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数据集引用格式：何进忠; 吕传元; 曹海龙; 张祥年; 武凌; 牛鹏飞. 甘肃省巴藏幅 1：50 000 矿产地质图数据库 (V1).甘肃省地质调查院;甘肃地矿局第三地质矿产勘查院;甘肃地矿局第二地质矿产勘查院 [创建机构]，2016. 全国地质资料馆 [传播机构], 2020-12-30. 10.35080/data.C.2020.P29; http://dcc.cgs.gov.cn/cn//geologicalData/details/doi/10.35080/data.C.2020.P29

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甘肃省巴藏幅 1：50 000 矿产地质图数据库

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摘要: 甘肃省巴藏幅 (I48E013009)1：50 000 矿产地质图数据库在《矿产地质调查成果图件编制指南 (1：50 000)》(讨论稿) 和三位一体找矿预测地质模型的指导下编制完成。采用数据为既往 1：50 000 区域地质调查实际材料图、矿产勘查报告、科学研究报告、论文和 1：50 000 专项填图采集的数据，共形成数据记录：产状 811 条、地质界线 102 条、同位素年龄 5 条、化石 2 条、矿产信息 21 条、矿化蚀变带 22 条、断层 86 条、褶皱 111 条、建造 65 条。图面以主图和角图相结合地方式全面客观地表达了区域地质界线、岩石建造、年代、断层、褶皱轴迹、节理、劈理、皱纹线理、窗棂构造、断层面擦痕、矿化蚀变、矿产信息及典型矿床的成矿地质特征，其中包括加里东期风暴沉积和褶皱变形、早石炭世铁质结核及一系列新发现和新认识。在“建造构造”图层的属性中强调了含矿建造、矿化蚀变；在“断层”图层及“褶皱”构造图层的属性中强调了成矿构造。该数据库为区域成矿规律及工程地质、环境地质等领域的调查研究提供了基础资料，可供使用者根据需求进行检索。本文提交的巴藏幅 MapGIS 空间数据库数据量约为 90.2 MB，Access 数据库 2.51 MB。

关键词: 矿产地质图；数据库；加里东期褶皱；铁锰结核；风暴沉积；含矿建造；成矿构造；矿化蚀变；地质调查工程；甘肃
数据服务系统网址: http://dcc.cgs.gov.cn

1 引言

甘肃省巴藏幅 (I48E013009) 所处构造单元为秦祁昆造山系 (IV) 秦岭弧盆系 (IV–10)，泽库前陆盆地 (IV–10–5) 与南秦岭陆缘裂谷 (IV–10–6) 的过渡部位，主体处于南秦岭陆缘裂谷带；横跨西秦岭 Pb–Zn–Fe–Cu–Au–Sb–Hg 成矿带 (III–28) 的夏河—两当 Au–Sb–Hg 成矿亚带 (IV–28③，图 1) 和碌曲—广金坝 Au–Sb–Hg–As–Cu–V–U–Se 2 个成矿亚带 (IV–28④，图 1)。

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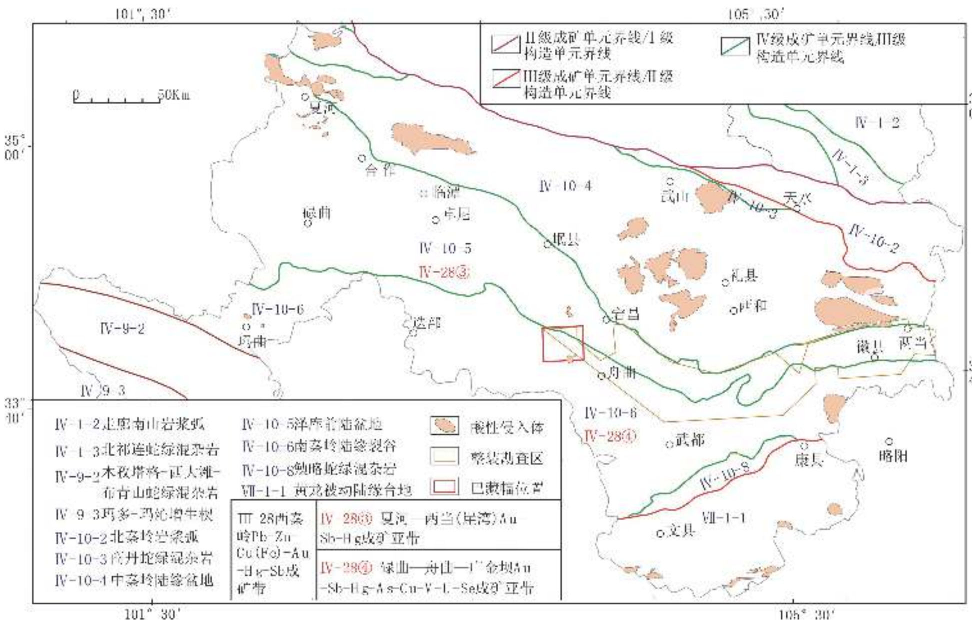

图 1　甘肃省巴藏幅 1：50 000 矿产地质图成矿区带位置图

最早涉及该区域的地质学著述为《甘肃中南部地质志》(叶连俊和关士聪，1945)。其后的地质工作者确认了该区域迭部组、舟曲组、卓乌阔组、当多组等地层名称及其特征 (甘肃省地质矿产局区调队，1986；甘肃省地质矿产局，1997；曹宣铎等，1990)，统一了部分地层岩组的称谓[❶❷]，进行了多重地层划分和对比，厘定了测区的填图单位和 11 个非正式填图单位[❸]。本次“巴藏幅 (I48E013009) 矿产调查专项填图”完全基于“巴藏幅 (I48E013009)1：50 000 区域地质调查”厘定的岩石地层填图单位进行。

侵入岩体的记载最早见于 1：200 000 武都幅 (I–48–(21)) 地质图[❹]，其中圈定了 5 个岩株。后续工作[❷❸❺]，否定了萨热唉梁花岗闪长岩岩株；将憨班岩体确定为花岗闪长岩体，并将其划分为内、外 2 个带；获得了憨班岩体和黑峪沟岩体的锆石 U–Pb 年龄分别为 212±1.4 Ma 和 213±1.2 Ma (刘明强，2012)[❺]，得力坎花岗闪长岩岩株被确定为英云闪长岩岩株 ($\gamma\delta o$)。出露的变质岩有区域变质岩、接触变质岩和动力变质岩。

褶皱较发育，以葱地—三圣爷梁断裂为界，北为碌曲—成县倒转向斜构造，南为白龙江复式背斜构造带。断层按性质划分为正断层、逆断层及平推断层；按其延伸展布方向归为 NW 向、NWW 向、NE 向、NNW 向 4 组。其中 NW 向、NNW 向断层较为发育，且规模大、延伸远，构成工作区内断裂构造的基本格架 (李亚东，1994)。

前人已发现金、铁矿床 (点)13 处，金矿是该区域的主要矿种 (王东华等，2014，2015；李鸿睿等，2011；冯永忠和李亚东，2005；Zhang FX et al.，2003；Hu RZ et al.，2002；李通国，2001；田莉莉等，2003；张复新和于岚，2002；李通国和谢建强，1998；谭光裕，1992)。

甘肃省巴藏幅 (I48E013009) 矿产地质图数据库 (何进忠等，2020) 反映了在三位一体找矿预测地质模型 (叶天竺等，2014) 指导下对既往成果和本次矿产地质调查数据综合研究的结果，数据库元数据的主要特征数据项列于表 1。

表 1　数据库 (集) 元数据简介

条目	描述
数据库(集)名称	甘肃省巴藏幅1：50 000矿产地质图数据库
数据库(集)作者	何进忠，甘肃省地质调查院，野外数据采集、入库，数据质量检查 吕传元，甘肃地矿局第三地质矿产勘查院，野外数据采集 曹海龙，甘肃省地质调查院，野外数据采集及部分路线整理 张祥年，甘肃省地质调查院，野外数据采集 武　凌，甘肃省地矿局第二地质矿产勘查院，图形数据采集 牛鹏飞，甘肃省地质调查院，数据质量检查
数据时间范围信息	2016年6月—2019年3月
地理区域	104° ~ 104°15′ E；33°50′ ~ 34° N
数据格式	MapGIS 6.7(*.WT，*.WL，*.WP)
数据量	90.2 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“甘肃崖湾-大桥地区金锑矿整装勘查区(巴藏幅)矿产调查与找矿预测”(121201004000150017–35)
语种	中文
数据集组成	基本要素类包括地质(界)线、河、水库岸线、脉岩(点)、矿产地(点)、产状、样品、同位素采样点、化石；综合要素类包括标准图框(内图框)、岩石建造花纹、图切剖面；独立要素类包括责任表、接图表、图例、综合柱状图、图切剖面、典型矿床角图、其他辅助角图(构造纲要图和成矿区带位置图)；对象类包括断层、褶皱、建造构造(面)、矿化蚀变、图幅基本信息

2　数据采集和处理方法

2.1　数据来源与采集处理流程

采用原始数据有既往数据和专项填图数据 2 部分。既往数据为巴藏幅区域地质剖面图 (1：2 000、1：5 000)[6]、巴藏幅区域地质草图 (1：50 000)[6]、羊里尾沟金矿普查报告 (1：10 000)[7]、巴藏幅 1：50 000 地形图及甘肃省行政区划图[8]，专项填图数据为野外采集路线数据 (1：50 000) 及综合地质剖面测量数据 (1：2 000)。数据采集处理流程如图 2 所示。

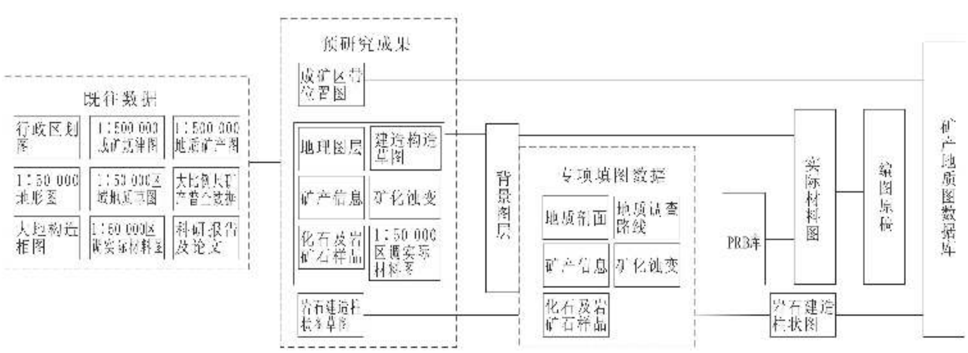

图 2　甘肃省巴藏幅数据采集处理流程图

2.2　既往数据的采集处理与背景图层的生成过程

为使既往数据便于专项填图人员参考，将既往数据采集、处理成能在数字填图系统 (李超岭，2011) 使用的背景图层数据。通过对既往数据的处理，获得地理底图图层、建造构造草图图层、矿产信息图层、矿化蚀变图层、同位素采样点图层、化石图层及岩

矿石样品图层、岩石建造柱状图草图图层、成矿区带位置图图层，其余编图内容待获得专项填图数据后再行完善。图形文件的比例尺为 1：50 000。

2.2.1 地理底图

标准图框：在 MapGIS6.7 系统下，生成与 1：50 000 地形图相匹配的巴藏幅 (I48E013009)1：50 000 标准图框，投影参数为高斯–克吕格投影，坐标系统为西安 80 坐标系。在编制完成矿产地质图后，整体转换成“2000 国家大地坐标系”。

地物及居民点信息：提取自巴藏幅 (I48E013009)1：50 000 地形图。

行政区划及道路信息：提取自新版甘肃省行政区划图[8]。

2.2.2 建造构造草图

由区域地质草图 (1：50 000)[3]、区域地质测量实际材料图 (1：50 000)[6]、填图路线调查数据、地质剖面测量数据及重点路线岩石建造花纹组成。在完全继承 1：50 000 区域地质调查成果的基础上，依据羊里尾沟金矿等矿床的矿产普查成果，修编了相应地段岩组或岩段的地质界线。岩石建造花纹仅绘制于部分填图路线和地质剖面，在岩组或岩段内概略地划分了岩石建造，该岩石建造尚不能作为岩石建造填图单元的可靠依据，暂未对其赋以岩石建造单元代号，图面整体表现为：地质界线+岩石地层单元及其代号+路线岩石建造花纹+地质剖面线+地质观察点+化石及岩矿石样采样点。

