

THE PLEISTOCENE GEOMORPHOLOGY
OF THE
SOUTH-EASTERN PART OF THE PESHAWAR VALE

By

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"S"
The dissertation titled "The Pleistocene geomorphology
of the south-eastern part of the Fozhwar Vale"
Submitted by Mr. Mahmood-ul-Hasan for the award
of a Ph.D. degree is approved.

Internal Examiner

External Examiner

Dated This study is dedicated to my parents,
in token of a great debt of gratitude
and love

C.E.

dl: 24.7.96

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Kamal for their help and assistance in several different
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Lastly, I owe a debt of gratitude to my father
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TABLE OF CONTENTS

	PAGE
ACKNOWLEDGEMENTS	i
LIST OF FIGURES	iv
LIST OF PLATES	vi
ABSTRACT	vii
CHAPTER	
1. INTRODUCTION	1
1.1 Study Area	1
1.2 Scope	2
1.3 Aims and Objectives	2
2. TECHNIQUES OF STUDY	4
2.1 Field Techniques	4
2.2 Laboratory Techniques	5
3. REVIEW OF THE GEOMORPHOLOGICAL STUDIES	12
4. GEOLOGY	18
4.1 Introduction	18
4.2 Lithology	19
4.3 Faults	23
5. SECTIONS IN THE PLEISTOCENE DEPOSITS	25
5.1 Section 1	25
5.2 Section 2	37
5.3 Section 3	43
5.4 Section 4	56

5.5	Section 5	63
5.6	Section 6	71
5.7	Section 7	84
5.8	Section 8	92
5.9	Section 9	98
5.10	Section 10	114
5.11	Section 11	120
5.12	Section 12	130
5.13	Section 13	138
5.14	Section 14	145
5.15	Section 15	149
6.	SURFACE DEPOSITS	153
7.	GEOMORPHOLOGICAL HISTORY OF THE PESHAWAR VALLEY	160
8.	SUMMARY AND CONCLUSIONS	178
REFERENCES		185
APPENDICES		
5.4.1	Roundness analysis	38
5.5.1	Section 5	42
5.5.2	Particle size distribution	44
5.6.1	Section 6	70
5.6.2	Particle size distribution	74
5.6.3	Particle size distribution	74
5.6.4	Cross-profile of Pishan torrent channel	82
5.7.1	Section 7	84
5.7.2	Particle size distribution	86
5.8.1	Section 8	92

5.3.2	Particle size	LIST OF FIGURES	22
5.3.1	Section 1		27
5.1.1	Location map of study area		1
5.2.1	Location of sections		4
5.4.1	Geology of the area		22
5.1.1.1	Section I		24
5.1.1.2	Particle size distribution		28
5.2.1	Section 2		36
5.2.2	Particle size distribution		38
5.3.1	Section 3		42
5.3.2	Particle size distribution		45
5.3.3	Shape analysis of gravels		47
5.3.4	Roundness analysis of gravels		47
5.4.1	Section 4		55
5.4.2	Particle size distribution		57
5.4.3	Shape analysis		58
5.4.4	Roundness analysis		58
5.5.1	Section 5		62
5.5.2	Particle size distribution		64
5.6.1	Section 6		70
5.6.2	Particle size distribution		74
5.6.3	Particle size distribution		74
5.6.4	Cross-profile of Piran torrent channel		82
5.7.1	Section 7		83
5.7.2	Particle size distribution		85
5.8.1	Section 8		91

5.8.2	Particle size distribution	93
5.9.1	Section 9	97
5.9.2	Particle size distribution	101
5.9.3	Shape analysis of gravels	103
5.9.4	Roundness analysis of gravels	103
5.10.1	Section 10	113
5.10.2	Particle size distribution	115
5.11.1	Section II	119
5.11.2	Particle size distribution	123
5.12.1	Section 12	129
5.12.2	Particle size distribution	132
5.13.1	Section 13	137
5.13.2	Particle size distribution	139
5.14.1	Section 14	144
5.14.2	Particle size distribution	146
5.15.1	Section 15	148
6.1	Surface deposits of the study area	153
6.1.1	Micrograph of loess particle	154
6.1.2	Section 14	155
6.1.3	Foundations of walls in loess	157
6.1.4	Houses and pathways in loess	157
6.1.5	Section 15	158
6.1.6	Fan-gravels, exposed on the surface	158
6.1.7	Erratics, embedded in siltstone	159
6.1.8	Gravels, exposed on the surface	160

LIST OF PLATES

5.1.1	Section 1	25
5.2.1	Section 2	37
5.2.2	Micrograph of the sand grain	39
5.2.3	Micrograph of the sand grain	39
5.3.1	Cervical vertebra of <u>Bos</u>	43
5.4.1	Section 4	56
5.6.1	Siltstone in Piran nala	71
5.10.1	Section 10	114
5.11.1	Section 11	120
5.12.1	Section 12	130
5.12.2	Rhizoconcretions (fossilised parts of plants).	134
5.12.3	Micrograph of silt particle	135
5.13.1	Section 13	138
5.13.1a	Loess in the study area	138
5.13.2	Micrograph of loess particle	140
5.14.1	Section 14	145
5.14.2	Foundations of walls in loess	147
5.14.3	Bones and pottery in loess	147
5.15.1	Section 15	148
6.1.1	Fan-gravels, exposed on the surface	156
6.1.2	Erratics, embedded in siltstone	155
6.1.3	Loess, exposed on the surface	158

ABSTRACT

Peshawar valley is located on the junction of the Indo-Pakistan platform and the Asian shield. The geological evolution of the valley has taken, a long time period, of about 20 myr, from the middle of the Cenozoic, to the beginning of the Pleistocene. However, the final configuration was achieved, during the later phases of the Himalayan orogeny. Since then, it has passed through several phases of erosion and deposition. The deposits on the surface as well as in the sections, preserve a good record of environmental changes.

The study area lies in the south-eastern part of the valley. Its surface deposits include fan-gravels, river-gravels, medium-grained sand, thick deposit of loess and fine alluvium. The deposits on the surface reflect the preparation of deep regolith on the Attock-Cherat range, due to the growth of vegetation, in pluvial environment, and its subsequent deposition in the foot of the mountain range, as alluvial fans, in moderately arid to semi-arid climate. The deposits also record flood of low to moderate magnitudes, and periglacial environment, during the Pleistocene period.

On the basis of stratigraphical investigations, five pluvial and interpluvial phase have been identified. First, second and fourth pluvial phases seem to be cold and

humid, during which, vegetation growth took place on the Attock-Cherat range, and deep regolith was prepared. Third and fifth phases were too cold and dry for the growth of vegetation. Periglacial environment prevailed in the valley, during which loess was deposited in the plain as well as over the surrounding mountains.

The erosion of the weathered zones, occurred in warm-dry interpluvial phases. Subsequent to the decay of vegetation cover and rapid tectonic uplift of the Attock-Cherat range, the material, exposed, was carried down, and deposited at the base of the mountain range, forming alluvial fans. Four phases of fan formation have been identified.

There are also evidence to show that Peshawar valley was transformed into a lake twice, perhaps, due to the damming of the Indus river, below Khwara valley. It occurred during the second and fourth pluvial phases. Siltstone beds of enormous thickness, were formed in the lake environment.

A variety of river deposits, including, sand, gravel-conglomerate, huge boulders and erratics, and fine alluvium are preserved in the area. Sandstone and gravel-conglomerate have been deposited on the siltstone beds, by the Kabul and Indus rivers, during the second and fourth pluvial phases. The fine alluvium was deposited by the Kabul river and its tributaries, in the flood plains, during the Holocene.

The deposits mentioned, have also been eroded and deformed due to intermittent tectonic uplift, during the Pleistocene period.

INTRODUCTION

1.1 STUDY AREA

Peshawar valley is a semi-circular depression in the mountains of the north-west of Pakistan. From west to east, it has a maximum length of 115 km, while from south towards north, the maximum breadth is 30 km, covering an area of about 3500 sq. km. The depression is surrounded by mountains on three sides: Malakand - Lower Swat ranges in the north, Mohmand and Khyber hills in the west; towards south it is delimited by the Khyber - Chitral range, while in the east, the Indus river forms the boundary between Peshawar valley and the Potwar plateau. The mountains in the surrounding varies in height, from 1700 to 1800 m. The valley is filled by a variety of sediments, about 300m thick. The deposits on the surface and in the sections comprise silt, clay, gravel, huge boulders and erratics. There are also bedrock outcrops, scattered throughout the valley.

The study area lies in the north-western part of the Peshawar valley (Fig. 1.1). It is delimited by the Malakand range in the north, the Indus towards east, towards south by the Khyber - Chitral range in the south. It covers an area of about 115 km from west to east and 30 km from south to north, covering an area of about 3500 sq. km. The area has

CHAPTER I

INTRODUCTION

1.1 STUDY AREA

Peshawar vale is a semi-circular depression in the mountains of the north-west of Pakistan. From west to east, it has a maximum length of 110 km, while from south towards north, the maximum breadth is 80 km, covering an area of about 8800 sq. km. The depression is surrounded by mountains on three sides; Malakand - Lower Swat ranges in the north, Mohmand and Khyber hills in the west; towards south it is delimited by the Attock - Cherat range, while in the east, the Indus river forms the boundary between Peshawar valley and the Potwar plateau. The mountains in the surrounding varies in height, from 1200 to 1800 m. The valley is filled by a variety of sediments, about 300m thick. The deposits on the surface and in the sections comprise silt, clay, gravel, huge boulders and erratics. There are also bedrock outcrops, scattered throughout the valley.

The study area lies in the south-eastern part of the Peshawar valley. (Fig.1.1). It is delimited by the Kabul river in the north, the Indus towards east, warmondo khwar in the west and Attock - Cherat range in the south. It extends for 24 km from west to east and 16 km from south to north, covering an area of about 300 sq.km. The area has

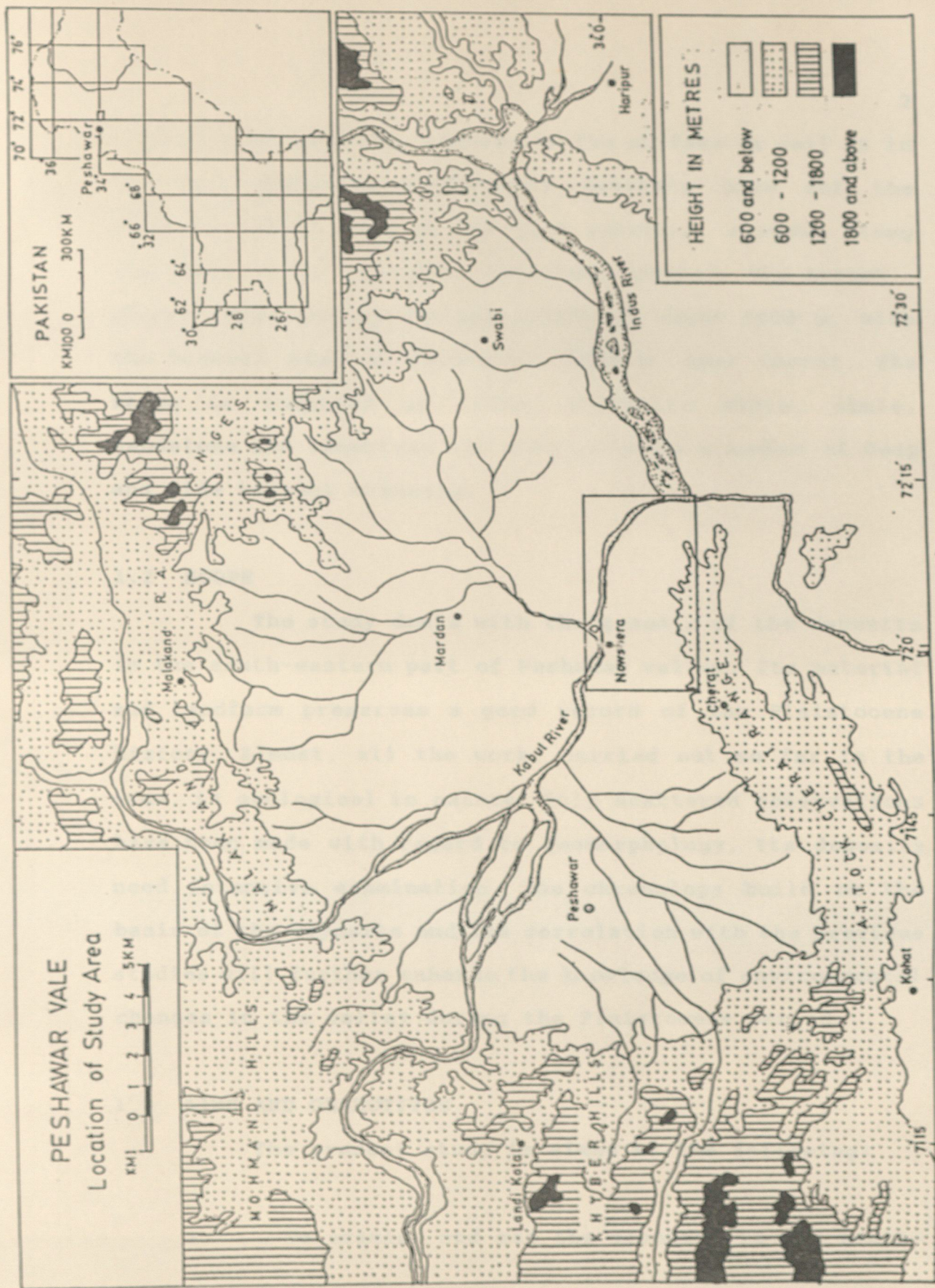


Figure 1.1

a variety of deposits, exposed on the surface as well as in sections. Numerous north-south torrents have cut the deposits, where some of the good sections, exposed along the banks of the torrents, have been studied. The Attock - Cherat range has an average height of about 1000 m, with the highest peak at Jalalasar, 1538 m, near Cherat. The range is composed of slate, phyllitic slate, shale, sandstone and limestone. It also contains a number of deep and wide torrent channels.

1.2 SCOPE

The study deals with the genesis of the deposits in the south-eastern part of Peshawar valley. Its material and landform preserves a good record of the Pleistocene history. Almost, all the work, carried out so far in the area, is geological in nature. Only scattered observations have been made with regard to geomorphology. Its deposits need intensive examination. The chronology build on the basis of the deposits and its correlation with the previous studies will further enhance the knowledge of environmental changes in the valley during the Pleistocene period.

1.3 AIMS AND OBJECTIVES

The present study is aimed at the following:

- a. To examine and map the deposits in the south-

eastern part of the valley and to establish their lateral and vertical relationship.

- b. To establish on the basis of the deposits, a chronology of the Pleistocene events.
- c. To interpret the genesis of the material.
- The surface deposits, section study and laboratory analysis. The sections were interpreted, correlated and finally, a chronology was worked out.

2.1 FIELD TECHNIQUES

2.1.1 Mapping of Surface Deposits

Mapping of surface deposits was carried out by field observations, aided by the study of the topographic sheets on scale 1:50,000 and aerial photographs of the same scale 1:40,000. Samples of various sediments were also collected for detailed laboratory analysis.

2.1.2 Examination of Sections

In order to establish the litho-stratigraphy, sections exposed along the torrent banks were examined. In the beginning a preliminary survey was made. On the basis of it, fifteen sections were selected for detailed study. The selection was made in such a way that the minimum repetition of the sequence should occur. The sections were

CHAPTER 2

TECHNIQUES OF STUDY

In order to achieve the objectives of study, a number of field and laboratory techniques have been used. To start with, a review of geological and geomorphological literature was made. It was followed by a mapping of the surface deposits, section study and laboratory analysis. The sections were interpreted, correlated and finally, a chronology was worked out.

2.1 FIELD TECHNIQUES

2.1.1 Mapping of Surface Deposits

Mapping of surface deposits, was carried out by field observations, aided by the study of the topographic sheets on scale 1:50,000 and aerial photographs of the scale 1: 40,000. Samples of various sediments were also collected for detailed laboratory analysis.

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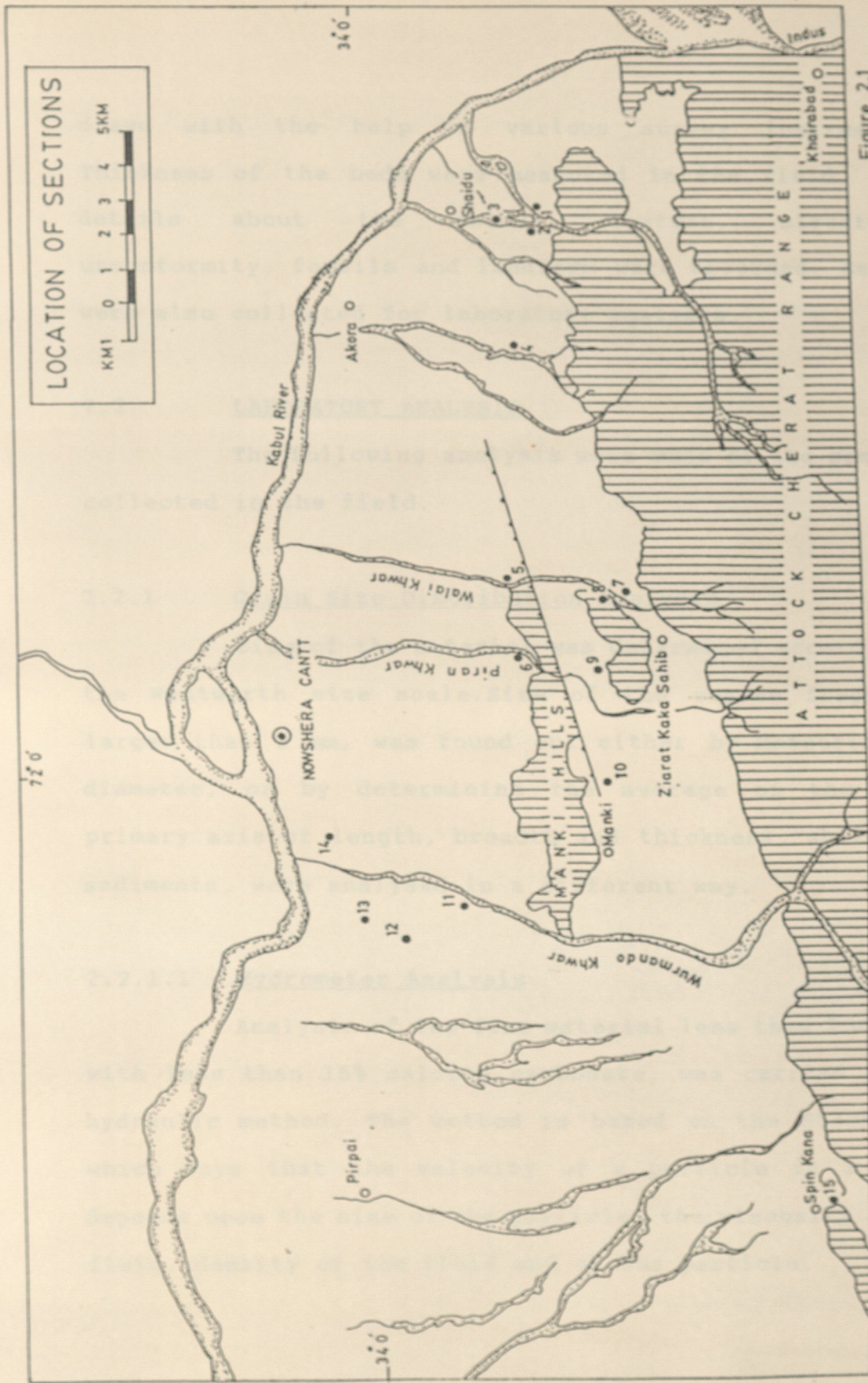


Figure 2.1

drawn with the help of various survey instruments. Thickness of the beds were measured in the field, while details about the colour, texture, structures, unconformity, fossils and landform were recorded. Samples were also collected for laboratory analysis.

2.2 LABORATORY ANALYSIS

The following analysis were made of the samples, collected in the field.

2.2.1 Grain Size Distribution Analysis

Size of the material was determined according to the Wentworth size scale. Size of the coarse fragments, larger than 2 mm, was found out either by measuring the diameter, or by determining the average of the three primary axis of length, breadth and thickness, while fine sediments, were analysed in a different way.

2.2.1.1 Hydrometer Analysis

Analysis of the fine material less than 2 mm, and with less than 15% calcium carbonate, was carried out by hydraulic method. The method is based on the Stock Law, which says that the velocity of a particle in a fluid depends upon the size of the particle, the viscosity of the fluid, density of the fluid and of the particle.

2.2.1.2 Centrifuge Method

Sample with more than 15% of the calcium carbonate, was treated in a different manner. In hydrometer analysis, calcium carbonate reacts chemically with dispersing agent, sodium pyrophosphate, forming new grains, that disturb the actual grain size distribution of the material. All such calcareous samples were first made to react with hydrochloric acid, so that all the calcium carbonate may be converted into carbon dioxide gas and the remaining sample is devoid of the calcareous matter. In this method, the sample is centrifuged for 15 minutes in a centrifuging machine, after the addition of hydrochloric acid. After the sample is devoid of calcareous content, it is analysed by hydrometer method, adding sodium pyrophosphate as dispersing agent. The data was described in form of cumulative frequency curves. Statistical and mathematical techniques were used to derive parameters, describing grain size distribution from cumulative frequency curves.

2.2.1.3 Average Grain Size

Three mathematical measures i.e. mean, median and mode are in common use for the average grain size, Mean size is the arithmetic average of all the particle sizes in a sample. In the present study, the 16th, 50th and 84th percentile values of the cumulative frequency graphs have

been used to find out the mean. Median is the mid-point of the grain size on the cumulative curve, while mode is the most frequently occurring particle size, represented by the steepest point on the cumulative graph.

2.2.1.4 Sorting

Sorting is a measure of the range and the magnitude of spread of grain sizes around the mean size. The mathematical expression of sorting is standard deviation. The formula for calculating standard deviation by graphical method is given below:

$$\text{Standard Deviation} = \frac{\phi_{48} - \phi_{16}}{4} + \frac{\phi_{95} - \phi_5}{6.6}$$

ϕ_i are the values on cumulative frequency graph. Verbal terms for sorting corresponding to various values of standard deviation are given below, after Folk (1974)

Standard Deviation

> 0.350	very well-sorted
0.350 to 0.500	well-sorted
0.500 to 0.710	moderately well-sorted
0.710 to 1.000	moderately sorted
1.000 to 2.000	poorly sorted
2.000 to 4.000	very poorly sorted
< 4.000	extremely poorly sorted

2.2.1.5 Symmetry or Skewness

Most natural sediments don't exhibit normal grain-size distribution. They show some degree of asymmetry or skewness. Population with excess fine particles is said to be positively or fine skewed, while population with excess of coarse particles, is negatively skewed or coarse skewed. The skewness values of the samples have been calculated according to the formula:

$$\text{Skewness} = \frac{(\phi_{84} + \phi_{16} + \phi_{50})}{2(\phi_{84} - \phi_{16})} + \frac{(\phi_{95} + \phi_5 - 2\phi_{50})}{2(\phi_{95} - \phi_5)}$$

Where ϕ_i are the values on cumulative frequency curve. Verbal terms for symmetry corresponding to various values of skewness are given below:

Skewness

> + 0.30	strongly fine skewed
+ 0.30 to + 0.10	fine skewed
+ 0.10 to - 0.10	near symmetrical
- 0.10 to - 0.30	coarse skewed
< - 0.30	strongly coarse skewed

2.2.2 Mineralogical Analysis

Mineralogical composition of the samples have been determined for the inference to be made concerning the source rock formations.

2.2.3 Scanning Electron Microscopy

Microrelief and textural patterns of the fine sediments were examined with the help of scanning electron microscope. A magnification upto 15000 times, greatly enhanced, the study of very fine-size particles of sand, clay and silt, that could not be examined effectively, with naked eye, or petrographic microscope.

2.2.4 Calcium Carbonate Analysis

Accurate determination of calcium carbonate is a pre-requisite for the size analysis of fine sediments. Besides, it reveals the environment of deposition. For the purpose of present study, 7 gram of the sediment was made to react with one ml 10% dilute HCL. This way the carbonates of the sample convert into carbon dioxide. After the weighing of the sample again, the percentage of calcium carbonate was calculated.

2.2.5 Pollen Analysis

Pollen analysis, is the most important technique for the reconstruction of the Pleistocene environment. Eighty samples, collected from the lacustrine sediment, flood plain deposit and loess, were analysed. None of the sample had pollen grains.

2.2.6 Diatom Analysis

Diatoms, preserved in the lake sediments, are important from palaeo-ecological point of view. Diatom analysis of the 64 samples, was carried out. Like pollen grains, in none of the slides, diatom was observed.

2.2.7 Charcoal Analysis

Charred particle analysis also contributes to the reconstruction of the palaeo-ecological conditions of an area. It may be used as an index of the palaeoclimates, because certain weather conditions initiate lightning, which in turn are the cause of natural fires, producing charred particles (Payett, 1980). Historic and pre-historic man is also a potential cause of ignition. Charred particles can be studied and counted from the pollen slides. A number of pollen slides, prepared for the present study, were found to contain charred particles, when examined under a powerful microscope.

2.2.8 Colour Identification

Colour is an important clue of the chemical composition of the sediment. In present study "Munsell Soil Colour Chart, 1973" was used for colour identification. The colour of the material in dried form, was matched with the coloured chart.

2.2.9 Shape and Roundness Analysis

Shape and roundness of the fragments were determined according to Zingg (1935) and Caileux (1954) method respectively. Hundred gravels, collected randomly from each of the bed, were used for the purpose.

2.2.10 Microscopic Study of Fine Sediments

Microscopic study of fine sediments, was carried out. Quartz and mica grains, their roundness, shape, tiny and delicate rootlets, the broken pieces of the crusts of the snails and the very fine grains of the local rock formations were identified in the samples.

On the basis of the above mentioned analyses, sediments in different sections were interpreted. In order to build up the chronology of the area, the beds were correlated with each other, on the basis of their stratigraphic position and the analyses mentioned.

CHAPTER 3

REVIEW OF THE GEOMORPHOLOGICAL

STUDIES

Past researches on the various aspects of the geography, geology and geomorphology of the Peshawar valley, have been sketchy and highly generalised. In 19th century Peshawar valley was considered to be the north-western extension of the Punjab plain and work on the Quaternary geology was mainly concentrated on the northern Punjab, particularly the Potwar plateau. Whatever little observations have been made regarding the deposits of Peshawar valley, were either by the geologists accompanying the British forces during their punitive expeditions against the Frontier tribes or by travellers, explorers and secret agents. Vicary's (1851) work is one of the earliest, regarding the geology of the Punjab and Peshawar. In Peshawar valley his work is confined to the surrounding of the Kabul river. He has mentioned the alternating beds of clays, gravels and conglomerate in the vicinity of Akora, where he has also found the bones of camel (?) from the gravelly beds. The deposits have been assigned Pliocene period. Wynne (1877) has described the detrital beds of saline yellow, pale, pink, greenish red and white sands, clays and gravelly beds with bones and soft micaceous sandstone in the surrounding of Spinkhak, Peshawar valley. He has also described alluvial fans in the foot of the

Attock - Cherat range. Theobald (1880) has mentioned the deposits of the broad open plain of Yousafzai (Peshawar valley) as consisting of thick deposits of alluvium, laid down by the Kabul river and its tributaries, that may partly be of lacustrine origin. He has observed the area between Nowshera and Hoti Mardan and reported a "number of limestone blocks resting on the alluvium that may have been rafted by ice from the surrounding mountain ranges". He has also put forward the idea that the Indus river ran far south of its present course and east of the Attock near Barotha during the Pleistocene period. Hayden (1897) made observations on the post Tertiary beds of the Bazar, Bara and Mastura valleys, west of the Peshawar vale, during the Tirah Expeditionary Force in 1897. He has reported coarse conglomerate from Bara valley, derived from Sufaid-Koh. He has also mentioned erratics on the hill sides as much as 120 m above the present level of the river bed and has suggested the glacial origin of the blocks. Coulson (1937) has put forward the idea that the Indus river was dammed just below its junction with Kabul river in fairly recent times, which resulted in the formation of a lake, covering part of the Peshawar vale. According to him, the clayey sediments near Jahangira have been deposited in the lake during the later glacial phase. He has also suggested that there has been progressive sinking of the Kabul river valley with the deposition of alluvium in the lake, when

Indus and Kabul rivers were dammed near Attock. Allen and Dani (1964) have described a generalised section representing a composite of a number of localities north of Mardan. The oldest unit in the sequence is the laterite zone followed by older loess, breccia, younger loess, lake beds and recent alluvium. The deposits have been correlated with the climatic epochs. Jan (1968) in his observations on the Pleistocene sandstone, south-east of Jallozai village, has described the mineralogical analysis of the sandstone and classified it as calc-lithiic arsenite. On the basis of the mineralogical composition, he is of the view that the probable source of the sandstone was the igneous rocks of the mountains, north of the Peshawar vale. Syal and Afzal (1972) of the Soil Survey of Pakistan, have studied the landforms of Peshawar valley. The description of the landforms start with a brief account of the nature of parent material and its mode of deposition. The main landforms that they have identified are the piedmont plain, loess plain, river terraces and subrecent flood plain in the valley. A tentative brief description of the chronologic order of landforms, based on the degree of soil development, has also been given. Elberson et al. (1973) of the Soil Survey Of Pakistan have carried out a reconnaissance soil survey of Peshawar vale. They have also recognised a number of landforms comprising, flood plains of the Indus, Kabul and Swat rivers, loess plains and

piedmont zones. They also considered Peshawar vale to be the extreme north-western tip of the Indo-Gangetic synclinorium, filled with the alluvial material. They believed that faults are common at the bottom of the geosyncline, as the area is tectonically unstable. Said and Majid (1977) have studied the terrestrial deposits of Bar Daman area of Peshawar valley and suggested a sequence of events, during the Pleistocene and Holocene periods. They have identified a variety of deposits on the surface as well as in sections and suggested that the valley was covered by a fresh water lake, during the Second Himalayan glaciation, during which siltstone, mainly reworked older loess was deposited. They suggested that the early phase of third glacial is recorded by fan gravels while the last phase is characterized by loess deposition. The last glacial phase is recorded by fan formation, while during Holocene large scale changes in the drainage of the area has occurred. Rendell and Thomas (1980) have described a sequence of Pleistocene and Holocene events from the northern Peshawar basin near the ruined Buddhist monastery of Takht-i-Bahi and have compared it with the other deposits, both within the Peshawar basin and in the adjacent Potwar region. The oldest bed in the sequence is yellow, horizontally bedded siltstone, overlain by red bed, composed of silt with no obvious signs of beddings. The historic sequence is represented by rock fragments,

composed of locally derived slates and schists. Burbank (1983) has examined the thick siltstone deposits near Piran, south of Nowshera. He has suggested at least 40 catastrophic floods that inundated Peshawar vale in prehistoric time. Burbank and Tahirkheli (1985) carried out the study of magnetostratigraphy, fission-track dating on volcanic ashes and stratigraphic evolution of Peshawar basin. They have reported more than 300 m of basin-filling sediments accumulated at a rate of 15 cm per thousand years. Alluvial fan facies, flood plain and shallow lacustrine deposits have been described from sections, studied at Garhi Chandan, Dag and Piran, in the southern part of Peshawar basin. Yeats and Hussain (1987) have worked on the timing of structural events in the Himalayan foothills of the northwestern Pakistan. They have described Plio-Pleistocene deposition and late-Quaternary high-angle faultings and localised foldings near the southern margin of Peshawar basin, that has deformed the Quaternary deposits in many localities, south of river Kabul. Rendell (1988) has worked on the loess deposition during the Late-Pleistocene in northern Pakistan. She has suggested that Peshawar vale was dominated by loess deposition during the late Pleistocene. Thermoluminescence (TL) dating reveals that the dominant phase of loess accumulation in Peshawar vale dates to between 65 Ka to 20 Ka. Inam (1990) has described four major facies in the southern part of

Peshawar valley i.e. lacustrine, flood plain, alluvial and aeolian. Vast deposits of volcanic ash have also been reported from certain localities. He has suggested that the vale was transformed into a lake at least four times during the Pleistocene, and various erratic blocks lying on the lacustrine sediments, have been deposited by floating ice-blocks, during one of the stades of the middle Pleistocene. Three phases of loess deposition in warm dry and semi-dry climatic conditions have also been suggested.

It is evident, from the previous works, that a number of attempts have been made in the past, to study landforms and Pleistocene deposits of the Peshawar valley. Most of the studies have been carried out by pedologists, archaeologists, hard rock geologists and engineers with only scattered references to the geomorphology of the valley. The present work is aimed at a study of the surface deposits in the south-eastern part of the Peshawar valley. It will be correlated with the deposits, exposed in the sections. Secondly, an attempt will be made to interpret the deposits exposed in the sections to build up a chronology of Pleistocene events. Work of this nature has not been carried out previously, in the south-eastern part of Peshawar Valley.

1948, 1952 and 1953 have identified twelve lithological units in the Khyber - Choral range. Four have been placed in Pleistocene, three in Neogene and five in Tertiary. Sugden et al.

CHAPTER 4

GEOLOGY

4.1 Introduction

Peshawar valley forms one of the most important feature in the topography of the north-western mountain of Pakistan. It has developed on the north-western margin of the Indo-Pakistan platform. The rampart of the mountains, surrounding the valley, forms part of the Himalayan orogenic belt, having been formed due to collision of the Indian mass, Kohistan Island Arc and Asian shield, from Cretaceous to Tertiary. The mountains consist of a variety of rock formations ranging from Precambrian to Pleistocene. The floor of the valley is formed of the Attock slate, which is overlain by gravelly and clayey alluvium, about 320 m thick. (Spate et al. 1967).

The study area lies in the south-eastern part of the valley, at the foot of the Attock-Cherat range. The mountain range extends from the Indus in the east, as far as Adamkhel pass in the west, for a distance of about 80 km, and forms the southern boundary of the Peshawar valley. It has an average height of about 1000 m, with the highest point, Jalala Sar, 1536 m high. Tahirkheli (1965, 1967, 1968, 1970) has identified twelve lithological units in the Attock - Cherat range. Four have been placed in Palaeozoic, three in Mesozoic and five in Tertiary. Hussain et al.

(1983) have studied the slate formation of the Peshawar basin, and have established a generalised stratigraphic sequence of the Attock - Cherat range. Only five lithological unit of Late Precambrian and Cambrian period are exposed in the area.

4.2 Lithology

Manki Formation

This is one of the oldest formations in Peshawar valley. It covers extensive part of the area. It is exposed all along the northern foothills of the Attock - Cherat range, from Manki as far as Indus (Fig. 4.1). Its type locality is an isolated hillock, Manki hill, five kilometer south of Nowshera. The formation consists of a thick sequence of slate and phyllitic slate, with intercalations of quartz and limestone. Doleritic sills, dykes and hydrothermal veins are frequently found in the Manki slate. At Kund, the quartz usually fill the fractures in the formation. The slate has dark-grey, dark-green, black and grayish colour with thin beddings and shows ripple marks. The slate generally strikes nearly in east-west direction and dips from 45° to 65° north. Secondary foldings of smaller magnitudes can also be observed in the formation. It has been assigned a tentative age of Late Precambrian (Hussain et al. 1983).

Shahkot Bala Formation

The formation consists of slaty shale, slate and limestone. It is exposed along the northern slopes of the Attock - Cherat range, in the vicinity of Shahkot Bala village and along the Shakai nala, in the central part of the range. Towards east, there is an isolated pocket of the formation, around the village, Kund. Slate is very hard and displays light-green, greenish-grey and brownish-grey colours. It is overlain by white, light to dark-grey and yellowish-brown, thin-bedded to massive dolomite limestone. Hydrothermal veins are common in limestone. Tahirkheli (1970) has assigned an age from Upper Ordovician to Lower Silurian, while Hussain et al. (1983) have put the formation in Late Precambrian period.

Uch Khattak Formation/Khattak Limestone

The formation consists of medium to fine-grained, thin-bedded to massive unfossiliferous limestone, with shale on the top. It shows light-grey and black colour. The topmost light-grey layer, 6 to 18 m in thickness is bedded, containing argillaceous laminations and streaks, disturbed horizontally and vertically. The middle horizon is thinly bedded crystalline limestone, having light-coloured argillaceous and calcareous laminations, developed parallel to the bedding planes. The basal portion is thick-bedded to massive, dark-grey in colour. It is exposed in a few

isolated sections, west of Shakai nala, where its maximum thickness is 24 m. It is also exposed in the form of a narrow strip on the northern slopes of the Attock-Cherat range, from Ziarat Kaka Sahib as far as Khairabad. Middle to Upper Silurian age was suggested by Tahirkheli (1970), while later on, it was assigned a Late Precambrian age (Hussain et al. 1983).

Attock Shale/Dakhner Formation

The formation has extensive distribution in the Attock-Cherat range, extending from the vicinity of Shahkot in the west as far as Dakhner in the east. It consists of shale and slaty shale, displaying grey, light to dark-grey, greenish-grey and yellowish-brown colours. The formation also preserves ripple marks and cross-beddings. It supports the idea that the Attock shale represents flysch type deposits. In the vicinity of Manki, siltstone forms conspicuous bands in the Attock shale, ranging from 0.5 m to 3 m in thickness, while there are also fossiliferous limestone bands and pockets in the formation. Previously, a probable age, between Middle Jurassic and Cretaceous was suggested for the Attock - shale (Tahirkheli, 1970), but later on, Late Precambrian age was assigned to the formation by Hussain et al. in 1983. It has also been suggested that the formation is stratigraphically equivalent to Manki Formation, differing only in the degree

of metamorphism (Yeats and Hussain, 1987).

