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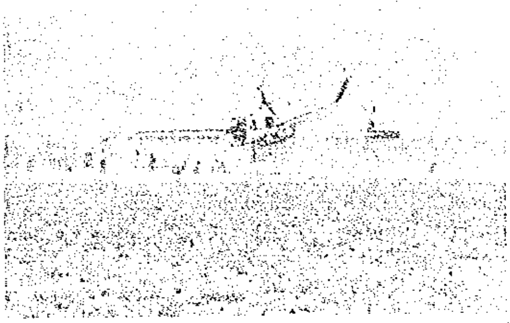
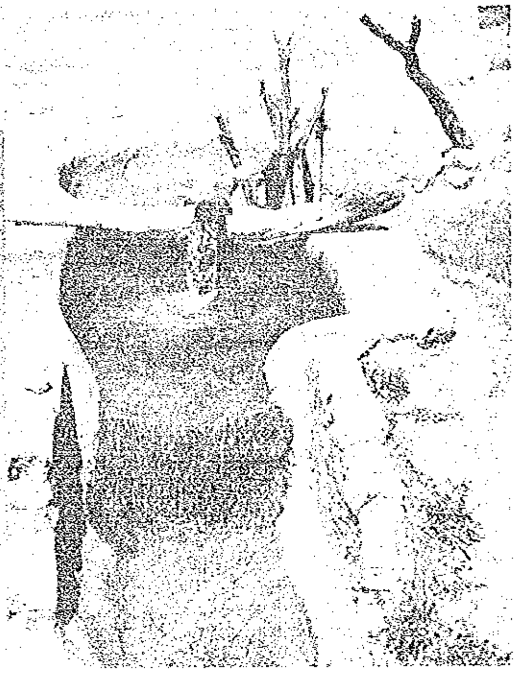
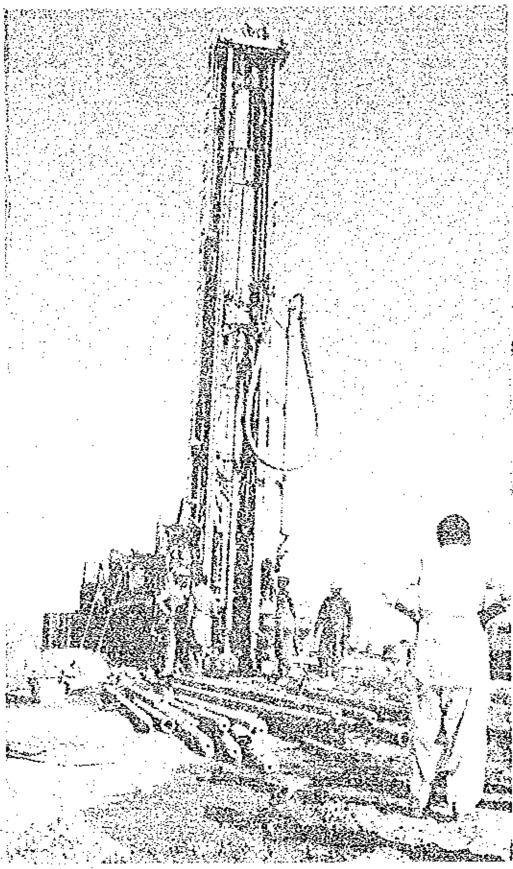
THE ISLAMIC REPUBLIC OF PAKISTAN



MASTER PLAN STUDY ON
BALUCHISTAN IRRIGATION DEVELOPMENT PROJECT
THROUGH GROUNDWATER DEVELOPMENT





FINAL REPORT

VOLUME III

AERIAL GAMMA-RAY
SPECTRO PROSPECTING

MARCH 1988

JAPAN INTERNATIONAL COOPERATION AGENCY

THE ISLAMIC REPUBLIC OF PAKISTAN

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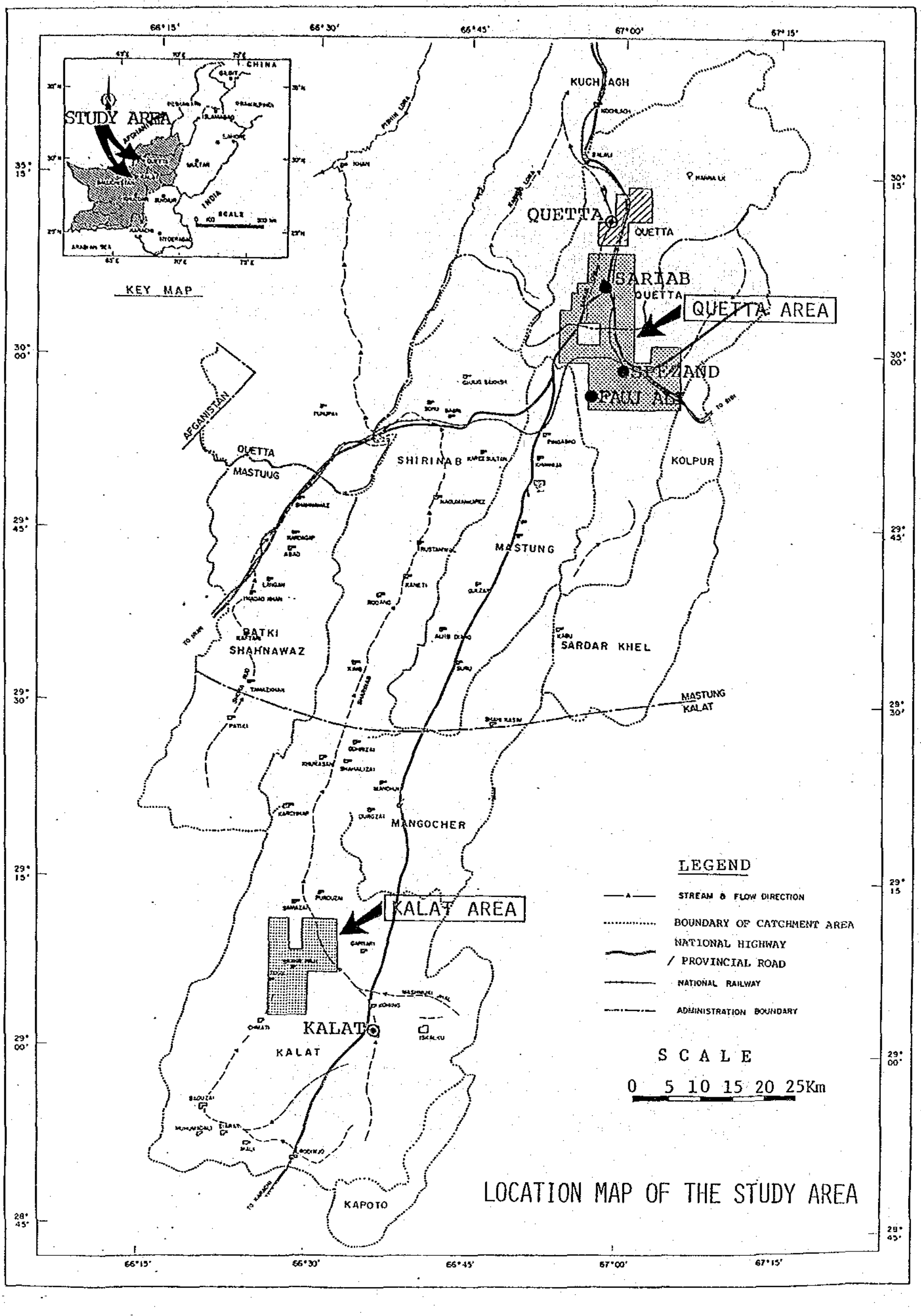


