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河南省石门幅 1∶50 000 地质图数据库

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摘要: 河南省石门幅 (I49E017018)1∶50 000 地质图数据库是按《区域地质调查技术要求 (1∶50 000)》和地质行业的统一标准及要求，在充分搜集和利用 1∶200 000、1∶250 000 和 1∶50 000 等区域地质调查工作成果资料的基础上，采用数字填图系统 (DGSS) 进行野外地质填图和数据库建设，并应用室内与野外填编图相结合的方法完成的。通过本数据库的建设，重点对图幅内侵入岩时代及岩石类型进行了归纳总结，将原划定的石门岩体和五垛山岩体统一归并为晚奥陶世、早志留世、中—晚志留世及志留纪末期 4 期岩浆活动，建立了岩浆演化序列。根据侵入岩的形成时代及其与地层接触关系，将早古生代二郎坪群大庙组和火神庙组的时代归属进行了重新厘定，将其置于寒武纪–奥陶纪。本数据库包含 5 个地层单元和 4 期岩浆岩，数据量约为 10.4 MB, 包括 66 个样品的岩石化学分析数据，19 个样品的年龄数据。这些数据充分反映了 1∶50 000 区域地质调查最新成果，对该区矿产地质调查、地质灾害防治及生态环境保护等具参考和指导意义。

关键词: 数据库；地质图；1∶50 000；岩浆岩；地质调查工程；石门幅；河南

数据服务系统网址: http://dcc.cgs.gov.cn

1 引言

河南省石门幅 1∶50 000 地质图调查区位于秦岭造山带东段，区域上横跨 3 个一级构造单元 (图 1)，以商丹和勉略缝合带为界，自北向南依次划分为北秦岭 (及华北克拉通南缘) 板块、中秦岭板块和扬子板块 (Wang Y et al., 2019; 张国伟等, 2001; 许志琴等, 2015; 张翔等, 2019)，这 3 大板块沿 2 条主断裂带，自寒武纪开始俯冲，于三叠纪发生碰撞造山，随后经历中—新生代陆内造山作用叠加，形成了现今秦岭造山带基本构造格局 (Shi Y et al., 2018; Bader T et al., 2020; 李承东等, 2018, 2019)。前人对东秦岭花岗岩做了大量研究工作，张国伟等 (2001) 依据秦岭造山带大地构造演化特征，将花岗质岩浆活动划分为中元古代初至早前寒武纪前造山期、新元古代至早中生代主造山期及中—新生

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代后造山期。王晓霞等 (2015) 则将秦岭造山带花岗质岩浆作用分为新元古代、古生代、早中生代和晚中生代 4 期岩浆作用，并有学者对各期岩浆作用进行了详细研究 (Liu L et al., 2016; 王涛等, 2009; 张昕等, 2017; 赖亚等, 2017; 王江波等, 2018)。

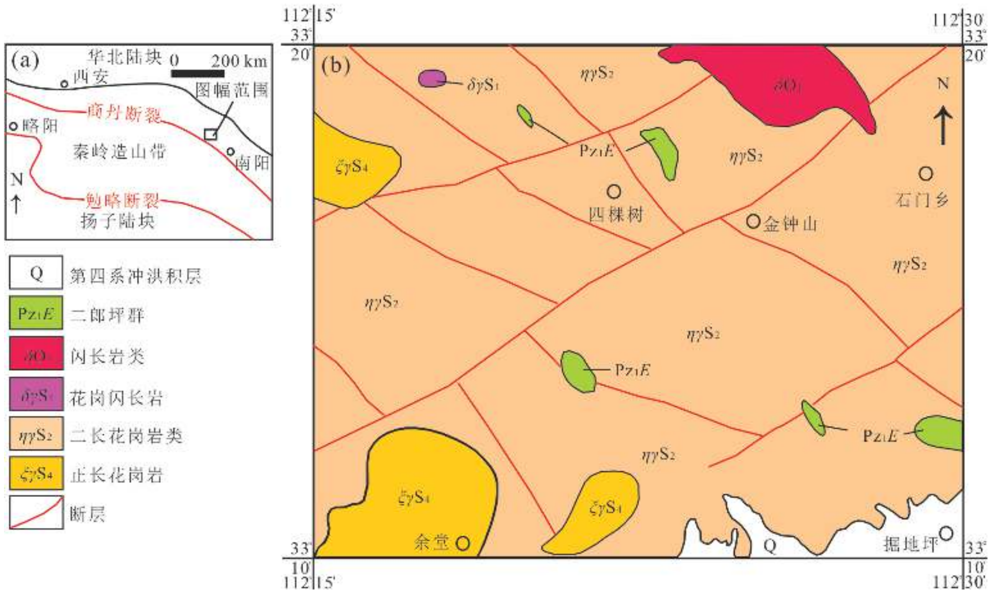

图 1　河南省石门幅 1∶50 000 地质图区域位置 (a) 与地质简图 (b)

河南省石门幅 1∶50 000 地质图调查区地质调查研究始于 20 世纪 30 年代，20 世纪 50 年代以后开展较为系统的地质找矿工作，先后进行过 1∶200 000 区域地质调查、水系沉积物测量、重砂测量、重力测量、航磁测量，1∶50 000 矿产地质调查及磁法测量、水系沉积物测量，1∶250 000 区域地质调查，局部还开展过 1∶50 000 区域地质调查片区总结等。这些前期工作为石门幅地质图的编制提供了基础性研究资料。近年来北秦岭早古生代花岗岩地质、地球化学及同位素研究工作取得了较大进展，许多学者对花岗岩类的演化过程进行了全面总结，提出了新的认识 (Li N et al., 2018; 张国伟等, 1996, 2001; 王涛等, 2009; 王宗起等, 2009; 张成立等, 2013)，但在早古生代岩浆演化阶段与其所对应的岩石类型，以及早古生代板块俯冲、碰撞和后碰撞的时限 (Zhang YQ et al., 2019; 刘晓春等, 2015) 等重大科学问题上却存在不同观点。河南省石门幅 1∶50 000 地质图作为中国地质调查局地质调查的成果图件，力争反映新一轮地质调查工作中取得的地质调查及科研新成果，为该地区下一步开展矿产资源调查、地质灾害调查、生态环境调查等提供基础性地质图件，为野外地质调查和科学研究提供详细的参考资料。

