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1 **The construction mechanism of the Neoproterozoic S-type Sanfang-Yuanbaoshan**
2 **granitic plutons in the Jiangnan Orogenic Belt, South China revealed by geological**
3 **observation, geochronology, AMS and Bouguer gravity modeling**

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15 **Abstract**

16 The Neoproterozoic S-type granitic plutons, distributed along the suture zone of the Yangtze
17 and Cathaysia blocks, play an important role in the tectonic evolution of the Jiangnan Orogeny.
18 However, few researchers had focused on the scientific issues on the physical construction process
19 of these plutons. Therefore, we carried out multidisciplinary approaches on the Sanfang and
20 Yuanbaoshan plutons in the western Jiangnan Orogenic Belt to figure out the construction
21 mechanism of these plutons. Zircon Hf and U-Pb dating indicates that the magma, originated from
22 the crustal partial melting, was crystallized at ca. 830 Ma. Field investigation shows that the
23 plutons are dome shaped, and the bedding/foliation of the country rocks, the Sibao group, conform

24 plutons boundaries and their inclinations gradually decrease away from the contact zone. A top-
25 to-the-E kinematic sense was observed in the eastern margin of Yuanbaoshan pluton. Both the
26 textural analysis and AMS measurement reveal primary magmatic and secondary general top-to-
27 the-W/NW post-solidus fabrics. The Bouguer gravity modeling reveals that the feeder zone
28 probably locates in the southern part of each pluton and these two plutons are connected at depth.
29 According to the primary magmatic fabric patterns, deep geometric shape as well as structural
30 features of the country rocks, we propose that crustal partial melting magma probably intruded
31 into the pre-existing mechanically weak (fold/fault) zone of the Sibao group, then lateral and
32 upward accreted to construct the dome-shape plutons. The timing and mechanism of the post-
33 solidus deformation are not well constrained, the interpretations are remain hypothetical.

34 **Keywords:** South China; Jiangnan Orogenic Belt; Neoproterozoic S-type granite; Anisotropy of
35 magnetic susceptibility; Bouguer gravity modeling

36 **1 Introduction**

37 Magmatic rocks are important constituents of the continental crust and good markers for the
38 crust evolution ([Castro, 2014](#); [de Saint-Blanquat et al., 2006](#); [Paterson, 2009](#)), and magmatic
39 activity plays a significant role in the crust-mantle interaction and recycling of crustal material
40 ([Faure and Pons, 1991](#); [Roman and Jaupart, 2016](#)). Therefore, it is essential to study the
41 magmatism to have a better understanding of the magmatic process and the crustal evolution.
42 Several aspects, such as: i) magma generation, ii) differentiation, iii) transport and ascent, and iv)
43 emplacement, must be distinguished in the magmatic evolution ([Glazner and Bartley, 2006](#)). The
44 magma emplacement is an important stage of the process as it is the only one that can be directly
45 investigated through field and laboratory studies. During the emplacement, some features observed
46 both in the pluton and country rocks embody the interaction between the magma fluids and

47 lithosphere as well as the mechanism of space accretion during the magma emplacement ([Paterson](#)
48 [et al., 2008](#)).

49 Previous studies showed that the magma intrusion are not only dominated by the physical
50 properties (i.e., magma composition, temperature, pressure and the rheology of the crust etc.), but
51 also controlled by syn-magmatic regional tectonic setting ([Caricchi, et al., 2007](#); [Castro, 1987](#);
52 [Castro et al., 2014](#); [de Saint-Blanquat et al., 2006](#); [Hutton, 1988](#); [Moyen et al., 2003](#); [Pitcher, 1979](#);
53 [Wei et al., 2016](#)). Consequently, deciphering the process of magma emplacement, i.e., (1) the 3D
54 structure of the pluton ([Cruden, 1988](#); [Mathieu et al., 2008](#); [O'Driscoll et al., 2006](#); [Stevenson et](#)
55 [al., 2007](#)); (2) granite internal fabrics ([Liu et al., 2018](#); [Tarling and Hrouda, 1993](#); [Wei et al., 2014](#));
56 (3) the magma flow pattern ([Clemens and Mawer, 1992](#); [Ernst and Baragar, 1992](#); [Moreira et al.,](#)
57 [2015](#); [Paterson, 2009](#)); (4) the thermal conditions and deformation of the granite and country rocks
58 ([Byerly et al., 2017](#); [de Saint-Blanquat et al., 2001](#); [Paterson et al., 1989](#); [Žák et al., 2007](#)), can
59 help to understand the evolutions of the granitic pluton and the continental crust.

60 S-type granite is considered as produced by partial melting and crystallization of Al-rich
61 rocks, such as orthogneiss and pelitic sedimentary rocks forming the lower to middle continental
62 crust. It is commonly accepted that peraluminous magma is a syn- to post-orogenic product formed
63 by the melting of the thickened orogenic root ([Chappell and White, 2001](#)). Moreover, S-type
64 granite may emplace in a post-orogeny setting (e.g., most of the post-orogenic plutons in the Early
65 Paleozoic orogen of SE China; [Song et al., 2015](#); [Wang et al., 2012b](#); [Yan et al., 2017](#)), and also
66 in an active continental margin (Cenozoic western Pacific; [Collins and Richards, 2008](#)).

67 In the Jiangnan Orogenic Belt (JOB), which marks the collision belt between the Yangtze and
68 Cathaysia blocks, the peraluminous granitic plutons sporadically crop out from east to west, such
69 as the Shexian, Xucun, Shiershan, Jiuling, Yuanbaoshan, Sanfang, Bendong and Fanjingshan

70 plutons (Fig. 1). A large quantity of work on the geochronology and geochemistry suggest that
71 these plutons are post-orogenic ones (e.g., Shu, 2012; Shu et al., 2019; Wang et al., 2013, 2014b;
72 Yao et al., 2014a, Zhang and Wang, 2016; Zhang et al 2013).

73 So far, rare studies have focused on the physical construction process of the S-type granite in
74 the JOB, however it is essential for understanding the process of the Jiangnan Orogeny. The
75 geological observation, anisotropy of magnetic susceptibility (AMS) and gravity are efficient ways
76 to decipher the construction process and deep geometric shape of the plutons (Liu et al., 2018). In
77 order to obtain a better knowledge of the Neoproterozoic Jiangnan Orogeny, studies on the
78 emplacement of the Neoproterozoic S-type granitic plutons along the JOB as well as their detailed
79 consideration of the pluton construction, syn-magmatic and syn (post)-tectonic settings are
80 necessary. Consequently, we choose the Sanfang-Yuanbaoshan plutons as the study targets to
81 decipher the evolution of the Jiangnan Orogeny.

82 **2 Geological setting**

83 **2.1 The Jiangnan Orogenic Belt (JOB)**

84 The JOB is a key tectonic element of the South China Block, representing the Neoproterozoic
85 NE–SW to E-W trending belt developed as a consequence of the amalgamation between the
86 Yangtze and Cathaysia blocks. The oceanic subduction of the Paleo-South China Ocean beneath
87 the Yangtze Block since ca. 1000 Ma (Shu et al., 2014, 2019; Wang et al., 2007; Yao et al., 2014b,
88 2019) was responsible for the formation of the Jiangnan magmatic arc, and followed by the
89 collision (or continental subduction) of the Cathaysia Block after its final closure (Shu, 2012;
90 Wang et al., 2012a). Groups of ultramafic, mafic magmatic, volcanic rocks, limestones, cherts and
91 turbidites are interpreted as ophiolites and dated from ca. 1000 Ma to ca. 840 Ma, distributing

92 along the suture zone (BGMRAH, 1982; BGMRJX, 1984; BGMRZJ, 1989; Shu et al., 2015, 2019;
93 Sun et al., 2017; Xia et al., 2018).

94 The Precambrian strata in the JOB are composed of the Sibao and Danzhou groups and their
95 equivalents. The Danzhou group unconformably covers the Sibao group. The unconformity
96 between these two groups indicates that an orogenic event took place before the sedimentation of
97 the Danzhou group and its equivalents. This collision resulted in essentially folding and weak
98 metamorphism (mainly under greenschist facies conditions) in the Sibao group and its equivalents
99 (BGMRGX, 1985; BGMRHN, 1988; Charvet, 2013; Shu, 2006, 2012). The tight NE-SW to N-S
100 striking folding and faulting are widely developed in the Sibao group and its equivalents in the
101 whole JOB resulted by the northwestward subduction of the Paleo-South China oceanic crust and
102 the subsequent collision of the Yangtze and Cathaysia blocks (Shu, 2012), whereas the structure
103 of the Danzhou group was characterised by broad and gentle folds with a weak metamorphism, or
104 even no metamorphism (BGMRGX, 1985; BGMRHN, 1988; Yao et al., 2014b).

105 In the JOB, the Sibao group was intruded by peraluminous granitic plutons dated at ca. 840-
106 815 Ma with a peak of 830 Ma (e.g., Bendong, Fanjingshan, Sanfang, Shexian, Shiershan, Jiuling,
107 Xucun and Yuanbaoshan plutons; Fig. 1; Guo et al., 1989; Shu et al., 1991, 1994, 2019; Xin et al.,
108 2017; Yao et al., 2014b). After the formation of the original South China continent, the Nanhua
109 intracontinental rifting developed at ca. 810 Ma–760 Ma by probably upwelling mantle magma
110 just ending the Jiangnan Orogeny (Li et al., 2003). The NE-SW striking Nanhua rifting was coeval
111 with the generation of bimodal igneous rocks in the Jiangnan and Cathaysia regions, including the
112 western Yunnan, northern Guangxi, northern Hunan, northern Jiangxi, northern Zhejiang and
113 Northern Fujian basins (Li et al., 2008; Shu et al., 2006, 2011; Wang and Li, 2003).

114 2.2 Sanfang-Yuanbaoshan granitic plutons and country rocks

115 The Sanfang and Yuanbaoshan granitic plutons are located in the western segment of the JOB
116 (Fig. 1), and show sub a N-S elongated elliptic shape with an area of ca. 1,000 km² and ca. 300
117 km², respectively, and an aspect ratio about 2:1 (Fig. 2).

118 These two granitic plutons both intruded into the Sibao group which is mainly composed of
119 bathyal to abyssal terrigenous arenaceous-argillaceous metasediments with bedded flysch, and
120 chaotic turbidity deposits with olistoliths (BGMRGX, 1985; Yao et al., 2014a). Previous studies
121 reveal that the crystallization age of these plutons ranged from 823 ± 5 Ma to 833 ± 6 Ma with
122 high Aluminium Saturation Index ranging in 1.15-1.40 (Yao et al., 2014b). Their geochemical
123 features indicate that the magma of Sanfang and Yuanbaoshan plutons were derived from
124 supracrustal source rocks (Wang et al., 2006). The widespread occurrence of tourmaline in these
125 plutons (Li, 1999) reveals that the granites are highly evolved and incorporated a significant
126 amount of fluids.

127 As for the deformation, Li (1999) proposed that all the granitic intrusions were deformed in
128 different degrees showing foliation with gneissic texture. Faults are developed in both plutons as
129 well as in their country rocks (Fig. 2), mainly striking in the NE-SW and N-S directions. Some
130 kilometer to meter- scale mafic and ultramafic blocks enclosed in the mudstone-sandstone of the
131 Sibao group crop out around the plutons. The well folded but low greenschist-facies
132 metamorphosed Sibao group is commonly recognized by the accretionary complex coeval with
133 the subduction of the Paleo-South China oceanic crust (Wang et al., 2014a; Zhou et al., 2009), and
134 recently work reveals that the upper Sibao group was deposited during the Yangtze-Cathaysia
135 continental collision (Yan et al., 2019).

136 The Danzhou group unconformably covers the Sibao group, with distinct differences in the
137 deformation style. It mainly consists of sandstone and mudstone featured by gentle folds with a
138 low grade metamorphism, or even no metamorphism (BGMRGX, 1985).

139 **3 Field observation and microscopic investigation**

140 In the field, we made observations on these two plutons and their adjacent country rocks as
141 much as possible in order to obtain maximal information on macroscopic features of rocks with a
142 large surface covering, and figured out their geological nature.

143 **3.1 Granitic plutons**

144 The Sanfang and Yuanbaoshan plutons stand at a varying elevation ranging from ca. 200 to
145 ca. 2000 meters above sea level (a.s.l.). These two porphyritic monzogranitic plutons are mainly
146 made up of quartz, K-feldspar, plagioclase, muscovite and biotite. Tourmaline and plagioclase
147 nodules can be observed in some outcrops where the monzogranite shows fine or coarse grain
148 facies (Fig. 2).

149 It is worthy to note that these two plutons are generally undeformed in the relatively lower
150 part though some deformation can be occasionally observed in contact zone, whereas deformed in
151 the upper part (generally above 700 meters a.s.l.). In our visited localities, all the massive and
152 undeformed granites are at the relatively low elevation (e.g., A51: 566m, A55: 317m, B14: 234m,
153 B19: 329m). These undeformed granites display magmatic textures with euhedral crystals of quartz,
154 feldspars and micas (Fig. 3A and 3B). The quartz grains show a slightly undulose extinction (Fig.
155 4A, 4B and 4C).

156 However, the most deformed granites crop out in the relatively higher part (e.g., A43: 993m,
157 A46: 983m, B08: 802m, B17: 837m). A consistent low angle ($\sim 25^\circ$) foliation is developed within
158 the deformed granites, dipping to the W and SW. Augen structure, gneissic structure and shear

159 band are common in this deformed part. The mineral and stretching lineations are developed by
160 elongated quartz grains, biotite and muscovite aggregates, and pressure shadows around the K-
161 feldspar megacrysts trending in the E-W direction, with the top-to-the-W kinematics (Fig. 3C).
162 Moreover, in the highly deformed granites, the quartz and muscovite are totally recrystallized and
163 show a preferred orientation. Myrmekites develop within the K-feldspars (Fig. 4D), indicating that
164 the granites have experienced dynamic metamorphism as the myrmekite is an exsolution of quartz
165 and plagioclase due to fluid circulation during deformation (Castle and Lindsley, 1993; Garcia et
166 al., 1996). And mica fishes from these two granitic plutons both show the top-to-the-W or -SW
167 kinematics (Fig. 4E and 4F).

168 **3.2 Country rocks**

169 The Sibao group is well exposed in the Sanfang-Yuanbaoshan area. Previous studies indicate
170 that the Sibao group was tightly folded with general N-S and NNE-SSW striking axes (BGMRGX,
171 1985). However, our investigation reveals that the structural occurrence of the Sibao group is also
172 accommodated to the shape of the pluton with generally outward dipping. The original
173 sedimentary bedding (S_0) and foliation (S_1) with moderate to steep angle mostly strike parallel
174 with the border of the Sanfang and Yuanbaoshan plutons (Fig. 2). Moreover, we can find that the
175 dip angle of the S_{0-1} gradually decreases as the distance away from the contact border (Fig. 3E and
176 3F). In our visited area, two hornfel outcrops with width of 20-30cm are found in the western and
177 eastern contact borders between the Sanfang pluton and Sibao group (Fig. 3D). The top-to-the-
178 downward and -outward deformations are founded in the contact zones in the northern margin of
179 the Sanfang pluton and eastern margin of the Yuanbaoshan one (Fig. 3K).

180 Previous studies also revealed a greenschist facies metamorphism for the Sibao group
181 (BGMRGX, 1985). Based on our macro-/microscopic observations, we found the degree of
182 deformation and metamorphism of the Sibao group varies greatly in different zones.

