收稿日期：2020-04-15
改回日期：2020-06-14

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 白土街、三川幅区域地质矿产调查”（项目编号：DD20160043-02）联合资助。

doi: 10.12029/gc2020Z116

论文引用格式：晁红丽, 任建德, 吕际根, 谢朝永, 李莹琪, 李瑞强, 焦静华. 2020. 河南省三川幅 1∶50 000 地质图数据库 [J].中国地质，47(S1):173−188.
数据集引用格式：任建德; 吕际根; 张毅星; 晁红丽; 谢朝永; 李春艳; 李莹琪; 贺承广; 王小娟; 李瑞强; 翟文建; 焦静华; 孙学静; 李敏; 刘姗姗. 河南省三川幅 1∶50 000 地质图数据库 (V1). 河南省地质调查院 [创建机构], 2016. 全国地质资料馆 [传播机构], 2020-06-30.10.35080/data.A.2020.P16; http://dcc.cgs.gov.cn/cn//geologicalData/details/doi/10.35080/data.A.2020.P16

河南省三川幅 1∶50 000 地质图数据库

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摘要：河南省三川幅 (I49E013014)1∶50 000 地质图数据库的数据源采用实测和数字填图方法获得，野外数据采集过程中实施构造–岩性填图，注重特殊地质体及非正式填图单位的表达，共采集薄片 66 件，全岩岩石化学样品 180 件，同位素测年样品 19 件，化学分析样品 21 件。图幅主要成果有：在陶湾群层型剖面上发现多门类、时限短的微体化石，确定陶湾群为奥陶纪；在陶湾群发现碱性火山岩夹层，指示奥陶纪在华北板块南缘发育伸展性盆地；确定宽坪岩群四岔口岩组、谢湾岩组内的绿片岩为板内火山岩，指示宽坪岩群主体形成于伸展性盆地；在图幅区南部填绘出志留纪碱长花岗斑岩岩墙群，限定了秦岭洋关闭的时代不晚于志留纪；将晚中生代侵入岩划分为 5 个侵入期次；厘定了栾川断裂带存在早古生代、早中生代、晚中生代 3 期活动；在区内新发现震旦纪冰积物。该数据库的数据内容分为基本要素类、综合要素类和对象类，数据量约为 63.5 MB，充分反映了本图幅区的地质矿产成果资料，对该区矿产勘查与开发、地质灾害防治、秦岭造山带研究与地质科普等提供基础数据支撑。

关键词：数据库；地质图；1∶50 000；三川幅；河南；秦岭造山带；地质调查工程
数据服务系统网址：http://dcc.cgs.gov.cn

1　引言

河南省三川幅 1∶50 000 地质图幅区位于河南省西部，地处华北板块南缘的三门峡—鲁山断裂与朱阳关—夏馆断裂之间 (图 1)，以栾川断裂带为界，南部为北秦岭造山带东段之宽坪弧后盆地 (张寿广等, 1991; 张宗清等, 1995; 陆松年等, 2003)，北部为华北板块南缘之逆冲推覆构造带 (河南省地质调查院, 2013)。河南省三川图幅区在中–新元古代为秦岭洋的被动陆缘，发育蓟县纪官道口碳酸盐台地 (张恒等, 2019)、青白口纪栾川陆缘裂陷盆地 (石铨曾等, 1996; 阎国翰等, 2007; 中国地质调查局天津地质调查中心, 2019)；

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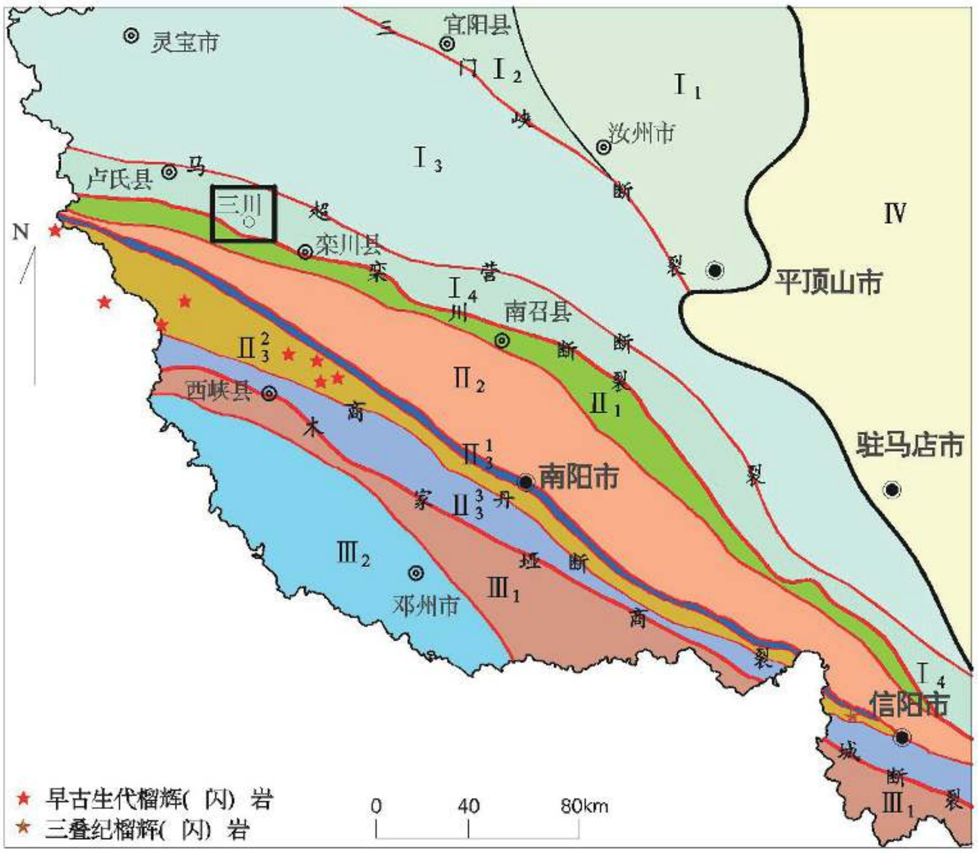

图 1　河南省三川地区大地构造位置图

I—华北陆块；I_1—晋豫陆表海盆地；I_2—熊耳古裂谷北支；I_3—华北陆块南缘褶断带；I_4—华北陆块南缘逆冲推覆构造带；II—北秦岭造山带；II_1—宽坪弧后盆地；II_2—二郎坪古生代岛弧及弧后盆地；II_3—龟山–夏馆对接带；II_3^1—朱阳关–夏馆蛇绿混杂岩带；II_3^2—北秦岭微陆块 (寨根超高压变质带)；II_3^3—镇平–龟山 (商丹) 俯冲增生杂岩；III—南秦岭造山带；III_1—陡岭–大别中新元古代微陆块；III_2—淅川震旦纪古生代碳酸盐台地；IV—新生代上叠内陆盆地

早古生代时期转换为活动陆缘，在南部大陆斜坡上沉积了奥陶纪陶湾群 (王宗起等, 2007, 2009)；其后，依次经历早古生代末秦岭洋关闭–碰撞造山、三叠纪勉略洋关闭–碰撞造山 (中国地质调查局天津地质调查中心, 2019)、侏罗–白垩纪滨太平洋体系汇聚加厚和岩石圈伸展减薄等过程形成了如今复杂的地质构造格局 (毛景文等, 2018; 图 2)，造就了区内世界级钼钨多金属矿床。

河南省三川地区地质调查研究始于 20 世纪 30 年代，50 年代开始进行较为系统的地质找矿工作，先后开展了 1∶200 000 区域地质调查、1∶100 000 航空放射性测量、1∶50 000 航磁测量、1∶50 000 水系沉积物测量、围绕成矿带的专题图幅 1∶50 000 区域地质调查、1∶200 000 重力测量、1∶250 000 区域地质调查、1∶50 000 矿产远景调查和高精度地面磁测；同时，众多学者对该地区地层、岩石的成因及时代、构造期次及演化、矿床成因及成矿规律进行了大量研究 (盛中烈等, 1980; 罗铭玖等, 1991; 宋传中等, 1999; 叶会寿等, 2006; 霍立新等, 2008; 陆松年等, 2009; Yang et al., 2013, 2017; 中国地质调查局天津地质调查中心, 2015, 2019; 王赛等, 2016)。这些前期工作为河南省三川幅 1∶50 000 地质图的编制提供了重要的基础性资料。由于该区地质构造复杂，一些科学问题目前仍存在争议，主要集中于宽坪岩群、陶湾群、栾川断裂带及秦岭洋俯冲关闭时

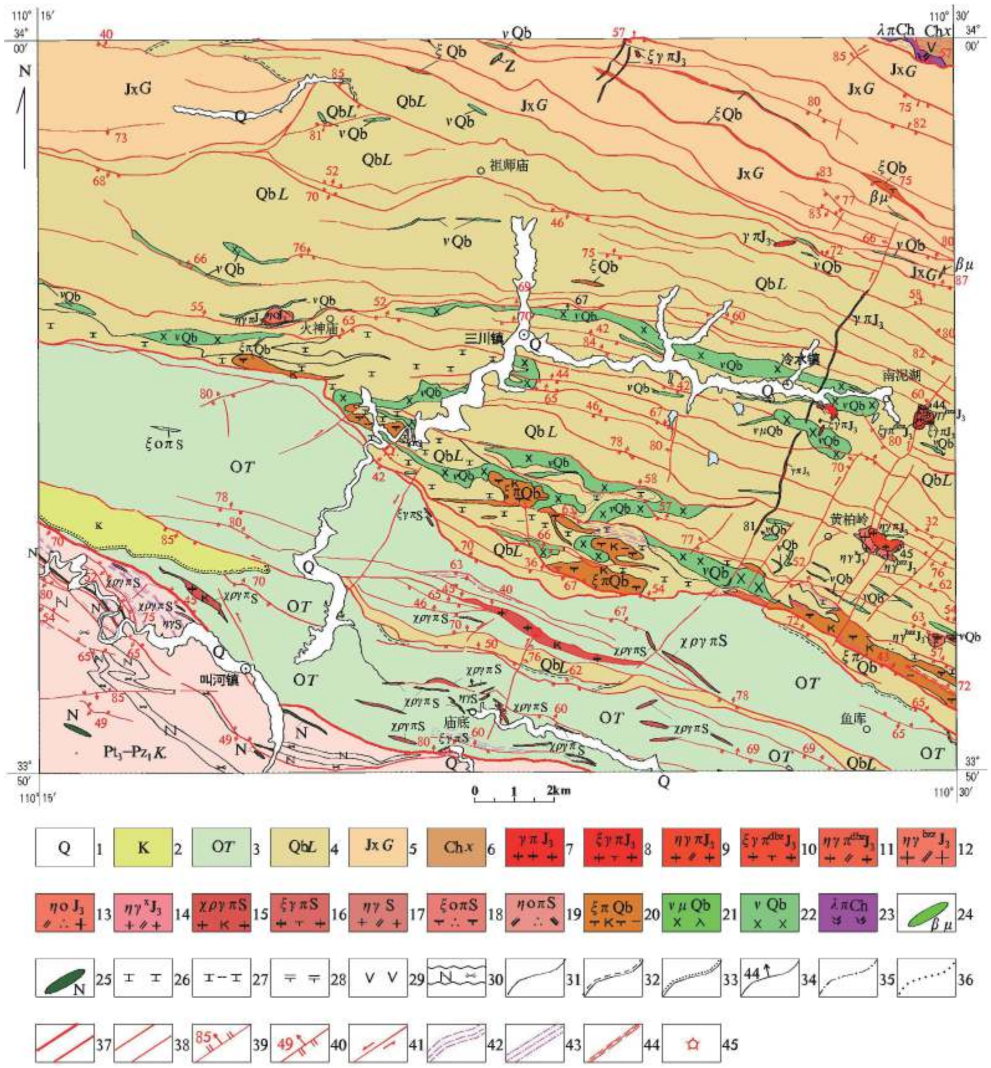

图 2　河南省三川地区地质简图

1—第四系；2—白垩系；3—奥陶系陶湾群；4—青白口系栾川群；5—蓟县系官道口群；6—长城系熊耳群许山组；7—晚侏罗世花岗斑岩；8—含斑正长花岗斑岩；9— 含斑二长花岗斑岩；10—多斑状正长花岗斑岩；11—多斑状二长花岗斑岩；12—小中斑状中粒黑云母二长花岗岩；13—小中斑状细粒黑云石英二长岩；14— 细粒二长花岗岩；15—志留纪碱长花岗斑岩；16—正长花岗斑岩；17—细粒黑云母二长花岗岩；18—石英正长斑岩；19—石英二长斑岩；20—青白口纪变黑云母碱长正长斑岩；21—变辉长玢岩；22—变中粒辉长岩；23—长城纪潜流纹斑岩；24—辉绿玢岩脉；25—基性岩脉；26—粗面岩；27—黑云母粗面岩；28—安粗岩；29—安山岩；30—钠长阳起片岩；31—整合界线；32—平行不整合界线；33—角度不整合界线；34—侵入接触界线；35—脉动侵入界线；36—相变界线；37—一级、二级构造单元边界断裂；38—主干断裂、一般断裂；39—正断层；40—逆断层及产状；41—平移断层；42—片理化带；43—糜棱岩带；44—韧性剪切带；45—火山口

