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内蒙古 1∶50 000 清河沟幅区域地质图数据库

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摘要: 内蒙古 1∶50 000 清河沟幅 (K47E010009) 区域地质图是全国区域地质调查优秀图幅 (2018)。该图幅在充分利用前人区域地质调查成果资料的基础上，采用遥感、物化探、路线地质调查、实测剖面和大比例尺填图等多种手段相结合的方法，对区内百合山蛇绿混杂岩带、沉积地层、岩浆岩以及构造变形特征等进行了详细的调查。查明了百合山蛇绿混杂岩带的空间展布、物质组成以及变质变形特征，并明确其为石炭纪俯冲带型 (Supra-Subduction Zone, SSZ 型) 蛇绿岩；对区内岩浆岩进行了详细解体，划分出晚志留世—泥盆纪、石炭纪—早二叠世、中二叠世 3 期岩浆事件，建立了构造–岩浆演化序列；将区内地层以百合山蛇绿混杂岩带为界划分为 2 个不同的地层分区，明确了岩石组合和沉积环境差异，建立了地层综合柱状图。图幅数据库包含 67 件样品的地球化学分析数据和 17 件锆石 U–Pb 测年数据。本数据库是清河沟幅区域地质调查的综合性成果，由主图和图饰图廓构成，涵盖了区内沉积岩、岩浆岩、蛇绿混杂岩等多种地质体的属性特征，充分反映了该地区造山带结构和地质演化过程，可为北山地区的地质找矿和造山带精细研究工作提供基础数据支撑。

关键词: 内蒙古；清河沟幅；1∶50 000；区域地质图；数据库；蛇绿混杂岩；北山地区；地质调查工程

数据服务系统网址: http://dcc.cgs.gov.cn

1 引言

北山造山带位于中亚造山带的中南段，向西与天山造山带相连，向东与兴蒙造山带相连，南部与敦煌地块相接，是由多个微陆块、岛弧、增生杂岩和蛇绿混杂岩经历长时间、多期次的俯冲拼贴作用而形成的增生型造山带 (Xiao WJ et al., 2010, 2017；贺振宇等，2014；Yu JY et al., 2016；张金龙等，2017)。古生代以来，北山造山带自北向南共形成了红石山—百合山、石板井—小黄山、红柳河—洗肠井、辉铜山—帐房山 4 条蛇绿混杂岩 (超基性岩) 带 (李向民等，2012；王国强等，2014；杨富林等，2016；牛文超等,

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2017, 2019)。清河沟幅工作区位于北山造山带的北部，红石山—百合山蛇绿混杂岩带即从图幅内穿过。区内出露地层可以划分为早古生代活动陆缘沉积体系、晚古生代陆缘弧火山–沉积体系以及新生代盆地沉积体系，对应早古生代构造层、晚古生代构造层和新生代构造层。与之伴生的岩浆岩包括早—中奥陶世—泥盆纪岛弧岩浆岩、石炭纪—早二叠世陆缘弧岩浆岩和中二叠世造山后伸展岩浆岩，尤以石炭纪—二叠纪岩浆岩最为发育，主要岩性包括石英闪长岩、花岗岩闪长岩、二长花岗岩、正长花岗岩和少量的辉长岩。区内褶皱和断裂构造发育，褶皱构造分为早古生代、晚古生代和晚中生代 3 期，其中早古生代褶皱主要分布于图幅北部，以不对称和紧闭褶皱为主；晚古生代褶皱主要分布于图幅中部，以翼间角为 30° ~ 70°的中常褶皱和翼间角小于 5°的紧闭褶皱为主；晚中生代褶皱是区内最晚期褶皱，为北东向走滑断层引起的牵引褶皱，规模较小，常与断裂伴生。断裂构造包括北西向、东西向、北东向和近南北向 4 组，以北西向和北东向最为发育，各个方向的断层相互切割，北西向断层时代最早，北东向断层时代最晚。

清河沟幅 (K47E010009) 位于北山造山带北部 (图 1)，该地区在 2009—2012 年开展过初步的矿产地质调查[1]，新增加矿床 1 处，矿化点 2 处，目前图幅内百合山铁矿和碧玉山铁矿均在开采当中。虽然早期的矿产调查研究成果不同程度地提高了区内基础地质调查研究程度，但由于其工作侧重点不同，对于区内存在的重大基础地质问题尚缺少专题研究 (例如简单地将蛇绿岩划归为超基性岩侵入体；未建立构造–岩浆演化序列等)。鉴于此，亟需在该地区开展系统的 1：50 000 区域地质填图工作，查明区内蛇绿混杂岩的构造属性、地层区划和岩浆岩空间展布特征以及构造–岩浆演化序列。内蒙古清河沟幅 1：50 000 区域地质图 (图 2) 数据库 (表 1，牛文超等，2020) 旨在反映该地区新一轮地质调查在蛇绿混杂岩和造山带研究方面的最新成果，为该区地质矿产调查、重大地质问题研究提供基础地质图件，为后续更深入地探讨造山带结构和演化提供参考资料。

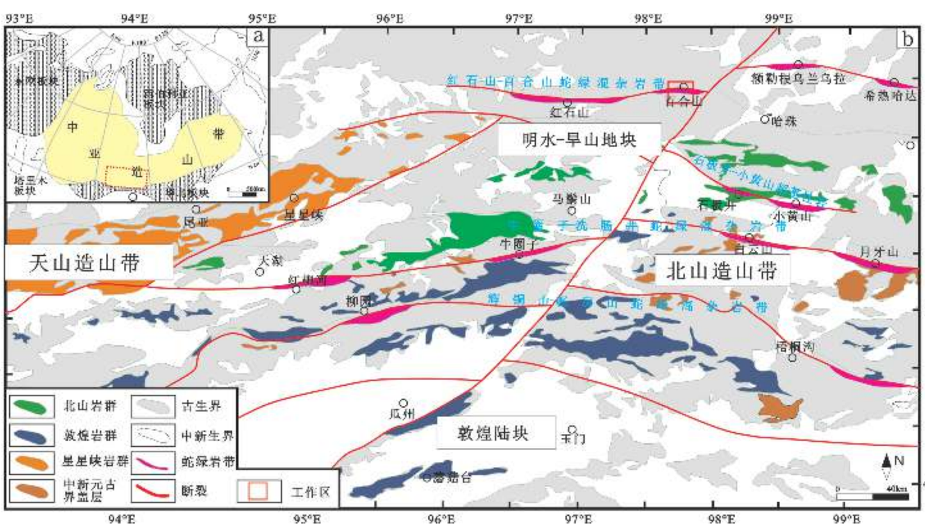

图 1　北山造山带大地构造位置简图 (据 Xiao WJ et al., 2010 修编)

2　数据采集和处理方法

2.1　基础数据采集

2.1.1　数据基础

内蒙古 1：50 000 清河沟幅区域地质图以《区域地质调查技术要求 (1：50 000)》(DD2019-01) 为基本要求，综合应用了野外路线调查、大比例尺填图、物化探、遥感和

