东北地区尘暴研究

DONGBEI DIQU
CHENBAO YANJIU

介冬梅 胡 克 陈 兵 著

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序

当强风袭来，飞沙走石，天昏地暗，空中弥漫着尘埃，此时不仅空气污浊，还会严重地破坏生态环境和建筑设施，干扰交通，给人类社会带来很大的灾难。这就是人们常说的沙尘天气，一种常见的气象灾害。沙尘来临时，风力大小不同，空气中夹杂沙土浓度不同，进而产生的能见度也不同。据此，沙尘天气可分为浮尘、扬沙、沙尘暴和强沙尘暴四个级别，最严重的强沙尘暴天气，其水平能见度小于500米。

沙尘暴与气候和生态环境密切相关，强风是沙尘暴产生的动力，沙土是沙尘暴的物质基础。一旦气候干旱，地面裸露，就会为沙尘暴创造条件。我国北方地区，从西向东，沙漠一个接着一个，从新疆的古尔班通古特沙漠和塔克拉玛干沙漠，到内蒙古的毛乌素沙漠和科尔沁沙地，都是沙尘暴频繁发生的地区，其影响范围远远超出沙尘暴的源区。研究沙尘暴的发生、发展及其影响，从源头上找到沙尘暴产生的机理和防治措施，对于减少沙尘灾害、保护生态环境有着重要的意义。

由介冬梅、胡克等撰写的《东北地区尘暴研究》一书是他们对东北地区尘暴长期研究的成果，该书内容丰富，资料翔实，提出了碱尘暴的新概念，全面论述了该地区沙尘和碱尘及其气溶胶的物质成分特征和物质来源、发生机理和分布规律，并以长春市为例，阐述了远源气溶胶对城市生态环境的影响，提出了防治沙尘的措施，对认识和防治沙尘灾害很有启迪。更可贵的是，该书作者都是中青年科学家和学者，他们多年来一直潜心于条件恶劣的荒漠调查和沙尘监测研究，付出了许多艰辛。如今，他们的艰辛结出了丰硕的成果，我为他们高兴，并祝愿他们的成果早日为广大读者分享，祝愿他们在今后的工作中取得更大的成就。

中国科学院地质与地球物理研究所

2010年11月8日

前　言

沙尘暴作为一种灾害性的天气，它的频繁发生是地球系统各个组元要素相互作用、反馈耦合的结果。其中，人类活动作为地球系统的一个子系统，已经随着物质文明程度的提高，越来越强势地介入沙尘物质的循环之中，并在沙尘暴的频发中扮演了重要的角色。

2000 年春季以来，沙尘暴以其发生频率之大、强度之高、影响范围之广和影响程度之深受到我国党和政府及科学界的高度重视。沙尘暴的频发不但直接影响交通、通信、电力等国民经济各个部门，给人类的生命财产、生活秩序和健康状况造成极大的威胁，而且对我国乃至全球的生态安全和经济的可持续发展也带来了深刻的影响。沙尘物质在传输和沉降过程中通过影响太阳辐射和云的形成，影响地表能量的收支平衡和水分循环，对气候的长期和短期变化产生重要影响。同时，沙尘暴通过影响光合作用改变海洋生物的初级生产量，影响营养元素的循环，通过影响深海沉积改变生物地球化学循环。此外，沙尘暴对土壤层的形成和发育具有相当大的破坏作用。

我国北方是沙尘暴频繁发生的地区之一，以我国北方沙漠化土地为主的亚洲沙尘源区是全球四大沙尘源区之一，是我国、东亚乃至全球沙尘暴的重要来源地。其影响范围已跨越我国东部海域，直达我国台湾、韩国和日本，因此，我国政府、和日本及韩国政府对此十分关注，分别设立了国家“973”项目、中国科学院重大基金项目和中国科学院知识工程创新项目，以及中日韩三国联合资助项目。由中国科学院地球环境研究所等多家单位组成的课题组对亚洲气溶胶粉尘开展试验研究，以期确定亚洲粉尘源区具体的空间分布、粉尘向邻近区域的传输动力过程、不同气候状况下的输送方式，以及通过对亚洲粉尘释放量的估算评价其对区域、半球甚至全球的贡献能力。

为了获得气溶胶粉尘的试验样品，沙尘暴形成机制及预报、预警方法课题组在中国北方沙漠区自西向东的塔克拉玛干沙地、腾格里沙地、毛乌素沙地和科尔沁沙地分别建立了 4 个大气气溶胶观测站，安放气溶胶的接收仪，动态采集气溶胶的粉尘样品，开展不同沙地粉尘贡献率的研究。

