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支撑服务广州市规划建设与绿色发展资源环境图集数据集

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摘要：在对最新的水工环地质调查资料和成果进行梳理和总结的基础上，以粤港澳大湾区三极之一的广州市为重点，编制了地学专业综合图集——《支撑服务广州市规划建设与绿色发展资源环境图集》。《图集》收集和整理了国土资源大调查以来粤港澳湾区开展的环境地质调查、监测数据资料和研究成果等，经二次开发研究，以通俗易读或图或表的形式表示出来。《图集》整体分为序图、国土空间开发利用的地质适宜性评价、城市规划建设应关注的重大地质安全问题、产业发展可以充分利用的优势地质资源、生态环境保护需要重视的资源环境状况和基础地质条件类图件 6 大类，共 53 张图，并提出了助力大湾区绿色生态农业发展、清洁能源产业发展、用水安全、旅游产业发展和提升防灾减灾能力等五方面的地质建议，有效服务了广州国土空间规划与海绵城市建设。

关键词：规划建设；绿色发展；地质资源；地质环境；地下空间；城市地质；图集；广州市；广东省

数据服务系统网址：http://dcc.cgs.gov.cn

1　引言

广州市地处中国南部、濒临南海、珠江三角洲北缘，总面积 7 434 km^2，是广东省省会、国家历史文化名城、我国重要的国家中心城市、国际商贸中心和综合交通枢纽，是粤港澳大湾区城市群重要组成部分。广州作为改革开放的前沿城市，对外开放时间早、程度高，经济发达、具有发展活力。广州市“十三五”城市建设规划明确提出，打造珠三角世界级城市群核心城市，国家“一带一路”的战略枢纽，建设成为经济繁荣、和谐宜居、生态良好、富有活力、特色鲜明的现代化城市。

为有力支撑广州市国土空间规划编制实施和合理开发利用，服务宜居宜业宜游优质生活圈规划建设，中国地质调查局组织协调直属有关单位和广东省地质局、广州市国土规划委等单位，系统梳理总结了多年的区域地质、水文工程地质、环境地质、矿产资

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源、地球物化探等基础地质调查成果和专题图件，通过对成果的综合研究分析，以及调研广州市规划建设和绿色发展需求，编制了《支撑服务广州市规划建设与绿色发展资源环境图集》，该图集使用面广、可读性强，并针对国土空间开发利用、城镇和重大工程建设、产业布局、生态环境保护等方面，提出相应对策建议 (自然资源部中国地质调查局，2019)。该《图集》的数据库（集）的元数据基本信息见表 1。

表 1　数据库 (集) 元数据简表

条目	描述
数据库(集)名称	支撑服务广州市规划建设与绿色发展资源环境图集数据集
数据库(集)作者	刘凤梅，中国地质调查局武汉地质调查中心 黄长生，中国地质调查局武汉地质调查中心 郑小战，广州市地质调查院 赵信文，中国地质调查局武汉地质调查中心
数据时间范围	2016年1月—2018年3月
地理区域	广东省广州市
数据格式	MapGIS数据格式：*.wt, *.wl, *.wp
数据量	6.25 GB
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“粤港澳湾区1：50 000环境地质调查”(DD20160291)
语种	中文
数据库(集)组成	由53张MapGIS格式图件、53份说明书和一份地球科学建议组成，地球科学建议围绕国土空间开发利用、城镇和重大工程规划建设、产业规划布局、生态环境保护四个方面提出建议

2　数据采集和处理方法

2.1　数据采集

支撑服务广州市规划建设与绿色发展资源环境图集是中国地质调查局规划部署的二级项目——“粤港澳湾区 1：50 000 环境地质调查”的重要项目系列成果之一。以 1：1 000 000 国家基础地理数据为图集底图，结合 SRTM3 DEM（全称：Digital Elevation Model，数字高程模型）数据、LandSat 8 OLI（全称：Operational Land Imager , 陆地成像仪）遥感数据、广州市各区统计年鉴 (2014—2016)、水资源公报、气候公报、《广州城市总体规划 (2011—2020)》等数据资料，充分吸收和总结国土资源大调查以来粤港澳湾区开展的环境地质调查、监测数据资料和研究成果，地质资料截至 2018 年 3 月。采用已有的技术标准以及国内外通用的计算机软件进行数据处理和管理，按 1：500 000 数据精度，多维角度展示了广州市环境地质调查成果。

2.2　数据处理过程

该图集已出版，地理地图及数据内容已通过国家地理信息局的审查，地理资料通过了测绘主管部门的审批。其数据处理过程如下:

(1) 地理底图：采用全国 1：1 000 000 地理底图 G49、F49、F50 三幅作为基础地理地图。数据经 ArcGIS 及 MapGIS 软件将 E00 格式转换为*.wt，*.wl，*.wp 格式，作为本次编图使用的数据格式，根据编图范围及比例尺，重新确定图件的投影参数，生成标准经纬网和内图框来对图形进行校正，地理底图数学基础采用兰伯特等角圆锥投影，投

影中央经线：113°30′00″；投影第一纬线：23°00′00″；投影第二纬线：23°30′00″。在选取基础地理要素时，剔除高程数据，选取县级以上行政界线、地级以上居民地、主要交通、河流 (三级以上)、主要湖泊、山脉等注记，然后根据图面表达内容进行配准修编和更新，对经纬度、省市县等地名、水系、山脉、山名等进行增补、删减、简化等处理。

(2) 底图背景：在统一的地理底图上，对每幅图进行三维叠底，叠置 DEM 阴影晕渲 (周成虎和程维明，2010)，增强地图的立体感和层次感。

(3) 图幅版面设计：图集版式为 A3 开本，图幅页码配置采用一页图件一页文字说明的方式，保持页面空间平衡，图件说明以文字、图表相结合的方式表达 (李廷栋，2007)。图廓整饰采用统一要求，图名、图例编排的位置、间距、字体符号大小采用统一规格 (左伟等，2009)。图例按照点、线、区的顺序进行编排，以保证图幅版面样式统一、美观。

(4) 色彩符号设计：色彩的配置首先遵循地质、矿产、资源、环境专业用色规范的基础上，利用色彩象征属性，选择事物相近颜色表达专题元素，便于阅读联想，注重色彩对比，调和冷暖色调，做到色彩层次分明，丰富协调。

(5) 专题元素表示：采用不同表示方法表达专题元素，主要以质底法、范围法、线状符号法、等值线法，定点符号法为主，为使图集达到“面向政府应用，兼顾科技阅读”的目的和主旨，同时对专题元素内容进行量化，以分区统计和分级统计为主，采用饼图、柱状图、对比图等通俗易读的形式表示图面信息。

3 数据样本描述

3.1 图集题材内容与结构

《图集》内容结构分为 6 大部分 53 张图。

(1) 序图 (图 1)，主要反映广州市三维地势、遥感影像全貌、行政区划和人口密度、重点发展功能区划、重大基础设施规划、中心城区地下空间利用现状、土地利用现状和水系分布等信息。

