2. Petrology and Mineralogy

In the period from 1999 to 2002, many studies on petrology and mineralogy have been made by Japanese earth scientists as well as the previous period.

Significant progress has been made at the Japanese-USA cooperative studies on Hawaiian volcanoes (Naka et al., 2000; see section VII of this report), including deep-sea survey with the submersible "Shinkai 6500", the world's most advanced deep-sea probe. Major part of the outcome was published as a monograph (Takahashi, E. et al., 2002), including petrological and geochemical studies on products collected by the deep-sea survey (Kaneoka et al., 2002; Sherman et al., 2002; Shinozaki et al., 2002; Tanaka et al., 2002) and melting experiments on basalt-peridotite (Takahashi, E. and Nakajima, 2002). Other studies on the Hawaii project were appeared as individual papers (e.g., Lipman et al., 2000).

Research on Unzen volcano also progressed significantly after its eruption of 1990-1995 (Chen, C. H. et al., 1999; Kusakabe et al., 1999; Nakada and Motonura, 1999; Sato et al., 1999; Tateyama et al., 2002; Watanabe, K. et al., 1999). At the volcano, international scientific drilling project (Unzen volcano Scientific Drilling Project) is going on (Sakuma and Nakada, 2002; Sakuma and Saito, 2000; Uto et al., 2000; see section VII of this report) and many publications will be appeared in the next period.

Research on subduction-zone magmatism around Japan was made energetically. As for Northeast Japan, spatial distribution of volcanoes was noticed (Umeda et al., 1999), and a new concept of "hot fingers" in the mantle wedge was proposed (Tamura, Y. et al., 2001, 2002). The magmatism in this region was summarized (Yoshida, 2001) and compared with Southern Chile arc (Takahashi, M. et al., 2002b). Also Cenozoic volcanism on Hokkaido area (Hirose, W. et al., 2000; Hirose, W. and Nakagawa, 1999; Ikeda, Y. et al., 2000; Nakagawa, 1999; Nakagawa et al., 1999a; Okamura et al., 2000; Takagi et al., 1999) was discussed in connection with its tectonic setting. As for Southwest Japan, many geochemical studies were made especially on the Setouchi volcanics or related rocks (Furukawa and Tatsumi, 1999; Hanyu et al., 2002; Nakashima et al., 2000; Seno and Matsuura, 2000; Shimoda and Tatsumi, 1999; Sumii, 2000; Tatsumi, 2000b, 2001; Tatsumi et al., 2002), including contemporary adakitic rocks in central Japan (Takahashi, T. and Shuto, 1999). Also studies on the region before (Kagami et al., 1999a, 2000) and after (Ikeda, Y. et al., 2001; Kamata and Kodanna, 1999; Shukuno and Ara, 1999) the opening of the Japan Sea were made. Studies on premature arcs and active back-arc basins, such as Izu-Bonin arc (Hochtstaedter et al., 2000; Ishii et al., 2000a-b; Ishizuka, O. et al., 2002), Mariana arc (Ishikawa and Tera, 1999; Ohara et al., 2002), Ryukyu arc (Shinjo and Kato, 2000; Shinjo et al., 2000, 2000a; Watanabe, K., 2000, 2001) and West Philippine back-arc basin (Fujikoka et al., 1999), were made mainly by deep-sea survey. In connection to the above studies, it was proposed that continental crust with andesitic composition was generated by delamination (Tatsumi, 2000a), and that silicic magma in oceanic arc was generated by remelting of an andesitic crust (Tamura, Y. and Tatsumi, 2002). Analyses on light elements in subduction-zone magma, such as boron (Sano, T. et al., 2001b), beryllium (Shimaoka and Kaneoka, 2000) and carbon (Nishio and Sano, 2000), were made to investigate contribution of recycled elements from subducting sediment. There were studies on high-pressure melting experiments for related rocks (see later) and numerical simulation for wedge-mantle convection (Iwamori, 1999a-b, 2000a-b, 2001a-b, 2002a-b; Iwamori and Zhao, 2000a-b; Zhao et al., 2000). A textbook on subduction-zone magmatism was published by Takahashi, M. (2000). Research on plume-origin magmatism (Hanyu and Nakamura, 2000; Hirano et al., 2001; Tatsumi et al., 1999b, 2000a-b) was also progressed in addition to the Hawaiian project.

