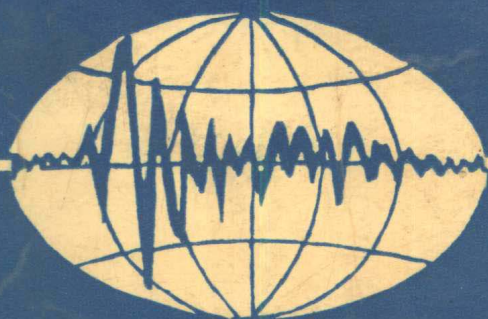


# 中国数字地震台网文集

The Collected Papers on China Digital  
Seismograph Network

中国数字地震台网 编



学术书刊出版社

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## 内 容 提 要

《中国数字地震台网文集》一书记载了中美合作建设中国数字地震台网(CDSN)的全过程并详细介绍了 CDSN 装备和性能以及所获得的新型数据源、CDSN 产出的网日带和事件带的编辑、解调格式和方法。本书还收集了从事数字地震观测研究多年的中外知名科学家在中国数字地震台网验收期间所作的学术报告和开展 CDSN 数据应用研究的建议,供从事地球物理研究的科技人员参考。

## Abstract

Abstract records the whole process of the construction of the Sino-American cooperative project CDSN, introduces in detail its equipments, characteristics, and new type of data source, as well as the method of compilation and playback of the network day tapes. Reports and recommendations for the use of CDSN data in seismological studies by domestic and foreign scientists using digital seismograph observations during the testing period were also collected for the reference of geophysicists.

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特约编辑 朱 詮 徐玉凤 宋文瑞

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# 目 录

前言 .....	(1)
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## 中国数字地震台网文件

中华人民共和国国家地震局和美利坚合众国地质调查局关于列入中美地震科技合作议定书附件一中的中国数字地震台网的原则协议 .....	(4)
中国数字地震台网仪器设备配置方案 .....	(11)
中华人民共和国国家地震局地球物理研究所和美利坚合众国地质调查局阿尔布开克地震实验室的联合报告 .....	(26)

## 中美双方项目主任报告和中外专家及领导的讲话

关于中国数字地震台网建设的报告 .....	(83)
关于中国数字地震台网设备的报告 .....	(90)
国际地震专家组对中国数字地震台网的评审验收报告 .....	(99)
国家地震局高文学副局长在中国数字地震台网双方项目主任汇报会上的讲话 .....	(106)
国家地震局安启元局长在欢迎美国地震代表团及国际地震专家宴会上的讲话 .....	(107)
国家地震局地球物理研究所陈运泰所长在招待会上的讲话 .....	(108)
国家地震局安启元局长在中国数字地震台网剪彩仪式上的致辞 .....	(109)
美国地质调查局副局长迪瓦因博士在中国数字地震台网剪彩仪式上的致辞 .....	(110)
美国高级研究计划局布兰德福德博士在中国数字地震台网剪彩仪式上的致辞 .....	(111)
美国地震代表团及国际地震专家参加中国数字地震台网剪彩及技术验收和访华活动的小结 .....	(113)

## 台网运行测试报告

中国数字地震台网数据采集系统动态范围评价 .....	(116)
中国数字地震台网数据采集系统时间服务精度评价 .....	(126)
中国数字地震台网的事件检测能力 .....	(129)
中国数字地震台网事件检测器的检测情况 .....	(135)
中国数字地震台网台站仪器设备运行及故障情况小结 .....	(143)
中国数字地震台网台站磁带管理 .....	(149)
利用数字地震记录的参数评价台站数据质量 .....	(157)
中国数字地震台网网日带处理软件使用的几点意见 .....	(174)
中国数字地震台网数据处理工作报告 .....	(185)

STS-1 H/V 宽频带反馈式地震计系统的安装技术 .....	(216)
中国数字地震台网资料评价 (1): 对中国数字地震台网记录的几点评论 .....	(223)
中国数字地震台网资料评价 (2): 试用数字台网记录资料报告 .....	(226)
中国数字地震台网资料评价 (3): 数字台网资料使用情况 .....	(228)

