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Reviews and new metallogenic models of mineral deposits in South China: An introduction

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ABSTRACT

In South China, the Yangtze and Cathaysia blocks were welded together along the Jiangnan Fold Belt during Neoproterozoic time (~830 Ma). Large-scale mineralization in these two blocks occurred from Proterozoic to Cenozoic, making the region one of the most important polymetallic metallogenic provinces in the world. Of particular importance are world-class deposits of iron-oxide copper gold (IOCG), sediment-hosted Mn-P-Al-(Ni, Mo, PGE), syenite-carbonatite-related REE, felsic intrusion-related Sn-W-Mo-Cu-Fe-Pb-Zn, mafic intrusion-related V-Ti-Fe and Cu-Ni-PGE and low-temperature hydrothermal Pb, Zn, Au, and Sb (Fig. 1). In addition, the Ta-Nb, Hg, As, Tl and U deposits in South China are among the world largest of these kinds. Because of these deposits, South China has been a focus of researches for many years. Publications before 2005 were mostly restricted in Chinese. In the past decade, some case studies on some world-class deposits in South China are available in international journals. These recent studies have advanced our understanding of their mode of formation. However, some important issues regarding the timing, tectonic setting and mechanisms of metal concentration still remain poorly understood. This special issue brings together some of the latest information on these topics, including major review papers on specific types of mineralization and several papers dealing with some specific deposits in the region. We anticipate that this issue will generate more interests in the studies of mineral deposits in South China. In this introduction, we outline the tectonic framework and associated deposits.

1. Introduction

In South China, the Yangtze and Cathaysia blocks were welded together along the Jiangnan Fold Belt during Neoproterozoic time (~830 Ma). Large-scale mineralization in these two blocks occurred from Proterozoic to Cenozoic, making the region one of the most important polymetallic metallogenic provinces in the world. Of particular importance are world-class deposits of iron-oxide copper gold (IOCG), sediment-hosted Mn-P-Al-(Ni, Mo, PGE), syenite-carbonatite-related REE, felsic intrusion-related Sn-W-Mo-Cu-Fe-Pb-Zn, mafic intrusion-related V-Ti-Fe and Cu-Ni-PGE and low-temperature hydrothermal Pb, Zn, Au, and Sb (Fig. 1). In addition, the Ta-Nb, Hg, As, Tl and U deposits in South China are among the world largest of these kinds. Because of these deposits, South China has been a focus of researches for many years. Publications before 2005 were mostly restricted in Chinese. In the past decade, some case studies on some world-class deposits in South China are available in international journals. These recent studies have advanced our understanding of their mode of formation. However, some important issues regarding the timing, tectonic setting and mechanisms of metal concentration still remain poorly understood. This special issue brings together some of the latest information on these topics, including major review papers on specific types of mineralization and several papers dealing with some specific deposits in the region. We anticipate that this issue will generate more interests in the studies of mineral deposits in South China. In this introduction, we outline the tectonic framework and associated deposits.

2. Tectonic framework and igneous activities in South China

The South China Craton in the southeastern part of the Eurasian continent is made up of the Yangtze Block to the northwest and the

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Cathaysia Block to the southeast, which were amalgamated along the Jiangshao suture zone at around 830 Ma (Zhao et al., 2011). In the Triassic, the South China Craton was collided with the North China Craton to the north and the Indochina Block to the south (Fig. 1) (Faure and Ishida, 1990; Zhou et al., 2006; Wang et al., 2007b). The basement of the Yangtze Block is composed of late Archean metamorphic rocks in the north and younger, only weakly metamorphosed late Paleo- to Neo-proterozoic rocks in the west and east, all of which were intruded by widespread Neoproterozoic igneous rocks (Zhou et al., 2002a, 2014). The sedimentary succession of the Yangtze Block consists mainly of Cambrian to Triassic marine sedimentary rocks and Jurassic-Cretaceous and Cenozoic continental sedimentary rocks (Yan et al., 2003). On the other hand, the Cathaysia Block is characterized by widespread, 1.9–1.8-Ga sedimentary rocks and Neoproterozoic to Early Paleozoic metamorphic rocks (Yu et al., 2005). Late Ordovician to Middle Devonian strata are absent but there are widespread igneous intrusions with ages ranging from 480 to 400 Ma, 230 to 200 Ma, 100 to 80 Ma (Yu et al., 2005). These tectonothermal events and igneous activities are spatially and temporally associated with widespread polymetallic mineralization in South China.