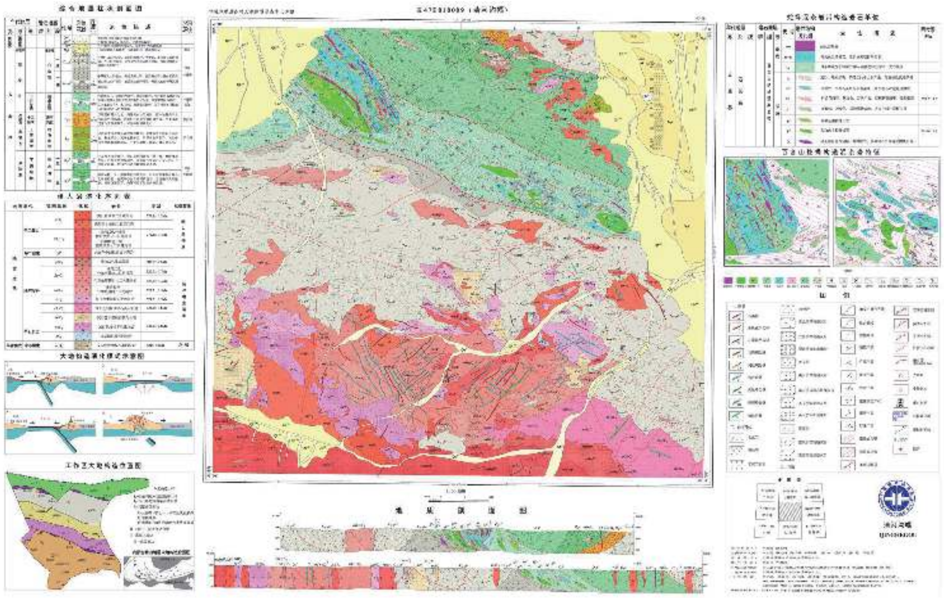

图 2　内蒙古 1：50 000 清河沟幅区域地质图示意图

表 1　数据库 (集) 元数据简表

条目	描述
数据库(集)名称	内蒙古1：50 000清河沟幅区域地质图数据库
数据库(集)作者	牛文超，中国地质调查局天津地质调查中心 段连峰，中国地质调查局天津地质调查中心 赵泽霖，中国地质调查局天津地质调查中心 张国震，中国地质调查局天津地质调查中心 辛后田，中国地质调查局天津地质调查中心 任邦方，中国地质调查局天津地质调查中心
数据时间范围	2017—2018年
地理区域	经纬度：东经98°00′ ~ 98°15′，北纬42°10′ ~ 42°30′
数据格式	MapGIS (*.wp, *.wl, *.wt), *.msi
数据量	10.2 MB
数据服务系统网址	http://dcc.cgs.gov.cn
基金项目	中国地质调查局地质调查项目“阴山成矿带小狐狸山和雅布赖地区地质矿产调查”(编号：DD20160039；DD20160039-17)资助
语种	中文
数据库(集)组成	1：50 000清河沟幅区域地质图数据库包括地质图库和图饰图廓。地质图库包括地质面实体(沉积岩、侵入岩、变质岩、蛇绿混杂岩等)、地质界线、断裂、产状、矿化(点)、垂向剖面、岩性花纹、各类代号等。图饰图廓包括地层综合柱状图、侵入岩演化序列表、蛇绿混杂岩带构造–岩石单位、百合山蛇绿构造混杂岩大比例尺图、大地构造位置图、大地构造演化模式图、图切剖面、图例和责任签栏等

实测剖面等多种技术手段进行数据采集，调查所用地理底图采用国家测绘地理信息局最新数据，坐标系统采用 1980 年西安坐标系，1985 年国家高程基准，在后期数据入库过程中按国家最新要求，对成果图件统一转换成为国家 2000 大地平面直角坐标系 (China Geodetic Coordinate System 2000，缩写为 CGCS 2000)。1：50 000 地质调查全程采用数字区域地质调查系统 (DGSS) 进行。

2.1.2　数据采集方法

野外调查中针对不同的地质体采用不同的方法进行地质填图 (数据采集) 工作。区内百合山蛇绿混杂岩带采用“穿越+追索路线”的方法，详细调查其空间展布、物质组成、变质变形特征；对重点区域和构造复杂区开展 1：10 000 大比例尺精细填图，详细勾绘不同地质体形态、变形以及岩石组合特征，并编制 1：10 000 蛇绿混杂岩带大比例尺地质图。岩浆岩采用穿越路线法，详细调查其岩石组合、接触关系等宏观地质特征，并进行解体和期次划分，填图单位采用“岩性+时代”表达。对于沉积岩区则采用实测剖面与路线调查相结合的方式，重点调查地层分布、岩石组合、沉积类型以及变质变形特征。

本图幅共布置野外调查路线 87 条，路线总长度 441.8 km，实测剖面 6 条，总长度 56 km，地质点 821 个，地质界线 1 567 条，产状总计 468 个，平均每 460 m 有 1 个地质点，平均每 210 m 有 1 条地质界线；完成 1：50 000 遥感解译 381 km^2，1：500 垂向剖面 40 m 和槽探施工 150 m。按要求编制了矿化异常蚀变图和遥感解译图，针对重点地区开展了地球化学异常综合评价。同时，完成薄片鉴定样品 324 件，岩石地球化学全分析样品 67 件，同位素测年样品 17 件，照片拍摄 1300 余张。薄片制片及鉴定、全岩样品碎样和单矿物锆石分选工作在河北省区域地质矿产调查研究所实验室完成。锆石制靶和透射光、反射光、阴极发光照相在北京锆年领航科技有限公司完成。全岩地球化学样品测试和同位素测年工作在中国地质调查局天津地质调查中心实验测试室完成。样品的全岩地球化学测试内容包括主量元素 (SiO_2、TiO_2、Al_2O_3、Fe_2O_3、FeO、MgO、MnO、CaO、Na_2O、K_2O、P_2O_5)、稀土元素 (La、Ce、Pr、Nd、Sm、Eu、Gd、Tb、Dy、Ho、Er、Tm、Yb、Lu、Y) 和微量元素 (Cs、Sc、V、Cr、Co、Ni、Ga、Rb、Sr、Zr、Nb、Ba、Hf、Ta、Th、U、Pb)，其中主量元素采用 Axios 4.0 kW 顺序式 X 射线荧光光谱仪测试，微量元素使用 ICP-MS 测试，锆石测年采用 LA-MC-ICP-MS 进行，仪器型号为 Agilent 7500a。

在野外路线调查 (包括大比例尺填图) 中对地质点 (P)、点间路线 (R) 和地质界线 (B) 等不同的野外要素采用掌上填图系统 (Rgmap) 有针对性地进行记录。地质点 (P) 在 DGSS 系统中填写点性、点号、微地貌、风化程度、露头情况、填图单元、接触关系以及野外现象描述等；点间路线 (R) 记录地质点号、路线号、填图单元和岩石名称等，方向角、本站距离、累计距离等数据系统会自行计算；地质界线 (B) 填写界线类型、两侧地质体填图单位、走向、倾向以及倾角等，地质点号和对应的点间路线使用系统默认数据。在此过程中，2 个点间路线 (R) 进行连续记录，地质界线 (B) 上不同地质体的接触关系详细描述，并正确区分左右地质体。

2.2　数据处理

2.2.1　室内数据整理

将野外采集的数据资料 (包括但不限于地质点、点间路线、地质界线等) 导入电脑中，并利用数字填图桌面系统进行适当的补充整理。其中，地质点 (P) 补充完善野外现象描述，注意岩石名称的一致性，对后期薄片鉴定与野外定名不一致的，以多块岩石的薄片鉴定结果综合分析定名，并进行批注。点间路线 (R) 进行光滑处理 (3 次 Bizer 光滑)，并在补充点间描述前重新进行点间路线计算，修正方位角和距离信息。地质界线 (B) 结合野外接触关系在室内采用光滑线、延长线等方式进行必要的修饰，同时统一线型、线宽、颜色等参数。对于特殊的界线类型 (如断层、角度不整合等)，按照《区域地

质图图例》(GB958-99) 进行相应的修改。对于路线中采集的照片、样品以及产状等要素，补充属性信息 (如照片内容、产状类型、样品类型等)。此外，数字填图系统PRB 库只默认地层产状 (S_0) 符号，其他类型产状 (如变质岩的片理、片麻理；岩浆岩的流面等次生或原生面理产状) 需要在桌面数字填图系统上更新相应符号后，在 DGSS 程序“图式图例整理”一栏中执行“旋转产状实体、生成产状注释图层”命令，才会自动按产状倾向值旋转实体符号，并形成产状 (角度值) 注释图层。最后，将整理完成的PRB 数据库生成实际材料图，并在实际材料图库中进行勾绘连图。在连图过程中，注意结合野外地质路线对不同的地质实体进行合并或夸大表示，保证图面的合理性和客观性，实际材料图完成后将其更新至编稿原图。

2.2.2 图饰图廓整理

在完成编稿原图的基础上，针对图幅内的重大发现和需要强调的内容编制不同的图件并分列主图两侧，包括地层综合柱状图、侵入岩演化序列表、蛇绿混杂岩带构造–岩石单位、大比例尺图、大地构造位置图、大地构造演化模式图、图切剖面、图例和责任签栏。

(1) 地层综合柱状图：该柱状图对图幅内不同地层单元的岩石组合、时代特征以及厚度等进行详细表达，重点表述了不同时代地层之间的接触关系、沉积层序以及沉积环境特征，为后续沉积相分析和区域地层对比提供依据。

(2) 侵入岩演化序列表：按照岩浆演化和相互之间的侵入关系从底到顶编制岩浆岩填图单元，标注时代以及填图单位，按照主图图例填充岩性花纹，结合岩石组合和地球化学特征分析岩浆岩形成的大地构造环境，划分岩浆演化序列。

(3) 蛇绿混杂岩带构造–岩石单位和大比例尺图：该角图重点反映蛇绿混杂岩带中不同岩块和基质的划分方案，在此基础上，根据野外路线调查资料编制混杂岩带大比例尺图。大比例尺图在精度要求范围内对岩石组合、变质变形特征以及野外接触关系详细表达，尽可能客观反映混杂岩带野外实际特征。

