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甘肃崖湾—大桥整装勘查区石峡幅 1∶50 000矿产地质调查成果数据库

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摘要：甘肃石峡幅（I48E014014）1∶50 000 矿产地质调查按照中国地质调查局《固体矿产地质调查技术要求（1∶50 000）》（DD2019-02），在系统收集和综合分析已有地质、物探、化探、遥感、矿产等资料基础上，采用数字填图技术，开展石峡幅 1∶50 000 矿产地质专项填图、综合检查、找矿预测和圈定找矿靶区。专项地质填图采用填编结合的方式，将图幅地层划分为 19 类非正式沉积建造类型，划分侵入岩建造类型 1 个；结合重点工作区矿产综合检查，填写矿产信息卡片。在此基础上开展典型矿床研究，总结成矿要素，完成 1∶50 000 矿产地质图、成矿规律图、矿产预测图等成果图件编制和数据库建设。成果图件和数据库突出表达了成矿建造、区域构造、矿化蚀变信息；系统总结了石峡幅成矿要素信息，建立了典型矿床成矿模型；圈定了 7 处中低温热液型金矿找矿预测靶区。

关键词：石峡幅；矿产地质调查；数据库；1∶50 000；崖湾—大桥整装勘查区；甘肃省

数据服务系统网址：http://dcc.cgs.gov.cn

1 引言

甘肃崖湾—大桥地区位于向南凸出的临潭—宕昌—江洛镇弧形深大断裂和舟曲—成县—徽县弧形断裂之间 (李通国等，2000)，其大地构造位置属西秦岭造山带东段，为秦岭弧盆系中秦岭陆缘盆地、泽库前陆盆地与南秦岭陆缘裂谷带的过渡部位。区域深大断裂控制着区内地层、构造、岩浆岩的展布以及矿产的产出 (图 1)。在中–新生代陆内造山与陆缘构造动力学成矿背景下，西秦岭地区发育大量逆冲推覆构造，形成与浅成低温热液作用有关的金汞锑矿床 (张国伟等，1996)。甘肃崖湾—大桥地区所在的碌曲—成县金汞锑成矿带是西秦岭地区最重要的成矿带之一 (图 2；张新虎等，2008)。沿区域深大断裂自西向东分布有加甘滩超大型金矿、枣子沟超大型金矿、鹿儿坝大型金矿、羊尾里沟中型金矿、崖湾大型锑矿、坪定中型金矿、大桥超大型金矿以及安房坝中型金矿 (肖力等，2008)。

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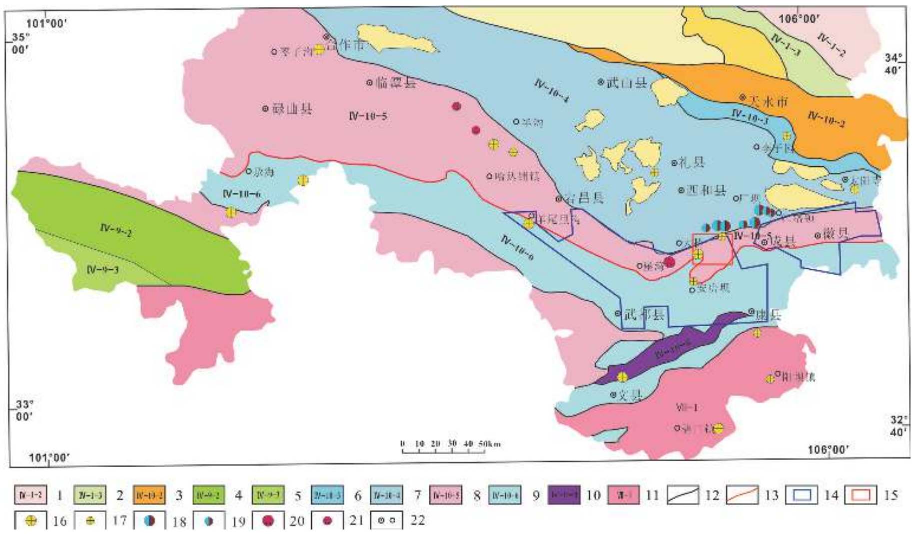

图 1　甘肃省西秦岭地区大地构造相图

1—走廊南山岩浆弧相；2—北祁连蛇绿混杂岩相；3—北秦岭岩浆弧；4—木孜塔格西大滩—布青山蛇绿混杂岩相；5—玛多—玛沁增生楔相；6—商丹蛇绿混杂岩相；7—中秦岭陆缘盆地相；8—泽库前陆盆地相；9—西倾山—南秦岭陆缘裂谷相；10—勉略蛇绿混杂岩相；11—巴颜喀拉地块大相；12—构造相边界；13—区域大断裂；14—甘肃崖湾—大桥金锑矿整装勘查区范围；15—石峡幅范围；16—大型金矿；17—中型金矿；18—大型铅锌矿；19—中型铅锌矿；20—大型锑矿；21—中型锑矿；22—县市

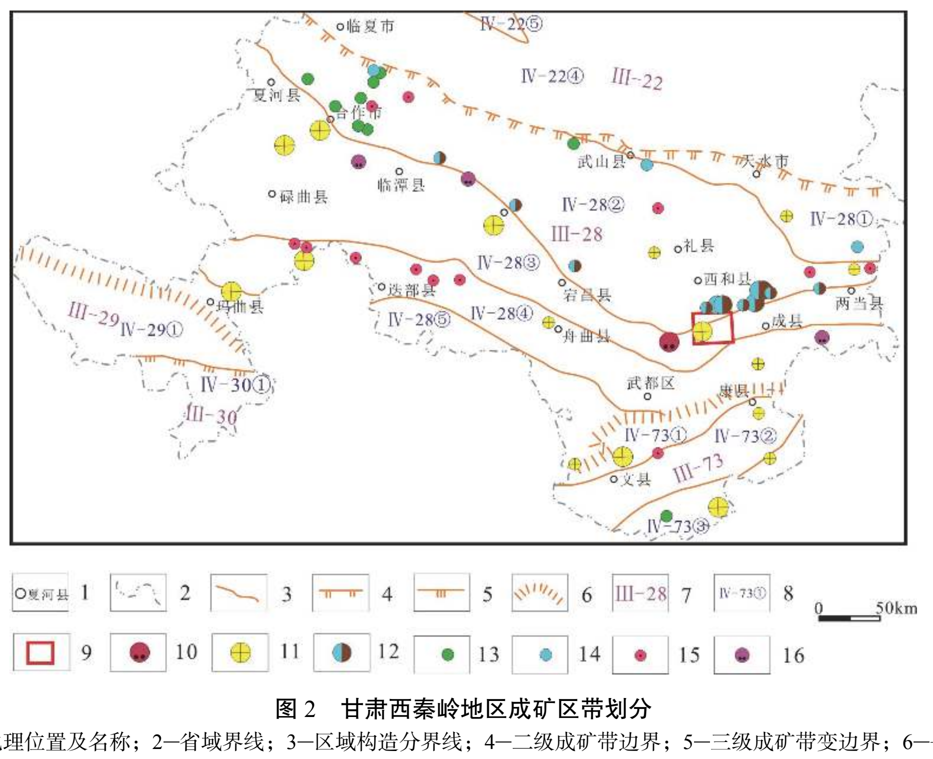

图 2　甘肃西秦岭地区成矿区带划分

1—地理位置及名称；2—省域界线；3—区域构造分界线；4—二级成矿带边界；5—三级成矿带变边界；6—一级成矿带边界；7—三级成矿带代号；8—四级成矿带代号；9—石峡幅范围；10—锑矿；11—金矿；12—铅锌矿；13—铜矿；14—铜钼矿；15—铁矿；16—汞矿；Ⅲ–22—中祁连成矿带；Ⅳ–22④—炭山林—清水铁–铜–钨成矿亚带；Ⅳ–22⑤—河桥镇—兴隆山锰–铬–金成矿亚带；Ⅲ–28 西秦岭成矿带；Ⅳ–28①—武山—天水金–银–铜成矿亚带；Ⅳ–28②—临潭—徽县铅–锌–铜 (铁)–金成矿亚带；Ⅳ–28③—夏河—两当铅金–锑–汞–银成矿亚带；Ⅳ–28④—碌曲—舟曲—广金坝金–铁–锰–铜成矿亚带；Ⅳ–28⑤—玛曲 (西倾山) 金–铁成矿亚带；Ⅲ–29 阿尼玛卿成矿带；Ⅳ–29①—布青山—积石山铜–钴–金–锑成矿亚带；Ⅲ–30 北巴颜喀拉—马尔康成矿带；Ⅳ–30①—加给龙洼—昌马河金–锑–稀土成矿亚带；Ⅲ–73 龙门山—大巴山成矿带；Ⅳ–73①—新关—阳山金–铁成矿亚带；Ⅳ–73②—文县东—康县锰–金 (钼–钴)–重晶石成矿亚带；Ⅳ–73③—碧口—阳坝铜–金 (钴) 成矿亚带

甘肃崖湾—大桥地区内的金矿分布在上古生界和三叠系，分别约占 25% 和 75%，含矿建造主要以三叠系碳酸盐岩夹细碎屑岩建造为主。碌曲—成县金汞锑成矿带目前发现的超大型金矿床均处于三叠系碳酸盐岩夹细碎屑岩建造中 (李永军等，2002)。

石峡幅 (I48E014014) 位于崖湾—大桥整装勘查区中北部，图幅内已发现有各类矿床、矿 (化) 点共 24 处，其中工业矿床 3 处，分别为大桥金矿、饮马河金矿、人头山铅锌矿。图幅内以往工作程度较高，已开展 1：50 000 地质矿产远景调查工作，且在大桥一带完成了 1：50 000 地面高精度磁法测量，图幅内完成 1：50 000 水系沉积物测量。同时，以大桥金矿区作为重点工作区，前人开展了大量的科研工作，总结了大桥金矿典型矿床的成矿要素、建立了成矿模型及预测模型、研究了“成矿地质体、成矿构造/成矿结构面、成矿作用特征标志”，探讨分析了矿床成因、成矿物质来源 (刘月高等，2011；Liu YH，2018)。前人工作提供了丰富、详实的地质、矿产及物、化探资料。