(2) 国土空间开发利用的地质适宜性评价 (图 2)，从区内 4 个自然景观保护区及旅游开发适宜区、3 个优质耕地保护及特色农业开发适宜区、4 个地下水水源地保护及开采适宜区及岩溶塌陷防范区、软土地面沉降防范区、活动断裂防范区进行了适宜性评价 (黄长生等，2015)。

(3) 城市规划建设应关注重大地质安全问题 (支兵发，2005)，加强对活动断裂、岩溶地面塌陷、软土地面沉降、崩滑流地质灾害、矿山采空区的防范，充分利用地质条件良好的区域，科学布局重大工程 (董好刚等，2012)。

(4) 产业发展可以充分利用的优势地质资源 (图 3)，建议在富硒优质耕地集中连片分布区，规划建设特色农业现代化产业基地；合理开发利用矿泉水；积极推进地质遗迹、地热资源开发利用，打造集度假、休闲、旅游、科普一体的地质公园，优化广州市现代产业布局。

(5) 生态环境保护需要重视的资源环境状况，需加强水土污染调查评价与治理，尽快开展海岸带生态防治与修复，控制自然岸线保有率，保障广州市生态地质安全。

(6) 基础地质条件类图件，包含广州市地貌分区、基础地质、水文地质、第四纪地质、基岩埋深及粤港澳大湾区区域地质、地壳稳定性等方面的图件，图集内容见表 2。

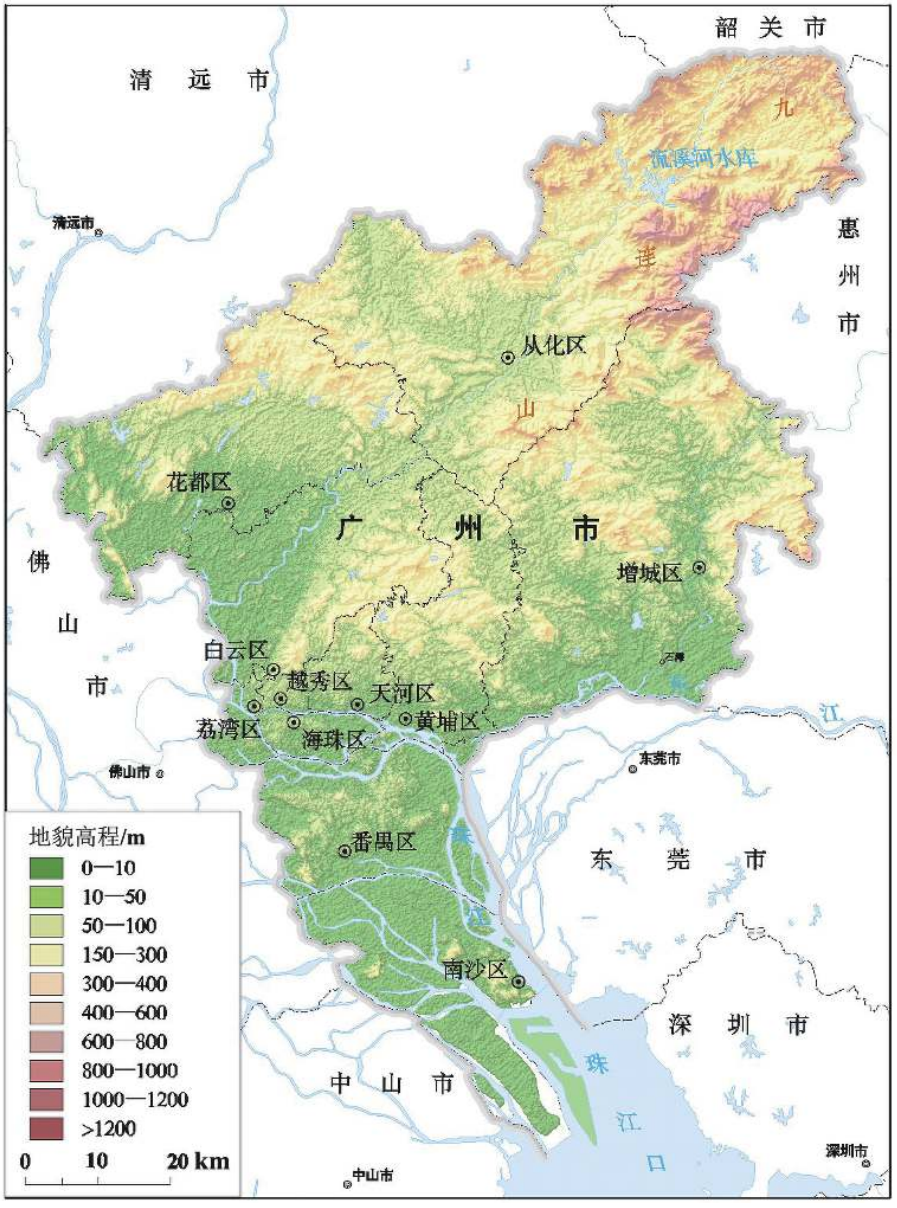

图 1　广州市三维地势图（自然资源部中国地质调查局，2019）

3.2　图件说明书

图件说明书内容包括资料来源、图件说明和建议 3 个部分，总字数不超过 1500 字。资料来源部分，明确成果名称、调查单位名称，资料截止日期及图件编制单位；图件说明则对图件编制过程，数据分析结果进行简洁明了的阐述，配合相应的图表进行说明，图表所使用配色与图件图例颜色一致或相近，以便于延伸、联想阅读；建议部分则根据图件需要来编写，如序图、基础性图件无须编写建议内容，资源分布类、评价类、安全问题类、环境状况类图件则需要做简单总结、建议性说明。

