IMPACT-GENERATED PSEUDOTACHYLITES DO NOT NECESSARILY HAVE THE COMPOSITION OF THEIR HOST.

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Introduction: Impact-generated pseudotachylites are *in situ* melt veins found in a few impact structures on Earth [1]. Pseudotachylites have been repeatedly shown to correspond chemically and isotopically to their host rocks [e.g., 2,3,4]. Lithic clasts in pseudotachylitic melt seem to be derived from the immediate wall rocks, and not transported over significant distances [2]. These observations have led to an understanding that pseudotachylites are formed entirely *in situ*, with insignificant transport of melt.

The Vredefort impact crater is a 250-300 km in diameter impact structure in South Africa [5]. The structure contains two important reservoirs of shock-generated melt: (1) pseudotachylites and (2) Vredefort granophyre, generally considered to be a part of the melt sheet that has penetrated to great depths along major faults. An important distinction between pseudotachylite and granophyre is that granophyre is formed of mixed compositions of target rocks, with a variety of clasts within the granophyre derived from numerous sources, while the pseudotachylites are formed only from the immediate wall rock with no mixing between lithologies [3].

Field Observations: Near the town of Parys, Free State, South Africa, a body of (meta) gabbro is in contact with a body of (meta) granite. The gabbro is exposed in two bodies, with the larger being a ca. 60 m by 80 m diameter teardrop-shaped body enclosed in the basement granite. The granite is coarse-grained and locally foliated and/or contains migmatites. The granite has a typical mineralogy, consisting of quartz, K-feldspar, biotite and plagioclase, with zircon, ilmenite, apatite and monazite as accessory phases. The gabbro has a massive texture, and is composed mainly of 1 mm laths of plagioclase, with subordinate clinopyroxene, amphibole, ilmenite and rare grains of olivine. Pseudotachylites are developed within both the gabbro and the granite.

Pseudotachylites at this location are observed to have a maximum diameter of approximately 12 cm in the gabbro, and up to 20 cm in the granite. Granite-hosted pseudotachylites are much easier to observe, as the veins are dark-colored against a light-colored host rock, while the gabbro-hosted pseudotachylites are dark-colored veins on a dark-colored host rock and thus are not so obvious (Fig. 1A). Pseudotachylites in both lithologies contain abundant clasts. Within the granite-hosted pseudotachylites, all observed clasts have granitic composition, and hence, are derived from the wall rock. Within the gabbro-hosted pseudotachylites, clasts of both granite and gabbro are observed.

Methods: Samples were collected from both lithologies. Rock powders were prepared for X-ray fluorescence (XRF) analysis at the University of the Free State. Thin sections were analyzed petrographically and by scanning electron microscope (SEM) at the University of the Free State. Chemical mapping of the hand samples was performed on a micro-XRF (μXRF) at the University of Pretoria. Analysis of selected zircon and monazite grains was performed *in situ* by electron backscatter diffraction (EBSD) at the University of Vienna.

Results: Gabbro-hosted pseudotachylite melts have two compositions (Fig. 1): (1) purely gabbroic, and (2) gabbroic with a granite component. These melts sharply contact one another and appear to be immiscible. Melt 1 contains only gabbroic clasts, whereas melt 2 contains clasts of both gabbro and granite, and has a composition intermediate between granite and gabbro, as shown by both bulk-rock XRF analysis and μXRF mapping (Fig. 2).

Within granite clasts found in the gabbro-hosted pseudotachylite, shocked zircon and monazite were found, indicating shock deformation prior to clast transport into the gabbro. A previously unknown [6] shock twin geometry of the 180°/<010> plane of monazite has been discovered (Fig. 3).

Interpretation: Because granitic clasts can be found in gabbro-hosted pseudotachylites, but not vice versa, rocks of differing composition apparently respond differently to the passage of the shock wave. As the shock wave passed, gabbro melted due to the low fracture toughness of its phases. Simultaneously, quartz in granite transformed from α to β quartz as a result of the accompanying thermal pulse, thereby creating a positive pressure gradient that caused the granite to explode into the newly opened void space in the adjacent gabbro, with clasts finally being emplaced in the newly formed pseudotachylites. This process explains the absence of gabbroic clasts within granite-hosted pseudotachylites. This may also have relevance to the observation that granitic pseudotachylites never contain exotic clasts and compositionally correspond to their wall rocks. Further study of foreign clasts in impact pseudotachylites may provide new insight into the behavior of different lithologies under the same shock conditions.