2018 年，甘肃省地质调查院开展的 1：50 000 综合地质调查与找矿预测子项目应用了新技术和新方法进行了野外地质调查 1：50 000，圈定了找矿靶区，评价了资源潜力。同时，填编了 1：50 000 矿产地质图、成矿规律图和矿产预测图等成果图件，完成甘肃省石峡幅 1：50 000 矿产地质图数据库 (宋小兵等，2020；表 1)，该成果图件符合 1：50 000 矿产地质调查技术要求及编图规范，作为新一轮矿产调查工作的创新性图件，为区域矿产资源勘探与研究提供了基础地质资料。

2 数据收集与处理

2.1 数据采集基本要求

甘肃省石峡幅 1：50 000 矿产地质图以《固体矿产地质调查技术要求 (1：50 000)》(DD 2019–02) 为基本要求，以“三位一体”勘查区找矿地质理论为综合指导 (叶天竺等，2014，2017)，开展矿产地质调查与找矿预测工作，以《数据地质图空间数据库》(DD2006–06) 为执行标准，进行数据采集、数据建设，并贯穿矿产地质调查全过程，数据库建库流程与具体工作流程一致，确保数据的科学性、一致性与继承性。

2.2 野外数据采集

甘肃省石峡幅 1：50 000 矿产地质图数据采集采用 DGSS 手机安卓系统 4.0 版，矿产地质专项填图使用中国地质调查局发展研究中心开发的数字地质调查系统 DGSInfo。系统采集工作区地球化学数据、地球物理数据、异常查证结果数据、矿点检查结果数据、探槽数据、成矿规律与矿产预测数据、综合地质构造数据、含矿地质建造数据、控矿构造数据、矿产地数据、矿化信息及找矿标志数据、蚀变带信息、物、化、遥等综合异常数据等。

石峡幅完成路线调查长度 565.47 km、各类调查地质点 2 253 个、专项地质填图 428.00 km^2，高精度磁法剖面测量 4.08 km、遥感解译与异常提取 1 714.00 km^2、矿产地质钻探编录 986.93 m、槽探编录 131.00 m^3、各类岩样测试鉴定 2 604 件/项。大致查明了石峡幅范围内重要矿产金、铅锌、钴 (金) 等的含矿建造特征，重新系统划分了含矿建造类型; 基本查明大桥金矿田控矿因素，建立三位一体找矿预测模型，认为矿田内矿床主要受北东向隆起带控制，矿床 (点) 均分布于隆起带的北西、南东两翼 (图 3)；对石峡幅范围内的主要异常及矿化有利地段进行了检查，新发现矿 (化) 点 5 处，圈定找矿预测靶区 7 个，A 类靶区 2 处，B 类靶区 3 处，C 类靶区 2 处。

表 1 数据库 (集) 元数据简表

条目	描述
数据库(集)名称	甘肃省石峡幅1∶50 000矿产地质图数据库
数据库(集)作者	宋小兵，甘肃省地质调查院 寇银川，甘肃省地质调查院 闫少波，甘肃省地质调查院 王　伟，甘肃省地质调查院
数据时间范围	2018—2019年
地理区域	东经105°15′～105°30′，北纬33°40′～33°50′
数据格式	*.wl，*.wt，*.wp
数据量	137 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“甘肃崖湾-大桥地区金锑矿整装勘查区综合地质调查与潜力评价示范”(121201004000172201–66)资助
语种	中文
数据库(集)组成	该数据库包括1∶50 000矿产地质图、成矿规律图、矿产预测图和系统库Slib组成。 1∶50 000成果图件主要由主图、角图和整饰部分组成。矿产地质图主图主要包括沉积岩建造、侵入岩建造、第四纪、脉岩、构造、地质界线、产状、矿床(点)、蚀变、地质代号、地理信息。角图主要包括沉积岩和侵入岩建造柱状图，脉岩、构造、矿化蚀变图及其图例，图切地质剖面图，大桥典型矿床平面图、典型勘探线剖面图、典型剖面立体图、大桥一带隆滑构造示意图、成矿带位置示意图，矿种及规模图例、矿产地名录。 成矿规律图主图主要包括容矿地层、含矿建造，构造、地质界线、产状、矿床(点)、蚀变、地质代号、地理信息、地球物理、地球化学、遥感信息。角图主要为区域构造格架图、金锑矿成矿模型、成矿区带位置图，区域金成矿要素表，区域锑成矿要素表，成矿构造信息表，成矿谱系表。 矿产预测图主图主要包括含矿建造，构造、地质界线、产状、矿床(点)、地质代号、地理信息，预测找矿靶区。辅图主要为区域成矿模式图，区域中低温热液型金矿、锑矿、钴(金)矿预测要素信息表，新发现矿产地及估算资源量结果，资源储量估算表。成果图件整饰部分主要包括图名、比例尺、接图表、中国地质调查局局徽、图框、坐标参数、责任签等

2.3 室内数据处理

(1) 野外数据导入 DGSInfo 桌面填图系统。

(2) 数据检查，工作量统计，统计指定路线的长度、地质点数、采样数、照片数等工作量值，提供一个包括指定路线工作量的文本窗口，在窗口中进行路线小结。

(3) 导入图形 (空间) 数据，在空间数据库工程中添加数字化地质图图形数据。

(4) 分离、提取要素类、综合要素类图形 (空间) 数据，在空间数据库中分离数字化地质图空间数据为相应的要素类、综合要素类空间数据。

(5) 录入属性数据，在空间数据库中，按要素类→综合要素类→对象类数据输入次序录入属性数据。

3 数据描述

石峡幅 1∶50 000 矿产地质调查成果数据库主要由 1∶50 000 矿产地质图、成矿规律图、矿产预测图数据库及系统库 Slib、24 份矿产信息卡片组成。数据库数据包括

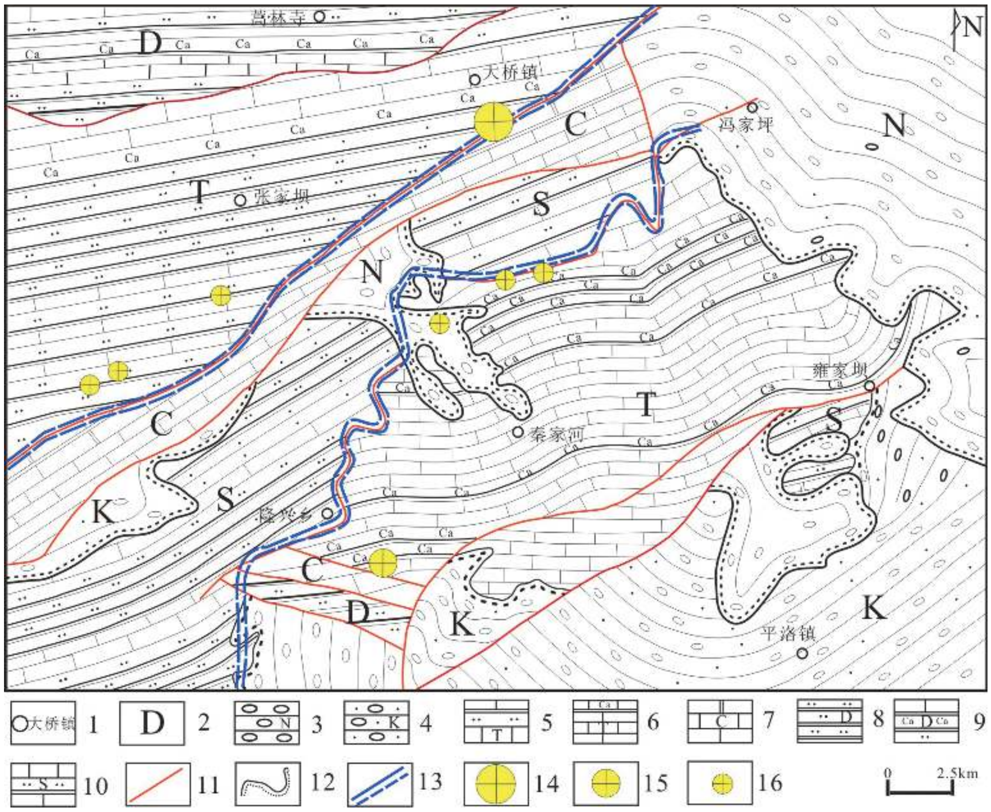

图 3　大桥金矿床隆滑构造示意图

1—地理位置及名称；2—地层时代代号；3—新近系砂砾岩建造；4—白垩系砂砾岩建造；5—三叠系粉砂质板岩夹薄层灰岩建造；6—三叠系粉砂质板岩与砂岩互层建造；7—石炭系灰岩建造；8—泥盆系粉砂质板岩建造；9—泥盆系钙质板岩夹灰岩建造；10—志留系粉砂质板岩夹灰岩建造；11—断层界线；12—不整合接触界线；13—隆滑构造线；14—大型金矿；15—中型金矿；16—小型金矿

MapGIS 格式的 1∶50 000 矿产地质图、成矿规律图、矿产预测图和属性库，主要包含地层建造图层、地质界线图层、控矿构造图层、矿产地图层、矿化信息及找矿标志图层、蚀变带信息、地球物理、地球化学、遥感等综合异常和推断解译隐伏构造图层、隐伏岩体图层、找矿靶区图层及各图层属性表信息。矿产信息卡片囊括了石峡幅内全部矿产和主要矿 (化) 点。

产状属性 (表 2) 主要有产状要素代码、产状要素类型、原始资料代码、产状名称、走向、倾向、倾角。

表 2　石峡幅矿产地质图产状属性表

序号	数据项目名称	标准编码	数据类型	实例
1	产状要素代码	Feature_Id	字符串	AI48E014014000000858
2	产状要素类型	Feature_Type	字符串	01
3	原始资料代码	Source_Id	字符串	D6008_1
4	产状名称	Attitude_Name	字符串	岩层产状
5	走向	Strike	整数型	95°
6	倾向	Dip	整数型	5°
7	倾角	Dip_Angle	整数型	79°