(4) 大地构造位置图：主要表达工作区在区域上 (中亚造山带) 所处的大地构造位置。在收集北山地区 1∶250 000 区域地质图的基础上，结合图幅实际位置进行裁剪。裁剪时注意保持工作图幅在中心位置，同时尽可能保留北山地区 4 条蛇绿混杂岩带均处于裁剪图中。

(5) 大地构造演化模式图：根据野外区域调查成果和综合研究资料编制工作区大地构造演化模式图，分不同的演化阶段进行绘制，保证演化模式与综合研究成果资料的一致性，同时符合全球地质演化规律。

(6) 图切剖面：根据工作区构造线方向和地质体展布特征，分别在北西部和中部设置 2 条北东—南西向图切剖面 (剖面 AB 和剖面 CD)。图切剖面 AB 主要控制百合山蛇绿混杂岩带及其两侧地质体，包括石炭系白山组、下–中奥陶统咸水湖组以及石炭纪蛇绿混杂岩；图切剖面 CD 控制下–中奥陶统咸水湖组、下石炭统绿条山组、石炭系白山组、石炭纪增生杂岩以及石炭–二叠纪侵入岩。表达方式采用标准剖面线型和花纹描绘地质体，每个地质体分别标注填图单位，同时标绘产状要素和特殊界线性质 (如断层性质等)。

(7) 图例和责任签：图例标注地质体类型、花纹、颜色、填图单位、产状、年龄信息、剖面位置、矿化点、断层等所有主图中需要说明的地质要素类型；责任签按照《区域地质调查技术要求 (1∶50 000)》(DD2019-01) 最新要求编制。

3 数据样本描述

内蒙古 1∶50 000 清河沟幅地质图数据库包括区域地质图主图和其他角图。主图内容包括侵入岩建造、沉积岩建造、蛇绿混杂岩建造、火山岩建造、第四系、地质界线、断层、填图单位以及产状等。角图内容包括地层柱状图、侵入岩演化序列、蛇绿混杂岩构造–岩石单位、大地构造位置图、构造演化模式图、图切剖面、大比例尺图、图例和责任签。数据类型包括点实体、面实体和线实体，其中点实体包括各类地质体填图单位、产状、花纹等；面实体包括侵入岩、沉积岩、蛇绿混杂岩和火山岩；线实体包括地质界线、断裂、岩相界线等。数据样本坐标系采用国家 2000 平面直角坐标系 (CGCS 2000)，投影类型采用高斯–克吕格投影。

清河沟幅 (K47E010009)1∶50 000 区域地质图数据库主要由地质实体要素信息组成，包括地质面实体属性表、地质界线属性表、断裂属性表以及地质点实体属性表。图幅内“地质面实体属性表”可分为沉积建造属性表和侵入岩建造属性表。

“沉积建造属性表”(表 2) 由沉积建造实体类型代码、建造实体标识号、建造实体名称、建造类型、建造大类、岩石组合、地层时代和沉积环境组成。

表 2　内蒙古 1∶50 000 清河沟幅区域地质图沉积岩建造图层属性

序号	数据项名称	标准编码	数据类型	实例
1	建造实体标识号	Feature_Id	字符串	AK47E010009000003945
2	建造大类	Formation	字符串	沉积岩建造
3	建造类型	Metallogenic	字符串	复理石建造
4	建造实体类型代码	Feature_Type	字符串	C_1l^1
5	建造实体名称	Geobody_Name	字符串	下石炭统绿条山组上段
6	岩石组合	Combination	字符串	中细粒变质长石石英砂岩、砾岩夹薄层变质粉砂岩等
7	地层时代	Geobody_Era	字符串	C_1
8	沉积环境	Sedimentary_Env	字符串	深海—半深海浊流沉积

“侵入岩建造属性表”(表 3) 包括要素标识号、要素分类、填图单位名称、填图单位符号、岩石颜色、岩石名称 (岩性)、岩石结构和构造、主要和次要矿物及含量、与围岩接触关系和形成时代。

“断裂属性表”(表 4) 包括要素分类代码，断层名称，断层类型，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，断层形成时代和活动期次。

“地质界线属性表”(表 5) 包括要素标识号，地质界线类型，地质界线 (接触) 代码，界线两侧 (左侧和右侧) 地质体代码，界面走向、倾向和倾角。

“地质点实体属性表”(表 6) 主要由产状要素组成，包括要素标识号，产状类型名称代码，产状类型名称，走向，倾向和倾角。

4 数据质量控制和评估

内蒙古 1∶50 000 清河沟幅区域地质调查填图精度按照《区域地质调查技术要求 (1∶50 000)》(DD2019–01) 执行，遥感解译和槽探施工也均按照相应的技术规范完成。路线布置中，以不平均使用工作量为原则，对重点地区 (如蛇绿混杂岩带) 适当增加野外调查路线，对一般地区 (岩性和构造简单区) 路线布置可以适当减少。在图面表达中，对于宽

表 3　内蒙古 1∶50 000 清河沟幅区域地质图侵入岩建造图层属

序号	数据项名称	标准编码	数据类型	实例
1	要素标识号	Feature_Id	字符串	AG50E010008000000001
2	要素分类	Feature_Type	字符串	$x\eta\gamma P^2$
3	填图单位名称	Intru_Body_Name	字符串	中二叠世细粒二长花岗岩
4	填图单位符号	Intru_Body_Code	字符串	$x\eta\gamma P^2$
5	岩石名称	Rock_Name	字符串	细粒二长花岗岩
6	岩石颜色	Rock_Color	字符串	肉红色
7	岩石结构	Rock_Texture	字符串	细粒结构
8	岩石构造	Rock_Structure	字符串	块状构造
9	主要矿物及含量	Primary_Mineral	字符串	石英20%～25%、斜长石25%、钾长石45%～50%
10	次要矿物及含量	Secondary_Mineral	字符串	黑云母5%
11	与围岩接触关系	Contact_Relation	字符串	侵入接触
12	形成时代	Era	字符串	中二叠世

表 4　内蒙古 1∶50 000 清河沟幅区域地质图断裂构造图层属性

序号	数据项名称	标准编码	数据类型	实例
1	要素分类代码	Feature_Type	字符串	F11
2	断层类型	Fault_Type	字符串	611
3	断层名称	Fault_Name	字符串	百合山南侧走滑断层F11
4	断层编号	Fault_Code	字符串	K47E010009F11
5	断层性质	Fault_Character	字符串	走滑断层
6	断层上盘地质体代号	Fault_Up_Body	字符串	$C_{1\text{-}2}b^1$, $C_{1\text{-}2}b^2$
7	断层下盘地质体代号	Fault_Bottom_Body	字符串	$C_{1\text{-}2}b^1$, $C_{1\text{-}2}b^2$
8	断层破碎带宽度	Fault_Wide	字符串	50 m
9	断层走向	Fault_Strike	整数型	65
10	断层倾向	Fault_Dip	整数型	155
11	断层面倾角	Fault_Dip_Angle	整数型	43
12	估计断距	Fault_Distance	浮点型	2~5 km
13	断层形成时代	Era	字符串	K_1之后
14	活动期次	Movement_Period	字符串	喜山期

表 5　内蒙古 1∶50 000 清河沟幅区域地质图地质界线图层属性

序号	数据项名称	标准编码	数据类型	实例
1	要素标识号	Feature_Id	字符串	AK47E010009000002322
2	地质界线类型	Boundary_Name	字符串	岩相界线
3	地质界线(接触)代码	Feature_Type	整数型	23
4	界线左侧地质体代号	Left_Boundary_Code	字符串	O_1x^2
5	界线右侧地质体代号	Right_Boundary_Code	字符串	O_1x^2
6	界面走向	Strike	整数型	302
7	界面倾向	Dip_Direction	整数型	32
8	界面倾角	Dip_Angle	整数型	53

表 6 内蒙古 1：50 000 清河沟幅区域地质图产状要素属性

序号	数据项名称	标准编码	数据类型	实例
1	要素标识号	Feature_Id	字符串	AK47E010009000000436
2	产状类型名称代码	Attitude_Code	整数型	02
3	产状类型名称	Attitude_Name	字符串	片理产状
4	走向	Strike	整数型	130°
5	倾向	Dip_Direction	整数型	220°
6	倾角	Dip_Angle	整数型	56°

度小于 50 m 的地质体一般不予表达，但对于蛇绿混杂岩带中的特殊地质体 (如超基性岩、斜长花岗岩、榴辉岩、蓝片岩等)，可适当夸大表示，同时考虑在大比例尺地质图中予以勾绘，并注意在图例中对原始大小进行描述。

