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Compositional variation of sphalerites from Cu and Pb-Zn deposits in the Lower Yangtze area, eastern China

Kohei SATO*, Ruoshui NI**, Fuwei CHAO** and Wenda LI**

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Abstract: Microprobe analyses are presented for sphalerites from eight Cu and Pb-Zn deposits in the Lower Yangtze area, eastern China. The sphalerites show a large variation of FeS content ranging from 0.1 to 24.6 mole per cent, but MnS and CdS contents are generally less than 1 and 0.5 mole per cent, respectively. Relatively high MnS values (1-2 mole%) obtained for Pb-Zn deposits containing rhodochrosite indicate Mn-rich environments.

Sphalerites from the hydrothermal deposits related to the Yanshanian magmatism of magnetite-series have high FeS contents (8-24.6 mole%), especially in pyrrhotite-bearing deposits (>18 mole%), which are ascribed to high temperature condition suggested by skarn formation in Paleozoic to Early Mesozoic carbonate sediments around the intrusive bodies. The FeS variation of sphalerite does not correlate directly with fo_2 condition of related magmatism.

The Qixiashan bedded Pb-Zn deposit, which is resemble to the Mississippi Valley type deposits in many aspects, has varying FeS contents of sphalerites (0.3-11.9 mole%). This deposit may have formed or recrystallized in higher temperature condition than the typical Mississippi Valley type deposits, being related to hydrothermal activity during Mesozoic period.

Introduction

Various types of copper, lead-zinc and iron ore deposits are abundantly distributed in the Lower Yangtze area, eastern China. Yet genesis of individual deposits is still debatable because of complex geologic history of this area. Geological studies and mineral prospectings are in progress in the area, but little study has been made on mineral chemistry of the ores, which could provide useful information as to the genesis of the deposits.

In this reconnaissance study, we describe chemical composition of sphalerites, because sphalerite is a common ore mineral, not only in lead-zinc deposits but also in copper and iron deposits, and its chemical composition is a good indicator of physicochemical conditions of ore formations. Eight representative ore deposits were selected for this study, and sphalerites were chemically analysed by an electron microprobe. The specimens were collected by NI and LI and microprobe analysis was done by SATO and CHAO at the Geological Survey of Japan. The results have been preliminarily reported by NI *et al.* (1985).

Outline of ore deposits

Locations of the studied ore deposits are shown in Figure 1 together with the distribution of pre-Cambrian basements and Mesozoic igneous masses. The Lower Yangtze area consists of Paleozoic to Earley Mesozoic strata overlying pre-Sinian systems and Jurassic to Cretaceous igneous rocks. The Paleozoic strata, in which most of the studied skarn and bedded type ore deposits occur, are

* Mineral Deposits Department, Geological Survey of Japan, Higashi 1-1-3, Yatabe, Tsukuba, Ibaraki, 305 Japan
** Nanjing Institute of Geology and Mineral Resources, 534 East Zhongshan Road, Nanjing, The People's Republic of China