沉积岩建造属性 (表 3) 主要有：地质体面实体代码、地质面实体类型、岩石地层单位名称、地层时代、建造大类、建造类型、岩性组合、大地构造环境。

表 3　石峡幅矿产地质图建造–构造图层属性表

序号	数据项目名称	标准编码	数据类型	实例
1	地质体面实体代码	Feature_Id	字符串	AI48E014014000000379
2	地质面实体类型	Feature_Type	字符串	02
3	岩石地层单位名称	Geobody_Name	字符串	甘肃群第二岩性段
4	地层时代	Geobody_Era	字符串	N
5	建造大类	Formation	字符串	沉积岩建造
6	建造类型	Metallogenic	字符串	砂砾岩建造
7	岩性组合	Combination	字符串	紫红色含砾砂岩
8	大地构造环境	Structural_Env	字符串	泽库前陆盆地相

断裂属性表属性 (表 4) 主要有：断裂要素代码、断裂要素类型、断裂名称、断裂编号、断裂性质、断裂运动方式、断裂上盘地质体代号、断裂下盘地质体代号、断裂宽度、断裂长度、断裂走向、断裂面倾向、断裂面倾角、断距、断裂形成时代、活动期次。

表 4　石峡幅矿产地质图断裂属性表

序号	数据项目名称	标准编码	数据类型	实例
1	断裂要素代码	Feature_Id	字符串	AI48E014014000001721
2	断裂要素类型	Feature_Type	字符串	03
3	断裂代码	Fault_Type	字符串	压扭性断裂
4	断裂名称	Fault_Name	字符串	青岗岭山口—人头山断裂
5	断裂编号	Fault_Code	字符串	F1–1
6	断裂性质	Fault_Character	字符串	逆冲推覆断裂
7	断裂运动方式	Fault_motion	字符串	逆冲推覆
8	断裂上盘地质体代号	Fault_Up_Body	字符串	T_2d^1
9	断裂下盘地质体代号	Fault_Bottom_Body	字符串	D_2h^1
10	断裂宽度	Fault_Wide	浮点型	100
11	断裂长度	Fault_Wide	浮点型	24.9
12	断裂走向	Fault_Strike	整数型	60°
13	断裂面倾向	Fault_Dip	整数型	330°
14	断裂面倾角	Fault_Dip_Angle	整数型	70°
15	断距	Fault_Distance	浮点型	1
16	断裂形成时代	Era	字符串	中生代
17	活动期次	Movement_Period	字符串	印支期

地质界线属性 (表 5) 主要有：地质界线要素标识号、地质界线要素类型、地质界线类型、界线左侧地质体代号、界线右侧地质体代号。

矿产地属性 (表 6) 主要有：矿产地要素代码、矿产地要素类型、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、成因类型、工业类型。

表 5　石峡幅矿产地质图地质界线数据属性表

序号	数据项目名称	标准编码	数据类型	实例
1	地质界线要素标识号	Feature_Id	字符串	AI48E014014000001742
2	地质界线要素类型	Feature_Type	字符串	04
3	地质界线类型	Boundary_Name	字符串	角度不整合
4	界线左侧地质体代号	Left_Boundary_Code	字符串	N_1G^2
5	界线右侧地质体代号	Right_Boundary_Code	字符串	K_1j^2

表 6　石峡幅矿产地质图矿产地属性表

序号	数据项目名称	标准编码	数据类型	实例
1	矿产地要素代码	Feature_Id	字符串	AI48E014014000000003
2	矿产地要素类型	Feature_Type	字符串	05
3	矿种名称	Commodities_Name	字符串	铅锌矿
4	共生矿	Paragenic_Ore	字符串	/
5	伴生矿	Associated_Ore	字符串	银
6	矿产地数	Ore_Sums	整数型	/
7	矿石品位	Ore_Grade	字符串	铅0.5%，锌3.44%
8	规模	Deposite_Size	字符串	中型
9	成矿时代	Metallogenetic_Epoch	字符串	印支期阶段
10	矿产地名	Placename	字符串	甘肃省西和县人头山铅锌矿
11	成因类型	Genesis_Types	字符串	浅成中–低温热液型铅锌矿
12	工业类型	Industrial_Types	字符串	有色金属铅锌矿

预测靶区属性 (表 7) 主要有：靶区周长、靶区面积、图幅号、靶区要素代码、靶区要素类型、颜色代码、靶区名称、靶区编号、靶区面积、地理位置、主矿种、典型矿床、已知矿床、靶区类别、靶区级别、预测资源量、成矿时代、容矿地层、大地构造位置、岩浆类型、地球化学特征、蚀变特征。

4　数据质量控制与评估

本次工作原始数据主要通过收集前人资料和野外实测获取，野外实测主要包括 1：50 000 矿产地质专项填图及重点工作区矿产综合检查。工作方法及技术要求严格按照《固体矿产地质调查技术要求 (1：50 000)》(DD 2019–02)、《固体矿产勘查工作规范》(GB/T 33444—2016) 及相关矿调标准规范执行。其他物、化探工作亦严格执行相关物、化探标准规范，确保资料达到精度要求，具备可靠性。

1：50 000 矿产专项地质填图根据石峡幅实际地质情况采用沉积建造构造地质填图，填图调查重点圈定控制与成矿作用有关的沉积建造、特殊岩性层、构造、矿化蚀变及重要的地质界线。本次专项地质填图野外调查路线精度为: 平均 108 m 路线包含一个地质点或点间界线; 重点工作区内，填图路线线距一般 80 ~ 150 m，点距在 80 ~ 100 m，达到了 1：10 000 的精度。一般工作区及图幅内白垩纪、新近纪砂砾岩覆盖区，线距 500 m，点距 250 m。填图精度符合规范要求。

成果图件编制和数据属性库建设遵照《矿产地质调查成果性图件编制相关要求 (1：50 000)》(讨论稿)、《数字地质图空间数据库》(DD 2006–06)、《固体矿产勘查地

表 7　石峡幅矿产预测图预测靶区属性表

序号	数据项目名称	标准编码	数据类型	实例
1	靶区周长	周长	双精度型	537.6
2	靶区面积	面积	双精度型	6 293.48
3	图幅号	MAPCODE	字符串	I48E014014
4	靶区要素代码	FEATURE_ID	字符串	A0000000000000000008
5	靶区要素类型	FEATURE_Type	字符串	06
6	颜色代码	COLOUR	字符串	283
7	靶区名称	TARGET_NAME	整数型	大桥金矿预测区
8	靶区编号	TARGET_CODE	字符串	AuA001
9	靶区面积	QDTCBA	浮点型	21.14
10	地理位置	DLWZ	字符串	甘肃省西和县大桥
11	主矿种	KCCA	字符串	Au
12	典型矿床	DXKC	字符串	大桥金矿
13	已知矿床	DXKE	字符串	大桥金矿、饮马河金矿
14	靶区类别	QDTCBF	字符串	Ⅰ
15	靶区级别	QDTCBT	字符串	A
16	预测资源量	PKCAAG	整数型	160 585
17	成矿时代	KCDS	字符串	印支期
18	容矿地层	DDDA	字符串	三叠系滑石关组一段
19	大地构造位置	GZAN	字符串	临潭—两当深大断裂和窑上石峡断裂
20	岩浆类型	YSEA	字符串	中低温热液型
21	地球化学特征	QDHX	字符串	Ag、Au、Hg、Sb、Sn异常套合很好
22	蚀变特征	KCAGA	字符串	硅化、黄铁矿化、碳酸盐化、萤石化

质资料综合整理综合研究技术要求》(DZ/T 0079—015) 等规定。矿产地质图、成矿规律图、矿产预测图等成果图件中的图式图例、符号等按照《区域地质图图例》(GB/T 958—2015)、《地质图用色标准及用色原则》(DZ/T0179—1997) 进行表达。

野外数据采集及数据库建设严格执行三级质量检查制度，开展自检、互检、项目组检查，检查和修改情况均填写了质量检查记录卡片，形成纸质文件或录入数据库，符合地质调查项目质量管理要求。

5　数据价值

(1) 石峡幅 1：50 000 矿产地质调查成果性图件编制及数据库建设遵循了《固体矿产地质调查技术要求 (1：50 000)》(DD 2019−02) 的编图思想，按照新一轮矿产地质调查工作制图要求表达图面内容及图面布局。地层划分以建造为基本单元，对成矿建造和构造突出表达，添加了重要矿化蚀变信息内容。重新划分的建造内容添加在矿产地质图的属性库中 (贺根文等，2019；刘翠辉等，2019)。

根据收集及实测资料，在 1：50 000 矿产地质图中将沉积岩地层划分为 19 类非正式沉积建造类型，划分侵入岩建造 1 个。其中，在中三叠系滑石关组中划分出赋矿硅化角砾岩建造；将原新近系甘肃群一段 (N_1G^1) 砂砾岩建造根据其与下伏地层的角度不整合接触关系及岩性组合对比，划归为下白垩统鸡山组二段 (K_1j^2) 砂砾岩建造 (表 8)。

