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胶东成矿区栖霞—牟平地区1：50 000 地质矿产调查数据库

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摘要：胶东成矿区栖霞—牟平地区地质矿产调查是中国地质调查局开展新一轮矿产地质调查工作项目。填（编）的 10 幅 1：50 000 矿产地质图是根据《固体矿产地质调查技术要求（1：50 000）》（DD 2019−02）和行业其他统一标准及要求，结合区域地质调查成果资料，采用数字填图系统进行野外地质专项填图，并应用室内与室外填编图相结合的方法完成的。在充分利用最新获得的 1：50 000 遥感地质解译、地面高精度磁法测量、重力测量成果资料的基础上，全区新发现矿点矿（化）点 31 处，包括金矿（化）点 24 处、铜矿点 4 处、银铅矿点 3 处，圈定找矿靶区 42 处，其中 A 级 25 处、B 级 14 处、C 级 3 处，并纳入数据库中。胶东成矿区栖霞—牟平地区地质矿产调查数据库是 1：50 000 矿产地质图库和图饰、地球物理数据库、遥感数据库、样品数据库、综合成果数据库、勘探工程库等成果的集成，数据容量合计 299 MB，包含矿产地数据 275 处，涉及多金属矿、贵金属矿以及非金属矿 23 种，预测金资源量 836.94 t、银 499 t、铜 72.71 万 t、铅 17.41 万 t、锌 28.31 万 t、钼 35.70 万 t、钨 2.8 万 t、石墨 164 万 t。对该区基础地质研究、矿产资源勘探等具重要参考意义。

关键词：胶东成矿区；栖霞—牟平；数据库；地质矿产调查；1：50 000；山东省

数据服务系统网址：http://dcc.cgs.gov.cn

1 引言

胶东成矿区位于华北克拉通东南缘，以郯庐断裂带为界与鲁西地区相邻，大地构造区划属于柴达木—华北板块和羌塘—扬子—华南板块 2 个Ⅰ级大地构造单元的结合部位，由胶北隆起、胶莱坳陷、胶南—威海超高压变质带和苏北高压变质带 4 个Ⅳ级构造单元组成。栖霞—牟平地区位于胶东成矿区东部，相对于胶西北黄金矿集区来说，该区

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金多金属矿普遍发育，以出露前寒武纪结晶基底、中生代陆源碎屑岩、晚侏罗世—早白垩世二长花岗岩为特征（图 1）。张田和张岳桥（2007）对胶东地区中生代侵入岩58 个同位素年龄数据的统计分析，将中生代深成岩浆活动划分为 3 个显著不同的演化阶段: 晚三叠世（225 ~ 205 Ma）幔源型花岗岩，晚侏罗世（160 ~ 150 Ma）地壳重熔型花岗岩（S 型）和早白垩世（130 ~ 105 Ma）壳幔混合型花岗岩（I–A 型）。区内脆性断裂构造发育，NE、NNE 向断裂是工作区的主要构造线，以左行压扭性为主，常控制或明显改造早期地质体，且与金矿成矿关系密切。

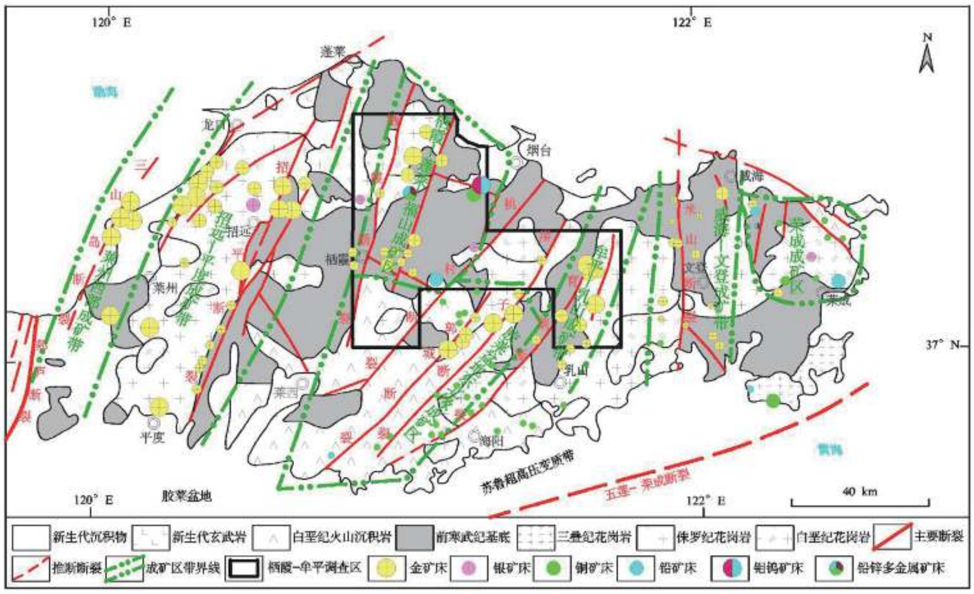

图 1　胶东成矿区栖霞—牟平地区地质矿产略图（据丁正江等，2015 修改）

胶东栖霞—牟平地区 1∶50 000 矿产地质调查包括 10 个图幅：栖霞市幅（J51E017004）、桃村幅（J51E017005）、山前店幅（J51E018004）、高疃幅（J51E016005）、臧家庄幅（J51E016004）、大辛店幅（J51E015004）、岗嵛幅（J51E015005）、水道幅（J51E017007）、观水幅（J51E017006）、冯家幅（J51E018007）。20 世纪 80—90 年代，在这些图幅开展了区域地质调查工作（刘建明等，1988；赵运伦等，1990；张富中等，1993；薛志忠等，1996；杨国福等，2000），除山前店幅外，其他 9 个图幅还完成了 1∶50 000 土壤地球化学测量（陈运环等，1987；王天君等，1991；陈立博，1992）。前人对该区基础地质、矿产地质等方面进行了大量的研究工作（翟明国，2013；祝德成等，2018；Yang KF et al., 2018；Wan YS et al., 2006；谢士稳等，2014；Jahn et al., 2008；Zhou JB et al., 2008；刘建辉等，2011,2013；Xie SW et al., 2014；侯明兰等, 2004,2006；苗来成等, 1997,1998；关康等，1998；丁正江等, 2012,2015a,2015b；于学峰等，2012；李杰等，2016；刘建明等，1988；张富中等，1993；李守军等，2016；薛志忠等，1996；薛玉山等，2014；杨国福等，2000；崔元俊等，2016；赵运伦等，1990；王沛成等，1991；王天君等，1991；陈运环等，1987；黄峰等，1990；王奎峰等，2016；张丕建等，2015），这些成果为该区的矿产地质调查提供了丰富的地质数据和资料。胶东成矿区栖霞—牟平地区地质矿产调查数据库在前人工作的基础上，综合利用了 1∶50 000 遥感地质解译、1∶50000 重力测

量、1∶50 000 地面高精度磁法测量、1∶50 000 矿产地质填图、槽探、钻探等多种手段，对该区成矿地质条件、成矿规律、成矿远景、矿产资源潜力进行了系统总结与评价，为该区矿产资源勘查和研究提供基础地质图件及信息支撑。该矿产地质调查数据库（付超等，2020）的元数据见表 1。

表 1　数据库（集）元数据简表

条目	描述
数据库（集）名称	胶东成矿区栖霞—牟平地区1∶50 000地质矿产调查数据库
数据库（集）作者	栖霞市幅（J51E017004）、桃村幅（J51E017005）、山前店幅（J51E018004）: 付超，彭丽娜，中国地质调查局天津地质调查中心 高疃幅（J51E016005）、臧家庄幅（J51E016004）、大辛店幅（J51E015004）、岗嵛幅（J51E015005）: 戴广凯，朱学强，山东省地质调查院 水道幅（J51E017007）、观水幅（J51E017006）、冯家幅（J51E018007）: 邹键，马方，山东省第三地质矿产勘查院
数据时间范围	2016—2018年
数据格式	MapGIS
数据量	299 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“胶东成矿区栖霞—牟平地区地质矿产调查”（项目编号:DD20160044）资助
语种	中文
数据库（集）组成	胶东成矿区栖霞—牟平地区地质矿产调查数据库包括1∶50 000矿产地质图库和图饰、地球物理数据库、遥感数据库、样品数据库、综合成果数据库、勘探工程库等。矿产地质图库包括沉积岩、岩浆岩、火山岩、变质岩、第四系、脉岩、构造、地质界线、产状、矿床（点）、蚀变、岩性花纹、各类代号等;图饰包括接图表、柱状图、图例、图切剖面、典型矿床成矿要素图、典型矿床实测剖面图、矿产地名录、所属成矿区带位置图、责任表;地球物理数据库包括地球物理异常图和平面图;遥感数据库包括遥感异常提取、推测线性构造;综合成果数据库包括异常查证结果表、矿产地预测远景区图层、找矿靶区图层;勘探工程库包括探槽、钻孔等

2　数据采集和处理方法

2.1　数据基础

（1）1∶50 000 矿产地质图数据基础

工作区 10 幅 1∶50 000 矿产地质图在图面设计、内容表达、角图处理等均以《固体矿产地质调查技术要求（1∶50 000）》（DD2019–02）为指导，以各图幅相应区域地质调查原始资料（包括实际材料图、剖面图、野外地质记录）为基础，对工作区科研论著进行系统收集与整理，将已获成岩年代、成矿时代、含矿建造、控矿构造在图面进行标注，同时充分结合本次野外矿产地质填图、不同比例尺剖面测量、地质单元年代学测试、岩矿石样品鉴定与测试等最新成果编制完成。地理底图采用 1983 年总参测绘局出版的 1∶50 000 地形图。应用已有的技术标准和数字填图系统（DGSS）、MapGIS 等计算机软件进行数据处理。

（2）遥感数据基础

工作区遥感地质解译按照《矿产资源遥感调查技术要求》（DD 2011-05），充分参

考已有地质资料，利用美国陆地卫星 Landsat-5 Thematic Mapper（TM）（分辨率为 30 m）、Landsat-7 Enhanced Thematic Mapper（ETM）（分辨率为 15 m）、Landsat-8 Operational Land Imager（OLI）（分辨率为 15 m）和日本 ASTER 遥感数据（分辨率为 15 m）、国产高分一号（分辨率为 2 m）卫星数据，进行数据处理、地质解译及蚀变信息提取，并利用 NV、MapGIS 等计算机软件进行数据处理。

2.2 数据处理过程

2.2.1 数据准备

在建造–构造图编制前，将收集到的各幅对应的 1：25 000 实际材料图、1：50 000 区域地质图、路线、剖面等地质资料进行数字化处理，形成 MapGIS 点、线、面文件；按照各幅经纬度拐点坐标，生成 1：50 000 标准图框，投影系统为高斯–克吕格投影参数，坐标系统为西安 80，然后将实际材料图 MapGIS 文件校正到标准图框中。

2.2.2 编制建造–构造草图

工作区前寒武纪变质基底覆盖严重，中生代花岗质侵入岩与 Au、Cu、Mo、Pb、Zn 多金属成矿关系密切，NE、NNE 向断裂控制着区内矿床的产出及空间分布。因此，中生代侵入岩、断裂构造特征及蚀变类型、矿化带分布及与已知矿床的空间关系成为建造–构造图编制的重点内容。

根据已有区域地质资料、实测剖面、野外路线等实际材料，结合典型矿床含矿特征，赋矿地质单元、成矿地质体、矿化蚀变特征等信息，对工作区内组Ⅰ级地质单元进行分解，建立建造单元，确定含矿建造特征及空间展布状态，相应地补充建造界线，并将野外记录以岩性建造花纹点或线的形式表达在实际材料图上。例如栖霞市幅建造–构造草图（图 2）。