## 研究报告和经验交流

中国数字地震台网的传感器系统 .....	(230)
中国数字地震台网的数据管理系统 .....	(260)
中国中部的地壳上地幔构造 .....	(286)
用长周期面波研究华南及华北的地壳上地幔结构 .....	(293)
1987 年台湾地震的体波波形拟合 .....	(298)
中国数字地震台网事件带的解析 .....	(303)
中国数字地震台网微机事务管理系统 .....	(317)
CDSN 报告 (1): 中国数字地震台网在解决地震学问题的潜力简论 .....	(338)
CDSN 报告 (2): 超长周期地震记录的分析 .....	(350)
CDSN 报告 (3): 记录与检波器 .....	(353)
CDSN 报告 (4): 在挪威记录的区域地震信号的分析与研究 .....	(358)
CDSN 报告 (5): 利用 GDSN 资料研究上地幔结构的一些问题 .....	(360)
CDSN 报告 (6): 球面雷当变换及用 CDSN 资料反演三维地球结构 .....	(366)
讨论会小结 .....	(373)
附录: 中美双方参加 CDSN 验收和技术评审会议人员名单 .....	(376)
附图 .....	(378)

## CONTENTS

Foreword .....	(2)
----------------	-----

### **The Documents of China Digital Seismograph Network**

Agreement for the China Digital Seismograph Network under Annex 1 of the PRC-US Cooperative Protocol in Earthquake Studies .....	(7)
Instrumentation Plan for the China Digital Seismograph Network (Appendix 1 of Annex 1) .....	(17)
A Joint Report by Institute of Geophysics, State Seismological Bureau and the Albuquerque Seismological Laboratory, U.S. Geological Survey .....	(49)

### **Speech and Reports by Managers, Experts and Leaders at the Meeting for the CDSN Project**

Report on the Establishment of The China Digital Seismograph Network .....	(86)
Report on CDSN Facility .....	(93)
The China Digital Seismograph Network Evaluation Report by An International Panel Experts .....	(102)
Speech in the Meeting with CDSN Project Managers and Experts Made by Gao Wenxue, Deputy Director of SSB (omitted)	
Speech in the Meeting to Welcome U.S. Delegation and International Seismologists Made by An Qiyuan, Director of SSB (omitted)	
Speech in the Meeting to Welcome U.S. Delegation and International Seismologists Made by Chen Yuntai, Director of the Institute of Geophysics, SSB (omitted)	
Speech in the Dedication Ceremony for CDSN Made by An Qiyuan, Director of SSB (omitted)	
Speech in the Ceremony for the Establishment of CDSN Made by Dr. James Devine, Deputy Director of USGS (omitted)	
Speech in the Ceremony for the Establishment of CDSN Made by Dr. R.R. Blandford of ARPA (omitted)	
Summary of Activities of U.S. Seismological Delegation and International Seismologists during the Acceptance and Ceremony for the Establishment of China Digital Seismograph Network (omitted)	

## **Reports on the Operation and Testing of CDSN**

A Preliminary Evaluation on the Dynamic Range of the Data Acquisition System of CDSN .....	(125)
A Brief Evaluation on the Timing Precision of the Data Acquisition System of CDSN .....	(128)
The Ability of the Event Detection of CDSN .....	(130)
Event Detect Situation of the CDSN Event Detector.....	(139)
A Brief Summary of the CDSN Data Acquisition System Operation and Maintenance .....	(146)
Report on the CDSN Station Tape Management .....	(151)
Using Parameters of Digital Earthquake Records to Evaluate the Quality of the CDSN Data .....	(161)
Some Viewpoints on the Usage of the Network Day Tape Software .....	(179)
Working Report on Data Processing of CDSN .....	(190)
The Installation Technique of the STS-1 H / V Broad-Band Feedback Seismometers .....	(219)
Evaluation for Data Quality of CDSN (1): Remarks on the Reecording sin CDSN.....	(224)
Evaluation for Data Quality of CDSN (2): Report on Preliminary Utilizing CDSN .....	(227)
Evaluation for Data Quality of CDSN (3): Some Results while Using the Data of CDSN.....	(229)

