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中国南部及邻区能源资源成矿区带数据集

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摘要：能源矿产是国家安全和经济发展的战略资源，加强我国及周边地区油气和煤等能源资源的研究和开发利用意义重大。依据板块构造和大陆动力学以及油气与煤成藏地质学理论，以深部构造控制盆—山发育、盆—山耦合和热动力系统控制成矿的研究工作思路，应用 70 个油气田、471 个煤田的基础地质资料，从沉积盆地发育的区域地质特征、成矿地质条件和成矿单元诸多方面，在地理信息系统（GIS）平台上提示了该区板块构造格局与能源资源的时空分布规律。中国南部及邻区能源资源可划分为 3 个成矿域，每个成矿域又可进一步划分为成矿省、含矿区（盆地）、矿田聚集区带、矿田（油气田）五个级别的成矿区域。数据集由构造带（断裂带和造山带）类型和时代、盆地类型和时代、能源矿产资源类型和丰度、成矿区带等元数据组成。该数据集是在区域大地构造研究的基础上，结合沉积盆地能源矿产（石油、天然气、煤）资源评价资料，综合分析成矿区带特征，利用地理信息系统（GIS）建立的一套完整的数据库，不仅是对中国南部及邻区区域地质认识和沉积盆地能源资源勘查工作成果的集成，而且为国家科学地引导地质找矿工作部署提供理论基础。

关键词：能源资源；成矿区带；数据集；中国南部及邻区

数据服务系统网址：http://dcc.cgs.gov.cn

1　引言

中国南部及邻区处于欧亚板块、印度板块与太平洋板块三大岩石圈板块的结合部位，在扬子克拉通形成和演化的基础上，经历了特提斯洋形成演化以及西太平洋的构造改造过程。随着陆块和造山带的形成演化，发育其中的沉积盆地也历经多次盆地改造，在沉积盆地中的油气和煤等能源资源也经历了多期复杂的聚集。中国南部及邻区是我国能源资源勘探和开发的重要远景区之一，也是近些年来新区新领域新层系油气勘探评价值得重视和重新认识的战略选区。

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数据集所指的能源资源主要是指在沉积盆地中形成的石油、天然气和煤等。中国南部及邻区能源资源成矿区带数据集是中国与俄罗斯、蒙古、哈萨克斯坦和韩国开展国际合作研究、由中方完成的阶段性成果。开展我国与周边国家的基础地质以及能源资源和矿产资源合作研究，既可以深化对东亚—中亚—南亚等区域地质与成矿特征的认识，也能够为我国解决关键地质问题和开展深部找矿提供基础地质支撑。

地理信息系统（GIS）的迅速发展和广泛应用，使小比例尺地质图件的编制、更新和空间数据库建设的周期大大缩短（韩坤英等，2005 ；万常选等，2009），并可实现资源共享。国际上对一个领域或一个地区海量数据资源的整理和研究最常用的一种方法就是利用地理信息系统（GIS）建设数据库，并在数据库的基础上形成不同比例尺的图件。美国、俄罗斯、日本、韩国、蒙古和欧洲各国以及前苏联独联体国家等世界各国对1∶100 万或 1∶250 万或 1∶500 万基础地质、构造和矿产等小比例尺地质数据库建设、图件编制和更新非常重视（Asch，2001 ；Bouysse et al., 2004 ；李廷栋，2007 ；庞健峰等，2017）。同样，中国也非常重视 GIS 技术在地质研究和制图方面的应用。二十世纪末由原国家计委和原地矿部共同立项，利用 GIS 技术建立了中华人民共和国 1:50 万数字地质图空间数据库（张庆合等，2002）；本世纪初，以全国 1∶50 万地质图数据库为基础，充分吸收 1∶25 万、1∶5 万区域地质调查的新成果以及专题研究的新资料和新进展，按国际标准分幅建立了全国 1∶100 万地质图空间数据库、以及编制数字地质图（庞健峰等，2017）；同时期，完成了我国 1∶250 万数字地质图空间数据库和 1∶250 万地质图（叶天竺等，2017）、国际亚洲 1∶500 万空间数据库和 1∶500 万数字地质图（Ren et al., 2013 ；王军等，2017）、以及各种类型不同比例尺的地质及矿产数据库和图件。限于篇幅，在此不再赘述。

成矿区带是在具有地质构造演化史的地质体中经历一次或多次成矿作用而形成丰富的矿产资源，并且具备资源潜力和找矿远景的成矿地质单元。成矿区带是 20 世纪初在研究金属矿产时提出的，直到 20 世纪 90 年代成矿区带研究才达到了理论研究和勘查实践的紧密结合。最早法国地质学家 L.de Launay 于 1905 年提出 “ 成矿区带是研究金属的自然富集作用 ”的概念，并于 1913 年提出金属成矿省的概念，意指在地壳特定的区域内产出异常多特定类型的矿床；在国内 1920 年翁文灏提出矿床成带状分布，将南岭地区划分出锡、锌—铅—铜、锑、汞4个成矿带；陈毓川提出中国主要成矿单元分为5级（陈毓川，1999）。近些年来，由于国家对能源资源和矿产资源研究和开发的重视，成矿规律的成果不断涌现（宋相龙等，2017）。

中国南部及邻区范围系指北界为喀拉昆仑山—昆仑山—秦岭—大别山、南界为印度北部—中国南海北部，西界为塔吉克斯坦，东界为我国台湾省和南海北部区域。其编图范围为：东经 68 °~ 122 °，北纬 18 °~ 36 °，其中，地理和构造带的研究内容为全图范围，沉积盆地的能源资源研究内容主要为我国昆仑山—秦岭—大别山以南的陆地区和南海北部地区。

“ 中国南部及邻区能源矿产成矿图 ”是 2008—2010 年 “ 东—中亚深部地质结构与成矿作用研究 ”项目完成的 1∶250 万 “ 亚洲中部及邻区地质图系 ”之一，是中国、俄罗斯、蒙古、哈萨克斯坦和韩国五国继续合作第二阶段开展基础地质研究和图件编制成果。它主要由我国南部及邻区区域构造单元、以及我国南部主要沉积盆地石油、天然气和煤等

能源资源数据库构成。本数据集为 25 幅 1∶100 万国际分幅范围内沉积盆地发育的石油、天然气和煤等能源资源找矿勘查工作成果数据资料（表 1）。

表 1　沉积盆地中油气田和煤田数据统计表

序号	1∶100 万图幅	图幅中矿点数（个）	油气田数（个）	煤田数（个）	国家	主要矿种
1	E49 海口幅	10	4	6	中国	油气和煤
2	F47 普洱幅	6	1	5	中国	油气和煤
3	F48 百色幅	13	3	10	中国	油气和煤
4	F49 广州幅	24	1	24	中国	油气和煤
5	F50 汕头幅	8	1	7	中国	油气和煤
6	F51 高雄幅	3	3	0	中国	油气
7	G47 攀枝花幅	19	0	19	中国	煤
8	G48 昆明幅	52	0	52	中国	煤
9	G49 株洲幅	112	12	100	中国	油气和煤
10	G50 福州幅	45	0	45	中国	煤
11	G51 台北幅	11	2	9	中国	油气和煤
12	H44 门士幅	1	0	1	中国	煤
13	H45 日喀则幅	2	0	2	中国	煤
14	H46 那曲幅	5	0	5	中国	煤
15	H47 昌都幅	4	0	4	中国	煤
16	H48 成都幅	72	39	33	中国	油气和煤
17	H49 长沙幅	27	0	27	中国	煤
18	H50 武汉幅	65	0	65	中国	煤
19	H51 上海幅	14	0	14	中国	煤
20	I45 改则幅	1	1	0	中国	油气
21	I46 安多幅	7	0	7	中国	煤
22	I47 玉树幅	15	0	15	中国	煤
23	I48 宝鸡幅	20	3	17	中国	油气和煤
24	I50 南京幅	3	0	3	中国	煤
25	I53 南通幅	1	0	1	中国	煤
	合计	541	70	471		

中国南部及邻区能源资源成矿区带数据库（集）元数据简介见表 2。表 2 内容包括数据库（集）名称、数据作者、数据采集时间、地理区域、数据格式、数据量、数据出版地址、基金项目、语种、数据库（集）组成等。