数据图层有：地质界线、断层、岩石建造花纹、地质剖面、PRB 库文件、化石采样点、岩石化学样采样点、同位素样采样点。各图层点、线、面文件中的符号参数完全遵照《区域地质图图例》(GB/T 958−2015) 设置，对地质剖面、地质观察点及各种采样点附加注记。图形属性项完全继承自安卓版数字矿产调查系统 (RgMapforAndroid 4.x)。

2.2.3 矿产信息

将甘肃省区域成矿规律图[8] 中的矿产信息及羊里尾沟金矿、黑峪沟金矿、老沟金矿、黑水沟金矿等矿产地按 1：50 000 比例尺和对应的投影参数投绘到巴藏幅内，并形成矿产图层文件。各图层点文件中的图形参数完全遵照《区域地质图图例》(GB/T 958−2015) 或《全国矿产资源潜力评价数据模型统一图例规定分册 (V3.10)》设置。

2.2.4 矿化蚀变

从 1：50 000 区域地质草图[3]、武都幅 1：200 000 矿产地质图[9] 及羊里尾沟金矿[7]、黑峪沟金矿、老沟金矿、黑水沟金矿等矿产普查报告中汇集矿化蚀变信息，依矿化蚀变信息的空间展布特点选择使用对应的 MapGIS 文件类型，以散点状存在的蚀变生成点 (.WT) 文件，以线状存在的蚀变生成线 (.WL) 文件，按 1：50 000 比例尺和对应的投影参数投绘到巴藏幅内。

2.2.5 化石及岩矿石样品

化石采样点、岩石化学样采集点和同位素样品采集点分别按照《区域地质图图例》(GB/T 958–2015) 规定符号及标注方式生成各自的点文件。数据来源于 1：50 000 区域地质调查实际材料图[6]、甘肃崖湾—大桥地区金锑矿整装勘查区专项填图与技术应用示范子项目报告[5] 及论文 (刘明强，2012)。

2.2.6 岩石建造柱状草图

依据对搜集到的地质剖面和地质调查路线的概略研究，初步形成区域岩石建造柱状草图，岩石建造单元颜色及花纹完全遵照《区域地质图图例》(GB/T 958–2015) 和《矿产地质调查成果图件编制指南 (1：50 000)》(讨论稿)“1： 50 000 矿产地质图编图格式要求”绘制。

2.2.7 成矿区带位置图

数据来源于甘肃省成矿规律图[8]。遵循《矿产地质调查成果图件编制指南 (1∶50 000)》(讨论稿)“1∶50 000 矿产地质图编图格式要求”绘制，添加了中酸性侵入岩体。

2.2.8 生成背景图层

将地理底图图层、建造构造草图图层、矿产信息图层、矿化蚀变图层、同位素采样点图层、化石图层及岩矿石样品图层、岩石建造柱状图草图图层纳入同一个文件夹，或统一复制到 DGSData 的背景图层文件夹。

2.3 专项填图中的数据采集与处理过程

2.3.1 数据格式转换

掌机数字地质调查系统 RgMapforAndroid 4.x 默认数据格式为 DGSGIS，在野外作业前，需要在 PC 版 DGSInfo (2016 版) 系统中创建工作数据目录和工作区、转换背景图层文件格式 (MapGIS–DGSGIS) 和设计野外工作路线，并将设计好的野外工作路线文件传送到掌机存储器中指定的文件夹。

室内数据处理采用便于处理 MapGIS 格式文件的数字地质调查系统 DGSInfo (2010 版)。对于利用掌机数字地质调查系统 RgMapforAndroid 4.x 获取的数据，需要将其利用 DGSInfo (2016 版) 转换成 MapGIS 格式文件，再将其复制到 DGSInfo (2010 版) 系统的相应文件夹。

2.3.2 综合地质剖面测量

掌机系统在野外主要用来获取定位信息和样品采集信息，并概略记载一些地质现象和观测数据。剖面测量数据和地质现象均采用野外记录薄现场详细记录，室内在 DGSInfo (2010 版) 系统录入。在补充了岩矿鉴定数据，并通过系统检查后入库。

2.3.3 路线地质调查数据

地质点 (P)、点间路线 (R) 和地质界线 (B) 的地理信息数据完全在现场获取；地质记录内容部分实现现场数字化记录，部分采用野外记录薄记录、室内在 DGSInfo (2010 版) 系统补录的方式进行，直至每条地质路线数据完整、正确后入库。

2.4 创建实际材料图和编稿原图

实际材料图的图面由图名、比例尺、接图表、图框、主图区、图例和责任栏组成，主图区的内容由专项填图工作形成的地质剖面、地质调查路线、高精度磁测剖面、岩矿石样品、同位素测年样品、化石、异常查证工作区和地质草图组成。

在 DGSInfo (2010 版) 系统，基于 PRB 库文件，将专项填图中形成的调查路线数据、地质剖面数据、岩矿石样品数据与背景图层文件合并，形成实际材料图。对既往数据和专项填图数据采用不同的颜色表达。

用实际材料图生成编稿原图，在编稿原图中基于既往地质草图完成断层、岩组或岩段地质界线的勾绘和修订，在岩组或岩段内勾绘岩性层，圈定出脉岩等特殊地质体，利用地质剖面数据和路线地质调查数据补充完善矿化蚀变和矿产信息。

2.5 创建空间数据库

在 DGSInfo (2010 版) 系统，基于编稿原图，遵循空间数据库的建库操作流程 (李超岭等，2011)，针对基本要素类、综合要素类和对象类要素类建立空间数据库。

2.6 创建矿产地质图数据库

2.6.1 数据库架构及空间参照系

甘肃省巴藏幅 (I48E013009)1：50 000 矿产地质图数据库，根据《矿产地质调查成果图件编制指南 (1：50 000)》(讨论稿)“1：50 000 矿产地质图数据模型”，按照四级目录架构制作 (表 2)。

表 2 成果图件数据库提交目录

一级目录	二级目录	三级目录	文件名称	说明
I48E013009 成果数据库	I48E013009 矿产地质图	MAP	-Geopolygon.WP -Geoline ……	用于输出的全要素图形数据、工程文件以及图整饰文件。左下角原点，底边水平
		MAPGIS高斯(北京、西安、2000)	-Geopolygon.WP -Geoline ……	按规范命名的具有投影参数的所有要素类文件
		METADATA 矿产地质图.XML	元数据文件	
	MDB		BASE-FCLS.MDB DSGMAP.MDB SYNTH-FCLS.MDB	要素类、对象类数据表
	README		LEGEND	图式图例说明及系统库增加的内容说明
			ADD-LAYER	增加的图层说明
			质量检查表	自检、互检、抽检记录

高程系统为 1956 年黄海高程系，投影参数为 2000 国家大地坐标系 (野外作业采用西安 80 坐标系)，磁偏角为 3°35′41″偏西。

2.6.2 矿产地质图

图式在遵循《矿产地质调查成果图件编制指南 (1：50 000)》(讨论稿)“1：50 000 矿产地质图编图格式要求”前提下，针对本图幅的岩石建造及读图需求，对该矿产地质图的图式进行了适当调整，图面由主图、沉积岩建造柱状图、侵入岩建造柱状图、图切地质剖面图、角图、矿产地名录及图例组成。图 3 为巴藏幅矿产地质图主图及与其相邻的柱状图、图切地质剖面图和成矿区带位置图缩略图，羊里尾沟金矿实体平面图、羊里尾沟金矿 505 勘探线剖面图、羊里尾沟金矿矿体产状三维示意图和巴藏幅 (I48E013009) 构造纲要图等角图位于其下方，受幅面限制未能显示。

2.6.3 主图的编制与完善过程

主图的基本要素类、综合要素类和对象要素类均继承自 DGSInfo (2010 版) 系统的空间数据库，如图框、河流、地名、岩性层、产状、断层、褶皱、节理、劈理、窗棂构造、皱纹线理、化石采样点、同位素年龄采样点、矿化蚀变、矿产。要求各地质、矿产要素的表示符合《区域地质图图例》(GB/T 958–2015)。

结合地质剖面测量数据实现岩石建造划分，并在主图区勾绘岩石建造界线；依据产状信息和建造展布特点勾绘褶皱构造轴迹，并编号注记，图面线型颜色为深灰色 (235 号色)；据前人调查成果和本次调查数据判断区域断裂的性质、几何学与运动学特征、矿化蚀变特点及其与成矿的关系，成矿构造因其中存在矿化蚀变而使其自然地得到突出表达；遵循岩层产状和《区域地质图图例》(GB/T 958–2015) 填绘岩石建造花纹；

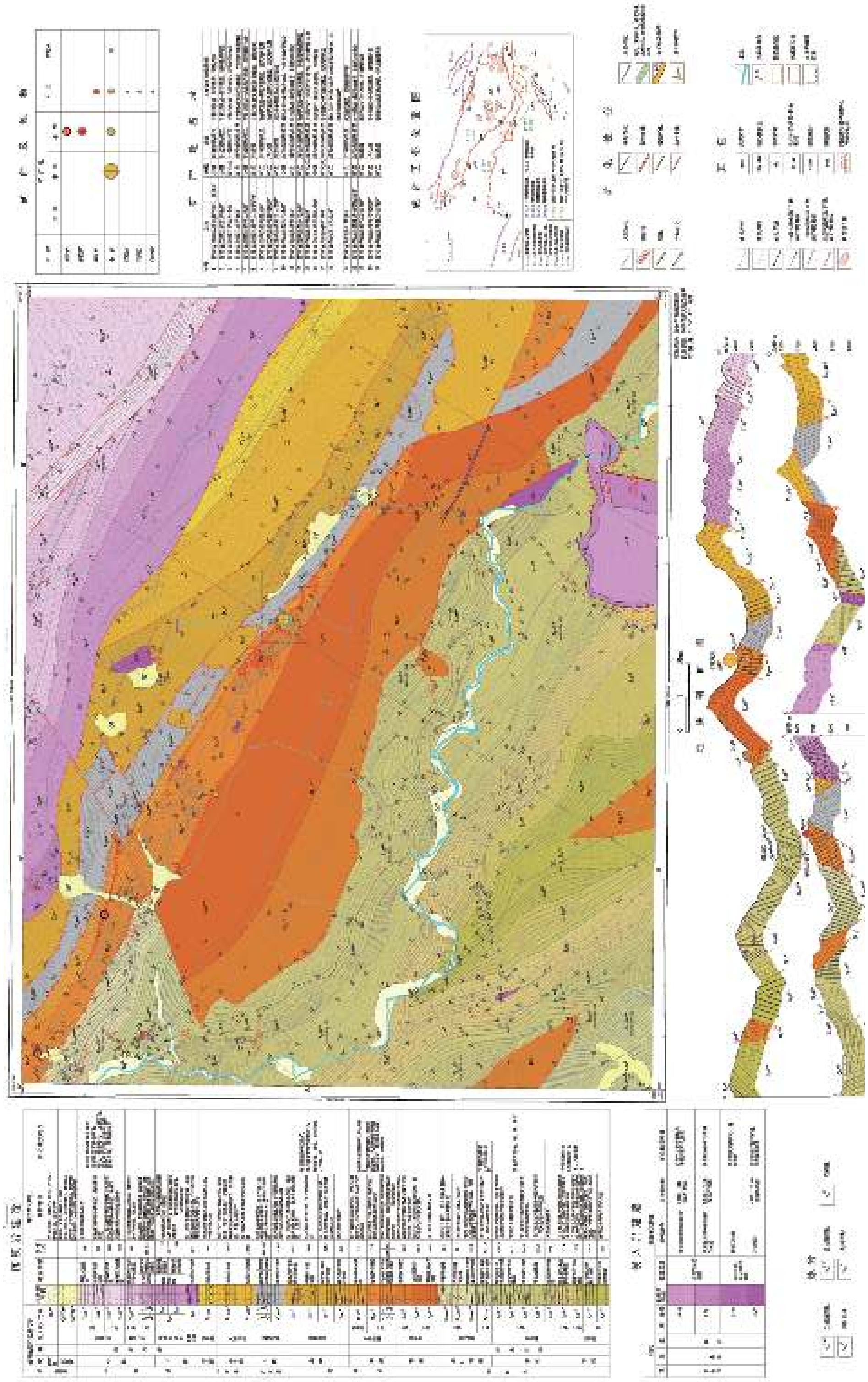

图 3 甘肃省 1：50 000 巴藏幅矿产地质图 (主体部分) 缩略图

要求矿产符号完整表达矿种、规模、找矿预测矿床类型和成矿时代。

2.6.4 独立要素类图件的编制或完善过程

独立要素类图件包括柱状图、图切剖面、典型矿床角图、构造纲要图和成矿区带位置图，成矿区带位置图形成于对既往数据的采集处理过程，此处只介绍其余 4 种独立要素类图件的编制过程。

