BASIC DESIGN STUDY REPORT
ON
THE PROJECT FOR CONSTRUCTING
THE GEOSCIENCE LABORATORY
IN
THE ISLAMIC REPUBLIC OF PAKISTAN

AUGUST, 1989

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to the request of the Government of the Islamic Republic of Pakistan, the Government of Japan has decided to conduct a Basic Design Study on the Project for Constructing the Geoscience Laboratory and entrusted the study to the Japan International Cooperation Agency (JICA). JICA sent to Pakistan a survey team headed by Dr. Teruo Shirahase, Director of Geological Information Center, Geological Survey of Japan, AIST, MITI from April 3rd to April 23rd, 1989.

The team exchanged views with the officials concerned of the Government of Pakistan and conducted a field survey in Islamabad and Quetta. After the team returned to Japan, further studies were made. Then, a mission was sent to Pakistan in order to discuss the draft report and the present report has been prepared.

I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Islamic Republic of Pakistan for their close cooperation extended to the team.

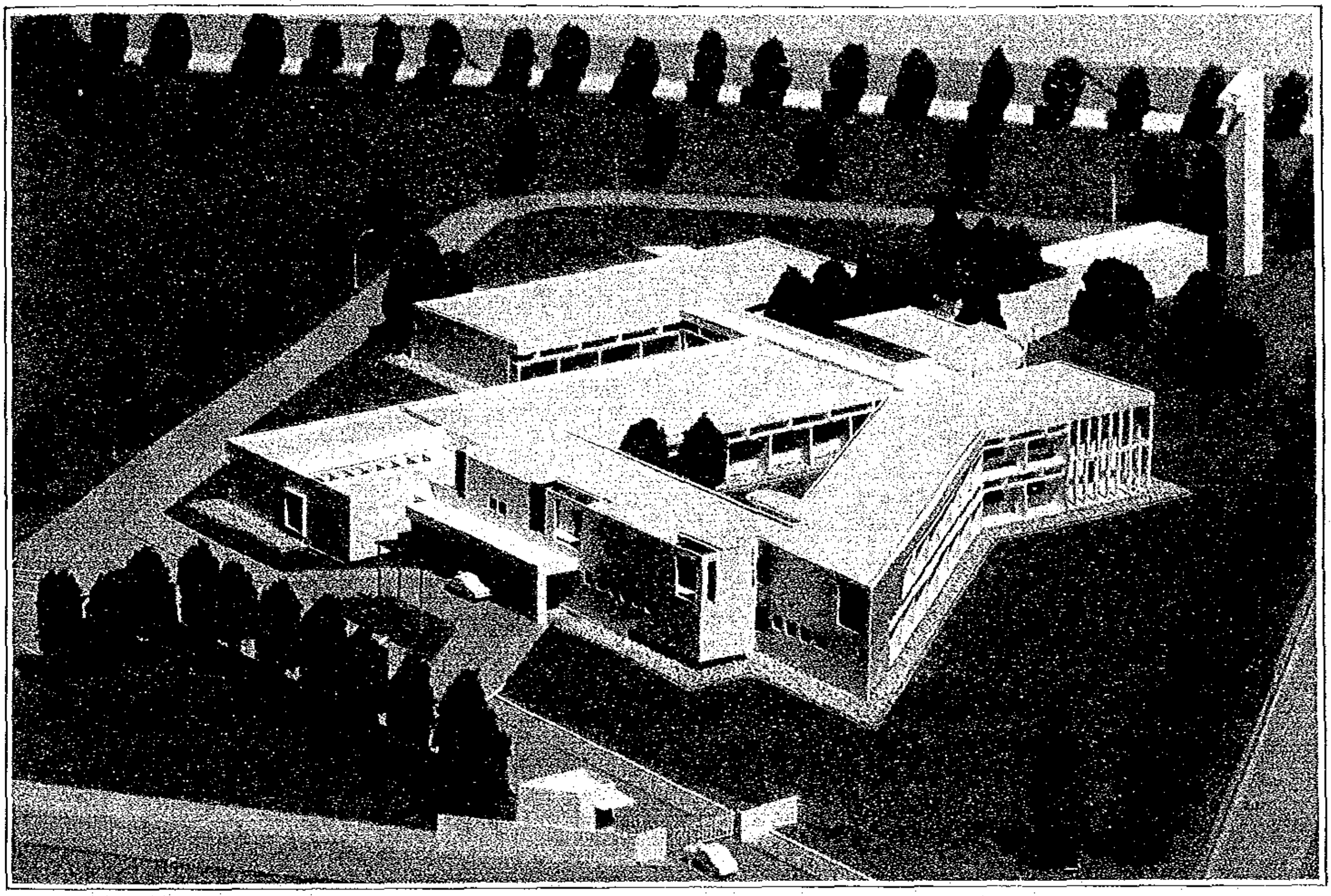
August, 1989

Kensuke Yanagiya

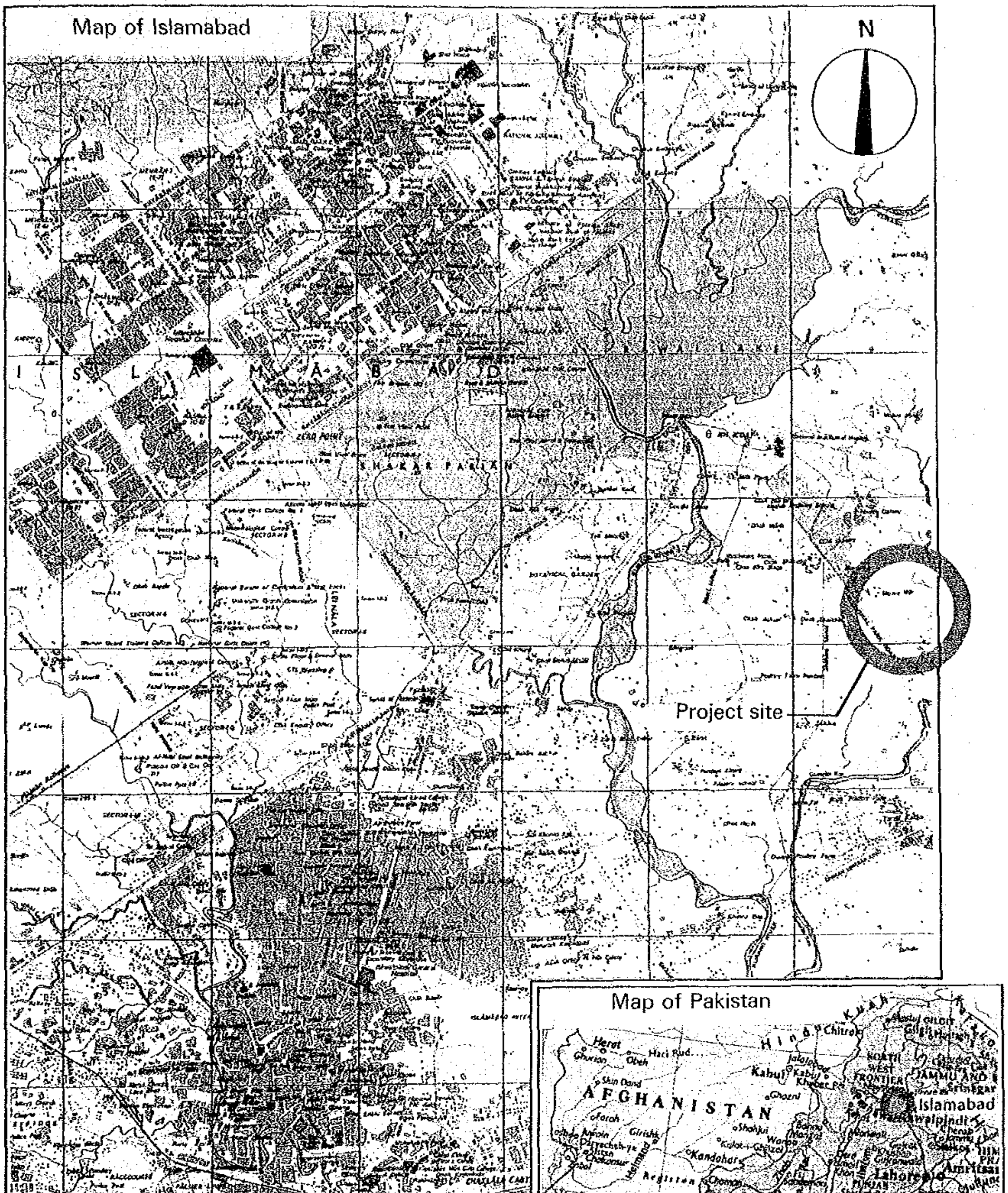
Kensuke Yanagiya

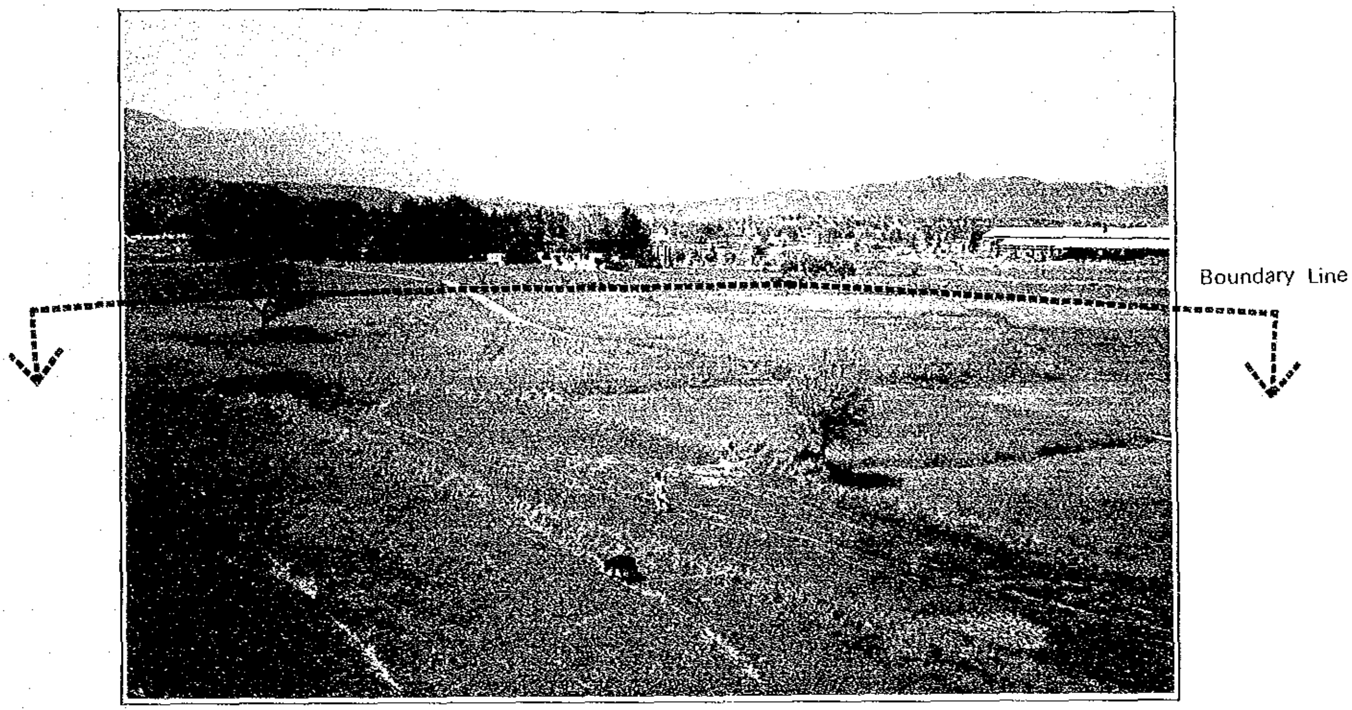
President

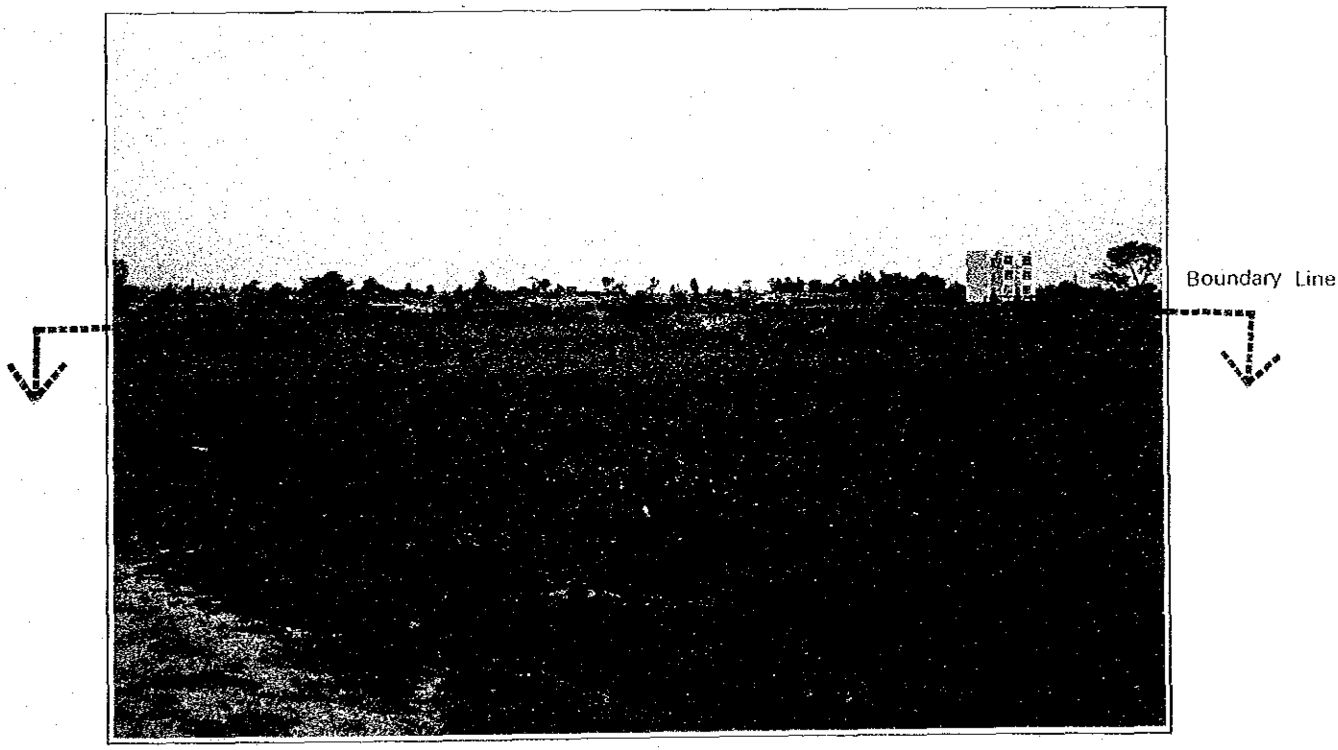
Japan International Cooperation Agency



GEOSCIENCE LABORATORY BIRD'S EYE VIEW


Map of Islamabad
N
Project site
Map of Pakistan
AFGHANISTAN
PAKISTAN
Islamabad
Kabul
Herat
Lahore
Karachi
Hyderabad
Makran Coast Range
Tropic of Cancer





PROJECT SITE

SUMMARY

SUMMARY

In Pakistan, approximately 40 kinds of energy and minerals resources were exploited in 1987. Throughout the 1970's, the development of energy resources was empahsised. As a result, the country is now able to satisfy 35 percent of domestic demand for crude oil, 100 percent of domestic demand for natural gas and 75 percent of domestic demand for coal. On the other hand, the country has not yet made the necessary progress in the development of metallic and non-metallic mineral resources, importing most of these mineral resources needed for domestic use. In the light of these facts, the Government of Pakistan has begun to stress the development of metallic and non-metallic mineral resources since the start of the sixth five-year plan (1983) to decrease imports and to stem the outflow of foreign currency through increased self-sufficiency in these mineral resources. Furthermore, in the seventh five-year plan started in 1988, the Government of Pakistan has been promoting expanded and improved geological investigation and mineral resources exploration.

Meanwhile, in the field of geology there has been marked progress in the theory of plate tectonics since the late 1960s. According to this theory, the surface of the earth consists of a dozen or so plates. Each has a thickness of about 70km and continues to move horizontally. At places where a plate subsides underneath another, various tectonic events occur. At present, this theory is considered most plausible in explaining various geological phenomena. Considering this, there is a strong possibility that commercially viable mineral resources exist in northern and western Pakistan.

In order to achieve satisfactory results in mineral resources exploration, it is essential to expand and improve field survey and exploration activities, while enhancing the ability of scientists to analyse rock and mineral samples so that their laboratory work may be effectively reflected

in field activities. However, the Geological Survey of Pakistan (GSP), the central geological research organisation in the country, which had been very active in geological investigation since its establishment immediately after national independence (1947) until the early 1960s, suffered successive reductions in its current and development budgets and technical manpower mainly because of the two wars with India in 1965 and 1971 and the oil crisis in 1973-74. As a result, facilities and equipment of the GSP have become rather old and the technical capabilities of the staff generally are not high enough to meet the expectations of the Government of Pakistan. For example, at present, most rock and mineral samples are referred for ultimate and check analysis to laboratories of developed countries.

For these reasons, the Government of Pakistan decided to establish the Geoscience Laboratory in Islamabad as part of the Geological Survey of Pakistan. This new institute is to analyse rock and mineral samples and apply the results to mineral resources exploration activities. The Government of Pakistan decided to incorporate the project in the 7th five-year plan (1988-1993). In October 1988, it requested that the Government of Japan extend grant aid for construction of the institute and technical cooperation to develop local human resources to investigate and explore for mineral resources.

In response to the request from the Government of Pakistan, the Government of Japan decided to implement a survey on the proposed project. The Japan International Cooperation Agency (JICA) dispatched a preliminary survey team from December 9 to December 21, 1988, concerned with the technical cooperation and the grant aid cooperation to Pakistan. The preliminary survey team analysed the background of the proposed project and details of the request made by the Government of Pakistan. As a result, the propriety of the project-type technical cooperation was confirmed. A basic design study on the planned grant aid was then required. Consequently, the JICA dispatched a basic design study team to Pakistan from April 3 to April 23, 1989. On the basis of the preliminary survey result, the basic design study team conducted field surveys in Pakistan. After analyses in Japan and explanation of draft reports to the Pakistani counterparts, this basic design study report was completed.

The Geological Survey of Pakistan is responsible for executing the project. The proposed laboratory will be managed and operated by 64 staff members. It will have a Paleomagnetic Geochronology Laboratory, a Petrology and Mineralogy Laboratory, an Analytical Chemistry Laboratory, a Geochemical Exploration Section, an Isotope Geochronology Section and a Geology Section. Installation of precision equipment to identify, classify and analyse rock and mineral samples is indispensable for the laboratory to contribute to the development of mineral resources in the country.

The project site is located in the southeastern suburbs of Islamabad, approximately 7 km from the centre of the city. It has an area of approximately 4 ha. The site is owned by the Capital Development Authority and is to be leased to the Geological Survey of Pakistan on a long-term basis.

The outline of the facilities and equipment included in this project is as follows.

- Project Site : Chalk Shahdad, National Park Area located in the suburbs of Islamabad

- Total Floor Area of the Facilities : 3,664 m^2

- Facilities

  1. Laboratory Building

     Paleomagnetism room, microscope room, electron probe micro analyser room, X-ray diffractometer room, atomic absorption spectrometer room, chemical analysis room, mineral separation room, etc.