2.1. Paleoproterozoic assembly and breakup of Columbia

Global-scale 2.1–1.8-Ga continental collision events have been well documented in a number of large continental cratons, and are linked with the assembly of the supercontinent Columbia (Rogers and Santosh, 2002; Zhao et al., 2002, 2004). The Paleoproterozoic tectonic evolution of the Yangtze Block and its position in the reconstructed Columbia supercontinent are still poorly known due to sparse outcrops of Paleoproterozoic rocks. Magmatic and granulite-facies metamorphic events at 2.05–1.90-Ga were recently identified in the northern Yangtze Block (Wu et al., 2008; Zhang et al., 2006). In the southwestern Yangtze Block, sedimentary rocks of the Dahongshan, Dongchuan, and Hekou Groups contain abundant 2.05–1.95 Ga detrital zircons with low Th/U ratios, which are also indicative of such metamorphic events (Zhao et al., 2010; Hieu et al., 2012; Chen et al., 2013). Therefore, the Yangtze Block is suggested to have been involved in the assembly of Columbia.

The break-up of Columbia is thought to be associated with widespread 1.7–1.3 Ga intra-continental rifting and anorogenic magmatism in many cratons (e.g., Rogers and Santosh, 2002; Zhang et al., 2012; Zhao et al., 2002). Both ~1.8-Ga mafic dykes and rapakivi granites in the northern Yangtze Block are thought to have formed in a continental rifting environment (Xiong et al., 2009; Peng et al., 2009; Zhang et al., 2011), possibly related to the initial fragmentation of the Columbia supercontinent. In the southwestern Yangtze Block, there are rifting-related ~1.70–1.66 Ga bimodal volcanic rocks in the Dongchuan, Dahongshan and Hekou Groups and associated mafic dykes, indicating an intra-plate rifting environment at least during the period of ~1.7–1.66 Ga. These rift-related igneous rocks were also suggested to be related to the breakup of Columbia (Zhao et al., 2010; Chen et al., 2013; Wang and Zhou, 2014). Moreover, Fan et al. (2013) provided the first evidence of mantle plume-related mafic magmatism that produced the ca. 1.5 Ga Fe-Ti-V oxide-bearing Zhuqing intrusions. Therefore, the southwestern Yangtze Block was likely a part of Columbia and underwent magmatic events related to activity of mantle plumes during its break-up.

2.2. Meso- to Neo-proterozoic evoltuion

A regional unconformity in the southeastern Yangtze Block has long been thought to mark the Grenvillian orogenesis, locally named as the Sibao/Jiangnan Orogenic Belt (Fig. 1a) (Wang et al., 2007a). This orogenic belt was traditionally thought to extend from the southeastern to southwestern Yangtze Block, and to represent part of the global Grenvillian orogenic belt that linked South China to Laurentia and Australia in central Rodinia (Fig. 1a) (e.g. Li et al., 2008; X.H. Li et al., 2009; Ye et al., 2007). However, new geochronological and geochemical data of sedimentary and igneous rocks from the eastern Jiangnan Belt indicate that this orogenic belt likely formed at mid-Neoproterozoic (~830–815 Ma) (e.g., Zhao et al., 2011; Zhang et al., 2012).

In the southwestern Yangtze Block, there are ~1.0-Ga Huili and Kunyang Groups unconformably overlying the Dongchuan, Hekou and Dahongshan Groups. These strata contain considerable amounts of volcanic rocks that are intruded by slightly younger, ~1.0 Ga gabbroic intrusions. Recent studies indicated that these igneous rocks exhibit geochemical affinities of intra-plate igneous rocks (Geng et al., 2007; Zhang et al., 2007; Chen et al., 2014), and thus were suggested to be formed at a continental-rift setting. These new results thus argue against the existence of a so-called Grenvillian orogen in the southwestern Yangtze Block. Instead, in combination with extensive arc-related magmatism between 860 and 740 Ma in the western Yangtze Block (e.g., Zhou et al., 2002a; Zhao et al., 2008), the western Yangtze Block may have been in a passive margin setting during the assembly of the supercontinent Rodinia.

2.3. Early Paleozoic tectonic event

Early Paleozoic event was responsible for abundant deformation and ductile shearing on the Sinian to lower Paleozoic strata and formation of angular unconformities (Shu, 2006; Wang et al., 2010, 2013). This tectonic event has also produced voluminous granitic rocks that are mostly distributed in the Wuyishan and Gannan regions. Recent studies indicate that these rocks have ages ranging from 480 to 390 Ma, of which the 480–430 Ma ones have I-type affinity, whereas those of 430–390 Ma are S-type granites.

2.4. Late Permian mantle-plume activities

The late Permian Emeishan large igneous province (ELIP) covers an area of $\sim 5 \times 10^5$ km^2 in SW China and northern Vietnam, bounded by the Tibetan Plateau to the west and the Yangtze Block to the east (Chung et al., 1998). It is characterized by voluminous volcanic rocks within a short period of time induced by a mantle plume at the Permian-Triassic boundary (~260 Ma; Chung et al., 1998; Song et al., 2001; Xu et al., 2001; Zhou et al., 2002b). The ELIP continental flood basalts range in thicknesses from ~5 km in the west to a few hundred meters in the east (Chung and Jahn, 1995), and are temporally and spatially associated with abundant mafic-ultramafic intrusions and subordinate amounts of granitic and alkaline rocks (Xu et al., 2001; Zhong and Zhu, 2006; Zhou et al., 2002b).

