial conductance, derived from the resistivity structure to recognize the anomalous region indicated that a high conductance zone trending W-E from around Tachibana Bay to the summit area with values from 450 to 700 S. This high conductance region corresponds to the distribution of earthquake hypocenters around the shore of Tachibana Bay toward an area west from the summit as inferred by Umakoshi et al. (1994) indicated by a dashed line in Fig.3. The earthquake occurrences before the eruption probably were seated in many fracture zones in the western part of the peninsula, and these fracture zones became the pathways of volcanic gases to escape and dissolve into the water-saturated layer. The elongated high conductance zone which is related to a high ionic concentration might be attributed to the continuous supply of magmatic volatiles that initiated long before the eruption. Another high conductance zone occupies the northeastern part of the investigated area, near from Mayu-Yama with conductance value higher than 1000 S. This zone is correlated with the high spatial distribution of volcanic gases as inferred from geochemical studies (Notsu et al., 2001; Ohsawa et al., 2002; Takahashi et al., 2004) that traced the escape of volcanic gas from a deeper magmatic source, and might indicate the presence of magmatic source beneath Mayu-yama.

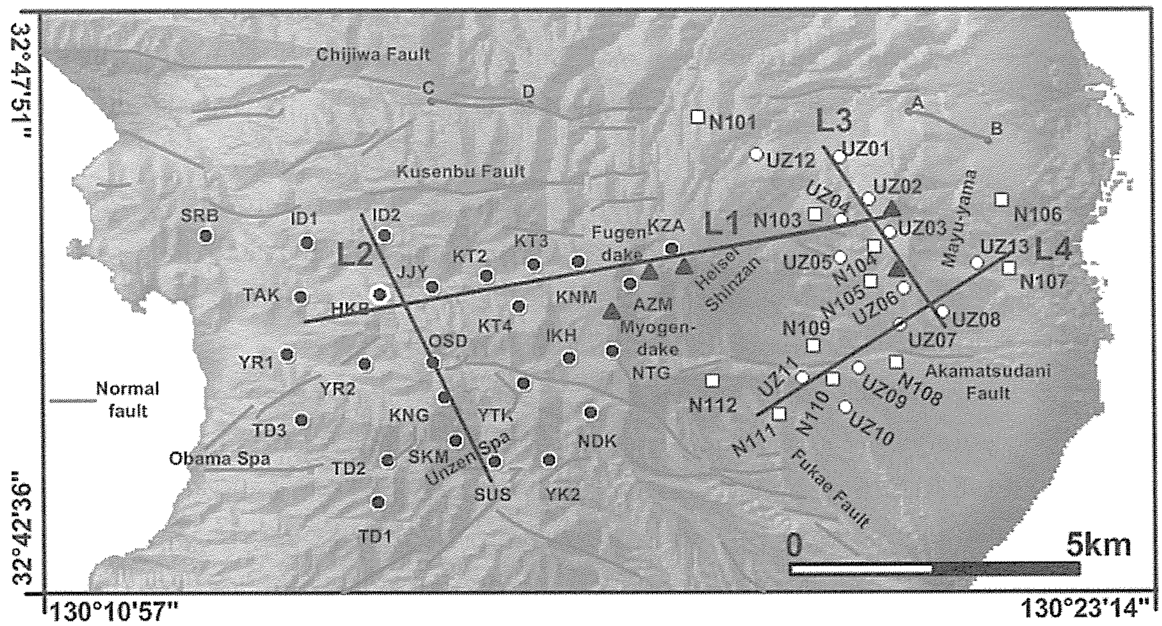


Fig.1 .Locations of TDEM sounding receivers. UZ01 – UZ13 denote location of 2001 TDEM survey; N101 – N112 denote 2002 survey. AB is the current transmitter used in both surveys. The solid circles in the western part of Unzen and CD denote TDEM sounding locations and the current transmitter of the 1995 surveys (Kanda, 1997) respectively.

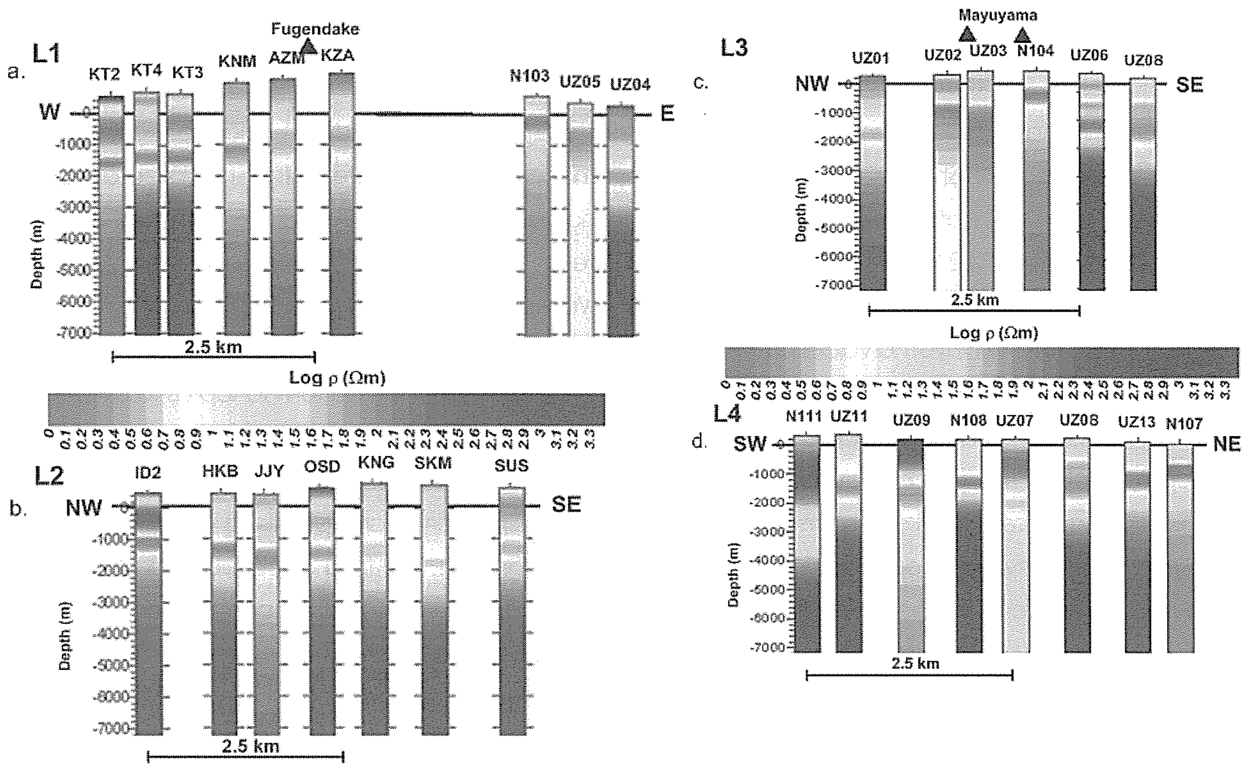


Fig. 2. (a), (b), (c), and (d) are resistivity sections along L1, L2, L3, and L4 lines respectively as shown in Fig. 1

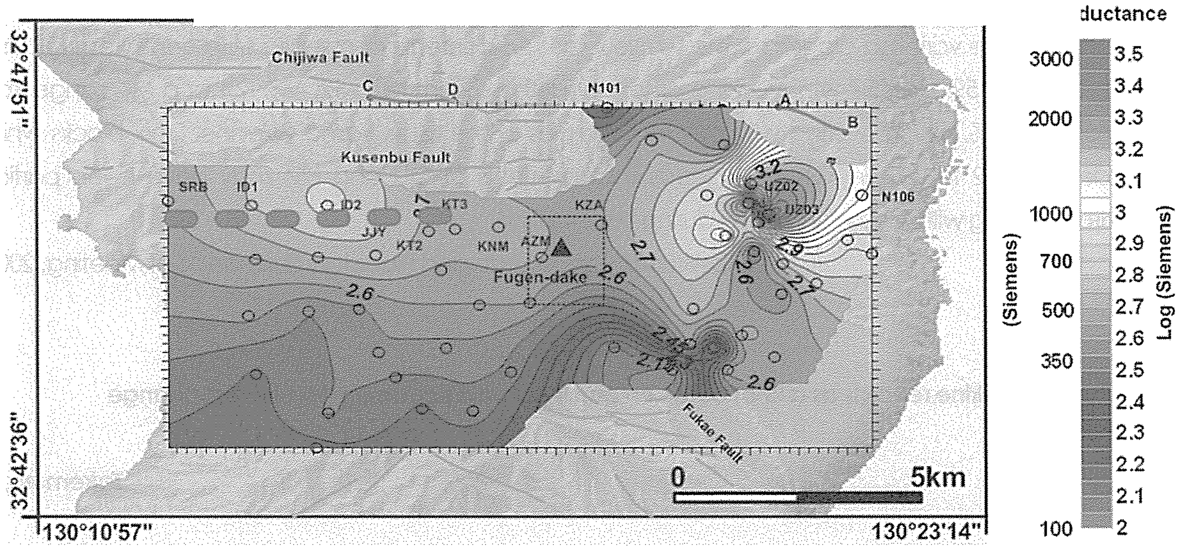


Fig. 3. Distribution of conductance in Shimabara Peninsula from the TDEM data. Dashed line indicates the distribution of hypocenters from 1989-1991 (Umakoshi et al., 1994).

Lithofacies and bulk rock chemistry of borehole cores from Mayuyama, Unzen volcano, Japan

***Takeshi Sugimoto*, Hideo Hoshizumi (GSJ), Hiroshi Shimizu (Kyusyu Univ)**

The Mayuyama volcano is located at the easternmost part of the Unzen volcano. It comprises two lava domes of the Shichimenzan and the Tenguyama. A fission track date for the Shichimenzan lava is 5.1 ka and a 14C date for the Mutsugi pyroclastic flow that derived from the northern part of the Mayuyama dome is 4.2 ka BP. The borehole cores have been obtained from the northeastern flank of the Mayuyama volcano (75.0 - 119.8 m in depth). We have made a detailed growth history and stratigraphy of the Mayuyama volcano by lithofacies and bulk rock chemistry analysis of cores.

The borehole cores are subdivided into four geologic units from bottom to top as follows. First unit is dacitic lava flows of the Older Unzen volcano (OU). The second unit is products of pre-Mayuyama volcanic rocks (PM), which may correlate with Older Unzen volcano, Nodake, Myokendake and Fugendake collapse. Small and sparse biotite with pyroxene phenocrysts are specific to the rocks of PM. PM contains many glassy dark blocks as essential dacitic fragments. The third unit is subdivided to four subunits. They are correspondent to the growth of the Mayuyama volcano, composed of three pyroclastic flows (M1-M3) and related lahar deposits (M4). Large biotite phenocrysts are specific to the essential fragments of M1-M4. M1 is monomictic and contains vesicular blocks and their ash. M2, M3 and M4 contain dark blocks which originated in OU and PM. Soil appear at the top of M4. The fourth unit is correspondent to the erosion of the Shichimenzan dome characterized by many lahar deposits (MC). Large biotite phenocrysts are specific to the rocks of MC. MC contains few dark blocks.

Rock samples were collected from whole geologic units. They chemically show a broad cluster in Harker's variation diagrams. The whole rock SiO_2 contents of essential fragments from OU and PM range from 59.8 to 65.7 wt.%. On the other hand, those from M1, M2, M3, M4 and MC range from 65.1 to 66.5 wt.%, which overlap with outcrop samples of the Mayuyama volcano. Dark blocks which included from 2 to 30% in M1-M4 suggests that products of OU and PM may have been partially withdrawn along with Mayuyama lava during the eruption.

(Abstract of Japan Earth and Planetary Science Joint Meeting, 2005)

Japanese lacustrine records as a knot between continent and ocean environmental change

Takemura, K.

Located on the convergent margin of the Eurasian plate, Japanese Archipelago has long suffered from tectonic deformation during the Quaternary. Lakes in Japan between Pacific Ocean and Asian continent have the important record on environmental history in East Asia. For example, Lake Biwa and Lake Suigetsu were formed as tectonic depressions, where lacustrine sediments have been continuously deposited at least since the Middle Pleistocene.

Lake Biwa is the largest and oldest fresh-water lake in Japan, where deep drillings for paleolimnological studies were carried out in 1970's and 1980's. These studies revealed that the Lake Biwa basin bears a sedimentary sequence of about 900 m thickness, which were deposited in lacustrine or fluvial environments during the Quaternary. The uppermost unit is a continuous sequence of lacustrine clay of 250 m thick intercalating more than 50 layers of volcanic ashes. The tephrochronological and paleoclimatological data suggest that the 250 m clay unit has been deposited from the last 430 kyrs and is correlated to major glacial-interglacial cycles (e.g., Takemura, 1990; Meyers et al., 1993).

