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河南省小水幅 1∶50 000 地质图数据库

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摘要：河南省小水幅 (I49E016015)1∶50 000 地质图是在充分收集、综合分析已有地质矿产资料基础上，应用数字填图技术，通过地质填图及数据库建设完成的。本地质图数据库为 MapGIS 格式，包括 9 个地层单元和 6 期岩浆岩事件，数据量为 31.9 MB, 其中电子探针数据 70 个、化学捡块样测试数据 57 个、锆石 U-Pb 测年数据 73 个、全岩地球化学分析数据 147 个。图幅采用造山带填图新理论和新方法，重点突出构造–岩性填图和特殊地质体及非正式填图单位的表达，图面表达内容的科学性、易读性和实用性提高。本图幅建立了由商–丹构造带、朱–夏蛇绿构造混杂岩带、秦岭微陆块构造和二郎坪岛弧–弧后盆地组成的北秦岭造山带结构，明确了朱–夏蛇绿构造混杂岩带形成于早古生代，查明了秦岭岩群的物质组成及 4 期褶皱变形，确定了高压–超高压岩石空间分布规律、原岩及变质时代，揭示了秦岭微陆块整体卷入早古生代造山带并遭受强烈改造。图幅成果为《河南地质志》编写、河南省地质勘查基金提供了新的基础地质资料支撑，荣获 2018 年度全国区域地质调查造山带填图区“优秀图幅奖”。

关键词：数据库；地质图；1∶50 000；小水幅；蛇绿混杂岩带；地质调查工程；河南
数据服务系统网址：http://dcc.cgs.gov.cn

1 引言

秦岭造山带系中国大陆中央造山带的主要组成部分，由 2 个主缝合带（商丹和勉略缝合带）和北秦岭（及华北克拉通南缘）、扬子克拉通北缘及两者间的中秦岭地块 3 个块体组成（Bader T et al., 2020; Meng QR et al., 2000; 张国伟等, 2001; 张翔等, 2019）。其中北秦岭造山带夹持于商–丹断裂带与洛南–栾川断裂带之间（图 1），是秦岭造山带中变形变质、岩浆活动最为强烈的地带（张国伟等, 1995），特别是近年来北秦岭东侧多种类型高压–超高压岩石的发现和陆壳深俯冲的确定（Wang H et al., 2011; Zhu XY et al., 2011; 胡能高等, 1994; 刘良等, 1996, 2013; 杨经绥等, 2002; 张建新等, 2011; 王浩等, 2013;

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翟文建等, 2019a），证明了北秦岭高压–超高压岩石经历了～500 Ma（490～500 Ma）的陆壳俯冲–深俯冲及～450 Ma（450～470 Ma）和～420 Ma（400～420 Ma）2 次抬升–折返–退变–叠加作用过程（刘良等, 2013; 陈丹玲等, 2019），对北秦岭早古生代构造演化过程产生了新的认识。

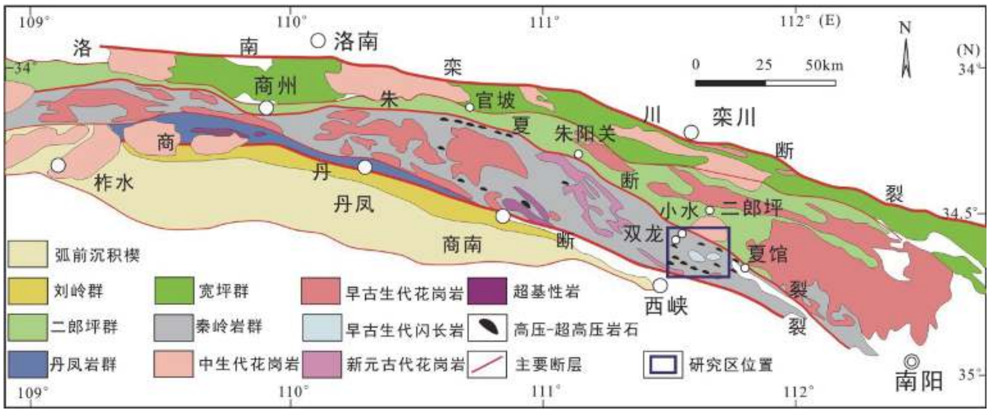

图 1　北秦岭构造带构造地质简图（据 Wang H et al., 2011 修改）

河南省小水幅调查区位于北秦岭造山带东段，夹持于商–丹断裂带和朱–夏断裂带之间（图 1）。区内地质体出露有中元古界秦岭岩群（王世炎等, 2002; 翟文建等, 2019b）、中–新元古界峡河岩群（李承东等, 2018）、新元古界–早古生界龟山岩组（刘晓春等, 2015; 李承东等, 2019）、早古生界二郎坪群（赵姣, 2012）、新元古代片麻状二长花岗岩（Wang Y et al., 2019; 卢欣祥, 1999; 刘丙祥等, 2013; 王晓霞等, 2015）和广泛发育的早古生代花岗岩（王涛等, 2009; 李开文等, 2019a）、闪长岩（马昌前等, 2004; 李开文等, 2018, 2019b）等。其中，元古界的岩石组合和构造面貌各异，但普遍遭受了角闪岩相和绿片岩相 2 期区域变质作用及构造变形叠加作用。以榴辉岩（刘良等, 2013; 何宇等, 2018）、榴闪岩（刘良等, 2013; 翟文建等, 2019a）、麻粒岩（张建新等, 2011）等为代表的高压–超高压岩石记录了早古生代榴辉岩相或麻粒岩相的区域变质作用，致使现今元古代地层单元之间表现为由韧性断层分隔的构造岩块、岩片叠置而成的组合体。

河南省小水幅图幅区的区域地质调查工作始于 20 世纪 30—40 年代，50 年代以后开展了较为系统的基础地质工作，先后完成 1：200 000 栾川幅区域调查、1：50 000 西峡北部区域修测、1：50 000 小水幅和夏馆幅区域调查、西峡—鲁山地区 1：50 000 片区总结、1：250 000 内乡县幅区域调查、豫西南地区 1：200 000 区域重力和重磁调查等工作，在大地构造单元划分、岩石地层厘定、地质找矿等方面取得一批重要成果，为小水幅地质图的编制提供了基础性研究资料。近年来许多学者对小水幅内地质体尤其是超高压变质岩进行了大量研究工作，并取得了一些重要成果（Zhang YQ et al., 2019; 刘良等, 2013; 何宇等, 2018; 翟文建等, 2019b），但对与其有成因联系的朱–夏蛇绿构造混杂岩带研究不足。本次工作依据《区域地质调查技术要求（1：50 000）》（DD2019–01），对图幅内地质体及构造进行了系统的地质调查和研究，并建立了地质图数据库（表 1; 郭君功等, 2020），成为图幅区内最为全面的基础地质资料。

2　数据采集和处理方法

2.1　数据准备

河南省小水幅 1：50 000 地质图以《区域地质调查技术要求（1：50 000）》（DD2019–

表 1　数据库（集）元数据简表

条目	描述
数据库（集）名称	河南省小水幅1∶50 000地质图数据库
数据库（集）作者	沉积岩类：郭君功，河南省地质科学研究所 火山岩类：晁红丽，河南省地质调查院 岩浆岩类：赵　焕，河南省地质调查院 变质岩类：翟文建，河南省地质调查院
数据时间范围	2016—2019年
地理区域	经纬度：东经 111°30′ ~ 111°45′，北纬 33°20′ ~ 33°30′
数据格式	MapGIS
数据量	31.9 MB
数据服务系统网址	http://dcc.cgs.gov.cn
基金项目	河南1∶50 000二郎坪幅等三幅区域地质矿产调查项目（编号：DD20160043-03）和中条—熊耳山成矿区地质矿产调查(编号：DD20160043)联合资助
语种	中文
数据库（集）组成	河南省小水幅1∶50 000地质图数据库包括1∶50 000地质图库和图饰。地质图库包括沉积岩、岩浆岩、火山岩、变质岩、第四系、脉岩、特殊地质体、矿物、构造、地质界线、产状、同位素样品及年龄、岩性花纹、地质代号以及地名、道路、河流、水库等。图饰包括接图表、柱状图、侵入岩单位图、混杂岩带构造岩石单位图、大地构造位置及高压–超高压岩石分布图、地质演化史、地质图切剖面、图例等

01）为基本要求，在充分收集、综合分析已有地质矿产资料基础上，应用数字填图技术，采用造山带填图新理论和新方法，加强岩石、构造的调查，重点突出构造–岩性填图和特殊地质体及非正式填图单位的表达，大幅提高了图面表达内容的科学性、易读性和实用性（图 2）。地理底图采用国家测绘局最新地理数据，应用已有的技术标准和数字填图系统（DGSS）及 MapGIS 等计算机软件进行数据处理。