东北平原西部的科尔沁沙地是中亚沙漠带的最东部边缘，其沙漠化的面积大、程度重、速度快，在该区域设立沙尘地面监测站对于亚洲沙尘的研究十分重要。

科尔沁沙地地处东北平原西部，属于松花江和西辽河流域，为我国北方农牧交错带的北段。该区为温带亚湿润季风气候区，生态环境十分敏感，既具有脆弱性，又具有可恢复性。近年来，草原沙化、草场退化和土壤盐碱化造成地表植被覆盖度迅速降低，土壤风蚀严重，这些都与人类的活动密切相关。目前，已有的沙尘暴研究很少涉及东北地区，对于碱尘暴这种东北地区特殊的尘暴类型，还没有开展研究工作。因此，对东北平原区沙尘暴和碱尘暴粉尘的物质组成特征、粉尘贡献能力的研究是必要的，也是迫切的。东北地区是

沙尘影响区，既是沙尘的汇同时也是沙尘的源。通过地面监测站系统采样和测试，可以更好地了解东北地区沙尘源地的气溶胶物质的粒度特征、矿物成分、元素构成等物质特征，建立系列化的沙尘源地谱系，研究沙尘来源。同时，也可以了解沙尘暴的时空演变规律，对沙尘暴演变的未来趋势实施预测，可以弥补沙尘影响区作为沙尘源研究的空白。此外，结合地表沉积物特征的研究，开展不同土地类型的粉尘贡献率研究，探讨人类活动对沙尘暴的影响，明确东北地区沙尘暴形成的机制。上述研究对于区域尘暴预警和防治具有重要的现实意义，碱尘暴概念的提出及其系统研究对于沙尘暴的分类研究也具有十分重要的理论意义。我国是黄土广布的国家，黄土的堆积与风沙活动密切相关，现代沙尘暴的物源、路径和沉积过程的研究，对于我国黄土形成机制的研究也具有重要意义。

东北平原沙尘暴和碱尘暴的研究工作自 2001 年春季开始，历时 3 年，在收集有关资料的基础上，曾进行 3 次区域野外考察和两次典型区调研，建立了东北平原区降尘监测网络。2002 年 2 月，吉林大学与中国科学院地球环境研究所在内蒙古通辽科左后旗巴胡塔镇中学联合建立了沙尘地面监测站，实施沙尘的实时监测、记录和沙尘暴漂浮物的收集；同时，根据东北平原沙碱相伴的特殊性，在环保部门和草原站协助下，课题组还在东北平原建立了降尘监测网络和大安碱尘暴地面观测站，开始了东北地区沙尘暴和碱尘暴的系统监测和研究工作。课题组收集了不同地点的降尘样品和气溶胶样品，同时采集了不同土地利用类型和不同地貌部位的表土样品。实验室分析工作包括粒度分析、孢粉分析、X 衍射分析、扫描电镜分析、离子色谱分析等。经课题负责人同意，在课题组成员大力协助下，作者将课题组多年工作成果的精华整理，撰写成书。

本书的研究内容包括 3 个部分：沙尘气溶胶的元素成分、矿物成分、粒度特征、沙尘物质的来源和时空演变规律；提出了碱尘暴的概念，碱尘气溶胶的元素成分、矿物成分、粒度特征、形成因素和时间演变规律；长春市城市远源气溶胶对城市生态环境的影响，城市降尘的时空分布、物质特征和来源及防治对策。

本书是在国家“973”项目和吉林大学共同资助下获得的主要成果。参加该项研究的人员有：吉林大学地球科学学院胡克教授（现为中国地质大学（北京）海洋学院教授）、硕士研究生曹振、陈兵等，东北师范大学城市与环境学院介冬梅（时为吉林大学地球科学学院在职博士后）、中国科学院地球环境研究所张小曳、沈振兴、王亚强等，通辽市环保局白跃华、赵明洁、韩超等。

在项目的前期研究中，东北师范大学的景贵和教授、肖荣寰教授、吕金福教授和中国科学院东北地理与农业生态研究所的裘善文研究员、孙广友研究员等做了大量的工作，取得了丰硕的成果，为本项工作提供了重要的基础资料。在本课题的研究工作中，得到了吉林大学科研处和地球科学学院有关领导和专家的大力支持。长春市环境监测站于连贵、双辽市环境监测站李黎明、白城市环境监测站牟春友、大安草原站等单位和个人帮助收集样品；巴胡塔中学为地面监测站提供场地和电力保障；通辽市水利设计院和自来水公司帮助施工建设地面监测塔。实验室孢粉分析由吉林大学林泽蓉教授完成；元素分析和矿物分析等工作由吉林大学地学部测试中心和东北师范大学测试中心、中国科学院地球环境研究所和名古屋大学环境研究科承担。在此谨对上述单位、领导、专家和朋友的支持与帮助深表

