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甘肃西成铅锌矿田黄渚关幅 1∶50 000 矿产地质图数据库

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摘要：甘肃省黄渚关幅 (I47E013015)1∶50 000 矿产地质图根据《矿产地质调查技术要求 (1∶50 000)》(DD 2019—02) 和行业的统一标准及要求，充分利用 1∶50 000、1∶250 000 等区域地质调查工作成果资料，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编制完成。本图幅矿产地质图重点对泥盆系西汉水群的建造类型进行了重新划分，建立了泥盆纪成铅锌期 3 个建造单元，即含铅锌碳酸盐岩建造 (D_1a^{1a})、富铅锌碳酸盐岩建造 (D_1a^{1c})、贫铅锌千枚岩夹灰岩建造 (D_1a^2)；建立了图幅内 EW 向褶皱–断裂构造系统；突出表达铅锌矿含矿建造及与铅锌矿成矿密切相关的特殊岩性层，辅以岩相古地理略图和构造纲要图，创新表达了喷流沉积阶段及热液改造阶段与铅锌矿成矿有关的地质要素。本数据库包含 16 个地层单位、5 期侵入岩、3 期构造相关数据、4 个同位素年龄数据、12 个岩石全分析数据、30 个矿点数据，数据容量约为 30.6 MB。这些数据充分反映了 1∶50 000 矿产地质调查示范性成果，可对其他类似区域提供借鉴作用。

关键词：西成矿田；厂坝；黄渚关幅；1∶50 000；喷流沉积；数据库；地质调查工程；甘肃

数据服务系统网址：http://dcc.cgs.gov.cn

1　引言

西成矿田作为西秦岭地区主含矿单元之一，构造位置处于秦祁昆造山系秦岭弧盆系中秦岭陆缘盆地。西秦岭造山带北以新阳—元龙大型韧性走滑剪切构造带 (区域上为天水—宝鸡走滑剪切带) 为界与祁连造山带相接，南以略阳蛇绿混杂岩带为界 (图 1a)。造山带内部以李子园—关子镇俯冲—碰撞杂岩构造带为界分为北秦岭与中南秦岭。中秦岭

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陆缘盆地北接北秦岭加里东褶皱带，南邻松播甘孜印支褶皱带，整体构造线呈东西向，东部紧缩向西延伸散开，形成多个弧形构造（霍福臣，1995；潘桂棠，2009）。

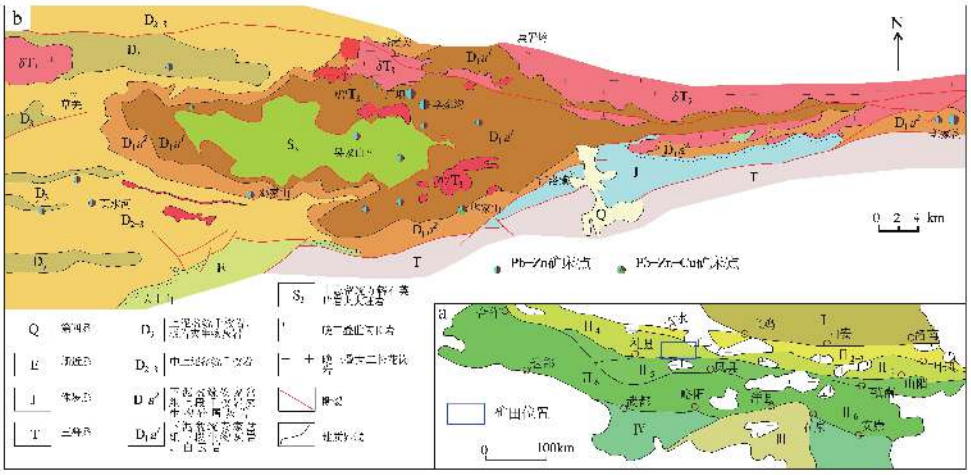

图 1　甘肃西成铅锌矿田大地构造位置

a—西秦岭构造简图；b—西成铅锌矿田地质图 Ⅰ—华北板块；Ⅱ$_{2-3}$—北秦岭岩浆弧；Ⅱ$_4$—中秦岭陆缘盆地；Ⅱ$_5$—泽库前陆盆地；Ⅱ$_6$—西倾山—南秦岭陆缘裂谷带；Ⅲ—扬子板块；Ⅳ—巴颜喀拉褶皱系

西成矿田系统的区域地质调查始于 20 世纪 50 年代末至 70 年代，于 80 年代完成了 1∶25 000 水系沉积物测量、1∶100 000 航磁测量、1∶200 000 重砂测量，黄渚关幅已在 20 世纪 90 年代完成 1∶50 000 区域地质调查。前人对该地区的构造环境、成矿地质背景、含矿建造、岩矿石特征、典型矿床等方面也进行了大量研究 (王集磊，1996；叶会寿和王义天等，2016；祝新友，2005；俞中辉，2008；国阿千等，2011；张长青等，2013)，基本查明了西成矿田建造构造特征及铅锌成矿规律，总结了找矿标志，形成了大量原始数据。这些前期工作为黄渚关幅矿产地质图的编制奠定了基础。

西成矿田位于西秦岭 Pb–Zn–Cu(Fe)–Au–Hg–Sb 成矿带 (III–28) 厂坝–页水河华力西、印支期铅锌金银成矿亚带 (Ⅳ–28⑤)（孙矿生，2004；张新虎，2013）。铅锌矿产地均产于由南侧人土山—江洛弧形深大断裂和北侧黄渚关活动断裂控制的二级沉积盆地内，典型的喷流沉积型铅锌矿床局限存在于三级断陷盆地内，经沉积改造的铅锌矿床均赋存于Ⅲ级倒转紧闭背斜核部（程小久，1995；李益桂，1988；张复新，1991；祝新友，2006），并且严格受安家岔组顶部碳酸盐岩和黄家沟组底部千枚岩建造的控制（马国良，1996；宋春晖，1992）。

黄渚关幅 1∶50 000 矿产地质图作为中国地质调查局矿产地质调查的示范图件（王春女，2019），力争反映新一轮矿产调查工作中取得的地质调查、矿产勘查以及科研新成果，为该地区的矿产资源研究、能源勘探等提供基础地质图件，为科研和野外地质调查提供有益的参考资料。甘肃省黄渚关幅 1∶50 000 矿产地质图数据库（贾祥祥等，2020）的元数据简表如表 1 所示。

2　数据采集和处理方法

2.1　数据基础

甘肃省黄渚关幅 1∶50 000 矿产地质图以《矿产地质调查技术要求 (1∶50 000)》

表 1 数据库 (集) 元数据简表

条目	描述
数据集(库)名称	甘肃省黄渚关幅1∶50 000矿产地质图数据库
数据集(库)作者	沉积岩类：贾祥祥，甘肃省地质矿产勘查开发局第一地质矿产勘查院 岩浆岩类：王树明，甘肃省地质矿产勘查开发局第一地质矿产勘查院 变质岩类：贾祥祥，甘肃省地质矿产勘查开发局第一地质矿产勘查院 地质构造类：贾儒雅，中国地质调查局发展研究中心，自然资源部矿产勘查技术指导中心
数据时间范围	2016—2018年
地理区域	东经105°30′00″~105°45′00″，北纬33°50′00″~34°00′00″
数据格式	*.wl，*.wt，*.wp
数据量	30.6 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”(编号：121201004000172201)
语种	中文
数据集(库)组成	数据库包括：1∶50 000地质图库、角图和整饰。地质图库包括沉积岩、岩浆岩、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。角图包括沉积岩建造、侵入岩建造、脉岩、构造，典型矿床(区)平面图、重要勘探线剖面图、地质剖面图及构造纲要图、岩相古地理图等，以及矿产图例、矿产地名录、矿化蚀变图例、成矿区(带)位置图；整饰部分包括接图表、中国地质调查局局徽、图名、比例尺、坐标参数、责任表等

(DD 2019–02) 为基本要求，以勘查区找矿预测理论（叶天竺，2014， 2017）为指导，以甘肃省黄渚关幅 1∶50 000区域地质调查和西成矿田矿区大比例尺原始资料 (包括实际材料图、剖面图、记录本) 为基础，并充分结合了本次黄渚关幅 1∶50 000 岩性构造专项填图、厂坝—毕家山典型矿床调查研究、构造地球化学测量新成果。地理底图采用国家测绘地理信息局 2016 年地理数据。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。

2.2 数据处理过程

2.2.1 数据准备

将收集到的区域地质调查成果和实际材料图进行数字化处理，形成 MapGIS 点、线、面文件。根据黄渚关幅范围生成 1∶50 000 标准图框，投影系统为高斯-克吕格投影参数，坐标系统为国家 2000 大地坐标系。

2.2.2 编制建造-构造草图

通过查阅和分析黄渚关幅 1∶50 000 区域地质调查报告中涉及的实测剖面、野外路线记录等实际材料，分解组一级编图单元，补充岩性 (组合) 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。

(1) 建造

按照统一的用色标准，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“岩性+时代”表达。其中，泥盆系西汉水群沉积岩建造中的碳酸盐岩、海相火山岩夹层使用岩性岩相界线作为界线，并按照相应的花纹表达建造。