2.2　数据采集

2.2.1　数据采集准备

数字填图地理底图采用国家基础地理信息中心提供的 1∶50 000 数字化地形图，投影类型为高斯—克吕格投影，1980 年西安坐标系椭球参数，高程基准为 1985 国家高程基准。结合前人资料与野外踏勘，依据调查区实际情况编制并不断完善数字填图 PRB 字典库，内容主要由图幅基本信息数据模型、野外分段路线观测数据采集模型、简化地理数据模型、统计数据采集数据模型及剖面数据模型组成；其中，图幅基本信息数据包括图幅基本信息、填图人员信息；简化地理数据模型包括地理底图标准图框、地理底图注释、地理底图符号属性、地理底图线状属性、地理底图等高线属性、地理底图面状图层属性。

2.2.2　数据采集

以 1∶25 000 数字化地形图为底图，通过野外实际调查，在数字填图野外采集系统中标绘出点、线等相关地质信息，初步建立数字填图（PRB）数据库。

地质点（Point）：地质点中的路线号、地质点号、微地貌、点性、露头、风化程度、位置说明、填图单位、岩石名称和接触关系等信息由手动录入野外数据采集系统，坐标信息由系统自动读取。

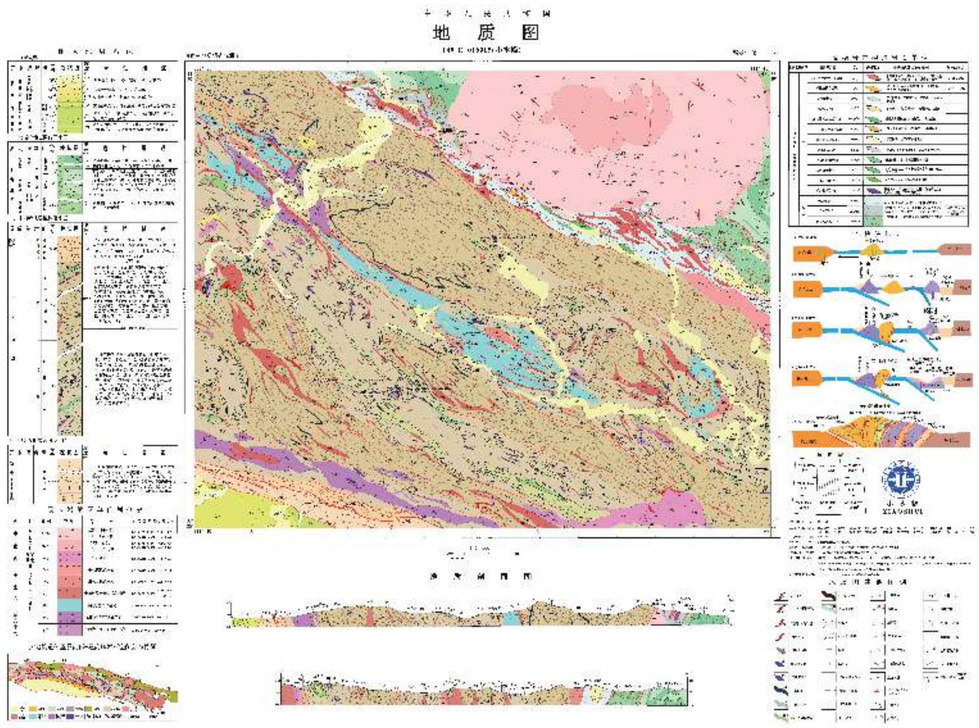

图 2　河南省小水幅（I49E016015）1∶50 000 地质图示意图

地质路线（Routing）：地质路线中的路线号、地质点号、R 编号、填图单位和岩石名称等信息由手动录入野外数据采集系统，方向、本站距离、累计距离由系统自动读取。

地质界线（Boundary）：通过野外数据采集系统收集的地质界线信息包括：路线号、地质点号、B 编号、R 编号、界线类型、左侧填图单位、右侧填图单位、接触关系、界线走向、界线倾向及界面倾角。

沿途所测地质体的产状（Attitude）、拍摄的照片（Photo）、绘制的素描（Sketch）、采集的标本（Sample）等信息，通过定位、拍摄、测量等方法完善相关属性数据。

2.3　数据整理

（1）将野外数据采集系统收集到的原始数据资料导入电脑版 DGSS 系统，并依据相应规范进行数据整理。

（2）利用 DGSS 系统对原始地质点（Point）位进行校准，并将相关内容进行整理完善。样品在鉴定完成后，结合野外岩石定名进行综合定名。

（3）利用 DGSS 系统对原始地质界线（Boundary）位置进行校准，并根据“V”字型法则及合理美观的原则完善界线形态。根据地质界线的不同类型，确定对应的线型参数（线型、颜色、线宽等）。完善地质界线描述，用“界线左侧为…，界线右侧为…”来描述两侧岩性差异，并统一界线左侧为上一路线岩性，右侧为下一路线岩性，对两侧岩性接触关系应给出明确定名并提供相关地质证据。

（4）校准地质路线（Routing）起点和终点，对线段进行光滑处理，统一线型、线颜色、线宽等，重新计算并写入路线方位、距离等，最后对路线内容进行完善，包括路线岩性组成及变化特征等。

（5）校准产状、样品、照片、素描等要素的位置，完善相关属性信息。所有要素

的编号依据所属地质点按 1、2、3 顺序编排。

2.4 编制地质图

2.4.1 野外总图库

将计算机 DGSS 系统中 4 幅完善后的 1：25 000 地质路线及地质剖面统一入库，生成野外总图库数据库，检查所有地质要素的属性结构。

2.4.2 实际材料图库

实际材料图库继承野外总图库野外路线实体观测数据点、线采集层及标注图层，同时自动生成点要素（GEOLABEL）、线要素（GEOLINE）、区要素（GEOPOLY）3 个文件。检查所有要素的属性结构，根据路线及剖面地质界线进行拓扑造区，按《区域地质图例》（GB/T 958–2015）要求将地质体进行颜色标注。

2.4.3 编稿原图

在 DGSS 系统中将 I49F031029 幅、I49F032029 幅、I49F031030 幅和 I49F032030 幅 1：25 000 实际材料图入库到编稿原图，形成小水幅（I49E016015）1：50 000 编稿原图库。

2.4.4 空间数据库

在 DGSS 系统中将小水幅 1：50 000 编稿原图库入库到成果数据库中，形成小水幅 1：50 000 地质图空间数据库，内容包括地理要素、地质要素和图面整饰 3 部分。划分为如下图层：图幅基本信息图层、水系图层、交通图层、居民地图层、境界图层、地形等高线图层、地质体图层、非正式地层单位图层、图切剖面图图层、蚀变带图层、矿化带图层、变质相带图层、断层图层、构造变形带图层、产状符号图层、摄像（照片）图层、同位素测年图层、样品图层、图例图层和其他图元图层。

2.5 编制角图

2.5.1 综合地层柱状剖面图

对地质图中岩石地层单元的组合特征进行详细表达。通过对图幅内地层的岩性、厚度、时代、单元归属等进行综合分析研究，编制综合地层柱状剖面图。

2.5.2 混杂岩带构造岩石单位

通过对图幅内化山峪构造蛇绿混杂岩带中基质和岩块的物质组成、构造变形特征及年代学数据等进行综合分析，编制混杂岩带构造岩石单位图。

2.5.3 侵入岩填图单位

通过对图幅内主要的侵入岩岩石组成、侵入关系、同位素时代、构造环境等进行综合分析，划分出侵入岩期次，编制侵入岩填图单位图。

2.5.4 大地构造位置及高压–超高压岩石空间分布特征图

着重表达本图幅大地构造位置，以及以榴闪岩、退变榴辉岩、麻粒岩为代表的高压–超高压岩石空间展布特征和赋存状态。

2.5.5 地质剖面图

为了能充分反映图幅内主体构造格架和地质体特征，垂直主构造线方向布置了 2 条图切剖面，编号为剖面 AB 和剖面 CD，采用标准剖面线型+标准代号进行表达，并在相应的位置标注花纹、代号及接触关系等。

2.5.6 地质演化史

在前人研究资料的基础上，结合本图幅成果，初步建立了由商–丹构造带、朱–夏蛇

绿构造混杂岩带、秦岭微陆块构造和二郎坪岛弧–弧后盆地组成的北秦岭造山带结构，从纵向上刻画北秦岭造山带早古生代构造演化史。

2.5.7 图例

按《区域地质图例》（GB/T 958–2015）要求，对地质图内所涉及的脉岩、高压–超高压岩石等特殊地质体、非正式填图单元、特殊矿物，地质界线、断层、产状、年龄样品及子图的颜色、线型、岩石类型、符号、代号等进行描述。

