Annual Report FY 1998

平成10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

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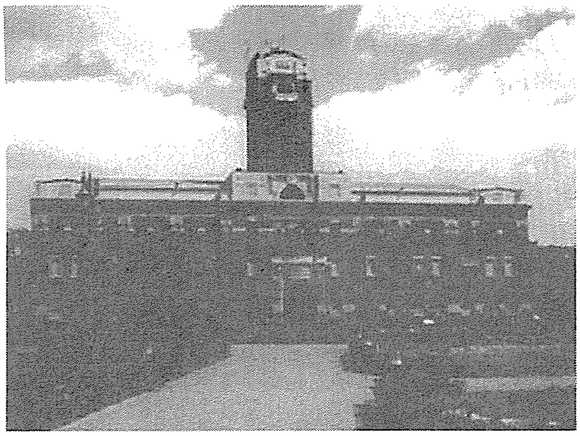

Beppu Geothermal Research Laboratory
Noguchibaru, Beppu 874-0903, Japan
Telephone: +81-977-22-0713
Facsimile: +81-977-22-0965

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

阿蘇 (火山研究センター)

〒869-1404 熊本県阿蘇郡長陽村
電話: 09676-7-0022
ファックス:09676-7-2153

Homepage: http://www.kugi.kyoto-u.ac.jp/avl.html

Front Cover Image:
The strombolian explosion in the 1st crater of Mt.Nakadake, Aso volcano in October 1979.
(Photograph: M.Sako)

表紙の写真,
1979年10月の阿蘇中岳第1火口のストロンボリ式噴火の様子
(迫幹雄撮影)

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序

平成９（1997）年４月に地球熱学研究施設が発足してから、はやくも２年が経過し、ここに、施設の皆様のご努力とご協力を得て、第２年次に当たる平成10（1998）年度の活動記録をまとめることができました。

この新しい施設を充実・発展させるには、その設置理念「地球熱現象の総合的解析」を強く意識した研究活動を可能とする、組織と設備の整備が不可欠です。そのため、まず、施設の大きな柱である物質科学およびこれと関わりの深い研究分野の整備に重点がおかれ、平成10年４月１日付けで古川善紹助教授と川本竜彦助手が着任されたことは、すでに前年度の活動報告に記したとおりです。ついで、８月１日付けで大沢信二助手が助教授に昇任され、12月16日付けで東京大学大学院総合文化研究科からの配置換により鈴木勝彦助手が着任されました。もう一つの柱である火山研究の組織を整備するため、田中良和助教授が５月１日付けで主勤務地を火山研究センター（阿蘇）に移されました。これらにより、本施設の教官定員12名は一応の充足をみましたが、前身の地球物理学研究施設時代から25年の長きわたって、施設の運営と活動に多大のご貢献をいただいた北岡豪一助教授が、平成11年４月１日付けで岡山理科大学基礎理学科の教授にご栄転されました。

また、日本学術振興会の特別研究員２名、文部省の特別予算による非常勤研究員２名、外国人客員研究員2名、７名の大学院生、さらに２名の留学生が別府と阿蘇の施設に滞在して研究活動を行いました。

設備に関しては、別府の施設に、岩石など固体試料の高精度分析装置類が新たに導入されました。既存のものも含めると、数多くの最先端の機器類が設置されたことなりますが、それらの運転に要する電源設備の大幅な改善が行なわれました。他方、火山の研究においては、広帯域地震計を中心機器とした観測網整備の予算が認められ、九重火山地域に２カ所の観測点が建設されました。

これらの整備事業にご尽力をたまわった関係諸機関と担当者諸氏に対し、深く感謝の意を表する次第です。

以上に加えて、科学研究費補助金を始めとする研究費が支給され、また、国内外における共同研究も行なわれました。

こうして研究環境が改善され、研究活動も活発化し、施設の理念を具体化する方向への芽が成長しつつあるように感じられるのは、大きな喜びです。

万全とは言えないまでも、恵まれた研究環境が実現したのは、それだけ当施設への期待が大きいからでもありましょう。これに応えられるよう、私たちはいっそうの努力を払っていかなければなりません。この活動報告が、施設全員の相互理解と研鑽の拠り所として活用されることを願います。施設外の方々には、この報告を通して私たちの活動をご理解いただき、さらにご指導ご助言をたまわりますよう、お願い申し上げます。

平成11年４月

地球熱学研究施設長

由佐　悠紀

Preface

Two years have passed since April 1997, when the Institute for Geothermal Sciences of Kyoto University was reorganized to promote comprehensive studies of thermal phenomena within the solid Earth. I would like to report here our research activities in the 1998 fiscal year, from April 1998 to March 1999.

Replenishing and developing the Institute, and optimum deployment of staff and equipment are indispensable for our research aims. We are now actively consolidating our section in the area of earth forming material sciences and related disciplines. For this purpose, Associate Professor Y. Furukawa, and Assistant Professor T. Kawamoto joined us at Beppu on 1 April 1998. Dr. S. Ohsawa took up an Associate Professorship at Beppu on 1 August 1998, and Assistant Professor K. Suzuki joined us at Beppu from the University of Tokyo on 16 December 1998. On the other hand, on 1 May 1998, Associate Professor Y. Tanaka moved his main office and laboratory from Beppu to Aso in order to study volcanic phenomena. As the result of these changes, the number of staff at the Institute was at a maximum. On 1 April 1999, Associate Professor K. Kitaoka took a Professorship in Okayama University of Science after making great contributions to the Institute throughout the last 25 years.

Regular staff members, two JSPS research fellows, two Special Research Fellows, 2 visiting foreign researcher, 7 graduate students and 2 foreign students studied at Beppu and/or Aso.

With regard to facilities, high precision analytical equipment for rock samples has been newly installed at Beppu. In order to operate an increasing number of advanced pieces of equipment effectively at Beppu, the power supply system was renewed. In the area of volcanic studies, two observation stations were constructed in the Kuju area, supported by a new budget for establishment of a seismic observation network system.

I would like to express my cordial gratitude to those members of organizations involved in these decisions, who made great efforts to consolidate the Institute both in terms of personnel and equipment.

In addition to the regular budget, we were supported by other funds including Grants in Aid for Scientific Research from the Ministry of Education, Science, Sports and Culture of Japan, and much successful collaborations with domestic and foreign researchers has taken place.

It is my great pleasure to see the improvement in research facilities and activity , and also to feel that the Institute is now beginning to develop its full potential.

The task of establishing circumstances fully conducive to active research is still incomplete, but the Institute can be expected to rapidly develop in the future. To meet this expectation, we must make efforts all the more. I hope that this annual report will promote mutual understanding between staff in our Institute and other scientists interested in Geothermal Sciences. I trust that all of you will better grasp the full range of our activities through this issue and look forward to hearing your advice on how to further develop the Institute.

Beppu, April 1999
Yuki Yusa, Professor/Director

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研 究 活 動　Research Activities

研究報告　Scientific Reports

Compressional wave velocity of single-crystal quartz up to 1100°C and 1.0 GPa

Yoshitaka Aizawa[1], Kazuhiko Ito[2] and Yoshiyuki Tatsumi[3]

[1]Graduate School of Human and Environmental Studies, Kyoto University, Yoshida-Nihon-Matsucho, Kyoto 606-8501, Japan

[2]Faculty of Business Administration, Southern Osaka University, Mihara 587-8555, Japan

[3]Institute for Geothermal Sciences, Kyoto University, Noguchibaru, Beppu 874-0903, Japan

Compressional wave velocity (Vp) of single-crystals quartz was obtained at temperatures up to 1100°C at 1.0 GPa pressure. Vp decreased towards the temperature of the α-β transition and then increased with raising temperature. The transition temperatures indicated by the minimum velocities were shifted to higher temperatures as pressure was raised. The present results, together with the inferred crustal geotherm, suggests that the compressional wave velocity structure of tonalitic/granitic crust, which is characterized by the location of low velocity zone in the mid-crustal region especially with high heat flow conditions, is likely to be governed by the α-β transition of quartz.

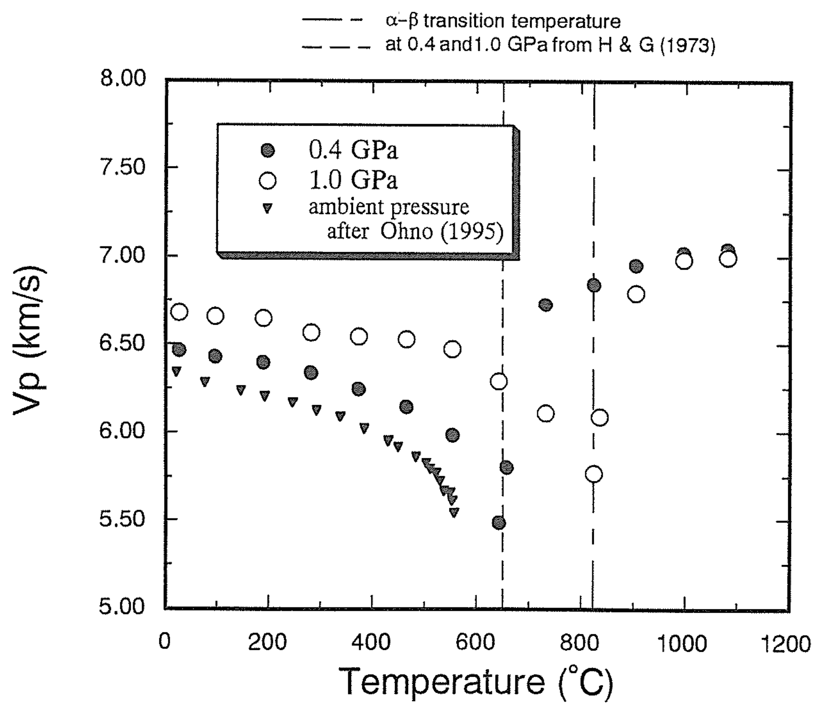

Fig. 1. Compressional wave velocities (Vp) at 0.4, 1.0 GPa and ambient pressure as a function of temperature. Transition temperatures from H & G are from Groos and Heege (1973).

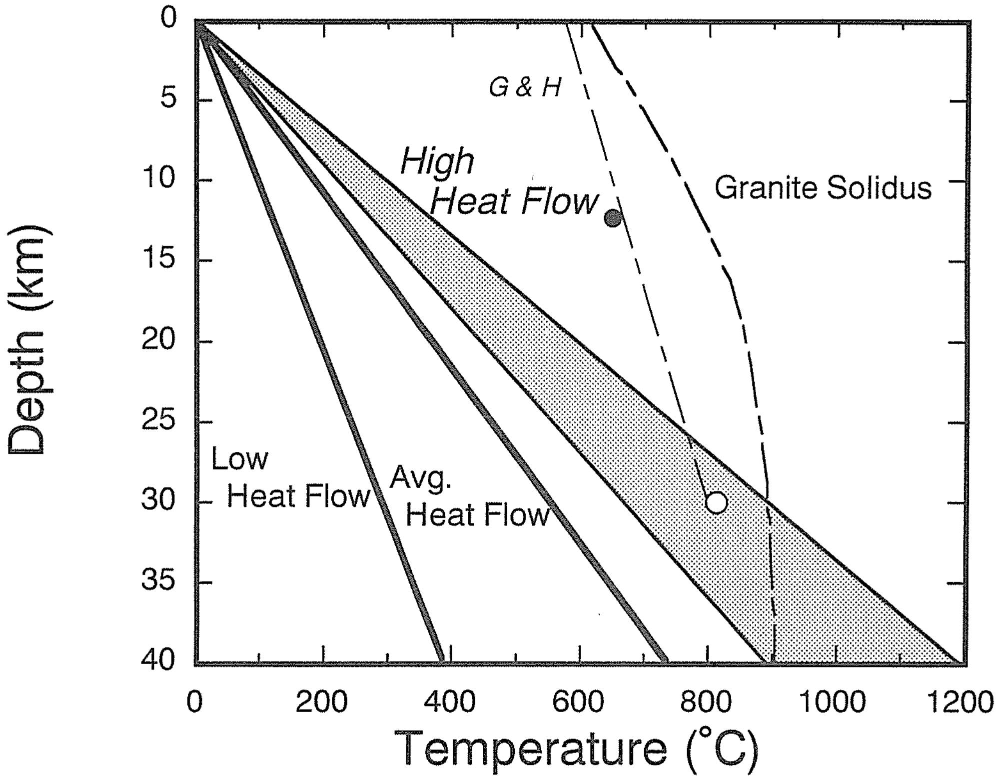

Fig. 2. Inferred geotherms for three heat flow provinces modified from Christensen and Mooney (1995). Filled and open circles represent the quartz transition temperatures at 0.4 and 1.0 GPa in this study respectively, and G & H are those of Groos and Heege (1973) obtained by DTA technique. A granite soildus is from Huang and Wyllie (1981).

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Christensen, N. I. and W. D. Mooney, Seismic velocity structure and composition of the continental crust: A global view, *J. Geophys. Res.*, **100**, 9761-9788, 1995.

Groos, A. F. K. Van and J. P. T. Heege, The high-low quartz transition up to 10 kb pressure, *J. Geol.*, **81**, 717-724, 1973.

Huang, W. L. and P. J. Wyllie, Phase Relationships of S-Type Granite With H2O to 35 kbar: Muscovite Granite From Harney Peak, South Dacota, *J. Geophys. Res.*, **86**, 10,515-10,529, 1981.

Flow Paths of Thermal Groundwaters Inferred from Chemical Compositions of Water Dischrges from Hot Spring Wells in the Northern Part of Beppu, Japan

Kazuhiro Amita, Shinji Ohsawa, Yuki Yusa

Flow paths of thermal groudwaters in the northern part of the Beppu geothrmal field were inferred from chemical data of about 150 water samples collected from hot spring wells. Two types of boiling water; Na-Cl and H-Na-Cl-SO_4 ,and 4 types of warm water; H-SO_4, Ca,Mg-HCO_3, Na-HCO_3 and dilute Na-Cl exist in this area. Large scale Na-Cl type thermal groundwater, bifucating into two tributaries, flows laterally from the western upland to the alluvial lowland. The H-Na-Cl-SO_4 type water, which is formed by mixing the Na-Cl type and the H-SO_4 type waters flowing down from the upland, flows downward along one of the tributary of Na-Cl type water. The dilute Na-Cl type water is formed as the result of seepage from the other tributary of Na-Cl type to aquifer of Ca,Mg-CO_3 type in the lowland area of the alluvial fan. The Ca,Mg-HCO_3 type water, which may be warmed shallow grounwater containing biogenic carbon dioxide, runs across over the flow path of Na-Cl type water. The steam-heated water of Na-CO_3 type is located nallowly above the Na-Cl type water flow.

Vertical Heterogeneity of Major Elements in Hydrous Trachyandesite Melts

Du, W., Sano, T. and Tatsumi, Y.

Melting experiments were performed at 1GPa and 1200 °C on a trachyandesite with 7.1 - 13.0 wt. % H_2O. The solubility of H_2O in the present system was estimated to be between 10.0 and 11. 3 wt. %, by using the presence of vesicles as a criterion of over-saturation. The vertical heterogeneity of major elements was observed: SiO_2, Al_2O_3, K_2O and Na_2O gradually increased upwards, while FeO and MgO gradually decreased in the same direction.

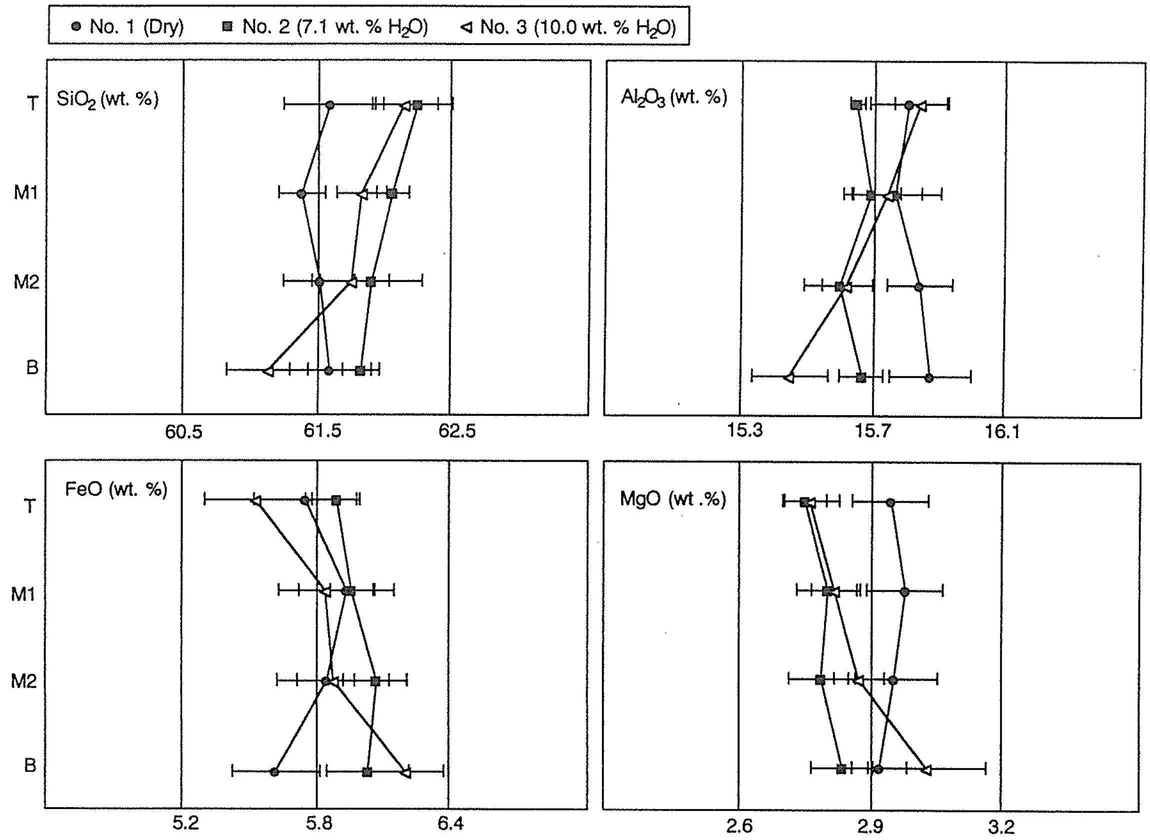


Fig. 1. Vertical compositional variations in water-undersaturated products.

Heat flow in the southwest Japan arc and its implication for thermal processes under arcs

Furukawa, Y., Shinjoe, H., and Nishimura, S.

In subduction zones where cold lithosphere is subducting and deep seismic slabs are observed, volcanic arcs are developed. Heat flow is relatively low (~40 mW/m^2) in the fore-arc region, and very high in the volcanic belt. This heat flow variation is considered to be caused by subduction of the low temperature lithosphere in the fore-arc and the induced flow of hot asthenosphere in the mantle wedge: high temperatures necessary for genesis of arc magmas are maintained by the induced flow.

In the southwest Japan arc the relatively young Shikoku basin (~20 Ma) subducts northwestward. The seismic slab extends only to depths of ~50 km, but seismic studies show that aseismic slab is located under the volcanic front at depths of ~100 km. The volcanic front is located along the north coast of this arc, but the magmatic activity is relatively low compared with that in arcs with deep seismic slabs. In this arc thermal structure in the crust and the upper mantle will give important constraints on the mantle flow induced by the subduction of young lithosphere and the magma genesis in this arc.

We present 35 new heat flow measurements for the Kinki district in the eastern part of the southwest Japan arc. Heat flow distribution in this region shows zonal structure parallel to the trench. In the across-arc heat flow profile there are two high heat flow peaks: one is located at the volcanic front and the other is between the south coast of this arc and the trench. The high heat flow at the volcanic front is probably caused by the induced flow in the mantle wedge. The high heat flow off the south coast is located in the zone where slab depth is 10~20 km, and is immediately to the ocean side of the boundary at which P-wave velocity increases landward in the upper crust. We thus consider the high heat flow is caused by the uplift of accreted materials along the backstop in the accretionary prism, assuming that seismic velocity is an indicator of rigidity of rocks. The upward flow velocity is estimated to be ~1 mm/yr using a simple one-dimensional erosion model, which is consistent with that estimated from the present heights of marine terraces.

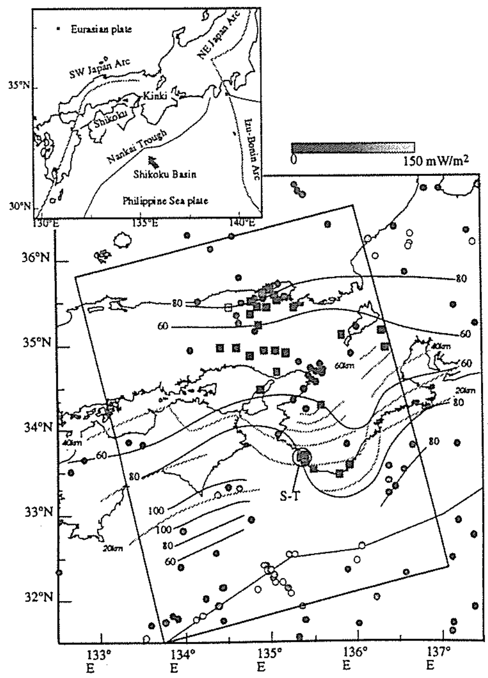


Fig. 1 Distribution of heat flow data in this study (squares) and previously published data (circles). Contour lines of estimated heat flow in this area, drawn by hand, are also shown as solid lines; the contour interval is 20 mW/m^2. Depth of the slab is shown as hatched lines. S-T denotes the Shirahama-Tanabe area. Inset shows simplified tectonic structure in southwest Japan, in which the volcanic front and the subduction direction of the Philippine Sea plate are denoted as hatched lines and an arrow, respectively.

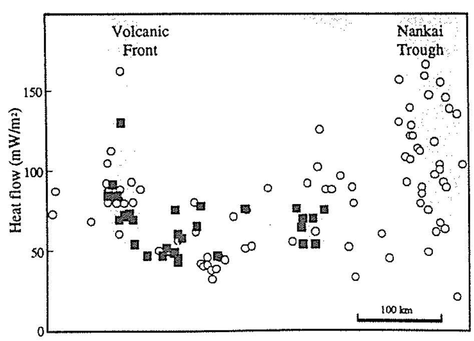


Fig. 2 Heat flow profile in the across-arc direction using heat flow data in the rectangle in Fig. 1. Hatched areas denote the location of heat flow peaks.

Melting of a subducting slab and production of high-Mg andesite magmas: unusual magmatism in SW Japan at 13~15 Ma

Furukawa, Y. and **Tatsumi, Y.**

Sinking of the oceanic lithosphere into the mantle and magmatism in subduction zones have played a key role in the chemical evolution of the solid Earth. Dehydration and/or partial melting occurring in a subducting crust with increasing pressures and temperatures cause changes in its compositions, and are further responsible for recycling of the subduction component to the surface through production of arc magmas. Melting of the sinking oceanic crust would have been a plausible consequence of plate subduction in the Archean mantle possibly with steeper geothermal gradient than the present mantle, and would have greatly contributed to making continental crusts.

The modern sinking crust, on the other hand, does not melt in most subduction zones and instead releases aqueous fluids that trigger melting of the mantle wedge. However, if high-temperatures are attained both in the subducting plate and the mantle wedge, then the slab-melting-induced arc magmatism would take place even in the modern Earth.

Characteristic high-Mg andesite magmas were produced in the SW Japan arc at 13~15 Ma that was synchronous with the commencement of subduction of a very young (<11 m.y.) lithosphere of the Shikoku Basin. Numerical simulation suggests that temperature at the surface of such a young subducting plate is high enough for partial melting both of the subducting sediments and oceanic crust at the beginning of the subduction. High-Mg andesite magmas were likely to be produced by interaction between silicic slab melts and the overlying mantle wedge. HMA magmas may be commonly produced in the Archean subduction zones under relatively high mantle temperature conditions, contributing to making continental crusts.

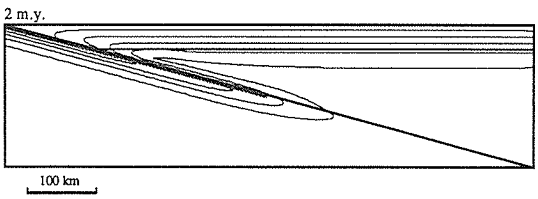


Fig. 1 Calculated temperature structure at 2 m.y. after the initiation of the subduction of the Shikoku Basin. The age of the subducting lithosphere is 5 m.y. Contour interval is 250 °C. Hatched areas at the top of the subducting plate denote the oceanic crust. No vertical exaggeration.

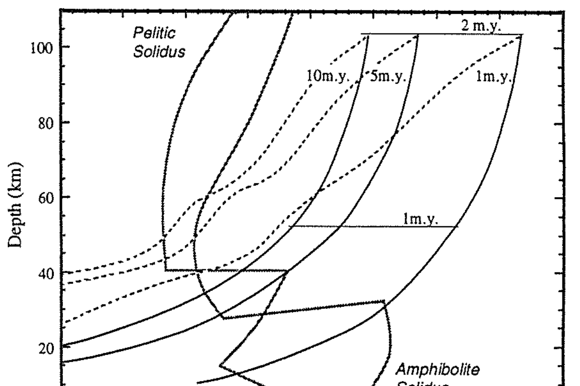


Fig. 2 Calculated temperatures are plotted versus depth with solidi of pelitic sediments and amphibolite (oceanic crust). Dotted lines: temperature profile of the subducting slab surface at 2 m.y. after the initiation of the subduction for three plate ages (1, 5, 10 m.y.); solid lines: temperature change of the leading edge of the subducting plate until 2 m.y. after the initiation of the subduction for the three slab ages; hatched lines: the solidi of pelitic sediments and amphibolite. Bends in the solidi correspond to the garnet-in reactions with decomposition of mica and amphibole for pelitic and amphibolitic systems, respectively. Thin horizontal lines indicate the depth of the leading edge at 1 and 2 m.y. after the initiation of the subduction.

Electroseismic changes observed at an explosion experiment in Aso Volcano

Hase, H., Tanaka, Y., Hashimoto, T., Sakanaka, S.,
Mori, T., Masuda, H. and Yoshikawa, S.

Investigation of co-seismic geoelectric changes is important as a first step to elucidate a relationship between an earthquake and various kinds of pre-seismic or post-seismic changes. Some mechanisms have been proposed as causes of the electroseismic phenomena. For instance, N.G.Khatiashvili et al. (1989) proposed the piezoelectric effect and Mikhailov et al. (1997) explained the electroseismic phenomena by the electric streaming current. We observed geoelectric potential changes at an explosion experiment conducted at Aso Volcano on November 26, 1998 (Fig.1). We selected two shot points of explosion (S3, S4) as target to investigate electroseismic changes, and we have set up five observation points (from Site A to Site E). In this paper, we report results of Site E.

We detected electroseismic signals containing three kinds of changes at Site E (from Fig.2 to Fig. 4) . The first is an impulsive change with its duration of a few msec. It was observed closely at the time of a seismic shot. The second continues for several tens msec immediately after the shot, attenuating with distance from the shot point according to 1/r law (Fig.5). The third change occurs at the arrival of seismic wave and seems to be generated by ground motion.

