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Major Element Indicator Mineral Chemistry of the Lulo Kimberlite Province, Lunda Norte, Angola

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Introduction

The 3000 km^2 Lulo Concession is located along the Lucapa kimberlite corridor within the Cuango River Basin, Lunda Norte, Angola and is associated with the Cuango – Cucumbi kimberlite cluster. Exploration and alluvial mining within the permit have largely concentrated along the Cacuilo River where numerous large high value Type II "CLIPPIR" diamonds have been recovered. Variations in the local diamond distributions along the greater Cacuilo river suggest that relatively local primary diamond input into the greater catchment is a possibility. Kimberlite exploration has thus concentrated initially over the greater Cacuilo catchment area of the license with a total of 560 anomalies being inferred from aerial magnetic and electromagnetic studies. Over 160 of these targets have been drilled with over 140 kimberlite discoveries (hereafter termed the Lulo Kimberlite Cluster). Major element xenocryst mineral chemistry from 89 of these occurrences are reviewed here, not only in terms of traditional mineral chemistry interpretations, but also with respect to interpretations related to more recent theories for the origin of CLIPPIR diamonds.

Peridotitic garnet xenocryst chemistry

The peridotitic xenocryst mineral chemistry of the Lulo cluster is dominated by a lherzolite mantle signature, in common with several of the other kimberlite clusters in Lunda Norte, including Catoca (Robles et al, 2008) and the general rarity of extremely depleted harzburgite garnets in the region (Zinchenko et al, 2021). Several high interest garnet lherzolite bearing kimberlites have been discriminated using high Cr_2O_3 as well as by comparing the individual kimberlite MnO distributions to the world-wide diamond inclusion lherzolite populations of Grutter et al, (2004) and Stachel et al, (2018).

Eclogitic garnet xenocryst chemistry

Lulo eclogitic garnet xenocrysts show wide ranges in composition with a significant population of grains classifying as G3 and G4 (Grutter et al, 2004) plotting within the crustal field of Schultze (2003) and/or as crustal according to the major element multivariate statistical methods of Hardman (2020). Several of the diamondiferous occurrences at Lulo show an association with G3 and G4 diamond inclusion chemistry.

Pyroxenitic Garnets are widespread throughout the NE Angolan kimberlites (Zinchenko et. al. 2021), of which websterite may be of particular significance within the Lulo Kimberlite Cluster. Diamond inclusion type websterite is dominant among websterite recovered from one of Lulo's high interest diamondiferous occurrences. Websterite has been noted to account for 72% of diamond inclusions in framesite (Michail et al, 2019) and large framesites (up to 133ct) have been recovered at Lulo. This may suggest a tentative link to CLIPPIR diamonds, although Moore and Helmsteadt (2023) note substantial chemical overlap between websteritic garnets and megacrysts.

Majoritic garnets (Sensu lato), although extremely rare, are present within the Lulo dataset and indicate pressures of 13 GPa using Collerson's geobarometer (Collerson et.al, 2010) for two of the Lulo occurrences.