过去许多学者对图幅内地质体尤其是侵入岩进行了大量分析测试工作，并取得了一些重要成果 (卢书炜, 1994; 雷敏, 2010; 李名则等, 2014)，但往往是针对某一类型岩石进行分析，代表性及系统性不足。本次工作依据《区域地质调查技术要求 (1∶50 000)》准则，对每一类型地质体均进行了系统的地质调查和采样分析，并建立了地质图数据库（方怀宾等, 2020），代表了图幅内最为全面的基础地质资料。

河南省石门幅 1∶50 000 地质图数据库的元数据信息见表 1。

表 1　数据库 (集) 元数据简表

条目	描述
数据库(集)名称	河南省石门幅1：50 000地质图数据库
数据库(集)作者	沉积岩类：方怀宾，河南省地质调查院 火山岩类：晁红丽，河南省地质调查院 侵入岩类：李开文，河南省地质调查院 变质岩类：刘　坤，河南省地质调查院
数据时间范围	2014—2016年
地理区域	地理坐标：东经 112°15′ ~ 112°30′，北纬 33°10′ ~ 33°20′
数据格式	MapGIS
数据量	10.4 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“中条–熊耳山成矿区地质矿产调查”(项目编号：DD20160043)和“河南省1：50 000石门、内乡、镇平、安皋幅区域地质矿产调查”(项目编号：12120114027001)联合资助
语种	中文
数据库(集)组成	河南省石门幅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、火山岩、侵入岩、变质岩、第四系、脉岩、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、图例、图切剖面、构造纲要图、责任表

2　数据采集和处理方法

2.1　数据准备

河南省石门幅 1：50 000 地质图按照《区域地质调查技术要求 (1：50 000)》，以当代地球科学系统观、造山带和区域地质构造研究新理论为指导,在遥感技术 (RS)、全球卫星定位系统 (GPS)、地理信息系统 (GIS) 基础上，应用数字填图 (PRB) 技术方法，遵循遥感解译与地面调查相结合、地质填图与宏观、微观相结合的原则完成的测区基础地质调查。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

本次数据采集使用的地形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，椭球参数为“西安 80”，高程基准为 1985 国家高程基准。原始数据包括数字化装备配置、1：50 000 数字地形图、多元数据的整合。在充分利用前人资料的基础上，根据野外踏勘和工作区的具体情况编制数字填图 PRB 字典库，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。图幅基本信息数据包括图幅基本信息、填图人员信息。

2.2.2　数据采集

以数字填图掌上机中 1：25 000 地形图为底图，通过野外实际调查，在数字填图系统中标绘出地质点、地质界线及地质路线等点、线信息，初步建立数字填图 (PRB) 数据库。

地质点 (Point)：坐标信息由 GPS 自动读取，在数字填图系统中填写地质点属性，包括路线号、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、产状等。

地质路线 (Routing)：野外需要在系统中填写的地质路线属性，包括路线号、地质点号、R 编号、方向、本站距离、累计距离、填图单位和岩石名称。其中，方向、本站距离、累计距离为系统自动读取。

地质界线 (Boundary)：野外需要在填图系统中填写的地质界线属性，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、界面倾向及界面倾角。

沿途所测地质产状 (Attitude)、拍摄的照片 (Photo)、绘制的素描 (Sketch)、采集的标本 (Sample) 等信息，要在系统中定位并录入相关信息，填写相关属性数据。

2.3 数据整理

(1) 将野外掌上机采集到的 GPS 点、地质点、地质路线、地质界线等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) 将野外所采集的所有地质点移至对应的 GPS 点上后进行坐标重写入，完善地质点路线号、地质点号、填图单位、岩石名称和接触关系等信息，地质点文字描述 (PRB_P) 的岩石名称与地质点数据输入内岩石名称相一致。待薄片鉴定结果完成后，结合野外岩石定名进行综合定名。

(3) 将野外所采集的所有地质界线移至所对应的 GPS 点上，根据实际情况进行延长或缩短，根据“V”字型法则对地质界线进行处理，最后对线进行光滑美化。整个图幅的地质界线及断层的线型、线颜色、线宽等要素统一设置 (如地质界线线型为 1，线颜色为 1，线宽为 0.1)。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，并默认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做出明确判定并提供相关地质证据。

(4) 将野外所采集的所有地质路线两侧分别调整至路线的起点和终点 GPS 点坐标上，然后对线进行光滑处理，整个图幅路线的线参数如线型、线颜色、线宽等统一设置 (如线型为 1，线颜色为 1，线宽为 0.1)，随后对路线方位、距离等进行重新计算。最后对路线内容进行补充，包括路线岩性组成及变化特征等。

(5) 将路线中所采集的产状、样品、照片、素描等均移至所对应的 GPS 点上进行坐标重新写入，补充相关属性信息，如产状的走向、倾向、倾角、产状类型、填图单位等，样品的内容、镜头方向、照片详细说明等，素描的名称、比例尺、素描图等。所有要素的编号根据所属地质点按 1、2、3 等进行统一顺序编号。

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.wt)、线要素 (Geoline.wl)、区要素 (Geopoly.wp) 这 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

在编稿原图基础上将 4 幅 1∶25 000 实际材料图进行入库，形成石门幅 1∶50 000 编稿原图库。

2.4.4 空间数据库

将石门幅 1∶50 000 编稿原图库入库到成果数据库中，形成石门幅 1∶50 000 地质图空间数据库，包括地理要素、地质要素和图面整饰 3 部分，并划分为如下图层：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、地层图层、火山岩岩性图层、非正式地层单位图层、侵入岩图层、脉岩图层、围岩蚀变图层、变质相带图层、断层图层、构造变形带图层、产状符号图层和其他图元图层。

2.5 编制角图和图饰

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沉积建造、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 侵入岩填图单位

图幅内主要发育侵入岩地质体，对地质图中侵入岩期次进行划分。通过对图幅内侵入岩体的岩石组成、侵入关系、同位素时代、构造环境等进行综合分析，编制侵入岩填图单位图。

2.5.3 图例

按《区域地质图图例》(GB/T 958–2015) 要求，对地质图内所涉及的地质体、线及子图的颜色、线型、岩石类型、符号、代号等进行描述。

2.5.4 构造纲要图

图幅内断层构造发育，构造纲要图对地质图的构造格架进行重点表达，着重表达地质图中的断层产状和性质等，有利于对整个图幅区构造样式的了解。

2.5.5 地质剖面图

图幅内构造线的主体方位为北西向，其次为北东向。为了能充分反映图幅内总体构造格架，展示了 2 条与主构造线垂直的北东向图切剖面，分别显示出下古生界二郎坪群、晚奥陶世—早志留世—中—晚志留世—志留纪末期花岗岩。主要采用“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 接图表

