收稿日期：2019-03-28
改回日期：2019-06-10

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”青海都兰沟里金矿整装勘查区矿产调查与找矿预测子项目 2016-2018（12120100400150017-37、12120100400160901-62、12120100400172201-51）资助。

doi: 10.12029/gc2019Z111

论文引用格式：周红智，徐崇文，张松涛，张里斌，张新铭. 2019. 青海都兰沟里金矿整装勘查区 1∶100 000 地质矿产数据集 [J].中国地质，46(S1):93−104.

数据集引用格式：周红智；徐崇文；张松涛；张里斌；张新铭. 青海都兰沟里金矿整装勘查区 1∶100 000 地质矿产数据集 (V1).中国地质大学（武汉）;青海省有色第三地质勘查院;中国地质调查局武汉地质调查中心 [创建机构]，2016. 全国地质资料馆 [传播机构]，2019-06-30. 10.23650/data.C.2019.P10; http://dcc.ngac.org.cn/geologicalData/rest/geologicalData/geologicalDataDetail/ba0b6546577f5d01ab075ab4f1077987

青海都兰沟里金矿整装勘查区 1∶100 000 地质矿产数据集

周红智[1,3]　徐崇文[1*]　张松涛[2]　张里斌[2]　张新铭[1]

(1. 中国地质大学（武汉），湖北 武汉 430074；2. 青海省有色第三地质勘查院，青海 西宁 810000；3. 中国地质调查局武汉地质调查中心，湖北 武汉 430205)

摘要：青海都兰沟里金矿整装勘查区 1∶100 000 地质矿产数据集由系统库、建造构造图、地质矿产图、地磁 ΔT 平面等值线图、地磁 ΔT 化极平面等值线图、化探综合异常图、矿产预测成果图及附表组成；每张图文件夹内有对应的编图说明。沟里整装勘查区总体被新元古代−早古生代东昆中缝合带（Pt_3-P_2 末）、中−晚古生代兴海−苦海缝合带（D-P_3）、晚古生代−早中生代（C-T_2 末）阿尼玛卿缝合带分割为 4 个二级构造单元。区内岩浆活动以奥陶纪−泥盆纪和二叠纪−三叠纪为主，分别代表了两期不同的造山旋回，成矿期可能在晚三叠世−早侏罗世。此次工作在整装勘查区内共圈定了 1∶50 000 磁异常 21 处、化探综合异常 80 处；划分 4 个三级成矿带 (区)、7 个四级成矿亚带、8 个五级矿带（矿田）、17 个六级有利找矿区块；在有利找矿区块中筛选并提交找矿靶区 14 处；通过后续投入，区内相继发现了那更康切尔大型银矿、德龙金矿、迈龙金矿点、浪木日铜镍矿点、龙什更铜钴矿点等一批有找矿潜力的矿床（点）；估算区内金资源总量 588.04 吨、银资源总量 3 197.85 吨、铅−锌资源总量 235.83 万吨，铜−钴资源总量 121.49 万吨。

关键词：东昆仑东段；青海都兰；沟里金矿；地质矿产；1∶100 000
数据服务系统网址：http://dcc.cgs.gov.cn

1　引言

青海省都兰沟里金矿整装勘查区（图 1）位于东昆仑构造带（东昆仑中央造山带）的南东段，毗邻西秦岭单元−巴沟逆冲滑脱构造带，是我国著名的成矿带之一（丰成友等，2003；马昌前等，2015；陈加杰等，2016），属青海省都兰县、玛多县管辖，是 2012 年新部署的国家级整装勘查区，面积 4 795 km^2，区内蕴藏着丰富的矿产资源，也

第一作者简介：周红智，男，1991 年生，在读博士研究生，主要从事矿床学、矿产勘查与找矿预测研究；E-mail：zhzszxs@163.com。
通讯作者简介：徐崇文，男，1994 年生，在读硕士研究生，主要从事矿产勘查与找矿预测研究；E-mail：18753370159@163.com。

是青海省重要的成矿带，素有“金腰带”之称，是我国重要的矿产资源基地。自显生宙以来东昆仑地区经历的大的构造运动主要有两期，即早古生代加里东运动（原特提斯演化）、晚古生代–早中生代古特提斯演化（张雪亭等，2007）。沟里整装勘查区共涉及前述系列地球动力学过程所形成的4个二–三级构造单位：以东昆仑中部新元古代–早古生代缝合带（昆中断裂带）、阿尼玛卿晚古生代–早中生代缝合带（昆南断裂带）、兴海–苦海晚古生代缝合带为界，整装勘查区跨越东昆仑中部岩浆弧带（Pt_3-J）、东昆仑南坡俯冲碰撞杂岩带（早古生代为华南北部被动陆缘，晚古生代为华北板块南部活动陆缘）、昆仑山口–昌马河俯冲增生楔（C_2-T_2）、宗务隆山–兴海坳拉槽（D-P）（丰成友等，2003；潘彤，2004；李碧乐等，2012）。整装勘查区内存在多期造山旋回，构造岩浆活动强烈，与之对应的岩浆作用和变质作用等活跃，为金属矿床的形成创造了有利条件，发育多种类型矿产（图1），典型的有：脉状金矿床（果洛龙洼）、铜钴矿床（督冷沟）、金铅锌多金属矿床（坑得弄舍）、汞矿床（苦海）等（Xia R et al., 2015；Chen JJ et al., 2017；刘颜等，2018），区内找矿工作以金矿床为重点，并兼顾银铅锌铜钴等矿种（岳维好等，2013；李华健等，2017；唐洋等，2017）。

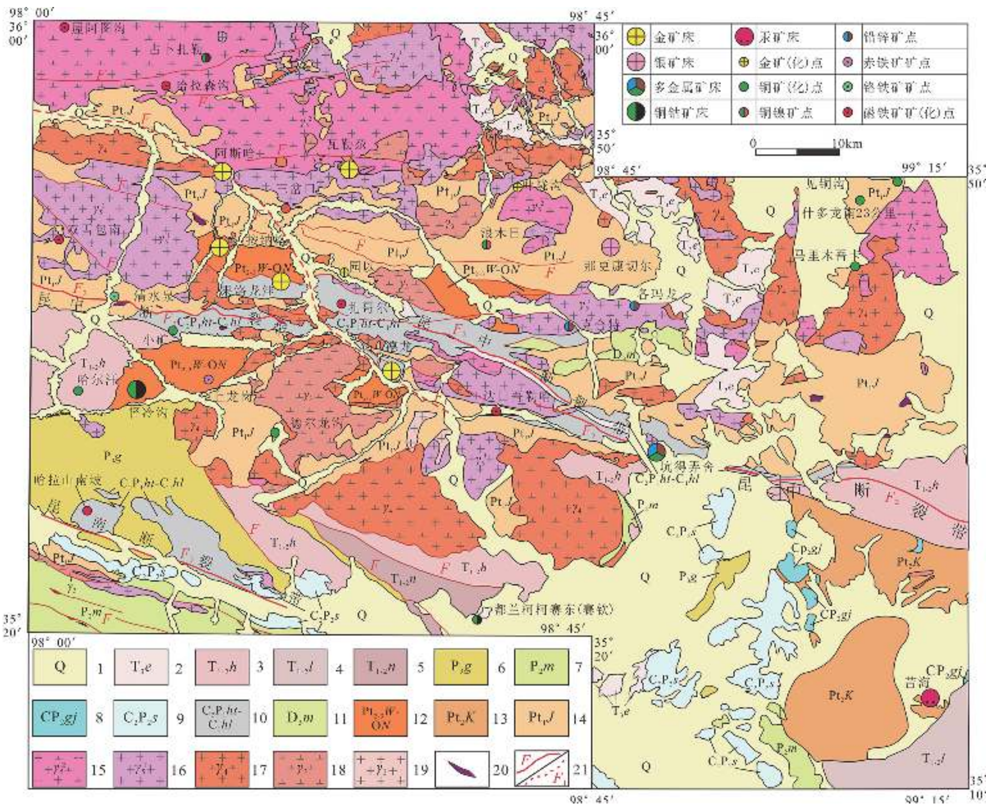

图1　东昆仑沟里金矿整装勘查区地质简图

1—第三系–第四系；2—上三叠统鄂拉山组；3—下–中三叠统洪水川组；4—下–中三叠统隆务河组；5—下–中三叠统闹仓坚组；6—上二叠统格曲组；7—中二叠统马尔争组；8—石炭系–中二叠统甘家组；9—上石炭统–中二叠统树维门科组；10—下石炭统–下二叠统浩特洛洼组/下石炭统哈拉郭勒组；11—上泥盆统牦牛山组；12—中–新元古界万宝沟群–奥陶系纳赤台群；13—中元古界苦海杂岩群；14—下元古界金水口岩群；15—燕山期侵入岩；16—印支期侵入岩；17—华力西期侵入岩；18—加里东期侵入岩；19—晋宁期侵入岩；20—超基性岩；21—断裂/推测断裂及编号

整装勘查区目前开展工作的区域不足1 500 km^2，约占整装勘查区总面积的31.3%；同时，区内物、化探异常反映找矿信息明显，说明整装勘查区储量开拓空间巨大。但目

前工作中，对异常区地层、构造、岩浆岩与已知矿区对比、分析不够，找矿前景不明，急需通过开展综合编图与矿产地质专项填图工作，查明整装勘查区内建造构造特征，重点弄清含矿建造和已知致矿异常的特征，开展区内成矿潜力评价，划分出有利成矿地段并提交找矿靶区。将上述工作成果编制成 1∶100 000 地质、矿产、地球物理、地球化学、矿业权设置等基础图件数据集，可为整装勘查区后续部署找矿工作提供基础资料。青海都兰沟里金矿整装勘查区 1∶100 000 地质矿产数据集元数据简表见表 1。

表 1　数据库（集）元数据简表

条目	描述
数据库（集）名称	青海都兰沟里金矿整装勘查区1∶100 000地质矿产数据集
数据库（集）作者	周红智，中国地质大学（武汉），中国地质调查局武汉地质调查中心 张新铭，中国地质大学（武汉） 张松涛，青海省有色第三地质勘查院 沈志远，中国地质大学（武汉） 徐崇文，中国地质大学（武汉）
数据时间范围	2016.05—2018.12
地理区域	青海省海西州都兰县–玛多县，经纬度范围：东经98°00′ ~ 99°15′，北纬35°10′ ~ 36°00′
数据格式	MapGIS 6.7矢量格式(*.wt，*.wl，*.wp)、*.msi、*.xls、*.doc
数据量	177.7 MB
数据服务系统网址	http://dcc.cgs.gov.cn
基金项目	中国地质调查局地质调查项目“整装勘查区找矿预测与技术应用示范”青海都兰沟里金矿整装勘查区矿产调查与找矿预测子项目2016−2018（12120100400150017-37、12120100400160901-62、12120100400172201-51）资助
语种	中文
数据库（集）组成	该地质矿产数据集由系统库（沟里Slib）、青海都兰沟里金矿整装勘查区1∶100 000建造构造图、地质矿产图、地磁ΔT平面等值线图、地磁ΔT化极平面等值线图、化探综合异常图组成；每张图件以建造构造图为底图编制而成，并配有相应镶图及图例，修饰部分主要为边框、比例尺、图例等；每张图文件夹内有对应编图说明word文件及整装区数据字典。本数据集还包括3个Excel表格：青海省沟里整装区成矿区带划分及成矿预测列表、青海省沟里整装区建议新立勘查项目及重点续作勘查项目列表、青海省沟里整装区锆石U-Pb年龄测试数据。

2　数据采集和处理方法

2.1　数据资料收集情况

本次工作共计收集到青海都兰沟里金矿整装勘查区已完成的 1∶50 000 区域地质调查、地质矿产调查、矿产远景调查资料等，包括区域地质图 4 幅、地质矿产图 7 幅、水系沉积物测量 19 幅、地面高精度磁测 12 幅及相关报告，总共收集 1∶50 000 化探采样数据 37 455 件，磁法测量数据 98 040 件。具体如下：

（1）1993—1995 年，青海省区调综合地质大队开展的 1∶50 000 那更幅（I-47-6-D）、鲁木切幅（I-47-6-B）、错扎玛幅（I-47-19-A）区调资料。

（2）1993—1994 年，青海省第六地质队开展的 1∶50 000 苦海幅（I-47-31-A) 区调资料。

（3）2005—2007 年，青海省有色地勘局地质矿产勘查院联合长安大学地质调查研

究院和青海省有色地勘局八队开展的沟里地区 I47E00 2009（魏日）、I47E00 2010（圆以）、I47E003009（塔妥煤矿）、I47E003010（沟里乡）四幅 1∶50 000 矿产地质和水系沉积物测量综合调查资料。

