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河北省古冶幅、唐山幅、范各庄煤矿幅 1∶50 000 地质图空间数据库

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摘要: 河北省古冶幅 (J50E002018)、唐山幅 (J50E003017)、范各庄煤矿幅 (J50E003018) 1∶50 000 地质图空间数据库是在充分收集以往地质资料的基础上, 在唐山市区及周边开展古冶幅、唐山幅、范各庄煤矿幅 1∶50 000 区域地质调查工作, 编制相应图幅的 1∶50 000 地质图, 并依据《数字地质图空间数据库标准》(DD 2006–06) 建立而成。通过遥感解译、野外数字填图、第四系钻探、人工浅钻及浅层地震剖面等手段采集数据。数据库包括基本要素类、综合要素类、对象类及独立要素类。其中基本要素类共包括 651 个地质体面实体 (第四系、沉积岩、变质岩、侵入岩等面实体) 数据、1428 个地质界线数据、194 个产状数据、562 个照片数据、70 个年龄 (锆石 U–Pb 测年、^{14}C、OSL 测年) 数据、5 个第四系钻孔数据; 综合要素类数据主要为标准图框 (内图框); 对象类包括 57 个沉积岩岩石地层单位 (包括第四系) 数据、2 个侵入岩岩石年代单位数据、断层、脉岩、面状水域、图幅基本信息数据; 独立要素类主要为角图, 未添加属性。本数据库建立过程始终坚持完善的质量控制体系, 确保了数据的真实性、可靠性和准确性, 为相应区域的经济可持续发展、城市规划建设、生态环境保护和重大工程施工等提供基础地质支撑。

关键词: 空间数据库；古冶幅；唐山幅；范各庄煤矿幅；1∶50 000；第四系；地质调查工程；京津冀

数据服务系统网址: http://dcc.cgs.gov.cn

1　引言

河北省唐山市区及其周边区域是京津冀一体化发展的重要组成部分, 近年来, 其生态文明建设面临的诸如地下水资源紧张、地面沉降等问题亟待解决。为更好地服务国民经济建设, 适时开展该区域的 1∶50 000 区域地质调查, 对城市建设所需的应急水源地以及合理开采、利用地下水资源具有十分重要的意义, 也为后期区域经济和地方政府在重大工程建设规划和减灾防灾等方面提供基础地质资料支撑 (胥勤勉等, 2014)。

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河北省 1∶50 000 古冶幅 (J50E002018)、唐山幅 (J50E003017)、范各庄煤矿幅 (J50E003018) 区域位于燕山山脉与华北平原的接壤处,属古滦河沉积区域。长期以来,燕山山脉的阶段性抬升造成古滦河的改道和变迁,控制和影响了区内沉积物的分布、沉积相组合及变化 (吴忱, 1984, 2001; 大港油田地质研究所等, 1985; 高善明, 1985; 李从先等, 2013; 胡云壮等, 2014)。陡河以西地表以晚更新世早中期古滦河冲积扇冲洪积物为主,陡河以东主要为晚更新世晚期—全新世中期古滦河冲积扇冲洪积物 (图 1)。

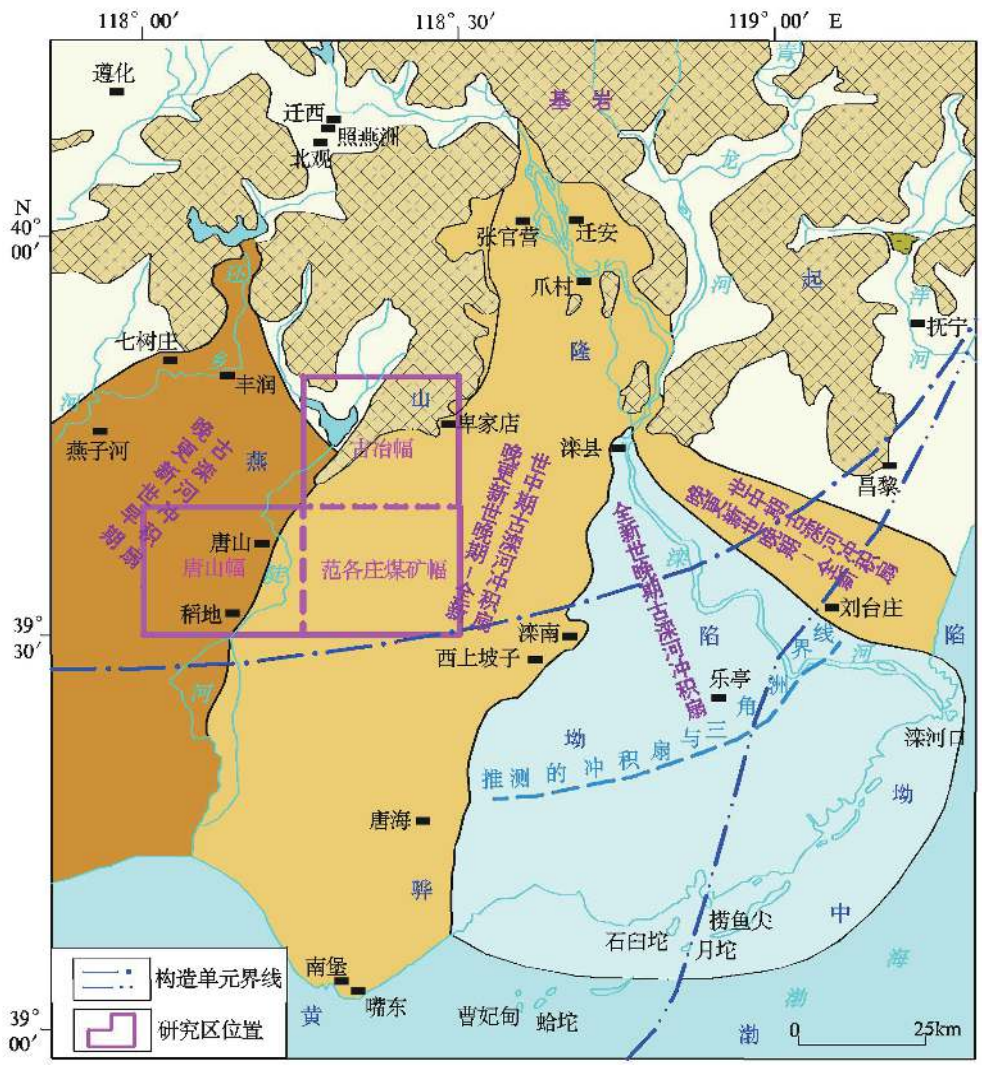

图 1 河北省 1∶50 000 古冶幅、唐山幅、范各庄煤矿幅区域位置图 (据胡云壮等, 2014 修编)

河北省古冶幅 (J50E002018)、唐山幅 (J50E003017)、范各庄煤矿幅 (J50E003018) 1∶50 000 地质图空间数据库 (表 1, 赵保强等, 2020) 建设基于“河北 1∶50 000 古冶幅、唐山幅、范各庄煤矿幅区域地质调查”子项目,属于“燕山–太行成矿带丰宁和天镇地区地质矿产调查”计划项目,包括 3 个 1∶50 000 标准国际图幅区域地质调查,实施时间为 2016—2018 年。本次调查采用野外数字填图、遥感解译、钻探、综合物探等多种技术,以第四纪地质结构和断裂构造的活动性为重点调查对象,旨在查明制约水文地质、工程地质、环境地质、灾害地质等问题的基础地质条件。同时, 该数据库可为第四纪区域地质调查和研究提供一套基础性数据资源,为实现基础性、公益性地质调查成果的社

会共享奠定基础。

表 1　数据库 (集) 元数据简表

条目	描述
数据库(集)名称	河北省古冶幅、唐山幅、范各庄煤矿幅1：50 000地质图空间数据库
数据库(集)作者	赵保强, 河北省地质调查院 张兆祎, 河北省地质调查院 王克冰, 河北省地质调查院 徐永利, 河北省地质调查院 王　川, 河北省地质调查院 耿晓磊, 河北省地质调查院
数据时间范围	2016—2018年
地理区域	地理坐标:东经118°00′ ~ 118°30′, 北纬39°30′ ~ 39°40′; 东经118°15′ ~ 118°30′, 北纬39°40′ ~ 39°50′
数据格式	MapGIS
数据量	54.8 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“河北1：50 000古冶幅(J50E002018)、唐山幅(J50E003017)、范各庄煤矿幅(J50E003018)幅区域地质调查(项目编号:DD20160042-5)”
语种	中文
数据库(集)组成	本数据库由1：50 000地质图库和图饰构成。地质图库包括9个基本要素类数据集(地质体面实体、地质界线、产状、照片、素描、化石、同位素测年、钻孔、河、湖、海、水库岸线等)、1个综合要素数据集(内图框)、6个对象类数据集(沉积岩岩石地层单位、侵入岩岩石年代单位、断层、脉岩、面状水域、图幅基本信息); 图饰为独立要素类数据, 主要有接图表、柱状图、图例、图切剖面(每个标准图幅包括1个基底剖面图和2个第四系剖面图)、责任表

2　数据采集和处理方法

2.1　数据采集

本次区域地质调查综合应用野外路线地质调查、野外实测剖面、遥感解译、地球物理勘查、钻探、样品测试等多种工作手段进行数据采集。在开展 1：50 000 区域地质调查过程中, 以《河北 1：50 000 古冶幅、唐山幅、范各庄煤矿幅区调项目任务书》要求和《区域地质调查总则 (1：50 000)》(DZ/T 0002–1991)、《1：50 000 覆盖区区域地质调查工作指南 (试行)》等规范为基准, 按照项目设计工作量, 完成各类基础数据采集 (表 2)。