标注与石门幅毗邻的 1∶50 000 地质图的图名和图幅代号，便于检索相邻图幅信息。

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：侵入界线、岩相界线、断层构造、道路、河流等。

面实体：沉积岩、火山岩、侵入岩、变质岩、第四系、水库等。

3.2 图层内容

地质图内容包括沉积岩、火山岩、侵入岩、变质岩、第四系、地质界线、构造、地质体产状、各类代号等。

角图和图饰内容包括综合地层柱状剖面图、侵入岩填图单位、图例、构造纲要图、地质剖面图、接图表等。

3.3 数据属性

河南省石门幅 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。晚奥陶世闪长岩地质体面实体属性表见表 2。

表 2 晚奥陶世闪长岩地质体面实体属性

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	AI49E017018000000012
2	原编码	Source_Id	Character	
3	类型代码	*Feature_Type	Character	δO@3
4	名称	Geobody_Name	Character	晚奥陶世闪长岩
5	时代	Geobody_Era	Character	O@3
6	下限年龄值	Geobody_Age1	Double	449.1 Ma
7	上限年龄值	Geobody_Age2	Double	465.0 Ma
8	子类型标识	Subtype	Interger	1

注：@代表下标。

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。

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、被测定年龄的地质体单位及代号、测定分析单位、测定分析日期、子类型标识。

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、被蚀变的地质体代号、子类型标识。

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 (火山) 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、生物化石带或生物组合、地层厚度，含矿性、子类型标识。

侵入岩岩石年代单位 (_Intru_Litho_Chrono)：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。晚奥陶世闪长岩侵入岩年代单位属性表见表 3。

表 3 晚奥陶世闪长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	δO@3
2	岩体填图单位名称	Intru_Body_Name	Character	晚奥陶世闪长岩
3	岩体填图单位符号	Intru_Body_Code	Character	δO@3
4	岩石名称(岩性)	Rock_Name	Character	片麻状粗中粒角闪闪长岩
5	岩石颜色	Color	Character	灰绿色
6	岩石结构	Rock_Texture	Character	半自形粒状结构
7	岩石构造	Rock_Structure	Character	块状构造、片麻状构造
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	斜长石(40%～50%)和角闪石(30%～35%)
11	次要矿物及含量	Secondary_Mineral	Character	钾长石(3%～5%)、石英(2%～4%)
12	与围岩接触面走向/°	Strike	Integer	93
13	与围岩接触面倾向/°	Dip_Direction	Integer	3
14	与围岩接触面倾角/°	Dip_Angle	Integer	65
15	形成时代	Era	Character	O@3
16	含矿性	Commodities	Character	*
17	子类型标识	Subtype	Integer	0

注：@代表下标。

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。

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

河南省石门幅 1：50 000 区域地质调查按照《区域地质调查技术要求 (1：50 000)》，在系统收集和综合分析已有地质资料基础上共完成路线总长度 904 km，各类地质点 1 602 个，平均 3.76 个/km^2；地质界线 2765 个，平均点距 564 m；样品采集 295 件，产状采集 303 个，素描图 17 张，照片 502 张。填图精度达到 1：50 000 地质填图的具体要求。

野外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。工作中对直径大于 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，长度大于 250 m 的断层均进行了填绘，对第四系分布区中基岩露头，不论大小均进行了勾绘，不足填图尺寸的进行放大表示，野外现场采用数字填图技术，路线间距及各项工作均达到了总体工作要求。

各类测试样品的采集均按有关规定执行，并经有相应资质认证的单位进行分析测试，所提供的鉴定报告和测试数据准确可靠，符合要求。其中硅酸盐、稀土、微量元素分析样品由湖北省地质实验测试中心承担，锆石 U–Pb 同位素年龄测定 (LA-ICPMS 法) 由天津地质矿产研究所、中国科学院地球化学研究所完成。

填图过程中建立河南省地质调查院、项目部、作业组“三级质量管理”网络，严格按照设计书和有关规范开展工作。野外工作前统一填图单位划分标准，统一认识，工作期间开展不间断的自检、互检和抽检。自检、互检率均为 100%，项目负责人抽检率为 32%，河南省地质调查院抽检率 6%，各级质量检查有文字记录。中国地质调查局天津地质调查中心于 2016 年 11 月 22 日—29 日在河南省郑州市组织有关专家对该图幅进行了野外验收。验收组一致认为，项目较好地完成了任务书规定的目标任务和设计批准的主要实物工作量，各项工作部署符合设计及规范要求，工作方法正确，工作质量较好；提交的原始资料齐全，资料收集丰富，并进行了较为系统的整理，分析测试资料齐全，项目质量管理及保障措施得力，尤其是在侵入岩期次划分等基础地质调查研究方面取得了多项重要进展。经评定石门幅 (I49E017018) 为优秀级。

5 数据价值

河南省石门幅 1：50 000 地质图是中国地质调查局开展新一轮地质调查工作的成果，在系统搜集前人研究资料的基础上，依据《区域地质调查技术要求 (1：50 000)》，对图幅进行了详细的地质填图，提高了区域地质调查与基础研究水平，在解决重大基础地质问题方面获得新突破。本次工作重点对图幅内侵入岩岩石类型、侵位时代及构造环境进行了归纳总结，将原划定的石门岩体和五垛山岩体统一归并为晚奥陶世 (465.0 ~ 449.1 Ma)、早志留世 (435.7 ~ 433.3 Ma)、中—晚志留世及志留纪末期 (418.0 Ma) 等 4 期岩浆活动 (表 4)，结合区域资料，认为该区经历了晚寒武世—中奥陶世板块俯冲、晚奥陶世—中志留世板块碰撞和志留纪末期—早泥盆世后碰撞作用 (Yang LM et al., 2018; 孟祥舒等, 2017; 李开文等, 2018, 2019b)，并提出北秦岭南召地区在早志留世末期由俯冲环