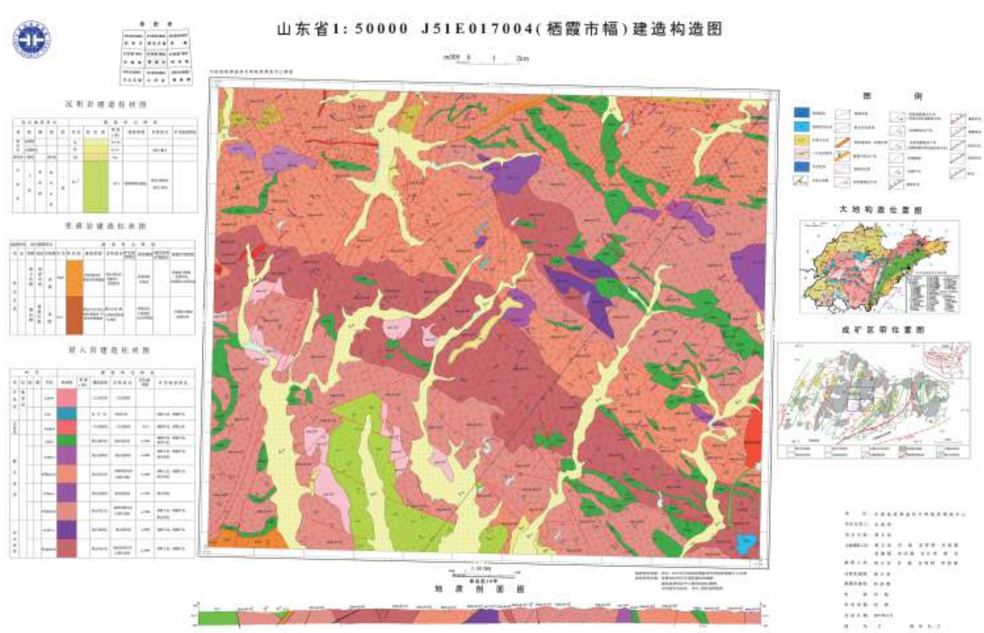

图 2 胶东成矿区栖霞市幅 1：50 000 建造–构造图示意图

（1）建造

参照《地质图用色标准及用色原则》（DZ/T 0179-1997），使用不同颜色的面元表达建造的时代，使用建造花纹表达建造类型，并用相应的花纹表达岩石组合，代号用时

代+岩性表达。在图面表达中，变质岩区考虑到原岩的不同成因，对于岩浆成因变质岩建造花纹采用侵入岩花纹与变质类型相结合的方式表达；侵入岩区采用相应岩浆岩花纹表达，沉积岩区采用沉积建造花纹表达，火山岩区采用火山岩性、岩相内容表达。矿化蚀变带按照其空间展布用相应的蚀变花纹进行表示。

（2）脉岩

按照统一的用色标准使用面元的颜色表达岩性，代号用岩性代号表示，含矿脉岩在岩性代号后用元素符号标注。脉岩边界存在矿化蚀变信息的，则根据野外调查记录，采用相应蚀变花纹在脉岩边界处进行表示。

（3）构造

构造—蚀变信息的表达是本次建造—构造图编制的重点，在图面上，以野外实际调查记录为基础，集成遥感构造解译、地球物理构造解译等综合信息，详细表示韧性剪切带、断裂等构造变形特征及空间展布，对断裂带内矿化蚀变现象、分布区域采用相应蚀变花纹进行表示。按照统一的用色标准使用红色统一表示，用不同线型表达断裂、韧性剪切带等构造变形性质。

（4）地质剖面

使用“标准剖面线型+剖面代号”表达位置，并以地质点及编号表达实际控制点情况，以相应的花纹表达各层岩性，同时在地质剖面上表达产状要素。

（5）岩石化学样品采样点

使用“标准子图号+样品编号”表达采样点位置，并建立数据库。

（6）地球化学样品采样点

使用“标准子图号+样品编号”表达采样点位置，并建立数据库。

（7）同位素样品采样点

使用“标准子图号+样品编号”表达采样点位置，并建立数据库。

（8）综合柱状图编制

利用最新获得的成果资料，结合已有地质调查、科学研究数据，确定全区所处大地构造位置，综合分析工作区时空演化特征，建立全区构造–岩浆格架，并在此基础上，编制工作区变质岩、沉积岩、火山岩、侵入岩建造柱状图。

2.2.3　野外数据采集

（1）野外专项地质填图

根据已有资料的综合分析整理和建造–构造草图的编制，对工作区进行了重点工作区和一般工作区的划分，对于重点工作区，采用路线地质调查、剖面测量、大比例尺填图、工程控制等多手段开展调查工作，对于一般工作区，则充分利用前人开展的1∶50 000、1∶250 000区域地质矿产调查资料，采用原地质路线为主，结合野外实测地质路线进行稀疏控制的原则开展工作。确定了NE、NNE台前—陡崖断裂、栖霞断裂、盘子涧断裂、马家窑断裂、虎路线断裂、东吴家断裂、黑岚沟断裂、大柳行断裂、八甲—唐家沟断裂、金牛山断裂、岔河—下初断裂、仙姑顶断裂和桲椤—石城断裂为工作区主要控矿断裂，矿体赋存于断裂下盘，以断层泥和黄铁绢英岩为主要见矿标志；中生代印支期玲珑系列花岗岩为重要的含矿岩体，燕山早期郭家岭系列花岗岩、燕山晚期韦德山系列花岗岩为成矿岩体；硅化、黄铁矿化、绢云母化、钾化蚀变为重要的找矿标志；闪长玢岩、煌斑岩常与矿体平行或交叉产出等系重点填图内容。以数字填图掌上电脑中1∶250 00实际材料图为底图，通过野外实际路线调查，在数字填图系统中标绘出地质

点、界线点和地质界线及路线等点、线信息，观察并录入各点的性质、岩性、产状等信息，初步建立数字填图（PRB）数据库。

对沿途所见的地质产状和采集的标本信息，随时在系统中定位录入相关信息，填写属性数据。

（2）地面高精度磁法测量、重力测量

1：50 000 地面高精度磁法测量完成测地工作、仪器检测、总基点与日变站联测后即可开展日变及观测点观测，每个闭合观测单元的观测，始于校正点，终于校正点。将每个测量点观测数据采集入磁力仪中，并依据规范要求，对磁测资料和日变资料作预处理，删除或修正受干扰的畸变点数据，对数据进行编辑，对原始观测值进行日变改正、正常梯度与高度改正、总基点改正。利用该套数据完成工作区磁法图件的编制与异常解释。

1：50 000 重力测量基点网是以山东省烟台市莱山机场重力Ⅰ级基点为起算点，在各图幅均布设基准点 1 个并标记、编录，建立基点档案。重力点的观测采用单程观测法，野外观测起闭于基点，基点闭合时间严格按动态试验确定的闭合时间控制，重力测点观测的每个闭合段的零点位移值，不大于重力测点观测精度的 3 倍。野外观测数据经理论固体潮改正、零点位移改正后，最后计算出实测重力值 g_{i}，经正常重力值改正、布格改正后，即可计算布格重力异常值，利用该套数据完成工作区重力图件的编制与异常解释。

（3）工程数据采集

工程数据采集包括探槽和钻孔。在数字地质调查信息综合平台探矿工程界面下，执行探矿工程数据→新建工程点→探槽→录入探槽基本信息；执行探矿工程数据→工程数据库编辑→探槽→依次录入导线库、轮廓库、分层库、刻槽样、产状、照片等地质数据→生成素描图，并对其进行整理、整饰。

在数字地质调查信息综合平台探矿工程界面下，执行探矿工程数据→新建工程点→钻孔→录入钻孔基本信息；执行探矿工程数据→工程数据库编辑→钻孔→依次录入回次、分层、劈心样、照片等地质数据→生成柱状图，并对其进行整理、整饰。

2.2.4 室内数据整理

（1）地质图库整理

工作区 10 个 1：50 000 图幅共包含 1：25 000 图幅 PRB 库（地质点、地质路线、地质界线）、实际材料图库、采集日备份、野外手图、背景图层、样品数据库等数字填图原始资料数据库各 40 个。其中野外手图库存储野外地质路线各类地质数据，是最重要的野外第一性原始资料数据库。单条野外手图路线库均由 Images（存储照片）、note（存储 XML 文档及 TXT 文本）、素描图（存储素描图）3 个文件夹及 10 个野外路线实体观测数。其中 PRB 库是各类地质数据库的基础，也是野外地质填图的第一手资料，关系着其余图库的质量及完整性。因此，对 PRB 库的录入需相应规范结合野外观测现象进行数据整理。

①地质点（P）录入过程基本要求: 路线号、风化程度、接触关系、露头特点等信息按照实际情况填写完整，注重地物坐标的表示，填图单位填写相应填图单元代号，岩石名称与地质描述对话框中保持一致（包括颜色、结构、构造等），批注信息为包括薄片鉴定结果，并按照实际情况综合定名后填写。

②地质路线（R）录入过程基本要求: R 在室内按照“光滑曲线→修改线参数（线

性 1 颜色 1 线宽 0）→点间路线计算→（统计工作量）”进行。补充完善 R 属性数据库，并在进行路线地质描述前重新计算方位和距离。

③地质界线（B）录入过程基本要求: 在室内计算机上用剪短线、延长线的方法按照接触情况对地质界线进行美化。统一颜色、线性及线宽等参数。补充地质界线描述信息，用“东侧为 xxx，西侧为 xxx”来说明界线两侧岩性，并对两种岩性的接触关系及其证据加以表述，避免了用左、右表示方向所带来的混乱。

④路线中的产状、采样、照片要求: 核实、补充产状、采样、照相等相应属性描述信息。产状编号在换地质点后重新从 1、2、3 等开始编号，照片按照要求导入后在照片详细描述中对照片内容及所反映地质现象进行描述。

图幅 PRB 库文件类型及文件名与野外手图库完全一致。实际材料图库继承 PRB 库野外路线实体观测数据点、线采集层及标注图层，同时自动生成 GEOLABEL.wt、GEOLINE.wl、GEOPOLY.wp 点、线、面 3 个文件。采集日备份数据库存放掌上机野外路线采集数据，按路线备份，其数据未解压还原，是野外地质路线进一步室内整理的依据。背景图层存储地理底图数据，主要包括地理信息、水系、交通、居民地、境界、地形等要素。样品数据库存储图幅不同类型样品，分为样品采集库、送样库和测试鉴定成果库 3 类，数据存放在 RgSample.mdb 数据库中。

完成 PRB 库整理后，将本次野外实际采集的 PRB 数据为主的实际材料图与编制建造构造草图时整理的区域地质调查实际材料图进行合并，对地层单元界线、建造花纹、反映各类建造的构造形态进行修正，对新形成的地质单元的界线进行勾连。

完成主图图面编辑后，在图面两侧分别建立建造柱状图、工作区典型矿床成矿模式图、典型矿床勘探线剖面图、工作区大地构造位置图、所处成矿区带位置图、矿产地名录、其他图例、图签等信息，形成完整的矿产地质图，如图 3 所示。

