The Redox Signature of Impact Melts: The Fulgurite Record

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Shock processes are one of the most important drivers of surface geologic evolution across the solar system. Shock reduction of silicate material is well documented in lunar agglutinates [1] and terrestrial tektites [2], although shock oxidation has also been observed [3]. Shock reduction is believed to result from volatile release (i.e., H, C) and/or high temperatures from the shock event. We have analyzed seven fulgurite melts produced by lightning strikes to study the redox conditions of shock processes. Lightning strikes can trigger rapid changes in temperature and pressure similar to those of meteor impacts, producing both impact melt [4] and mineral shock signatures [5]. Fulgurites, therefore, are natural laboratories in which to study impact melt redox states.

The processes of shock and high temperature do not lend themselves to creating equilibria; rather, they result in often fine-grained mixtures of vapor condensation products and Fe-containing compounds with oxidation states from Fe^0 metal to Fe^{3+} oxides. Microanalytical methods such as X-ray Absorption spectroscopy (XAS) are needed to quantify redox variations *in situ* at ~1 μm scales. Fe XAS predictions of Fe^{3+} are accurate to ±3.6% absolute, comparable to Mössbauer analyses [6]. XAS studies of the fulgurite suite [4] show most samples are strongly reduced, with both Fe^0 and Fe^{2+}. Careful XAS mapping of redox variations is ongoing to constrain the spatial distribution of Fe^{3+}/Fe^{2+} variations as a means to relate it to redox processes during impact.

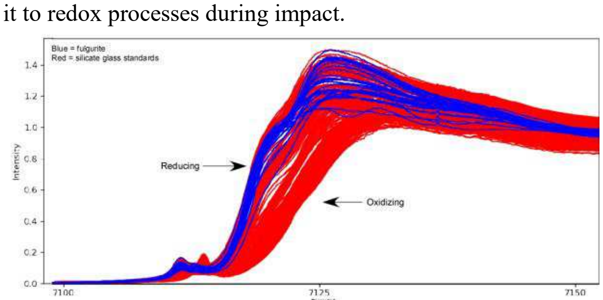

Fig. 1. Fe XAS comparison of fulgurites & synthetic glass.

[1] Hapke (2001) *JGR* 106, 10039-10073. [2] Fudali *et al.* (1987) *GCA* 51, 2749-2756. [3] McCanta & Dyar (2017) *MaPS* 52, 320-332. [4] Sheffer (2007) U. Ariz. dissertation, 246p. [5] Chen *et al.* (2017) *GRL* 44, 8757-8768. [6] Dyar *et al.* (2016) *AmMin* 101, 744-748.