# 中国地热资源

## ——形成特点和潜力评估

陈墨香　汪集旸　邓　孝　主编

中国科学院科学出版基金资助项目

# 中国地热资源

## ——形成特点和潜力评估

陈墨香　汪集旸　邓　孝主编

科学出版社

1994

(京)新登字092号

## 内 容 简 介

本书共分4编18章。循板块构造观点和实测大地热流数据，评述我国地热资源形成和赋存的地质构造-热背景；分析构造隆起区和沉积盆地热水分布的基本特点，讨论各类地热系统的属性和形成机制；详细剖析典型地热田热水的赋存特点，建立成因模型，评价资源的潜力和对开发动态进行预测；最后评估全国热水资源的量级和开发前景。

本书内容丰富，是一本可供科研人员及有关高等院校师生参考的专业论著，对生产技术人员也有一定的阅读查考价值。

**中国地热资源**

——形成特点和潜力评估

陈墨香　汪集旸　邓　孝　主编

责任编辑　刘延敏

科学出版社出版

北京东黄城根北街16号

邮政编码：100717

北京市朝阳区东华印刷厂印刷

新华书店北京发行所发行　各地新华书店经售

*

1994年12月第　一　版　　开本：787×1092 1/16

1994年12月第一次印刷　　印张：18

印数：1—700　　字数：385 000

ISBN 7-03-004102-X/P・747

**定价：17.00元**

# 本 书 作 者

（按姓氏汉语拼音字母顺序排列）

LIST OF AUTHORS


**中国科学院地质研究所**

**(Institute of Geology, Chinese Academy of Sciences)**

陈墨香(Chen Moxiang)　　邓　孝(Deng Xiao)

胡圣标(Hu Shengbiao)　　黄少鹏(Huang Shaopeng)

庞忠和(Pang Zhonghe)　　沈显杰(Shen Xianjie)

汪缉安(Wang Ji'an)　　汪集旸(Wang Jiyang)

王　钧(Wang Jun)　　汪屹华(Wang Yihua)[①]

夏斯高(Xia Sigao)[②]　　熊亮萍(Xiong Liangping)

徐　青(Xu Qing)[③]　　杨淑贞(Yang Shuzhen)

张菊明(Zhang Juming)　　张文仁(Zhang Wenren)

赵　平(Zhao Ping)

**中国科学院广州能源研究所**

**(Guangzhou Institute of Energy Sources, Chinese Academy of Sciences)**

肖庆龙(Xiao Qinglong)　　朱德燕(Zhu Deyan)


① 现在南京大学，南京。

② 现在中国科学院南海海洋研究所，广州。

③ 现在中南工业大学，长沙。

# 序

地热学是地球科学一个新兴的分支。地热能是一种可供选择开发利用的新能源。地热资源的赋存状态和形成机制，地热系统的分布特点和资源的评价，则是地热学中最为活跃的研究领域。

我国是温泉广布和利用热水历史悠久的国家，但系统研究地热资源起步较晚，始于70年代初。20多年来，经过我国广大科技人员的努力，开展地热资源的普查和考察，以及勘探和开发，均取得了长足的进展。中国科学院地质研究所地热研究室陈墨香、汪集旸和邓孝等撰写的《中国地热资源——形成特点和潜力评估》专著，是当今有关中国地热资源研究第一部较为系统而全面的科学论作，是我国地热应用基础研究方面一项突出的有代表性的科研成果。

