Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SVC052-P01 Room:Convention Hall Time:May 26 10:30-13:00

Volcanic history of Atami district in and around the southern part of Hakone Volcano

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The Atami district is located on the northwestern part of the Izu Peninsula, central Japan. Kuno (1952) pointed out that the age of the volcanic rock in this district was the Neogene to Quaternary. However, based on the volcanic stratigraphy and the radiometric dating, it is clear that the volcanic rocks exposed on the surface in this district are the Quaternary only. These Quaternary volcanic rocks are divided roughly into the Hakone Volcanic Group and Usami - Taga Volcanic Group. In this district, the Hakone Volcanic Group comprises two stratovolcanoes: the Hakone Volcano (0.4Ma to present) and Yugawara Volcano (0.4 - 0.2Ma). The product of the Hakone Volcanic Group is distributed in the northern part of the district. These volcanic products of volcanoes consist of basalt to dacite lavas, and pyroclastics. The rock types of these volcanic products are mainly olivine-clinopyroxene or olivine-clinopyroxene-orthopyroxene basalt to andesite, and clinopyroxene-orthopyroxene andesite to dacite. The Usami - Taga Volcanic group, distributed in the southern part of the district, comprise seven stratovolcanoes that are divided by structure and topography of the volcanic body and radiometric (K-Ar and 40Ar/39Ar) ages: the Shimotaga (1.2 - 0.8 Ma), Usami (0.8 - 0.75Ma), Osaki (0.75 - 0.65 Ma), Atami (0.7 - 0.45 Ma), Uomisaki (0.6 - 0.5 Ma), Hatsushima (0.7 - 0.6 Ma and younger 0.3 Ma) Volcanoes. These volcanic products consist of basalt to andesite with dacite lavas, and pyroclastics. The rock types of these volcanic products are mainly olivine-clinopyroxene or olivine-clinopyroxene-orthopyroxene basalt to andesite, and clinopyroxene-orthopyroxene andesite. The volcanic products are low-K tholeiitic basalt to andesite.

These Quaternary volcanic rocks are not recognized as water chilled structures. Thus, it is determined that this district became land after the late Quaternary (about after 1 Ma). However, water-chilled structures are sometimes recognized in a seashore area (seashore to 100 m a.s.l.) of volcanic rocks (i.e. products of Uomisaki Volcano). This suggests that the northern part of the Izu Peninsula is an uplift tendency.

The Usami-Taga and Hakone Volcanic Group are covered on the small volcanoes, which are the rhyolite monogenetic volcanoes and Sukumoyama Volcano and Chojagahara Marl of the Higashiizu monogenetic volcanoes. The activity periods of the rhyolite monogenetic volcanoes, Sukumoyama Volcano and Chojagahara Marl are 0.45 - 0.15 Ma, 0.15-0.3 Ma, and 0.15-0.3Ma respectively.

Keywords: Atami, Usami-Taga Volcanic Group, Hakone Volcanic Group, Volcanic stratigraphy, Radiometric dating

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Topographic survey of lake-bottom of Ashi-no-ko in the Hakone Volcano using the narrow multi-beam sonar system

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Hakone-machi active fault, one of the A.D. 1930 Kita-Izu earthquake fault system, runs along the southeastern part of lake Ashi-no-ko in the Hakone volcano, corresponding to the western margin of the Maizuru micro-plate. Strike-slip motion of the fault system is considered to have caused the caldera and central cone formation of the volcano. The fault probably passes through between Byoubu-yama and Do-ga-shima, and extends to the lake-bottom of Ashi-no-ko, where rise-like morphologic features with several terraces are developed. Such lake-bottom surface forms may show tectonic activities of the Hakone-machi fault. Topographic survey of lake-bottom of Ashi-no-ko, using the SeaBat 8101 narrow multi-beam sonar system, clarifies such morphologic features as swell, hollow, scarp, hummock, and terrace. Those features tend to be arranged in the direction of northwest and southeast, and in particular the scarp parallel to the Hakone-machi active fault is tectonically noted, because the fault running along the east side of lake Ashi-no-ko may correspond to one of north extension spray faults of the Kita-Izu active fault system.