2.5. Early Mesozoic Indosinian event

The Indosinian event was responsible for formation of voluminous granitic plutons in the South China Craton (Qiu et al., 2014), mainly in the Cathaysia Block and eastern part of the Yangtze Block. These granitic rocks have ages ranging from ca. 255 to 200 Ma (Wang et al., 2005, 2007b; Chen et al., 2011a), and were suggested to be related to the westward subduction of the Paleo-Pacific plate underneath the eastern margin of the Eurasian continent (Li and Li, 2007). On the other hand, the associated deformation may have been mainly due to the collision between the Indochina Block and South China Craton in response to the closure of Paleotethys (Wang et al., 2005, 2007b; Lepvrier et al., 2004; Chen et al., 2011a; Qiu et al., 2016). It is noteworthy that the

Indosinian Movement has produced the present tectonic framework of South China.

2.6. Late Mesozoic Yanshanian event

The late Mesozoic Yanshanian event is responsible for formation of the giant Yanshanian granitic province present as a swath >1000 km wide across the whole Cathaysia Block and southeastern Yangtze Block (Li and Li, 2007; Hu and Zhou, 2012). These granitic rocks were formed mainly in the Jurassic to Cretaceous, notably at 160–150 Ma and 120–85 Ma (Mao et al., 2013; Wang et al., 2013), and were generated by crustal-mantle interaction during lithospheric extension (Wang et al., 2013), in response to the westward subduction of the Pacific oceanic lithosphere beneath the Eurasian continent (Li and Li, 2007).

3. Major metallogenic events in South China

South China is well known for its large-scale mineralization from Proterozoic to Cenozoic, making the region one of the most important polymetallic metallogenic provinces in the world. Recent advantages on the analytical techniques for isotopic dating have revealed that the mineralization in South China can be divided into following stages (Figs. 1 and 2).

3.1. Paleo- to meso-proterozoic Fe-Cu mineralization

Major hydrothermal Fe-Cu deposits are present in the southwestern part of the Yangtze Block where they form the Kangdian Fe-Cu metallogenic province in southern China and northern Vietnam (Fig. 1) (Zhao and Zhou, 2011; Zhou et al., 2014). Large Fe-Cu deposits include Lala and Xikuangshan to the north, Yinachang in the center, Dahongshan and Sin Quyen to the south and possibly Shilu to the south-east. These deposits are characterized by an association of low-Ti Fe-oxides and Cu-sulfides with REE, Mo, Co, Ag, and Au as common by-products, and were recently considered to be similar to typical IOCG deposits worldwide (Zhao and Zhou, 2011; Chen and Zhou, 2012; Zhou et al., 2014).

The ore deposits are hosted in variably metamorphosed, ~1.65–1.7 Ga Dahongshan, Dongchuan, Hekou, and Sin Quyen Groups. Molybdenite separates from the Yinachang and Lala deposits have Re-Os model ages of 1.66 and ~1.0 Ga (Fig. 2), respectively, coeval with the ~1.7 and ~1.0 Ga rifting-related magmatism in the region, respectively (Chen and Zhou, 2012; Zhao et al., 2013). These

