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An Unique Glomerophyric Diorite Porphyry from the Southern Margin of North China Craton: Geochronology, Geochemical and Quantitative Textural Analysis Constraints

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1 Introduction

The Wulong glomerophyric diorite porphyry has an extremely peculiar texture with plagioclase phenocrysts clustered as flower-like glomerocrysts (**Figs. 1a&b**), which is never discovered elsewhere of the world. The diorite porphyry dyke is located in Luoyang city, and thus also known as “Luoyang Peony Stone”.

Distribution of plagioclase glomerocrysts in Wulong glomerophyric diorite porphyry is heterogeneous. It is likely that plagioclase glomerocrysts and/or megacrysts are rich in the dyke center and reduced towards dyke margin. Most of the plagioclase glomerocrysts are flower-like, but other shapes do present. Single isolated crystals are also developed. For comparison reason, two individual groups of the plagioclase phenocrysts have been divided: (1) cluster touching crystals (CT-type) and single isolated crystals (SI-type, up to 8cm long).

The genesis of plagioclase flower-like glomerocrysts in Wulong diorite porphyry is completely unknown. However, genesis models of other chaotic shapes of glomerocryst textures have been approached before, such as synneusis model (Vance 1969), accumulation model (Scoates 2000), heterogeneous nucleation model (Cheng et al., 2014), plagioclase resorption model (Hogan 1993) and single megacryst fragmentation model. Shane (2015) documented that the morphological texture (e.g. glomerocryst and synneusis) were formed by strong influences of crystallization kinetics in the magma chamber, such as convection, turbulence, degassing, magma mixing, and so on.

The Wulong glomerophyric diorite porphyry is a small-scale dyke (width 20m) intruded into the Archean gneiss at the southern margin of the North China Craton. Fundamental geological studies of the dykes are rather limited and their petrogenesis and geochronology are poorly understood up to now.

2 Geochemical and geochronology study

2.1 Major and trace elements

Whole-rock chemical composition shows that the rocks contain low SiO_2 (50-52 wt %) and K_2O (1.5 wt %) contents but high CaO (8-9 wt %) and Al_2O_3 (15-16 wt %) concentrations, and are medium-K calc-alkaline rock series. They are depleted in HFSEs (Nb, Ta, Zr, Hf and Y) and enriched in LILEs (e.g., Ba). The chondrite normalized REE patterns show significant enrichment of LREE with steep slopes (La_N/Yb_N = 4.7-7.5) and slightly Eu negative anomaly (Eu/Eu* = 0.74-0.97).

2.2 Geochronology and Sr-Nd-Pb isotopes

Zircon U-Pb dating reveals that the Wulong glomerophyric diorite porphyry was formed in 480±3Ma, consistent with the vast Early Paleozoic magmatisms in North Qinling Orogen. Isotopic data implies an enriched mantle source for the magmas, with high initial Sr isotopic ratios (0.7107-0.7158), low Nd (t) values (-9.9 to -11.3) and variable initial Pb isotopic ratios (e.g., $^{206}Pb/^{204}Pb_t$ vary from17.3 to 19.3).

3 Mineral chemistry and Crystal Size Distributions (CSDs) calculation

3.1 Mineral composition

The plagioclase phenocrysts are generally altered to sericite and/or zoisite, but typical magmatic texture is clear in the rocks, precluding a deterioration cause for the plagioclase glomerocrysts. Chemical compositions of both CT- and SI-type plagioclase phenocrysts are similar

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and display slightly higher anorthite numbers (An_{35-45}) than the plagioclases in the matrix (An_{25-35}). Weak compositional zoning in terms of Na and K was observed in individual plagioclase phenocrysts of a single glomerocryst, indicating that the plagioclase glomerocryst texture is likely to result from massive individual crystals cluster model, rather than fragmentation of a single megacryst.

3.2 CSD data

The two types of plagioclase have an S-CSD crystal size distribution with the almost same slopes and different intercepts, the characteristic lengths (CL) are 0.6 to 0.9cm. The obvious lack of smaller phenocrysts (<2mm) indicates that textural coarsening play an important role in the nucleation and growth processes of crystals. Assuming crystals continuously grow in a steady magma chamber, the crystallization time of plagioclase phenocrysts has been calculated using the growth rates of 10^{-9} to 10^{-10}cm/s (Cheng et al., 2014). The results show that the CT-type plagioclases (164-2,758 years) spend less time for crystallization than the SI-type (190-2,949 years). This suggests the SI-type plagioclase crystals have a longer cooling time than the CT-type plagioclase crystals.

4 Petrogenesis and tectonic setting

Whole rock geochemical and isotopic features indicate that the parent magma of Wulong diorite porphyry is likely to be originated from an enriched mantle, but contaminated by a certain amounts of crustal materials during magma upwelling. The similar intrusive ages of Wulong diorite porphyry with adjacent Fushui mafic complex suggest that they were both products of an island arc magmatism induced by northward subduction of North Qinling micro-landmass.

5 Genesis of the flower-like plagioclase glomerophyric texture

Combined with quantitative textural data and mineral chemical composition, we propose that the flower-like plagioclase glomerocryst texture is probably formed in a strongly convective environment similar to "water vortex". The crystal transport process must be turbulent and rapid. The driven mechanism could be by replenishment of new pulsating magma, accompanied with plagioclase nucleation, grown, separation and aggregation processes.

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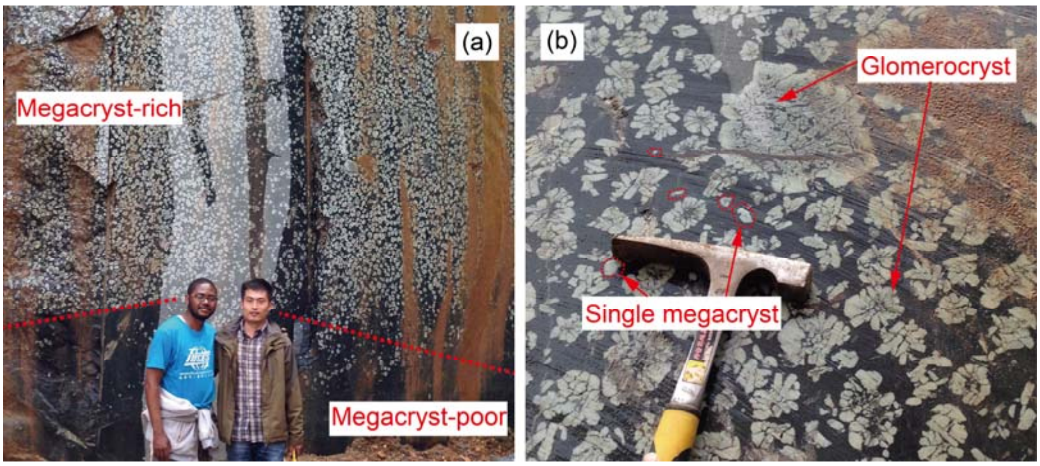

Fig. 1. Field photographs the Wulong glomerophyric diorite porphyry.
(a), The dykes include two components: megacryst-rich and megacryst-poor; (b), The plagioclase phenocrysts are divided into glomerocryst and single megacryst.