表 8　沉积岩建造一览表

年代地层单元		岩石地层单元		建造单元特征		
系	统	组	代号	建造类型	厚度/m	岩性
第四系	全新统		Qh^{pal}		15	冲洪积砂、砂砾石、亚砂土
	更新统		Qp^{eol}		5～10	黄土状粉砂质黏土、粉砂土、含砾砂土
新近系			N_1G^a	砂砾岩建造	1 179	砖红色砂砾岩夹泥质粉砂岩、粉砂质泥岩
白垩系		鸡山组	K_1j^{2a}	砂砾岩建造	282	紫红色砂砾岩
三叠系	中三叠统	大河坝组	T_2d^{1c}	粉砂质板岩与砂岩互层建造	923	灰褐色粉砂质板岩、灰绿色砂岩
			T_2d^{1b}	钙质板岩夹薄层灰岩建造	500	灰黄色钙质板岩夹薄层灰岩、夹少量砂岩
			T_2d^{1a}	粉砂质板岩夹砂岩建造	437	灰色粉砂质板岩夹砂岩
		滑石关组	T_2h^{2a}	钙质板岩夹薄层灰岩、砂岩建造	679	灰色钙质板岩夹青灰色薄层灰岩、少量角砾状灰岩、夹薄层砂岩
			T_2h^{1d}	钙质板岩夹薄层灰岩建造	500	灰色钙质板岩夹青灰色薄层灰岩、少量角砾状灰岩
			T^2h^{1c}	粉砂质板岩夹薄层灰岩建造	400	灰色、青灰色粉砂质板岩夹薄层灰岩、角砾状灰岩
			T_2h^{1b}	硅化角砾岩建造	5～216	硅化角砾岩、纹层状硅质岩复成分角砾岩
			T_2h^{1a}	薄层灰岩建造	30	青灰色薄层灰岩
石炭系	上石炭统	岷河组	C_2m^a	厚层灰岩建造	301	灰白色厚层灰岩、大理岩化灰岩
泥盆系	上泥盆统	红岭山组	D_3hl^a	厚层灰岩与千枚状板岩互层建造	1 472	深灰色厚层灰岩与浅灰绿色千枚状板岩 互层
	中泥盆统	黄家沟组	D_2h^{3a}	千枚岩夹中厚层灰岩建造	260.30	浅灰绿色千枚岩夹中厚层灰岩
			D_2h^{2b}	薄中层灰岩夹粉砂质板岩建造	400	灰色薄中层灰岩夹粉砂质板岩、夹硅质岩、少量砂岩
			D_2h^{2a}	板岩夹灰岩、砂岩建造	589	灰色钙质板岩、粉砂质板岩、浅灰色千枚状板岩夹薄中层灰岩、钙质长石石英砂岩，夹含少量厚层灰岩、生物碎屑灰岩
			D_2h^{1a}	粉砂质板岩与砂岩互层建造	968	浅灰色粉砂质板岩、少量钙质板岩与灰褐色钙质岩屑石英砂岩、钙质长石石英砂岩互层
	下泥盆统	安家岔组	D_1h^{2a}	粉砂质板岩夹砂岩建造	1 040	灰色粉砂质板岩夹中薄层砂岩
志留系	上志留统	卓吾阔组	$S_{3-4}zw^{3a}$	粉砂质板岩夹厚层灰岩、硅质岩建造	1 308	灰褐色粉砂质板岩夹灰色薄层灰岩、夹灰黑色硅质岩
			$S_{3-4}zw^{2a}$	中厚层灰岩夹碎屑岩建造	973	深灰色中厚层灰岩、砂屑灰岩夹灰色粉砂岩、灰褐色粉砂质板岩、夹灰黑色硅质岩

(2) 区域成矿规律图重点反映了与成矿相关的沉积建造内容以及区域构造、成矿构造等要素，叠加了物探、化探、遥感调查解译推断的与成矿相关的隐伏岩体、区域构造和地球物理、地球化学异常分布区。

在勘查区找矿理论的指导下，以典型矿床研究为基础，建立了大桥金矿、崖湾锑矿

典型矿床的成矿模型，编制了成矿模型角图。在图中详细标示了金、锑矿预测类型成矿地质体、成矿构造及成矿作用特征标志等区域展布特征。

(3) 综合区域地质、物探、化探、遥感、矿产资料, 通过 mras 软件圈定出 7 处找矿靶区, 其中 A 类靶区 2 处, B 类靶区 3 处, C 类靶区 2 处（表 9，图 4）。靶区信息反映在矿产预测图及数据库中。

表 9　找矿靶区一览表

序号	靶区编号	靶区名称	靶区位置	靶区分类
1	AuA001	大桥金找矿预测靶区	大桥乡	A
2	AuA002	安房坝金找矿预测靶区	安房坝	A
3	AuB001	崖湾金找矿预测靶区	崖湾	B
4	AuB002	朱家河金找矿预测靶区	朱家河	B
5	AuB003	安子山金找矿预测靶区	安子山	B
6	AuC001	六巷金找矿预测靶区	六巷乡	C
7	AuC002	月溜坡金找矿预测靶区	太石山	C

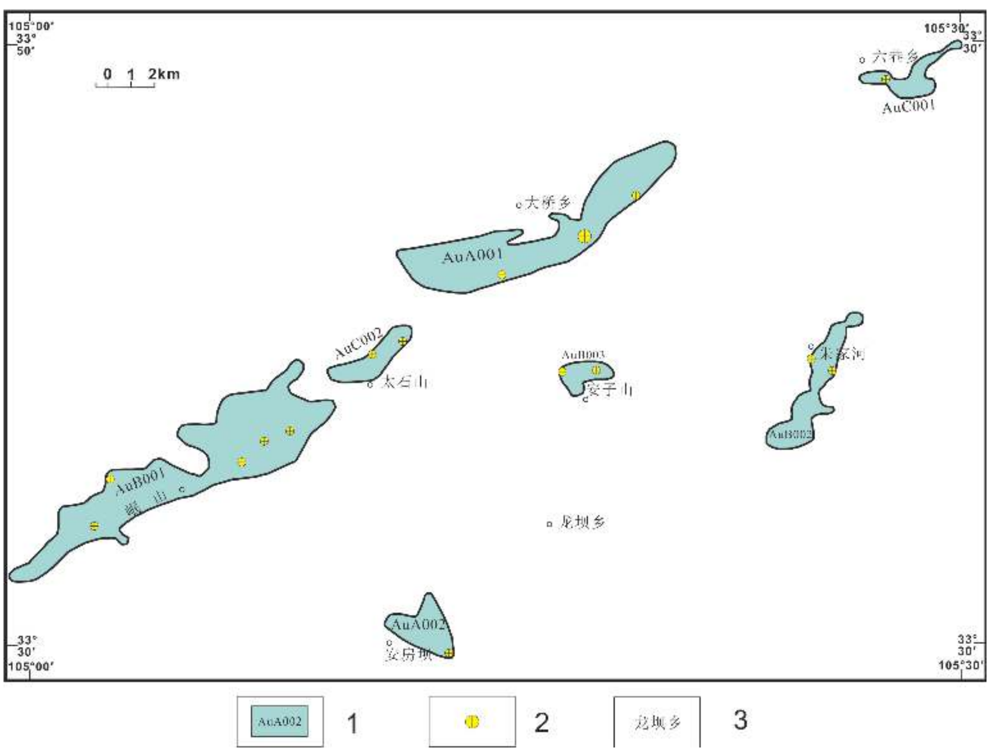

图 4　崖湾—大桥地区找矿靶区示意图

1—找矿靶区及代号；2—金矿床（点）；3—乡镇地理位置及名称

6　结论

(1) 通过专项地质填图工作，在甘肃崖湾—大桥地区石峡幅 1∶50 000 矿产地质图中将沉积岩地层划分为 19 类非正式沉积建造类型，划分侵入岩建造 1 个。在中三叠统滑石关组中划分出赋矿硅化角砾岩建造; 将原新近系甘肃群一段 (N_1G^1) 砂砾岩建造根据其与下伏地层的角度不整合接触关系及岩性组合对比，划归为下白垩统鸡山组二段 (K_1j^2) 砂砾岩建造。

(2) 石峡幅 1：50 000 矿产地质成果数据库包含了矿产地质图、成矿规律图、矿产预测图等成果图件和相对应的属性数据库。突出表达了成矿建造、区域构造、矿化蚀变信息；全面分析资料，系统总结了石峡幅区域成矿要素信息，建立了大桥金矿、崖湾锑矿等矿床成矿模型；圈定了 7 处找矿靶区，系统体现了新一轮矿产调查工作的最新成果。

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Database of 1∶50 000 Mineral Geological Survey Results of the Shixia Map-sheet in Yawan–Daqiao Integrated Exploration Area, Gansu Province

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Abstract: The 1∶50 000 mineral geological survey of Shixia Map-sheet (I48E014014) in Gansu Province was conducted according to the *Technical Requirements of Solid Mineral Geological Survey* (1∶50 000) (DD2019−02) issued by the China Geological Survey. During this survey, the digital mapping technique was employed to carry out 1∶50 000 mineral geology-specific mapping, comprehensive mineral inspection, and prospecting prediction and to delineate prospecting target areas based on the systematical collection and comprehensive analysis of existing geological, geophysical, geochemical, remote sensing, and mineral data. The geology-specific mapping was completed by field mapping and indoor map compilation. As a result, the Shixia Map-sheet was divided into 19 types of informal sedimentary suites and one type of intrusive rock suites. Meanwhile, the mineral information cards were filled in combination with comprehensive mineral inspection of major survey sites in the Map-sheet area. On these bases, typical deposits in the Map-sheet area were researched and metallogenic factors were summarized. Moreover, the result maps such as 1∶50 000 mineral geological map, metallogenic regularity maps, and mineral prediction maps were prepared, and a database of these maps was developed. In the result maps and database, metallogenic suites, regional structures, and mineralized alteration are highlighted, metallogenic factors in the Shixia Map-sheet are systemically summarized, the metallogenic models of typical deposits are established, and seven prospecting and prediction targets of medium-low temperature hydrothermal gold deposits was delineated.

Key words: Shixia Map-sheet; mineral geological survey; database; 1∶50 000; Yawan–Daqiao Integrated Exploration Area; Gansu Province

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

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1 Introduction

The Yawan–Daqiao area, Gansu Province is located between the Lintan–Tanchang–Jiangluo arc-shaped deep fault protruding southwards and the Zhouqu–Chengxian–Huixian arc-shaped fault (Li TG et al., 2000). It lies in the eastern section of the West Qinling orogen and falls in the transition part between the epicontinental basin and Zeku foreland basin in central Qinling area and epicontinental rift zone in southern Qinling area (all these belong to the Qinling arc–basin system). The regional deep faults control the distribution of the strata, structures, and magmatic rocks and the occurrence of minerals in the area (Fig. 1). In the West Qinling area, large numbers of thrust nappe structures have developed owing to the dynamic metallogenic background consisting of Meso–Cenozoic intracontinental orogeny and epicontinental structures, and thus meso–epithermal Ag–Hg–Sb deposits are formed (Zhang GW et al., 1996). The Luqu–Chengxian Au–Hg–Sb metallogenic belt containing the Yawan–Daqiao area is one of the most important metallogenic belts in West Qinling area (Fig. 2; Zhang XH et al., 2008). Multiple major deposits are distributed along the regional deep fault in the metallogenic belt, namely Jiagantan and Zaozigou super-large gold deposits, large Luerba gold deposit, medium-sized Yangweiligou gold deposit, large Yawan antimony deposit, medium-sized Pingding gold deposit, super-large Daqiao gold deposit, and medium-sized Anfangba gold deposit from west to east (Xiao L et al., 2008).

