GEOCHEMICAL CHARACTERISTICS OF THE PSEUDOTACHYLITES OF MUSGRAVE PROVINCE

CONNELLY, Daniel P., MAPCIS Research, 4815 Covered Bridge Rd, Millville, NJ 08332, **SIKDER, Arif M.**, Center for Environmental Studies (CES), Virginia Commonwealth University (VCU), 1000 West Cary Street, Richmond, VA 23284, **TURNER, Joseph B. McGee**, (VCU), Department of Chemistry, 1001 West Main Street, Richmond, VA 23284, **HILL, Tina R.**, Bruker AXS Inc., 5465 E. Cheryl Parkway, Madison, WY 53711 and **BRUM, Jose**, Olympus Scientific Solutions Americas, 48 Woerd Ave, Suite 105, Waltham, MA 02452

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Abstract

The pseudotachylite breccia deposits of Musgrave Province of Australia, are in zones about 5 km wide and run intermittently for 300 km with approximately 10% pseudotachylite veining. The veins are range in width from a few centimeters up to 4 m and can be traced for up to 10 m. Pseudotachylites occur only in the granulite facies rocks and some pseudotachylite veins have been plastically deformed, indicating nearly contemporaneous ductile and brittle behavior.

XRD analysis by using energy discrimination settings to reduce fluorescence due high concentration Fe, of separated pseudotachylite vein confirmed the presence of about 17% of pargasite [$NaCa_2(Mg_4Al)(Si_6Al_2)O_{22}(OH)_2$], that ruled out the anhydrous origin of the Musgrave pseudotachylites. Evidence of majorite [$Mg_3(MgSi)(SiO_4)_3$] supports a deep mantle source of the melt.

The matrix of the pseudotachylite veins is less siliceous than the host rocks, probably owing to non-equilibrium melting of pyroxene, garnet and plagioclase. The igneous assemblages of the melt, notably the crystallization of pigeonite, are consistent with rapid cooling from very high-temperature (>1000°C). Melting and quenching is probably due to very local, short-lived rises in temperature accompanied by dilation. Pseudotachylite veins are relatively depleted in Ca, Mg, Mn and H_2O than the host rock, but the veins are relatively enriched in Ca, Mg and Na along with Fe, Ti, and Cr perhaps due to instantaneous non-equilibrium melting and very high oxygen fugacity.

The geochemical evidence strongly suggests that the melt was probably injected from the mantle below during the impact process and mixing proximal frictional and decompressional melts of the fractured crust.

Objectives

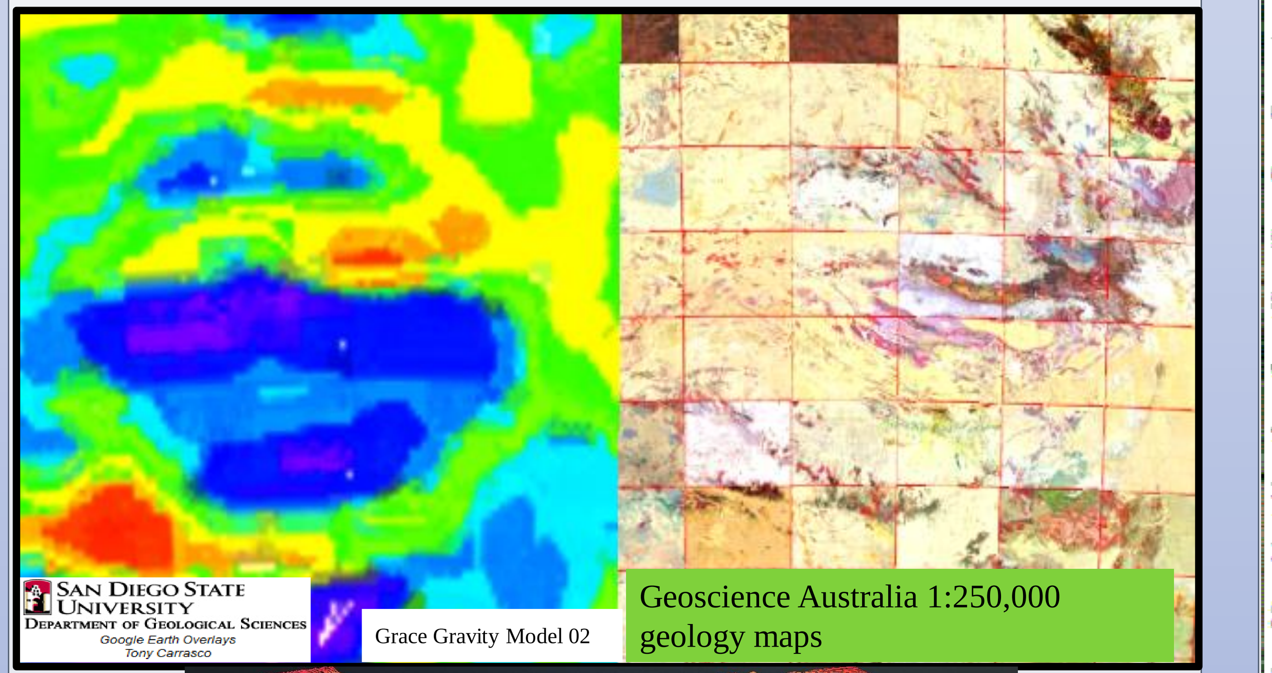
1. To possibly differentiate more clearly the source of the pseudotachylite melt portion between host/country rock, bolide melt and/or mantle.
2. To verify the anhydrous nature of the pseudotachylite melt found in older analyses.