2. Sample Preparation and Storage Building
   Crushing room, pulverising room, mineral crushing room, thin section room, polishing room, sample storage, etc.

3. Study and Administration Building
   Senior scientist room, scientist room, drawing room, map room, library, stack room, sample stock room, seminar room, office room, etc.

4. Mechanical building, garage, guard house, power receiving house, neutralisation tank, elevated tank

- Equipment

1. Paleomagnetic Geochronology Laboratory
   AC demagnetiser, thermal demagnetiser, magnetic susceptibility meter, magnetic balance, etc.

2. Petrology and Mineralogy Laboratory
   Electron probe micro analyser, X-ray diffractometer, differential thermal analyser and thermal gravimeter, etc.

3. Analytical Chemistry Laboratory
   X-ray fluorescence spectrometer, flame atomic absorption spectrometer, flameless atomic absorption spectrometer, ultraviolet-visible spectrometer, balance, water still, etc.

4. Geochemical Exploration Section
   Data processing equipment

5. Isotope Geochronology Section
   Isodynamic separator, hot plate, etc.

6. Geology Section

   Drafting table, tracing table, etc.

7. Sample Preparation Secton

   Jaw crusher, vibrating mill, automatic agate mortar, rock cutter, lapping machine, thin section preparation machine, etc.

The Government of Japan will implement this project in two phases. Phase 1 (building work: approximately 12 months) and Phase 2 (building work: approximately 9 months; procurement and installation of equipment work: approximately 11 months). The estimated project cost to be borne by the Government of Pakistan for securing the project site and raising the infrastructure is 19,980,700Rs.

Based on the project implementation plan (PC-1 Form), budgets for maintenance and operation of the laboratory will be allocated to the Geological Survey of Pakistan by the Government of Pakistan. It will be possible to cover the estimated annual recurrent cost of the laboratory (approximately 4,044,000Rs) with the local currency budget of the implementation plan. Besides, this amount equals only 0.26% of the Ministry of Petroleum and Natural Resources' total budget for 1988/89 (approximately 1,527,948,000 Rs), so it will be possible to secure the necessary budget for maintenance and operation of the laboratory after expiration of the implementation plan.

If the project-type technical cooperation by the Japanese government is implemented for this project, and the proposed laboratory operated smoothly, the technical capabilities of scientists of the laboratory will be enhanced. Then, accuracy of geological and structural geology maps will be improved, and it will be possible to prepare standard mineral occurrence maps, geochemical maps, paleomagnetism distribution maps, metallogenic maps and generalised maps. These maps have been difficult to make using existing equipment of the GSP. This will improve the quality of basic information on mineral resources exploration. Then, high quality exploration activities can be carried out on a much larger scale. Consequently, discoveries of mineral resources peculiar to the geotectonic features of Pakistan will be more likely. If the laboratory's activities lead to discovery of new mineral resources in the long run, this project will greatly contribute to the national economy of Pakistan in terms of foreign exchange earnings, employment, and regional development. Therefore, this project is considered to be very valuable. It is concluded that the grant aid programme by the Japanese Government for the project is sufficiently appropriate.

In order to amplify the effect of the project, further efforts towards the realisation of the project-type technical cooperation by the Japanese government should be made by both countries in conjunction with the grant aid programme. In this connection, it is necessary for the Pakistani side to recruit competent personnel and take necessary budgetary measures to maintain and operate the laboratory. To enhance the project's effects, a high operating rate and a high level of analytical accuracy and reliability should be maintained in the laboratory.

CONTENTS

CHAPTER 1 INTRODUCTION

INTRODUCTION

In the energy and mineral resources development programme of Pakistan, the development of fuel resources such as crude oil, natural gas and coal was emphasised throughout the 1970s. As a result, the country is now able to satisfy 35 percent of domestic demand for crude oil, 100 percent of domestic demand for natural gas and 75 percent of domestic demand for coal. On the other hand, the country has not yet made the necessary progress in the development of metallic and nonmetallic mineral resources, importing most of these resources needed for domestic use. In order to improve the country's self-sufficiency in these mineral resources and thereby stem the outflow of foreign currency, the government of Pakistan began to stress the development of metallic and nonmetallic mineral resources beginning with the 6th five-year plan (1983). Furthermore, in the 7th five-year plan started in 1988, the Government of Pakistan has been trying to expand and improve the geological investigation and mineral resources exploration projects.

In order to achieve satisfactory results in this area, it is essential to expand and improve field survey and exploration activities, while enhancing the ability of scientists to analyse samples of the rocks and minerals collected so that the results of their laboratory work may be effectively reflected in field activities. However, the Geological Survey of Pakistan (GSP), which is the national centre for geological research and which had been very active in geological investigation since its inception immediately after national independence (1947) until the early 1960s, suffered successive reductions in its current and development budgets and technical manpower mainly because of the two wars with India in 1965 and 1971 and the 1973-74 oil crisis. As a result, the facilities and equipment of the GSP have become rather old, and the technical capabilities of the staff generally are not high enough to meet the present requirements and future expectations of the Government of Pakistan. At present, for example, most rocks and minerals sample analysis is commissioned to laboratories of developed countries.

Meanwhile, in the field of geology there has been marked progress in the theory of plate tectonics since the late 1960's. As a result, it is now presumed that useful minerals may exist in areas which had been considered short of such minerals. According to this theory, there is a strong possibility that mineral resources exist in northern and western Pakistan.

For these reasons, the Government of Pakistan decided to establish the Geoscience Laboratory in Islamabad as part of the Geological Survey of Pakistan. This new establishment is to analyse samples of the rocks and minerals collected and apply the results to mineral resources exploration activities. The Government of Pakistan decided to incorporate the project in the 7th five-year plan (1988-1993). In October 1988, it requested that the Government of Japan extend grant aid for the construction of the institute and technical cooperation to develop local human resources for the investigation and exploration of mineral resources.

In response to the request from the Government of Pakistan, the Government of Japan decided to implement a survey on the proposed project and the Japan International Cooperation Agency (JICA) dispatched a preliminary survey team concerned with the technical cooperation and the grant aid cooperation to Pakistan from December 9 to December 21, 1988. The preliminary survey team analysed the background of the proposed project and details of the request made by the Government of Pakistan. As a result, the propriety of the project-type technical cooperation of the proposed project was confirmed. A basic design study on the planned grant aid was then required. Consequently, the JICA dispatched a basic design study team to Pakistan from April 3 to April 23, 1989. On the basis of results of the preliminary survey, the basic design study team conducted the following works to determine the feasibility of the proposed grant aid to be supported by project-type technical cooperation: (A long-term expert related to project-type technical cooperation accompanied the team.)

(1) Analysis of the background and propriety of the proposed project

(2) Survey of present activities by the Geological Survey of Pakistan and other related organisations

(3) Consultations with the Pakistani side on the outline of current and future activities by the Geoscience Laboratory

(4) Examination of the facilities and equipment requests

(5) Confirmation of systems to implement the project, operating and management systems of the Geoscience Laboratory, the scope of works by the Government of Pakistan and budgetary measures for the project

(6) Survey of the project site

(7) Investigation of similar existing facilities

(8) Data collection regarding the construction situation in Pakistan

This report compiles the results of the above-mentioned survey in Pakistan, analyses in Japan, and the explanation of the draft report in Pakistan in June 1989. The member list of the study team, the survey schedules, the member list of the Pakistani counterparts and the copies of the minutes of discussions are added to the end of this report.

CHAPTER 2 BACKGROUND OF THE PROJECT

BACKGROUND OF THE PROJECT

2-1 Present Situation and Prospects of Mineral Resources

In 1947, when Pakistan became independent, only six kinds of minerals (chromite, fireclay, gypsum, limestone, rock salt and silica sand) were mined and marketed on a small scale. Energy minerals such as crude oil and coal had not yet been commercialized, although their existence had already been confirmed. After the independence, gradual progress was made to exploit new mineral deposits. By 1987, the 40th anniversary of the country's independence, as many as 40 kinds of minerals had been mined.

Table 2-1 Minerals Being Mined in Pakistan

Year	1947	1987
Minerals	chromite, fireclay, gypsum, limestone, rock salt, silica sand	antimony, aragonite (marble), baryte, bauxite, celestite, china clay, chromite, coal, ebry stone, fireclay, fluorite, fuller's earth, gravel, gypsum, limestone, magnesite, manganese, ocher, rock salt, silica sand, soap stone, sulfur, crude oil, natural gas, argillaceous clay, bentonite, chalk, dolomite, feldspar, flint stone, gemstone, graphite, iron ore, mica, mill stone, phosphate rock, quartz, serpentine, slate stone, trona

(Source: Geological Survey of Pakistan)

A large number of the minerals shown in the above table are used in domestic demand-oriented industries, and are in rather low demand in international markets. The whole output of crude oil, coal and natural gas is consumed within the country. In addition, 65 percent of total crude oil consumed and 25 percent of total coal consumed are imported.

The trends in production of main minerals for the last 10 years are shown in the following figures. Generally, production is increasing gradually.

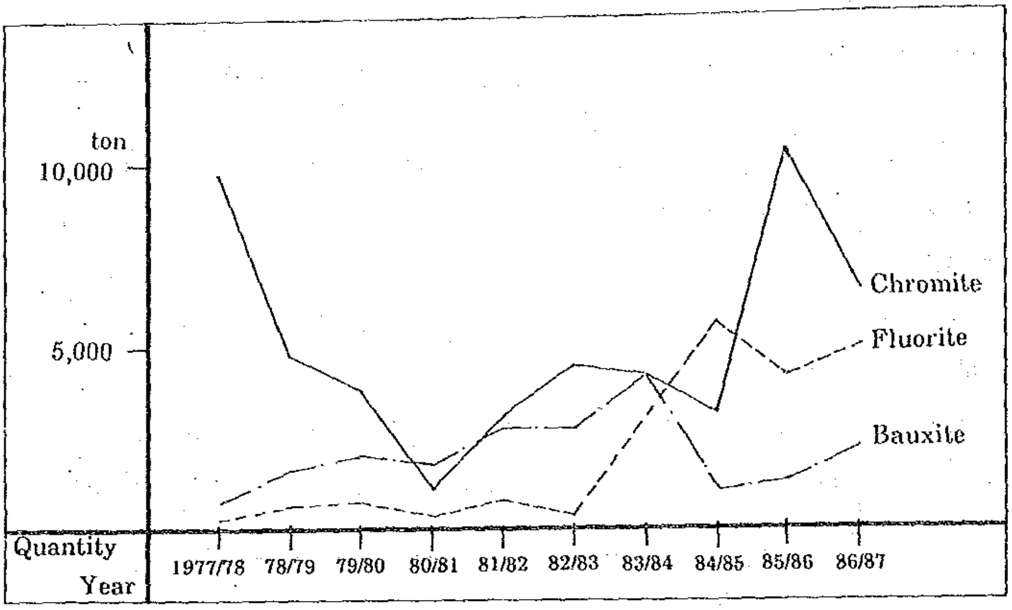


Fig. 2-1 Trends in Production of Major Minerals (1) (Source: Pakistan Statistical Yearbook, 1988)

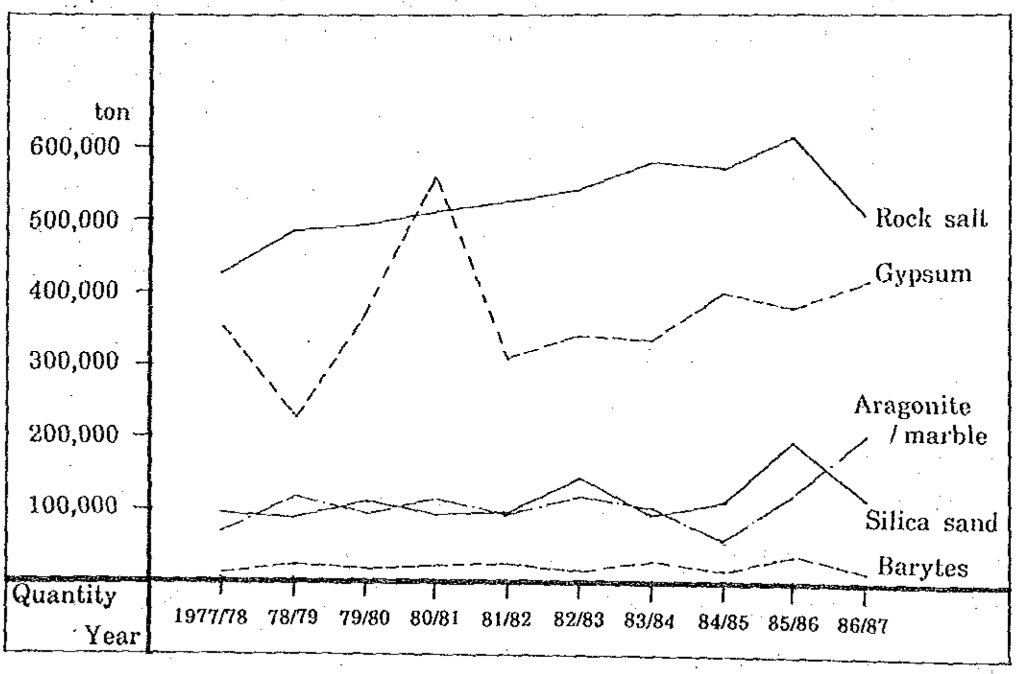


Fig. 2-2 Trends in Production of Major Minerals (2) (Source: Pakistan Statistical Yearbook, 1988)

Apart from these metallic and non-metallic resources, the fuel resources sector, produced 15,005,000 barrels of crude oil, 11,161,365m3 of natural gas and 2,158,904 tons of coal in 1986/87. These productions represented 35 percent of domestic consumption for crude oil, 100 percent of domestic consumption for natural gas and 75 percent of domestic consumption for coal. Consequently, crude oil and coal were imported to meet the total domestic demand. In recent years, the production of natural gas and coal have been almost at the same level, although the production of crude oil has increased remarkably. Crude oil and natural gas are produced mainly in Sind and Punjab provinces, whereas coal is produced in Sind, Punjab and Baluchistan provinces.

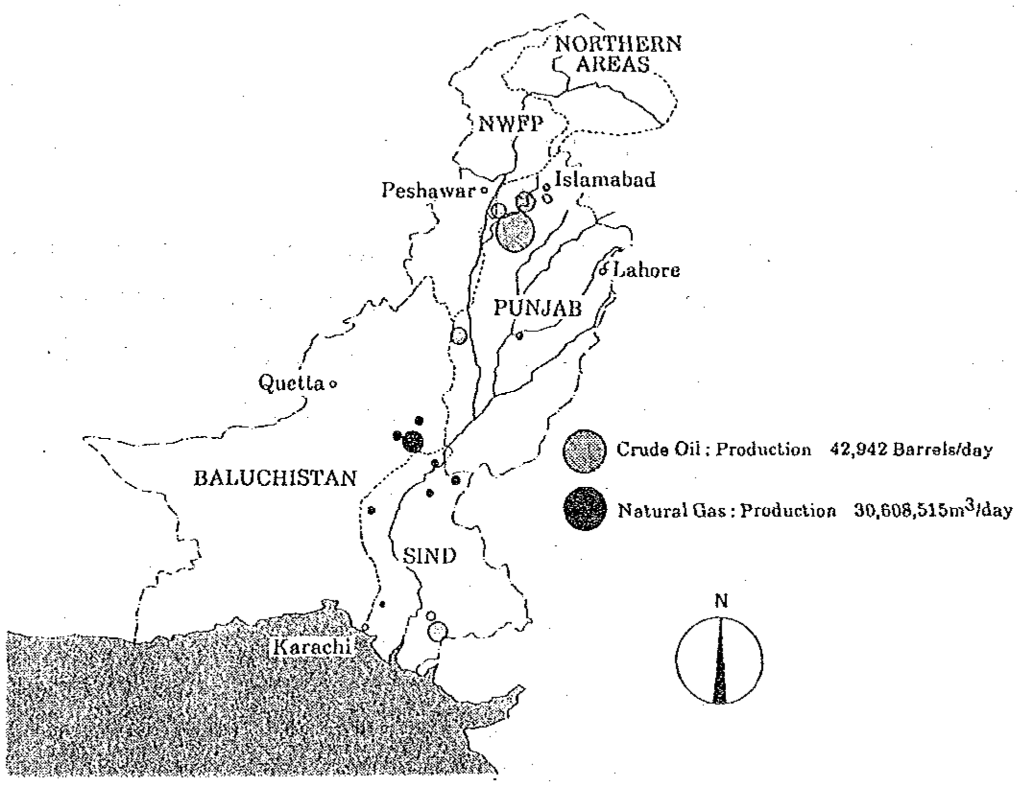


Fig. 2-3 Oil and Gas Fields in Pakistan

The mineral sector's contribution (excluding energy minerals) to GDP was only 2.3 percent in 1986/87. This low percentage is due to the scarcity of valuable metals in spite of the wide variety of exploited mineral resources, the remoteness and sporadic locations of mines and the underdevelopment of precise methods to explore mineral deposits. Under these circumstances, exploitation of economically useful minerals such as copper, gold, lead, nickel, tungsten, zinc can promote national economic development; this is a matter of urgent necessity.

In the meantime, one of the most noteworthy geological developments in recent years related to mineral resources of Pakistan, was the progress made in the theory of plate tectonics. According to this theory, the surface of the earth is covered with a dozen or so plates. Each has a thickness of about 70km and moves horizontally. Where a plate subsides underneath another, various tectonic events occur. At present, this theory is considered most plausible in explaining various geological phenomena.

On the basis of this theory, the history of the earth around India and Pakistan can be briefly explained as follows:
About 200 million years ago there was a single large terrestrial part of the earth, which was first divided into the Eurasian continent and the Gondwana continent. Then the latter was further subdivided into the North American, South American, African, Australian and Indian continents.

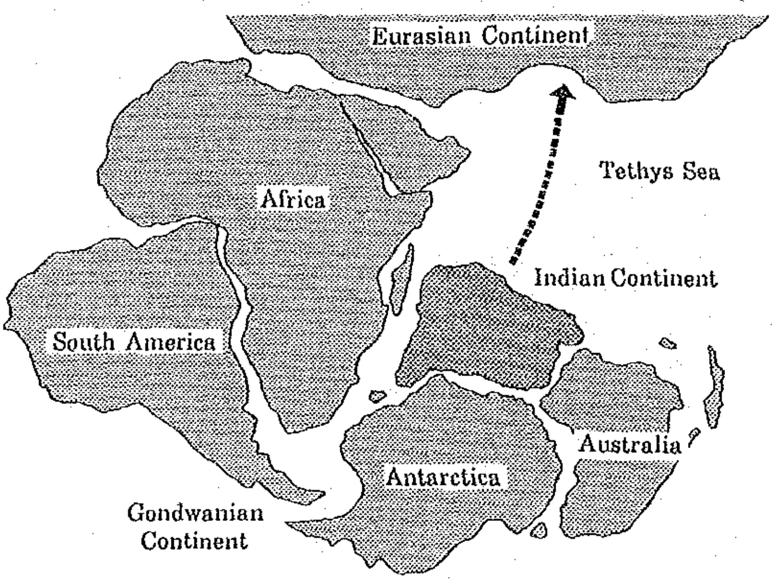


Fig. 2-4 Drift of Continents

About 65 million years ago, the Indian continent began drifting towards Eurasian continent as the Indian plate subsided underneath the Eurasian plate. The Tethys sea, developed between the two continents, gradually narrowed down and disappeared about 20 million years ago. Finally the Indian continent collided against the Eurasian continent producing great mountain ranges such as the Himalaya, the Karakoram and the Hindu Kush Mountains. In the process of the Indian plate subsiding underneath the Eurasian plate, the subduction zone between the two plates was activated in magmatism in the upper part of the mantle. This magmatic activity brought about intense volcanism to the surface, accompanied with various types of mineralisation. As the Indian continent further migrated to the Eurasian continent, a broad area of the subduction zone was subjected to intense plutonism accompanied with other types of mineralisation.