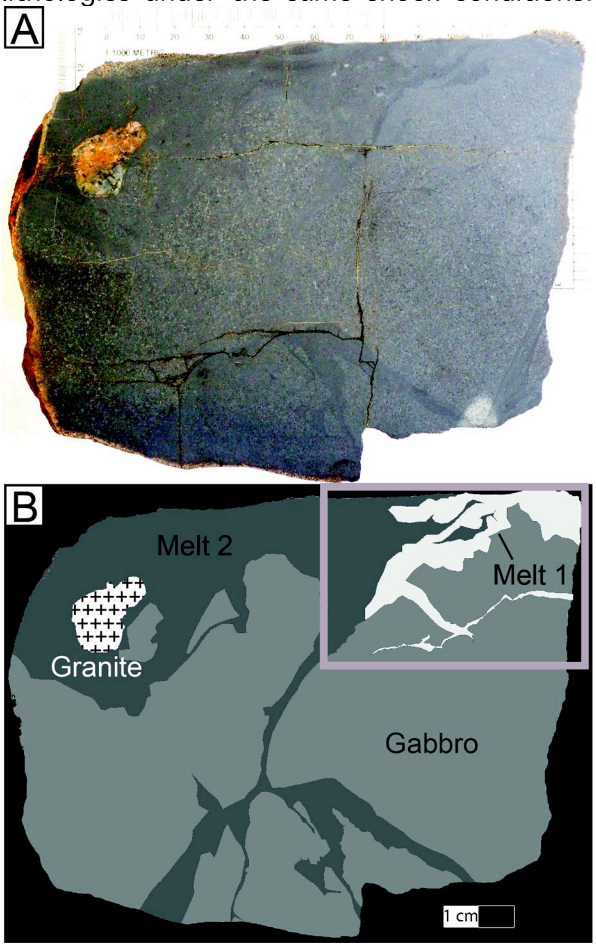

Figure 1: Gabbro sample containing two compositions of pseudotachylite (Melt 1 and Melt 2). Within Melt 2, clasts of granite are present. Box indicates area mapped in Figure 2.

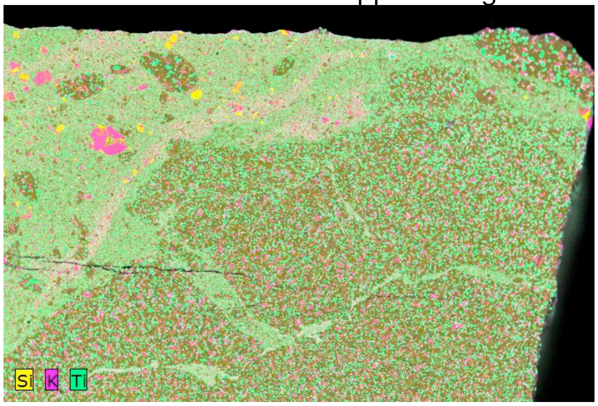

Figure 2: μXRF map of the top-right corner of the sample shown in Figure 1. Si, K, and Ti, are mapped, showing the host gabbro and the contact between Melt 1 (right) and Melt 2 (left). Melts have a sharp contact, as outlined by K content, and appear to mingle immiscibly. Granitic clasts are clearly visible within Melt 2.

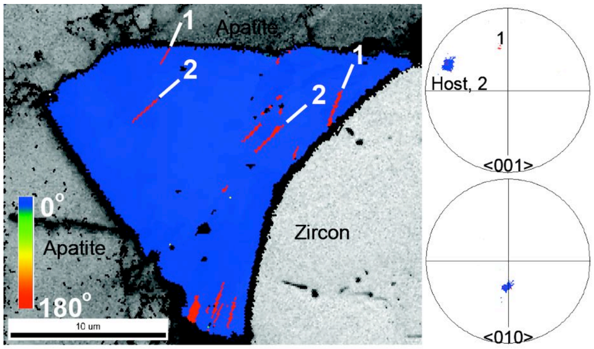

Figure 3: EBSD map of shocked monazite grain with pole figures indicating orientations. Lines point to two sets of microtwin lamellae. The 180°/<010> geometry has not previously been observed (set "1").

References:

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