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Proterozoic granitization and charnockitization in the Central Zone of the Limpopo granulite belt, South Africa

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Precambrian Limpopo granulite facies terrain experienced two regional high-grade events. The first one, D2/M2 (2.67-2.53 Ga), was marked by numerous sheath folds, while the subsequent overprinting event D3/M3 (2.02 Ga) formed both regional and local linear shear zones. The Z-shaped P-T path shows two metamorphic events reflecting the polymetamorphic nature of the Limpopo Belt (LB) [1 and refs. therein]. The D2/M2 event represents the oldest decompression cooling path from $P < 9.0$ kbar and $T<900$˚C to $P \sim 5.0$ kb and $T\sim600$˚C, reflecting an exhumation of the LB from the lower to the middle continental crust. The subsequent D3/M3 event is characterized by the initial near isobaric heating (IH) by about 200^{O}C at 5.5-6.0 kbar followed by D3/M3 decompression cooling (DC) to $<600^{O}$C and 4.5-3.5 kbar [1].

Both D2/M2 and D3/M3 events were accompanied by granitization processes. During the former metamorphism, the voluminous melting of host gneisses occurred with formation of large granitic bodies. Unlike the earlier event, the metamorphism D3/M3 in the Central Zone of the LB was associated with less intensive granitization, which occurred predominantly in narrow domains along the regional and local shear-zones.

Three major types of granitization processes are identified along the D3/M3 shear-zones: (1) *in situ* partial melting with a leucosome separation during IH; (2) charnockitization, and (3) granite pegmatite formation during DC. It seems that processes (2) and (3) represented a single event triggered by an infiltration of the aqueous brine and H_2O-CO_2 fluids. In order to decipher the fluid conditions of the later granitization, we have analyzed variations in compositions of coexisting minerals, fluid inclusions, as well as trace element patterns through progressions from host gneiss to charnockite, from one hand, and to pegmatite, from another hand.

The rock texture systematically changes from the host Hbl-Bt gneisses to the typical granite textures in charnockites and pegmatite rocks. In the host gneisses, fluid inclusions are presented by both aqueous brine and H_2O-CO_2 varieties. Aqueous or aqueous brine (23-29 wt. % of NaCl) inclusions dominate in charnockite, while rare CO_2inclusions are preserved in cores of quartz grains only. Homogenization temperature of the CO_2 inclusions varies from 3.0 to 13.4˚C, corresponding to the P-T conditions at the end of the D3/M3 path. No primary fluid inclusions were found in the transitional rocks. Nevertheless, it is evident that the charnockitization is accompanied by an increase in role of the aqueous brine fluids. They were responsible for an increase of alkali activity, resulted in alkali-exchange reactions such as $Pl_{>Ab}$ + K_2O (in fluid) = $Pl_{<Ab}$ + Kfs + Na_2O (in fluid) and $Opx_{>Al}$ + K_2O (in fluid) + Qtz = $Opx_{<Al}$ + Kfs [2] which were conjugate with the amphibole and biotite dehydration in charnockites. In addition, activity of the brines is reflected in composition of amphibole and biotite, which become more Cl-enriched in the charnockites. The transitional rocks are depleted in REE, while the charnokites concentrate LREE at comparable level of HREE as in the initial gneiss. Pegmatites contain aqueous fluid inclusions, exclusively. However, CO_2-rich inclusions are preserved in the transition types of rocks. Their density corresponds to temperatures about 700˚C, i.e. to the middle-to-end portion of the D3/M3 path. In contrast, the granite pegmatites are enriched in HREE in comparison to the transitional zone and depleted in LREE with prominent Eu-maximum. These patterns indicate a spectacular re-distribution of REE during fluid-rock interaction and subsequent (or coeval) melting.

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