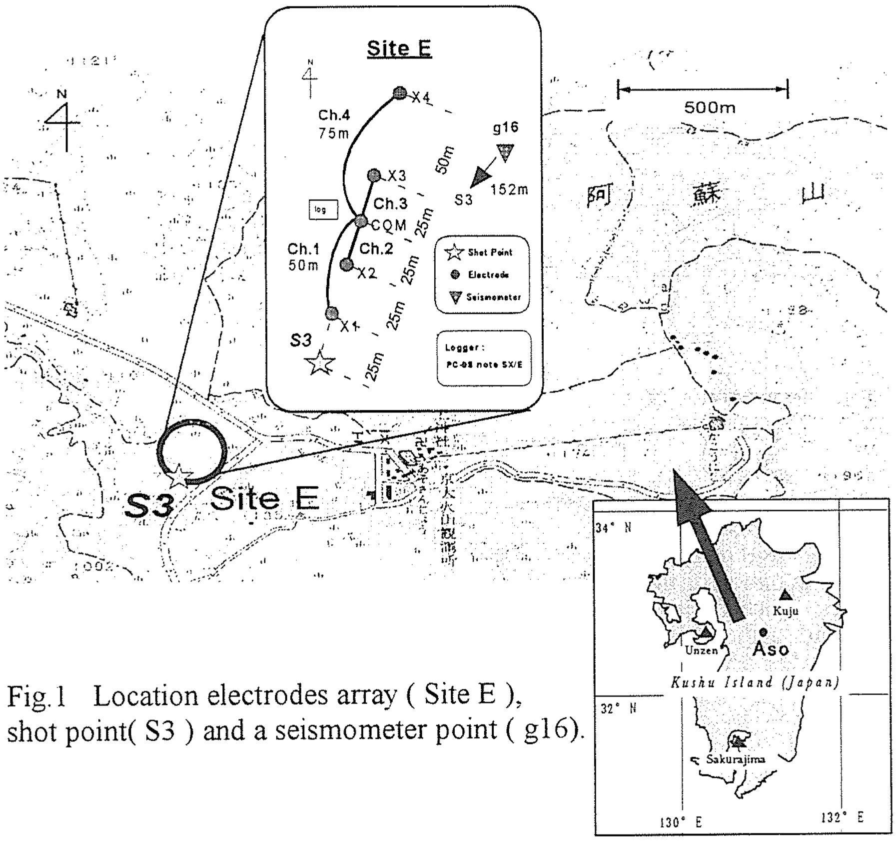


Fig.1 Location electrodes array (Site E), shot point(S3) and a seismometer point (g16).

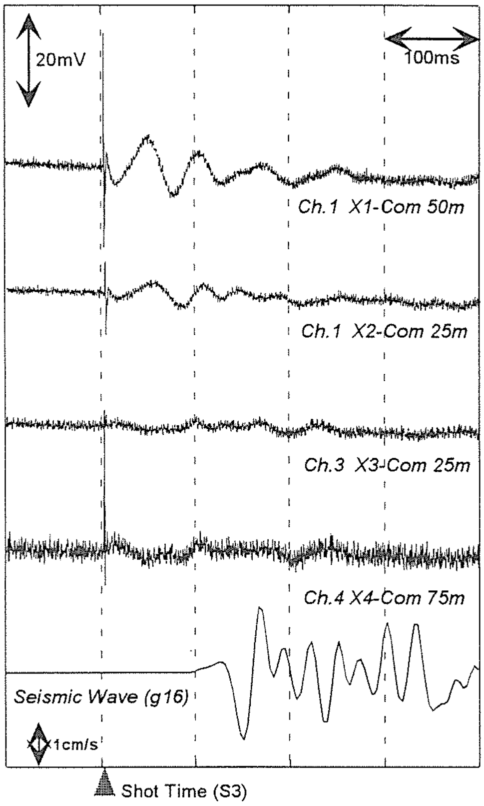


Fig. 2. Geoelectric changes (Site E) and seismic wave (g16) for 500 msec before and after the shot time (S3).

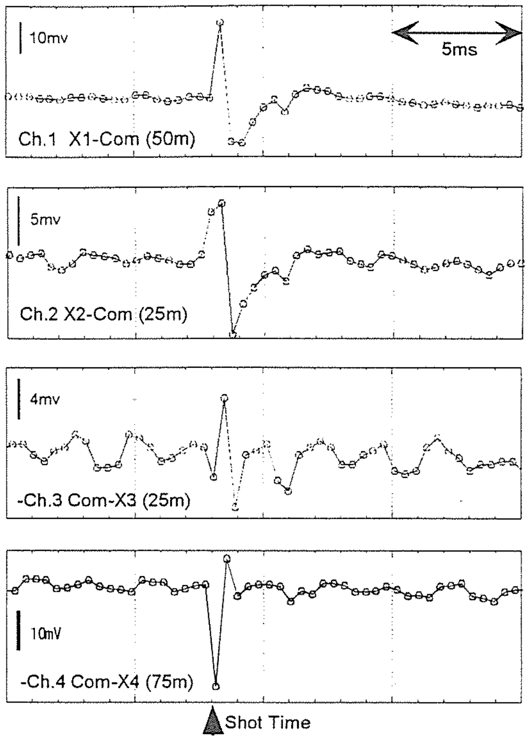


Fig. 3. Geoelectric changes for 20 msec before and after the shot time (S3).
(Ch.3 and Ch.4 are changed to negative sense)

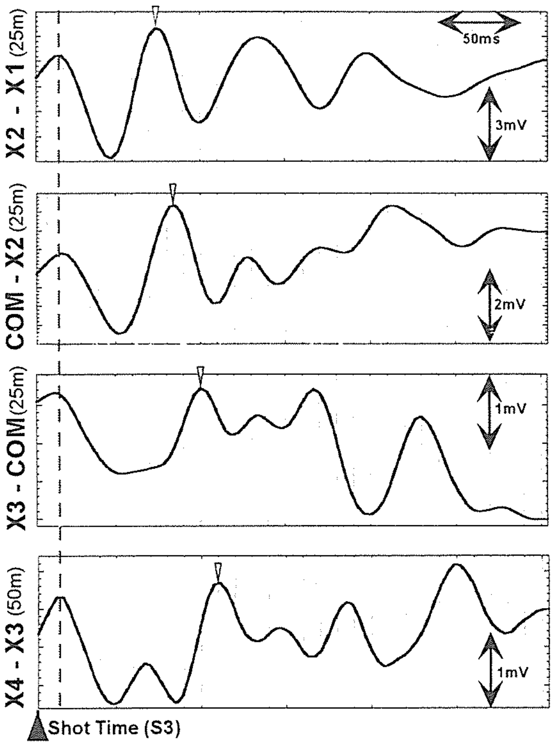


Fig. 4. Geoelectric changes (Site E) for 300 msec immediately after the shot time (S3).

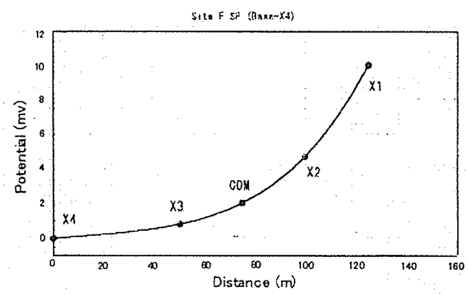


Fig. 5. The solid-line and symbols show accumulated amplitude (base point is X4) of electroseismic changes for 50 msec immediately after the shot time (S3).

Resistivity structure of Kyushu island investigated by Network-MT method

Hashimoto, T., Amita, K., Mawatari, H., Tanaka, Y.,
Shimoizumi, M.(Pol-Tech. Coll. KitaKyushu),
Uyeshima, M., Sasai, Y.(ERI, Univ. Tokyo)
and Kanda, W.(DPRI, Kyoto Univ.)

Bulk electrical resistivity of earth's interior is sensitive to water-content, temperature and alteration. In particular, subsurface fluids are expected to play important roles in subduction zones and seismically active areas. The aim of this research is clarifying the resistivity structure of the crust and the upper mantle in Kyushu region and investigating in which part of a subduction zone and how such fluids exist. Network-MT is a kind of Magneto-Telluric method with a long (normally up to several tens of km) spanned dipoles using metallic telephone lines for the telluric components. Advantages of this method are its intensive spatial coverage and better telluric response for lower-frequency magnetic source rather than standard MT. We have deployed 36 networks (172 dipoles) in Kyushu island (Fig.1). Some features can be pointed out on apparent resistivity curves of Kumamoto and Miyazaki Areas (Fig.2). Stations of the eastern coast commonly show the clear splitting of two modes (rho-xy and rho-yx), suggesting a 2D-like structure striking NS direction (plausibly caused by sea/land contrast). On the other hand, those of the western coast do not show such splitting feature but show a slight dip around period 200sec in the sounding curves, suggesting a low resistivity layer in the lower crust or the upper mantle. The curves of Yabe network (south of Aso caldera) are also splitted, however, components are reversed compared with the case in eastern Kyushu. This implies a EW striking structure in central Kyushu.

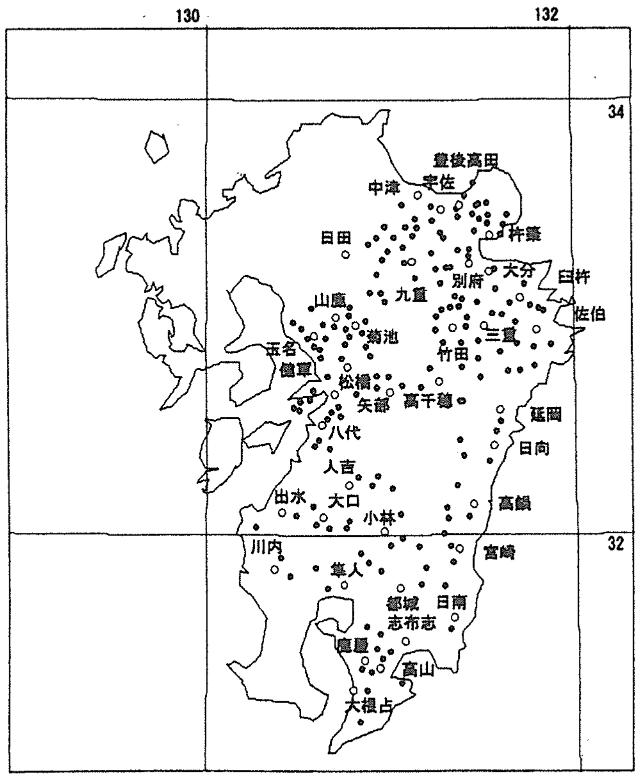


Fig.1: Location of electrodes (solid circles) and of recording instruments (open circles) deployed in 1997 and 1998.

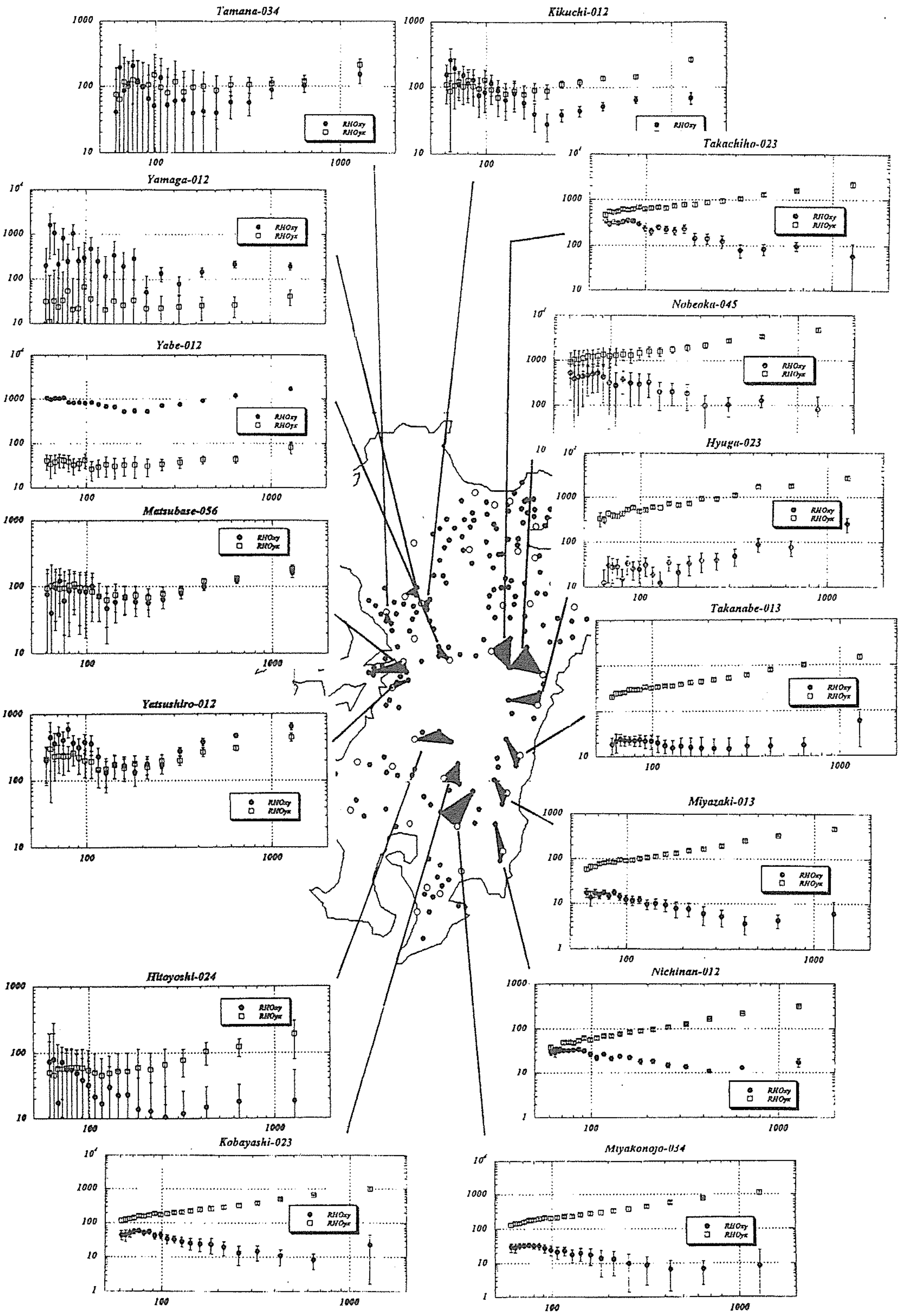


Fig.2: Apparent resistivity curves obtained in Kumamoto and Miyazaki networks. The vertical axis represents apparent resistivity (ohm-m) and the horizontal axis does period (sec).

Electromagnetic explorations in Aso Volcano using active sources (I)
—TDEM and bipole-dipole mapping—

Hashimoto, T., Tanaka, Y., Sakanaka, S., Hase, H., Amita, K., Masuda, H.,
Kanda, W. (DPRI, Kyoto Univ.),
Kagiyama, T., Munekane, H., Koyama, T., Ogawa, T. (ERI, Univ. Tokyo),
Mogi, T., Ikoma, Y., Djedi S., Widarto (Kyushu Univ.),
Handa, S. (Saga Univ.) and Shimoizumi, M. (Pol-tech Coll. Kitakyushu)

Over the past few decades some researchers have attempted to investigate the electrical structure of Aso Volcano. Both NEDO and GSJ have already made intensive MT surveys in Aso caldera and the electrical structure of Aso caldera has been roughly revealed. However, geoelectrical information around the central cones was not still enough. In particular, the electrical structure deeper than 1km was almost completely unknown. We believe that the electrical structure up to a few kilometer deep can give a effective constraint to understand the system of energy and material transfer of a volcano because many kinds of geophysical variations are detected at this depth in many volcanoes. Aso Volcano is one of the most appropriate fields to investigate the structure nearby the crater or the conduit system because we can approach close to the object, observe and experiment it. In FY1998, we conducted TDEM (Time Domain Electromagnetic Method) experiment and bipole-dipole mapping electric sounding around the active crater of Aso Volcano as a cooperative work with other researchers. The TDEM is one of the electromagnetic exploration methods using an active source. In our experiment we injected alternative direct current (DC) up to 15A into the earth with frequency of 5 seconds. We deployed a couple of bipole sources with their length of 2.2 and 1.5km, respectively. The transient waveforms of received magnetic signals depend on the conductivity of the earth. On the other hand, bipole-dipole mapping uses the telluric components as receiving signals, however the source is the same as TDEM. On the method we use DC amplitude and vector direction of received electric fields to infer the conductivity of the earth.

The advantage of using active sources is as follows. Stacking is one of the most effective ways to avoid random noise including artificial ones and improve the signal to noise ratio. In addition we can control the location, direction and intensity of the source to fit an object. The resistivity structure around the crater is expected to be highly complicated and laterally inhomogeneous. To overcome the complexity the spatial coverage should be intensive and data should be accurate enough to be processed with a 3-D modeling. The data collected by the experiment in December 1998 are now under processing. What we are going to do next is building a 1-D resistivity model by TDEM at first. Then refine the model structure using 3-D forward calculation with shallow 3-D structure obtained by bipole-dipole method. Additional experiments should be done if necessary.

Pb-Pb geochronology of limestones and greenstones in the accretionary prisms in SW Japan

Tomomi Kani

Direct radiometric dating using newly-developed experimental procedures was conducted for limestones in the accretionary prisms in southwest Japan. The Pb isotope analyses for these limestones yielded reliable Pb-Pb isochron ages of 352±44 and 287±19 Ma for the Akiyoshi and the N-Chichibu belts, respectively, and provided the first report of radiometric ages of Phanerozoic limestones. The ages of limestones obtained are consistent with previous estimates based on macro-fossils and further with the present result of an Pb-Pb internal isochron age of 296±120 Ma for greenstones, which are directly overlain by limestones in the N-Chichibu belt. It is suggested that the age of magmatic activity of mafic rocks, which originally formed in the oceanic region and are stored as enormous volumes of metamorphosed greenstones in subduction complexes, can be obtained by Pb-Pb dating both of greenstones and limestones in orogenic belts.

Geochemistry of greenstones in the accretionary prisms in SW Japan

Tomomi Kani

Greenstones are variably metamorphosed mafic igneous rocks which were originally produced as massive lavas / intrusions / volcaniclastics by intraplate or ridge magmatism and have been stored in subduction complexes at convergent plate margins. Compositions of greenstones from the Akiyoshi and Chichibu belts in the southwest Japan, especially their high Nb / Y ratios at a given Nb / Zr ratio, suggest that SW Japanese greenstones, at least part of them, possess geochemical characteristics identical to present basalt lavas in the S Pacific region and different from those of other hotspots in the present Pacific Ocean. If the present magmatic activity in the S Pacific superswell region is caused by a whole-mantle-scale, "superplume" upwelling, then SW Japanese greenstones with high Nb / Y ratios may represent the surface manifestation of ancient activity of the S Pacific superplume. This, together with Pb-Pb isochron ages both of greenstones and coeval limestones in the Akiyoshi and Chichibu belt and the previous geochemical works on the W Pacific oceanic plateaus, may provide rather compelling reasons for believing that the S Pacific superplume was active at 350-280 and 150-100 Ma. The superplume activity estimated in the present study preceded the onset of the superchron and other global changes, supporting an idea that the superplume acted as a trigger for such global events in the Earth system.

Hydrous Phase Stabilities and Partial Melt Chemistry of H_2O-saturated KLB-1 Peridotite up to 24 GPa

T. Kawamoto, D. C. Rubie (Bayreuth, Germany)

The existence of liquid H_2O is one of the most unique features characterizing the planet earth. H_2O has a significant effect on the properties of earth forming materials, and especially on the generation and the differentiation processes of magmas. Every magma has more or less H_2O before its eruption, because hydrogen is present over the whole mantle and is preferentially partitioned into silicate melts under pressure. The production and subsequent eruption of magmas is an effective degassing device in the planetary system. Therefore, it is important to know the possible distribution of H_2O or OH in the earth's mantle in order to understand the differentiation processes of the planet. We experimentally determined the stabilities of hydrous minerals and the chemistry of partial melts in an H2O-saturated in a model mantle peridotite, KLB-1 mantle peridotite (13.6 wt. percent H_2O, 0.89 Mg/(Mg+Fe), 1.46 (Mg+Fe)/Si atomic ratio) in a pressure range from 14 to 24 GPa and a temperature range from 900 to 1400 °C. We carried out a series of experiments by the use of Kawaii type multi anvil high pressure apparatus at Bayerisches Geoinstitut, Deutschland. In order to know partial melt compositions we determined major element compositions of chemical compositions of dendritic portions over a 30 x 40 micrometer scanning area.

Hydrous phases as phase E, D (Yang et al. 1997 American Mineralogists 82) or G (Ohtani et al. 1997, Geophysical Research Letter 24, Kudoh et al. 1997, Geophysical Research Letter 24), superhydrous B, and β and γ phases of olivine are found in the present experimental conditions (Figure 1). Phase E is stable at 14 - 17 GPa, phase D/G and superhydrous B are found at 20 and 24 GPa. At 24 GPa and 1400 °C, Mg-perovskite is observed with stishovite and a quenched partial melt showing dendritic texture. (Mg, Fe)O was not observed at these experimental conditions. The phase boundary of β and γ phases of olivine in hydrous conditions is found to be at higher pressure than in the dry conditions (Figure 1).

(Mg+Fe)/Si atomic ratios of partial melts in the same system increase from 1 at 5 GPa to 2 at 11 GPa (Kawamoto and Holloway 1997, Science 276). At 7.5 GPa, (Mg+Fe)/Si ratios of partial melts increase with increasing temperature (Figure 2). In contrast, at a given pressure greater than 10 GPa, (Mg+Fe)/Si ratios of partial melts decrease with increasing temperature (Figure 2). (Mg+Fe)/Si ratios of partial melts decrease from 2.5 at 1100 °C to 1.6 at 1300 °C at 14 GPa, and from 3.3 at 1100 °C to 1.8 at 1300 °C at 17 GPa. At 20 GPa, (Mg+Fe)/Si ratios decrease from 2.8 at 1200 °C to 1.7 at 1400 °C. Similar characteristics were also observed in the MgO-SiO_2-H_2O system at 12 and 15.5 GPa (Inoue 1994, Physics of Earth and Planetary Interior 85). At a given temperature, (Mg+Fe)/Si ratios of partial melts increase with increasing pressure. It is likely that the structure of wet silicate melts changes drastically as a function of pressure, therefore, spectroscopic observation of those wet melt compositions should be conducted to explain this conspicuous feature. A partial melt coexisting with Mg-perovskite and stishovite at 24 GPa and 1400 °C has 2.2 (Mg+Fe)/Si atomic ratio. Ultramafic hydrous melts similar to those observed experimentally under uppermost lower mantle conditions may have contributed to chemical differentiation between the upper and lower mantle.

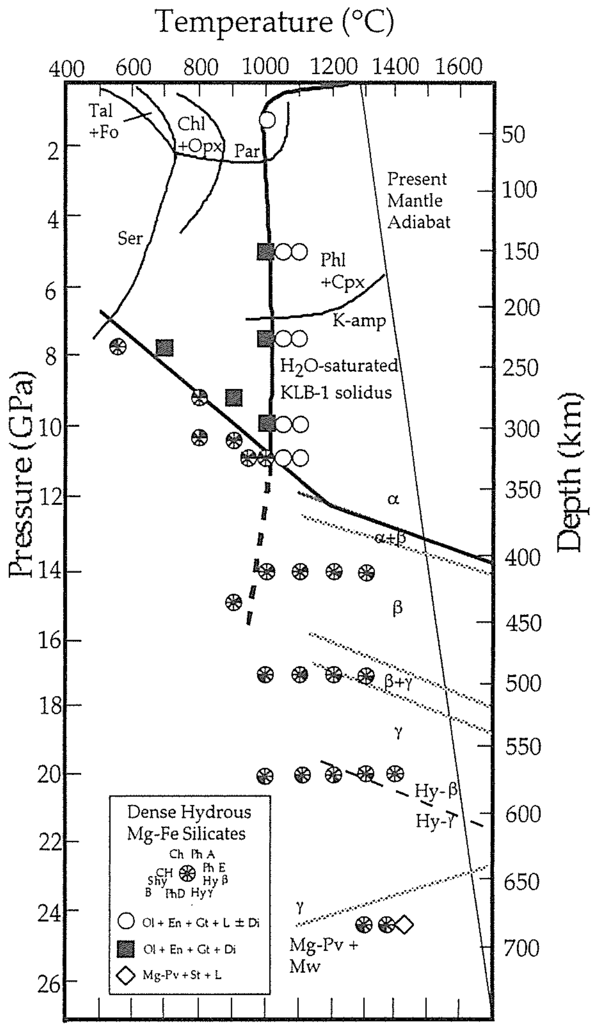


Figure 1. Pressure - temperature projection of the stabilities of dense hydrous Mg-Fe silicates in H_2O-saturated KLB-1 peridotite. Open circles represent the phase assemblage of liquid, olivine, garnet, Ca-poor pyroxenes, with or without Ca-rich pyroxene. Closed squares represent sub-solidus assemblages: olivine, garnet, and two pyroxenes at 5 - 10 GPa. Experiments at 1 GPa are after Hirose (1997 Geology); the stabilities of pargasite (Par), chlorite (Chl), serpentine (Ser), talc (Tal) and phlogopite - K-amphibole (K-rich) are after Schmidt and Poli (1998 Earth Planet Sci Lett) and Sudo and Tatsumi (1990 Geophys Res Lett); phase boundaries among α, $\alpha + \beta$, β, and $\beta + \gamma$ - $(Mg_{0.9}Fe_{0.1})_2SiO_4$ and γ - $(Mg_{0.9}Fe_{0.1})_2SiO_4$ and Mg-perovskite (Mg-Pv) + magnesium wüstite (Mw) in the dry conditions are after Katsura and Ito (1989, J Geophys Res), and Ito and Takahashi (1989, J Geophys Res), respectively.

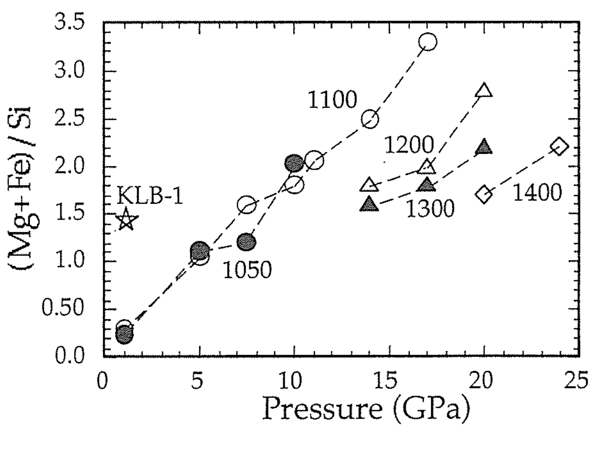


Figure 2. Molar (Mg+Fe)/Si in the partial melts of H_2O -saturated KLB-1 peridotite increases with pressure. The composition of subsolidus KLB-1 peridotite is represented by the star. Numerals represent the experimental temperatures in °C.

Volatiles in the melt inclusion from French Polynesian HIMU basalts

Kudo, K. and Tatsumi, Y.

