Journal of Asian Earth Sciences 137 (2017) 1–8

Contents lists available at ScienceDirect

Journal of Asian Earth Sciences

journal homepage: www.elsevier.com/locate/jseaes

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

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ARTICLE INFO

Article history:
Received 14 February 2017
Received in revised form 21 February 2017
Accepted 21 February 2017
Available online 22 February 2017

Keywords:
South China
Mineral deposits
Dynamic model

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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http://dx.doi.org/10.1016/j.jseaes.2017.02.035
1367-9120/

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