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内蒙古居力格台幅 1∶50 000地质图数据库

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摘要: 内蒙古居力格台幅 (K48E017019)1∶50 000 地质图是根据《区域地质调查技术要求 (1∶50 000)》(DD 2006-XX) 和行业统一标准及要求，充分利用 1∶200 000 区域地质、1∶50 000 矿产调查资料，结合 Spot、ETM、Aster 等多种遥感影像，以造山带理论指导填图的重要成果图件之一。本次运用复杂构造区的地质填图方法，创新性地在地质图上表达了多期构造形迹及其产状要素；图件全面反映了狼山地区乌拉特后旗一带不同侵入体的空间展布和侵入岩的岩浆序列，以及渣尔泰山群变质沉积岩的韵律和变形特征、沉积时代和沉积环境；进一步明确了霍各乞大型铜矿的赋矿围岩为阿古鲁沟组二段炭质–钙质板岩，矿床总体位于该地层中片理褶皱形成的转折端部位。图幅数据库的数据内容包含有 3 个非正式填图单位，12 个正式填图单位、3 期岩浆事件和 3 期构造变形，以及 120 个岩石化学分析数据，13 个样品的锆石 U-Pb 年龄数据，数据量为 106 MB。数据库成果为 1∶50 000 造山带地质调查示范性成果，对造山带填图的图面表达具有引领作用，可为后续地质基础研究及找矿提供重要的基础资料支撑。

关键词: 内蒙古；狼山地区；居力格台幅；1∶50 000；地质图；数据库；霍各乞铜矿；古生代岩浆作用

数据服务系统网址: http://dcc.cgs.gov.cn

1 引言

中亚造山带作为世界上最大的显生宙造山带，东西和南北延长达数千千米 (图 1a)，其复杂的构造演化过程与古亚洲洋的构造运动密切相关 (Windley BF et al., 2007; Han BF et al., 2011; Xu Z et al., 2012; Zhang XH et al., 2012; Xu B et al., 2013; Zhang W et al., 2013; 王树庆等，2019)。古亚洲洋盆的俯冲增生造山与地体拼贴过程造就了现有的构造格架 (Coleman RG, 1989； Windley BF et al., 1990， 2007; Allen MB et al., 1993, 1995; Sengor AMC et al., 1993; Gao J et al., 1998; Jahn BM et al., 2000; Xiao WJ et al., 2004, 2010; Li YJ

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et al., 2018, 2020; Yuan Y et al., 2018; Zheng RG et al., 2018; 赵磊等，2019；赵闯等，2020)。近些年围绕华北地块北缘古生代构造岩浆作用及前寒武纪地层划分等重要地质问题进行了大量科学研究，获得了丰富的资料 (张维等，2012；Zhang W et al., 2013；吴飞等，2014；Wang ZZ et al., 2015; Liu M et al., 2016; 田健等 2018；Wang XY et al., 2018；滕学建等，2019)。狼山地区位于华北地块北缘西部 (图 1a)，北侧为中亚造山带，南侧为华北克拉通 (Wu TR et al., 1998; 刘烨，2012；冯丽霞等，2013；Peng RM et al., 2013)，其特殊的构造位置对于认识区域构造演化具有重要意义。

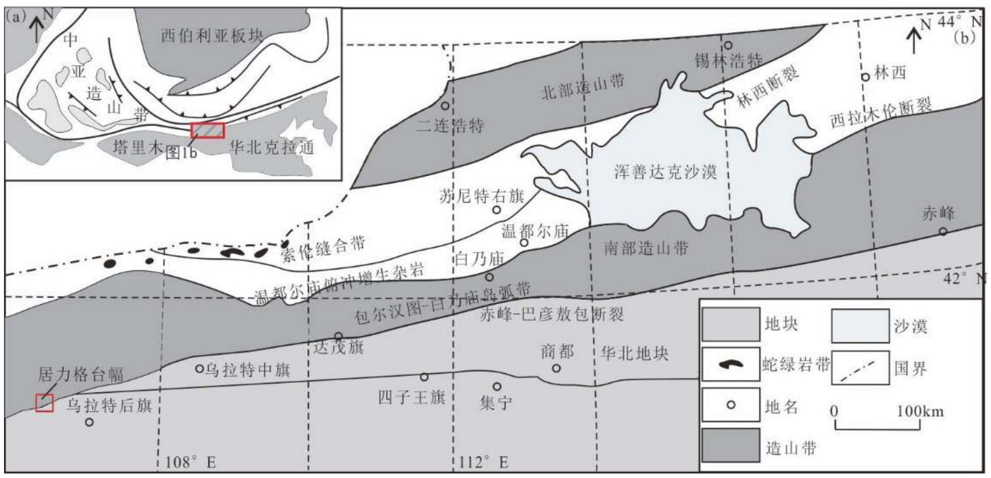

图 1　内蒙古狼山地区大地构造位置图 (a) 及居力格台幅位置示意 (b)
(据 Wang ZZ et al.，2015 修改)

内蒙古居力格台幅位于狼山地区乌拉特后旗北西侧 (图 1b)，区内出露地质体主要为元古宙变质沉积岩及古生代侵入岩，其中以晚古生代侵入岩的大面积发育为特征。内蒙古自治区第一区域地质调查队 (1982) 完成了 1：200 000 区域地质矿产调查，对区内的地层格架、岩浆活动、构造演化及成矿地质背景等方面进行了全面系统的总结。然而，一些重要的地质问题，如华北地块北缘古生代构造体制转换、渣尔泰山群的形成时代及霍各乞大型铜矿的成矿地质背景等仍然需要进一步调查和研究，为此开展了内蒙古居力格台幅 1：50 000 区域地质矿产调查，形成内蒙古居力格台幅 1：50 000 地质图数据库 (表 1，刘洋等，2020)。

内蒙古居力格台幅 1：50 000 地质图作为狼山地区造山带填图的探索性图件，力争在客观表达野外地质事实的基础上，结合前人地质调查、矿产勘查以及科研新成果，采用造山带填图思路，综合造山带构造解析手段 (白瑾，2003)，精细刻画狼山地区地质构造演化过程。

2　数据采集和处理方法

2.1　数据基础

内蒙古居力格台幅 1：50 000 地质图以《区域地质调查技术要求 (1：50 000)》(DD 2006-XX) 为规范，根据项目野外实际资料 (实际材料图、剖面图) 重新连图而成，代表居力格台幅 1：50 000 最新地质填图新成果。地理底图采用国家测绘地理信息局最新地理数据。应用已有的技术标准和数字填图系统 (DGSS)、MapGIS 等计算机软件进行数据处理。

表 1　数据库 (集) 元数据简表

条目	描述
数据库(集)名称	内蒙古居力格台幅1：50 000地质图数据库
数据库(集)作者	沉积岩类：刘　洋，中国地质调查局天津地质调查中心 火山岩类：郭　硕，中国地质调查局天津地质调查中心 岩浆岩类：滕学建，中国地质调查局天津地质调查中心 变质岩类：滕　飞，中国地质调查局天津地质调查中心
数据时间范围	2014—2016年
地理区域	经纬度：东经106°30′ ~ 106°45′，北纬41°10′ ~ 41°20′
数据格式	MapGIS
数据量	106 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“特殊地质地貌区填图试点” (项目编号：12120113056300)资助
语种	中文
数据库(集)组成	居力格台幅1：50 000地质图数据库由主图和图外整饰两部分组成。主图内容包括第四系、沉积岩、火山岩、侵入岩、构造形迹、地质界线、产状、各类代号等；图外整饰内容包括接图表、地层综合柱状图、侵入岩填图单位、图切剖面、构造纲要图、大地构造位置图、图例、责任表等。整体数据内容包含有3个非正式填图单位，12个正式填图单位、3期岩浆事件和3期构造变形，以及120个岩石化学分析数据，13个样品的锆石U-Pb年龄数据

2.2　数据处理过程

数据处理过程是将收集到的区域地质调查成果和实际材料图进行数字化处理，形成 MapGIS 点、线、面文件，建立野外原始数据库。成果空间数据库是由野外原始数据库继承而来。

2.2.1　野外原始数据库

根据已有资料的综合分析和地质草图的编制，划分重点工作区和一般工作区，确定了重点填图内容为渣尔泰山群及古生代岩浆岩。原始数据库整体又可分为数字填图资料和数字剖面库。

数字填图原始资料包含 1：25 000 图幅 PRB 库、实际材料图库、原始资料备份、野外手图、背景图层、样品数据库等数字填图原始资料数据库各 4 个。其中野外手图库存储野外地质路线各类地质数据，是最重要的野外第一手原始资料数据库。单条野外手图路线库均由 Images(存储照片)、Note(存储 XML 文档及 TXT 文本)、素描图 (存储素描图)3 个文件夹及 9 个野外路线实体观测数据点线采集层 (表 2) 和 ATTNOTE.WT(产状标注)、GPTNOTE.WT(地质点标注)2 个标注图层以及野外设计地质路线 (ROUTE.MPJ) 和以路线编号为文件名 (如 L0001.MPJ) 的 2 个工程文件及地理背景图层等组成。图幅 PRB 库文件类型及文件名与野外手图库完全一致。实际材料图库继承 PRB 库野外路线实体观测数据点、线采集层及标注图层，同时自动生成 GEOLABEL.WT、GEOLINE.WL、GEOPOLY.WP 点、线、面 3 个文件。背景图层存储地理底图数据，主要包括地理信息、水系、交通、居民地、境界、地形等要素。样品数据库存储图幅不同类型样品，分为样品采集库、送样库和测试鉴定成果库 3 类，数据存放在 RgSample.MDB 数据库中。

