

**IMPACT RELATED PSEUDOTACHYLITIC BRECCIA IN THE SCHURWEDRAAI AND BAVIAAN-KRANTZ ALKALI GRANITE COMPLEXES IN THE COLLAR OF THE VREDEFORT DOME, SOUTH AFRICA.** C. Crasselt<sup>1</sup> and W. U. Reimold<sup>1</sup>, <sup>1</sup>Museum für Naturkunde (Mineralogy) – Leibniz Institute at the Humboldt University Berlin, Invalidenstrasse 43, 10115 Berlin, Germany; claudia.crasselt@museum.hu-berlin.de.

**Introduction:** The formation of impact related pseudotachylitic breccias and their occurrence in large impact structures such as Vredefort and Sudbury is still a matter of debate. The main formation processes that are currently considered – in the absence of large-scale fault/shear zones where massive friction melts could be generated – are shock melting, frictional melting and decompression melting, or combinations of these. Local formation and accumulation of allochthonous melt in dilatational zones are also debated. Hence the purpose of this work is to contribute to the understanding of the genesis of such pseudotachylitic breccia bodies in the central uplift of a very large impact structure. Macro- and microscopic structural, micropetrographic, and chemical analysis of pseudotachylitic breccia occurrences in the Schurwedraai and Baviaan-Krantz Alkali Granite intrusion in the northwestern part of the collar of the Vredefort Dome, South Africa, have been carried out.

**Structural observations:** Detailed fieldwork determined that pseudotachylitic breccia veins and dikes exhibit preferred orientation trends. Relatively smaller pseudotachylitic breccia veins (< 1m width) show preferred ENE-WSW and NW-SE strike trends and larger pseudotachylitic breccias veins (> 1 m width) a preferred NW-SE strike trend. Pseudotachylitic breccia networks have prominent NW-SE and ENE-WSW strike trends. These results indicate that the majority of pseudotachylitic breccia bodies seemingly follow a concentric and radial pattern with respect to the center of the Vredefort Dome. Another notable observation was that thin shear zones (< 3 cm in width) with alternating zones with pronounced grain comminution and enhanced recrystallization and apparently melt-bearing (pseudotachylite like) bands are intimately related to thicker occurrences of pseudotachylitic breccias (e.g. Fig. 1). This scenario could be interpreted to suggest that friction in narrow zones led to initial melt formation followed by discharge of melt into adjacent open fractures and pockets (as discussed in [1]) or dilatational sites.

**Petrographic and chemical methods:** Samples of host rock and pseudotachylitic breccias were analysed in the laboratory. Pseudotachylitic breccia occurrences sampled for this study range from a few millimeters wide veinlets to large (up to 6 m wide) network zones. Polished thin sections of these samples were initially investigated by optical microscopy. Scanning electron

microscopy was used to investigate in more detail textures and mineralogy of pseudotachylitic breccia matrices and adjacent host rock. X-ray fluorescence spectrometry for major and trace elements was employed to compare bulk chemical compositions of host rock and pseudotachylitic breccias pairs. Electron microprobe analysis (EMPA) with operating conditions of 20 kV and a defocused beam of 20 µm diameter was used to obtain quantitative analyses of matrices of both mm-wide and network-derived pseudotachylitic breccias, without extensive clast contamination. Moreover, we utilized the microprobe to check whether there are systematic changes in chemical composition along and across pseudotachylitic breccia veins (for comparison, see [2]).

**Petrographic results:** The alkali granite consists of quartz, K-feldspar, albite, potassic amphibole (mainly arfvedsonite), aegerine and minor biotite. The matrices of the pseudotachylitic breccias are extremely fine-grained and holocrystalline. They are mainly composed of quartz, K-feldspar, albite, potassic and calcium-potassic amphiboles. The amphibole occur as microliths, whereas quartz and feldspar are intergrown in a micrographic texture. Clasts in pseudotachylitic breccia are mostly quartz and feldspar, with feldspar grains more extensively melted and showing stronger recrystallization than quartz grains. This implies that assimilation of host rock clasts by melt has occurred, to a degree, but is seemingly restricted to haloes still visible around molten clasts. These were excluded from electron microprobe analysis.

**Chemical analysis:** X-ray fluorescence spectrometry revealed very similar bulk compositions for host rock and pseudotachylitic breccias pairs with respect to both major and trace elements. Both host rock and pseudotachylitic breccias show alkali granite composition, e.g. in a total alkalis versus silica plot for plutonic rocks (Fig. 2). However, as the analysed material for X-ray fluorescence spectrometry contained abundant microscopic clasts, the compositions of matrices of pseudotachylitic breccias were also determined by electron microprobe to exclude microclast components. Comparison between respective electron microprobe and X-ray fluorescence spectrometric results for a given sample show slightly lower silica and slightly higher alumina concentrations. This observation is readily explained by the exclusion of quartz microclasts from the matrix volumes analysed by electron

microprobe. All other major element concentrations for average groundmass by electron microprobe and for bulk breccia samples by X-ray fluorescence spectrometry are very similar.

