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Microstructural and chemical heterogeneity of pseudotachylytes from Indian craton, and its implications for frictional melting process along seismic faults

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Pseudotachylytes (Pt) are produced by melting of rocks by seismic faulting, or by meteorite impacts (Sibson [1], Shand [2]). Of these, the first type (fault-generated) is thought to be a product of melting of host rocks by frictional heat produced during rapid (1-10 m/sec) fault slip, although the melting origin has been contested, citing the lack of identifiable glass phase in some Pt samples (Spray [3]). Abundance of felsic minerals (e.g. quartz, feldspar) as refractory clasts in Pt, and the generally mafic character of the matrix (i.e. the solidified melt) are interpreted as a result of preferential melting of mafic minerals (e.g. biotite, hornblende) of the host rock by flash heating (Spray [3]). Clast-size analysis also suggests localized melting and melt-clast interaction in Pt, following an initial phase of cataclasis (Ray [4]). However, the frictional melting process is not completely understood. Rapid melting and solidification of the rock leads to extremely fine grain size and strong chemical heterogeneity of Pt matrix that can be characterized only through domain scale chemical and microstructural analysis using Electron Probe Micro Analyzer (EPMA) and through Back-scatter Electron (BSE) imaging in a Scanning Electron Microscope (SEM), preferably fitted with an Energy-dispersive X-Ray spectroscopy (EDS).

We have studied 'melt-origin' and 'cataclasis-origin' pseudotachylytes (*sensu* Lin [5]) from Gavilgarh-Tan Shear Zone (GTSZ) in the central, and Sarwar-Junia Fault Zone (SJFZ) in the western part of Indian craton. Cataclastic Pt from GTSZ shows angular host rock/mineral fragments (clasts) floating in an ultrafine grained matrix under optical microscope. SEM-BSE images show presence of a very thin (<10 µm) melt layer along the margins of the angular clasts which has possibly induced a chemical change from the clast core toward the rim, as observed from composition data of different points by EDS. In contrast, the SJFZ Pt- samples show spectacular melt-origin microstructures, e.g. spherulites and microlites. Radial growth of biotite laths around a relict clast (mostly quartz) commonly constitutes the spherulites. Skeletal growth of ilmenite and biotite into dendritic, star-shaped or spider-like microlites also supports a melt origin. Wing-like structures around some quartz grains, similar to porphyroclast tails in mylonites, indicate flow of silicate melts derived by partial melting of quartz. X-ray Diffraction (XRD) analysis of these Pt samples also indicates presence of a glassy phase in these rocks. Flow structures of different colors impart a banded nature to the Pt matrix. SEM and EPMA analysis show that melts of different composition, likely derived through melting of different minerals (e.g. ilmenite/biotite/hornblende and quartz/feldspar), were not homogeneously mixed, and flowed through different distances depending on the respective melt viscosity. Melting or survival of a mineral grain is not only controlled by its composition (i.e. specific heat) but also by its relative position in the Pt vein (Bizzari [6]). The extremely heterogeneous nature of the Pt matrix is clearly reflected in their chemical analysis. Bulk chemical analysis by X-Ray Fluorescence (XRF) shows an average composition close to that of the host rock. EPMA analysis shows wide variation in the chemical composition of different domains, due to preferential melting of minerals at micro domain-scale. Grain-size analysis of SJFZ Pt samples contradicts the idea of uniform rim melting and post-melt modifications of clast size, as proposed earlier by Ray [4].

References:

[1] Sibson, R.H. (1975) Geophysical Journal of the Royal Astronomical Society 43(3):775–794
[2] Shand, S. J. (1916) Quarterly Journal of the Geological Society 72(1-4): 198-221.
[3] Spray, J. G. (1995) Geology 23(12): 1119-1122.
[4] Ray, S. K. (1999) Tectonophysics 301(3): 283-304.
[5] Lin. A. (1996) Engineering Geology 43: 213-224.
[6] Bizzarri, A. (2014) Bulletin of the Seismological Society of America 104:2399-2411.