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Nature, diversity of deposit types and metallogenic relations of South China

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Abstract

The South China Region is rich in mineral resources and has a wide diversity of deposit types. The region has undergone multiple tectonic and magmatic events and related metallogenic processes throughout the earth history. These tectonic and metallogenic processes were responsible for the formation of the diverse styles of base and precious metal deposits in South China making it one of the resource-rich regions in the world. During the Proterozoic, the South China Craton was characterised by rifting of continental margin before eruption of submarine volcanics and development of platform carbonate rocks, and the formation of VHMS, stratabound copper and MVT deposits. The Phanerozoic metallogeny of South China was related to opening and closing of the Tethyan Ocean involving multiple orogenies by subduction, back-arc rifting, arc–continent collision and post-collisional extension during the Indosinian (Triassic), Yanshanian (Jurassic to Cretaceous) and Himalayan (Tertiary) Orogenies. The Late Palaeozoic was a productive metallogenic period for South China resulting from break-up and rifting of Gondwana. Significant stratabound base and precious metal deposits were formed during the Devonian and Carboniferous (e.g., Fankou and Dabaoshan deposits). These Late Palaeozoic SEDEX-style deposits have been often overprinted by skarn systems associated with Yanshanian magmatism (e.g., Chengmenshan, Dongguashan and Qixiashan). A number of Late Palaeozoic to Early Mesozoic VHMS deposits also developed in the Sanjiang fold belt in the western part of South China (e.g., Laochang and Gacun).

South China has significant sedimentary rock-hosted Carlin-like deposits, which occur in the Devonian- to Triassic-aged accretionary wedge or rift basins at the margin of the South China Craton. They are present in a region at the junction of Yunnan, Guizhou, and Guangxi Provinces called the 'Southern Golden Triangle', and are also present in NW Sichuan, Gansu and Shaanxi, in an area known as the 'Northern Golden Triangle' of China. These deposits are mostly epigenetic hydrothermal micron-disseminated gold deposits with associated As, Hg, Sb+Tl mineralisation similar to Carlin-type deposits in USA. The important deposits in the Southern Golden Triangle are Jinfeng (Lannigou), Zimudang, Getang, Yata and Banqi in Guizhou Province, and the Jinya and Gaolong deposits in Guangxi District. The most important deposits in the Northern Golden Triangle are the Dongbeizhai and Qiaoqiaoshang deposits.

Many porphyry-related polymetallic copper–lead–zinc and gold skarn deposits occur in South China. These deposits are related to Indosinian (Triassic) and Yanshanian (Jurassic to Cretaceous) magmatism associated with collision of the South China and North China Cratons and westward subduction of the Palaeo-Pacific Plate. Most of these deposits are distributed along the Lower to Middle Yangtze River metallogenic belt. The most significant deposits are Tonglushan, Jilongshan, Fengshandong, Shitouzui and Jiguanzui. Au–(Ag–Mo)-rich porphyry-related Cu–Fe skarn deposits are also present (Chengmenshan and Wushan in Jiangxi

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Province and Xinqiao, Mashan-Tianmashan, Shizishan and Huangshilaoshan in Anhui Province). The South China fold belt extending from Fujian to Zhejiang Provinces is characterised by well-developed Yanshanian intrusive to subvolcanic rocks associated with porphyry to epithermal type mineralisation and mesothermal vein deposits. The largest porphyry copper deposit in China, Dexing, occurs in Jiangxi Province and is hosted by Yanshanian granodiorite. The high-sulphidation epithermal system occurs at the Zijinshan district in Fujian Province and epithermal to mesothermal vein-type deposits are also found in the Zhejiang Province (e.g., Zhilingtou). Part of Shandong Province is located at the northern margin of the South China Craton and the province has unique world class granite-hosted orogenic gold deposits. Occurrences of Pt–Pd–Ni–Cu–Co are found in Permian-aged Emeishan continental flood basalt (ECFB) in South China (Jinbaoshan and Baimazhai in Yunnan Province and Yangliuping in Sichuan Province). South China also has major vein-type tungsten–tin–bismuth–beryllium–sulphide and REE deposits associated with Yanshanian magmatism (e.g., Shizhuyuan and Xihuashan), important world class stratabound base metal–tin deposits (Dachang deposit), and the large antimony deposits (Xikuangshan and Woxi). During the Himalayan Orogeny, many giant deposits were formed in South China including the recently emerging Yulong and Gangdese porphyry copper belts in Tibet and the Ailaoshan orogenic gold deposits in Yunnan.

Keywords: Mineral deposits; Metallogeny; Base metals; Gold; South China; SE Asia; China

1. Introduction

The People's Republic of China (PRC) is endowed with a variety of mineral resources and has a long history of metal and non-metal mining. This introductory paper provides an overview of the metallogeny and mineral potential of base and precious metal deposits in the South China Region. The South China Region we

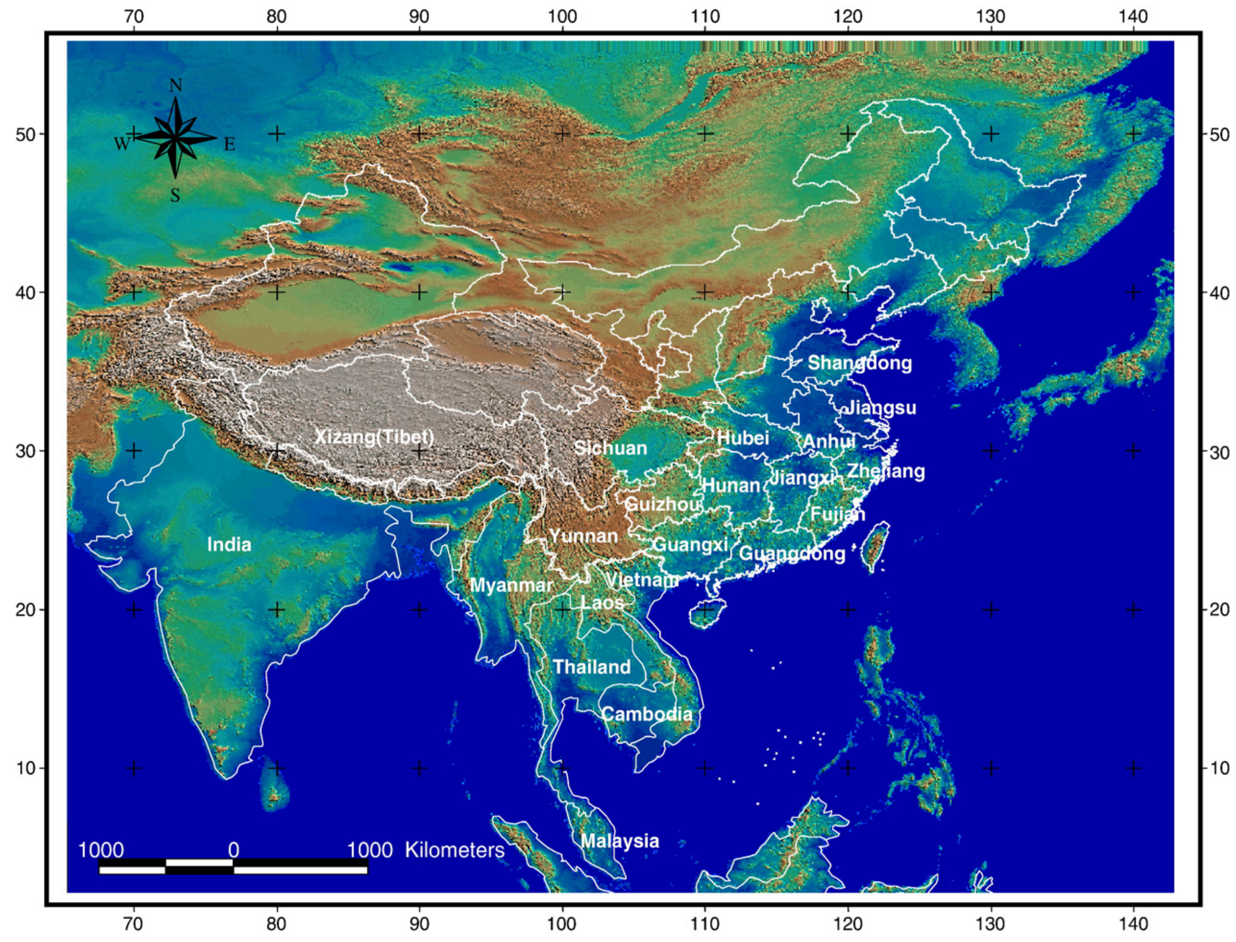

Fig. 1. Map showing the Provinces in South China covered in this volume.

refer to in this thematic issue is a resource-rich region to the north of Myanmar, Lao PDR and Vietnam, and includes Yunnan, Sichuan, Guizhou, Guangxi, Hunan, Guangdong, Jiangxi, Hubei, Fujian, Anhui, Zhejiang, Jiangsu, Tibet and part of Shandong Provinces in the PRC (Fig. 1). In this paper, we describe and discuss regional geological and tectonic setting, deposit types and mineralisation styles, metal endowment relative to the deposit types and metallogenic history of the South China Region.

2. Regional tectonic setting

The tectonic and metallogenic features of South China are controlled by two major Proterozoic cratons, the North China (NCC) and South China (SCC) Cratons, with mineralised fold belts, accreted island arcs, back-arcs and extensional rift basins adjacent to or between these two cratons (Fig. 2). The SCC has the most important metallogenic provinces in China containing world-class base and precious metal deposits (Guo, 1987; Mineral Deposits of China, 1990, 1992; Song, 1992; Mineral Deposits of China, 1995; Zhai and Deng, 1996; Chen, 1999; Khin Zaw et al., 2000a,b, 2001, 2002; White, 2002; Yang et al., 2002; Goldfarb et al., 2004). The SCC is generally hilly, cut by numerous minor rivers including the major Yangtze River system, and rimmed by mountains. It also has numerous, well-exposed outcrops of Proterozoic to Mesozoic rocks. The SCC formed about 1 Ga–860 Ma and thereafter behaved as a cohesive tectonic unit, with growth on its peripheries (e.g., the addition of Cambrian island arcs in the south of south China and in North Vietnam). The Phanerozoic unity of the SCC is based on fossils (e.g., numerous endemic families and genera of Devonian fish are found over the whole of the SCC but are not found elsewhere) and on SCC palaeomagnetism, which is quite different from that of the NCC (Long and Burrett, 1989; Burrett et al., 1990; Enkin et al., 1992).

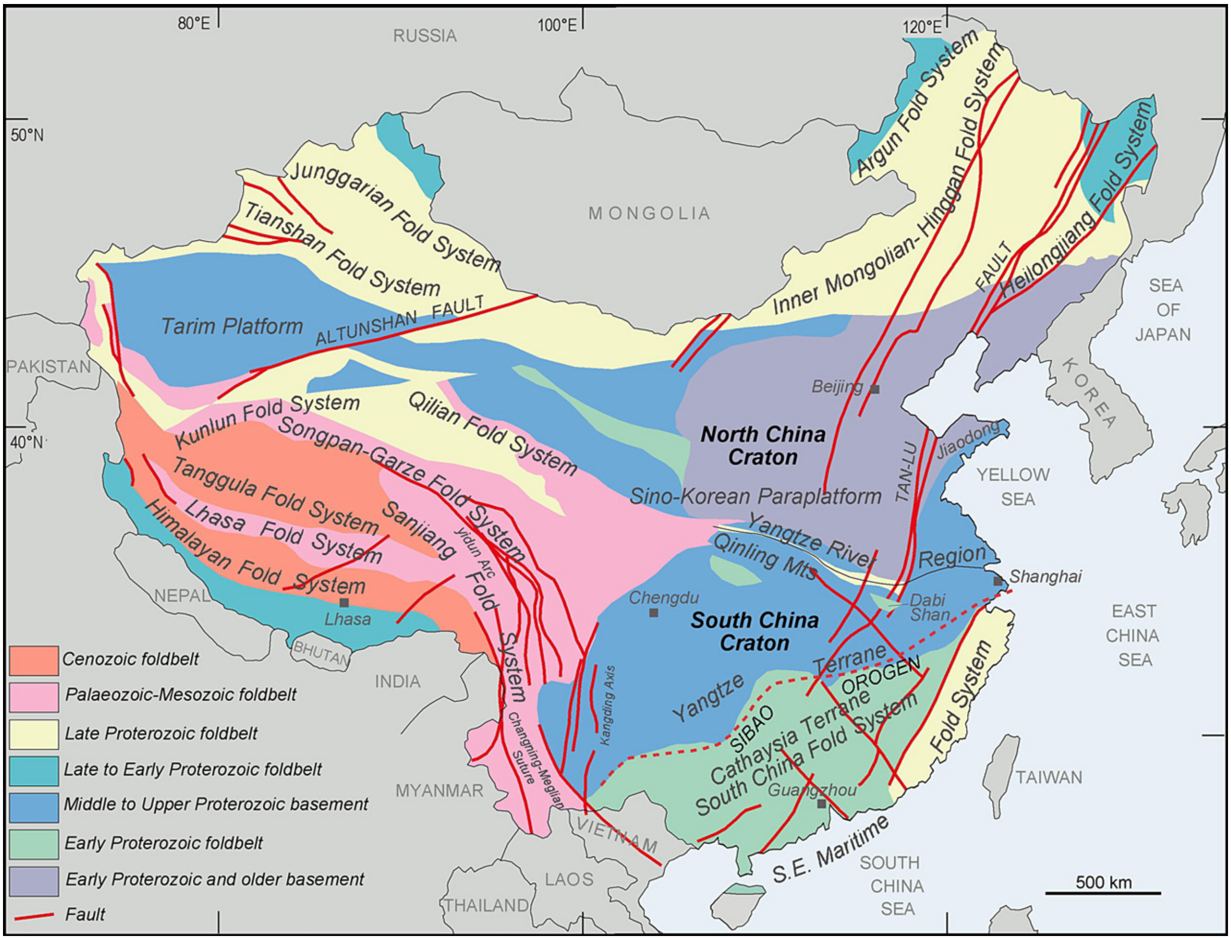

Fig. 2. Generalised geological map of China (modified after Cromie, 2001).

Although the SCC was a coherent tectonic block throughout the Phanerozoic, a number of intense tectonic events resulted in a complex history of folding, metamorphism, uplift, granite intrusion, volcanism, and rifting along its margins. The main orogenies in South China have been designated as the Jinningian (Mesoproterozoic), Caledonian (Early Palaeozoic), Variscan (Late Palaeozoic), Indosinian (Triassic), Yanshanian (Jurassic–Cretaceous), and Himalayan (Tertiary). Magmatic events during these orogenies were genetically and spatially associated with iron, lead, zinc, copper, gold, tin, tungsten, and rare-metal mineralisation.

The SCC was part of Greater Gondwana until the Silurian or Devonian and was probably situated close to India. By Devonian time, the SCC had moved away from Gondwana and eventually collided with the NCC during the Late Triassic along the wide and economically important Qinling Mountain Fold System (Burrett, 1974; Meng and Zhang, 1999; Raschtbacher et al., 2003). The Qinling Fold System is a complex belt of sutures and small terranes of arc and back-arc affinities. This belt contains the famous and intensely studied mid-Triassic ultra high pressure eclogites of the Dabie Shan and their 500 km northeasterly offset by the Tan-Lu Fault, continuation in the Su-Lu Region of the Jiaodong Peninsula (Faure et al., 2001). Both the NCC and SCC were probably part of Greater Gondwana during the Early Palaeozoic (Burrett and Stait, 1986) and rifted off during or prior to the Devonian (Burrett et al., 1990). However, the exact placement and orientation of these cratonic blocks in Early Palaeozoic Greater Gondwana remains to be determined.

The Phanerozoic SCC is itself composite and was the result of the fusion of several terranes during the Precambrian. The north–south trending Kangding ‘axis’, along the western margin of the SCC, was an active Mesoproterozoic island–arc complex with synorogenic granite–gneisses at 1007 Ma (Li et al., 2005). The major event in the SCC was the collision of the western Yangtze terrane with the eastern Cathaysian terrane along the Sibao orogenic belt at about 860–850 Ma (Fig. 2). The resulting broad NW-trending Sibao orogenic belt extends from Guangxi Province to Zhejiang Province and includes 1200–850 Ma island arc and back-arc basin complexes and extensive syn- and post-orogenic granitoids of the Late Jinningian Orogeny. The Cathaysian terrane has six felsic igneous events between 2713 to 644 Ma, and bimodal volcanism at 818 Ma with major deformation events at 1850 and 868 Ma (Li et al., 2005). The Yangtze terrane has major felsic igneous events at 2957, 2450, 1657, 907 and 890–830 with deformation at 1200–1000 and 850 Ma (unpublished compilation, Burrett and Berry, 2002).

Thick packages of post-orogenic terrestrial siliciclastic rocks (‘molasse’), including extensive rhyolitic–dacitic volcanic rocks, and extensive glacial deposits are widespread on the SCC and form the basis for the Sinian chronostratigraphic unit in China. The Sinian interval is regarded as a local chronostratigraphic (time-rock) term for the pile of sedimentary rocks deposited above the unconformity caused by the collision of Yangtze and Cathaysian terranes in South China at about 850 Ma. The Sinian sequence ranges in age from about 850 Ma to about 545 Ma (base of the Cambrian) and is widely distributed on the SCC. The Sinian siliciclastic rocks are followed by 1000 m of widespread, platform carbonate rock grading to deeper water condition along the Qinling margin in Sichuan and Hunan Provinces. The mafic protoliths of the ultrahigh pressure Dabie Shan eclogites are dated to 780, 733 and 684 Ma (Liu et al., 2004).

Platform carbonates continued to be widespread in the Early Palaeozoic of the Yangtze terrane grading to deeper water conditions in the area of the Cathaysian terrane (Fig. 2). The eastern (Cathaysian) margin of the SCC became active in the Late Ordovician and Silurian with folding and granite intrusions related to the Xingkaian Orogeny in Hunan and Guangxi Provinces. The Xingkaian Orogeny was restricted to the southeast parts of the SCC and in other areas of the SCC there are continuous and conformable sequences throughout the Ordovician and Silurian. This orogeny also led to uplift and widespread continental deposition in the southern half of the SCC in the Silurian. During the Devonian through to the Permian, platform sediment extended across most of the SCC and an island–arc complex developed in the Qinling belt in the Devonian. The SCC and NCC were close enough in the Late Carboniferous for floral interchange to occur. Localised mid-Permian folding in western Sichuan Province and extensive latest Permian continental flood basalts, the Emei Traps, in Yunnan and Guizhou Provinces also took place (Ali et al., 2004, 2005).

During the Triassic, an extensive carbonate platform contracted resulting in widespread terrestrial deposition in the Jurassic. The collision of the SCC and the NCC occurred along the Qinling belt in the Triassic. Dating of the Dabie Shan coesite and diamond-bearing eclogites within the Qinling belt, reveals that subduction continued until 220 Ma (Carnian) and that extreme sub-horizontal shortening occurred from 200–180 Ma (Latest Triassic to Early Jurassic) with extension from 133 to 122 Ma (Early Cretaceous) (Hacker et al., 1995).

The northwestern margin of the SCC and eastern end of the Qinling belt is characterised by a large area of thick Triassic turbidites known as the Songpan Garze accretionary wedge or Songpan Garze Fold System (Fig. 2). Triassic granites are widespread in Yunnan, Sichuan and Hunan Provinces due to the Indosinian SCC/NCC and the Shan-Thai/SCC collisions.

In the Changning–Menglian suture of western Yunnan, deep water radiolarian cherts are dated as Late Devonian to mid-Triassic. During the Devonian to Permian an ocean containing numerous oceanic islands is inferred to have existed in the western part of the suture with an arc–back-arc basin complex in the east. The final closure of the ocean occurred along the Changning–Menglian suture in the Late Triassic due to the fusion of the Shan-Thai terrane with the SCC (Fang et al., 1996).

The Late Triassic collisions produced mountains such as the Palaeo-Qinling mountains, which became major sources of sediments feeding the terrestrial Jurassic Sichuan Basin. Deformation in the Qinling continued into the Early Jurassic. During the Jurassic and Cretaceous, subduction from the east took place along the Palaeo-Pacific margin of South China. Yanshanian (Jurassic–Cretaceous) granites are widespread in Sichuan and Guangxi Provinces. Subduction along the Palaeo-Pacific margin led to extensive calc-alkaline volcanic rocks and granite intrusions in the Jurassic and Cretaceous extensional regime. Peaks of magmatism occurred at 145, 126, 103 and 91 Ma (Li, 2000). Mesozoic and Oligocene collision of the Tibetan blocks during the Himalayan Orogeny was caused by the progressive indentation of India into Asia. Huge transcurrent faults such as the Altunshan and Red River faults fractured the composite Asian continent and allowed for the eastward 'escape' of China between 10 mm/yr and 23 mm/year due to the northward movement of India at 44 mm/yr (Larson et al., 1999).

The Sanjiang Tethyan Metallogenic Domain (STMD) or Sanjiang fold belt system (Fig. 2) occurs along the western part of the South China Terrane in Yunnan, Sichuan, and eastern parts of Tibet, and contains a diverse range of mineral deposit types and metal associations (e.g., Lou et al., 1994). Hou et al. (2007-this volume) described the mineralisation styles in the STMD and relate the metallogenic epochs from the Early Palaeozoic, Late Palaeozoic, Late Triassic and Himalayan to the tectonic development of the region. The STMD is a collage of accreted island arcs, back-arcs and rift basins. The Triassic Yidun volcanic arc hosts world-class VHMS deposits (e.g., the Gacun deposit).

The Yidun arc is located along the Songpan–Ganze Fold System (Fig. 2). Reid et al. (2007-this volume) report on laser ICP-MS U/Pb geochronology and Hf isotopic signatures of the granitic plutons from the Yidun arc, which have yielded Early–Middle Triassic (~245–229 Ma), Late Triassic (~219–216 Ma) and Cretaceous (~105–95 Ma) ages. They interpret that Triassic granites were derived from an isotopically heterogeneous, largely crustal source and the Cretaceous granite from a more homogeneous crustal source. The source region of these magmas may be from Mesoproterozoic material from the Yangtze terrane, which probably underlies the Yidun arc (Reid et al., 2007-this volume).

3. Deposit types and mineralisation styles

A variety of base metal mineralisation occurs in the South China Region: volcanic-hosted massive sulphide (VHMS), sedimentary exhalative (SEDEX), Mississippi Valley type (MVT), base metal skarn and polymetallic vein deposits. Precious metal (gold and silver) deposits are also present as Carlin-like, epithermal vein, breccia-type, and structurally-controlled orogenic-type deposits. It is difficult to classify all of the South China base and precious metal deposits into currently available deposit models. Recently, Large (2004) highlighted this problem and indicated the existence of hybrid deposits. For example, the world-class Cambrian Cu–Au deposit at Mt Lyell in western Tasmania shares many features of VHMS, porphyry and epithermal deposit types and Large (2004) suggests it is better classified as a hybrid deposit than a VHMS or porphyry deposit types. Due to the multiple orogenic and metallogenic episodes, ore deposits in the South China Region have been affected by reworking, remobilisation, and recrystallisation by later magmatic, metamorphic, and tectonic events. Hence, some of the mineral deposits in South China do not fit into the classical deposit models. Keeping these aspects in mind, the South China base and precious metal deposit types are described in the sections to follow.

3.1. VHMS deposits

Selected major VHMS deposits in South China are listed in Table 1 and shown in Fig. 3. Significant VHMS deposits occur in Yunnan Province in the Late Palaeozoic island-arc related Changning–Menglian felsic volcanic belt (Haitan, 1992; Yang and Mo, 1993; Hou and Mo, 1993; Yang et al., 1993, 1999; Hou et al., 1999). This belt is 20 to 60 km wide and

Table 1
Characteristics of selected important mineral deposits in South China

Fig. no.	Deposit name	Province	Lat./Long	Deposit type	Commodity	Tonnage	Grade	Host rocks	Host rock ages	Reference
3	Gacun	Sichuan	99° 32′ 31° 11′	VHMS	Zn–Pb–Cu–Ag–Au	4 Mt (metal): combined (Cu+Zn+Pb+Ag+Au)	0.44% Cu, 5.4% Zn, 3.7% Pb, 160 g/t Ag, 0.3 g/t Au	Felsic and mafic volcanic rocks (bimodal)	Triassic	Hou et al. (2000, 2001, 2006-this volume)
3	Liwu	Sichuan	101° 48′ 28° 36′	VHMS	Cu–Zn	0.26 Mt (metal): Cu 0.13 Mt (metal): Zn	2.5% Cu, 0.6% Zn	Metavolcanic rocks	Silurian-Devonian	Hou et al. (1999)
3	Lalachang	Sichuan	101° 54′ 26° 06′	VHMS	Cu–Fe	0.6 Mt (metal): Cu	0.9% Cu	Spilite–keratophyre	Proterozoic	Hou et al. (1999)
3	Dahongshan	Yunnan	101° 41′ 24° 06′	VHMS	Cu–Fe	0.8 Mt (metal): Cu	0.64% Cu	Volcanic rocks	Late Proterozoic	Hou et al. (1999)
3	Dapingzhang	Yunnan	100° 31′ 22° 47′	VHMS	Cu–Pb–Zn	0.30 Mt (metal): Cu 0.15 Mt (metal): Pb 0.15 Mt (metal): Zn 0.6 Mt (ore): Ag, Au	1.9–6.1% Cu, 0.2–1.1% Pb, 0.4–1.8% Zn, 110 g/t Ag, 3.5 g/t Au	Felsic volcanic rocks	Late Carboniferous	Hou et al. (2006-this volume)
3	Laochang	Yunnan	99° 44′ 22° 45′	VHMS	Pb–Zn–Ag	0.5 Mt (metal): Pb 0.16 Mt (metal): Zn >500 t (metal): Ag	1.2–8.9% Pb, 2.9–5.1% Zn, 57–195 g/t Ag	Trachybasalt – andesite and associated volcanoclastic rocks	Late Carboniferous	Hou et al. (2006-this volume)
3	Tongchangjie	Yunnan	99° 45′ 24° 20′	VHMS	Cu–Zn	0.2 Mt (metal): Cu No data for Zn	1.54% Cu, 0.4% Zn	Mafic volcanic rocks	Permian–Carboniferous	Hou et al. (2006-this volume)
4	Jinding	Yunnan	99° 25′ 26° 24′	Probable SEDEX	Zn–Pb–Ag	200 Mt (ore)	6.08% Zn, 1.29% Pb, 1 – 20 g/t Ag	Sandstone, siltstone, limestone	Eocene	Kyle and Li (2002); Xue et al. (2006-this volume); Hou et al. (2006-this volume)
4	Dabaoshan	Guangdong	113° 43′ 24° 33′	SEDEX	Cu–Pb–Zn–W	0.86 Mt (metal): Cu 0.85 Mt (metal): Zn 0.31 Mt (metal): Pb 0.11 Mt. (metal): W	0.86% Cu, 12% Zn, 1.77% Pb, 0.12% WO_3	Limestone, shale, dacite, tuffaceous rock	Middle Devonian–Carboniferous	Gu L. et al. (2006-this volume)
4	Fankou	Guangdong	117° 49′ 30° 55′	SEDEX	Zn–Pb–Ag	3.4 Mt (metal): Zn 1.7 Mt (metal): Pb	12% Zn, 5.1% Pb, Ag credits	Limestone, siltstone, shale	Middle Devonian–Early Carboniferous	Gu L. et al. (2006-this volume)
4	Dongchuan	Yunnan	102° 56′ 26° 13′	SEDEX	Cu (Fe)	No data	No data	Sandstone, shale, dolomite	Proterozoic	Huichu et al. (1991) ; Chen W. (1997)
4	Dongguashan	Anhui	113° 37′ 25° 07′	SEDEX/Skarn overprint	Cu–Au	0.94 Mt (metal): Cu 22 t (metal): Au	1.00% Cu, 0.24 g/t Au	Limestone, dolomite with intercalated anhydrite	Middle Devonian–Early Carboniferous	Gu L. et al. (2006-this volume)
4	Qixiashan	Jiangsu	118° 58′ 32° 09′	SEDEX/Skarn overprint	Zn–Pb–Mn–Au	0.4 Mt (metal): Pb 0.8 Mt (metal): Zn 0.4 Mt (metal): Mn 27 t (metal): Au	2.6% Pb, 4.9% Zn, 17% Mn, 0.9 g/t Au	Dolomite, limestone, shale, siltstone, sandstone	Carboniferous	Gu L. et al. (2006-this volume)
5	Daliangzi	Sichuan	102° 52′ 26° 38′	MVT	Zn–Pb–Ag	24 Mt (ore)	10.4% Zn, 0.8% Pb, 43 g/t Ag	Dolomite	Sinian (850 Ma–545 Ma)	Zheng and Wang (1991)
5	Dayinchang	Sichuan	102° 45′ 26° 33′	MVT	Zn–Pb	5.6 Mt (ore)	3% Zn+Pb	Dolomite	Sinian	Cromie et al. (1996)
5	Tianbaoshan	Sichuan	102° 15′ 26° 58′	MVT	Zn–Pb–Ag	11 Mt (ore)	10.1% Zn, 1.5% Pb, 93.6 g/t Ag	Dolomite	Sinian	Cromie et al. (1996)
5	Tuanbaoshan	Sichuan	102° 51′ 29° 27′	MVT	Zn–Pb–Ag	No data	No data	Dolomite	Sinian	Khin Zaw et al. (2002)
5	Qilingchang and Kuangshanchang (Huize district)	Yunnan	103° 44′ 26° 38′	MVT	Zn–Pb–Ag	5 Mt (metal)	Combined Zn–Pb >25% Ag credits	Dolomite	Early Carboniferous	Zhou C. et al. (2001); Han et al. (2006-this volume)
6	Dexing (district)	Jiangxi	117° 44′ 29° 01′	Porphyry	Cu–Mo–Au–Ag	1500 Mt (ore)	0.43% Cu, 0.02% Mo, 0.16 g/t Au, 1.9 g/t Ag	Granodiorite porphyry	Yanshanian (208 Ma – 90 Ma)*	Zhai et al. (1997); He W. et al. (1999)
6	Yinshan	Jiangxi	120° 00′ 25° 00′	Porphyry	Cu–Pb–Zn–Ag–Au	120 Mt (ore): Cu 5.2 Mt (ore): Zn 5 Mt (ore): Pb 125 Mt (ore): Au 127 Mt (ore): Ag	0.54% Cu, 2.3% Zn, 1.8% Pb, 0.63 g/t Au, 11 g/t Ag	Intermediate to felsic porphyries	Yanshanian (167 Ma–139 Ma)*	Zhang D. et al. (2006-this volume)

