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全国 1∶200 000 数字地质图（公开版）空间数据库

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摘要: 全国 1∶200 000 数字地质图空间数据库是基于目前中国唯一的、实测的、全国性的 1∶200 000 区域地质调查成果，由全国多家单位共同完成的全国性基础地质学空间数据库之一。数据库在空间上包含 1 163 幅 1∶200 000 地质图数据，覆盖整个国土范围的 72%，包含 MapGIS 和 ArcGIS 两种格式，总数据量达到 90 GB。数据库主要资料来源于 1∶200 000 区域地质调查报告和地质图及矿产图，原始资料时间跨度从 20 世纪 50 年代中期到 90 年代初期。全国 1∶200 000 数字地质图（公开版）空间数据库通过国家级验收，数据完整性、逻辑一致性、位置精度、属性精度、接缝精度均符合中国地质调查局制定的有关技术规定和标准的要求，质量优良可靠。全国 1∶200 000 数字地质图空间数据库是国家空间数据的重要组成部分，为国民经济信息化提供数字化空间平台，为国家和省级各部门进行区域规划、地质灾害监测、地质调查、找矿勘查、宏观决策等提供信息服务。

关键词: 1∶200 000 数字地质图；空间数据库；地理信息系统

数据服务系统网址: http://dcc.cgs.gov.cn

1 引言

1∶200 000 地质图是最广泛使用的地质工作用图，在基础地质调查、矿产资源评价、地下水勘查、工程勘察和地质环境调查评价等方面有重要的使用价值，建设全国 1∶200 000 数字地质图空间数据库对提高上述工作的水平和效率具有重要意义 (刘锋英等，2002；唐海燕，2002；李军，2006；刘英才，2013)。

全国 1∶200 000 数字地质图 (公开版) 空间数据库 (以下简称“1∶200 000 地质图库”) 是在“八五”、“九五”期间，在地勘生产费用逐年减少、找矿风险不断加大的形势下，急需合理部署普查前期工作，以确保地质找矿重大突破的背景下，作为利用地

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理信息系统等先进技术辅助选准找矿远景地区的数据基础之一，并随后作为地勘信息系统建设的重中之重开始酝酿、试点和规模生产的。

全国 1：200 000 数字地质图 (公开版) 空间数据元数据简表如表 1 所示。

表 1　数据库 (集) 元数据简表

条目	描述
数据库（集）名称	全国1：200 000数字地质图（公开版）空间数据库
数据库（集）作者	李晨阳，中国地质调查局发展研究中心 王新春，中国地质调查局 何春珍，中国地质调查局发展研究中心 吴　轩，中国地质调查局发展研究中心 孔昭煜，中国地质调查局发展研究中心 李晓蕾，中国地质调查局发展研究中心
数据时间范围	1957—1995 年
地理区域	全国1：200 000国际分幅数字地质图研究区范围为中华人民共和国陆域部分为主。经度范围为：东经72°~138°，北纬16°~56°，采用1：200 000地形图的分幅编号
数据格式	.mpj, .shp, .doc
数据量	90 GB
数据服务系统网址	http://dcc.cgs.gov.cn
基金项目	原地质矿产部地质调查局、中国地质调查局委托项目（S3.2.1.1-27, 19961831004015-225, 199918310102-08, 19991831008015, 199918310120）
语种	中文
数据库（集）组成	数据集由1 163幅1：200 000地质图数据组成，每个地质图数据(即一个图幅)包含如下文件：一个图幅栅格数据文件、全要素矢量化地质图数据文件、MapGIS各图层数据文件(包括高斯\经纬度两种格式数据)、ArcInfo各图层数据文件、E00数据文件、属性库(*.DBF)，主要电子文档：元数据(图幅、分层、图层属性等说明)、说明文件(图饰图例库、修改字段、为制图要求添加注释图层等说明)。

2　数据采集和处理方法

全国绝大多数省、自治区建库地质资料主要来源于从 20 世纪 50 年代中期到 90 年代初期的 30 多年所测得的 1：200 000 区域地质调查报告和地质图及矿产图、各省的《地层多重划分和对比研究》、部分省的《区域地质志》、1：50 000 区域地质调查成果及相关地质报告、科研专题报告及图件。数据采集与综合处理是 1：200 000 数字地质图空间数据库建设的核心环节之一。

2.1　数据采集过程

建库采集数据均是使用的 MapGIS 6.7。建库采集数据过程归纳起来基本可分为五个阶段：

2.1.1　准备阶段

(1) 资料准备。根据所选图幅，全面收集有关资料 (包括图件、报告、分析数据、野外原始记录卡片、记录本等)，以满足建库需求。

(2) 文档准备。建库工作全面展开之前，首先根据《地质图空间数据库建设工作指南 (2.0 版)》编写操作性较强的作业指导书，编制各种属性卡片 (表)、工作日志、自检表、互检表、组检表等文档。

(3) 系统库准备。在 MapGIS 系统库的基础上，修改或补充各种花纹符号、线型、颜色库和制图参数索引表等。

2.1.2　数据采集阶段

(1) 扫描图形，形成栅格文件。在对聚脂薄膜地质底图或地质 (地质矿产图) 原图进行扫描时，为了减少扫描所产生误差，根据图件的清晰及复杂程度，选择适当的分辨率进行扫描。选择彩色扫描应在 150 dpi 以上，而黑白扫描应在 300 dpi 以上。

(2) 图形数据采集与编辑。图形采集编辑是对点、线、多边形等图形要素的空间数据进行编辑修改。为了确保所建空间数据库的质量，遵循图形数据线与线之间要建立结点，所有的多边形要闭合，图形数据和属性数据要一一对应，杜绝超出相关比例尺图件编绘标准的图形误差，特别是空间误差的原则。图形采集所用的线型、符号、图例及各种点的参数等均按国标、部标及行标的有关标准执行。因此无论是线或点，都要先分别选择参数后，再分别进行采集。

图形矢量化分层采集前，建立一系列标准的文件夹，设置系统路径。在图形矢量化过程中，首先将所有地质要素分层矢量化。按一定的顺序对图层进行数字化采集，即内图框→方里网 (经纬网)→河流→湖泊、水库→断层→脉岩→第四系地层→侵入岩→火山岩→非正式地层→其它地层。其它图层不存在重复利用图形要素的现象，可随意确定矢量化采集顺序。

经过对点、线要素的编辑后，对数字化地质图素图进行校正。校正完毕后输出数字化地质图素图，并进行图面自检、互检和组检。

2.1.3　建立分层文件、采录属性阶段

(1) 建立分层文件。根据地质体所在的图层，从综合多边形数据文件中分层提取 (多边形、线、点) 数据文件。线图层数据文件可利用弧转线建立其相应的文件。点用其所在不同层建立独立的分层文件。