柱状图：首先利用地质剖面测量数据重新划分岩石建造单元，并修正利用既往数据编制的岩石建造柱状图草图；其次，利用主图区的岩石建造圈定结果完善建造柱状图。在区域内共划分 40 个岩石建造填图单元，其中沉积岩岩石建造填图单元 38 个，侵入岩岩石建造填图单元 2 个，未确定变质岩岩石建造填图单元和火山岩岩石建造填图单元。建造单元的命名及其代码表达遵循《矿产地质调查成果图件编制指南 (1：50 000)》(讨论稿)“1：50 000 矿产地质图编图格式要求”中的规则。

图切地质剖面图：自北西至南东依次等间距布置 3 条图切剖面，使剖面通过岩浆侵入体或典型矿床羊里尾沟金矿和柴马山铁矿，并在地质剖面上标注了矿产地符号，以能更直观地表现矿产与地质构造的空间关系。剖面的垂直比例尺与水平比例尺相同，所示地形起伏与实地相同。

典型矿床角图：由羊里尾沟金矿实体平面图和羊里尾沟金矿 505 勘探线实体剖面图组成；实体平面图源于 1：2 000 羊里尾沟金矿区地质图，实体剖面图源于 1：500 羊里尾沟金矿 505 勘探线剖面图。图面客观地表达了金矿体与构造、岩石建造和矿化蚀变的关系，清晰地显示出金矿体产出于薄层灰岩与炭质板岩的过渡部位。

自选角图：利用野外观测的矿体产状数据绘制了羊里尾沟金矿矿体产状示意图，该图明确地显示矿床具有羽状构造控矿的特点，矿体在主要控矿断裂与次级羽状裂隙交汇部位增厚的成矿规律。

构造纲要图：在表达褶皱和断层的基础上，增加了区域隆起构造和侵入岩体信息，清晰地显示出区内有加里东期北西西向隆起、印支期北东向隆起和喜马拉雅期北西西向隆起构造变形，存在印支期北东向构造变形的依据是印支期闪长岩脉的北东向成带分布规律及其气球状底辟侵入形态 (图 4)，这一点补充了“秦岭上部地壳以东西向构造为主导”(张国伟等，1995) 的传统认识。

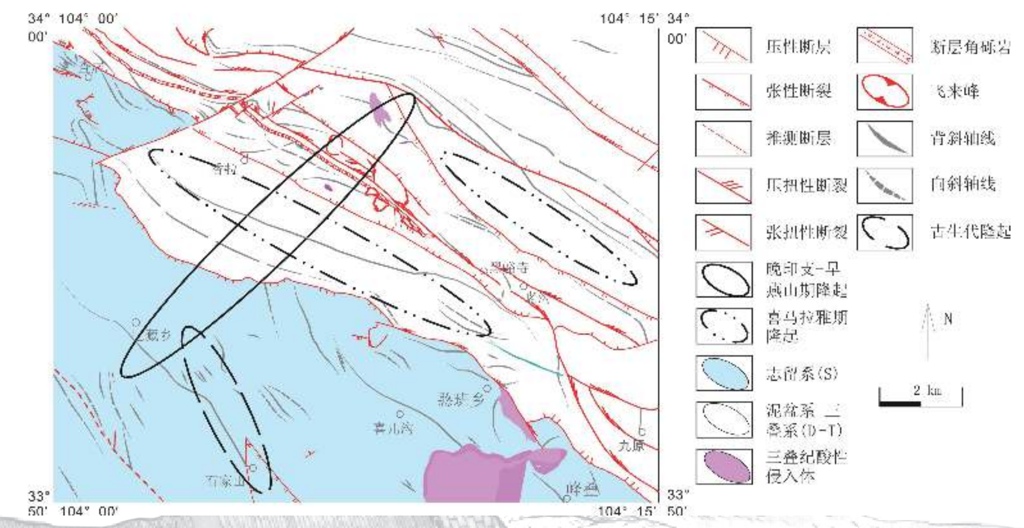

图 4 甘肃省巴藏幅构造纲要图

3 数据内容描述

MapGIS 元数据规定采集内容包括 12 个类目、113 项内容，其中 12 个类目中的数据库 (集) 名称、元数据创建日期、语种、数据质量信息、空间参照系信息前已述及，此处叙述数据库的图层设置、图层属性项及属性结构。

3.1 图层设置及其属性项

3.1.1 图层设置

甘肃省巴藏幅 (I48E013009)1：50 000 矿产地质图数据库图层按《矿产地质调查成果图件编制指南 (1：50 000)》(讨论稿)“1：50 000 矿产地质图数据模型”设置，矿产地质图图层结构与其“1：50 000 矿产地质图编图格式要求”相对应，由地理图层、建造构造图层、矿产地图层和整饰图层 4 部分组成 (表 3)。在主图区增设的图层有矿化蚀变 (.WT、.WL)、建造界线 (.WL)、居民地 (.WT)、地名 (.WT)、高程点 (.WT)、主要居民地 (.WT) 和井泉 (.WT)；在整饰图层图外部分增设了图名 (.WT) 图层以存储填图基本信息。

表 3 甘肃巴藏幅矿产地质图图层结构

图层类别	图层名称
地理图层	图框(.WT、.WL、.WP)、主要行政境界(.WL)、主要居民点(.WT)、主要面状水系(.WP)、主要线状水系(.WL)、主要地理标注(.WT)
建造构造图层	建造构造(.WP)、地质(界)线(.WL)、构造变形带(.WP)、褶皱(.WL)、断层(.WL)、产状要素(.WT)、重要钻孔(.WT)、化石样点(.WT)、同位素年龄(.WT)
矿产地图层	矿产地(.WT)
整饰图层图内部分	地质注记(.WT)、建造花纹(线)、指引线(.WL)、断层倾向倾角及断层性质(.WT)、产状倾角(.WT)、同位素注记(.WT)、图切剖面(.WT、.WL)、方里网(.WT、.WL)
整饰图层图外部分	接图表(.WL)、图例(.WT、.WL、.WP)、建造柱状图(.WT、.WL、.WP)、图切剖面(.WT、.WL、.WP)、典型矿区图件(.WT、.WL、.WP)、责任表(.WT、.WL)、图外其他整饰(.WT、.WL)
增设图层	矿化蚀变(DZKHSB.WT、DZKHSB.WL)、建造界线 (DZJZJX.WL)、居民地(DLJJBZ2K.WT)、地名(DLDMBZ.WT)、高程点(DLGCDBZ.WT)、主要居民地(DLJMDBZ.WT)和井泉(DLJQBZ.WT); 图名(MAP_NAME.WT)

带属性对象类文件有：建造构造 (_GeoPolygon.WP)、构造变形带 (_TECOZONE.WP)、地质 (界) 线 (_GEOLINE.WL)、褶皱 (_FOLD.WL)、断层 (_FAULT.WL)，其中构造变形带 (_TECOZONE.WP) 和重要钻孔 (_DRILLHOLE.W) 在本区域无实体图形数据。

带属性的基本要素类文件有：产状 (_ATTITUDE.WT)、化石样点 (_FOSSIL.WT)、同位素年龄 (_ISOTOPE.WT) 和矿产地 (_MINERAL_PNT.WT)，带属性的独立要素类文件为责任表 (DUTY_TABLE.WT) 和图名 (MAP_NAME.WT)。

主图区各要素类图层的空间展布状况如图 3 所示，全图形成数据库记录数为：产状 811 条、同位素年龄 5 条、化石采样点 2 条、矿产地 21 条、地质界线 102 条、矿化蚀变 22 条、断层 86 条、褶皱 111 条、建造构造 65 条。其中同位素年龄均为岩体或岩脉的锆石 U–Pb 法测年数据；矿产信息中，新增了本次新发现的矿点或矿化线索 8 处。

3.1.2 带属性图层的属性项及属性结构

各图层的属性项及属性结构按《矿产地质调查成果图件编制指南 (1：50 000)》(讨

论稿)“1∶50 000 矿产地质图数据模型”设置。

3.1.3 综合要素类整饰图层

该类图层不带属性，有标准图框 (FRAME.WT、FRAME.WL、FRAME.WP)、建造花纹 (A_ZSNYSJZ.WL、A_ZSNYSJZ.WT)、图切剖面 (a_PROFILE.WL、a_PROFILE.WT)。

3.1.4 独立要素类图层

该部分图层中仅责任表 (DUTY_TABLE.WT) 带属性；除此而外的下列图层均不带属性：图例 (LEGEND.WT、LEGEND.WL、LEGEND.WP)、建造柱状图 (COLUMNAR_SECTION.WT、COLUMNAR_SECTION.WL、COLUMNAR_SECTION.WP)、图切剖面 (CUTTING_PROFILE.WT、CUTTING_PROFILE.WL、CUTTING_PROFILE.WP)、典型矿区图件 (TYPICAL DEPOSITS.WT、TYPICAL DEPOSITS.WL、TYPICAL DEPOSITS.WP)、图外其他整饰 (OTHER MODIFY.WT、OTHER MODIFY.WL、OTHER MODIFY.WP)。

4 数据质量的控制与评估

该数据库严格遵照《矿产地质调查成果图件编制指南 (1∶50 000)》(讨论稿)“1∶50 000 矿产地质图数据模型”和“1∶50 000 矿产地质图编图格式要求”创建，先后经历了自检、互检、抽检，以及甘肃省资源厅专家和自然资源部专家的审查，作者根据专家意见进行了修改，最终由自然资源部主管领导随“甘肃崖湾—大桥金锑矿整装勘查区矿产调查与找矿预测 (巴藏幅)1∶50 000 矿产地质调查报告”一起审定。内容丰富、详实可靠、数据完整。

2018 年 7 月—8 月，经甘肃省自然资源厅专家和自然资源部专家评审后，按照评审意见进行了规范化制作。

2019 年 3 月 12 日，中国地质调查局组织专家对“甘肃崖湾—大桥地区金锑矿整装勘查区矿产调查与找矿预测 (巴藏幅)1∶50 000 矿产地质调查报告”进行了评审，被评定为优秀级。其中针对数据库的评审意见是“数据较完整，逻辑一致性、空间定位准确”。

5 数据价值

该图幅对象类数据、基本要素类数据和独立要素类数据在基础地质与成矿规律研究方面具有重要价值，同时对象类数据在工程地质、环境地质等领域具有应用价值。

5.1 新发现的地质现象

5.1.1 侵入岩

憨班岩株被划分为内、中、外 3 个带，外带为闪长玢岩 (δuT)，中带为中细粒花岗闪长岩，内带为似斑状花岗闪长岩；黑峪沟岩体的形态显著改变，并被确定为闪长玢岩。新发现闪长岩脉若干条，并且自图幅西南的得力坎至图幅北部的黑峪沟一带，岩脉的形态均呈气球状底辟侵入的形态，该类岩脉的成岩年龄为 (212±1.4) Ma[5]，指示该区域存在印支期北东向隆起构造 (图 4)。

5.1.2 断层

在下泥盆统当多组与志留系舟曲之间发现呈带状存在的杆状构造，进而将该 NWW 向不整合面确定为断层。填图过程中新发现断层若干条，其中新发现的“香拉东

平移正断层”等北东向断层与已知同向正断层形成了完整的地垒构造组合。

5.1.3 褶皱

图幅南部志留系中褶皱轴迹线的走向为北北西向，图幅北部的晚古生代—三叠纪地层中的褶皱轴迹线走向有近东西向和北西向 2 组。显示图幅南部的志留系与图幅北部的上古生界—三叠系属于 2 个构造层 (图 4)，为南秦岭存在加里东期造山运动提供了证据，进而对“晚加里东—早海西期南秦岭呈现碰撞闭合不造山”传统认识 (杜远生等，1997；王根宝等，1998) 提出了质疑。

5.1.4 铁质结核与风暴沉积

在图幅西北部香拉一带的下石炭统益哇沟组泥质板岩建造 (C_1yw^b) 中发现同生含铁质结核层，结核呈椭圆状，直径 0.2 ~ 1 m 不等，目估结核的主要成分为泥质，褐铁矿含量约 20%(图 5)，目前尚无其他金属元素的测试结果。类似的锰结核是洋盆扩张到最大程度时的沉积 (彭东等，2011)，结核形成的过程中热液作用影响有限 (何高文等，2011)，但有效地记录了古海洋环境演变的信息，是古海洋学、矿物成因学等方向重要的研究对象 (于淼等，2018)。