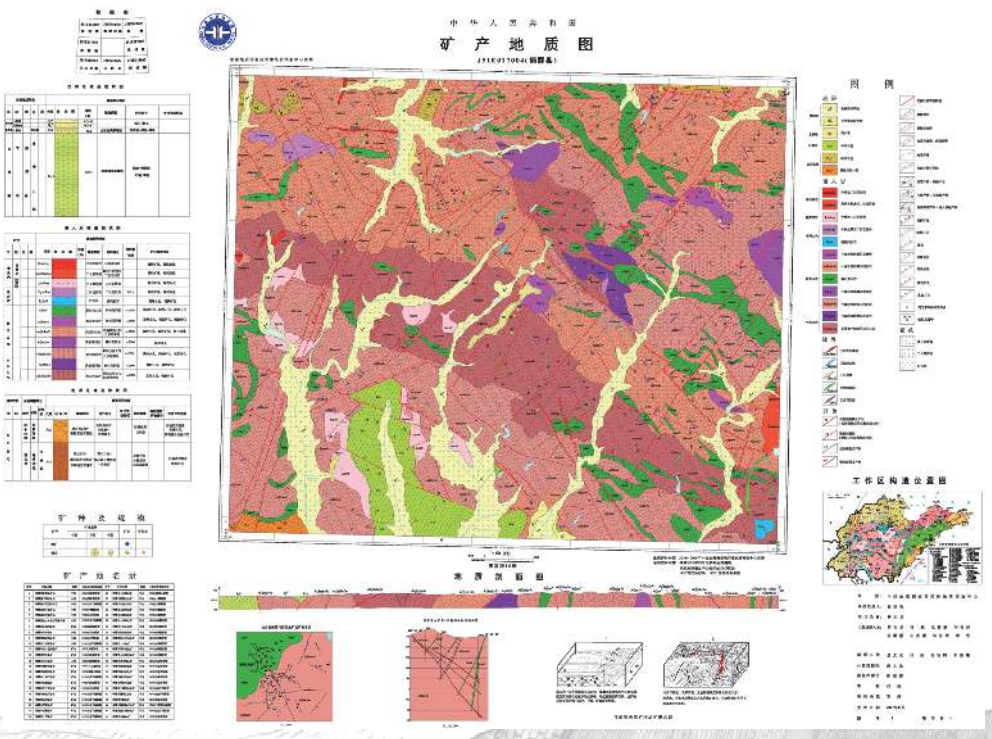

图 3　胶东成矿区栖霞市幅矿产地质图示意图

（2）地球物理及遥感数据录入

将物探工作提取的数据转换为MapGIS数据格式后，在1∶50 000图幅数字填图下分幅建立了地球物理库，在物化遥数据操作菜单栏下进行数据结构标准化，包括文件命名和属性结构的标准化。鉴于工作区成矿与中生代岩体、断裂关系密切的现状，对全区重磁测量数据开展解译推断工作，新推断裂76条，推断隐伏岩体15处，圈定重力异常101处，高磁异常60处，重磁综合异常10处，筛选出成矿远景区15处，提出了金矿找矿的地球物理标志，并与矿产地质填图成果进行比较、修正，进一步完善矿产地质图内容，为该区矿产勘查提供基础地质资料。

遥感数据库包括遥感影像、蚀变异常提取及遥感解译。遥感影像为.jpg格式数据，直接存储在数字填图下“遥感”文件夹中；遥感解译和蚀变异常提取为MapGIS数据格式，在物化遥数据操作菜单栏下执行“成果数据新增”→遥感推断地质构造→推断线性构造图层（推断环形构造图层）和遥感异常图层，录入推断线性构造图层、环形构造图层和异常图层的属性内容，即完成遥感数据库的建设工作。

3　成果数据内容描述

3.1　数据存储

以《数字地质图空间数据库》（DD 2006–06）为矿产地质图数据库建设的基本要求，工作区1∶50 000矿产地质调查成果数据库通过基本要素类、综合要素类、对象类以及独立要素类对数据进行分别存储。根据DGSS版本不同，存储格式有2种: 地质面.wp，地质线.wl，地质点.wt；地质面.pm，地质线.lm，地质点.tm。

3.2　图层内容

图层内容主要包括3大类: 基本要素类、综合要素类、对象类、地球化学数据、地球物理数据、遥感数据等。其中基本要素类、综合要素类、对象类数据分别对应BASE_FCLS.mdb、DSGMAP.mdb、SYNTH_FCLS.mdb具有相应属性结构的数据表，以大辛店幅为例，具体要素类信息见表2。地球化学数据、地球物理数据、遥感数据建立相应的数据库，最后形成包括异常查证结果表、矿点检查结果表、找矿靶区、矿产预测远景区等信息的综合成果库。

基本要素类包括：地质体面实体（_GEOPOLYGON），地质界线（_GEOLINE），矿产地（_MINERAL_PNT），产状（_ATTITUDE），样品（_SAMPLE），照片。

综合要素类包括：构造变形带（_TECTZONE），蚀变带（_ALTERATION_POLYGON），变质相带（_METAMOR_FACIES），火山岩相带（_VOLCA_FACIES），标准图框（_MAP_FRAME）。

对象类包括：沉积（火山）地层单位（STRATA），侵入岩岩石年代单位（INTRU_LITHO_CHEONO），断层（FAULT），变质岩地（岩）层单位（METAMORPHIC），特殊地质体（SPECIAL_GEOBODY），脉岩（面）（_DIKE_OBJECT）、面状水域与沼泽（_WATER_REGION），图幅基本信息（_SHEET_MAPINFO）。

独立要素类主要以角图形式表达，主要包括图例、柱状图、图切剖面、接图表典型矿床解剖图、矿产地名录、矿种及规模、所处成矿区带位置图、责任表等角图。

遥感推断地质构造包括：遥感异常图层（Rsanomaly）、推断线性构造图层

表 2　大辛店幅成果数据库基本要素类、综合要素类和对象类数据表

图幅号	数据集	实体名称	文件名	数据类型
J51E015004（大辛店幅）	基本要素类	地质体面实体	_GEOPOLYGON.wp	Area
		地质（界）线	_GEOLINE.wl	Line
		矿产地	_MINERAL_PNT.wt	Point
		产状	_ATTITUDE.wt	Point
		样品	SAMPLE.wt	Point
		同位素测年	_ISOTOPE.wt	Point
		钻孔	DRILLHOLE.wt	Point
		火山口	_CRATER.wt	Point
		河、湖、海、水库岸线	_LINE_GEOGRAPHY.wl	Line
	综合要素类	构造变形带	_TECOZONE.wp	Area
		蚀变带（面）	_ALTERATION_POLYGON.wp	Area
		变质相带	_METAMOR_FACIES.wp	Area
		火山岩相带	_VOLCA_FACIES.wp	Area
		矿化带	MINERAL_ZONE.wp	Area
		标准图框（内图框）	_MAP_FRAME.wl	Line
	对象类	沉积（火山）岩岩石地层单位	_STRATA	ACCESS
		侵入岩岩石年代单位	_INTRU_LITHO_CHRONO	ACCESS
		断层	_FAULT	ACCESS
		变质岩地（岩）层单位	_METAMORPHIC	ACCESS
		特殊地质体	_SPECIAL_GEOBODY	ACCESS
		非正式地层单位	INF_STRATA	ACCESS
		脉岩（面）	_DIKE_OBJECT	ACCESS
		面状水域与沼泽	_WATER_REGION	ACCESS
		图幅基本信息	_SHEET_MAPINFO	ACCESS
	遥感推断地质构造	遥感异常图层	Rsanomaly.wp	Area
		推断线性构造图层	Rslinear.wl	Line
		推断环形构造图层	RSRing.wl	Line
	地球物理数据类	重磁异常预测区图层	GRAVMAGNETICLINEAR.wl	Line
		重磁异常预测区图层	GRAVMAGNETICLINEAR.wt	Point
	地球化学数据类	水系沉积物异常图层	ANOMALY_STREAM.wl	Line
		水系沉积物异常图层	ANOMALY_STREAM.wt	Point
	成矿规律与矿产预测	矿产预测远景区图层	PredictedProspectiveArea.wp	Area
		找矿靶区图层	TargetArea.wp	Area
		地质工作部署建议图层	WorkPlan.wp	Area

（Rslinear）、推断环形构造图层（Rsring）。

地球物理数据包括：重磁异常预测区图层（GRAVMAGNETICLINEAR）。

地球化学数据包括：水系沉积物异常图层（ANOMALY_STREAM）。

成矿规律与矿产预测包括：矿产预测远景区图层（PredictedProspectiveArea）、找矿靶区图层（TargetArea）、地质工作部署建议图层（WorkPlan）。

4　数据质量控制和评估

矿产地质填图精度按照《固体矿产地质调查技术要求（1∶50000）》（DD 2019−02）采用填编结合的方法，重点地区以实测为主，一般工作区根据各幅区域地质调查原始资料编图为主。地质点采集以充分控制与成矿有关的地质体、矿化蚀变带、重要地质界线等为原则。数据库的投影参数和比例尺精度均按要求定义，空间定位准确，系统节点/裁剪搜索半径为 10^{-9}，满足图形精度要求。

图面表达一般只表达直径大于 100 m 的闭合地质体，宽度大于 50 m、长度大于 250 m 的线状地质体，以及长度大于 250 m 的断层、褶皱构造。对矿化蚀变构造带及其他矿化地质体规模不论大小，均在图上表示；厚度较小者，用适当的花纹、符号放大或归并表示。一般地质点在野外手图上所标定的点位与实地位置误差不得大于 25 m。

地质图空间数据库文件种类齐全，文件命名及属性结构符合相关规范要求；数据库各数据集（基本要素类、综合要素类、独立要素类、对象类）数据项与地质图图面表达内容吻合，各数据项属性内容表达准确，基本能反映原地质图及文字报告资料的实际情况，符合建库要求。

数据质量方面，填图路线自检、互检达 100%，项目组抽检 30%，符合地质调查项目质量管理要求。2018 年 12 月 1—2 日中国地质调查局天津地质调查中心组织专家采用室内、现场两者相结合的检查方法对胶东成矿区栖霞—牟平地区地质矿产调查项目进行了野外验收，结果为优秀级。2019 年 8 月 13—15 日，中国地质调查局华北项目办会同中国地质调查局网信办组织专家对该项目数据库进行了验收，经过专家缜密的审核、质询后，顺利通过验收。

5　数据价值

胶东成矿区栖霞—牟平地区地质矿产调查是中国地质调查局开展新一轮矿产地质调查工作项目。在项目实施过程中，按照《固体矿产地质调查技术要求（1∶50000）》（DD 2019−02）要求，对全区矿产地进行了系统梳理与总结，入库矿产地数据 275 处（表 3），涉及多金属矿、贵金属矿以及非金属矿 23 种，其中金矿 218 处，大型矿床 22 处，中型矿床 18 处，小型矿床 60 处；砂金矿 3 处；银矿 5 处；铜矿 21 处，中型矿床 1 处；铅矿 6 处；铅锌矿 4 处；铜铅锌多金属矿 2 处，中型矿床 1 处；钨钼矿大型矿床 1 处；锰矿 5 处；铁矿 5 处；石榴子石矿 1 处；石墨矿 1 处。

项目在实施过程中，以建造为划分基础，通过建造与构造的综合分析与研究，建立了岩浆岩的演化序列，确定了该区含矿建造、控矿构造的空间展布，利用最新遥感地质解译、地面高精度磁法测量、重力测量等多种手段的综合运用，对工作区地球物理场进行了精细解译，根据工作区构造、中生代岩体控矿的特征，对全区进行了重磁推断断裂及隐伏岩体解译，新解译隐伏岩体 15 处，确定了 16 条北东、北北东向断裂控制着全区金矿的产出及空间展布，提出遥感、地球物理的找矿标志，筛选了成矿远景区；结合化探异常、地质剖面测量、地质路线调查，新发现矿点矿（化）点 31 处，包括金矿（化）点 24 处、铜矿点 4 处、银铅矿点 3 处，并对物化探异常及矿点开展异常查证和检查工作，圈定了找矿靶区 42 处，其中 A 类 25 处、B 类 14 处、C 类 3 处（表 4），通过对全区重要矿种开展矿产资源潜力评价，预测金资源量 836.94 t；银 499 t；铜 72.71 万 t；铅 17.41 万 t，锌 28.31 万 t；钼 35.70 万 t、钨 2.8 万 t；石墨 164 万 t，并将

表 3　测区矿种数量及规模一览表

矿种	规模					合计
	大型矿床	中型矿床	小型矿床	矿点	矿化点	
岩金	22	18	60	87	31	218
砂金			1	2		3
银		1	2	2		5
铜		1	1	8	10	20
铜钼			1			1
钼		1		1		2
铅				3	3	6
铅锌				2	2	4
铜铅锌多金属		1			1	2
钨钼	1					1
锰				4		4
铁			1	4		5
石榴子石			1			1
石墨矿		1				1
总计	23	23	67	113	47	275