There were two major eruptions during this period, on which many studies were made (see section II of this report). One was the 2000 eruption of Usu volcano, Hokkaido (phreatomagmatic/phreatic). In this eruption, it was pointed out that detailed petrographical research was needed for detection of essential materials of phreatomagmatic eruptions (Tomiya et al., 2001) because apparently fresh and clear volcanic glass from this eruption was found to be accidental fragment. Studies on the magmatic process of the eruption in comparison with the past eruptions (Tomiya, 2001; Tomiya and Miyagi, 2002), on vesiculation of the magma during ascent (Suzuki and Nakada, 2001, 2002), on fragmentation of country rocks due to explosion within the conduit (Yahata, 2002) and on petrographical and geochemical analyses of the volcanic ash (Nakagawa et al., 2002b; Nogami et al., 2002; Shimano et al., 2001) were also made. The other major eruption in this period was the 2000 eruption of Miyakejima volcano, Izu Islands (phreatomagmatic/phreatic). Again, the detection of essential materials in the eruptive products required detailed and complex researches (Miyagi, I. and Tomiya, 2002a-b; Miyagi, I. et al., 2001a-c). Studies on mechanism of the voluminous emission of SO2 gas (Uto et al., 2001; Yasuda et al., 2001, 2002), on magmatic process of the eruption (Amma-Miyasaka and Nakagawa, 2002; Geshi et al., 2002) and on formation history of the volcano (Tsukui et al., 2001) were also made.

Petrological studies of other individual volcanoes (volcanic areas) around Japan include: Abu Monogenetic Volcano Group (Kakabuchi et al., 2000), Adataru (Fujinawa et al., 2001b), Akagi (Kobayashi, K. and Nakamura, 2001), Akan (Ikeda, Y., 2002), Akusekijima (Furutama and Toya, 2002), Aso (Toya and Ban, 2001), Aso (Obata et al., 2001), Bishamon-dake (Ujike et al., 2001), Daikanjojima basalt (Morris et al., 1999), Daisen (Tamura, Y. et al., 2000), Daisetsu (Nakamura, Y. and Hirakawa, 2000), Fuji (Fujibayashi et al., 1999; Ui et al., 2002), Hachijjo-Nishiyama (Tsukui and Hoshino, 2002), Hachimantai (Ohba and Umeda, 1999), Hakone (Hirata et al., 2001), Higashi-Izu Monogenetic Volcano Group (Suzuki, 2000; Takahashi, M. et al., 2002a), Iwate (Nakagawa and Togari, 1999), Iki and Satsunaga-Iwojima (Maeno et al., 2002; Saito et al., 2002), Kita-Hakkoda Volcano Group (Kudo et al., 2000), Kurikoma (Fujinawa et al., 2001a), Myojin-sho (Ueda et al., 2001), Nasu (Ban and Yamamoto, 2002), Nekoma (Kimura et al., 2001, 2002b), Norikura (Kimura et al., 1999), Numazawa (Numazawa Volcano Research Group, 1999), Ontake (Kimura and Yoshida, 1999), Rausu (Miyagi et al., 2000), Rishiri (Ishizuka, Y. and Nakagawa, 1999; Kuritani, 1999a-b, 2001), Sannome-gata (Yoshinaga and Nakagawa, 1999), Toga (Kano et al., 2002), Towada (Kuri and Kurita, 1999), Tyatya (Nakagawa et al., 2002a) and Ueno volcano (Ueno basalts) (Kimura et al., 2002a; Nakano, S. et al., 2000; Ujike and Stix, 2000).
2000).

Studies focused on a special eruption include: the 1929 eruption of Hokkaido-Komagatake (Takeuchi, 2000; Takeuchi and Nakamura, 2001), the 1813 eruption of Suwanose (Shimano and Koyaguchi, 2001) and the 100-ka eruption of Hijiori (Matsuda et al., 2002).

Studies on volcano-related geothermal areas include: Yuzawa-Ogachi-Doroyu area (Takashima et al., 1999; Zhang et al., 1999), Hachimantai-Appi area (Takashima et al., 2001) and Yanaizu-Nishiyama (Okuaimu) area (Mizugaki, 2000).