The gold deposits in Yawan–Daqiao area are distributed in Upper Paleozoic and Triassic strata, which bear about 25% and 75% of the gold deposits, respectively. The ore-bearing suites are dominated by the suites consisting of Triassic carbonate rocks interbedded with fine-

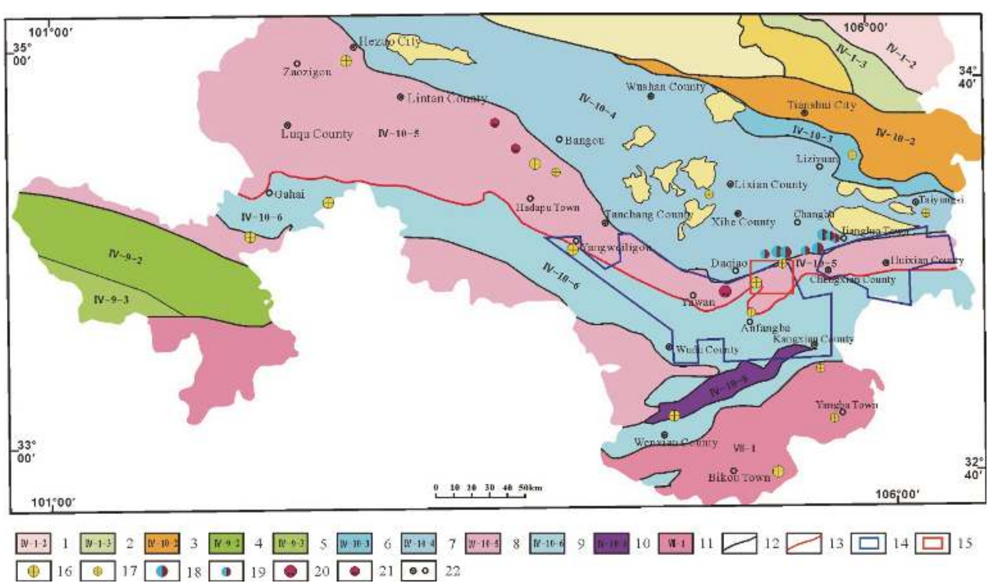

Fig. 1 Geotectonic map of West Qinling area, Gansu Province

1—Zoulangnanshan magmatic arc; 2—North Qilian ophiolitic melange; 3—North Qinling magmatic arc; 4—Xidatan–Buqingshan ophiolitic mélange in Muztag; 5—Maduo–Maqin accretionary wedge; 6—Shangdan ophiolitic melange; 7—Central Qinling epicontinental basin; 8—Zeku foreland basin; 9—Xiqingshan–south Qinling epicontinental rift; 10—Mianlue ophiolitic melange; 11—Bayankala Block; 12—tectonic boundary; 13—regional deep and large fault; 14—scope of Yawan–Daqiao Integrated Exploration Area in Gansu Province; 15—scope of the Shixia Map-sheet; 16—large gold deposit; 17—medium-sized gold deposit; 18—large lead—zinc deposit; 19—medium—sized lead—zinc deposit; 20—large antimony deposit; 21—medium—sized antimony deposit; 22—counties and cities

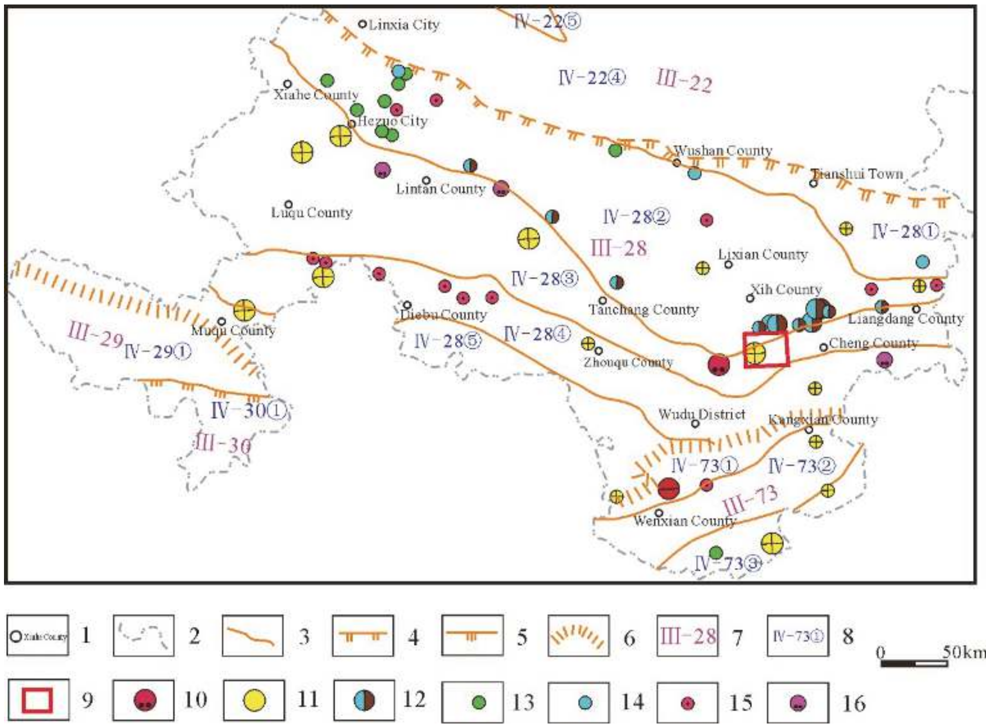

Fig. 2 Division of metallogenic belts in West Qinling area, Gansu Province

1—geographical location and name; 2—provincial border; 3—boundary of regional structures; 4—boundary of Level–Ⅱ metallogenic belts; 5—boundary of Level–Ⅲ metallogenic belts; 6—boundary of Level–Ⅰ metallogenic belts; 7—code of Level–Ⅲ metallogenic belts; 8—code of Level–Ⅳ metallogenic belts; 9—scope of the Shixia Map-sheet; 10—antimony deposit; 11—gold deposit; 12—lead–zinc deposit; 13—copper deposit; 14—copper–molybdenum deposit; 15—iron deposit; 16—mercury deposit; III–22—Central Qilian metallogenic belt; IV–22④—Tanshanlin–Qingshui Fe–Cu–W metallogenic sub-zone; IV–22⑤—Heqiao zhen–Xinglongshan Mn–Cr–Au metallogenic sub-zone; Ⅲ–28—West Qinling metallogenic belt; Ⅳ–28①—Wushan–Tianshui Au–Ag–Cu metallogenic sub-zone; Ⅳ–28②—Lintan–Huixian Pb–Zn–Cu (Fe)–Au metallogenic sub-zone; Ⅳ–28③—Xiahe–Liangdang Au–Sb–Hg–Ag metallogenic sub-zone; Ⅳ–28④—Luqu–Zhouqu–Guangjinba Au–Fe–Mn–Cu metallogenic sub-zone; Ⅳ–28⑤—Maqu (Xiqingshan) Au–Fe metallogenic sub-zone; Ⅲ–29—Aemye Ma-chhen metallogenic belt; Ⅳ–29①—Buqingshan–Jishishan Cu–Co–Au–Sb metallogenic sub-zone; Ⅲ–30—North Bayankala–Maerkang metallogenic belt; Ⅳ–30①—Jiageilongwa–Changmahe Au–Sb–rare-earth metallogenic sub-zone; Ⅲ–73—Longmenshan–Dabashan metallogenic belt; Ⅳ–73①—Xin'guan–Yangshan Au–Fe metallogenic sub-zone; Ⅳ–73②—East Wenxian–Kangxian Mn–Au (Mo–Co)–barite metallogenic sub-zone; Ⅳ–73③—Bikou–Yangba Cu–Au (Co) metallogenic sub-zone

grained clastic rocks, which covers all of the super-large gold deposits currently discovered in Luqu–Chengxian Au–Hg–Sb metallogenic belt (Li YJ et al., 2002).

The Shixia Map-sheet (I48E014014) lies in the north-central Yawan–Daqiao Integrated Exploration Area. A total of 24 deposits and ore occurrences (mineralized points) have been discovered in the Map-sheet area, including three industrial deposits, namely Daqiao gold deposit, Yinmahe gold deposit, and Rentoushan lead-zinc deposit. This map-sheet features high exploration level, and the surveys previously conducted include 1∶50 000 geological mineral prospect surveys, 1∶50 000 high-precision ground magnetic surveys in Daqiao area, and 1∶50 000 stream sediment surveys in the whole map-sheet area. Moreover, substantial researches have been carried out focusing on Daqiao gold deposit. As a result, for the typical deposits in Daqiao gold deposit, the metallogenic factors were summarized, metallogenic and prediction models were established, "metallogenic geologic blocks, metallogenic structures/

structural planes, and characteristic indicators of metallogenesis" were analyzed, and the genesis and ore-forming material source were explored and analyzed (Liu YG et al., 2011; Liu YH, 2018). In this way, detailed geological, mineral, geophysical, and geochemical data were obtained.

In 2018, the Gansu Institute of Geological Survey implemented the 1∶50 000 comprehensive geological survey and prospecting prediction subproject, during which new techniques and methodology were applied to conduct 1∶50 000 field geological survey, delineate prospecting target areas, and assess resource potential. Meanwhile, the result maps were compiled and the database of 1∶50 000 mineral geological map of the Shixia Map-sheet in Gansu Province (also referred to as the Database; Song XB et al., 2020; Table 1) was developed. The result maps include the 1∶50 000 mineral geological map, metallogenic regularity maps, and mineral prediction maps. They meet technical requirements and map compilation specifications of 1∶50 000 mineral geological surveys. As innovative maps in the new round of mineral surveys initiated by the China Geological Survey, the result maps provide fundamental geological information for the exploration and study of regional mineral resources.

