Introduction

A traditional tool for understanding ore deposit genesis is the deposit model, and more sophisticated deposit models proposed in the past two decades have included links between different deposit types and defined the mineral systems (McCuaig and Hronsky, 2014). Large Cu skarn deposits, described as porphyry-related Cu skarns, are associated with all porphyry Cu plutons emplaced in carbonate rocks (Einaudi et al., 1981). These porphyry copper systems, for example, may contain porphyry Cu ± Mo ± Au, as well as Cu, Au, and/or Zn skarns and epithermal Au ± Ag ± Cu deposits (Sillitoe, 2010). Cu and Fe skarns are the world’s most abundant and largest skarn type deposits (Meinert et al., 2005) and are economically important, particularly in China where Cu and Fe skarn deposits provide 32%, and 57% of high-grade (>50%) iron ore, respectively (Zhang et al., 2014; Chang et al., 2019). Although all skarn deposits contain some Au, porphyry-skarn Cu and skarn Au deposits supply 61% and 35% of the world’s total gold reserves, respectively, and there is a strong correlation between Cu and Au values (Meinert, 1989). Au skarns include four major subdivisions: (1) reduced; (2) oxidized; (3) magnesian; and (4) metamorphic (Meinert, 2000). Reduced and oxidized Au skarns are related to shallow Phanerozoic plutons with depth estimates of ≤5 km, which is broadly similar to the general environment of porphyry-type deposits (Meinert, 2000). Cu, Fe skarn deposits have been extensively studied, and their common features have been summarized (see the latest review by Meinert et al., 2005); however, few papers have focused on mineral deposit models of Cu–Fe–Au skarn systems, and the main mechanisms controlling the bulk Cu/Au/Fe ratios of skarn deposits require further investigation.

The Middle–Lower Yangtze River metallogenic belt (hereafter referred to as the MLYRB) is one of the most important Cu and Fe metallogenic skarn provinces in China (Chang et al., 2017). The MLYRB consists of several ore districts, from west to east, these are the Edong, Jiurui, Anqing–Guichi, Tongling, Luzong, Ningwu, and Ningzhen (Fig. 1; Pan and Dong, 1999). Most ore deposits in these districts have been extensively studied (see the latest reviews by Mao et al., 2011; Chang et al., 2017; Zhou et al., 2017), which has clarified that they are associated with Late Mesozoic igneous rocks that can be grouped into two series: the Fe–related group and...
the Cu-related group (Yang et al., 2011). The polymetallic skarn deposits in the MLYRB can be considered as Fe-dominated, Au-dominated, and Cu–Mo skarns (Pirajno, 2013), and oxidized Au skarn deposits have been estimated at more than 600 t Au (Zhao et al., 1999). The Edongnan region contains the Edong ore district and the western part of the Jiurui ore district (Fig. 1), and includes important Fe, Cu–Fe (Au), Fe–Cu (Au), Cu–Au and Au–Cu skarn deposits and distal Au deposits (Fig. 2).

In this contribution based on literature and our work in the Edongnan region, we review the principal geological characteristics of some Cu–Fe, Cu–Au and Au–Cu skarn, and distal Au deposits, and propose a new mineral deposit model for the Cu–Fe–Au skarn system.

2 Geological Background

The MLYRB is located on the northern margin of the Yangtze Craton and along the southeastern margin of the North China Craton and the Dabieshan orogenic belt (Fig. 1). The MLYRB is bounded by the Xiangfan–Guangji Fault (XGF) to the northwest, the regional strike-slip Tancheng–Lujiang Fault (TLF) to the northeast, and the Yangxin–Changzhou Fault (YCF) to the south (Fig. 1). Geophysical evidence indicates that the Yangtze Fracture Zone that exists in the MLYRB might have been initiated in the Neoproterozoic and subsequently reactivated in the Triassic and Jurassic–Cretaceous (Chang et al., 1991), which resulted in the development of an extensive network of faults and S-style folds.