(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，如花岗岩脉用1238号字图表示并以代号γ标识岩性。

(3) 构造

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性质，以线段粗细表达断裂级别。

(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) 化石采样点

按照统一的用色标准+子图样式表达位置及化石类型，建立相应数据表，填写相关属性数据。

(6) 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，建立相应数据表，填写相关属性数据。

(7) 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，建立相应数据表，填写相关属性数据。

(8) 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，建立相应数据表，填写相关属性数据。

2.2.3 野外专项地质填图

在已有资料的综合分析整理和建造−构造草图的编制基础上，划分重点工作区和一般工作区，确定了专项地质重点填图内容为泥盆系西汉水群、矿化蚀变、构造、脉岩等。以数字填图掌上电脑中1：250 000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、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。

地质点 (P)：分为界线点和控制点。野外调查时在系统中填写简单的属性，包括点号、点性、微地貌、露头情况、风化程度、位置说明、填图单元和接触关系，坐标信息由系统自动读取。

地质路线 (R)：野外需要在系统中填写的属性包括路线号、地质点号、路线编号、方向角、本站距离、累计距离、填图单元和岩石名称。其中，方向角、本站距离、累计距离为系统自动计算。

地质界线 (B)：野外需要在系统中填写的属性包括路线号、地质点号、B编号、R编号、界线类型、左侧填图单位、右侧填图单位、接触关系、走向、倾向以及倾角。对沿途所见的地质产状和采集的标本信息，可随时在系统中定位录入相关信息，填写属性数据。

2.2.4 室内数据整理

(1) 将野外采集的地质点 (P)、地质路线 (R)、地质界线 (B) 数据资料导入电脑中，并根据相应规范进行数据整理。

① 地质点 (P) 数据整理基本要求：路线号、风化程度、接触关系等信息按照实际情况填写完整，填图单位填写相应代号，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) 数据整理基本要求：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) 数据整理基本要求：在室内计算机上用剪断线、延长线或者重新画线的方法按照接触情况对地质界线进行美化。统一颜色、线型及线宽等参数。补充地质界线描述信息，用“左侧为 xxx，右侧为 xxx”来说明界线两侧岩性，默认左侧为先观察的岩性，右侧为后观察到的岩性，并对 2 种岩性的接触关系及其证据加以表述。

④ 路线中的地质体产状、采样、照片资料整理要求：补充产状、采样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。

(2) 将以野外实际采集的 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，对新发现的地质单元之间的界线进行勾连。

2.2.5　编制各类角图

(1) 建造柱状图

对主图中岩石地层单元的建造特征进行详细表达。通过对图幅内各类建造与构造及其与矿化的关系进行综合分析研究，编制沉积岩建造柱状图、侵入岩建造柱状图。

(2) 厂坝铅锌矿床相关图件

包括典型矿床厂坝喷流沉积型铅锌矿床成矿要素平面图 (图 2) 及 77 线地质剖面图，为本区的找矿预测工作提供参考。在收集以往资料成果的基础上，充分借鉴本次典型矿床野外实地调查与综合研究的成果，编制了典型矿床平面图。

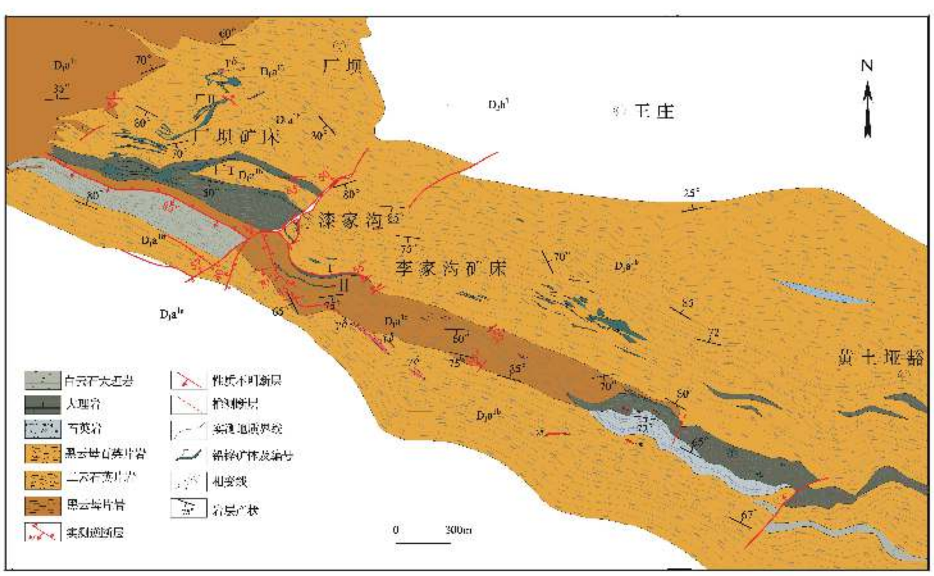

图 2　厂坝铅锌矿床成矿要素平面图

(3) 图切剖面

图幅内建造和构造的总体走向为东西向，为了能有效反映图幅内总体建造和构造特征及其与铅锌、金矿化的关系，布置了 2 条近南北向的图切剖面，AB 图切剖面贯穿全区，分别反映志留系、泥盆系、晚三叠纪花岗岩，CD 线图切剖面为了突出有关金矿的成矿信息只选取了下半幅，反映严家河闪长岩体及两侧泥盆系。表达方式主要使用了“标准剖面线型+标准代号”表达位置，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。

(4) 矿产地名录

对本区的矿产地按照矿产地名称、规模、类型、主要含矿建造等方面进行了分析，编制矿产地名录（表 2），有利于对整个黄渚关幅区域矿产情况的了解。

(5) 图幅岩相古地理略图

喷流沉积型铅锌矿的成矿均局限于由同生断裂控制的断陷滞留盆地（武安斌，1992；李建中，1993；方维萱，2001），因此对泥盆纪沉积相及微相的研究更能清晰地反映铅锌矿的成矿空间 (图 3)。

(6) 图幅构造纲要图

研究岩相古地理是为了查明成矿原始空间位置，研究成矿后构造是为了更好地说明矿床的赋矿位置。工作区喷流沉积型铅锌矿，尤其是南带毕家山—邓家山一带铅锌矿床均受到了岩浆期后热液的改造，原始热水沉积的矿体在改造过程中运移，赋存于褶皱–断裂构造系统的虚脱空间，因此成矿后构造对铅锌矿床的最终定位具有明显的控制作用。

(7) 其他

对脉岩、构造、矿化蚀变图例进行梳理，编制各种图例。

3 数据样本描述

3.1 数据的命名方式

地质面.wp，地质线.wl，地质点.wt。

3.2 图层内容

主图内容包括沉积岩建造、侵入岩建造、特殊岩性层、各类脉岩、第四系、断裂构造、褶皱轴迹、地质界线、产状、矿产地、矿化蚀变、各类代号等。

角图内容包括接图表、柱状图、图例、图切剖面、厂坝铅锌矿床成矿要素平面图、厂坝铅锌矿床主矿体勘探线剖面图、图幅构造格架图、岩相古地理略图、矿产地名录、所属成矿区带位置图、责任表等。