2.1.1　遥感解译数据集

本次 1：50 000 遥感影像图使用 SPOT 数据, 辅以 ETM(增强型专题绘图仪, Enhanced Thematic Mapper)、MSS(多光谱扫描仪, Multi-Spectral Scanner) 数据, 采用数字图像处理、目视解译与人机交互式解译相结合方法, 建立解译标志, 提取地质、地貌、环境等信息, 进而在矢量化电子地图基础上, 编制解译地质图, 工作平台为 MapGIS 地理信息系统软件。

依据研究区特点将解译工作分为遥感地质、地貌、环境地质等 3 个部分。根据工作性质不同, 使用不同的影像数据源有针对性解译。

遥感地质解译: 使用 ETM 数据、SPOT(地球观测系统) 数据解译断裂构造、岩石地

表 2 基础数据量统计表

数据类型		数据量	单位
野外地质观测点		2 030	个
地质界线		1 717	条
产状		350	个
野外照片		600	张
钻探	第四系钻探(进尺997.4 m)	5	眼
	浅钻(0 ~ 20 m)	335	米
物探	浅层地震剖面测量(点距100 m)	300	点
样品采集(主要)	稀土元素、微量元素、硅酸盐全岩地球化学	30	件
	薄片鉴定	225	件
	古地磁样	878	件
	色度	910	件
	同位素年龄(U-Pb法)	2	件
	光释光(OSL)测年	36	件
	^{14}C同位素测年	29	件
	微古生物鉴定	227	件
	粒度分析(薄片)	336	件

层影像单元等遥感地质信息。

地貌解译: 使用 ETM、MSS 数据进行宏观地貌划分, 主要解译地貌类型、冲积扇、洼地、古河道等宏观遥感地貌信息; 微观地貌使用 SPOT 数据, 解译河流阶地、河堤、水库、古河道等地貌信息。

环境地质解译: 使用 SPOT 数据解译塌陷、采场等矿山地质环境信息和城市垃圾、工业垃圾等环境地质信息。

2.1.2 野外地质填图

野外地质路线以穿越路线为主, 追索路线为辅。结合初步解译结果, 部署填图工作, 布设疏密不均、主次不等的野外填图路线和观测点。提出各线、点观测的主要内容, 所有路线填图做到目的性强、针对性强, 提高野外工作效率和精度。基岩出露区依据《区域地质调查总则 (1：50 000)》(DZ/T 0002–1991)、《1：50 000 区域地质调查工作指南(试行)》布设路线、实测剖面,覆盖区依据《1：50 000 覆盖区区域地质调查工作指南 (试行)》。在研究区北东部山前区 (古冶幅) 多利用陡坎、水坝、公路路基等天然和人工开挖剖面, 路线间距控制在 1 000 ~ 1 500 m。南部平原区 (冲积扇区) 路线间距为 1 500 ~ 2 500 m, 地质点的布置依据地貌变化、土壤变化、植被变化、污染、灾害、工程层和地质界线点, 凡是有陡坎等天然露头、砖瓦场等人工挖掘点一定要定点, 点的间距和数量一般不等距。山区与平原过渡的山前丘陵区, 地形、地貌复杂, 地质体成因多样、连续性较差, 本次工作采用垂向比例尺不小于 1：200 的多个短剖面, 组成横向比例尺 1：5 000 的地貌地质剖面, 对第四纪沉积 (堆积) 的物质组成、成因类型、结构构造、空间分布及其与构造作用的关系等进行详细调查, 研究第四纪地质体与地貌类型的关系。对研究区主要河流采用 1：1 000 的实测剖面, 局部辅以 1：100 的垂向大比例尺短剖面, 研究各河流的河床、阶地 (形成时代)、古河道等地貌特征及其与新构造运动的关系。

所有的路线观测记录、实测剖面均在 DGSS 系统中完成。在数字填图野外数据采集仪中以 1∶25 000 数字化地形图为底图, 通过野外实际路线调查, 在数字填图系统中标绘出地质点、地质界线及分段路线、产状、照片、样品、化石等点、线信息, 初步建立数字填图 (PRB) 数据库。

地质点 (P): 分为界线点、岩性分界点、观测点。在系统中填写简单的属性, 包括点号、点性、微地貌、露头情况、风化程度、位置说明、填图单元和接触关系, 坐标信息由系统自动读取。

地质路线 (R): 在系统中填写的属性包括路线号、地质点号、路线编号、路线方向、本站距离、累计距离、填图单元和岩石名称。其中, 方向角、本站距离、累计距离为系统自动计算。

地质界线 (B): 在系统中填写的属性包括路线号、地质点号、地质界线号、分段地质路线号、界线类型、左侧填图单位、右侧填图单位、接触关系、走向、倾向以及倾角。

对沿途所见的地质体的产状、采集的标本、拍摄的照片等信息, 随时在系统中录入相关信息, 填写属性数据。

2.1.3 第四系钻探

第四系钻探主要用于查明区内第四纪沉积物的地质特征, 采集必要的分析测试样品, 分析岩石地层、气候地层、生物地层、年代地层、磁性地层等, 建立第四纪地层柱状图, 为区域地层对比、建立地层层序和第四系三维地质结构提供依据。

区内共布置第四系钻孔 5 眼, 与已有水文地质等钻孔结合, 构成长短不一的北西西向剖面 5 条, 北北东向剖面 7 条, 间距 2 ~ 10 km 不等, 在平面上构成北西西向和北北东向的钻孔剖面网格。根据地层特征, 现场采用正循环回转钻进工艺, 采用单管投弹子干钻采心、泵压退心的取心方法。全孔平均取心率不小于 80%, 其中粘性土不小于 90%, 砂性土不小于 70%, 淤泥层不小于 60%, 卵砾石层不小于 40%。钻孔每钻进 100 m 测量孔斜及校正孔深 1 次, 使孔斜差每 100 m 不超过 1.0°, 孔深误差不大于 1‰, 并以校正后的孔深为准。岩心取出后按顺序放入 PVC 半合管内, 岩心劈开后及时照相、编录、取样, 并编制钻孔地质柱状图。

钻探地质编录主要描述岩心的岩性成分、粒径 (粒度特征、分选性和粒级组成等)、颜色 (沉积物的基色和所夹色斑、色带)、结构构造 (层面构造和层间构造)、上下层接触关系、沉积物的可塑性、坚硬程度、特殊的岩性夹层特征等。终孔后按照技术要求采用自然电位、视电阻率、自然伽马及声波等 4 种方式进行地球物理测井。

2.1.4 浅层地震勘查

本次物探工作利用浅层地震多次迭加法测量, 主要用于查明活动断裂的上断点位置及其新构造运动特征, 与钻探配合进行第四系松散沉积物分层和古滦河冲洪积扇叠置关系的研究。可控震源激发, 检波器间距 5 m, 接收道数 48 道, 道间距 5 m, 炮间距 20 m, 覆盖次数 12 次, 最小采样间隔 0.5 ms, 采样点数 2048, 通频带为全通。

2.2 数据处理过程

地质图空间数据库是通过野外手图数据库、实际材料图数据库、剖面数据库、钻孔数据库等不同工作阶段数据互通、继承、提取和凝练形成 (康庄等, 2012)。河北 1∶50 000 古冶幅、唐山幅、范各庄煤矿幅地质图空间数据库的数据处理过程见图 2。

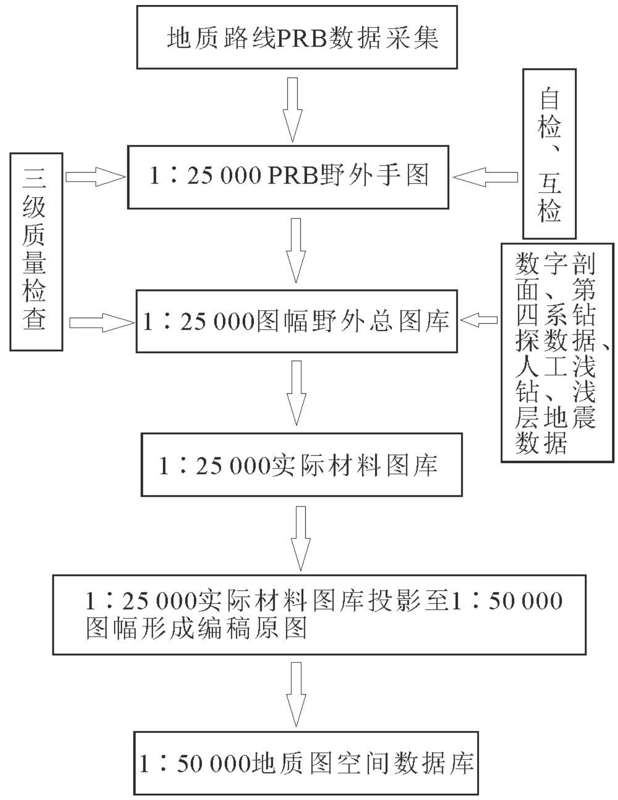

图 2　地质图空间数据库工作流程图

2.2.1　地质填图野外数据库

数据采集结束后，对经过数据检查和备份的野外路线 PRB 数据和实测剖面数据，①在数字填图桌面系统中由掌上机转入桌面系统，形成野外路线手图库和实测剖面库，并根据相应规范进行数据整理；②将第四系钻探数据输入到第四系钻孔库；③对野外路线手图 PRB 数据、实测剖面数据、第四系钻探数据进行自检、互检、项目检三级质量检查，并将其入库到野外总图库。

2.2.2　实际材料图库

将野外总图库更新到实际材料库，编制实际材料图。依据图幅 PRB 库中的实际观测资料，按“V”字形法则勾绘地质界线。正确提取和赋予与野外一致的地质界线实体属性内容，保证图元与属性及连接空间、非空间数据公共项的一致性。完善地质面要素、地质界线要素的属性。