## **Reports on Research and Experience**

Description and Preliminary Testing of the CDSN Seismic Sensor Systems .....	(242)
Data Management System for the China Digital Seismograph Network...	(270)
The Crustal and Upper Mantle Structure in Central China .....	(289)
The Crust-Upper Mantle Structure in North China and South China Regions .....	(295)
Modelling the Body Waveforms of Taiwan Earthquake of Jan. 6. 1987 ...	(300)
CDSN Network Event Tapy Analyse .....	(307)
The Microcomputer General Affairs Management System of the China Digital Seismograph Network .....	(327)
The Potential Capability of CDSN in Seismological Studies .....	(343)
Very Broadband Analyses of Earthquakes .....	(351)
Records and Detectors .....	(355)

Research of Regional Seismic Signal Analysis in Norway (omitted)	
Some Problem Using GDSN Data to Study	
Upper Mantle Structure.....	(362)
Spherical Radon Transform and 3-D Earth Structure	
Inversion with CDSN Data .....	(369)
A Summary of the Symposium .....	(374)
Appendix: People List Who Joined in the CDSN Evaluation Meeting.....	(376)
Figures .....	(378)



# 前 言

1987年10月21日至29日,中国国家地震局(SSB)和美国地质调查局(USGS)联合对中美合作建设的中国数字地震台网(CDSN)进行了验收,由美国、法国、联邦德国、挪威和中国的地震学家们组成了国际地震专家组,对中国数字地震台网进行了技术评审。

此次技术评审和台网验收活动包括:

1. 审查《中国数字地震台网中美联合报告》和台网测试报告。
2. 在台网维修中心、数据管理中心、北京台、兰州台和余山台实地检查了台网硬软件设备的运行情况。
3. 了解数据用户意见,观看中国数字地震台网建设展览和录像,听取中美双方项目主任汇报并执行技术调查,在台网两个中心组织双方台网技术组成员进行技术答辩、操作演示和现场质疑,以深入掌握台网全面情况。
4. 台网验收剪彩后,中外专家还专门进行了学术交流。

中美联合组织的中国数字地震台网的验收剪彩活动较全面地反映了台网的建设情况和技术水平。我们编辑本书的主要目的,旨在介绍中国数字地震台网的建设过程,以便于读者了解情况,总结经验和促进这一新型数据源的广泛应用。

《中国数字地震台网文集》主要由三个部分组成。第一部分收集了建立中国数字地震台网的有关文件,其中包括中美地震科技合作议定书附件一中的中国数字地震台网的原则协议,这是建立项目的依据。其中也包括中国数字地震台网中美联合报告、关于中国数字地震台网的建设报告和关于中国数字地震台网的设备报告,他们反映了协议的执行情况、项目技术设计和所取得的成果。此外,本部分还包括国际地震专家组对中国数字地震台网的技术评审报告以及围绕台网验收活动,中美双方官员和专家的讲话。其内容实际上就是为中国数字地震台网作的结论。第二部分收集了在台网试运行期间所做的测试、技术管理和资料评价报告。其中的测试报告是指对台网部分设备用不同方法所做的补充测试的报告。第三部分为研究报告和经验交流报告。国际地震专家对如何利用数字化地震资料,给予了指导。国外学者的研究报告是根据他们在北京学术交流会上的发言录音整理的。由于录音效果不佳,整理的报告有些地方不够准确,但这些报告对于应用新型数据源开展深入的课题研究是很有启发的。国际专家组成员在兰州所作的学术报告,由于没有录音,未收集在本书中。