（4）2005—2007 年，青海省地质调查院开展的察汗乌苏河地区 1∶50 000 地质矿产、水系沉积物地球化学及磁法测量综合调查资料，编图涉及图幅 I47E001010（大高山幅）、I47E001011（浪麦滩幅）。

（5）2006—2008 年，青海省金星矿业有限公司和山东省第七地质矿产勘查院开展的青海省都兰县哈图地区三幅 1∶50 000 水系沉积物地球化学测量，编图涉及图幅 I47E001009（沟里公社幅）。

（6）2007—2008 年，青海省有色地质矿产勘查局地质矿产勘查院开展的青海省苦海–那更地区 I47E00 2011（卡鲁幅）、I47E00 2012（那更幅）、I47E00 2013（马里木吾卡幅）、I47E003011（智益幅）、I47E003012（肉早某日幅）、I47E003013（错扎玛幅）、I47E004009（月日岗幅）、I47E004010（查果日幅）、I47E004011（扎智益幅）、I47E004012（赫里塘幅）、47E004013（花石峡五道班幅）、I47E005013（苦海幅）12 幅 1∶50 000 水系沉积物和地面磁法测量资料。

（7）2012 年，中南大学完成的沟里地区 1∶100 000 遥感影像图、遥感地质构造解译图、遥感信息提取图及解译报告。

另外，利用的资料还包括：1∶250 000 兴海幅区域地质调查（青海省地质矿产勘查研究院，1998）❶、1∶250 000 冬给措纳湖幅区域地质调查（中国地质大学，1999）❷、1∶1 000 000 青海省地质图及说明书和青海省大地构造图及说明书（青海省地质调查院，2005—2006）❸、青海省第三轮成矿远景区划研究及找矿靶区预测（青海省地质矿产勘查开发局，2003）❹、青海省矿产资源潜力评价（青海省地质矿产勘查开发局，2013）❺ 等资料、涉及沟里整装勘查区公开发表的基础地质和地质矿产等文献。

基于上述原始资料和数据，开展了青海都兰沟里金矿整装区地质矿产、建造构造、地球化学、地球物理、成矿预测图等多元信息图件编制。

2.2　数据处理方法

2.2.1　1∶50 000 高精度磁测数据处理

2007—2008 年，青海省有色地质矿产勘查局地质矿产勘查院开展了青海省苦海–那更地区 I47E002011 等 12 幅 1∶50 000 地面磁法测量工作，圈定磁法异常 55 处，异常范围较大，每个异常带包含多个子异常，且异常分散不成规模，异常查证也未取得突破。有部分图幅完成的地质物探化探调查工作不对应，尚未开展系统的地质调查工作。地质体的控制程度、物化探与找矿信息的匹配程度，已无法适应进一步开展矿产勘查工作的需求。因此有必要实现整装勘查区 1∶50 000 精度物探数据的整理集成。

由于高精度磁测受地形限制，部分观测点未按设计进行测量或者有所舍弃，从而造成测点分布不均匀。为了更好地进行编图和各种数据转换处理，首先对全区磁测数据利用 Kriging 插值法进行网格化处理。网格化的数据再利用 MORPAS 3.0 软件进行化极处理，将斜磁化的异常化为垂直磁化（化到地磁极），以消除由于磁化场的倾角和偏角引起的磁异常的不对称性。最后采用 MapGIS DTM 分析，分别制作原始等值线和化极后等值线，其中 0 ~ 25 nT 采用等值线间距 5 nT，25 ~ 125 nT 采用等值线间距 25 nT，125 ~ 625 nT 采用等值线间距 125 nT。

2.2.2　1∶50 000 高精度磁测异常分类

通过对 12 个图幅 5 470 km^2 1∶50 000 地面高精度磁测数据重新处理及编制图件，得出沟里整装查区磁测异常幅值变化范围为+6 172～−2 286 nT，总体与区域构造线和岩体侵位关系密切，结合地质矿产、化探综合异常、构造−岩石信息，共计圈出磁异常区带 21 处，局部异常 50 处，可划分为甲、乙、丙、丁四类。具体分类原则如下：

甲类：矿致异常或矿化（点）引起的磁异常。

乙类：推断的矿致异常或对解决其他地质问题有意义的异常。

丙类：无法判明性质，尚不能确定成因的异常。

丁类：按目前认识水平，对找矿或解决其他地质问题无意义的异常。

按上述分类原则，本次工作区内共圈定乙类异常 16 个，丙类异常 3 个、丁类异常 2 个，未圈定出甲类异常。上述磁异常总体可以划分出两种类型，一类为北西向条带状磁异常，与昆中、阿尼玛卿一级构造带走向一致；另外一类为近椭圆状磁异常，异常长轴大体近东西向，与晚印支期−早燕山期岩体分布大致一致。

本区含磁铁矿岩（矿）石、铜镍硫化物矿石、超基性−基性火成岩、蚀变火山岩呈中−强磁性，磁化率的变化范围很大，理论上应能引起一定规模的磁异常，且整装勘查区内金属矿产与火山岩、中酸性侵入岩的发育程度关系密切，1∶50 000 磁异常群，可作为地质找矿工作的间接指示。

2.2.3　1∶50 000 成矿元素地球化学数据处理

根据收集、检查、整理 1∶50 000 水系沉积物数据，对不同图幅之间存在的地球化学数据系统偏差，利用归一法（刘大文，2004）进行数据调平等预处理后再求取异常下限。本次工作得出的单元素异常下限见表 2。

表 2　沟里地区 1∶50 000 土壤测量元素异常下限及浓度分带一览表

元素	异常下限计算值	异常下限实际使用值	异常中带下限	异常内带下限
Ag	119.97	119.97	179.95	239.93
As	16.83	21.24	31.85	42.47
Au	2.72	2.72	4.08	5.43
Bi	0.54	0.54	0.82	1.09
Co	17.87	17.87	26.80	35.74
Cu	38.46	38.46	57.69	76.92
Mo	1.94	1.94	2.91	3.89
Pb	37.31	37.31	55.97	74.62
Sb	1.50	1.50	2.25	3.00
Sn	4.50	4.50	6.75	9.00
W	1.64	1.64	2.46	3.28
Zn	93.08	93.08	139.62	186.16

备注：Au和Ag的单位是$\times10^{-9}$，其他元素为$\times10^{-6}$。

本次工作共圈定单元素异常 1 561 个，其中单点异常 454 个，占总异常数的 29.08%，有效地提高了弱异常的发现率。对圈定的每一个单元素异常统计其异常面积内坐标、面积、点数、极大值、平均异常强度、异常衬度、异常规模、地质背景等指标，其中平均

异常强度为异常范围内元素含量的平均值，异常衬度=平均异常强度/背景值，异常规模=面积×（平均异常强度−背景值）（蒋敬业等，2006），各个单元素异常汇总见表 3。

表 3　1∶50 000 水系沉积物测量单元素异常汇总表

项目元素	异常个数	其中单点异常个数	占总异常数的百分比（%）	项目元素	异常个数	其中单点异常个数	占总异常数的百分比（%）
Ag	115	40	34.78%	Mo	69	11	15.94%
As	71	15	21.13%	Pb	90	27	30.00%
Au	298	85	28.52%	Sb	82	21	25.61%
Co	146	66	45.21%	Sn	181	43	23.76%
Bi	119	55	46.22%	W	156	36	23.08%
Cu	126	31	24.60%	Zn	108	24	22.22%

2.2.4　1∶50 000 化探综合异常圈定

对全区水系沉积物测量数据统一经过相关分析、聚类分析、因子分析等流程，结合地质、矿产、构造−岩石分布及组合特点，判别与 Au、Pb、Zn、Cu 等主成矿元素密切相关的其他元素的组合形式，最终将元素分为 Au-As-Sb、Au-Pb-Zn-Ag、Cu-Co-Cr-Ni、W-Sn-Mo-Bi 四组。

综合异常图是将各元素的单元素异常图与简化地质、地理图进行套合绘制而成。是通过将各元素的单元素异常图中表示异常的线文件及各单元素异常的编号进行提取，将所有元素的异常组合按照相关的原则圈定综合异常，简化地质、地理图套合。

将综合异常分为三类：甲类异常，是指见矿或矿致异常；乙类异常，是指推断矿致异常或对找矿和解决某些地质问题有意义的异常；丙类异常，是指性质不明异常。此次工作在整装勘查区内共划分出 80 处综合异常，其中甲类异常 4 处，乙类异常 45 处，丙类异常 31 处。

2.2.5　锆石 LA-ICP-MS U-Pb 年龄测试

锆石 U-Pb 同位素测试在中国地质大学（武汉）地质过程与矿产资源国家重点实验室（GPMR）和南京大学内生金属矿床成矿机制研究国家重点实验室（SKLMDR）完成。两个实验室的分析流程、方法基本一致，采用激光剥蚀等离子质谱仪（LA-ICP-MS）进行测试，激光剥蚀系统为 GeoLas 2005，ICP-MS 为 Agilent 7500a。测试过程中选用 91 500 作为内标对 U-Th-Pb 同位素进行校正，并选用 GJ-1 作为监测样，选用 NIST610 作为外标，详细的分析流程及仪器参数参见 (Liu YS *et al*., 2010)。锆石年龄数据及微量元素数据处理采用 ICP-MS-DataCal 9.5 软件完成。U-Pb 年龄谐和图和加权平均年龄的计算采用 Isoplot 3.75 软件（Ludwig KR, 2012）。

2.3　图件编制要点

所有图件编制时采用 1∶50 000 和部分 1∶250 000 地质图为底图，成图比例尺为 1∶100 000；坐标系为投影平面直角坐标系；投影类型为高斯−克吕格横切椭圆柱等角投影；投影中心点经度为 99°；投影带类型 6 度带；椭球参数为西安 80IUGG 推荐椭球。

2.3.1　地质矿产图

整装勘查区地质矿产图形成独立图层，点、线、面三种数据格式重点需要解决不同

图件之间的拼接问题，以及统一系统库文件。图上表示的主要内容有：地层、岩浆岩、构造等基本地质内容；全部矿种的各种规模的矿床（按大、中、小型三种符号分别表示)、矿点、矿化点，并由左至右、由上而下连续编号；物探、化探方法所确定的全部异常区和异常点及编号；矿体（层）的实际形状；矿床不同的成因类型和工作程度；按时代标出矿体 (层)；以及各种矿化蚀变带等。

2.3.2　建造构造图

根据青海省地质图及说明书、青海省大地构造图及说明书、1：250 000 冬给措纳湖幅、兴海幅资料及前述的 1：50 000 区域地质调查、矿产地质调查资料，初步划分了整装勘查区内成矿地质背景和建造构造。2016—2018 年通过“青海都兰沟里金矿整装勘查区矿产调查与找矿预测”项目，对巴加别里赤尔幅（IE47E002011）、肉早某日幅（I47E003012）、沟里乡幅（I47E003010）开展 1：50 000 矿产地质专项填图工作，基本查明了沟里整装勘查区内典型金矿、银矿、铅锌矿、铜镍矿等含矿建造。此外还收集了 2005—2007 年，青海省有色地勘局地质矿产勘查院、长安大学地质调查研究院和青海省有色地勘局八队联合开展的沟里地区四幅 1：50 000 矿产地质调查原始地质记录资料和实际材料图。基于上述资料采用填编结合的方式系统划分了沟里整装勘查区内沉积岩建造、岩浆岩建造、火山岩建造、变质岩建造、大型变形构造等。对图面中不同建造地层、岩浆岩、构造等进行了相应花纹充填，花纹充填既要遵循岩性岩相组合及展布特点，也要结合实际构造形迹要素和构造演化过程。

2.3.3　磁测类图件

整装勘查区磁测类图件首先运用 SURFE 软件对磁测异常数据（日变、正常梯度、高度等）改正后重新网格化，方法为反距离加权，形成 GIS 数据格式。绘制化极平面等值线图采用软件 GDPS 或 MORPAS 中“物化探异常分析”模块，两种绘图方式的数据处理环节所要求的数据格式均为网格化后的栅格数据，同时必须赋有栅格信息参数。将最终得到的 GIS 数据采用 MapGIS 软件做 DTM 分析，制作等值线图。图式图例和用色标准参考《区域地质图图例》(GB/T 958−2015)、《地质图用色标准及用色原则》（DZ/T0179−1997），然后结合地质矿产、化探综合异常、构造−岩石信息，圈定异常区带及局部异常，依据综合异常所处位置采用 C_x（例如 C_1、C_2 等），从上到下，从左往右，顺序编号。

2.3.4　综合异常图

综合异常图是将各元素的单元素异常图与简化地质、地理图进行套合绘制而成。是通过将各元素的单元素异常图中表示异常的线文件及各单元素异常的编号进行提取，将所有元素的异常组合按照相关的原则圈定综合异常，简化地质、地理图套合。根据相关原则划分综合异常后，兼顾图面负载，以颜色区分元素，以线型区分浓集分带。综合异常编号以 HS 开头，然后从上到下，从左往右，顺序编号，并依照规范规定的图式图例、用色标准成图。

