Mt. OIKEYAMA STRUCTURE: FIRST IMPACT STRUCTURE IN JAPAN?

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Introduction: The origin of the Mt. Oikeyama structure in Central Japan has been debated for many decades. The purpose of this study is to provide new information about scanning electron microscope-cathodoluminescence (SEM-CL) data of planar microdeformations in quartz samples to determine whether this area was formed by tectonic, regular geological processes or shock metamorphic events.

Experimental Procedure: SEM-CL imaging and CL spectral analyses were performed on selected polished thin sections coated with a 20-nm thin film of carbon in order to avoid charge build-up. SEM-CL images were collected using a scanning electron microscope (SEM), JEOL 5410LV, equipped with a CL detector, Oxford Mono CL2, which comprises an integral 1200 grooves/mm grating monochromator attached to reflecting light guide with a retractable paraboloidal mirror. The operating conditions for all SEM-CL investigation as well as SEM and backscattered electron (BSE) microscopy were accelerating voltage: 15 kV, and 2.0 nA at room temperature and 0.05 nA at low temperature, where a cryostage controlled down to –195 °C with liquid nitrogen and embedded heater was employed. Less beam current was required at low temperature due to temperature quenching effect, since CL emission of quartz significantly increases below –80 °C [1].

Results: Mt. Oikeyama (1905 m above the sea level) on Shirabiso Highland, which lies in the southern part of the Akaishi Mountains, Nagano Prefecture, Japan (Fig 1). In the eastern side of this mountain, there is a semi-circular topographic feature. The regional geology of this area consists of sandstone and mudstone interbedded with chert belonging to Chichibu Paleozoic terrain. Secondary electron (SE) images following a hydrofluoric-acid etching of quartz from chert of Mt. Oikeyama exhibits planar (width: 1-6 μm), parallel, widely spaced (approximately 30-60 μm) microdeformations oriented mainly in one direction (Figs. 2a,b). These features are often intersected by micro-cracks showing other orientations. The commonly designated “pillaring” (white arrow) and “array” (black arrow) textures are visible at a higher magnification scale (Fig. 2a). Similar features have been described by Gratz *et al.* (1996) [2], who distinguished shocked quartz from tectonically deformed quartz by SEM. Comparing to the optical microscope plane-polarized, SEI and backscattered electron (BSE) images of (obtained at same area) (Figs. 3a-c), SEM-CL photomicrographs of the quartz grains in the chert show two or more sets of planar microstructures presumably referred to planar deformation features, PDFs (Fig. 3b). This image of the same sample exhibits the contrast with dark streaks and even cross-hatched pattern sufficiently corresponding to the texture of planar microstructures in petrographic microscopy, where CL-bright area is higher luminescent than dark one (Fig. 3b).

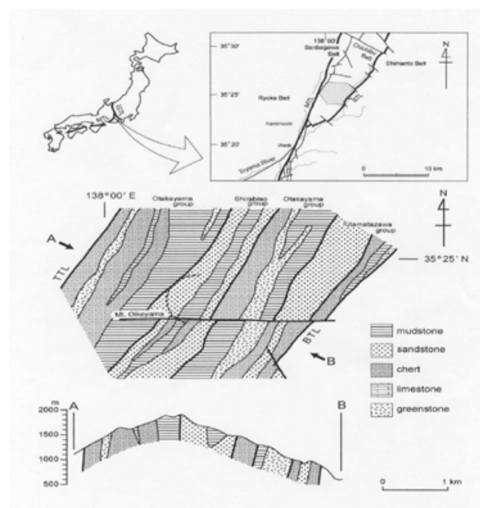

Figure 1. *Geographical location and regional geology of the Mt. Oikeyama area in Central Japan.*