(2) 建立属性结构、采录属性。地质专业人员按照各图层属性结构中数据项内容要求，查阅地质报告、说明书及其他相关资料，对地质图中各种地质要素在合并的临时图件上分别采集各图层属性。

2.1.4　投影转换及文件格式转换阶段

将分层文件进行成批投影转换，形成高斯北京、经纬度无投影坐标 (以秒为单位) 的数据成果。然后进行文件格式转换，即 MapGIS 数据向 ArcInfo 格式转换是通过 MapGIS 文件转换功能输出双精度的 E00 文件，通过 E00 文件得到 PC ArcInfo 的数据，并重建拓扑关系。

2.1.5　最终检查及内部验收阶段

检查各文件夹中文件放置是否正确，再次检查全要素数字化地质图是否符合规范，各种文档是否齐全。

MapGIS 数据采集工作流程，见图 1。

2.2　数据处理过程

MapGIS 格式数据为基础综合处理工作方法与技术流程，可分为两种情况：满标准图幅的数据、跨省界非满幅需要接缝综合处理的数据。

2.2.1　满标准图幅的数据综合处理工作方法与技术流程

为了便于工作和质量监控，将 MapGIS 格式数据综合处理过程分为 6 个步骤：

(1) 准备工作。查清各省图幅数据情况，包括单幅图各种文件是否齐全、投影参数、原地质图的坐标系统，单图幅数据是否跨省、数据是否采集满幅等，并输出含有省界的全国 1：200 000 国际分幅接图表，为下一步工作做好准备。

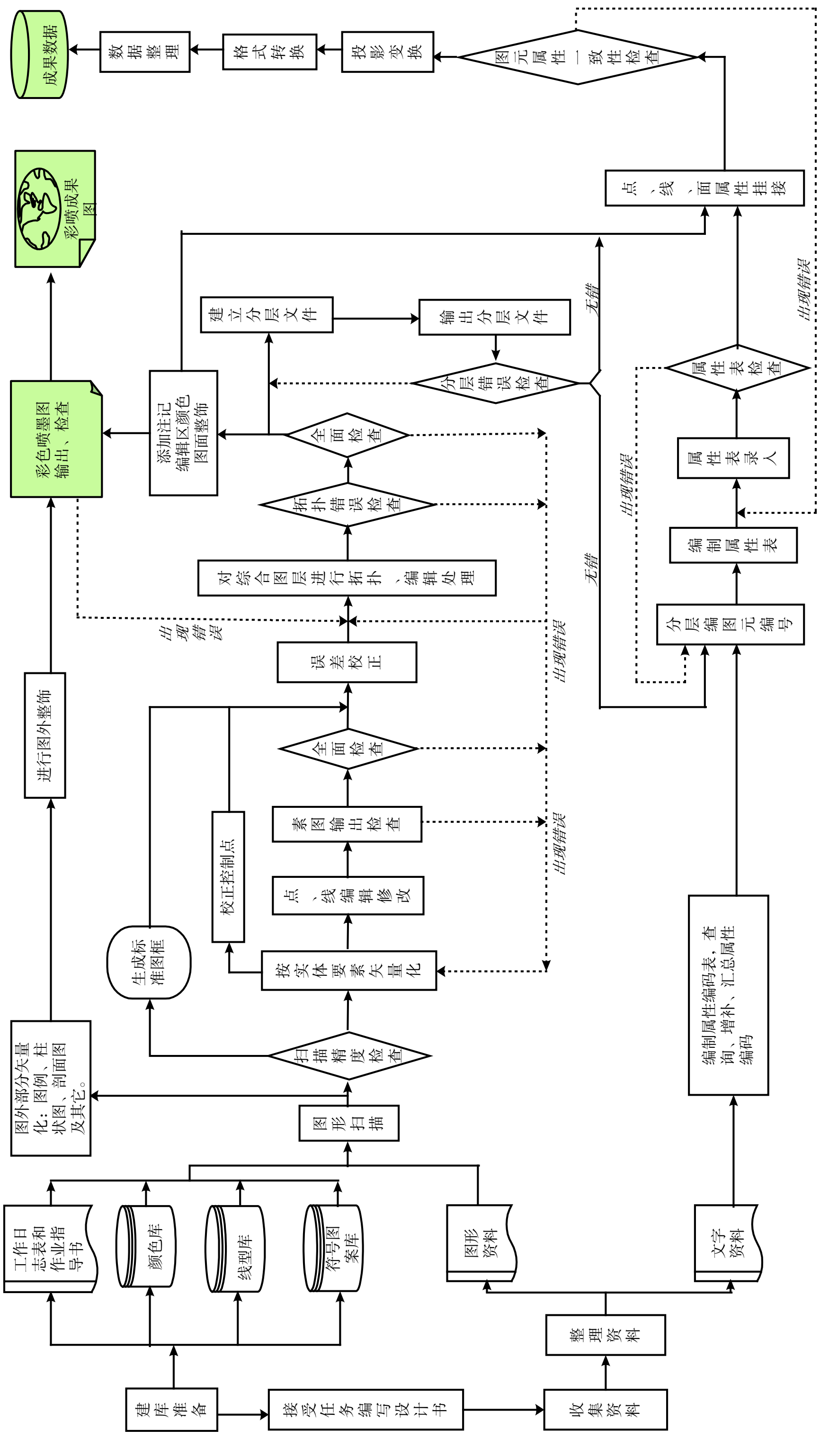

图 1 MapGIS 数据采集工作流程图

(2) 目录整理、图层命名标准化。严格按要求进行单图幅目录标准化，建立八个相应的标准文件夹。选择图层，将所有整饰图层文件及非《地质图空间数据库建设工作指南 (2.0 版)》中的图层属性文件删除，修改图层命名使其标准化。

(3) 各图层属性结构标准化。在 MapGIS 属性管理库中把属性结构按《地质图空间数据库建设工作指南 (2.0 版)》各图层属性表中数据项要求，对数据项名称、顺序、类型和长度等进行修改、增加缺少的数据项，删除多余数据项。

(4) 各图层属性数据项中图元编号标准化。检查 L02H，D01J(D02J、D03J、D04J)，L02S，D01D 等图层中线或弧段长度是否有坐标点超过 500 点的线或弧段，并对坐标点超过 500 点的线或弧段进行处理后，多边形图层要重新建立拓扑关系，压缩存盘。按标准重新赋值图元编号。

(5) 投影变换、E00 格式输出。投影转换前分别建立经纬度文件夹，放置准备进行投影变换的各图层文件。按目录采用成批投影转换方法进行投影变换。避免了个别文件的投影错误。文件格式转换，即 MapGIS 数据输出 E00 格式数据。格式转换后得到的 E00 文件，其名称按图层标准名称来命名。