183 Similar to the phenomenon of *elevation vs metamorphism and deformation* within the granitic
184 plutons, in general, the degree of the metamorphism and deformation of the Sibao group seems
185 gradually increases from the lower part to the higher part, the field investigation revealed that: (i)
186 The Sibao group at the elevation below 200 meters mainly consists of sandstone and mudstone
187 and doesn't display metamorphism neither deformation (Fig. 3E and 3F); (ii) At the elevation of
188 ca. 200-700 meters, the degrees of the metamorphism and deformation are higher than those of
189 below the 200 meters. In this unit, the rocks mainly consist of slate and phyllite. The foliation (S_1)
190 transposed from the original sedimentary bedding (S_0) is rather scattily distributed, the lineations
191 are better developed with a sub E-W direction, meanwhile the textures reveal top-to-the-W
192 kinematics (Figs. 3G, 4G and 4H); (iii) For the Sibao group at the altitude higher than 700 meters,
193 the degrees of deformation and metamorphism are much more developed with respect to the former
194 lower parts. The original beddings (S_0) are well folded and even overturned as recumbent fold (S_1),
195 with the axis gently plunging to the north (Fig. 3H). However, the later foliations S_2 consistently
196 dip to the W with angles of 15-45°, with consistently oriented sub E-W lineations (Fig. 3I).
197 Moreover, mylonite and ultramylonite of the Sibao group were observed at the altitude of 1000-
198 1600 meters, with horizontal foliation and E-W directed lineation (Fig. 3J).

199 **4 Magma crystallization age and Hafnium isotopic analysis**

200 The magma U-Pb crystallization age and geochemical features of the Sanfang and
201 Yuanbaoshan plutons have been investigated since the past twenty years (e.g., Li, 1999; Yao et
202 al., 2014b). With the recent development of analysis techniques, we have collected two dating

203 samples, A37 (1403) and B13 (2024) (Figs. 2 and 7), to obtain constraints on the age of these
204 plutons.

205 **4.1 Zircon U-Pb age**

206 Heavy liquid and magnetic techniques are used for separating the zircon grains, which were
207 afterward mounted in epoxy resin, polished and coated with gold. The zircon U–Pb isotopes were
208 analyzed at the Testing Center of Shandong Bureau of China Metallurgical Geology Bureau
209 (TCSBCMGB), using a ThermoX2 ICP–MS connected to a GeoLas Pro 193 nm laser ablation
210 system. The detailed measurements and data calculation can be referred in Liu et al. (2010).

211 Cathodoluminescence (CL) images of zircons were acquired by using a JEOL JXA8230
212 electron probe microanalyzer at TCSBCMGB. Typical CL images of zircons are showed in Figure
213 5A and 5B, revealing that the grains are characterized by oscillatory zoning. Moreover, the high
214 Th/U values (0.35 in average) indicate the zircons are magmatic originated (Hoskin and
215 Schaltegger, 2003).

216 All of the U–Pb ages are listed in Table 1 and graphically displayed in Figure 5. Thirty seven
217 ages are obtained for each pluton (Sanfang and Yuanbaoshan), yielding the range of 814-1150 Ma
218 and 827-2720 Ma, respectively (Fig. 5D and 5G). However, most of the data provide ages between
219 820 to 850 Ma (Fig. 5E and 5H), with weighted mean $^{206}\text{Pb}/^{238}\text{U}$ ages of 830 ± 2 Ma and 830 ± 5
220 Ma, respectively (Fig. 5F and 5I). Some ages older than 2.0 Ga may indicate the existence of
221 Paleoproterozoic rocks below the plutons. These grains may be xenocrystals involved in the
222 granitic magma.

223 **4.2 Zircon Hf isotopic analysis**

224 The zircon Hf isotopic model age tells a minimum age for the material from which the zircons
225 sourced. In order to have an idea about the evolution of the zircons, we carried out the analysis on

226 the Zircon Hf isotopes by Neptune MC–ICP–MS at Nanjing University. For calculating the model
227 ages of the zircons, we used the standard zircon 91500 as external sample with a $^{176}\text{Hf}/^{177}\text{Hf}$ value
228 of $0.282300 \pm 8 (2\sigma)$. During analysis, the $^{176}\text{Lu}/^{177}\text{Hf}$ of average crust is 0.015. Lu decay constant
229 of 1.865×10^{-11} was applied for the calculation of the initial $^{176}\text{Hf}/^{177}\text{Hf}$ values (Scherer et al., 2001).
230 The isotopic ratios of the $^{176}\text{Hf}/^{177}\text{Hf}$ and $^{176}\text{Lu}/^{177}\text{Hf}$ for the chondrite and depleted mantle are
231 0.282772 and 0.0332, 0.28325 and 0.0384, respectively (Blichert–Toft and Albarede, 1997).

232 About half of the U–Pb dated zircons from the Sanfang granite were selected for in–situ Hf
233 isotopic analysis that performed where used for U–Pb dating. All of the Hf isotopic analytical
234 results and $\epsilon\text{Hf}(t)$ versus U–Pb age diagram are presented in Table 2 and Figure 5C, respectively.
235 The sample of A37 (1403) shows negative $\epsilon\text{Hf}(t)$ values, ranging from -1.89 to -11.15, with an
236 average of -4.63. Correspondingly, the two-stage model ages chiefly plot on 1828–2143 Ma, while
237 separately project at 2418 Ma (Fig. 5C). The results suggest that such granite sample was derived
238 from some Paleoproterozoic basement rocks. Moreover, all the $\epsilon\text{Hf}(t)$ values are under the
239 Chondritic uniform reservoir (CHUR) line, which indicates that little or no mantle component has
240 been involved into the source rock during the partial melting and magma ascent.

241 **5 Rock magnetic investigation and results**

242 **5.1 Field sampling**

243 A total of 352 cores from 55 sites were sampled for the AMS study, 35 and 20 for the Sanfang
244 and Yuanbaoshan plutons, respectively, along all possible roads with an interval of ~2 km (Fig.
245 7). Each site of fresh outcrop covers several tens of square meters and at least six cores are drilled
246 with an interval of 3 to 4 meters between each other from each site.

247 **5.2 Magnetic mineralogical analysis**

248 In order to define the magnetic susceptibility carriers in our samples, we have carried out
249 following methods: (1) magnetic hysteresis loop characterization by using a vibrating
250 magnetometer in the Laboratoire de Paleomagnétisme of the Institut de Physique du Globe de
251 Paris (IPGP); (2) isothermal remanence magnetization characterization with an IM30 pulsed
252 magnetizer and a JR5 spinner magnetometer at the Institut des Sciences de la Terre d'Orléans
253 (ISTO); (3) thermomagnetic characterization using a KLY5 kappabridge coupled with a CS3
254 furnace at ISTO; and (4) scanning electron microscope (SEM) with the ZEISS MERLIN Compact
255 for the minerals at ISTO.

256 A total of nine samples were chosen for magnetic mineralogical analysis, and the
257 representative results are presented in **Figure 6**. The hysteresis curves (**Fig. 6A**) present similar S-
258 shaped hysteresis loops with significant difference between the corrected and uncorrected curves,
259 suggesting that the main magnetic susceptibility carriers could be both ferromagnetic and
260 paramagnetic minerals. Rapid saturation of isothermal magnetic remanence at about 200 mT is
261 featured by Sample A46 (**Fig. 6B**), indicating the existence of ferromagnetic minerals with low
262 magnetic coercivity. However, for Sample A48, the gradual saturation until to 1.0 Tesla (**Fig. 6B**)
263 highlights that the existence of ferromagnetic minerals with high magnetic coercivity. The rates of
264 saturation of Samples A65 and A67 are in-between A46 and A48 (**Fig. 6B**), revealing both the
265 weak and high coercive ferromagnetic minerals in the granites. The thermomagnetic
266 measurements on Samples A10 and A23 yield a quick decrease of the magnetic susceptibility at
267 about 580°C (A10 in **Fig. 6C**) and continuous drop until to 680°C (A23 in **Fig. 6C**), which suggest
268 the existence of (titano) magnetite and hematite. Moreover, these two samples show a continuous
269 rise of magnetic susceptibility in the cooling stage (owing to oxidation reactions) revealing that a

270 significant mineral transformation occurred during the heating, e.g. iron sulfide to iron oxide (Fig.
271 6C). The SEM investigation reveals that the existence of titanomagnetite with the mass fraction of
272 the TiO₂ ranged from 45.51% to 50.65%, and they are commonly intergrown or partly enclosed
273 along the cleavage and boundary of biotite (Fig. 6D). The Day-plot of hysteresis parameters is
274 presented in Figure 6E, showing that (titano) magnetite of the measured samples drop in the
275 multidomain zone (e.g., Dunlop, 2002). It indicates that the major (elongated) axis of the magnetic
276 susceptibility ellipsoid can be correlated to the major morphological axis of minerals (e.g.,
277 Borradaile and Henry, 1997).

278 Consequently, the carriers of magnetic susceptibility are composed by ferromagnetic
279 minerals, for instance, multidomain (titano) magnetite and hematite, and of paramagnetic minerals,
280 such as biotite, muscovite and feldspar. According to Rochette et al. (1992), the magnetic fabrics
281 of these minerals are comparable to the petrographic ones. Therefore, the AMS measurements will
282 be an effective way to obtain the information on the petrofabrics of granite, so that to decipher the
283 granitic magma emplacement (Martín-Hernández et al., 2004).

284 5.3 AMS parameters

285 The measurements of AMS were performed with a KLY5 Kapprabridge at ISTO. A total of
286 352 (228 and 124 from the Sanfang and Yuanbaoshan, respectively) specimens with 2.5 cm in
287 diameter and 2.2 cm in length from 55 sites were prepared. Detailed information can be found in
288 Table 3. The mean bulk magnetic susceptibility (K_m) of each sampling site from the Sanfang and
289 Yuanbaoshan plutons varies from 27.5 to 133.0x10⁻⁶ SI and 32.7 to 197.0x10⁻⁶ SI, respectively
290 (Fig. 8A, 8B and 8D). The site-mean value of the anisotropy degree of the magnetic susceptibility
291 (P_j) ranges in [1.017, 1.156] and [1.009, 1.172] for the Sanfang and Yuanbaoshan plutons,
292 respectively (Fig. 8B, 8C and 8E). The site-mean of shape parameter (T) ranges in [-0.384, 0.912]

293 and [-0.384, 0.817] for the Sanfang and Yuanbaoshan, respectively (Fig. 8C and 8F). No obvious
294 correlation of P_J can be observed with K_m (Fig. 8B) and elevation (Fig. 8C), however, the P_J and
295 T are positively related (Fig. 8F). Moreover, P_J and T values both increase with the rising of
296 elevation (Fig. 8D and 8E), which is illustrated in the cross section of Figure 8H.

297 **5.4 AMS results**

298 The AMS results for all sampling sites are given in Figure 7. Differences are obvious and
299 significant between the undeformed and deformed granites according to the features of their
300 magnetic foliation and lineation, degree of anisotropy and shape parameter (Figs. 7 and 8). In our
301 visiting area, the undeformed granites with magmatic fabrics can be roughly partitioned as NW
302 and SW borders, S part, and SE border of the Sanfang pluton, and SE part and NE border of the
303 Yuanbaoshan pluton, meanwhile in order to read easily, these zones are also shown by Arabic
304 numbers 1, 2, 4 and 6, respectively in Figure 8. In the NW and SW borders of the Sanfang pluton
305 (Zone 1), the magnetic foliations consistently dip to the E with the inclination ranged from 33° to
306 79°, but the magnetic lineations span from N to S with a relative concentration on the SE dipping.
307 Almost all the specimens show P_J value lower than 1.1 and magmatic fabrics with even shape
308 parameters between oblate ($T > 0$) and prolate ($T < 0$). In the S part of the Sanfang pluton (Zone 2),
309 the magnetic foliations mainly dip to the W with inclinations varying from 31° to 63°, and
310 magnetic lineations span from ~230° to 330°, with a relative concentration in nearly E-W directed.
311 94% of the specimens have P_J values lower than 1.1 and the ratio between the oblate and prolate
312 shapes is about 2:1. The SE border of the Sanfang pluton (Zone 4) displays the gentle magnetic
313 foliations with dispersed magnetic lineations. All the P_J values are lower than 1.1 and the ratio of
314 shape parameter between the oblate and prolate is about 2:1. Moreover, in the SE part and NE
315 border of the Yuanbaoshan pluton (Zone 6), the strikes of the magnetic foliations mainly dip SW

316 with relative steep inclinations from 35° to 76° , and the magnetic lineations are essentially SSE.
317 Most of the P_J values are lower than 1.1, and the ratio between the oblate and prolate shapes is
318 about 1:1.

319 However, the deformed granites are recognized in the Central to NE Sanfang pluton and in
320 the Central to NW Yuanbaoshan pluton (Zones 3 and 5, respectively; Fig. 8). In the Central to NE
321 part of the Sanfang pluton (Zone 3), the P_J values, with the range from 1.041 to 1.187, are higher
322 than other zones in the Sanfang pluton. 37% of the specimens with the P_J value higher than 1.1,
323 suggesting that the magnetic fabric could have been modified in the post-solidus state (Tarling and
324 Hrouda, 1993). The magnetic foliations gently dip to the SW, with coherent NEE-SWW directed
325 magnetic lineations. More than 95% of the shape parameters of specimens are greater than zero,
326 i.e., oblate shape. Similarly, the Central to NW part of the Yuanbaoshan pluton (Zone 5) highlights
327 P_J values ranging from 1.017 to 1.183. 57% of sites in this zone provide P_J values higher than 1.1,
328 and almost all of these sites present positive values for shape parameter, i.e., oblate shape. They
329 show moderate magnetic foliations dipping ranging from 4° to 27° , with consistent NW-SE
330 directed magnetic lineations.

331 Consequently, the AMS results of these two plutons can be divided into two aspects, namely,
332 the magmatic fabric and tectonic one, corresponding to the undeformed and deformed granites,
333 respectively (Figs. 7 and 8). These two parts seem to be qualitatively distinguished at the
334 approximate altitude of 600-800m. To simplify the description, we utilize the average altitude line
335 of 700m as the separatrix between the undeformed and deformed granites.

336 Moreover, it is worth noting that a few samples (about less than 5 per cents) show the
337 incoherent results with respect to above description. The samples B01, B03 and B04 are in the
338 relative low elevation (~500m), but their petro/magnetic fabrics seem like a tectonic origin, with

339 obvious sigmoid feldspar and high P_J values ranges in [1.064, 1.079] (Fig. 7), therefore, these
340 localities have been classified to Zone 5. Meanwhile, the samples A48, A60 and A61 are in the
341 relative higher part, but displaying massive granite and lower P_J values ranges in [1.026, 1.042]
342 compared to the ductilely deformed granites (Figs. 7 and 8G), hence, these localities are
343 categorized in Zone 1. Furthermore, the two massive granite samples A33 and B11 display
344 different magnetic features with respect to the adjacent ones, showing vertical magnetic foliations
345 and gentle lineations which are all parallel to the boundary between the granitic plutons and
346 country rocks (Fig. 9).

347 In order to have an integrated view of features of the magnetic foliations and lineations, a
348 synthetic distribution map of magnetic foliations and lineations are presented in Figure 9.
349 Generally, the magnetic foliations and lineations can be separated into two parts as previously
350 documented, respectively. For the magmatic fabrics, the predominant strike of the foliation of the
351 Sanfang and Yuanbaoshan plutons is sub N-S directed, and the secondary group is sub E-W
352 directed. Two major groups of lineations are identified in the Sanfang pluton, namely the NEE-
353 SWW and NNW-SSE directed ones. And the distinct magmatic lineations are sub NNW-SSE
354 directed in the Yuanbaoshan pluton. However, for the tectonic fabrics, a set of consistent gentle
355 SW dipping magnetic foliation and gently SWW directed magnetic lineation is recognized in the
356 Sanfang pluton. Whereas dispersed magnetic foliations with gentle inclination are identified in the
357 deformed granite in the Yuanbaoshan within a group of gently NW directed magnetic lineations
358 (Fig. 9).