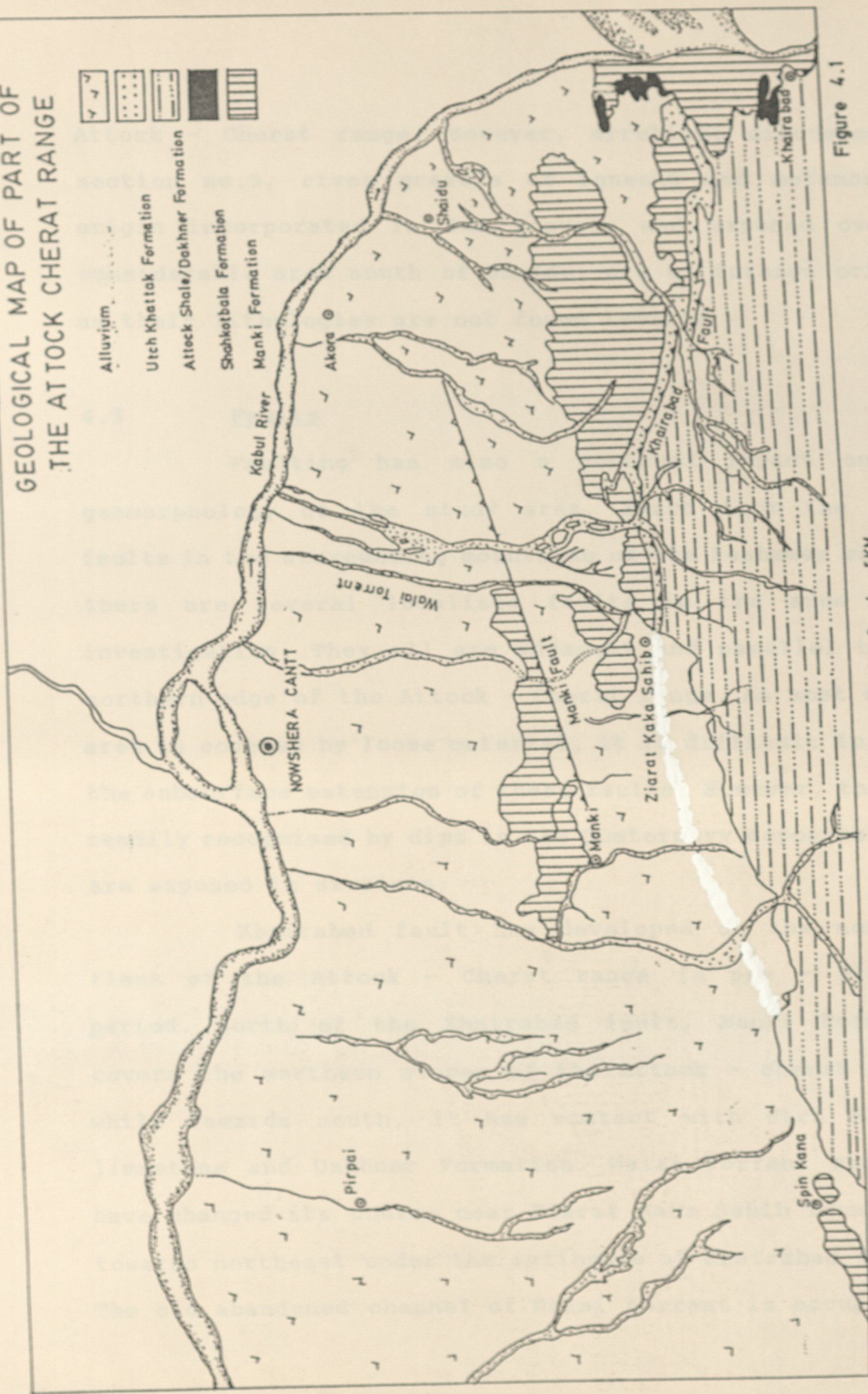
Shakai Limestone

The formation occupies a small area between Shakhi and Uch Khattak nala, where it rests unconformably on Precambrian Khattak limestone. It is also exposed in a section in the vicinity of the Khawrai village. It has a thickness from 6 to about 96 m. The formation is subdivided into three lithologies i.e. limestone, quartzite and shale. The basal portion of the formation is composed of thin-bedded medium to very coarse texture quartzite and quartzitic sandstone. Thin-bedded to massive crystalline limestone occurs above the quartzitic sandstone. About 90 m thick bed of limestone has been measured, forming ridges and escarpments, around Uch Khattak nala. Shakai formation has been correlated with the Abbottabad Formation (Tahirkheli,, 1970). Earlier, Abbottabad Formation was assigned Permo-Carboniferous age (Marks and Ali, 1961), but later on, it was placed in Cambrian period (Latif, 1970). It reveals that the Shakai Formation may also belong to Cambrian period.

Lithological formations have effected the nature of the deposits of the study area. Lithology of the clasts, dscribed in Chapter nos. 5 and 6, reveals that bulk of the material on the surface as well as in the sections i.e. older and recent fan gravels, have been derived from the

GEOLOGICAL MAP OF PART OF THE ATTOCK CHERAT RANGE

- Alluvium
- Utch Khattak Formation
- Attock Shale/Dakhrer Formation
- Shahkotbala Formation
- Manki Formation



KMI 0 1 2 3 4 5KM

Figure 4.1

Attock - Cherat range. However, erratics, discussed in section no.9, river gravels of igneous and metamorphic origin incorporated in fan gravels and exposed over a considerable area south of Shaidu, are of foreign origin, as their lithologies are not found locally.

4.3 Faults

Faulting has also a profound impact on the geomorphology of the study area. Apart from the major faults in the surrounding mountains of the Peshawar valley, there are several localised faults in the area under investigation. They all are adjacent and parallel to the northern edge of the Attock - Cherat range. As most of the area is covered by loose material, it is difficult to trace the subsurface extension of these faults. However, they are readily recognised by dips in the Quaternary deposits, that are exposed in sections.

Khairabad fault has developed on the northern flank of the Attock - Cherat range in pre - Pliocene period. North of the Khairabad fault, Manki Formation covers the northern slopes of the Attock - cherat range, while towards south, it has contact with Utch Khattak limestone and Dakhner Formation. Walai torrent seems to have changed its course near Ziarat Kaka Sahib from north towards northeast under the influence of Khairabad faults. The old abandoned channel of Walai torrent is occupied by

the road from Ziarat Kaka Sahib to Nowshera, in Spinsali hills. Another marked thrust fault has been located in Manki hills, between Manki and Walai. It has deformed Quaternary deposits in Walai, discussed in detail in section No.5. The uplift of the sediments, cut the drainage pattern of Walai torrent in the vicinity of Walai, and resulted in the diversion of the entire drainage pattern towards east, northeast. The uplift of the material due to faulting, also initiated a new cycle of erosion, that resulted in the cutting torrent channels in the deformed material i.e. the present Walai torrent channel east of Rangmahal and Dwa Khlo torrent channel near Naino Kurona.

The Pleistocene sediments in section nos. 7 and 15 i.e. in the vicinity of Ziarat Kaka Sahib and Jabba-Spinkani have also been disturbed by Late-Quaternary deformations. It indicates subsurface localised faulting. Their steep dips also reveal that the faults are of relatively high angle. All these faults in the southern parts of Peshawar valley may be attributed to the compressive forces, created by Margalla Thrust in post-Miocene period (Tahirkheli, 1980).

It is evident from the above description that geology has deeply effected the geomorphology of the study area.

SECTION 1

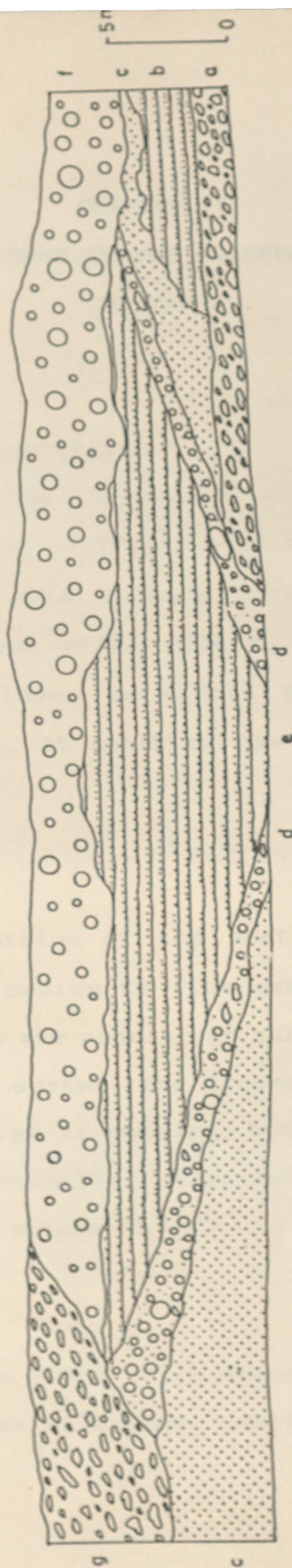


Figure 5.1.1

CHAPTER 5
SECTIONS IN THE PLEISTOCENE
DEPOSITS

5.1 SECTION 1

5.1.1 Field Description

This section is exposed along the eastern bank of Khaweri khwar (GR U222849), near the northern flank of the Attock-Cherat range. Bedrock is not exposed at the base of the section, but within 200 m, there are extensive outcrops of the lower to middle Silurian Manki slate (Tahirkheli, 1970). It exhibits the following beds (Fig. 5.1.1.):

Bed a:

The basal portion of the section displays a meter thick deposit of medium to fine gravels, of local Manki slate. The gravels are angular to subangular, dark-gray in colour and poorly sorted. The fragments are predominantly bladed. The material is compact, but can be easily broken with hammer. Occasionally, there can be seen, boulders of local and foreign origin in it.

Bed b:

There is 2.5 m thick deposit of light-gray (2.5 Y 7/2), calcareous siltstone, overlying unconformably on



Section I



Plate 5.1.1.1

the gravels in bed a. It contains 19% calcium carbonate, and shows 8 - 12 cm thick horizontal beds. The material is hard but can be scratched with hammer. It has also unconformable contact with the overlying sand.

Bed c:

Light-brownish gray (2.5y 6/2), structureless sand, with a maximum thickness of two meter, is exposed in bed c. Predominantly, composed of fine sand (77%), it contains 23% silt. Evidence of rootlets, burrows and small circular holes, about 5 mm in diameter, have also been noticed in the deposit. There are also small rounded gravels of foreign as well as of local origin in the sand. The material is compact, but can be scratched with hammer. It has conspicuous erosional unconformity, making a channel-like form in this section.

Bed d:

It is a bed of rounded gravels of foreign origin, comprising white quartz, gray quartzite, green amphibolite, granite, gneiss and schist. It has also a considerable number of fine sandstone and slate gravels of local origin. There can also be seen a number of boulders of foreign origin, upto the size of 0.4 x 0.5 x 0.7 m. The gravels are embedded in the matrix of fine brown sand. The bed has also a very marked erosional unconformity.

Bed e: detached with fingers. The material is also exposed

It is composed of pale yellow (2.5y 7/4), hard siltstone rich in calcium carbonate (14%). The thickness of the bed varies from 0.5 to 4 meter. It has also horizontal bands 6 to 10 cm thick, that show vertical cracks and joints. Black rust has developed on the deposit. It shows a prominent erosional unconformity.

Bed f:

The material in bed f, ranges in size from 0.0015

mm to 0.2 The bed is composed of well-rounded river gravels of foreign origin. They are exposed on the surface as loose and incoherent material, while the sub-surface fragments are hard and compact and embedded in the matrix of gray sand. Lithologically, the gravels are quartz, quartzite, schist, granite and ultramafic rocks. A lot of angular to subangular gravels of local origin i.e. sandstone and slate are incorporated in the bed. On the surface, the material forms low hillocks.

Bed g: coefficient of sorting is 0.34, indicating that the

The bed is composed of fine to coarse gravels, having a maximum thickness of 3 meter. About 90% of the gravels are locally derived, olive-gray, angular to subangular slate and sandstone, with about 10% rounded gravels of foreign origin i.e. quartz and quartzite. The bed is semi-compact, and the gravels from the bed can be

easily detached with fingers. The material is also exposed on the surface. It has severely been eroded, having a number of gullies and channels. The gravels have been totally eroded from the surface in the surrounding area.

5.1.2 Laboratory Examination

5.1.2.1 Texture

Bed b:

The material in bed b, ranges in size from 0.0015 mm to 0.05 mm. It is composed of 32% clay, 34%, very fine silt, 16% fine silt and 18% medium silt. The average grain size i.e. the median of the material is 0.007 mm (Fig. 5.1.2.).

Bed c:

The material ranges in size between 0.05 mm to 1.0 mm. It contains 6% coarse silt, 12% very fine sand, 16% fine sand, 51% medium sand and 15% coarse sand. The average grain size i.e. the mean of the material is 0.29 mm(1.83 ϕ). The co-efficient of sorting is 0.54 ϕ , indicating that the sand is moderately well sorted. The skewness value determined is -0.6 ϕ , showing that it is near symmetrical sand.

Bed e:

The deposit is silty loam composed of 24.8% clay,

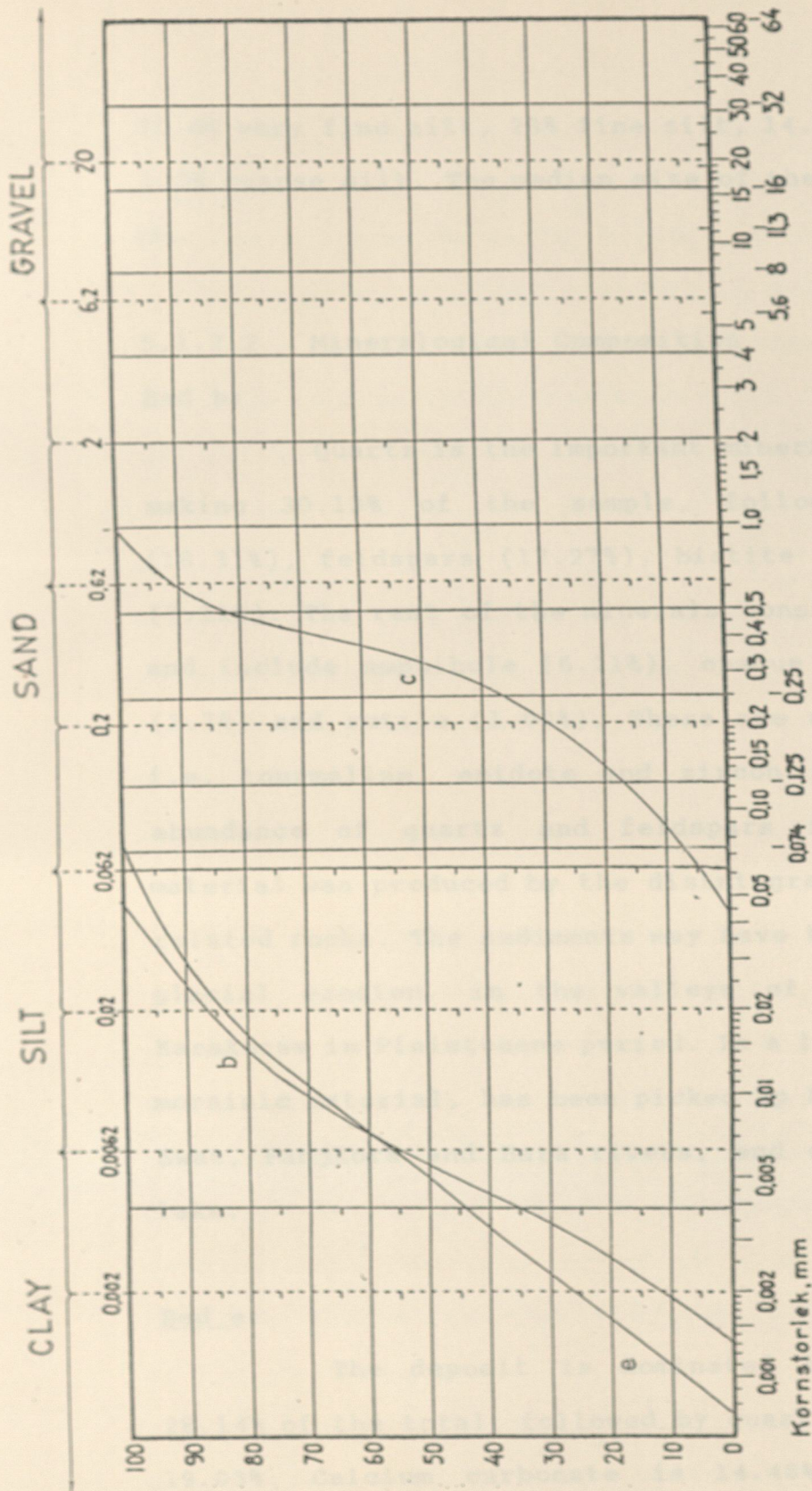


FIGURE 5.1.2

PARTICLE SIZE DISTRIBUTION

31.6% very fine silt, 28% fine silt, 14.0% medium silt and 1.6% coarse silt. The median size of the material is 0.007 mm.

5.1.2.2 Mineralogical Composition

Bed b:

Quartz is the important mineral in the material, making 30.13% of the sample, followed by carbonates (18.31%), feldspars (17.27%), biotite (12.17%) and clays (7.11%). The rest of the minerals constitute less than 7% and include amphibole (6.21%), opaque (4.01%), muscovite (3.7%) and rutile (1.00%). There are also trace elements i.e. tourmaline, epidote and zircon in the sample. The abundance of quartz and feldspars indicates that the material was produced by the disintegration of granite and related rocks. The sediments may have been produced by the glacial erosion, in the valleys of the Hindukush and Karakoram in Pleistocene period. In a later phase, the fine morainic material, has been picked up by the Kabul, Kunar, Swat, Panjkora and Bara rivers, and deposited it in the lake.

Bed e:

The deposit is dominated by feldspars, being 28.14% of the total, followed by quartz (18.27%) and clays 19.03%. Calcium carbonate is 14.48% while biotite is

10.52%. The remaining minerals, less than 5%, include amphibole (4.02%), opaque (3.13%) and rutile (1.00%). There are also traces of chlorite, zircon, epidote and tourmaline in the sample. A high content of feldspars indicates derivation directly from igneous and metamorphic rocks. As feldspars is chemically less stable and softer than quartz, and is more susceptible to chemical destruction during weathering, it is less likely than quartz to survive several episode of recycling, although it can survive more than one cycle, if weathering occurs in a moderately arid climate. Owing to this property, the presence of high percentage of feldspars in mineral composition reveals the direct derivation from source rock in an moderately arid climate.

5.1.3 Discussion

It is evident from the lithological composition of bed a, that the material has been derived from the local nearby rocks. The boulders of foreign origin in the material suggest that, these were deposited along the northern foot-slope of the Attock-cherat range at an earlier phase. The material of the foreign origin seems to have been eroded from the tectonically active ranges, north of the Peshawar vale. The mode of deposition of torrent gravels, represent an alluvial fan facies. Erosional unconformity shows that the material has suffered a phase

of degradation by torrents, due to a change in the base level, as a result of tectonics.

The regolith on the slope of the Attock - Cherat range was produced in response to intensified mechanical weathering due to the growth of vegetation, during episodes of climatic cooling and rapid tectonic uplift. The large amount of the weathered material was transported and deposited as alluvial fans in the area during a warm dry interglacial.

Fine grained, moderately-sorted sediment in bed b, suggests that the material was deposited in a lake, as the lacustrine sediments are commonly well-sorted and display a general tendency towards fining (Folk, 1974). The lake in Peshawar valley was probably formed due to the damming of the Indus below Khwara valley.

The 8 to 12 cm thick horizontal beds in the lacustrine sediments may have been produced under constant physical, chemical and biological conditions. Many beds may also have been produced very rapidly by a single event such as flood in the rivers draining into the lake. The bedding planes represent periods of nondeposition or change to a completely different depositional conditions.

The high percentage of calcium carbonate in the lacustrine sediments reflect the numerous lake organism in the lake. This is evident from the faint impression of fossils in the lake deposit. Paleocypods, gastropods,

calcareous algae and ostracods seem to be the important contributors of calcium carbonate in lacustrine sediments.

Erosional unconformity in bed b is an indication of the fact that the bed was eroded, after the lake was drained and the siltstone was exposed on the surface. The draining of lake resulted in the change of local base level and the river and torrents incised the deposit.

It is evident from fig. 5.1.1, that a deep channel-like form and a general uneven topography was formed here, in which light brown sand was deposited. The sand is predominantly medium to coarse, reflecting the fluvial nature of the material. Skewness and sorting of the sand shows low energy of depositional medium. It may have been deposited on or near the bank of the river or probably in the flood plain. Burrows and worm-holes reveals the shallowness of water, inhabited by organisms such as worms, crustaceans, insects, bivalves, gastropods, fish, amphibian and reptiles.

The gravels in bed d, reveal a phase of aggradation, when the rounded gravels, derived from the igneous and metamorphic rocks, were released in abundance and deposited as first valley fill of the Peshawar vale. The clasts are rounded, suggesting a long transport by rivers. They have been deposited in an environment where the total energy was high enough, to transport gravel-size sediment. The gravels may be considered as the lowest part

of a thick deposit, whose upper parts have been eroded during a subsequent cycle of erosion. Cold climate is suggested for the first valley fill.

Fine silt of bed e seems to have been deposited in lacustrine environment. The appearance of the lake deposit shows that lake was perhaps formed in this area, in an abandoned river channel. This was the second phase of lake formation in the valley.

Mineral composition reveals that the lacustrine sediment has been derived from the crystalline igneous and metamorphic rocks. The sediments have been transported, deposited and reworked in the lake by a number of agencies, including river and wind. The horizontal beds in the material in bed e seem to have resulted from variation in grain size. This is perhaps due to the variation in energy condition during the sediment transport, because in a particular energy condition, selective deposition of certain sizes and shapes take place. The bedding planes in the material indicates a change to completely different deposition condition or a period of non-deposition. The source of calcium carbonate in the lake sediments may be the erosion of calcareous rocks, but it may have been formed in the lake due to chemical reactions. The blue green algae and the lake - dwelling organisms such as palecypods and gastropods, may also have contributed precipitate of carbonates to the lake deposits. The folds,

joints, cracks and warping in the lake beds, and its subsequent erosion suggest that the whole area has been disturbed by tectonic movement, during a phase of Himalayan orogeny.

The igneous and metamorphic clasts in bed f, have been deposited by the Indus river, and form a part of the second phase of fan formation. The roundness reveals that the gravels have been transported for a distance of more than three hundred kilometer by the Indus river, because a gravel can become well-rounded by stream transport, in a distance ranging from 11 km for limestone to 300 km for quartz (Pettijohn, 1975). Perhaps, the source of the gravels, is in the Karakoram range, north of the Peshawar vale.

The river gravels of bed f, are also exposed on the surface, forming low hillocks. The uneven topography of the area and the marked erosional unconformity of bed f with the overlying bed g i.e. of the local torrent gravels, shows that the river gravels of bed f, has suffered a long phase of degradation. As the area is tectonically active, the river may have been pushed towards north by tectonic movement, changing the local base level. The torrents have eroded and carved broad channels in the deposit.

Lithological composition of bed g shows that the material has been derived from the regolith, released by the slopes of the Attock-Cherat range. It was perhaps

prepared due to the growth of vegetation cover in a cold humid climate and deposited as alluvial fans at the foot of the mountain range in a subsequent arid interglacial phase. The broad and deep torrent channels, show that the area has suffered a long phase of degradation by torrents, perhaps due to tectonic uplift.

5.1.4 Chronological order of the major events recorded in the section.

- a. The deposition of torrent gravels as bed a.
- b. Tectonic uplift of the area and a change of base level.
- c. The erosion of gravels in bed a.
- d. Tectonic uplift of the area due to Himalayan orogeny.
- e. The deposition of siltstone in bed b (The first phase of lake formation).
- f. Draining of lake, exposition of the siltstone on the surface and its subsequent erosion.
- g. The deposition of sand in bed c.
- h. The erosion of sand in bed c.
- i. The deposition of river gravels as bed d.
- j. The erosion of river gravels-bed d.
- k. The tectonic uplift of the area and damming of the Kabul river.
- l. The deposition of siltstone in the lake as bed e

(Second phase of lake formation).

- m. The draining of lake, exposition of siltstone on the surface and its subsequent erosion.
- n. The deposition of rounded gravels as bed f.
- o. A phase of erosion of gravels in bed f.
- p. The deposition of torrent gravels in bed g.
- q. The erosion of torrent gravels and the formation of broad torrent channels in the area.



Siltstone

Clay

Figure 5.23

5.2 SECTION 2

SECTION 2

5.2.1 Field Description

The section is exposed on the western bank of Khawari khud (ON 575541). Two to three m of siltstone and clay ball have been studied in the section (Fig. 5.2.1).

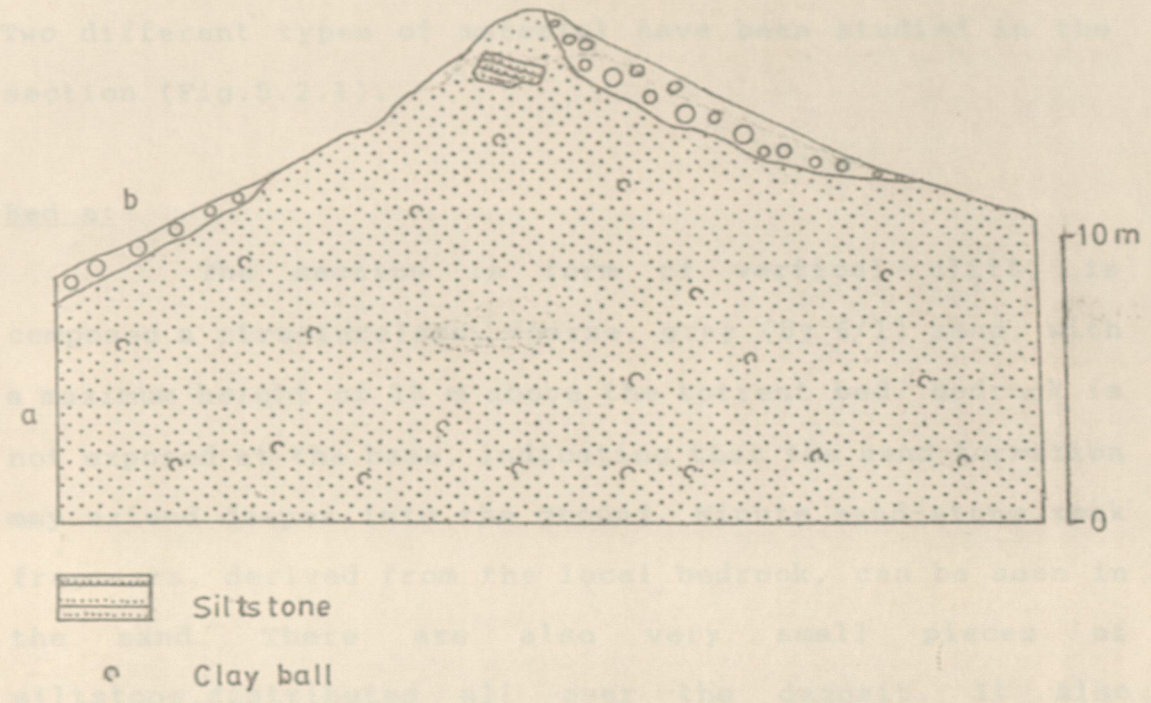


Figure 5.2.1

5.2 SECTION 2

5.2.1. Field Description

The section is exposed on the western bank of Khawari khwar (GR U215849), two km south of Shaidu village. Two different types of material have been studied in the section (Fig.5.2.1).

Bed a:

The section in form of vertical cliff, is composed a structureless, coarse, gray (5y 6/1) sand, with a maximum height of 16 m above the torrent bed. Bedrock is not exposed at the base, indicating that the sand formation may extend deeper into the ground. Minute sand-stone rock fragments, derived from the local bedrock, can be seen in the sand. There are also very small pieces of siltstone, distributed all over the deposit. It also contains numerous, smooth-surfaced, brownish, oblate to equant clay-ball of the size of gravels.

There is a huge, light-brownish gray (2.5y 6/2) boulder of siltstone (1.5 x 1 m), exposed and embedded within the sand, 8 m above its base. The sand contains 4.8% calcium carbonate. Occasional minute circular holes can be seen in the bed. The sand can be easily scratched with hammer. It has also been extensively quarried.



Plate 5.2.1 Section 2

Bed b:

The sand is overlain by a meter thick bed of rounded gravels of foreign origin. The gravels are also exposed on the surface. The gravelly material is composed of quartz, quartzite, metavolcanic, schist, amphibolite, sandstone and argillite rocks. The gravels, exposed on the surface are loose and incoherent, but where exposed in the sections, they are embedded in a matrix of gray sandstone, forming conglomerate.

5.2.2 Laboratory Examination5.2.2.1 Grain Size DistributionBed a:

The cumulative frequency graph (fig. 5.2.2) shows that the sand in bed a ranges in size from 0.074 mm to 2.00 mm. It is composed of 7% very fine, 22% fine, 48% medium, 22% coarse and 1% very coarse sand. The mean, median and mode of the sand are 0.35 mm (1.42 ϕ), 0.42 mm (1.25 ϕ) and 0.42 mm (1.25 ϕ) respectively. The standard deviation of the sand is 0.825 ϕ , showing that it is moderately sorted. The skewness value, determined is - 0.33 ϕ , an indication of the fact that the material is strongly coarse skewed.

Sorting and skewness of the sand shows that it has been reworked by eolian processes, before its final deposition.

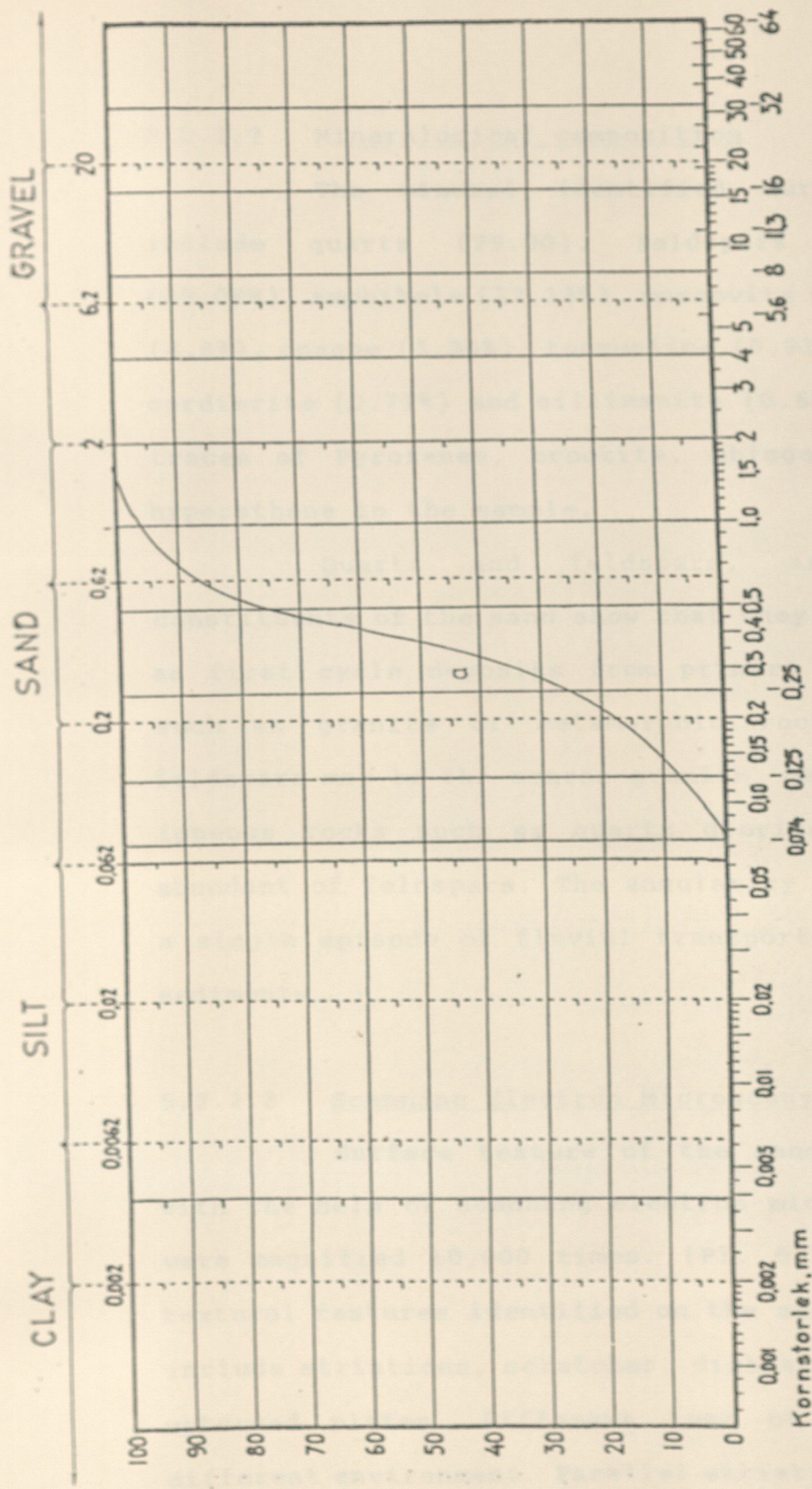


FIGURE 5.2.2

PARTICLE SIZE DISTRIBUTION

5.2.2.2 Mineralogical composition

The mineral identified during the analysis include quartz (29.90), feldspars (21.74), biotite (19.08%), amphibole (12.13%), muscovite (4.18%), carbonates (4.8%), opaque (3.30%), tourmaline (0.93), zircon, (0.80%), cordierite (0.71%) and sillimanite (0.68%). There are also traces of Pyroxenes, brookite, phlogopite, monazite and hypersthene in the sample.

Quartz and feldspars, as the dominating constituents of the sand show that they may have originated as first cycle deposits from primary crystalline rocks, such as granite or metamorphic rocks. The source of feldspars may be the coarse granite, metasomatic rocks and igneous rocks such as quartz diorites as they contain abundant of feldspars. The angularity of the grains, show a single episode of fluvial transport of the first cycle sediments. .

5.2.2.3 Scanning Electron Microscopy

Surface texture of the sand grain was studied with the help of scanning electron microscope. The grains were magnified 10,000 times. (Pl. 5.2.2 and 5.2.3). The textural features identified on the surfaces of the grains include striations, scratches, dish-shaped concavities and upturned plates. Different type of markings show two different environment. Parallel striations, is the evidence

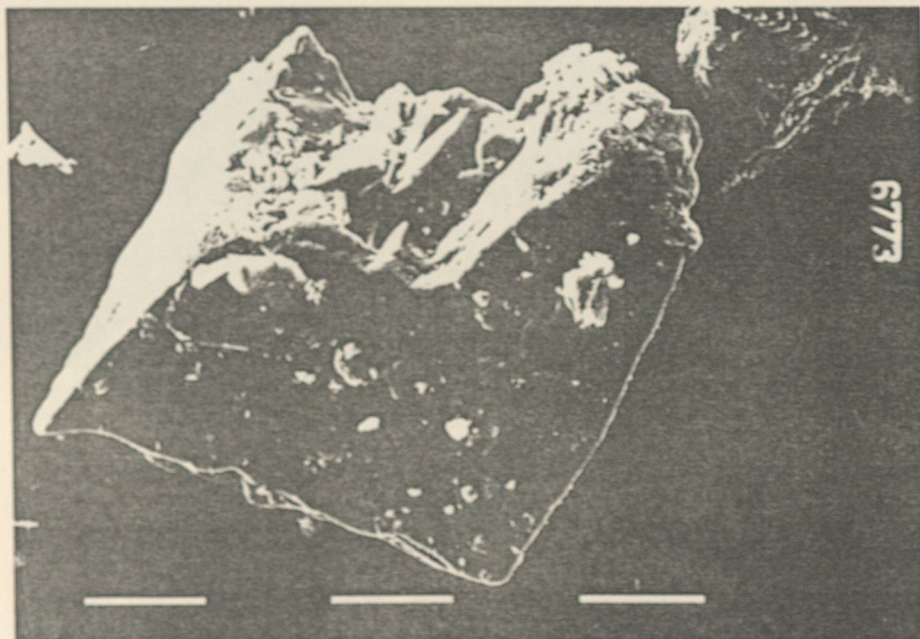


Plate 5.2.2a

A sand grain from bed a, magnified 156 times. Most of the sand grains, studied by scanning electron microscopy, were found to be angular.

of the fact that the sand was involved in glacial abrasion.

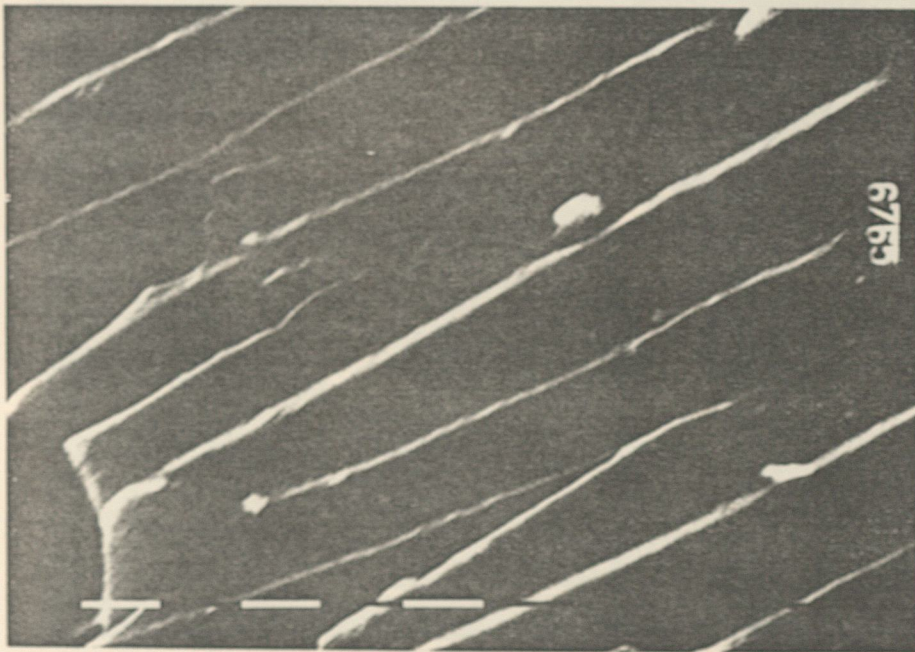


Plate 5.2.2b

Scanning electron micrograph of quartz grain in plate 5.2.2a, magnified 10,000 times. There are parallel striations on the surface, an indication of the fact that the sand was involved in glacial abrasion.