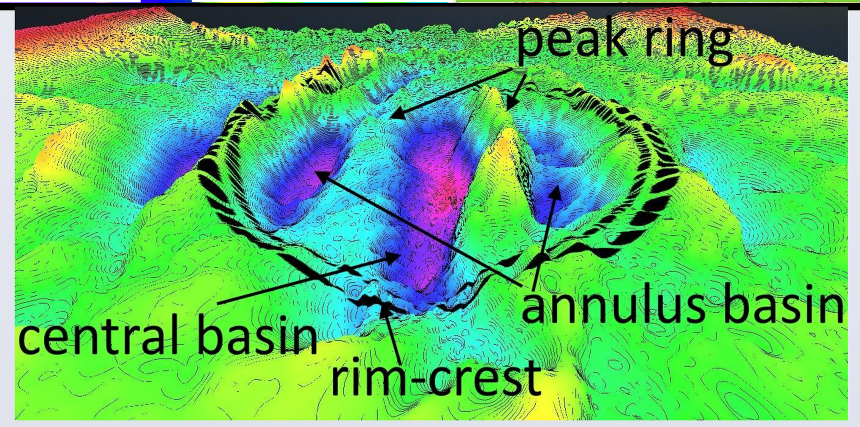
Materials and Methods

The vein samples were separated very carefully from host-rock by using a slow cutter. Then the Pseudotachylites were analyzed with XRD for obtaining the bulk mineralogy and the polished samples were further analyzed with SU-70, a Field Emission Scanning Electron Microscope (SEM) equipped with Energy Dispersive Spectrum Analyzer (EDS).

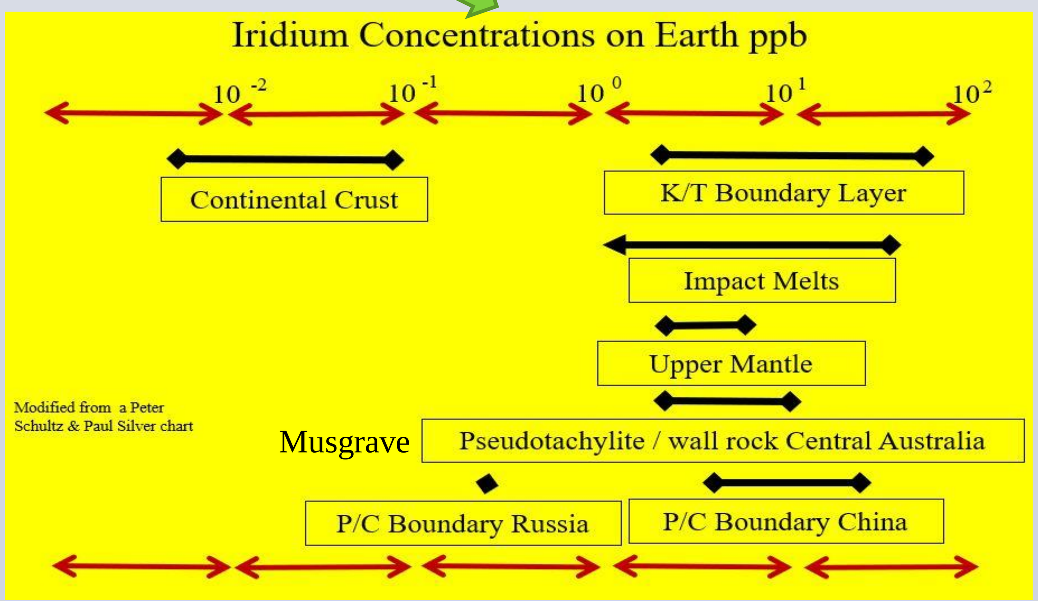
Background

Massive Australian Precambrian/Cambrian Impact Structure (**MAPCIS**) a 600km diameter proposed impact ~542Ma. Around the center of the proposed impact structure are some of the largest known deposits of pseudotachylite breccia.