359 **6 Gravity modeling**

360 The regional gravity anomaly embodies the density heterogeneity of the underground, hence,
361 the proper decipherment of the gravity anomaly data would help us to know the construction of

362 the geological bodies in the deep (Martelet et al., 2013), especially, the intrusive geological bodies
363 usually present obvious density contrast with the wall rocks. Consequently, the gravity modeling
364 method has been applied to deduce the Sanfang and Yuanbaoshan pluton shapes within the Sibao
365 strata. The Bouguer gravity anomaly map for the Sanfang-Yuanbaoshan area is acquired at the
366 China Geological Survey. The Digital Elevation Model (DEM) for the Sanfang-Yuanbaoshan area
367 is obtained from the CGIAR-CSI database.

368 We collected both the granites and country rocks for the density measurements, which have
369 been carried out at the University of Nanjing by using the Matsuhaku Electronic Densimeter GH-
370 300. For each sample, we measured twice and took the average value at a precision of 0.001g/cm³.
371 Detailed density data for the samples from the granites, Sibao group, Danzhou group and Sinian
372 strata can be referred in Table 4. As the post Sinian strata is poorly exposed, we take it as same as
373 the density of the Sinian strata. Besides, the density of the mafic-ultramafic block is referred to the
374 geological survey of the Guangxi province (BGMRGX, 1985). The density value of 2.670g/cm³
375 for the background in the study area is referred in CRUST 1.0.

376 In the Bouguer gravity anomaly data, both the short and long wavelength signals are involved,
377 which reflect the surface and deep signatures, respectively. Thus the long wavelength signals
378 should be removed for the purpose of getting appropriate gravity anomaly information just induced
379 by the sub-surface geological units. The Butterworth Low-Pass Filter is applied for removing the
380 long wavelength signals with cut-off wavelengths of 10, 20, 30... to 130, 140 and 150 kilometers.
381 Through the comparison of the residual gravity anomaly and geological maps, we found that the
382 residual gravity anomaly with the cut-off wavelength of 130 km is the most suitable one, which
383 matches best with ground surface features (Fig. 10).

384 The selected residual Bouguer gravity anomaly map shows two obvious negative anomaly
385 centers in the central and southern parts of the Sanfang and Yuanbaoshan plutons, respectively
386 (Fig. 10). The negative anomaly regions for these two plutons are both N-S directed, which concur
387 the geometry of these two plutons. According to the residual Bouguer gravity anomaly data and
388 regional tectonic features, five profiles are chosen for gravity modeling, two of them (WE1 and
389 WE2) are perpendicular to the regional tectonic lines, and three (NS1, NS2 and NS3) are parallel
390 with the regional structures.

391 Five interpreted profiles are presented in Figure 10. Their deep structures are modelled with
392 the residual Bouguer gravity anomaly data, however, the surface contact relationship between each
393 unit is depicted according to the field observations and geological maps (BGMRGX, 1985).
394 According to the Bouguer gravity modeling along these profiles, we can characterize these two
395 plutons as following: (1) Negative gravity anomalies are N-S long axis orientated within the Sibao
396 group; (2) The roots of the granitic plutons are presented in a N-S orientated dyke shape; (3) In the
397 E-W direction, two plutons are in a tongue shape; (4) For the Sanfang pluton, the deepest root is
398 located in its southern part, and the depth is progressively decreased northwards with the
399 shallowest depth of ca. 0.5-1 km in its northern part; (5) For the Yuanbaoshan one, the thickest
400 part is situated in the central pluton; (6) The Sanfang and Yuanbaoshan plutons seem to be
401 connected in the deep.

402 **7 Discussion**

403 **7.1 Origin of the magma and its crystallization age**

404 Numerous researches have studied the petrogeneses and tectonic settings of the
405 Neoproterozoic granites in the JOB, the Neoproterozoic S-type granitic plutons in the JOB have
406 been dated with U-Pb crystallization ages ranged from 840 to 815 Ma, peaking at ca. 830 Ma (e.g.,

407 Wang et al., 2006; Wu et al., 2006; Xue et al., 2010; Zhong et al., 2005). Besides, these plutons
408 are characterised by the high Aluminium Saturation Index ranging from 1.15 to 1.40 (Yao et al.,
409 2014b and references therein) and low initial ϵNd values from -4.8 to -7.6 with high enrichment in
410 Rb, K and Th elements (Li, 1999). Thus the geochemical features indicate that the granites were
411 sourced from supracrustal rocks (Wang et al., 2006).

412 In this study, several methods are carried out for deciphering the origin of the magma.
413 Petrologically, the granite samples are K-feldspar megacryst rich (Fig. 3C). Structurally, the
414 cathodoluminescence (CL) images (Fig. 5A and 5B) show zircons with clear oscillatory zoning,
415 revealing the typical feature of zircons from acidic magma. Isotopically, moreover, all of the $\epsilon\text{Hf}(t)$
416 values are under the CHUR line (Fig. 5C), suggesting the melting of magma with little or even no
417 mantle components. Consequently, we suggest the granites of the Sanfang and Yuanbaoshan
418 plutons were generated by the partial melting of crustal materials, furthermore, the relatively
419 homogeneous lithological features of these granitic plutons may suggest that the magma was
420 derived from single component within the chamber.

421 Moreover, the new zircon results from the Sanfang and Yuanbaoshan granites provide the
422 mean ages of these two plutons at 830 ± 2 Ma and 830 ± 5 Ma, respectively (Fig. 5F and 5I), which
423 further indicates the magma crystallized at ca. 830 Ma. Few zircon grains give ages older than 2.0
424 Ga (Fig. 5G), indicating that a Paleoproterozoic basement probably exists below the upper crust
425 in this area, and these old zircons were captured during the magma ascent. Furthermore, the Hf
426 isotopic analyses show a group of two-stage model ages at ca. 1800–2400 Ma, which suggest the
427 possible existence of Paleoproterozoic rocks beneath the JOB.

428 **7.2 Acquisition of magnetic fabrics**

429 According to macro/microscopic observations and AMS study, the surveyed areas in the
430 Sanfang and Yuanbaoshan plutons can be divided into two fabric domains, namely, the sub-solidus
431 (or magmatic) and post-solidus (or solid-state) ones (Figs. 8 and 9).

432 The magmatic domain concerns the zones with the elevation below ~700 meters a.s.l., in this
433 domain, most of the granites are macroscopically quasi isotropic (Zones 1, 2, 4 and 6 in Fig. 8G).
434 Meanwhile, relatively coherent, magnetic fabrics with N-S to NNE-SSW striking lineations and
435 eastward and westward dipping foliations have been observed for the Yuanbaoshan pluton,
436 however, relatively dispersed lineations with general E-W and N-S dipping foliations for the
437 Sanfang pluton. The microscopic investigations show that quartz grains are euhedral with slightly
438 undulose extinction (Fig. 4A and 4B), however, the biotite grains in the granite do not show any
439 post-solidus deformation (Fig. 4B). These evidence suggest the granites have not suffered
440 significant post-solidus deformation. Furthermore, 96% of the P_J values in this domain lower than
441 1.1, which indicates that the magnetic fabrics were probably acquired during the magma
442 crystallization (Borradaile and Henry, 1997). Therefore, we propose that the magnetic fabrics in
443 this domain are primary ones, i.e. without post-solidus overprint due to post-emplacement
444 geological events. The shape parameters indicate both oblate and prolate shapes with equivalent
445 proportion, which indicates that the magnetic foliation and lineation were almost equally
446 developed, thus we may propose that the original magma probably flowed without significant
447 influence of a regional tectonics (Tarling and Hrouda, 1993).

448 On the contrary, in the post-solidus domain (Zones 3 and 5 in Fig. 8G) at altitudes above
449 ~700m a.s.l., the granites are foliated with augen gneissic structures and shear bands. Microscopic
450 studies reveal that the quartz grains are mostly recrystallized as neograins with serrated boundaries,

451 showing the evidence of high temperature and high strain deformation. A top-to-the-W kinematics
452 is macroscopically documented by the sigmoidal augen structure and shear bands, and
453 microscopically by mica fish and pressure shadows. In addition, the P_J values of this zone are
454 generally higher than 1.1, i.e., higher than those in the magmatic domain, suggesting that the
455 magnetic fabrics were acquired after the magma crystallization. Moreover, it is worthy to note that
456 almost all the shape parameters for the specimens in this domain are greater than zero (Fig. 8G),
457 indicating the planar magnetic fabric is more developed than the linear magnetic one probably due
458 to the deformation posterior to the crystallisation. Thus, the evidence above reveals that the
459 magnetic fabrics of this domain are secondary, i.e., the synmagmatic ones are overprinted.
460 However, the formation time of these post-solidus fabrics is not yet constrained, they might have
461 been developed during the later stage of the magma emplacement or recrystallized during regional
462 tectonic events that post-dated the plutons emplacement (Tarling and Hrouda, 1993). As this is out
463 of the scope of this study, the possible hypotheses for this ductile deformation will not be discussed
464 in detail in this text.

465 **7.3 Mechanism of the magma emplacement and space creation**

466 In this section, we concentrated on the lower part (primary magmatic fabrics) of the plutons
467 and their wall rocks to decipher the magma emplacement process of the Sanfang and Yunabaoshan
468 plutons, using our macro/micro observations, geochronological results, fabric measurements,
469 gravity modelling as well as the previous data.

470 **7.3.1 Sanfang pluton**

471 The Sanfang pluton is elliptic shaped in the N-S long axis. Previous geological survey reveals
472 that both of the granitic plutons and their country rocks are cut by the sub N-S directed faults,

473 which were probably generated in the Neoproterozoic period and reactivated in the Paleozoic or
474 in the Mesozoic (Fig. 2).

475 Our field investigation indicates that the bedding of the Sibao group close to the Sanfang
476 pluton conform the geometry of the pluton, the original sedimentary bedding (S_0) and foliation (S_1)
477 are nearly parallel with the border of the granite, suggesting a dome shaped pluton (Fig. 2).
478 Moreover, the dip angle of the S_{0-1} gradually decreases as the strata away from the contact border
479 (Fig. 3E and 3F). At the exposure level, the Sanfang pluton seems having rarely heated the country
480 rocks with no evidence for obvious thermal aureole, and hornfels have been only observed in two
481 localities in the contact boundary (Fig. 3D), with length 3~5m by width 20~30cm. This means that
482 the amount of heat was not so large and thus we can infer that the first magma injection was
483 probably in a small volume. It probably reveals that the magma injections took place though multi
484 episodic injections but with a small magma volume at each injection, which could be referred to
485 magma pulse amalgamation (Fig. 11; de Saint-Blanquat et al., 2006; Horsman et al., 2005).

486 In the NW and SW borders of the Sanfang pluton (Zone 1), the magnetic foliations dip E-
487 wards with moderate dipping angles ($31-60^\circ$), whereas the magnetic lineations in this zone show
488 two direction groups, i.e., sub E-W plunging with steep angles ($61-90^\circ$) in the southern part, and
489 N-S plunging with gentle angles ($0-30^\circ$) in the northern part (Fig. 9). Moreover, in the southern
490 part of the Sanfang pluton (Zone 2), the foliations dipping W-wards with steep angles and mainly
491 W-dipping lineations may imply that the magma dominantly flowed quasi vertically and accreted
492 in the E-W direction. Furthermore, the magnetic foliations dip SE/SW-wards with moderate angles,
493 and the magnetic lineations generally show a sub E-W preferred orientation in the SE border of
494 the Sanfang pluton (Zone 4, Figs. 8 and 9).

495 From the integrated results, it is obvious that the magmatic foliations of the Sanfang pluton
496 can be roughly distinguished as two sets, namely, the sub N-S striking (major) and sub E-W
497 striking (minor). Meanwhile, the orientations of the magmatic lineations seem more scattered (Fig.
498 9).

499 The residual Bouguer gravity anomaly data show that the Sanfang pluton is also N-S
500 elongated at depth, and reveal that the root of the Sanfang pluton is located in its southern part.
501 And the interpreted profile NS1 suggests that the thickness of the Sanfang pluton decreases
502 northwards (Fig. 10). From the unravelled profiles WE1 and WE2, moreover, the dyke shaped
503 channels seem to be characterized in the pluton.

504 **7.3.2 Yuanbaoshan pluton**

505 The geometry of the Yuanbaoshan pluton is N-S elongated with an aspect ratio of 2:1. The
506 field observation shows that the pluton geometric shape also well affects the occurrence of the
507 country rocks of the Sibao group, i.e., the bedding of the sedimentary rocks follows the shapes of
508 the pluton (Fig. 2). This appearance seems becoming weaker leaving away the pluton. The sigmoid
509 quartz vein within the Sibao group locates to the east of the Yuanbaoshan pluton might be
510 interrelated with the ductile shearing during the magma emplacement since such top-to-the-E
511 kinematic is rarely developed in the study area except in the contact area between the eastern
512 Yuanbaoshan pluton and its country rock (Fig. 3K). In the SE part and NE borders (Zone 6) of this
513 pluton, the strikes of the magmatic foliations are principally NNW-SSE directed with steep and
514 even vertical inclinations. And the magmatic lineations are mostly sub N-S directed and few NW-
515 SE directed with gentle dipping angles (Fig. 9), suggesting that the magma might vertically ascend
516 and mainly horizontally flow in the sub N-S direction in these parts. Moreover, two samples of
517 B02 and B11, close to the boundary between the Yuanbaoshan pluton and Sibao strata, display

518 foliation with moderate to vertical inclination, and gentle lineations which parallel to the boundary
519 of country rocks. It may suggest that the magma probably flowed along the boundary of the country
520 rocks (Fig. 11).

521 Moreover, the residual Bouguer gravity anomaly yield that the root of the pluton is located in
522 the central to southern part (Fig. 10). Similar to the case of Sanfang pluton, the inferred profiles
523 NS2 and NS3 suggest that the thickness of pluton is slightly decreasing from south to north, and
524 the profiles WE1 and WE2 suggest that the dyke shaped channels seem alike also within the
525 Yuanbaoshan pluton.

526 **7.3.3 Construction processes of the two plutons**

527 Following observations and results may help to understand the pluton construction process:

528 1. the strata surrounding the pluton strike parallel to its border with progressive decrease of the
529 bedding inclination; 2. magnetic fabric patterns are characterised by principal sub N-S striking
530 foliation and partial sub E-W ones with relatively dispersed lineations for the Sanfang pluton and
531 sub N-S directed ones for the Yuanbaoshan pluton; 3. gravity modelling reveals a thick ‘root’
532 located in the central to south part of the plutons with possible N-S directed dyke-shaped channels.

533 By integrating the above phenomena, we propose that the magma probably made its
534 upwelling into the Sibao group in the central to southern part of the plutons through dyke-shaped
535 channels, probably resulted by the pre-existing abundant and large-scale folds/faults within the
536 Sibao group, and laterally pushed the country rocks outwards. Due to probably the shape of pre-
537 existing structures, i.e. N-S oriented folds/faults, the magma dominantly flowed north-southwards
538 to construct the tongue- and/or sill-shaped plutons. Meanwhile, the granitic bodies were
539 progressively accreted in sub E-W direction to form the principal sub N-S oriented foliation.
540 Therefore, the N-S flow of magma and E-W accretion of pluton seem likely forming two dome

541 shaped plutons (Fig. 11). Nevertheless, the depth of emplacement is unclear and worthy for future
542 investigation.