《中国数字地震台网文集》、《中国数字地震台网建设纪实》和《中国数字地震台网》录像片是这次验收剪彩活动的总结和记录。它基本上可以反映中国数字地震台网建设阶段的全面情况;当然,还有中美双方技术人员在项目执行过程中早已写出但还未经本国政府批准公布的技术报告,因时间上赶不上出版而未能收集到本书中。我们相信,我们的同行不会因此而责怪我们。我们更希望广大读者能充分利用这一新的数据源开展研究并指导我们进一步改进和完善我们的台网。

本文集在曲克信的直接指导下,由周公威、牟其铎和张伯明编纂完成的。由于时间仓促,不妥之处敬请读者指正。

## FOREWORD

From October 21st to 29th, 1987, the State Seismological Bureau (SSB) of China and U.S. Geological Survey (USGS) jointly examined and accepted the Sino-American cooperative China Digital Seismograph Network (CDSN). An international group of seismologists from U.S.A., France, Federal Republic of Germany, Norway and China appraised technically the China Digital Seismograph Network.

The technical appraisal and acceptance of the seismographic network contains the following items:

1. Examined the Sino-American Joint on CDSN and the Reports on the Testing of the Seismographic Network;

2. Examined on the spot the working condition of the hard- and softwares of the network at the network maintenance center, the data administration center, and Beijing, Lanzhou and Sheshan stations.

3. Listen to the opinions of the data users, visited CDSN construction exhibition, listened to reports from Chinese and U.S. experts taking charge the research item and executed technical investigations—organized technical members of both sides at the two centers to carry out technical reply, to demonstrate manipulation and to query on the spot, in order to thoroughly grasp the overall conditions of the network of stations.

4. After the inauguration ceremony, Chinese and foreign experts exchanged scientific views of the works.

The Sino-American joint group examined the capability of the network. The purpose of the compilation of this book is to introduce the process of construction of CDSN and to sum up our experience, in order to facilitate the users to have a general understanding, and to promote the extensive use of the new tape of data.

This pamphlet "The Collected Papers of China Digital Seismograph Network" is mainly composed of three parts. Documents concerning the establishment of CDSN, including the "AGREEMENT-IN-PRINCIPLE" between the State Seismological Bureau of the People's Republic of China and the U.S. Geological Survey of the Department of the Interior for the China Seismograph Network under Annex 1 of the PRC-US Cooperative Protocol in Earthquake Studies, are collected in Part I. It also contains the Sino-American joint report of CDSN, the report of the establishment of CDSN, the report of the facilities of CDSN, all of them show the implementation of the agreement, the technical

design goal of the project and the achievement obtained. In addition, the technical appraisal of the international specialist group, and the speeches given by officials and experts of both sides during the CDSN check and acceptance are also included in this book. These are actually their conclusions to the CDSN. The 2nd part contains reports of testing during the test-run period of the CDSN, the technical management, and the evaluation of the data quality. The testing reports collected in this part are the supplementary report of some CDSN equipment by using different methods. Part three are reports of exchanging experiences and research papers. Seismologists and experts of the international specialists group gave their valuable suggestions on using digital data in their speeches. Reports of these specialists collected here are produced and translated from tape recordings of their speeches made in a seminar held in Beijing. Some places in these reports are certainly not quite accurate. Still, they will be very helpful to us in the further study using the new type of data. But those speeches made in Lanzhou city by members of the specialist group are not included in this book, because no recording was done during that seminar.

"The Collected papers of CDSN", "Records of Construction of CDSN" and "video recording tape" are the summary and record of the check and acceptance activity. It basically reflects the construction procedure of the CDSN all sidedly. We apologize for not including those technical reports written by Chinese and American scientists and, technicians, which were not yet approved by their respective governments to be published. We heartily hope that the readers will fully utilize this new source of data in their study, and give suggestions for further improvement and perfection of our work.

