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Evaluation of Thermal Effect of a Large-scale Pyroclastic Flow Deposits on Basement Rocks by Fission-Track Method

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1. Background and purpose

Investigation of thermal effect of a large-scale pyroclastic flow deposit (PFD) on underlying basement is necessary for assessment of long-term stability of the geological environment. For example, the thermal effect of a PFD can be estimated by calculation using the Thermal Conduction Model (TCM)(Kamata et al.,1993) . In a case of a 100m-thick PFD with an emplacement temperature of 900 degrees C.(Celsius), over 100 degrees C. will be kept for 600 years at 100m below the contact. In this study, we examined thermal influence of large scale PFDs on basement by using fission-track (FT) method.

2. Geological setting and sampling

The Imaichi PFD (0.85+/-0.03: NEDO, 1989) was selected out of some large scale PFDs in central Kyushu. In the studied area (Naoiri town, Oita), the Miyakeyama Rhyolite belonging to the Ohno volcanic rocks (13.6-14.4Ma: Shibata and Ono,1974) is overlaid with the Imaichi PFD which consists of non welded(0.1m thick), partially welded(0.5m thick) and densely welded parts(20m+thick) in ascending order.

Basement samples were taken from 5cm, 10cm and 40cm below the contact. The three samples (lithofacies) are named THM1-05 (discolored red, flexible), THM1-10(many cracks developed) and THM1-40(fresh), respectively.

3. Method

In general, number (or density) of spontaneous FTs in a mineral increase with the passage of time and its mean length is constant unless the mineral is heated. On the contrary, heating causes reduction of FT length, and as a result, FT ages become younger apparently. Recently, the kinetic parameters for FT annealing in zircon and/or apatite have been established(Laslett and Galbraith,1996; Galbraith and Laslett,1997; Tagami et al.,1998).

Thermal history analysis by means of the FT method with annealing kinetics is carried out as follows:

(a) To assess thermal influence of basement rock samples, FT ages and length distributions of zircon and/or apatite are measured.

(b) To determine initial conditions (thickness and temperature) of the PFD, the calculated and observed FT data (age and length distribution) of basement rock samples with different distance from the PFD are compared.

(c) Based on the initial conditions given by (b), thermal history or temperature-with-time profile of basement rock is calculated using the TCM analysis.

Only zircon crystals were separated from the basement rock samples. For dating, zircon samples were analyzed using the external detector method applying to internal surfaces of zircon (ED1 method: Danhara et al.,1991). FT ages were calculated using the zeta calibration approach. For FT length analysis, confined FTs were used.

4. Results and discussion

The resulting FT ages of THM1-05, 10 and 40 are 0.84+/-0.08 Ma (1 sigma), 0.83+/-0.07 Ma and 1.39+/-0.09 Ma, respectively. The two ages of THM1-05 and THM1-10 are concordant with each other, and also with the reported age of Imaichi PFD. Moreover, their confined-FT lengths are not shortened. This, therefore, indicates that zircons of THM1-05 and 10 reached to the total annealing zone (TAZ) by the heat influence of the Imaichi PFD.

On the other hand, the FT age of THM1-40 is significantly different from both ages of the Imaichi PFD and Miyakeyama Rhyolite, and the FT lengths are remarkably shortened. This implies that resetting of FT age in zircon of THM1-40 was incomplete.

Based on the FT thermal history analysis, the most suitable temperature and thickness as the initial condition of Imaichi PFD were determined to be 730degrees C. and 50m, respectively. Applying these conditions to the TCM analysis, the highest temperatures are estimated to be 375-370 degrees C. at 5-40cm below the boundary, and 60 degrees C. at 100 m below the boundary.