With the geological history described above, it may well be expected that various types of mineral resources exist in Pakistan, particularly in northern and western mountainous districts of the country. Advanced technologies and sophisticated laboratory equipment have been developed in keeping with the progress of this theory. High expectations are being placed on future discoveries of new mineral deposits in Pakistan, using such technologies and equipment.

2-2 Outline of the Five-Year Plan

The seventh five-year plan started in 1988/89. It has the following 8 basic aims.

1) Movement toward full employment, especially of the educated

2) Provision of adequate nutrition, shelter, health, education, transport and other public services

3) Development of human resources, with emphasis on education and training of manpower

4) Progressive achievement of self-reliance in all spheres of life, including the gradual reduction of dependence on foreign loans, technology and know-how

5) Promotion of private sector activity through further economic deregulation, to transfer the bulk of the financial burden of investment and growth from the government's budgetary resources to the private sector's own resources

6) Restoration of equilibrium in public finances by means of a concrete programme to balance the revenue budget, and eliminate the imbalance between the government's expenditures and revenues

7) Strengthening the balance of payments by aggressively promoting exports through industrial, commercial and exchange rate policies and by better balancing import and export levels

8) Pursuit of a restrained monetary policy to ensure continued price stability

As regards the aims of the mining sector, expansion of mineral resources development is necessary to diversify indigenous industry. It is also necessary to step up efforts to improve the quality of geological investigation and exploration, and to reinforce the infrastructure in areas with promising mineral deposits. Furthermore, it is necessary to modernize and improve the facilities and equipment of testing laboratories. The Government of Pakistan expressed its intention of enlarging the role of the mining sector in the national economy, and gave top priority to the following items in geoscience study in its seventh five-year plan.

1) The Geological Survey of Pakistan will cover the mineralized zones on appropriate maps and establish geological reserves, and develop portfolios of exploration prospects to attract local and foreign investments.

2) The number of public sector agencies in mining will be restructured to make optimal use of scarce manpower and capital resources.

3) Government will set up a service under an appropriate agency for low cost rapid mineral analysis and cost/benefit testing for the benefit of private mine owners.

Limits to public investment make the Government of Pakistan aware of the need to utilise both foreign private investments and vital local private organisations. On the other hand, the following problems were pointed out in the development of metallic and nonmetallic minerals in reviewing the sixth five-year plan.

1) Inadequate geological knowledge
2) Lack of adequate research and development facilities
3) Shortage of trained and experienced manpower
4) Lack of adequate equipment and infrastructure

Expansion and improvement of research facilities is necessary to achieve self-sufficiency in mineral resources development. This is recognized in the national economic development plan of the Government of Pakistan.

2-3 Present Situation of Administration of Investigation and Development of Energy and Mineral Resources

(1) Government Organisation

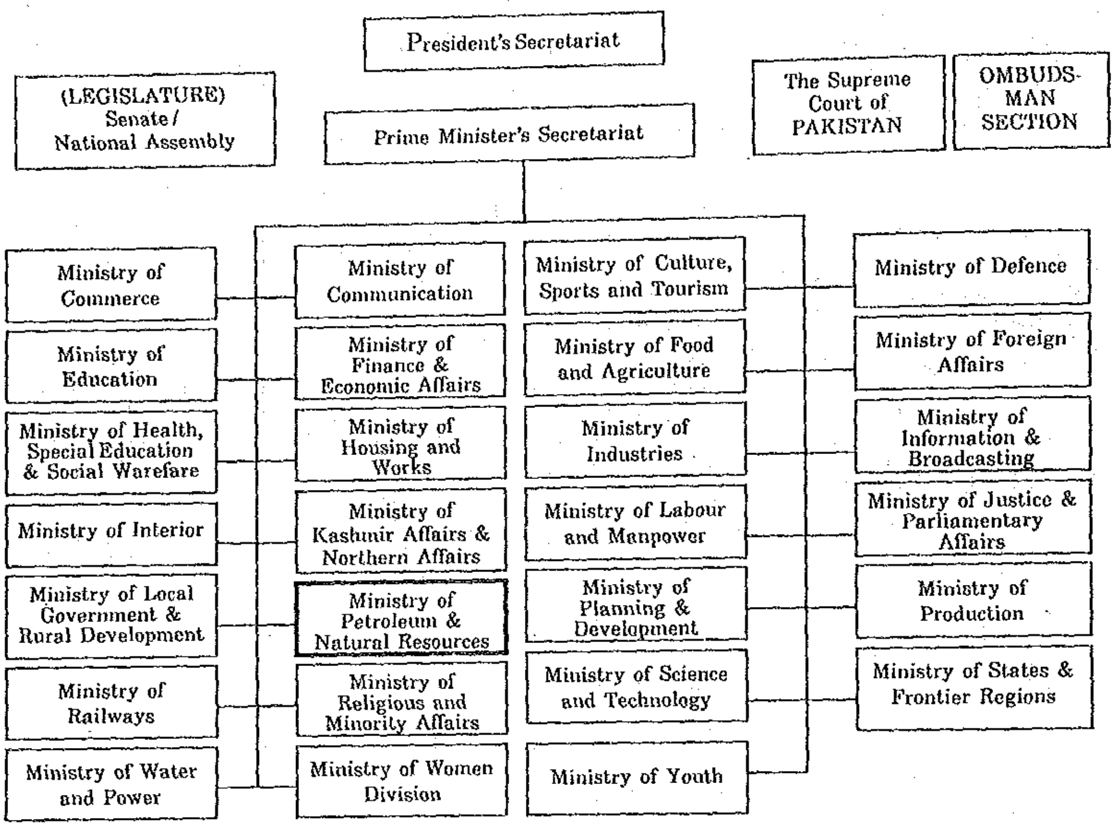


Fig. 2-5 Organisation of the Government of Pakistan

(2) Organisation of the Ministry of Petroleum and Natural Resources

The Ministry of Petroleum and Natural Resources is composed of the following organisations. As regards the investigation and development of underground resources, the Geological Survey of Pakistan is responsible for investigation of and basic exploration for mineral deposits. On crude oil and natural gas in particular, the Hydrocarbon Development Institute of Pakistan has been set up for research and technical support. Various public sector corporations are responsible for the practical exploration of mineral deposits and mine development. Except for crude oil-related foreign companies, the private mining sector has been suffering shortages of capital, technology and manpower. As a result, activities in private companies are limited to mining of surficial deposits of nonmetallic minerals such as coal, gypsum, limestone, argillaceous clay and marble, which require less advanced technology and promise quick returns.

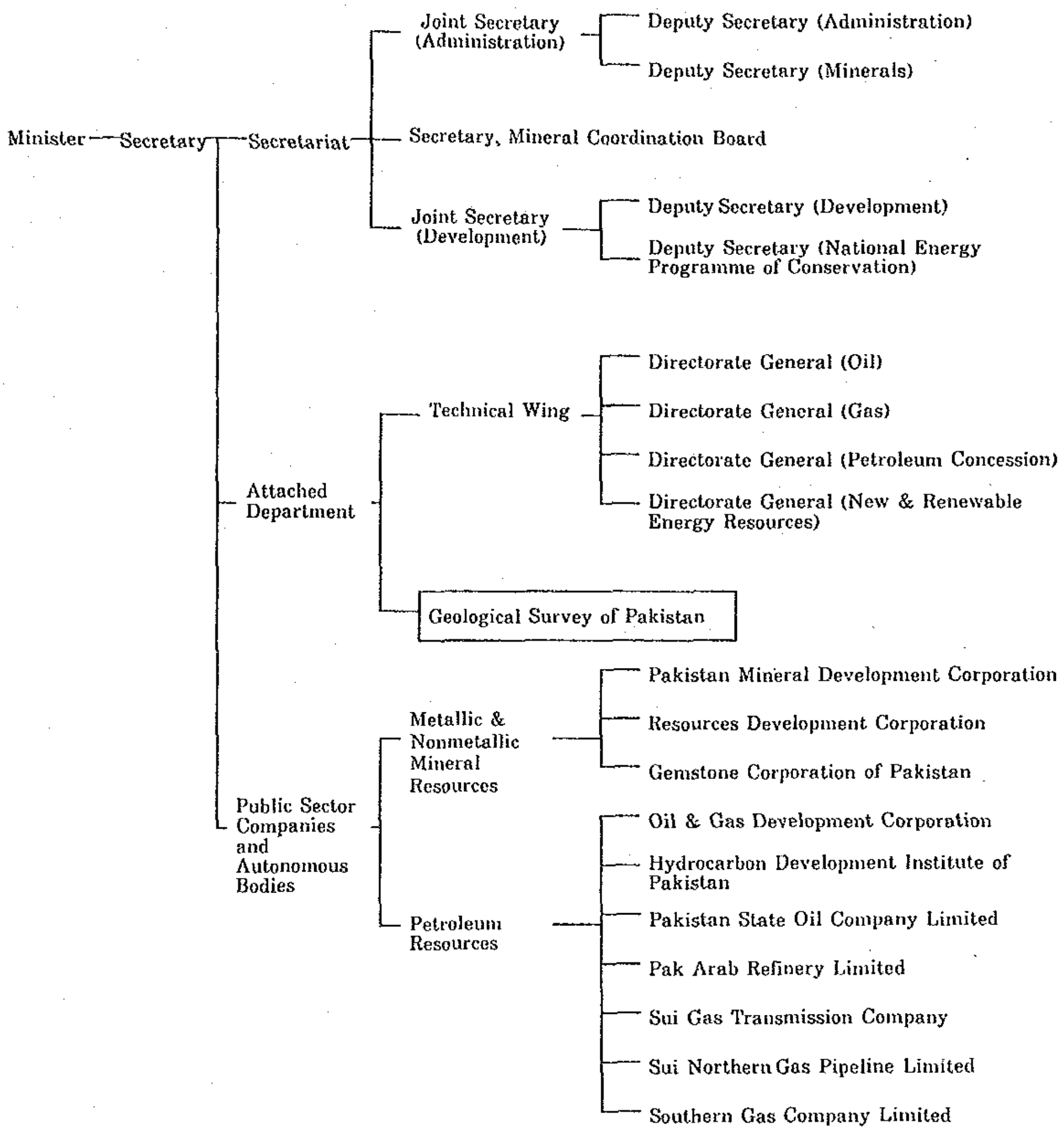


Fig. 2-6 Organisation of the Ministry of Petroleum and Natural Resources

(3) Budget of the Ministry of Petroleum and Natural Resources

Trends during the past 4 years in the annual budget of the Ministry of Petroleum and Natural Resources are shown in the following table.

Table 2-2 Budget of the Ministry of Petroleum and Natural Resources

(Unit: 1,000Rs)

Year	1985/86	1986/87	1987/88	1988/89
Current Budget	519,382	250,000	222,842	210,249
Development budget	3,329,616	2,700,100	2,960,588	1,317,699
Total	3,848,998	2,950,100	3,183,430	1,527,948

(Source: Geological Survey of Pakistan)

Year-to-year fluctuations in the amount of the budget are attributable mainly to the fact that the dates of start and completion of ordinary activities and development projects are not always included in the same fiscal year of the Government of Pakistan, which commences on July 1 and ends on June 30. It can be said that the amount of the budget of the Ministry of Petroleum and Natural Resources during the past 4 years has almost remained the same.

(4) Outline of the Attached Departments, Public Sector Companies and Autonomous Bodies

Table 2-3 Main Functions of Each Organisation

Name of organisation	Main functions
Technical Wing	Control of fuel resources, their transactions and development
Geological Survey of Pakistan	Collection and dissemination of basic geological information for promoting effective exploration and development of the country's underground resources
Pakistan Mineral Development Corporation	Exploration, mining and sale of non-oil mineral resources such as coal, rock salt, chromite and silica sand
Resource Development Corporation	Exploration and development of copper in Saindak area of Baluchistan Province
Gemstone Corporation of Pakistan	Mining, control and sale of gemstones mined in the northern area of the country
Oil & Gas Development Corporation	Exploration and development of crude oil and natural gas
Hydrocarbon Development Institute of Pakistan	Research and development of crude oil and natural gas and technical back-up support to petroleum development
Pakistan State Oil Company Limited	Storage, distribution and sale of petroleum products
Pak Arab Refinery Limited	Joint venture between the Government of Pakistan and Emirates of Abu Dhabi for refinery and pipeline transmission of petroleum
Sui Gas Transmission Company	Purification and transmission of natural gas discovered at Sui
Sui Northern Gas Pipeline Limited	Transmission and distribution of natural gas in the provinces of Punjab and NWFP
Southern Gas Company Limited	Distribution of natural gas in the provinces of Sind and Baluchistan

To avoid overlapping of activities by so many organisations and to promote efficiency, the Ministry established a Mineral Coordination Board in the Secretariat. The total number of senior officials responsible for survey, investigation, exploration and development of energy and mineral resources and the total number of staff members of each of the Ministry's main technical organisations are shown in the following table.

Table 2-4 Number of Staff of Each Organisation

			No. of senior officials (mainly scientists)	Total No. of staff
Attached department	Technical Wing	Crude oil	5	68
		Natural gas	8	50
		Coal	8	50
		Petroleum Concession	10	50
		New & Renewable Energy Resources	8	36
	Geological Survey of Pakistan		303	1,543
Public Sector Companies and Autonomous Bodies	Pakistan Mineral Development Corporation		67	7,500
	Oil & Gas Development Corporation		750	4,240
	Hydrocarbon Development Institute of Pakistan		70	325
Total			1,229	13,862

(Source: Geological Survey of Pakistan)

Of the 303 senior officials of the Geological Survey of Pakistan, 292 are scientists and engineers, which evidences the importance of this department as a scientific and technological organisation responsible for survey, investigation and exploration of energy and mineral resources, particularly mineral resources, in Pakistan.

(5) Present Situation of Geological Education

At present, national universities are responsible for purely academic research on energy and mineral resources. Shown in the following table are the universities in Pakistan which have courses on geology and the annual turn-out of graduates.

Table 2-5 Present Situation of Geological Education

Name of university	Length of education	Annual intake number (1987)	Annual output number (1987)
1. University of Baluchistan	4 years	9	8
2. University of Karachi	4 years	50	20
3. University of Punjab	4 years	44	35
4. University of Peshawar	4 years	16	7 (M. Phil.)
	4 years	35	2 (M. Science)
5. Quaid-i-Azam University	4 years	30	10
Total		184	82

(Source: Geological Survey of Pakistan)

The total annual number of graduates from these universities is 82, of which 4 or so get positions with the Geological Survey of Pakistan each year. The other graduates are employed by other attached departments, public sector companies, autonomous bodies of the Ministry of Petroleum and Natural Resources and private companies, go to graduate schools, or study abroad.

2-4 Present Situation of the Geological Survey of Pakistan (GSP)

2-4-1 Historical Perspective

The Geological Survey of Pakistan (GSP) was separated from the Geological Survey of India in August 1947, immediately after the country became independent. At that time, the department was staffed with 6 geologists and 2 other scientists.

At the time of its inception, emphasis was on the preparation of geological maps. In the beginning, the department prepared a reconnaissance map with a scale of 1 to 250,000 covering 537,790km^2 which accounted for approximately 90 percent of the country's total outcrop area. Then the department started preparing geological maps with a scale of 1 to 50,000. By the early 1960s the department had collected field survey data on the general geology of the country. In 1964 the GSP published a geological map with a scale of 1 to 2,000,000 which was designed to get a clear grasp of the general geology of the entire country. The completion of this map in 1964 was largely responsible for exploration and development of crude oil, natural gas, coal, antimony, dolomite, magnesite and other resources.

Just as the GSP activities were about to progress smoothly, the Pakistan-India war broke out in 1965, and again in 1971. Furthermore, Pakistan was seriously affected by the oil crisis during 1973 and 1974. As a result, the GSP went through successive personnel and budget reductions, which paralysed its field and laboratory activities. Meanwhile, since the late 1960s, new theories related to geology including the theory of plate tectonics, have been developed. This triggered a review of mineral deposits in orogenic zones in various parts of the world, and rapidly improved sophisticated laboratory equipment and data processing technologies. The technical gap between the Geological Survey of Pakistan and geological survey departments of industrialized countries appears to have widened because of the above-mentioned inhibiting factors.

For these reasons, the Government of Pakistan started to take various measures from its sixth five-year plan (1983-1988) including renewing of laboratory, improving residential and publication facilities, in-service training programmes, and filling of vacant posts, in an effort to strengthen the geoscience investigation and mineral resources exploration capabilities of the Geological Survey of Pakistan.

2-4-2 Activities

As an attached department of the Ministry of Petroleum and Natural Resources, the Geological Survey of Pakistan is responsible for collecting and providing basic data and information on the general geology of the country, which will contribute to exploitation and utilisation of the energy and mineral resources of the country. While the department is regularly engaged in basic geological investigation activities, including preparation and publication of geological reports and maps, and basic study of underground resources, it is carrying out exploration of underground resources, such as coal and metallic minerals, in cooperation with related national and international organisations. Although basic geological investigation essential for crude oil and natural gas is included in the activities of the GSP, the Hydrocarbon Development Institute of Pakistan, the Oil & Gas Development Corporation and private companies are mainly responsible for research, exploration and development of these energy resources.

The main activities of the Geological Survey of Pakistan are summarised as follows:

(1) To conduct systematic geological mapping of the country and to prepare geological maps on desired scales

(2) To investigate in detail areas indicated by geological mapping to be favourable for accumulation of industrial rocks, mineral fuels, ground water and other natural resources

(3) To conduct extensive geochemical, geophysical and test drilling operations in order to evaluate known mineral deposits

(4) To conduct stratigraphic studies to identify, correlate and determine the sequence of rock units in support of mapping and exploration programmes, including reconstruction of depositional environment, and determine age with the help of fossils

(5) To conduct geological investigations in connection with construction of dams, canals, tunnels, highways, bridges, new townships and other public construction projects, so as to advise sponsoring agencies about the possible natural hazards and geological feasibility of such construction projects

(6) To systematically sample minerals, mineral fuels and ground water resources, and carry out mineralogical and chemical analysis of the samples

(7) To carry out marine geological and geophysical investigations

(8) To conduct research in various fields of geology

(9) To advise the Government in all matters connected with geology and resources of the earth

(10) To provide information and assistance in geological work to concerned government and semi-government agencies

(11) To publish the results of the activities in the form of standard maps and reports

As is clear from the above list, the Geological Survey of Pakistan is responsible mainly for the most basic investigation and exploration efforts which provide the fundamental information for the country's natural resources development programme.

2-4-3 Organisation, Personnel and Budget

(1) Organisational Structure

The headquarters of the Geological Survey of Pakistan is located at Quetta with its Central, Geophysics and Analytical Chemistry Divisions. Regional divisions and branches are located at Karachi, Lahore, Peshawar, Islamabad and Muzaffarabad.