限方面。如：(1) 对宽坪岩群时代的认识存在争议，部分学者认为其属于中–新元古代(陕西地质矿产局, 1989; 河南地质矿产厅, 1997; 张寿广等, 1991; Dong Y et al., 2014; 张宗清等, 1995; 闫全人等, 2008; 张国伟等, 2001)，其他学者认为属于新元古代—早古生代(陆松年等, 2003; 第五春荣等, 2010a; 李承东等, 2018) 以及早古生代 (王宗起等, 2009)。(2) 对宽坪岩群的形成环境认识不一致，一种观点认为宽坪岩群是由不同成因的岩片构造拼贴形成 (贾承造等, 1988; 张寿广等, 1991; 王宗起等, 2009; 第五春荣等, 2010a; Dong et al., 2014)，一种观点认为属于弧后盆地 (陆松年等, 2003; 张宗清, 1995; 张寿广等, 1991)，还有一种观点认为属华北板块南缘被动边缘大陆裂谷环境 (闫全人等, 2008; 张国

伟等, 2001)。(3) 陶湾群构造属性有较大争议，有人认为陶湾群属于秦岭造山带的一个岩片 (河南省地质调查院, 2002)，有人认为属于华北陆块南缘的陆表海较深部位沉积 (河南省地质调查院, 2013)。(4) 对陶湾群时代的判定主要依据陕西境内的微体化石研究 (王宗起等, 2007; 王宗起等, 2009)，而对于建群及层型剖面所在地的栾川地区尚缺乏直接证据。(5) 栾川断裂的性质及活动期次尚争议，有的学者将陶湾群北界断裂作为栾川断裂 (河南省地质矿产厅区域地质调查队, 1995; 河南省地质调查院, 2002)，有的将陶湾群南界断裂作为栾川断裂 (宋传中等, 2009; 河南省地质调查院, 2013)。鉴于以上地质问题，本次地质调查工作以现代板块构造理论为指导，采用实测结合高分辨率遥感解译，实行构造–岩性填图，突出特殊地质体及非正式填图单位的表达，取得了一批重要成果。三川幅数据库 (表 1；任建德等, 2020) 全面反映该区新一轮地质矿产调查及科研工作中取得的成果资料，为该区野外地质调查和科研科普提供详实的参考资料，为后续开展矿产资源调查、地质灾害调查、生态环境调查及修复、国土空间规划等提供基础性地质图件。

表 1　数据库 (集) 元数据简介

条目	描述
数据库(集)名称	河南省三川幅1：50 000地质图数据库
数据库(集)作者	构造类：任建德，李春艳，翟文建，河南省地质调查院 沉积岩类：吕际根，李莹琪，焦静华，河南省地质调查院 火山岩类：张毅星，贺承广，孙学静，河南省地质调查院 侵入岩类：晁红丽，王小娟，李　敏，河南省地质调查院 变质岩类：谢朝永，李瑞强，刘姗姗，河南省地质调查院
数据时间范围	2016—2018年
地理区域	地理坐标：东经 111°15′ ~ 111°30′，北纬 33°50′ ~ 34°00′
数据格式	MapGIS
数据量	63.5 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白土街、三川幅区域地质矿产调查”(项目编号：DD20160043-02)联合资助
语种	中文
数据库(集)组成	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、化石样品、火山口、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、侵入岩填图单位划分表、图例、图切剖面、大地构造位置图、责任表等

2　数据采集和处理方法

2.1　数据准备

河南省三川幅 1：50 000 地质图按照《区域地质调查总则 (1：50 000)》(DZ/T0001−1991)、《1：50000 区域地质调查工作指南 (试行，2016)》，在充分收集、综合分析利用已有地质矿产资料基础 (表 2) 上，以现代板块构造、大陆动力学及其他地质理论为指导，以区域地质构造研究为先导，充分应用遥感技术 (RS)、全球卫星定位系统 (GPS)、地理信息系统 (GIS)，采用数字填图 (PRB) 技术方法，进行构造–岩性填图，突出特殊地质体及非正式填图单位的表达。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、面上调查与重点解剖相结合的原则，采用系统实测的方式完成测区的基础地质调查，数据库建库严格按照《数字地质图空间数据库标准》(DD2006–6) 及《1：5 万区域地质图空间数据库 (分省) 建设实施细则》(2008) 的要求，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 版本为 1.0) 及 MapGIS 等计算机软件进行数据处理。

表 2　三川幅数据基础简表

序号	数据类型	数据内容	资料来源
1	地质调查	1：200 000栾川幅(I49-XXII)地质报告	河南省地质局秦岭地质队, 1958
2	区域物探	豫西地区1：100 000航磁测量和航空放射性测量成果报告	地质部物探局902队, 1960
3	区域物探	豫西地区1：50 000航磁测量成果报告	地质部物探局903队, 1966
4	区域化探	河南省栾川县三川–合峪地区水系沉积物测量研究报告	国家地质总局第二物探大队, 1975
5	地质调查	1：50 000栾川县南部区域地质调查报告	河南省地质三队, 1977
6	矿产勘查	河南省栾川县三道庄矿区钼钨矿详细勘探地质报告	河南省地质局地调一队, 1980
7	区域物探	豫西南地区1：200 000区域重力调查报告	河南省物探队, 2000
8	地质调查	1：250 000内乡县幅区域地质调查报告	河南省地质调查院, 2002
9	矿产调查	河南卢氏地区矿产远景调查	河南省地质调查院, 2009
10	地质调查	豫西关键地区区域地质调查成果报告	中国地质调查局天津地质调查中心, 2015
11	地质调查	中条–熊耳山成矿区关键地区地质调查与成果集成成果报告	中国地质调查局天津地质调查中心, 2019

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为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“西安 80 大地坐标系”，高程基准为 1985 国家高程基准。在野外踏勘和充分利用前人资料的基础上，根据工作区的具体情况编制数字填图 PRB 字典库。

本次数据采集使用的遥感影像为 TM8-OLI、SPOT7(精度为 2.5 m) 卫星遥感数据，TM8-OLI 数据时相为 2014 年 2 月 9 日，SPOT7 数据时相为 2015 年 12 月 16 日，波段组合为 Band7(R)+Band5(G)+Band2(B)+SPOT7 全色波段，图像较为清晰。采用中国地质调查局推广的“去干扰异常主分量门限化技术”进行遥感异常提取。数据源收集了 ETM 数据 (数据时相为 2014–1–21，波段组合为 741)，采用数字图像处理方法，提取像元地面分辨率为 30 m×30 m 的羟基、铁染遥感异常信息。其中采用 B1、4、5、7 提取羟基 (泥化) 异常，采用 B1、3、4、5 提取铁染 (铁化) 异常。

2.2.2　野外路线数据采集

河南省三川幅 (I49E013014)1：50 000 地质图数据库野外路线地质数据的采集要素包括地质点、地质界线、地质路线、样品、素描、产状、照片等。以 1：25 000 地形图为野外底图，创建野外手图，通过野外实际调查，在数字填图系统中初步建立数字填图 (PRB) 原始数据库。

添加地质点 (Point) 操作：地质点是野外数据采集的基本，野外路线所有数据的采

集均隶属于地质点。在野外，地质点的坐标信息由 GPS 自动获取，弹出地质点属性表对话框，录入地质点属性，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。

添加分段路线 (Routing) 操作：在野外路线窗口中依次选择新增路线数据/分段路线，然后在图上相应位置手动勾画线条轨迹，弹出分段路线属性表，输入其属性及描述内容，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写入。

添加地质界线 (Boundary) 操作：在野外路线窗口中依次选择新增路线数据/点和点间界线，然后在野外手图相应位置处划线，弹出地质界线属性表对话框，输入其属性并对界线特征进行描述。

沿途所测地质体产状 (Attitude)、拍摄的照片 (Photo)、绘制的素描 (Sketch)、采集的样品 (Sample) 首先进行 GPS 定位，然后利用系统的新增菜单功能，依次把各要素点画到图上，在弹出的对话框内输入属性。

野外路线数据采集过程中，将遥感影像叠加于图层内，使地质实测与地质解译有机结合，提高了实测的精度。

2.3 数据整理

将掌上机野外采集的数据资料导入电脑版 DGSS 系统，按照《区域地质图图例 (1：50 000)》(GB 958-1999) 及其他相关要求进行数据整理。

(1) 将野外所采集的所有地质点 (Point) 移至对应的 GPS 点上，然后进行坐标重写入，在地质点属性项里检查完善地质点路线号、地质点号、填图单位、点两侧岩石名称，地质点文字描述 (PRB_P) 的岩石名称与地质点属性输入的岩石名称保持一致。薄片鉴定结果完成后，结合野外岩石定名进行综合定名，批注于地质点属性项内及文字描述框内。

(2) 将野外所采集的所有地质界线 (Boundary) 移至所对应的 GPS 点上，检查消除野外所画地质界线的错误，采用系统内的“三次 Bizer 光滑线”功能对线进行光滑美化。整个图幅的地质界线及断层的线型、线颜色、线宽等要素保持统一 (如地质界线的线型为 1，线颜色为 1，线宽为 0.1，断层线的线型为 1，线颜色为 6，线宽 0.15)。完善地质界线描述，用“界线左侧为…，界线右侧为…”来描述两侧岩石名称，对两侧岩性接触关系应给出明确表达并给出相关地质证据。

(3) 将野外所采集的所有地质路线 (Routing) 调整至 GPS 点上，衔接好各分段路线，然后采用系统内的“三次 Bizer 光滑线”功能对线进行光滑美化，整个图幅路线的线参数保持统一，本图幅采用的地质路线线型为 1，线颜色为 90，线宽为 0.1，随后对路线方位、距离等进行重新计算，最后检查完善路线描述内容 (包括路线岩性组成及变化特征等)，将分段路线岩性写入 free 图层内。

(4) 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，检查完善相关属性信息及描述信息，如产状的走向、倾向、倾角、产状类型、填图单位，样品的内容、镜头方向、照片详细说明，素描的名称、比例尺、素描图等。所有要素的编号据所属地质点按 1、2、3 等进行顺序编号。采用系统中“按属性值统改图层图示图例”功能对产状、样品统一修改参数，子图号按照国标规定，对于国标中没有明确规定的，本图幅统一规定子图号如下：面理 (流面及构造面理)1011，断层面

产状 996，接触面产状 1729，线理 1018，原生晕样 (Y) 1492，硅酸盐、稀土元素、微量元素分析样品 (GS、XT、WL)1737，微体化石鉴定样 (WT) 1215；孢粉鉴定样 (BF)1173；电子探针分析 (DT)1097；粒度分析样 (L) 1167。对于有鉴定测试结果的化石样及同位素测年样以红色表示。

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

在计算机 DGSS 系统中打开图幅 PRB 库，执行“更新野外总图库到实际材料图库”命令，系统自动将图幅 PRB 原始数据更新形成初始实际材料图 PRB 的数据，打开初始实际材料图界面，编制实际材料图。首先在图幅 PRB 库纸质图上编制实际材料图，连图时参考了同比例尺遥感影像，然后经计算机扫描，对其形成的图像进行校正，在此基础上编制出本图幅所辖的 4 幅 1∶25 000 实际材料图。实际材料图属性录入采用继承关系：地质界线 Geoline 的部分属性内容是从野外路线地质界线 (Boundary.wl) 上提取，地质体面实体 Geopoly.wp 的属性是从分段路线 (Routing.wl) 属性提取。提取后缺失的属性字段后期进行检查补充完善。实际材料图属性录入结束后利用综合检查工具进行了线弧一致性检查；地质界线代码与线型一致性检查；Geopoly 填图单位代号与注释一致性等检查。