2.5.8 接图表

标注与小水幅毗邻的 1：50 000 地质图的图名和图幅代号、便于检索相邻图幅信息。标注中国地质调查局标识、图幅负责、主要完成人、完成单位、项目来源和资料来源等相关信息，利于后续查询、检索和引用本图幅信息。

3 数据样本描述

3.1 数据类型

实体类型名称：点（.wt）、线（.wl）、面（.wp）。

点实体：各类地质体代号、地质花纹、断层编号、产状、同位素等。

线实体：整合及侵入界线、岩相界线、构造面理接触界线、不整合界线、断层构造、道路、河流等；

面实体：沉积岩、侵入岩、高压–超高压岩石（榴闪岩、麻粒岩）、非正式填图单位实体、构造岩块、第四系、水库等。

3.2 图层内容

地质图内容包括沉积岩地层、侵入岩体、变质岩地层、第四系、地质界线、构造、产状、各类代号等。

角图内容包括综合地层柱状剖面图、混杂岩带构造岩石单位、侵入岩填图单位、大地构造位置图、地质剖面图、图例、接图表等。

3.3 数据属性

河南小水幅 1：50 000 地质图数据库包括基本要素类、综合要素类和对象类数据集。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，一般一个要素类对应多个对象类。

3.3.1 基本要素类

地质体面实体（_GeoPolygon）：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。雁岭沟岩组地质体面实体属性表见表 2。

地质界线（_GeoLine）：要素标识号：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）：产状类型代码、产状类型名称、走向、倾向、倾角、子类型标识。

样品（_Sample）：样品编号、样品类型代码、样品岩石名称、子类型标识。

照片（_Photograph）：照片编号、照片题目、照片说明、子类型标识。

表 2 雁岭沟岩组地质体面实体属性表

序号	数据项名称	标注编码	数据类型	内容描述实例
1	标识号	*Feature_Id	Character	AI49E016015000000143
2	原编码	Source_Id	Character	
3	类型代码	*Feature_Type	Character	Pt@2y@.
4	名称	Geobody_Name	Character	雁岭沟岩组
5	时代	Geobody_Era	Character	Pt@2
6	下限年龄值/a.B.P	Geobody_Age1	Double	
7	上限年龄值/a.B.P	Geobody_Age2	Double	
8	子类型标识	Subtype	Interger	1

注：@表示下角标。

素描（_Sketch）：素描编号、素描题目、素描说明、子类型标识。

同位素测年（_Isotope）：样品编号、样品名称、年龄测定方法、测定年龄、所测定地质体单位及代号、测定单位、测定日期、子类型标识。

河、水库岸线（_Line_Geography）：图元类型、图元名称、子类型标识。

3.3.2 综合要素类

蚀变带（_Alteration_Polygon）：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、发生蚀变的地质体代号、子类型标。

变质相带（_Metamor_Facies）：变质相带地质体代码、变质相带类型、变质程度、变质温压条件、变质相带岩石名称、变质相带岩石颜色、变质相带岩石结构、变质相带岩石构造、变质相带矿物组合及含量、含矿性、子类型标识。

构造变形带（_Tecozone）：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、变形力学特征、形成时代、活动期次、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。

3.3.3 对象类

沉积岩岩石地层单位（_Strata）：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、地层厚度，含矿性、子类型标识。

侵入岩岩石年代单位（_Intru_Litho_Chrono）：岩体填图单位名称、岩体填图单位符号、岩石名称、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。早白垩世黑云母二长花岗岩侵入岩年代单位属性表见表 3。

断层（_Fault）：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（_Dike_Object）：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。

表 3　早白垩世黑云母二长花岗岩侵入岩年代单位属性表

序号	数据项名称	标准编码	数据类型	内容描述实例
1	要素分类（地质代码）	*Feature_Type	Character	$\eta\gamma\beta$K@1$1
2	岩体填图单位名称	Intru_Body_Name	Character	早白垩世黑云母二长花岗岩
3	岩体填图单位符号	Intru_Body_Code	Character	$\eta\gamma\beta$K@1$1
4	岩石名称（岩性）	Rock_Name	Character	黑云母二长花岗岩
5	岩石颜色	Color	Character	灰–灰白色
6	岩石结构	Rock_Texture	Character	中–粗粒花岗结构，似斑状构造
7	岩石构造	Rock_Structure	Character	块状构造
8	岩相	Rock_Phases	Character	深成相
9	与围岩接触关系	Contact_Relation	Character	侵入接触
10	主要矿物及含量	Primary_Mineral	Character	钾长石（30%～40%）、斜长石（25%～40%）、石英（20%～30%）
11	次要矿物及含量	Secondary_Mineral	Character	少量黑云母
12	与围岩接触面走向	Strike	Integer	135°
13	与围岩接触面倾向	Dip_Direction	Integer	325°
14	与围岩接触面倾角	Dip_Angle	Integer	48°～80°
15	形成时代	Era	Character	K@1
16	含矿性	Commodities	Character	*
17	子类型标识	Subtype	Integer	0

注：@表示下角标；$表示上角标。

面状水域（_Water_Region）：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）：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

河南省小水幅 1∶50 000 地质图以《区域地质调查技术要求（1∶50 000）》（DD2019–01）为基本准则，在系统收集和综合分析已有地质资料基础上，开展野外地质调查。野外地质填图采用数字填图仪实地采集数据，手图采用 1∶25 000 数字化地形图。对直径大于 50 m 的闭合地质体，宽度大于 25 m、长度大于 50 m 的线状地质体以及长度大于 250 m 的断层均进行了填绘，对于特殊地质体如变橄榄岩、（蛇纹石化）辉石岩、辉绿玢岩脉、变硅质岩、榴闪岩、麻粒岩、石英（片）岩、大理岩透镜体等，厚度不论大小，均在图上适当夸大表示。共完成 1∶50 000 地质填图 422 km^2，路线总长度为 760 930.3 m，包括实测路线 628 269.0 m 和修订录入路线 132 661.3 m，完成各类地质点 1 526 个，平均 3.62 个/km^2，地质界线 4612 个，平均点距 498.64 m，样品数 285 件，产状 3 212 个，素描图 48 个，照片 837 张，完全满足 1∶50 000 地质填图的精度要求。

地质剖面测制前均进行了路线调查，剖面位置选择露头连续、露头面积大于 60%、岩层顶底齐全、接触关系清楚的地段，剖面线方向基本垂直于地质体走向，两者之间的夹角大于 60°。采用罗盘测剖面方位、坡度，利用测绳进行距离测量，地质点，导线起

点、终点，全岩地球化学分析和锆石 U–Pb 测年采样点均用 GPS 采集坐标，数据录入前均在室内检查投影是否正确等。本图幅地层剖面、“地层+构造”剖面共测制 3 条，总长度为 20 902 m，比例尺均为 1：2 000，除零星出露的新近系外，其他所有地层均有剖面控制。岩体剖面共测制 2 条，总长度为 11 514 m，重点对黄花墁二长花岗岩体和晚侏罗世花岗斑岩体进行解体，对于出露面积较小的小岩滴、岩脉，如新元古代二长花岗片麻岩、中志留世黑云母闪长岩、志留纪花岗岩脉（二长花岗岩、正长花岗岩）等未专门测制其剖面，基本上随地层构造剖面一并测制。

本次工作严格按照中国地质调查局有关质量管理要求和河南省地质调查院《质量管理体系》开展工作，建立了河南省地质调查院、项目部、作业组三级质量管理网络，严格执行当日检查、阶段检查和专家组检查等检查制度。本图幅野外调查路线共计 207 条，实测剖面 5 条，其中项目组自检、互检率为 100%，项目部检查调查路线 63 条、实测剖面 3 条，检查率分别为 30.4%、80%；河南省地质调查院抽查路线 12 条，剖面 1 条，检查率分别为 5.8%、20%；项目开展期间中国地质调查局天津地质调查中心每年均组织专家进行年度设计评审和野外质量检查等工作，各级质量检查均有文字记录。中国地质调查局天津地质调查中心于 2018 年 10 月 22—27 日在河南省洛阳市对该图幅成果进行野外验收，认定该图幅在蛇绿构造混杂岩及高压变质岩的调查研究等方面取得了重要进展，评定得分为 93 分，综合评定为优秀级。荣获 2018 年度全国区域地质调查造山带填图区“优秀图幅奖”。

