CALDERA COLLAPSE STRUCTURE, ITS IMPORTANCE IN UNDERSTANDING GEOTHERMAL SYSTEMS

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ABSTRACT

Large collapse calderas caused by huge pyroclastic eruptions are thought to have good potential for geothermal development. But the collapse structure and post-caldera volcanism which largely affects post-caldera geothermal systems have a wide variety. Examples such as gravity survey and core geology from Aso and other Japanese calderas give information on caldera structure and caldera-forming and filling processes.

The collapse structure of calderas may have wide variation and the location (alignment) and characteristics of post-caldera volcanism can be an indicator of the collapse structure. The size and aspect ratio of magma chamber, and regional tectonic stress may affect the occurrence of these different type collapses. In geothermal potential assessment of caldera volcanoes, estimation based on caldera forming magma chamber tends to over-estimate. Estimation based on post-caldera volcanism is rather realistic.

Keywords: caldera, collapse structure, post-caldera volcanism, geothermal system, resource assessment

1. VARIATION IN COLLAPSE STRUCTURE AND POST-CALDERA VOLCANISM

Large collapse calderas caused by huge pyroclastic eruptions are thought to have good potential for geothermal development. Geothermal systems in calderas should be controlled by collapse structure but direct observation of the collapse structure in young calderas are difficult. Alignment and characteristics of post-caldera volcanism may reflect collapse structure.

There exists wide variation in alignment of post-caldera volcanism. Followings are two examples in Japan. In Aso caldera, post-caldera volcanoes are clustered in the central part of the caldera and do not show clear alignment (Fig. 1). Rocks of post-caldera volcanoes have a wide range of chemical composition, from basalt to dacite. Surface geothermal features are located in the area where several volcanoes are concentrated.

The second example is from Onikobe Caldera. Post-caldera volcanism which are dacitic and andesitic occurred only in southwestern part of the caldera (Fig. 2). Surface geothermal features are also restricted in the area of post-caldera volcanism.

On the other hand, in many ,especially larger, calderas, post-caldera volcanoes show circular alignment, and this circular alignment may indicate cylindrical caldera collapse. Such circular alignment of post-caldera volcanoes are rare in Japanese Late Quaternary calderas but reported in some Miocene and

Pliocene calderas.

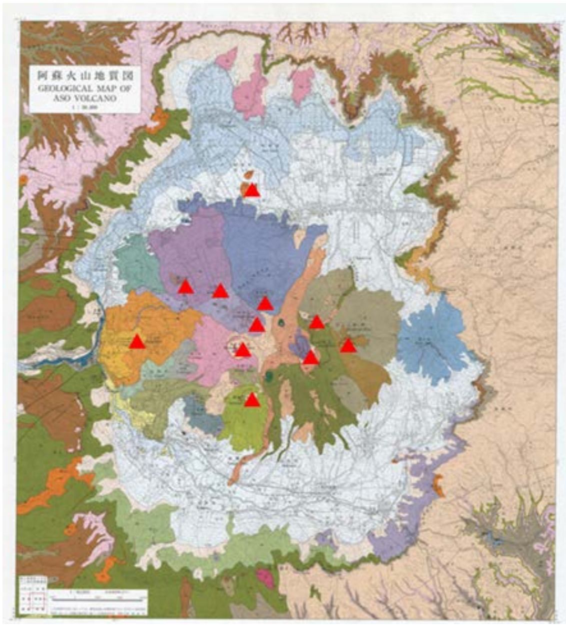

Fig. 1 Geologic map of Aso caldera (Ono and Watanabe, 1985) and location of post-caldera volcanoes (red triangles)

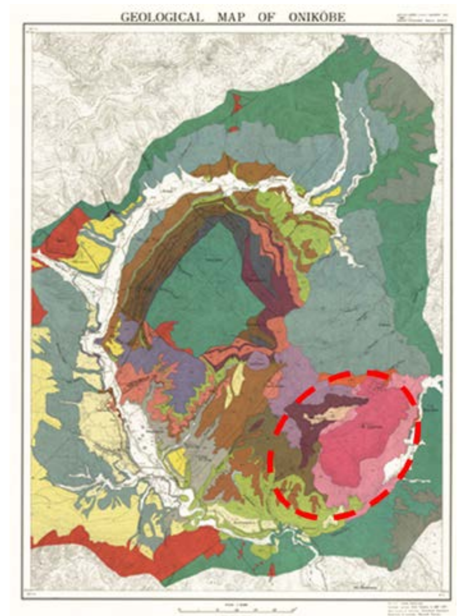

Fig. 2 Geologic map of Onikobe caldera (Yamada, 1972) and location of post-caldera volcanoes (red dashed line)

2. CASE STUDY OF ASO CALDERA

In Aso caldera, a geothermal survey by NEDO (New Energy and Industrial Science Development Organization) brought us some new information about caldera structure (NEDO, 1989).