The volatile contents from Mangaia (HIMU; $^{206}Pb/^{204}Pb>20.5$) and Rarotonga (non-HIMU) island basalts, Southern Pacific are determined using melt inclusions in olivine. The crystallized melt inclusions were homogenized by using the heating stage. The bubbles are still present in melt inclusions, possibly because the melt inclusions were saturated in a volatile component when it trapped in the phenocrysts. The volatile contents in the glass part of the homogenized inclusions were determined using a Secondary Ion Mass Spectrometry (SIMS). The volatile contents in the vapor equilibrated with the melt at the stage of trapping were calculated using the method of Dixon (1997). The pre-eruptive volatile contents are estimated. The minimum pre-eruptive estimation in Mangaia HIMU basalt is 0.3-0.45 wt% H_2O and 680-1950ppm CO_2. These estimations in Mangaia basalts are in the range of volatile contents in hotspot basalts, which is slightly higher than those in MORB magmas. It is suggested that HIMU basalts are surface manifestation of the superplume activity. The Ontong Java plateau may be suggested to be produced by the mid-Cretaceous superplume activity. Based on the content of Mangaia HIMU basalts, the flux of CO_2 from Ontong Java plateau is estimated $1.2\text{-}3.4\times10^{12}$ mole/yr. This estimation is a little larger than the present flux from the mid-ocean ridge and might influence atmospheric CO_2 in mid-Cretaceous.

Fate of a mantle plume at a density interface

Kumagai, I. and Kurita, K. (University of Tokyo)

Ascending modes of plume through compositionally layered system are investigated to understand the ascending mechanism of deep mantle plumes. Two modes of interaction between a plume and the density interface are identified (Fig. 1), depending on the average density of a plume head: (1) a pass-through mode when small entrainment occurs, and (2) rebirth mode in the case of large entrainment. Large entrainment disturbs the plume passing through the interface and entrained material is removed above the interface between two layers. The difference between these two modes is imprinted in space and time characteristics of geochemical data of mantle plume products. (submitted to Science)

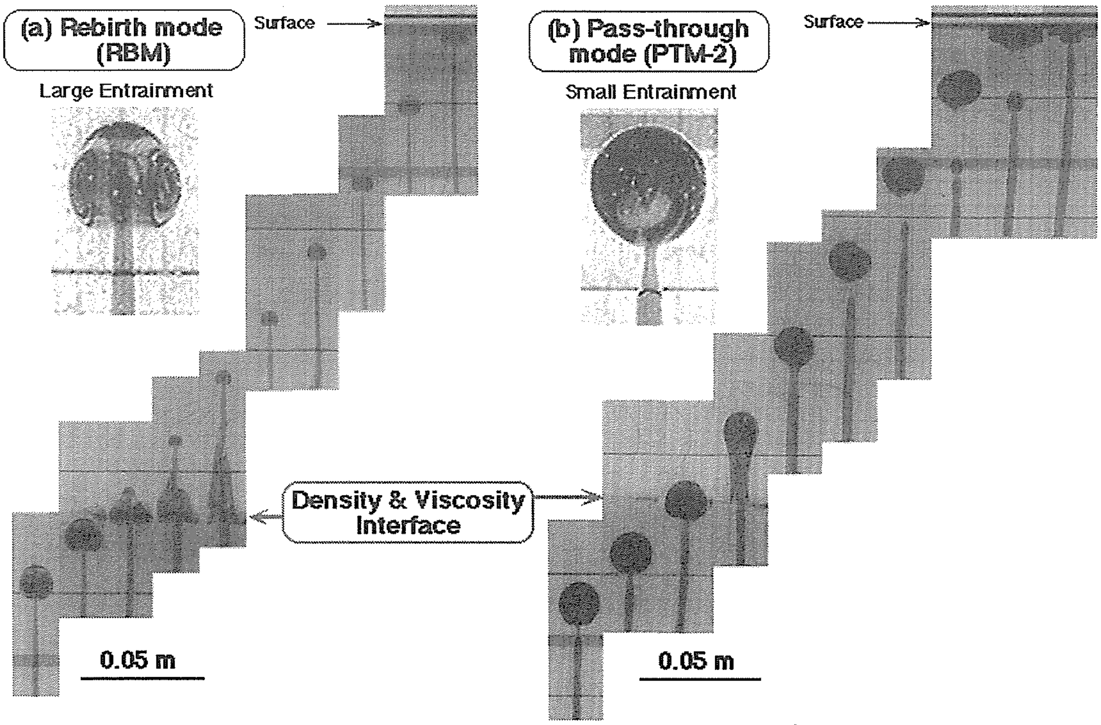


Fig. 1: A sequence of photos of RBM (a) and PTM-2 (b). In the case of RBM, large volume of the matrix fluid is entrained spirally into the plume head. In the case of PTM-2, the first plume head keeps holding the lower layer fluid in it even after passing through the interface. Fluid properties are same as Table 1. Time interval of RBM and that of PTM-2 are 250 and 100 sec, respectively.

Table 1 Fluid properties of mixtures (Syrup + Water) used in experiments (at 18.5 °C)

Fluid	Density (kg/m^3)	Viscosity (Pas)
Upper layer	1375	7.6
Lower layer	1385	29.4
Buoyant	1337	0.36

Amplitude Variation of Volcanic Tremor in Aso Volcano
- Monitoring with broadband seismometer -

Mori, T., Sudo, Y., Tsutsui, T., Yoshikawa, S.,
Kawakatsu, H., Kaneshima, S., Yamamoto, M.,

The tremor observation with a broadband seismometer is performed in Aso Volcano. The purpose of this observation is to investigate the mechanism of very-long-period volcanic tremor. Temporal amplitude variation of this very-long-period volcanic tremor was not distinguished until installed of the broadband seismometer in Hondo tunnel.

The tremor signals are telemetried from Hondo and recorded in a real time at A.V.L..Figure1 shows the temporal variation of volcanic tremor from November in 1998 to March in 1999. From December in 1998 to January in 1999, the amplitude of very-long-period volcanic tremor is at a lower level, but there was no change in volcanic activity.

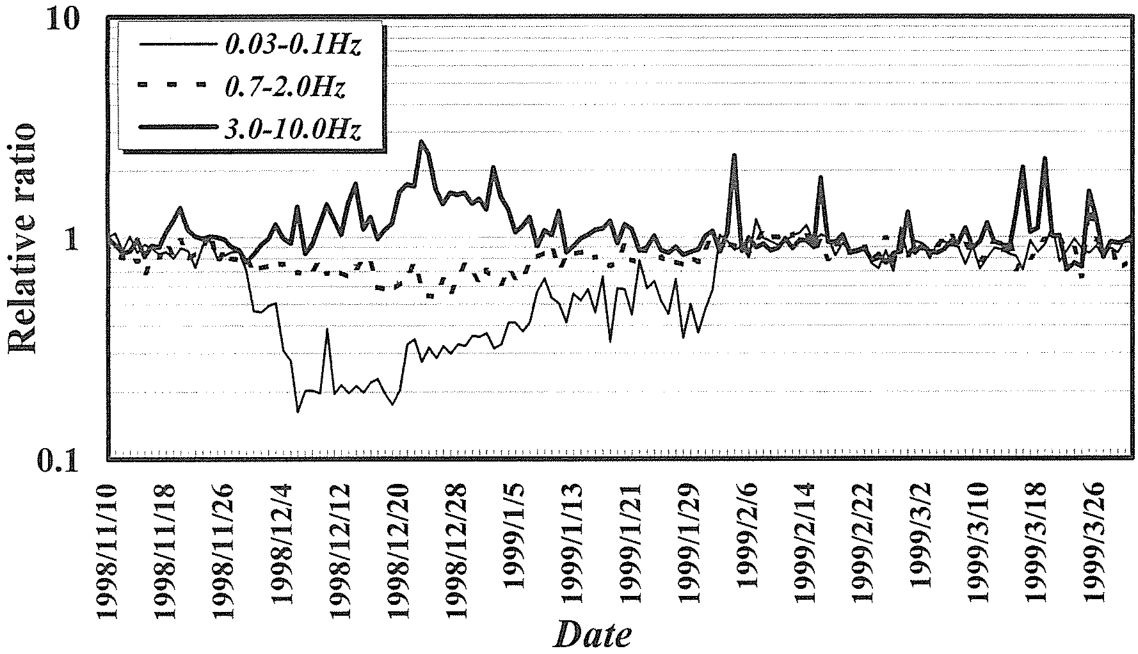


Figure1 RMS Amplitude Variation of Volcanic Tremor at Hondo tunnel (Type CMG3 Seismometer)
Note, the temporal change between short-period band (3.0-10.0Hz) and very-long-period band (0.03-0.1Hz).

Leveling survey at Aso Volcano

*Nakaboh, M., Ono, H., Sako, M., Hoka, T., Masuda, H., Yoshikawa, S., Hase, H., Hashimoto, T., Tsutsui, Y., Sudo, Garces, M., Diago, C. **, Yoshikawa, M., Tanaka, Y., Nishijima, J. *, Yoneshige, K. *, Kawaguchi, M. *, Kudou, T*. and Fujimitsu, Y. **

*Kyushu Univ., **OVSP(INGEOMINAS)

Leveling survey is the most precise measurement to obtain vertical ground deformation data. Since 1937, Aso Volcanological Laboratory (AVL) has made leveling measurements 15 times at Aso Volcano. The length of the survey line is about 17km. We found a subsidence zone between BM10405 and BM10407 that is in accord with the trend of the vertical ground deformation from 1958 to 1997. We made a new leveling survey at southwest side of Aso Volcano in November 1997 and June 1998 to estimate how the subsidence zone extends. This leveling route was constructed by Geographical Survey Institute (GSI) in 1989.

The vertical ground deformation from 1989 to 1998 is showed in the contour map on Fig. 1. The subsidence zone seems to extend to the south of AVL from the north of Kusasenri. We don't have enough number of data to determine a deformation model. However, as a first approximation, the subsidence area between BM10405 and BM10407 can be explained by a deflation Mogi source located between Yunotani and Kusasenri.

There were approximately 10 eruptions during 1950-1998. However, the elevation of the benchmark near the active crater (reference point is 5.3km from the crater) changes only 1-3 cm in this time period (Fig.2). The latest eruption occurred at Naka-dake in 1989. This fact indicates the possibility that Magma supply is well balanced to output flow by ash or Strombolian eruptions.

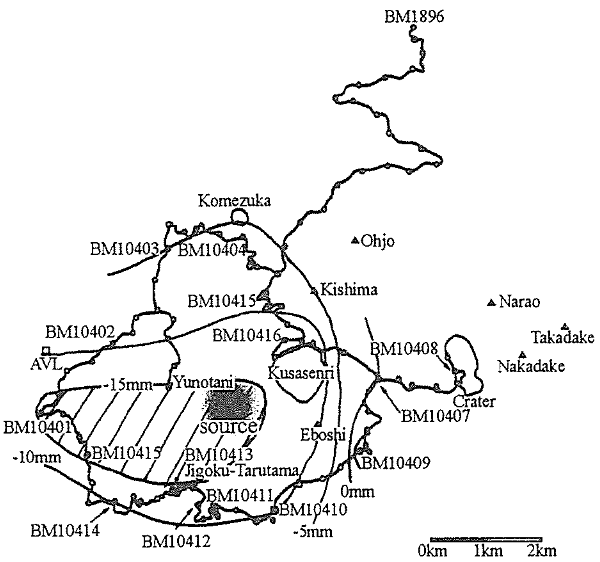
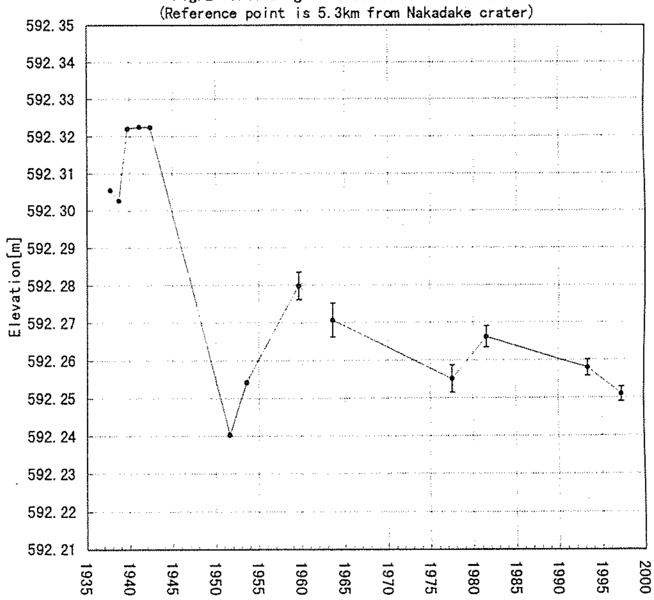


Fig.1 Vertical ground deformation at Aso Volcano from 1989 to 1998

Fig. 2 Vertical ground deformation at AVL-14 (Reference point is 5.3km from Nakadake crater)

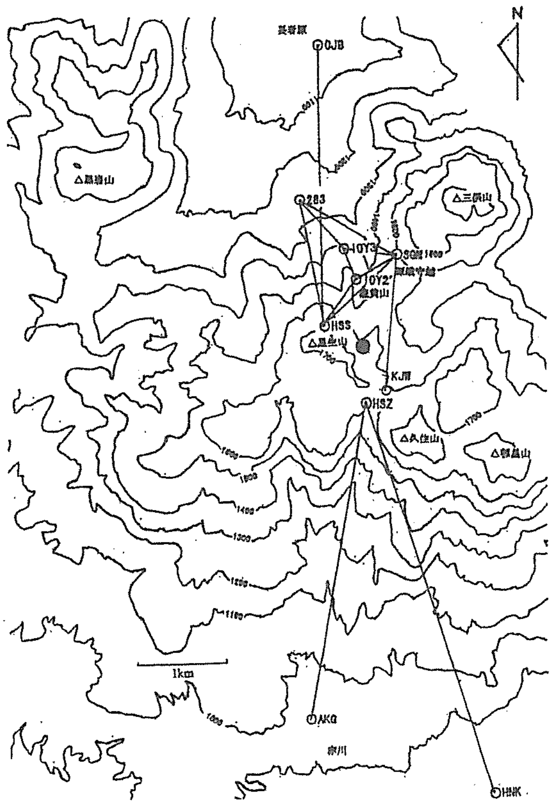


Ground deformation of Kuju Volcano

Nakaboh, M., Ono, H., Sako, M., Sudo, Y., Tsutsui, T., Mori, T., Masuda, H., Hoka, T., Yoshikawa, S. and Hashimoto, T.

Kuju volcano erupted on Octover, 1995 after 250 years dormancy. Fumarole activity from new craters and ground deformation near the craters have continued for 3.5 years after the eruption. EDM surveys have been carried out after the eruption. The base lines were showed in Fig. 1.

Distances along several base lines near the new crater showed predominant contraction. For example, the contraction of baseline SGM-HSS (distance 1110m) was 34cm for 30months after eruption and was equivalent to $-3x10^{-4}$ strain. The contraction of these base lines continued and base line SGM-HSS contracted 8cm in 1998. The source location of contraction didn't change at about 500m beneath the crater computed by Mogi's model.



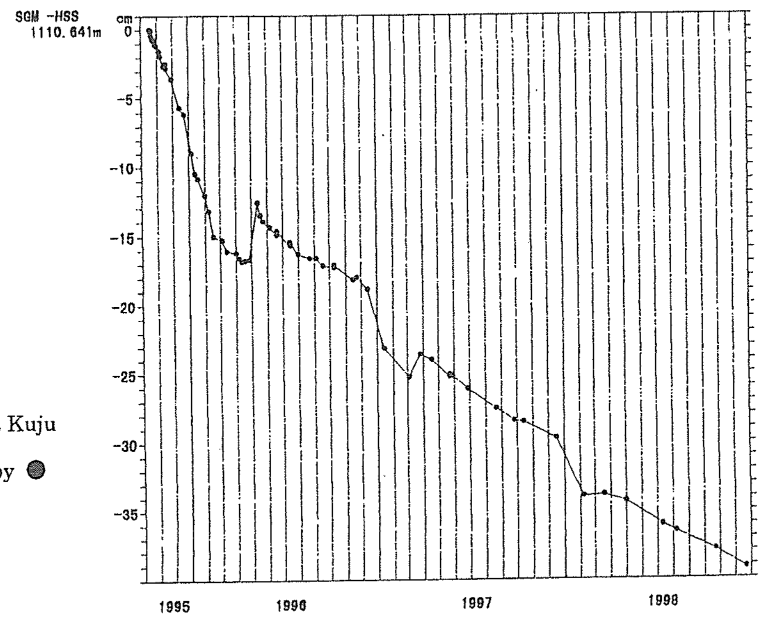


Figure 1. (upper)

Location map of EDM base lines at Kuju Volcano and new crater indicated by ●

Figure 2. (lower)

Variation of distance SGM-HSS.

High $\delta^{13}C$ magmatic CO_2 discharged from an active volcanic island, Ogasawara-Iwojima in Izu-Bonin arc

Ohsawa, S. and Yusa, Y.

The $^{13}C/^{12}C$ ratios of CO_2 in fumarolic gas and coral samples collected from an active volcanic island, Ogasawara-Iwojima in the Izu-Bonin arc were measured together with chemical compositions of the gas samples. Three carbon sources in fumarolic gas (air, coral and magmatic gas) are suggested from the relationship between the He/Ar ratio of the fumarolic gas and the stable carbon isotope composition of the fumarolic CO_2. The plot of concentration versus $^{13}C/^{12}C$ ratio of the fumarolic CO_2 indicates that the magmatic CO_2 in this island has remarkably high $\delta^{13}C$ value (+3 ‰), which is possibly derived from marine carbonate in the subducting oceanic sediments. The high $\delta^{13}C$ value of the magmatic CO_2 exceeding the mantle CO_2 in quantity suggests that the recyclic carbon by the plate subduction through the process of magma genesis of the Ogasawara-Iwojima Volcano. (Submitted to Chem. Geol.)

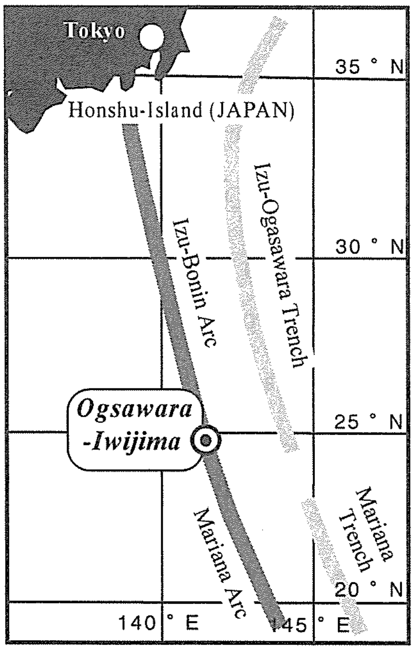


Figure 1. Location map of Ogasawara-Iwojima.

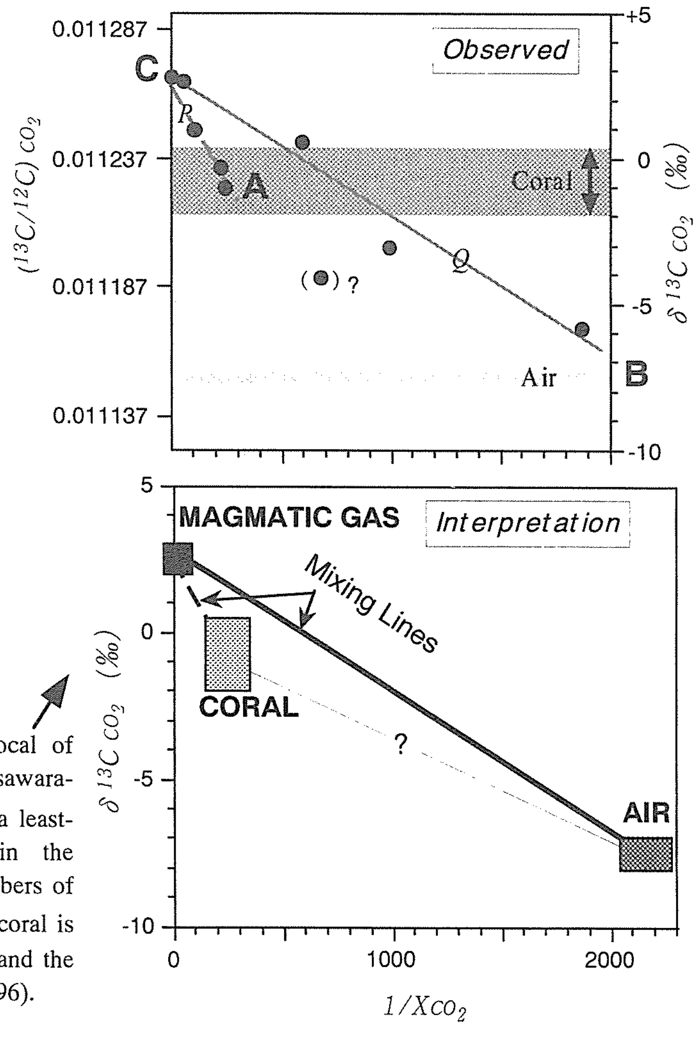


Figure 2. Plot of $^{13}C/^{12}C$ ratios and reciprocal of concentration of the fumarolic CO_2 from Ogasawara-Iwoijima. Lines P and Q show the best fits by a least-squares method excluding one data point in the parenthesis. A, B and C are presumed end-members of the mixing relations. Range of $\delta^{13}C$ values of coral is expressed by the measured values in this study and the value of air is cited from Sakai and Matsuhisa (1996).

Information of geothermal system and basement geology beneath Hakone Volcano, Japan, obtained by chemical compositions of discharged gases

Ohsawa, S., Yusa, Y. and Oyama, M.

Gas samples for chemical analysis were collected from fumaroles, steam wells and boiling pool in Owakudani, Sounzan and Iwoyama of Hakone Volcano, Japan. Althogh discharging temperatures of gases are relatively low (95.0～136℃) compared with those of ordinary volcanic gases, some gases have high ratios of H_2/Ar and CO_2/Ar similar to ratios of high temperature gases over 400℃ released from andesitic volcanoes. The others except for a steam from a drilling well in Sounzan are explained to be volcanic gas mixed with air. The gas from the steam well would be separated from hydrothermal water of about 240℃. The H_2/H_2O ratios of some gases from Owakudani are remarkably constant ranging from 1.12×10^{-4} to 1.03×10^{-4}, in spite of their SO_2/H_2S ratios widely ranging from 0.58 to 0.01 or below. This suggests that the H_2/H_2O ratio buffered by the reaction, $SO_2 + 3H_2 = H_2S + 2H_2O$, at an elevated temperature would be frozen due to rapid removal of SO_2 from the gas buffering system. Assuming the chemical equilibrium and using data showing the maximum SO_2/H_2S ratio, the apparent equilibrium temperature is calculated to be 430℃. The proportionality between HCl content and SO_2/H_2S ratio of the Owakudani gases points that a strongly acidic thermal water of $Cl\text{-}SO_4$ type is formed by absorption of HCl and SO_2 in the gas by shallow groundwater. The values of Cl/SO_4 ratio in the thermal water are estimated to be 0.46～1.7 assuming the disproportionation reaction, $3SO_2 + 2H_2O \rightarrow 2H_2SO_4 + S$, are in roughly agreement with the ratios of the acid $Cl\text{-}SO_4$ type thermal water taken from the drilled wells in Owakudani (0.65～0.78). Relative $He\text{-}Ar\text{-}N_2$ contents of the gas samples indicate that magmatic gas of Hakone Volcano has the N_2/He ratio of about 2000 identical with magmatic gases in the mainlands of Japan excluding Central Kyushu (Beppu-Shimabara Graben), suggesting that the Hakone's magmatic gas is derived from the magma seated within a latent sedimentary basement belonging to the Shimant Group. (Submitted to J. Balneological Soc. Japan)

Volcanic earthquakes near Naka-dake, Aso Volcano in 1998

H. Ono

Volcanic earthquakes locate beneath the active 1st crater of Naka-dake, Aso Volcano. The location of deeper source shifts to east. Volcanic earthquake near the Naka-dake doesn't occur below 3km depth under sea level. Most of shallow earthquakes are low frequency earthquakes which have predominant frequency below 7Hz. High frequency earthquakes locate under sea level and occur also in the period of calm stage.

Volcanic earthquake activity was calm in 1998 and was reflected in the quiet of crater activity. Shallow volcanic earthquake was not observed above sea level. The source distribution hasn't change for 20 years.

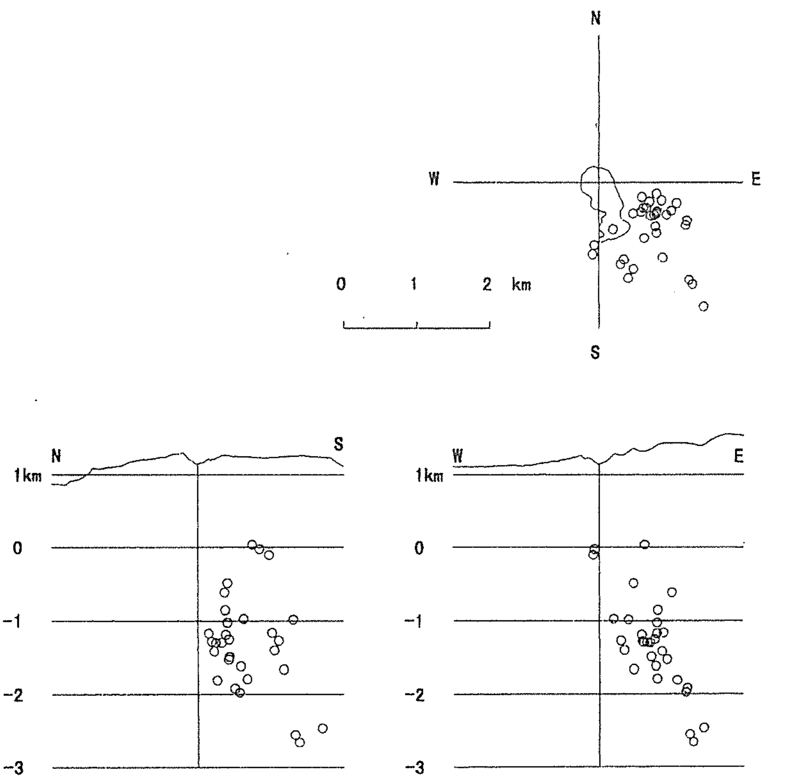


Figure 1. Source distribution of volcanic earthquakes near Naka-dake in 1998.

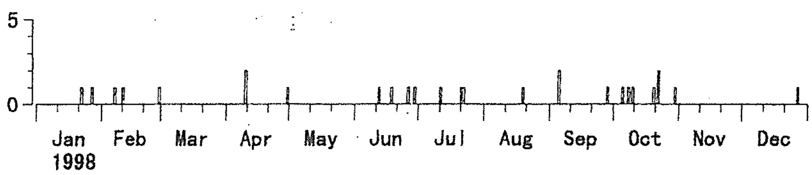


Figure 2. Daily frequency distribution of volcanic earthquakes in 1998.

Continuous observation of ground deformation using
water tube tiltmeters and extensometers
in underground tunnel near Naka-dake, Aso Volcano

Ono, H.