表 2　数据库（集）元数据简表

条 目	描述
数据库（集）名称	中国南部及邻区能源资源成矿区带数据集
数据库（集）作者	游国庆，中国地质科学院地质研究所 易荣龙，中国地质科学院地质研究所 耿树方，中国地质科学院地质研究所 陈炳蔚，中国地质科学院地质研究所 庞健峰，中国地质科学院地质研究所 杨志新，中国地质科学院地质研究所 李桂林，中国地质科学院地质研究所，中国地质大学 (北京)
数据时间范围	2008—2010 年
地理区域	中国南部及邻区，东经 68° ~ 122°，北纬 18° ~ 36°
数据格式	*.wl, *.wt, *.wp
数据量	431.4 M
数据服务系统网址	http://dcc.cgs.gov.cn
基金项目	中国地质调查项目“ 东—中亚深部地质结构与成矿作用研究 ”。
语种	英文
数据库（集）组成	中国南部及邻区能源资源成矿区带数据集包括： Data_China_EnergyResources_MMB_26_Mapgis 矢量数据， 数据量 196 MB

2　数据采集和处理方法

2.1　数据基础

本数据集是依据板块构造和大陆动力学以及油气与煤成藏地质学理论，以深部构造控制盆—山发育、盆—山耦合和热动力系统控制成矿的研究工作思路，根据国家和能源公司提供的资评材料（内部资料）以及文献（李春昱等，1982 ；黄汲清等，1987 ；中国石油地质志编辑出版委员会，1994 ；徐旺，1997 ；张渝昌，1997 ；关士聪等，1999 ；戴金星等，2000 ；高瑞琪等，2001 ；李德生等，2002 ；李国玉等，2002 ；周玉琦等，2004）等基础地质资料，在综合分析沉积盆地形成和演化受板块构造控制与油气和煤形成受地球热动力控制研究的基础上形成的数据库。数据集包括地理数据、构造带数据和能源资源数据。地理数据、构造带数据延续执行中国、俄罗斯、蒙古、哈萨克斯坦和韩国五国合作制定的“ 亚州中部及邻区能源资源成矿规律研究 ”的技术要求和标准（俄罗斯、中国、哈萨克斯坦、蒙古、韩国联合编图项目组，2008），如：研究工作指导思想和思路、研究内容、构造带的划分、编图原则、地理底图、图示图例等。能源资源数据为中国南部地区 70 个油气田、471 个煤田地质特征和资源量等。中国南部及邻区区域基础地质资料与沉积盆地油气和煤田地质资料截止时间为 2010 年底。

2.2 数据处理

2.2.1 数据处理流程

中国南部及邻区能源资源区带数据处理主要由两方面，一方面是1∶250万地形图数据和地理新资料数据整理和数字化处理；另一方面是区域构造地质资料与含油气和煤盆地地质资料数据整理分析和综合研究以及数据化处理（图1）。

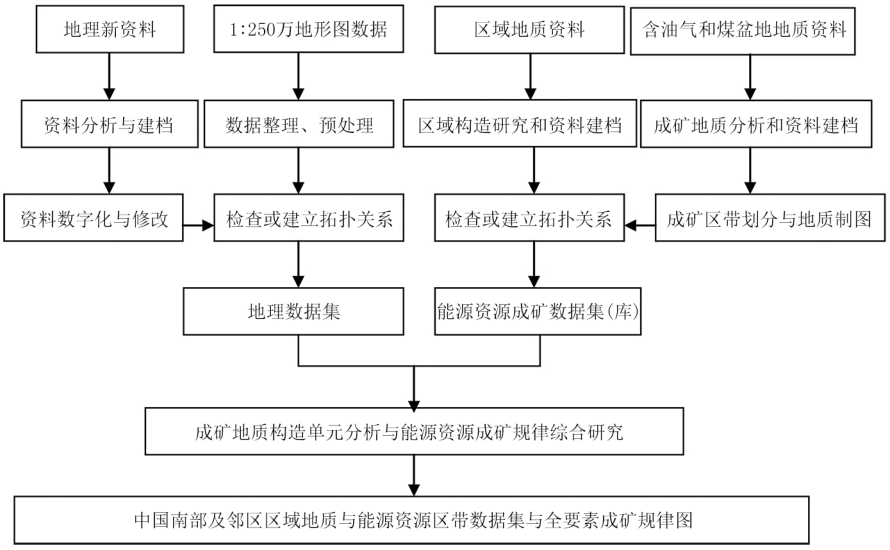


图1 中国南部及邻区能源资源区带数据处理工作流程图

2.2.2 数据处理方法

中国南部及邻区能源资源成矿规律研究与图件编制，是按照五国合作第一阶段制定的研究工作指导思想和思路、研究内容、编图原则、图示图例等要求及标准，建立区域地质特征、含油气和煤沉积盆地地质特征和能源资源成矿单元地质特征数据表，应用国内外通用的计算机编图软件，在MapGIS应用软件平台上进行数据处理和管理，按1∶250万比例尺专业地质图数据库和制图精度要求，建立1∶250万中国南部及邻区能源资源成矿区带数据库和编制图件。

成矿区带/成矿单元的划分主要依据区域地质构造环境、以及能源资源成矿类型、成矿系统、能源资源丰度和其他相关成矿特征，结合已知矿田三维空间展布和形成地质时代，同时，研究成矿构造环境及地球动力学等相关问题，通过成矿规律的分析和推测，划分成矿区带。

中国南部及邻区能源资源成矿划分为5个级别，即：

Ⅰ级：成矿域，系指全球洲际范围内巨型大地构造单元为基础的一个能源资源矿产形成区域。

Ⅱ级：含油气省或含煤省，系指同一大地构造环境中多个不同类型的有成因联系的盆地所组成的含煤—含油气区域。在区域性范畴内煤及油气的形成、聚集与成藏以及时空分布有其一定的共性。

Ⅲ级：含油气区或含煤区，系指含油气盆地和含煤盆地。根据沉积盆地的形成历史分为原型盆地和残留盆地，绝大部分为叠合残留盆地。

Ⅳ级：油气聚集区带或煤聚集区带，系指已发现与查明能源资源矿产分布范围和资源量的聚集成藏区。

Ⅴ级：油气田或煤田，系指已具有探明储量、控制储量及预测储量油—气或煤聚集成藏的区域。

在中国南部及邻区能源资源成矿规律图上，能源资源（石油、天然气、煤）成矿区带以不同彩色线型和面色圈定。

2.2.3　数据处理成果

依据板块构造理论、大陆动力学以及油气和煤地质学等理论的指导，形成了中国南部及邻区能源资源（石油、天然气、煤）成矿区带区划等数据成果。这些成果数据表示了中国南部及邻区能源资源成矿的时空分布，提示了板块构造格局与能源矿产的时空分布规律。中国南部及邻区区域范围涉及古亚洲洋构造成矿域、东特提斯构造成矿域、扬子陆块成矿域、华南构造成矿域、冈瓦纳陆块成矿域 5 个成矿域，其中，古亚洲洋构造成矿域和冈瓦纳陆块成矿域没有纳入本次项目研究区域和编图范围。东特提斯构造成矿域、扬子陆块成矿域、华南构造成矿域包含 10 个成矿省（图 2）。在中国南部及邻区能源资源（石油、天然气、煤）成矿区带数据集中，成矿域和成矿区带的名称如下：

1　扬子陆块成矿省域
　（1）上扬子陆块构造成矿省
　（2）中扬子陆块构造成矿省
　（3）下扬子陆块构造成矿省
2　东特提斯构造成矿域
　（1）巴颜喀拉构造成矿省
　（2）唐古拉山—三江—横断山构造成矿省
　（3）拉萨—冈底斯构造成矿省
　（4）喜马拉雅构造成矿省
3　华南构造成矿域
　（1）南岭—武夷构造成矿省
　（2）右江—云开构造成矿省
　（3）南海—东南沿海构造成矿省

