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贵州铜仁松桃锰矿盘信幅 1：50 000 矿产地质图数据库

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摘要：贵州铜仁松桃锰矿盘信幅 (H49E024005)1：50 000 矿产地质图数据库是以中国地质调查局《矿产地质调查技术要求 (1：50 000)》(DD2019–02) 为标准, 开展的新一代 1：50 000 矿产地质调查工作系列成果之一。本次工作梳理了盘信幅调查区的岩石地层层序, 厘定了 39 个填图单元, 划分了 8 个建造类型, 重点划分了 5 个成因相互关联的含锰建造填图单元。该数据库为 MapGIS 格式, 数据内容主要由地理图层、建造构造图层、矿产地图层和整饰图层等组成, 并包含 150 个岩石化探分析数据、333 个一般岩矿分析数据、90 个锆石 U–Pb 年龄数据、6 条矿产地信息、2 种矿床类型。该数据库以重点突出含矿建造、控矿构造和矿化蚀变信息为特色, 为锰矿资源研究、能源勘探、矿产资源规划等提供基础资料。

关键词：锰矿整装勘查区；盘信幅；矿产地质图；数据库；矿产调查工程；铜仁；贵州
数据服务系统网址：http://dcc.cgs.gov.cn

1 引言

锰是新能源电池、新材料等战略新兴产业和钢铁冶金的关键材料, 对外依存度超过 60% (陈甲赋等, 2015), 寻找锰矿是我国的一项重要战略任务。贵州铜仁松桃锰矿国家整装勘查区, 是中国南方南华纪“大塘坡式”锰矿最重要的富集区。该区按照大地构造单元划分 (潘桂棠等, 2009), 属于上扬子陆块南部碳酸盐岩台地 (VI–2–4); 按照《中国成矿区带划分方案》(徐志刚等, 2008), 属于滨太平洋成矿域 (I– 4) 的扬子成矿省 (II–15)、III 级成矿单元中属于上扬子中东部 (坳褶带)Pb–Zn–Cu–Ag–Fe–Mn–Hg–Sb–P–铝土矿–硫

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铁矿成矿带 (III–77); 按照华南南华纪锰矿成矿区带划分 (周琦等, 2016a), 位于南华裂谷盆地锰矿成矿区、武陵锰矿成矿带、石阡–松桃–古丈锰矿成矿亚带。盘信幅即位于该锰矿整装勘查区核心区域 (图 1)。

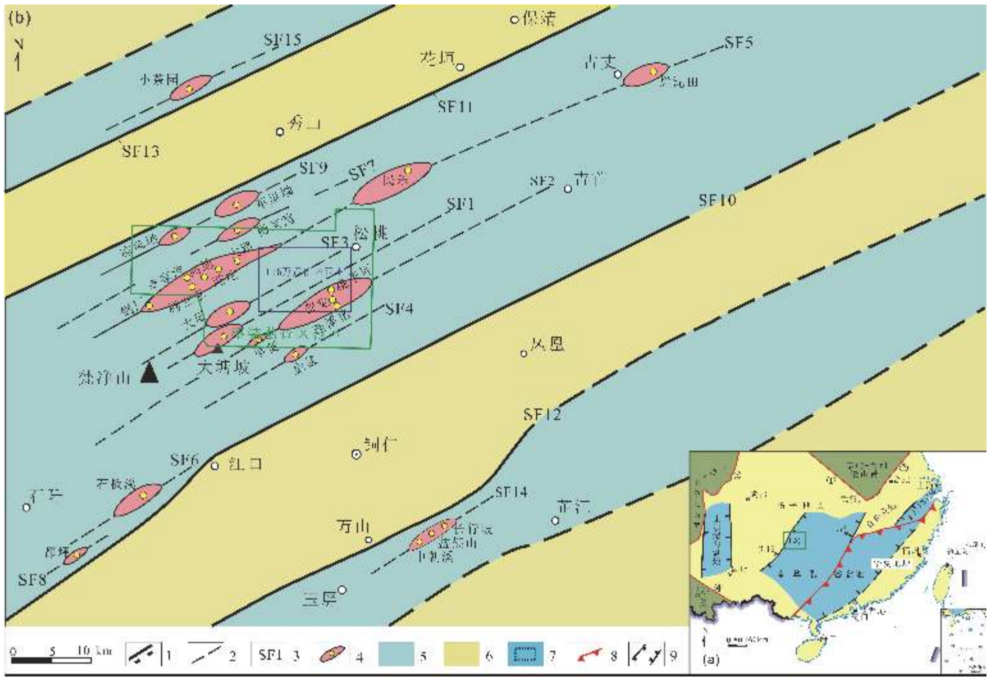

图 1　黔东及毗邻区南华纪早期武陵次级裂谷盆地结构与构造古地理图 (据周琦等, 2016b 修改)

1—控制Ⅲ级断陷盆地和隆起的同沉积断层; 2—控制Ⅳ级断陷盆地和隆起的同沉积断层; 3—同沉积断层编号; 4—Ⅳ级断陷盆地及所控制的锰矿床名称; 5—Ⅲ级断陷盆地; 6—Ⅲ级隆起; 7—主要研究区范围; 8—区域性断裂及地块边界; 9—一级裂谷盆地边界; ①, ②—秦岭—大别山断裂带; ③—龙门山—盐源断裂带; ④—红河剪切带

贵州铜仁松桃锰矿国家整装勘查区 1∶50 000 区域地质调查工作始于 20 世纪 80 年代中期, 至当前已基本完成, 基于 1∶50 000 精度的物探、化探等基础性、面积性工作程度低。自 2000 年以来, 贵州省地矿局 103 地质大队与中国地质大学 (武汉) 长期的产学研协同攻关, 发现了南华纪“大塘坡式”锰矿是一种新的锰矿床类型——古天然气渗漏沉积型锰矿床 (周琦和杜远生等, 2012, 2019; 周琦等, 2013; 刘雨等, 2015a, 2015b), 改变了传统认为的海相沉积型锰矿床认识。随后, 厘清了锰矿大规模成矿作用的独特地质背景和构造古地理格架 (周琦等, 2016b)，建立了锰矿裂谷盆地古天然气渗漏成矿理论和深部隐伏矿找矿预测模型 (周琦等, 2017), 同时依托贵州铜仁松桃锰矿国家整装勘查区和贵州省整装勘查区实践检验平台, 先后发现了松桃西溪堡、松桃道坨、松桃高地和松桃桃子坪 4 个世界级隐伏超大型锰矿床, 实现了我国锰矿地质找矿有史以来的最大突破 (周琦等, 2016a)，为本次矿产地质调查工作提供了丰富的资料基础。

本次 1∶50 000 盘信幅矿产地质图及建立的数据库, 是在充分利用 1∶50 000 区域地质调查成果[1]、矿产勘查和科研成果资料基础上, 采用数字地质调查技术, 应用室外与室内相结合填 (编) 图的方法, 以南华纪“大塘坡式”锰矿为主攻矿种, 重点围绕划分和建立南华纪成矿期含锰建造填图单元、识别填绘锰矿成矿期同沉积断层和后期对锰矿保存条件产生影响的构造开展锰矿专项填图工作, 是以找矿预测为主要目的矿产专项填图成果。贵州省盘信幅 1∶50 000 矿产地质图数据库 (刘健等, 2020) 的元数据简表如表 1。

表 1 数据库 (集) 元数据简表

条目	描述
数据库(集)名称	贵州铜仁松桃锰矿盘信幅1：50 000矿产地质图数据库
数据库(集)作者	刘　健, 贵州省地质矿产勘查开发局一〇三地质大队 袁良军, 贵州省地质矿产勘查开发局一〇三地质大队 谢小峰, 贵州省地质矿产勘查开发局一〇三地质大队 占朋才, 贵州省地质矿产勘查开发局一〇三地质大队
数据时间范围	2016—2018年
地理区域	经纬度: 东经109°00′ ~ 109°15′, 北纬28°00′ ~ 28°10′
数据格式	*.wp, *.wl, *.wt
数据量	39.7 MB
数据服务系统网址	http://dcc.cgs.gov.cn
基金项目	中国地质调查局地质调查项目“整装勘查区找矿预测与技术应用示范”子项目(121201004000160901–36)资助
语种	中文
数据库(集)组成	盘信幅1：50 000矿产地质图数据库包括: 地理图层、建造构造图层、矿产地图层及整饰图层。地理图层包括主要行政境界、主要居民点、主要面状水系、主要线状水系、主要地理标注等。建造构造图层包括: 建造构造(地质面实体)、地质(界)线、褶皱、断裂、同沉积断层、产状要素、同位素年龄等。矿产地图层: 矿产地。整饰图层分为图内部分和图外部分, 图内整饰图层包含地质注记与建造花纹、指引线、断层倾向、倾角及断层性质、产状倾角注记、同位素注记、图切剖面等。图外整饰图层包含接图表、中国地质调查局局徽、图名、比例尺、坐标参数、责任签、图例、沉积岩建造柱状图、图切剖面图、矿种及规模、矿产地名录、所处成矿区带位置图、含矿建造分布图、典型矿床地质图及剖面图、含矿期建造柱状图、含矿建造与古喷溢口群分布图等

2 数据采集和处理方法

2.1 数据基础

贵州省盘信幅 1：50 000 矿产地质图以《矿产地质调查技术要求 (1：50 000)》(DD2019–02) 为标准, 在系统收集贵州省盘信幅 1：50 000 区调地质调查成果[❶]资料 (包括实际材料图、剖面图、记录本)、锰矿勘查资料[❷❸❹❺](包括矿床实际材料图、勘探线剖面图、钻孔柱状图、钻孔编录原始记录本等) 及地质调查研究成果[❻❼](包括成果报告、附图及附表等) 资料基础上, 结合本次盘信幅 1：50 000 矿产地质专项填图新成果, 利用数字填图系统 (DGSS)、MapGIS 等软件进行原始数据整理和成果图件综合编制。原始数据采集过程中采用 1954 年北京坐标系, 后对成果图件进行了坐标系转换, 数据投影类型为高斯克吕格投影, 椭球参数为“2000 国家大地坐标 (CGCS 2000)”。