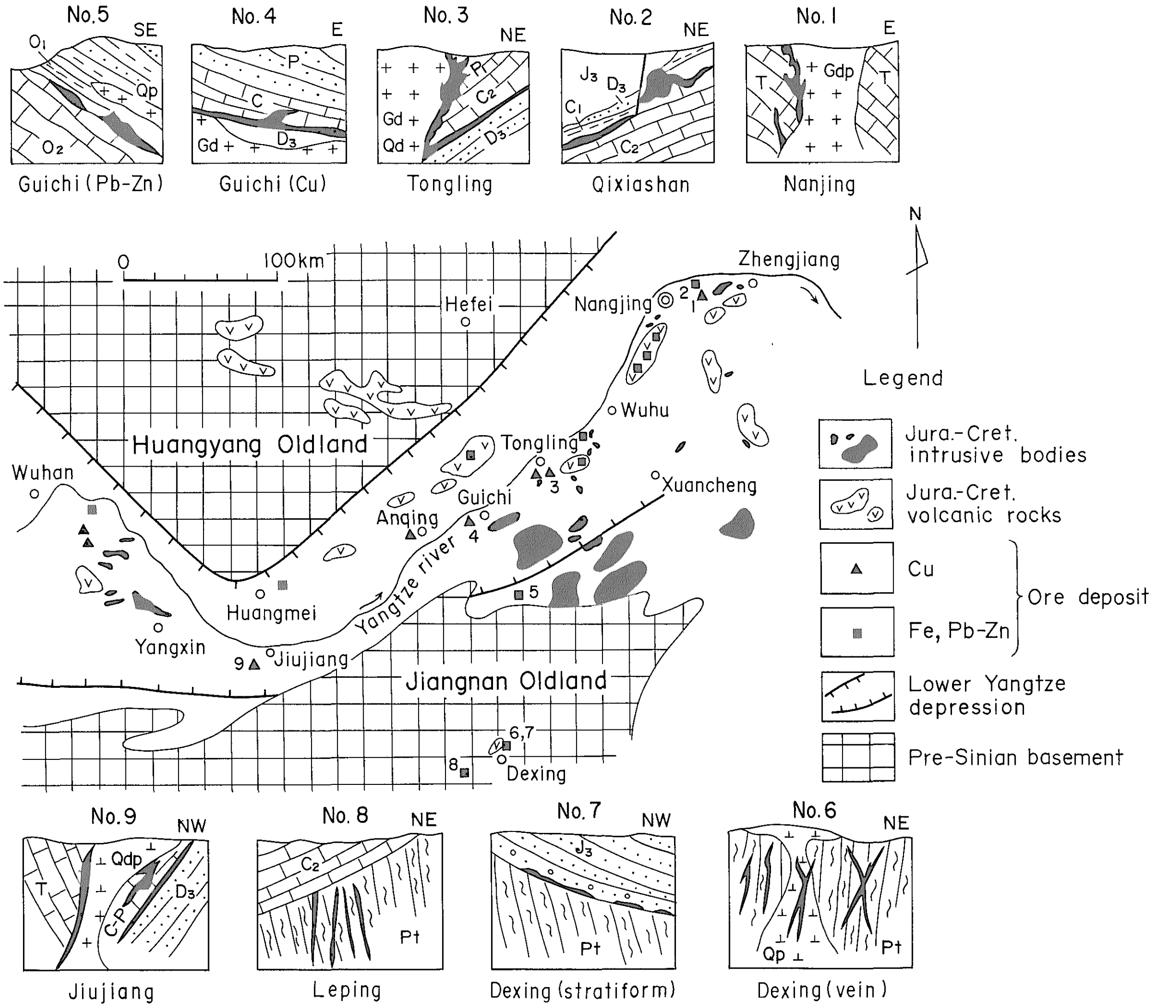

Fig. 1 Geology and distribution of ore deposits in the Lower Yangtze area with schematic cross-sections of the studied ore deposits. Numbers of the deposits correspond to those of Table 1. Abbreviations for lithology of the cross-sections are as follows: Qp, quartz porphyry; Gd, granodiorite; Gdp, granodiorite porphyry; Qd, quartz diorite; Qdp, quartz diorite porphyry; J, Jurassic; T, Triassic; P, Permian; C, Carboniferous; D, Devonian; O, Ordovician; Pt, Proterozoic. Small numbers 1, 2 and 3 indicate lower, middle and upper series of each system, respectively. Black parts show ore bodies.

dominated by carbonate sediments of Ordovician to Permian age and they were folded during the Indosinian orogeny (Late Triassic). During the Yanshanian (Jurassic to Cretaceous) time, intermediate to felsic igneous activity took place along the eastern margin of the Asian continent, producing many intrusive and extrusive units in the Lower Yangtze area. Radiometric ages of 178–96 Ma have been obtained for granitoids in this area. The Yanshanian igneous activity was accompanied by iron, copper and lead-zinc mineralizations in the area, but some of the bedded ore deposits are inferred to have formed syngenetically in Paleozoic period (LI *et al.*, 1980). The studied deposits are briefly described below and their characteristics are summarized in Table 1.

Nanjing Cu deposit (No. 1)

The deposit is of porphyry copper type with skarn mineralization. A granodiorite porphyry of Cretaceous age intuded into Triassic carbonate sediments. Copper ore occurs in the intrusive body and surrounding carbonate rocks with skarns. Main ore minerals are chalcopyrite and pyrite with small amounts of galena and sphalerite. Quartz, epidote and garnet are the principal gangue minerals. The samples containing sphalerite were taken from exoskarn formed in the carbonate sediments.

Qixiashan Pb-Zn deposit (No. 2)

The main ore bodies occur in Carboniferous carbonate sediments in stratiform or lens shape. The ore has banded, disseminated and massive texture. Banded ore is alternation of mudstone layers and sulfide beds having sedimentary structures. Brecciated ores are common in the deposit, which may be collapse breccia formed by dissolution of host carbonate rocks during the karst development (XIA *et al.*, 1983). Irregular-shaped massive ore bodies also occur in Permian carbonate rocks nearby the unconformity plane overlain by Jurassic clastic sediments (NAKAJIMA and TAO, 1985). The ores consist of sphalerite, galena, pyrite, marcasite and rhodochrosite with gangue minerals composed mainly of quartz, calcite and some dolomite. Solid bituminous materials occur in the ores. Thus the ore deposit have many characteristics of the Mississippi Valley type deposits, though the filling temperatures of 150–300°C for fluid inclusions in sphalerites are higher than those for the Mississippi Valley type deposits (40–150°C, HAGNI, 1976).