表 4　胶东成矿区栖霞—牟平地区找矿靶区一览表

序号	名称	位置	矿种	类别
1	下雨村金矿床深部找矿靶区	烟台市牟平区西南24 km处的高陵镇下雨村北山，行政区划属烟台市牟平区高陵镇	金	A类
2	磨山金矿深部找矿靶区	烟台市牟平区南约15 km，行政区划属牟平区高陵镇	金	A类
3	磨山金矿床外围找矿靶区	位于烟台市牟平区南约15 km，行政区划属牟平区高陵镇	金	A类
4	双山屯金矿深部找矿靶区	位于烟台市牟平城区西南12 km，双山屯村东，行政区划属牟平区武宁镇和高陵镇	金	A类
5	下潘格庄金矿深部找矿靶区	下潘格庄矿区位于牟平城区西南约15 km，行政区划属高陵镇管辖	金	A类
6	上潘格庄金矿找矿靶区	山东省烟台市牟平区上潘家庄南部一带	金	A类
7	唐家沟金矿深部找矿靶区	位于乳山市城区北约18 km处的唐家沟村南东，行政区划隶属乳山市午极镇	金	A类
8	西直格庄金矿深部找矿靶区	位于牟平城区南25 km，行政区划隶属牟平区水道镇	金	A类
9	邓格庄—金牛山金矿深部找矿靶区	位于牟平区城区南30 km处的西邓格庄村南，东邓格庄—金牛山一带，行政区划属水道镇管辖	金	A类
10	英格庄金矿床深部找矿靶区	位于乳山市城区北约14 km处的英格庄村东，行政区划属下初镇	金	A类
11	福禄地金矿深部找矿靶区	位于山东省烟台市牟平区城南约25 km的西邓格庄村北一带，行政区划属牟平区莒格庄镇管辖	金	A类
12	金青顶矿区金矿床深部找矿靶区	位于乳山市东北25 km，行政区划属乳山市下初镇	金	A类
13	黑岚沟金矿深部预测靶区	山东省蓬莱市大辛店镇	金	A类
14	齐沟金矿一分矿深部预测靶区	山东省蓬莱市大辛店镇	金	A类
15	燕山金矿深部预测靶区	山东省蓬莱市大柳行镇	金	A类

续表 4

序号	名称	位置	矿种	类别
16	门楼金矿深部预测靶区	山东省蓬莱市大柳行镇	金	A类
17	齐家沟金矿深部预测靶区	山东省蓬莱市大辛店镇	金	A类
18	香夼铅锌矿深部预测靶区	山东省栖霞市臧家庄镇	铅锌	A类
19	王家庄铜矿深部预测靶区	山东省福山区东厅镇	铜	A类
20	邢家山钼（钨）矿深部预测靶区	山东省福山区东厅镇	铜	A类
21	刁龙嘴找矿靶区	三山岛西部海域	金铅	A类
22	大流口金找矿靶区	山东栖霞市大流口村	金	A类
23	上崖头银铅多金属找矿靶区	山东栖霞市上崖头村—虎鹿夼村一带	银、铅	A类
24	东山庄金矿找矿靶区	山东省栖霞市臧家庄镇	金	A类
25	高家银矿找矿靶区	山东省蓬莱市庄园街道	银	A类
26	芙蓉岛找矿靶区	位于潘家屋子以南，芙蓉岛东部海域，三山岛断裂（F_3）西南延伸部位	金	B类
27	双山金矿找矿靶区	山东省栖霞市臧家庄镇与蓬莱市村里集镇交界	金	B类
28	阎家疃金矿床深部找矿靶区	烟台市牟平区城南7 km，阎家疃村南部，行政区划隶属牟平区文化街道办事处	金	B类
29	辉湛金矿找矿靶区	山东省烟台市牟平区辉湛村北部一带	金	B类
30	东桑杭埠—黑牛台金矿床深部找矿靶区	位于烟台市牟平区城南东约30 km处的黑牛台一带，行政区划隶属牟平区玉林店镇	金	B类
31	西邓格庄—高行山金矿深部找矿靶区	位于烟台市牟平区城区南约20 km，水道镇西北约3 km，处行政区划属烟台市牟平区水道镇	金	B类
32	育林山—岔河金矿深部找矿靶区	位于烟台市牟平城区南32 km处的岔河村北一带，行政区划属牟平区水道镇管辖	金	B类
33	郭落庄金找矿靶区	山东栖霞市郭落庄村一带	金	B类
34	后夼金找矿靶区	山东栖霞市草庵村—草夼村一带	金	B类
35	盘子涧金找矿靶区	山东栖霞市盘子涧村一带	金	B类
36	马家窑金找矿靶区	山东栖霞市马家窑—安子夼一带	金	B类
37	町夼金找矿靶区	山东栖霞市町夼村一带	金	B类
38	上范家沟铜金找矿靶区	山东栖霞市上范家沟村一带	铜	B类
39	曲家庵口金矿找矿靶区	山东省蓬莱市大柳行镇	金	B类
40	罗家金找矿靶区	山东栖霞市罗家村一带	金	C类
41	占疃金找矿靶区	栖霞市占疃村—李家圈村一带	金	C类
42	马院山多金属矿找矿靶区	山东省栖霞市经济开发区	铅锌	C类

注：A类指成矿地质条件有利；与已知矿床找矿预测模型吻合程度高，含矿建造、控矿构造等基本清楚；反映与成矿有关的蚀变作用强烈、规模较大、分带明显；有已知矿产地；预测资源量达中型及以上规模。B类指成矿地质条件较有利；与已知矿床找矿预测模型吻合程度较高，含矿建造、控矿构造等较清楚；虽反映与成矿有关的蚀变作用强烈，但规模小、分带弱；有已知矿（化）点；预测资源量达中型及以上规模。C类指成矿地质条件较有利；含矿建造、控矿构造等不甚清楚；蚀变较弱；预测资源量达中型及以上规模。

各类信息、数据全面、准确的录入数据库中，为该地区的矿产勘查的可持续发展提供基础数据支撑，发挥科技创新引领作用，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）胶东成矿区栖霞—牟平地区地质矿产调查是中国地质调查局新一轮地质矿产调查项目，完成的 10 幅矿产地质图以建造为基础，积极探索创新矿产地质专项填图成果表达方式，综合反映了图幅最新研究成果，对矿产地质调查起到了示范作用。

（2）全面系统编制了工作区 10 幅 1：50 000 矿产地质图并建立了空间数据库，突出了成矿信息的表达，确定了含矿建造、控矿构造的空间展布，数据库添加了矿化带、蚀变带、成矿构造、成矿结构面等综合信息的表达。

（3）本次工作在系统收集分析前人资料和研究成果的基础上，结合本次 1：50 000 专项地质填图、1：50 000 地面高精度磁法测量、1：50 000 重力测量、1：50 000 遥感地质解译等综合成果，确定了工作区含矿建造、控矿构造时空分布特征，新发现矿（化）点 31 处；圈定了找矿靶区 42 处；对重要矿种完成了资源潜力评价。

致谢：胶东成矿区栖霞—牟平地区地质矿产调查是一项集体成果，野外一线地质工作人员付出了辛勤的努力。在数据库的建立过程中，得到多位地质矿产、地球物理专家的辛勤指导，在此对各位专家和野外项目组所有成员表示最诚挚的感谢。

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1∶50 000 Geological and Mineral Survey Database of Qixia–Muping Area, Jiaodong Metallogenic Province

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Abstract: The geological and mineral survey in Qixia–Muping area, Jiaodong metallogenic province (also referred to as the survey site) is one of a new round of mineral and geological survey projects initiated by the China Geological Survey. During this project, ten 1∶50 000 mineral geologic maps were mapped (prepared) in accordance with uniform industrial standards and requirements such as the *Technical Requirement of* 1∶50 000 *Solid Mineral Geological Survey* (DD 2019–02). Meanwhile, the results of relevant regional geological surveys were adopted, special geological field mapping was conducted by using digital mapping, and indoor mapping (preparation) was combined with outdoor mapping (preparation). Thirty-one ore occurrences (mineralized points) were newly discovered, and 42 prospecting target areas were delineated throughout the area by making full use of the latest results of geological interpretation of 1∶50 000-scale remote sensing data, high-precision ground magnetic survey and gravity survey. Among them, the former consists of 24 gold ore occurrences (mineralized points), four copper ore occurrences and three silver–lead ore occurrences, and the latter is composed of 25 areas of grade A, 14 areas of grade B, and three areas of grade C. All these survey results were included in the database. The geological and mineral survey database of Qixia–Muping Area, Jiaodong Metallogenic Province (also referred to as the Database) integrates the databases of 1∶50 000-scale mineral and geological maps and their map decorations, geophysical databases, remote sensing databases, sample databases, comprehensive result databases, and prospecting engineering databases, with a total data size of 299 MB. It covers the data of 275 mineral occurring sites, and 23 species of polymetallic, precious metallic and non-metallic deposits. The resources of Au, Ag, Cu, Pb, Zn, Mo, W and

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graphite are predicted to be 836.94 tonnes, 499 tonnes, 727 100 tonnes, 174 100 tonnes, 283 100 tonnes, 357 000 tonnes, 28 000 tonnes and 1.64 million tonnes, respectively. The Database serves as an important reference for basic geological research and exploration of mineral resources in the Qixia–Muping area.

Key words: Jiaodong metallogenic province; Qixia–Muping area; database; mineral and geological survey; Database; 1 ∶ 50 000; Shandong

Data service system URL: http://dcc.cgs.gov.cn

1 Introduction

The Jiaodong metallogenic province is located in the southeastern margin of the North China Craton and is adjacent to west Shandong Province with Tan–Lu fault zone as the boundary. It lies at the junction of two first-order geotectonic units, namely Qaidam–North China Plate and Qiangtang–Yangtze–South China Plate, and consists of four fouth-order tectonic units, namely Jiaobei uplift, Jiaolai depression, Jiaonan–Weihai ultra-high pressure metamorphic belt and north Jiangsu high pressure metamorphic belt. Compared to the gold ore concentration area in northwest Jiaodong Peninsula, the Qixia–Muping area located in the eastern part of Jiaodong metallogenic province generally boasts developed gold polymetallic deposits and features outcrops of Precambrian crystalline basement, Mesozoic terrigenous clastic rocks, and Late Jurassic–Early Cretaceous monzonitic granite (Fig. 1). Based on a statistical analysis of 58 isotopic ages of Mesozoic intrusions in Jiaodong area, Zhang T and Zhang YQ (2007) divided the Mesozoic plutonic magmatic activities in the area into three distinct evolutionary stages, namely Late Triassic (225–205 Ma) mantle-derived granite, Late Jurassic (160–150 Ma) crust-derived S-type granitic plutons, and Early Cretaceous (130–105 Ma) crust-mantle mixing granite (types I–A). Brittle fault structures are developed in the

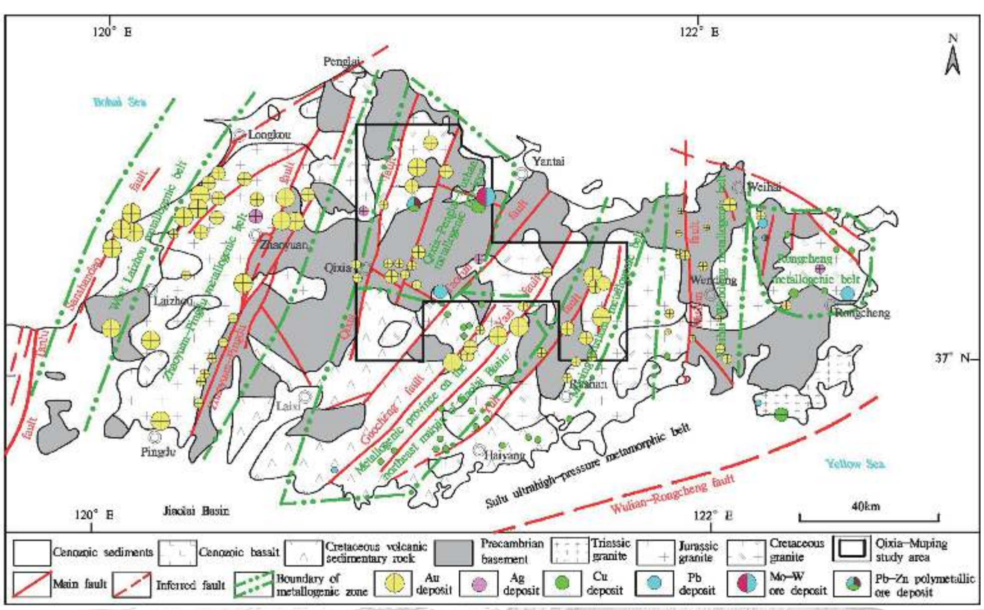

Fig. 1 Geological and mineral simplified map of the Qixia–Muping area, Jiaodong metallogenic province (modified from Ding ZJ et al., 2015)

survey area, with NE- and NNE-trending faults as main tectonic lines. The faults are dominated by sinistral compression-shearing faults, which have controlled or transformed early geologic blocks and are closely related to the formation of gold deposits in the survey area.