Studies on volcanics of around Neocene, besides those described above (e.g., Setouchi volcanics), include: Anamizu Formation (Lopez and Ishiwatari, 2002), Beppu-Shimabara graben (Kita, I. et al., 2001; Yokose et al., 1999), Daiyauna and Nishinou areas (Shimakura et al., 1999), Hahajima (Yajima et al., 2001), Hamamasu area (Aoki et al., 1999), Hisatsu area (Nagao et al., 1999), Inamiwadake (Yasui and Yamamoto, 2000), Masuda basinite (Sawada and Takasu, 1999), Oki-Dogo (Kobayashi, S. et al., 2002), Shimane Peninsula (Iizumi et al., 1999), Shirogishi Tuffs (Imaoka et al., 1999) and southern Fossa Magra region (Miyagi, S. and Kanai, 2002). Studies on volcanics and granites of Paleogene or older (Aoya, 2001; Ikawa et al., 1999; Kagami et al., 1999b; Kanayama et al., 1999; Kawano, Y. and Kagami, 1999; Owada et al., 1999; Rezanov et al., 1999; Sugii and Sawada, 2000; Tsuchiya et al., 1999a) were made to investigate the relation between the arc crust and felsic magmatism in Japan.

Volcanic fields outside Japan were also studied, such as: Ruapehu volcano (Nakagawa et al., 1999b, 2002c), Flores island (Muraoka et al., 2002; Otake et al., 2002), East African Rift Zone and related areas (Kabeto et al., 2001a-b; Oritashi et al., 2001; Sawada et al., 2001; Tadesse et al., 1999), Deccan trap (Sano, T. et al., 2001a), Korea (Kim et al., 1999), China and Mongolia (Kanisawa, 1999; Liu and Taniguchi, 2002; Nozaka and Liu, 2002; Zheng et al., 2002), Siberia (Agashev et al., 2001; Hasenaka et al., 1999; Litasov, K. and Taniguchi, 2002; Litasov, K. et al., 2000, 2001c-d, 2002; Litov, Y. et al., 2002; Morikyo et al., 2000), Sikkhat Aatin (Shimazu and Kawano, 1999; Tatsumi et al., 2000c) and Kokchetav 'lamproite' (Zhu, K., 2000; Hirose, K., 2002; Hirose, K. and Fei, 2002; Inoue et al., 2000, 2001b; Oguri et al., 2001). Volcanics closely related to ophiolites were also studied (Imanaka and Miyashita, 1999; Ishiwatari, 1999; Kawabata et al., 1999; Miyashita and Sokolov, 1999) and other Japanese peridotites (Abe et al., 1999; Kadoshima and Arai, 1999; Matsumoto and Arai, 2001; Namura, A. et al., 1999). Volcanics closely related to ophiolites were also studied (Imanaka and Miyashita, 1999; Ishiwatari, 1999; Kawabata and Kiminnami, 1999; Kinominami et al., 1999; Miyashita, 1999; Miyashita and Kiminnami, 1999; Niida and Kito, 1999; Ozaawa, H. et al., 1999; Sakakibara et al., 1999; Tsuchiya et al., 1999b). In addition, mantle xenoliths (Arai et al., 2000, 2001; Hattori, K. H. et al., 2002; Yamamoto et al., 1999) and inclusions in diamonds (Akagi, 1999; Wang et al., 2000) and Cr-spinel (Shimizu, K. et al., 2001) were investigated for mantle studies.

There was mass production of papers in the field of high-pressure experiments on mantle mineralogy (Chen et al., 2001, 2002; Hattori et al. et al., 1999, 2001; Hirose, K. et al., 1999, 2001a-b; Katsura, 2002; Kuroda et al., 2001). Connectivity of melt in crystal-rich (Yamaoka and Li, 2001), solidification of lava domes (Smith et al., 1999, 2002), solidification of lava domes (Smith et al., 2001), and formation of layered structure of gabbro (Arai et al., 2000, 2001), Pb-isotope measurement (Nohda, 1999) and 1-atm gas-mixing furnace (Sugawara, 1999). New types of analyses of rock texture were introduced such as X-ray CT (Nakanou, T. et al., 2000; Ohtani et al., 2000, 2001; Tsuchiyama et al., 2000), high-resolution TEM (Hiraga, 1999) and polarized laser-scanning microscope (Shimizu, I. and Shimada, 2002). Fluid connectivity (wetting angle) in porous rocks and its role on various processes were noticed. Mibe et al. (1999, 2000) suggested that the generation of arc magma and, therefore, the location of the volcanic front may be controlled by aqueous fluid connectivity in the mantle. The connectivity of fluid was also thought to be important on water transport within mantle (Ono et al., 2002, 2002b), crust (Nakurama, M., 2000; Nakamura, M. and Watson, 2001; Yoshino et al., 2002) and metamorphic rocks (Hiraga et al., 2001, 2002). Connectivity of melt in crystal-rich magma was also studied in relation to the textural development of igneous rocks in the stage of their crystallization (Ikeda, S. et al., 2002).