Lake Suigetsu is a part of Mikata Five Lakes, located near the coast of the Japan Sea to the north of Lake Biwa. Sediments of Lake Suigetsu are characterized by dark-colored clay with white layers due to the diatom blooming in spring, constituting thin, sub-millimeter scale laminations. The sequence of annually laminated sediments provides a unique continuous age control to the paleoenvironmental record, probably since the last interglacial period (Fukusawa, 1995, Kitagawa and van der Plicht, 1998, Nakagawa et al., 2004).

To recover and to investigate complete set of lacustrine sequences, which cover at least the Holocene and the last interglacial period, from Lake Biwa and Suigetsu is useful for understanding the environmental change at eastern rim of Asian continent. The composite records will provide a database and conceptual framework for understanding paleoenvironmental history of Asian summer and winter monsoon and tectonic development of island arcs.

(COE KAGI 21 Interanational Meeting at Wuhan, 2005)

Lake Biwa sediments in Japan: Correlation with deep drilling cores and reconstruction of paleoenvironment during Quaternary

Takemura, K. **, Hayashida, A. (Doshisya Univ), Inoue, N. (Kyoto Univ)**
Danhara, T. (Kyoto Fission Track), Masuda, F. (Doshisya Univ)

Lake Biwa is the largest freshwater lake in Japan, measuring 22.6 km side by 68 km long and having a maximum depth of 104 m. The lake has a long history from the early Pliocene based on the geological survey and paleogeographical study of lake sediments around Lake Biwa (Kobiwako Group). The sediments revealed the paleoenvironmental change and tectonic events at the convergent margin of the Eurasian plate since early Pliocene times.
Deep drillings were carried out 1970's and 1980's in and around present Lake Biwa. These studies showed that the present Lake Biwa Basin bears a sedimentary sequence of about 900 m thickness, which were deposited in lacustrine or fluvial environments. Recently obtained fission-track age of tephra layer at deeper part in the present lake shows the continuous sedimentation of whole lake basion during Quaternary. After correlation of three deep core samples in lake basin and on land by tephrochronological method, we can figure out the paleotopography of the initiation of present Lake Biwa basin. Correlation of sequence in lake basin with that on land by precise tephrochronology and sedimentaray sequence shows the sedimentary reply at lake basin and shore to major glacial – interglacial cycles.

(American Geophysical Union, Fall Meeting, 2005)

Subsurface geology of Kansai International Airport, central Japan

***Takemura, K.,* Nakaseko, K. (Inst Eng Geol Res)**

The subsurface sediments of Kansai International Airport (KIX) is composed mainly of Pliocene – Pleistocene sediments called Osaka Group. The Osaka Group is characterized by alternating sequences of marine and nonmarine strata. The stratigraphy at KIX established by micropaleontological, tephrochronological and magnetostratigraphical method and correlated with the standard stratigraphy of Osaka Group using marine clay and volcanic ash layers. The sedimentary sequence at KIX is divided into two main units (Kukojima and Sennanoki Formations in ascending order) with the uncomformable relation. Although thick marine clay units are main components of the subsurface sequence, characteristics of coarser sediment units have an important role of moving of water during construction of the reclaimed land. Coarser units (S1 – S10) of the Kukojima Formation, which is the uppermost unit of the subsurface sequence, are characterized from the viewpoint of evaluation of coarser sand units on the basis of sedimentary environmental analysis and characteristics of distribution of coarser sand units. Especially, S1 and S10 units have the characteristics of more permeable rather than other coarser units.

(Proc. of International Symposium on Geotechnical Aspects of Kansai International Airport)

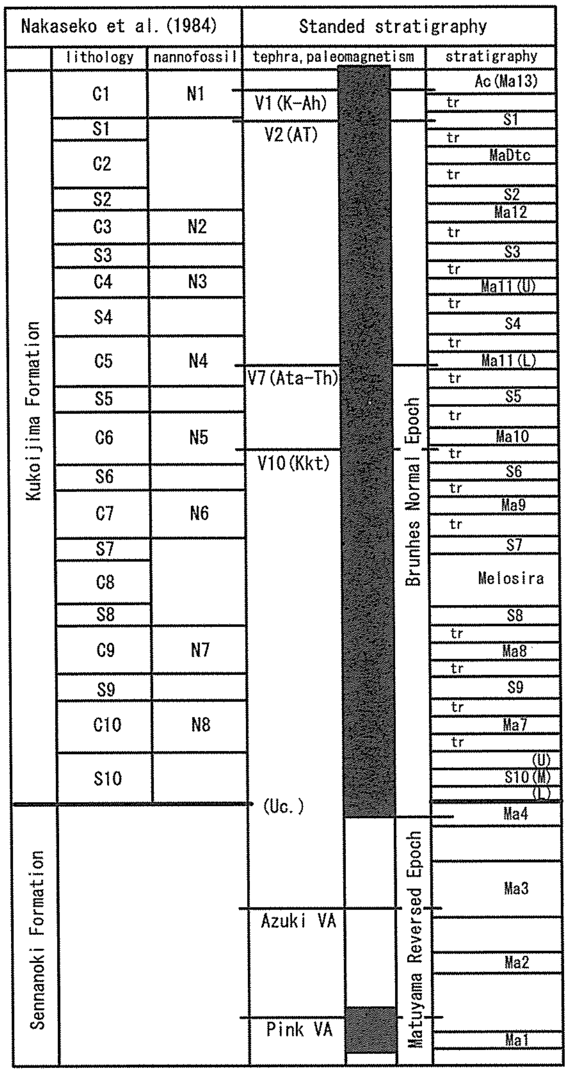


Figure 1. Subsurface stratigraphy around Kansai International Airport. C and S in the left column are the fine-grained sediment unit composed of clay and silt, and sandy units, respectively. N1-N8 indicates the horizons where nannofossils are found. 'Ma Dtc' and 'tr' refer to shallow marine environments without nannofossils and the transitional facies between massive deep marine clay and fluvial sediment, respectively. Massive marine clays in the Kukojima Formation were deposited within deep marine bay environments. (Itoh et al., 2001).

The Petrology and Geochemistry of Oto-Zan Composite Lava Flow on Shodo-Shima Island, SW Japan: Remelting of a Solidified High-Mg Andesite Magma

Tatsumi, Y., Suzuki, T., Kawabata, H., Sato, K., Miyazaki, T.., Chang, Q., Takahashi, T. Tani, K. (JAMSTEC), ***Shibata, T., Yoshikawa, M.***

The Oto-Zan lava in the Setouchi volcanic belt is composed of phenocryst-poor, sparsely plagioclase-phyric andesites (sanukitoids) and forms a composite lava flow. The phenocryst assemblages and element abundances change but Sr–Nd–Pb isotopic compositions are constant throughout the lava flow. The sanukitoid at the base is a high-Mg andesite (HMA) and contains Mg- and Ni-rich olivine and Cr-rich chromite, suggesting the emplacement of a mantle-derived hydrous (~7 wt % H_2O) HMA magma. However, Oto-Zan sanukitoids contain little H_2O and are phenocryst-poor. The liquid lines of descent obtained for an Oto-Zan HMA at 0.3 GPa in the presence of 0.7–2.1 wt % H_2O suggest that mixing of an HMA magma with a differentiated felsic melt can reasonably explain the petrographical and chemical characteristics of Oto-Zan sanukitoids. We propose a model whereby a hydrous HMA magma crystallizes extensively within the crust,resulting in the formation of an HMA pluton and causing liberationof H_2O from the magma system. The HMA pluton, in which interstitial rhyolitic melts still remain, is then heated from the base by intrusion of a high-T basalt magma, forming an H_2O-deficient HMA magma at the base of the pluton. During ascent, this secondary HMA magma entrains the overlying interstitial rhyolitic melt, resulting in variable self-mixing and formation of a zoned magma reservoir, comprising more felsic magmas upwards. More effective upwelling of more mafic, and hence less viscous, magmas through a propagated vent finally results in the emplacement of the composite lava flow.
(Journal of Petrology, 47, 595-629, 2006)

The petrology and geochemistry of volcanic rocks on Jeju Island; plume magmatism along the Asian continental margin

Tatsumi, Y., Shukuno, H. (JAMSTEC), ***Yoshikawa, M.,*** **Chang, Q., Sato, K. (JAMSTEC) Lee, M.W. (Kangwon National University)**

The incompatible element signatures of volcanic rocks forming Jeju Island, located at the eastern margin of the Asian continent, are identical to those of typical intraplate magmas. The source of these volcanic rocks may be a mantle plume, located immediately behind the SW Japan arc. Jeju plume magmas can be divided into three series, based on major and trace element abundances: high-alumina alkalic, low-alumina alkalic, and sub-alkalic. Mass-balance calculations indicate that the compositional variations within each magma series are largely governed by fractional crystallization of three chemically distinct parental magmas. The compositions of primary magmas for these series, using inferred residual mantle olivine compositions, suggest that the low-alumina alkalic and sub-alkalic magmas are generated at the deepest and shallowest depths by lowest and highest degrees of melting, respectively. These estimates, together with systematic differences in trace element and isotopic

compositions, indicate that the upper mantle beneath Jeju Island is characterized by an increased degree of metasomatism and a change in major metasomatic hydrous minerals from amphibole to phlogopite with decreasing depth. The original plume material, having rather depleted geochemical characteristics, entrained shallower metasomatized uppermost mantle material, and segregated least-enriched low-alumina alkalic, moderately enriched high-alumina alkalic, and highly enriched sub-alkalic magmas, with decreasing depth.
(Journal of Petrology. 46, 523-553, 2005).

3-D magnetic imaging using 2-D Fourier transform.

M. Utsugi

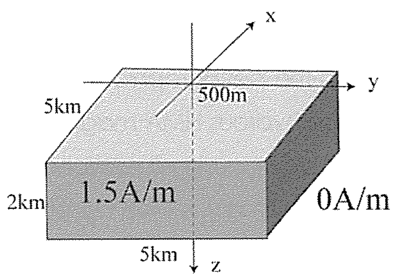


Fig. 1 Model geometry. We assume that a subsurface region (5x5x2km) is only magnetized (1.5A/m) and outside of it is demagnetized.

In the study of aeromagnetic field observation, it has a very important meaning to estimate the three dimensional subsurface structure. In usually, to estimate the magnetic structure using aeromagnetic data, 2 dimensional analyses are widely performed. But, in the volcanic region, aeromagnetic observation is performed for the purpose of detecting anomaly of subsurface magnetization distribution associated with underground heat distribution. For this purpose, we cannot obtain enough information to discuss about the subsurface heat distribution from 2D analysis because of the calculated structure obtained by 2D analyses includes not only structure of shallower area but also magnetization distribution of a depth direction. So, to break off this problem, we have to perform 3D structure analysis.

In the case of the 3D magnetic structure analysis, stability of a solution obtained by inversion is lost by the number of unknown parameters becoming enormous. To improve this point, we tried to formulate the equation of magnetic field in a cycle domain using 2D Fourier transform. In generally, the equation of magnetic structure analysis is expressed by convolution integral of subsurface magnetization distribution and the magnetic field created by a magnetic dipole in an underground arbitrary point. Using the formula of a Fourier transform of convolution integral, most of summation that appear in the field equation are gathered up and the dimensions of equation is largely decrease. Thus, stability of a solution of inversion improves drastically. We show the result that performed inversion which was based on the algorithm using 2D Fourier transform. We assume a very simple magnetic structure as shown in Fig. 1. We used the magnetic anomaly produced by this model as an input data, and calculated the subsurface structure by inversion. The result is shown in Fig. 2. From this result, we can see that, the resulting magnetization distribution accords with a model of Fig. 1 very well. We can obtain this result very rapidly and with high accuracy.

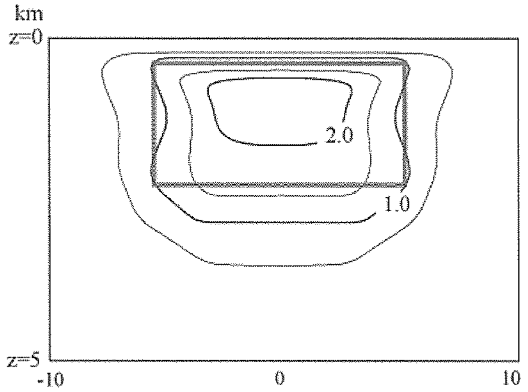


Fig. 2 Susceptibility derived from inversion of synthetic model data shown in Fig. 1(Cross section along the line x=0).

The thermal structure of lithospheric mantle beneath Japan Trench oceanward slope

***Yamamoto J.*, Hirano N. (TiTech) *Goto S.*, Kagi H. (Lab Earthq Chem, Tokyo)**

Pillow alkali-basalt outcrops were sampled at depth of 7324 to 7360 m on the oceanward slope of the northern Japan Trench during JAMSTEC (Japan Marine Science and Technology Center) R/V Kairei/ROV KAIKO cruise KR97-11, Kr03-07, KR04-08 and YK05-06. The Ar-Ar age of the alkali-basalt is 5.95 +/- 0.31 Ma and is reported as a new form of intra-plate volcanism where decompression and magmatic activity occurs off the fore bulge of the downgoing Pacific slab (Hirano et al., 2001; 2004). Several mantle xenoliths and xenocrystic olivine were observed in the basalts. Assuming P-T conditions of the xenoliths, the geothermal gradient of the downgoing Pacific slab is estimated. The thermal structure of the subducted slab is absolutely essential to elucidate a lot of geological phenomena occurring at the mantle wedge such as dehydration, magma generation and deep-focus earthquakes.