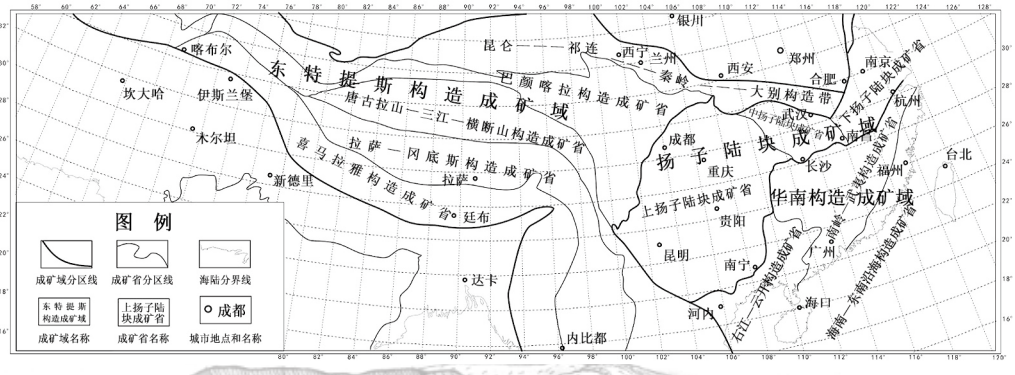


图 2　中国南部及邻区能源资源成矿区带分布简图

3 数据样本描述

中国南部及邻区能源资源成矿区带数据主要包括三个方面（如图 3 所示）：区域地质特征数据表、沉积盆地地质特征数据表、能源资源成矿地质条件数据表。

区域地质特征数据表（见表 3）涵盖区域地理信息、重要断裂性质和方向、陆块性质和时代、造山带性质和时代等；沉积盆地特征数据表（见表 4）涵盖盆地名称、类型、形成时代、热体制、基底时代、次级构造单元等；成矿地质条件数据表（见表 5）涵盖油气田和煤田名称、油气田类型、煤田类型、烃源岩特征、成矿系统单元、资源量等。

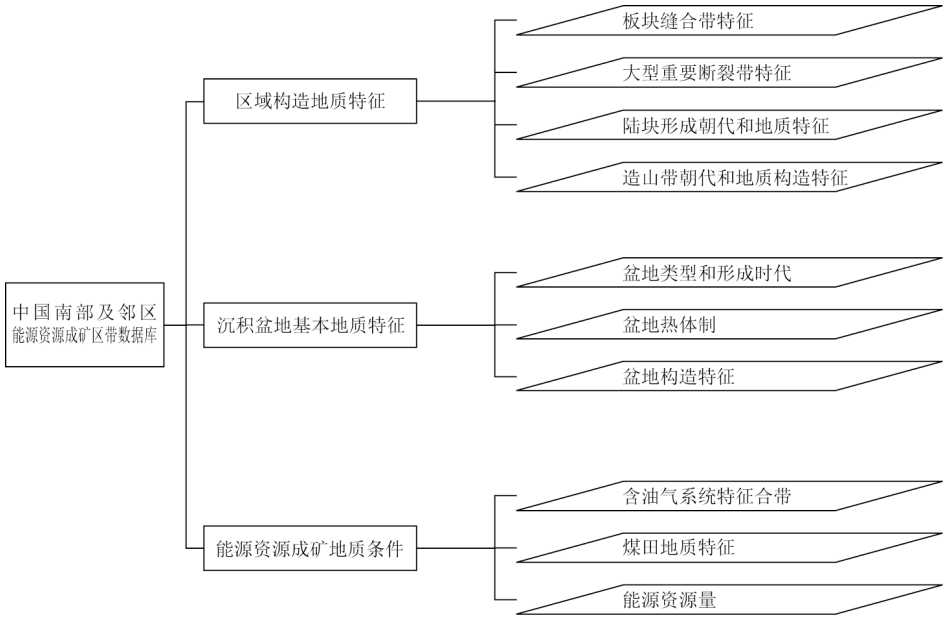


图 3 中国南部及邻区能源资源成矿区带数据集结构图

表 3 数据库区域地质特征数据表

序号	字段名称	单位	数据类型	实例
1	城市地名	—	字符型	北京、武汉等
2	地理位置	—	字符型	中国南部及邻区
3	陆块	—	字符型	扬子陆块
4	造山带	—	字符型	华南构造带、喜马拉雅构造带
5	缝合带	—	字符型	早侏罗世澜沧江缝合带、古近纪台东缝合带
6	断裂带	—	字符型	龙门山断裂、丽水—海丰断裂

表 4 数据库沉积盆地地质特征数据表

序号	字段名称	单位	数据类型	实例
1	盆地名称	—	字符型	四川盆地
2	地理位置	—	字符型	上扬子地区
3	盆地类型	—	字符型	板内拗陷—前陆盆地
4	形成时代	—	字符型	古生代—中生代

续表 4

序号	字段名称	单位	数据类型	实例
5	热体制	—	字符型	温热盆地
6	基底时代	—	字符型	新元古代
7	次级构造单元	—	字符型	川西—川北龙门山及大巴山的冲断—推覆体等

表 5　数据库能源资源成矿地质条件数据表

序号	字段名称	单位	数据类型	实例
1	成矿系统单元名称	—	字符型	扬子陆块构造带成矿域
2	地理位置	—	字符型	上下扬子地区
3	油气田类型	—	字符型	宣汉东岳寨构造川岳 83 井气田、楚雄南华煤田、浩口油田
4	煤田类型	—	字符型	龙潭煤系气煤、肥煤、焦煤及无烟煤
5	烃源岩	—	字符型	白垩系烃源岩、二叠纪含煤建造等
6	煤田和油气田规模	$\times10^8$t；$\times10^8$m^3；	浮点型	大型、中型及小型油气田或煤田
7	能源资源量	$\times10^8$t；$\times10^8$m^3；	浮点型	在江汉盆地已发现的 36 个油气田中，预测石油资源量 3.75 亿 t，预测天然气资源量 341 亿 m^3

4　数据质量控制和评估

中国南部及邻区能源资源成矿区带数据集包括基础地理数据子集和能源资源数据子集，本数据集的数据质量具有适用性、较完整性、规范性、准确性等。数据质量的控制主要是数据收集和整理过程中可能产生的误差。为了确保原始数据质量能准确客观地反映实际情况并符合各类技术标准要求，在形成过程中，主要从两个方面进行质量控制和评估：一是数据采集和处理过程的质量，二是地形地理数据和能源资源数据建库和成图的质量。

基础地理数据来源于项目底图编制组提供的 1∶250 万地理底图数据。该数据是根据国家测绘局提供的亚洲及邻区 1∶250 万地形图数据，并经国家测绘局审查通过。同时，对于地理新资料与区域地质新资料的采集和处理是地质组专业技术人员在项目结构设计范围内严格按技术标准和研究内容获得的数据，并且多次咨询专家的意见，按项目技术要求不断补充或删节内容缩编而成。最终这些数据均经过国内地理信息系统和区域地质专家以及五国合作项目的国际工作会议专家的讨论、修改与确认。数据权威可靠，满足编图要求。

能源资源数据来源于项目地质工作组提供的能源资源数据。这些数据主要是从国家和油公司关于煤和油气资评成果以及正式出版的文献中获得，数据的结构、格式、内容详略程度与数据质量差别较大，具有典型的多源异构特征。项目地质组根据确定的不同结构的数据进行整合；针对部分研究区内容缺失的数据，通过各种渠道，多方搜集数据进行补充和完善，形成了可以满足数据库需要的统一的数据，并通过专家审查、咨询研讨的途径加以控制。

在地质编图过程中，除了按一般要求缩编归并地质图内容以外，在编图过程中广泛听取国内权威专家意见，处理地质内容中的争议及疑难问题，做到地质图内容都有资料依据，客观、真实地反映地质特征。基于该数据编制的1∶250万中国南部能源资源成矿图被五国合作项目纳入1∶250万亚洲中部及邻区能源矿产（石油、天然气、煤）成矿规律图的内容，并最终审查通过，获得高度评价。

5 结论

（1）本次建立的中国南部及邻区能源资源成矿区带数据集，是以板块构造和大陆动力学理论以及油气与煤成藏地质学理论等为指导，根据深部构造控制盆—山发育、盆—山耦合和热动力控制成藏的研究工作思路，综合研究了70个油气田和471个煤田发育的大地构造地质背景、沉积盆地地质特征、油气和煤成藏地质条件以及资源潜力，提示了该区能源资源时空分布特征和成矿规律，划分出3个成矿域。同时，应用地理信息系统和地质制图等新技术和新方法，按照中国、俄罗斯、蒙古、哈萨克斯坦和韩国五国合作制定的编图原则、技术要求、图示图例等开展数字地图编制工作，建立了中国南部及邻区能源资源成矿区带数据集。这项成果不仅是对中国南部及邻区区域地质认识和能源资源勘查工作成果的集成，同时，也为科学和高效地引导国家能源资源地质找矿工作部署提供宏观指导和基础地质图件。

（2）中国南部及邻区能源资源成矿区带数据集基础数据信息量大，并且涉及地球动力学、板块构造、油气与煤田地质学等多学科领域。虽然成矿区带划分是在充分利用该地区基础地质研究成果和能源资源数据基础上提出的方案，但也只是阶段性成果，仍然存在诸如某些沉积盆地的大地构造性质及其归属、有些矿田成因类型和形成时代等有争议的问题，从而导致成矿构造环境解释的不确定性而影响成矿区带划分结果。因此，本次提供的成矿区带数据集仍有待进一步修正和完善。

致谢：中国南部及邻区能源资源成矿区带研究工作是中国、俄罗斯、蒙古、哈萨克斯坦和韩国五国合作第一阶段工作的继续，在学术指导思想、技术要求、编图原则、图示图例等方面均延续了第一阶段工作，在此，对参加完成第一阶段相关工作的各位国内外专家表示衷心感谢。特别感谢总项目技术负责人李廷栋院士、董树文研究员等专家为本次研究工作提供的技术指导。本次工作的完成得到了中国地质调查局基础部、中国地质科学院地质研究所的大力支持，在此深表感谢。

参考文献

Asch K. 2001, Under construction: the geological GIS of the 1∶5 000 000 international geological map of Europe and adjacent areas [J]. Episodes, 24(3): 201−204.