4　数据质量控制和评估

图集专题内容和地理底图进行严格套合，每幅图按照地理底图经纬网进行误差校正，保证经纬网误差和图廓点误差小于或等于 0.1 mm。

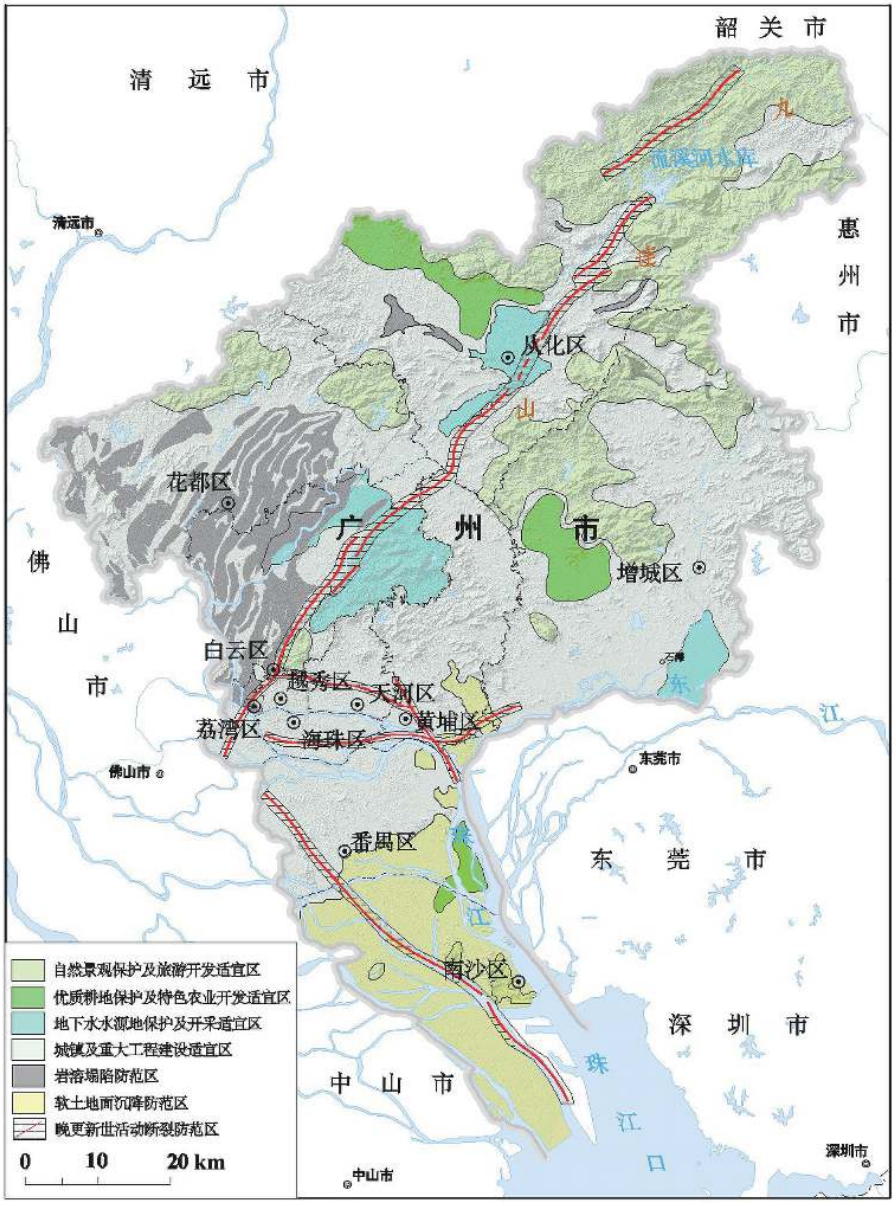

图 2　广州市国土空间开发利用管控建议图（自然资源部中国地质调查局，2019）

图集中社会经济类图件数据资料以已发表的论文、著作，已对社会公开的年鉴、公报为主，地质、环境类资料主要来源于已经归档汇交的历年来地质大调查成果，部分更新数据也经过质量检查、野外验收合格。数据资料来源可靠、精度准确。

《图集》编制完成后组织过相关领域专家进行多次审查和修改，符合客观性、实用性、特色性、先进性、普适性和通俗性的原则。图集用途明确，简单易读，便利使用，适宜推广。

5　数据价值

该《图集》所有图件采用 MapGIS 格式制作，查询方便、可编辑性强，数学基础扎实，可与同类型数据实现叠加、合并与再处理，便于数据集的管理与信息共享，满足专业人员应用研究的需求，为相关支撑服务类图集编制提供较为重要的参考借鉴意义。

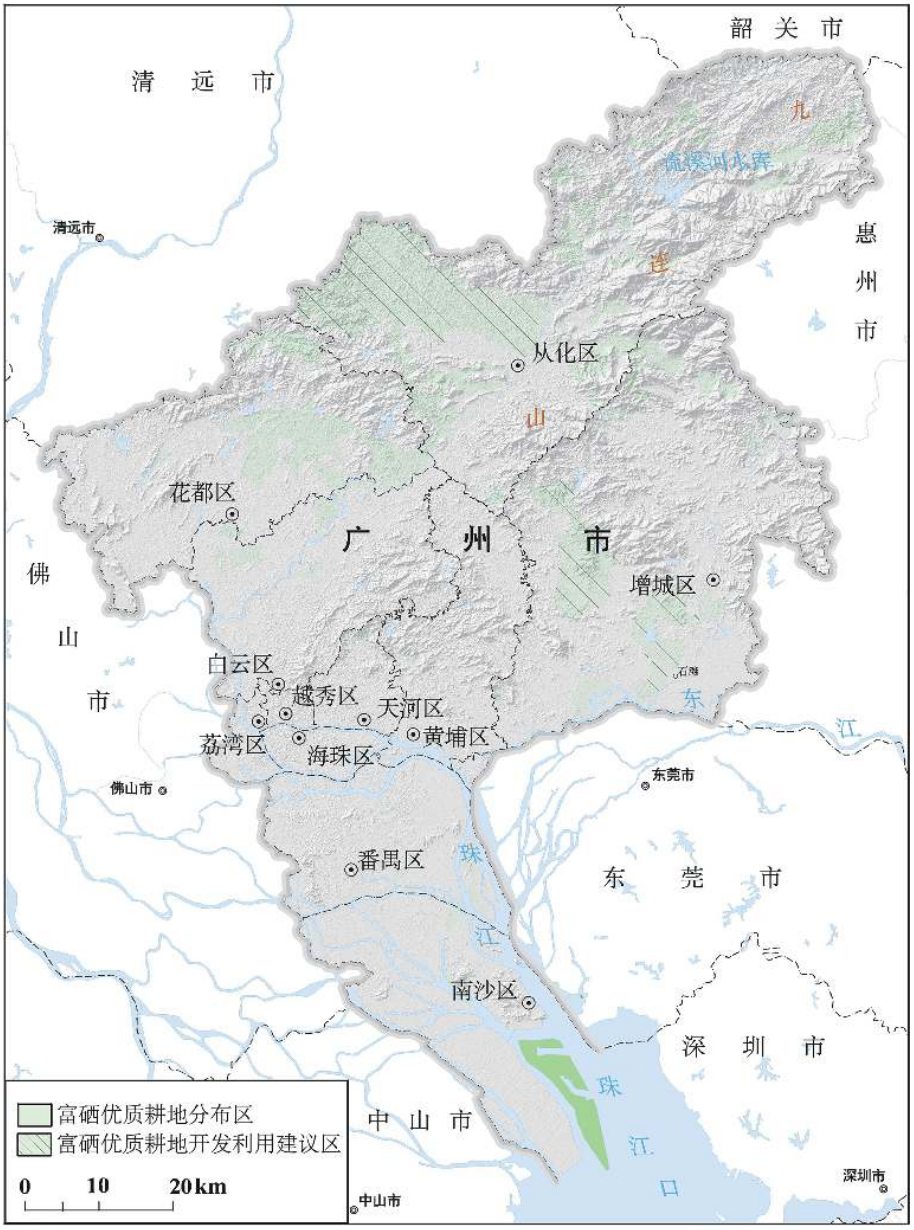

图 3　广州市优质富硒耕地资源保护及开发利用建议图（自然资源部中国地质调查局，2019）

表 2　图集章节与内容结构

类别	序号	图集内容结构	页码
序图	1	广州市三维地势图	2–3
	2	广州市遥感影像图	4–5
	3	广州市行政区划与人口密度分布图	6–7
	4	广州市重点发展功能区划图	8–9
	5	广州市重大基础设施规划图	10–11
	6	广州市中心城区地下空间利用现状分布图	12–13
	7	广州市土地利用现状图	14–15
	8	广州市水系分布图	16–17
	9	广州市2010—2017年降水均值等值线图	18–19

