中国南方锰矿地质

MANGANESE DEPOSIT GEOLOGY IN SOUTH CHINA

侯宗林　薛友智　主编

EDITORS: HOU ZONGLIN XUE YOUZHI

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内 容 简 介

本书是关于我国南方锰矿地质的科学论文集。全部论文都是在冶金工业部“八五”重点科技项目“扬子地台周边及其邻区优质锰矿成矿规律及资源评价”的有关子题研究成果基础上改写的，作者基本上是各级子题科研工作负责人。论文集以现代地学理论为支撑，以优质锰矿为主要研究目标，通过对优质锰矿成矿地质背景、时空分布规律、含锰沉积建造、含锰岩系、矿床成因类型、成矿作用机理、勘查技术方法等领域的研究，总结出关于我国南方锰矿地质的若干重要结论。本书可供锰矿地质勘查、生产、科研、教学单位参考。

《中国南方锰矿地质》编辑委员会

前　言

为了满足我国钢铁工业迅猛发展向地质勘查部门提出的资源需求，冶金工业部地质勘查总局在1991年4月召开的冶金地质科技工作会议上决定，于国民经济和社会发展第八个五年计划(1991～1995)期间，开展扬子地台周边及其邻区的优质锰矿地质科研工作。1991年5月，全国锰矿地质工作规划会议同意以课题系列形式实施这一锰矿地质科研计划。1991年8月，课题系列第一次工作会议在成都召开，讨论通过了由西南地质勘查局和天津地质研究院联合起草的项目立项论证报告、子题设置方案、项目管理办法及组织机构。赓即，冶金工业部行文批准把锰矿科研项目列为部"八五"重点科技项目。项目名称是："扬子地台周边及其邻区优质锰矿成矿规律及资源评价"，项目主持单位是冶金工业部地质勘查总局，项目负责单位是冶金工业部西南地质勘查局和天津地质研究院。项目参加单位有：冶金工业部中南地质勘查局、西北地质勘查局、地球物理勘查院、第二地质勘查局、北京科技大学、遥感中心、东北工学院(后更名为东北大学)。项目设综合组，负责规范制订、设计审查、质量监控和技术指导。项目设办公室，负责协调处理日常事务。项目下设5个Ⅱ级课题，22个Ⅲ级专题。冶金地质部门17个局、院、所、校、队的110多名各类技术人员参加了这个课题系列的科学研究工作。

锰矿地质科研项目工作，是在90年代先进地质科学技术理论和手段支持下，对中国南方锰矿地质开展的新一轮应用基础理论及应用技术研究活动。项目研究具有涉及地域广，科学系统性强，工作起始点高的显著特点。项目研究充分发挥了冶金地质系统的整体科研能力，参加人员多，学科手段广，时间跨度长，组织规模大，在不少领域中开展了创造性的工作，并推动中国南方锰矿地质研究工作进入到新的阶段。随着锰矿地质科研计划的实施，我国锰矿地质勘查工作也取得了重大的成就。

截至现在，锰矿地质科研项目下属的所有子题工作都已顺利结束，科研成果也已接受冶金工业部或其委托单位主持的审查鉴定，部分成果已正式出版。本文集即是根据锰矿地质科研成果改写成的科学研究论文的汇集。撰稿人基本上是相关科研题目的负责人。借此，向中外同行们交流我们的工作，并以此向第30届国际地质大会献礼。

项目研究工作始终得到冶金工业部主管领导同志的关心和支持，冶金部地质勘查总局提供了良好的组织条件和工作条件，技术负责人对项目工作进行了具体指导和帮助。参加项目工作的西南地质勘查院、天津地质研究院、中南地质勘查院、地球物理勘查院、西北地质勘查局、第二地质勘查局的有关领导对项目研究给予了大力协助。项目研究工作还得到国际地质对比计划IGCP318中国工作组、中国科学院、地质矿产部、中国有色金属总公司、中国地质大学、中国地质科学院的有关专家的指导、帮助及资料支撑，借此一并表示衷心的谢意。

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Mn ore with values of P/Mn$<$0.005 and Mn/Fe$>$4 are specified as high quality Mn ore, otherwise, faulty Mn ore.

Prospecting assessment of high quality Mn ores and industrial utilization of faulty Mn ores remain the two problems for Mn resource in China. In order to meet needs of the metallurgical industry, China has imported high quality and rich Mn ores for many years.

