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An attempt to obtain empirical evidences for petrological assessment of volcanic activity based on magma database

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For Japanese volcanoes, high-quality databases of volcanic eruptions have been developed, for example Japanese active volcanoes (Kudo and Hoshizumi, 2006-) and one-million years chronology of volcanic eruptions (Hayakawa, 1996-). These databases involve eruptive age, eruption style and eruption magnitude, M. In contrast, it is often the case that properties of magma that caused these eruptions remain unrevealed. We have sampled and analyzed eruptive products of ca. 90 eruptions in Japan during the last one hundred thousand years and are constructing a database of magmatic properties (petrological properties), as a magma database. This database involves mainly large scale eruptions with M=4-8 and additionally recent small eruption of M=1-3. In the magma database, we estimate melt compositions, and phenocryst contents, which are important factors controlling physical properties of magmas, and thus eruption dynamics. Based on the magma database, we have attempted to obtain empirical evidences between these magmatic properties and eruption characteristics (eruption magnitude, eruption style and so on).

Examining relationship between eruption magnitude, M, and magmatic properties for ca. 100 eruptions, including 11 eruptions compiled in Takeuchi (2011), some relationships are found.

(1) Rhyolitic melt (>70 wt% SiO2)-bearing magmas (andesitic to rhyolitic magmas) caused M=4-8 eruptions. In contrast, basaltic to dacitic melt (<70 wt% SiO2)-bearing magmas (basaltic to dacitic magmas) caused M=1-5 eruptions.

(2) For rhyolitic melt-bearing magma, the maximum eruption magnitudes are correlated with phenocryst content. Phenocryst-poor magmas with 0-20 vol% caused caldera-forming eruption with M=8 at the maximum, where phenocryst-rich magmas with 20-50 vol% phenocryst have the maximum eruption magnitude with ca.6.

These empirical evidences suggest that petrological properties, such as melt composition and phenocryst content, are some level of constraint on eruption magnitude. Thus, petrological analysis of eruptive materials in early eruptive stage may contribute to constructing eruption scenario.

Keywords: magma, petrological analysis of volcanic rock, assessment of volcanic activity, database