(6) 检查阶段。对前面整合的数据进行 100% 的自检、互检和组检。

2.2.2 非满幅的图幅数据综合处理工作方法与技术流程分为 7 个步骤：

(1) 准备工作。同满标准图幅的数据综合处理准备工作阶段一致，检查分层数据文件和图形数据文件的情况，做好准备工作。

(2) 目录整理、图层命名标准化。图层命名标准化与满标准图幅的数据综合处理图层命名标准化一致。

(3) 图层属性结构标准化。分别修改所涉及省的各个分层文件的属性结构，使其标准化，方法与满标准图幅的数据综合处理图层命名标准化一致。

(4) 分层数据组合接缝。用一省的省界线与内图框制作裁剪框，如果地质体界线 (D01J.WL) 中没有省界线，则用多边形图层中省界弧段提取省界线，随后连接成一条线与内图框形成裁剪框。另外，当省界线以河为界时，以河岸为界，做裁剪框的一部分。裁剪框用于裁剪分层数据。裁剪后，将两省或三省分层数据分别添加到一起进行组合，同时进行拓扑错误检查，修改直至无误。

(5) 属性数据项中图元编号标准化阶段。

(6) 投影变换、E00 格式输出阶段。

(7) 检查阶段。后三个阶段与满标准图幅的数据综合处理工作方法一致。

3 数据样本描述

一个标准图幅中主要包括如下文件：栅格数据文件、全要素矢量化地质图数据文件、MapGIS 各图层数据文件 (包括高斯\经纬度两种格式数据)、ArcInfo 各图层数据文件、E00 数据文件、属性库 (*.DBF)、主要电子文档：元数据 (图幅、分层、图层属性等说明)、说明文件 (图饰图例库、修改字段、为制图要求添加注释图层等说明)。

全国 1∶200 000 数字地质图 (公开版) 空间数据库包括地理、地质和装饰三大类图层。地理图层中只包含水系数据，境界、居民地和交通等数据请直接使用国家基础地理信息中心的 1∶250 000 地形数据库；装饰图层主要用于模拟地质图输出，不带属性。水系与地质图层划分则包含具体的图层划分、命名与存储结构规则 (图 2)。

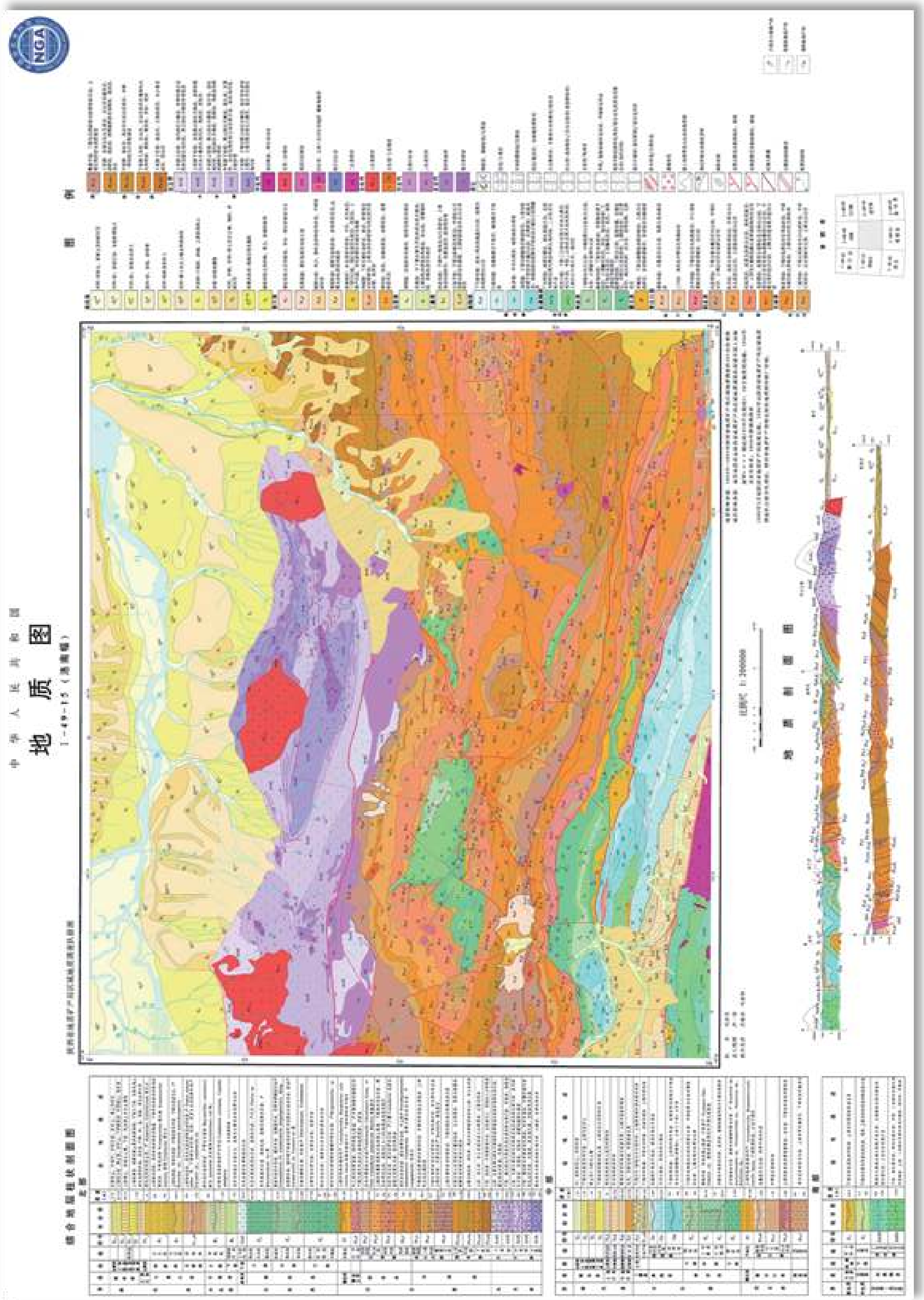

图 2　1：200 000数字地质图(渭南幅)

MapGIS 系统以文件的形式来管理图层空间数据和属性数据，一个文件表示一个图层。根据空间要素的几何类型不同，MapGIS 用*.wt、*.wl、*.wp 文件分别来存储点、线、面图层数据。

4 数据质量控制和评估

全国 1∶200 000 数字地质图 (公开版) 空间数据库项目中质量包括数据质量和软件系统质量，其中数据质量是经过数据采集和综合处理后，数字化信息与原始资料在空间位置精度与属性信息精度上的偏差程度，而软件系统质量在本项目中专指软件系统在全部满足用户需求功能和使用环境下运行的稳定性和用户满意度。

全国 1∶200 000 数字地质图空间数据库数据质量标准执行《地质图空间数据库建设指南 (2.0 版)》有关数据质量要求，并参照《数字化质量监控规范》，同时还较为系统地研究了 IS09000 19113 地理信息《质量基本原理》、19114 地理信息《质量评价过程》等系列 TC211 标准，用以指导全国 1∶200 000 数字地质图 (公开版) 空间数据库建设。

对于数字化地质图同时引用了《区域地质图图例 (1∶50 000)》(GB958−89)、《1∶200 000 地质图地理底图编绘规范及图式》(DZ/T0160−95)、《地质图用色标准及用色原则》(DZ/T 0179−1997) 及 1∶200 000 地质图出版图有关要求。

软件系统质量标准参照有关国家标准和地质调查行业软件工程规范要求执行。

该数据建库参与单位及各项目负责人员见表 2.