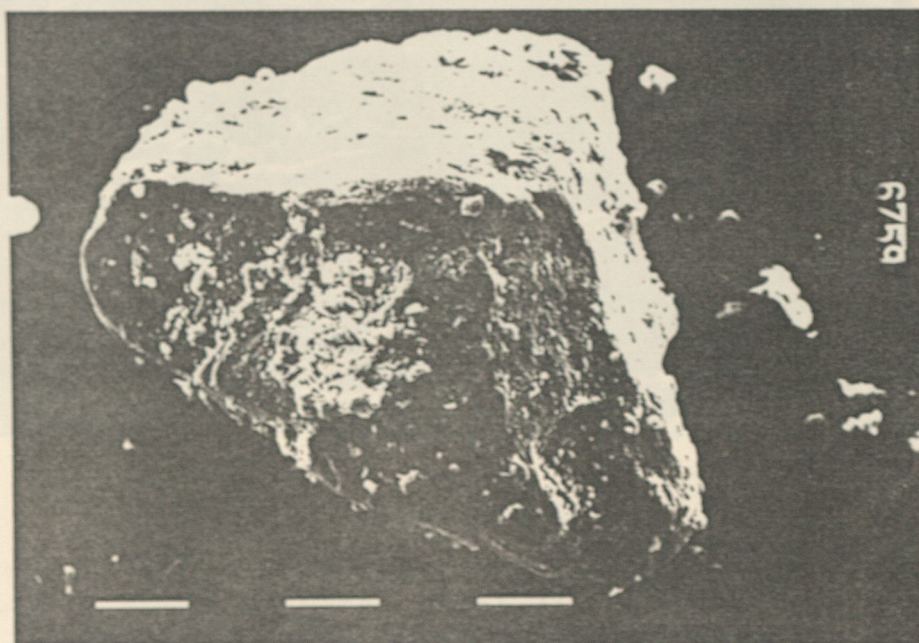


Plate 5.2.3a

Micrograph of a subangular sand grain
from bed a, magnified 1200 times.

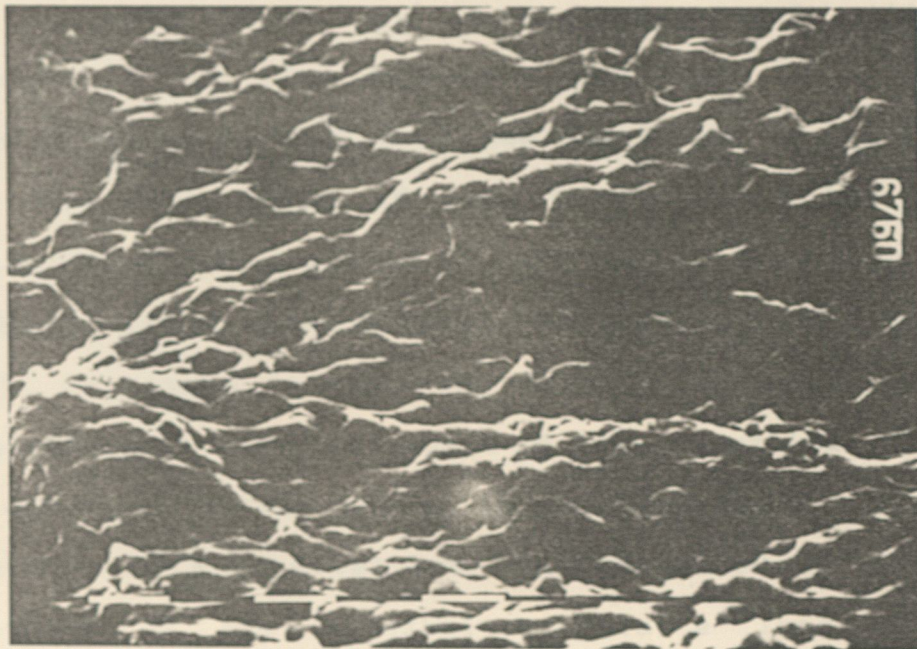


Plate 5.2.3b

The sand grain of plate 5.2.3a, magnified 10400 times, shows upturned plate like surface texture, an evidence of the eolian processes on the sand grain.

of glacial action, while upturned plates are typical of eolian action and dune sand.

5.2.3 Discussion

Huge block and minute pieces of siltstone, embedded in the sand deposit, shows that in an earlier phase of sedimentation silt was deposited in still water i.e. the first phase of lake formation in the valley. Subsequent to the drainage of lake bulk of the material was eroded by river, over a large part of the area. Siltstone block, entrapped in the sand deposit in bed a, is the remanent of this earlier phase of lake formation. The block and minute siltstone pieces in the sand deposit also show that the whole material has been deposited by river. The thickness of the material reveals a long phase of deposition.

The sand is moderately sorted. It is an indication of the fact, that it has been reworked by eolian processes, before its final deposition. Sorting reflects the persistence of depositional processes. The best sorted sediment occurs in the environments such as beaches and dunes. The negative strong skewness value of sand further supports the reworking of sand by eolian processes. The numerous gravel-size fragments of brown clay, in the sand deposit, may be the fossilised remains of the organisms present in the river, at the time of deposition.

Mineral analysis and surface texture suggests that the sand has been derived from the morainic material produced during the Pleistocene period, in the valleys of Hindukush, where Kabul river and its tributaries originate. It also suggests that a considerable part of the sand may have been derived from the nearby sand of the Indus river and the Potwar plateau, by eolian processes. The uneven topography of the area suggests that the sand has been eroded for a long period by the Kabul river and the local torrents. The erosion may have been initiated as a result of the tectonic uplift and a change in the local base level. The erosion resulted in the carving of broad deep channels and the complete removal of sand from a considerable area.

The gravelly material in bed b, forms part of the second phase of fan formation by the Indus river. They have been transported over a long distance from the valleys of the Karakoram, and were deposited over a large part of the area. The widespread distribution of the river gravels on the surface also suggest that the river changed its course several times during the Pleistocene period.

The local torrent gravels, incorporated in the river gravels, indicate that the torrent from the south were encroaching onto the river. The alluvial fans were being formed in the area, between the mountain range and the river. A large number of torrent gravels were mixed

with the river gravels, during this process. The gravelly material of bed b, represents the lower portion of a thick valley fill, as the upper portion has been eroded in a later phase of erosion.

The sand and river gravels in bed a and b may be contemporaneous with the Potwar Boulder Conglomerate, that is a complex valley fill, containing substantial conglomerate elements. It is fluvial and the oldest possible date of the deposition is 1.9 m.y (Rendell, 1980).

5.2.4 Summary of the important events recorded in the section.

- a. Deposition of the siltstone.
- b. Erosion of the siltstone
- c. Deposition of sand by the ancient Kabul river.
- d. Tectonic uplift of the area
- e. Erosion of the sand.
- f. Deposition of the river gravels
- g. Erosion of the river gravels.

SECTION 3

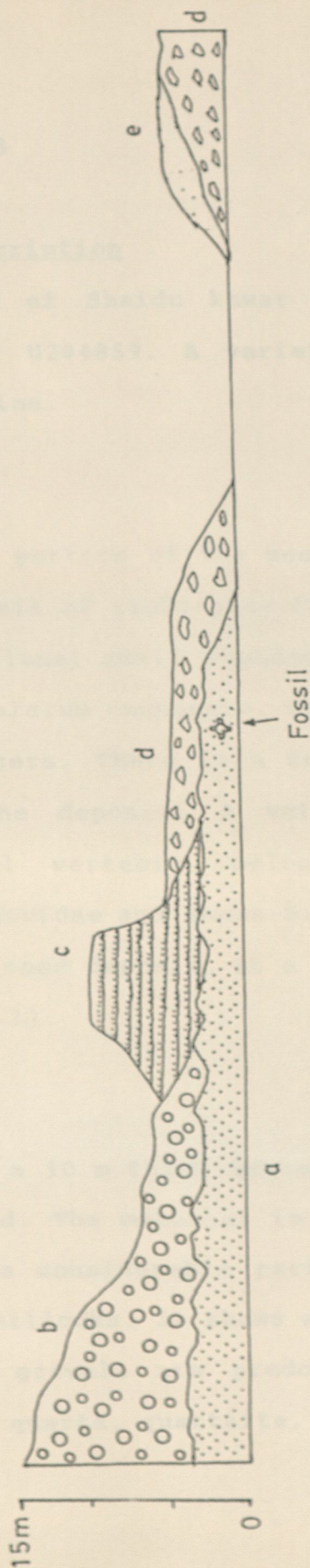


Figure 5.3.1

5.3 SECTION 3

5.3.1 Field Description

A section of Shaidu khwar has been shown in figure 5.3.1 on GR U204859. A variety of material are exposed in the section.

Bed a:

The basal portion of the section is composed of 4 m thick sand deposit of light-gray (2.5Y 7/2) colour. It also contains occasional small rounded-gravels of foreign origin. It has 4% calcium carbonate. The sand can be easily scratched with fingers. There is a conspicuous erosional unconformity in the deposit. A well-preserved, almost fossilised cervical vertebra, belonging to the order Mammalia, family, Bovidae and genes Bos (Buffalo) has been recovered from the sand deposit, at a height of 2 m, above its base, (Pl. 5.3.1).

Bed b:

There is a 10 m thick deposit of river gravels, resting on the sand. The material is also exposed on the surface, covering a considerable part of the surrounding area, forming low hillocks. It shows a prominent erosional unconformity. The gravels are predominantly of foreign origin, comprising quartz, quartzite, amphibolite, schist,



Plate 5.3.1

Cervical vertebra of Bos

diorite, gneiss, cherty limestone, granite, micaschist, and green schist. The deposit has also gravels, derived from the local sandstone formation. A few boulders of local and foreign origin are also found in the deposit. Roundness reveals that the clasts have been worked and reworked by fluvial processes for a very long time. The material exposed on the surface is loose and incoherent. In section, however, it can often be seen in form of conglomerate. The uneven topography of the area reveals that the gravelly material has suffered a long phase of degradation.

Bed c:

The bed is composed of a 10 m thick, light-gray (2.5y 7/2), calcareous siltstone, containing 18% calcium carbonate. It consists of horizontal bands, 5 to 15 cm in thickness. The siltstone is in the form of an isolated hillock, perhaps the result of a long phase of erosion. A thin layer of loose river-gravels, covers most of the deposit.

Bed d:

It is 4 m thick bed, consisting of locally derived slate gravels. A considerable number of rounded gravels of foreign origin is also incorporated in the bed. The bulk of the local material is angular to subangular and poorly sorted. However, occasional layer can be distinguished in

the deposit. There can also be seen a few boulders in the material, derived from local rock formation. The deposit is also exposed on the surface and forms a terrace, about 40 m wide as can be seen in figure 5.3.1. It has been eroded severely by torrents.

Bed e:

The bed is composed of an isolated patch of pale-brown (IOYR 6/3), loessic silt. The material lacks stratification and structure. It rests on sand and gravels, forming a terrace that rises 3 m above the torrent bed. The loessic silt is poorly sorted and strongly coarse-skewed.

5.3.2 Laboratory Examination

5.3.2.1 Texture

Bed a:

Size distribution analysis shows that sand in bed a ranges in size from 0.072 mm to 1.0 mm. The material is composed of 16% very fine sand, 24% fine sand, 45% medium sand and the remaining 15% is coarse sand (Fig.5.3.3). The mean and median i.e. the average grain sizes of the sand are 1.92 ϕ and 1.75 ϕ respectively. The sorting co-efficient is 0.95 ϕ , showing that it is moderately sorted. The skewness index of the material is -0.20 ϕ , revealing that the material is coarse skewed.

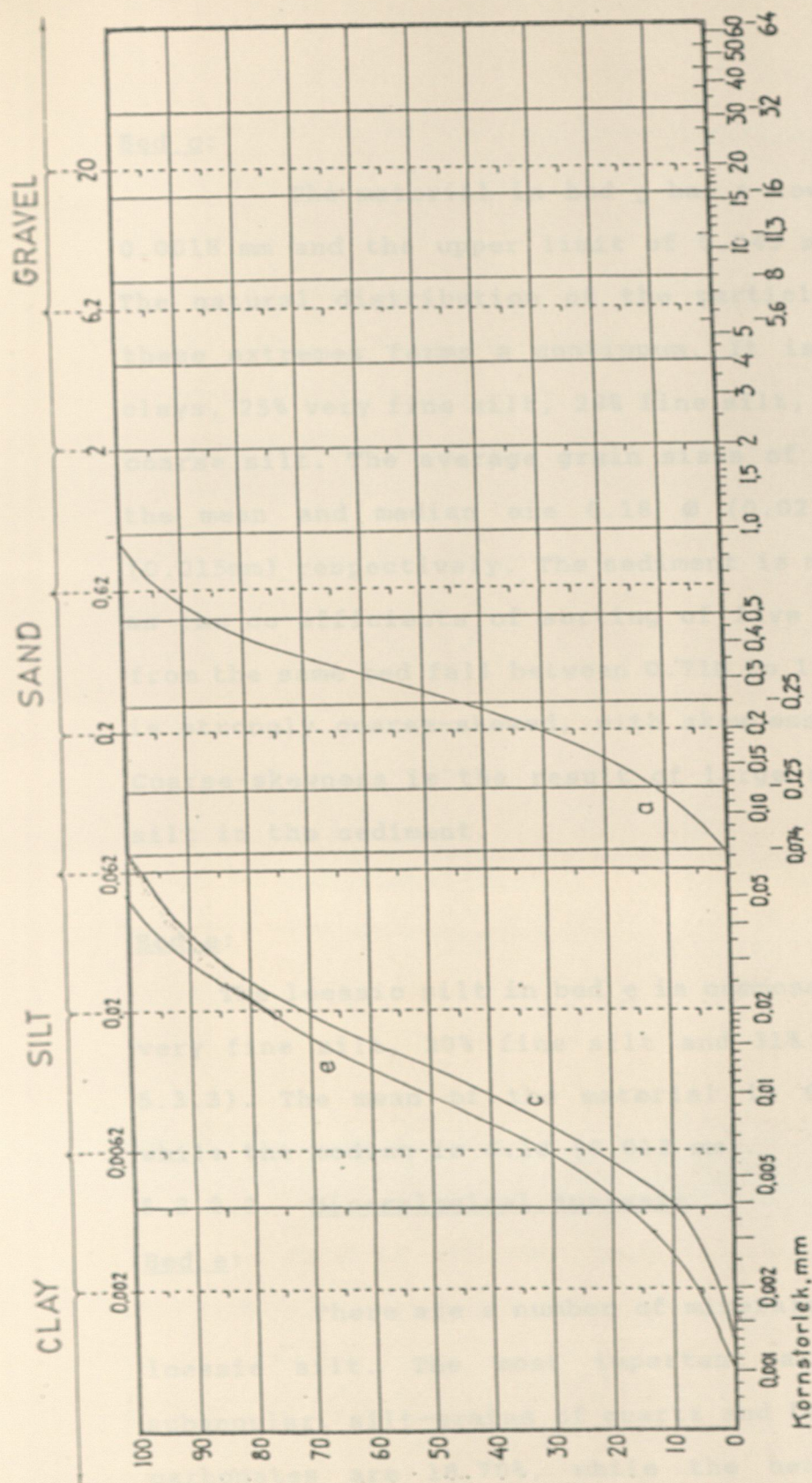


FIGURE 5.3.2

PARTICLE SIZE DISTRIBUTION

Bed c:

The material in bed c has a lower size limit of 0.0018 mm and the upper limit of 0.045 mm (Fig. 5.3.3). The natural distribution of the particles sizes between these extremes forms a continuum. It is composed of 10% clays, 25% very fine silt, 28% fine silt, 31% medium and 6% coarse silt. The average grain sizes of the material i.e. the mean and median are 6.18 ϕ (0.021 mm) and 6.0 ϕ (0.015mm) respectively. The sediment is moderately sorted, as the co-efficients of sorting of five different samples from the same bed fall between 0.71 ϕ to 1.00 ϕ . The material is strongly coarse-skewed, with skewness index of 0.007 ϕ . Coarse-skewness is the result of large amount of clay and silt in the sediment.

Bed e:

The loessic silt in bed e is composed of 13% clay, 26% very fine silt, 30% fine silt and 31% medium silt (Fig. 5.3.3). The mean of the material is 6.23 ϕ (0.0156 mm), while the median is 6.1 ϕ (0.013 mm).

5.3.2.2. Mineralogical AnalysisBed e:

There are a number of minerals identified in the loessic silt. The most important are the angular to subangular, silt-grains of quartz and feldspars. The total carbonates are 18.70%, while the heavy mineral suite,

principally tourmaline, epidote, hornblende and biotite is 11% of the total. The details of the mineral composition of the loessic silt is as follows: quartz, 32.48%; feldspars, 20.07%; carbonates, 18.70%; clay minerals, 10.12%; biotite, 8.01%; mica, 4.00%; muscovite, 2.21%; tourmaline, 1.50%; epidote, 1.00%; hornblende, 0.50%; chlorite, 0.06%. There are also traces of illite and zircon in the sample.

5.3.2.3 Scanning Electron Microscopy

Bed e:

The surface form and texture of silt grains are dominated by planar fracture surfaces, with angular often sharp edges and corners.

5.3.2.4 Shape Analysis

Bed b: (River Gravels)

Analysis reveals that 68% of the clasts are equant, 18% prolate and the remaining 14% oblate.

Bed d: (Torrent Gravels)

ROUNDNESS ANALYSIS

Hundred gravels were collected randomly for analysis. It was found that 74% of the gravels, mostly slate, from the local Attock-Cherat range, were bladed, 21% equant and 5% prolate.

FIGURE 9.3.4

Bed d

0 1 2 3 4 5 6 7 8 9

SHAPE ANALYSIS

43

5.3.3.3

Bed b:

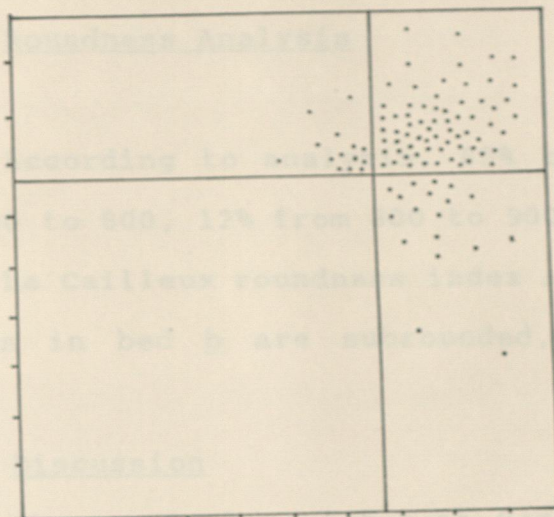


FIGURE 5.3.3

Bed b

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deposit. It seems that the sand

has been deposited by the river.

that would have been deposited by the river.

it is not totally fluvial. It has been suggested

by some workers that it is a fluvial deposit.

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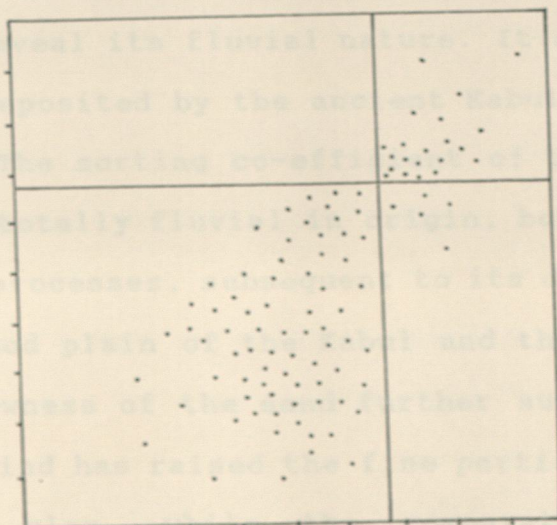
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Bed d

ROUNDNESS ANALYSIS

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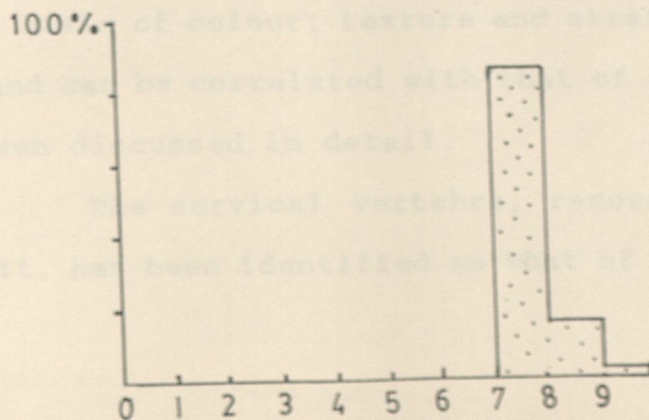


FIGURE 5.3.4

Bed b

5.3.2.5 Roundness Analysis

Bed b:

According to analysis, 85% of the gravels fall between 700 to 800, 12% from 800 to 900 and 3% from 900 to 1000, on the Cailleux roundness index scale. It shows that the clasts in bed b are subrounded, rounded and well-rounded.

5.3.3 Discussion

The cervical vertebra of *Bos*, recovered from the sand in bed a, and the occasional river gravel, in the sand deposit, reveal its fluvial nature. It seems that the sand has been deposited by the ancient Kabul river.

The sorting co-efficient of the sand shows that it is not totally fluvial in origin, but has been reworked by eolian processes, subsequent to its deposition by river, in the flood plain of the Kabul and the Indus rivers. The coarse skewness of the sand further support the assertion that the wind has raised the fine particles in the range of silt and clay, while the comparatively coarse sand particles were left. A cold and arid environment is suggested at the time of deposition of sand in the valley. On the basis of colour, texture and stratigraphic position, the sand can be correlated with that of section 2, where it has been discussed in detail.

The cervical vertebra, recovered from the sand deposit, has been identified as that of *Bos* (Buffalo), that

is a typical Villafranchian fauna. On the quality of Preservation, extent of mineralisation and lack of organic matter, the fossilised vertebra could belong to middle Pleistocene period.

Bos is also known from two different zones of the Potwar region, in close proximity to Peshawar vale (De Terra et al. 1939). Pinjore zone of the Lower Pleistocene, correlated with first interglacial of Kashmir, has a typical Villafranchian assemblage including such type as *Elephas hysudricus* (elephant), *Equus sivalensis* (Horse), *Bos planifrons* and *Rhinoceros palaeindicus*. The Boulder Conglomerate Zone of Middle Pleistocene, correlated with the second glacial phase has Narbada fauna including *Elephas namadicus* (Elephant), *Equus namadicus* (Horse), *Bos namadicus* (Buffalo), *Hippopotamus* and *Camelus* (Camel). The specimen from bed a, perhaps belongs to *Bos namadicus*. It seems that the Villafranchian and Narbada fauna roam all over the northwest Pakistan, including Peshawar valley, in the Pleistocene period. Some of the species like rhinoceros and elephant, though not found today, were common a few hundred years back. It is on record that Mughal emperors, Baber and Jahangir, hunted rhinoceros in the vicinity of Ali Musjid (Khyber pass) and Nowshera, in 1525 and 1607 respectively. Elephants were used only a hundred years back for a variety of purposes.

The British Archaeological Mission to Pakistan,

working since 1980 in the Potwar region has also collected the fossilised remains of cattle, elephant, rhinos, horse, pig, hippopotamus, giraffe, lion, jackal, tiger, bear and crocodile. It seems that large carnivores (meat-eating animals), herbivores (grass-eater) and omnivores (meat as well as plant eater) may have also been a common sight in Peshawar valley in the Pleistocene period due to its proximity to the Potwar region. Most of the animals that lived in the area during the Pleistocene period, preferred open-grasslands and there is hardly any indication of the type of animals that thrive in thick forest. All evidence suggest that Peshawar valley as well as Potwar region, probably had a moist savanna climate with open grasslands, in certain phases of the Pleistocene period.

Lithology of the gravels in bed b reveals that they have been derived from different rock formations, north of the Peshawar valley. Roundness of the clasts show that the material has been transported over a long distance, before it was finally deposited. Thickness of the deposit and its widespread distribution also suggests a river system, characterised by more than one channels, separated by sand bars.

The local torrent gravels entrapped in the foreign material suggests a simultaneous process of fan-formation. The fan-gravels, encroaching onto the river channel were picked up by the river and incorporated in the

river gravels. The irregular relief shows a long phase of erosion of gravels by torrents, perhaps as result of the uplift of the area and a change of local base-level.

On the basis of grain-size analysis and stratigraphic position, siltstone of bed c can be correlated with the lake deposit of bed e, in section no. I.

The slate and sandstone clasts, which constitute the bulk of the deposit in bed d, has been derived from the nearby Attock-Cherat range, and deposited as alluvial fan fascies, at the foot of the range.

Majority of the workers on alluvial fans appear to be of the opinion that fans are characteristics of arid or semi-arid climates. The largest alluvial fans are formed at the foot-hills of the mountains in the drier regions of the world (Rachocki, 1981). Alluvial fans were considered as secondary features of the desert landscape by Davis (1905), Bryan (1922), and Johnson (1932). Blissenbach (1954) believes that semi-arid or moderately dry climates are most favourable. He suggests that intensive weathering together with periodic rainfall, is conducive to the production and transportation of large amount of material by ephemeral streams. These streams then tend to deposit their load as alluvial fans, whereas perennial streams in colder climates remove material far from mountain front. Langbein and Schumm (1958) consider an average precipitation of 25 - 40 cm as optimum for fan

development. Such conditions simultaneously reduce plant cover to a minimum and ensure adequate supply of water for the transportation of debris.

In the light of the above discussion, the alluvial fans, seem to have been developed in arid and semi-arid type of environmental condition, which prevailed in Peshawar valley, during the interglacial phases of the Pleistocene period. A thick cover of debris was already prepared on the slopes of the Attock-Cherat range, perhaps in response to the growth of vegetation on the range and rapid tectonic uplift, during a cold and moist glacial phase. The poor sorting of the fan-gravels, is an indication that the gravels were deposited by swollen and turbulent torrents, obviously the result of torrential rainfall. The river gravels incorporated in bed d, have been picked up from the material deposited in an earlier phase of deposition.

The material in bed e possesses all characteristics of loessic silt. According to a more recent definition of loess, strictly within a sedimentological framework (Pettijhon, 1975) "loess is an unconsolidated porous silt, commonly buff in colour, characterised by its lack of stratification and remarkable ability to stand in vertical slope. It commonly shows a crude columnar structure. It is generally highly calcareous and effervesces in weak acids. Loess is essentially a silt". It

is further characterised by the narrow size range in the coarse silt region, and its large scale deposits are among the most spectacular features of eolian nature. The material in bed e fulfils all the requirements described and it can be concluded that the sediment was deposited by eolian processes.

A number of sources for the loessic material, have been described by sedimentologists. Smalley(1966) proposed that glacial grinding provided loessic material for the bulk of world loessic deposits. The assertion was repeated by Smalley and Vita-Finzi (1968) and supported by Boulton (1978), who proposed - "I would support them in this and go further to suggest that, most of this is produced in the basal zone of the traction, which I believe to be uniquely glacial environment, in which large forces at non-inertial shear contacts produce fine-grained wear products".

Nahon and Trompette (1982) suggested that chemical weathering, particularly in tropical areas, is an active agent of silt formations. Zeuner (1949) has favoured insolation, weathering and frost action, to be the major causes of silt. The original observations by Zeuner (1949) have been supported by Brockies (1973) investigations in New Zealand, and it appears that the weathering processes of the cold climates are the main agents for producing loessic material.

The cold mountain regions are the suppliers of the loess to deserts. Smalley and Krinsley (1978) reviewed the desert loess problem with some emphasis on Central Asian regions and concluded that cold weathering processes could explain the formation of world major loessic deposits.

The loessic silt in bed e seems to have been produced in the Hindukush and Karakoram mountain regions by frost weathering processes during the Quaternary cold phases. In the first stage, the material was deposited in form of moraines. Bulk of the fine silt particles may have been raised by wind and carried away in suspension, but the major activity was probably fluvial, involving the transportation of finer sediments by the Indus, Kabul, Swat and their tributaries. Subsequently, the material was deposited in the form of the Indus and Kabul floodplains. In a later stage, the material in silt and clay region, was deflated from the floodplains by eolian processes, in a cold dry periglacial environment and redeposited as loess. In the post depositional changes, calcium carbonate and clay minerals, stabilised the loess structure and produced the classic loess composition in the valley. A more detailed account of the loess has been given in section nos.13 and 14.

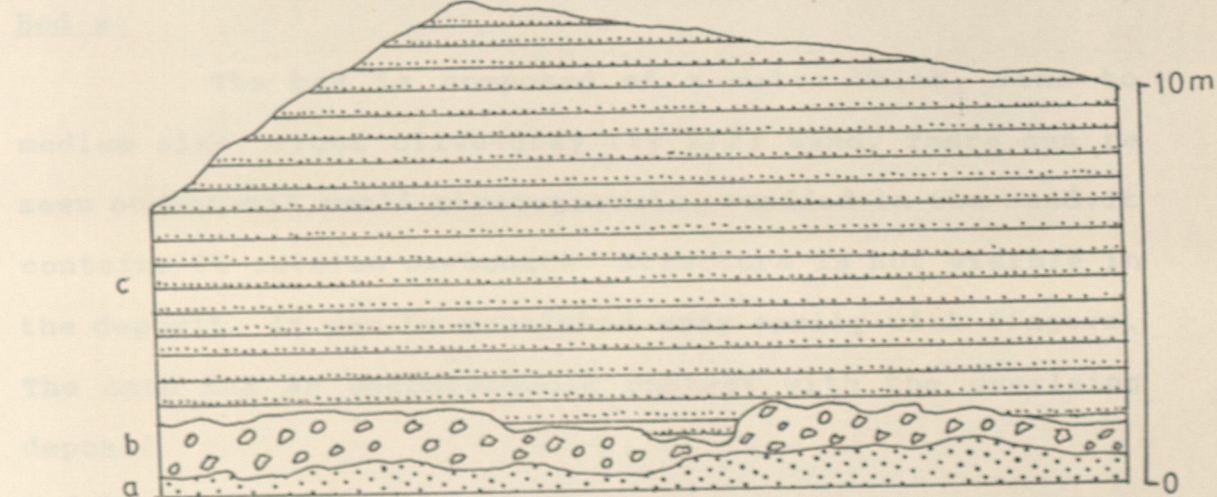
5.3.4 Chronological order of major events recorded in the section.

- a. The deposition of sand by river and its subsequent erosion.
- b. Open grasslands in Peshawar valley with Villafranchian and Narbad fauna.
- c. The deposition of river gravels.
- d. Slow tectonic uplift of the area and a change in the local base level.
- e. Erosion of the river gravel bed and the development of irregular topography.
- f. The formation of lake in the Peshawar valley and the deposition of silt in lacustrine environment.
- g. Growth of vegetation and preparation of deep regolith on the Attock - Cherat range.
- h. Draining of lake and the exposition of siltstone.
- i. Erosion of the siltstone by river and torrents.
- j. Decay of vegetation on the Attock - Cherat range due to a change of climate from moist glacial to warm - dry interglacial.
- k. Release of regolith from the Attock - Cherat range and its deposition in the valley, forming alluvial fans.
- l. Deposition of loess in cold-dry periglacial environment.
- m. The cutting of deep torrent channels in the deposits already mentioned.

5.4 SECTION 4

5.4.1 Field Description

The section is exposed along the western bank of Inari Lake, 100 m north of the Hyatt-1-Khuakha Dam. It is one of the few sections where sand is overlain by the torrent gravels. Thick lake deposits of the same stage of lake formation can also be seen in the section (Fig. 5.4.1).



The bed, 3.5 m thick, is composed of torrent gravels. They are predominantly greenish slate, dark-gray sandstone and some quartz, quartzite and amphibolite, embedded in the matrix of sand. The deposit is too hard to be scratched with fingernail, but it can easily be broken with hammer.

Figure 5.4.1

5.4 SECTION 4

5.4.1 Field Description

The section is exposed along the eastern bank of Isori khwar, (GR U174845), a kilometer north of the Myazar-i-Khushhal Khan. It is one of those few sections, where sand is overlain by the torrent gravels. Thick lake deposit of the second phase of lake formation can also be seen in the section (Fig. 5.4.1).

Bed a:

The bed is composed of a metre thick, fine to medium size, light olive-gray (5y 6/2) sand. There can be seen occasional small river-gravels, embedded in the sand. It contains 8% calcium carbonate. Structure is not visible in the deposit. It can be scratched very easily with fingers. The sand has an unconformable contact with the overlying deposit.

Bed b:

The bed, 1.5 m thick, is composed of torrent gravels. They are predominantly greenish slate, dark-gray sandstone and rounded gravels of quartz, quartzite and amphibolite, embedded in the matrix of sand. The deposit is too hard to be scratched with fingers, but it can easily be broken with hammer.



Plate 5.4.1

Section 4

Bed c:

This is a thick deposit of light-gray (2.5y 7/2), calcareous clayey siltstone, with a maximum thickness of 10 metres. It has an unconformable contact with the underlying bed b. It contains 30% calcium carbonate. The bed shows 10 to 15 cm thick horizontal layers. The material is hard and has suffered a long phase of erosion, as evident from the irregular surface topography.

5.4.2 Laboratory Examination5.4.2.1 TextureBed a: (Sand)

The sand is composed of 2% silt, 58% fine sand, 36% medium sand, and 4% coarse sand (Fig. 5.4.2). The measures of central tendency i.e. the mean and median are 2.17 ϕ (0.22 mm) and 2.25 ϕ (0.21 mm) respectively. The coefficient of sorting is 0.61 ϕ , showing that the sand is moderately sorted. The sand is coarse skewed, as the index of skewness is -0.15 ϕ .

Bed c: (Siltstone)

Siltstone in bed c is composed of 20% clay, 20% very fine silt, 30% fine silt, 25% medium and 5% coarse silt. The mean and median of the material are 5.00 (0.031 mm) respectively. The co-efficient of sorting is 2.25 ϕ ,

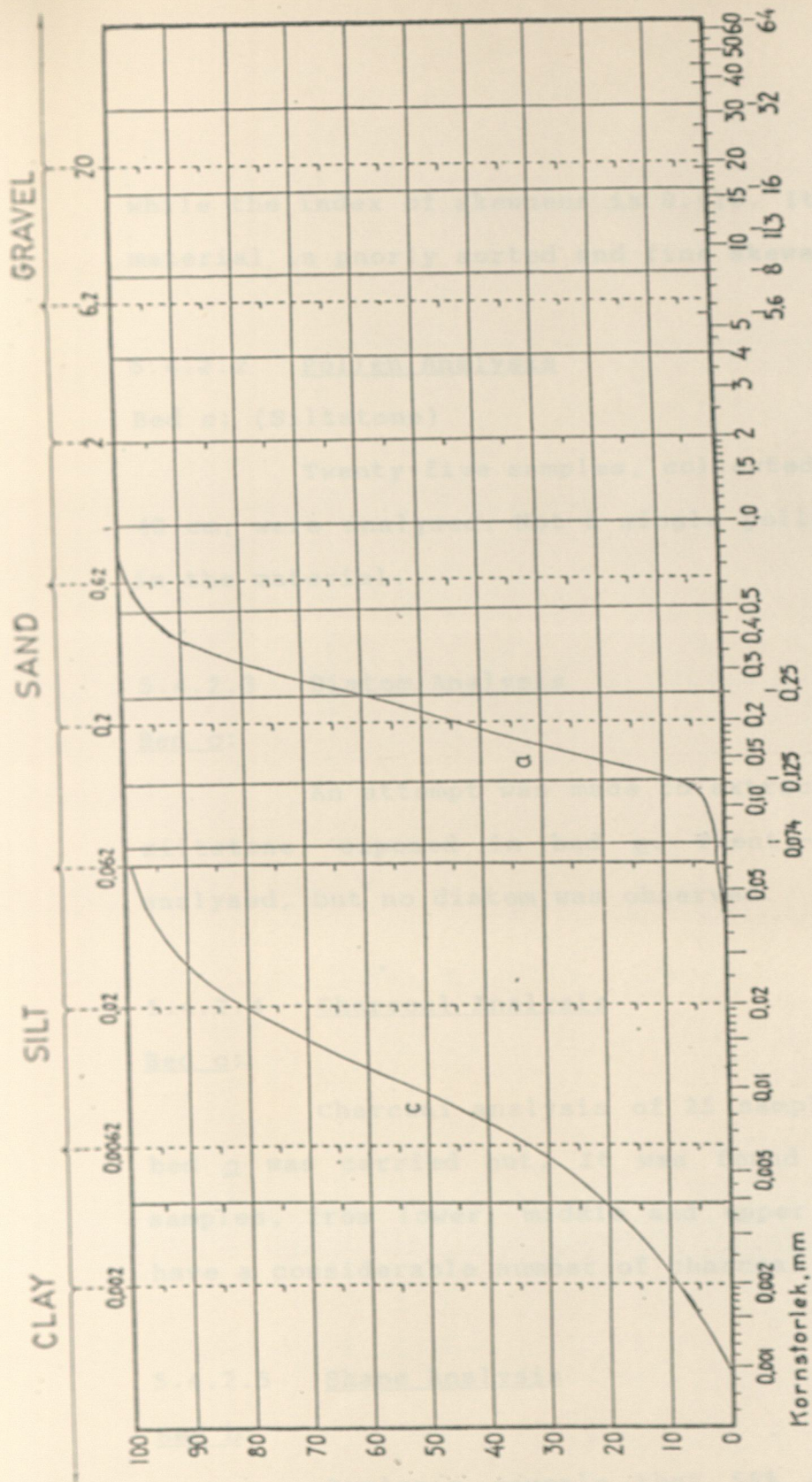


FIGURE 5.4.2

PARTICLE SIZE DISTRIBUTION

while the index of skewness is 0.610. It reveals that the material is poorly sorted and fine skewed.

5.4.2.2 Pollen Analysis

Bed c: (Siltstone)

Twenty-five samples, collected at an interval of 40 cm, were analysed. Not a single pollen grain was found in the material.