2.2.3　编稿原图

将完成的 1∶25 000 实际材料图投影合并至 1∶50 000 图幅，形成编稿原图，并按规范要求进行整理，该过程部分继承了实际材料图库的空间数据结构。不同时代的地质面体、地质界线、脉岩、产状、样品、钻孔、化石等均按照《区域地质图图例》(GB958–2015) 和《地质图用色标准及用色原则》(DZ/T0179–1997) 中规定的图饰图例、符号等进行表示。编制各类辅图及图例。

2.2.4　地质图空间数据库

在编稿原图的基础上进行地质图空间数据库建设，空间数据库具有继承性，将实际材料图库已有的要素类、对象类属性数据集成到空间数据库，在此基础上进行空间数据库基本要素类数据、综合要素类数据及对象类数据的属性录入和完善。

3 数据样本描述

河北省 1：50 000 古冶幅、唐山幅、范各庄煤矿幅地质图空间数据库包括地理要素信息、地质实体要素信息和地质图整饰要素信息。本次使用的地理底图为国家测绘局国家基础地理信息中心提供的 1：50 000 矢量地形图数据, 地理要素信息属性沿用国家测绘地理信息局购买数据的属性结构。地质实体要素信息和地质图整饰要素信息包括 9 个基本要素数据集、1 个综合要素数据集、6 个对象类数据集和独立要素数据集。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。对象类数据集是一个 Excel 数据表格, 存储非空间数据, 在地质图数据模型中, 一般 1 个要素类数据对应多个对象类数据。

3.1 基本要素数据集

基本要素数据集包括地质体面实体、地质 (界) 线、产状、照片、化石、同位素测年、钻孔、河、湖、海、水库岸线等。

地质体面实体 (_GeoPolygon) 包括: 地层、变质岩、岩浆岩面实体。数据属性主要有地质体面实体标识号、地质代码、名称、时代、下限年龄值、上限年龄值、子类型标识 (表 3)。

表 3 地质体面实体数据属性表

字段名称	字段类型	实例
地质体面实体标识号	Character	AJ50E002018000000383(软件根据编码规则自动编号)
地质代码	Character	Pt@2$2y$2
地质体面实体名称	Character	杨庄组二段
地质体面实体时代	Character	Pt@2$2
地质体面实体下限年龄值	Double	0(0表示为空值)
地质体面实体上限年龄值	Double	0(0表示为空值)
子类型标识	Integer	0(0表示沉积地层单位)

注: “$”表示上标; “@”表示下标。

地质 (界) 线 (_GeoLine) 属性主要有: 要素标识号、地质界线 (接触) 代码、界线类型、界线左侧地质体代号、界线右侧地质体代号、走向、倾向、倾角、子类型标识 (表 4)。

产状 (_Attitude) 数据属性主要有: 要素标识号、产状类型名称代码、产状类型名称、产状走向、倾向、倾角 (表 5)。

照片 (_Photograph) 数据属性主要有: 要素标识号、照片编号、照片题目、照片说明 (表 6)。

化石 (_Fossil) 数据属性主要有: 要素标识号、化石样品编号、化石所属生物门类、化石属或种名、化石产出层位、含化石地层单位代号、化石时代 (表 7)。

同位素年龄 (_Isotope) 数据属性主要有: 要素标识号、样品编号、样品名称、年龄测定方法、测定年龄、被测定出地质体单位及代号、测定分析单位、测定分析日期 (表 8)。

钻孔 (_Drillhole) 数据属性主要有: 要素标识号、钻孔编号、钻孔深度、基岩或目的层孔深、基岩或目的层岩性、基岩或目的层时代、松散沉积层的年代、松散沉积层的分层厚度、松散沉积层的岩性 (表 9)。

表 4　地质 (界) 线数据属性表

字段名称	字段类型	实例
要素标识号	Character	AJ50E002018000001133
地质界线(接触)代码	Character	01
地质界线类型	Character	整合
界线左侧地质体代号	Character	Pt@2$2w$1
界线右侧地质体代号	Character	Pt@2$2w$2
界面走向/°	Integer	110
界面倾向/°	Integer	200
界面倾角/°	Integer	33
子类型标识	Integer	0(0表示地质界线)

注: “$”表示上标; “@”表示下标。

表 5　产状数据属性表

字段名称	字段类型	实例
要素标识号	Character	AJ50E002018000000099
产状类型名称代码	Character	01
产状类型名称	Character	岩层产状
走向/°	Integer	345
倾向/°	Integer	255
倾角/°	Integer	28

表 6　照片数据属性表

字段名称	字段类型	实例
要素标识号	Character	AJ50E002018000000133
照片编号	Character	D1171_1
照片题目	Character	燧石质角砾岩
照片说明	Character	巨厚层状燧石质角砾岩, 角砾成分以燧石为主, 少量白云岩, 角砾均呈棱角状及次棱角状, 角砾大小一般3 ~ 5 cm, 大者可达10 cm

表 7　化石数据属性表

字段名称	字段类型	实例
要素标识号	Character	AJ50E002018000000013
化石样品编号	Character	D1216HS01
化石所属生物门类(地质代码)	Character	块茎状高于庄叠层石
化石属或种名	Character	*Gaoyuzhuangia bulbosa* Zhu et al
化石产出层位	Character	高于庄组三段白云岩
含化石地层单位代号	Character	Pt@2$2g$3
化石时代	Character	Pt@2$2

注: “$”表示上标; “@”表示下标。

河、湖、海、水库岸线 (_Line_Geography) 数据属性主要有: 要素标识号、图元类型代码、图元名称等 (表 10)。

表 8　同位素数据属性表

字段名称	字段类型	实例
要素标识号	Character	AJ50E002018000000014
样品编号	Character	P7-OSL2
样品名称	Character	灰白色细砂
年龄测定方法	Character	OSL测年
测定年龄	Character	22.11±1.14 ka
被测定出地质体单位及代号	Character	Qp@3
测定分析单位	Character	北京光释光实验室科技有限公司
测定分析日期	Character	2018-09-25

注:“@”表示下标。

表 9　钻孔数据属性表

字段名称	字段类型	实例
要素标识号	Character	AJ50E002018000001000
钻孔编号	Character	KK01
钻孔深度	Character	80.22 m
基岩或目的层孔深	Character	71.23 m
基岩或目的层岩性	Character	灰白色细晶白云岩, 灰黄色泥质白云岩
基岩或目的层时代	Character	Pt@2$2w$2
松散沉积层的年代	Character	Qh, Qp@3, Qp@2, Qp@1, N@2
松散沉积层的分层厚度	Character	Qh, 0 ~ 2 m; Qp@3, 2 ~ 18.39 m; Qp@2, 18.39 ~ 26 m; Qp@1, 26 ~ 47.77 m; N@2, 47.77 ~ 71.23 m
松散沉积层的岩性	Character	粉砂质黏土, 黏土质粉砂, 砾质粉砂质黏土, 泥砾层等

注:“$”表示上标;“@”表示下标。

表 10　河、湖、海、水库岸线数据属性表

字段名称	字段类型	实例
要素标识号	Character	AJ50E002018000000069
图元类型	Character	21021
图元名称	Character	单线时令河

3.2　综合要素数据集

本次综合要素数据集主要为标准图框 (内图框), 其数据属性主要有: 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 (表 11)。

3.3　对象类数据集

本次地质图空间数据库涉及沉积岩岩石地层单位、侵入岩岩石年代单位、断层、脉岩 (面)、面状水域、图幅基本信息 6 个对象类数据集。

沉积岩岩石地层单位数据属性主要有: 要素分类 (地质代码)、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 (表 12)。

表 11　标准图框 (内图框) 数据属性表

字段名称	字段类型	实例
图名	Character	古冶幅
图幅代号	Character	J50E002018
比例尺	Character	1∶50 000
坐标系统	Character	1980年国家大地坐标系
高程系统	Character	1985国家高程基准
左经度	Character	1 181 500
下纬度	Character	394 000
图形单位	Character	mm

表 12　沉积 (火山) 岩岩石地层单位数据属性表

字段名称	字段类型	实例
要素分类(地质代码)	Character	O@1y
地层单位名称	Character	冶里组
地层单位符号	Character	O@1y
地层单位时代	Character	O@1
岩石组合名称	Character	豹皮状泥晶灰岩、泥质条纹灰岩、砾屑灰岩
岩石组合主体颜色	Character	灰色、浅灰色
岩层主要沉积构造	Character	具泥质条纹
生物化石带或生物组合	Character	三叶虫*Asaphellus* sp., *Hystricurus* sp., *Pcnchiaspis* sp., *Endoaspisrectangulosa*; 腹足类*Maciuriscs* sp.; 腕足类*Acrothele* sp.
地层厚度	Character	96.9 ~ 149.4 m
含矿性	Character	石灰岩矿

注: “@”表示下标。

侵入岩岩石年代单位数据属性主要有: 要素分类 (地质代码)、岩体填图单位名称、岩体填图单位符号、岩石名称 (岩性)、岩石颜色、岩石结构、岩石构造、岩相、主要矿物及含量、次要矿物及含量、与围岩接触关系、围岩时代、与围岩接触面产状 (走向、倾向、倾角)、流面产状、流线产状、形成时代、含矿性等 (表略, 参见数据库)。

变质岩地 (层) 单位数据属性主要有: 要素分类 (地质代码)、地 (岩) 层单位名称、地 (岩) 层单位符号、岩石名称 (岩性)、岩石颜色、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 (岩) 层产状 (含各种构造面理)、矿物组合及含量、岩层厚度、含矿性、所属变质相带等 (表略, 参见数据库)。

断层数据属性主要有: 要素分类代码、断层类型 (地质代码)、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 (表 13)。

脉岩 (面) 数据属性主要有: 脉岩类型分类代码、脉岩名称、脉岩符号、岩性、颜色、结构、构造、主要矿物及含量、次要矿物及含量、与围岩接触面产状 (走向、倾向、倾角)、形成时代、含矿性 (表略, 参见数据库)。