谢意。

东北平原沙尘暴和碱尘暴的研究基础薄弱，目前的研究才刚刚开始，尚不够系统和深入，多侧重于基础性研究，研究成果远远满足不了对于沙尘暴和碱尘暴的预测、预警及防治的要求。由于研究条件和作者水平的限制，错误和不当之处难免存在，还望读者提出宝贵意见。

介冬梅

2010 年 1 月 25 日

Foreword

As a catastrophically climate, the frequent sand storm is the result of interaction and feedback coupling of the elements of the Earth system. Among them, human activities as a subsystem of the Earth system has been improved with the boosted material civilization, more and more powerfully involved in a cycle of dust and play an important role in the frequently-happened sand storms.

Since the spring of 2000, the high frequency, the strong intensity and the wide impact of sand storm, attract the great attention of the Party and the government and the scientific community in China. Frequent dust storms not only directly affect the transportation, telecommunications, electricity and other various national economic sectors, greatly threatening daily life, health, property and social order in people's life, but also have a profound impact on ecological security and sustainable economic development of China and the whole world. The transport and deposition process of dust material affects the surface energy absorb and release balance and the moisture circulation by affecting the solar radiation and cloud formation and then has a significant impact on long-term and short-term climate changes. The sand storm changes marine primary production through reducing photosynthesis, and affects nutrient cycling, and also changes deep-sea sediments by influencing in biogeochemical cycles. In addition, the sand storm is destructive to the formation and development of the soil layer of dust.

Northern part of China is one of the areas sand storm happens frequently. As one of the world's four major dust source areas, Asian dust source area which mainly consists of desertification land in northern China is the causing one of our country, eastern Asia and global sand storm. Its influence has crossed the East Sea of China, directly to Taiwan of China, Korea and Japan. Therefore, our government and Japanese and South Korean government take it seriously, respectively established Some research projects such as the 973 national project, the major fund project and the knowledge engineering innovation project of Chinese Academy of Sciences in China, as well as co-funded project of Japan, South Korea and China. A discussion group of Institute of Earth Environment and some other units of Chinese Academy of Sciences is founded to carry out the pilot study on Asian dust aerosol. Expected to confirm the specific spatial distribution in Asian dust source areas, dynamic processes of dust transportation to the neighboring region, transmission modes under different climatic conditions, and to estimate its contribution to regional, hemispheric and even global world by the evaluation of Asian dust emission.

In order to obtain test samples of dust aerosols, the discussion group sets up from west to east

four aerosol observation stations in northern China desert including Taklamakant sand, Teng Grisa, Mu Us desert and Horqin sand land. With placing aerosol receivers to dynamically collect dust aerosol samples, it carries out study on the contribution rate of different sandy dust.

Horqin sand land is in the west of northeastern China, at the easternmost edge of central Asia desert strip. Its desertification is so large-scale, deep-degree and fast-speed that it is very important to set up a station for supervising dust and sand on the ground in this region for the Study of dust and sand of Asia.

Horqin sand land in the west of the Northeast Plain, belonging to the Songhua River and West Liao River basin, is in the northern part of Agriculture-Pasture Transition Zone in the Northern China. The area is in the temperate sub-humid monsoon climate zone, and the ecological environment there is very sensitive, vulnerable and recoverable. In recent years, grassland desertification, lawn degradation and soil alkalization have caused the rapid decrease of surface vegetation cover and wind erosion of soil more serious, all of which have a close relationship with human beings. So far, little research has been involved in dust storms in northeast China, not to mention research on alkali dust storms as a special type of the Northeast region. It is urgent and essential to do research on the material composition features and dust contribution ability of alkali dust storms and dust storms in the Northeast Plain. Northeast China is affected by sand and dust, where dust and sand get together and originate. Through the sampling and testing of the station for supervising dust on the ground, it is helpful to understand better physical characteristics of the aerosol dust source materials including the size, mineral composition, elemental composition and other characteristics and then to establish serial genealogy of sand and dust sources and to find out the source of them. At the same time, people can understand the spatial and temporal evolution of sandstorm and forecast the dust storm evolution trend in the future, which can implement the blank of research on the region affected by dust and sand as the dust source. In addition, people should carry out different types of land contribution of dust, explore the impact of human activities on dust storms, and make a clear mechanism for the formation of dust storms in northeast China by combining surface sediment characteristics of the study. The above study has the practical significance to the regional dust storm warning and prevention, and the presentation and systematical research of alkali dust storms also plays a very important theoretic role in the study of sandstorm classification. China is widely distributed in the state of loess of which accumulation and sand activities are closely related. The research of modern source, path and process of deposition of dust storms is of great importance to the study of the formation mechanism of loess in China.