2.3.5　矿产预测成果图

由矿产预测区图层叠加预测要素及预测成果图层构成。整装勘查区内最为重要的成矿类型包括 4 种：金矿床、铜钴及多金属矿床、金铅锌及多金属矿床、汞（金）及多金属矿床。地质方面有利的找矿信息包括：（1）地层岩性信息，主要是：围绕万宝沟群、纳赤台群等变质火山岩寻找金矿床；围绕哈拉郭勒组中基性火山岩寻找铜钴矿床；

围绕加里东期超基性岩寻找铜镍硫化物矿床；围绕洪水川组流纹质凝灰岩−碳酸盐岩、鄂拉山组凝灰岩寻找金铅锌矿床。（2）构造−侵入岩信息，主要是：围绕区域性昆中断裂及其北侧北西向次级断裂和印支期−燕山期岩体开展金铅锌多金属矿床找矿。（3）构造−火山岩信息，主要是：围绕昆中−昆南断裂及其次级构造和哈拉郭勒组寻找铜钴矿床。同时 1∶50 000 化探异常和磁异常为金铅锌铜钴矿带的划分提供了重要信息，金铅锌银及多金属成矿主要与北西向二级构造带基本一致，而铜钴等成矿与昆中、昆南、苦海一级构造带一致。

根据上述研究成果，从三级成矿带（区）（找矿远景区域）、四级成矿亚带（有利找矿区带）、五级矿带（矿田）（有利找矿区段）、六级有利找矿区块（找矿靶区）4 个层次划分了整装勘查区内不同级别的找矿预测区带，并编制青海省沟里整装区成矿区带划分及成矿预测列表。其中，找矿远景区划分根据区域构造转换带、区域矿产分带和 1∶200 000 区域物探化探信息；找矿有利区带划分则根据昆中断裂的北西向次级断裂，哈拉郭勒组、洪水川组地层及 1∶50 000 地球物理、地球化学分带信息；找矿有利区段（找矿靶区）的划分根据近东西向的三级断裂，哈拉郭勒组中基性火山岩、洪水川组流纹质凝灰岩及 1∶50 000 物化探局部异常；有利找矿区块（找矿靶区）的划分应该重视 1∶10 000、1∶5 000 物化探异常及地表蚀变露头信息。预测成果图综合考虑控矿因素、找矿标志、矿床共生及时空分布规律，以及物化探异常区带展布性。其中有利找矿区块（找矿靶区）为成矿预测的最小最有利找矿地段，应结合区内已有矿产勘查资料、异常查证情况等来划定。通过上述工作筛选了建议新立勘查项目靶区 14 处，以及建议重点续作勘查项目 9 个，并编制青海省沟里整装区建议新立勘查项目及重点续作勘查项目列表。金矿、铅锌金银及多金属矿、铜钴及多金属矿、汞（金）及多金属矿成矿规律及成矿预测要素见镶图。

2.4 数据集属性数据赋值

数据集属性赋值依据中国地质调查局《地质信息元数据标准》（DD2005−05）、《数字地质图空间数据库建库标准》（DD2006−06），参照《区域地质图图式图例》（GB/T 958−2015）、《地质图用色标准及用色原则》（DZ/T0179−1997）、《1∶50 000 地质图地理底图编绘规范》（DZ/T 0157−95）等有关要求执行。全程采用数字地质调查综合信息平台（DGSS）完成。

3 数据样本描述

地质矿产图建立了相应的数据集单元，包括：图中地质体的图元编号、地质体名称、地质时代、岩石组合、蚀变矿化类型；断裂的长度、性质、运动方式，断裂面倾向、倾角；韧性剪切带的编号、类型；面理倾向、倾角、形成时代；矿产地的编号、名称、地理位置、矿床类型、矿床规模、成矿时代，以及共伴生矿产。

建造构造图建立了相应的数据库，有以下单元：沉积岩建造的编号、地层单元、单元代码、建造、形成时代、沉积相、岩石组合、含矿层厚度；火山岩建造的编号、岩石组合、地层单元、单元代码、形成时代、构造环境、火山岩相类型、特殊岩石；岩浆岩建造的编号、岩石名称、形成时代、岩石成因类型、岩石构造组合、大地构造环境、矿物成分、岩石结构、构造；变质岩建造的编号、建造类型、建造、岩性特征、地层单元、单元代码、原岩建造、形成时代、大地构造环境、含矿层厚度。

磁测类与化探类图件对其属性数据赋值，建立了相应的数据库的有以下单元：地磁 ΔT 等值线和地磁 ΔT 化极等值线中的等值线的编号、等值线值，等值线区的编号、起始值、终止值；单元素地球化学图中的等值线的编号、元素组分、含量值，等值线区的编号、元素组分、含量范围上限值、含量范围下限值；单元素地球化学异常图中地球化学异常边界线的异常编号、异常下限，地球化学异常范围面的编号、异常下限、极值点、异常编号、计量单位、异常面积；地球化学异常图中综合异常范围的编号、面积、主要伴生元素、共生元素，主成矿元素范围的元素种类、异常下限、计量单位、异常面积。

矿产预测成果图对其属性数据赋值，建立了相应的数据库，包含有以下单元：矿产预测成果图中成矿地质体的编号、名称、岩石组合、形成时代、空间特征、构造环境，成矿构造/结构面的编号、名称、类型、形态、规模、产状，各种异常的编号、名称、类型、形态、规模、产状，预测区的名称、编号、地理位置、预测矿种、预测资源量、资源量单位、预测区类别、区域构造位置、矿化蚀变、成矿地质体、成矿构造/结构面以及找矿标志。

附表均为 Excel 列表，青海省沟里整装勘查区锆石 U-Pb 年龄测试数据列表，共有 6 个 sheet，分表为项目组测试的 5 个岩体的年龄实测数据和搜集的涉及整装勘查区的公开发表的年龄数据（70 个）。青海省沟里整装勘查区成矿区带划分及成矿预测列表包含此次划分为 4 个三级成矿带（区）（找矿远景区域）、7 个四级成矿亚带（有利找矿区带）、8 个五级矿带（矿田）（有利找矿区段）、17 个六级有利找矿区块（找矿靶区）的名称及编号等相应信息。青海省沟里整装勘查区建议新立勘查项目及重点续作勘查项目列表的属性数据包括项目的序号、级别、类别/方向、主攻矿种、名称、面积等信息。

4 数据质量控制和评估

此次数据集建设过程中收集的资料丰富齐全可靠，对于部分未开展 1∶50 000 区调工作的苦海−那更 12 个图幅采用 1∶250 000 冬给措纳湖幅区域地质调查资料和遥感解译资料开展图件修编工作；沟里乡（I47E003010）等 3 幅地质矿产图与建造构造图数据库建设数据来源主要为野外实测，磁测类与化探类图件均由收集的 1∶50 000 资料统一处理。成矿预测图中成矿地质体、成矿结构面等实验数据来自 2016—2018 年《青海都兰沟里金矿整装勘查区矿产调查与找矿预测》子项目完成的测试与研究，相关测试在中国地质大学（武汉）地质过程与矿产资源国家重点实验室、南京大学内生金属矿床成矿机制研究国家重点实验室、核工业北京地质研究院等相关实验室完成。上述工作严格按照《1∶50 000 矿产地质调查工作指南（试行）》（中国地质调查局，2016 年 3 月）中规定执行，数据来源可靠，属性库建设完善。图件的修编遵照《地质图空间数据库建设工作指南》（中国地质调查局，2001 年）、《固体矿产勘查地质资料综合整理、综合研究规定》（DZ/T 0079−93）等规定。地质图中的图式图例、符号等按照《区域地质图图例》（GB/T 958−2015）、《地质图用色标准及用色原则》（DZ/T0179−1997）中规定的进行表示。

数据集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，在自检互检的基础上，进行必要的室内检查，抽检率为67.31%。单位质量检查，由青海省有色第三地质勘查院安排，项目组积极协助进行，抽检率31.21%。各级检查及作者修改情况均要填写质量检查记录卡片，单位对各类综合性图件要进行100%审核，对存在的问题责成责任人予以解决。当遇到重要疑难问题时，应及时向上级单位汇报并邀请有关专家咨询。本次数据集的编制是依托"青海都兰沟里金矿整装勘查区矿产调查与找矿预测子项目（2016—2018）"完成，由中国地质调查局发展研究中心联合青海省地质调查局专家组开展了野外验收，项目组连续三年均顺利通过验收工作。根据专家组提出的关于图件规范性、资源潜力评价等方面的意见与建议，项目组进一步开展了补充与修改工作，于2019年4月验收了项目成果数据库及报告，总评分优秀，项目成果受到专家组一致认可。

5 数据价值

（1）系统整理并划分了沟里整装勘查区内沉积岩建造、侵入岩建造、火山岩建造、变质岩建造、大型变形构造、第四系成因类型；查明了金、银、铜、铅、锌等矿种的矿床（按大、中、小型三种符号分别表示)、矿点、矿化点的空间分布，及其成因类型和工作程度。

（2）补充并收集整理了沟里整装勘查区内岩浆岩年代学资料，区内岩浆岩以加里东期、印支期中酸性花岗岩类为主。

（3）根据磁测图件在整装勘查区内共圈定了21个磁异常，其中乙类异常16个、丙类异常3个、丁类异常2个。磁异常总体可以划分出两种类型，一类为北西向条带状磁异常（与昆中、阿尼玛卿一级构造带走向一致），另外一类为近椭圆状磁异常（与晚印支期–早燕山期岩体分布大致一致），可作为地质找矿工作的间接指示。

（4）在整装勘查区范围内共圈定金元素异常336处，银元素异常115处，铅元素异常90处，锌元素异常108处，铜元素异常125处，钴元素异常146处；化探综合异常80处，其中甲类异常4处，乙类异常45处，丙类异常31处。目前区内前人已发现中–大型金及多金属矿床6处，其中有4处位于1∶50 000甲类异常内，分别为阿斯哈金矿、按纳格金矿、果洛龙洼金矿、督冷沟铜钴矿，其余2处分布在乙类异常内及附近，如瓦勒尕金矿、坑得弄舍多金属矿。根据上述圈定的异常，青海省有色第三地质勘查院对其中部分异常开展综合检查后发现了一批有找矿潜力的矿床（点），如德龙金矿、卡龙金矿点、迈龙金矿点、色日金银矿点、浪木日铜镍矿点、龙什更铜钴矿点等；此外其他工作单位也在整装区内相继发现的哈日扎大型银铅锌矿、那根切尔大型独立银矿（有望达超大型）与圈定的综合异常也吻合较好，表明区内1∶50 000化探异常对找矿具有较为明确的指示意义。

（5）集成了沟里整装勘查区地质、物探、化探、遥感多源综合找矿信息，将沟里整装勘查区划分为4个三级成矿带（区）（找矿远景区域）、7个四级成矿亚带（有利找矿区带）、8个五级矿带（矿田）（有利找矿区段）、17个六级有利找矿区块（找矿靶区）。其中有利找矿区块（找矿靶区）为成矿预测的最小最有利找矿地段；综合矿产勘查资料、异常查证情况等，从中筛选了建议新立勘查项目靶区14处，其中A类工作区10个、B类工作区4个（据中国地质调查局，2016年3月颁布的《1∶50 000矿产地质调查工作指南（试行）》划分）。

6 结论

（1）沟里整装勘查区总体被新元古代−早古生代东昆中缝合带（Pt_3-P_2末）、中−晚古生代兴海-苦海缝合带（D-P_3）、晚古生代−早中生代（C-T_2末）阿尼玛卿缝合带分割为4个二级构造单元。以岩浆岩分布面积及年代学实测数据来看，区内岩浆活动强度呈现波动变化特点，其中以奥陶纪−泥盆纪（加里东期）和二叠纪−三叠纪（华力西期−印支期）岩浆活动强度最大，两期岩浆岩早期主要发育花岗闪长岩和闪长岩类，晚期主要发育二长花岗岩、钾长花岗岩等，代表了两期不同的造山旋回，成矿期可能在晚三叠世−早侏罗世。

（2）整装勘查区内共圈定了1∶50 000磁异常21处、化探综合异常80处，区域断裂的次级断裂和1∶50 000物探化探信息对于矿床的预测效果较明显，通过后续工作投入，区内相继发现了哈日扎大型银铅锌矿、那更康切尔大型独立银矿、德龙金矿、卡龙金矿点、迈龙金矿点、色日金银矿点、浪木日铜镍矿点、龙什更铜钴矿点等一批有找矿潜力的矿床（点）。

（3）对沟里整装勘查区内不同级别成矿区（带）进行了预测，提交找矿靶区14处，建议重点续作勘查项目9个，估算区内金资源总量588.04吨、银资源总量3 197.85吨、铅−锌资源总量235.83万吨，铜−钴资源总量121.49万吨。

致谢：感谢青海省有色第三地质勘查院杨宝荣高级工程师、谢智勇高级工程师、王晓云高级工程师在收集资料过程中给予的帮助；感谢中国地质大学（武汉）谭俊副教授、付乐兵副教授、赵旭博士、白惠文、孔德鼎在数据集制作过程中给予的指导与帮助。感谢审稿专家对本文图件与文字提出的宝贵的修改意见与建议。

注释：

❶ 张智勇，朱迎堂，周光第等. 1998. 1∶250 000兴海幅区域地质调查. 青海省地质矿产勘查研究院.