Both xenoliths and xenocrysts include abundant liquid CO_2 inclusions. For mantle-derived rocks, residual pressure in the fluid inclusions has often been used to estimate the depth where the xenolith was entrained by host magma. If the density of CO_2 in the fluid inclusions is determined, the P-T condition where the fluid inclusions were equilibrated with the host minerals can be determined using the equation of state for CO_2 and a temperature estimated from a geothermometer. Micro-Raman spectroscopic analysis allows us to estimate density of a very small amount of CO_2 by non-destructive analysis (Yamamoto et al., 2002; 2005; Kawakami et al., 2003). The density of CO_2 is estimated to be 1.2 g/cm^3. The equilibration temperature estimated from the two-pyroxene geothermometer is around 1130˚C. Extraporation of the density of 1.2 g/cm^3 to higher temperature indicates that the internal pressure of inclusions corresponds to about 1.3 GPa at 1130˚C. Such a pressure corresponds to 44 km or more in depth. The xenoliths are derived from the lowermost part of the downgoing Pacific lithosphere. The geothermal gradient determined from the P-T conditions of the xenoliths is clearly high (see figure) and is not consistent with some models for thermal evolution of oceanic lithosphere (e.g., GDH-1 or CHABLIS). The anomalously high thermal gradient may have an effect on thermal structure of the mantle wedge.

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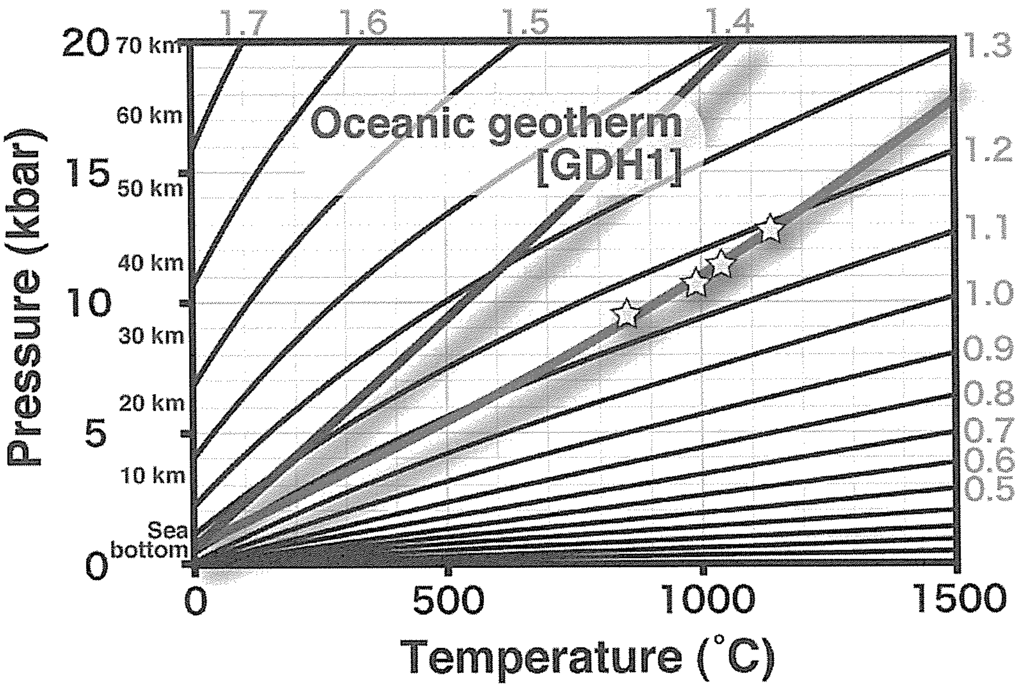


Rb-Sr and Sm-Nd isotopic systematics of the Kurose mantle xenoliths from the southwest Japan arc

Masako Yoshikawa, Shoji Arai (Kanazawa University)

Cenozoic volcanism of the southwest Japan arc has following characteristics, (1) extensive alkaline volcanism which is consisted with monogenetic volcanic groups, (2) voluminous andesitic volcanism restricted to the back arc side and (3) no observation of the Wadati-Benioff zones of the Pacif and Phillippin Sea plates (Takamura, 1973; Sugiura and Ueda, 1973, Yoshii, 1973, Iwamori, 1991, 1992). From these geological and geophysical characteristics, many petrological and geochemical studies have been accumulated to understand the magma generation process. As the results, it has been suggested that the Cenozoic alkaline magmas in the SW Japan have been derived from mantle plume, of which the chemical composition was affected by fluid with volatile and incompatible elements (Nakamura et al., 1986; Iwamori, 1991, 1992). Recently, however, Tatsumi et al. (2005) inferred that the mantle plume of the SW Japan arc had rather depleted isotopic signature on the bases of the comprehensive data set including mineral compositions, major and trace element compositions and Sr-Nd-Pb isotopic ratios of volcanic rocks from the Cheju Island. Thus, it has been controversial issue that the chemical and isotopic structure of upper mantle beneath the SW Japan arc and origin of the enriched component. These alkaline basalts frequently contain mantle xenoliths (e.g. Takamura, 1973; Aoki, 1987). Petrological, petrographical and isotopic researches of these mantle xenoliths suggested that the upper mantle beneath the SW Japan arc were heterogeneous (e.g. Kaneoka et al., 1978; Arai and Kobayashi, 1981). Recently, Arai et al.(2000) indicated that these mantle xenoliths could be divided into two types, unmetasomatized (Kurose) type and metasomatized (Aratoyama) type. It was inferred that the latter type is metasomatized by alkali basaltic melts which was concerned with asthenospheric upwelling in the Miocene time (Arai et al., 2000). Therefore, it is suitable to obtain the geochemical and isotopic information of upper mantle beneath the SW Japan before opening of the Japan Sea.

Geochemical and isotopic compositions of the mantle xenoliths under the Japan arc including the Kurose mantle xenoliths were investigated by several scientists (Kaneoka et al., 1978; Kagami et al.,1993; Abe et al. 1998; Nishio et al 2004., Abe and Yamamoto, 1999). Kagami et al. (1993) observed regional variation in Sr and Nd isotopic compositions of them and similarity of isotopic compositions of the Cretaceous felsic igneous rocks. Abe et al. (1998) obtained the trace element compositions of clinopyroxenes in mantle xenoliths from the NE and the SWJapan arcs. They inferred that these xenoliths suffered various degree of metasomatism originated from island arc magma or magma derived from plume which is responsible for opening of the Japan Sea. On the basis of an extremely low δ7Li value from mantle xenoliths in the SW Japan, Nishio et al. (2004) proposed that metasomatic agent was derived from subducted highly altered basalt. Abe and Yamamoto (1999) determined Rb-Sr isotopic systematics of whole rocks and their constituent minerals of the Kurose mantle xenoliths. They inferred that the metasomatism or partial melting with metasomatism was occurred around 1, 3 and 5 Ga ago. From these researches, it was presumed that Kurose xenoliths recorded several metasomatic events. However, origin of each metasomatic agent is unclear because of insufficient isotopic information. Thus, we determined the Rb-Sr and Sm-Nd isotopic systematics of separated minerals from the Kurose mantle xenoliths to understand origin of the metasomatic agent, and isotopic and chemical evolution of upper mantle beneath the SW Japan arc.

(Abstract of Japan Earth and Planetary Science Joint Metting, 2005)

Rb-Sr and Sm-Nd isotopic systematics of the Hayachine-Miyamori ophiolitic complex: Melt generation process in the mantle wedge beneath an Ordovician island arc

***Masako Yoshikawa*, Kazuhito Ozawa (University of Tokyo)**

The Hayachine-Miyamori (HM) ophiolitic complex in the Kitakami Mountains, Northeastern Japan consists of ultramafic tectonite and cumulate members. The most fertile lherzolites have mineral and trace element compositions similar to those of abyssal peridotites. They show 350-430 Ma Nd depleted mantle model ages, which are within the range of the K-Ar emplacement ages obtained from intrusive gabbroic rocks, suggesting a partial melting event just before the emplacement. The measured

$^{143}Nd/^{144}Nd$ ratio of clinopyroxene in the tectonite peridotites shows positive correlation with $^{147}Sm/^{144}Nd$ and decreases with increasing refractoriness, which cannot be explained by a simple melting and melt extraction to a various extent followed by radiogenic ingrowth. It clearly suggests influx of a melt/fluid enriched in highly incompatible trace elements during melting. Time corrected isotopic compositions of the HM complex exhibit a clear island arc signature with uniform initial isotopic ratio ($^{87}Sr/^{86}Sr$ =0.7035-0.7041, $_{Nd}$ =+7.8-+5.0). Application of an open-system melting model to the observed trace element abundances in clinopyroxene suggests influx of three distinct agents to the HM mantle with the following characteristics: 1) moderate enrichment in highly incompatible elements with negative anomalies of Sr and Zr, 2) extensive enrichment of highly incompatible elements with positive Sr and negative Zr anomalies, and 3) extensive enrichment of highly incompatible elements with positive anomalies of Sr and Zr. These characteristics cover a variety of slab-derived components proposed in the literatures, suggesting the agents responsible for the open-system melting in the HM ophiolite might represent full spectrum of slab-derived components from back-arc to fore-arc regions of the Ordovician island arc system.

(Gondowana Research, in press)

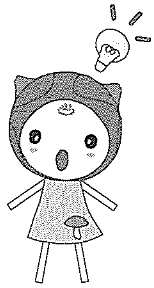
Nd-Sr isotopic compositions of the Hannuoba peridotite xenoliths beneath the North China craton: a preliminary study

***Masako Yoshikawa*, Xiachen Zhi (University of Science & Technology of China)**
Katsuhiko Suzuki (JAMSTEC)

In order to understand evolution of subcontinental lithospheric mantle beneath the north China, we determined the mantle-derived xenoliths in Cenozoic alkali basalts from Hannuoba. Our obtained 4 acid leached clinopyroxene separates display in the small range on $^{143}Nd/^{144}Nd$ - $^{87}Sr/^{86}Sr$ diagram ($^{143}Nd/^{144}Nd$=0.5130-0.5133, $^{87}Sr/^{86}Sr$ = 0.7026-0.7032). These data are within the previous reported variation (e.g. Song and Frey 1989; Tatsumoto et al., 1992; Rudnick et al, 2004). Song and Frey (1989) divided the six Hannuoba peridotite xenoliths into three types, that is depleted, PREMA and LoNd-like mantle types on the bases of isotopically distinct mantle components (Zindler and Hart, 1986). In our result, two samples (P12 and P17) are overlapped with PREMA type xenoliths and rest two samples (P15, P16) are plotted on the field for MORB between depleted and PREMA mantle types.

On the $^{147}Sm/^{144}Nd$-$^{143}Nd/^{144}Nd$ diagram, the former samples are on reference isochron of 1.9Ga which was interpreted to formation age of the lithospheric mantle beneath Hannuoba obtained from Re-Os systematics (Gao et al., 2002). The latter samples are consistent with reference ishochron of around 1.1 Ga. Song and Frey (1989) suggested that LREE enrichment of Lo-Nd like type xenoliths had occurred at 1.1 Ga ago on the bases of the Sm-Nd reference isochron through their samples. If our above inference is correct, Sm-Nd systematics of the clinopyroxene separates support removal of archean lithospheric keel under the eastern block of the North China craton and replacement by younger lithspheric mantle as suggested by Menzies et al.,(1993) and Griffin et al. (1998). On the bases of contents of heavy rare earth elements (HREE)(Xiachean, unpublished data), the xenoliths were divided into three groups. The samples P12 and P17 (which have relatively depleted isotopic signature) belong to $(HREE)_N$<10 group (the subscript N indicates a chondrite-normalized value). On the other hand, the

samples P15 and P16 are in $(HREE)_N>10$ group. It is possible that the samples with relatively high REE contents preserve the primary isotopic compositions. In this case, the reference isochron of 1.9Ga could represent a mixing line between ancient (around 1.9Ga) depleted mantle and enriched component.
(Abstract of IUGS-SECE, Beijing, China, June 25-30, 2005)



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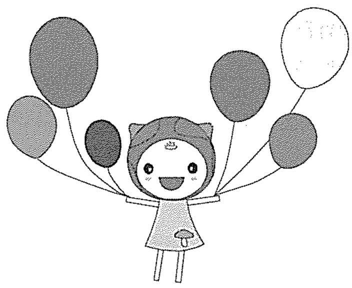

共同研究一覧　List of Collaborations

国内

後藤秀作、総合地球環境学研究所　研究プロジェクト2-4（研究課題：都市の地下環境に残る人間活動の影響，研究代表者：谷口真人（総合地球環境学研究所））．

鍵山恒臣、竹村恵二、大倉敬宏、大沢信二、柴田知之、西村光史、東京大学地震研究所特定共同研究（B）カルデラの構造と活動そして現在‐ Out of range への挑戦

