COOLING OF GEOTHERMAL SYSTEM AND ESR DATING

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The ESR (Electron Spin Resonance) dating can be applied to the materials such as geothermally altered rock, vein and sinter, which are usually difficult to apply K-Ar and Fission track datings. Therefore, ESR dating is one of the most useful dating methods to estimate the age of geothermal activity.

Usually, we can detect several ESR signals from a quartz sample separated from the products of geothermal activity. Fig. 1 shows ESR spectra of quartz samples from the Hokusatsu gold field in south Kyushu. Among them, ESR signals with g-values of 2.011, 2.001, and 1.997 are called OHC, E' and Ge centers respectively. In the case of geothermal products, these centers give usually different ages. For example of the Masaki silicified rock, ESR ages of E', OHC and Ge centers show 8×10^4, 50×10^4 and 61×10^4 years respectively. If the sample was formed at the same time, the three centers should give the same ages. However, age of E' center is usually younger than the other ages. These differences among the ESR ages indicate that the each ESR center has different thermal stabilities. That is, closing temperature of each center is different with each other.

Fig.2 shows the result of annealing experiment on the quartz sample from the Masaki silicified rock. As shown this figure, thermal stability of E' center is weaker than that of the other centers. According to the result of the annealing experiment on the Masaki silicified rock, OHC and E' centers start to clock the time when the temperature cross down about 110°C and 60°C respectively, If the temperature was kept at least 1000 years under the same temperature.

Fig.3 and 4 show the temperature and age relation at the Hishikari gold mine and its surrounding. The Hishikari mine is located in the south Kyushu, and is well-known for the anomalous high grade ore. The K-Ar datings of the vein minerals indicate that the gold mineralization was occurred 0.78 to 0.98 Ma, and ore forming temperature was estimated about 200°C from the fluid inclusion study (Urashima et al., 1987). Interesting enough, this vein system still accompanies hot spring water with 65°C. On the other hand, Masaki area is located about 7 km to the north of the Hishikari mine, and silicification and advanced argillic alteration were dominant indicating shallow level of alteration. The age of hydrothermal activity is believed to be the same as that of the Hishikari mine.

Three samples from both fields show the following ages in 10^4 years unit; E'=0, OHC=4 and Ge=7 for the Hishikari quartz vein, E'=11, OHC=28 and Ge=24 for the Masaki quartz vein at low elevation, E'=8, OHC=50 and Ge=61 for the Masaki silicified rock at high elevation. The OHC ages from the Masaki area is older than that of the Hishikari mine. This is partly due to the difference of the elevation of the place where the hydrothermal activities

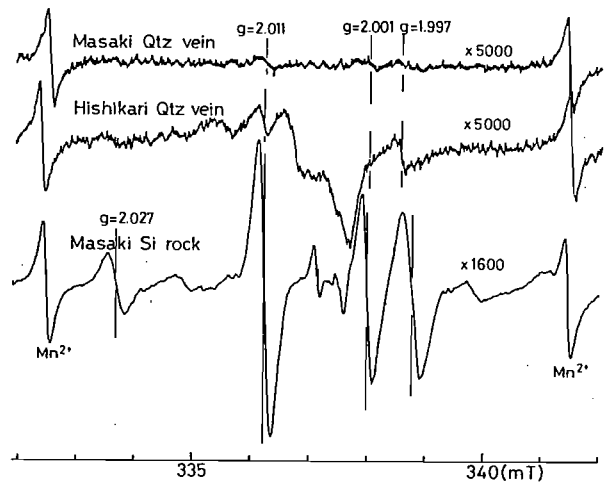

Fig.1 ESR spectra of quartz samples from the Hokusatsu gold field, south Kyushu, Japan.

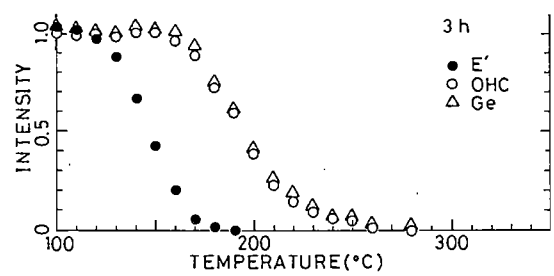

Fig.2 Thermal annealing of E', OHC and Ge centers in quartz sample of the Masaki silicified rock.

occurred; cooling effect by erosion. However, it is largely due to the hot spring activities with 65°C at the Hishikari mine, although the vein was formed about 1 Ma ago. Therefore, E' age show 0 year at the Hishikari mine. On the other hand, as shown in Fig.4, large difference between the OHC ages at Masaki is probably due to the difference of the cooling by erosion, since the location of the silicified rock is situated at the margin of the system and at the topographically high elevation.

As above mentioned, the ESR ages of the geothermal products are easily affected by the cooling of the geothermal system, since the each ESR center has the different thermal stabilities. Therefore, the difference of the each ESR age of a sample will be applicable to reveal a thermal history of a geothermal system.

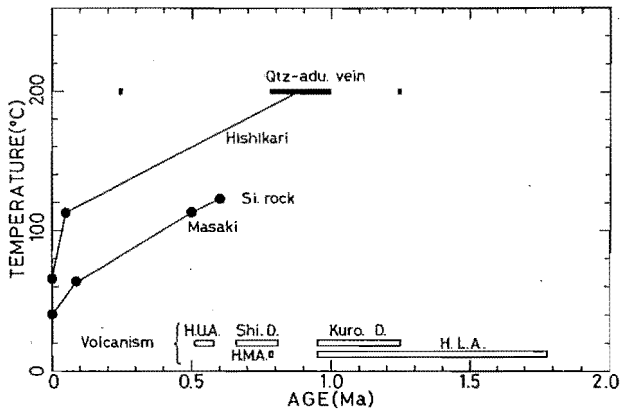

Fig.3 Temperature-age-volcanism relation of the Hishikari gold mine and its surroundings.

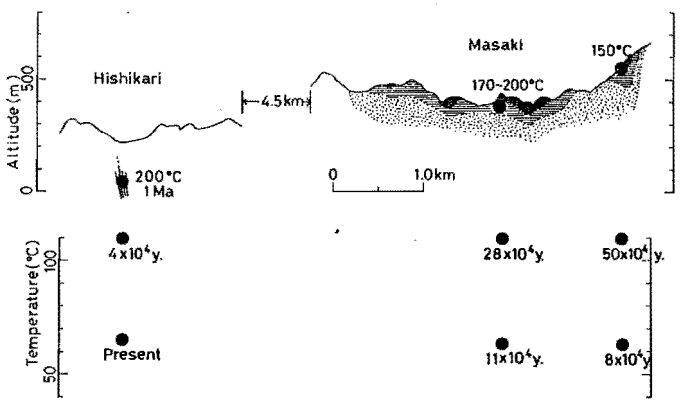

Fig.4 N-S cross section of the Hishikari gold mine and the Masaki alteration zone, showing the relation of age and temperature