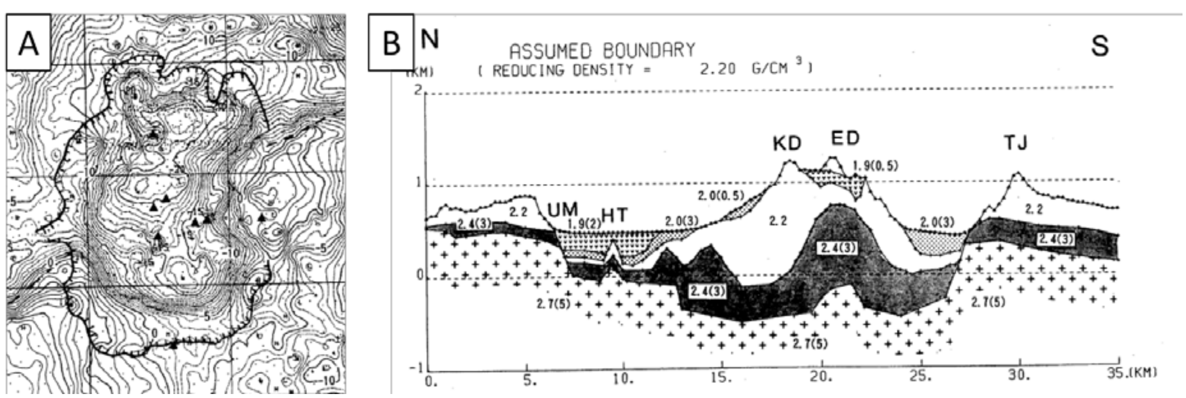

Fig.3 Bourguer anomalies (A) and estimated N-S direction cross section (B) of Aso caldera (Komazawa, 1995). Note the cross section is vertically exaggerated five times.

A detailed gravity survey with dense survey points revealed a clearer collapse structure than before (Fig.

3). The collapse wall or margin is located 1 to 3 km inside of the topographic caldera rim. The angle of the collapse rim is not so steep, therefore, simple cylindrical collapse structure is not appropriate for the gravity data. Segmented collapse model or a series of small step collapse faults may adaptable (Ono et al., 1993) (Fig.4). The size and aspect ratio of magma chamber, and regional tectonic stress may affect the occurrence of these different type collapses.

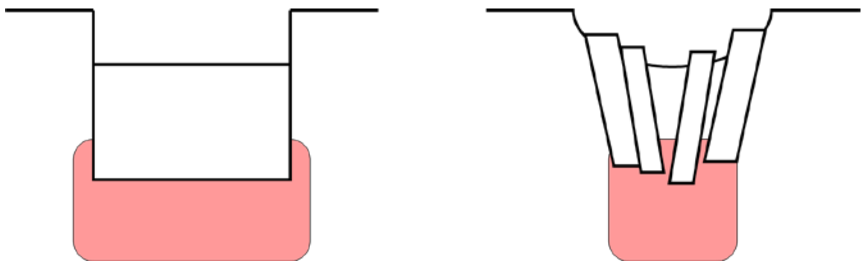

Fig.4 Schematic profiles of simple cylindrical collapse (left) and segmented collapse(right)

3. GENERAL SEQUENCE OF COLLAPSE AND CALDERA FILLING PROCESS

The study of core geology in Onikobe, Aso and Old-Kirishima calderas revealed that there is a common geologic sequence in .caldera-forming and filling stages. The cores are composed of (a) welded tuff identical to caldera-forming eruption product, (b) volcanic breccia to tuff breccia which contains abundant caldera wall rocks, (c) lake sediments with upward grading, and (d) post-caldera volcanic rocks, in ascending order (Fig. 5). This sequence corresponds to (a) caldera subsidence and deposition of intra-caldera tuff, (b) collapse of unstable caldera wall, (c) growth of caldera lake, and (d) post-caldera volcanism.

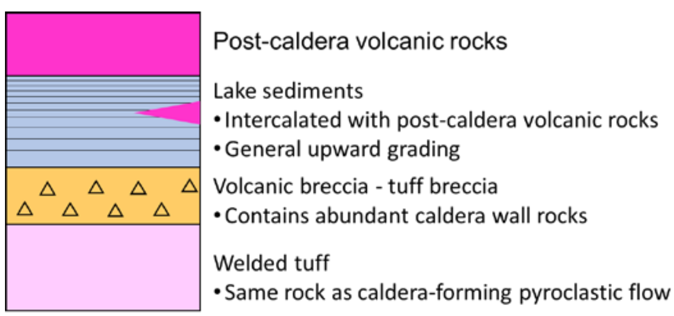

Fig. 5 General sequence of drilling core geology of Onikobe, Aso and Old-Kirishima calderas

4. DISCUSSION

At the very early stage of geothermal survey, the relation between volume of magma chambers and the age of volcanoes (so-called "Smith-Shaw diagram" by Smith and Shaw, 1975) is often used to assess the geothermal potential of the area. Caldera volcanoes tends to be over-estimated.

The present geothermal systems seems to be driven not by caldera-forming magma chamber but rather by post-caldera volcanic activity. In some calderas, initial magma chambers are long-lived and can be the heat source of the present geothermal activities. But the geothermal activities in many Japanese calderas seem to be limited in the post-caldera volcano areas.

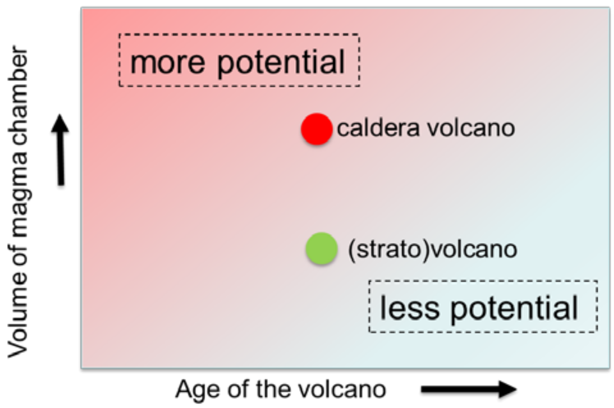

Fig. 6 So-called "Smith-Shaw diagram"

5. CONCLUSIONS

- The collapse structure of calderas may have wide variation and the location (alignment) and characteristics of post-caldera volcanism can be an indicator of the collapse structure.
- The size and aspect ratio of magma chamber, and regional tectonic stress may affect the occurrence of these different type collapses.
- In geothermal potential assessment of caldera volcanoes, estimation based on caldera forming magma chamber tents to over-estimate. Estimation based on post-caldera volcanism is rather realistic.

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