HEATING EXPERIMENTS OF MASKELYNITE IN ZAGAMI, ELEPHANT MORAINE A79001 AND ALLAN HILLS 77005: IMPLICATIONS FOR THE EFFECT OF SHOCK HEATING. R. Shikina[1,2] and T. Mikouchi[1,2], [1]Department of Earth and Planet. Science, The University of Tokyo, Hongo, Tokyo 113-0033, Japan (r-shikina@um.u-tokyo.ac.jp), [2]The University Museum, The University of Tokyo, Hongo, Tokyo 113-0033, Japan.

Introduction: Plagioclase is one of the important constituents of extraterrestrial materials and is sensitive to the shock metamorphism. Maskelynite is understood as a diaplectic plagioclase glass that has been transformed from plagioclase in solid-state transformation by strong impact and is commonly found in Martian meteorites [1]. Maskelynite is known to be easily converted to crystalline plagioclase by reheating and the degree of recrystallization depends upon shock pressure [2]. Such plagioclase recrystallizations is found in meteorites. For example, the lunar meteorite Y-793169 shows a recrystallized polycrystalline plagioclase texture by a reheating event after the formation of diaplectic glass by impact during the late heavy bombardment of the Moon [3].

However, comprehensive study for annealing of shocked plagioclase has been reported only by dynamic high-pressure experiments [2]. Because the time scale of the impact is significantly different between natural events and laboratory experiments [4-5], recrystallization experiments of shocked plagioclase using natural shocked samples may show different behaviors from laboratory results.

In this study, we performed heating experiments of maskelynite in Martian meteorites. We tried to evaluate the recrystallization degree of plagioclase by heating experiments using three shergottites (Zagami, EETA 79001 and ALH 77005) because they are reported to have experienced different shock degrees [1].

Experiments: Small slices (~5 mm in size) of Zagami, EETA 79001 and ALH 77005 were heated at 800 °C (24 and 168 hours), 900 °C (1, 8, 24 and 168 hours) and 1000 °C (1 hour) in a CO_2-H_2 gas mixing furnace at the oxygen fugacity of two log units above the iron-wüstite buffer ($\log fO_2$=IW+2). The heated samples were observed with an optical microscope to estimate the degree of plagioclase recrystallization and mineral compositions were analyzed by electron microprobes (JEOL JXA 8530F and JXA 8900L at Univ. of Tokyo).

Results: Zagami did not show clear evidence of recrystallization in the experiment heated at 900 °C for 1 hour and at 800 °C for 168 hours, but fibrous crystalline plagioclase was observed in the experiments heated at 900 °C for 8, 24, and 168 hours. Zagami maskelynites heated at 900 °C for 24 and 168 hours were almost completely converted to polycrystalline plagioclase. In maskelynites heated at 900 °C for 8 hours (shown in Fig. 1) and heated at 1000 °C for 1 hour, fibrous crystalline plagioclase was observed only along the cracks and at edges of the original grains. Although maskelynites appear to have a smooth surface through optical microscopy, the recrystallized plagioclase shows a dirty devitrified texture. Electron microprobe analysis (shown in Fig. 2) revealed that Na and K are reduced, but Ca is enriched in the recrystallized plagioclase of the samples showing partial recrystallization (900 °C for 8 and 24 hours and 1000 °C for 1 hour). In the maskelynite grains heated at 900 °C for 168 hours, small glass regions enriched in Na and K are present (Na_2O: ~6.5 wt%, K_2O: ~2.5 wt%), suggesting that Na and K concentrate in areas where recrystallization did not start yet.

Different from Zagami, in the experiments of EETA 79001, fibrous crystalline plagioclase was observed in samples heated at 800 °C (24 and 168 hours) and 900 °C (≥1 hour heating time). Maskelynites heated at 1000 °C for 1 hour also showed fibrous crystalline plagioclase. Maskelynite heated at 800 °C for 168 hours was recrystallized in ~ 33% of one grain.

ALH 77005 also shows clear evidence of recrystallization in the sample heated at 900 °C for 8 hours, and the recrystallization degree is intermediate between those of Zagami and EETA 79001. Samples heated at 900 °C for 24 hours and 168 hours were almost completely recrystallized like the other two samples, but sample heated at 800 °C for 168 hours shows only slight evidence of recrystallization. The ALH 77005 samples showed a higher degree of plagioclase recrystallization than Zagami.

Discussion and Conclusion: The degree of recrystallization of maskelynite is reported to be related to the original shock degree of plagioclase as experimentally demonstrated [2]. The results of [2] showed that the higher the degree of impact, the lower the recrystallization rate, as compared for the samples with the same heating time. Mineralogical observations suggest that Zagami, EETA 79001, and ALH 77005 were more strongly shocked in this order [1], but comparing our Zagami experiments with those of EETA 79001 and ALH 77005, the recrystallization degree of EETA 79001, which has the second highest shock degree, was the highest, and the recrystallization degree was higher in the order of EETA 79001, ALH 77005, and Zagami (shown in Table 1).