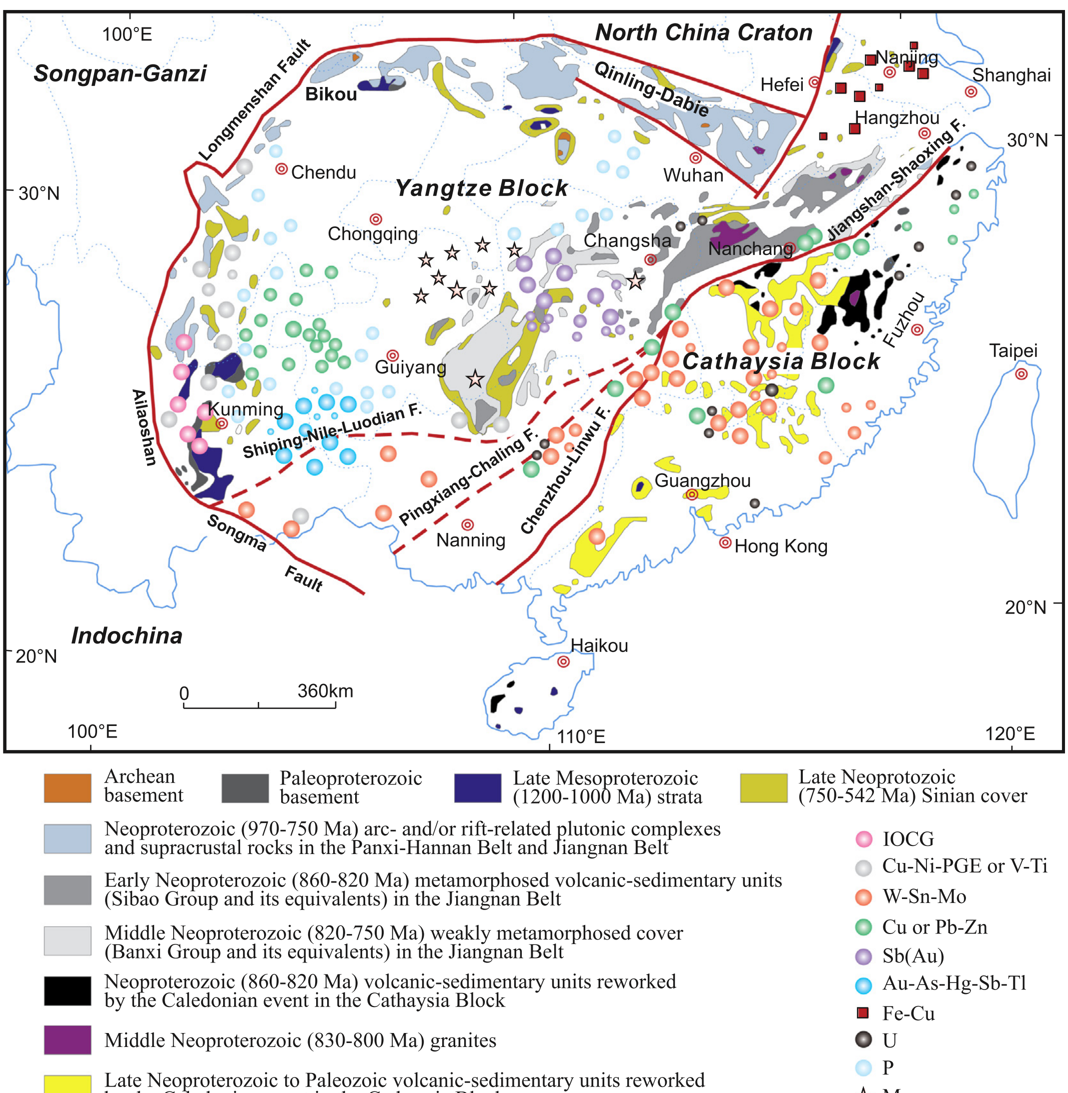

Fig. 1. Simplified geological map of the South China Craton and adjacent regions showing the structural framework and the distribution of ore deposits (Modified from Zhao and Cawood, 2012; Hu and Zhou, 2012).

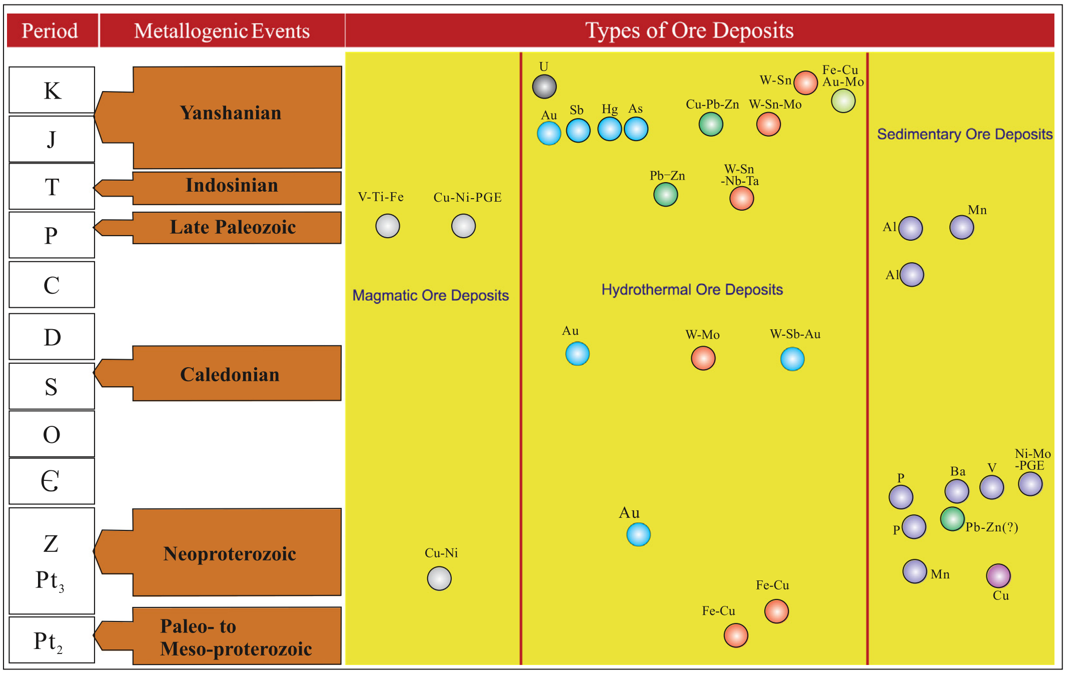

Fig. 2. A summary of major metallogenic events in South China.