境转换为陆陆碰撞环境 (李开文等, 2019a)，这与 Chen YW et al.(2018)、Li N et al.(2018)、周澍等 (2020)) 认识一致。重新厘定了早古生代二郎坪群大庙组和火神庙组的时代，确认其归属于寒武纪—奥陶纪 (表 5)。以上成果的取得为该地区进行下一步地质找矿调查提供了基础资料，并为后续开展地质灾害防治、生态环境保护等提供了基础性图件。

表 4　侵入岩填图单位表

代	世	代号	岩性	LA-ICPMS 锆石U-Pb年龄/Ma
古生代	志留纪末期	$\xi\gamma S_4$	多斑粗中粒黑云母正长花岗岩	418.0±2.9
	中—晚志留世	$\eta\gamma S_{2-3}$	中细粒含白云母黑云母二长花岗岩	433.1±2.1; 435.4±3.9
			中斑中细粒黑云母二长花岗岩	
			含斑中细粒黑云母二长花岗岩	
			中细粒黑云母二长花岗岩	435.2±2.4; 445.4±2.8
	早志留世	$\gamma\delta S_1$	细粒黑云母花岗闪长岩	435.7±2.0
			中斑中细粒黑云母花岗闪长岩	433.3±3.2
	晚奥陶世	$\eta o O_3$	多中斑中粒角闪石英二长岩	434.6±3.2
		$\delta\eta o O_3$	少斑粗中粒角闪石英二长闪长岩	
		ηO_3	细粒角闪石黑云母二长岩	449.1±6.7
		δO_3	粗中粒角闪闪长岩	465.0±14

表 5　综合地层柱状剖面表

界	系	统	群	组	代号	厚度/m	岩性
新生界	第四系	全新统			Qh^{pal}	0～7	砂砾石、细砂、亚砂土
		上更新统			Qp^{3pal}	0～21	含泥砂砾、含泥细砂、黏土
		中更新统			Qp^{2pal}	0～10	砂砾、粗砂、中砂、细砂及黏土，含钙质结核
下古生界	寒武系—奥陶系		二郎坪群	火神庙组	Є–O*h*	>120	斜长角闪片岩、斜长角闪岩
				大庙组	Є–O*d*	>176.9	大理岩、斜长角闪片岩、黑云石英片岩

6　数据使用方法和建议

河南省石门幅 1：50 000 地质图数据库有着广泛的应用前景，可依托该数据库作为相同或不同比例尺基础地质图的基本信息库，可为区域及局部地质灾害防治、生态环境保护等提供基础资料支撑。本数据库采用 MapGIS 格式建立，内容翔实丰富，查询方便，可编辑性强，可与同类型数据实现叠加、合并及再处理，有利于数据库信息共享。

7　结论

(1) 将原划定的石门岩体和五垛山岩体统一归并为晚奥陶世、早志留世、中—晚志留世及志留纪末期 4 期岩浆活动，建立了区域岩浆演化序列。

(2) 根据侵入岩的形成时代及与地层接触关系，重新厘定了早古生代二郎坪群大庙组和火神庙组的时代，确认其归属于寒武纪–奥陶纪。

(3) 系统编制了河南省石门幅 (I49E017018)1：50 000 地质图数据库，其包含 5 个地

层单元和 4 期岩浆岩，数据量约为 10.4 MB，反映了 1∶50 000 区域地质调查最新成果，为该区下一步开展矿产地质调查、地质灾害防治及生态环境保护等提供基础性图件。

致谢：河南省石门幅 1∶50 000 地质图数据库是一项集体成果，野外一线地质工作人员和室内绘图人员均付出了辛勤的努力。在野外地质调查和地质图数据库的建立过程中，得到多位专家的大力指导与帮助，在此代表项目组向各位专家致以诚挚的谢意!

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

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Abstract: The 1∶50 000 geologic map database of the Shimen map sheet (I49E017018), Henan Province (also referred to as the Database) was developed in accordance with the '*Technical Requirements for Regional Geological Survey* (*Scale: 1∶50 000*)' and other unified standards and requirements in the geologic industry, of which previous 1∶200 000-, 1∶250 000- and 1∶50 000-scale regional geological survey results were fully collected and utilized. In addition, the digital mapping system (DGSS) was adopted for geological field mapping and database building, and indoor map preparation was conducted along with field mapping. This Database was mainly built to summarize the eras and types of intrusions in the map sheet, as well as further incorporating the previously determined Shimen and Wuduoshan intrusives into the four stages of magmatic activities, specifically the Late Ordovician, Early Silurian, Mid-Late Silurian and the end of the Silurian period. As a result, the magma evolution sequence was built. Furthermore, based on the formation eras of the intrusions and the contact relationships between the intrusions and strata, the eras of the Damiao Formation and Huoshenmiao Formation of the Early Paleozoic Erlangping Group were re-determined to be of the Cambrian – Ordovician. The Database covers five stratigraphic units and four stages of magmatites, as well as rock geochemistry analytical data of 66 samples and dating data of 19 samples, with a data size of about 10.4 MB. The Database fully reflects the latest results of the 1∶50 000-scale regional geological surveys, providing references and guidance for future mineral and geological surveys, geologic hazard prevention & control and ecological environmental protection in the Shimen map sheet area.

Key words: database; geologic map; 1∶50 000; magmatite; Shimen map sheet; Henan Province

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

1 Introduction

The 1：50 000 geologic map survey area in the Shimen map sheet, Henan Province (also referred to as the study area) is located in the eastern part of the Qinling orogen. It spans three first-order tectonic units (Fig. 1), namely the North Qinling plate (and the southern margin of the North China Craton), Central Qinling plate and Yangtze plate from north to south, with the Shangdan and Mianlue suture zones as their boundaries (Wang Y et al., 2019; Zhang GW et al., 2001; Xu ZQ et al., 2015; Zhang X et al., 2019). These three plates have started undergoing subduction along the two main fault zones since the Cambrian, underwent collisional orogeny in the Triassic and experienced the superimposition of intracontinental orogeny in the Mesozoic–Cenozoic, thus forming the current basic tectonic framework of the Qinling orogen (Shi Y et al., 2018; Bader T et al., 2020; Li CD et al., 2018, 2019). Previous scholars conducted extensive research on the granite in the east Qinling Mountains. According to the geotectonic evolutionary features of the Qinling orogen, Zhang GW et al. (2001) divided granitic magmatic activities into three stages: the pre-orogenic stage of Mesoproterozoic – Early Precambrian, main orogenic stage of Neoproterozoic – Early Mesozoic and post-orogenic stage of Mesozoic – Cenozoic. Wang XX et al. (2015), however, divided the granitic magmatism in the Qinling orogen into four stages: the Neoproterozoic, Paleozoic, Early Mesozoic and Late Mesozoic, which were all researched by scholars in detail (Liu L et al., 2016; Wang T et al., 2009; Zhang X et al., 2017; Lai Y et al., 2017; Wang JB et al., 2018).