在黑水沟上–顶志留统泥质板岩夹中厚层灰岩建造中发现含软体动物化石碎块的风暴沉积 (图 6)，岩石基体为黄褐色泥岩，化石碎块呈杂乱无序状态分散于泥岩中，相当于海相风暴沉积岩的 A 段 (田景春等，2014；郑宁等，2010)。风暴作用具有一定的区域性，与其时代相近的风暴沉积岩有米仓山南缘中志留统罗惹坪组风暴岩 (白志强等，2015)。

图 5 巴藏幅香拉下石炭统益哇沟组中的铁质结核

图 6 巴藏幅黑水沟含软体动物化石碎块的风暴沉积

5.1.5 矿 (化) 点

新发现金属及非金属矿 (化) 点 8 处，分别是各皂金矿、赛布金矿、各岭磨金矿、巴藏金矿、查阿白云岩矿、柴马山石英岩、磨沟红柱石矿和峰叠红柱石矿。其中的峰叠红柱石矿的出露宽度达 500 m，规模巨大，产状稳定，不利之处是矿体下方为舟曲水电站地下涵洞。

5.2 新认识

5.2.1 岩石建造与含矿建造

区内共划分 40 个岩石建造填图单元，其中沉积岩岩石建造填图单元 38 个，侵入岩岩石建造填图单元 2 个，对出露的区域变质岩、接触变质岩和动力变质岩，均再未单独划分岩石建造。含矿岩石建造是区域成矿学研究中的一项重要内容 (翟裕生等，2001)，

也是《矿产地质调查成果图件编制指南 (1：50 000)》规定的基本填图单元。羊里尾沟金矿的含矿建造在平面上表现为下吾拉组炭质板岩–薄层灰岩建造，金矿体赋存于该岩石建造与下伏岩层下石炭统厚层灰岩建造间的断层接触带，或该建造中的切层裂隙中 (图 7)，与含矿建造毗邻的岩石组合为中厚层灰岩建造 (D_1d^1) 和砂岩建造，两者均不含矿。

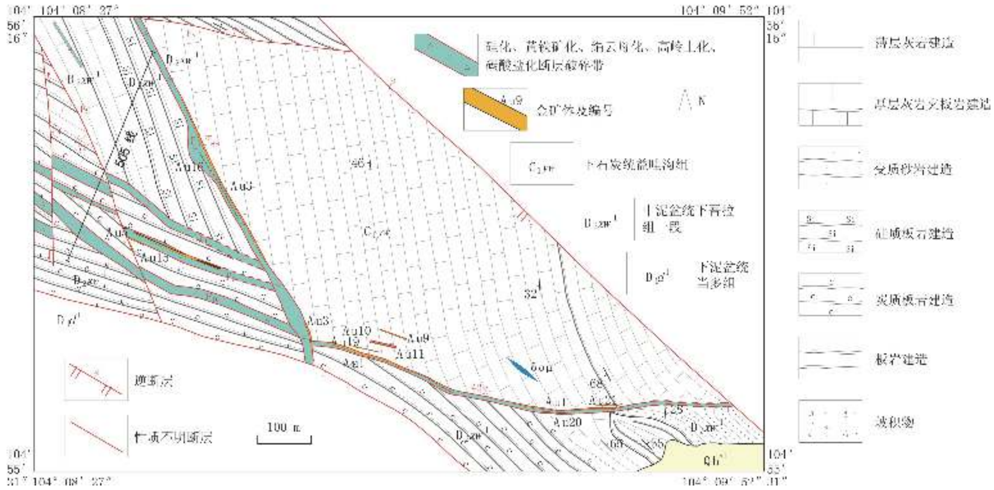

图 7　羊里尾沟金矿含矿建造示意图

5.2.2　隆起构造

识别出 4 处隆起构造：石家山泥盆纪北北西向隆起；巴藏–黑峪沟晚三叠世北东向隆起；黑水沟–憨班喜马拉雅期北西西向隆起和四林场二工段北西西向隆起 (图 4)。

5.2.3　褶皱

褶皱轴面倾向有北东、南西、北、西 4 组，但以倾向北东和南西为主。轴面倾向北、北北东、南南西的 3 组褶皱，属于印支期以来的变形。中泥盆统的褶皱轴面倾向南、南东，是南北向挤压、东西向挤压及北西–南东向挤压的产物。下泥盆统和下石炭统的褶皱轴面倾向北，属于东西向挤压变形。下志留统–上志留统的褶皱变形基本一致，轴面倾向南西西 (走向北北西，图 4)，为加里东期南西西–北东东向挤压变形的产物，也是存在加里东期造山运动的证据。

根据褶皱轴迹线展布方向的一致性及轴迹线的集中程度，在全图幅可以识别出 3 个褶皱组合：石家山复背斜、四林检查站复背斜和朱各沟复向斜。

5.2.4　断层

有 4 组共轭的断层：即倾向北北东–南南西、南西–北东、北西–南东、北西西–南东东和一组倾向北东东的断层面。切割三叠系的断面倾向有北西、北东东、南东东、南南西、南西 5 组，表明该 5 组断层面属于印支期后构造变形的产物或着早期断层在印支期后又重新活动。前人研究证明，北西西–近东西向深大断裂是最早形成的主干断裂，属华北、扬子 2 大板块在新元古代–三叠纪分别沿商丹、勉略缝合带南北向俯冲碰撞的产物 (张翔等，2019)。总体来讲，切割三叠系的断层产状表明其为印支期后定型的构造。

断层构造组合有 4 种：石家山早泥盆世古地堑、香拉北早石炭世古地垒、四林场检查站背冲式构造和朱各沟前展式逆冲推覆构造。

5.2.5　矿床成矿构造、成矿结构面及成矿构造机制

柴马山菱铁矿矿体的成矿构造为菱铁矿化灰质角砾岩代表的层间挤压破碎带，矿脉充填于透镜状灰岩中的网状裂隙系统。赤铁矿矿体的成矿构造为赤铁矿化碎裂白云岩透

镜体，也与层间挤压有关。部分矿体存在于灰岩—砂岩的过渡地带，部分矿体存在于中厚层灰岩内，与氧化–还原障和酸碱障有关。

羊里尾沟金矿的成矿构造是北西—近东西向弧形构造及其次级裂隙组成的羽状构造(图 8)；成矿结构面明显具有“硅钙面”成矿特征。

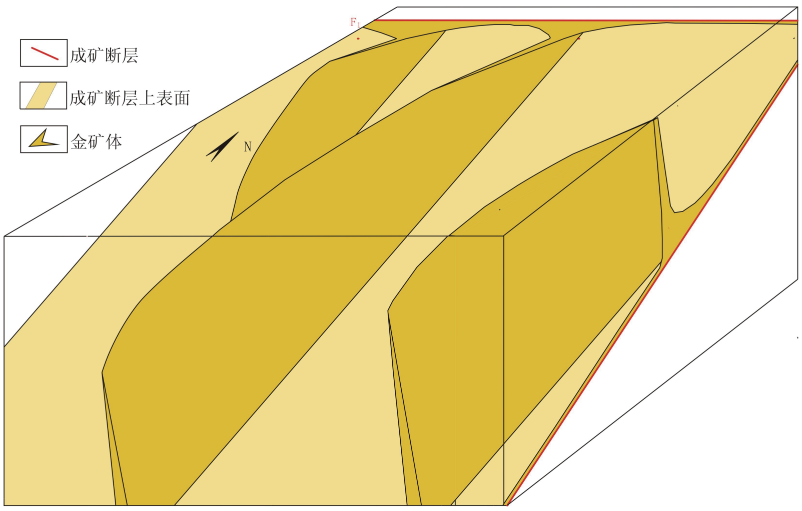

图 8　羊里尾沟金矿矿体产状示意图

5.2.6　环境地质问题

自羊里尾沟金矿至老沟金矿，金矿点密布，矿石伴生组分中有害元素砷含量较高，存在环境污染的潜在威胁。

6　结论

(1) 数据库采用数据为巴藏幅 1：50 000 区域地质草图、羊里尾沟金矿等已知矿产 1：10 000 矿区地质图、巴藏幅 1：50 000 区域地质调查实际材料图和巴藏幅 1：50 000 矿产地质调查专项填图野外采集数据，数据采集全面完整。

(2) 图面以主图和角图相结合地方式全面客观地表达了区域地质界线、岩石建造、年代、断层、褶皱轴迹、节理、劈理、皱纹线理、窗棂构造、矿化蚀变、矿产信息及羊里尾沟金矿的成矿地质特征及对应的地理信息，内容丰富。

(3) 数据库是在三位一体找矿预测地质模型的指导下创建的，在“建造构造”图层的属性中强调了含矿建造、蚀变等内容，在断层图层及褶皱构造图层的属性中强调了成矿构造。除矿产信息图层外，新增了“矿化蚀变”图层，使成矿要素的表达更加完善。

(4) 在侵入岩、断层、褶皱、铁锰结核与风暴沉积、矿 (化) 点等 5 方面取得新发现，在岩石建造与含矿建造、隆起构造、褶皱、断层、矿床成矿构造和环境地质问题方面取得新认识。

(5) 区域地质现象丰富，属性数据的描述质量较高，不仅可以被用来研究区域成矿规律、评价区域或勘查区矿产资源，而且为基础地质及工程地质、环境地质等领域的调查研究工作提供了基础资料，可供使用者根据需求实现本图幅区域基础地质信息和矿产成矿信息的检索。

致谢：该数据库是甘肃省地质调查院“甘肃崖湾—大桥金锑矿整装勘查区矿产调查与找矿预测 (巴藏幅)1：50 000 矿产地质调查”项目组相关人员辛勤努力的成果，工作

过程中，先后多次得到甘肃省地质调查院、甘肃省国土资源厅和自然资源部专家的检查指导，提出了许多宝贵意见，在此一并表示感谢!

注释：

❶ 甘肃省地质调查院. 2009. 1：250 000 岷县幅构造建造图 [R].
❷ 甘肃省地质调查院. 2009. 1：250 000 武都幅构造建造图 [R].
❸ 甘肃省地质调查院. 2016. 甘肃省任藏 (I48E01 2009)、巴藏 (I48E013009)、大草坡 (I48E014009) 三幅区域地质调查报告 [R].
❹ 陕西省地质局区域地质测量队. 1969. 1：200 000 I–48–(21) 武都幅地质图 [R].
❺ 甘肃省地质调查院. 2016. 甘肃崖湾—大桥地区金锑矿整装勘查区专项填图与技术应用示范子项目报告 [R].
❻ 甘肃省地质调查院. 2015. 巴藏幅 (I48E013009)1：50 000 区调实际材料图 [R].
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❽ 甘肃省地质调查院. 2012. 甘肃省区域成矿规律图 [R].
❾ 陕西省地质局区域地质测量队. 1969. 1：200 000 I–48–(21) 武都幅矿产图 [R].

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Dataset Citation: He Jinzhong; Lyu Chuanyuan; Cao Hailong; Zhang Xiangnian; Wu Ling; Niu Pengfei. 1∶50 000 Mineral Geological Map Database of the Bazang Map-sheet, Gansu(V1). Gansu Institute of Geological Survey; The Third Geological Mineral Exploration Institute of Gansu Provincial Geology and Mineral Bureau; The Second Geological Mineral Exploration Institute of Gansu Provincial Geology and Mineral Bureau[producer], 2016. National Geological Archives of China[distributor], 2020-12-30. 10.35080/data.C.2020.P29; http://dcc.cgs.gov.cn/en//geologicalData/details/doi/10.35080/data.C.2020.P29.

1∶50 000 Mineral Geological Map Database of the Bazang Map-sheet, Gansu

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Abstract: The 1∶50 000 mineral geological map database of the Bazang Map-sheet (I48E013009), Gansu was compiled under the guidance of the *Guide for Compiling Maps of Mineral Geological Survey Results* (draft for discussion) and the three-in-one ore prospecting prediction geological model. The collected data include the previous 1∶50 000 regional geological survey primitive data maps, mineral investigation reports, scientific research reports, academic papers, and gathered data in the 1∶50 000 specific mapping. Data records include 811 entries on attitude, 102 on geological boundary, 5 on isotopic age, 2 on fossil, 21 on mineral information, 22 on mineralization alteration, 86 on fault, 111 on fold, and 65 on formation. The map face is a combination of the master map and corner maps to give a full, objective presentation of the regional geological boundaries, rock formations, eras, faults, fold axial traces, joints, cleavages, wrinkle lineations, mullion structures, fault plane striations, mineralization alterations, mineral information, and the metallogenic geology of typical deposits, covering the Caledonian storm deposits and fold deformations, Early Carboniferous ferruginous nodules, and a series of new discoveries and new understandings. In the attributes of the "formation-structure" layer, ore-bearing formations and mineralization alterations are emphasized. In the "fault" layer and "fold" structure layer, ore-forming structures are emphasized. The database provides basic data for the investigation and research of regional metallogenesis as well as engineering geology and environmental geology, and can be retrieved by users whenever so needed. The data volume of the Bazang Map-sheet is

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approximately 90.2 MB for the MapGIS spatial database and 2.51 MB for the Access database.

