ESR Dating - No. 1

Introduction

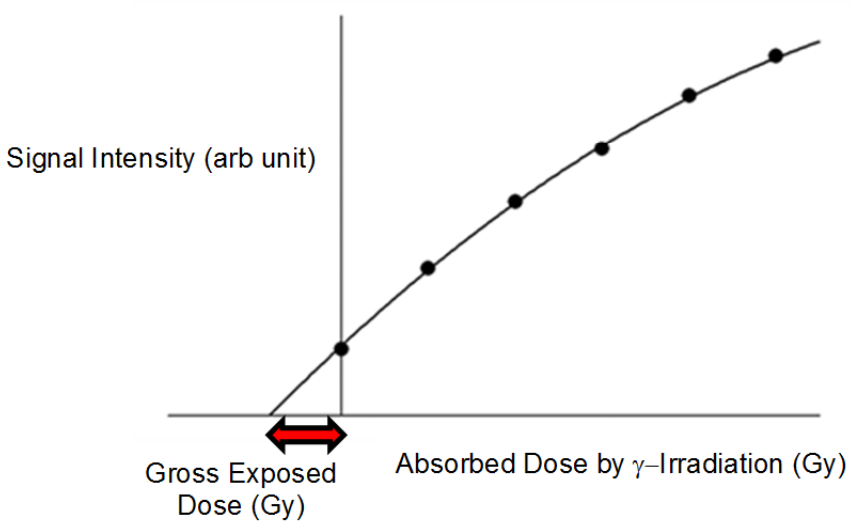
ESR dating is a new dating method in range from ~60 thousand years ago to 2 million years ago, a period when the application of radiocarbon dating is problematic.

Each radioactive isotope decays according to its half-life period and emits α or β particles, or γ rays. Radiation from the radioactive elements in the earth is about 3 to 6 mGy (Gray) per year and cosmic sources contribute approx.0.2 mGy per year. Even with such weak natural radiation, radiation damage in materials generates unpaired electrons. This damage is generated even with artificial radiation. If natural radiation continues to irradiate at a constant intensity and if unpaired electrons are generated in proportion to the radiation dosage, the quantity of unpaired electrons in a material should increase in proportion to the elapsed time, and a dating method therefore becomes possible. Other dating methods, also measuring radiation damage, e.g. thermal luminescence (TL) and optically stimulated luminescence (OSL) methods are available. These are based on the same principle as the ESR method, but the detection methods are different.

ESR Dating

In ESR dating, in order to increase the ESR signal generated by natural radiation, γ rays are irradiated to the sample artificially. After irradiation, the increased ESR signal intensity is measured and extrapolated back to the point where the signal intensity is 0 to estimate the gross exposed dose in natural conditions (Fig. 1: additive-dose method). Alternatively, the signal is extinguished by heating, etc. and then irradiated to the point where the original signal intensity is restored (signal regeneration method). If we assume that the natural radiation (annual dose rate) is constant, the age can be obtained as follows:

$$\text{Date} = \text{Gross Exposed Dose} / \text{Dose Rate per Year}$$



ESR Dating Method Applicable Range

The applicable range is from several thousand years to ~2 million years. The geoscience relates to the dates of tectonic plate movement, and events of change in the earth's crust, such as volcanic eruptions in the Quaternary era. In order to apply ESR dating, certain conditions need to be met: **samples do not contain elements (e.g. transition metals) that interfere in the ESR measurement, and that radicals and lattice defects generated by natural radiation remain during the dating period.**

Many studies have proven that ESR dating is reliable for samples of coral, shell, bone, quartz, etc. thus it has begun to be used in wide fields such as geosciences, anthropology, archeology, and geology, etc. (Table 1).

The date obtained through ESR dating needs to be put into the context of other dating methods and geological information.

Sample	Phenomenon Showing Date	Measurement Target
Stalactite	Generation	Calcite
Fossil Shell	Growing	Aragonite, Calcite
Fossil Coral		
Teeth	Upbringing of Animals	Hydroxyl Apatite
Fossil Bone		
Volcanic Product	Volcanic Eruption	Quartz
Granite	Cooling of Rocks	
Sediment	Sedimentation	

Table 1. Applicable Samples for ESR Dating

Reference

Motoji Ikeya (1987)：ESR (Electron Spin Resonance) Dating, IONICS, p210.

Motoji Ikeya (1993)：“New Applications of Electron Spin Resonance, Dating, Dosimetry, and Microscopy”,World Scientific, p.500.