6	Shaxi	Anhui	117° 12′ 31° 07′	Porphyry	Cu	0.5 Mt (ore)	>0.2% Cu	Quartz diorite porphyry	Yanshanian (Late Jurassic to Early Cretaceous)*	(per. comm. Bin Fu, 2004)
6	Beiya (district)	Yunnan	100° 12′ 26° 09′	Porphyry	Cu–Au	No data	0.1 – 5% Cu 0.02 – 3.3 g/t Au	Alkali–rich porphyry	Himalayan (Tertiary)*	Xu X. et al. (2006-this volume)
6	Xuejiping	Yunnan	99° 53′ 27° 56′	Porphyry	Cu–Au–Mo	5.4 Mt (ore)	No data	Syenite porphyry	Triassic*	Khin Zaw et al. (2002)
6	Machangqing	Yunnan	100° 30′ 25° 40′	Porphyry	Cu–Mo	16 Mt (ore): Cu 56 Mt (ore): Mo	0.5% Cu, 0.08% Mo	Felsic porphyry, monzonite porphyry	Himalayan (26 Ma–52 Ma)*	Peng et al. (1998)
6	JinJinzui	Hubei		Porphyry	Au–(Cu–Ag)	~78 Mt (ore)	9 g/t Au, 0.2% Cu, 30 g/t Ag	Diorite porphyry	Yanshanian (Cretaceous)*	Peters (2002)
6	Yulong (district)	Tibet	97° 44′ 31° 24′	Porphyry	Cu–Mo–Au	1000 Mt (ore):	0.99% Cu, 0.06% Mo, 0.35 g/t Au	Monzogranite porphyry, Quartz monzonite porphyry	Himalayan (Tertiary)*	Hou et al. (2003a,b, 2006-this volume)
6	Gangdese (district)	Tibet	90° 00′ 29° 30′	Porphyry	Cu–Mo–Au	3 Mt (metal) Cu:	0.2–3.5% Cu, 0.45% Mo, 0.5 g/t Au	Granodiorite porphyry	Himalayan (Tertiary)*	Qu et al. (2006-this volume)
7	Xinqiao (district)	Anhui	118° 00′30° 55′	SEDEX/Skarn overprint	Au–Cu–Fe	116 t (metal): Au 0.23 Mt (metal): Cu, No data for Fe	6.0 g/t Au, 0.89% Cu, No data for Fe	Carbonates, volcaniclastics/ Quartz diorite	Carboniferous/ Yanshanian (Jurassic–Cretaceous)*	Chen Y. et al. (2006-this volume); Gu L. et al. (2006-this volume)
7	Funishan	Jiangsu	119° 03′ 32° 06′	Skarn	Au–Cu	9.3 t (metal): Au No data for Cu	0.85 g/t Au, No data for Cu	Carbonates/Granodiorite porphyry intrusions	Carboniferous/ Yanshanian (Jurassic–Cretaceous)*	Chen Y. et al. (2006-this volume)
7	Jinlongshan	Hubei	115° 25′ 29° 48′	Skarn	Au–Cu	15 t (metal): Au No data for Cu	4.0 g/t Au, No data for Cu	Carbonates/Granodiorite porphyry intrusions	Carboniferous/ Yanshanian (Jurassic–Cretaceous)*	Chen Y. et al. (2006-this volume)
4 and 7	Chengmenshan	Jiangxi	115° 50′ 29° 41′	SEDEX/Skarn overprint	Cu–Mo–Au	1.8 Mt (metal): Cu.6 t (metal): Au No data for Mo	0.75% Cu, 0.24 g/t Au, 0.047% Mo	Carbonates/Granodiorite porphyry intrusions	Carboniferous/ Yanshanian (Cretaceous)*	Gu L. et al. (2006-this volume)
4 and 7	Wushan	Jiangxi	115° 39′ 29° 46′	SEDEX/Skarn overprint	Cu–Au–Ag	2.48 Mt (metal): Cu 67 t (metal): Au	1.38% Cu, 0.5 g/t Au	Carbonates/Granodiorite porphyry intrusions	Carboniferous/ Yanshanian (Cretaceous)*	Gu L. et al. (2006-this volume)
7	Tonglushan	Hubei	114° 52′ 30° 07′	Skarn	Cu–Au	1.0 Mt (metal): Cu 69 t (metal): Au	1.8% Cu, 1.15 g/t Au	Shale/Granodiorite porphyry intrusions	Palaeozoic/ Yanshanian (Cretaceous)*	Pan and Dong (1999); Chen Y. et al. (2006-this volume)
7	Huangshaping	Hunan	112° 41′ 25° 42′	Skarn	Pb–Zn–Cu	0.8 Mt (metal): Pb 0.8 Mt (metal): Zn 0.3 Mt (metal): Cu	5.9% Pb, 5.8% Zn, 0.5% Cu	Granite porphyry	Yanshanian (Jurassic)*	Khin Zaw et al. (2002)
7	Kangiawan (Shuikoushan district)	Hunan	112° 33′ 26° 36′	Skarn	Au–Ag–Pb–Zn	30 t (metal): Au 150 t (metal): Ag 0.5 Mt (metal): Pb 0.5 Mt (metal): Zn	3.65 g/t Au, 86.8 g/t Ag, 3.9% Pb, 4.5% Zn	Silicified limestone	Permian	Zhang Y. et al. (2006-this volume)
7	Tongshankou	Hubei	114° 53′ 30° 39′	Skarn	Cu–Mo	0.5 Mt (metal) Cu 0.01 Mt (metal): Mo	0.94% Cu, 0.04% Mo	Granodiorite porphyry	Yanshanian (Late Jurassic–Cretaceous)*	Lu X. et al. (submitted for publication)
7	Yueshan district	Anhui	116° 52′ 30° 01′	Skarn	Cu–Au	0.4 Mt (metal) Cu 10 t (metal): Au	>2.0% Cu, 0.2–2.0 g/t Au	Diorite	Yanshanian (Cretaceous)*	Zhou Taofa et al. (2006-this volume)
8	Jinfeng (Lannigou)	Guizhou	105° 51′ 25° 10′	Carlin-like	Au	107.1 t (metal): Au	5.1 g/t Au	Carbonaceous siltstone, claystone	Middle Triassic	Hu et al. (2002); Jones (2003); Sino Gold Limited (2004); Peters et al. (2006-this volume)
8	Zimudang	Guizhou	105° 28′ 25° 34′	Carlin-like	Au	60 t (metal): Au	6 g/t Au	Siltstone, claystone, silty limestone	Permo-Triassic	Hu et al. (2002); Peters et al. (2006-this volume)
8	Getang	Guizhou	105° 18′ 25° 17′	Carlin-like	Au	22 t (metal): Au	6.2 g/t Au	Silicified limestone	Upper Permian	Hu et al. (2002); Peters et al. (2006-this volume)
8	Yata	Guizhou	105° 39′ 24° 56′	Carlin-like	Au	15 t (metal): Au	5 g/t Au	Carbonaceous siltstone, sandstone	Middle Triassic	Hu et al. (2002); Peters et al. (2006-this volume)

(continued on next page)

Table 1 (*continued*)

Fig. no.	Deposit name	Province	Lat./Long	Deposit type	Commodity	Tonnage	Grade	Host rocks	Host rock ages	Reference
8	Banqi	Guizhou	105° 38′ 24° 46′	Carlin-like	Au	10 t (metal): Au	5 g/t Au	Claystone, pelitic siltstone	Early Triassic	Hu et al. (2002); Peters et al. (2006-this volume)
8	Jinya	Guangxi	106° 53′ 24° 33′	Carlin-like	Au	30 t (metal): Au	5.3 g/t Au	Silty dolomite, dolomitic siltstone	Middle Triassic	Hu et al. (2002)
8	Gaolong	Guangxi	106° 38′ 24° 14′	Carlin-like	Au	25 t (metal): Au	4 g/t Au	Calcareous argillite, calcareous siltstone	Middle Triassic	Hu et al. (2002)
8	Mingshan	Guangxi	106° 51′ 24° 23′	Carlin-like	Au	10 t (metal): Au	4.5 g/t Au	Argillite, siltstone, sandstone	Middle Triassic	Hu et al. (2002)
8	Tangshang	Yunnan	104° 49′ 22° 57′	Carlin-like	Au	>21 t (metal): Au	1–3 g/t Au	Argillite, siltstone, sandstone, tuffaceous rocks	Permo-Triassic	Peters et al. (2006-this volume)
8	Kuzhubao (Gedang)	Yunnan	105° 31′ 23° 36′	Carlin-like	Au–Sb	7 t (metal): Au	5.3 g/t Au	Carbonaceous siltstone, argillite	Early Devonian	Cromie and Khin Zaw (2003); Hu et al. (2002)
8	Bashishan (Piaosi)	Yunnan	105° 38′ 23° 40′	Carlin-like	Au	No data	3 g/t Au	Carbonaceous mudstone	Early Devonian	Cromie and Khin Zaw (2003)
8	Dongbeizhai	Sichuan	103° 33′ 32° 47′	Carlin-like	Au	>50 t (metal): Au	6.2 g/t Au	Calcareous siltstone, carbonaceous slate	Early Triassic	Hu et al. (2002); Peters (2002)
8	Manaoke	Sichuan	104° 04′ 33° 39′	Carlin-like	Au	20 t (metal): Au	5.0 g/t Au	Siltstone, silty limestone	Upper Triassic	Hu et al. (2002); Peters (2002)
8	Qioaqiaoshang	Sichuan	103° 40′ 32° 44′	Carlin-like	Au	15 t (metal) Au	4.0 g/t Au	Carbonaceous slate, pelitic siltstone, sandstone	Early Triassic	Hu et al. (2002); Peters (2002)
9	Dashuigou	Sichuan	102° 11′ 29° 10′	Epithermal	Te–Au	~100 t (metal): Te No data for Au	~0.2–25% Te, ~3–15 g/t Au	Marble, slate, metabasalt	Triassic	Mao et al. (1995)
9	Zhilingtou (Yinkengshan)	Zhejiang	119° 25′ 28° 37′	Epithermal	Au–Ag	18 t (metal): Au 306 t (metal): Ag	12 g/t Au, 494 g/t Ag	Orthogneiss, paragneiss, felsic volcanics	Early Proterozoic–Cretaceous	Xu et al. (1995); Pirajno et al. (1997)
9	Zijinshan (district)	Fujian	116° 40′ 25° 05′	Epithermal	Au –Ag–Cu	15 t (metal): Au 619 t (metal): Ag 1.6 Mt (metal): Cu	0.1 4 g/t Au, 6.2 g/t Ag, 1.1% Cu	Volcanic rocks/ Granodiorite porphyry	Yanshanian (Cretaceous) *	So et al. (1998); Mutschler et al. (1999)
9	Changkeng	Guangdong	112° 40′ 23° 01′	Epithermal	Au	32 t (metal): Au	7 g/t Au	Siltstone, limestone, brecciated quartzite	Carboniferous	Liang et al. (2006-this volume)
9	Fuwang	Guangdong	112° 40′ 23° 00′	Epithermal	Ag	6000 t (metal): Ag	268 g/t Ag	Siltstone, limestone, brecciated quartzite	Carboniferous	Liang et al. (2006-this volume)
10	Ailoashan Belt (Laowangzhai and Daping Districts)	Yunnan	101° 27′ to 102° 59′ 22° 51′ to 23° 54′	Orogenic	Au	150 t Au (combined metal resource)	1 – 55 g/t Au	Basaltic tuff, mafic–ultramafic rocks, sandstone, limestone	Tertiary	Hou et al. (2006-this volume)
10	Gaocun and Yunxi (Hetai district)	Guangdong	112° 16′ 23° 15′	Orogenic	Au	30.7 t (metal): Au	3 g/t Au	Mica schist, feldspar schist, mica gneiss	Sinian	Wang et al. (1997); Zhang G. et al. (2001)
10	Cangshang	Shandong	119° 54′ 37° 20′	Orogenic	Au	60 t (metal): Au	4 g/t Au	Granitoid	Mesozoic	Qiu et al. (2002); Zhou Taihe and Lu (2000)
10	Donggerzhang	Shandong	121° 36′ 37° 10′	Orogenic	Au	20 t (metal): Au	11 g/t Au	Granitoid	Mesozoic	Qiu et al. (2002); Zhou Taihe and Lu (2000)
10	Jiaojia	Shandong	120° 07′ 37° 24′	Orogenic	Au	>60 t (metal): Au	7 g/t Au	Granitoid	Mesozoic	Qiu et al. (2002); Zhou Taihe and Lu (2000)

10	Jingqingding (Rushan)	Shandong	121° 40′ 37° 06′	Orogenic	Au	25 t (metal): Au	9 g/t Au	Granitoid	Mesozoic	Qiu et al. (2002); Zhou Taihe and Lu (2000)
10	Xincheng	Shandong	120° 10′ 37° 26′	Orogenic	Au	>60 t (metal): Au	8 g/t Au	Granitoid	Mesozoic	Qiu et al. (2002); Zhou Taihe and Lu (2000)
10	Linglong	Shandong	120° 32′ 37° 26′	Orogenic	Au	>100 t (metal): Au	3–30 g/t Au	Granitoid	Mesozoic	Qiu et al. (2002); Zhou Taihe and Lu (2000)
10	Sanshandao	Shandong	119° 56′ 37° 21′	Orogenic	Au	>60 t (metal): Au	7 g/t Au	Granitoid	Mesozoic	Fan et al. (2003); Qiu et al. (2002); Zhou Taihe and Lu (2000)
10	Wangershang	Shandong	120° 09′ 37° 23′	Orogenic	Au	45 t (metal): Au	7 g/t Au	Granitoid	Mesozoic	Qiu et al. (2002); Zhou Taihe and Lu (2000)
11	Yangliuping	Sichuan	102° 00′ 30° 40′	Noril′sk-type	Ni–Cu–Co–PGE	0.27 Mt (metal): Ni 0.1 Mt (metal): Cu 10,200 t (metal): Co 35 t (metal): PGE′s	0.45% Ni, 0.16% Cu, 0.016% Co, 0.55 g/t PGE	Emeishan continental flood basalt sequence (ECFB): mafic–ultramafic sills	Permian	Song et al. (2003)
11	Lengshuiqing	Sichuan	101° 33′ 26° 48′	Proterozoic ultramafic-hosted Ni	Ni–Cu–PGE	2.5 Mt (ore)	0.9% Ni, 0.5% Cu, 1 g/t PGE	Ultramafic intrusion	Proterozoic	Khin Zaw et al. (2002)
11	Limahe	Sichuan	102° 05′ 26° 19′	Proterozoic ultramafic-hosted Ni	Ni–Cu–PGE	1.5 Mt (ore)	1.0% Ni, 0.5% Cu, 1 g/t PGE	Ultramafic intrusion	Proterozoic	Khin Zaw et al. (2002)
11	Baimazhai	Yunnan	102° 58′ 22° 50′	Noril′sk-type	Ni–Cu–PGE	0.6 Mt (metal): Ni 1.2 Mt (metal): Cu	>4.0% Ni, 0.3–4.0% Cu	ECFB: mafic–ultramafic intrusion	Permian	Wang and Zhou (2004)
11	Jinbaoshan	Yunnan	100° 52′ 25° 03′	Noril′sk-type	Ni–Cu–Pt–Pd	13 Mt (ore)	0.19% Ni, 0.19% Cu, 0.65 g/t Pt, 1.1 g/t Pd	ECFB: mafic–ultramafic sill	Permian	Jinshan Gold Mines (2005); SEGNL (2005)
11	Deze	Yunnan	103° 37′ 25° 53′	Sedimentary-type	Ni–Mo	No data	No data	Black shale	Cambrian	Lott et al. (1999)
12	Shizhuyuan (district)	Hunan	113° 10′ 25° 47′	Vein–greisen–skarn	Sn–W–Bi–Mo	0.75 Mt (metal): WO_3 0.49 Mt (metal): Sn 0.30 Mt (metal): Bi 0.13 Mt (metal): Mo	Combined W–Sn–Bi–Mo, 1–5% with an average 2%	Dolomitic limestone and porphyritic biotite granite	Late Devonian and Yanshanian	Mao and Li (1995); Mao et al. (1996a,b); Lu H.Z. et al. (2003)
12	Xihuashan	Jiangxi	114° 23′ 25° 22′	Vein	W	No data	Average 1.08% WO_3	Biotite granite	Yanshanian	Tanelli (1982); Giuliani et al. (1988)
12	Dachang	Guangxi	107° 34′ 24° 51′	Stratiforn, vein	Sn–Pb–Zn–Sb	Combined 100 Mt (ore)	1% Sn, 3–5% combined Cu, Pb, Zn and Sb, 100–300 g/t Ag	Limestone, dolomite, shale and siliceous rock	Late Devonian and Yanshanian	Fu et al. (1991, 1993); Peng et al. (1997); Gu L. et al. (2006-this volume)
12	Xikuangshan	Hunan	111° 29′ 27° 47′	Stratabound, vein	Sb	>0.2 Mt (metal): Sb	3.5–4.5% Sb	Carbonates, shale and sandstone	Late Devonian	Wu (1993); Xu X. et al. (1996)
12	Woxi	Hunan	111° 54′ 28° 32′	Stratabound	Sb–Au–W	1.67 Mt (metal): Sb 0.25 Mt (metal): WO_3 42 t (Metal): Au	2–6% Sb, 0.2–0.8% WO_3, 5–10 g/t Au	Siltstone, sandy slate, slate	Proterozoic	Gu X. et al. (2006-this volume)

* Mineralisation age.

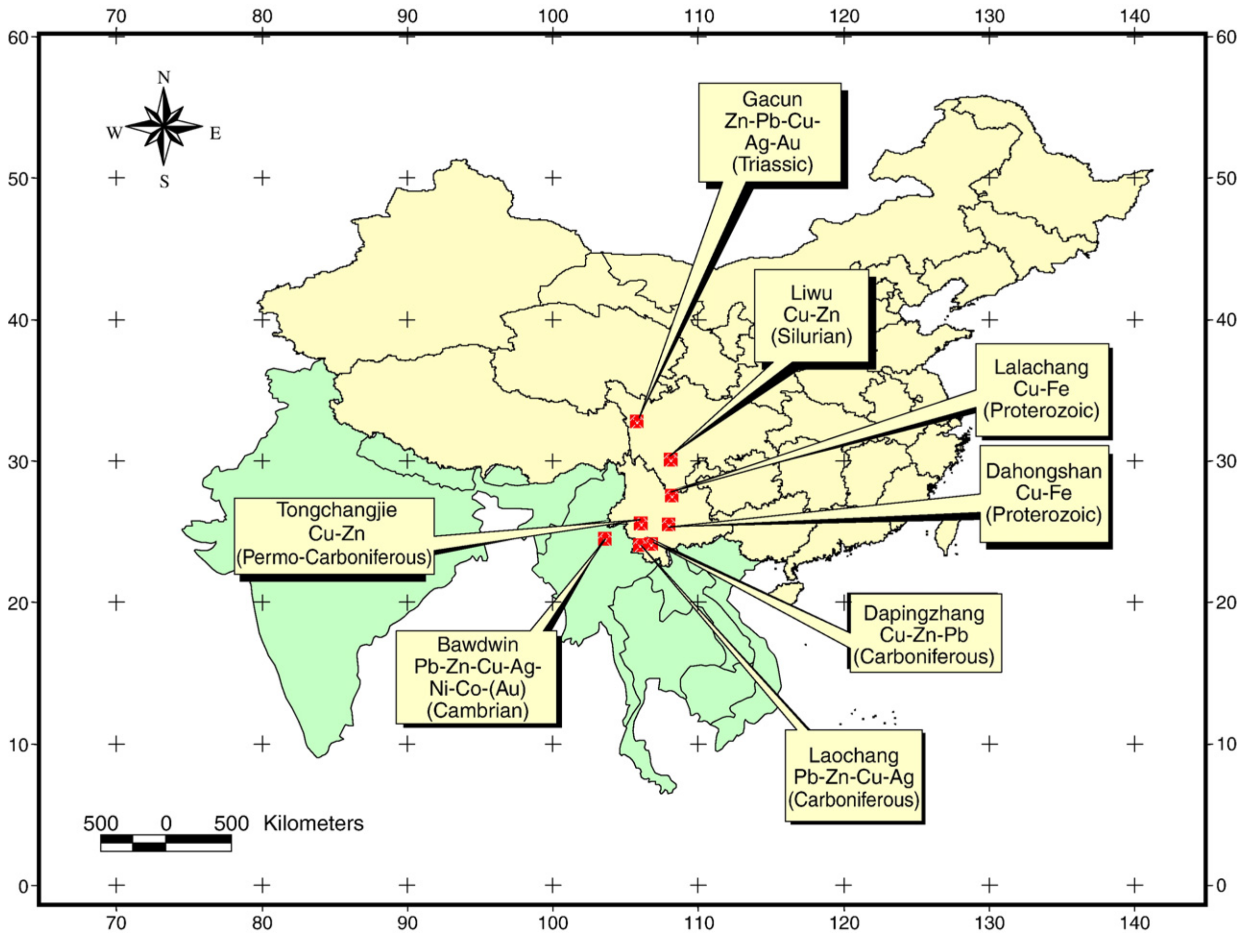

Fig. 3. Map showing spatial distribution of selected major VHMS deposits in South China and adjacent region (modified after Khin Zaw et al., 1999b, 2002).

250 km long and extends south into Myanmar. The volcanic rocks are mafic tholeiitic to felsic and alkaline, and host both Pb–Zn–Cu–Ag and Cu–Zn deposit types. The Laochang deposit is an example of the Pb–Zn–Cu–Ag type VHMS deposit in the Menglian felsic volcanic belt, with mining activity dating back to the 14th Century. As the deposit is an old mine, it is difficult to obtain accurate ore reserves, but it contained at least 20 Mt ore (Yang and Mo, 1993; Hou et al., 1999; per. comm., Yang K., 2000) and is currently described as 0.5 Mt metal grading 1.2–8.9% Pb, 0.16 Mt metal grading 2.9–5.1% Zn, 0.5–1.0% Cu and >500 t at 57–195 g/t Ag (Hou et al., 2007-this volume). The deposit is hosted in Late Carboniferous volcaniclastic basaltic–andesitic rocks with alkaline affinities (Yang and Mo, 1993; Yang et al., 1993, 1999) and the volcanic units are in fault contact with limestone. Major faults strike N–NW near the deposit. The ore is generally massive, fine-grained and banded, but sedimentary features, such as graded-bedding, ripple marks and sulphide mineral clasts, are also reported. The ore minerals are sphalerite, galena, chalcopyrite, pyrite, pyrrhotite, arsenopyrite, minor sulphosalts, bornite, magnetite, hematite and cassiterite. Carbonate minerals are relatively abundant, and realgar and orpiment also are present at the top of the ore lenses (Yang and Mo, 1993; Yang et al., 1993, 1999).

The Dapingzhang deposit is a Late Carboniferous Cu–Zn type VHMS deposit in the Yunnan Province. The deposit was discovered in 1996 by a Chinese geological team after following up a regional 1:200,000-scale stream sediment Cu anomaly. The deposit occurs within two small isolated Carboniferous felsic volcanic inliers near the southwest margin of the Simao Basin. The mineralisation occurs along a strike length of 3000 m and the sulphide zone is 10 to 70 m thick. The extent of the sulphide mineralisation has not been closed off to the SE; it consists of bands of chalcopyrite, sphalerite, galena, and pyrite. The deposit has metal reserves of 0.6 Mt with an average grade of 4.0% Cu, 1.1% Zn, 0.6% Pb, 3.5 g/t Au and 110.6 g/t Ag (Hou et al., 2007-this volume; unpub. data, Paul Cromie, 1999).

Other VHMS deposits in Yunnan and Sichuan are the Early Proterozoic Cu–Fe type Dahongshan deposit (0.8 Mt metal grading 0.64% Cu) and the Lalachang deposit (0.6 Mt Cu metal grading 0.9% Cu) (Fig. 3). Both deposits are hosted in the Early Proterozoic spilite–keratophyre sequence (Hou et al., 1999). The Lalachang deposit is currently being mined, and comprises large, layered Cu–Fe sulphide lenses. The Permo-Carboniferous Cu–Zn type Tongchangjie deposit (0.1 Mt metal grading av. 1.3% Cu and av. 0.4% Zn) occurs in Yunnan. There are smaller Permian Cu–Zn type Yagra (Yangla) deposit and the Triassic cupriferous Sandashan deposit (not shown in Fig. 3). All these deposits are hosted in volcanic and metavolcanic rocks (Haitan, 1992; Yang et al., 1999; Xu, 1999; Hou et al., 1999, 2003a, 2007-this volume). In addition, Silurian–Devonian-aged Cu-rich VHMS deposits occur in Sichuan (e.g., Liwu deposit) (Hou et al., 1999). The Liwu deposit is hosted in Silurian–Devonian metavolcanic rocks and contains layered massive to disseminated types of copper–zinc mineralisation with 0.26 Mt Cu metal grading 2.5% Cu and 0.13 Mt Zn metal grading 0.6% Zn.

One of the most important VHMS deposits in South China is the Triassic Gacun deposit in Sichuan Province. The deposit has metal reserves of 4 Mt grading 0.44% Cu, 5.4% Zn, 3.7% Pb, 160 g/t Ag and 0.31 g/t Au, and other smaller occurrences are also present in the area (Hou et al., 2000, 2001). The deposit is hosted in felsic volcanic rocks associated with an underlying mafic unit (bimodal suite). The volcanics underwent regional lower greenschist facies metamorphism and related deformation during the Yanshanian–Himalayan Orogeny, resulting in folding and shearing of the ore lenses. The deposit is made up of three mineralised zones: (1) a sheet-like upper massive sulphide zone with exhalite (barite, chert and jasper); (2) a middle stringer-stockwork stratabound zone hosted in rhyolitic volcanics, and; (3) an underlying lower stringer stratabound zone occurring in dacitic volcanics. The ore zone consists of a series of tabular lenses dipping 70° to 80°W, and extends over a strike length of 1200 m and a depth of 700 m. The ore minerals are sphalerite, galena, chalcopyrite, pyrite, arsenopyrite, bournonite, boulangerite, and gold (Hou et al., 2000, 2001). The deposit is similar to sheet-style VHMS deposits (Large et al., 2001) and the ore geometry is comparable to the Cambrian Rosebery VHMS deposit in western Tasmania (Khin Zaw et al., 1997, 1999a). Overall, these VHMS metallogenic belts extend into SE Asia and host the Cambrian Bawdwin deposit (~10.8 million tons at 22.8% Pb, 13.9% Zn, 1.05% Cu and 670 g/t Ag with cobalt and nickel credits) in NE Myanmar (Khin Zaw, 1990a, 1992; Khin Zaw and Burrett, 1997; Khin Zaw, 2003, 2004) and the Permo-Triassic Tesek Chini deposit in Malaysia (unpub. data, Khin Zaw, 1998).

3.2. Stratabound and stratiform deposits

Two groups of stratabound and stratiform base metal deposits have been recorded in South China, Cenozoic and Proterozoic to Palaeozoic age and these deposits appear to be similar to the SEDEX-type deposits (e.g., Gu L. et al., 2007-this volume). Important SEDEX deposits in South China are listed in Table 1 and shown in Fig. 4.

The Cenozoic Jinding deposit is the largest strabound Zn–Pb–Ag deposit in China. The deposit is probably the only Cenozoic-aged stratabound Zn–Pb–Ag type deposit in the world, and contains a reserve of 200 Mt of ore grading 6.08% Zn and 1.29% Pb, 1–20 g/t Ag and 0.1–0.2% Cd (metal reserves of 15 Mt) (Kyle and Li, 2002; Xue et al., 2007-this volume). The deposit has an enrichment of celestite ($SrCO_3$) at the base, followed upward by barite, then sphalerite and galena. It is hosted in the Eocene Yunlong Formation consisting of sandstone, siltstone, and limestone. These rocks form the upper section of the Lanping-Simao Basin that was developed during the Permian to Eocene. The deposit occurs in the northern part of the basin (e.g., Zhu and Chi, 1993; Li and Kyle, 1997; Kyle and Li, 2002; Xue et al., 2007-this volume). The Jinding ores were deposited in a smaller sub-basin (probably a rift basin) that was rich in gypsum. The deposit area is characterised by thrusting of Late Triassic limestone and Jurassic sandstone over the Eocene sequence. The origin of the deposit is controverstial from a probable syngenetic SEDEX origin to an epigenetic replacement origin (Xue et al., 2007-this volume). The deposit is located on either side of the thrust and appears to be an epigenetic deposit (unpub. data, Steve Peters, 2005; Xue et al., 2007-this volume), however further work remains to be done relating to the timing of ore formation and whether the primary syngenetic ore have been affected by later remobilisation process.

The Cu–Fe sedimentary type Proterozoic stratabound deposits in Yunnan Province (e.g., Dongchuan deposits) are hosted in marine to non-marine (red bed) sedimentary sequence but many of these deposits are

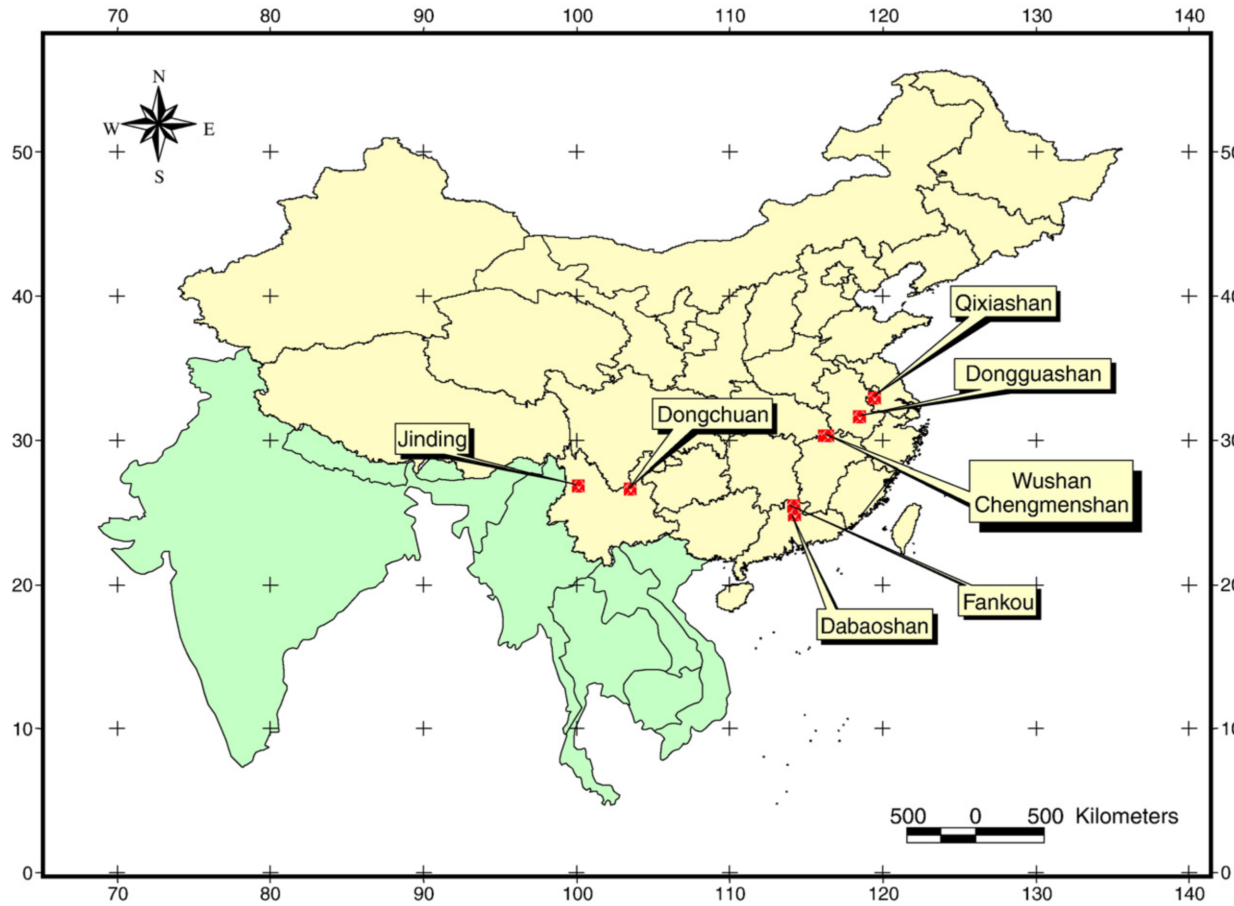

Fig. 4. Map showing spatial distribution of selected major SEDEX deposits in South China (modified after Khin Zaw et al., 2002).

still poorly documented. The Dongchuan deposits are interpreted to be copper-dominant SEDEX deposits (Huichu et al., 1991; Chen, 1997).

Significant Late Palaeozoic stratabound base metal deposits occur in the eastern part of South China in Guangdong, Fujian, Jiangxi, Anhui and Jiangsu Provinces along the margin of the SCC. These deposits have been compared with SEDEX deposits (Gu L. et al., 1992, 2000, 2007-this volume). Different metal associations are also recorded and include: the zinc–lead type Fankou deposit in Gaungdong Province, the copper–iron type Wushan deposit, the recently discovered copper–tungsten Yongping deposits in Jiangxi Province, and the copper–(lead–zinc–tungsten) Dabaoshan deposit and the Hongyan pyrite deposit in Guangdong Province. Gu L. et al. (2007-this volume) documented that the Late Palaeozoic SEDEX deposits fall into two types of deposits: (1) Nanling Region type (e.g., Fankou and Dabaoshan) and (2) Lower Yangtze Region type (e.g., Qixiashan, Wushan, Yongping, Dongguashan and Chengmenshan).