3.3 数据类型

实体类型名称：点、线、面。

点实体：各类地质体符号及标记、地质花纹、矿产地、矿化蚀变、产状。

线实体：断裂构造、地质界线、岩相界线、建造花纹等。

面实体：沉积岩、变质岩、侵入岩、第四系等。

3.4 数据属性

黄渚关幅 (I47E013015)1∶50 000 矿产地质图数据库包含地质实体要素信息、地理

表 2　甘肃西成铅锌矿田黄渚关幅矿产地信息简表

序号	矿产地名称	规模	成因类型	主要含矿建造构造	估算资源量
1	甘肃省成县爷殿山铁矿	矿化点	热液型	砂岩建造	
2	甘肃省成县庙沟铅锌矿	矿化点	喷流沉积型	大理岩建造	
3	甘肃省西和县漩潭沟铅锌矿	矿点	喷流沉积型	千枚岩建造	
4	甘肃省成县厂坝北铅锌（铜）矿	矿化点	热液型	大理岩建造	Cu 244 kg
5	甘肃省成县清水沟外围铅锌矿	矿点	喷流沉积型	片岩建造	Pb+Zn 165 913 t
6	甘肃省成县挖泉山大理岩矿	大型	区域变质	大理岩建造	
7	甘肃省成县厂坝铅锌矿	特大型	喷流沉积型	硅钙面	Pb 586 910 t; Zn 2 807 870 t
8	甘肃省成县厂坝白云岩矿	大型	区域变质	白云岩建造	
9	甘肃省成县清水沟钨矿	矿化点	热液型	砂岩建造	
10	甘肃省成县二郎对长沟金矿	矿点	蚀变岩型	砂岩建造	
11	甘肃省成县二郎对长沟铅锌矿	矿点	喷流沉积型	碳酸盐岩建造	
12	甘肃省成县李家沟铅锌矿	特大型	喷流沉积型	片岩建造	
13	甘肃省成县向阳山西铅锌矿	中型	喷流沉积型	片岩建造	Pb+Zn 2 414.9 t
14	甘肃省成县徐明山铅锌矿	矿化点	喷流沉积型	大理岩建造	Pb 4 789 t; Zn 42 852 t
15	甘肃省成县二郎对长沟铁矿	矿化点	热液型	硅钙面	
16	甘肃省成县老硐上铅锌矿	矿点	喷流沉积型	白云岩建造	Pb+Zn 105 304.9 t
17	甘肃省成县向阳山铅锌矿	中型	喷流沉积型	硅钙面	Pb+Zn 208 809 t
18	甘肃省成县大沙湾铜矿	矿化点	热液型	片岩建造	
19	甘肃省成县官子沟铅锌矿	矿点	喷流沉积型	大理岩建造	Pb 106.7 t; Zn 719.2 t
20	甘肃省成县小沟里金矿	中型	热液型	千枚岩建造	Au 7 696.72 kg
21	甘肃省成县空子沟铅锌矿	矿化点	喷流沉积型	千枚岩建造	Pb+Zn 2 778.34 t
22	甘肃省成县冉家河铅锌矿	矿化点	喷流沉积型	千枚岩建造	
23	甘肃省成县甘沟铅锌多金属矿	中型	喷流沉积型	碳酸盐岩建造	Pb 6 518.6 t; Zn 54 958.4 t
24	甘肃省成县小沟里铅锌矿	矿化点	喷流沉积型	千枚岩建造	
25	甘肃省成县马门下大理岩矿	大型	区域变质	大理岩建造	
26	甘肃省成县熊家河铅锌矿	矿点	喷流沉积型	碳酸盐岩建造	Pb 1 763 t; Zn 8 818 t
27	甘肃省成县毕家山铅锌（铜）矿	大型	喷流沉积型	硅钙面	Pb 9 322.89 t; Zn 39 748.87 t
28	甘肃省成县甘蔗沟铅锌多金属矿	矿点	喷流沉积型	碳酸盐岩建造	Pb+Zn 25 160.06 t; Ag 7 085.73 t
29	甘肃省成县三架山铅锌矿	矿点	喷流沉积型	碳酸盐岩建造	
30	甘肃省成县陈家庄铅锌矿	矿点	喷流沉积型	碳酸盐岩建造	

要素信息和地质图整饰要素信息。地理要素信息属性沿用国家测绘地理信息局收集数据的属性结构。地质实体要素信息属性按照 1：50 000 矿产地质调查专项地质填图数据库建库要求分 3 大岩类 (沉积岩、侵入岩、变质岩)、断裂构造、产状要素、矿产地等分别建立数据库属性。

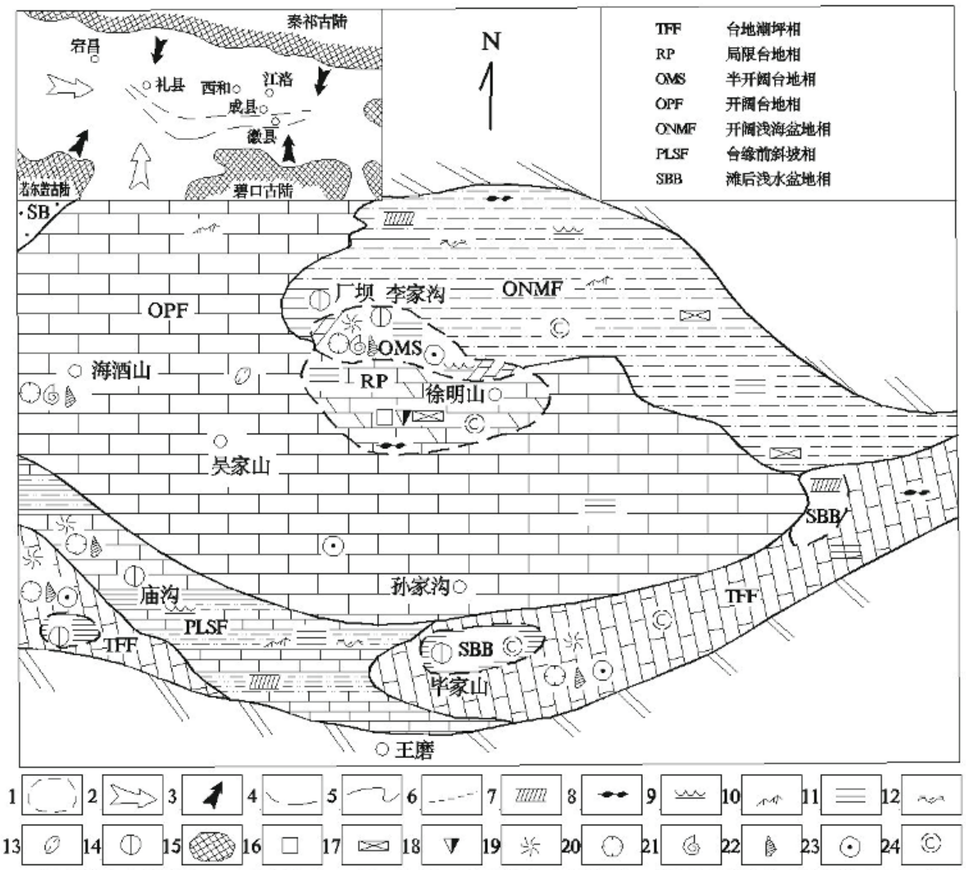

图 3　图幅早泥盆世古地理略图

1—西成矿田位置；2—海侵方向；3—物源方向；4—水下隆起；5—相带界线；6—相界线；7—斜层理；8—脉状、透镜状层理；9—变形层理；10—微细交错层理；11—水平层理、纹理；12—冲刷构造；13—藻屑；14—矿床、矿点；15—古陆；16—黄铁矿；17—重晶石或天青石；18—脉状闪锌矿；19—层孔虫；20—珊瑚；21—腕足类；22—腹足类；23—海百合茎；24—炭质、炭屑

沉积岩建造数据属性主要有：年代地层单位、岩石地层单位、建造名称、建造代码、岩性组合、地层时代、建造厚度、建造含矿性、岩石结构、沉积构造、岩石颜色、沉积作用类型、沉积相类型、同沉积构造。

侵入岩建造数据属性主要有：建造名称、建造代码、岩性组合、建造含矿性、岩石结构、岩石构造、侵入期次、岩体产状、平面形态、剖面形态、岩体侵位构造特征、接触带特征、成因类型、同位素年龄。

断裂构造数据属性主要有：断裂名称、断裂类型、断裂延长、断裂延深、断裂宽度、断裂走向、断裂面倾向、断裂面倾角、断距、断裂面形态、构造岩特征、运动方式、活动期次、力学性质。

产状数据属性有：产状类型、倾向、倾角。

矿产地数据属性主要有：矿产地编号、矿产地名称、矿产地类别、交通位置、地理经度、地理纬度、矿种、矿床成因类型、规模、共 (伴生) 矿产、查明资源量。

4　数据质量控制和评估

填图精度按照《固体矿产地质调查技术要求 (1∶50 000)》(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《黄渚关幅 I–48–80–甲 1∶50 000区域地质调查报告》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。为编制黄渚关幅 1∶50 000 矿产地质图，使用资料涉及总路线长度 540 km，其中，收集前人路线资料 240 km；矿点踏勘检查路线 30 km，实测路线 300 km (45 条)，地质点数 1 000 个，地质界线数 616 个，基本分析样品 127 个，光薄片鉴定样品 141 个，岩石全分析样品 12 个，闪锌矿 Rb–Sr 年龄样品 3 件，照片 1 200 张，素描 13 张。填 (编) 图总体精度达到 1∶50 000 矿产地质专项填图的具体要求。

数据库建设过程中严格执行质量检查制度，落实原始资料的自检互检、项目组检查和单位检查三级检查制度。日常性质量检查由组长安排进行，对原始记录、实际材料图、收录资料的属性录入进行 100% 自检和互检。项目组检查由项目负责人主持，在野外自检互检的基础上，进行室内检查，抽检率为 60%。单位质量检查，由甘肃省地矿局第一地质矿产勘查院安排，项目组积极协助进行，抽检率 32%。各级检查及作者修改情况均填写质量检查记录卡片，单位对各类综合性图件进行 100% 审核，对存在的问题责成责任人予以解决。

2019 年 3 月 18—22 日中国地质调查局发展研究中心组织检查验收专家在北京对甘肃省矿产勘查开发局第一地质矿产勘查院承担的“甘肃省厂坝矿集区找矿预测”子项目形成的黄渚关幅数据库进行了检查验收 (包含图件编图部分、空间数据、属性数据、元数据等方面)，并将其评为优秀级。

5　数据价值

甘肃省黄渚关幅 (I47E013015)1∶50 000 矿产地质图是中国地质调查局开展新一轮矿产地质调查的示范图幅，是项目组积极探索创新使用矿产地质专项填图成果表达方式编制完成的；以建造单元为划分原则，将泥盆系西汉水群的建造类型进行了重新划分，建立了泥盆纪铅锌成矿期 3 个建造单元，即含铅锌碳酸盐岩建造 (D_1a^{1a})、富铅锌碳酸盐岩建造 (D_1a^{1c})、贫铅锌千枚岩夹灰岩建造 (D_1a^2)(表 3)；建立了成矿期后与铅锌矿改造作用相关的 5 种侵入岩建造类型 (表 4)。确定了铅锌矿成矿地质体为“含矿建造+同生断裂”组合，成矿构造为 NE 向同生断裂，主成矿结构面为绢云千枚岩与生物灰岩的岩性界面，次成矿结构面为近 EW 向的层间断裂，重新建立了成矿断裂—褶皱构造系统。