This book was directed by prof. Qu kexin and completed by Zhou Gongwei, Mu Qiduo, and Zhang Boming. Due to the hurriedly in time, any suggestion concerning the inappropriateness of the book will be gratefully appreciated.

# 中华人民共和国国家地震局 和美利坚合众国地质调查局 关于列入中美地震科技合作议定书 附件一中的中国数字地震台网的原则协议

## 总 则

1. 为了建立可用于多种科学研究的全国性高质量地震数据库，中国国家地震局拟建立中国数字地震台网（以下简称 CDSN）。要求该台网能获得动态范围大、频带宽的数据，具有准确的时间服务、标定数据线性的特点，能长期可靠运转。国家地震局和美国地质调查局（以下简称中方和美方）的目标是对该台网在设计、建造、安装、操作和维修方面进行有效的合作；分享台网资料；并利用该台网资料进行科学研究合作。这些项目将视双方能否连续获得科研经费而定。

2. 该台网将由九套数字地震仪系统、一个数据管理系统和一个台网维修中心组成。全部系统将按照双方同意的“中国数字地震台网仪器设备配置方案”（附录一）进行设计。美方负责执行该仪器配置方案。在项目进展过程中根据双方了解的意愿和需要，设备可能有某些改动，中方有对在发展过程中对该方案所作出的任何必要的重大修改进行审查的机会。

3. 为了便于本项目的实施，双方同意采用联合采购数据系统设备的方法，即其中一方均为每一套数据系统提供部分设备。中方负责购买的设备列于附录一附表 2，根据上面 2 款所规定的条件，美方将购买附录一附表 1 清单中除中方在附录一附表 2 中所购买的设备以外的设备。关于设备所有权管理，中方将承担九套数据系统中的五套，美方将提供其余四套数据系统。双方承担的整个项目（包括数据管理系统和台网维修中心）的设备和软件的费用以及其它必要的初始费用应大致均等。

4. 美方提供的四套数据系统将安装在北京、昆明、兰州和牡丹江，井下摆将安装在兰州地震台。如果上述地点因技术方面的原因不能满足要求，例如背景噪声高，可以选择经双方同意的替换地点。为此，可在所建议的场地进行噪声测试。

5. 资料分享：中方将向美方在基本连续和常规的基础上提供属于美方台站的磁带资料，以及将来经双方同意的乌鲁木齐和其它属于中方台站的磁带资料。另外，中方将在基本连续和常规的基础上向美方提供该台网网日带副本。作为交换，美方将向中方提供全球台网网日带副本。该台网的资料任何一方均可向世界科学界提供。

6. 在该台网提供资料的基础上，可建立包括软件和处理技术的开发、数据分析和基础研究等方面的合作研究项目。

## 中方的责任

1. 中方负责九个台站（包括属于美方的台站）、数据管理中心和台网维修中心的基本建设和准备工作。这些工作包括但不限于诸如土地购买、房屋建筑、山洞或地下室建设、井孔钻凿与准备、道路修建和养护、供电线路的连接以及通讯联络设备的提供和准备等方面的基本工作。

2. 中方承担购买相当于五套数据系统的设备和投资。

3. 中方承担购买数据管理系统的设备和投资。

4. 中方负责整个台网（包括属于美方设备的台站）的连续操作和维修工作，承担有关的中国国内支付的费用。

5. 中方技术人员将与美方人员一道共同参加该台网设备的研制、组装和测试工作。

6. 中方负责在资料到达数据管理中心的 30 天内，或尽快将按总则第 5 款所规定的台站的磁带资料提供给美方。

7. 中方负责承担中方购买的全部设备的运费。

## 美方的责任

1. 美方负责一套示范性数据系统的设计、研制、测试和安装工作及其费用，并向中方提供有关手册、图纸及其它有关的资料。这套示范性设备系统将作为美方提供设备中的一套。中方技术人员将参加这些活动。