The 1∶50 000-scale mineral and geological survey of the Qixia–Muping area, Jiaodong metallogenic province covers 10 map sheets, namely Qixia City Map-sheet (J51E017004), Taocun Map-sheet (J51E017005), Shanqiandian Map-sheet (J51E018004), Gaotong Map-sheet (J51E016005), Zangjiazhuang Map-sheet (J51E016004), Daxindian Map-sheet (J51E015004), Gangyu Map-sheet (J51E015005), Shuidao Map-sheet (J51E017007), Guanshui Map-sheet (J51E017006) and Fengjia Map-sheet (J51E018007). Regional geological surveys were conducted in these map sheets from the 1980s to the 1990s (Liu JM et al., 1988; Zhao YL et al., 1990; Zhang FZ et al., 1993; Xue ZZ et al., 1996; Yang GF et al., 2000). Additionally, 1∶50 000-scale soil geochemical surveys were also carried out in these map sheets except Shanqiandian (Chen YH et al., 1987; Wang TJ et al., 1991; Chen LB et al., 1992). Intensive research has been made on basic and mineral geology in this area by previous scholars (Chen YH et al., 1987; Liu JM, 1988; Huang F et al., 1990; Zhao YL et al., 1990; Wang PC et al., 1991; Wang TJ et al., 1991; Zhang FZ et al., 1993; Xue ZZ et al., 1996; Miao LC et al., 1997, 1998; Guan K et al., 1998; Yang GF et al., 2000; Hou ML et al., 2004, 2006; Wan YS et al., 2006; Jahn et al., 2008; Zhou JB et al., 2008; Liu JH et al., 2011; Ding ZJ et al., 2012, 2015a, 2015b; Yu XF et al., 2012; Zhai MG, 2013; Xie SW et al., 2014a, 2014b; Xue YS et al., 2014; Zhang PJ et al., 2015; Cui YJ et al., 2016; Li J et al., 2016; Li SJ et al., 2016; Wang KF et al., 2016; Yang KF et al., 2018; Zhu DC et al., 2018), providing rich geological data for mineral and geological surveys in this area. The Database, based on previous research, was established by comprehensively applying multiple methods including geological interpretation of 1∶50 000-scale remote sensing data, 1∶50 000-scale gravity survey, 1∶50 000-scale high-precision ground magnetic survey, 1∶50 000-scale mineral and geologic mapping, trenching, and drilling. As a result, it contains systemic conclusion and evaluation of geological conditions, metallogenic rules, metallogenic prospect, and potential of mineral resources in the metallogenic province, thus providing basic geologic maps and information for the exploration and research of mineral resources in the area. The brief metadata table of the Database (Fu Chao et al., 2020) is shown in Table 1.

2 Methods for Data Acquisition and Processing

2.1 Data Basis

(1) Data for the 1∶50 000 mineral geologic maps

The ten 1∶50 000 mineral geologic maps of the survey site were all established according to the *Technical Requirement of* 1∶50 000 *Solid Mineral Geological Survey* (DD 2019-02) in aspects of map face design, content presentation, and processing of corner maps. The data of the ten maps include original data obtained from regional geological surveys of each map sheet, including draft data maps, sections (profiles), and field geological records. Meanwhile, scientific and research works of the area were systemically gathered and collated.

Table 1 Metadata Table of Database (Dataset)

Items	Description
Database (dataset) name	1∶50 000 Geological and Mineral Survey Database of Qixia–Muping Area, Jiaodong Metallogenic Province
Database (dataset) authors	Qixia City Map-sheet (J51E017004), Taocun Map-sheet (J51E017005), Shanqiandian Map-sheet (J51E018004): Fu Chao, Peng Li'na, Tianjin Center, China Geological SurveyGaotong Map-sheet (J51E016005), Zangjiazhuang Map-sheet (J51E016004), Daxindian Map-sheet (J51E015004), Gangyu Map-sheet (J51E015005): Dai Guangkai, Zhu Xueqiang, Shandong Institute of Geological Survey Shuidao Map-sheet (J51E017007), Guanshui Map-sheet (J51E017006), and Fengjia Map-sheet (J51E018007): Zou Jian, Ma Fang, No.3 Exploration Institute of Geology and Mineral Resources of Shandong Province
Data acquisition time	From 2016 to 2018
Data format	MapGIS
Data size	299 MB
Data service system URL	http://dcc.cgs.gov.cn
Fund project	The geological survey project entitled *Geological and Mineral Survey of Qixia–Muping Area, Jiaodong Metallogenic Province* initiated by China Geological Survey (DD20160044)
Language	Chinese
Database (dataset) composition	The Database consists of libraries of 1∶50 000-scale mineral and geologic maps and their map decorations, geophysical databases, remote sensing databases, sample databases, comprehensive result databases, and prospecting engineering databases. The 1∶50 000-scale mineral and geologic map library includes sedimentary rocks, magmatic rocks, volcanic rocks, metamorphic rocks, Quaternary, dikes, structures, geological boundaries, attitude, deposits (mineralized points), alteration, lithologic pattern, and various codes.Map decorations consist of index map, diagrams, legends, transverse cutting profiles, metallogenic factor maps of typical deposits, measured profiles of typical deposits, mineral deposit list, location maps of metallogenic belts and a duty table. The geophysical database consists of geophysical anomaly maps and plans.The remote sensing database consists of extraction data of remote sensing anomaly and inferred linear structures.The comprehensive result database consists of a table of anomaly verification results, predicted mineral deposit prospect area layers and prospecting target area layers.The prospecting engineering database includes the data of trenches and boreholes

As a result, the diagenetic ages, metallogenic eras, ore-bearing formations, and ore-controlling structures obtained were used to label the map face. Additionally, the ten maps were prepared by fully combining the latest results of field mineral geologic mapping, section (profile) surveys on different scales, geological unit dating, and identification and testing of rock and ore samples. The geographic base maps of the ten maps were the 1∶50 000 topographic maps issued by the Bureau of Surveying and Mapping under the PLA Headquarters of the General Staff in 1983. The data were processed using computer software such as DGSS and MapGIS according to existing technical standards.

(2) Remote sensing data

The geological interpretation of remote sensing data of the survey site was conducted according to *Technical Requirements of Remote Sensing Survey of Mineral Resources* (DD 2011-05). Data processing, geological interpretation, and alteration information extraction were carried out by fully referring to existing geological materials and using the data from Landsat-5 Thematic Mapper (TM; resolution: 30 m), Landsat-7 Enhanced Thematic Mapper (ETM; resolution: 15 m), and Landsat-8 Operational Land Imager (OLI; resolution: 15 m) of the United States, ASTER (resolution: 15 m) of Japan, and Gaofen-1 satellite (resolution: 2 m) of China. Meanwhile, software such as NV and MapGIS was used for data processing.

2.2 Data Processing

2.2.1 Data Preparation

Before suite-tectonic maps were prepared, the geological data collected such as the 1∶25 000 draft data maps, 1∶50 000 regional geological maps, survey routes, and sections (profiles) of each map sheet were digitalized to generate points, lines and polygons in MapGIS. Then the 1∶50 000-scale standard map frames were generated based on the coordinates of inflection points of latitudes and longitudes of each map, with Gauss–Kruger project parameters as the projection system and Xi’an 1980 as the coordinates system. Finally, the MapGIS files of draft data maps were corrected and exported into the standard map frames.

2.2.2 Preparation of Suite-Tectonic Draft Maps

In the survey site, Precambrian metamorphic basement is widely distributed, Mesozoic granitic intrusions are closely related to the formation of Au, Cu, Mo, Pb, and Zn polymetallic deposits, and NE- and NNE-trending faults control the occurrence and spatial distribution of the deposits. Therefore, the preparation of the suite-tectonic maps focuses on the Mesozoic intrusions, characteristics and alteration type of the faults, the distribution of mineralized zones, and the spatial relation between the mineralized zones and identified deposits.

Based on existing practical materials such as regional geological data, surveyed sections (profiles), and field routes, as well as data on ore-bearing characteristics of typical deposits, ore-hosting geological units, metallogenic geological blocks, and characteristics of mineralization and alteration, the first-order geological units were subdivided, formation units were established, and the characteristics and spatial distribution of ore-bearing formations were determined. Accordingly, the formation boundaries were supplemented, and field records were presented in the draft data maps in the forms of pattern points or lines of lithological formation. For instance, the suite-tectonic draft map of the Qixia City Map-sheet is shown below (Fig. 2).

(1) Geologic formations

The eras of geological formations were presented with graphic drafts of different colors according to the *Standard and Principle of Coloring in Geologic Map* (DZ/T 0179-1997). Meanwhile, the formation types were presented with formation patterns, the rock associations with according patterns, and the formation codes with era and lithology. As for the metamorphic rock area, the patterns of magmatogene metamorphic rock formation in the metallogenic province were presented by intrusion pattern and metamorphic type, given

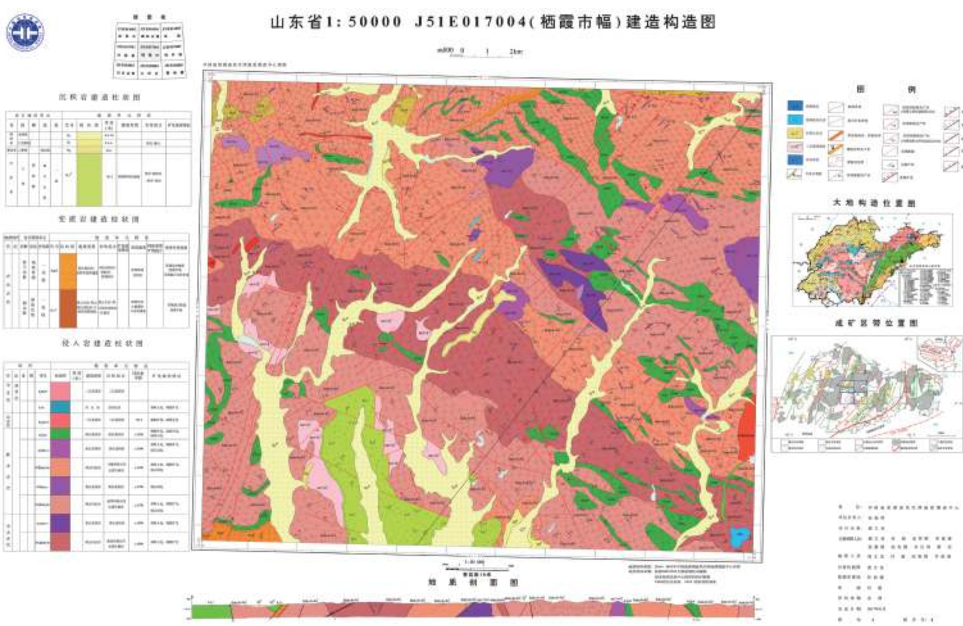

Fig. 2 1：50 000 formation-tectonic draft map of the Qixia City map sheet in Jiaodong metallogenic province

different geneses of the protoliths. The intrusion area was represented with the patterns of according magmatites, the sedimentary rock area with the pattern of sedimentary formations, and the volcanic rock area with volcanic lithology and lithofacies. Furthermore, the mineralized alteration zones were represented with alteration pattern according to their spatial distribution.