The geological surveys of the study area began in the 1930s. In contrast, systematical geological prospecting of the area was not conducted until after the 1950s, including the 1：200 000-scale regional geological surveys, stream sediment survey, heavy concentrate

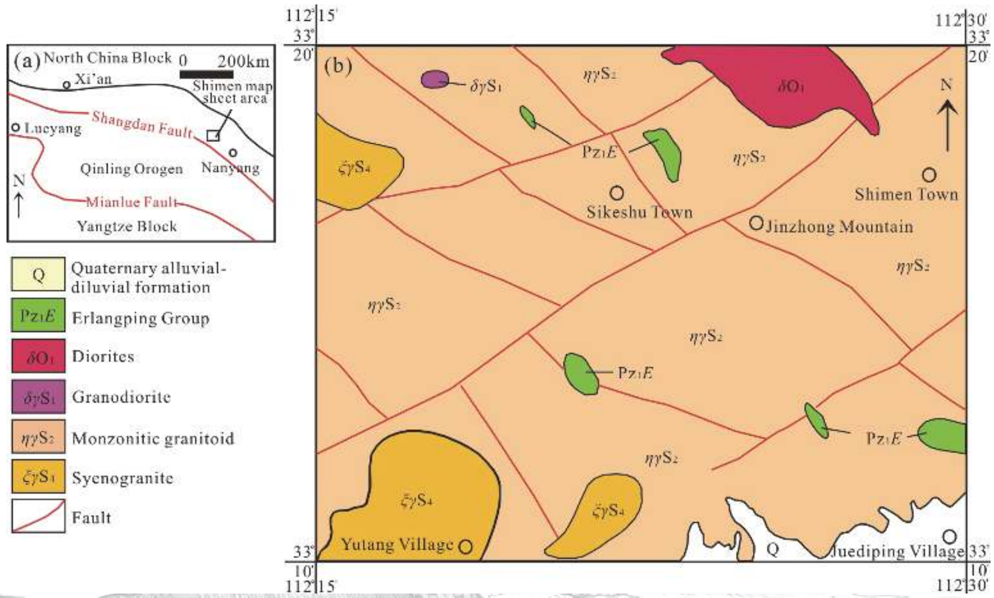

Fig. 1 **Regional location (a) and geologic sketch (b) covered by the 1：50 000 Geologic Map of the Shimen map sheet, Henan Province**

survey, gravity survey, aeromagnetic survey, 1∶50 000-scale mineral and geological survey and magnetic survey, and 1∶250 000-scale regional geological surveys, which were conducted successively. Furthermore, the 1∶50 000-scale regional geological survey areas were locally summarized. All these provide basic research data for the preparation of the geologic maps of the Shimen map sheet. In recent years, significant progress has been made in research on the geology, geochemistry and isotopes of the Early Paleozoic granite in the north Qinling Mountains. Many scholars have comprehensively summarized the evolutionary process of the granite and put forward new understandings (Li N et al., 2018; Zhang GW et al., 1996, 2001; Wang T et al., 2009; Wang ZQ et al., 2009; Zhang CL et al., 2013). However, there are still different views on critical scientific issues, such as the evolutionary stages and corresponding rock types of the Early Paleozoic magma and the age ranges of the subduction, collision and post-collision of Early Paleozoic plates (Zhang YQ et al., 2019; Liu XC et al., 2015). The 1∶50 000 geologic map of the Shimen map sheet, Henan Province is the geological survey result achieved by China Geological Survey. Great efforts have been made in order to allow it to reflect the achievements of the geological survey and scientific research obtained from a new round of geological surveys. The purpose is to provide basic geologic maps for further surveys of the mineral and resources, geologic hazards and ecological environment in the study area, and to provide detailed references for geological field surveys and scientific research.

A great number of analyses and testing were previously conducted on the geologic blocks in the map sheet, especially on the intrusions, achieving some significant results (Lu SW, 1994; Lei M, 2010; Li MZ et al., 2014). However, they are not representative and systematical since they tend to focus on certain types of rocks. In this study, systematical geological surveying, sampling and analysing were conducted for every type of geologic block in the map sheet according to the '*Technical Requirements for Regional Geological Survey* (*Scale: 1∶50 000*)'. As a result, a geologic map database (Fang HB et al., 2020) was established, which represents the most complete basic geological data in the map sheet.

The brief metadata table of the Database is shown in Table 1.

2 Methods for Data Acquisition and Processing

2.1 Data Preparation

The 1∶50 000 geologic map of the Shimen Map sheet, Henan Province was developed according to the '*Technical Requirements for Regional Geological Surveys* (*Scale: 1∶50 000*)' based on remote sensing (RS), global satellite positioning system (GPS) and geographical information system (GIS). It was guided by the contemporary systematical perspective of geosciences and new theories on the research of orogen and regional geologic tectonics. During the development of the map, a basic geological survey of the study area was conducted by applying the *Point–Routing–Boundary* (PRB) digital mapping technique, following the principles of combining remote sensing interpretation with ground survey and combining macroscopic with microscopic geologic mapping. The geographical base map of the 1∶50 000

Table 1 Metadata Table of Database (Dataset)

Items	Description
Database (dataset) name	1∶50 000 Geologic Map Database of the Shimen Map Sheet, Henan Province, China
Database (dataset) authors	For sedimentary rocks: Fang Huaibin, Henan Institute of Geological Survey For volcanics: Chao Hongli, Henan Institute of Geological Survey For intrusions: Li Kaiwen, Henan Institute of Geological Survey For metamorphic rocks: Liu Kun, Henan Institute of Geological Survey
Data acquisition time	2014 – 2016
Geographical area	112°15′ – 112°30′E, 33°10′ – 33°20′N
Data format	MapGIS
Data size	10.4 MB
Data service system URL	http://dcc.cgs.gov.cn
Fund project	Jointly funded by the projects titled '*Geological and Mineral Survey of the Zhongtiao-Xiongershan Metallogenic Area*' (No.: DD20160043) and '*1∶50 000-scale Regional Geological and Mineral Survey of Shimen, Neixiang, Zhenping and Angao Map Sheets, Henan Province*' (No.: 12120114027001) initiated by China Geological Survey
Language	Chinese
Database (dataset) composition	The Database consists of databases and map decorations of a 1∶50 000 geologic map. The databases include the data of sedimentary rocks, volcanics, intrusions, metamorphic rocks, the Quaternary, dikes, structures, geologic boundaries, attitude, isotopic samples and ages, lithologic patterns, geologic codes and local names, roads, rivers, and reservoirs. The map decorations include an index map, histograms, an intrusion unit map, legends, transverse cutting profiles, a geologic structure outline map and a duty table

geologic map is taken as the latest geographic data from the National Administration of Surveying, Mapping and Geoinformation of China, and the data were processed by applying existing technical standards and using computer software such as DGSS and MapGIS.

