American Mineralogist, Volume 108, pages 686–694, 2023

Structural changes in shocked tektite and their implications to impact-induced glass formation

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Abstract

Heavy meteorite impacts on Earth's surface produce melt and vapor that are quenched rapidly and scattered over wide areas as natural glasses with various shapes and characteristic chemistry, which are known as tektites and impact glasses. Their detailed formation conditions have long been debated using mineralogical and geochemical data and numerical simulations of impact melt formations. These impact processes are also related to the formation and evolution of planets. To unravel the formation conditions of impact-induced glasses, we performed shock recovery experiments on a tektite. Recovered samples were characterized by X-ray diffraction, Raman spectroscopy, and X-ray absorption fine structure spectroscopy on the Ti *K*-edge. Results indicate that the densification by shock compression is subjected to post-shock annealing that alters the density and silicate-framework structures but that the local structures around octahedrally coordinated Ti ions remain in the quenched glass. The relationship between the average Ti-O distance and Ti *K* pre-edge centroid energy is found to distinguish the valance state of Ti ions between Ti^{4+} and Ti^{3+} in the glass. This relationship is useful in understanding the formation conditions of impact-derived natural glasses. The presence of Ti^{3+} in tektites constrains the formation conditions at extremely high temperatures or reduced environments. However, impact glasses collected near the impact sites do not display such conditions, but instead relatively mild and oxidizing formation conditions. These different formation conditions are consistent with the previous numerical results on the crater size dependence.

Keywords: Tektite, shock-recovered tektite, impact conditions, Ti *K* edge XAFS, local structure of Ti