There are three tectono–stratigraphic units in the MLYRB: Archean–Proterozoic metamorphic rocks; Cambrian to Lower Triassic marine sedimentary rocks; and Middle Triassic to Cretaceous terrigenous clastic and volcanic rocks. The basement rocks comprise greenschist, phyllite, and slate, which are intercalated with 2900–990 Ma metaspilite and keratophyre (Chang et al., 1991). Unexposed Archean of 3.4–2.9 and 2.8–2.5 Ga components might be present beneath the MLYRB (Tang et al., 2012). The metamorphic basement was unconformably overlain by extensive Cambrian to Triassic marine sedimentary rocks, and Middle Triassic to Cretaceous terrigenous clastic and volcanic rocks. The basement rocks comprise greenschist, phyllite, and slate, which are intercalated with 2900–990 Ma metaspilite and keratophyre (Chang et al., 1991). Unexposed Archean of 3.4–2.9 and 2.8–2.5 Ga components might be present beneath the MLYRB (Tang et al., 2012). The metamorphic basement was unconformably overlain by extensive Cambrian to Triassic marine carbonate and clastic rocks, and then Carboniferous, Permian and Triassic carbonate rocks and clastic rocks are the most important host sedimentary successions for the porphyry–skarn Cu polymetallic deposits (Chang et al., 1991).

Unconformably overlying these sediments is a sequence of Cretaceous volcanic and volcano–clastic rocks, which are primarily welded breccia, tuff, andesite, rhyolite, trachyte, and basalt. Recent integrated geological studies,
coupled with zircon U–Pb dating, have provided compelling evidence that Late Jurassic volcanic–sedimentary rocks are absent and that volcanic rocks in the Jinniu, Luzong, Fanchang, and Ningwu basins (Fig. 1) formed during 130–125, 137–127, 134–126, and 135–127 Ma, respectively (Xie et al., 2011a; Zhou et al., 2011). Upper Cretaceous to Quaternary rocks are characterized by clastic red-bed sediments intercalated with minor Paleogene basalts (Chang et al., 1991).

Two important types of metallic mineral deposits with different ages and associated magmatism have been recognized in the MLYRB (Mao et al., 2011; Zhou et al., 2017): (1) 148–135 Ma Cu–Au–Fe porphyry–skarn deposits associated with 156–137 Ma high-K calc-alkaline granitoids (Fig. 1); and (2) 135–123 Ma magnetite–apatite deposits associated with 135–123 Ma shoshonitic rocks in the Cretaceous volcanic basins (Fig. 1). In addition, some hydrothermal Au, Tl and Sr deposits, and copious sedimentary gypsum deposits (Fig. 1) have been discovered and recognized (Fan et al., 2014; Zhou et al., 2014; Xie et al., 2015, 2017; Zhu et al., 2015; Duan et al., 2018), but their genesis is poorly constrained. Recently, a metallogenic model of intracontinental porphyry–skarn Cu polymetallic deposits in the MLYRB was discussed and reviewed (Zhou et al., 2015).

The Edongnan region is one of the most important Cu–Fe–Au skarn concentrations in China (Zhao et al., 2012). In the southern part of this region, Upper Proterozoic metamorphic rocks are poorly exposed, but Cambrian to Middle Triassic marine carbonate rocks, clastic rocks, flysch and minor gypsum successions (>6000 m thick) are widespread, and Upper Triassic to Middle Jurassic clastic rocks are locally exposed (Shu et al., 1992). To the western of the region there are Lower Cretaceous volcanic and sedimentary rocks in the Jinniu Basin (Fig. 2), and volcanic rocks have been dated at 125–130 Ma using the SHRIMP zircon U–Pb method (Xie et al., 2011a). This is younger than the quartz diorite and Cu–Fe–Au skarn.
deposits, which have ages of 137–142 Ma based on SHRIMP and LA–ICPMS zircon U–Pb methods (Xie et al., 2011a,b; Li et al., 2014). In the east, sites such as Caojiashan and Zhulintang contain carbonate-hosted Au deposits, and related Pb–Zn occurrences (Fig. 2).