ages suggest that the Fe-Cu deposits formed in multiple mineralization events over an exceptionally broad time range. There was a minor hydrothermal overprint at ~1.45 Ga, as recorded by the Re-Os model age of sulfides from veins in some deposits (Huang et al., 2013). Biotite, amphibole, and quartz from several deposits have $^{40}Ar/^{39}Ar$ plateau ages ranging from 850 to 780 Ma, but cluster at 830–820 Ma (Zhou et al., 2014). These $^{40}Ar/^{39}Ar$ ages are considerably younger than the Fe-Cu deposits and are interpreted as the result of thermal resetting of the K-Ar system during the Neoproterozoic, consistent with the extensive Neoproterozoic igneous activity in the Yangtze Block.

3.2. Neoproterozoic Cu-Ni and Au mineralization

Neoproterozoic mineralization in South China includes mainly volcanic rocks-hosted massive sulfide (VMS), magmatic Cu-Ni sulfide and orogenic-gold deposits (Figs. 1 and 2). The VMS deposits are mostly distributed in the northeastern section of the Qinhang suture zone, such as the Pingshui and Tieshanjie Cu deposits in Zhejiang province. On the other hand, magmatic Cu-Ni sulfide deposits are mainly distributed in the western margin of the Yangtze Block, and are hosted in the coeval,~820 Ma mafic-ultramafic intrusions, including the Yuanbaoshan and Qingmingshan deposits in north Guangxi, and the Lengshuiqing deposit in Sichuan (Munteanu et al., 2010; Zhu et al., 2006, 2007). In addition, numerous gold deposits of late Neoproterozoic age are distributed along the Qinhang suture zone, and they are hosted in ductile shear zones in the slightly metamorphosed rocks of the Neoproterozoic Shuangqiaoshan Group. These Au deposits have fluid inclusions rich in CO_2 (e.g., Jinshan Au deposit), and were thus considered to be typical orogenic gold deposits (Li et al., 2010).

3.3. Neoproterozoic to early Paleozoic sedimentary Ni-Mo-PGE, P and Mn mineralization

There are numerous sedimentary deposits hosted in the Neoproterozoic to early Paleozoic strata in South China, characterized by the Ni-Mo-PGE, P and Mn mineralization. Available geochronological studies indicated that the sedimentary mineralization have ages ranging from 700 to 500 Ma (Figs. 1 and 2) (Hu et al., 2007; Jiang et al., 2007; Lehmann et al., 2007).

Ni-Mo-PGE mineralization is hosted in sulfide layers of black shales in the lower part of the early Cambrian Niutitang Formation. The sulfide layers have a total thickness of several to tens of centimeters, and extend along the southeastern margin of the Yangtze Block, i.e. the Hunan-Guizhou region. Re-Os isochron dating of the black shales indicated that the timing of the mineralization should be 535 ± 11 Ma (Jiang et al., 2007).

P mineralization is predominantly present in the Yangtze Block, and has a total reserve accounting for more than 85% of that of China (Hu et al., 2007). The P mineralization is characterized by the phosphorites hosted in the Upper Sinian Doushantuo Formation that distributes along the Central Guizhou-West Hunan-West Hubei region, such as the Wenan, Kaiyang and Xifeng deposits, and those hosted in the lower Meishuchun Formation distributing along the West Guizhou-East Yunnan-Central Sichuan region, such as the Zhijin deposit. Available dating results show that the P mineralization in the Doushantuo Formation likely occurred at 550–600 Ma, whereas that in the Meishuchun Formation was present at about 530 Ma (Barfod et al., 2002; Chen et al., 2004; Hu et al., 2007).

Mn mineralization in South China has a total reserve accounting for more than 50% of that in China (Zhou et al., 2016). The Mn deposits are mostly hosted in black shales of Nanhua Period in the southeastern margin of the Yangtze Block, and were considered to be tectonically related to the formation of the Nanhua rifting basin. Typical examples include the Gucheng, Xiangtang and Songtao deposits, all of which were traditionally proposed to be "Datangpo-type". The ore minerals in these deposits are dominated by rhodochrosite. Previous zircon U-Pb dating of associated tuff and Rb-Sr isochron dating of Mn ores indicated that the Mn mineralization was likely present at about 700 Ma (Zhou et al., 2004; Yin et al., 2006).