5.4.2.3 Diatom Analysis

Bed c:

An attempt was made to extract diatoms from the siltstone, exposed in bed c. Twenty-five samples were analysed, but no diatom was observed.

5.4.2.4 Charcoal Analysis

Bed c:

Charcoal analysis of 25 samples, collected from bed c was carried out. It was found that eight of the samples, from lower, middle and upper parts of the bed, have a considerable number of charcoal particles.

5.4.2.5 Shape Analysis

Bed b:

Analysis reveals that 58% of the gravels are bladed and 21% oblate. These are predominantly local

SHAPE ANALYSIS

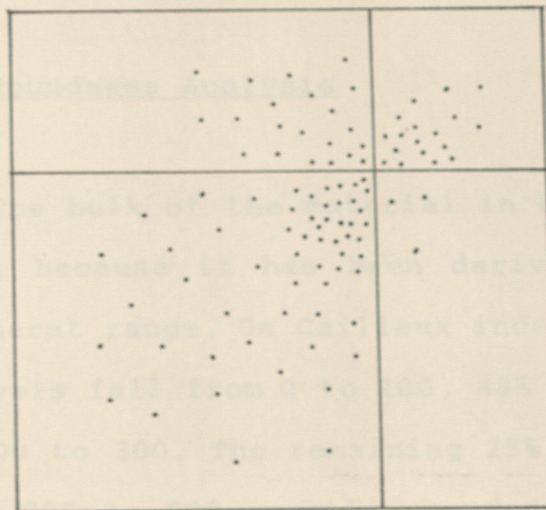


FIGURE 5.4.3
Bed b

ROUNDNESS ANALYSIS

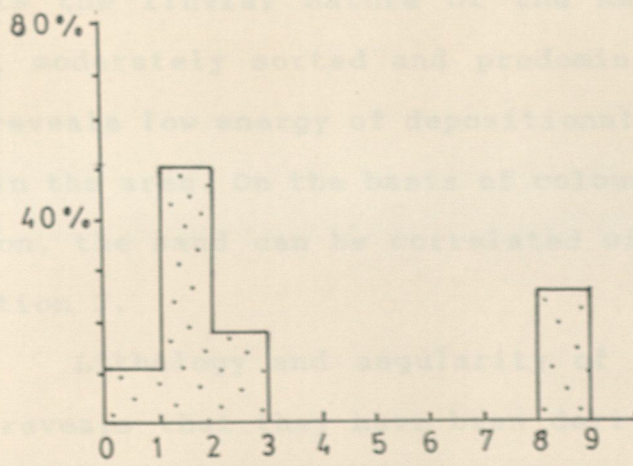


FIGURE 5.4.4
Bed b

torrent gravels. The remaining 18% are equant and 3% prolate. These are mostly gravels of foreign origin (Fig. 5.4.3.).

5.4.2.6 Roundness Analysis

Bed b:

The bulk of the material in bed b is angular to subangular, because it has been derived from the nearby Attock - Cherat range. On Cailleux index of roundness, 11% of the gravels fall from 0 to 100, 48% from 100 to 200 and 16% from 200 to 300. The remaining 25% of the clasts fall in between 800 to 900, mostly rounded gravels of foreign origin (Fig. 5.4.4.).

5.4.3 Discussion

The grain size distribution of sand in bed a reflects the fluvial nature of the material. Negatively skewed, moderately sorted and predominantly fine sand of bed a reveals low energy of depositional medium i.e. a slow river in the area. On the basis of colour and stratigraphic position, the sand can be correlated with the sand of bed a, section 2.

Lithology and angularity of torrent gravels in bed b reveals that they have been derived from the nearby Attock - Cherat range and deposited as alluvial fans in front of the mountain range. The same gravel bed is exposed

on the surface, forming hillocks, about 30 m high, above the torrent bed. It also contains a number of huge boulders of local origin. The size of the fragments, particularly boulders, suggests that the material has been deposited by turbulent torrents, during torrential rains, as they emerged from the mountains. The phenomenon of torrential rainfalls, swift and turbulent khwars, during the monsoon can also be observed in the present day climatic condition. It seems that the valley has also experienced monsoon during certain phases of the Pleistocene period.

The fan-material has suffered a long phase of degradation, during the subsequent phases. The fan gravels were totally washed away from over a large area, whereas, in certain localities, they were reduced to only a metre or half in thickness. This is perhaps due to the tectonic uplift, as the area is tectonically active. It appears as if the erosion of torrent gravels, was followed by the deposition of river gravels. In a later phase, the river gravels were eroded and removed from over a large area, and the underlying fan-gravels re-exposed, as is evident from the rounded gravels, incorporated in the upper parts of bed b.

Size analysis reveals that the material in bed c is mainly composed of fine to medium silt. The material seems to have been deposited in still water. The poor sorting reveals that the sediments may have been disturbed

by bioturbation or turbidity currents after deposition. Size analysis, colour and stratigraphic position show that the deposit can be correlated with the siltstone of the second phase of lake formation, discussed in detail in Section no I.

The lack of pollen grains and diatoms in the siltstone indicate that they may have been destroyed by biochemical oxidation related to localised fungal and bacterial activity during the hot and dry phases of the Pleistocene period, in which these micro-fossils could not be preserved for a very long time.

The large number of charcoal particles in the deposit has been produced by the burning of any carbonaceous material (wood, coal) in the Pleistocene period, when silt was in process of sedimentation. At many sites in the world, both historic and prehistoric man, are the potential causes of the fire. The charred particles in bed c may be the evidence of presence of prehistoric man in Peshawar valley. Fire places, charcoal particles and Palaeolithic tools, collected during the excavation of the sangao cave in the northern part of Peshawar valley further support the existence of prehistoric man in the valley.

Natural fires, which require lightning and the presence of vegetation, may also be the potential cause of the charcoal particles in the deposit. Even today, Peshawar valley is famous for the occurrence of thunderstorms in

summer season. It is possible that both man and natural fires, may be the causes of charcoal particles in the siltstone deposit.

5.4.4 Summary of the major events recorded in the section.

- a. The deposition of sand by river in bed a.
- b. The erosion of sand.
- c. Deposition of the fan-gravels and a phase of fan formation.
- d. Tectonic uplift of the area.
- e. The erosion and removal of fan gravels.
- f. The deposition of river gravels.
- g. The erosion of river gravels.
- h. The deposition of silt in still water.
- i. The exposition of silt after the draining of lake.
- j. The erosion of siltstone.

SECTION 5

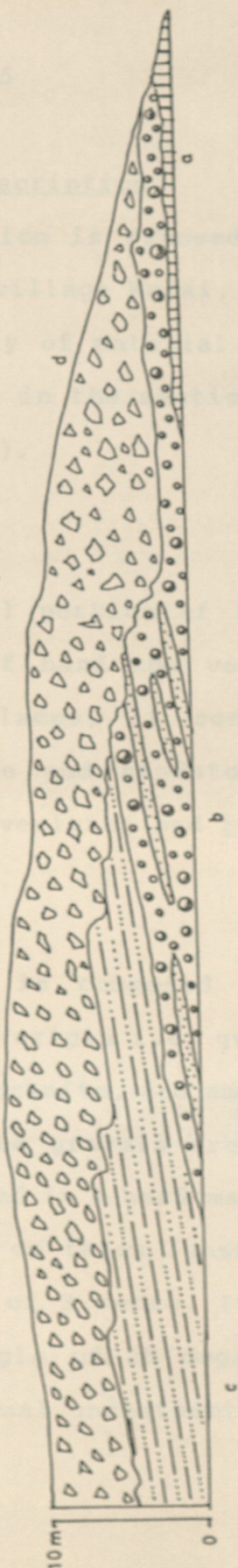


Figure 5.5.1

5.5 SECTION 5

5.5.1 Field Description

The section is exposed along the right bank of Walai khwar, near village Walai, opposite to Rangmahal (GR U102843). A variety of material has been examined in the exposure. The beds in the section are disturbed by active faults (Fig. 5.5.1).

Bed a:

The basal portion of the section displays half metre thick bed of hard and very pale brown (IOYR 7/4) silty clay. In places, it contains very fine angular fragments of slate and sandstone. It has unconformable contact with the overlying bed b.

Bed b:

The bed is composed of subrounded to rounded gravels of foreign origin i.e. quartz, quartzite, diorite, dolerite, gabbro, granite, and amphibolite. Locally derived sandstone and slate gravels are also mixed with it. The gravels are embedded in a hard matrix of sand. The bed also contains 30 to 45 cm thick lenses of sandstone. It has a maximum thickness of 3 metre. It is also dipping towards north, with an angle of 25 degrees, and displays a very conspicuous erosional unconformity.

Bed c:

The bed is composed of hard and compact deposit of siltstone, with a maximum thickness of about 10 m. It has a light-gray (2.5y 7/2) colour. The bed has thin layers, 15 to 20 cm in thickness, and is tilted towards north with an angle of 25 degrees. The bed has a conspicuous erosional unconformity.

Bed d:

The bed is composed of 5 m thick deposit of locally derived sandstone gravels, with occasional rounded gravels of foreign origin. The gravels are loose, incoherent and can be easily detached from the bed. It has also been eroded severely.

5.5.2 Laboratory Examination5.5.2.1 TextureBed a

The deposit ranges in size from 0.0015 mm to 0.05 mm. It is composed of 20% clay, 20% very fine silt, 25% fine silt, 28% medium silt and 7% coarse silt. The mean and median i.e. the average grain size of the material, are 4.8 ϕ (.037 mm) and 6.0 ϕ (0.056 mm) respectively (Fig. 5.5.2).

Bed c: (Siltstone)

The material has a lower size limit of 0.0015 mm

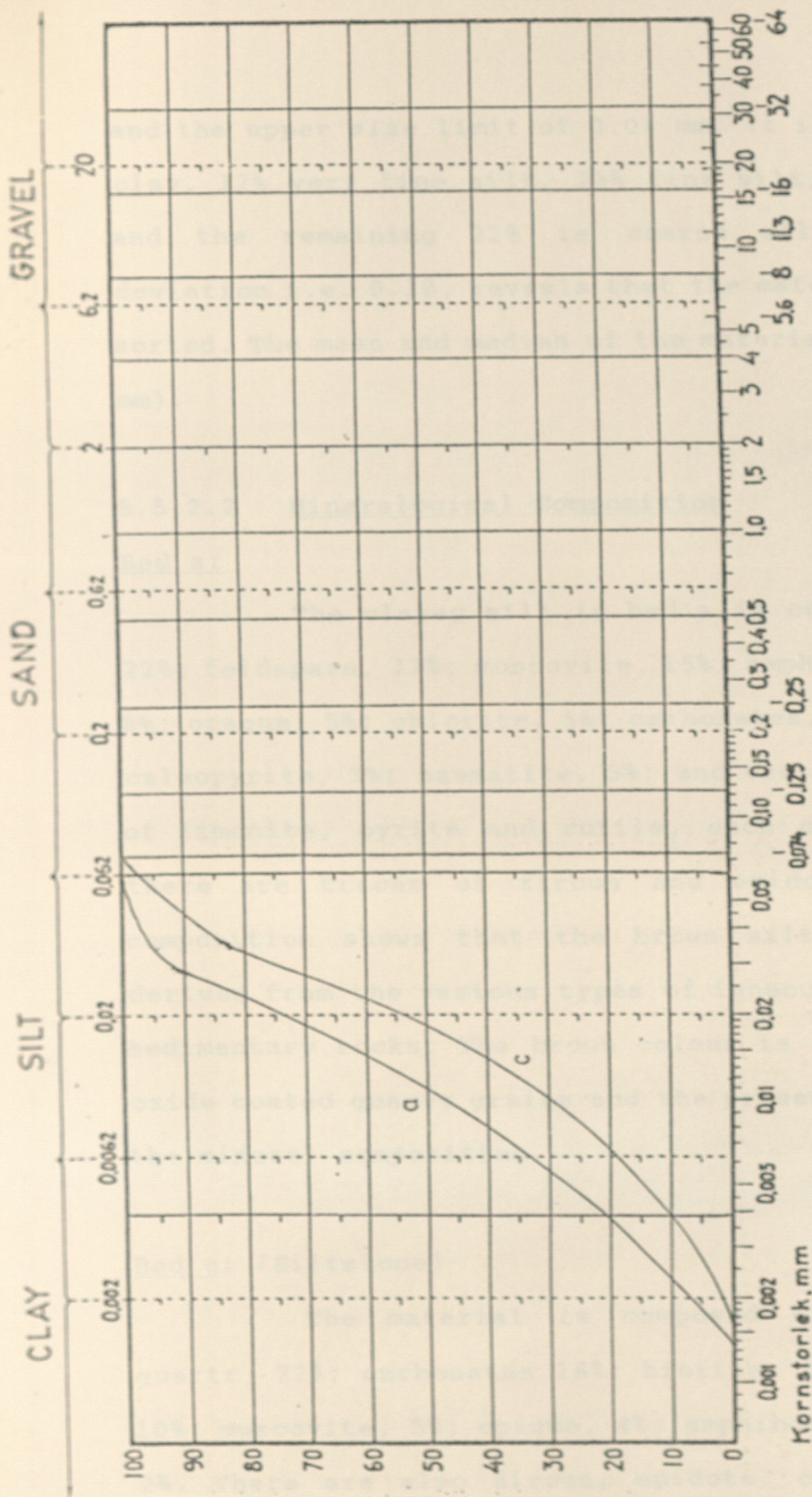


FIGURE 5.5.2

PARTICLE SIZE DISTRIBUTION

and the upper size limit of 0.04 mm. It is composed of 10% clay, 12% very fine silt, 25% fine silt, 31% medium silt and the remaining 22% is coarse silt. The standard deviation i.e. 0.10, reveals that the material is very well sorted. The mean and median of the material are 6.00(0.0156 mm).

5.5.2.2 Mineralogical Composition

Bed a:

The clayey silt in bed a is composed of quartz, 22%; feldspars, 17%; muscovite, 15%; amphibole, 10%; clays, 8%; opaque, 5%; chlorite, 5%; carbonates, 4%; biotite, 4%; calcopyrite, 3%; haematite, 3%; and the accessory minerals of limonite, pyrite and rutile, each one percent, while there are traces of zircon and epidote. Mineralogical composition shows that the brown silt has been mainly derived from the various types of igneous, metamorphic and sedimentary rocks. The brown colour is due mainly to iron oxide coated quartz grains and the presence of haematite in the mineral composition.

Bed c: (Siltstone)

The material is composed of feldspars, 25%; quartz, 22%; carbonates 16%; biotite, 13%; clay minerals, 10%; muscovite, 5%; opaque, 4%; amphibole, 2%; and rutile, 2%. There are also zircon, epidote, chlorite, limonite,

olivine and brookite in the siltstone. It shows that the material has been derived from the disintegration of massive plutonic granitoid rocks, in the mountainous region, north of the Peshawar vale.

5.5.3 discussion

Colour, texture and mineralogical composition suggest that the brown silty facies at the base may be the older loess, redeposited in an alluvial environment. Thick deposits of pink and brown silt have also been studied in several other localities in Peshawar valley and Potwar region. The petrologic analysis of pink silt from Soan region as worked out by Krynine shows the material to be of loessic origin. The details about the brown silt of the Peshawar valley has been given in section no 12.

The sequence of interbedded river gravels and sand in bed b, seems to be alluvial in origin. It appears that a braided channel, has produced thick deposit of river gravels and sand, over a considerable part of the study area. Repeated bar formation and channel branching in Peshawar valley generated a network of braided channels over the entire depositional area. Thus the alluvium of braided river is typically composed of sand and gravels.

Poor sorting of sand and gravels further support the assertion that the sediments in bed b is fluvial in nature. The clasts in bed b are also composed of highly

resistant rocks, suggesting a long distance of transport, and deposition under high energy conditions, that destroyed less resistant clasts. Lithology, roundness and medium of deposition suggest the source of the material to be the morainic sediments in the Hindukush mountains in Afghanistan, Swat, Chitral and Tirah.

The unconformable contact of bed b with the overlying siltstone deposits indicate a phase of degradation. It seems that the sediments in bed b were subjected to erosion by the same river, after a change in base level, due to the tectonic uplift of the area.

Fine-grained laminated sediments show that the material in bed c is an aqueous deposit. Basically, lacustrine sediments can easily be identified by the low energy aqueous deposits, but still the distinction between lacustrine and fluvial sediments may be difficult. However, the absence of cross-beddings and desiccation cracks and parallel layers in the facies suggest that the formation originated in a lacustrine environment and deposition took place below wave base in still water.

The mineralogy of sediments in bed c reveal that the material has been derived from the disintegration of massive plutonic granitoid rocks, in the Hindukush and Karakoram. However, the proximate source of the material is the morainic sediments, lying in the valleys, surrounding the Peshawar vale. The sediments have been transported by

fluvial and eolian processes and deposited in the lacustrine environment of the vale.

The carbonates may also have been derived by the dissolution of older limestone rocks over which Kabul, Swat and Bara rivers flowed on its way to the lake. Ooliths, skeletal particles of fresh water organisms and algal structures may have also contributed carbonates to the sediments.

Lithology, roundness and poor sorting of the torrent gravels in bed d suggest that the material has been derived from the Attock - Cherat range, and deposited as an alluvial fan. The material on the Attock - Cherat range was prepared, perhaps due to the growth of vegetation in a moist, cold pluvial environment. In subsequent phases, due to a change of climate to warm dry interpluvial, the vegetation cover decayed. As a consequence the material was released and deposited as alluvial fans. Fan-gravels may also have been eroded from the Attock - Cherat range, due to an episode of rapid tectonic uplift, of the mountains, as the area is tectonically active.

The beds in the section are dipping towards north, because the Palaeozoic Manki salte, forming the block of bedrock, has been disturbed by recently active faults. Thrusting to the south, appears to have elevated the block above the adjacent terrain. The fault bounding the southern margin of the block at Manki, has been traced

to east-northeast past Walai, where Pleistocene alluvial fans are offset as much as 40 m, by differential uplift of the northern block (Burbank, 1982, 1983). The tectonic uplift by recent active faults, has been recoded in the section, in form of the disturbed beds, dipping towards north. According to Yeats and Hussain (1987), the present tectonic setting is in existence for the past 0.6 m.y. in the Peshawar basin. It reveals that the torrent gravels in bed d, that are not disturbed, the rest of the material has been deposited prior to 0.6 m.y. i.e. during mid-to-late Pleistocene.

The uplift of the Pleistocene deposits in and around Walai, seems to have a profound impact on the drainage pattern of the area. The uplift, cut the torrent channels and blocked the torrents flowing from south towards north. It resulted in the diversion of drainage system from north to east-northeast. Consequently, the older material, deposited prior to the tectonic uplift, was removed over a considerable area between Isori khwar in the east and Hawii khwar in the west.

The phase of erosion was followed by a period of aggradation and the formation of alluvial fan i.e. the Hawii fan with northeast - southwest orientation. The drainage pattern developed on the fan surface has also the same orientation, a direct consequence of the tectonic uplift of the area.

The drainage system developed on the uplifted fan-gravel extended by headward erosion towards south and ultimately cut the entire uplifted patch at two different points. As a result, the two important torrents of the area i.e. Walai and Watter khwar, changed their courses from northeast to north and started to flow through the incised channels, in the tectonically disturbed material.

5.5.4 Summary of the important events recorded in the section

- a. The deposition of older loess, of bed a.
- b. The erosion of older loess.
- c. The deposition of river gravels with interbedded sand lenses.
- d. Degradation of river gravels.
- e. Deposition of the siltstone in lacustrine environment.
- f. The disturbance of the material by tectonic uplift.
- g. The deposition of torrent gravels, forming alluvial fans.
- h. The change of courses of torrents.
- i. The erosion of the disturbed material.
- j. The re-orientation of Walai and Watter khwars.

Figure 3.61

SECTION 6

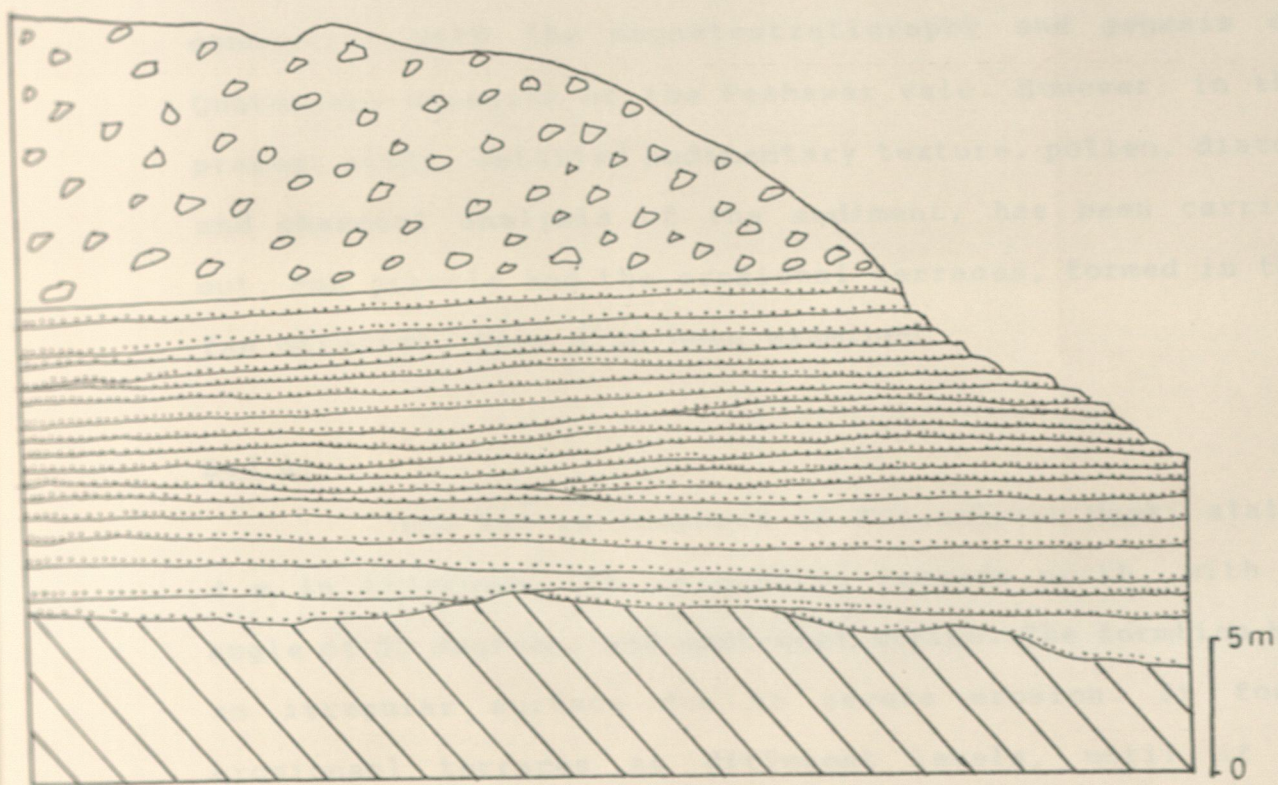


Figure 5.6.1

5.6 SECTION 6

5.6.1 Field Description

The section is exposed along Piran nala (GR U075848), near Bait-ul-Gharib (Fig. 5.6.1). It is located at a point, where Piran nala debouches from the Manki hills, onto the plains of Peshawar vale. It can serve as a type locality for the study of siltstone, because it is here that the siltstone and the overlying fan gravels are exposed with its maximum thickness. The section has also been studied by Burbank (1983) and Inam (1990), in connection with the magnetostratigraphy and genesis of Quaternary deposits of the Peshawar vale. However, in the present study, detailed sedimentary texture, pollen, diatom and charcoal analysis of the sediment, has been carried out. Fan gravels and the erosional terraces, formed in the fan material, have also been examined.

Bed a:

The bed is composed of Precambrian Manki slate, 4 m in thickness. It is dipping towards north, with an angle of 50 degrees, and east-west strike. The formation has an irregular surface due to severe erosion. It forms erosional terraces at different levels, until it is exposed on the surface as Manki hills, immediately south of the section under discussion.

Bed 2

A thick deposit of light-colored siltstone is exposed in the
to 11500 feet (2.57-7/37). siltstone is exposed in the
section, where, it is in direct contact with the underlying



bedrock
deposited
siltstone
varies in
and horizon
The upper
conspicuous
length ran
m. The be
10 to 20
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bedrock
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varies in
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The upper
conspicuous
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Plate 5.6.1

Thick deposit of siltstone i.e. lacustrine sediment,
is exposed in Piran nala.

Bed 2

The bed is composed of 20 m thick deposit of
locally derived sandstone and shale fragments. dark-gray is
color. The shale are predominantly coarse, angular to
sub-angular gravels, with considerable number of boulders

Bed b:

A 15 m thick deposit of light olive-gray (5Y 6/2) to light-gray (2.5Y 7/2), siltstone is exposed in the section, where, it is in direct contact with the underlying bedrock. The bed comprises 38, almost horizontal sedimentation units. Each one of the unit can be clearly distinguished from that of th above and below. It also varies in thickness from 20 cm to 60 cm. Abundant rootlets and burrows can be seen in the upper parts of each unit. The upper sequence of the bed has a wave-like form, with conspicuous small-scale anticlines and synclines. The wave length ranges from 3 to 5 m, and an amplitude of about 40 cm. The bed has been crossed by vertical and oblique dykes, 10 to 20 cm in thickness. The bed has also been eroded severely and deep canyons have been carved in it. The material as worked out by Burbank (1983) is normally magnetised and has been interpreted as belonging to Brunhes chron. The Brunhes Normal Epoch has the age boundary between 0.69 m.y to 0.02 m.y. revealing that the material in bed b is less than 0.69 m.y.old.

Bed c:

The bed is composed of 20 m thick deposit of locally derived sandstone and slate fragments, dark-gray in colour. The clasts are predominantly coarse, angular to sub-angular gravels, with considerable number of boulders

and occasional rounded gravels of foreign origin. The material is unsorted, but in places, horizontal layers can be seen in the deposit. They are imbricated towards south, and also have a north-south orientation. The bed is sloping towards north and due to erosion, gullies have developed on its surface. A prominent erosional terrace has been formed in the gravelly material, about 300 m downstream of the section. The bed has an unconformable contact with the underlying bed a, and a direct contact with the bedrock i.e. the slope of the Manki hills, as shown in the figure 5.6.1.

5.6.2 Laboratory Examination

5.6.2.1 Texture

The size of the sediment-grains vary in each sedimentation unit of bed b. The individual units or sedimentation cycle show gradation from coarser particles at the base to finer particles at the top i.e. normal grading. None of the cycle displays a reverse grading. For the purpose of grain size analysis, two sedimentation units, one in the basal and the other at the top sequence of bed b were selected. Three samples from each of the two units were collected, in the lower, middle and upper part of the cycle.

Bed b: (Basal Sedimentation Unit)

The unit is composed of 25% very fine sand, 28% fine sand and 47% medium sand in the base; 20% coarse silt and 80% very fine to fine sand in the middle; 6% clay and 94% silt in the upper part. The grains are getting finer in the sequence from bottom to top. The average grain size i.e. the mean of the lower, middle and upper parts are 0.21 mm, 0.10 mm and 0.031 mm respectively, revealing normal graded beddings. The average grain sizes also indicate that the deposition may have taken place from suspension, settling in a lacustrine environment (Fig. 5.6.2.).

Bed b: (Upper Sedimentation Unit)

The basal part of the unit is composed of 15% silt, 65% fine sand and 20% medium sand. The middle part is 50% fine sand and 50% silt, while the upper part of the unit has 78% silt and 22% clay. It is evident from the analysis that the basal part is predominantly fine to medium sand, while the upper part is mainly silt. There is a gradual variation in the grain size from medium sand to silt and clay. The mean i.e. the average grain size of the lower part of the unit is 0.14 mm; middle part, 0.053 mm; and the upper part, 0.0078 mm. The normal grading shows that the unit has also been produced under the same physical, chemical and biological conditions as the previous sedimentation unit (Fig. 5.6.3).

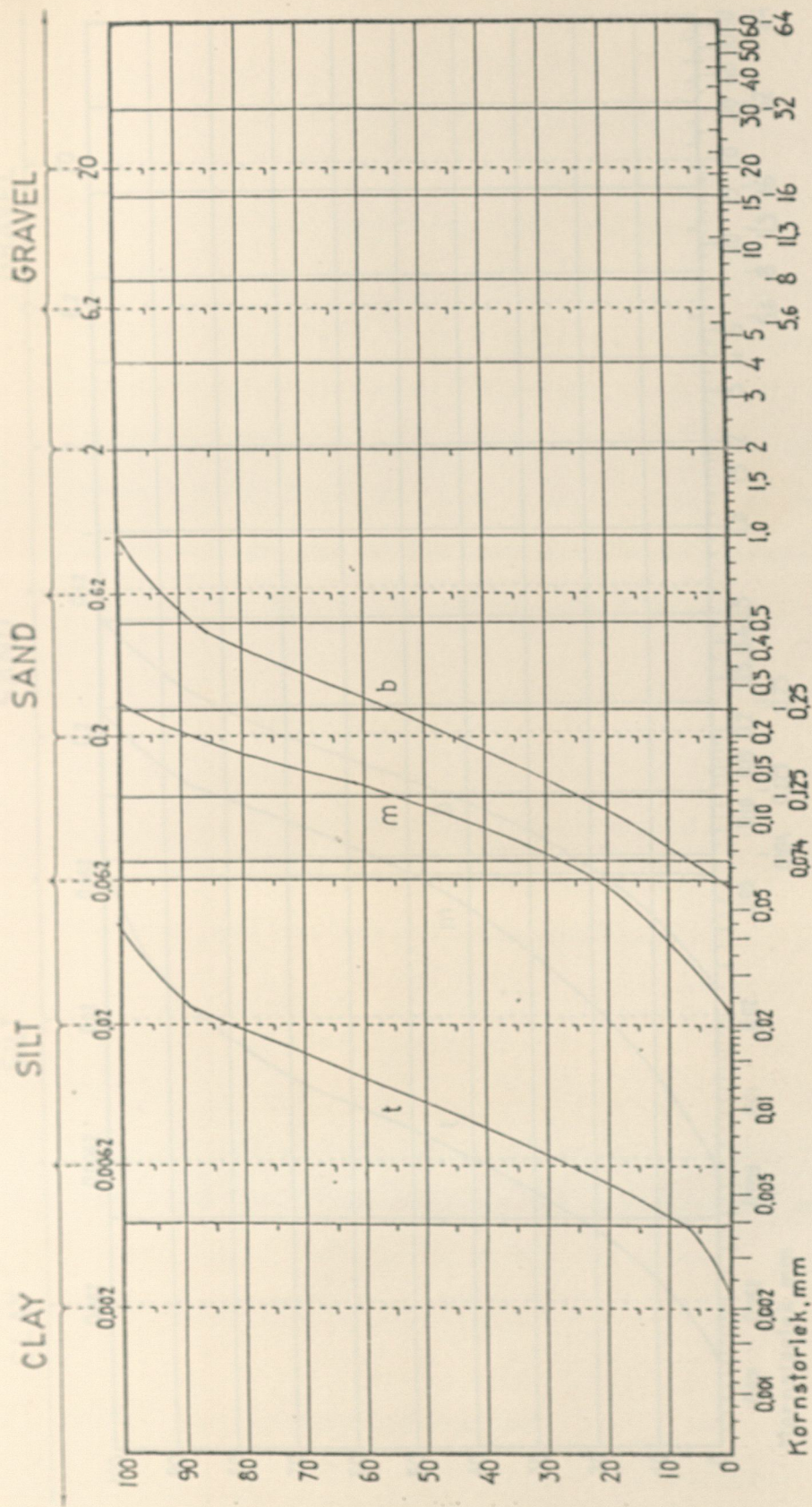


FIGURE 5.6.2

Basal sedimentation unit

t - top

m - middle

b - base

PARTICLE SIZE DISTRIBUTION

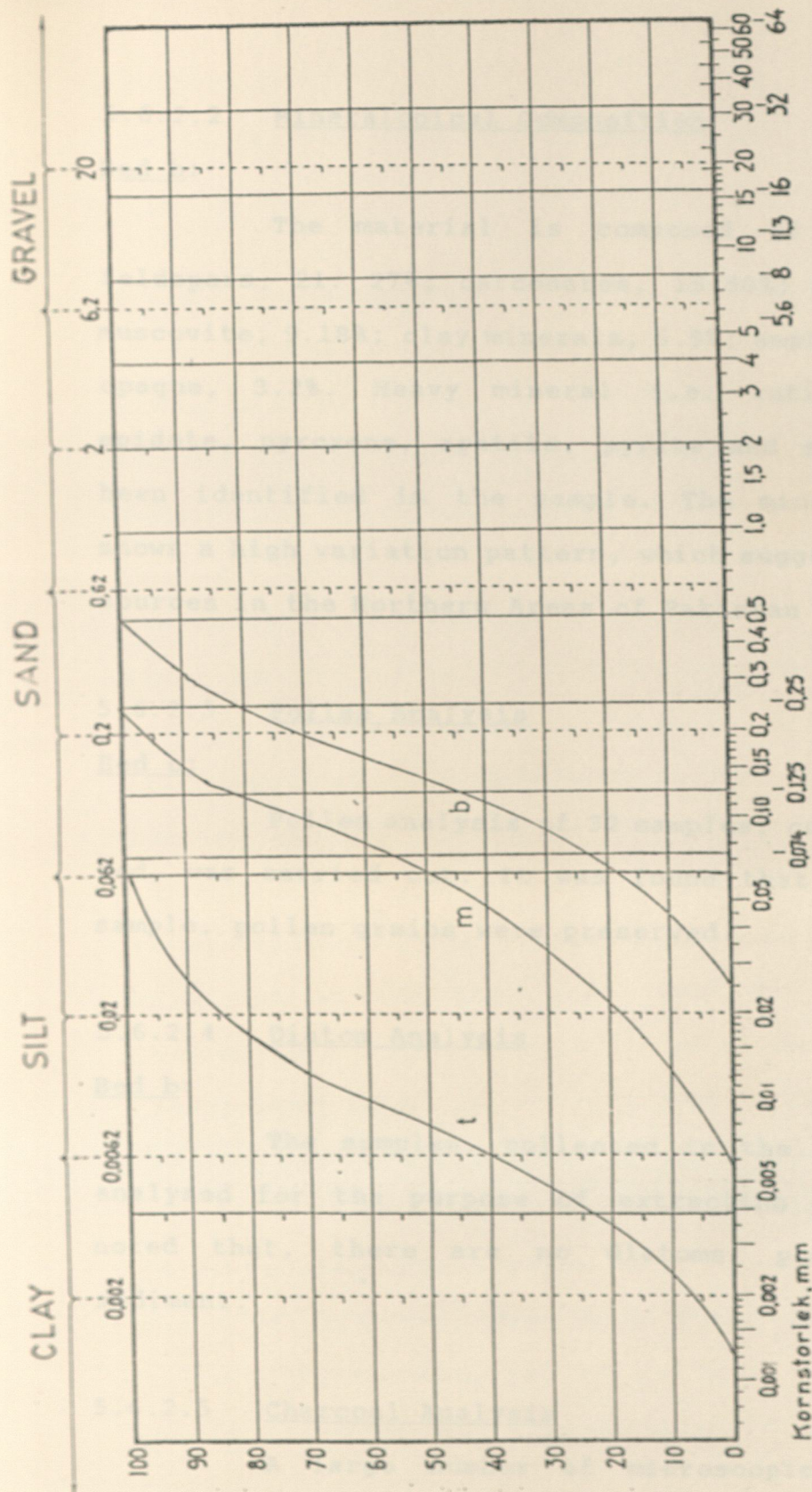


FIGURE 5.6.3
Upper sedimentation unit
t - top
m - middle
b - base

PARTICLE SIZE DISTRIBUTION

5.6.2.2 Mineralogical Composition

Bed b:

The material is composed of quartz 26.40%; feldspars, 21.27%; carbonates, 15.50%; biotite, 10.10%; muscovite, 9.18%; clay minerals, 6.9%; amphibole, 6.5%; and opaque, 3.2%. Heavy mineral i.e. rutile, tourmaline, epidote, pyroxene, apatite, pyrite and zircon have also been identified in the sample. The mineral composition shows a high variation pattern, which suggests a variety of sources in the Northern Areas of Pakistan and Afghanistan.

5.6.2.3 Pollen Analysis

Bed b:

Pollen analysis of 32 samples, collected from the bed, was carried out. It was found that in none of the sample, pollen grains were preserved.

5.6.2.4 Diatom Analysis

Bed b:

The samples, collected in the field were also analysed for the purpose of extracting diatoms. It was noted that, there are no diatoms, preserved in the sediment.

5.6.2.5 Charcoal Analysis

A large number of microscopic size charcoal

particles were observed in the slides, prepared for the purpose.

5.6.3 Discussion

The thick deposit of siltstone is exposed on either side of the narrow and deep gorge, incised by Piran torrent in the Manki hills. The Manki hills, composed of Precambrian slate and dipping towards north, have been cut by Piran torrent at almost right angle to the strike. It has resulted in carving a deep narrow gorge, about 2 km long, in the hills. The gorge has an interrupted long profile, marked by rapids, falls and nickpoints. There is also topographic unconformity in the long profile of the torrent channel. The upper torrent channel forms, cut in the Manki hills, are those of maturity, while the lower forms below the interruption are those of youth. It shows rejuvenation of the area due to tectonic uplift. Intermittent tectonic uplift and climatic changes may be interpreted from the careful and detailed study of the interrupted long profile of Piran torrent.

It is evident from the previous discussion, that prior to the sedimentation of siltstone, there was a long phase of erosion, when deep channels were cut in the bedrock. Tectonic uplift of the area and the rejuvenation of the torrents, had also occurred in the same period.

This was followed by the formation of a vast lake, covering Peshawar valley, perhaps also Khwara basin and Potwar region. This was due to the blockade of the course of the Indus river below Khwara basin, perhaps due to the tectonic changes or formation of a huge alluvial fan. Thick deposits of siltstone in the Peshawar valley, Khwara basin and Potwar region is the result of sedimentation in the lake. Piran siltstone forms a part of the thick and vast deposits, laid down in the lacustrine environment. The deposits are preserved all along the foothills of the Manki hills, particularly in the vicinity of Manki Tarakai. Thickness of the deposits reveals that the lake was deep.