2.2 Data Acquisition

2.2.1 Data Acquisition and Preparation

The topographic map in this study was taken as a 1∶50 000 digital topographic map provided by the National Geomatics Center of China, and the Gauss-Kruger projection, Xi'an 1980 and National Height Datum 1985 were adopted as the projection type, ellipsoidal parameters and elevation datum, respectively. The original data include the configuration of digital devices, 1∶50 000 digital topographic map and multivariate data. The PRB dictionary library was developed according to both field survey and specific conditions of the study area based on the full utilization of previous data. It mainly consists of the data model's 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. The basic information of the map sheet also includes information about the mapping personnel.

2.2.2 Data Acquisition

The PRB digital mapping database was preliminarily established by plotting the points and lines including geologic points, geologic boundaries and geologic routes on DGSS based on the field survey, using the 1：250 000 topographic map in the palm-sized personal digital assistant as the base map.

Geologic points (Point): coordinates of the geologic points were read from GPS; the attributes of the geologic points were filled in on DGSS, including route No., geologic point No., micro-landform, sites, outcrops, weathering level, location description, mapping unit, names and contact relationships of rocks, and attitude.

Geologic routes (Routing): the attributes of geologic routes that need to be filled in on the DGSS include route No., geologic point No., route code, direction, the distance of current station, accumulative distance, mapping units and rock names. Among these attributes, the direction, distance of current station and accumulative distance were automatically read by DGSS.

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

Geologic attitude (Attitude), photos (Photo), sketches (Sketch) and samples (Sample) acquired along the routes: they were positioned on DGSS, relevant position data were input into the system, and related attribute data were filled in on DGSS.

2.3 Data Collation

(1) Import the original data gathered on the palm-sized personal digital assistant in the field such as GPS points, geologic points, geologic routes and geologic boundaries into the desktop version of DGSS, and then collate the data according to applicable specifications.

(2) Move all geologic points gathered in the field to corresponding GPS points and then rewrite the coordinates of the geologic points. Complete the data such as route Nos. of the geologic points, geologic point Nos., mapping units and names and contact relationships of rocks. The rock names in the text description of the geologic points (PRB_P) should be the names input into the geologic points. Then comprehensively designate the rocks by combining their names in the field after results of the thin section identification are determined.

(3) Move all geologic boundaries gathered in the field to corresponding GPS points. Then successively lengthen or shorten the geologic boundaries based on actual conditions, process them by following the V-like rule, and finally smoothen and beautify them. Then set geologic boundaries, as well as the features of faults, such as types, colors and width of lines for the whole map sheet in a unified way (for instance, set the line type, line color and line width of geologic boundaries to 1, 1 and 0.1, respectively). Then complete the geologic boundary description and use the phrasing: “the mapping units on the left side of the boundary include..., the ones one the right side include…” to describe the lithologic difference between two sides. 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, determine the contact relationship between the lithology on the two sides and provide related geological evidence.

(4) Adjust the two ends of all geologic routes gathered in the field to the coordinates of GPS points corresponding to the start- and end-points of the routes, and smoothen the routes. Then set the line parameters of the routes in a unified way in the whole map sheet, such as line type, line color and line width (for instance, set the line type, line color and line width to 1, 1, and 0.1, respectively), and then re-calculate the orientation and distance of the routes. Finally, complement the contents of the routes, including the lithologic composition and change features of the routes.

(5) Move the attitude, samples, photos and sketches gathered along the routes to corresponding GPS points and rewrite their coordinates. Then complement related attribute data such as the strike, dip, dip angle, type and mapping units of attitude; information, lens direction and detailed photo description of samples; and the name, scale and image of sketches. 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

Put the four improved 1∶250 000-scale geologic routes and profiles (sections) onto the desktop version of DGSS into a database in a unified way. In this way, the field general map database was generated. After this, examine attribute structures of all geologic tectonics.

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 observed along field routes from the field general map database. This resulted in the automatic generation of three files, specifically the point feature file (Geolabel.wt), line feature file (Geoline.wl) and polygon feature file (Geopoly.wp). Next, check the attribute structures of all features, conduct topological area creation according to routes and geologic boundaries in 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

Transfer the four 1∶250 000 primitive data maps into a database based on the original map for compilation. As a result, a compilation of the database of the 1∶50 000 original map of the Shimen map sheet was formed.

2.4.4 Spatial Database

Import the compilation of the database of the 1∶50 000 original map of the Shimen map sheet into the result database, generating the spatial database of the 1∶50 000 geologic map of the Shimen map sheet. This database includes three parts: geographical features, geologic tectonics and map decorations It is divided into map layers of basic information of the map sheet, including water systems, transportation, habitations, boundaries and borders, topographic contour, strata, volcanic lithology, informal stratigraphic units, intrusions, dikes, alteration of surrounding rocks, metamorphic facies zones, faults, tectonic deformation zones, attitude symbols and other primitives.

2.5 Preparation of Corner Maps and Map Decorations

2.5.1 Comprehensive Histograms

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

2.5.2 Mapping Unit Map of Intrusions

The intrusions are mainly developed in the map sheet. The stages of the intrusions in the master map 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 setting.

2.5.3 Legends

The colors, line types, rock types, symbols and codes of the geologic blocks, lines and sub-maps involved in the master map were described in accordance with the '*Geological Symbols Used for Regional Geological Maps*' (GB/T 958–2015).