本书依据他们和全国许多单位多年来累积的有关地热地质和地热资源勘探研究的大量资料，深入地分析了地热资源形成和赋存的地质构造-热背景，研究和归纳各类型地热资源分布的基本特点，详细剖析典型地热田热水的赋存状态，建立成因模型，探讨地热系统的形成机制诸方面，得出许多极有见地的新认识和比较符合我国实际的重要结论。诸如：高温地热资源是特定大地构造部位的产物，处于板块边界及其近邻的台湾、藏南、滇西和川西地区具有产生强烈水热活动和孕育高温水热系统必要的地质构造条件和高热背景，远离板块边界的广大板内地区，热背景正常以至偏低，一般形成中低温地热系统。中国高温水热区总体上远离晚新生代火山分布，火山活动并不是形成高温水热系统唯一必要的条件，存在浅成年青岩浆侵入活动或壳内局部熔融活动的板缘地区，同样可以形成高温水热系统。台湾高温地热带虽属环太平洋地热带的一部分，但无该地热带的典型意义。东南沿海地区不具备形成高温地热资源的条件，几个中温水热系统的形成与地下水循环深度较大有关，并非有高温岩浆热源的作用。众多中、新生代沉积盆地低温地热资源的形成机制，可用“层控热储-侧向径流补给-大地热流供热”的模式来概括。华北和苏北等断陷盆地，在基底凸凹相间的构造格局控制下，地热呈高低相间带状展布，由于大地热流于地壳表部再分配的结果，形成许多与凸起区相一致的局部地热异常。这些认识和结论对进一步研究我国地热资源的赋存状态和性质，评估地热资源的潜力以及确定其开发利用的方向等均有重大的理论和实际应用意义。本书也对我国地下热水的积存资源和可采资源作了量级估算和远景评价，认为我国热水资源有一定的开发潜力，但并不十分丰富，除我国西南边境地区的地热在一定时期内可成为主要的能源之外，一般适宜作为辅助能源和疗养、旅游资源。这一结论是求实的，为国家和地方的能源决策部门规划地热工作提供了重要的科学依据。最后，作者们还提出我国开展地压地热资源研究和注视国际干热岩研究动态的两点有远见的建议，应获得有关方面的重视和支持。

本书是我国地热研究深化与发展的表征。当本书即将问世之际，于此表示衷心的祝贺，并望继续努力，为创建和发展我国的地热学以及更有成效地开发地热作出新的贡献！

陈梦熊　1993年9月

# FOREWORD

Geothermics is a newly developed branch of Earth sciences. Geothermal energy is regarded as a new and renewable alternative energy. The occurrence and formation mechanism of geothermal resources, the distribution and resource assessment of a geothermal system, all these are, at present, the most active aspects in geothermal studies.

China has a long history of utilization of thermal water and hot springs are widely distributed all over the country. However, it was not until the early 1970's that systematical studies on geothermal resources began in China. During the past 20 years, a lot of work on reconnaissance, exploration and exploitation of geothermal energy has been done by Chinese scientists and great achivements have been made. The monograph " Geothermal Resources in China—— Formation Characteristics and Potential Evaluation" edited by Chen Moxiang, Wang Jiyang and Deng Xiao from the Lab for Geothermics, Institute of Geology, Chinese Academy of Sciences, is the first publication on this topic and may also be regarded as a representative of scientific achivements in geothermal study of China.

In this monograph, based on a lot of geothermal data obtained by the authors and their colleagues, the geologo-tectonic settings concerned with the occurrence and formation of geothermal resources were analysed; the distribution of resource types, formation mechanism and genesis model of geothermal system were investigated. As a result, new insight into above-mentioned problems on geothermal resources of China was gained and several important conclusions have been reached. For instance, the authors point out that high-temperature geothermal resources are associated with certain geotectonic settings. Taiwan, southern Tibet, western Yunnan and western Sichaun are favorable places for strong hydrothermal activity and for occurrence of high-temperature geothermal systems because these regions are located near the plate boundary and have the geologo-tectonic settings and geothermal background necessary for these systems. Low-medium temperature geothermal systems are widespread in regions with normal and/or relatively low geothermal background, away from the plate boundary. Generally, the distribution of high-temperature hydrothermal areas in China is not coincident with that of Late Cenozoic volcanos. Therefore, volcanic activity does not seem to be the necessary condition for the occurrence of high-temperature geothermal systems. High-temperature geothermal systems may also occur either in the region with shallow young magma emplacement or near the plate boundary with partial melting of the upper crust. Although high-temperature geothermal systems in Taiwan belong to the so-called "Circum-Pacific Geothermal Belt", they do not have the representative characteristics of this Belt. The southeast coastal area of China has no necessary conditions for appear-