Key words: mineral geological map; database; Caledonian fold; iron-manganese nodule; storm deposit; ore-bearing formation; ore-forming formation; mineralization alteration; Geological survey engineering; Gansu

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

1 Introduction

The tectonic unit hosting the Bazang Map-sheet (I48E013009) is the Qinling arc basin system (IV–10) of the Qinling–Qilian–Kunlun orogenic system (IV), located at the transition between the Zeku foreland basin (IV–10–5) and the South Qinling epicontinental rift (IV–10–6), with its main body in the South Qinling epicontinental rift zone. It also traverses the two metallogenic subzones of the West Qinling Pb–Zn–Fe–Cu–Au–Sb–Hg metallogenic zone (III–28), which are the Xiahe–Liangdang Au–Sb–Hg metallogenic subzone (IV–28③, Fig. 1) and the Luqu–Guangjinba Au–Sb–Hg–As–Cu–V–U–Se metallogenic subzone (IV–28④, Fig. 1).

The earliest geological literature covering this area is the *Geological Annuals of Central South Gansu* (Ye LJ and Guan SC, 1945). Subsequent geological workers have confirmed the strata names and characteristics of the Diebu, Zhouqu, Zhuowukuo, and Dangduo formations (Regional Geological Survey Brigade of Gansu Provincial Geology and Mineral Bureau, 1986; Gansu Provincial Geology and Mineral Bureau, 1997; Cao XD et al., 1990), unified the designations of some of the stratigraphic rock formations[1,2], performed multi-stratigraphic division and comparison, and determined the mapping units and 11 non-formal mapping units[3]. The present mineral survey-specific mapping of the Bazang Map-sheet (I48E013009) is totally based on the lithostratigraphic mapping units determined by the *1：50 000 Regional*

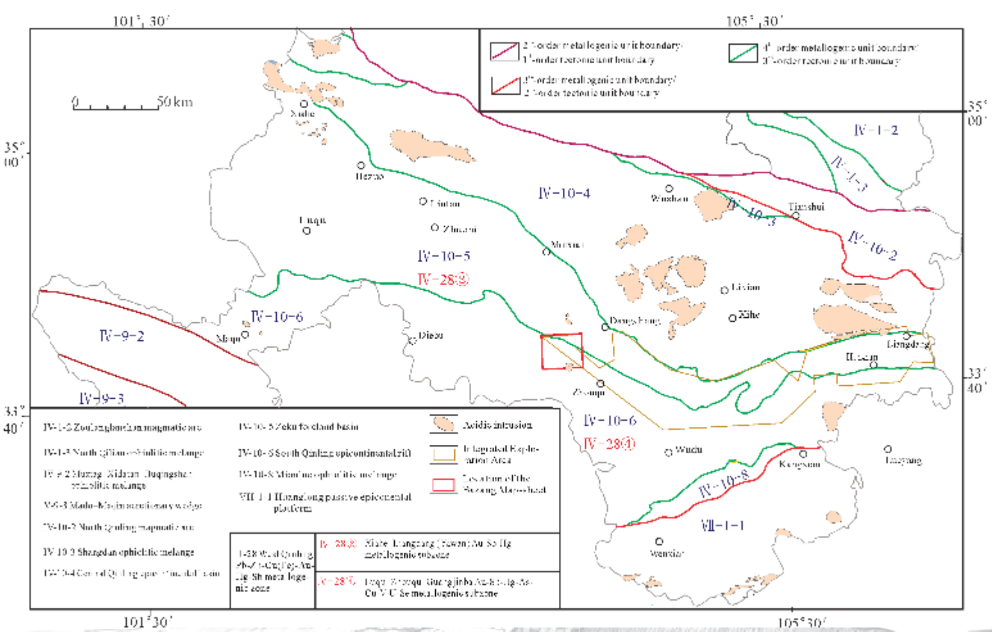

Fig. 1 Metallogenic zone location map of the 1：50 000 mineral geological map of the Bazang Map-sheet, Gansu

Geological Survey of the Bazang Map-Sheet (*I48E013009*).

The earliest record of intrusive rock bodies is found in the 1 ∶ 200 000 geological map of the Wudu Map-sheet (I–48–(21))❹, which delineates five stocks. Subsequent work❷❸❺ has rejected the Sare'ailiang granodiorite stock, determined the Hanban pluton as granodiorite and divided it into an inner zone and an outer zone. The zircon U–Pb ages of the Hanban pluton and the Heiyugou pluton were dated to be 212±1.4 Ma and 213±1.2 Ma, respectively (Liu MQ, 2012)❺. The Delikan granodiorite stock was determined to be a tonalite stock ($\gamma\delta o$). Exposed metamorphic rocks include regional metamorphic rocks, contact metamorphic rocks and dynamic metamorphic rocks.

Folds are quite developed. Divided by the Congdi–Sanshengyeliang fault, to the north is the Luqu–Chengxian inverted syncline structure, and to the south is the Bailongjiang complex anticline structural zone. By nature, the faults can be grouped into normal faults, reverse faults, and translational faults. By extension direction, they can be categorized into NW, NWW, NE, and NNW faults. NW and NNW faults are more developed with large scale and far extension. They constitute the basic framework of the fault structures in the work area (Li YD, 1994).

Previous work has discovered 13 gold and iron deposits (spots), and gold is the main mineral species in this area (Wang DH et al., 2014, 2015; Li HR et al., 2011; Feng YZ and Li YD, 2005; Zhang FX et al., 2003; Hu RZ et al., 2002; Li TG, 2001; Tian LL et al., 2003; Zhang FX and Yu L, 2002; TG and Xie JQ, 1998; Tan GY, 1992).

The mineral geological map database of the Bazang Map-sheet (I48E013009), Gasu (He JZ et al., 2020) reflects the result of comprehensive research into previous findings and the data of the present mineral geological survey under the guidance of the three-in-one ore prospecting prediction geological model (Ye TZ et al., 2014). Table 1 gives the main characteristic data of the metadata of the database.

2 Data Acquisition and Processing Method

2.1 Data Source and Acquisition–Processing Flow

The collected data are made up of previous data and specific mapping data. The former include regional geological profile maps (1 ∶ 2 000 and 1 ∶ 5 000)❻ of the Bazang Map-sheet, regional geological sketch map❻ of the Bazang Map-sheet (1 ∶ 50 000), general geological survey report❼ of the Yangliweigou gold deposit (1 ∶ 10 000), and the 1 ∶ 50 000 topographic map of the Bazang Map-sheet and administrative division map of Gansu province❽. The latter include field acquisition route data (1 ∶ 50 000) and comprehensive geological profile survey data (1 ∶ 2 000). Fig. 2 shows the data acquisition and processing flowchart.

2.2 Acquisition-Processing of Previous Data and Generation of Background Layer

To make the previous data easier for the specific mapping workers to reference, they were acquired and processed into background layer data that can be used in the digital mapping system (Li CL, 2011). By processing the previous data, the geographic base map layer, formation–structure sketch map layer, mineral information layer, mineralization alteration

Table 1 Metadata Table of Database (Dataset)

Items	Description
Database (dataset) name	1：50 000 Mineral Geological Map Database of the Bazang Map-sheet (I48E013009), Gansu
Database (dataset) authors	He Jinzhong, Gansu Institute of Geological Survey, field data acquisition and entry, data quality check Lyu Chuanyuan, The Third Geological Mineral Exploration Institute of Gansu Provincial Geology and Mineral Bureau, field data acquisition Cao Hailong, Gansu Institute of Geological Survey, field data acquisition & reorganization of some of the routes Zhang Xiangnian, Gansu Institute of Geological Survey, field data acquisition Wu Ling, The Second Geological Mineral Exploration Institute of Gansu Provincial Geology and Mineral Bureau, graphic data acquisition Niu Pengfei, Gansu Institute of Geological Survey, data quality check
Data acquisition time	Jun 2016–Mar 2019
Geographical area	104°–104°15′ E; 33°50′–34° N
Data format	MapGIS 6.7(*.WT, *.WL, *.WP)
Data size	90.2 MB
Data service system URL	http://dcc.cgs.gov.cn
Fund project	China Geological Survey Project *Mineral Survey and Prospecting Prediction of the Integrated Exploration Area of Gold Antimony Deposits in Yawan–Daqiao*, *Gansu* (No.: 121 201 004 000 150 017–35)
Language	Chinese
Database (dataset) composition	Basic feature classes include geological (boundary) lines, rivers/reservior shorelines, dykes (spots), mineral deposits (ore occurrences), attitudes, samples, isotopic sampling points, and fossils. Comprehensive feature classes include standard map frames (internal map frames), rock formation patterns, and transverse cutting profiles. Independent feature classes include duty tables, index maps, legends, integrated columnar sections, transverse cutting profiles, typical deposit corner maps, and other auxiliary maps (tectonic outline maps and metallogenic zone location maps). Object classes include faults, folds, formations and structure (planes), mineralization alterations, and basic information of the Map-sheet

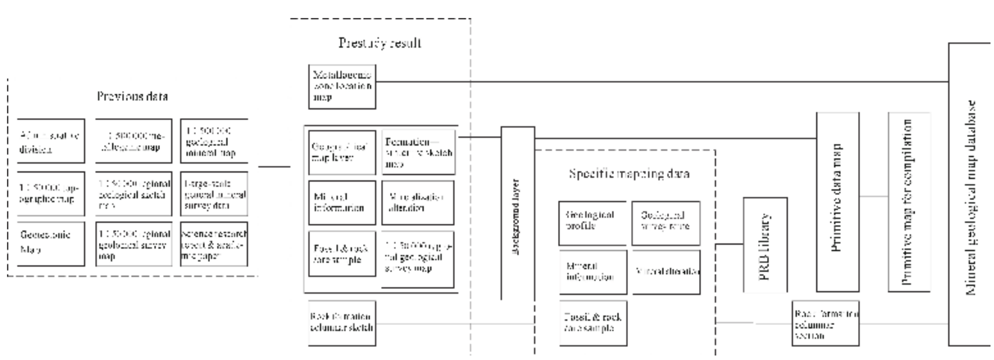

Fig. 2 Data acquisition and processing flowchart of the Bazang Map-sheet, Gansu

layer, isotopic sampling layer, fossil layer, as well as the rock-ore sample layer, rock formation columnar sketch map layer, and metallogenic zone location map layer were yielded. The remaining mapping content was left undone until the specific mapping data were obtained. The scale of the graphic files is 1∶50 000.

2.2.1 Geographic Base Map

A 1∶50 000 standard map frame of the Bazang Map-sheet (I48E013009) matching the 1∶50 000 topographic map was generated under the MapGIS6.7 system,, using the Gauss Kruger projection parameters and the Xi'an 80 coordinate system. After the mineral geological map had been compiled, it was converted into the National Geodetic Coordinate System 2000 all together.

Surface feature and settlement information were extracted from the 1∶50 000 topographic map of the Bazang Map-sheet (I48E013009).

Administrative division and road information were extracted from the latest edition of the administrative division map of Gansu province[8].

2.2.2 Formation–Structure Sketch Map

This map is composed of the regional geological sketch map (1∶50 000)[3], regional geological survey primitive data map (1∶50 000)[6], mapping route survey data, geological profile survey data, and rock formation pattern of key routes. In addition to fully inheriting the 1∶50 000 regional geological survey result, the geological boundaries of the rock formations or members in the corresponding areas were revised based on the general mineral survey result of the Yangliweigou gold deposit and other deposits. The rock formation pattern was provided only for some of the mapping routes and geological profiles. Rock formations were briefly marked off in these rock formations or members. As these rock formations cannot be used as reliable basis for rock formation mapping units, they are not assigned a rock formation unit code. Overall, the map face is presented as "geological boundary + lithostratigraphic unit and its code + rock formation pattern of the route + geological profile line + geological observation point + fossil and rock/ore sampling point".

Data layers include geological boundary, fault, rock formation pattern, geological profile, RPB library file, fossil sampling point, rock chemical sample collecting point, and isotopic sample collecting point. The symbol parameters in the point, line, and areal files of each layer are set precisely in accordance with the *Geological Legends Used for Regional Geological Maps* (GB/T 958–2015). Additional annotations were provided for geological profiles, geological observation points, and various sampling points. The graphic attributes are totally inherited from the digital mineral survey system for Android (RgMapforAndroid 4.x).