表 2　参与数据建库的单位及各项目负责人员列表

序号	地区	建库图幅数量	建库项目参与单位	项目负责人
1	西藏部分	12	西藏自治区地质调查院	徐开锋
2	西藏部分	16	山东省国土资源信息中心	李军
3	山东部分	15	山东地勘局遥感中心	李军
4	山东部分	3	山东省地质科学实验研究院	
5	山东部分	3	山东地矿信息中心	
6	山东部分	3	山东省第七地质勘查院	
7	江苏部分	14	江苏省地质调查研究院	姚文江
8	湖南部分	24	湖南省地质调查院	尹建生
9	四川部分	70	四川省地调院	何思彬
10	四川部分	10	四川省地矿局化探队	
11	甘肃部分	76	甘肃省地质调查院	徐东、李文胜
12	吉林部分	34	吉林省地质调查院	刘建民
13	黑龙江部分	15	黑龙江省地调院，齐齐哈尔分院	王月平、马丽玲
14	内蒙古部分	68	内蒙古自治区地质调查院	赵军
15	山西部分	9	山西省地质调查院	孙春娟
16	湖北部分	20	湖北省地质调查院	宋丽霞
17	广西部分	48	广西壮族自治区地质调查研究院	李文鑫、马隆文
18	安徽部分	35	安徽省地质调查院	曹静平、胡海风、许卫
19	陕西部分	33	陕西省地质调查院	蔡波、谢晓波
20	青海部分	66	青海省地质调查院	侯元才、郝维杰、祁兰英

续表 2

序号	地区	建库图幅数量	建库项目参与单位	项目负责人
21	新疆部分	120	新疆维吾尔自治区地质调查院	肖志坚
22	辽宁部分	41	辽宁省地质矿产研究院	杨光时
23	海南部分	11	海南省地质调查院	何国伟
24	浙江部分	28	浙江省地质调查院	蔡子华
25	江西部分	30	江西省地质调查院 江西省地勘局地勘信息中心	顾敏
26	河南部分	14	河南省地质调查院	蒙胜华
27	广东部分	42	广东省地质调查院	邓勇
28	河北部分	26	河北省地质调查院	胡殿常
29	云南部分	40	云南省地勘局区调队 云南省地勘局信息中心 云南省地勘局第一、二、三、四、五地质队	何家学、谢蕴宏
30	宁夏部分	19	宁夏回族自治区地质调查院	李天斌
31	贵州部分	41	贵州省地质调查院	张泽标
32	福建部分	31	福建省地质调查研究院	潘金滇、张顺金、李建豪

5　数据使用方法和建议

本数据集中的数据为标准 shapefile 文件，主流的 GIS 软件均可读写数据。系统采用先进的系统体系结构，开放式客户机/服务器 (C/S) 模式；快速的数据响应速度，系统能够比较迅速响应用户操作；强有力的数据操作管理，数据存取操作和管理采用国际先进的空间数据库管理模式 (ArcSDE + Microsoft SQL Server 2000)；友好的操作界面采用菜单和工具条相结合来进行操作，操作方便、使用简单。用户可用 SQL Server 等主流数据库编程语言调用相关函数库读写数据，实现数据批处理。

致谢：在全国 1∶200 000 数字地质图空间数据库 8 年建设过程中，有大批专家直接参与其中，有很多领导具体协调本项目的工作，有一批老地质工作者和地调系统以外的同仁给予了技术指导与咨询。主要有 (按姓氏笔划排名)：

河北省：王丽亚，刘恩华，宋朝辉，张晔卿，张爱丽，张崇山，李树林，胡殿常，徐岩。

山西省：卫根，方立鹤，王美芳，任翠芳，先小群，刘时雨，刘坤藻，刘得佑，刘惠敏，孙春娟，严谨，吴少荣，宋玉萍，宋红梅，张亚仙，张青梅，张桂英，张素贞，张福忠，李永厚，李红霞，李振国，李效广，李雪萍，李德胜，李慧勤，杨丙全，杨艳丽，沈玉玲，陈志刚，岳炜谦，郑勤成，胡瑞香，胡瑞锋，贺文莲，赵娟，赵善付，郭立卿，钱兆卉，顾其昌，高建平，商培林，曹屹璇，曹润花，梁宝丽，梁宝珍，续世朝，董消雷，谢桂芳。

内蒙古自治区：马丽萍，毛德鹏，王挨顺，王涛，丛丽娟，孙玉梅，孙政平，朱绅玉，吴之理，张丽莉，张彤，张梅，李玉玺，李建莉，杨文海，沈存利，苏宏伟，邵和明，陈少华，明珠，武宏伟，武跃勇，封书凯，胡凤翔，赵军，徐宗培，常忠耀，梁立新，黄增芳，廖蕾，蔡红军。

辽宁省：王丽艳，杨光时，桥秀芬。

吉林省：王立民，史新增，关键，刘冶兵，刘建民，吕振江，庄毓敏，许良久，吴玉章，李树田，武贵禄，郑传久，赵庆英，崔光浩，梁伟杰。

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江苏省：马秋斌，刘晓玲，刘聪，华建伟，朱建南，朱静萍，许鸿基，张于，李晓燕，李维佳，李锋，陆瑞宝，周洁，姚文江，赵立鸿，唐海燕，徐蓉，袁晓军，谢祖齐，谢增平，薛宁菊。

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福建省：文斐成，石建基，许勇波，宋咏宪，张明辉，张顺金，李建豪，连天萍，陈明光，陈涌，林雄达，郭小平，高海青，黄衡，潘金滇。

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山东省：丁慧，于广亭，于学锋，孔艳，尹琦，王凤华，王世进，王芳，王虹，王海芹，王敏，王敬洁，冯琦，史辉，田文新，艾宪森，仲卫国，任志康，刘书才，刘伟，刘福魁，安郁宏，纪兆发，纪军，宋之龙，张帆，张庆，张成基，张相峰，张淑芳，李军，杨东来，杨哲，陈保民，范存国，夏立宪，柴本红，盛文静，黄文慧，解立业。

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贵州省：张扑，张林，张权莉，张泽标，杜黔枫，汪玉琼，岳云茹，袁义生。