The Ministry of Metallurgical Industry of China is changing the high-quality-Mn-ore-importing situation by establishing a "Mn ore tecnology committee" to deal with industrial utilization of faulty Mn ores (including poor ore, ore with complexed composition and the very fine grain ore) and organizing researches on prospecting assessment of high quality Mn ore to increase reserves. Results of the prospecting assessment are as follows.

1 Geological Features of Major high-quality Mn Ore Deposits

1.1 High quality Mn ore deposits in Middle-Late Proterozoic rocks

1.1.1 Baye-Mengsong-Jingkang Mn ore belt through the boundary China and Burma

In recent years gondite type Mn ore deposits have been discovered in green schist facies of mica schist in Huimin Formation of Middle Proterozoic Lancang Group which occurs in Lincang interblock, Southwest Yunnan Province. The primary ore is composed of rosy rhodonite, grey white mangnesian garnet, tephroite and minor magnesian riebeckite and hedenburgite. After supergene oxidation it becomes high quality and rich Mn ore with enrichment of Mn, Al and deple-

tion of Si, Ca and Mg and the primary Mn-silicate minerals changed to todorokity and orientite. The primary and oxidized ore minerals are listed in table 1.

Table 1 Ore types, ore minerals and chemical analysis of Mn ore in Baye-Mengsong-Jingkang Mn ore belt

No	ore type	ore mineral		chemical composition (%)						
		common	minor	TMn	TFe	SiO_2	Al_2O_3	CaO	MgO	P
1	rosy rhodonite ore	rhodonit	manganesian garnet	24.43	2.26	43.56	8.90	5.40	5.38	0.055
2	grey white manganesian garnet ore	manganesian garnet	tephroite	29.98	3.36	33.12	7.30	5.80	4.55	0.089
3	grey white manganesian garnet ore	manganesian garnet	tephroite	31.63	3.09	33.58	8.50	4.50	6.25	0.110
4	brown oxidized ore	todorokite	orientite	33.46	3.81	8.68	7.90	0.23	0.07	0.046
5	brown oxidized ore	todorokite	orientite	42.53	2.52	10.52	16.10	0.67	0.33	0.076

The ore belt extends about 70km from Baye, Menghai in the north, NanLeHe River banks of Jingkang in the south. Two primary ore beds are totally 50m thick. One million tons of high quality and rich Mn ore (Mn>40%) has been mined from the ore belt in the period of 1991 – 1995. The total Mn reserve for the belt is estimated at 2 billion tons. This is really a world-scale Mn ore deposit.

1.1.2 Lijiaying Mn ore deposit, Shanxi Province

The mining area is located in Donghuang Xiang, Ningqiang county. A paved way can access to the mine from Daijiaba railway station at a distance of 11km. It covers an area of 1.5km^2(3km(S-N)×0.4~0.7km(E-W)).

Lijiaying Mn ore deposit occurs in the green schist facies of red Mn-siliceous limestone and Ca-mica slate of Guojiagou Formation of Proterozoic Bikou Group in the NE side of Motian-ling folding belt. In the same horizon Mn ore occurances have been found at Lianghekou, Shigunba, Hudouwan, Gangouxia and Zhengjiaba. In the deposit braunite is the common ore mineral, manganese calcite, manganese amphibole, rhodonite and piedmontite are the minor ore minerals and gangue minerals are calcite, quartz, anorthose, chlorite and barite. In the ore samples from Lianghekou kuttenburgite, friedelite are the common ore minerals, and some rhodochrosite; gangue minerals, quartz and the very rare mica. The deposit consists of ten ore bodies in layer, layered, lense and pod forms. They are folded simutaneously with the host rock. Orebody I is the biggest one, covering 90% of the total reserve of the deposit. It extends 1404.50m in strike and 553m to depth. The average thickness is 2.81m(0.5 – 11.79m). The banded braunite ore prevails over the ore body. The chemical analysis is Mn = 15.01% – 44% (average = 22.28%), P/Mn 0.0024, Mn/Fe = 8 – 12, CaO = 17.95% and SiO_2 = 23.92%. At Lianghekou Mn ore is massive with values of Mn = 37.63%, SiO_2 = 29.19%. Ore reserve(A + B + C + D) of 5 milliontons has been obtained in the area.