2.2 数据处理过程

2.2.1 数据准备

本次工作收集到的盘信幅 1：50 000 区域地质调查实际材料图 (4 幅 1：25 000 图幅: H49F047009、H49F047010、H49F048009、H49F048010) 均为 MapGIS 点、线、面文件, 地图参数正确, 采用高斯–克吕格投影, 6 度带投影, 坐标系统为 1954 年北京坐标系, 无需进行数字化处理, 可直接作为数字填图的基础图层使用, 为本次工作提供了良好的基础数据。

1∶50 000 图幅需选用 1∶25 000 的手图作为基础进行野外数据采集。在收集到的 4 幅 1∶25 000 图幅野外总图库中完成野外路线的设计工作，形成野外手图工程。

2.2.2 野外数据采集

野外手图工程形成后，通过数据交换，从桌面系统转出至掌上机系统，通过掌上机进行野外数据采集初步建立数字填图 (PRB) 数据库。野外专项地质填图主要采集数据简介如下：

(1) 地质点 (P 过程)：野外采集信息包括路线号、地质点号、坐标、微地貌、点性、露头、风化程度、位置说明、填图单位、接触关系、地质描述等。

(2) 分段路线 (R 过程)：野外采集信息包括路线号、地质点号、R 编号、方向、分段距离、累计距离、填图单位、岩石名称、沿途地质描述等。

(3) 地质路线 (B 过程)：野外采集信息包括路线号、地质点号、R 编号、B 编号、界线类型、接触关系、左侧填图单位、右侧填图单位。

除上述外，野外专项地质填图对沿途所见的产状、采样、照片、素描等信息均进行了采集。对物探、化探、遥感、探矿工程资料均做了采集。本次物探剖面测点原始数据采集音频大地电磁测深各类数据，反演后形成物探剖面成果图件。从遥感图中提取各类遥感异常、线形和环形构造等信息完善图层属性。

2.2.3 室内 PRB 数据整理

由于野外工作的环境与时间限制，野外采样的数据往往比较粗糙，在室内进一步做了补充完善。通过数据交换，从掌上机系统转出至桌面系统。重点进行数据属性完善，补充路线小结与检查。

2.2.4 图幅 PRB 库 (野外总图库) 汇总

完成单条路线的数据整理之后，通过“路线数据入库”，将其汇总到图幅 PRB 库。

2.2.5 建立实际材料图

通过“更新野外总图库到实际材料图”，将野外总图库文件继承到实际材料图，在实际材料图中结合本次野外实际采集的数据与区域地质调查实际材料图进行综合，重新连接地质界线，拓扑造区形成地质体并完善地质界线、地质面要素的属性和图式图例等内容。

2.2.6 建立编稿原图

完成 4 幅 1∶25 000 的实际材料图之后，将 4 幅 1∶25 000 的实际材料图依次投影到 1∶50 000 编稿原图中，完成 4 幅 1∶25 000 的实际材料图接边工作、1∶50 000 图幅拓扑工作及图框外的各种图式图例的整理，最终形成完整的编稿原图。

2.2.7 建立空间数据库

按照《数字地质图空间数据库标准》(DD2006–06) 的建库要求，地质图空间数据库需要包含 15 个基本要素类、8 个综合要素类、12 个对象类及图式图饰等独立要素类。具体建库操作包括以下几个基本步骤：①进入空间数据库建库环境，生成标准属性结构的要素类和对象类文件；②从编稿原图的相关文件中提取信息到基本要素类，并编辑完善基本要素类属性；③根据地质图特点，建立相关综合要素类，并编辑完善综合要素类属性信息；④从要素类提取信息到对象类，并完善对象类属性；⑤在图件整饰过程中，增加地质代号注释等信息，增加接图表、综合柱状图等独立要素类信息，形成完整的空间数据库。经过以上操作过程，初步建设完成原始空间数据库，可转入矿产地质图数据库编制。

2.2.8 矿产地质图编制

矿产地质图是以建造构造图为底图, 反映矿产地、矿 (化) 点类型、成因、规模及其他矿产信息的一类客观性成果图件。为全面反映本次开展的 1∶50 000 盘信幅矿产地质调查成果, 以“南华纪锰矿裂谷盆地古天然气渗漏沉积成矿系统理论与找矿预测关键技术方法体系”为指导, 以《矿产地质调查技术要求 (1∶50 000)》(DD2019–02) 为依据, 按照“三突出”(即突出主要含矿建造、突出控矿构造和突出矿化蚀变信息) 和“三协调”(协调主图与角图、协调平面与剖面、协调主图内各要素之间的关系) 要求开展矿产地质图的编制。

(1) 建造构造图

建造构造图是以本次专项填图实测完成的实际材料信息与收集以往 1∶50 000 区域地质调查信息综合编制而成的实际材料图, 是开展成矿规律研究、找矿预测的客观性基础图件。具体反映和表达调查区内沉积岩、岩浆岩、变质岩等各类建造, 以及褶皱、断裂等构造的地质特征、空间分布和相互关系, 突出反映各类建造、构造与成矿的关系。图面包括主图、各类建造柱状图, 以及构造、矿化蚀变、图例等内容。主图包括各时代地层组 (段) 级岩石地层单元，实测的与成矿有关的建造、构造、地质界线，及其他面状与线状地质要素、产状等。

(2) 建造柱状图

包含沉积岩建造柱状图和南华纪成矿期建造柱状图。沉积岩建造柱状图是对主图中岩石地层单元的建造特征的详细表达, 通过对以往区域地质调查填图地层单元的梳理, 结合本次工作成果, 全面总结了区内沉积序列的岩石组成和结构构造, 重新建立了调查区的岩石地层层序。以全国最新地层表为依据, 本次矿产调查共厘定了 39 个填图单元, 并对建造类型进行了划分。南华纪成矿期建造柱状图 (图 2) 是根据锰矿裂谷盆地古天然气渗漏沉积成矿系统模式和构造古地理单元特征建立的, 划分了 5 个建造构造填图单元, 包括: ①富锰页岩建造 (Nh_2d^{1a}), 对应锰矿古天然气渗漏沉积成矿系统中心相的一套黑色炭质页岩建造构造组合, 以发育古天然气渗漏沉积构造、凝灰岩或凝灰质粉砂岩透镜体, 特别是被沥青充填的气泡状及块状菱锰矿石类型为特征; ②贫锰页岩建造 (Nh_2d^{1b}), 对应锰矿古天然气渗漏沉积成矿系统过渡相的一套黑色炭质页岩建造构造组合, 夹部分块状和条带状菱锰矿体; ③含锰页岩建造 (Nh_2d^{1c}), 对应锰矿古天然气渗漏沉积成矿系统边缘相的一套黑色炭质页岩建造构造组合, 夹少量薄层条带状菱锰矿体; ④黑色页岩建造 (Nh_2d^{1d}), 为一套无锰矿产出的黑色炭质页岩建造构造, 相当于 III 级地堑盆地黑色页岩相; ⑤盖帽白云岩建造 (Nh_2d^{1e}), 对应隆起 (地垒) 区大塘坡组底部的盖帽白云岩, 与锰矿是同时异相的沉积产物。南华纪成矿期建造构造柱状图揭示了南华纪成矿期不同沉积环境 (IV 级地堑盆地区、地垒区) 岩 (矿) 石组合特征、锰矿成矿作用特征标志与成矿要素等信息, 为锰矿专项填图单元划分提供重要依据。

(3) 图切剖面

为有效反映图幅内总体建造和构造特征及其与矿化的关系, 编制了 2 条贯穿全区的图切剖面, 一条为北西向、另一条为北北东向。图幅区内超大型锰矿床均隐伏在地下 1 000 m 以下, 因此增加了切穿普觉、桃子坪 2 个超大型锰矿床和西溪堡中型锰矿床的图切剖面, 避免了锰矿床 (点) 因为水平投影在地表出露的寒武系中, 而产生锰矿体赋存在寒武系中的误解。

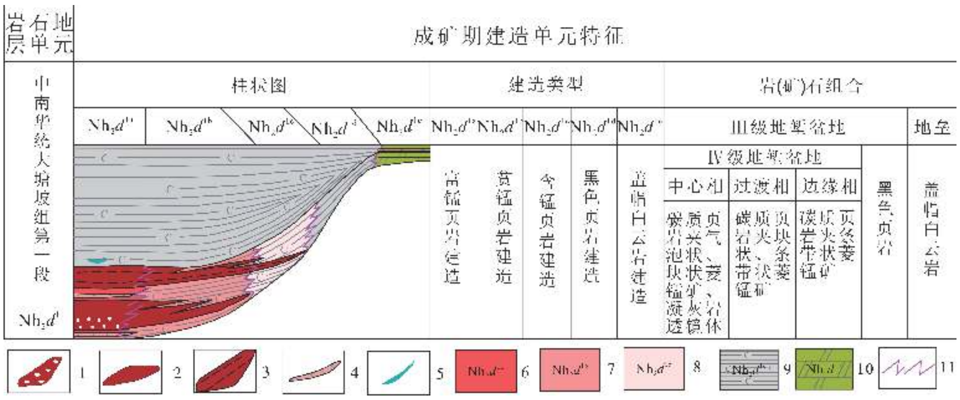

图 2　南华纪成矿期建造柱状图

1—气泡状菱锰矿; 2—块状菱锰矿; 3—条带状菱锰矿; 4—凝灰岩; 5—甲烷成因白云岩透镜体; 6—中心相(富锰页岩建造); 7—过渡相 (贫锰页岩建造); 8—边缘相 (含锰页岩建造); 9—黑色页岩建造; 10—盖帽白云岩; 11—成锰期建造单元界线

(4) 典型矿床

将具有广泛代表性的贵州松桃大塘坡锰矿床作为南华纪的典型锰矿床, 该锰矿床位于工作区南西侧毗邻的普觉幅 (G49E001004) 中, 与工作区内松桃普觉锰矿床相距 20 km, 是目前黔东与周缘地区含锰岩系建造组合出露最全、勘查开发和研究程度最高的锰矿床。典型矿床相关图件包含: 松桃大塘坡典型锰矿床地质图、大塘坡锰矿床 G—H 剖面图、大塘坡锰矿床含矿建造与古喷溢口群分布图 (图 3)。