One of the important characteristics of the lacustrine facies in the section is its cyclicity. Bed b is composed of 38 vertical sequences of sub-facies. Grain-size analysis shows that the basal part of the sub-facies is composed of fine sand, overlain by sandy silt in the middle, and fine silt in the upper part. Burbank (1983) has interpreted each of the graded bed as a deposit, resulted from a single catastrophic flood and has reported at least forty floods, that inundated Peshawar basin in pre-historic times. The siltstone also dated by him is less than 0.7 m.y. old.

The flood origin of Piran siltstone is doubtful and debateable. It seems very strange that during a long

time span of 0.7 m.y. only forty catastrophic floods occurred in the Indus, while during mid-1800's, there were at least four such floods that has inundated the portions of Peshawar valley.

According to Burbank's interpretation, there is a long time interval between the sedimentation of each successive cycle of Piran siltstone. It may not be possible that during a long time interval, 60 cm thick layer of siltstone is preserved, without being eroded totally or partially, until the next cycle of sedimentation commenced during the next catastrophic flood. It was also possible that in the time interval between the two floods, when the siltstone was exposed on the surface, another bed like that of gravels or loess, was deposited on siltstone. It may be concluded that the continuous sedimentation of siltstone in form of normally graded beds, has taken place in a uniform sedimentary environment i.e. lacustrine environment.

The exact manner in which the grading processes operate is not well-understood. However, on the basis of vertical variation in the grain sizes, the cycle of sedimentation around the margin of the lake, can be interpreted as due to the transgressions and regressions of shoreline as the level of the lake water fluctuated. During the rise of lake water, only fine silty material could find the way to be deposited in the lake near Piran, while during the regression, the sediments may have undergone

extensive reworking under moderate energy conditions near the shoreline, removing fine material and leaving behind coarse sand and silt.

Rise and fall of lake water may be the result of climatic variation, tectonic uplift, subsidence and to a lesser degree of the eustatic changes. A change of climate after a particular period i.e. stadial/interstadial phases, may have accelerated and retarded the rate of snow-melting on the surrounding mountain ranges, and hence changes in the discharge of rivers draining into the lake may have occurred. This would have caused a change in the level and dimension of lake.

Changes in the level of lake may also have resulted from the tectonic movements. The area has evidence of recent faulting and tectonic movements, which are recorded in the sediments of bed b.

The bioturbated silty material with a lot of rootlets and burrows on the top of each cycle indicate the presence of a variety of shallow water organisms, calcareous algae and oolites in the marginal water during the periods of regressions. They may have contributed calcium and various other carbonates to the sediments.

The mineral composition of siltstone reveals that the ultimate sources of the material are the igneous and metamorphic formations of the Hindukush and Karakoram, in Pakistan and Afghanistan. The material was eroded by

glaciers in the Pleistocene period, and deposited as moraines in the mountainous valleys. In subsequent phases, the fine material was brought down by eolian and fluvial processes and the lake was filled with sediments. The loessic material, derived mainly from the glacial outwash, seems to have been deposited in the surroundings of the lake, and also covered the adjacent mountains. It seems to have also been deposited in the lake, by torrents and wind.

The vertical and oblique dykes, disturbed strata with anticlines and synclines are the evidence of orogenic movements during the Pleistocene period. It shows that the area was tectonically active until recently.

Pollen and diatom analysis reveal that none of the microfossil is preserved in the deposit. It can be concluded that the material is too old and has passed through several phases of warm and dry environment, that destroyed the microfossils.

The charcoal particles preserved in bed b seem to have been derived from the forest fires. The historic and pre-historic man could also be the potential cause of the fire, but the material seems to be too old, prior to the advent of man on the scene. It can be concluded that, the weather condition in Peshawar valley, like that of today, initiated lightning. Charcoal particles, show that natural fires were frequent in the valley, when the siltstone was in process of sedimentation in the Pleistocene period. The

phenomenon of natural fires due to lightning in monsoon is common in present day climatic condition in sub-Himalayan zone, where there are thick forests on the mountain slopes.

After the draining of lake, siltstone was exposed on the surface. It was subjected to erosion by Piran torrent. As a result, irregular surface topography was developed on siltstone, as is evident from the unconformable contact of the material with the overlying fan gravels.

Based on colour, stratigraphic correlation and mineral composition, the siltstone can be correlated with the sediment in bed e, section no I.

It seems that Attock-Cherat range was covered by vegetation in a moist, cold pluvial climate, when Peshawar valley was occupied by lake. A thick zone of loose material developed on the mountain range. Subsequent to the draining of lake, it seems that there was also a change of climate from moist cold pluvial to warm, dry, interpluvial, that resulted in the decay of vegetation on the Attock - Cherat range.

It was followed by the release of weathered material from the Attock - Cherat range due to torrential rains in interpluvial climate, and was deposited at the foot of the range, forming alluvial fans, and piedmont plain. The thickness of gravels bed is maximum here, because, it is the apex of the fan, formed at the outlet of

Piran torrent. The thickness and comparatively coarse fragments, indicate a turbulent torrent, that built the fan. Lithology and angularity of the debris reveal that the material has been derived from the local sandstone and slate formation of the Attock - cherat range. Fan-gravels may also have been produced, because of the tectonic uplift of the Attock-cherat range.

It was followed by a long phase of erosion, when the present-day Piran torrent was formed by cutting the fan gravels and underlying siltstone deposit and forming a 40 m deep gorge, near Bait-ul-Gharib.

It is evident from the erosional terrace, formed in the fan-gravels, near Bait-ul-Gharib, that Piran torrent channel was formed in two phases. In the first phase, the torrent was deepened by Piran torrent, and after the base-level was reached, the widening of the channel started by lateral erosion. The terrace shows that Piran torrent was rejuvenated perhaps due to the periodic tectonic uplift of the area. The Piran torrent was engaged again actively in the deepening of torrent channel. The chief characteristics of the cross profile of Piran torrent is a break of slope along the eastern side, marked by the erosional terrace, separating the youthful channel form below from the older channel form above (Fig. 5.6.3). It can be concluded from the study of Piran gorge and Piran section that the tectonic activities have played a very important role in

CROSS PROFILE OF PIRAN TORRENT

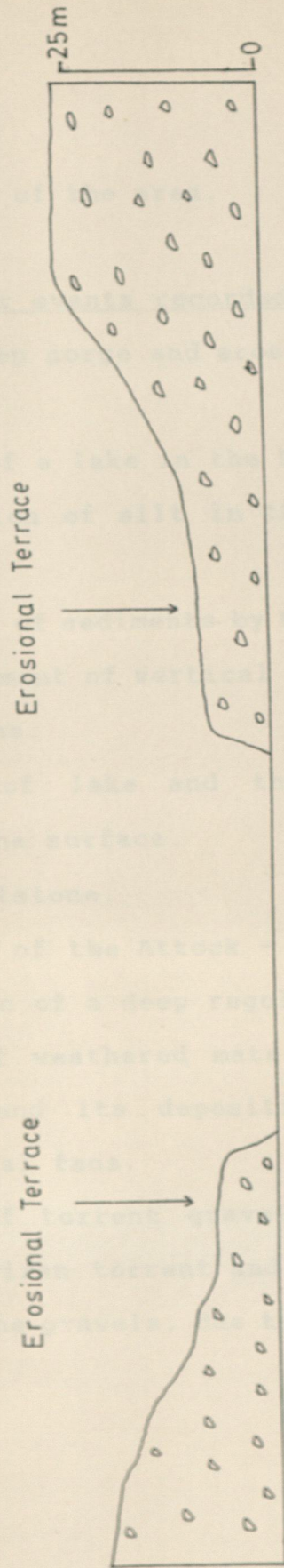


FIGURE 5.6.4

shaping the geomorphology of the area.

5.6.4 Summary of major events recorded in the section

- a. Cutting of a deep gorge and erosional terrace in Manki slate.
- b. The formation of a lake in the Peshawar valley.
- c. The sedimentation of silt in the lake, forming bed b.
- d. The disturbance of sediments by tectonic movement and the development of vertical and oblique dykes in the siltstone.
- e. The draining of lake and the exposition of siltstone on the surface.
- f. Erosion of siltstone.
- g. The weathering of the Attock - Cherat range and the preparation of a deep regolith.
- h. The release of weathered material in warm dry environment, and its deposition on siltstone forming alluvial fans.
- i. The erosion of torrent gravels and underlying siltstone by Piran torrent and the formation of a terrace in the gravels, due to tectonic uplift.

SECTION 77

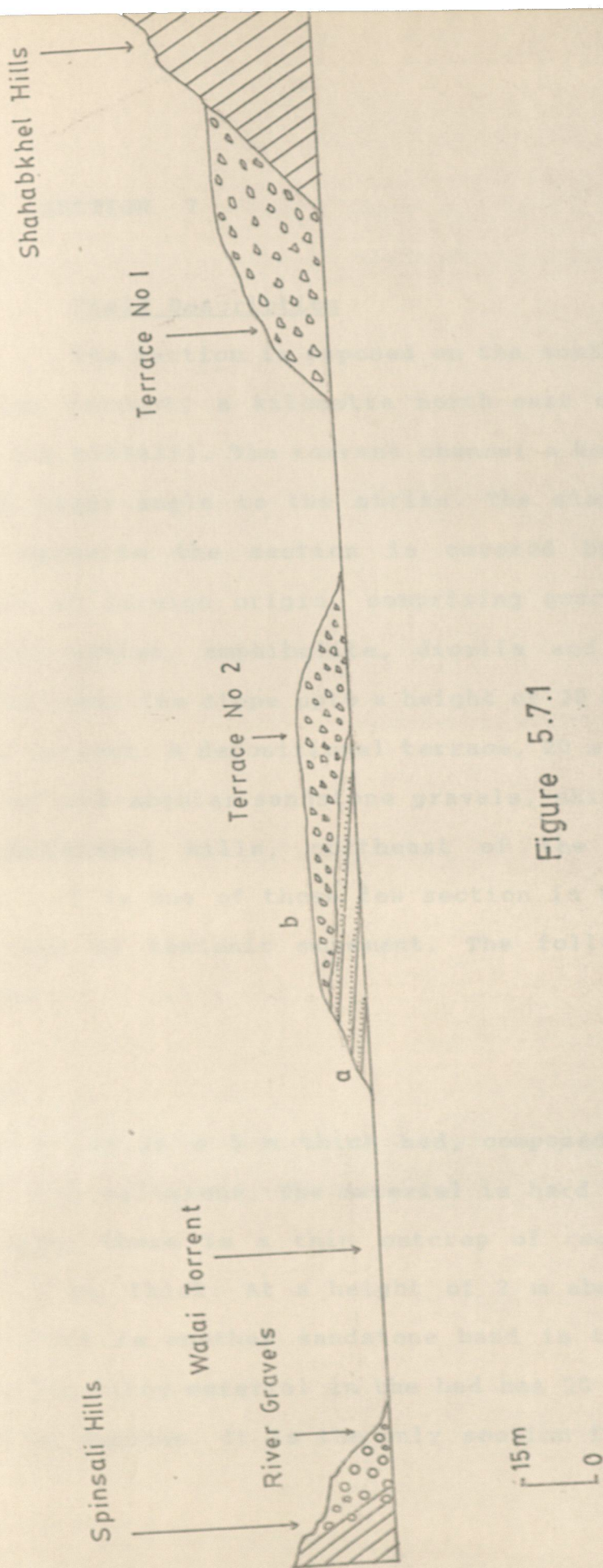


Figure 5.7.1

5.7 SECTION 7

5.7.1 Field Description

The section is exposed on the south-eastern bank of Walai torrent, a kilometre north-east of Ziarat Kaka Sahib (GR U093815). The torrent channel a km wide has been cut at right angle to the strike. The slope of Spinsali hills opposite the section is covered by well-rounded gravels of foreign origin, comprising quartz, quartzite, granite, schist, amphibolite, diorite and dolerite. The gravels cover the slope upto a height of 20 m above the bed of the torrent. A depositional terrace, 20 m high, composed of local sub-angular sandstone gravels, skirts the foot of the Shahabkhel hills, northeast of the section (Fig. 5.7.1). It is one of those few section in the study area, disturbed by tectonic movement. The following beds are exposed: (Silty material)

Bed a:

It is a 5 m thick bed, composed of light-gray (2.5y 7/2) siltstone. The material is hard and compact. At the base, there is a thin outcrop of recent sandstone, about 0.5m, thick. At a height of 2 m above the torrent bed, there is another sandstone band in the bed, 0.8 m, thick. The silty material in the bed has 20 to 30 mm thick, parallel laminae. It is the only section from Indus river

as far as Jabba Khattak, where siltstone bed is dipping towards southeast, with an angle of 24 degrees.

Bed b:

The bed is composed of dark-gray torrent gravels, with a maximum thickness of 11m. Thin horizontal layers can also be perceived in the material. Most of the fragments in the bed are fine, subangular, sandstone gravels, that can be detached easily from the bed. Occasional boulders of local origin can also be seen in the bed. Numerous vertical gullies have developed in the section. The bed has a smooth, uniform surface at the top.

5.7.2 Laboratory Examination

Texture

Bed a: (Silty material)

The silty material ranges in size from 0.001 mm to 0.05mm. The material is composed of 37% clay, 15% very fine silt, 10% fine silt, 14% medium silt and 24% coarse silt. About two third of the material is silt and one third clay (Fig.5.7.2).

Bed a: (Sandy material)

The material ranges in size from 0.08 mm to 1.6 mm. The band of sandy material is composed of 6% very fine

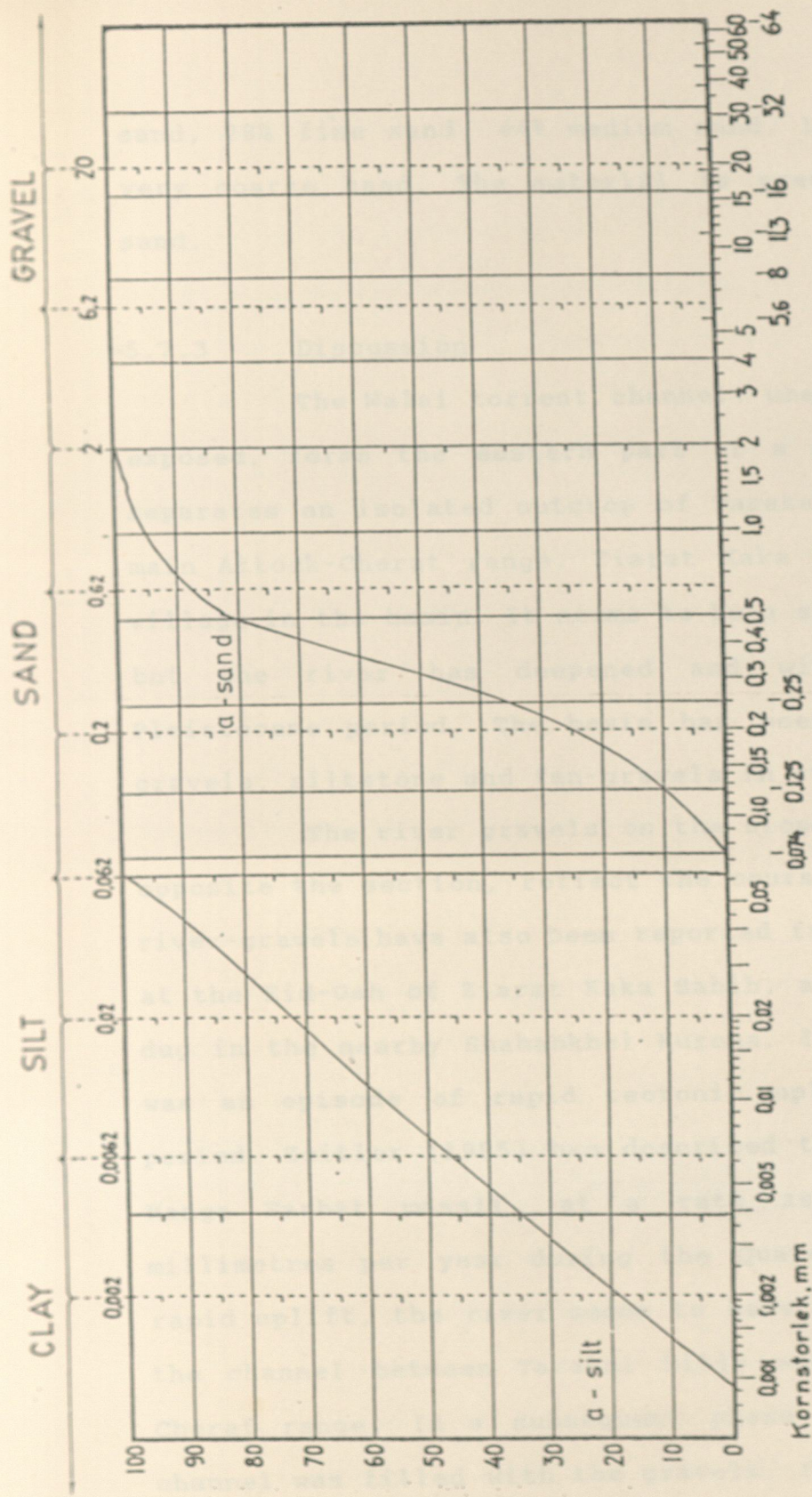


FIGURE 5.7.2

PARTICLE SIZE DISTRIBUTION

sand, 28% fine sand, 44% medium sand, 16% coarse and 6% very coarse sand. The material is predominantly medium sand.

5.7.3 Discussion

The Walai torrent channel, where the section is exposed, forms the eastern part of a narrow basin that separates an isolated outcrop of Tarakai hills, from the main Attock-Cherat range. Ziarat Kaka Sahib is the main village in the basin. It seems to be a structural feature, but the river has deepened and widened it in the Pleistocene period. The basin has been filled by river gravels, siltstone and fan-gravels in subsequent phases.

The river gravels on the slope of Spinsali hill opposite the section, reflect the course of a river. The river-gravels have also been reported from tube well logs, at the Eid-Gah of Ziarat Kaka Sahib, and from the wells, dug in the nearby Shahabkhel Kurona. It seems that there was an episode of rapid tectonic uplift in Quaternary period. Zeitler (1985) has described the rapid uplift of Nanga Parbat massif, at a rate as high as several millimetres per year during the Quaternary. Due to the rapid uplift, the river seems to have eroded and deepened the channel between Tarakai hills and the main Attock-Cherat range. In a subsequent phase of deposition, the channel was filled with the gravels, followed by a period

of erosion of the material. The gravels on the slope of Spinsali hill and deep in the basin, appear to be the remains of the river deposit. In a later phase, the buried river - gravels became conglomerate.

The lithological composition and roundness of the clasts reveal the source of the material to be the igneous and metamorphic formations in the far-off regions of the Hindukush and Tirah mountain ranges in the west, from where Kabul river and its tributaries take their origin.

The sandstone outcrop, exposed at the basal portion of bed a, shows that the conglomerate was covered by a thick sand deposit, laid by a river. The deposition of sand, overlying the gravels may either be due to the cessation of the gravelly material in the source regions, or to a decrease in flow of river, as a result of change in the gradient.

On the basis of size-analysis, colour, stratigraphic position and primary structure i.e. laminae, the material in bed a can be correlated with the lacustrine sediments of bed c, section no 5 in Walai and bed b, section no 6, of Piran. The lake deposit of bed a at the foothill of Shahabkhel hills, shows that the lake extended right upto the foothill of the Attock - Cherat range.

The parallel laminae composed of silt and clay have been generated by the deposition of sediments from slow suspension, settling in the lake, where there was no

organic reworking of the sediments, or it was very low. The laminae are the result of short-lived fluctuations in the sedimentation conditions in the lake, when the clay and silt layers were deposited as laminae.

The 0.8 m thick sandstone band in the siltstone may be the result of regression of the lake water and exposition of silt for a short time period. It seems that the river resumed its original course between Spinsali and Shahabkhel hills, and the thin band of sand was deposited over siltstone. After the transgression of the lake, the process of deposition of silt started once again, which seems to have lasted for very long time period, as is evident from the thickness of siltstone in bed a.

Another important event recorded in bed a, is its tilt towards southeast, with an angle of 24 degrees. This may be the result of a localised fault in Shahabkhel hills, towards south, during the late Quaternary. Section no 5, in Walai, shows the siltstone in the same stratigraphic position, dipping towards north. The distance between the two sections, is hardly 2 km. It shows the development of a local fault as well as folds during late Quaternary period. Yeats et al. (1987) have also reported high-angle faulting and localised folding near the southern margin of Peshawar basin, during the late Quaternary, in existence for the past 0.6 m.y.

It seems that the Attock-Cherat range was covered

by vegetation, in a moist cold climate, when the valley was occupied by lake. As a result of the vegetation growth, a thick layer of weathered debris was prepared on the mountain range. With the change of climate to warm and dry, the vegetation perished, and the material was released with torrential rains and deposited as alluvial fans, at the foot of the mountain range.

It is also possible that the fan-material has been eroded from the Attock - Cherat range, by local torrents, because of an episode of rapid tectonic uplift of the mountain range. Due to a change of base-level, a phase of erosion of the mountain range may have begun, and the eroded material was deposited as alluvial fans, in the foot of the mountain range. It appears as if both the processes, of vegetation growth and tectonic uplift, are responsible for the formation of alluvial fans in the area.

After the cessation of the weathered material, the torrent started to cut a deep and wide channel in the fan-gravels. It resulted in the formation of the terrace 1 (Fig. 5.7.1) in the foot of Shahabkhel hills. Due to the slow tectonic uplift, the torrents in the area started to rejuvenate, and another deep and wide channel was incised within the previous old torrent channel, forming terrace 2, as has been shown in the figure. Terrace no 2 of the present section and the erosional terrace of section no. 6 of Piran, formed in the torrent gravels, seem to be contemporaneous.

5.7.4 Summary of the major events recorded in the section of the range

- a. Deepening and widening of a palaeo-river channel, in between Walai and Spinsali hills, due to the tectonic uplift.
- b. The deposition of thick deposit of river gravels in the eroded channel, and its subsequent erosion.
- c. The deposition of sand, overlying the gravels.
- d. The formation of lake and deposition of silty material.
- e. The regression of lake and exposition of silt for a short time period.
- f. The flow of river over the silt and deposition of a layer of sand.
- g. The transgression of lake and deposition of thick deposit of siltstone, overlying the sand.
- h. The growth of vegetation and tectonic uplift of the Attock-cherat range and preparation of weathered material on the mountain slopes.
- i. The draining of lake and exposition of siltstone on the surface.
- j. The development of local faults and the tilting of siltstone deposit.
- k. A change of climate to warm and dry, decay of vegetation on the mountain range, and the release

of weathered material, forming alluvial fans at the foot of the range.

- l. The filling of Walai khwar with the fan material upto a considerable height.
- m. The erosion of fan gravels, formation of deep torrent channels as well as terrce I, along the foothills of Shahabkhel hills.
- n. Rejuvenation of the torrent due to the tectonic uplift and the formation of terrace 2.

SECTION 8

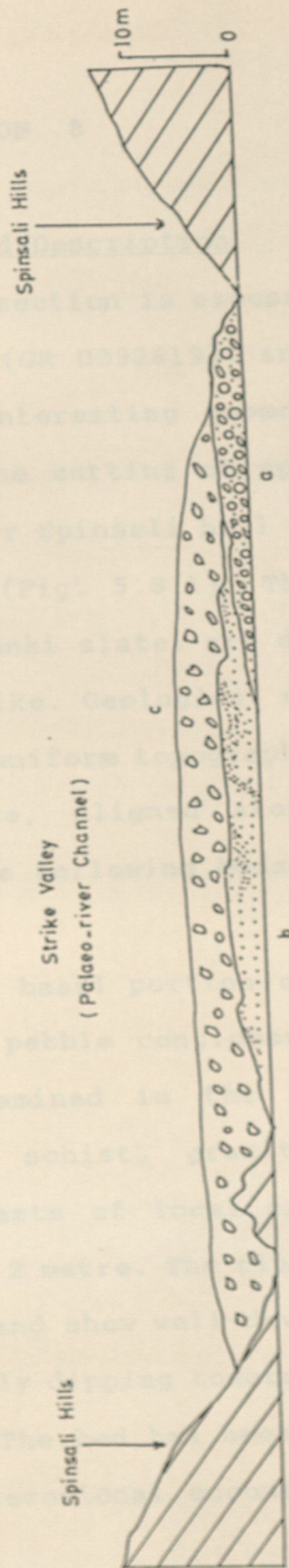


Figure 5.8.1

5.8 SECTION 8

5.8.1 Field Description

The section is exposed along the western bank of Walai torrent (GR U092819), in a 200 m wide, palaeo-river channel. An interesting geomorphological feature of the locality is the cutting of spinsali hills into two units i.e. the proper Spinsali hill in the south and Walai hills in the north (Fig. 5.8.1). The Spinsali and Walai hills, composed of Manki slate, are dipping towards north with an east-west strike. Geological structure shows that both the hills formed uniform topographic surface, until it was cut in the centre, aligned along the strike of the rock formation. The following beds are exposed in the section:

Bed a:

The basal portion of the section exhibits a bed of petromict pebble conglomerate. The clasts of the mixed lithology examined in the bed, are quartz, quartzite, amphibolite, schist, granite, diorite, and occasional sandstone clasts of local origin. The bed has a maximum thickness of 2 metre. The clasts have a preferred east-west orientation and show well-developed imbrication, with long axes generally dipping towards west, with an angle of 10 to 15 degrees. The bed has been severely eroded and displays a prominent erosional unconformity with the overlying bed b. very coarse sand. The material ranges in size from 0.05

Bed b:

The bed is composed of light-gray (2.5Y 7/2), sandstone, 2 to 3 m thick. There are parallel laminae, 1 to 2 cm thick, while there are also curved, non-parallel cross-beddings in some parts. Numerous burrows, about a centimetre in diameter, have also been examined in the material. The bed has been eroded severely and huge blocks of sandstone, detached from the bed are lying on the torrent bed. The bed has an unconformable contact with the overlying bed c.

Bed c

It consists of 2 to 3 m thick deposit of loose gravels. The clasts, predominantly angular to subangular are composed of brown sandstone and shale fragments. Occasional boulders of local origin and lenses of clay can also be seen in the bed. Numerous gullies have developed on the surface of the material.

5.8.2 Laboratory Examination5.8.2.1 TextureBed b:

The sediments in bed b is predominantly very fine to fine sand. It is composed of 4% coarse silt, 21% very fine sand, 30% fine sand, 26% medium sand, 14% coarse and 5% very coarse sand. The material ranges in size from 0.05

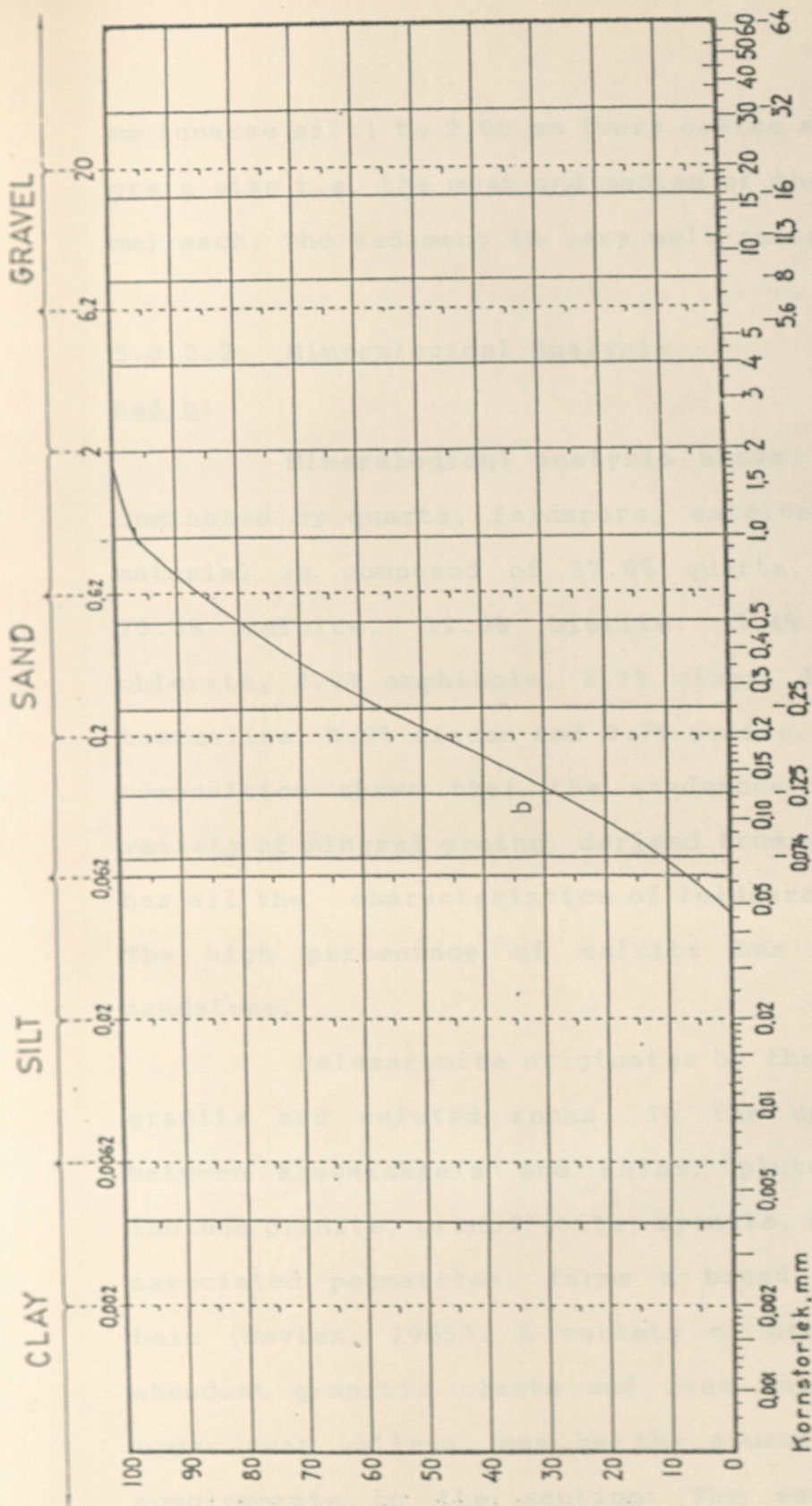


FIGURE 5.8.2

PARTICLE SIZE DISTRIBUTION

mm (coarse silt) to 2.00 mm (very coarse sand). The average grain size i.e. the mean and median of the sand is 2ϕ (0.25 mm) each. The sediment is very well-sorted (Fig. 5.8.2).

5.8.2.2 Mineralogical Analysis

Bed b:

Mineralogical analysis shows, that the sand is dominated by quartz, feldspars, calcite and biotite. The material is composed of 27.8% quartz, 22.5% feldspare, 20.5% calcite, 11.9% biotite, 5.4% muscovite, 3.5% chlorite, 2.7% amphibole, 1.7% clays, 1.0% epidote, 0.9% tourmaline, 0.9% zircon and 0.7% rutile. The mineralogical composition shows that the sandstone is composed of a variety of mineral grains, derived from various sources. It has all the characteristics of feldsarenite (Folk, 1970). The high percentage of calcite has cemented it into sandstone.

Feldsarenite originates by the disintegration of granite and related rocks. In the upper Swat valley, between Khawazakhela and Kalam, plutonic rocks, which include granite, granodiorite, syenite, diorite, gabbro and associated pegmatites, forms a broad northeast-trending belt (Davies, 1965). A variety of granitic rock types, abundant granitic clasts and fine material in till, in upper Swat valleys, may be the sources of the sand and conglomerate in the section. The sediments have been

brought down by Swat river, a tributary of the Kabul river. It seems that the Kabul river was flowing at the foothills of the Attock - Cherat range in the Pleistocene period. The Kabul river, with its sources in the central Hindukush valleys of Afghanistan has contributed a considerable amount of sand to the deposits all along the northern foothills, of the khattak ranges. The sand exposed in bed b of the section is a part of this widespread sandstone formation.

5.8.3 Discussion

Bedrock is not exposed at the base of the section. The conglomerate in bed a seems to have been deposited by a high energy river. The highly resistant rounded clasts of conglomerate seem to have been reworked and redeposited through several cycles of sedimentation. The less resistant clasts may have been destroyed under high energy condition.

The wells dug in the area show that the conglomerate extends deep in the sub-surface, revealing that prior to the deposition of conglomerate, the river had cut a deep channel in the bedrock. This is perhaps due to the tectonic uplift in late Quaternary period. This tectonic episode includes the rapid uplift of Tibetan plateau in the Quaternary (Li et al. 1979). This was followed by a phase of deposition, when the palaeo-river

channel was filled with river gravels. With the passage of time, the gravels embedded in the matrix of sand were cemented to form conglomerate. The irregular contact of conglomeratic bed with the overlying bed reveals a phase of degradation during which conglomeratic bed was eroded by a river.

The cross-bedding and presence of occasional river gravels in the sandstone are suggestive of the fluvial nature of the material in bed b. It was the second phase of deposition by river. Figure 5.8.1. shows that the conglomerate and sandstone beds were deposited in a river channel. The tectonic uplift of the area has changed the entire drainage system of the region. The river, flowing in the foothills of the Attock - Cherat range was forced to change its course and was pushed towards north. As a result, the channel deposits were exposed.

Lithological characteristics and angularity of the clasts in bed c reveal that the material was derived from the Attock - Cherat range, and was deposited in form of fans. The present - day torrent channel shows that the phase of fan-formation was followed by a long phase of erosion, when the fan - gravels and the underlying deposits were cut vertically and laterally and broad deep torrent channel was carved out in it. This may have been caused by load-free torrents and slow tectonic uplift of the area.

5.8.4 Summary of important events recorded in the section

- a. The flowing of Kabul river or a branch of it in the foothills of the Attock - Cherat range.
- b. An episode of rapid tectonic uplift.
- c. The erosion of the bedrock of Spinsali hills and the carving of a deep river channel.
- d. The deposition of river gravels in the channel and the formation of conglomeratic bed.
- e. The degradation of conglomeratic bed by erosional processes in response to tectonic uplift.
- f. The sedimentation of sand by river and the formation of sandstone.
- g. A phase of erosion of sandstone.
- h. The shifting of river towards north and the exposition of channel deposits on surface.
- i. Growth of vegetation, weathering and preparation of weathered material on the Attock - Cherat range.
- j. Change of climate to warm and dry and the decay of vegetation; the release of weathered material and formation of alluvial fans.
- k. The cutting of fan gravels and the formation of broad and deep torrent channels in it.

SECTION 9

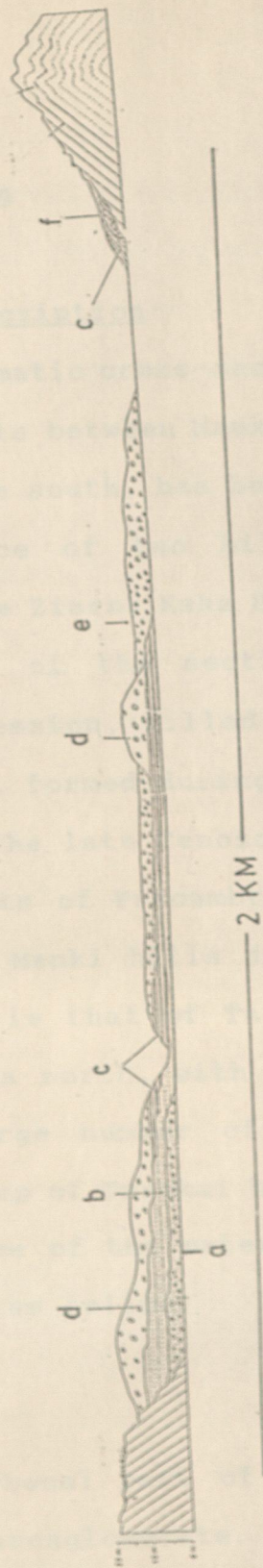


Figure 5.9.1

5.9 SECTION 9

5.9.1 Field Description

A diagrammatic cross-section, showing sequence of a variety of deposits between Manki hills towards north and Tarakai hills in the south, has been shown in figure 5.9.1, covering a distance of two kilometre. The section is located, west of the Ziarat Kaka Sahib - Nowshera road. The important locality of the section is Shagai Kanda (GR U080820). The depression, filled with the sediments, is a part of a syncline, formed during the uplift of the Attock - Cherat range in the late Cenozoic (Burbank et al. 1984). The bedrock consists of Precambrian Manki slate. The rock formations of the Manki hills in the north, are dipping towards south, while that of Tarakai hills in the south, are dipping towards north, with angles varying from 45 to 70 degrees. A large number of river gravels are lying scattered on the top of Tarakai hills, north of Ziarat Kaka sahib. The sequence of the material from base to the top, in the section is as follow:

Bed a:

At the basal part of the section there is 4 m thick bed of paraconglomerate. The clasts of the deposit consist of sub-rounded to rounded, locally-derived sandstone, slate and shale, with a considerable number of

river gravels of foreign origin. The bed has been eroded severely and huge blocks of conglomerate have been detached from it. The bed decreases in thickness towards north, until it disappears about 200 m downstream of Shagai torrent. The unconformity is not clear with the overlying sandstone formation.

Bed b:

The bed is composed of fine to medium-size, light-gray (2.5y 7/2), bedded sandstone. It has a maximum thickness of 12 m in Shagai torrent, but decreases towards north. There are 10 to 15 cm thick horizontal layers in the deposit, with black coating of lichen developed on it. Occasional small rounded gravels can also be seen in the sand. It is hard to break even with hammer, but there are also patches of loose sand which are quarried. The sandstone bed has been eroded severely, particularly in the central part of the depression.

Bed c:

The bed exhibits 5 m thick lacustrine facies, composed of light-gray (2.5y 7/2) siltstone. It has horizontal layers, 5 to 12 cm thick. There is half metre thick band of light-gray (2.5y 7/2) sandstone, having conformable contacts, with the underlying and overlying siltstone beds. As is evident from figure 5.9.1, the

siltstone deposit is confined to the central part of the depression, covering a distance of about one kilometre. At the foot of Manki hills, siltstone bed has been disturbed, dipping towards south, making an angle of about 50 degrees. There is a considerable number of river gravels of foreign origin in the vicinity of the disturbed strata, and it seems as if they have been deposited on the slope of the hill prior to the sedimentation of siltstone. There are also two huge erratics of granite, lying at the foot of the exposure. In places the bed has been eroded and washed away by torrents. It has an unconformable contact with the overlying bed.

