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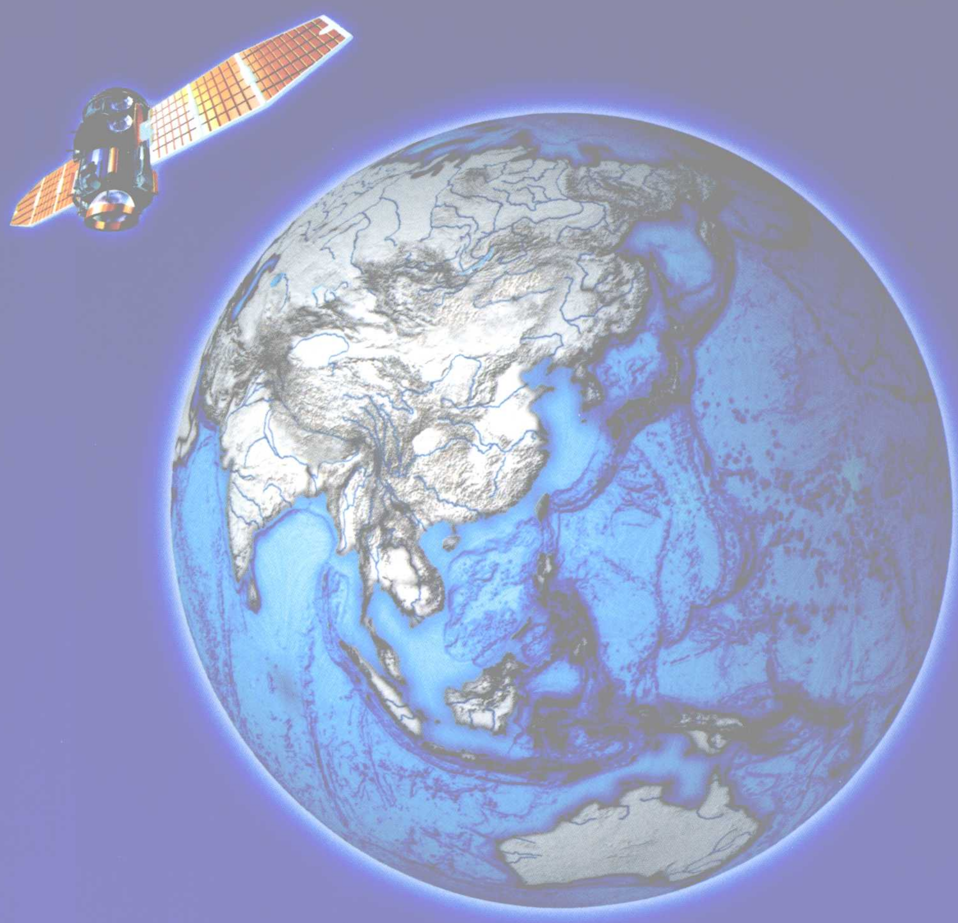
陈永清 陈建国 汪新庆 等著



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基于GIS矿产资源综合定量评价技术

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地质出版社
·北　京·

内 容 提 要

本书是一部将矿产资源综合定量评价基本原理和方法与GIS技术相结合实施矿产定量勘查评价的专著。其主要内容除包括应用GIS技术评价矿产的基本原理，矿产勘查评价基础空间数据库建设，矿产勘查评价系统开发与应用等内容外；还包括作者在长期矿产勘查评价理论方法技术研究和实践的基础上，深入探索运用新理论（地质异常致矿理论）、新方法（证据权方法）和新技术（多重分维技术）在我国西部重要成矿区带实施找矿信息提取、关联、转换和集成，以及矿产资源综合定量评价的最新研究成果；并在此基础上开发了具有自主知识版权的矿产资源评价预测系统（MORPAS3.0），和全国重要成矿区带矿产资源评价基础空间数据库管理系统（DMSMPBC1.0）。

