The Effect of Impact on Paramagnetic Defects in Quartz

T. Usami[1], S. Toyoda[1], K.Noritake[1], and K. Ninagawa[1]. [1]Okayama University of Science. E-Mail: s06rd01@physics.dap.ous.ac.jp

Introduction: The impact is one of the major processes in the formation of the solar system as well as those which the earth has experienced from outer space in its history. The relics of such impacts are sometimes found in the crystal features as PDFs (plannar deformation features). However, when the impact was not strong enough to make such features, the debate whether the crater-like geomorphic feature was made by an impact or not would be very tough. In the present paper, we would like to propose that ESR (electron spin resonance) signals in quartz could be such an indicator to detect impact phenomena.

Experiments: A slice of natural quartz crystal used in the present experiments was taken from Naegi quartz crystal in Naegi, Nakatsugawa city, Gifu Prefecture, Japan. This crystal was sliced in about 5 mm thickness and irradiated to a gamma ray dose of 2.5 Gy. Four column samples (diameter of 5 mm, height of 5 mm) were then taken from the slice. Shock experiments were performed with the two-stage light gas gun at JAXA (Japan Aerospace Exploration Agency). The velocities of the bullets were 1.85, 3.26, 3.33 and 3.76 km/s. The shocked sample became powder by the impact. Gamma ray doses from 0.1 kGy to 2.0 kGy were subsequently given again to the shocked sample. ESR measurements were made for those samples. Al and Ti-Li centers were measured at liquid nitrogen temperature and Ge and heat treated E_1' centers were measured at room temperature. After all ESR measurements, qualitative X-ray diffraction analysis was performed.

Results: The signals of Al, Ti-Li, Ge and heat treated E_1' centers were observed by the ESR measurements after the first gamma ray irradiation. The signals of all those centers completely vanished after the shock experiments even with the lowest velocity. All the signals did not recover even after the second irradiation after the impact. These experimental results indicate that impact shock not only erases the ESR signals but also destroys the "seed" of the signals while the samples were proven still to be quartz by the qualitative X-ray diffraction analysis. ESR signals could be used as indicators of impact for quartz crystals in the shock range that no crystallographic changes are observed.