续表 2

类别	序号	图集内容结构	页码
国土空间开发利用的地质适宜性评价	1	广州市国土空间开发利用管控建议图	22–23
	2	广州市重点发展功能区重大地质问题防范建议图	24–25
	3	广州市中心城区地铁规划建设重大地质问题防范建议图	26–27
	4	广州国际空港经济示范区国土空间开发利用管控建议图	28–29
	5	广州国家空港经济示范区地下空间利用综合建议图	30–31
	6	广州市南沙区国土空间开发利用管控建议图	32–33
	7	广州市南沙区地下空间利用基础条件图	34–35
	8	广州市南沙区三维结构模型图	36–37
	9	服务广州市海绵城市建设降雨入渗系数分区图	38–39
城市规划建设应关注的重大地质安全问题	1	广州市岩溶塌陷易发性分区图	42–43
	2	广州市区域地壳稳定性分区图	44–45
	3	广州市软土地面沉降危险性分区图	46–47
	4	广州市崩滑流地质灾害易发程度分区图	48–49
	5	广州市崩滑流地质灾害风险区划图	50–51
	6	广州市矿山采空区分布图	52–53
	7	广州市南沙区区风暴潮灾害易发性分布图	54–55
产业发展可以充分利用的优势地质资源	1	广州市优质富硒耕地资源保护及开发利用建议图	58–59
	2	广州市耕地资源分布图	60–61
	3	广州市地学旅游资源分布及开发利用建议图	62–63
	4	广州市公园分布图	64–65
	5	广州市林地资源分布图	66–67
	6	广州市草地资源分布图	68–69
	7	广州市湿地资源分布图	70–71
	8	广州市自然保护区分布图	72–73
	9	广州市地下水水源地分布图	74–75
	10	广州市南沙区咸水资源开发利用建议图	76–77
	11	广州市水资源分布图	78–79
	12	广州市地热资源分布开发利用建议图	80–81
	13	广州市滩涂资源分布图	82–83
	14	广州市矿产资源分布图	84–85
	15	广州市珠江口海砂资源分布图	86–87
	16	广州市白云区龙归盐穴资源分布图	88–89
生态环境保护需要重视的资源环境状况	1	广州市浅层地下水质量状况图	92–93
	2	广州市土地环境质量综合评价分区图	94–95
	3	广州市珠江口围填海变迁图	96–97
基础地质条件类图件	1	广州市地貌分区图	100–101
	2	广州市区域地质图	102–103
	3	广州市基岩地质图	104–105
	4	广州市水文地质图	106–107
	5	广州市第四纪地质图	108–109
	6	广州市软土分布及软土厚度分区图	110–111
	7	广州市基岩埋深图	112–113
	8	粤港澳大湾区区域地质图	114–115
	9	粤港澳大湾区地壳稳定性分区图	116–117

《图集》综合性强，表达方式灵活，内容丰富，可读性高，已提交当地政府及相关部门使用，为构建“透明南沙”和广州市海绵城市建设、国土空间规划提供了重要基础，支撑服务了国家发展战略需求。

6 结论

《图集》展示了广州市的基础地质条件、城市规划建设应关注的重大地质安全问题、产业发展可以充分利用的优势地质资源以及生态环境保护需要重视的资源环境状况等内容，作为广州市自然资源管理、国土空间规划、重大工程建设及生态环境保护等重要技术资料，有效服务了广州国土空间规划与海绵城市建设，也为水文工程环境地质相关专业人员进行专业研究提供了重要参考资料。

致谢：《支撑服务广州市规划建设与绿色发展资源环境图集》是一项综合性成果，研究工作顺利开展与全体项目组科技人员的辛勤劳动和共同努力密不可分，对广州市国土规划委、自然资源局、广东省地质局等单位的多部门协作，表示衷心的感谢。感谢项目承担单位中国地质调查局武汉地质调查中心给予的一贯支持。

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Dataset of Resource and Environment Atlas for the Purpose of Supporting and Serving the Planning, Construction and Green Development of Guangzhou

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Abstract: The *Dataset of the Resource and Environment Atlas for the Purpose of Supporting and Serving the Planning*, *Construction and Green Development of Guangzhou* (also referred to as the *Atlas*), a professional integrated atlas in geology, was prepared based on a collation and summary of the latest materials and results obtained from hydrogeological, engineering geological and environmental geological surveys. It focuses on the development of Guangzhou, one of the three poles of the Guangdong – Hong Kong – Macao Greater Bay Area. In the *Atlas*, it collected and collated environmental geological surveys, monitoring data and research results carried out in Guangdong, Hong Kong, Macau and Bay Area since the Land and Resources Survey.. Moreover, they were expressed in a more popular and legible means such as figures or forms based on secondary study and development. In general, the *Atlas* consists of 53 maps and 6 categories, i.e., introductory maps, maps on the assessment of the geological suitability for the development and utilization of national land space, maps on the major geological safety problems that ought to be noted in urban planning and construction, maps on the advantageous geological resources that ought to be fully utilized for industrial development, maps on the state of the resources and environment that ought to be focused on for ecological environmental protection and maps on the basic geological conditions. Furthermore, the *Atlas* also contains the geological recommendations to support the development of green ecological agriculture, the development of a clean energy industry, safe use of water, the development of a tourism industry and the enhancement of the abilities to prevent and reduce natural disasters in the Guangdong – Hongkong – Macao Greater Bay Area, effectively serving the planning of national land space and the building of sponge cities in Guangzhou.

Key words: planning and construction; green development; geological resources; geological

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environment; underground space; urban geology; Atlas; Guangzhou city; Guangdong
Data service system URL: http://dcc.cgs.gov.cn

1 Introduction

Guangzhou lies in South China, on the verge of the South China Sea and in the northern margin of the Pearl River Delta, covering an area of 7 434 km^2 in total. As the capital city of Guangdong Province, it is one of the most renowned, historic and cultural cities in China. It is also one of the most important national central cities and one of the most significant internal trade centers and integrated transportation hubs, that is a critical component of the city cluster in the Guangdong – Hong Kong – Macao Greater Bay Area. As a frontier city in the reform and opening up of China, Guangzhou boasts an early and high-degree of opening up, developed economy and upmost dynamic development. It was clearly stated in the Thirteenth Five-Year Plan of Urban Construction Planning of Guangzhou that the city will be built into a core city of the world-class city cluster of the Pearl River Delta, a strategic hub of the Belt and Road Initiative and also a modernized city that is harmonious, habitable and dynamic with a prosperous economy, sound ecological environment and distinctive characteristics.

