国家科学技术学术著作出版基金
NFAPST

脉状金矿床深部大比例尺统计预测理论与应用

Maizhuang Jinkuangchuang Shenbu Dabilichi Tongji Yuce Lilun yu Yingyong

郭光裕 林卓虹 编著

冶金工业出版社

国家科学技术学术著作出版基金资助出版
国家自然科学基金资助项目

脉状金矿床深部
大比例尺统计预测理论与应用

郭光裕　林卓虹　编著

北　京
冶　金　工　业　出　版　社
2002

内 容 提 要

本书详尽地论述了脉状金矿床深部大比例尺统计预测理论、方法与应用。全书共分8章，主要论述了脉状金矿床的地质、地球化学特征，金沉淀富集成矿的控制因素，脉状金矿床深部大比例尺统计预测的理论基础，建立了成矿模式，金矿产资源量估计及评价，矿体定位预测方法及跟踪预测。

本书可供从事金矿地质理论研究和地质找矿人员、高等院校相关专业师生参考。

图书在版编目(CIP)数据

脉状金矿床深部大比例尺统计预测理论与应用/郭光裕等编著.—北京:冶金工业出版社,2002.7

ISBN 7-5024-3005-9

Ⅰ.脉… Ⅱ.郭… Ⅲ.脉金矿床-区域-地质调查-统计预测,比例尺 Ⅳ.P618.510.8

中国版本图书馆 CIP 数据核字(2002)第 026771 号

出版人 曹胜利 (北京沙滩嵩祝院北巷 39 号,邮编 100009)
责任编辑 王之光 美术编辑 熊晓梅 责任校对 符燕蓉 责任印制 李玉山
北京鑫正大印刷有限公司印刷;冶金工业出版社发行;各地新华书店经销
2002 年 7 月第 1 版,2002 年 7 月第 1 次印刷
787mm×1092mm 1/16;14.25 印张;341 千字;205 页;1-1000 册
38.00 元
冶金工业出版社发行部 电话:(010)64044283 传真:(010)64027893
冶金书店 地址:北京东四西大街 46 号(100711) 电话:(010)65289081
(本社图书如有印装质量问题,本社发行部负责退换)

序　言

社会的可持续发展要求有可持续供给的矿产资源为其提供保证。人们一直关注作为不可再生资源的各类矿产资源现有储量的保证程度和采取何种措施提高这种保证程度的问题。一个严峻的客观事实是现有的许多大中型矿山都不同程度的面临资源危机。有人预测，我国现有147座大型矿山，到2010年将消失50%以上，到2020年将消失80%。这不仅会造成矿产资源供给的紧张，而且还将使大量国有资产流失和带来大量的失业人员。为了缓解矿产资源供给的紧张形势和满足21世纪对矿产资源的新要求，应积极开展国土资源大调查，努力寻找新矿床，开发和建立新的矿物原料后备基地；积极开展非传统矿产资源的发现与开发研究，寻求新型的接替资源和建立新型的资源产业；积极开展国际合作，开拓国际矿业市场，充分利用国外资源等都是重要的、可取的措施。与此同时，还应积极开展现有生产矿山周边和深部地质勘查工作，发现新资源，获取新储量，延长矿山寿命，焕发矿山青春也是十分重要的，而且是具有更大的社会和经济效益的工作。

在貌似资源已经枯竭，甚至面临闭坑危机的老矿山开展地质勘探工作，从中发现新资源、获取新储量的潜力是很大的。首先，已知矿山，特别是大型矿山所在区，在地质环境上都位于有利成矿的地质异常区，在成矿环境上代表着金属或其他有用矿物的富集区。这种大型的含矿地质异常区不仅具有巨大的成矿潜力，而且具有以其综合地质、地球化学及地球物理特征为基础的成矿多样性，表现为以某种主导成矿元素为中心、多种相关元素配套、在不同地质环境和不同地质演化阶段而构成的复杂成矿谱系。现在一些生产矿山所开采利用的主要矿床(矿体)可能只是整个成矿谱系中的一部分“成员”。“就矿找矿”之所以经常奏效，“多层楼式”的不同矿种、不同成矿类型和不同形态类型矿化时空组合与配套之所以屡见不鲜，恰是这种成矿多样性和配套性的明证。从这个角度说，在已知生产矿山不仅具有扩大已知类型矿床的潜力，而且还具有发现新类型矿床的前景。

