Volcano-Tectonic insights into Miocene felsic volcanism of Kii Peninsula, SW Japan

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1. Introduction

A sudden massive volcanism of felsic magma occurred in the Kii area, southwest Japan, during middle Miocene. It remained in this region as volcanic and plutonic bodies consisting of an incised and exposed collapse caldera body. A study of the volcanism in view of volcano-tectonics is as an important key to give us its characteristics in detail. Yet, in a last couple of decades, there are few papers in such an attitude of research. We reviewed and reappraised recent data through view in the attitude, and gained some new insights into give a good interpretation to the massive and enormous volcanism.

2. Felsic volcanism in the Kii area

The volcanism is distinct in three points of its volcano-tectonic characteristics: (1) a sudden eruption of a large felsic magma in an area having no previous massive volcanism; (2) a fore-arc volcanism far from the present volcanic front of SW Japan; and (3) a contemporaneous volcanism in the time of Japan Sea opening. The second and third characters give us a hint of compressional tectonics in the fore-arc region.

Recent extensive studies on the rocks and deep structure of the area revealed following new implications of the volcanism; (a) Some ash-flow tuff sheets emplaced at the same time and probably from the same source. One ash-flow sheet, Muro, has a ca. 100 cubic km in volume; (b) A gigantic mass of solidified magma is inferred just beneath the Kumano caldera (41x23 km in size: Fuji-ta et al., 1997; Miura, 1999). In addition to the volume of surface deposits, the buried volume of magma is over several 100 cubic km. Hence, total volume of the belonged felsic magma may be of over 1,000 cubic km; (c) Candidates as a source conduit of ash-flow sheets are: the pyroclastic breccia dyke of the Kumano caldera, the northern body of the Kumano acidic rocks, and the Omine and Nakaoku tuffite dykes. A MT survey suggested that the Omine acidic rocks connect with the gigantic mass of the Kumano caldera in several km deep. The Omine and Nakaoku dykes seem to be relevant to the Kumano caldera. One possible source of the tuffs at least occurs in the area of 50 by 40 km outside northern part of the Kumano caldera.

3. Stress field

To form gigantic magma chamber, an efficient storage of felsic magma in subsurfaces is needed. Compressional tectonics is the stress field to promote the storage. Do evidences obtained from the igneous bodies in and around the Kii area support such a compressional tectonics?

An approximate eruption rate is estimated based on the recent K-Ar dating and the volume of rocks. The dating indicates that the formation of Kumano caldera took a time less than several hundred thousand years. Therefore, the eruption rate ranges from 1 to 10 cubic km/1,000 years. Order of the rate is quite similar to that of the Yellowstone caldera, USA. Such kind of large felsic volcanism should produce an excess magma pressure in the chamber before its climatic eruption. The excess pressure could reduce the tectonic stress and form a sub-neutral stress field at the time of caldera collapse. On the other hand, a differential stress remains in a great influence on caldera shape. There are at least two evidences to prove the influence. One is the trapdoor structure of the caldera. Such an asymmetric structure could be formed under great anisotropy of stress. Another is the shape of Kumano caldera toward NNE-SSW. The NNE-SSW direction is the orientation of the Omine acidic rocks, the Omine tuffite dyke, and the Kumano acidic rocks as a whole. Thus, it is suggested that this was the horizontal maximum stress direction at the time of their emplacements.

4. Conclusion

We, therefore, gained following conclusions. The relevant rocks are composed of the enormous caldera or the caldera cluster. The volcanism took place on the compressional and/or transpressional tectonics in fore-arc. The maximum orientation of stress at that time is on the direction of NNW-SSE.