The Fankou deposit (3.4 Mt metal grading 12% Zn and 1.7 Mt metal Pb at 5.1% with silver credit) and the Dabaoshan deposit (0.86 Mt metal Cu grading 0.86%, 0.31 Mt metal Pb at 1.77%, 0.85 Mt Zn at 4.4%, 0.11 Mt WO_3 at 0.12%) are the most important deposits in the Nanling Region (Gu L. et al., 2007-this volume) (Fig. 4). These deposits are hosted in Devonian to Carboniferous limestone, siltstone and sandstone. The tectonic setting of these deposits is poorly documented but interpreted to be an intra-arc trough between island-arcs (Zhu and Chi, 1993) or intracontinental rift basin (Gu L. et al., 1992, 2000, 2007-this volume). The ore metals at Fankou are lead, zinc, and copper with by-product tungsten, tin, silver, gold, antimony, mercury, uranium, bismuth, thallium, and molybdenum. Ore mineralogy is sphalerite, galena, pyrite, chalcopyrite with minor scheelite and stibnite. The deposits show vertical and lateral stratigraphic zonation. The general trend from the base upwards is Fe–sulphide > Cu > (Cu–W) > Pb > Zn–Fe > Mn-carbonates, and laterally from feeders they show Cu > W > Pb > Zn > Ag–Fe > Mn zonation. The deposits are commonly controlled by the host rock lithology and growth faults. Under the stratiform ores in some deposits, there are fissure-fillings, breccia-cementing and impregnated mineralisation that represent the submarine hydrothermal feeder zone, and sub-seafloor replacement of host limestone in the feeder zone (e.g., Fankou).

Most of the Lower Yangtze Region type deposits were affected by later remobilisation and recrystallisation associated with Yanshanian magmatism. The Qixiashan Pb–Zn–Mn–Au deposit in Jiangsu Province is an example of a SEDEX deposit that is hosted in Carboniferous dolomite, limestone, shale and sandstone (Gu L. et al., 2000, 2007-this volume), and has been later overprinted by a skarn system associated with Yanshanian magmatism (Chen Y. et al., 2007-this volume). The deposit contains 0.4 Mt metal Pb at 2.6%, 0.8 Mt metal Zn at 4.9% and 0.4 Mt metal Mn at 17% with gold credits of 27 t at 0.9 g/t Au (Gu L. et al., 2007- this volume; Chen Y. et al., 2007-this volume). Other similar overprinted SEDEX systems are the Wushan, Yongping, Dongguashan, and Chengmenshan deposits. As these systems were overprinted by later Yanshanian magmatism forming skarn assemblages, they are also considered as skarn deposits (e.g., the Wushan and Chengmenshan deposits, see below). On the basis of paragenesis, textural, sulphur isotopes and fluid inclusion studies, Hou et al. (submitted for publication) recently documented that the Dongguashan Cu–Au deposit in Shizishan district, Anhui Province was initially formed as a SEDEX deposit in the Carboniferous and later overprinted by Late Jurassic skarn-forming fluids associated with Yanshanian magmatism. The overprinting effect has resulted in the recrystallisation and reconstitution of the copper and gold resources in the deposit (0.94 Mt metal Cu at 1% Cu with gold credit). This process is similar to metal remobilisation in the Cambrian Rosebery VHMS deposit, western Tasmania which was overprinted by garnet–magnetite–pyrrhotite skarn assemblages related to Devonian-granite intrusion (Khin Zaw et al., 1997, 1999a). Further detailed geological and geochemical studies are required to understand the origin and post-depositional overprinting nature of the SEDEX deposits in South China. It is noteworthy that the presence of the stratabound base metal deposits in South China suggests the potential for the discovery of large SEDEX deposits in the region.

3.3. MVT deposits

The presence of MVT deposits has recently been reported in Yunnan Province (e.g., Qilinchang deposit, Zhou et al., 2001). This, and other major MVT deposits in South China, are shown in Fig. 5. The Qilinchang deposit is hosted in dolomite of the Early Carboniferous Baizuo Formation and reserves are about 3.32 Mt ore grading 17.5% Zn and 6.6% Pb. The ore minerals are sphalerite, galena and pyrite with a gangue of quartz and carbonates (Zhou et al., 2001). Han et al. (2007-this volume) describe the geological features and origin of the Huize carbonate-hosted Zn–Pb–(Ag) district including the Qilinchang and Kuangshanchang deposit in Yunnan Province. The Huize Zn–Pb–(Ag) district contains medium- to large-size, high-grade Zn–Pb–(Ag) deposits present in the Sichuan–Yunnan–Guizhou Pb–Zn metallogenic region. The total metal reserve of Zn and Pb exceeds 5 Mt. The district contains high-grade ores ($Zn+Pb \geq 25\%$), with enrichment of Ag and dispersed elements (Ge, In, Ga, Cd, and Tl) which are carried in galena, sphalerite and pyrite. The ore distribution at Huize is controlled by structure and lithological character. Other characteristics include simple and limited wall-rock alteration, mineral assemblage zonation in the orebodies, and evaporite layers present in the ore-host wall rocks of the Early Carboniferous Baizuo Formation and underlying basement. Recent laboratory and field studies indicate that the Zn–Pb–(Ag) deposits in Huize district are deformed MVT deposits (Han et al., 2007-this volume). A detailed study of the deposits has provided new clues to the localisation of concealed orebodies in the Huize district and the potential for similar deposits in north-eastern Yunnan Province, as well as the Sichuan–Yunnan–Guizhou Pb–Zn metallogenic region (Han et al., 2007-this volume).

MVT deposits are reported in Sichuan Province and are hosted in the Sinian carbonate sequence (e.g., Daliangzi and Tianbaoshan deposits). The Daliangzi deposit contains 24 Mt ore grading 10.4% Zn, 0.8% Pb and 43 g/t Ag, and the Tianbaoshan deposit contains 11 Mt ore grading 10.1% Zn, 1.5% Pb, 93.6 g/t Ag (e.g., Zheng and Wang, 1991; Cromie et al., 1996). These deposits are similar to the MVT deposits of the Lennard Shelf, Western Australia (Dorling et al., 1998; Cromie, 1999).

Host stratigraphy for the MVT Pb–Zn mineralisation is mainly the Sinian Upper Dengying Formation consisting of algal and vuggy dolomites, which unconformably overlie a Proterozoic basement of phyllite and schists (Huili Group). Cambrian black siltstone, shale and sandstone unconformably overlie the host Sinian sequence and are, in turn, unconformably overlain by Permian limestone and basalt. Basement stratigraphy has a dominant EW-striking faulted

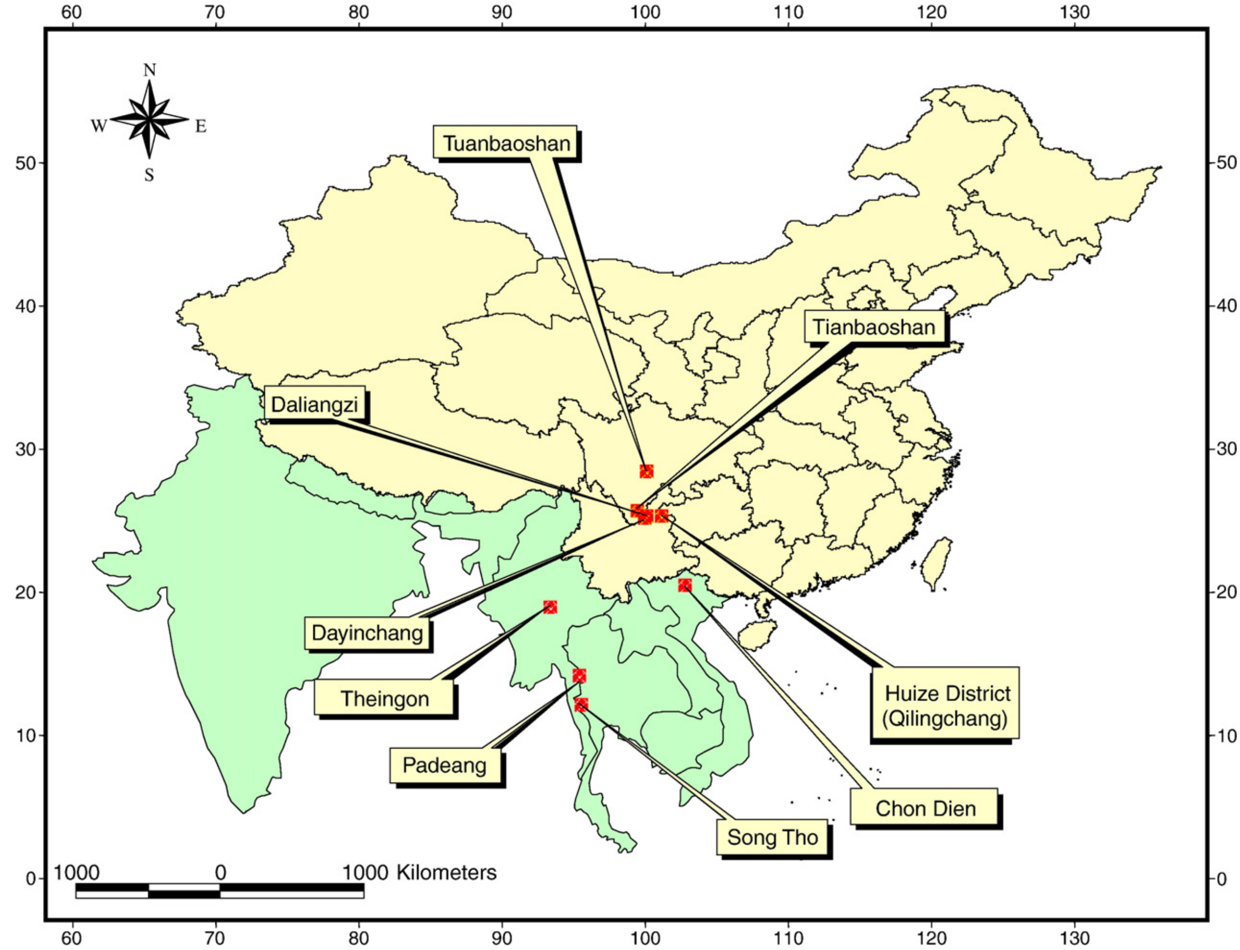

Fig. 5. Map showing spatial distribution of selected major MVT deposits in South China and adjacent regions (modified after Khin Zaw et al., 1999b, 2002).

structural trend, whereas Sinian and younger platform strata are cut by NW, NNW and NS fault strikes. Sulphide deposits occur where NW- and NNW-striking faults intersect close to regional EW-trending thrust zones (Cromie et al., 1996; Cromie, 1999).

The unconformity between the Cambrian and the Sinian Dengying sequences is important for localising mineral deposition. Mineralisation is predominantly epigenetic and occurs within black carbonaceous mudstone, commonly associated with fault-related breccias, veins, joints, karst features, and solution collapse breccias. Sphalerite, galena, pyrite, barite and calcite are present, along with occasional minor chalcopyrite and fluorite. Oxidised surface occurrences contain hydrozincite and are currently mined at several locations. Most of the known resources were identified earlier in remote areas from regional stream sediment sampling, soil sampling, and structural mapping (Cromie et al., 1996; Cromie, 1999).

During 1993, the Sichuan Kang Dian exploration Joint Venture (SKD) was established, comprising BHP Minerals Exploration Inc., two Chinese companies, the South West Metallurgical and Geological Exploration Bureau (SMGEB) and the China Non-Ferrous Metal Industrial Corporation (CNNC), to explore for Daliangzi type Pb–Zn deposits within the Sichuan Kang Dian area. Exploration methods consisted of reconnaissance, regional and detailed mapping, contour and grid soil geochemistry, induced polarisation (IP) surveying and drilling. Because these deposits are similar to MVT deposits in the Lennard Shelf, Western Australia (Dorling et al., 1998; Cromie, 1999), BHP adopted the exploration model and criteria used in the Lennard Shelf area and discovered the Dayinchang deposit (5.6 Mt ore at combined 3% Zn+Pb) located 10 km south of the Daliangzi deposit (Cromie et al., 1996; Cromie, 1999).

The Middle Proterozoic to Sinian carbonate sequence in the Janning–Anning County area of Yunnan Province hosts discordant Zn–Pb mineralisation in cavity-fill, veins, and breccia (e.g., Liaocaoba). However, the nature of mineralisation is not completely understood, and is thought to be discordant SEDEX type mineralisation or MVT type mineralisation.

MVT deposits also occur in mainland SE Asia. The Theingon deposit in Myanmar, the Padeang and Song Tho deposits in Thailand and the Chon Dien deposit in Vietnam are important examples (Fig. 5). Many MVT type Pb–Zn–Ag–Ba occurrences are distributed in the Heho–Bawsaing and Pindaya–Yegnan areas in Southern Shan State, Myanmar, and the mineral district extends into Thailand. The Theingon Pb–Zn–Ag–Ba deposit in Myanmar is hosted in Ordovician limestone (Wunbye Formation); mining of the deposit dates back to the 14th Century (Khin Zaw et al., 1999b). Brown (1930) estimated the ore reserves of the Theingon deposit to be 0.2 Mt ore at 7% Pb.

Numerous lead–zinc–silver deposits occur in limestone and shale of Ordovician age in western Thailand (e.g. Kanchanaburi Province) (Diehl and Kern, 1981). Two major mines — for zinc at Mae Sot (Padaeng) and for lead, zinc and silver at Kanchanaburi (Song Tho, 4 Mt ore at 7% Pb, 3% Zn and 120 g/t Ag) have been in production for the last few years. The Padaeng deposit is a secondary zinc deposit (25 Mt ore at 5% Zn) in its present position and may have been derived from stratabound or stratiform mineralisation in a limestone host. The deposits in Myanmar and Thailand show characteristics of MVT as is evident from their strong stratabound and some stratiform nature, the limestone host rock, brecciation in parts of some deposits, possible collapse structures, and the presence of mineralisation in algal reefs. Some deposits are at least 30 km from the nearest granitoid intrusion, making a connection with intrusion unlikely.

The Chon Dien deposit in Vietnam has been known since the 18th Century, and during the colonial period the French operated the deposit until 1944. The deposit occurs as a series of stratabound veins in Siluro-Devonian calcareous shale, limestone and dolomite (Khin Zaw et al., 1999b).

3.4. Porphyry copper deposits

The South China Region hosts significant copper–(gold) porphyry deposits (e.g., the Yulong and Gangdese deposits in Tibet, the Xuejiaping deposit in Yunnan and the Dexing deposit in Jiangxi Province) (Table 1, Fig. 6). Some of these porphyry copper deposits contain molybdenum (e.g., Machangqing deposit in Yunnan). The porphyry copper deposits are commonly associated with epigenetic vein-type and epithermal/skarn deposits. Most of the deposits are Himalayan in age (e.g., the Machangqing Cu–Mo porphyry deposit, Peng et al., 1998; the Yulong deposits in Tibet, Hou et al., 2003b; and the Gangdese deposits, Qu et al., 2007-this volume) or Yanshanian in age (e.g. the Dexing deposit). These deposits form clusters or camps such as the Yulong belt in Tibet consisting of the Yulong, Mangzhong, Duoxiasongduo, and Malasongduo Cu–Mo (Au) deposits (Hou et al., 2003b) and the Gangese belt with the Jiama, Qulong, Chongjiang, Tinggong, Nanmu, Lakang'e and Dongga deposits (Qu et al., 2007-this volume). The Yulong district has ∼1000 Mt ore at 0.99 Cu%, 0.06% Mo and 0.35 g/t Au (Hou et al., 2003b). The Yulong belt is up to 300 km in length and 15–30 km wide and perpendicular to the collision zone between the Indian and Asian continents. The porphyry belt is closely associated with the Tertiary potassic volcanic rocks and alkali-rich intrusions and controlled by NS-NNW, large-scale, strike-slip faults in Eastern Tibet. The Gangdese belt contains more than 3 Mt Cu metal grading 0.2 to 3.5% Cu, 0.03–0.06% Mo, 0.5 g/t Au with base metal credits. The Gangese belt is 400 km long and 50 km wide and related to northward subduction of the Tethyan ocean floor beneath the Lhasa continental block (Beaudoin et al., 2005). The mineralised alkaline porphyries were emplaced during post-collisional extention setting (Qu et al., 2007-this volume). Xu et al. (2007-this volume) also described and documented the geological and mineralisation characteristics of the alkai-rich porphyry and hydrothermal copper and gold deposits in the Beiya area, western Yunnan Province, China. The Beiya district contains polymetallic Pb–Zn–Cu–Fe–Au deposits and five types of mineral deposits have been reported: (1) porphyry Cu–Au deposits, (2) magmatic Fe–Au deposits, (3) sedimentary polymetallic deposits, (4) polymetallic skarn deposits, and (5) palaeo-placers associated with karsts. These deposits account for 39 Mt of Pb–Zn ore, incorporating a resource of 1.4 Mt of Pb with an average grade of 2.5% and 0.06 Mt of Zn with an average grade of 1.4% with an additional 60 t Au and 800 t Ag with variable grades. Although no tonnage data are recorded, the porphyry Cu–Au deposits from the Beiya area have 0.1–5% Cu and 0.03–3.3 g/t Au (Xu et al., 2007-this volume).

The Dexing district in Jiangxi Province is the largest porphyry copper orefield in China and contains 1500 Mt ore at 0.43% Cu, 0.02% Mo, 0.16 g/t Au and 1.9 g/t Ag, approximately equivalent to 6.45 Mt Cu, 0.25 Mt Mo,

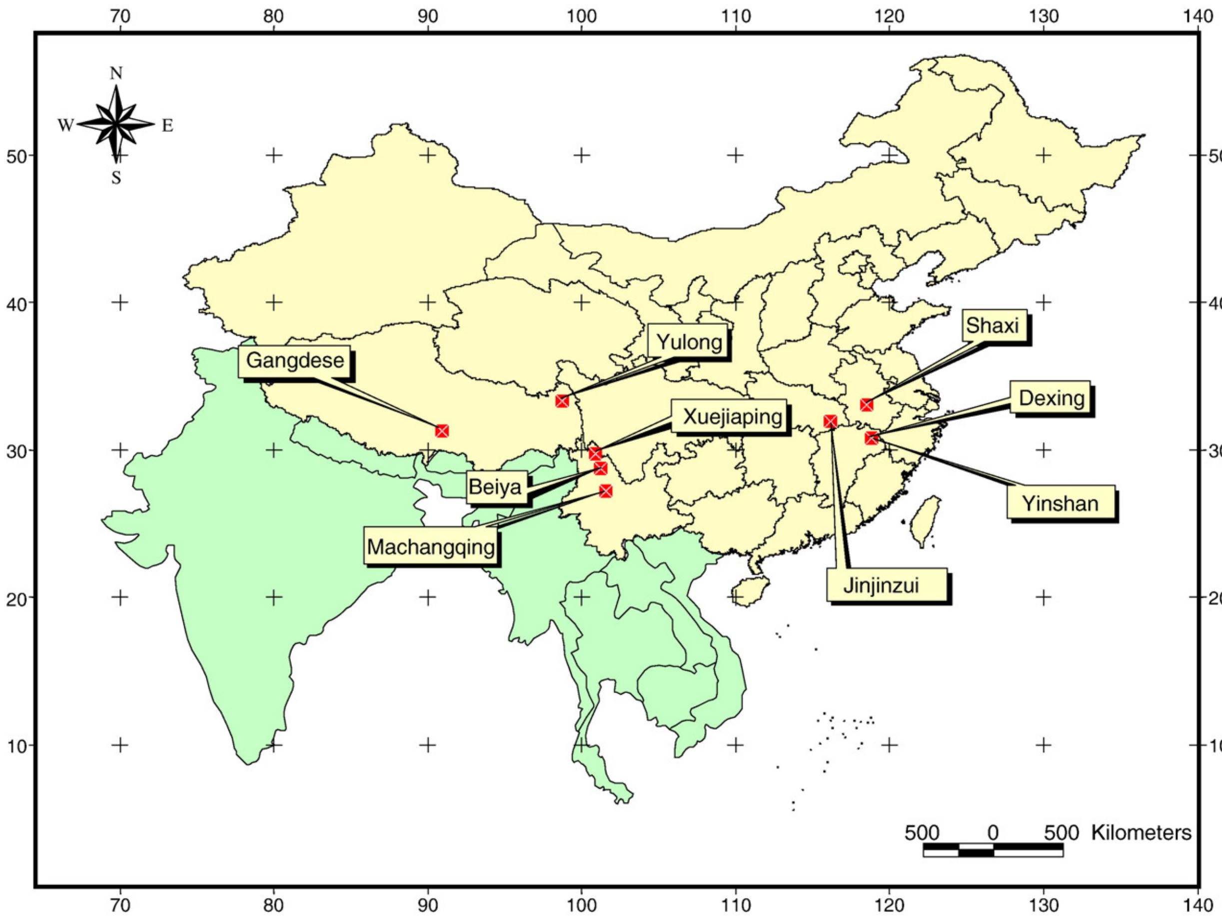

Fig. 6. Map showing spatial distribution of selected major porphyry copper deposits in South China (modified after Khin Zaw et al., 2002).

24 t Au and 285 t Ag (Yan and Hu, 1980; Zhai et al., 1997; Mutschler et al., 1999; He et al., 1999). The Dexing deposits are associated with granodiorite porphyries of Yanshanian age (148–170 Ma) that intruded slate and phyllite of the Mesoproterozoic Shuanqiaoshan Group. The granodiorite porphyries lie along the intersection of a NW trending fault and NE trending anticlinal axis. The three orebodies, Tongchang, Fujiawu and Zhushahong are pipe-like in profile and circular in plan, with the largest, Tongchang, being 0.7 km in diameter. The contact zone between the porphyry and the host rocks is metamorphosed to hornfels. Two thirds of the copper reserves in the Tongchang deposit are in the country rock and the contact zone. The ore minerals are pyrite, chalcopyrite, molybdenite, tennantite, bornite, and electrum.

Yinshan near the Dexing deposit is an Au-rich polymetallic porphyry deposit (Fig. 6). It has reserves of 120 Mt of Cu ore at 0.54%, 5 Mt of Pb ore at 1.8% Pb, 5.2 Mt of Zn ore at 2.3% Zn, 125.4 Mt of Au ore at 0.63 g/t Au and 127 Mt of Ag ore at 11 g/t Ag (Zhang D. et al., 2007-this volume). The deposit forms part of the zoned Le–De Cu–Pb–Zn–Au–Ag belt in Jiangxi Province and the area is characterised by low-grade metamorphic rocks of the Middle Proterozoic Shuangiaoshan Group and the overlying rhyolitic to dacitic volcanic rocks of the Late Jurassic Ehuling Formation and the continental clastic rocks of the Early Cretaceous Shixi Formation. This sequence was intruded by mineralised Mesozoic intermediate to felsic porphyries associated with the Yanshanian Orogeny (167 to 139 Ma). The deposit displays a zonal arrangement of mineralisation with Cu–Au in the center, Cu–Zn–Pb in the middle, and Pb–Zn–Ag at the periphery of the deposit (Zhang D. et al., 2007-this volume).

The Shaxi porphyry Cu deposit in Anhui Province is associated with Late Jurassic to Early Cretaceous quartz diorite porphyry that intruded Silurian argillaceous siltstone and Jurassic sandstone (e.g., Pan and Dong, 1999). Very little is known about the deposit; it is small, about 500,000 tonnes ore grading >0.2% Cu. Ore minerals are chalcopyrite, pyrite, bornite, and magnetite. The host diorite porphyry yielded a whole rock Rb–Sr age of 128 Ma, and the mineralisation age is 125 Ma from Ar–Ar dating of hydrothermal biotite (pers. comm., Bin Fu, 2004).

Peters (2002) suggested that porphyry Au deposits may occur in South China. The Jinjinzui porphyry Au deposit is one example. It is located between Daye City and the Tonglushan Mine on the north-eastern margin of the Yangxin pluton and the edge of the Daye syncline (Peters, 2002). The deposit was discovered by the South-Central Geological Survey, Wuhan, by targeting minor gravity anomalies in the shadow of the large gravity anomaly of the Yangxin pluton. These small anomalies represent pillow-shaped, steeply-plunging, 80 Ma porphyry stocks that intruded favourable Triassic limestone horizons. Skarn, however, is not well developed. Drilling, using 1 m-spaced sampling, identified a gold resource that is from 5 to 10 m inside the contact of the stock with geochemically anomalous, but sub-economic, concentrations of Cu, Ag, Zn, and Pb. Gold is present in pyritic veinlets and stockworks as 0.5 to 3 mm-size native Au grains and is associated with sericite and quartz alteration. The Jinjinzui Au porphyry deposit represents a separate Au-mineralizing event in south-eastern Hubei Province that is younger than the Cu–Fe skarns in the region. Many skarn deposits are spatially associated with weakly to moderately mineralised porphyry systems (see below).

3.5. Skarn deposits

Base metal and gold skarn deposits are widely distributed along the lower reaches of the Yangtze River in the South China Region (e.g., Zhou Taihe, 1995; Zhai et al., 1996; Zhou Taihe, 1999; Zhao et al., 1999; Pan and Dong, 1999; Peters, 2002). These skarns are one of the major sources of gold in China, and form as gold only skarns or skarns with copper, iron and gold. Chen Y. et al. (2007-this volume) reviewed the gold skarn deposits in China and reported that they account for more than 20% of China's gold resources and the South China Region contains about 625 tons of gold. Selected major skarn deposits are listed in Table 1 and shown in Fig. 7.

Porphyry-related Cu–Fe–Au skarn systems are associated with multiple phases of Yanshanian intrusions into carbonate-rich sequences that formed the Lower to Middle Yangtze River metallogenic belt stretching from Hunan, Jiangxi, Hubei, Anhui to Jiangsu Provinces (e.g., Zhou Taihe, 1995; Zhai et al., 1996; Zhou Taihe, 1999; Zhao et al., 1999; Pan and Dong, 1999; Chen Y. et al., 2006-volume). The Lower to Middle Yangtze River area contains several hundred Cu, Fe, Au, S and polymetallic deposits and is one of the most important metallogenic belts in China (Ge et al., 1990; Zhao et al., 1990; Zhao, 1991). This belt accounts for more than 600 t of gold. Main rock types include local Archaean and well-developed Proterozoic, Palaeozoic and Mesozoic sedimentary rock sequences and a number of Mesozoic plutonic rocks (Deng et al., 1986; Yin and Nie, 1996). Late Palaeozoic to Early Mesozoic sedimentary rocks form the favourable host horizons for replacement of copper, gold, and polymetallic deposits. The structural and tectonic framework, in combination with the sedimentary and igneous rocks, has directly affected the regional copper and gold metallogeny in the Lower to Middle Yangtze River area.

The most important Au-rich porphyry/skarn deposits are found in Jiangxi Province (e.g., Chengmenshan: 1.7 Mt Cu metal at 0.76% Cu, 57 t Au at average 0.25 g/t Au and 224 t Ag at 9.9 g/t Ag, and Wushan: 2.48 Mt Cu metal at 1.38% Cu, 67 t Au at average 0.5 g/t Au). Lead–zinc skarn deposits are also found in Hunan Province (e.g., Shuikoushan, Kangjiawan and Huangshaping) associated with Yanshanian granite magmatism (Zeng et al., 2000; Zhang Y. et al., 2007-this volume). These lead–zinc skarn deposits commonly contain high silver contents as well as copper, gold, tungsten, molybdenum and bismuth. The Shuikoushan and Kangjiawan Pb–Zn–Au–Ag deposits in Hunan Province are the major skarn deposits in South China. Numerical modelling of deformation and fluid flow in the Shuikoushan district by Zhang Y. et al. (2007-this volume) indicates that fluids associated with the mineralising system are controlled by permeability and are generally focused towards fold hinges during regional shortening and folding. On a local scale, tensile failure, fluid focusing and mixing and fracture development are critical factors in ore formation and are consistent with localisation of orebodies in brecciated zones. They indicated that such brecciated zones associated with extensive fluid focusing and mixing represent the most favourable sites for mineralisation.

Hubei Province hosts a major Cu–Au metallogenic belt along the lower to Middle Yangtze River area that extends west into Anhui Province, and consists of significant Cu–Fe or Pb–Zn skarn deposits with high precious metal credits. The most significant deposits are Tonglushan (1 Mt Cu metal grading 1.8% Cu, 69 t Au at 1.15 g/t Au), Jilongshan (0.3 Mt Cu metal at 1.6% Cu,

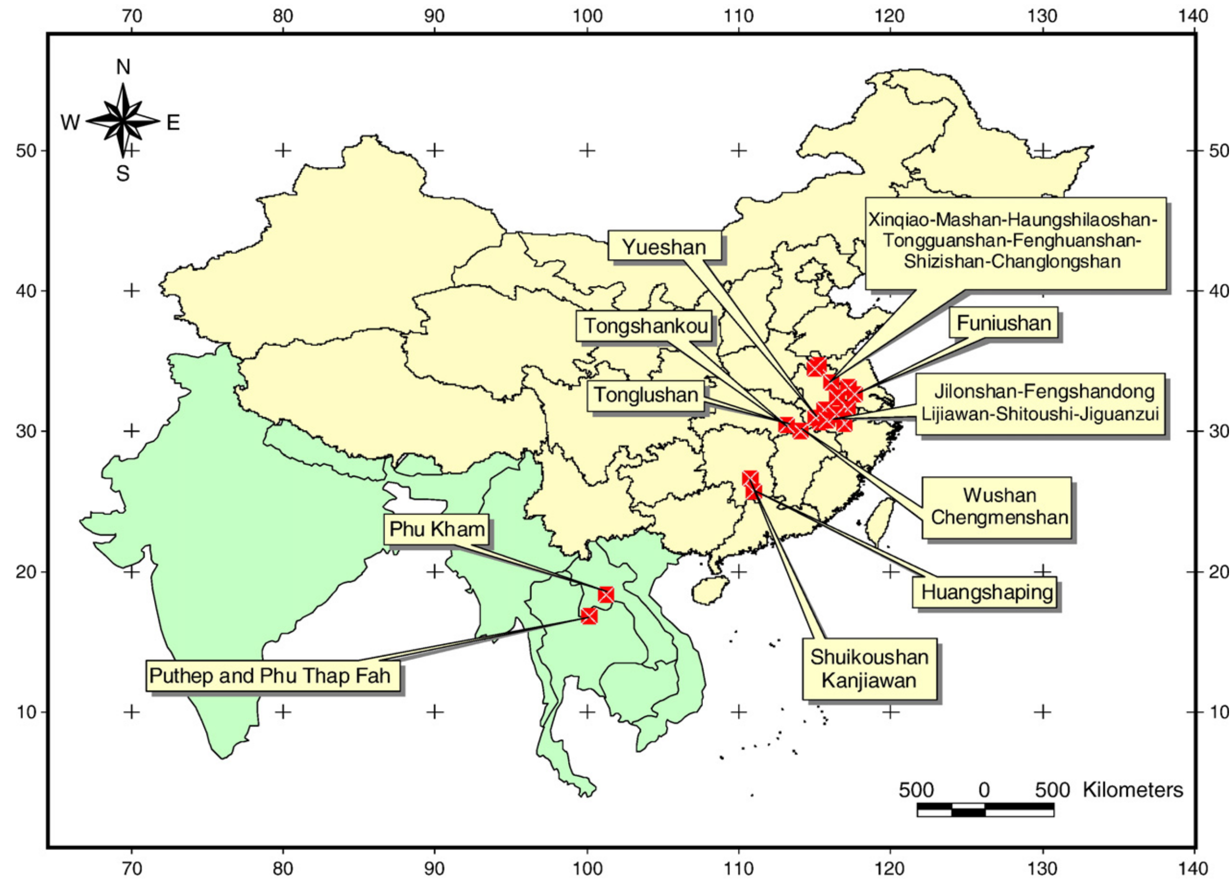

Fig. 7. Map showing spatial distribution of selected major skarn deposits in South China and adjacent regions (modified after Khin Zaw et al., 1999b, 2002).

37 t Au at 4 g/t Au), Fengshandong (0.7 Mt Cu metal at 1.2% Cu, 16 t Au at 0.38 g/t Au), Shitouzui (1 Mt Cu metal at 1.8% Cu, 19 t Au 0.5 g/t Au), and Jiguanzui (20 t Au at 4.87 g/t Au). Some skarn deposits are molybdenum- and tungsten-rich (e.g., Tongshankou, Fengshandong and Longjiaoshan). Most of the deposits are located in the Daye district, and associated with multiple Yanshanian diorite–granodiorite intrusions. The country rocks are mainly Triassic carbonates and less commonly Carboniferous and Permian carbonates (e.g., Pan and Dong, 1999). Major ore minerals are chalcopyrite, chalcocite, bornite, pyrite, molybdenite, pyrite, magnetite, galena, sphalerite, tetrahedrite and pyrrhotite. The granodiorite porphyry-related Tongshankou deposit in Hubei Province is also a significant Cu–Mo system and the ore reserves of the deposit are 0.5 Mt metal Cu grading 0.94% and 14,000 tons metal Mo grading 0.04% (Lu X. et al., 2003, 2004, submitted for publication). Recent fluid inclusion and stable isotopic studies of the deposit demonstrated that the Tongshankou ore-forming system evolved from early magmatic fluids to late meteoric fluids (Lu X. et al., 2003, 2004, submitted for publication).