Bouysse P, Mendel V, Munschy M, et al. 2004, A new CGMW map: The structural map of the Indian Ocean: An attempt at ocean cartography[J]. Episodes, 26(2): 199−202.

Ren Jishun, Niu Baogui, Wang Jun, Jin Xiaochi, Xie Liangzhen, Zhao Lei, Liu Renyan. 2013. Advances in research of Asian geology-A summary of 1:5M International Geological Map of Asia project [J]. Journal of Asian Earth Sciences, 72: 3−11.

陈毓川 . 1999. 中国主要成矿区带矿产资源远景评价 [M]. 北京 : 地质出版社 .

戴金星 , 钟宁宁 , 等 . 2000. 中国煤成大中型气田地质基础和主控因素 [M]. 北京 : 石油工业出版社 .

俄罗斯、中国、哈萨克斯坦、蒙古、韩国联合编图项目组 . 2008.“ 亚洲中部及邻区大地构造图 ” [M]. 北京 : 中国地质出版社 .

高瑞琪 , 赵政璋主编 . 2001. 中国油气新区勘探 [M]. 北京 : 石油工业出版社 .

关士聪 , 等 . 1999. 中国海相、陆相和海洋油气地质 [M]. 北京 : 地质出版社 .

韩坤英 , 丁孝忠 , 范本贤 , 等 . MapGIS 在建立地质图数据库中的应用 [J]. 地球学报 , 2005, 26(6): 587−590.

黄汲清 , 陈炳蔚 . 1987. 中国及邻区特提斯海的演化 [M]. 北京 : 地质出版社 .

李春昱 , 等 . 1982. 亚洲大地构造图 [M]. 北京 : 地图出版社 .

李德生 , 等 . 2002. 中国含油气盆地构造学 [M]. 北京 : 石油工业出版社 .

李国玉 , 金之钧 , 等主编 . 2002.（新编）世界含油气盆地图集 [M]. 北京 : 石油工业出版社 .

李廷栋 . 2007. 国际地质编图现状及发展趋势 [J]. 中国地质 , 34(2) ∶206−211.

庞健峰 , 丁孝忠 , 韩坤英 , 等 . 2017. 1∶100 万中华人民共和国地质图空间数据库 [J]. 中国地质 , 44(S1): 8−18.

宋相龙 , 肖克炎 , 丁建华 , 范建福 , 李楠 . 2017. 全国重要固体矿产重点成矿区带数据集 . 中国地质 , 44（S1）∶72−81.

万常选 , 廖国琼 , 吴京慧 , 等 . 2009. 数据库系统原理与设计 [M]. 北京 : 清华大学出版社 . 1−44.

王军 , 姜兰 , 牛宝贵 , 任纪舜 , 何政军 , 金小赤 , 谢良珍 , 赵磊 , 刘仁燕 . 2017. 1:500 万国际亚洲地质图空间数据库 [J]. 中国地质 , 44(S1):25−41.

徐旺 . 1997. 中国含油气区划 [M]. 北京 : 石油工业出版社 .

叶天竺 , 黄崇轲 , 邓志奇 . 2017. 1∶250 万中华人民共和国数字地质图空间数据库 [J]. 中国地质 , 44(S1): 19−24.

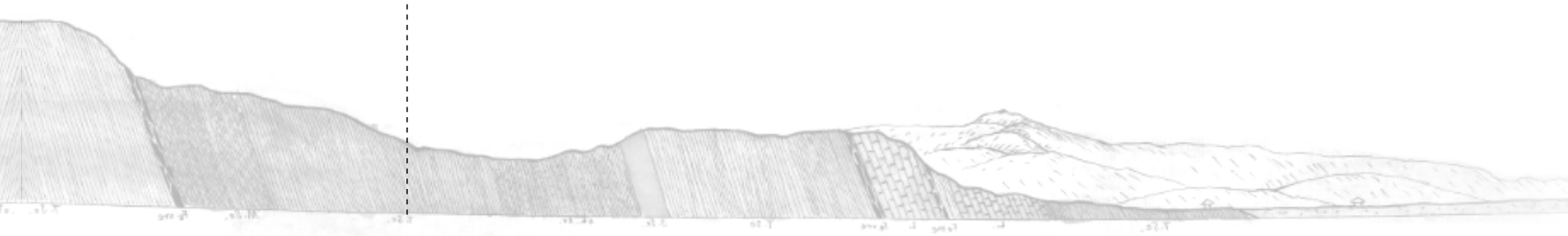
张庆合 , 曹邦功 , 姜兰 . 2002. 1∶50 万地质图数据库的研建 [J]. 中国地质 , 29(2): 208−212.

张渝昌 . 1997. 中国含油盆地原型分析 [M]. 南京 : 南京大学出版 .

中国、俄罗斯、哈萨克斯坦、蒙古、韩国联合编图项目组 . 2008.“ 亚洲中部及邻区地质图 ”[M]. 北京 : 中国地质出版社 .

中国石油地质志编辑出版委员会 . 1994. 中国石油地质志 [M]. 北京 : 石油工业出版社 .

周玉琦 , 易荣龙 , 舒文培 , 何治亮主编 . 2004. 中国石油与天然气资源 [M]. 武汉 : 中国地质大学出版社 .



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Dataset of Metallogenic Provinces and Belts of Energy Resources in Southern China and Adjacent Areas

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Abstract: Energy and mineral resources constitute a country's strategic resources for national security and economic development. It is of paramount importance to strengthen research and development (R&D) on oil, gas, coal and other energy resources in China and surrounding regions. According to plate tectonics, continental dynamics and geological theory of oil, gas and coal reservoir, with the research thought of deep structure controlling the basin-range development, basin-range coupling and geothermal dynamical system controlling the mineralization, by the basic geological data of 70 oil and gas fields and 471 coal fields, in aspects such as the regional geological characteristic, metallogenic geological condition and metallogenic unit of sedimentary basin development, the spatial-temporal distribution law of plate tectonic pattern and energy resources of the area are prompted on the GIS platform. The energy resources in Southern China and adjacent areas may be divided into three metallogenic domains. Therein, each tectonic metallogenic domain may be subdivided into metallogenic regions of four levels: metallogenic province, ore-bearing area (basin), ore field aggregation zone (belt), and ore field (oil and gas field). Moreover, the dataset is composed of type and time of tectonic zone (fault zone and orogenic belt), type and time of basin, type and abundance of energy and mineral resources, metallogenic province and belt, and other metadata. Based on regional tectonic research, this dataset is a complete database established by GIS. It is in line with the evaluation data of energy and mineral resources (oil, natural gas, coal) of sedimentary basin, and the comprehensive analysis of the characteristics of metallogenic provinces and belts. It not only features the integration of regional geological cognition and energy resource prospection achievements of sedimentary basin in Southern China and adjacent areas, but also the theoretical foundation for the scientific direction of geological prospecting deployment of the State.