LOCATION MAP OF THE STUDY AREA

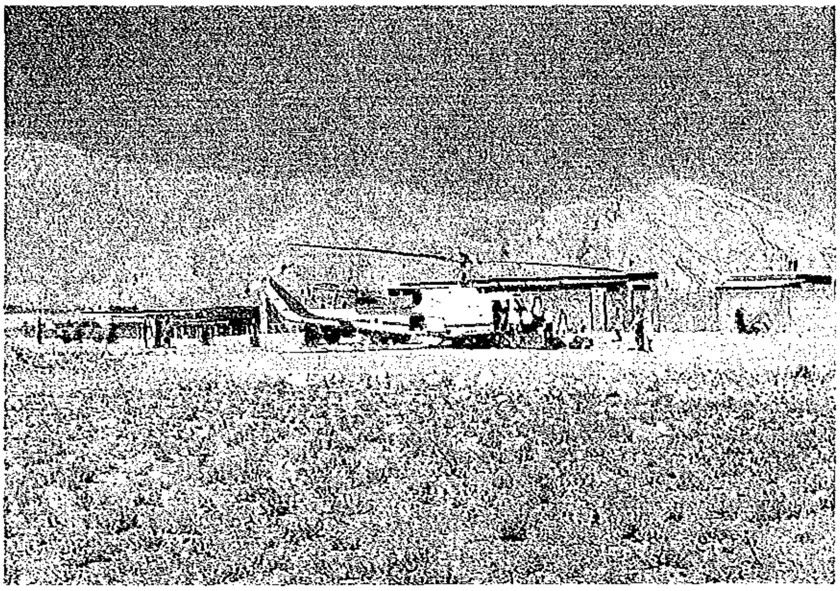


PHOTO 1 HELI-PAD IN QUETTA AREA

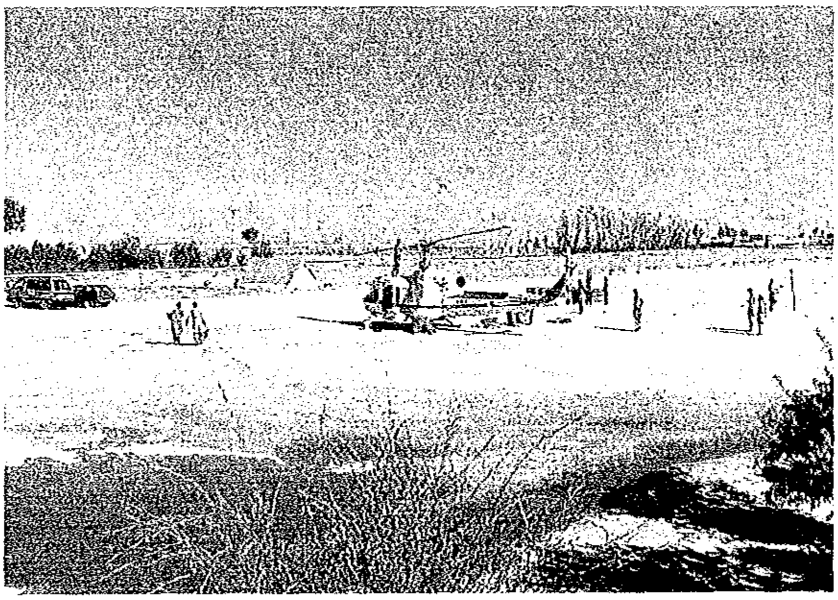


PHOTO 2 HELI-PAD IN KALAT AREA

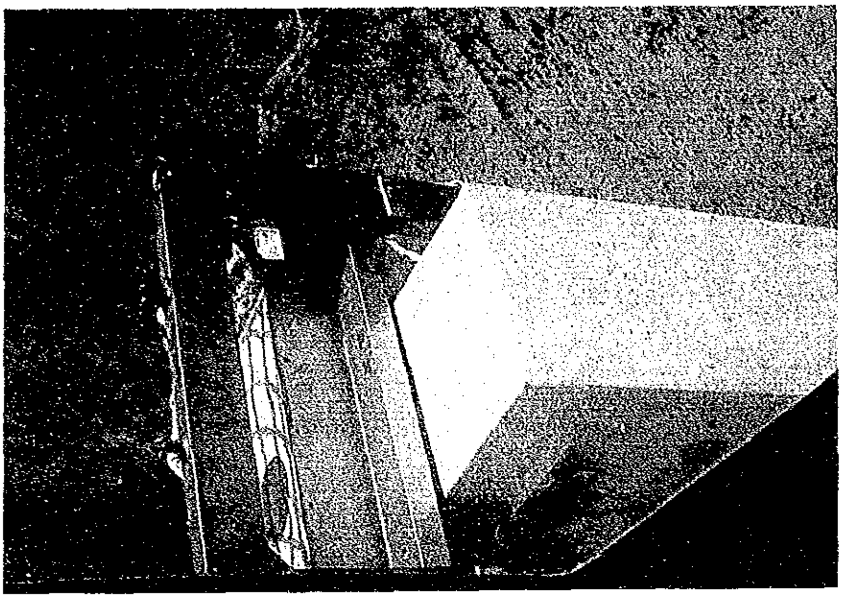


PHOTO 3 GAMMA-RAY SPECTRO DETECTOR

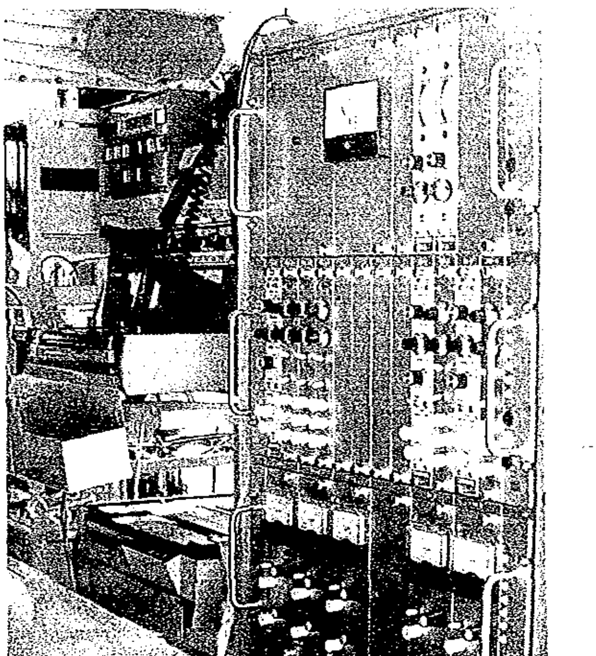
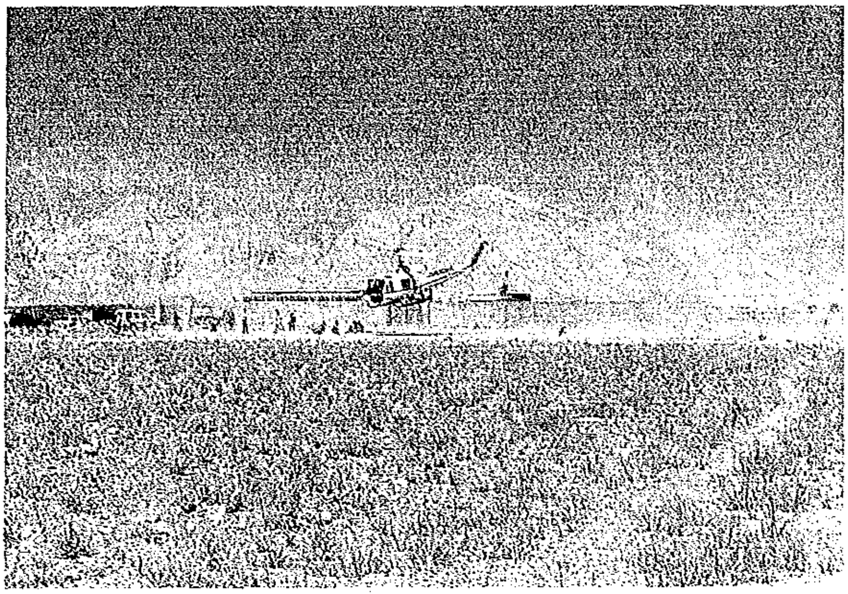


