Thermoluminescence and ESR study of shocked minerals

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Introduction

The collision is an important process for planets formation and afterwards for cratering in the history of solar system. A number of phase transitions, such as stishovite and coesite from quartz, and other shock-induced petrographic features, such as mosaicism, planar fracture, planar deformation features, and maskelynite in minerals by shock metamorphism have been investigated [1, 2, 3].

The changes in the lattice defects in the minerals by shock metamorphism are also expected. However, their changes have not been investigated aggressively. This time we investigated the change by the shock metamorphism in the lattice defects in quartz, albite and oligoclase by thermoluminescence (TL) and ESR.

Experimental

We used a quartz from Minas Brazil, three albites from Minas Brazil, Niigata Japan and Siga Japan, and a oligoclase from Aichi, Japan as standard samples. Shock experiments were carried out by two stage light-gas gun in JAXA, which is able to accelerate a projectile to ~4km/s.

10kGy gamma rays irradiation was carried out by ^{60}Co in KURRI. Their thermoluminescence (TL) spectra were measured by TL readout system in Okayama Univ. of Science. ESR spectra were measured by JEOL X-band ESR spectrometer JES-PX2300 at room temperature, with the conditions; a microwave power of 1mW, a modulation amplitude of 0.1mT, a frequency of 100kHz, a sweep range of 10mT/30sec , a time constant of 0.03sec.

Results

Quartz: Minas Gerais, Brazil

The quartz emits mainly at 450nm in TL spectra. TL intensity between 180-280^{o}C decreases, and that at 100^{o}C increases by shock (projectile velocity 2.85km/s). On the other hand, an ESR intensity (g=1.997 corresponding to Ge center) decrease, and another ESR intensity (g=2.001 corresponding to the unstable type of the E_1' center) increases after the shock, respectively.

Albite: Minas Gerais, Brazil

This albite has two peaks around 380 and 550nm in TL spectra. TL glow curves have peaks at 100^{o}C and 230 ^{o}C. However, its TL glow curve increases at 300^{o}C and 500nm by shock (projectile velocity 4.21km/s). A new ESR signal (g=2.0031 unknown) is produced after the shock.

Albite: Siga, Japan

This albite has a peak at 440nm in TL spectra. TL glow curves have a peak around 140^{o}C. TL intensity also increases around 300^{o}C and 500nm by shock (projectile velocity 4.18km/s). A new ESR signal (g=2.0031 unknown) is also produced after the shock.

Albite: Niigata, Japan

This albite has three peaks at 380, 440 and above 700nm in TL spectra. TL glow curves have a peak around 130^{o}C. TL intensity also increases around 300^{o}C and 500nm by shock (projectile velocity 4.15km/s). A new ESR signal (g=2.0031 unknown) is also produced after the shock.

For all of the three albites, TL spectra increase around 500nm 300^{o}C, and the new ESR signal (g=2.0031 unknown) produced by the shock.

Oligoclase: Aichi, Japan

The oligoclase emits mainly at 430nm in TL spectra. It has a TL glow peak at 120^{o}C. TL spectra of shocked oligoclase (projectile velocity 3.5km/s) is the same as those of unshocked. An ESR intensity (g=2.012 unknown) decrease after the shock.

Ries crater

ESR of three samples, Ries IV (~10GPa Monomict Granitic Breccia Everywhere), Ries II (Stage III 25-35GPa SEELBRONN), and Ries III (Stage IV 35-40GPa AUMÜHLE) from Ries crater was measured. Samples were not purified to specific minerals. Therefore they would contain quartz and oligoclase. The Ries IV shows three singals at g = 1.997, 2.001, and 2.012, and the other two samples don't show the ESR signals at g = 1.997 and 2.012. These observation would correspond to the tendency for the Ge center of quartz and the unknown center of oligolase

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