数据质量方面，本数据库依托项目“阴山成矿带小狐狸山和雅布赖地区地质矿产调查”严格按照中国地质调查局《地质调查项目管理办法》(中地调发〔2011〕18 号) 相关要求，执行项目自检和互检、项目专检、项目质量抽查“三级质量检查制度”，其中填图路线自检、互检率达 100%，项目组抽检 40%，部门抽检率不小于 15%。总体质量符合地质调查管理要求。样品测试分析均在具有相关资质的实验室进行，分析过程和分析质量符合要求。2018 年 9 月，本数据库依托项目组织评审专家对内蒙古清河沟幅区域地质调查项目进行了野外验收，评定结果为优秀级。

5 数据价值

内蒙古 1：50 000 清河沟幅 (K47E010009) 区域地质图是中国地质调查局新一轮造山带填图试点图幅，为全国区域地质调查优秀图幅 (2018)。该图幅按照《区域地质调查技术要求 (1：50 000)》(DD2019–01) 要求，通过野外路线调查、实测剖面和大比例尺填图等工作，精细填绘出百合山蛇绿混杂岩带的物质组成和结构构造，通过识别岩块和基质，清晰表达了野外地质实体特征和洋壳空间结构，注重突出表达混杂岩带内构造样式，查明了百合山蛇绿混杂岩带主要由超镁铁–镁铁质岩、辉长岩、玄武岩、斜长花岗岩、硅质岩等洋壳残块以及奥陶纪火山岩、灰岩等外来岩块和蛇纹岩、砂板岩、绿泥绿帘片岩等基质组成；明确了百合山蛇绿混杂岩带存在俯冲期剪切流变、碰撞期挤压收缩变形和造山后走滑伸展 3 期构造变形；结合锆石 U-Pb 同位素测年数据厘定了百合山洋盆开启和闭合的时间分别为早石炭世早期和早二叠世；依据地球化学组成特征和年龄数据明确了百合山蛇绿岩为石炭纪俯冲带型 (Supra-Subduction Zone, SSZ 型) 蛇绿岩，而弧岩浆岩空间展布则指示了洋盆向南俯冲的极性；根据图幅内侵入岩时代和地球化学特征将其划分为 3 个期次，包括志留纪—泥盆纪岛弧岩浆岩、石炭纪—早二叠世陆缘弧岩浆岩和中–晚二叠世造山后伸展岩浆岩，与之对应的大地构造演化则划分为早古生代活动陆缘形成演化阶段、晚古生代俯冲增生和造山后伸展阶段以及中新生代陆内盆地演化和差异升降剥蚀阶段。

清河沟幅数据库取得的成果可为北山造山带地层分区和构造单元划分新方案提供支撑，为北山地区的地质找矿和造山带结构研究工作提供基础数据支撑，提升北方造山系研究水平。

6 结论

(1) 内蒙古 1：50 000 清河沟幅 (K47E010009) 区域地质图是全国区域地质调查优秀

图幅 (2018)，本次工作创新了造山带地质填图成果的表达方式，编制了清河沟幅区域地质图，对造山带地质调查具有一定的示范作用。

(2) 完成并建立了 1：50 000 清河沟幅 (K47E010009) 地质图空间数据库，空间数据库数据继承一致性良好，数据库文件种类齐全，各数据库数据项完整，投影参数和比例尺精度均按要求定义，空间定位准确。

(3) 对百合山蛇绿混杂岩带的物质组成进行了精细划分，厘定了百合山蛇绿岩的岩石组合、空间展布等特征；结合地球化学和同位素测年资料明确百合山蛇绿岩为一套石炭纪 SSZ 型蛇绿岩。

(4) 开展了清河沟图幅内岩浆岩同位素测年工作，将其划分为 3 个演化阶段，重新建立了清河沟图幅区的构造–岩浆演化序列。

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注释：

❶ 内蒙古地质调查院. 2009. 内蒙古额济纳旗甜水井等五幅 1：50 000 区域矿产地质调查报告.

参考文献

Xiao W J, Mao Q G, Windley B F, Han C M, Qu J F, Zhang J E, Ao S J, Guo Q Q, Cleven N R, Lin S F, Shan Y H, Li J L. 2010. Paleozoic multiple accretionary and collisional processes of the Beishan orogenic collage[J]. American Journal of Science, 310: 1553−1594.

Xiao W J, Ao S J, Yang L, Han C M, Wan B, Zhang J E, Zhan Z Y, Li R, Chen Z Y, Song S H. 2017. Anatomy of composition and nature of plate convergence: Insights for alternative thoughts for terminal India-Eurasia collision[J]. Science China (Earth Sciences), 60: 1015−1039.

Yu JY, Guo L, Li JX, Li YG, Smithies RH, Wingate MTD, Meng Y, Chen SF. 2016. The petrogenesis of sodic granites in the Niujuanzi area and constraints on the Paleozoic tectonic evolution of the Beishan region, NW China[J]. Lithos, 256–257: 250−268.

贺振宇, 宗克清, 姜洪颖, 向华, 张泽明. 2014. 北山造山带南部早古生代构造演化: 来自花岗岩的约束 [J]. 岩石学报, 30(8): 2324−2338.

李向民, 余吉远, 王国强, 武鹏. 2012. 甘肃北山地区芨芨台子蛇绿岩 LA-ICP-MS 锆石 U-Pb 测年及其地质意义 [J]. 地质通报, 31(12): 2025−2031.

牛文超, 段连峰, 赵泽霖, 张国震, 辛后田, 任邦方. 2020. 内蒙古 1：50 000 清河沟幅区域地质图数据库 [DB/OL]. 地质科学数据出版系统. (2020-06-30). DOI: 10.35080/data.A.2020.P8.

牛文超, 任邦方, 任云伟, 孙立新, 段霄龙, 段连峰, 李敏, 张家辉. 2017. 内蒙古北山地区发现新元古代片麻状花岗岩: 锆石 U−Pb 定年证据 [J]. 中国地质, 44(2): 409−410.

牛文超, 辛后田, 段连峰, 王根厚, 赵泽霖, 张国震, 郑艺龙. 2019. 内蒙古北山地区百合山蛇绿混杂岩带的厘定及其洋盆俯冲极性—基于 1：5 万清河沟幅地质图的新认识 [J]. 中国地质, 46(5): 977−994.

王国强, 李向民, 徐学义, 余吉远, 武鹏. 2014. 甘肃北山红石山蛇绿岩锆石 U−Pb 年代学研究及构造意义 [J]. 岩石学报, 30(6): 1685−1694.

杨富林, 赵志雄, 贾文艳, 杨亮, 许海, 贾元琴, 高勇. 2016. 内蒙古北山地区北山岩群形成时代探讨 [J]. 地质调查与研究, 39(2): 89−94.

张金龙, 陈超, 潘志龙, 张桂凤, 张欢, 李庆喆. 2017. 内蒙古北山西林淘勒二断井组的厘定与沉积环境分析 [J]. 地质调查与研究, 40(4): 274−280.

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Abstract: The 1∶50 000 regional geological map (K47E010009) of the Qinghegou Map-Sheet in Inner Mongolia, as an excellent national regional geological survey map (2018), was compiled by making full use of previous regional geological survey results. Through remote sensing, geophysical and geochemical exploration, geological survey, surveyed geological cross section, large-scale mapping and other means, an in-depth investigation was conducted on the ophiolitic mélange belt, sedimentary strata, igneous rock and tectonic deformation characteristics in the region. The spatial distribution, material composition and metamorphic deformation characteristics of the ophiolitic mélange belt were identified and classified as a Carboniferous Supra-Subduction Zone (SSZ) ophiolite. A detailed analysis of igneous rocks in the area has led to the classification of three magmatic events, namely, in the Late Silurian-Devonian, Carboniferous-Early Permian and Middle Permian, and the establishment of a tectonic-magmatic evolution sequence. The strata in the area have a comprehensive stratigraphic column established and are divided into two stratigraphic subregions separated by the Baiheshan ophiolitic mélange belt with distinct differences in rock combination and sedimentary environment. The map database contains geochemical analysis data of 67 samples and zircon U–Pb dating data of 17 samples. It represents the comprehensive results of the regional geological survey of the Qinghegou Map-Sheet, which is composed of the main maps, along with the map appearance and map border, covering the attributes of sedimentary and igneous rocks, ophiolitic mélanges and other geobodies in the area. It fully reflects the structure of the orogenic belt and the geological evolution process in the area, providing basic data support for geological prospecting and in-depth investigations on orogenic belts in the

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Beishan area.

