**CHEMICAL ANALYSIS OF SMALL-SCALE PSEUDOTACHYLITIC BRECCIA IN ARCHEAN GNEISS OF THE VREDEFORT DOME, SOUTH AFRICA.** T. Mohr-Westheide and W. U. Reimold, Museum für Naturkunde (Mineralogy) – Leibniz Institute at the Humboldt University Berlin, Invalidenstrasse 43, 10115 Berlin, Germany (Tanja.Mohr@Museum.HU-Berlin.de, Uwe.Reimold@Museum.HU-Berlin.de).

**Objectives:** Since Shand [1], the Vredefort Dome has been known as the type locality for "pseudotachylyte" (modern spelling "pseudotachylite"), which can be investigated in detail in a range of different host lithologies. Such melt breccias represent the most prominent impact-induced deformation in the central uplift of the Vredefort Impact Structure [2, 3] and occur in microscopic veins and in up to hundreds of meters long and tens of m wide breccia zones. The exact mechanisms by which such melt breccias in impact structures form (e.g., [4, 5]), by either impact melting, friction melting, decompression melting, or a combination of these processes, is still debated. Tectonic "pseudotachylite" is widely known from fault/shear zones [6]. We here prefer the term "pseudotachylitic breccia (PTB)" for impact structure occurrences of this melt breccia type, as this term is nongenetic. The violent genesis of the dome would suggest that faulting/shearing related movement zones could occur in abundance, but the enormous breccia volumes observed in the dome seemingly can not be produced along fault/shear zones [7]. For example, the large displacement zones that such voluminous friction melting might require, have not been observed to date.

While some previous work has focused on orientation and geometry of pseudotachylitic breccia veins, detailed geometric and microchemical analysis has not been adequately related to micro-deformation studies of pseudotachylitic breccia. This study uses a novel approach by small-scale structural and microchemical analysis of a polished 3 x 1.5 m granite slab from a dimension stone quarry in the core of the Vredefort Dome [8].

Detailed microstructural investigations of melt breccias and two systems of microfractures in the granite slab, supplemented by field data, has resulted in improved understanding of emplacement of melt into Archean gneiss of the Vredefort dome. Unravelling the development of individual structural deformation features resulted in a sequence of 4 processes: (a) Development of closely-spaced sets of microfractures, (b) Fragmentation along with dilation and melt emplacement, (c) Continued displacements on microstructures, and (d) Formation of a younger fracture system. What remains is to unravel how melt originated in the first place. To this effect, a microchemical study of the granite slab is now carried out.

**Method:** Chemical characterization of microfractures and pseudotachylitic breccia (PTB) veins of 0.1 cm, 0.5 cm, 1.5 cm and 3 cm width, respectively, as well as of the matrix of a several decimeter wide breccia zone, was done on the slab by polarization microscopy, scanning electron microscopy (SEM), X-ray fluorescence spectrometry, and electron microprobe analysis (EPMA, spot size 20 µm). Pairs of host rock and PTB matrix were analysed by XRF spectrometry, the breccia samples were also analysed for their microclast mode by semi-automated image analysis. EMPA traverses through breccia matrix were carried out, along vein extensions, and across PTB veins and into adjacent host rock minerals. The chemical compositions of bulk vein fillings from XRF were recalculated based on the clast populations, thus allowing to compare pure groundmass, bulk breccia, and bulk host rock compositions.

In addition, twenty-two samples of PTB and host rock from the Rand Granite Quarry in the northern part of the Vredefort dome were analysed. This includes microchemical analysis of 10 PTB, and analysis of 12 host rock samples by XRF spectrometry. EMP analysis, including major element mapping, was done on a 1.5 cm wide PTB vein. Further EMPA data for PTB samples from Leeukop, Kudu, National Sun and Broodkop are currently evaluated.