Table 1 Outline of the studied ore deposits

No.	Mine	Type	Recovered metal	Mineral assemblages*	Wall rocks (age)	Related igneous body (age)
1	Nanjing	porphyry & skarn	Cu	Py, Cp, Sph, Gn qz, ep, garn	limestone (Trias.)	granodiorite-porphyry (Cret.)
2	Qixiashan	stratabound	Pb-Zn-Mn	Sph, Gn, Py, Marc, Rhc, cal, dol, qz, ser	dolomite & limestone (Carb.-Perm.)	
3	Tongling	skarn	Cu-Fe	Py, Po, Mt, Cp, Sph, Gn, cpx, garn, qz, cal	limestone & dolomite (Carb.-Perm.)	quartz diorite granodiorite (late Jura.)
4	Guichi (Cu)	skarn	Cu	Py, Cp, Sph, Tet, cal, qz	limestone (Carb.-Perm.)	granodiorite (late Jura.)
5	Guichi (Pb-Zn)	skarn	Pb-Zn	Py, Sph, Gn, Cp, Po, garn, ep, qz	dolomite & limestone (Ordov.)	quartz porphyry (Cret.)
6	Dexing	vein	Pb-Zn-Ag	Sph, Gn, Enar, Aspy, qz	volcanics (Jura.-Cret.) schists (pre-Sinian)	quartz porphyry (late Jura.)
7	ditto	stratiform	Pb-Zn	Sph, Py, Gn, cal, sid, qz	sandstone & gravel (Jura.) schists (pre-Sinian)	
8	Leping	vein	Pb-Zn-Mn	Sph, Gn, Py, Cp, Po, Aspy, Rhc, cal, qz, ser, chl	schists & greenstone (pre-Sinian)	?
9	Jiujiang	porphyry & skarn	Cu	Py, Cp, Sph, Po, qz, garn, cpx	limestone & dolomite (Carb.-Perm.)	quartz diorite-porphyry (late Jura.)

Numbers of the mines correspond to those in Figure 1.

* In order of abundance, mineral abbreviations; Py, pyrite; Cp, chalcopyrite; Mt, magnetite; Sph, sphalerite; Gn, galena; Marc, marcasite; Po, pyrrhotite, Aspy, arsenopyrite; Tet, tetrahedrite; Enar, enargite; Rhc, rhodochrosite; cal, calcite; dol, dolomite; sid, siderite; qz, quartz; cpx, clinopyroxene; garn, garnet; ep, epidote; ser, sericite; chl, chlorite

Tongling (No. 3), Guichi (No. 4) and Jiujiang (No. 9) Cu deposits

These three ore deposits have similar characteristics. The mineralizations were related to late Jurassic plutons of quartz diorite to granodiorite composition. The copper ores occur in the intrusive bodies as well as in the surrounding skarn zones formed in Carboniferous to Permian limestone and dolomite. Thus the deposits consist essentially of skarn and porphyry copper ores, but they also include strata-bound Cu-bearing massive pyrite ores occurring along the boundary between Devonian strata and Carboniferous carbonate sediments. Main ore minerals are pyrite, pyrrhotite, magnetite, chalcopyrite, marcasite, greigite and siderite. The principal gangue minerals include quartz, calcite, dolomite, hedenbergitic clinopyroxene and andraditic garnet. Sphalerite occurs mainly in exoskarn zones and locally in veins.

Guichi Pb–Zn deposit (No. 5)

This is a skarn type Pb–Zn deposit formed in Ordovician carbonate sediments composed of dolomite and dolomitic limestone near a quartz porphyry dyke of Cretaceous age. The Pb–Zn ores occur in garnet-diopside-epidote skarn containing pyrite, sphalerite, galena, chalcopyrite and locally pyrrhotite.