Bed d:

The bed consists of about 9 m thick deposit of locally derived gravels and boulders, with a large number of rounded gravels of foreign origin. Lithologically, the material is composed of sandstone, slate, shale, quartz, quartzite, diorite, dolerite etc. The deposit is exposed on the surface, forming low undulating hillocks. Due to long exposure on the surface, the gravels have been reweathered. Patina has also developed on the majority of the clasts. Lithology suggests that the material forms a part of the older alluvial fans. Irregular topography reveals that the older fans have suffered a long phase of degradation.

Bed e:

A large part of the area is covered by dark-gray, angular to subangular, sandstone gravels and boulders of local origin. The thickness of the bed varies from one to thirty metres. They are also exposed on the surface, forming more or less uniform plains with low gradient, incised by torrent channels and numerous gullies.

Bed f:

There is a small isolated patch of pale-brown (IOYR 6/3), loess, overlying the disturbed siltstone bed at the foot of Manki hills. The material has a lot of limestone concretions. It has been eroded severely. There is thin layer of scree on the top of loess.

5.9.2 Laboratory Examination5.9.2.1 TextureBed b: (Sand)

The bed is composed of 2% coarse silt, 6% very fine sand, 42% fine sand, 34% medium sand, 14% coarse and 2% very coarse sand. The average grain size i.e. the mean and median of the sand are 1.92 ϕ (0.27 mm) and 2.0 ϕ (0.25 mm) respectively (Fig. 5.9.2). The deposit is well-sorted and coarse-skewed. The well-sorted sediment indicates an environment such as the bank of river, where it has undergone extensive reworking under moderate energy

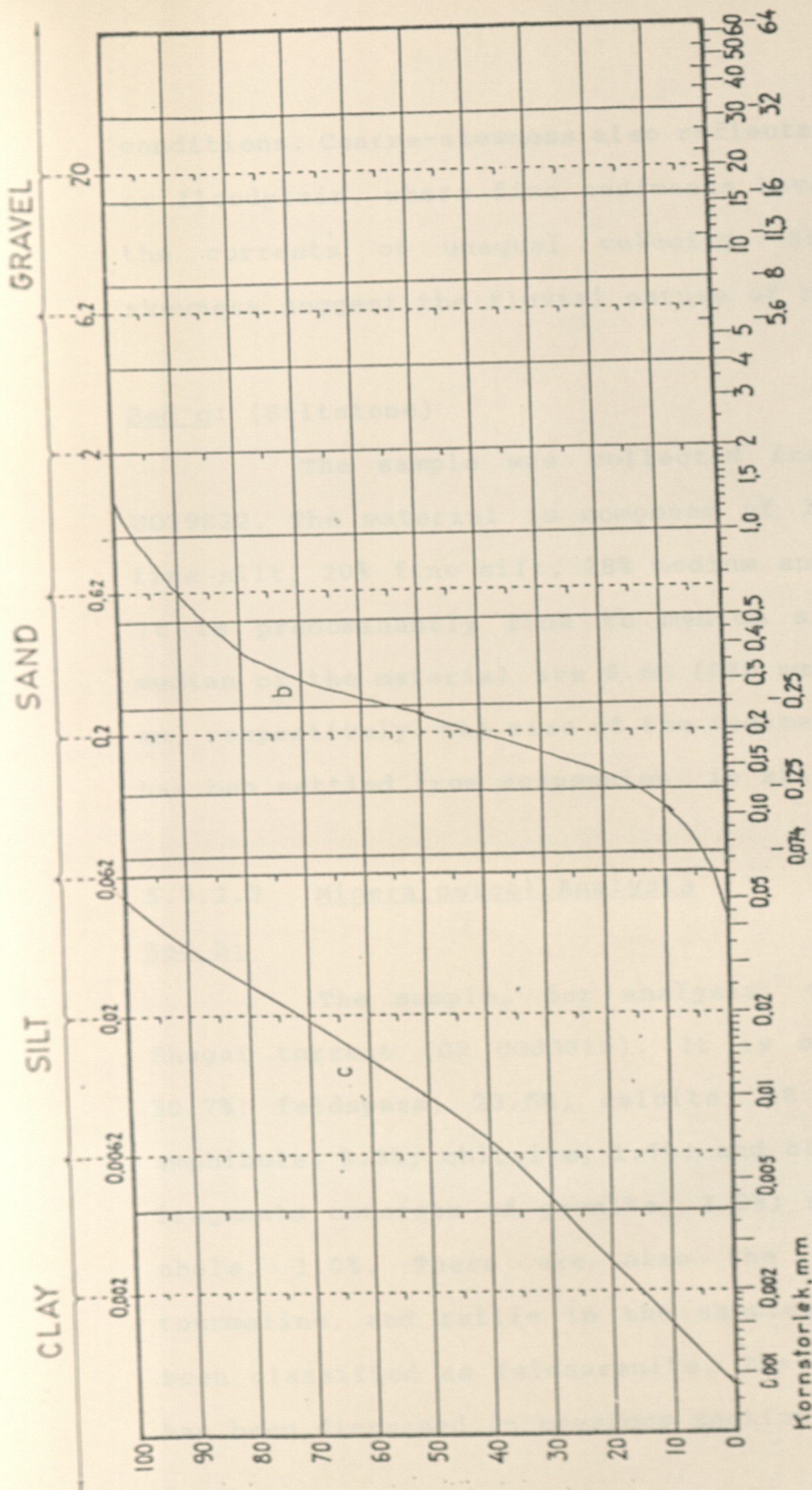


FIGURE 5.9.2

PARTICLE SIZE DISTRIBUTION

conditions. Coarse-skewness also reflects the bank of river or floodplain, where fine sediments have been removed by the currents of unequal velocity. Size, sorting and skewness suggest the fluvial nature of the sand.

Bed c: (Siltstone)

The sample was collected from the bed on GR U079822. The material is composed of 25% clay, 14% very fine silt, 20% fine silt, 28% medium and 13% coarse silt. It is predominantly fine to medium silt. The mean and median of the material are 6.6 ϕ (0.10 mm) and 6.5 ϕ (0.11 mm) respectively. The size of the sediment suggests that it has been settled from suspension, in still water.

5.9.2.2 Mineralogical Analysis

Bed b:

The sample, for analysis, was collected from Shagai torrent (GR U083816). It is composed of quartz, 30.7%; feldspars, 23.5%, calcite, 18.6; biotite, 15.6%; amphibole, 3.5%; chlorite, 1.7%; and clays, 1.1%; The rock fragments consists of granite, 1.2%; sandstone, 2.7% and shale, 1.0%. There are also the traces of zircon, tourmaline, and rutile in the sample. The sandstone has been classified as feldsarenite. The origin of sandstone has been discussed in previous section 8.

5.9.2.3 Shape Analysis

Bed d

Analysis reveals that 68% of the clasts are equant, 21% oblate and the remaining 11% bladed (Fig. 5.9.3)

Bed e:

According to analysis, 48% of the gravels are equant, 35% bladed, and 17% oblate. The composition shows a marked difference from the older fan gravels. This is due to the fact that the older fan gravels are predominantly composed of sandstone and a large number of river gravels, that are usually equant, while the younger fan gravels has a lot of slate fragments, bladed in shape. This explains the reason why the material is dominated by bladed shape after equant.

5.9.2.4 Roundness Analysis

Bed d: (Older Fan Gravels)

Roundness analysis shows that 74% of the gravels fall in RC II, (angular), 14% in RC III (sub-angular), and 12% in RC 9 (rounded). The clasts in the bed are mostly angular to sub-angular, showing a nearby source of the material, and the re-weathering due to the long exposure to weathering agencies (Fig. 5.9.4).

SHAPE ANALYSIS

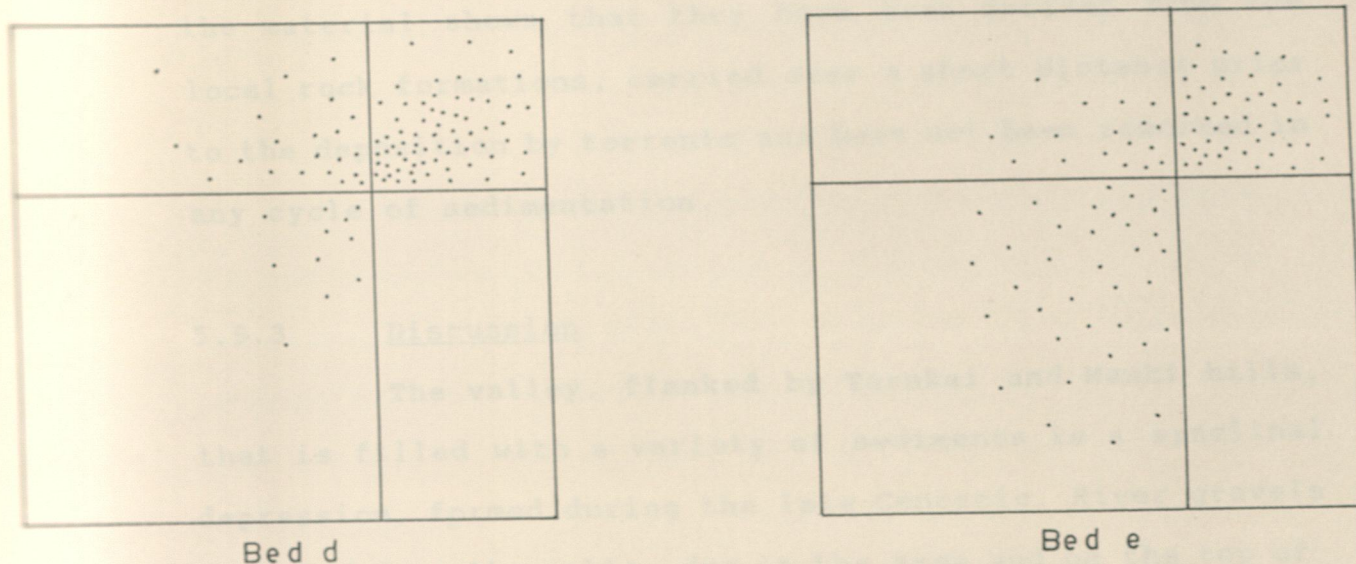


FIGURE 5.9.3

ROUNDNESS ANALYSIS

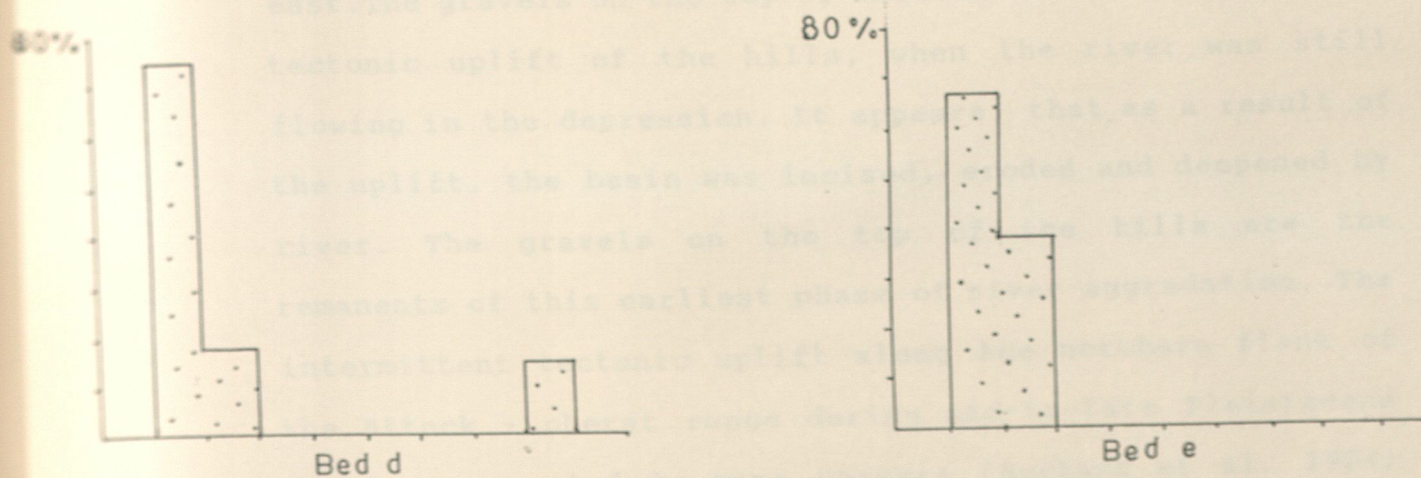


FIGURE 5.9.4

Bed e: (Younger Fan Gravels)

According to roundness analysis, 64% of the fragments are angular and 36% subangular. The angularity of the material shows that they have been derived from the local rock formations, carried over a short distance prior to the deposition by torrents and have not been reworked in any cycle of sedimentation.

5.9.3 Discussion

The valley, flanked by Tarakai and Manki hills, that is filled with a variety of sediments is a synclinal depression, formed during the late Cenozoic. River gravels reported from the wells, dug in the area, and on the top of Tarakai hills, and gravels on the slopes of Manki hills, are evidence of the fact that the basin was occupied by a river flowing along the strike of the valley from west to east. The gravels on the top of Tarakai hills also shows the tectonic uplift of the hills, when the river was still flowing in the depression. It appears, that, as a result of the uplift, the basin was incised, eroded and deepened by river. The gravels on the top of the hills are the remnants of this earliest phase of river aggradation. The intermittent tectonic uplift along the northern flank of the Attock - cherat range during mid-to-late Pleistocene has been reported by many workers (Burbank et al. 1984; Yeats and Hussain, 1987). The conglomerate exposed in bed

a has a considerable amount of locally derived gravels. It shows the extension of fan-gravels from the south, forming delta in the river. This also reveals that the fans were in processes of formation in the foothills of the Attock - Cherat range, when the river was flowing in the depression. This seems to have pushed the river further to the north.

There is no sharp boundary between conglomerate in bed a and sandstone in bed b. The gradational change of conglomerate into sandstone, shows a slow and gradual change in the velocity, and shifting of river channel further north. The slowing of the river may have been the result of the bifurcation and change in the discharge, while the shifting of the river course may be due to the formation of alluvial fans.

Bed b consists of thick, bedded sandstone with occasional river gravels. It suggests the fluvial nature of the facies. Its thickness indicates a long duration of the environment of deposition. Beds in the sandstone represent the periodic fluctuations in the discharge of the river. Individual bed may have been produced under the constant physical condition. The bedding planes in the deposit may represent the period of non-deposition, due to the non-availability of the material in the source region or a very low discharge of the river. The sandstone has been classified as feldsarenite according to Folk's (1970) classification. The source region of the material has been

discussed in previous section no 8.

As it is evident from figure no 5.9.1, the sandstone has suffered a long phase of degradation, particularly in the central and northern part of the depression, where it has been totally removed. Only in certain parts, the sandstone is exposed in form of a thin bed. The degradation may have been due to the intermittent tectonic uplift.

Due to the episode of tectonics, it seems that the Indus was blocked somewhere between Khwara valley and Kalabagh. It resulted in the damming of the course of Kabul river, converting Peshawar valley, Khwara basin and the Potwar region into vast fresh water lake. Deposition of silt took place in the lake by the settling of fine particles, suspended in water. The material was brought down by inflowing rivers and streams into the lake, from the surrounding mountainous region. The source of the lacustrine sediments may be the morainic material in the surrounding valleys that were glaciated several times in the Pleistocene period. Scanning electron microscopy of the lake deposit reveals that wind has also contributed a considerable amount of the material to the lake.

A band of sandstone in the lacustrine facies indicates the temporary regression of the lake water and the deposition of sand from the sandstone deposit in the south.

The disturbed part of the lake deposit on the slope of Manki hills shows that the material has been deposited prior to the development of the recent thrust fault from Manki to walai and was involved in the tectonics that has deformed and tilted the piedmont deposit.

An interesting feature of the siltstone at the foot of Manki hills, is the presence of two granitoid erratics. In fact, erratics in the southern part of Peshawar vale are scattered all over the study area. A number of erratics can be seen in Shaidu, Chashmai, Isori, and Warmondo khwar. They range in size from small boulders - 0.5 m in diameter to as large as 1.5 m. Almost, all of them have been derived from the igneous and metamorphic rocks. They are sub-angular to sub-rounded, and are embedded in siltstone, river gravels, fan gravels or lying on the bedrock. Similar erratics have also been reported from Potwar plateau and Kashmir valley, since the beginning of the 19th century.

Serious attention was given to the origin of these boulders by the geologists of the Geological Survey of India. Upto 1880, most of the workers including Theobald (1877) were of the opinion that the erratics were the result of the extension of glaciers from the mountains to the plains during the Pleistocene period. In 1880, Theobald, put forward the idea of floating ice as the vehicle for the transport of Potwar erratics is the vast

lake, formed in the Potwar area. Wynne (1879) was of the opinion that the historic Indus floods of the years 1811, 1831, 1841, 1856, and 1874 were responsible for these boulders. According to Cotter (1929), an avalanchlike mud-flow released by the bursting of a temporary dam in the Indus valley above Attock may have deposited erratics in Potwar. Many of the 19th century explorers, including Godwin Austen (1860) have described mud-flow containing huge boulders in the upper Indus region. De Terra and Paterson (1939) have mentioned that the boulder fans of the Potwar region merge into glacio-fluvial gravels belonging to second glaciation. The origin of the boulders can be traced to the catastrophic floods, released under the influence of glacial climate. Said and Majid (1977) have described the origin of the boulders, due to the pieces of ice from the glaciers of Afghanistan and Tirah, that used to float in the lake, formed in Peshawar vale during the Pleistocene period. According to Inam (1990), the blocks have been transported by the Indus river and driven into the lake, in Peshawar valley during the Pleistocene period.

regolith There are no signs of glacial action on the erratics in Peshawar valley. They are usually sub-angular to sub-rounded, and are confined to the old course of the Kabul river, at the foot of the Attock - Cherat range. On the basis of lithology, roundness and location, it is suggested that most of the erratics have been transported

by rolling as bed-material load, by Swat river from the morainic material of the Swat valley during the Pleistocene period. The Kabul river seems to have also contributed erratics by rolling it down from Afghanistan, as there are evidence of erratics, in the huge alluvial fan, formed by the Kabul river at Warsak, during the Pleistocene period. It seems that originally all the boulders were transported with the river gravels, that overlies the siltstone. In the subsequent phases, when the river gravels were eroded and removed from over a considerable area, the huge erratics were left on the underlying siltstone deposit or bed-rock. A number of erratics were transported by torrents and were incorporated in fan-gravels, during the phases of fan formation. It was followed by another warm dry interstadial

Thick deposit of torrent gravels in bed d, suggest that the material has been deposited as alluvial fans by Spinsali and Spinkani khwars. It appears that the Attock - Cherat range was covered by vegetation in glacial (pluvial) phases, while the valley was occupied by a lake. Due to the extension of roots deep into the soil, a thick regolith was prepared on the Attock - Cherat range. There was a complete cessation of the material supply from the mountain range to the valley, caused by the growth of plant cover. A change of climate from glacial to warm dry interglacial, resulted in the decay of plant cover on the mountain range. The thick weathering mantle, prepared

during the previous phase was released with the periodic torrential rains. The material was deposited as alluvial fans at the foot of mountain range. The river flowing in the area was pushed further to the north. This seems to have occurred in the first interstadial of the interglacial phase.

This seems to have been followed by a slight change in climatic conditions i.e. stadial, with warm humid climate. Soil started to develop on the Attock - Cherat range for a short period. The supply of debris and the development of alluvial fans stopped in the valley. The torrents began to erode the fan-gravels in the valley. As a result, deep and broad torrent channels were cut in the material. It was followed by another warm dry interstadial phase. The vegetation cover perished on the Attock - Cherat range. The weathered material was released, and a second phase of fan formation started in the valley. This is evident from the fan-gravels in bed e, as well as, over a large part of the surface.

The two consecutive phases of fan-formation may also be attributed to the intermittent tectonic uplift of the Attock - Cherat range, during the Pleistocene period. As a result of recurring orogeny, the mountain range seems to have been subjected to severe erosion by local torrents. Consequently, deep and wide valleys, and gorges were cut in the mountains, while the eroded material was deposited at

the foot of the mountain range, forming alluvial fans.

The two beds of the fan-gravels, occur between the lacustrine facies of bed c, and the loess of bed f. The lake beds material from Nowshera Tarakai yielded a minimum age of 124 ka, while the dominant phase of loess accumulation in Peshawar basin dates to between 65 ka to 20 ka (Rendell, 1988). It indicates that the possible dates of fan formation in the valley are from 124 ka to 65 ka. It appears as if the climatic changes, growth of vegetation and intermittent tectonic uplift are the causes of the erosion of the Attock - Cherat range, and the formation of alluvial fans, in the southern parts of the Peshawar valley.

Loess marks the last phase of deposition. It is exposed in small isolated patches at the foot of the Manki hills. Loess was probably derived from the glacial outwash, from the mountainous region, north and west of the Peshawar vale, during the cold dry periglacial environment. It was subjected to severe gully erosion, and removed from a large area. Today isolated patches of loess are found around Tangi, Manki-Sharif and Bait-ul-Gharib.

5.9.4 Summary of major events recorded in the section

- a. The formation of a synclinal depression during the uplift of the Attock - Cherat range during the late Cenozoic.

- b. The flow of river in the depression.
- c. The tectonic uplift of the area during mid-to-late Pleistocene.
- d. The erosion and deepening of the depression by river.
- e. The deposition of river gravels in the synclinal depression, and a simultaneous phase of fan formation, forming delta in the river.
- f. The formation of conglomerate in the depression with the passage of time.
- g. The deposition of thick-bedded sand, by river and its conversion into sandstone in the subsequent phases.
- h. A severe and long phase of erosion of sandstone
- i. The formation of a lake in the valley and deposition of silt.
- j. The growth of vegetation and tectonic uplift of the Attock - Cherat range and the preparation of a thick layer of weathered debris.
- k. The drainage of the lake and the exposure of siltstone on the surface. and its subsequent erosion.
- l. The decay of vegetation, due to the change of climate.
- m. The release of weathered material and its deposition in the foot of the Attock - Cherat

- range, forming alluvial fans, in an interstadial.
- n. The development of soil and growth of vegetation on the Attock - Cherat range.
 - o. Tectonic uplift of the Attock - Cherat range.
 - p. A phase of erosion and degradation of older fan-gravels by torrents.
 - q. The decay of vegetation on the Attock - Cherat range, the release of the weathered material and its deposition as alluvial fans i.e. the second phase of fan formation.
 - r. The deposition of loess in periglacial environment and its subsequent erosion.

5.10 SECTION 10

5.10.1 Field Description

The section is exposed along the western bank of Tangi torrent, 2 km north of Tangi village (GR U040818). This is one of the few sections that show the carving of deep and wide torrent channels in the sand and siltstone and their subsequent filling with fan-gravels. The following beds are exposed in the section (Fig. 5.10.1).

Bed a:

the lower bed is composed of 5 m thick deposit of gray (2.5Y 6/0) sand. The material is loose, fine to medium in size, in which horizontal layers, about 15 cm thick, can be seen. Occasional small-sized, rounded, white gravels are also incorporated in the bed. It contains small burrows, about a cm in diameter. Erosional unconformity is not clear in the bed.

Bed b:

It is composed of 8 m thick deposit pale-yellow (5y 7/4), bedded siltstone. There are three layers of light-gray (5y 7/2) sandy silt in the deposit. Occasionally, there can be seen small quartzite gravels in the sandy layers. The material is also exposed on the surface, in small isolated patches. The irregular



Plate 5.10.1

Section 10

topography and deep channels cut in the bed shows a long phase of degradation of the material.

Bed c:

The bed is composed of dark-brown torrent gravels, 11 m thick. They are largely derived from sandstone formation of the Attock - Cherat range, but occasional boulders and gravels of foreign origin can also be seen. The gravels are deposited in a channel, cut in bed a and b. Faint beddings can also be observed. The gravels are also exposed on the surface, forming low hillocks. Irregular topography shows that the bed has passed through a long phase of degradation, and can be correlated with the bed d of section no 9, i.e. the older phase of fan formation.

5.10.2 Laboratory Examination

5.10.2.1 Texture

Bed a:

The material ranges in size from 0.02 mm (medium silt) to 2.00 mm (very coarse sand). It is composed of 2% medium silt, 6% coarse silt, 10% very fine sand, 30% fine sand, 34% medium sand, 16% coarse and 2% very coarse sand (Fig. 5.10,2). The deposit is predominantly fine to medium sand. The average grain size i.e. the mean of the sand is 2.8ϕ (0.149 mm). The co-efficient of sorting shows that the

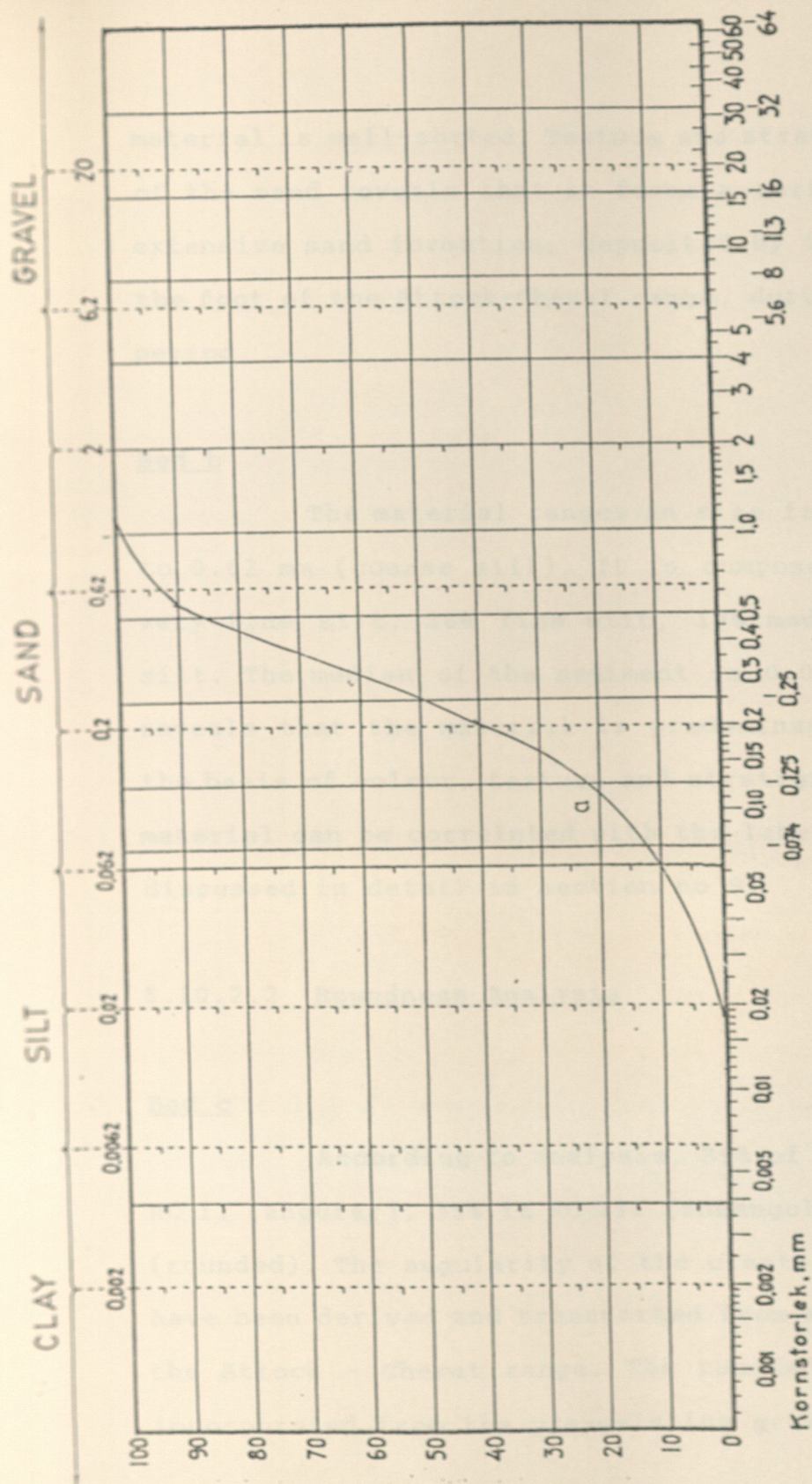


FIGURE 5.10.2

PARTICLE SIZE DISTRIBUTION

material is well-sorted. Texture and stratigraphic position of the sand reveals that it forms a part of the thick and extensive sand formation, deposited by the Kabul river at the foot of the Attock-Cherat range, during the Pleistocene period.

Bed b

The material ranges in size from 0.002 mm (clay) to 0.62 mm (coarse silt). It is composed of 3% clay, 34% very fine silt, 36% fine silt, 18% medium and 9% coarse silt. The median of the sediment is 0.01 mm. The analysis reveals that the material is predominantly fine silt. On the basis of colour, texture and stratigraphic position the material can be correlated with the lake deposits of bed c, discussed in detail in section no 9.

5.10.2.2 Roundness Analysis

Bed c

According to analysis, 39% of the gravels fall in RC II (angular), 58% in RC III (subangular) and 3% in RC 9, (rounded). The angularity of the clasts indicate that they have been derived and transported from a nearby source i.e. the Attock - Cherat range. The rounded gravels have been incorporated from the pre-existing gravels in the area.

5.10.3 Discussion

Colour, texture, stratigraphic position, occasional river gravels, incorporated in the sand and its proximity to the sand deposit, discussed in section no. 9, bed b, shows that the sand in bed a is a part of the sandstone formation, deposited by the Kabul river in the foot of the Attock - Cherat range, during the Pleistocene period. The details of sedimentary texture, mineral composition and environment of deposition have been discussed in section no 9. The siltstone overlying the sand bed, seems to have been deposited in lacustrine environment. The thickness of the bed shows a long phase of deposition. On the basis of colour, texture and stratigraphic position, the material can be correlated with the siltstone of bed c, discussed in detail in section no.9.

The channel cut in the silt and sandstone shows a phase of erosion. It seems that the Attock - Cherat range was covered by vegetation, when the valley was occupied by a lake and even after the lake was drained away. The torrents emerging from the mountain range were devoid of their load. The area was also tectonically active. Due to slow tectonic uplift and lack of sediments, the torrents were incised. Such an incised channel can be seen in the section under discussion.

Due to the growth of vegetation, a thick zone of

weathered material was prepared on the Attock - Cherat range. With a change of climate to warm and dry, the vegetation cover decayed on the mountains and the weathered material was released with torrential rains. It was deposited in the form of alluvial fans at the foothills. All the existing torrent channels, seem to have been filled by fan-gravels. The erosion of the Attock - Cherat mountains, and the subsequent formation of alluvial fans, may have also been complemented by the recurring orogeny of the mountain range.

The gravels are exposed on the surface as low hillocks, forming an undulating topography. It shows the ceasing of weathered material on the mountain range and the rejuvenation of torrents. It resulted in the removal of fan-gravels, from over a considerable part of the area, degrading it in the other parts, producing an irregular topography of low hillocks, composed of fan-gravels, over a large part in the southern vale of Peshawar. The fan-gravels have been deposited after the episode of tectonic disturbance in late Quaternary i.e. after 0.6 m.y. and before the accumulation of loess i.e. 135 ka.

5.10.4 Summary of important events, recorded in the section.

- a. The deposition of sand by river during the Pleistocene.

- b. Sedimentation of silt in the lake, forming bed b.
- c. The growth of vegetation on the Attock - Cherat range, and preparation of thick layer of weathered debris.
- e. The cutting of deep torrent channels in the silt and underlying sand.
- f. Decay of forests due to a change of climate.
- g. The release of weathered material with torrential rains, formation of alluvial fans, and the filling of channels cut by torrents.

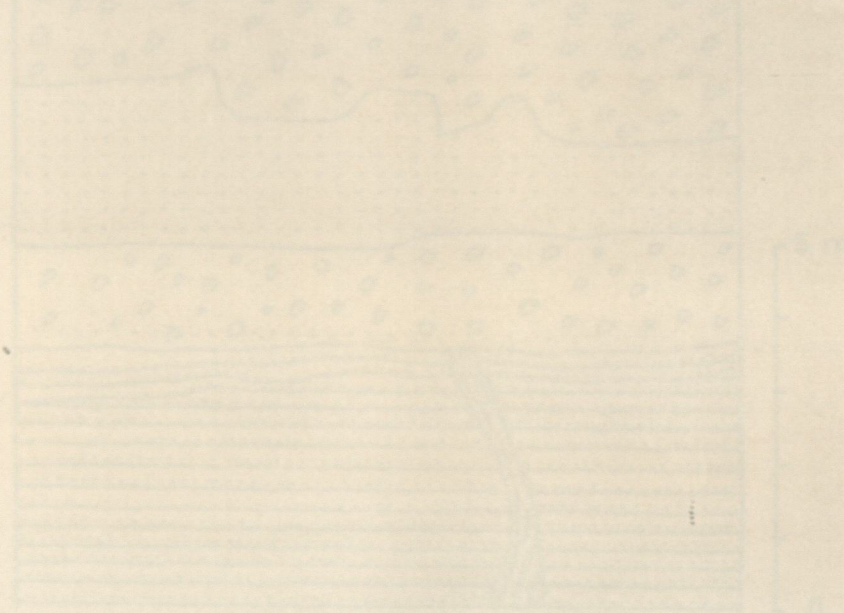


Figure 5.1.1

SECTION 11

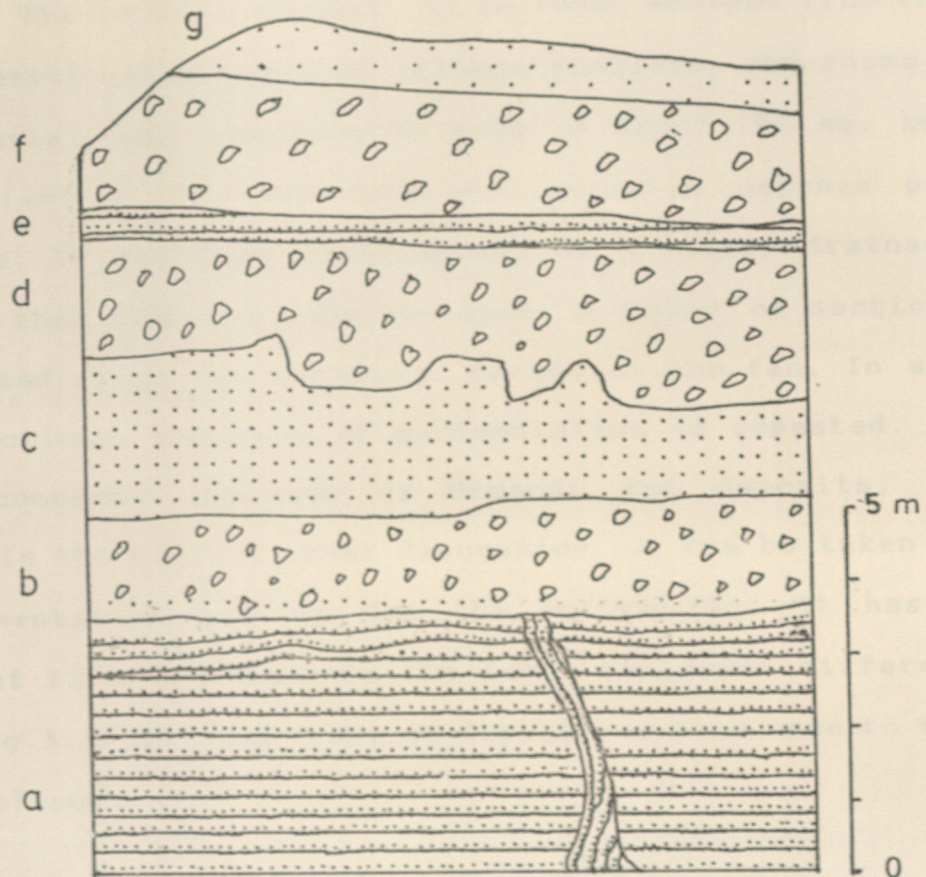


Figure 5.11.1

5.II SECTION II

5.II.I Field Description

The section is exposed along the western bank of Urmandi torrent (GR T993854), two kilometre south of G.T.road. The torrent channel, 15 km long, emerges from the Attock-Cherat range, east of village-Khaisare, and forms a huge alluvial fan, covering an area of about 150 sq. km. The gradient of the fan does not exceed 8 degrees per kilometre. It has been superimposed by a radial drainage pattern, that radiates from the apex. A number of sections are exposed along the torrents, formed on the fan. In all these sections, sequence of sedimentation is repeated. An almost complete sequence of Urmandi fan deposits, is exposed in the section under discussion. It can be taken as a representative section for the entire fan. It has a height of 12 m from base to the top, with seven different beds (Fig.5.11.1). The order of deposition from base to top is as follows:

Bed_a (siltstone)

The bed, forming a terrace, consists of pale-yellow (2.5Y 7/4), very hard calcareous siltstone, with a maximum thickness of 3 m. It contains horizontal, vertical and oblique dykes. The material is also exposed in form of small isolated patches, all along the bed of Urmandi



Plate 5.11.1 Section 11

torrent channel. In certain parts, it incorporates the impressions of fossilised organisms. The bed has a very conspicuous unconformity.

Bed b

The bed consists of a metre thick deposit of sub-angular to sub-rounded, dark-gray, locally derived, sandstone gravels. Pale yellow siltstone balls of gravel and boulder-size can also be seen in it. There is 15 cm thick layer of gray sand in the material. Mass wasting frequently occurs along the section, that has covered most of the torrent gravels in the bed. The bed has also a marked erosional unconformity.

Bed c

The bed is composed of 3 m thick deposit of loose and coarse, light olive-gray sand, that contains 3% calcium carbonate. Small circular holes, about a centimetre in diameter, and fossilised roots can also be seen in the material. There is also 15 cm thick layer of locally derived sandstone gravels in the centre of the bed. The bed can be traced about 2 km downstream, as far as Kabul river. There is a marked erosional unconformity in the deposit.