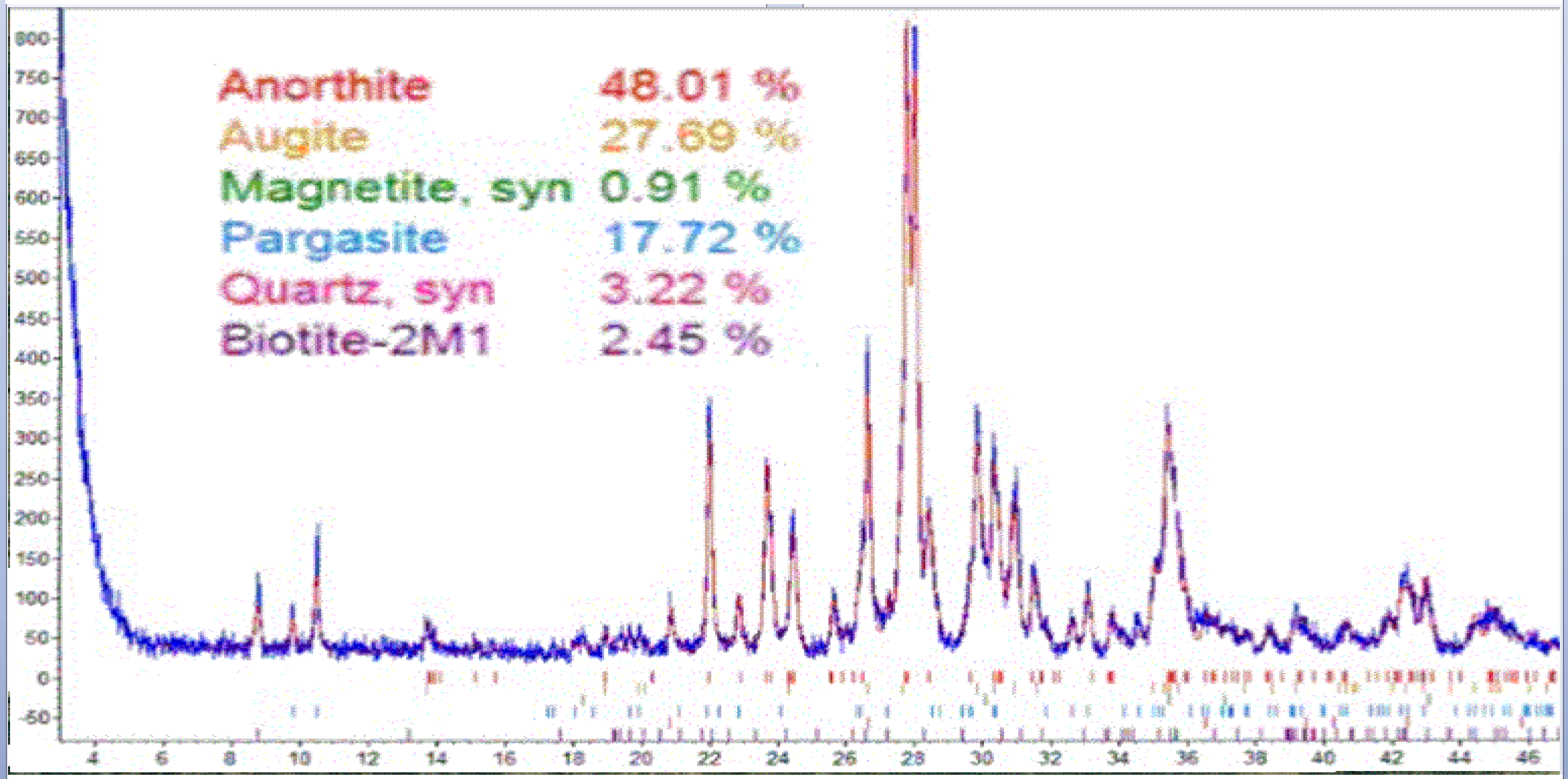


The MAPCIS Pt. breccia is in zones of 4% to 10% melt that run for 300km and zones up to 5km wide.