表 2 野外数据实体表

PRB过程	实体名	实体编码	实体数	单位	描述
野外数据采集	地质路线	ROUTE	154	条	顺序号，图幅编号，图幅名称，路线号，日期，天气，路线描述，目的任务，手图编号，记录者，同行者，摄像者，路线总结
	地质点(P)	GPOINT	1 094	个	顺序号，图幅编号，路线号，地质点号，经度，纬度，高程，纵坐标，横坐标，地理位置，露头性质，点性，微地貌，风化程度，岩性A，岩性B，岩性C，岩性代码A，岩性代码B，岩性代码C，地层单位A，地层单位B，地层单位C，接触关系AB，接触关系BC，接触关系AC，描述，国际标准编码，日期，地质点描述文件名
	分段路线(R)	ROUTING	3 154	条	顺序号，路线号,地质点号,点间编号，填图单位，日期，分段路线距离，点间累计距离，路线方向，备注，分段路线描述文件名
	点间界线(B)	BOUNDARY	2 963	条	顺序号，图幅编号，路线号，地质点号，B编号，R编号，纵坐标，横坐标，高程，经度，纬度，界线右边地质体，界线左边地质体，界线类型，走向，倾向，倾角，接触关系，国际标准编码，备注，日期，点间界线描述文件名
	产状	ATTITUDE	877	个	顺序号，图幅编号，路线号，地质点号，点间编号，产状编号，产状类型，纵坐标，横坐标，经度，纬度，高程，走向，倾向，倾角，国际标准编码，日期
	样品	SAMPLE	449	件	顺序号，图幅编号，路线号，地质点号，点间编号，野外编号，样品类别，纵坐标，横坐标，经度，纬度，地理位置，采样深度cm，样品重量kg，袋数，块数，采样人，日期，填图单位，野外原始定名，室内鉴定定名，送样单位，分析要求，备注，国际标准编码
	素描	SKETCH	134	个	顺序号，图幅编号，路线号，地质点号，点间编号，素描编号，纵坐标，横坐标，经度，纬度，素描名称，比例尺，素描说明，国际标准编码，日期，素描图文件夹
	照片	PHOTO	1990	个	顺序号，图幅编号，路线号，地质点号，点间编号，照片编号，纵坐标，横坐标，经度，纬度，描述内容，照片序号，镜头方向，国际标准编码，日期

2.2.2 成果空间数据库

地质图空间数据库包括基本要素类、综合要素类、对象类和独立要素类数据集。其中要素数据集是共享空间参考系统的要素类的集合，在地质图数据模型中，由地质点、面、线实体类构成。对象类是一个表，存储非空间数据，在地质图数据模型中，一般1 个要素类对应多个对象类。居里格台幅对应的要素类和对象类列于表 3。

2.2.3 图外要素整饰

内蒙古居力格台幅 (K48E017019)1∶50 000 地质图图外要素包括：综合柱状图、侵入岩填图单位、图切剖面、构造纲要图、所处大地构造位置图和其他图表 (图 2)。

表 3　1：50 000 居力格台幅地质图空间数据库要素类和对象类一览表

数据类型	名称	标准编码	说明
基本要素类	地质体面实体	_GEOPOLYGON.WP	实体数：611个
	地质(界)线	_GEOLINE.WL	实体数：1 624个
	矿产地	_MINERAL_PNT.WT	实体数：7个
	产状	_ATTITUDE.WT	实体数：877个
	同位素测年	_ISOTOPE.WT	实体数：13个
对象类	沉积(火山)岩岩石地层单位	_Strata	包括中–新元古界渣尔泰山群书记沟组一段(Chs_1)、二段(Chs_2)，增隆昌组一段(Chz_1)、二段(Chz_2)，阿古鲁沟组一段(Jxa_1)、二段(Jxa_2)、三段(Jxa_3)；白垩系乌兰苏海组(K_2w)、及第四系等共计10个地层单位
	侵入岩岩石年代单位	_Intru _Litho_Chrono	新元古代辉长岩；志留纪二长花岗岩、花岗伟晶岩；早二叠世辉长岩、角闪闪长岩、中细粒石英闪长岩、细粒石英闪长岩、含角闪石黑云母花岗闪长岩、黑云母花岗闪长岩、花岗闪长岩、似斑状二长花岗岩、黑云母二长花岗岩；晚二叠世黑云母二长花岗岩、中粒二长花岗岩；中三叠世二长花岗岩；晚三叠世似斑状二长花岗岩，共计16个单位
	脉岩	_Dike_Object	脉岩共计8类
综合要素类	标准图框	_MAP_FRAME.WL	标准图框内图框4条线，属性相同
	构造变形带	_TECTZONE.WP	韧性剪切带
	蚀变带	_ALTERATION_POLYGON.WP	中—新元古代渣尔泰山群角岩化蚀变带及褐铁矿化蚀变带
独立要素类	接图表	SelfJtb	
	综合柱状图	Column_sec	
	图切剖面	Cutting_profile	
	图例	Legend	

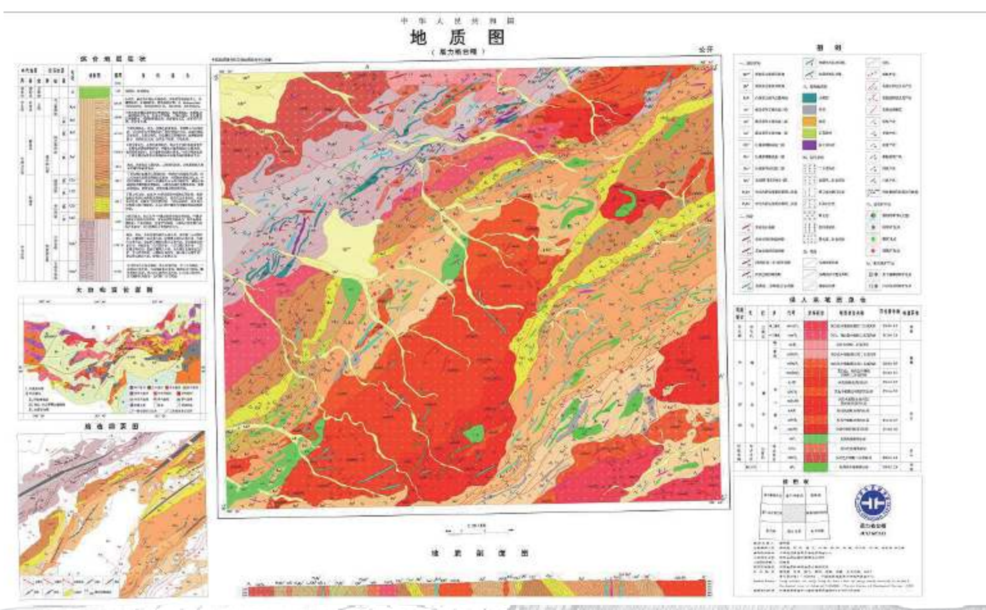

图 2　内蒙古居力格台幅 1：50 000 地质图示意图

(1) 综合柱状图：对地层分区内的岩石地层单元沉积建造特征进行详细表达。系统梳理图幅内各地层单元地层层序、沉积建造特征，结合锆石测年资料，综合反映其沉积背景及时代属性。

(2) 侵入岩填图单位：图幅内侵入岩填图单位包括晚元古代辉长岩，晚志留世侵入岩 (主要岩性为中细粒二长花岗岩及花岗伟晶岩)，早二叠世侵入岩 (主要岩性为中粒辉长岩、细粒石英闪长岩、中细粒石英闪长岩、中粒黑云母花岗闪长岩、中细粒 (含角闪石) 黑云母花岗闪长岩、中粒二长花岗岩、中细粒似斑状二长花岗岩)，中–晚三叠世酸性侵入岩 (主要岩性为中细粒二长花岗岩，中细粒似斑状二长花岗岩)。

(3) 图切剖面：图幅内建造和构造的总体走向为北东向，为直观表达区内各地质体接触关系及空间位态，布置 1 条北西向贯穿全区的剖面，反映不同地质体之间的接触关系及渣尔泰山群中变质沉积岩的褶皱变形特征。

(4) 构造纲要图：以板块构造理论为基础，采用构造—岩性填图方法、以不同规模相对稳定的古老陆块区和不同时期的造山系时空结构分析为主线，并以特定区域主要构造事件形成的沉积建造、岩浆活动、变形和变质作用等具体地质事件，充分体现本区的地质构造格架为原则，绘制构造纲要图 (图 3)。