2.4.3　编稿原图

将 4 幅 1∶25 000 实际材料图数据投影至 1∶50 000 编稿原图后，删除工程及文件夹中的多余文件 (PRB 库内容)，如地质点 (Point)、地质点注记 (GPTNOTE)、GPS、地质路线 (Routing)、地质界线 (Boundary)、free 等图层，保留产状、照片、素描、样品、化石等图层。修改地质界线 Geoline 及地质体面实体 Geopoly，首先删除内图框，四幅相邻处连接地质界线，拷贝 1∶50 000 内图框，从水系图层文件里拷贝面状水体界线添加到地质界线 Geoline，进行线拓扑错误检查，从原地质体面实体 Geopoly 提取 Label 点文件，拓扑造区，执行 Label 点与区合并后，其中属性字段和实际材料图属性字段一致，手动补充了少部分新的地质体和面状水体，重新整理岩性花纹、产状及注释、填图单位代号。在编稿原图新增的独立图层中，编制地层综合柱状图、图切剖面、图例、侵入岩填图单位划分表、大地构造位置图、接图表等图外整饰图层；按 1∶50 000 地质图地理底图编绘规范及地质图制作的相关标准及要求，最终形成标准的三川幅 1∶50 000 编稿原图。

2.4.4　地质图空间数据库

将三川幅 1∶50 000 编稿原图更新到空间数据库，进行数据库建设。执行自动合并编稿原图到空间数据库后，首先删除合并时不带下划线文件，把独立要素图层文件拷贝到成果数据库文件夹并添加到工程文件中，将_Sample 同位素样品点剪切添加到 ISTOPE 图层文件中，从地理图层拷贝水体界线添加到_Line_Geography 图层中。

(1) 基本要素类属性编辑。基本要素类属性继承了编稿原图的部分属性内容，并在成果数据库里完善了地质年代代号与编码 (遵循地质体代号与编码的上下标特殊符号表示的原则)，注意补充地质体面实体的子类型标识，补充地质界线的子类型标识和断层

编号，补充产状类型名称代码与名称，补充样品类型代码，补充照片题目，补充素描说明等。

(2) 综合要素类属性编辑。本图幅包括构造变形带、蚀变带、变质相带、火山岩相带、标准图框，除了标准图框外其余均是区文件，需要从地质体面实体图层文件里提取，综合要素属性编辑完成后，对所有要素类赋 ID，利用辅助检查工具进行属性检查。

(3) 对象类数据输入。本图幅提取的对象类包括沉积 (火山) 地层单位、侵入岩岩石年代单位，变质岩地层单位、脉岩 (面)、断层、面状水域与沼泽、非正式地层单位和图幅基本信息。

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、同位素测年、泉。

线实体：侵入界线、岩相界线、断层构造、引线、道路、水系、境界等。

面实体：沉积岩、侵入岩、变质岩、非正式地层单位、脉岩、水库。

3.2 数据内容评述

河南省三川幅 1：50 000 地质图数据库主要由基本要素类、综合要素类、对象类数据及独立要素类数据组成。

3.2.1 基本要素类

地质体面实体 (_GeoPolygon)(1 531 个)：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、子类型标识。晚侏罗世黑云母石英二长岩地质体面实体属性见表 3。

表 3 晚侏罗世黑云母石英二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	AI49E013014000000535
2	原编码	Source_Id	Character	
3	类型代码	*Feature_Type	Character	*η*oJ@3
4	名称	Geobody_Name	Character	晚侏罗世黑云母石英二长岩
5	时代	Geobody_Era	Character	J@3
6	下限年龄值(a.B.P)	Geobody_Age1	Double	0
7	上限年龄值(a.B.P)	Geobody_Age2	Double	0
8	子类型标识	Subtype	Interger	1

注：@代表后面数字格式为下标。

地质界线 (_GeoLine)(4 330 个)：地质界线代码、地质界线类型、界线左侧地质体代号、界线右侧地质体代号、子类型标识。

矿产地 (_Mineral_pnt)(33 个)：矿产地、矿种代码、原编码、矿种名称、共生矿、伴生矿、矿产地数、成矿时代、矿石品位、规模、矿产地名、矿化类型。

产状 (_Attitude)(385 个)：产状类型名称代号、产状类型名称、走向、倾向、倾角。

样品 (_Sample)(180 个)：样品类型代码、样品编号、原编码、样品类型名称、样品岩石名称。

照片 (_Photograph)(1 048 个)：照片编号、照片题目、照片说明。

素描 (_Sketch)(43 个)：素描编号、素描题目、素描说明。

化石 (_Fossil)(18 个)：化石所属生物门类、化石样品编号、原编码、化石属或种名、化石产出层位、含化石地层单位代号、化石时代。

同位素测年 (_Isotope)(19 个)：样品编号、样品名称、年龄测定方法、测定年龄、被测定出地质体单位及代号、测定分析单位、测定分析日期。

火山口 (_Crater)(1 个)：火山口类型、火山口名称、火山口大小、火山产出的地质体单位及代号、火山口岩石类型、火山口形成时代。

河、水库岸线 (_Line_Geography)(434 个)：图元类型、图元名称、子类型标识。

泉 (_Spring)(15 个)：泉类型代码、泉类型名称。

3.2.2 综合要素类

构造变形带 (_Tectzone)(17 个)：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。

蚀变带 (_Alteration_Polygon)(8 个)：蚀变类型名称代号、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。

变质相带 (_Metamor_Facies)(22 个)：变质相带地质体代号、变质相带岩石颜色、变质相带类型、变质程度、变质温压条件、变质相带岩石结构、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。

火山岩相带 (_Volca_Facies)(42 个)：火山岩岩相类型及代码、产出的地层单位及代号、火山岩相岩石类型、岩石结构、岩石构造、形成时代、所含矿种。

标准图框 (内图框)(_Map_Frame)(4 个)：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。

3.2.3 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。

侵入岩岩石年代单位 (_Intru_Litho_Chrono)(31 个)：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、形成时代、含矿性。晚侏罗世黑云母石英二长岩侵入岩年代单位属性表见表 4。

断层 (_Fault)(119 个)：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。

变质岩地 (岩) 层单位 (Metamorphic)(3 个)：地 (岩) 层单位名称、地 (岩) 层单位符号、地 (岩) 层单位时代、岩石名称、岩石结构、岩石构造、主要矿物及含量、特征变质矿物及含量、地层产状、矿物组合及含量、含矿性、所属变质相带、岩层厚度、岩石颜色。

非正式地层单位 (Inf_Strata)(48 个)：非正式地层单位代码、岩性、岩石结构构造、

表 4　晚侏罗世黑云母石英二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	ηoJ@3
2	岩体填图单位名称	Intru_Body_Name	Character	晚侏罗世黑云母石英二长岩
3	岩体填图单位符号	Intru_Body_Code	Character	ηoJ@3
4	岩石名称(岩性)	Rock_Name	Character	黑云母石英二长岩
5	岩石颜色	Color	Character	黄褐色
6	岩石结构	Rock_Texture	Character	似斑状结构，基质不等粒结构
7	岩石构造	Rock_Structure	Character	块状构造
8	岩相	Rock_Phases	Character	侵入相
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	条纹长石斑晶5%~10%，基质石英7%~12%，角闪石6%~10%，平均8%±
11	次要矿物及含量	Secondary_Mineral	Character	黑云母2%
12	与围岩接触面走向	Strike	Integer	*
13	与围岩接触面倾向	Dip_Direction	Integer	*
14	与围岩接触面倾角	Dip_Angle	Integer	*
15	形成时代	Era	Character	J@3
16	含矿性	Commodities	Character	*
17	子类型标识	Subtype	Integer	0

注：@代表后面数字格式为下标。

所含生物化石带或生物组合、出露宽度或厚度、含矿性、所在地层单位符号。

脉岩 (_Dike_Object)(5 个)：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、形成时代、含矿性。

面状水域 (_Water_Region)(1 个)：要素分类代码、图元类型、图元名称、图元特征。

图幅基本信息 (_Sheet_Mapinfo)(1 个)：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

(1) 野外质量控制和评估

河南省三川幅 1：50 000 地质图数据库严格按照《区域地质调查技术要求 (1：50 000)》(DZ/T 0001−1991) 等相关规范开展工作，野外采用数字填图设备采集数据，手图采用 1：25 000 数字化地形图。按照工作分区采用不同的填图方法，在系统收集和综合分析已有地质资料基础上，开展 1：50 000 区域地质调查。其中，沉积 (浅变质) 岩区 (官道口群、栾川群、陶湾群) 采用岩石地层法填图，进行基本层序划分；侵入岩区在填绘侵入体的基础上，采用岩性填图；变质岩区 (宽坪岩群) 采用构造–地 (岩) 层–事件法；火山岩区 (熊耳群及栾川群大红口组) 采用火山地层—岩性 (岩相) 双重填图法，进行单元流层、韵律划分，通过参考前人资料进行火山机构解译，围绕火山机构布设放射状调查路线；第四系采用地质–地貌双重填图法。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，对第四系中的基岩露头，不论大小均进行了勾绘，不足填图尺寸的地质体通过放大进行表示。图幅内共完成路线总长度 613.8 km，地质点数 1 952 个，平均 4.52 个 /km^2，地质界线 3 778 个，平均点距 314 m，采集岩石地球化学样品 180 件，同位素年龄测试样品 19 件，产状 3 435 个，素描图 43 张，照片 1 048 张，化石点 18 个，火山口 1 个，矿产地 33 个。填图精度达到 1∶50 000 地质填图的具体要求。

(2) 测试数据质量控制和评估

各类测试样品的采集均按有关规定执行，均经具有相应资质的单位测试，鉴定报告和测试数据准确可靠，符合要求。其中硅酸盐、稀土元素、微量元素样品由国土资源部武汉矿产资源监督检测中心分析测试；微体古生物样由中国地质科学院高联达研究员鉴定；锆石 U–Pb 测年及锆石 Hf 同位素分析由天津地质矿产研究所完成；电子探针微区分析由郑州矿产资源综合利用研究所承担；粒度分析由河北省欣航测绘院实验室完成。

(3) 数据库质量控制

河南省三川幅 1∶50 000 地质图数据库建设，遵循《数字地质图空间数据库建库标准》(DD2006−06) 等相关标准，在原始资料数据库基础上，从野外手图、图幅 PRB 库、实际材料图、编稿原图到成果数据库的整个建库过程严格利用空间数据库辅助检查工具进行线弧一致性检查、地质体面实体的地质代号与图形参数匹配检查、要素类与对象类逻辑一致性检查、产状类型名称与符号一致性检查、地质体面实体代号与注记一致性检查。

(4) 工作过程监控

工作过程中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，严格按照有关规范开展工作。野外工作前统一填图单位划分标准，工作期间不间断开展自检、互检和抽检。自检、互检率 (包括数据库) 均为 100%，项目负责人抽查地质路线比例为 32%、抽查地质剖面比例为 35%，抽查数据库比例为 100%，河南省地质调查院技术管理部门每年赴野外对本项目进行质量检查和指导，其中抽查地质路线比例为 6%、抽查地质剖面比例为 9%，抽查数据库比例为 100%，中国地质调查局天津地质调查中心每年组织专家采用室内和现场相结合的方式对本项目原始资料及数据库进行质量检查，结论为“质量管理体系运行正常，总体质量较好，质量等级为良好级”。中国地质调查局天津地质调查中心于 2018 年 10 月 22—27 日组织有关专家在河南省洛阳市对该项目取得的原始资料及其原始资料数据库进行了野外工作验收，评分 91 分，属优秀级。于 2019 年 1 月 27—28 日再次组织有关专家在河南省郑州市对该项目进行成果验收，评分 91 分，属优秀级；并于 2019 年 8 月 3 日在天津市对三川幅数据库进行了验收，评分 91 分。

5 数据价值

河南省三川幅 1∶50 000 地质图数据库建设中，地质调查工作以现代板块构造为指导，在充分吸收前人资料和成果的基础上，围绕三川图幅区内存在的重大问题重点开展调查和研究工作，获取了一批基础数据和地质科学问题新认识。

5.1 基础数据

本数据库分析整理了三川图幅区的岩石地球化学测试分析数据 (表 5)，可以反映该

区的岩石和矿床成因、成岩和成矿年龄等重要信息，为河南省三川幅区域地质背景与秦岭造山带地质历史演化研究提供科学依据。同时，数据库还汇总了化石、矿床、泉水等分布点 (表 5)，为地质遗迹调查、矿产勘查和水资源勘查提供参考价值。

表 5　河南省三川幅 (I49E013014) 地质图空间数据库数据表

数据类型	数据量	数据基本特征
岩石化学分析数据	180件	火山岩、侵入岩的11种主量元素
微量元素分析数据	180件	火山岩、侵入岩的31种微量元素
同位素年龄数据	19件	火山岩、侵入岩、碎屑岩的LA–ICP–MS锆石U–Pb同位素年龄
化石点数量	18个	几丁虫、虫鄂、疑源、苔藓植物孢子
矿点数量	33个	铁矿(10个)、铅矿(10个)、钼矿(5个)、铜矿(3个)、金矿(1个)、锌矿(1个)、锰矿(1个)、石墨矿(1个)、软玉矿(1个)
矿床类型	5种	热液型、矽卡岩型铅锌钼矿，沉积变质型铁矿、石墨矿、软玉矿，风化壳型金矿，沉积型锰矿
泉点数量	15个	矿泉水