Key words: energy resources; metallogenic provinces and belts; dataset; southern China and adjacent areas

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

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1 Introduction

Southern China and its adjacent areas are located at the junction of three lithospheric plates: Eurasian Plate, Indian Plate, and Pacific Plate. They have gone through the formation and evolution history of Tethys Ocean and tectonic reworking of Pacific Ocean based on the formation and evoluton of Yangtze Craton. During the formation and evolution process of the blocks and orogens, the sedimentary basins formed has undergone multiple deformations and reconstructions. Meanwhile, oil, gas, coal and other energy resources developed in the sedimentary basin have undergone complicated and diversified generation and aggregation processes. Southern China and adjacent areas are important prospective areas for the exploration and development of energy resources of China. At the same time, they are one of the strategic regions worthy of attention and re-understanding in the oil and gas exploration evaluation of new series of strata in the new field in the new area recently.

The energy resources in this paper mainly refer to oil, natural gas, coal and the like formed in the sedimentary basin. The Dataset of Metallogenic Provinces and Belts of Energy Resources of Southern China and Adjacent Areas has been made by the Chinese side as a part of an international cooperative research by China, Russia, Mongolia, Kazakhstan, and South Korea. The scientific and technological cooperative research on the basic geology and energy resource and mineral resource of China and neighboring countries may deepen the understanding of continental regional geology and metallogenic characteristics of East Asia-Central Asia-South Asia. In addition, it may provide the basic geological theory support for China to solve key geological problems and carry out deep-ore prospecting.

Thanks to the rapid development and extensive application of GIS, the period of compilation and update of geological map of small scale and spatial database construction has greatly shortened (Wan Changxuan et al., 2009; Han Kunying et al., 2005), and the resources can now be shared. The most common method in the world to classify and research on mass data resources in a field or a region is constructing a database by virtue of GIS and forming maps of different scales based on the database. The USA, Russia, Japan, South Korea, Mongolia and European countries and countries of Commonwealth of Independent States of the former Soviet Union attach great importance to the construction, map compilation and updating of basic geology, structure, mineral and other geological databases of small scales, such as 1:1, 000, 000, 1:2, 500, 000 or 1:5, 000, 000 (Asch, 2001; Bouysse et al., 2004; Li Tingdong, 2007; Pang Jianfeng et al., 2017). Likewise, China also attaches great importance to the application of GIS technology in geological research and mapping. At the end of the 20th century, State Development Planning Commission and the Ministry of Geology and Mineral Resources jointly conducted project approval and established 1:500, 000 digital geological map spatial database of the People's Republic of China by using GIS technology (Zhang Qinghe et al., 2002). At the beginning of this century, based on the national 1:500, 000 geological map database, new achievements of 1:250, 000, 1:50, 000 regional geological survey, fully adopting new data and progress of special research national 1:1, 000, 000 geological map spatial database was established per the international standard division range, and a digital geological map was also compiled (Pang Jianfeng et al., 2017). Moreover, during the same period,

national 1:2, 500, 000 digital geological map spatial database and 1:2, 500, 000 geological map (Ye Tianzhu et al., 2017), InterAsia 1:5, 000, 000 spatial database, 1:5, 000, 000 digital geological map (Ren et al., 2013; Wang Jun et al., 2017) and other different types of geological and mineral databases and maps of different scales were completed. Due to space limitation, important details have been provided only.

In the history of geologic structural evolution, the metallogenic provinces and belts have emerged as rich mineral resources formed in a geologic body which had undergone one or multiple mineralization activities. These areas are metallogenic geological units for measuring resource potential and undertaking ore prospecting. The metallogenic provinces and belts came to the fore during researches on metal minerals at the beginning of the 20th century. The research on metallogenic provinces and belts did not achieve the combination of theoretical research and prospecting until the late 1990s. For the first time in 1905, L.de Launay, a French geologist, presented the idea that "metallogenic provinces and belts are about research on the natural enrichment processes of metal elements". In addition, he raised the concept of metal metallogenic provinces in 1913, which referred to the unusually tremendous ore deposits of specific types in the specific crustal areas. Furthermore, in 1920, Weng Wenhao in China introduced the concept of belt distribution of ore deposits and divided the Nanling Region as four metallogenic belts: tin, zinc-lead-copper, stibium and mercury. Meanwhile, Chen Yuchuan believed that main metallogenic units of China were divided as five levels (Chen Yuchuan, 1999). In recent years, as the State pays close attention to the research and development of energy resources and mineral resources, the achievements of metallogenic regularities have emerged (Song Xianglong et al., 2017).

The scope of Southern China and adjacent areas covers the region from Karakorum Mountain-Kunlun Mountain-Qinling Mountain-Dabie Mountain in the north to Northern India-Northern South China Sea in the south, and from Turkmenistan in the west to Taiwan Province and Northern South China Sea in the east. The mapping range covers the region in longitude 60°E-122°E and latitude 18°N-36°N, including geographic and tectonic zone research data in the whole range of the map, and research data on sedimentary basins energy and resource in land area to the south of Kunlun Mountain-Qinling Mountain-Dabie Mountain and in the northern part of South China Sea.

"Energy and Mineral Metallogenic Map of Southern China and Adjacent Areas" is the achievement of basic geological research and map compilation conducted in the second phase cooperation of China, Russia, Kazakhstan, Mongolia and South Korea Joint Mapping Project, as a part of the 1:2, 500, 000 Geological Map of Central Asia and Neighboring Areas completed by the project of Study on Deep Geological Structure and Mineralization of East-Central Asia from 2008 to 2010. This map mainly consists of databases for regional geotectonic elements in southern China and adjacent areas and energy resources including oil, gas and coal in major sedimentary basins of southern China. This dataset is achievement data on survey and exploration of oil, gas and coal in sedimentary basins within the scope of 25 international maps sheets at 1:1, 000, 000 (Table 1).

Table 1 Statistical data of oil and gas fields and coal fields in sedimentary basins

S/N	1:1, 000, 000 sheet	Number of mines in the frame	Number of oil and gas fields	Number of coal fields	Country	Main mineral
1	E49 Haikou sheet	10	4	6	China	Oil and gas and coal
2	F47 Pu'er sheet	6	1	5	China	Oil and gas and coal
3	F48 Baise sheet	13	3	10	China	Oil and gas and coal
4	F49 Guangzhou sheet	24	1	24	China	Oil and gas and coal
5	F50 Shantou sheet	8	1	7	China	Oil and gas and coal
6	F51 Kaohsiung sheet	3	3	0	China	Oil and gas
7	G47 Panzhihua sheet	19	0	19	China	coal
8	G48 Kunming sheet	52	0	52	China	coal
9	G49 Zhuzhou sheet	112	12	100	China	Oil and gas and coal
10	G50 Fuzhou sheet	45	0	45	China	coal
11	G51 Taipei sheet	11	2	9	China	Oil and gas and coal
12	H44 Menshi sheet	1	0	1	China	coal
13	H45 Shigatse sheet	2	0	2	China	coal
14	H46 Nagqu sheet	5	0	5	China	coal
15	H47 Changdu sheet	4	0	4	China	coal
16	H48 Chengdu sheet	72	39	33	China	Oil and gas and coal
17	H49 Changsha sheet	27	0	27	China	coal
18	H50 Wuhan sheet	65	0	65	China	coal
19	H51 Shanghai sheet	14	0	14	China	coal
20	I45 Gerze sheet	1	1	0	China	Oil and gas
21	I46 Amdo sheet	7	0	7	China	coal
22	I47 Yushu sheet	15	0	15	China	coal
23	I48 Baoji sheet	20	3	17	China	Oil and gas and coal
24	I50 Nanjing sheet	3	0	3	China	coal
25	I53 Nantong sheet	1	0	1	China	coal
	Total	541	70	471		

The metadata of dataset (database) of metallogenic provinces and belts of energy resources in Southern China and adjacent areas are shown in Table 2. Table 2 includes the database (set) name, data author, data collection time, geographical area, data format, data volume, data publishing address, fund project, language, database (set) composition, etc.

