Shock metamorphic features of olivine, orthopyroxene, amphibole, and plagioclase in phlogopite-bearing ultramafic-mafic inclusions in Contact Sublayer, Sudbury Igneous Complex

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The Sudbury Structure is one of the world's oldest, largest, and best exposed impact structures and contains one of the world's largest deposits of Ni-Cu-PGE mineralization. Despite intensive study for over 100 years, many important aspects remain unresolved, including whether phlogopite-bearing ultramafic-mafic inclusions in Contact Sublayer that have no counterpart in the exposed (surface/underground) footwall rocks are exotic or cognate in origin, and why they are so strongly associated with mineralization. The olivine, orthopyroxene, amphibole, and plagioclase in many Contact Sublayer inclusions appear to show shock metamorphic features, including kink banding, shock-induced recrystallized mosaic textures, planar microstructures, shock darkening, and/or opaque domains/veins. Coarse oikocrystic phlogopite is commonly present in ultramafic inclusions, especially in pyroxenite, and is characterized by kink banding. Shocked olivine often occur as polygonal crystals in elliptical clusters that have the same dimensions as unshocked olivine crystals, which are interpreted to represent recrystallized shock-induced "mosaic" textures. Opaque domains/veins in these clusters are optically (e.g., hardness, relief) and chemically similar to adjacent undarkened olivine. In some cases, half of an individual olivine grain is opaque and the other half is transparent. Orthopyroxene, amphibole, and plagioclase show multiple sets of parallel planar and curviplanar fractures that are similar to typical shock metamorphic features, (e.g., planar fractures and planar deformation features). SEM studies indicate that some of the fractures in orthopyroxene and amphibole are filled with exsolved plagioclase and clinopyroxene, whereas those in plagioclase appear to contain exsolved ferromagnesian phases. The presence of high-pressure shock metamorphic features is a crucial evidence for an exotic (rather than cognate) origin for some of the ultramafic-mafic inclusions. Future work will be aimed at using the shock features to constrain the shock state, the mineral assemblages to constrain impact excavation depth, and their distribution to establish whether the association with mineralization is physical or genetic.