其次，从我国金属、非金属矿床目前勘探和开采的深度而言，发现新矿床(矿体)、探获新储量的潜力也是很可观的。据报道，南非兰德金矿一竖井将加深至4117m，这将是世界上最深的矿井。在俄罗斯，黑色金属矿石平均采矿深度为600m，有色金属矿石平均开采深度为500m，但许多已超过1000m，将来可达1500～2000m。已探明的三分之一以上的铜储量，几乎所有的镍、钴，大部分铝土矿、金刚石、金、优质铁矿及磷矿的开采深度将大于1000m。其他国家的采矿

深度：加拿大2000m，美国3000m，印度最深达3500m。而我国绝大多数金属矿床开采深度不足500m。在我国，埋深大于500m的矿床被称为“大深度矿床”，目前还很少勘查和评价。但在已知生产矿山，充分挖掘矿床浅部的勘探和开采资料信息，充分利用已有的采矿和探矿工程，特别是以创新性的成矿地质环境分析为基础，以新理论、新技术、新方法为指导和手段，努力获取新信息，形成对成矿和找矿的新认识，再以新的勘查工程进行追踪和验证，则扩大矿山成矿远景，延长矿山寿命，甚至获得找矿勘探工作的新突破都是完全可能的。

由郭光裕、林卓虹编著的《脉状金矿床深部大比例尺统计预测理论与应用》一书正是作者多年来在山东招掖金矿化带、云南腾冲-梁河热泉型金矿分布区进行矿区外围及深部矿体定量定位预测理论与实践的总结。作者采用多学科理论与方法的综合研究手段，全面分析脉状金矿床地质、地球化学、数学地质特征，成矿机制和控矿因素，并建立矿床和矿体成矿模型。在此基础上，提出了一套矿床深部矿体定量定位预测理论、预测工作途径及定量定位预测方法。其中，有一些方法，如模糊聚类分析法、欧氏距离分析法、波的分解与合成方法等是作者在预测工作实践中创建的，具有很大的实用性。

最近，作者领导的一个科研组在玲珑金矿田深部成矿定位预测及开采技术条件研究中，应用上述理论和方法对地表以下370～1080m深处开展矿体定位预测，确定了21个成矿远景区段。有关矿山对其中的18个投入资金1615.59万元进行探矿（投入坑探工程4256m，钻探工程29749.8m），结果有17个见矿（见矿率达94%），探获D+E级储量18147.61kg。其中的9916.87kgD级储量创潜在价值74082万元，经济效益总额4826万元。应该说，这是本书作者与该区矿山地质工作者共同努力进行生产矿山深部预测找矿的一次十分有益的实践，实现了在新深度上取得找矿的突破。这一实践再次表明老矿山发现新资源的巨大潜力，也证明了本书所述预测理论、预测方法的正确性和实用性。这是本书在当今找矿勘探新形势和新要求下具有重要启示作用和指导作用的价值所在。

“深部找矿”还是一个较少涉足的半处女地，然而在老的生产矿山开展深部找矿已是当务之急。但愿今后在这方面涌现出更多的新成果，为满足21世纪对矿产资源的新需求，为丰富和发展我国成矿预测和找矿地质理论与方法做出更大的贡献。

赵　鹏　大

2000年8月5日于北京

前　言

当今世界上的矿产大国,矿业开发深度多数在千米以上。印度的科拉尔金矿开采深度已达3000m以上。在南非,最深的金矿井已达4117m。而我国对于固体矿产的开发利用,多数局限于地下500m以上的浅部空间。经过长年开采,上部矿产资源大幅度减少。至2010年,由于我国主要矿种的大多数主干矿山将面临资源危机,因此探寻、开发深部矿产资源工作势在必行。作为深部找矿工作的一个重要环节和前驱,需要开展深部大比例尺矿床预测。该工作是在三度空间上对矿床进行的立体预测,是在深部预测区地质情况不确知的条件下,估计矿产资源量和矿体空间位置的工作。该工作通常隐含着两种不确定性:一是根据现有控矿地质条件推断类比所得出的深部预测区有矿无矿结论是否为真;二是在有矿条件下,根据现有成矿条件与矿床值的推断类比所得出的矿产资源估计量和矿化空间位置是否确切。这两种不确定性构成了矿床预测工作的风险。不难想象,这种风险是极大的。由于难度太大,至今尚无较成熟和较系统的理论与方法解决该问题。本书作者提出一套较系统的、行之有效的深部大比例尺统计预测理论和方法,为我国21世纪势必开展的深部矿产资源开发工作做出贡献。

