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Isobaric heating as a record of polymetamorphism

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$P-T$paths represent the only true record of the thermal and dynamic evolution of metamorphic complexes [5, 6], implying that they may serve as a basis for geodynamic models that simulate exhumation of such complexes from the Earth's lower crust. Many high-temperature (HT) complexes formed during one geodynamic event also underwent retrograde metamorphism, and therefore record evidence for only one $P-T$ path [3, 6, 9]. On the other hand, diachronous HT tectono-metamorphic events that are related to high-grade terrains are more difficult to discriminate and, as a result, debates concerning the age of specific complexes commonly arise. This problem can be resolved, if the rocks were exhumed by a mechanism of gravitational redistribution initiated by a mantle plume [6, 3]. Theoretical analysis of $P-T$ paths [8] has shown that the overwhelming majority of Precambrian granulite complexes are repeatedly exhumed. First, they are accommodated in the middle crust, where they can cool down and remain forever or else exist in a metastable state in the Earth's gravity field for many hundreds of million years, until a new plume drives them upwards. This scenario requires that the rocks must be heated until the ductile state. This fluid-heat flow can reduce the viscosity, and set in motion the process of gravitational redistribution. In this case, the exhumation of the rocks may follow any tectonic scenario (including explosion).

Knowledge of the configuration of $P-T$paths in combination with structural and isotopic geochronologic data thus not only allows the nature of polymetamorphism to be established, but also to define a mechanism of rock exhumation. For example, a high-grade complex could be exhumed from the lower crust and cooled at the level of the middle crust (a DC model [8]) at given P_1 and T_1. Due to rheological constraints further movementtowards the surface is only possible with additional input of heat. This heating and the second exhumation may occur hundreds of millions years later, in which case P_{min} (P_1) of the first metamorphic/deformational event (M1/D1) at T_1 should be approximately equal to P_{max} of the second event (M2/D2) at a higher T_2. In other words, a composite $P - T$diagram for both events must demonstrate that isobaric heating (from T_1 to $T_2)$ links P_{min} (M1/M1) to P_{max} (M2/D2). High-grade rocks from the core of the Vredefort impact crater, South Africa, demonstrate evidence that this is true. The granulitic core of the complex was formed in the lower crust and exhumed to a depth of $\sim$10 km at $\sim$ 3.1 Ga [4] where it remained until $\sim$2.023 Ga, when the core was rapidly moved almost to the surface as a result of a giant explosion [2, 4]. The rocks of the core thus were isobarically heated by 200 ˚C at P= 3 kbar, and then hydrostatically driven upward as is evidenced by the following observations: (1) the ubiquitous development of textures characterized by the Fe-rich products of the reaction Grt+Qtz =$>$ Crd+Opx that surround fractured garnet grains, and (2) the development of a hornfelsic rim around the high-grade core of the complex during the course of uplift under non-isobaric conditions after the explosion [7]. This natural evidence for gravitational redistribution is also applied to the evolution of polymetamorphic complexes in Russia (S.W Baikal and Kola Peninsula) and South Africa (the Limpopo high-grade terrain), for which petrologic data are supported by structural and geochronological data [1].

Thus, on the basis of discussed data we conclude that in contrast to Phanerozoic time period when the Phanerozoic subduction/collision tectonics dominated, the formation and evolution of the continental Eart's crust during the Precambrian time was mainly driven by gravitational instability that lead to redistribution of material within the crust.

References: [1] Boshoff R. *et al.* (2006) J. Geology. 114, 699-716. [2] Gerya T. V. *et al.*, (2000), V.30, 17-35. [2] Gibson R.L., Reimold W.U. (2001) The Vredefort impact structure, South Africa. Council of Geosciences of South Africa. Memoir 92. 111 p. [3] Harley S.L. (1989) Geological Magazine. 126. 215-231. [4] Hart R.J. *et al.*, (2004). S. Afric. J. Geol. 107. 83-94

[5] Perchuk L.L. Physics of the Earth and Planetary Interiors, 1976. 13, 232-239. [6] Perchuk L.L. (1989) Geol. Soc. London. Special Publication. 2(20). 275-291. [7] Perchuk L. L. *et al.*, (2002) Petrology 10, 395-432. [8] Perchuk L.L. (2005) Dokl. Earth Sciences. 401. 311–314. [9] Spear F.S. (1993). Metamorphic phase equilibria and pressure-temperature-time paths. Min. Soc. America Publication, Washington, D.C.