Table 2 Metadata table of Database (Dataset)

Items	Description
Database (dataset) name	Dataset of Metallogenic Provinces and Belts of Energy Resources in Southern China and Adjacent Areas (DMPBERSCAA)
Database (dataset) authors	You Guoqing, Institute of Geology, Chinese Academy of Geological Sciences Yi Ronglong, Institute of Geology, Chinese Academy of Geological Sciences Geng Shufang, Institute of Geology, Chinese Academy of Geological Sciences Chen Bingwei, Institute of Geology, Chinese Academy of Geological Sciences Pang Jianfeng, Institute of Geology, Chinese Academy of Geological Sciences Yang Zhixin, Institute of Geology, Chinese Academy of Geological Sciences Li Jialin, Institute of Geology, Chinese Academy of Geological Sciences; China University of Geosciences
Data acquision time	2008—2010
Geographic area	Southern China and Adjacent Areas, East Longitude 68°−122°, Northern Latitude 18°−36°
Data format	*.wl, *.wt, *.wp
Data size	196MB
Data service system URL	http://dcc. cgs.gov.cn
Fund project	China Geological Survey Project “Study on the deep geological structure and mineralization of East-Central Asia”
Language	English
Database (dataset) Composition	DMPBERSCAA includes: Data_China_ EnergyResources _MMB_26_Mapgis vector data, data volume 196 MB

2 Data Acquisition and Processing

2.1 Base of Data

According to the plate tectonics, continental dynamics and reservoir geological theory of oil, gas and coal, with the research thought of deep structure controlling the basin-range development, basin-range coupling and geothermal dynamical system controlling the mineralization, based on the research of plate tectonic setting of sedimentary basin development in Southern China and adjacent areas, and pursuant to the resource evaluation materials and official literature provided by the State and oil and gas and coal companies (Huang Jiqing et al., 1987; Li Chunyu et al., 1982; Editing and Publishing Committee

of Petroleum Geology of China, 1994; Zhang Yuchang, 1997; Xu Wang, 1997; Guan Shicong et al., 1999; Dai Jinxing et al., 2000; Gao Ruiqi et al., 2001; Li Guoyu et al., 2002; Li Desheng et al., 2002; Zhou Yuqi et al., 2004), this dataset features geological characteristics. The data set includes geographic data, structural data and energy resources data. In addition, geographic data and tectonic zones data continuously executes the technical requirements and standards of "metallogenic regularity research of energy resources of Central Asia and adjacent areas" established in a cooperative manner by China, Russia, Mongolia, Kazakhstan and South Korea (Joint Mapping Project Team of Russia, China, Kazakhstan, Mongolia and South Korea. 2008). Therein, it follows research ideology, research content, division of tectonic zones, mapping principle, geographic base map, graphical representation, and legend. Resource quantity and other basic geological data of 70 oil and gas fields and 471 coal fields discovered and exploited in this research area. The deadline for the collection of regional basic geological data and geological data of oil and gas and coal fields of sedimentary basins in Southern China and adjacent areas was the end of 2010.

2.2 Data Processing

2.2.1 Data Processing Flow

The data processing of energy resource belts in Southern China and adjacent areas was carried out in two aspects: classification and digital processing of 1:2, 500, 000 topographic map data and new geographic data; and classification and analysis, and comprehensive research, as well as digital processing of regional tectonic-geological data and geological data of oil and gas and coal bearing basins (Fig. 1).

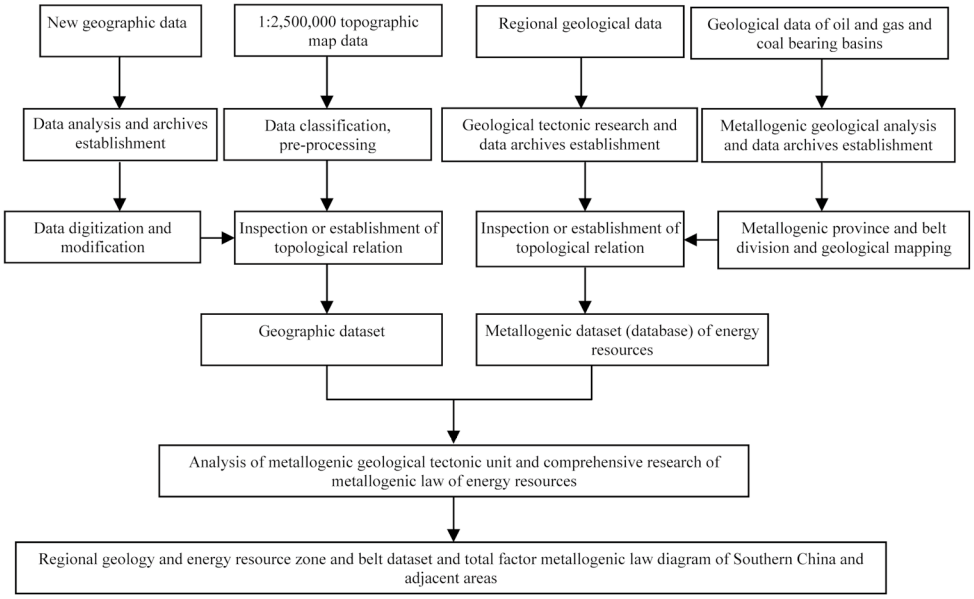

Fig. 1 Flowchart of Data Processing of DMPBERSCAA

2.2.2 Data Processing Method

Aimed at research on metallogenic regularities and compilation of maps on energy resources in Southern China and adjacent areas, the datasheet of regional geological

characteristics, geological characteristics of oil and gas and coal bearing sedimentary basins, and geological characteristics of metallogenic unit of energy resources has been established based on the research guiding ideology and thought, research contents, mapping principles, graphical representations, legends and other existing requirements and standards formulated in the first stage of cooperation among five countries. For the purpose, data processing and management have been carried out by using domestically and internationally known computer mapping software, particularly the MapGIS application software platform. The 1:2, 500, 000 database of metallogenic provinces and belts of energy resources in Southern China and adjacent areas has been established and metallogenic regularities map has been compiled based on 1:2, 500, 000 professional geological map database and mapping precision requirements.

The metallogenic provinces and belts/metallogenic units are mainly divided based on the regional geological structural setting, mineralization type of energy resources, metallogenic system, energy resource abundance, and other related metallogenic characteristics. The metallogenic tectonic setting, geodynamics and other related issues have been researched according to the three-dimensional spatial distribution and formation age of known ore field. The metallogenic provinces and belts have been divided after analyzing metallogenic law.

Energy resources mineralization in southern China and adjacent areas is divided into 5 levels:

Level I: Metallogenic Domain. It includes a formation area of energy mineral resources based on the giant geotectonic unit within the global intercontinental scope.

Level II: Oil and Gas Bearing Province or Coal Bearing Province. It includes coal bearing-oil and gas bearing areas constituted by different types of basins of formation cause connection in the same geotectonic setting. Within the scope of this area, coal, oil and gas formation, aggregation reservoir, and spatial-temporal distribution have certain similarities.

Level III: Oil and Gas Bearing Area or Coal Bearing Area. It includes oil and gas bearing basins and coal bearing basins. According to the formation history of sedimentary basins, they are divided as prototype basins and residual basins. Most basins are superimposed residual basins.

Level IV: Oil and Gas Aggregation Belt or Coal Aggregation Belt. It includes aggregation reservoir areas whose mineral product distribution scope and quantity of energy resources are discovered and ascertained.

Level V: Oil and Gas Field or Coal Field. It includes areas of oil-gas or coal aggregation reservoir of proved reserves, controlled reserves and predicted reserves.

In the metallogenic regularity map of energy resources in Southern China and adjacent areas, the metallogenic provinces and belts of energy resources (oil, gas, coal) are delineated by different color lines or surface colors.

2.2.3 Data Processing Results

The data results, including the division of metallogenic provinces and belts of energy resources (oil, natural gas, coal) in Southern China and adjacent areas, have been drawn under the guidance of plate tectonics theory, continental dynamics, and oil, gas and coal geology, etc. These results exhibit the metallogenic spatial-temporal distribution

characteristics of energy resources in Southern China and adjacent areas which indicates the spatial-temporal distribution regularity of plate tectonic pattern and energy and mineral resources.