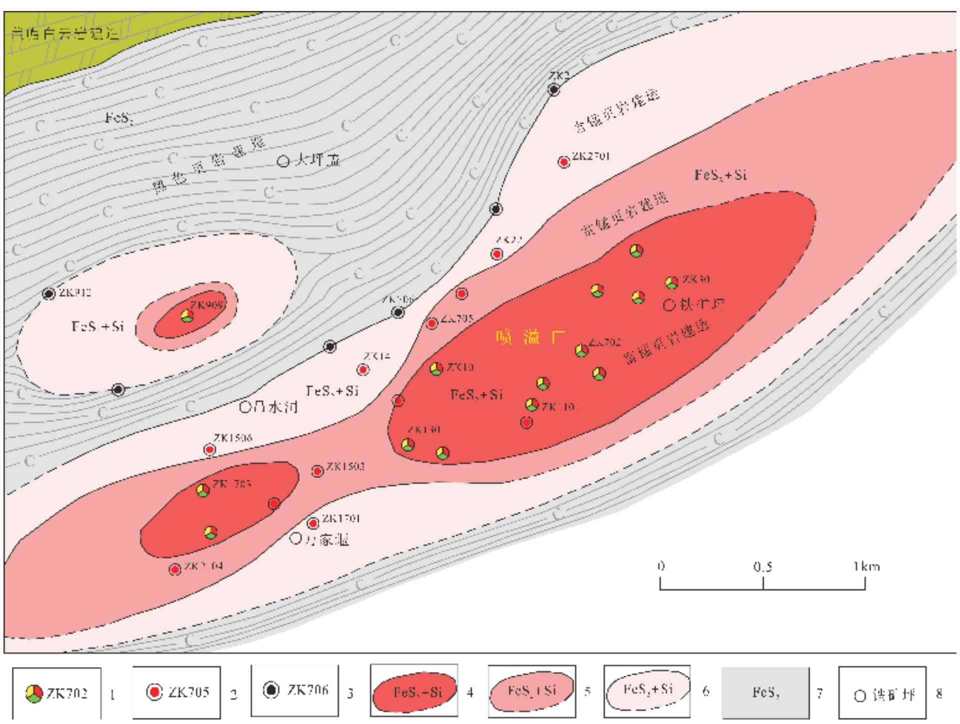

图 3　大塘坡锰矿床含矿建造与古喷溢口群分布图

1—见气泡状菱锰矿钻孔位置及编号; 2—见矿 (未见气泡状菱锰矿) 钻孔位置及编号; 3—未见矿钻孔位置及编号; 4—中心相 (古喷溢口), 具强黄铁矿化和硅化; 5—过渡相, 具黄铁矿化和弱硅化; 6—边缘相, 具弱黄铁矿化和弱硅化; 7—弱黄铁矿化; 8—居民地

(5) 矿产地名录

矿产地名录包矿产地名称、规模、类型、主要含矿建造等信息。

(6) 所处成矿区带位置图

在收集贵州省及毗邻的湖南省、四川省、重庆市 1：50 000 区域成矿规律图的基础上, 编制盘信幅所处成矿区带位置图, 显示有 I—IV 成矿区带、主要地名和矿产地等 (图 4)。该图表达了盘信幅在区域大地构造中所处的位置及其区域地质背景情况。

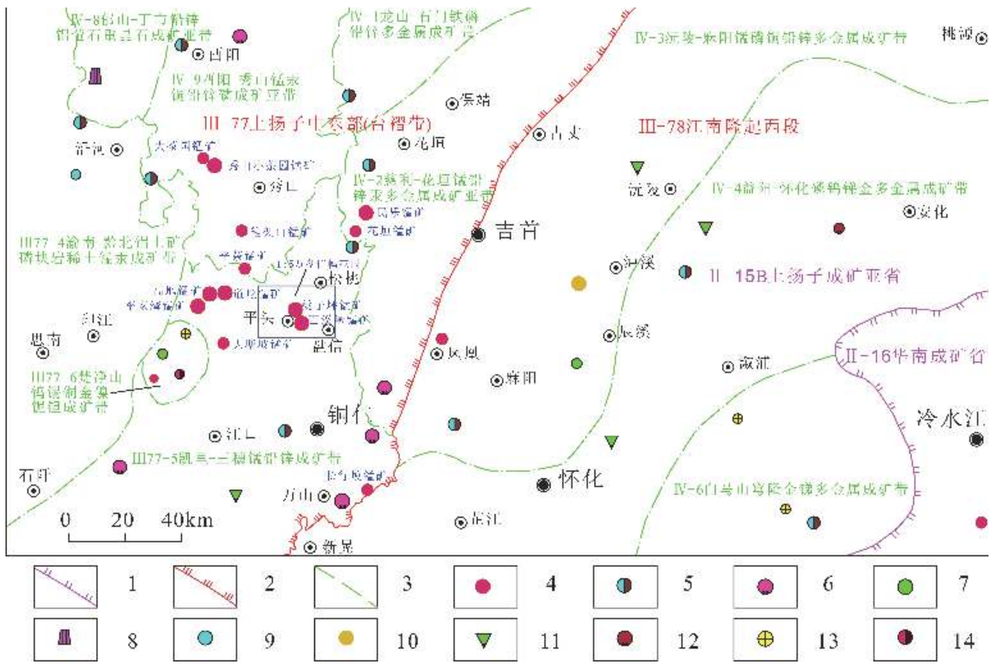

图 4　1：50 000 盘信幅所处成矿区带位置图

1—Ⅱ级成矿构造单元界线; 2—Ⅲ级成矿构造单元界线; 3—Ⅳ级成矿构造单元界线; 4—锰矿床 (点); 5—铅锌矿床 (点); 6—汞矿床 (点); 7—铜矿床 (点); 8—萤石矿床 (点); 9—重晶石矿床 (点); 10—铝土矿床 (点); 11—磷矿床 (点); 12—锑矿床 (点); 13—金矿床 (点); 14—钨锡多金属矿床 (点)

(7) 含矿建造分布图

对于主图区中出露地表的含矿建造分布区 (冷水溪—老云盘地区) 进行放大形成的图件, 突出表示与锰矿成因有关的建造及其变化规律。

3　数据样本描述

3.1　图层内容

盘信幅 1：50 000 矿产地质图数据库图层可分为 4 大类: 地理图层、建造构造图层、矿产地图层及整饰图层, 各图层内容见表 1。

3.2　数据属性

盘信幅 1：50 000 矿产地质图数据库数据属性按照《1：50 000 矿产地质调查成果图件数据库建设要求》提供的数据表建立数据库属性 (李永胜等，2020)。以下部分描述主要图层的必要数据属性。

建造构造 (地质面实体) 图层数据属性 (表 2): 地质体面实体标识号、地质体面实体类型代码 (地质代码)、地质体面实体名称、地质体面实体时代、建造大类、建造类型、岩石组合、大地构造环境。

表 2　建造构造图层数据表

序号	数据项名称	标准编码	数据类型	实例
1	地质体面实体标识号	*Feature_Id	Character	AH49E024005000000001
2	地质体面实体类型代码(地质代码)	*Feature_Type	Character	O_1h
3	地质体面实体名称	Geobody_Name	Character	红花园组
4	地质体面实体时代	Geobody_Era	Character	O_1h
5	建造大类	Formation	Character	沉积岩建造
6	建造类型	Metallogenic	Character	灰岩
7	岩石组合	Combination	Character	生物碎屑灰岩、粗晶灰岩
8	大地构造环境	Structural_Env	Character	上扬子地块、鄂渝湘黔前陆褶断带

地质 (界) 线图层数据属性 (表 3): 要素标识号、地质界线 (接触) 代码、地质界线类型、界线左侧地质体代号、界线右侧地质体代号、界面走向、界面倾向、界面倾角。

表 3　地质 (界) 线图层数据表

序号	数据项名称	标准编码	数据类型	实例
1	要素标识号	*Feature_Id	Character	AH49E024005000000001
2	地质界线(接触)代码	*Feature_Type	Character	01
3	地质界线类型	Boundary_Name	Character	整合
4	界线左侧地质体代号	Left_Boundary_Code	Character	O_1h
5	界线右侧地质体代号	Right_Boundary_Code	Character	$O_{1-2}d$
6	界面走向/°	Strike	Integer	197
7	界面倾向/°	Dip_Direction	Integer	107
8	界面倾角/°	Dip_Angle	Integer	39

断裂图层数据属性 (表 4): 要素分类代码、断层类型 (地质代码)、断层名称、断层编号、断层性质、断层上盘地质体代号、断层下盘地质体代号、断层破碎带宽度、断层走向、断层倾向、断层面倾角、估计断距、断层形成时代、活动期次、子类型标识。

褶皱图层数据属性 (表 5): 图元编号、褶皱名称、褶皱类型、褶皱形态、枢纽倾伏向、枢纽倾伏角、轴面倾向、轴面倾角、卷入褶皱的地层、形成时代。

同位素年龄图层数据属性 (表 6): 要素标识号、样品编号、样品名称、年龄测定方法、测定年龄、被测定出地质体单位及代号、测定分析单位、测定分析日期。

产状要素图层数据属性 (表 7): 要素标识号、产状类型名称代码、产状类型名称、走向、倾向、倾角。

矿产地图层数据属性 (表 8): 要素标识号、原编码、矿种代码、矿种名称、共生矿、伴生矿、矿产地数、矿石品位、规模、成矿时代、矿产地名、矿化类型、成因类型、子类型标识。

4　数据质量控制和评估

盘信幅 1∶50 000 矿产地质图是中国地质调查局 2017 年开展 1∶50 000 矿产调查与找矿预测矿产专项填图示范点, 主要目的是以黔东地区南华系“大塘坡式”锰矿为主攻矿种, 在贵州铜仁松桃锰矿整装勘查区以 1∶50 000 图幅为单元, 在系统收集和综合分析

表 4 断裂图层数据表

序号	数据项名称	标准编码	数据类型	实例
1	要素分类代码	*Feature_Type	Character	F9
2	断层类型(地质代码)	Fault_Type	Character	F9
3	断层名称	Fault_Name	Character	水源头断层
4	断层编号	Fault_Code	Character	H49E024005F9
5	断层性质	Fault_Character	Character	逆断层, 平移断层
6	断层上盘地质体代号	Fault_Up_Body	Character	S_1sh, S_1xt, $O_{1-2}d$, O_1h
7	断层下盘地质体代号	Fault_Bottom_Body	Character	S_1l, $O_{2-3}sh$–O_3w, $O_{1-2}d$
8	断层破碎带宽度/m	Fault_Wide	Character	0.6–2
9	断层走向/°	Fault_Strike	Integer	27–48
10	断层倾向/°	Fault_Dip	Integer	117–138
11	断层面倾角/°	Fault_Dip_Angle	Integer	43–86
12	估计断/m	Fault_Distance	Float	100
13	断层形成时代	Era	Character	燕山期
14	活动期次	Movement_Period	Character	燕山期–加里东期
15	子类型标识	Subtype	Integer	1