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川本竜彦、東京大学地震研究所　一般共同研究研究員

川本竜彦、愛媛大学地球深部ダイナミクス研究センター　客員研究員

川本竜彦、岡山大学固体地球研究センター　共同利用研究員

大沢信二、河川及び河口域に及ぼす温泉排水の影響評価に関する環境化学的研究　参加機関、東邦大学理学部化学科

大沢信二、岡山県下の鍾乳洞の水文調査　参加機関、岡山理科大学理学部基礎理学科

斎藤武士、東京大学地震研究所特定共同研究B（研究課題名：活火山における噴火様式の時代的変遷と長期噴火予知の基礎的研究，研究分担課題：由布火山の鉄チタン酸化物の岩石磁気学的解析による溶岩ドームの噴火，崩壊機構の解明）

杉本健、中田節也、東京大学地震研究所，平成17年度一般共同研究（研究課題：雲仙火山の噴火史および火道の実体の解明）

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竹村恵二、「地域地盤研究部会　地質WG、土質WG」　関西地盤研究会　関西地盤情報の研究協議会

竹村恵二、京都大学防災研究所一般共同研究　代表、大塚　悟　（長岡科学技術大学）「地盤情報を活用した大規模斜面崩壊危険箇所の同定に関する研究

竹村恵二、国際日本文化研究センター　共同研究員

山本順司、地震研究所　一般共同研究，共同研究者：中井俊一助教授，研究題目：日本海溝近傍で発見された新たな深海底火山の噴火機構を探る

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国際

竹村恵二、「High resolution reconstruction of Holocene environmental changes from lagoonal sediments along the East Sea (the Japan Sea)」(Prof. Yu, Yonsei Universiry , Korea)

竹村恵二、ICDP Project Lake Biwa and Lake Suigetsu: Recorders of Global Paleoenvironments and Island arc Tectonics

研究費　Funding

科学研究費補助金

鍵山恒臣、　特定領域研究（2）可視映像解析による噴煙の時間変動と噴火発生場の構造に関する研究, 1,100 千円
川本竜彦、古川善紹、　基盤研究（C）沈み込み帯における水の構造と物性の変化 1,900　千円
大倉敬宏、　基盤研究（A）（1）火山流体のモニタリングと深部マグマ上昇メカニズムの解明（分担）　代表者　川勝均　4100千円
大倉敬宏、　萌芽研究　いくつかの地域で外帯低周波微動が起こらない理由　代表者　瀬野徹三　800 千円
竹村恵二、　基盤研究（C）企画調査　琵琶湖掘削計画：国際陸上科学掘削計画（ICDP）本プロポーザルの作成に向けて　代表　1,600 千円
竹村恵二、　基盤研究（A）　長大活断層のセグメント区分, 地下構造, 活動履歴の再検討と大地震予測の総合的研究 (分担)　（代表：岡田篤正）　課題名：13,700 千円
竹村恵二、　21 世紀 COE プログラム　（研究推進者）　代表　余田成男　活地球圏の変動解明—アジア，オセアニアから世界への発信—
田中良和、　特定領域研究、火山爆発の発生場と発生過程、47,200 千円
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山本順司、　基盤研究（A）（一般）大陸衝突帯の地下深部ダイナミクス—高温高圧下での流体活動とその役割の解明—（分担）（代表　平島崇男）
山本順司、　基盤研究（B）（企画調査）1 億 3 千万年前の白亜紀太平洋プレート上で活動する新しい海底火山の形成過程解明　（分担）（代表　阿部なつ江）
芳川雅子、　基盤研究（C）　微少量同位体分析による阿蘇火山マグマ供給系進化過程の解明（分担）研究代表者：金子克哉　H17 年度直接経費　1400 千円
吉川慎、　奨励研究「阿蘇火山の降雨による重力変化の検知」（代表）　660 千円

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川本竜彦、　日産科学振興財団　奨励研究（延長）　富士火山の下でのマグマと H_2O フルイドの間の超臨界現象 1,100　千円
大沢信二、　産業総合技術研究所深部地質環境研究センター研究費　2300 千円
柴田知之、　九電産業　熱水のストロンチウム同位体組成の測定」に対する研究助成　1,900 千円
田中良和、　産学官連携イノベーション創生経費、空中電磁、2,500 千円
芳川雅子、　九電産業株式会社環境部研究助成　598 千円

教育活動 Education

学位, 授業 Academics

学位審査

鍵山恒臣：　（審査員）山崎健一　（博士　京都大学理学研究科）
大倉敬宏：　（主査）　池田さや香（修士　京都大学理学研究科）
大沢信二：　（主査）　山田誠　　（博士　京都大学理学研究科）
竹村恵二：　（審査員）杉戸信彦　（博士　京都大学理学研究科）
　　　　　　（審査員）山田誠　　（博士　京都大学理学研究科）
　　　　　　（審査員）山崎新太郎（修士　京都大学理学研究科）
　　　　　　（審査員）山本佑介　（修士　京都大学理学研究科）
田中良和：　（審査員）山崎健一　（博士　京都大学理学研究科）
　　　　　　（審査員）山田誠　　（博士　京都大学理学研究科）
　　　　　　（審査員）井筒潤　　（博士　京都大学理学研究科）
　　　　　　（審査員）三宅尚徳　（修士　京都大学理学研究科）
　　　　　　（審査員）相馬桂　　（修士　京都大学理学研究科）
　　　　　　（審査員）油江宏明　（修士　京都大学理学研究科）

講義, ゼミナール

（学部）

ポケットゼミ：地球の熱を測ってみよう　Introductory Seminar on Observation in Volcanoes
　鍵山恒臣, 田中良和, 大倉敬宏
地球惑星科学I　竹本修三, 岡田篤正, 竹村恵二, 久家慶子
観測地球物理学演習A　田中良和, 鍵山恒臣, 須藤靖明, 大倉敬宏, 宇津木充, 里村雄彦, 藤森邦夫, 西憲敬, 古川善紹
観測地球物理学演習B　竹村恵二, 大沢信二, 堤浩之, 柴田知之, 川本竜彦, 山本順司
グローバルテクトニクス　田上高広, 古川善紹
地球熱学　竹村恵二, 鍵山恒臣, 大沢信二, 古川善紹
火山物理学I　古川善紹
火山物理学II　田中良和, 鍵山恒臣, 須藤靖明, 大倉敬宏, 石原和弘, 井口正人, 古川善紹
陸水物理学　大沢信二, 諏訪浩
課題演習DA　固体地球系　古川善紹ほか
課題演習D3：地下構造と活構造, 地表変動　岡田篤正, 竹村恵二, 堤浩之, 赤松純平, 福岡浩, 岩田知孝
課題演習D4：地球熱学　古川善紹, 柴田知之, 川本竜彦, 宇津木充, 山本順司
課題演習D6：気象学総合演習　余田成男, 石岡圭一, 内藤陽子, 大沢信二, 林泰一, 石川裕彦
課題演習D7：地球磁気圏の構造と波動現象　町田忍, 家森俊彦, 田中良和, 亀井豊永, 竹田雅彦, 齋藤昭則, 能勢正仁
課題研究T8：地表変動, 固体地球物理, 火山物理　岡田篤正, 竹村恵二, 須藤靖明, 堤浩之

（大学院，修士課程）

第四紀地質学　　竹村恵二

活地球変動，結合論 B　　増田富士雄，竹本修三，福田洋一，竹村恵二

水圏地球物理学 IIA　　大沢信二，Sidle，Roy C.，諏訪浩

水圏地球物理学 IIB　　大沢信二，Sidle，Roy C.，諏訪浩

地球熱学，地熱流体学 IA　　田中良和，大沢信二，鍵山恒臣

地球熱学，地熱流体学 IB　　田中良和，大沢信二，鍵山恒臣

地球熱学，地熱流体学 IIA　　竹村恵二，須藤靖明，古川善紹，大倉敬宏

地球熱学，地熱流体学 IIB　　竹村恵二，須藤靖明，古川善紹，大倉敬宏

応用地球電磁気学 A　　大志万直人，田中良和，鍵山恒臣

応用地球電磁気学 B　　大志万直人，田中良和，鍵山恒臣

活地球固体圏 B　　平島崇男，小畑正明，中西一郎，大沢信二，古川善紹，竹村恵二

地球惑星科学特殊研究（修士論文）　　全教員

（大学院修士課程および博士後期課程）

地球物質科学セミナーI　　小畑正明，平島崇男，柴田知之，山本順司

地球生物圏史セミナー　　増田富士雄，前田晴良，竹村恵二，大野照文

固体地球物理学ゼミナール IV　　中西一郎，久家慶子，大倉敬宏

水圏地球物理学ゼミナール III　　大沢信二，Sidle，Roy C.，諏訪浩，斉藤隆志

活構造論ゼミナール I 岡田篤正，竹村恵二，堤浩之

活構造論ゼミナール II　　岡田篤正，竹村恵二，堤浩之

地球熱学，地熱流体学ゼミナール I　　田中良和，大沢信二，川本竜彦，柴田知之，山本順司

地球熱学，地熱流体学ゼミナール II　　竹村恵二，須藤靖明，古川善紹，大倉敬宏，鍵山恒臣

応用地球電磁気学ゼミナール　　大志万直人，田中良和，鍵山恒臣，神田径，吉村令慧

野外実習

観測地球物理学演習 A　　（別府、7 月 31 日～8 月 2 日）教員多数

観測地球物理学演習 B　　（阿蘇、8 月 3 日～5 日）教員多数

地質鉱物学野外実習　　（3 月 18 日～19 日）竹村恵二ほか

課題演習 D2 阿蘇実習　　（阿蘇、9 月 27 日～30 日）大倉敬宏ほか

課題演習 D3 別府実習　　（別府、8 月 3 日～5 日）竹村恵二

課題演習 D5 別府実習　　（別府、11 月 24 日～26 日）大沢信二

セミナー　Seminars

＜地熱セミナー＞　別府

2005 年 4 月 13 日（水）竹村，山本，馬渡、火山灰，ローム層セクションを用いた中部九州東部における後期更新世火山活動史と環境変遷

大沢，山本，西村，網田，山田、プレート脱水流体と CO_2 に関する研究

柴田，芳川，西村，竹村、九州地域での火成岩の化学的特徴の時空変化

山本，竹村、鬼の箕玄武岩の物質源の解明

大倉，馬渡，古川，竹村、地震観測ネットワークの構築

宇津木，網田，大沢、ネットワーク MT データを用いた九州地方の地殻比抵抗構造の解明

ライ, 柴田, 山本, 芳川、微量元素, 同位体組成分析の技術開発

Ｄｕ, 竹村, 柴田, 芳川、中国大陸の超高圧変成岩の地球化学的研究

4月27日（水）山本、沈み込むリソスフェリックマントルの地球化学的特徴を探る

5月11日（水）柴田、姫島火山群第四紀島弧マグマの起源

5月18日　芳川、西南日本弧黒瀬マントル捕獲岩のSr, Nd同位体組成

6月8日（水）齋藤、マグネティックペトロロジー、火山学への適用

6月22日（水）杉本、伊豆鳥島火山のマグマシステムの進化

7月13日（水）網田、別府温泉における空気イオン測定

7月20日（水）大沢、火口湖水のカラーモニタリングによる火山活動の診断

9月13日（火）西村、マグマ溜まりにおける同化分別結晶作用(AFC)の熱的, 流体力学的モデル

10月12日 (水)　Wahyu、 Indonesia volcanoes: Their scientific challenges and lessons from Unzen volvano integrated study.

