Available online at www.sciencedirect.com
ScienceDirect
Journal of Volcanology and Geothermal Research 164 (2007) 268–283
Journal of volcanology and geothermal research
www.elsevier.com/locate/jvolgeores

Magnetic petrology of the 1991–1995 dacite lava of Unzen volcano, Japan: Degree of oxidation and implications for the growth of lava domes

Takeshi Saito [a,*], Naoto Ishikawa [b], Hiroki Kamata [b]

[a] *Institute for Geothermal Sciences, Kyoto University, Noguchibaru, Beppu, Oita 874-0903, Japan*
[b] *Graduate School of Human and Environmental Studies, Kyoto University, Yoshida-Nihon-Matsu, Sakyo-ku, Kyoto 606-8501, Japan*

Received 25 November 2005; received in revised form 13 April 2007; accepted 17 May 2007
Available online 2 June 2007

Abstract

To understand the oxidation state and process of oxidation of lava domes, we carried out magnetic petrological analyses of lava samples obtained from domes and block-and-ash-flow deposits associated with the 1991–1995 eruption of Unzen volcano, Japan. As a result, we recognize three different types of magnetic petrology, each related to deuteric high-temperature oxidation during initial cooling. Type A oxides are characterized by homogenous titanomagnetite and titanohematite, indicating a low oxidation state and high titanomagnetite concentrations. Type B oxides are weakly exsolved and contain titanohematite laths and rutile lenses, indicating a higher oxidation state. Type C oxides, which represent the highest oxidation state, are completely exsolved and composed of Ti-poor titanomagnetite, titanohematite, rutile, and pseudobrookite, indicating high hematite concentrations. Some grains in Types A and B show indications of reduction, which was related to interaction with volcanic gases subsequent to high-temperature oxidation. In terms of geological occurrence, the oxidation processes probably differed for endogenous and exogenous domes. Endogenous dome lavas are oxidized concentrically and are classified into the three types according to their location within the dome: samples from the surface are strongly oxidized and classified as Type C, while the inner part is unoxidized and classified as Type A. Exogenous dome lavas are unoxidized and assigned to Type A. Some samples show signs of reduction, which may have occurred around fumaroles. We propose that location within the dome and the process of dome growth are the factors that control oxidation.

Keywords: Unzen volcano; lava dome; block-and-ash flow; iron–titanium oxide; magnetic petrology; oxidation

1. Introduction

Lava dome eruptions are typical of non-explosive silicic volcanism. Silicic lavas are quietly effused on steep slopes, such as the summit area, and form lava domes. Unstable parts of the dome commonly collapse to form small pyroclastic flows (block-and-ash flows) that can have devastating consequences for human settlements. Such events may occur with little warning and continue for several months following the initial growth of the dome. The emplacement of lava domes is therefore one of the most dangerous types of volcanic eruptions (e.g., Fink and Anderson, 2000).

The 1991–1995 eruption of Unzen volcano, Japan, provided an ideal opportunity to investigate the process

* Corresponding author. Tel.: +81 977 22 0713; fax: +81 977 22 0965.
E-mail address: saito@bep.vgs.kyoto-u.ac.jp (T. Saito).

0377-0273/$ - see front matter © 2007 Elsevier B.V. All rights reserved.
doi:10.1016/j.jvolgeores.2007.05.015