表 5 褶皱图层数据表

序号	数据项名称	数据项代码	实例
1	图元编号	CHFCAC	1
2	褶皱名称	GZCAB	杉树湾向斜
3	褶皱类型	GZCE	向斜
4	褶皱形态	GZCDD	长轴
5	枢纽倾伏向	GZCCBE	NE
6	枢纽倾伏角/°	GZCCBF	5
7	轴面倾向	GZCCAE	近直立
8	轴面倾角/°	GZCCAF	74
9	卷入褶皱的地层	GZCFA	$Є_2p$、$Є_2q$
10	形成时代	GZEKG	$Є_2q$

表 6 同位素年龄图层数据表

序号	数据项名称	标准编码	数据类型	实例
1	要素标识号	*Feature_Id	Character	AH49E024005000000001
2	样品编号	Sample_Code	Character	HY–3
3	样品名称	Sample_Name	Character	硅化白云岩
4	年龄测定方法	Measuring_Kinds	Character	锆石定年
5	测定年龄/Ma	Age	Character	229.2±2.1
6	被测定出地质体单位及代号	Geobody_Code	Character	$Є_{3-4}ls^3$
7	测定分析单位	Unit	Character	武汉上谱分析科技有限责任公司
8	测定分析日期	Date	Character	2017.9

已有地质、物探、化探、遥感、矿产等资料基础上，采用数字地质调查技术，开展该图幅 1：50 000 沉积型矿产地质专项填图与专题研究，综合测试分析数据（表 9），进行找矿预测，圈定找矿靶区。为保证调查精度，收集到的基础图层精度均符合要求，其次掌上机均在 C 级控制点进行 GPS 校正。

项目在开展过程中，严格按照中国地质调查局《矿产地质调查技术要求 (1：50 000)》(DD2019–02) 及专项填图、潜力评价细则与设计要求实施各项调查工作。项目承担单位

表 7　产状要素图层数据表

序号	数据项名称	标准编码	数据类型	实例
1	要素标识号	*Feature_Id	Character	AH49E024005000000001
2	产状类型名称代码	*Feature_Type	Character	01
3	产状类型名称	Attitude_Name	Character	岩层产状
4	走向/°	Strike	Integer	161
5	倾向/°	Dip_Direction	Integer	71
6	倾角/°	Dip_Angle	Integer	19

表 8　矿产地图层数据表

序号	数据项名称	标准编码	数据类型	实例
1	要素标识号	*Feature_Id	Character	AH49E024005000000001
2	原编码	Source_Id	Character	01
3	矿种代码	*Feature_Type	Character	CMMD010006
4	矿种名称	Commodities_Name	Character	菱锰矿
5	共生矿	Paragenic_Ore	Character	无
6	伴生矿	Associated_Ore	Character	无
7	矿产地数	Ore_Sums	Integer	1
8	矿石品位	Ore_Grade	Character	矿石Mn品位15.83%～16.40%，平均16.00%
9	规模	Deposite_Size	Character	超大型
10	成矿时代	Metallogenetic_Epoch	Character	南华纪
11	矿产地名	Placename	Character	贵州省松桃县桃子坪锰矿
12	矿化类型	Genesis_Types	Character	黄铁矿化、硅化
13	成因类型	Industrial_Types	Character	冶金用高磷低铁酸性锰矿石
14	子类型标识	Subtype	Integer	AH49E024005000000001

表 9　贵州铜仁松桃锰矿盘信幅 (H49E024005)1：50 000 矿产地质图数据库数据

数据类型	数据量	数据基本特征
岩石化探分析数据	150件	15种元素(U、Th、Fe、Mn、Co、Ni、Cu、Pb、Zn、Cr、Au、Ag、V、Ti、Al)
一般岩矿分析数据	333件	基本化学分析
薄片鉴定数据	200片	矿物成分、含量; 岩石结构、构造等
同位素年龄数据	90点	锆石U–Pb年龄
矿产地数量	6个	锰矿(3个)、铅锌矿(2个)、汞矿(1个)
矿床类型	2种	沉积型锰矿、热液型铅锌矿、汞矿

于 2017 年 6—12 月，按照项目设计方案完成野外调查工作，期间严格执行“作业组、项目部、大队三级质量检查制度”，作业组自检、互检比例均为 100%，项目部检查比例大于 30%，大队质检组抽查比例大于 10%，保证了资料数据的质量，并于 2018 年 6 月 19—20 日完成野外验收，评级为优秀。2019 年 3 月 19 日，中国地质调查局发展研究中心 (自然资源部矿产勘查技术指导中心) 会同贵州省自然资源厅组织专家对项目成果进行评审，评定等级为优秀。

5 数据价值

(1) 贵州铜仁松桃锰矿盘信幅 (H49E024005)1：50 000 矿产地质图是中国地质调查局新一轮地质矿产调查的示范图幅，项目组积极探索创新矿产地质专项填图成果表达方式，形成了盘信幅矿产地质图，对矿产地质调查起到了示范作用。

(2) 该矿产地质图按照《矿产地质调查技术要求 (1：50 000)》(DD2019–02) 要求，在深入研究本图幅内沉积序列的岩石组成和结构构造的基础上，以建造为划分原则，通过建造与构造的综合分析与研究，对沉积岩地层进行了重新划分，厘定了 39 个填图单元，划分了 8 个建造类型。

(3) 划分了南华纪锰矿主攻矿种成矿期 5 个建造填图单元，大致基本查明了与锰矿床形成分布与形成分布有密切联系的含锰岩系、同沉积断层等特征和对锰矿保存条件产生影响的后期构造特征。

(4) 为该区锰矿成矿规律研究、锰矿深部找矿预测、能源勘探、矿产资源规划等提供基础数据支撑，提升矿产地质调查工作服务资源安全、经济社会发展和生态文明建设的能力。

6 结论

(1) 建立了 1：50 000 盘信幅 (H49E024005) 岩石地层层序，厘定了 39 个填图单元，划分了 8 个建造类型。根据锰矿裂谷盆地古天然气渗漏沉积成矿系统模式和构造古地理单元特征，划分了 5 个相互关联的含锰建造填图单元。

(2) 通过矿产专项填图工作，基本查明了含锰岩系、同沉积断层和后期对锰矿保存条件产生影响的构造特征，为锰矿成矿规律研究和深部隐伏锰矿找矿预测提供了支撑。

(3) 编制了《古天然气渗漏沉积型锰矿专项填 (编) 图指南》，为在其他地区、其他地质时代寻找类似锰矿床提供借鉴和参考。

(4) 全面系统编制了 1：50 000 盘信幅 (H49E024005) 矿产地质图并建立了空间数据库，突出了含矿建造、控矿构造和矿化蚀变信息的表达，为新一轮 1：50 000 矿产地质调查工作矿产专项填图起到了示范作用。

致谢：新一代 1：50 000 盘信幅 (H49E024005) 矿产地质图及其数据库是在中国地质调查局发展中心、自然资源部矿产勘查技术指导中心、贵州省自然资源厅、贵州省地质矿产勘查开发局等单位众多专家、学者的指导下完成，是集体智慧的结晶。向所有为此付出辛勤劳动的工作者，表示衷心的感谢!

注释：

❶ 贵州省地矿局 115 地质大队. 2016. 盘信幅 (H49E024005)1：50 000 区域地质调查报告 [R].

❷ 贵州省地矿局 103 地质大队. 2011. 贵州省松桃县西溪堡锰矿 (外围) 详查地质报告 [R].

❸ 贵州省地矿局 103 地质大队. 2016. 贵州省松桃县普觉锰矿 (整合) 详查报告 [R].

❹ 贵州省地矿局 103 地质大队. 2016. 贵州省松桃县桃子坪锰矿详查报告 [R].

❺ 贵州省地矿局 103 地质大队. 2003. 贵州省松桃县西溪堡锰矿床普查地质报告 [R].

❻ 贵州省地质调查院. 2012. 贵州省锰矿资源潜力评价报告 [R].

❼ 成都地质调查中心. 2013. 黔东地区大塘坡期锰矿成矿地质背景综合研究报告 [R].

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1∶50 000 Mineral Geological Map Database of the Panxin Map-sheet of the Songtao Manganese Deposit in Tongren, Guizhou

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Abstract: The 1∶50 000 mineral geological map database of the Panxin Map-sheet (H49E024005) of the Songtao manganese deposit in Tongren, Guizhou represents one of the achievements of the new round of 1∶50 000 mineral geological survey work series in accordance with the *Technical Requirements for Mineral Geological Survey* (1∶50 000) (DD2019-02) initiated by the China Geological Survey (CGS). The work reviews the lithostratigraphic sequence of the Panxin Map-sheet surveying area, determines 39 mapping units, identified eight formation types, and emphatically divides five genetically interrelated manganese-bearing formation mapping units. The database is built in MapGIS format. It mainly includes geographic layers, formation-structure layers, mineral deposit layers, and finishing layers, covering 150 pieces of rock geochemical analysis data, 333 pieces of general rock and ore analysis data, 90 pieces of zircon U–Pb age data, 6 pieces of mineral deposit information, and two deposit types. The database highlights ore-bearing formation, ore-controlling structure and mineralization alteration information, providing base data for manganese-related resource research, energy exploration, and mineral resource planning.