The study of Alkali dust storms and dust storms in the Northeast Plain began in the spring of 2001 and lasted three years. Based on the collection of information, we have conducted regional field investigations for three times and typical area studies for twice, establishing dust monitoring network of Northeast Plain area. The ground monitoring stations jointly established by Jilin

University and Institute of Earth Environment of Chinese Academy of Sciences in February, 2002 in Bahuta town middle school in Kezuohouqi supervises and records sandstorm timely, collects dust floating debris, and meanwhile, according to characteristic of sand combined with alkali in the Northeast Plain, our group also founded monitoring network of decreasing dust and Da'an alkali dust storms monitoring station with the help of the environmental sector and the grassland assistance station, which means the start of systematical monitor and research of sandstorms and alkali dust storms in the northeastern China. We have collected dust and aerosol samples in different locations, and also surface land samples from different types of land of different uses and different landscape positions. Laboratory analysis includes analysis of particle size, pollen, X diffraction, scanning electron microscopy, ion chromatography, and so on.

The book contains three parts: about the elemental composition, mineral composition, grain size characteristics of dust aerosol, sources and the spatial and temporal evolution of the material source; about the proposed concept of alkali dust storms, elemental composition, mineral composition, grain size characteristics, causes and the evolution of alkali dust aerosol; about distal aerosol impact on the urban environment, the spatial and temporal distribution, material characteristics and sources and control countermeasures of dust in Changchun City.

This book is the major achievement after a series of activities funded by both 973 Project and Jilin University. Participators in the study are: Professor Hu Ke (School of Ocean Sciences, China University of Geosciences, Beijing), Postgraduates Cao Zhen, Chen Bing, etc. from College of Earth Sciences, Jilin University, Jie Dongmei from School of Urban and Environmental Sciences, Northeast Normal University (used to be a postdoctor in service of College of Earth Sciences, Jilin University), Zhang Xiaoye, Shen Zhenxing and Wang Yaqiang from Institute of Earth Environment of Chinese Academy of sciences, Bai Yuehua, Zhao Mingjie, Han Chao, etc. from Environmental Protection Agency of Tongliao City in Liaoning Province.

In the early studies of the Northeast Plain, Professor Jing Guihe, Xiao Ronghuan, and Lu Jinfu from Northeast Normal University and the researchers Qiu Shanwen, Sun Guangyou from Northeast Institute of Geography and Agroecology of Chinese Academy of Sciences and other researchers have done a lot of work and achieved fruitful results, providing important basic information for the research. In the research, it has been supported by leaders and experts of Scientific and technological Research Division and Da'an Earth Sciences Department of Jilin University. Yu Liangui from Changchun City environmental monitoring station, Li Liming from Shuangliao City environmental monitoring station, Mou Chunyou from Baicheng City environmental monitoring station, Da'an grassland station, and other units and individuals helped to collect samples. Bahuta town middle school provided the space, power and water for the ground stations. Tongliao City Water Resources Design Institute and Water Supply Company helped build the ground monitoring tower. Laboratory Pollen Analysis has been completed by Professor Lin Zerong from Jilin University. Elemental analysis and mineral analysis were charged by the testing

centre of Division of Earth Sciences of Jilin University, the testing centre of Northeast Normal University, Institute of Earth Environment of Chinese Academy of Sciences and Environmental Studies of Nagoya University. Here, we record our warmest acknowledgement to these units, leaders, experts and friends for the support and help.

As the research base of Alkali dust storms and dust storms in the Northeast is weak, the present research is just in the beginning, which is still not systematic and in-depth study of content and more focus is on basic research, and research results are less to meet the need of for forecasting and early warning and control requirements of the dust storms. Due to the limitation of research conditions and understand level of the authors, hope readers to point out errors and irregularities.

Jie Dongmei

2010 - 01 - 25

目　　录