1.1.3 Qujiashan Mn ore deposit

The mining area is located geographically at the boundary between Ziyang county and Zhenba

county, geotectonically, in the Longmenshan-Dabashan marginal folding belt in the north margin of Yangtz pene-platform, metallogenically, at the middle part of Bashan Mn ore belt. Mn ore occurrances at Shibaoshan, Liziya and Shuijingping in the north of Qujiashan Mn ore deposit were found in grey green or purple red shales of Doushantuo Formation of Late Sinian Epoch which hosts Qujiashan Mn ore deposit. Seven ore bodies of the deposit are strictly controled by the shales and closely fold together. Ore bodies are 345 – 555m long extending 87 – 350m to depth with thickness 0.5 – 6.23m. Ore is characterized by alternated bands of pinkish red rhodochrosite, blackish-brown braunite, yellow and brown bementite and purple red argillaceous materials. Ore value are Mn = 10 – 43.44% (average = 21.45%), P/Mn = 0.003, Mn/Fe = 8, SiO_2 = 29.74%. The reserve(B + C + D) obtained is 3 million tons.

1.2 High quality Mn ore in rocks of Middle – Late Ordovician Epoch

1.2.1 Taojiang Mn ore deposit, Hunan Provinec

The deposit is in the southwest of Taojiang county at a distance of 41km locating in a series of open folds with axial line roughly trending in E-W direction at the passive continental margin of Jiangnan Palaeo-continent. From north to south the deposit is divided into Muyusha, Nanshichong, Modaoxi, Doulishan and Heiyandong mining domains, Mn ore is hosted by massive limstone of Modaoxi Formation (Middle Ordovician Epoch) which is intercalated with black shale. There are two ore beds. The lower ore bed is the main one stablely distributed in the whole mining area in layer or layered form with thickness of 0.3 – 1.0m(the maximum = 4.73m, average = 0.92m). Above a metre interval is the upper ore bed which is composed of banded carbonate ore and black shale intercaliths. The lower ore bed includes massive and banded ore . Ore values are Mn = 15 – 30% (17 – 21% averagely), Mn/Fe > 5, P/Mn = 0.0009 – 0.0046. The ore is basically alkalic. Ore minerals are rhodochrosite, greinerite, mangnocalcite, then Mn – bearing calcite and dolomite; gangue minerals are dominated by calcite, dolomite and quartz. The banded ore is composed of the algal laminae Mn-carbonate layer. and the very thin black layer or grey white Mn layer and sarco-red Mn layer. The massive Mn ore is homogeneously made up of Mn carbonate is sarco-red or grey colour. It is common to see micrite, organic clastics, such as algae, spongy bone needle, ostracoda and oolite. The proved reserve is about 20 million tons.

1.2.2 Jiaodingshan Mn ore deposit, Sichuan Province

The deposit is located in the northeast of Hanyuan County town at a distance of 18 km and 23 km to Jinkouhe Railway station. It was formed in the intraplate basin at the northeast margin of Kangdian Geoaxis. The mine area is dominated by a brachy-axis syncline. There are seven ore bodies of which six are concentrated in the north end of the syncline. All of them occur in layered and lense form conformable with the host rock. Ore body I is the biggest one about 1000m long, 600m wide and 1.5m thick (averagely). Mn grade is 8 – 42%. Ore with Mn values more than

25% covers 80% of the total reserve. The rich ore is high quality Mn ore (Mn/Fe>8, P/Mn< 0.002), the poor, faulty Mn ore. Ore is hosted by micro-crystalized limestone and dolomitic mudstone of Upper Ordovician Wufeng Formation. Algal laminae is found in rhodochrosite ore layer; the abyssal organism, inarticulata brachiopoda and graptolite in black shale and mudstone. Ore is characterized by massive, banding, breccia structures and micro-crystalline, oolitic, fibrous and radiate textures. Rhodochrosite, manganocalcite, manganodolomite, minor hausmannite, manganosite, rhodonite and lemenite are ore minerals: calcite, chlorite, quartz, minor barite, adularia, hematite, magnetite, pyrite and perkerite, are the gangue minerals. The mineralogy is so complicated that manganosite stable under special condition occurs in the ore. Including Dawashan Mn ore deposit the proven reserve in the area is 2 million tons.