Keywords: Hakone volcano, Hakonemachi fault, SeaBat 8101 narrow multi-beam sonar system, lake Ashi-no-ko

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Practical report of the education of volcano at Hakone, Japan

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Hakone-machi exists in an active volcano named Hakone which had studied by Dr. Kuno. The board of education of Hakone-machi is executing the Hakone Education. The Hakone education is a curriculum done from the kindergarten to the junior high school. Hakone Education uses teaching materials, such as nature, history, sightseeing and industry, existed in the Hakone area. The education of volcano in junior high school is done by the cooperation of the Kanagawa prefectural museum, the board of education of Hakone-machi, and the Hakone junior high school. The curriculum was made by teachers of the board of education and junior high school. It is depended on Dr. Kuno's previous works that teachers feel a great interest of Hakone Volcano. The study of the volcano consists of the class of seven schools. Kanagawa prefectural museum takes charge of the experiment of volcano using waste food oils (Kasama et al.,2010) and observation of rock forming minerals. Hakone education started in 2007. The continuance of Hakone Education is effective for Hakone Geopark and the succession of educational property to young teachers.

Keywords: science of junior high school, education of volcano, Hakone volcano, board of education of Hakone-machi, experiment of volcano using waste food oils, observation of minerals

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Viscosity change of magmas during crystallization: a summary

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Recent development of viscometry of magmatic suspensions are reviewed, and our experimental works on the subliquidus viscometry on some magmatic systems are summarized. Prof. Hisashi Kuno together with Dr. Tsutomu Murase attended the 1968 Andesite conference in Oregon, convened by Prof. A.R. McBirney, and Prof. Kuno was surely aware of the importance of viscosity of magmas to understand the volcanic and magmatic processes.

Theoretical consideration of Einsten(1906) together with the modification of Roscoe(1952) and Marsh(1981) gave the Einstein-Roscoe-Marsh's equation: u=u0(1-p/0.6)^(-2.5), where u, u0, p represent bulk viscosity, viscosity of melt, and crystal fraction, respectively. This equation is useful for estimating rough viscosity of magmas where the crystal contents and melt viscosity can be obtained from the analyses of rock textures, temperature and groundmass compositions. Actually, effect of morphology of crystals (e.g., aspect ratio of oblate or prolate crystals) and dispersion of crystal size distribution may cause the departure from the ERM equation, and the last several years have seen renewed experimental and theoretical works on this topics (e.g., Costa, 2005, 2009; Sato, 2005; Ishibashi & Sato, 2007; Arbaret et al., 2007; Carrichi et a., 2007, 2008; Mueler et al., 2010, Vetere et al., 2007, 2008). These works are mostly based on the ERM equation and extends them to non-Newtonian (shear rate dependence) or high crystal fraction systems.

We installed an atmosphere-controlled furnace available for viscometry, and carried out viscometry and sampling of some magmatic systems. The starting materials we used are, high-Alumina basalt of Fuji volcano, alkali basalt of NW Kyushu,shoshonite from Vulcanello, MORBs, Hawaiian tholeiite, arc basalt from Izu-Oshima Island. The furnace atmosphere are controlled by mixed gas of H2 and CO2 under FMQ for MORBs and Hawaiian tholeiite, NNO for alkali basalt, arc basalts and shoshonite. Samples are fused in Pt(Fe saturated) crucible 30mm inner diameter and 60mm high, and ceramic rod of 6mm in diameter is used for torque measurements and sampling. The system is calibrated with standard oil (JS180000) for variations of the depth of the ceramic rod tip and the depth of immersed melt. We firstly melted the samples ca. 50 degree above the liquidus temperatures, and cooled step by step, with measurement and sampling at the end of each step. When the crystal contents reach 14-30 vol.%, the samples are too viscous to measure viscosity and the measurements are terminated. The liquidus phases are plagioclase for the high-Alumina basalt, MORBs and arc basalt, olivine for alkali basalt and Hawaiian tholeiite, and clinopyroxene for shoshonite. Relative viscosity (bulk viscosity over melt viscosity) tends to fit the ERM equation where olivine is the liquidus phase, whereas in systems with liquidus plagioclase or clinopyroxene tend to show larger relative viscosity compared with the ERM equation by a factor of 3-8. The aspect ratio of plagioclase (thin platy) and clinopyroxene (thin prism) in the experimental charges are mostly 5-15, and such large aspect ratio is expected to increase the relative viscosity by strong interaction of crystals (Mueller et al.2010). We analyzed the data for non-Newtonian models of power law fluid or Bingham fluid, and such non-Newtonian effect is obvious for systems with higher crystal contents.

