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Modes of granulite-facies metamorphism and deformation in hot orogens: A case study from the East African Neoproterozoic-Cambrian mobile belts

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The East African Orogen (EAO) expanding from Sinai and Jordan in the north to Mozambique and Madagascar to the south is the World´s largest Neoproterozoic to Cambrian mountain belt. It comprises a collage of individual oceanic domains and continental fragments between the Archaean Sahara-Congo-Kalahari Craton in the west and the Dharwar Craton to the east. Four types of high- to ultra-high temperature granulite facies metamorphism (HT/UHT) are distinguished. (1) Localized HT-metamorphism within the northern part of the belt (Arabian-Nubian Shield) formed in an island arc setting. (2) The formerly extending continental margin represented by the Eastern Granulites and Cabo Delgado Nappes experienced distributed, ca. 630 Ma UHT-metamorphism associated with conspicuous slow and isobaric cooling. (3) Reworked Archean continental fragment such as the Western Granulites show distributed, ca. 550 Ma HT / high-pressure metamorphism and isothermal decompression textures. (4) Localized HT / low-pressure metamorphism later 530 Ma within southern Madagascar and the Nampula Block of Mozambique was related to post-orogenic delamination. The extended HT/UHT granulite belts in domains 2 and 3 contribute to still unresolved questions about cause of metamorphism and mode of deformation in the deep crust.

In general, UHT-metamorphic belts with thermal gradients between 1500°/GPa and 700°/GPa concentrate from the Neoarchean to the Cambrian. Many Neoproterozoic-Cambrian UHT-metamorphic belts appear to have developed in settings of extending crust that was closed and inverted during consolidation of Gondwana (e.g., Brown, 2007). In this setting two parameters likely promote formation of UHT metamorphism; enhanced heat flow through thinned crust and insulation through sediments deposited on formerly extending crust. HT-granulite belts, by contrast, are also frequent in Phanerozoic times and, as the Himalayan example shows, may evolve within doubly-thickened continental collision zones. UHT- and HT-orogens display significantly different deformation pattern. With respect to Gondwana formation UHT orogens show complex basin-and-dome type fold interference pattern that are linked with emplacement of melts and vertical and horizontal shear zones. These pattern are documented from India (Chardon et al., 2009), Madagascar (Concalves et al., 2003), Tanzania (Fritz et al., 2009, 2013) and many other sites within East Africa. Other specific features are isobaric cooling paths and slow cooling suggesting prolonged residence time of rocks within the deep crust (Hauzenberger et al., 2005). In general, the low viscous lower crust in UHT orogens tends to resisted one-sided subduction, instead a sagduction-type orogen develops. Such orogens are large and have vertical and horizontal flow pattern. Although the crust is significantly thickened minor relief develops because of insignificant rheology contrast. HT-orogens, by contrast tend to evolve channelized flow and clockwise PT-path (e.g., Beaumont et al., 2001). Isothermal decompression textures evolve as soon as rock particles approach the frontal edge of the channel. Large orogens with significant relief form due to pronounced rheology stratification. In East African such a setting is proposed for the Western Granulites of Tanzania (Fritz et al., 2009, 2013) where isothermal decompression textures point to rapid exhumation.

References

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