本书可供矿产资源勘查评价、专用GIS系统开发与应用研究人员参考使用，亦可作为高等院校矿产勘查与地球探测与信息技术等相关专业的本科生、研究生教学参考书。

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序

由陈永清、陈建国、汪新庆等人编著的《基于GIS矿产资源综合定量评价技术》一书由上、中、下三篇组成。上篇对国内外现有的矿产资源定量评价理论和方法技术进行了扼要概述。自20世纪80年代初国际地质对比计划98号专题有关研究者美国麦坎蒙、波特布尔及克拉克博士以及日本西胁二一博士来华介绍并推行矿产资源计算机定量评价技术与方法之后，我国也开展了包括全国范围总合式和非总合式矿产资源定量评价工作，获得了全国若干矿种的资源总量数据，圈定了一批成矿远景预测区，特别是在实践中培养了一批人才，建立了一支技术队伍，为我国进一步开展资源定量预测评价打下了良好基础。我国在学习国外先进经验的同时，更注重创新和丰富定量评价理论，研发和改进评价方法技术，建立和完善定量评价信息系统。从早期基于相似类比理论的“矿床统计预测”到基于求异理论的“地质异常”及随后的“三联式”定量成矿预测理论及数字找矿模型，从基于关联分析的单因素预测到基于GIS的综合信息预测，从基于传统理论的线性预测到基于复杂性理论的非线性预测，使成矿定量预测理论、方法、技术更加完善和成熟。所有这些基本内容和新进展都不同程度地在本书中作了介绍，由于作者们是各项创新研究的参与者和实践者，所以理论阐述重点突出，方法技术关键到位。中篇介绍了矿产资源综合定量评价系统开发成果，是本书的重要组成部分，涵概了九章，包括基础数据、空间数据库设计，数据库系统功能设计及环境配置，数据库系统开发与功能实现，矿产资源评价预测系统总体设计，常规物化探空间分析方法技术实现，地质统计学分析技术实现，分形滤波和空间主成分分析技术实现，小波分析信息提取技术实现以及矿产资源综合定量评价技术的实现等。常用方法齐全，内容丰富具体，可操作性好，可借鉴性强。下篇为定量评价系统应用实例介绍，作者汇集了在西南“三江”南段、陕甘相邻地区及东天山成矿带定量预测评价及找矿靶区圈定工作的理论和方法，包括地质、物探、化探及遥感异常信息提取、处理、成果分析解释及靶区圈定技术，包括区域成矿多样性，成矿系列及成矿谱系分析和成矿规律研究。由于各实例均为本书作者长期在该地区实践结果的凝炼和总结，所以资料翔实，内容丰富，其应用方法、步骤和途径过程具有示范性和指导性。

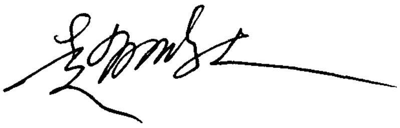
本书体现了矿产资源定量预测评价信息系统中模型库、数据库和方法库三库一体的思路。当然，本书不包括各类矿床的具体模型，不过在具体应用时可根据需要建立地区的或矿种的模型库，也可以建立某类矿种的矿床模型库，以备相似类比或选择变量或评价预测结果之用。

本书基本概括了20世纪初以前我国开展矿产资源定量预测及评价的方法技术及其应用状况。进入新世纪以来，无论是危机矿山接替资源的勘查还是全国矿产资源潜力评价都要求加大预测找矿深度。不久前发布的“国土资源部关于促进深部找矿工作指导意见”要求我国固体矿产勘查向深部拓展，以实现找矿重大突破。意见要求开展主要成矿区带地下500m至2000m的深部资源潜力评价，重要固体矿产工业矿体勘查深度推进到1500m。面向新的要求，矿产资源综合定量评价理论、方法、技术也应适应新情况，研究新问题，这将是我国新一代资源预测评价系统所急待实现的国家目标和必须研究解决的科学问题。

本书作为一个时期和阶段的方法技术概括和总结有其编年和里程碑的意义。书中的基本内容仍将长时期发挥参考和指导作用，只是在具体应用过程中需重视创新、完善和发展。相信广大读者将在自己的应用实践中为发展我国的资源定量评价事业做出新的贡献。

中国科学院院士

中国地质大学前校长



2008年2月28日

前　言

21世纪初，正值我国新一轮国土资源大调查起步的关键时刻，为提高我国矿产资源勘查评价的技术含量和信息化水平，实现找矿的重大突破，满足我国社会经济高速发展对矿产资源的巨量需求，科技部在“十五”国家科技攻关计划中分阶段（2001～2003；2004～2005）相继设立“金属矿产资源快速评价预测系统（2001BA609A02）”和“基于GIS金属矿产资源快速评价预测系统开发和应用研究（2003BA612A02）”课题。其主要任务是：① 在前期“九五”国家科技攻关成果的基础上，跟踪国内外先进的软件开发技术，继续开发、完善金属矿产资源评价预测系统，最终使该评价预测系统成为具有显著优势和特色的国产矿产资源调查评价的主要工具软件；② 结合新一轮国土资源大调查矿产资源调查评价项目的实施，应用该系统对我国西部示范区优势矿种和国家紧缺矿产（铜、铅、锌、金、银等）进行快速预测评价。根据科技部的要求，结合新一轮国土资源大调查地质调查工作的需求，中国地质调查局配套了一系列地质调查项目：矿产资源潜力快速评价技术（200310200082），全国重要成矿区带数据库建设与资源评价成果综合（200218310077）和重要成矿区带工作部署跟踪研究（200310200080）等。在上述课题（项目）资助下，经过课题（项目）组全体成员五年的开拓性工作，取得诸多创新性研究成果。

1. MORPAS3.0系统在关键技术上取得了突破性进展

（1）矿产资源预测评价系统，即MORPAS3.0改用CPRJEditView与CPRJListView为基础平台进行开发，移植、修编原有MORPAS1.0系统中的所有功能模块，实现了工程化的管理方案。

