Zircon U-Pb geochronological framework of Qitianling granite batholith, middle part of Nanling Range, South China

ZHU JinChu†, WANG RuCheng, ZHANG PeiHua, XIE CaiFu, ZHANG WenLan, ZHAO KuiDong, XIE Lei, YANG Ce, CHE XuDong, YU APeng & WANG LuBin

State Key Laboratory for Mineral Deposits Research, School of Earth Sciences and Engineering, Nanjing University, Nanjing 210093, China

The Qitianling granite batholith (QGB) is located in the southern Hunan Province, middle part of the Nanling Range, South China. Its total exposure area is about 520 km². Based on our 25 single grain zircon U-Pb age data and 7 published data as well as the geological, petrological, and space distribution characteristics, we conclude that QGB is an Early Yanshanian (Jurassic) multi-staged composite pluton. Its formation process can be subdivided into three major stages. The first stage, emplaced at 163-160 Ma with a peak at about 161 Ma, is mainly composed of hornblende-biotite monzonitic granites and locally biotite granites, and distributed in the eastern, northern, and western peripheral parts of the pluton. The second stage, emplaced at 157-153 Ma with a peak at 157-156 Ma, is mainly composed of biotite granites and locally containing hornblende, and distributed in the middle and southeastern parts of the pluton. The third stage, emplaced at 150-146 Ma with a peak at about 149 Ma, is mainly composed of fine-grained (locally porphyritic) biotite granites, and distributed in the middle-southern part of the pluton. Each stage can be further disintegrated into several granite bodies. The first two intrusive stages comprise the major phase of QGB, and the third intrusive stage comprises the additional phase. Many second stage fine-grained granite bosses and dykes intruded into the first stage host granites with clear chilling margin-baking phenomena at their intrusive contacts. They were emplaced in the open fracture space of the earlier stage consolidated rocks. Their isotopic ages are mostly 2-6 Ma younger than their hosts. Conceivably, the time interval from magma emplacement, through cooling, crystallization, solidification, up to fracturing of the earlier stage granites cannot exceed 2-6 Ma. During the Middle-Late Jurassic in the Qitianling area and neighboring Nanling Range, the coeval granitic and basic-intermediate magmatic activities were widely developed. It indicates that the Early Yanshanian period was the culmination time of magmatic activities in this region. The Nanling Range was under a post-orogenic, intracontinental geotectonic environment with an obvious lithospheric extension and thinning. The crust-mantle interaction played an important role in formation of granitic rocks in this region.

Nanling Range, Qitianling granite batholith (QGB), zircon U-Pb dating, intrusion stages, granite body disintegration

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†Corresponding author (email: jczhu@nju.edu.cn)
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The Qitianling granite batholith (hereafter known as QGB) is a representative granite pluton in the middle part of the Nanling Range, South China. The distance from its NE margin to the Chenzhou city is within 20 km. It is nearly round in shape, with an exposure area of approximately 520 km². Because there exist many large even super-large non-ferrous and rare metal deposits around and inside QGB, such as the Shizhuyuan W-Sn-Mo-Bi, Yaogangxian W-Mo, Baoshan Pb-Zn, Huangshaping Pb-Zn-W-Mo, Xianghualing Sn-W-Pb-Zn-Nb-Ta, Xintianling W and Furong Sn deposits etc, the geology, geochemistry, geochronology, petrogenesis, and metallogenetic relations have been attracting attention of many scientists.

Based on extensive field and laboratory works in recent years, we systematically studied petrology, geochemistry, geochronology, and metallogenetic relations of QGB. Here we report the results of single grain zircon U-Pb dating. Combined with the existing geochronological data and information on geology, petrology, and space distribution of the granitic rocks within this pluton, the zircon U-Pb geochronological framework, subdivision of emplacement stages, and granite body disintegration are discussed.

1 Geotectonic background and outline of geochronological studies

In regional tectonics, QGB is located in the S Hunan-NE Guangxi-N Guangdong Hercynian-Indosinian (Late Paleozoic-Triassic) depression area. Two important deep faults intersect here. One is the NE trending Chaling-Chenzhou-Lingwu fault, which controls the distribution of a NE trending granite zone with relatively low Nd model ages[1,2] and with abundant Sn-W mineralizations[3]. Based on the systematic geologic-geochemical differences of the Mesozoic basalts in both sides of this fault, Wang et al.[4] suggested it as a boundary between the Yangzi Block and the Cathaysia Block during the Neo-Proterozoic collision. The other is the WE trending Jiuyishan-Qitianling-Jiufengshan fault, which controls the distribution of the WE trending northern granite belt in the Nanling Range[5]. Exposed sedimentary strata in neighboring area are Sinian-Silurian sandy-pelitic marginal sea facies and Devonian-Middle Triassic carbonate shallow sea facies. In the deep-fault controlled depressions, the Late Triassic-Jurassic and Cretaceous-Late Tertiary terrigenous sediments were developed.

The QGB is a multi-staged composite granite pluton. Because QGB is one of the most representative ore-bearing granite plutons in the Nanling Range, the Guangdong Regional Geological Survey Team for Nanling Region[6] was the first to systematically study its emplacement age. They found that for this pluton, the youngest intruded strata are the Early Triassic limestone of Daye Formation. In the Early Cretaceous red bed, very close to the pluton, the pebbles of granite lithologically similar to the major phase of QTB and the interlayers of granitic clastic sediments were found. Consequently, they considered that the emplacement age of QTB is between Late Jurassic and Early Cretaceous.

The Geological Institute, Chinese Academy of Sciences, obtained a biotite K-Ar age of 204 Ma by the volumetric method in 1961. Since that time, the emplacement age of the QGB has been popularly recognized as the Indosinian (Triassic). Although from 1963 to 1975, different methods were employed to date the Qitianling granites, including the biotite K-Ar, K feldspar K-Ar, whole rock K-Ar, conventional zircon U-Pb, and conventional monazite U-Pb methods. The yielded ages were significantly variable due to technical limitation of different methods at that time, determination in different laboratories, and sampling at different locations[7–15].

In late 1980s the South Hunan Geologic Team conducted a regional geologic survey and mapping in a scale of 1:50000 (Yongchun and Yizhang sheets). They recognized more than 90 granite bodies of different sizes (stocks, bosses, dykes), obtained 3 whole rock Rb-Sr isochron ages and 4 conventional zircon U-Pb ages, and divided QTB into two superunits: the Cailing superunit (belonging to Indosinian or Triassic, which includes 4 units: Fengshuxia, Zhangxishui, Liangkoutang and Qingshanli units) and the Furong superunit (belonging to Yanshanian or Jurassic to Cretaceous, which includes 6 units: Lijiadong, Wuliqiao, Nanxi, Jiangjunzhi, Huangtangling and Huitouwan units). No more units were established for the still later acidic dykes[16,17].

During the 1990s, no geochronological work was done related to QGB. Since the beginning of this century, in the wake of finding the large-tonnage Furong tin deposit inside the Qitianling pluton and progress in analytical techniques, a new round of geologic-geochemical research on granites and related mineral resources of QGB began. Zheng et al.[18], Bai et al.[19], Zhu et al.[20],