6　结论

(1) 全面系统编制了 1∶50 000 黄渚关幅 (I47E013015) 矿产地质图并建立了数据库，突出了矿产地、矿产与成矿信息的表达，如特殊岩性层、褶皱构造、同生断裂构造、成矿结构面等，汇集了重要建造–构造、断裂、地质界线、岩浆岩、矿产地的属性数据，并建立了相互之间的时空关系。

(2) 黄渚关幅矿产地质图数据库的建立为今后该区的矿产勘查、资源开发利用、基础矿产地质科学研究提供了系统的数据支撑，发挥了科技创新引领作用，提升了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。

表 3　沉积岩建造一览表

岩石地层单位						建造单元特征		
系	统	群	组	段	代号	建造类型	厚度/m	岩石组合
新近系		甘肃群			N_1G	砾岩建造	695	红色块状砾岩、砂砾岩、黏土质粉砂岩、黏土岩
白垩系			鸡山组		K_1js	陆相碎屑岩建造	1 202	杂色泥岩、粉砂岩夹紫红色砂岩、砾岩，炭质泥岩夹劣质煤层
三叠系			光盖山组	上段	T_1gg^2	碳酸盐岩夹砂岩建造	789	灰–深灰色薄层状灰岩夹薄层状钙质细砂岩、钙质粉砂岩、钙质板岩，偶见砾屑灰岩夹层
				下段	T_1gg^1	碎屑岩夹碳酸盐岩建造	124	岩屑(石英)砂岩、钙质砂岩、钙质粉砂岩、钙质板岩夹薄层灰岩、角砾状灰岩、灰质砾岩透镜体
泥盆系	上统	西汉水群	双狼沟组	上段	D_3sl^2	粉砂岩与砂岩互层夹灰岩建造	223.	长石石英细砂岩、粉砂岩、钙质砂岩夹薄层结晶、灰岩、泥灰岩
				下段	D_3sl^1	千枚岩与板岩互层夹灰岩建造	267.9	绢云千枚岩、千枚岩、绢云板岩、板岩、钙质粉砂质板岩
	中统		红岭山组		$D_{2–3}hl$	生物泥晶灰岩夹礁灰岩	476	生屑灰岩、条带状泥晶灰岩、泥质条带灰岩、生屑泥晶灰岩，局部夹礁灰岩碎块、礁灰岩条带
			黄家沟组	上段	D_2h^2	板岩夹千枚岩建造	454.4	下部为绿泥石千枚岩夹薄层微晶灰岩生物灰岩透镜体，上部为千枚状板岩夹千枚岩
				下段	D_2h^1	砂岩建造	350.7	薄层状长石石英砂岩、变长石砂岩
	下统		安家岔组	上段 焦沟层	D_1a^2	贫铅锌千枚岩夹灰岩建造	434.2	下部为中层状细晶灰岩与绢云千枚岩互层，中部为中层状结晶灰岩、条带状细晶灰岩，上部为绢云绿泥千枚岩夹结晶灰岩、薄层状泥晶灰岩、中层条带状结晶灰岩　在厂坝一带受热变质作用相变为石英片岩夹大理岩化灰岩、大理岩透镜体
				下段 厂坝层	D_1a^{1c}	富铅锌碳酸盐岩建造	908.2	薄层状条带状细晶灰岩、薄层条带状灰岩、大理岩化灰岩、中厚层状含炭质灰岩　在厂坝一带受热变质作用相变为，下部二云石英片岩、二云片岩、方解石石英片岩等；上部为石英岩夹大理岩
					D_1a^{1b}	砂岩建造	191.2	中厚层状–块状长石石英砂岩、石英千枚岩　在厂坝一带受热变质作用相变为石英片岩、黑云母石英片岩
					D_1a^{1a}	含铅锌碳酸盐岩建造	360	绢云千枚岩夹礁灰岩、礁灰岩碎块、骨架灰岩

表 4　侵入岩建造一览表

时代			建造单元特征				
代	纪	世	岩体名称	代号	建造类型	岩性特征	年龄/Ma
中生代	三叠纪	晚三叠世	厂坝岩体	$\eta\gamma T$	黑云母二长花岗岩建造	灰白色中–粗粒黑云母二长花岗岩	184~196(K–Ar)
			榆树坝岩体	$\eta o T$	闪长岩建造	细粒石英二长岩、中细粒石英二长闪长岩	217±4(锆石U–Pb)
			黄渚关—沿川子岩体	$\eta\delta o T$	辉长岩建造	紫苏辉长岩	184~222(K–Ar)
			严家河岩体	$\gamma\delta\mu T$	花岗闪长玢岩建造	灰白色花岗闪长玢岩	
			挖泉山岩体	$\psi\delta T$	辉石闪长岩建造	深绿色辉石闪长岩	195.5(K–Ar)
晚古生代	泥盆纪		双碌礴岩体	ΣPz_1	超基性岩建造	暗绿色超基性岩	

致谢：甘肃省黄渚关幅 1：50 000 矿产地质图是一项集体成果，野外一线地质工作人员付出了辛勤的努力。在矿产地质图数据库的建立过程中，得到多位矿产地质调查专家的辛勤指导，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 Mineral Geological Map Database of the Huangzhuguan Map-sheet in the Xicheng Pb-Zn Orefield, Gansu

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Abstract: The 1∶50 000 mineral geological map of the Huangzhuguan Map-sheet, Gansu (I47E013015) is compiled in accordance with the *Technical Requirements* of *Solid Mineral Geological Survey* (DD 2019–02) and unified industrial standards and requirements. On the basis of existing 1∶50 000 and 1∶250 000 regional geological survey results, the work was performed through field geology-specific mapping both outdoors and indoors with the help of digital mapping systems. The Huangzhuguang mineral geological map redivides the formation types of the Devonian Xihanshui Group, and establishes three formation units of the Devonian lead and zinc-forming period, including lead-zinc-bearing carbonate rock formation (D_1a^{1a}), lead-zinc-rich carbonate rock formation (D_1a^{1c}), and lead-zinc-poor phyllite with limestone formation (D_1a^2). The map also establishes the EW fold–fault structure systems within the map-sheet area, highlights the lead-zinc ore-bearing formations and the special lithologic layers closely related to the metallogenesis of lead and zinc, and innovatively presents geological features related to the metallogenesis of lead and zinc in the exhalation sedimentation period and hydrothermal reformation period supplemented by a lithofacies paleogeographic sketch map and a tectonic outline map. The database contains 16 stratigraphic units, five stages of intrusive rocks, three stages of structures, four isotopic ages, 12 pieces of whole-rock analytical data, and 30 pieces of mineral deposit data, with a data volume of 30.6 MB. The database gives a full presentation of the demonstrative results of 1∶50 000 mineral geological survey and can provide reference for other similar areas.

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Key words: Xicheng orefield; Changba; Huangzhuguan Map-sheet; 1∶50 000; exhalative sedimentation; database; geological survey engineering
Data service system URL: http://dcc.cgs.gov.cn

1 Introduction

The Xicheng orefield, as one of the main ore-bearing units in West Qinling, is located in the Central Qinling epicontinental basin in the Qinling arc-basin system of the Qinling–Qilian–Kunlun orogenic system. The West Qinling orogenic belt is connected to the Qilian orogenic belt by the Xinyang–Yuanlong large ductile strike-slip shear zone (belonging to the Tianshui–Baoji strike-slip shear zone regionally) in the north and bounded by the Lueyang ophiolite complex zone in the south (Fig. 1a). The West Qinling orogenic belt is divided into North Qinling and Central-South Qinling by the Liziyuan–Guanzizhen subduction-collision complex structure zone. The Central Qinling epicontinental basin is connected to the North Qinling Caledonian fold zone in the north and bounded by the Songpan–Garze Indosinian fold zone in the south. The basin trends EW at large. In the east, it is tightly contracted, but branches out westward into a number of arc structures (Huo FC and Li YJ, 1995; Pan GT et al., 2009).