从20世纪80年代中期开始,本书作者就通过实际金矿带、金矿田、金矿床、金矿体的研究工作,开展脉状金矿床深部大比例尺统计预测理论和方法研究。先后开展了"招掖金矿化带地球化学异常(次生晕)致矿性数学地质评判"、"山东招远玲珑108矿脉矿床统计预测"、"云南腾冲-梁河地区现代热泉型金矿床成矿模式及成矿远景评价"、"龙口地区金矿控矿地质条件、找矿方向研究及105矿床深部及外围找矿前景评价"、"山东招掖金矿带金矿成矿模式和资源评价"等项目的系统研究工作。在此基础上,在国家自然科学基金委员会资助下,开展了"脉状金矿床深部大比例尺统计预测理论和方法研究"的课题。采用了多学科理论方法的综合研究手段,全面地总结了脉状金矿床地质、地球化学、数学地质特征,成矿机制,主要控矿因素,建立了成矿模式。在此基础上,提出一套矿床深部矿体定量定位预测理论,系统完整地阐明了预测工作途径和矿体定位预测方法。以此为指导,进一步开展"玲珑金矿田深部成矿定位预测及开采技术条件研究"项目。其中的一个目的是检验研究所得矿床深部大比例尺统计预测理论和方法的正确性、实用性。其间,改进了波的分解与合成技术,建立了一组波形分布数学模型,用该模型能够定量地把控矿地质标志向深部推测,从而实现了定量定位地预测深部空间地质环境。作者在上述一系列研究工作成果基

础上，编写了此书。

全书共分8章。第1章是脉状金矿床的地质特征。框定了脉状金矿床的含义。阐述了脉状金矿床空间分布特征、脉状金矿床矿化的时空特点、金矿体特征等。指出，脉状金矿床受区域上分布的断裂构造控制。控矿的断裂构造规模大，发育时间长，具有继承、间断，频繁活动特点。1级构造控制矿化带的分布，2级构造控制矿田的分布，3级构造控制矿床的产出，3级构造内部致矿构造异常及更次级构造控制矿体的产出。矿脉具有垂向分带、水平等间距分布及多期、多阶段不均匀矿化特点。矿体的成生受构造结构面控制，按一定方向和角度向下多层等间距侧列分布。

第2章是脉状金矿床金矿化地球化学特征。内容包括金的统计分布特征及其研究方法；金矿化最佳地球化学标志组合及其研究方法；金矿化元素地球化学模型；金矿体原生晕及其研究方法。指出，金在大多数脉状金矿床中服从多个对数正态分布总体叠加的混合分布，不同的矿化阶段金分布函数不同，金矿化强度差异极大，最佳控矿地球化学标志组合也不同。金矿体原生晕分带规律明显，同一空间上发生不同阶段矿化信息和不同深度矿体地球化学信息的叠加。

第3章是金沉淀富集成矿的控制因素。阐明了金的基本性质；热液迁移循环的主要动力；控制金沉淀富集成矿的构造与围岩因素。指出，热液本身的高温过压性质和构造及构造活动是热液迁移循环的主要动力，也是金矿体成生的主要控制因素。

第4章是脉状金矿床深部大比例尺统计预测的理论基础。阐明了脉状金矿床深部大比例尺统计预测的基本任务、工作性质、工作条件、研究途径。全面系统地探讨了脉状金矿床深部大比例尺统计预测的特点、基本内容及研究工作步骤。指出，开展深部矿体定量、定位预测的研究途径是对地表和近地表处各种工程揭露出来的地质现象，以及应用各种手段和方法(地质的、矿物的、地球化学的、地球物理的、数学地质的)获得的矿化及控矿标志信息进行详细研究，从中提取矿产值的统计分布特征和空间分布规律，建立深部资源定量估计模型，估计预测空间的金矿产资源量，做出是否进一步开展深部探矿的决策。提取最佳控矿地质标志，查明它们的空间变化规律，以这种规律为依据，把标志向矿床深部推测。研究上部已知矿与控矿地质标志之间的内在联系，建立多种数学模型，以推测的控矿地质标志为变量，对深部预测区的含矿性定量评价，确定成矿或聚矿的有利地段。进行“预测-验证-再预测-再验证”的跟踪研究。