2. 美方承担购置另外相当于三套数据系统的设备和投资，其中包括一套 KS36000 井下地震计。

3. 美方将根据附录一的“中国数字地震台网仪器设备配置方案”承担该台网维修中心所需的设备和备件的投资。

4. 美方在部分中方技术人员参与工作的情况下，负责对数据管理系统和数据系统的数字记录部分进行组装和测试，并支持数据系统的数字记录部分在中国运行一年。

5. 美方将参加数据管理系统和属于美方提供的数据系统的安装工作。美方人员负责井下地震计的安装、定向和测试工作，并指导中方人员进行操作。

6. 美方将向中方提供为了进行台网数据检查和网日带汇编工作所必需的全部软件。所提供的软件功能基本上与美国地质调查局在阿尔布开克地震实验室进行全球数字地震资料处理时所用软件的功能相同。对台网数据管理和处理所需的软件，美方也将给予协助，因为这些软件可用于资料管理中心。

7. 美方将负责对向美方提供磁带资料的台站提供其常规运行和维修所必需的全部备件和消耗品。此外，并应提供足够的磁带，以便能把从中方送往美方的资料复制二份，一份送交美方，一份留给中方。

8. 美方负责承担由美方购买的全部设备的运费。

9. 美方同意作为中国仪器进出口公司为中方购买设备的执行合同代理人。此项具体协议详见附录二。

## 执 行

1. 本项目合作计划在协议生效后即开始执行。
2. 美方即开始示范性数据系统的研制工作，并经双方鉴定，应于 12 个月内在 中国安 装。
3. 美方将协助中方立即开始数据管理系统的购置工作，当交货日期确定后，美方将 着手承办数据管理系统的软件的开发工作。数据管理系统应在 11 个月内在 中国安 装。
4. 中美双方根据经双方同意的仪器设备配置方案，开始数据系统和台网维修中心所 需设备的购置工作，以期在大约 24 个月内使整个台网安装完毕并投入运行。
5. 示范性数据系统、数据管理系统和数字记录仪将在美国阿尔布开克地震实验室进 行组装和测试，但整个数据系统的总装和联调将在中国进行。
6. 中方技术人员的培训和参加工作的时间，将在示范性数据系统和数据管理系统的 订购合同生效以及厂家交货日期确定后开始安排。

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注：1. 原则协议中关于中国数字地震台网的简称，在中美双方签署的正式协议文本中用 ZSTW，由于在项目执行中， 各种文件均采用 CDSN，故在本文本沿用 CDSN，特此说明。

2. 本文集略去原则协议附录二。

3. 本文集略去原则协议附录一中的附表 1 和附表 2。

**"AGREEMENT-IN-PRINCIPLE" BETWEEN THE  
STATE SEISMOLOGICAL BUREAU OF THE  
PRC AND THE U.S. GEOLOGICAL SURVEY  
FOR THE CHINA DIGITAL SEISMOGRAPH  
NETWORK UNDER ANNEX 1 OF THE  
PRC-US COOPERATIVE PROTOCOL  
IN EARTHQUAKE STUDIES**

**General**

1. The State Seismological Bureau of the PRC is planning to establish the China Digital Seismograph Network (hereinafter referred to as CDSN) in order to generate a high-quality national seismic data base that will be useful for a variety of research applications; hence, design emphasis will be placed on achieving wide dynamic range and bandwidth, on the validation of the data with respect to timing, calibration, and linearity, and on long-term operational reliability. The purpose of this cooperative project between the State Seismological Bureau and the U.S. Geological Survey (hereinafter referred to as the PRC side and the US side) is to cooperate effectively in design, construction, installation, operation, and maintenance of the CDSN, to share the network data; and to conduct joint scientific research using the network data. These activities are subject to the continuing availability of funds on both sides.

2. The CDSN will consist of a network of nine sets of digital seismograph systems, a data management system, and a depot maintenance center. The design of all these systems will be based on a jointly-approved "Instrumentation Plan for the China Digital Seismograph Network" (Appendix I). The US side will be responsible for implementing the instrumentation plan. Both sides understand that some equipment changes may become desirable or necessary as development progresses. The PRC side will have the opportunity to review any major revisions to the that may become necessary during the development phase.