3 Au-bearing Deposits

Considering the Au contents in the ores, three types of Au-rich deposits have been recognized in the Edongnan region, which were formed between 148 Ma to 137 Ma (Xie et al., 2011b, 2019; Wang et al., 2014; Li et al., 2014). Previous studies have shown that there are skarns that produce Au and skarns from which Au is produced as a coproduct or byproduct of porphyry–skarn Cu deposits (Meinert, 1989). In China, the MLYRB is one of the most important Au-rich skarn deposits which are hosted by limestone, dolomitic limestone and dolomite in the Middle to Lower Cambrian, Carboniferous–Permain and Triassic Formations. These Au–rich skarn deposits are characterized by diopside and andradite and elevated Cu/Au and Ag/Au contents and genetically associated with oxidized quartz diorite and granodiorite porphyry with high Fe₂O₃/FeO contents (>0.5), indicating oxidized gold-rich skarns (Zhao et al., 1999).

(1) skarn Cu–Au deposits with average gold contents of > 0.4 ppm follow the definition of porphyry Au–rich deposits (Sillitoe, 2000). In addition, some skarn Cu–Fe deposits in the Edongnan region contain recoverable Au; for example, the Tonglushan skarn Cu–Fe deposit (Fig. 2) with 68.9 metric tonnes of Au averaging 1.15 ppm Au (Zhao et al., 1999; Xie et al., 2011b) is the largest Au reserve in the MLYRB.

(2) skarn Au–Cu deposits with high average gold contents (generally > 3 ppm). Jilongshan and Jiguangzu (Fig. 2), for example, contain 13.0 Mt @ 1.3% Cu and 6.3 Mt @ 3.5 ppm Au, and 8.1 Mt @ 1.6% Cu and 4.7 Mt @ 4.3 ppm Au, respectively (Xie et al., 2011b). Au–Cu orebodies occur predominantly in the exoskarn along the contacts between intrusion and carbonate rocks with a positive correlation existing between the Au and Cu contents (Fig. 3), which supports the fact that Au and Cu normally correlate closely in porphyry Cu systems (Sillitoe, 2010). Metal zoning has been recognized (Fig. 4) from Cu–Au stockwork veinlets within the stock to Cu–Au or Au–Cu skarns at the intrusive contact (Fig. 5a), carbonate-replacement Pb–Zn ore (Fig. 5b) in marble and peripheral Au–As ore (Fig. 5c) toward the marble front. Native gold, hessite (Ag₂Te), tetradymite (Bi₂Te₂S), and aikinite (PbCuBiS₃) coexist with chalcopyrite, pyrite, and bornite in the Cu–Au skarn ores (Figs. 5d–e), whereas coloradoite (HgTe) coexists with calcite and realgar in the Au–As ores toward the marble front (Fig. 5f).