5 数据价值

5.1 建立合理的地层格架，厘定岩石（构造）地层单位

在原龟山岩组中新识别出一套变质碎屑岩组合。在大块地一带新填绘出峡河岩群，并在斜长阳起黑云片岩内获得岩浆锆石 U–Pb 上交点年龄为 1 448±51 Ma。重新厘定了秦岭岩群，查清了郭庄岩组和雁岭沟岩组的物质组成，研究了郭庄岩组内深熔作用纵向变化特征，获得深熔作用时限为 424.3±2.2 Ma ~ 415.8±1.6 Ma。

5.2 查明侵入岩侵入期次及演化特征

将青白口纪花岗岩类划分为片麻状含榴花岗闪长岩和片麻状含榴白云母二长花岗岩 2 种岩石类型，分别获得成岩年龄为 890±14 Ma 和 907±25 Ma；在化山峪朱–夏蛇绿构造混杂岩带内新发现具幔源橄榄岩性质的变辉橄榄岩岩块和碱性正长岩岩块，获得碱性正长岩成岩年龄为 457.4±1.9 Ma；在秦岭岩群内新发现中奥陶世二长花岗岩，获得岩浆锆石 U–Pb 年龄为 461.3±3.6 Ma。

5.3 在秦岭岩群中识别出大面积高压–超高压构造带

在秦岭岩群中填绘出榴闪岩、退变榴辉岩以及基性麻粒岩，这些岩石多呈似层状、条带状、豆荚状和透镜状产出，整体呈面状展布，表明秦岭岩群整体上经历过深俯冲作用；利用激光拉曼光谱仪（Laser Raman Spectroscopy）识别出绿辉石包裹体，获得岩浆残核锆石年龄为 654.1±5.6 Ma ~ 656.1±6.7 Ma、变质年龄为 484.8±5.8 Ma ~ 356.0±11.0 Ma，同时对 17 个样品的岩石地球化学进行了系统测试和初步研究。

5.4 初步建立北秦岭造山带结构

北秦岭造山带由商–丹构造变形带、朱–夏蛇绿构造混杂岩带、秦岭微陆块和二郎坪

岛弧–弧后盆地组成。首次厘定出化山峪朱–夏蛇绿构造混杂岩带是由不同“时态”、“位态”及“相态”的岩块和强烈变形的基质组成，由南向北填绘出钙质糜棱岩、钠长阳起石片岩和黑云石英片岩 3 种基质，以及由变质橄榄岩、变辉石岩、变辉长岩、大理岩和变硅质岩等组成的十余种构造岩块，总体表现出“多基质、少岩块”的特点，且洋壳地层组合构成的岩块形成时代为寒武纪–奥陶纪，基质主期变形时代介于早奥陶世–末志留世，因此认定朱–夏蛇绿构造混杂岩带为早古生代蛇绿混杂岩带。而传统的商–丹带在图幅西南部仅仅表现为龟山岩组与峡河岩群接触界线及两侧发育强烈的韧性变形，为一韧性变形带。构造方面在秦岭岩群内识别出 4 期褶皱叠加，在峡河岩群内识别出 2 期褶皱叠加，在二郎坪群内识别出 3 期褶皱叠加。

6　数据使用方法和建议

河南省小水幅 1：50 000 地质图数据库采用 MapGIS 格式建立，内容翔实，便于查询，可编辑性强，可与同类型数据进行叠加、合并及再处理，有利于数据库信息共享，应用前景广泛。该数据库为基本地质信息库，可以为北秦岭造山带的岩石地层、构造、地质找矿等多方面提供基础性研究资料；为区域开展同种或不同比例尺生态环境调查、地质灾害防治等提供基础性图件；为《河南地质志》编写、河南省地质勘查基金提供新的基础地质资料支撑。

7　结论

河南省小水幅 1：50 000 地质图数据库包括 9 个地层单元和 6 期岩浆岩事件，数据量为 31.9 MB，充分反映了 1：50 000 区域地质调查最新成果。运用造山带填图新理论和新方法，突出构造–岩性填图和特殊地质体及非正式填图单位的表达，建立了由商–丹构造带、朱–夏蛇绿构造混杂岩带、秦岭微陆块构造和二郎坪岛弧–弧后盆地组成的北秦岭造山带结构；明确了朱–夏蛇绿构造混杂岩带形成于早古生代，查明了秦岭岩群的物质组成及 4 期褶皱变形，确定了高压–超高压岩石空间分布规律、原岩及变质时代，揭示了秦岭微陆块整体卷入早古生代造山带并遭受其强烈改造。

致谢：河南省小水幅 1：50 000 地质图数据库是集体性成果，在野外地质调查和地质图数据库的建立过程中，得到来自河南省地质调查院、河南省地质矿产勘查开发局、天津地质调查中心等单位多名专家的无私帮助和大力指导，在此对各位专家表示衷心的感谢!

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1∶50 000 Geologic Map Database of the Xiaoshui Map Sheet, Henan Province

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Abstract: The 1∶50 000 geologic map of the Xiaoshui map sheet (I49E016015), Henan Province was prepared by using the digital mapping technology and database building, during which existing geologic and mineral data were fully collected and comprehensively analyzed. The database of this geologic map (also referred to as the Database) is in the format of MapGIS and covers nine stratigraphic units and six stages of magmatic events, which also includes electronic probe data of 70 samples, chemistry testing data of 57 samples, zircon U–Pb dating of 73 samples and whole-rock geochemical data of 147 samples, coming to a total data size of 31.9 MB. Meanwhile, the new mapping theory and methodology based on orogenic belts were adopted to highlight tectonic and lithologic mapping as well as the presentation of special geologic bodies and informal mapping units. In this way, the contents on the map face were expressed in a more scientific, readable and practical manner. In this study, the structure of the North Qinling Orogenic Belt (NQOB) was established, consisting of the Shangnan–Danfeng tectonic belt, Zhu–Xia ophiolitic mélange belt, Qinling microcontinent and Erlangping island arc, a back-arc basin. Following this, it was clear that the Zhu–Xia ophiolitic mélange belt was formed in the early Paleozoic era. Furthermore, the composition and four stages of fold deformations of the Qinling Group were ascertained; the spatial distribution law, protolith and metamorphic era of the high and ultrahigh-pressure rocks in the map sheet area were determined. Thus, revealing that the whole Qinling microcontinent was involved in the early Paleozoic orogen and had undergone great transformation. The achievements of this study have provided new basic geological data for the preparation of the '*Annals of Geology of Henan*

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Province' and the projects funded by the '*Geological Exploration Fund of Henan Province*'. Moreover, the 1：50 000 geologic map of the Xiaoshui map sheet was awarded the 'Excellent Map Sheet Prize', among the areas mapped, based on orogenic belts in the national regional geological surveys of China in 2018.
Key words: Database; geologic map; 1：50 000; Xiaoshui map sheet; ophiolitic mélange belt; geological survey engineering; Henan Province
Data service system URL: http://dcc.cgs.gov.cn

1 Introduction

The Qinling orogen is one of the main components of the Central Orogenic Belt of China. It consists of two main suture zones (Shangdan and Mianlue suture zones) and three blocks, namely the NQOB (and the southern margin of the North China Craton), the northern margin of the Yangtze Craton and the central Qinling block, which lies between the other two blocks (Bader T et al., 2020; Meng QR et al., 2000; Zhang GW et al., 2001; Zhang X et al., 2019). Among them, the NQOB is sandwiched between the Shangdan fault zone and the Luonan – Luanchuan fault zone (Fig. 1). It is the zone with the strongest deformation, metamorphism and magmatic activities in the Qinling orogen (Zhang GW et al., 1995). In particular, a variety of high and ultrahigh-pressure rocks were discovered and deep subduction of the continental crust was determined on the eastern side of North Qinling in recent years (Wang H et al., 2011; Zhu XY et al., 2011; Hu NG et al., 1994; Liu L et al., 1996, 2013; Yang JS et al., 2002; Zhang JX et al., 2011; Wang H et al., 2013; Zhai WJ et al., 2019a). These proved that the high and ultrahigh-pressure rocks in the NQOB underwent deep subduction of the continental crust at ~500 Ma (490–500 Ma) and twice underwent uplift, exhumation, retrograde and superimposition at ~450 Ma (450–470 Ma) and ~420 Ma (400–420 Ma), respectively (Liu L et al., 2013; Chen DL et al., 2019). This provides new knowledge about the tectonic evolution process of the early Paleozoic of the NQOB.