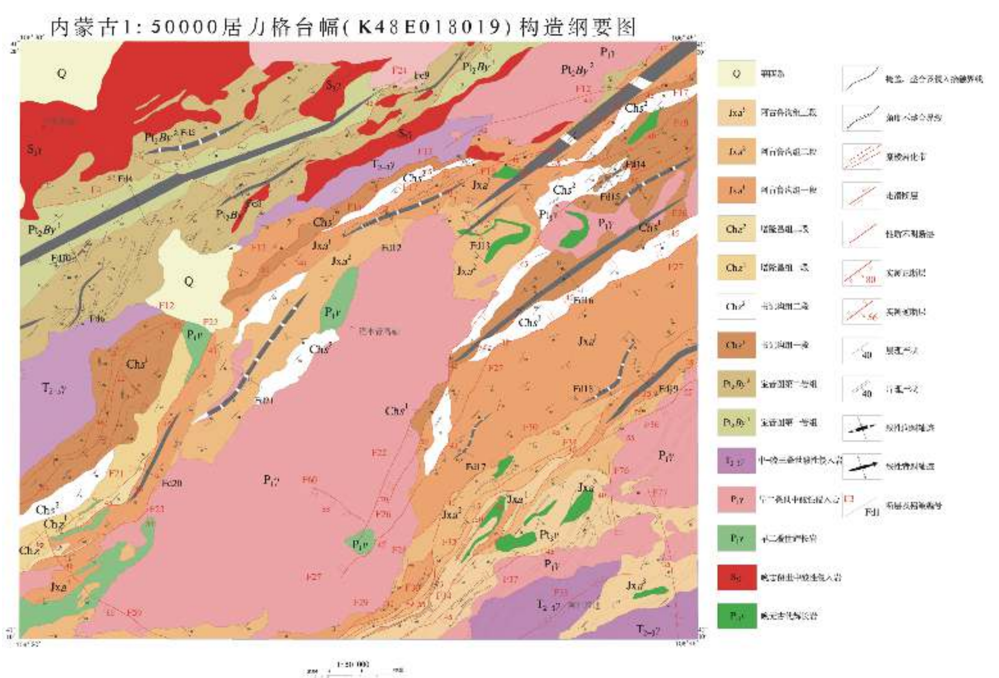

图 3　内蒙古 1：50 000 居力格台幅构造纲要图

(5) 所处大地构造位置图：表达了居力格台幅在区域大地构造中所处的大地构造位置及大地构造单元划分情况。本图幅位于 II 级大地构造单元包尔汉图—赤峰陆缘活动带。

(6) 其他图表：对脉岩、地质代号、地质符号及岩性花纹进行梳理，编制图例及责任表。

3　数据内容

3.1　数据命名

地质面.WP，地质线.WL，地质点.WT。

3.2 图层内容

主图内容包括第四系、沉积岩、火山岩、侵入岩、构造形迹、地质界线、产状、各类代号等。

图外要素内容包括接图表、地层综合柱状图、侵入岩填图单位、图切剖面、构造纲要图、大地构造位置图、图例、责任表等。

3.3 数据类型

实体类型名称：点、线、面。

点实体：各类地质体符号及标记、地质花纹、矿化蚀变。

线实体：地质界线、岩相界线、断裂构造、构造界线等。

面实体：第四系、沉积岩、火山岩、变质岩、侵入岩等。

3.4 数据属性

不同图幅由于地质内容有别，对应的地质图空间数据库要素类和对象类亦不尽相同。其中独立要素类属地质图廓外相关内容，不带属性。除上述各要素图层外，另有断层线、地质体面实体引线、地质体代号、岩性花纹、产状标注、同位素年龄值、图切剖面线及标注等没有属性内容的地质整饰图层。此外，尚有等高线、交通、居民地、境界等相关地理底图图层等。现将地质图基本要素类、综合要素类和对象类各数据项属性列表见表 4。

表 4　内蒙古居力格台幅 1∶50 000 地质图空间数据库数据属性表

数据类型	名称	标准编码	数据项属性
基本要素类	地质体面实体	_GeoPolygon	地质体面实体标识号，地质体面实体类型代码，地质体面实体名称，地质体面实体时代，地质体面实体下限年龄值，地质体面实体上限年龄值，子类型标识
	地质(界)线	_GeoLine	要素标识号，地质界线代码，地质界线类型，界线左侧地质体代号，界线右侧地质体代号，界面走向，界面倾向，界面倾角，子类型标识
	产状	_Attitude	要素标识号，产状类型名称代码，产状类型名称，走向，倾向，倾角，子类型标识
	样品	_Sample	要素标识号，样品编号，样品类型代码，样品类型名称，样品岩石名称，子类型标识
	照片	_Photograph	要素标识号，照片编号，照片题目，照片说明，子类型标识
	素描	_Sketch	要素标识号，素描编号，素描题目，素描说明，子类型标识
	化石	_Fossil	要素标识号，化石样品编号，化石所属生物门类，化石属或种名，化石产出层位，含化石地层单位代号，化石时代，子类型标识
	同位素测年	_Isotope	要素标识号，样品编号，样品名称，年龄测定方法，测定年龄，被测定出地质体单位及代号，测定分析单位，测定分析日期，子类型标识
	火山口	_Crater	要素标识号，火山口类型，火山口名称，火山口大小，火山口产出的地质体单位及代号，火山口岩石类型，火山口形成时代，子类型标识

续表 4

数据类型	名称	标准编码	数据项属性
基本要素类	泉	_Spring	要素标识号，泉类型代码，泉类型名称，泉水流量，泉水温度，泉的地质体单位及代号，子类型标识
	河、湖、海、水库岸线	_Line_Geography	要素标识号，图元类型，图元名称，子类型标识
综合要素类	构造变形带	_Tectzone	要素标识号，变形带代码，变形带类型名称，变形带岩石名称，变形带组构特征，变形带力学特征，形成时代，活动期次，含矿性，子类型标
	蚀变带(面)	_Alteration_Polygon	要素标识号，蚀变类型名称代码，蚀变类型名称，蚀变矿物组合及含量，含矿性，被蚀变的地质体代号，子类型标
	火山岩相带	_Volca_Facies	要素标识号，火山岩岩相类型及代码，产出的地层单位及代号，火山岩相岩石类型，岩石结构，岩石构造，流面产状，流线产状，形成时代，含矿性，子类型标识
	标准图框(内图框)	_Map_Frame	图名，图幅代号，比例尺，坐标系统，高程系统，左经度，下纬度，图形单位
对象类	沉积(火山)岩岩石地层单位	_Strata	要素分类，地层单位名称，地层单位符号，地层单位时代，岩石组合名称，岩石组合主体颜色，岩层主要沉积构造，生物化石带或生物组合，地层厚度，含矿性，子类型标识
	侵入岩岩石年代单位	_Intru_Litho_Chrono	要素分类，岩体填图单位名称，岩体填图单位符号，岩石名称(岩性)，岩石颜色，岩石结构，岩石构造，岩相，主要矿物及含量，次要矿物及含量，与围岩接触关系，围岩时代，与围岩接触面走向，与围岩接触面倾向，与围岩接触面倾角，流面产状，流线产状，形成时代，含矿性，子类型标识
	断层	_Fault	要素分类代码，断层类型，断层名称，断层编号，断层性质，断层上盘地质体代号，断层下盘地质体代号，断层破碎带宽度，断层走向，断层倾向，断层面倾角，估计断距，断层形成时代，活动期次，子类型标识
	脉岩(面)	_Dike_Object	脉岩分类代码，脉岩名称，脉岩符号，岩性，颜色，结构，构造，主要矿物及含量，次要矿物及含量，与围岩接触面走向，与围岩接触面倾向，与围岩接触面倾角，形成时代，含矿性，子类型标识
	非正式地层单位	_Inf_Strata	要素分类代码，非正式地层单位代码，岩性，岩石结构构造，所含生物化石带或生物组合，出露宽度或厚度，含矿性，所在地层单位符号，子类型标识
	面状水域	_Water_Region	要素分类代码，图元类型，图元名称，图元特征，子类型标识
	图幅基本信息	_Sheet_Mapinfo	地形图编号，图名，比例尺，坐标系统，高程系统，左经度，右经度，上纬度，下纬度，成图方法，调查单位，图幅验收单位，评分等级，完成时间，出版时间，资料来源，数据采集日期

4 数据质量控制和评估

填图精度总体按照《区域地质调查技术要求 (1：50 000)》(DD2006—XX) 标准进行野外填图。在实际填图过程中，对基岩区采取加密地质路线调查，对中—新生代地层区采取遥感解译为主、野外验证为辅的方式进行。

居力格台幅 1：50 000 地质图数据库的野外实测入库路线 154 条，地质点数 1 094 个，地质点间界线数 2 963 个，基本分析样品 449 件，产状 877 个，素描 134 个，照片 1 990 张，填图总体精度达到 1：50 000 区域地质专项填图的具体要求。