❷ 殷鸿福，张克信，陈能松等. 1999. 1∶250 000冬给措纳湖幅区域地质调查. 中国地质大学.

❸ 张雪亭，杨生德，杨站君等. 2005—2006. 1∶1 000 000青海省地质图及说明书和青海省大地构造图及说明书. 青海省地质调查院.

❹ 伊有昌，罗才让，潘彤等. 2003. 青海省第三轮成矿远景区划研究及找矿靶区预测. 青海省地质矿产勘查开发局.

❺ 吴正寿，赵呈祥，易平乾等. 2013. 青海省矿产资源潜力评价. 青海省地质矿产勘查开发局.

参考文献

Chen Jiajie, Wei Junhao, Fu Lebing, Li Huan, Zhou Hongzhi, Zhao Xu, Zhan Xiaofei, Tan Jun. 2017. Multiple sources of the Early Mesozoic Gouli batholith, Eastern Kunlun Orogenic Belt, northern Tibetan Plateau: Linking continental crustal growth with oceanic subduction[J]. Lithos, 292−293: 161−178.

Liu Yongshen, Hu Zhaochu, Zong Keqing, Gao Changgui, Gao Shan, Xu Juan, Chen Haihong. 2010. Reappraisement and refinement of zircon U-Pb isotope and trace element analyses by LA-ICP-MS[J]. Chinese Science Bulletin, 55(15): 1535−1546.

Ludwig KR. 2012.User's manual for Isoplot 3.75—A geochronological toolkit for Microsoft Excel[M]. Berkeley: Berkeley Geochronology Center Special Publication No. 5, 1−75.

Xia Rui, Wang Changming, Qing Min, Li Wenliang, Emmanuel John M. Carranza, Guo Xiaodong, Ge Liangsheng, Zeng Guanzhong. 2015. Zircon U-Pb Dating, Geochemistry and Sr-Nd-Pb-Hf-O Isotopes for the Nan'getan granodiorites and mafic microgranular enclaves in the East Kunlun Orogen: Record of closure of the Paleo-Tethys[J]. Lithos, 234−235, : 47−60.

陈加杰, 付乐兵, 魏俊浩, 田宁, 熊乐, 赵玉京, 张玉洁, 祁月清. 2016. 东昆仑沟里地区晚奥陶世花岗闪长岩地球化学特征及其对原特提斯洋演化的制约 [J]. 地球科学, 41(11): 1863−1882.

丰成友, 张德全, 李大新, 佘宏全. 2003. 青海东昆仑造山型金矿硫、铅同位素地球化学 [J]. 地球学报, 24(6): 593−598.

蒋敬业, 程建萍, 祁士华, 向武. 2006. 应用地球化学 [M]. 武汉: 中国地质大学出版社, 147−148.

李碧乐, 沈鑫, 陈广俊, 杨延乾, 李永胜. 2012. 青海东昆仑阿斯哈金矿Ⅰ号脉成矿流体地球化学特征和矿床成因 [J]. 吉林大学学报 (地球科学版), 42(6): 1676−1687.

李华健, 王庆飞, 杨林, 于华之, 王璇. 2017. 青藏高原碰撞造山背景造山型金矿床:构造背景、地质及地球化学特征 [J]. 岩石学报, 33(7): 2189−2201.

刘大文. 2004. 区域地球化学数据的归一化处理及应用 [J]. 物探与化探, 28(3): 273−275.

刘颜, 付乐兵, 王凤林, 魏俊浩, 管波, 谭俊, 杨宝荣, 汪殿钟. 2018. 东昆仑东段坑得弄舍多金属矿床 Pb-Zn 与 Au-Ag 成矿关系研究 [J]. 大地构造与成矿学, 42(3): 480−493.

马昌前, 熊富浩, 尹烁, 王连训, 高珂. 2015. 造山带岩浆作用的强度和旋回性: 以东昆仑古特提斯花岗岩类岩基为例 [J]. 岩石学报, 31(12): 3555−3568.

潘彤. 2004. 青海东昆仑督冷沟铜钴矿床控矿条件的探讨 [J]. 矿产与地质, 18(2): 109−112.

唐洋, 付乐兵, 杨宝荣, 祁月清, 谢智勇, 李文君, 马忠贤. 2017. 东昆仑东段果洛龙洼脉状金矿床断裂构造控矿规律 [J]. 地质科技情报, 36(2): 160−167.

岳维好, 高建国, 周家喜. 2013. 青海果洛龙洼金矿基性岩脉锆石 U-Pb 年龄及岩石地球化学特征 [J]. 矿物岩石, 33(3): 93−102.

张雪亭, 杨生德, 杨站君. 2007. 青海省板块构造研究:100 万青海省大地构造图说明书 [M]. 北京: 地质出版社, 1−220.

Received: 28-03-2019
Accepted: 10-06-2019

Fund Project:
China Geological Survey Project "Demonstration Project for Prospecting Prediction and Technical Application in Integrated Exploration Areas", sub-project named "Mineral Investigation & Prospecting Prediction of the Gouli Gold Deposit Integrated Exploration Area in Dulan County, Qinghai Province" from 2016 to 2018 (No. 12120100400150017-37, 12120100400160901-62, and 12120100400172201-51)

doi: 10.12029/gc2019Z111

Article Citation: Zhou Hongzhi, Xu Chongwen, Zhang Songtao, Zhang Libin, Zhang Xinming. 2019. The 1：100 000 Mineralogical Dataset of the Gouli Gold Deposit Integrated Exploration Area in Dulan County, Qinghai Province[J]. Geology in China, 46(S1):125−143.

Dataset Citation: Zhou Hongzhi; Xu Chongwen; Zhang Songtao; Zhang Libin; Zhang Xinming. The 1：100 000 Mineralogical Dataset of the Gouli Gold Deposit Integrated Exploration Area in Dulan County, Qinghai Province(V1). China University of Geosciences (Wuhan); The Third Non-ferrous Metals Geological Exploration Institute, Qinghai Provincial Non-ferrous Metals Geological Exploration Bureau; Wuhan Center, China Geological Survey[producer], 2016. National Geological Archives of China [distributor], 2019-06-30. 10.23650/data.C.209.P10; http://dcc.ngac.org.cn/geologicalData/rest/geologicalData/geologicalDataDetail/ba0b6546577f5d01ab075ab4f1077987.

The 1：100 000 Mineralogical Dataset of the Gouli Gold Deposit Integrated Exploration Area in Dulan County, Qinghai Province

ZHOU Hongzhi [1,3], XU Chongwen [1*], ZHANG Songtao [2], ZHANG Libin [2], ZHANG Xinming [1]

(1. *China University of Geosciences (Wuhan)*, *Wuhan* 430074, *China*; 2. *The Third Non-ferrous Metals Geological Exploration Institute*, *Qinghai Provincial Non-ferrous Metals Geological Exploration Bureau*, *Xining* 810000, *China*; 3. *Wuhan Center*, *China Geological Survey*, *Wuhan* 430205, *China*)

Abstract: The 1：100 000 mineralogical dataset of the Gouli Gold Deposit integrated exploration area in Dulan County, Qinghai Province (also referred to as "the Area") consists of a systematic database, tectonic formation maps, mineralogical maps, geomagnetic ΔT plane isoline maps, geomagnetic ΔT RTP plane isoline maps, geochemical integrated anomalies maps, mineral prediction result maps, and attached tables. In the folder of each map, there are the corresponding preparation manuals for the map. The Area is divided into four second-order tectonic units by the Central Suture Zone of the East Kunlun Orogenic Belt from the Neoproterozoic Era to the Early Paleozoic Era (from Pt_3 to the end of P_2), the Xinghai-Kuhai Suture Zone from the Middle Paleozoic Era to the Late Paleozoic Era (from D to P_3), and the A'nyemaqen Suture Zone from the Late Paleozoic Era to the Early Mesozoic Era (from C to the end of T_2). The magmatic activities in the Area mainly occurred from the Ordovician to the Devonian and from the Permian to the Triassic, which represents two different orogenic cycles. The metallogenic period may be from the Late Triassic Epoch to the Early Jurassic Epoch. A total of 21 magnetic anomalies and 80 geochemical integrated anomalies on a scale of 1：50 000 were delineated in the Area. Furthermore, four grade III metallogenic belts (areas), seven grade IV metallogenic sub-belts, eight grade V metallogenic belts (ore fields), and 17 grade VI favorable prospecting blocks were determined. 14 prospecting target areas were screened and submitted in the favorable prospecting blocks. In addition, a number of mineral deposits (occurrences) with prospecting potential were found in the Area through follow-up

About the first author: ZHOU Hongzhi, male, born in 1991, doctoral candidate, mainly engages in research on mineral deposit geology, mineral exploration, and prospecting prediction; E-mail: zhzszxs@163.com.

The corresponding author: XU Chongwen, male, born in 1994, masters candidate, mainly engages in research on mineral exploration and prospecting prediction; E-mail: 18753370159@163.com.

work, such as the Nagenkangqieer large-scale silver deposit, the Delong gold deposit, the Mailong gold occurrence, the Langmuri copper-nickel occurrence, and the Longshigeng copper-cobalt occurrence. It is estimated that the total amount of gold, silver, lead-zinc and copper-cobalt resources in the Area are 588.04 tons, 3 197.85 tons, 2 358 300 tons, and 1 214 900 tons respectively.

Key words: Eastern part of the East Kunlun Orogenic Belt; Dulan County; Qinghai Province; Gouli Gold Deposit; mineralogical; 1：100 000

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

1 Introduction

Located in the southeastern part of the East Kunlun Tectonic Belt (central part of the East Kunlun Orogenic Belt), and adjacent to the West Qinling Unit−Bagou thrust and decollement tectonic belt, the Gouli Gold Deposit integrated exploration area in Dulan County, Qinghai Province (also referred to as the Area) (see Fig. 1) is one of the most renowned metallogenic belts in China (Feng CY et al., 2003; Ma CQ et al., 2015; Chen JJ et al., 2016). Subject to the administration of the Dulan County and the Maduo County in Qinghai Province, the Area is a newly designated national integrated exploration area with an area of 4 795 km^2 since abundant mineral resources have been developed in the Area. Furthermore, the Area is also an important metallogenic belt of Qinghai Province and is known as the “Gold belt”. Therefore, the Area is an important mineral resource base in China. Two major tectonic movements, namely the Caledonian Movement in the Early Paleozoic Era (Proto-Tethys Evolution) and the evolution of the Paleo-Tethys from the Late Paleozoic Era to the Early Mesozoic Era (Zhang XT et al., 2007) have taken place in the East Kunlun Tectonic Belt since the Phanerozoic Eon. Four second-order or third-order tectonic units formed by the geodynamic processes mentioned above were involved in the development of the Area. With the Central Suture Zone of the East Kunlun Orogenic Belt from the Neoproterozoic Era to the Early Paleozoic Era (the central fracture zone of the Kunlun Orogenic Belt), the A'nyemaqen Suture Zone from the Late Paleozoic Era to the Early Mesozoic Era (the southern fracture zone of the Kunlun Orogenic Belt), and the Xinghai−Kuhai Suture Zone from the Middle Paleozoic Era to the Late Paleozoic Era as a boundary, the Area spans the central magmatic arc belt in the middle part of the East Kunlun Tectonic Belt (Pt_3-J), the subduction-collision complex belt in the south slope of the East Kunlun Tectonic Belt (with a passive continental margin in the north of southern China in the Early Paleozoic Era and an active continental margin in the north China plate of the Late Paleozoic Era), the Kunlun Mountain Pass−Changmahe Subduction Accretionary Wedge (C_2-T_2), and the Zongwulong Mountain−Xinghai Aulacogen (D-P) (Feng CY et al., 2003; Pan T, 2004; Li BL et al., 2012). In the Area, orogenic cycles of multiple eras as well as intense tectonic magmatic activities and corresponding active magmatism and metamorphism contribute greatly to the formation of metal deposits and thus various types of minerals have developed (see Fig. 1). Typical deposits in the Area include veined gold deposits (in Guoluolongwa), Cu-Co deposits (in Dulenggou), gold-lead-zinc polymetallic deposits (in

Kengdelongshe), mercury deposits (in Kuhai), etc. (Xia R et al., 2015; Chen JJ et al., 2017; Liu Y et al., 2018). Prospecting in the Area is focused on gold deposits, with consideration also being given to minerals of silver, lead, zinc, copper, cobalt, etc. (Yue WH et al., 2013; Li HJ et al., 2017; Tang Y et al., 2017).