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Key words: integrated exploration area of manganese deposit; Panxin Map-sheet; mineral geological map; database; mineral survey engineering; Tongren, Guizhou
Data service system URL: http://dcc.cgs.gov.cn

1 Introduction

Manganese is an important material for strategic new industries like new energy battery and new material, as well as ferrous metallurgy, and its external dependence in China is more than 60% (Chen JF et al., 2015). Therefore, Seeking manganese ore is an important strategic task. The Songtao integrated exploration area of manganese deposit in Tongren, Guizhou is the most important enrichment area of the Nanhuanian "Datangpo-type" manganese deposits in South China. According to the geotectonic unit division scheme (Pan GT et al., 2009), the area belongs the carbonate rock platform (VI–2–4) in the south of the Upper Yangtze Block. On the basis of *the National Metallogenic Zone Division Scheme* (Xu ZG et al., 2008), it belongs to the Yangtze metallogenic province (II–15) of the Peripacific metallogenic domain (I–4), and Pb–Zn–Cu–Ag–Fe–Mn–Hg–Sb–P–bauxite–pyrite metallogenic zone (III–77) in the central eastern part of the Upper Yangtze (platform-fold zone). According to Nanhuanian manganese metallogenic zone division scheme in South China (Zhou Q et al., 2016a), it is a part of the manganese metallogenic region in Nanhuanian rift basin, Wuling manganese metallogenic zone, and Shiqian–Songtao–Guzhang manganese metallogenic subzone. The Panxin Map-sheet is seated right at the core of this integrated manganese exploration area (Fig. 1).

The 1∶50 000 regional geological survey of the Songtao integrated exploration area of manganese deposit in Tongren, Guizhou began in the mid-1980s and has virtually drawn to an end up to now. Howver, the basic area survey of geophysical and geochemical prospecting to the accuracy of 1∶50 000 is quite poor. The No.103 Geological Brigade of Guizhou Bureau of Geology and Mineral Exploration and Development has been working hand in hand with China University of Geosciences (Wuhan) since 2000. As a result, they discovered that the Nanhuanian "Datangpo-type" manganese deposit is actually a new type of manganese deposit—paleo-natural gas leakage sedimentary manganese deposit (Zhou Q and Du YS et al., 2012, 2019; Zhou Q et al., 2013; Liu Y et al., 2015a, 2015b), rather than marine sedimentary manganese deposit as traditionally assumed. After that, they clarified the unique geological background and tectonic paleogeographic framework of the mass manganese metallogenesis (Zhou Q et al., 2016b), and established the rift basin paleo-natural gas leakage metallogenesis theory and deep concealed ore prospecting prediction model of manganese deposit (Zhou Q et al., 2017). Also, by utilizing the Songtao integrated exploration area of manganese deposit in Tongren, Guizhou and the Guizhou integrated exploration area practice testing platform, four world-class superlarge concealed manganese deposits have been discovered, including Xixibao, Daotuo, Gaodi and Taoziping occurred in the Songtao area, marking the greatest breakthrough ever in the manganese prospecting of China (Zhou Q et al., 2016a), and providing rich data base for the present mineral geological survey.

The present 1∶50 000 mineral geological map of the Panxi Map-sheet and the resulted

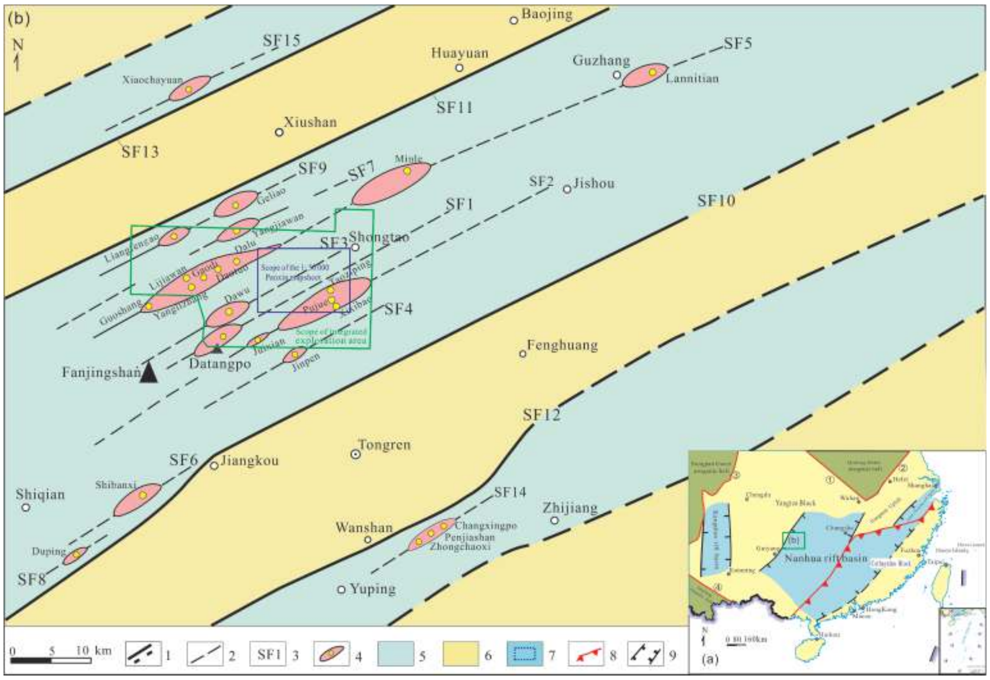

Fig. 1 Texture and structure paleogeographic map of the early Nanhuanian Wuling secondary rift basin in and adjacent to Eastern Guizhou (modified from Zhou Q et al., 2016b)

1—synsedimentary fault controlling 3rd-orderfaulted basins and uplifts; 2—synsedimentary fault controlling 4th-order faulted basins and uplifts; 3—number of a synsedimentary fault; 4—name of a 4th-order faulted basin and the Mn deposit controlled by it; 5—3rd-order faulted basin; 6—3rd-order uplift; 7—Scope of main study area; 8—regional fault and block boundary; 9—1st-order rift basin boundary; ①,②—Qinling–Dabieshan fault zone; ③—Longmenshan–Yanyuan fault zone; ④—Honghe shear zone

database is based on the 1：50 000 regional geological survey result❶, as well as mineral exploration and science research results. The map was compiled by dividing and establishing the Nanhuanian metallogenic period manganese-bearing formation mapping units—principally those related to the Nanhuanian “Datangpo-type” manganese deposits, identifying and filling in the manganese-forming period synsedimentary faults and the structures controlling subsequent manganese preservation conditions through both field and indoor map filling (editing) by means of digital geological survey technology. It is the result of mineral-specific mapping purported for ore prospecting prediction. Table 1 gives the metadata table of the 1：50 000 mineral geological map database of the Panxin Map-sheet (Liu J et al., 2020).

2 Data Acquisition and Processing Method

2.1 Data Base

The 1：50 000 mineral geological map of the Panxin Map-sheet, Guizhou was compiled in accordance with the *Technical Requirements for Mineral Geological Survey* (1：50 000) (DD2019–02). The mapping work involved collecting and reorganizing primitive data, such as the 1：50 000 regional geological survey results❶ (including primitive data maps, profile maps, and log books), manganese exploration results❷❸❹❺ (including the primitive data maps of deposits, profile maps of exploration lines, columnar sections of drillholes, and primitive records of drillhole logging), and geological survey research results❻❼ (including result

Table 1 Metadata Table of Database (Dataset)

Items	Description
Database (Dataset) name	1∶50 000 Mineral Geological Map Database of the Panxin Map-sheet of the Songtao Manganese Deposit in Tongren, Guizhou
Database (Dataset) authors	Liu Jian, No.103 Geological Brigade of Guizhou Bureau of Geology and Mineral Exploration and Development Yuan Liangjun, No.103 Geological Brigade of Guizhou Bureau of Geology and Mineral Exploration and Development Xie Xiaofeng, No.103 Geological Brigade of Guizhou Bureau of Geology and Mineral Exploration and Development Zhan Pengcai, No.103 Geological Brigade of Guizhou Bureau of Geology and Mineral Exploration and Development
Data acquisition time	2016–2018
Geographic area	109°00′–109°15E, 28°00′–28°10′N
Data format	*.wp, *.wl, *.wt
Data size	39.7 MB
Data service system URL	http://dcc.cgs.gov.cn
Fund project	Funded by a subproject (121201004000160901–36) of China Geological Survey Project entitled *Prospecting Prediction and Technical Application Demonstration in Integrated Exploration Areas*
Language	Chinese
Database (Dataset) composition	The 1∶50 000 mineral geological map database of the Panxin Map-sheet includes geographic layers, formation–structure layers, mineral layers, and finishing layers. The geographic layers include main administrative boundaries, main settlements, main areal drainage systems, main linear drainage systems, and main geographic tags. The formation–structure layers include formations and structures (geological plane entity), geological (boundary) lines, folds, faults, synsedimentary faults, attitude features, and isotopic ages. The mineral deposit layer includes mineral deposits. The finishing layers include an internal and an external part. The internal finishing layer includes geological annotations and formation patterns, leader lines, fault dip directions, angles and fault natures, attitude dip angle annotations, isotope annotations, and transverse cutting profiles. The external finishing layer includes the index map, CGS emblem, map name, scale, coordinate parameter, duty tag, legend, columnar section of sedimentary rock formations, transverse cutting profile map, mineral species & size, mineral deposit directory, metallogenic zone location map, ore-bearing formation distribution map, typical deposit geological map and profile map, ore-bearing formation columnar section, and ore-bearing formation and ancient spray overflow port group distribution map.

reports, attached maps and attached tables), as well as the new 1∶50 000 mineral geology-specific mapping result of the Panxin Map-sheet, and systematically consolidating primitive data and result maps using digital mapping systems (DGSS) and MapGIS. Primitive data were collected using the Beijing Coordinate System 1954 before their coordinate system was converted. Data projection was based on Gauss Kruger projection. The ellipsoid parameters are based on the China Geodetic Coordinate System 2000 (CGCS2000).

2.2 Data Processing

2.2.1 Data Preparation

The 1：50 000 regional geological survey primitive data maps of the Panxin Map-sheet collected in the present work (four 1：25 000 map-sheets H49F047009, H49F047010, H49F048009, and H49F048010) are MapGIS point, line, and areal files with correct map parameters, using Gauss Kruger projection and 6-degree zone projection, and Beijing Coordinate System 1954. Therefore they can directly be used as the base map layer for digital map filling without digitalization, providing good base data for the present work.

The 1：25 000 hand charts were needed to collect field data for the 1：50 000 Map-sheet. Field routes were designed and field hand charts were created in the field master library of the four 1：25 000 Map-sheets collected.