The Jilongshan, Fengshandong, and Lijiawan Cu–Fe–Mo–(Au) skarn and porphyry deposits in Yangxin County, Hubei Province consist of three clustered Au-skarn and porphyry Cu–Mo deposits and peripheral polymetallic lodes around cylindrical 120 to 150 Ma plutons in folded terrane. Mining began there during the Song Dynasty (960 to 1279 AD). The area also includes the Dongleiwan and Lijiawan porphyry prospects. The three main deposits include large Cu resources with additional reserves of Mo, Au, Ag and Ag.

The Fengshandong Cu–Mo deposit is the largest of the three deposits and has a reserve of 50 t Au at 0.5 to 0.8 g/t Au, 2,000 t Ag at 39 g/t Ag, 0.9 Mt Cu grading 1.01% Cu, and 50,000 t Mo at 0.02 to 0.05% Mo (Peters, 2002). The Jilongshan deposit has 290,000 t Cu at 1.5 to 1.8% Cu, 50 t Au at 3.5 g/t Au, and 380 t Ag at 19 g/t Ag. The Lijiawan deposit contains a reserve of 120,000 t Cu at 1.3% Cu, and 10 t Au at 2.5 g/t Au. These deposits are zoned from a core of central potassic alteration to peripheral sericite and then chlorite, and from a central Mo zone to zones of Fe, Cu, Pb–Zn, Au, and Ag toward the outside. All three deposits have rich Cu skarns with >2% Cu grades and peripheral distal-disseminated and replacement zones of Pb, Zn, Au, and Ag.

Anhui Province covers the western extension of the Cu–Au metallogenic belt along the lower to Middle Yangtze River area. Most of the skarn deposits are porphyry-related and cluster in the Tongling district, which is a major producer of copper and iron with the potential for economic zinc, lead, gold and silver. The deposits consist of Fe–Cu–Au, Cu–Au–Mo, Cu–Au, and Au–Cu metal associations. The Tongling district polymetallic skarn and replacement deposits are associated with contact zones around Jurassic intermediate plutons and stocks, usually hosted in narrow carbonate-rich horizons of Carboniferous and Permian rocks (Kuo, 1957; Fan, 1984; Ge et al., 1990; Zhao et al., 1990; Zhao, 1991; Xu et al., 1992). The area contains 300,000 t Cu in reserves, much of it from Cu–Fe skarns such as the Tongguanshan, Fenghuangshan, and Shizishan deposits. Gold is mined from sulphide ores, but is mainly extracted from the gossanous upper parts of these deposits (e.g., Xinqiao, Mashan, and Huangshilaoshan Au deposits, Peters, 2002). In addition to these deposits, small Carlin-like gold deposits are present in some Silurian sandstone, and the newly discovered disseminated Jiaochong gold deposit, 2.5 km south of the Huangshilaoshan deposit, contains high concentrations of Zn, Pb, As and S, and is hosted in Permian limestone.

The deposits in Anhui Province are larger in size than those of Hubei and contain more iron and gold. The largest deposits are Xinqiao (0.5 Mt Cu metal at 0.7% Cu, 24 Mt Fe metal at 46% Fe, 105 t Au at 0.3 g/t Au in sulphide ore and 11.2 t Au at 4.7 g/t Au in oxide ore), Mashan (32 t Au at 6.5 g/t Au), Shizishan (46 t Au at 0.3 g/t Au) and Huangshilaoshan (13.5 t Au at 5.8 g/t Au) (Xu and Zhou, 2001; Chen Y. et al., 2007-this volume). These skarn deposits mostly have copper grades of more than 1% (e.g., Tongguanshan, 1.8% Cu, Fenghuangshan, 1.24% Cu).

Mashan is a large gold deposit located 2 km from Tongling City and about 6 km from the Yangtze River, Anhui Province. Mashan consists of about 44 orebodies surrounding the 137 Ma Mashan diorite. The main 2000-m-long, 4.4- to 64.9-m-thick stratabound orebody contains Au-rich lenses along a 500 m dip length, with near-horizontal plunges. Distributions of Cu and Au are spatially separate and Cu contents of the Au ores are generally low.

The Huangshilaoshan Au deposit is located 6 km from Tongling City, Anhui Province. The deposit consists of 11 orebodies. The main orebody is tabular, 1100 m long, 349 to 123 m wide, 1 to 17.82 m thick, and strikes NW, and dips SE at angles between 75 and 88°. The Huangshilaoshan Au deposit is a medium-size Au deposit (Wang, 1996). Orebodies at Huangshilaoshan are more uniform and continuous than those at Mashan on the other limb of the anticline.

The Tongguanshan Cu–Fe–(Au) skarn deposit is the best known and one of the largest skarn deposits in the Tongling area (Fan, 1984; Ge et al., 1990). The deposit lies along the southeast contact of an elliptical 136 to 158 Ma pluton intruded into northeast-striking anticlines and synclines in the Guichi–Fanchang fold and fault belt. Ore is present as stratabound bodies, pipes, veins and locally as stockworks and disseminations. The main commodities recovered are Cu, Fe, Mo, S and Au. Primary ore-stage minerals are pyrrhotite, pyrite, magnetite, and chalcopyrite, as well as lesser amounts of marcasite, molybdenite, chalcocite, galena, arsenopyrite, bismuth minerals, stibnite, and local scheelite. Gangue and skarn-related minerals include andradite and grossular garnet, diopside, wollastonite, serpentine, scapolite, vesuvianite, epidote, magnetite, actinolite, tremolite, biotite, sericite, quartz, chlorite, muscovite, and talc. Zoning and complex paragenetic sequences are described by Ge et al. (1990). These minerals are characteristic of pluton-related skarn deposits and are common in other deposits in the Tongling Mining District.

These deposits are commonly deformed and/or have been generated by multiple ore-forming episodes resulting in remobilisation and enrichment of metals. For instance, the largest Xinqiao Cu–Fe–S–Au–Ag deposit in Xinqiao township, Anhui Province is considered to have formed as a SEDEX deposit during the Early Carboniferous and was later overprinted by a skarn system related to a Yanshanian diorite (110–168 Ma) (Xu and Zhou, 2001; Gu L. et al., 2007-this volume). This resulted in high gold enrichment (116 t Au), although most of the gold is locked in chalcopyrite or pyrite. The Xinqiao Au deposit consists of 23 high-grade polymetallic orebodies and a total of 40 orebodies in the surrounding district. The deposits are referred to as pyritic Cu deposits (Ge et al., 1990) and as residual (gossan) Au deposits (Xu et al., 1992). The main orebody is stratabound along a narrow stratigraphic interval of Carboniferous limestone and shale, striking 57°, and dipping northwest at 16°, extending horizontally for 500 m and vertically for 50 to 155 m (average 87 m); the average thickness is 7.5 m (Peters, 2002).

Zhou Taofa et al. (2007-this volume) also studied the geochemistry and thermodynamic evolution of ore-forming fluids of the Yueshan Cu–Au skarns (Anqing; >0.3 Mt metal at 2.7% Cu) and vein-type deposits (Tongliujing; 0.1 Mt metal at 2.3% Cu) in Anhui Province, and indicated that two contrasting ore-forming processes were involved in the Yueshan Cu–Au skarn system; one with magmatic fluids and the other with mixed magmatic and meteoric fluids based on isotopic and fluid inclusion studies.

Iron only skarn deposits are abundant in Anhui Province (e.g., Changlongshan Fe deposit). Changlongshan is hosted by Middle Carboniferous to Early Permian limestones and contains 29 Mt of metal grading 35.9–58.6% Fe (Xu and Lin, 2000). Minor gold-bearing iron skarn deposits are also found in Jiangsu Province (e.g., Funiushan, 9 t at 0.85 g/t Au). The REE-associated iron–copper–gold deposits are also found in Yunnan Province along the Red River/Ailaoshan Fault zone. Although these deposits are considered to be skarn or SEDEX overprinted by Yanshanian metasomatism, they are commonly stratabound or stratiform, at a distance from outcropping intrusive rocks and have abundant hematite, and evaporite units in some of the host sequence (e.g., Shizishan district, Anhui Province), and display a variety of tectonic environments from intra-continental to subduction-related continental margin setting. These data suggest that presence of world-class FeOx-Cu-Au or IOCG (Iron Oxide Copper–Gold) deposits such as Olympic Dam type deposit (e.g., Hiztman et al., 1992; Barton and Johnson, 1996; Davidson and Large, 1998; Hiztman, 2001) in the Lower to Middle Yangtze River area and the other South China Provinces cannot be ruled out and considered as potential exploration targets.

Porphyry-related Cu–Fe–Au skarn systems are also found in contiguous mainland SE Asia (e.g., the Puthep Cu–Fe skarn and the Phu Thap Fah Au skarn in Thailand and the Phu Kham Cu–Au deposit in Lao PDR) (Fig. 7). These deposits occur along the Palaeozoic to Mesozoic volcanic–magmatic Loei fold belt stretching from central Thailand to Laos PDR. The Puthep Cu–Fe skarn deposit includes two ore zones (Put 1 and Put 2) and contains a resource of 121 Mt ore at 0.43% Cu (www.panaustralian.com.au). The Puthep skarn mineralisation is associated with Permo-Triassic intrusion of dioritic composition and consists of prograde garnet–magnetite–pyrite with retrograde assemblages of chlorite, sericite, carbonate and quartz. The mineralisation is located within both the intrusion and host volcano–sedimentary sequence where it consists of oxide, supergene and primary types. The Phu Thap Fah deposit is a reduced pyhrrotite–garnet–clinoproxene Au skarn and contains about a resource of 0.9 Mt ore grading 3–4 g/t Au with as high as 200 g/t Au in some ore intersection (Khin Zaw et al., 1999b; Rodmanee, 2000). The deposit is hosted in a Permian sequence of siltstone and limestone that is intruded by a granodiorite and related dioritic dykes. The early garnet–diopside skarn at Phu Thap Fah was followed by massive pyrrhotite skarn, and retrograde assemblages of tremolite, chlorite and quartz, calcite. The gold occurs as free electrum in massive pyrrhotite skarn together with chalcopyrite, pyrite and sometimes bismuth.

The Phu Kham copper–gold deposit occurs in the Lao PDR at the northern part of the Loei fold belt and approximately 100 km north–northeast of the capital, Vientiane. The deposit contains a resource of 311 Mt ore grading 0.5% Cu and 0.2 g/t Au (www.panaustralian.com.au). The deposit occurs in a sequence of Permo-Carboniferous volcaniclastics interbedded with limestone. The deposit includes distal sulphide skarn, proximal silicate-oxide skarn and quartz stockwork mineralisation styles that are spatially related to a dioritic porphyry. Most of the mineralisation is associated with magnetite–garnet skarns with retrograde hematite, carbonate, chlorite and pyrite. The alteration assemblages, vein styles and intrusive associations of the deposit suggest that it represents the upper or distal portions of a porphyry copper–gold mineralisation system (Tate, 2005).

3.6. Precious metal (Au–Ag) only deposits

Zhou Taihe and Goldfarb (2002) recently edited a special issue that gives a comprehensive overview of the tectonic and metallogenic relations of gold deposits in China, including the regional to district-scale geological setting focusing mainly on the North China Region. Precious metal (gold–silver only) deposits are also widely distributed in the South China Region, in addition to gold and silver associated with VHMS, skarn and porphyry deposits, and mafic–ultramafic rock related gold–platinum–palladium deposits. Three primary gold–silver only mineralisation types are recognised in South China: (1) Carlin-like gold deposits, (2) epithermal vein and breccia gold deposits, and (3) orogenic gold deposits. It is difficult to pigeon-hole all of the South China gold–silver deposits into the currently available gold deposit models as some deposits show a hybrid nature between typical Carlin-like, orogenic type and intrusion-related type. The depth of ore formation is also not well-constrained for many of the South China

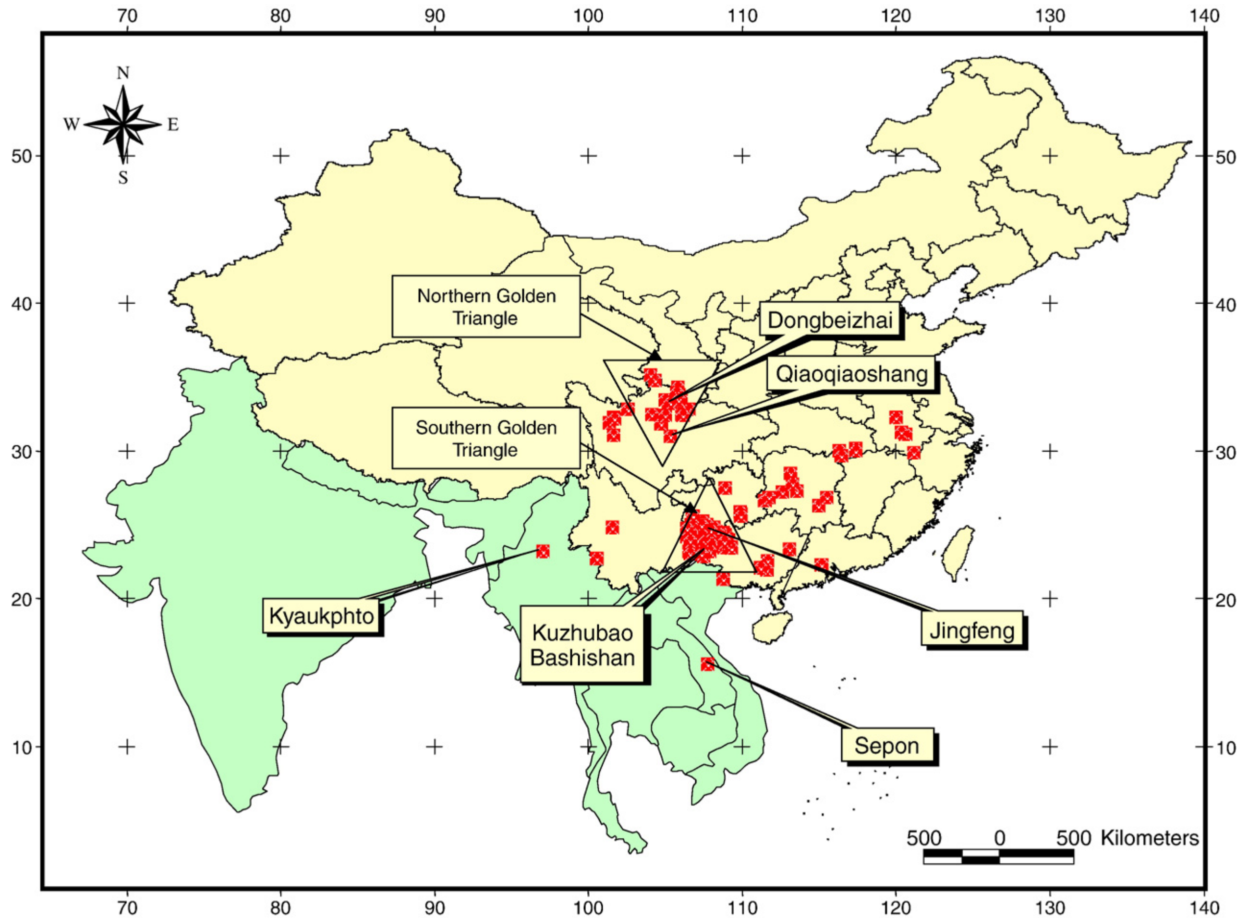

Fig. 8. Map showing spatial distribution of selected major Carlin-like deposits in South China and adjacent regions (modified after Khin Zaw et al., 1999b, 2002).

precious metal deposits. With these constraints in mind, we will briefly describe these deposits in three broad deposit types in the sections that follow.

3.6.1. Carlin-like and disseminated gold deposits

Carlin-like gold deposits are widely distributed in the South China Region, but are concentrated in the Southern Golden Triangle (Guizhou, Guangxi and Yunnan — also known as the Dian-Qian-Gui area) and in the Northern Golden Triangle (Sichuan, Gansu and Shaanxi — also known as the Chuan-Shaan-Gan area) (Table 1, Fig. 8) (e.g., Li and Peters, 1998; Zhou Taihe et al., 2002; Hu et al., 2002; Peters, 2002; Peters et al., 2007-this volume).

The Southern Golden Triangle (the Dian-Qian-Gui area) occurs along the southwest margin of the SCC, in the northern Nanpanjiang orogenic fold zone, at the join between the Tethyan–Himalayan and Pacific Plates (Zheng et al., 1984; Ji and Coney, 1985; Wang, 1992; Yin and Nie, 1996). Regionally, tectonic units in the Dian-Qian-Gui area belong to a northwest-trending triangular-shaped deformation zone, which is surrounded by north–northeast–northwest-, and east–west-striking structural zones (Dong, 1993). Sedimentation was controlled by a palaeo-tectonic basin that changed from the Late Palaeozoic to Early Mesozoic, such that the north-western parts of the basin contain Palaeozoic sedimentary rocks developed along a broad, restricted platform environment, which then evolved into a tidal flat during the Early Triassic (Deng et al., 1986; Yang et al., 1986; Hsu et al., 1990).

The Carlin-like deposits in the Southern Golden Triangle occur within the Youjiang margin sag-basin that covers an area of approximately 100,000 km^2 at the junction between the Guizhou and Yunnan Provinces and Guangxi District. These deposits have several similarities with Carlin-type deposits in Nevada (Cunningham et al., 1988; Ashley et al., 1991; Li and Peters, 1998; Cromie, 2001; Cromie and Khin Zaw, 2001, 2003; Peters, 2002; Peters et al., 2007-this volume).

The Southern Golden Triangle Carlin-like gold deposits in Yunnan Province are exemplified by the Kuzhubao and Bashishan deposits (Cromie, 2001; Cromie and Khin Zaw, 2001, 2003) (Fig. 8). The deposits contain epigenetic micro-disseminated gold hosted within Devonian carbonaceous mudstone units, along fault breccia zones at the contact between Triassic gabbro for the Bashishan deposit, and Devonian mudstone units for the Kuzhubao deposit. Gold mineralisation generally occurs within zones of strong deformation, especially where later strike-slip and normal faults crosscut earlier low-angled thrust faults. Major sulphide minerals are euhedral and disseminated pyrite, rhombic and acicular arsenopyrite, as well as stibnite and minor iron-poor sphalerite. Gangue minerals are quartz, sericite, calcite, ankerite and chlorite (Cromie, 2001; Cromie and Khin Zaw, 2001, 2003).

The Southern Golden Triangle Carlin-like gold deposits in Guizhou and Guangxi Provinces are hosted predominantly by Palaeozoic- to Mesozoic-aged siliciclastic and carbonate lithologies. These deposits have average grades ranging from 2 g/t to 8 g/t Au and some high grade intercepts of up to 16.8 g/t Au (Cunningham et al., 1988; Li and Peters, 1998; Peters, 2002; Peters et al., 2007-this volume).

The Carlin-like deposits in Guizhou Province include Jinfeng (Lannigou), Zimudang, Getang, Yata, Banqi, Ceyang, and Sanchahe, and are hosted predominantly by Permian carbonate and Triassic siliciclastic lithologies. Among these deposits, Jinfeng is the largest deposit (107 t Au at 5.1 g/t Au; Jones, 2003; Sino Gold Ltd., 2004), followed by Zimudang (60 t Au at 6 g/t Au), Getang (22 t Au at 6.2 g/t Au), Yata (~15 t Au at ~5 g/t Au) and Banqi (~10 t Au at ~5 g/t Au) (Zhou Taihe et al., 2002; Hu et al., 2002; Peters et al, 2007-this volume). The Carlin-like deposits in the Guangxi District include Gaolong, Huaping, Jinya, Langquan, Lianlong, Luoluo, Mingshan, Siling and Xiangbo. Among these deposits, Jinya and Gaolong are large deposits with ~30 t Au at 5.3 g/t Au and 25 t Au at 4 g/t Au, respectively (Hu et al., 2002). Similar to the Carlin-type deposits in USA, they are mostly sedimentary-rock hosted epigenetic hydrothermal micron-disseminated gold deposits with associated As, Hg, Sb+Tl mineralisation.

Significant Carlin-like gold deposits also occur in the Northern Golden Triangle of China covering NW Sichuan and SW Qinghai, Gansu and Shaanxi Provinces. The region is currently one of the largest potential producers of gold in China and continues to be the focus of further extensive exploration. More than 30 gold deposits and prospects have been found in Sichuan Province alone over the past 10 years. The most important Carlin-like deposits in NW Sichuan, adjacent to Gansu and Shaanxi Provinces are the Dongbeizhai and Qiaoqiaoshang deposits (Gu, 1996; Wang and Zhang, 1999; Mao et al., 2002). Dongbeizhai is one of the largest gold deposits discovered to date in western China (50 t Au at 6.2 g/t Au). It is located about 25 km northwest of the town of Songpan, at an elevation of 3000 m. It was discovered during early 1980 as a result of a reinvestigation program of old realgar showings by the Regional Geological Survey Team of Sichuan Province (Gu, 1996; Hu et al., 2002). Qiaoqiaoshang is also a large deposit (15 t Au at 4 g/t Au) similar to Dongbeizhai (Hu et al., 2002). BHP explored in the region (e.g., Maerkang) from 1996–2000, and followed by Sino Gold Limited who drilled some of the prospects (e.g., Shuiniujia deposit) (unpub. data, Paul Cromie, 2000).

The gold deposits in the Northern Golden Triangle show many characteristics of Carlin-type gold deposits such as host rock, mineralogy and structural setting. The host rocks are mostly Devonian to Triassic carbonaceous turbidite sequences within the Songpan-Garze accretionary wedge terrain, along the NW margins of the SCC. They consist of largely sandstone–siltstone–mudstone, and it is interpreted that the host rocks were accumulated in a back arc basin situated between an active continental island margin (the Qinling fold belt) and a continental island arc (the Yidun island arc). The dominant structure consists of N–S and E–W trending regional faults (Palaeozoic) that are crosscut by NW–SE trending faults (Mesozoic). Mineralisation appears to be associated with late structures and occurs mostly within graphitic shear zones or along the altered contacts with quartz–porphyritic or granodioritic dykes of Mesozoic age, related to the Indosinian (Triassic) and Yanshanian (Jurassic to Cretaceous) Orogenies. Ore mineral assemblages are pyrite, arsenopyrite, realgar, stibnite, scheelite, and traces of chalcopyrite, tetrahedrite, tennantite, sphalerite, galena, native arsenic, native gold, pyrrhotite and marcasite. The gangue minerals are mostly quartz, calcite and dolomite. The gold is commonly fine-grained, usually less than 1 μm in size, and refractory. The deposits also show different metal association such as: Au–As (Dongbeizhai), Au–W (Manaoke), Au–Sb (Qiuluo), Au–U (Laerma) and Au only (Pulongba) (pers. comm., Xiaochun Wang, 2000).

The Lower to Middle Yangtze River area is a major Au-mineralised area in which a variety of Au deposits are present, including Carlin-like deposits. Three types of Au deposits are recognised: (1) Yanshanian (185- to

67-Ma) magmatic hydrothermal (pluton-related) Au deposits; (2) supergene-oxidation-enrichment (red earth, laterite-hosted) deposits; and (3) micro-disseminated (Carlin-like) Au deposits (Liu and Wu, 1988; Liu and Yeap, 1992; Cun, 1995; Wang et al., 1996; Li and Peters, 1998). Pluton-related Au deposits are the main types of Au deposits in the Lower to Middle Yangtze River area and account for 90% of the total proven reserves of Au ore in the area (Kuo, 1957; Wang, 1982; Fan, 1984; Chen, 1996a,b; Rei et al., 1999). The Au deposits are associated with Cu and polymetallic ores and are controlled by northeast- and north–northeast-striking basement faults and by detachment faults in the overlying sedimentary rocks. Changes in geochemical elemental ratios of ores, brought about by oxidation in these distal-disseminated deposits, cause some high-level pluton-related occurrences to have Carlin-type geochemical signatures, particularly due to enrichment of As, Sb, and Hg in both Carlin-type systems and in distal-disseminated Ag–Au deposits.

Gossan type gold deposits that are known to contain invisible gold in a weathered zone, with up to 5 g/t Au (e.g., Shewushan), occur in South China (Hong et al., 1999). The Shewushan Au orebody occurs in Jiayu County, Hubei Province, and is the largest supergene red earth Au deposit in China. It is hosted in a well-developed lateritic profile, consisting of near-horizontal stratabound layers and large, supergene, conformable Au ore lenses at depths of 0 to 45 m. The main orebody is 1520 m long, 200 to 300 m wide, and 10 to 20 m thick (maximum, 44 m), dipping east and west at angles of 10° to 20°. Gold grades in lateritic ores vary from 1.5 to 5 g/t Au. Hypogene cataclastic limestone samples from drill holes show maximum gold values of 1 to 3 g/t Au. Gold recovery from cyanide heap-leaching operations is 88% to ~99% (Peters, 2002). Genesis of the orebody and stratigraphic identification are obscured by local, pre-weathering, intense shearing, cataclasis, and by the laterite profile. Due to lack of detailed mapping and the intense weathering, the age of host rock is not well-constrained but appears to be similar to the Silurian-aged sedimentary host-rock of the nearby Zhanghai Carlin-like deposit (Peters, 2002; unpub. data, Stephen Peters, 2003).

Carlin-like deposits are also found in adjoining parts of the SE Asian region. Intensive exploration programs in the Sepon Mineral District (SMD), Lao PDR conducted by CRA/Rio Tinto (1993–1999) and Oxiana Limited (2000–2003) resulted in the discovery of a new mineral field containing about 142 t Au at 1.8 g/t Au and 1.4 Mt of contained copper at 2.3 to 4.6% Cu (Smith et al., 2005) (Fig. 8). The SMD is located in the Sepon Basin within the NW-trending Palaeozoic to Mesozoic Truongson fold belt. It displays a district-scale zonation with a core of Permian-aged porphyry molybdenum-(copper) system outward through skarn and carbonate replacement copper deposit to sedimentary-rock hosted gold deposits (Manini et al., 2001; Cromie et al., 2004a, b; Smith et al., 2005). Gold in the SMD is predominantly micro-disseminated, closely associated with decalcification and partial silica replacement of calcareous shale of Permo-Carboniferous age, and is commonly localised in stratigraphic and structural traps, especially anticlines, shallow dipping stratigraphy, fault zones and along the faulted contact of porphyry sills, all of which suggest similarities with Carlin-type deposits in Nevada, USA (Manini et al., 2001; Cromie et al., 2004a,b; Smith et al., 2005).

Carlin-like deposits are also recorded along the Sagaing Fault in central Myanmar. The most important deposit is the Kyaukpahto gold deposit (4 Mt ore at 3 g/t Au) in the Kawlin–Wuntho district, Sagaing Division, Myanmar (Khin Zaw et al., 1999b; Khin Zaw, 2002; Ye Myint Swe et al., 2004) (Fig. 8). Gold mineralisation is hosted in calcareous sandstone of the Male Formation (Early to Middle Eocene) and is disseminated or occurs in stockworks. Major sulphide minerals are pyrite and arsenopyrite with minor galena, chalcopyrite and sphalerite. Gold mineralisation is associated with intense silicification, sericitisation and argillic alteration. The host calcareous sandstone sequence, trace element geochemistry, and the disseminated nature of sulphide and gold mineralisation are common characteristics of sediment-hosted gold deposit indicating a Carlin-like affinity (Khin Zaw, 2002; Ye Myint Swe et al., 2004).

3.6.2. *Epithermal gold deposits*

South China contains sizable epithermal gold deposits, in particular deposits within the South China fold belt along the southeastern margin of the SCC. The fold belt is characterised by well-developed Yanshanian intrusive to subvolcanic rocks. Major epithermal deposits in South China are listed in Table 1 and shown in Fig. 9. The most important example is the Zijinshan district where the only high-sulphidation epithermal system in mainland South China has been reported and it is located about 17 km north of Shanghang, Fujian Province (So et al., 1998). The district accounted for at least 100 Mt of ore containing 1.6 Mt Cu metal at 1.09% Cu and 15 t Au at 0.14 g/t Au and 619 t Ag at 6.2 g/t Ag (So et al., 1998; Mutschler et al., 1999). The Zijinshan deposits are associated with a

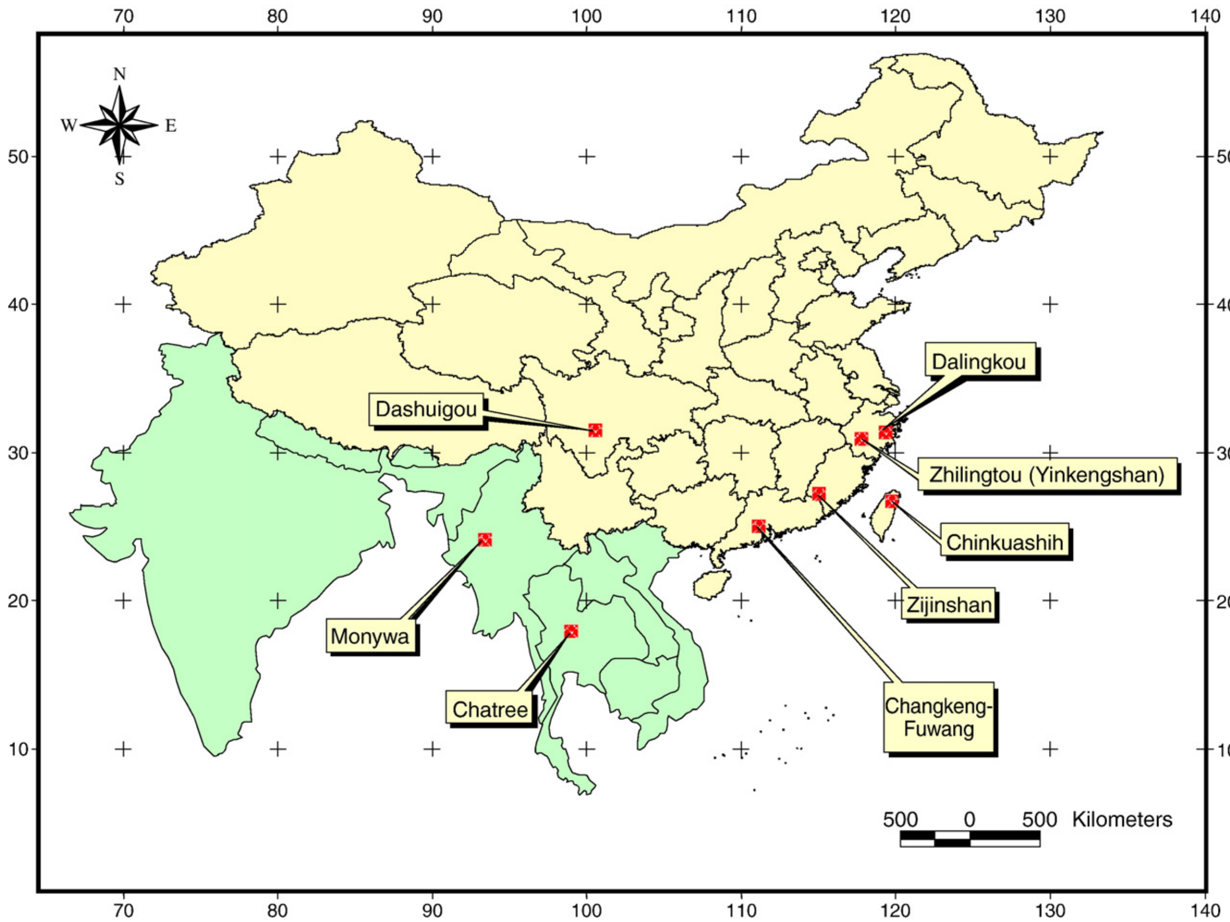

Fig. 9. Map showing spatial distribution of selected major epithermal gold–silver deposits in South China and adjacent regions (modified after Khin Zaw et al., 1999b, 2002).