（2）在统一的工程化管理框架下，集成了MapGIS强大的图形编辑、空间分析、属性管理与统计、属性重分类、数据格式转换、图件的输入输出、投影变换、图框图例的生成等工具类通用功能，以及单元划分、变量赋值、致矿地质异常信息提取与综合，以及资源评价等专用性的功能。

（3）在信息提取单元方面，兼顾网格单元与自然（不规则）单元预测两种情况，考虑了ROI功能的实现；在菜单布局与操作界面上得到了尽可能的统一，并增加必要的提示，以方便用户的理解与使用；在开发过程中，使用MapGIS的“并口”与“USB”两种软件狗均支持的二次开发函数，以便MORPAS3.0可同时适用不同的用户；同时，考虑了通用与专用的兼顾，使得MORPAS3.0系统的功能不仅可用于矿产资源评价，亦可作为通用的工具解决用户日常工作的一些问题，如图例自动生成、属性统计与重分类等。

（4）多重分形技术模块开发移植，较好解决了复杂地质地球化学背景下，弱矿化信息提

取的关键技术问题。

（5）在 MORPAS3.0 系统中，有效实现了致矿信息提取、关联、转换和合成技术，这是基于综合致矿信息应用该系统实现矿产资源综合定量评价的关键。

2. 应用 MORPAS3.0 在我国西部重要成矿区带定量圈定和评价若干成矿远景地段，为国家正在开展的矿产资源远景调查评价提供了技术支撑和科学依据

（1）应用多重分形技术，在西南“三江”南段成功地实现了复杂地质背景下铜、锌、金异常和背景的分离，新发现 3 条北北东向锌矿化异常带和若干铜、金矿化异常区，为该区找矿开辟了新的领域。

（2）应用 MORPAS3.0 评价系统，分别实现了对我国西部若干个示范区金（铂钯）、铜、镍、铅、锌、银和锡等矿种找矿靶区圈定及其资源潜力评价，为国家正在实施的矿产资源远景调查评价战略选区提供了科学依据。

3. MORPAS3.0 成果推广应用情状况

（1）新研制开发的矿产资源预测评价系统（MORPAS3.0）是一套具有自主知识产权的软件系统，并达到了推广应用的水平。该系统将是今后我国矿业勘查部门实施战略性矿产资源快速综合定量评价的主要工具之一。MORPAS3.0 在原有 MORPAS 系统的基础上，不仅在系统稳定性、可操作性上有所改进，且在信息提取方法技术上进行了扩充，尤其是开发移植了多重分形非线性信息提取技术。

（2）MORPAS 矿产资源评价分析系统软件已具备推广应用的基本条件。中国地质调查局于 2004 年 5 月和 2006 年 4 月分别在昆明和三亚举办了为期一周的 MORPAS 软件推广应用培训班，来自全国地矿、冶金、有色、核工业以及武警黄金部队等单位的 180 余人参加了培训。MORPAS3.0 系统已在地质调查“全国十四个重要成矿区带成矿规律与找矿综合研究”、“重要成矿区带工作部署跟踪研究”以及“东天山－北山综合编图与初步选区”等项目中应用。此外，在云南、河南、甘肃、陕西、江西、湖北等省地矿单位、武警黄金部队及部分科研院所的资源评价项目中亦应用该软件开展了矿产资源评价工作。

4. 开发了地学基础空间数据库管理系统，建立了全国 14 个重要成矿区带地（矿）物化遥基础空间数据库

在配套的地质调查项目的支持下，以 Visual Basic 为系统开发语言，以 SQL Server2000 为后台数据库，成功开发了基于 MapGIS 和 ArcGIS 的基础数据库管理系统，前端的数据浏览与数据查询等功能利用 MapGIS 和 ArcGIS 提供的一系列 COM 组件，通过编程实现。该系统基于 Client/Server 结构，能够实现不同软、硬件系统之间的空间数据的快速转换与传输；能够实现各重要成矿区带基础数据库的无缝联接和统一管理。

收集汇总了全国 14 个重要成矿区带矿产资源调查评价系列数据，并将全国 14 个重要成矿区带数据汇总入库，建立了全国重要成矿带地（含矿产）物化遥多学科基础空间数据库。全国重要成矿带资源评价基础空间数据库系统，可有效管理各类数据，实现空间数据的转换

和灵活查询，提高数据利用价值，为政府部门进行相关空间基础数据分析和工作决策提供支持；能够对成矿区带基础空间数据库、基础属性数据库以及基础空间数据公用平台、基础属性数据公用平台进行数据综合和知识挖掘，为基层勘查单位、科研单位和有关院校进行成矿区带的成矿条件研究和资源潜力预测评价，提供充分的数据支持。该著作正是在上述研究成果的基础上，参阅国内外大量相关文献撰写而成的。

