A review of the rare-element pegmatites of the Alto Ligonha Pegmatite Province, northern Mozambique

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INTRODUCTION: The Pan African (PA) rare-element pegmatites of the Alto Ligonha Pegmatite Province (ALPP) of northern Mozambique are famous for their gemstones, rare and unique mineral specimens and as a source for a variety of rare element minerals such as beryllium, tantalum and niobium.

REGIONAL SETTING: The main concentration of economic pegmatites in N. Mozambique are in the ALPP in the Nampula Subprovince, mostly NNE-SSW orientated PA Namama Thrust Belt (NTB), which extends from the Mugeba Klippe in the SW to NE of Alto Ligonha in the north (Figure 1). The geology is dominated by Mesoproterozoic medium- to high-grade gneisses of the Nampula Complex that were reworked during the PA Orogeny and intruded by early Palaeozoic late-PA granitoids and pegmatites.

PEGMATITES OF THE ALTO LIGONHA PEGMATITE BELT: The economic pegmatites are characteristic of the LCT family, with some NYF (Niobium-Yttrium-Fluorine) family affinities, and can be subdivided into 4 main types - 1) Sodalithic; 2) Potassic with beryl and columbotantalite; 3) Potassic rich in metamict uranium, thorium and rare-earth bearing minerals; 4) Amazonite-bearing (found in the Nacaroa pegmatite field) and tourmaline-bearing pegmatite.These pegmatites can also be differentiated on the complexity of the internal structure or relative lack thereof. These pegmatites have been dated at between 481-440 Ma, thereby post-dating the intrusion of the late undeformed Pan African granites dated at ~521-495 Ma. The per- to sub-aluminous composition of the granites is also consistent with fertile granites related to late- to post-orogenic LCT (and NYF) pegmatite provinces. The sodalithic pegmatites have important concentrations of Nb-Ta, beryl and lithium and include large pegmatites, such as Muiane, Naipa, Marropino, Morrua and Moneia. Mineral and geochemical typomorphism show the potassic and RE-type have similar degrees of fractionation and possibly represent two sub-types of a single pegmatite type corresponding to the Beryl type of Cerný (1991). The amazonite-bearing and tourmaline-bearing pegmatites have similar degrees of fractionation to the sodalithic and potassic pegmatites respectively. There is a strong lithostratigraphic control on pegmatite distribution with >50% of all the pegmatites hosted in the paragneisses of the Molócuè Group (which is more pronounced for the sodalithic types with ~79%). Structurally ~73% of all pegmatites and 95% of the sodalithic pegmatites are within the broad limits of the NNE-SSW orientated NTB and are orientated parallel to the regional fabric within the NTB and the Mugeba Klippe. The potassic pegamtites tend to be more widely distributed through the region (Figure 1).

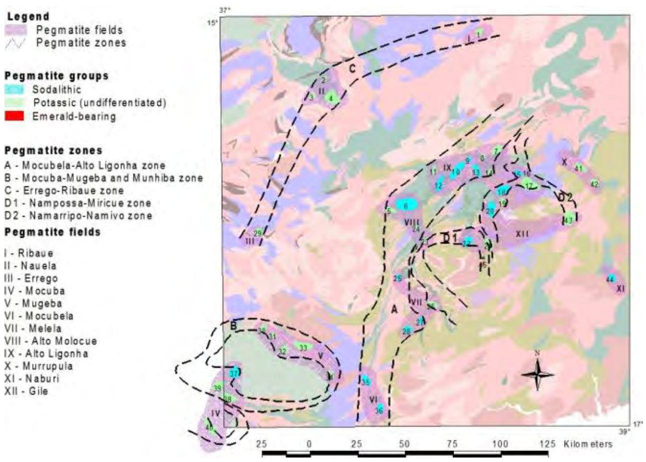

Figure 1: Pegmatite distribution in Northern Mozambique

Which parameters control the Variscan pegmatites field-scale organization ?

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The emplacement of rare-element granitic pegmatites is subjected to a lively debate opposing mainly two genetic models with essential metallogenic consequences. In the first model an underlying parent granitic body releases residual enriched melt which, at the end of its crystallization, leads to the formation of pegmatites. The second model does not involve a granitic parent but rather a low melting rate of crustal material and successive injections of independent batches of melts which are favoured by regional shear-zones. The first model is commonly assumed for regional exploration; however few recent studies favour the second model. In particular, the emplacement of the LCT-type pegmatite field of Monts d'Ambazac (Massif Central, France) is first controlled by a NNE-SSW oriented faults-system rather than by the crystallization of its host granite. In order to strengthen these findings, we investigated through statistical spatial analysis two other Variscan (320-310 Ma) pegmatite fields which present similar mineralized objects (barren to petalite-spodumene and barren to petalite-lepidolite subtypes), but different spatial organizations and hosts: the Forcarei pegmatite field (FPF, NW Galicia, Spain) and the The Barroso-Alvão pegmatite field (BAPF, Northern Portugal, ~ 100 km southeast from FPF). Many data are available on these fields where granitic bodies, migmatites and shear-zones are present. The FPF is limited in its southern edge by the Celanova migmatitic dome, resulting from a low-temperature hydrated melting of crustal material. Moreover, some pegmatites occurred in a "reservoir zone" which give to the local migmatites a diatexite texture. These observations favor *a priori* the second model of direct crustal anatexis. Finally, spatial statistical analyses and syn-kinematic criteria as shear-bands and pulled-apart tourmaline, that are observed in pegmatites seem to suggest that the left-lateral Serra do Suido shear-zone near to the pegmatite field has a major role during pegmatite emplacement. Indeed, pegmatites are clustered and preferentially oriented in the same broad N-S direction as the associated shear-zone. The formation of the BAPF also matches the second model since it is located near to the southern edge of Celanova migmatic dome. The distribution of pegmatite bodies shows no preferred orientation and cross-cutting of pegmatite-subtypes. The lack of recognized regional shear zones in BAPF indicates the key role of such structures on the pegmatite field. These preliminary results favour the influence of shear zones as flow channels on i) the Variscan LCT-type pegmatite field emplacement and ii) pegmatites subtypes field-scale organization. As demonstrated recently by laboratory experiments, the fluxes enrichment of H_2O, Li and F drastically reduces the viscosity of pegmatitic melts favouring their ascent through crustal-scale permeable zones as confirmed by our preliminary numerical model where the role of low viscosity on magma ascent is especially investigated. Thus, we hypothesize that the spatial distribution of mineralized pegmatites could be partly controlled by surrounding tectonic structures, their fluxe content and the resulting pegmatitic melt rheology.