5.2　地质科学问题新认识

(1) 在区内陶湾群层型剖面上发现较丰富的几丁虫 (*Desmochitina minor cocco* Eisenack 等)、虫鄂 (*Pronereites primes* Stauffer 等)、疑源 (*Rhopaliophora palmata* 等)、苔藓植物孢子 (*Pseudodyosporalaevigata* Johusson) 微体化石，部分化石在中国首次发现，具有多门类、时限短的特点，以此确定了陶湾群时代归属于奥陶纪，并很可能为早奥陶世 (Eisenack, 1962; Combaz and Penignel, 1972; Timofeev, 1973; Johnson, 1985; 高联达, 1986; 胡元绪等, 1986; 卢礼昌等, 1987; 高联达, 1991; 王宗起等, 2007)。在陶湾群内发现火山岩夹层，夹层厚 5 ~ 7.7 m，岩性为变杏仁状安山岩、黑云母变安粗岩，为拉张背景下形成的碱性火山岩。由此推测华北陆块南缘在奥陶纪时期发育伸展性盆地。

(2) 在三川镇祖师庙一带发现震旦纪冰积–冰水沉积砾岩，以发育冰积落石为特征，根据特征对比为罗圈组。

(3) 确定宽坪岩群四岔口岩组、谢湾岩组内的绿片岩大部分为火山岩，以发育大量残余杏仁、高 TiO_2 为特征，分属碱性系列与拉斑玄武岩系列，该火山岩形成于板内裂解环境，指示宽坪岩群主体形成于伸展性盆地。

(4) 在图幅区北部的官道口群出露区填绘出辉长岩、霓石正长岩岩墙群，属碱性系列，以高稀土、高 TiO_2 为特征，与南部的栾川群内部广泛分布的青白口纪辉长岩、正长岩 (中国地质调查局天津地质调查中心, 2019) 可以对比，二者构成双峰式岩套，共同反映了青白口纪的裂解事件。在图幅区南部填绘出志留纪 (428±11 Ma) 碱长花岗斑岩岩墙群，经分析，与古生代秦岭洋闭合碰撞后的间歇性松弛有关，从而限定了秦岭洋关闭的时代。对与成矿有关的晚中生代侵入岩进行了详细解体，根据接触关系将其确定为 5 次侵入活动，在火神庙、黄背岭、南泥湖侵入体中均发现闪长质包体，表明该期侵入岩存在着不同程度的岩浆混合，为研究岩浆起源及栾川超大型钼钨多金属矿的成因提供了地质依据。

(5) 将褶皱主要划分为早古生代、早中生代、晚中生代 3 期。发现陶湾群北界与栾川群为平行不整合接触，将陶湾群南界与宽坪岩群之间的断裂确定为栾川断裂，确定栾川断裂带主要有 3 期活动，主活动期为早古生代，表现为向北推覆；早中生代表现为向

南推覆；晚中生代表现为右行平移。论证了区内早古生代、早中生代、晚中生代的地质构造，分别为早古生代碰撞造山、早中生代碰撞造山、滨太平洋体系汇聚加厚和岩石圈伸展减薄的响应。

(6) 新发现 8 个矿化点，确定了 1 个找矿靶区。

河南省三川幅 1∶50 000 地质图数据库成果可为该区的后续地质矿产工作提供基础数据支撑，提升地质矿产调查工作服务于找矿勘探、地质灾害防治、生态环境保护与修复、国土空间规划、地质遗迹保护与科谱、地质科研与教学的能力。

6　数据使用方法和建议

河南省三川幅 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同种或不同比例尺基本地质信息库，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。本数据库为 MapGIS 矢量数据格式，包括各填图单位的组成、火山岩相和变质岩相的特征、断层性质、产状和样品的属性，内容翔实丰富，查询方便，可编辑性强，并能够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) 河南省三川幅 (I49E013014)1∶50 000 地质图在三川幅沉积岩区进行了基本层序划分，实行构造–岩性填图，突出特殊地质体及非正式填图单位的表达，提高了填图精度。

(2) 在陶湾群层型剖面上发现了多门类、时限短的微体化石，陶湾群时代为奥陶纪，并很可能为早奥陶世。陶湾群发现的碱性火山岩夹层指示奥陶纪在华北陆块南缘发育伸展性盆地。确定宽坪岩群四岔口岩组、谢湾岩组内的绿片岩为板内火山岩，指示宽坪岩群主体形成于伸展性盆地。

(3) 在图幅区北部的官道口群内新填绘出的辉长岩、霓石正长岩等均属碱性系列，与南部的栾川群内广泛分布的青白口纪辉长岩、正长岩可以对比，共同反映了青白口纪的裂解事件。在图幅区南部新填绘出的碱长花岗斑岩岩墙群为志留纪，为板块碰撞后松弛产物，说明秦岭洋关闭的时代应不晚于志留纪。

(4) 确定陶湾群南界与宽坪岩群之间的断裂应为栾川主断裂。栾川断裂带主要有 3 期活动，主活动期为早古生代，表现为向北推覆；早中生代表现为向南推覆；晚中生代表现为右行平移。区内相应发育 3 期褶皱。区内主要的地质构造分别为早古生代碰撞造山、早中生代碰撞造山、晚中生代滨太平洋体系汇聚加厚和岩石圈伸展减薄的响应。

(5) 河南省三川幅 (I49E013014)1∶50 000 地质图数据库系统反映了本次地质调查共享获取的基础数据和新成果认识，信息量大，查询检索方便，可为找矿勘探、地质灾害防治、生态环境保护与修复、国土空间规划、地质遗迹保护与科普、秦岭造山带研究与教学等提供基础性支撑。

致谢：河南省三川幅 1∶50 000 地质图是一项集体成果，野外一线地质工作人员付出了辛勤的努力，刘文斌、贺承广、翟文建、孙学静参与了数据采集过程，在地质图数据库的建立过程中，得到天津地质调查中心赵风清研究员、辛后田研究员、李承东教授级高工、山西省地质调查院潘永胜教授级高工、孙占亮教授级高工、河南省地质调查院王世炎、张延启、方怀宾教授级高工、中国地质大学周志广教授等地质矿产专家的辛勤指导，在此对各位专家和野外项目组所有成员表示最诚挚的感谢。

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Received: 15-04-2020
Accepted: 14-06-2020

Fund Project:
jointly funded by the projects titled "Geological and Mineral Survey of Zhongtiao—Xiong'ershan Metallogenic Area" (No.: DD20160043) and "1∶50 000-scale Regional Geological and Mineral Survey of Baitujie and Sanchuan Map-sheets, Henan Province" (No.: DD2016 0043-02) initiated by the China Geological Survey

doi: 10.12029/gc2020Z116

Article Citation: Chao Hongli, Ren Jiande, Lyu Jigen, Xie Chaoyong, Li Yingqi, Li Ruiqiang, Jiao Jinghua. 2020. 1∶50 000 Geological Map Database of Sanchuan Map-sheet, Henan Province[J]. Geology in China, 47(S1):243−266.
Dataset Citation: Ren Jiande; Lyu Jigen; Zhang Yixing; Chao Hongli; Xie Chaoyong; Li Chunyan; Li Yingqi; He Chengguang; Wang Xiaojuan; Li Ruiqiang; Zhai Wenjian; Jiao Jinghua; Sun Xuejing; Li Min; Liu Shanshan. 2020. 1∶50 000 Geological Map Database of Sanchuan Map-sheet, Henan Province(V1). Henan Institute of Geological Survey[producer], 2016. National Geological Archives of China[distributor], 2020-06-30. 10.35080/data.A.2020.P16; http://dcc.cgs.gov.cn/en//geologicalData/details/doi/10.35080/data.A.2020.P16.

1∶50 000 Geological Map Database of Sanchuan Map-sheet, Henan Province

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Abstract: The 1∶50 000 Geologic Map Database of Sanchuan Map-sheet (I49E013014), Henan Province (also referred to as the Database) was established using data obtained through practical measurement and digital mapping. The structural and lithologic mapping was conducted during field data acquisition, focusing on the presentation of special geological blocks and informal mapping units. The samples collected in the field included 66 samples for microscopic petrography identification, 180 samples for whole-rock petrochemical analysis, 19 samples for isotopic dating, and 21 samples for chemical analysis in total. In this study, the main achievements obtained in this map-sheet are as follows. The Taowan Group was found to have occurred during the Ordovician according to multiple taxonomic classifications and short age ranges found in its stratotype section. Alkaline volcanic intercalations were found in the Taowan Group, indicating that an extensional basin developed on the southern margin of the North China Plate in the Ordovician. The greenschists in the Sichakou Formation and Xiewan Formation of the Kuanping Group were determined to be intraplate volcanic rocks, indicating that the main part of the Kuanping Group was formed in an extensional basin. The dike swarms of Silurian alkali-feldspar granite porphyry were found in the southern part of the map-sheet by mapping, restricting the closure era of the Qinling Ocean to a time not later than the Silurian. The intrusions of the late Mesozoic were divided into five intrusive stages. The Luanchuan fault zone was determined to have undergone three stages of activities in the early Paleozoic, early Mesozoic, and late Mesozoic. Furthermore, Sinian glacial sediments were newly discovered in the map-sheet. The Database consists of data on feature classes, complex classes,

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and object classes, with a data size of about 63.5 MB. It fully reflects the geological and mineral achievements of the map-sheet, and will provide basic data for mineral exploration and exploitation and prevention and control of geological hazards in the map-sheet, research on the Qinling Orogenic Belt, and the popularization of geoscience.
Key words: database; geological map; 1∶50 000; Sanchuan map-sheet; Henan Province; Qinling Orogenic Belt; geological survey engineering
Data service system URL: http://dcc.cgs.gov.cn

1 Introduction

The area covered by the 1∶50 000 geological map of Sanchuan map-sheet, Henan Province (also referred to as the study area) is in the western part of Henan Province. It lies between the Sanmenxia–Lushan and Zhuyangguan - Xiaguan faults on the southern margin of the North China Plate (Fig. 1). With the Luanchuan fault zone as the boundary, its southern part is the Kuanping back-arc basin in the eastern segment of the North Qinling Orogenic Belt (Zhang SG et al., 1991; Zhang ZQ et al., 1995; Lu SN et al., 2003), and its northern part is a thrust nappe tectonic zone on the southern margin of the North China Plate (Henan Institute of Geological Survey, 2013). During the Mesoproterozoic - Neoproterozoic, the study area was on the passive continental margin of the Qinling Ocean, with the Jixianian Guandaokou carbonate platform (Zhang H et al., 2019) and Qingbaikouian Luanchuan continental-margin rift basin (Shi QZ et al., 1996; Yan GH et al., 2007; Tianjin Center of China Geological Survey, 2019) developing. In the early Paleozoic, the study area was transformed into an active continental margin, with the Ordovician Taowan Group being deposited on the southern continental slope (Wang ZQ et al., 2007, 2009). Afterwards, the study area successively underwent Qinling Ocean closure - collisional orogenesis at the end of the early Paleozoic, Mianlue Ocean closure - collisional orogenesis in the Triassic (Tianjin Center of China Geological Survey, 2019), and the convergence and thickening of the peri-pacific system and the extension and thinning of the lithosphere during the Jurassic - Cretaceous. As a result, the current complicated geological tectonic framework (Mao JW et al., 2018; Fig. 2) and world-class molybdenum-tungsten polymetallic deposits were formed in the study area.