2.2.3 Mineral Information

The mineral information and the mineral sites—the Yangliweigou gold deposit, Heiyugou gold deposit, Laogou gold deposit, and Heishuigou gold deposit—in the regional metallogenic map of Gansu province[8] were projected into the Bazang Map-sheet at the 1∶50 000 scale and the corresponding projection parameters, and mineral layer files were produced. The graphic parameters in individual layer files are set precisely in accordance with the *Geological Legends Used for Regional Geological Maps* (GB/T 958–2015) or the *National Mineral Resource Potential Evaluation Data Model: Volume of Unified Legend Provisions* (V3.10).

2.2.4 Mineralization Alteration

Mineralization alteration information was gathered from the 1∶50 000 regional geological sketch map[3], 1∶200 000 mineral geological map of the Wudu Map-sheet[9], and the general mineral survey reports of the Yangliweigou gold deposit[7], Heiyugou gold deposit, Laogou gold deposit, and Heishuigou gold deposit. By choosing the corresponding MapGIS file type according to the spatial extension of the mineralization alteration information, point (.WT) files were generated with alterations existing in scattered form. Line (.WL) files were generated with alterations existing in linear form. Finally, the files were projected into the Bazang map at the 1∶50 000 scale and the corresponding projection parameters.

2.2.5 Fossil and Rock/Ore Samples

Point files were generated for individual fossil sampling points, rock chemical sample collecting points, and isotopic sample collecting points, using the symbols and marking methods identified by the *Geological Legends Used for Regional Geological Maps* (GB/T 958–2015). Data come from the 1∶50 000 regional geological survey primitive data map[6], the report of the specific mapping and technical application demonstration subproject of the Yawan–Daqiao integrated exploration area of gold antimony deposits, Gansu[5], and academic papers (Liu MQ, 2012).

2.2.6 Rock Formation Columnar Sketch

Based on brief research of the geological profiles and geological survey routes collected, a regional rock formation columnar sketch was preliminarily created. The color and pattern of the rock formation units follow the rules prescribed in the *Geological Legends Used for Regional Geological Maps* (GB/T 958–2015) and the “Format requirements for compiling 1∶50 000 mineral geological maps” in the *Guide for Compiling Maps of Mineral Geological Survey Results* (*1∶50 000*) (draft for discussion).

2.2.7 Metallogenic Zone Location Map

Data are sourced from the metallogenic map of Gansu province[8]. Intermediate-acidic intrusive rock bodies are added according to the “Format requirements for compiling 1∶50 000 mineral geological maps” in the *Guide for Compiling Maps of Mineral Geological Survey Results* (*1∶50 000*) (draft for discussion).

2.2.8 Generating Background Layer

The geographic base map layer, formation-structure sketch map layer, mineral information layer, mineralization alteration layer, isotopic sampling point layer, fossil layer, and the rock-ore sample layer and rock formation columnar sketch layer were included into one same folder or copied altogether into DGSData’s background layer folder.

2.3 Data Acquisition and Processing in Specific Mapping

2.3.1 Data Format Conversion

The defaulted data format of the palmtop digital geological survey system RgMapforAndroid 4.x is DGSGIS. Before starting field work, it is necessary to create a work data directory and a work area in the DGSInfo (2016 version) system for PC, convert the format of the background layer files (MapGIS–DGSGIS), design the field work route, and transfer the designed field work route files into the designated folders in the palmtop memory.

The digital geological survey system DGSInfo (2010 version), which is convenient for processing MapGIS format files, was used for indoor data processing. Data obtained with the palmtop digital geological system RgMapforAndroid 4.x had to be converted into MapGIS format files with DGSInfo (2016 version) before they were copied into the respective folders of the DGSInfo (2010 version) system.

2.3.2 Integrated Geological Profile Surveying

During field work, the palmtop system was mainly used to obtain positioning information and sample collection information, and briefly record some geological phenomena and observation data. Both profile survey data and geological phenomena were recorded in detail in a field log book and entered in the DGSInfor (2010 version) system indoors. The data were input into the database after rock and ore identification data were added and passed the system check.

2.3.3 Route Geological Survey Data

The geographic information data of geological points (P), inter-point routes (R), and geological boundaries (B) were all obtained on the spot. Geological records were partly digitally recorded on the spot and partly recorded in the field log book, and were supplemented indoor in the DGSInfo (2010 version) system. They were not entered into the database until making sure that each geological route was completed and data were correct.

2.4 Creating Map and Primitive Map for Compilation

The primitive data map is composed of the map name, scale, index map, map frame, master map zone, legend, and duty bar. The master map zone comprises geological profiles, geological survey routes, high-accuracy airborne magnetic survey profiles, rock and ore samples, isotopic age samples, fossils, anomaly verification work areas and geological sketch maps.

In the DGSInfo (2010 version) system, based on the PRB library files, the survey route data, geological profile data and rock-ore sample data formed in the specific mapping were combined with the background layer files into a primitive data map. Previous data and specific mapping data were presented in different colors.

The primitive data map was used to generate a primitive map for compilation. In the primitive map for compilation, based on the geological sketch map, the boundaries of faults and rock formations or members were plotted and revised. In the rock formations or members, lithologic layers were plotted, dykes and other special geobodies were delineated, and additional mineralization alteration and mineral information were implemented using geological profile data and route geological survey data.

2.5 Creating Spatial Database

In the DGSInfo (2010 version) system, based on the primitive map for compilation, a spatial database was established for basic feature classes, comprehensive feature classes, and object feature classes according to the operational flowchart for building spatial databases (Li CL et al., 2011).

2.6 Creating Mineral Geological Map Database

2.6.1 Database Architecture and Spatial Reference System

The 1 ∶ 50 000 mineral geological map database of the Bazang Map-sheet (I48E013009), Gansu was prepared in a four-level directory framework according to the “1 ∶ 50 000 mineral geological map data model” in the *Guide for Compiling Maps of Mineral Geological Survey Results* (*1 ∶ 50 000*) (draft for discussion) (Table 2).

The elevation system is the Yellow Sea Elevation System 1956, the projection parameters are the National Geodetic Coordinate System 2000 (for field work, the Xi’an 80 Coordinate System is used), and the magnetic declination is 3°35′41″ to the west.

2.6.2 Mineral Geological Map

Subject to the “Format requirements for compiling 1 ∶ 50 000 mineral geological maps” in the *Guide for Compiling Maps of Mineral Geological Survey Results* (*1 ∶ 50 000*) (draft for discussion), the scheme of the present mineral geological map was moderately adjusted according to the rock formations of the Map-sheet and to facilitate map reading. The map face is composed of the master map, sedimentary rock formation columnar sections, intrusive rock formation columnar sections, transverse cutting profile maps, corner maps, mineral site directories, and legends. Fig. 3 shows the thumbnail of the master map, the adjacent columnar section, transverse cutting profile map and metallogenic zone location map. The physical plane map of the Yangliweigou gold deposit, the profile map of exploration line 505 of the Yangliweigou gold deposit, the 3D schematic view of the orebody attitude of the Yangliweigou gold deposit, the tectonic outline map of the Bazang Map-sheet (I48E013009) and other corner maps are located below the master map, but they are not displayed in the map (Fig. 3) due to space limitation.

2.6.3 Compilation and Refinement of the Master Map

All basic feature classes, comprehensive feature classes, and object classes of the master

Table 2 Directory for submission of the result map database

L1 Directory	L2 Directory	L3 Directory	File Name	Description
I48E013009 Result database	I48E013009 Mineral geological map	MAP	-Geopolygon.WP -Geoline ……	Used for total-feature graphic data, engineering files & map finishing files outputted. Origin at bottom left corner, bottom level
		MAPGISGauss (Beijing, Xi’an, 2000)	-Geopolygon.WP -Geoline ……	All feature class files named per standard and with projection parameters
			METADATA of the mineral geological map.XML	Metadata file
	MDB		BASE-FCLS.MDB DSGMAP.MDB SYNTH-FCLS.MDB	Feature class, object class access files
	README		LEGEND	Annotations of scheme & legend and added contents in SLIB
			ADD-LAYER	Annotations of added layers
			Quality check sheet	Record of self-check, mutual check, spot check

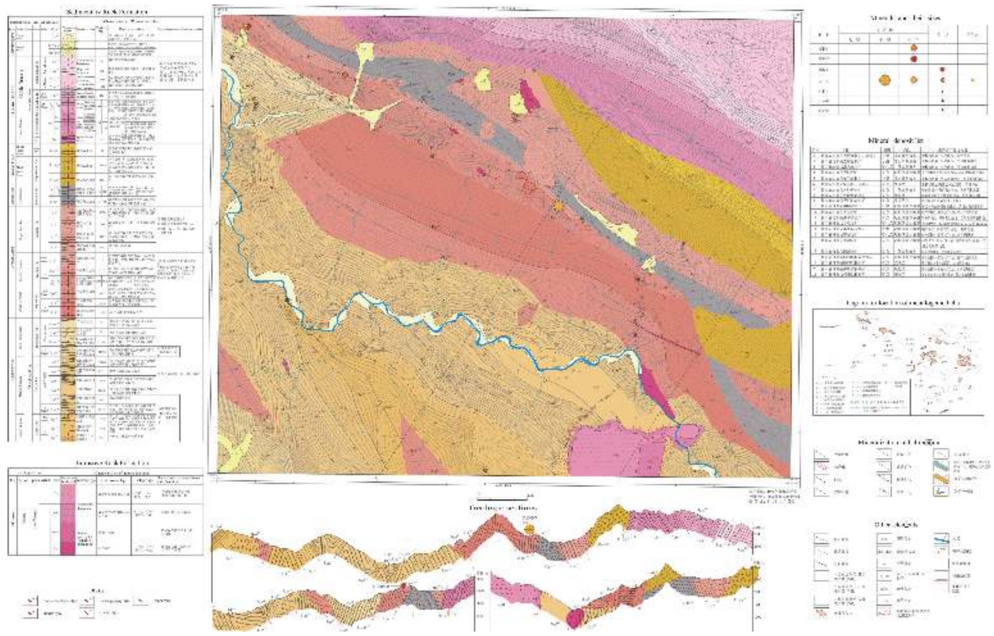

Fig. 3 Thumbnail of the 1：50 000 mineral geological map of the Bazang Map-sheet, Gansu (main part)

map are inherited from the spatial database of the DGSInfo (2010 version) system, such as map frames, rivers, place names, lithologic layers, attitudes, faults, folds, joints, cleavages, mullion structures, wrinkle lineations, fossil sampling points, isotopic age sampling points, mineralization alterations, and minerals. All geological and mineral features are presented in compliance with the the *Geological Legends Used for Regional Geological Maps* (GB/T 958–2015).

Rock formations were divided in light of the geological profile survey data, and rock formation boundaries were plotted in the master map zone. Fold structure axial traces were plotted according to the attitude information and formation occurrence before they were numbered and annotated. On the map face, the line type was marked in dark gray (color 235). The nature, geometric and kinematic characteristics, mineralization alteration characteristics of regional faults and their relationship with metallogenesis were determined according to previous survey results and the present survey data. Ore-forming structures are naturally highlighted as they contain mineralization alterations. Rock formation patterns were added according to the attitude of the rock layer and the *Geological Legends Used for Regional Geological Maps* (GB/T 958–2015). Mineral symbols were used in a manner to fully present the mineral species, size, ore prospecting prediction deposit type, and metallogenic era.

2.6.4 Compilation or Refinement of Independent Feature Class Maps

Independent feature class maps include columnar sections, transverse cutting profiles, typical deposit corner maps, and metallogenic zone location maps. As metallogenic zone location maps are generated from acquisition and processing of previous data, a description is given only on the compilation of the other four independent feature class maps.

Columnar section. First, rock formation units were redivided according to the geological profile surveying data, and the rock formation columnar sketch compiled based on the previous data was corrected. Next, the formation columnar section was refined using the rock formation delineation result in the master map zone. Inside the area, 40 rock formation mapping units, including 38 sedimentary rock formation mapping units and two intrusive rock formation mapping units, were marked off. No metamorphic rock formation mapping units or volcanic rock formation mapping units were determined. The formation units were named and coded following the rules prescribed in "Format requirements for compiling 1：50 000 mineral geological maps" in the *Guide for Compiling Maps of Mineral Geological Survey Results* (*1：50 000*) (draft for discussion).