PHOTO 4 AERIAL SELECTIVE GAMMA-RAY PROSPECTING UNIT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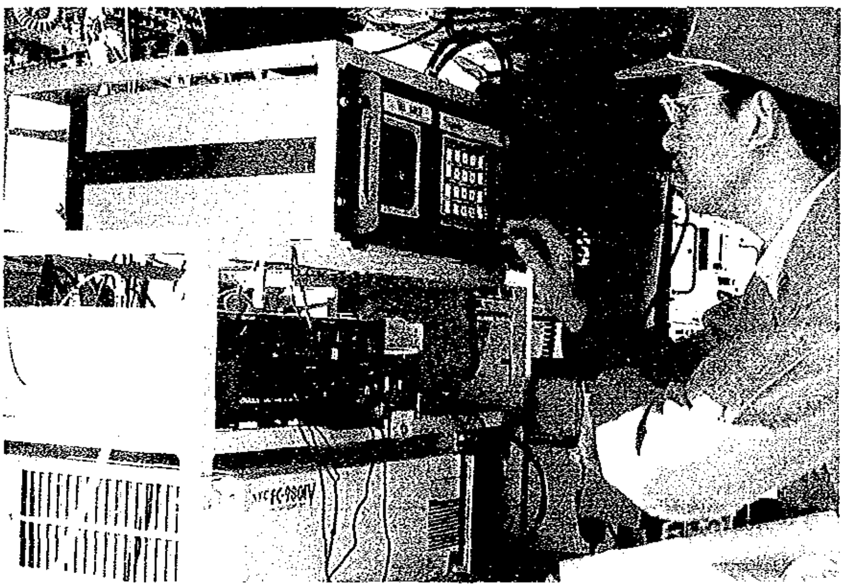
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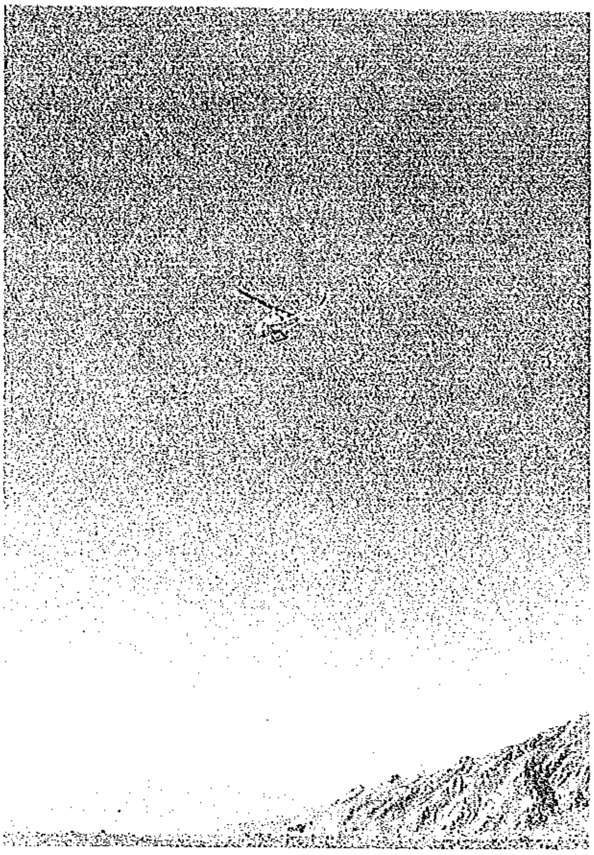

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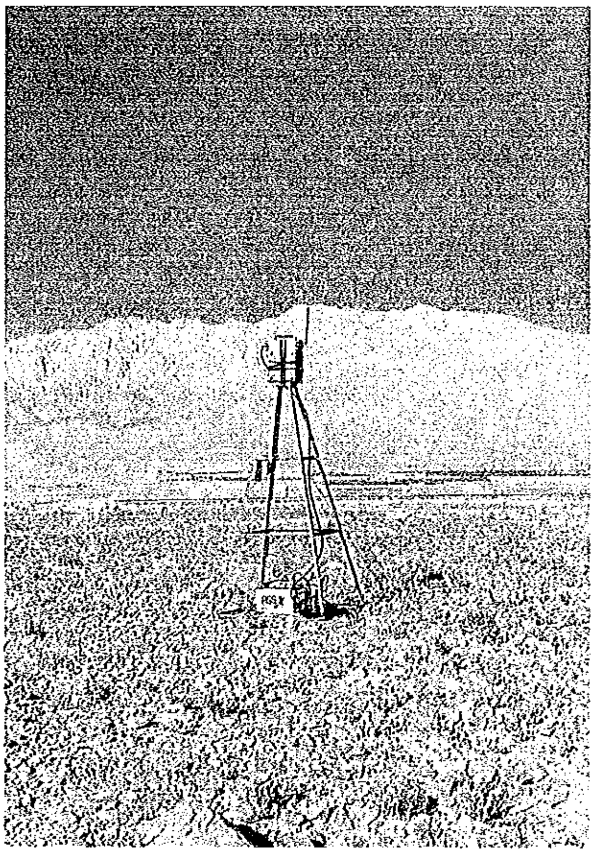

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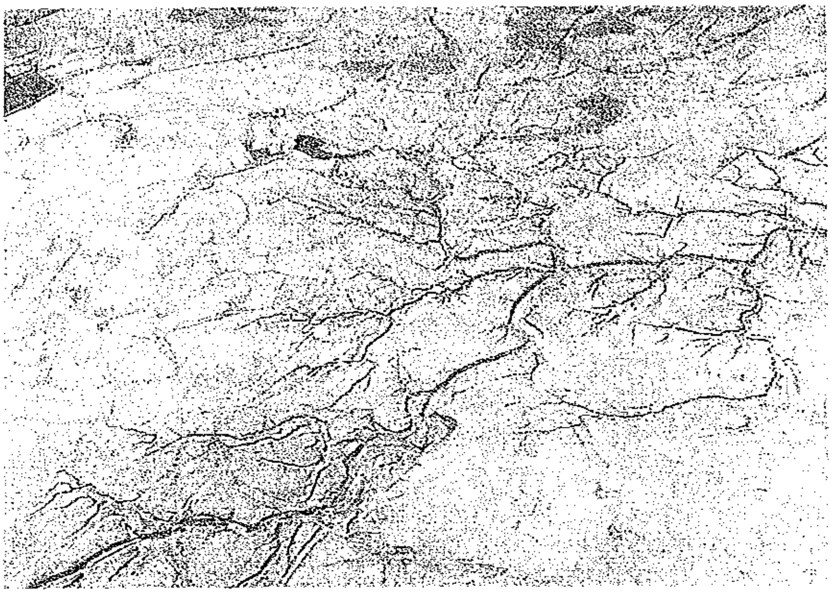