Cretaceous volcanic and/or subvolcanic dacitic dome where mineralised granodiorite porphyry forms a steeply dipping pipe intruding S-type Jurassic granite and Late Proterozoic phyllite and metasiltstone. The deposits show typical epithermal high-sulphidation alteration zonation assemblages from the deep sericite + quartz + pyrite (phyllic) upward to dickite + quartz + pyrite and alunite + quartz + pyrite (argillic). High copper levels are typically developed within the alunite alteration zone and show gradual change of ore assemblages from digenite and enargite at deeper levels to covellite and gold in shallower levels. Subeconomic chalcopyrite + tennantite + bornite mineralisation is associated with the deeper phyllic alteration zone (So et al., 1998). The Chinkuashih deposit in Taiwan is also an important high-sulphidation epithermal gold system (Tan, 1991) (Fig. 9).

Zhejiang Province is characterised by Proterozoic and Palaeozoic sequences of the Yangtze terrane and the South China fold belt, separated by NE trending faults and ophiolitic mélange along the south-western Pacific margin. Gold and base metal mineralisation in the province is related to the plate interaction along this Pacific margin (Pirajno et al., 1996, 1997; Pirajno and Bagas, 2002). Formations of the Cu–Au mineral deposits are attributed to Yanshanian tectono-magmatic activity, which resulted from the northeast subduction of the Pacific Plate.

The vein-type Zhilingtou (Yinkengshan) deposit in Zhejiang Province (2 Mt ore grading 12 g/t Au and 306 g/t Ag) is considered to be an epithermal (Xu et al., 1995) or mesothermal deposit formed by multiple mineralising events (Pirajno et al., 1996, 1997; Pirajno and Bagas, 2002). The deposit is hosted in orthogneiss and paragneiss of Early Proterozoic age, overlain by Late Jurassic to Cretaceous intermediate to felsic volcanic rocks. The mineralised veins are gold and silver-rich or copper-, lead- and zinc-rich, and occur as stockwork, veins, and breccia. The ore minerals are pyrite, sphalerite, galena, chalcopyrite, pyrrhotite, electrum and rare hessite and sylvanite. The gangue minerals include a variety of quartz from smoky to vuggy texture, sericite, chlorite, rhodonite and rhodochrosite. Geological, fluid inclusion and K–Ar age data suggest that although the deposit is hosted in the Precambrian metamorphic rocks, the mineralisation is related to Yanshanian magmatism and appears to be similar to an epithermal style deposit (Xu et al., 1995). Many epithermal deposits tend to be silver dominant and can be classified as epithermal silver deposits (e.g., Dalinkou deposit).

Tellurium-rich epithermal vein gold deposits occur in South China (e.g., Dashuigou deposit, Sichuan Province) (Fig. 9). Mao et al. (1995) indicated that the Dashuigou deposit is comparable to the tellurium-rich epithermal gold deposit at Emperor, Fiji. Liang et al. (2007-this volume) also studied the geology and geochemistry of Changkeng-gold and Fuwang-silver deposits, Guangdong Province, China. The Changkeng-gold deposit is hosted in brecciated siliceous rocks, siltstone and limestone of the Early Carboniferous Zimenqiao Group and has a total reserve of about 32 t Au at av. 7 g/t Au. The Fuwang deposit is a giant silver deposit and the largest silver deposit in the South China fold belt, with more than 6000 t grading 268 g/t Ag with minor lead and zinc. The deposit is hosted in the Zimenqiao Group but occurs stratigraphically below the Changkeng deposit. Recent isotopic and fluid inclusion studies of both deposits indicate that they represent a single evolved epigenetic, epithermal ore-forming system that is temporally linked to Himalayan (Tertiary) volcanic activity (Liang et al., 2007-this volume).

Epithermal style gold deposits also occur in nearby mainland SE Asia. The Chatree gold deposit in Thailand is a low-sulphidation epithermal system in Permo-Triassic volcanic rocks of the Loei-Phetchabun Volcanic Belt (Dedenczuk, 1998; Diemar and Diemar, 1999; Kromkhun, 2005) (Fig. 9). The deposit has a geological resource of 14.5 Mt of ore at 2.1 g/t Au and 14 g/t Ag and it is the only operating gold mine in Thailand (http://www.kingsgate.com.au).

A high-sulphidation copper deposit occurs at Monywa, central Myanmar (Fig. 9). The three copper orebodies, Sabetaung, Kyisintaung and Letpadaung, are discrete, circular-shaped bodies along the Cenozoic Central Volcanic belt of Myanmar (Kyaw Win and Kirwin, 1998; Khin Zaw et al., 1999b). The deposit is operated by a joint venture of 50% Myanmar Government and 50% Ivanhoe Mines Ltd., forming Myanmar Ivanhoe Copper Co. Ltd. (MICCL). The three orebodies have a total resource of more than 1.5 billion tons with a cut-off grade of 0.4% Cu (http://www.ivanhoe-mines.com/i/pdf/letpadaung-info.pdf). The Monywa deposit is hosted in a series of Cenozoic sedimentary clastic rocks and felsic to intermediate volcanic rocks of Late Miocene age.

3.6.3. Orogenic gold deposits

Structurally controlled, shear-zone hosted, orogenic gold deposits are present in South China (Table 1, Fig. 10). Several orogenic gold deposits lie along the NW-trending Ailaoshan mega-shear belt in SW China, extending about 120 km in length and 500–5000 m in width. These deposits account for more than 150 t Au reserves and a potential resource of 500 t Au within the belt (Hou et al., 2007-this volume). The grade of the deposits varies from less than 1 g/t Au to as much as 55 g/t Au. They are mostly hosted in ophiolitic mafic–ultramafic rocks and basaltic tuffaceous rocks, as well as minor sandstone and crystalline limestone. Some gold deposits are spatially associated with the Himalayan (Tertiary) lamprophyre and granodiorite-porphyries that intruded the ophiolitic sequence. The most important deposits in the Ailaoshan belt are Laowangzhai, Dongguolin, Jinchang and Daping deposits in Yunnan Province (Fig. 10).

Guangdong Province contains significant mylonite-hosted, orogenic gold deposits (e.g., Gaocun and Yunxi deposits, also known as the Hetai goldfield), that occur from south-eastern Guangxi Province to western Guangdong Province (Fig. 10). At least six major deposits have been discovered in the field since 1982 making it the largest goldfield in South China (Wang et al., 1997; Zhang G. et al., 2001). The gold deposits are confined to a series of ductile shear zones in the Sinian-age Yunkai metamorphic rocks (mica schist, feldspar-mica schist, and mica gneiss). These rocks have been later affected by the Hercynian–Indosinian Orogeny resulting in a series of ENE-oriented ductile shear zones (mylonite belts). The Gaocun gold deposit is hosted in one of these shear zones. The deposit is the largest in the field and has been mined since 1989. Prior to mining, it was estimated to contain 30.7 t of gold grading 3 g/t Au with intersection as high as 73 g/t Au in sulphidic ores (Zhang G. et al., 2001).

Structurally controlled, shear-zone hosted, orogenic gold deposits (e.g., the Huangshan gold deposit, 3.3 t Au at 9 g/t Au) occur in Zhejiang Province. The deposits are hosted in basement rock (Proterozoic diorite) and associated with Mesozoic volcanic rocks (Pirajno et al., 1996, 1997; Pirajno and Bagas, 2002). The Huangshan orebody strikes NE, dips 40° to 70° SE and is localised in sheared diorite. The ore minerals are pyrite, galena, and rare altaite, hessite and calaverite.

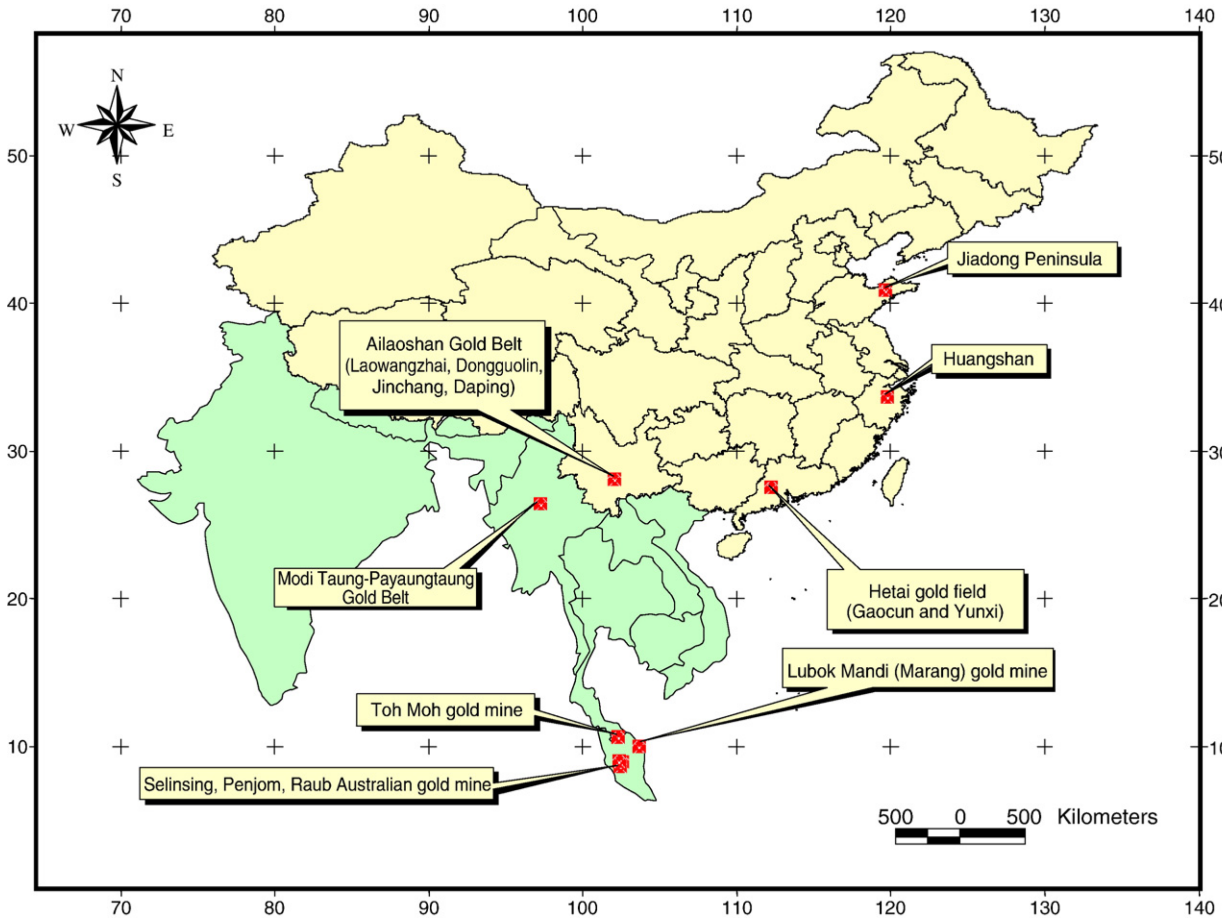

Fig. 10. Map showing spatial distribution of selected major orogenic gold deposits in South China and adjacent regions (modified after Khin Zaw et al., 1999b, 2002).

Gold is present as in-fills in the pyrite. The gangue minerals are sericite, ankerite, chlorite, muscovite, calcite, and tourmaline.

Orogenic gold deposits extensively occur in Shandong Province. The deposits are located in the Jiaodong Peninsula along the boundary of the NCC and SCC. The Peninsula is characterised by Archaean and Proterozoic rocks intruded by Mesozoic granitoids. The gold deposits in the province are unique world class granitoid-hosted orogenic gold deposits, and the history of gold mining in the province dates back to the Tang Dynasty (907 AD). Shandong Province is currently the most important gold province in China, both in terms of gold production (55 t Au in 2000), and ore reserves (>900 t Au). Many world class gold belts (>100 t Au) have been found in the province during the last two decades (Qiu et al., 2002). These deposits are considered as orogenic-type here although they may be intrusion-related gold depostis as they are spatially associated with extensive granitoid intrusions.

The gold mineralisation occurs as vein deposits (Linglong type) and disseminated to stockwork style deposits (Jiaojia type). The majority of the deposits are hosted in granitoids and account for more than 90% of the gold resources. Recent detailed geological and SHRIMP geochronological studies indicate that the gold mineralisation is related to the two Yanshanian magmatic events (160–150 Ma and 130–126 Ma) (Wang et al., 1998; Zhou Taihe and Lu, 2000; Qiu et al., 2002).

Most of the deposits in the Jiaodong area are structurally controlled along prominent NNE-trending brittle-ductile shear zones, and typically contain silicification, sericitisation, and K-feldspar alteration. The orebodies vary from tens of meters to 2000 to 3000 m in length, 2 mm to 3–6 m in thickness, and tens of meters to 500 to 600 m in depth. The ore minerals are native gold, electrum, pyrite, chalcopyrite, magnetite, pyrrhotite, galena and sphalerite.

The most important gold deposits in the Jiaodong area are the Linglong (>100 t Au at 3–30 g/t Au), Sanshandao (~60 t Au at 7 g/t Au), Cangshang (~60 t Au at 4 g/t Au), Jiaojia (>60 t Au at 7 g/t Au), Xincheng (>60 t Au at 8 g/t Au), Wangershan (45 t Au at 7–8 g/t Au), Jingqingding–Rushan (25 t Au at 9 g/t Au), Donggerzhuang (20 t Au at 11 g/t Au), and Hedong and Shangzhuang deposits (~20 t Au at 7 g/t Au), as well as small deposits that contain 5 to 10 t Au at 3–6 g/t Au. Because Shandong Province is currently the richest gold region in China and has one of the largest granitoid-hosted orogenic gold belts in the world, considerable geological and ore deposit research has been undertaken by Chinese and overseas geologists (e.g., Zhai et al., 1997; Wang et al., 1998; He et al., 1989; Zhou Taihe and Lu, 2000; Qiu et al., 2002 and references therein; Fan et al., 2003). However, the nature and source of the gold remains unclear.

Orogenic gold deposits are also fairly widespread in the contiguous SE Asian regions, in particular, Myanmar, Thailand and Malaysia (Khin Zaw et al., 1999b), although these deposits have not attracted much attention from international exploration and mining companies. Examples include Modi Taung and Payaungtaung deposits in Myanmar, and Toh Moh deposit in Thailand. Several orogenic gold deposits occur in Malaysia (e.g., Selingsing, 3 Mt ore grading 3 g/t Au, Penjom, 3.4 Mt ore at 3.5 g/t Au, and world-class pre-War Raub Australian gold mine, ~30 t grading up to 1000 g/t Au in central Malaysia and Lubok Mandi (Marang) deposit, 3 Mt ore at 3 g/t Au in eastern Malaysia) (Yeap, 1993; Khin Zaw et al., 1999b). Most of these deposits are structurally controlled and hosted in mostly Palaeozoic metamorphic rocks such as phyllite, quartzite, slate and gneiss.

3.7. Other deposits

3.7.1. Nickel deposits

Sulphide deposits containing Ni–Cu–(PGE) associated with continental flood basalts are present in

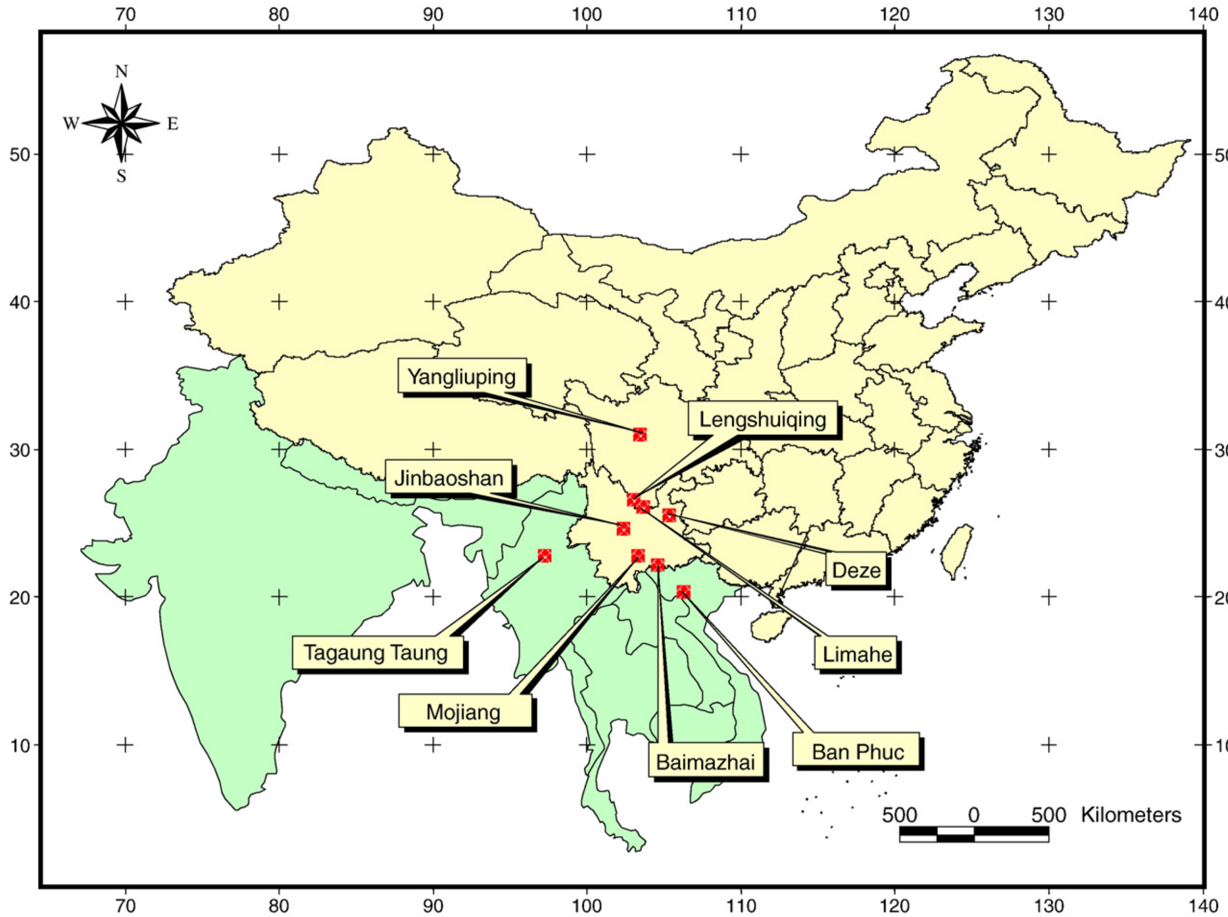

Fig. 11. Map showing selected major nickel deposits in South China and adjacent regions (modified after Khin Zaw et al., 1999b, 2002).

South China (Table 1, Fig. 11). The best known world-class examples of nickel sulphide deposits associated with continental flood basalts described in White and Herrington (2000) include: the Phanerozoic Noril'sk-type deposits, Russia (900 Mt of ore at 2.7% Ni; Naldrett, 1997; Arndt et al., 2003); the Proterozoic Jinchuan deposit, China (515 Mt of ore at 1.2% Ni and 0.7% Cu; Guo and Dentith, 1997; Barnes and Tang, 1999) and the Proterozoic Voisey's Bay deposit, Canada (136.7 Mt of ore at 1.59% Ni and 0.85% Cu; Naldrett, 1997; Naldrett and Li, 2000).

Extensive exposure of Permian-aged flood basalt belonging to the Emeishan continental flood basalt system (ECFB) covers an area of 500,000 km^2 along the SW margins of the SCC in SW China, including the Yunnan, Sichuan and Guizhou Provinces and ECFB is believed to be related to mantle plume activity (Zhong et al., 2002; Song et al., 2003). Younger mafic and ultramafic rocks intrude the ECFB and are best exposed near eroded basaltic margins. Occurrences of Pt–Pd–Ni–Cu–Co are recorded in Sichuan and Yunnan Province in association with these mafic and ultramafic rocks. Nickel sulphide deposits at Jinbaoshan and Baimazhai in Yunnan Province (Wang and Zhou, 2004; Jinshan Gold Mines, 2005; SEGNL, 2005) and at Yangliuping in Sichuan Province (Song et al., 2003) are described as having some similar characteristics to Noril'sk-type deposits. The Fe–V–Ti deposits such as the Taihe, Baima, Xinjie, Panzhihua and Hongge deposits (not plotted in Fig. 11) are also associated with the Permian ECFB in the Panxi rift in Sichuan Province (Zhong et al., 2002).

The Jinbaoshan Pt–Pd–Ni–Cu deposit is located approximately 134 km south of Dali in Mindu County, Yunnan Province and is currently under exploration by Jinshan Gold Mines. Mineral occurrences at this deposit include platinum group metals, chalcopyrite, and pentlandite that formed as magmatic segregations within conformable layers in a Permian ultramafic sill, thought to be associated with the ECFB system, intruding Devonian siltstone and dolomite. The deposit was discovered in 1971 by the Third Geological Brigade and further exploration work included geological mapping, magnetic surveys, trenching, tunnelling, and diamond drilling. Chinese geologists estimated a geological resource of 13 Mt of ore grading 0.65 g/t Pt, 1.1 g/t Pd, 0.185% Ni, and 0.19% Cu (Jinshan Gold Mines, 2005; SEGNL, 2005). The Baimazhai Ni–Cu–(PGE) deposit contains 600, 000 t of Ni metal at ore grade higher than 4% Ni and 1.2 Mt of Ni metal at ore grade of 0.3–4.0% Ni (Wang and Zhou, 2004). The deposit has been mined by the Yunnan Nickel Company since the 1980s. It is hosted in a concentric mafic–ultramafic intrusion that is part of the Permian ECFB in SW China.

The Yangliuping (Danba) Ni–Cu–(PGE) sulphide deposits in NW Sichuan Province are hosted in four Permian mafic–ultramafic sills that are associated with the Late Permian Dashibao Formation basalts and are also interpreted to belong to the ECFB. Devonian carbonaceous marble and graphitic schist located in the Yangliuping tectonic dome have been intruded by the Permian mafic–ultramafic sills. The Bureau of Geological and Mineral Resources of Sichuan Province (BGMS) discovered the Ni–Cu–(PGE) sulphide deposits in the Yangliuping area during the 1970s, and subsequent exploration work established a combined resource from both the Yangliuping and Zhengziyanwuo sills containing: 275,000 t of Ni metal (average grade of 0.45% Ni), 100,000 t Cu (0.16% Cu), 10,000 t Co (0.016% Co) and 35 t PGEs (0.55 ppm; Song et al., 2003). Ore minerals hosted by the mafic–ultramafic sills include: pyrrhotite, chalcopyrite and pentlandite, with minor sphalerite, galena, ilmenite, cobaltite, violarite, sperrylite and testibiopalladite occurring mostly in disseminated, veinlet and massive ore types (Song et al., 2003).

Middle Proterozoic mafic–ultramafic bodies are distributed in Yunnan and Sichuan Provinces. Pt–Pd–Ni–Cu–Co occurrences are recorded in Yunnan in association with these mafic and ultramafic rocks. The important Middle Proterozoic-aged deposits in Sichuan Province are Lengshuiqing (2.5 Mt of ore at 0.9% Ni, 0.5% Cu and 1 g/t PGE) and Limahe (1.5 Mt of ore at 1% Ni, 0.5% Cu and about 1 g/t PGE) that are hosted in Proterozoic ultramafic rocks.

A new sedimentary exhalative Ni–Mo mineralisation style in Cambrian black shale has been reported at Deze, in Yunnan Province (Coveney et al., 1992; Lott et al., 1999; Coveney, 2000). The deposits appear to be related to a deep fracture zone extending from Yunnan, through Guizhou, Hunan, to Zhejiang Provinces (Lott et al., 1999). South China has nickeliferous laterite deposits (e.g., Mojiang) (Fig. 11), and similar laterite nickel deposits are also found in Myanmar (Tagaung Taung, 41 Mt at 2.02% Ni (Khin Zaw et al., 1999b). Vietnam has few Cu and Cu–Ni deposits. The largest Cu–Ni deposit occurs at Ban Phuc in Son La Province. The deposit occurs as massive sulphides consisting of pyrrhotite, pentlandite, niccolite, violarite, pyrite and chalcopyrite, and is hosted in Permo-Triassic mafic–ultramafic rocks with geological ore reserves of ~0.2 Mt of nickel grading >0.7% Cu and >0.5% Ni (Khin Zaw et al., 1999b).

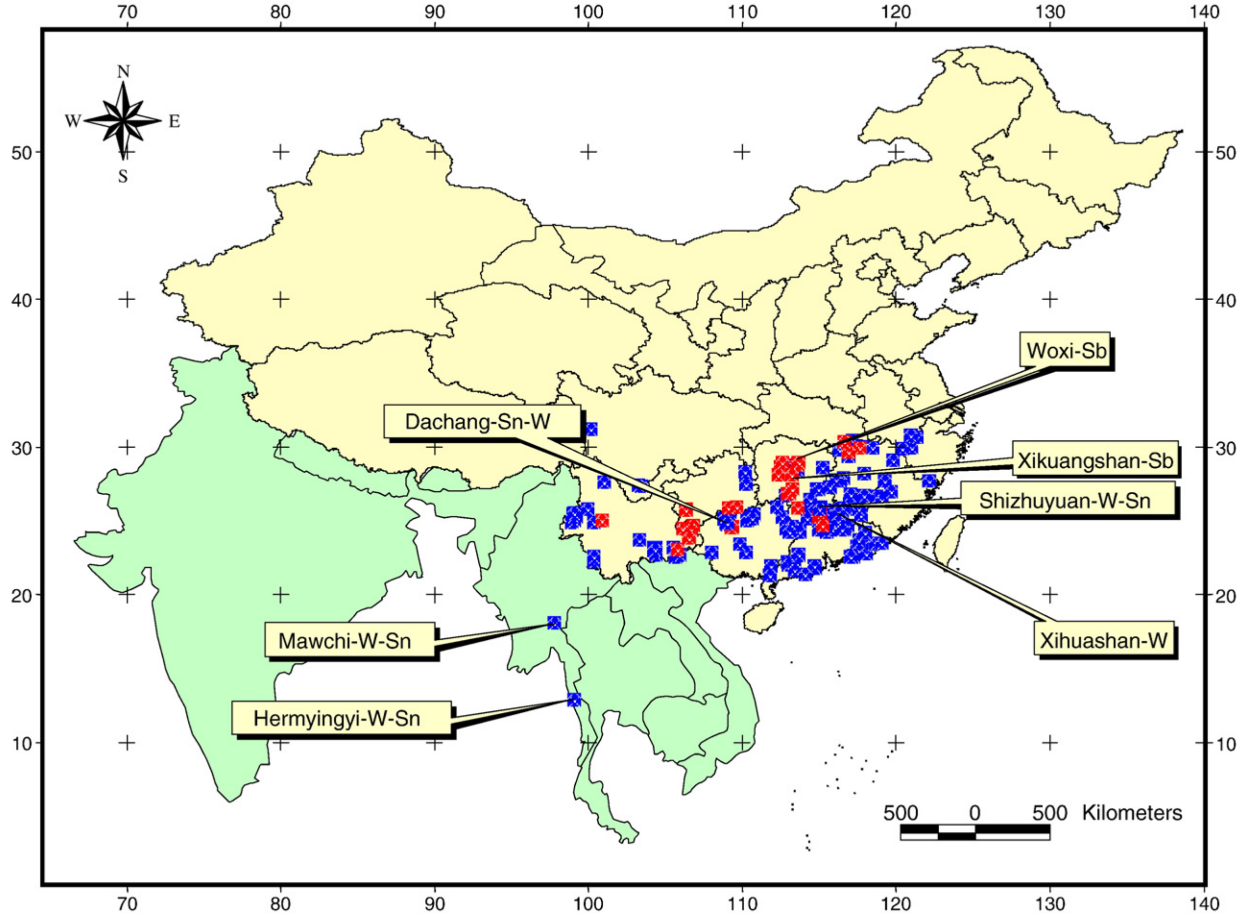

Fig. 12. Map showing selected major tin–tungsten and antimony deposits in South China and adjacent regions (modified after Khin Zaw et al., 1999b, 2002). Tin–tungsten occurrences are in blue colour and antimony deposits are in red colour.

3.7.2. Tin–Tungsten deposits

South China hosts significant tin–tungsten–sulphide skarn/vein deposits (e.g., Chen et al., 1992; Liu and Ma, 1993) along mineralised belts that extend south into mainland SE Asia. The Shizhuyuan deposit in Hunan Province is the largest among the economically important skarn–greisen–vein tungsten–polymetallic deposits in China (Mao and Li, 1995; Mao et al., 1996a,b; Yin et al., 2002; Lu H.Z. et al., 2003) (Fig. 12). The deposit occurs along the contact between a Late Devonian dolomitic limestone and a Jurassic to Cretaceous (Yanshanian) granitoid. The Shizhuyuan deposit is a very large polymetallic calcic skarn deposit containing 750,000 t WO_3, 490,000 t Sn, 300,000 t Bi, 130,000 t Mo and 200,000 t Be with combined grades ranging from 1 to 5% (Lu H.Z. et al., 2003). In addition, the deposit is rich in fluorine with a reserve of 76 Mt at 2% fluorite, making it one of the largest fluorite deposit found in China (Lu H.Z. et al., 2003). Recently, a series of manganese skarn/veins with lead–zinc–silver mineralisation have been found in the area (Mao et al., 1996a,b).

Yanshanian granite-related tin–tungsten–sulphide skarn deposits occur widely in Guangxi Province. The most notable example is in the Dachang ore field, where numerous geochemical studies have been undertaken (e.g., Tanelli and Lattanzi, 1985; Lattanzi et al., 1989; Fu et al., 1991, 1993; Peng et al., 1997). The Dachang orefield has about 100 Mt of ore at 1% Sn, 3 to 5% combined Cu, Pb, Zn and Sb and 100 to 300 g/t Ag, making it one of the largest tin-polymetallic ore fields in the world. Major deposits include the Changpo, Bali, and Longtaoshan tin-sulphide deposits, the Lamo copper–zinc deposit, the shale-hosted Dafulou deposit and the Kangma vein–greisen deposit. The Dachang deposits, such as Changpo–Lamo, are similar to the Renison-style carbonate replacement tin deposits in western

Tasmania (Kitto, 1998). However, recent textural, trace elements and isotopic studies of the deposits favour a model that the ores were primarily sedimentary–diagenetic deposit that have been modified by Yanshanian magmatism (e.g., Fan et al., 2004b; Gu L. et al., 2007-this volume).

A few porphyry tungsten deposits (e.g., Lianhuashan) are also recorded in Gaungdong Province (Mutschler et al., 1999). Important Jurassic–Cretaceous vein-type tungsten deposits occur in Jiangxi Province (e.g., Xihuashan, Dangping and Piaotang) (Yan et al., 1980; Wu and Mei, 1982; Tanelli, 1982; Giuliani et al., 1988). Himalayan-aged vein-type tin deposits occur in Yunnan (e.g., Lailishan, Hou et al., 2007-this volume). Similar vein-type deposits are found in adjacent Myanmar associated with Cretaceous to Eocene granitoids (e.g., the Hermyingyi Mine, Khin Zaw, 1978; the Mawchi Mine, Khin Zaw and Khin Myo Thet, 1983; Khin Zaw, 1990a,b) (Fig. 12). The Mawchi Mine was one of the largest W (Sn) deposits in the world before World War II.

3.7.3. Antimony and uranium deposits

South China is rich in antimony resources, accounting for 55% of the world's antimony reserves, with large world-class deposits such as the Xikuangshan and Woxi deposits in Hunan Province, and Qinglong and Banpo in Guizhou Province (Wu et al., 1990; Wu, 1993; Xu et al., 1996; Gu X. et al., 2007-this volume). The distribution of antimony deposits is shown in Fig. 12 and the characteristics of the important deposits (Xikuanshan and Woxi) are listed in Table 1. Xikuanshan is the largest antimony deposit in the world (Fan et al., 2004a) and Woxi is one of the giant antimony–tungsten–gold deposits in China (1.6 Mt Sb metal at average 4% Sb, 250,000 tonnes WO_3 at average 0.5% WO_3 and 42 t Au at 5–10 g/t Au) (Gu X. et al., 2007-this volume). Although most of these antimony deposits in South China occur as vein deposits associated with Yanshanian magmatism or as a by-product of Carlin-like deposits, recent studies on the Woxi deposit by Gu X. et al. (2007-this volume) and Xikuanshan by Fan et al. (2004a) indicate that the accumulations of the ore elements were probably formed by SEDEX-style mineralisation.