Systematic differences in matrix composition for pseudotachylitic breccias veins of different size (and even network derived matrix) could not be identified. Also chemical compositions of melt bands in narrow shear zones and matrices of linked larger pseudotachylitic breccia zones are very similar. Traverses across matrices of pseudotachylitic breccias showed that matrices are homogeneous laterally and along vein extension – similar to the results by [2]. Only in very wide (> 2 m wide) pseudotachylitic breccia zones zonation is apparent: near host rock contacts the relatively fine-grained matrices are very homogeneous with respect to all major elements. In contrast vein interiors display variable potassium or sodium enrichment. It is thought that the fine-grained vein margins were considered homogeneous because of the 20  $\mu\text{m}$  wide electron beam, which averages out the compositions of individual minerals. In the relatively coarser-grained vein interior, individual poikilitic intergrowths of a feldspar (either K-feldspar or albite) oikocryst with various poikiloblasts are analysed. Thus, the apparent chemical zonation in these larger pseudotachylitic breccia zones seems to be due to differential cooling histories of marginal and interior zones.

**Some first conclusions:** 1. X-ray fluorescence spectrometry is indicative of bulk alkali granite fusion on formation of pseudotachylitic breccia. It appears probable that these melts were formed within the confines of the alkali granite complex; thus we consider these melts, autochthonous.

2. We could not find distinct or systematic differences in chemical composition with regard to either bulk composition (by X-ray fluorescence spectrometry) or groundmass compositions (by electron microprobe analyses) between pseudotachylitic breccia veins of different size (from about 0.1 mm to several meter sized breccias).

3. Our attempt to investigate whether thin melt formations (located in narrow shear zones) could have fed major melt accumulations in wider pseudotachylitic breccia zones remained inconclusive. The similar chemical composition of both does not allow to distinguish in which direction melt was transported – or whether transported at all. But our observations do not contradict that friction melting in narrow shear zones followed by discharge of this melt into adjacent open fractures and pockets or into adjacent dilatational sites could be one possible process for the formation of pseudotachylitic breccias in the central uplift of a large impact structure.

4. In comparison to the composition of Vredefort Granophyre – the impact melt rock at Vredefort [3] – the major element abundances of the pseudotachylitic breccia from the alkali granite complexes differs strongly. The Granophyre shows explicitly higher concentrations in iron, magnesium and calcium and lower concentrations of sodium and potassium.

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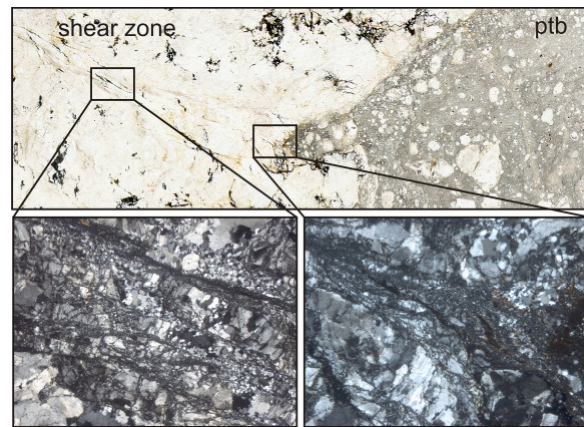


Fig. 1: Thin shear zone with alternating grain comminution and apparently melt-bearing bands (dark in magnified areas) that is related to a larger occurrence of pseudotachylitic breccia (top, right).

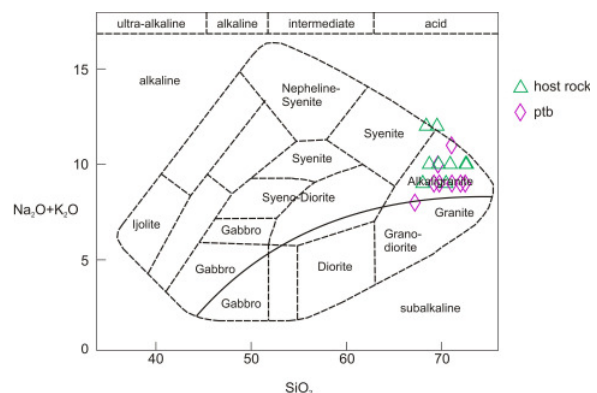


Fig. 2: Total alkalis versus silica plot for plutonic rocks (after [4]), showing alkali granitice compositions for host rock and pseudotachylitic breccia alike.

**References:** [1] Melosh H.J. (2005) in: *Impact Tectonics* (Eds. Koeberl C. & Henkel H.), Springer, 55-88. [2] Mohr-Westheide T. & Reimold W.U. *LPSC-40*, this volume. [3] Reimold W.U. & Gibson R. (2006) *Chemie der Erde*, 66, 1-35. [4] Wilson 1989.