The tunnel for ground deformation observation locates in 30m underground at about 1km south-west of Naka-dake crater and consists of horizontal tunnels forming equilateral right-angled triangle. Watertube tiltmeters of 25m span (WT1 and WT2) and extensometers of 20m span (E1 and E2) and 25m span (E3) have been installed.

The remarkable ground deformation in 1998 was detected on the records observed water tube tiltmeters. Southward uplift of 4 μ rad/year has been observed except summer season since 1996. Southwest uplift of 8 μ rad were observed from July to December in 1998. This ground tilt indicate subsidence of crater side and is compatible with low activity of crater. But no other geophysical data showed predominant change in summer of 1998 and supported the ground tilt..

Extensometers recorded annual variation with strain amplitude of 10^{-6} order that is contraction in summer season and expansion in winter season

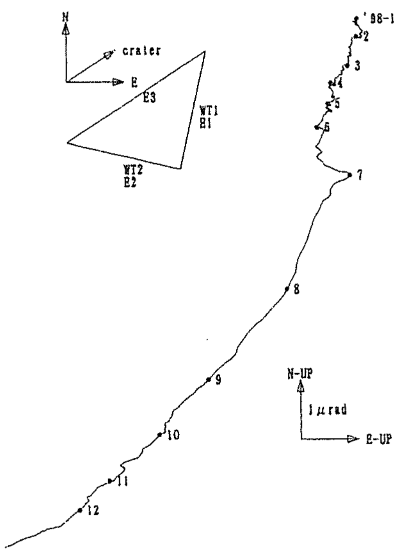


Figure 1. Tunnel and setting of watertube tiltmeters (WT1,WT2) and extesometers (E1,E2,E3) and upward vector from watertube tiltmeter observation. Attached numbers show months(1st day).

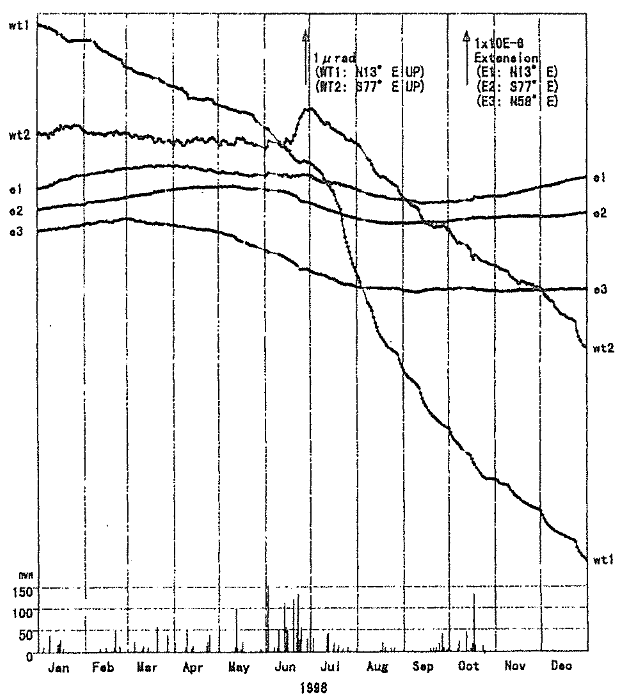


Figure 2. Ground deformation records in 1998. Lower is daily precipitation.

A new chemical geothermometer for strongly acidic thermal water

Oue. K., Ohsawa. S., Yusa. Y., Kawano. T.

Geothermometers enable to estimate temperature of the reservoir fluid, and they are valuable tools in the evaluation of geothermal field and in monitoring the geothermal system. All of them can be applied to hot spring water in a range of slightly acidic to weakly alkaline, but not to strongly acidic waters. The purpose of this study is to develop a geothermometer for strongly acidic thermal water.

Anhydrite ($CaSO_4$) is selected as mineral which is in equilibrium with strongly acidic thermal water on the basis of field observation and hydrothermal experiment using autoclave. Calculating procedure, on the other hand, is constructed based on the anhydrite equilibration. The errors in the use of the new geothermometer are within 7 ℃, which is predicted by comparison calculated results with measured temperature of strongly acidic mud pool and saturation temperature obtained by hydrothermal experiments.

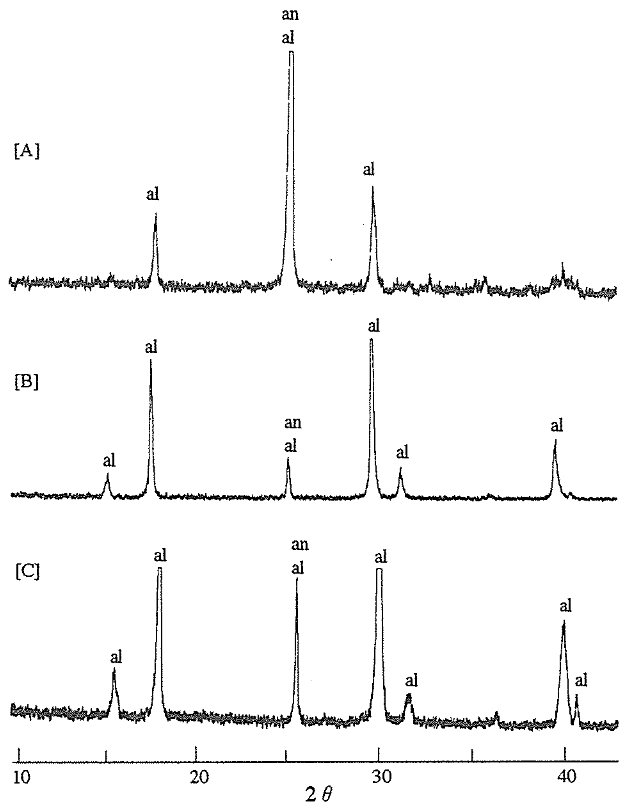


Fig.1 Results of XRD analysis of the perecipitates produced from heated strongly acidic hot spring water.
A: Kuju-Iwoyama, B: Myoban-Yamadaya,
C: Tsukahara hot spring an: anhydrite, al: alunite
(measuring conditions)
Target: Cu (Ni filter), 30kV-30mA, Slit: 1° -0.15-1° ,
Scan: 2 θ =0.5/min, Detector voltage: 1200V: Time constant: 1sec

Tectonomagnetic Models Evaluated by Numerical Surface Integrals

Sakanaka, S.

Local geomagnetic changes are sometimes accompanied by tectonic activities such as earthquake occurrences, volcanic activities, and crustal movements. Mechanical stress change in the crust is expected as one of mostly probable causes of the local magnetic changes. In order to investigate such local magnetic changes, a new method of numerical calculation for tectonomagnetic (piezomagnetic) modeling is developed and entailed problems in application of the method are discussed. The new method in this study is based on surface integrals numerically estimated over the surface of a magneto-elastic medium, instead of volume integrals traditionally employed in this research field.

First the new surface integral method is applied to two-dimensional models, in addition, three-dimensional models in volcanomagnetism. The size effect of elements in numerical modeling is investigated in both two-dimensional and three-dimensional cases. As for two-dimensional cases, a hybrid method combined the surface integral method with BEM (Boundary Element Method) is introduced in this study and applied to practical problems. It is confirmed that the hybrid method can effectively exploit an advantage of numerical calculations, which can apply to an arbitrarily shaped medium. Secondly, as an example of calculations for three-dimensional tectonomagnetic models, magnetic changes due to an inclined columnar pressure source are evaluated in respect of several parameters. Finally, making use of one of advantages of the surface integral method, which can treat arbitrarily shaped demagnetized areas, an effect of a combination of inflated and deflated sources with a demagnetized area is evaluated.

One of examples of the magnetic changes that have not calculated so far is shown in Fig.1. A semi-infinitely long pressure source is supposed to be inflated underground. An inclined source model proposed by Walsh and Decker (1971) have been sometimes compared to a pressure source within volcanic bodies. Given several parameters, we can obtain the distribution of the magnetic changes as the result of stress and/or strain changes. When the (geomagnetic) inclination is 0°, the magnetic changes become smaller as the dip angle of the columnar source gets larger as shown in Fig.1. On the other hand, when the inclination is 90°, the magnetic changes become larger as the source gets upright.

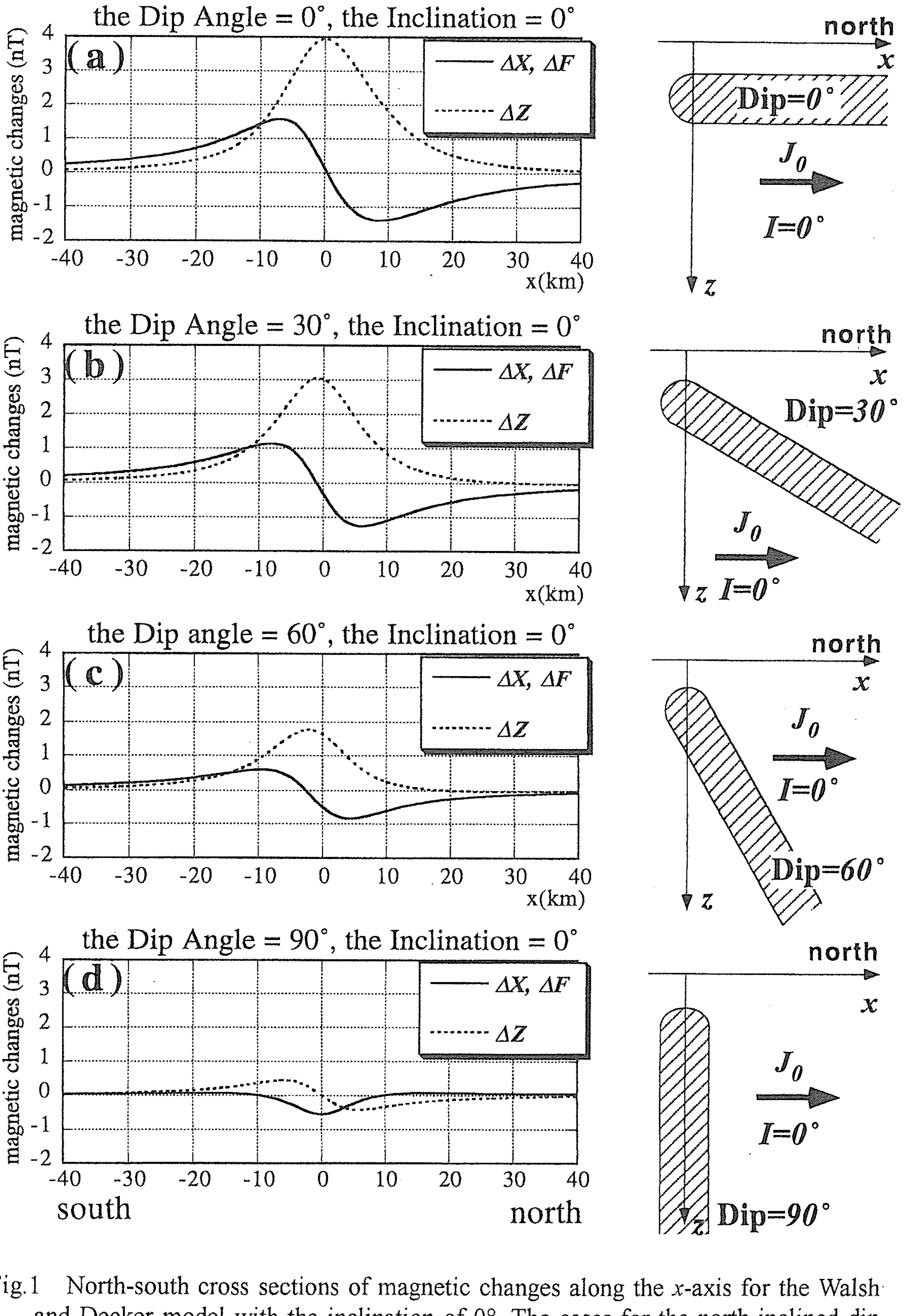


Fig. 1 North-south cross sections of magnetic changes along the x-axis for the Walsh and Decker model with the inclination of 0°. The cases for the north-inclined dip angles of the column source for (a) 0°, (b) 30°, (c) 60°, and (d) 90°are presented. The north component, ΔX, the downward component, ΔZ, and the total intensity, ΔF, are shown. The uppermost end of the column is placed just below the origin of the x-axis.

Determination of boron content in volcanic rocks by using neutron-induced prompt gamma-ray: correction of count rate fluctuation using silicon internal standard

Sano, T., Fukuoka, T., Hasenaka, T., Yonezawa, C., Matsue, H., and Sawahata, H.

We improved procedures to analyze boron contents in volcanic rocks by using neutron-induced prompt gamma-ray.

The improvements include: (1) calculation of boron peak area only for the high energy half portion to avoid sodium peak overlap effect (Fig. 1), (2) Increase of sample weight by using pressed powdered pellets to save irradiation time (Fig. 2), (3) correction of boron peak count rate fluctuations and effect of sample geometry using silicon as an internal standard (Fig. 3).

We determined the boron contents of GSJ (Geological Survey of Japan) volcanic standard rocks more than three times, to get less than 8 % error. Our boron analyses agree well with the recommended values obtained from previous analyses.

(RADIOISOTOPES, 47, 735-744, 1998)

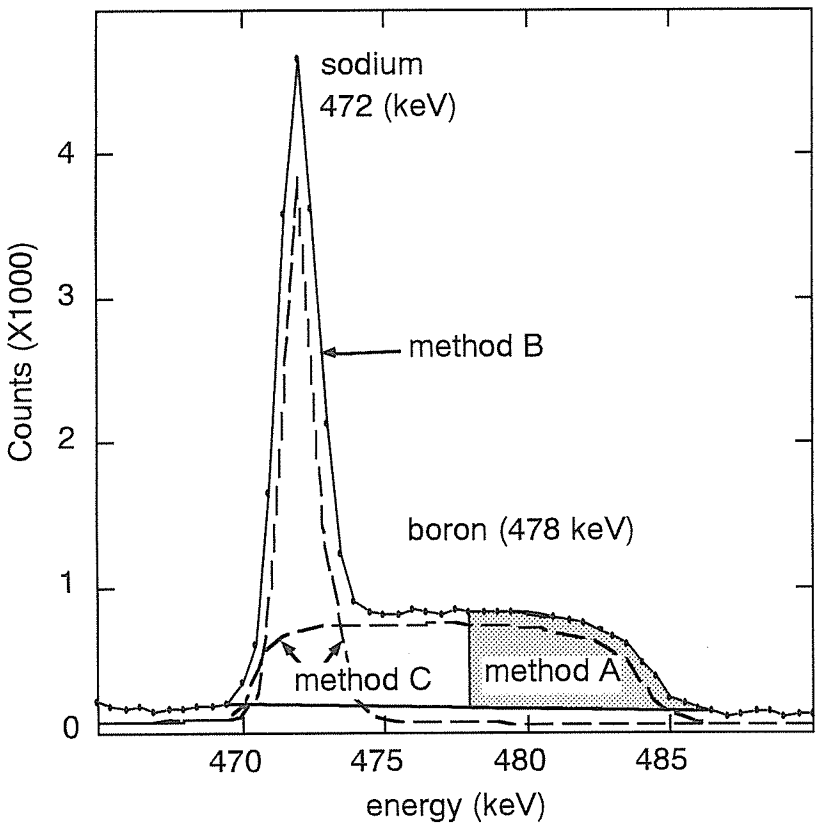


Fig. 1. A doppler-broadened boron peak (478 keV) showing sodium peak (472 keV) overlap. Three methods of compensation for the sodium interference on boron are indicated. A) Only the shaded right-hand region is integrated, B) The overlapped sodium peak area was estimated from that of 92 keV peak as a reference. C) The interfered peak was decomposed by fitting the boron and sodium peaks as the Gaussian function curve.

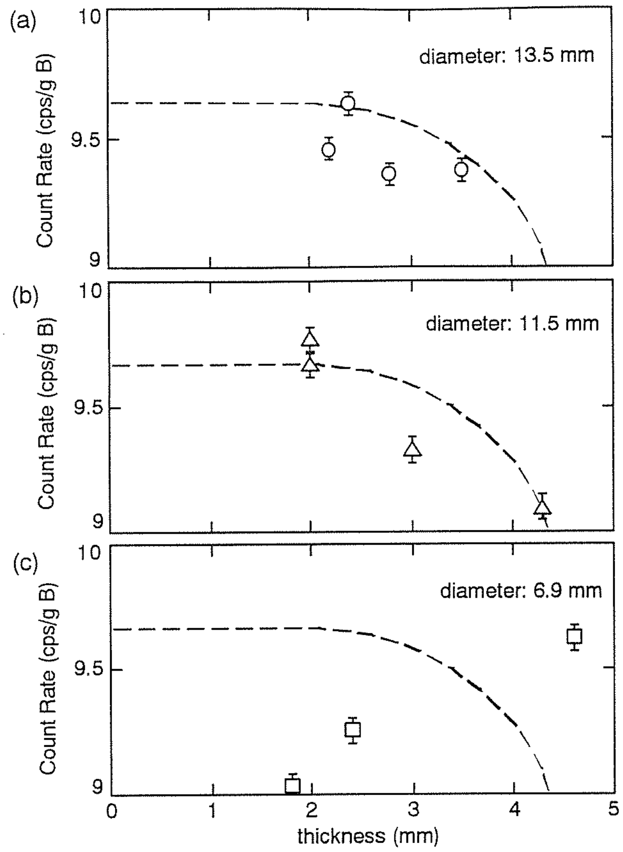


Fig. 2. Effect of sample thickness variations for boron count rates of a volcanic rock (GSJ JR-1). Diameters of the cold-pressed samples are (a) 13.5 mm, (b) 11.5 mm and (c) 6.9 mm. Error bar shows ±1_standard deviation.

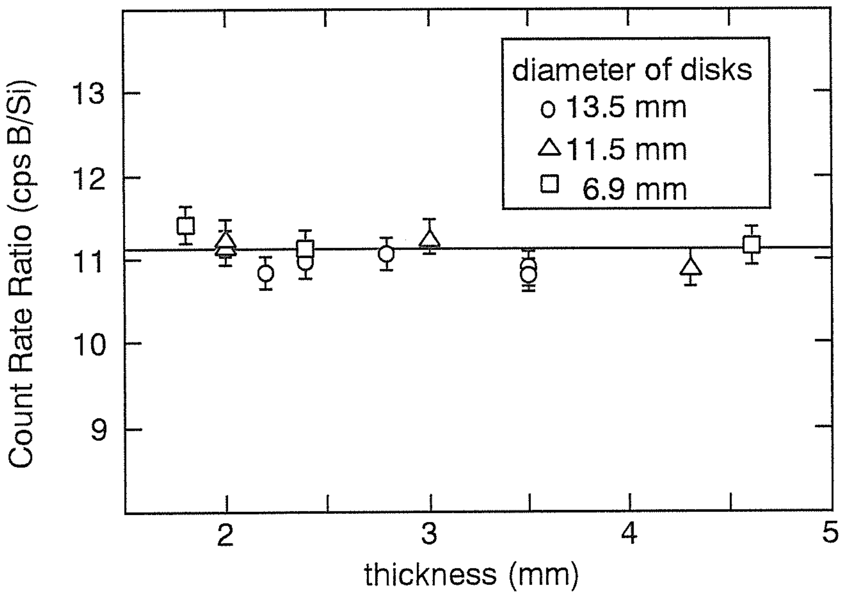


Fig. 3. Ratio of boron to silicon prompt gamma-ray intensity (cps/g) for the analysis of volcanic rocks shown in Fig. 2. Symbols are the same as in Fig. 2.

Accurate and efficient determination of boron content in volcanic rocks by neutron induced prompt gamma-ray analysis

Sano, T., Fukuoka, T., Hasenaka, T., Yonezawa, C., Matsue, H., and Sawahata, H.

An accurate and efficient analytical method using neutron-induced prompt gamma-ray was developed for the determination of boron contents in volcanic rocks.

We corrected the effect of sample geometry and flux fluctuation by using silicon as an internal standard. However, we found that the slopes of the calibration line vary among volcanic samples with different matrix (Fig. 1). Because the increase of boron activity correlate positively with gamma-ray count rate of hydrogen (Fig. 2), we call this as the hydrogen effect. The hydrogen effect was confirmed by our experiment in which the boron activities showed systematic increase with the amount of added hydrogen (Fig. 3). Most volcanic rocks, however, contain little water (< 2 wt. %) to show this effect.

We determined boron contents in various volcanic rocks in order to confirm the validity of the procedure that we established. The analyzed boron contents agreed well with the previous reported values (Fig. 4).

For efficient PGA of boron in volcanic rocks, we recommend JB-2 (GSJ standard rock) as a single geochemical standard, because of its high boron content (31.2 ppm).

(J. Radioanal. Nucl. Chem., 239. 613-617, 1999)

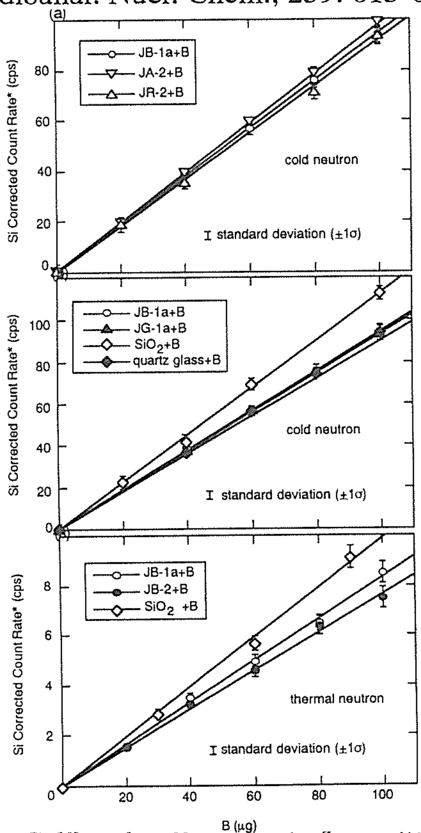


Fig. 1. Calibration lines made from different standard sample disks, each of which contain known amount of boron standard solution. The disks are made of cold pressed volcanic rock powders. The gamma-ray measurements were carried out by using a), b) cold neutron and, c) thermal neutron flux.

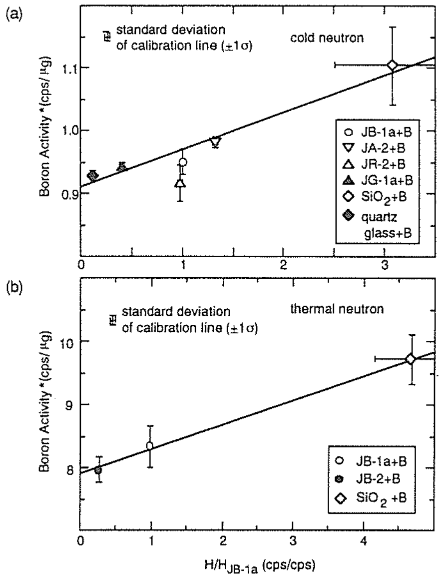


Fig. 2. Inclination of the calibration line in Fig. 1 plotted against the normalized count rate of hydrogen for each sample. The hydrogen count rate for each sample is divided by that of JB-1a samples. a) cold neutron and, b) thermal neutron flux.

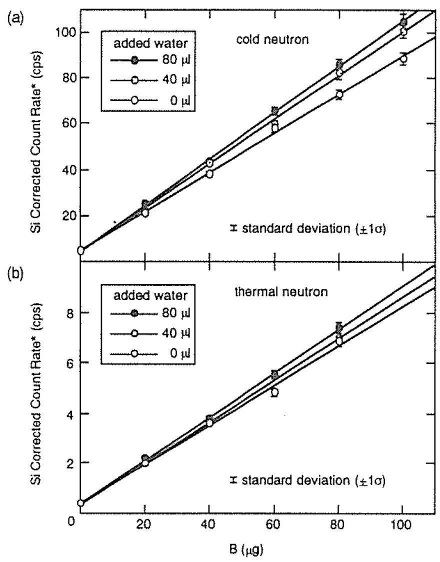


Fig. 3. Results of boron analyses for disks that contain known amount of boron standard solution and different water content. The gamma-ray determinations were carried out by using a) cold neutron and, b) thermal neutron flux.

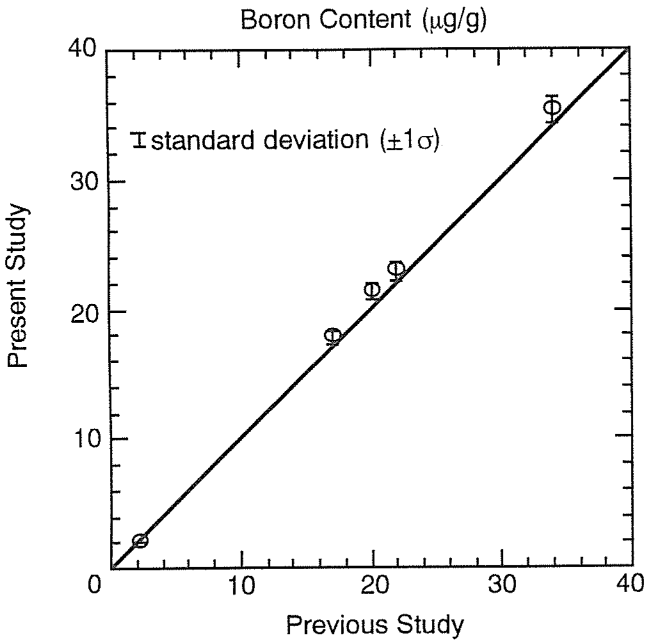


Fig. 4. Analytical results of boron contents in some volcanic rocks plotted against the previously reported value. The analyses were carried out by the irradiation of cold neutron flux.)

Seismic Activeity around Aso Caldera and Kuju Volcano in 1998

Sudo, Y.

A telemetrically seismic network around Aso Caldera and Kuju Volcano is composed of 10 stations. Several earthquake swarms have occurred at the western region of Aso Caldera and the northwestern side area of Kuju Volcano. From May to September in 1998, at the northern caldera floor small swarms occurred, some events were felt. From May to July at the southwestern region of Kuju Volcano many earthquakes occurred. The mechanisms of their events indicate a combination of both normal and right lateral strike-slip type faults. The tension axis maintains a horizontal north-south orientation. From attempts to image the upper crustal structure beneath Aso Caldera and Kuju Volcano using the residual delay times of P-waves, it was confirmed that the low velocity regions are located at the depth of 6km beneath the west central cones, not beneath the active crater, in Aso Caldera and are located at the same depth beneath the northern area of Kuju Volcano.