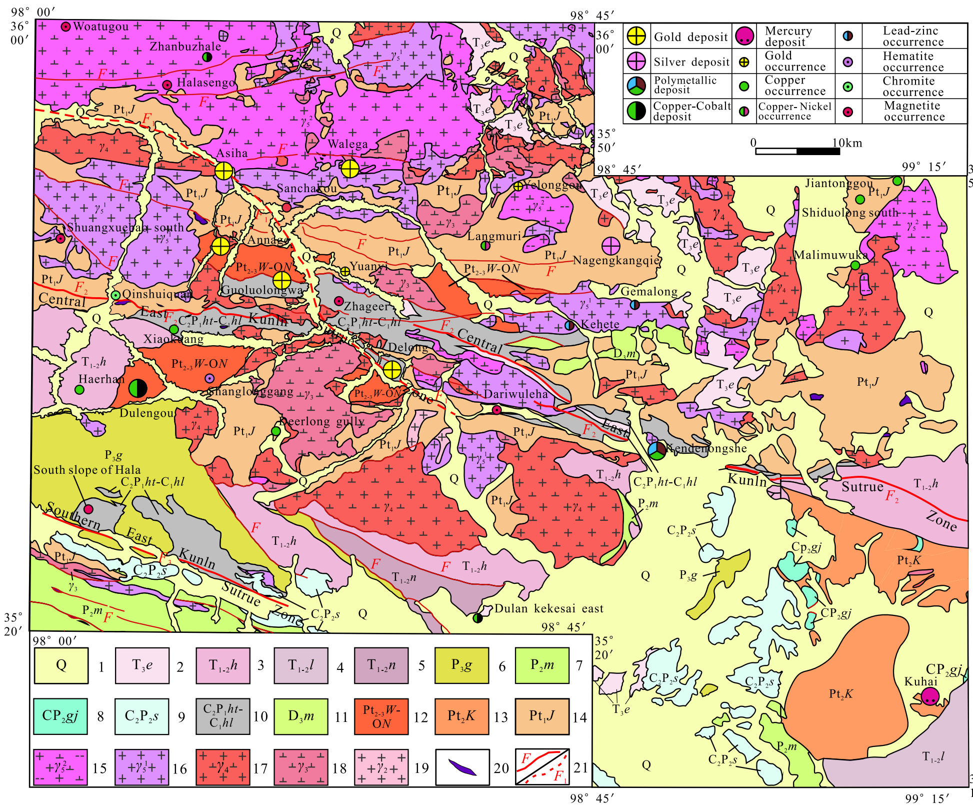

Fig. 1 Generalized geological map of the Area

1−Tertiary System - Quaternary System; 2−Ela Mountain Formation, Upper Triassic Series; 3−Hongshuichuan Formation, Lower-Middle Triassic Series; 4−Longwuhe Formation, Lower-Middle Triassic Series; 5−Naocangjian Formation, Lower-Middle Triassic Series; 6−Gequ Formation, Upper Permian Series; 7−Maerzheng Formation, Middle Permian Series; 8−Ganjia Formation, Carboniferous System-Middle Permian Series; 9−Shuweimenke Formation, Upper Carboniferous Series-Middle Permian Series; 10−Haoteluowa Formation, Lower Carboniferous Series-Lower Permian Series / Halaguole Formation, Lower Carboniferous Series; 11−Maoniushan Formation, Upper Devonian Series; 12−Wanbaogou Group from the Mesoproterozoic Erathem to the Neoproterozoic Erathem - Nachitai Group, Ordovician System; 13−Kuhai Complex Group of the Mesoproterozoic Erathem; 14−Jinshuikou Rock Group of the Lower Proterozoic Erathem; 15−Intrusive rocks of the Yanshanian Period; 16−Intrusive rocks of the Indosinian Period; 17−Intrusive rocks of the Variscan Period; 18−Intrusive rocks of the Caledonian Period; 19−Intrusive rocks of the Jinning Period; 20−Ultrabasic rocks; 21−Fractures/inferred fractures and their numbers.

Only an area of less than 1 500 km^2 is involved in current exploration in the Area, accounting for approximately 31.3% of the whole Area. Obvious prospecting data are reflected by the geophysical and geochemical anomalies in the Area, indicating a considerable potential of mineral reserves in the Area. However, sufficient and analyses of strata, structure, magmatic rocks in the anomaly areas along with comparisons with those in known mining areas, are not available at present, rendering prospecting uncertain. Therefore, the preparation of comprehensive maps and special mapping of minerals and geology is urgently required, in order to determine the tectonic formation characteristics in the Area, especially the characteristics of the ore-bearing formation and known ore-forming anomalies, Likewise, an assessment of the metallogenic potential in the Area, and accordingly the identification of favorable metallogenic blocks and target prospecting areas is similarly required. In this way, the dataset of 1：100 000 basic maps of geology, minerals, geophysics, geochemistry, optimal mining settings, etc. can be prepared, thus providing basic data for follow-up prospecting deployment in the Area. The basic information of the 1：100 000 Mineralogical Dataset of the Gouli Gold Deposit Integrated Exploration Area in Dulan County, Qinghai Province is briefly summarized in Table 1.

Table 1 Metadata Table of Database (Dataset)

Items	Description
Database (dataset) name	The 1：100 000 Mineralogical Dataset of the Gouli Gold Deposit Integrated Exploration Area in Dulan County, Qinghai Province
Database (dataset) authors	Zhou Hongzhi, China University of Geosciences (Wuhan); Wuhan Center, China Geological Survey Zhang Xinming, China University of Geosciences (Wuhan) Zhang Songtao, The Third Non-ferrous Metals Geological Exploration Institute, Qinghai Provincial Non-ferrous Metals Geological Exploration Bureau Shen Zhiyuan, China University of Geosciences (Wuhan) Xu Chongwen, China University of Geosciences (Wuhan)
Data acquisition time	2016.05—2018.12
Geographical region	In Dulan County and Maduo County, Haixi Mongolian and Tibetan Autonomous Prefecture, Qinghai Province. Geographic coordinates: east longitude 98°00′ ~ 99°15′and north latitude 35°10′ ~ 36°00′
Data formats	MapGIS 6.7 (*.wt, *.wl, *.wp), *.msi, *.xls, *.doc
Data size	177.7 MB
Data service system URL	http://dcc.cgs.gov.cn
Fund projects	China Geological Survey Project “Demonstration Project for Prospecting Prediction and Technical Application in Integrated Exploration Areas”, sub-project named “Mineral Investigation & Prospecting Prediction of the Gouli Gold Deposit Integrated Exploration Area in Dulan County, Qinghai Province” from 2016 to 2018 (No. 12120100400150017-37, 12120100400160901-62, and 12120100400172201-51)
Language	Chinese
Database (dataset) composition	The dataset consists of a systematic database, formation tectonic maps, mineralogical maps, geomagnetic △T plane isoline maps, geomagnetic △T RTP plane isoline maps, and geochemical integrated anomaly maps. Each map is prepared with a tectonic formation map as its base map, equipped with corresponding mosaic maps and legends, and decorated with borders, scales, legends, etc. In the folder of each map, there is the corresponding preparation manual in Word format of the map as well as a data dictionary of the Area. In addition, the dataset includes three Excel files, namely *Metallogenic Areas (Belts) Division and Metallogenic Prediction in Qinghai Gouli Integrated Exploration Area*, *List of Suggested Newly Established Exploration Projects and Important Subsequent Exploration Projects in Qinghai Gouli Integrated Exploration Area*, and *Zircon U-Pb Age Test Data of the Qinghai Gouli Integrated Exploration Area.*

2 Method for Data Acquisition and Processing

2.1 Data Collection

The following data of the Area were collected: 1∶50 000 data acquired previously by regional geological survey, mineralogical survey, mineral prospect survey, etc., including four regional geological maps, seven mineralogical maps, 19 maps of stream sediment survey results, 12 maps of surface high-precision magnetic survey results, and related reports. In terms of the quantity of data, a total of 37 455 pieces of 1∶50 000 geochemical sampling data and 98 040 pieces of magnetic survey data were collected. The details are as follows:

(1) 1∶50 000 regional geological survey data of the Nageng Map Sheet (1-47-6-D), Lumuqie Map Sheet (1-47-6-B) and Cuozhama Map Sheet (I-47-19-a), which were obtained by the Comprehensive Geological Team of the Qinghai Regional Geological Survey from 1993 to 1995.

(2) 1∶50 000 regional geological survey data of the Kuhai Map Sheet (I-47-31-A), which were obtained by the Sixth Geological Team of Qinghai Province from 1993 to 1994.

(3) 1∶50 000 comprehensive survey data of mineralogy and stream sediments of four map sheets including I47E002009 (Weiri), I47E002010 (Yuanyi), I47E003009 (Tatuo Coal Mine) and I47E003010 (Gouli Town) in the Gouli area, which were obtained by the Geological and Mineral Exploration Institute of the Qinghai Provincial Non-ferrous Metals Geological Exploration Bureau, together with the Geological Exploration Institute of the Chang'an University and the Eighth Team of the Qinghai Provincial Non-ferrous Metals Geological Exploration Bureau from 2005 to 2007.

(4) 1∶50 000 comprehensive mineralogical survey data, geochemistry of stream sediments, and magnetic survey in the Chahanwusu River area, which were obtained by the Qinghai Geological Survey Institute from 2005 to 2007. The I47E001010 (Dagaoshan Map Sheet) and I47E001011 (Longmaitan Map Sheet) were involved in map preparation.

(5) 1∶50 000 geochemical survey results for stream sediments of the three map sheets in the Tuha area, Dulan County, Qinghai Province, which were obtained by the Qinghai Jinxing Mining Co., Ltd. and the 7th Institute of Geology & Mineral Exploration of Shandong Province from 2006 to 2008. I47E001009 (the Gouli Commune Map Sheet) was involved in map preparation.

(6) 1∶50 000 data of stream sediments and surface magnetic survey of the 12 map sheets including I47E002011 (Kalu Map Sheet), I47E002012 (Nageng Map Sheet), I47E002013 (Malimuwuka Map Sheet), I47E003011 (Zhiyi Map Sheet), I47E003012 (Rouzaomouri Map Sheet), I47E003013 (Cuozhama Map Sheet), I47E004009 (Yuerigang Map Sheet), I47E004010 (Zhaguori Map Sheet), I47E004011 (Zhazhiyi Map Sheet), I47E004012 (Helitang Map Sheet), 47E004013 (Huashixiawudaoban Map Sheet) and I47E005013 (Kuhai Map Sheet) in the Kuhai−Nageng area of Qinghai Province, which were obtained by the Geological and Mineral Exploration Institute of the Qinghai Provincial Non-ferrous Metals Geological Exploration Bureau from 2007 to 2008.

(7) 1∶100 000 remote sensing images, remote sensing geological structure interpretation

maps, and remote sensing information extraction maps, as well as the interpretation reports of the Gouli area, which were completed by the Central South University in 2012.

In addition, the data utilized also included: 1∶250 000 regional geological survey data of the Xinghai Map Sheet (Qinghai Institute of Geological and Mineral Exploration, 1998)[❶], 1∶250 000 regional geological survey data of the Donggeicuona Lake Map Sheet (China University of Geosciences, 1999)[❷], 1∶1 000 000 geological maps and geotectonic maps of the Qinghai Province and their manuals (Qinghai Geological Survey Institute, 2005—2006)[❸], the third-round mineralization prospect zoning and prospecting target area prediction of Qinghai Province (Qinghai Bureau of Geology and Minerals Exploration, 2003)[❹], and the potential assessment of mineral resources in Qinghai Province (Qinghai Bureau of Geology and Minerals Exploration, 2013)[❺]. In addition, public literature of basic geology and mineralogical resources in the Area was also involved.

Based on the original data as mentioned above, the multivariate mineralogical information maps, tectonic formations, geochemistry, geophysics, and metallogenic predictions for the Area were prepared.

2.2 Data Processing Method

2.2.1 Achievement of 1∶50 000 High-Precision Magnetic Survey Data

A surface magnetic survey of the 12 map sheets, including I47E002011 in the Kuhai–Nageng area, Qinghai Province, was carried out by the Geological and Mineral Exploration Institute of the Qinghai Provincial Non-ferrous Metals Geological Exploration Bureau from 2007 to 2008. 55 magnetic anomalies were described. However, a large anomaly range is involved, each anomaly belt containing multiple sub-anomalies, the anomalies are dispersed, and no breakthrough has been made in anomaly verification. Furthermore, for some map sheets, the completed results for geological exploration, geophysical prospecting and geochemical prospecting were inconsistent, and the systematic geological survey had not yet been carried out. In addition, the controlling degree of geological bodies and the degree of geophysical prospecting and geochemical prospecting matching prospecting information can fulfil the need for further mineral exploration. Therefore, it is necessary to sort out and integrate the 1∶50 000 geophysical data in the Area.