云南省：马腾，王臣兴，王树琼，王珏，王陶，包佳凤，田洪亮，刘文华，刘德丽，吕世琨，何家学，何艳丽，何智德，余丽文，吴建忠，张秀芬，张笃信，张富良，张蓉，李文昌，李华，李红，李定平，李静，杨志勇，杨建波，杨荣根，苏兰，陈飞，陈少玲，周云，周耀军，岳伟，施建萍，胡居贵，胡忠富，夏迎红，秦德厚，曾宪华，

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陕西省：丰文庆，田小宇，许丽，许纯义，张拴厚，李铁，杨妮，沙江，卓联昌，周宣，谢晓波，蔡波。

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China National Digital Geological Map (Public Version at 1∶200 000 Scale) Spatial Database

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Abstract: As the only one of its kind, China National Digital Geological Map (Public Version at 1∶200 000 scale) Spatial Database (CNDGM-PVSD) is based on China's former nationwide measured results of regional geological survey at 1∶200 000 scale, and is also one of the nationwide basic geosciences spatial databases jointly accomplished by multiple organizations of China. Spatially, it embraces 1 163 geological map-sheets (at scale 1∶200 000) in both formats of MapGIS and ArcGIS, covering 72% of China's whole territory with a total data volume of 90 GB. Its main sources is from 1∶200 000 regional geological survey reports, geological maps, and mineral resources maps with an original time span from mid-1950s to early 1990s. Approved by the State's related agencies, it meets all the related technical qualification requirements and standards issued by China Geological Survey in data integrity, logic consistency, location accuracy, attribution fineness, and collation precision, and is hence of excellent and reliable quality. The CNDGM-PVSD is an important component of China's national spatial database categories, serving as a spatial digital platform for the information construction of the State's national economy, and providing information backbones to the national and provincial economic planning, geohazard monitoring, geological survey, mineral resources exploration as well as macro decision-making.

Key words: 1∶200 000 Digital Geological Map; Spatial Database; Geographical Information System

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

1 Introduction

The 1∶200 000 geological map is the most widely used map for geological routine work, and is of important value for basic geological survey, evaluation of mineral resources,

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groundwater exploration, engineering survey and geological environment investigation and assessment; the construction of the China's national 1∶200 000 digital geological map spatial database is of great significance to improve the efficiency of the aforementioned geological work (Liu FY, et al., 2002; Tang HY, 2002; Li J, 2006; Liu YC, 2013).

The CNDGM-PVSD came into being under the background of China's duration of the 8th and 9th Five-Year-Plans, when the investment in geological exploration had been decreasing annually while the ore-searching risks were increasingly soaring. At that circumstances, the State was eager to deploy reasonably the pre-exploration work so as to ensure the breakthroughs of geological research and mineral resources exploration. The GIS system was then recognized as the most advanced technical-aided approach that can precisely detect the ore-searching perspectives, the CNDGM-PVSD based on GIS system was consequently defined as one of China's fundamental databases to be constructed along the process of incubation, pilot testing, and massive production, which was seriously treated as the first key project of China's geology-exploration information system construction.

Table 1 is a brief introduction of the spatial data metadata of CNDGM-PVSD.

Table 1 Metadata Table of Database (Dataset)

Items	Description
Database(dataset) name	China National Digital Geological Map (Public Version at 1∶200 000 Scale) Spatial Database
Database(dataset) authors	Li Chenyang, Development and Research Center of China Geological Survey Wang Xinchun, China Geological Survey He Chunzhen, Development and Research Center of China Geological Survey Wu Xuan, Development and Research Center of China Geological Survey Kong Zhaoyu, Development and Research Center of China Geological Survey Li Xiaolei, Development and Research Center of China Geological Survey
Data acquisition time	1957—1995
Geographic area	Mainly the land area of the People's Republic of China of 72°~138°E and 16°~56°N; all the map-sheets at scale of 1∶200 000 are coded.
Data format	.mpj, .shp, .doc
Data size	90 GB
Data service system URL	http://dcc.cgs.gov.cn
Fund project	The Geological Survey of the Former Ministry of Geology and Mineral Resources Project and China Geological Survey Project (S3.2.1.1-27, 19961831004015-225, 199918310102-08, 19991831008015, 199918310120).
Language	Chinese
Database(dataset) composition	The dataset consists of 1 163 digital maps at scale of 1∶200 000; and each of the digital geological map (i.e. a map-sheet) contains the following files: a map-sheet grid data file, all-factor vectored geological map data files, MapGIS graphic layers data files (including data in both Gauss\meridian formats), ArcInfo graphic layer data, E00 data files, and attribute database (*.DBF). Main electronic documents: metadata (illustrations for map-sheet, graphic layer, and graphic layer attribute, etc.), illustrative documentation (on legends and decorations, modified field, annotation graphic layer for map-making).

2 Method of Data Collection and Processing

The geological data of most provinces and autonomous regions used in the construction of CNDGM-PVSD is mainly sourced from the measured 1∶200 000 regional geological exploration reports, geological maps, mineral resources maps that were fulfilled over the 3 decades from mid-1950s to early 1990s; the other vital sources data include the "Correlation Researches on Provincial Multiple Stratigraphic Divisions", the "Provincial Regional Geological Memoirs", the results of 1∶50 000 regional geological surveys, the related geological reports, research reports, and the thematic geological maps. Data collection and comprehensive processing is one of the key steps in constructing the 1∶200 000 CNDGM-PVSD.

2.1 Data Collection Process

Data collection for the database construction is completed by MapGIS 6.7; and the process of collecting data can be divided into 5 stages:

2.1.1 Preparation Stage

(1) Data preparation. According to the selected map-sheets, relevant information (including maps, reports, analysis data, original filed records cards, and record books) are collected and trimmed to meet the needs of constructing the database.

(2) Document preparation. Before constructing the database, a highly practical operation instructions is compiled based on the *Guidebook for the Constructing Geological Map Spatial Database* (2.0 version); efforts are also made to compile various attribute cards (tables), working logs, self-inspection tables, mutual inspection tables, group inspection tables and other documents.

(3) System database preparation. On the basis of the MapGIS system database, a variety of rock symbols, line patterns, color box, and indices tables of cartographic parameters are modified or supplemented.

2.1.2 Data Collection Stage

(1) Scanning the paper-back maps to form digital grid files. When scanning the polyester-filmed base geological maps or the original copies of paper-back geological maps (or geology and mineral resources maps), the sharpness and complexity of the original maps are essential factors for selecting the appropriate scanning resolution in every effort to reduce the scanning error. Color scanning should be above 150 dpi, while the black-and-white scanning should be above 300 dpi.

(2) Graphic data collection and editing, i.e., the editing and modification of the spatial data of points, lines, polygons and other graphic elements. In order to ensure the quality of the spatial database, knots shall be created between the digital graphic lines; all the polygons shall be enclosed; the graphical data and attribute data shall be corresponded one to another respectively; and any graphic error that goes beyond the standard for mapping on relative scales shall be avoided; especially, the spatial error standard should be obeyed. The line patterns, rock symbols, legends and various point parameters shall all follow the relevant national, ministry and industry standards. Therefore, for line or point, their attributes should be

selected in advance and then are collected separately.