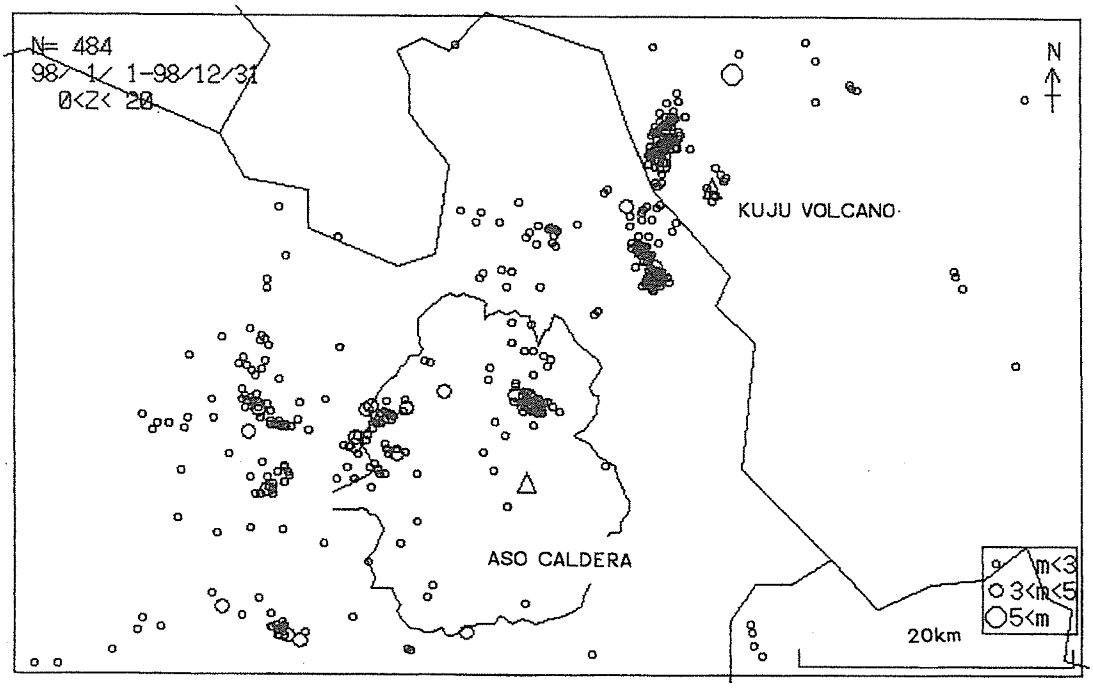


Figure 1: Distribution of epicenters around Aso Caldera and Kuju Volcano in 1998.

Temperature changes at depths to 150 metres near the active crater of Aso Volcano

Sudo, Y. and Hurst, A.W.

Two holes were drilled to depths of 150 m and 70 m from the surface about 200 m from the active crater of Aso Volcano and quartz thermometers were installed in the holes at depth intervals of 30 m and 35 m, respectively. This series of observations is one of the first measurements of temperature at depth so close to an active crater. The ground temperature at a depth of 2 m had an annual variation with a range of about 10 ℃, as expected, clearly corresponding to the atmospheric temperature variation, but delayed by about one month. Temperatures measured at depths from 30 m to 70 m had very small annual temperature variations. The range of temperature at 30 m depth was about 0.04 ℃. The temperature at a depth of 60 m, however, was particularly stable, probably because at this depth the hole is in the middle of a massive lava flow. At depths of 70 m or more, small (less than 0.2 ℃) annual temperature variations were again observed. These variations are probably due to the effects of surface water descending to these levels through cracks and fissures. At 120 m depth, the average temperature is about 17.5 ℃, over 5 ℃ above the surface average temperature, and the annual temperature variation has a range of about 2 ℃, out of phase with the atmospheric changes. This is probably due to the interaction of rainfall descending from the surface with convecting hotter fluids from below. The temperature gradient below 100 m depth is very high, with the average temperature at a depth of 150 m being about 31 ℃. The temperature variations at this depth are dominated by long-period variations, with a steady decline after a peak in November-December 1989, overlain by a rather irregular seasonal variation, with a range of about 0.5 ℃. October 1989 was the time of most active volcanic activity, with Strombolian eruptions depositing ash to a distance of 50 km from the crater, accompanied by very high amplitude volcanic tremor. So the temperature changes at 150 m seem to be mainly the result of volcanic activity. The maximum temperature at this depth occurred one or two months after the peak of observed volcanic activity. So it is likely that the temperature variations show a delayed influence of the level of volcanic activity. These results show that in the unconsolidated materials often found by active volcanic craters, the effects of seasonal atmospheric variations are carried to substantial depths by groundwater flows, so that at Aso Volcano, only at the maximum depth of 150 m are the temperature variations clearly dominated by the level of volcanic activity.

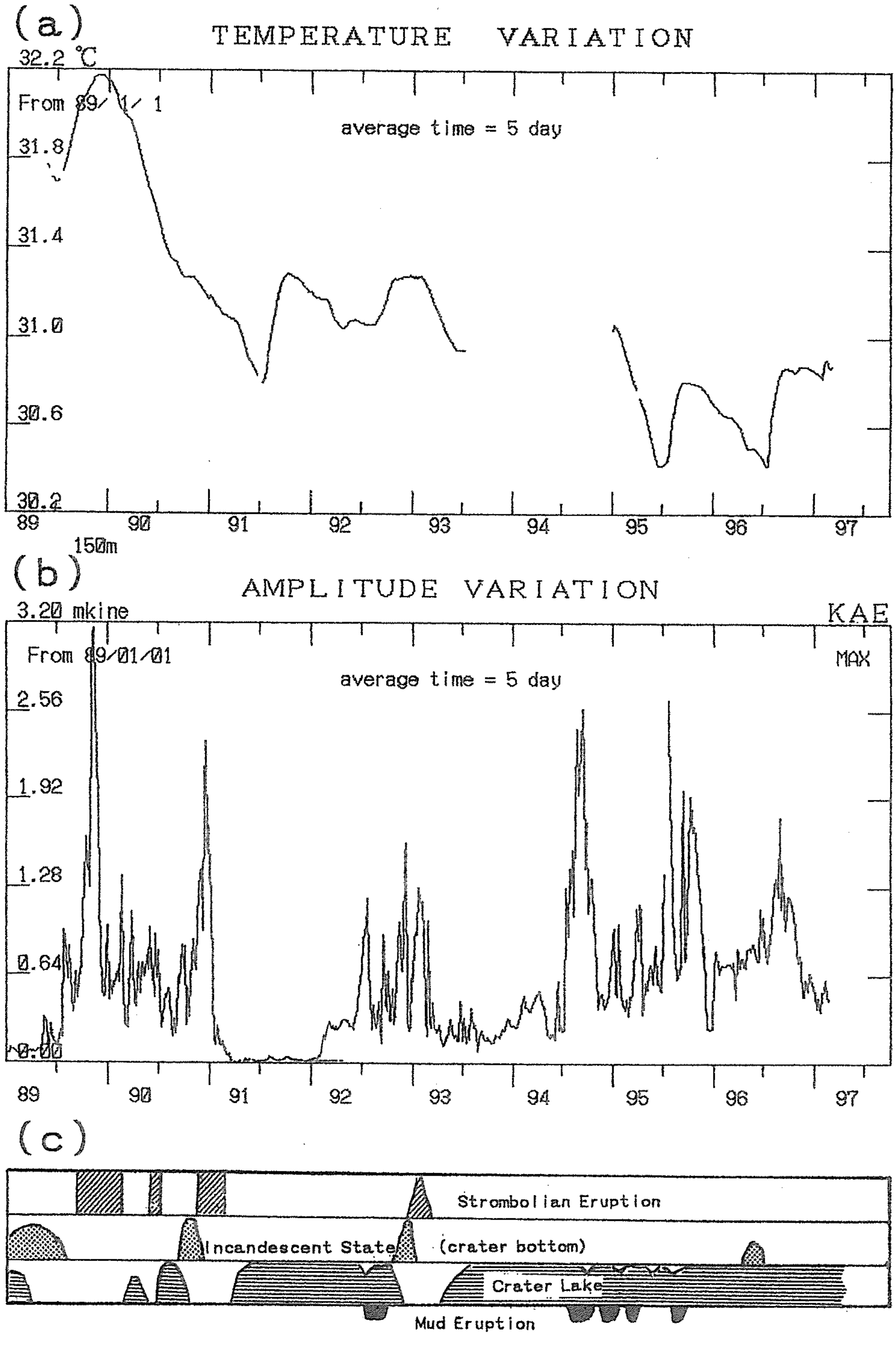


Figure 1 (a) Temperature changes at a depth of 150 m in 150 m hole. The temperature attained a maximum in December 1989 and then has been falling gradually. (b) Amplitude variations of volcanic tremors observed at the nearest station KAE, about 300 m east from the centre of the crater. The amplitude is the maximum value measured every 3 seconds and averaged over every 5 days (Sudo, 1988). Changes in volcanic tremor amplitudes closely correspond to the states of volcanic activity in 1st Crater. (c) Volcanic states in 1st Crater, during the period from 1989 to 1996. During the active state, when the crater was ejecting a lot of ash and scoria-blocks as Strombolian eruptions, or producing very strong rumbling sounds or mud eruptions, the amplitude of volcanic tremor was always at a high level.

Three-dimensional P-wave velocity structure in the upper crust beneath Kuju Volcano, central Kyushu, Japan

Sudo, Y. and Matsumoto, Y.

Kuju Volcano lies near Aso Caldera at the center of Kyushu Island, western Japan. After a few hundred years of dormancy, a phreatic explosion accompanied by a small ash eruption occurred on 11 October, 1995. This study was undertaken to determine the subsurface seismic velocity structure associated with the active magmatic regime in the Kuju volcanic region. The three-dimensional, upper crustal, P-wave velocity structure beneath Kuju Volcano was determined using methods for the simultaneous inversion of P-wave arrival times from local earthquakes in and around the Kuju volcanic region for velocities and hypocentral parameters. Results reveal two shallower low velocity anomalies located in the northern and southern parts of Kuju Volcano, consistent with the presence of significant negative Bouguer gravity anomalies. In addition, a high velocity anomaly is located about 5 km northwest of Mt. Kuju, one of the domes in Kuju Volcano. Beneath this high velocity anomaly, a low velocity anomaly is present. This velocity structure suggests a magmatic regime that has a lid consisting of a cooled solid material overlying a chamber of partially molten material.

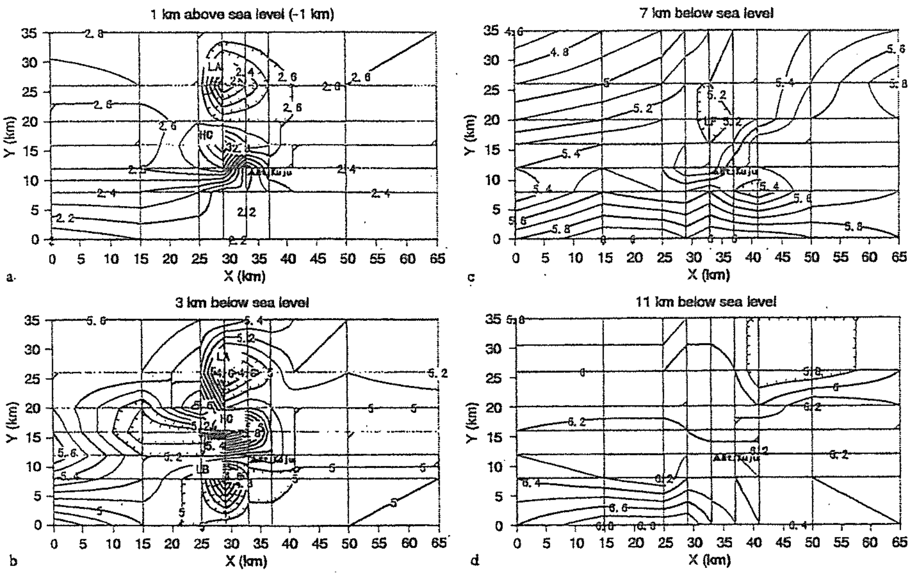


Figure 1 P-wave velocity results of the final step. Layers of -1 km, 3 km, 7 km, and 11 km are shown. Some low and high velocity anomalies are present. The high velocity anomaly at the center (HC) is present in layers from -1 km to 3 km. Two low velocity anomalies at the north (LA) and south part (LB) of the center are present in layers from -1 km to 3 km. In addition, one low velocity anomaly (LF) is present at the north of the center in 7-km layer. Layers below 15 km are not shown because there is little resolution at these depths.

Disturbance of Re-Os chronometry in molybdenites from the late-Caledonian Galway Granite, Ireland, in post-depositional alteration.

***Suzuki, K.**, Feely, M. and O'Reilly, C.*

Re-Os ages were determined for molybdenites from the late-Caledonian Galway Granite in the west of Ireland. Molybdenites from three localities within the batholith, Mace Head, Murvey, and Travore, yield respective Re-Os ages of 425.2 ± 3. 1 Ma, 383.2 ± 8.1 & 426.1 ± 5.5 Ma, and 338.9 ± 5.6 & 464 ± 28 Ma. These molybdenites from three localities were deposited contemporaneously. However, the Re-Os ages obtained for each locality are not only in disagreement with the ages of the samples from the other localities and but also are inconsistent even within each locality (Fig. 1). In addition, most of the Re-Os ages obtained in this study deviate from the ages of magmatic activity; the Rb-Sr age of 398 ± 10 Ma and the U-Pb age of 412 ± 15 Ma (Fig. 1). Our previous studies demonstrated that the analytical technique has given reliable Re-Os ages for molybdenites from various locations (Suzuki et al., 1992; 1993; 1996) and therefore discrepancies of the ages should not be attributed to analytical errors. Suzuki et al. (1999) revealed experimentally that the Re-Os system in molybdenite has an open-system behavior in a certain alteration condition. Detailed fluid inclusion studies (Gallagher et al. 1992 and O'Reilly et al., 1997) have shown that the Galway Granite was subjected to a major incursion of moderate temperature (270-340°C) and moderate salinity (0-10 wt.% NaCl eq.) fluids of meteoritic origin after the deposition of molybdenite. These results suggest that the Re-Os systematics of molybdenites from the Galway Granite have been perturbed by the hydrothermal alteration.

(to be submitted to Geology)

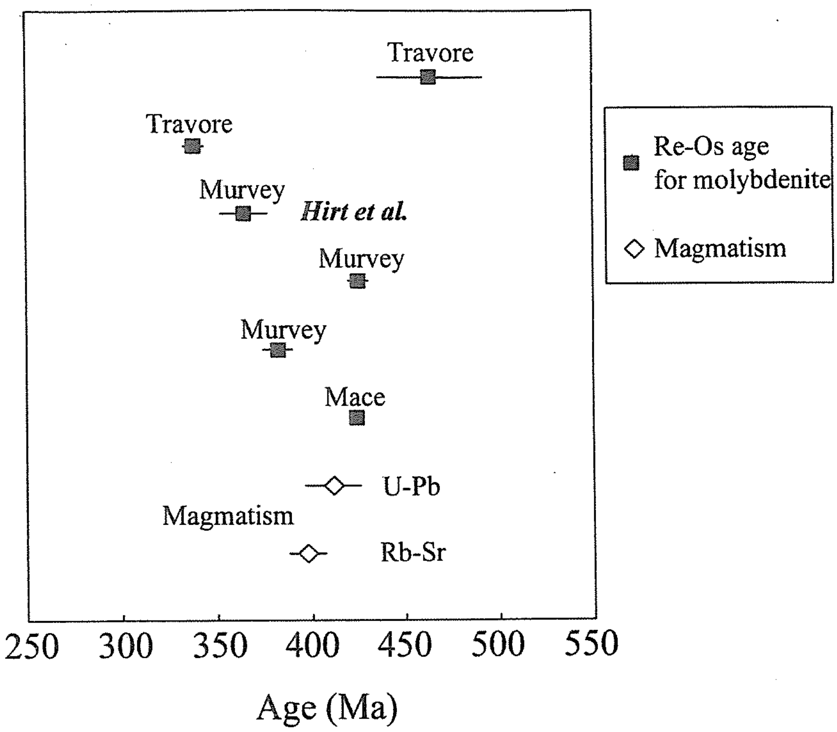


Fig. 1. Re-Os ages for molybdenites from Mace, Murvey, and Travore in the Galway Granite. The Re-Os age obtained by Hirt et al. (1963) and magmatism ages (Rb-Sr, Leggo et al., 1966; U-Pb, Pidgeon, 1969) are also shown.

Re-Os isotope systematics of Rottenstone Ni-Cu-PGE deposit, Canada.

Suzuki, K., Hulbert, L., Miyata, Y., Amakawa, H. and Nozaki, Y.

The Re-Os system is uniquely suited to ascertain the crystallization age of the host mafic-ultramafic intrusions and the metallogenesis of contained magmatic sulfides, which are generally not amenable to other isotopic systems. However, the successful cases of Re-Os dating of sulfide minerals have been limited except for molybdenites (e.g., Suzuki et al., 1993; 1996; Stein et al., 1998). In this study, Re-Os isotope systematics were applied to investigate the Rottenstone Ni-Cu-PGE sulfide deposit of northern Saskatchewan, Canada.

Os and Re concentrations of the samples were determined through isotope dilution mass spectrometry. Samples were decomposed by the microwave digestion method, modified from Suzuki et al. (1992). Our repeated trials revealed that the Carius tube decomposition (Shirey and Walker, 1995), which is commonly used for Re and Os analysis, is not suitable for digestion of sulfide minerals. High Re blanks in the mass spectrometric procedure, which were pointed out in some papers (e.g., Birck et al., 1998, Shen et al., 1996), were carefully checked in this study: blanks in filaments, in Ba solution loaded with samples, in a filament holder and in the spot weldering procedure, and memory effects in a de-gassing machine and a mass spectrometer. Finally, the mass spectrometric blanks of Re were reduced to 1 - 2 pg.

The Re and Os isotopic results obtained for 7 samples from the Rottenstone deposit yields an Re-Os isochron age of 2820 ± 45 Ma (MSWD = 1.851, n = 7) with an initial $^{187}Os/^{188}Os$ ratio of 0.12292 (γ Os = +14 at 2820 Ma). The sulfide samples from Rottenstone ore give the positive γ Os values of +7 - +21, indicating slight crustal contamination their its formation. On the other hand, the samples from Tremblay-Olsen and Red Hill show the γ Os values of +990 - +3000 and +1970, respectively. These extremely positive values suggest greater contamination of crustal materials.

Common Os concentrations obtained for samples from the Rottenstone ore are plotted against their Re/Os ratios in Fig. 2. We propose a model of the ore genesis involving (1) mixing of 90 % komatiite and 10 % sulfidic sediment, (2) a process of R-factor, i.e., the mass ratio of the flowing silicate liquid to the immiscible sulfide liquid and (3) 20 - 50 % fractional crystallization of mono-sulfide solid solution. The data obtained for the Rottenstone samples are plotted near the fractional crystallization path (Fig. 2), and therefore this model possibly explain the ore formation process. Additionally, the model is consistent with the results of the Os isotopic ratios, the PGEs abundance patterns and the S/Se ratios. The ore forming process modeled in this study is likely illustrated in Fig. 3.

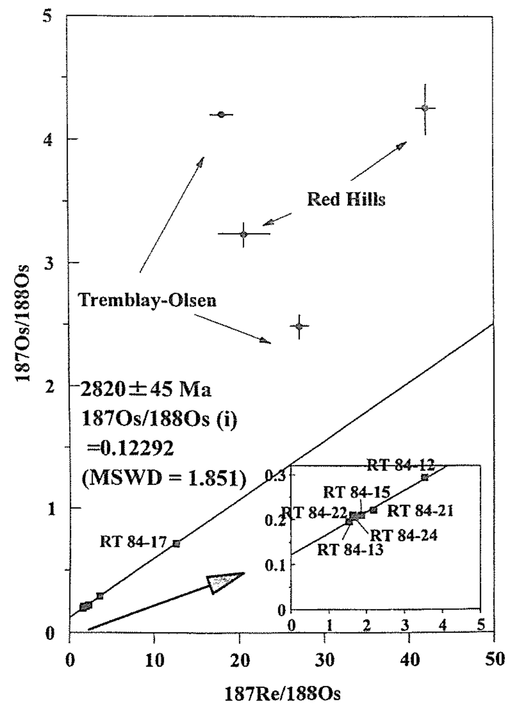


Fig. 1. Re-Os isotopic plots for sulfides from the Rottenstone, Tremblay-Olsen and Red Hill ore deposits, Canada.

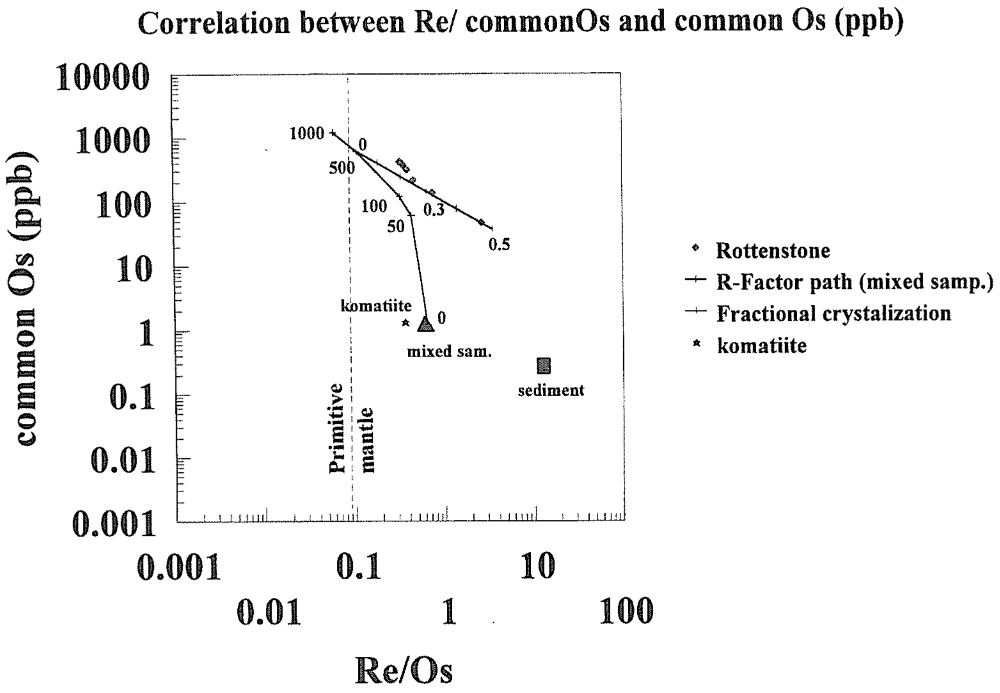


Fig. 2. Common Os concentration vs. Re/Os ratio plots for sulfide samples from the Rottenstone ore.

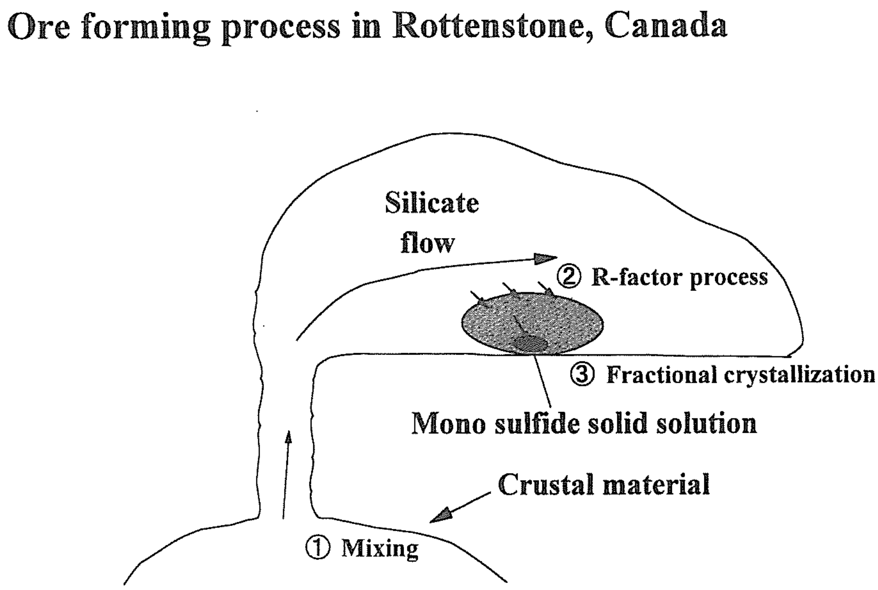


Fig. 3. A possible model of the ore formaiton process of the Rottenstone ore deposit.

Experimental alteration of molybdenite: Fractionation of Re-Os system and change in infrared spectroscopic profile.

Suzuki, K., Kagi, H., Nara, M., Takano, B. and Nozaki, Y.

Experiments have been carried out to clarify the effect of alteration on Re-Os system and infrared (IR) spectroscopic characteristics of a natural molybdenite mineral (MoS_2). The molybdenite sample was placed in H_2O and various media of 0.1 M NaCl, $NaHCO_3$, $CaCl_2$, and $AlCl_3$ solutions, and heated in a sealed quartz tube at a temperature of 180 °C for 20 days. The unaltered and altered samples were subsequently used for analysis of Re and Os, IR microscopy and spectroscopy, and micro-focus X-ray diffraction (XRD). Re-Os ages of the molybdenite subjected to NaCl and $NaHCO_3$ solutions show deviation from the age of the original unaltered molybdenite (Fig. 1). This result demonstrates the possibility of Re-Os fractionation even in natural environments similar to the experimental condition adopted here. The molybdenite used for the experiment is originally opaque under near infrared (NIR) light (Fig. 2a). After the experimental alteration, some parts of the molybdenite subjected to $CaCl_2$ and $AlCl_3$ solutions become transparent under the NIR microscope (Fig. 2b, 2c). In addition, the original molybdenite before the experimental alteration has an IR profile with two-fold stepwise increases in transmittance with decreasing wavenumber in the regions of 11500 - 10000 cm^{-1} and 3000 - 1000 cm^{-1} (Fig. 3). Low transmittance is observed in the region of 10000 - 3000 cm^{-1} , which is consistent with the opaque texture under the NIR microscope observations. The molybdenite subjected to NaCl and $NaHCO_3$ solutions and H_2O changes its IR profile little. On the contrary, molybdenite induced in $CaCl_2$ and $AlCl_3$ solutions shows high transmittance through 10000 - 1000 cm^{-1} and resulting in greater increase of transmittance in 11500 - 10000 cm^{-1} (1.4 - 1.2 eV) as shown in Fig. 3, which is close to the band gap energy of synthesized pure MoS_2 (1.4 - 1.2 eV). The increase in transmittance in 3000 - 1000 cm^{-1} (0.37 - 0.12 eV) observed in the original molybdenite suggests the existence of an impurity band in natural molybdenite at 0.12 eV below the conduction band (Fig. 4). High IR transmittance in the region of 10000 - 3000 cm^{-1} found for the molybdenite subjected in $CaCl_2$ and $AlCl_3$ solutions is possibly attributed to the removal of the impurity band in the molybdenite, and the band structure of these samples changed to be similar to that of pure MoS_2 (Fig. 4).