面状水域数据属性主要有: 要素分类代码、图元类型、图元名称、图元特征 (表略, 参见数据库)。

表 13　断层数据属性表

字段名称	字段类型	实例
要素分类代码	Character	F4
断层类型(地质代码)	Character	F4
断层名称	Character	磨石板断裂
断层编号	Character	J50E002018F4
断层性质	Character	逆断层
断层上盘地质体代号	Character	Pt@2$2w$1, Pt@2$2w$2, Pt@2$2w$3, Pt@3$1l, Pt@3$1j
断层下盘地质体代号	Character	Pt@2$2g$3, Pt@2$2g$4, Pt@2$2y$1, Pt@3$1j, Pt@2$2w$1, Pt@3$1l
断层破碎带宽度	Character	5 ~ 10 m
断层走向/°	Integer	300
断层倾向/°	Integer	210
断层面倾角/°	Integer	60
估计断距	Float	0(0表示为空值)
断层形成时代	Character	印支期
活动期次	Character	印支期

注:“$”表示上标;“@”表示下标。

图幅基本信息数据属性主要有:地形图编号、图名、比例尺、坐标系统、高程系统、左经度、右经度、上纬度、下纬度、成图方法、调查单位、图幅验收单位、评分等级、完成时间、出版时间、资料来源、数据采集日期(表略,参见数据库)。

3.4　独立要素类数据集

独立要素类属于地质图廓外相关内容,未添加属性,主要包括接图表、图例、综合柱状图、责任表、图切剖面等。综合柱状图由图幅内标准孔综合柱状剖面图和前新生代地层综合柱状图组成;图切剖面由地质剖面图和第四系地质剖面组成,其中地质剖面图主要依据基岩钻孔编制,以反映测区深部地层分布及构造情况为主,第四纪地质剖面图主要依据已有水文钻孔及本次完成的第四系钻孔编制,以反映测区第四纪地层层序及活动断裂为主。

4　数据质量控制和评估

本次工作按照中国地质调查局天津地质调查中心统一安排开展工作方案设计、野外调查、样品采集、分析测试等工作。工作中严格执行国家和行业相关标准和规范,精度满足区域地质调查工作的规范要求。

为保证数据采集质量,项目执行过程中严格按照《中国地质调查局地质调查项目管理办法(试行)》的要求,严格执行自检、互检、项目检“三级质量检查制度”,做到数据自检、互检率100%,项目检率大于30%,院检抽检率超过10%。2018年10月中旬、2019年1月下旬,中国地质调查局天津地质调查中心分别组织专家对该项目进行野外验收和最终成果验收。野外验收采用室内、现场两者相结合的方式,其中古冶幅为良好级,唐山幅、范各庄煤矿幅为优秀级,最终成果(成果报告及地质图空间数据库)92分,优秀级。

以上措施和方法都保证了本数据库的数据质量符合相关规范的要求，保证了成果数据库的准确性。

5 数据价值

河北省古冶幅、唐山幅、范各庄煤矿幅 1∶50 000 地质图空间数据库建设基于依据《区域地质调查总则 (1∶50 000)》(DZ/T 0002–1991)、《1∶50 000 覆盖区区域地质调查工作指南 (试行)》、《1∶50 000 区域地质调查工作指南 (试行)》等规范和技术要求开展的古冶幅、唐山幅和范各庄煤矿幅 3 个标准图幅的 1∶50 000 区域地质调查，在调查成果的基础上编制了标准的 1∶50 000 地质图。调查精度提高、调查方法可靠、调查内容全面，数据采集过程具有完善的质量控制体系，确保了数据的真实性、可靠性和准确性。本数据库的建设不仅可向社会各界提供基础性地质资料和信息，更好地为相应区域的经济可持续发展、城市规划建设、生态环境保护和重大工程施工等提供基础地质支撑，而且可为相应区域制定经济发展的战略决策，保证国土资源信息化工作的高水准、高效率，为国家经济持续发展起到有力的促进作用 (康庄等, 2012; 庞建峰等, 2017; 张源等, 2018)。

(1) 古冶幅为低山丘陵区，前第四纪地层共划分出 23 个组级岩石地层单位，建立了测区岩石地层序列。将区内新太古代变质深成岩进一步解体为二长花岗质片麻岩 ($Ar_3gn^{\eta\gamma}$) 和正长花岗质片麻岩 ($Ar_3gn^{\xi\gamma}$)2 个填图单位，获得二长花岗质片麻岩 U–Pb 年龄 2 547±41 Ma，为早前寒武纪地质演化提供了基础资料。

(2) 唐山幅、范各庄煤矿幅为山前倾斜平原，浅表第四系划分了 24 个成因地层单位；编制了上新世晚期—第四纪期间的 10 个时期的岩相古地理图，为研究生态环境、地质灾害及地热和地下水资源分布特征提供丰富的地质背景数据。

(3) 利用完成的 4 个第四系综合研究钻孔数据，开展了岩石地层、生物环境地层、气候地层、化学地层、年代地层、磁性地层等多重地层划分对比研究，建立了第四纪地层层序，可为河北平原北部第四纪地质调查和研究提供基础数据支撑。

(4) 查明区内主要断裂的分布及其活动性，建立了区域构造格架，为地壳稳定性评价提供基础资料支撑，也为重大工程建设规划和减灾防灾提供依据。

(5) 研究区位于古滦河以丰润为顶点的第 I 期冲积扇和以迁安西峡口为顶点的第 Ⅱ期冲积扇的交叉部位，该数据库集成野外地质填图、第四系钻探、物探、年代学数据等成果，为研究古滦河冲洪积扇的形态、结构、物质组成及其演化特征提供了大量翔实的基础地质资料及年代学数据。

(6) 研究区位于山区和平原的过渡地带，本次进行了三维立体地质填图和多学科综合调查研究，探索了山区和平原的过渡地区 1∶50 000 填图的地质图件及成果表达方式，为同类地区开展地质调查项目开拓了新的思路。

6 结论

(1) 河北省古冶幅、唐山幅、范各庄煤矿幅 1∶50 000 地质图空间数据库包括古冶幅、唐山幅和范各庄煤矿幅 3 个标准图幅，数据采集通过遥感解译、野外数字填图、第四系钻探、人工浅钻及浅层地震剖面等手段获取，采集过程具有完善的质量控制体系，确保了数据的真实性、可靠性、准确性。

(2) 河北省古冶幅、唐山幅、范各庄煤矿幅 1：50 000 地质图空间数据库包括基本要素类、综合要素类、对象类及独立要素类。其中基本要素类包括 651 个地质体面实体 (第四系、沉积岩、变质岩、侵入岩等面实体) 数据、1 428 个地质界线数据、194 个产状数据、562 个照片数据、70 个年龄 (锆石 U–Pb 测年、^{14}C、OSL 测年) 数据、5 个第四系钻孔数据; 综合要素类数据主要为标准图框 (内图框); 对象类包括 57 个沉积岩岩石地层单位 (包括第四系) 数据、2 个侵入岩岩石年代单位数据、断层、脉岩、面状水域、图幅基本信息数据; 独立要素类主要为角图, 未添加属性。各类数据继承一致性良好, 数据质量较高, 为地质调查成果的社会化服务提供了基础。

(3) 河北省古冶幅、唐山幅、范各庄煤矿幅 1：50 000 地质图空间数据库的建立为唐山地区可持续发展、重大工程建设和地质环境保障、城市规划和生态环境保护等提供了详实的基础地质数据, 对揭示唐山地区第四纪时期的古环境、古地貌提供了丰富的资料, 为水文地质、环境地质和工程地质的研究提供宏观的视野。

致谢：参加野外数据采集工作的还有杨红宾、李锋、刘何凡、陈晓航、杨建、刘世琦等, 在工作和数据库完成过程中得到了中国地质调查局天津地质调查中心胥勤勉高工、王惠初研究员和河北省地质调查院肖文暹教授级高工的辛勤指导和帮助, 在此对各位专家和野外项目组所有成员表示最诚挚的感谢。

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1∶50 000 Geological Map Spatial Database of Guye Map-sheet, Tangshan Map-sheet and Fangezhuangmeikuang Map-sheet, Hebei Province

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Abstract: In accordance with the '*Standard of Digital Geological Map Spatial Database*' (DD 2006–06), the 1∶50 000 Geological Map Spatial Database of Guye Map-sheet (J50E002018), Tangshan Map-sheet (J50E003017) and Fangezhuangmeikuang Map-sheet (J50E003018), Hebei Province was completed by fully collecting previous geological data, and conducting 1∶50 000 regional geological survey of Guye Map-sheet, Tangshan Map-sheet and Fangezhuangmeikuang Map-sheet in and around Tangshan City, with 1∶50 000 geological maps compiled. Data was collected by means of remote sensing interpretation, field digital mapping, Quaternary drilling, manual shallow drilling and shallow seismic profiles. The database includes four datasets, i.e. basic element, comprehensive element, object and independent element, of which the basic element dataset includes 651 pieces of geopolygons (Quaternary, sedimentary rocks, metamorphic rocks, intrusive rocks and other area entities), 1428 geological boundaries, 194 attitudes, 562 photos, 70 data for dating (zircon U–Pb, ^{14}C and OSL dating), and five data pertaining to Quaternary drill holes; the comprehensive element dataset consists primarily of standard frame (internal map frame); the object dataset includes 57 data on sedimentary lithostratigraphic units (including the Quaternary), two data applied to intrusive lithochronological units, faults, dikes, water region and map-sheet basic information; the independent element dataset comprises primarily angular maps, with no attributes added. The database was constructed under a stringent quality control system throughout the entire process, which ensures the authenticity, reliability and accuracy of data, thus providing reliable

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geological support for sustainable economic development, urban planning, construction, ecological preservation and major engineering projects in corresponding regions.