Dexing Pb–Zn deposit (Nos. 6 and 7)

The deposit is located in a Mesozoic volcanogenic basin on the Jiangnan Oldland near the Dexing porphyry copper deposit. The Pb–Zn veins (No. 6) with high-angle dips occur in volcanic and subvolcanic rocks (quartz andesite porphyry and quartz porphyry) of Jurassic-Cretaceous age (140 Ma, ZHU *et al.*, 1983) as well as in pre-Sinian metamorphic rocks. The ore deposits may have formed in relation to post-volcanic hydrothermal activity, which appears to be younger than that of the Dexing porphyry copper deposit formed in relation to granodiorite porphyry dated at 170–160 Ma (YAN and HU, 1980; ZHU *et al.*, 1983). The main ore minerals are sphalerite, galena and small amounts of enargite and arsenopyrite. Quartz is a principal gangue mineral. Stratiform Pb–Zn ore bodies (No. 7) occur along the unconformity plane between late Jurassic sandstone accompanying gravel beds and the pre-Sinian schists. The principal ore minerals are sphalerite, pyrite and galena. Gangue minerals consist of calcite, siderite and subordinate quartz.

Leping Pb–Zn deposit (No. 8)

The deposit consists of Pb–Zn veins occurring in schist and greenstone of pre-Sinian age. No intrusive body has been found around the deposits, except for metadiabase which may not have been related with the mineralization. Further study is needed to identify the genesis of this deposits. The ore minerals are pyrite, sphalerite and galena with minor amounts of chalcopyrite, arsenopyrite and pyrrhotite. Calcite, quartz, sericite and chlorite are the principal gangue minerals.

Microprobe analysis

Microprobe analysis was carried out on individual polished sections of ore specimens from the deposits described above, using a JXA-733 automated microprobe operated at accelerating voltage of 25 kV and beam current of about 0.02 μA. Standard materials were synthetic ZnS for Zn and S, synthetic MnS and CdS for Mn and Cd, and natural chalcopyrite of known composition for Fe and Cu. Cu was analysed to detect possible occurrence of chalcopyrite inclusions in sphalerite. Correction calculation was done based on ZAF method. A total of 71 analyses was made on 20 specimens. The results are shown in Figure 2 and representative analyses are given in Table 2.

Chemical composition of sphalerite

As seen in Figure 2 and Table 2, sphalerites in the Lower Yangtze area consist essetially of ZnS and FeS components. MnS and CdS contents are generally less than 1 and 0.5 mole

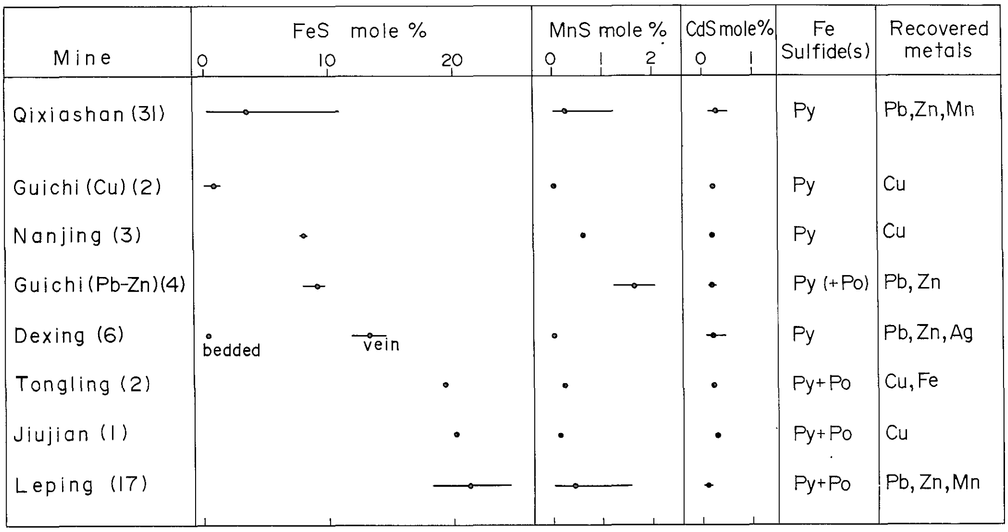

Fig. 2 Plot showing FeS, MnS and CdS contents of sphalerite. Solid circles and horizontal lines indicate average values and ranges of data, respectively. Also shown are the iron sulfide minerals and recovered metals for each deposit. The local occurrence of pyrrhotite is shown in perentheses. The numbers of sphalerite analyses are given in parentheses to the right of names of the mines.

per cent, respectively, regardless of type of the deposits and mineral assemblages. The Mn and Cd-poor chemistry is also a common feature of sphalerites in hydrothermal base mental deposits in the Japanese Islands (TSUKIMURA *et al.*, 1982; SHIMAZAKI and SHIMIZU, 1984). MnS contents higher than 1 mole per cent were recognized in four specimens from the Qixiashan, Guichi (Pb-Zn) and Leping deposits, all of which are characterized by Pb-Zn mineralization and Mn-rich chemistry of the ores (Table 1). In the Qixiashan and Leping mines, Mn is also recovered besides Pb and Zn.