10月19日　(水) 川本、沈み込み帯の水に溶け込むケイ酸塩の化学組成の圧力変化：　スラブの部分融解液と含水鉱物の脱水分解によるフルイドとの関係

11月2日　柴田、西南日本弧におけるスラブメルティングの西南端

11月30日　山本、マントルは地球化学的に何層あるのか？

12月14日（水）大沢、温泉地の河川と沿岸海洋の環境化学

12月21日（水）竹村、大分平野から別府にかけての活断層系　一府内断層, 朝見断層, 堀田断層一

2006年1月10日（火）網田、大分平野の深層熱水について

テレビ会議システムを利用したランチタイムセミナー

Steve Kirby 博士 (USGS, Menlo Park)　New observations relevant to the roles of intraplate volcanism and mantle CO2 in the physics of the double seismic zone of NE Japan　2005年4月11日(月)12:10-13:00　(ランチタイムセミナー)　場所：京都大学理学部4号館1階会議室

特別セミナー　別府

2005年8月11日　小畑正明 (京都大学理学研究科地球惑星科学教授)

造山帯かんらん岩の層構造に畳み込まれたマントル進化の歴史にどうせまるか」

10月3日　頼　勇　(京都大学理学研究科地球熱学研究施設外国人客員)

1. Rb-Sr, Sm-Nd システマティクス及び希ガス同位体の特徴から見る中国東部のマントル構造
2. 大別山超高圧エクロジャイトの希ガス同位体の挙動
3. 別府での一年の思い出

10月18日　谷内勇介　(熊本大学自然科学研究科　環境共生科学専攻 D3)

ヒューマイト族鉱物による高温沈み込みスラブでの深部マントルへの水の輸送

11月15日 Udo Fehn　(Univ. of Rochester)

Fluid flow in fore arc and main arc situations: Results from I-129 and halogen studies

11月18日　石橋秀巳（九州大学研究員）

サブリキダスでのマグマの粘性率測定　～北西九州, 東松浦地域のアルカリ玄武岩の場合～

12月1日　氏家治　(富山大学教授)

北米大陸スペリオル区の始生代アダカイトの地球化学的特徴

両白山地におけるアダカイト質溶岩について（予報）

12月15日　井上和久（京都大学大学院人間, 環境学研究科　M2)

阿蘇火山における大規模噴火をもたらしたマグマ溜まりの形成プロセス

2006年1月19日　清水洋平（金沢大学理学部地球学教室研究員）

Geochemical signature of the quartz diorite veins in mantle peridotite xenolith from Tallante, southeast Spain: Laser-ablation ICP-MS analysis（南東スペイン、タヤンテ地域からのかんらん岩捕獲岩における石英閃緑岩質脈の地球化学的特徴）

2月22日　午後1時半　川本　スラブ由来の流体相

午後2時 駒林（東京工業大学PD）　マントル含水鉱物の熱力学

午後4時 谷内（熊本大学D3）　コンドロダイト、クライノヒューマイトの熱力学と相関係から見た流体中の水の活動度の見積り

2月23日　午前：別府セミナー室

午前10時半　駒林（東京工業大学PD）　マントルでの脱水分解反応

2月23日　午後：ニューライフプラザ2階第一セミナー室

午後2時 安東（広島大学助手）　オリビンの相転移メカニズムに与える水の影響

午後3時 井上（愛媛大学助教授）マントル含水鉱物の将来

午後4時 終了

3月29日-31日　兼岡一郎　（元東京大学地震研究所教授）カネオカワールド in べっぷ

その他

大沢信二, 網田和宏, 山田誠, 杜建国, 山本順司、宮崎平野の温泉の起源水について：粘土鉱物からの脱水流体. 21世紀COE「活地球圏の変動解明」J2(b)班「プレート収斂域における水, 熱フロー」研究集会（別府）2006年2月23日

＜火山研究センターゼミ＞（テレビ会議システムを用い別府セミナー室で放送）

阿蘇　火山研究センター講義室

2005年　4月26日　九重火山に於ける空中磁気観測～繰り返し空中磁気観測の試み～宇津木

5月17日　後藤秀作、　孔内温度から復元した淡路島北部の過去500年の地表面温度変動

後藤秀作、　Contribution of diffuse fluid output to neutrally buoyant plume at the TAG hydrothermal mound, MAR

鍵山恒臣、　赤外映像で捉えた浅間火山2004年噴火における噴煙の時間変動

6月28日　山田　誠、火山地下水システムにおけるマグマ起源CO_2混入過程に関する同位体水文学的研究

9月26日　大倉敬宏、阿蘇火山における地殻変動

11月24日　中村卓司(京都大学生存圏研究所)、　ライダーによる火山噴煙観測

11月29日　須藤靖明、エトナ火山の地震

2006年2月6日　ワヒュー スリグトモ 、Resistivity structure of Unzen Volcano from Time Domain Electromagnetic (TDEM) data and its implication to magma-groundwater interaction

後藤秀作　地下温度に記録された地表面温度履歴の復元

3月7日　後藤秀作　地下温度に記録された地表面温度履歴の復元

そのほか

鍵山　火山学, 火山砂防工学集団研修講義(JICA), 火山熱学, 2005.5.

鍵山　地震, 火山こどもサマースクール, 霧島, 8.18-20, 2005.

田中　防災研究所研究担当、火山地域の地下構造に関する電磁気学的研究

田中　活地球圏セミナー、7月6日　「空中磁気測量による火山性磁場変化の検出

大沢信二, 山田誠, 風早康平, 安原正也、同位体で見る温泉, 湧水へのマグマ起源流体の寄与. カルデラ勉強会第2回（阿蘇）2006年3月14-15日

学会活動 Activities in Scientific Societies

田中良和

文部科学省研究振興局科学技術，学術審議会専門委員　平成17年2月1日—平成18年1月31日

火山噴火予知協議会委員

火山噴火予知研究委員会委員

地磁気観測小委員会委員　平成16年6月—平成18年9月30日

大沢信二

日本温泉科学会理事，広報，国際交流委員長

日本地熱学会編集委員

日本水文科学会評議員，奨励賞選考委員

竹村恵二

日本第四紀学会評議員

日本地質学会地方地質誌九州地方編集委員会委員

日本地質学会地方地質誌近畿地方編集委員会委員

川本竜彦

Geochemical Journal 誌　Associate Editor

大倉敬宏

火山学会大会委員

社会活動　Public Relations

鍵山恒臣

火山噴火予知連絡会委員

東京都三宅島活動検討委員会委員

宮崎県防災会議地震専門部会専門委員

霧島火山防災検討委員会および霧島火山災害予測図検討分科会，委員

火山噴火予知研究協議会，委員

火山噴火予知研究委員会，委員

JICA 研修「火山学，総合土砂災害対策コース」，カリキュラム委員および講師

一般セミナー　地震，火山こどもサマースクール，霧島，8.18-20, 2005.

川本竜彦

京都大学総合博物館レクチャーシリーズ no.47（ジュニアレクチャー）実験室でマグマと水を見よう、京都大学地域子ども教室推進事業実行委員会　2006年3月11日

大沢信二

大分県温泉調査研究会理事

大分県温泉監視調査委員会委員

別府市緑の基本計画策定委員

大分市廻栖野地区地下水調査検討委員

竹村恵二

独立行政法人産業技術総合研究所研究ユニット評価委員会委員

大阪府大規模地震ハザード評価部会

日本学術振興会科学研究費委員会専門委員

『三重県地域活断層調査委員会』委員

『大分県別府－挾間線橋脚安全検討委員会』委員

『京都府地域活断層調査委員会』委員

『大分県温泉監視調査委員会』委員

文部科学省　科学技術政策研究所　科学技術動向研究センター　専門調査員

『関西国際空港（二期地区）地盤挙動調査委員会』委員

『奈良，生駒高速鉄道トンネル技術委員会』委員

『石川県能登町真脇遺跡調査指導委員会』委員

大分地方気象台　職員研修　「大分の活断層と地震」。大分地方気象台

滋賀県琵琶湖サステイナブルミーテイング講演　「琵琶湖第四紀変動論」滋賀県厚生会館

日本文化財科学会講演会、縄文真脇遺跡を科学する。「よみがえった縄文時代の海岸線」　金沢文教会館

地球熱学研究施設（別府）施設公開　「夏休み地獄ハイキング」講師

「福岡県の活断層」、測量の日防災セミナー「福岡の大地を知る」講演、福岡サンパレス

一般公開報告　Openhouse

一般公開報告「別府」

京都大学大学院理学研究科附属地球熱学研究施設では，平成 17 年 7 月 27 日（水）午後 2 時〜午後 5 時半に別府市朝見川断層沿いを対象とした夏休み地獄ハイキングを行った．また，同日夜間（19 時〜22 時）に研究施設のライトアップを行い，一般市民とより親密に触れ合う場を設けた．翌日の 7 月 28 日（木）は午前 9 時〜午後 4 時まで研究施設の一般公開を行った．ハイキングには非常に暑いなか 55 名の市民に参加して戴き，ライトアップにも 32 名の来場者を数えた．一般公開には昨年度を大幅に上回る 193 名にお越し戴いた．更に，事前に連絡を受けていた明豊高校の学生と教員約 100 名を対象に別の日（8 月 25 日）に特別公開を行った．

一般公開，公開講義の運営は，昨年度までと同様に当研究施設で働く職員と学生の協力を得て行い，実施形態や準備，広報，片付け，反省会なども昨年度までの方法にほぼ従った．今年度の一般公開で新しく導入された点は，夏休みハイキングと広報活動の拡充である．

夏休みハイキング

施設建物一般公開の前日午後に，一般市民対象（小学生以上）のハイキングを行った．この企画は，前年度の一般公開事業において行った来訪者対象のアンケート調査結果にて，温泉や火山，地震に関する関心がかなり高いことが窺えたための措置である．そのため，ハイキングコースとして選んだのはそれらの事象が実地で体感できる朝見川断層に沿ったルートである．昨年度のアンケート結果を受け，温泉や火山，地震を肌で感じられる企画を設けることにした．温泉や火山，地震を全て網羅するにはやはりある程度移動しなければならないが，竹村教授によってそれらを短時間で見聞できる理想的なルートが策定された．

ハイキングルート

研究施設−杉の井地熱発電所−杉の井ホテルの石碑−キャッスル南西の温泉変質岩−ラクテンチ駐車場−乙原の滝−朝見浄水場−朝見神社

ハイキング内容

7 月 27 日（水）14 時，研究施設に集合し，受付を済ませた後，タクシーで杉の井地熱発電所へ向かった．案内者は 6 名（竹村教授，大沢助教授，網田博士，齋藤博士，杉本博士，山田氏）．参加者は 52 名．その他 2 つの新聞社と地元ケーブルテレビ局の記者及びカメラマンが同行した．タイトルは「夏休み地獄ハイキング」．参加者全員には，竹村教授監修のパンフレット（附録 2 参照）が配布され，ハイキング中は随時，竹村教授による解説が行われた．杉の井地熱発電所では，発電所所員による発電所についての説明を受けたほか，朝見神社では宮司から湧水についての説明を受けた．移動距離は約 7 k m，標高差は約 200mほどであったが，一部の参加者（小学生，低学年）は全行程を歩くのが困難であったため，数名が途中で帰宅したり，有事に備えて随行していた研究施設の公用車で移動した．ハイキング中は天候に恵まれ，事故もなく無事に朝見神社で解散することができた．

広報活動の拡充

昨年度までは別府市内の公共機関を通した広報活動を主に行ってきた．その努力はアンケート結果に表れているが，年々減少する参加者数を底上げするには広報活動の趣向を変えるのも一つの方途であろう．今回は，別府市の全市民の目に留まる宣伝と別府市外からの参加者増を目標に広報活動を展開した．

（1）今年度の一般公開で改善された点

平成 16 年度の研究施設一般公開報告書にて，以後の一般公開で改善されるべき点が列挙されている．今年度の一般公開では，それらの提案に沿って様々な対応を行った．

（提案）準備期間を多く設けるため，年度初めに初会合を行う．
（対応）5 月上旬に担当者を決め，6 月上旬に全体話合いを行った
（提案）一般公開担当者ではなく担当委員会のような複数の人員を擁するチームを結成し機動力を増す．
（対応）3 人の担当者で実行委員会を結成し，担当者の出張等で準備が滞ることがないよう配慮した
（提案）一般公開前に勉強会を行い，それぞれの出し物を相互に説明できるようにしては？
（対応）勉強会は行わなかったが担当部署をある程度固定し，その部署内で融通をつけあう体制を確立させた（昼食時が少し問題）
（提案）ライトアップへの参加者が少ない．別府市の祭りに組み込む等の工夫をするべき．
（対応）別府夏の宵祭の一環にしてもらい，夏の宵祭ホームページに一般公開の紹介を掲載してもらった
（提案）一般公開，公開講義を各一日ずつ行ったが，一日で公開講義，一般公開，ライトアップを行う事も可能であろう．時期や曜日とともに検討すべき事項であろう．
（対応）人員が減ったため一日で複数の催し物を行うのは難しかった
（提案）「研究施設一般公開，公開講義」という言葉は一般市民にとって解り難い．気楽に楽しめる催しである事が解るよう工夫するべき．
（対応）タイトルを決めた（別府で感じる地球の息吹）
（提案）広報手段として，今回から導入した A0 ポスターの効果が大きかった．来年度はもう少し多くの A0 ポスターを貼り出したらどうだろうか．
（対応）A0 ポスターの他に横断幕を用意し，一般公開当日には一般公開中である旨を記した看板を掲げた
（提案）最先端研究紹介コーナーは観衆にとって難解なものも多くあった．学会で使用したものであることや解説を充実させるべきであろう．
（対応）企画の一部を最先端研究コーナーに隣接させ，担当者が 2 名になるよう配慮した
（提案）当研究施設の研究以外の実態に関する質問を多く受けた．構成員数や職，京大本学との関係など，基本的な疑問に答える場を用意したらどうだろうか．
（対応）機関研究員の居室を廊下に面した窓から観覧できるようにするとともに，居室内にパソコンを設置し，一年間の主な行事を記録した写真をスライドショーで流した
（提案）一昨年度の報告書で提案された若年齢層の参加者増はかなえられなかった．教育委員会を通したポスター配布や明豊学園に向けて掲示したポスターも効果がなかった．中学，高校の理科教師への広報や出張講演等の努力が必要である．
（対応）理科教師への直接案内や科学教育啓蒙団体等に呼びかけた
（提案）アンケート結果によると，温泉や火山，地震に関する関心が高いことが窺える．今年度まで，一般公開，公開講義とも建物内で行ったが，人数を絞って屋外で巡検を行うことも検討するべきではなかろうか．
（対応）夏休みハイキングを行った

