Thermoluminescent mechanism of natural SiO_2

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Introduction

SiO_2 crystals have been used for the thermoluminescence (TL) dating of earthen vessel and lava. However, the TL mechanism has not yet been clear. Therefore TL dating has supplementary used to justify the stratigraphic data. Then, we have studied on the TL phenomena of tridymite SiO_2 phosphors to clear up TL mechanism of natural quartz. We have found that TL spetrum of Eu^{3+}-doped tridymite has many peaks due to the electron transition from ^5D_j to ^7F_j, of Eu^{3+} over wide range of wavelength from 450nm to 800nm. This fact suggets that absolute dating with TL dosimetry can be expected if quantam effects of these peaks is evaluated. This study aims at the absolute dating with TL and ESR dosimetries of natural quartz.

Experimental

Amorphous and highly pure SiO_2 prepared by the Sol-gel method was used as matrix and was followed by doping with Al^{3+} and/or Eu^{3+} at 1573K for 6 hr in air and then the SiO_2 phosphor doped with Al^{3+} and/or Eu^{3+} was prepeared. Al^{3+} and Eu^{3+} are reported as the source of blue and red TL emissions, respectively and widespread impurities in natural quartz. The TL and ESR measurements were carried out on natural quartz of which the impurity concentration is known and on the SiO_2 phosphor doped with Al^{3+} and/or Eu^{3+}.

Results and Discussion

The TL spectrum on natural quartz obtained from Tazawa Lake in Japan, irradiated by X-ray about 0.8kGy is shown in figure below. A broad TL peak was observed around 450nm at ca. 500K. A large number of narrow TL peaks which were able to assigned to f-f electronic transitions of Eu^{3+} were observed at ca. 350K and ca. 500K. The TL emissions except red were emitted in the Eu substituting Si site with inversion symmetry, on the contrary, red TL was emitted in that without inversion symmetry in SiO_2. In order to realize absolute evaluation of TL dating, it is necessary to estimate the quantum efficiency on each TL peak.

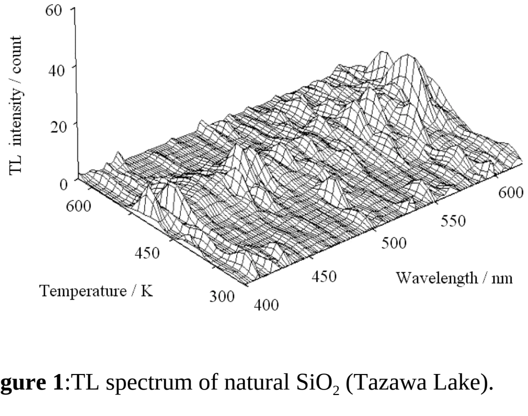

Figure 1:TL spectrum of natural SiO_2 (Tazawa Lake).

Spatial variation of trace element abundances in clinopyroxenes from the layered orogenic lherzolite (Horoman peridotite, Japan): Implications for melt flow and reaction in the upper mantle

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Abundances of trace elements including rare earth elements (REE) in clinopyroxenes were determined by ion microprobe to observe their spatial variation in a scale of meters in the Horoman peridotite. Chondrite-normalized REE patterns vary significantly within 140 meters (harzburgite-lherzolite-plagioclase lherzolite) but indicate some systematics as a function of distance from harzburgite layer. Chondrite-normalized REE patterns of clinopyroxenes near the lherzolite-harzburgite boundary are convex upward and have $[La/Yb]_{CN}>1$. Those clinopyroxenes are strongly enriched in REE, Sr, Zr and Y relative to clinopyroxenes further from the contact. With increasing distance from the contact lherzolite clinopyroxenes are only enriched in light REE ($[La/Nd]_{CN}>1$) and shows a pattern inflected at Ce or Nd. Abundances of highly incompatible elements in the lherzolite clinopyroxenes gradually decrease toward the lherzolite-plagioclase lherzolite boundary, but middle and heavy REE abundances are almost constant.

These observations are interpreted by reaction between percolating melt and lherzolite wallrock. An exotic melt may have migrated within harzurgite layer parallel to the lithological boundary. At the boudary, small amount of melt percolated into lherzolite wallrock and progressively reacted it to dissolve clinopyroxene and garnet and to precipitate olivine and/or orthopyroxene thereby converting lherzolite into harzburgite (Kelemen et al., 1992). As a consequence of porous flow of melt into lherzolite a chromatographic reaction occurred near the boundary creating strongly fractionated REE patterns. The strongest fractionation of LREE was observed at the lherzolite clinopyroxnes three meters apart from the contact implying smaller melt/rock ratio and smaller porosity in the lherzolite relative to the harzburgite.

Reference

Kelemen, P.B., Dick, H.J.B. and Quick, J.E. (1992) Nature, 358, 635-641.