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Petrogenesis of I-type granites from Yuqikapa granite pluton of the western Kunlun orogen: Deformation-driven filter-pressing differentiation

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1 Introduction

The western Kunlun orogen, located in the northwest Tibet Plateau, and is a conjunction between the Pan-Asian and the Tethys tectonic domains. From north to south, the Western Kunlun orogen includes four tectonic terranes: northern Kunlun terrane, southern Kunlun terrane, Tianshuihai terrane and Karakoram terrane. Theses terranes are combined by three sutures: Oytag-Kudi suture, Mazha-Kangxiwa suture and Hongshanhu-Qiaoertianshan suture (Matte et al., 1996; Mattern et al., 1996; Xiao et al., 2005). The Western Kunlun orogen has underwent multi-stage plate subduction, collision and accretion from early Paleozoic to Mesozoic. Abundant Triassic granitoids are adjacent to the Mazha-Kangxiwa suture which is regard as the early-Mesozoic suture of the Paleo-Tethys Ocean (Mattern et al., 1996; Jiang et al., 2013; Zhang et al., 2016). Previous research data show that these granites are principally formed in the Late Triassic (ca. 230 – 210 Ma). However, the intrusion of the early-middle (ca. 250 – 230 Ma) Triassic granite is scarce. Yuqikapa granite pluton, exposed on the Kangxiwa strike-slip shear zone, is located in the northwest of Western Kunlun Orogen. In this paper, zircon U-Pb geochronology, whole-rock major and trace elements on the Yuqikapa pluton were carried out to unravel the petrogenesis of the pluton.

2 Sampling, Analytical Methods and Result

2.1 Sampling and analytical methods

Yuqikapa pluton has a wide compositional variation, a continuum from porphyritic granite to alkali-feldspar granite. The strongly deformed porphyritic monzogranite and the undeformed medium-fine grained monzogranite occurred respectively in the east and west of the pluton. In this study, we collected 9 samples from surface exposures of the Yuqikapa pluton, from east to west. All sample were crushed to 200-mesh for whole-rock geochemical analysis. Zircons extracted from deformed rock (YQKP-5) and undeformed rock (YQKP-9), were cast in epoxy and then polished for CL image observation and LA-ICPMS or SIMS analyses. All analyses were done at the Guangzhou Institute of Geochemisty.

2.2 Result

La-ICPMS zircon U-Pb ages of the deformed rock are 242.7±3.3 Ma and SIMS zircon U-Pb ages of undeformed rock are 242.6±2.3 Ma. It demonstrates the intrusions of them are coeval.

The granite of Yuqikapa is peraluminous and belongs to the high-K calc-alkaline series. They are characterized by high SiO_2, K_2O, Rb, Th, U, and low P_2O_5, Ba, Sr, Eu and Ti, showing I-type granite character. Most major and many trace elements of Yuqikapa pluton yield excellent linear correlations with silica content (Table.1). With silica increasing, the contents of MgO, Al_2O_3, $Fe_2O_3^T$, CaO, Sr, Ba, Eu, Ti, P, Co, Ni, V, LREE, Nb/Ta ratios and Zr/Hf ratios show gradually decrease, while the Rb, Ta, U, Rb/Sr and Rb/Ba ratios show gradually increase. The correlations between the silica and REE (exclude Eu) are increase with the number of protons, resulting in a decrease（La_N/Yb_N）ratio to SiO_2.

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3 Crystallization Differentiation

The Yuqikapa granites have variable major and trace element compositions, and MgO, Al_2O_3, $Fe_2O_3^T$, CaO, Sr, Rb, Ta, U, Ba, Eu, Ti, P, Co, Ni, and V have negative correlations against SiO_2. Previous studies suggest that these compositional variations may have resulted from fractional crystallization (Yang et al., 2016). The progressively decreasing in MgO, $Fe_2O_3^T$ and Al_2O_3 with SiO_2 content increasing indicates the fractionation of mafic minerals. Nb/Ta and Zr/Hf ratios show decreasing with the SiO_2 content increasing in the pluton, suggests biotite and zircon fractionation (Claiborne et al., 2006; Pfander et al., 2007; Stepanov and Hermann, 2013). With the increasing differentiation, the contents of Sr, Ba and Eu progressively decrease, that indicates the fractionation of plagioclase and K-feldspar. Depletion of Ti and P indicates the separation of Ti-bearing phases and apatite. LREE decreasing and HREE increasing respectively with the increasing of SiO_2, that suggest allanite fractionation.

The high viscosity of granitic and granodioritic magmas, and the moderate density contrast between the melt and precipitating phases (plagioclase, biotite and hornblende), this lead to the fact that crystal fractionation is difficult to occur in granitic magma without external forces. In Yuqikapa pluton, the lower SiO_2 porphyritic monzogranite are strongly deformed whereas the higher SiO_2 medium-fine grained monzogranite are undeformed. These suggest that deformation-driven filter pressing may be the dominant fractionation mechanism of Yuqikapa granite magmas crystallizing.

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Table 1 Correlations between some element contents and SiO_2 (wt. %).

Element	TiO_2	Al_2O_3	$Fe_2O_3^T$	MgO	CaO	Na_2O	K_2O	P_2O_5	V	Co
Pearson correlation	-0.882	-0.931	-0.93	-0.871	-0.925	0.249	-0.033	-0.884	-0.846	-0.875
Element	Ni	Rb	Sr	Ba	Ta	Th	U	La	Ce	Pr
Pearson correlation	-0.93	0.698	-0.925	-0.886	0.768	0.566	0.877	-0.856	-0.844	-0.846
Element	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb
Pearson correlation	-0.847	-0.701	-0.97	-0.556	0.133	0.246	0.381	0.458	0.57	0.606
Element	Lu	δEu	Th/U	Zr/Hf	Nb/Ta	Sr/Y	Rb/Sr			
Pearson correlation	0.633	-0.802	-0.862	-0.902	-0.735	-0.787	0.854			