提出并论证求异理论，相似类比理论，空间分带理论，波形分布理论，时、空叠加理论，不确定理论。它们是应用本文提出的一系列预测方法的理论依据。

第5章是建立成矿模式。包括金沉淀富集成矿的理论分析；描述性模型；空

间几何模型；构造－围岩异常模型。指出，含金热液是一种过压流体。在中低温条件下，金的硫氢化物络合物是金在热液中迁移最重要的形式。异常事件（构造活动、围岩变异）的发生是促使热液物理状态发生改变，金硫氢化物络合物解体，金沉淀富集成矿的重要机制。强调成矿模式必须反映矿体的形成机制、控制因素、空间分布特征。通过实例阐明了金矿体的描述性模型，空间几何模型，构造－围岩异常模型。

第6章是金矿产资源量估计及评价。包括金矿产资源量估计的理论与方法，预测区进一步找矿工作的统计决策等。阐明了体积估计法，矿石品位-矿床规模经验估计模型法，齐波夫分布律估计法，矿产值历史资料估计模型法等金矿产资源量估计的方法原理、理论基础、数学模型、应用条件及实例。指出，为减少风险，应通过经济价值、找矿效益和开发风险的综合分析，对预测区进一步找矿工作做出统计决策。为此，需要调整好开发成本、找矿概率、期望价值三者的关系。

第7章是矿体定位预测方法。内容包括异常地质环境类比法；空间分带模型法；矿床模型法等。在异常地质环境类比法中，用实例阐明了研究途径，研究内容，预测范围和预测单元的划分原则，控矿地质标志确定和取值方法。介绍了一系列单元含矿性评判数学模型。其中，本书作者创建的欧氏距离分析法不但能精确地评判“矿”与“非矿”，而且能检验模型单元的代表性，发现新的矿化类型。本书作者还以波形分布理论为依据，创造性地改进波的分解与合成技术，建立了一组波形分布模型，实现了深部预测区地质环境的定量定位推测。阐明了矿体有利赋存空间划分原则。在空间分带模型法中，介绍了矿体空间分布找矿模型和地球化学标志值空间变异模型。前者是根据矿体在矿脉中沿一定方向和角度向下多层等间距侧列分布规律建立起来的。后者是根据矿体原生晕垂向分带规律建立起来的。包括“矿”与“非矿”的识别模型和样品相对于矿体空间位置估计模型两大类，7个具体的数学模型。此外，还给出了矿物包体信息空间变异模型和黄铁矿形态标型空间变异模型。用实例介绍了矿床模型法。指出，矿体定位预测是对矿床及其外围深部矿体赋存空间位置的预测。一般情况下，深部预测区地质情况是不确知的，只能根据地表及近地表处工程揭露的地质现象，以及地质现象显现的空间分布规律向深部推测。在实际预测中，应根据具体的矿床特征、控矿因素、资料状况、工作条件等选择合适的方法进行。

第8章是跟踪预测。对深部大比例尺统计预测工作性质、工作条件分析后指出，通过一次预测，很难达到矿体精确定位目的。应把深部矿体定位预测看作一项不断深化的跟踪找矿研究。根据初始预测结论，进行工程验证。用验证所获深部预测区地质与矿化信息，检验各种推测标志状态的合理性。并以其为

依据。重新对控矿标志在深部预测区各点上的状态进行推测，重新开展定位预测。对深部预测区多次"预测-验证-修订预测方案-再验证"后，必然会取得好的找矿效果。本章以108矿床的深部预测为例，说明了跟踪预测的必要性和具体做法。