数据质量方面，采用填图路线自检、互检达 100%，项目组抽检 30%，符合地质调查项目质量管理要求，图面拓扑无错误率、属性填写规范、填写率为 90% 以上，保证了数据库的质量。原始资料丰富、翔实，总体均完成或超额完成了项目各项工作量，在地层划分对比、侵入岩解体和年代学研究、构造地质等方面均取得明显进展。居力格台幅 (K48E017019) 野外验收专家组评定 92.5 分，成果验收专家组评定 94 分，为优秀级，居力格台幅参加全国区域地质调查优秀图幅展评 (毛晓长，2018)，在 2018 年中国地质调查局优秀图幅评选中被评为优秀图幅。

5 数据价值

内蒙古居力格台幅 (K48E017019)1：50 000 地质图对测区发育的侵入岩、渣尔泰山群及构造变形等进行了详细分析，获得的主要成果如下：

(1) 查明了不同侵入体的岩石类型、相互间接触关系及与其与围岩的接触关系，初步探讨了侵入岩的演化规律和构造背景 (表 5)。根据构造岩浆期次将古生代以来的侵入岩划分为 3 期构造岩浆作用，第一期形成早古生代大陆边缘弧岩浆岩 (花岗闪长岩–二长花岗岩 (468 Ma)、石英闪长岩–花岗闪长岩–二长花岗岩 (440 ~ 420 Ma))、第二期形成晚古生代俯冲–碰撞岩浆岩 (辉长岩–闪长岩–石英闪长岩–花岗闪长岩–二长花岗岩 (330 ~ 290 Ma) 及二叠纪早–晚期辉长岩–闪长岩–石英闪长岩–花岗闪长岩–二长花岗岩 (280 ~ 260 Ma))，第三期形成早中生代后造山岩浆岩带花岗闪长岩–二长花岗岩–正长花岗岩 (260 ~ 230 Ma)。通过锆石 Hf 同位素手段对测区主要岩浆岩的物质来源及成因进行了初步研究，单颗粒锆石 Lu–Hf 测试分析表明，奥陶纪–志留纪的岩浆岩 $\varepsilon_{Hf}(t)$ 表现为较大的负值，锆石 Hf 二阶模式年龄为古元古代 (2 077 ~ 1 779 Ma)，显示了早古生代晚期大陆边缘弧岩浆岩的源区可能为以宝音图岩群为主的基底；晚石炭世—三叠纪岩浆岩的源区 $\varepsilon_{Hf}(t)$ 变化较大，多为较小的正值，显示了以年轻地壳熔融为主的特点。

(2) 对渣尔泰山群的书记沟组、增隆昌组和阿古鲁沟组进行了段级单位的划分。这套地层呈复式向斜产出，测得侵入阿古鲁沟组中的辉长岩年龄为 850 Ma，结合碎屑锆石年龄特征，将该地层时代厘定为新元古代。

(3) 查明测区经历了 3 期构造变形，第 1 期为发育在宝音图岩群中的早期顺层剪切褶皱变形——大理岩标志层的顺层掩卧褶皱和无根勾状褶皱，斜长角闪岩和石英岩发育的石香肠和不对称剪切褶皱；第 2 期变形发育在渣尔泰山群的透入性片理 S1 形成以及复向斜构造，还造成了宝音图岩群的片理褶皱和新生面理 S2 的形成和志留纪花岗岩的褶皱；第 3 期变形发育早二叠世大石寨组之后，表现为中浅部构造层次同斜倒转褶皱，造成了渣尔泰山群片理褶皱带的发育。

(4) 明确霍各乞大型铜矿的赋矿围岩为阿古鲁沟组二段炭质–钙质板岩，矿床总体位于该地层的片理褶皱形成的转折端部位。

表 5　内蒙古居力格台幅侵入岩时间序列表

时代		填图单位	主体岩性	主要分布位置	面积/km^2	产状	主要接触关系	同位素年龄/Ma	构造背景	
三叠纪	晚三叠世	$zx\pi\eta\gamma T_3$	中细粒似斑状二长花岗岩	恩格仁乌日腾	9.11	岩株	侵入$zc\beta\eta\gamma P_1$、渣尔泰山群	230.2±1.5 247.3±1.4	伸展	后造山
	中三叠世	$zx\eta\gamma T_2$	中细粒二长花岗岩	昂格日–布敦毛德、霍布阿木–巴拉更伊高勒	118.83	岩基	被$x\beta\eta\gamma T_2$侵入	237.8±2.4		
二叠纪	晚二叠世	$x\gamma\delta P_1$	灰白色中细粒花岗闪长岩	乌兰浑迪–陶布格仁高勒一带	4	岩枝	侵入$x\delta C_1$中	268.0±1.1	挤压	大陆边缘弧
	早二叠世	$z\eta\gamma P_2$	灰白色中粒二长花岗岩	那仁塞尔南部、瑙滚额热格高勒–敦德萨拉	15	岩枝	侵入$zx\delta o P_1$中	258.24±0.75		
		$zc\beta\eta\gamma P_1$	灰白色中粗粒黑云母二长花岗岩	塔黑勒图–恩格日尔一带北部(韧性剪切带)	6	岩枝	被$zx\pi\eta\gamma T_1$侵入	269.92±0.85		
		$zx\pi\beta\eta\gamma P_1$	灰白色、肉红色中细粒似斑状二长花岗岩	敖包伊高勒–巴润贵力森乃高勒一带	49	岩株	侵入$zx\beta\gamma\delta P_1$	288.58±0.99		
		$z\beta\gamma\delta P_1$	灰色中粒黑云母花岗闪长岩	呼和陶勒盖高勒附近	0.6	岩滴	侵入$zx\beta\gamma\delta P_1$	278.05±0.69 278.07±0.66		
		$x(zx)\delta o P_1$	灰白色细粒、中细粒石英闪长岩	阿日音珠斯郎南部、哈日陶勒盖–推木日图、毛浩日尧音高勒–居力格台	35.2	岩枝	侵入宝音图岩群、渣尔泰山群、$zx\delta o P_1$	275.25±0.68 270.10±0.74		
		$zx\delta\psi P_1$	灰色中细粒角闪闪长岩	阿伦珠斯朗一带	3.6	岩枝	侵入渣尔泰山群中	272±2		
志留纪	晚志留世	$zx\eta\gamma S_3$	灰红色中细粒二长花岗岩	乌兰敖包–善达；呼和陶勒盖	124	岩基	侵入宝音图岩群中；被$\gamma\delta C_1$侵入	420.8±4.4	挤压	同造山(拼贴)
新元古代		νPt_3	灰黑色中细粒辉长岩	德勒–好勒包	2	岩枝或岩脉	侵入渣尔泰山群之中	850.6±2.9	伸展	

注：zx—中细粒；x—细粒；z—中粒；zc—中粗粒。

6 结论

(1) 内蒙古居力格台幅 (K48E017019)1：50 000 地质图是中国地质调查局新一轮地质调查的探索性图幅，采用构造–岩性填图方式提升成果表达方式，对区域地质调查特别是造山带填图起到了示范作用。

(2) 以中国地质调查局《数字地质图数据库标准》(DD2006−06) 为标准，全面系统编制了居力格台幅 (K48E017019)1：50 000 地质图并建立了空间数据库，详细表达了不同地质体的基本属性。

(3) 通过野外沉积建造、构造变形序列研究，结合岩石地球化学及年代学测试资料，系统查明了中元古代宝音图岩群岩石组成、变形变质特征、原岩建造及中–新元古代渣尔泰山群的基本层序、沉积环境；明确了宝音图岩群经历了 3 期变形,表现为早期顺层剪切变形、片理褶皱及片理膝褶，渣尔泰山群经历了 2 期变形，表现为早期层理褶皱及晚期片理褶皱；梳理了古生代侵入岩演化序列为早古生代大陆边缘弧岩浆岩、晚古生代俯冲–碰撞岩浆岩，早–中生代后造山岩浆岩；认为霍各乞大型铜矿的成矿构造为阿古鲁沟组二段炭质–钙质板岩片理褶皱导致的转折端部位，这些资料可为后续基础地质调查与科学研究工作提供基础。

致谢：内蒙古居力格台幅 1：50 000 地质图是一项集体成果，项目组一线地质工作人员付出了辛勤的努力。在地质图填绘及数据库的建立过程中，得到中国地质调查局天津地质调查中心赵风清研究员、王惠初研究员、辛后田教授级高级工程师及中国地质科学院地质力学所胡健民研究员的辛勤指导，在此对各位专家和野外项目组所有成员表示最诚挚的感谢。

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1∶50 000 Geological Map Database of the Juligetai Map-sheet, Inner Mongolia

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Abstract: The 1∶50 000 Geological Map of the Juligetai Map-sheet (K48E017019), Inner Mongolia was compiled according to the '*Technical Requirements for Regional Geological Surveys (1∶50 000)*' (DD 2006-XX) and other uniform standards and requirements. It also makes full use of the data from the 1∶200 000 regional geological survey and 1∶50 000 mineral resource survey, and adopts various remote sensing imagery systems including Spot, ETM and Aster. It is an important mapping achievement guided by the orogenic belt theory. In the current project, a geological mapping method for complex tectonic areas was used to creatively express the structural features in multiple stages and their attitude features in geological maps. The map comprehensively reflects the spatial distribution of different intrusive bodies and magmatic sequence of intrusive rocks in the Wulatehou Banner in Langshan area, as well as the rhythm and deformation characteristics, sedimentary age and sedimentary environment of metamorphic sedimentary rocks of the Zhaertaishan Group. The wall-rocks of the Huogeqi Copper Deposit was further identified as carbonaceous-calcareous slates of the Agulugou Formation's second member. The deposit is mostly located at the hinge zone of the schistose fold in the stratum. The map database includes 3 informal mapping units, 12 official mapping units, 3 periods of magmatic events and 3 tectonic deformations, in addition to 120 pieces of petrochemical analysis data and zircon U–Pb age data of 13 samples, with a data size of 106 MB. The database represents an exemplary result of the 1∶50 000 orogenic belt geological survey. It plays a leading role in orogenic belt mapping and is able to support subsequent basic geological research and prospecting by providing essential basic data.