(submitted to Geochim. Cosmochim. Acta)

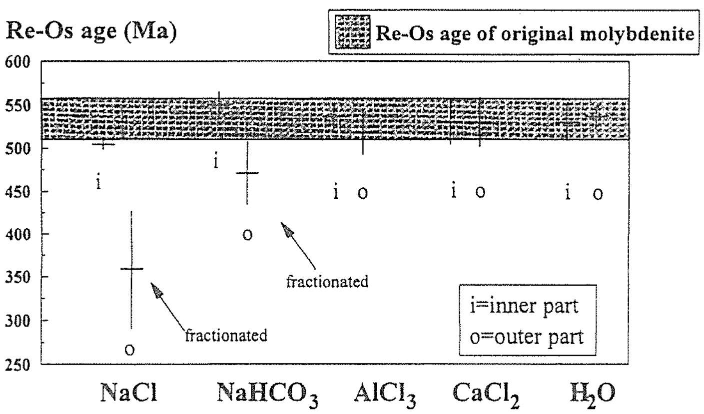


Fig. 1 Re-Os ages obtained for molybdenites altered in the various media of 0.1 M NaCl, $NaHCO_3$, $CaCl_2$, and $AlCl_3$ solutions and H_2O. Shaded area means Re-Os age of unaltered molybdenite, including analytical errors. Bars in the left and the right sides for each altering solution are the data for the inner and outer parts of the altered material, respectively.

(a) (b) (c)

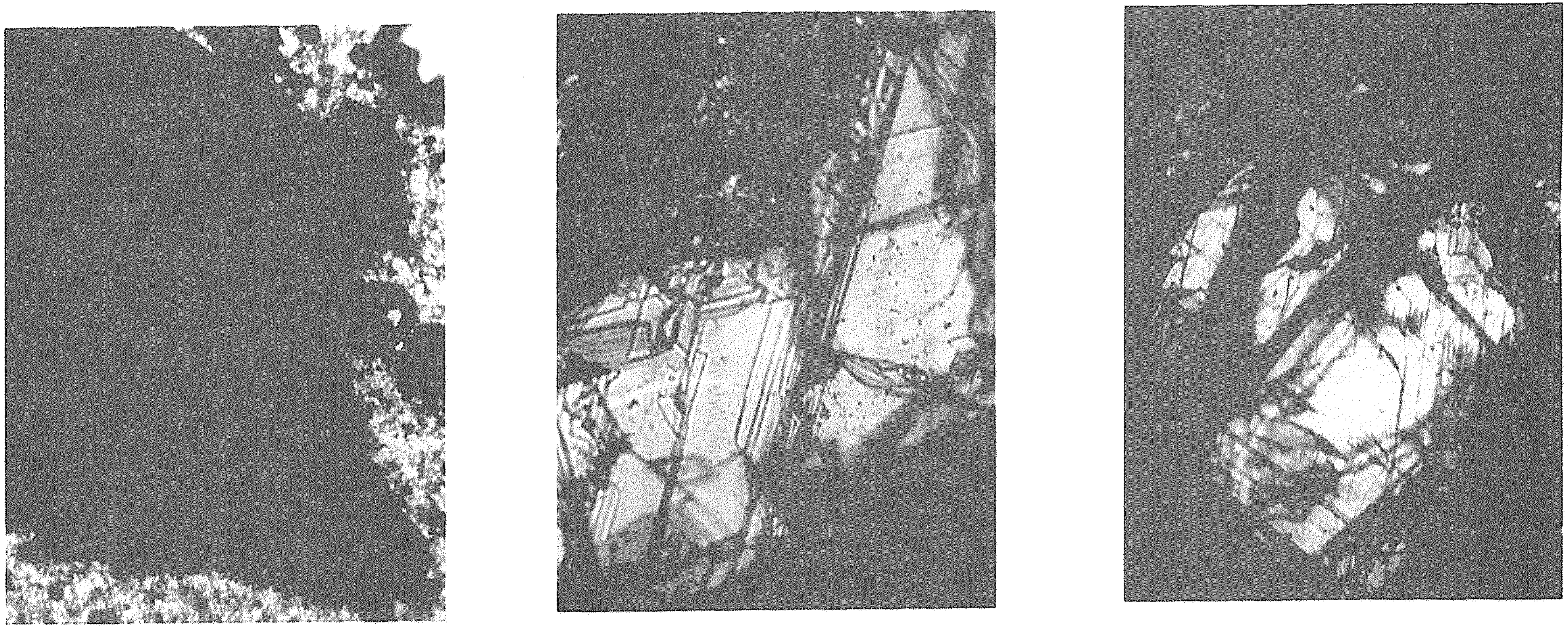


Fig. 2. Near infrared microscopic images of (a) the original molybdenite, (b) molybdenite subjected to $CaCl_2$, and (c) to $AlCl_3$. The original molybdenite shows no transparency under N-IR. Images of (b), and (c) shows that their N-IR transparency increases much in some parts of the mineral during alteration.

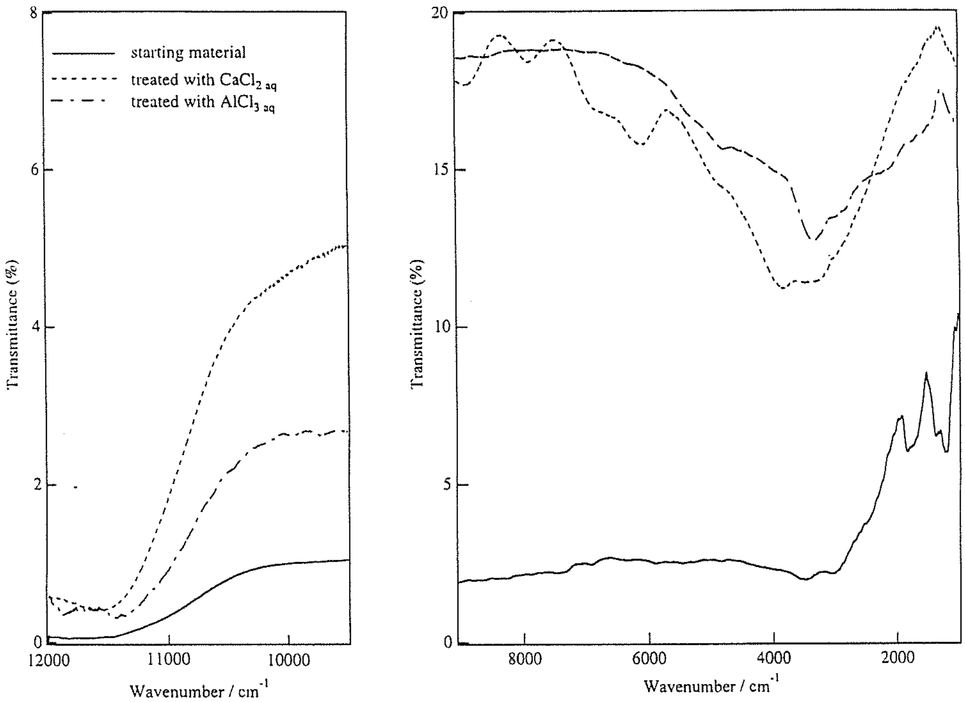


Fig. 3. Infrared absorption spectra of the unaltered and altered molybdenite. Some dips are observed for IR spectrum of the original molybdenite in the region of 3000 - 1000 cm^{-1}. They are identical to the absorption of the bonding agent, which was used in preparation of the polished slab and has not been completely removed.

Natural molybdenite subjected to $AlCl_3$ and $CaCl_2$

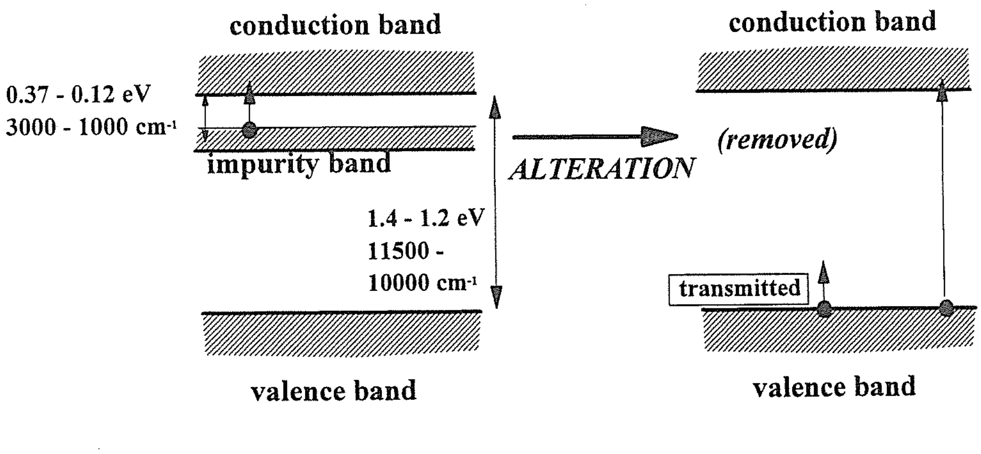


Fig. 4. A possible explanation for change in IR transparency and IR spectroscopic characteristics of the molybdenite during experimental alteration.

Co-seismic Telluric Currents in Southern Sumatra, Indonesia

Tanaka Y., Hase H., Mogi T.[(1)], *Widarto D.S.*[(2)], *Arsad E.M*[(2)],
Puspito N.T[(2)], *Nagao T.*[(3)], *Kanda W.*[(4)] *and Uyeda S.*[(3)]

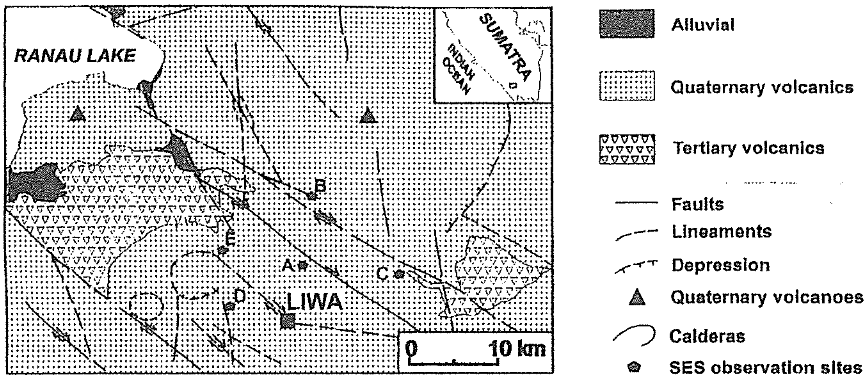
[(1)] *Depaartment of Mining, Kyushu Univ.* [(2)]*Res.Dev.Center for Geotechnology -LIPI*
[(3)]*Earthquake Prediction Research Center, Tokai Univ.* [(4)]*The Inst. Physical and Chemical Research (RIKEN); now Sakurajima Volcano Research Center of Kyoto Univ.*

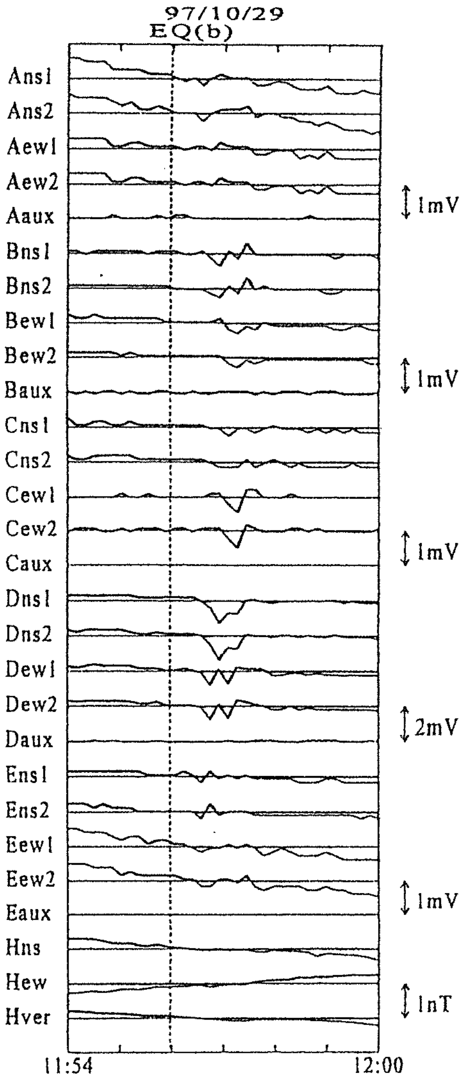
Since September 1997, telluric current monitoring has been carried out in the Liwa area under a cooperative research program between LIPI and RIKEN. The Liwa locates in the Great Sumatra Fault (GSF) zone in western Indonesia. The GSF is a right lateral strike-slip fault dragged by the Indian Ocean plate obliquely subducting under Sumatra with slip rate of 23 ± 3 mm/yr in the northern part and 6 ± 4mm/yr in the southern part. Earthquakes occur frequently in areas close to the GSF, but the seismicity is much higher in the Indian Ocean southwest of Sumatra, where subduction type earthquakes occur along the Sunda trench.

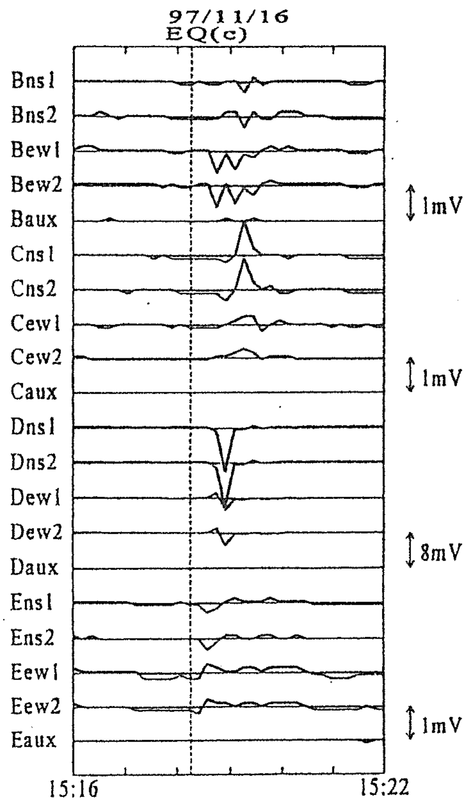
We deployed five monitoring stations to detect co-seismic telluric current signals. Site A locates about 200 m southwest of Geo-engineering Implementation Unit (GIU) of LIPI. Both electric and magnetic sensors were set up here. Sites B (northeast), C (southeast), D (west) and E(northwest), which only measure the horizontal components of electric field were set up at around 10 km distance from GIU. At each site two parallel bipoles of the same length (about 90m) were installed approximately 1 m apart in both N-S and E-W directions from a central (common) electrode in "L" shape, to reject the each electrode noises. The data sampled at every 10 seconds were stored in a data logger (Hakusan, LS-3300) with 20-MB memory.

Five mb>5 earthquakes occurred around 200 km from the monitoring sites during Sep. - Dec. 1997 as listed in Table 1, and some co-seismic telluric signals were observed. For the earthquake a and e, the signal was detected in 1mV/100m only at site D, but for the earthquake b and c the signals were observed at sites B, C, D and E. Similar changes was observed at sites B and D for the earthquake d.

Another two M>5 earthquakes occurred at 251 km and 361 km distance in this period, however, no signals were detected. The earthquake of mb=4.6 (Oct.3) and mb=4.3 (Nov.5) occurred at relatively closer places (114km and 96km), but no signals were detected. Thus, co-seismic changes seem to be detectable for mb>5 earthquakes occurring within 170 km distance in the Liwa area. Fig.2 shows records for 3 minutes before and after the occurrence of earthquakes b and c.







(Table 1)

	origin time (local time)	epicenter	distance	depth	mb	rem.
a	13, September, 13:46'03"	4.45S, 102.84E	147km	97km	5.0	
b	29, October, 11:55'58	6.38S, 104.01E	152km	45km	5.7	Mw
c	16, November, 15:18'16	4.96S, 103.19E	95km	58km	5.5	
d	23, November, 15:35'55	5.41S, 102.52E	174km	33km	5.1	
e	20, December, 13:33'43	6.33S, 104.08E	146km	71km	5.1	

Thermal-state monitoring of active volcanoes by geomagnetic observation

Tanaka, Y., Hashimoto, T., Masuda, H. and Sakanaka, S.

Monitoring the thermal state of an active volcano is important to predict how the volcanic activity is going to change in the near future. However, it is sometimes difficult to pursue a in-situ temperature measurement to an active crater. Although remote sensing technique such as an infrared camera is an alternative way, it only gives us the information of surface temperature. Magnetic field is defined as a result of the volumetric integration of magnetized bodies and hence contains the information of the subsurface. It is well-known by laboratory experiments of rock magnetism that magnetic property (magnetization) of rocks changes with its temperature. Namely, a subsurface body gets hot, it loses the magnetization.

We have been monitoring geomagnetic changes of volcanic origin by proton magnetometers in some actual fields such as Aso, Unzen, Tsurumi, Kuju and Iwate volcanoes. Here we present a recent result in Aso Volcano as an example of detecting the volcano-magnetic effect (Fig.1). The pattern of geomagnetic changes around Aso Volcano can be grouped into two types. One is the northern type and the other is the southern type (Fig.2). These two types are well-correlated each other, although they are in anti-phase. The result can be attributed to intensity changes of a equivalent magnetic dipole under the active crater which has been inferred to locate at a few hundred meters deep. As is interpreted from the result shown in Fig.2, subsurface magnetization increased before March 1998, which implies the temperature decrease. Thereafter, the situation has been reversed, namely, temperature has started to increase. However, we have no evidence showing any significant superficial change on the active crater in March 1998. We suppose that supply rate of thermal energy from the depth has suddenly increased at the time. It is not yet clear that what triggers such a sudden change. We consider it is important to estimate correctly the energy discharge from the crater to the atmosphere in order to confirm the change in energy supply from the depth and elucidate the trigger mechanism.

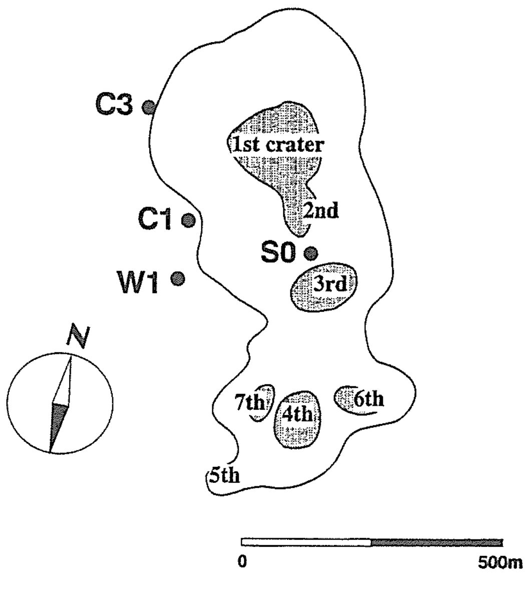


Fig.1: Location of geomagnetic observation by proton magnetometers.

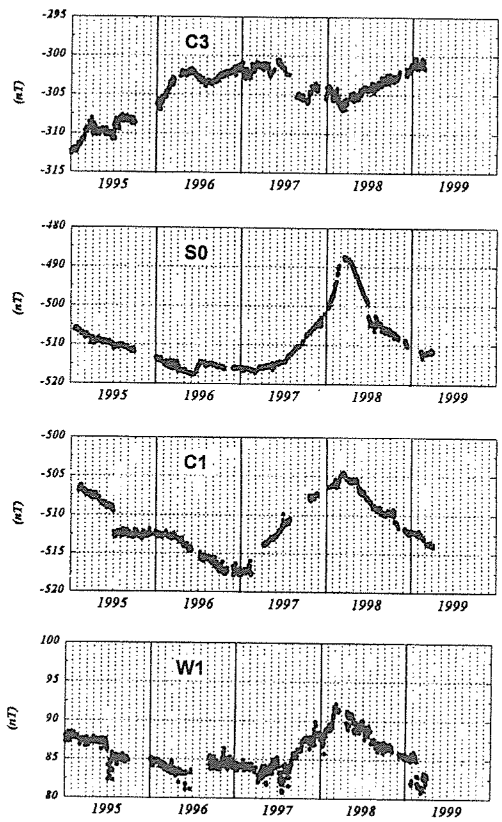


Fig.2: Variation of geomagnetic total force around the active crater of Aso Volcano.

SP Measurement on the Central Cones of Aso Volcano

Tanaka Y., Hashimoto T., Hase H. and Sakanaka S.

Flows of the ground water make electric field in the ground. We can search a movement of ground water and geothermal states through the intensities or distributions of the electric field. Many SP surveys have been attempted on many volcanoes in Japan e.g.; Me-akan, Usu, Esan, Miharayama, Miyakejima, Unzen and Sakurajima, and positive SP anomalies were observed around the crater and fumaroles. Those positive SP anomalies suggest upward flow motion of the geothermal fluid water. The property and decay of the potential will be related to the volcanic activity, and we make it to an useful tool for monitoring the volcanic activity. In the summer of 1998, SP survey was conducted on the central cones of Aso volcano. Fig. 1 shows SP profile along the NS route. Relative base value of SP is taken at Suna-senri point. It looks like "W" character profile. Namely, SP decreases in proportion to the height at the foot of the mountain, but it changes to increase at the flank of Nakadake (3-4 Km south and 5 Km north). The former topographic effect represents potential flow of the ground water. The latter one will be explained by upward motion of thermal water beneath the crater. The width of the positive anomaly will represent 2-3 km source depth. The profile along the EW route is shown in Fig. 2. The base value is same as Fig. 1. Although the SP decreases gradually to the eastern part of Suna-senri, it changes drastically at the western part of Kusa-senri. On this route, the topographic effect is not clear. The most remarkable positive anomaly appeared around Yunotani hot-spring area which locates in about 8 km west of Suna-senri. In the section between Kusa-senri and Suna-senri, the topography is flat and no geothermal area exists. Corresponding to it, SP changed within 100 mV. However, remarkable negative anomaly amounted to 300 mV exists around the western part of Kusa-senri and -150 mV anomaly at the western part of Suna-senri should be attended.

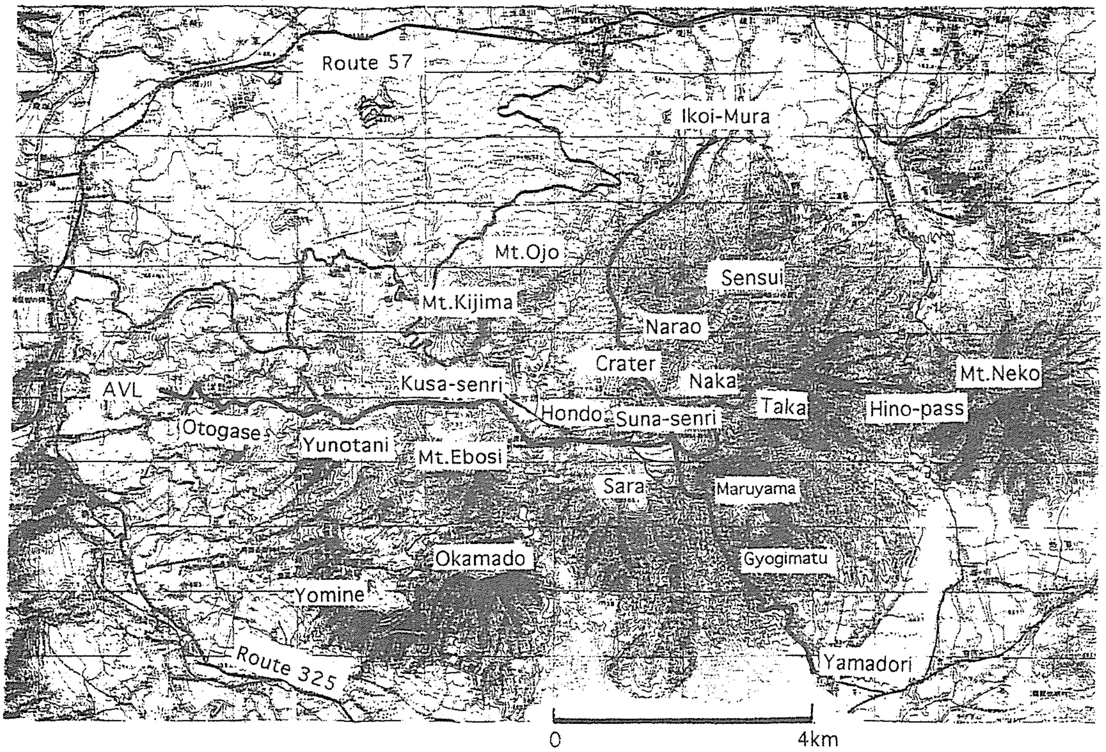
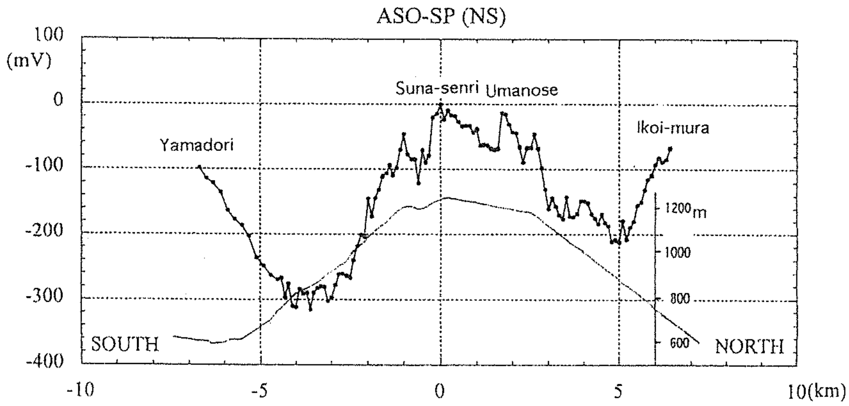
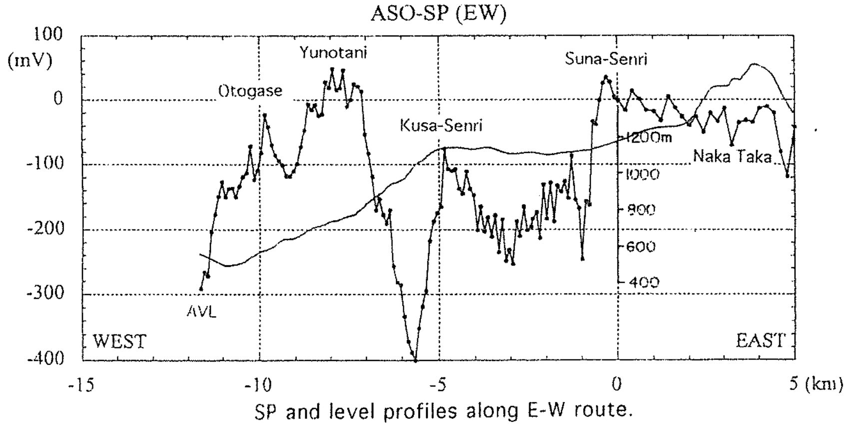


Fig. 1 SP route map, crossing the central cone of Aso volcano.



SP and level profiles along N-S route.



SP and level profiles along E-W route.