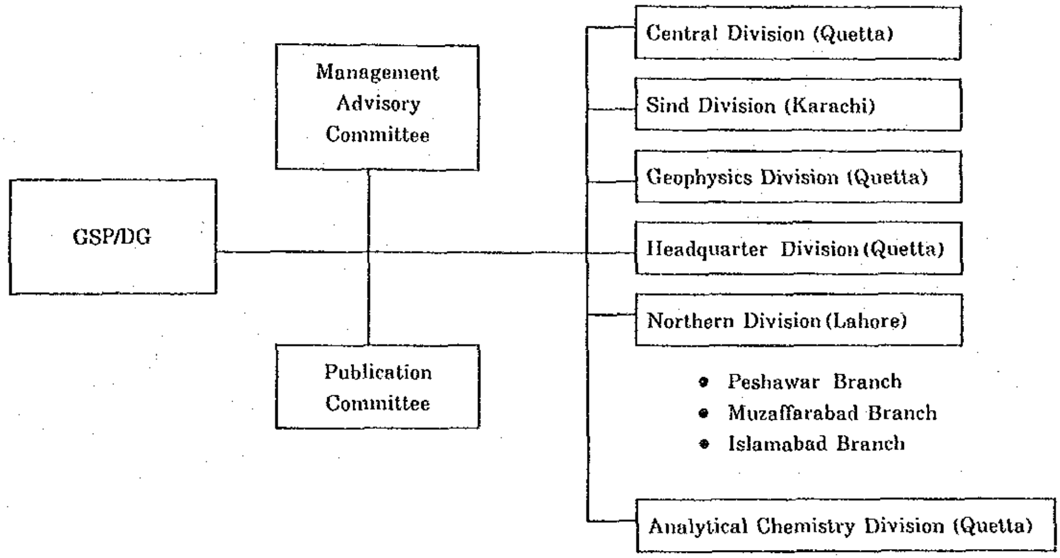


Fig. 2-7 Organisational Structure of the Geological Survey of Pakistan

As the mineral resources investigation and exploration works were conducted mainly in Baluchistan province before national independence, it was decided to establish the headquarters of the GSP at Quetta to facilitate its field works. Afterwards, regional divisions and branches were set up in each province.

(2) Personnel

At present, the Geological Survey of Pakistan has a staff of 1,543, of whom 303 are senior officials. The distribution by discipline and divisions of its personnel is as shown in the following table.

Table 2-6 Manpower of Each Division

Division \ Discipline	Geology	Geo-physics	Chemistry	Photo survey	Test drilling	Other professional work	Adminis-trative work	Total
Central Div. (Quetta)	24	–	–	5	–	–	–	29
Sind Div. (Karachi)	31	5	5	–	10	1	1	53
Geophysics Div. (Quetta)	–	16	–	–	–	–	–	16
Headquarters Div. (Quetta)	39	–	–	–	20	14	7	80
Northern Div. (Lahore, Peshawar, Islamabad, Muzaffarabad)	83	6	9	–	9	3	3	113
Analytical Chemistry Div. (Quetta)	–	–	12	–	–	–	–	12
Total	177	27	26	5	39	18	11	303

(Source: Geological Survey of Pakistan)

As its headquarters is located at Quetta, 137 senior officials, accounting for 45.2 percent of the total number of its senior officials, are working there. It is important to have its personnel distributed evenly across the country because each mineral deposit developed belongs to the province in which it is found, and also because the field survey activities must be carried out efficiently and effectively. In view of the geographical distribution of the known mineral deposits in the country, the present geographical distribution of its personnel is considered reasonable. It should be noted, however, that of 113 staff members of Northern Division, only about 30 are stationed at Islamabad and Muzaffarabad branches. It is necessary to review the number of personnel of these branches in order to strengthen the mineral resources exploration activities in moutainous areas in the northern part of the country.

(3) Budget

The trend over the last 6 years in the budget allocated to the Geological Survey of Pakistan through the Ministry of Petroleum and Natural Resources is shown in the following table.

Table 2-7 Budgetary Allocation for the GSP

(in: 1,000Rs)

item \ year	1983/84	1984/85	1985/86	1986/87	1987/88	1988/89
Current Budget						
• Local Currency	33,290	34,387	38,334	53,331	41,196	44,392
• Foreign Currency	100	100	100	120	150	150
Sub-total	33,390	34,489	38,434	53,451	41,346	44,542
Development Budget						
• Local Currency	13,182	18,500	11,639	22,516	27,100	36,336
• Foreign Currency	12,818	6,700	35,960	32,110	53,000	39,386
Sub-total	26,000	25,200	47,599	54,626	80,100	75,722
Current + Development						
• Local Currency	46,472	52,889	49,973	75,847	68,296	80,728
• Foreign Currency	12,918	6,800	36,060	32,230	53,150	39,536
Total (index number: 100 for 1983/84)	59,390 (100)	59,689 (101)	86,033 (145)	108,077 (182)	121,446 (204)	120,264 (202)
Percent of total budget of the Ministry	–	–	2.24%	3.66%	3.81%	7.87%

(Source: Geological Survey of Pakistan)

While the total budget of the Ministry of Petroleum and Natural Resources has remained almost unchanged in recent years, that for the Geological Survey of Pakistan has been increasing, reflecting the importance attached to geological investigation and exploration by the Government of Pakistan.

2-4-4 Present Situation of the Facilities and Equipment

(1) Facilities

The facilities of the headquarters had been developed and had reached their climax by the early 1960s when the GSP began to actively engage in geological investigation and study. Since then, however, its budget has been reduced successively, therefore, sufficient budget for maintaining and repairing the facilities has not been allocated. As a result, the facilities of the headquarters have gradually become rather obsolete. Furthermore, sufficient budget has not been allocated for construction of the newly established regional divisions and branches. Consequently, these divisions and branches are renting portions of buildings of other government agencies and private companies or individuals. Although projects to expand and improve the facilities were incorporated in the sixth five-year plan (1983-88), these projects have not yet made any headway.

Table 2-8 Existing Facilities of the GSP

	Floor area of building (m^2)	Construction Year	Remarks
Headquarters (Quetta) (including Central Div., Geophysics Div., Analytical Chemistry Div.)	• Bldg. No.1 5,410 • Bldg. No.2 1,709 • Bldg. Nos. 3~10 677(each) • Bldg. No. 11 1,393 • Bldg. No. 12 1,393 • Storehouse 668 • Others 111	1962	
Sub Total	16,100		
Sind Div. (Karachi)	1,115	relatively new construction	Rented
Northern Div. (Lahore)	1,672	〃	〃
• Peshawar Branch	557	〃	〃
• Islamabad Branch	1,115	〃	〃
• Muzaffarabad Branch	372	〃	〃
Total	20,931		

(Source: Geological Survey of Pakistan)

(2) Equipment

From the sixth five-year plan onward, efforts have been made to improve the equipment on a small and selective scale, with assistance from the United States and other foreign countries. At the headquarters, Sind Division and Northern Division, atomic absorption spectrometers have been installed and these are in operation. Also, an X-ray fluorescence spectrometer and a differential thermal analyser have been installed at Sind Division and an X-ray diffractometer commissioned at the headquarters. In addition, gypsum content analysing equipment such as ash content analyser, ancillary devices such as scales, and sample preparation equipment such as sample crusher have been installed. Most of these equipment and devices are simple in function and structure and therefore do not require much expenditure for operation and maintenance. But they are not sophisticated enough for precise determination, classification or analysis of rock and mineral samples.

2-5 Present Situation of the Geoscientific Investigation and Exploration of Mineral Resources by the GSP

2-5-1 Geoscientific Investigation

The Geological Survey of Pakistan is conducting geological mapping, geophysical surveys, geochemical prospecting, exploratory drilling, chemical studies and publication of results as the investigation activities.

(1) Geological Mapping

Geological mapping occupies a pivotal position in the technical activities of every national geological survey organisation and is given the highest priority in the overall technical activities of the GSP. Mapping is generally done on the standard 1:50,000 scale in the light of the quality of information socially needed, the relation between the condition of rock exposures and the precision required, and work efficiency. The geological mapping on the standard 1:50,000 scale shown in the following table has been achieved since the establishment of the GSP.

Table 2-9 Status of Reginal Geological Mapping on 1:50,000 Scale

Region	Total area (km^2)	Area mapped during 1947-88 (km^2)	Remarks
Baluchistan province	347,190	80,080	
Punjab province	205,345	43,520	
Sind province	140,914	49,280	
Northwest Frontier province	101,741	62,000	
(including federally administered tribal areas)	(27,220)	(–)	
Islamabad	906	800	
Sub Total (outcrop area)	796,096 (658,000)	236,950	29.8% (36.0%)
Northern areas	72,496	8,610	
Azad Jammu and Kashmir	13,296.778	5,120	
Total	881,888.778	250,680	

(Source: Geological Survey of Pakistan)

Generally, there are wide variations in the quality of information incorporated in geological maps for the same area because of differences in precision of laboratory analysis of the samples collected through field survey and differences in judgement among geoscientists. It is natural that there are also differences in the results of exploration projects conducted on the basis of such geological mapping. It is therefore essential for the GSP to try to improve the quality of information incorporated in geological mapping while making efforts to expand reconnoitred areas.

(2) Geophysical Surveys

The geophysical surveys are important in interpreting the subsurface geology, improving the efficiency of mineral resources exploration, and in formulating large-scale civil engineering projects. For this reason, various types of geophysical exploration methods, including gravity and magnetic surveys, have been utilised.

(3) Geochemical Prospecting

Geochemical prospecting is to predict subsurface mineral resources, by interpreting the contents, modes of occurrences, distribution and contents of various elements in rocks, minerals, soils and other materials. For this reason the GSP has been trying various geochemical studies. Advanced analytical equipment is essential for determining the contents of trace elements.

(4) Exploratory Drilling

Exploratory drilling is costliest of all operations normally undertaken by a geological survey organisation, and is used only at places which are most likely to contain mineral deposits. As it makes it possible to collect subsurface samples and conduct stratigraphic and structural examination, it is effective in exploring subsurface mineral resources. The GSP is conducting necessary exploratory drilling, and is frequently asked to undertake exploratory drilling for other government agencies, such as Pakistan Mineral Development Corporation, Pakistan Atomic Energy

Commission, State Cement Corporation of Pakistan, and Water and Power Development Authority.

(5) Chemical Studies

It is essential to evaluate the potential for mineral resources in certain areas; concentration and distribution of major and trace elements will be determined by chemical analyses. The GSP is presently undertaking chemical analysis work of limited use at laboratories in Quetta, Karachi and Lahore.

(6) Publications

The Geological Survey of Pakistan is publishing a variety of reports and geological maps to make the results of its activities available to the general public. Although some of its publications are edited and printed at its own facilities, printing of most (90 percent) of the geological maps is commissioned to private presses in Karachi after transparencies are made at its own facilities in Quetta.

The main achievements in geoscientific investigation during the fifth and sixth five-year plans and the major programmes during the seventh five-year plan are shown in the following table.

Table 2-10 Achievements in Geoscience Investigation

Discipline	5th five-year plan (1978~1983)	6th five-year plan (1983~1988)	7th five-year plan (programme) (1988~1993)
(1) Geological mapping	51,600 km^2	57,591 km^2	60,000 km^2
(2) Geophysical survey	30,000 km^2	30,275 km^2	30,000 km^2
(3) Geochemical prospecting	640 km^2	1,280 km^2	5,000 km^2
(4) Exploratory drilling	9,612 m	12,866 m	15,000 m
(5) Chemical analysis			
• Sampel	9,788	13,711	20,000
• Radicals	(33,035)	(54,312)	(120,000)
(6) Publications			
• Reports	133	125	50
• Geologial maps	43	66	60

(Source: Geological Survey of Pakistan)

The collaborative activities with outside organisations during the 6th five-year plan from 1983 to 1988 as part of its overall geological investigation activities are shown in table 2-11. Since the introduction of the theory of plate tectonics, interest in the unique geotectonic characteristics of Pakistan has been growing in various countries. As a result, there have recently been increasing collaborative activities with international geoscientific organisations. However, there is a shortage of permanent facilities and equipment capable of precisely analysing the field survey samples. Most of the samples collected are sent abroad for precise analysis and check work. Consequently, these activities have not always resulted in the improvement in the technical capabilities of Pakistani scientists.

Table 2-11 Collaborative Investigation Activities with Other Domestic Organisations

Investigation		Organisation	Remarks
A-1	Geological Mapping of Kan Mehtarzi area, Zhob District	Government of Baluchistan	Completed
A-2	Electrical resistivity survey in Ziarat	〃	〃
A-3	Land-slide investigations in Malam Jabba ski area	Ministry of Tourism and Culture	〃
A-4	Study of ski slopes in Malam Jabba	〃	〃
A-5	Study of geological feasibility for pipe-line at Narthong, Skardu Baltistan	Northern Affairs and Kashmir Affairs Division	Under investigation
A-6	Geological Mapping of Poonch-Kahuta Area	〃	〃
A-7	Survey and investigation for coal in Orakzai agency	Federal Administered Tribal Area	〃
A-8	Magnetic survey to locate a crane near Ghazi Ghat, D.G. Khan	Highway Mechanical Department, Lahore	Completed

(Source: Geological Survey of Pakistan)

A resume of collaborative investigation activities undertaken with international organisations is given in table 2-12.

Table 2-12 Collaborative Investigation Activities with Foreign Organisations

Investigation	Organisation	Remarks
B-1 Biostratigraphic and sedimentological studies of Siwalik Group, Potwar Plateau	British Archaelogical Mission	Completed
B-2 Tectonics and sedimentation of the Indo-Eurasian colliding plate boundary regions and its influence on the mineral development	Hiroshima University	Under investigation
B-3 Research on geology and mineral resources of the collision zone	Geological Survey of Japan	〃
B-4 Glacier research project in the Astor and Rupal Valley, Gilgit and Azad Jammu and Kashmir	University of Regensburg, West Germany	Under preparation
B-5 Reconnaissance geological mapping of Misgar-Chapursan area on 1:250,000, Gilgit District	Italy	〃
B-6 Tectonics of northern areas of Pakistan	Oregon State University, USA	Completed
B-7 Cenozoic mammals and biostratigraphy of Pakistan	Howard University · Harvard University, USA	〃

(Source: Geological Survey of Pakistan)

2-5-2 Exploration of Mineral Resources

The Geological Survey of Pakistan is conducting exploration activities aiming at promoting the development of mineral resources, on its own or in collaboration with other organisations. The main exploration projects carried out and started during the sixth five-year plan (1983-88) and the number of senior scientists who participated in these activities are shown in the following tables.

Table 2-13 Main Exploration Projects During the Past Five Years

Project		Scientists Involved	Remakrs
C-1	Aeromagnetic Survey and Follow-up Ground Investigations in Part of Baluchistan	Geophysicist: 6 Geologist : 4	Completed, collaboration with CIDA - Canada
C-2	Exploration of Placer Minerals in the Punjab Province	Geologist : 3	Completed
C-3	Integrated Exploration for Metallic Minerals in NWFP	Geologist : 3	〃
C-4	Exploration of Sonda Thatta Coal in Sind	Geologist : 2	〃
C-5	Geological Evaluation of Sulphide and Metallic Mineral Deposits in Baluchistan	Geologist : 3	Completed, collaboration with UNDP

(Source: Geological Survey of Pakistan)

Table 2-14 On-going Exploration Projects

Project		Scientists Involved	Remarks
D-1	Energy Planning and Development Umbrella Project	Geologist : 4 Geophysicist: 3 Chemist : 3	Joint project with USAID
D-2	The Salt-Range Tertiary Coal Exploration, Punjab, Pakistan	Geologist : 2	
D-3	Exploration and Evaluation of Khost Shahrig and Harnai Coal Field, Baluchistan	Geologist : 2	
D-4	Exploration and Development of Surmai Lead-Zinc Prospect, Khuzdar District, Baluchistan	Geologist : 4	Joint project with JICA - Japan
D-5	Geological Appraisal of Mineral Resources of AJK	Geologist : 12 Chemist : 1	Joint project with AKMIDC
D-6	Exploration of Minerals Associated with Active Foreland Fold and Thrust Belt of Northern Pakistan	Geologist : 1 Geophysicist: 2	Joint project with Oregon State University, USA
D-7	Exploration and Evaluation of Sor-Range Dighari Coal Field, Baluchistan (1988~91) and Mach-Abe-Gum Coal Field, Baluchistan (1988~92)	Geologist : 7 Geophysicist: 5 Chemist : 3	
D-8	Exploration of Lead-Zinc Prospects in Lasbela Khuzdar Metallogenic Belt, Baluchistan	Geologist : 4	Collaborative project with UNDP

(Source: Geological Survey of Pakistan)

The following map shows the locations of those collaborative investigation activities and exploration projects which were carried out in selected areas. In recent years, there has been a marked increase in the number of projects carried out in the northern areas.

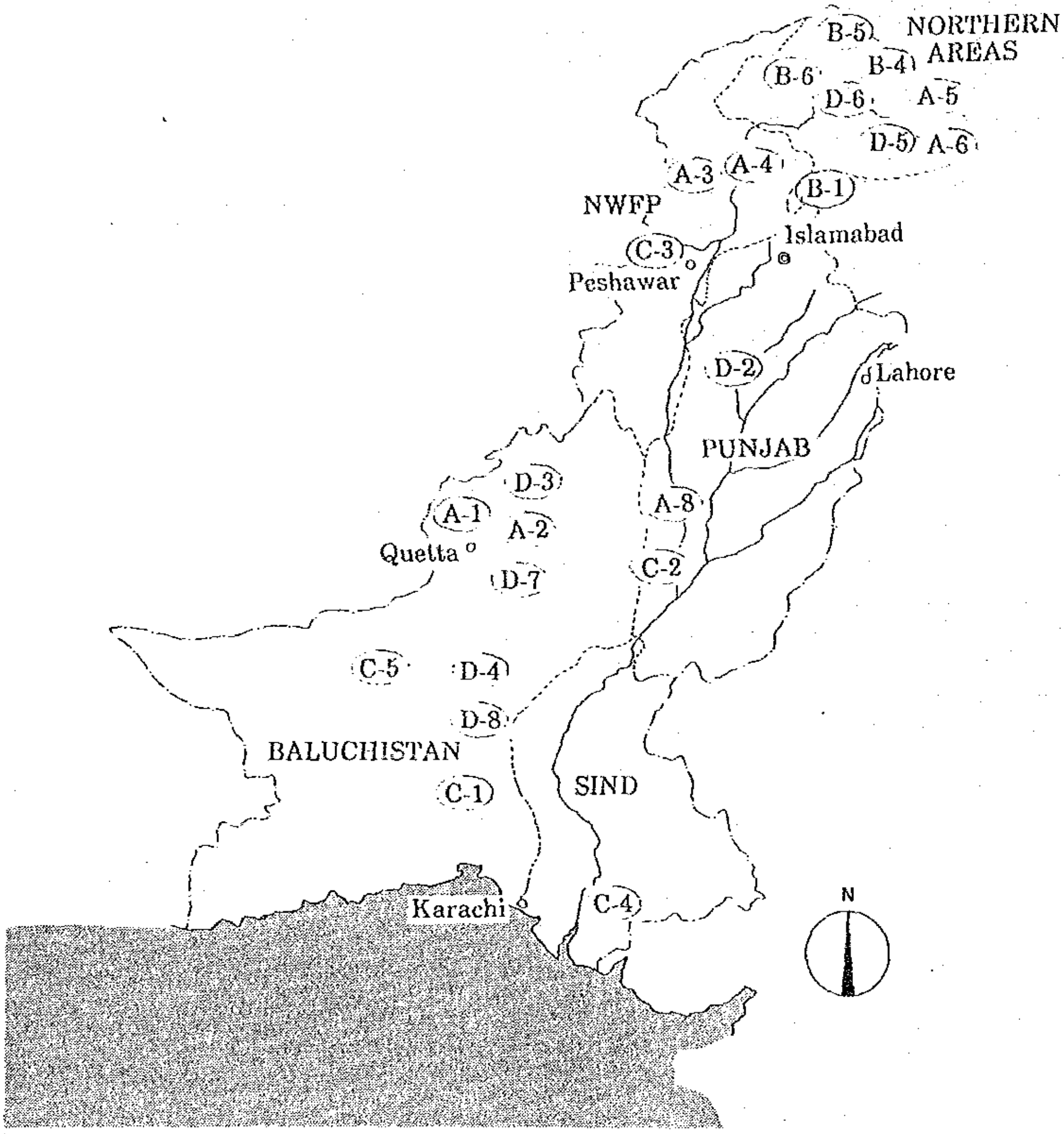


Fig. 2-8 Locations of Collaborative Investigation Activities and Exploration Projects (alphanumeric characters correspond to those listed in the related tables)

2-6 Background and Contents of the Request

2-6-1 Background of the Request

According to recent developments in geology, high expectations are placed on the possibility of further mineral resources existing in Pakistan and it is likely that the mining industry will contribute to the growth of the national economy in the long run. For this reason, investigation, exploration and development of mineral resources are considered one of the important policies in the seventh five-year plan (1988-93). In order to achieve substantial results in exploration for mineral resources, it is necessary to expand and improve field activities, and enhance the ability of scientists to conduct laboratory work. However, the facilities and equipment of the Geological Survey of Pakistan of the Ministry of Petroleum and Natural Resources, are getting rather obsolete. Consequently, the technical capabilities of the staff are generally not very high, making it difficult for the department to meet the expectations of the Government of Pakistan.