本著作共分为上、中、下3篇、20章。具体分工如下：前言（陈永清）；上篇，矿产资源综合定量评价方法技术，包括 第1章 绪论（陈永清），第2章 基于GIS矿产资源潜力定量评价技术（陈永清，黄静宁），第3章 地质异常矿产资源定量评价技术（陈永清，刘红光），第4章 成矿系列综合信息定量评价技术（陈永清，刘红光），第5章“三部式”矿产资源定量评价技术（陈永清，黄静宁）；中篇，矿产资源综合定量评价系统开发，包括 第6章 矿产资源评价基础空间数据库设计（汪新庆，王勇），第7章 数据库系统功能设计与环境配置（汪新庆，王勇），第8章 数据库系统开发与功能实现（王勇，琚锋），第9章 矿产资源评价预测系统总体设计（陈建国，胡光道，陈守余），第10章 常规物化探空间分析方法技术实现（陈建国，陈超，陈守余），第11章 地质统计学分析技术实现（陈建国，陈志军），第12章 分形滤波和空间主成分分析技术实现（张生元，赵彬彬），第13章 小波分析信息提取技术实现（陈建国，胡飞），第14章 矿产资源综合定量评价技术实现（陈建国，曹瑜，陈守余）；下篇，矿产资源综合定量评价系统应用，包括 第15章 西南“三江”南段成矿地质背景和成矿地质异常事件（陈永清，刘红光），第16章 西南“三江”南段金属成矿系列与成矿谱系（张寿庭，孙华山），第17章 西南“三江”南段矿产资源综合定量评价（陈永清，夏庆霖），第18章 陕甘相邻区矿产资源综合定量评价（陈建国，解华明），第19章 东天山成矿带矿产资源综合定量评价（陈永清，夏庆霖）；第20章 结论与展望（陈永清）；陈永清负责整个著作的编写和统稿。

课题研究过程中，得到了科学技术部农业与社会发展司、国土资源部科技与国际合作司、项目管理办公室、项目专家组、中国地质调查局科技外事部和资源评价部、中国地质调查局发展研究中心、中国地质大学（北京，武汉）、中国地质科学院矿产资源研究所以及云南、新疆、陕西和甘肃地质调查院等单位有关领导和专家的支持和帮助；尤其是得到陈毓川、常印佛、裴荣富、翟裕生、叶天竺、黄宗理、刘士毅、彭齐鸣、王瑞江、白星碧、马岩、卢民杰、严光生、吕庆田、邓志奇、姚华军、谭永杰、杨东来、李文昌和卢映祥等专家的技术指导，在此深表感谢！

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陈永清
2008年4月5日

Foreword

The book entitled "*Quantitatively Integrated Techniques for Assessment of Mineral Resources Based on GIS*" consists of three parts written by Dr. Chen Yongqing, Dr Chen Jianguo and Dr. Wang Xinqing et al. The theories, methods and techniques for quantitative assessment of mineral resources are briefly summarized in Part I. At the early of 1980s, certain methods and techniques for mineral resources assessment by using computer were introduced into China by Mr. R. B. McCammon, Mr. J. M. Botbol, Dr. G. R. Clark and Dr. N. Nishiwaki, researchers of the No. 98 project of International Geological Correlation Program. Since then, the national assessment of mineral resources had been implemented over China, including the disaggregated and aggregated estimates of undiscovered deposits. The total amounts of mineral resources for a few of commodities such as iron, nickel, copper and gold etc were obtained, and a set of ore-forming potential areas are delineated through this national project. At the same time, a number of specialists familiar with quantitative resources assessment techniques grew up in practice that laid the foundation for further implementing quantitative assessment of mineral resources. At the same time of learning advanced techniques and experiences from abroad, we paid more attention on innovation and enrichment of the quantitative resources assessment theory, and improving the assessment techniques and developing the special GIS system for quantitative assessing mineral resources. In past decades, mineral resources assessment, from the statistical prediction of ore deposits based on the principle of "similar-analogy" to the geo-anomaly theory based on the principle of "searching for differences" and to the latest theory of three component quantitative mineral prediction based on integrated digital ore-prospecting pattern, from the assessment techniques based on unitary factor correlation analysis to quantitatively integrated assessment techniques based on GIS, from the linear mathematical models based on the traditional geological concepts to the nonlinear mathematical models based on the complexity theory of geosciences, has gone a complicatedly successful way, which makes the theory, methodology and technique of quantitative ore-forming prognosis tend to be perfect and completed. The all basic contents and new development of quantitative assessment of mineral resource mentioned above are introduced at varied extends in this book. Because the contributors of this book are pioneers who practice quantitative resource assessment, the important points of quantitative resource assessment are stressed on in theoretical elucidation and the key methods and techniques are clearly demonstrated in this book, which make it easy to understand for readers, especially for the beginners. Part II is a very important part of this book, covering nine chapters. Firstly, the fundamental spatial data management system for mineral resource are explicitly introduced, including the fundamental data of geosciences for mineral assessment, the design of spatial database, the system function and the requirements of spatial database, development and function realization of spatial database management system and so on. Secondly, the general design of metal ore resources prediction and assessment system (MORPAS3.0) is elucidated and how to realize the following techniques for quantitative mineral estimation in MORPAS is demonstrated, including the conventional spatial analysis in geophysics and geochemistry, Geostatistical analysis, fractal filter and spatial principal component analysis, extraction information by wavelets, and integrated quantitative assessment of mineral resources. Almost all conventional quantitative assessing techniques are introduced in this part that the readers may easily chose various kinds of techniques for extraction of ore-forming information and mineral assessment according to their practical needs. In Part III, the case studies in three typical ore-forming belts, including the south segment of "Sanjiang" ore-forming belt in southwestern China, the adjacent area between Shaanxi and Gansu province, and the eastern Tianshan ore-forming belt, are introduced to show the advantage of mineral estimation by using MORPAS3. 0. The sequences include the following steps: (a) the studies on the ore-forming diversity, ore-forming series, ore-forming spectrum and ore-forming regularity; (b) ore-forming information extraction from the geological, geophysical, geochemical and remote sensing data; (c) the delineation and assessment of the ore-forming target areas based on ore-forming geo-anomaly. Because these case studies concentrated come from writers′ practices of quantitative mineral assessments for a long time, this book is of abundant and concrete contents. The approaches described in this book provide good guidance and demonstration for the operation of national mineral resources assessments.