FeS contents are highly variable, ranging from 0.1 to 24.6 mole per cent, though fairly homogeneous within individual specimens ($<\pm 2\%$) in most cases. There seems to be no correlation between the contents of FeS and other elements. Fe-poor sphalerites occur in the Qixiashan (0.3–11.9% FeS), Dexing stratiform ore body (0.4% FeS) and Guichi Cu deposits (0.1% FeS). Among the nine analysed specimens from the Qixiashan mine, eight specimens have FeS contents lower than 6 mole per cent. On the contrary, sphalerites from the Tongling (19.5% FeS), Dexing vein (13.7% FeS), Leping (18.3–24.6% FeS) and Jiujiang deposits (20.3% FeS) are rich in iron. Examined specimens from the Nanjing and Guichi Pb-Zn deposits have intermediate FeS contents, 8.0 and 8.6–9.7 mole per cent, respectively.

The Tongling and Jiujiang deposits characterized by Fe-rich sphalerites are skarn type Cu deposits, whereas bedded Pb-Zn deposits of the Qixiashan and Dexing mines are characterized by Fe-poor sphalerites. It is noted that sphalerite in vein ores in the Dexing mine has high FeS content in contrast with sphalerite in bedded ores of the same mine (Fig. 2). The Nanjing and Guichi (Pb-Zn) deposits associated with skarns also contain Fe-rich sphalerites, although the FeS contents are not so high as those of the Tongling and Jiujiang deposits. It is summarized, therefore, that sphalerites in the intrusive-related deposits are richer in iron than those of the bedded deposits. No clear correlation is seen between the FeS contents and character-

Table 2 Representative microprobe analyses of sphalerites from the studied ore deposits.

Ore deposit Sample No.	Zn	Fe	Mn	Cd	Cu	S	Total (wt.%)	ZnS	FeS (mole %)	MnS	CdS	Mineral assemblage
1.Nanjing												
15(14)	61.37	4.68	0.34	0.29	0.04	33.10	99.81	91.03	8.12	0.60	0.25	Sph, Py, Cp
2.Qixiashan												
3(5)	65.06	1.25	0.04	0.29	0.00	33.15	99.79	97.48	2.19	0.07	0.25	Sph, Gn, Py
4(5)	63.89	0.88	0.70	0.40	0.58	34.59	101.04	96.83	1.56	1.26	0.35	Sph, Py
5(22)	65.77	0.39	0.05	0.36	0.12	32.86	99.55	98.90	0.68	0.09	0.32	Sph, Gn, Py
8(19)	63.71	1.51	0.34	0.28	0.10	35.28	101.22	96.46	2.68	0.62	0.24	Sph, Py
13(11)	65.63	1.16	0.07	0.25	0.00	33.05	100.15	97.65	2.02	0.12	0.21	Sph, Py
14(7)	62.63	2.44	0.27	0.41	0.51	35.12	101.39	94.82	4.32	0.49	0.36	Gn, Sph
23(1)	58.62	6.80	0.03	0.74	0.03	35.19	101.42	87.44	11.86	0.06	0.64	Sph, Gn, Py, Marc
3.Tongling												
11(10)	54.38	11.42	0.14	0.27	0.00	33.95	100.16	79.89	19.63	0.25	0.23	Gn, Sph, Po, Cp, Py
4.Guichi (Cu)												
24(6)	65.74	0.06	0.00	0.30	0.30	35.13	101.53	99.63	0.10	0.00	0.27	Sph, Py, Tet
5.Guichi (Pb-Zn)												
9(3)	59.98	5.59	0.71	0.29	0.00	34.80	101.36	88.81	9.69	1.26	0.25	Py, Sph, Gn, Cp
10(3)	60.39	4.60	1.08	0.23	0.02	32.91	99.22	89.88	8.02	1.90	0.19	Sph, Gn, Py
6, 7.Dexing												
17(8)*	58.25	8.14	0.03	0.34	0.09	34.10	100.94	85.65	14.00	0.05	0.29	Sph, Aspy, Py
16(8)**	65.05	0.21	0.00	0.34	0.28	34.81	100.71	99.31	0.38	0.00	0.31	Sph, Gn, sid
8.Leping												
18(2)	54.18	11.84	0.20	0.18	0.28	32.88	99.56	79.22	20.27	0.35	0.15	Gn, Sph
19(3)	51.68	12.88	0.07	0.03	0.31	34.82	99.78	77.30	22.55	0.12	0.03	Sph, Gn, Py, Aspy
21(6)	53.54	11.76	0.25	0.22	0.36	33.78	99.91	79.05	20.32	0.45	0.18	Sph, Py, Gn
9.Jiujiang												
20(1)	53.73	11.75	0.10	0.38	0.04	34.66	100.65	79.23	20.27	0.17	0.32	Sph

*vein, **stratiform

istics of host rocks of the deposits.