Within the scope of Southern China and adjacent areas, five metallogenic domains (Paleo-Asian Ocean Tectonic Metallogenic Domain, Eastern Tethys Tectonic Metallogenic Domain, Yangtze Continental Block Metallogenic Domain, South China Tectonic Metallogenic Domain, and Gondwana Continental Block Metallogenic Domain) are involved. Among them, the Paleo-Asian Ocean Tectonic Metallogenic Domain and Gondwana Continental Block Metallogenic Domain are not included in the research area and mapping range of this project. The Eastern Tethys Tectonic Metallogenic Domain, Yangtze Continental Block Metallogenic Domain, and South China Tectonic Metallogenic Domain contain 10 metallogenic provinces (Fig.2). In the dataset of metallogenic provinces and belts of energy resources (oil, natural gas, coal) in Southern China and adjacent areas, names of metallogenic domain and metallogenic provinces and belts are as follows:

I Yangtze Continental Block Metallogenic Domain
- (1) Upper Yangtze Continental Block Tectonic Metallogenic Province
- (2) Middle Yangtze Continental Block Tectonic Metallogenic Province
- (3) Lower Yangtze Continental Block Tectonic Metallogenic Province

II Eastern Tethys Tectonic Metallogenic Domain
- (1) Bayan Har Tectonic Metallogenic Province
- (2) Tunggula Mountain-Sanjiang-Hengduan Mountain Tectonic Metallogenic Province
- (3) Lhasa–Gangdise Tectonic Metallogenic Province
- (4) Himalayan Tectonic Metallogenic Province

III South China Tectonic Metallogenic Domain
- (1) Nanling–Wuyi Tectonic Metallogenic Province
- (2) Youjiang–Yunkai Tectonic Metallogenic Province
- (3) Tectonic Metallogenic Province of South China Sea-Southeast coast

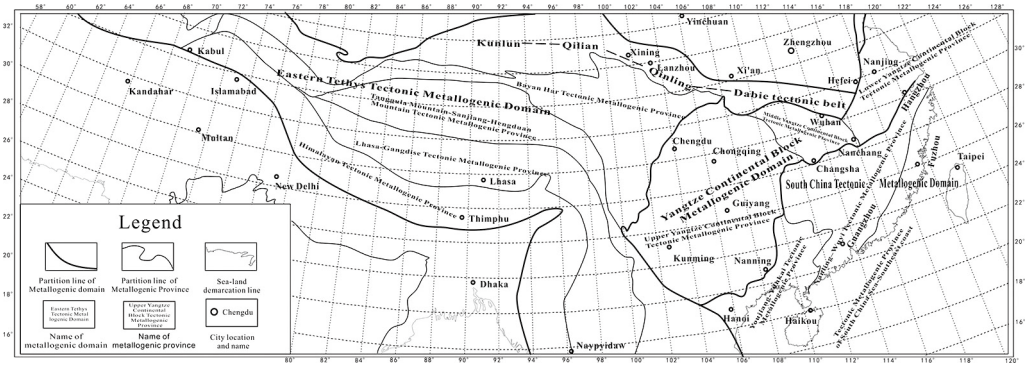

Fig. 2 Distribution Diagram of Metallogenic Provinces and Belts of Energy Resources in Southern China and Adjacent Areas

3 Description of Data Samples

The data of metallogenic provinces and belts of energy resources in Southern China and adjacent areas mainly include three aspects (see Fig. 3): regional geological characteristic datasheet, geological characteristic datasheet of sedimentary basin, and metallogenic geological condition datasheet of energy resources.

The regional geological characteristic datasheet (see Table 3) covers regional geographic information, important fault property and direction, continental block property and age, orogenic belt property and age, and others. Moreover, the characteristic datasheet of sedimentary basin (see Table 4) covers the basin name, type, formation age, thermal system, basement age, secondary tectonic unit, and others. Furthermore, the metallogenic geological condition datasheet (see Table 5) covers the oil and gas field and coal field name, oil and gas field type, coal field type, source rock characteristic, metallogenic system unit, Resource quantity, and others.

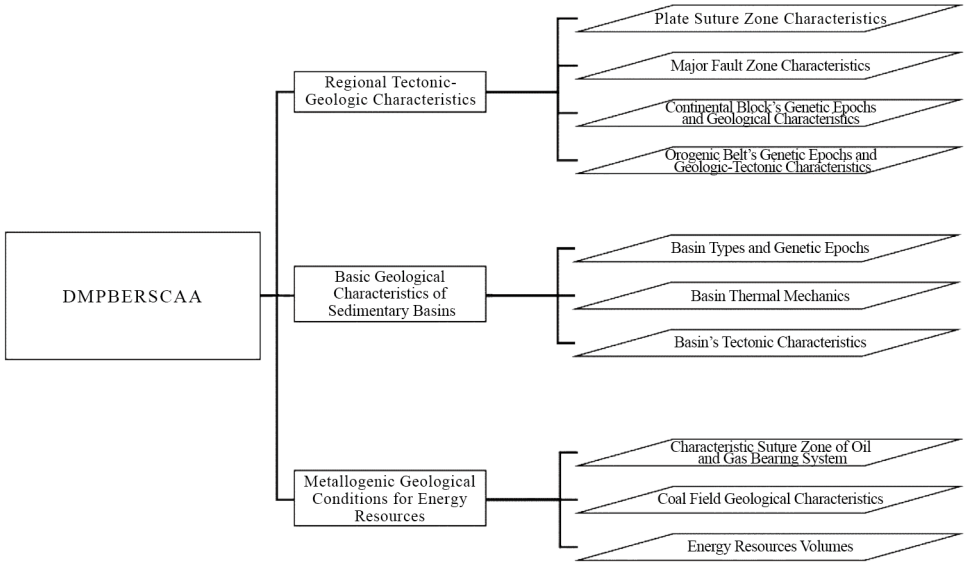

Fig. 3 Structural Diagram of DMPBERSCAA

Table 3 Data Table of geological feature of Database area

S/N	Field Name	Unit	Data Type	Example
1	Name of city	−	Character	Beijing, Wuhan, etc.
2	Geographic position	−	Character	Southern China and adjacent areas
3	Continental block	−	Character	Yangtze continental block
4	Orogenic belt	−	Character	South China tectonic belt, Himalaya tectonic belt
5	Suture zone	−	Character	Early Jurassic Lanchangjiang suture zone, Paleogene Taidong suture zone
6	Fault zone	−	Character	Longmenshan fault, Lishui−Haifeng fault

Table 4 Data table of geological feature of Database sedimentary basin

S/N	Field Name	Unit	Data Type	Example
1	Name of basin	–	Character	Sichuan Basin
2	Geographic position	–	Character	Upper Yangtze region
3	Type of basin	–	Character	Depression in plate–foreland basin
4	Genetic epochs	–	Character	Paleozoic–Mesozoic
5	Thermal mechanics	–	Character	Warm basin
6	Basement age	–	Character	Neoproterozoic
7	Secondary tectonic unit	–	Character	Thrust–nappe of Chuanxi–Chuanbei Longmenshan and Dabashan

Table 5 Data table of metallogenic geological conditions of Database energy resource

S/N	Field Name	Unit	Data Type	Example
1	Name of metallogenic system unit	–	Character	Metallogenic domain of tectonic belt of Yangtze continental block
2	Geographic position	–	Character	Upper and lower Yangtze regions
3	Type of oil and gas field	–	Character	Gas field of Chuanyue Well 83 of Xuanhan Dongyuezhai structure, oil and gas reservoir of Nanhua Coalfield and Haokou Oilfield in Chuxiong
4	Type of coal field	–	Character	Gas coal, fat coal, coking coal and anthracite of Longtan Coal
5	Source rock	–	Character	Source rock of Cretaceous system, coal-bearing formation of Permian period
6	Coal field and oil and gas field scale	$\times 10^8$ t; $\times 10^8$ m^3;	Floating point	Large, medium and small oil or gas fields or coal fields
7	Energy resource quantity	$\times 10^8$ t; $\times 10^8$ m^3;	Floating point	About 36 oil or gas fields discovered in Jianghan Basin Predicted oil resources of 375, 000, 000 t, Predicted natural gas resources of 34, 100, 000, 000 m^3

4 Data Quality Control and Evaluation

DMPBERSCAA includes the basic geographic data subset and energy resource data subset. This dataset boasts applicability, integrity, ability to be standardized, and accuracy. The data quality was mainly controlled for possible errors during data acquisition and classification. In order to ensure that data accurately and objectively reflect actualities and meet technical standard requirements, quality control and assessment were carried out during the formation process in two aspects: quality of data acquisition and processing process; and quality of topographic and geographic data and energy resource database construction and mapping.

The basic geographic data come from 1:2, 500, 000 geographical base map data provided by the compilation team of project base map. Such data are based on 1:2, 500, 000 topographic map data of Asia and adjacent areas provided and examined by the Surveying and Mapping Bureau of China. Meanwhile, as far as acquisition and processing of new geographic data and new regional geological data is concerned, professionals of geological team provided data within the scope of project structural design and in strict accordance with the technical standards and research contents. Besides, the experts were consulted many times, and data were obtained through persistent supplementation or deletion of contents according to the project's technical requirements. Finally, the data passed discussion, modification, and confirmation by the domestic geographic information system, regional geological experts, and international working conference experts of cooperative project of five countries. The dataset is authoritative and reliable, and meets mapping requirements.