The general idea combined three bases - model base, data bases, and method base into one body is highlighted in the book. Of course, the special type of mineral deposit models are not included, but when mineral assessment is implemented in one ore-forming region, the special mineral deposit model base could be established according to requirement to help select prognosis variables and interpret the assessment results based on analogy.

The current methods and techniques of the quantitative mineral resource assessment are summarized in this book. However in the new century, not only the exploration of replaceable resources for crisis mine but also the nationwide mineral resource potential assessments are all facing the same subject, that is the mineral assessment in depth. Recently, the guidance and implication of promoting deep mineral exploration issued by the Ministry of Land and Resources recently requires that the national mineral resource exploration should extend into depth to make important breakthrough in mineral exploration. The guidance and implication propose to implement mineral potential estimation under 500 meters to 2000 meters in some crisis mine fields, and extend the exploring depth of important commercial ore bodies for 1500 meters. Therefore, facing the new national needs, the theory, methods, and techniques of integrated quantitative assessment of mineral resources must make innovation to solve new problems, which is becoming the national goal and the scientific subject need to further study for new generation of mineral resource assessment system.

As the summarization and conclusion of one period or certain stage for quantitative resource assessing methods and techniques, the significance of this book is equal to annals and a milestone of quantitative mineral resource assessments. The basic contents in the book will take profound effect as the reference and guidance on quantitative mineral resource assessments for a long term. Nevertheless, the innovation and improvement on the assessment theory, method and technique should be emphasized in practice to make it more perfect. Believe that everyone who reads this book will make new contribution to our national quantitative resource assessments in their application field.

Academician of Chinese Academy of Sciences
Former President of China University of Geosciences

Zhao Pengda

February 28, 2008

Preface

With the advent of the 21st century, the highly speed economic development of China need consuming the huge amounts of mineral resources. The national project for a new cycle of land resources survey for twelve years starts to be implemented to meet this demand. It is at key time that the Ministry of Sciences and Technology successively financed two projects of both one that developed a special GIS software for assessment and prediction of mineral resources during 2001 ~ 2003 (2001BA609A02) and that one that studied the development and application of this GIS software in assessment of mineral resources during 2004 ~ 2005 (2003BA612A02) in "tenth national five years plan" to provide technical support for the national mineral assessment. The main tasks of the projects are s follows: (a) apply advanced technique of both GIS and mineral assessment to develop and improve a special GIS software for assessment and prediction of mineral resources on the MORPAS 1.0 (Metal Ore Resource Prediction and Assessment System, vision 1.0) ; (b) combine this research with the mineral resource assessment project from the new cycle of land resources survey and apply the newly developed MORPAS software in assessment of the advantage and short minerals such as copper, lead, zinc, gold and silver etc. in some ore-forming belts in western China. In order to do it better, China Geological Survey set up a series of projects which apply the new MORPAS software in assessment of mineral resources, including "Establishment of geosciences and mineral database of main ore-forming belts in China and Integration of mineral resource assessment fruits (200218310077)", "Quick assessment technique for mineral resources (200310200082)" and "Tracing study on exploration plans for main ore-forming belts in China (200310200080)".

MORPAS3.0 with powerful function in extracting and integrating ore-forming information from the multidiscipline geo-scientific data such as geology, geophysics, geochemistry, and remote sensing image is created through the research group' innovative works for five years and apply MORPAS3.0 to quantitatively delineate and assess a few ore-finding target areas in the south section of "Sanjiang" ore-forming belt in southwestern China.

1. MORPAS3.0 in the key techniques made the following breakthrough progresses.

(a) Engineering plan of management is realized in MORPAS3.0 through developing, transplanting and revising all function molds from MORPAS1.0 based on CPRJEditView and CPRJListView.