2.5.4 Geologic Structure Outline Map

Fault structures are developed in the map sheet. The geologic structure outline map is used to present the tectonic framework of the 1：50 000 geologic map of the map sheet, focusing on attitude and properties of the faults in the geologic map. This will help to understand the tectonic pattern of the whole map sheet.

2.5.5 Geologic Profiles

The tectonic lines in the map sheet are mainly in a NW trending, followed by NE trending. Two NE-trending transverse cutting profiles perpendicular to the primary tectonic lines are presented to fully reflect the overall tectonic framework in the map sheet. They are used to show the Erlangping Group of the Lower Paleozoic and the granite of the Late Ordovician – Early Silurian - Mid-Late Silurian - the end of the Silurian period, respectively. They are mainly presented using 'line type for standard profiles + standard code'. Meanwhile, patterns, codes and contact relationships are labeled at proper locations in the two profiles.

2.5.6 Index Map

The index map is used to display the information of the map sheets adjacent to the Shimen map sheet, including the names of the map sheets and names of the 1：50 000 geologic maps of the map sheets. This makes it convenient to retrieve the information on the adjacent map sheets.

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: intrusive boundaries, lithofacies boundaries, fault structures, roads, rivers, etc.

Polygons: sedimentary rocks, volcanics, intrusions, metamorphic rocks, the Quaternary, reservoirs, etc.

3.2 Contents in Map Layers

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

Contents in corner maps and map decorations include the comprehensive histograms, mapping units of intrusions, legends, geologic structure outline map, geologic profiles 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, minimum and maximum ages of the geologic polygon entity and subtype ID. The attributes of geologic polygon entities of Late Ordovician diorites 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; subtype ID.

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

Table 2 Attributes of geologic polygon entities of ordovician diorites

No.	Data item	Label code	Data type	Example of content description
1	ID	*Feature_Id	Character	AI49E017018000000012
2	Original code	Source_Id	Character	
3	Type code	*Feature_Type	Character	*δ*O@3
4	Name	Geobody_Name	Character	Late Ordovician diorites
5	Era	Geobody_Era	Character	O@3
6	Minimum age	Geobody_Age1	Double	449.1 Ma
7	Maximum age	Geobody_Age2	Double	465.0 Ma
8	Subtype ID	Subtype	Integer	1

Note: @ denotes subscript.

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 No. and name of the sample, dating method, age dated, the unit and code of the geologic block dated, the unit and date of dating analysis, and subtype ID.

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

3.3.2 Complex Classes

The attribute structure of an alteration zone (_Alteration_Polygon): the name code, 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 and 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 (volcanic) 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; biofossil zone or biotic association; 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 and subtype ID. The attributes of lithostratigraphic units of Late Ordovician diorite intrusions 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 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;

Table 3 Attributes of lithochronologic units of late Ordovician diorite intrusions

No.	Data item	Standard code	Data type	Examples of content description
1	Feature type (geologic code)	*Feature_Type	Character	δO@3
2	Name of rock-mass mapping unit	Intru_Body_Name	Character	Late Ordovician diorite
3	Symbol of rock-mass mapping unit	Intru_Body_Code	Character	δO@3
4	Rock name (lithology)	Rock_Name	Character	Gneissic coarse–medium-grained hornblende diorite
5	Rock color	Color	Character	Grayish-green
6	Rock texture	Rock_Texture	Character	Hypidiomorphic granular texture
7	Rock structure	Rock_Structure	Character	Massive structure, gneissic structure
8	Lithofacies	Rock_Phases	Character	Plutonic facies
9	Contact relationship with surrounding rocks	Contact_Relation	Character	Intrusive contact
10	Primary minerals and their content	Primary_Mineral	Character	Plagioclase (40–50%) and hornblende (30–35%)
11	Secondary minerals and their content	Secondary_Mineral	Character	Orthoclase (3–5%) and quartz (2–4%)
12	Strike of the interface with surrounding rocks/°	Strike	Integer	93
13	Dip of the contact surface with surrounding rocks/°	Dip_Direction	Integer	3
14	Dip angle of the contact surface with surrounding rocks/°	Dip_Angle	Integer	65
15	Formation era	Era	Character	O@3
16	Ore-bearing properties	Commodities	Character	*
17	Subtype ID	Subtype	Integer	0

Note: @ denotes subscript.

active stages, 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, name, characteristics of primitive; subtype ID.

The attribute structure of the basic information of map sheet (_Sheet_Mapinfo): map name, coordinate system, elevation system, left longitude, right longitude, upper latitude, lower latitude, mapping method, survey organization, organization responsible for acceptance check of the map sheet, rated level, completion date, publication date, data source and data acquisition date.

4 Data Quality Control and Assessment

The 1：50 000-scale regional geological survey of Shimen map sheet, Henan Province was conducted in accordance with the '*Technical Requirements for Regional Geological Surveys* (*Scale: 1：50 000*)' based on the systematical acquisition and comprehensive analysis of existing geologic data. Meanwhile, a geological survey of total 904 km routes was conducted, which involves 1 602 various geologic points (average density: 3.76 points/km^2) and 2 765 geologic boundaries (average point interval: 564 m). Moreover, 295 samples, 303 attitudes, 17 sketches and 502 photos were obtained. In this way, the specific requirements of the mapping precision of 1：50 000 geologic mapping were met.

The digital mapping instruments were utilized to acquire data in the field and the 1：250 000 digital topographic maps were adopted for the preparation of freehand field maps. The following geologic blocks were all plotted in the geologic map: the sealed geologic blocks with a diameter greater than 50 m, the linear geologic blocks with a width greater than 25 m and a length greater than 50 m and the faults with a length greater than 250 m. The outlines of all bedrock outcrops distributed in the Quaternary were plotted, regardless of their sizes. The outcrops with a size less than mapping sizes were presented after having been amplified. The digital mapping technology was applied in the field, with the route interval, and all work meeting general requirements of the survey.

All samples for various testing were acquired according to applicable provisions and then analyzed and tested by certified organizations. Therefore, the authentication reports and testing data are accurate and reliable, and meet relevant requirements. The samples for analysis of silicate, rare earth elements and trace elements were analyzed at the Hubei Geological Research Laboratory, China. LA-ICPMS zircon U-Pb dating was conducted in the Tianjin Institute of Geology and Mineral Resources, China and the Institute of Geochemistry, Chinese Academy of Sciences.