PHOTO 11 WADI IN KALAT AREA

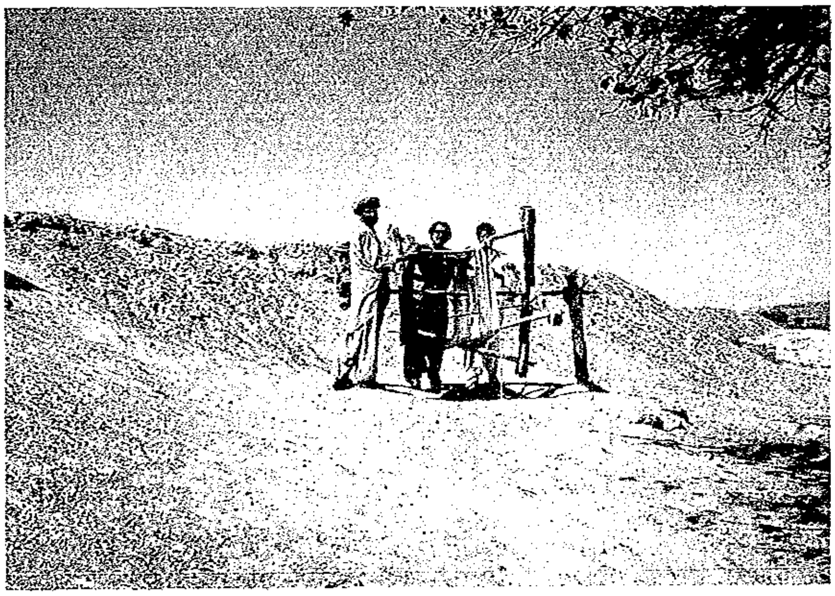

PHOTO 12 OPEN WELL IN KALAT AREA

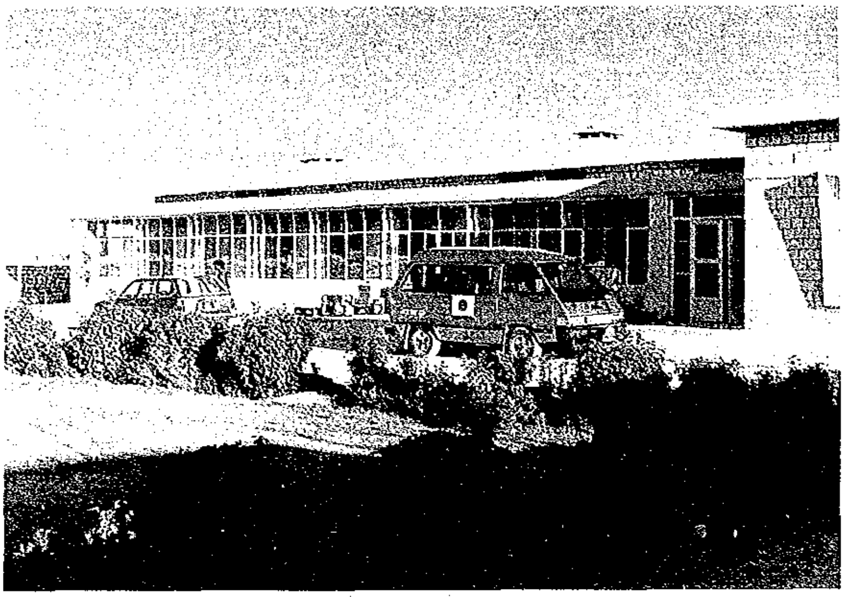

PHOTO 13 AERIAL PROSPECTING SUPPORT CAR

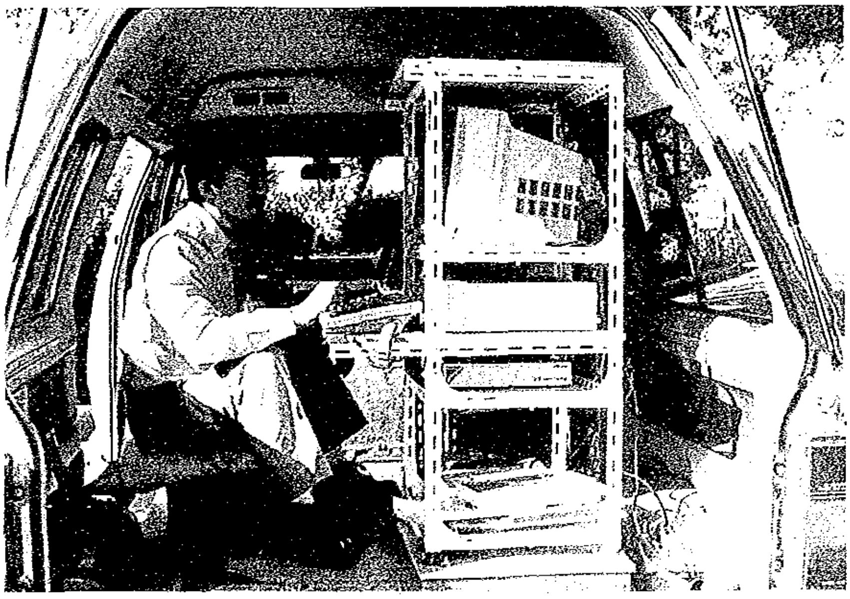

PHOTO 14 INTERIOR OF THE SUPPORT CAR

SUMMARY

SUMMARY

1. By the aerial selective gamma-ray prospecting, four (4) groundwater veins and three (3) groundwater veins have been detected in the Quetta and Kalat Areas, respectively. All the groundwaters in these veins are the moving groundwaters. The movement of these groundwaters is judged by the fact that these groundwaters have been formed recently which is proved by the tritium content analysis of them.

2. An overall evaluation shows that all those veins are ranked as large-scaled groundwater veins.

3. By the aerial selective gamma-ray prospecting, a possibility is found out that the moving groundwater vein is developed in both the Quaternary sedimentary layer on the bedrock and the fissured vein of the bedrock. Therefore, in the future, the existence of this fissured groundwater vein should be checked by the test boring.

It is advised that the depth of the test borings be planned to excavate the bedrock by 100m beyond the location where the test borings attain the bedrock. If the existence of the fissured groundwater vein system can be confirmed, it will be of great value for the development of groundwater resources in the future.

4. The flow capacities of the moving groundwater are estimated to be 22,160 m^3/d and 16,840 m^3/d in the Quetta and Kalat Areas, respectively. When the groundwater is utilized, supplemental recharge is further induced, and it is anticipated that the actual flow capacity will exceed the calculated one.

