Frequency of volcanic eruptions and long-term magma discharge rate in sub-regions in Japan

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Frequency of volcanic eruptions is an important factor to evaluate volcanic activity. Together with eruption magnitude, which is defined by mass of ejecta, frequency of eruptions can be used to estimate long-term magma discharge rate. Such estimation will provide an insight of material circulation through volcanoes. Calculating frequency of eruptions is, however, a challenging problem due to difficulty of estimating the amount of under-recording of volcanic eruptions. The main mechanisms of under-recording are absence of historical records, erosion and alteration of tephra deposits, burial of tephra deposits by younger deposits, disappearance of the source volcano itself due to burial or erosion, deposition of majority of tephra on the sea surface and occurrence of submarine eruption. In this study, I calculated frequency of volcanic eruptions and estimated long-term magma discharge rate in sub-regions in Japan, in which eruption records account for about 39 % of the entire set of eruptive events in the world.

I investigated the dataset of age and magnitude, *M*, of volcanic eruptions (*M* 2), which occurred in the Hokkaido, Tohoku, Izu, Central and Kyushu regions in Japan in recent about 2 million years. The analyzed data are compiled from documentation including Machida and Arai (2003), Committee for Catalog of Quaternary volcanoes in Japan (2000), Geological Survey of Japan, AIST (2014) and Hayakawa (2010). In estimating frequency of eruptions, under-recording of events was taken into account by modeling a decreasing trend of recording rate of analyzed volcanic eruptions with time.

The results of the analysis show that the frequency of eruptions (*M* 2) in those regions varies more than one order of magnitude. For relatively large eruptions (4 *M* 6), frequency of eruptions decays by a factor of about 10 for each successive eruption magnitude category. On the other hand, frequency of eruptions (2 *M* 4) decays by a factor of about 1.5 - 2.6, showing that the frequency of smaller eruptions is smaller than the frequency expected from the magnitude-frequency relationship of the relatively larger eruptions. One possible explanation of this small frequency is that smaller batch of magma is less buoyant and is more likely stuck in the crust.

The long-term magma discharge rate was calculated on the basis of the magnitude-frequency relationships in those regions. After considering the length of those subduction zones, the long-term magma discharge rate in Kyusyu, Central and Tohoku regions show similar value (2×10^{10} kg/ka/km). On the other hand, the long-term magma discharge rate in Hokkaido and Izu regions is about one third of that of the other regions. The smaller long-term magma discharge rate in the Hokkaido region than that in the Tohoku region is probably caused by an oblique subduction of the Pacific plate, which results in a smaller effective subduction velocity of the Pacific plate beneath the North American plate in the Hokkaido region than that in the Tohoku region. On the other hand, the similar amount of long-term magma discharge rates in different subduction zones, including the Tohoku, Central and Kyushu regions, suggest that such tectonic constraint is not significant. Furthermore, the estimated small magma discharge rate in the Izu region may be caused by insufficient estimation of the amount of under-recording of events. This region consists of small volcanic islands where wide-spread tephra deposits are less likely preserved, and hence eruptions in large eruption magnitude categories (*M* 6) are almost completely missing. In addition, no

eruptions are recorded for some submarine volcanoes in this region. For these missing eruption categories and volcanoes, it is impossible to estimate the amount of under-recording of events. Therefore, additional statistical approach is required for more accurate estimation of frequency of eruption and long-term magma discharge rate in the region of oceanic islands.

Keywords: eruption database, frequency of eruption, long-term magma discharge rate