Under these circumstances, the Government of Pakistan planned to construct the Geoscience Laboratory to promote the development of economically viable mineral resources by raising the level and scope of geological investigation. Islamabad was selected as the place for establishing the laboratory in consideration of availability of the infrastructure, proximity to the northern areas, availability of support from other organisations and universities, and facility to accept Japanese experts for technical cooperation. The Government of Pakistan incorporated this project in the seventh five-year plan, and in October 1988 requested the Government of Japan to extend a grant aid for this construction project and technical cooperation for developing human resources for geological investigation and exploration.

In response to this request from the Government of Pakistan, the Government of Japan decided to conduct a study related to the proposed project, and the Japan International Cooperation Agency (JICA) dispatched a preliminary survey team to Pakistan in December 1988 for the purpose of confirming the background and contents of the proposed project. As a result of this preliminary survey, the appropriateness of the requested technical cooperation and the necessity of conducting a basic design study on the requested grant aid were confirmed. In April 1989 the JICA dispatched a basic design study team to Pakistan.

2-6-2 Contents of the Request

The outline of the request, finally confirmed as a result of discussions in April 1989 between the basic design study team and the Pakistani side, is described as follows:

(1) Facilities

Facilities necessary for the following sections;

1) Paleomagnetic Geochronology Laboratory
2) Petrology and Mineralogy Laboratory
3) Analytical Chemistry Laboratory
4) Geochemical Exploration Section
5) Isotope Geochronology Section
6) Geology Section
7) Sample Preparation Section
8) Administration Section
9) Service Section

(2) Equipment

- Paleomagnetic Geochronology Laboratory
  - a. Digital spinner magnetometer
  - b. Magnetic susceptibility meter
  - c. Diamond drill
  - d. Other equipment necessary for paleomagnetic analysis

- Petrology and Mineralogy Laboratory
  a. X-ray fluorescence spectrometer
  b. X-ray diffractometer
  c. Electron probe micro-analyser
  d. Differential thermal analyser
  e. Spectrometer
  f. Other equipment necessary for Petrology and Mineralogy Laboratory

- Analytical Chemistry Laboratory
  a. Atomic absorption spectrometer w/flame
  b. Atomic absorption spectrometer w/flameless
  c. Other equipment necessary for chemical analysis

- Geochemical Exploration Section
  a. Data processing system
  b. Vehicles for field survey
  c. Other equipment necessary for geochemical sampling

- Sample Preparation Section
  Equipment and machinery necessary for preparation and processing of samples

- Administration Section
  Equipment necessary for administrative and financial management

The main modifications made to the former request (which was confirmed at the stage of the preliminary survey of December 1988) during the discussions between the basic design study team and the Pakistani side are shown below.

(1) Organisational structure of the Geoscience Laboratory

After review of the proposed organisational structure of the Laboratory, with emphasis on the flow of operations, the organisational structure was rearranged according to the sections shown in 2-6-2(1).

(2) Equipment

The scanning electron microscope which was included in the former request was deleted because although it would be effective for exploring organic underground resources (i.e., geochronological measurements through identification of index fossils), it was not considered indispensable for practical exploration of inorganic mineral resources. The gas chromatograph was also deleted because organic substances are not programmed to be analysed in the Geoscience Laboratory. The ICP spectrometer was deleted because it was assumed that the high cost for gas consumption would put pressure on the maintenance budget of the GSP, and because the flameless atomic absorption spectrometer could substitute for the ICP.

CHAPTER 3 CONTENTS OF THE PROJECT

CONTENTS OF THE PROJECT

3-1 Objective of the Project

The objective of the project is to contribute to the development of mineral resources in Pakistan by improving knowledge and technologies in geological investigation and mineral resources exploration. To this end, the Government of Japan will implement the grant aid programme to construct the Geoscience Laboratory in Islamabad.

3-2 Examination of the Contents of the Request

3-2-1 Examination of the Contents of the Request

As stated in Chapter 2, it is urgent to strengthen the quality of geological investigation and mineral resources exploration in Pakistan. In this context, it is essential to construct the proposed Geoscience Laboratory. Generally, the outline of the method of investigation and exploration of mineral resources can be illustrated as follows:

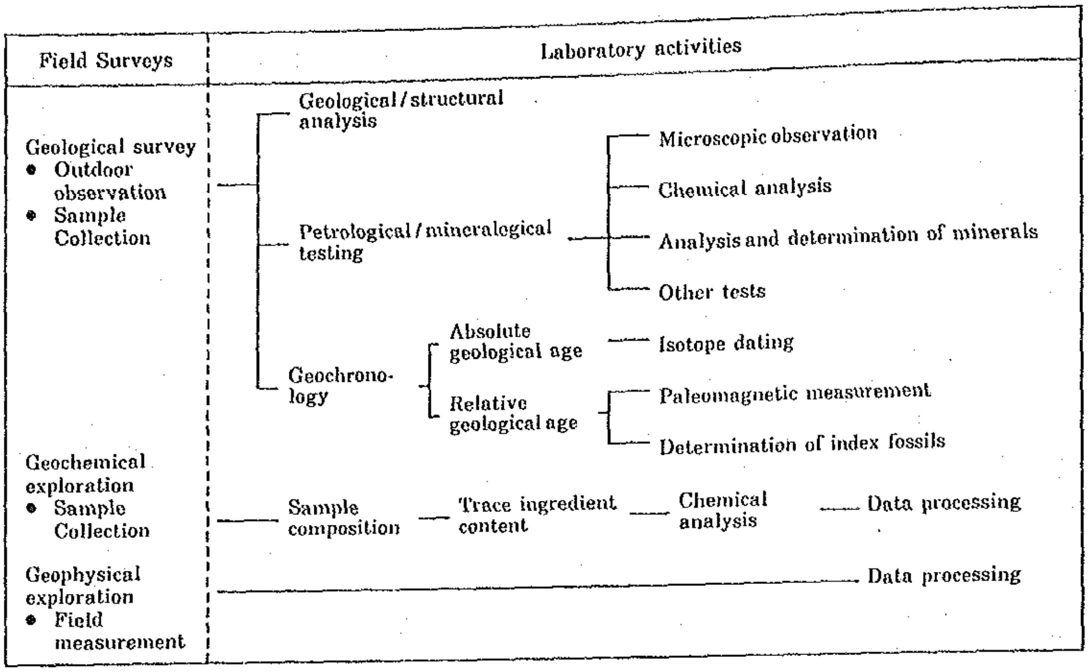


Fig. 3-1 Method of Investigation and Exploration of Mineral Resources

As shown in Fig.3-1, the fields of paleomagnetic geochronology, petrology and mineralogy, analytical chemistry, geochemical exploration, isotope geochronology and geology form the basis of investigation and exploration of mineral resources. The main activities of the Geoscience Laboratory will be laboratory activities using analytical equipment. Therefore, no section or equipment for geophysical exploration is included in this project. However, the Geological Survey of Pakistan is carrying out geophysical exploration at the central division and other regional divisions. It is not necessary to include the section for paleontological geochronology because the GSP is in the process of constructing facilities for paleontological geochronology in Islamabad. In addition to the above reasons, considering expected conditions for maintenance and operation of the Geoscience Laboratory, it is appropriate to include the requested fields in the project.

The field of marine geology, which is covered by the Geological Survey of Pakistan, was excluded in view of the fact that the site for the laboratory is located in Islamabad, which is far from the Arabian Sea coast. Also, the field of energy resources was excluded because research on crude oil and natural gas is conducted mainly by the Hydrocarbon Development Institute of Pakistan, which is attached to the Ministry of Petroleum and Natural Resources, and also because coal deposits are located mainly in the provinces of Baluchistan, Punjab and Sind, and research on coal can be conducted by the central division or other regional divisions of the GSP. It is expected that the requested fields will play important roles in the major activities of the GSP as described 2-4-2 of Chapter 2, except for geophysical exploration, marine geology and energy resources.

The requested fields included in the proposed laboratory have already been covered by the Geological Survey of Pakistan. However, technical understanding has not gone beyond knowledge acquired through desk study, mainly due to the shortage of equipment needed for precise analysis. It has been difficult for scientists of the GSP to obtain reliable data in areas other than a part of analytical chemistry. Consequently, technology transfer to the GSP staff to be involved in activities of the proposed laboratory is essential for the satisfactory achievement of the proposed laboratory for the development of the country's mineral resources. The proposed laboratory will be managed and operated basically in accordance with the personnel plan made by the Pakistani side. Although no change has been made in the number of staff members after review of the requested fields, some modifications have been made to the proposed personnel allocation. The final personnel plan is shown in Table 3-1 in 3-3-2 of this chapter.

The site for this project is located approximately 7km south of the central district of Islamabad. It has an area of approximately 4 ha, which is large enough for this laboratory. The site, which is in the possession of the Capital Development Authority, will be leased to the Geological Survey of Pakistan for 33 years. The term of lease is to be extended for a further 66 years, so the GSP will be able to use the site for at least 99 years. Consequently, it can be concluded that this site is not unsuitable for a project implemented with grant aid from the Japanese government.

3-2-2 Examination of the Facilities and Equipment Requested

(1) Facilities

The proposed laboratory requires laboratory facilities for the requested fields, scientist rooms and rooms for the sample preparation section (responsible for preparing and processing samples), and the administration and service sections. The individual laboratories should be air-conditioned so that they meet operational and maintenance requirements, such as temperature and humidity of the equipment. For this reason, the laboratories should be centre-corridored to alleviate outside heat in the summer. Scientist rooms, office rooms, etc. should be single-corridored for better natural ventilation.

(2) Equipment

As mentioned in 2-6-2 of Chapter 2, the major equipment finally confirmed by the basic design team includes, X-ray fluorescence spectrometer, X-ray diffractometer, electron probe microanalyser, atomic absorption spectrometer, and so on. This equipment is indispensable for precise laboratory work to determine, classify and analyse the samples collected. Such work at the proposed laboratory will promote development of mineral resources by improving the quality of basic geological information and technologies for mineral resources exploration.

3-3 Project Description

3-3-1 The Executing Agency of the Project

The Geological Survey of Pakistan is responsible for execution of this project. As shown in Fig. 2-7 in 2-4-3 of Chapter 2, the GSP has a headquarters at Quetta, and geographically separated regional divisions. The Geoscience Laboratory is to be incorporated into the GSP's organisational structure on an equal footing with each of these regional divisions.

3-3-2 Management System

The Geoscience Laboratory will be managed by a Director who is to be appointed by the Director General of the Geological Survey of Pakistan.

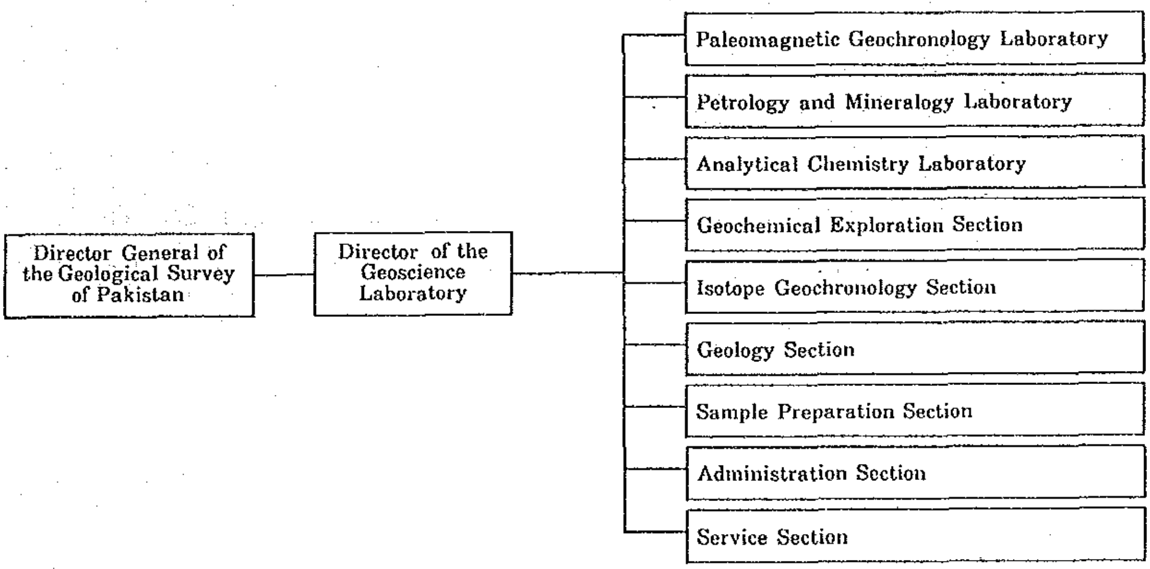


Fig. 3-2 Planned Organisation of the Geoscience Laboratory

The Geological Survey of Pakistan formulated a five-year plan (PC-1 Form) for the implementation of the grant aid and technical cooperation from the Government of Japan, which commences in 1989/90. According to this plan, a special local currency budget for the Geoscience Laboratory (which includes acquisition of the project site, personnel and maintenance and operational expenses, etc.) will be allocated to the GSP in addition to annual current and development budgets. After completion of this five-year plan (PC-1 Form), the total annual budget for the GSP allocated by the Ministry of Petroleum and Natural Resources will be increased, taking into account the actual recurring expenditures of the Geoscience Laboraotry.

The Geoscience Laboratory will have a staff of 64. The number of staff members will be increased annually in keeping with the progress of the five-year plan, and it is expected that the whole staff will be employed before completion of this five-year plan. Specifically, 20 out of 22 senior scientists, and 50 of the whole staff of 64, are scheduled to be placed by 1991-92. Consequently, the number of the staff will probably be large enough to start full-scale operation of the Geoscience Laboratory after the completion of the grant-aid project. Of the 64 staff members, 6 will be transferred to this laboratory from other regional divisions and branches of the GSP, and the remaining 58 will be newly recruited. The latter staff members will be required to have experience and knowledge of their respective research fields. The personnel expenses for the staff members are included in the local currency budget of the above-stated five-year plan of the GSP.

Table 3-1 Proposed Assignment Plan of Personnel

Title of Post	BPS	No. of persons	Title of Post	BPS	No. of persons
1. Paleomagnetic Geochronology Laboratory			7. Sample Preparation Section		
Assistant geochronologist	17	2	Laboratory attendant	3	2
Geophysical engineer	17	1	Section Cutter	2	4
Laboratory assistant	7	1			
2. Petrology and Mineralogy Laboratory			8. Administration Section		
			Director (chief geoscientist)	20	1
Superintending petrologist	19	1	Deputy director (librarian)	18	1
Petrologist	18	2	Documentation officer	17	1
Assistant petrologist	17	3	Accounts officer	17	1
3. Analytical Chemistry Laboratory			Administration officer	16	1
			Stenographer	15	2
Superintending chemist	19	1	Accounts assistant	9	1
Senior chemist	18	1	Casher	7	1
Chemist	17	3			
Laboratory Assistant	7	3			
4. Geochemical Exploration Section			9. Service Section		
Superintending geochemist	19	1	Maintenance /electronic engineer	18	1
Computer programmer	18	1	Caretaker of building	16	1
5. Isotope Geochronology Section			Instrument officer	16	1
Geochronologist	18	1	Senior store keeper	7	1
Assistant geochronologist	17	1	Upper division clerk	7	1
Laboratory assistant	7	1	Lower division clerk	5	2
6. Geology Section			Driver	4	4
Straitigrapher	19	1	Laborer (sweeper, gardener, guard, cook, general labors)	1	10
Structural geologist	18	1			
Senior mining geologist	18	1			
Field assistant	11	1			
Laboratory assistant	7	1	Total number of persons		64

3-3-3 Activity Plan

The Geoscience Laboratory is to engage in the following activities within the organisational framework as shown in Fig. 3-2 to contribute to the development of mineral resources in Pakistan.

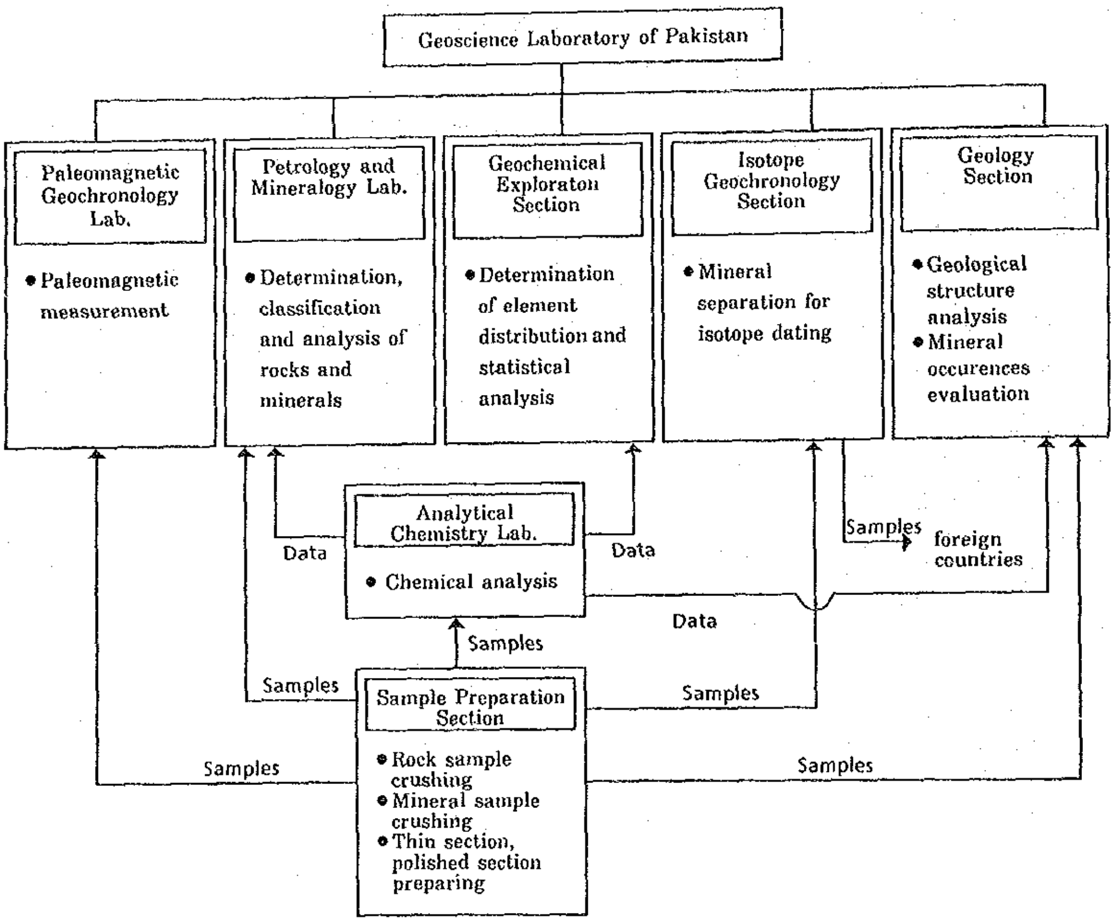


Fig. 3-3 Interrelationships among Laboratories / Sections

(1) Paleomagnetic Geochronology Laboratory

The activity of this laboratory is to clarify location changes of the Indian continent during the period from its separation from the Gondwana continent to its collision with the Eurasian continent. This will be done by measuring the directions of remanent magnetisation and paleomagnetic thermal changes of the orientated rock samples using remanent magnetism measuring equipment, demagnetisers, magnetic scales and other instruments (to map paleomagnetic distribution). Then, geochronological location of the Indian plate and its island arcs will be estimated, based on the results of the above laboratory works. Information on mineral resource concentration consistent with the geological history from the standpoint of plate tectonics theory will thereby be obtained.