5. The possible yields, when calculated from the concept of safe yield, are estimated to be 17,730 m^3/d in the Quetta Area and 13,470 m^3/d in the Kalat Area.

6. In addition to the moving groundwater veins, the stagnant groundwater zones are detected at 10 places in the Quetta Area and at 2 places in the Kalat Area. These zones are also intended for groundwater development. However, the

pumpage is not permanent and exhaustible. When the permissible critical groundwater drawdown is set at 10m, the possible yields of stagnant groundwater are estimated to be 7,880 m^3/d and 3,880 m^3/d in the Quetta and Kalat Areas, respectively.

7. The total possible yields from both moving and stagnant groundwater development are estimated to be 25,610 m^3/d and 17,350 m^3/d in the Quetta and Kalat Areas, respectively.

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CHAPTER 1 INTRODUCTION

CHAPTER 1 INTRODUCTION

1.1 Purpose

Global groundwater prospecting is conducted with the aerial selective gamma-ray prospecting method in the Quetta and the Kalat Areas of the Province of Baluchistan. With this propecting, the distribution of groundwater veins and zones is discovered; additionally groundwater flow capacity and possible yield of groundwater, which will be the basis of an irrigation development project through groundwater development, are calculated.

1.2 Aerial Selective Gamma-Ray Prospecting

1.2.1 Prospecting System and Method

The aerial selective gamma-ray prospecting method and its support systems used in this survey are covered by Japanese Patents. The detection of the ground surface gamma-rays is made by both two-detector packages attached to each side of the body of a prospecting helicopter and one aerial gamma-ray detector installed inside the helicopter. The combination of these detectors removes the effects of surrounding gamma-rays such as cosmic rays which disturb the detection of gamma-rays from the fissured veins. Still and video cameras are installed at the bottom of the helicopter to take pictures of the prospecting line. When significant fissured vein/zone is detected during the measurement on the prospecting line, its signal enters the monitoring device. Detected signals are then registered in a survey display. Detected gamma-rays are recorded on magnetic tape and judgements about groundwater veins/zones made by analyzing these recorded data (FIGs 1.1 and 1.2).

FIG. 1.1 SYSTEM DIAGRAM OF HELI-BORNE AERIAL SELECTIVE GAMMA-RAY SPECTRO PROPECTING

Japanese patented

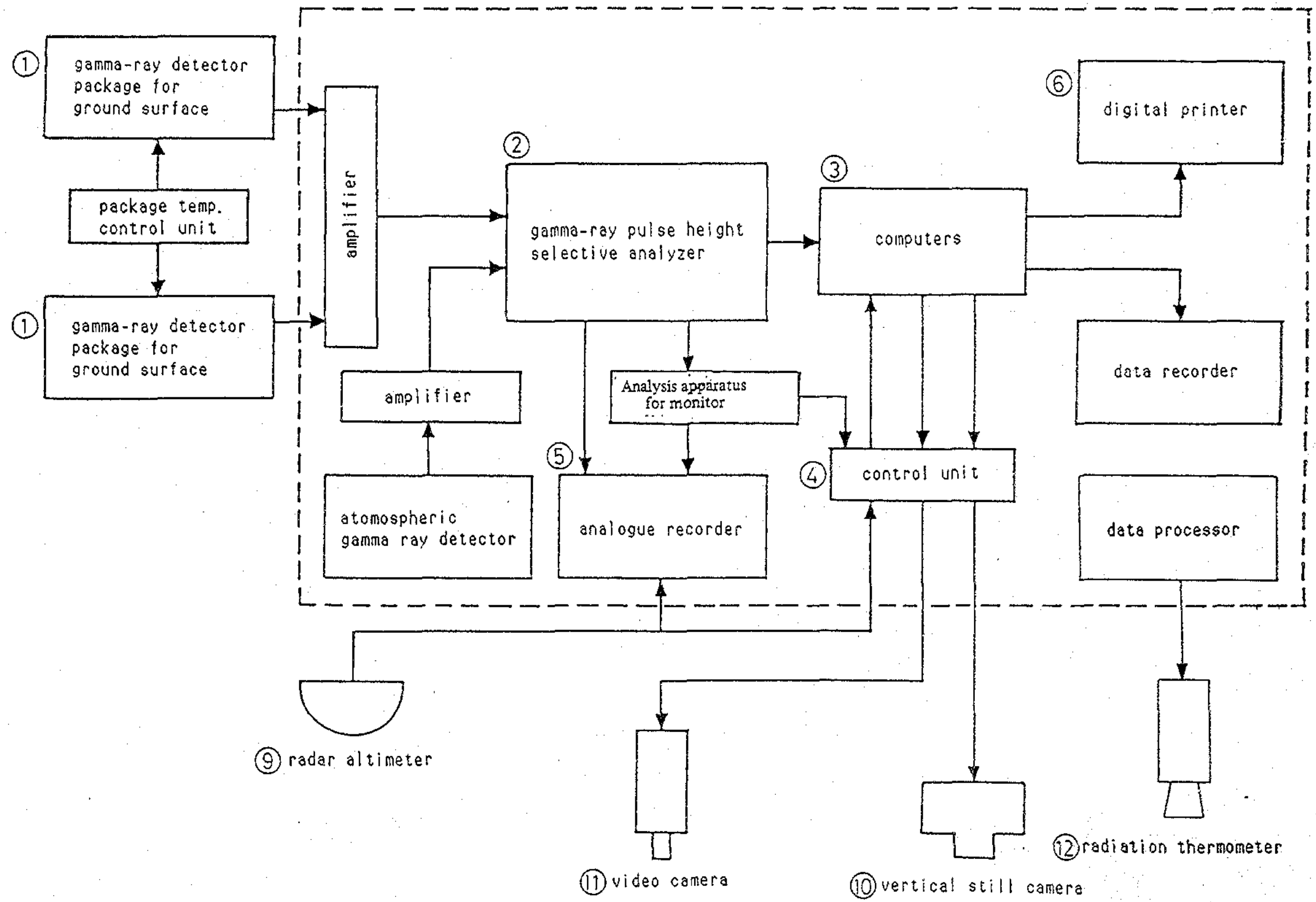
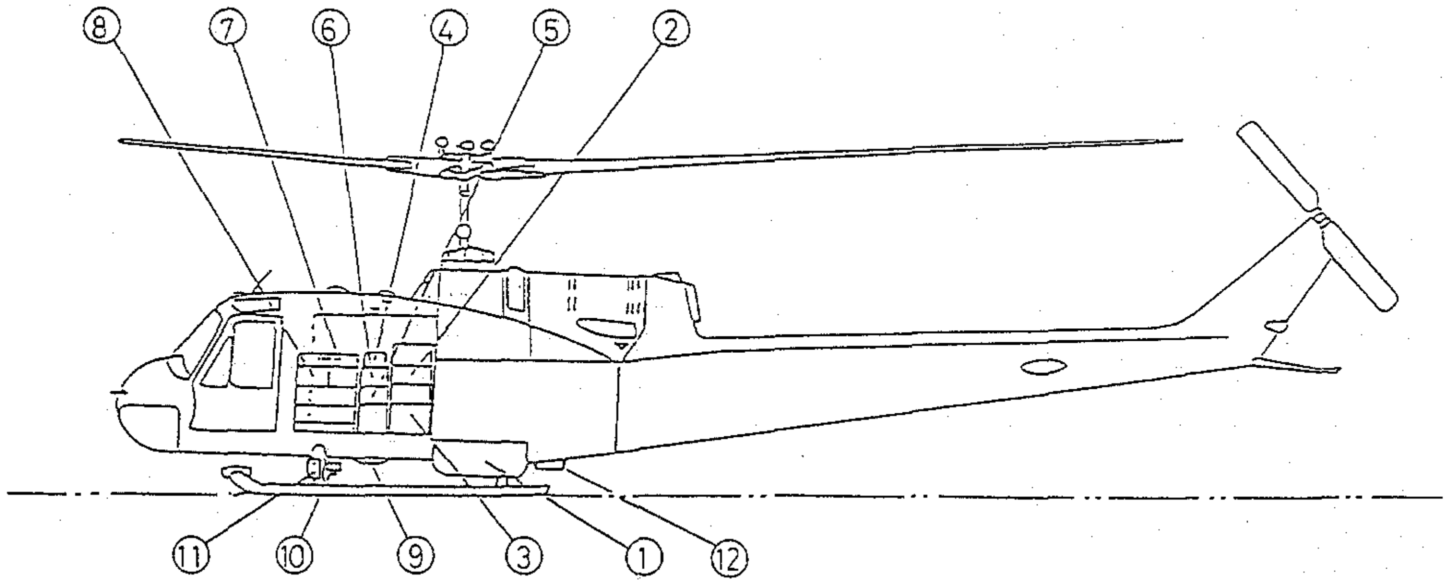