2.2.2 Field Data Acquisition

After the field hand charts were created, through data exchange, they were transferred from the desktop system to the portable system. Using a portable PC, field data were collected and a digital mapping (PRB) database was preliminarily established. The following data were collected for field geology-specific mapping:

(1) Geological point (P process): the collected information during the field survey includes the route No., geological point No., coordinate, microtopography, attribution of point, outcrop, weathering degree, location description, mapping unit, contact relationship, and geological description.

(2) Segment route (R process): the collected information during the field survey includes the route No., geological point No., route (R) code, direction, segment distance, cumulative distance, mapping unit, rock name, and description of geology along the way.

(3) Geological route (B process): the collected information during the field survey includes the route No., geological point No., route (R) code, boundary (B) code, boundary type, contact relationship, left-side mapping unit, and right-side mapping unit.

In addition, field geology-specific mapping also collected attitudes, samples, photos, and sketches along the way, covering geophysical, geochemical, remote sensing, and ore exploration engineering data. Various audio-frequency magnetotelluric sounding data were collected as the primitive data at the geophysical prospecting profile measuring points before they were inverted into geophysical prospecting profile result maps. Various remote sensing anomalies, were extracted from the remote sensing maps to refine the attributes of the layers.

2.2.3 Indoor PRB Data Reorganization

As field collected data are usually quite rough due to the environmental and time limitations of field work, they were further supplemented and refined indoors and, through data exchange, were transferred from the portable system into the desktop system. Main work included refinement of data attributes and addition of route summaries and checks.

2.2.4 Summarization of the PRB Library (Field General Map Library) of the Map-sheet

After the collected data of each route were reorganized, they were summarized into the RPB library of the map-sheet through “Route Data Loading”.

2.2.5 Creating Primitive Data Map

Through the method of "Update Field Master Library into Primitive Data Map", the field master library files were inherited into the primitive data map, in which data actually collected during the present field work were combined with the regional geological survey primitive data map. Geological boundaries were reconnected. Areas were topologically created to form geobodies and refine the attributes, schemes and legends of geological boundaries and geological plane features.

2.2.6 Creating Primitive Map for Compilation

After completing the four 1∶25 000 primitive data maps, they were each projected into the 1∶50 000 primitive map for compilation. The edges of the four 1∶25 000 primitive data maps were connected, the topological work of the 1∶50 000 map-sheet work was completed, and the various schemes and legends outside the map frame were reorganized before a complete primitive map for compilation was finally established.

2.2.7 Creating Spatial Database

According to the database-building requirements of the *Spatial Database Standard of Digital Geological Maps* (DD2006–06), a geological map database should contain 15 basic feature classes, 8 comprehensive feature classes, 12 object classes, and other separate feature classes like schemes and decorations. Database-building operation includes the following basic steps. (i) Entered the database building environment and generated feature class and object class files with standard attribute structure. (ii) Extracted information from files related to the primitive map for compilation into the basic feature class and edited/refined the attributes of the basic feature class. (iii) Established the related comprehensive feature class and edited/refined the attribute information of the comprehensive feature class. (iv) Extracted information from the feature class into the object class and refined the attribute of the object class. (v) During map finishing, added annotations to the geological code and other information, and added separate feature class information like the index map and comprehensive columnar section to form a complete database. Through these operation steps, a primitive database was preliminarily established and the compilation of a mineral geological database could be started.

2.2.8 Compiling Mineral Geological Map

The mineral geological map is a kind of objective result maps that is based on formation-structure maps and reflects the mineral deposits, the type, genesis and size of ore (mineralization) spots, and other mineral information. In order to give a full representation of the result of the present 1∶50 000 mineral geological survey of the Panxin Map-sheet, inspired by the "rift basin paleo-natural gas leakage sedimentary metallogenic system theory and ore prospecting prediction key technical methodological system of the Nanhuanian manganese deposit", the mineral geological map was compiled in accordance with the *Technical Requirements for Mineral Geological Survey* (1∶50 000) (DD2019–02), following the principle of "three highlights" (i.e., highlighting the main ore-bearing formations, ore-controlling structures, and mineralization alteration information) and "three coordinations" (coordination between the master map and corner maps, between planes and profiles, and among features in the master map).

(1) Formation–structure map

The formation–structure map is a primitive data map generated by consolidating the primitive data information resulted from specific mapping measurement and the previous 1∶50 000 regional geological survey information collected. It is an objective basic map for metallogenic research and ore prospecting prediction. The map cover the geological characteristics of formations like sedimentary rocks, magmatic rocks and metamorphic rocks, and structures like folds and faults in the survey area, highlighting their relationship with metallogenesis. The map face includes the master map, various formation columnar sections, as well as structures, mineralization alterations, and legends. The master map includes the stratigraphic formation (member)-level lithostratigraphic units of different eras, measured metallogenesis-related formations, structures, geological boundaries, and other areal and linear geological features and attitudes.

(2) Formation columnar sections

The columnar sections of the sedimentary rock formations and the Nanhuanian metallogenic period formations were prepared. The columnar section of the sedimentary rock formations is a detailed presentation of the formation characteristics of the lithostratigraphic units in the master map. By combining the stratigraphic units in the previous regional geological survey mapping results with the present work results, the map summarizes the rock composition, texture and structure of the sedimentary sequence in the area, and reestablishes the lithostratigraphic sequence of the survey area. On the basis of the latest national stratigraphic table, it finalizes 39 mapping units and divides the formation type. The columnar section of the Nanhuanian metallogenic period formations (Fig. 2) is based on the rift basin paleo-natural gas leakage sedimentary metallogenic system model and the characteristics of the tectonic paleogeographic units of manganese deposit. It covers fibe formation–structure mapping units, namely, (i) manganese-rich shale formations (Nh_2d^{1a}), which correspond to a black carbonaceous shale formation–structure combination of the manganese paleo-natural gas leakage metallogenic system central facies, as characterized by the development of paleo-natural gas leakage sedimentary structures, tuff or tuffaceous siltstone lenses, especially bitumen-filled bubbly and massive rhodochrosite ores; (ii) manganese-poor shale formations (Nh_2d^{1b}), which correspond to a black carbonaceous shale formation–structure combination of the manganese paleo-natural gas leakage sedimentary metallogenic system transitional facies, as intercalated by some massive and banded rhodochrosite orebodies; (iii) manganese-bearing shale formations (Nh_2d^{1c}), which correspond to a black carbonaceous shale formation–structure combination of the manganese paleo-natural gas leakage sedimentary metallogenic system marginal facies, as intercalated by a small amount of thin-bedded banded rhodochrosite orebodies; (iv) black shale formations (Nh_2d^{1d}), which are a black carbonaceous shale formation–structure system without manganese occurrence, as equivalent to a third-order graben basin black shale facies; and (v) cap dolomite formations (Nh_2d^{1e}), which correspond to the cap dolomite at the bottom of the Datangpo Formation in the uplift (graben) area, as a

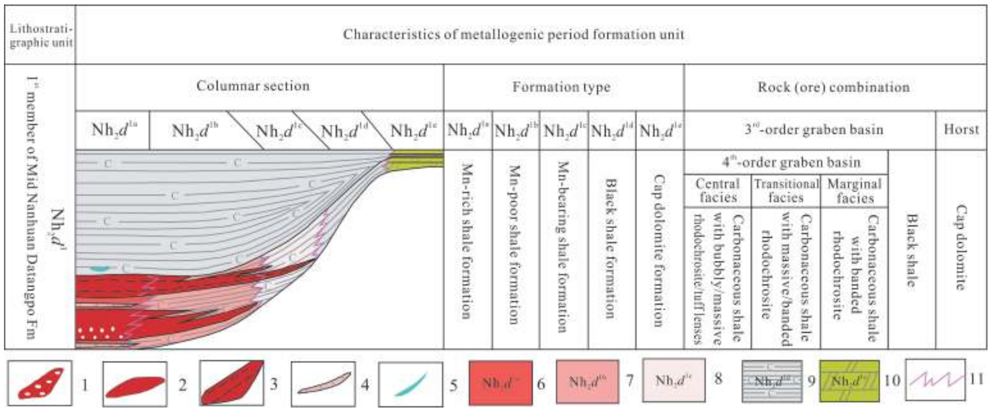

Fig. 2　Columnar section of the Nanhuanian metallogenic period formations

1—bubbly rhodochrosite; 2—massive rhodochrosite; 3—banded rhodochrosite; 4—tuff; 5—methanogenic dolomite lens; 6—central phase (Mn-rich shale formation); 7—transitional phase (Mn-poor shale formation); 8—marginal facies (Mn-bearing shale formation); 9—black shale formation; 10—cap dolomite; 11—boundary of Mn-forming period formation unit

contemporaneous heterotopic product to the manganese ores. The columnar section of the Nanhuanian metallogenic period formations and structures reveals the rock (ore) combination characteristics, the characteristic metallogenic signatures of the manganese deposits, and the metallogenic features of the manganese deposits across different sedimentary environments (fourth-order graben areas, horst areas) in the Nanhuanian metallogenic period. It provides important basis for dividing manganese-specific mapping units.

(3) Transverse cutting profile

In order to effectively reflect the overall characteristics of the formations and structures within the map-sheet area and their relationship with mineralization, two transverse cutting profiles running throughout the area were compiled, one NW trending and the other NNE trending. As all superlarge manganese deposits in the map-sheet area are hidden 1 000 m below the ground level, a transverse cutting profile cutting through the two superlarge manganese deposits of Pujue and Taoziping and the medium manganese deposit of Xixibao, was added, which could avoid misunderstanding that the manganese orebodies are hosted in the Cambrian, when a manganese deposit (spot) is horizontally projected into the Cambrian exposed on the earth's surface.

(4) Typical deposit

The widely representative Datangpo manganese deposit in Songtao, Guizhou is taken as the typical Nanhuanian manganese deposit. This deposit is situated in the Pujue Map-sheet (G49E001004) adjacent to the southwest side of the survey area, with a 20 km distance from the Pujue manganese deposit of Songtao in the Panxin Map-sheet area. It is a manganese deposit with the most complete exposure of manganese-bearing formation combinations and the highest degree of exploration, development and research so far in and around Eastern Guizhou. The maps related to the typical deposit include the geological map of the Datangpo typical manganese deposit in Songtao, G–H profile map of the Datangpo manganese deposit, and distribution map of the ore-bearing formations and ancient spray overflow port groups in the Datangpo manganese deposit (Fig. 3).