543 **7.4 Tectonic implications and perspectives**

544 S-type granitic plutons are interesting geological markers to understand the tectonic process,
545 numerous such plutons are distributed along the JOB. However, their tectonic setting is still hotly
546 debated in the past decade. Some scholars suggested that the peraluminous plutons were generated
547 and made their intrusion during the amalgamation of the Yangtze and Cathaysia blocks, i.e., the
548 syn-orogenic stage, while considering the coeval mafic rocks dated at ca. 850-830 Ma (Ding et al.,
549 2008; Zhou et al., 2004). Nevertheless, some others hold the view that the granitic plutons were
550 formed at the post-orogenic stage (Wang et al., 2013; 2014b; Yan et al., 2019; Zhang et al., 2013,
551 2016). These suggestions are, however, proposed only on the basis of the geochronological logic,
552 without direct geological and physical evidence.

553 In this study, the field observations show some pluton emplacement related deformation in
554 the country rocks, but no any evidence for a syn-magmatism regional scaled tectonic deformation.
555 The primary magmatic fabrics in both plutons seem having been acquired in a regional tectonic
556 free environment. Thus we propose that the crustal partial melting magma in the western Jiangnan
557 area might be produced by the thickened crust and emplace into the Sibao group during a period
558 of tectonic quiescence, in other words, the S-type granitic magma emplacement probably signifies
559 the ending stage of the Jiangnan Orogeny.

560 However, the timing and mechanism of the top-to-the-W post-solidus deformation
561 distinguished by the macro-/micro observations, and AMS study is still poorly studied. Two
562 possible hypotheses are supposed, one is that the deformation occurred during the magma intrusion
563 at ca. 830 Ma, whereas the other one is that it maybe caused by the Paleozoic or Mesozoic tectonic

564 events. However, the latter one is puzzled because of the regional deformation/metamorphism is
565 not yet recognized in the Jiangnan region (Shu, 2012 and references therein). In order to solve
566 these scientific issues, detailed field work on the regional deformation as well as the
567 geochronology study, e.g., Ar-Ar dating, should be carried out in the further research.

568 **8 Conclusions**

569 Through this multidisciplinary study, the emplacement process and tectonic setting of the
570 Neoproterozoic S-type Sanfang-Yuanbaoshan granitic plutons in the JOB can be concluded as
571 following:

572 (1) The magma of the plutons sourced from the partial melting of crustal material, and
573 crystallized at ca. 830 Ma;

574 (2) Magnetic/petrographic fabrics can be divided into two groups, namely, a primary sub-
575 solidus, or magmatic, fabric developed during the pluton emplacement; and a secondary post-
576 solidus, or solid-state, one related to a still uncertain tectonic process;

577 (3) The crustal partial melting magma probably intruded into the pre-existing mechanically
578 weak (fold/fault) system in the Sibao group through dyke-shape channels, and afterwards
579 dominantly flowed north-southwards to construct the tongue- and/or sill-shaped plutons,
580 meanwhile, the granitic bodies were progressively accreted in sub E-W direction to form two dome
581 shaped plutons;

582 (4) The intrusion of the S-type granitic magma probably occurred in a regional tectonic free
583 environment, the emplacement probably marked the latest stage of the Jiangnan Orogeny.

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869 **Figure captions**

870 Figure 1. Simplified tectonic map of the South China Block.

871 Figure 2. Geological sketch map of the Sanfang-Yuanbaoshan area with a NW-SE cross-section.

872 For the cross-section, the contact relationship between each geological unit is depicted
873 according to the field observations, however, the deep structure of the profile is inferred
874 from the gravity modeling. Note that the vertical scale is exaggerated in order to show
875 more details.

876 Figure 3. Representative field photos in the Sanfang-Yuanbaoshan area, with the geographic
877 localities in the sketch map. (A) Massive granite in the Sanfang pluton; (B) Massive
878 granite in the Yuanbaoshan pluton; (C) Foliated porphyritic granite with the top-to-the-
879 W kinematics; (D) Hornfel between the Sanfang pluton and Sibao group; (E) Sibao
880 group with vertical beddings; (F) Sibao group with moderate inclination; (G) Sigmoid
881 quartz vein indicates a top-to-the-W kinematic; (H) Recumbent folding of the Sibao
882 group, with the axis gently plunging to the north; (I) E-W directed lineations in the Sibao
883 group; (J) Mylonite on the roof of the Yuanbaoshan pluton; (K) Eastward kinematics in
884 the Sibao group.

885 Figure 4. Microphotographs with the representative features of the granites and country rocks in
886 the Sanfang-Yuanbaoshan area. (A and B) Microphotographs of undeformed granites
887 with crossed polarized light; (C) Undeformed granite in the Yuanbaoshan pluton; (D)
888 Highly deformed granites showing orientated quartz and interstitial myrmekite, crossed
889 polarized light; (E) Mica fish in the highly deformed granites showing top-to-the-W
890 kinematics, crossed polarized light; (F) Deformed granite in the Yuanbaoshan pluton;
891 (G) Microphotographs in reflected light of the Sibao group with top-to-the-W
892 kinematics; (H) Sigma structure and pressure shadows in the Sibao group with top-to-
893 the-W kinematics, crossed polarized light.

894 Figure 5. The Cathodoluminescence, U-Pb ages and epsilon Hf(t) results of the granite samples of
895 A37 and B13 from the Sanfang and Yuanbaoshan plutons, respectively. (A and B)
896 Cathodoluminescence (CL) images of zircons from two samples, with analyzed
897 locations and U-Pb ages; (C) Plot of epsilon Hf(t) versus U-Pb age of zircons from the
898 Sanfang pluton; (D) U-Pb concordia plots for the zircons from Sanfang granite; (E)

899 Enlarged interval of the concentrated ages in the D; (F) The average of the ages showed
900 in the E; (G) U–Pb concordia plots for the zircons from Yuanbaoshan granite; (H)
901 Enlarged interval of the concentrated ages in the G; (I) The average of the ages showed
902 in the H.

903 Figure 6. Magnetic mineralogic analyse of the granites in the Sanfang pluton. (A) Hysteresis loop
904 diagrams; (B) Acquisition of isothermal remanent magnetization (IRM); (C)
905 Thermomagnetic curves; (D) Scanning Electron Microscope imagines of the biotite
906 grains; (E) Day-plot of hysteresis parameters. Abbreviation: Magnetic coercivity of the
907 measured sample (H_c); Coercivity of magnetic remanence (H_{cr}); Multidomain (MD);
908 Saturation intensity of magnetic remanence (M_{rs}); Saturation intensity of induced
909 magnetization (M_s); Pseudo-Single-Domain (PSD); Single-Domain (SD).

910 Figure 7. Sketch map with the sampling sites and AMS results for each site.

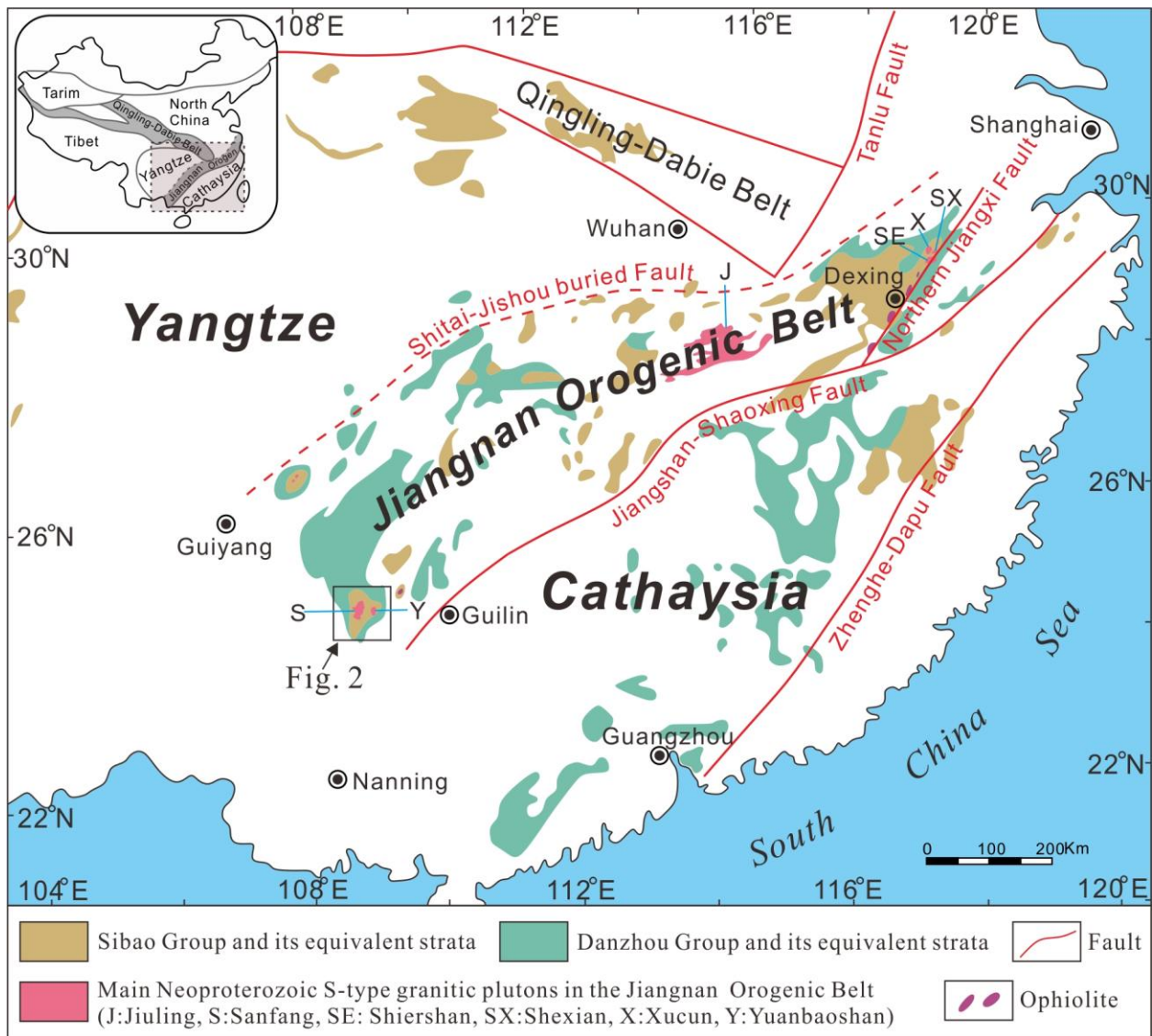
911 Figure 8. Magnetic parameters of the granites of the Sanfang-Yuanbaoshan plutons. (A)
912 Distribution of the K_m ; (B) Scatter plot of the K_m versus PJ; (C) Scatter plot of the K_m
913 versus elevation; (D) Scatter plot of the PJ and elevation with a positive correlation; (E)
914 Scatter plot of the T and elevation with a positive correlation; (F) Scatter plot of the T
915 and PJ with a positive correlation. All the data are site-mean value for each sampling
916 site; (G) Partition of the two plutons according to the integrated criteria of field
917 observations, features of the magnetic foliations and lineations and PJ values; (H) A
918 sampling section showing generally positive correlation between the PJ value and
919 elevation. Abbreviation: Bulk magnetic susceptibility (K_m); Anisotropy degree of the
920 magnetic susceptibility (PJ); Shape parameter (T).

921 Figure 9. A synthetic distribution map of the magnetic foliations and lineations in the Sanfang and
 922 Yuanbaoshan granitic plutons. The black symbols represent the sub-solidus fabrics,
 923 whereas the white ones correspond to post-solidus fabrics.

924 Figure 10. The residual Bouguer gravity anomaly map of the Sanfang-Yuanbaoshan area with five
 925 interpreted profiles.

926 Figure 11. 3-D model for the emplacement mechanism of the Sanfang and Yuanbaoshan plutons
 927 in ca. 830 Ma ago.

928 **Figures**



929

Figure 1

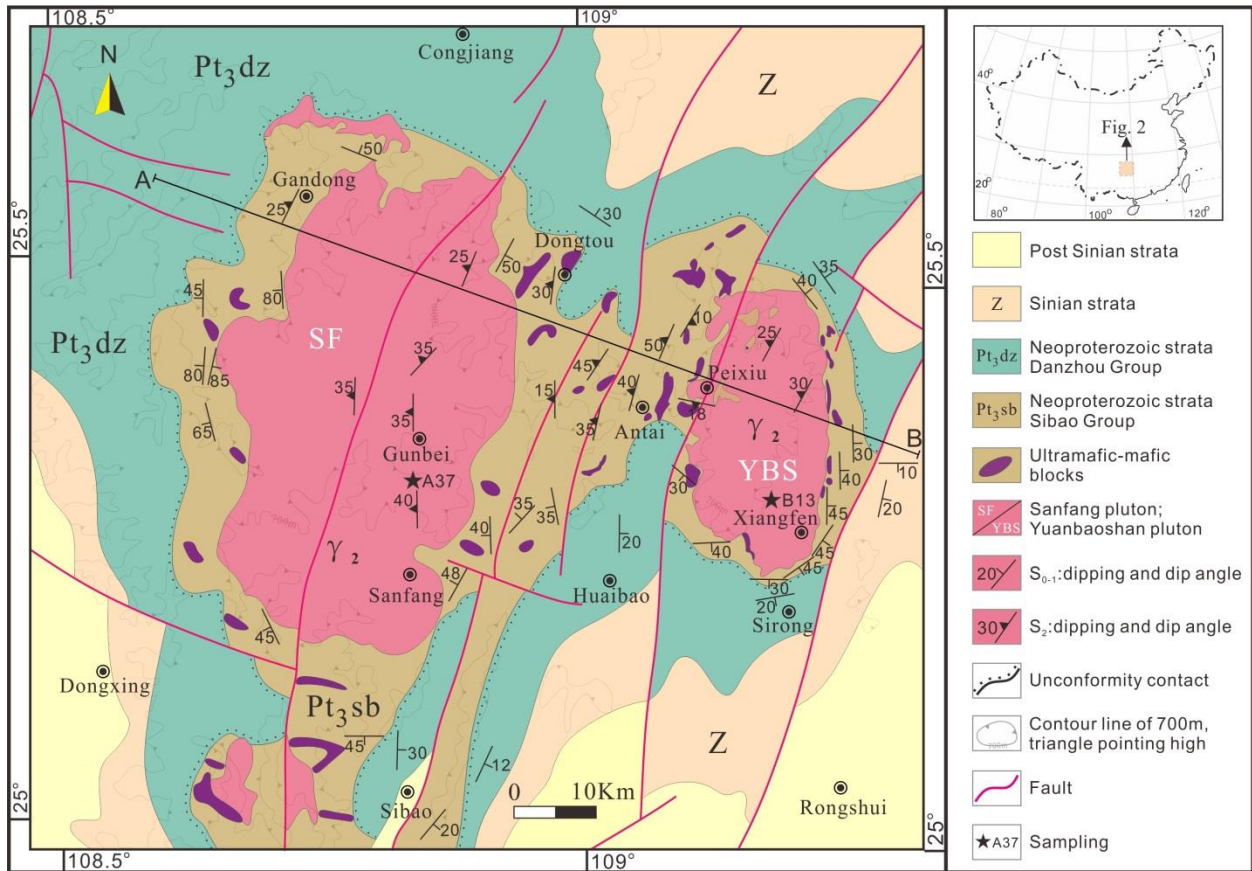
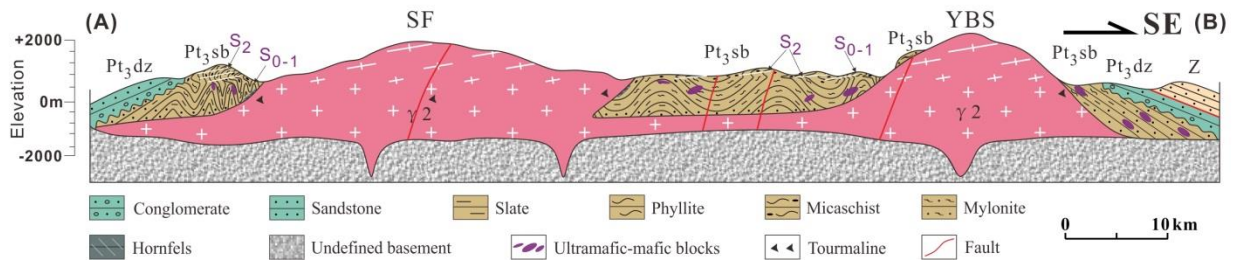
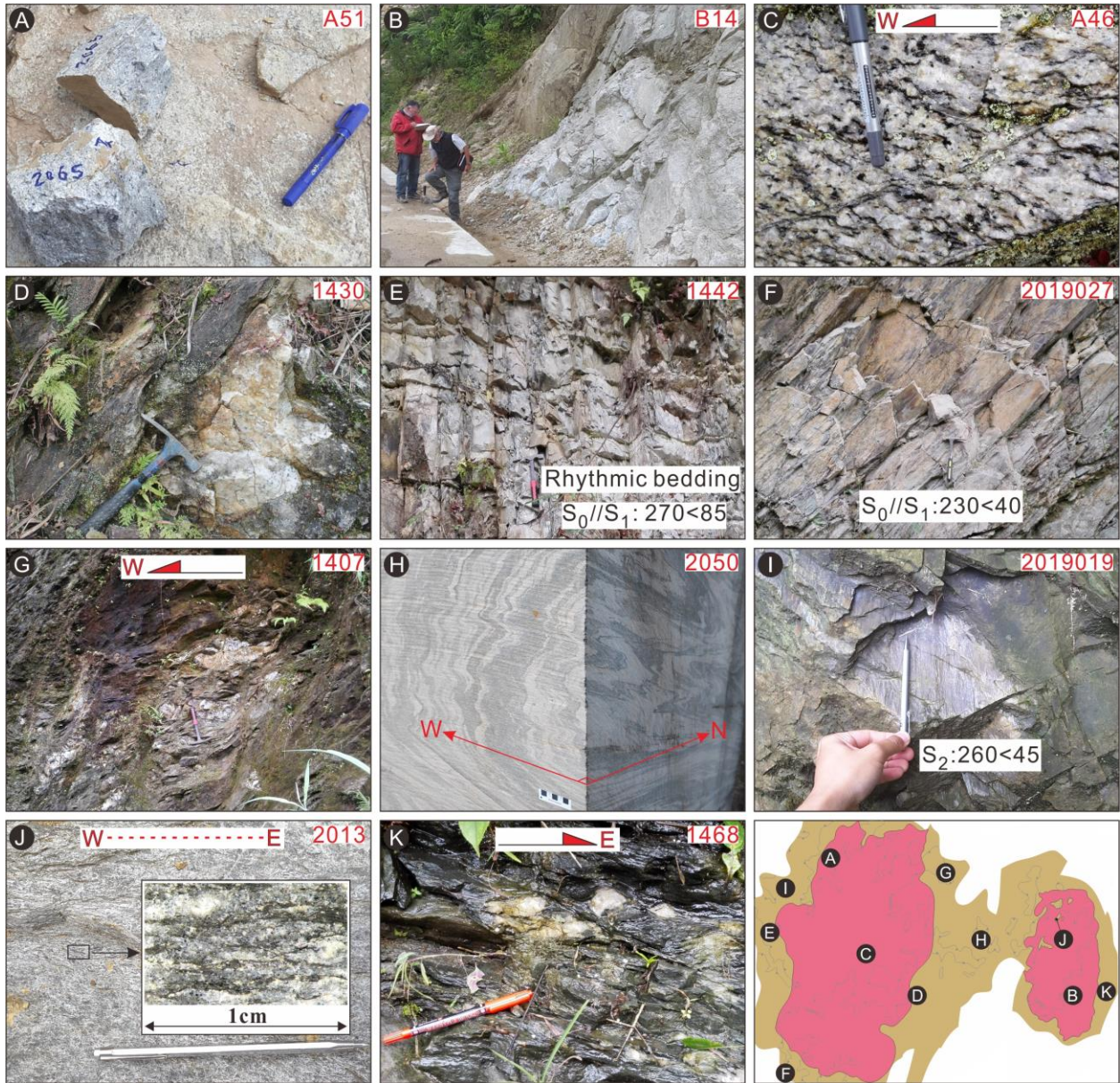