Systematic regional geological survey of the Xicheng orefield began in the late 1950s to 70s. In the 1980s, 1∶25 000 stream sediment survey, 1∶100 000 airborne magnetic survey, and 1∶200 000 heavy sand survey were completed. For the Huangzhuguan Map-sheet, 1∶50 000 regional geological survey was completed in the 1990s. Previous authors have made intensive studies on the tectonic environment, metallogenic geology, ore-bearing formations, rock mineral characteristics, and typical deposits in the area (Wang JL and He BC, 1996; Ye HS et al, 2016; Zhu XY et al., 2005; Yu ZH et al., 2008; Guo AQ et al, 2011; Zhang CQ et al., 2013). The formation-structure characteristics and Pb-Zn metallogenesis of the Xicheng

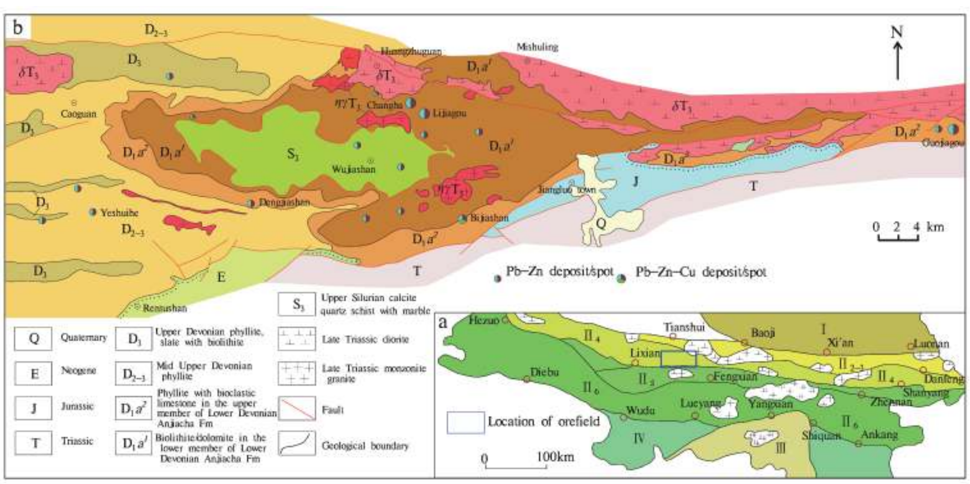

Fig. 1 Geotectonic location of the Xicheng Pb-Zn orefield, Gansu

a—tectonic sketch map of West Qinling; b—geological map of the Xicheng Pb-Zn orefield Ⅰ—North China plate; Ⅱ$_{2\text{-}3}$—North Qinling magmatic arc; Ⅱ$_4$—Central Qinling epicontinental basin; Ⅱ$_5$—Zeku foreland basin; Ⅱ$_6$—Xiqingshan–South Qinling epicontinental rift zone; Ⅲ—Yangtze block; Ⅳ—Bayankara fold system orefield have been virtually identified, the ore prospecting signatures have been summarized, and a large stock of primitive data were built up. These previous efforts lay firm foundation for the compilation of the mineral geological map of the Huangzhuguan Map-sheet.

The Xicheng orefield lies in the Changba–Yeshuihe Hercynian/Indosinian Pb-Zn-Au-Ag metallogenic subzone (Ⅳ–28⑤) of the West Qinling Pb-Zn-Cu(Fe)-Au-Hg-Sb metallogenic zone (III–28) (Sun KS and Peng DQ, 2004; Zhang XH et al., 2013). Lead-zinc mineral deposits occurred in the second-order sedimentary basins controlled by the Rentushan–Jiangluo arc deep large fault to the south and the Huangzhuguan active fault to the north. Typical exhalative sedimentary Pb-Zn deposits are confined to third-order faulted basins. Pb-Zn deposits having received sedimentary reformation are all hosted at the core of third-order inverted tight anticlines (Cheng XJ and Zhai YS, 1995; Li YG et al., 1988; Zhang FX and Wang JF, 1991; Zhu XY et al., 2006), which are also strictly controlled by the carbonate rocks at the top of the Anjiacha Formation and the phyllite at the bottom of the Huangjiagou Formation (Ma GL et al., 1996; Song CH and Wu AB, 1992).

The 1：50 000 mineral geological map of the Huangzhuguan Map-sheet, as a demonstrative map for the mineral geological survey campaign of the China Geological Survey (Wang CN et al., 2019), strives to present the latest results of geological survey, mineral exploration and scientific research in the new round of mineral geological survey, and provides base geological map for the mineral resource research and energy exploration in the area, as well as useful reference information for research and field geological survey activities. Table 1 gives a brief list of the metadata of the 1：50 000 mineral geological map database of the Huangzhuguan Map-sheet, Gansu (Jia XX et al, 2020) .

2 Data Acquisition and Processing Method

2.1 Data Base

The 1：50 000 mineral geological map of the Huangzhuguan Map-sheet, Gansu is compiled according to the *Technical Requirements of Solid Mineral Geological Survey* (1：50 000) (DD 2019–02), under the guidance of the ore prospecting prediction theories for the exploration area(Ye TZ et al., 2014, 2017). Based upon the 1：50 000 regional geological survey of the Huangzhuguan Map-sheet and the large-scale primitive data of the Xicheng orefield area (including the primitive data map, profile map, and log book), the map also incorporates the latest results from the 1：50 000 specific lithological structure mapping, investigation on typical deposits in Changba–Bijiashan, and tectonic petrochemical measurement within the present project. The geographic base maps are based on the 2016 geographic data of the National Bureau of Surveying, Mapping and Geologic Information. Data were processed to current technical standards using computer software programs such as digital mapping system (DGSS) and MapGIS.

2.2 Data Processing

2.2.1 Data Preparation

The regional geological survey results and primitive data maps collected were digitalized

Table 1 Metadata Table of Database (Dataset)

Items	Description
Database (Dataset) name	1：50 000 Mineral Geological Map Database of the Huangzhuguan Map-sheet, Gansu
Database (Dataset) authors	Sedimentary rocks: Jia Xiangxiang, The First Geological Mineral Exploration Institute of Gansu Provincial Geology and Mineral Bureau Magmatic rocks: Wang Shuming, The First Geological Mineral Exploration Institute of Gansu Provincial Geology and Mineral Bureau Metamorphic rocks: Jia Xiangxiang, The First Geological Mineral Exploration Institute of Gansu Provincial Geology and Mineral Bureau Geological structures: Jia Ruya, Development and Research of China Geological Survey; Mineral Exploration Technical Guidance Center, Ministry of Natural Resources
Data acquisition time	2016–2018
Geographic area	105°30′00″–105°45′00″E, 33°50′00″–34°00′00″N
Data format	*.wl, *.wt, *.wp
Data size	30.6 MB
Data service system URL	http://dcc.cgs.gov.cn
Fund project	China Geological Survey Project “Prospecting Prediction and Technical Application Demonstration in Integrated Exploration Area” (No.: 121201004000172201)
Language	Chinese
Database (Dataset) composition	The database includes a 1：50 000 geological map library, corner maps and finishing. The geological map library includes sedimentary rocks, magmatic rocks, metamorphic rocks, Quaternary, dykes, structures, geological boundaries, attitudes, ore deposits (spots), alterations, lithologic patterns, and various codes. The corner map includes sedimentary rock formations, intrusive rock formations, dykes, structures, typical ore deposit plane map, profile map of important exploration lines, geological profile map, and tectonic outline map, lithofacies paleogeographic sketch map, as well as mineral legend, mineral deposit directory, mineralization alteration legend, and metallogenic zone location map. The finishing part includes the index map, China Geological Survey emblem, map name, scale, coordinate parameters, and duty table

into MapGIS point, line, and areal files. The 1：50 000 standard map frame was generated according to the scope of the Huangzhuguan Map-sheet, using the Gauss Kruger projection parameters and the China Geodetic Coordinate System 2000.

2.2.2 Compiling Formation−Structure Sketch

By looking up and analyzing the measured profiles and field route records involved in the 1：50 000 regional geological survey report of the Huangzhuguan Map-sheet, group level mapping units were decomposed, lithologic (combination) boundaries were added, and field records were presented on the primitive data map in the form of lithologic formation pattern points or lines.

(1) Formation

Formations are presented with the same color use standard. Bins of different colors are used to show the era of the formations. Formation patterns are used to show the type of the formations. Corresponding patterns are used to show the lithologic combinations. The codes are presented with “lithology + era”. For the carbonate and marine volcanic interbeds in the Devonian Xihanshui Group sedimentary formations, lithologic and lithofacies boundaries are used as the boundaries. The formations are presented with corresponding patterns.

(2) Dyke

Dykes are presented with the same color use standard. The bin color is used to show the lithology. The code is presented with the lithology code. For example, a granite dyke is presented with word pattern No.1238 and its lithology is marked with code γ.

(3) Structure

Structures are presented in red color with the same color use standard. Different line types are used to show the nature of the faults. The line thickness is used to present the order of faults.

(4) Geological profile

The location is presented with “standard profile line type + profile code”. Geological points and numbers are used to present the conditions of the actual control points. Corresponding patterns are used to show the lithology of individual layers. The attitude feature is also presented on the geological profile.

(5) Fossil sampling points

The location and fossil type are presented with the same color standard + submap style. A datatable is established and the related attribute data are provided.

(6) Rock chemical sample collecting points

The location of the sampling point is presented with the “standard submap ID + sample ID”. A datatable is established and the related attribute data are provided.

(7) Geochemical sample collecting points

The location of the sampling point is presented with the “standard submap ID + sample ID”. A datatable is established and the related attribute data are provided.

(8) Isotope sampling points

The location of the sampling point is presented with the “standard submap ID + sample ID”. A datatable is established and the related attribute data are provided.

2.2.3 Field Specific Geological Mapping

After reorganizing existing data and compiling formation−structure sketches, the study area was divided into key work areas and general work areas. The focus of the specific key geological mapping was determined to be the Devonian Xihanshui Group, mineralization alterations, structures, and dykes. Using the 1：250 000 primitive data map in the digital mapping portable system as the base map, through field survey of the actual routes, a digital mapping (PRB) library was preliminarily established by marking point and line information like geological points, geological boundaries and routes in the digital mapping system, and entering the nature, lithology and attitude at each point.

Geological point (P): These include boundary points and control points. Simple attributes, such as point number, point nature, microtopography, outcropping condition, weathering degree, location description, mapping unit and contact relationship, were provided in the system during field survey. The coordinate information was automatically read out by the system.