（提案）一般公開，公開講義開催を告知するホームページを見て来られた方もおられた．来年度も開催日を告知するページを早めに立ち上げるべきであろう．

（対応）担当者決定日にホームページを立ち上げ，企画が決まる毎に掲載した

（2）研究施設ライトアップの内容

昨年度から，市民と触れ合う機会を増やす事や大学資本の社会還元の一環としてライトアップを一般公開の一事業として実施している．日時はハイキング後の 19 時から 22 時まで．昨年度は宣伝不足のためか来場者は数名にとどまったが，今回はラジオやテレビで事前に宣伝した事や，別府夏の宵祭の一部に加えて戴いたため 27 名の来場者を数えた．研究施設建物内は翌日の一般公開の準備に追われていたため公開できなかったが，玄関から見える部分の説明や玄関に設置している展示ケースを用いた解説が竹村教授によって行われた．

（3）研究施設一般公開の内容

7 月 28 日（木）午前 9 時から午後 4 時まで研究施設の一般公開を行った．来場者は 193 名．7 時間の間，常に二十人ほどの市民が研究施設内を観覧する状態であったため終始緊張感が漂っていたが，比較的時間をかけて展示物の解説を行うことができたように思われる．

公開，または提供した題材：

一般公開用プロモーションムービー，別府の自然，ハザードマップ，石の輪廻転生，顕微鏡で見る石の世界，水飴で作るマントルプルーム，別府温泉の科学，地質年代表，1／130 万地球断面図，研究室公開！，最先端研究紹介コーナー，超臨界流体，浮かぶ大陸，赤熱現象，地震特集

アンケート集計結果（一般公開）：

1 どちらからいらっしゃいましたか？

	別府市内	大分県内別府市外	大分県外	回答なし	合計
回答数	58	60	11	10	139
百分率	41.7	43.2	7.9	7.2	100

2 年代を教えて下さい

	6歳未満	6-15歳	16-19歳	20-39歳	40-59歳	60-79歳	80歳以上	回答なし	合計
回答数	1	39	9	25	40	24	1	1	140
百分率	0.7	27.9	6.4	17.9	28.6	17.1	0.7	0.7	100

3 どのようにして今回の一般公開を知りましたか？

	ポスター	市報	新聞	テレビ	人に聞いて	ラジオ	看板	学校	ウェブ	その他	回答なし	合計
回答数	20	13	10	17	51	7	10	5	5	3	1	142
百分率	14.1	9.2	7.0	12.0	35.9	4.9	7.0	3.5	3.5	2.1	0.7	100

4 昨年以前の一般公開にお越しになられたことがありますか？

	はい	いいえ	回答なし	合計
回答数	13	124	2	139
百分率	9.4	89.2	1.4	100

5 今回の一般公開の全体的な感想をお聞かせ下さい

	非常に良かった	良かった	普通	良くない	非常に良くない	回答なし	合計
回答数	50	70	14	1	0	4	139
百分率	36.0	50.4	10.1	0.7	0.0	2.9	100

6 今回の一般公開の各イベントの感想をお聞かせ下さい

		良かった	普通	良くない	覚えていない	回答なし	合計
別府の自然	回答数	76	34	1	9	19	139
	百分率	54.7	24.5	0.7	6.5	13.7	100
顕微鏡	回答数	101	21	0	2	15	139
	百分率	72.7	15.1	0.0	1.4	10.8	100
ハザードマップ	回答数	65	34	1	11	28	139
	百分率	46.8	24.5	0.7	7.9	20.1	100
別府温泉の科学	回答数	74	38	0	4	23	139
	百分率	53.2	27.3	0.0	2.9	16.5	100
石の輪廻転生	回答数	71	37	1	5	25	139
	百分率	51.1	26.6	0.7	3.6	18.0	100
地震特集	回答数	96	24	1	2	16	139
	百分率	69.1	17.3	0.7	1.4	11.5	100
赤熱観測	回答数	98	17	0	5	19	139
	百分率	70.5	12.2	0.0	3.6	13.7	100
マントルプルーム	回答数	106	19	2	3	9	139
	百分率	76.3	13.7	1.4	2.2	6.5	100
超臨界現象	回答数	68	34	0	10	27	139
	百分率	48.9	24.5	0.0	7.2	19.4	100
浮かぶ大陸	回答数	81	31	0	8	19	139
	百分率	58.3	22.3	0.0	5.8	13.7	100
地球断面図	回答数	68	40	0	6	25	139
	百分率	48.9	28.8	0.0	4.3	18.0	100
地質年代表	回答数	60	42	0	5	32	139
	百分率	43.2	30.2	0.0	3.6	23.0	100
研究室公開	回答数	68	37	0	8	26	139
	百分率	48.9	26.6	0.0	5.8	18.7	100

（4）来年度の一般公開，公開講義において改善すべき点や提案

今年度の一般公開の反省会において交わされた議論の中心は，一般公開を開催する意義についてであった．構成員それぞれがそれぞれ異なった思いを持っており，その温度差が準備を進める過程で時には独創的な企画を生み，また全体の調和を乱すこともあったように思われる．

本来，一般公開とは一般市民にとって閉鎖的になりがちな研究施設を開放し，研究教育財源を提供して下さっている一般市民に知識の還元を行う事が第一義であろう．当研究施設の一般公開事業に対するアンケート結果を概観するとその満足度の高さからこの目標はある程度達成されているように思われる．しかし，今回行った大規模な宣伝活動によって年々減少傾向にあった来場者が増加に転じた事実や戴いたアンケートに書かれた一般公開事業拡大へのご要望に鑑みると，一般市民の一般公開事業に対する期待と我々の達成感にはまだ隔たりがあるようである．ただし，大学内で漂っている社会貢献活動への低い評価基準のなか，研究や教育活動に追われる我々がこのような一般公開事業に今後どれくらいの人的および金銭的資源を注力していくべきか深い議論が必要になっていくであろう．社会還元に対する一般市民と大学間の認識のずれを研究施設内だけの議論で埋められるかは甚だ疑問であるが，構成員の間である程度統一した意見を見出さなければ一般公開の準備の過程で齟齬を来し調和した展示の妨げになるかもしれない．施設の一般公開が始まって6年目となる来年度は，一般公開事業の意義を根本から問い直す必要があろう．

その他，反省会や事前の会議にて交わされた意見を下に記す．

，開催時期を他の行事と重ならないよう配慮すべき

，展示内容が分かり難いという意見が多いため，対象年齢を上げるか対象毎に複数回開催する等の対応を検討すべき

，一般公開を開催する意義を議論してある程度統一した見解を共有すべき

，ポスターや看板に企画を記すべき

，ハイキングを一般公開と併せて行うのは一般公開の準備に支障を来す

，ライトアップは一般公開時に限らず定期的もしくは記念日等に行っても良いのではないか

，ポスターは印刷業者に依頼した方が安くなるだろう

，当研究施設の研究以外の実態に関する質問を多く受けた．研究室公開などの企画を立ち上げたが基本的な情報を記したパネル等を用意したらどうだろうか

，夏休みであっても平日だと来られないとのご意見をメールや口頭で多く受けた．特に別府市外から子供が参加する場合は大人が付き添わなければならないため，別府市外からの来場者をも望むならば土日祝日開催を検討すべきであろう

平成17年度研究施設一般公開担当　齋藤武士，杉本健，山本順司

オープンハウス報告書（阿蘇）

1．目的

一般市民，特に地域住民，関係機関に，当センターの活動内容を広く知ってもらうことで，センターに対する関心，理解を得る．また，社会への学術的知識の還元，啓蒙をはかる．

2．開催日時

平成16年10月23日（日）　9：30〜16：00

3．内容

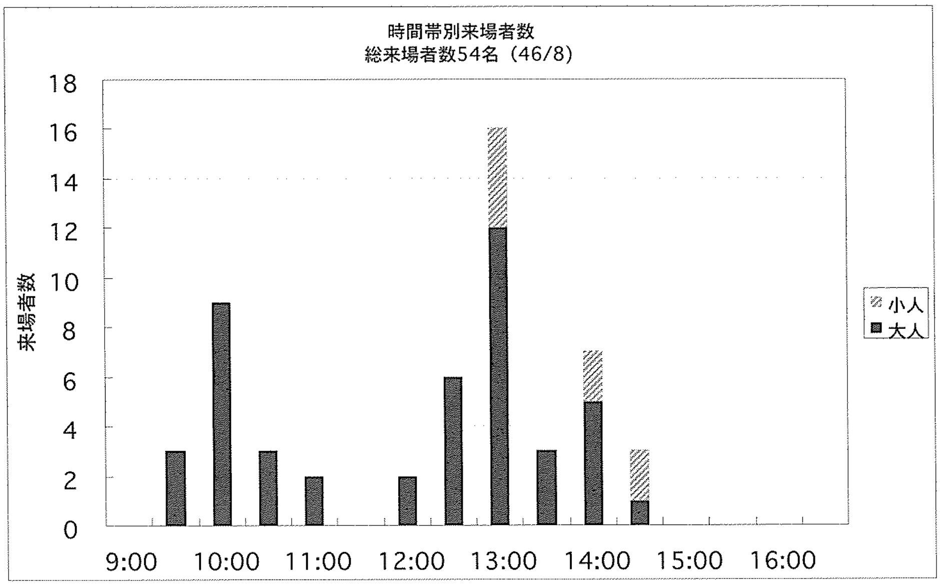
- ポスター展示（約30点）による研究内容の紹介，火山学の一般向け解説
- 公開実験
  - 「地震計のデモンストレーション」
  - 「火山噴火実験　〜火山灰の降灰分布を観察〜」
  - 「火山を作ろう！」
  - 「ポップコーンを使ったスコリア丘の実験」
  - 「空気中のマイナスイオンを測る」
- 施設備品展示（新旧地震計等各種観測装置の展示，解説）
- 火山に関するビデオの上映
- 火山に関する書籍の閲覧供与
- 視覚的展示物
  - 「九州の地震活動リアルタイムモニター」
  - 「阿蘇火山の微動振幅レベルモニター」
  - 「サーモグラフィーを使った体温モニター」
  - 「色々な岩石の展示」
- 特別講演（午前：鍵山，午後：須藤　各30分）
- 見学者パンフレット（大人用，子供用）を配布
- お年寄りの来場者を考慮し休憩室を設置

4．社会告知の方法

- Ａ4，Ａ3版ポスター，チラシを配布，掲示
  配布先：赤水郵便局，アゼリア，阿蘇駅，阿蘇火山防災協議会，阿蘇火山博物館，阿蘇青年の家，阿蘇山測候所，阿蘇市役場，井出酒店，ウィナス，株式会社キンキ，河陽郵便局，九州東海大学，熊本大学，グリーンストック，セブンイレブン，たわら屋，地球熱学研究施設，地球物理学教室，東工大草津白根火山観測所，ニコニコドー，花阿蘇美，マグマ食堂，南阿蘇村観光協会，南阿蘇村教育委員会，南阿蘇村役場，民宿阿蘇の湯，ルナ天文台（50音順）
- 阿蘇テレワークセンターメールマガジン
- 校外学習通信（メールマガジン）
- 火山研究センターホームページによる公示

5. 見学者に関する集計

来場者数：54 名（大人 46，小人 8）



Q1. どちらからお越しになりましたか？

	阿蘇郡市内	熊本県内 阿蘇郡市外	熊本県外	回答なし			合計
回答数	4	6	2	14			26
百分率	15.4%	23.1%	7.7%	53.8			100%

Q2. 年代を教えてください

	10 代	20 代	30 代	40 代	50 代	60 代以上	合計
回答数	1	6	4	1	9	7	28
百分率	3.6%	21.4%	14.3%	3.6%	32.1%	25.0	100%

Q3. どのようにして今回の一般公開を知りましたか？

	友人，知人	インターネット	新聞，雑誌	ポスター	その他		合計
回答数	20	3	0	2	3		28
百分率	71.4%	10.7%	0.0%	7.1%	10.7%		100%

Q4. 特別講演は面白かったですか？

	面白かった	つまらなかった	難しかった	いずれでもない		聞かなかった	合計
回答数	15	0	1	2		3	21
百分率	71.4%	0.0%	4.8%	9.5%		14.3	100%

Q5. 日ごろから阿蘇の火山活動に関心がありますか？

	ある	ない	合計
回答数	27	0	27
百分率	100%	0.0%	100%

Q6. 一般見学会に参加して阿蘇火山への関心は高まりましたか？

	高まった	低まった	変わらない	合計
回答数	25	0	3	28
百分率	89.3%	0.0%	10.7%	100%

6. まとめ

市町村合併によって南阿蘇村（長陽村，白水村，久木野村）となったことで、これまで10月に開催されていた長陽村のイベント（陽の長い日の美術館）は，公のイベントとしては消滅した．このことは，オープンハウスの来場者数に大きな影響を及ぼしている．