A 'three-level quality management' network consisting of the Henan Institute of Geological Surveys, project department and work teams were established during geologic mapping. Additionally, the project design document and applicable specifications were strictly followed. Before any fieldwork, the division criteria of mapping units and the knowledge of the project were unified. During the project, self-check, mutual check and spot check were continually carried out. The self-check rate and mutual check rate were both at 100%, and the spot check rates performed by the project leader and the Henan Institute of Geological Surveys were 32% and 6%, respectively, with writing records of all checks being kept. During Nov. 22–29 2016, the Tianjin Center of China Geological Survey organized experts to conduct field acceptance checks of the map sheet in Zhengzhou, Henan Province. The experts unanimously considered that the project team successfully completed the goals and tasks specified in the project charter, as well as approving the main physical workload design. They thought various work arrangements met the requirements of the design and applicable specifications, consisting of correct work methodologies and high work quality. The original data submitted were considered to be complete; the data acquired were rich and systematically collated; and the analysis and testing data were complete. Meanwhile, the experts believed the quality management and its guarantee measures were effective, and most importantly, good progress was made in the basic geological survey and research, such as the division of intrusion stages. Finally, the 1：50 000 geologic map of the Shimen map sheet was rated excellent.

5 Data Value

The 1：50 000 geologic map of the Shimen map sheet, Henan Province is a result map of a new round of geological surveys initiated by China Geological Survey. Detailed geologic mapping was conducted for the map sheet according to the '*Technical Requirements for Regional Geological Survey* (*Scale: 1：50 000*)' based on the systematical collection of previous research data. It has improved the level of regional geological survey and fundamental research, and achieved new breakthroughs in solving major basic geological problems. The main focus of this study is to summarize the types of the intrusions, emplacement eras and tectonic setting in the map sheet. As a result, the previously determined Shimen and Wuduoshan intrusives were incorporated into the four stages of magmatic activities, namely Late Ordovician (465.0–449.1 Ma), Early Silurian (435.7–433.3 Ma), Mid-Late Silurian and the end of the Silurian period (418.0 Ma) (Table 4). It can be argued that the map sheet underwent Late Cambrian – Middle Ordovician plate subduction, Late Ordovician – Middle Silurian plate collision and the end of the Silurian period – Early Devonian post-collision process (Yang LM et al., 2018; Meng XS et al., 2017; Li KW et al., 2018, 2019b). Furthermore, it was put forward that the Nanzhao area in the north Qinling Mountains changed from a subduction environment to a continent-continent collision environment at the end of Early Silurian (Li KW et al., 2019a), which is consistent with the understanding of Chen YW

Table 4 Mapping units of the intrusions

Era	Epoch	Code	Lithology	LA–ICPMS Zircon U–Pb age /Ma
Paleozoic	The end of the Silurian period	$\xi\gamma S_4$	Highly-porphyritic coarse- –medium-grained biotite syenogranites	418.0±2.9
	Mid–Late Silurian	$\eta\gamma S_{2-3}$	Medium–fine-grained muscovite-biotite adamellites	433.1±2.1; 435.4±3.9
			Moderately-porphyritic medium–fine-grained biotite adamellites	
			Porphyritic medium–fine-grained biotite adamellites	
			Medium–fine-grained biotite adamellites	435.2±2.4; 445.4±2.8
	Early Silurian	$\gamma\delta S_1$	Fine-grained biotite granodiorites	435.7±2.0
			Moderately-porphyritic medium- – fine-grained biotite granodiorites	433.3±3.2
	Late Ordovician	$\eta o O_3$	Highly–moderately-porphyritic medium-grained hornblende-quartz monzonites	434.6±3.2
		$\delta\eta o O_3$	Lowly-porphyritic coarse– medium-grained hornblende-quartz monzodiorites	
		ηO_3	Fine-grained hornblende-biotite monzonites	449.1±6.7
		δO_3	Coarse–medium-grained hornblende diorites	465.0±14

et al. (2018), Li N et al. (2018) and Zhou S et al. (2020). In this study, the eras of the Damiao Formation and Huoshenmiao Formation of the Early Paleozoic Erlangping Group were re-determined to be of Cambrian – Ordovician (Table 5). These findings will provide basic geologic data for further surveys of geology and mineral prospecting in the map sheet, basic maps for follow-up geologic hazard prevention and control, and ecological environmental protection in the map sheet.

6 Methods and Recommendations for Data Usage

The Database boasts broad application prospects. It can be used as the basic database of basic geologic maps on both the same or different scales. It can also provide basic data for regional and local geologic hazard prevention and control, and ecological environmental protection. The Database is in MapGIS format, in which the detailed data are easy to query and highly editable. Furthermore, they can be superimposed and combined with other data in the same format and further re-processed. Therefore, the data in the Database can be easily shared.

7 Conclusion

(1) The previously determined Shimen and Wuduoshan intrusives were incorporated into four stages of magmatic activities, namely Late Ordovician, Early Silurian, Mid-Late Silurian and the end of the Silurian period. As a result, the magma evolution sequence was built.

(2) Based on the formation eras of the intrusions and contact relationships between the intrusions and strata, the eras of the Damiao Formation and Huoshenmiao Formation of the Early Paleozoic Erlangping Group were re-determined to be of the Cambrian – Ordovician.

(3) The 1：50 000 geologic map database of the Shimen map sheet, Henan Province was systematically developed. It covers five stratigraphic units and four stages of magmatites, with a data size of about 10.4 MB. It fully reflects the latest results of the 1：50 000-scale regional geological surveys, and will provide basic maps for mineral and geological surveys, geologic hazard prevention and control and ecological environmental protection in the Shimen map

Table 5 Comprehensive histogram section table

Erathem	System	Series	Group	Formation	Code	Thickness/m	Lithology
Cenozoic	Quaternary	Holocene			Qh^{pal}	0–7	Sandy gravels, fine sand, sandy loam
		Upper Pleistocene			Qp^{3pal}	0–21	Argillaceous sandy gravels, argillaceous fine sand, clay
		Middle Pleistocene			Qp^{2pal}	0–10	Sandy gravels, coarse sand, medium sand, fine sand and clay, calcareous nodules
Lower Paleozoic	Cambrian–Ordovician		Erlangping Group	Huoshenmiao Formation	Є–O*h*	>120	Plagioclasite- hornblende schists, amphibolites
				Damiao Formation	Є–O*d*	>176.9	Marbles, plagioclasite-hornblende schists, biotite-quartz schists

sheet area.

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