3. In order to facilitate the implementation of the project, both sides agree

to combine the procurement of the data system equipment in such a way that each side provides a portion of the equipment for each data system. The equipment to be purchased by the PRC side is listed in Appendix I, Attachment 2. Within the conditions of paragraph B above, the US side will purchase the equipment listed in the Appendix I, Attachment 1 equipment list except that listed in Appendix I, Attachment 2. For purposes of property management, the PRC side will be providing five of the nine data systems. The cost of the equipment, software, and other necessary initial expencese for the entire project (including the data management system and the depot maintenance center) will be shared about equally.

4. Distribution of US-supplied stations: The four US-supplied stations will be those installed at Beijing, Kunming, Lanzhou, and Mudanjiang. A borehole seismometer will be installed at the Lanzhou Station. Mutually acceptable alternate sites may be chosen if the sites listed above are not satisfactory for technical reasons, such as high background noise. Therefore, noise surveys may be conducted at the proposed sites.

5. Sharing of the data: The PRC side will provide the US side with station-tape data on a basically continuous and routine basis from the US-equipped stations, from Urumqi, and from other PRC-equipped stations as may be mutually agreed upon in the future. In addition, the PRC side will provide the US side with copies of CDSN network any-tapes on a basically continuous and routine basis and, in return, the US side will provide the PRC side with copies of global network-day tapes. CDSN data may be provided by either side to the world scientific community.

6. Based on the data that become available from the network, cooperative projects may be established that will involve the development of software and processing techniques, data analysis, and basic research.

### **Responsibilities of The PRC Side**

1. The PRC side is responsible for capital construction and preparation of the network facilities for the nine stations (including the US-equipped stations), a data processing center, and a depot maintenance center. This includes, but is not limited to, basic activities such as land purchasing, housing construction, the building of tunnels or vaults, drilling and preparation of the borehole, road construction and repair, power line connections, and supply and preparation of communication facilities.

2. The PRC side will purchase the equivalent of five sets of the digital data systems.



3. The PRC side will purchase the data management system.
4. The PRC side will provide ongoing operation and maintenance of the entire network, including the US-equipped stations, and bear the costs which are necessary to be sent in China.
5. The PRC technical personnel will take part in the development, assembly, and testing of CDSN components together with US technical personnel.
6. The PRC side will be responsible for providing the US side with station-tape data from the stations as specified in paragraph E, Section 1 within 30 days or sooner if possible after the arrival of the data at the data management center.
7. The PRC side will be responsible for the cost of shipping all equipment purchased by the PRC side.

### **Responsibilities of the US Side**

1. The US side will be responsible for designing, developing, testing, and installing a demonstration data system, and the expenses thus incurred will be borne by the US side. The US side will provide manuals, drawings, and other pertinent documentation to the PRC side. This demonstration system will be one of the US-supplied systems. PRC personnel will participate in these activities.
2. The US side will purchase the equivalent of three sets of additional data systems, one of which will be equipped with a KS 36000 borehole seismometer.
3. The US side will be responsible for the cost of equipment and spare parts for the depot maintenance center, according to Appendix I "Instrumentation Plan for the China Digital Seismograph Network".
4. The US side, with some participation of the PRC personnel, will assemble and test the data management system and the digital recording part of the data systems and will support the digital recording part of the data systems for on year of operation in China.
5. The US side will participate in the installation of the data management system and the US-supplied data systems. US personnel will install, orient, and test the borehole seismometer and instruct PRC personnel in its operation.
6. The US side will provide the PRC side with all software needed for network data review and compilation of the network-day tapes. The software will perform essentially the same functions as the software used at the Albuquerque Seismological Laboratory for processing global digital data. The US side will also render assistance in providing data management software and data processing software, as these may be used at the data management center.