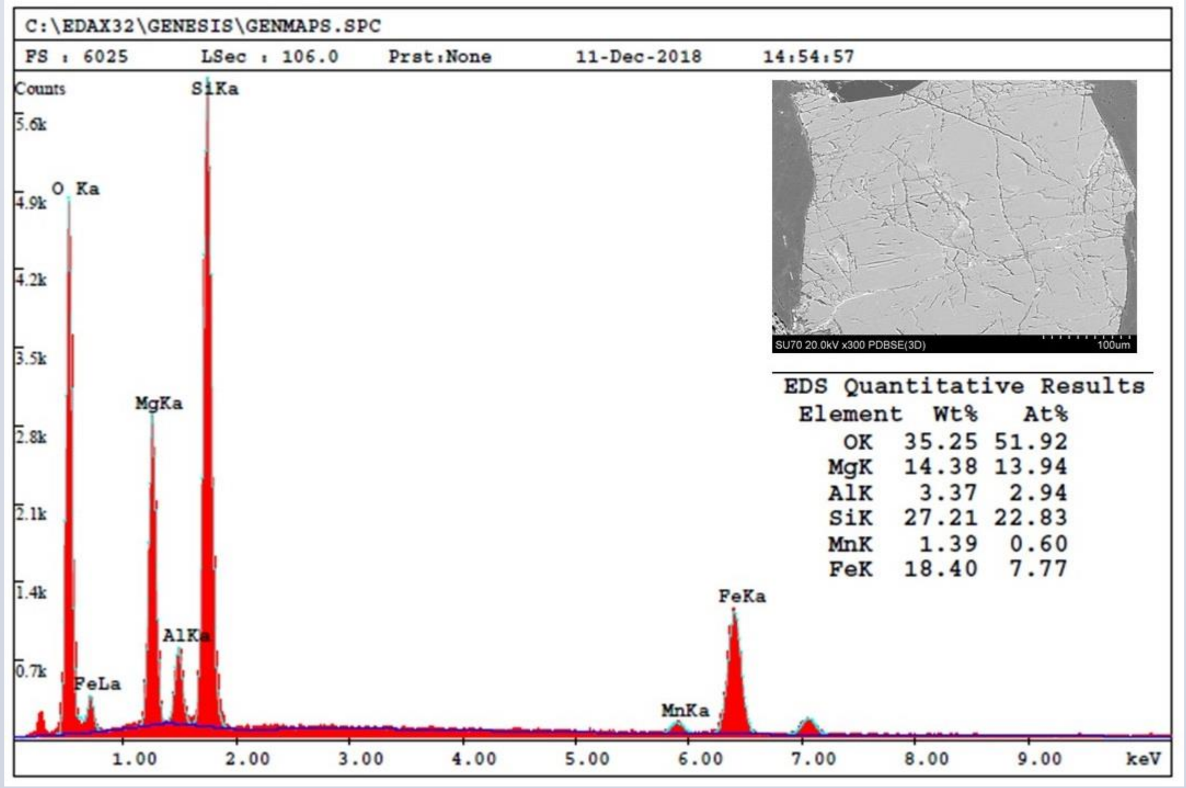


The concentrations of Iridium in the pseudotachylite veins and wall rock is an order of magnitude greater than what would be expected in granitoid continental crust. It is more consistent with other **known impact melts or upper mantle.**