The survey area of the Xiaoshui map sheet, Henan Province is located in the eastern section of the NQOB and is sandwiched between the Shangdan and Zhuxia fault zones (Fig. 1). The geologic bodies exposed in this area include the Mesoproterozoic Qinling Group (Wang SY et al., 2002; Zhai WJ et al., 2019b), Mesoproterozoic – Neoproterozoic Xiahe Group (Li CD et al., 2018), Neoproterozoic – early Paleozoic Guishan Formation (Liu XC et al., 2015; Li CD et al., 2019), early Paleozoic Erlangping Group (Zhao J, 2012), Neoproterozoic gneissic monzogranites (Wang Y et al., 2019; Lu XX, 1999; Liu BX et al., 2013; Wang XX et al., 2015), and widely developed granite (Wang T et al., 2009; Li KW et al., 2019a) and diorites of the early Paleozoic (Ma CQ et al., 2004; Li KW et al., 2018, 2019b). Among these outcrops, the Proterozoic rock associations and their tectonic features vary greatly, but generally underwent two stages of regional metamorphism of hornblende and greenschist facies, in addition to the superposition of tectonic deformation. The high and ultrahigh-pressure rocks, represented by eclogites (Liu L et al., 2013; He Y et al., 2018), garnet amphibolites (Liu L et al., 2013; Zhai WJ et al., 2019a) and granulites (Zhang JX et al., 2011), recorded the regional

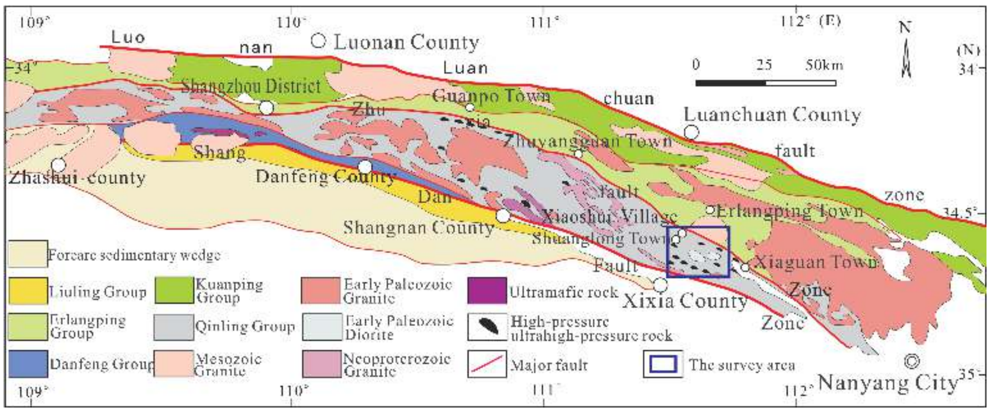

Fig. 1 Generalized geotectonic map of the North Qinling orogen (modified after Wang H et al., 2011)

metamorphism of both the eclogite and granulite facies of the early Paleozoic. As a result, the combinations that are forming through superimposition of tectonic rock blocks and rock slices, which are separated by ductile faults, are present between the Proterozoic stratigraphic units.

The regional geological surveys in the Xiaoshui map sheet, Henan Province began in the 1930s – 1940s. Since the 1950s, more systematical basic geological surveys have been conducted, including a 1∶200 000-scale regional survey of the Luanchuan map sheet, 1∶50 000-scale regional geological amendment survey of north Xixia, 1∶50 000-scale regional survey of the Xiaoshui and Xiaguan map sheets, summary of 1∶50 000-scale surveys of the Xixia – Lushan area, 1∶250 000-scale regional survey of the Neixiang County map sheet and 1∶200 000-scale regional gravity and gravity-magnetic surveys of the southwest of Henan Province. As a result, a number of key achievements were made in the division of geotectonic units, the determination of lithostratigraphic units and geological prospecting. All these provided basic research data for preparation of the geologic map of the Xisohui map sheet. In recent years, many scholars have conducted extensive research on the geologic bodies in the Xiaoshui map sheet, particularly on ultrahigh-pressure metamorphic rocks, and some critical results have been achieved (Zhang YQ et al., 2019; Liu L et al., 2013; He Y et al., 2018; Zhai WJ et al., 2019b). However, little efforts have been made on the Zhu–Xia ophiolitic mélange belt, which encompasses the genesis of the ultrahigh-pressure metamorphic rocks. In this study, the systematic geological survey and research on the geologic bodies and structures in the Xiaoshui map sheet were conducted and a geologic map database (Table 1; Guo JG et al., 2020) was established according to the '*Technical Requirements for Regional Geological Survey (Scale: 1∶50 000)*' (DD2019–01). Therefore, the most complete basic geological data of the map sheet were obtained.

2 Methods for Data Acquisition and Processing

2.1 Data Preparation

The 1∶50 000 geologic map of the Xiaoshui map sheet, Henan Province was prepared according to '*Technical Requirements for Regional Geological Survey (Scale: 1∶50 000)*' (DD2019 –01), during which existing geologic and mineral data were fully collected and

Table 1 Metadata Table of Database (Dataset)

Items	Description
Database (dataset) name	1∶50 000 Geologic Map Database of the Xiaoshui Map Sheet, Henan Province
Database (dataset) authors	Sedimentary rocks: Guo Jungong, Henan Geological Science Research Volcanics: Chao Hongli, Henan Institute of Geological Survey Intrusions: Zhao Huan, Henan Institute of Geological Survey Metamorphic rocks: Zhai Wenjian, Henan Institute of Geological Survey
Data acquisition time	2016 – 2019
Geographic area	111°30′ – 111°45′E, 33°20′ – 33°30′N
Data format	MapGIS
Data size	31.9 MB
Data service system URL	http://dcc.cgs.gov.cn
Fund project	Jointly funded by the projects titled '*1∶50 000-scale Regional Geological and Mineral Survey of Three Map Sheets including Erlangping, Henan Province*' (No.: DD20160043-03) and '*Geological and Mineral Survey of the Zhongtiao-Xiongershan Metallogenic Area*' (No.: DD20160043)
Language	Chinese
Database (dataset) composition	The Database consists of databases of a 1∶50 000 geologic map database and map decorations. The geologic map databases include the data of sedimentary rocks, magmatites, volcanics, metamorphic rocks, the Quaternary, dikes, special geologic blocks, minerals, structures, geologic boundaries, attitude, isotopic samples and ages, lithologic patterns, geologic codes, place names, roads, rivers and reservoirs. The map decorations include index map, histograms, intrusion unit map, lithotectonic unit map of mélange belts, map of geotectonic location and spatial distribution of high and ultrahigh-pressure rocks, history of geological evolution, transverse cutting profiles and legends

comprehensively analyzed. Meanwhile, the survey focused on the rocks and structures in the map sheet according to the new mapping theory and methodology based on orogenic belts. In addition, the digital mapping technology was adopted to highlight tectonic and lithologic mapping, as well as the presentation of special geologic bodies and informal mapping units. In this way, the contents on the map face were expressed in a more scientific, readable and practical manner (Fig. 2). The geographic base map was prepared using the latest geographical data from the National Administration of Surveying, Mapping and Geoinformation of China. The data were processed according to existing technical standards using software such as the Digital Geological Survey System (DGSS) and MapGIS.

2.2 Data Acquisition

2.2.1 Preparation for Data Acquisition

The geographic base map in this study was taken as a 1∶50 000 digital topographic map provided by the National Geomatics Center of China, with the Gauss-Kruger projection, 1980 Xi'an and 1985 National Height Datum being adopted as the projection type, ellipsoidal parameters and elevation datum, respectively. The digital mapping PRB dictionary library was