2 Data Acquisition and Processing

2.1 Basic Requirements of Data Acquisition

In this study, the mineral geological survey and prospecting prediction were carried out under the comprehensive guidance of the "trinity" prospecting geological theory of exploration areas that integrates metallogenic geologic blocks, metallogenic structures, metallogenic

Table 1 Metadata Table of Database (Dataset)

Item	Description
Database (dataset) name	Database of 1∶50 000 Mineral Geological Map of the Shixia Map-sheet in Gansu Province
Database (dataset) authors	Song Xiaobing, Gansu Institute of Geological Survey Kou Yinchuan, Gansu Institute of Geological Survey Yan Shaobo, Gansu Institute of Geological Survey Wang Wei, Gansu Institute of Geological Survey
Data acquisition time	2018–2019
Geographical area	105°15′–105°30′E, 33°40′–33°50′N
Data format	*.wl, *.wt, *.wp
Data size	137 MB
Data service system URL	http://dcc.cgs.gov.cn
Fund project	The geological survey project entitled *Comprehensive Geological Survey and Potential Assessment Demonstration of Gold-Antimony Deposit Integrated Exploration Area in Yawan-Daqiao Area*, *Gansu Province* (No.: 121 201 004 000 172 201–66), a subproject of the project entitled *Prospecting Prediction and Technological Application Demonstration of Integrated Exploration Areas* initiated by the China Geological Survey
Language	Chinese

Continued table 1

Item	Description
Database (dataset) composition	The Database mainly consists of a 1∶50 000 mineral geological map, metallogenic regularity maps, mineral prediction maps, and a system library Slib. The 1∶50 000 result maps mainly include master map, corner maps, and map decorations. The master map cover sedimentary rock suites, intrusive rock suites, Quaternary, vein rocks, structures, geological boundaries, occurrence, mineral deposits (ore occurrence), alternation, geological codes, and geographic information. The corner maps mainly include the histograms of sedimentary rock suites and intrusive rock suites; maps of vein rocks, structures, and mineralized alternation and map legends; cross-sections; maps of Daqiao gold deposit, including plans of typical deposits, profiles of typical exploration lines, stereograms of typical sections, diagrams of uplifting-slipping structures in Daqiao area, and diagrams of metallogenic belts; legends of mineral types and their scale; list of mineral deposits. The master maps of metallogenic regularity maps mainly cover ore-hosting strata, ore-bearing suites, structures, geological boundaries, occurrence, mineral deposits (ore occurrence), alternation, geological codes, and geographic, geophysical, geochemical, and remote sensing information. The corner maps of the metallogenic regularity maps consist of regional tectonic framework maps, metallogenic models of gold-antimony deposits, maps of metallogenic zone/belt location, regional metallogenic factor tables of gold and antimony, a metallogenic structure information table, and a metallogenic pedigree table. The master maps of mineral prediction maps mainly cover ore-bearing suites, structures, geological boundaries, occurrence, deposits (ore occurrence), geological codes, geographic information, and predicted prospecting target areas. The auxiliary maps of mineral prediction maps include regional metallogenic model maps; a predictive factor table of regional low-medium temperature hydrothermal gold, antimony, and cobalt (gold) deposits; mineral deposits newly discovered and their estimated resources, and an estimated mineral reserves table. The decorations of the result maps mainly include map titles, scale, an index map, the logo of the China Geological Survey, map frames, coordinate parameters, and signatures

structural planes, and metallogenic characteristic indicators (Ye TZ et al., 2014, 2017) according to the *Technical Requirements of Solid Mineral Geological Survey* (1∶50 000) (DD2019-02). Meanwhile, the *Spatial Database Establishment Code of Digital Geological Maps* (DD 2006-06) was followed to acquire data and build the database in the whole process of mineral geological survey. Moreover, the Database was built according to the process consistent with specific working process, thus ensuring that the data are scientific and consistent and can be inherited.

2.2 Data Acquisition in the Field

For the 1∶50 000 mineral geological map of Shixia Map-sheet in Gansu Province, the data were acquired in the field using the DGSS version 4.0 for Android phones and mineral geology-specific mapping was conducted using DGSInfo—the software for digital mineral survey developed by the Development and Research Center of China Geological Survey. Various data were systematically acquired in the Shixia Map-sheet area, including geochemical and geophysical data; anomaly verification results; inspection results of ore occurrence; trench data; data on metallogenic regularity and mineral prediction; data on comprehensive geological structures; data on ore-bearing geological suites, ore-controlling structures, mineral deposits, mineralization, and prospecting indicators; information of alteration zones, and the data on integrated anomalies of geophysical exploration, geochemical exploration, and remote sensing.

The mapping Shixia Map-sheet involves the survey of 565.47 km of geological routes and 2 253 various geologic points, 428.00 km^2 of geology-specific mapping, 4.08 km of profiles of high-precision magnetic survey, 1 714.00 km^2 of remote-sensing interpretation and anomaly extraction, 986.93 m of mineral geological drilling and records, 131.00 m^3 of trench records, and testing and identification of 2 604 rock samples. On these bases, the characteristics of ore-bearing suites of major minerals such as Au, Pb–Zn and Co (Au) within Shixia Map-sheet area were roughly figured out and the ore-bearing suites were systematically reclassified. Meanwhile, the ore-controlling factors in the orefield of the Daqiao gold deposit were generally ascertained and the "trinity" prospecting prediction models were established. It can be considered that the deposits in the orefield are mainly controlled by NE-trending uplift zone and that all deposits (mineral occurrences) are distributed on the NW and SE wings of the uplift zone (Fig. 3). Furthermore, according to the inspection of the main anomalies and favorable mineralization sections in the Shixia Map-sheet area, five ore occurrences (mineralized points) were newly discovered and seven target areas for prospecting prediction were delineated, including two Class A, three Class B, and two Class C target areas.

2.3 Indoor Data Processing

(1) The data obtained in the field were imported into the DGSInfo.

(2) Data were checked. Meanwhile, statistics were made for workloads, such as the length of designated routes and the number of geologic points, samples, and photos of the routes. The workloads were summarized in a text window.

(3) Graphic (spatial) data were imported into spatial databases. In detail, graphic data of digitalized geological maps were added from a spatial database project of DGSInfo.

(4) Graphic (spatial) data of feature classes and complex classes were separated and extracted. That is, the spatial data of digitalized geological maps were classified as the data of feature classes and complex classes in the spatial databases.

(5) Attribute data were input. Specifically, the attribute data were input into the spatial databases for the data of feature classes, complex classes, and object classes successively.

3 Data Description

The Database consists mainly of databases of 1 : 50 000 mineral geological map, metallogenic regularity map, and mineral prediction map, a system library Slib, and 24 pieces of mineral information. The data in the Database include 1 : 50 000 mineral geological map, metallogenic regularity map, and mineral prediction map in the format of MapGIS and

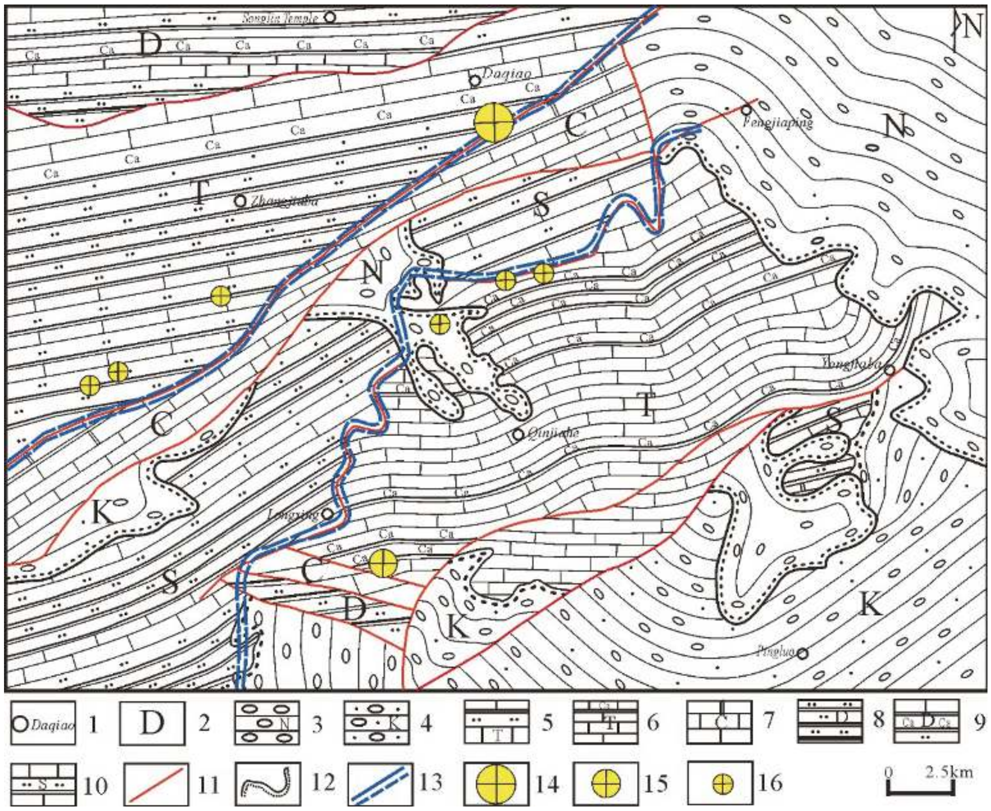

Fig. 3 Schematic view of uplifting–slipping structures in Daqiao gold deposit

1—geographical location and name; 2—code of stratigraphic time; 3—Neogene sandy conglomerate; 4—Cretaceous sandy conglomerate; 5—Triassic silty slate interbedded with thin laminated limestone; 6—Triassic alternating layers of silty slate and sandstone; 7—Carboniferous limestone; 8—Devonian silty slate; 9—Devonian calcareous slate interbedded with limestone; 10—Silurian silty slate interbedded with limestone; 11—fault boundary; 12—unconformity; 13—uplifting–slipping structure; 14—large gold deposit; 15—medium-sized gold deposit; 16—small gold deposit

attribute databases. The maps are mainly composed of the map layers of stratigraphic suites, geologic boundaries, ore-controlling structures, mineral deposits, mineralization information, prospecting indicators, alteration zones, integrated anomalies of geophysical exploration, geochemical exploration, and remote sensing, concealed structures and rock masses inferred and interpreted from the integrated anomalies, and prospecting target areas as well as the attribute tables of these map layers. The mineral information cards cover all minerals and main ore occurrences (mineralized points) in the Shixia Map-sheet area.

Main attributes of an occurrence (Table 2) include code and type of occurrence feature, code of raw data, occurrence name, strike, dip, and dip angle.