(2) Dikes

The lithology of a dike was presented with colors of graphic drafts according to a uniform color standard. The code of a dike was expressed with lithology code, and an ore-bearing dike was marked with element symbols behind the lithology code. Based on field survey records, the dike with mineralized alteration existing on its boundaries was presented with appropriate alteration patterns on the dike boundary.

(3) Structures

In this paper, preparation of suite-tectonic maps focuses on how to present structures and their alteration information on the map face. The deformation characteristics and spatial distribution of the structures such as ductile shear zones and faults were presented in a detailed way by integrating comprehensive information obtained from the interpretation of remote sensing data and geophysical data of the structures based on field survey records. Meanwhile, the mineralized alteration phenomena in a fault zone and their distribution areas were presented with corresponding alteration patterns. A red color was adopted according to uniform coloring standards, and the deformation of structures such as faults and ductile shear zones was represented with different line types.

(4) Geologic profiles

For a geological profile, the location was presented with the standard line type and code of the section, an actual control point with the geological point and its number, and the lithology of each stratum with proper patterns. Meanwhile, attitude elements were presented in the geological section.

(5) Sampling points of petrochemical samples

The sampling location of a petrochemical sample was presented with standard sub-map no. and sample no, and a sample database was created.

(6) Sampling points of geochemical samples

The sampling location of a geochemical sample was presented with standard sub-map no. and sample no, and a sample database was created.

(7) Sampling points of isotopic samples

The sampling location of an isotopic sample was presented with standard sub-map no. and sample no., and a sample database was created.

(8) Preparation of synthetic histograms

Firstly, based on the latest results as well as existing data from geological surveys and scientific research, the geotectonic location of the whole survey site was determined, the spatio-temporal evolutionary characteristics of the survey site were comprehensively analyzed, and the framework of tectonics and magma of the whole area was built. Synthetic histograms were prepared for the formations in the metallogenic province such as metamorphic rocks, sedimentary rocks, volcanics, and intrusions.

2.2.3 Acquisition of Field Data

(1) Special geological field mapping

The survey site was divided into key survey sites and minor survey sites based on comprehensive analysis and collation of existing data as well as preparation of the suite-tectonic draft maps. The key survey sites were surveyed by multiple methods such as survey of geological survey routes, survey of sections, large-scale mapping, and engineering control. The minor general survey sites were researched by making full use of previous data of 1：50 000 and 1：250 000-scale regional geological and mineral surveys on the principle that the original geological routes were primarily adopted and geological routes surveyed in the field were combined for the purpose of sparse control. As a result, the main ore-controlling faults on the survey site were found to be NE- and NNE-trending faults, namely Taiqian–Douya, Qixia, Panzijian, Majiayao, Huluxian, Dongwujia, Heilangou, Daliuxing, Bajia–Tangjiagou, Jinniushan, Chahe–Xiachu, Xianguding, and Poluo–Shicheng, with ore bodies occurring in the footwall of these faults and with fault gouge and beresite as the main ore-prospecting indicators. Important ore-bearing structures were found to be the Mesozoic Indosinian Linglong granites, and metallogenic structures were discovered to include early Yanshanian Guojialing granites and late Yanshanian Weideshan granites, with silicification, pyritization, sericitization and potassic-alteration as important ore-prospecting indicators. In addition, dioritic porphyrite and lamprophyre that tend to occur in parallel with or intersecting with orebodies were also discovered as key contents needed to be plotted. The points and lines such as geological points, boundary points, geological boundaries, and survey routes were labeled and marked in the digital mapping system based on field route survey, with 1：25 000 draft data maps in palm-sized personal digital assistants (PDAs) for digital mapping as the base maps. Meanwhile, information such as the features, lithology, and attitude of each point were observed and input. In this way, the digital mapping (PRB) database was preliminarily created.

The geological attitudes and specimens discovered and acquired along the survey routes were positioned, their information was input into the system, and their attributes were filled from time to time.

(2) High-precision ground magnetic survey and gravity survey

After the completion of geodetic survey, instrument detection, and joint testing of the total base station and diurnal variation stations, a 1：50 000-scale high-precision ground magnetic survey was used to observe diurnal variations and observation points—with the observation of each closed observation unit starting and ending at the calibration point. The data observed at each survey point was input into the magnetometer. Then the data of magnetic survey and diurnal variation were pre-processed in accordance with applicable specifications, including deleting or modifying the data of aliased points resulting from disturbance, editing the data, and conducting diurnal correction, correction with normal gradient and height, and total base station correction for original observation data. The data were used for preparation and anomaly interpretation of the magnetic maps on the survey site.

The base station network for the 1：50 000-scale gravity survey was established as follows. With Level-I gravity base station at Yantai Laishan International Airport of Shandong Province being taken as the starting point, one reference station was deployed and recorded at each map sheet. Accordingly, archives of the stations were set up. Gravity points were observed by single-pass observations, with field observations starting and ending at the base station. The closing time of the base station was strictly determined by dynamic testing, and the zero point drift value during each closed interval of each gravity point was not higher than three times that of the observation precision of the gravity point. Surveyed gravity values (g_i) were calculated after theoretical earth tide correction and zero point drift value correction of field observation data. Then Bouguer gravity anomaly values were calculated after correction with normal gravity values and Bouguer correction of the surveyed gravity values. The data were used for preparation and anomaly interpretation of gravity maps on the survey site.

(3) Acquisition of engineering data

Engineering data were acquired from trenches and boreholes. The engineering data of trenches were determined as follows. On the “Exploration engineering” interface of the digital geological survey information comprehensive platform, after successively clicking the menus of “Exploration Engineering Data” → “Built New Engineering Point” → “Trenches”, input the basic information about trenches. Then successively input geological data such as traverse library, contour library, layer library, and trenching samples and their attitude and photos in turn after successively clicking the menus of “Exploration Engineering Data” → “Edit Engineering Database” → “Trenches” on the interface. After that, click the menu “Generate Draft Maps”, and then collate the draft maps and add map decorations.

The engineering data of boreholes were determined as follows. On the “Exploration engineering” interface of the digital geological survey information comprehensive platform, after successively clicking the menus of “Exploration Engineering Data” → “Built New Engineering Point” → “Boreholes”, input the basic information about boreholes. Then successively input geological data such as roundtrips, layers, and split-core samples and their photos in turn after successively clicking the menus of “Exploration Engineering Data” → “Edit Engineering Database” → “Boreholes” on the interface. After that, click the menu “Generate histograms”, and then collate the histograms and add map decorations.

2.2.4 Indoor Data Collation

(1) Collation of geologic map database

The digital mapping of the ten 1∶50 000-scale map sheets on the survey site involve multiple original information databases, including 40 PRB (geological observation point, route, and boundary) databases of 1∶25 000-scale map sheets, 40 databases of draft data maps, 40 backup databases of acquisition dates, 40 databases of freehand field maps, 40 databases of background layers, and 40 databases of samples. Among these databases, the databases of freehand field maps are used to store various geological data obtained along the field geological routes, and they are the most first-hand databases of the primary original data obtained in the field. The database of a single route of freehand field maps consists of three folders, namely “Images” (used to store photos), “note” (used to store XML files and TXT text), and “Draft maps” (used to store draft maps), as well as the observation data of field entities along 10 routes. The PRB databases serve as the foundation of various geological databases and also the first-hand data obtained from field geologic mapping. They determine the quality and integrity of other map databases; therefore, data inputting of the PRB databases should be conducted according to applicable specifications and by combining the phenomena observed in the field.

(i) Geological point (P) inputting process. Information such as the route no., weathering degree, contact relationship, and outcrop features should be completely filled according to the actual conditions. Special attention should be paid to the coordinate representation of ground objects. The mapping units should correspond to the codes of corresponding mapping units. The rock names should be consistent with those input into the dialogue box of geological description (including color, tectonics, and structure). The thin section identification results should be labeled, and should be filled in after being comprehensively named according to actual conditions.

(ii) Geological route (R) inputting process. Routes should be modeled indoor in the order of “smooth curve—modifying line parameters (line type: 1; color: 1; line width: 0) —calculating routes between points—(make statistics of workload)”. The database of route attributes should be supplemented and improved, and the orientations and distance of the routes should be re-calculated before describing the geological conditions of the routes.

(iii) Geological boundary (B) inputting process. The geological boundaries should be made aesthetically pleasing by cutting or extending lines on visual software according to contact relationships. The Parameters such as color, line type, and line width should be selected in a uniform way. The information used to describe geological boundaries should be supplemented. The lithology of both sides of a boundary should be expressed with consistent terminology such as “the east side consists of xxx and the east side consists of xxx”, and the contact relationship between the lithology of the two sides and its evidence should also be described, in order to avoid confusion caused by expressing direction with left and right.

(iv) The inputting process of the attitude, sampling and photos along the geological routes. Descriptive information on attributes such as attitude, sampling and photos should be verified and supplemented. The attitudes of a new geological point should be numbered starting from 1, 2, 3, etc. As for a photo, its contents and the geological phenomena it reflects should be described in a detailed way after the photo is imported.

The PRB databases share totally the same file types and filenames with databases of freehand field maps. The databases of draft data maps inherited some layers from the PRB databases, including the layers of acquired points and lines of entities observed along field routes as well as label layers. Meanwhile, three files of points, lines, and polygons were automatically generated, namely GEOLABEL.wt, GEOLINE.wl, and GEOPOLY.wp. The backup databases of acquisition dates are used to back up data acquired along the field routes by PDAs, which were backed up according to the survey routes and were not decompressed. They serve as the basis for further indoor collation of field geological routes. The databases of background layers are used to store the data of geographic base maps, mainly including geographic information, streams, transportation, habitations, boundaries, and topography. The sample databases are used to store various samples of the map sheets and are classified into sampling databases, presented sample databases, and the databases of testing and identification results. In this paper, the data of sample databases were stored in the database RgSample.mdb.

Two types of draft data maps were merged after the PRB databases were collated. The maps of one type were prepared mainly based on field PRB data, while the maps of the other type were prepared based on regional geological survey data that were collated during the preparation of the formation-tectonic draft maps. Meanwhile, correction was performed for boundaries between stratigraphic units, formation patterns, and tectonic morphology reflecting various formations; the boundaries of newly formed geological units were connected.

After the map face of a master map was edited, other information was set up on both sides of the master map, including the histograms of various formations, the metallogenic model diagrams and the exploratory-line sections of typical deposits on the survey site, the geotectonic location map of the survey site, the map of metallogenic belt location, the list of mineral deposits, other legends, and signature tables of the maps. In this way, a complete mineral and geologic map was formed, as shown in Fig. 3.