The geological surveys of the study area began in the 1930s. In contrast, systematic geological prospecting of the area was conducted after the 1950s, and the following surveys were successively carried out: 1∶200 000-scale regional geological survey, 1:100 000-scale airborne radioactivity measurement, 1∶50 000-scale aeromagnetic survey, 1∶50 000-scale stream sediment survey, as well as the thematic surveys focusing on metallogenic belts including 1∶50 000-scale regional geological survey, 1∶200 000-scale gravity survey, 1∶250 000-scale regional geological survey, and 1∶50 000-scale mineral prospect survey and high-precision ground magnetic survey. Meanwhile, many scholars conducted intensive research on the genesis and formation eras of the strata and rocks, the stages and evolution of the structures, and the genesis and metallogenic properties of the deposits in the study area (Sheng ZL et al., 1980; Luo MJ et al., 1991; Song CZ et al., 1999; Ye HS et al., 2006; Huo LX

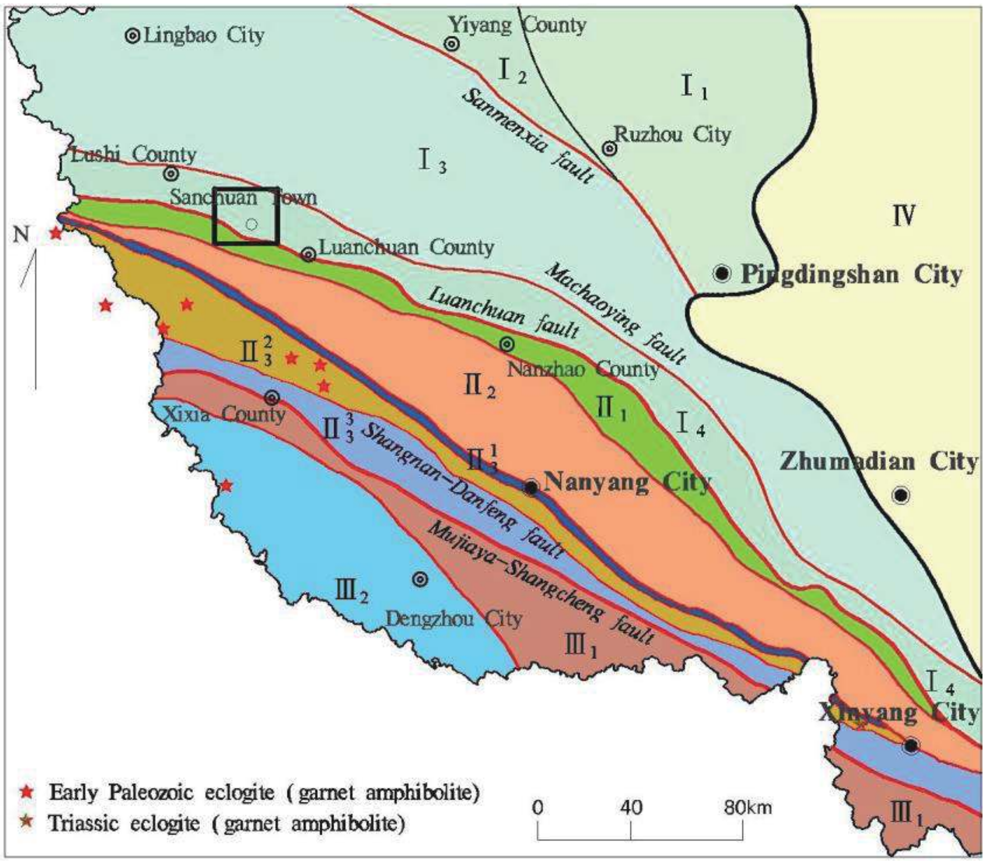

Fig. 1 Geotectonic location map of Sanchuan map-sheet, Henan Province

I–North China Plate; I_1–Shanxi-Henan epicontinental-sea basin; I_2–Northern branch of Xiong'er paleo-rift; I_3–Fold-fault belt on the southern margin of North China plate; I_4–Thrust nappe tectonic zone on the southern margin of North China plate; II–North Qinling Orogenic Belt; II_1–Kuanping back-arc basin; II_2–Erlangping Paleozoic island arc and back-arc basin; II_3–Guishan–Xiaguan suture zone; II_3^1–Zhuyangguan–Xiaguan ophiolitic melange zone; II_3^2–North Qinling Microcontinent (Zhaigen ultrahigh-pressure metamorphic zone); II_3^3–Zhenping–Guishan (Shangnan–Danfeng) subduction-accretionary complex; III–South Qinling Orogenic Belt; III_1–Douling–Dabie Mesoproterozoic–Neoproterozoic microcontinent; III_2–Xichuan Sinian Paleozoic carbonate platform; IV–Cenozoic superimposed inland basin

et al., 2008; Lu SN et al., 2009; Yang et al., 2013, 2017; Tianjin Center of China Geological Survey, 2015, 2019; Wang S et al., 2016). All these works provided critical fundamental information for preparation of the 1：50 000 geological map of Sanchuan map-sheet, Henan Province. However, some scientific issues of the study are still under dispute owing to the complicated geological tectonics in the area. The issues are mainly about the Kuanping Group, Taowan Group, Luanchuan fault zone, and the time limits of subduction and closure of the Qinling Ocean. The details are as follows: (1) The age range of the Kuanping Group is controversial. Some scholars think that it is of the Mesoproterozoic - Neoproterozoic (Shaanxi Bureau of Geology and Mineral Resources, 1989; Department of Geology and Mineral Resources of Henan Province, 1997; Zhang SG et al., 1991; Dong Y et al., 2014; Zhang ZQ et al., 1995; Yan QR et al., 2008; Zhang GW et al., 2001), while others argue that it was formed during the Neoproterozoic - early Paleozoic (Lu SN et al., 2003; Diwu CR et al., 2010a; Li CD et al., 2018) or early Paleozoic (Wang ZQ et al., 2009); (2) There are different opinions on the formation environment of the Kuanping Group. One such opinion is that the Kuanping Group

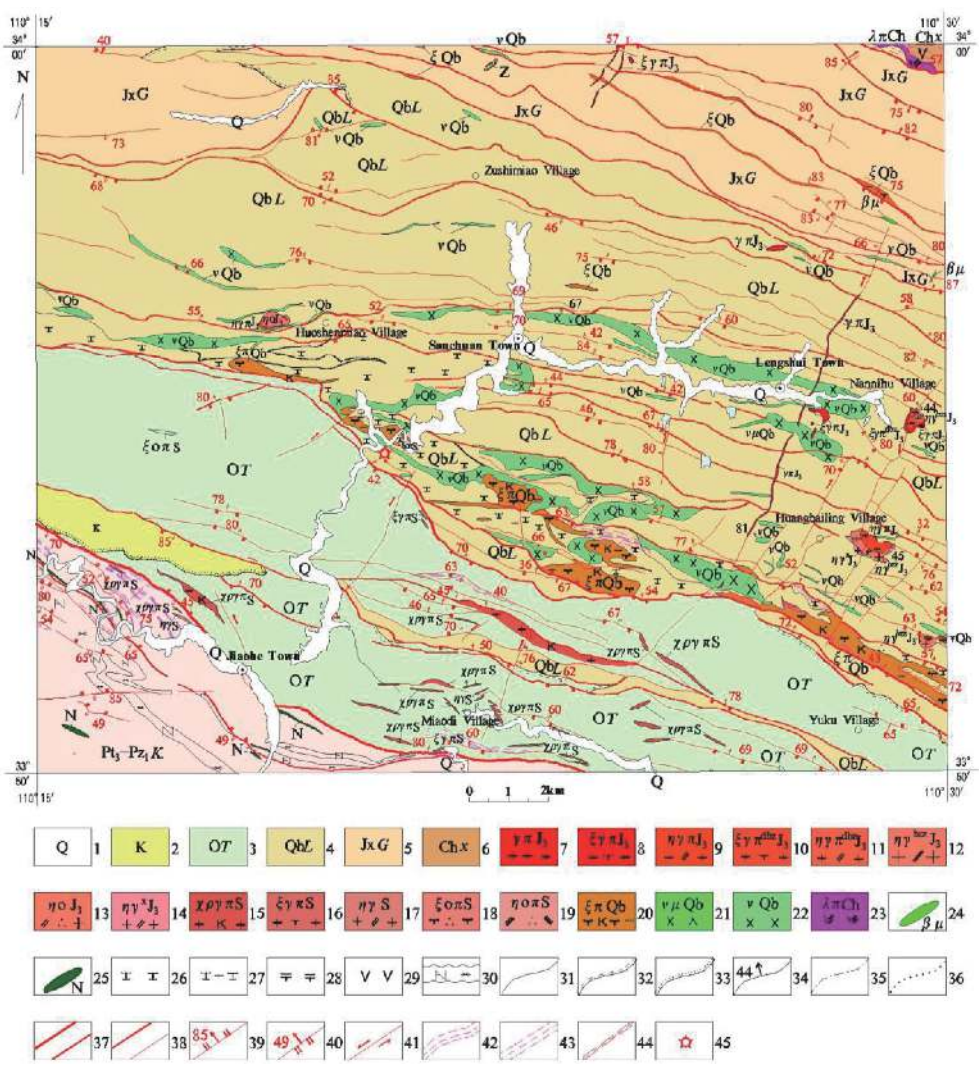

Fig. 2 Geological sketch of Sanchuan area, Henan Province

1–Quaternary; 2–Cretaceous; 3–Ordovician Taowan Group; 4–Luanchuan Group of Qingbaikou System; 5–Guandaokou Group of Jixian System; 6–Xushan Formation of Xiong'er Group of Changcheng System; 7–Late Jurassic granite porphyry; 8–Porphyritic syenogranite porphyry; 9–Porphyritic monzonitic granite porphyry; 10–Highly-porphyritic syenogranite porphyry; 11–Highly-porphyritic monzonitic granite porphyry; 12–Lowly- to moderately-porphyritic medium-grained bio-adamellite; 13–Low- to moderately-porphyritic fine-grained biotite-quartz monzonite; 14–fine-grained adamellite; 15–Silurian alkali-feldspar granite porphyry; 16–Syenogranite porphyry; 17–Fine-grained bio-adamellite; 18–Quartz orthophyre; 19–Quartz-monzonite porphyry; 20–Metamorphic biotite-alkali-feldspar orthophyre of Qingbaikou period; 21–Metagabbro porphyrite; 22–Metamorphic medium-grained gabbro; 23–Subvolcanic rhyolitic porphyry of Changcheng period; 24–Diabase-porphyrite dike; 25–Basic dike; 26–Trachyte; 27–Biotite trachyte; 28–Latite; 29–Andesite; 30–Albite-actinolite schist; 31–Conformity; 32–Parallel unconformity; 33–Angular unconformity; 34–Intrusive contact; 35–Pulsating intrusive boundary; 36–Facies-transition boundary; 37–Fault on the boundary of first- and second-order tectonic units; 38–Major fault; minor fault; 39–Normal fault; 40–Thrust fault and attitude; 41–Strike-slip fault; 42–Foliated belt; 43–Mylonite belt; 44–Ductile shear zone; 45–Crater

was formed due to the merging of rock slices of different genesis (Jia CZ et al., 1988; Zhang SG et al., 1991; Wang ZQ et al., 2009; Diwu CR et al., 2010a; Dong et al., 2014). Some scholars consider that the Kuanping Group is a back-arc basin (Lu SN et al., 2003; Zhang ZQ, 1995; Zhang SG et al., 1991). Another opinion is that the Kuanping Group was formed in the continental rift environment on the southern passive margin of the North China Plate (Yan QR et al., 2008; Zhang GW et al., 2001); (3) The tectonic attribute of the Taowan Group is highly controversial. Some scholars think that the Taowan Group is a rock slice of the Qinling Orogen (Henan Institute of Geological Survey, 2002), while others think that it resulted from the sedimentation of deep parts of the epicontinental sea on the southern margin of the North China Plate (Henan Institute of Geological Survey, 2013); (4) The formation era of the Taowan Group was mainly determined based on the research of microfossils in Shaanxi Province (Wang ZQ et al., 2007, 2009). However, direct evidence for the formation era of the Taowan Group has not been found in the Luanchuan area, where the Taowan Group was established, named and its stratotype section is located; (5) The properties and activity stages of the Luanchuan fault are still under dispute. Some scholars consider the Luanchuan fault to be the fault on the northern boundary of the Taowan Group (Regional Geological Survey Team of the Department of Geology and Mineral Resources of Henan Province, 1995; Henan Institute of Geological Survey, 2002), while others consider the Luanchuan fault to be the fault on the southern boundary of the Taowan Group (Song CZ et al., 2009; Henan Institute of Geological Survey, 2013). Given the aforementioned geological issues, the geological survey in this study was conducted under the guidance of the modern theory of plate tectonics, during which field measurement combined with high-resolution remote sensing interpretation were adopted, and the special geological blocks and informal mapping units were highlighted by adopting tectonic and lithologic mapping. As a result, a number of critical achievements were obtained. The Database (Table 1; Ren JD et al., 2020) comprehensively reflects the achievements obtained from a new round of geological and mineral survey and scientific research in the study area. It will provide detailed references for field geological survey, scientific research, and geoscience popularization in the area, and will offer basic geological maps for follow-up mineral resource survey, geological hazard survey, ecological environment survey and restoration, and spatial planning of land.