ance of high-temperature geothermal resources, several medium-temperature geothermalsystems in this area are belived to be caused by deep-circulation of ground water, but not due to high-temperature magma body. The formation of low-temperature geothermal resources in numerous Meso-Cenozoic sedimentary basins may be formulated as follows: heated by normal to relatively low heat flow from beneath, the layered reservoir is recharged by the lateral water flow. In Meso-Cenozoic basins of fault-depression origin such as North China Basin and Northern Jiangsu Basin, isotherm pattern "hight-low-high" corresponding to basement relief "uplift-depression-uplift" is obvious. Consequently, local geothermal anomaly coincides with basement uplift due to redistribution of heat flow in the uppermost part of the Earth's crust. These conclusions are of theoretical and practical importance for the study of nature and accumulation state of geothermal resources, resource assessment and their utilization and development in China. Prospect evaluation of geothermal resources and magnitude calculation of accumulative and recoverable resources have been carried out by the authors. Based on this calculation, the authors have concluded that thermal water resources of China are of certain potential but not rich. In most areas of China, thermal water resouces can only be used for tourism and/or resort purpose rather than used as energy source. However, in the remote border areas of SW China, geothermal resources may play an important role in solving the energy-shortage problem nowadays. This conclusion is correct and may be referenced by appropriate authority in establishing national or provincial geothermal development strategy.

Finallly, two suggestions were made by the authors: 1) Investigation on geopressured geothermal resources must start as soon as possible because of the huge energy potential and wide distribution of the resources in some basins in China; 2) Follow up the-State-of-the-Art of "Hot Dry Rock" Project abroad because this is also an exciting project, but, at present, it seems to be unable to do in China owing to the limited funds available. These two suggestions are farseeing and of great importance, much attention should be paid by the approriate authority in this regard.

The scope of geothermal study appears to be wide. This monograph along with the newly published two other books "Low-Medium Temperature Geothermal System of Convective Type" (Wang Jiyang, ed., 1993, Science Press, Beijing, China) and "Mining Geothermics and Prevention of Geothermal Hazard" (Deng Xiao et al., 1991, Coal Industry Publishing House, Beijing, China) may be considered as a mard symbolizing the deepening and progress in geothermal study in China. Congratulate the authors on the publishing of this monograph and hope, that they will continuously put their effort in the future and make further more contributions to the Geothermics and development of geothermal studies in China.

**Chen Mengxiong**, September, 1993.

# 前　言

《中国地热资源——形成特点和潜力评估》是国家计划委员会资源节约和综合利用司于"七五"期间委托，并受中国科学院能源委员会部分资助，由中国科学院地质研究所地热研究室承担的"全国地热资源调研"项目研究总结报告的基础上写成的。该研究项目是基于国际地热资源研究和开发进展的趋势以及我国地热工作的实际需要而设立。

地热资源的评价和研究是地热资源开发和利用的基础，必须先行。本世纪70年代以来，世界各国对地热能的研究和开发都给以很大的关注，经济发达的国家和地区以及地热资源丰富的发展中国家，相继进行了地热资源的评价工作。1975—1982年，美国三次对全国地热资源进行了全面的评价，发表了三份评价研究报告。前些年，日本、意大利、欧洲经济共同体和墨西哥也分别进行了全国性或区域性地热资源的评价。这些工作的结果，为这些国家和地区部署开发利用地热能工作提供了重要的科学依据。

我国是温泉广布和利用热水历史悠久的国家，但系统性的地热资源研究则起步较晚，始于70年代初。经过我国广大地质、地热和水文地质工作者20多年来对我国地热资源的普查、考察研究，以及勘探和开发，获得了一大批地热地质和地热资源的研究成果和基础资料；另外，我国在油气、煤炭资源和金属矿山的勘探和开发中，也累积了颇多的有关地热地质的资料。对这些成果和资料加以汇总、分析和综合，并作必要的补充性调查，有可能对我国地热资源形成和分布的基本特点在总体上有一个较为明确的认识，和对我国地热资源开发潜力的量级做出评估，以便为国家有关部门对我国开发利用地热能作出决策和制订远景规划提供参考，并为今后进一步评价全国地热资源打下基础，对当前的地热工作亦有所裨益。

该项目的研究任务和内容为：

1. 我国地热资源形成和赋存的地热地质背景的分析和研究；
2. 我国地热资源分布基本特点和形成机制的研究；
3. 若干重要地区区域地热资源量级的估算和远景评价；
4. 典型地热田的剖析、模型的建立、地热资源评价和开发动态预测；
5. 对我国今后地热资源研究工作提出建议。