FIG. 1.2 INSTRUMENTATION OF HELI-BORNE AERIAL SELECTIVE GAMMA-RAY SPECTRO PROSPECTING



① Gamma-ray detector package
② Gamma-ray pulse height selective analyzer
③ Computers
④ Computer controler
⑤ Analogue recorder
⑥ Degital printer
⑦ Video recorder
⑧ Video monitor
⑨ Radar altimeter
⑩ Vertical still camera
⑪ Vertical video camera
⑫ Radiation thermometer

1.2.2 Survey Period

The survey period for gamma-ray prospecting was as follows:

(1) Field survey

During the period between June 12 and July 21, 1986, and August 1 and August 31, 1986, preparations for incoming of equipment and materials from Japan were made. Various approvals were acquired, and preliminary arrangements for propsecting work were carried out. From September 15 through November 14, actual prospecting work and its relevant work were carried out.

(2) Home office work in Japan

During the period between November 15, 1986 and March 14, 1987, analytical work was carried out.

CHAPTER 2 AERIAL PROSPECTING WORK

CHAPTER 2 AERIAL PROSPECTING WORK

2.1 Base Camp and Heli-pad

Two base camps for gamma-ray prospecting using the helicopter, one in Quetta and another in Kalat, were established.

(1) Quetta Area

A provincial government building located in the center of the Quetta Area was used as the base camp. A heli-pad where the helicopter landed and took off was constructed in front of the above building. As there was no iron plate available for the heli-pad, a thick layer of gravel was placed over the heli-pad and the access road for working trucks. Water was sprayed over them with a WAPDA watering truck. Every day, helicopter was operated out of Quetta airport.

(2) Kalat Area

A provincial government lodging situated in Kalat town was used as the base camp. A heli-pad of the Pakistan army situated beside the national road No. 25, 6 km north of Kalat town, was used. The data collected in the area by prospecting flights were checked by instruments brought from Japan and loaded on a special vehicle.

2.2 Prospecting Lines

As all the features of groundwater veins and zones were intended to be measured and examined, prospecting lines of a 1,000m-grid pattern covering both Quetta and Kalat Areas were determined as shown in FIGs 2.1 and 2.2. However, 500m grids covered some portions of the areas, because practical considerations made this necessary. As continental topography and large-scaled topographical structures dominated in these survey areas, and many fractured zones were 10 to 100 km long, this prospecting line interval was judged to be sufficiently proper to detect groundwater veins/zones.

The number of prospecting lines surveyed was 30 north-south and 25 east-west lines in the Quetta Area, and 12 north-south and 16 east-west lines in the Kalat Area.