Key words: Spatial database; Guye map-sheet; Tangshan map-sheet; Fangezhuangmeikuang map-sheet; 1∶50 000; Quaternary; geological survey engineering; Beijing-Tianjin-Hebei region

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

1 Introduction

Tangshan City and its surrounding areas in Hebei Province are an integral part of the coordinated development of the Beijing-Tianjin-Hebei region. In recent years, the city faces various ecological problems, such as groundwater shortage and land subsidence, which demand a timely solution for the benefit of long-term economic development. The 1∶50 000 regional geological survey in the region is of great significance to emergency water sources and responsible exploitation and utilization of groundwater resources, while providing basic geological data to support the regional economy and local governments' efforts in major project planning and disaster reduction and prevention (Xu QM et al., 2014).

The 1∶50 000 Guye Map-sheet (J50E002018), Tangshan Map-sheet (J50E003017) and Fangezhuangmeikuang Map-sheet (J50E003018) in Hebei Province are located at the border between the Yanshan Mountains and North China Plain, as part of the ancient Luanhe River sedimentary area. For a long time, the gradual uplift of the Yanshan Mountains has caused diversion and change of the ancient Luanhe River, controlling and affecting the distribution of sediments, and sedimentary facies associations, as well as change in the area (Wu C, 1984, 2001; Geological Research Institute of Dagang Oil Field et al., 1985; Gao SM, 1985; Li CX et al., 2013; Hu YZ et al., 2014). The earth surface to the west of Douhe River is dominated by alluvial and proluvial deposits of the ancient Luanhe River alluvial fan in the early and middle stages of the Late Pleistocene, and to the east of Douhe River conditions are dominated by the alluvial and proluvial deposits of the ancient Luanhe River alluvial fan in the late stage of Late Pleistocene-middle Holocene (Fig. 1).

The Geological Map Spatial Database of 1∶50 000 of Guye Map-sheet (J50E002018), Tangshan Map-sheet (J50E003017) and Fangezhuangmeikuang Map-sheet (J50E003018), Hebei Province (Table 1; Zhao BQ et al., 2020) was developed as a result of the sub-project '*1∶50 000 Geological Survey of Guye Map-sheet, Tangshan Map-sheet and Fangezhuangmeikuang Map-sheet, Hebei Province*', and as part of the '*Geological and Mineral Survey in Fengning and Tianzhen Areas of Yanshan-Taihang Metallogenic Belt*'. It involves the regional geological survey of three 1∶50 000 standard international map-sheets, and was implemented from 2016–2018. This survey adopted various techniques such as field digital mapping, remote sensing interpretation, drilling and comprehensive geophysical exploration. Taking the Quaternary geological structure and the activity of fault structures as the focus of investigation, it aims to identify the basic geological constraints to hydrogeology,

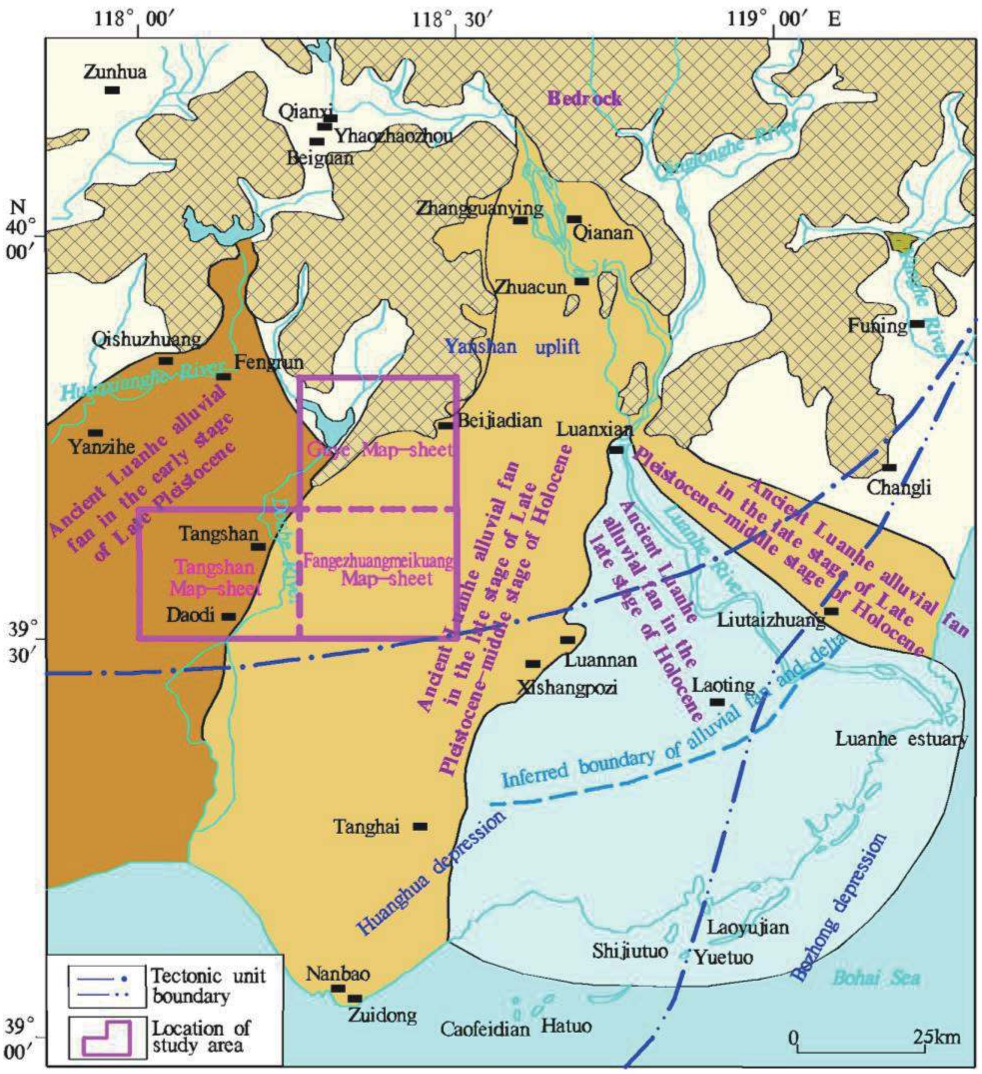

Fig. 1 Location of 1 : 50 000 Guye map-sheet, Tangshan map-sheet and Fangezhuangmeikuang map-sheet, Hebei Province (modified from Hu YZ et al., 2014)

engineering geology, environmental geology, disaster geology, etc. Meanwhile, the database can provide basic data resources for Quaternary regional geological survey and research, towards realizing the social sharing of geological survey results for basic research and public benefit.

2 Data Acquisition and Processing Methods

2.1 Data Acquisition

This regional geological survey applied a combination of various working methods including field route geological survey, field measured profile, remote sensing interpretation, geophysical exploration, drilling and sample testing for effective data acquisition. The 1 : 50 000 regional geological survey was carried out in line with the requirements of the '*1 : 50 000 Regional Survey Project Task Book of Guye Map-sheet, Tangshan Map-sheet, and Fangezhuangmeikuang Map-sheet*', and in conformity with the '*General Provisions for*

Table 1 Metadata Table of Database (Dataset)

Items	Description
Database (dataset) name	1：50 000 Geological Map Spatial Database of Guye Map-sheet, Tangshan Map-sheet and Fangezhuangmeikuang Map-sheet, Hebei Province
Database (dataset) authors	Zhao Baoqiang, Hebei Institute of Geological Survey Zhang Zhaoyi, Hebei Institute of Geological Survey Wang Kebing, Hebei Institute of Geological Survey Xu Yongli, Hebei Institute of Geological Survey Wang Chuan, Hebei Institute of Geological Survey Geng Xiaolei, Hebei Institute of Geological Survey
Data acquisition time	2016—2018
Geographic area	118°00′–118°30' E, 39°30′– 39°40′ N; 118°15′–118°30′ E, 39°40′–39°50′ N
Data format	MapGIS
Data size	54.8 MB
Data service system URL	http://dcc.cgs.gov.cn
Fund project	China Geological Survey project titiled "Regional Geological Survey of 1：50 000 Guye Map-sheet (J50E002018), Tangshan Map-sheet (J50E003017), Fangezhuangmeikuang Map-sheet (J50E003018), Hebei Province" (Project No.: DD20160042-5)
Language	Chinese
Database (dataset) composition	This database consists of a 1：50 000 geological map library and map decorations. The geological map library includes nine basic element datasets (geological polygon, geological boundary, attitude, photograph, sketch, fossil, isotope age, drillhole, river-lake-sea-reservoir coastline), one comprehensivex element dataset (internal map frame) and six object datasets (sedimentary rock lithostratigraphic unit, intrusive rock lithochronological unit, fault, dike, water region, basic map-sheet information); the map decorations are independent element data, including index map, columnar section, legend, cutting profile (each standard map-sheet includes one basement section and two Quaternary sections) and duty table

Regional Geological Survey (1：50 000)' (DZ/T 0002-1991), and '*Guidelines for 1：50 000 Regional Geological Survey (Trial)*'. All kinds of basic data acquisition were completed according to the project workload design (Table 2).

2.1.1 Remote Sensing Interpretation Dataset

The 1：50 000 remote sensing images in the present project used SPOT data, supplemented by the data of ETM (Enhanced Thematic Mapper) and MSS (Multi-Spectral Scanner). The combined methods of digital image processing, visual interpretation and human-computer interactive interpretation were adopted to establish interpretation marks, extract geological, geomorphological and environmental information, so as to develop interpretation of geological maps on the basis of vectorized electronic maps. The working platform was MapGIS geographic information system software.