Discussion

FeS content in sphalertie coexisting with iron-sulfides is controlled essentially by temperature and sulfur fugacity (Fig. 3). High temperature and/or low fs_2 conditions favor the formation of Fe-rich sphalerite; the FeS content is above 20 mole per cent in the stability field of pyrrhotite under low pressure condition, say below 1 kb, which is usual condition of hydrothermal ore deposits. Although detailed temperature and fs_2 conditions cannot be estimated for individual ore deposits in the Lower Yangtze area, the FeS variation of sphalerites obtained in this study is in accord with the mineral assemblages and geologic environments of the deposits. That is, the iron-rich sphalerites ($\geq 20\%$ FeS) occur in the intrusive-related deposits bearing pyrrhotite as a common ore mineral (Fig. 2), whereas FeS-poor sphalerites tend to occur in pyrrhotite-free deposits especially of low temperature bedded type (e.g., Qixiashan). Approximate estimates of fs_2-T condition for the bedded and intrusive-related deposits are illustrated in Figure 3 based on the sphalerite compositions and the assemblages of iron sulfides. Temperatures of the Qixiashan deposit are

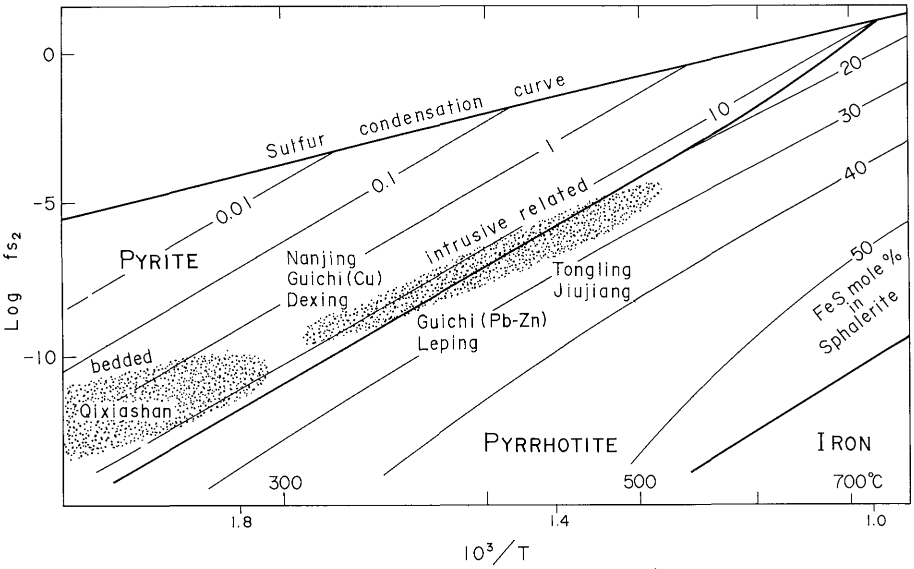

Fig. 3 Schematic illustration of fs_2-T condition of the studied deposits. Temperatures of the Qixiashan deposit are based on fluid inclusion data (see text), but others are approximate values common to skarn deposits (e.g., EINAUDI *et al.*, 1981). The log fs_2-T relation of Fe-Zn-S system is based on BARTON and SKINNER (1979).

based on the fluid inclusion data. The intrusive-related deposits may have formed in higher temperature conditions in which pyrrhotite locally becomes stable. Since temperature data for the individual deposits are not available, the range of reported temperatures for skarn deposits (e.g., EINAUDI *et al.*, 1981) was considered for the estimates in Figure 3. The intrusive-related deposits formed under the conditions near pyrite-pyrrhotite phase boundary. Among the skarn deposits, the Tongling and Jiujiang characterized by FeS-rich sphalerite and abundant pyrrhotite are related with relatively mafic and/or holocrystalline intrusives (quartz diorite and granodiorite), whereas the Nanjing and Guichi (Pb-Zn) deposits having intermediate FeS contents of sphalerite are related with more felsic and hypabyssal facies (quartz porphyry and granodiorite porphyry) (Figs. 1 and 4). This correlation suggests that the FeS-rich sphalerites formed in deeper and higher temperature environments. Fe-poor sphalerite from the Guichi Cu deposit is considered to have precipitated in the latest stage under low temperature conditions, because the ore occurs as veins cutting the early formed skarns. In the Dexing mine, FeS content in sphalerite is much higher in the vein ore (13.7 mole%) that is clearly related with volcano-plutonic activity than in the bedded ore (0.4 mole%). The high T/fs_2 condition of the Leping deposit suggested by FeS-rich sphalerites (18.3–24.6 mole%) implies a genetic relation of the deposit with intrusive activities. The occurrence of related igneous rocks is to be checked in more detail.