(3) some Au deposits have been discovered and recognized in the past decade, such as the porphyry Au deposits at Paodaoling (Fig. 1) with an average Au grade up to 1.7 ppm in the Anqing–Guichi ore district (Duan et al., 2018), and the carbonate-hosted Au (Tl) deposits with an average Au grade up to 5.0 ppm at Caojiashan and Zhulintang (Fig. 2) in the Jiurui ore district (Xie et al., 2019). The latter are characterized by trace (<2%) amounts of sulfides (Fig. 6a), consisting of locally massive realgar and orpiment (Fig. 6b), and rare amounts of lorandite (Fig. 6c), indicating relatively low temperatures (below 235°C) during mineralization (Sobott et al., 1987), with argillic-altered granodiorite porphyry dikes locally containing Au up to 1.1 ppm (Fig. 6d). Abundant tellurides including altaite, calaverite, coloradoite and petzite, and electrum (Figs. 6e–f) occur as calcite veinlets and dissemination in the limestone. Gold ores from Zhulintang (Fig. 2) have relatively high Tl contents of up to 2016 ppm (Xie et al., 2017), similar to the economic Tl ore (3000 ppm Tl) from the Allchar Sb–
Fig. 5. Photographs and photomicrographs of the representative ore-types from the Fengsandong Cu–Au skarn and Jilongshan Au–Cu skarn deposits, Edongnan region (modified from Xie et al., 2019).
(a) disseminated chalcopyrite (Ccp) overprinting diopside (Di) –andradite (Ad) skarn at Fengsandong; (b) sphalerite (Sp) –galena (Gn) veins in marble at Jilongshan; (c) fault-controlled realgar (Rlg)–orpiment (Orp) vein in marble at Jilongshan; (d) native Au coexisting with chalcopyrite (Ccp) and pyrite (Py) replacing andradite (Ad) skarn at Jilongshan (reflected light, plane-polarized); (e) hessite (Hes), aikinite (Aik), and tetradymite (Tet) coexisting with chalcopyrite (Ccp) replacing andradite (Ad) skarn at Fengsandong (backscattered electron image); (f) coloradoite (Col) coexisting with realgar (Rlg) and calcite (Cal) at Jilongshan (backscattered electron image).

Fig. 6. Photographs and photomicrographs of the representative ore-types from the Caojiashan and Zhulintang Au–Tl deposits, Edongnan region (modified from Xie et al., 2017, 2019).
(a) calcite veinlet in limestone ore at Caojiashan; (b) realgar (Rlg)–orpiment (Orp) aggregates at Zhulintang; (c) breccia ore with limestone clasts and matrix of calcite–lorandite (Lor)–realgar (Rlg)–fluorite (Fl) assemblages at Zhulintang; (d) argillic–altered granodiorite porphyry dike with 1.1 ppm Au at Caojiashan; (e) altaite (Alt)–petzite (Ptz)–calaverite (Cly)–electrum (Elc) coexisting with calcite veinlet cutting limestone at Caojiashan (reflected light, plane polarized); (f) disseminated coloradoite (Col)–sericite–pyrite–quartz (Qz) in brecciated limestone at Zhulintang (backscattered electron image).
As–Tl–Au deposit in Macedonia (Amthauer et al., 2012) and the Xiangquan (Fig. 1) Tl deposit in the MLYRB (Fan et al., 2014).

### 4 Fe±Cu Deposits

Based on the Cu contents in the ores and the precise radiometric dating, two different types of Cu and Fe skarn mineralization are recognized in the Edongnan region (e.g., Xie et al., 2011a, b; Li et al., 2014). Fe skarn deposits are mined for their magnetite contents, and Fe is typically the dominant commodity recovered in Fe skarn deposits, but some deposits contain significant amounts of Cu and are transitional to more typical Cu skarn deposits and vice versa. Hematite and magnetite are common in most Cu skarn deposits, and the presence of dolomitic wall rocks is coincident with massive magnetite lodes, which can be mined on a local scale for Fe (Meinert et al., 2005). Many skarn deposits in China are described as polymetallic, and the MLYRB is one of the most important Cu and Fe skarn deposits in China (Zhai et al., 1992). Cu and Fe mineralization belts have been recognized and formed at ~140 Ma and ~130 Ma, respectively, in the MLYRB, and significant amounts of magnetite are common in some Cu skarn deposits in the Edong and Anqing–Guichi ore districts (Fig. 1), which are located in the superimposed region of the Cu and Fe mineralization belts (Zhou et al., 2017). Tonglushan and Tieshan (Fig. 2) in the Edong ore district, for example, have reserves of 1.1 Mt of Cu at an average grade of 1.78% and 56.8 Mt of Fe ores, and 0.67 Mt of Cu at an average grade of 0.57% and 160 Mt of Fe ores, respectively (Xie et al., 2015). In addition, there have been a few exceptions with the important Fe skarn deposits in the Edongnan region (Figs. 1–2), which are coeval with the magnetite–apatite deposits (Xie et al., 2011a). Fe skarn deposits such as those at Chengchao and Zhangfushan (Fig. 2) contain neither Au nor Cu as byproducts and contain reserves of 280 Mt of magnetite ore at an average grade of 45.1% Fe, and 128 Mt of Fe ore with an average grade of 42.3%, respectively (Xie et al., 2015).