3.4. Early Paleozoic W-Mo-Au-Sb mineralization

In the Nanling Range, there are numerous granite-related W-Mo deposits forming at 415–448 Ma (Hua et al., 2013), such as the world-class Zhangjialong W, Niutangjie skarn-type W and Baishiding quartz-type Mo deposits (Fig. 1) (X.F. Li et al., 2009; Hua et al., 2013). Formation of these deposits were suggested to be related to the Caledonian intra-continental orogenesis during which orogenic-type gold mineralization was also formed and occurred at the ductile shear zones in the Neoproterozoic Shuangxiwu and Chencai Groups. Typical examples of the Au deposits include the Huangshan and Pingshui deposits with ages ranging from 397 to 450 Ma (Ni et al., 2015). In addition, there are numerous Caledonian Au-(Sb, W) deposits located in the Xuefeng tectonic uplift belt in the southwestern margin of the Yangtze Block. In this region, the deposits are mostly hosted in the Proterozoic Lengjiaxi and Banxi Groups with minor also hosted in the Lower Sinian Tongjiangkou Formation, such as the Huangjingdong Au and Woxi Au-Sb-W, Banxi Sb and Mobin Au deposits. Recent isotopic dating results show that these Au-(Sb, W) deposits have been mainly formed at 380–435 Ma (Peng et al., 2003; Hu et al., 2007), broadly synchronous with the W-Mo deposits in Nanling (Fig. 2), suggesting that they were also likely genetically related to the Caledonian intra-continental orogen in this region.

3.5. Late Paleozoic mantle-plume-related mineralization

The ELIP, formed at late Permian (~260 Ma), covers an area of 5×10^5 km^2 from Songpan-Ganzi terrane in SW China in the north to northwestern Vietnam in the south (Chung and Jahn, 1995; Song et al., 2001). It consists dominantly of flood basalts with subordinate mafic-ultramafic and syenitic-granitic intrusions. The intrusive portions of the ELIP are volumetrically small compared to the volcanic rocks, but they are economically important because of their association with magmatic Cu-Ni-(PGE) sulfide, Fe-Ti-(V) oxide and Zr-Nb-REE deposits (Fig. 1) (Hu et al., 2010). The Fe-Ti-(V) oxide deposits (e.g., Taihe, Baima, Hongge, Panzhihua) are genetically related to and hosted in mafic-ultramafic layered intrusions, whereas the Cu-Ni-(PGE) sulfide deposits (Yangliuping, Jinping, Limahe) are mainly hosted in mafic-ultramafic sills. In addition, more than 30 Nb-Ta-Zr-REE deposits or mineralized zones in the Panxi region are spatially associated with alkali-syenite dikes that are genetically related to adjacent granitic and syenitic plutons (He, 2004; Wang et al., 2015). Typical examples include the Luku and Baicao Nb-Ta-Zr-REE deposits that were originally prospected in the 1960s.

3.6. Mesozoic polymetallic mineralization

An important Mesozoic event in South China was the formation of a large granitic province and associated large-scale Mesozoic metallogeny in both the Yangtze and Cathaysia Blocks (Fig. 1) (Hu and Zhou, 2012; Mao et al., 2013). These deposits can be classified into polymetallic hydrothermal systems closely related to granitic rocks and low temperature hydrothermal systems without clear connections with magmatism (Hu and Zhou, 2012). Numerous isotopic dating in recent years have revealed that the Mesozoic polymetallic mineralization has been formed at three main stages.

Indosinian stage (230–200 Ma): the Indosinian magmatic event and associated mineralization in the Cathysia Block is characterized by 258–205 Ma peraluminous S-type granites (Wang et al., 2013; Gao et al., 2016) and associated W-Sn-Nb-Ta mineralization (Fig. 2), such as the ~214 Ma Limu Sn-Nb-Ta and Hehuaping Sn deposits (Cai et al., 2006). In contrast, the Indosinian mineralization in the Yangtze Block is characterized by numerous low-temperature MVT-type Pb-Zn-Ag, Carlin-type Au and vein-type Sb, Hg and As deposits forming at 230–200 Ma (Hu and Zhou, 2012; Hu et al., 2017), such as the Huize, Maoping, Tianbaoshan and Daliangze Pb-Zn deposits, and Lannigou and Shuiyindong Carlin-type Au deposits. It was proposed that the Indosinian magmatism and mineralization may have been due to collision between the Indochina Block and South China Craton in response to the closure of Paleo-Tethys (Wang et al., 2005, 2007b; Lepvrier et al., 2004; Chen et al., 2011a; Qiu et al., 2016).