Key words: Inner Mongolia; Qinghegou Map-Sheet; 1 ∶ 50 000; regional geological map; database; ophiolitic mélange; Beishan area; Geological survey engineering

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

1 Introduction

Situated in the center of the southern section of the Central Asian Orogenic Belt (CAOB), the Beishan orogenic belt is connected to the Tianshan orogenic belt in the west, the Xing'an–Mongolian orogenic belt in the east and the Dunhuang block in the south. It is an accretionary orogenic belt formed by the subduction and collision of multiple micro-continents, island arcs, accretionary complexes and ophiolitic mélanges during a long period of time and in multiple stages (Xiao WJ et al., 2010, 2017; He ZY et al., 2014; Yu JY et al., 2016; Zhang JL et al., 2017). Since the Paleozoic, the Beishan orogenic belt has formed four ophiolitic mélange (ultramafic rock) belts from north to south, including from Hongshishan–Baiheshan, Shibanjing–Xiaohuangshan, Hongliuhe–Xichangjing and Huitongshan–Zhifangshan (Li XM et al., 2012;Wang GQ et al., 2014; Yang FL et al., 2016; Niu WC et al., 2017, 2019). The Qinghegou Map-Sheet working area is located in the northern part of the Beishan orogenic belt and the Hongshishan–Baiheshan ophiolitic mélange belt runs through the geological map. The exposed strata in the area can be divided into an active continental marginal sedimentary system from the Early Paleozoic, continental marginal arc-sedimentary system from the Late Paleozoic and basin sedimentary system from the Cenozoic, corresponding to an Early Paleozoic tectonic layer, Late Paleozoic tectonic layer and Cenozoic tectonic layer, respectively. The associated igneous rocks include: Early–Middle Ordovician–Devonian island-arc igneous rocks, Carboniferous–Early Permian continental marginal arc igneous rocks and Middle Permian post-orogenic extensional igneous rocks, and the Carboniferous–Permian igneous rocks are the most developed, which are mainly composed of quartz diorite, granodiorite, monzonitic granite, syengranite and a small amount of gabbro. Fold and fault structures in the area are well-developed, with fold structures divided into three stages, i.e., Early Paleozoic, Late Paleozoic and Late Mesozoic, of which the Early Paleozoic folds are mostly distributed in the northern region of the map and are primarily asymmetric with tight folds. The Late Paleozoic folds are mostly distributed in the central region of the map and principally have close folds with an approximate interlimb angle between 30°–70° and tight folds with an interlimb angle of less than 5°. Late Mesozoic folds are the more recent folds in the region, having been formed by being dragged by the smaller scale NE strike-slip fault and are often associated with ruptures. Fault structures can be divided into 4 groups, specifically, NW-trending, EW-trending, NE-trending and nearly NS-trending, all of which cut across each other. Both the NW and NE structures are the most developed, with the NW fault being the earliest in era and the NE fault being the latest.

The Qinghegou Map-Sheet (K47E010009) is located in the northern part of the Beishan orogenic belt (Fig. 1). A preliminary mineral geological survey[1] was conducted in the region

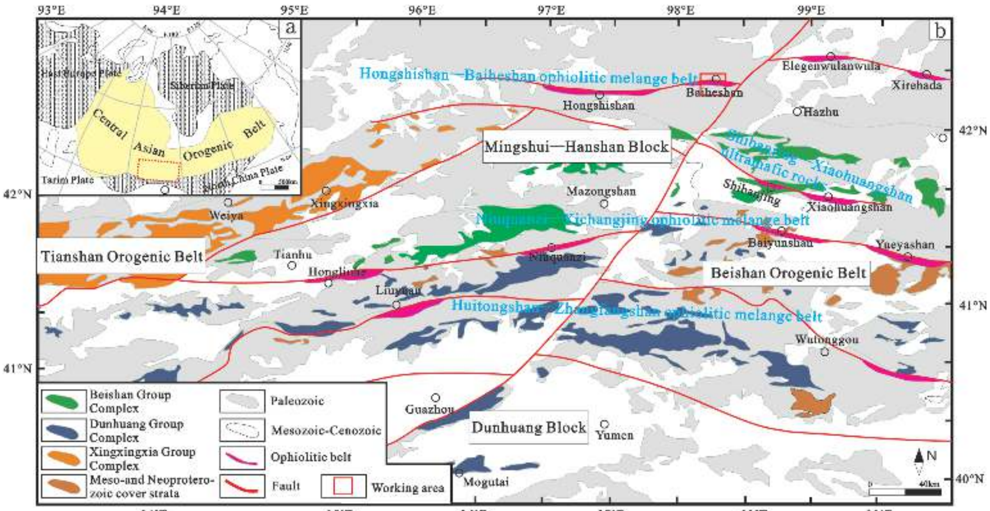

Fig. 1　Geotectonic location of the Beishan orogenic belt (modified from Xiao WJ et al., 2010)

from 2009 to 2012, adding one new deposit and two mineralized spots. At present, both the Baiheshan and Biyushan iron mines in the region are being exploited. Despite a better understanding, to various degrees, of basic geological characteristics from the results of the previous mineral investigations and research, specific research dedicated to major basic geological issues in the area remains lacking. For example, ophiolite was simply classified as an ultramafic intrusive rock and no tectonic-magmatic evolution sequences have been established. In view of this, there is an urgent need for systematic 1：50 000 geological mapping of the region, in order to identify the tectonic attributes and stratigraphic zoning of ophiolitic mélanges, the spatial distribution of igneous rocks and the tectonic-magmatic evolution sequence there. The Database (Table 1; Niu WC et al., 2020) of the Regional Geological Map of the Qinghegou Map-Sheet (1：50 000) (Fig. 2) aims to reflect the latest results of the new geological survey in the area on ophiolitic mélanges and orogenic belts. It provides basic geological maps for the study of major geological problems in the geological and mineral survey of this area, as well as reference material for further discussions on the structure and evolution of the orogenic belt.

2　Data Acquisition and Processing Methods

2.1　Basic Data Acquisition

2.1.1　Data Source

Guided by the *Technical Requirements for Regional Geological Surveys (1：50 000)* (DD 2019–01), the 1：50 000 Regional Geological Map Database of the Qinghegou Map-Sheet uses a variety of technical means for data collection, such as field route survey, large-scale mapping, geophysical and geochemical exploration, remote sensing and surveyed geological cross section. The basic geographical map in the survey adopts the latest data from the National Geomatics Center of China (NGCC) for basic geographical maps, the 1980 Xi’an Coordinate System and the 1985 National Height Datum. During the later stages of the data storage process, the figures were uniformly converted into the 2000 version of the China

Table 1 Metadata Table of Database (Dataset)

Items	Description
Database (dataset) name	1：50 000 Regional Geological Map Database of the Qinghegou Map-Sheet, Inner Mongolia
Database (dataset) authors	Niu Wenchao, Tianjin Center, China Geological Survey Duan Lianfeng, Tianjin Center, China Geological Survey Zhao Zelin, Tianjin Center, China Geological Survey Zhang Guozhen, Tianjin Center, China Geological Survey Xin Houtian, Tianjin Center, China Geological Survey Ren Bangfang, Tianjin Center, China Geological Survey
Data acquisition time	2017 – 2018
Geographic area	98°00'–98°15' E, 42°10'–42°30' N
Data format	MapGIS (*.wp, *.wl, *.wt), *.msi
Data size	10.2 MB
Data service system URL	http://dcc.cgs.gov.cn
Fund project	China Geological Survey Project “Geological and Mineral Survey of the Xiaohulishan and Yabulai Areas in the Yinshan Metallogenic Belt” (No.: DD20160039; DD20160039–17)
Language	Chinese
Database (dataset) composition	The 1：50 000 Regional Geological Map Database of the Qinghegou Map-Sheet includes geological map database, map appearance and map border. The geological map database includes geological surface entities (sedimentary rock, intrusive rock, metamorphic rock, ophiolitic mélange etc.), geological boundary, fault, attitude, mineralized spot, vertical section, lithological pattern, codes etc. Map appearance and map border include a comprehensive stratigraphic column, intrusive rock evolution sequence table, tectonics-rock unit in the ophiolitic mélange belt, large-scale maps of Baiheshan ophiolitic mélange, geotectonic location map, geotectonic evolution model map, map cross section, legend and signature