There were various types of studies on dynamics of magma from petrological points of view, such as, melt migration within dikes (Geshi, 2000, 2001), crystallization and cooling history of magma (Miyake and Shimobayashi, 2000; Nishimura and Yaragi, 2000; Sano, Y. et al., 2002), solidification of lava domes (Smith et al., 2001), and formation of layered structure of gabbro (Akehata et al., 1999) and peridotite (Toramaru et al., 2001). A series of analogue experiments on crystallization of magma within melttable material (a binary eutectic system) was carried out (Kaneko and Koyaguchi, 2000) in order to discuss evolution of a magma chamber within the crust (Koyaguchi and Kaneko, 1999). There was also a numerical experiment of crystallization for a binary eutectic system for the purpose of applying to igneous textures (Toramaru, 2001). A textbook on dynamics of petrogenesis was published by Banno et al. (2000). Theoretical approach to viscosity of magma (Taniguchi,
Thermodynamical and mineralogical research was made on mixing properties of Ca in olivine (Kawasaki, 1999, 2001a-b), phase relations of enstatite at high temperatures (Jiang et al., 2002), behavior of Sr in CaAl-silicates (Enami, 1999), fine structure of amphiboles (Ishida et al., 2002) and oxybiotite (Kogure and Nepolo, 2001), partition of Mg between olivine/orthopyroxene and melt (Sugawara, 2000a), Fe and Mg between plagioclase and melt (Sugawara, 2000b, 2001b) and trace-elements within mantle materials (Kanzaki, 2000; Taura et al., 2001) in even open magmatic systems (Ozawa, K., 2001). Studies on other kinetic processes include: diffusion in garnet (Nishiyama, 1999) and biotite (Utsumi, 2002), equilibrium form of negative crystals in quartz (Asada et al., 2002), and weathering/hydration of volcanic glass or minerals (Kawano, M. and Tomita, 2001; Kita, S. et al., 1999; Nakamura, Y. et al., 2002).

References


Izumi, S., Otani, S. and Hara, K. (1999) Sr and Nd isotope ratios of Middle Miocene volcanic rocks from Shimane Peninsula, San'in district,


trace element variations in Quaternary volcanics from Hokkaido, Japan. Resource Geology Special Issue, 20, 159-174.


Sawada, Y. and Takasu, A. (1999) A kyanite bearing gneissic xenolith with partial melt glass in the Late Miocene basanite, Masuda, Shimane


18, 69-84. *

CaCO₃ at high pressure and high temperature. Amer. Mineral., 86, 997-1002.


553, 27-32. **


425-445.


Takahashi, M., Kikuchi, K., UruUSHiHATA, T., Aramaki, S. and Hamuro, K. (2002a) Incompatible element chemistry for basaltic rocks in the

Takahashi, M., Tagiri, M., Notsu, K., Lopez-Escobar, L. and Moreno-Roa, H. (2002b) Comparative study of Quaternary arc volcanic belts:

incipient melt migration and segregation in the partially molten upper mantle. J. Petrol., 42, 39-54.

Takahashi, T. and Shuto, K. (1999) Genesis of adakitic andesite, high-magnesian andesite, calc-alkaline andesite and tholeiitic andesite in the
Miocene Iwaine Formation, southern part of Toyama Prefecture, Japan. J. Geol. Soc. Japan, 105, 789-809. *


rocks in the Hachimantai Appi geothermal field, NE Japan ---Proposal for selection of promising geothermal areas by alteration survey,

complex, Japan. J. Petrol., 40, 1827-1851.

Takeuchi, S. (2000) Eruption initiation from a highly crystallized magma chamber —Evidence from the 1929 eruption of
Hokkaido-Komagatakage—. Monthly Earth, 22, 341-348. **


Soc. Japan, 45, 149-171. *