Keywords: magma, viscosity, crystallization, Einstein-Roscoe equation, crystal morphology, non-Newtonian fluid

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H2O concentration in primary arc magmas estimated by experimental petrological studies and analyses of melt inclusions

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The slab-derived fluids and/or hydrous slab melts released from a subducted slab hydrate the mantle wedge, lower its melting temperature and induce generation of hydrous arc magmas. Experimental petrological studies have clarified that the H_2O shift pressure and temperature conditions of magma generation at subduction zones (Tatsumi *et al.*, 1983 JGR), and thus it is critical to estimate H_2O concentration in primary arc magmas. We will give an overview on selected attempts to estimate H_2O concentration in primary arc magmas by experimental petrological studies and analyses of melt inclusions in recent 30 years. Melting experiments of hydrous primary arc magmas by Pichavant *et al.* (2002 GCA) demonstrated that only primary magmas with low H_2O ($<$ 2 wt.%) can erupt without modification of their primary composition by crystallization differentiation due to comparable dP/dT between olivine liquidus and basalt adiabat. These constraints do not exclude presence of hidden H_2O-rich primary magmas. Indeed, the H_2O concentration in primary magma estimated from the analyses of primitive melt inclusions suggest wide variation (e.g., 2 wt. % at Kamchatka arc and 4 wt. % at Central American arc). H_2O-rich primary magmas may ascend and erupt after differentiation and/or supply volatiles to magmas at shallower level and cause so-called "excess degassing".

The H_2O concentration in primary magmas can be variable not only among different arcs and/or volcanoes, but also in a single arc volcano: both H_2O-rich and H_2O-poor primary magmas can coexist. This idea has been proposed by many petrologists to explain coexistence of tholeiitic series rocks and calc-alkaline series rocks in a single arc volcano since Kuno (1950). Further studies on variation of H_2O concentration in primary magmas, in combination with geochemical studies and numerical studies, will constrain genetic conditions of such dual primary arc magmas.

Keywords: H2O concentration in primary arc magma, Experimental petrology, Melt inclusion, Island arc magmatism, Subduction zone

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Multi pressure thermodynamic calculation of partial melting of peridotite by system energy minimization

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Throughout the Earth's history from early Earth when a dense melt could have accumulated at the bottom of the mantle to present day setting where melting at ridges, subduction zones and hotspots drives material differentiation, partial melting of the mantle is an essential process for its material and thermal evolution. Thermodynamic modeling is a general approach suitable for describing such material and thermal evolution during melting. It can provide an internally consistent model in terms of phase assemblage, mass- and energy-balance. We have been developing a general energy minimization algorithm for describing such mantle melting. The algorithm calculates gradient of total Gibbs free energy of the system with respect to any tiny mass of melting or solidification of melt and solid end-components under the constraint of closed system at constant pressure and temperature. Molar contents of solid and melt end-components are recalculated along the steepest gradient of total Gibbs free energy of the system at each calculation step. Equilibrium state of the system is found where the gradient becomes zero with respect to any tiny mass perturbation. Thermodynamic model had constructed with the algorithm, thermodynamic formulation of silicate melt and calibrated thermodynamic parameters for silicate melt successfully reproduced melting phase relations of mantle peridotite at 1GPa.

Here we present a new multi pressure thermodynamic calculation with newly calibrated thermodynamic parameters for silicate melt. Calibration data source is expanded to include higher-pressure experiment, up to 2 GPa. The thermodynamic model describes melting of spinel lherzolite at 1-2GPa. The calculation is carried out in a system SiO2-Al2O3-FeO-Fe3O4-MgO-CaO with olivine, clinopyroxene, orthopyroxene, spinel and silicate melt. The dCp values, which are a difference of specific heat between solid and melt end-component, and dV, which is a difference of volume between solid and melt end-component have been calibrated utilizing previously reported results of high-pressure melting experiments of mantle peridotite and thermodynamic properties of rock forming minerals. Simple ideal solution is employed for the activity model of silicate melt in this study.

Thermodynamic calculation with newly calibrated parameters successfully predicted multi pressure melting relation of mantle peridotite, including elevated solidus temperature at higher pressure. At 1.5 or 2 GPa calculation, temperatures 50-100 degrees higher than that of 1GPa are required to derive a certain degree of melting, which coincides well with experimentally predicted effect of pressure on melting degree (e.g.; Falloon et al., 1999; Hirose and Kushiro, 1993). Effects of pressure on partial melt compositions are well reproduced, though FeO/MgO partition between melt and solid are not well reproduced with the ideal solution activity model. Decrease of SiO2 content and increase of FeO in a partial melt with increasing pressure and increase of MgO content with increasing temperature, as shown in Hirose and Kushiro (1993), are well reproduced. In addition to the effects of temperature and bulk composition, effect of pressure on melting relation is successfully introduced to our thermodynamic calculation with relatively simple thermodynamic formulation for silicate melt.

Keywords: thermodynamics, melting, mantle, magma