Before the collection of graphics according to the vectorized layers, a series of standard folders are set up, and the system path is well laid out. In the process of graphic vectorization, all the geological factors are vectorized in different layers. Digitalized collection of layered graphics shall be according to the following sequence: internal graphic frame → meridian nets → rivers → lakes (reservoirs) → faults →dikes → Quaternary strata → intrusives → volcanic rocks → quasi-strata → other strata. In other graphic layers, there is no need to repeatedly use the graphic layer factors, hence, the vectorization sequence can be determined at will.

After finishing the editing of elements of points and lines, the digitalized plain-colored geological map can be modified and corrected. The plain-colored map can be output after the aforementioned modification and correction. The map-sheet self-checking and mutual inspection and team check can be done later.

2.1.3 Making Map-layers and Attribute-editing Stage

(1) Setting up graphic layer files. According to the graphic layer hosting the geological body, the data file (of Polygons, Lines and Points) is extracted from the comprehensive polygon data files respectively from the different graphic layers. The line-graphic layer data files can be established respectively through the transformations from the arcs to the line files. The Points are created independently in their original layer files using their hosting layers respectively.

(2) Establishing the attribute structure and inputting the attributes. According to the requirements for the data fields in the attribute structure of each layer, the geological experts check the data from geological reports, explanatory notes to the geological maps, and many other related references, and then collect the attributes of various geological factors in the geological maps in different layers, and finally collate them on the comprehensive temporary map.

2.1.4 Projection-transforming and Format-transforming Stage

The graphic layers are put into the projection transformation in batches to form the digital results of the Gauss Beijing Coordinate System and the meridian non-projection coordinate system (with per second as the unit). Then the file formats are transformed; i.e., the MapGIS files are transformed through its own dual-precision output function to the E00 files which are later used to obtain the PC ArcInfo data, and meanwhile the topological relationship is re-established.

2.1.5 Final Inspection and Self-checking Stage

Checking whether the files in each folder are placed correctly, and whether the all-factor digitized geological map is in conformity with the specification, and documents are complete.

The MapGIS data collection work flow is shown in Fig. 1.

2.2 Data Processing

According to the basic comprehensive processing methodology and technical flowchart, the MapGIS format data processing can be treated in 2 ways: (1) the treatment of full map-sheet standard data, and (2) the collation of non-full map-sheet crossing provincial border data.

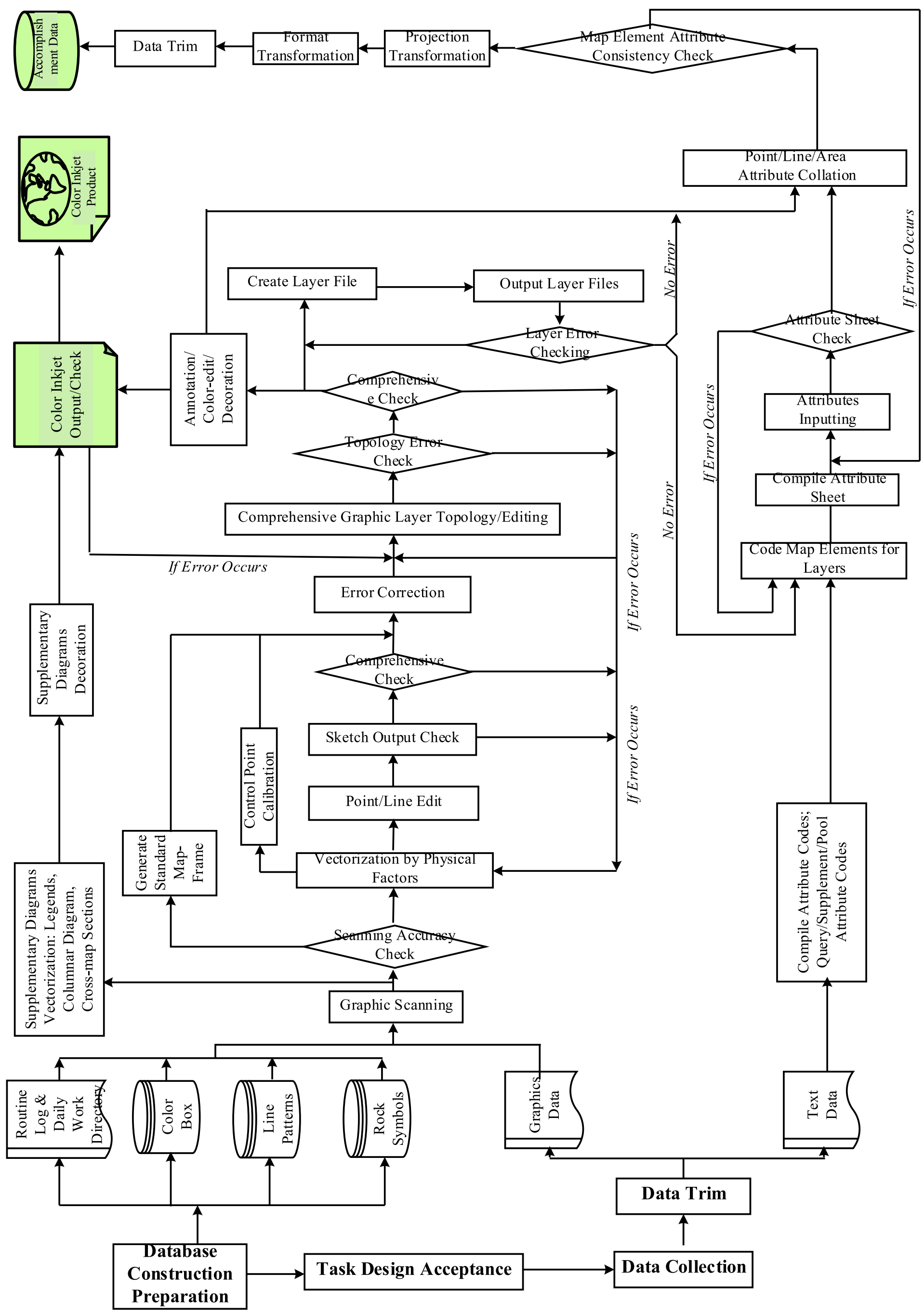

Fig. 1 The Workflow Chart for MapGIS Data Collection

2.2.1 Full map-sheet standard data processing and its technical work flow

For the convenience of operation and quality control, the processing of the MapGIS format data is divided as 6 steps:

(1) Preparation. Inspect the conditions of the all the provincial map-sheets, including: whether all the documents for the full-sized map-sheet are ready, what the projection parameters are, what the coordinate system of the original geological map is, whether the full-sized map-sheet is trans-provincial boundary, whether the data for the full-sized map-sheet is complete or not; after all these are ensured, efforts should be made to output an international map-sheet index diagram which embraces the whole national boundaries at scale of 1：200 000.