According to the characteristics of the study area, the interpretation work was divided into three parts: remote sensing geology, geomorphology and environmental geology. Targeted

Table 2　Statistics of basic data volume

	Data type	Data volume	Unit
Field geological observation point		2 030	–
Geological boundary line		1 717	–
Attitude		350	–
Field photograph		600	–
Drilling	Quaternary drilling (footage 997.4 m)	5	–
	Coring drill (0–20 m)	335	Meter
Geophysical prospecting	Shallow seismic profile survey (point distance 100 m)	300	Point
Sample collection (main)	Rare earth elements, trace elements and silicate whole-rock geochemistry	30	Piece
	Microscope petrography identification	225	Piece
	Paleomagnetic sample	878	Piece
	Chromaticity	910	Piece
	Isotopic age (U–Pb method)	2	Piece
	Optical luminescence (OSL) dating	36	Piece
	^{14}C isotope dating	29	Piece
	Micropaleontological identification	227	Piece
	Particle size analysis (slice)	336	Piece

interpretation was adopted according to the needs of different tasks.

Remote sensing geological interpretation: ETM data and SPOT (Earth Observation System) data were used to interpret fault structures and lithostratigraphic image units, among other remote sensing information.

Geomorphic interpretation: ETM and MSS data were used for macro-geomorphic division, mainly interpreting geomorphic types, alluvial fans, depressions, ancient river courses, among other macro-remote sensing geomorphic information. For microscopic geomorphology, SPOT data were used to interpret geomorphological information such as river terraces, riverbanks, reservoirs, and ancient river courses.

Environmental geological interpretation: SPOT data were used to interpret mineralogical, geological and environmental information such as ground collapse and mineral fields, as well as environmental geological information such as municipal waste and industrial waste.

2.1.2　Field Geological Mapping

The traverse method was adopted for field geological routes, complemented by recovery routes. Mapping work was deployed based on preliminary interpretation results, with a differentiated approach to the deployment of field mapping routes and observation points in terms of density and importance. The main contents for observation were formulated for each line and point, in order to achieve purposeful and targeted mapping for all routes. To improve the efficiency and accuracy of field work, routes and measured profiles were deployed according to the '*General Provisions for Regional Geological Survey (1：50 000)*' (DZ/T 0002−1991) and the '*Guidelines for 1：50 000 Regional Geological Survey (Trial)*' for exposed bedrock area, and the '*Guidelines for 1 ∶ 50 000 Regional Geological Survey in Covered Areas (Trial)*' for covered areas. Natural and excavation sections such as scarps, dams, highway subgrade were mostly used in the piedmont area (Guye Map-sheet) in the northeast of the study area, with route spacing kept between 1 000 and 1 500 m. In the southern plain area (alluvial fan area), route spacing was between 1 500 and 2 500 m. The arrangement of geological points was based on geomorphological changes, soil changes, vegetation changes, pollution, disaster engineering layers and geological boundary points. Any excavation point such as brick and tile yard with natural outcrops such as scarps would be assigned a point. For the most part, the spacing and number of points were not even. The piedmont area, where mountain transitions to plain, is characterized by complex topography, and diverse genesis and poor continuity of geobodies. The present project adopted multiple short sections with a vertical scale of not less than 1 ∶ 200 to form geomorphological and geological sections with a transverse scale of 1 ∶ 5 000. The material composition, genetic type, structural structure, and spatial distribution of Quaternary sediments (deposits) and their relationship with tectonism were investigated in detail, in order to shed light on the relationship between Quaternary geobodies and geomorphological types. 1 ∶ 1 000 measured sections and 1 ∶ 100 vertical large-scale short sections were used to study the geomorphological characteristics of riverbed terraces (formative era) and paleochannels of various rivers and their relationship with neotectonic movements.

All route observation records and measured profiles were completed in the DGSS system. Fordata acquisition, the 1 ∶ 25 000 digital topographic map was taken as the base map. Through field actual route investigation, point and line information about geological points, geological boundary lines and routing, attitude, photography, sampling, and fossil content were marked in the digital mapping system, and a digital mapping (PRB) database was initially established.

Geological point (P): includes boundary point, lithologic boundary point, and observation point. Simple attributes were filed in the system, including point number, point micro-geomorphology outcrop, weathering degree, position description, mapping unit and contact relation. Coordinate information was automatically read by the system.

Geological route (R): the attributes filled in the system include route number, geological point number, route code, direction angle, distance from geological point, cumulative distance, mapping unit and rock name. Among them, the direction angle, distance from geological point, and cumulative distance were automatically calculated by the system.

Geological boundary line (B): the attributes filled in the system include route number, geological point number, geological boundary number, routing number, boundary type, left mapping unit, right mapping unit, contact relation, strike, dip and dip angle.

Relevant information regarding the attitude of geobodies seen along the way, collected specimens, and photographs, etc., were input into the system, along with attributed data.

2.1.3 Quaternary Drilling

Quaternary drilling aims to identify the geological characteristics of Quaternary sediments in the area. Necessary samples were collected for analysis of lithostratigraphy, climate stratigraphy, biostratigraphy, chronostratigraphy, and magnetostratigraphy, so as to establish a Quaternary stratigraphic columnar section, which can provide a basis for regional stratigraphic correlation and the establishment of stratigraphic sequences and three-dimensional Quaternary geological structures.

Five Quaternary drillholes were deployed in the area, which when combined with existing hydrogeological drillholes constitute five NWW-trending sections with different lengths, seven NNE-trending sections, with spacing from 2 km to 10 km, thus forming a NWW and NNE drillhole grid in a plane. According to the stratigraphic characteristics, normal circulation rotary drilling was adopted on site. The average drill-core recovery was not less than 80% by adopting the coring method of single-tube projectile drilling and pumping pressure core drilling, in which drill-core recovery in the cohesive soil was not less than 90%, sand soil, not less than 70%, sludge layer, less than 60%, and gravel layer, not less than 40%. When every 100 m was drilled, hole deflection was measured and hole depth was corrected once, so that hole deflection was kept under 1.0° every 100 m, and hole depth error under 1‰. The corrected hole depth prevails. After the cores were recovered, they would be put into PVC semi-closed pipes in order. After the cores were split, they would be promptly photographed, recorded and sampled in time, and the geological columnar section of the drillhole would be compiled.

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Geological documentation of a drillhole describes the lithological composition and particle size of cores (particle size characteristics, sortability and composition, etc.), color (primary color of deposit and color stains and belts), structure (bedding surface structure and interlayer structure), contact relation between upper and lower layers, plasticity and hardness of sediments, and special lithological interlayer characteristics. After drilling was finished, geophysical well logging was carried out using four methods of spontaneous potential, apparent resistivity, natural gamma ray and acoustic wave according to technical requirements.

2.1.4 Shallow Seismic Exploration

Geophysical prospecting in the present project used the shallow seismic multiple superposition method to identify the position of the upper breaking point of the active fault and its neotectonic movement characteristics. The relationship between Quaternary loose sediment stratification and ancient Luanhe alluvial-proluvial fan superposition was investigated in combination with drilling. In excitation using vibroseis, geophone spacing was 5 m, the number of receiving channels was 48, channel spacing was 5 m, blasthole spacing was 20 m, the number of coverage was 12, minimum sampling interval was 0.5 ms, the number of sampling points was 2 048, and the passband was all-through.

2.2 Data Processing

A geological map spatial database was formed by exchanging, inheriting, extracting and condensing data in different working stages such as a free hand field map database, actual material map database, profile database, and drillhole database (Kang Z et al., 2012). The work flow of data processing of the 1∶50 000 geological map spatial database of Guye Map-sheet, Tangshan Map-sheet and Fangezhuangmeikuang Map-sheet, Hebei is shown in Fig. 2.

2.2.1 Geological Mapping Field Database

After data acquisition is completed, for the field route PRB data and the measured profile data that have been checked and backed up, (1) data was transferred from the mobile platform to the desktop system in the digital mapping desktop system to form the field route hand map

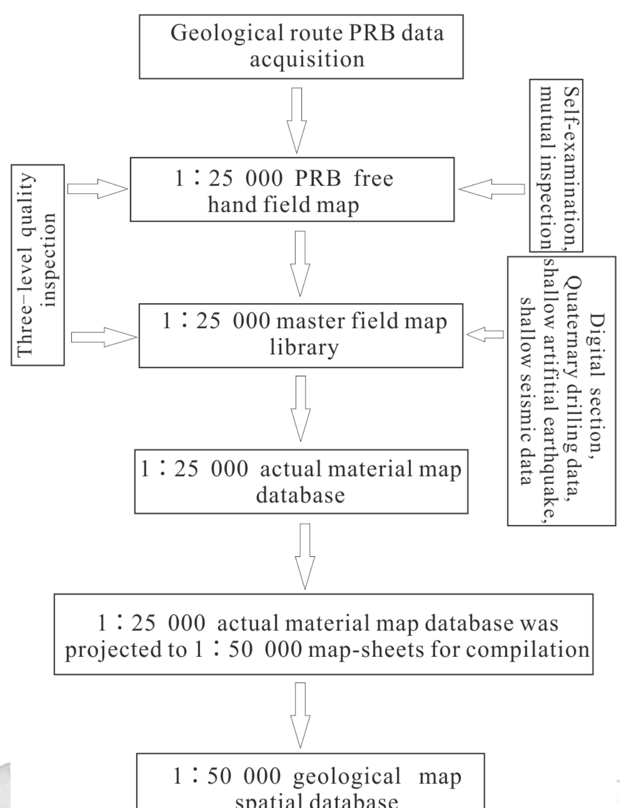

Fig. 2 Work flow of geological map spatial database

library and the measured profile library, and the data was processed according to the corresponding specifications; (2) Quaternary drilling data was input into a Quaternary drilling library; (3) three-level quality inspection (self-examination, mutual inspection and project inspection) was conducted regarding PRB data of the field route hand map, measured section data and Quaternary drilling data, and input into the master field map library.

2.2.2 Actual Material Map Library

The master field map library was updated to the actual material library for the compilation of actual material maps. According to observation data in the PRB database of the map-sheet, geological boundary lines were drawn in accordance with the V-like rule. Attribute content of geological boundary consistent with field observation was correctly extracted and assigned, so as to ensure the consistency between map elements and attributes and the common items connecting spatial and non-spatial data. The attributes of the features of geological polygons and geological boundary lines were refined.