During a natural impact event, both pressure and temperature raise, but their decreasing degrees are different by the scale of impact. In the case of large scale impact, pressure first decreases, but temperature remains high, which result in residual heat. Therefore, we assume that the atomic ordering of maskelynite was significantly disturbed in the more shocked samples, but the effect of residual heat accompanying the high impact level restored the atomic disordering. Thus, both positive and negative effects influence the atomic disordering degree of maskelynite in shergottites. By this combined effect, the degrees of plagioclase recrystallization were in the order of EETA 79001, ALH 77005 and Zagami.

In addition, in the heating experiment of the experimentally shocked labradorite sample, the sample subjected to the high impact pressure did not recrystallize at all [2], but the experiment using the natural sample in this study showed a high degree of recrystallization at the same heating condition. This is also caused by the difference in residual heat due to the difference in impact energy between natural and laboratory experiments [6]. This supports the suggestion of the study of dark olivine in Martian meteorites on the effect of residual heat during the shock metamorphism of meteorites [7].

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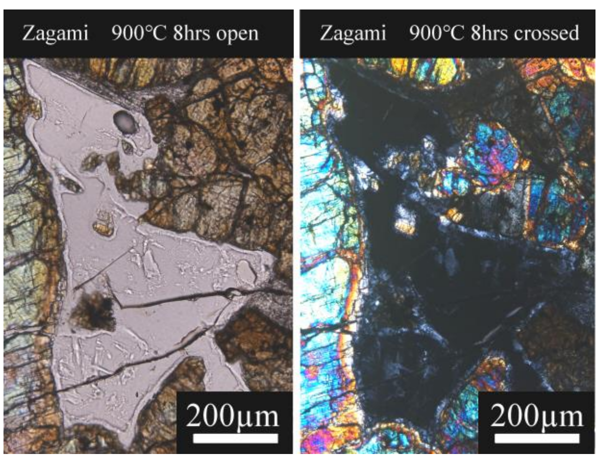

Figure 1: Open nicol image (left) and crossed nicols image (right) of the same area from Zagami maskelynites heated at 900 °C for 8 hours; fibrous crystalline plagioclase was observed only along the cracks and at edges of the original grain. Dark regions in crossed nicols images are optically isotropic and so correspond to maskelynite. Crystalline plagioclase has a different refractive index from maskelynite.

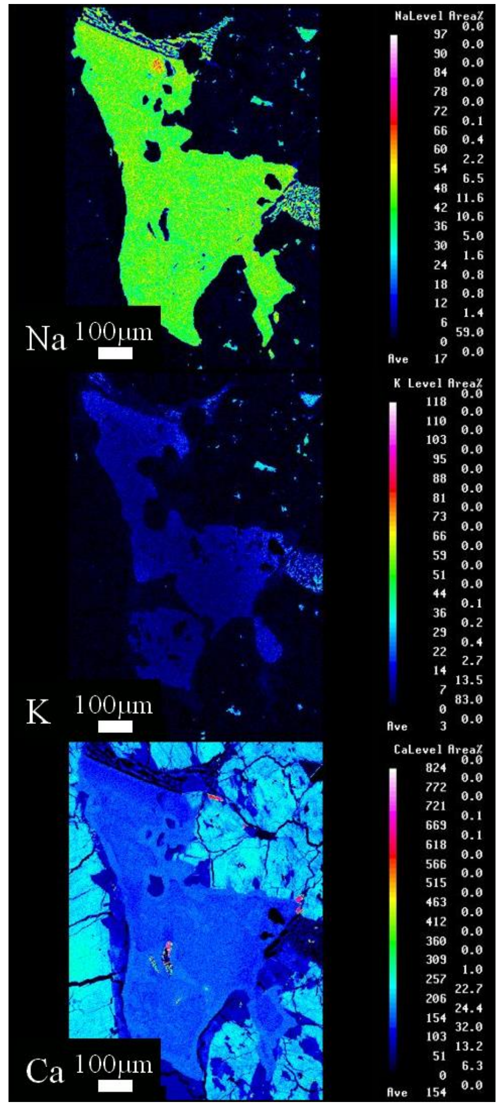

Figure 2: Na map (top), K-map (middle), and Ca-map (bottom) of maskelynite and crystalline plagioclase from Zagami (900 °C for 8 hours); Na- and K-maps show Na and K are depleted in the recrystallized plagioclase of the samples, Ca-map shows Ca enrichment in the same areas.

Table 1: The area percentage of the recrystallization of plagioclase in one maskelynite grain in each sample (Zagami, EETA 79001, ALH 77005) for all runs.

Heating conditions	Zagami / %	EETA 79001 / %	ALH 77005 / %
800℃, 24 hours		~8	0
800℃, 168 hours	0	33~40	~8
900℃, 1 hour	~3	7~17	~5
900℃, 8 hours	~40	~97	~70
900℃, 24 hours	~95	~99	~98
900℃, 168 hours	~99	~99	~99
1000℃, 1 hour	~91	~99	~95