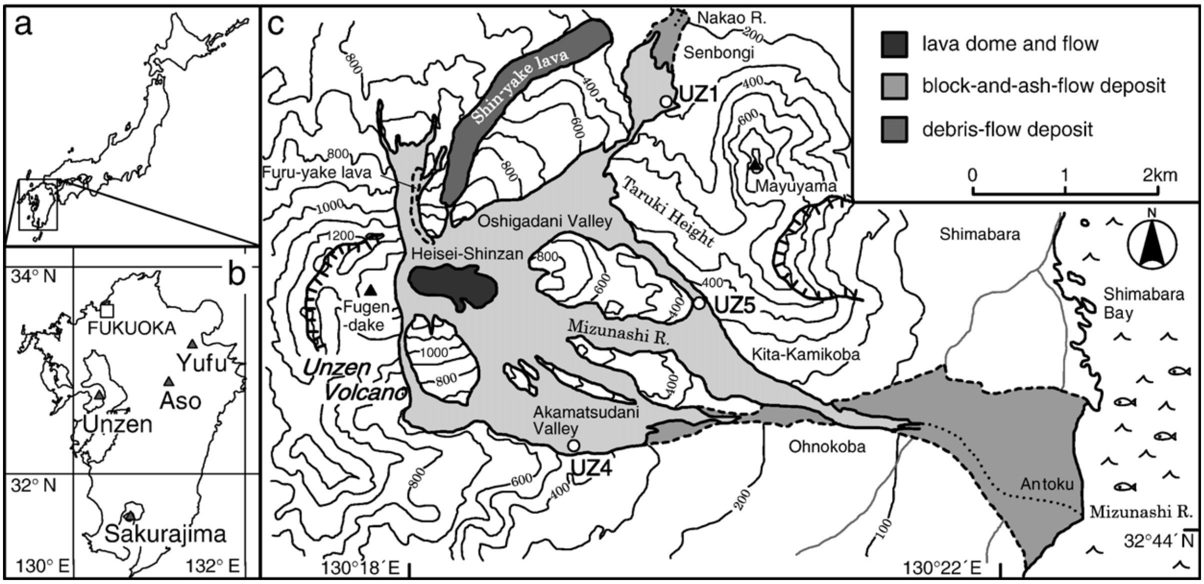

Fig. 1. Simplified geologic map of Unzen volcano (after Ui et al., 1999) showing sampling locations (UZ1, 4, and 5).

of dome growth and collapse. Visual observations of lava domes leading up to the formation of block-and-ash flows have helped to improve our understanding of eruption processes (Sato et al., 1992; Nakada and Fujii, 1993; Nakada et al., 1995; Ui et al., 1999). Sato et al. (1992) suggested that the explosivity of lava domes is controlled by the degree of degassing of the magma and the tensile strength of the lava, and Ui et al. (1999) showed that the formation processes of block-and-ash flows differ depending on the growth style of the dome;

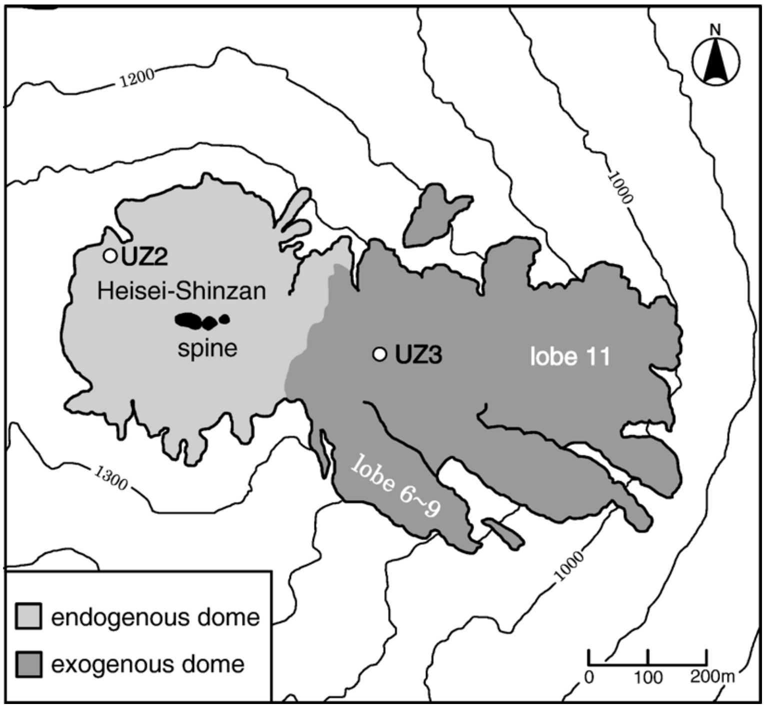

Fig. 2. Simplified map of the lava dome formed during the 1991–1995 eruption. Sampling locations (UZ2 and 3) are also shown.