Since high-precision magnetic survey is limited by topography, some observation points have not been measured according to the design, or have been abandoned, thus causing an uneven distribution of the measuring points. In order to prepare maps and complete various data conversion processing more accurately, gridding was conducted for the magnetic survey data in the whole Area by the Kriging interpolation method. Reduction to the pole (RTP) was then performed for all the data with the MORPAS 3.0 software. In this way, the anomalies of oblique magnetization were reduced to vertical magnetic anomalies (reduced to the geomagnetic pole), in order to eliminate the asymmetry of magnetic anomalies caused by inclination and deviation of the magnetization field. Finally, original contours and the contours after RTP were drawn step by step by adopting MapGIS DTM analysis. The contour intervals of 0 ~ 25nTt, 25 ~ 125nT, and 125 ~ 625nT were 5nT, 25nT, and 125nT respectively.

2.2.2 Classification of 1∶50 000 High-Precision Magnetic Anomalies

The amplitude variation range for magnetic anomalies in the Area is +6,172nT ~ −2,286nT, according to reprocessing and map preparation of the 1∶50 000 surface high-precision magnetic survey data of the 12 map sheets with a total area of 5 470 km^2. Generally, this is closely related to regional tectonic lines and rock emplacement. 21 magnetic anomaly areas (belts) and 50 local anomalies were delineated by combining the information of mineralogical, geochemical integrated anomalies, and tectonic rock. These magnetic anomalies can be divided into four categories named A, B, C and D. The specific classification principles are as follows:

Category A: ore-forming anomalies or anomalies caused by mineralization (mineralized points).

Category B: inferred ore-forming anomalies or anomalies having significance for the resolution of other geological problems.

Category C: the anomalies whose nature and origins cannot yet be determined.

Category D: the anomalies having no significance for prospecting or the resolution of other geological problems, according to the current level of understanding.

According to the classification principles mentioned above, a total of 16 anomalies of Category B, three anomalies of Category C, and two anomalies of Category D were delineated in the Area, and no anomalies of Category A were determined. These magnetic anomalies can be generally divided into two types: the magnetic anomalies of one type are distributed in a NW trending banded pattern, consistent with the trend of the first-order central tectonic belts of the East Kunlun Orogenic Belt and the A'nyemaqen first-order tectonic belt; the magnetic anomalies of the other type are distributed in a nearly elliptical shape with the long axis generally in a nearly EW direction, approximately consistent with the distribution of rock masses from the Late Indosinian Period to the Early Yanshanian Period.

Medium-strong magnetism with a wide range of variation of magnetic susceptibility is presented by the rocks (ore) bearing magnetite, copper-nickel sulfide ore, ultrabasic-basic igneous rocks, and altered volcanic rocks in the Area. Theoretically, magnetic anomalies on a certain scale can be induced. Furthermore, the metallic minerals in the Area are closely related to the degree of development of the volcanic rocks and mid-acidic intrusive rocks. Therefore, the 1∶50 000 magnetic anomaly groups can be used as an indirect indication for geological prospecting.

2.2.3 Processing of 1∶50 000 Geochemical Data of Metallogenic Elements

To eliminate the systematic deviation of geochemical data between different map sheets, the 1∶50 000 stream sediment data was preprocessed (i.e. leveling) by a normalization method after data collection, check and organization (Liu DW, 2004). The thresholds of single element anomalies were then calculated. The results are shown in Table 2.

A total of 1 561 single element anomalies were delineated, among which 454 were single anomalies, accounting for 29.08% of the total single element anomalies. Therefore, the discovery rate of weak anomalies was effectively improved. For each single element anomaly delineated, the indicators within the anomaly area (such as coordinate, point number, maximum value, average anomaly intensity, anomaly contrast, anomaly size, and geological background) were calculated statistically. Among these indicators, the average anomaly intensity is the average content of the elements within the anomaly range, anomaly contrast=average anomaly intensity/background value, and anomaly size = area × (average anomaly intensity-background value) (Jiang JY et al., 2006). The single element anomalies are summarized in Table 3.

Table 2 Thresholds and Concentrations of Single Element Anomalies According to the 1∶50 000 Soil Survey in the Area

Element	Calculated threshold	Actual threshold used	Threshold of anomaly mesozone	Threshold of anomaly inner zone
Ag	119.97	119.97	179.95	239.93
As	16.83	21.24	31.85	42.47
Au	2.72	2.72	4.08	5.43
Bi	0.54	0.54	0.82	1.09
Co	17.87	17.87	26.80	35.74
Cu	38.46	38.46	57.69	76.92
Mo	1.94	1.94	2.91	3.89
Pb	37.31	37.31	55.97	74.62
Sb	1.50	1.50	2.25	3.00
Sn	4.50	4.50	6.75	9.00
W	1.64	1.64	2.46	3.28
Zn	93.08	93.08	139.62	186.16

Note: the units of Au and Ag are $\times10^{-9}$ and the other elements are $\times10^{-6}$.

Table 3 Summary of Single Element Anomalies According to the 1∶50 000 Stream Sediment Survey

Item Element	Number of anomalies	Number of single point anomalies	Percentage of number of single point anomalies (%)	Item Element	Number of anomalies	Number of single point anomalies	Percentage of number of single point anomalies (%)
Ag	115	40	34.78%	Mo	69	11	15.94%
As	71	15	21.13%	Pb	90	27	30.00%
Au	298	85	28.52%	Sb	82	21	25.61%
Co	146	66	45.21%	Sn	181	43	23.76%
Bi	119	55	46.22%	W	156	36	23.08%
Cu	126	31	24.60%	Zn	108	24	22.22%

2.2.4 Delineation of 1∶50 000 Geochemical Integrated Anomalies

The processes including unified correlation analysis, cluster analysis, and factor analysis were conducted for the stream sediment survey data of the whole Area. Then the association forms of other elements closely related to the major metallogenic elements such as Au, Pb, Zn, and Cu were distinguished, based on the characteristics of distribution and the association of geology, mineral, and tectonic rocks. Finally, four element association forms were determined, namely, Au-As-Sb, Au-Pb-Zn-Ag, Cu-Co-Cr-Ni, and W-Sn-Mo-Bi respectively.

Integrated anomaly maps were prepared by overlapping single element anomaly maps of each element with simplified geological maps and simplified geographical maps. The detailed process was as follows: *.JDX files representing anomalies in single element anomaly maps of each element were extracted, along with the number of each single element anomalies; integrated anomalies for anomaly association of all elements were then determined, according to relevant principles; finally, these were overlapped with simplified geological maps and simplified geographical maps.

The integrated anomalies were divided into three categories, namely, Category A, Category B, and Category C. The anomalies of Category A referred to ore-discovery anomalies or ore-forming anomalies. The anomalies of Category B referred to inferred ore-forming anomalies or anomalies having significance for the resolution of some geological problems. The anomalies of Category C referred to the anomalies of unknown nature. A total of 80 integrated anomalies were delineated in the Area, including four anomalies of Category A, 45 anomalies of Category B, and 31 anomalies of Category C.

2.2.5 Zircon U-Pb LA-ICP-MS analyses

The Zircon U-Pb isotope test was completed in the State Key Laboratory of Geological Processes and Mineral Resources, China University of Geosciences (Wuhan) (GPMR) and the State Key Laboratory for Mineral Deposits Research, Nanjing University (SKLMDR). The analytical process and method in the two laboratories were basically consistent with each other. Laser ablation - inductively coupled plasma mass spectrometry (LA-ICP-MS) was used for the test, with a GeoLas2005 selected as the laser ablation system and an Agilent 7500a selected as ICP-MS. During the test, 91 500 was selected as the internal standard to correct the U-Th-Pb isotope, GJ-1 was selected as the monitoring sample, and NIST610 was selected as the external standard. For a more detailed description of the analytical process and instrument parameters, please refer to (Liu YS et al. 2010). Zircon age data and trace element data were obtained by using the ICP-MS-DataCal 9.5 software. The U-Pb age concordia diagrams and weighted average ages were calculated by using the Isoplot 3.75 software (Ludwig KR, 2012).

2.3 Key Points of Map Preparation

For preparation of all maps, 1∶50 000 geological maps and parts of 1∶250 000 geological maps were adopted as base maps, with 1∶100 000 selected as the mapping scale, the projection plane rectangular coordinate system selected as the coordinate system, the Gauss-Kruger transverse elliptical cylinder equiangular projection selected as the projection type, the center point of projection of 99° selected as longitude, a 6-degree zone selected as projection zone type, and the ellipsoid which was recommended by the IUGG and adopted in the 1980 Xian Coordinate System selected as the ellipsoid parameter.

2.3.1 Mineralogical Maps

The mineralogical maps in the Area consist of independent layers. For the three data formats of point, line, and plane, close attention should be paid to the splicing between different maps and the unification of the system database file. The following contents were mainly represented on the maps. (1) Basic geological contents such as strata, magmatic rocks and structures. (2) Deposits of various scales (represented by three symbols corresponding to large-, medium- and small-scale deposits), ore occurrences, and mineralized points for all types of minerals. They were numbered consecutively from left to right and from top to bottom. (3) All anomaly areas, anomaly points and their numbers. The anomaly areas and anomaly points were determined by geophysical prospecting and geochemical prospecting. (4) Actual shapes of ore bodies (beds). (5) Different origin types and prospecting degree of the deposits. (6) Ore bodies (beds) that are marked according to their ages. (7) Various mineralized zones and alteration zones, etc.

2.3.2 Tectonic Formation Maps

The metallogenic geological background and tectonic formations in the Area were preliminarily divided according to the geological maps and geotectonic maps of Qinghai Province and their manuals, the 1：250 000 regional geological survey data of the Donggeicuona Lake Map Sheet, the 1：250 000 regional geological survey data of the Xinghai Map Sheet, as well as the 1：50 000 regional geological survey data and mineral & geological survey data mentioned above. During the implementation of the project entitled "Mineral Investigation & Prospecting Prediction of the Gouli Gold Deposit Integrated Exploration Area in Dulan County, Qinghai Province" from 2016 to 2018, the 1：50 000 mineral & geology special mapping was conducted for the Bajiabielichier Map Sheet (IE47E00 2011), Rouzaomouri Map Sheet (I47E003012), and Gouli Town Map Sheet (I47E003010). As a result, typical ore-bearing formations were basically determined, including gold deposits, silver deposits, lead-zinc deposits, and copper-nickel deposits in the Area. In addition, four maps of 1：50 000 original geological records and actual data obtained by mineral & geological surveys conducted by the Geological and Mineral Exploration Institute of the Qinghai Provincial Non-ferrous Metals Geological Exploration Bureau, together with the Geological Exploration Institute of the Chang'an University and the Eighth Team of the Qinghai Provincial Non-ferrous Metals Geological Exploration Bureau from 2005 to 2007 was acquired. Based on the data mentioned above, sedimentary rock formation, magmatic rock formation, volcanic rock formation, metamorphic rock formation, large deformation structure, etc. were all systematically determined in the Area by means of mapping combined with preparation. Corresponding pattern filling was carried out for different formation strata, magmatic rocks, structures, etc. on the map surface according to the characteristics of the combination and distribution of lithology and lithofacies as well as actual tracks and the evolutionary process of the structures.

2.3.3 Magnetic Survey Maps

Magnetic survey maps in the Area were prepared according to the following process. Firstly, the magnetic anomaly data (such as diurnal variation, normal gradient, and height) was corrected using the software SURFE. Gridding was then conducted again by the inverse distance weighted method, in order to form GIS data. RTP plane isoline maps were drawn with the module named Geophysical and Geochemical Anomaly Analysis in the GDPS or

MORRPAS software. The data processing of the two drawing methods required that the data were rasterised after gridding.Raster information parameters were provided. Furthermore, DTM analysis was conducted for the GIS data, which was obtained by using the MapGIS software, and then isoline maps were drawn. *Geological Legends Used for Regional Geological Maps* (GB/T 958–2015) and *Standards and Principles of Colors Used for Geological Maps* (DZ/T0179–1997) were referred to as the standards for formats, legends and colors used in the maps. Finally, anomaly areas (belts) and local anomalies were delineated by combining the information of mineralogy, geochemical integrated anomalies, and tectonic rocks. In addition, the anomalies C_x (such as C_1 and C2) were numbered consecutively from top to bottom and from left to right, according to the positions of the integrated anomalies.