The China Geological Survey organized the development of the *Atlas* by coordinating with multiple organizations such as the entities directly under itself, the Guangdong Geological Bureau and Guangzhou Municipal Land, Resources & Urban Planning Commission. They did this in order to powerfully support the preparation and implementation of the national land space plan, reasonably develop and utilize the national land space and serve the planning and building of high-quality life circles that are suitable for living, entrepreneurship, employment and tourism in Guangzhou. The *Atlas* was built on the systematical collation and summary of the results and thematic maps obtained from basic geological surveys such as the regional geological survey, hydrogeological engineering survey, environmental geological survey, mineral resources survey, geophysical prospecting and geochemical prospecting. It was also based on the comprehensive study and analysis of the results and the investigation of the demand of Guangzhou for planning, construction and green development. Compiled *the Atlas of Resources and Environment for Supporting Planning and Construction and Green Development of Guangzhou City*. The *Atlas* features wide application fields and strong legibility, whilst also containing measures and recommendations for the development and utilization of national land space, construction of towns and critical projects, industrial layout and ecological environmental protection (China Geological Survey, 2019). The basic information of the *Atlas* is shown in Table 1.

2 Methods For Data Acquisition And Processing

2.1 Data Acquisition

The *Atlas* is one of the critical result series obtained from the secondary-level project titled *Environmental Geological Survey on a Scale of 1 : 50 000 in the Guangdong – Hong*

Table 1 Metadata Table of Database (Dataset)

Items	Description
Database (dataset) name	Dataset of the Resource and Environment Atlas for the Purpose of Supporting and Serving the Planning, Construction and Green Development of Guangzhou
Database (dataset) authors	Liu Fengmei, Wuhan Center, China Geological Survey Huang Changsheng, Wuhan Center, China Geological Survey Zheng Xiaozhan, Guangzhou Institute of Geological Survey Zhao Xinwen, Wuhan Center, China Geological Survey
Data acquisition time	January 2016 – March 2018
Geographical area	Guangzhou, Guangdong Province
Data format	Data format of MapGIS: *.wt, *.wl, *.wp
Data size	6.25 GB
Data service system URL	http://dcc.cgs.gov.cn
Fund project	China Geological Survey project titled "Environmental Geological Survey on a Scale of 1∶50 000 in Guangdong – Hong Kong – Macao Greater Bay Area" (DD20160291)
Language	Chinese
Database (dataset) composition	A set of atlases consisting of 53 maps of MapGIS format, 53 specifications and a recommendation file of geoscience for the development and utilization of national land space, planning and construction of towns and critical projects, industrial planning and layout and ecological environmental protection.

Kong – Macao Greater Bay Area, which was planned and deployed by the China Geological Survey. National basic geographical data on a scale of 1∶1 000 000 were collected as the base maps for the *Atlas*. The data of SRTM3 DEM (Digital Elevation Model), remote-sensing data collected from LandSat 8 OLI (Operational Land Imager), the materials of various districts of Guangzhou such as statistical yearbooks (2014—2016), water resource bulletins and climate bulletins and also the *Urban Master Plan of Guangzhou* (*2011—2020*) were combined in the *Atlas*. Furthermore, fully absorbed and summarized the environmental geological surveys, monitoring data and research results carried out in Guangdong, Hong Kong and Macau Bay Area since the Land and Resources Survey. All these data were obtained as of March 2018 and were then processed and managed with existing technical standards and computer software universal at home and abroad, with the data precision requirements for the scale of 1∶500 000 being satisfied. In this way, the results of the environmental geological surveys in Guangzhou can be presented from multiple aspects.

2.2 Data Processing

The *Atlas* has been published and the geographical maps and related data in the *Atlas* have been audited and approved by the Former National Bureau of Surveying and Mapping Geoinformation. The data processed are as follows:

(1) Geographical base maps: Three national geographical base maps on a scale of 1∶1 000 000, i.e., G49, F49 and F50 were taken as basic geographical maps. The data in the maps were converted with software ArcGIS and MapGIS from E00 format into *.wt, *.wl and *.wp

formats, which were the formats for plotting the maps in the *Atlas*. The projection parameters of the maps were determined again according to mapping scope and scale and the maps were corrected with standard graticules and inner map frames being generated. Lambert Conformal Conic Projection was adopted for the mathematical basis of the geological base maps, with a central meridian of 113°30′00″, the first latitude line of 23°00′00″ and the second latitude line of 23°30 ′00 ″. As for the selection of basic geographical elements, elevation data were excluded, while letterings such as administrative borders of counties or above, residential areas of prefecture-level divisions or above, main transportation roads, rivers (level 3 and above), lakes and mountains were selected. These geographical elements were then aligned, modified and updated according to the contents expressed. Furthermore, the longitudes and latitudes, names of provinces, cities and counties, water systems, mountains and mountain names were also added, deleted or simplified according to the contents expressed.

(2) Background of the base maps: For each map, 3D DEM hill-shading were overlapped on the unified geographical base map (Zhou CH, 2010), aiming to enhance stereoscopic and layered impressions of the maps.

(3) Layout design of map sheets: A3 sized layouts were adopted for the maps in the *Atlas* and one page of the maps was followed by one page of text description, in order to maintain a balanced page space. The map descriptions were expressed in the form of combined text and graphs/charts (Li TD, 2007). Map border and map decoration followed unified requirements and the location, spacing and font size of the map title and legends were arranged in accordance with a unified specification (Zuo W et al., 2009). Furthermore, the legends were arranged in the order of successive points, lines and zones to ensure that the layout and style of the map sheets are unified and aesthetically appealing.

(4) Design of color symbols: The colors in the maps were configured according to the specifications for color use in the majors of geology, minerals, resources and environment. Particular elements were expressed by the colors similar to the elements according to the symbolic attributes of colors, for ease of reading and association. Color contrast and a harmony of cold and warm hues were considered so that colors are distinctly layered, rich and harmonious.

(5) Expression of thematic elements: Thematic elements were mainly expressed by quality base, area, line symbol, isoline and point symbol method. To ensure that the *Atlas* is used by governments and also used as reading material for science and technology, the contents of thematic elements were quantified mainly by zonal and graduation statistics and the information on the maps were expressed in popular and legible forms, such as pie charts, histograms and contrast diagrams.

3 Description of Data Samples

3.1 Contents and Structure of the *Atlas*

The *Atlas* consists of 53 maps of six categories according to the design outline.

(1) Introductory maps (Fig. 1), mainly used to reflect 3D relief, full view from remote-