(b) Under the engineering frame of management, a few powerful function from MapGIS are integrated into MORPAS3.0, including both tool functions such as graphic edition, spatial analysis, attribute statistics, transform of data format, in and out of map and file, transform of projection; and special functions such as unit division, endowment value for geological variables, extraction and integration of ore-forming information from the multidiscipline geo-scientific data and assessment of mineral resources.

(c) In the processes of developing software, two types of software dogs of both the parallel interface of MapGIS and the interface of USB supporting quadratic develop functions are used to make MORPAS3.0 fit to various kinds of usages such as mineral, environment and hazard assessment.

(d) Newly develop a few modules containing multi-fractal, principal component spatial analysis, and wavelet analysis and these techniques can be applied to better solving the extraction of hidden and weak ore-forming information from complicated geological background.

(e) The key techniques such as extraction, connection, transform and integration of ore-forming information from the multidiscipline geo-scientific data are realized in MORPAS3.0, which lay a foundation for quantitative assessment of mineral resources using integrated ore-forming information.

2. Application of MORPAS3.0 in quantitatively delineating and assessing a few ore-finding target areas in the ore-forming belt in western China for providing new ore-finding areas for national strategic exploring and assessing mineral resources in the area.

(a) The multi-fractal technique (S-A) is successfully applied to extracting the hidden and weak ore-forming anomalies of copper and zinc, and a few of anomalous and mineralized zones (districts) of lead-zinc, copper and gold are discovered in the south segment of "Sanjiang ore-forming belt in southwestern China, which open up new areas for searching the deposits of lead-zinc, copper and gold.

(b) MORPAS3.0 is applied to quantitatively delineating and assessing a lot of new ore-finding target areas of copper, lead, zinc, nickel, tin, gold, and platinum etc. of main ore-forming belts such as the "Sanjiang" ore-forming belt in southwestern China, the eastern Yunnan province ore-forming zone, the eastern Tianshan ore-forming belt, and the ore-forming area adjacent Sichuan, Shaanxi and Gansu provinces etc., which provide new ore-finding areas for national strategic exploring and assessing mineral resources in the area mentioned above.

3. Popularizing application of MORPAS3.0

MORPAS3.0 is a special GIS software system with independent intellectual property rights and arrives at level of popularizing application. The workshops on MORPAS2.0&3.0 were held respectively both during may 8-14, 2004 in Kunming city and during April 22-28, 2006 in Sanya city by China Geological Survey. About 180 persons were trained from the Geological and Mineral Division, the Metallurgical Industry Division, the Nonferrous Metal Industry Division the Nuclear Industry Division and the Armed Police Force Division for Prospecting Gold etc. MORPAS3.0 is also applied to quantitatively delineating and assessing ore-finding target areas in many provinces such as Yunnan, Henan, Gansu, Shaanxi, Jiangxi, Hubei etc in China. In conclusion, MORPAS3.0 arrives the level of popularizing application.

4. The Database Management System for Mineral Potential Belts of China based on both MapGIS and ArcGIS platforms has been successfully developed by aid of matching fund from geological survey project.

The Database Management System based on Client/Server structure is able to realize fast transform and transmit between different software and hardware system. At the same time the integrated basic spatial database from geology, geophysics, geochemistry, and remote sensing image of the fourteen main ore-forming belts of China is established, which provides data basis for assessing mineral resource potential in this belts.

It is based on the research fruits mentioned above that this book is written on reading and referencing a lot of relevant literatures from domestic and oversea at the same time.

This book consists of twenty chapters besides foreword and preface and it is divided into three parts. The contributors are as following. Preface is written by Chen Yongqing. Part I is Quantitative Methods and techniques for Integrated Assessment of Mineral Resources, including five chapters. Chapter 1 Introduction (written by Chen Yongqing); Chapter 2 Quantitative assessment of mineral resources based on GIS (written by Chen Yongqing and Huang Jingning); Chapter 3 Quantitative assessment of mineral resources based on geo-anomaly theory (written by Chen Yongqing and Liu Hongguang); Chapter 4 Quantitatively integrated assessment of mineral resources based on the ore-forming series theory (written by Chen Yongqing and Liu Hongguang); Chapter 5 Three-part quantitative assessment of mineral resources (written by Chen Yongqing and Huang Jingning). Part II is Development of the