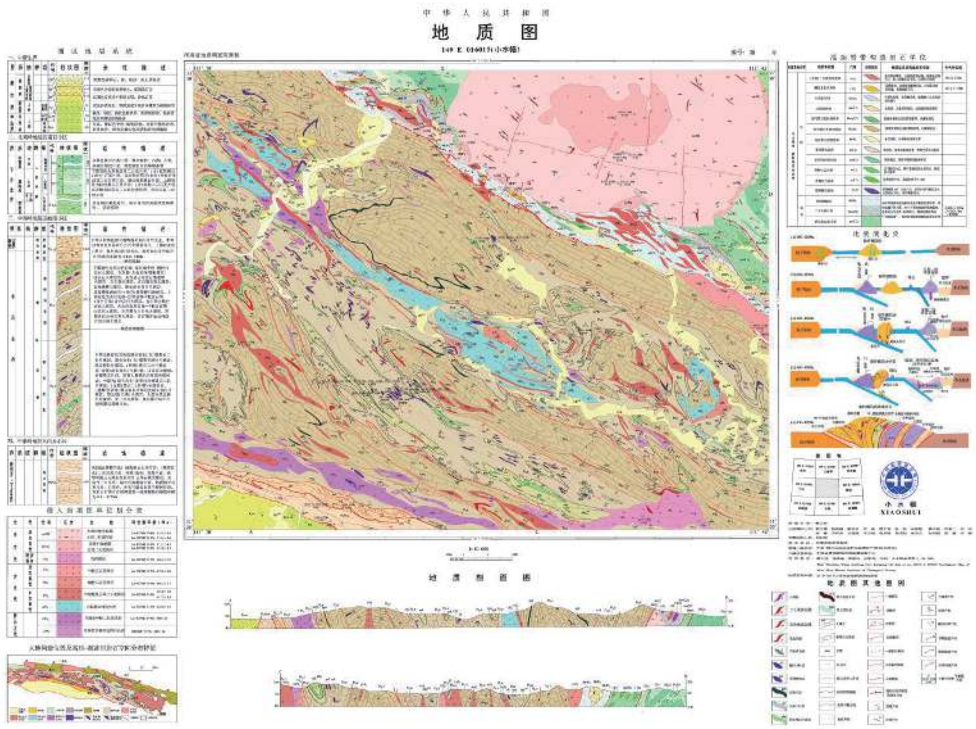

Fig. 2 Diagram of the 1：50 000 geologic map of the Xiaoshui map sheet (I49E016015), Henan Province

developed and constantly improved according to the specific conditions of the survey area, in combination with previous data and field reconnaissance. It mainly consists of the data model of basic information of the map sheet, the acquisition model of data observed along segmented routes in the field, simplified geographical data model, statistical data acquisition model and the data model of profiles. Among these models, the basic information of the map sheet includes the information about the mapping person. Meanwhile, the simplified geographical data model consists of the information about the geographic base map, including stand map frames, annotations, symbol attributes, linear attributes, contour attributes and the attributes of polygon map layers.

2.2.2 Data Acquisition

The digital mapping (PRB) database was preliminarily established by plotting the points and lines in the DGSS in the palm-sized personal digital assistant during the field survey, using the 1：25 000 digital topographic map as the base map.

Geologic points (Point): the following attributes of geologic points were manually input to the DGSS: route No., geologic point No., micro-landform, sites, outcrops, weathering level, location description, mapping unit and the names and contact relationships of rocks. The coordinates of geologic points were read from GPS.

Geologic routes (Routing): the following attributes of geologic routes were manually input to the DGSS: route No., geologic point No., route code, mapping units and rock names; the direction, distance of current station and accumulative distance of geologic routes were automatically read by the DGSS.

Geologic boundaries (Boundary): the attributes of geologic boundaries that need to be collected using the DGSS include: route No., geologic point No., boundary code, route code, boundary type, mapping units on the left and right sides, contact relationship, boundary strike, boundary dip and contact surface dip angle.

Geologic attitude (Attitude), photos (Photo), sketches (Sketch) and samples (Sample) acquired along the routes: their attributes were completed by positioning, photographing and measuring.

2.3 Data Collation

(1) Import the original data acquired using the DGSS in the palm-sized personal digital assistant into the desktop version of DGSS and then collate the data according to the applicable specifications.

(2) Calibrate the original geologic points (Point) using DGSS and collate and complement relevant contents. Afterwards, comprehensively designate the rocks by combining their names in the field after sample identification.

(3) Calibrate the original geologic boundaries (Boundary) using DGSS and improve their morphology according to the V-like rule, in order to make them more reasonable and aesthetically pleasing. Then determine their line parameters (i.e., line type, color and width) according to the different types of geologic boundaries. Afterwards, complete the geologic boundary description and describe the lithologic difference between two sides in the form of: “the mapping units on the left side of the boundary include… and the ones one the right side include…”. The mapping units on the left and right sides of the boundary respectively belong to the lithology of the previous route and the next route by default. Finally, designate the lithologic contact relationship between the two sides and provide related geological evidence.

(4) Calibrate the two ends of the geologic routes (Routing) and smoothen them. Then set the line parameters of the routes in a unified way and re-calculate and input the orientation and distance of the routes. Finally, complete the contents of the routes, including the lithologic composition and its change features along the routes.

(5) Calibrate the positions of the attitude, samples, photos and sketches, then complete the related attributes. All features should be numbered in a unified sequence, such as 1, 2, 3…, based on the geologic points they belong to.

2.4 Preparation of Geologic Maps

2.4.1 Field General Map Database

The four improved 1：25 000-scale geologic routes and profiles in the desktop version of DGSS were input into a database using a unified manner, generating the general field map database. The attribute structures of all geologic features in the database were examined.

2.4.2 Database of Primitive Data Maps

The database of primitive data maps inherited the acquisition and label layers of the points and lines of the entities from the general field map database, which were observed along field routes. Consequently, the following three files were automatically generated: point feature file (GEOLABEL), line feature file (GEOLINE) and polygon feature file (GEOPOLY). Then check the attribute structures of all features, conduct topological area creation according to the routes and geologic boundaries of the profiles, and then label geologic blocks with colors in accordance with the *'Geological Symbols Used for Regional Geological Maps'* (GB/T 958–2015).

2.4.3 Database of Original Map for Compilation

The four 1：25 000 primitive data maps of map sheets I49F031029, I49F032029, I49F031030 and 49F032030 were accumulated into a database based on the original map. As a result, the database/databases of the 1：50 000 original map was/were compiled together to form the Xiaoshui map sheet (I49E016015).

2.4.4 Spatial Database

The database of the original 1：50 000 map was imported into the result database, resulting in the generation of the spatial database of the 1：50 000 geologic map of the Xiaoshui map sheet. This database is a combination of three parts, which are geographical features, geologic tectonics and map decorations. It is subsequently divided into several map layers that contain the basic information of the map sheet, water systems, transportation, habitations, boundaries and borders, topographic contour, geologic blocks, informal stratigraphic units, transverse cutting profiles, alteration, mineralized, metamorphic facies and tectonic deformation zones, faults, attitude symbols, photos, isotopic dating, samples, legends and other primitive graphics.

2.5 Preparation of Corner Maps

2.5.1 Comprehensive Histograms

The comprehensive histograms are used to present the combined features of the master map's lithostratigraphic units in detail. They were prepared based on the comprehensive analysis and research of the lithology, thickness, eras and stratigraphic units of the strata in the map sheet.

2.5.2 Lithotectonic Units of the Mélange Belt

The lithotectonic unit map of the mélange belts was prepared through a comprehensive analysis of material composition, tectonic deformation features and geochronological data of the matrix and rock masses in the ophiolitic mélange belt in Huashanyu Village of the map sheet.

2.5.3 Mapping Unit Map of Intrusions

The stages of the intrusions in the map sheet were determined and the mapping unit map of the intrusions was prepared based on the comprehensive analysis of the rock composition, intrusive relationships, isotope eras and tectonic environment.

2.5.4 Map of Geotectonic Location and Spatial Distribution Features of High and Ultrahigh-Pressure Rocks

This map was prepared to highlight the presentation of geotectonic location of the Xiaoshui map sheet and the spatial distribution features and occurrence status of high-pressure and ultrahigh-pressure rocks, of which are represented by garnet amphibolites, retrograde eclogites and granulites.

2.5.5 Geologic Profiles

Two transverse cutting profiles perpendicular to the primary tectonic lines were arranged to fully reflect the overall tectonic framework and the features of the geologic blocks in the map sheet. They were labelled as AB and CD. They were mainly presented in the form of 'line type for standard profiles + standard code'. Meanwhile, patterns, codes and contact relationships were labelled at the proper locations in the two profiles.

2.5.6 History of Geological Evolution

The structure of the NQOB consisting of the Shangnan-Danfeng tectonic belt, Zhu–Xia ophiolitic mélange belt, Qinling microcontinent and Erlangping island arc, a back-arc basin, was preliminarily established based on previous research data in combination along with the findings in this study. The history of the tectonic evolution of the NQOB in the early Paleozoic was portrayed longitudinally.

2.5.7 Legends

Legends are used to describe the colors, line types, rock types, symbols and codes of the contents in the master map following the guidance from the *'Geological Symbols Used for Regional Geological Maps'* (GB/T 958–2015). The contents include dikes, special geologic blocks; such as high-pressure and ultrahigh-pressure rocks; informal mapping units, special minerals, geological boundaries, faults, attitude, samples for dating and sub-maps.

2.5.8 Index Map

The index map incorporates the information from the map sheets that lie adjacent to the Xiaoshui map sheet, including the codes and names of the 1：50 000 geologic maps of the map sheets. This makes it convenient to retrieve the information on these neighboring map sheets. Additionally, the index map also contains the China Geological Survey logo and information about the Xiaoshui map sheet, including the person responsible for the map sheet, key personnel and organizations that helped develop the geologic map and database of the map sheet, project sources and data sources. This will assist in any future follow-up inquiry, retrieval and citation of the information of this map sheet.