The nature of the ore–bearing intrusion and evaporitic sedimentary rocks might be two main controls on the formation of either Cu–Fe or Fe skarn deposits in the Edongnan region (Xie et al., 2015, 2016). There is considerable variation in the spatial distribution of two different types of Cu and Fe skarn deposits. (1) The Cu–Fe skarn deposits are mainly found in the eastern part of the region (Fig. 2) and are genetically associated with quartz diorite and diorite, which are characterized by adakitic geochemical features with relatively high Sr/Y (35.0–81.3) and (La/Yb)N (15.0–31.6) ratios that are thought to be in equilibrium with a garnet–rich residue (Xie et al., 2015); (2) the Fe skarn deposits are mainly present in the western part of the region (Fig. 2) and spatially associated with granite and diorite (Fig. 7), which are different from the adakitic rocks with large variations in their (La/Yb)N ratios (3.84–24.6) and Eu anomalies (δEu = 0.32–1.65) and relatively low Sr/Y ratios (4.2–44.0) and high Yb contents (1.20–11.8 ppm) that are thought to be in equilibrium with a plagioclase residue (Xie et al., 2015). In this context, similar circumstances in the Cu and Fe skarn deposits in the Edongnan region are consistent with the relationships seen in the 45–61 Ma Cu skarn and 15 Ma Fe skarn deposits in the NW Neuquén Basin, Argentina (Pons et al., 2010), and two different types of granitoids in the Suyunhe porphyry Mo deposit, NW China (Zhong et al., 2017). Integrated studies of Sr–Nd isotopes, zircon Hf isotopes and He–Ar isotopes have indicated that Cu–Fe skarn deposits have a greater contribution of mantle components than Fe skarn deposits (Xie et al., 2015, 2016). This scenario is similar to different Sr–Nd isotopes.

![Fig. 7. Geological map and cross section of the Chengchao skarn Fe deposit, Edongnan region, showing the occurrence of granite and diorite, Fe orebodies and coexisting anhydrite orebodies (modified from Li et al., 2016, 2019).](image-url)
for the Fe-related and Cu-related intrusions in the Lhasa terrane, Himalayan–Tibetan orogen, and granitoid rocks associated with skarn Fe–(Cu) deposits have more radiogenic Sr–Nd isotopes than those associated with porphyry Cu–Au and Cu–Mo deposits (Hou et al., 2015).