Geological route (R): Attributes to be provided in the system during field work include the route No., geological point No., route No., direction angle, distance of the station, cumulative distance, mapping unit, and rock name. The direction angle, distance of the station, cumulative distance were automatically calculated by the system.

Geological boundary (B): Attributes to be provided in the system during field work include the route No., geological point No., B No., R No., boundary type, left-side mapping unit, right-side mapping unit, contact relationship, strike, dip direction, and dip angle. Geological attitudes detected and specimens collected along the way may be entered into the system right away. Their attribute data were also provided.

2.2.4 Indoor Data Reorganization

(1) The geological point (P), geological route (R), and geological boundary (B) data collected during field work are imported into the computer and reorganized against the applicable specifications.

① Minimum requirements for reorganizing geological point (P) data. Route number, weathering degree, and contact relationship should be provided in full detail according to their real conditions. The mapping unit should be the code of the mapping unit. The rock name should be the same as shown in the dialog box (including the color, texture, and structure). The annotation information should be the thin section identification result. The name should be provided after comprehensive consideration according to the real conditions.

② Minimum requirements for reorganizing geological route (R) data. The R data should be reorganized indoors by “smooth curve–line parameter modification (linearity 1 color 1 line width 0)–inter-line route calculation–(work quantity statistics). The R attribute database should be refined. The azimuth and distance should be recalculated before geologically describing the route.

③ Minimum requirements for reorganizing geological boundary (B) data. Geological boundaries should be beautified indoor according to the contact conditions, using broken lines, extended lines or by replaying the old lines with new ones on the computer. Color, line type, and line width parameters should be unified. Geological boundary description information should be added by using “xxx on the left and xxx on the right” to describe the lithology on the two sides of the boundary. It was defaulted that the lithology on the left was the lithology first observed and that on the right was the lithology observed later. A description should be added for the contact relationship of the two lithologies and the evidence thereof.

④ Minimum requirements for reorganizing the attitude, sampling, and photographs of geobodies in the route. Attribute information like attitude and sampling should be added. The numbering of attitudes should begin with 1, 2, 3... for each individual geological point. Photos should be imported in the specified way. A description should then be provided for the photo and the geological phenomenon reflected therein.

(2) The primitive data maps—principally PRB data—actually collected during field work were combined with the regional geological map of regional geological survey reorganized when compiling the formation–structural draft map. The stratigraphic unit boundaries, formation patterns, and the structural forms of various formations were corrected. The boundaries of the newly formed geological boundaries were connected.

2.2.5 Compiling Corner Maps

(1) Formation columnar sections

The formation characteristics of the lithostratigraphic units in the master map were described in full detail. The various formations and structures, and their relationship with mineralization, were comprehensively analyzed. Columnar sections of sedimentary rock formations and intrusive rock formations were compiled.

(2) Maps related to Changba Pb-Zn deposit

These include the plane map of the ore-forming factors of the Changba exhalative sedimentary Pb-Zn deposit (Fig. 2) and a geological profile map of line 77, providing reference for the ore prospecting prediction work of the area. After collecting all necessary previous results, typical deposit corner maps were compiled based on field survey and comprehensive research of typical deposits within the present project.

(1)Transverse cutting profile

The formations and structures in the Huangzhuguang Map-sheet trend EW at large. In order to effectively reflect the overall characteristics of the formations and structures in the Map-sheet and their relationship with lead-zinc and gold mineralization, two nearly NS transverse cutting profiles were deployed. The AB transverse cutting profile runs throughout the area to reflect the Silurian, Devonian, and Late Triassic granite. In order to highlight the metallogenic information of the gold deposits, the CD transverse cutting profile only covers the lower half of the Map-sheet to reflect the Yanjiehe diorite pluton and the Devonian System on

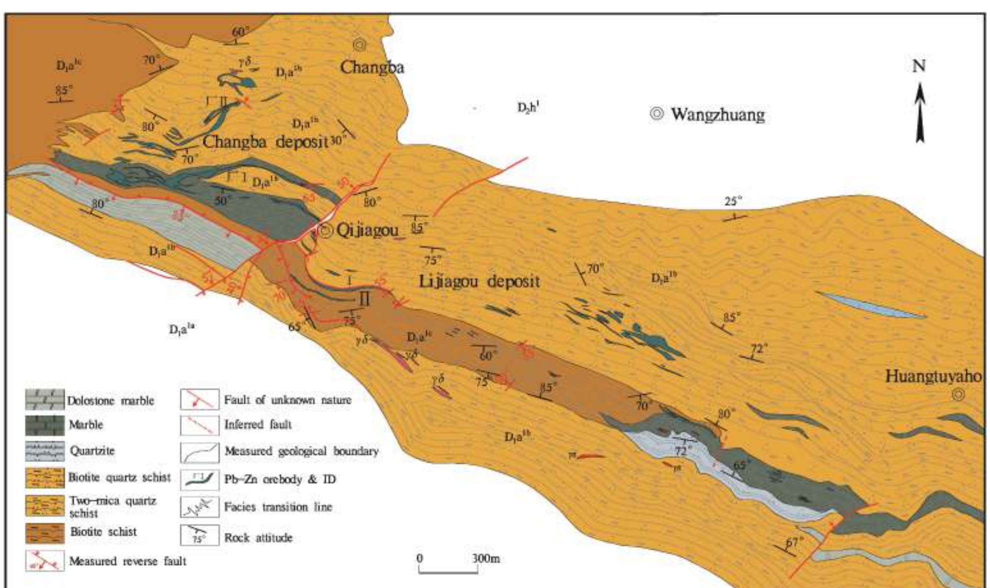

Fig. 2 Plane map of ore-forming features of the Changba Pb-Zn deposit

its two sides. Regarding the presentation form, "standard profile line type + standard code" is used to present the location. Corresponding patterns are used to present the lithology of individual layers. Attitude features are also presented on the geological profile.

(4) Mineral deposit directory

Mineral deposits in the area were summarized with respect to their name, size, type, and main ore-bearing formations before a mineral deposit directory (Table 2) was prepared to facilitate understanding of the mineral distribution throughout the Huangzhuguan Map-sheet.

(5) Lithofacies paleogeographic sketch map of the Map-sheet

The metallogenesis of all exhalative sedimentary Pb-Zn deposits is limited to faulted stagnant basins (Wu AB et al., 1992; Li JZ and Gao ZK, 1993; Fang WX et al., 2001). Hence an examination on the Devonian sedimentary facies and microfacies can give a better insight into the metallogenic spaces of Pb-Zn deposits (Fig. 3).

(6) Tectonic outline map of the Map-sheet

The purpose of studying lithofacies paleogeography is to find out the original spatial location of ore formation. The purpose of studying post-metallogenic structure is to give a better description of the ore-hosting location of the deposit. All exhalative sedimentary Pb-Zn deposits in the work area, especially those in Bijiashan–Dengjiashan in the south, have been reformed by postmagmatic hydrothermal fluids. The originally hydrothermally deposited orebodies migrated during the reformation and are hosted in the prostrated spaces of fold−fault structural systems. Hence post-metallogenic structures play an obviously controlling role in the final positioning of Pb-Zn deposits.

(7) Others

Various legends were prepared by sorting out the dyke, structure, and mineralization alteration legends.

3 Data Sample Description

3.1 Naming Method of Data

Geological plane.wp, geological line.wl, and geological point.wt.

3.2 Layer Content

The master map includes sedimentary rock formations, intrusive rock formations, special lithologic formations, various dykes, Quaternary, fault structures, fold axial traces, geological boundaries, attitudes, mineral deposits, mineralization alterations, and various codes.

Corner maps include the index chart, columnar section, legend, transverse cutting profile, plane map of ore-forming features of the Changba Pb-Zn deposit, profile map of the main orebody exploration lines of the Changba Pb-Zn deposit, tectonic framework map of the Map-sheet, lithofacies paleogeographic sketch map, mineral deposit directory, metallogenic zone location map, and duty table.

3.3 Data Type

Entity type name: point, line, and area.

