# Geochemical and SHRIMP U-Pb zircon chronological constraints on the Magam-mixing event in eastern Kunlun orogenic belt, China

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A spectacular east-west extending granitoid belt in the Eastern Kunlun Orogeny, China is about 800 km long by 40~80 km wide and composed of many complex plutons, which contain abundant mafic microgranular enclaves (MME). The late Paleozoic- early Mesozoic granites are prevelent in the granitoid belt. As one of the typical plutons, Yugelu pluton with an area of about 100 $km^2$ situated at about 30 km southeast from Xiangride town of Qinghai province.

The pluton constitutes a magma series that ranges from hornblende-gabbro, diorite, granodiorite to monzogranite, and minor syenogranite etc.with dominance of granodiorite. MME are widely distributed in granodiorite and are only a few in others. The abundance of MME in the granites of Yuegelu pluton in the most felsic body is less than 0.5%, whereas in the most mafic one is up to 10%. Most MME are well-defined and have a sharp contact with diffused boundary. The enclave sizes range from less than 1 cm to more than 2 m in diameter, a few even up to 5 m, but most of them are in the range of 10 to 50 cm. The various shapes of MME, such as spheroidal, ellipsoidal, banded, wedge-shaped and irregular ones are commonly observed and show the streamlined shape with the features of rheology. These features provide a convincing evidence that they result from magma mingling (Chengdong Liu et al. 2002).

All MME show igneous texture, and are commonly porphyritic , with plagioclase, hornblende and biotite occurring both as phenocrysts and in the groundmass. Flow structures are occasionally developed with hornblendes underling linear flow structure. Structure of this type may result from plastic flowage under high-temperature conditions (Didier et al. 1991). Moreover, quenched rims, acicular apatites, irregular overgrowth of plagioclase, mantled quartz ocelli have frequently been seen within them. All of these evidences imply that MME are formed by magma mingling process (Vernon 1983).

The mineral assemblage of MME is plagioclase, hornblende, quartz, and subordinate biotite and K-feldspar. Accessory phases include zircon, titanite, apatite, magnetite, ilmenite and hematite. Plagioclases range widely from An8 to An87, but most from An35 to An55. Analyses of amphiboles by EPMA reveal that the enclaves have mainly magnesia-hornblende compositions, with ratio of Mg/(Mg +Fe) between 0.48 and 0.50, similar to those found in their host rocks.

Major, REE and trace elements were investigated in the Central Laboratory of Hubei Geological Bureau using conventional chemical analysis techniques, ICP and atomic absorption spectrometry respectively. Major element abundances in MME indicate that they are mostly intermediate in terms of $SiO_2$ content from 52.13% to 62.4%. Together with their host rocks, they belong to calc-alkaline, weakly peraluminous series, reflecting a subduction environment. Abundances of many elements of rocks show good linear variation on Harker diagrams, which indicate magama mixing origin (Chappell 1996).

ΣREE of MME are from 111.87 to 197.03 ppm, and those of their host rocks range more widely from 66.68 to 226.85 ppm. Moreover, ΣREE abundances of MME are slightly higher than their host rocks. Chondrite-normalized REE patterns for MME are generally similar to those of the host granites. Both have a LREE enrichment ($(La/Yb)_N$=1.04-34.80) and a slight negative Eu-anomaly.

The trace elements in both MME and their host granites are characterized by a slightly high abundance of Rb, Th, Zr, Y and low Ba, Nb, Sr, Ti. This feature reflects that MME and their host granites are in one hybrid series.

Isotope data of Sm, Nd, Rb and Sr were determined by VG-354 in Solid Isotope Laboratory of Institute of Geology and Geophysics Chinese Academy of Sciences. Isotopic data from MME have initial $^{87}Sr/^{86}Sr$ from 0.70859 to 0.70956, and those of their host granites are from 0.70144 to 0.70972; and εNd in MME from –4.5 to –9.2, and in host rocks from -5 to -6.2.These data are roughly similar.

Single-grain zircon U-Pb dating for MME, host granodiorite, and related hornblende-gabbro have been conducted in Beijing SHRIMP Center by using SHRIMP II and yielded 241±5Ma, 242±6Ma and 239±6Ma of ages, respectively. The results indicate that the three types of rocks were formed almost in the same event.

All these data imply that the granites have the origin of magma mixing. The mixing/mingling event between the crust- and mantle-derived magmas prevailed in the early-middle Triassic epoch in Eastern Kunlun orogeny. And the granitoid host rock and hornblende-gabbro may approximately represent the acid and basic end-members of the mixing with the ratio of about 70% and 30% estimated by $SiO_2$, respectively. MME are the incompletely mixed clots of the basic magma injected into the acid magma. Consequently, the injection and reaction of mantle mass and energy into/with the crust play an important role in the origin of granites and the vertical growth of the crust.

## References

Chengdong Liu et al. 2002.Characteristics and origin of mafic microgranular enclaves in Yuegelu granitic pluton in Eastern Kunlun. *Geol Bull China*. 739-744

Didier J and B Barbarin. 1991. *Enclaves and Granite Petrology*. Elsevier. Amsterdam. 625p

Vernon RH 1983. Restite, xenoliths and microgranitoid enclaves in granites. *J Proc R Soc N S W* 77—103

Chappell BW. 1996. Magma mixing and the production of compositional variation within granite suites: evidence from the granites of southeastern Australia. *J Petrol.* p 449—470

Compston W et al. 1992. Zircon U-P ages of early Cabbrian time-scale. *J Geol Soc* 171-184