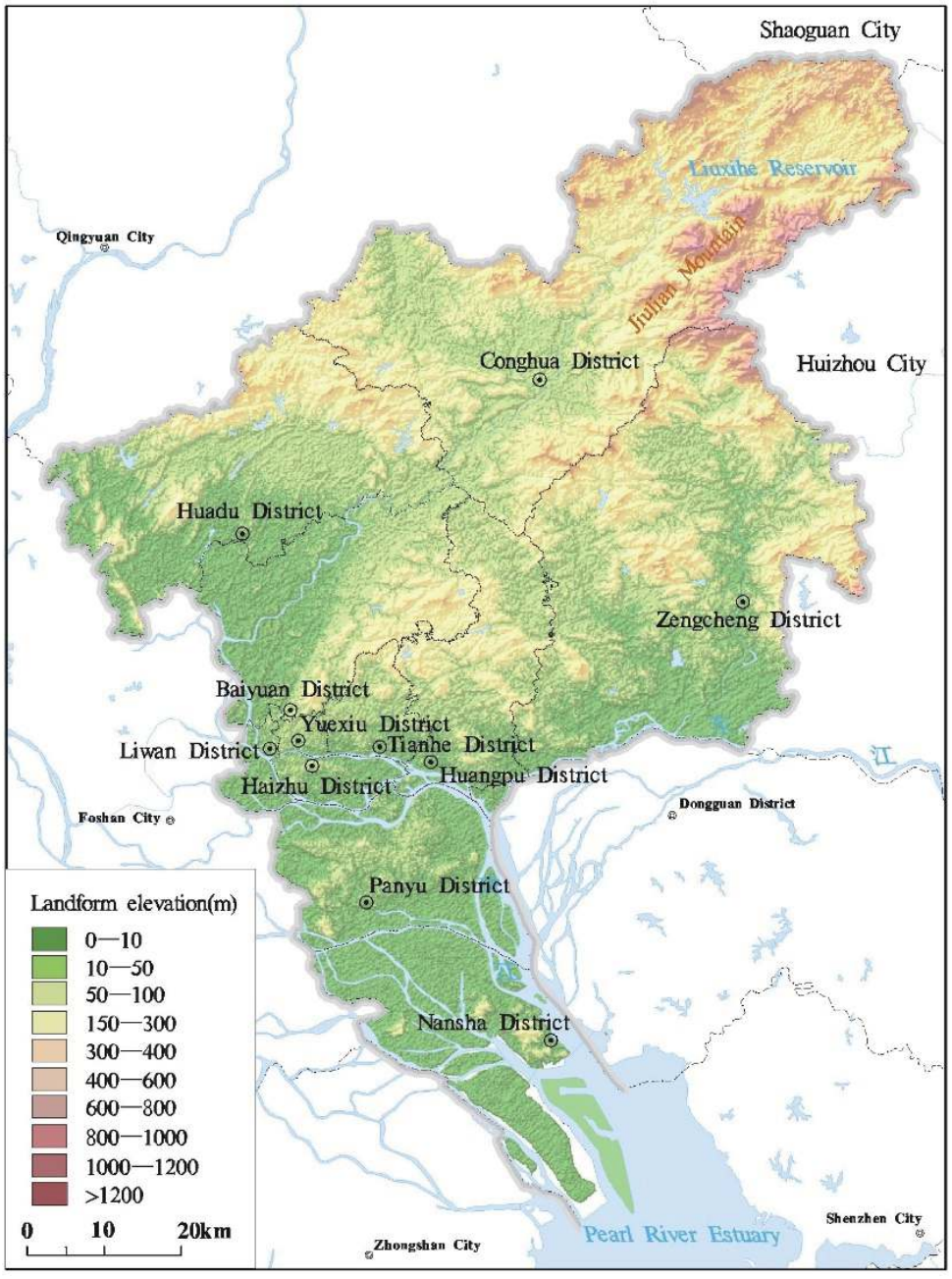

Fig. 1 3D Relief Map of Guangzhou (China Geological Survey, 2019)

sensing images, administrative division and population density, zoning of key functions to be developed, planning of major infrastructures, utilization status quo of underground spaces in the central urban area, status quo of land use and distribution of water systems in Guangzhou.

(2) Maps on the assessment of the geological suitability for the development and utilization of national land space (Fig. 2). The assessment of the geological suitability was made for 4 areas suitable for natural landscape reservation and tourism development, 3 areas suitable for high-quality arable land protection and characteristically agricultural development and 4 areas suitable for the protection and development of groundwater sources, karst collapse prevention areas, soft-soil surface subsidence prevention areas and active fracture prevention

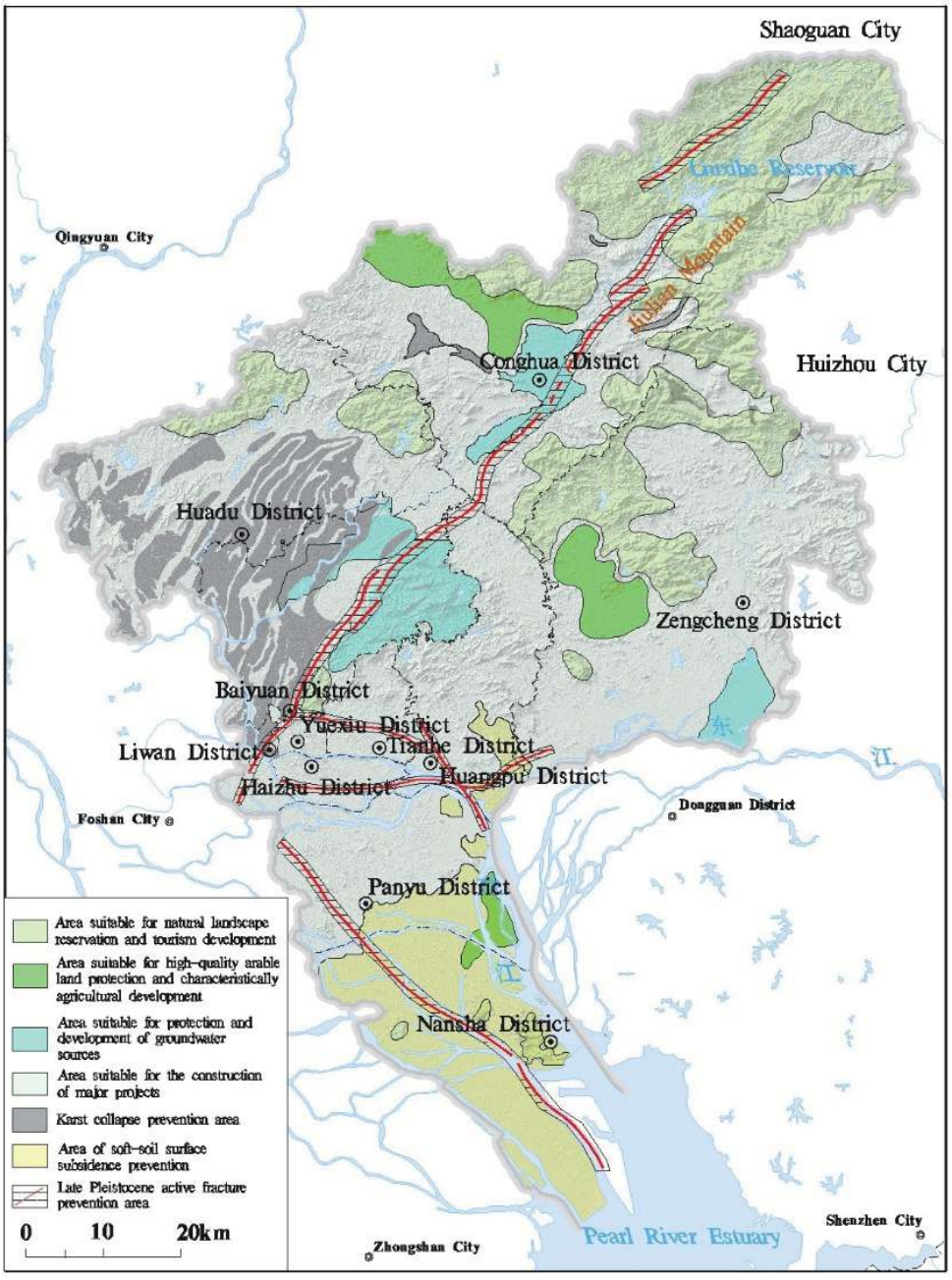

Fig. 2 Map on recommendations for the development, utilization, control and management of national land space in Guangzhou (China Geological Survey, 2019)

areas (Huang CS et al., 2015).