It is significant to compare the Qixiashan Pb-Zn deposit with the Mississippi Valley type deposits (NAKAJIMA and TAO, 1985). Sphalerites from the Qixiashan deposit show FeS contents varying from 0.3 to 11.9 mole per cent, though mostly below 6 per cent, and CdS contents ($\leq 0.5\%$) are always less than FeS contents. In the Mississippi Valley type deposits, Fe content in sphalerite is generally minor (e.g., HAGNI, 1976) and average Cd

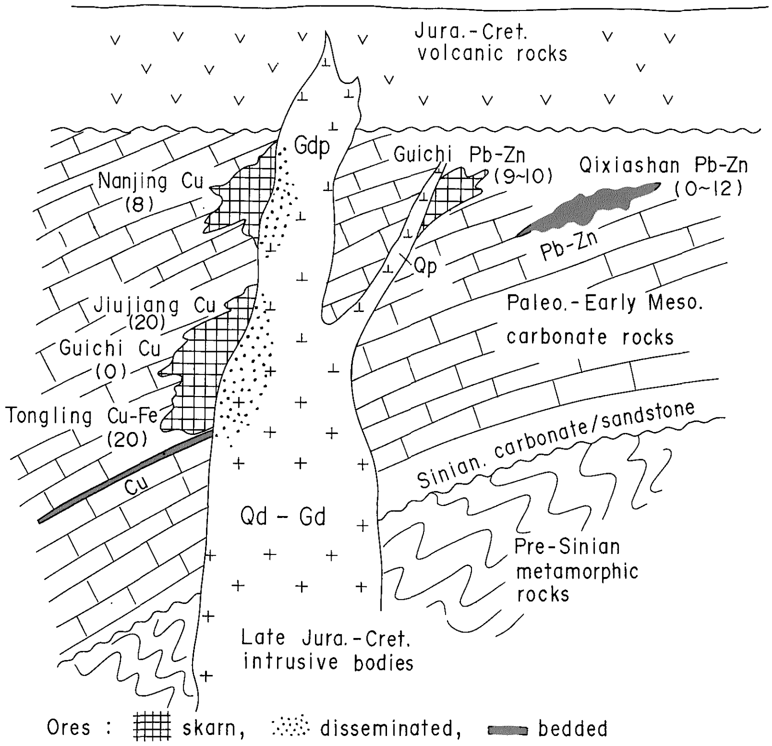

Fig. 4 Mode of occurrence of the studied deposits and FeS content of sphelerites (round number in parentheses) in the Lower Yangtze area. Dexing and Leping deposits on the Jiangnan Oldland are excluded.

content commonly exceeds that of iron, for example CRAIG *et al.* (1983) gave average Fe and Cd contents of 0.27 and 0.38 weight per cent, respectively, for sphalerites from 16 deposits in Tennesse. The filling temperatures of fluid inclusions are low, ranging from 40 to 150°C in the Mississippi Valley type (HAGNI, 1976). In the Qixiashan deposit, however, relatively high filling temperatures of 150–300°C were obtained for inclusions in sphalerites. The ores show intense recrystallization and pyrrhotite is found as a minor constituent (Qixiashan mine, oral communication, cited in NAKAJIMA and TAO, 1985). The relatively high temperatures indicated by the fluid inclusion measurement and low fs_2 and fo_2 conditions suggested by the association of carbonaceous materials would be responsible for the formation of Fe-bearing sphalerites in this deposit. Sulfur isotope ratios for sphalerite and galena from the Qixiashan mine fall in a narrow range around 0 per mil, which are similar to the $\delta^{34}S$ (CDT) values of ore sulfur in the intrusive-related deposits in the Lower Yangtze area (-1 to $+7$‰, av. near $+1$‰, WANG, 1982), suggesting "magmatic" origin of sulfur. It appears to be difficult to explain the $\delta^{34}S$ characteristics by a simple reduction model of seawater sulfate. Thus the Qixiashan deposit is different in some aspects from the typical Mississippi Valley type deposits and its genesis still remains as a matter of debate. It is likely, however, that the Qixiashan ores were modified by or genetically realted with hydrothermal activity caused by the Mesozoic igneous activity.

