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Petrogenesis of the Early Cretaceous Tiantangshan A-type Granite in northwestern Guangdong province, SE China and tectonic implications

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1 Introduction

During the late Mesozoic times, the SE China is characterized by extensive magmatism and mineralization. The widely distributed granitoids with different (I-, S- and A-) types have been inferred to be closely related to the large-scale polymetallic mineralization. The Nanling tungsten-tin polymetallic belt is endowed with considerable mineral resources. The recently discovered Tiantangshan Tin Polymetallic Deposit is located in the eastern area of the Nanling tungsten-tin polymetallic belt. The mineralization of the Tiantangshan Tin Polymetallic Deposit and the petrogenesis of ore-associated intrusions remains enigmatic. In this work, we have investigated two ore-associated intrusions in Tiantangshan Tin Polymetallic Deposit. We present the first detailed SHRIMP zircon U–Pb dating, major and trace element geochemical and Nd isotopic data for these two intrusions. These new data allow us to explore the origin of the intrusions and their geodynamic implications.

2 Geology and Petrology

Detailed field geological survey show that Tiantangshan tin polymetallic deposit is hosted in Late Jurassic volcanic-sub volcanic rocks. The major ore bodies mainly distribute in the top and the outer contact zones of the altered Tiantangshan quartz porphyries and the fractured alteration zone of volcanic rocks. The exploration pits have revealed the hidden Tiantangshan alkali-feldspar granite underneath the altered quartz porphyries. The Tiantangshan quartz porphyries are light grey with a typical porphyritic texture. Phenocrysts (0.8–5 mm, ~20-50%) include quartz and plagioclase. The matrix consists of quartz, plagioclase, biotite. They have experienced different degrees of alteration with plagioclases are commonly altered into sericites. Only the fresh quartz porphyries are discussed below. The Tiantangshan alkali-feldspar granite is composed of K-feldspar, quartz, plagioclase and biotite with a medium-grained granitic texture. Biotites are commonly anhedral and interstitial to both feldspar and quartz. Accessory minerals include magnetite, ilmenite, and zircon.

3 Geochronology

The SHRIMP zircon U–Pb dating show that the Tiantangshan alkali-feldspar granite was formed at 137.7 ± 2.4 Ma and the Tiantangshan quartz porphyry was emplaced at 138.4 ± 1.2 Ma.

4 Whole-rock Geochemistry

The Tiantangshan alkali-feldspar granites have high SiO_2 contents of 73.0–75.4 wt.%. They are mainly metaluminous to weakly peraluminous with alumina saturation index ASI [= molar Al_2O_3/ (CaO + Na_2O + K_2O)] from 0.92 to 1.11. These rocks have relatively high alkalis contents with the data plotting in the calc-alkaline and alkaline field, and have high K_2O contents with the data plotting mainly in the field of high-K calcalkaline series. They show similar Mg# [= atomic Mg/(Mg+Fe_T)] to pure crustal melts. These granites have relatively high HREE contents, but are depleted in Eu, showing notable negative Eu anomalies. They are depleted in Ba and Sr, with significant negative Ba and Sr anomalies. These granites

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have high Ga/Al ratios (>2.5) and high HFSE contents (>350ppm). The Tiantangshan quartz porphyry samples have lower SiO_2 and similar alkaline contents and Mg# with comparison to alkali-feldspar granites. They also have similar REE patterns and trace element patterns to the alkali-feldspar granites. They also have high Ga/Al ratios and high HFSE contents. The Tiantangshan alkali-feldspar granites exhibit relatively concentrated Nd isotopic compositions with ε_{Nd} (T) ranging from -3.8 to -5.8 while the Tiantangshan quartz porphyries also have similar ε_{Nd} (T) ranging from -4.1 to -5.1.

5 Origin of the Intrusions

The geological and geochemical characteristics of the Tiantangshan alkali-feldspar granites mentioned above strongly suggest an A-type affinity (e.g. Collins et al., 1982; Eby, 1992; Jiang et al., 2002; Whalen et al., 1987). The Tiantangshan quartz porphyries also show similar geochemical characteristics of A-type granites affinity. We thus attribute these granitoids as A-type granites.

The A-type granites could derive from either extensive fractional crystallization from basaltic magmas (e.g. Turner et al. 1992), or partial melting of specific crustal sources (e.g. Whalen et al. 1987). The Early Cretaceous Tiantangshan A-type granites have Nd isotopic compositions that are distinct from the Early Cretaceous mafic rocks. We thus exclude the first possibility. In contrast, similar Mg# of these A-type granites to pure crustal partial melts suggests that they were produced by partial melting of crustal rocks. Their Nd isotopic compositions further indicate that the Early Cretaceous A-type granites may have been generated by partial melting of both Precambrian metaigneous and metasedimentary basement.

The Tiantangshan A-type granites have relatively high HREE (Yb> 1.9 ppm) and Y (>18 ppm) and relatively low Sr (<400 ppm) and show remarkable negative Eu anomalies which require melting of a source rock within the stability field of plagioclase. These suggest that the source regions of these rocks are relatively shallow (~30 km).

6 Tectonic Implications

It is now generally accepted that the origin and evolution of Late Mesozoic magmatism are related to the subduction of the Palaeo-Pacific plate and different tectonic models have been suggested. More recently, Jiang et al. (2015) propose a new tectonic model involving repeated slab-advance-retreat of the Palaeo-Pacific plate on the basis of new geochronological and geochemical data of Late Triassic to Early Jurassic mafic rocks and Early Jurassic A-type granites in southern Jiangxi and western Fujian provinces. This repeated slab-advance-retreat model suggests the progressive slab rollback caused the regional extension gradually migrated from inland to the coastal area, forming the Early Cretaceous (141–124 Ma) A-type granite belts. Our new data presented in this paper further support this model. The origin of the Early Cretaceous Ti antangshan A-type granite suggests that since the beginning of Early Cretaceous a back-arc extension has developed along the Early Cretaceous A-type granite belt as a consequence of slab rollback (Jiang et al., 2015). Such an extension caused lithosphere thinning, accompanying asthenosphere upwelling. The underplating of basaltic magmas triggered partial melting of the thinned lower-crust rocks, forming the Early Cretaceous A-type granite belt include the Tiantangshan A-type granites.

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