Key words: Inner Mongolia; Langshan area; Juligetai Map-sheet; 1∶50 000; geological map; database; Huogeqi Copper Deposit; Paleozoic magmatism

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

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1 Introduction

As the largest Phanerozoic orogenic belt in the world, the Central Asian Orogenic Belt (CAOB) extends for thousands of kilometers in all directions (Fig. 1a). Its complex tectonic evolution process is closely associated with the tectonic movement of the Paleo-Asian Ocean (Windley BF et al., 2007; Han BF et al., 2011; Xu Z et al., 2012; Zhang XH et al., 2012; Xu B et al., 2013; Zhang W et al., 2013; Wang SQ et al., 2019). The process of subduction, accretion, orogeny and terrane collage of the Paleo-Asian ocean basin resulted in the current tectonic framework (Coleman RG, 1989; Windley BF et al., 1990, 2007; Allen MB et al., 1993, 1995; Sengor AMC et al., 1993; Gao J et al., 1998; Jahn BM et al., 2000; Xiao WJ et al., 2004, 2010; Li YJ et al., 2018, 2020; Yuan Y et al., 2018; Zheng RG et al., 2018; Zhao L et al., 2019; Zhao C et al., 2020). In recent years, a large number of scientific studies have been conducted on important geological issues such as Paleozoic tectonic magmatism and Precambrian stratigraphic subdivision in the northern margin of the North China Block, obtaining rich data (Zhang W et al., 2012; Zhang W et al., 2013; Wu F et al., 2014; Wang ZZ et al., 2015; Liu M et al., 2016; Tian J et al. 2018; Wang XY et al., 2018; Teng XJ et al., 2019). Located in the west of the northern margin of the North China block (Fig. 1a), with the Central Asian Orogenic Belt in the north and the North China Craton in the south (Wu TR et al., 1998; Liu Y, 2012; Feng LX et al., 2013; Peng RM et al., 2013), the Langshan area is of great significance for understanding regional tectonic evolution due to its special tectonic location.

The Juligetai Map-sheet, Inner Mongolia is located on the north–west side of the Wulatehou Banner in the Langshan area (Fig. 1b). The exposed geobodies in the area are primarily Proterozoic metamorphic sedimentary rocks and Paleozoic intrusive rocks, characterized by the development of Late-Paleozoic intrusive rocks in large areas. The First Regional Geological Survey Team of the Inner Mongolia Autonomous Region (1982) completed a 1：200 000 Regional Geological and Mineral Survey, providing a comprehensive and systematic review of the stratigraphic framework, magmatism, tectonic evolution and metallogenic background in the area. However, important geological issues including the

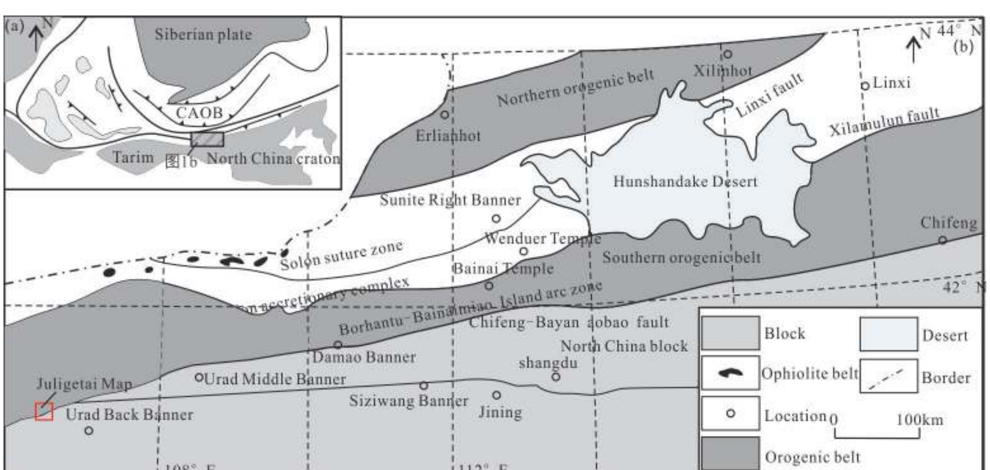

Fig. 1 Geotectonic location (a) of the Langshan area, Inner Mongolia, and location of the Juligetai map-sheet (b) (modified from Wang ZZ et al., 2015)

Paleozoic tectonic regime transformation in the northern margin of the North China block, formative era of the Zhaertaishan Group and metallogenic background of the Huogeqi Copper Deposit still need further investigation. In the current project, we conducted a 1 ∶ 50 000 Regional Geological and Mineral Survey in the Juligetai Map-sheet, Inner Mongolia, and established a corresponding 1 ∶ 50 000 Geological Map Database (Table 1, Liu Y et al., 2020).

The 1 ∶ 50 000 Geological Map of the Juligetai Map-sheet, Inner Mongolia represents a pilot project of orogenic belt mapping in the Langshan area. It aims to describe in detail the tectonic evolution in the Langshan area with objectively expressed field geological facts by incorporating previous geological surveys, mineral exploration and the latest research results, in addition to adopting advanced mapping approaches combined with tectonic analysis of the orogenic belt (Bai J, 2003).

2 Data Collection and Processing Methods

2.1 Data Source

In line with the '*Technical Requirement for Regional Geological Surveys (1 ∶ 50 000)*' (DD 2006-XX), the 1 ∶ 50 000 Geological Map of the Juligetai Map-sheet, Inner Mongolia

Table 1 Metadata Table of Database (Dataset)

Items	Description
Database (dataset) name	1 ∶ 50 000 Geological Map Database of the Juligetai Map-Sheet, Inner Mongolia
Database (dataset) authors	Sedimentary rocks: Liu Yang, Tianjin Center, China Geological Survey Volcanic rocks: Guo Shuo, Tianjin Center, China Geological Survey Magmatic rocks: Teng Xuejian, Tianjin Center, China Geological Survey Metamorphic rocks: Teng Fei, Tianjin Center, China Geological Survey
Data acquisition time	2014 – 2016
Geographic area	106°30′ – 106°45′ E,41°10′ – 41°20′ N
Data format	MapGIS
Data size	106 MB
Data service system URL	http://dcc.cgs.gov.cn
Fund project	Funded by China Geological Survey project titled 'Pilot Mapping of Special Geological and Geomorphological Areas' (Project No.: 12120113056300)
Language	Chinese
Database (dataset) composition	The 1 ∶ 50 000 Geological Map Database of the Juligetai Map-Sheet consists of two parts: the master map and outer finishing. The master map includes Quaternary, sedimentary rock, volcanic rocks, intrusives, structural features, geological boundary, attitude and various codes. The outer finishing includes an index map, stratigraphic columnar section, intrusive rock mapping units, cutting profile, structure outline map, geotectonic location, legend and author information. Overall, the map database includes 3 informal mapping units, 12 formal mapping units, 3 periods of magmatic events and deformations, as well as 120 pieces of petrochemical analysis data and the zircon U–Pb age of 13 samples

was created according to actual field data (including actual material maps and profiles) as a new achievement of the 1∶50 000 geological mapping of the Juligetai map-sheet. The project adopted the latest geographic data from the National Geomatics Center of China (NGCC) for geological base maps and applied existing technical standards and computer software such as the Digital Geological Survey System (DGSS) and MapGIS for data processing.

2.2 Data Processing

The purpose of data processing is to digitize the collected regional geological survey results and actual material maps to form MapGIS point, line and area files; and to establish the original field database, as the spatial database originate from it.

2.2.1 Field Original Database

Based on the comprehensive analysis of the existing data and geological sketches, we established key working areas and general working areas, and identified the Zhaertaishan Group and Paleozoic magmatic rocks as the key contents of mapping. The original database as a whole can be divided into digital mapping data and a digital profile database.

The original data of the digital mapping includes 4 original databases of the 1∶25 000 map PRB database, actual material map database, original data backup, free hand field maps, background layers and sample database; of which the free hand field map database stores various data of geological field routes and represents the most important first-hand original database. A single field map route database is composed of Images (photos), Note (XML files and TXT text files), Sketch (sketches), 3 folders, 9 point and line acquisition layers of field route observation data (Table 2), ATTNOTE.WT (attitude note), GPTNOTE.WT (geological point note), 2 labeled layers and geological routes (ROUTE.MPJ), and 2 engineering documents and geographical background layers with the route number as the file name (e.g. L0001. MPJ).