2 Methods for Data Acquisition and Processing

2.1 Data Preparation

The 1：50 000 geological map of Sanchuan map-sheet, Henan Province was prepared in accordance with the *General Principles on Regional Geological Survey* (*1：50 000*) (DZ/T 0001–1991) and the *Guidelines for 1：50 000-Scale Regional Geological Survey* (Trial, 2016) based on full collection and comprehensive analysis and utilization of existing geological and mineral materials (Table 2). It was guided by geological theories such as the modern theory of plate tectonics and continental dynamics, as well as the research on regional geological tectonics. The technologies of remote sensing (RS), global position system (GPS), and geographic information system (GIS) were fully applied. The digital mapping (PRB) technology was adopted to conduct tectonic and lithologic mapping, with the presentation of special geological blocks and informal mapping units being highlighted. The basic geological survey in the study area was conducted by employing systematic measurements based on the principle of combining remote sensing interpretation with ground survey, macroscopic

Table 1 Metadata Table of Database (Dataset)

Items	Description
Database (dataset) name	1：50 000 Geologic Map Database of Sanchuan Map-sheet, Henan Province
Database (dataset) authors	For structures: Ren Jiande, Li Chunyan, Zhai Wenjian, Henan Institute of Geological Survey For sedimentary rocks: Lyu Jigen, Li Yingqi, Jiao Jinghua, Henan Institute of Geological Survey For volcanics: Zhang Yixing, He Chengguang, Sun Xuejing, Henan Institute of Geological Survey For intrusions: Chao Hongli, Wang Xiaojuan, Li Min, Henan Institute of Geological Survey For metamorphic rocks: Xie Chaoyong, Li Ruiqiang, Liu Shanshan, Henan Institute of Geological Survey
Data acquisition time	2016—2018
Geographical area	111°15′–111°30′ E, 33°50′–34°00′ N
Data format	MapGIS
Data size	63.5 MB
Data service system URL	http://dcc.cgs.gov.cn
Fund project	Jointly funded by the projects titled *Geological and Mineral Survey of Zhongtiao-Xiongershan Metallogenic Area* (No.: DD20160043) and *1：50 000-scale Regional Geological and Mineral Survey of Baitujie and Sanchuan Map-sheets*, *Henan Province* (No.: DD20160043-02) initiated by the China Geological Survey
Language	Chinese
Database (dataset) composition	The Database consists of databases and map decorations of a 1：50 000 geological map. The databases include data on sedimentary rocks, volcanics, intrusions, metamorphic rocks, the Quaternary, dikes, structures, geological boundaries, attitudes, isotopic samples and ages, fossil samples, craters, lithologic patterns, geological codes and place names, roads, rivers, and reservoirs. The map decorations include an index map, histograms, a division table of intrusion mapping units, legends, transverse cutting profiles, a geotectonic location map, and a duty table.

geological mapping with microscopic geological mapping, and surface survey with dissection of critical areas. The database was set up in strict accordance with the *Standard on Spatial Databases for Digital Geological Maps* (DD 2006–06) and the *Detailed Rules for Building of 1：50 000 Regional Geological Map Spatial Database* (*Provincial level*) (2008). The latest geographic data from the National Administration of Surveying, Mapping and Geoinformation of China were adopted in the geographic base map. Meanwhile, relevant data were processed according to existing technical standards using software such as the Digital Geological Survey System (DGSS 1.0) and MapGIS.

2.2 Data Acquisition

2.2.1 Data Acquisition and Preparation

For the data acquisition in this study, the topographic map was taken as 1：50 000 digital topographic map from the National Geomatics Center of China, and the Gauss-Kruger

Table 2 Data basis of Sanchuan map-sheet

No.	Data type	Data content	Source
1	Geological survey	1：200 000-scale geological survey report of Luanchuan map-sheet (I49–XXII)	Qinling Geological Team of Henan Bureau of Geo-exploration & Mineral Development, 1958
2	Regional geophysical exploration	Result report of 1：100 000-scale aeromagnetic survey and airborne radioactivity measurement in West Henan Province	902nd Aeromagnetic Team of Geophysical Exploration Bureau under the Ministry of Geology and Mineral Resources, 1960
3	Regional geophysical exploration	Survey and research report of 1：50 000-scale aeromagnetic survey in West Henan Province	903rd Team of Geophysical Exploration Bureau under the Ministry of Geology and Mineral Resources, 1966
4	Regional geochemical exploration	Survey and research report of stream sediments in Sanchuan-Heyu area, Luanchuan County, Henan Province	2nd Geophysical Exploration Team of the National Geological General Administration, 1975
5	Geological survey	1：50 000 regional geological survey report of South Luanchuan County	3rd Geological Survey Team of Henan Bureau of Geo-exploration & Mineral Development, 1977
6	Mineral exploration	Detailed exploration geological report of molybdenum-tungsten deposits in Sandaozhuang mining area, Luanchuan County, Henan Province	1st Geological Survey Team of Henan Bureau of Geo-exploration & Mineral Development, 1980
7	Regional geophysical exploration	1：200 000-scale regional gravity survey report of Southwest Henan Province	Geophysical Exploration Team of Henan Bureau of Geo-exploration & Mineral Development, 2000
8	Geological survey	1：250 000-scale regional geological survey report of Neixiang map-sheet	Henan Institute of Geological Survey, 2002
9	Mineral survey	Mineral prospect survey of Lushi area, Henan Province	Henan Institute of Geological Survey, 2009
10	Geological survey	Result report of regional geological survey of key areas of West Henan Province	Tianjin Center of China Geological Survey, 2015
11	Geological survey	Report of geological survey and result integration of key areas of Zhongtiao Mountain —Xiong'er Mountain metallogenic area	Tianjin Center of China Geological Survey, 2019

projection, Xi'an 1980 geodetic coordinate system, and National Height Datum 1985 were adopted as the projection type, ellipsoidal parameters, and elevation datum, respectively. The PRB dictionary library was developed according to the specific conditions of the study area based on both field survey and full utilization of previous data.

The remote-sensing images used for data acquisition in this study were obtained from satellites TM8-OLI and SPOT7 (precision: 2.5 m), with respective time phases of TM8-OLI and SPOT7 of February 9, 2014 and December 16, 2015. Meanwhile, the band combination adopted consisted of Band7(R) + Band5(G) + Band2(B) + the panchromatic band in SPOT7. Therefore, the images are clear. The remote sensing anomalies were extracted by using the "De-interfered Anomalous Principal Component Thresholding" technique popularized by the China Geological Survey. Data from Enhanced Thematic Mapper (ETM) were collected as data sources (time phase: January 21, 2014, band combination: Band7 + Band4 + Band1). The remote sensing anomalies of hydroxyl and iron-staining were extracted by digital image processing methods, with a ground pixel resolution of 30 m × 30 m. B1, B4, B5, and B7 were utilized to extract hydroxyl (argillization) anomalies, while B1, B3, B4, and B5 were used to extract iron-staining (ferrugination) anomalies.

2.2.2 Field Data Acquisition Along Routes

The features acquired along field survey routes for the building of the Database include geological points, geological boundaries, geological routes, samples, sketches, attitude, and images. The freehand field maps were developed with the 1：25 000 topographic map as the base map. Then the original digital mapping (PRB) database was preliminarily established in DGSS through field survey.

Process of adding geological points (Point): Geological points serve as the base of all the data acquired along the field routes. During field data acquisition, the coordinates of the geological points were automatically obtained from GPS, and the attributes of the geological points were input in the popped-up dialogue box in DGSS, including route no., geological point no., micro-landform, sites, outcrops, weathering level, location description, mapping unit, and names and contact relationships of rocks on two sides of the geological points.

Process of adding segmented routes (Routing): select the “adding new route data” and “adding a segmented route” in turn in the field route window of DGSS, and then draw the route trajectory at the corresponding locations of the map. Afterwards, input the attributes and description of the segmented route in the popped-up segmented route attribute table, including route no., geological point no., route code, direction, the distance of current station, accumulative distance, mapping units, and rock names. Among these attributes, the direction, the distance of current station, and accumulative distance were automatically read by DGSS.

Process of adding geological boundaries (Boundary): select the “adding new route data” and “adding a geologic boundary between geologic points” in turn in the field route window of DGSS, and then draw lines at the corresponding locations on the freehand field map. Afterwards, input the attributes and characteristic descriptions of the geological boundary in the popped-up geological boundary attribute table.

Process of adding geological attitude (Attitude), photos (Photo), sketches (Sketch), and samples (Sample) surveyed along the routes: they were positioned using GPS firstly. Then the features were drawn on the map using the menus for adding new features, and their attributes were input in the popped-up dialogue box.

During field data acquisition along the routes, the remote-sensing images were superimposed onto map layers to combine the measured data with geological interpretation in a harmonious way, thus improving the measurement precision.

2.3 Data Collation

The data gathered in the palm-sized personal digital assistant in the field were imported into DGSS (PC edition), and then were collated according to the *Geological Symbols Used for Regional Geological Maps* (*1*: *50 000*) (GB/T 958–2015) and other relevant requirements. The details are as follows.

(1) Move all geological points (Point) acquired in the field to corresponding GPS points, and then rewrite their coordinates. Then check and complete the attributes of the geological points, such as route nos. of the geological points, geological point nos., mapping units, and names of the rocks on two sides of the geological points. As for the rocks on both sides of the geological points, their names in the text description of the geological points (PRB_P) should be consistent with the names input into the geological point attributes. After the thin section identification results are determined, comprehensively designate the rocks by combining their names in the field and make corresponding comments in the attributes and text description of the geological points.

(2) Move all geological boundaries (Boundary) gathered in the field to corresponding GPS points. Then check and remove the errors in geological boundaries drawn in the field and smoothen and hone them by utilizing the “Cubic Bezier” function in DGSS. The geological boundaries and faults should be presented with unified line types, line colors, and line width across the whole map-sheet (for instance, the line type, line color, and line width of geological boundaries should be set to 1, 1, and 0.1, respectively, while the line type, line color, and line width of the faults should be set to 1, 6, and 0.15, respectively). Then complete the geological boundary description and use “the rocks on the left side of the boundary include... and the ones on the right side include...” to describe the names of the rocks on both sides. Meanwhile, specifically express the lithologic contact relationship of both sides and provide related geological evidence.

(3) Adjust all geological routes (Routing) gathered in the field to GPS points, connect the segmented routes, and smoothen the routes by utilizing the “Cubic Bezier” function in DGSS. Unified line parameters should be used for all routes in a map-sheet. The line type, line color, and line width of the geological routes in this map-sheet were set to 1, 90, and 0.1, respectively. Afterwards, re-calculate the orientation and distance of the routes. Finally, check and complement the route description (including the lithologic composition and change features of the routes), and write the lithology of segmented routes into the free map layers.

(4) Move the attitude, samples, photos, and sketches gathered along the routes to corresponding GPS points and rewrite their coordinates. Then check and complement related attribute data such as the strike, dip, dip angle, type, and mapping units of attitude; contents of samples; the lens direction and detailed description of photos, 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 geological points they belong to. Then modify the parameters of the attribute and samples in a unified way by utilizing the function of “Modify the graphical presentation and legends in the map layers as per attribute values” in DGSS. The nos. of sub-maps should be in accordance with applicable national standards. For the sub-maps in this map-sheet whose nos. are not specified in applicable national standards, their nos. were specified uniformly as follows: foliation (including flow foliation and structural foliation): 1011; attitude of fault surface: 996; attitude of contact surface: 1729; lineation: 1018; primary halo pattern (Y): 1492; samples for

analysis of silicate, rare earth elements, and trace elements (GS, XT, and WL): 1 737; samples for microfossil authentication (WT): 1 215; samples for sporopollenin authentication (BF): 1 173; electron probe analysis (DT): 1 097; samples for particle-size analysis (L): 1167. The fossil samples with authenticated or testing results and the samples for isotopic dating were presented in red.

2.4 Preparation of Geological Maps

2.4.1 Field General Map Database

Input the four completed 1∶25 000-scale geological routes and profiles in DGSS (PC edition) into a database in a consistent way. In this way, the field general map database was generated. Then check the attribute structures of all geological features.

2.4.2 Database of Primitive Data Maps

Open the PRB database of the map-sheet in DGSS (PC edition), and execute the command "update the field general map database to form the database of primitive data maps". Then DGSS automatically updates the original PRB data of the map-sheet to form the PRB data required by the primitive data maps. Then open the interface of the initial primitive data maps to prepare the primitive data maps as follows. First, prepare the primitive data maps on the paper maps of the PRB database, with remote-sensing images on the same scale being referred to during map preparation. Then scan them into computers and correct the legends formed. Afterwards, develop four 1∶25 000 primitive data maps covered by the map-sheet. The attributes of the primitive data maps were inherited as follows. Partial attributes of geological boundaries (Geoline) were extracted from the geological boundaries (Boundary.wl) obtained along the field routes, while the attributes of geological polygon entities (Geopoly.wp) were extracted from the attributes of segmented routes (Routing.wl). After that, check attributes of the primitive data maps and complement and complete the missing attribute fields later. Then conduct consistency checks using the comprehensive check tool in DGSS, including the consistency between lines and arcs, between codes and line types of geological boundaries, and between codes and annotations of Geopoly mapping units.