A few intrusion-related uranium deposits, carbonaceous pelitic rock-hosted uranium deposits and carbonate palaeokarst-hosted uranium deposits are present in South China (e.g., Min, 1995; Min et al., 1997, 1999). Rare metals and REE deposits are also associated with Yanshanian granitoid magmatism in the South China region (e.g., Yin et al., 1995). Metallogeny of non-metals in South China is not the focus of this Special Issue and is therefore not addressed in this paper.

4. Metal distribution relative to deposit types

4.1. Lead–zinc

At least five different styles of lead–zinc–silver mineralisation occur in South China: (1) VHMS deposits (e.g., Carboniferous Laochang and Dapingzhang deposits in Yunnan, and the Triassic Gacun deposit in Sichuan); (2) SEDEX deposits (e.g., Cenozoic Jinding deposit in Yunnan); (3) MVT deposit (e.g., Sinian Daliangzi and Tianbaoshan deposits in Sichuan); (4) lead–zinc skarn deposits (e.g., Jurassic Huangshaping deposit in Hunan), and; (5) with precious metals in veins and porphyry deposits (e.g., Tertiary Beiya deposit in Yunnan).

Available contained metal tonnage data for the lead–zinc metals from the different deposit types show that the SEDEX type accounts for 57% and they are the most important style for lead–zinc mineralisation in South China followed by MVT (23.0%) and VHMS (12.5%) (Fig. 13A). The high tonnage Cenozoic Jinding deposit strongly influences this distribution. Significant Devonian to Carboniferous SEDEX type deposits occurs in South China (e.g., Fankou and Dabaoshan deposits). Some of these Late Palaeozoic SEDEX deposits have been later affected by magmatic and metamorphic processes associated with the Yanshanian Orogeny (see below). Many important MVT and VHMS deposits occur in the Sanjiang Region at the western part of South China and these deposit types appear to be attractive for further exploration targets. Porphyry Cu and skarn Cu–Fe deposits contain only minor lead and zinc resources accounting for 7.5% of the total zinc and lead resources. Some small tonnage polymetallic lead–zinc vein deposits are associated with Indosinian (Triassic) and Yanshanian (Jurassic to Cretaceous) magmatism in Yunnan, Hunan and Guangdong Provinces.

4.2. Copper

The South China region has the largest porphyry copper deposit in China (i.e., the Dexing deposit in Jiangxi) and the other emerging porphyry Cu–Mo–Au systems such as the Yulong and Gangdese deposits in Tibet and the Beiya deposits in Yunnan. Au–(Ag–Mo)-rich porphyry-related Cu–Fe skarn deposits are present along the Lower to Middle Yangtze River

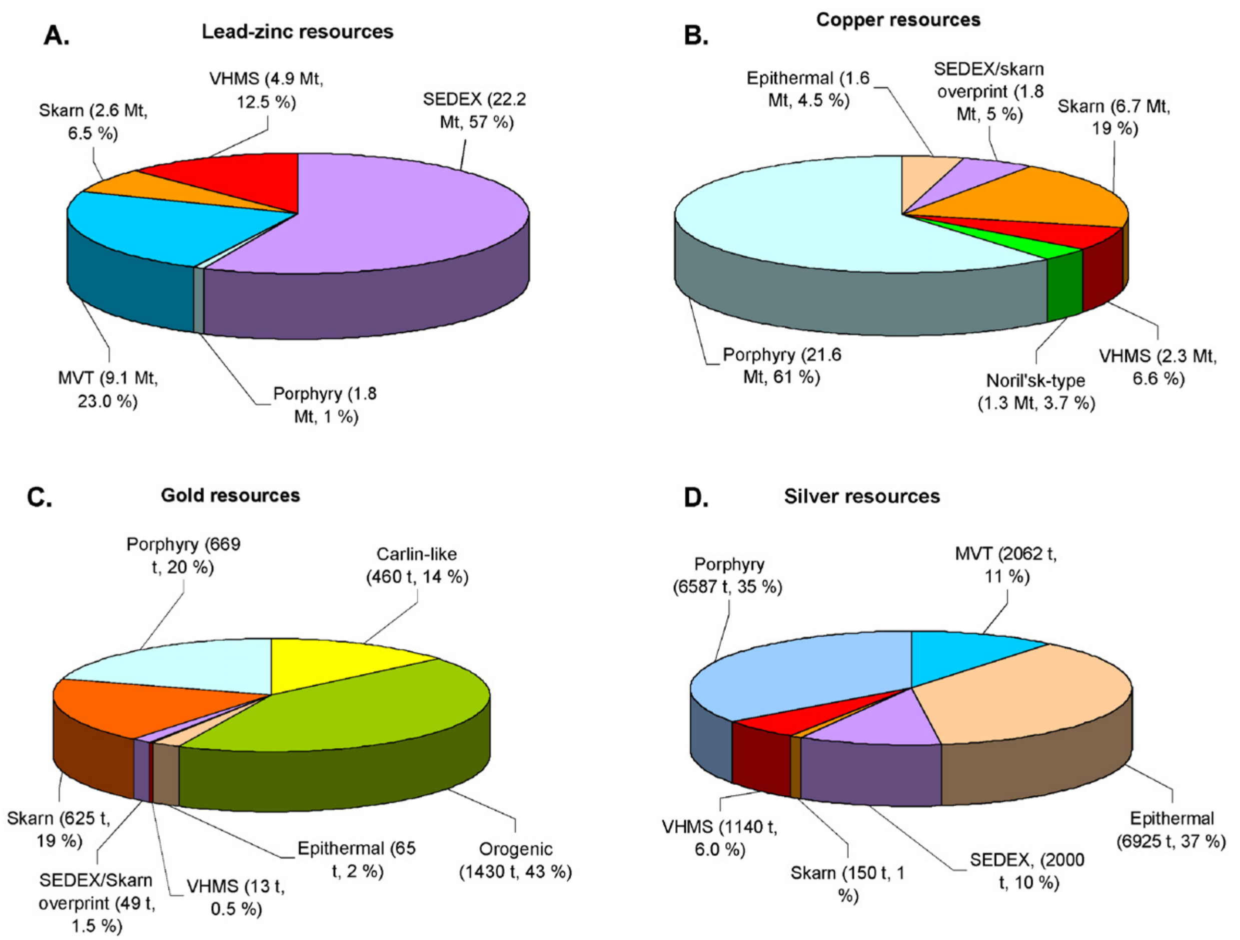

Fig. 13. Metal distribution of major ore deposit types in South China. **A**. Lead–Zinc. **B**. Copper. **C**. Gold. **D**. Silver. Data after Table 1, this study, Hou et al. (2006-this volume), Gu L. et al. (2006-this volume), Chen Y. et al. (2006-this volume), Peters et al. (2006-this volume), and Qiu et al. (2002).

metallogenic belt. Available contained metal tonnage data of copper for the different deposit types show that porphyry copper and skarn deposits are the major source of copper in South China (61% and 19%) accounting for at least 28 Mt contained Cu metal. Other deposit types contain minor copper resources: VHMS (6.6%), SEDEX with skarn overprint (5%), epithermal (4.5%) and Noril'sk-type (3.7%) (Fig. 13B). Some of the skarn deposits have complex origins (e.g., Chengmenshan, Dongguashan, Wushan, Qixiashan and Xinqiao) with recent research indicating that they were initially formed as SEDEX deposits during the Devonian and Carboniferous and later overprinted by skarn system associated with Yanshanian magmatism. The Yanshanian overprinting affect appears to have remobilised and reconcentrated, or added copper and gold in these deposits as higher copper and gold tonnage and grade have been recorded in these SEDEX deposits with skarn overprints such as Dongguashan (e.g., Gu L. et al., 2007-this volume; Hou et al., submitted for publication).

4.3. Gold–silver

The South China region is rich in precious metal resources. At least three primary gold–silver only deposit types are present: (1) Carlin-like gold deposits; (2) epithermal vein and breccia gold deposits, and; (3) orogenic gold deposits. Precious metals also are extracted from skarn, porphyry copper, SEDEX and VHMS deposits. Available contained metal tonnage data for the different deposit types show that most of the gold in South China is contained in orogenic gold deposits (43%) followed by porphyry copper (20%), skarn (19%), and Carlin-like (14%) (Fig. 13C). Other deposit types appear to have less potential for gold resources: epithermal (2%), SEDEX/skarn overprint (1.5%), and VHMS (0.5%).

Many orogenic gold deposits lie along the NW-trending Ailaoshan mega-shear belt in SW China, and these deposits account for more than 500 t Au. Orogenic gold deposits are found in Guangxi and Guangdong Provinces (e.g., Hetai goldfield). The Hetai gold deposits contain more than 30 t Au. Unique world class granitoid-hosted orogenic gold deposits occur in Shandong Province. These deposits are the major producers of gold in China with ore reserves of more than 900 t Au. Porphyry Cu and skarn Cu–Fe deposits in South China are enriched in precious metals and some gold dominant porphyry and skarn deposits are known. These deposits accounted for more than 600 t Au. The Carlin-like deposits accounted for a total resource of at least 460 t of Au (Peters et al., 2007-this volume).

The epithermal type has a low gold resource compared to Carlin-like and orogenic-type in South China. However, there is a potential for further discovery of epithermal deposits as the South China fold belt, covering Fujian and Zhejiang Provinces along the south-eastern margin of the SCC, is characterised by well-developed Yanshanian intrusive to subvolcanic rocks associated with porphyry to epithermal type copper–gold mineralisation and mesothermal vein deposits. It is of note that the epithermal-type deposits in South China are more enriched in silver with high Ag/Au ratios than the other gold deposit types. Available contained metal tonnage data for the different deposit types show that most of the silver in South China is contained in the epithermal deposits (37%) followed by porphyry (35%), MVT (11%), SEDEX (10%), VHMS (6%) and skarn (1%) deposits (Fig. 13D).

5. Metallogenic relations

Different deposit types and mineralisation styles in South China are present in the following clusters or belts (Fig. 14): (1) the Sanjiang fold belt covering eastern Tibet, Sichuan and Yunnan, (2) the Lower to Middle Yangtze River belt covering from Hunan, Hubei, Anhui to Jiangsu, (3) the Nanling Mountain belt in northern Guangxi District and northern Guangdong Province, (4) the Dexing belt in Jiangxi, (5) the Jiaodong belt in Shandong, (6) the South China fold belt covering Fujian and Zhejiang Provinces, (7) the Chuan-Shan-Gan (northern Golden Triangle) belt in NW Sichuan and SW Qinghai, Gansu and Shaanxi, (8) the Dian-Qian-Gui (southern Golden Triangle) belt at the junction of Yunnan, Guizhou, and Guangxi, (9) the Gangdese belt in Tibet, (10) the Yulong belt in Tibet, (11) the Ailaoshan belt in Yunnan, and (12) the Hetai belt in Guangxi District and western Guangdong Province. The Sanjiang fold belt is a part of the Sanjiang Tethyan Metallogenic Domain (STMD) (Hou et al., 2007-this volume) and represents the most important metallogenic province in South China and hosts a diverse range of mineral deposit types.

5.1. Metallogenic history

South China has undergone multiple tectonic and magmatic events that have resulted in related metallogenic processes since the Early Proterozoic. A simplified temporal evolution of the different deposit types in relation to metallogenic events in South China is shown in Fig. 15. No Archaean base and precious metal mineralisation have been recognised in South China, although Archaean basement older than 3.2 Ga has been identified in the northern part of the SCC (e.g., Qiu et al., 2000). Only minor iron occurrences are present within the Archaean basement in the SCC. In comparison, the Archaean greenstone belt in the NCC hosts the Houtoushan Cu–Zn VHMS deposit in the Liaoning Province (Hou et al., 1999; Gu L. et al., submitted for publication). The Houtoushan is the only known Archaean VHMS deposit in China.

The *Proterozoic* era was one of the important metallogenic periods for the formation of VHMS, SEDEX and MVT mineralisation in South China, in particular, along the Sanjiang fold belt (1a) and the Kangdian belt (1b). Mafic to meta-volcanic hosted Early Proterozoic Dahongshan and Lalachang Cu–Fe deposits were formed in the rift zone in the form of graben-like depression along the Sanjiang fold belt within the SCC (Haitan, 1992) (Fig. 15). The Middle Proterozoic in South China is characterised by the formation of Cu-rich SEDEX deposits such as the Dongchuan deposit in Yunnan. Although much work remains to be done, Huichu et al. (1991) indicated that the Dongchuan deposit formed in a geologic environment similar to that of many of the world's largest deposits of this type in which reduced marine sedimentary sequence overlies non-marine (red bed) sediments in a continental rift setting.

The Kangdian belt is characterised by presence of MVT and nickel deposits. The Late Proterozoic to Sinian dolomites of Upper Dengying Formation in the belt host MVT deposits (e.g., the Daliangzi deposit in Sichuan) and the MVT mineralisation appears to have formed in the platform carbonate sequence at the margin of the SCC (Cromie et al., 1996; Cromie, 1999). The Middle Proterozoic-aged mafic–ultramafic bodies in the Kangdian belt also host Pt–Pd–Ni–Cu–

Co occurrences in Yunnan and Sichuan Provinces (e.g., the Lengshuiqing and Limahe deposits). These occurrences are similar to the Proterozoic Jinchuan deposit in the NCC, suggesting a potential for discovery of the world class Jinchuan-style deposits in the SCC. The Lengshuiqing and Limahe deposits were probably formed due to mantle plume activity related to the Jinningian Orogeny and further work remains to be done to test this model.

The complex tectonic history and metallogeny of South China during the *Phanerozoic* era was related to opening and closing of Tethyan Ocean involving multiple orogenies by subduction, back-arc rifting, arc-continent collision and post-collisional extension during the Palaeozoic and Early Mesozoic. This was followed by the Late Mesozoic magmatism (Yanshanian Orogeny) and Cenozoic continental collision (Himalayan Orogeny). Although the Early Palaeozoic is not a productive period in South China, Cambrian and Ordovician VHMS deposits are found in neighbouring Myanmar (Bawdwin) and North China (Bayinchang and Xitieshan). During the Silurian–Devonian, the small Cu–Zn VHMS Liwu deposit (0.2 Mt ores at 2.5% Cu and 0.6% Zn) was formed in South China. The deposit is

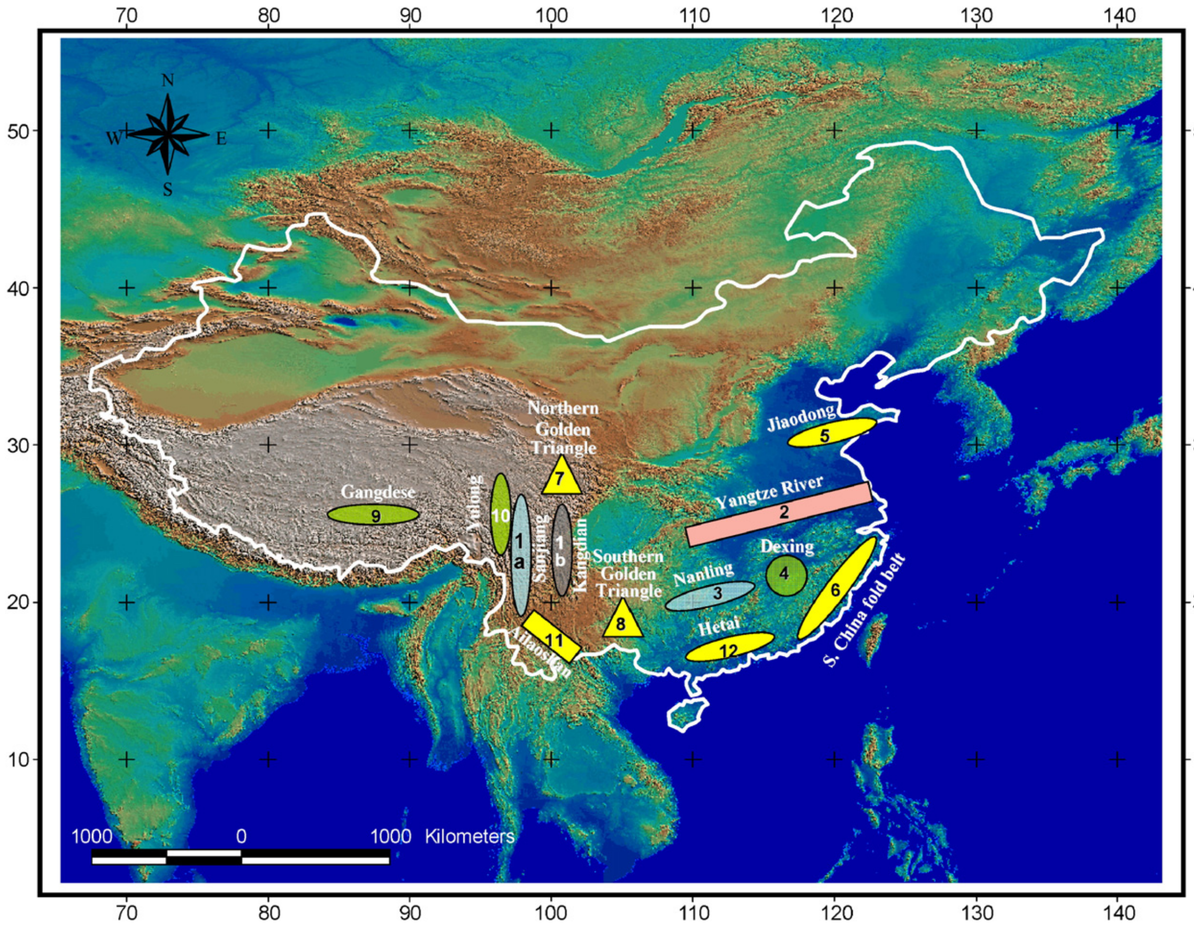

Fig. 14. Map showing metallogenic belts of South China. (**1a**) the Sanjiang fold belt (Pb–Zn–Cu–Au–Ag + W–Sn) covering eastern Tibet, Sichuan and Yunnan Provinces, (**1b**) the Kangdian belt (Pb–Zn–Cu–Ag + Ni) covering Yunnan and Sichuan Provinces, (**2**) the Lower to Middle Yangtze River belt (Cu–Au–Pb–Zn–Ag + Sn–W + Sb) covering from Hunan, Hubei, Anhui to Jiangsu Provinces, (**3**) the Nanling Mountain belt (Pb–Zn–Cu–Ag + Sn) in northern Guangxi and northern Guangdong Provinces, (**4**) the Dexing belt (Cu–Au–Ag + Pb–Zn) in Jiangxi Province, (**5**) the Jiaodong belt (Au + Ag) in Shandong Province, (**6**) the South China fold belt (Au–Ag + Pb–Zn–Cu) covering Fujian and Zhejiang Provinces, (**7**) the Chuan-Shan-Gan (northern Golden Triangle) belt (Au + Ag) in NW Sichuan and SW Qinghai, Gansu and Shaanxi Provinces, (**8**) the Dian-Qian-Gui (southern Golden Triangle) belt (Au + Ag) at the junction of Yunnan, Guizhou, and Guangxi Provinces, (**9**) the Gangdese belt (Cu–Au–Mo) in Tibet, (10) the Yulong belt (Cu–Au–Mo) in Tibet, (**11**) the Ailaoshan belt (Au + Ag) in Yunnan Province, and (**12**) the Hetai belt (Au + Ag) in Guangxi Province and Guangdong Provinces. Note that green colour = Cu-dominant belts, yellow colour = gold-dominant belts and other colour = polymetallic belts.

hosted in basaltic to intermediate volcanic rocks along a back-arc rift basin (Hou et al., 1999).

In comparison, the Late Palaeozoic was a productive metallogenic period for South China; in particular, the Devonian to Carboniferous is a significant period due to the break-up and rifting from Gondwana (e.g., Li et al., 1999; Yin et al., 1999). These rift zones were filled with Late Devonian shallow marine-facies sandstone–siltstone to Carboniferous carbonate sequence in the Lower to Middle Yangtze River belt (2), and similar Devonian to Carboniferous clastic and carbonate sequence occurred in a fault-bounded basin in the Nanling Mountain belt (3). These Late Palaeozoic sedimentary sequence superimposed on the folded Early Palaeozoic sequence or metamorphosed Mesoproterozoic basement (Gu L. et al., 2007-this volume). A number of SEDEX deposits were formed in these basins. The deposits such as Fankou, Dabaoshan and Dachang were formed in the Nanling Mountain belt, whereas the Xinqiao, Wushan, Dongguashan and Chengmenshan deposits with mineralised ages of 313–328 Ma (Gu and Xu, 1986; Xie et al., 1995) were deposited in the Lower to Middle Yangtze River metallogenic belt (Hou et al., 2004; Yang et al., 2004; Gu L. et al., 2007-this volume).

The Late Palaeozoic Palaeo-Tethys zone in the Sanjiang fold belt is characterised by marine volcanic environments and the development of arc and back-arc basins and the formation of VHMS deposits. In the Changning–Menglian back-arc basin, felsic to intermediate volcanic-hosted Carboniferous Laochang and

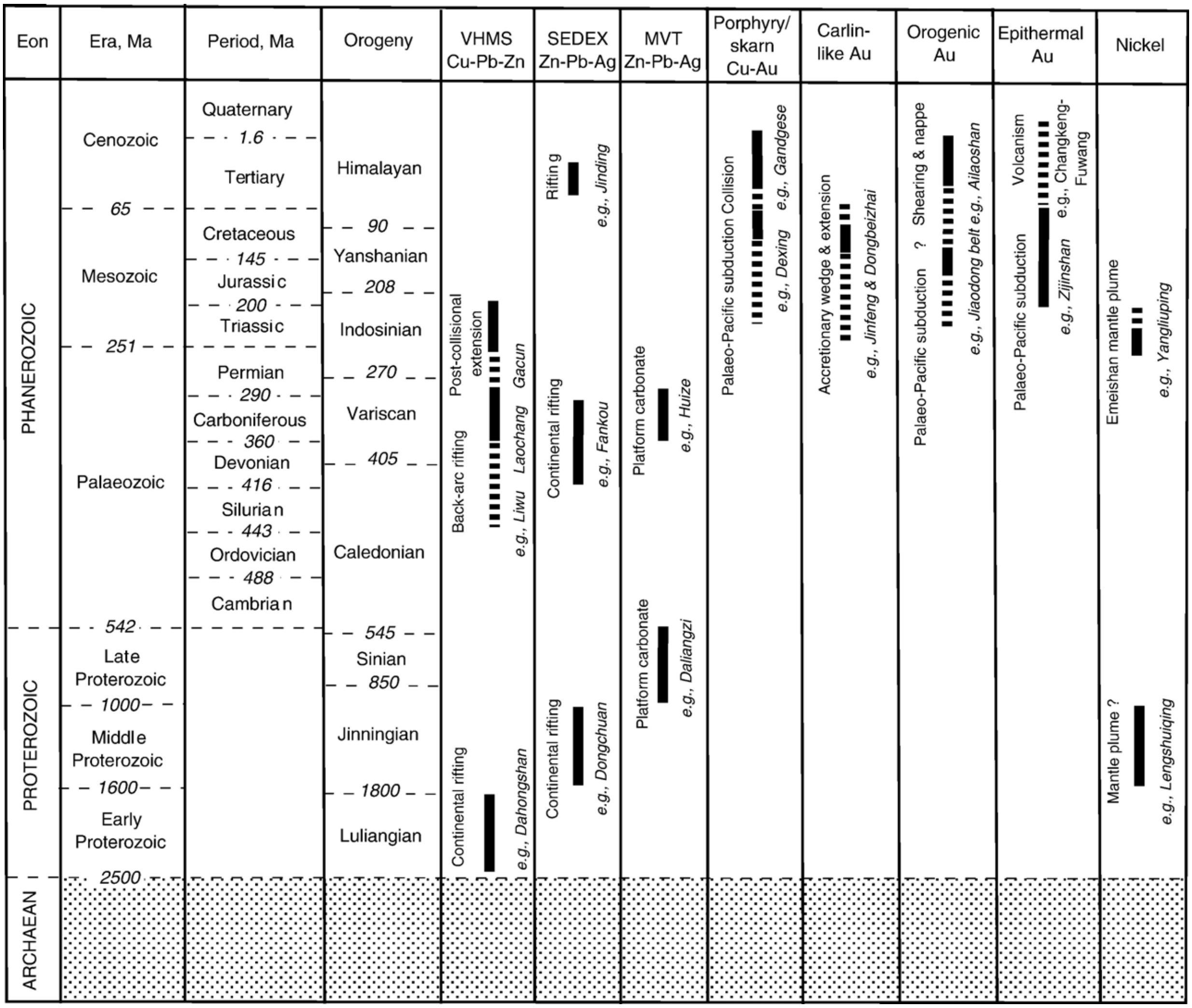

Fig. 15. Schematic diagram showing a simplified temporal evolution of the different deposit types in relation to tectonic and metallogenic events in South China. Multiple orogenic stages during the evolution of the South China Region were modified from Wang and Mo (1995) and Zhou Taihe et al. (2002).

Dapinzhang deposits were formed during continental margin rifting related to Late Palaeozoic arc-trench subduction of the Tethyan oceanic slab along the Sanjiang belt (Hou et al., 2007-this volume). Along the western margin of the SCC, an Early Carboniferous sequence of marine-facies carbonate rocks hosts a number of MVT deposits, such as the Qilinchang Pb–Zn deposit (Zhou et al., 2001) and the Huize Zn–Pb–(Ag) deposits in Yunnan (Han et al., 2007-this volume). During the Permian, the Tongchangjie Cu deposit was formed in the basaltic volcanic rocks with MORB affinity (Yang et al., 1999) due to rifting along the Changning–Menglian back-arc, whereas the Yagra-style Cu deposits were formed in the calc-alkaline andesitic rocks in the intra-oceanic arc-related Jinshajiang tectono-magmatic belt (Hou et al., 2003a).

At the end of the Permian, a mantle plume formed the Emeishan Large Igneous Province (LIP) in southwestern China. This highly productive magmatic event with a peak age of 259 Ma (Lu, 1996) produced a large volume (0.3×10^6 km^3) of flood basalts and associated mafic and ultramafic intrusions, and the Noril'sk-type Pt–Pd–Ni–Cu deposits in South China (e.g., Yangliuping, Jinbaoshan, and Baimazhai deposits) (Song et al., 2003).

The Triassic is a significant tectonic and metallogenic period for South China, during which the SCC under-thrusted northward and collided with the NCC, resulting in the Lower to Middle Yangtze River metallogenic belt (2) and the deformation related to this collision continued into the Jurassic and Cretaceous. Chen Y. et al. (2007-this volume) considered that porphyry-related skarn deposits in the Lower to Middle Yangtze River metallogenic belt were related to this collisional process. A foreland basin was also developed during the Middle Triassic along the belt and basal gypsum-bearing beds were formed in the basin (Hou et al., 2004). These and subsequent Mesozoic evaporite sequences host red bed copper deposits in many of the isolated sedimentary basins of South China (Kirkham et al., 1994; Cox et al., 2003). In the Sanjiang Palaeo-Tethys, the Late Triassic Yidun arc is the latest arc-basin system, in which the Gacun-style VHMS Cu–Pb–Zn–Ag deposits developed in the intra-arc rift basins, with bimodal volcanic suites at the northern segment of the arc, and the Xuejiaping porphyry Cu deposits formed due to intrusion of monzogranite–granite stocks in the southern segment of the arc (Hou et al., 2001; 2007-this volume). By the end of the Triassic, arc–arc collision and arc–continent (block) collision occurred due to Indosinian Orogeny and resulted in the closure of the Sanjiang Palaeo-Tethys Ocean.

The Jurassic and Cretaceous periods were characterised by the tectono-magmatic activity related to the Yanshanian Orogeny. This metallogenic event mainly occurred in eastern China. At least three main metallogenic epochs have been recognised (Hua et al., 2005).

The first metallogenic epoch took place from 180–170 Ma, and is characterised by porphyry and skarn Cu–Au and Pb–Zn mineralisation along the Lower to Middle Yangtze River metallogenic belt in northeastern Jiangxi and southeastern Hunan Provinces. This metallogenic event is related to calc-alkaline intermediate to felsic intrusions which probably formed in a post-orogenic extensional setting with contemporaneous basaltic andesite and A-type granitoid (Chen F.-R. et al., 1999). The Cu deposits associated with the Jurassic calc-alkaline porphyry stocks are found along the Dexing belt (4), including Tongchang, Fujiawu and Zhushahong deposits (Zhai et al., 1997; Mutschler et al., 1999; He et al., 1999).

The second metallogenic epoch is related to large-volume crustal derived granitoids with a peak age of 150–140 Ma and is characterised by W–Sn mineralisation. These granitoids probably emplaced in an anorogenic setting and formed a large felsic igneous province in the Nanling region of South China. Deposits related to these granitoids are represented by the world-class vein and skarn-type W–Sn deposits such as Shizhuyuan and Xihuashan. Corresponding to this metallogenic event, the high-level emplacement of intermediate to felsic magmas is probably related to underplating of basaltic magmas at the bottom of the lower crust (Lu Q.-T. et al., 2004), and was developed along the Lower to Middle Yangtze River metallogenic belt. This magmatic activity resulted in a series of magmatic-hydrothermal systems to have produced porphyry-type (e.g., Yinshan Au-rich polymetallic deposit), porphyry and skarn Cu–Au deposits (e.g., Chengmenshan, Shizishan, Dongguashan, Tonglushan, Jilongshan, Fengshandong and Lijiawan), which partially overprinted the Late Palaeozoic SEDEX-type massive sulphides (Yang et al., 2004; Hou et al., submitted for publication).

The third metallogenic epoch took place at 130–98 Ma (Hua et al., 2005), and widely developed in the entire eastern China. This metallogenic event is mostly considered to relate to potassic felsic magmatism triggered by large-scale subcontinental lithospheric thinning (Deng et al., 1999). In the Lower to Middle Yangtze River metallogenic belt, the third metallogenic event formed porphyry-type Cu–Fe deposit associated with quartz diorite stocks (Chang et al., 1991; Pan and Dong, 1999).

To the east of the Tan-Lu fault system, the largest gold province in China including several tens of granitoid hosted orogenic gold deposits was developed along the Jiaodong belt (5) in Shandong Province. Most of the deposits in the Jiaodong area are structurally controlled along prominent NNE-trending brittle-ductile shear zones and appear to have been emplaced during the two Yanshanian magmatic events (Wang et al., 1998; Zhou Taihe and Lu, 2000; Qiu et al., 2002). The tectonic environments of these deposits are not well understood. Qiu et al. (2002) favoured a temporal link with the subduction of the Pacific Plate, whereas Chen Y. et al. (2005) recently suggest that collision between the NCC and SCC was probably the dominant factor for the gold deposits in the Jiaodong area.

In the southeastern China along the South China fold belt (6), mineralisation is characterised by Au, Cu and Pb–Zn–Ag associations, and is usually associated with potassic calc-alkaline and shoshonitic volcanic rocks (e.g., Lengshuikeng) and granodioritic porphyry intrusions (e.g., Zijinshan). The Zijinshan Cu–Au deposit in Fujian Province show metal zonation from Cu to Au upwards, and has been classified as a typical high-sulphidation epithermal deposit (So et al., 1998). Epithermal to mesothermal vein-type deposits are also present in the South China fold belt (e.g., Zhilingtou in Zhejiang Province), hosted in Proterozoic basement to Mesozoic volcanics and were formed by multiple mineralising events (Pirajno et al., 1996, 1997; Pirajno and Bagas, 2002). The mineralisation is considered to be related to Yanshanian magmatism (Xu et al., 1995) produced above a westward dipping subduction zone.

The Carlin-like Au deposits were developed along the southwestern margin of the SCC (Hu et al., 2002; Li and Peters, 1998; Peters, 2002; Peters et al., 2007-this volume). Two mineralised belts are recognised: (1) the Chuan-Shan-Gan (northern Golden Triangle) belt (7) in NW Sichuan and SW Qinghai, Gansu and Shaanxi, and (2) the Dian-Qian-Gui (southern Golden Triangle) belt (8) (Fig. 14) at the junction of Yunnan, Guizhou, and Guangxi Provinces. These Carlin-like deposits are hosted within Devonian–Triassic carbonaceous mudstone and siliciclastic units, and generally are associated with zones of high deformation. The Southern Golden Triangle deposits are spatially located around the Youjiang rift in the Nampanjiang fold zone at the western margin of the SCC (e.g., Cromie, 2001; Li and Peters, 1998; Peters, 2002; Peters et al., 2007-this volume), whereas the Northern Golden Triangle deposits occur in the Songpan–Ganze accretionary wedge at the northwestern part of the SCC (Li and Peters, 1998; Zhou Taihe et al., 2002; Peters, 2002; Peters et al., 2007-this volume). Available age data indicate that peak mineralised ages for the Carlin-like deposits cluster in the Cretaceous period (Hu et al., 2002), whereas Zhou Taihe et al. (2002) favoured a Jurassic age for most of the Carlin-like deposits. Most workers believe that the tectonic regime changed from compression to extension during the gold mineralisation. Zhou Taihe et al. (2002) considered that both South and North Golden Triangles have undergone regional uplift during gold mineralisation. The present authors also consider that the Carlin-like gold mineralisation is most likely to be related to the Yanshanian tectonothermal activities.