Figure 2

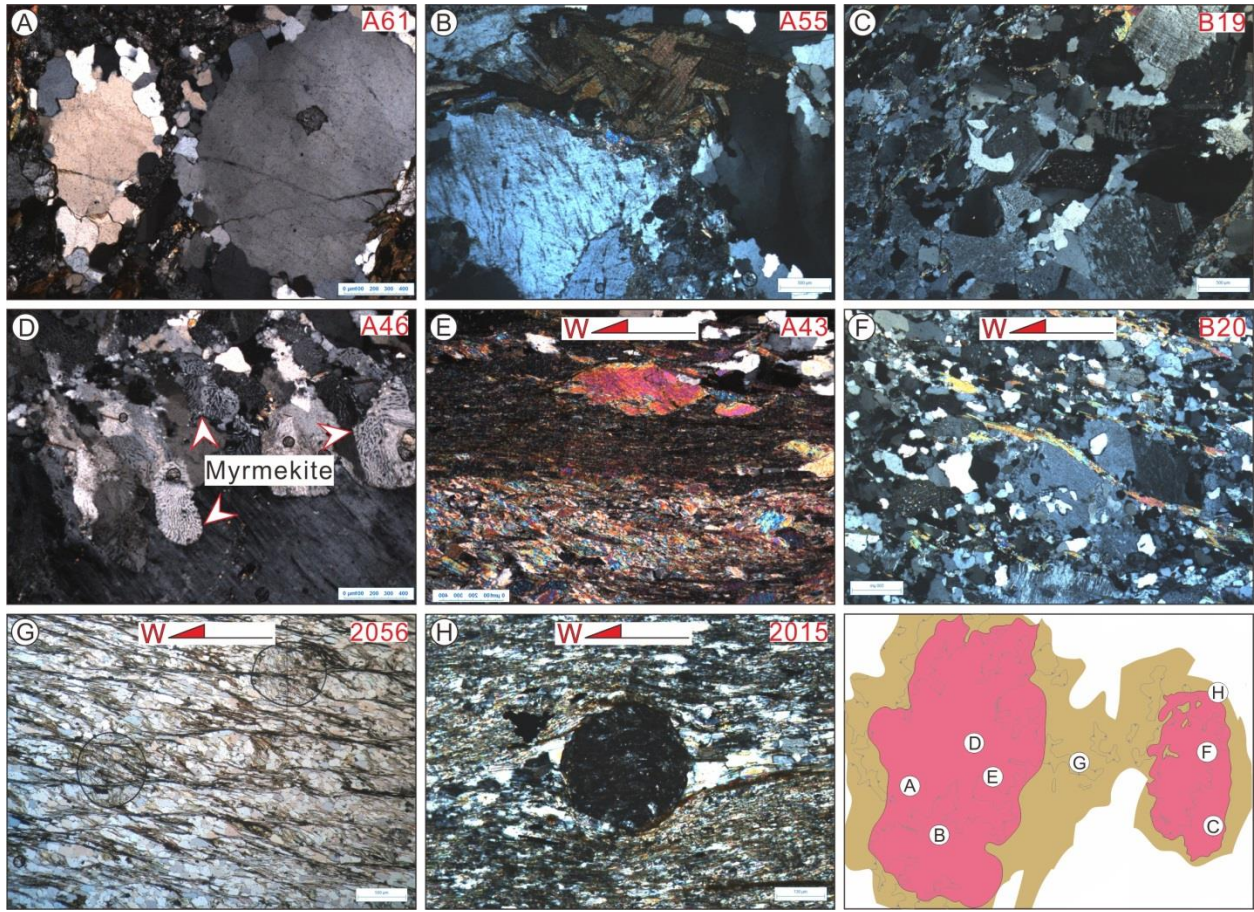




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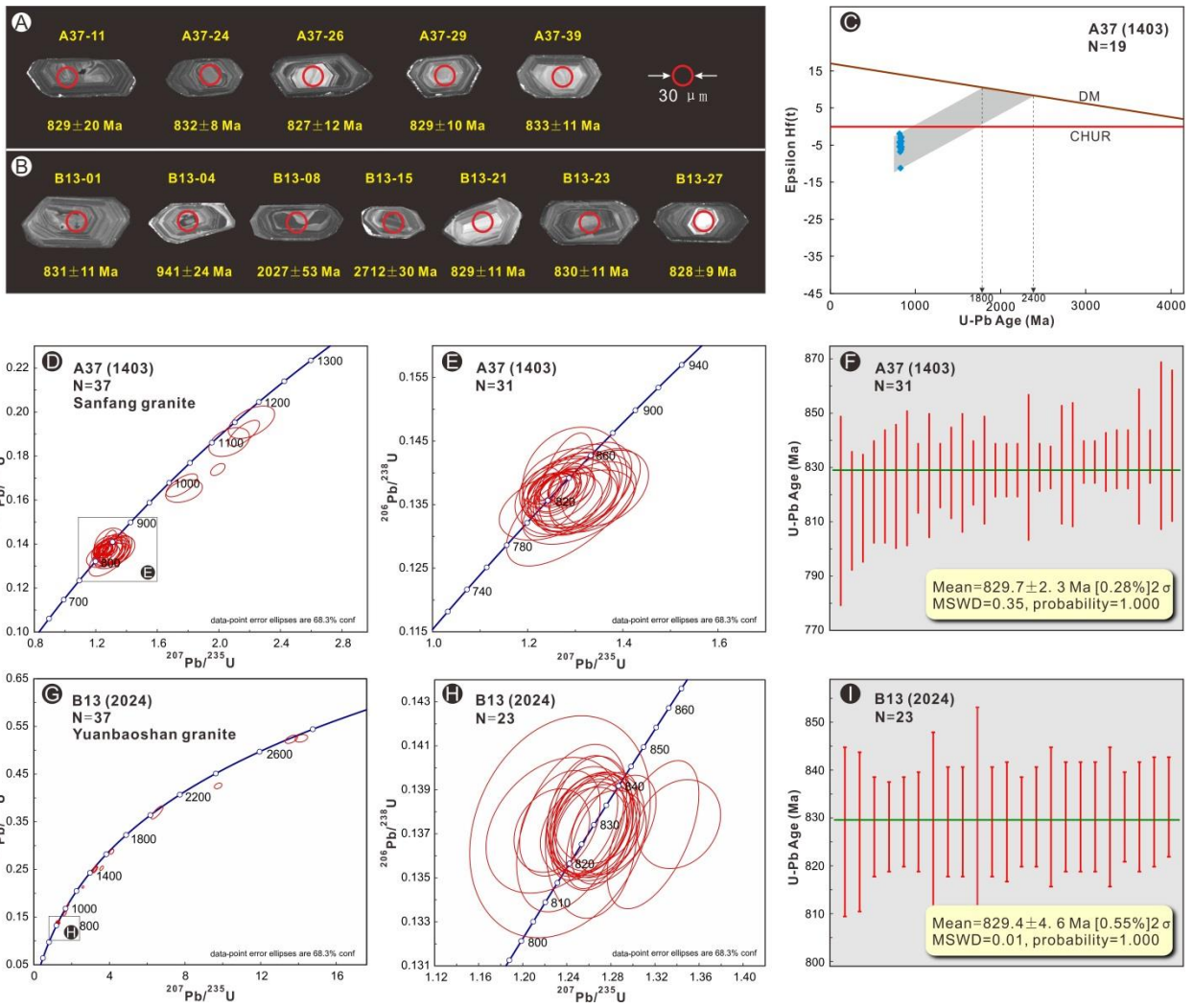
Figure 3



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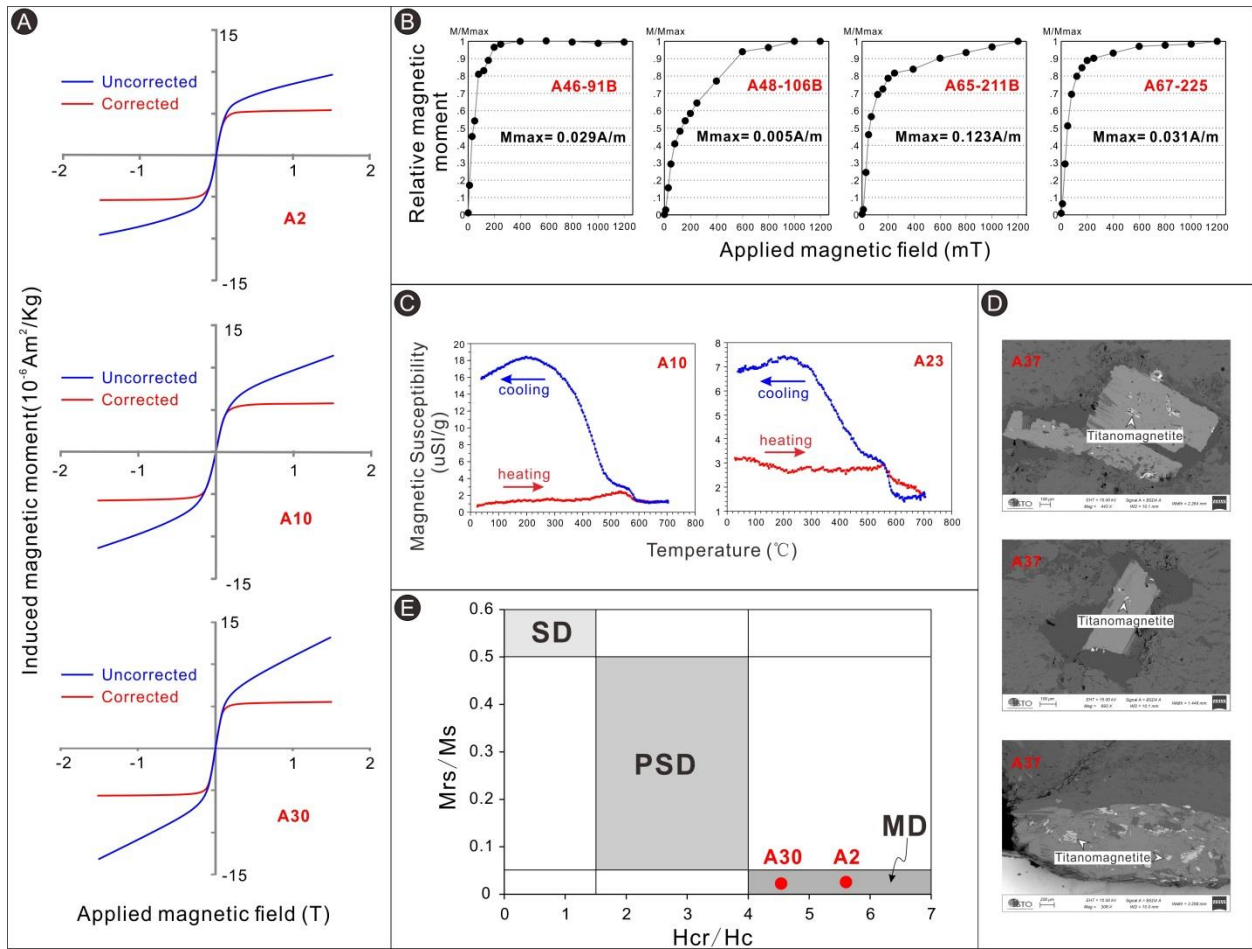
Figure 4