Table 2 List of the mineral deposits occurred in the Huangzhuguang Map-sheet area, Xicheng lead-zinc orefield, Gansu

No.	Mineral deposit name	Size	Origin type	Main ore-forming formation-structure	Estimated resources
1	Yedianshan iron deposit, Chengxian County, Gansu	Mineralized spot	Hydrothermal type	Sandstone formation	
2	Miaogou lead-zinc deposit, Chengxian County, Gansu	Mineralized spot	Exhalative sedimentary type	Marble formation	
3	Xuantangou lead-zincdeposit, Xihe County, Gansu	Ore occurrence	Exhalative sedimentary type	Phyllite formation	
4	North Changba lead-zinc (copper) deposit, Chengxian County, Gansu	Mineralized spot	Hydrothermal type	Marble formation	Cu 244 kg
5	Qingshuigou lead-zinc deposit, Chengxian County, Gansu	Ore occurrence	Exhalative sedimentary type	Schist formation	Pb+Zn 165 913 t
6	Waquanshan marble deposit, Chengxian County, Gansu	Large	Regional metamorphic type	Marble formation	
7	Changba lead-zinc deposit, Chengxian County, Gansu	Super-large	Exhalative sedimentary type	Si-Ca interface (interface between the pluton and carbonate rock)	Pb 586 910 t; Zn 2 807 870 t
8	Changba dolomite deposit, Chengxian County, Gansu	Large	Regional metamorphic type	Dolomite formation	
9	Qingshuigou tungsten deposit, Chengxian County, Gansu	Mineralized spot	Hydrothermal type	Sandstone formation	
10	Erlangduichanggou gold deposit, Chengxian County, Gansu	Ore occurrence	Altered rock type	Sandstone formation	
11	Erlangduichanggou lead-zinc deposit, Chengxian County, Gansu	Ore occurrence	Exhalative sedimentary type	Carbonate rock formation	
12	Lijiagou lead-zinc deposit, Chengxian County, Gansu	Super-large	Exhalative sedimentary type	Schist formation	
13	West Xiangyangshan lead-zinc deposit, Chengxian County, Gansu	Medium	Exhalative sedimentary type	Schist formation	Pb+Zn 2 414.9 t
14	Xumingshan lead-zinc deposit, Chengxian County, Gansu	Mineralized spot	Exhalative sedimentary type	Marble formation	Pb 4 789 t; Zn 42 852 t
15	Erlangduichanggou iron deposit, Chengxian County, Gansu	Mineralized spot	Hydrothermal type	Si-Ca interface (interface between the pluton and carbonate rock)	

Continued table 2

No.	Mineral deposit name	Size	Origin type	Main ore-forming formation-structure	Estimated resources
16	Laodongshang lead-zinc deposit, Chengxian County, Gansu	Ore occurrence	Exhalative sedimentary type	Dolomite formation	Pb+Zn 105 304.9 t
17	Xiangyangshan lead-zinc deposit, Chengxian County, Gansu	Medium	Exhalative sedimentary type	Si-Ca interface (interface between the pluton and carbonate rock)	Pb+Zn 208 809 t
18	Dashawan copper deposit, Chengxian County, Gansu	Mineralized spot	Hydrothermal type	Schist formation	
19	Guanzigou lead-zinc deposit, Chengxian County, Gansu	Ore occurrence	Exhalative sedimentary type	Marble formation	Pb 106.7 t; Zn 719.2 t
20	Xiaogouli gold deposit, Chengxian County, Gansu	Medium	Hydrothermal type	Phyllite formation	Au 7 696.72 kg
21	Kongzigou lead-zinc deposit, Chengxian County, Gansu	Mineralized spot	Exhalative sedimentary type	Phyllite formation	Pb+Zn 2 778.34 t
22	Ranjiahe lead-zinc deposit, Chengxian County, Gansu	Mineralized spot	Exhalative sedimentary type	Phyllite formation	
23	Gangou lead-zinc plymetallic deposit, Chengxian County, Gansu	Medium	Exhalative sedimentary type	Carbonate rock formation	Pb 6 518.6 t; Zn 54 958.4 t
24	Xiaogouli lead-zinc deposit, Chengxian County, Gansu	Mineralized spot	Exhalative sedimentary type	Phyllite formation	
25	Mamenxia marble deposit, Chengxian County, Gansu	Large	Regional metamorphic type	Marble formation	
26	Xiongjiahe lead-zinc deposit, Chengxian County, Gansu	Ore occurrence	Exhalative sedimentary type	Carbonate rock formation	Pb 1 763 t; Zn 8 818 t
27	Bijiashan lead-zinc (copper) deposit, Chengxian County, Gansu	Large	Exhalative sedimentary type	Si-Ca interface (interface between the pluton and carbonate rock)	Pb 9 322.89 t; Zn 39 748.87 t
28	Ganzhegou lead-zinc polymetallic deposit, Chengxian County, Gansu	Ore occurrence	Exhalative sedimentary type	Carbonate rock	Pb+Zn 25 160.06 t; Ag 7 085.73 t
29	Sanjiashan lead-zinc deposit, Chengxian County, Gansu	Ore occurrence	Exhalative sedimentary type	Carbonate rock formation	
30	Chenjiazhuang lead-zinc deposit, Chengxian County, Gansu	Ore occurrence	Exhalative sedimentary type	Carbonate rock formation	

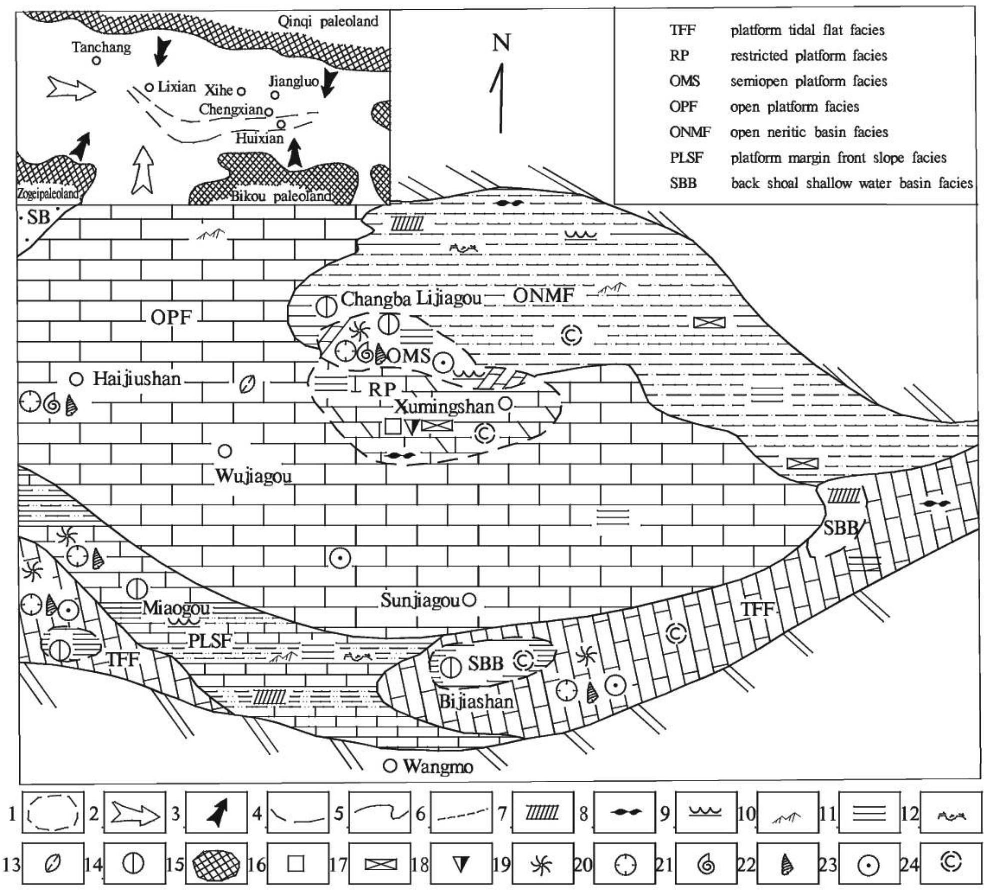

Fig. 3 Early Devonian paleogeographic sketch map of the Huangzhuguan Map-sheet

1—location of the Xicheng orefield; 2—transgression direction; 3—source direction; 4—submarine uplift; 5—facies zone boundary; 6—facies boundary; 7—oblique bedding; 8—vein, lenticular bedding; 9—deformed bedding; 10—fine cross bedding; 11—horizontal bedding; 12—erosion structure; 13—algal debris; 14—ore deposit/spot; 15—paleoland; 16—pyrite; 17—barite or celestite; 18—sphalerite vein; 19—stromatoporoid; 20—coral; 21—brachiopods; 22—gastropods; 23—crinoid stem; 24—carbon, carbon chip

Point entity: symbol and mark, geological pattern, mineral deposit, mineralization alteration, and attitude of individual geobodies.

Line entity: fault structure, geological boundary, lithologic boundary, and formation pattern.

Area entity: sedimentary rock, metamorphic rock, intrusive rock, and Quaternary.

3.4 Data Attribute

The 1：50 000 mineral geological map database of the Huangzhuguan Map-sheet (I47E013015) contains geological entity feature information, geographic feature information, and geological map finishing feature information. For the attributes of geographic feature information, the attribute structure of the National Bureau of Surveying, Mapping and Geologic Information for data collection applies. For the attribute of geological entity features information, database attributes were established for the three major rocks (sedimentary rock, intrusive rock, and metamorphic rock), fault structure, attitude feature, and mineral deposit, respectively, according to the database-building requirements for specific geological mapping of 1：50 000 mineral geological survey.

Data attributes of sedimentary rock formations include chronostratigraphic unit, lithostratigraphic unit, formation name, formation code, lithologic combination, stratigraphic age, formation thickness, formation ore-bearing property, rock texture, sedimentary structure, rock color, sedimentation type, sedimentary facies type, and synsedimentary structure.

Data attributes of intrusive rock formations mainly include formation name, formation code, lithologic combination, formation ore-bearing property, rock texture, rock structure, intrusive period, orebody attitude, plane shape, profile shape, orebody emplacement structure characteristics, contact zone characteristics, genetic type, and isotopic age.

Data attributes of fault structures mainly include fault name, fault type, fault extended length, fault extended depth, fault width, fault strike, fault plane dip direction, fault plane dip angle, fault distance, fault plane shape, structural rock characteristics, way of movement, active period, and mechanical property.

