NEW MINERALOGICAL INDICATORS OF SHOCK METAMORPHISM

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1. Introduction

Shock (or impact) metamorphism [1,2,3] of natural materials is mainly discussed by physical, mineralogical and morphological changes of rocks and minerals. However, there are few detailed data of mineral contents and density variation of shock metamorphism.

The purposes of the present study are (1) establishment of new indicators of shock metamorphism [4] in artificial impact crater [5], and (2) application of the indicators to natural impact craters and Cretaceous-Tertiary (K/T) boundary samples.

2. Artificial impact crater

Experiments that generated artificial impact craters have been carried out with rail-gun at the National Institute of Space and Astronautical Science (ISAS), Japan by using two kinds of target rocks (i.e. Khoyama gabbroic anorthosite and Tokuyama granite) and projectiles (i.e. steel and plastic projectiles) performed at higher velocity from 2.8 to 7.9 km/sec. The following results are obtained in this study [5]:

(1) Content of quartz is increased at the rim of the crater. Figure 1 shows that ratio of 'quartz' to feldspar is 2.2 compared the rim to the center. Even in gabbroic anorthosite with little quartz small amount of quartz is formed after impact. This is mainly because K, Na and Ca ions of feldspar minerals in the original rocks are evaporated to form silica phase (i.e. quartz or cristobalite). The reason why the quartz could not observed clearly at the center of the crater is due to flow out and remove the materials by vapor plume. Thus the content of quartz between original rock and the basement rock of the center are almost the same, as shown in Fig.1. Formation of cristobalite which is the relict of quenching at the impact events, is also observed at the rim of crater. Typical data of cristobalite content are obtained in the granite target up to 3 vol. %. Therefore, mineral content of quartz is considered to be good indicator of shock metamorphism.

(2) Density variation ($\Delta \rho$) is also considered to be good indicator of shock metamorphism, though the value changes with the rock target; that is, smaller grains of quartz inthe gabbroic anorthosite shows larger value of $\Delta \rho$; larger quartz grain of the granite, the smaller vaule.

3. Application to the natural impact craters.

Three indicators of shock metamorphism(i.e. quartz and cristobalite contents and density variation) are checked at impact samples of various impact craters [6,7] (cf. Table 1).

1) Anomalous contents of cristobalite up to 20 volume percents are found in larger impact craters of Manicouagan and Charlevoix, though anomalous values of stishovite and coesite are found only in Barringer crater.

2)Density variations of quartz are obtained in these impact craters up to +0.7 %, compared with standard rock crystal.

3) Possible impact craters in Japan (e.g. Kuga, Ohtaki and Hoshinoko) are checked by these indicators of shock metamorphism.

INDICATOR OF SHOCK METAMORPHISM

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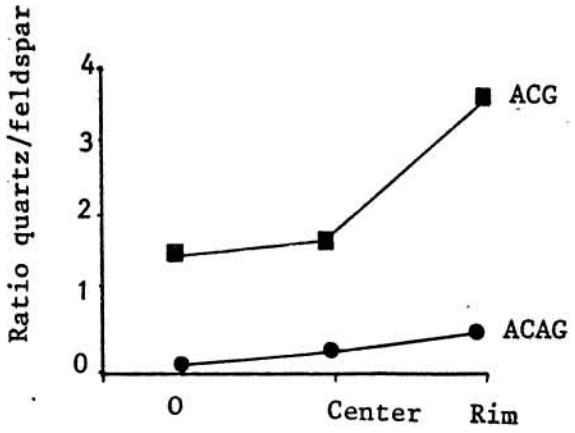

Fig. 1. Relation between sample site (Original:O. Center. Rim) and quartz content (to feldspar) in artificial impact crater. ACG: Tokuyama granite. ACAG: Kohyama gabbroic anorthosite.

Table 1. Maximum mineral contents of quartz, cristobalite, stishovite and coesite, and density variation of quartz.

Sample	Cristobalite (vol.%)	Quartz/ Feldspar	Stishovite (vol.%)	Coesite (vol.%)	Δ ρ of quartz(%)
Artificial ACG	3	2.2 (rim)	0	0	+0.30(r.c)
ACAG	0	2.2 (rim)	0	0	+0.04(rim)
Barringer(B-3)	5	-	2	20	+0.64(rim)
Charlevoix(7,11)	20	-	0	0	+0.30(rim)
Manicouagan	20	-	0	0	+0.08(rim)
Clearwater Lakes	2	-	0	0	+0.42(Hole)
Lake Mistastin	0	-	0	0	+0.42(melt)
Dalgaranga(4)	0	-	0	0	+0.35(rim)
Gosses Bluff(3)	0	-	0	0	+0.38(shat)

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References:

[1]French, B. (1968): Shock metamorphism of natural materials, 1-17.
[2]Chao, E.T.C. (1967): Science, 156, 192-202.
[3]Dietz, R.S. (1960): Science, 131, 1781-1784.
[4]Bohor B. F. et al. (1986): Science, 224, 867-869.
[5]Miura, Y. (1991): Shock Wave, an International Journal (in press).
[6]Robertson, P.B. (1968): Meteoritics, 4, 89-112.
[7]Grieve, R.A.F. and Floran, R. (1883): J. G. R., 88, A807-A818.