Cu–Fe and Fe skarn deposits in the Edongnan region are predominantly hosted in the Triassic carbonate rocks with intercalating gypsum, accounting for 40% and 90% of total Fe and Cu reserves, respectively (Zhai et al., 1992). However, the ore-hosting sedimentary rocks are different between these Fe and Cu–Fe skarn deposits (Fig. 8), and the Tonglushan and Tieshan skarn Cu–Fe deposits are hosted in Lower Triassic carbonate rocks with minor gypsum pseudocrystals, whereas the Chengchao and Zhangfushan skarn Fe deposits are hosted in the Middle Triassic thin to medium thick-bedded dolomite containing a thick anhydrite layer and Upper Triassic clastic rocks (Fig. 8). By contrast, there is larger amount of hydrothermal anhydrite within the ores of the Fe skarn deposits than within the Cu–Fe skarn deposits (Xie et al., 2015). Minor anhydrite coexisting with pyrite and chalcopyrite is seen in the Cu ores of the Tonglushan Cu–Fe skarn deposit (Yu et al., 1985); however, the proven reserves in the Chengchao Fe skarn deposit are 45.6 Mt of anhydrite with 78.0% CaSO$_4$ and 2.1% MgO (Yao et al., 1993), and anhydrite orebodies coexisting with magnetite orebodies (Fig. 7b) are common in the cross section of this Fe skarn deposit (Li et al., 2016). Sedimentary anhydrite clasts (Fig. 9a) are observed in the magnetite ore, and have been remobilized to form purple hydrothermal anhydrite at the margin of clasts (Li et al., 2016), and there are obvious differences between sedimentary and hydrothermal anhydrite (Fig. 9b), i.e., the altered sedimentary grains are relatively fine, while the hydrothermal grains are coarse euhedral crystals coexisting with magnetite as seen under the microscope and in hand specimen (Figs. 9c, f). Halogen-rich scapolite intergrown with magnetite (Figs. 9d–e) shows high Cl content of up to 4.04%, suggesting that the hydrothermal fluid with high NaCl content was probably derived from evaporites before or during the late prograde stage (Zhu et al., 2015). Sulfur isotopic compositions are markedly different between the Cu–Fe and Fe skarn deposits in the Edongnan region (Fig. 10), indicating that different sulfur sources were responsible for the formation of the Cu–Fe and Fe skarn deposits (Xie et al., 2015).

### 5 Mineral Deposit Model

Most large skarn deposits are zoned in both space and time relative to associated intrusions, zonation occurs in scales from kilometers to micrometers, and deposit- or

<table>
<thead>
<tr>
<th>Formation</th>
<th>Lithology</th>
<th>Hosting-ore formation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Puqi (Middle to Upper Triassic)</td>
<td>Purple silty claystone, clayey siltstone</td>
<td>Tonglushan</td>
</tr>
<tr>
<td>Jialingjiang (Middle Triassic)</td>
<td>Gray-green sandy shale with siltstone</td>
<td>Tieshan</td>
</tr>
<tr>
<td>Daye (Lower Triassic)</td>
<td>Grey, pink thick and thin brecciated dolomite</td>
<td>Chengchao</td>
</tr>
<tr>
<td></td>
<td>Light gray, gray thick-bedded dolomite, with gypsum pseudocrystal</td>
<td>Zhangfushan</td>
</tr>
<tr>
<td></td>
<td>Gray, white thin and thick-bedded limestone</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gray, light red thin-bedded dolomite, with gypsum pseudocrystal</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Light gray, gray medium to thick-bedded micrite</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Light gray, gray medium to thick-bedded micrite</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gray thin-bedded limestone, yellow-green shale</td>
<td></td>
</tr>
</tbody>
</table>

Fig. 8. Triassic stratigraphic column of the Edongnan region, showing the location of ore-hosting sedimentary rocks in the selected Cu–Fe and Fe skarn deposits (modified from Yu et al., 1985; Shu et al., 1992).
Fig. 9. Photographs and photomicrographs of the anhydrite and scapolite for the Chengchao and Zhangfushan Fe skarn deposits, Edongnan region (modified from Zhu et al., 2015; Li et al., 2016).
(a) anhydrite (Anh) clasts in the magnetite (Mt) ore at Chengchao; (b) differences between sedimentary (Anh–S) and hydrothermal anhydrite (Anh–H) at Chengchao (transmitted light, cross polarized); (c) hydrothermal anhydrite (Anh–H) grains coexisting with magnetite (Mt) at Chengchao (transmitted light, cross polarized); (d) scapolite (Scp) coexisting with magnetite (Mt) at Zhangfushan (transmitted light, plane polarized); (e) scapolite (Scp) coexisting with magnetite (Mt) at Zhangfushan; (f) hydrothermal anhydrite (Anh–H) coexisting with magnetite (Mt) at Zhangfushan.