(2) Inputting of geophysical and remote sensing data

After the format of the data from geophysical exploration was converted into MapGIS, geophysical databases were created according to map sheet by 1：50 000-scale digital mapping of the map sheets. The data structures were standardized under the menu bar for the

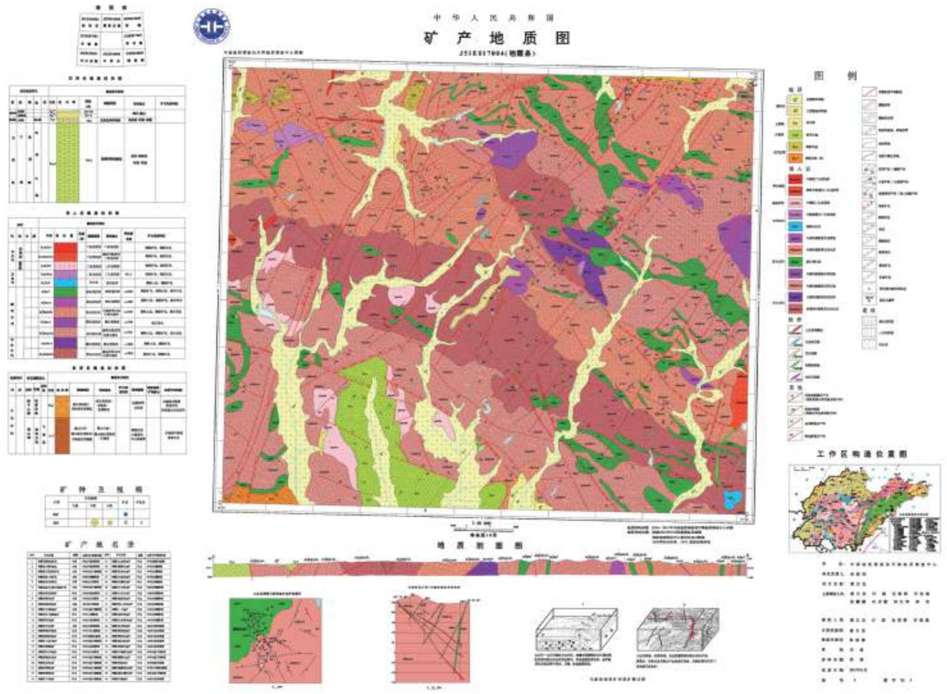

Fig. 3 The diagram of mineral geologic map of the Qixia Map-sheet in Jiaodong metallogenic province

operation of geophysical, geochemical, and remote sensing data, including the standardization of filenames and attribute structures. Given the current conditions that the metallization on the survey site is closely related to Mesozoic intrusions and faults, the gravity survey and magnetic survey data throughout the survey site were interpreted and inferred. As a result, 76 new faults and 15 concealed intrusions were inferred; 101 gravity anomalies, 60 high magnetic anomalies, 10 mixed gravity and magnetic anomalies were delineated, and 15 metallogenic prospect areas were screened. Meanwhile, geophysical prospecting indicators of Au deposits were proposed. By comparing all these with the results of mineral and geological mapping and making modifications accordingly, the contents of the mineral and geological maps were improved, thus providing basic geological materials for mineral exploration on the survey site.

A remote sensing database includes remote sensing images and the data of alteration anomaly extraction and remote sensing interpretation. The remote sensing images are in the format of.jpg and were directly stored in the folder named “Remote sensing” under the digital mapping. The data of alteration anomaly extraction and remote sensing interpretation are in the data format of MapGIS. The remote sensing database was established as follows. Under the menu bar for the operation of geophysical, geochemical, and remote sensing data, successively click “Add New Result Data”→ “Infer Geologic Structure from Remote Sensing” → “Infer Linear Structure Layer (Infer Circular Structure Layer) and Remote Sensing Anomaly Layer”, and then input the attributes of the linear structure layer, annular structure layer, and remote sensing anomaly layer. In this way, the remote sensing database was set up.

3 Description of Result Data

3.1 Data Storage

Fundamentally based on the requirements of database establishment in DD 2006-06 *Spatial Database for Digital Geologic Maps,* the data in the Database were stored according to four types of classes, namely feature classes, object classes, complex classes, and independent feature classes. There are two sets of storage formats of the data according to different versions of DGSS, namely.wp (for geologic polygons),.wl (for geological lines), and.wt (for geological points);.pm (for geologic polygons),.lm (for geological lines), and.tm (for geological points).

3.2 Contents in map layers

The contents in map layers mainly include six types, namely feature classes, complex classes, object classes, geochemical data, geophysical data, and remote sensing data. Among them, the former three types respectively correspond to the tables with corresponding attribute structures in BASE_FCLS.mdb, DSGMAP.mdb, and SYNTH_FCLS.mdb. For instance, the specific information about these classes of Daxindian map sheet is shown in Table 2. Databases were respectively set up for geochemical, geophysical, and remote sensing data. Finally, a comprehensive results database was formed, which includes information such as the tables of anomaly verification results, the tables of ore occurrence inspection results, prospecting target areas, and the predicted mineral prospect areas.

Table 2 Feature classes, complex classes, and object classes in the result databases of the Daxindian map-sheet

Map-sheet No.	Dataset	Entity name	File title	Data type
J51E015004 (Daxindian map sheet)	Feature classes	Geologic polygon entity	_GEOPOLYGON.wp	Area
		Geologic (boundary) line	_GEOLINE.wl	Line
		Mineral deposit	_MINERAL_PNT.wt	Point
		Attitude	_ATTITUDE.wt	Point
		Sample	SAMPLE.wt	Point
		Isotopic dating	_ISOTOPE.wt	Point
		Borehole	DRILLHOLE.wt	Point
		Crater	_CRATER.wt	Point
		Shoreline of river, lake, sea, or reservoir	_LINE_GEOGRAPHY.wl	Line
	Complex classes	Tectonic deformation zone	_TECOZONE.wp	Area
		Alteration zone (section)	_ALTERATION_POLYGON.wp	Area
		Metamorphic facies zone	_METAMOR_FACIES.wp	Area
		Volcanic facies zone	_VOLCA_FACIES. wp	Area
		Mineralized zone	MINERAL_ZONE. wp	Area
		Standard map frame (inner map frame)	_MAP_FRAME.wl	Line

Continued table 2

Map-sheet No.	Dataset	Entity name	File title	Data type
J51E015004 (Daxindian map sheet)	Object classes	Petrostratigraphic unit of sedimentary (volcanic) rocks	_STRATA	ACCESS
		Chronologic unit of intrusions	_INTRU_LITHO_CHRONO	ACCESS
		Fault	_FAULT	ACCESS
		Petrostratigraphic unit of metamorphic rocks	_METAMORPHIC	ACCESS
		Special geological body	_SPECIAL_GEOBODY	ACCESS
		Informal stratigraphic unit	INF_STRATA	ACCESS
		Dike (section)	_DIKE_OBJECT	ACCESS
		Planar waters and swamp	_WATER_REGION	ACCESS
		Basic information of map sheets	_SHEET_MAPINFO	ACCESS
	Geologic structures inferred from remote sensing	Layer of remote sensing anomalies	Rsanomaly.wp	Area
		Inferred linear structure layer	Rslinear.wl	Line
		Inferred annular structure layer	RSRing.wl	Line
	Geophysical data	Layer of predicted areas with gravity and magnetic anomalies	GRAVMAGNETICLINEAR. wl	Line
		Layer of predicted areas with gravity and magnetic anomalies	GRAVMAGNETICLINEAR. wt	Point
	Geochemical data	Layer of stream sediment anomalies	ANOMALY_STREAM. wl	Line
		Layer of stream sediment anomalies	ANOMALY_STREAM. wt	Point
	Metallogenic rule and mineral prediction	Layer of predicted mineral prospect areas	PredictedProspectiveArea.wp	Area
		Layer of prospecting target areas	TargetArea.wp	Area
		Layer of recommended geological work deployment	WorkPlan.wp	Area

Feature classes include geological polygon entities (_GEOPOLYGON), geological boundaries (_GEOLINE), mineral deposits (_MINERAL_PNT), attitude (_ATTITUDE), samples (_SAMPLE), and photos.

Complex classes include tectonic deformation zones (_TECTZONE), alteration zones (_ALTERATION_POLYGON), metamorphic facies zones (_METAMOR_FACIES), volcanic facies zones (_VOLCA_FACIES), and standard map frames(_MAP_FRAME).

Object classes include stratigraphic units of sedimentary (volcanic) rocks (STRATA), chronologic units of intrusions (INTRU_LITHO_CHEONO), faults (FAULT), petrostratigraphic units of metamorphic rocks (METAMORPHIC), special geologic blocks

(SPECIAL_GEOBODY), dikes (_DIKE_OBJECT), planar waters and swamps (_WATER_REGION), and basic information on map sheets (_SHEET_MAPINFO).

Independent feature classes are mainly presented with corner diagrams including legends, histograms, transverse cutting profiles, index map, analytical graph of typical ore deposit, list of mineral deposits, mineral species and scale, location map of the metallogenic belts, duty table.

Geologic structures inferred from remote sensing include layers of remote sensing anomalies (Rsanomaly), inferred linear structure layers (Rslinear), and inferred annular structure layers (Rsring).

Geophysical data include layers of predicted areas with gravity and magnetic anomalies (GRAVMAGNETICLINEAR)

Geochemical data include layers of stream sediment anomalies (ANOMALY_STREAM).

The Metallogenic rule and mineral prediction contents include layers of predicted mineral prospect areas (PredictedProspectiveArea), layers of prospecting target areas (TargetArea), and layers of recommended geological work deployment (WorkPlan).

4 Data Quality Control and Assessment

The Database was established through the method of mapping combined with preparation, with the precision consistent with the *Technical Requirement of* 1∶50 000 *Solid Mineral Geological Survey* (DD 2019-02). The key survey sites were mapped mainly based on field surveys, while the minor general survey sites were mapped mainly based on the original data obtained from regional geological surveys of each map sheet. Geological points were collected on the principle that the geological blocks, mineralized alteration zones, and major geological boundaries related to metallization can be fully controlled. The projection parameters and scale precision of the Database were defined as required, spatial positioning is accurate, and the search radius of system node/tailoring is 10^{-9}, thus meeting the requirement of map precision.

The required contents to be presented on the map face generally included sealed geological blocks with a diameter greater than 100 m, linear geological bocks with a width greater than 50 m and a length greater than 250 m, and faults and folds with a length greater than 250 m. All mineralized geological blocks such as mineralized alteration tectonic zones were present in the map, regardless of size. Among them, those with a small thickness were presented with particular patterns or symbols by zooming in or incorporating with each other. The error in the location of a geological point (i.e., the difference between its location marked on the freehand field map and its actual location) should not exceed 25 m in general.

The files consisting of the spatial database of geological maps feature complete file types, with filenames and attribute structures meeting the requirements of applicable specifications. The data items in all datasets of the database (feature classes, complex classes, independent feature classes, and object classes) coincide with contents presented on the map face, and their attributes are presented accurately, thus basically reflecting the actual conditions in the original geological maps and text reports and meeting requirements of database establishment.

As for the data quality, the self-check rate and mutual check rate of the survey routes for geological mapping were both 100%, and the rate of spot inspection conducted by the project team was 30%, meeting the requirements of quality management of geological survey projects. During December 1 to 2, 2018, the Tianjin Center of China Geological Survey organized experts to conduct a field acceptance check on this project by indoor inspection combined with field inspection, and the project was ranked excellent. During August 13 to 15, 2019, the North China Project Office of China Geological Survey and the Network and Information Office of China Geological Survey jointly organized experts to conduct an acceptance check on the Database of the project. After meticulous review and inquiry of the experts, the Database passed the acceptance smoothly.

5 Data Value

The Geological and Mineral Survey of The Qixia–Muping Area, Jiaodong Metallogenic Province is one of a new round of mineral and geological survey projects initiated by China Geological Survey. During the implementation of this project, the deposits throughout the survey site were systematically sorted and summarized in consistent with the *Technical Requirement of* 1：50 000 *Solid Mineral Geological Survey* (DD 2019-02). As a result, 275 mineral occurring sites (Table 3) were input into the Database, including 23 species of polymetallic, previous metallic and non-metallic deposits. In detail, there are 218 gold mineral occurring sites (22 large-scale ones, 18 medium-scale ones, and 60 small-scale ones), three placer gold deposits, five silver deposits, 21 copper deposits (including one medium-scale), six lead deposits, four lead–zinc deposits, two copper–lead–zinc polymetallic deposits (including

Table 3 Mineral types and scale of the deposits in the Qixia-Muping Area, Jiaodong Metallogenic Province

Mineral type	Scale					Total
	Large-scale	Medium-scale	Small-scale	Ore occurrence	Mineralized point	
Rock gold	22	18	60	87	31	218
Placer gold			1	2		3
Ag		1	2	2		5
Cu		1	1	8	10	20
Cu–Mo			1			1
Mo		1		1		2
Pb				3	3	6
Pb–Zn				2	2	4
Cu–Pb–Zn polymetal		1			1	2
W–Mo	1					1
Mn				4		4
Fe			1	4		5
Garnet			1			1
Graphite		1				1
Total	23	23	67	113	47	275

one medium-scale), one large tungsten–Molybdenum deposit, five manganese deposits, five iron deposits, one garnet deposit, and one graphite deposit.

