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Magmatic evolution of Paranja-Etendeka related mafic intrusive rocks in Western Namibia - impact on lithosphere heating and weakening?

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Countless studies have been conducted in order to determine the magmatic evolution and genetic heritage of extrusive magmatic rocks associated to continental intraplate magmatism, which in case of large igneous provinces (LIPs) is frequently linked to mantle plumes associated to continental breakup and rifting. By contrast, less attention is paid to the plumbing systems of LIPs, to magma transport, storage and differentiation en route to the surface, and to the volume and composition of the plutonic portion of intraplate magmatism. Studying the origin and magmatic evolution of LIP related plutonic rocks as counterparts of more evolved extrusive series, however, provides crucial knowledge about their volume and heat budget and will have direct implications on estimates about lithospheric strength.

Here we present mineral and whole-rock geochemical and petrological data from different types of gabbros from Western Namibia which are thought to represent a deeper crustal section of a plumbing system that fed the Paranja-Etendeka LIP ~132 Ma ago. Magmatism at this time broadly coincides with Gondwana breakup and opening of the South Atlantic. Intense differentiation and cooling of larger volumes of primary mafic magmas within the lithosphere and crust might have reduced lithospheric strength and thus might have supported or even triggered continental breakup.

Major- and trace element systematics and thermodynamic modelling suggest that the gabbro parental magma developed from a tholeiitic picritic melt with up to 18wt% MgO by >10% olivine fractionation. The picritic primary magma was formed by ~14% partial mantle melting. Liquidus temperatures have been as high as ~1525°C (3 GPa) and mantle potential temperatures in the order of 1455-1470°C, significantly higher than estimates for the convecting mantle (1280-1340°C; McKenzie & Bickle, 1988) but consistent with estimates assigned to the Tristan mantle plume head upon impacting the Gondwana lithosphere (Gibson et al., 2005). Clinopyroxene trace element data reveal that the REE concentration variation between the gabbro parental magmas was nearly an order of magnitude, inconsistent with gabbro formation by pure fractional crystallization from a common magma, but in support of substantial assimilation of Pan-African continental crust accompanied by high crystallization rates. These observations imply intense heat exchange between the plumbing system and ambient lithosphere, which possibly led to marked local heating and lithosphere weakening.

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