2.2.3 Original Maps for Compilation

The completed 1∶25 000 actual material maps were projected and combined into 1∶50 000 map-sheets for compilation and were processed in accordance with relevant requirements. In this process, the spatial data structure of the actual material library was partially inherited. Geological polygons, geological boundary lines, dikes, attitudes, samples, drillholes, and fossils were all expressed in accordance with the specifications for map appearance, legend, and symbols specified in the '*Geological Symbols Used for Regional Geological Maps*' (GB 958–2015) and '*Standard and Principle for Coloration of Geological Map*' (DZ/T 0179–1997), with various auxiliary maps and illustrations compiled.

2.2.4 Geological Map Spatial Database

On the basis of the compilation of original maps, the spatial database of geological maps was constructed. The spatial database is characterized by inheritance, i.e., the existing attributes of element and object in the actual material library are integrated into the spatial database before inputting and completing the attributes of the basic element, comprehensive element and object.

3 Data Sample Description

The 1∶50 000 Geological Map Spatial Database of Guye Map-sheet, Tangshan Map-sheet and Fangezhuangmeikuang Map-sheet, Hebei Province includes geographical features, geobody features and geological map appearance features. The geographical base map used in the present project is the 1∶50 000 vector topographic map provided by the National Geomatics Center of China (NGCC) of the State Bureau of Surveying and Mapping. The attributes of geographical features follow the attribute structure of the data purchased by the National Bureau of Surveying, Mapping and Geographic Information. The geological entity feature and geological map finishing feature include nine basic element datasets, one comprehensive element dataset, six object datasets and independent element datasets. The element dataset is an assemblage of features sharing the same spatial reference system, and are composed of geological point, area and line entities in a geological map database model. The object dataset is an Excel form storing non-spatial data. In a geological map data model, generally one element data corresponds to multiple object data.

3.1 Basic Element Dataset

The basic element dataset includes geological polygons, geological (boundary) lines, attitude, photography, fossils, isotope ages, drillholes, and river-lake-sea-reservoir coastline.

Geopolygon (_GeoPolygon) includes the following attributes: strata, metamorphic rock, magmatic rock geopolygon. Data attributes include geological polygon identification number, geological code, geological polygon name, geological polygon era, lower age limit of geological polygon, upper age limit of geological polygon and subtype identification (Table 3).

The attributes of geological (boundary) line (_GeoLine) include: feature identification number, geological boundary line (contact) code, boundary name, geobody code on the left side of the boundary, geobody code on the right side of the boundary, strike, dip direction, dip angle, and subtype identification (Table 4).

The attributes of attitude (_Attitude) include: feature identification number, attitude type code, attitude name, strike, dip direction, and dip angle (Table 5).

Table 3 Attribute table of geological polygon

Field name	Field type	Examples
Geological polygon identification number	Character	AJ50E0020180 00000383 (automatically numbered by software according to coding rules)
Geological code	Character	Pt@2$2y$2
Geological polygon name	Character	Member 2 of Yangzhuang Formation
Geological polygon era	Character	Pt@2$2
Lower age limit of geological polygon	Double	0 (0 denotes null)
Upper age limit of geological polygon	Double	0 (0 denotes null)
Subtype identification	Integer	0 (0 denotes sedimentary stratigraphic units)

Note: “$” indicates superscript; “@” indicates subscript.

Table 4 Attribute table of geological (boundary) line

Field name	Field type	Examples
Feature identification number	Character	AJ50E0020180 00001133
Geological boundary line (contact) code	Character	01
Boundary name	Character	Integration
Geobody code on the left side of the boundary	Character	Pt@2$2w$1
Geobody code on the right side of the boundary	Character	Pt@2$2w$2
Strike/°	Integer	110
Dip direction/°	Integer	200
Dip angle/°	Integer	33
Subtype identification	Integer	0 (0 indicates geological boundary)

Note: “$” indicates superscript; “@” indicates subscript.

The attributes of photograph (_Photograph) include: Feature identification number, sample code, photo title and photo note (Table 6).

The attributes of fossil (_Fossil) include: feature identification number, fossil sample code, biological category of fossil, genus or species, bed, code of fossil-bearing lithostratigraphic unit, and era (Table 7).

The attributes of isotope age (_Isotope) include: feature identification number, sample code, sample name, age measuring method, age, unit and code of measured geobody, measuring and analysing unit, measuring and analysing date (Table 8).

The attributes of drillhole (_Drillhole) include: feature identification number, drillhole number, drillhole depth, depth of bedrock or target layer, lithology of bedrock or target layer, era of bedrock or target layer, era of loose sedimentary layer, thickness of loose sedimentary

Table 5 Attribute table of attitude

Field name	Field type	Examples
Feature identification number	Character	AJ50E002018000000099
Attitude type code	Character	01
Attitude name	Character	Attitude of strata
Strike/°	Integer	345
Dip direction/°	Integer	255
Dip angle/°	Integer	28

Table 6 Attribute table of photograph

Field name	Field type	Examples
Feature identification number	Character	AJ50E002018000000133
Sample code	Character	D1171_1
Photo title	Character	Cherty breccia
Photo note	Character	Giant thick-laminated cherty breccia; the breccia composition is mostly chert, with a small amount of dolomite; the shape is invariably angular and sub-angular; breccia size is generally 3–5 cm, and can reach up to 10 cm

Table 7 Attribute table of fossil

Field name	Field type	Examples
Feature identification number	Character	AJ50E002018000000013
Fossil sample code	Character	D1216HS01
Biological category of fossil	Character	Tuber-like Gaoyuzhuang stromatolite
Genus or species	Character	*Gaoyuzhuangia bulbosa* Zhu et al
Bed	Character	Dolomite of the 3rd Member of Gaoyuzhuang Formation
Code of fossil-bearing lithostratigraphic unit	Character	Pt@2$2g$3
Era	Character	Pt@2$2

Note: "$" indicates superscript; "@" indicates subscript.

layer, and lithology of loose sedimentary layer (Table 9).

The attributes of the River-Lake-Sea-Reservoir coastline (_Line_Geography) include: feature identification number, feature type, and feature name (Table 10).

3.2 Comprehensive Element Dataset

This complex feature dataset uses a standard frame (internal map frame), and its attributes include: map name, sheet code, scale, coordinate system, height system, left longitude, lower latitude, and coordinates unit (Table 11).

Table 8 Attribute table of isotope

Field name	Field type	Examples
Feature identification number	Character	AJ50E002018000000014
Sample code	Character	P7-OSL2
Sample name	Character	Grey-white fine sand
Age measuring method	Character	OSL dating
Age	Character	22.11±1.14 ka
Unit and code of measured geobody	Character	Qp@3
Measuring and analysing unit	Character	Beijing Optical Luminescence Laboratory Technology Co., Ltd.
Measuring and analysing date	Character	2018-09-25

Note: “@” indicates subscript.

Table 9 Attribute table of drillhole

Field name	Field type	Examples
Feature identification number	Character	AJ50E002018000001000
Drillhole code	Character	KK01
Drilling depth	Character	80.22 m
Depth of bedrock or target layer	Character	71.23 m
Lithology of bedrock or target layer	Character	Grey-white fine grained dolomite, grey-yellow argillaceous dolomite
Era of bedrock or target layer	Character	Pt@2$2w$2
Era of loose sedimentary layer	Character	Qh, Qp@3, Qp@2, Qp@1, N@2
Thickness of loose sedimentary layer	Character	Qh, 0–2 m; Qp@3, 2–18.39 m; Qp@2, 18.39–26 m; Qp@1, 26–47.77 m; N@2, 47.77–71.23 m
Lithology of loose sedimentary layer	Character	Silty clay, clayey sand, gravel silty clay, muddy gravel layer, etc

Note: “$” indicates superscript; “@” indicates subscript.

Table 10 Attribute table of River-Lake-Sea-Reservoir coastline

Field name	Field type	Examples
Feature identification number	Character	AJ50E002018000000069
Feature type	Character	21021
Feature name	Character	Single-track seasonal river

3.3 Object Dataset

This geological map spatial database involves six object datasets of sedimentary lithostratigraphic units, intrusive lithochronological units, faults, dikes (area), the water region, and basic map-sheet information.

The attributes of sedimentary lithostratigraphic units include: feature type (geological code), stratigraphic unit name, stratigraphic unit code, stratigraphic unit era, rock association name, rock association color, sedimentary structure, biological assemblage zone, stratigraphic thickness, and commodities (Table 12).

The attributes of intrusive lithochronological units include: feature type (geological code), intrusive name, intrusive code, rock name (lithology), color, rock texture, rock structure, rock phases, primary minerals and content, secondary minerals and content, contact relation with wall-rock, wall-rock era, attitude of wall-rock contact surface (strike, dip direction, dip angle), flow plane attitude, flow line attitude, formative era, and commodities (table omitted, please see database).

Table 11 Attribute table of standard frame (internal map frame)

Field name	Field type	Examples
Map name	Character	Guye Map-sheet
Sheet code	Character	J50E002018
Scale	Character	1 : 50 000
Coordinate system	Character	1980 National Geodetic Coordinate System
Height system	Character	1985 National Elevation Datum
Left Longitude	Character	1 181 500
Lower latitude	Character	394 000
Coordinates unit	Character	mm

Table 12 Attribute table of sedimentary (volcanic) rock lithostratigraphic unit

Field name	Field type	Examples
Feature type (geological code)	Character	O@1y
Stratigraphic unit name	Character	Yeli Formation
Stratigraphic unit code	Character	O@1y
Stratigraphic unit era	Character	O@1
Rock association name	Character	Leopard skin-like micritic limestone, argillaceous stripe limestone, gravel limestone
Rock association color	Character	Grey, light-grey
Sedimentary structure	Character	With argillaceous stripes
Biological assemblage zone	Character	*Trilobites: Asaphellus sp., Hystricurus sp., Pcnchiaspis sp., Endoaspisrectangulosa; Gastropods: Maciuriscs sp.; Brachiopods: Acrothele sp.*
Stratigraphic thickness	Character	96.9–149.4 m
Commodities	Character	Limestone ore

Note: “@” indicates subscript.

