Issues and applications of ESR dating of quartz

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Quartz is one of the most abundant minerals on the earth's surface, and has many applications of electron spin resonance (ESR) dating. ESR detects unpaired electrons which have been created by natural radiation and accumulated in minerals. The ESR measurements are repeated for samples after gamma ray irradiation of several doses. The trend of increase of the signal intensities is extrapolated to the zero ordinate to obtain the accumulated natural radiation dose (D_E). The D_E is divided by the natural dose rate which is obtained by separate measurement. We now have following applications of ESR dating of quartz. The progress and issues of each application will be presented and discussed.

Tephra

The heat of volcanic eruption should have erased the paramagnetic defects (ESR signals) in quartz contained in tephra, therefore, tephra would be the best sample to obtain ESR ages. Several dating examples of tephra in Japan and in the US will be presented. The estimation of Rn escape should be well evaluated where 50% of loss has been assumed to give consistent results so far.

Fault gouge

Fault gouge was shown first to be useful for ESR dating using containing quartz. However, it has been in debate how to show complete zeroing of the signals at the time of fault movement. The grain size plateau criterion was later proposed and was shown to be practically useful. The mechanism of zeroing has been also one of the issues. The results of high speed friction experiments will be presented.

Sediments

Sediments are one of the most important samples to be dated especially in Archaeology. Based on the sun light bleaching mechanism, their ages have been obtained. The zeroing of the signals is the problem as fault gouge. A new criterion of "multiple center method" was proposed and is now being studied.

Origin of loess

It was found that the intensity of a signal associated with oxygen vacancies in quartz has positive correlation with the ages of host rocks. The signal intensity in quartz of loess should have such information, therefore, the origin could be identified from the intensity where the ages of the basement rocks are varied. This was successfully applied to loess samples of Japanese Islands and the variation of paleo-monsoon has been discussed.

Heterogeneous distribution of paleoenvironmental proxy trace metals in carbonate of benthic foraminifera

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Magnesium ions are one of the abundant bivalent cationic elements in foraminiferal calcitic tests. Magnesium concentration in foraminiferal tests are important as paleo-temperature proxies, since Mg uptake rates are dependent on the temperature of which calcification have took palece. Many works have been attempted to calibrate the relationship between foraminiferal Mg contents and ambient temperatures. However, Mg variations and spatial distributions in foraminiferal tests are not clear yet.

We demonstrate Mg micro-distribution in benthic foraminiferal chamber wall calcite. Mg contents of both *Planoglabatella opercularis* (d'Orbigny) and *Quinqueloculina yabei* Asano, that were collected from natural environments, were measured using on electron probe micro analyzer (EPMA). These species are suitable for elemental mapping with EPMA, because their tests usually contain a few weight percent Mg.

Our microprobe measurements revealed that Mg variations and distributions within single foraminiferal chamber walls have large variations in both species. No biased distribution was observed from inner to outer chamber walls of either species. However, the range of variation in Mg contents were significantly different between species. The variation of Mg/Ca of *P. opercularis* reached is ~70 mmol/mol while the variation of Mg/Ca in *Q. yabei* was less than 20 mmol/mol. This dissimilarity is most likely caused by different test architectures between species.