1.3 High quality Mn ore in rocks of Middle－Late Triassic Epoch

1.3.1 Heishui Mn ore deposit, Sichuan Province

Heishui Mn ore deposit is situated in Heishui county, in the west part of Shidaguan are structural belt of Bayankela miogeosynclinal folding belt pertaining to Songpan-Ganzi folding sys tem. Tens of Mn ore deposits, occurances known nowadays in the county are distributed in the south and north limbs and the east and west pitch ends of (W-E) Waboliangzi - Simeigou bracky anticlinorium. Deshigou is the only area which has been explored in an area of $4km^2$. Ore beds are hosted by multi-coloured and fine-grained clastic rocks of Zhaganshan Formation of Mn-Ca siltstone silty and phyllitic chlorite rocks within Middle Triassic Series. Ore bodies in layer, layered and lense form deformed into close folds, even into overturned isoclinal folds together with the host rocks. According to contents of Mn-silicates, Mn-carbonate, and Mn-oxides ore is diveded into three types: ①Mn-silicate and Mn-carbonate ore which is subdivided into massive ore in cream yellow or grey white colours domianted by rhodochrosite, massive ore colour of pig- liver dominated by manganesian garnet and banded ore made up of grey rhodochrosite band, pink red greinerite band and earthy yellow manganesian garnet and pod-like ore; ②the massive primary oxidation ore which is dominated by braunite and accompanied by rhodochrosite, ganophyllite, mangno-flogopite, gamsigradite and richterite; ③Fe-Mn ore which is dominated by magnetite and manganesian garnet. All the Mn ore deposits and occurrences in the area are similar in ore type. structure and texture and chemical composition. 38 economic ore bodies are located at Deshiwogoul, Duerbu and Duowo. They are 50－1160m long, 0.6－4.03m thick. Ore values are Mn=15.01－23.02%, Fe =5.61%, SiO_2=35.68%, P=0.064%, Total reserve is 4.5 million tons.

1.3.2 Dounan Mn ore deposit, Yunnan Province

The deposit is situated in Jumei village, Ashe county, about 18km to Pingyuanjie. It can be accessed by a paved way. The mining area is composed of Gake, Kata, Bâigu and Milike domains

covering and area of 11.8km^2. Geotectonically, the mining area is located in the west part of Youjiang folding belt of the South China fold system in the north margin of the southeast Yunnan palaeo-continent. Dounan syncline, a bracky syncline with axis trending N50° – 70° E preponderates the mining area. Mn ore occurs in silty mudstone with intercalith of minor argill acous limestone of Falang Formation pertaining to Triassic Series. Fossils of radiolaria and foraminifera can be seen in the limestone. There are 16 ore beds of which the lower and the upper are the two main ore beds in length of 2154 – 2320m, width of 500 – 1000m and thickness of 1.30 – 1.50m. Mn grade of the supergene oxidized ore is averagely 39.52%. In the primary ore 71% is high quality Mn ore with an average Mn value = 23.26%, low value of P, Fe and Si and big fire loss values. Braunite, manganite and minor hausmannite, bementite are the primary oxidation Mn minerals; greinerite, manganocalcite, Mn-bearingcalcite and rhodochrosite are the primary Mn-carbonate minerals. The primary ore is characterized by the common olitic, pisolitic texture and banded, massive and taxitic structure. It is the first primary sedimentary oxidation Mn ore deposit in China discovered in marine environment. The proven reserve is 2 million tons.