Magnetotelluric Study in Three Transects across the Sunda Arc, Indonesia

Tanaka Y., Mogi T. [(1)], *Widarto D.S* [(2)], *Arsadi E.M.* [(2)], *Nishimura S.* [(3)] *and Harjono H.* [(2)]

[(1)] *Department of Mining, Kyushu Univ.*
[(2)] *Res.Dev.Center for Geotechnology-LIPI*
[(3)] *Kyoto Institute of Natural History*

We have conducted three transect of MT soundings across central part of the Java island and Bengkulu area in Sumatra that are situated in the Sunda arc, and the Flores island in the east end of Sunda arc. The present tectonic situation of the Sunda arc is divided by three types based on the plate subduction style. The Sumatra area is characterized by the oblique subduction of the Indian Ocean plate being subducted beneath the Eurasian plate. The Java-Sumbawa area is characterized by the normal subduction at Jawa trench and the Flores-Timor area is characterized by the collision of the arc with the northward moving Australian continental plate. These situation may have affected a crust structure regarded as a stage of volcanic and geothermal activity. Although the crustal structure has reflected these present situations as well as the tectonic evolution in each area for a long time, present crust activities, such as volcanic, geothermal and seismic activity, are reflecting present tectonic situation. We attempted to delineate the framework of the crust structure which strongly reflected long time tectonic evolution and the feature of structure relating to present crust activity in this study. Survey have been made by a combination of the AMT and ULF-MT at three locations in the Sunda arc; Central Java (Semarang-Yogyakarta line, 13 sites in 160 km), South Sumatra Section (Bengkulu - Lubuklinggau, 12 sites in 100km), and Central Flores (Reo - Ruteng line, 11 sites in 70 km). To delineate a feature of crust structure from the fore-arc to back-arc region and beneath volcanic front, those lines were set to cross at right angle to the volcanic chains. Time series of natural electromagnetic signals (Hx, Hy, Hz, Ex and Ey) were measured at frequency range of 0.005 Hz to 0.625 Hz with a fluxgate magnetometer. Coil sensors were used in AMT (4.2 Hz to 17.4 kHz), the spectrum and phase were directly obtained by the system at each frequency. Obtaining the invariant apparent resistivity, a 2-D inversion based on the finite element numerical modeling was computed with a smoothness constraint using statistical criterion ABIC.

We will point out remarkable feature of the resistivity structure for each area. In Central Java section, the resistivity of deeper part of upper crust and lower crust is different between fore-arc side and back-arc side. The resistivity of back-arc side is lower than the fore-arc side. This seems attribute different geothermal at each area in the lower crust. And the big batholith, detected by resistive structure, was appeared beneath giant quaternary volcano, Merbabu and Ungaran. In contrast, the resistivity of the upper crust in the South Sumatra section is wholly quite low, except just beneath the fault zone. In particular, the resistivity beneath the volcanic belt along the Sumatra fault is quite low at depth of lower crust. This means the crust of this area is fractured by the movement of the Sumatra fault and contains geothermal fluid. The resistivity of the lower crust at back-arc site is lower than the fore-arc. The resistivity of upper crust is mostly low in the Flores section, except beneath the volcanic belt. Probably big batholith was formed beneath the active volcano in this area. The resistivity of the lower crust is larger at beneath the volcanic belt.

The behaviour of platinum-group elements during magmatic differentiation in Hawaiian tholeiites

Tatsumi, Y., Oguri, K. and Shimoda, G.

Concentrations of platinum-group elements (PGEs) and gold in basalts from Kilauea and Mauna Loa, Hawaii were determined by ICP-MS using an improved fire-assay and tellurium coprecipitation technique for preconcentrating the metals. Major and trace elements, together with Pb-Sr isotope compositions of basalt samples confirmed that these samples are typical Hawaiian tholeiites. PGEs and Au abundance in Hawaiian tholeiites is rather constant during magmatic differentiation processes, whereas MORBs show strong fractionation of those elements. The distinctive behaviour of these PGEs in Hawaiian tholeiites cannot be explained solely *via.* fractionation of those elements by separation of crystallizing phases such as chromite, olivine and clinopyroxene. Oversaturation of sulfur and separation of sulfides from magmas are required for elucidating PGEs and Au concentrations in Hawaiian tholeiites.
(Geochem. J., in press.)

Making continental crust by crustal delamination in subduction zones, and complementary accumulation of the EMI component in the deep mantle

Tatsumi, Y.

Geochemical modeling suggests that partial melting of the subducting oceanic crust and subsequent melt-mantle reactions cannot yield andesitic magmas with trace element compositions identical to the andesitic continental crust. The most striking difference between such andesite compositions is the lack of Pb-spike in slab-derived melts. Instead, anatexis of the initial basaltic crust, which was created by underplating of basaltic magmas produced by overprinting of hydrous subduction component *via.* slab-dehydration, can reasonably account for the bulk continental crust composition, either leaving pyroxenitic or eclogitic restite. Separation of such mafic restites from the initial crust *via.* delamination process must have taken place for building the present continental crust. Examination of isotopic evolution of delaminated components demonstrates that the pyroxenite component, which formed at 3.0-3.5 Ga and probably was stripped off shortly after its formation, possesses Sr-Nd-Pb isotopic compositions identical to the EMI component, one of the enriched geochemical reservoirs located in the deep mantle. Making continental crust and complementary accumulation of the EMI reservoir in the deep mantle took place simultaneously in the Archean subduction factory.

Petrological and geochemical characteristics of the Tokoro paleo-seamount, central Hokkaido, Japan

Tatsumi, Y. and Niida, K. (Sapporo)

Petrographical and geochemical characteristics of greenstones in the Tokoro belt, central Hokkaido were examined. Most Tokoro greenstones possess petrographical signatures of alkaline rocks, which is consistent with the presence of normative nepheline especially in basaltic greenstones, although concentrations of alkali elements may have been modified by metamorphic reactions. This together with the mutual occurrence with pelagic sediments and limestones suggests that these greenstones may be fragments of an ancient sea-mount formed by activity of mantle plume, not fragments of oceanic crusts. Tatsumi et al. (1998) demonstrated that lavas in the S Pacific superswell region are characterized by higher Nb/Y for a given Nb/Zr than other oceanic lavas. These differences may be caused by a more fertile source, i.e., more enriched in basaltic components, for the superswell/superplume-related magmas, because a peridotite source with such fertile compositions contains a greater amount of garnet into which Y can be strongly partitioned. This is a mechanism consistent with earlier suggestions including the involvement of ancient subducted oceanic crust in forming the mantle source for particular magmas known as HIMU basalts that typify S Pacific hotspot magmatism (Zindler and Hart 1986; Weaver 1991; Chauvel et al. 1992; Kogiso et al., 1997ab). Nb/Y and Nb/Zr ratios for Tokoro greenstones indicate that Tokoro seamount lavas possess Nb/Y-Nb/Zr systematics clearly different from that for superplume-related Polynesian lavas, rather more similar to those for other "normal" Pacific hotspot lavas.

Project ASO98; Seismic exploration of Aso volcano - Perspective -

Tsutsui, T., Sudo, Y., Ono, H., Tanaka, Y., Hashimoto, T., Sakanaka, S., Hoka, T., Masuda, H., Sako, M., Yoshikawa, S., Mori, T., Nakaboh, M., Hase, H., Matsushita, S., Yoshikawa, M. (Fukuoka University), Ikeda, S., Hiramatsu, H., Kokubo, N., Murakami, R., Tsutsui, Y., Takamatsu, M., Nakamura, M., Shimazu, M., Fujiwara, Y., Torisu, K., Fukuda, N. (Japan Meteorological Agency), Okada, H., Maekawa, T., Katsumata, K., Wada, N. (Hokkaido University), Tanaka, St., Nita, K., Hori, S., Nishimura, T., Tanaka, Sc., Watanabe, R., Kobayashi, T. (Tohoku University), Ohba, T., Nogami, K., Hirabayashi, J. (Tokyo Institute of Technology), Notsu, K., Mori, T., Kagi, H., Pedro A. Hernandez (University of Tokyo), Kawakatsu, H., Kaneshima, S., Okabe, A., Tani, K., Ohbayashi, M., Niu, F., Yamamura, K., Yamamoto, M., Misawa, M., Iidaka, T., Watanabe, H., Kagiyama, T., Oikawa, J., Osada, N., Hagiwara, M., Koyama, E., Masutani, F., Tsuji, H., Munekane, H., Terada, A. (ERI, University of Tokyo), Mizuno, T. (Hiroshima University), Tsuruga, K. (Japan Nuclear Cycle Development Institute), Ichihara, M. (Tokyo University of Agriculture and Technology) , Yamaoka, K., Okuda, T., Tomatsu, T., Kawai, M. (Nagoya University), Shimizu, H., Matsuwo, N., Matsushima, T., Uehira, K., Uchida, K., Takagi, A., Watanabe, A., Nakamura, M. (Kyushu University), Miyamachi, H., Yakiwara, H., Hirano, S. (Kagoshima University), Nishi, K., Kishimoto, Y. (DPRI, Kyoto University), Yamamoto, H., Ando, H., and Hakamada, A. (Hakusan Industry)

A joint project of seismic exploration, ASO98, was carried on 23 to 28 November, 1998 under collaboration of institutes and universities. This project is a part of the fifth term of National Project for Prediction of Volcanic Eruption. A major targets of this project is the central cone area of Aso volcano and exact purposes are listed below;

Purposes;

-1: determinations of precise seismic velocity structure beneath the central cones down to several kms,

-2: estimation of seismic effects caused by detail structure or conduit system

-3: obtain detail structure around and beneath the active crater,

-4: detection of later arrivals from deeper scatters and reflectors,

-5: detection of propagation of volcanic tremor with high density network.

In order to determine proper field design, simple simulations had been made previously and presented on the spring conference of JGU in Tokyo. The final field design was concluded as below;

Field design;

Shot points; 6

Energy source; Underground dynamites (Two 250kg shots and four 200kg shots)

Two of 200kg shots are located by the active crater. One located on the north and another on the west of the active crater.

Network extent; 9km approximately,

Station density; 0.1km average,

Major deployment style: Two linear array through the central cone area and four compound tripartites located on the northeast, the west, the south of the active crater and the west flank of the central cone.

Up to 300 temporal stations with 2Hz seismometer were deployed and covered central cone area of Aso volcano. All data were recorded in digital recorders and distributed to participants at the camp. Total data size was approximately 1.8G bytes. A data qualify committee was organized after this observation in order to determine an official arrival time of explosion signals.

Project ASO98; Seismic exploration of Aso volcano - A draft report on volcanic tremor signals -

Tsutsui, T., Mori, T., and Sudo, Y.

There are several vacant recording schedule among the shots for exploration. In this project, ASO98, some Isolated volcanic tremor were recorded in these recording schedules. All recorders deployed densely that time have same vacant schedule. Such style of the tremor recording with high density network is very rare.

This records reveals interesting character of the volcanic tremor in seismological sense;

-1: High frequency component appears in the distance range within 2km from the active crater.

-2: Arrival time pattern of high frequency component is identical with that of low frequency component.

-3: Apparent velocity changes at about 3km from the active crater.

Exact wave mode identification is a next task because of an important procedure to make analyses and interpretations. This analysis is also under working.

Project ASO98; Seismic exploration of Aso volcano - A draft report on explosion signals -

Tsutsui, T., Sudo, Y., Mori, T., Katsumata, K. (Hokkaido University), Fujiwara, Y. (Japan Meteorological Agency), Tanaka, St. (Tohoku University), Oikawa, J. (ERI, University of Tokyo), Tomatsu, T. (Nagoya University), Matsuwo, N., Matsushima, T. (Kyushu University), Miyamachi, H. (Kagoshima University), and Nishi, K. (DPRI, Kyoto University)

First arrivals are qualified in the committee. The committee is organized by members listed above. Some features in travel time curve is established through our discussion as follows;
-1: Major appearance of the travel time curves has three vend within the range up to 9km from the shots,
-2: Approximate apparent velocity corresponding the surface layer is around 1.6km/s in the flank of central cone, around 2.4km/s in the flank of the active cone,
-3: Apparent velocity corresponding to the intermittent layer is around 3.5km/s,
-4: Apparent velocity corresponding to the bottom layer is above 6km/s and this fact can suggest up-dip top face of the bottom layer to the colder rim,
-5: A clear gap of the travel time curve is observed around the summit area in a record from the south-east shot. This suggests some irregular structures beneath the active crater area.
-6 Some clear later arrivals appear after several seconds of the first breaks and they are assumed to be reflection from inclined and/or irregular surfaces.

3D travel time tomography with whole data and 2D analysis (Method of difference) are the major approach to the data. These approach and later phase analysis is under working now.

Seismic Activity at Kuju Geothermal area, Kyushu, Japan

Yoshikawa, M., Sudo, Y., Tsutsui, T. and Taguchi, S (Fukuoka univ.)

The northwestern area of Kuju volcano is one of the most active geothermal fields in Japan, where seismic activity including swarms has been observed. In this area, we studied microearthquakes which occured during the period from November 1995 to May 1998 from the point of view of the ratio of P- to S-wave velocities (Vp/Vs) and m-value.

The results are as follows; 1) erthquakes having high Vp/Vs value were observed mainly at the shallow part (above 1.5km below sea level) and along NW- and NE-trending faults. 2) The values of Vp/Vs and m changed with time. 3) Both Vp/Vs and m-values were low before the seismic swarm, and high after the swarm. Such characteristics of seismic activity is plausibly affected by the presence of geothermal fluids, because the studied area is water-dominated geothermal field, and rich in fractures.

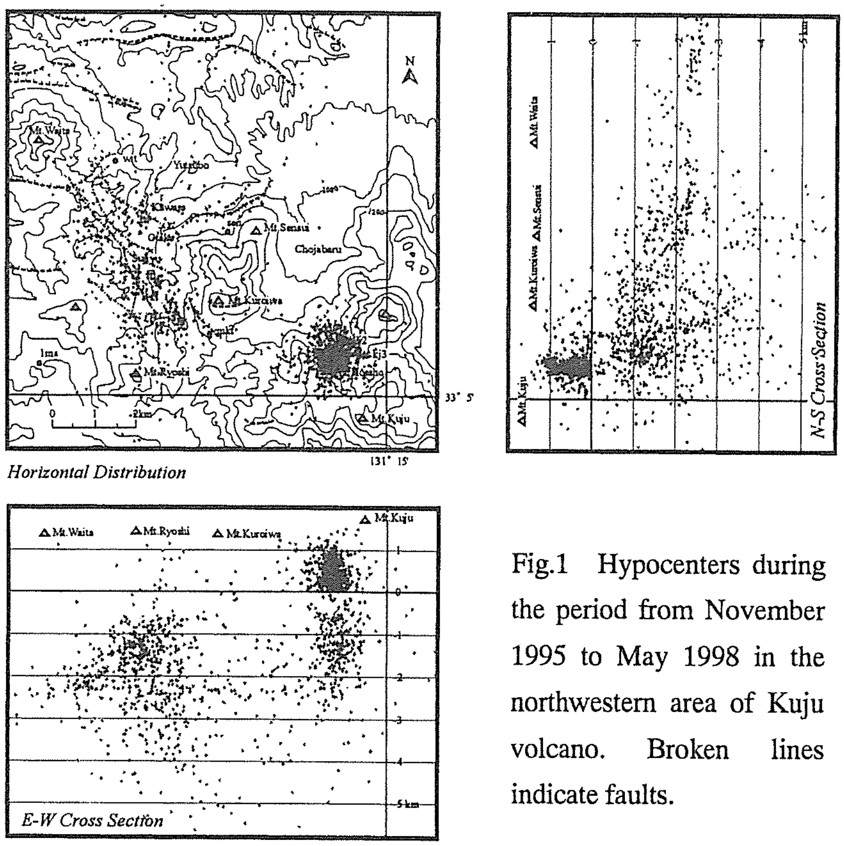


Fig.1 Hypocenters during the period from November 1995 to May 1998 in the northwestern area of Kuju volcano. Broken lines indicate faults.

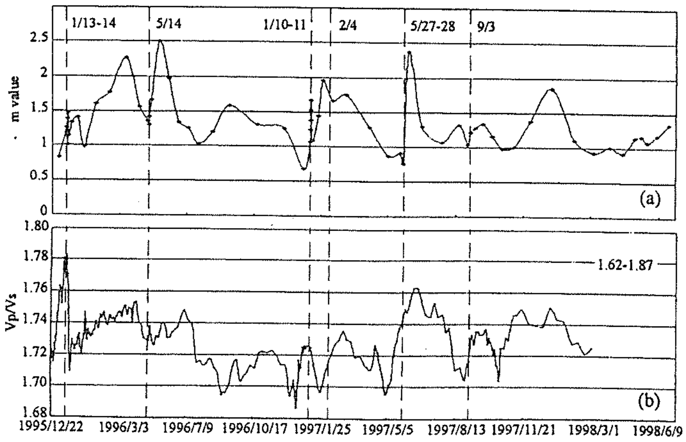


Fig.2 (a) m-value and (b) Vp/Vs ratio changes with time. Broken lines indicate the occurrence of swarms.

Long-term changes associated with exploitation of the Beppu Hydrothermal System, Japan

Yuki Yusa, Shinji Ohsawa and Koichi Kitaoka

The Beppu Hydrothermal Field is developed in an area of 5 km (E-W) and 8 km (N-S) on the eastern flanks of the late Quaterary Yufu-Tsuruki-Garan Volcanic Center, located at the eastern end of a volcanic belt along the Beppu-Shimabara Graben which crosses Kyushu Island from east to west. The hydrothermal activities are fed by outflows of the parent sodium-chloride type hydrothermal water beneath the volcanic center, where active fumaroles are visible near the summits of Mts. Tsurumi and Garan. Ancient people had long used its natural hydrothermal manifestations for hot spring bathing and cooking.

Exploitation of the Beppu Hydrothermal System started mainly in the lowland areas as early as the 1880s, and by the 1920s the number of wells had increased to about 1000. This caused the piezometric head of the thermal groundwater to draw down, and seawater to intrude into the thermal groundwater aquifer near the coast. A second flurry of exploitation occurred during the 1960s and 1970s, by which time there were over 2300 wells, and the mass and heat flows had increased due mainly to the discharge of high-temperature chloride waters in the highland areas. This caused a decline in piezometric head of the deep chloride water, a decline in the subsurface flow of chloride water towards the lowlands, and intrusion of steam-heated shallow water into the chloride water layer.

(Geothermics, in press)

PETROGRAPHY OF PRE AIRA CALDERA VOLCANICS, SOUTHERN KYUSHU JAPAN; A Preliminary Result

Iskandar Zulkarnain

Aira Caldera is situated in the northern part of Kagoshima bay in southern Kyushu. The caldera was formed about 22.000 years ago (Aramaki, 1984) through three plinian volcanic eruptions which have formed Osumi pumice fall (~98 km^3), Tsumaya pumice fall (~13 km^3) and Ito pyroclastic (~300 km^3). The magmatic activities in the period of pre caldera formation produced basaltic rocks, andesite and rhyolitic rocks. Inoue (1994) reported that basaltic magma activities was ceased about 0.5 million years ago and since that time the magma character was changed into intermediate or felsic magmas. He concluded that the generation of andesite was not derived from fractionation or crystallization of basaltic magma but it is more correlated to mixing of basaltic magma with felsic magma. Furthermore, he carried out that the rhyolitic rocks was not formed through fractionation of the primitive magmas but it is believed to be produced by partial melting processes of the basement rocks such amphibolites in certain physical conditions.

Petrographic analysis and mineral chemistry pattern of the rocks show almost homogenize composition of the pyroxenes and olivines or they reflect normal zoning in respect to Mg and Fe. A few points in several samples show unclear reverse zoning. Generally, these indicate that there is no clear evidence for magma mixing processes can be identified in the mafic minerals. Similar pattern of insignificant reverse zoning is also observed in the plagioclase, but the variation in chemical composition of the plagioclase in respect to Ca and Na content is very wide. It reflects a disturb chemical equilibrium during the crystallization of the plagioclase. One of the possibility causing the disturbing in equilibrium during mineral crystallization is magma mixing processes. However, the petrographic analysis reveal out that the olivine basalts in the area can be distinguished into pure basalts and "disturb" basalts as well also for the andesite and rhyolite.

The age data of the rocks from the Aira Caldera ranges from 1.41 Ma to 0.03 Ma. The basaltic activities was recorded from 0.63 Ma to 0.37 Ma, while the andesite started from 1.41 Ma to 0.06 Ma and the rhyolite was formed from 0.38 Ma to 0.03 Ma. It is very interesting to find out how was the andesite initiated at 1.41 Ma without the generation of basaltic magmas, due to occurrences of basaltic magmas just since 0.63 Ma. The basaltic magmas is needed as heat sources during the generation of andesitic magmas. It is also not yet clear what is relationship between the old andesites with the young one as well as the old rhyolite and the young rhyolite.

This preliminary results lead to conclusion that separation of types of magmatic activities in the area is not so simple as Inoue (1994) proposed. It is needed more data, specially isotopic data, to reveal the relationship among rocks in the area that can contribute in getting better understanding about magmatic activities before caldera formation.

火山研究センターの定常観測

【定常観測の目的】

火山研究センターでは、火山を対象とした地球物理学的な手法による研究活動を行っている。火山研究センターの中心的な研究課題は、活動する火山の内部における現在の活動状態の推移を認識し、このような火山活動の変化が起きる機構を解明することである。

阿蘇火山ならびに九重火山では 1998 年度には定常的な噴気活動のほか目立った表面活動はなかった。しかし火山活動の状態の変化を検知し研究するためには、火山活動の最盛期のデータばかりではなく火山活動の平穏な時期のデータ（たとえば地震活動度や地磁気変化、傾斜変化など）を基礎量として変化の規模や方向を検討しなければならない。また火山活動に伴う個々の現象はその発生を予測することが困難であるとともに、すでに取得されたデータの中にも発見を待っている現象が潜んでいる可能性が秘められている。したがって定常観測から得られるデータは非常に重要なものであるうえ、このデータに立脚して演繹的に研究を発展させなければならない。

以上の理由から火山研究センターでは、定常観測によって得られたデータを研究の背景を構成するものであると同時に、火山の動的現象の研究の興味の中心となるものと位置づけたうえで、総力を挙げて定常観測の維持と運用に力を注いでいる。

定常観測結果の成果については、火山噴火予知連絡会によって気象庁発行「火山噴火予知連絡会会報」に詳細なデータが公表されているので参照されたい。

【定常観測従事者一覧】

＜教官＞
須藤靖明、田中良和、小野博尉、筒井智樹、橋本武志
＜技官＞
外　輝明、増田秀晴、迫　幹雄、吉川　慎
＜大学院生＞
森　健彦、中坊　真、長谷英彰、吉川美由紀

【定常観測項目】

＜地震観測＞
広域地震観測網の統括（須藤）
広域地震観測網データの解析（須藤）
火口周辺観測網の統括（小野）
火口周辺観測網データの解析（小野・森）
地震観測計器維持保守（迫・外・増田・吉川）
地震観測点維持（迫・外・増田・吉川慎）
九重火山地震観測網の維持（筒井・外）
九重火山地震観測網データの解析（筒井・吉川美）
阿蘇火山の火山性微動積算観測（須藤・迫）

＜地盤変動観測＞
阿蘇火山傾斜・伸縮観測（小野・迫）
九重火山傾斜観測（迫）
阿蘇火山ＧＰＳ・辺長観測（迫・小野・中坊）
九重火山辺長観測（小野・迫・中坊）
九重火山ＧＰＳ観測（小野・中坊）
阿蘇火山水準測量（中坊ほか全員が支援）
超伝導重力計観測（須藤・吉川慎・森）

＜地磁気観測＞
阿蘇火山地磁気連続観測（橋本・田中）
九重火山地磁気連続観測（田中）
九重火山自然電位観測（橋本・増田）

＜その他＞
阿蘇火山における地温観測（須藤・迫）
可視画像による九重火山の活動状況観測（須藤・中坊）

A brief report on routine observations of AVL

Purpose of routine observations

A major activity of AVL is research for volcanoes through geophysical approaches. Geophysical approaches enables us to monitor a status of a volcanic activity at a present. We intend to make clear dynamic mechanisms of volcanic activities through these observations.

There were no significant activity in Aso volcano and Kuju volcano through FY1998 except for steady fumarolic activities. However, in order to recognize volcanic processes and status of their activity exactly, it is nesessory to have data not only on the active state but also the quiet state through continuous routine observations. These data enables us to define present status of the activity and forecasting forthcoming state of the volcano exactly. Occurence of individual phenomena is not able to be forcasted and data already obtained have a potential to be a great discovery which can achieve an great advance in volcanology. Then data obtained with routinely observations are very important resource and can be a start point of our volcanological study.

We have defined that our routine observation is very important facility and our foundation of research. All AVL staffs spends most of their official time to support routine observation under the concept described above.

Exact data and detail description of these volcanoes, Aso and Kuju, is reported to Coordinating Comittee for Prediction of Volcanic Eruption and is published as "Report of Coordinating Comittee for Prediction of Volcanic Eruption" by JMA.. If you need to have detail informations about these volcanoes, access this publication.