本书所述脉状金矿床深部大比例尺统计预测理论和方法，是依据我国目前矿山开发状况和深部预测工作条件提出来的。如果条件允许，在预测工作中能补充少量必要的工程，开展详细的地质、构造、矿物、地球化学观测和取样，以及系统的化探、物探工作。对构造-围岩异常、标型矿物异常、地球化学异常、地球物理异常，以及矿体空间分布规律等进行综合研究，开展多种找矿手段、多信息、多方法的深部统计预测，必然会取得更好的预测效果。因条件所限，我们具体进行的几个矿床的深部统计预测工作，没有一个能达到上述"以必要的工程相配合……"水平。

本书的第1至第3章、第8章由林卓虹撰写，第4至第7章由郭光裕撰写，全书最后由郭光裕负责汇编审定完成。

参加各个项目的其他研究人员有朱学文、丛桂新、张俊芩、白宇辉、陈瑞、郭万超、吴贺军、康慧、马力、韩秋芬、武际春、刘永堂、哈本海、戴立新、刘维民、刘建强、张玉森、高广军等。本书的每个章节都反映了他们的智慧和劳动成果。在此，本书著者向他们表示崇高的敬意！本书的诞生和出版得到国家自然科学基金委员会、国家科学技术学术著作出版基金委员会、国家黄金管理局、冶金部地质局、冶金部天津地质研究院的资助。中国科学院院士、中国地质大学教授赵鹏大，中国科学院地质研究所研究员刘承祚，北京科技大学教授侯景儒，冶金部天津地质研究院教授黄佳展，中国地质科学研究院地质所研究员柴耀楚和矿床所研究员陈文明等审阅了本书初稿并提出宝贵的意见。赵鹏大院士又为本书作序，高级工程师李永明为本书翻译英文目录和前言。在此，本书著者向他们表示衷心的感谢！我们热忱希望本书的出版能对从事地质工作的科技工作者有所裨益，并欢迎对该书不足之处予以指正。

作　者

1999年8月

INTRODUCTION

Ores are being mined to depth more than 1000m in some countries. In Kolar gold mine of India mining depth is over 3000m and it reaches 4117m in South Africa. China mines her solid ores only within depth of 500m so as to confront resource crisis in many of her mines till 2010. It is imperative to make projects for ore search, exploration and development to more depthes. Prediction of deep ore bodies at large scale is the prerequisite for such projects foreseeing the ore bodies in three dimensions and estimating location and volume under uncertain geological condition at depth. The predition includes two uncertainties. The first is the authenticity of conclusion drawn from inferring and correlating the known ore-controling geologial conditions at shallow to depth. The second is the definiteness of mineral resource volume of spatial location of ore bodies within the predicted area estimated by inferring and correlating. No theories and methods have been matured and systemized for the prediction up to now thus it is doomed to take risks and face many difficulties. The authors attempt to devote a series of prediction theories and methods in this book to next century's mineral resource exploration and development to more depth in China.

Since 1980s the authors have been working at researches on theories and methods of large scale statistical prediction for Au ore belts and fields in China. Projects have been completed, such as "Mathematical Judgement of Ore-Causing Geochemical Anomlies (secondary halo) in Zhaoye Au ore Belt, Shandong Province", "Statistical prediction for No. 108 Ore Vein in Linglong Au Mine, Shandong Province", "Metallogenic Model and Prospect Appreciation of Modern Hot Spring Type Au Deposit in Tengchong-Lianghe Area, Yunnan Province", "Research On Au Ore-controlling Conditions of Longkou and Prospecting Directions and Prospect Assessment at depth and in the surroundings of 105 Au Deposit", "Metallogenic Model and Au Mineral Resource Assessment of Zhaoye Au ore Belt". According to results of the projects Scientific Fund Organization of China supported the authors to carry out the program "Research on Theories and Methods of Large Scale Prediction of Deep Quartz Vein Au Deposit". The researches mentioned above adopted and integrated multi-disciplinary theories and methods summing up geological, geochemical and mathematical characteristics, metallogenic mechanism and main ore-controlling factors of quartz vein Au deposits and establishing the metallogenic model. A set of prediction theories for quantitative volume and location of deep ore bodies is put forward and the methodology is systemized on basis of the characteristics, factors and models. Then the theories and methods were applied to the program "Study on Locality Prediction of Ore Bodies at Depth and Technical Condition of Mining in Linglong Au Ore Field". Their practicity and validity are cheked and proved by the program and the decomposition and composition technique of wave is improved. A mathematical model for a set of morphological distribution of wave is established.