System for Quantitatively Integrated Assessment of Mineral Resources, including nine chapters. Chapter 6 The basic spatial database designed for mineral resources assessment (written by Wang Xinqing and Wang Yong); Chapter 7 Function design and requirements of database management system (written by Wang Xingqing and Wang Yong); Chapter 8 Development and function realization of database management system (written by Wang Yong and Ju Feng); Chapter 9 General design of mineral resources assessment and prediction system (written by Chen Jianguo, Hu Guangdao and Chen Shouyu); Chapter 10 Realization of the conventional spatial analysis in geophysics and geochemistry (written by Chen Jianguo, Chen Chao and Chen Shouyu); Chapter 11 Realization of Geostatistical analysis in MORPAS (written by Chen Jianguo and Chen Zhijun); Chapter 12 Realization of fractal filter and spatial principal component analysis in MORPAS (written by Zhang Shengyuan and Zhao Binbin); Chapter 13 Realization of extraction information by wavelets in MORPAS (written by Chen Jianguo and Hu Fei); Chapter 14 Realization of quantitatively integrated assessment of mineral resources in MORPAS (written by Chen Jianguo, Cao Yu and Chen Shouyu). Part III is Application of Quantitatively Integrated Mineral Resources Assessment System, including six chapters. Chapter 15 The geological background and ore-forming geo-anomalies in the south segment of "Sanjiang" ore-forming belt, southwestern China (written by Chen Yongqing and Liu Hongguang); Chapter 16 Ore-forming series and ore-forming spectrum of the ore deposits in the south segment of "Sanjiang" ore-forming belt, southwestern China (written by Zhang Shouting and Sun Huashan); Chapter 17 Quantitatively integrated assessment of mineral resources in the south segment of "Sanjiang" ore-forming belt, southwestern China (written by Chen Yongqing and Xia Qinglin); Chapter 18 Quantitatively integrated assessment of mineral resources in the adjacent area between Shaanxi and Gansu provinces (written by Chen Jianguo and Xie Huaming); Chapter 19 Quantitatively integrated assessment of mineral resources in the eastern Tianshan ore-forming belt (written by Chen Yongqing and Xia Qinglin); Chapter 20 Conclusion and prospect (written by Chen Yongqing).

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Professor Zhao Pengda is particularly thanked for many wonderful ideas during the whole process of developing MORPAS3.0 and for the foreword for this book, which encourage us do further new explorations in the frontier areas of quantitative exploration and assessment of mineral resources.

Chen Yongqing

April 5, 2008

目　次

序
前　言

上篇　矿产资源综合定量评价方法技术

1　绪论 …… 3
　1.1　地学基础空间数据库建设 …… 3
　　1.1.1　数据管理的基础——关系数据库 …… 4
　　1.1.2　空间数据模型 …… 5
　　1.1.3　异构的 GIS 平台 …… 6
　　1.1.4　MapGIS 数据在空间数据库中的无损存取 …… 6
　　1.1.5　数据支持 …… 6
　　1.1.6　数据字典技术 …… 6
　1.2　致矿信息提取与集成 …… 6
　1.3　矿产综合定量勘查与评价 …… 9
　1.4　矿产资源评价预测系统 …… 11
　　1.4.1　系统结构与功能 …… 11
　　1.4.2　专用型空间致矿信息提取与集成分析模块 …… 12
2　基于 GIS 矿产资源潜力定量评价技术 …… 13
　2.1　概念模型 …… 13
　2.2　空间数据结构与数据模型 …… 14
　　2.2.1　空间数据结构 …… 14
　　2.2.2　空间数据模型 …… 16
　　2.2.3　空间数据的特性 …… 16
　　2.2.4　数据信息场 …… 16
　　2.2.5　空间信息与空间知识 …… 18
　2.3　空间数据分析与模拟 …… 19
　　2.3.1　Buffer 分析 …… 19
　　2.3.2　图模拟 …… 20
　　2.3.3　空间数据分析 …… 20
　2.4　矿产资源潜力评价 …… 23
　　2.4.1　矿物资源潜力区的概念 …… 23

2.4.2 矿产资源评价中的地学信息…… 24
2.4.3 信息关联和转换…… 26
2.4.4 信息量化与集成…… 27
2.4.5 矿产资源潜力评价…… 27
3 地质异常矿产资源定量评价技术…… 30
3.1 概述 …… 30
3.2 地质异常体和矿产资源体 …… 31
3.3 地质异常体和矿产资源体的基本属性 …… 31
3.4 不同尺度找矿地段圈定的地质异常原理 …… 32
3.5 不同尺度找矿地段圈定的地质异常方法 …… 33
3.6 不同尺度找矿地段的定量圈定和评价 …… 34
3.6.1 金矿找矿有利地段的圈定和评价…… 34
3.6.2 金矿产资源体潜在地段定量圈定和评价…… 37
3.6.3 金矿体远景地段定量圈定和评价…… 40
4 成矿系列综合信息定量评价技术…… 43
4.1 成矿系列与矿化系列 …… 43
4.1.1 成矿系列及基本类型…… 43
4.1.2 矿化系列及基本类型…… 44
4.2 成矿系列综合信息预测与评价的基本原理 …… 45
4.2.1 成矿学原理…… 45
4.2.2 地球化学原理…… 45
4.2.3 成矿系列综合信息预测的地球物理和遥感地质基础…… 48
4.3 成矿系列综合信息预测的基本方法 …… 49
4.3.1 基本原则…… 49
4.3.2 综合信息找矿模型…… 50
4.4 单元划分和变量提取、赋值、筛选及分级 …… 54
4.4.1 单元划分和变量提取…… 54
4.4.2 变量赋值、筛选及分级 …… 55
4.5 成矿系列综合信息定位预测 …… 56
4.5.1 数学模型…… 56
4.5.2 模型单元的选择与扩充…… 58
4.5.3 成矿系列定位预测及靶区评价…… 59
5 “三部式”矿产资源定量评价技术 …… 60
5.1 基本概念 …… 60
5.1.1 矿床模型…… 60
5.1.2 找矿靶区圈定…… 62
5.1.3 品位和吨位…… 63
5.1.4 未发现矿床数…… 65
5.1.5 小结…… 66
5.2 评价案例——Alaska Seward 半岛的未发现脉状锡矿资源评价…… 66