3 Description of Data Samples

3.1 Data Types

Names of entity types: points (.wt), lines (.wl) and polygons (.wp).

Points: codes of various geologic blocks, geologic patterns, fault Nos., attitude, isotopes, etc.

Lines: conformable boundaries, intrusive boundaries, lithofacies boundaries, contact boundaries of tectonic schistosity, unconformity, fault structures, roads, rivers, etc.

Polygons: sedimentary rocks, intrusions, high-pressure and ultrahigh-pressure rocks (i.e., garnet amphibolites and granulites), informal mapping units, tectonic rock masses, the Quaternary, reservoirs, etc.

3.2 Contents in Map Layers

Contents of the master map include the strata of sedimentary and metamorphic rocks, intrusions, the Quaternary, geologic boundaries, structures, attitude and various codes.

Corner maps include the comprehensive histograms, lithotectonic unit map of mélange belts, mapping unit map of intrusions, geotectonic location map, geologic profiles, legends and index map.

3.3 Data Attributes

The Database includes a feature class dataset, a complex class dataset, an object class dataset, and an independent feature class dataset. The feature class dataset is the collection of feature classes that share the same spatial reference system. It is composed of the entities of geologic points, polygons and lines in the data model of geologic maps. The object class dataset is a data table used to store non-spatial data. One feature class generally corresponds to multiple object classes in the data model of geologic maps.

3.3.1 Feature Classes

The attribution structure of a geologic polygon entity (_GeoPolygon): the type code, name, era and minimum and maximum ages of the geologic polygon entity - subtype ID. The attributes of geologic polygon entities of the Yanlinggou Formation are shown in Table 2.

The attribution structure of a geologic boundary (_GeoLine): feature ID No., geologic boundary type, codes of geologic blocks on the left and right sides of the geologic boundary, the strike, dip and dip angle of the contact surface and subtype ID.

The attribution structure of attitude (_Attitude): the name code and name of attitude type, strike, dip, dip angle and subtype ID.

The attribution structure of a sample (_Sample): the No., type code, rock name of the sample and subtype ID.

The attribution structure of a photo (_Photograph): the No., title, description of the photo and subtype ID.

The attribution structure of a sketch (_Sketch): the No., title, description of the sketch and subtype ID.

The attribute structure of an isotope for isotopic dating (_Isotope): the name and No. of the sample, dating method, age dated, the unit and code of the geologic block dated, the unit and date of dating and subtype ID.

Table 2 Attributes of geologic polygon entities of the Yanlinggou Formation

No.	Data item	Label code	Data type	Example of content description
1	ID	*Feature_Id	char	AI49E016015000000143
2	Original code	Source_Id	char	
3	Type code	*Feature_Type	char	Pt@2y@.
4	Name	Geobody_Name	char	Yanlinggou Formation
5	Era	Geobody_Era	double	Pt@2
6	Minimum age	Geobody_Age1	double	
7	Maximum age	Geobody_Age2	int	
8	Subtype ID	Subtype	char	1

Note: @ denotes subscript.

The attribute structure of shoreline of rivers and reservoirs (_Line_Geography): primitive type, name and subtype ID.

3.3.2 Complex Classes

The attribute structure of an alteration zone (_Alteration_Polygon): the name code and name of alteration type, altered mineral assemblages and their content, ore-bearing features, code of altered geologic mass and subtype ID.

The attribute structure of a metamorphic facies zone (_Metamor_Facies): the geologic mass code and type of metamorphic facies zone; metamorphic degree; metamorphic pressure and temperature; the name, color, texture, and structure of the rocks in the metamorphic facies zone; mineral assemblages and their content in the metamorphic facies zone; ore-bearing features and subtype ID.

The attribute structure of a tectonic deformation zone (_Tecozone): the code, type name, rock name, structural features of the tectonic deformation zone; deformation dynamic features; formation era; activity stages; ore-bearing features and subtype ID.

The attribute structure of a standard map frame (inner map frame) (_Map_Frame): map name, code of map sheet, scale, coordinate system, elevation system, left longitude, lower latitude and map units.

3.3.3 Object Classes

The attribute structure of a lithostratigraphic unit of sedimentary rocks (_Strata): the name, symbol and era of the lithostratigraphic unit,; the name and main colors of rock association; main sedimentary structures in the lithostratigraphic unit; stratum thickness; ore-bearing features and subtype ID.

The attribute structure of a lithochronologic unit of intrusions (_Intru_Litho_Chrono): the name and symbol of the rock-mass mapping unit; the name, color, texture and structure of rocks; lithofacies; primary minerals and their content; secondary minerals and their content; contact relationships with surrounding rocks; eras of surrounding rocks; the strike, dip, and dip angle of contact surface with surrounding rocks; attitude of planar flow planes and streamlines; formation era; ore-bearing features; subtype ID. The attributes of a lithostratigraphic unit of the intrusions of early Cretaceous bio-monzogranites are shown in Table 3.

The attribute structure of a fault (_Fault): the type, name, No., and characteristics of the fault; codes of geologic blocks in the hanging wall and foot wall of the fault; the fractured zone width, strike, dip, and dip angle of the fault; estimated fault throw; formation era of the fault; active stages and subtype ID.

The attribute structure of a dike (_Dike_Object): the name and symbol of the dike; lithology; color; texture; structure; primary minerals and their content; secondary minerals and their content; the strike, dip and dip angle of the contact surface with surrounding rocks; formation era; ore-bearing features and subtype ID.

The attribute structure of planar waters (_Water_Region): type and name of primitive and subtype ID.

The attribute structure of the basic information of map sheet (_Sheet_Mapinfo): map name, coordinate system, elevation system, right and left longitude, upper and lower latitude,

Table 3 Attributes of a lithochronologic unit of intrusions of the Early Cretaceous bio-monzogranites

No.	Data item	Standard code	Data type	Examples of content description
1	Feature type (geologic code)	*Feature_Type	char	*ηγβ*K@1$1
2	Name of rock-mass mapping unit	Intru_Body_Name	char	Early Cretaceous bio-monzogranites
3	Symbol of rock-mass mapping unit	Intru_Body_Code	char	*ηγβ*K@1$1
4	Rock name (lithology)	Rock_Name	char	Bio-monzogranites
5	Rock color	Color	char	Gray – grayish-white
6	Rock texture	Rock_Texture	char	Medium – coarse-grained granite texture and porphyritic structure
7	Rock structure	Rock_Structure	char	Massive structure
8	Lithofacies	Rock_Phases	char	Plutonic facies
9	Contact relationship with surrounding rocks	Contact_Relation	char	Intrusive contact
10	Primary minerals and their content	Primary_Mineral	char	Potash feldspar (30%–40%), plagioclase (25%–40%) and quartz (20%–30%)
11	Secondary minerals and their content	Secondary_Mineral	char	A small amount of biotite
12	Strike of the interface with surrounding rocks	Strike	int	135°
13	Dip of the contact surface with surrounding rocks	Dip_Direction	int	325°
14	Dip angle of the contact surface with surrounding rocks	Dip_Angle	int	48°–80°
15	Formation era	Era	char	K@1
16	Ore-bearing properties	Commodities	char	*
17	Subtype ID	Subtype	int	0

Note: @ denotes subscripts and $ denotes superscripts.

mapping method, survey organization, organization responsible for the acceptance check of the map sheet, rated level, completion and publication date, data source and data acquisition date.

4 Data Quality Control and Assessment

The field geological survey for the 1：50 000 geologic map of the Xiaoshui map sheet, Henan Province was conducted by taking the '*Technical Requirements for Regional Geological Survey (Scale: 1：50 000)*' (DD2019-01) as the basic criterion based on systematical acquisition and comprehensive analysis of existing geologic data. During the process of geological field mapping, the digital mapping instruments were utilized for field data acquisition and 1：25 000 digital topographic maps were adopted for the preparation of freehand field maps. The following geologic blocks were all plotted on the geologic map: sealed geologic blocks with a diameter greater than 50 m, linear geologic bocks with a width greater than 25 m and a length greater than 50 m and faults with a length greater than 250 m. Special geologic blocks were presented after being appropriately amplified, regardless of their thickness. This included metaperidotites, (pyroxenite) pyroxenites, diabase-porphyrite dikes, metamorphic siliceous rocks, garnet amphibolites, granulites, quartzites (quartz schist) and marble lens. As a result, the 1∶50 000 geologic mapping covered an area of 422 km^2 and survey routes of 760 930.3 m in total, including 628 269.0 m of routes surveyed and 132 661.3 m of routes revised and input. Meanwhile, the geologic mapping covered 1 526 various geologic points, 4 612 geologic boundaries, 285 samples, 3 212 attitude, 48 sketches and 837 photos, with an average density and average interval of geologic points of 3.62 per km^2 and 498.64 m respectively. In this way, the requirements of the mapping precision of 1∶50 000 geologic mapping were fully met.