(3) Maps on major geological safety problems that ought to be noted in urban planning and construction (Zhi BF et al., 2005). They are used to describe the areas where active fractures, karst surface collapse, surface subsidence of soft soil and geological hazards such as collapse, landslides and debris flow shall be prevented with better efforts and good geological conditions shall be fully utilized. Furthermore, major projects shall be scientifically deployed in these areas (Dong HG et al., 2012).

(4) Maps on advantageous geological resources that ought to be fully utilized for

industrial development (Fig. 3). It is recommended to plan and construct a modern industrial base with agricultural characteristics in high-quality, Se-rich, concentrated and well-connected arable areas. This will help to reasonably develop and utilize mineral water and proactively advance the development and utilization of geological relics and geothermal resources; build geological parks integrating vacation, leisure, tourism and science popularization, and thus optimize the layout of modern industries in Guangzhou.

(5) Maps on the state of the resources and environment that ought to be focused on for ecological environmental protection. It is necessary to enhance the survey, assessment, control

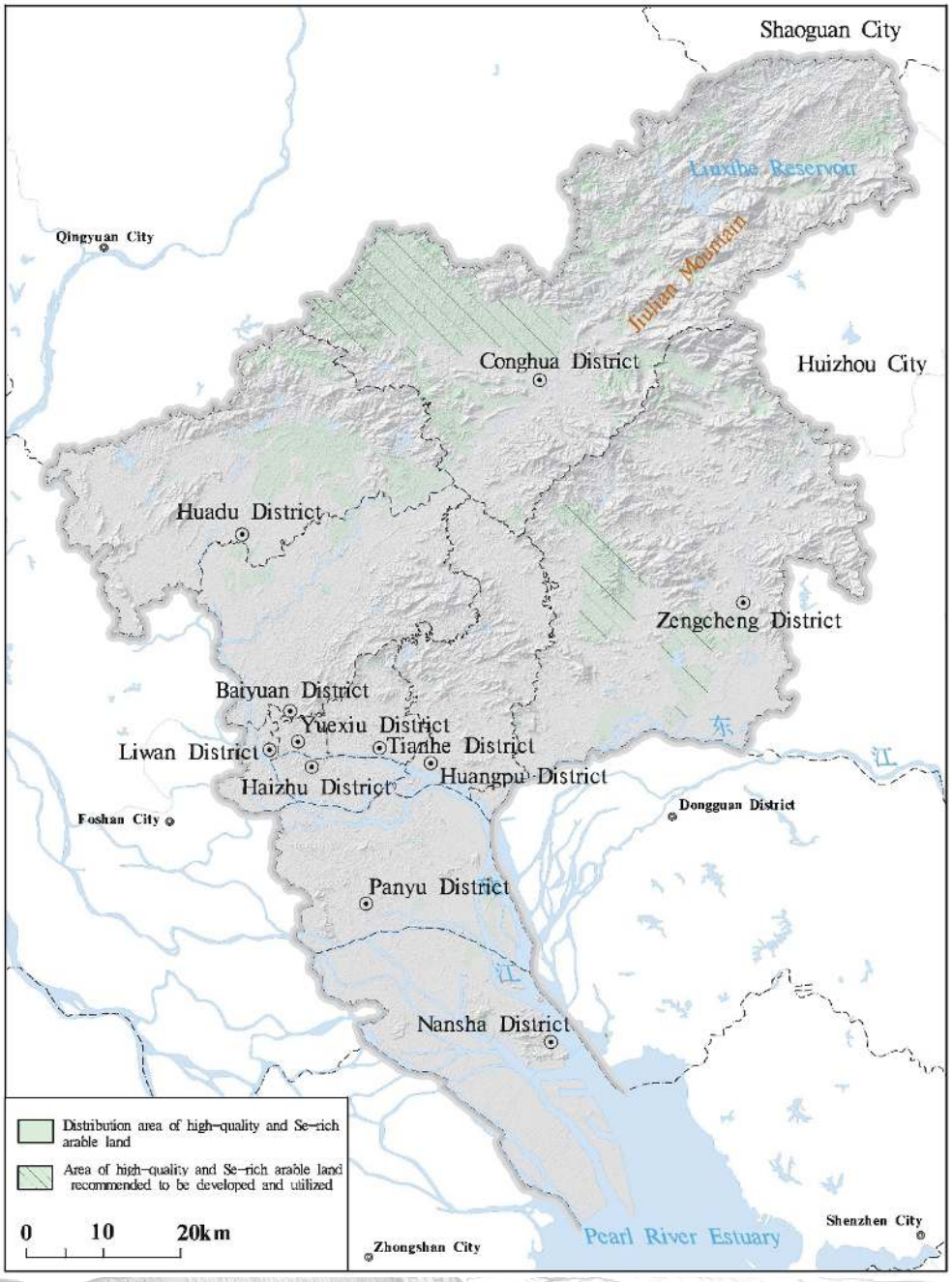

Fig. 3 Map on recommendations for the protection, development and utilization of high-quality and Se-rich arable land resources in Guangzhou (China Geological Survey, 2019)

and treatment of water and soil pollution, carry out the prevention, control and rehabilitation of the ecological environment in coastal areas as soon as possible, control the retention rate of natural coast and guarantee the safety of the ecological geology in Guangzhou.

(6) Maps on the basic geological conditions, including those on landform-based zones, basic geological conditions, hydrogeological conditions, Quaternary geological conditions and the burial depth of the bedrock in Guangzhou; and also the regional geological conditions and crust stability in the Guangdong – Hong Kong – Macao Greater Bay Area. The contents of the *Atlas* are shown in Table 2.

3.2 Map Specifications

Map specifications consist of material source, map description and recommendations, with the number of Chinese characters no greater than 1 500 in total. Any outcome names, names of survey organizations, deadlines for information collection and entities in charge of map preparation should be clearly provided in the material source section. The map preparation process and data analysis results are briefly stated and described with corresponding charts and tables, in which the colors are consistent with or similar to those of map legend for the ease of extension and association in reading, in the map description section. The recommendations were prepared as needed for the maps. For instance, it is unnecessary to prepare any recommendations for introductory and basic maps, whereas a brief summary and advisory explanations are required for maps on resource distribution, assessment, safety-related problems and the environment.

4 Data Quality Control and Assessment

In the *Atlas*, the thematic contents and geographical base maps were strictly overlapped with each other, with each map being corrected based on the graticules on the geographical base map to ensure that the errors of the graticules and the points on the map border are less than or equal to 0.1 mm.

