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Temporal variations of gas compositions of fumaroles in the Tatun Volcano Group, northern Taiwan

Hsiao-Fen Lee [a], Tsanyao Frank Yang [a,*], Tefang Faith Lan [a], Cheng-Hong Chen [a], Sheng-Rong Song [a], Shuhjong Tsao [b]

[a] Department of Geosciences, National Taiwan University, No. 1, Sec. 4, Roosevelt Road, Taipei 106, Taiwan
[b] Central Geological Survey, MOEA, P.O. Box 968, Taipei 235, Taiwan

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ABSTRACT

Hydrothermal activity is common in the Tatun Volcano Group of northern Taiwan. Helium isotopic compositions of fumarolic samples show that mantle component occupies more than 60% in the previous study. Along with recent seismic results, a magma reservoir is inferred to have existed beneath the area of Da-you-keng, where fumarolic venting is the most active in Tatun Volcano Group. Progressive increases of HCl concentrations and SO_2/H_2S ratio in fumaroles from Da-you-keng have been observed since August 2004. The HCl concentration changed from almost the detection limit to thousands of ppm, even up to 30,000 ppm. SO_2/H_2S ratios varied from almost 0 to 3; hence SO_2 became the dominated S species in this area. These variations were accompanied by rising temperature of fumaroles in the Tatun Volcano Group, especially in the area of Da-you-keng (from boiling point to 131 °C). Meanwhile, $^3He/^4He$ ratios showed a decreasing trend but returned to normal values shortly thereafter. We propose two possible processes, 1) new magma supply and 2) recent opening of fractures in local area, to explain these observations. Based on the change of $^3He/^4He$ ratio and lack of ground deformation, we consider the latter might be more plausible.

1. Introduction

The variation of volcanic gas composition is considered as an important index of volcanic activity (e.g. Ohnishi and Kamada, 1981; Sano et al., 1984; Menyailov et al., 1986; Chiodini et al., 1993; Giggenbach, 1996; Notsu et al., 2001). Compositions of volcanic gases can help to understand the sources and origin of magmas in one area (e.g. Symonds et al., 1994; Giggenbach, 1996; Capasso et al, 1997; Giammanco et al, 1998; Yang et al., 2003b, 2005; Chen et al., 2005; Pecoraino and Giammanco, 2005). Previous studies have shown that the compositions of volcanic gas and some reactive gas ratios change dramatically before eruption (e.g. Noguchi and Kamiya, 1963; Walker, 1974; Oskarsson, 1984; Hirabayashi et al., 1986; Fischer et al., 1996; Duffell et al., 2003; Carapezza et al., 2004; Aiuppa and Federico, 2004; Capasso et al., 2005). Integrated with other available data/investigations, observations of chemical and isotopic compositions of volcanic gases can monitor the volcanic activity and predict forthcoming eruptions (e.g. Aramaki, 1991; Aiuppa et al., 2007).

Taiwan is located on the boundary of the Philippine Sea Plate and the East Asian continent that makes the tectonic setting not merely a collision zone but also a transform region between Luzon and Ryukyu subduction systems (Fig. 1A) (e.g. Teng et al., 1992; Teng, 1996; Wang et al., 1999). Situated at the northern tip of Taiwan, the Tatun Volcano Group (hereafter called the TVG) is a part of the Northern Taiwan Volcanic Zone. It also belongs to the southwest part of the Okinawa Trough which might be related to post-collisional collapse rather than arc volcanism (Wang et al., 1999). The TVG includes more than 20 Quaternary volcanoes which are mainly composed of andesitic lavas and pyroclastic flows (Chen and Wu, 1971). The most important geological structure in the TVG is the Chinshan Fault, which strikes in the NE–SW direction. The major fumaroles and hot springs are distributed along this reverse fault indicating that volcanic activities of the TVG may be associated with the activities of Chinshan Fault (Yen et al., 1984).

The eruption history of the TVG can be divided into two major periods according to the results of K–Ar dating (Juang and Chen, 1989; Tsao, 1994) and fission track analysis (Wang and Chen, 1990). The first eruptive period began around 2.5–2.8 Ma, then ceased after about one million years. The second period started 1.5 Ma and continued until around 0.1–0.2 Ma (Song et al., 2000a). The TVG is considered dormant because of no previous historical eruptions, however, post-volcanic activities i.e., hot springs and gas fumaroles, are well developed now, suggesting that the TVG might not be extinct. Chen and Lin (2002) reported some volcanic ashes in sedimentary formations that are younger than about 20 ka along with grains of charcoals in the Taipei Basin deposits. In addition, helium isotopic results from fumarolic gas demonstrate that more than 60% of helium

* Corresponding author. Tel.: +886 2 3366 5874; fax: +886 2 2363 6095.
E-mail address: tyyang@ntu.edu.tw (T.F. Yang).

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