Finally, we discuss the relation between FeS content of sphalerite and characteristics of related igneous rocks. In the Japanese Islands, FeS-rich sphalerite accompanied by pyrrhotite tends to occur in the ilmenite-series granitoid terrains and this correlation was inferred to be due to reduced condition of solidifying magma (TSUKIMURA *et al.*, 1982). In the studied deposits FeS-rich sphalerite or pyrrhotite is not uncommon, then a question arises whether the igneous rocks also have ilmenite-series characteristics. Based on petrographical observation, biotite chemistry and whole-rock Fe^{+3}/Fe^{+2} ratio (YANG *et al.*, 1983; ISHIHARA *et al.*, 1985), the Yanshanian magmatism in the studied area is considered to have oxidizing nature similar to the magnetite-series, in contrast with the contemporaneous magmatism accompanied by W-Sn mineralization in southern China. Paucity of lithophile elements such as Sn, Be and F in the deposits is in accord with that of the magnetite-series terrain in Japan (ISHIHARA, 1977; SATO, 1980). The $\delta^{34}S$ characteristics of ore sulfur (WANG, 1982, ISHIHARA *et al.*, 1985) are also consistent with those of the magnetite-series ore sulfur in Japan and the southern Korean peninsula (SASAKI and ISHIHARA, 1980; SATO *et al.*, 1981). Therefore, the studied area is assigned to a magnetite-series terrain. CHON *et al.* (1981) reported chemical compositions of sphalerites from the representative hydrothermal deposits of Cretaceous age in the southern Korean peninsula, where Cretaceous magnetite-series rocks prevail. The sphalerites are rich in iron and the average FeS contents for the examined 14 deposits range from 6 to 21 mole per cent (mostly above 13%). In the Japanese Islands as well, FeS-rich sphalerites accompanied by pyrrhotite do occur in some part of the magnetite-series granitoid terrains, particularly of the Kitakami area (TSUKIMURA *et al.*, in prep.). It is also noted that FeS-poor sphalerites in Japan occur mainly in the vein deposits of the Miocene to Quaternary volcanic regions, but not in plutonic areas. Thus FeS content of sphalerite does not correlate directly with the magnetite- and ilmenite-series classification of related igneous rocks, but ore-forming environments need to be examined in detail in individual regions. The fs_2 condition at the site of ore deposition may also be influenced by chemistry of host rocks. For example, carbonaceous matter in host sediments could give rise to low fs_2 condition through such a reaction as $2H_2O+S_2+C=2H_2S+CO_2$. It is inferred, therefore, that the FeS content of sphalerite is related with chemical characteristics of host rocks as well as fs_2, fo_2 and temperature conditions of solidifying magma.

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Chinese expression of locality name:

Dexing	德兴	Guichi	贵池
Huangyang	淮阳	Jiangnan	江南
Jiujiang	九江	Leping	乐平
Nanjing	南京	Qixiashan	栖霞山
Tongling	銅陵	Yangtze	杨子

中国東部揚子江下流域の Cu, Pb–Zn 鉱床中の閃亜鉛鉱の化学組成

佐藤興平・侊　若木・晃　福為・李　文達

要　　旨

中国揚子江下流域に分布する Cu, Fe, Pb–Zn 鉱床のうち代表的な 8 鉱床について，鉱石中の閃亜鉛鉱の化学組成を EPMA を用いて検討した．閃亜鉛鉱の FeS 含有量は0.1から24.6モル%にわたるが，MnS と CdS の含有量はそれぞれ 1 モル%および0.5モル%以下のことが多い．1 モル%以上の MnS 成分を含む閃亜鉛鉱は菱マンガン鉱を伴う Pb–Zn 鉱床に見出され，Mn に富む生成条件を反映しているとみられる．

燕山期の貫入岩類に伴う鉱床中の閃亜鉛鉱は FeS 成分に富む(8–24.6モル%)．スカルン鉱床のうち，とくに FeS に富む閃亜鉛鉱を産する鉱床は，磁硫鉄鉱を含み比較的苦鉄質な貫入岩類に伴い，相対的に高温の条件下で生成したと考えられる．この地域の貫入岩類は磁鉄鉱系に区分され，日本列島や朝鮮半島のデータも合せると，閃亜鉛鉱の FeS 含有量と花崗岩系列の間に直接的な対応関係はみられない．

栖霞山層状 Pb–Zn 鉱床の閃亜鉛鉱は，FeS に比べ CdS が少なく(≲0.5モル%)，典型的なミシシッピバレー型鉱床の閃亜鉛鉱より FeS に富み(0.3–11.9モル%)，より高温の条件下で生成した．中生代の火成活動もしくは造構運動がこの鉱床の形成に関与した可能性がある．

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