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Vesicular Structure in a Lava Flow

Masaaki OBATA* and Toshio MIZUTA**

**Department of Geology, Kumamoto University,*
Kurokami, Kumamoto 860, Japan
***Institute of Mining Geology, Mining College, Akita University,*
Tegata Gakuen-cho, Akita 010, Japan

Vesiculation occurs in many geological circumstances. Many lava flows, that are consolidated magmas on or near the Earth's surface, contain vesicles, which are now vacant or filled with secondary hydrothermal precipitates. Volcanic ejecta, such as pumice or ashes are very porous and, therefore, vesiculation is essential in their formation. From geochemical analysis it has been known that many primary

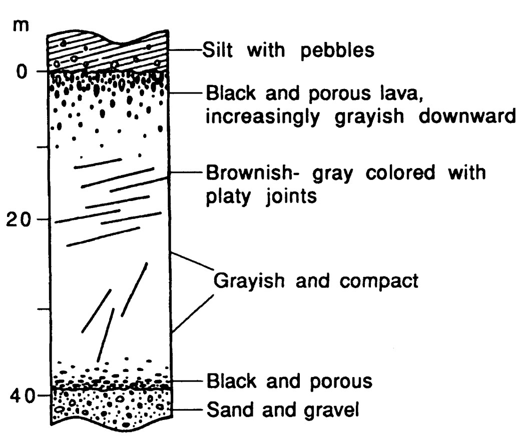

Fig. 1. Lithological structure of an anseditic lava flow obtained from boring core samples. Modified from Mizuta *et al.*, 1990.

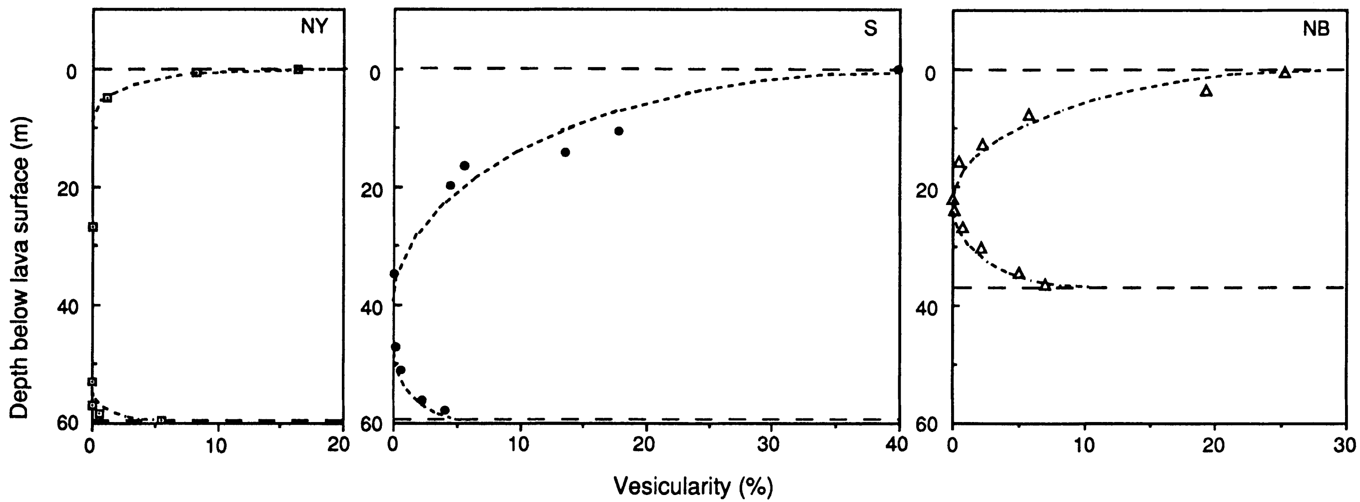

Fig. 2. Vertical variation profiles of the vesicularity for the three lava sections, NY, S and NB. (from Mizuta *et al.*, 1990).