Bed d

It is a bed, 2 m thick, composed of locally

derived sandstone gravels. It looks brownish, as compared to the other torrent gravels beds in the section. It also contains lenses of pale brown silt.

Bed e

There is a metre thick deposit of light-gray to pale-yellow (2.5Y 7/2 - 2.5y 7/4) siltstone, overlying the torrent gravels. There are layers of sandy and silty material in the bed, 15 cm in thickness. It has 14% calcium carbonate content. The material in the bed is hard and compact, but the silty layers are harder than the sandy one. The bed attains a maximum thickness of 5 m, as one traces it downstream in the torrent channel. It has a prominent erosional unconformity.

Bed f:

The bed consists of 2 m thick deposit of angular to sub-angular, dark-gray sandstone gravels. It gives a faint impression of layers. The material is also exposed on the surface, where the overlying loess is eroded. Shallow gullies, are developed in the material.

Bed g:

The bed is composed a meter thick deposit of structureless, pale-brown (10YR 6//3) silt. There is a lot of calcium carbonate concretions in the bed, while the

black coating of lichen has developed on the surface. The material also forms surface deposit over a wide area in the vicinity of the section.

5.11.2 Laboratory Examination

5.11.2.1 Texture

Bed a:

The material ranges in size from 0.0015 mm (clay) to 0.062 mm (coarse silt). It is composed of 17% clay, 18% very fine silt, 24% fine silt, 27% medium and 14% coarse silt. The material is predominantly fine to medium silt. The average grain size i.e. the mean and median of the material are 6.3 ϕ (0.0256 mm) and 6.0 ϕ (0.0156 mm) respectively (Fig. 5.11.2).

Bed c:

The sediment is composed of 8% very fine sand, 50% fine sand, 35% medium sand, 5% coarse and 2% very coarse sand. The mean and median of the material are 2.08 ϕ (0.24 mm) and 2.25 ϕ (0.22mm) respectively. The material is very well - sorted and fine - skewed. It shows that the sand has undergone extensive reworking under moderate energy conditions, before final deposition.

Bed c:

The material has a lower size limit of 0.002 mm

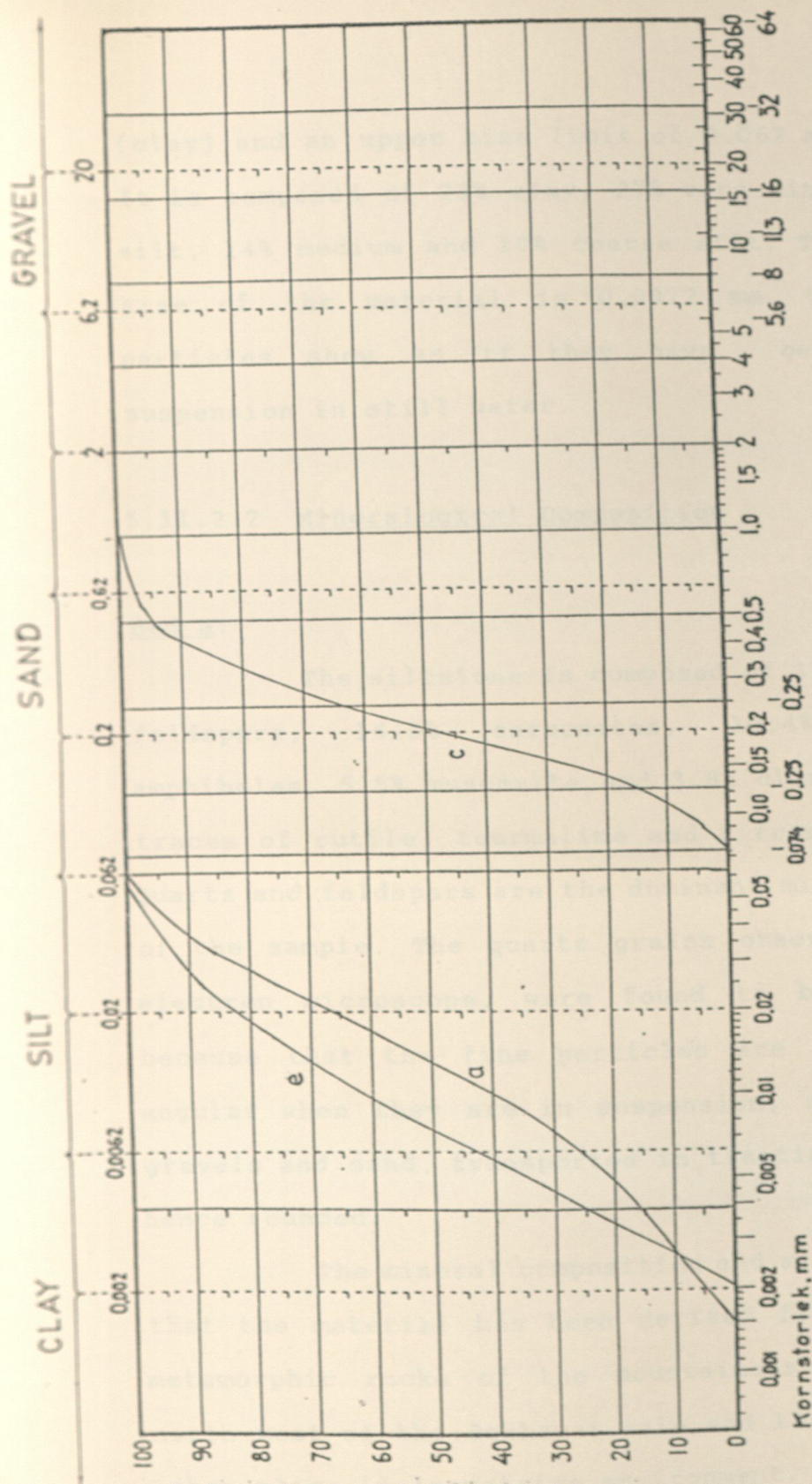


FIGURE 5.11.2

PARTICLE SIZE DISTRIBUTION

(clay) and an upper size limit of 0.062 mm (coarse silt). It is composed of 23% clay, 27% very fine silt, 26% fine silt, 14% medium and 10% coarse silt. The average grain size of the material is 0.0072 mm. The size of the particles show as if they have been settled from suspension in still water.

5.11.2.2 Mineralogical Composition

Bed a:

The siltstone is composed of 32.7% quartz, 24.4% feldspars, 16.3% carbonates, 10.4% biotite, 6.5% amphiboles, 5.5% muscovite and 3.8% clays. There are also traces of rutile, tourmaline and zircon in the material. Quartz and feldspars are the dominant mineral constituents of the sample. The quartz grains observed with scanning electron microscope, were found to be angular. It is because that the fine particles are comparatively more angular when they are in suspension, as compared to the gravels and sand, transported in traction or saltation and hence rounded.

The mineral composition and size analysis suggest that the material has been derived from the igneous and metamorphic rocks of the mountainous region, north and north-west of the Peshawar vale and the sedimentation has taken place in lacustrine environment.

Bed e:

The material is composed of 26.7% feldspars, 21.9% quartz, 14.4% carbonates, 12.5% biotite, 11.9% clays, 8.2% amphiboles, 3.1% opaque and 0.5% rutile. There are also traces of tourmaline, zircon, epidote and chlorite.

As compared to the mineralogical composition of bed a, the composition in bed b is dominated by feldspars, followed by quartz. It reveals that the ultimate sources of the material are the plutonic granitoid, quartzo-feldspatic gneisses and schist in the northern mountainous region, where it has been derived during the glacial phases of the Pleistocene period, and was deposited in form of moraines in the valleys. In subsequent phases, it was transported by rivers and wind and was deposited in a lacustrine environment.

5.11.3 Discussion

Textural and mineralogical characteristics of the sediments in bed a are similar to the lacustrine sediments, discussed in bed b and e of section no I, bed c of section no 3, bed c of section nos 4 and 5, bed b of section no 6, bed a of section no 7 and bed c of section no 9. It reveals that the material has been deposited in the lacustrine environment, discussed in detail in the above sections. The presence of dykes show that the bed has been disturbed by tectonics during mid-to-late Pleistocene period.

The gravelly bed b represents a shallow torrent channel, carved in the siltstone, where the gravels brought down from the south, have been deposited. It reveals that the lacustrine facies in bed a was exposed on the surface and passed through a phase of degradation, after the lake was drained. Torrent channels seem to have been incised in the siltstone, all over the area, due to the lack of sediments in the torrents.

It appears that after the draining of lake, a branch of the Kabul river was flowing near to its present course, north of the section under discussion. The sand in bed c may have been deposited by overbank flood water of the Kabul river. Erosional unconformity shows that the sand passed through a phase of erosion by torrents.

The brownish gravelly bed d forms a part of the alluvial fan, that extended from the Attock-Cherat range as far as Kabul river. It is only in Wurmando torrent channel that a bed of fan gravels, is exposed below the siltstone of the second phase of lake formation. The origin and causes of the fan formation have been discussed in detail in section nos 9 and 10. The gravel's bed can be traced to the south as well as north. The thickness of the bed increases in the south, until it reaches a maximum of 9 m in the vicinity of Manki-Sharif. Towards north, there is a gradual decrease in its thickness, till it disappears completely near the Kabul river.

Grain size distribution, sedimentary structure and mineralogical composition of the sediments in bed e suggests that the material was deposited as lacustrine facies. It shows a second phase of lake formation in the valley. The origin and causes of lacustrine environment have been discussed in detail in section nos. 3,4,5,7 and 9.

The bed f, composed of fan-gravels, is a part of the youngest fan that covers a considerable part of the study area. It increases in thickness towards south i.e. the apex of the fan. Due to its stratigraphic position, widespread distribution and preservation, it can be very easily correlated in various sections. It has been correlated with bed e of section nos. 6 and 9. The origin and causes of the fan-formation have been discussed in the sections, mentioned above. Bed f, exposed also on the surface has been dissected by numerous gullies, showing a phase of degradation. The featureless, pale-brown silt in bed g, with limestone concretions, appears to have been deposited by wind in periglacial environment. A detailed account of the loess has been given in section nos. 13 and 14.

5.11.4 Summary of the important events recorded in the section

- a. The formation of lake in Peshawar valley and the

- deposition of siltstone. *loess in periglacial*
- b. The formation of dykes in the siltstone due to tectonics. *on of loess and underlying beds, and the*
 - c. Draining of lake and the exposition of siltstone on the surface.
 - d. A phase of degradation of the siltstone, carving of torrent channels and their subsequent filling by fan-gravels.
 - e. A phase of degradation of the torrent gravels in bed b.
 - f. The formation of floodplain by the Kabul river and the deposition of sand.
 - g. The erosion of sand.
 - h. Another phase of fan formation and deposition of the fan-gravels, forming bed d.
 - i. Second phase of lake formation in the valley and the sedimentation of siltstone, forming bed e.
 - j. Draining of the lake and exposition of siltstone on the surface.
 - k. A long phase of degradation of siltstone in bed e, forming a rough and irregular topography.
 - l. Deposition of torrent gravels during the third phase of fan formation, and the covering of pre-existing irregular topography by fan-gravels.
 - m. The degradation of fan-gravels and development of gullies on the surface of the deposit.

- n. The deposition of loess in periglacial environment.
- o. The erosion of loess and underlying beds, and the formation of broad and deep torrent channels in the area.

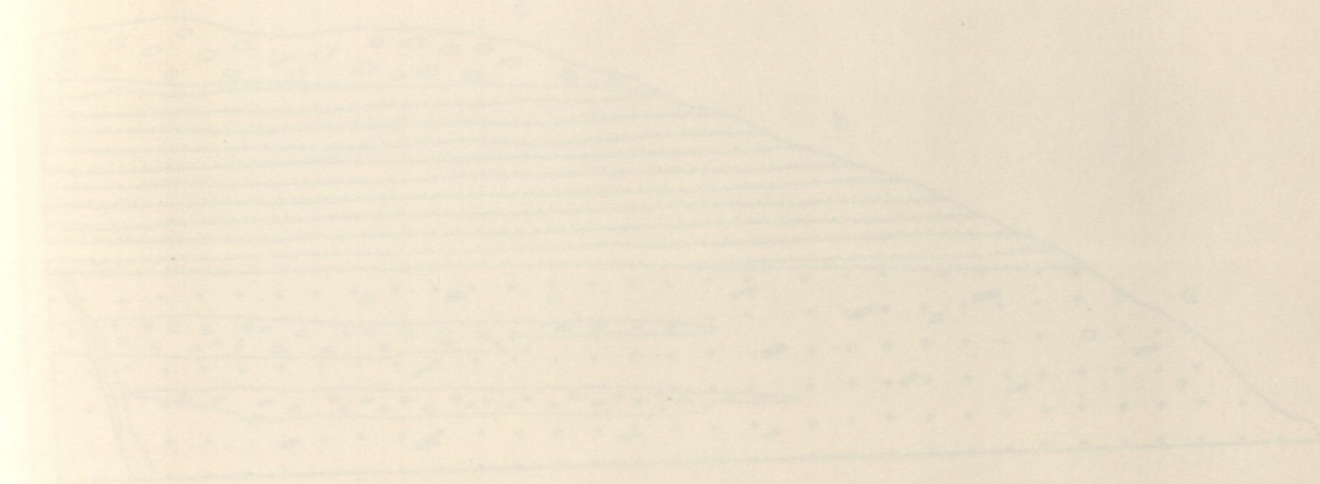


Figure 5.12.1

Figure 5.12.1

SECTION 12

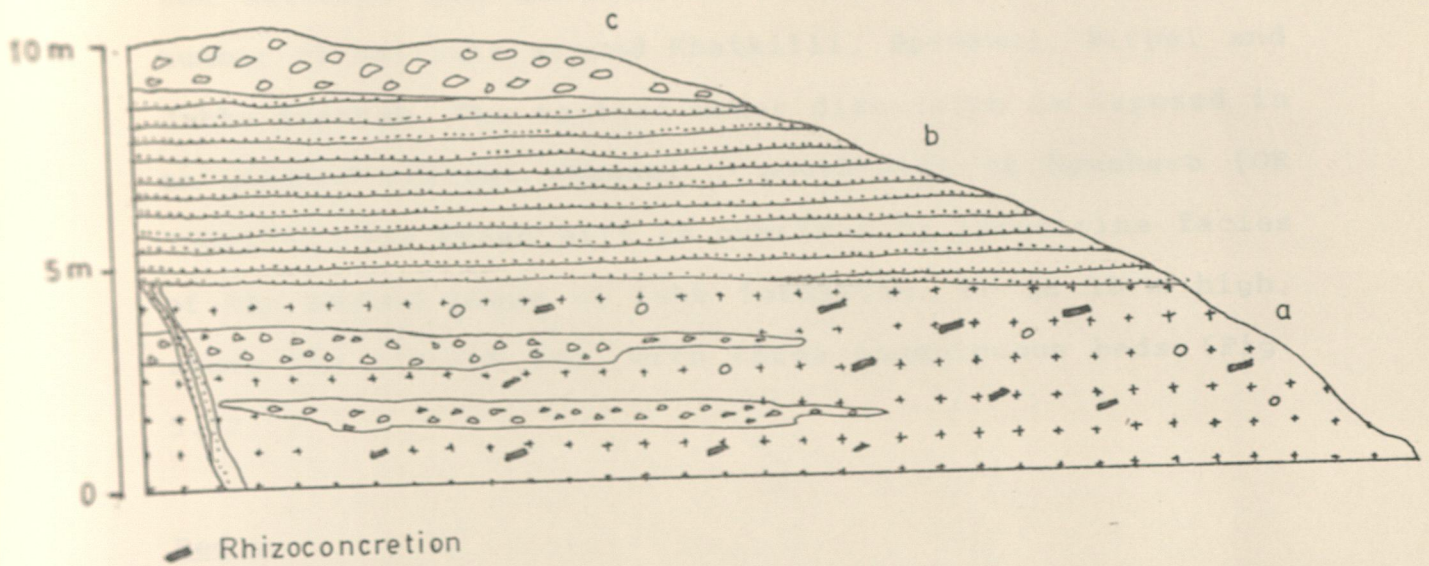


Figure 5.12.1

5.12 SECTION 12

5.12.1 Field Description

Red brown clayey silt is exposed in a number of sections all over the study area. It can be examined in the vicinity of Walai, Tangi and Manki, but good exposures of the material can be seen in Warmondo torrent and in a number of torrents around Khatkilli, Spinkani, Pirpai and Jabba Khattak. The section under discussion is exposed in an unnamed torrent channel, south-west of Nowshera (GR T993877). The brown silt is overlain by lacustrine facies of the second phase of lake formation. It is 10 m high, above the torrent bed, with three conspicuous beds (Fig. 5.12.1).

Bed a

The bed consists of 4 m thick, featureless and massive deposit of brown silt (7.5YR 5/4). It is hard but can be broken with hammer. There are root traces, minute fragments of sandstone and few badly weathered quartz and quartzite gravels, incorporated in the bed. Five to ten cm thick, vertical and oblique dykes of pale-yellow siltstone can be seen in the bed. It contains a lot of limestone concretions, and has 18% calcium carbonate content. Lenses of fine torrent gravels can also be seen. A number of rhizoconcretions (fossilised parts of the branches of



Plate 5.12.1 Section 12

plants) have been extracted from the deposit, indicating vegetation cover and development of soil (Pl. 5.12.2). The siltstone grains as evident from the scanning electron micrograph (Pl. 5.12.3) are generally sub-rounded, with dispersed fine silt and clay particles adhering to most of the surface. The bed shows a conformable contact with the overlying siltstone bed.

Bed b:

The bed is composed of 4 m thick deposit of pale-yellow (2.5Y 7/4) siltstone, showing 8 to 10 cm thick horizontal layers. Vertical dykes and small circular holes (one to four millimetre in diameter) can also be seen. It contains 14% calcium carbonate. A black coating of lichen has developed on the siltstone. The bed is hard and compact, and can only be scratched with hammer. The bed also shows a marked erosional unconformity.

Bed c:

A 2 m thick bed of sub-angular, dark-gray sandstone gravels, overlies bed b. The material has been derived from the Attock - cherat range, forming part of the youngest fan, discussed in section no.11. Thin horizontal layers can also be seen in the bed. The material is also exposed on the surface. As a result of the development of gullies, it shows a rough topography.

5.12.2 Laboratory Examination

5.12.2.1 Texture

Bed a:

The material in bed a has a minimum size limit of 0.0016 mm (clay), and maximum limit of 0.05 mm (coarse silt). It is composed of 15% clays, 25% very fine silt, 20% fine silt, 27% medium and 13% coarse silt. The material is predominantly fine to medium silt (Fig. 5.12.2).

Bed b:

The material ranges in size from 0.0015 mm (clay) to 0.062 mm (coarse silt). It is composed of 17% clay, 20% very fine silt, 25% fine silt, 28% medium and 10% coarse silt. The material is predominantly, very fine to medium silt. Size of the grains suggest that the sediment was deposited in still water environment, due to settling from suspension.

5.12.2.2 Mineralogical Composition

Bed a:

The material is composed of 24% quartz, 18% feldspars, 18% carbonates, 10% clays. 6% amphiboles, 5% biotite, 5% muscovite 4% opaque, 3% hematite, 3% chlorite, 2% limonite and 1% rutile. There are also traces of garnet, tourmaline, sillimanite and staurolite in the sample. Mineralogical

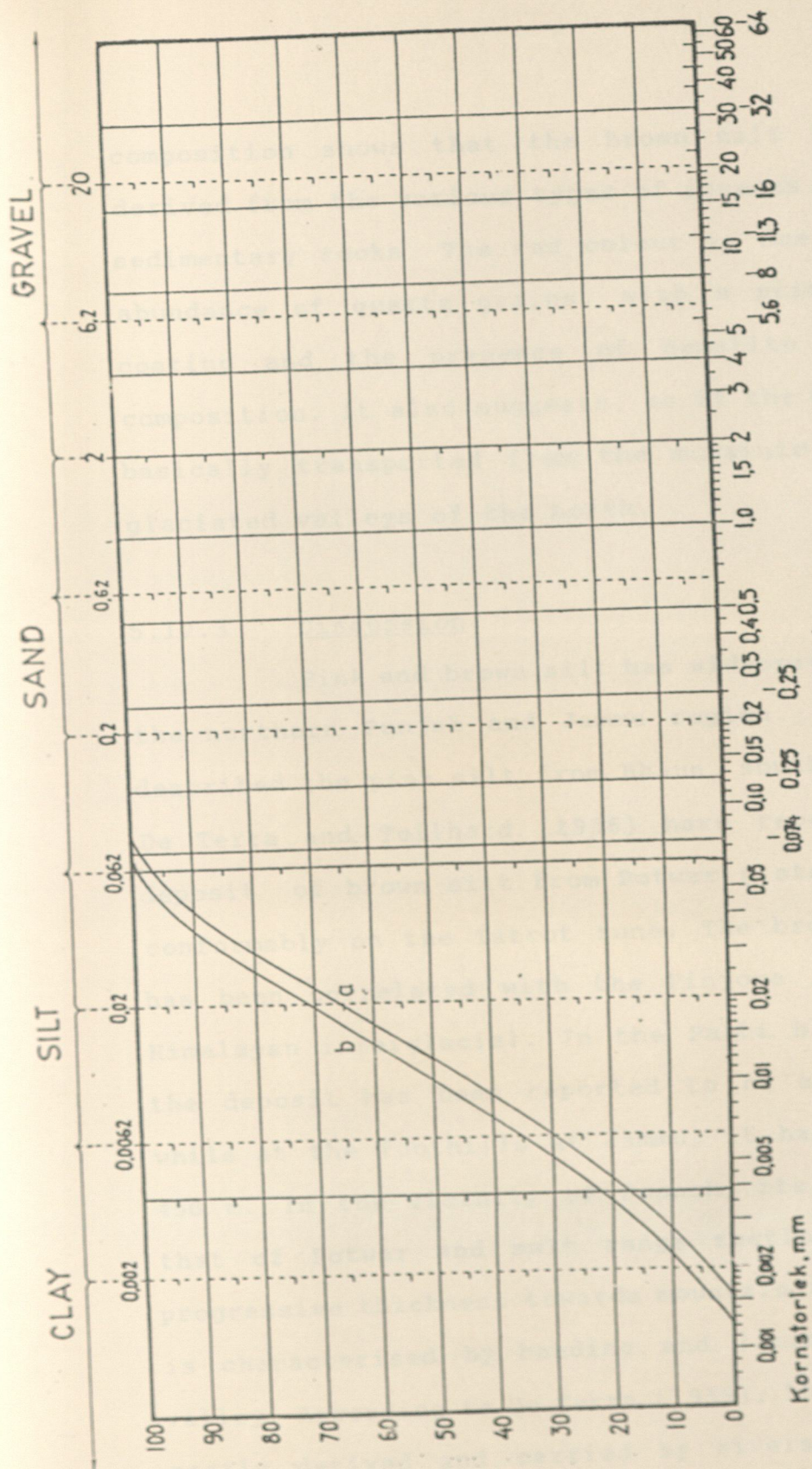


FIGURE 5.12.2

PARTICLE SIZE DISTRIBUTION

composition shows that the brown silt has been mainly derived from the various types of igneous, metamorphic and sedimentary rocks. The red colour is due, mainly, to the abundance of quartz grains, with a primary iron oxide, coating and the presence of hematite in the mineral composition. It also suggests, as if the material has been basically transported from the morainic material of the glaciated valleys of the north.

5.12.3 Discussion

Pink and brown silt has widespread distribution in the northern Punjab and Jammu region. Cotter (1933) has described the pink silt from Bhaun, south-west of Chakwal. De Terra and Teilhard (1936) have reported 280 m thick deposit of brown silt from Potwar plateau, where it lies conformably on the Tatrot zone. The brown silt of Potwar has been correlated with the Pinjore zone of the first Himalayan interglacial. In the Pabbi hills, near Jhelum, the deposit has been reported to be about 150 m thick, while at the foothills at Jammu, it has been measured as 450 m. In the vicinity of Poonch, its thickness exceeds that of Potwar and salt range sections, which shows a progressive thickness towards mountain front. The material is characterised by banding and lamination in the Soan valley. According to De Terra (1939), the material has been partly derived and carried by rivers from the glacial

deposits and partly from the plains of Punjab, by eolian drift. The red colour according to De Terra, is due mainly to the abundance of oxidised quartz grains. He has also correlated the deposits near Rawalpindi with the third ice advance.

Pink or brown silt has also been reported from various parts of the Peshawar valley. Allen (1963) and Dani (1964) both have reported that the lower parts of the younger and older loess, are reddened in the northern parts of the Peshawar valley, particularly, around the Sangao cave. According to Dani (1964), in few other places, the lower part of the older loess rests upon a well-defined red zone of lateritic soil. The red zone below the clay horizon is also preserved in the Sangao cave. He has also opined that if the lateritic zone represents the Penultimate (third) interglacial, it is from 400,000 to 600,000 years old, also representing a warm and moist climate. Said and Majid (1977) have described light-brown silt i.e. Razghay silt, from Bar Daman area, in the southern part of Peshawar valley. They have suggested that the material was produced due to the chemical weathering of the Azakhel siltstone in a warm and wet climate, forming A and B horizons of a weathering profile on the siltstone deposits. The formation was exposed to pedogenic processes in the same warm and wet phase, which resulted in the development of soil on the material. Rendell and Thomas (1980) have examined massive



Plate 5.12.2

Rhizoconcretion i.e. the fossilised Parts of plants,
recovered from siltstone

red siltstone bed in the vicinity of Takht-i-Bahi, in the central part of Peshawar valley. They have presumed that the red beds have developed *in situ* as a result of the oxidation of iron-bearing detrital grains under suitable condition of climate. Inam (1990) has also considered the brown silt of Babu Khwar to be a soil profile, developed in a warm and humid environment.

The upper parts of the red-brown silt under discussion appears to be redeposited older soils, as it contains a lot of fossil roots, root traces, and the lenses of fine gravels of local origin, with occasional river gravels. The red colour perhaps, indicates the development of soil in a warm humid climate. The basal portion of bed a consists of structureless, massive fine silt, abundant in calcium carbonate concretions. It appears as if the parent material of the soil includes bulk of the loess, blown from the flood-plains of the Kabul and the Indus rivers, as well as from the morainic material of the mountainous region, north and north-west of the valley, in a periglacial environment.

The vegetation, grown on the loess, covering the Attock - Cherat range and the valley, perished, with the change of climate from warm humid interglacial to very cold glacial phase, as it could not adapt itself to the changing environment. The soil was subjected to erosion by local torrents, from the slopes of the Attock - Cherat range and

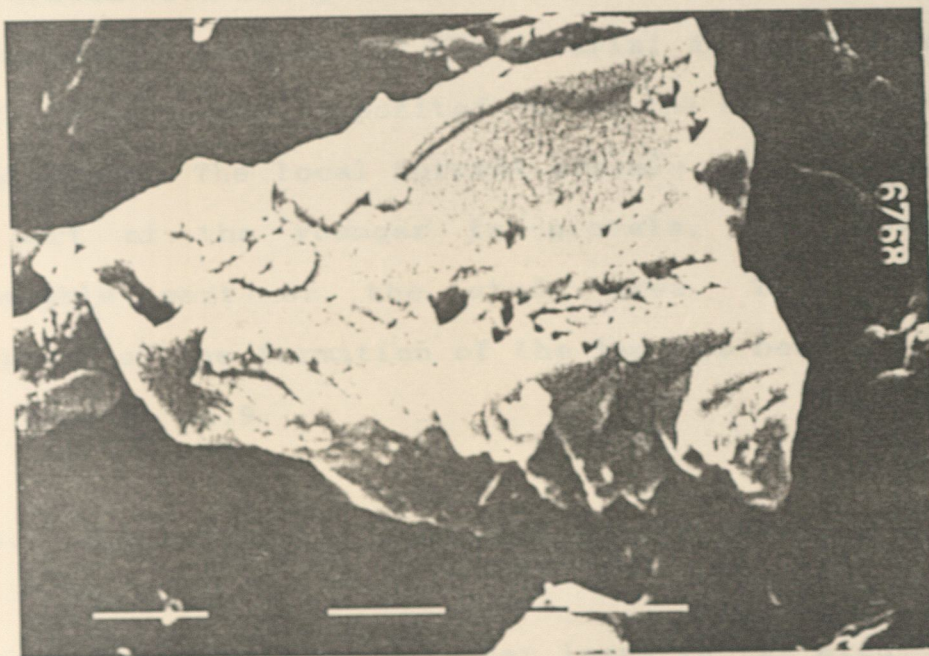


Plate 5.12.3

Micrograph of silt particle from bed a.

was redeposited on the pre-existing soil in the valley. Due to the removal of soil from over a considerable area in the south, the underlying old fan-gravels were exposed. All this has occurred prior to the late-Quaternary tectonic episode-about 0.6 m.y. ago.

On the basis of grain-size distribution, colour, sedimentary structure and stratigraphic position, bed b can be correlated with bed e in section no. 6, bed c in section no. 9 and bed e section II. The material in bed b forms a part of the sediments, deposited during the second phase of lake formation. The local torrent gravels, forming bed c, is a part of the younger fan-gravels, that cover a considerable part of the study area. The detailed description of the formation of the fan has been given in bed e, section no.9.

5.12.4. Summary of the important events recorded in the section

- a. The deposition of older loess in the area, in a periglacial environment.
- b. The development of soil profiles on the loess and the growth of vegetation, in a warm-humid interglacial climate.
- c. Change of climate from interglacial to very cold glacial. The decay of vegetation cover, and exposition of soil to erosion.

- d. The removal of soil from over a considerable area in the foothills of the Attock-Cherat range and its deposition in the vicinity of present-day villages of Khatkilli, Amangarh, Pirpai, and Azakhel.
- e. The formation of lake in the valley and sedimentation of siltstone in the lake, forming bed b.
- f. The draining of lake and exposition of siltstone.
- g. The degradation of siltstone.
- h. The deposition of fan-gravels on siltstone.
- i. The erosion of fan gravels, and the development of gullies and torrent channels.

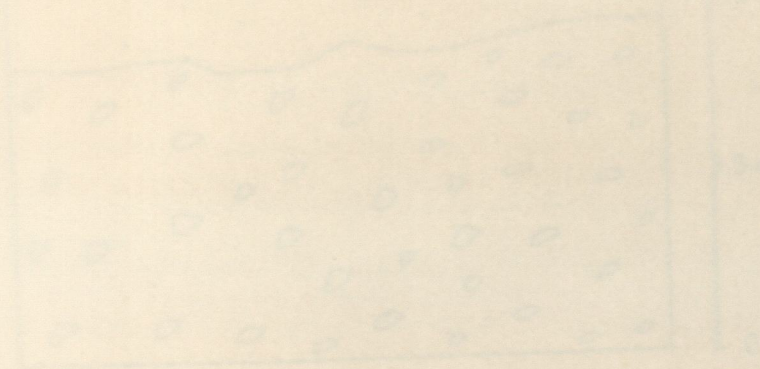


Figure 5.133

SECTION 13

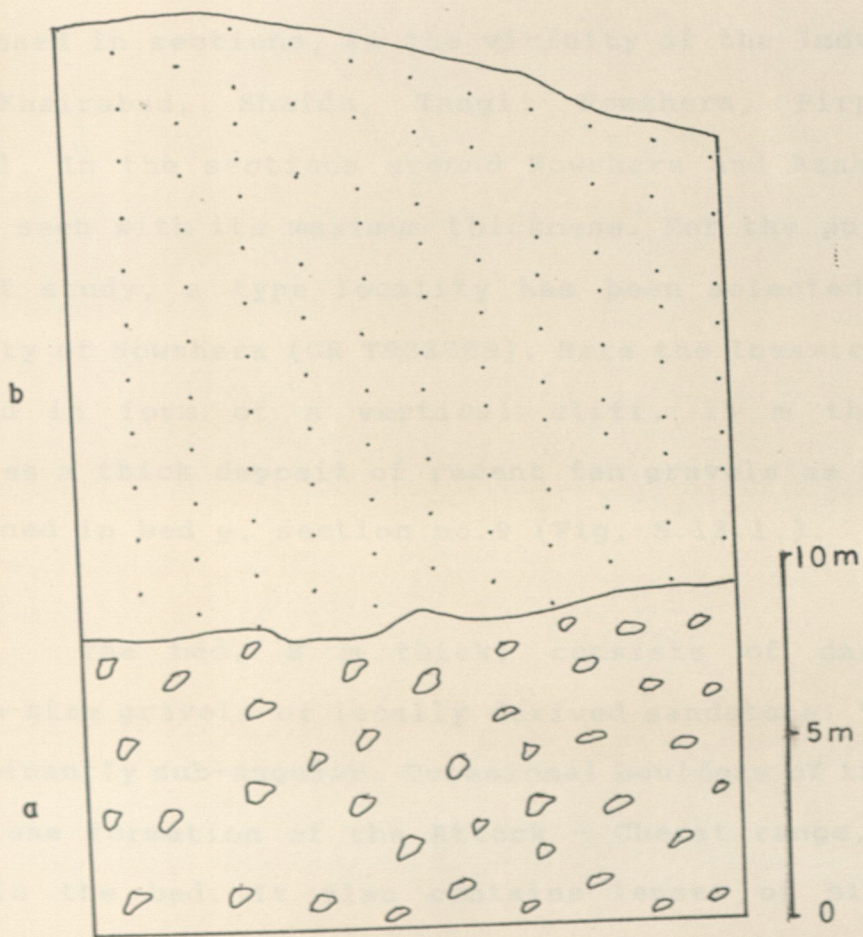


Figure 5.13.1

5.13 SECTION 13

5.13.1 Field Description

One of the most important feature of the geomorphology of the Peshawar valley is a thick mantle of pale-brown (IOYR 6/3), clayey silt of variable thickness, that covers a considerable part of the area. The material is exposed in sections, in the vicinity of the Indus river near Khairabad, Shaidu, Tangi, Nowshera, Pirpai and Azakhel. In the sections around Nowshera and Azakhel, it can be seen with its maximum thickness. For the purpose of present study, a type locality has been selected in the vicinity of Nowshera (GR T988889). Here the loessic silt is exposed in form of a vertical cliff, 15 m thick. It overlies a thick deposit of recent fan gravels as has been mentioned in bed e, section no.9 (Fig. 5.13.1.).

Bed a:

The bed, 8 m thick, consists of dark-gray, medium-size gravels of locally derived sandstone. They are predominantly sub-angular. Occasional boulders of the local sandstone formation of the Attock - Cherat range, can be seen in the bed. It also contains lenses of silt. The gravels can be easily detached with fingers.

Bed b: (Loessic Silt)

The bed consists of featureless pale-brown (IOYR



Plate 5.13.1 Section 13

Thick deposit of sand, south-west of Soudan.



Plate 5.13.1a

Thick deposit of loess, south-west of Nowshera.

6/3), calcareous clayey silt, having 32% calcium carbonates. The deposit contains a lot of calcareous nodules. It has a maximum thickness of 15 m. Due to erosion, vertical columns have been formed in the bed. Thin coating of lichen gives a black appearance to the deposit in sections as well as on the surface. A number of gastropods (snails) have been recovered from the material. Pollen grain or diatom have not been recovered from the bed. The material is also exposed on the surface, forming badland topography.

5.13.2 Laboratory Examination

5.13.2.1 Texture

Bed b:

The material ranges in size from 0.0013 mm (clay) to 0.062 mm (coarse silt). It is composed of 10% clay, 10% very fine silt, 15% fine silt, 42% medium and 23% coarse silt. The average grain size is 0.02 mm, showing that the material is predominantly medium silt (Fig. 5.13.2.).

5.13.2.2 Mineralogical Composition

The material is composed of 32.7% carbonates, 28.17% quartz, 18.13% feldspars, 4.7% clays, 8.1% biotite, 3.3% muscovite, 2.0% amphiboles and 1.2% opaque. There are also traces of chlorite, hornblende, tourmaline, staurolite, zircon and epidote. A high variation in the

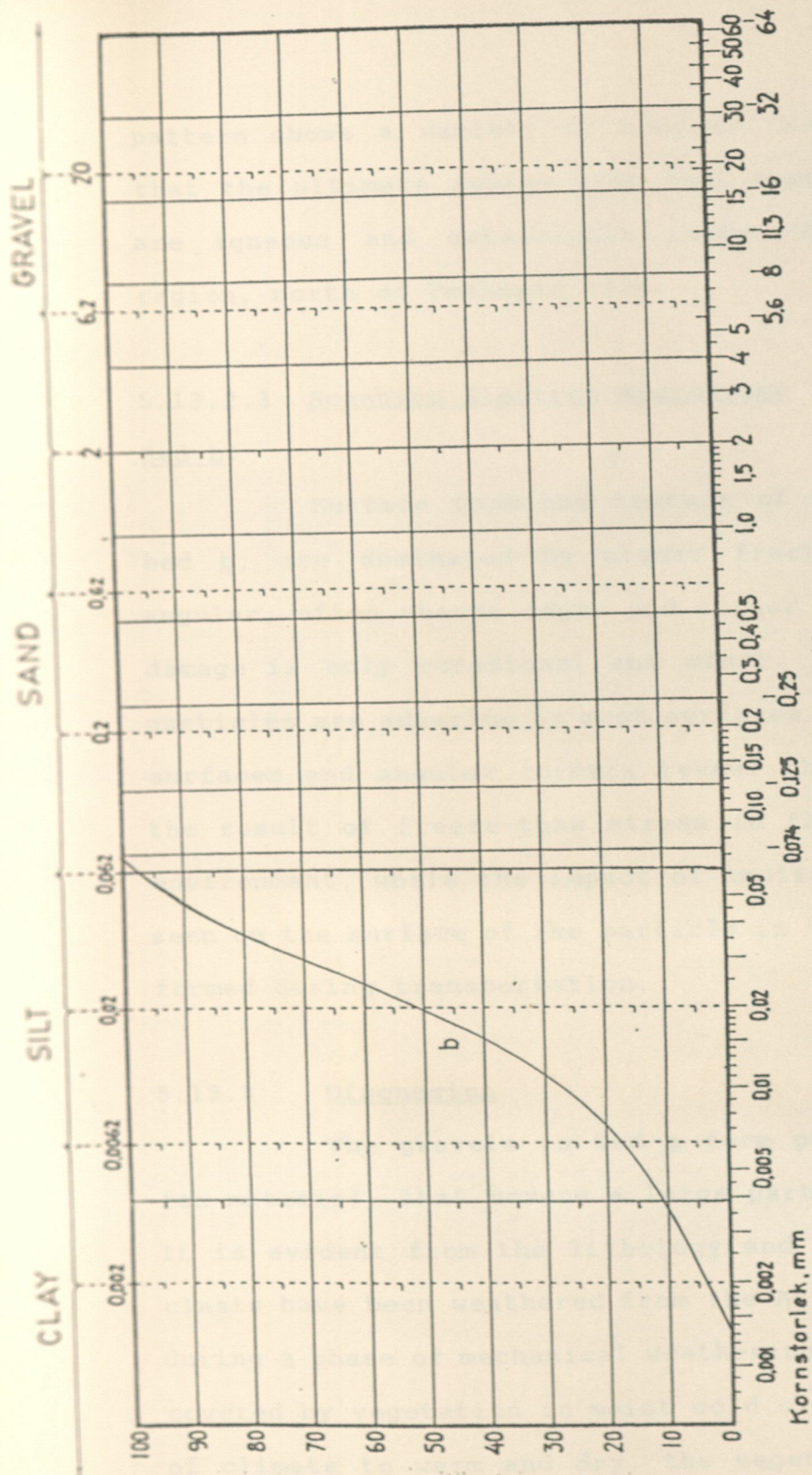


FIGURE 5.13.2

PARTICLE SIZE DISTRIBUTION

pattern shows a variety of sources. However, it reveals that the ultimate source area that supplied the material are igneous and metamorphic rocks of the mountainous region, north of Peshawar vale.

