MINERALOGICAL DATA OF SHOCKED QUARTZ GRAINS FROM K-T BOUNDARY.
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1. Introduction
Quartz minerals show wide pressure-dependent region (~30 kbar) in the low-temperature quartz, as well as many high-temperature phases with each low-temperature phase [1]. The detailed mineralogical data of quartz silica indicate the formation process of the host rocks.

The Cretaceous-Tertiary (K-T) boundary samples have been discussed from archaeological, mineralogical and geochemical data by many scientists [cf.2-6]. Anomalous density-variation data and probable formation processes of shocked quartz from four K-T boundary sites (Japan, Italy, Denmark and Tunisia) have been found in the progressive sampling data obtained by powdered X-ray diffractometer [7].

The purposes of the present study are (1) investigation of shocked quartz grains from K-T boundary sample of Clear Creek North (CCN), Colorado, U.S.A. [8] by using the Rigaku four-circle single-crystal X-ray diffractometer, compared with those of the Barringer meteorite crater and 5 terrestrial metamorphic, volcanic and plutonic rocks and tectonic complex, and (2) discussion of the probable formation process.

2. Physical properties of shocked quartz
Cell-parameters (as hexagonal-cell) of quartz grains with and without shocked lamellae have been obtained from least square method of 25 peaks with higher degree of accuracy, summarized as follows.
(1) Standard quartz crystals are used from Gifu rock-crystal and Yamaguchi granite; the calculated density ($\rho_{calc}$) is 2.645.
(2) Three quartz grains (B1M, B3W, B10W) from the Barringer meteorite crater show higher $\rho_{calc}$; the B10W coexisted with coesite, 2.669.
(3) Six quartz grains from the CCN K-T boundary sample reveal three types of rock-crystal (sample Q2), temperature-dependent quartz (Q1 and SQ4) and new anomalous shocked quartz (SQ1, SQ2 and SQ3).

3. Anomalous cell-parameters of CCN shocked quartz
The CCN shocked quartz with multiple shocked lamellae indicates that (1) higher a-axis (+1.3% in sample SQ3) and lower c-axis (-0.7% in SQ3) and (2) lower $\rho_{calc}$ value (-0.6% in SQ3), as shown in Fig. 1.

These anomalous cell-parameters of the CCN shocked quartz grains cannot find in any of quartz samples from 2 impact craters (Barringer and Manicouagan), and 5 terrestrial rocks (Sangun high-pressure type, Rhyoke high-temperature type metamorphic rocks, Nagato tectonic complex, Mesozoic volcanic and plutonic rocks from Japan [7]).

Therefore, these CCN shocked quartz grains with shocked lamellae are considered to be partly glassy quartz by impact process, by the following reasons:
(1) CCN-SQ3 shocked quartz with multiple lamellae shows 7 times the diffuse spots than those of clear normal quartz (in sample Q2).
(2) Negative value of $\rho_{calc}$ is the similar characteristics with silica glass [9].
K-T SHOCKED QUARTZ
Miura, Y.

Fig. 1. Relation among c-axis, calculated density and volume per SiO$_2$ unit in the CCN K-T quartz samples (O: with shocked lamellae; ■: without lamellae; ○: standard rock-crystal; ▲: Barringer meteorite crater).

(3) Glassy phases of quartz grains with multiple lamellae are found in higher shocked-pressure [10].

(4) It is considered that higher impact process produces distortion of the SiO$_4$ tetrahedra (i.e. higher a-axis), and the compression of stacking direction (i.e. lower c-axis) which is the similar features of the quartz grains in the Barringer impact crater.

4. Formation processes of the CCN K-T boundary samples

Probable formation processes of the CCN K-T boundary samples are summarized as follows:

(1) Impact process of the CCN K-T sample is different with that of Barringer meteorite crater, because positive values of $\rho_{ca1}$ in the Barringer quartz grains without multiple shocked lamellae (B1OW, B1W and B3M) but coexisting with coesite indicating simple impact process has not been found in the CCN K-T boundary sample so far [8].

(2) Shocked quartz with lamellae of the CCN K-T boundary samples probably formed at the different sites of the original impact site, compared with the other K-T boundary samples [7] showing higher positive values of $\rho_{ca1}$.

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