magmas dissolve significant amount of volatiles such as H_2O and CO_2 at great depths. Because the solubility limit of the volatiles in magmas generally decreases with decrease of pressure, even if the magma is undersaturated with the volatiles in the beginning, it may become oversaturated by decompression on its way to the Earth's surface and vesiculation may start to occur. If this exsolution process occurred rapidly, the magma undergoes a rapid expansion, that may lead to a violent volcanic eruption. Therefore, study of vesicular structure and vesiculation processes of the magma have fundamental importance for the study of volcanic eruption (Williams and McBirney, 1979). This article reviews an example of such vesicular structure of a lava flow from Japan that we studied (Mizuta *et al.*, 1990).

Figure 1 is a cross section of an basaltic andesite lava flow, which has been erupted about 200 thousand years ago from the Aso volcano. It is now mostly covered by marine sediments and is buried underneath Kumamoto City. The lava is spread over 65 km^2 area, its maximum thickness being 60 m. It consists of a single lava flow; the top and the bottom of the lava flow are quite porous, containing many vesicles, while middle horizon is non-porous and compact. Figure 2 shows vertical variation of volume proportion of vesicles (vesicularity) across the lava at three different sections. The vesicularity gradually and monotonically increases both towards the top and towards the bottom surfaces of the flow and it reaches up to 40% at the top-most.

Figure 3 shows detailed structure of the vesicles from the top and the bottom zones of the lavas. The vesicles are more abundant and, in average, larger in size in the upper zone than in the lower zone. The vesicles are elongated vertically in the upper zone and they are considerably flattened horizontally in the lower zone. In particular, large vesicles in the upper zone have round heads and narrow prolonged

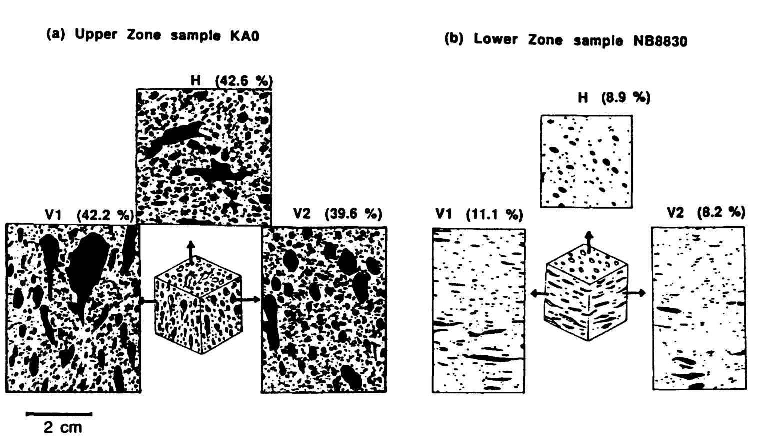

Fig. 3. Morphology and structure of the vesicles. (a) from uppermost part. (b) from the lower zone. Vesicularities are given in parentheses for each section. (from Mizuta *et al.*, 1990).