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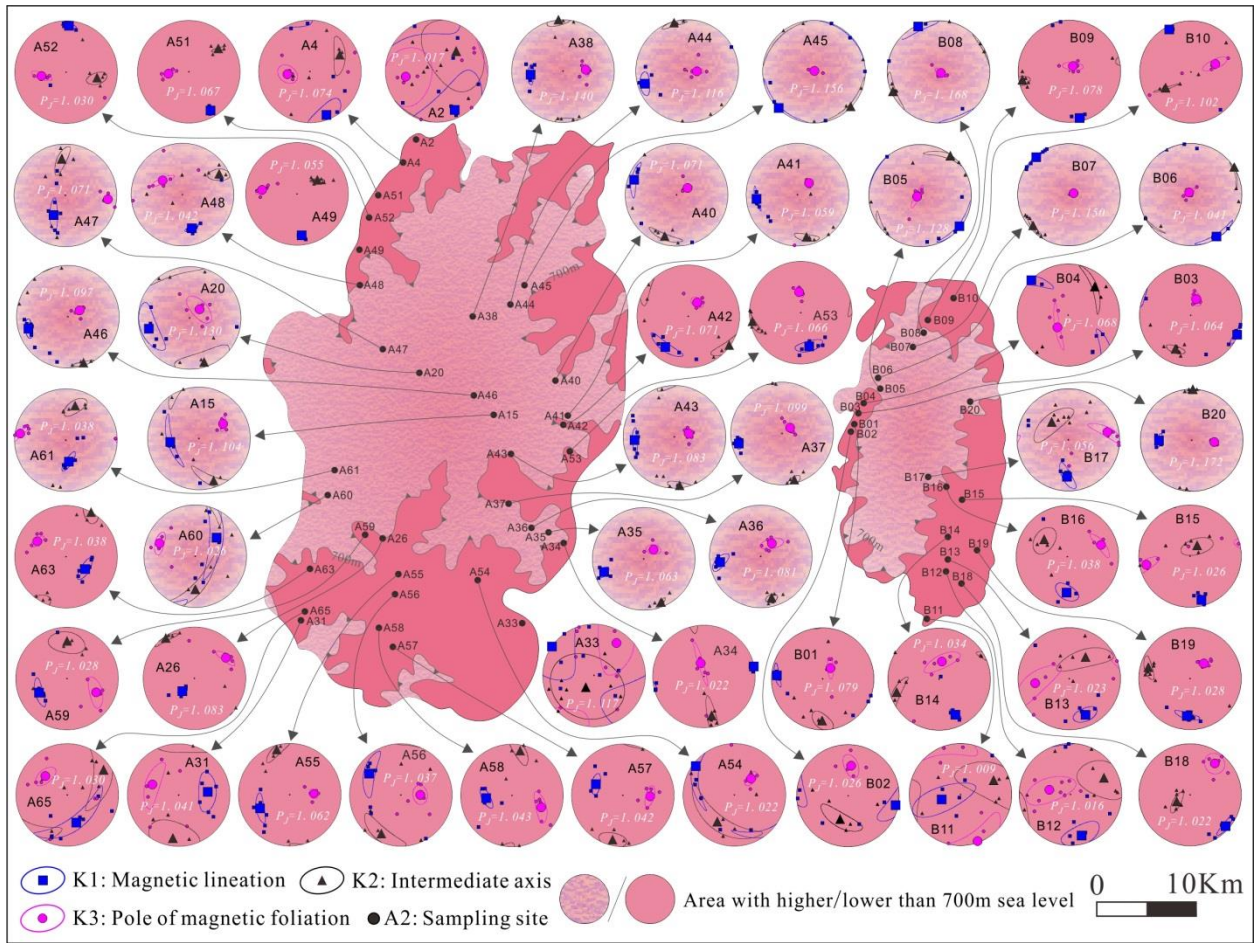
Figure 5



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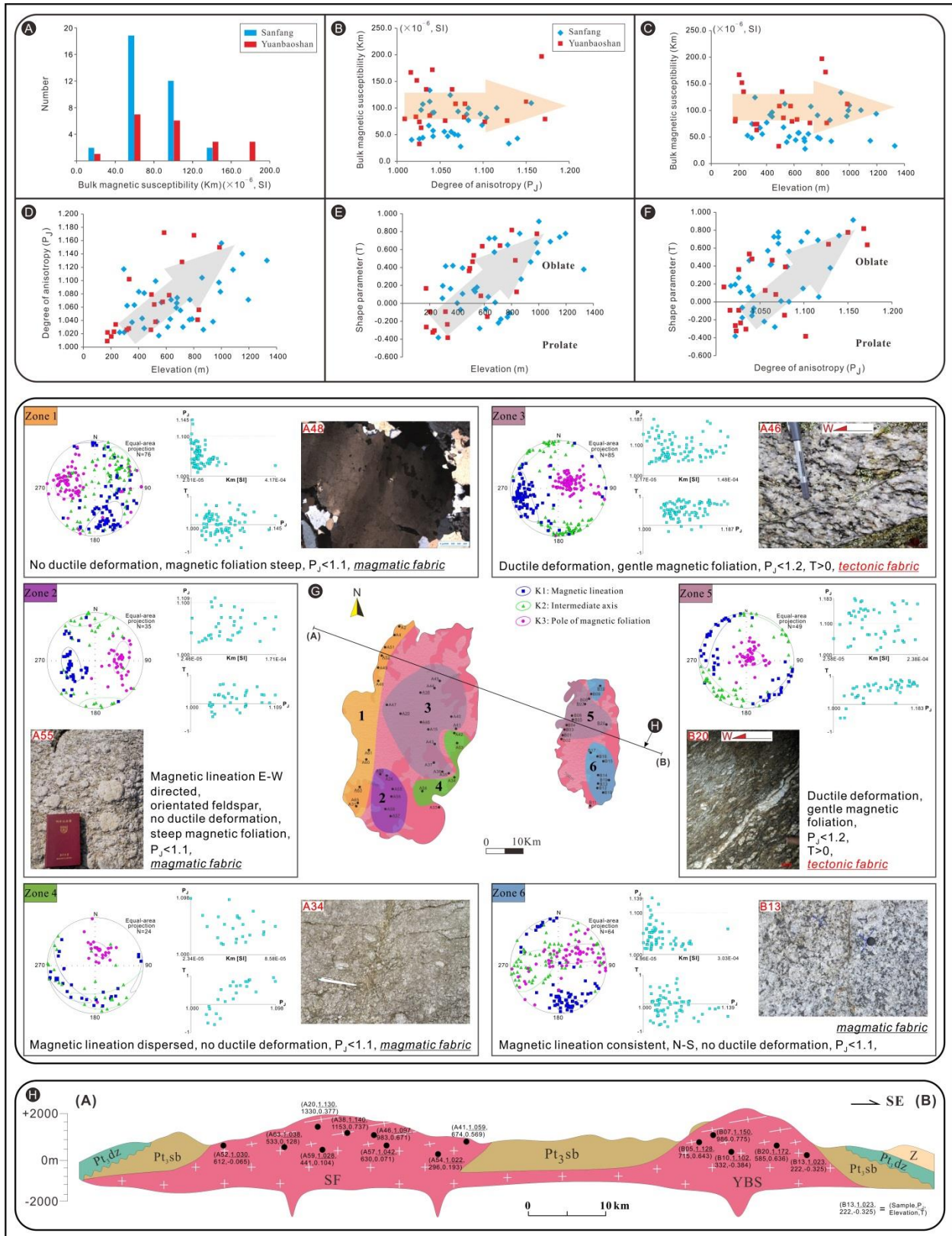
Figure 6



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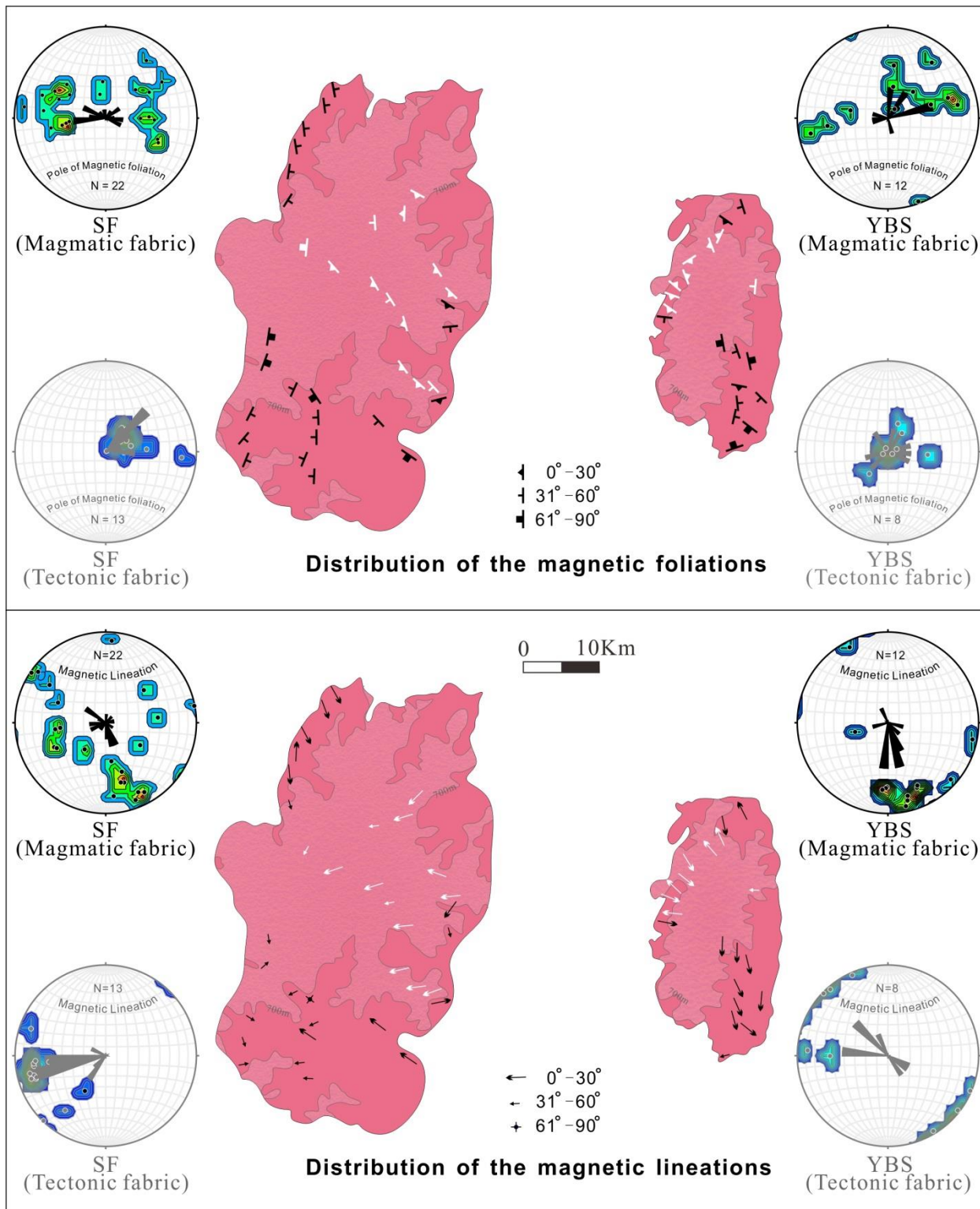
Figure 7



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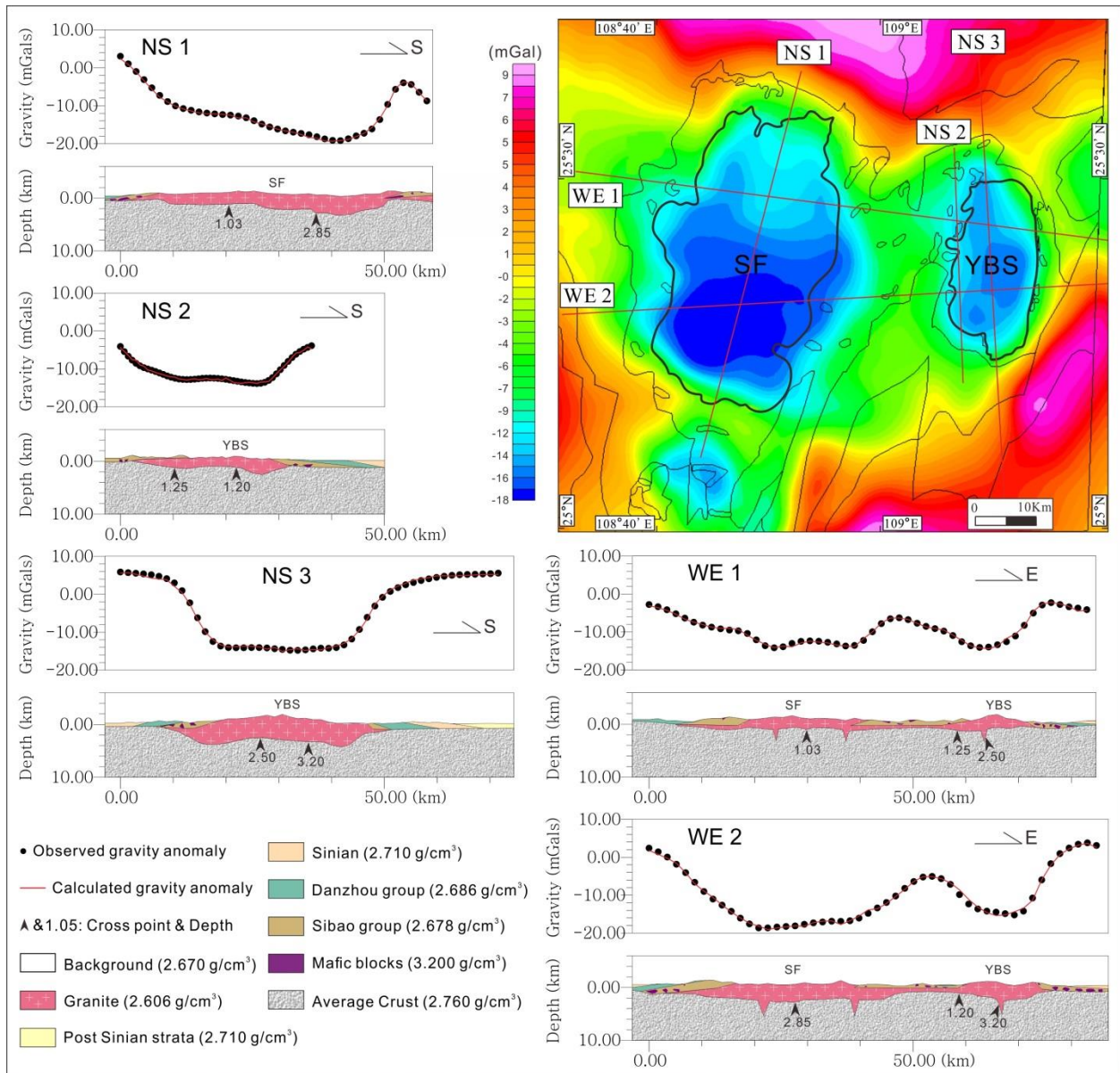
Figure 8