本书分4编共18章，分别对上述诸问题进行分析和讨论。

第1编为总论，内含第1、2两章。第1章以板块构造的观点，概述我国的大地构造格局，汇总了我国多年来实测的441个大地热流数据，以经纬度1°×1°网格平均值的方式成图，展示我国地热场的基本概貌，据此以评述我国的构造-热背景，作为分析我国地热资源形成和分布基本特点的基础。第2章首先根据2200处温泉的资料，新编了中国温泉图，阐述水热区的地理分布，按省(区)统计温泉的放热量；分析水热活动与地质条件的关系，从宏观上归纳出其主要特点；按各地区水热活动的强度和温泉的密度，结合地质背景，划分出若干主要的水热活动密集带，并评述其开发潜力。其次，评述中、新生代沉积盆地中的低温热水资源的赋存和分布特点，指出大型沉积盆地有利于资源的形成与赋存，热水储层

的发育和热水水质与沉积建造岩相、古地理条件密切相关，裂谷式的盆地有开采条件较优的基岩热储层发育；汇总了有关章节中对10个主要的大中型盆地积存资源和可采资源的评算结果，基本上反映了我国大陆地区沉积盆地型热水资源的量级，从而获得了全局性的了解。最后，根据地热资源形成和分布的特点，改善我国地热系统基本类型的划分，列表简要说明其构造-热背景、地热系统的结构和规模、热源和水源、热水的矿化度以及代表性地区和地热田等等，作为本章的小结。

第2编、第3编和第4编为各论，内分别含第3—5章、第6—13章、第14—17章。在分析地下热水赋存的地热地质背景和地热资源分布特点的基础上，分别对我国西南地区、东中部中、新生代沉积盆地和东南沿海地区热水的积存资源和可采资源作出量级估算和远景评价。下面对有关章节的安排作必要的说明：(1)一般以地热地质和地热资源研究程度较高的省(区)和盆地独立成章，但对于地热上有重要意义的地区，例如川西地区，虽然我们掌握的资料有限，也专辟一章论述。因为该区邻接并有一部分属于喜马拉雅地热带，连同西藏和云南地热状况和地热资源的评述，可使读者对整个喜马拉雅地热带的热状况有一个较为全面的了解。(2)在沉积盆地热水资源的量级估算中，着重以赋存低矿化度热水的储层为计算对象，因为低矿化度的热水可水热并用。(3)每编选取1个典型的地热田作详细的剖析，即西藏羊八井高温水热系统(非火山型)，福建漳州中低温水热系统(深循环型)和河北束鹿-宁晋低温地热系统(断陷盆地型)。在热田地质，热田热场和热水赋存分布特点研究的基础上，建立地热田的模型，对热水积存资源和可采资源作出定量评价，对开发动态进行预测。(4)鉴于国内外地热学家和工业界人士对我国东南沿海地区水热系统的属性有不同的认识，众说纷纭，很有必要加以澄清，故另立一章分析和讨论。(5)台湾及其邻近的岛屿是我们祖国神圣领土不可分割的一部分。台湾地热界同行在60年代中期至70年代末期做了大量的地热资源普查和勘探研究工作。根据文献和尽可能获得的资料，有关台湾地热资源的情况在总论部分有较多的反映，为了避免不必要的重复，不另设一章论述。

最后一章(第18章)为结论和建议，可视为本书的详细提要。

我们在野外地热地质考察和地热测试以及搜集地热资料的工作中，得到有关省(区)地质矿产、石油和煤炭部门所属许多单位的支持和帮助。在西藏羊八井地热田、福建漳州地热田和河北束鹿-宁晋地热田以及雷州半岛热水赋存特点的剖析和研究过程中，分别与西藏地质矿产局地热地质大队、福建地质矿产局第一水文地质工程地质队、华北石油局地质处和广东省地质矿产局第一水文地质工程地质队进行了卓有成效的协作。一并于此致以衷心地感谢。