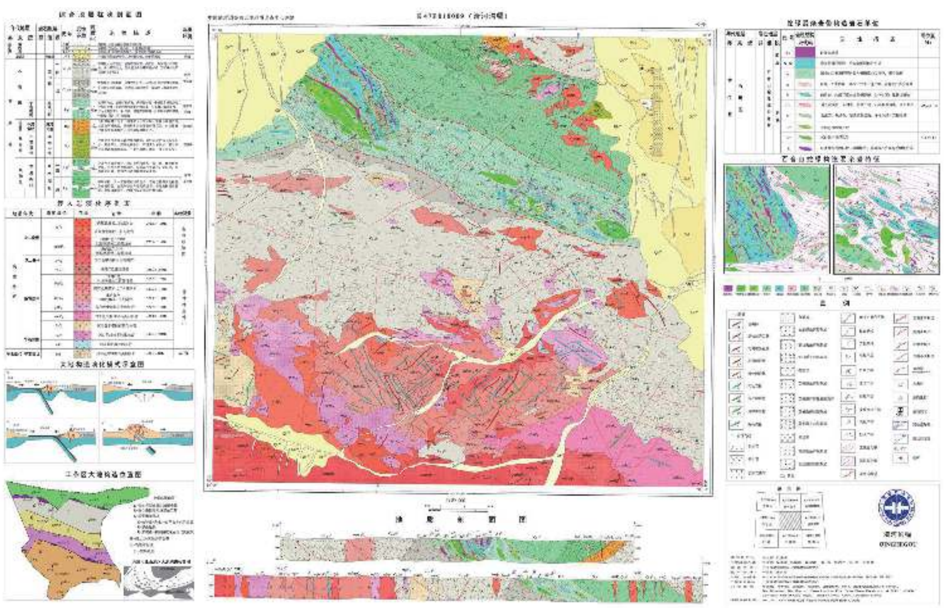

Fig. 2 Schematic diagram of 1：50 000 regional geological map database of the Qinghegou map-sheet, Inner Mongolia

Geodetic Coordinate System (CGCS 2000), in line with the latest requirements of China. The 1：50 000 geological survey uses the Digital Geological Survey System (DGSS) throughout the whole process.

2.1.2 Data Acquisition Method

During the field investigation, different methods were used for the geological mapping (data collection) of different geobodies. The “traverse + tracing” method was adopted for the Baiheshan ophiolitic mélange belt for an in-depth investigation of its spatial distribution, material composition and metamorphic and deformation characteristics. Detailed mapping on a 1：10 000 scale was carried out for both key areas and areas with complex structures. This provided detailed information on the structure, deformation and rock combination characteristics of different geobodies for the compilation of the large-scale geological map (1：10 000) of the ophiolitic mélange belt. The traverse method for igneous rocks was applied in order to fully examine their macroscopic geological characteristics, such as rock combination and contact relation, and classify them into different periods. The mapping units are expressed in the form of “lithology + era”. For the sedimentary rock area, surveyed geological cross section and route survey were combined to put an emphasis on the investigation of stratigraphic distribution, rock combination, sedimentary types and metamorphic and deformation characteristics.

This map includes 87 field survey routes with a total length of 441.8 km, 6 cross sections with a total length of 56 km, 821 geological points, 1 567 geological boundaries and 468 entries of attitude; with one geological point per 460 m and one geological boundary per 210 m on average. We conducted remote sensing interpretation for an area of 381 km^2 on a scale of 1：50 000, completed the mapping of a 40 m vertical section (1：500) and the construction of a 150 m trial trench. The mineralization anomaly alteration map and remote sensing interpretation map have been compiled following the appropriate standards. Comprehensive evaluation of geochemical anomalies was also carried out in key areas. Meanwhile, petrography identification was completed for 324 slice samples, 67 samples for rock geochemical analysis and 17 samples for isotopic dating. More than 1 300 photos were taken. Slice making and identification, whole rock samples and zircon selection were completed in the laboratory at the Hebei Institution of Regional Geology and Mineral Resources Survey. Zircon target making, photography of transmitted and reflected light and cathodoluminescence were all performed in the laboratory at the Beijing Gaonianlinghang Technology Co., Ltd. The whole-rock geochemical testing of the samples was completed in the experimental testing room of the Tianjin Center of China Geological Survey. The contents of the samples include major elements (SiO_2, TiO_2, Al_2O_3, Fe_2O_3, FeO, MgO, MnO, CaO, Na_2O, K_2O and P_2O_5), rare earth elements (La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu and Y) and trace elements (Cs, Sc, V, Cr, Co, Ni, Ga, Rb, Sr, Zr, Nb, Ba, Hf, Ta, Th, U and Pb). The major elements were measured by an Axios 4.0 kW sequential X-ray fluorescence spectrometer; the trace elements were measured by an ICP-MS; and zircon dating was carried out by an LA-MC-ICP-MS, with the instrument model being an Agilent 7500a.

In the field route survey (including large-scale mapping), different field features such as geological point (P), geological route (R) and geological boundary (B) were recorded, in a targeted way, using the digital geological mapping system (Rgmap). Geological points (P) were included in the DGSS system with information on the station property, station number, micro-geomorphology, weathering degree, outcrop, mapping unit, contact relation and field phenomenon description. The geological route (R) records geological point number, route number, mapping unit, rock name, with the azimuth, distance of the station and accumulated distance calculated automatically by the system. The geological boundary (B) records boundary type, mapping unit of geobodies on both sides, strike, dip direction and dip angle. The geological point number and the corresponding route use the default data already present in the system. In this process, every other route (R) was recorded continuously. The contact relation between different geobodies on the geological boundary (B) was described in detail, correctly distinguishing between geobodies on the left and right sides.

2.2 Data Processing

2.2.1 Indoor Data Collation

The data collected in the field (including but not limited to geological points, routes and boundaries) were imported onto the computer, went through proper processing and supplemented using a digital mapping software.

For the geological points (P), description of field phenomena was added, with special attention being paid to the consistency of rock names. In order to minimise inconsistencies between later slice identification and field naming. The identification results of multiple rock slices were considered for the final naming with the addition of annotations. The geological route (R) is smoothed (3 Bizer smoothings) and route calculation was repeated before an inter-point description was supplemented with modified azimuths and distance information. The geological boundary (B) was embellished indoors by means of smooth lines and extension lines in combination with field contact conditions, along with the unification of parameters such as line type, line width and color. For special types of boundaries (such as fault and angle unconformity), modifications were conducted according to the *Geological Symbols Used for Regional Geological Maps* (GB 958–99). For photos, samples, attitude and other features collected along the route, attribute information was added (including photo content, attitude type, sample type etc.).

Additionally, in the PRB database of the digital mapping software, the only default attitude symbol is the stratigraphic attitude (S_0); for other types of attitude (such as schistosity and gneissosity of metamorphic rocks; secondary or original flow surface attitude such as that of igneous rocks). After updating the corresponding symbols on the digital mapping software, it is necessary to execute the order ‘Rotate Attitude Entity to Generate Attitude Annotation Layer’ in the ‘Schema and Symbol Processing’ column of the DGSS system to automatically rotate entity symbols according to the attitude tendency value, so that an attitude (angle value) annotation layer is generated.

Finally, the finished PRB database was used to generate the actual material map, which was drawn in the actual material map library. During the continuous mapping process, attention was paid to merging or exaggerating different geological entities and considering geological field routes to ensure the appropriateness and objectivity of the map surface. Once the actual material map was completed, it was then updated to the original draft map.

2.2.2 Processing of Map Appearance and Map Border

After compiling the original map, different maps were compiled and listed on both sides of the main map according to the major discoveries and contents that needed highlighting, including comprehensive stratigraphic column, intrusive rock evolution sequence table, tectonic-rock unit in the ophiolitic mélange belt, large-scale map, geotectonic location map, geotectonic evolution model map, map cross section, legend and signature.

(1) Comprehensive stratigraphic column: This diagram displays in detail the era and thickness of rock combinations of different stratigraphic units on the map, focusing on the contact relation between strata of different eras and the sedimentary sequence and environment, thereby providing a reference for subsequent sedimentary facies analysis and regional stratigraphic correlation.

(2) Intrusive rock evolution sequence table: Igneous rock mapping units are compiled from bottom to top according to their magmatic evolution and intrusive relationships. The eras and mapping units are marked, lithological patterns are filled according to the legend of the main map, geotectonic environments of igneous rock formations are analyzed, taking into consideration rock combination and geochemical characteristics, and the magmatic evolution sequence is divided.

(3) Tectonic-rock units in the ophiolitic mélange belt and large-scale maps: The angle map mainly reflects the division scheme of different rock blocks and matrices in the ophiolitic mélange belt. On this basis, the large-scale map of the mélange belt is compiled according to the field route investigation. The large-scale map displays the metamorphic deformation characteristics of rock combinations and the field contact relation in detail, within the required range of accuracy, so as to reflect the actual field characteristics of the mélange belt as objectively as possible.

(4) Geotectonic location map: This mainly displays the tectonic position of the working area in the CAOB. Cutting is achieved on the basis of collecting 1∶250 000 regional geological maps in the Beishan region, while considering the actual position. During the cutting process, attention should be paid in order to keep the working map sheet in a central position and ensuring all four ophiolitic mélange belts in the Beishan region stay within the edited map at the same time.