The Cenozoic metallogeny of South China is closely related to the Himalayan Orogeny. Large-scale strike-slip fault system and nappe-thrust system were formed by the Indo-Asian collision since the Paleocene in the Sanjiang Tethys. This collision also affected the other parts of the SCC. Many giant deposits were formed during this epoch, including the Gandgese porphyry Cu (Qu et al., 2007-this volume), the Yulong porphyry Cu (Hou et al., 2003b), the Beiya porphyry Cu–Au (Xu et al., 2007-this volume) and the Ailaoshan Au deposits (Hou et al., 2007-this volume). Liang et al. (2007-this volume) also demonstrated that the giant epithermal Changkeng-gold and Fuwang-silver deposits in Guangdong Province were formed as the result of the Himalayan (Tertiary) volcanic activity.

Collision of the Indian–Asian continents was initiated during the Palaeocene, and caused intense shortening and thickening of the crust in the interior of the Tibetan Plateau, as well as the formation of the extensive granitoid belt at about 55 Ma (Allegre et al., 1984). This continent–continent collision also caused right-lateral shearing along the eastern margin of the converging continents, resulting in the formation of large-scale strike-slip faulting and thrust systems in East Tibet, which in turn, controlled the formation and distribution of the porphyry copper deposits along the Yulong belt (9) at the western part of the Sanjiang fold belt but oblique to the E–W Indian–Asian collision zone (Hou et al., 2003b; Hou et al., 2007-this volume) (Figs. 2 and 14). The Yulong porphyry copper deposits are associated with potassic porphyry stocks with Re–Os ages of 40–36 Ma (Unpub. data, Hou Z., 2005).

Qu et al. (2007-this volume) indicated that the Gandgese belt (10) in Tibet (Fig. 14) was genetically related to emplacement of late orogenic granitic porphyry stocks during post-collisional crustal relaxation of the Late Himalayan Orogeny. Twelve molybdenite samples from the copper belt yielded isochron ages of 14.76±0.22 Ma and 13.99±0.16 Ma and $^{40}Ar/^{39}Ar$ isotopic dating of two biotite phenocrysts gave plateau ages of 13.5±1.0 Ma and 13.42±0.10 Ma (Qu et al., 2007-this volume). Intrusion of the ore-bearing porphyries resulted from the India–Asia collision and they lie along the E–W extension of the Tibetan Plateau. A series of nappe-detachment zones and subsequent strike-slip pull-apart basins that were also developed due to the Himalayan Orogeny and led to the formation of a number of SEDEX-like Pb–Zn deposits (e.g., Jinding) in the Sanjiang belt in western Yunnan (Xue et al., 2007-this volume; Hou et al., 2007-this volume).

The Ailaoshan belt (11) (Fig. 14) is a significant orogenic gold belt and the 38–23 Ma gold deposits are hosted in the ophiolitic mélange zone. The location of the deposits was controlled by strong shearing and nappe development during the Himalayan Orogeny (Hu et al., 1995; Huang et al., 1997; Hou et al., 2007-this volume).

The Hetai belt (12) (Fig. 14) in Guangxi District and Guangdong Province is a metallogenic belt in South China receiving renewed exploration activity. It consists of a number of major orogenic gold deposits. The gold deposits are confined to a series of ductile shear zones in the Sinian-aged Yunkai metamorphic rocks (mica schist, feldspar–mica schist, and mica gneiss) (Zhang G. et al., 2001). The age of mineralisation is not well understood but is most likely related to repeated structural deformation and shearing during the Yanshanian and Himalayan Orogeny.

6. Conclusions

The South China Region had been affected by multiple orogenic, magmatic and metallogenic processes. These tectonic and metallogenic processes were responsible for the formation of the diverse styles of base and precious metal deposits in South China making it one of the resource-rich regions in the world. Many different deposit types and mineralisation styles of South China appear to occur in cluster or belts, and twelve mineralised belts have been recognised. At least five different styles of lead–zinc–silver mineralisation occur such as VHMS, SEDEX, MVT, skarn and porphyry related skarn and veins. All of the VHMS deposits of South China are located in the Sanjiang fold belt at the western part of the South China Region. Significant Devonian to Carboniferous and Cenozoic stratabound base metal mineralisation occurs in South China (e.g., Fankou, Dabaoshan and Jinding deposits). The Late Palaeozoic stratabound deposits have features in common with the SEDEX class. The SEDEX type deposits are the most important style for lead–zinc mineralisation in South China followed by MVT, VHMS and skarn deposits.

The South China region has the largest porphyry copper deposit in China (i.e., the Dexing deposits in Jiangxi). The other emerging porphyry Cu–Mo–Au belts in South China include the Yulong and Gangdese districts in Tibet and Beiya district in Yunnan. Au–(Ag–Mo)–rich porphyry-related Cu–Fe skarn deposits are present in South China along the Lower to Middle Yangtze River metallogenic belt. This metallogenic belt extends from Jiangxi, through Hubei to Anhui and Jiangsu Provinces. Some of these skarn deposits may have complex origins (e.g., Chengmenshan, Wushan, Qixiashan and Xinqiao). They were initially formed as SEDEX deposits during the Devonian and Carboniferous and later overprinted by skarn assemblages related to Yanshanian magmatism.

Primary gold–silver-only deposits occur as (1) Carlin-like deposits; (2) orogenic-type deposits and (3) epithermal vein and breccia deposits. The Carlin-like deposits occur in the Southern Golden Triangle and the Northern Golden Triangle of China and are hosted predominantly by Palaeozoic to Mesozoic-aged siliciclastic and carbonate lithologies. The Southern Golden Triangle deposits occur within the Youjiang margin sag-basin along the southwest margin of the SCC, whereas the Northern Golden Triangle deposits are present within the Songpan-Garze accretionary wedge terrain, along the northwestern margins of the SCC. They are similar to Carlin-type deposits in USA and are mostly epigenetic hydrothermal micron-disseminated gold deposits with associated As, Hg, Sb+Tl mineralisation.

Unique world class granitoid-hosted orogenic gold deposits occur along the boundary of the NCC and SCC in Shandong Province but their tectonic environment remains unclear. These deposits are the major producers of gold in China. Orogenic gold deposits are also found in Guangxi and Guangdong (e.g., Hetai goldfield). Several orogenic gold deposits lie along the NW-trending Ailaoshan mega-shear belt in SW China. They are mostly hosted in ophiolitic mafic–ultramafic rocks and basaltic tuffaceous rocks, as well as minor sandstone and crystalline limestone. These deposits were most likely formed due to strong shearing and nappe development during the Himalayan Orogeny.

The South China fold belt, covering Fujian and Zhejiang Provinces along the south-eastern margin of the Yangtze terrane, is characterised by well-developed Yanshanian intrusive to subvolcanic rocks associated with porphyry to epithermal type copper–gold mineralisation and mesothermal vein deposits. The most important example is the Zijinshan district in Fujian Province. It is currently the only high-sulphidation epithermal system in mainland South China. Epithermal to mesothermal vein-type deposits are also found in Zhejiang Province (e.g., Zhilingtou).

South China has the potential for nickel sulphide deposits associated with continental flood basalts. Extensive exposures of Permian Emieshan continental flood basalt (ECFB) and Proterozoic mafic–ultramafic bodies occur in SW China especially in Yunnan, Guizhou and Sichuan Provinces. Other Palaeozoic ultramafic/mafic intrusions also occur near the ECFB margins. Pt–Pd–Ni–Cu–Co occurrences are recorded in Yunnan and Sichuan Provinces in association with these mafic and ultramafic rocks.

Major skarn–vein–greisen type tungsten–tin–bismuth–beryllium–sulphide deposits associated with Yanshanian magmatism occur in South China (e.g., the Shizhuyuan and Xihuashan deposits). The South China region has important world class stratabound base metal–tin deposits (the Dachang deposit in Guangxi District). Large antimony deposits are also found in South China.

Many iron deposits are abundant in South China. They are commonly enriched in copper and gold. In particular, metamorphosed Proterozoic sedimentary rocks adjacent to the Red River Fault in South Yunnan contain iron–oxide–copper occurrences, and they are similar to those found along the same zone at Sin Quyen in Vietnam (Mclean, 2001). The potential and propectivity of the iron oxide copper–gold (IOCG or FeOx–Cu–Au) mineralisation in South China remains to be investgated. Similarly Mesozoic and Cenozoic sandstone-hosted stratabound copper deposits are distributed in South China (e.g., Chen, 1988; Kirkham et al., 1994; Cox et al., 2003) but their nature, origin and potential are poorly explored.

It is difficult to adequately classify all of the South China mineral deposits using the currently available ore deposit models because some deposits show hybrid natures between various typical deposit types, and the many deposits were formed by multiple episodic mineralisation and overprinting processes. The depth of ore formation and age of mineralisation are also not well-constrained for many of the South China precious metal deposits. Further extensive research is required not only to understand the genesis of the individual ore deposits or districts, but also to constrain the age of magmatic–volcanic events and mineralisation to establish the context of the time–space relations for mineralisation in the entire region.

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References

Ali, J., Lo, C., Thompson, G., Song, X., 2004. Emeishan Basalt Ar–Ar overprint ages define thermal events that affected the western Yangtze platform in the Mesozoic and Cenozoic. Journal of Asian Earth Sciences 23, 163–178.

Ali, J., Thompson, G., Zhou, M., Song, X., 2005. Emeishan large igneous province, SW China. Lithos 79, 475–489.

Allegre, C.J., et al., 1984. Structure and evolution of the Himalayan–Tibet orogenic belt. Nature 307, 17–22.

Arndt, N.T., Czamanske, G.K., Walker, C., Chauvel, C., Fedorenko, V. A., 2003. Geochemistry and origin of the intrusive hosts of the Noril'sk–Talnakh Cu–Ni–PGE sulphide deposits. Economic Geology 98, 495–516.

Ashley, R.P., Cunningham, C.G., Bostick, N.H., Dean, W.E., Chou, I.-M., 1991. Geology and geochemistry of three sedimentary rock-hosted disseminated gold deposits in Guizhou Province, People's Republic of China. Ore Geology Review 6, 133–151.

Barnes, S.J., Tang, Z.L., 1999. Chrome spinels from the Jichuan Ni–Cu sulphide deposit, Gansu Province, People Republic of China. Economic Geology 94, 343–356.

Barton, M.D., Johnson, D.A., 1996. Evaporitic-source model for igneous-hosted Fe–oxide–(REE–Cu–Au–U) mineralisation. Geology 24, 259–262.

Beaudoin, G., Hebert, R., Wang, C.S., Tang, J., 2005. Epithermal Au–Ag–Cu, porphyry Cu–(Au–Mo) and Cu–Au–Ag–Zn–Pb skarn deposits of the Gangdese arc, Tibet. In: Mao, J., Bierlein, F. (Eds.), Mineral Deposit Research: Meeting the Global Challenge. Proceedings of the 8th Biennial SGA Meeting, 18–21 August 2005, Beijing, China, vol. 2, pp. 1219–1222.

Brown, C.J., 1930. The geology and lead ore deposits of Mawson, Federated Shan State. Records Geological Survey of India 65 (3), 349–433.

Burrett, C., 1974. Plate tectonics and the fusion of Asia. Earth and Planetary Science Letters 21, 181–189.

Burrett, C.F., Stait, B., 1986. China and SE Asia as part of the Tethyan margin of Cambro-Ordovician Gondwanaland. In: McKenzie, K. (Ed.), Shallow Tethys, vol. 2. Balkema, Rotterdam, pp. 65–77.

Burrett, C., Long, J., Stait, B., 1990. Early to Middle Palaeozoic biogeography of Asian terranes derived from Gondwana. Geological Society London, Memoir 12, 163–174.

Chang, Y.F., Liu, X.P., Wu, Y.C., 1991. The Copper and Iron Deposits in the Lower Yangtze River District. Geological Publishing House, Beijing. 379 pp. (in Chinese with English abstract).

Chen, W., 1988. Mesozoic and Cenozoic sandstone-hosted copper deposits in South China. Mineralium Deposita 23, 262–267.

Chen, P., 1996a. The iron–copper–gold metallogenic regularities of the lower-middle reaches of the Yangtze River. In: Wang, Y., Qin, Y., Chen, P. (Eds.), Geology of iron, copper, gold, and silver mineral resources in the middle and lower reaches of the Yangtze River. Press House of Metallurgical industry, Beijing, pp. 19–34 (in Chinese).

Chen, P., 1996b. Geological characteristics of gold deposits in middle and lower reaches of the Yangtze river. In: Wang, Y., Qin, Y., Chen, P. (Eds.), Geology of Iron, Copper, Gold, and Silver Mineral Resources in the Middle and Lower Reaches of the Yangtze River. Press House of Metallurgical industry, Beijing, pp. 97–101 (in Chinese).

Chen, W., 1997. Metallogenic model of Donchuan-type sedimentary copper deposits in China. Proc. 30th International Geol. Congress, China, vol. 9, pp. 101–110.

Chen, Y. (Chief Editor), 1999. Minerogenetic series map of mineral deposits of China, 1:500,000 scale, three sheets — Precambrian, Palaeozoic, Mesozoic-Cenozoic- with Explanatory notes, Chinese Academy of Geological Sciences, Geological Publishing House, 127 pp.

Chen, J., Hall, C., Stanley, C.J., 1992. Tin-bearing skarns of South China: geological setting and mineralogy. Ore Geology Reviews 7, 225–248.

Chen, F.-R., Kong, X.-G., Wang, Y.-X., 1999. Early Yanshanian post-orogenic granitoids in the Nanling Region. China Universities Geological Journal 5, 378–383 (in Chinese with English abstract).

Chen, Y.J., Pirajno, F., Qi, J.P., 2005. Origin of gold metallogeny and source of ore-forming fluids, Jiaodong Province, Eastern China. International Geology Reviews 47, 530–549.

Chen, Y.J., Chen, H.Y, Khin Zaw, Pirajno, F., Zhang, Z.J., 2007. Geodynamic setting and tectonic model of skarn gold deposits in China—an overview. Ore Geology Reviews 31, 139–169 (this volume). doi:10.1016/j.oregeorev.2005.01.001.

Coveney Jr., R.M., 2000. Metalliferous shales and the role of organic matter with examples from China, Poland, and the United States. In: Giordano, T.E., Kettler, R.M., Wood, A. (Eds.), Ore Genesis and Exploration, the Roles of Organic Matter. Reviews in Economic Geology, vol. 9, pp. 251–280.

Coveney Jr., R.M., Murowchick, J.B., Grauch, R.I., Chen, N., Gascock, M.D., 1992. Field relations, origins, and resource implications for platiniferous molybdenum–nickel ores in black shales of South China. Journal of Exploration Mining Geology 1, 21–28.

Cox, D.P., Lindsey, D.A., Singer, D.A., Diggles, M.F., 2003. Sediment-hosted copper deposits of the world — deposit models and database: U. S. Geological Survey Open-File Report 03-107. http://geopubs.wr.usgs.gov/open-file/of03-107/.

Cromie, P.W., 1999. Geochemical exploration for carbonate-hosted Pb–Zn resources in Sichuan Province, PRC. In: Gemmell, B. (Ed.), Geochemical Case Studies, March, 1999. . Master of Economic Geology Short course, CODES SRC. University of Tasmania, pp. 34–42.

Cromie, P.W., 2001. Geological setting, mineralogy and geochemistry of the Fu Ning Carlin-type gold deposits, Yunnan Province, China. Unpublished Master of Economic Geology Thesis, University of Tasmania, Hobart, Australia, 146 pp.

Cromie, P.W., Khin Zaw, 2001. Geological setting, nature of ore fluids and sulphur isotope geochemistry of the Fu Ning Carlin-type gold deposits, Yunnan Province, China. In: Noronha, F., Dora, A., Guedes, A., (Eds.,), ECROFI (European Current Research on Fluid Inclusions), Porto, Portugal, Faculdade Ciencias do Porto, Departamento de Geologia, Memoria No. 7, p. 448–469.

Cromie, P.W., Khin Zaw, 2003. Geological setting, nature of ore fluids and sulphur isotope geochemistry of the Fu Ning Carlin-type gold deposits, Yunnan Province, China. Geofluids 3, 133–144.

Cromie, P.W., Gosse, R.R., Zhang, P., Zhu, X., 1996. Exploration for carbonate hosted Pb–Zn deposits, Sichuan. P.R.C. 30th International Geological Congress, Beijing, China, 4–14 August, 1996, Abstract volume, p. 412.

Cromie, P.W., Khin Zaw, Manini, A.J., 2004a. The Sepon mineral district, Lao PDR: an overview of the currently known geological setting and mineralisation. In: McPhie, J., McGoldrick, P. (Eds.), Dynamic Earth: Past, Present and Future, 17th Australian Geological Convention, 8–13 February, 2004. Geological Society of Australia Abstract, vol. 73, p. 64.

Cromie, P.W., Khin Zaw, Manini, A.J., 2004b. Geological setting and mineralisation characteristics of the gold and copper deposits in the Sepon Mineral District, Lao PDR. SEG Conference 2004, Predictive Mineral Discovery Under Cover, Centre for Global Metallogeny, The University of Western Australia, Publication, vol. 33, p. 411.

Cun, G., 1995. Typical Gold Deposits in China. Geological Press, Beijing. 466 pp. (in Chinese).

Cunningham, C.G., Ashley, R.P., Chou, I.-M., Huang, Z., Wan, C., Li, W.K., 1988. Newly discovered sedimentary rock-hosted disseminated gold deposits in People's Republic of China. Economic Geology 83, 1462–1467.

Davidson, G.J., Large, R.R., 1998. Proterozoic copper–gold deposits. AGSO Journal of Australian Geology and Geophysics 17, 105–113.

Deng, S., Shen, Q., Sun, P., Tu, L., 1986. Metamorphic map of China with explanatory text: Geological Publishing House, Beijing, 162 pp, 1 sheet [1 : 4,000,000].

Deng, J.-F., Mo, X.-X., Zhao, H.L., 1999. The Yanshanian lithosphere–asthenosphere catastrophe and metallogenic environment in east China. Mineral Deposits 18, 309–315 (in Chinese with English abstract).

Dedenczuk, D., 1998. Epithermal gold mineralisation at Khao Sai. Unpub. BSc (Hons) thesis, Centre for Ore Deposit Research, University of Tasmania, Hobart, Tasmania, Australia.

Diehl, P., Kern, H., 1981. Geology, mineralogy, and geochemistry of some carbonate-hosted lead–zinc deposits in Kanchanaburi Province, western Thailand. Economic Geology 76, 2128–2146.

Diemar, M.G., Diemar, V.A., 1999. Geology of the Chatree epithermal gold deposit, Thailand. Proceedings of Pacrim'99, Bali, 10–13 October, 1999, Australian Institute of Mining and Metallurgy, pp. 227–231.

Dong, S.B., 1993. Metamorphic and tectonic domains of China. Journal of Metamorphic Geology 11, 465481.

Dorling, S.L., Groves, D.I., Muhling, P., 1998. Lennard shelf Mississippi Valley-type (MVT) Pb–Zn deposits, Western Australia. AGSO Journal of Australian Geology and Geophysics 17, 115–120.

Enkin, R.J., Yang, Z., Chen, Y., Courtillot, V., 1992. Paleomagnetic constraints on the geodynamic history of the major blocks of China from Permian to the present. Journal of Geophysical Research 97, 13953–13989.

Fan, P., 1984. Geologic setting of selected copper deposits of China. Economic Geology 79, 785–795.

Fan, H.R., Zhai, M.G., Xie, Y.H., 2003. Ore-forming fluids associated with granite-hosted gold mineralisation at Sanshandao deposit, Jiaodong gold province, China. Mineralium Deposita 38, 739–750.

Fan, D., Zhang, T., Ye, J., 2004a. The Xikuangshan Sb deposit hosted by the Upper Devonian black shale series, Hunan, China. Ore Geology Reviews 24, 121–133.

Fan, D., Zhang, T., Ye, J., Pasava, J., Kribek, B., Dobes, P., Varrin, I., Zak, K., 2004b. Geochemistry and origin of tin-polymetallic sulphide deposits hosted by the Devonian black shale series near Dachang, Guangxi, China. Ore Geology Reviews 24, 103–120.

Fang, N., Feng, Q., Liu, B., 1996. Devonian to Triassic Tethys in Western Yunnan, China. China University of Geosciences Press, Wuhan. 135 pp.

Faure, M., Lin, W., Breton, N.L., 2001. Where is the North China–South China block boundary in eastern China? Geology 29, 119–122.

Fu, M., Changkakoti, A., Krouse, H.R., Gray, J., Kwak, T.A.P., 1991. An oxygen, hydrogen, sulphur, and carbon isotope study of carbonate-replacement (skarn) tin deposits of the Dachang tin field, China. Economic Geology 86, 1683–1703.

Fu, M., Kwak, T.A.P., Mernagh, T.P., 1993. Fluid inclusion studies of zoning in the Dachang tin-polymetallic ore field, People's Republic of China. Economic Geology 88, 283–300.

Ge, C., Sun, H., Zhou, T.-F., 1990. Copper deposits of China. In: Liu, N. (Ed.), Mineral Deposits of China, vol. 1. Geological Publishing House, pp. 1–106.

Giuliani, G., Li, Y.D., Sheng, T.F., 1988. Fluid inclusion study of Xihuashan tungsten deposit in the southern Jianxi province, China. Mineralium Deposita 23, 24–33.

Goldfarb, R.J., Hart, C.J.R., Mao, J., Hofstra, A.H., 2004. Gold in China—the present understanding of emerging world-class resources. In: McPhie, J., McGoldrick, P. (Eds.), Dynamic Earth: Past, Present and Future, 17th Australian Geological Convention, 8–13 February, 2004. Geological Society of Australia Abstract, vol. 73, p. 82.

Gu, X., 1996. Turbidite-hosted micro-disseminated gold deposits. Chengdu University of Sciences and Technology Press. 239 pp.

Gu, L.-X., Xu, K.-Q., 1986. Middle Carboniferous massive sulphide deposits in the Lower Yangtze River. Sinica Geologica Acta 2, 176–188 (in Chinese with English abstract).

Gu, L., Hu, W., He, J., Xu, Y., 1992. Geology and genesis of Upper Palaeozoic massive sulphide deposits in South China. Transactions of the Institution of Mining and Metallurgy London (Section B) B83–B96.

Gu, L., Hu, W., He, J., Ni, P., Xu, K., 2000. Regional variations in ore composition and fluid features of massive sulphide deposits in South China: implications for genetic modelling. Episodes 23, 110–118.

Gu, L., Khin Zaw, Hu, W., Zhang, K., Ni, P., He, J., Xu, Y., Lu, J., Lin, C., 2007. Distinctive features of Late Palaeozoic massive sulphide deposits in South China.. Ore Geology Reviews 31, 107–138 (this volume). doi:10.1016/j.oregeorev.2005.01.002.

Gu, X., Schulz, O., Vavtar, F., Liu, J.M., Zheng, M.H., Fu, S.H., 2007. Rare earth element geochemistry of the Woxi W–Sb–Au deposit, South China. Ore Geology Reviews 31, 319–336 (this volume). doi:10.1016/j.oregeorev.2005.01.003.

Gu, L., Zheng, Y., Tang, X., Khin Zaw, Della-Pasque, F., Wu, C., Tian, Z., Lu, J., Ni, P., Xiao, X., submitted for publication. Copper, Gold and Silver Enrichment in Ore Mylonites within Massive Sulphide Orebodies at Hongtoushan, NE China. Ore Geology Reviews.

Guo, W.K. (Editor) 1987. Guide to the Metallogenic Maps of China (1:4,000,000). Cartographic Publishing House, Beijing.

Guo, W.W., Dentith, M.C., 1997. Geophysical signature of the Jinchuan Ni–Cu–PGE deposit, Gansu Province, China. Exploration and Mining Geology 6, 223–231.

Hacker, B.R., Ratschbacher, L., Webb, L., Dong, S., 1995. What brought them up? Exhumation of the Dabie Shan ultrahigh-pressure rocks. Geology 23, 743–746.

Haitan, S., 1992. A general review of volcanogenic massive sulphide deposits in China. Ore Geology Reviews 7, 43–71.

Han, R.-S., Liu, C.-Q., Huang, Z.-L., Chen, J., Ma, D.-Y., Lei, L., Ma, G.-S., 2007. Geological features and origin of the Huize carbonate-hosted Zn–Pb–(Ag) District, Yunnan, China. Ore Geology Reviews 31, 360–383 (this volume). doi:10.1016/j.oregeorev.2006.03.003.

He, Z., Yuan, H., Xu, J., 1989. Fluid inclusion geochemistry in minerals obtained from Zhao–Ye gold metallogenetic belt, Shandong Province. Journal of Geochemical Exploration 33, 121–133.

He, W., Zhengyu, B., Tieping, L., 1999. One-dimensional reactive transport models of alteration in the Tongchang porphyry copper depositm, Dexing district, Jiangxi Province, China. Economic Geology 94, 307–323.

Hiztman, M.W., 2001. Iron oxide–Cu–Au deposits: what, where, when and why. In: Porter, T.M. (Ed.), Hydrothermal Iron Oxide Copper-Gold and Related Deposits: A Global Perspective, vol. 1. PGC Publishing, Adelaide, pp. 9–25.

Hiztman, M.W., Oreskes, N., Einaudi, M.T., 1992. Geological characteristics and tectonic setting of Proterozoic iron oxide (Cu–U–Au–REE) deposits. Precambrian Research 58, 241–287.

Hong, H., Wang, Q., Chang, J., Liu, S., Hu, R., 1999. Occurrence and distribution of invisible gold in the Shewushan supergene gold deposit, southeastern Hubei, China. Canadian Mineralogist 37, 1525–1531.

Hou, Z., Mo, X., 1993. Geology, geochemistry and genetic aspects of kuroko-type volcanogenic massive sulphide deposits in Sanjiang region, southwestern China. Journal of Exploration and Mining Geology 2, 17–29.

Hou, Z., Deng, J., Sun, H., Song, A., 1999. Volcanogenic massive sulphide deposits in China: setting, features and styles. Journal of Exploration and Mining Geology 8, 149–175.

Hou, Z., Khin Zaw, Qu, X., Ye, Q., Yu, J., Xu, M., Fu, D., Yin, X., 2000. Origin of the Gacun volcanic-hosted massive sulphide deposit in Sichuan, China: fluid inclusion and stable isotope evidence. International conference on Volcanic Environments and Massive Sulphide Deposits, 16–19 November, 2000, Hobart, Tasmania, Australia, pp. 87–88.

Hou, Z., Khin Zaw, Qu, X., Ye, Q., Yu, J., Xu, M., Fu, D., Yin, X., 2001. Origin of the Gacun volcanic-hosted massive sulphide deposit in Sichuan, China: fluid inclusion and stable isotope evidence. Economic Geology 96, 1491–1512.

Hou, Z., Khin Zaw, Wang, L., Mo, X., Wang, M., Li, D., 2003a. Post-collisional crustal extension setting and VHMS mineralisation in the Jinshajiang orogenic belt, southwestern China. Ore Geology Reviews 22, 177–199.

Hou, Z., Khin Zaw, Ma, H., Zhang, Y., Wang, M., Wang, Z., Pan, G., Tang, R., 2003b. The Himalayan Yulong porphry copper belt: product of large-scale strike-slip faulting in eastern Tibet. Economic Geology 98, 125–145.

Hou, Z., Yang, Z., Li, Y., Pusheng, Z., Yifeng, M., 2004. Large-scale migration of fluid toward foreland basins during collisional orogeny: evidence from Triassic anhydrite rock sequences and regional alteration in the Middle-Lower Yangtze Area. Acta Geologica Sinica 78, 203–220 (in Chinese with English abstract).

Hou, Z., Khin Zaw, Pan, G., Xu, Q., Hu, Y., Li, X., 2007. Sanjiang Tethyan metallogenesis in S.W. China: Tectonic setting, metallogenic epochs and deposit types. Ore Geology Reviews 31, 48–87 (this volume). doi:10.1016/j.oregeorev.2004.12.

Hou, Z., Khin Zaw, Yang, Z., Zeng, P., Xie, Y., Meng, Y., Tian, S., Xu, W., submitted for publication. Genesis of the Dongguashan deposit, Shizishan district in East China: Carboniferous SEDEX-type Massive Sulphides Overprinted by Late Jurassic Skarn Cu Mineralisation Ore Geology Reviews.

Hsu, K.J., Li, J., Chen, H., Wang, W., Sun, S., Sengor, A.M.C., 1990. Tectonics of South China: key to understanding west Pacific geology. Tectonophysics 183, 9–40.

Hu, Y.-Z., Tang, S.-C., Wang, H.-P., Yang, Y.-Q., Deng, J., 1995. Geology of the Ailaoshan gold deposits. Geological Publishing House, Beijing. 278 pp. (in Chinese with English abstract).

Hu, R., Su, W., Bi, X., Tu, G., Hofstra, A.H., 2002. Geology and geochemistry of Carlin-type gold deposits in China. Mineralium Deposita 37, 378–392.

Hua, R.-M., Chen, P.-R., Zhang, W.-L., Lu, J.-J., 2005. Three major metallogenic events in Mesozoic in South China. Mineral Deposits 24, 107–120 (in Chinese with English abstract).

Huang, Z.-L., Wang, L.-K., Zhu, C.-M., 1997. Petrological study of lamprophyres in the Laowangzhai gold mine. Yunnan Geological Sciences 32, 74–87 (in Chinese with English abstract).

Huichu, R., Hua, R., Cox, D.P., 1991. Copper deposition by fluid mixing in deformed strata adjacent to a salt diapir, Dongchuan area, Yunnan Province, China. Economic Geology 86, 1539–1545.

Ji, X., Coney, P.J., 1985. Accreted Terranes of China. In: Howell, D.G. (Ed.), Tectonostratigraphic Terranes of the Circum-Pacific Region. Circum-Pacific Council for Energy and Mineral Resources, Earth Science Series, vol. 1, pp. 349–361.

Jinshan Gold Mines, 2005 (http://www.sinogold.com.au/).

Jones, G., 2003. Geology of the Jinfeng gold deposit: a Chinese 'Carlin' analogy. Asian Update on Mineral Exploration and Development, Australian Institute of Geoscientists. AIG Bulletin 39, 39–47.

Khin Zaw, 1978. Fluid inclusion studies on the Hermyingyi tungsten–tin deposit, southern Burma. Proceedings of the 3rd Regional Conference on Geology and Mineral Resources of SE Asia, Bangkok, pp. 393–397.

Khin Zaw, 1990a. Mineralogy, ore metal distribution and zonation at Bawdwin Mine, northern Shan State, Myanmar: an Ag-rich volcanic-hosted, polymetallic massive sulphide deposit. 10th Australian Geological Convention, Hobart, Australia. Geol. Soc. Aust. Abstr., vol. 25, p. 289.

Khin Zaw, 1990b. Geological, petrological and geochemical characteristics of granitoid rocks in Myanmar: with special reference to W–Sn mineralisation and their tectonic setting. SE Asian Journal of Earth Sciences 4, 293–335.

Khin Zaw, 1992. An overview of mineral deposits in Myanmar with special reference to precious and base metal potential: Asia Update—Geology, Metallogenesis, Exploration and Recent Development in Asia. A Symposium held by Sydney Mineral Exploration Discussion Group, April 1992, Sydney, Australia, pp. 2–3.

Khin Zaw, 2002. Sediment-hosted gold mineralisation at Kyaukpahto, Kawlin–Wuntho district, northern Myanmar. 16th Australian Geological Convention, Adelaide, Australia. Geol. Soc. Aust. Abstr., vol. 67, p. 349.

