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Quartz amorphization due to friction and wear : Raman spectroscopic analysis

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Solid state amorphization of minerals is known to occur in hardness indentations, during ball milling, in diamond anvil experiments, and in shock experiments. A production of SiO2 amorphous material is also reported in experimentally created fault gouges [1]. High speed friction experiments of quartz rocks imply extraordinary weakening at seismic rates [2]. Because weakening requires the combined effects of large displacement and high velocity, formation of a thin silica gel layer which comprises of very fine particles of amorphous silica was thought to cause weakening. Therefore, physical process of amorphization is important to better understand weakening of quartz bearing rocks at seismic rates. In this study, we conducted a pin-on-disc experiment to investigate details of amorphization of quartz [3]. Discs were made of single crystals of synthetic and Brazilian quartz. The normal load and sliding velocity were ranged from 0.01 N to 1 N and from 0.01 m/s to 0.25 m/s, respectively. The friction experiments were conducted using quartz and diamond pins (curvature radii of 0.5 ˜ 1.5 mm) to large displacement (˜80 m) under controlled atmosphere. Raman microspectroscopy (excitation wavelength 532.1 nm) provides lattice vibrational modes, and was used to investigate the degree of amorphization of samples. Raman spectra of frictional tracks on the disc show clear bands at wavenumbers of 126, 204, 356, 394, and 464 cm-1, their bands are restored E(LO+TO), A1, A1, E(TO), A1 vibration modes respectively. However, the bands at 464 and 204 cm-1 gradually broaden to reveal shoulders on the higher-wavenumber side of these peaks. Especially, a new distinguished peak appears at 480cm-1. In an experiment conducted at low stress (125 MPa) to large displacement (˜ 80 m), Raman spectra show complete lack of lattice vibrations mentioned above, indicating that quartz lost intermediate range structure of SiO2 during friction experiments. In the presentation, we will present the degrees of the amorphization as a function of normal stress, displacement and sliding velocity.

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