本书引用了我所地热研究室20多年来取得的有关地热资源方面的成果和累积的资料，其中包括“七五”期间国家自然科学基金资助课题和国家科技攻关项目的成果和资料。我室几位硕士生和博士生曾参与“七五”期间的工作，也引用了他们的硕士和博士学位论文的资料。

在国家计划委员会资源节约和综合利用司及中国科学院资源环境科学局的共同组织和主持下，邀请我国地热、水文地质和新能源科技管理专家于1991年10月对本书稿进行了评审。出席评审会的有：任湘高级工程师(中国能源研究会地热专业委员会主任委员)、佟伟教授和廖志杰教授(北京大学)、黄尚瑶研究员(中国地质科学院地质力学研究

所)、王大纯教授和沈照理教授(中国地质大学,北京)、张振国高级工程师(地质矿产部地质环境管理司)和郑克棪高级工程师(地质矿产部科技司)、初滨高级工程师(农业部农业工程研究院)、吴方之高级工程师(能源部电力科学研究院)、朱俊生和王明威高级工程师(国家计划委员会资源节约和综合利用司)、胡成春高级工程师(国家科学技术委员会工业局)、王世中高级工程师和居琦工程师(中国科学院能源委员会)以及易善锋研究员(中国科学院地质研究所)等,他们对本书稿进行了仔细的审阅并提出了许多宝贵的修改意见。本书第一章中"大地构造格局"一节,由构造地质学家强祖基研究员(国家地震局地质研究所)协助定稿。我所所长王思敬研究员一直关心和支持本书的撰写工作。本书编者和作者均在此致以最诚挚的谢忱。

本书是我国第一本较为系统而全面地阐述我国地热资源赋存的地质构造-热背景、资源形成和分布特点和其潜力评估的著作,如果对我国今后地热研究与勘探开发工作能够发挥一定的作用,对地球科学有关学科的研究也有所裨益,我们将深感欣慰。由于各地区地热研究程度的差异和其他方面的原因,本书各章节论述内容的深度和广度不平衡,更由于我国疆域辽阔,地质条件复杂,加之对资料的收集不全,吸收、消化已获得的资料也未必很透彻,所以对一些地区地热资源赋存状况的评述带有某种推论的性质,对某些问题的论证和看法也许有一定的片面性,敬请读者惠予指正。

本书由中国科学院出版基金资助出版。本书编者和作者对出版基金专家委员会的信任和支持致以衷心的感谢。

陈墨香 1993年1月修订

# PREFACE

The monograph "Geothermal Resources in China——Formation Characteristics and Pontential Evaluation" is based on the materials obtained by the staff from the Lab for Geothermics, Institute of Geology, Chines Academy of Sciences during the period 1986-1991 under the Project "Investigation of Geothermal Resources in China" sponsered by Resources Saving & Integrated Utilization Division (RSIUD), State Committee of Planning (SCP) and partly funded by Energy Research Committee, Chines Academy of Sciences, This project has been initiated upon the demand for the development and utilization of geothermal energy in China considering the recent status of geothermal study and development abroad.

It is well-known that resources assessment is the foundation for development and utilization of geothermal energy. Since the early 1970's, development and utilization of geothermal energy has attracted more and more attention and resource assessments were attempted by both developed and developing countries with abundant geothermal resources. During the period 1975-1982, assessments of geothermal resources of the United States were conducted three times by U. S. Department of Energy in the form of Geological Survey Circular No. 726 (1975), No. 790 (1979) and No. 892 (1982). In recent years, nation-wide and/or regional resource assessments were carred out in Japan, Italy, Mexico and European Community Countries. All these works serve as the scientific base for planning and coordination of development and utilization of geothermal energy in these countries.

Hot springs are widespread in China which has a long history of thermal water utilization. However, systematical studies on geothermal resources only started in the early 1970's. During the past 20 years, numerous relevant data were obtained from the investigations on geothermal resources by joint efforts of geologists, hydrogeologists, geothermists and geophysisists. In addition, a large number of temperature logging data in boreholes and geothermo-geological information were accumulated during exploration and prospecting for oil and gas, coal, as well as ore deposits. Integrating and summarizing all these data whith supplement survey, it is possible to get better understanding of the formation and distribution of geothermal resources as well as the resource protential which are useful and necessary for planning geothermal exploration and utilization in China. Furthermore, this also may serve as the basis of nation-wide resource assessment in China.