Main attributes of a sedimentary rock suite (Table 3) include codes and types of geological polygon entities, name of lithostratigraphic unit, stratum time, category and type of the suite, lithologic association, and geotectonic environment.

Main attributes of a fault (Table 4) include code and type of fault feature; the name, code, characteristics, and motion mode of the fault, codes of geologic blocks on the hanging and foot walls of the fault; the width, length, and strike of the fault; the dip and dip angle of fracture face; fault throw; formation time and activity stage of the fault.

Main attributes of a geological boundary (Table 5) include ID and type of geological

Table 2 Attributes of occurrence in the mineral geological map of Shixia Map-sheet

No.	Data item	Standard code	Data type	Example
1	Code of occurrence feature	Feature_Id	string	AI48E014014000000858
2	Type of occurrence feature	Feature_Type	string	01
3	Code of raw data	Source_Id	string	D6008_1
4	Occurrence name	Attitude_Name	string	Strata occurrence
5	Strike	Strike	int	95°
6	Dip	Dip	int	5°
7	Dip angle	Dip_Angle	int	79°

Table 3 Attributes of suite-tectonic map layers in the mineral geological map of Shixia Map-sheet

No.	Data item	Standard code	Data type	Example
1	Code of geological polygon entity	Feature_Id	string	AI48E014014000000379
2	Type of geological polygon entity	Feature_Type	string	02
3	Name of lithostratigraphic unit	Geobody_Name	string	The Second Member of Gansu Group
4	Stratum time	Geobody_Era	string	N
5	Suite category	Formation	string	Sedimentary-rock suite
6	Suite type	Metallogenic	string	Sandy conglomerate suite
7	Lithologic association	Combination	string	Purplish red pebbly sandstone
8	Geotectonic environment	Structural_Env	string	Zeku foreland basin

Table 4 Attributes of faults in the mineral geological map of Shixia Map-sheet

No.	Data item	Standard code	Data type	Example
1	Code of fault feature	Feature_Id	string	AI48E014014000001721
2	Type of fault feature	Feature_Type	string	03
3	Fault code	Fault_Type	string	Transpressional fault
4	Fault name	Fault_Name	string	Qingganglingshankou–Rentoushan fault
5	Fault code	Fault_Code	string	F1-1
6	Fault characteristics	Fault_Character	string	Thrust nappe fault
7	Motion mode of fault	Fault_motion	string	Thrust nappe
8	Code of geologic blocks on the hanging foot wall of fault	Fault_Up_Body	string	T_2d^1
9	Code of geologic blocks on the foot wall of fault	Fault_Bottom_Body	string	D_2h^1
10	Fault width	Fault_Wide	float	100
11	Fault length	Fault_Wide	float	24.9
12	Fault strike	Fault_Strike	int	60°
13	Dip of fracture face	Fault_Dip	int	330°
14	Dip angle of fracture face	Fault_Dip_Angle	int	70°
15	Fault throw	Fault_Distance	float	1
16	Formation time of fault	Era	string	Mesozoic
17	Activity stage	Movement_Period	string	Indosinian

boundary feature, the type of the geological boundary, and codes of geologic blocks on the left and right sides of the geological boundary.

Main data attributes of a mineral deposit type (Table 6) include code and type of mineral deposit feature, names of mineral types, paragenetic and associated minerals, number of mineral deposits, ore grades, scale, metallogenic time, deposit names, genesis types, and industrial types.

Main attributes of a predicted target area (Table 7) include the perimeter, area, name, no., geographical location, type, and level of the predicted target area; map-sheet no.; code and type of predicted target area feature; color code; major mineral type; typical deposits; known deposits; predicted resources; metallogenic time; ore-hosting strata; geotectonic location; magma type; geochemical characteristics, and alteration characteristics.

4 Data Quality Control and Assessment

In this study, primary data were mainly acquired by field surveys and collection of previous data strictly according to working methods and technical requirements in the

Table 5 Attributes of geological boundaries in the mineral geological map of Shixia Map-sheet

No.	Data item	Standard code	Data type	Example
1	ID of geological boundary feature	Feature_Id	string	AI48E014014000001742
2	Type of geological boundary feature	Feature_Type	string	04
3	Type of geological boundary	Boundary_Name	string	Angular unconformity
4	Code of geologic block on the left side of geological boundary	Left_Boundary_Code	string	N_1G^2
5	Code of geologic block on the right side of geological boundary	Right_Boundary_Code	string	K_1j^2

Table 6 Attributes of mineral deposit types in the mineral geological map of Shixia Map-sheet

S. No.	Data item	Standard code	Data type	Example
1	Code of mineral site feature	Feature_Id	string	AI48E014014000000003
2	Type of mineral site feature	Feature_Type	string	05
3	Name of mineral deposit type	Commodities_Name	string	Lead–zinc deposit
4	Paragenic minerals	Paragenic_Ore	string	/
5	Associated minerals	Associated_Ore	string	silver
6	Number of mineral deposits	Ore_Sums	int	/
7	Ore grades	Ore_Grade	string	Pb 0.5%, Zn 3.44%
8	Scale	Deposite_Size	string	Medium-sized
9	Metallogenic time	Metallogenetic_Epoch	string	Indosinian
10	Mineral deposit name	Placename	string	Rentoushan lead–zinc deposit in Xihe County, Gansu Province
11	Genesis types	Genesis_Types	string	Meso-epithermal lead–zinc deposit
12	Industrial type	Industrial_Types	string	Non-ferrous lead–zinc deposit

Table 7　Attributes of predicted target areas in the mineral prediction map of Shixia Map-sheet

S. No.	Data item	Standard code	Data type	Example
1	Perimeter of target area	Perimeter	double	537.6
2	Area of target area	Area	double	6 293.48
3	Map-sheet no.	MAPCODE	string	I48E014014
4	Code of target area feature	FEATURE_ID	string	A0000000000000000008
5	Type of target area feature	FEATURE_Type	string	06
6	Color code	COLOUR	string	283
7	Name of target area	TARGET_NAME	int	Predicted target area of Daqiao gold deposit
8	No. of target area	TARGET_CODE	string	AuA001
9	Area of target area	QDTCBA	float	21.14
10	Geographical location	DLWZ	string	Daqiao Town, Xihe County, Gansu Province
11	Major mineral type	KCCA	string	Au
12	Typical deposits	DXKC	string	Daqiao gold deposit
13	Known deposits	DXKE	string	Daqiao gold deposit and Yinmahe gold deposit
14	Type of target area	QDTCBF	string	Ⅰ
15	Level of target area	QDTCBT	string	A
16	Predicted resource	PKCAAG	int	160 585
17	Metallogenic time	KCDS	string	Indosinian
18	Ore-bearing strata	DDDA	string	The first member of Triassic Huashiguan Formation
19	Geotectonic location	GZAN	string	Lintan–Liangdang deep and large fault and Yaoshang–Shixia fault
20	Magma type	YSEA	string	Meso-epithermal hydrothermal type
21	Geochemical characteristics	QDHX	string	Anomalies of Ag, Au, Hg, Sb, and Sn well overlap
22	Alteration characteristics	KCAGA	string	Silicification, pyritization, carbonatization, fluoritization

Technical Requirements of Solid Mineral Geological Survey (1：50 000) (DD2019-02), the *Specification for Exploration of Solid Mineral Resources* (GB/T 33 444–2016), and applicable standards or specifications of mineral surveys. Among them, the field surveys mainly involve 1：50 000 mineral geology-specific mapping and comprehensive mineral inspection in major survey areas. Meanwhile, geophysical exploration and geochemical exploration were also conducted in strict accordance with applicable standards and specifications to ensure that the data are precise and credible.

The 1：50 000 mineral geology-specific mapping of Shixia Map-sheet in this study was carried out surrounding sedimentary suites and structures according to the actual geological conditions in the map-sheet area. As a result, sedimentary suites, special lithologic strata, structures, and mineralized alteration related to metallogenesis as well as important geological boundaries were delineated. The survey precision of field routes is as follows. One geological point or one boundary between geological points was surveyed every 108 m of geological routes on average. In detail, the intervals between two mapping routes and between two geological points are 80−150 m and 80−100 m, respectively in general in major survey areas, thus reaching the precision of 1:10 000; while they are 500 m and 250 m, respectively in minor survey areas and the areas in the map-sheet covered by Cretaceous and Neogene sandy conglomerate. In this way, the mapping precision meets the requirements of applicable specifications.

Result maps were compiled and data attribute databases were built in accordance with the *Requirements for Compilation of Resulted Maps of Mineral Geological Surveys* (1：50 000) (Draft for comments), the *Standard on Spatial Databases for Digital Geological Maps* (DD 2006-06), and the *Technical Requirements of Integrated Compilation and Study on Geological Data about Solid Mineral Exploration* (DZ/T 0079–015). The formats, legends, and symbols in result maps (i.e., mineral geological maps, metallogenic regularity maps, and mineral prediction maps) are represented in accordance with the *Geological Symbols Used for Regional Geological Maps* (GB 958-2015) and the *Standards and Principles of Colors Used for Geological Maps* (DZ/T 0179-1997).

The field data acquisition and database (dataset) building were subject to three-level quality inspection system consisting of self-check, mutual check, and inspection conducted by the project team. Meanwhile, all checks and modification were recorded in the quality inspection record cards to form paper files or to be input into databases. All these meet the requirements for quality management of geological surveys.

5 Data Value

(1) During the 1：50 000 mineral geological survey of Shixia Map-sheet in this study, result maps were prepared and databases were built according to the *Technical Requirements of Solid Mineral Geological Survey* (1：50 000) (DD 2019-02). Meanwhile, the contents and layout of the result maps were arranged in accordance with the mapping requirements for the new round of mineral geological surveys. The strata in the map-sheet were divided into suites. The metallogenic suites and structures were highlighted and important mineralized alteration information was added in the result maps. Moreover, the suites re-determined were added into the attribute databases of the mineral geological maps (He GW et al., 2019; Liu CH et al., 2019).

On the 1：50 000 mineral geological map, the sedimentary-rock strata in the Shixia Map-sheet are divided into 19 types of informal sedimentary suites and one type of intrusive rock suites based on the data collected and measured. Among them, an ore-hosting, silicified breccia suite is identified in Middle Triassic Huashiguan Formation. Meanwhile, the former sandy conglomerate suite in the first member of Neogene Gansu Group (N_1G^1) is classified as the sandy conglomerate suite in the second member of Lower Cretaceous Jishan Formation (K_1j^2) according to angular unconformity and lithological association comparison between the suite and its underlying strata (Table 8).