Meanwhile, the dataset's energy resource data have been provided by the project's geological working team. Primarily, these data were obtained from the coal, oil and gas resource evaluation results of the State and oil companies, as well as officially published literature. The data obtained varies greatly in terms of structure, format, content details, and quality. In addition, the typical multi-source heterogeneous characteristic exists. Therefore, the project's geological team ensured integration upon finding data with different structures. For deficient data in some research areas, the project team collected data via multiple channels and ways to supplement and improve the dataset. In this way, the data was homogenized to meet the requirements of the dataset, while also being controlled through expert examination, consultation, and discussion.

Furthermore, in addition to reduction and incorporation of geological map contents per general requirements, the opinions of domestic authoritative experts were extensively followed in the process geological mapping. At the same time, issues in geological content were persistently resolved. In this way, it has been ensured that the geological map contents are based on data, and objectively and truly reflect geological characteristics. The 1:2, 500, 000 metallogenic map of energy resources in Southern China has been compiled by the cooperative project of five countries by using the contents of 1:2, 500, 000 metallogenic regularities map of energy mineral resources (oil, gas, coal) in Central Asia and adjacent areas. It is highly regarded as it has passed relevant examinations.

5 Conclusions

(1) DMPBERSCAA has been established according to theories of plate tectonics and continental dynamics as well as the genetic theory of oil-gas reservoirs and coal seams. The authors adopt the academic viewpoints that the deep structures have controlled over the basin-range's growths, and furthermore, the basin-range's coupling and geothermal dynamical system have altogether controlled over the metallogenesis. It is a product of comprehensive research on geotectonic geological setting of development of 70 oil and gas fields and 471 coal fields, geological characteristics of sedimentary basins, geological conditions of oil-gas reservoirs and coal seams, as well as their respective resource potentials. At the same time, it studies the spatial-temporal distribution characteristics and metallogenic regularities of energy resources of this area based on the division three

metallogenic domains. Moreover, digital mapping has been actualized by using geographic information system, geologic mapping and other new technologies and methods according to the mapping principles, technical requirements, graphical representations, and legends formulated by China, Russia, Mongolia, Kazakhstan, and South Korea in a cooperative manner. The establishment of this dataset paves way for the integration of regional geological cognition and energy resource prospection in Southern China and adjacent areas. It also provides macro-level guidance and basic geological mapping for the State to guide geological prospecting of energy resources in a scientific and efficient manner.

(2) DMPBERSCAA features a large volume of basic data and involves geodynamics, plate tectonics, oil and gas and coal geology, and other disciplines and fields. The plan for division of metallogenic provinces and belts has been put forward for aptly capitalizing on geological research achievements and energy resource data in this region. However, it is only a preliminary achievement and many problems persist, such as controversial geotectonic property of some sedimentary basins and attribution, and genetic type and genetic epochs of some ore fields. As a result, there exists an uncertainty in interpreting metallogenic tectonic settings, and the division result of metallogenic provinces and belts is affected. Therefore, this dataset should be corrected and improved in the future.

Acknowledgments: The research on metallogenic provinces and belts of energy resources in Southern China and adjacent areas is the continuation of cooperative work by China, Russia, Mongolia, Kazakhstan, and South Korea. The first stage work has progressed in aspects such as academic guiding ideology, technical requirements, mapping principles, graphical representations, and legends. We express our sincere thanks to the domestic and overseas experts for participating in relevant work in the first stage. We extend special thanks to academician Li Tingdong, General Project Technical Director, Researcher Dong Shuwen, and other experts for their technical guidance. This research has been supported by Department of Basics of China Geological Survey and Institute of Geology, Chinese Academy of Geological Sciences. We would like to express our heartfelt gratitude to them all.

References

Asch K. 2001. Under construction: the geological GIS of the 1:5, 000, 000 international geological map of Europe and adjacent areas [J]. Episodes, 24(3): 201–204.

Bouysse P, Mendel V, Munschy M. 2004, A new CGMW map: The structural map of the Indian Ocean: An attempt at ocean cartography[J]. Episodes, 26(2): 199–202.

Chen Yuchuan. 1999. Long-term evaluation of mineral resources in major metallogenic belts in China[M]. Beijing: Geological Publishing House (in Chinese).

Ren Jishun, Niu Baogui, Wang Jun, Jin Xiaochi, Xie Liangzhen, Zhao Lei, Liu Renyan. 2013. Advances in research of Asian geology–A summary of 1:5M International Geological Map of Asia project [J]. Journal of Asian Earth Sciences, 72: 3–11.

Dai Jinxing, Zhong Ningning, Liu Dehan, Xia Xinyu. 2000. Geological Basis and Controlling Factors of Large and Middle-sized Gas Fields in China[M]. Beijing: Petroleum Industry Press (in Chinese).

Gao Ruiqi, Zhao Zhao Zhengzhang. 2001. Oil and Gas New Area Exploration in China[M]. Beijing: Petroleum Industry Press (in Chinese).

Guan Shicong. 1999. China's marine, continental and marine oil and gas geology[M]. Beijing: Geological

Publishing House (in Chinese).

Han Kunying, Ding Xiaozhong, Fan Benxian, Ma Lifang, Ji Yuanjing, Wang Zhenyang. 2005. The Application of MAPGIS to the Construction of Geological Map Database[J]. Acta Geoscientica Sinica, 26(6): 587–590 (in Chinese with English abstract).

Huang Jiqing, Chen Bingwei. 1987. Evolution of China and Neighboring Tethys Sea[M]. Beijing: Geological Publishing House (in Chinese).

Li Chunyu, 1982. Asiatic tectonic map[M]. Beijing: Map Publishing House (in Chinese).

Li Desheng. 2002. Chinese petroliferous basin tectonics[M]. Beijing: Petroleum Industry Press (in Chinese).

Li Guoyu Jin Zhijun. 2002. (New edition) World Oil and Gas Basin Atlas[M]. Beijing: Petroleum Industry Press (in Chinese).

Li Tingdong. 2007. International Geological Mapping Status and Development Trend[J]. Geology in China, 34(2): 206–211 (in Chinese with English abstract).

Pang Jianfeng, Ding Xiaozhong, Han Kunying, Zeng Yong, Chen Anshu, Zhang Yanling, Zhang Qinghe, Yao Dong sheng. 2017.The national 1:1, 000, 000 geological map spatial database[J]. Geology in China, 44(S1): 10−23 (in Chinese with English abstract).

Song Xianglong, iao Keyan, Ding Jianhua, Fan Jianfu, Li Nan. 2017. Dataset of major mineralization belts of China's solid mineral resources [J]. Geology in China, 44(S1):89−99.

Wan Changxuan, Liao Guoqiong, Wu Jinghui. 2009. Database System Principle and Design[M]. Beijing: Tsinghua University Press (in Chinese).

Wang Jun, Jiang Lan, Niu Baogui, Ren Jishun, He Zhengjun, Jin Xiaochi, Xie Liangzhen, Zhao Lei, Liu Renyan. 2017. The spatial database of the 1:5, 000, 000 International Geological Map of Asia [J]. Geology in China, 44(S1):32−50.

Xu Wang. 1997. China's petroleum division[M]. Beijing: Petroleum Industry Press (in Chinese).

Ye Tianzhu, Huang Chongke, Deng Zhiqi. 2017. Spatial database of 1:2, 500, 000 digital geologic map of People's Republic of China [J]. Geology in China, 44(S1):19−24 (in Chinese with English abstract).

Zhang Qinghe, Cao Banggong, Jiang Lan. 2002. Development and construction of the 1:500, 000 geological map database[J]. Geology in China, 29(2): 208–212 (in Chinese with English abstract).

Zhang Yuchang. 1997. Prototype Analysis of Chinese Oil-bearing Basin[M]. Nanjing: Nanjing University Publishing (in Chinese).

China, Russia, Kazakhstan, Mongolia, South Korea Joint Mapping Project Team. 2008. "Geological Map of Central Asia and Neighboring Areas" [M]. Beijing: China Geological Publishing House (in Chinese).

China Petroleum Geography Editing and Publication Committee. 1994. China Petroleum Geology[M]. Beijing: Petroleum Industry Press (in Chinese).

Zhou Yuqi, Yi Ronglong, Shu Wenpei, He Zhiliang. 2004. Petroleum and Natural Gas Resources in China[M]. Wuhan: China University of Geosciences Press (in Chinese).