5.2.1 未发现矿产资源评价…… 67
5.2.2 未发现矿产资源潜力估计…… 70
5.2.3 讨论…… 71
5.2.4 未来的挑战…… 72

中篇 矿产资源综合定量评价系统开发

6 矿产资源评价基础空间数据库设计…… 75
6.1 实体模型设计 …… 75
6.2 概念模型设计 …… 76
6.2.1 数据模型结构分析概述…… 76
6.2.2 综合管理数据模式的建立…… 78
6.2.3 元数据模型…… 79
6.3 数据模型结构及数据项编码描述标准化 …… 83
6.3.1 参考标准及成矿带基础数据库信息编码现状…… 84
6.3.2 地学领域数据模型标准化设计的重要性…… 84
6.3.3 利用国家标准术语和辅助设计技术来进行数据模型标准化设计…… 85
6.4 空间数据库编码体系 …… 85
6.4.1 数据库各数据实体编码…… 85
6.4.2 基础数据库文件命名编码及 MapGIS 源数据图层编码设计 …… 86
6.4.3 RDBMS 中数据图层编码 …… 86
6.4.4 图元编码…… 88
6.4.5 重要成矿带空间数据库建设的总体框架…… 88
6.5 系统数据文件的组织形式 …… 88
6.5.1 MapGIS 和 ArcGIS 数据文件夹组织 …… 89
6.5.2 基于 ArcSDE 的面向对象数据组织 …… 89
6.6 数据字典设计 …… 92
6.6.1 数据字典的分类…… 93
6.6.2 建立数据字典的功能与意义…… 93
6.6.3 标准化及智能建模技术数据字典体系…… 95
6.6.4 数据字典的应用设计…… 97
7 数据库系统功能设计与环境配置 …… 109
7.1 数据库建设的目的…… 109
7.2 系统总体构架与系统目标…… 109
7.2.1 研究路线与设计思想 …… 109
7.2.2 总体功能目标 …… 110
7.3 各功能模块设计…… 111
7.3.1 后台数据库的选择与维护 …… 111
7.3.2 客户端数据应用软件 …… 112
7.4 系统软硬件环境配置…… 115

7.4.1 系统硬件配置 …… 115
7.4.2 系统软件配置 …… 115
8 数据库系统开发与功能实现 …… 118
8.1 系统开发概述 …… 118
8.2 软件功能界面简介 …… 119
8.2.1 连接服务器 …… 119
8.2.2 文档管理 …… 120
8.2.3 数据检查 …… 121
8.2.4 数据入库 …… 122
8.2.5 数据检索 …… 123
8.2.6 数据处理 …… 123
8.2.7 数据导出 …… 125
8.2.8 数据转换 …… 125
8.2.9 数据维护 …… 125
8.2.10 系统帮助 …… 127
8.3 系统实现中的关键技术 …… 128
8.3.1 基于 Clinet/Server 模式的软件结构 …… 128
8.3.2 对象－关系型数据库统管空间数据和属性数据 …… 129
8.3.3 大对象(LOB)数据的数据库管理技术 …… 130
8.3.4 MapGIS 格式数据和 ArcGIS 格式数据集成管理 …… 131
8.3.5 MapGIS 数据在数据库中的无损存取 …… 131
8.3.6 COM 技术在客户端软件中的应用 …… 132
8.3.7 基于数据字典数据检查技术 …… 134
8.4 数据库的安全机制 …… 134
9 矿产资源评价预测系统总体设计 …… 136
9.1 金属矿产资源评价预测系统的设计目标 …… 136
9.2 多元地学数据类型及数据格式 …… 137
9.3 矿产资源评价预测系统总体结构 …… 137
9.4 矿产资源评价预测系统的主要功能 …… 137
9.5 MORPAS 系统开发策略 …… 139
10 常规物化探空间分析方法技术实现 …… 140
10.1 物化探资料数据处理概述 …… 140
10.1.1 物探数据处理任务 …… 140
10.1.2 化探数据处理任务 …… 141
10.2 物化探资料数据处理子系统功能 …… 142
10.2.1 物化探数据处理子系统设计 …… 142
10.2.2 数据预处理模型 …… 144
10.2.3 位场转换与异常分离 …… 146
10.2.4 定量解释模型 …… 148
10.2.5 多元统计分析 …… 148