(2) Petrology and Mineralogy Laboratory

The activity of this laboratory is to determine and classify rock and mineral samples using microscopes, an electron probe microanalyser, etc., and conduct mineralogical analyses using the X-ray diffractometer and other instruments. Then, based on the analysis of the analytical chemistry laboratory, and the above-mentioned studies, the mineral and chemical composition of collected rocks and the chemical characteristics of collected minerals are clarified, and the conditions of genesis of these rocks and minerals are investigated. Next, from a petrological and mineralogical viewpoint, areas where it is likely that mineral resources exist are identified by comparing these results with the results of surveyed area's structural analyses and studies of the geographical distribution of mineral occurrences.

(3) Analytical Chemistry Laboratory

The activity of this laboratory is to determine the contents and distribution of rock, mineral, soil, stream sediment, plant and water samples collected during the field surveys. Major and trace elements are analysed using an X-ray fluorescence spectrometer, atomic absorption spectrometers and other instruments. The results of these chemical analyses will also be utilised in the petrology and mineralogy laboratory, the geochemical exploration section and the geology section.

(4) Geochemical Exploration Section

The activity of this section is to compare the primary distribution of elements (trace element contents) and their secondary distribution (weathering, erosion and movement) with the results of surveyed area's structural analyses and studies of the distribution of mineral occurrences. The existence of mineral deposits in the covered outcrop areas can be deduced by conducting computer-aided statistical analyses of the distribution of elements and by preparing geochemical maps.

(5) Isotope Geochronology Section

Isotope geochronology is a field which determines the absolute geologic ages of rocks by utilising the phenomenon of destruction of radioactive elements with time. Samples for isotope dating will be prepared at this section of the Geoscience Laboratory. Determination of the geologic ages of rocks is to be commissioned to laboratories in Japan and other foreign countries. Genetic ages of rocks, minerals and corresponding geological structures are to be clarified by isotopically analysing rock samples. This information, incorporated with that obtained in other laboratories and sections, will be effectively used in evaluating mineral potentials of specific areas.

(6) Geology Section

This section will prepare structural geology maps by comprehensively interpreting geological structures based on classification of surface and subsurface rocks according to the results of field and microscopic observations and of chemical analysis of rock samples. Also, mineral occurrence and metallogenic maps will be prepared in this section by clarifying natures of mineralisation based on the results of field and microscopic observation and of chemical analysis of mineralised samples. This section is to specify target areas with high potentials for certain mineral resources by comparing, examining and comprehensively interpreting these maps.

(7) Sample Preparation Section

Rocks and minerals collected during the field surveys will generally be sent to laboratories in the form of lumps. It is usually difficult to observe, measure or analyse these rocks and minerals using precision equipment. This section will prepare thin, polished sections, crush/pulverise samples of the rocks and minerals in compliance with specifications of the precision equipment to be used, and supply these samples to each of the above-mentioned laboratories and sections.

Scientists at the headquarters, regional divisions and branches of the GSP will participate in the above-stated activities if necessary. Scientists of governmental organisations under the Ministry of Petroleum and Natural Resources will also be able to participate if such activities are deemed suitable as collaborative projects. The Geoscience Laboratory will be able to undertake analyses of samples commissioned by private companies to promote various types of mineral resources development programmes in the country.

It is expected that the following geological maps and related reports which are fundamental for the development of mineral resources will be prepared as a result of the above-mentioned activities of the Geoscience Laboratory:

Table 3-2 Types of Geological and Other Related Maps

Type	Scale	Contents
Geological maps	1/50,000~1/100,000	Stratigraphy, faults and folds etc.
Structural geology maps	〃	Surface distribution of faults, folds and other structural elements
Mineral occurrence maps	〃	Surface mineral occurences and their geologic, tectonic, petrologic and mineralogic characteristics and ages of mineralisation
Geochemical maps	〃	Surface distribution of elements and rock types and its relationship with economically useful elements
Paleomagnetism distribution maps	1/100,000	Surface distribution of paleomagnetism in various types of rocks of various geological ages
Metallogenic maps	〃	Classification of mineral provinces in relation to geological provinces at various geological ages
Generalised maps	〃	Extraction of potentially promising areas for economically useful elements by generalising the above geological and other related maps

Since the introduction of precision equipment and expected improvement in technical skills of scientists of the Geoscience Laboratory and the GSP will make these maps much more precise than those produced by their predecessors, opportunities for discovery of new mineral deposits will increase substantially. When the above-mentioned activities make further advances, more detailed geological maps and structural geology maps, geochemical maps and mineral exploration implementation charts, etc. with scales ranging from 1:10,000 to 1:25,000 will be prepared.

3-3-4 Location and Condition of the Project Site

(1) Location

The project site is located in Chalk Shahdad area in the southeastern suburbs of Islamabad. It is approximately 7km away from the center of the city and approximately 3km from Rawal Lake. In the neighbourhood of the project site, there are the National Institute of Health, the National Agricultural Institute and other research institutions. It is approximately 300 meters away from National Park Road and approximately 200 meters from Nursery Road. The present access road to the project site is a farm road with a width of approximately 3 meters. A bus line to the center of the city runs on National Park Road.

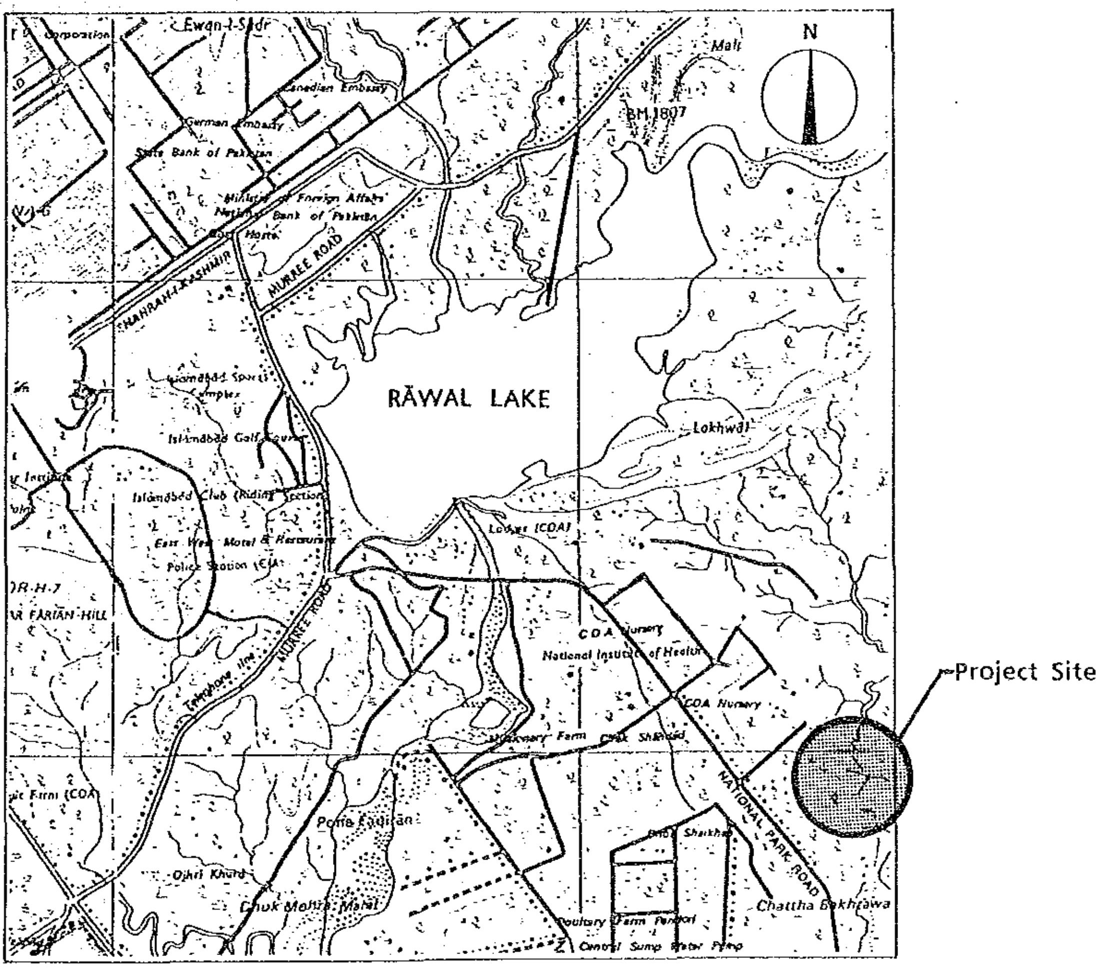


Fig. 3-4 Map of the Project Site

(Source: Islamabad and Surroundings, Survey of Pakistan)

(2) Title to the Project Site

The project site is owned by the Capital Development Authority and is to be leased to the Geological Survey of Pakistan on a long-term basis. The existing farm houses on the site will be removed by the Capital Development Authority before the site is handed over to the GSP.

(3) Topography

The shape of the project site is a rectangle, 220 meters by 183 meters. The project site slopes down from west-southwest to east-northeast in the form of terraced fields. The maximum difference of elevation on the site is approximately 5 meters.

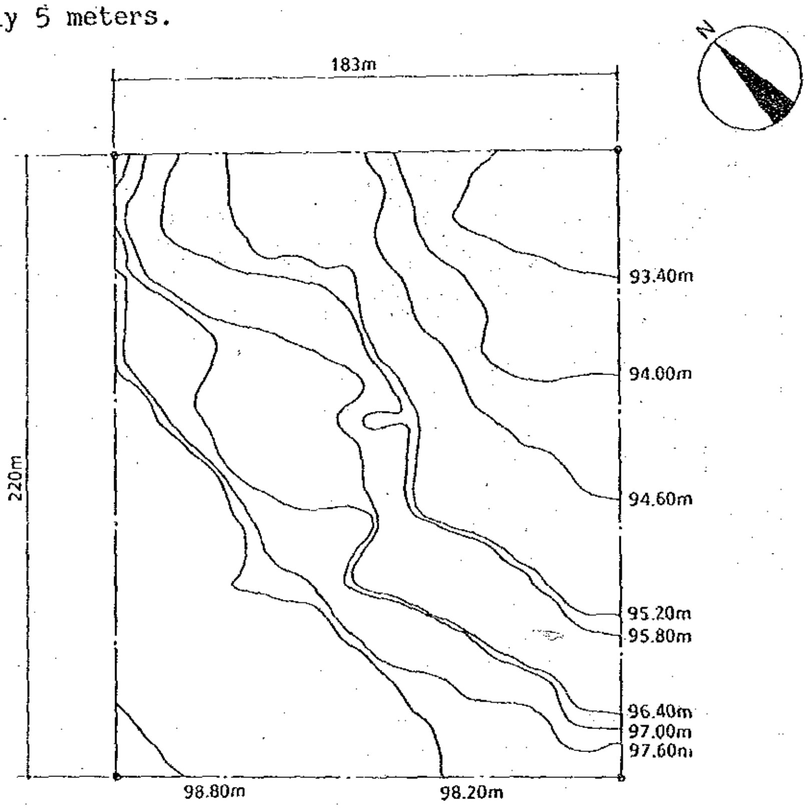


Fig. 3-5 Undulation Map of the Project Site

(4) Soil Conditions

According to the geological data on the project site obtained from the GSP, almost uniform soil characteristics are distributed over the project site. The approximately 2-meter deep layer consists of soft clay and silty clay of N values not exceeding 10. The layer below it consists of hard clay and silty clay of N values ranging from 10 to 15. The ground water level is approximately 6 meters below surface level. Generally, silty clay tends to lose its strength when it is mixed with water. Therefore, its N value is considerably smaller near the ground water level.

(5) Natural Environment

The project site is surrounded by barley fields (except for the National Centre for Rural Development) so there will be no difficulty in terms of sunshine, natural ventilation, noise and air pollution.

(6) Infrastructure

1) Electric Power

11kV overhead power lines are installed along National Park Road from the Universal Grid Substation near Rawal Lake. It is possible to connect these power lines with the proposed buildings. In this area, power failures occur often, approximately 80 times a year. Most power failures are caused by the low capacity of the power source, but a large number of them do not last for more than 20 minutes. The voltage regulation rates are estimated at more than ±5 percent.

2) Telephone

To the southwest of the project site is the National Centre for Rural Development. Near the south gate of the site of this Centre, a telephone terminal board (DC-25A) of the Pakistan Telephone and

Telegraph Department (PTTD) is installed. The terminal board has a capacity of 50 lines, of which 48 are already in use. So the Geological Survey of Pakistan will soon make an application for expansion of the capacity of the board.

3) Water Supply

Almost all central parts of the city of Islamabad are supplied with city water. However, near the project site, only the National Centre for Rural Development and the Model Village located southwest of National Park Road are supplied with city water. Since at present the Capital Development Authority (CDA) has no plan to supply city water to the project site, the GSP will ask the CDA to consider supplying city water to the project site.

4) Sewerage

Public sewerage is not installed near the project site. Waste water from buildings near the project site is treated in septic tanks and then penetrates the earth through soak wells. Rainwater penetrates the earth or flows down to lower land naturally.

5) Natural Gas

A medium-pressure gas main of the Sui Northern Gas Pipeline Limited is installed along National Park road. The gas supply pressure is 5.6 kg/cm^2, the gas main diameter is 150mm, and the gas calories is approximately 8,900 $kcal/m^3$. It is possible to connect a branch of the gas main to the proposed buildings.

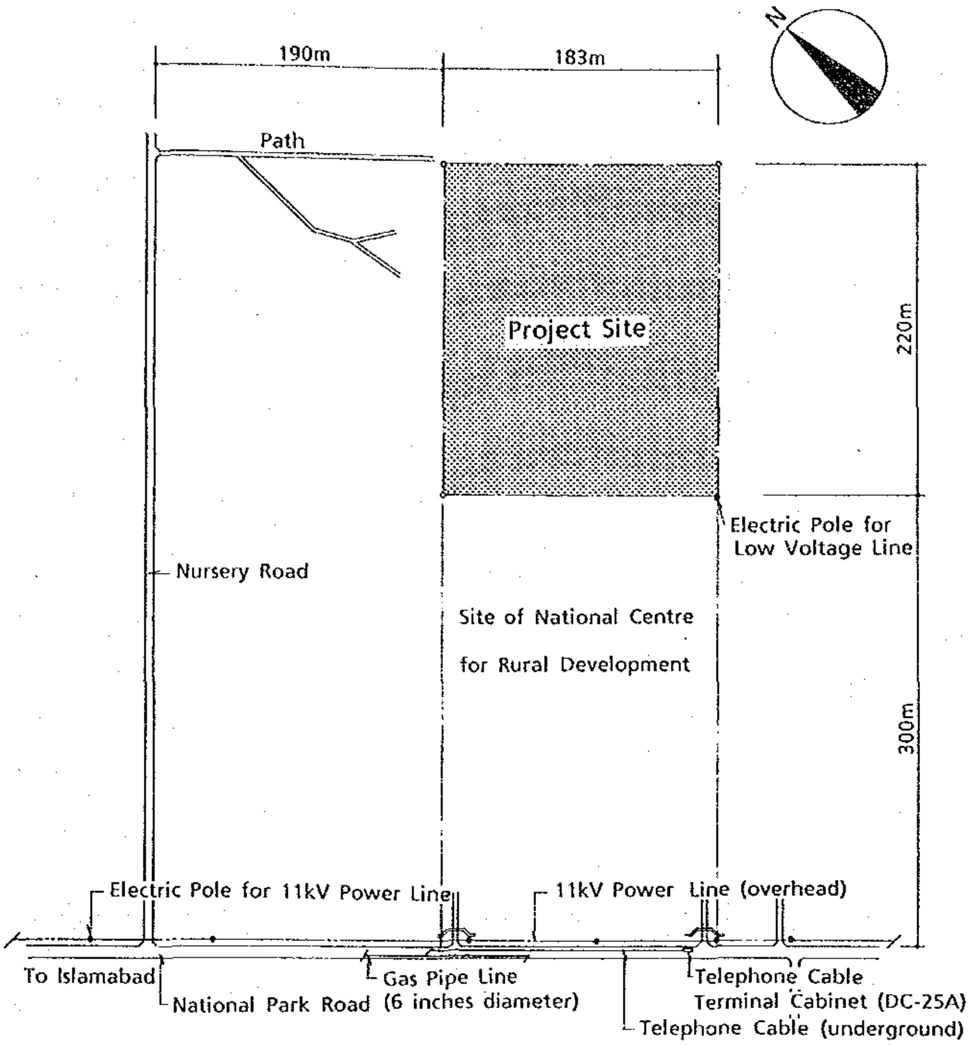


Fig. 3-6 Infrastructure near the Project Site

3-3-5 Outline of the Facilities and Equipment

(1) Facilities

1) Laboratory Building

Paleomagnetism room, microscope room, standard sample room, electron probe micro analyser room, X-ray diffractometer room, thermal analyser room, X-ray fluorescence spectrometer room, atomic absorption spectrometer room, chemical analysis room, balance room, data processing room, mineral separation room, photography room, dark room, etc.

2) Sample Preparation and Storage Building

Crushing room, pulverising room, mineral crushing room, thin section room, cutting room, finishing room, polishing room, unloading room, sample storage, etc.

3) Study and Administration Building

Senior scientist room, scientist room, meeting room, drawing room, map room, library, stack room, sample stock room, seminar room, office room, director room, reception room, etc.

4) Canteen Building

Canteen, kitchen, food storage, etc.

5) Mechanical Building

6) Others

Garage, guard house, power receiving house, neutralisation tank, elevated tank

(2) Equipment

1) Paleomagnetic Geochronology Laboratory

AC demagnetiser, thermal demagnetiser, magnetic susceptibility meter, magnetic balance, spinner magnetometer, etc.

2) Petrology and Mineralogy Laboratory

Electron probe micro analyser, vacuum evaporator, X-ray diffractometer, differential thermal analyser and thermal gravimeter, polarising microscope, cooling water circulating unit, etc.