Fig. 10. Sulfur isotopic contour map of important metal deposits in the Edongnan region (modified from Zhu and Xie, 2018 and references therein).
Fig. 11. Mineral deposit model for the Cu–Fe–Au skarn system in the Edongnan region, MLYRB.

district-scale zoneation models can be used to evaluate mineral exploration (Meinert, 1997). Within an idealized Au-rich porphyry–skarn system, a composite zoning pattern from the center of the system outward may include the following zones: (1) barren (or subeconomic) core; (2) molybdenum; (3) bornite–gold; (4) chalcopyrite; (5) pyrite halo (gold in shear zones, and distal skarns); (6) lead–zinc–silver; and (or) (7) distal gold (Jones, 1992). The skarn deposits in the Edongnan region comprise a continuum of systems from Cu–Au to Fe (Zhou et al., 2017), and the location of distal Au–Tl mineralization assemblages beyond the limit of the calc-silicate skarns is located less than 1.5 km away from the Cu–Au skarn deposits (Xie et al., 2019).

Distal expressions of skarn deposits are particularly important for exploration purposes, because such alteration features form a significantly larger “bull’s eye” than just the skarn ore zones (Meinert et al., 2005). Integrated studies of the host sedimentary rocks, reserves of anhydrite, and sulfur and He–Ar isotopes have indicated that the hydrothermal fluids responsible for formation of Fe skarn deposits involved a greater contribution from evaporitic sedimentary rocks as compared with Cu–Fe skarn deposits (Xie et al., 2015, 2016). Some evaporitic sedimentary components are involved in the formation of Fe skarn deposits from southeastern Pennsylvania (Rose et al., 1985), and the Han–Xing ore districts, East China (Wen et al., 2017), as well as in the magnetite–apatite deposits of the MLYRB (Zhou et al., 2014). Several lines of evidence including metal zonation, Cu–Au–Bi–Te mineral assemblages, geochronology, and C–O–S sulfur isotopes support genetic linkage of distal Au–Tl mineralization in carbonate rocks with the Cu–Au skarn mineralization in the Edongnan region (Xie et al., 2019; Han et al., 2020). Based on the observations reported above, we propose a new mineral deposit model of the Cu–Fe–Au skarn system (Fig. 11) to illustrate the relationship between the skarn Cu–Fe–Au mineralization, the evaporitic sedimentary rocks, and the distal Au–Tl deposits. This new model proposed here will have important implications for the exploration for carbonate-hosted Au–Tl deposits in the more distal parts of Cu–Fe–Au skarn systems, and skarn Fe deposits with the occurrence of gypsum-bearing sedimentary rocks in the MLYRB, and possibly elsewhere.

Acknowledgments

This contribution honors Academician CHANG Yinfo for his contributions to our understanding of the genesis of skarn deposits on the occasion of his 90th birthday. This work was supported by the National Science Foundation of China (41925011), the National Key Research and Development Program of China (2016YFC0600206), China University of Geosciences (3–8–2020–002), China Geological Survey (DD202011173) and Hubei Sanxin Gold Copper Limited Company (CG–2019–HX–S004). Professor ZHOU Taofa and FAN Yu are thanked for the invitation to write this paper. We are deeply indebted to two anonymous reviewers for their valuable constructive comments to improve the presentation of this manuscript. We thank the local geologists for providing assistance during fieldwork.

Manuscript received Dec. 21, 2019 accepted Sept. 15, 2020 associate EIC: ZHOU Taofa edited by杨强

References


Li, J.W., Vasconcelos, P.M., Zhou, M.F., Deng, X.D., Cohen, B.,


About the first and corresponding author
XIE Guiqing is a research professor at the China University of Geosciences. He graduated from Changchun College of Geology with a Bachelor degree in geology in 1998, and from the Institute of Geochemistry, Chinese Academy of Sciences with a Ph.D. degree in economic geology in 2003. His most recent research has focused on the genesis of Cu-Fe-Au-W skarn and distal Au-Sb deposits and related exploration tools, through a combination study of field mapping, mineralogy, stable and radiogenic isotopes, fluid inclusions, and geochronology. E-mail: xieguiqing@cugb.edu.cn