Table 2 Field data entity table

PRB process	Entity name	Entity code	Number of entities	Description
Field data collection	Geological route	ROUTE	154	Sequence number, map-sheet number, map-sheet name, route number, date, weather, route description, task, hand map number, recorder, companion, photographer, route summary
	Geological point (P)	GPOINT	1 094	Sequence number, map-sheet number, route number, geological point number, longitude, latitude, elevation, vertical coordinates, horizontal coordinates, geographical location, outcrop property, point nature, micro-geomorphology, weathering degree, lithology A, lithology B, lithology C, lithology code A, lithology code B, lithology code C, stratigraphic unit A, stratigraphic unit B, stratigraphic unit C, contact relation AB, contact relation BC, contact relation AC, description, International Standard Code, date, geological point description file name

Continued table 2

PRB process	Entity name	Entity code	Number of entities	Description
Field data collection	Routing (R)	ROUTING	3 154	Sequence number, route number, geological point number, inter-point number, mapping unit, date, routing distance, cumulative distance between points, route direction, note, routing description file name
	Inter-point boundary (B)	BOUNDARY	2 963	Sequence number, map-sheet number, route number, geological point number, B number, R number, vertical coordinates, horizontal coordinates, elevation, longitude, latitude, geobody on the right side of the boundary, geobody on the left side of the boundary, boundary line type, strike, dip, dip angle, contact relation, International Standard Code, note, date, inter-point boundary description file name
	Attitude	ATTITUDE	877	Sequence number, map-sheet number, route number, geological point number, inter-point number, attitude number, attitude type, vertical coordinates, horizontal coordinates, longitude, latitude, elevation, strike, dip, dip angle, International Standard Code, date
	Sample	SAMPLE	449	Sequence number, map-sheet number, route number, geological point number, inter-point number, field number, sample type, vertical coordinates, horizontal coordinates, longitude, latitude, geographical location, sampling depth (cm), sample weight (kg), number of bags, number of pieces, sample collector, date, mapping unit, original naming in field, naming based on indoor identification, unit sending sample, analysis requirements, note, International Standard Code
	Sketch	SKETCH	134	Sequence number, map-sheet number, route number, geological point number, inter-point number, sketch number, vertical coordinates, horizontal coordinates, longitude, latitude, sketch name, scale, sketch description, International Standard Code, date, sketch folder
	Photo	PHOTO	1990	Sequence number, map-sheet number, route number, geological point number, inter-point number, sample code, vertical coordinates, horizontal coordinates, longitude, latitude, description, photo serial number, lens direction, International Standard Code, date

The file type and file name of the PRB library are completely consistent with that of the field map library. The actual material library inherits the point and line acquisition layers and labeled layers of the field route observation data of the PRB library, while automatically generating the 3 point, line and area files, i.e., of GEOLABEL.WT, GEOLINE.WL and GEOPOLY.WP. The background layer stores the data of the geographic base maps, including geographic information, water system, transportation, residential area, boundary and topography. The sample database stores different types of samples from the map-sheet and is divided into three categories: sample collection database, sample submission database, and test and identification result database, with the data being stored in the RgSample.MDB database.

2.2.2 Spatial Database

The geological map spatial database includes the datasets of basic feature class, complex class, object class and independent feature class; of which the feature dataset is a collection of features sharing the same spatial reference system and is composed of geological point, area and line entities in the geological map data model. The object class is a table storing non-spatial data. In a geological map data model, 1 Feature type generally corresponds to multiple object classes. The feature class and object class of the Juligetai map-sheet are shown in Table 3.

2.2.3 Figure Outer Finishing

The outer features of the 1：50 000 geological map of the Juligetai map-sheet (K48E017019), Inner Mongolia include: columnar section, intrusive rock mapping unit, cutting profile, structural outline, geotectonic location and other figures (Fig. 2).

(1) Columnar section: the characteristics of sedimentary formations of different lithostratigraphic units were expressed in detail, and the characteristics of the stratigraphic sequence and rock association of various stratigraphic units in the map were systematically processed to comprehensively reflect their sedimentary background and era attributes, in combination with zircon dating.

(2) Intrusive rock mapping unit: the intrusive rock mapping units in the map include Late Proterozoic gabbro, Late Silurian intrusive rocks (mainly medium-fine-grained monzonitic granite and granite pegmatite), Early Permian intrusive rocks (mainly medium-grained gabbro, fine-grained quartz diorite, medium-fine-grained quartz diorite, medium-grained biotite granodiorite, medium-grained (hornblende-bearing) biotite granodiorite, medium-grained monzonite and medium-grained porphyritic monzonite), and Middle – Late Triassic acidic intrusive rocks (mainly medium-fine-grained adamellite and medium-fine-grained porphyritic adamellite).

(3) Cutting profile: the general strike of the formation and structure in the map is NE. To visually display the contact relation and spatial position of geobodies in the region, a NW-trending section was arranged throughout the whole area, reflecting the contact relationship between different geobodies and the folding and deformation characteristics of metamorphic sedimentary rocks in the Zhaertaishan Group.

(4) Structural outline: Based on the plate tectonics theory and with a “polycyclic opening – closing tectonics” approach, the outline focuses on the analysis of the spatial – temporal structure of the relatively stable ancient continental block areas of different scales and orogenic systems of different periods. It aims to fully reflect the geological tectonic framework in this area by expressing specific geological events such as sedimentary formation, magmatism, deformation and metamorphism formed due to major tectonic events in a specific region (Fig. 3).

Table 3 Feature and object class of 1：50 000 geological map database of the Juligetai map-sheet

Data type	Name	Standard code	Description
Basic feature class	Geological polygon	_GEOPOLYGON.WP	Number of entities: 611
	Geological boundary line	_GEOLINE.WL	Number of entities: 1 624
	Mineral area	_MINERAL_PNT.WT	Number of entities: 7
	Attitude	_ATTITUDE.WT	Number of entities: 877
	Isotope dating	_ISOTOPE.WT	Number of entities: 13
Object class	Sedimentary (volcanic) rock lithostratigraphic unit	_Strata	10 stratigraphic units including the first member (Chs_1) and second member (Chs_2) of the Shujigou Formation, the first member (Chz_1) and second member (Chz_2) of the Zenglongchang Formation, and the first member (Jxa_1), second member (Jxa_2) and third member (Jxa_3) of the Agulugou Formation of the Middle-Neoproterozoic Zhaertaishan Group; Cretaceous Wulansuhai Formation (K_2w) and the Quaternary System
	Intrusive rock lithochronological unit	_Intru _Litho_Chrono	A total of 16 units including Neoproterozoic gabbro; Silurian adamellite, granite pegmatite; Early Permian gabbro, hornblende diorite, medium-fine-grained quartz diorite, fine-grained quartz diorite, hornblende-bearing biotite granodiorite, biotite granodiorite, granodiorite, porphyritic monzonitic granite, biotite monzonitic granite; Late Permian biotite monzonitic granite and medium-grained monzonitic granite; Middle Triassic adamellite; Late Triassic porphyritic monzonitic granite
	Dike	_Dike_Object	8 types of dikes
Complex class	Standard frame	_MAP_FRAME.WL	4 lines in the standard frame with the same attributes
	Tectonic deformation zone	_TECTZONE.WP	Ductile shear zone
	Alteration polygon	_ALTERATION_POLYGON.WP	Meso-Neoproterozoichornfelsed alteration polygon and Limonitization alteration polygon of the Zhaertaishan Group
Independent feature class	Index map	SelfJtb	
	Columnar section	Column_sec	
	Cutting profile	Cutting_profile	
	Legend	Legend	