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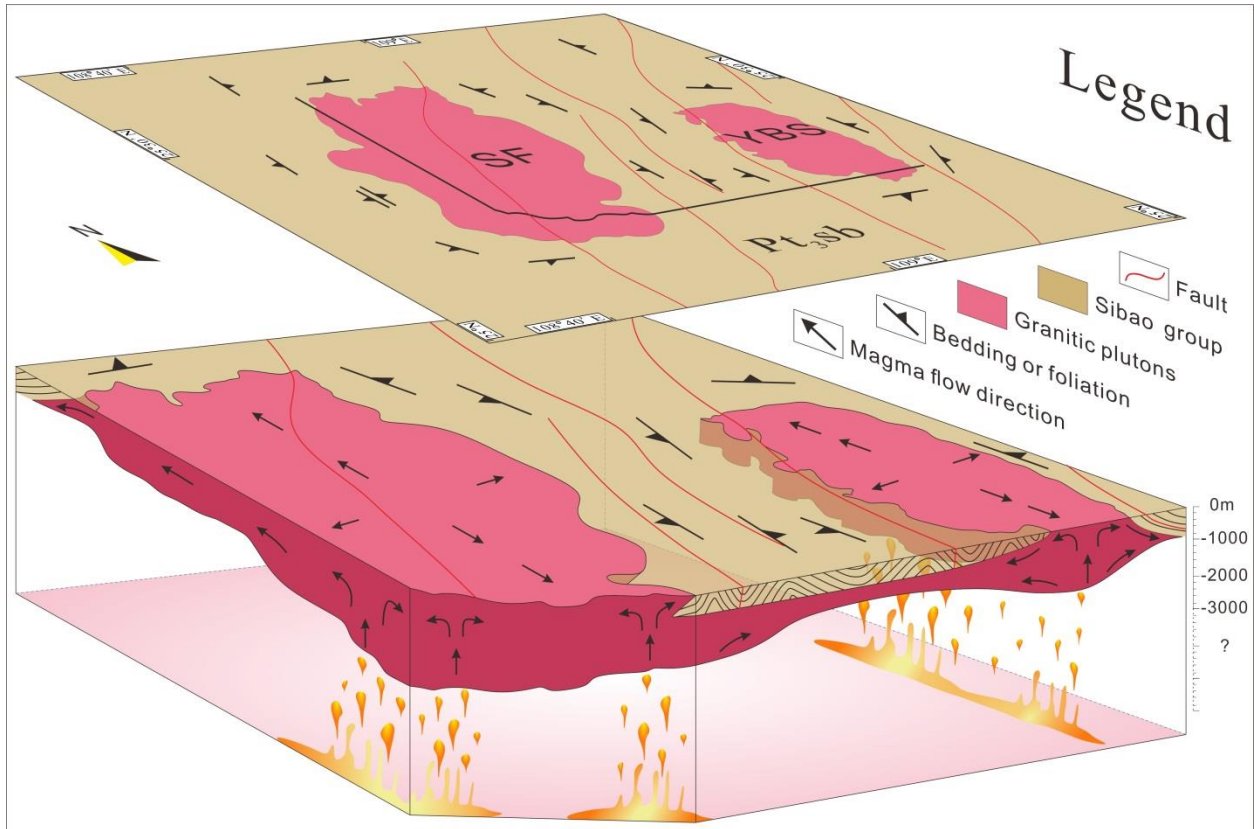
Figure 9



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Figure 10



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950

Figure 11

Table 1. LA-ICP-MS zircon U-Pb dating results for the granite samples from the Sanfang and Yuanbaoshan plutons

Analysis <i>s</i>	CORRECTED RATIOS						CORRECTED AGES (Ma)						concordance	Th/U ratios
	$^{207}\text{Pb}/^{206}\text{Pb}$ <i>b</i>	1σ	$^{207}\text{Pb}/^{235}\text{U}$	1σ	$^{206}\text{Pb}/^{238}\text{U}$	1σ	$^{207}\text{Pb}/^{206}\text{Pb}$ <i>b</i>	1σ	$^{207}\text{Pb}/^{235}\text{U}$	1σ	$^{206}\text{Pb}/^{238}\text{U}$	1σ		
Sample A37 (1403)														
1403-1	0.064170	0.00337 0	1.248450	0.07149 0	0.134730	0.00351 0	747	11 4	823	3 2	815	2 0	99%	0.94
1403-2	0.066760	0.00355 0	1.296120	0.09280 0	0.134580	0.00609 0	830	11 4	844	4 1	814	3 5	96%	0.24
1403-3	0.067440	0.00349 0	1.306550	0.07720 0	0.134610	0.00385 0	851	11 0	849	3 4	814	2 2	95%	0.27
1403-4	0.075440	0.00315 0	1.773600	0.07894 0	0.164030	0.00335 0	1080	11 86	1036	2 9	979	1 9	94%	0.15
1403-5	0.068760	0.00293 0	1.337000	0.05990 0	0.136220	0.00367 0	892	11 90	862	2 6	823	2 1	95%	0.37
1403-6	0.079070	0.00305 0	2.212030	0.09938 0	0.195370	0.00488 0	1174	78 1185	1185	3 1	1150	2 6	97%	0.56
1403-7	0.065360	0.00255 0	1.264680	0.05093 0	0.136980	0.00301 0	786	84 830	830	2 3	828	1 7	99%	0.43
1403-9	0.078520	0.00310 0	2.067010	0.08720 0	0.186330	0.00433 0	1160	80 1138	1138	2 9	1101	2 4	96%	0.40
1403-10	0.067610	0.00318 0	1.294370	0.06193 0	0.135810	0.00329 0	856	10 0	843	2 7	821	1 9	97%	0.43
1403-11	0.066860	0.00324 0	1.283580	0.06133 0	0.137200	0.00355 0	833	10 3	838	2 7	829	2 0	98%	0.05
1403-12	0.067490	0.00379 0	1.281600	0.07151 0	0.136250	0.00398 0	853	12 0	838	3 2	823	3 3	98%	0.23
1403-13	0.069100	0.00291 0	1.331060	0.05784 0	0.138100	0.00443 0	902	89 859	859	2 5	834	2 5	96%	0.12
1403-14	0.067310	0.00287 0	1.289490	0.05486 0	0.136940	0.00410 0	847	91 841	841	2 4	827	2 3	98%	0.10
1403-15	0.071780	0.00315 0	1.362270	0.06041 0	0.137590	0.00394 0	980	92 873	873	2 6	831	2 2	95%	0.14
1403-16	0.067260	0.00376 0	1.288130	0.06947 0	0.137630	0.00411 0	846	11 9	840	3 1	831	3 2	98%	0.13
1403-17	0.067700	0.00432 0	1.298600	0.07225 0	0.138830	0.00552 0	859	13 6	845	3 2	838	3 1	99%	0.26
1403-18	0.066130	0.00269 0	1.280030	0.06139 0	0.136630	0.00441 0	811	87 837	837	2 7	826	2 5	98%	0.09
1403-19	0.068080	0.00310 0	1.317510	0.06638 0	0.137140	0.00387 0	871	97 853	853	2 9	828	2 2	97%	0.07
1403-20	0.067920	0.00320 0	1.305320	0.06168 0	0.137340	0.00473 0	866	10 0	848	2 7	830	2 7	97%	0.35
1403-21	0.075510	0.00217 0	1.759020	0.06791 0	0.166670	0.00344 0	1082	59 1030	1030	2 5	994	1 9	96%	0.29
1403-22	0.066880	0.00210 0	1.280900	0.03741 0	0.138870	0.00489 0	834	67 837	837	1 7	838	2 8	99%	0.38
1403-23	0.064280	0.00123 0	1.228120	0.02578 0	0.138060	0.00182 0	751	41 813	813	1 2	834	1 0	97%	0.16
1403-24	0.066260	0.00124 0	1.264570	0.02497 0	0.137730	0.00143 0	814	40 830	830	1 1	832	8 8	99%	0.16
1403-25	0.064920	0.00113 0	1.234900	0.02308 0	0.137450	0.00157 0	772	37 817	817	1 0	830	9 9	98%	0.28
1403-26	0.066510	0.00157 0	1.263570	0.03267 0	0.136920	0.00216 0	823	50 830	830	1 5	827	1 2	99%	0.40
1403-27	0.065110	0.00115 0	1.235710	0.02398 0	0.137220	0.00177 0	778	38 817	817	1 1	829	1 0	98%	0.27
1403-28	0.068180	0.00124 0	1.297320	0.02711 0	0.137290	0.00183 0	874	38 845	845	1 2	829	1 0	98%	0.17
1403-29	0.066420	0.00139 0	1.260180	0.02649 0	0.137220	0.00174 0	820	45 828	828	1 2	829	1 0	99%	0.35
1403-30	0.066360	0.00140 0	1.263390	0.03091 0	0.137100	0.00212 0	818	45 829	829	1 4	828	1 2	99%	0.13
1403-32	0.081160	0.00173 0	2.164630	0.06578 0	0.190400	0.00386 0	1225	43 1170	1170	2 1	1124	2 1	95%	0.09
1403-33	0.065520	0.00112 0	1.251830	0.02261 0	0.137720	0.00141 0	791	37 824	824	1 0	832	8 8	99%	0.20
1403-34	0.067610	0.00164 0	1.291380	0.03148 0	0.138000	0.00200 0	857	52 842	842	1 4	833	1 1	98%	0.63
1403-35	0.066110	0.00187 0	1.252750	0.03496 0	0.136620	0.00229 0	810	61 825	825	1 6	826	1 3	99%	0.16
1403-36	0.082480	0.00111 0	1.993340	0.03110 0	0.173880	0.00179 0	1257	27 1113	1113	1 1	1033	1 0	92%	0.21
1403-38	0.066920	0.00118 0	1.276980	0.02320 0	0.137420	0.00139 0	835	38 836	836	1 0	830	8 8	99%	0.20
1403-39	0.067410	0.00133 0	1.284140	0.02711 0	0.137860	0.00190 0	850	42 839	839	1 2	833	1 1	99%	0.24
1403-40	0.066030	0.00123 0	1.266980	0.02943 0	0.137720	0.00193 0	807	40 831	831	1 3	832	1 1	99%	0.21

Sample B13 (2024)

2024-1	0.065500	0.00182 0	1.261080	0.03157 0	0.137580	0.00202 0	790	60	828	1 4	831	1 1	99%	0.76
2024-3	0.065550	0.00151 0	1.261460	0.02696 0	0.137480	0.00177 0	792	49	829	1 2	830	1 0	99%	0.67
2024-4	0.073800	0.00226 0	1.639830	0.07227 0	0.157100	0.00430 0	1036	63	986	2 8	941	2 4	95%	0.43
2024-5	0.065770	0.00171 0	1.267560	0.03172 0	0.137710	0.00168 0	799	56	831	1 4	832	1 0	99%	0.17
2024-6	0.065610	0.00151 0	1.259910	0.02870 0	0.137160	0.00160 0	794	49	828	1 3	829	1 9	99%	0.10
2024-7	0.192840	0.00375 0	14.152860	0.27214 0	0.524830	0.00644 0	2767	33	2760	1 8	2720	2 7	98%	0.58
2024-8	0.125120	0.00292 0	6.523570	0.25613 0	0.369490	0.01122 0	2031	42	2049	3 5	2027	5 3	98%	0.15
2024-9	0.066640	0.00242 0	1.262060	0.03383 0	0.136860	0.00302 0	826	78	829	1 5	827	1 7	99%	0.95
2024-10	0.064080	0.00244 0	1.226520	0.04888 0	0.137390	0.00252 0	744	82	813	2 2	830	1 4	97%	0.52
2024-11	0.066140	0.00188 0	1.265900	0.03624 0	0.137420	0.00196 0	811	61	831	1 6	830	1 1	99%	0.75
2024-12	0.065710	0.00168 0	1.256240	0.03288 0	0.137210	0.00176 0	797	55	826	1 5	829	1 0	99%	0.34
2024-13	0.065450	0.00201 0	1.244370	0.04078 0	0.137260	0.00311 0	789	66	821	1 8	829	1 8	98%	0.23
2024-14	0.091810	0.00181 0	3.232250	0.09501 0	0.251450	0.00549 0	1463	38	1465	2 3	1446	2 8	98%	0.51
2024-15	0.187020	0.00318 0	13.625470	0.26920 0	0.522990	0.00715 0	2716	29	2724	1 9	2712	3 0	99%	0.50
2024-16	0.065920	0.00125 0	1.258770	0.02696 0	0.137290	0.00196 0	804	41	827	1 2	829	1 1	99%	0.08
2024-17	0.066710	0.00166 0	1.268090	0.03102 0	0.137130	0.00173 0	829	53	832	1 4	828	1 0	99%	1.35
2024-18	0.067360	0.00143 0	1.282690	0.03134 0	0.137190	0.00202 0	849	45	838	1 4	829	1 1	98%	0.57
2024-19	0.064720	0.00149 0	1.233740	0.02989 0	0.137480	0.00196 0	765	50	816	1 4	830	1 1	98%	0.12
2024-20	0.065460	0.00363 0	1.233810	0.06695 0	0.137320	0.00412 0	789	0	816	12 3	829	2 3	98%	0.51
2024-21	0.066630	0.00173 0	1.265260	0.03105 0	0.137180	0.00189 0	826	56	830	1 4	829	1 1	99%	0.05
2024-22	0.074260	0.00150 0	1.810960	0.04373 0	0.175420	0.00257 0	1049	42	1049	1 6	1042	1 4	99%	0.55
2024-23	0.066190	0.00159 0	1.261210	0.03078 0	0.137450	0.00190 0	812	51	828	1 4	830	1 1	99%	0.30
2024-24	0.067000	0.00123 0	1.272010	0.02652 0	0.137150	0.00216 0	838	39	833	1 2	829	1 2	99%	0.25
2024-25	0.102110	0.00180 0	3.584060	0.07952 0	0.252520	0.00385 0	1663	33	1546	1 8	1451	2 0	93%	0.37
2024-26	0.064560	0.00148 0	1.226440	0.02806 0	0.137150	0.00155 0	760	50	813	1 3	829	1 9	98%	0.27
2024-27	0.067460	0.00150 0	1.278110	0.02780 0	0.137070	0.00156 0	852	47	836	1 2	828	1 9	99%	0.99
2024-28	0.091880	0.00183 0	3.249860	0.10258 0	0.249300	0.00547 0	1465	39	1469	2 5	1435	2 8	97%	0.30
2024-29	0.066310	0.00183 0	1.262900	0.03063 0	0.137480	0.00249 0	816	59	829	1 4	830	1 4	99%	0.16
2024-30	0.103270	0.00206 0	4.121880	0.09396 0	0.287030	0.00418 0	1684	38	1659	1 9	1627	2 1	98%	0.38
2024-32	0.165130	0.00275 0	9.749940	0.16470 0	0.425100	0.00489 0	2509	29	2411	1 6	2284	2 2	94%	0.27
2024-34	0.087950	0.00142 0	2.597700	0.04192 0	0.213070	0.00222 0	1381	32	1300	1 2	1245	1 2	95%	0.61
2024-35	0.067390	0.00193 0	1.332540	0.03908 0	0.142400	0.00157 0	850	61	860	1 7	858	1 9	99%	0.32
2024-36	0.073230	0.00192 0	1.663310	0.04593 0	0.163620	0.00209 0	1020	54	995	1 8	977	1 2	98%	0.13
2024-37	0.073210	0.00114 0	1.704990	0.03831 0	0.167600	0.00301 0	1020	32	1010	1 4	999	1 7	98%	0.74
2024-38	0.070540	0.00167 0	1.341650	0.03098 0	0.137440	0.00165 0	944	50	864	1 3	830	1 9	96%	0.35
2024-39	0.066290	0.00143 0	1.262510	0.02869 0	0.137480	0.00186 0	816	46	829	1 3	830	1 1	99%	0.48
2024-40	0.069440	0.00155 0	1.318220	0.03404 0	0.136960	0.00275 0	912	47	854	1 5	827	1 6	96%	0.37

Table 2. LA-MC-ICP-MS zircon Lu-Hf isotopic data for the granite sample from the Sanfang pluton