The attributes of metamorphic rock units include: feature type (geological code), lithostratigraphic unit name, lithostratigraphic unit code, rock name, color, rock texture, rock structure, primary minerals and content, metamorphic minerals and content, attitude, mineral association and content, thickness, commodities, metamorphic facies (table omitted, please see database).

The attributes of faults include: feature type, fault type (geological code), fault name, fault code, fault character, fault hanging wall geobody code, fault footwall geobody code, fault fracture zone width, fault strike, fault dip, fault dip angle, estimated fault distance, formative era of fault, and movement period (Table 13).

The attributes of dike (polygon) include: feature type, dike name, dike code, dike lithology, dike color, rock texture, rock structure, primary minerals and content, secondary minerals and content, attitude of contact surface with wall-rock (strike, dip direction, dip angle), dike era, and commodities (table omitted, please see database).

The attributes of water region include: feature type, element, feature name, and object feature (table omitted, please see database).

The attributes of basic map-sheet information include: sheet numbering, sheet name, scale, coordinate system, height system, left longitude, right longitude, upper latitude, lower latitude, mapping method, survey unit, accepting unit, grade, finished date, publish date, data origin, data acquisition date (table omitted, please see database).

3.4 Independent Element Dataset

The independent element belongs to the contents outside the geological map profile, and

Table 13 Attribute table of fault

Field name	Field type	Examples
Feature type	Character	F4
Fault type (geological code)	Character	F4
Fault name	Character	Grindstone fracture
Fault code	Character	J50E002018F4
Fault character	Character	Reverse fault
Fault hanging wall geobody code	Character	Pt@2$2w$1, Pt@2$2w$2, Pt@2$2w$3, Pt@3$1l, Pt@3$1j
Fault footwall geobody code	Character	Pt@2$2g$3, Pt@2$2g$4, Pt@2$2y$1, Pt@3$1j, Pt@2$2w$1, Pt@3$1l
Fault fracture zone width	Character	5–10 m
Fault strike/°	Integer	300
Fault dip/°	Integer	210
Fault dip angle/°	Integer	60
Estimated fault distance	Float	0 (0 denotes null)
Formative era of fault	Character	Indosinian period
Movement period	Character	Indosinian period

Note: “$” indicates superscript; “@” indicates subscript.

no attributes were added. It includes index map, legend, columnar section, duty table, and cutting profile. The columnar section consists of the columnar sections of standard holes in the map and the columnar sections of the pre-Cenozoic strata. The cutting profile is composed of geological section and Quaternary geological section, among which the geological profile was compiled primarily based on bedrock drillholes to reflect the distribution and structure of deep strata in the survey area. The Quaternary geological profile was compiled primarily based on the existing hydrological drillholes and the Quaternary drillholes completed this time to reflect the Quaternary stratigraphic sequence and active faults in the survey area.

4 Data Quality Control and Evaluation

The present project carried out work plan design, field survey, sample collection, analysis and testing, under the unified management of the Tianjin Center, China Geological Survey. Relevant national and industry standards and specifications were strictly implemented throughout the whole process, with accuracy meeting the specifications of regional geological survey.

To ensure the quality of data acquisition, the project was carried out in strict accordance with relevant requirements of the '*Administrative Measures for Geological Survey Projects (Trial)*' issued by China Geological Survey for implementing the 'Three-level Quality Inspection System' for self-examination, mutual inspection, and project inspection of quality, of which both the self-examination rate and mutual inspection rate of mapping routes reach 100%, project inspection rate exceeds 30% and the rate of sampling by the Tianjin Center of China Geological Survey exceeds 10%. In mid-October, 2018 and late-January, 2019, the Tianjin Center of China Geological Survey organized experts to carry out field acceptance and final result acceptance respectively. Field acceptance was conducted through a combination of indoor and site inspection. The Guye Map-sheet was rated good, and the Tangshan Map-sheet and Fangezhuangmeikuang Map-sheet were rated excellent. The final achievement (achievement report and geological map spatial database) was rated 'excellent' with a score of 92.

The above measures and methods ensure that the data quality of this database meets the requirements of relevant specifications, as well as the accuracy of the spatial database.

5 Data Value

The 1∶50 000 Geological Map Spatial Database of Guye Map-sheet, Tangshan Map-sheet and Fangezhuangmeikuang Map-sheet, Hebei Province was developed based on the 1∶50 000 regional geological survey of three standard map-sheets (Guye Map-sheet, Tangshan Map-sheet and Fangezhuangmeikuang Map-sheet), with compilation of standard 1∶50 000 geological maps. The survey was carried out in accordance with the '*General Provisions for Regional Geological Survey (1∶50 000)*' (DZ/T 0002–1991), '*Guidelines for 1∶50 000 Regional Geological Survey in Covered Areas (Trial)*', and '*Guidelines for 1∶50 000 Regional Geological Survey (Trial)*'. The survey was characterized by improved accuracy, reliable survey method and complete survey content. A well-established quality control system was adopted to ensure data authenticity, reliability and accuracy throughout the data acquisition process. The construction of this database, by offering basic geological data and information to all sectors of society, can provide basic geological support for sustainable economic development, urban planning and construction, ecological preservation and major engineering construction in relevant regions, as well as inform strategic decisions for economic development, thus helping to ensure the quality and efficiency of national land and resource informatization and promote sustainable development of the national economy (Kang Z et al., 2012; Pang JF et al., 2017; Zhang Y et al., 2018).

(1) The Guye Map-sheet is an area with low mountains and hills. The pre-Quaternary strata were divided into 23 formation-level lithostratigraphic units, and the lithostratigraphic sequence of the survey area has been established. The Neoarchean metamorphic plutons in the area were further classified into two mapping units, namely, monzonitic granitic gneiss ($Ar_3gn^{\eta\gamma}$) and syenitic granitic gneiss ($Ar_3gn^{\xi\gamma}$). The U–Pb age of monzonitic granitic gneiss is 2 547±41 Ma, which provides basic data for Early Precambrian geological evolution.

(2) The Tangshan and Fangezhuangmeikuang Map-sheets represent a piedmont inclined plain, and the superficial Quaternary was divided into 24 genetic stratigraphic units. The lithofacies paleogeographic maps of 10 periods from the late stage of Pliocene to the Quaternary have been compiled, providing abundant geological background data for the study of ecological environment, geological disasters and the distribution of geothermal and groundwater resources.

(3) Based on the four comprehensive drillhole data that have been acquired for the Quaternary, multiple stratigraphic subdivision and correlation studies have been conducted, e.g., lithostratigraphy, bio-environmental stratigraphy, climate stratigraphy, chemical stratigraphy, chronostratigraphy, and magnetostratigraphy. The Quaternary stratigraphic sequence has been established, which can provide basic data support for Quaternary geological survey and research in northern Hebei Plain.

(4) The distribution and activity of the main faults in the area were identified, and the regional tectonic framework was established, providing basic data support for crustal stability evaluation, and for major engineering construction planning and disaster reduction and prevention.

(5) The study area is located at the intersection of Stage I alluvial fan with Fengrun as its apex and Stage Ⅱ alluvial fan with Xixiakou, Qian’an as its apex. The database integrates the results of field geological mapping, Quaternary drilling, geophysical exploration and chronological data, providing large quantities of detailed basic geological data and chronological data for studying the morphology, structure, material composition and evolution of the ancient Luanhe alluvial-proluvial fan.

(6) The study area is located in the transition zone between mountain area and plain. In the present project, three-dimensional geological mapping and multidisciplinary comprehensive investigation have been carried out to explore the expression of 1：50 000

geological maps and results in the transition zone between mountain area and plain, with an exemplary effect for geological survey projects in similar areas.

6 Conclusion

(1) The 1：50 000 Geological Map Database of Guye Map-sheet, Tangshan Map-sheet and Fangezhuangmeikuang Map-sheet, Hebei Province includes three standard maps of Guye Map-sheet, Tangshan Map-sheet and Fangezhuangmeikuang Map-sheet. Data was collected by means of remote sensing interpretation, field digital mapping, Quaternary drilling, manual shallow drilling and shallow seismic profiles, with a well-established quality control system, which ensures the authenticity, reliability and accuracy of data.

(2) The 1：50 000 Geological Map Database of Guye Map-sheet, Tangshan Map-sheet and Fangezhuangmeikuang Map-sheet, Hebei Province includes basic element, comprehensive element, object and independent element, of which the basic element dataset includes 651 pieces of geopolygons (Quaternary, sedimentary rocks, metamorphic rocks, intrusive rocks and other area entities), 1428 geological boundaries, 194 attitudes, 562 photos, 70 data for dating (zircon U–Pb, 14C and OSL dating), and five data pertaining to Quaternary drill holes; the comprehensive element dataset consists primarily of standard frame (internal map frame); the object includes 57 data on sedimentary rock lithostratigraphic units (including Quaternary), two data for intrusive rock lithochronological units, as well as faults, dikes, the water region and basic map-sheet information; the independent element includes angular maps, with no attributes added. All kinds of data show good inheritance consistency and high quality, which provides a basis for realizing the social value of geological survey results.

(3) The construction of the 1：50 000 Geological Map Database of Guye Map-sheet, Tangshan Map-sheet and Fangezhuangmeikuang Map-sheet, Hebei Province provides detailed basic geological data for sustainable development, major engineering construction, geological environment protection, urban planning and ecological preservation in the Tangshan area. It provides abundant data for revealing the Quaternary paleoenvironment and paleogeomorphology in Tangshan and a macro perspective for the study of hydrogeology, environmental geology and engineering geology.

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