Discussion and Conclusion: Gratz *et al.* (1996) [2] distinguished shocked quartz from tectonically deformed quartz by SEM (Secondary Electron Image-SEI) on the HF-etched quartz, and reported differences between glass-filled PDFs (“pillaring” texture) and glass-free tectonic deformation arrays. These similarities of the shock-related pillaring texture and tectonic-related arrays in a quartz sample from Mt. Oikeyama are visible in the secondary image followed HF-etching. This indicates that the presence of glass-filled micro-cracks such as wide planar transformation lamellae might be related to the shock-metamorphic processes (Gratz *et al.* 1996) [2]. Comparing to the optical microscope plane-polarized, SEI and backscattered electron (BSE) images of (obtained at same area) (Figs. 3a,c,d). SEM-CL photomicrograph of the quartz grains in the chert show two or more sets of planar microstructures presumably referred to planar deformation features, PDFs (Fig. 3b). This image of the same sample exhibits the contrast with dark streaks and even cross-hatched pattern sufficiently corresponding to the texture of planar microstructures in petrographic microscopy, where CL-bright area is higher luminescent than dark one (Fig. 3b). Low-temperature monochromatic CL image at 455 nm shows almost same contrast pattern as obtained in room-temperature panchromatic CL image, but with slightly less intensity. Nevertheless SE and BSE images reveals no distinguishing features for the same sample. These facts that the texture of CL image reflects substantial character concerning to planar microstructures of the quartz displayed in a petrographic micrograph, not to compositional heterogeneity, micro fractures and growth zonation, of which CL image has no crossing-over pattern. Such obvious shocked lamellae of CL image are rare to be found even in the quartz grains showing well defined planar microstructures in an optical image. In many cases they can be recognised as separated individual segments closely associated with wide, diverse and irregular non-luminescent ones mentioned below.

Recently Seyedolali *et al.* (1997) [3] and Boggs *et al.* (2001) [4] revealed that planar microstructures in shocked quartz resulted from meteorite or cometary impact can be discriminated from other resemble features by SEM-CL image. Typical CL image of PDFs described by Boggs et al. (2001) [4] is characterised by fine dark streaks with 1-2 µm thickness in bright luminescent background and sufficient parallelism of dark streaks with 5-20 µm spacing, where the texture of CL image is favourably compared with planar microstructures illustrated in petrographic optical image. Overwhelming parallel dark streaks observed in CL image of Oikeyama quartz are quite narrow in thickness of 1 to 2 µm or less near to effective resolution of CL imaging, whereas several broad dark bands with 5-10 µm thick can be recognised. The spacings of dark streaks are predominant in 3-5 µm. According to the verification by Boggs *et al.* (2001) [4] parallel dark streaks in CL image of Oikeyama quartz could be unambiguously led to the evidence of PDFs.

Consequently, All arguments of an impact origin of the Mt. Oikeyama and related rocks are based on interpretation of selected SEM-CL observations. The secondary electron image of an HF-etched shows clear evidences (e.g. pillaring texture) for the presence of glass-filled wide, planar transformation lamellae. The absolutely straight, planar character of the glass-filled features have not been known from e.g., tectonic deformation lamellae. Therefore CL images of the quartz with planar microstructures seem to exhibit complex features superimposed by tectonic fractures.

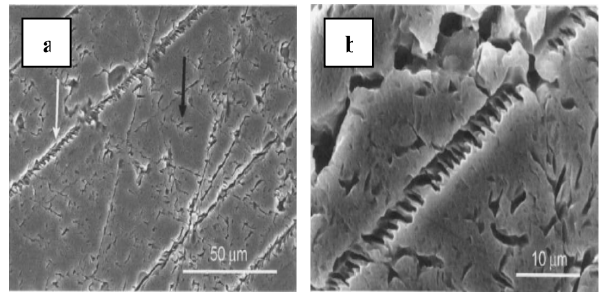

Figure 2. *HF-etched quartz (SE) images (a,b) exhibit the shock-induced pillaring structure (white arrow) and tectonic-related array structure (black arrow). The pillaring texture as clearly visible at higher magnification (b).*

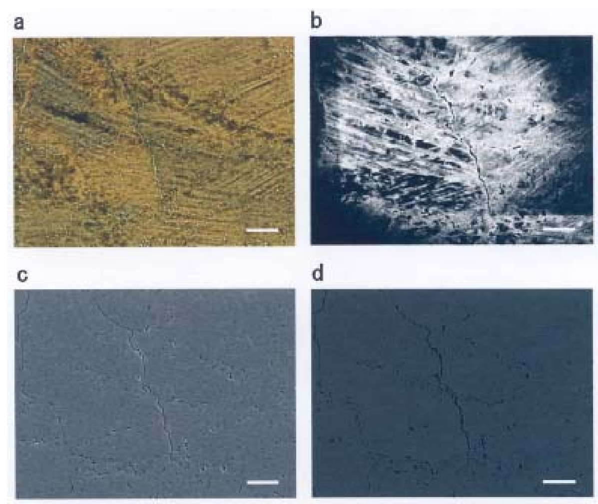

Figure 3. *Optical (a), SEM-CL (b), SE (c) and BSE (d) images of a quartz sample from Oikeyama structure showing three orientations of PDFs mostly in the CL image (a scale corresponds to 25 µm in all images).*

References:

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