また，来年度の10月には日本火山学会秋季大会が阿蘇で開催されるため，オープンハウスの開催を8月に変更することになった．小中学生の夏休み時期ということもあり，多くの親子連れの参加が期待できる．したがって，長陽村のイベントに変わる効果的な宣伝，告知方法を見出すことが，次回のオープンハウスに向けて最も重要な課題であると考えている．

最後にアンケートに回答していただいた方々の感想をいくつか紹介する．

娘が地学関係の分野に進みたいということで，親としては，どんなことをする分野なのか知りたいと思って参加しましたが，かなり引き込まれました，自分がもう少し若かったらと思った．

普通見ることのできないこの研究所の仕事がわかりました．今度は孫たちを連れて来たいと思います．

子供の感想

私は3回目で，来るたびに色んな実験，体験をさせてもらうのが楽しみでした．スコリア丘の実験，火山灰の実験とっても面白かったです．また，来年も来たいと思います．今度は，友達をたくさん連れてきたいと思います．

最初実験がこわかったけど，終わったらポップコーンができて面白かったです．

面白かったことは，噴火の実験で1000mとか10000mぐらい噴火するとはじめて知りました．色々な山とか知れて良かったです．

以上　　火山研究センター　吉川　慎

来訪者 Visitors

【別府】

平成 17 年（2005 年）

4 月 9 日　井上正文，姫野由香他 30 名　（大分大学工学部）

4 月 13 日　明石秀平（大分地方気象台台長），武辺正就（大分地方気象台次長）

4 月 18 日　松山尚典ほか 1 名（応用地質九州）

4 月 18 日　小林記之（京大地質）

4 月 24 日～30 日　三根崇彦（京大地球物理）

5 月 18 日　吉持，幸，藤本，本山　（別府大学生）

5 月 23 日　巽好幸，竹岡　（JAMSTEC）

5 月 31 日　増田，渡邉，藤本　（名古屋大学総合博物館）

6 月 1 日　甲斐成昭，日名子典子　（別府市総合教育センター）

6 月 8 日　小田毅ほか 1 名　（別府市中央公民館）

6 月 8 日　甲斐成昭，日名子典子　（別府市総合教育センター）

6 月 16 日～28 日　東邦大学　渡邊康平，他 4 名

6 月 17 日　鍵裕之　（東京大学）

7 月 7 日　京大事務部，理学研究科施設掛　4 名

7 月 17 日　九州大学院生　4 名

7 月 20 日　楠野，藤崎（別府土木），松山，川本（応用地質）

7 月 20 日　江竜，片岡　（京大理学研究科用度）

7 月 21 日　新見藹　（NHK 大分放送局）

7 月 21 日～24 日　潘　懋，魏春景ほか学生 8 名　（北京大学）

7 月　井上　（京大人間環境）

7 月 25 日　能登征美　（九電産業）

7 月 25 日　伊藤勇二　（ｷﾘﾝﾋﾞｰﾙ）

7 月 27 日　新見藹，高山真樹他 8 名　（NHK　大分放送局）

7 月 27 日　吉野宏昭　（CTB メディア）

7 月 27 日　施設公開　ハイキング　一般 46 名

7 月 27 日　施設公開　ライトアップ　一般 32 名

7 月 28 日　施設公開　一般 196 名

7 月 28 日～8 月 1 日　Prof. Yu Kang-Min (Yonsei Univ., Korea)

7 月 31 日～8 月 2 日　堤浩之ほか学生 19 名　観測地球物理学演習 B　（京都大学）

8 月 2 日～8 月 5 日　堤浩之ほか学生 5 名　課題演習 D3　（京都大学）

8 月 3 日～8 月 11 日　楠本成寿　（東海大学海洋学部）

8 月 10 日　丸山茂徳　（東京工業大学）

8 月 11 日～12 日　小畑正明ほか院生　（京都大学地質学鉱物学）

8 月 17 日～9 月 11 日　Eric Suello Andal　（金沢大学）

8 月 18 日　池田昌之　（京大地質学鉱物学）

8 月 18 日～9 月 3 日　三根崇彦　（京大地球物理）

8 月 19 日～8 月 25 日　山本晋也　（京大地球物理）

8 月 22 日　別府市教職員　約 60 名　（別府市総合教育センター）

8月22日　寺岡悌二　（別府市総合教育センター）
8月22日　福田保　（財団法人ハイパーネットワーク社会研究所）
8月22日～25日　中西利典（産業技術総合研究所）
8月23日　上原弘子　（大分合同新聞別府）
8月25日　明豊高校　高校生103，教員4名
9月1日　斎藤福栄，東部浩志，福田浩二　，田中哲郎，東辻保男　（京大施設部，理施設，経理）
9月12日　田中，桑原，三宅　（京大理経理）
9月14日～15日　原，大柿，福本，馬場　（京大本部，理学研究科）
9月16日～29日　東邦大学　渡邊康平，他3名
9月26日～28日　前田保夫（兵庫県立大），横山祐典（東大），Yechieli(Israel)ほか1名
9月27日　河野貞祐ほか1名　（別府市公園緑地課）
9月30日～10月2日　鈴木勝彦　（IFREE）
10月17日～21日　澤井啓伍　（京大理学部）
10月18日～19日　谷内勇介　（熊本大学自然科学研究科 D3）
10月19日　島津恵造ほか4名　（大分県土木建築部，応用地質）
10月24日　山崎由貴子　（大分南高校3年生）
10月25日　須藤茂，松永烈　（産業技術総合研究所）
11月1日　堤節子　（一般、兵庫県）
11月4日～7日　増田富士雄，松岡廣繁ほか5名　（京大，理，地質学鉱物学）
11月7日　福田浩二（京都大学施設環境部）
11月9日　福田浩二（京都大学施設環境部）
11月14日～16日　ロチェスター大学 U. Fehn
11月17日～18日　石橋秀巳(九大地球惑星研究員)
11月24日～26日　京都大学大学院理学研究科地球物理学教室　余田成男，他6名
12月1日～13日　三根崇彦　(京大地球物理)
12月5日　環境エンジニアリング株式会社事業企画部 山口隆志，他2名
12月13日～15日　井上和久　（京大人間環境）
12月13日～16日　東邦大学　渡邉康平
12月19日　桑原耕治　（応用地質大分）
12月22日　大分県企画振興部景観自然室　佐伯久，他1名
12月27日　大分市環境部環境対策課水質係　津野博光，姫野光明
平成18年（2006年）
1月12日～13日　岡山理科大学　山田誠
1月19日～20日　佐野有司　（東京大学）
1月26日　武辺正就，山内　博　（大分地方気象台）
2月2日～3日　上坂，上田，福田　（京大施設部）
2月4日　松山尚典　（応用地質）
2月14日　四方，新野，山沖　（京大情報環境部）
2月16日～17日　東辻，馬場，安達　（理，施設，司計，本部管財）
2月17日～18日　北田直人　（京大地球物理）
2月19日～22日　平野直人　（東京工業大学）
2月22日～24日　駒林鉄也（東京工業大学）

2 月 22 日～23 日　井上徹、新名亨ほか（愛媛大)、安東淳一（広島大)、谷内勇介（熊本大)
2 月 22 日～25 日　早河秀章　（京大地球物理)
2 月 23 日～24 日　平島崇男ほか 5 名　（京大地質学鉱物学)
2 月 24 日～27 日　中西利典　（産業技術総合研究所)
3 月 2 日　小林記之　（京大地質学鉱物学)
3 月 3 日～4 日　鈴木勝彦（JAMSTEC)
3 月 6 日　新正裕尚　（東京経済大学)
3 月 9 日　北海道立地質研究所　秋田藤夫，鈴木隆広
3 月 15 日　長門輝久,小西民雄　（京大施設部施設活用課)
3 月 17 日～18 日　平島崇男，瀬戸口烈司ほか 6 名　（京大地質学鉱物学)
3 月 27 日　大嶋教授，中原教授，京大施設 3 名　（京大本部)
3 月 28 日～29 日　下山正一，石村　（九州大学地球惑星)

【阿蘇】

平成 17 年（2005 年)
6月1～3日　東工大　金嶋氏、高木氏、　東北大　山本氏
6月14日　気象庁阿蘇測候所2名
7 月 29～30 日　北海道大学理学研究科　中川光弘，大島弘光，橋本武志、東京大学地震研究所　森田祐二，青木陽介、京都大学防災研究所　ジム　モリ，井口正人，神田　径、京都大学人間環境学研究科　金子克哉、九州大学理学研究院　松島　健，河野裕希、熊本大学教育学部　渡辺一徳、熊本大学理学部 長谷中利昭、森林総合研究所九州支所　宮縁育夫、鹿児島大学理学部　小林哲夫、阿蘇火山博物館　池辺伸一郎，吉川みゆき
7 月 29 日　建築研究所　古川氏
10 月 2 日　防災研究所岡田教授ほか 20 名
10 月 18 日　気象庁阿蘇測候所 2 名
10 月 28 日　大野正夫 阿蘇の酸性火山ガス調査
11月15～18日　九大 金嶋氏、東北大　山本氏
11 月 23～24　中村卓司、橋本武志、寺田暁、杉本 ライダーによる噴煙観測
12月14～16日　東大　及川氏
平成18年（2006年)
1月23～25日　東北大　山本氏
2 月 17 日　建築研究所　横井氏 2 月 22 日　気象庁阿蘇測候所 2 名
2 月 27 日　阿蘇火山博物館　池辺伸一郎，吉川みゆき、熊本大学理学部　長谷中利昭、森林総合研究所九州支所　宮縁育夫
3 月 7 日　大野正夫 阿蘇の酸性火山ガス調査
3月13～15日　東大　川勝氏、　九大　金嶋氏、　東北大　山本氏、東工大　高木氏
3月14～15日　東京大学地震研究所　藤井敏嗣，青木陽介，小山崇夫，高橋優志、日本大学文理学部　高橋正樹、九州大学理学研究院　河野裕希、熊本大学理学部 長谷中利昭、森林総合研究所九州支所　宮縁育夫

定常観測　Routine Observations

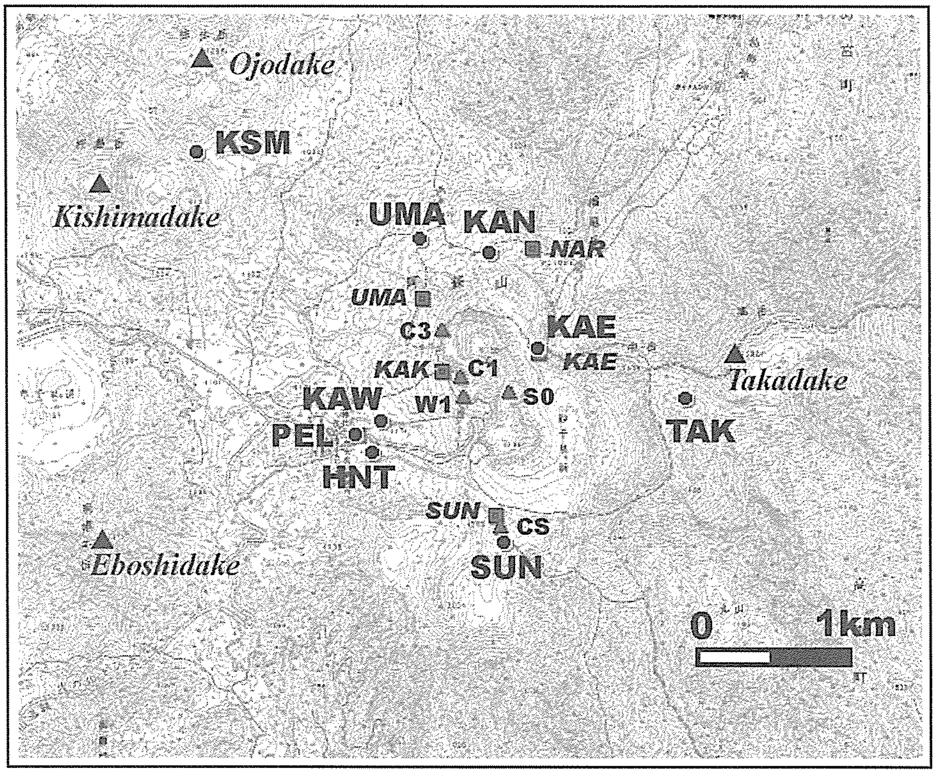
Geophysical Monitoring Under Operation at AVL

Aso Volcanological Laboratory

Permanent Stations

<u>Nakadake monitoring network</u>

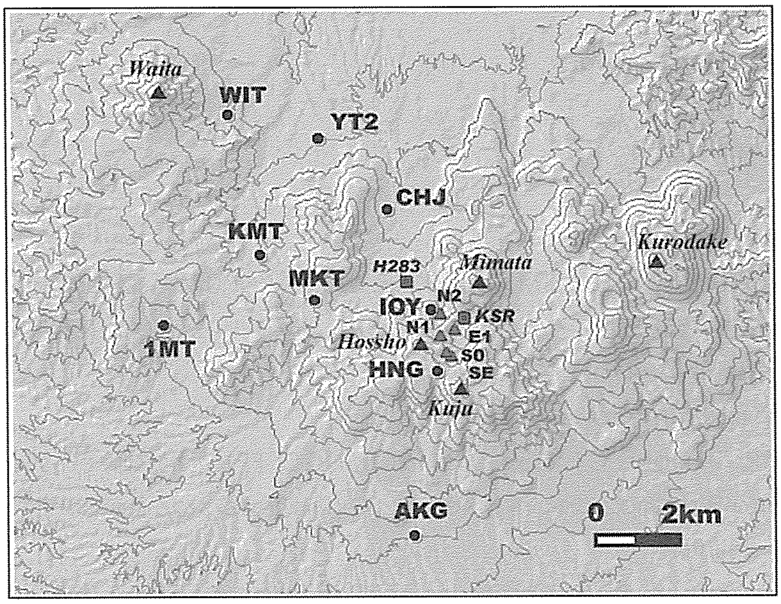
Seismic Stations: HNT, PEL, KSM, SUN, KAE, KAE, KAN, UMA, TAK (microwave telemetry)
Tiltmeters: HNT (water tilt 3-comp.), SUN, KAE, NAR, UMA, KAK (on-site logging)
Extensometers: HNT (invar 3-comp.)
Microphone: HND (microwave telemetry)
Geomagnetic Stations: C1, C3, S0, W1, CS, NGD, FF1 (proton; on-site logging)
C223 (fluxgate 3-comp.; on-site), newC223 (fluxgate 3-comp.; online)
FF2 (proton; online)
Ground Temperature: KAK (boreholes of 70 and 150 m deep; microwave telemetry)



Seismic, geodetic and geomagnetic stations in the central part of Aso.