(5) Geotectonic evolution model map: The geotectonic evolution model map of the working area is compiled and drawn in different evolution stages, according to the field investigation results and comprehensive research data, to ensure the consistency between the evolution model and the comprehensive research results, while conforming to global geological evolution patterns.

(6) Map cross section: Considering the direction of tectonic lines and the distribution of geobodies in the working area, two NE – SW-trending sections (section AB and CD) are set up

in the west and center of the north, respectively. Section AB mainly controls the Baiheshan ophiolitic mélange belt and the geobodies on both sides of it, including the Carboniferous Baishan Formation, the Lower-Middle Ordovician Xianshuihu Formation and the Carboniferous ophiolitic mélange. Section CD controls the Lower-Middle Ordovician Xianshuihu Formation, the Lower Carboniferous Lütiaoshan Formation, the Carboniferous Baishan Formation, Carboniferous accretionary complexes and Carboniferous-Permian intrusive rocks. Standard section line types and patterns are used to describe geobodies, each of which is separately marked with mapping units, along with attitude features and special boundary properties (such as fault properties).

(7) Legend and signature: The legend indicates geobody type, pattern, color, mapping unit, attitude, era information, section location, mineralized spot, fault and other geological feature types that need to be explained in all main maps; the signature section is compiled in accordance with the latest requirements of the *Technical Requirements for Regional Geological Surveys (1：50 000)* (DD 2019–01)

3 Data Sample Description

The 1：50 000 Regional Geological Map Database of the Qinghegou Map-Sheet includes the main map and other corner maps. The main map features intrusive rock formation, sedimentary rock formation, ophiolitic mélange formation, volcanic rock formation, quaternary geological boundary, fault, mapping units and attitude. The corner maps include stratigraphic column, intrusive rock evolution sequence, tectonic-rock unit in the ophiolitic mélange, geotectonic location map, tectonic evolution model map, map cross section, large-scale map, legend and signature. Types of data include point, surface and line entities, of which the point entities are comprised of geobody mapping units, attitude and pattern; surface entities encompasses intrusive rocks, sedimentary rocks, ophiolitic mélange and volcanic rocks; line entities are comprised of geological boundary, fault and lithofacies boundaries. The 2000 China Geodetic Coordinate System (CGCS 2000) was adopted for data samples and the Gauss-Kruger projection was adopted for projection.

The 1：50 000 Regional Geological Map Database of the Qinghegou Map-sheet (K47E010009) is mainly composed of geobody information elements, including a geological surface entity attribute table, geological boundary attribute table, fault attribute table and geological point attribute table. The *Geological Surface Entity Attribute Table* in the map-sheet can be divided into a sedimentary formation attribute table and intrusive rock formation attribute table.

The *Sedimentary Formation Attribute Table* (Table 2) consists of geobody type code, geobody identification number, geobody name, formation type, formation category, rock combination, geobody era and sedimentary environment.

The *Intrusive Rock Formation Attribute Table* (Table 3) includes feature identification number, feature type, mapping unit name, mapping unit symbol, rock color, rock name (lithology), rock texture and structure, primary minerals and contents, secondary minerals and contents, contact relation with surrounding rocks and fault formation era.

Table 2 Layer attributes of sedimentary rock formation in the 1：50 000 regional geological map database of the Qinghegou map-Sheet

Serial number	Data item name	Standard code	Data type	Example
1	Geobody identification number	Feature_Id	String	AK47E010009000003945
2	Formation category	Formation	String	Sedimentary formation
3	Formation type	Metallogenic	String	Flysch formation
4	Geobody type code	Feature_Type	String	C_1l^1
5	Geobody name	Geobody_Name	String	Upper segment of Lütiaoshan Formation
6	Rock combination	Combination	String	Medium-fine-grained metamorphic feldspar-quartz sandstone, conglomerate with thin layers of siltstone, etc.
7	Geobody era	Geobody_Era	String	C_1
8	Sedimentary environment	Sedimentary_Env	String	Deep-sea–semi-deep-sea turbidite deposits

Table 3 Layer attributes of intrusive rocks in the 1：50 000 regional geological map database of the Qinghegou map-Sheet

Number	Data item name	Standard code	Data type	Example
1	Feature identification number	Feature_Id	String	AG50E010008000000001
2	Feature type	Feature_Type	String	$x\eta\gamma P^2$
3	Mapping unit name	Intru_Body_Name	String	Fine-grained monzonitic granite in the Middle Permian
4	Mapping unit symbol	Intru_Body_Code	String	$x\eta\gamma P^2$
5	Rock name	Rock_Name	String	Fine-grained monzonitic granite
6	Rock color	Rock_Color	String	Flesh red
7	Rock texture	Rock_Texture	String	Fine-grained texture
8	Rock structure	Rock_Structure	String	Massive texture
9	Primary Minerals and Contents	Primary_Mineral	String	Quartz 20%–25%, plagioclase 25%, potassium feldspar 45%–50%
10	Secondary Minerals and Contents	Secondary_Mineral	String	Biotite 5%
11	Contact Relation with surrounding rocks	Contact_Relation	String	Intrusive contact
12	Fault formation era	Era	String	Middle Permian

The *Fracture Attribute Table* (Table 4) includes feature type code, fault name, fault type, fault code, fault character, fault hanging wall code, fault heading wall code, fault fracture zone width, fault strike, fault dip, fault dip angle, estimated fault distance, fault formation era and movement period.

The *Geological Boundary Attribute Table* (Table 5) includes feature identification number, geological boundary name, geological boundary (contact) feature type, geobody code on both sides of the boundary (left and right), geological surface strike, dip direction and dip angle.

Table 4　Layer attributes of fracture in the 1：50 000 regional geological map database of the Qinghegou map-sheet

Number	Data item name	Standard code	Data type	Example
1	Feature type code	Feature_Type	String	F11
2	Fault type	Fault_Type	String	611
3	Fault name	Fault_Name	String	Strike-slip fault F11 on the south side of Baiheshan
4	Fault code	Fault_Code	String	K47E010009F11
5	Fault character	Fault_Character	String	Strike-slip fault
6	Hanging wall of fault code	Fault_Up_Body	String	$C_{1\text{-}2}b^1$, $C_{1\text{-}2}b^2$
7	Heading wall of fault code	Fault_Bottom_Body	String	$C_{1\text{-}2}b^1$, $C_{1\text{-}2}\mathrm{b}^2$
8	Fault fracture zone width	Fault_Wide	String	50 m
9	Fault strike	Fault_Strike	Int	65
10	Fault dip	Fault_Dip	Int	155
11	Fault dip angle	Fault_Dip_Angle	Int	43
12	Estimated fault distance	Fault_Distance	Float	2–5 km
13	Fault formation era	Era	String	After K_1
14	Movement period	Movement_Period	String	Himalayan period

Table 5　Layer attributes of geological boundary in the 1：50 000 regional geological map database of the Qinghegou map-Sheet

Number	Data item name	Standard code	Data type	Example
1	Feature identification number	Feature_Id	String	AK47E010009000002322
2	Geological boundary name	Boundary_Name	String	Lithofacies boundary
3	Geological boundary (contact) feature type	Feature_Type	Int	23
4	Geobody code on the left side of the boundary	Left_Boundary_Code	String	O_1x^2
5	Geobody code on the right side of the boundary	Right_Boundary_Code	String	O_1x^2
6	Geological surface strike	Strike	Int	302
7	Dip direction	Dip_Direction	Int	32
8	Dip angle	Dip_Angle	Int	53

The *Geological Point Entity Attribute Table* (Table 6) is comprised of attitude features, including feature identification number, attitude code, attitude name, strike, dip direction and dip angle.

4　Data Quality Control and Evaluation

The mapping accuracy of the 1：50 000 Qinghegou Map-Sheet Regional Survey in Inner Mongolia was carried out in accordance with the *Technical Requirements for Regional Geological Surveys (1：50 000)* (DD 2019–01). Remote sensing interpretation and trench trial construction were also completed in accordance with relevant technical specifications. The layout of routes was based on the principle of differentiated workload, with reasonably more field investigation routes in key areas (such as the ophiolitic mélange belt and fewer in other

Table 6 Attributes of elements of attitude in the 1∶50 000 regional geological map database of the Qinghegou map-Sheet

Number	Data item name	Standard code	Data type	Example
1	Feature identification number	Feature_Id	String	AK47E010009000000436
2	Attitude code	Attitude_Code	Int	02
3	Attitude name	Attitude_Name	String	Schistosity
4	Strike	Strike	Int	130°
5	Dip direction	Dip_Direction	Int	220°
6	Dip angle	Dip_Angle	Int	56°

areas (areas with simple lithology and structure). In terms of mapping expression, geobodies with a width less than 50 m were generally not expressed, but special geobodies in the ophiolitic mélange belts (such as ultrabasic rocks, plagiogranite, eclogite, blueschist) were reasonably exaggerated and expressed. At the same time, large-scale geological maps were utilised for mapping, with the original size specified in the legend.