Early Yanshanian stage (180–125 Ma): The Early Yanshanian mineralization includes high-temperature W-Sn, Cu-Fe-Mo polymetallic and Cu-Mo-(Pb-Zn) porphyry types, and low-temperature Sb-Au-Hg-As-Tl types (Figs. 1 and 2). The low-temperature types are mainly distributed in the Cathaysia Block, and have ages ranging mostly from 170 to 150 Ma, such as the ~170 Ma Dexing porphyry Cu and ~165 Ma Dabaoshan Cu-Pb-Zn deposits (Lu et al., 2005; Mao et al., 2004), ~158 Ma Shuikoushan, Tongshanling and Baoshan plolymetallic deposits (Lu et al., 2006, 2015; Peng et al., 2006; Hu et al., 2012; Huang and Lu, 2014; Zhao et al., 2016), ~158 Ma Xihuashan and ~155 Ma Yaogangxian W deposits. There are also abundant 140–125 Ma porphyry-skarn deposits in the Middle-Lower Yangtze River Valley (Ling et al., 2009). On the other hand, the low-temperature types are mostly present in the Yangtze Block, including the 150–130 Ma Au-Hg-Sb-As-Tl deposits in the Youjiang basin and the 160–150 Ma Sb deposits in the Xiangzhong basin. It is proposed that both the low- and high-temperature type deposits were temporally and/or spatially related to magmatic rocks in response to an extensional regime in the entire South China Craton during that time.

Late Yanshanian stage (125–80 Ma): This stage of mineralization is widespread in entire South China, including the 76–89 Ma W-Sn deposits in Southeast Dian (Yunnan)-West Gui (Guangxi) metallogenic province (e.g., the world-class Gejiu and Dulong Sn deposits) (Liu et al., 2007; Yang et al., 2008; Cheng et al., 2010), 110–90 Ma porphyry-epithermal Cu-Au-Ag deposits in the southeast coast (Zhang et al., 2003; Liu and Hua, 2005), and 120–80 Ma U deposits in the Cathaysia Block (Fig. 1) (Hu and Zhou, 2012). It is noteworthy that except the U mineralization, other metallic mineralization is temporally and/or spatially associated with granitic activities.

4. The thematic issue of mineral deposits in South China

Recent studies of mineral deposits in South China have advanced our understanding of their occurrence and model of formation. This special issue brings together some of the latest information on this topic in ten papers dealing with mineral deposits forming at different periods during tectonic evolution of South China, including some review papers on specific types of mineralization and papers involving case studies of major deposits in the region.

4.1. Part I: Reviews of major metallogenic provinces

Hu et al. (2017) give a review on Mesozoic low-temperature deposits in South China. The giant South China low-temperature metallogenic domain (LTMD) includes an area of ~500,000 km^2 in the Yangtze Block and is composed of the Chuan-Dian-Qian, Youjiang and Xiangzhong metallogenic provinces. The Chuan-Dian-Qian province contains numerous MVT Pb-Zn deposits, whereas the other two provinces are characterized by Carlin-type Au and vein-type Sb, Hg and As deposits. This paper summarized that these deposits formed dominantly at 200–230 Ma and 130–160 Ma, corresponding to Indosinian (Triassic) and Yanshanian (Jurassic to Cretaceous) orogenies, respectively. This study proposed that the Indosinian orogeny was the key factor in establishing the metallogenic framework of the LTMD. It produced widespread mineralization in the three metallogenic provinces, each of which has unique features reflecting differences in the nature and composition of the basement rocks. In contrast, the

Yanshanian metallogeny was less important and overprinted the Indosinian ore deposits.

Liu and Zengqian Hou (2017) give a review on the geology, geochronology and origin of the REE deposits in the Mianing-Dechang REE belt, SW China. These REE deposits are hosted in carbonatite-syenite complexes, and both the REE deposits and hosting rocks have similar ages of 11 and 22–27 Ma. Moreover, available isotopic and fluid inclusion data indicates that formation of the largest REE deposits are genetically related to voluminous carbonatite–syenite complexes, compositionally similar ore-forming fluids and tectonic setting, and all involved multiple stages of REE mineralization and extensive alteration. The parental, fertile magmas, which lead to the formation of hosting complexes and related REE deposits, were generated by the partial melting of sub-continental lithospheric mantle (SCLM) that was metasomatized by REE- and CO_2-rich fluids derived from subducted marine sediments. In addition, Liu et al. highlights that REE of subducted marine sediments in the SCLM is likely critical to formation of giant REE deposits.

Xu et al. (2017) conducted a review on geology of Mesozoic gold deposits in Hainan Province of South China, as well as providing new fluid inclusion geochemistry, C-H-O-S-Pb isotopic and geochronological data on several deposits. Their study identified two types of gold deposits including the orogenic- and intrusion-related types. It was indicated that the orogenic-type Au deposits have formed in a post-collisional setting at 228–224 Ma, and formation of relatively high-grade ores involved magmatic fluids. On the other hand, the intrusion-related Au deposits may have formed at ca. 100 Ma in a back-arc extension setting.