A Route survey was conducted before geologic profiles were surveyed and plotted. According to the route survey results, the segments that featured continuous outcrops, of which the outcrop area accounted for greater than 60%, complete floor and roof and clear contact relationships were selected to prepare profiles. The profile lines were approximately perpendicular to the strike of the geological body, with an angle between them greater than 60°. The orientation and slope of the profiles were measured using compasses and the distance was determined using measuring lines.

Furthermore, the coordinates of the geological points, the start and end points of the measuring lines and the sampling points of the samples for whole-rock geochemical analysis and zircon U-Pb dating were all determined using GPS. The projection coordinates of the measuring points were checked indoor before the data were input. Three stratum profiles including 'stratum + structure' profiles were surveyed and plotted in total, with a total length of 20 902 m and a scale of 1∶2 000. They covered all strata except for Neogene strata that were sparsely exposed. Two rock mass profiles were surveyed and plotted in total, giving a total length of 11 514 m. The rock masses mainly involved the monzogranites and late Jurassic granite porphyry in Huanghuaman. As for small rock drops and dikes with a small area of outcrops such as Neoproterozoic monzonitic granitic gneiss, middle Silurian biotite diorites and Silurian granite dikes (monzogranites and syenogranites); they were generally surveyed and mapped along with stratigraphic structure profiles rather than specifically measured and mapped.

In this study, the quality management requirements imposed by China Geological Survey and the *Quality Management System* issued by the Henan Institute of Geological Survey were strictly followed. Additinoally, a 'three-level quality management' network consisting of the Henan Institute of Geological Survey, project department and work teams were established to strictly implement a check system comprised of daily checks, staged inspections and checks conducted by an expert panel. A total of 207 field survey routes and five profiles were obtained for this map sheet area during this study. The work teams performed self-checks and mutual checks for all of them. The project department inspected 63 survey routes and three measured profiles, accounting for 30.4% and 80%, respectively. The Henan Institute of Geological Survey conducted spot checks for 12 survey routes and one measured profile, accounting for 5.8% and 20%, respectively. Furthermore, the Tianjin Center of the China Geological Survey organized experts to conduct design review and field quality inspection every year. Written records were kept for these quality inspections at all levels. The Tianjin Center of the China Geological Survey conducted field acceptance checks on the findings of this map sheet in Luoyang City, Henan Province during October 22–27, 2018, and affirmed that great progress was made in the survey particularly on the research of ophiolitic mélanges and high-pressure metamorphic rocks. As a result, the map sheet scored 93 and was rated ‘excellent’. Furthermore, the 1：50 000 geologic map of the Xiaoshui map sheet was awarded ‘Excellent Map Sheet Prize’ among the areas mapped based on orogenic belts in the national regional geological surveys in 2018.

5 Data Value

5.1 Establishment of Reasonable Stratigraphic Framework and Determination of Lithostratigraphic (Lithotectonic) Units

A set of associations of metamorphic clastic rocks were newly identified in, what was originally called, the Guishan Formation, which the Xiahe Group has recently determined as the Dakuaidi area by mapping. The magmatic zircons obtained from the plagioclase-actinolite-biotite schist yielded a U–Pb upper intercept age of 1 448±51 Ma. The Qinling Group was re-determined and the material composition of the Guozhuang Formation and Yanlinggou Formation were ascertained. Meanwhile, the time limits of the anatexis in the Guozhuang Formation was determined to range from 424.3±2.2 Ma to 415.8±1.6 Ma, according to the research on the longitudinal variation characteristics of the anatexis.

5.2 Ascertainment of the Intrusive Stages and Evolution Characteristics of Intrusive Rocks

The Qingbaikouan granites were grouped into two types, namely gneissic garnet-bearing granodiorites and gneissic garnet-bearing muscovite granodiorites, of which the diagenetic ages were determined to be 890±14 Ma and 907±25 Ma, respectively. Metamorphic-pyroxenite peridotite rock masses with the nature of mantle-derived peridotites and alkaline syenite rock masses were found in the Zhu–Xia ophiolitic mélange belt in Huashanyu Village, and the diagenetic age of the alkaline syenites was determined to be 457.4±1.9 Ma. Middle Ordovician monzogranites were found in the Qinling Group, yielding a U-Pb age of magmatic zircons of 461.3±3.6 Ma.

5.3 Identification of Large Areas of High-pressure – Ultrahigh-pressure Tectonic Zones in Qinling Group

Garnet amphibolites, retrograde eclogites and basic granulites were determined in the Qinling Group by mapping. Most of them occur in stratiform, banded, podiform and lensoid shapes. They are all generally distributed along a plane, indicating that the Qinling Group underwent deep subduction overall. The inclusions of omphacite were identified using a Laser Raman Spectroscopy. Their residual magmatic cores yielded the zircon age ranging from 654.1±5.6 Ma to 656.1±6.7 Ma, and they underwent metamorphism from 484.8±5.8 Ma to 356.0±11.0 Ma. Their petrogeochemical features were also systematically tested and initially researched.

5.4 Primary Establishment of the Structure of the North Qinling Orogen

The NQOB is composed of the Shangdan tectonic deformation zone, Zhu–Xia ophiolitic mélange belt, Qinling microcontinent and Erlangping island arc- a back-arc basin. The Zhu–Xia ophiolitic mélange belt in Huashanyu Village was determined to be composed of strongly deformed matrixes and the rock blocks of different eras, positions and phases for the first time. Three types of matrixes were mapped from south to north, namely calcareous mylonites, albite-actinolite schist and dolomite-quartz schist. At same time, more than 10 kinds of tectonic rock masses were also mapped, including metamorphic peridotites, metamorphic pyroxenites, metagabbros, marbles and metamorphic siliceous rocks. In general, the Zhu–Xia ophiolitic mélange belt features more matrixes and fewer rock masses. The rock masses are composed of a combination of oceanic crust strata formed during the Cambrian – Ordovician periods and the main-stage deformation of the matrixes occurred between the early Ordovician to the end of the Silurian period. Therefore, the Zhu–Xia ophiolitic mélange belt is considered to have been formed in the early Paleozoic. In the southwestern part of the map sheet area, the traditional Shangnan-Danfeng tectonic belt merely shows the strong ductile deformation developing along both sides of the contact boundary between the Guishan Formation and Xiahe Group. Thus, it is a ductile deformation zone. In terms of the tectonics, four stages, two stages and three stages of fold superimposition were identified in the Qinling Group, Xiahe Group and Erlangping Group, respectively.

6 Methods and Recommendations for Data Usage

The Database was established in the format of MapGIS. It contains detailed data that are easy to query and highly editable. Furthermore, the data can be superimposed and combined with other data in the same format and further re-processed, and thus can be easily shared. The Database boasts broad application prospects. As a database of basic geologic information, it can provide basic information for research on the lithostratigraphy, tectonics and geological prospecting of the north Qinling orogen.Simultaneously, it can provide basic maps for the ecological environment survey on both the same or different scales and the prevention and control of geologic hazards in the map sheet area. Furthermore, it has provided new basic geological data for the preparation of '*Annals of Geology of Henan Province*' and the projects funded by the *Geological Exploration Fund of Henan Province*.

7 Conclusion

The Database covers nine stratigraphic units and six stages of magmatic events, with a data size of 31.9MB. It fully reflects the latest results of the 1∶50 000 regional geological surveys of the map sheet. The new mapping theory and methodology based on orogenic belts were adopted to highlight tectonic and lithologic mapping as well as the presentation of special geologic bodies and informal mapping units. The structure of the north Qinling orogen consisting of the Shangnan-Danfeng tectonic belt, Zhu–Xia ophiolitic mélange belt, Qinling microcontinent and Erlangping island arc, a back-arc basin, was established. Simultaneously, it was made clear that the Zhu–Xia ophiolitic mélange belt was formed in the early Paleozoic. Furthermore, the material composition and four stages of fold deformation of the Qinling Group were ascertained; the spatial distribution law, protolith and metamorphic era of high and ultrahigh-pressure rocks in the map sheet area were determined and the whole Qinling microcontinent was revealed to have been involved in early Paleozoic orogen and undergone strong transformation.

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