Transverse cutting profile map. Three transverse cutting profiles were deployed from NW to SE so that they ran through the magmatic intrusions or typical deposits—the Yangliweigou gold deposit and Chaimashan iron deposit)—and were marked with the mineral site symbol so as to render a more intuitive presentation of the spatial relationship between the mineral site and geological structures. The vertical scale of the profiles is the same as the horizontal scale. The shown topographic relief is the same as in real place.

Typical deposit corner map. This comprises the physical plane map of the Yangliweigou gold deposit and the physical profile map of exploration line 505 of the Yangliweigou gold deposit. The former was derived from the 1：2 000 geological map of the Yangliweigou gold orefield, while the latter from the 1：500 profile map of exploration line 505 of the Yangliweigou gold deposit. The map face gives an objective presentation of the gold deposits in relation to structures, rock formations and mineralization alterations, clearly revealing that gold orebodies originate from the transition between thin limestone and carbonaceous slate.

Optional corner map. A schematic view of the orebody attitudes in the Yangliweigou gold deposit was drawn using the field observation of the orebody attitudes there. This map explicitly shows that the deposit features ore controlling by pinniform structures, and orebodies thicken at the conjunction between the main ore-controlling faults and secondary pinniform fissures.

Tectonic outline map. In addition to folds and faults, regional uplift structure and intrusive rock body information was added, clearly showing that inside the area, there existed Caledonian NWW uplift, Indosinian NE uplift, and Himalayan NWW uplift tectonic deformations. Existence of Indosinian NE tectonic deformation is evidenced by the NE zoning of the Indosinian granite dykes and their balloon diapir intrusion form (Fig. 4). This supplements the traditional proposition that the upper crust of Qinling was predominantly comprised of EW structures (Zhang GW et al., 1995).

3 Data Content Description

For MapGIS metadata, the acquisition covers 12 categories and 113 items. As the database (dataset) name, metadata creation date, language, data quality information, and space reference system information of the 12 categories have been described earlier, a description will be given only on the layer setting, layer attribute items and attribute structure of the database.

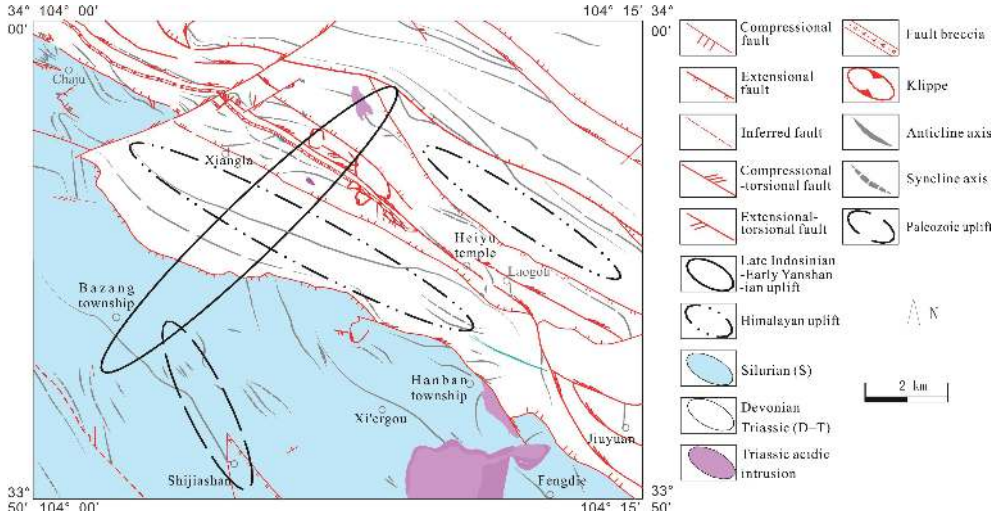

Fig. 4　Tectonic outline map of the Bazang Map-sheet, Gansu

3.1　Layer Setting and Attribute Items

3.1.1　Layer Setting

The map layers of the 1：50 000 mineral geological map database of the Bazang Map-sheet (I48E013009), Gansu is set according to the “1：50 000 mineral geological map data model in the *Guide for compiling maps of mineral geological survey results* (*1*：*50 000*) (draft for discussion). The mineral geological map layer structure, in correspondence with the “Format requirements for compiling 1：50 000 mineral geological maps” of this standard, is composed of geographic layers, formation–structure layers, mineral deposit layers, and finishing layers (Table 3). Additional layers placed in the master map zone include mineralization alteration (.WT,.WL), formation boundary (.WL), settlement (.WT), place name (.WT), elevation point (.WT), main settlement place (.WT), and well spring (.WT). In the external part of the finishing layer, a map name (.WT) layer is added to store the basic mapping information.

Object class files with attributes include formation and structure (_GeoPolygon.WP), tectonic deformation zone (_TECOZONE.WP), geological (boundary) line (_GEOLINE.WL), fold (_FOLD.WL), and fault (_FAULT.WL). No physical graphic data are contained in the area for tectonic deformation zone (_TECOZONE.WP) and important drillhole (_DRILLHOLE.W).

Basic feature class files with attributes include attitude (_ATTITUDE.WT), important drillhole (_DRILLHOLE.WT), fossil sampling point (_FOSSIL.WT), isotopic age (_ISOTOPE.WT), and mineral site (_MINERAL_PNT.WT), Independent feature class files with attributes are the duty table (DUTY_TABLE.WT) and map name (MAP_NAME.WT).

Fig. 3 shows the spatial distribution of the feature class layers in the master map zone. Resulted database records throughout the map include 811 entries on attitude, 5 on isotopic age, two on fossil, 21 on mineral deposit, 102 on geological boundary, 22 on mineralization alteration, 86 on fault, 111 on fold, and 65 on formation and structure. All isotopic age records are the zircon U–Pb age data of the rock bodies or dykes. The mineral information contains

Table 3 Layer structure of the Mineral Geological Map of the Bazang Map-sheet, Gansu

Layer Type	Layer Name
Geographic layer	Frame (.WT,.WL,.WP), main administrative boundary (.WL), main settlement (.WT), main areal drainage system (.WP), main linear drainage system (.WL), main geologic annotation (.WT)
Formation–structure layer	Formation and structure (.WP), geological (boundary) line (.WL), tectonic deformation zone (.WP), fold (.WL), fault (.WL), attitude feature (.WT), important drillhole (.WT), fossil sampling point (.WT), isotopic age (.WT)
Mineral deposit layer	Mineral deposit (.WT)
Finishing layer: internal part	Geological annotation (.WT), formation pattern (line), leader line (.WL), fault dip direction, dip angle & fault nature (.WT), attitude dip angle (.WT), isotope annotation (.WT), transverse cutting profile (.WT,.WL), square grid (.WT,.WL)
Finishing layer: external part	Index map (.WL), legend (.WT,.WL,.WP), formation columnar section (.WT,.WL,.WP), transverse cutting profile (.WT,.WL,.WP), typical mineral area map (.WT,.WL,.WP), duty table (.WT,.WL), other external decoration (.WT,.WL)
Additional layer	Mineralization alteration (DZKHSB.WT, DZKHSB.WL), formation boundary (DZJZJX.WL), settlement (DLJJBZ2K.WT), place name (DLDMBZ.WT), elevation point (DLGCDBZ.WT), main settlement (DLJMDBZ.WT) and well spring (DLJQBZ.WT); map name (MAP_NAME.WT)

eight additional ore spots or mineralization clues discovered in the present survey.

3.1.2 Attribute Items and Attribute Structure of Layers with Attributes

The attribute items and attribute structure of the individual layers are set in accordance with the “1：50 000 mineral geological map data model in the *Guide for Compiling Maps of Mineral Geological Survey Results* (*1：50 000*) (draft for discussion).

3.1.3 Comprehensive Feature Class Finishing Layer

These layers are filled without attributes. They include standard frame (FRAME.WT, FRAME.WL, FRAME.WP), formation pattern (A_ZSNYSJZ.WL, A_ZSNYSJZ.WT), and transverse cutting profile (a_PROFILE.WL, a_PROFILE.WT).

3.1.4 Independent Feature Class Layer

Among these layers, except the duty table (DUTY_TABLE.WT), all the following other layers are filled without attributes, including legend (LEGEND.WT, LEGEND.WL, LEGEND.WP), formation columnar section(COLUMNAR_SECTION.WT, COLUMNAR_SECTION.WL, COLUMNAR_SECTION.WP), transverse cutting profile (CUTTING_PROFILE.WT, CUTTING_PROFILE.WL, CUTTING_PROFILE.WP), typical deposit map (TYPICAL DEPOSITS.WT, TYPICAL DEPOSITS.WL, TYPICAL DEPOSITS.WP), and other external finishing (OTHER MODIFY.WT, OTHER MODIFY.WL, OTHER MODIFY.WP).

4 Data Quality Control and Evaluation

The database was created precisely in accordance with the “1：50 000 mineral geological map data model” and the “Format requirements for compiling 1：50 000 mineral geological maps” in the *Guide for Compiling Maps of Mineral Geological Survey Results* (*1：50 000*) (draft for discussion). During the process, it passed the review by experts from Department of Natural Resources of Gansu Province and Ministry of Natural Resources of China. The database was modified by the authors according to the opinions of the experts and finally approved together with the *Report of the 1：50 000 Mineral Geological Survey* (*Bazang Map-sheet*) *for Mineral Survey and Ore Prospecting Prediction of the Yawan–Daqiao Integrated Gold-Antimony Exploration Area* by the competent leaders of Ministry of Natural Resources. The contents of the database are abundant, reliable and integral.

In July and August, 2018, after reviewed by experts from Department of Natural Resources of Gansu Province and Ministry of Natural Resources of China, the database was produced in standardized manner according to the opinions of the experts.

On March 12, 2019, the *Report of the 1：50 000 Mineral Geological Survey* (*Bazang Map-sheet*) *for Mineral Survey and Ore Prospecting Prediction of the Yawan–Daqiao Integrated Exploration Area* of *Gold-Antimony Deposits* was reviewed by experts from the China Geological Survey, and rated "Excellent". The database was considered to be "data integrity, logical consistency, and accurate spatial positioning".

5 Data Value

The object class data, basic feature class data, and independent feature class data of the Bazang Map-sheet are of great value with regard to basic geology and metallogenic research. The object class data also have application value for engineering geology and environmental geology.

5.1 Newly Discovered Geological Phenomena

5.1.1 Intrusive Rock

The Hanban stocks are separated into an inner zone, a middle zone, and an external zone. The outer zone comprises diorite porphyrite (δuT); the middle zone comprises medium-fine grained granodiorite; the inner zone comprises porphyritic granodiorite. As the morphology of the Heiyugou pluton has changed remarkably, it is determined to be diorite porphyrite. A number of diorite dykes have been newly discovered. From Delikan in the southwest of the Map-sheet up to Heiyugou in the north of the Map-sheet, all stocks exhibit a balloon diapir intrusion morphology. The diagenetic age of these dykes is (212±1.4) Ma[5], indicating that there exist Indosinian NE uplift structures in this area (Fig. 4).

5.1.2 Fault

Rodding structures existing in banded form were discovered between Lower Devonian Dangduo Formation and Silurian Zhouqu Formation, hence this NWW unconformity was determined to be a fault. Some faults were newly discovered during mapping, among which the newly discovered "Xiangladong strike-slip normal fault" and other NE faults make up a complete horst structure combination with the known synthetic normal faults.

5.1.3 Fold

The strike of the fold axial traces in the Silurian System in the south of the Bazang Map-sheet is NNE, and that of the fold axial traces in the Late Paleozoic–Triassic strata in the north of the Map-sheet is either nearly EW or NW, suggesting that the Silurian System in the south and the Upper Paleozoic–Triassic System in the north belong to two different tectonic layers

(Fig. 4). This discovery provides evidence for the existence of Caledonian orogenesis in South Qinling, challenging the traditional assumption that “collision closure without orogenesis took place in South Qinling in Late Caledonian–Early Hercynian” (Du YS et al., 1997; Wang GB et al., 1998).

5.1.4 Ferruginous Nodule and Storm Deposit

In the Lower Carboniferous Yiwagou Formation argillaceous slate formations (C_1yw^b) around Xiangla in the northwest of the Bazang Map-sheet, syngenetic ferruginous nodule layers were discovered. The nodules are elliptical in shape with diameter spanning from 0.2 to 1 m. As visually estimated, the nodules mainly consist of argillaceous substances with limonite content of approximately 20% (Fig. 5). No other metallic elements have been tested yet. Similar manganese nodules are the deposits when the oceanic basin expanded to the maximum extent (Peng D et al., 2011) and the hydrothermal effect was limited during the nodulation (He GW et al., 2011), but it effectively recorded the information of marine environmental evolution, representing an important research object for paleooceanography and mineralogenesis (Yu M et al., 2018).