Routine observation crew

< Research staffs> *Yasuaki SUDO, Yoshikazu TANAKA, Hiroyasu ONO, Tomoki TSUTSUI, and Takeshi HASHIMOTO.*

<Technical staffs> *Teruaki HOKA, Hideharu MASUDA, Mikio SAKO, and Shin YOSHIKAWA*

<Postgraduate course students> *Takehiko MORI, Makoto NAKABOH, Hideaki Hase and Miyuki YOSHIKAWA*

Functions of routine observations

<Seismology>

A control of the broad area network; *Y. SUDO*

Analysis with the broad area network; *Y. SUDO*

A control of the summit network in Aso; *H. ONO*

Analysis with the summit network in Aso; *H. ONO and T. MORI*

Maintenance works on instruments; *T. HOKA, M. SAKO, H. MASUDA, T. YAMADA, and S. YOSHIKAWA,*

Maintenance works on the field; *T. HOKA, M. SAKO, H. MASUDA, T. YAMADA, and S. YOSHIKAWA*

Maintenance works in Kuju seismic network; *T. TSUTSUI, T. HOKA, H. MASUDA, and S. YOSHIKAWA*

Analysis with Kuju seismic network; *T. TSUTSUI, M. TANAKA, and M. YOSHIKAWA*

Volcanic tremor accumulator; *Y. SUDO and M. SAKO*

<Ground deformation>

Tiltmeters and extensiometers in Aso; *H. ONO and M. SAKO*

Tiltmeters in Kuju; *M. SAKO*

GPS and EDM in Aso; *H. ONO,M. NAKABOH and M. SAKO*

EDM in Kuju; *H. ONO, M. SAKO, and M. NAKABOH*

GPS in Kuju; *H. ONO*

Leveling survey in Aso; *M. NAKABOH and all*

Super conductivity gravitymeter; *Y. SUDO, S. YOSHIKAWA, and T. MORI*

<Geomagnetism>

Fulltime monitoring of total force in Aso; *T. HASHIMOTO and Y. TANAKA*

Fulltime monitoring of total force in Kuju; *Y. TANAKA*

Self-potential observation in Kuju; *T. HASHIMOTO and H. MASUDA*

<Miscellaneous>

Geothermal observation by the active crater in Aso; *Y. SUDO and M. SAKO*

Visual monitoring of the new vents in Kuju; *Y. SUDO and M. NAKABOH*

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教育活動　Education

学位，授業　Academics

学位審査

大沢信二	（審査員）川村隆夫（修士	東邦大学大学院理学研究科）
巽好幸	（主査）　工藤浩司（修士	京都大学大学院人間・環境学研究科）
由佐悠紀	（審査員）北川有一（博士	京都大学大学院理学研究科）
田中良和	（審査員）三浦敏郎（博士	東京大学地震研究所）
	（審査員）市来啓雅（博士	防災研究所）
須藤靖明	（審査員）田中貴光（修士	京都大学大学院理学研究科）
須藤靖明	（審査員）山里平　（博士	京都大学大学院理学研究科）

授業，実習

科目	担当教官
学部	
地熱学	古川善紹，北岡豪一，須藤靖明，田中良和，巽好幸，由佐悠紀
陸水物理学	由佐悠紀，*諏訪浩*[1]
火山物理学	須藤靖明，田中良和
大学院 (修士課程)	
水圏地球物理学Ⅱ	北岡豪一，由佐悠紀，*奥西一夫*[1]，*諏訪浩*[1]
地球熱学，地熱流体学Ⅰ	北岡豪一，田中良和，由佐悠紀
地球熱学，地熱流体学Ⅱ	須藤靖明，*竹村恵二*[2]
応用地球電磁気学	田中良和，*大志万直人*[1]，*住友則彦*[1]
環境地球科学Ⅱ	巽好幸，*井口正人*[1]，*石原和弘*[1]
大学院 (修士，博士課程)	
水圏地球物理学ゼミナールⅢ	北岡豪一，由佐悠紀，*奥西一夫*[1]，*諏訪浩*[1]，*斉藤隆志*[1]
地球熱学，地熱流体学ゼミナールⅠ	古川善紹，川本竜彦，北岡豪一，大沢信二，鈴木勝彦，巽好幸，由佐悠紀
地球熱学，地熱流体学ゼミナールⅡ	小野博尉，橋本武志，須藤靖明，田中良和，筒井智樹
応用地球電磁気学ゼミナール	橋本武志，田中良和，*大志万直人*[1]，*住友則彦*[1]
環境地球科学ゼミナールⅡ	巽好幸，*井口正人*[1]，*石原和弘*[1]，*西潔*[1]，*山本圭吾*[1]

([1] 防災研究所，[2] 地球物理学教室)

野外実習

地熱学野外実習 (7月28日 - 8月1日)
　別府，別府温泉噴気の放熱量測定
　阿蘇，火山性微動の観測＋地磁気3成分絶対測定
　担当：大沢信二，由佐悠紀
地球電磁気学課題演習 (阿蘇中央火口丘における自然電位観測)
　担当：田中良和，橋本武志，坂中伸也，長谷英彰

講義 (他大学) ほか

坂中伸也　熊本大学大学教育研究センター担当 (後期)
須藤靖明　JICA火山学コース研修生受入
鈴木勝彦　基礎実験I，基礎実験II，東京大学
田中良和　インドネシアＭＴ共同研究検討会 (1998年11月19日-21日，火山研究センター)
巽好幸　東京大学海洋研究所教授 (併任、1999年1月から) 集中講義：名古屋大学，広島大学，岡山大学，大阪府立大学，神戸大学
由佐悠紀　集中講義：九州大学工学部，大分県立芸術文化短期大学

セミナー　Seminars

地熱学セミナー

1998年

5月15日　佐野貴司　「マグマ生成状況（温度，圧力等）を化学組成から推定する方法の紹介」
　　　　　橋本武志　「桜島火山の自然電位と熱水系」

6月12日　網田和宏「四国東部地域の地殻比抵抗構造」
　　　　　吉川美由紀 Condition for rapid large-volume flow (R.H.Sibson (1998)」《論文紹介》

7月3日　長谷英彰「VAN法について」
　　　　　大沢信二「マグマ性ガス中の窒素の起源　-新しい解釈とその証拠について-」

7月24日　相澤　義高「弾性波速度と地球内部構造」

8月28日　中坊真　「動かない阿蘇」
　　　　　ミルトン ガルセス　「Seismoacoustic Waveから見た桜島，阿蘇，雲仙，九重にまつわるお話」

9月11日　大上和敏　研究報告

9月25日　森健彦 研究報告
　　　　　吉川美由紀　「修論中間発表」

10月23日　坂中伸也　「傾いた円筒状圧力源の火山地磁気変化モデル」
　　　　　渋谷秀敏　「阿蘇の麓の古地磁気屋のお仕事」

1999年

1月29日　工藤浩司　研究報告
　　　　　吉川美由紀　研究報告

2月12日　ドゥー　ウェイウェイ　" Experimental Investigations on the Behaviour of H_2O and Major Elements in　Hydrous Trachyandesite Melt "
　　　　　須藤靖明　「阿蘇について」

3月26日　中坊真　「阿蘇の地殻変動」
　　　　　北岡豪一　「自然から学んだこと」

火山研セミナー

1998年

5月22日　合同学会リハーサル

6月10日　坂中伸也「ダム磁気効果の検出の試み」

6月25日　Andreas Pietbrock「アンデス地域の速度構造」
　　　　　Juan Carlos Diago「プラセ火山の地震活動と火山ガスの相関」
　　　　　須藤靖明　「ニュージーランドルアペフ火山とホワイト島火山の微動観測」

8月8日　戸田茂「近畿地方の活構造と地震探査」

8月13日　吉川美由紀 論文紹介「A Student's Guide to and Review of Moment Tensors, Seismological Research Letters, Vol.60, NO.2, 1989」

9月4日　Juan Carlos Diago「プラセ火山の地震活動と火山ガスの相関」

11月20日　茂木透 「Introductory-Detection capability of MT method」
Widarto, D. S. 「Resistivity Structure at Flores Island」
田中良和 「Source Field of MT」
西村進 「Tectonics of West Banda Arc」
E. M. Arsadi 「Volcanic Activity and Tectonics in Indonesia」
12月2日　中坊真　「Ground deformation at Aso Volcano」
1999年
1月8日　吉川美由紀 「九重火山周辺部の地熱地帯における地震活動について」
2月6日　森健彦 「阿蘇火山の火山性微動について」

BGRLセミナー

1998年
4月24日　川本竜彦　珪酸塩成分に富むH_2OとH_2Oに富む珪酸塩メルト
5月7日　中島剛（京都大学大学院人間環境学科）瀬戸内海小豆島の斑晶質安山岩の成因
5月22日　相澤義高　実験から地球内部の地震波速度構造を解釈する
6月19日　佐野貴司　通常のマントルの溶融によって洪水玄武岩マグマは生成可能か？
6月26日　Du Wei-wei, Genesis of Cenozoic alkaline basalts around the Japan Sea: two different models
8月14日　中島剛（京都大学大学院人間・環境学研究科）小豆島安山岩の起源
9月4日　工藤浩司（京都大学大学院人間・環境学研究科）HIMU basaltのCO_2
10月2日　佐野貴司　岩手火山の玄武岩中のホウ素含有量から沈み込んだスラブの影響を見積もる努力
10月22日　佐藤佳子（京都大学大学院理学研究科地球惑星科学専攻地質学鉱物学教室）北部シホテアリン地域中部の火山活動史
11月20日　可児智美　Part1　Pb-Pb isochron study of the limestomes found in the accretionary prisms in the Japanese Island.
Part2 Trace elements and Pb and Sr isotopic study of greenrocks in accretioanry prisms.
12月11日　Iskandar Zulkarnain　Petrography of Aira pre-caldera volcanics, Southern Kyushu, Japan. A preliminary Result
1999年
2月19日　Du Weiwei, Experimental Investigations on the Behaviour of H_2O and Major Elements in Hydrous Trachyandesite Melt.
巽好幸　Towards comprehensive understanding of the origin of continental crust and EM1 mantle reservoir.
3月11日　本多了（広島大学理学部地球システム）マントル対流と大陸の相互作用
中久喜伴益（広島大学理学部地球システム）Dynamic modelling of subduction zone

研　究　費　Funding

科学研究費補助金

基盤研究A　橋本武志，須藤靖明，筒井智樹（分担）「阿蘇山の火口直下に存在する圧力源の実体と噴火活動における役割の解明　代表者，川勝均

基盤研究A　巽好幸，古川善紹「中新世西南日本のテクトニクス，マントル内異常高温の総合解析」2,300千円

基盤研究B　須藤靖明「活動火口におけるマグマ熱水系構造探査法の実用化実験」9.200千円

基盤研究B　田中良和，橋本武志（分担）「電気的手法による火山の場とマグマの探査（有珠山，三宅島，北海道駒ヶ岳）」代表　西田泰典 2,950千円

基盤研究B　巽好幸，川本竜彦「含水珪酸塩溶融体の高温高圧下におけるその場観察，マントルの融解過程における水の役割の解明」8,600千円

基盤研究B　由佐悠紀，大沢信二「九州中部地域における地熱構造及び熱水流動過程の研究」2,200千円

基盤研究C　田中良和（分担）「九州北西海域域下の電気伝導度構造の研究」（代表　半田駿）2,261千円

奨励研究A　古川善紹　「初期地球の沈み込み帯ダイナミクス，地球の化学的進化の解明に向けて」1,100千円

奨励研究A　橋本武志「阿蘇火山の浅部熱活動に伴う地下水流動と熱放出過程の研究」400千円

奨励研究A　鈴木勝彦　「レニウム－オスミウム年代測定法を用いた金属鉱床の生成過程の探索，生成年代並びに鉱床構成物質の起源」　1,000千円

奨励研究A　筒井智樹　「人工地震を用いた活火山の物質供給路システムの研究」　1,900千円

創成的基礎研究　田中良和（分担）「海半球ネットワーク，地球内部を覗く新しい目」代表　深尾良夫

日米科学協力事業共同研究　田中良和（分担）「ロングバレーカルデラの電磁気共同観測」代表　笹井洋一 1,780千円

受託研究　巽好幸「スーパープリュームの岩石学的研究」10,656千円

京都大学防災研究所特定共同研究　橋本武志，田中良和（分担）「桜島火山の地下水，熱水系に関する研究」代表者，平林順一，1,840千円

京都大学学術研究奨励金　橋本武志「地電位変動を用いた阿蘇火山の超長周期微動に伴う流体流動の解明」1,000千円

奨学寄付金（株）地域エネルギー研究所　須藤靖明　1,500千円

京都理学研究協会国際交流助成金　川本竜彦　200千円

新規導入の装置　Newly Installed Instruments

四重極型ICP-MS装置　Inductively Coupled Plasma Mass Spectrometer (ICP-MS)

VG Elemental社製　PQ3

性能，halogen，chalcogen，noble gasを除くLi - Uのほぼすべての元素を同時に高感度定量分析することが可能である。検出限界は，例えばBeで10 ppt，In，Bi，Uで2 ppt以下 (溶液噴霧) である。signal強度の安定性は，RSD ≦ 4 %以下 (2時間) である。

ICP-MS用レーザーアブレーション装置　Laser Ablation System

CETAC Technologies社製　LSX200

性能，laser ablationシステムをICP-MSに接続することにより，固体試料の直接分析を可能にする。移動分解能は1.25 μm / xyz (各方向) である。ICP-MSで分析可能な元素は原理的にすべて定量可能となる。偏光レンズが装備されており，鉱物を同定しながらの分析が可能である。

表面電離型質量分析装置　Thermal Ionization Mass Spectrometer (TIMS)

Finnigan MAT社製　MAT 262

性能，positive modeでは，Sr，Nd，Ce，Pb，Uなど，negative modeでは，B，Re，Osなどの高感度，高精度同位体比分析が可能である。具体的には、positive modeでは、300 ngのSrの$^{87}Sr/^{86}Sr$比，あるいは200 ngのNd の$^{143}Nd/^{144}Nd$比が，RSD = 0.002 % (external) で、negative modeでは，1 ngのOsの$^{190}Os/^{192}Os$比が，RSD = 0.02 %で測定が可能である。

外熱式ダイアモンドアンビルセル　Externally heated diamond anvil cell

Foxwood社製　106

性能，コーネル大学バセット教授が開発制作したこのダイアモンドアンビルセルは、常温から1000℃までの温度範囲で使用できる。H_2Oを圧力媒体として使用し、H_2Oの状態方程式を用いて圧力を測定する場合，2.5GPaまでの圧力範囲で使用することが出来る。それ以上の圧力範囲では他の圧力測定方法を用いなくてはならず，現在そのための設備はない。

フーリエ変換型近赤外分光光度計　FT-NIR spectrometer，IR microscope

日本分光社製　FTIR610+MICRO-20-16

性能，近赤外顕微鏡は，外熱式ダイアモンドアンビルセルを使用できるように、標準よりも長い作動距離と焦点距離を有するように改造されている。InSbディテクターとCaF_2ビームスプリッターの組み合わせることによって、波数2000cm^{-1}から8000cm^{-1}までの赤外～近赤外領域での測定に最適化されている。

加熱ステージ　Heating stage

リンカム社製　TS1500

性能，1500℃までの温度範囲で、微小な液体包有物や流体包有物の加熱観察を実体顕微鏡下で行うことが可能である。アルゴンと水素の混合気体を用いて還元的な雰囲気で実験を行うことが可能である。

実験装置　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，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，全自動微小地震観測システム，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，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）およびデータロガー，人工震源車，重力計，超伝導重力計，地磁気地電流法測定装置（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, Energy dispersive electron microprobe analyzer, Wavelength dispersion type X-ray fluorescence analyzer, Energy dispersion type X-ray fluorescence analyzer, Powder X-ray diffractometer, Liquid scintillation system, Ion chromatography, Gas chromatography, Automatic titration system, Full-automated micro-earthquake monitoring 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, FT-NIR spectrometer, IR microscope, Heating 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] and data-loggers, Car-mounted seismic source, Gravimeters, Super-Conducting Gravimeter, Magneto-Telluric measurement system (broad-band type, ULF, ELF, VLF-band), Electronic distance measurement system, Leveling survey system (automatic reading).

学会活動　Activities in Scientific Societies

受賞

橋本武志　地球電磁気・地球惑星圏学会　大林奨励賞

委員

北岡豪一
　編集委員：日本陸水学会誌
　評議員：日本地下水学会，日本水文科学会
　運営委員：陸水物理研究会

須藤靖明
　会計監査：日本火山学会

鈴木勝彦
　庶務幹事：日本温泉科学会

巽好幸
　編集委員長："The Island Arc"
　評議員：日本地質学会，日本火山学会

田中良和
　運営委員：地球電磁気・地球惑星圏学会
　日本学術会議地球電磁気研究連，地磁気観測作業委員会委員

筒井智樹
　編集委員：日本火山学会誌

由佐悠紀
　編集委員：日本温泉科学会誌
　評議員：日本陸水学会，日本温泉科学会，日本地熱学会
　学会賞選考委員：日本陸水学会

社会活動　Public Relations

古川善紹
　別府市消防本部主催防災会議講師　1998年7月

北岡豪一
　大分県温泉地保全検討委員会委員 (大分県保険環境部)
　道路工事影響検討委員会委員 (大分県竹田土木事務所)
　海洋環境評価委員会委員 (財団法人 環境科学技術研究所)

大沢信二
　大分県九重町南山田地区温泉地保全検討委員会委員
　地熱開発促進調査辻之岳地域検討委員会委員
　地熱開発促進調査委員会辻之岳ワーキンググループ特別委員

須藤靖明

測地審議会臨時委員

火山噴火予知連絡会委員

阿蘇火山ガス安全対策専門委員会委員

くじゅう山系（硫黄山）防災協議会委員

田中良和

雲仙火山崩落の危険度調査指導（長崎県振興局）

巽好幸

IODP国内連絡委員会委員

ODP国内研究連絡会委員

由佐悠紀

資源エネルギー庁環境審査顧問

地熱開発促進調査委員会委員

大分県環境審議会委員

大分県自然環境保全審議会委員

大分県土地利用審査会委員

大分県温泉地保全検討委員会委員長

地熱発電所環境保全実証調査委員会委員

地熱構造モデル構築スタンダード作成調査検討委員会委員長

地熱開発促進調査崩平山地域検討会委員長

日本温泉協会学術部委員

陸上自衛隊第4師団防災担当者研修会講師 (1998年5月)

平成10年度九州博物館協議会総会特別講演講師 (1998年6月)

歴史と自然を学ぶ会土曜講座講師 (1998年7月)

九州ブロック保健所長会特別講演講師 (1998年7月)

熊本県天草青年の家野外モデル事業「九州横断科学探検隊」講話講師 (1998年8月)

来　訪　者　Visitors

阿蘇

1998年4月-1999年3月　随時　吉川美由紀（福岡大学理学部）

池辺伸一郎（阿蘇火山博物館）

宮縁育夫（農水省森林総合研究所）

1998年

5月18日　熊本地方裁判所一行12名

5月12日　JICA研修生一行　6名

6月1日～2日　理学研究科事務室司計掛　稲田一美

6月　地震観測技術センター　村上寛史

7月14日-18日　阿蘇火山広帯域地震計観測　川勝　均，山本　希（東京大学地震研究所）

金嶋　聡（東京工業大学）

7月21日　日本新聞協会一行　10名

7月30日　無線定期検査　九州電気通信管理局　1名　沖電気　上滝

8月20日　九州工業大学　一行　18名

9月11日　長陽村教育委員会　1名

9月16日-17日　長者原，赤川観測室および観測井工事入札　理学研究科事務長　木村　経理部第二監査掛　谷川　理学研究科施設掛　阿部　理学研究科経理掛　佐藤　その他　業

9月24日　県道拡幅に伴う京大所有地分筆登記申請他　理学研究科管財課　2名

9月25日　宮崎県北方町民大学　一行　17名

10月　鈴木亮教授，学生（竹，井手，園田（佐賀大学理工学部））
高倉伸一（地質調査所）
小池克明（熊本大学工学部）

10月　阿蘇火山人工地震探査削孔打ち合わせ　応用地質　畠山　日鉄鉱コンサルタント　佐藤　日鉄鉱コンサルタント　北園

10月28日　京都大学建物施設研修　建築課第4工営掛長　坂上定敬　工事計画掛員　堀田浩志　企画課　企画掛員　治岡淳一郎　機械設備課第一機械掛員　古川清隆　電気情報設備課第一電気掛主任　西村明博

10月29日　1998年阿蘇火山人工地震探査報道説明会　各報道機関　合計13社

10月30日　佐賀地方検察庁修習生および引率者　合計7名

11月日27-30日　マルコムジョンストン（USGS）

11月日19-21日　ウィダルト，アルサディ（ＬＩＰＩ），西村進，茂木透

11月23日～28日　阿蘇火山人工地震探査　岡田弘，前川徳光，勝俣啓，和田直人（北海道大学理学研究科地震火山研究観測センター）浜口博之，田中聡，仁田交市，堀修一郎（東北大学理学研究科　地震噴火予知センター）西村太志，田中佐千子，渡邊理恵子，小林知勝（東北大学理学研究科）大場武，野上健治，平林順一（東京工業大学草津白根火山観測所）野津憲治，森俊哉，鍵裕之，ヘルナンデス（東京大学理学研究科地殻化学実験施設）川勝均，金嶋聡，岡部明，谷健司，大林政行，鈕鳳林，山村恵子，山本希，三澤美香，飯高隆（東京大学地震研究所海半球センター）渡辺秀文，鍵山恒臣，及川純，長田昇，萩原道徳，小山悦朗，増谷文雄，辻浩，宗包浩志，寺田暁彦（東京大学地震研究所火山センター），水野高志（広島大学），鶴我佳代子（核燃料サイクル機構），市原美恵（東京農工大学）山岡耕春，奥田隆，戸松稔貴，河合優行（名古屋大学理学研究科）清水洋，松尾のり道，松島健，植平賢司，内田和也（九州大学理学研究科島原地震火山観測所），高木朗充，渡辺篤志，中村めぐみ（九州大学理学研究科），栗山　都（奈良女大）宮町宏樹，八木原寛，平野舟一郎（鹿児島大学理学部南西島弧観測所）西潔，岸本優子（京都大学防災研究所桜島観測所）山本肇，安藤浩，袴田亜希子（白山工業）池田滋，平松秀行，小窪則夫，村上龍二，筒井良隆，高松政美，中村政文，嶋津稔（気象庁阿蘇山測候所），藤原善明，鳥巣啓多（気象庁雲仙岳測候所）福田信夫（気象庁地磁気観測所鹿屋出張所）

12月　西祐司（地質調査所）
神田経（京都大学防災研究所）
茂木透（九州大学工学部）
下泉政志（ポリテクカレッジ北九州）
半田駿（佐賀大学農学部）
鍵山恒臣（東京大学地震研究所）
小山崇夫（東京大学地震研究所）
宗包浩志（東京大学地震研究所）
小河勉（東京大学地震研究所）

Djedi S. Widarto (九州大学学振招聘研究員)
生駒良友 (九州大学理学部)
12月9日～10日　長者原，赤川観測室及び観測井　竣工検査　理学研究科事務室　2名
12月13日～22日　阿蘇中岳火口周辺反射法地震探査　戸田茂，他9名 (愛知教育大学)
12月15日-18日　阿蘇火山広帯域地震計観測　川勝均 (東京大学地震研究所)
12月17日　京都大学経理部　4名
1999年
1月25日　理学研究科経理掛　山本　司計掛　壷内　用度掛　竹村
2月，3月　小川康雄 (地質調査所)
2月15日～19日　阿蘇火山人工地震探査データ検討委員会　東北大学理学研究科　田中聡　東大地震研火山センター　及川純　九大理学部島原観測所　松尾のり道　気象庁雲仙岳測候所　藤原善明
2月18日　理学研究科司計掛長　古関　用度掛長　熊谷
2月19日　敬愛大学国際学部　高山茂美　中村敬三
3月17日－19日　地質巡検，見学　島根大学理工学部　沢田順弘ほか学生9名
3月29日-30日　広島工業大学環境学部　小林芳正ほか学生3名
3月30日-31日　金庫検査　京大事務局経理掛　長谷川　功　第一契約掛　池野和樹　理学研究科経理掛　青柳輝夫
3月　大和田ほか2名 (気象庁地磁気観測所)

別府

1998年
4月　藤沢康弘 (鹿児島大学理学部)
鈴木勝彦 (東京大学教養学部)
藤沢，小林，溜池，奥野 (鹿児島大学)
5月9日　吉田，有田 (全国中学理科教育研究会)
5月14日　安部一雄 (九電工)
5月13日　大分放送，神屋記者
5月15日　地球物理4回生，筒井和男　ゼミ参加
5月20日　大分県生活環境課　2人
下池，八田 (西日本技術開発)
5月22日　永富 (大分中央保健所)
5月27日　有吉ほか2人 (応用地質)
5月29日　青柳輝夫 (経理掛)
6月1日　加藤義則 (別府市会議員)
6月5日　山崎達雄 (九大名誉教授)，久保寺章 (京大名誉教授)，三浪俊夫 (福岡教育大学教授)，本松利郎 (出光大分地熱)
7月　斉藤武士 (京都大学総合人間学部)
7月7日　塩崎一郎 (鳥取大学助教授)
7月8日　松山尚典 (応用地質)
7月28～29日　理学部学生6人 (地熱学野外実習)
7月28日　野邑憲二 (ボーゲンファイル)

8月	鈴木勝彦（東京大学教養学部）
	川村隆夫（東邦大学大学院理学研究科化学専攻）
	岩倉一敏（東邦大学大学院理学研究科化学専攻）
8月9日	John Townend（海洋科学技術センター）
8月9日	日比野容子（朝日新聞記者）
8月10日	星名さん親子（中学1年男子，東京）温泉のことで
8月22日	小坂丈予（玉川大学学術研究所）ほか多数（日本温泉科学会）
8月24日	高松信樹（東邦大学助教授）
8月28日	京大学生3名　ゼミ
8月31日	加藤知弘（大分大学名誉教授），平野統之（大分合同新聞記者）
9月	岩倉一敏（東邦大学大学院理学研究科化学専攻）
	龍田，藤田，加藤（日本大学文理学部）
	藤沢，上野（鹿児島大学）
	伊東和彦（南大阪大学）
9月2日	甲斐賢一（ホテル風月社長）　国際温泉フォーラム
9月9日	御沓稔弘（大分県生活環境課），松山尚典（応用地質）
9月10日	後藤正治（大分県企画部水資源，土地対策局次長）ほか1人
9月14日	小島友行（日本テレビ，ディレクター）ほか1人
9月16日	堀内清司（日大教授）ほか学生3人，大分合同新聞，平野統之（大分合同新聞記者）
9月18日	木村事務長ほか2人　電気工事竣工検査
10月	小松貴史（山大理学部）
10月5日	Trevor Hunt（NZ Wairakei Research Centre），佐藤久美（別府ビーコンプラザ）
10月6-7日	John P. Matthews（前京都大学教授）
10月9日	岩男道也（別府土木事務所長）ほか1人，西田慎介（朝日新聞記者）
10月12日	西田慎介（朝日新聞記者）
10月13日	田仲敬司（版画家），伊豆富生（別府市観光課）　研究所建物版画寄贈
10月16日	相原和博（伊予銀行別府支店次長）
10月27日	福田道博（九大教授）ほか国際地熱研修コース一行12人
11月	鳥居雅之（岡山理科大学）
	藤沢康弘（鹿児島大学理学部）
	宇井忠英（北海道大学理学部）
	奥野（福岡大学地球圏）
	小林哲夫（鹿児島大学理学部）
	斉藤武士（京都大学総合人間学部）
11月4日	石川光太郎（NHK大分放送局アナウンサー）
11月5日	京大施設部一行5人　研修
11月11日	春田忠雄（地球科学全般につき）
11月13日	宇野（別府市観光課長補佐）ほか1人，有吉ほか2人（応用地質）
	小林哲夫（鹿児島大学）ほか2人
11月15-17日	総人院生
11月17-18日	構内にて環境騒音調査（別府市）

11月19日	東辻施設掛長ほか5人（浜村，城山，土井，杉本，南条）
	鳥居雅之（岡山理科大教授）
11月25日	太田幸憲（大分県生活環境課）ほか1人
12月19日	江原幸雄（九大教授）　ゼミ
12月28日	熊谷達彦（出光大分地熱社長）ほか1名
1999年	
1月12日	藤田洋三（カメラマン），都留広之（大分合同新聞記者）ほか1名
1月13日	高田和代，成井明徳，福島慎吉，永田憲司（経理部）
2月1日	川村政和（地質調査所地殻物理部長）
2月20日	竹村恵二（地球物理教室助教授）ほか1名
2月23日	渡辺泰徳（東京都立大学教授）
3月	大分県立森高等学校教諭6名
	大谷竜（東京大学理学系研究科）
	金子克哉（地質調査所）小屋口剛博（東京大学地震研究所）
	廣瀬敬（東京工業大学理学部）
	岩倉一敏（東邦大学大学院理学研究科化学専攻）高松信樹（東邦大学理学部化学科）
3月1日	木村悠（佛教大学）
3月8日	人間環境研究科，張田（M2）
3月9日	同上学生1来
3月10日	橋川和男，木村智子，奥山諭（施設部）
	広島大学，本田了教授＋中久喜伸益（12日まで）
3月11日	鎌田賢（経理部長），平井宏（管財課長），井尻恒博（主計課長補佐），川崎理学部事務長補佐
3月15日	別府外湯協議会一行6人
3月18日	太田幸憲（大分県生活環境課）ほか1人
3月23日	総合人間学部，鎌田教授，酒井助教授，飯澤，齋藤，須田
3月30日	小林芳正（広島工大教授）ほか3名
3月31日	小寺英治，坂本雄美（経理部），稲田一美（理学部司計掛）　金庫検査