Khin Zaw, 2003. Geology and sulphur isotope implications of Bawdwin deposit, Northern Shan State, Myanmar: an Ag-rich, volcanic-hosted, polymetallic massive sulphide deposit. SGA Conference, Athens, Greece, pp. 217–220.

Khin Zaw, 2004. Geological setting and formation of Bawdwin deposit, Northern Shan State, Myanmar: A silver-rich, volcanic-hosted polymetallic massive sulphide deposit. 17th Australian Geological Convention, February, Hobart, Australia, p. 94.

Khin Zaw, Khin Myo Thet, 1983. A note on fluid inclusion study of W–Sn mineralisation at Mawchi Mine, Kayah State, Myanmar. Economic Geology 78, 530–534.

Khin Zaw, Burrett, C.F., 1997. Cambrian volcanic-hosted massive sulphide mineralisations in Australia and Southeast Asia: Are they related to rifting of northern Gondwanaland? The International Conference on Stratigraphy and Tectonic Evolution of Southeast Asia and the South Pacific, Bangkok, Thailand, August 19–24, 1997, pp. 690–692 (extended abstract).

Khin Zaw, Large, R.R., Huston, D.L., 1997. Petrological and geochemical significance of a Devonian replacement zone in the Cambrian Rosebery VHMS deposit, western Tasmania. Canadian Mineralogist 35, 1–25.

Khin Zaw, Huston, D.L., Large, R.R., 1999a. A chemical model for remobilisation of ore constituents during Devonian replacement process within Cambrian VHMS Rosebery deposit, western Tasmania. Economic Geology 94, 529–546.

Khin Zaw, Burrett, C.F., Berry, R.F., Bruce, E., 1999b. Geological and metallogenic relations of mineral deposits in SE Asia: Australian

Mineral Industry Research Association (AMIRA) Final Report and CD-ROM, February 1999 (Unpublished), University of Tasmania, 225 pp.

Khin Zaw, Bruce, E., Burrett, C.F., Berry, R.F., Large, R.R., 2000a. Geological and metallogenic relations of mineral deposits in South China: Australian Mineral Industry Research Association (AMIRA) Report No. 1 and CD-ROM (Unpublished), June 2000 (Unpublished), University of Tasmania, 56 pp.

Khin Zaw, Bruce, E., Burrett, C.F., Berry, R.F., Large, R.R., 2000b. Geological and metallogenic relations of mineral deposits in South China: Australian Mineral Industry Research Association (AMIRA) Report No. 2 and CD-ROM (Unpublished), November 2000 (Unpublished), University of Tasmania, 45 pp.

Khin Zaw, Bruce, E., Burrett, C.F., Berry, R.F., Large, R.R., 2001. Geological and metallogenic relations of mineral deposits in South China: Australian Mineral Industry Research Association (AMIRA) Report No. 3 and CD-ROM (Unpublished), November 2001 (Unpublished), University of Tasmania, 123 pp.

Khin Zaw, Bruce, E., Burrett, C.F., Berry, R.F., Large, R.R., 2002. Geological and metallogenic relations of mineral deposits in South China: Australian Mineral Industry Research Association (AMIRA) Final report and CD-ROM (Unpublished), November 2002 (Unpublished), University of Tasmania, 203 pp.

Kirkham, R.V, Carriere, J.J., Laramee, R.M., Garson, D.F., 1994. Global distribution of sediment-hosted stratiform copper deposits and occurrences. Geological Survey of Canada Open File 2915b. 256 pp.

Kitto, P., 1998. Renison-style carbonate-replacement Sn deposits. AGSO Journal of Australian Geology and Geophysics 17, 163–168.

Kromkhun, K., 2005. Geological setting, mineralogy, alteration, and nature of ore fluids of the H zone, the Chatree deposit, Thailand. Unpublished MSc thesis, Centre of Ore Deposit Research, University of Tasmania, Hobart, Tasmania, 232 p.

Kuo, T., 1957. The skarn type copper ore deposits of the Middle-Lower Yangtze, China. Acta Geologica Sinica 37, 1–10.

Kyaw Win, Kirwin, D., 1998. Exploration, geology and mineralisation of the Monywa copper deposits, central Myanmar. Porphyry and hydrothermal Copper and Gold Deposits: Global Perspective, Perth, Australia, November 30-December 1, 1998, Conference Proceedings, pp. 61–74.

Kyle, J.R., Li, N., 2002. Jinding: a giant Tertiary sandstone-hosted Zn–Pb deposit, Yunnan, China. SEG Newsletter 50, 1–15.

Large, R.R., 2004. SEG Presidential address: ore deposit models, the deposit spectrum and hybrid ore deposits. Predictive Mineral Discovery Under Cover, SEG Conference, 27 September–1 October, 2004, Perth, Australia, Centre for Global Metallogeny. The University of Western Australia, Publication, vol. 33, pp. 162–164.

Large, R.R., McPhie, J., Gemmell, J.B., Herrmann, W., Davidson, G. J., 2001. The spectrum of ore deposit types, volcanic environments, alteration halos and related Exploration vectors in submarine volcanic successions: some examples from Australia. Economic Geology 96, 913–938.

Lattanzi, P., Corazza, M., Corsini, F., Tanelli, G., 1989. Sulphide mineralogy in the polymetallic cassiterite deposits of Danchang, P. R. China. Mineralium Deposita 24, 141–147.

Larson, K.M., Burgmann, R., Bilham, R., Freymueller, J.T., 1999. Kinematics of the India–Eurasia collision zone from GPS measurements. Journal of Geophysical Research 104 (B1), 1077–1093.

Li, X.-H., 2000. Cretaceous magmatism and lithospheric extension in Southeast China. Journal of Asian Earth Sciences 18, 293–305.

Li, N., Kyle, J.R., 1997. Geologic controls sandstone-hosted Zn–Pb–(Sr) mineralisation, Jinding deposit, Yunnan province, China — a new environment for sediment-hosted Zn–Pb deposits. Proc., 30th International Geol. Congr., vol. 9, pp. 67–82.

Li, Z., Peters, S.G., 1998. Comparative geology and geochemistry of sedimentary rock-hosted (Carlin-type) gold deposits in People's Republic of China and Nevada, USA. USGS Open-File, vol. 98.

Li, X.-Z., Liu, W.-J., Wang, Y.-Z., Zhu, Q.-W., 1999. Tectonic Evolution of the Tethys and Mineralisation in the Sanjiang Region, S. W. China. Geological Publishing House, Beijing. 258 pp (in Chinese with English abstract).

Li, W., Li, X., Li, Z., 2005. Neoproterozoic bimodal magmatism in the Cathaysia Block of South China and its tectonic significance. Precambrian Research 136, 51–66.

Liang, H.-Y, Wang, X.-Z., Zhao, Z.-H., 2007. Geology and Geochemistry of Changkeng-Fuwang Au–Ag deposit, Guangdong Province, South China. Ore Geology Reviews 31, 304–318 (this volume). doi:10.1016/j.oregeorev.2005.10.007.

Liu, Y., Ma, D., 1993. Vein-type tungsten deposits of China and adjoining regions. Ore Geology Reviews 8, 233–246.

Liu, X., Wu, Y., 1988. Metallogenic conditions and regularities in the Middle and Lower Reaches of the Chunjiang River. Acta Geologica Sinica 62, 167–177.

Liu, B., Yeap, E.B., 1992. Gold deposits of China. Newsletter of the Geological Society of Malaysia 18 (6), 291–293.

Liu, X., Jahn, B., Liu, D., Dong, S., Li, S., 2004. SHRIMP U–Pb zircon dating of metagabbro and eclogite from the Dabieshan (Hongan Block), China and its tectonic implications. Tectonophysics 394, 171–192.

Long, J., Burrett, C., 1989. Fish from the Upper Devonian of the Shan-Thai Terrane indicate proximity to east Gondwana and south China terranes. Geology 17, 811–813.

Lott, D.A., Coveney Jr., R.M., Murowchick, J.B., Grauch, R.I., 1999. Sedimentary exhalative nickel–molybdenum ores in South China. Economic Geology 94, 1051–1066.

Lou, J., Yang, Y., Zhao, Z., Chen, J., Yang, J., 1994. Evolution of the Tethys in western Yunnan and mineralisation for main metal deposits. Geol. Memoirs, Series 4, vol. 45. Geological Publishing House, P. R. China, pp. 328–330 (in Chinese with English abstract).

Lu, J.-R., 1996. Geodynamics of the Emei mantle plume. Acta Geoscientia Sinica 17, 424–438.

Lu, H.-Z., Liu, Y., Wang, C., Xu, Y., Li, H., 2003. Mineralisation and fluid inclusion study of the Shizhuyuan W–Sn–Bi–Mo–F skarn deposit, Hunan Province, China. Economic Geology 98, 955–974.

Lu, X., Khin Zaw, Yao, S., Li, Z., 2003. Characteristics and Origin of Fluid Inclusions in the Tongshankou Porphyry-skarn Cu–Mo deposit, Hubei Province, P. R. China. ECROFI (European Current Research on Fluid Inclusions), Budapest, Hungary, p. 113.

Lu, Q.-T., Hou, Z.-Q., Shi, D.-N., Zhao, J.-H., Xu, M.-C., Chai, M.-T., 2004. Tentative seismic reflection study of Shizishan orefield in Tongling and its significance in regional exploration. Mineral Deposits 24, 390–398 (in Chinese with English abstract).

Lu, X., Yao, S., Khin Zaw, 2004. Characteristics and origin of the fluid inclusions in the Tongshankou porphyry-skarn Cu (Mo) deposit, Hubei Province, China. In: McPhie, J., McGoldrick, P. (Eds.), Dynamic Earth: Past, Present and Future, 17th Australian

Geological Convention, 8–13 February, 2004. Geological Society of Australia Abstract, vol. 73, p. 139.

Lu, X., Khin Zaw, Yao, S., Li, Z., submitted for publication. Alteration, fluid inclusion, and stable isotope characteristics of the Tongshankou porphyry-skarn Cu–Mo deposit, Hubei Province, P.R. China. Ore Geology Reviews.

Manini, A.J., Aquino, J., Gregory, C., Aneka, S., 2001. Discovery of the Sepon district gold and copper deposits, Laos. NewGenGold 2001, Perth, 2001, pp. 93–108.

Mao, J., Li Hongyan, 1995. Evolution of the Qianlishan granite stock and its relation to the Shizhuyuan polymetallic tungsten deposit. International Geology Review 37, 63–80.

Mao, J., Chen, Y., Wang, P., 1995. Geology and geochemistry of the Dashuigou tellurium deposit, western Sichuan, China. International Geology Review 37, 526–546.

Mao, J., Hongyan, L., Shimazaki, H., Raimbault, L., Guy, B., 1996a. Geology and metallogeny of the Shizhuyuan skarn–greisen deposit, Hunan Province, China. International Geology Reviews 38, 1020–1039.

Mao, J., Raimbault, L., Guy, B., Shimazaki, H., 1996b. Manganese skarn in the Shizhuyuan polymetallic tungsten deposit, Hunan province, China. Resource Geology 46, 1–11.

Mao, J., Qiu, Y., Goldfarb, J.R., Zhang, Z., Garwin, S., Fengshou, R., 2002. Geology, distribution, and classification of gold deposits in the western Qinling belt, central China. Mineralium Deposita 37, 352–377.

Mclean, R.N., 2001. The Sin Quyen iron–oxide–copper–gold–rare earth oxide mineralisation of North Vietnam. In: Porter, T.M. (Ed.), Hydrothermal Iron Oxide Copper–Gold and Related Deposits: A Global Perspective, vol. 2. PGC Publishing, Adelaide, pp. 293–301.

Meng, Q., Zhang, G., 1999. Timing of collision of the North and South China blocks. Geology 27, 123–126.

Min, M., 1995. Carbonaceous–siliceous–pelitic rock type uranium deposits in southern China: geological setting and metallogeny. Ore Geology Reviews 10, 51–64.

Min, M., Zheng, D., Shen, B., Wen, G., Wang, X., Gandhi, S.S., 1997. Genesis of the Sanbaqi deposit: a palaeokarst-hosted uranium deposit in China. Mineralium Deposita 32, 505–519.

Min, M., Luo, X.Z., Du, G.S., He, B.A., Campbell, A.R., 1999. Mineralogical and geochemical constraints on the genesis of the granite-hosted Huangao uranium deposit, SE China. Ore Geology Reviews 14, 105–127.

Mineral Deposits of China, 1990, Volume 1, Geological Publishing House, Beijing.

Mineral Deposits of China, 1992, Volume 2, Geological Publishing House, Beijing.

Mineral Deposits of China, 1995, Volume 3, Geological Publishing House, Beijing.

Mutschler, F.E., Ludington, S., Bookstrom, A.A., 1999. Giant porphyry-related metal camps of the world — a database: USGS open-file Report 99.

Naldrett, A.J., 1997. Key factors in the genesis of Noril'sk, Sudbury, Jinchuan, Voisey's Bay and other world-class Ni–Cu–PGE deposits: implications for exploration. Australian Journal of Earth Sciences 44, 283–315.

Naldrett, A.J., Li, C. (Eds.), 2000. A special issue on Voisey's Bay Ni–Cu–Co deposit. Economic Geology, vol. 95, pp. 673–915.

Pan, Y., Dong, P., 1999. The Lower Changjiang (Yangzi/Yangtze River) metallogenic belt, east central China: intrusion- and wall rock-hosted Cu–Fe–Au, Mo, Zn, Pb, Ag deposits. Ore Geology Reviews 15, 177–242.

Peng, Z., Watanabe, M., Hoshino, K., 1997. Overview of tin-bearing polymetallic mineralisation in the Dachang ore field. Resource Geology 47, 331–341.

Peng, Z., Watanabe, M., Hoshino, K., Sueoka, S., Yano, T., Nishido, H., 1998. The Machangqing copper–molybdenum deposits, Yunnan, China—an example of Himalayan porphyry-hosted Cu–Mo mineralization. Mineralogy and Petrology 63, 95–117.

Peters, S.G., (Ed.), 2002. Geology, geochemistry, and geophysics of sedimentary-hosted Au deposits in P.R. China. USGS Open-file Report: 02-131, version 1, CD-ROM.

Peters, S.G., Huang, J.Z., Li, Z.P., Jing, C.G., 2007. Sedimentary rock-hosted Au deposits of the Dian-Qian-Gui area, Guizhou and Yunnan Provinces, and Guangxi District, South China. Ore Geology Reviews 31, 170–204 (this volume). doi:10.1016/j.oregeorev.2005.03.014.

Pirajno, F., Bagas, L., 2002. Gold and silver metallogeny of the South China fold belt: a consequence of multiple mineralising events? Ore Geology Reviews 20, 109–126.

Pirajno, F., Bagas, L., Hickman, A.H., 1996. Geology and mineralisation of the Chencai-Suichang uplift, Zhejiang province, Southeast China: Dept. of Minerals and Energy, Geol. Surv. West Aust. Report. 94 pp.

Pirajno, F., Bagas, L., Hickman, A.H., 1997. Gold mineralisation of the Chencai-Suichang uplift and tectonic evolution of Zhejiang province, southeast China. Ore Geology Reviews 12, 35–55.

Qiu, Y., Gao, S., McNaughton, N.J., Groves, D.I., Ling, W., 2000. First evidence of 3.2 Ga continental crust in the Yangtze craton of south China and its implication for Archaean crustal evolution and Phanerozoic tectonics. Geology 28, 11–14.

Qiu, Y., Groves, D.I., McNaughton, N.J., Wang, L., Zhou, T., 2002. Nature, age, and tectonic setting of granitoid-hosted orogenic gold deposits of the Jiadong Peninsula, eastern North China Craton, China. Mineral Deposita 37, 283–305.

Qu, X., Hou, Z., Khin Zaw, Li, Y., 2007. The characteristics and genesis of Gangdese porphyry deposits in southern Tibetan Plateau: Evidence from preliminary geochemical and geochronological results. Ore Geology Reviews 31, 205–223 (this volume). doi:10.1016/j.oregeorev.2005.03.012.

Raschtbacher, L., Hacker, B., Calvert, A., Webb, L., Grimmer, J., McWilliams, M., Ireland, T., Dong, S., Hu, J., 2003. Tectonics of the Qinling (central China): tectonostratigraphy, geochronology and deformation history. Tectonophysics 366, 1–53.

Rei, R., Wang, P., Peng, C., 1999. Deep tectonic processes and super accumulation of metals related to granitoids in the Nanling Metallogenic Province, China. Acta Geologica Sinica 73 (2), 181–192 (in Chinese).

Reid, A., Wilson, C.J.L., Shun, L., Pearson, N., Belousova, E., 2007. Mesozoic plutons of the Yidun Arc, SW China: U/Pb geochronology and Hf isotopic signature. Ore Geology Reviews 31, 88–106 (this volume). doi:10.1016/j.oregeorev.2004.11.003.

Rodmanee, T., 2000. Genetic model of Phu Thap Fha gold deposit, Ban Huai Phuk Amphoe Wang Saphung, Changwat Loei. MSc thesis (Unpublished), Chiang Mai University, Chiang Mai, Thailand, 128 pp.

SEGNL, 2005. Exploration reviews. SEG News Letter 60, 42 (January).

Sino Gold Limited, 2004. Jinfeng mineral resources estimate. Sino Gold Limited Media Release, 21 June 2004, pp. 1–7 (www.sinogold.com.au).

Smith, S., Olberg, D., Manini, T., 2005. The Sepon gold deposits, Laos: Exploration, geology, and comparison to Carlin-type gold deposits in the Great Basin. In: Rhoden, H.N., Steininger, R.C., Vikre, P.G. (Eds.), Geological Society of Nevada Symposium 2005: Window to World, Reno, Nevada, May 2005.

So, C.-S., Zheng, D.-Q., Yun, S.-T., Li, D.X., 1998. Alteration mineralisation zoning and fluid inclusions of the high sulphidation epithermal Cu–Au mineralisation at Zijinshan, Fujian province, China. Economic Geology 93, 961–980.

Song, S.H. (Editor), 1992. The explanatory notes on the mineral resources map of China (1:5,000,000). Geological Publishing House, Beijing (in Chinese with English abstract).

Song, X.Y., Zhou, M.F., Cao, Z.M., Sun, M., Wang, Y.L., 2003. Ni–Cu–(PGE) magmatic sulphide deposits in the Yangliuping area, Permian Emeishan igneous province, SW China. Mineralium Deposita 38, 831–843.

Tan, L.P., 1991. The Chinkuashih gold–copper deposits, Taiwan. Society of Economic Geologists Newsletter 7, 21–24.

Tanelli, G., 1982. Geological setting, mineralogy and genesis of tungsten mineralisation in Dayu district, Jiangxi—an outline. Mineralium Deposita 17, 279–294.

Tanelli, G., Lattanzi, P., 1985. The cassiterite–polymetallic sulphide deposits of Dachang (Guangxi), People's Republic of China. Mineralium Deposita 20, 102–106.

Tate, N., 2005. Discovery, geology and mineralisation of the Phu Kham copper-gold deposit, Lao People's Democratic Republic. In: Mao, J., Bierlein, F. (Eds.), Mineral Deposit Research: Meeting the Global Challenge, Proceedings of the 8th Biennial SGA Meeting, 18–21 August 2005, Beijing, China, vol. 2, pp. 1077–1080.

Wang, Z., 1982. Complex model of copper metallogeny in middle-Middle-Lower Yangtze Valley and its significance for ore exploration. Scientia Sinica B 25, 765–776 (in Chinese).

Wang, Y., 1992. Tectonic frame and features of Guizhou. Proceeding of the Conference of Regional Structure-Ore-Field in the Guizhou Province. Guizhou Scientific and Technology Publishing House, Guiyan. unpaginated (in Chinese).

Wang, B.H., 1996. Geological characteristics of Huangshilaoshan–Mashan gold deposits, Tongling, Anhui Province. In: Wang, Y., Qin, Y., Chen, P. (Eds.), Geology of Iron, Copper, Gold, and Silver Mineral Resources in the Middle and Lower Reaches of the Yangtze River. Press House of Metallurgical industry, Beijing, pp. 301–308.

Wang, H., Mo, X., 1995. An outline of the tectonic evolution of China. Episodes 8, 6–16.

Wang, X., Zhang, Z., 1999. Types and distribution of endogenic gold deposits in western Sichuan, China. International Geology Reviews 41, 1099–1113.

Wang, Y., Zhou, M.F., 2004. Origin of the Baimazhai Ni–Cu–(PGE) sulphide deposit, Southern Yunnan, SW China. SEG Conference 2004. Predictive Mineral Discovery Under Cover, Centre for Global Metallogeny, The University of Western Australia, Publication, vol. 33, p. 468.

Wang, Y., Jing, C., Wei, Z., Yang, Q., 1996. The tectonics and its control on the gold-mineral deposits in the Tethyan domain of southwest China. In: Liu, Y., Ma, W., Wang, Y., Chen, J., Shen, M., Miao, L. (Eds.), Geology and Mineral Resources Proceedings of Ministry of Metallurgical Industry, pp. 109–114 (in Chinese).

Wang, H., Chen, J., Ji, J., Qu, K., 1997. Geological and geochemical characteristics of the Hetai gold deposits, South China. International Geology Reviews 39, 181–190.

Wang, L.G., Qiu, Y.M., McNaughton, N.J., Groves, D.I., Luo, Z.K., Huang, J.Z., Miao, L.C., Liu, Y.K., 1998. Constraints on crustal evolution and gold metallogeny in the northwestern Jiaodong Peninsula, China, from SHRIMP U–Pb zircon studies of granitoids. Ore Geology Reviews 13, 275–291.

White, N.C., 2002. Introduction to the metallogeny and ore deposits of Asia: Mineral Potential of Asia: a forum on Asian metallogeny and ore deposits, exploration and development potential, regulatory and investment climate, and management practicalities. Metal Mining Agency of Japan, pp 5–6 with CD-ROM (also see www.mmaj.go.jp).

White, N.C., Herrington, R.J., 2000. Mineral deposits associated with volcanism. Encyclopaedia of Volcanism. Academic Press, pp. 897–912.

Wu, J., 1993. Antimony vein deposits of China. Ore Geology Review 8, 213–232.

Wu, Y.L., Mei, Y.W., 1982. Multi-phase intrusions and multi-phase mineralisation and their evolution in Xihuanshan tungsten ore field. Tungsten Geology Symposium, Jiangxi, China. ESCAP-RMRDC, Bundung, pp. 437–449.

Wu, J., Qiming, X., Zhao, S., 1990. Antimony Deposits of China: Chapter 3 in Mineral Deposits of China, vol. 1. Geological Publishing House, Beijing, pp. 209–287.

Xie, G.-H., Wang, W.-B., Li, W.-D., 1995. The genesis and metallogenic epoch of the Xinqiao Cu–S deposit, Anhui. Volcanoes and Mineral Resources 16, 101–107 (in Chinese with English abstract).

Xu, Q., 1999. Geochemistry of the Proterozoic metavolcanic rocks and relation to Cu–Fe VMS deposits in central Yunnan. Journal of Exploration and Mining Geology 8, 177–188.

Xu, Guojian, Lin, X., 2000. Geology and geochemistry of the Changlongshan skarn iron deposit, Anhui province, China. Ore Geology Reviews 16, 91–106.

Xu, Guojian, Zhou, J., 2001. The Xinqiao Cu–S–Fe–Au deposit in the Tongling mineral district, China: synorogenic remobilisation of a stratiform sulphide deposit. Ore Geology Reviews 18, 77–94.

Xu, Enshou, Jin, Y., Zhu, F., Wang, X., Yang, L., 1992. Gold, silver and platinoid deposits of China. In: Liu, N. (Ed.), Mineral Deposits of China, vol. 2. Geological Publishing House, Beijing, pp. 294–349.

Xu, Guojian, Yao, S., Zhang, C., Wang, P., 1995. A case study of the Zhilingtou gold–silver deposit, Zhejiang, China. Proceedings of Pacrim'95. Australasian Institute of Mining and Metallurgy Publication Series, vol. 9, pp. 645–649.

Xu, Xiongwei, Murao, S., Shi, M., Li, B., 1996. Classification and distribution of antimony deposits in China. Resource Geology 46, 287–297.

Xu, Xingwang, Cai, X., Peters, S.G., 2006-this volume. Porphyry and hydrothermal copper and gold deposits in the Beiya area, western Yunnan Province, China. Ore Geology Reviews 31, 224–246 (this volume). doi:10.1016/j.oregeorev.2005.03.015.

Xue, C., Zeng, R., Liu, S., Chi, G., Qing, H., Chen, Y., Yang, J., Wang, D., 2007. Geologic, fluid inclusion and isotopic characteristics of the Jinding Zn–Pb deposit, western Yunnan, South China: A review. Ore Geology Reviews 31, 337–359 (this volume). doi:10.1016/j.oregeorev.2005.04.007.

Yan, M.Z., Hu, K., 1980. Geological characteristics of the Dexing porphyry copper deposits, Jiangxi, China. Mining Geology Special Issue 8, 197–203.

Yan, M.Z., Wu, Y.L., Li, C.Y., 1980. Metallogenic systems of tungsten in SE China and their mineralisation characteristics. Granitic Magmatism and Related Mineralisation Mineral Geol. Spec. Issue, Japan, pp. 215–221.

Yang, K., Mo, X., 1993. Characteristics of the Laochang volcanogenic massive sulphide deposit, southwestern Yunnan China. Journal of Exploration and Mining Geology 2, 31–40.

Yang, Z., Cheng, Y., Wang, H., 1986. The Geology of China. Calreden Press, Oxford. 303 pp.

Yang, K., Hou, Z., Mo, X., 1993. Volcanogenic massive sulphide deposits in southwestern China. Resource Geology Special Issue 17, 263–276.

Yang, K., Scott, S.D., Mo, X., 1999. Massive sulphide deposits in the Changning–Menglian back-arc belt in western Yunnan, China: comparison with modern analogues in the Pacific. Journal of Exploration and Mining Geology 8, 211–231.

Yang, K., Zhang, H., Mo, X., Yang, W., 2002. Mineral potential of China: Mineral Potential of Asia: a forum on Asian metallogeny and ore deposits, exploration and development potential, regulatory and investment climate, and management practicalities: Metal Mining Agency of Japan, p 17–18 with CD-ROM (also see www.mmaj.go.jp).

Yang, Z.-S., Hou, Z.-Q., Meng, Y.-F., Zeng, P.-S., Li, H.-Y., Xu, W.-Y., Tian, S.-H., Wang, X.-C., Yao, X.-D., Jiang, Z.-P., 2004. Spatial–temporal structures of the Hercynian exhalative–sedimentary fluid systems in Tongling orefield, Anhui Province. Mineral Deposits 23, 297–307 (in Chinese with English abstract).

Ye Myint Swe, Khin Zaw, Than Htay, 2004. Sedimentary rock-hosted gold mineralisation along Sagaing fault zone, northern Myanmar. International Symposium on Geological Evolution of East and Southeast Asia, Bangkok, Thailand, pp. 67–68.

Yeap, E.B., 1993. Tin and gold mineralisation in Peninsular Malaysia and their relationships to tectonic development. Journal of Southeast Asian Earth Sciences 8, 329–348.

Yin, A., Nie, S., 1996. A Phanerozoic palinspastic reconstruction of China and its neighbouring regions. In: Yin, A., Harrison, T.M. (Eds.), The Tectonic Evolution of Asia. Cambridge University Press, Cambridge, pp. 442–485.

Yin, L., Pollard, P.J., Hu, S., Taylor, R.G., 1995. Geologic and geochemical characteristics of the Yichun Ta–Nb–Li deposit, Jiangxi Province, South China. Economic Geology 90, 577–585.

Yin, H.-F., Wu, S.-B., Du, Y.-S., 1999. South China defined as part of Tethyan archipelago oceanic system. Earth Science 24, 1–12 (in Chinese with English abstract).

Yin, J., Kim, S.J., Lee, H.K., Itaya, T., 2002. K–Ar ages of plutonism and mineralisation at the Shizhuyuan W–Sn–Bi–Mo deposit, Hunan Province, China. Journal of Asian Earth Sciences 20, 151–155.

Zeng, N., Izawa, E., Motomura, Y., Lai, L., 2000. Silver minerals and paragenesis in the Kangjiawan Pb–Zn–Ag–Au deposit of the Shuikoushan mineral district, Hunan Province, China. Canadian Mineralogist 38, 11–22.

Zhai, Y., Deng, J., 1996. Outline of the mineral resources of China and their tectonic setting. Australian Journal of Earth Sciences 43, 673–685.

Zhai, Y., Xiong, Y., Yao, S., Lin, X., 1996. Metallogeny of copper and iron deposits in the Eastern Yangtze Craton, east-central China. Ore Geology Reviews 11, 229–248.

Zhai, Y., Deng, J., Peng, R., 1997. Some major mineral deposits in China: their tectonic setting and deposit model characteristics. Proc., 30th International Geol. Congress, vol. 9, pp. 367–379.

Zhang, Guilin, Boulter, C.A., Jincheng Liang, 2001. Brittle origin for disseminated gold mineralisation in mylonite: Gaocun gold deposit, Hetai goldfield, Guangdong Province, China. Economic Geology 96, 49–59.

Zhang, Dehui, Xu, G., Zhang, W., Golding, S.D., 2007. High salinity fluid inclusions in the Yinshan polymetallic deposit from the Dexing district, Jiangxi Province: their origin and significance for ore genesis. Ore Geology Reviews 31, 247–260 (this volume). doi:10.1016/j.oregeorev.2004.011.002.

Zhang, Yanhua, Lin, G., Roberts, P.A., Ord, A., 2007. Numerical modelling of deformation and fluid flow in the Shuikoushan district, Hunan Province, South China Ore Geology Reviews 31, 261–278 (this volume). doi:10.1016/j.oregeorev.2005.03.013.

Zhao, Y., 1991. Skarn deposits in the Circum Pacific belt. Mineral Deposits 10, 41–51.

Zhao, Y., Lin, W., Bi, C., Li, D., Jiang, C., 1990. Skarn deposits of China. Geological Publishing House, Beijing. 354 pp.

Zhao, Y., Zhang, Y., Bi, C., 1999. Geology of gold-bearing skarn deposits in the middle and lower Yangtze River Valley and adjacent regions. Ore Geology Reviews 14, 227–249.

Zheng, M., Wang, X., 1991. Genesis of the Daliangzi Pb–Zn deposit in Sichuan, China. Economic Geology 86, 831–846.

Zheng, Z.M., Liou, J.G., Coleman, R.G., 1984. An outline of plate tectonics of China. Geological Society of America Bulletin 95, 295–312.

Zhong, H., Zhou, X.H., Zhou, M.F., Sun, M., Liu, B.G., 2002. Platinum-group element geochemistry of the Hongge Fe–V–Ti deposit in the Pan-Xi area, southwestern China. Mineralium Deposita 37, 226–239.

Zhou, C., Wei, C., Guo, J., Li, C., 2001. The source of metals in the Qilinchang Zn–Pb deposit, Northeastern Yunnan, China: Pb–Sr isotope constraints. Economic Geology 96, 583–598.

Zhou Taihe, 1995. Copper skarn deposits in eastern China: Proceedings of Pacrim'95. Australasian Institute of Mining and Metallurgy Publication Series, vol. 9, pp. 675–679.

Zhou Taihe, 1999. Tectonics and gold mineralisation in East China. Proceedings of Pacrim'99, Australasian Institute of Mining and Metallurgy Publication, pp. 341–345.

Zhou Taihe, Lu, G., 2000. Tectonics, granitoids and Mesozoic gold deposits in East Shandong, China. Ore Geology Reviews 16, 71–90.

Zhou Taihe, Goldfarb, R.J. (Eds.), 2002. Tectonic and metallogeny of gold deposits in China. Mineralium Deposita, vol. 37, pp. 247–418.

Zhou Taihe, Goldfarb, R.J., Phillips, G.N., 2002. Tectonics and distribution of gold deposits in China — an overview. Mineralium Deposita 37, 249–282.

Zhou Taofa, Yuan, F., Yue, S., Liu, X., Xin Zhang, Fan, Y.e, 2007. Geochemistry and evolution of ore-forming fluids of the Yueshan Cu–Au skarn and vein-type deposits, Anhui Province, South China Ore Geology Reviews 31, 279–303 (this volume). doi:10.1016/j.oregeorev.2005.03.016.

Zhu, S., Chi, S., 1993. Geology and Prospecting of Stratabound Deposits in China. Geological Publishing House, Beijing, P.R. China. 80 pp.