Data attributes of attitudes include attitude type, dip direction, and dip angle.

Data attributes of mineral deposits mainly include the mineral deposit number, mineral deposit name, mineral deposit type, transportation location, geographic longitude, geographic latitude, mineral type, deposit genetic type, size, syngenetic (associated) mineral, and identified resource amount.

4 Data Quality Control and Evaluation

Mapping was implemented through both map filling and map editing in accordance with the *Technical Requirements of Solid Mineral Geological Survey* (1∶50 000) (DD 2019–02). For the key areas, mainly real measurements were used. For general work areas, map editing was performed based on the primitive data of the 1∶50 000 *Regional Geological Survey Report of the Huangzhuguan Map-sheet (I–48–80–A)*. Geological points were collected in a way to substantially control metallogenesis-related geobodies, mineralization alteration zones, and important geological boundaries. Data used to compile the 1∶50 000 mineral geological map of the Huangzhuguan Map-sheet cover a total route length of 540 km, which includes 240 km for previous route data collected, 30 km for ore spot visits and checks, 300 km for measured routes (45 routes), 1 000 geological points, 616 geological boundaries, 127 basic analysis samples, 141 optical thin section identification samples, 12 whole-rock analytical samples, three sphalerite Rb–Sr age samples, 1 200 photos, and 13 sketches. The overall map filling/editing accuracy meets the specified requirement for 1∶50 000 geological specific mapping.

During database building, a strict quality inspection system was followed. All primitive data were subject to a three-level inspection procedure: self and mutual check, project team inspection, institute inspection. Daily quality check was arranged by the group leader so that 100% of the primitive records, primitive data maps, and the attributes of the entered materials had received self and mutual check. The project team inspection was arranged by the project chief and involved indoor check at the ratio of 60%. The institute inspection was arranged by the First Geological and Mineral Exploration Institute of Gansu Provincial Geology and

Mineral Bureau with the assistance of the project team and implemented at the ratio of 32%.

All these checks and the subsequent modifications were recorded in the quality check cards. The institute examined 100% of all kinds of comprehensive maps and made sure that any problem discovered was resolved by the responsible person.

On March 18–22, 2019, in Beijing, Development and Research of China Geological Survey organized an inspection and acceptance of the database (including the map editing part, spatial data, attribute data, and metadata) of the Huangzhuguan Map-sheet yielded under the *Ore Prospecting Prediction of the Changba Ore Concentration Area, Gansu Province* undertaken by the First Geological Mineral Exploration Institute of Gansu Provincial Geology and Mineral Bureau, and rated it Excellent.

5 Data Value

The 1：50 000 mineral geological map of the Huangzhuguan Map-sheet (I47E013015), Gansu, as a demonstrative Map-sheet of the CGS's new round of the mineral geological survey campaign, was compiled with an innovative manner to present the mineral geological specific mapping results. Based on formation units, the formation type of the Devonian Xihanshui Group was redivided, three formation units of the Devonian Pb-Zn metallogenic period were established, namely, Pb-Zn-bearing carbonate rock formation (D_1a^{1a}), Pb-Zn-rich carbonate rock formation (D_1a^{1c}), and Pb-Zn-poor phyllite with limestone formation (D_1a^2) (Table 3), and five different types of intrusive rock formations related to Pb-Zn reformation after metallogenesis, were also established (Table 4). The Pb-Zn ore-forming geobodies were determined to be an "ore-bearing formation +syngenetic fault" combination, and the submetallogenic structural plane was the nearly EW interlaminar fault, with the main metallogenic structural plane determined to be the lithologic interface between sericite phyllite and biolithic limestone. The metallogenic fault–fold structural system was also reestablished.

6 Conclusions

The 1：50 000 mineral geological map of the Huangzhuguan Map-sheet (I47E013015) and its database were compiled in a comprehensive, systematic manner in this work. Information of mineral deposits, minerals and mineralization is emphatically presented, such as specific lithologic layers, fold structures, syngenetic fault structures, metallogenic structural planes. Important attribute data are established for important formations/structures, faults, geological boundaries, magmatic rocks, and mineral deposits. Their mutual spatio-temporal relationships are also established.

(2) The mineral geological map database of the Huangzhuguan Map-sheet provides systematic data support for future mineral exploration, resource development and utilization, and basic mineral geological research efforts in the area. It serves as a sci-tech innovation pacemaker and upgrades the ability of mineral geological survey work to serve resource security, economic-social development, and ecological civilization.

Table 3 List of sedimentary rock formations

Lithostratigraphic Unit					Characteristics of Formation Unit			
System	Series	Group	Formation	Member	Code	Formation Type	Thickness/m	Rock Combination
Neogene		Gansu Group			N_1G	Conglomerate formation	695	Red massive conglomerate, gritstone, clayey siltstone, claystone
Cretaceous			Jishan Formation		K_1js	Continental clastic rock formation	1 202	Particolored mudstone, siltstone with purplish red sandstone, conglomerate, carbonaceous mudstone with dirt coal seam
Triassic			Guanggaishan Formation	Upper	T_1gg^2	Carbonate rock with sandstone formation	789	Gray to dark gray thin stratiform limestone with thin stratiform calcareous fine sandstone, carbonaceous siltstone, calcareous slate, occasionally with calcirudyte interbeds
				Lower	T_1gg^1	Clastic rock with carbonate rock formation	124	Lithic (quartz) sandstone, calcareous sandstone, carbonaceous siltstone, calcareous slate with thin limestone, brecciated limestone, calcareous conglomerate lenses
Devonian	Upper	Xihanshui Group	Shuanglanggou Formation	Upper	D_3sl^2	Siltstone-sandstone interlayer with limestone formation	223.	Feldspar quartz fine sandstone, siltstone, calcareous sandstone with thin crystals, limestone, marlite
				Lower	D_3sl^1	Phyllite-slate interlayer with limestone formation	267.9	Sericite phyllite, phyllite, sericite slate, slate, calcareous silty slate
	Middle		Honglingshan Formation		$D_{2-3}hl$	Biomicrite with reef limestone formation	476	Bioclastic limestone, banded micrite, argillaceous banded limestone, bioclastic micrite, with local reef fragment limestone, reef limestone bands
			Huangjiagou Formation	Upper	D_2h^2	Slate with phyllite formation	454.4	The lower part consists of chlorite phyllite with thin micrite biolithite lenses; the upper part consists of phyllitic slate with phyllite
				Lower	D_2h^1	Sandstone formation	350.7	Thin stratiform feldspar quartz sandstone, meta-feldspar sandstone

Continued table 3

Lithostratigraphic Unit						Characteristics of Formation Unit				
System	Series	Group	Formation	Member		Code	Formation Type	Thickness/m	Rock Combination	
	Lower		Anjiacha Formation	Upper	Jiaogou layer	D_1a^2	Pb-Zn-poor phyllite with limestone formation	434.2	The lower part consists of medium-thick stratiform micrite-sericite phyllite interlayer; the middle part consists of medium-thick stratiform crystalline limestone, banded micrite; the upper part consists of sericite chlorite with crystalline limestone, thin stratiform micrite, medium-thick stratiform banded crystalline limestone	In and around Changba, the lithology changes to quartz schist with marblized limestone, marble lenses as a result of thermal metamorphosis.
				Lower	Changba layer	D_1a^{1c}	Pb-Zn-rich carbonate rock formation	908.2	Thin stratiform banded fine-grained limestone, thin banded limestone, marblized limestone, medium-thick stratiform carbonaceous limestone	In and around Changba, the lithology changes to two-mica quartz schist, two-mica schist, calcite quartz schist in the lower part, and quartzite with marble in the upper part, as a result of thermal metamorphosis.
						D_1a^{1b}	Sandstone formation	191.2	Medium-thick stratiform to massive feldspar quartz sandstone, quartz phyllite	In and around Changba, the lithology changes to quartz schist, biotite quartz schist as a result of thermal metamorphosis
						D_1a^{1a}	Pb-Zn-bearing carbonate rock formation	360	Sericite phyllite with reef limestone, reef fragment limestone, skeleton limestone	

Table 4 List of intrusive rock formations

Time			Characteristics of Formation Unit				
Era	Period	Epoch	Rock Body Name	Code	Formation Type	Lithology	Age/Ma
Mesozoic	Triassic	Late Triassic	Changba rock body	$\eta\gamma T$	Biotite monzonitic granite formation	Grayish white medium to coarse-grained biotite monzonitic granite	184–196 (K–Ar)
			Yushuba rock body	$\eta o T$	Diorite formation	Fine-grained quartz monzonite, medium-fine-grained quartz monzonite diorite	217±4 (Zircon U–Pb)
			Huangzhuguan–Yangchuanzi rock body	$\eta\delta o T$	Gabbro formation	Hypersthene gabbro	184–222 (K–Ar)
			Yanjiahe rock body	$\gamma\delta\mu T$	Granite diorite porphyrite formation	Grayish white granite diorite porphyrite	
			Waquanshan rock body	$\psi\delta T$	Pyroxene diorite formation	Dark green pyroxene diorite	195.5 (K–Ar)
Late Paleozoic	Devonian		Shuangliuzhou rock body	ΣPz_1	Ultramafic rock formation	Dark green ultramafic rock	

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