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Lithological controls on microstructural development in the Pofadder Shear Zone and the role of fluids, rheology and metamorphic grade.

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Straddling the border between southern Namibia and northwestern South Africa, the NW-SE striking Pofadder Shear Zone is an oblique, dextral crustal scale shear zone that is between 2 and 7 km in width. The Pofadder Shear Zone is associated with the terminal stages of the Mesoproterozoic Namaqua Orogeny, however, the specific controls on its formation and evolution are not well constrained. The shear zone is characterised by a heterogeneous lithological assemblage where strain is preferentially partitioned into supracrustal sequences resulting in a number of distinct mylonite zones within the broader boundaries of the shear zone. The complexity of the lithological assemblage suggests that microstructures will be highly variable. Therefore, the variability and modes of formation of microstructures across the shear zone must first be constrained before they can be used to infer the mechanisms controlling the regional architecture. To do this, detailed microstructural observations in two rock types that occur across the shear zone, a granitic gneiss and a supracrustal migmatitic biotite gneiss, were made. The predominance of irregular, lobate quartz-quartz grain boundaries for both rock types within the core of the shear zone indicates that dislocation creep resulting in grain boundary migration recrystallization was the dominant mechanism for the deformation of quartz. The brittle microtextures within feldspar grains within both rock types indicates that cataclasis was the main deformation mechanism for feldspar. However, the common occurrence of myrmekite textures within the alkali feldspar grains in the granitic gneisses, particularly along the shortening axes which are areas of high strain, suggests that the formation of myrmekite and the neocrystallisation of feldspar was an important deformation mechanism within this rock type. Based on the microstructures, strain was partitioned into the migmatitic biotite gneisses at higher temperatures and/or lower strain rates, while the locus of strain shifted to the granitic gneisses at lower temperatures and/or higher strain rates. However, the migmatitic biotite gneisses additionally preserve evidence for a retrograde generation of biotite with a different composition to the biotite inherited from the Namaqua Orogeny. Furthermore, in the high-strain mylonite zones, the occurrence of delta-type ilmenite+biotite tails on mica, and less commonly on feldspar porphyroclasts, are interpreted to be the result of breakdown of inherited biotite in a fluid-rich environment. The predominantly muscovite, actinolite and chlorite syn-kinematic retrograde metamorphic mineral assemblage in the host rocks, as well as the preferential infilling of the later C' shear bands by chlorite, indicates broadly greenschist-facies conditions within this section of the Pofadder Shear Zone. Further to the east, the Pofadder Shear Zone becomes lower grade with brittle structures dominating, whilst to the west, the metamorphic grade increases with ductile structures prominent. This difference in metamorphic and deformation conditions has been interpreted to be the result of syn-kinematic differential exhumation (Macey et al., 2014). The transition between these two regimes where this study takes place is thus a critical location for understanding how the intersection of rheology and fluid flow impacts microstructural development and thus how shear zones develop and evolve.