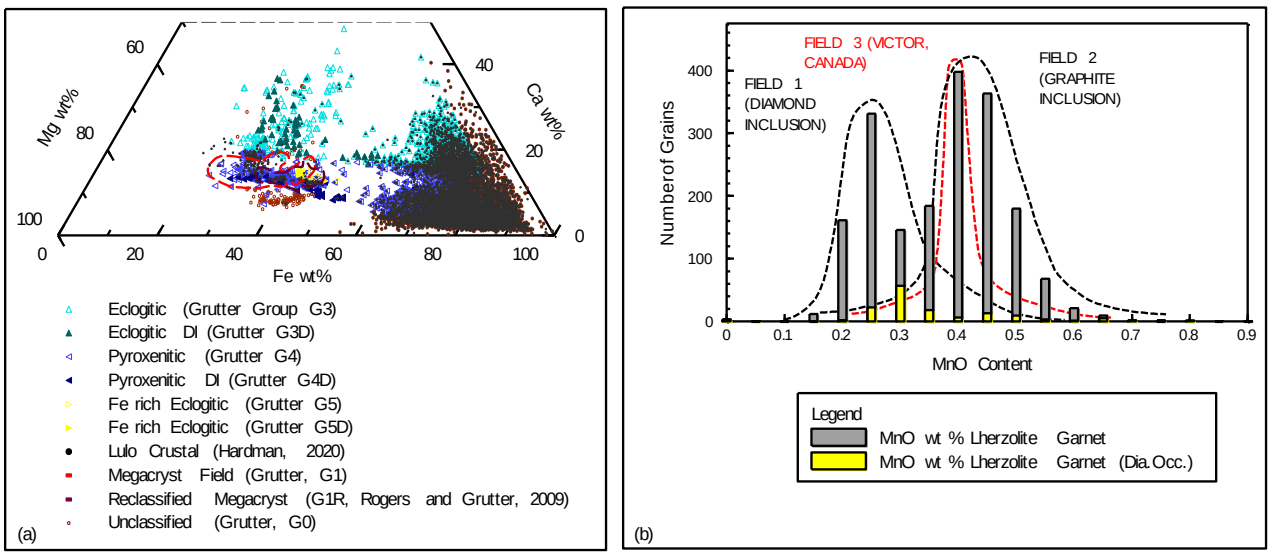

Figure 1. (a) Lulo Garnet Ternary Plot, eclogitic and megacrystic garnet, (b) Lulo MnO (wt%), lherzolite garnet (b).

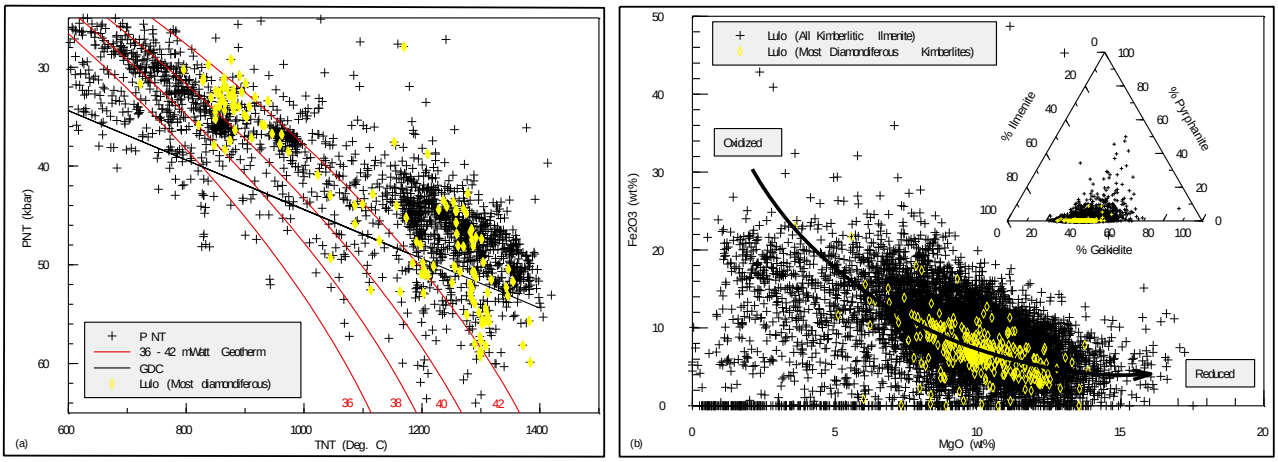

Figure 2. Lulo Kimberlite Cluster, Clinopyroxene Thermobarometry (a), Ilmenite Chemistry (b).

Clinopyroxene thermobarometry

Clinopyroxene single grain thermobarometry (Nimis and Taylor, 2000) for the Lulo dataset shows a high degree of variation both between and within individual occurrences, together with a substantial heated population resulting in a perturbed geotherm. The data from higher interest occurrences (in terms of the bulk sampling results to date), generally lie within the heated population but extending below the GDC (Graphite – Diamond Constraint) up to a pressure in the order of 65 kbars.

Spinel xenocryst chemistry

Spinel is extremely rare and no diamond inclusion type spinels are present in the Lulo Dataset. Several occurrences show fractionated spinel trends.

Ilmenite xenocryst chemistry

No detailed Ilmenite chemistry studies, either analytical or textural have been undertaken on any of the Lulo cluster kimberlites to date although the current kimberlitic xenocryst (Wyatt et al, 2004, classification) modelling does not suggest any unequivocal application of diamond preservation techniques (see figure 2b). Fe_2O_3 contents have been estimated based on the stoichiometric method described by Droop (1987). Mn enrichment of ilmenite has been suggested to have a relationship with diamond content (Kaminsky and Belousova, 2009) although the method is controvesial (Castillo-Oliver et al, 2017) and dependent on detailed textural studies (Robles-Cruz et al, 2008). No relationship of Mn enrichment in Ilmenite with either diamond presence or amount is suggested by the bulk sampling results of the Lulo Kimberlites to date, as demonstrated in the ilmenite ternary plot (figure 2b, inset).

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