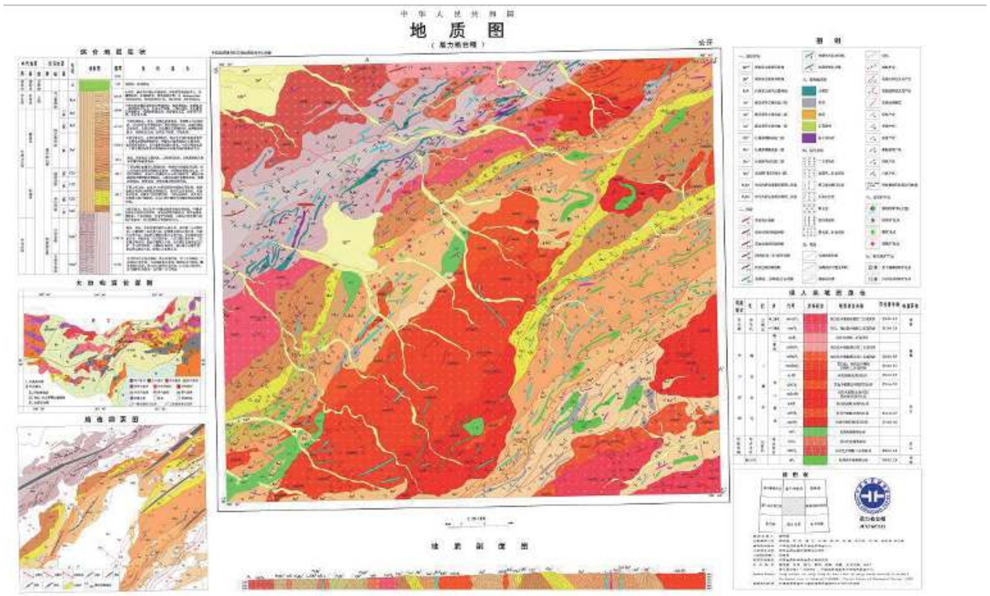

Fig. 2 1 ∶ 50 000 geological map of Juligetai map-sheet, Inner Mongolia

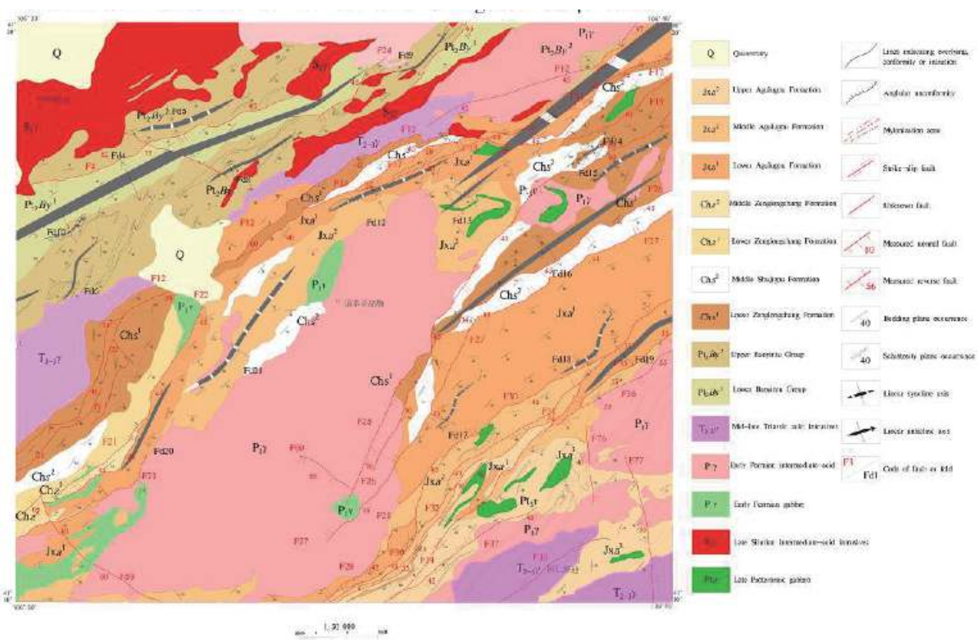

Fig. 3 Structural outline of the 1 ∶ 50 000 Juligetai map-sheet, Inner Mongolia

(5) Geotectonic location: it represents the geotectonic location of the Juligetai map-sheet in terms, and the division of geotectonic units. This map-sheet is located in the Baoerhantu – Chifeng continental margin active zone, a Class II geotectonic unit.

(6) Other figures: these figures provide detailed information on dike rocks, geological codes, geological symbols and lithological pattern, along with legends and the duty table.

3 Data Content

3.1 Data Naming

Geological polygon.WP, geological line.WL, geological point.WT.

3.2 Layer Content

The main map includes the Quaternary System, sedimentary rock, volcanic rock, intrusive rock, structural feature, geological boundary line, attitude and various codes.

Outer features include an index map, stratigraphic columnar section, intrusive rock mapping unit, cutting profile, structural outline, geotectonic location, legend and duty table.

3.3 Data Type

Entity type: point, line and area.

Point entities: symbols and marks of various geobodies, geological patterns, mineralization and alteration.

Line entities: geological boundaries, lithofacies boundary, fault structure and structural boundary.

Area entities: Quaternary System, sedimentary rock, volcanic rock, metamorphic rock and intrusive rock.

3.4 Data Attribute

As different map-sheets differ in geological content, the feature and object class of the corresponding geological map spatial database also differ. Among them, the independent feature class belongs to off-map contents with no attributes. In addition to the above-mentioned attribute layers, there are fault lines, geological polygon solid leads, geobody code, lithological patterns, attitude note, isotope age, cutting profile lines and notes among other appearance layers without attributes. In addition, there are still contour lines, traffic, residential areas and other related geographical base map layers. The adta item attributes of the basic feature class, complex class and object class of the geological maps are shown in Table 4.

4 Data Quality Control and Evaluation

Overall, field mapping was carried out in conformity with the accuracy standard of the '*Technical Requirement for Regional Geological Surveys (1：50 000)*' (DD2006—XX). In the actual mapping process, an intensive route deployment for the bedrock area, and remote sensing interpretation supplemented by field verification for the Mesozoic-Cenozoic stratigraphic area, were adopted.

The 1：50 000 Geological Map Database of the Juligetai Map-sheet had 154 routes measured in the field, 1 094 geological points, 2 963 boundary lines between geological points, 449 samples for basic analysis, 877 attitudes, 134 sketches and 1 990 photographs. The overall mapping accuracy meets the specific requirements of the 1：50 000 regional geological special mapping.

In terms of data quality, self-examination and mutual inspection of mapping routes reached 100% and random inspections by the project team reached 30%, which meets the relevant quality requirements for geological survey projects. The map topology has a zero-error rate and attribute filling conforms to the relevant standards with a filling rate above 90%, ensuring the quality of the database. The project also boasts full and detailed original materials. Overall, the expected workload of the project have been completed or exceeded, making significant progress in the stratigraphic subdivision and correlation, intrusive rock disintegration, chronological research and tectonic geology. The Juligetai map-sheet (K48E017019) was given a rating of 92.5 points by the expert group in field acceptance and 94 (excellent) by the expert group in final result acceptance. The Juligetai map-sheet participated in the National Regional Geological Survey Excellent Map Exhibition and Evaluation (Mao XC, 2018) and was rated as an excellent map in the 2018 China Geological Survey Excellent Map Award.

Table 4 Data attributes of 1: 50 000 geological map spatial database of Juligetai map-sheet, Inner Mongolia

Data type	Name	Standard code	Attribute of data item
Basic feature class	Geological polygon	_GeoPolygon	Geological polygon identification number, geological code, geological polygon name, geological polygon age, lower age limit of geological polygon, upper age limit of geological polygon, subtype identification
	Geological (boundary) line	_GeoLine	Feature identification number, geological boundary line code, boundary name, geobody code on the left side of the boundary, geobody code on the right side of the boundary, strike, dip direction, dip angle, subtype identification
	Attitude	_Attitude	Feature identification number, attitude type code, attitude name, strike, dip direction, dip angle, subtype identification
	Sample	_Sample	Feature identification number, sample code, sample type code, sample name, rock name, subtype identification
	Photograph	_Photograph	Feature identification number, sample code, photo title, photo note, subtype identification
	Sketch	_Sketch	Feature identification number, sample code, sketch title, sketch note, subtype identification
	Fossil	_Fossil	Feature identification number, fossil sample code, biological category of fossil, genus or species, bed, code of fossil-bearing lithostratigraphic unit, era, subtype identification
	Isotope	_Isotope	Feature identification number, sample code, sample name, age measuring method, age, unit and code of measured geobody, measure and analysis unit, measure and analysis date, subtype identification
	Crater	_Crater	Feature identification number, crater type, crater name, crater size, unit and code of geobody produced at the crater, crater rocktype, crater era, subtype identification
	Spring	_Spring	Feature identification number, spring code, spring name, spring runoff, temperature, geobody code, subtype identification
	River, lake, sea and water coastline	_Line_Geography	Feature identification number, feature type, feature name, subtype identification

Continued table 4

Data type	Name	Standard code	Attribute of data item
Complex class	Tectonic deformation zone	_Tectzone	Feature identification number, feature type, feature name, deformation name, fabric character, mechanics, era, movement period, commodities, subtype identification
	Alteration polygon	_Alteration_Polygon	Feature identification number, feature type, alteration type, association, commodities, altered geobody code, subtype identification
	Volcanic facies	_Volca_Facies	Feature identification number, feature type, stratigraphic unit, rock type, rock texture, rock structure, flow plane attitude, flow line attitude, era, commodities, subtype identification
	Map frame	_Map_Frame	Map name, sheet code, scale, coordinate system, height system, left longitude, lower longitude, coordinates unit
Object Class	Sedimentary (volcanic) rock lithostratigraphic unit	_Strata	Feature type identification, stratigraphic unit name, stratigraphic unit code, stratigraphic unit era, rock association name, rock association color, sedimentary structure, biological assemblage zone, stratigraphic thickness, commodities, subtype identification
	Intrusive rock lithochronological unit	_Intru_Litho_Chrono	Feature type, intrusive body name, intrusive body code, rock name, color, rock texture, rock structure, rock phases, primary minerals and content, secondary minerals and content, contact relation with wall-rock, wall-rock era, attitude of wall-rock contact surface (strike, dip direction, dip angle), flow plane attitude, flow line attitude, formative era, commodities, subtype identification
	Fault	_Fault	Feature type, fault type, fault name, fault code, fault character, fault hanging wall geobody code, fault footwall geobody code, fault fracture zone width, fault strike, fault dip, fault dip angle, estimated fault distance, formative era of fault, movement period, subtype identification
	Dike	_Dike_Object	Feature type, dike name, dike code, dike lithology, dike color, texture, structure, primary minerals and content, secondary minerals and content, strike, dip direction, dip angle, formative era, commodities, subtype identification
	Informal strata	_Inf_Strata	Feature type, informal stratigraphic unit code, lithology, rock texture and structure, fossil assemblage, outcrop width or thickness, commodities, stratigraphic unit code, subtype identification
	Water region	_Water_Region	Feature type, feature class, feature name, object feature, subtype identification
	Sheet map information	_Sheet_Mapinfo	Sheet numbering, sheet name, scale, coordinate system, height system, left longitude, right longitude, upper latitude, lower latitude, mapping method, survey unit, accepting unit, grade, finished date, publish date, data origin, data acquisition date