2.4.3 Original Map for Compilation

Project the data in the four 1∶25 000 primitive data maps onto the 1∶50 000 original map for compilation. Then delete unnecessary files in the project and the folders (i.e., the contents in the PRB database), such as the map layers of geological points (Point), geological point annotation (GPTNOTE), GPS, geological routes (Routing), geological boundaries (Boundary), and free map layers, retaining the map layers such as attitude, photos, sketches, samples, and fossils. Afterwards, modify geological boundary entities (Geoline) and geological polygon entities (Geopoly) as follows. First, delete the 1∶25 000 inner map frames, connect geological boundaries in the parts where the four maps are adjacent to each other, and copy the 1∶50 000 inner map frame. Then copy the boundaries of planar waters in the stream map layer file, add them to the geological boundary entities (Geoline), and check for errors in linear topology. Second, extract the file for label points from the original geological polygon entities (Geopoly) to conduct topological area creation. After merging the label points with the.wp files, the attribute fields of the original map for compilation should be consistent with the attributes in the primitive data maps. To this end, manually complement some new geological blocks and planar waters, and collate the lithologic patterns, the attitudes and annotations, and the codes of mapping units again. Afterwards, prepare decorative map layers in the newly added separated map layers of the original map for compilation, including comprehensive stratigraphic histograms, transverse cutting profiles, legends, a division table of intrusion mapping units, a geotectonic location map, and an index map. Then ultimately complete standard 1：50 000 original map for compilation in accordance with the plotting specifications of geographical base maps for 1：50 000 geological maps as well as applicable standards and requirements of the preparation of geological maps.

2.4.4 Geological Map Spatial Database

Update the spatial database using the 1：50 000 original map and develop the spatial database as follows. Automatically incorporate the original map for compilation into the spatial database. Then delete the files that are not underlined during incorporation. After that, copy the files of independent feature map layers and add them to the folder of the result database (i.e., the spatial database) and the project. Then cut the isotope sample points (_Sample) and add them to the ISOTOPE map layer file. Afterwards, copy the water boundaries from the geographic map layer and add them to the map layer _Line_Geography.

(1) Editing the attributes of the feature classes: Partial attributes of the feature classes were inherited from some attributes of the original map for compilation. The nos. and codes of geological eras were completed in the result database (by following the principle of expressing nos. and codes of geological blocks with superscripts and subscripts). Note that this includes complementing subtype IDs of geological polygon entities, the subtype IDs of geological boundaries, nos. of faults, name codes and names of attitude types, type codes of samples, titles of photos, and descriptions of sketches.

(2) Editing the attributes of the complex classes: This map-sheet includes tectonic deformation zones, metamorphic facies zones, volcanic facies zones, and standard map frames. All of them except for the standard map frames are.wp files and need to be extracted from the files of the geological polygon entity map layers. After editing the attributes of the complex classes, assign IDs to all complex classes, and check the attributes with auxiliary checking tools.

(3) Inputting data of object classes: The object classes obtained in this map-sheet include sedimentary (volcanic) stratigraphic units, petrostratigraphic units of intrusions, stratigraphic units of metamorphic rocks, dikes, faults, planar waters and swamps, informal stratigraphic units, and the basic information of the 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 geological blocks; geological patterns; fault nos.; attitude;

isotopes for dating; springs.

Lines: intrusive boundaries; lithofacies boundaries; fault structures; leader lines; roads; waters; and borders.

Polygons: sedimentary rocks; intrusions; metamorphic rocks; informal stratigraphic units; dikes; and reservoirs.

3.2 Description of Data Content

The Database mainly consists of data on feature classes, complex classes, object classes, and independent feature classes.

3.2.1 Feature Classes

The attribution structure of a geological polygon entity (_GeoPolygon) (1 531 geological polygon entities): the type code; name and era of the geological polygon entity; subtype ID. The attributes of geological polygon entities of Late Jurassic biotite-quartz monzonites are shown in Table 3.

The attribution structure of a geological boundary (_GeoLine) (4 330 geological boundaries): code and type of the geological boundary; codes of geological blocks on the left and right sides of the geological boundary; and subtype ID.

The attribution structure of a mineral locality (_Mineral_pnt) (33 mieral localities): mineral locality; codes and names of mineral types; original code; paragenetic minerals; associated minerals; associated ore; metallogenic era; ore grade; scale; name of the mineral area; and mineralization type.

The attribution structure of attitude (_Attitude) (385 attitudes): the name code and name of the attitude type; strike; dip; and dip angle.

The attribution structure of a sample (_Sample) (180 samples): the code and name of the sample type; sample no.; original code; and rock name of the sample.

The attribution structure of a photo (_Photograph) (1 048 photos): the no.; title; and description of the photo.

The attribution structure of a sketch (_Sketch) (43 sketches): the No.; title; and description of the sketch.

The attribution structure of a fossil (_Fossil) (18 fossils): the taxonomic classification of

Table 3 Attributes of geological polygon entities of late Jurassic biotite-quartz monzonites

No.	Data item	Label code	Data type	Example of content description
1	ID	*Feature_Id	Character	AI49E013014000000535
2	Original code	Source_Id	Character	
3	Type code	*Feature_Type	Character	*ηο*J@3
4	Name	Geobody_Name	Character	Late Jurassic biotite-quartz monzonite
5	Era	Geobody_Era	Character	J@3
6	Minimum age (a.B.P)	Geobody_Age1	Double	0
7	Maximum age (a.B.P)	Geobody_Age2	Double	0
8	Subtype ID	Subtype	Interger	1

Note: @ denotes that the following figures are subscripts.

the fossil; fossil sample no.; original code; genus or species name of the fossil; occurrence horizon of the fossile; the code of the fossil-bearing stratigraphic unit; and the era of the fossil.

The attribute structure of an isotope for isotopic dating (_Isotope) (19 isotope samples): the no. and name of the sample; dating method; age dated; the unit and code of the geological block dated; and the unit and date of dating analysis.

The attribution structure of a crater (_Crater) (one crater): the type; name; and size of the crater; the units and codes of the geological blocks resulting from volcanic eruption; rock types and formation era of the crater.

The attribute structure of a river or reservoir shoreline (_Line_Geography) (434 shorelines): primitive type and name; subtype ID.

The attribute structure of a spring (_Spring) (15 springs): the code and name of the spring type.

3.2.2 Complex Classes

The attribut;e structure of a tectonic deformation zone (_Tecozone) (17 tectonic deformation zones): the code; type name; rock name; and structural features of the tectonic deformation zone; deformation dynamic features; formation era; activity stages; ore-bearing features.

The attribute structure of an alteration zone (_Alteration_Polygon) (eight alteration zones): the name code and name of alteration type; altered mineral assemblages and their content; ore-bearing features; and codes of altered geological blocks.

The attribute structure of a metamorphic facies zone (_Metamor_Facies) (22 metamorphic facies zones): the geological block code; rock colors; and type of the metamorphic facies zone; metamorphic degree; metamorphic pressure and temperature; the texture, and structure of the rocks in the metamorphic facies zone; mineral assemblages and their content in the metamorphic facies zone; ore-bearing features.

The attribute structure of a volcanic lithofacies zone (_Volca_Facies) (42 volcanic lithofacies zones): the type and code of volcanic lithofacies; the stratigraphic units and their codes occurring; the types, texture, and structure of the rocks of volcanic lithofacies; formation era; mineral types contained.

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

3.2.3 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.

The attribute structure of a lithochronologic unit of intrusions (_Intru_Litho_Chrono) (31 lithochronologic unit of intrusions): 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; formation era; ore-bearing features. The attributes of lithostratigraphic units of the intrusions of the Late Jurassic biotite-quartz monzonites are shown in Table 4.

The attribute structure of a fault (_Fault) (119 faults): the type, name, no., and properties of the fault; codes of geological blocks in the hangingwall and footwall 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.

The attribute structure of a stratigraphic (rock formation) unit of metamorphic rocks (Metamorphic) (three units): the name, symbol, and era of the stratigraphic (rock formation) unit; the names, texture, and structure of rocks; main minerals and their content; characteristic metamorphic minerals and their content; stratigraphic attitude; mineral assemblages and their content; ore-bearing features; the metamorphic facies zone it belongs to; thickness of the rock

Table 4 Attributes of lithochronologic units of the intrusions of the late Jurassic biotite-quartz monzonites

No.	Data item	Standard code	Data type	Examples of content description
1	Feature type (geologic code)	*Feature_Type	Character	*η*oJ@3
2	Name of rock-mass mapping unit	Intru_Body_Name	Character	Late Jurassic biotite-quartz monzonites
3	Symbol of rock-mass mapping unit	Intru_Body_Code	Character	*η*oJ@3
4	Rock name (lithology)	Rock_Name	Character	Biotite-quartz monzonites
5	Rock color	Color	Character	Tan
6	Rock texture	Rock_Texture	Character	Porphyritic texture; matrix: inequigranular texture
7	Rock structure	Rock_Structure	Character	Massive structure
8	Lithofacies	Rock_Phases	Character	Intrusive facies
9	Contact relationship with surrounding rocks	Contact_Relation	Character	Intrusive contact
10	Primary minerals and their content	Primary_Mineral	Character	Perthite phenocryst: 5–10%, matrix quartz: 7–12%, hornblendes: 6–10%, average content: 8%±
11	Secondary minerals and their content	Secondary_Mineral	Character	Biotite: 2%
12	Strike of the interface with surrounding rocks	Strike	Integer	*
13	Dip of the contact surface with surrounding rocks	Dip_Direction	Integer	*
14	Dip angle of the contact surface with surrounding rocks	Dip_Angle	Integer	*
15	Formation era	Era	Character	J@3
16	Ore-bearing features	Commodities	Character	*
17	Subtype ID	Subtype	Integer	0

Note: @ denotes that the follow-up figures are subscripts.

formation; rock colors.

The attribute structure of an informal stratigraphic unit (Inf_Strata) (48 informal stratigraphic units): code of the informal stratigraphic unit; lithology, rock texture and structure; biofossil zone or biotic association contained; the width or thickness of outcrops; ore-bearing features; and the symbol of the stratigraphic unit it belongs to.

The attribute structure of a dike (_Dike_Object) (five dikes): the name and symbol of the dike; lithology, color, texture, structure, primary minerals and their content; secondary minerals and their content; formation era; and ore-bearing features.

The attribute structure of planar waters (_Water_Region) (one planar water): feature category code; the type, name, and characteristics of primitive.

The attribute structure of the basic information of map-sheet (_Sheet_Mapinfo) (one map-sheet): map name; scale; coordinate system: elevation system: left and right longitudes; upper and lower latitudes; 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

(1) Quality Control and Assessment of Field Survey

The Database was developed in strict accordance with relevant specifications such as the '*Technical Requirements for Regional Geological Survey* (*Scale*: *1∶50 000*)'(DZ/T 0001–1991). Digital mapping instruments were utilized to acquire data in the field, and the 1∶25 000 digital topographic maps were adopted for the preparation of freehand field maps. The 1∶50 000 regional geological survey was conducted by adopting different mapping methods for different survey sites based on systematic acquisition and comprehensive analysis of existing geological data. Lithostratigraphic mapping was used for sedimentary (epimetamorphic) rock areas (Guandaokou group, Luanchuan group and Taowan Group) to divide basic sequences. Lithologic mapping was used for intrusive rock areas to map intrusive bodies. Structure - stratum (rock formation) - event mapping was used for the metamorphic rock areas (Kuanping Group). Volcanic stratum - lithology (lithofacies) dual mapping was used for volcanic areas (Xiong'er Group and Dahongkou Formation of Luanchuan Group) to divide the flow units. Meanwhile, in the volcanic areas, the radial survey routes were arranged around the volcanic edifice determined according to the interpretation of referencing previous data. Geology - landform dual mapping was used for the Quaternary. In this study, the following geological blocks were all plotted in the geological map: sealed geological blocks with a diameter greater than 50 m; linear geological blocks with a width greater than 25 m and a length greater than 50 m; and faults with a length greater than 250 m. As for the bedrock outcrops distributed in the Quaternary, they were all plotted as well, regardless of their sizes, and those smaller than mapping scales were presented after being magnified. The geological survey was conducted along the routes with a total length of 613.8 km, involving 1952 various geological points (average density: 4.52 points/km^2) and 3 778 geological boundaries (average point interval: 314 m). Meanwhile, the other features acquired include 180 samples for lithogeochemical analysis, 19 samples for isotope dating, 3435 attitudes, 43 sketches, 1048 photos, 18 fossil points, one crater, and 33 mineral areas. In this way, the specific requirements of the mapping precision of 1：50 000 geological mapping were met.