In the Heishuigou Upper–Top Silurian argillaceous slate with thick limestone formations, storm deposits containing mollusc fossil fragments were discovered (Fig. 6). The rock matrix is yellowish brown mudstone, amid which fossil fragments are scattered in great disorder. They are equivalent to member A of marine storm sedimentary rocks (Tian JC et al., 2014; Zheng N et al., 2010). The storm processes have a level of regionality. Storm sedimentary rocks nearing its age include the South Micangshan Middle Silurian Luoreping Formation storm rocks (Bai ZQ et al., 2015).

Fig. 5 Ferruginous nodules in the Lower Carboniferous Yiwagou Formation of the Xiangla in the Bazang Map-sheet

Fig. 6 Storm deposits of the mollusc-bearing fossil fragments in the Heishuigou of the Bazang Map-sheet

5.1.5 Ore (Mineralization) Spots

Eight metallic and nonmetallic ore (mineralization) spots were newly discovered. They are the Gezao gold deposit, Saibu gold deposit, Gelingmo gold deposit, Bazang gold deposit, Cha’a dolomite deposit, Chaimashan quartzite, Mogou andalusite deposit, and Fengdie andalusite deposit. The Fengdie andalusite deposit is large in size and stable in attitude with exposed width of 500 m. The shortfall, however, is that the orebody is underlain by the underground culvert of Zhouqu hydropower station.

5.2 New Understanding

5.2.1 Rock Formation and Ore-bearing Formation

Inside the area, 40 rock formation mapping units, including 38 sedimentary rock formation mapping units and two intrusive rock formation mapping units, are marked off. No separate rock formations are marked off for exposed regional metamorphic rocks, contact metamorphic rocks or dynamic metamorphic rocks. Ore-bearing rock formations represent an important part of regional metallogenetic research (Zhai YS et al., 2001), as well as a basic mapping unit identified by the *Guide for Compiling Maps of Mineral Geological Survey Results* (*1：50 000*). Horizontally, the ore-bearing formations in the Yangliweigou gold deposit appear to be the Xiawula Formation carbonaceous slate–thin limestone formations. The gold orebodies are hosted in the fault contact zone between these rock formations and the underlying Lower Carboniferous thick limestone formations, or in the layer-cutting fissures of these formations (Fig. 7), and combined with the rocks adjacent to the ore-bearing formations into medium thick limestone formations (D_1d^1) and sandstone formations. Both contain no ore.

5.2.2 Uplift Structure

Four uplift structures were identified, including the Devonian Shijiashan NNW uplift, Late Triassic Bazang–Heiyugou NE uplift, Himalayan Heishuigou–Hanban NWW uplift, and Fourth Wood Farm Second Work Section NWW uplift (Fig. 4).

5.2.3 Fold

The dip direction of the fold axial plane includes northeast, southwest, north and west, but is principally northeast and southwest. The three groups of folds with axial plane dipping north, NNE and SSW, are deformations since the Indosinian. The fold axial plane of the Middle Devonian System dips south and southeast, as the product of N–S, E–W and NW–SE compressions. The fold axial plane of the Lower Devonian and Lower Carboniferous Systems dips north, as the product of E–W compression. The fold deformations of the Lower Silurian–Upper Silurian are virtually the same and the axial plane dips SWW (and strikes NNW, Fig. 4). They are the product of SWW–NEE compression deformation in the

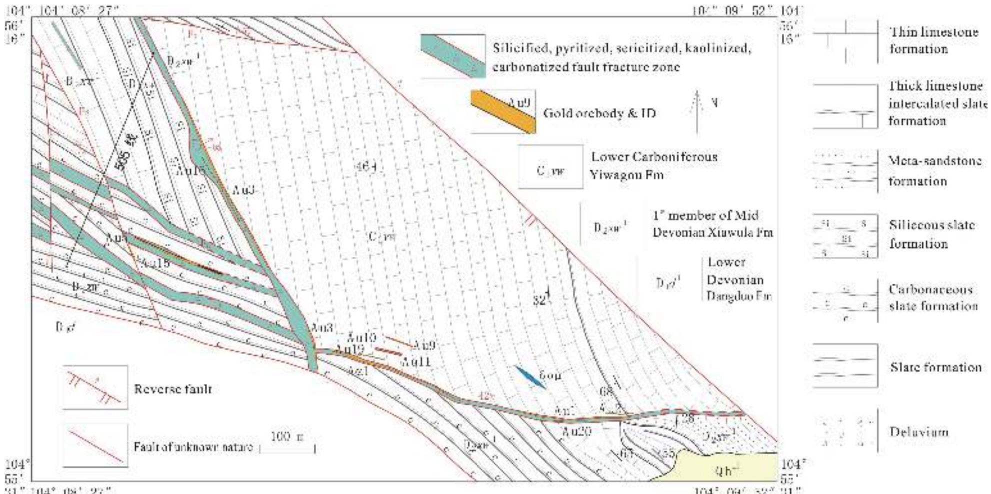

Fig. 7　Ore-bearing formation sketch map of the Yangliweigou gold deposit

Caledonian, as well as evidence for the existence of Caledonian orogenesis.

According to the direction consistency of the fold axial traces and their concentration degree, three fold combinations can be identified across the Map-sheet: the Shijiashan anticlinorium, Silin Inspection Station anticlinorium, and Zhugegou synclinorium.

5.2.4 Fault

There are four groups of conjugated faults, including NNE–SSW, SW–NE, NW–SE, NWW–SEE dipping fault planes, and a group of NEE dipping fault planes. The dip direction of Triassic-cutting faults includes NW, NEE, SEE, SSW, and SW, suggesting that these five groups of fault planes are the product of post-Indosinian tectonic deformation or the reactivity of earlier faults after the Indosinian period. Previous studies have proved that the NWW–near EW deep, large faults are the major faults that formed the earliest. They are the product of the subduction and collision of the North China and Yangtze blocks along the Shangdan and the Mianlue suture zone, respectively, in the Neoproterozoic–Triassic (Zhang X et al., 2019). Overall, the attitude of the Triassic-cutting faults suggests that they are structures finalized after the Indosinian period.

There are four kinds of fault structure combinations, including the Early Devonian Shijiashan paleograben, Early Carboniferous North Xiangla palaohorst, Fourth Wood Farm Inspection Station backthrust structure, and Zhugegou forward-spreading thrust nappe structure.

5.2.5 Ore-forming Structure, Ore-forming Structural Plane and Ore-forming Structural Mechanism of the Mineral Deposit

The ore-forming structures of the Chaimashan siderite orebodies are the interlaminar compressional fracture zones represented by the sideritized lime-rubble rocks. The ore veins are filled in the reticular fissure systems in lenticular limestone. The ore-forming structures of the hematite orebodies are the hematitized cataclastic dolomite lenses, also attributable to laminar compression. Some of the orebodies exist in the limestone–sandstone transitions and some exist in medium thick limestone, attributable to oxidation–reduction barriers and acid alkaline barriers.

The ore-forming structures of the Yangliweigou gold deposit are the NW–nearly EW arc structures and the pinniform structures made up of their secondary fissures (Fig. 8). The ore-forming structural planes show obvious signs of “silico-calcium plane” metallogenesis.

5.2.6 Environmental Geological Concern

From the Yangliweigou gold deposit to the Laogou gold deposits, the gold ore spots are densely distributed. The associated constituents of the ores contain high levels of hazardous element As, posing potential threat of environmental pollution.

6 Conclusions

(1) The collected data in the database include the 1 ∶ 50 000 regional geological sketch map of the Bazang Map-sheet, the 1 ∶ 10 000 mining area geological maps of the Yangliweigou gold deposit and other known orefields, the 1 ∶ 50 000 regional geological

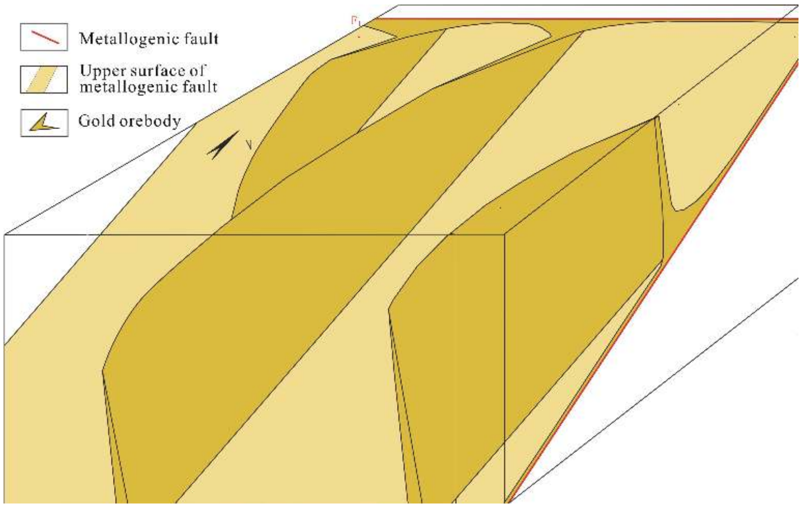

Fig. 8 Orebody attitude sketch map of the Yangliweigou gold deposit

survey primitive data map of the Bazang Map-sheet, and the field collected data for the 1：50 000 mineral geological survey-specific mapping. The data are complete and integral.

(2) The map face is a combination of the master map and corner maps to give a full, objective presentation of the regional geological boundaries, rock formations, ages, faults, fold axial traces, joints, cleavages, fold lineations, mullion structures, mineralization alterations, mineral information, as well as the metallogenic geology of the Yangliweigou gold deposit and the corresponding geographic information. The content is abundant.

(3) The database is created under the guidance of the three-in-one ore prospecting prediction geological model. In the attributes of the “formation-structure” layer, ore-bearing formations and alterations are emphasized. In the attributes of the fault layer and the fold-structure layer, ore-forming structures are emphasized. In addition to the mineral information layer, an additional mineralization alteration layer is added, making the presentation of metallogenic features even more complete.

(4) New discoveries are achieved with respect to intrusive rocks, faults, folds, iron-manganese nodules and storm deposits, and ore (mineralization) spots. New understandings are yielded with respect to rock formations and ore-bearing formations, uplift structures, folds, faults, deposit ore-forming structures and environmental geological concerns.

(5) The database contains a great variety of regional geological phenomena and provides high-quality description of attribute data. It can not only be used to study the regional metallogenesis and evaluate the mineral resources in the area or the exploration area, but also provides base data for the investigation and research work of basic geology, engineering geology, and environmental geology. With this database, users may retrieve the regional basic geological information and mineral metallogenic information of this map-sheet whenever so needed.

Acknowledgments: This database is the result of the collective effort of all members of the 1：50 000 Mineral Geological Survey under the *Mineral Survey and Prospecting Prediction* (*Bazang Map-sheet*) *in the Integrated Exploration Area of Gold Antimony Deposits* *in Yawan–Daqiao*, *Gansu* campaign initiated by Gansu Institute of Geological Survey. The authors want to thank experts from Gansu Institute of Geological Survey, Department of Natural Resources of Gansu Province and Ministry of Natural Resources of China for their inspection and instructions and for the valuable opinions they provided regarding our work.

Notes:

❶ Gansu Institute of Geological Survey. 2009. 1：250 000 Structure Formation Map of the Minxian Map-sheet[R].

❷ Gansu Institute of Geological Survey 2009. 1：250 000 Structure Formation Map of the Wudu Map-sheet[R].

❸ Gansu Institute of Geological Survey. 2016. Regional Survey Report of the Renzang (I48E01 2009), Bazang (I48E013009) and Dacaopo (I48E014009) Map-sheets[R].

❹ Regional Geological Surveying Team of Shaanxi Geological Bureau. 1969. 1：200 000 Geological Map of the Wudu Map-sheet (I–48–(21))[R].

❺ Gansu Institute of Geological Survey. 2016. Report on the Specific Mapping and Technical Application Demonstration Subproject of the Yawan–Daqiao Integrated Exploration Area of Gold-Antimony Deposits, Gansu[R].

❻ Gansu Institute of Geological Survey. 2015. Primitive Data Map for the 1：50 000 Regional Geological Survey Map of the Bazang Map-sheet (I48E013009)[R].

❼ The Third Geological Mineral Exploration Institute of Gansu Provincial Geology and Mineral Bureau. 2014. General Geological Survey Report of Yangliweigou Gold Deposit[R].

❽ Gansu Institute of Geological Survey. 2012. Regional Metallogenic Map of Gansu[R].

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