2.3.4 Integrated Anomaly Maps

The integrated anomaly maps were drawn by overlapping single element anomaly maps of each element with simplified geological maps and simplified geographical maps. The detailed process was as follows. *.JDX files representing anomalies in single element anomaly maps were extracted, along with the No. of each single element anomaly. Integrated anomalies for anomaly association of all elements were then determined according to relevant principles. This was then overlapped with simplified geological maps and simplified geographical maps. By taking the map surface loads into consideration, the elements could be distinguished by color and the concentration zoning could be distinguished by line type. Then the integrated anomalies were numbered consecutively with the prefix HS from top to bottom and from left to right. Finally, the maps were completed according to the standards of formatting, legends, and color given by the specifications detailed above.

2.3.5 Mineral Prediction Result Maps

The mineral prediction result maps were obtained by overlying the layers of the mineral resources prediction areas with the layers of prediction elements and prediction results. The four most important metallogenic types in the Area consist of gold deposits, copper-cobalt and polymetallic deposits, gold-lead-zinc and polymetallic deposits, and mercury (gold) and polymetallic deposits. Favorable geological prospecting information was as follows: (1) stratum lithological data, mainly consisting of gold deposits searched for around metamorphic volcanic rocks such as the Wanbaogou Group and the Nachitai Group, copper-cobalt deposits sought around the intermediate-basic volcanic rocks of the Halaguole Formation, cupro-nickel sulfide deposits looked for around the ultrabasic rocks of the Caledonian Period, and gold-lead-zinc deposits from around the rhyolitic tuff-carbonate rocks of the Hongshuichuan Formation and the tuff of the Elashan Formation; (2) tectonic-intrusive rock data, mainly including gold-lead-zinc polymetallic deposits prospected for around the regional central fracture zone of the East Kunlun Orogenic Belt and its NW-trending secondary fractures as well as rock masses from the Indosinian Period to the Yanshanian Period; (3) tectonic-volcanic rock data, mainly including copper-cobalt deposits detected around the central-southern fracture zones of the East Kunlun Orogenic Belt and their secondary structures as well as the Halaguole Formation. 1：50 000 geochemical anomalies and magnetic anomalies can provide important information for the identification of metallogenic belts of gold, lead, zinc, and copper. The mineralization of gold, lead, zinc, silver, and polymetallic deposits is basically consistent with the NW-trending second-order tectonic belts, while the mineralization of copper, cobalt, etc. is consistent with the first-order tectonic belts in central and southern parts of the East Kunlun Orogenic Belt, as well as Kuhai.

The prospecting prediction areas (belts) in the Area were divided into four grades, including grade III metallogenic belts (areas)–prospecting areas, grade IV metallogenic sub-belts–favorable prospecting areas (belts), grade V metallogenic belts (ore fields)–favorable prospecting sections, and grade VI prospecting favorable blocks (prospecting target areas) based on the research results mentioned above. Accordingly, the file named *Metallogenic Areas* (*Belts*) *Division and Metallogenic Prediction List in the Qinghai Gouli Integrated Exploration Area* was compiled. Among these different grades of metallogenic belts (areas), the prospecting areas were determined according to the regional tectonic transform zones, regional mineral zoning, as well as 1∶200 000 data obtained by regional geophysical and geochemical prospecting. The favorable prospecting zones were determined according to NW-trending secondary fractures of the central fracture zone of the East Kunlun Orogenic Belt, the strata of the Halaguole Formation and the Hongshuichuan Formation, as well as 1∶50 000 geophysical and geochemical zoning information. The favorable prospecting blocks (prospecting target areas) were determined according to the third-level fractures in nearly EW-trending, intermediate-basic volcanic rocks in the Halaguole Formation, the rhyolitic tuff in the Hougshuichuan Formation, and the 1∶50 000 geophysical and geochemical local anomalies. In the division of favorable prospecting blocks (prospecting target areas), close attention should be paid to 1∶10 000 and 1∶5 000 geophysical and geochemical anomalies as well as surface alteration outcrop information. During the preparation of prediction result maps, the following aspects were taken into comprehensive consideration: ore-controlling factors, prospecting indicators, deposit paragenesis, temporal and spatial distribution laws, as well as the distribution characteristics of the geophysical and geochemical anomaly areas. As the smallest and most favorable prospecting sections of predicted mineralization, the favorable prospecting blocks (prospecting target areas) should be determined according to the existing mineral resource exploration data, anomaly verification, etc. With the work mentioned above, 14 proposed new exploration target areas and nine proposed key follow-up exploration projects were selected. Accordingly, the file named *List of Proposed New Exploration Projects and Key Follow-up Exploration Projects in the Qinghai Gouli Integrated Exploration Area* was prepared. The metallogenic laws and metallogenic prediction elements of gold deposits, lead-zinc-silver and polymetallic deposits, copper-cobalt and polymetallic deposits, and mercury (gold) and polymetallic deposits were shown in mosaic maps.

2.4 Assignmentof Dataset Attributes

The dataset attributes were assigned according to the relevant requirements stipulated in the *Code of Geological Information Metadata* (DD2006–06) and *Spatial Database Establishment Code of Digital Geological Maps* (DD2005–05) prepared by the China

Geological Survey, as well as *Geological Legends Used for Regional Geological Maps* (GB/T 958−2015), *Standards and Principles of Colors Used for Geological Maps* (DZ/T0179−1997), and the *Preparation Specifications for Geographical Base Maps of 1∶50 000 Geological Maps* (DZ/T 0157−95).

3 Description of Data Samples

As for mineralogical maps, the corresponding dataset containing the following units were established. (1) Information on the geological bodies in the maps, including graphic element number, name, geological age, rock association, alteration type, and mineralization type. (2) Fracture information, including length, nature, and motion mode of fractures, as well as the inclination and inclination angle of the fracture surface. (3) Information of ductile shear zones, including number and type. (4) Information on mineral locality, including number, name, geographical location, deposit type, deposit size, metallogenic age, paragenetic mineral resources, and associated mineral resources.

As for tectonic formation maps, corresponding databases containing the following units were established. (1) Information on sedimentary rock formation, including number, stratigraphic unit and its code, formation, formation age, sedimentary facies, rock association, and the thicknesses of the ore-bearing strata. (2) Information on volcanic rock formation, including number, rock association, stratigraphic unit and its code, formation age, tectonic environment, volcanic facies type, and special rocks. (3) Information on magmatic rock formation, including number, rock name, formation age, petrogenetic type, petrotectonic association, geotectonic environment, mineral composition, and structure and tectonics of rocks. (4) Information on metamorphic rock formation, including number, formation type, formation, lithological characteristics, stratigraphic unit and its code, original rock formation, formation age, geotectonic environment, and thicknesses of ore-bearing strata.

As for magnetic survey maps and geochemical maps, attributes were assigned and corresponding databases containing the following units were established: (1) information of geomagnetic $\triangle T$ plane isoline maps and geomagnetic $\triangle T$ RTP plane isoline maps, including the number and value of contour, as well as the number, start value, and end value of the contour region; (2) contour and contour region information of single element geochemical maps; in terms of contour, the information includes number, element components, and content of the element components, and for contour region, the information includes the number, element components, and upper limits and lower limits of the content range of the element components; (3) information on the geochemical anomaly boundary line and geochemical anomaly range in single element geochemical anomaly maps, with the geochemical anomaly boundary line information including the anomaly number and anomaly threshold, and the geochemical anomaly range information including the number, anomaly threshold, extreme point, anomaly number, measurement unit, and anomaly area; (4) information on integrated anomaly range and the main metallogenic element range in the geochemical anomaly maps, with integrated anomaly range information including number, area, main associated elements and main paragenetic elements, and the main metallogenic element range information including element types, anomaly threshold, measurement unit, and anomaly areas.

For mineral prediction result maps, the attributes were assigned and corresponding databases containing the following units were established: (1) metallogenic geological body information, including number, name, rock association, formation age, spatial features, and tectonic environment; (2) metallogenic tectonic/structural plane information, including number, name, type, morphology, size, and occurrence; (3) information on various anomalies, including number, name, type, morphology, size, and occurrence; (4) information on prediction areas, including name, number, geographical location, mineral types predicted, resource quantity predicted, unit of resource quantity, type of prediction area, location of regional tectonics, mineralization & alteration, metallogenic geological body, metallogenic tectonic/structural plane, and prospecting indicators.

Excel files were attached. There are six sheets in the file named *Zircon U-Pb Age Test Data in the Qinghai Gouli Integrated Exploration Area*. The sub-tables include age data for five rock masses obtained by the tests of the project team, as well as public age data related to the Area (with a number of 70) which were collected. The file named *Metallogenic Areas* (*Belts*) *Division and Metallogenic Prediction List in the Qinghai Gouli Integrated Exploration Area* contains corresponding information such as the name and number of four grade III metallogenic belts (areas)–prospecting areas, seven grade IV metallogenic sub-belts–favorable prospecting areas (belts), eight grade V metallogenic belts (ore fields)–favorable prospecting sections, and 17 grade VI favorable prospecting blocks (prospecting target areas). The attributes of the file named *List of Proposed New Exploration Projects and Key Follow-up Exploration Projects in the Qinghai Gouli Integrated Exploration Area* comprises information on the projects such as number, grade, category/direction, chief prospecting mineral types, name and area.

4 Data Quality Control and Assessment

The data that were collected during the construction of the dataset are rich, complete and credible. For 12 map sheets in Kuhai-Nageng, in which a 1：50 000 regional survey had not been carried out, related data were obtained by revision and preparation of 1：250 000 maps of regional geological survey data and remote sensing interpretation data of the Donggeicuona Lake Map Sheet. For the mineralogical maps and tectonic formation maps of three map sheets such as the Gouli Town Map Sheet (I47E003010), the data in the database primarily came from field survey. In addition, the magnetic survey maps and geochemical maps were uniformly obtained by processing the 1：50 000 data collected. As for metallogenic prediction maps, the experimental data such as metallogenic geological bodies and the metallogenic structural planes in the Area were derived from the tests and research completed during the sub-project entitled *Mineral Investigation* & *Prospecting Prediction of the Gouli Gold Deposit Integrated Exploration Area in Dulan County, Qinghai Province* from 2016 to 2018. Relevant tests were completed in State Key Laboratory of Geological Processes and Mineral Resources, China University of Geosciences (Wuhan) (GPMR), the State Key Laboratory for Mineral Deposits Research, Nanjing University (SKLMDR), the Beijing Research Institute of Uranium Geology, etc. The work outlined above was carried out in strict accordance with the provisions of the *Guidelines for 1∶50 000 Mineral* & *Geological Survey* (*Trial*) (China Geological Survey, March 2016). The data sources are credible, and attribute databases were constructed perfectly. The maps were revised and prepared in accordance with the provisions stipulated in the *Guidelines for Spatial Database Construction of Geological Maps* (China Geological Survey, 2001), and *Code of Comprehensive Organization and Research of Geological Data of Solid Mineral Exploration* (DZ/T 0079-93). The formats, legends and symbols in the geological maps were presented in accordance with the *Geological Legends Used for Regional Geological Maps* (GB/T 958-2015) and *Standards and Principles of Colors Used for Geological Maps* (DZ/T0179−1997).

During the construction of the dataset, a quality inspection system was strictly implemented. A three-tier inspection system consisting of self-check and mutual-check, checks by the project team and checks by the organization was implemented for all original data. The daily quality inspection was arranged by the project team leaders. Self-check and mutual-check covered all the data input of the original records, actual data maps, and materials. The checks by the project team were presided over by the project leader. During checks by the project team, the necessary indoor checks were carried out on the basis of self-check and mutual-check, with a spot check rate of 67.31%. The checks by the organization were arranged by the Third Non-ferrous Metals Geological Exploration Institute, Qinghai Provincial Non-ferrous Metals Geological Exploration Bureau, and actively assisted by the project team, with a spot check rate of 31.21%. As for the check of each level and the modifications by the authors, quality inspection record cards were filled in. The Third Non-ferrous Metals Geological Exploration Institute, Qinghai Provincial Non-ferrous Metals Geological Exploration Bureau checked all forms of comprehensive maps, and was empowered to instruct the people responsible to solve existing problems. Important difficult problems would be reported to the superior organization in time and relevant experts invited for consultation. The dataset was prepared based on the sub-project entitled *Mineral Investigation* & *Prospecting Prediction of the Gouli Gold Deposit Integrated Exploration Area in Dulan County, Qinghai Province* (2016-2018). Field acceptance of the project was carried out by the Development and Research Center of the China Geological Survey, together with the expert panel of the Qinghai Provincial Geological Survey Bureau. The project has successfully passed field acceptance for three consecutive years. The project team further supplemented and revised the dataset according to the opinions and suggestions on map normalization, resource potential assessment, etc. proposed by the expert panel. Databases and reports as project results passed final acceptance in April 2019 with an excellent total score, achieving the unanimous approval of the expert panel.