Therefore, the aim and target of the above-mentioned project can be formulated as follows:

1. Geothermo-geological settings of formation and accumulation of geothermal resources;

2. Distribution and formation mechanism of geothermal resources;

3. Magnitude calculation of resources in several prospective regions;

4. Case histories of typical geothermal fields including setting up of genesis model, resource assessment and prediction on the regime during exploitation;

5. Recommendation on the further investigations of geothermal resources and development in China.

The monograph is divided into four parts containing eighteen chapters in total. Part 1, general overview, contains two chapters. In Chapter 1, geotectonic settings and thermo-tectonic background were given, 441 measured heat flow data have been summarized in the form of average value in 1° × 1°grids. This is the base for analyzing the formation and distribution of geothermal resources in China. In Chapter 2, newly compiled hot springs map of China with 2200 sites is presented. On the basis of this map, the geographical distribution of hydrothermal areas, its relationship to the geological conditions and the heat discharge of hot springs in every province (region) were demonstrated. Furthermore, major belts of hydrothermal activity and the potential for exploitation have been illustrated according to the intensity of hydrothermal activity and the density of hot springs in terms of geological conditions. In this chapter, the accumulation and distribution of low-temperature thermal water in Meso-Cenozoic sedimentary basins were stated. It has been noted that the reservoir development and the thermal water quality are closely related to the lithology of sedimentary formation and paleogeography. Especially, the thermal water resources are favourably formed and accumulated in large-scale sedimentary basins. In rift basins, basement rock reservoirs are developed quite well. Evaluation of accumulative and recoverable thermal water resources for ten major large and medium sedimentary basins was conduted in this chapter. It also gives magnitude of thermal water resources in sedimentary basins of continental area of China. Finally, improved classification of geothermal systems has been realized based on better understanding of the formation and distribution of geothermal resources in China. A table is made to outline structure and extent of geothermal systems, their tectono-thermal background, heat and water source as well as the repesentative geothermal fields and region is attached for better reference and information.

Part 2, 3 and 4 are devoted to "Geothermal resources in major regions of Southwest China," "Geothermal resources in major sedimentary basins of Centro-Eastern China" and "Geothermal resources in Southeast coastal areas of China" respectively. Chapter 3-5 belong to Part 2, Chapter 6-13, to Part 3 and Chapter 14—17, to Part 4 correspondingly. In these parts, based on the geologo-geothermal background and the distribution of geothermal resources, magnitude evaluation of accumulative and recoveable resources and their perspectives were attemped for Southweast China, Meso-Cenozoic sedimentary basins of Centro-Eastern China and Southeast coast respectively. Some overall notes on the specifics of these chapters are made as follows:

1) Generally, a single chapter is devoted to one province and/or one basin with better understanding of geothermal resources and geologo-geothermal settings. However, to regions important in geothremal resources, individual chapters are given no matter of information existed is sufficient or not. For instance, information obtained so far on geothermal resources for Western part of Sichuan Province appears not to be so sufficient, but the Chapter 5 is still given to it because this region is very close to and even partly belongs to the so-called Himalayan Geothermal Belt. It is of significant importance to have this region involved for better understanding the whole picture of this Belt.

2) For the magnitude evaluation of thermal water resources in sedimentary basins, emphisis has been put on the low salinity thermal water, becauce the water can be used for heat and water supply purpose.

3) One typical geothermal field with detail analysis is selected for each part, such as: Yangbajing high-temperature hydrothermal system (non-volcanic type) in Tibet for Part 2, Shulu-Ningjin low-temperature geothermal system (fault-depression basin type) in Hebei Province for Part 3 and Zhangzhou low-medium-temperature hydrothermal system (deep circulation type) in Fujian Province for Part 4. For all these geothermal fields based on investigations of geology, temperature field and formation plus distribution, genesis model of the above-mentioned geothermal fields was set up, accumulative and recoverable thermal water resources have been assessed and regime during exploitation of thermal water was predicted.

4) As there was a big argue at home and abroad about the nature of geothermal systems in the Southeast coastal area of China, special discussion on this problem is made in Chapter 14.