(2) Directory trim and graphic layer nomination standardization. Standardize the full-sized map-sheet directory strictly according to the requirements, and establish 8 corresponding standard folders. Select the graphic layer, delete all graphic layer attribute files that are contained in the trimmed map layer files and those that are not identified by the '*Guidebook for the Constructing Geological Map Spatial Database* (2.0 version)', and modify the graphic layer names to make them be standardized.

(3) Attribute structure of each graphic layer standardization. Modify the name of data entries, sequence, types, and length in the graphic layer attribute structure according to the *Guidebook for the Constructing Geological Map Spatial Database* (2.0 version), supplement the lacked data entries and delete the unnecessary entries.

(4) Code's standardization of the map elements in each graphic layer's attribute entries. Check if any of the line's or arc's lengths in the graphic layer L02H, D01J (D02J, D03J, D04J), L02S, D01D exceeds more than 500 points above the coordinate point; these exceeding ones would be re-processed, and their topological relationship should be re-established and compressed/saved into the disc; and furthermore, their codes should be re-coded.

(5) Projection transformation and E00 format output. Create meridian folders respectively before projection transformation so as to load the graphic layer files preparing for the projection transformation. Projection transformation is fulfilled in batches according to the directory, avoiding projection error of individual file. File format transformation, i.e., the MapGIS format data is output as E00 format data, the name of latter one is coded as that of the standardized graphic layer.

(6) Inspection. The aforementioned integrated data should be undergone 100% self-inspection, mutual inspection and team inspection.

2.2.2 Non-full map-sheet crossing provincial border data processing and its technical work flow

(1) Preparation. Do as the same as that of the full map-sheet standard data processing; and check the layered data files and graphic data files for further processing.

(2) Directory trimming and standardization of nomination of the graphic layers. Do the same as that of the aforementioned full map-sheet processing.

(3) Standardization of graphic layer attribute structure. Modify the attribute structure of

each related provincial layer file respectively, and improve them to the level of standardization using the same methods as the aforementioned in the full map-sheet processing.

(4) Graphic layer data collation. Use a certain provincial boundary and the inner map frame to create the cutting-frame; if there is no provincial boundary in the geological body boundary (D01J.WL), then extract the provincial boundary from the polygon graphic layer, and connect it to a straight line so as to combine it with the inner map frame to form the cutting-frame. In addition, when the provincial boundary is actually a river, use the river bank stretching curve as the provincial boundary and make it as the partial of the cutting-frame. The cutting frame is used to cut the graphic layer data. After cutting, the layer data of 2 or 3 provinces are added together separately, and then collate them together; meanwhile, check the errors of topology and correct the errors till no more error occurs.

(5) Standardization of codes of map elements in the attribute data.

(6) Projection transformation, and E00 format output.

(7) Inspection.

The last three steps are the same as that of the aforementioned full map-sheet processing.

3 Data Sample Description

A standard map-sheet data sample mainly includes the following files: grid data file, all-factor vectorized geologic data file, MapGIS graphic layer data files (including two formats: Gauss/meridian, ArcInfo layer data files, E00 data files, attribute database (*.DBF), and main electronic documents which embrace meta-data (illustrations of map sheet, map layers, map layer attributes), and illustrative documents (illustrations on legends, modified field names, annotation graphic layer for map-making).

The 1∶200 000 CNDGM-PVSD includes such three kinds of graphic layers as geography, geology and decoration. Geographic map layer contains only water system data; as for the boundaries, residential places and traffic data, please directly use the National Basic Geographic Information Center's 1∶150 000 topology database; the decorative map layer is mainly used to simulate the output of geological map and has no attribute data. The division of water system and geological map layer includes concrete map layer division, nomination, and storage structure rules (Fig. 2).

MapGIS system manages the spatial data and attribute data in the form of files, with one file representing a map layer. According to the different geometric elements of the spatial factors, MapGIS stores the data of point, line and area map layers respectively in the forms of *.wt, *.wl, and *.wp files.

4 Data Quality Control and Evaluation

The quality of 1∶200 000 CNDGM-PVSD project includes the data quality and the software system quality. As for the data quality, it is valued by the degree of deviation of the spatial precision and the attribute information accuracy between the comprehensively collected and processed digital information and the original paper-back data; while for the software