**Results:** Two types of structures, which mutually cut each other, are macroscopically observed in the granite slab: generally dark grey to black veinlets of pseudotachylitic breccias and a network of thin, often reddish-brown microfractures. The matrix of such melt breccias includes mineral and rock fragments of the host granite gneiss. Ninety-five % of clasts are composed of pure $SiO_2$ and 5 % of K-feldspar. Individual quartz fragments occur in schlieren or teardrop shape indicating that they were completely melted. K-feldspar clasts are mostly completely recrystallized, unlike quartz or quartz-rich fragments that are only partially annealed. Major element mapping revealed that the PTB matrix consists predominantly of silicate phases composed of Si, Al, K, Na, Ca and Mg (which includes primary crystallization as well as secondary alteration products), and accessory zircon, sphene, Ti-magnetite and other iron oxides. Microfractures are filled mainly by chlorite and fracture walls are coated with goethite, which is thought to be responsible for the red coloration.

Chemical traverses across breccia matrix and into adjacent host rock, as well as lateral traverses through the matrices of 0.5 to 3 cm wide PTB have shown that the chemical compositions of such melt breccia veins are quite homogeneous and essentially represent the host lithology. In contrast, traverses through a millimeter-wide veinlet reflect chemical variation on the host rock grain scale. This is also observed by analysis of thin PTB veinlets from outcrop-derived samples of gneiss and other lithologies. Specifically, local melt composition is consistently identical to the composition of the exact host mineral grain (quartz, K-feldspar, Plagioclase, or biotite).

Investigated melt breccias contain a number of microclasts including fragments < 1mm in size within the matrix, which are mainly pure $SiO_2$. The microclast content was calculated for PTB of 1 mm to tens of dm width by high resolution image analysis. The chemical compositon of PTB veins was then fragment population-based recalculated and plotted against respective host rock samples in the granite slab. It is, thus, noted that the PTB matrix directly reflects the composition of the adjacent host rock but is depleted in $SiO_2$ in comparison to the granitic host rock composition and in direct correspondence to the volume % of quartz clast component.

For Rand Granite Quarry samples, chemical compositions of host rock samples were plotted against bulk melt breccia compositions and compared to granite slab samples. Bulk outcrop breccia samples show nearly identical chemical compositions to the respective host rock. PTB margins often are enriched in K in comparison to vein interiors. CaO versus Sr and $K_2O$ versus Rb concentration plots for pairs of PTB and host rock samples from the Rand Granite Quarry and the granite slab show that each pair plots together. The marginal K enrichment is tentatively explained with late-stage alteration

**Conclusions:** 1. Microchemical analysis of PTB matrices of 1.5–3 cm wide PTB veins from the Vredefort Dome has shown that the composition of PTB matrix is very homogeneous along veins in Archean granite gneiss and relates directly to the chemical composition of host rock. The refractory behavior of quartz seems to be the main, if not the only, reason for chemical differences between bulk breccia matrix and granitic host rock [9]).

2. In contrast, < 1 mm wide PTB veinlets often feature locally different chemical compositions, which can be related directly to the respective compositions of adjacent host rock minerals. This is indicative of local melting.

3. Shape fabric analysis on SEM composites of PTB of up to 3 cm width points to a maximum clast transport of several centimeters and further supports that melt, at least in veins up to several cm width, was formed with minimal, at most, cm-wide movement. In even thinner veinlets (< 1mm) no or only grain-scale material tranport is observed.

4. Observed lamination flow in PTB veins of 0.5–3 cm width may allow melt mixing in the proximity of anastomosing PTBs, injection veins or in the immediate vicinity of different host rock lithologies.

5. The textural observation of melted quartz fragments points to very high temperatures during the melt forming process, which we tentatively relate to local enhancement of shock pressure. Variable and localised chemical compositions in very thin pseudotachylitic breccia veinlets provides strong evidence for a shock (plus/minus friction) origin, at least for these narrow breccia veinlets, in agreement with [3, 9]. Gibson and Reimold [4] suggested that the voluminous breccia dikes could comprise shock melt ponded in extensional sites during the formation of the central uplift. However, the zones of enhanced pseudotachylitic breccia development [10] do not correspond to enhanced shock degree [5].

Another possible origin for the pseudotachylitic breccias includes sudden decompression (*e.g.* Martini, 1991) following passage of the impact shock wave (post-shock decompression melting) and rapid rise of the crust caused by reversal of the strong compression in the central zone of the transient crater cavity and coincident with inward directed material flow from the collapse of the transient cavity wall. This process needs to be investigated in more detail.

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