EGU23-6324, updated on 28 Mar 2024
https://doi.org/10.5194/egusphere-egu23-6324
EGU General Assembly 2023

Pressure-Temperature-time-deformation (P-T-t-d) constraints on dome formation in the HTLP Pan-African Damara Belt, Namibia

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The Pan-African Damara Belt in southern Africa is a trench-trench-trench triple junctions orogen that formed at 590-470 Ma during the Gondwana Supercontinent assembly. The Damara Belt records up to granulite facies HTLP metamorphism in the core, upper plate of the orogen. However, the cause of this metamorphism is not well understood. To tackle this problem, we focus on the ENE-WSW-trending Namibfontein-Vergenoeg (NV) migmatitic domes. We use P-T-t-d data to investigate the temporal relationships of deformation fabrics, metamorphism and melting.

The NV domes formed through the superposition of four folding events. We use LA-(Q/MC)-ICP-MS U-Pb dating of monazite from structurally controlled granitoids and leucosomes to define the relative timing of the deformation phases. These include 1) an early phase of E-W shortening forming upright F1 folds and steep N-S-striking S1 deformation fabrics. D1 was active between ~559 and 530 Ma. 2) N-S shortening followed, forming dome-scale F2 anticlines with steep E-W-striking deformation fabrics at ~527 Ma. 3) Local inclined folding of S1 and S2 fabrics formed shallow NW-dipping S3 fabrics that was active before ~520 Ma. Lastly, 4) NE-SW shortening produced F4 folds and associated moderately NE-dipping S4 deformation fabrics at ~520-500 Ma.

Rocks of the NV domes are metamorphosed to upper amphibolite facies. Melt (up to 10%) exists within and defines structures of all four deformation phases. All deformation fabrics show similar mineral assemblage; cordierite + sillimanite + biotite + K-feldspar + quartz + melt ± garnet and plagioclase with accessory amounts of apatite, monazite, zircon, ilmenite, and magnetite. Matrix consists of sillimanite, garnet, cordierite, biotite, quartz, k-feldspar, plagioclase, ± ilmenite, magnetite, monazite, zircon, and apatite. Two distinct garnet porphyroblasts occur, i) an earlier large (1-2 mm) poikiloblastic garnet (with sillimanite, biotite, and quartz inclusions) partly replaced by cordierite occurring mostly in D1 and D2 samples, and ii) smaller (up to 1 mm sized), peritectic garnet. Pseudosection modelling shows that rocks of the NV domes record HTLP conditions (740-760 °C, 4-4.5 kbar). The overgrowth of cordierite on early garnet in the presence of melt supports the HTLP conditions along the retrograde path.

The rocks at the NV domes were deformed, in the presence of melt, four times over at least ~60 Ma under the same HTLP amphibolite facies conditions, during which granitic magmatism was prevalent. The absence of HP inclusions in porphyroblasts (either not preserved or never developed) and deformation structures supporting orogenic collapse, exclude decompression

melting as a mechanism for crustal anatexis. Rather these data suggest the rocks continuously melted during crustal shortening, likely during the collisional phase of the orogen.