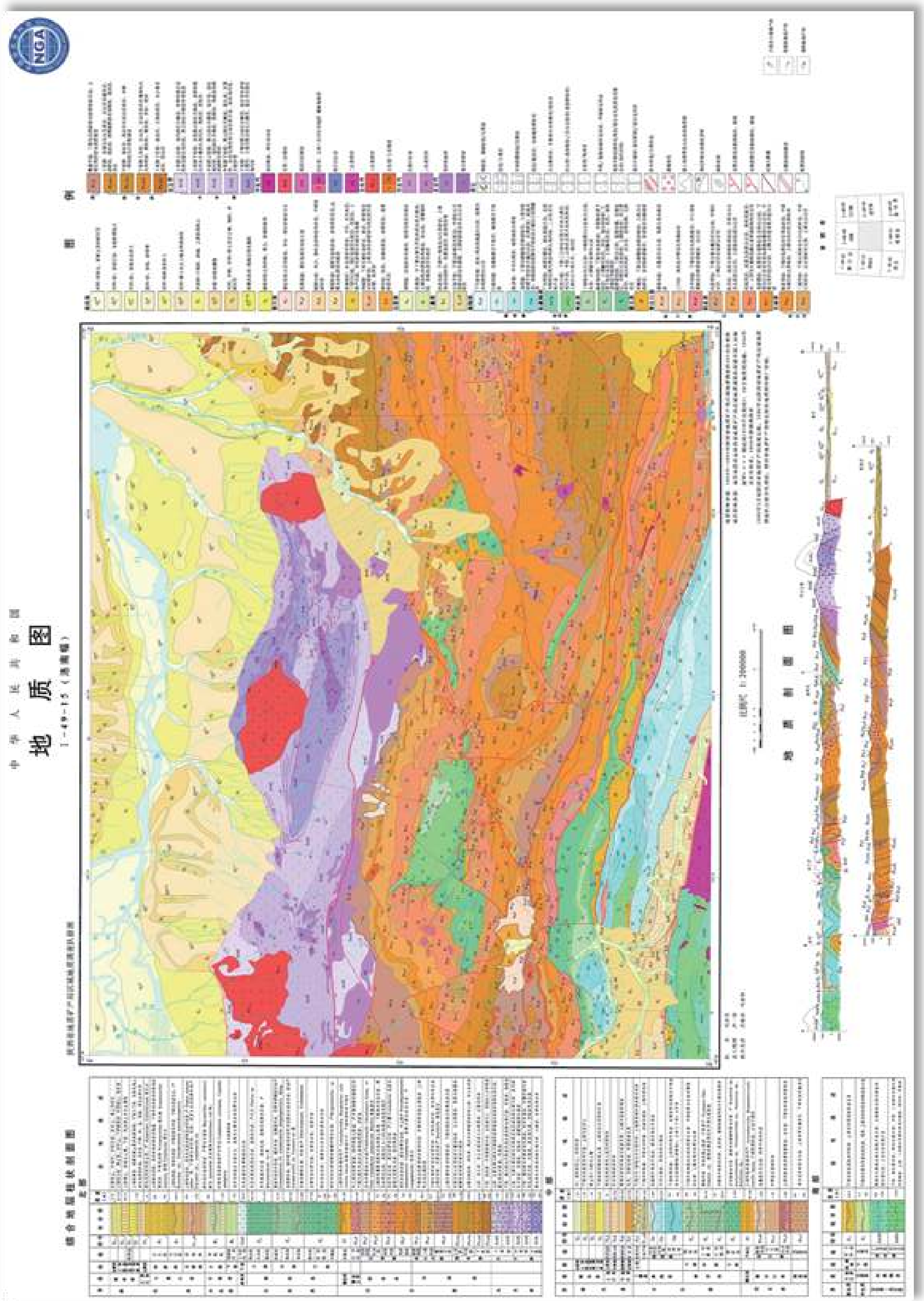

Fig. 2 The Sample of 1：200 000 Digital Geological Map (Weinan Mapsheet)

system quality in this project, it refers exclusively to the stability of the accessing system under all the inquiring operations and running environments when the users are fully served with the highest satisfactions.

The quality standards of the 1：200 000 CNDGM-PVSD follows the requirement for data quality specified in the *Guidebook for the Constructing Geological Map Spatial Database* (2.0 version) and are referred to the then being-calibrated *Regulations on Digitalization Quality Monitoring*; meanwhile, the essentials of the ISO9000 19113 *Basic Principles of Geographic Information Quality*, 19114 *Geographic Information Quality Evaluation Process*, and the TC211 serial standards have also been systematically added to guide the construction process of the 1：200 000 CNDGM-PVSD.

For the digitalizing processes of the geological map, the following related regulations and requirements are also adopted: *Legends for Regional Geological Maps* (*at scale of 1：50 000*) (GB958−89), *Regulations and Graphic Patterns for Geological Map-Oriented Geographic Base Map* (*at scale of 1：200 000*) (DZ/T0160−95), and *Standards and Principles for Geological Coloring*(DZ/T0179−1997) as well as the requirements for formal publication of geological maps at scale of 1：200 000.

The software system quality standards are adopted from that of the relevant national standards and from the software engineering regulations exclusively for geological survey industry.

The organizations and experts who have participated and are hence responsible for the database constructions are shown in Table 2.

Table 2 Organizations and experts responsible for the 1：200 000 CNDGM-PVSD

Serial No.	Regions	Map-sheets Amount	Organizations	Experts
1	Tibet	12	Tibet Institute of Geological Survey	Xu Kaifeng
2	Tibet	16	Shandong Information Center of Land & Resources	Li Jun
3	Shangdong	15	Remote Sensing Center, Shandong Bureau of Geological Exploration	Li Jun
4	Shandong	3	Shandong Institute of Geological Sciences Experiment	
5	Shandong	3	Shandong Information Center of Geology & Mineral Resources	
6	Shandong	3	Shandong 7th Institute of Geological Exploration	
7	Jiangsu	14	Jiangsu Institute of Geological Survey	Yao Wenjiang
8	Hunan	24	Hunan Institute of Geological Survey	Yin Jiansheng
9	Sichuan	70	Sichuan Institute of Geological Survey	He Sibin
10	Sichuan	10	Geochemical Exploration Team of Sichuan Geology and Mineral Resources Exploration Bureau	
11	Gansu	76	Gansu Institute of Geological Survey	Xu Dong, Li Wensheng
12	Jilin	34	Jilin Institute of Geological Survey	Liu Jianmin
13	Heilongjiang	15	Qiqihar Branch of Heilongjiang Institute of Geological Survey	Wang Yuping, Ma Liling

Continued table 2

Serial No.	Regions	Map-sheets Amount	Organizations	Experts
14	Inner Mongolia	68	Inner Mongolia Institute of Geological Survey	Zhao Jun
15	Shanxi	9	Shanxi Institute of Geological Survey	Sun Chunjuan
16	Hubei	20	Hubei Institute of Geological Survey	Song Lixia
17	Guangxi	48	Guangxi Institute of Geological Survey	Li Wenxin, Ma Longwen
18	Anhui	35	Anhui Institute of Geological Survey	Cao Jingping, Hu Haifeng, Xu Wei
19	Shaanxi	33	Shaanxi Institute of Geological Survey	Cai Bo, Xi Xiaobo
20	Qinghai	66	Qinghai Institute of Geological Survey	Hou Yuancai, Hao Weijie, Qi Lanying
21	Xinjiang	120	Xinjiang Institute of Geological Survey	Xiao Zhijian
22	Liaoning	41	Liaoning Institute of Geology and Mineral Resources	Yang Shiguang
23	Hainan	11	Hainan Institute of Geological Survey	He Guowei
24	Zhejiang	28	Zhejiang Institute of Geological Survey	Cai Zihua
25	Jiangxi	30	Jiangxi Institute of Geological Survey, Information Center of Jiangxi Geological Exploration Bureau	Gu Min
26	Henan	14	Henan Institute of Geological Survey	Meng Shenghua
27	Guangdong	42	Guangdong Institute of Geological Survey	Deng Yong
28	Hebei	26	Hebei Institute of Geological Survey	Hu Dianchang
29	>Yunnan	40	Regional Geological Survey Team of Yunnan Geological Exploration Bureau, Information Center of Yunnan Geological Exploration Bureau, The 1^{st}, 2^{nd}, 3^{rd}, 4^{th} and 5^{th} Geological Teams of Yunnan Geological Exploration Bureau	He Jiaxue, Xie Yunhong
30	Ningxia	19	Ningxia Institute of Geological Survey	Li Tianbin
31	Guizhou	41	Guizhou Institute of Geological Survey	Zhang Zebiao
32	Fujian	31	Fujian Institute of Geological Survey	Pan Jindian, Zhang Shunjin, Li Jianhao

5 How to Use the Database

The data in this dataset is of standard shapefile, which can be accessed by mainstream GIS software. The system adopts an advanced systematic framework, and operates in an open client/server (C/S) model with fast data response speed and swift feedback to any accessing; the data operation and management is strong and powerful with the data accessing and managing being of internationally advanced spatial database management model (ArcSDE + Microsoft SQL Server 2000). The user-friendly interface is aided with menus and toolbars which can be easily operated and used. Users can adopt SQL Server and other mainstream database programming languages to apply the relevant functions to access the database and to enable data being in batch processed.

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