(2) Quality Control and Assessment of Testing Data

All samples for various testing methods were acquired according to applicable provisions and then were tested by certified organizations. Therefore, the authentication reports and testing data are accurate and reliable and meet relevant requirements. The samples for the analysis of silicate, rare earth elements, and trace elements were analyzed and tested at the Wuhan Supervision and Inspection Center of Mineral Resources, Ministry of Land and Resources of the People’s Republic of China. The microfossil samples were identified by Gao Lianda, a researcher in the Chinese Academy of Geological Sciences. Zircon U–Pb dating and zircon Hf isotopic analysis were conducted at the Tianjin Institute of Geology and Mineral Resources, China. The electron probe microanalysis was carried out at the Zhengzhou Institute of Multipurpose Utilization of Mineral Resources. The particle size analysis was conducted at the lab of XinHang Surveying and Mapping Institute of Hebei Province.

(3) Quality Control of Database

The Database was built in accordance with applicable standards such as the ‘*Spatial Database Establishment Code of Digital Geological Maps*’ (DD 2006 –06). Meanwhile, consistency checks were performed by using auxiliary checking tools throughout the building of the Database, from the preparation of freehand field maps, the development of the PRB database, and the preparation of primitive data maps and the original map for compilation, to the development of the results database. The checks covered the consistency between lines and arcs, the match between geological codes and graphic parameters of geological polygon entities, the logical consistency between feature classes and object classes, the consistency between the names and symbols of attitude types, and the consistency between the codes and annotations of geological polygon entities.

(4) Monitoring of Work Process

A three-level quality management network consisting of the Henan Institute of Geological Survey, project department, and work teams were established during geological mapping. Meanwhile, applicable specifications were strictly followed. The division criteria of mapping units were unified before field survey, and self-checks, mutual checks, and spot checks were continually carried out during field survey. The self-check rate and mutual check rate (including the checks of the databases) were both 100%. The spot check rates of geological routes, geological profiles, and databases performed by the project leader were 32%, 35%, and 100%, respectively. The technology management department of the Henan Institute of Geological Survey went to the survey site to conduct quality inspections and provide guidance every year during the project work, obtaining spot check rates of geological routes, geological profiles, and databases of 6%, 9%, and 100%, respectively. Furthermore, the Tianjin Center of China Geological Survey organized experts to conduct quality inspections of the original data and the databases through laboratory inspection along with field inspection every year during the project. It was concluded that "the quality management system worked well, the quality of the original data and the databases is high in general, and the quality level is rated good". During October 22–27, 2018, the Tianjin Center of China Geological Survey organized experts to conduct an acceptance check of the field survey where the original data and databases were obtained in Luoyang City, Henan Province. As a result, the field survey was scored 91 points—an excellent level. During January 27–28, 2019, the Tianjin Center of China Geological Survey organized experts again to conduct an acceptance check of the project achievements in Zhengzhou City, Henan Province. As a result, the project achievements scored 91 points—an excellent level. On August 3, 2019, the Tianjin Center of China Geological Survey organized an acceptance check of the Database in Tianjin City, and the Database was scored 91 points.

5 Data Value

The Database was developed based on full absorption of previous data and results, with the modern theory of plate tectonics as the guidance. During the building of the Database, major issues existing in Sanchuan map-sheet were surveyed and researched, achieving a body of basic data and new understanding of the geoscientific issues.

5.1 Basic Data

The lithogeochemical analysis and testing data of Sanchuan map-sheet were analyzed and collated (Table 5). The data reflect important information such as the genesis and ages of the rocks and deposits in the study area, thus providing scientific bases for research on the regional geological setting of the study area and the geological history and evolution of the Qinling Orogenic Belt. Meanwhile, distribution sites of the fossils, deposits and springs in the area were gathered in the Database (Table 5), thus providing references for geological relic survey, mineral resource survey, and water resource exploration.

5.2 New Understandings on Geoscientific Issues

(1) Rich microfossils were discovered in the stratotype section of the Taowan Group in the map-sheet, including fossil chitinozoans (*Desmochitina minor* Eisenack and *D. cocca* Eisenack et al.), scolecodonts (*Pronereites* Stauffer et al.), acritarchs (*Rhopaliophora palmate et al.*), and bryophyte spores (*Pseudodyadospora laevigata*), some of which were found for the first time in China. The microfossils feature multiple taxonomic classifications and short age ranges. Therefore, the Taowan Group was determined to have occurred in the Ordovician, possibly the Early Ordovician (Eisenack, 1962; Combaz and Penignel, 1972; Timofeev, 1973; Johnson, 1985; Gao LD, 1986; Hu YX et al., 1986; Lu LC et al., 1987; Gao LD, 1991; Wang ZQ et al., 2007). Volcanic intercalations were found in the Taowan Group, with a thickness of 5–7.7 m. They consist of metamorphic amygdaloidal andesites and biotite-bearing metamorphic latites, which are alkaline volcanics formed under extensional background. Therefore, it can be inferred that extensional basins developed on the southern margin of the

Table 5 Data in the geological map spatial database of Sanchuan map-sheet (I49E013014), Henan Province

Data category	Data volume	Basic feature
Data of petrochemical analysis	180 pieces	11 major elements in volcanics and intrusions
Data of trace element analysis	180 pieces	31 trace elements in volcanics and intrusions
Data of isotope ages	19 pieces	LA–ICP–MS zircon U–Pb ages of volcanics, intrusions, and clastic rocks
Quantity of fossil sites	18 sites	Chitinozoas, scolecodonts, acritarchs, and bryophyte spores
Quantity of mineral occurrence	33 sites	Iron deposits (10), plumbum deposits (10), molybdenum deposits (5), copper deposits (3), gold deposits (1), zinc deposits (1), manganese deposits (1), graphite deposits (1), and nephrite deposits (1)
Deposit types	5 types	Hydrothermal type and skarn type: plumbum-zinc-molybdenum deposits; sedimentary metamorphic type: iron deposits, graphite deposits, and nephrite deposits; weathering crust type: gold deposits; sedimentary type: molybdenum deposits.
Quantity of springs	15	Mineral water

North China Plate in the Ordovician.

(2) Sinian glacial - aqueoglacial sedimentary conglomerates were found in Zushimiao Village, Sanchuan Town. They are characterized by the development of glacial sedimentary gravels and were determined to be from the Luoquan Formation based on characteristic comparison.

(3) Most of the greenschists in the Sichakou and Xiewan formations of the Kuanping Group were determined to be volcanic rocks. They are characterized by the development of massive amygdaloids and high TiO_2 content, which belong to the alkaline series and tholeiite series, respectively. The volcanic rocks were formed in an intraplate rifting environment, indicating that the main part of the Kuanping Group was formed in extensional basins.

(4) Dike swarms of gabbros and aegirine syenites were determined in the outcrop area of the Guandaokou Group in the northern part of the map-sheet by mapping. They belong to alkaline series and are characterized by high content of rare earth elements and high TiO_2 content. They are comparable to Qingbaikouian gabbros and syenites that are widely distributed inside the Luanchuan Group in the southern part of the map-sheet (Tianjin Center of China Geological Survey, 2019). Along with the dike swarms they constitute a bimodal suite and jointly reflect the rifting event that occurred in the Qingbaikou period. Meanwhile, Silurian (428±11 Ma) alkali-feldspar granite porphyry dike swarms were identified in the southern part of the map-sheet by mapping. They were analyzed to be related to intermittent relaxation after the closure and collision of the Qinling Ocean in the Paleozoic, thus restricting the closure era of the Qinling Ocean. The late Mesozoic intrusions related to mineralization were broken up in detail, and five stages of intrusive activities were determined according to the contact relationships. Dioritic inclusions were found in the intrusive bodies in

Huoshenmiao, Huangbeiling, and Nannihu villages, indicating that the intrusions of that stage were mixed with magma at different levels. This will provide geological bases for research on the magma origin and the genesis of super-large molybdenum-tungsten polymetallic deposits in the Luanchuan area.

(5) The folds in the study area were mainly divided into three stages, namely early Paleozoic, early Mesozoic, and late Mesozoic. The northern boundary of the Taowan Group was found to be in para-unconformity contact with the Luanchuan Group, and the fault between the southern boundary of the Taowan Group and the Kuanping Group was determined to be the Luanchuan fault. Three stages of activity were determined in the Luanchuan fault zone, namely the early Paleozoic, the early Mesozoic, and the late Mesozoic, with the early Paleozoic being the main activity stage. The activities of the three stages show northward nappe, southward nappe, and left-lateral strike slip, respectively. The geological structures in the early Paleozoic, the early Mesozoic, and the late Mesozoic in the study area were demonstrated to be responses to early Paleozoic collisional orogenesis, early Mesozoic collisional orogenesis, and the convergence and thickening of the peri-Pacific system and the extension and thinning of the lithosphere, respectively.

(6) Eight mineralized points were newly found and one prospecting target area was determined.

The achievements of the Database will provide basic data for future geological and mineral survey of the study area and promote the ability of geological and mineral survey to serve mineral prospecting and exploration, prevention and control of geological disasters, conservation and restoration of ecological environments, spatial planning of land, preservation of and scientific popularization of geological relics, and scientific research and teaching of geology.

6 Methods and Recommendations for Data Usage

The Database boasts broad application prospects. It can be used as the basic database of the basic geological maps on similar or different scales. It can also provide basic data for regional and local geological hazard prevention and control and ecological environment protection. It is in the format of MapGIS vector data, and contains the composition of various mapping units, the lithofacies characteristics of volcanic and metamorphic rocks, fault properties, and attributes of attitudes and samples. The detailed data in it 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) In the 1：50 000 geological map of Sanchuan map-sheet (I49E013014), Henan Province, basic sequences in the sedimentary rock areas are divided, and the special geological blocks and informal mapping units are highlighted by adopting tectonic and lithologic mapping. Meanwhile, mapping precision was improved by the mapping method.

(2) Microfossils of multiple taxonomic classifications and short age ranges were discovered in the stratotype section of the Taowan Group. Hence the Taowan Group was determined to have occurred in the Ordovician, possibly the early Ordovician. As indicated by the alkaline volcanic intercalation found in the Taowan Group, extensional basins developed on the southern margin of the North China Plate in the Ordovician. The greenschists in the Sichakou and Xiewan formations of the Kuanping Group were determined to be intraplate volcanic rocks, indicating that the main part of the Kuanping Group was formed in extensional basins.

(3) Dike swarms of gabbros and aegirine syenites were newly determined in the the Guandaokou Group in the northern part of the map-sheet by mapping. They belong to alkaline series and are comparable to Qingbaikouian gabbros and syenites that are widely distributed in the Luanchuan Group in the southern part of the map-sheet. All of them jointly reflect rifting occurring in the Qingbaikou period. Silurian alkali-feldspar granite porphyry dike swarms were newly determined in the southern part of the map-sheet by mapping. They were formed owing to relaxation after plate collision, indicating that the closure era of the Qinling Ocean should not be later than the Silurian.

(4) The fault between the southern boundary of the Taowan Group and the Kuanping Group was determined to be the main part of the Luanchuan fault. Three stages of activities were determined in the Luanchuan fault zone, namely the early Paleozoic, the early Mesozoic, and the late Mesozoic, with the early Paleozoic being the main activity stage. The activities of the three stages show northward nappe, southward nappe, and left-lateral strike slip, respectively. Correspondingly, three stages of folding were developed in the map-sheet. The geological structures in the early Paleozoic, the early Mesozoic, and the late Mesozoic in the map-sheet were demonstrated to be responses to early Paleozoic collisional orogenesis, early Mesozoic collisional orogenesis, and the convergence and thickening of the peri-Pacific system and the extension and thinning of the lithosphere in the late Mesozoic, respectively.

(5) The Database systemically reflects the basic data and new understandings obtained from this geological survey. It contains large amounts of data and is easy to query. It will provide basic data for mineral prospecting and exploration, prevention and control of geological disasters, conservation and restoration of ecological environments, spatial planning of land, preservation of and scientific popularization of geological relics, research on the Qinling Orogenic Belt, and geological teaching.

Acknowledgments: The 1：50 000 geological map of Sanchuan map-sheet, Henan Province is a collective achievement. The frontline colleagues responsible for the filed survey made great efforts, and Liu Wenbin, He Chengguang, Zhai Wenjian, and Sun Xuejing participated in field data acquisition. Furthermore, many experts in geological and mineral research and survey provided substantial guidance during the building of the databases, including Researcher Zhao Fengqing, Researcher Xin Houtian, and Professorate Senior Engineer Li Chengdong from the Tianjin Center of China Geological Survey; professorate senior engineers Pan Yongsheng and Sun Zhanling from the Shanxi Institute of Geological

Survey; professorate senior engineers Wang Shiyan, Zhang Yanqi and Fang Huaibin from the Henan Institute of Geological Survey, and Professor Zhou Zhiguang from the China University of Geosciences. We hereby extend our sincere gratitude to all of them.

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