In terms of data quality, this database was built as part of the Project *Geological and Mineral Survey of Xiaohulishan and Yabulai Areas in Yinshan Metallogenic Belt*, in strict accordance with the relevant requirements of the *Administrative Measures for Geological Survey Projects* (Document No.18) issued by China Geological Survey in 2011, which also implemented the “Three-level Quality Inspection System” for self-inspection and mutual inspection, special inspection and sampling inspection of project quality. The quality rating of the self-inspection and mutual inspection mapping routes reached 100%, sampling inspection reached 40% when inspected by the project team and greater than 15% when inspected by the department. Therefore, the overall quality meets the requirements for geological survey management. Sample testing and analysis were conducted in laboratories with the appropriate qualifications, with the analysis process and quality in conformity with relevant requirements. In September 2018, the Qinghegou Map-Sheet Regional Geological Survey Project in Inner Mongolia was evaluated by experts in field acceptance as “excellent”.

5 Data Value

The 1∶50 000 Qinghegou Map-Sheet (K47E010009) Regional Geological Map Database, Inner Mongolia is a pilot map of the latest orogenic belt mapping project of China Geological Survey. In 2018, it has been rated as an excellent map of the national regional geological survey. According to the *Technical Requirements for Regional Geological Surveys (1∶50 000)* (DD 2019–01), the project adopts field route survey, surveyed geological cross section and large-scale mapping to express in detail the material composition and structure of the Baiheshan ophiolitic mélange belt. By identifying rock blocks and matrices, it clearly expresses the characteristics of field geobodies and the spatial structure of oceanic crust. With special emphasis on the structural pattern within the mélange belt, the project finds that the Baiheshan ophiolitic mélange belt is mainly composed of oceanic crust residues including mafic and ultramafic rock, gabbro, basalt, plagiogranite, chert, exotic blocks including Ordovician volcanic rock, limestone and a matrix composed of serpentinite, sandstone, epidote-chlorite schist. The project identifies three distinct foliations of the Baiheshan ophiolitic mélange belt: shear rheology in the subduction period, contraction and deformation in the collision period and post-orogenic strike-slip in the extension period. Considering the results of U-Pb isotope dating, the project identifies the time of opening and closure of the Baiheshan ocean basin to be the Early Carboniferous and Early Permian respectively. Based on geochemical composition and era, the project identifies the type of the Baiheshan ophiolite as a Supra-Subduction Zone (SSZ), while the spatial distribution of arc igneous rocks indicates the polarity of the southward subduction of the ocean basin. According to their era and geochemical characteristics, intrusive rocks in the map are classified into three stages: Silurian-Devonian island-arc igneous rocks, Carboniferous-Early Permian continental marginal arc igneous rocks and Mid-Late Permian post-orogenic extensional igneous rocks. The corresponding geotectonic evolution can also be divided into three stages: active continental margin formation and evolution in the Early Paleozoic, subduction, accretion and post-orogenic extension in the Late Paleozoic and intracontinental basin evolution and differential uplift and denudation in the Mesozoic and Cenozoic.

The Qinghegou Map-Sheet database can provide support for the new scheme of stratigraphic and tectonic unit division of the Beishan orogenic belt, as well as basic data support for geological prospecting and investigation, regarding the structure of the orogenic belt in the Beishan area. Thus, contributing to an improved scientific understanding of the orogenic system in northern China.

6 Conclusion

(1) The 1 : 50 000 Regional Geological Map of the Qinghegou Map-Sheet (K47E010009), Inner Mongolia is rated as an excellent map of the national regional geological survey (2018). This project innovates the expression of geological mapping results of the orogenic belt and compiles the Qinghegou Map-Sheet regional geological map, which to a certain extent, has an exemplary effect on the geological survey of orogenic belts.

(2) The 1 : 50 000 Regional Geological Map Database of the Qinghegou Map-sheet (K47E010009) has been completed and established. The spatial database features good consistency of data inheritance, with complete types of database files and data items. Projection parameters and scale accuracy are defined in conformity with relevant requirements and precise spatial positioning.

(3) The material composition of the Baiheshan ophiolitic mélange belt is intricately divided. The characteristics of rock combination and spatial distribution of the Baiheshan ophiolite have been determined. Geochemical and isotopic dating indicate that the Baiheshan ophiolite is a set of Carboniferous SSZ ophiolites.

(4) Isotopic dating of igneous rocks in the Qinghegou Map-Sheet divides them into three stages of evolution, re-establishing the tectonic-magmatic evolution sequence in the area.

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Note:

❶ Geological Survey Institute of Inner Mongolia. 2009. 1：50 000 Regional Mineral Geological Survey Report of Five Map-sheets Including Tianshuijing, Ejina Banner, Inner Mongolia.

References

He Zhenyu, Zong Keqing, Jiang Hongying, Xiang Hua, Zhang Zeming. 2014. Early Paleozoic tectonic evolution of the southern Beishan orogenic collage: insights from the granitoids[J]. Acta Petrologica Sinica, 30: 2324−2338 (in Chinese with English abstract).

Li Xiangmin, Yu Jiyuan, Wang Guoqiang, Wu Peng. 2012. Geochronology of Jijitaizi ophiolite of Beishan aea,Gansu Provice,and its geological significance[J]. Geological Bulletin of China, 31(12): 2025−2031 (in Chinese with English abstract).

Niu Wenchao, Duan Lianfeng, Zhao Zelin, Xin Houtian, Ren Bangfang. 2020. 1：50 000 Regional Geological Map Database of the Qinghegou Map-sSheet, Inner Mongolia[DB/OL]. Geoscientific Data & Discovery Publishing System. (2020-06-30). DOI: 10.35080/data.A.2020.P8.

Niu Wenchao, Ren Bangfang Ren Yunwei, Sun Lixin, Duan Xiaolong, Duan Lianfeng, Li Min, Zhang Jiahui. 2017. Discovery of Neoproterozoic Gneissic Granite from the Beishan area, Inner Mongolia: Zircon U−Pb Chronologic Evidence[J]. Geology in China, 44(2): 409−410 (in Chinese with English abstract).

Niu Wenchao, Xin Houtian, Duan Lianfeng, Wang Genhou, Zhao Zelin, Zhang Guozhen, Zheng Yilong. 2019. The identification and subduction polarity of the Baiheshan ophiolite mélanges belt in the Beishan area, Inner Mongolia—New understanding based on the geological map of Qinghegou Sheet (1：50 000)[J]. Geology in China, 46(5): 977−994 (in Chinese with English abstract).

Wang Guoqiang, Li Xiangmin, Xu Xueyi, Yu Jiyuan, Wu Peng. 2014. Ziron U−Pb chronological study of the Hongshishan ophiolite in the Beishan area and their tectonic significance[J]. Acta Petrologica Sinica, 30(6): 1685−1694 (in Chinese with English abstract).

Xiao W J, Mao Q G, Windley B F, Han C M, Qu J F, Zhang J E, Ao S J, Guo Q Q, Cleven N R, Lin S F, Shan Y H, Li J L. 2010. Paleozoic multiple accretionary and collisional processes of the Beishan orogenic collage[J]. American Journal of Science, 310: 1553−1594.

Xiao W J, Ao S J, Yang L, Han C M, Wan B, Zhang J E, Zhan Z Y, Li R, Chen Z Y, Song S H. 2017. Anatomy of composition and nature of plate convergence: Insights for alternative thoughts for terminal India-Eurasia collision[J]. Science China (Earth Sciences), 60: 1015−1039.

Yang Fulin, Zhao Zhixiong, Jia Wenyan, Yang liang, Xu Hai, Jia Yuanqin, Gao Yong. 2016. Discussion on the forming age of the Beishan group in the Beishan area, Inner Mongolia[J]. Geological Survey and Research, 39(2): 89−94 (in Chinese with English abstract).

Yu J Y, Guo L, Li J X, Li Y G, Smithies R H, Wingate M T D, Meng Y, Chen S F. 2016. The petrogenesis of sodic granites in the Niujuanzi area and constraints on the Paleozoic tectonic evolution of the Beishan region, NW China[J]. Lithos, 256–257: 250−268.

Zhang Jinlong, Chen Chao, Pan Zhilong, Zhang Guifeng, Zhang Huan, Li Qingji. 2017. Affirm of the Erduanjing formation and analysis of its depositional environment in Xilintaole area, Inner Mongolia[J]. Geological Survey and Research, 40(4): 274−280 (in Chinese with English abstract).