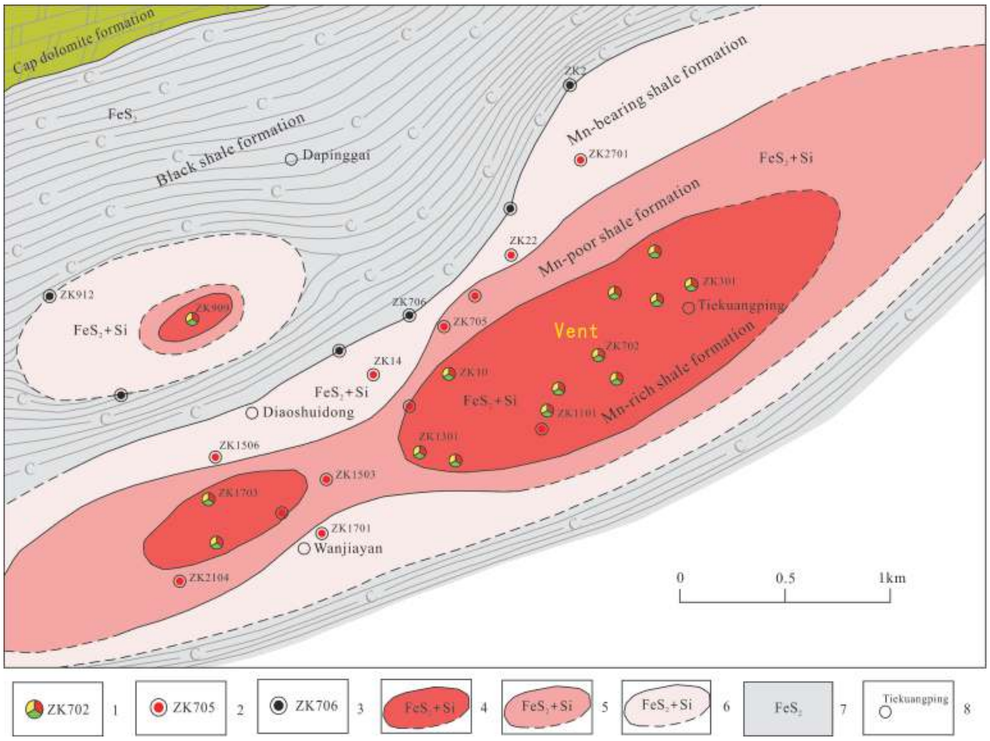

Fig. 3 Distribution map of the ore-bearing formations and ancient spray overflow port groups in the Datangpo manganese deposit

1—location and ID of drillhole encountering bubbly rhodochrosite; 2—location and ID of drillhole encountering ore (not encountering bubbly rhodochrosite); 3—location and ID of drillhole not encountering ore; 4—central facies (ancient spray overflow port) showing strong pyritization and silicification; 5—transitional facies showing pyritization and weak silicification; 6—marginal facies showing weak pyritization and weak silicification; 7—weak pyritization; 8—settlement place

(5) Mineral deposit directory

The mineral deposit directory includes the name, size, type, and main ore-bearing formations of the mineral deposits.

(6) Metallogenic zone location map

After collecting the 1 : 50 000 regional metallogenic maps of Guizhou and the neighboring Hunan, Sichuan, and Chongqing, the metallogenic zone location map of the Panxin Map-sheet was compiled, displaying the I–IV metallogenic zones, main place names and mineral deposits (Fig. 4). This map presents the position of the Panxin Map-sheet in the regional tectonics and its regional geological background.

(7) Ore-bearing formation distribution map

This is an enlargement of the ore-bearing formation area (Lengxishuixi–Laoyunpan area) exposed on the earth's surface, highlighting the formations related to manganese metallogenesis and its variations.

3 Data Sample Description

3.1 Layer Contents

The map layers of the 1 : 50 000 mineral geological map database of the Panxin Map-

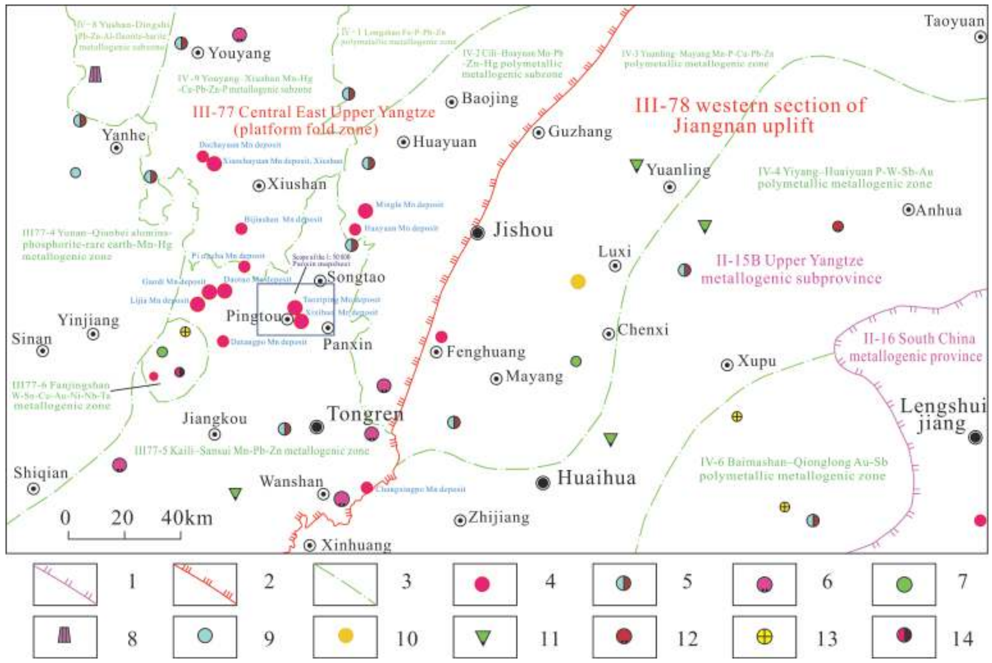

Fig. 4 Metallogenic zone location map of the 1∶50 000 Panxin Map-sheet

1—boundary of 2nd-order metallogenic tectonic unit; 2—boundary of 3rd-order metallogenic tectonic unit; 3—boundary of 4th-order metallogenic tectonic unit; 4—manganese deposit (spot); 5—lead-zinc deposit (spot); 6—mercury deposit (spot); 7—copper deposit (spot); 8—fluorite deposit (spot); 9—barite deposit (spot); 10—alumina deposit (spot); 11—phosphate deposit (spot); 12—antimony deposit (spot); 13—gold deposit (spot); 14—tungsten-tin polymetallic deposit (spot)

sheet fall into four categories: geographic layers, formation–structure layers, mineral deposit layers, and finishing layers. Table 1 gives the details of each of these map layers.

3.2 Data Attribute

The data attributes of the 1∶50 000 mineral geological map database of the Panxin Map-sheet were established according to the datatable provided in the *Requirements for Database Construction of* 1∶50 000 *Mineral Geological Survey Result Maps* (Li YS et al., 2020). The Following is a brief description of the necessary data attributes of the main map layers.

Data attributes of the formation–structure (geological plane entity) layer (Table 2) include geobody areal entity ID, geobody areal entity type code (geological code), geobody areal entity name, geobody areal entity era, formation category, formation type, rock combination, and tectonic environment.

Data attributes of the geological (boundary) line layer (Table 3) include feature ID, geological boundary (contact) code, geological boundary type, geobody code in the left-side of boundary, geobody code in the right-side of boundary, interface strike, interface dip direction, and interface dip angle.

Data attributes of the fault layer (Table 4) include feature classification code, fault type (geological code), fault name, fault No., fault nature, fault upside geobody code, fault downside geobody code, fault fracture zone width, fault strike, fault dip direction, fault plane dip angle, estimated fault distance, fault era, movement period, subtype ID.

Data attributes of the fold layer (Table 5) include pixel No., fold name, fold type, fold

Table 2 Datatable of the formation–structure layer

SN	Data Name	Standard Code	Data Type	Example
1	Geobody ID	*Feature_Id	Character	AH49E024005000000001
2	Geobody Type Code(geological code)	*Feature_Type	Character	O_1h
3	Geobody name	Geobody_Name	Character	Honghuayuan Fm
4	Geobody era	Geobody_Era	Character	O_1h
5	Formation category	Formation	Character	Sedimentary rock formation
6	Formation type	Metallogenic	Character	Limestone
7	Rock combination	Combination	Character	Bioclastic limestone, coarse-grained limestone
8	Tectonic environment	Structural_Env	Character	Upper Yangtze block, Hubei-Chongqing-Hunan-Guizhou foreland fold-fault zone

Table 3 Datatable of the geological (boundary) line layer

SN	Data Name	Standard Code	Data Type	Example
1	Feature ID	*Feature_Id	Character	AH49E024005000000001
2	Geological boundary (contact) code	*Feature_Type	Character	01
3	Geological boundary type	Boundary_Name	Character	Conformity
4	Geobody code in the left-side of boundary	Left_Boundary_Code	Character	O_1h
5	Geobody code in the right-side of boundary	Right_Boundary_Code	Character	$O_{1-2}d$
6	Interface strike/°	Strike	Integer	197
7	Interface dip direction/°	Dip_Direction	Integer	107
8	Interface dip angle/°	Dip_Angle	Integer	39

Table 4 Datatable of the fault layer

SN	Data Name	Standard Code	Data Type	Example
1	Feature classification code	*Feature_Type	Character	F9
2	Fault type (geological code)	Fault_Type	Character	F9
3	Fault name	Fault_Name	Character	Shuiyuantou fault
4	Fault code	Fault_Code	Character	H49E024005F9
5	Fault nature	Fault_Character	Character	Reverse fault, strike-slip fault
6	Fault upside geobody ID	Fault_Up_Body	Character	S_1sh, S_1xt, $O_{1-2}d$, O_1h
7	Fault downside geobody ID	Fault_Bottom_Body	Character	S_1l, $O_{2-3}sh$–O_3w, $O_{1-2}d$
8	Fault fracture zone width/m	Fault_Wide	Character	0.6–2
9	Fault strike/°	Fault_Strike	Integer	27–48
10	Fault dip direction/°	Fault_Dip	Integer	117–138
11	Fault dip angle/°	Fault_Dip_Angle	Integer	43–86
12	Estimated fault distance/m	Fault_Distance	Float	100
13	Fault era	Era	Character	Yanshanian
14	Movement period	Movement_Period	Character	Yanshanian–Caledonian
15	Subtype ID	Subtype	Integer	1

shape, hub pitch direction, hub pitch angle, axis dip direction, axis dip angle, strata involved in the fold, and forming era.

