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High-pressure polymorphs in Katol L6 chondrite: deciphering thermal history and shock conditions

Kishan Tiwari (1), Sujoy Gosh (1), Masaaki Miyahara (2), and Dwijesh Ray (3)

(1) Indian Institute of Technology, Kharagpur, India, (2) Hiroshima University, Higashi-Hiroshima, Hiroshima, Japan, (3) Physical Research Laboratory, Ahmedabad, India

We studied heavily shocked Katol L6 chondrite consisting of up to 1.2 mm thick shock melt vein. Host rock mainly consists of olivine (Fo74), clinopyroxene (En46Fs10 Wo44), orthopyroxene (En75.5 Fs21.5 Wo3), plagioclase, chromite, apatite, troilite and Fe-Ni metal where many plagioclase grains and olivine present in the vicinity of the shock veins have been transformed into maskelynite and ringwoodite respectively. Fragments in shock veins consist of wadsleyite, ringwoodite, majorite, bridgmanite, akimotoite, lingunite, tuite and xiete whereas the matrix consists of mainly aluminium bearing bridgmanite and majorite-pyrope solid solution, but these two do not coexist together in the same portion of the vein. Here we are reporting natural occurrence of bridgmanite as the liquidus phase as indicated by its idiomorphic and microcrystalline texture and aluminium enrichment relative to the host orthopyroxene.

Based on mineral assemblage and phase diagrams of high pressure polymorphs estimated shock pressure for host rock and fragments in veins is 18-24 GPa and temperature should be less than 2323 K, liquidus temperature at 24 Gpa. P-T condition experienced by the vein matrix is constrained by the occurrence of bridgmanite as the liquidus phase. For bridgmanite to crystallize as the liquidus phase, peak pressure should be higher than 25-27 GPa. Here we are taking 28 GPa as the peak pressure for the formation of Al-bearing bridgmanite at which the liquidus temperature, 2400 K, defines the minimum temperature of the melt as the maximum temperature cannot be known. Taking the initial temperature of the parent body as 245 K, calculated shock and post-shock temperatures are 486 K and 423 K respectively. Applying the method of Stefan problem, the crystallization time for 1.2 mm thick vein is calculated to be 76 ms, 64 ms and 58 ms for melt temperatures of 2400 K, 3000 K and 3500 K. Kinetic analysis of microcrystalline aggregates of $\sim$1-1.2 μm sized grains of ringwoodite in shock vein revealed that high pressure pulse duration must have persisted for at least 3.3 s.

Based on Rankine-Hugoniot relationship, for shock pressure 18-28 GPa, calculated values of particle velocity, Up, shock wave velocity, Us, impact velocity Ui and rarefaction wave velocity, Cr are $\sim$0.98-1.38 km/s, $\sim$5.33-5.87 km/s, $\sim$1.96-2.76 km/s and 5.66-6.32 km/s respectively Based on these data parent body size of the meteorite was calculated to be >10-11.3 km.