SHOCK METAMORPHIC EFFECTS CAUSED BY HYPERVELOCITY IMPACT OF METEORITE PROJECTILE INTO QUARTZ TARGET

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The aim of this work is to describe a shocked material from a small experimental crater. A single quartz crystal cut parallel to the (0001) plane was impacted horisontally in the light gas gun facility under an ambient air pressure of 46 mm. A bowl shaped 4.97 mm size projectile was made from a kamacite plate of the Sikhote-Alin iron meteorite (Fe 93,74 wt.%, Ni 5.35 %,Co 0.50 %). The projectile velocity was 5.1 km/sek. The pressure in the point of impact is estimated to be 80 GPa using the planar impact approximation and the Hugoniot curves of iron and quartz. This pressure condition corresponds to the shock temperature of about 1000 C and 4500 C in kamacite and quartz, respectively.

In the recovered material among broken clasts of the quartz target there are 4 types of mm-size particles with some shock effects. The white porcellan-like particles have no diaplectic transformations. These are fragments of the monocrystal quartz target with systems of subparallel cracks which do not show a crystallographic control. A peak pressure in the particles can be estimated to be not higher than 8 GPa. However similar particles with metal smears show wide-spread planar deformation structures. Some particles show reduced refractive indices and birefringency. In some cases lechateleirite veins are observed. The shock pressures experienced by these particles range from about 12 up to 30 GPa. The fragments of the kamacite projectile have an irregular shape.On the basis of some details of their surface it can be suggested that their shapewere formed by effects of a chopping. The intense plastic deformations occur mostly at edges of the particles. These particles have a fine-grained texture with a some elongating of grains. The Neumann lines are not observed as well as traces of a shock melting. According to the shock experiments with iron samples [1] the fine-grained texture of the particles can be interpreted as a result of a reversible phase transition under the shock compression.

The most interesting particles are agglomerates of the target and projectile material which are similar to the agglutinate-like particles described by [2]. The agglomerates contain clasts of the diaplectic quartz glass or of the diaplectic quartz which are cemented by a vesicular matrix. The matrix consists of a silica melt glass and dispergated kamacite melted inclusions. Unmelted metal fragments present in the matrix also [Fig.1]. There are chemical differences in composition among the target, the projectile, and the matrix phases. The silica melt glass from matrix shows slight enchancement in Fe (probably in Fe++ form) up to 0.5 wt.%. There is also a small decreasing of the Fe/Ni ratio in the melted metal inclusions. The ratios are 17.5+/-3.2 and 13.9+/-1.3 (2 σ) in the projectile and the metal droplets, respectively (Fig.2). The melted kamacite has a low silicon content up to 2 % (Fig.3). The 50-um size individual kamacite sphere separeted from the silica melt matrix, contains 0.1 % of Si that

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is evenly distributed in the sphere.

The hypervelocity impact of the kamacite projectile into monocrystalline quartz leads to both the typical shock metamorphic effects and the change of the chemical composition of the melted projectile and silica. On the basis of the reduced Fe/Ni ratio in the kamacite droplets, their enrichment in silicon, and the appearance of Fe in silica one can assume preliminary that there can be an interface chemical reaction between the target and projectile materials during the impact: 2Fe(projectile) + SiO2(target) = 2FeO(silica glass) + Si(kamacite droplets). According to the thermodinamical calculations [1] the reaction could take place at 3000 K and 1 bar at least. The increasing of the pressure would lead to a rise of the equilibrium reaction temperature. The thermal energy requiring for the reduction of silica must be resulted mainly from the shock heat of silica at the point of the impact, because the peak pressure (80 GPa) is not sufficient for the significant heating of the kamacite phase. The observed melted droplets of kamacite could be probably formed as a result of a heat change between the molten silica and kamacite or an intense plastic flow of the projectile.

REFERENCES: [1] Johnson P. et al., (1962), J. Appl. Phys., p.557; [2] See et al., (1987), LPS XVIII, Abstracts, p.900; [3] Kuskov O.L., (1975), Geochimia, 8, p.1137 (in Russian).

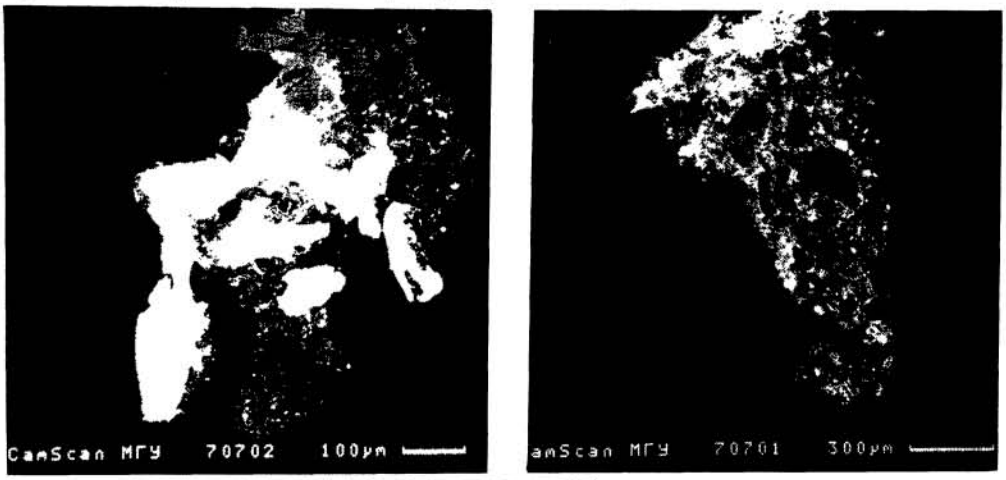

FIG.1

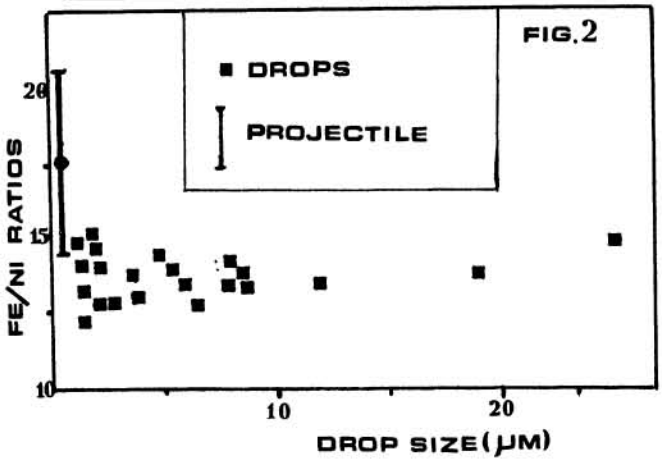

FIG.2

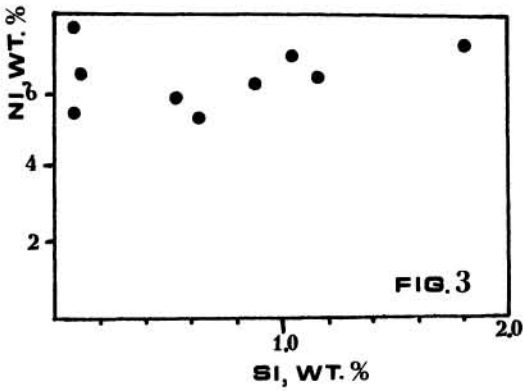

FIG.3