Data attributes of the isotopic age layer (Table 6) include feature ID, sample code, sample name, age measured method, measured age, unit and code of measured geobody, unit of measurement, and date of measurement.

Data attributes of the attitude feature layer (Table 7) include feature ID, name code of attitude type, name of attitude type, strike, dip direction, and dip angle.

Data attributes of the mineral deposit layer (Table 8) include feature ID, source ID,

Table 5 Datatable of the fold layer

SN	Data Name	Data Code	Example
1	Pixel No.	CHFCAC	1
2	Fold name	GZCAB	Shanshuwan syncline
3	Fold type	GZCE	Syncline
4	Fold shape	GZCDD	Major axis
5	Hub pitch direction	GZCCBE	NE
6	Hub pitch angle/°	GZCCBF	5
7	Axis dip direction	GZCCAE	Nearly vertical
8	Axis dip angle/°	GZCCAF	74
9	Strata involved in the fold	GZCFA	Є$_{2}p$、Є$_{2}q$
10	Forming era	GZEKG	Є$_{2}q$

Table 6 Datatable of the isotopic age layer

SN	Data Name	Standard Code	Data Type	Example
1	Feature ID	*Feature_Id	Character	AH49E024005000000001
2	Sample code	Sample_Code	Character	HY–3
3	Sample name	Sample_Name	Character	Silicified dolomite
4	Age measured method	Measuring_Kinds	Character	Zircon dating
5	Measured age/Ma	Age	Character	229.2±2.1
6	Unit & code of measured geobody	Geobody_Code	Character	Є$_{3-4}ls^{3}$
7	Unit of measurement	Unit	Character	Wuhan Sample Solution Analytical Technology Co., Ltd.
8	Date of measurement	Date	Character	2017.9

Table 7 Datatable of the attitude feature layer

SN	Data Name	Standard Code	Data Type	
1	Feature ID	*Feature_Id	Character	AH49E024005000000001
2	Name code of attitude type	*Feature_Type	Character	01
3	Name of attitude type	Attitude_Name	Character	Rock attitude
4	Strike/°	Strike	Integer	161
5	Dip direction/°	Dip_Direction	Integer	71
6	Dip angle/°	Dip_Angle	Integer	19

Table 8 Datatable of the mineral deposit layer

SN	Data Name	Standard Code	Data Type	
1	Feature ID	*Feature_Id	Character	AH49E024005000000001
2	Source ID	Source_Id	Character	01
3	Mineral species code	*Feature_Type	Character	CMMD010006
4	Mineral species name	Commodities_Name	Character	Rhodochrosite
5	Syngenetic ore	Syngenetic_Ore	Character	Null
6	Associated ore	Associated_Ore	Character	Null
7	Sum of mineral deposits	Ore_Sums	Integer	1
8	Ore grade	Ore_Grade	Character	Mn ore's grade: 15.83%–16.40%, avg. 16.00%
9	Size	Deposit_Size	Character	Superlarge
10	Metallogenetic epoch	Metallogenetic_Epoch	Character	Nanhuanian
11	Place name	Placename	Character	Taoziping Mn deposit in Songtao, Guizhou
12	Mineralization type	Genesis_Types	Character	Pyritization, silicification
13	Genesis type	Industrial_Types	Character	High-P low-Fe acidic rhodochrosite ore for metallurgy
14	Subtype ID	Subtype	Integer	AH49E024005000000001

mineral species code, mineral species name, syngenetic ore, associated ore, sum of mineral deposits, ore grade, size, forming era, mineral deposit name, mineralization type, genesis type, and subtype ID.

4 Data Quality Control and Evaluation

The 1∶50 000 mineral geological map of the Panxin Map-sheet is a mineral-specific mapping demonstration site for the 1∶50 000 mineral survey and ore prospecting prediction campaign conducted by CGS in 2017. Its task is to systematically collect and comprehensively analyze existing geological, geophysical, geochemical, remote sensing, and mineral data, principally those related to the Nanhuanian "Datangpo-type" manganese deposits in Eastern Guizhou, within the 1∶50 000 Panxin Map-sheet in the Songtao integrated exploration area of manganese deposits in Tongren, Guizhou; perform 1∶50 000 sedimentary mineral geology-specific mapping and thematic research, comprehensive geochemical data analysis (Table 9), and ore prospecting prediction of this map-sheet with digital geological survey technology; and delineate the ore prospecting targets. In order to guarantee the survey accuracy, the means were taken to ensure that the basic map layers collected meet the required accuracy, and all portable computers had their GPS system calibrated at class C control points.

All survey activities involved in the project were carried out in strict accordance with the CGS *Technical Requirements for Mineral Geological Survey* (1∶50 000)(DD2019–02), as well as detailed provisions and design requirements for specific mapping and potential evaluation. Field survey was performed and completed from June to December 2017 according to the project design. All work completed received a three-level check at the work group,

Table 9 The 1：50 000 mineral geological map database of the Panxin Map-sheet (H49E024005) of the Songtao Manganese Deposit in Tongren, Guizhou

Data Type	Data quantity	Data description
Petrochemical exploration analysis data	150	15 elements (U, Th, Fe, Mn, Co, Ni, Cu, Pb, Zn, Cr, Au, Ag, V, Ti, Al)
General rock/ore analysis data	333	General chemical analysis
Thin section identification data	200	Mineral composition & contents; rock texture & structure
Isotopic age data	90 spots	Zircon U–Pb age
Sum of mineral deposits	6	Mn deposit (3), Pb-Zn deposit (2), Hg deposit (1)
Mineral deposit type	2	Sedimentary Mn deposit, hydrothermal Pb-Zn deposit and Hg deposit

project department, and brigade levels, with work group-level self and mutual check ratio of 100%, project department-level check ratio of greater than 30%, and brigade-level spot check ratio of greater than 10%, thus guaranteeing the data quality. Field acceptance was performed on June 19–20 and the rating was Excellent. On March 19, 2019, experts from the Development and Research Center of China Geological Survey (Mineral Exploration Technical Guidance Center of Ministry of Natural Resources) and Department of Natural Resources of Guizhou Province reviewed the project results and rated them Excellent.

5 Data Value

(1) The 1：50 000 mineral geological map of the Panxin Map-sheet (H49E024005) of the Songtao manganese deposits in Tongren, Guizhou is a demonstrative map-sheet of the CGS' new round of mineral geological survey. The map introduces an innovative way of presenting mineral geology-specific mapping results, setting a good example for mineral geological survey activities.

(2) According to the *Technical Requirements for Mineral Geological Survey* (1：50 000) (DD 2019–02), after intensively investigating the rock composition, texture and structure of the sedimentary sequence in the Panxin Map-sheet area, basing on the formation division method and comprehensive analysis and studies on formations and structures, the sedimentary rock strata was redivided into 39 mapping units and eight formation types.

(3) It marks off five formation mapping units of the metallogenic period of the main mineral type of the Nanhuanian manganese deposits, and basically ascertains the manganese-bearing rock systems and synsedimentary faults closely related to the distribution and formation of manganese deposits, as well as the post structures affecting the preservation conditions of the manganese deposits

(4) It provides basic data support for the metallogenic research, deep prospecting prediction, energy exploration, and mineral resource planning of manganese deposits in the area, and upgrades the ability of mineral geology to serve resource security, economic-social development, and ecological civilization.

6 Conclusions

(1)The lithostratigraphic sequence of the 1：50 000 Panxin Map-sheet (H49E024005) is established, presenting 39 mapping units and eight formation types. According to the rift basin paleo-natural gas leakage sedimentary metallogenic system model and tectonic paleogeographic unit characteristics of manganese deposits, five interrelated manganese-bearing formation mapping units are marked off.

(2)Through mineral-specific mapping work, the manganese-bearing rock systems, synsedimentary faults, and tectonic characteristics affecting the preservation conditions of the manganese deposits are basically ascertained, providing support for the metallogenesis research of manganese deposits and the prospecting of deep hidden manganese deposits.

(3)The *Special Guide for the Specific Mapping of Paleo-natural Gas Leakage Sedimentary Manganese Deposits* was compiled, providing reference for similar manganese deposit prospecting in other areas and from other geological eras.

(4)The 1：50 000 mineral geological map of the Panxin Map-sheet (H49E024005) was comprehensively and systematically compiled and a database thereof was built. It highlights the information of ore-bearing formations, ore-controlling structures and mineralization alterations, setting an example for the mineral-specific mapping work in the new round of 1：50 000 mineral geological survey campaign.

Acknowledgments: The new generation 1：50 000 mineral geological map of the Panxin Map-sheet (H49E024005) and its database are the results of the collective effort of experts from Development and Research Center of China Geological Survey, Mineral Exploration Technical Guidance Center of Ministry of Natural Resources, Department of Natural Resources of Guizhou Province, and Guizhou Bureau of Geology and Mineral Exploration and Development. The authors thank all people that have contributed to this project.

Notes:

❶ No.115 Geological Brigade of Guizhou Bureau of Geology and Mineral Exploration and Development. 2016. The 1：50 000 Regional Geological Survey Report of the Panxin Map-sheet (H49E024005)[R].

❷ No.103 Geological Brigade of Guizhou Bureau of Geology and Mineral Exploration and Development. 2011. Detailed Geological Survey Report of the Xixibao Manganese Deposit (periphery) in Songtao County, Guizhou[R].

❸ No.103 Geological Brigade of Guizhou Bureau of Geology and Mineral Exploration and Development. 2016. Detailed Survey Report of the Pujue Manganese Deposit (consolidated) in Songtao County, Guizhou[R].

❹ No.103 Geological Brigade of Guizhou Bureau of Geology and Mineral Exploration and Development. 2016. Detailed Survey Report of the Taoziping Manganese Deposit in Songtao County, Guizhou[R].

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❻ Guizhou Institute of Geological Survey. 2012. Manganese Resource Potential Evaluation Report of Guizhou[R].

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