Geophysical Research Abstracts
Vol. 12, EGU2010-15589-1, 2010
EGU General Assembly 2010


# Heterogeneous strain and composite P-T paths: the key for unravelling complex tectonic histories in polymetamorphic high-grade terrains

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Leonid Perchuk calculated the first P-T paths for eclogites almost 40 years ago [1] and since then he has shown that P-T paths if correctly constructed, represent an accurate record of the thermal and dynamic evolution of high-grade metamorphic complexes [2]. This implies that P-T paths might serve as the basis for geodynamic models for the formation and exhumation of such complexes from the lower crustal levels [2]. His continued research in the Limpopo Complex of southern Africa also played an important role in the next direction in the study of complex high-grade polymetamorphic complexes. This new direction involves the link between composite (kinked) P-T paths [5; 6; 8] and the critical role of heterogeneous strain in the development and preservation of distinct granulite facies events at the regional, outcrop, hand specimen, and thin section scales [7; 9; 10]. Heterogeneous deformation that operated on the thin section scale allowed the construction of kinked P-T paths from single thin sections [5; 6; 9] and the integration of the P-T data with structural and isotopic geochronology [7; 9; 10]. D-P-T-t paths thus constructed not only allow the nature of polymetamorphism in the Limpopo Complex of southern Africa to be established, but also assisted in the construction of tectonic models for the evolution of this complex high-grade polymetamorphic complex. This complex evolution is demonstrated by the configuration of a kinked P-T path (5; 9) that reflects the following distinct stages of the multi-cycle D-P-T-t evolution of the Central Zone: (i) the earliest DC1 path reflects the emplacement before ∼2.63Ga of the Limpopo Complex at the crustal level of ∼20km. The DC1 stage of the D1/M1 exhumation event was accompanied by the formation of early D2A isoclinal folds; (ii) The DC2 stage of the D1/M1 exhumation event reflects the emplacement before ∼2.61Ga of the rocks at the crustal level of ∼15km. The DC2 stage was accompanied by the formation of major D2B sheath folds; (iii) the high-grade rocks resided and cooled at this crustal level in the Central Zone of the Limpopo Complex for more than 600Ma before the rocks were again reheated at ∼2.02Ga during a superimposed D2/M2 high-grade event. This event is reflected by an isobaric-heating (IC) P-T path that resulted in the widespread formation of polymetamorphic granulites; (iv) the IC path was followed a DC3 P-T path that reflects the final exhumation of the rocks to the upper crustal level during the D2/M2 event. High-grade D3A shear zones controlled the final exhumation of the rocks. Isobaric heating (IC) thus links Pmin (D1/M1) to Pmax (D2/M2) that resulted in a kinked configuration of the DC1/2=>IC=>DC3 P-T path. The end of the high-grade tectono-metamorphic event is signified by the development at ∼2.01Ga of completely undeformed melt patches that destroy the D2B and D3A gneissic fabric of the rocks in which they are developed. Reactivation of SW-NE-trending high-grade D3A shear zones at ∼1.9Ga resulted in the formation of upper crustal mylonitic shear zones that define the present belt-like geometry of the SW-NE trending Limpopo Complex. The successful link of composite (kinked) P-T paths with structural (D) and geochronological (t) data t formed the basis for the construction of D-P-T-t diagrams that demonstrate the polymetamorphic evolution of the Limpopo Complex as the result of superimposed Neoarchaean and Paleoproterozoic high-grade events.

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