1.3.3 Baixian Mn ore deposit, Yunnan Province

Located in Baixian village, Jianshui county the deposit covers an area of 8.3km^2 consisting of Pingtai, Luzhai and Shitouzhai domains. The mining area is in the west end of Youjiang fold belt of the South China fold system in the northeast side of Ailaoshan Mountain metamorphic belt and in the southwest side of granite area of Gejiu tin Mine. An open brachy-syncline dominates the whole mining area . Mn ore beds occur in Mn-bearing limestone or dolomite of Falang Formation within Trassic series and deformed into folds simultaneously with the host rocks. In Pingtai domain there are five ore beds and 92 ore bodies. Ore body I is the biggest primary ore body which is predominated by layer or layered rich ore covering 85% of the total reserve. It is 796m long, 2 – 6m(the maximum, 30 – 40m) thick extending 500m along dip. Ore occurs in three types: ① Primary oxidation ore with Mn value of 18 – 30% consists of hausmannite, braunite, jacobsite with band and laminae structure; ②Mn-carbonate ore with Mn value of 18 – 25% is composed of rhodochrosite, manganocalcite and braunite and characterized by the alternated band and laminae of the minerals; ③ supergene oxidized ore with banding, massive, botry oidal, honeycomb and powder texture is made up of pyrolusite, todorokite, chalcophanite, lithiophorite, rancieite, Mn grade is 32 – 48%, values of $MnO_2 > 55\%$, $Fe < 6.5\%$ meet the requirements of battery Mn ore. The proven rich Mn ore reserve in the area is 12 million tons.

1.3.4 Heqing Mn ore deposit, Yunnan Province

Being located 5km northwest of Heqing county town, Heqing Mn Mine consists of Houzipo, Wujunshan and Xiao Tianjing fold domains in the south end of the marginal Yangyuan-Lijiang fold belt pertaining to Songpan-Ganzhi fold system at margin of Yangtze Platform. Mn ore occurs in thin-medium-thick limestone (containing foraminifera and radiolaria fossils) in grey white colour and thin argillaceous limestone in grey colour of brick extending(NWW) about 5 km. In ore bed can be recognized three sedimentary layers from bottom to top which are ① the one-me-

tre-thick massive ore layer in cherry red colour whose Mn grade is 65%; hausmannite and rhodochrosite are ore minerals; ②Banded ore layer thick but quite variable in thickness and Mn grade with be-mentite, Mn-bearing calcite and rhodochrosite as ore minerals; ③1.5 m – thick brecciated ore layer which is low grade Mn ore containg Mn-bearing calcite. The main ore body in Xiaotianjing domain takes form of a long belt extending 670 – 870 m along strike and 90 – 110 m along dip. It is 0.5 – 20 m thick(average = 4.1 m) with Mn grade about 40%. Hausmanite, rhodochrosite, bementite and jacobsite are main ore minerals; calcite, dolomite, quartz and opal are the main gangue minerals; pyrolusite Nsutite, The supergene oxidation Mn minerals. The proven reserve is 3 million tons for high quality and rich ore.

1.3.5. Bingzhuang Mn ore deposit, Yunnan Province

The deposit is 3 km north in the Shaheba reservior, HouqingXiang, Yunxian County locating in the north part of volcanic rock belt of Lancang arc pertaining to Sanjinang fold system. The natives are mining in Xiaolongtan, Banpo and Dayangqing. The mining area is 3 km long showing 28 ore layers. The host rock is purple sumacoitic crystal tuff which is stratigraphically lower than that of Heqing Mine. Rich ore layer is 0.1 – 0.2 – 0.5 mthick at surfacial exposure but it is 1.5 – 2 – 3 m thick in mining pit. Braunite and high temperature sanidine are the only ore mineral and gangue mineral respectively (Table 2).

Table 2 Ore analysis of Bingzhuang Mn ore deposit

No	Location	Sampling trentch length	ore type	analysis (%)			
				Mn	Fe	P	SiO_2
1	Dayangjing	3 m	massive oxidation ore	52.30	0.67	0.007	10.05
2	Shiganjing	3 m	massive oxidation ore	46.53	1.13	0.04	9.24
3	Shiganjing	2 m	massive oxidation ore	39.24	1.75	0.042	23.08
4	Shiganjing	2 m	Mn-bearing rock	13.42	4.07	0.07	41.80

Three ore types can be recognized, i.e., stockwork and taxitic primary oxidization ore, dissemiated ore and massive primary oxidation ore. The deposit remains yet to be assessed and explored. The potential reserve may be 3 million tons

1.4 High quality Mn ore in faulty Mn ore deposits

1.4.1 Chatun Mn ore deposit

Being one of the domains of Hurun Mn Mine, Jingxi county, the Chatun Mn ore deposit is hosted by calc-mudstone, siliceous limestone, marlite and siliceous shale of lower Wuzhishan Formation (late Devonian Epoch) in Xiangui depressed belt in the South China fold system. Stratigraphically, the host rock is corresponding to that of Xialei Mn ore deposit, Guangxi