By using the model the known ore-controlling marks can be quantitatively inferred to depth and the unknown geological setting can be predicted quantitatively and localizably. This book is based on results of the mentioned above researches.

This book includes 8 chapters. The first summs up geological characteristics of quartz vein Au deposit and gives description to the the deposit. The spatial and temporal distribution and ore body features are described. Such deposit is controled by regional faults which are characterized by large size, multi-staged and intermittentely and prolongedly inherited movements. The faults related to ore occur in varied sizes. Au mineralization belts are controled by the first class fault; Au field, by the second class; ore deposit, by the third class. Au ore bodies are controled by ore-causing structural anomalies and sub-faults related to the third class. Ore veins show vertical zonation and horizontally equal distant distribution pattern, multi-staged uneven mineralization. Downward ore bodies occur in array which includes parallel ore bodies in different layers plunging in the same direction and at the same angle. The ore bodies are genetically related to structural planes.

The second chapter deals with geochemical characteristics of quartz vein Au deposit including statistical distribution characterisics and the research methods, the optimum geochemical mark's association and the research methods of Au mineralization, element geochemical model, primary halo of ore body and the research method. Gold distribution in most quartz vein Au deposits is coincided with the mixed population of multi-overprinted logarithmic normal distribution. Ore-forming stages are varied in gold distribution function, the optimum association of ore-controlling geochemical marks, especially in the mineralization intensity. Primary halo of ore bodies is clearly zoned. Mineralization informations of different ore-forming stages and geochemical information overprint or ore bodies at different depth appear in the same space.

The third chapter is concentrated on factors which control gold precipitation and enrichment to ore. Here is expounded the nature of gold, convecting dynamics of hydrothermal fluid and relation of gold precipitation and enrichment to structures and wallrocks. High temperature and overpressure of hydrothermal fluid, structures and their activity lead to fluid convection thus they are the main factors governing formation of ore bodies.

The fourth chapter lays theoretical foundation for large scale statistical prediction of deep quartz vein Au ore deposits. The nature, condition, methodology and tasks of the prediction are defined and the pediction characteristics, contents and steps are discussed systematically. Detail investigation and study of geological phenomna naturally and artificially exposed at surface and subsurface, ore-controlling and mineralization mark informations obtained from geology, mineralogy, math geology, geochemistry and geophysics are the only way to predict volume and location of deep ore bodies. During the investigation and study statitical distribution and spatial distribution pattern of mineral resource values are picked up and a model is established to make quantitative estimation of deep mineral resource within the predicted space. Then it would conclude if the localized prediction of deep ore bodies goes on. The optimum ore-controlling geological marks are extracted and their spatial variation pattern is acertained then infer the marks to depth. Study of internal relation between the known ore bodies and the ore-controlling marks gives rise to several mathematical models which use ore-controlling geological marks as variables to appraize ore-bearing property of the predicted areas at depth and locate ore focus. Tasks of the prediction is completed in a way of prediction-verification-reprediction-reverification.

In this book are described the theories, such as analogy, geo-anomlies extraction, spatial zontion, distribution of wave morphology, temporal-spatial overpint and uncertainty on which theories and methods of the prediction are based.

The fifth chapter deals with metallogenic model. The mechanism of gold precipitation and enrichment is discussed. Descriptive, spatialy geometric model and structure-wallrock anomly model of gold ore deposit are established. Gold-bearing fluid is an overpressure hydrothermal fluid by which Au sulhydryl complexes are transported at medium-low temperature. Anomly events(structural activity, wallrock variation etc.) are the main factors to change physical states and lead to decomposition of gold sulhydryl complexes and gold enrichment. The chapter stresses that formation mechanism, controlling factor and spatial distribution characteristics of ore bodies must be reflected in the metallogenic model. Descriptive model, spatial geometry and structure-wallrock anomly of ore bodies are examplified by some cases of quartz vein Au deposit.

The sixth chapter discusses estimation and assessment of gold mineral resource including the estimation methods and statisticaly-made decision for further exploration. Theories, principles, math models and application conditions of the methods, such as volumetric estimation, empiric estimation model of ore grade and size of ore deposit, estimation of Zipfs Law, estimation of historic resource values are elaborated and the estimation is examplified by known gold deposits. In order to reduce risk the statistically-made decision for further exploration in predicted areas must be based on analysing of ore development cost, ore discovery probability and the expectation value.