Table 8 List of sedimentary rock suites

Chronostratigraphic unit		Lithostratigraphic unit			Characteristics of suite units	
System	Series	Formation	Code	Suite type	Thickness/ m	Lithology
Quaternary	Holocene		Qh^{pal}		15	Alluvial-diluvial sand, sand gravel, and sandy loam
	Pleistocene		Qp^{eol}		5−10	Loess-like silty clay, silty soil, and pebbly sandy soil
Neogene			N_1G^{a}	Sandy conglomerate suite	1 179	Brick-red sandy conglomerate interbedded with muddy siltstone and silty mudstone
Cretaceous		Jishan Formation	K_1j^{2a}	Sandy conglomerate suite	282	Purplish-red sandy conglomerate
Triassic	Middle Triassic	Daheba Formation	T_2d^{1c}	Suite consisting of alternating layers of silty slate and sandstone	923	Grayish-brown silty slate and grayish-green sandstone
			T_2d^{1b}	Suite consisting of calcareous slate interbedded with thin laminated limestone	500	Grayish-yellow calcareous slate interbedded with thin laminated limestone and a small amount of sandstone
			T_2d^{1a}	Suite consisting of silty slate interbedded with sandstone	437	Gray silty slate interbedded with sandstone
		Huashiguan Formation	T_2h^{2a}	Suite consisting of calcareous slate interbedded with thin laminated limestone and sandstone	679	Gray calcareous slate interbedded with caesious thin laminated limestone, a small amount of brecciaous limestone and thin laminated sandstone
			T_2h^{1d}	Suite consisting of calcareous slate interbedded with thin laminated limestone	500	Gray calcareous slate interbedded with caesious thin laminated limestone and a small amount of brecciaous limestone
			T^2h^{1c}	Suite of silty slate interbedded with thin laminated limestone	400	Gray and caesious silty slate interbedded with thin laminated limestone and brecciaous limestone
			T_2h^{1b}	Silicified sandy conglomerate suite	5−216	Polymictic breccia composed of silicified sandy conglomerate and lamellar siliceous rock
			T_2h^{1a}	Thin laminated limestone suite	30	Caesious thin laminated limestone

Continued table 8

Chronostratigraphic unit		Lithostratigraphic unit			Characteristics of suite units	
System	Series	Formation	Code	Suite type	Thickness/ m	Lithology
Carboniferous	Upper Carboniferous	Minhe Formation	C_2m^a	Thick laminated limestone suite	301	Hoary thick laminated limestone and marblized limestone
Devonian	Upper Devonian	Honglingshan Formation	D_3hl^a	Suite consisting of alternating layers of thick laminated limestone and phyllitic slate	1 472	Alternating layers of dark-gray thick laminated limestone and light grayish-green phyllitic slate
	Middle Devonian	Huangjiagou Formation	D_2h^{3a}	Suite consisting of phyllite interbedded with medium-thick laminated limestone	260.30	Light grayish-green phyllite interbedded with medium-thick laminated limestone
			D_2h^{2b}	Suite consisting of thin-medium laminated limestone interbedded with silty slate	400	Gray thin-mid laminated limestone interbedded with silty slate, siliceous rock, and a small amount of sandstone
			D_2h^{2a}	Suite consisting of slate interbedded with limestone and sandstone	589	Gray calcareous slate, silty slate, and grayish phyllitic slate interbedded with thin-medium laminated limestone, calcareous feldspar quartz sandstone, a small amount of thick laminated limestone, and bioclastic limestone
			D_2h^{1a}	Suite consisting of silty slate interbedded with sandstone	968	Alternating layers consisting of grayish silty slate and a small amount of calcareous slate and grayish-brown calcareous lithic quartz sandstone and calcareous feldspar quartz sandstone
	Lower Devonian	Anjiacha Formation	D_1h^{2a}	Suite consisting of alternating layers of silty slate and sandstone	1 040	Gray silty slate interbedded with medium-thin laminated sandstone
Silurian	Upper Silurian	Zhuowukuo Formation	$S_{3\text{-}4}zw^{3a}$	Suite consisting of silty slate interbedded with thick laminated limestone and siliceous rocks	1 308	Grayish-brown silty slate interbedded with gray thin laminated limestone and grayish-black siliceous rock
			$S_{3\text{-}4}zw^{2a}$	Suite of medium-thick laminated limestone interbedded with clastic rock	973	Dark-gray medium-thick laminated limestone and calcarenite interbedded with gray siltstone, grayish-brown silty slate, and dark-gray siliceous rock

(2) The regional metallogenic regularity map mainly reflects sedimentary suites related to metallogenesis as well as regional structures and metallogenic structures. Meanwhile, the contents inferred and interpreted from geophysical exploration, geochemical exploration, and remote-sensing survey are superimposed on these maps, including concealed rock masses and regional structures related to metallogenesis and areas where geophysical and geochemical anomalies are distributed.

Under the guidance of prospecting theory for exploration areas and based on the research on typical deposits, the metallogenic models of typical deposits such as Daqiao gold deposit and Yawan antimony deposit were built. Accordingly, corner maps of the metallogenic models were prepared, which exhibit the regional distribution characteristics of the metallogenic geologic blocks, metallogenic structures, and metallogenic characteristic indicators of the gold-antimony deposits predicted.

(3) Seven prospecting target areas were delineated using the software *mras* by combining the data on regional geology, geophysical exploration, geochemical exploration, remote sensing, and minerals. They consist of two Class A, three Class B, and two Class C target areas (Table 9; Fig. 4). Meanwhile, their information is represented in the mineral prediction map and the Database.

6 Conclusions

(1) Through geology-specific mapping, the sedimentary strata of the Shixia Map-sheet area in Yawan–Daqiao area, Gansu Province, are divided into 19 types of informal sedimentary suites and one type of intrusive rock suites. Among them, an ore-hosting, silicified breccia suite is identified in Middle Triassic Huashiguan Formation. Meanwhile, the former sandy conglomerate suite in the first member of Neogene Gansu Group (N_1G^1) is classified as the sandy conglomerate suite in the second member of Lower Cretaceous Jishan Formation (K_1j^2) according to angular unconformity and lithological association comparison between the suite

Table 9 List of prospecting target areas

No.	Code of prospecting target areas	Name of prospecting target areas	Location of prospecting target areas	Level of prospecting target areas
1	AuA001	Daqiao gold prospecting target areas	Daqiao Town	A
2	AuA002	Anfangba gold prospecting target areas	Anfangba	A
3	AuB001	Yawan gold prospecting target areas	Yawan	B
4	AuB002	Zhujiahe gold prospecting target areas	Zhujiahe	B
5	AuB003	Anzishan gold prospecting target areas	Anzishan	B
6	AuC001	Liuxiang gold prospecting target areas	Liuxiang Town	C
7	AuC002	Yueliupo gold prospecting target areas	Tanshi Mountain	C

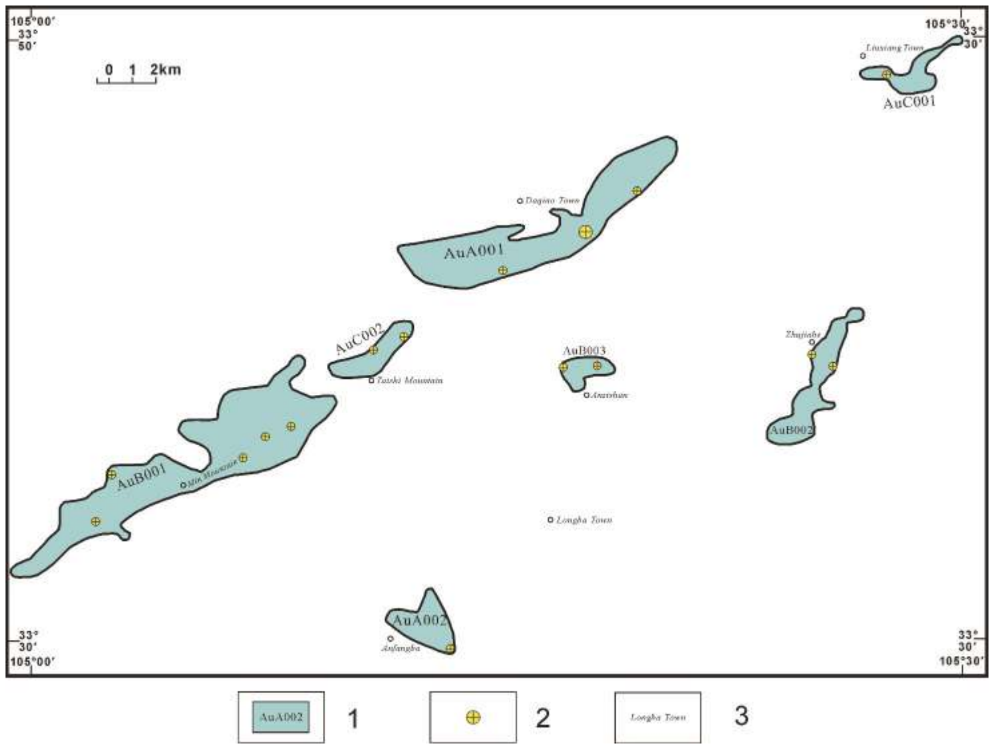

Fig. 4 Schematic map of the prospecting target areas of Yawan–Daqiao region

1—prospecting area and its code; 2—gold deposit or ore occurrence; 3—geographical location and name of town

and its underlying strata.

(2) The database of 1∶50 000 mineral geological survey results of Shixia Map-sheet in this study includes the result maps such as mineral geological map, metallogenic regularity map, and mineral prediction map and their attribute databases. It highlights the information of metallogenic suites, regional structures, and mineralized alteration. Moreover, it includes the metallogenic factors in Shixia Map-sheet area that were systemically summarized based on comprehensive data analysis, the established metallogenic models of typical deposits such as the Daqiao gold deposit and Yawan antimony deposit, and seven prospecting target areas that were delineated. Therefore, it systematically reflects the latest achievements of the new round of mineral surveys.

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