Kuju monitoring network

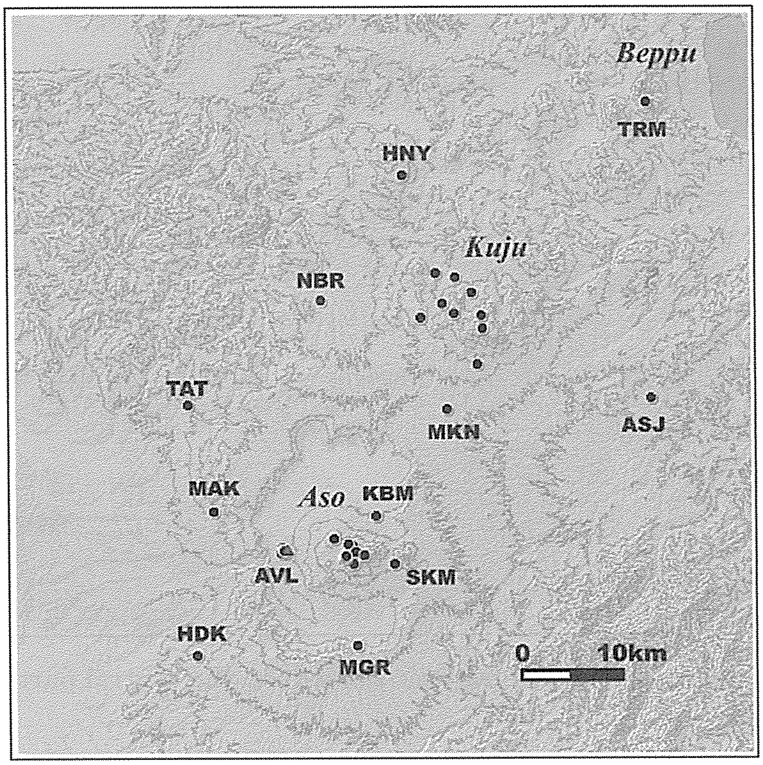
Seismic Stations: HNG (radio-telemetry), AKG, CJB, IOY (on-site logging)
Tiltmeters: H283, KSR (on-site logging)
Geomagnetic Stations: N2, E1, S0, SE (proton; on-site logging)



Seismic, geodetic and geomagnetic stations in Kuju area.

Central Kyushu regional network

Seismic Stations: AVL(6), MAK, NBR, MKN, HDK, TAT, MGR (online telemetry)
ASJ, HNY, SKM, KBM, TRM (dial-up)



Seismic network in the central Kyushu.

装置，設備　Instruments and Facilities

装置　Instruments

【別府】

ICP 発光分光分析装置
波長分散型電子プローブマイクロアナライザー（海洋科学技術センターに貸し出し中）
エネルギー分散型電子プローブマイクロアナライザ
波長分散型蛍光 X 線分析装置
エネルギー分散型蛍光 X 線分析装置
粉末 X 線回折装置
液体シンチレーションシステム
イオンクロマトグラフ
ガスクロマトグラフ
自動滴定装置
ピストンシリンダー型高圧発生装置
ICP-MS 用レーザーアブレーション装置
四重極型 ICP–MS 装置
表面電離型質量分析装置
外熱式ダイアモンドアンビル
ラマン顕微鏡
フーリエ変換型近赤外分光光度計
赤外顕微鏡
加熱ステージ

【阿蘇】

阿蘇，九重火山連続地震観測システム
地殻変動観測坑道
孔中温度観測システム
ビデオ映像監視システム
プロトン磁力計
フラックスゲート磁力計
地磁気絶対測定システム
傾斜計
可搬型地震計（広帯域，短周期）
人工震源車
重力計
超伝導重力計
地磁気地電流測定装置（広帯域型 ULF，ELF，VLF 型）
光波測距儀
水準測量システム（自動読み）

【Beppu】

ICP emission Spectrometer
Wavelength dispersive electron microprobe (lent to JAMSTEC)
Energy dispersive electron microprobe analyzer
Wavelength dispersion type X-ray Fluorescence analyzer
Energy dispersionty type X-ray Fluorescence analyzer
Powder X-ray diffractometer
Liquids scintillation system
Ion chromatography
Gas chromatography
Automatic titration system
Piston cylinder type high pressure apparatus
Laser ablation system
Inductively coupled plasma mass spectrometer (ICP-MS)
Thermal ionization mass spectrometer（TIMS）
Externally heated diamond anvil cell
Raman microscope
FT-NIR spectrometer
IR microscope
Heatings stage

【Aso】

Continuous seismic monitoring system for Aso and
Kuju Volcanoes
Observation tunnel for ground deformation
Borehole temperature monitoring system for Aso
Video monitoring system of Aso and Kuju Volcanoes
Proton and fluxgate magnetometers
Geomagnetic absolute measurement system
Tiltmeters
Portable seismometers (broadband short period)
Car-mounted seismicsource
Gravimeters
Super-Conducting Gravimeter
Magneto-Telluric measurement system (broad-band type, ULF, ELF, VLF-band)
Electronic distance measurement system
Leveling survey system (automatic reading)

設備　Facilities

岩石粉砕，鉱物分離室

パックミル，ディスクミルによる岩石粉砕やアイソダイナミックセパレータによる鉱物分離を行う．

器具洗浄室

実験に用いる器具の洗浄を行う．クリーンドラフト1台，ドラフト1台，イオン交換筒，Milli-Q が設置されている．

クリーンルーム

ニューロファインフィルターを設置し極力金属使用を控えた設計で，クラス100のクリーン度を達成している．Sr, Nd, Pb 同位体比分析のための化学処理（試料の分解，イオン交換クロマトグラフィーによる目的元素の抽出）を行っている．

地下観測坑道（阿蘇火山地殻変動観測坑道）

阿蘇中岳第一火口から南西1km の，地下30m に設けられた，直角三角形の水平坑道で，1987 年度に竣工した．現在は，水管傾斜計（25m），伸縮計（20，25m），短周期地震計，長周期地震計，広帯域、地震計、強震計、超伝導重力計が設置されている．

火山研究センター構内地震観測システム

火山研究センター構内では，従来からトリパタイトによる地震観測を行ってきたが，平成13年度に，ノイズ低減の為，約200m のボーリング孔を4本掘削し，孔底に地震計を導入した．これにより，S/N 比は大幅に改善され，従来識別できなかった中岳の長周期微動が検出されるようになった．また，ボーリングコアを採取したことにより，研究センターの丘，高野尾羽根（たかのおばね）火山について地質学的に新たな知見が得られつつある．これは，阿蘇中央火口丘の噴火史を研究する上でも貴重な資料である．

An analysing system of trace element and isotopic compositions

Radiogenic isotope and trace element compositions of natural samples (e.g. rock and water, etc.) provide us important information about source materials of a sample, generating processes from the sources and age of the sample formation. Therefore isotope and trace element compositions of natural samples are important for investigating the phenomena accompanied with material transfer, such as magma genesis and mantle-crust recycling. Hence, we established an analytical method for determining trace elements by using an inductively coupled plasma mass spectrometer (Fig. 1) and for isotopic ratios of Sr, Nd and Pb: employing a thermal ionization mass spectrometer (Fig. 2) at Beppu Geothermal Research Laboratory (BGRL). The system presented here is made from collaboration with Institute for Frontier Research on Earth Evolution. The methods of chemical preparation for the each analysis were also established. All our chemical procedures are performed under a clean environment, which is basically handmade with our original design (eg. Fig. 3). The analytical methods established at BGRL realize the precise analyses of trace and isotopic compositions of ultra trace amounts of the samples (Fig. 4). Furthermore, we are developing methods to realize the mass production of the assay tests. By employing the described analytical methods, we are progressing with the study of magma genesis and material transfer in the mantle, etc.

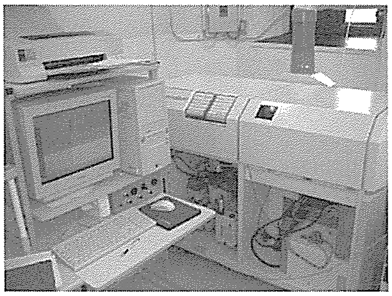


Fig. 1. Inductively coupled plasma mass spectrometer

Fig. 2. Thermal ionization mass spectrometer

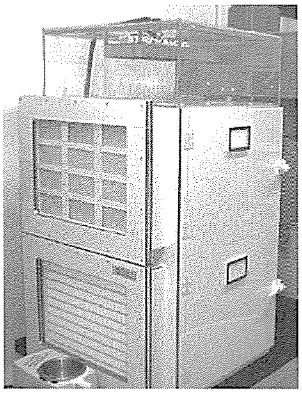


Fig. 3. Sample evaporation system under the ultra clean environment

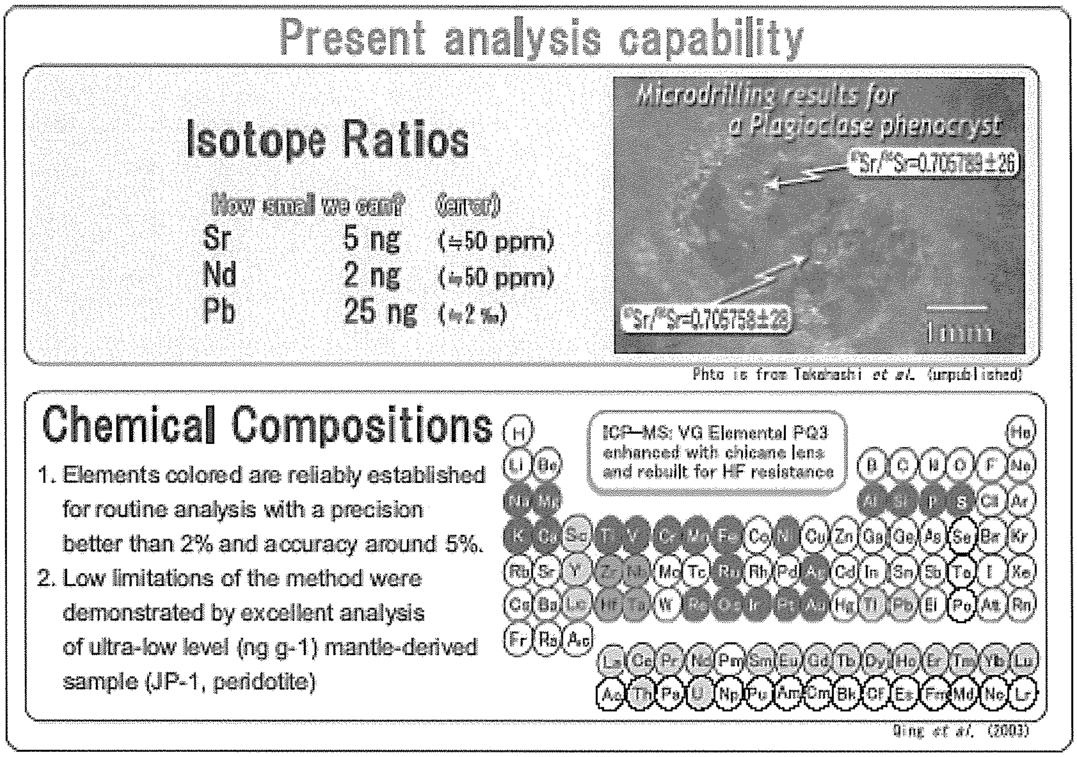


Fig. 4. Analytical method for isotopic and trace element compositions established at BGRL