The seventh chapter elboates prediction methods for locating ore bodies, such as analogy of anomly geological settings, spatial zonation model and ore deposit model. For the analogy of ore-causing anomly geological settings the ways, contents, limits of prediction and division principles of prediction cells and determination of ore-controlling geological marks and their vlues are described by known gold deposits. Math model for discriminating ore-bearing property of a serial cells is introduced. And Euclidean distance analysis method is invented which does not only make accurate discrimination of ore and non-ore but also check the representiveness and discover new mineralization type. Elaboration is made to the infering method for state of optimum ore-controlling geological marks in the deep predicted area. According to the theory of morphological distribution techniques for wave decomposition and composition are improved innovatively and a distribution model of a serial waves is established thus the quantitative and localizable infering of the geological setting for the predicted area at depth is realized and classification principles for favourable spaces in which ore might occur is defined. The spatial zonation model is introduced including ore-searching model of orebodie spatial distribution and spatial variation model of geochemical mark's values. The former is based on the ore distribution pattern that ore bodies in a vein occur as an array in which ore bodies located in different layers are horizontally in equal distance and plunge in the same direction and at the same angle; the later, on vertical zonation in the primary halo of gold deposits. Alltogether, seven math models for discriminating ore and non-ore and estimating the distance of samples which are collected to indicate ore body to the predicted ore bodies and models of spatial variation of fluid inclusion data and typomorphic facies of pyrite are introduced and taken into acount. The model methodology is exampli-fied by the known gold deposits. Localizable prediction of ore body is to forecast the possible spaces at depth and in the surroundings of the known ore deposit in which ore bodies might occur. Generally, geology of the deep area predicted is uncertain and it can be only infered on basis of geological phenomina exposed at surface and sub-surface and their spatial distribution. In practice the prediction must be carried out by choosing proper methods according to particular features, ore-controlling factors and availability of data of the ore deposit concerned.

The eighth chapter describes continuous predictions followed one by one. One prediction can not achieve the goal of accurate location of deep ore bodies. Conclusion of the primary prediction is checked by exploration engineerings. In turn results obtained from the engineerings of the predicted deep areas is used to check resonableness of state of the infered marks. The reasonableness is applied to infer state of ore-controlling marks at each point of the predicted deep area thus to repredict location of the unknown ore bodies. The deep prediction at large scale is completed in a process of "prediction-check-revision-prediction-recheck". Deep prediction of No. 108 ore deposit is a successful example showing necessity of the continuous prediction.

Theories and methodology mentioned above are drawn from the present situation in China. Explorational engineerings are recommended to the prediction. The engineering can reveal geology and structures and mineralogical and geochemical samples can be collected and comprehensive study of structure-wallrock, typomorphic mineralogy, geochemical and geophysical anomlies and spatial distribution pattern of ore bodies can be done. Muti-disciplinary data and methods must result in fruitful prediction. Prediction carried out by the authors for several gold deposits are not so completely done as mentioned above. However, the results are ok.

Participants of the projects and progras mentioned above are Zhu Xuewen, Cong Guixin, Zhang junling, Bai Yuhui and Chen Rui. Each of them makes contribution to the book. The authors take oppertunity of publication of the book to express the highest respect to them. Publication of the book is subsidized by China National Science Fund Commision, China Gold Bureau and Tianjin Geological Academy. Zhao Pengda (academian of Chinese Academy of Sciences, professor of China University of Geoscience), Liu Chengzuo (research fellow of Geological Institute of Chinese Academy of Sciences), Hou Jingru (professor of Beijing Scientific and Technological University), Huang Jiazhan (professor of Tianjin Geological Academy), Cai Yaochu (research fellow of Geological Institute of Chinese Academy of Geology and Mineral Resources) and Chen Wenming (research fellow of Ore Deposit Institute of Chinese Academy of Geology and Mineral Resources) go over manuscript of the book; Professor Zhao Pengda writes preface for the book; Li Yongming translates the introduction into English. Here the authors are sincerely grateful to them for help. Criticism is wellcome to the book.

目　录

CONTENT