STISHOVITE IN SHOCK VEINS WITHIN THE MANICOUAGAN IMPACT STRUCTURE

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The mineralogy and texture of shock veins developed within the central uplift of the 90 km rim-diameter Manicouagan impact structure, Canada, have been studied using micro-Raman spectrometry and analytical field emission scanning electron microscopy. The shock veins occur as thin fracture-microfault systems. They are less than 2.5 mm wide and can extend for several meters, depending on exposure. They are hosted by anorthositic and gabbroic gneisses. The shock veins were initiated during the contact/compression stage of crater formation at 214 Ma [1].

The shock veins comprise an amorphous to microcrystalline matrix, which may exhibit fluidal textures, hosting wall rock mineral fragments. The matrix is typically dominated by submicron plagioclase neocrystallites (An_{56}). Mineral fragments are dominated by hornblende and plagioclase (0.4 to >10 μm), which may form an aggregate lining to the veins, or define fluidal stringers within the matrix. Here we report the first discovery of the high pressure SiO_2 polymorph, stishovite, at Manicouagan. Its chemical composition and crystal structure have been confirmed by EDS and Raman analysis. Stishovite is the hard (H 8-9), dense (S.G. 4.35) tetragonal form of SiO_2 that is stable at pressures above 9 GPa [2][3]. Unlike quartz, the silicon in stishovite is in octahedral coordination with oxygen as SiO_6. The stishovite in the shock veins possesses 0.5-3 wt% Al_2O_3. Stishovite occurs as bleb-shaped clusters of granular crystals (<0.2-2.0 μm) within hornblende microfragment stringers and in the matrix, as fluidal stringers, and as isolated, larger (up to 5 μm) single crystals within the matrix.

In this study, we suggest that shock compression and rarefaction are responsible for shear failure, intra-vein shock reverberation, frictional melting, phase transformation, and crystallization within the fracture-microfault zones. The linear clusters of microfragments of hornblende along margins of the veins indicate that the crushing of materials is restricted to the sliding interface. The crystallization and flow texture of plagioclase neocrystallites in the matrix indicates high temperature effects (excursions) and melting at the local scale, in contrast to areas beyond the shock veins. Stishovite in shock veins can be formed by crystallization from a melt, or by solid-state transformation from quartz. This current study favours the former, although direct transformation remains a possibility. The granular and prismatic crystal habits of stishovite suggest that it was generated at ~900-1450 ^{o}C and 9.5-15 GPa [4][5][6]. The development of mosaic-fractured and broken stishovite crystals suggests localized volume expansion (during partial conversion to a less dense phase e.g. solid-phase amorphization) as a result of metastability [7][8] during the spatially and temporally heterogeneous shock process.

[1] Biren M.B. and Spray J.G. 2011 *Earth and Planetary Science Letters* 303:310–322. [2] Stishov S.M. and Popova S.V. 1961. *Geochemistry* 10:923-926. [3] Chao E.C.T. et al. 1962. *Journal of Geophysical Research* 67:419-421. [4] Sclar C.B. et al. 1964. *Science* 144:833-835. [5] Stoffler D. and Langenhorst F. 1994. *Meteoritics* 29:155-181. [6] Lityagina L.M. et al. 2001. *Journal of Crystal Growth* 222:627-629. [7] Brazhkin V.V. et al. 1991. *Journal of Noncrystalline Solids* 136:241-248. [8] Popova S.V. et al. 2002. Physics-Uspekhi 45 (4): 445-447.