5 Data Value

The 1∶50 000 Geological Map of the Juligetai Map-sheet (K48E017019), Inner Mongolia provides detailed information on the intrusive rocks, Zhaertaishan Group and tectonic deformations in the survey area, and the following results could be achieved.

(1) The rock types of different intrusive bodies, contact relationship between them and contact relationship with wall-rocks were identified, and the their evolutionary pattern and tectonic background were also preliminarily investigated (Table 5). According to the tectonic magmatic stages, the intrusives have been divided into three periods of tectonic magmatism since the Paleozoic. The first period led to the formation of the Early Paleozoic continental margin arc magmatic rocks Granodiorite–adamellite (468 Ma), quartz diorite–granodiorite–adamellite (440–420 Ma); the second period led to the formation of the late Paleozoic subduction – collision magmatic rocks (gabbro–diorite–quartz and diorite–granodiorite–adamellite (330–290 Ma) and Early–Late Permian gabbro–diorite–quartz and diorite–granodiorite–adamellite (280–260 Ma); the third period led to the formation granodiorite–adamellite–syenite (260–230 Ma) of the post-Mesozoic orogenic magmatic rock belt. The source and genesis of the dominant magmatic rocks in the survey area were preliminarily investigated by zircon Hf isotopic analysis. Lu–Hf analysis of single zircon grains shows a relatively high negative value of Ordovician–Silurian magmatic rocks ε_{Hf} (t) and the two-stage Hf isotopic model age is the Paleoproterozoic (2 077–1 779 Ma), indicating that the source region of continental margin arc magmatic rocks in the Late–Early Paleozoic/latter part of the Early Paleozoic may be the basement dominated by the Baoyintu Group. ε_{Hf} (t) in the source region of Late Carboniferous–Triassic magmatic rocks varies greatly, having primarily small positive values and showing the characteristics of young crustal melting.

(2) The Shujigou, Zenglongchang and Agulugou Formations of Zhaertaishan Group were divided into member-level units. The strata series occurred as duplex syncline. The gabbro intruding into the Agulugou Formation was dated to be 850 Ma, which in combination with the characteristics of clastic zircon ages, indicates that the stratigraphic age should be in the Neoproterozoic.

(3) Three periods of tectonic deformations were identified in the survey area. The first period was the early bedding shear fold deformation developed in the Baoyintu Group—bedding recumbent folds and rootless hook folds of marble marker layer, and stone sausages and asymmetric shear folds developed with amphibolites and quartzites; the second period of deformation was developed in the formation of permeable schistose S1 and syncline structure of the Zhaertaishan Group, which also resulted in the formation of schistose folds and new foliation S2 of the Baoyintu Group, and the folds of Silurian granite; the third period of deformation was developed after the Early Permian Dashizhai Formation and displays congruous overturned folds at middle- and shallow-seated tectonic levels, resulting in the development of the schistozoic fold belt of the Zhaertaishan Group.

(4) The wall-rock of the large-scale Huogeqi Copper Deposit was specified to be

Table 5 Time series of the intrusives in Juligetai map-sheet, Inner Mongolia

Era		Mapping unit	Main lithology	Main distribution	Area/km^2	Attitude	Main contact relation	Isotopic age/Ma	Tectonic setting	
Triassic	Late Triassic	zx$\pi\eta\gamma T_3$	Medium-fine-grained porphyritic monzonitic granite	Engerenwuriteng	9.11	Stock	Intruding zc$\beta\eta\gamma P_1$, Zhaertaishan Group	230.2±1.5247.3±1.4	Extension	Post-orogeny
	Middle Triassic	zx$\eta\gamma T_2$	Medium-fine-grained monzonitic granite	Anggeri – Budunmaude, Huobuamu – Balagengyigaole	118.83	Batholith	Intruded by x$\beta\eta\gamma T_2$	237.8±2.4		
Permian	Late Permian	x$\gamma\delta P_1$	Grey-white medium-fine granodiorite	Ulanhundi – Taubugerengaole area	4	Apophysis	Intruding xδC_1	268.0±1.1	Compression	Continental margin arc
	Early Permian	z$\eta\gamma P_2$	Grey-white medium-grained monzonitic granite	Southern part of Narensaier, Naoguneregegaole-Dundesala	15	Apophysis	Intruding zx$\delta o P_1$	258.24±0.75		
		zc$\beta\eta\gamma P_1$	Grey-white medium-coarse-grained biotite monzonitic granite	Northern part of Taheiletu-Engerier area (ductile shear zone)	6	Apophysis	Intruded by zx$\pi\eta\gamma T_1$	269.92±0.85		
		zx$\pi\beta\eta\gamma P_1$	Grey-white meat-red medium-fine grained porphyritic monzonitic granite	Aobaoyigole – Barunguilisennaigaole area	49	Stock	Intruding zx$\beta\gamma\delta P_1$	288.58±0.99		
		z$\beta\gamma\delta P_1$	Grey medium-grained biotite granodiorite	Vicinity of Huhetaolegaigaole	0.6	Rock drop	Intruding zx$\beta\gamma\delta P_1$	278.05±0.692 78.07±0.66		
		x(zx)$\delta o P_1$	Grey-white fine-grained and medium-fine-grained quartz diorite	Southern part of Hariyinzhusilang, Haritaolegai – Tuimuritu, Maohaoriyaoyingaole – Juligetai	35.2	Apophysis	Intruding Baoyintu Group and Zhaertaishan Group, zx$\delta o P_1$	275.25±0.682 70.10±0.74		
		zx$\delta\psi P_1$	Grey medium-fine grained hornblende diorite	Alunzhusilang area	3.6	Apophysis	Intruding Zhaertaishan Group	272 ±2		
Silurian	Late Silurian	zx$\eta\gamma S_3$	Grey- red medium-fine-grained monzonitic granite	Ulan Obo – Shanda; Huhetaolegai	124	Batholith	Intruding Baoyintu Group; intruded by $\gamma\delta C_1$	420.8 ±4.4	Compression	Synorogeny (collage)
Neoproterozoic		νPt_3	Grey-black medium-fine-	Dele – Haolebao	2	Apophysis	Intruding	850.6±2.9	Extension	

carbonaceous-calcareous slates of the second member of the Agulugou Formation and the main orebody is mostly located in the hinge zone of the schistose fold of the stratum.

6 Conclusion

(1) The 1∶50 000 Geological Map of the Juligetai Map-sheet (K48E017019), Inner Mongolia is an exploratory map of the new round of geological surveys performed by China Geological Survey. The structural-lithological mapping method was adopted to improve the expression of data in the final result, which has played an exemplary role in the regional geological survey, especially the orogenic belt mapping.

(2) In conformity with China Geological Survey's Standard of Digital Geological Map Spatial Databases (DD2006-06), the 1∶50 000 Geological Map of the Juligetai Map-sheet (K48E017019) was compiled in a comprehensive and systematic way, with a spatial database established, which expresses the basic attributes of different geobodies in detail.

(3) Through the study of field sedimentary formation and tectonic deformation sequence, and by referring to petrogeochemical and chronological test data, we have identified the rock composition, deformation and metamorphic characteristics, and protolith formation of the Mesoproterozoic Baoyintu Group; as well as the basic sequence and sedimentary environment of the middle Neoproterozoic Zhaertaishan Group. It is clear that the Baoyintu Group has undergone 3 periods of deformation, which manifested as early bedding shear deformation, schistose folds and kink folds; while the Zhaertaishan Group has undergone 2 periods of deformation, whichmanifested as early bedding and late schistose folds. The evolution sequence of Paleozoic intrusive rocks was identified as Early Paleozoic continental margin arc magmatic rocks, Late Paleozoic subduction-collision magmatic rocks and Early Mesozoic post-orogenic magmatic rocks. We believe that the metallogenic structure of the Huogeqi Copper Deposit is located at the hinge zone caused by carbonaceous-calcareous slate schistose folds in the second member of the Agulugou Formation. These understandings can provide a basis for subsequent basic geological surveys and scientific research.

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