The data and information of social-economical maps in the *Atlas* were mainly obtained from published articles and works mainly including public yearbooks and bulletins. The materials of geology and the environment in the *Atlas* were mainly collected from archived outcomes of geological surveys over the years and some of the data updated are also the qualified results according to a quality inspection and field acceptance. Therefore, the data and materials were obtained from reliable sources, and thus are accurate.

The *Atlas* was reviewed and modified many times by experts in the relevant fields in objective, practical, characteristic, advanced, universal and popular principles. As a result, the *Atlas* features clear purpose and is simple and legible, convenient for use and suitable for a variety of applications.

5 Value of the Data

All maps in the *Atlas* were prepared in the MapGIS format, and are therefore convenient for inquiry and strongly editable, features a clear mathematical basis and can be overlapped

Table 2 Structure of Chapters and Contents of the *Atlas*

Category	No.	Content structure of the *Atlas*	Page no.
Introductory map	1	3D relief map of Guangzhou	2–3
	2	Remote-sensing image map of Guangzhou	4–5
	3	Administrative division and population density distribution map of Guangzhou	6–7
	4	Map of key function zones to be developed in Guangzhou	8–9
	5	Major infrastructure planning map in Guangzhou	10–11
	6	Map on the status quo of the utilization of underground spaces in the central urban area of Guangzhou	12–13
	7	Map on the status quo of the land use in Guangzhou	14–15
	8	Map on the distribution of water systems in Guangzhou	16–17
	9	Isoline map of the average precipitation from 2010—2017 in Guangzhou	18–19
Maps on the assessment of geological suitability for the development and utilization of national land space	1	Map on recommendations for the development, utilization, control and management of national land space in Guangzhou	22–23
	2	Map on recommendations for the prevention of major geological problems in key functional zones to be developed in Guangzhou	24–25
	3	Map on recommendations for the prevention of major geological problems in terms of subway planning and construction in the central urban area of Guangzhou	26–27
	4	Map on recommendations for the development, utilization, control and management of national land space in the International Airport Economic Demonstration Area of Guangzhou	28–29
	5	Map on integrated recommendations for the utilization of underground space in the International Airport Economic Demonstration Area of Guangzhou	30–31
	6	Map on recommendations for the development, utilization, control and management of national land space in Nansha District, Guangzhou	32–33
	7	Map on the basic conditions of the utilization of underground space in Nansha District, Guangzhou	34–35
	8	3D structural model map of Nansha District, Guangzhou	36–37
	9	Map on rainfall infiltration coefficient-based zones for the purpose of serving the construction of sponge cities in Guangzhou	38–39
Maps on major geological safety problems to be noted in urban planning and construction	1	Map on susceptibility zoning of karst collapse in Guangzhou	42–43
	2	Map on regional crust stability zoning in Guangzhou	44–45
	3	Map on danger level zoning of soft-foil surface subsidence in Guangzhou	46–47
	4	Map on susceptibility zoning of geological hazards such as collapse, landslides and debris flow in Guangzhou	48–49
	5	Map on risk zoning of geological hazards such as collapse, landslides and debris flow in Guangzhou	50–51
	6	Map on the distribution of mined-out areas in Guangzhou	52–53
	7	Map on the susceptibility distribution of disasterous storm surges in Nansha District, Guangzhou	54–55

Continued table 2

Category	No.	Content structure of the *Atlas*	Page no.
Maps on advantageous geological resources to be fully utilized in industrial development	1	Map on recommendations for the protection, development and utilization of high-quality and Se-rich arable land resources in Guangzhou	58–59
	2	Map on the distribution of arable land in Guangzhou	60–61
	3	Map on the distribution and relevant recommendations for the development and utilization of geoscience tourism in Guangzhou	62–63
	4	Park distribution map of Guangzhou	64–65
	5	Forest land distribution map of Guangzhou	66–67
	6	Grassland distribution map of Guangzhou	68–69
	7	Wetland distribution map of Guangzhou	70–71
	8	Natural reserve distribution map of Guangzhou	72–73
	9	Groundwater source distribution map of Guangzhou	74–75
	10	Map on recommendations for the development and utilization of saltwater resources in Nansha District, Guangzhou	76–77
	11	Water resource distribution map of Guangzhou	78–79
	12	Map on the distribution and relevant recommendations for development and utilization of geothermal resources in Guangzhou	80–81
	13	Tidal flat distribution map of Guangzhou	82–83
	14	Mineral resource distribution map of Guangzhou	84–85
	15	Marine sand resource distribution map at the Pearl River Estuary of Guangzhou	86–87
	16	Salt-cavern distribution map of Longgui Town, Baiyun District, Guangzhou	88–89
Maps on basic geological conditions	1	Shallow groundwater quality map of Guangzhou	92–93
	2	Comprehensive assessment zoning map of soil environment quality in Guangzhou	94–95
	3	Sea reclamation change map at the Pearl River Estuary of Guangzhou	96–97
	1	Landform-based zone map of Guangzhou	100–101
	2	Regional geological map of Guangzhou	102–103
	3	Bedrock geological map of Guangzhou	104–105
	4	Hydrogeological map of Guangzhou	106–107
	5	Quaternary geological map of Guangzhou	108–109
	6	Soft-soil distribution and thickness zoning map of Guangzhou	110–111
	7	Bedrock burial depth map of Guangzhou	112–113
	8	Regional geological map of the Guangdong – Hong Kong – Macao Greater Bay Area	114–115
	9	Regional crust stability zoning in the Guangdong – Hong Kong – Macao Greater Bay Area	116–117

and merged with data of the same type and reprocessed. Furthermore, it is convenient for dataset management and information sharing. Therefore, the *Atlas* can satisfy the demand of professionals for any relevant application and research and provide important references for the compilation of relevant atlases used to provide supports and service. The *Atlas*, boasting strong integration, flexible expression means, rich content and high legibility, has been submitted to local governments and the associated departments for use. In this way, it has provided an important foundation for the building of a "transparent Nanshan", the construction of sponge cities and the planning of national land space in Guangzhou, thus supporting and serving the strategic needs of national development.

6 Conclusion

The *Atlas* presents basic geological conditions, major geological safety problems that ought to be noted in urban planning and construction, advantageous geological resources that ought to be fully utilized for industrial development and the state of resources and the environment that ought to be focused on for ecological environmental protection in Guangzhou. Therefore, it will provide technical materials for the management of natural resources, planning of national land spaces, construction of major projects and ecological environmental protection in Guangzhou. Furthermore, it has effectively served the planning of national land space and the construction of sponge cities; provided guidance and references on the popularization of scientific knowledge in the fields of hydrogeology, engineering geology and environmental geology for competent departments and also provided important references on industrial research for professionals in geoscience and any relevant majors.

Acknowledgments: We would like to extend our sincere appreciation to all scientific and technical staff participating in the development of the *Atlas* for their hard work and joint efforts. As a comprehensive result, the *Atlas* can only be successfully achieved as a result of their hard work. Our sincere appreciation also goes to the Guangzhou Municipal Land, Resources & Urban Planning Commission, Guangzhou Municipal Planning and Natural Resources Bureau and Guangdong Geological Bureau for their collaboration. Lastly, our thanks go to the Wuhan Center, China Geological Survey, the undertaker of the *Atlas* for their consistent support.

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