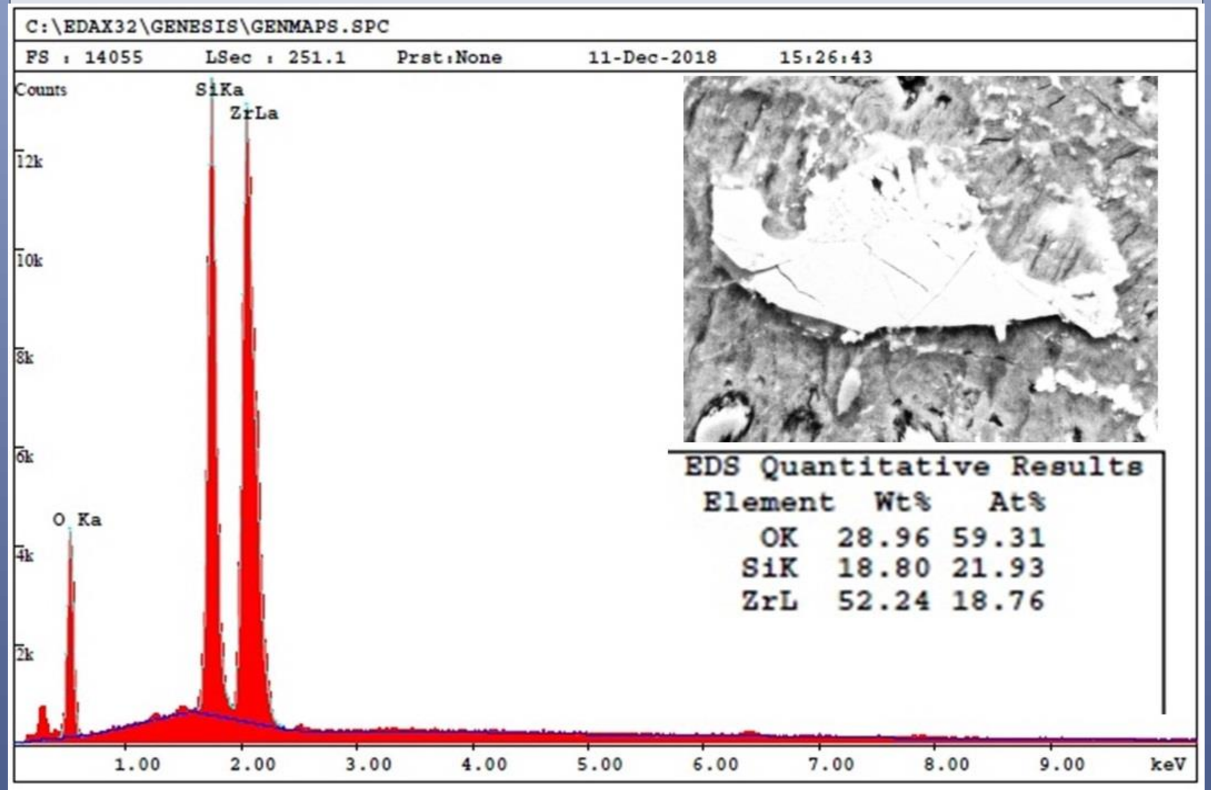
Results



XRD profile of separated pseudotachylite vein. Energy discrimination settings were used to reduce fluorescence due high concentration Fe and the phases were identified by using DIFFRAC.EVA. The presence of pargasite [$NaCa_2(Mg_4Al)(Si_6Al_2)O_{22}(OH)_2$], in the vein suggests a deep mantle source as well as the presence of water.



The chemical signature for the garnet group mineral majorite [$Mg_3(MgSi)(SiO_4)_3$] is expressed. Majorite produced by high pressure impact metamorphism in bolides or in the upper most, lower mantle. This is supportive of the finding of the pargasite in the melt with a mantle source.



A unique partially melted zircon was found in the melt. This suggests extremely short duration for a high temperature event.

Discussion

The Musgrave province pseudotachylite melt may not be classic frictional pseudotachylite melt where the melt is directly from proximal granitic host/country rock. One would expect to find the geochemistry of frictional melt to approximate the local source from which it has formed. The iron content of the melt far exceeds the host rock suggesting a distal source possibly kilometers distant. At 17% of melt, Pargasite [$NaCa_2(Mg_4Al)(Si_6Al_2)O_{22}(OH)_2$], of the amphibole group found in suggests an upper mantle source as well contradicting the contention that the melt is anhydrous. Majorite [$Mg_3(MgSi)(SiO_4)_3$] a group garnet minerals found and formed in the uppermost lower mantle has also been found in the melt which also supports the mantle source of the pseudotachylite melt.

Impact geology tends to view terrestrial impacts from the top down with a relatively passive interaction from mantle. This passive interaction with the mantle is true for smaller impacts especially on thicker continental crust. In the largest complex craters where fracturing reaches the mantle interface one must consider mantle as an active participant in the cratering process.

The geochemical evidence strongly suggests that the melt was probably injected from the mantle below during the impact process and mixing proximal frictional and decompressional melts of the fractured crust. Rapid cooling and solidification of the melts may have given a false impression of classic frictional pseudotachylite. We believe a reconsideration may be needed to re-classified Musgrave pseudotachylite melt from an anhydrous seismic melt to an impact pseudotachylite melt with a mantle component.

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Contact

danielconnelly@comcast.net
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