3) Analytical Chemistry Laboratory

X-ray fluorescence spectrometer, beads sampler, hand bricket press, flame atomic absorption spectrometer, flameless atomic absorption spectrometer, ultraviolet-visible spectrometer, cooling water circulating unit, balance, water still, etc.

4) Geochemical Exploration Section

Data processing equipment, etc.

5) Isotope Geochronology Section

Isodynamic separator, hot plate, etc.

6) Geology Section

Drafting table, tracing table, etc.

7) Sample Preparation Section

Jaw crusher, vibrating mill, automatic agate mortar, rock cutter, lapping machine, thin section preparation machine, secondary thin section cutter, dust collector, rock sample rack, etc.

8) Administration Section

Photocopy machine, typewriter, blue print machine, etc.

3-3-6 Technical Cooperation

In order to ensure the effective operation of the Geoscience Laboratory and the development of mineral resources in the country, the Government of Pakistan requested in October 1988 that the Government of Japan extend project-type technical cooperation in conjunction with the grant aid programme for the proposed laboratory. In response to this request, the Government of Japan decided to conduct a survey related to the request. In December 1988 the Japan International Cooperation Agency dispatched a joint preliminary survey team for the project-type technical cooperation and the grant aid programme to Pakistan to confirm and evaluate the background and contents of the request. As a result of the preliminary survey, the appropriateness of the project-type technical cooperation requested by the Government of Pakistan was confirmed. Besides, the basic design study team for the grant aid dispatched to Pakistan in April 1989 was accompanied by a long-term expert related to the project-type technical cooperation, who discussed with the Pakistani side details of the technical cooperation. An outline of the planned project-type technical cooperation by the Government of Japan is described as follows.

(1) Objectives of the Technical Cooperation

To develop human resources contributing to the promotion of the development of mineral resources and to transfer the technology for mineral resources exploration to Pakistani scientists.

(2) Targets of the Technical Cooperation

i) To develop human resources in the field of technologies/techniques for petrological and mineralogical identification and classification of rocks and minerals, for isotope geochronological and paleontological determination of geological age of rocks, and for geochemical analysis of rocks and minerals through day to day training using the facilities and equipment of the Geoscience Laboratory.

ii) To develop human resources in the field of exploration for mineral deposits through on-the-job field training and laboratory work at the Geoscience Laboratory. Such work includes preparation of geological maps, structural geology maps, mineral occurrence maps and geochemical maps.

(3) Period of the Technical Cooperation

The necessary period of the technical cooperation will be up to 5 years from the date of actual commencement of work as stipulated in the Record of Discussions on the project-type technical cooperation.

(4) Contents of the Technical Cooperation

i) Technology Transfer for Exploring Mineral Resources Associated with Igneous and Metamorphic Rocks

Geological surveys will be carried out on a model field mainly in the districts where igneous and metamorphic rocks are distributed along main rivers and roads, and then areas for detailed geological surveys will be selected in the field. Geological exploration maps on a scale of 1:50,000 will be prepared for prospecting mineral deposits and mineral occurrences. Then, detailed surveys of these areas will be made from the standpoint of petrology, mineralogy, structural geology and mining geology. Next, chemical and mineral analyses, as well as studies for determination of sample's geological ages will be conducted, and various data will be analysed from the standpoint of petrochemistry, mineralogy, geochemistry and isotope geochronology. Finally, geological maps, mineral occurrence maps, metallogenic maps and geochemical maps will be prepared. Through these activities, technologies for prospecting mineral resources associated with igneous and metamorphic rocks will be transferred to Pakistan in due course.

2) Technology Transfer for Exploring Mineral Resources Associated with Sedimentary Rocks

In a model field, areas for detailed surveys will be selected. These will extend from south to north, will be centered around areas where ophiolite deposits are distributed, and will include the continental areas in the southern part of the country and the northern areas where turbidite deposits are distributed. Then, detailed surveys will be conducted on the mineral deposits and mineral occurrences. Geological maps and structural geology maps on a scale of 1:50,000 will be prepared from the standpoint of mining geology, stratigraphy, petrology, paleontology, structural geology and geophysical exploration. Next, chemical and mineral analyses, as well as determination of samples' geochronological age will be conducted, and various data will be analysed from the standpoint of petrochemistry, geochemistry, paleontology, structural geology and geophysics. Finally, geological maps, mineral occurrence maps, metallogenic maps, geochemical maps and structural geology maps will be prepared. Through these activities, technologies for prospecting mineral resources associated with sedimentary rocks will be transferred in due course.

3) Technology Transfer for Geochemical Exploration

Technologies to identify and classify rocks and minerals using the electron probe micro analyser, the X-ray diffractometer, and thermal analysis equipment, etc., to determine geologic age by means of isotope geochronological dating, and to analyse samples using the X-ray fluorescence spectrometer, the atomic absorption spectrometer, etc. will be transferred through laboratory works at the Geoscience Laboratory.

(5) Implementation Plan

For the purpose of effecting the above-mentioned types of technology transfer, a comprehensive technical cooperation programme will be implemented. It will include dispatch of Japanese experts to Pakistan, training of the Pakistani counterparts in Japan and organising various on-the-job training programmes and seminars by Japanese experts in Pakistan. The tentative schedule for the technical cooperation programme is given in Table 3-3. Pakistani counterparts dispatched to Japan for training in the operation of sophisticated equipment, such as the X-ray fluorescence spectrometer and the electron probe micro analyser will be well-educated scientists capable of independently conducting scientific investigation and analysis. Also, necessary ancillary equipment and spare parts will be provided under the technical cooperation.

Table 3-3 Tentative Schedule of the Project-type Technical Operation

Year	1st	2nd	3rd	4th	5th	Nos. of Japanese Expert: Long-term	Nos. of Japanese Expert: Short-term	Nos. of Trainee in Japan
Grant aid programme	Facilities (1st–2nd)							
Project-type technical cooperation (A)	Equip. coordination (1st–2nd)	Adjustment	Model field sample analysis (3rd–4th)		General sample analysis			
Project-type technical cooperation (B)	Survey plan	Detailed survey · Sampling (2nd–3rd)	Geological & Chemical Investigation (3rd–4th)	Generalised analysis	Completion of maps			
1. Technology transfer of mineral resources exploration associated with igneous and metamorphic rocks								
• Long-term expert	Petrology (1st–5th)					1		
		Mining geology (2nd–4th)				1		
• Short-term expert	Petrology	Petrology, Mineralogy	Petrology, Mineralogy	Petrology	Mining geology		7	
• Counterpart training in Japan			Mineralogy, Petrology					2
• Lecture & Seminar in Pakistan		Mineralogy	Petrology		Mineral geology			
2. Technology transfer of mineral resources exploration associated with sedimentary rocks								
• Long-term expert	Stratigraphy (1st–5th)					1		
				Structural geology (4th–5th)		1		
• Short-term expert	Stratigraphy	Stratigraphy, Paleontology	Petrology	Stratigraphy	Mining geology		6	
• Lecture & Seminar in Pakistan		Stratigraphy, Paleontology	Petrology	Stratigraphy				
3. Technology transfer of geochemical exploration								
• Long-term expert		Petrochemistry (2nd–5th)				1		
			Paleomagnetism (3rd–4th)			1		
		Instrumental analysis (2nd–5th)				1		
• Short-term expert		Sample preparation	Geochemistry, Computer geoscience	Isotope geochronology			4	
• Counterpart training in Japan		Equipment (XRF), Equipment (chemistry), Equipment (EPMA)	Computer geoscience	Isotope geochronology	Equipment (physics)			6
• Lecture & Seminar in Pakistan		Geochemistry	Geochemistry, Paleomagnetism, Computer geoscience	Isotope geochronology				
					Total	7	17	8

CHAPTER 4 BASIC DESIGN

BASIC DESIGN

4-1 Basic Design Policies

The following polices are set up for the basic design of the facilities and equipment.

(1) To make the facilities conform to the planned activities and equipment.

Some equipment makes vibration and noise during operation, while other equipment requires the room conditions to remain within a prescribed range. Therefore, it is essential to make a plan of facilities and a layout of equipment considering features of type of equipment.

(2) To minimise the cost of maintaining and operating the facilities and equipment.

Durable building materials should be selected. In this way, it will be possible to minimise both the frequency of repairs of facilities and the maintenance costs. Also, sophisticated measuring and analysis equipment should be selected taking into account the capabilities of local agents to provide necessary services for repairs and maintenance and supply of consumables and spare parts.

(3) To make the contents of the proposed facilities meet the requirements of the project-type technical cooperation.

Project-type technical cooperation is to be provided by the Japanese government in conjunction with this project. The scale, layout and grade of the facilities and equipment should facilitate implementation of the above-mentioned technical cooperation.

(4) To make the proposed facilities adapt to the conditions existing in Pakistan in general and around the project site in particular.

The basic design for the proposed facilities should give consideration to factors of environment, custom, and conditions of construction in Pakistan. Furthermore conditions around the project site should also be taken into consideration; for instance, the project site gently slopes down toward the east. Its ground, which consists mainly of clay and silty clay, is relatively fragile. In and around the project site seasonal winds blow southwest or northeast. In addition to these natural conditions, the project site is located in a part of the national park area which is subject to various architectural regulations. Moreover land prices are fairly high in this area. All these factors should be deliberated on.

4-2 Examination of the Basic Design Conditions

The following conditions should be examined carefully for the implementation of the basic design.

(1) Required Functions

The basic functions of the proposed facilities are to improve the quality of technologies to identify, classify and analyse rocks and minerals, and thereby contribute to the development of mineral resources in Pakistan. Therefore, the contents of the proposed facilities and equipment should be determined in a manner that will satisfy the functional requirements specified in 3-3-3 of Chapter 3.

1. Experimenting

This project must provide facilities of paleomagnetic geochronology laboratory, petrology and mineralogy laboratory, analytical chemistry laboratory, geochemical exploration section, isotope geochronology section, geology section and sample preparation section for experimental work by scientists.

2. Development of Human Resources

This project is also aimed at enhancing scientists' analytical capabilities to acquire technologies/techniques to identify, classify and analyse rocks and minerals and to explore for mineral resources through experimentation.

3. Provision of Analytical Information

Scientists at the proposed laboratory are also to conduct experiments and analyses commissioned by other organisations in Pakistan, and provide information on the results of their analyses.

(2) Examination of the Natural Conditions

If the proposed facilities conform to the natural conditions existing in and around the project site, it will increase their durability and minimise their costs of maintenance and operation. Through the basic design for this project, special attention should be paid to the following natural conditions.

1) Sunshine and Temperature

Islamabad is situated at lat. 34° N., which is almost the same latitude for Fukuoka City, Fukuoka Prefecture, Japan. From May to August, however, sunlight is very strong and the temperature often exceeds 40°C. It is therefore necessary, to attach long eaves and insulators to some parts of the walls and roofs at the proposed facilities.

2) Rain

Islamabad is situated in a steppe climate zone. Although it has little rainfall throughout the year, it has a rainy season which lasts from July to August. During the rainy season, the city is often hit by a localised torrential downpour. Therefore, the facilities should be designed to cope effectively with heavy rainfalls, to be capable of quickly discharging rainwater and to prevent the rain from blowing inside. Since the project site and the areas surrounding it gently slope down eastward, there should be a plan to protect the exterior facilities against the inflow of rainwater from the higher portion of the site and facilitate quick discharge of rainwater.

3) Ventilation

In and around the project site, the wind blows from the southeast in July and August, and from the northwest in January and February.

Immediately before the rainfall, the wind contains lot of sand. Therefore, it is necessary that the proposed building, where sophisticated measurement and analytical instruments will be installed, be designed to protect against sand-laden wind. The exterior around the building should also be designed to protect against clouds of sand.

4) Earthquakes

The central and northern areas of Pakistan are in the Eurasian earthquake zone. Islamabad, where the project site is located, is very likely to be affected by earthquakes of moderate intensity.

(3) Construction Situation

1) Construction Machinery and Materials

Although the number of construction projects has been increasing each year in Pakistan, the country is still dependent on foreign countries for standard supplies of most building materials except cement, reinforcing bars and aggregate.

2) Building Laws and Regulations

General building laws or regulations applicable to Pakistan have not yet been enacted. However the Capital Development Authority (CDA) has been applying building laws and regulations to the Islamabad metropolitan area. Therefore, facilities for this project must be designed in compliance with the said laws and regulations. Moreover, since the project site is located in part of the premises of a national park area, it is also necessary to design the facilities in accordance with the CDA's administrative guideline for buildings constructed on the premises of the national park area.

(4) Conditions for Procurement of Equipment

Few of the measurement and analytical instruments required for the laboratory facilities are manufactured in Pakistan. If these instruments are to be procured in Japan, most of the consumables and spare parts can be procured in Pakistan direct from local manufacturers or through local agents.

4-3 Basic Design of the Facilities and Equipment

4-3-1 Layout Plan

(1) Project Site Utilisation Plan

In working out the overall site plan, utmost efforts should be made to make effective use of the whole project site while taking the following points into consideration.

1) All facilities should be layed out from east to west so that areas heated by sunshine may be minimised, and so that natural ventilation may be adequate during the rainy season lasting from July to August. On the other hand, both the longer and shorter sides of the project site deviate by approximately 50° from the magnetic north. If the proposed buildings are arranged simply along the east-to-west axis, it will be impossible to secure an area for future expansion. For this reason, some of the proposed buildings should be arranged in the same direction as the longer side of the project site to allow for future facilities expansion in its southern part. (see Fig.4-1)

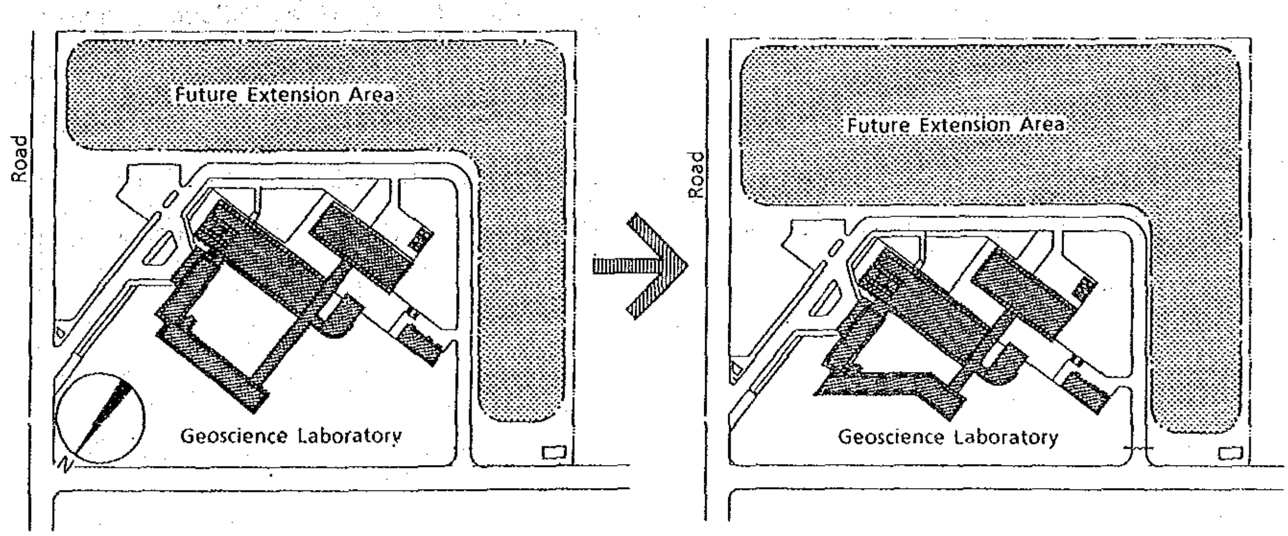


Fig. 4-1 Layout Plan

2) The project site slopes down eastward. Since the existence of differences in floor level inside the facilities would be undesirable because it would move experimental rock and mineral samples within the facilities, the floor level should be fixed. For this purpose, the quantity of soil dug out should be almost equal to that of soil heaped up so that there would be no need to bring soil into the site or remove it from the site. Therefore, it is necessary to select a ground level which will accommodate this arrangement.

3) According to the CDA's master plan, a road will be constructed on each of the northeastern and northwestern sides of the project site. The road to be constructed on the northeastern side is to serve as the main road. In this project, the entrance to the project site will face the main road on the northeastern side in accordance with the CDA's road plan, and a road within the site will connect to the road on the northwestern side to provide additional access to the site.

4) A single-storeyed building is ideal if the facilities' experimental functions are emphasised. However, this design will result in a considerably high building-to-land ratio, which in turn will be a serious constraint on future utilisation of the site. Such a design will also result in a disproportionately large foundation area for the buildings' structures, and consequently, high construction costs. Therefore, the study and administration building should be two-storeyed, and the laboratory building and others should be single-storeyed.

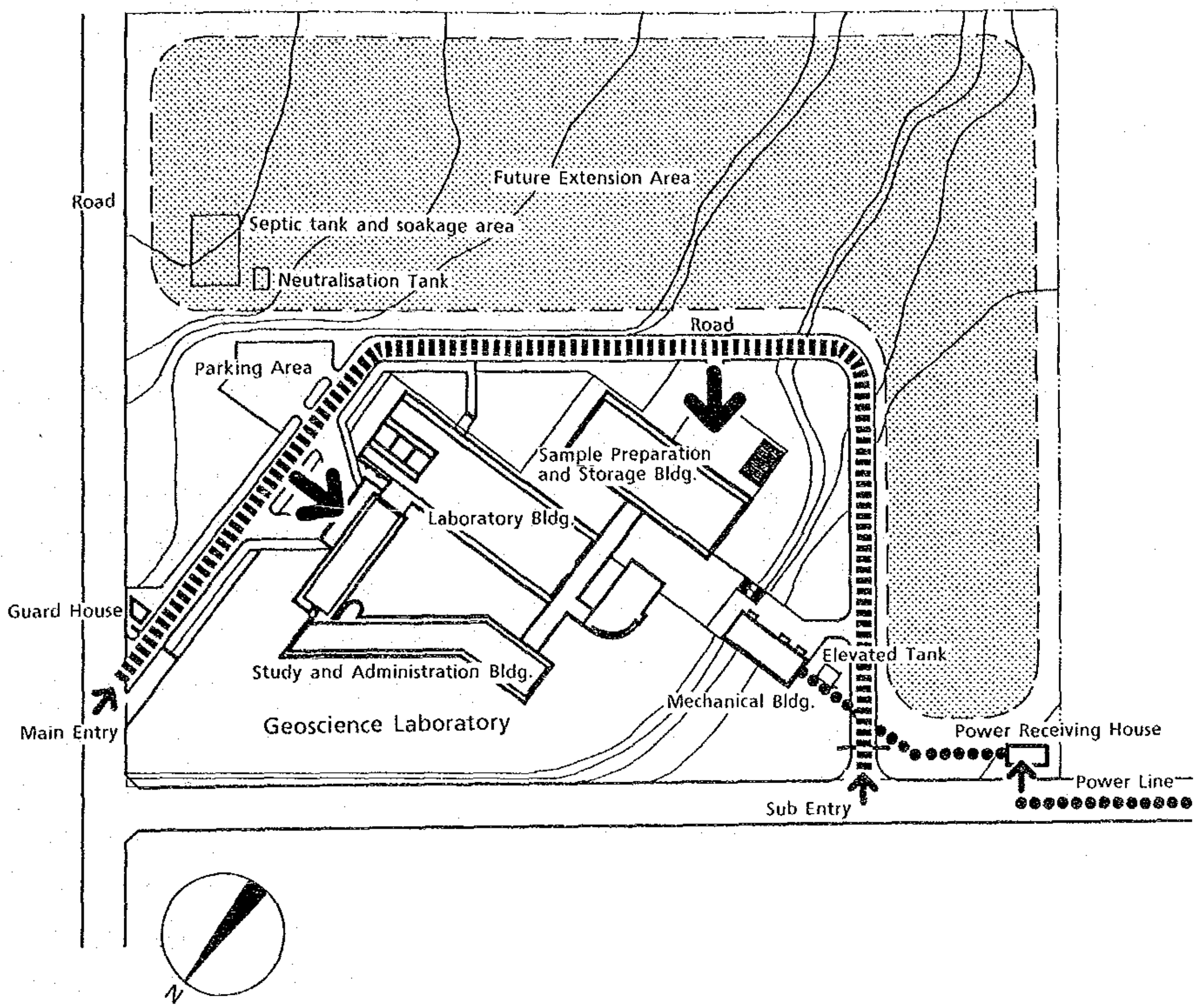


Fig. 4-2 Site Utilisation Plan

4-3-2 Architectural Plan

(1) Plan

1) Layout Plan for Each of the Laboratories and Sections

The proposed facilities should be divided into the following blocks according to types of required functions.

a. Experimentation block
The laboratory building and the sample preparation and storage building

b. Study and administration block
The study and administration building (including the scientists' room, the seminar room and administration offices)

c. Service block
The mechanical building, the garage, the guardhouse, etc.

