ESR dating of rhyolites from Kozushima, Japan

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Kozushima is a volcanic island in the Pacific Ocean located about 170 km southwest of Tokyo. Kozushima is composed of at least 16 rhyolitic monogenetic volcanoes. It has been inferred that the eruption of rhyolites began at least several tens of thousands years ago and continued intermittently until 838 A. D. (Isshiki, 1982). There are two eruptions whose ages were well determined. One is Tenjyosan lava (838 A. D., from historic record: in Isshiki, 1982) and another is Chichibuyama pyroclastic surge deposit (~20,000 B. P., 14C method: Isshiki, 1989). For many other rhyolites the ages were roughly estimated by hydration layer method (Taniguchi, 1980) or fission track method, but the accurate ages have not been determined yet. The present study aimed to elucidate the overall history of volcanism in Kozushima and to cross check the ages determined by ESR method with those by other methods. Samples of 16 rhyolites plus one surge deposit were collected.

Unpaired electrons created by natural radiation from radioactive elements accumulate in quartz after the rhyolite lavas cool. ESR (electron spin resonance) detects unpaired electrons in samples. An ESR signal intensity corresponds to the amount of unpaired electrons which have been accumulated in the quartz. The age is obtained by dividing the total accumulated dose (D_E) determined via ESR measurements by the annual dose (D) determined separately.

In order to determine total accumulated dose, quartz grains were extracted from each lava, sieved to grain size of 0.25-0.5 um and 0.5-1.0 um, subdivided into 8 fractions, and irradiated by 60Co gamma rays up to ~900 Gy. In order to determine the dose rate, concentrations of K_2O, U, and Th were measured by gamma ray spectroscopy using a low background high pure germanium detector. The concentrations of those elements were converted to the dose rates by using the table of annual dose conversion factors (Ogoh et al, 1993).

Regarding Tenjyosan, Kobeyama, Ananoyama, and Hanatateyama lavas (previously reported hydration layer ages were 1,100-3,400 y. B. P.), no ESR signals were observed because of too young ages of those samples. Regarding Chichibu-yama pyroclastic surge deposit, the ages of 20.4 (+3.6 -3.1) and 31.3 (+5.9 -4.3) ka were obtained for Al center and Ti-Li center, respectively. Although the age based on Al center was fairly close to the 14C age of the surge deposit, considerable discrepancy between Al center and Ti-Li center was present. So far the reason for this discrepancy is uncertain. Regarding Takodoyama, Ohsawayama, and Matsuyamahana lavas, the ages have been inferred to be close to that of Chichibuyama surge deposit (Isshiki, 1982). The ESR ages for these lavas were ~20-30 ka and the results are consistent with the estimation by Isshiki (1982). Regarding Awanomikotoyama lava, the ESR age of 50-56 ka was obtained. Last time we measured the ESR age of Awanomikotoyama, the age of ~52 ka was obtained. Thus, the good reproducibility of this method was confirmed. Regarding Membo lava, ESR age of 21-24 ka was obtained, although previously reported hydration layer age was 47-60 ka. As the Membo lava is covered with Chichibuyama surge deposits, it may be possible that the heating at the time of the deposition reset the ESR signal. However, the detailed reason is uncertain and needs to be investigated in further research.

References

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