Zhao et al. (2017) give a review on genetic types, mineralization styles, and geodynamic settings of Mesozoic tungsten deposits in South China. This study summarized that there are skarn, porphyry, greisen and quartz-vein types of Mesozoic W deposits mainly distributed in the E-W-trending Nanling region and the NE-trending Yangtze River region. Their work shows that the different types of W mineralization are all closely associated with the Mesozoic magmatism in South China, and can be divided into four episodes that were temporally related to the closure of paleo-Tethys and subduction of the paleo-Pacific plate. They have also proposed a new dynamic model that formation and distribution of the Mesozoic W deposits were resulted from the break-off and anticlockwise rotation of the subducted ridge in the paleo-Pacific plate.

4.2. Part II: Case studies of major mineral deposits

Lan et al. (2017) conducted an integrated geochronological, PGE, REE and trace element geochemical study on the shallow water Ni-Mo-PGE enriched layer of the Niutitang Formation around Hubei Province. Their results suggest the Ni-Mo-PGE ore deposits have a mixed origin involving seawater, hydrothermal and terrigenous materials. Organic matter played an important role in sourcing, transporting and precipitating trace metals that have precipitated from ambient seawater under anoxic-suboxic settingswith episodic injections of fresh oxidized seawater. This study also provided new SIMS U-Pb ages of 532–527 Ma for the Ni-Mo-PGE enriched layer, suggesting the Niutitang Formation could be correlated with the Shiyantou Formation.

Tang et al. (2017) conducted U-Pb, Re-Os and Ar-Ar dating on the Linghou polymetallic deposit in the Qingzhou-Hangzhou metallogenic belt, Southeastern China. The new results show that molybdenite from Cu-Au-Ag ore bodies have a mean Re–Os model age of 162.2 ± 1.4 Ma, similar to the Ar-Ar isochron age of 160.2 ± 1.0 Ma for the Pb-Zn-Cu ore bodies, but much younger than host strata. These new ages thusexclude the possibility that the deposit is of "SEDEX" type as previously proposed. Instead, the timing of the mineralization is comparable with the zircon U-Pb ages of 160 Ma for the spatially associated granodioritic porphyry, further supporting that this deposit is magmatic-hydrothermal in origin and is genetically related to the granitic rocks.

Li et al. (2017) studied the fluid and melt inclusions in quartz and lepidolite in the Yichun Ta-Nb deposit. Their new results show that physical properties of melt inclusions are gradually variable from bottom upward of different zones in the Yashan granitic intrusion. They also proposed that the initial H_2O contents of the melts range from 2 wt.% at lower zone to 3 wt.% at upper granite zones, and the identified fluid inclusions represent the hydrothermal fluid that was exsolved from the magma. This study thus provided new insights that the Yichun deposit has formed through continuous fractional crystallization of a granitic magma.

Yang et al. (2017) present a case study of the I-type granites in Dayang and Juzhou. This study shows that granites in Dayang and Juzhou have zircon U-Pb ages of 143 ± 2.3 Ma and 133 ± 2.1 Ma, respectively. Geochemical data indicates that formation of both granites have involved a similar, mixed source of Paleoproterozoic basement and juvenile materials, but are tectonically related to different stages of subduction of the Paleo-Pacific Plate. In addition, the new results reveal that the spatially associated Mo mineralization should be genetically related to the Dayang granite, an interpretation is further supported by the tetrad effect of the Dayang granites, indicative of melt–fluid interactions.

Cao et al. (2017) reports new zircon U-Pb ages, Hf isotopic and whole-rock elemental data of Eocene granite, and mica Ar-Ar age and C-H-O-S-Pb isotopic data for the Lailishan Sn deposit. The new results indicate that the Lailishan Sn deposit has a muscovite Ar-Ar age of 50.4 Ma, synchronous with the granitoid with zircon U-Pb age of ~50.5 Ma. The C-H-O-S-Pb isotopic compositions of quartz, calcite, pyrite and pyrrhotite from the deposit indicate a magmatic origin for the ore-forming fluids, further indicating that the Sn deposit is likely genetically related to nearby granitoids. The authors also proposed that the widespread Eocene magmatism and associated Sn mineralization in the Tengchong block resulted from slab breakoff at ca. 55 Ma.

Luo et al. (2017) reported a new age for a U deposit in South China and identified the U mineralization age at 2.0 Ma. They conduct EMP and SIMS U-Pb dating on uraninite from the Menggongjie granite-hosted uranium deposit. The newly obtained young age of ~2.0 Ma agrees well with the eruption ages of the extension-related Quaternary volcanic rocks (2.1–1.2 Ma) in South China, suggesting that the uranium mineralization may have formed at an extensional setting, possibly related to the Quaternary volcanic activities. Therefore, the robust, new age determination reveals an important granite-hosted uranium mineralization that is known the youngest in South China.

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