5 Value of the Data

(1) The sedimentary formations, intrusive rock formations, volcanic rock formations, metamorphic rock formations, large deformation structures, and the original types of the Quaternary System in the Area were systematically sorted and determined. The spatial distribution, original type and exploration degree of the deposits (represented by three symbols corresponding to large-, medium- and small-scale), occurrences, and mineralized points of gold, silver, copper, lead, zinc, etc. were ascertained.

(2) The chronological data of the magmatic rocks in the Area was supplemented, enabling it to be sorted out. The magmatic rocks in the Area mainly consist of the medium-acidic granitic rocks of the Caledonian Period and the Indosinian Period.

(3) A total of 21 magnetic anomalies were determined in the Area, including 16 anomalies of Category B, three anomalies of Category C, and two anomalies of Category D. These magnetic anomalies can generally be divided into the following two types: the magnetic anomalies of one type are distributed in a NW trending (consistent with the trending of the first-order central tectonic belts of East Kunlun and A'nyemaqen first-order tectonic belt) banded pattern; the magnetic anomalies of the other type are distributed in a nearly elliptical shape, with the long axis generally in a nearly EW direction (approximately consistent with the distribution of rock masses from the Late Indosinian Period to the Early Yanshanian Period), thus providing an indirect indication for geological prospecting.

(4) Single element anomalies were delineated in the Area, including 336 gold element anomalies, 115 silver element anomalies, 90 lead element anomalies, 108 zinc element anomalies, 125 copper element anomalies and 146 cobalt element anomalies. 80 geochemically integrated anomalies were delineated in the Area, including four anomalies of Category A, 45 anomalies of Category B and 31 anomalies of Category C. At present, medium-large gold deposits and polymetallic deposits totalling six have been found in the Area. Among them, four deposits are within the 1：50 000 anomalies of Category A, named the Asiha Gold Deposit, the Annage Gold Deposit, the Guoluolongwa Gold Deposit, and the Dulenggou Copper-Cobalt Deposit. The remaining two deposits are distributed in and around the anomalies of Category B, named the Walega Gold Deposit and the Kengdenongshe Polymetallic Deposit. According to these determined anomalies, the Third Non-ferrous Metals Geological Exploration Institute, Qinghai Provincial Non-ferrous Metals Geological Exploration Bureau has comprehensively inspected parts of these anomalies and has found a number of deposits (occurrences) with prospecting potential, such as the Delong Gold Deposit, the Kalong Gold Occurrence, the Mailong Gold Occurrence, the Seri Gold-silver Occurrence, the Langmuri Copper-Cobalt Occurrence, and the Longshigeng Copper-Cobalt Occurrence. In addition, the Harizha Large-scale Silver-Lead-Zinc Deposit and the Nagenqieer Large-scale Independent Silver Deposit (expected to be ultra-large scale) discovered by other organizations in the Area are in agreement with the integrated anomalies pattern that was determined. Therefore, it can be concluded that the 1：50 000 geochemical anomalies in the Area have definite significance in favorable indications for prospecting.

(5) The comprehensive prospecting information of the Area was integrated, including the information obtained from geological surveys, geophysical prospecting, geochemical prospecting, and remote sensing. Based on this information, the Area was divided into four grade III metallogenic belts (areas)–prospecting areas, seven grade IV metallogenic sub-belts–favorable prospecting areas (belts), eight grade V metallogenic belts (ore fields)–favorable prospecting sections, and 17 grade VI favorable prospecting blocks (prospecting target areas). The favorable prospecting blocks (prospecting target areas) are the smallest and most favorable prospecting sections for mineralization prediction. According to information such as comprehensive mineral exploration data and anomaly verification, 14 target areas were selected for proposed new exploration projects, including 10 target areas of Category A and four areas of Category B (divided according to the *Guidelines for 1：50 000 Mineral* & *Geological Survey* (*Trial*) issued by the China Geological Survey in March 2016).

6 Conclusion

(1) The Area is divided into four second-order tectonic units by the Central Suture Zone of the East Kunlun Orogenic Belt from the Neoproterozoic Era to the Early Paleozoic Era (from Pt_3 to the end of P_2), the Xinghai-Kuhai Suture Zone from the Middle Paleozoic Era to the Late Paleozoic Era (from D to P_3), and the A'nyemaqen Suture Zone from the Late Paleozoic Era to the Early Mesozoic Era (from C to the end of T_2). According to the distribution area of the magmatic rocks and the chronological data measured, the magmatic activity intensity in the Area is characterized by fluctuations. The magmatic activities with the highest intensity took place from the Ordovician to the Devonian (Caledonian Period) and from the Permian to the Triassic (from the Variscan Period to the Indosinian Period). During the two periods when magmatic activity with the highest intensity occurred, granodiorites and diorites mainly developed in the early period, while monzonitic granite, moyite, etc. mainly developed in the later period, which represents two different orogenic cycles. The metallogenic period may be from the Late Triassic Epoch to the Early Jurassic Epoch.

(2) A total of 21 1：50 000 magnetic anomalies and 80 geochemical integrated anomalies were delineated in the Area. The secondary fractures of regional fractures and the 1：50 000 geophysical and geochemical information have marked effects on deposit prediction. As a result, a number of deposits (occurrences) with prospecting potential have been successfully found in the Area through follow-up work, such as the Harizha Large-scale Silver-Lead-Zinc Deposit, the Nagengkangqieer Large-scale Independent Silver Deposit, the Delong Gold Deposit, the Kalong Gold Occurrence, the Mailong Gold Occurrence, the Seri Gold-Silver Occurrence, the Langmuri Copper-Nickel Occurrence, and the Longshigeng Copper-Cobalt Occurrence.

(3) The metallogenic areas (belts) of different grades in the Area were predicted. 14 prospecting target areas were submitted, and nine key follow-up exploration projects were proposed. It is estimated that the total amount of gold resources, silver resources, lead-zinc resources, and copper-cobalt resources in the Area are 588.04 tons, 3 197.85 tons, 2 358 300

tons, and 1 214 900 tons, respectively.

Acknowledgements: We would like to extend our sincere appreciation to senior engineer Yang Baorong, senior engineer Xie Zhiyong, and senior engineer Wang Xiaoyun from the Third Non-ferrous Metals Geological Exploration Institute, Qinghai Provincial Non-ferrous Metals Geological Exploration Bureau for their help during data collection. We would also like to extend our sincere appreciation to Associate Professor Tan Jun, Associate Professor Fu Lebing, Dr. Zhao Xu, Bai Huiwen, and Kong Deding from the China University of Geosciences (Wuhan) for their guidance and help during the dataset preparation. We would also like to extend our sincere appreciation to the peer reviewers for their valuable opinions and suggestions on the revision of the maps and text in this paper.

Notes:

❶ Zhang Zhiyong, Zhu Yingtang, Zhou Guangdi, et al. 1998. 1∶250 000 Geological Survey of the Xinghai Map Sheet Area. Qinghai Institute of Geological and Mineral Exploration.

❷ Yin Hongfu, Zhang Kexin, Chen Nengsong, et al. 1999. 1∶250 000 Geological Survey of the Donggeicuona Lake Map Sheet Area. China university of Geosciences.

❸ Zhang Xueting, Yang Shengde, Yang Zhanjun, et al. 2005—2006. 1∶1 000 000 Geological Maps and Geotectonic Maps of Qinghai Province and Their Manuals. Qinghai Geological Survey Institute.

❹ Yi Youchang, Luo Cairang, Pan Tong, et al. 2003. Research on Third-round Mineralization Prospect Zoning and Prospecting Target Area Prediction in Qinghai Province. Qinghai Bureau of Geology and Minerals Exploration.

❺ Wu Zhengshou, Zhao Chengxiang, Yi Pingqian et al. 2013. Potential Assessment of Mineral Resources in Qinghai Province. Qinghai Bureau of Geology and Minerals Exploration.

References

Chen Jiajie, Fu Lebing, Wei Junhao, Tian Ning, Xiong Le, Zhao Yujing, Zhang Yujie, Qi Yueqing. 2016. Geochemical characteristics of late ordovician granodiorite in Gouli Area, eastern Kunlun orogenic belt, Qinghai Province: Implications on the evolution of Proto-Tethys ocean[J]. Earth Science, 41(11): 1863−1882 (in Chinese with English abstract).

Chen Jiajie, Wei Junhao, Fu Lebing, Li Huan, Zhou Hongzhi, Zhao Xu, Zhan Xiaofei, Tan Jun. 2017. Multiple sources of the Early Mesozoic Gouli batholith, Eastern Kunlun Orogenic Belt, northern Tibetan Plateau: Linking continental crustal growth with oceanic subduction[J]. Lithos, 292-293: 161−178.

Feng Chengyou, Zhang Dequan, Li Daxin, She Hongquan. 2003. Sulfur and lead isotope geochemistry of the orogenic gold deposits in east Kunlun area, Qinghai Province[J]. Earth Science, (06): 593−598 (in Chinese with English abstract).

Jiang Jingye, Cheng Jianping, Qi Shihua, Xiang Wu. 2006. Applied Geochemistry [M]. Wuhan: China university of Geosciences Press, 147−148 (in Chinese).

Li Bile, Shen Xin, Chen Guangjun, Yang Yanqian, Li Yongsheng. 2012. Geochemicl features of ore-forming fluids and metallogenesis of vein Ⅰ in Asiha gold deposit, eastern Kunlun, Qinghai, Province[J]. Journal of Jilin University (Earth Science Edition), 42(06): 1676−1687 (in Chinese with

English abstract).

Li Huajian, Wang Qingfei, Yang Lin, Yu Huazhi, Wang Xuan. 2017. Orogenic gold deposits formed in Tibetan collisional orogen setting: Geotectonic setting, geological and geochemical features[J]. Acta Petrologica Sinica, 33(7): 2189−2201 (in Chinese with English abstract).

Liu Dawen. 2004. The normalization of regional geochemical data and its application[J]. Geophysical and Geochemical Exploration, 28(3): 273−275, 279 (in Chinese with English abstract).

Liu Yan, Fu Lebing, Wang Fenglin, Wei Junhao, Guan Bo, Tan Jun, Yang Baorong, Wang Dianzhong. 2018. Relationship Between Pb-Zn and Au-Ag Mineralization of Kengdenongshe Polymetallic Deposit in Eastern Segment of the Eastern Kunlun[J]. Geotectonica et Metallogenia, 42(03): 480−493 (in Chinese with English abstract).

Liu Yongshen, Hu Zhaochu, Zong Keqing, Gao Changgui, Gao Shan, Xu Juan, Chen Haihong. 2010. Reappraisement and refinement of zircon U-Pb isotope and trace element analyses by LA-ICP-MS[J]. Chinese Science Bulletin, 55(15): 1535−1546..

Ludwig K R. 2012. User's manual for Isoplot 3.75—A geochronological toolkit for Microsoft Excel [M]. Berkeley: Berkeley Geochronology Center Special Publication No. 5, 1 − 75.

Ma Changqian, Xiong Fuhao, Yin Shuo, Wang Lianxun, Gao Ke. 2015. Intensity and cyclicity of orogenic magmatism: An example from a Paleo-Tethyan granitoid batholith, Eastern Kunlun, northern Qinghai-Tibetan Plateau[J]. Acta Petrologica Sinica, 31(12): 3555−3568 (in Chinese with English abstract).

Pan Tong. 2004. Discussion on ore controlling condition of Dulengou Cu-Co depoist in estern Kunlun metallogenic belt, Qinghai[J]. Mineral Resources and Geology, 18(02): 109−112 (in Chinese with English abstract).

Tang Yang, Fu Lebing, Yang Baorong, Qi Yueqing, Xie Zhiyong, Li Wenjun, Ma Zhongxian. 2017. Ore controlling regularities of fault in the Guoluolongwa lode gold deposit,east segment of eastern Kunlun orogen[J]. Geological Science and Technology Information, 36(2): 160−167 (in Chinese with English abstract).

Xia Rui, Wang Changming, Qing Min, Li Wenliang, Emmanuel John M. Carranza, Guo Xiaodong, Ge Liangsheng, Zeng Guanzhong 2015. Zircon U-Pb Dating, Geochemistry and Sr-Nd-Pb-Hf-O Isotopes for the Nan'getan Granodiorites and Mafic Microgranular Enclaves in the East Kunlun Orogen: Record of Closure of the Paleo-Tethys[J]. Lithos, (234): 47−60.

Yue Weihao, Gao Jianguo, Zhou Jiaxi. 2013. LA-ICP-MS zicon U-Pb ages and lithogeochemistry of basic dykes in the guoluolongwa Au orefield, Qinghai Province, China[J]. Journal of Mineralogy and Petrology, 33(03): 93−102 (in Chinese with English abstract).

Zhang Xueting, Yang Shengde, Yang Zhanjun. 2007. Instructions of 1：1 000 000 Qinghai Tectonic Map in Study on Plate Tectonics of Qinghai Province.Beijing: Geological Publishing House, 1 − 220 (in Chinese).