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Eruption and degassing process in the abyssal alkalic basalts recovered from east of the Japan Trench

Naoki Takehara[1]; Naoto Hirano[2]; Eiichi Takahashi[1]

[1] Earth and Planetary Sci., Tokyo Inst. of Tech.; [2] Dept. Earth Planet. Sci., Tokyo Inst. Tech.

http://eps.geo.titech.ac.jp/lab/takahashi/takahashilab.html

Young alkalic basalt lava (6Ma) was found from the east side the Japan Trench wall (Hirano et al, 2001). Further study of this area has been carried out using JAMSTEC RVs, ROV-KAIREI and finally submersible Shinkai-6500. Very small alkali basalt cones were found as clusters at 37N and 149E at the water depth of more than 5000m. Very fresh glassy alkalic basalt of almost modern eruption age was recovered from the Yukawa knoll. One of the peculiar features of the recovered rock samples are their highly vesicular nature.

Volume fraction of the vesicles of the recovered samples from the Japan Trench and those from the Yukawa knoll are shown as a function of SiO_2 of the lava. Those from Yukawa knoll have vesicularity of 50 to 70 vol.% (Fig. 1) indicating that the lava contained nearly maximum amount of bubbles (closest packing) before quenching. On the other hand, those from the Japan Trench side are divided into two groups:1) vesicular sample (30-50 vol.%) and 2) none vesicular sample (see Fig. 1). There is no correlations between the vesicularity of the lava and their SiO_2 contents suggesting that both primitive and evolved magma contain similar amount of volatiles. In Fig.1, H_2O+ of the lavas as determined by the loss of ignition (LOI) method is also plotted. Regardless of the vesicularity and the SiO_2 content, the alkalic basalts contain approximately 1.5 to 2.0 wt% of H_2O+ (see Fig.1).

Magmas that erupted in water deeper than several hundred meters do not form bubbles usually. This is because solubility of H_2O in silicate melts increases dramatically with pressure. Accordingly, vesiculation should not take place at the studied area (5000m deep), if the major volatile component in magma were H_2O. Based on the study at the Hawaiian flexural North Arch basalts (Clague et al., 1990, 2002; Dixon et al, 1996), large amount of CO_2 may have included in the alkalic magma in our studied area. Because of the low solubility of CO_2 in silicate melt even at 500bar, the observed high vesicularity can be explained.

We have estimated the original H_2O and CO_2 contents in the alkali basalt magma before eruption following the method developed by Dixon et al. (1996). We assumed $CO_2/H_2O=0.6$ in the bubbles in alkalic basalts (using an averaged value from Dixon et al. for basalt with SiO_2=46.7 wt.%). Using the volume fraction of bubbles in Fig.1 and the partition coefficient of H_2O and CO_2 between the bubble and silicate melt determined by Dixon et al. (1996), we calculated the amount of H_2O and CO_2 in silicate melts that have coexisted with the bubbles. Calculated H_2O content in magma is close to or slightly higher than the H_2O+ shown in Fig. 1. Original volatile content of the alkalic magma (average of 11 samples) before eruption is estimated to be H_2O=2.3wt% and CO_2=1.3wt%, respectively. Considering that the magma was degassing as it solidifies, the real volatile content could be higher than above estimate.

Origin of the two rock types among the rock samples recovered from the Japan Trench side may be explained in the following way. The vesicular samples were recovered from small cones or ridges (a few hundred meters tall from the ocean floor) which may have formed near the volcanic vent. The non vesicular samples were obtained from steep fault walls formed by block movement inside the trench system. The former may correspond with the sinder cones in subaireal basalt monogenetic volcanoes and the latter may correspond with the basal lavas surrounding the sinder cones. Due to rapid degassing from the magma near the vent, magmas solidified near the vent (sinder cone) are highly vesicular. Non vesicular nature in the basal lava, however, may not necessary mean that they are volatile free. As calculated above, the magma may have contained nearly 2 wt% of H_2O after degassing of CO_2 near the vent and this will explain the fluidal nature of the abyssal alkalic basalt lavas.