GEOTHERMAL HEAT SOURCE ASSESSMENT WITH ELECTRON SPIN RESONANCE

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Electron spin resonance (ESR) is a microwave absorption spectroscopy recently used for dating geological, archaeological and forensic science materials. Details on ESR dating is in the literature of the book and review articles[1-4]. The first application of ESR dating to geothermal problems was made for altered minerals in geothermal boring cores at Hachobaru Power Plant in Kyushu, Japan and at Wairakei, New Zealand[5,6]. The work at Kurobe, Central Japan followed[7]. In this paper, a brief introduction of the ESR dating is given first and then the applications to geological problems especially geothermal field follow. Finally, our work on geothermal materials at Amagase Hot Spring and other area are given as typical examples.

The principle of ESR dating is to detect accumulated amount of unpaired electron spins created by natural radiation. The total dose of natural radiation (TD) is obtained from the enhancement of the ESR signal intensity by additive artificial irradiation: The extrapolation to zero ordinate give the total dose (TD). The separate assessment of the annual dose rate (D) gives the age T using T=Tb/D. ESR dating has been established beyond the limit of radiocarbon dating (50,000) from a few hundred years to a few million years for carbonate fossils like corals and shells[2] as well as several other materials[1,3,4].

The use ESR dating in geothermal and volcanic problems is based on the thermal annealing of the radiation-induced defects or electron spins. The lifetime (stability) is dependent on the temperature with the function of $\tau=\tau_0 ext(-E/kT)$ where E is the activation energy, k, Boltzman factor and T is the absolute temperature. The theoretical curve of the lifetime stability at several several geothermal temperature is given as a function of the temperature where the lifetime becomes one second: the latter temperature can be determined in a laboratory heating thermoluminescence experiment.[4]

Several samples from boring cores were measured to obtain the TD and compared with the lifetime at the geothermal temperature. Typical examples to show how one can assess the shrinkage history of geothermal heat sources are given using samples at Amagase Hot Spring Boring cores.

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