In the experimentation block, two separate buildings should be constructed. The laboratory building is where equipment which is apt to be easily damaged by changes in temperature, humidity, vibrations, and dust will be installed; the sample preparation and storage building is where rocks and minerals will be crushed to prepare thin, polished and other sections necessary for experiments and where equipment which generates vibrations and noises will be installed. The laboratory building will be air-conditioned to have the equipment operating smoothly at all times. For high-efficiency air-conditioning,the laboratory building should be centre-corridored and closed. With the sample preparation and storage building, some rooms which will generate vibration and noise should be located opposite to the laboratory building to minimise the adverse effects of the vibrations and noise on the laboratories. Both buildings should be single-storeyed and connected by a passageway. In the study and administration block, there should be natural lighting and ventilation, and all rooms should face a corridor on one side. The study and administration building should be two-storeyed to decrease the building-to-land ratio and reserve open space for future expansion. The experimentation block and the study and administration block should have connecting passageways. The facilities of the service block, the mechanical building, the elevated tank and others should be located in places close to the western corner of the project site where the power cable and water main are connected with the service cable and pipe. The place for well water should be located close to the elevated tank. On the other hand, such facilities as septic and neutralisation tanks should be located in the southeastern part of the site, which is originaly lower than the other parts, to prevent sewage from flowing into the well, and drainage pipes should be laid in a manner that takes advantage of the slope of the site.

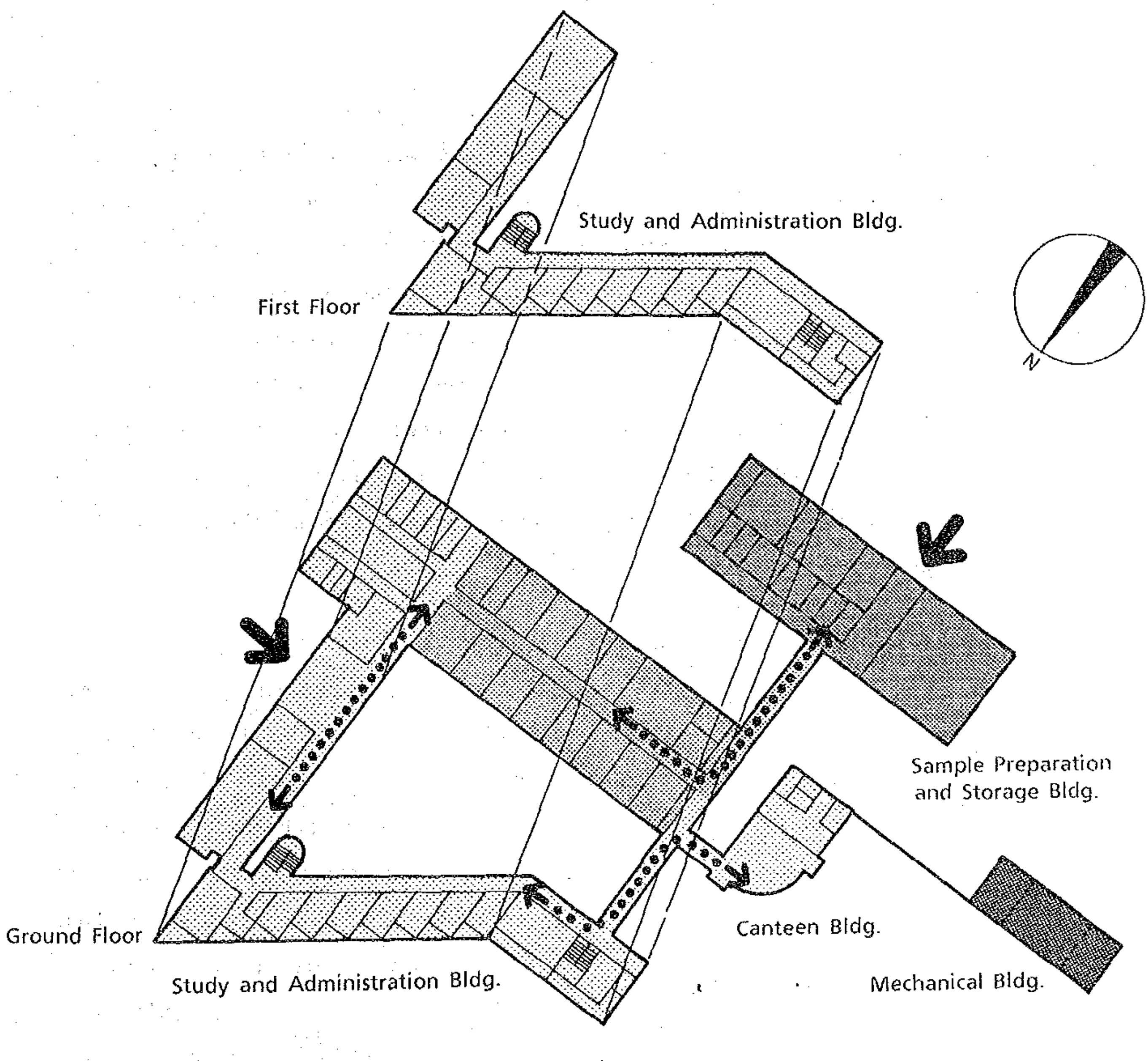


Fig. 4-3 Zoning of Buildings

2) Scale and Function of Each Main Facility

In designing the main facilities, it is necessary to establish a scale consistent with the laboratory's activities and the layout for equipment installed in the laboratory. Shown below are the scales established and the rationale for the main facilities.

a. Experimentation Block

Laboratory Building

As indoor environmental conditions and the experimentation procedures vary according to the equipment used in the laboratory building, separate laboratory rooms should be built for different major types of experimentation. Rooms to be equipped with sophisticated analytical and experimental equipment should be located on the northern side of the building to minimise the effects of sunshine. Moreover, the locations of all rooms on the northern and southern side should be decided taking into account the frequency of delivery of samples from the Sample Preparation Section.

<1> Paleomagnetism Room

This room is to serve as the paleomagnetic geochronology laboratory's experimentation room for examining the history of rock magnetism and the characteristics of magnetic minerals. The remanent magnetisation measurement equipment, the thermal demagnetiser, the AC demagnetiser, the magnetic balance and the like will be installed for measurement of the direction of remanent magnetisation of rock samples, elimination of the direction of secondary magnetisation caused by thermal and electric factors, and measurement of the Curie point (temperature) of magnetic minerals. (see Layout Drawing 1).

〈2〉 Microscope Room

This room is to serve as the experimentation room for the common use of the geology section and the petrology and mineralogy laboratory. It will be used for investigation into the general conditions of rocks and minerals. In this room polarising microscopes, metallurgical microscopes and stereographic polarising microscopes will be installed. (see Layout Drawing 2)

〈3〉 Standard Sample Room

This room is for storing standard samples for identification of rocks, minerals, heavy minerals and precious stones. It will also be used for storing standard samples of various types of rocks, minerals and heavy mineral samples collected during the field activities, together with their thin and polished sections. (see layout Drawing 2)

〈4〉 Electron Probe Micro Analyser Room

This room is to serve as the petrology and mineralogy laboratory to obtain information for understanding the processes of generation of rocks and minerals and crystallisation of differentiation. An electron probe micro analyser to clarify the element composition of microscopic objects by measuring X-ray generated, after electron beams are applied to polished or polished thin sections will be installed. (see Layout Drawing 3.)

〈5〉 Sample Preparation Room

This room is for preparation of samples used with an electron probe micro analyser and an X-ray fluorescence spectrometer. A vacuum evaporator, a hand bricket press, a beads sampler, and other equipment used in pretreating (carbon evaporating, molding, and processing) crushed, polished and polished thin samples will also be installed. (see Layout Drawing 3.)

<6> X-ray Diffractometer room

This room will be used as the petrology and mineralogy laboratory's experimentation room to identify minerals by obtaining information on crystallography. An X-ray diffractometer measuring angles and strengths of X-rays diffracted by crystal surfaces after those X-rays irradiated powdered samples will be installed. This equipment effectively identifies clay minerals, among others. (see Layout Drawing 5.)

<7> Thermal Analyser Room

This room will serve as the petrology and mineralogy laboratory's experimentation room for identifying rocks and minerals by utilising their thermal properties. A differential thermal analyser and thermal gravimeter for measuring endo-exthermic reaction and weight transition temperatures by applying heat to samples will be installed. The equipment effectively identifies amorphous and poorly crystalline minerals in particular. (see Layout Drawing 5.)

<8> X-ray Fluorescence Spectrometer Room

This room, also to serve as one of the analytical chemistry laboratory's experimentation rooms, will be used to determine major elements in rock samples. An X-ray fluorescence spectrometer for quick precision analysis of highly concentrated chemical elements in samples will be installed. (see Layout Drawing 3.)

<9> Chemical Analysis Room

This room will be the analytical chemistry laboratory's experimentation room primarily for pretreating crushed samples for use in chemical analysis. A high-temperature muffle furnace, a water still, a water bath, a sand bath and an automatic titrator, all using reagents to melt or dissolve the crushed samples for preparing measurement samples, are to be installed. An ultraviolet visible spectrophotometer will be installed in this room because there is a possibility that analytical results by this instrument may be affected due to a change in nature of pretreated samples during standing time. A preparation room equipped with a pure water production system for analysis and cooling of X-ray bulbs, and a balance room for weighing samples will be built as annexes to the chemical analysis room. (see Layout Drawing 4.)

<10> Atomic Absorption Spectrometer Room

This room will be the analytical chemistry laboratory's experimentation room for multi-element analyses of samples of rocks, minerals, soil, swamp sand and water. A flame atomic absorption spectrometer and a flameless atomic absorption spectrometer for precision analysis of extremely small quantities of ingredients will be installed. (see Layout Drawing 4.)

<11> Data Processing Room

A computer, a plotter and other data processing units for statistical analysis of various data of the geochemical exploration section and other laboratories sections will be installed. (see Layout Drawing 6.)

<12> Mineral Separation Room

This room is to serve as the isotope geochronology section's experimentation room for determining absolute geological periods of rocks and minerals. An isodynamic separator for separating and condensing minerals for use in analysis of radioactive isotopes and other instruments will be installed. (see Layout Drawing 6.)

<13> Engineer·Laboratory Assistant Room

This room is to serve as a waiting room for the maintenance / electronic engineer and laboratory assistants (6 persons).

<14> Spare Parts Stock Room

This room is for storing spare parts and consumables for use in the equipment installed.

Sample Preparation and Storage Building

In this building, rock and mineral samples collected during the field activities will be processed for use by scientists in experimentation in other buildings. The building will also store samples collected in the field or left over after experimentation for future re-examination. As experimentation with trace elements of rocks and minerals will often be carried out in addition to experimentations using an electron probe micro analyser, an X-ray fluorescence spectrometer, and other equipment, mixing of different substances must be avoided in the process of preparing samples. It is necessary, therefore, to divide the sample preparation operations into several workshops according to their functions.

<1> Crushing Room

Lumps of samples collected in field activities, delivered to this building, will be crushed by a rock trimmer, a jaw crusher or a brown crusher from approx. 5mm down to approx. 0.25mm in sizes. An acrylic cover should be attached to each unit which produces powdery dust to prevent dust from flying around. The powdery dust should be collected with a dust collector. (see Layout Drawing 7.)

<2> Pulverising Room

A vibrating mill, an automatic agate mortar and other equipment will be installed in this room to pulverise samples into fine powder (100 mesh or less). (see Layout Drawing 7.)

<3> Mineral Crushing Room

This room, equipped with a jaw crusher, an automatic agate mortar and other equipment, will be used for crushing and purverising ore lumps of minerals into fine powder. This room is separated from the crushing room and pulverising room to prevent highly concentrated elements of ore samples from contaminating other samples. (see Layout Drawing 7.)

<4> Cutting Room and Thin Section Room

In this room, lumps of rocks will be cut with a rock cutter and then cut and polished to thin sections by means of lapping machines and others. (see Layout Drawing 8.)

<5> Finishing Room and Polishing Room

A hot plate, a polishing machine and other equipment will be installed in this room for final preparation of polished or polished-thin sections. (see Layout Drawing 8.)

<6> Sample Storage

Rock sample racks capable of storing some 17000 samples will be installed to meet possible requirement in storing samples from a number of exploration projects for the next 8 to 10 years.

b. Study and Administration Block

Study and Administration Building

The study and administration building will be two-storeyed with passages running along one side. The scale of each room in this building should be determined on the basis of BPS specified in the personnel assignment plan.

<1> Senior Scientist Room, Scientist Room, Lecturer Room, Meeting Room, and Director Room

The floor spaces for these facilities can be determined on the basis of the Japanese and Pakistani criteria for calculating per capita floor spaces for laboratory institutions: 20m^2 for the senior scientist room, 20m^2 for the scientist room, (one office shared by two scientists), and 20m^2 for the director room. In accordance with social customs in Pakistan, a large common room will not be adopted for the design of the scientist rooms. Experts staying at the laboratory for a long period can utilise the lecturer room, and experts for a short period can utilise the meeting room.

<2> Drawing Room and Map room

Based on data of analyses and measurement in the laboratory building, master drawings of geological maps, structural geology maps, mineral occurence maps, geochemical maps and other related maps will be prepared and stocked in these rooms. For this purpose, drafting tables, tracing tables, map lockers and map suspenders will be installed. (See Layout Drawing 10)

<3> Library and Stack Room

Based on criteria (2m^2/person) for calculating per capita floor spaces for Japanese laboratory facilities, and libraries in existing facilities in Pakistan, the library will be 45m^2 and the stackroom 71m^2 for accommodating 8,000~9,000 books. (See Layout Drawing 11)

<4> Sample Stock Room

This room will be used for storing and displaying samples of rocks and minerals which are typically found in Pakistan or are scarce. It will also deepen understanding of the laboratory's activities by displaying the above-mentioned samples of rocks and minerals.

<5> Seminar Room

This room will be used for seminars related to the laboratory's activities. It will also be used for meetings.

<6> Office Rooms

The floor spaces for these facilities can be calculated on the basis of BPS of each of the staff members to occupy these facilities with reference to the Japanese and Pakistani criteria or standards for determining the per capita floor space for research institutions.

Canteen Building

This laboratory will be located in the suburbs of Islamabad and there will be no restaurant near its site. So a canteen for the personnel should be included in the facilities of the laboratory. The number of seats can be calculated on the assumption that three-fourths of the total staff of 74 (64 staff members and 10 experts) will take meals in two shifts. The kitchen equipment will be provided on the assumption that meals will be simple Pakistani dishes.

c. Service Block

The mechanical building, garage, guard house, power receiving house, neutralisation tank, and elevated tank should be planned to support experimentation, and study and administration blocks.

Room Name	Nos.	Area (m^2)
a. **Experimentation Block**		
LABORATORY BUILDING		
Paleomagnetism Room	1	46
Microscope Room	1	35
Standard Sample Room	1	18
Electron Probe Micro Analyser Room	1	35
Sample Preparation Room	1	35
X-ray Diffractometer Room	1	35
Thermal Analyser Room	1	35
Chemical Analysis Room	1	70
Balance Room	1	15
Preparation Room	1	20
Atomic Absorption Spectrometer Room	1	35
X-ray Fluorescence Spectrometer Room	1	35
Data Processing Room	1	35
Mineral Separation Room	1	35
Engineer · Laboratory Assistant Room	1	35
Spareparts Stock Room	1	35
Photography Room	1	16
Dark Room	1	12
Corridor	–	227
Sub Total		809
SAMPLE PREPARATION AND STORAGE BUILDING		
Crushing Room	1	52
Pulverising Room	1	35
Mineral Crushing Room	1	18
Thin Section Room	1	52
Cutting Room	1	18
Finishing Room	1	12
Polishing Room	1	24
Store Room 1	1	24
Store Room 2	1	12
Unloading Room	1	56
Laboratory Assistant Room	1	23
Sample Storage	1	212
Corridor	–	98
Sub Total		636
b. **Study and Administration Block**		
STUDY AND ADMINISTRATION BUILDING		
Senior Scientist Room	4	20

Room Name	Nos.	Area (m^2)
Scientist Room	6	120
Lecturer Room	3	60
Meeting Room	1	53
Drawing Room	1	41
Map Room	1	16
Library	1	53
Stack Room	1	79
Sample Stock Room	1	133
Seminar Room	1	37
Store Room	1	15
Printing Room	1	10
Entrance Hall	1	97
Director Room	1	24
Reception room	1	16
Office Room	1	48
Office Room	1	13
Telephone Exchange Room	1	13
Pantry	3	18
Resting Room	2	38
Toilet	1	72
Corridor	–	757
Sub Total		1793
CANTEEN BUILDING		
Canteen	1	80
Kitchen	1	35
Office Room	1	6
Food Storage	1	9
Corridor, Toilet	1	28
Sub Total		158
c. **Service Block**		
MECHANICAL BUILDING	1	142
GARAGE	1	52
GUARD HOUSE	1	15
POWER RECEIVING HOUSE	1	35
NEUTRALISATION TANK, ELEVATED TANK	1	24
Sub Total		268
Total		3664 m^2

(2) Elevations and Sections

1) Elevations

The plan of the proposed building consists of a laboratory building, a sample preparation and storage building, a study and administration building and ancillary buildings. Although these facilities will have different functions, building heights and spaces between pillars, unified expression of external appearances will convey an orderly external environment befitting such an institution. Therefore, there should be consistency in finishing materials, colors and wall details of this project.

2) Sections

When drawing up the sections, due consideration should be given to natural ventilation, as well as preventive measures against rainwater and direct sunlight. The height of a storey should be 3.8 meters for the laboratory building and the sample preparation and storage building to allow enough space for plumbing in ceilings and ceiling height requirements. The height of each storey of the study and administration building should be 3.8 meters to allow enough natural ventilation as well as the smooth operation of ceiling fans. In principle, balconies should be attached to each building to protect against direct sunlight and rainwater and make it possible to keep windows open for natural ventilation even when it rains. The roofing material will be a combination of waterproofing asphalt and heat insulation. In addition, there will be additional heat insulation spaces made of bricks to ensure enough heat insulation against sunlight in summer.