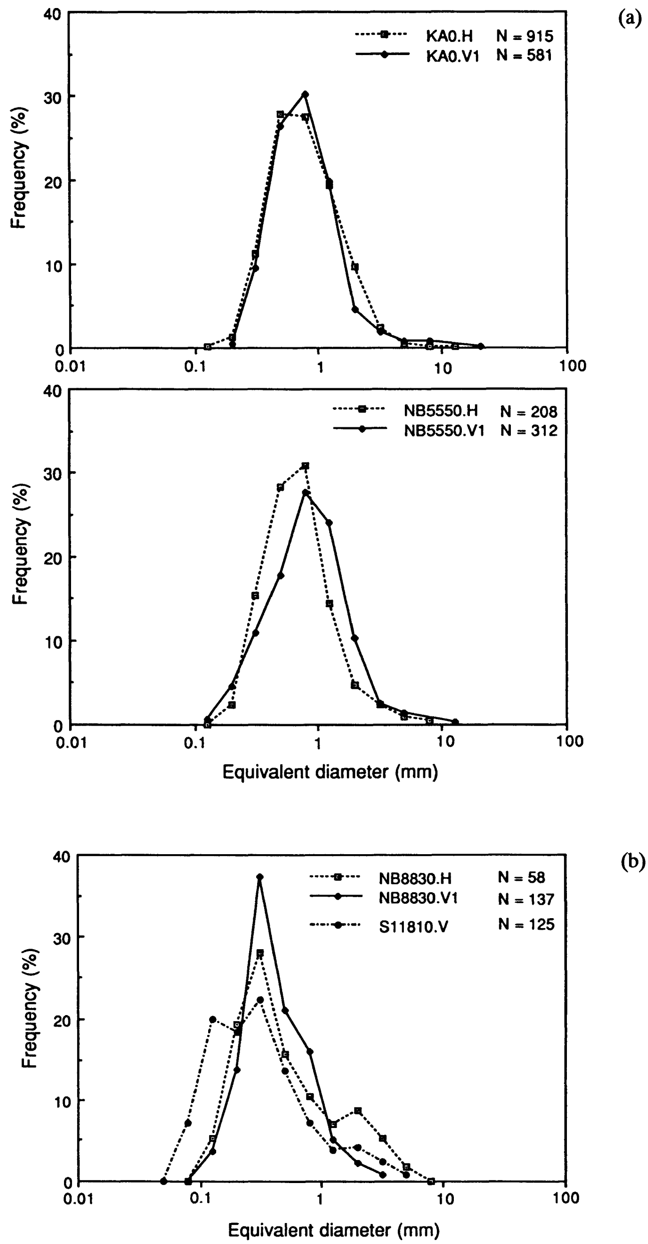

Fig. 4. Size distribution frequency diagrams for the vesicles. (a) Upper zone samples, KA0 and NB5550; (b) lower zone samples, NB8830 and S11810. Sample number extensions H denotes horizontal sections; V and V1 denote vertical sections. Numbers of vesicles measured, N are given for each sample. (from Mizuta *et al.*, 1990).

tails below. Such morphology of the vesicles suggests the presence of upward migration of bubbles in the upper zone and the presence of horizontal shear flows near the bottom of the lava at their molten stage.

Figure 4 shows size distribution of the vesicles for representative samples from the upper and lower vesicular zones. Measurement was made by the use of microcomputer-aided digital image processor. The size is represented by a diameter of equal-area circles. As is seen in the diagrams, the vesicle size distribution is nearly log-normal with slightly shallow slope on larger-size side. The mean size is greater for the upper zone than the lower zone. The log-normal size distribution is widely met for metals, ceramics, crystalline rocks (e.g. deHoff and Rhines, 1968) and is considered to be important for understanding the development the vesicular structure. The asymmetric component in the size distributions may be due to coalescence of bubbles during their growth and migration in the molten lava.

A simple explanation for such stratified structure is as follows. Suppose an andesitic magma that was oversaturated with volatiles and had contained numerous gas bubbles in it. When it was erupted and flowed on the ground, the magma is thoroughly stirred so that the bubbles are evenly distributed throughout the lava. As soon as the lava is exposed to the surface, it starts to cool from its margins by heat conduction; at the same time, the bubbles start to ascend because of the buoyancy. Because the lava viscosity exponentially decreases with decreasing temperature, the bubbles gradually become immobile and eventually will be frozen in the consolidated lava flow as vesicules. The lower zone vesicles, therefore, represent trapped bubbles by the cooling front that had advanced from the lava bottom. Bubbles that started to ascend from intermediate horizons have escaped the capture by the cooling front that was advancing upward from the lava base; instead, they have accumulated in upper horizons to form the upper vesicular zone. Such stratified structure is very common in basaltic and andesitic lava flows in the world (e.g. Aubele *et al.*, 1988) and they do indicate that bubbles can significantly migrate upward through the lava even after its eruption.

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