5) A lot of work on prospect and exploration of geothermal resources in Taiwan has been done from the mid 1960's to late 1970's by colleagues of Taiwan geothermal community. Based on publications and personal communications with Taiwan geothermists, an outline on geothermal resources in Taiwan was stated in Part 1. For this resaon, this problem was not specially discussed in other parts.

Conclusion and recommendations were made at the last part (Chapter 18) which may also be regarded as the extended summary of this monograph.

During the field work and data collection, great assistance came from numerous engineers, technicians and many organizations under Ministry of Geology and Mineral Resoueces (GMR), China National Oil and Gas Company and China National Coal Company. Successful cooperation and collaboration were carried out with Geothermo-Geological Team of Xizang (Tibet) Autonomous Region, Bureau of GMR; The First Team of Hydrogeology and Engineering Geology (HEG), Fujian Provincial Bureau of GMR; Geolocial Division of North China Petroleum Bureau and First Team of HEC, Guangdong Provincial Bureau of GMR. Sincerely thanks are due to the above-mentioned personnel

and organizations from the authors.

Materials and data used in this monograph also come from a number of projects including National Natural Science Foundation of China and Nation-wide State Key Projects for the period 1986—1990 conducted by the staff from the Lab for Geothermics, IGAS. Scientific reports and other documents about geothermal resources in China accumulated in the Lab for Geothermics, Thesis and description of MS and Ph. D. students of the Lab for Geothermics are also referenced in the monograph. Authors are indebted to the colleagues, friends and students in the Lab.

Under the auspices of Resource Saving & Integrated Utilization Division, SCP and Resource and Environment Bureau, Chinese Academy of Sciences, a meeting to review the manuscript of the monograph was held in October, 1991. Specialists (see list below) from geothermal commenity of China attended this meeting and valuable suggestions, comments and recommendations were made to improve the manuscript.

Prof. Ren Xiang, Head, Geothermal Committee, China Energy Research Society

Profs. Tong Wei and Liao Zhijie, Department of Geology, Peking University

Prof. Huang Shangyao, Institute of Geomechanics, Chinese Academy of Geological Sciences

Profs. Wang Dachun and Shen Zhaoli, Department of Hydrogeology and Engineering Geology, China University of Geosciences (Beijing)

Senior Engineers Zhang Zhengou and Zheng Keyan, Ministry of Geology and Mineral Resources

Senior Engineer Chu Bin, Institute of Agriculture Engineering, Ministry of Agriculture

Senior Engineer Wu Fangzhi, Instutite of Electric Industry, Ministry of Energy

Senior Engineers Zhu Junsheng and Wang Mingwei, State Committee of Planning

Senior Engineer Hu Chengchun, Division of Industry, State Committee of Science and Technology

Senior Engineer Wang Shizhoug, and Engineer Ju Qi, Energy Research Committee, Chinese Academy of Sciences

Prof. Yi Shanfeng, IGAS

Prof. Qiang Zuji from Institute of Geology, State Seismologcial Bureau carefully reviewed Section 1 "Tectonic Framework" of Chapter 1 and gave valuable comments. Prof. Wang Sijing, paid great attention and concern to this monograph. Authors are grateful to all those people.

Finally, it must be pointed out that this monograph is the first publication systematically descriping the geologo-geothermal settings for accumulating geothermal resources in China, their formation and distribution as well as resource potential evaluation. The authors would be happy if this monograph could play an important role in geothermal study for prospecting and exploration and could be useful to the disciplines

of Earth sciences. However, owing to the unequal deepness in understanding the aforementioned aspects and the vast area to study, several conclusions should be considered to be some sort of inference and deduction. Furthermore, open problems, shortcomings even mistakes might exist. The authors sincerely wish to receive new comments, suggestions and recommendations.

The publication of this monograph is finacially supported by Publication Foundation of Chinese Academy of Sciences. The authors highly acknowledge this support.

**Chen Moxiang**, January, 1993.

# GEOTHERMAL RESOURCES IN CHINA

## ——Formation Characteristics and Potential Evaluation

Chief Editors:

*Chen Moxiang, Wang Jiyang and Deng Xiao*

SCIENCE PRESS

1 9 9 4

# 目　　录