During the implementation of this project, the evolutionary sequence of magmatites and the spatial distribution of ore-bearing formations and ore-controlling structures on the survey site were determined by comprehensive analysis and research of formations and structures on the survey site based on formation division. The geophysical field on the survey site was meticulously interpreted by comprehensively applying multiple methods including the latest remote sensing geological interpretation, high-precision ground magnetic survey, and gravity survey. Furthermore, faults were inferred from gravity and magnetic survey and concealed intrusions were interpreted throughout the area according to the structures and ore-control characteristics of Mesozoic intrusions on the survey site. As a result, 15 new concealed intrusions were interpreted, 16 NE- and NNE-trending faults were determined to control the occurrence and spatial distribution of gold ore deposits in the whole area, remote sensing and geophysical ore-prospecting indicators were proposed, and metallogenic prospect areas were screened. Based on geochemical anomalies, geological section survey, and geological route survey, 31 ore occurrences (mineralized points) were newly discovered, i.e. 24 gold ore occurrences (mineralized points), four copper ore occurrences, and three silver–lead ore occurrences. By anomaly verification and inspection of the geophysical and geochemical anomalies and these ore occurrences, 42 prospecting target areas were delineated, including 25 areas of grade A, 14 areas of grade B, and three areas of grade C (Table 4). Meanwhile, the resource potential of major mineral types throughout the survey site was assessed, with the resources of Au, Ag, Cu, Pb, Zn, Mo, W and graphite being predicted to be 836.94 tonnes, 499 tonnes, 727 100 tonnes, 174 100 tonnes, 283 100 tonnes, 357 000 tonnes, 28 000 tonnes and 1.64 million tonnes, respectively. All these data were completely and accurately input into the Database. They will provide basic data for sustainable development of mineral exploration in the area, play a leading role in terms of scientific and technological innovation, and enhance the ability of mineral and geological survey to serve resource security, social and economic development, and the building of an ecological civilization.

Table 4 List of prospecting target areas in the Qixia-Muping area, Jiaodong Metallogenic Province

No.	Name	Location	Mineral type	Grade
1	Deep prospecting target area of the Xiayucun gold deposit	In the north mount of Xiayu Village, Gaoling Town, 24 km in the southwest of Muping District, Yantai. It belongs to Gaoling Town, Muping District, Yantai administratively	Au	Grade A
2	Deep prospecting target area of the Moshan golddeposit	About 15 km in the south of Muping District, Yantai. It belongs to Gaoling Town, Muping District administratively.	Au	Grade A
3	Peripheral prospecting target area of the Moshan gold deposit	About 15 km in the south of Muping District, Yantai. It belongs to Gaoling Town, Muping District administratively.	Au	Grade A

Continued table 4

No.	Name	Location	Mineral type	Grade
4	Deep prospecting target area of the Shuangshantun gold deposit	In the east of Shuangshancun Village, which is about 12 km to the southwest of Muping urban area, Yantai. It belongs to Wuling Town and Gaoling Town, Muping District administratively.	Au	Grade A
5	Deep prospecting target area of the Xiapangezhuang gold deposit	Xiapange Au deposit is located about 15 km to the southwest of Muping urban area. It belongs to Gaoling Town administratively.	Au	Grade A
6	Prospecting target area of the the Shangpangezhuang gold deposit	Around the south of Shangpangezhuang Village, Muping District, Yantai City, Shandong	Au	Grade A
7	Deep prospecting target area of the angjiagou gold deposit	In the southeast of Tangjiagou Village which is about 18 km to the north of Rushan urban area. It belongs to Wuji Town, Rushan administratively.	Au	Grade A
8	Deep prospecting target area of the Xizhigezhuang gold deposit	25 km to the south of Muping urban area. It belongs to Shuidao Town, Muping District administratively	Au	Grade A
9	Deep prospecting target area of the Denggezhuang–Jinniushan gold deposit	In the south of Xidenggezhuang Village which is 30 km to the south of Muping urban area and Dongdenggezhuang–Jinniushan area. It belongs to Shuidao Town administratively	Au	Grade A
10	Deep prospecting target area of the Yinggezhuang gold deposit	In the east of Yinggezhuang Village which is about 14 km to the north of Rushan urban area. It belongs to Xiachu Town administratively	Au	Grade A
11	Deep prospecting target area of the Fuludi gold deposit	In the north of Xidenggezhuang Village which is about 25 km to the south of Muping urban area, Yantai, Shandong. It belongs to Jugezhuang Town, Muping District administratively	Au	Grade A
12	Deep prospecting target area of the Jinqingding gold deposit	25 km to the northeast of Rushan City. It belongs to Xiachu Town, Rushan administratively	Au	Grade A
13	Deep prospecting target area of the Heilangou gold deposit	In Daxindian Town, Penglai City, Shandong Province	Au	Grade A
14	Deep prospecting target area of No. 1 branch of the Qigou gold deposit	In Daxindian Town, Penglai City, Shandong Province	Au	Grade A
15	Deep prospecting target area of the Yanshan gold deposit	In Daliuxing Town, Penglai City, Shandong Province	Au	Grade A
16	Deep prospecting target area of the Menlou gold deposit	In Daliuxing Town, Penglai City, Shandong Province	Au	Grade A
17	Deep prospecting target area of the Qijiagou gold deposit	In Daxindian Town, Penglai City, Shandong Province	Au	Grade A
18	Deep prospecting target area of the Xiangkuang lead–zinc deposit	In Zangjiazhuang Town, Qixia City, Shandong Province	Pb–Zn	Grade A

Continued table 4

No.	Name	Location	Mineral type	Grade
19	Deep prospecting target area of the Wangjiazhuang copper deposit	In Dongting Town, Fushan District, Shandong Province	Cu	Grade A
20	Deep prospecting target area of the Xingjiashan molybdennum (tungsten) deposit	In Dongting Town, Fushan District, Shandong Province	Cu	Grade A
21	Prospecting target area of the Diaolongzui deposit	In the west waters of Sanshan Island	Au–Pb	Grade A
22	Prospecting target area of the Daliukou gold deposit	In Daliukou Village, Qixia City, Shandong Province	Au	Grade A
23	Prospecting target area of the Shangyatou silver–lead polymetallic deposit	In Shangyatou Vilage–Hulukuang Vilage area, Qixia City, Shandong Province	Ag–Pb	Grade A
24	Prospecting target area of the Dongshanzhuang gold deposit	In Zangjiazhuang Town, Qixia City, Shandong Province	Au	Grade A
25	Prospecting target area of the Gaojia silver deposit	In Zhuangyuan sub-district, Penglai City, Shandong Province	Ag	Grade A
26	Prospecting target area of the Furong Island	In the south of Pangjiawuzi area, west waters of Furong Island, and the part of the Sanshan Island fault (F_3) extending towards southwest	Au	Grade B
27	Prospecting target area of the Shuangshan gold deposit	At the junction of Zangjiazhuang Town of Qixia City and Cunliji Town of Penglai City	Au	Grade B
28	Deep prospecting target area of the Yanjiatuan gold deposit	In the south of Yanjiatuan Village and 7 km to the south of Muping urban area, Yantai City. It belongs to Wenhua Sub-district Office, Muping District administratively	Au	Grade B
29	Prospecting target area of the Huizhan gold deposit	In the north of Huizhan Village, Muping District, Yantai City, Shandong Province	Au	Grade B
30	Deep prospecting target area of the Dongsanghangbu–Heiniutai gold deposit	In Heinitai area which is about 30 km to the southeast of Muping urban area, Yantai City. It belongs to Yulingdian Town, Muping District administratively	Au	Grade B
31	Deep prospecting target area of the Xidenggezhuang–Gaogxingshan gold deposit	About 20 km to the south of Muping urban area and about 3 km to the northwest of Suidao Town in Yantai City. It belongs to Shuidao Town, Muping District, Yantai City administratively	Au	Grade B
32	Deep prospecting target area of the Yulingshan–Chahe gold deposit	In the north of Chahe Village which is 32 km to the south of Muping urban area, Yantai City. It belongs to Suidao Town, Muping District administratively.	Au	Grade B
33	Prospecting target area of the Guoluozhuang gold deposit	Near Guoluozhuang Village, Qixia City, Shandong Province	Au	Grade B
34	Prospecting target area of the Houkuang gold deposit	Around Caoan Village–Caokuang Village, Qixia City, Shandong Province	Au	Grade B

Continued table 4

No.	Name	Location	Mineral type	Grade
35	Prospecting target area of the Panzijian gold deposit	Around Panzijian Village, Qixia City, Shandong Province	Au	Grade B
36	Prospecting target area of the Majiayao gold deposit	In Majiayao-Anzikuang area, Qixia City, Shandong Province	Au	Grade B
37	Prospecting target area of the Tingkuang gold deposit	Around Dingkuang Village, Qixia City, Shandong Province	Au	Grade B
38	Prospecting target area of the Shangfanjiagou gold–copper deposit	Around Shangfanjiagou Village, Qixia City, Shandong Province	Cu	Grade B
39	Prospecting target area of the Qujia'ankou gold deposit	In Daliuxing Town, Penglai City, Shandong Province	Au	Grade B
40	Prospecting target area of the Luojia gold deposit	Around Luojia Village, Qixia City, Shandong Province	Au	Grade C
41	Prospecting target area of the Zhantuan gold deposit	In Zhantuan Village–Lijiaquan Village area, Qixia City	Au	Grade C
42	Prospecting target area of the Mayuanshan polymetallic deposit	In the Qixia Economic Development Zone, Shandong Province	Pb–Zn	Grade C

Notes: Grade A prospecting target areas boast favorable geological conditions. They coincide with existing prospecting prediction models at a high degree, feature nearly definite ore-bearing formations and ore-controlling structures, and display strong, large-scale mineralization-related alteration with apparent zones. Furthermore, there are existing deposits corresponding to these areas, with predicted resources being up to a middle scale or above.

Grade B prospecting target areas boast less favorable geological conditions. They coincide with existing prospecting prediction models at a less high degree, feature less definite ore-bearing formations and ore-controlling structures, and display strong, small-scale mineralization-related alteration with unapparent zones. There are existing ore occurrences (mineralized points) corresponding to grade B prospecting target areas, with predicted resources being up to a middle scale or above.

Grade C prospecting target areas boast less favorable geological conditions, featuring indefinite ore-bearing formations and ore-controlling structures and weak alteration, with predicted resources being up to a middle scale or above.

6 Conclusions

(1) The geological and mineral survey in the Qixia–Muping area, Jiaodong metallogenic province is one of a new round of mineral and geological survey projects initiated by China Geological Survey. During this project, 10 mineral and geological maps were prepared based on formation division. The presentation of special geological mapping results was actively explored and innovated. These maps comprehensively reflect the latest research results of the map sheets, and will play a demonstrative role in mineral and geological survey.

(2) The ten 1∶50 000 mineral and geological maps were systemically prepared and spatial databases were created, highlighting the presentation of metallogenic information. As a result, the spatial distribution of ore-bearing formations and ore-controlling structures were determined. Meanwhile, comprehensive information was embodied in the databases, including mineralized zones, alteration zones, metallogenic structures, and metallogenic structural

planes.

(3) The spatio-temporal distribution characteristics of the ore-bearing formations and ore-controlling structures in the survey site were defined, 31 ore occurrences (mineralized points) were newly discovered, 42 prospecting target areas were delineated, and the resource potential of major mineral types throughout the survey site was assessed based on comprehensive results of the 1∶50 000-scale special geologic mapping, 1∶50 000-scale high-precision ground magnetic survey, 1∶50 000-scale gravity survey, and 1∶50 000-scale remote sensing geological interpretation as well as systematic collection and analysis of previous materials and research results.

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