Sample	$^{176}\text{Yb}/^{177}\text{Hf}$	2σ	$^{176}\text{Lu}/^{177}\text{Hf}$	2σ	$^{176}\text{Hf}/^{177}\text{Hf}$	2σ	$\epsilon_{\text{Hf}}(t)$	$\epsilon_{\text{Hf}}(0)$	Age(Ma)	TDM1(Ma)	TDM2(Ma)	$f(\text{Lu}/\text{Hf})$
Sample A37 (1403)												
1403-01.xls	0.069465	0.001329	0.002551	0.000049	0.282182	0.000018	-4.26	-20.85	815	1573	1977	-0.92
1403-02.xls	0.033276	0.002444	0.001317	0.000096	0.282133	0.000017	-5.35	-22.59	814	1591	2046	-0.96
1403-03.xls	0.052056	0.000445	0.001897	0.000020	0.282240	0.000019	-1.89	-18.82	814	1464	1828	-0.94
1403-05.xls	0.020281	0.000170	0.000823	0.000008	0.282080	0.000013	-6.79	-24.48	823	1645	2143	-0.98
1403-07.xls	0.061695	0.001249	0.002307	0.000047	0.282159	0.000038	-4.69	-21.68	828	1597	2014	-0.93
1403-10.xls	0.035740	0.000612	0.001399	0.000023	0.282159	0.000012	-4.33	-21.68	821	1558	1987	-0.96
1403-11.xls	0.015152	0.000361	0.000611	0.000014	0.282152	0.000011	-3.99	-21.94	829	1536	1971	-0.98
1403-12.xls	0.032853	0.000245	0.001274	0.000009	0.282167	0.000014	-3.95	-21.40	823	1542	1964	-0.96
1403-13.xls	0.060701	0.001586	0.002274	0.000052	0.282210	0.000017	-2.74	-19.88	834	1522	1896	-0.93
1403-14.xls	0.033084	0.001351	0.001302	0.000052	0.282124	0.000017	-5.39	-22.92	827	1603	2058	-0.96
1403-16.xls	0.031782	0.000622	0.001255	0.000024	0.282096	0.000014	-6.26	-23.89	831	1640	2116	-0.96
1403-17.xls	0.034896	0.000528	0.001431	0.000019	0.282118	0.000016	-5.43	-23.12	838	1617	2069	-0.96
1403-18.xls	0.018821	0.001017	0.000813	0.000046	0.281955	0.000025	-11.15	-28.91	826	1817	2418	-0.98
1403-19.xls	0.069655	0.001338	0.002645	0.000045	0.282206	0.000014	-3.22	-20.03	828	1544	1922	-0.92
1403-20.xls	0.043510	0.000604	0.001756	0.000024	0.282195	0.000019	-3.07	-20.41	830	1522	1914	-0.95
1403-22.xls	0.028666	0.000751	0.001136	0.000029	0.282155	0.000015	-3.96	-21.81	838	1553	1976	-0.97
1403-23.xls	0.060435	0.001617	0.002269	0.000057	0.282119	0.000015	-5.96	-23.10	834	1653	2099	-0.93
1403-24.xls	0.040540	0.001049	0.001561	0.000038	0.282197	0.000024	-2.84	-20.33	832	1511	1901	-0.95
1403-26.xls	0.033645	0.000740	0.001340	0.000028	0.282199	0.000015	-2.74	-20.25	827	1499	1891	-0.96

Table 3. Sampling sites and site-mean AMS measurement results for the Sanfang-Yuanbaoshan plutons

Site	Geographic coordinates		Alt.(m)	n	Km (10 ⁶ SI)	P _J	T	Site mean AMS results			
								K1	$\alpha 95(max/min)$	K3	$\alpha 95(max/min)$
								Dec (°)/Inc(°)	(°)	Dec (°)/Inc(°)	(°)
Sanfang											
A02	N25°36.269'	E108°46.973'	547	8	40.2	1.017	0.178	155.1/17.4	61.2/35.7	259.7/38.6	47.4/39.1
A04	N25°35.191'	E108°46.424'	680	6	27.5	1.074	0.007	159.2/10.1	28.2/15.6	263.1/53.5	17.6/12.7
A15	N25°22.597'	E108°49.759'	860	6	81.6	1.104	0.776	263.0/43.0	42/4.7	58.9/44.3	11.8/4.3
A20	N25°24.531'	E108°46.455'	1330	6	33.0	1.130	0.377	255.2/18.9	34.5/16.1	48.8/69.1	26.1/12.8
A26	N25°17.328'	E108°44.369'	402	6	76.9	1.083	0.000	223.2/61.7	8.7/5.4	56.9/27.6	16.5/6.2
A31	N25°13.954'	E108°40.646'	770	6	90.5	1.041	-0.155	83.9/42.4	29.7/15.0	292.0/44.0	36.5/12.5
A33	N25°13' 14.7"	E108°51' 33.4"	293	8	47.9	1.117	0.054	304.4/0.9	62.3/32.7	34.8/24.3	54.2/25.3
A34	N25°17' 08.1"	E108°53' 10.3"	263	6	52.5	1.022	-0.384	78.6/0.9	6.6/4.8	346.3/68.4	37.4/3.9
A35	N25°17' 24.0"	E108°52' 26.8"	715	6	55.2	1.063	0.417	251.6/19.7	11.0/4.7	46.5/68.4	11.6/7.6
A36	N25°17' 44.6"	E108°51' 38.9"	705	6	88.1	1.081	0.392	262.1/21.2	19.1/7.0	40.7/62.7	19/7.9
A37	N25°18' 45.8"	E108°50' 34.5"	724	6	67.8	1.099	0.148	256.9/14.5	7.9/4.9	54.3/74.3	11.0/3.1
A38	N25°26' 07.7"	E108°48' 50.7"	1153	7	42.6	1.140	0.737	263.9/36.6	14.7/4.9	86.4/53.4	10.1/4.7
A40	N25°22' 52.5"	E108°54' 03.7"	772	7	48.9	1.071	0.649	289.5/13.2	23.2/5.3	58.1/69.4	6.9/4.1
A41	N25°22' 24.9"	E108°53' 38.4"	674	6	46.9	1.059	0.569	264.2/20.8	17.3/2.6	44.9/63.9	7.3/2.6
A42	N25°21' 49.1"	E108°52' 57.9"	636	6	57.5	1.071	0.722	216.8/26.1	26.6/7.7	33.1/63.9	10.4/7.7
A43	N25°20' 43.1"	E108°50' 39.9"	993	7	99.5	1.083	0.562	265.4/23.0	16.4/4.5	76.2/66.7	6.7/4.4
A44	N25°27' 23.2"	E108°50' 42.3"	1085	7	100.0	1.116	0.687	253.3/14.8	15.7/9.1	91.6/74.4	10.3/5.5
A45	N25°28' 15.0"	E108°51' 27.9"	1001	6	109.0	1.156	0.912	224.1/1.4	37.8/3.7	30.7/88.6	7.4/0.6
A46	N25°23' 25.3"	E108°49' 03.4"	983	8	88.8	1.097	0.671	253.1/20.8	13.2/6.4	61.4/68.8	7.9/4.2
A47	N25°25' 51.6"	E108°44' 30.3"	1196	7	93.3	1.071	0.776	210.7/53.0	27.3/5.8	95.3/17.9	8.0/4.1
A48	N25°28' 29.2"	E108°43' 21.2"	788	8	46.6	1.042	-0.111	163.0/31.9	10.8/2.9	302.6/50.7	17.9/2.5
A49	N25°29' 45.9"	E108°43' 24.5"	704	8	55.5	1.055	-0.221	173.5/19.8	4.6/2.1	276.5/32.1	12.2/4.0
A51	N25°32' 04.4"	E108°43' 51.3"	566	6	50.3	1.067	-0.282	150.8/14.4	4.1/2.3	264.5/57.3	12.0/3.2
A52	N25°31' 10.6"	E108°43' 39.7"	612	6	44.0	1.030	-0.065	3.5/10.2	9.4/4.4	261.2/49.8	18.0/5.1
A53	N25°21' 09.7"	E108°53' 37.2"	677	6	41.9	1.066	0.725	166.0/32.7	19.9/9.0	355.4/56.9	10.1/3.7
A54	N25°15' 25.5"	E108°51' 46.0"	296	6	74.4	1.022	0.193	306.7/6.9	67.3/6.6	45.8/52.6	13.8/7.0
A55	N25°15' 52.1"	E108°45' 18.9"	317	6	124.0	1.062	0.413	245.2/36.5	22.3/6.8	87.8/51.3	8.0/6.9
A56	N25°15' 03.6"	E108°45' 05.5"	353	6	66.8	1.037	0.161	304.1/26.4	35.2/9.9	89.6/58.9	14.8/11.8
A57	N25°12' 51.7"	E108°45' 04.4"	630	5	57.3	1.042	0.071	292.5/42.4	16.1/7.1	91.9/45.7	16.2/7.1
A58	N25°13' 36.6"	E108°44' 15.8"	426	6	91.6	1.043	-0.073	264.2/48.0	17.4/6.9	112.2/38.5	25.3/8.5
A59	N25°17' 32.8"	E108°43' 37.6"	441	6	96.2	1.028	0.104	243.1/38.8	21.8/6.7	115.4/37.3	25.5/10.2
A60	N25°19' 20.4"	E108°41' 58.6"	870	6	41.9	1.026	0.268	49.1/44.1	68.8/10.6	289.8/26.8	16.1/8.5
A61	N25°20' 23.1"	E108°42' 24.2"	940	7	133.0	1.038	0.460	172.1/55.1	18.1/5.2	278.2/11.0	18.0/3.7
A63	N25°16' 04.1"	E108°41' 01.9"	533	7	112.0	1.038	0.128	122.9/53.3	18.6/7.2	298.1/36.6	12.0/5.2
A65	N25°14' 17.1"	E108°40' 46.5"	722	8	107.0	1.030	-0.178	161.9/42.6	67.4/11.4	310.7/43.0	17.9/11.2
Yuanbaoshan											
B01	N25°24' 11.4"	E109°06' 22.4"	494	7	108.0	1.079	0.390	274.4/11.5	16.1/4.4	36.0/68.8	17.3/4.7
B02	N25°24' 00.0"	E109°06' 18.9"	489	5	32.7	1.026	0.361	101.2/6.3	34.0/13.8	5.8/40.7	21.1/10.3
B03	N25°24' 30.1"	E109°06' 51.7"	514	6	135.0	1.064	0.464	112.8/2.0	13.5/5.9	19.0/62.8	7.6/5.1

B04	N25°25' 09.4"	E109°07' 23.8"	575	5	108.0	1.068	0.083	313.5/1.3	42.4/6.4	220.9/64.0	38.8/4.0
B05	N25°25' 43.0"	E109°08' 29.0"	715	6	76.4	1.128	0.643	128.1/2.6	32.4/3.7	249.7/85.0	20.5/3.8
B06	N25°26' 11.6"	E109°08' 24.6"	828	6	172.0	1.041	0.479	148.5/4.1	26.7/4.3	326.5/85.9	10.7/4.3
B07	N25°27' 34.9"	E109°09' 56.5"	986	7	112.0	1.150	0.775	318.9/2.9	15.4/1.6	71.1/82.3	3.7/1.5
B08	N25°28' 18.0"	E109°10' 32.0"	802	6	197.0	1.168	0.817	336.0/3.2	24.0/9.5	114.9/85.7	10.9/3.7
B09	N25°28' 47.3"	E109°10' 47.6"	622	6	82.9	1.078	-0.149	167.6/6.9	7.8/5.4	34.0/80.1	16.4/6.2
B10	N25°29' 41.9"	E109°12' 03.7"	332	6	74.2	1.102	-0.384	333.0/7.4	7.3/1.7	71.6/48.7	22.7/6.8
B11	N25°15' 13.7"	E109°10' 29.8"	173	6	79.7	1.009	0.166	255.3/58.8	58.1/18.9	159.5/3.2	46.7/18.8
B12	N25°17' 24.2"	E109°11' 45.9"	202	8	167.0	1.016	-0.094	165.0/17.7	27.5/18.6	282.4/55.3	43.4/18.5
B13	N25°18' 06.9"	E109°11' 52.2"	222	6	152.0	1.023	-0.325	155.9/23.4	16.9/12.4	262.5/33.4	48.7/15.3
B14	N25°19' 08.4"	E109°11' 46.9"	234	6	135.0	1.034	-0.305	155.4/24.6	13/3.4	8.9/61.3	31.6/10.5
B15	N25°20' 35.0"	E109°12' 26.6"	315	6	74.0	1.026	-0.094	165.5/12.6	14.0/3	258.8/14.4	26.7/6.8
B16	N25°21' 03.0"	E109°11' 38.0"	523	5	85.9	1.038	0.534	181.2/30.4	19.7/11.8	70.5/31.1	21.4/6.6
B17	N25°21' 46.0"	E109°10' 43.3"	837	8	76.3	1.056	0.127	182/28.5	26.1/6.5	78.5/23.2	33.7/6.8
B18	N25°16' 45.0"	E109°12' 38.5"	175	6	83.6	1.022	-0.265	131.6/8.3	14.8/5.7	38.1/22.9	18.8/13.9
B19	N25°18' 12.6"	E109°13' 29.7"	329	7	63.0	1.028	-0.235	184.9/27.2	18.1/5.7	42.5/57	8.8/4.8
B20	N25°25' 02.7"	E109°12' 54.6"	785	6	79.3	1.172	0.636	269.7/36.4	10.5/4.1	94.4/53.5	5.9/1.2

Note: Alt.: Altitude, n: number of specimen at sampling site, Km: bulk magnetic susceptibility PJ: degree of susceptibility anisotropy, T: shape parameter of the AMS ellipsoid, K1: Magnetic lineation, K3: The pole of the magnetic foliation, Inc.: Inclination, Dec.: Declination, α_{95} (max/min): the long and short axes of the confidence ellipsoid at 95% level

Table 4. The density of the Sanfang-Yuanbaoshan granites and country rocks

<i>Strata/Rock</i>	<i>Lithology</i>	<i>Sampling number</i>	<i>Density of each sample (g/cm³)</i>	<i>Average of measured density (g/cm³)</i>	<i>Standard derivation</i>
γ_2 Sanfang	Granite	1404	2.630	2.606	0.0425
		A35	2.534		
		A37	2.586		
		A38	2.601		
		A39	2.663		
		A40	2.549		
		A42	2.559		
		A45	2.670		
		A46	2.671		
		A48	2.592		
		A49	2.615		
		A51	2.591		
		A52	2.622		
		A55	2.673		
		A57	2.576		
		A58	2.648		
		A59	2.534		
		A62	2.582		
A63	2.631				
A65	2.602				
A66	2.587				
γ_2 Yuanbaoshan	Granite	B07	2.597	2.606	0.0129
		B09	2.594		
		B02	2.621		
		B05	2.623		
		B19	2.591		
		B20	2.612		
Sibao Group	Slate	1406	2.741	2.678	0.0577
	Slate	1415	2.673		
	Slate	1419	2.664		
	Slate	1422	2.757		
	Slate	1425	2.740		
	Sandstone	1427	2.648		
	Sandstone	1429	2.684		
	Slate	1439	2.706		
	Slate	1447	2.679		
	Slate	1451	2.622		
Sandstone	1453	2.763			
Sandstone	1458	2.568			
Slate	1459	2.763			

	Slate	1460	2.681		
	Slate	1468a	2.692		
	Slate	1469	2.754		
	Slate	2002	2.696		
	Slate	2003	2.601		
	Sandstone	2004	2.671		
	Sandstone	2006	2.545		
	Sandstone	2007	2.655		
	Sandstone	2020	2.628		
	Slate	2031	2.678		
	Slate	2051	2.584		
	Slate	2052	2.700		
	Slate	2054	2.722		
	Slate	2055	2.685		
	Sandstone	1420	2.756		
	Sandstone	1461	2.734		
	Sandstone	2000-1	2.528		
Danzhou Group	Sandstone	2001	2.738	2.686	0.0851
	Sandstone	2064	2.704		
	Blastopsammite	2066	2.585		
	Sandstone	2067	2.759		
		2040	2.715		
Sinian	Sandstone	2040-1	2.714	2.710	0.0066
		2040-2	2.701		