In both areas, north-south prospecting lines were made from north to south using the west-end line as a base line, and east-west prospecting lines were made from west to east using the north-end line as a base line. Radio markers were utilized by the helicopter to confirm sites to assure the exact prospecting flights.

The ground stations were set up by the Survey of Pakistan on the most important points in order to establish control points. Thirteen (13) control points in the Quetta Area and seven (7) in the Kalat Area were established. The prospecting lines are numbered from the west-end line for north-south lines and from the north-end line for east-west lines. as shown in FIGs 2.1 and 2.2.

2.3 Prospecting Blocks

The Quetta Area of 28,000 ha and Kalat Area of 12,000 ha, totalling 40,000 ha, were prospected by the selective aerial gamma-ray prospecting. The Quetta Area is divided into 10 blocks (A, B, B', C, D, E, F, G, H and I) and the Kalat Area is divided into 4 blocks (A, B, C and D). as shown in FIGs 2.1 and 2.2.

The area of each block is as follows:

Name of Block		Area (ha)
Quetta Area		
A		4,700
B		1,430
B'		2,500
C		1,500
D		3,500
E		2,600
F		3,300
G		3,650
H		3,250
I		1,570
	sub-total	28,000
Kalat Area		
A		4,200
B		1,800
C		3,000
D		3,000
	sub-total	12,000
Total		40,000

2.4 Survey Height and Flight Speed

When surveying the intensity of selected gamma-rays from a helicopter, if the height from the ground varies, the gamma-ray counter errs accordingly; thereby decreasing the detection accuracy. In this survey, a height of 100m from the ground, which had been determined to be the most efficient for prospecting in Japan, was adopted. During the survey, the helicopter flew at this constant height.

Similarily, a flight speed of 90 km/h, which had given the best prospecting results in Japan, was adopted in this survey.

The flight paths of the helicopter conformed to the signals emitted from radio makers installed on the coordinates, and the survey was executed along the prospecting lines.

FIG.2.1 PROSPECTING LINE BY HELI-SURVEY
QUETTA AREA

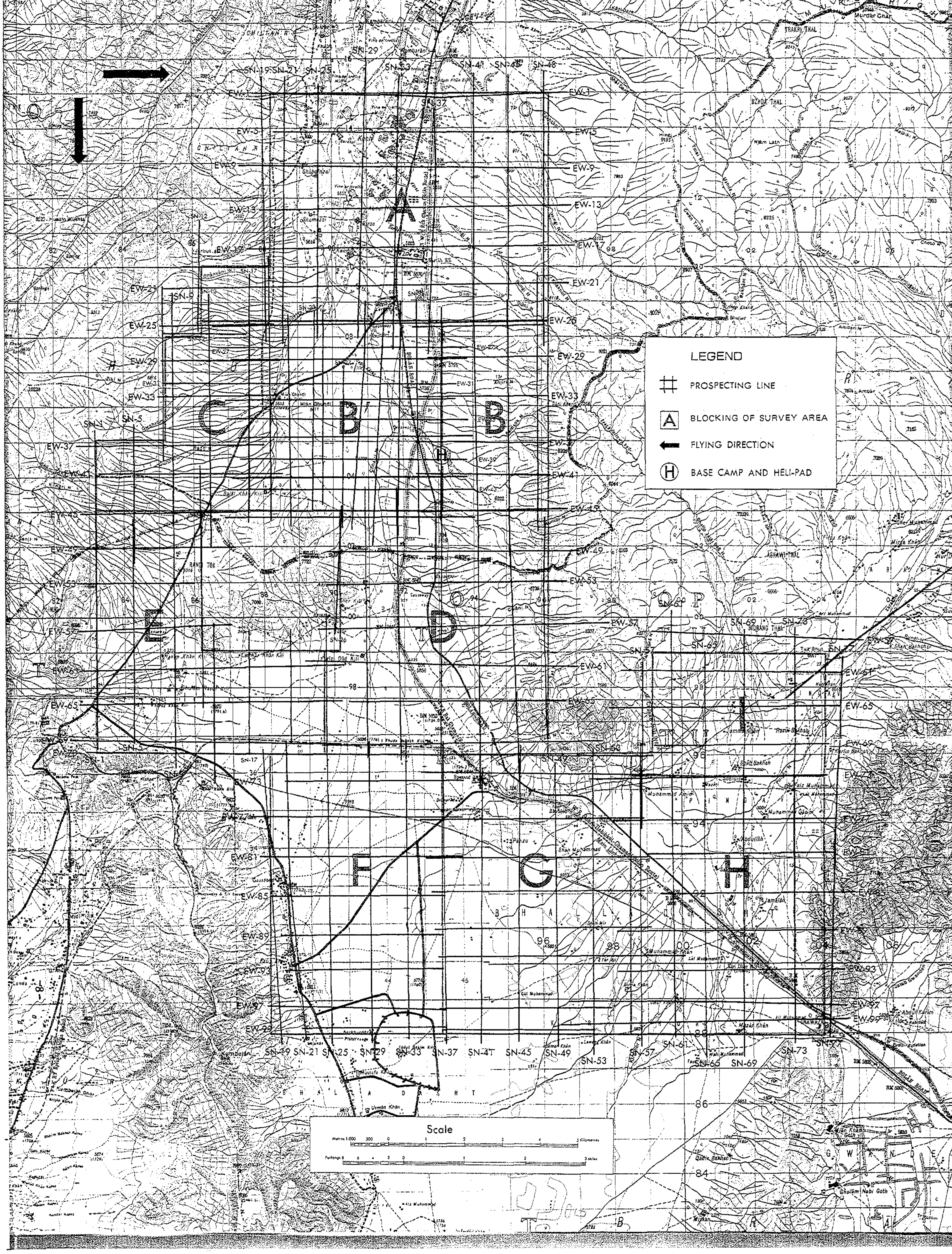


FIG.2.2 PROSPECTING LINE BY HELI-SURVEY
KALAT AREA