5.13.2.3 Scanning Electron Microscopy

Bed b:

Surface form and texture of the particles from bed b, are dominated by planar fracture surface, with angular, often sharpe edges and corner (pl. 5.13.2). Edge damage is only occasional and minor. Fine silt and clay particles are adhering to most surfaces of the silt. Planar surfaces and angular corners reveal that the silt may be the result of freeze-thaw stress in the cold mountainous environment, while the impact of aeolian transport can be seen on the surface of the particle in the form of grooves, formed during transportation.

5.13.3 Discussion

The gravels in bed a form part of the youngest fan material, that covers a large part of the study area. It is evident from the lithology and angularity that the clasts have been weathered from the Attock - cherat range, during a phase of mechanical weathering, when the range was covered by vegetation in moist cold climate. With a change of climate to warm and dry, the vegetation cover decayed

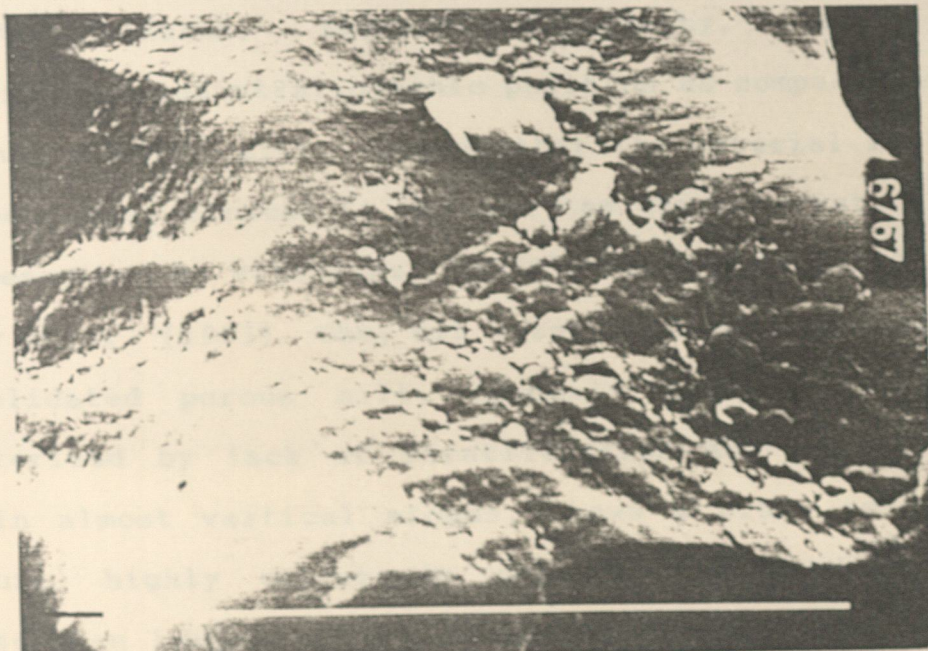


Plate 5.13.2
Micrograph of loess particle

and the weathered material was exposed to erosion by torrential rains. The material was carried down and deposited as alluvial fans, that extended from mountain range as far as Kabul river, and even beyond in certain localities.

All the available field and laboratory evidence like buff colour, narrow size range in silt region, calcium carbonate nodules, badland topography, lack of stratification and stratigraphic position as compared with the Potwar loessic silt, suggest that the material in bed b may be loess, because it has all the characteristics of loess described by Vita-Finzi (1968), Pettijhon (1975) and Smalley et al. (1983). They all agree that the loess is an unconsolidated porous silt, commonly buff in colour, characterised by lack of stratification and ability to stand in almost vertical slopes, shows a crude columnar structure, highly calcareous and has the tendency to collapse when loaded and wetted and mantle the landscape.

South-east of the Peshawar valley, a similar thick mantle of pale-yellow loessic silt covers the Potwar plateau, the foothills of Poonch and Jammu, the slopes of Pabbi hills near Jhelum and the lake basins of Central Salt Range. (De Terra et al. 1939). They have correlated the Potwar loessic silt with the third moraine in Kashmir and concluded that the loess has been deposited during the third Himalayan glacial phase. On the basis of field

characteristics and stratigraphic position, the loessic silt of Peshawar valley can be correlated with that of the Potwar.

Loess has been reported by many workers from Peshawar valley. In Mardan and Sangao area of the Peshawar basin, younger and older loess deposits have been mentioned by Allen (1963) and Dani (1964). According to Dani, the younger loess of the Mardan region can be correlated with the thick deposits of Campbellpore (Attock), and represents the cool and relatively dry period of Steppe climate during the last glaciation. It has been suggested that it was deposited from 15000 to 50,000 year b.p. The older loess also represents a cool dry glacial period with steppe climate, with probable date of deposition from 250,000 to 400,000 year during the Penultimate (Riss) glaciation. Said and Majid (1977) have reported loess from Bar Daman area of the southern part of Peshawar valley. The deposit has been correlated with the late cold phase of third glaciation. The origin of loess has been attributed to the glaciated area of the Himalaya and Hindukush. Rendell and Brighton (1988) have dated the youngest loess of the Peshawar valley by thermoluminescence (TL) dating technique. The sample was collected in the vicinity of Nowshera. It yielded ages of 20-22 ka, while the dates from the base of the loess section, gives a range of 48 - 132 ka. The dominant phase of loess accumulation in the Potwar and Peshawar area dates

to between 65 ka to 20 ka. The estimated rate of loess deposition varies greatly over the study area from 6-8 cm ka to as much as 27 cm/ka. Previously the loess deposition has been associated with the third glacial phase but the new dates reveal that the loess supply was more or less continuous process from 135 ka b.p. until 20 ka b.p. Inam (1990) has described loess from many sections, south of the Kabul river in Peshawar valley. He has suggested warm and dry climatic conditions for the deposition of loess, during an interglacial phase.

Mineralogical composition of loess shows that the bulk of the deposit of Peshawar valley was produced by glacial grinding during the Pleistocene period in the glaciated valleys of the Himalayas, Karakoram and Hindukush. Production of loess in cold mountainous environment is a continuous process, where frost action produces it in limited amount even in the present-day environment.

The weathered material, prepared, was transported first by glaciers and then by Kabul, Indus and Swat rivers, and deposited in the flood-plain of the Peshawar basin. This seems to have occurred in a cold glacial phase. It was followed by the deflation of silt and clay particles from the floodplain and its redeposition as loess. A significant amount of the material may have been picked and transported by wind, from the morainic material of the

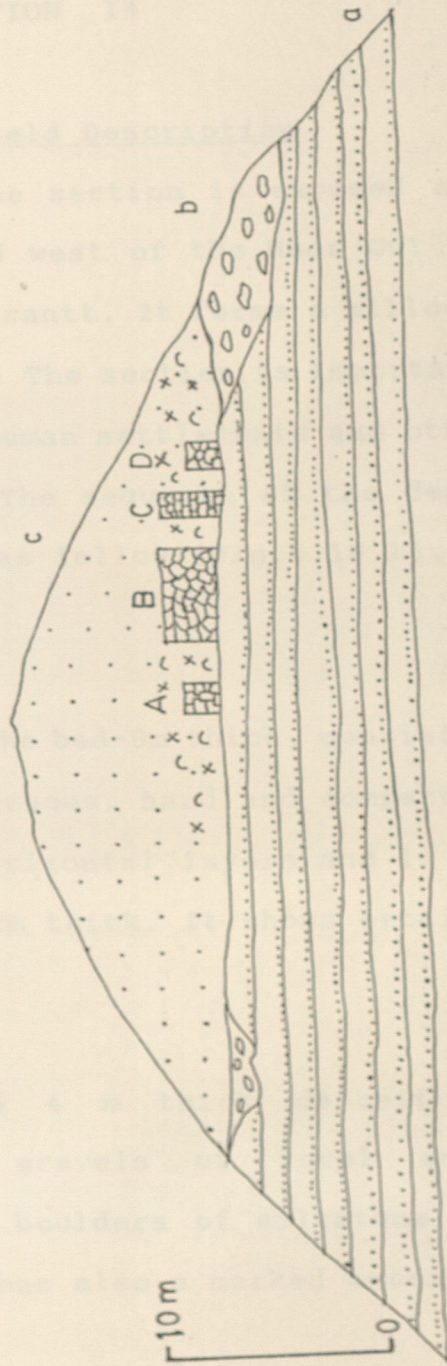
surroundings of the Peshawar valley. All this seems to have occurred in a periglacial environment.

In a subsequent phase of degradation, deep and wide torrent channels were cut in the loess and underlying torrent gravels. Loess was removed from over a wide area. The erosion of loess is still in progress. It has resulted in the development of gullies and badland topography. The cutting and degradation of loess may be the result of a change of local base level, due to the slow tectonic uplift of the area during post-glacial period.

5.13.4 Summary of important events recorded in the section

- a. A phase of fan-formation, forming bed a.
- b. A long phase of accumulation of loess in periglacial environment.
- c. Slow tectonic uplift.
- d. Erosion of loess and development of badland topography.

SECTION 14



- A] Walls, buried in loess
- B] Human bones
- C] Pottery
- D] Pottery

Figure 5.14.1

5.14. SECTION 14

5.14.1 Field Description

The section is exposed along the railway track (GR VO98876) west of the Noor Gul Baba cemetery, south-west of Nowshera cantt. It forms a hillock, 24 m high, above the torrent bed. The section is important because there are the remains of human settlements and other cultural deposits in the loess. The sequence of the deposits from the base to the top is as follows (Fig. 5.14.1).

Bed a:

The bed-8m thick, consists of a pale-yellow (2.5Y 7/4), calcareous, hard and compact siltstone. It shows 50 cm thick horizontal layers and is crossed by two vertical dykes, 12 cm thick. It shows erosional unconformity.

Bed b:

A 4 m thick deposit of angular, dark-gray sandstone gravels of local origin overlies bed a. Occasional boulders of siltstone are incorporated in the bed, that has also a marked erosional unconformity.

Bed c: (Loess)

The bed consists of a 12 m thick deposit of pale-brown (IOYR 6/3), clayey silt. It is soft, structureless



Plate 5.14.1

Section 14

and contains nodules of calcium carbonate. In places, black coating of lichen has developed on it. A fresh cutting exposes cultural deposits. As it is evident from Fig. 5.14.1, there are the foundations of walls. Wall A is half metre thick and two metre high. Wall B is 6x5 m. There are the remains of two other walls as shown in the figure. All the structures have been built of locally available slate and sandstone material. The walls have their bases in the siltstone deposit of bed a, while they are totally buried by overlying loess. Human bones, pottery, ash, pieces of charcoal and a possible human burial can also be seen in the loess, around the walls. So far, stone tools have not yet been recovered from the site.

5.14.2 Laboratory Examination

5.14.2.1 Grain size Distribution

Bed a:

The material has a lower size limit of 0.003 mm (clay) and upper size limit of 0.062 mm (coarse silt). It is composed of 21.6 clay, 30% very fine silt, 26% fine silt, 14.3% medium and 8.1% coarse silt. The size of the material reveals as if it has been deposited from suspension in still water.

Bed b: (loess)

The material ranges in size from 0.0011 mm (clay)

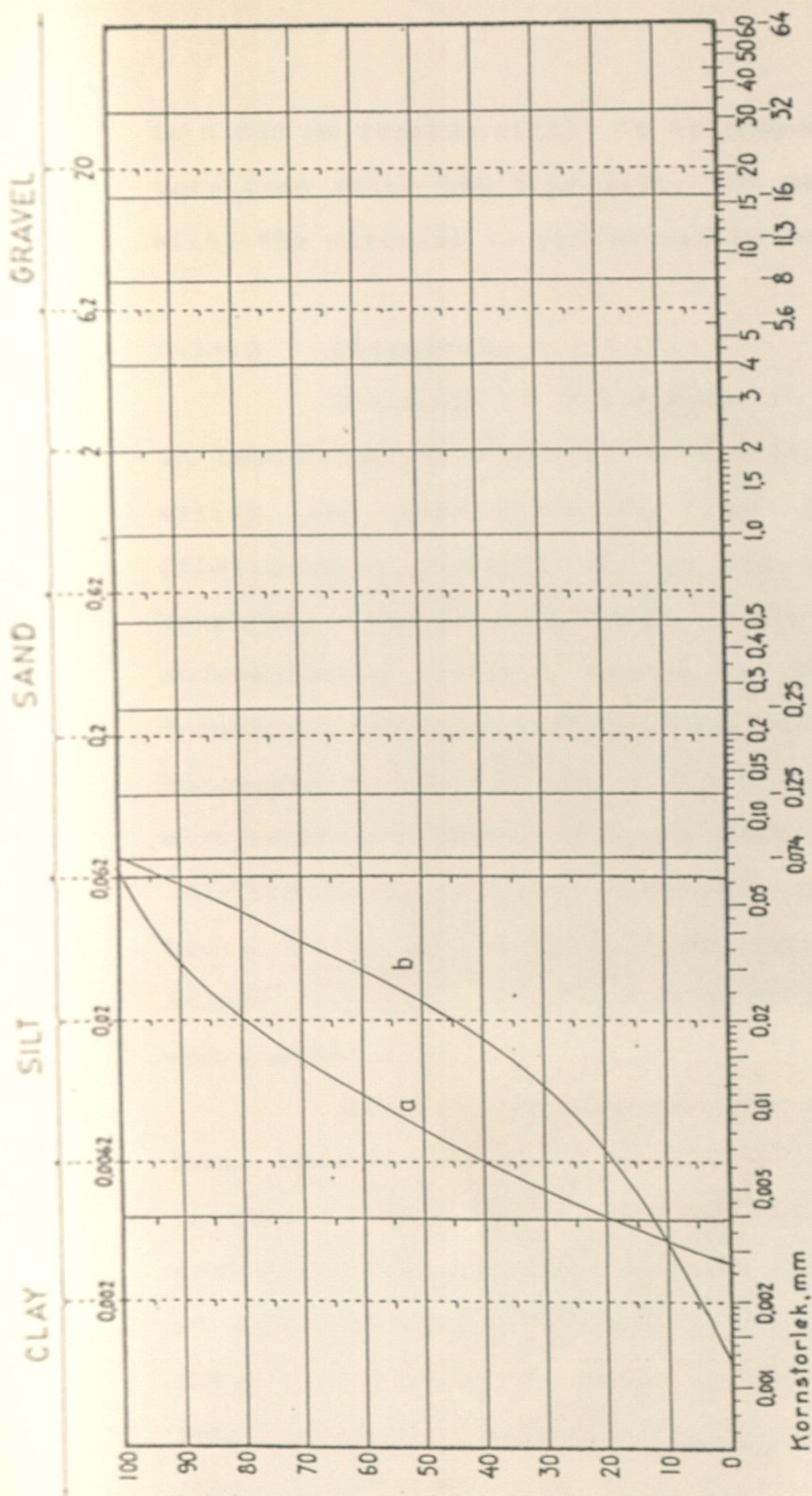


FIGURE 5.14.2

PARTICLE SIZE DISTRIBUTION

to 0.062 mm (coarse silt). It is composed of 12% clay, 11% very fine silt, 14% fine silt, 40% medium and 23% coarse silt. The material is predominantly medium silt.

5.14.3 Discussion

Siltstone of bed a seems to have been deposited in lacustrine environment, when a large part of Peshawar valley was ponded during the Pleistocene period. Stratigraphic position of the bed with respect to the overlying fan-gravels and loess shows that the sedimentation occurred during the second phase of lake formation. The origin of the lake and sediments have been discussed in section nos. 1,3,4,5,7 and 11. However, the most important feature of the present lake deposit, are the wall structures, with their foundations in the siltstone of bed a. It is an evidence of the existence of man in the valley, after the lake was drained off and the siltstone was exposed.

Several Palaeolithic and Neolithic sites have been uncovered in loess in the Potwar region. Near Uchali in Central Salt Range and in the vicinity of Riwat, southeast of Rawalpindi, skeletal remains of *Homo sapiens* of *dolichocephalic* type, and pottery, have been reported from loess (De Terra, 1939). Loessic silt above Adial in Soan valley has yielded scrapers, high-angle burins and other microliths, what Paterson (1939) has called "Late



Plate 5.14.2

Wall foundations in loess



Plate 5.14.3

Bones and pottery in the loess is an evidence of prehistoric human settlements in the valley.

Soan Industry". In 1935, a burial, in loess west of the Naushera, in Salt Range, yielded hand-made pottery, presumably of Neolithic type.

Pottery, walls, human burial and charcoal particles, show that the section under discussion is also a Neolithic site. Important feature of the loess is the cultural stratum that it contains. The walls in the section reveal that prior to the deposition of loess, neolithic man was living in Peshawar valley and there were human settlements on the siltstone. The phenomenon of the man's presence in the valley is perhaps coincident with pluvial (last glacial) climate. Aeolian processes appear to have been active in the valley, and consequently all the settlements were buried under loess.

5.14.4 Summary of the important events, recorded in the section

- a. The deposition of silt in the lake, forming bed a.
- b. The draining of lake and exposition of siltstone.
- c. The appearance of neolithic man on the scene and the development of human settlements.
- d. The burial of human settlements under loess in a periglacial environment.

SECTION 15

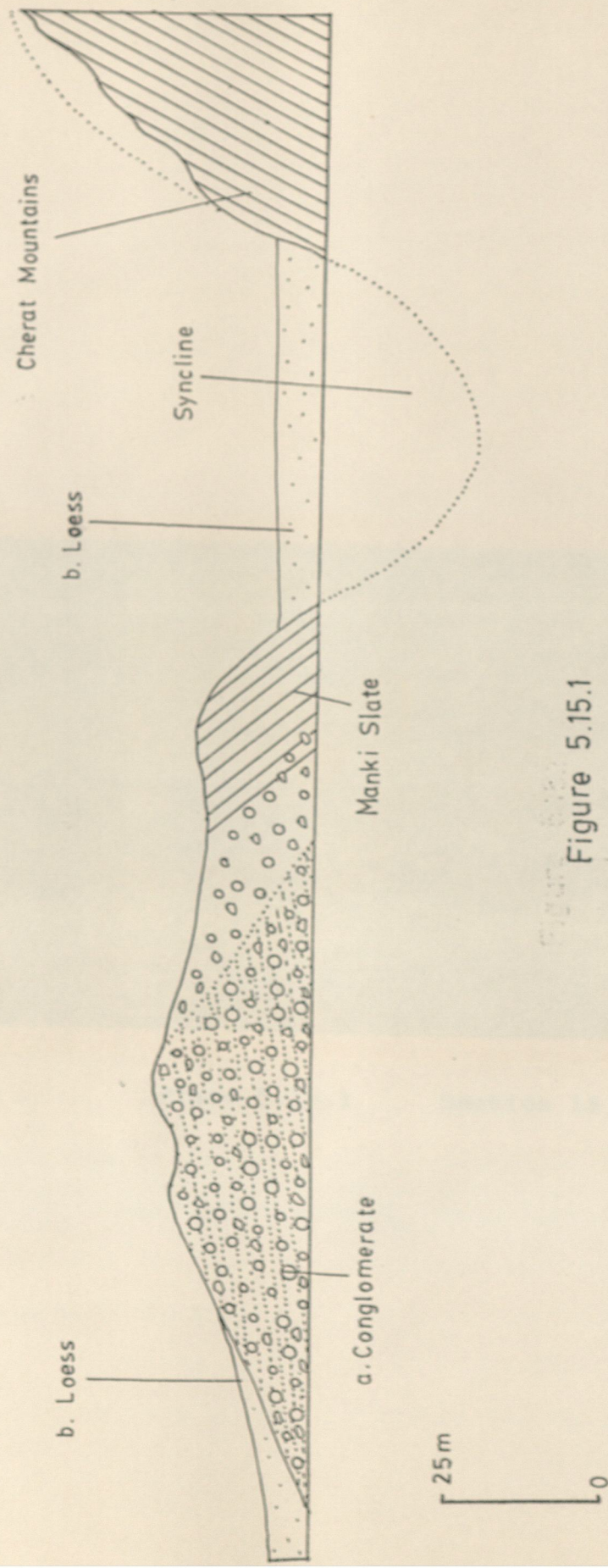


Figure 5.15.1



Plate 5.15.1 Section 15

5.15 SECTION 15

5.15.1 Field Description

The section is exposed along the eastern bank of Spinkani torrent channel, in Spinkani village (GR T932782), at the foot of the Attock-Cherat range. The section exhibits a disturbed strata of conglomerate. Precambrian Manki slate is exposed below the conglomeratic formation. The bedrock is sloping towards south, where it disappears below the loess. The section displays two different beds (Fig. 5.15.1).

Bed a:

The bed consists of petromict pebble conglomerate, composed of quartz, quartzite, granite, limestone, gabbro, amphibolite, sandstone and diorite. The material is also exposed on the surface, forming an elongated north-south hillock, about 400 m long. It has a maximum height of 25 m above the torrent bed, while the base of the formation is not exposed. The bed is dipping towards north, making a dip angle of 34 degrees. The material is very hard to break, even with a hammer. Most of the gravels display a preferred east-west orientation. Gullies have developed in the bed. Mass-wasting frequently occurs along the gullies. The gravels on reaching the torrent bed form scree and are picked up by torrent.

Bed b: (Loess)

South of the conglomeratic hillock, there is 2 km broad depression between the Attock - Cherat range and conglomeratic formation. The depression is filled with pale-brown (IOYR 6/3) loessic silt. The maximum thickness of the material has been measured to be 9 m. Loess is calcareous and rich in limestone nodules. North of the conglomeratic hillock, loess also forms, 6 m thick deposit, lying on the conglomerate. The deposit forms a typical badland topography due to severe erosion.

5.15.2 Discussion

A geological section across the Attock - Cherat range (Tahirkheli, 1970), exactly on the location of the section under discussion, shows that the depression at the foot of the Attock - Cherat range, filled by loessic silt, is a syncline, while the Manki slate, below the conglomerate in figure 5.15.1, forms a part of the anticline, formed during the uplift of the Attock - Cherat range during Cenozoic.

The evidence of river gravels from the wells, dug in the area reveal that the ancient Kabul river was flowing in the syncline, south as well as north of the Spinkani outcrop. The area passed through a long phase of river erosion. As a result, Spinkani ridge was reduced in height and ultimately submerged by river.

This was followed by a long phase of deposition of gravels by river. Lithology reveals that the clasts were derived from the igneous and metamorphic rocks of the Swat and Kabul river basins. The roundness of the fragments show that they have passed through several cycles of sedimentation. Over a long period of lateral shifting the river deposited gravels over a wide area on the valley floor. On the basis of lithological characteristics, stratigraphic position and surface morphology, the gravels can be correlated with the deposits, discussed in bed f, section no.1, bed b, section o.2, bed b, section no.3, bed b, section no.5, bed a, section no.8. The formations described, may be contemporaneous with the Potwar Boulder Conglomerate, which De Terra (1939) has correlated with second phase of the Himalayan glaciation, and which according to Rendell (1980) has been deposited 1.9 m.y. ago. Due to the slow tectonic uplift of the area, the Kabul river seems to have shifted towards north and the conglomeratic bed was exposed on the surface.

The exposed bedrock and disturbed conglomeratic bed in figure 5.15.1, shows that the bedrock has been elevated by thrusting to the south, that caused the differential uplift of the conglomeratic bed as much as about 30 m and exposed a part of the material on the surface, forming a hillock. The tectonic uplift may have occurred during the late Quaternary tectonic episode, about

0.6 m.y. ago, that has also disturbed the Pleistocene deposits in several other localities in the study area.

The detailed account of the thick mantle of loessic silt, surrounding the conglomeratic hill has been given in section nos. 13 and 14.

5.15.3 Summary of the important events recorded in the section

- a. The uplift of the Attock - Cherat range in Cenozoic, forming synclines and anticlines.
- b. A long phase of erosion of bedrock by the ancient Kabul river.
- c. The deposition of thick bed of gravels over a wide area, by the ancient Kabul river, and its conversion into conglomerate.
- d. The slow tectonic uplift of the area, pushing the course of Kabul river towards north and the exposition of conglomerate on the surface.
- e. The elevation and tilting of conglomeratic bed by thrusting to south.
- f. The accumulation of thick deposits of loess, covering the earlier topography.
- g. A phase of loess erosion, and the development of a badland topography.

CHAPTER 6

6.1

SURFACE DEPOSITS

A variety of surface deposits ranging in size from clay to boulders are exposed on the surface in the study area. Its detailed study throw light on the geomorphological history of the area. The material, mapped and examined during the field work are as follows (Fig.6.1).

6.1.1 Sand

An isolated pocket of light-gray (5y 7/1) sand, covering about nine square kilometres, is exposed southwest of Badrashi village. The sand is predominantly medium-grained and better sorted. Occasionally it incorporates small, rounded gravels of foreign origin. In places it is overlain by fan-gravels, siltstone and a thick mantle of loess. It contains 28.4% quartz, 21.5% feldspars, 14.3% plagioclase, 15.3% biotite, 10.5% amphibole, 7.8% calcite, and 1.7% chlorite. There are also traces of zircon, tourmaline and rutile, in the sample. The sand may have been deposited by the Kabul river, It may be as old as the sand deposits, discussed in section nos. 2 and 9. The morphology of the sand reveals as if the bulk of it has been reworked by eolian processes, subsequent to its deposition, forming dome-shaped dunes and sand sheets. Attempt are being made to stabilise the sand by vegetation.

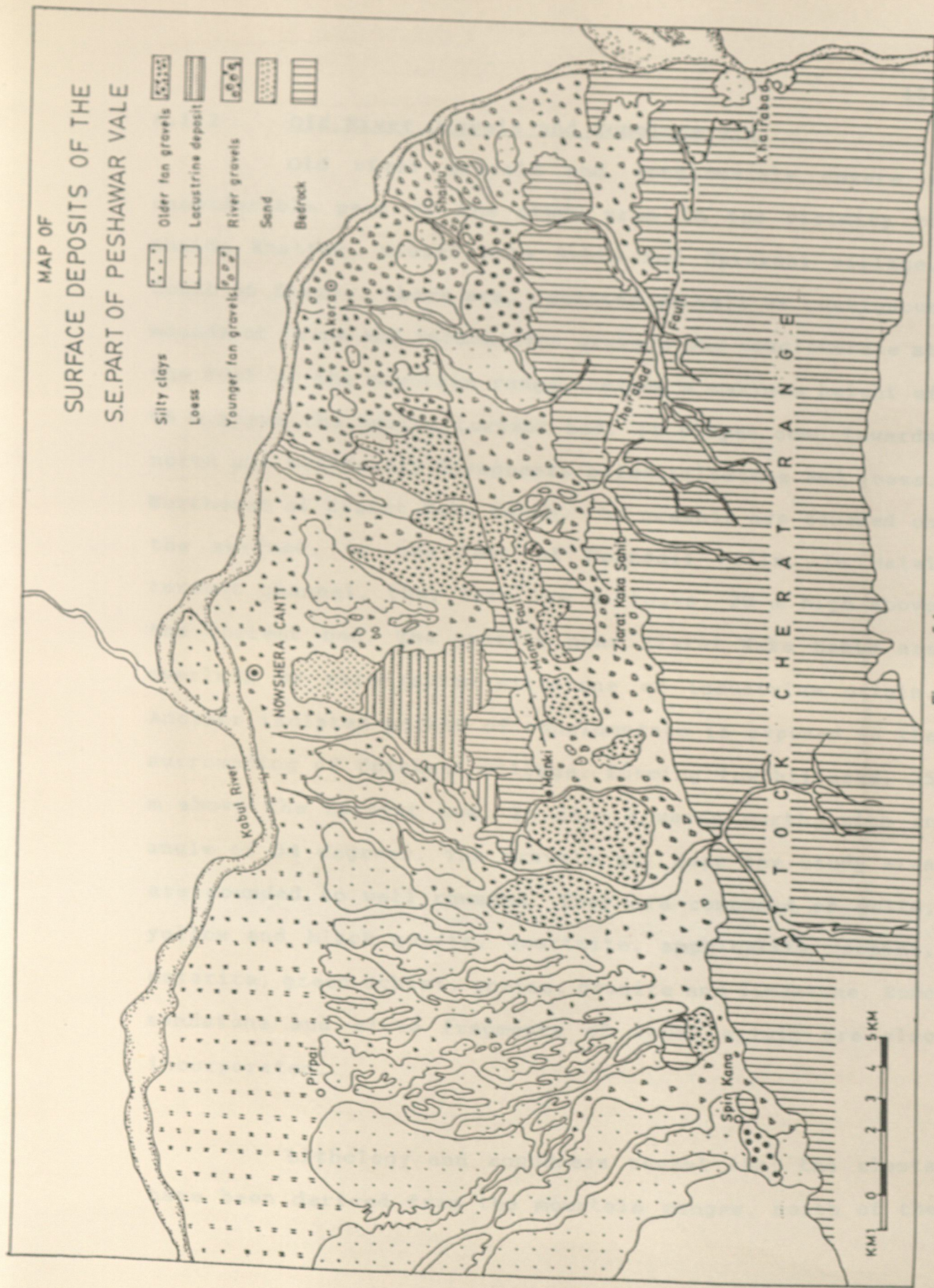


Figure 6.1

6.1.2 Old River Gravels and Conglomerate

Old river gravels and conglomerate covers a considerable part of the study area in the vicinity of Shaidu Khattak, Ziarat Kaka Sahib and Spinkani village. South of Shaidu, there are, isolated as well as contiguous mounds of loose and inchoherent gravels and conglomerate at the foot of the mountain range, having a maximum height of 65 m above the nearby torrent bed. It slopes down towards north and ultimately disappears below siltstone and loess. Northeast of Ziarat Kaka Sahib, the gravels are exposed on the surface, at the foot of Spinsali hills. In Walai torrent channel, they form low hillocks, 20 m high above the torrent bed. The gravels near Ziarat Kaka Sahib are overlain by pale-yellow siltstone of lacustrine origin. Another isolated pocket of conglomerate is exposed in the surrounding of Spinkani village, forming low hillocks, 25 m above the torrent bed. It dips towards north, with an angle of 34 degrees. The gravels all over the study area are rounded to well-rounded. They are composed of white, yellow and black quartz, quartzite, amphibolite, schist, dolerite, green schist, gneiss, granite and limestone. Some sandstone and slate fragments of local origin are also incorporated.

Lithology and roundness reveal that the clasts have been derived from the mountain ranges, north of the

Peshawar valley and deposited by ancestral Kabul river at the foot of the Attock - cherat range, during the Pleistocene period. They may be contemporaneous with Potwar Boulder Conglomerate which according to Rendell (1980) has been deposited 1.9 m.y. ago. The gravels were exposed on the surface as the river shifted its course towards north, due to tectonic uplift. In subsequent phases, the river gravels were either eroded from over a large area, or buried by fan gravels, siltstone and loess. They are preserved in places, where they have escaped erosion by torrents.

6.1.3 Siltstone (Lake deposit)

Hard light olive-gray (5Y 6/2) to light-gray (2.5Y 7/2) , siltstone is exposed over a large part of the area, north of Manki hills (Fig. 6.1), forming soil parent material. There are also small isolated pockets of the deposit, exposed in Wurmando khwar. Several erratics of granite are lying on the surface of the material in Wurmando khwar, as well as west of Manki Tarakai, on GR U010849(Pl. 6.I.4). The deposit has been eroded severely, and in sections, it consists of hard horizontal bands, about 20 to 40 cm thick. It also contains a number of dykes and sills, revealing that the deposit was involved in the last phases of the Himalayan orogeny, during the Pleistocene period.



Plate 6.1.1

Fan-gravels, exposed on the surface

Predominantly composed of silty material on the surface, the facies has the bands of silty sand, in sections. It preserves all the characteristics of Piran siltstone, discussed in detail in section no 6. Stratigraphically, it is the extension of Piran siltstone, revealing that it has been deposited in lacustrine environment, during the Middle Pleistocene. Thickness of facies shows the great depth and long time duration of lake in the valley.

6.1.4 Older Fan Gravels

Older fan gravels are exposed as conical and longitudinal hillocks, ranging in height from 15 to 20 m above the ground. They are recognised by their brownish colour. They are numerous in the surrounding of Ziarat Kaka Sahib, Tangi, Walai, Manki, south of Shaidu and north of Khasari. Generally, the material consists of fine gravels of sandstone, slate, shale and limestone, but in places, coarse gravels and boulders are also present. Incorporated are also a large number of rounded gravels of foreign origin. The gravels are generally sub-angular, but they are re-weathered, because of their long exposure on the surface. The material has been derived from the Attock - Cherat range and was deposited by torrents at the foot of the mountains, forming alluvial fans, and piedmont plain. Its stratigraphic position between the siltstone and loess



Plate 6.1.2

Erratics, embedded in siltstone, west
of Manki Tarakai.

reveals that the material has been deposited sometime between 0.6 m.y and 135 Ka. The irregular topography indicates that the fan-gravels, has suffered a long phase of degradation, due to the tectonic movement. The detailed account of the deposit has also been given in section study i.e. bed d, section no.9.

6.1.5 Younger Fan Gravels

A considerable part of the study area is covered by younger fan gravels. The bulk of the material is dark - gray sandstone, shale, slate and limestone gravels, derived from the Attock - Cherat range. Occasionally, there can be seen rounded gravels of foreign origin, along with cobbles and boulders. The fragments become coarser as one traces it towards south.

The fan-gravels are criss-crossed by large number of small and large torrent channels that increase in number as one moves towards the apron of the fans. Its thickness varies considerably, but reaches a maximum of 30 m, near Spinkani and Jabba Khattak. Owing to seepage through the gravels, the water table is deep. An important feature of the fan-gravel is the terraces. The terraces have been formed due to the cutting and entrenchment into fan-gravels, by torrents at several places i.e. Piran nala, Walai and Ziarat Kaka Sahib. The terraces have been correlated with tectonic movements and fluctuation in the

torrent discharge which are related to pluvial interpluvial climatic phases during the Pleistocene period, as discussed in section nos. 6 and 7. The stratigraphic position of the fan-gravels, reveal that they have been laid before the deposition of loess i.e. prior to 135 ka.

6.1.6 Loess

Over a large part of the study area, fan material is overlain by thick and extensive cover of pale-brown (IOYR 6/3), loessic silt, exposed on the surface as well as in the sections (Fig.6.1). Generally, it is soft and can be easily scratched with fingers. South-east of Nowshera cantt., it forms a continuous cover, showing severe gully erosion. In the eastern part of the study area, loess is found in form of small and thin isolated pockets, scattered in several places. The origin and other characteristics of loess has been described in detail in section nos. 3, 13 and 14.

6.1.7 Silt/silty clay

The narrow strip of plain area between the loessic plain and the Kabul river, is composed of fine silt and silty clays, 1-2 m in thickness. The lower parts of the formation contain fine limestone concretion. Bulk of the material seems to have been derived from the loess. The plain forms a part of the Kabul river floodplain.



Plate 6.1.3

Loess, exposed on the surface

Stratigraphically, it is the youngest material, accumulated during the Holocene period (Elberson et al. 1973). In places, the plain has been incised by torrent channels, containing fan-gravels.

Several conclusions can be drawn from the study of surface deposits concerning the depositional environment and major stages of geomorphic evolution of the Peshawar valley during the Pleistocene period. The surficial pattern of deposits, may be explained by the floods moderate to low magnitudes, with occasional short large floods in the Kabul river; mechanical weathering of the Attock - Cherat range during the pluvial phases and the formation of alluvial fans under moderately arid to semi-arid climate; ponding of Peshawar valley, and periglacial environment. The Holocene alluvium is characterised by fine silt and silty clays, with medium sized fan-gravels. It suggests the redeposition of loess and available debris by floods in the Kabul river flood plain.

CHAPTER 7
GEOMORPHOLOGICAL HISTORY OF THE
PESHAWAR VALLEY

7.1 PLIOCENE

Peshawar basin was formed during the Late Cenozoic, as the Attock - Cherat range and the Kala Chitta - Margalla range, marking the southern boundary of the Peshawar and Attock basins, were uplifted along the Attock Thrust and the Main Boundary Thrust (MBT). It was a period of rapid tectonic uplift and deformation in the latest Pliocene. During a period of - 200,000yr, beginning around 2.1 myr ago, more than 3000 m of structural relief was developed in the form of Attock - Cherat, Kala Chitta and Margalla range. The major movements along the Main Boundary Thrust (MBT) ceased by the end of the Pliocene and the beginning of the Pleistocene period. (Burbank & Reynolds, 1984).

Fluvial deposits all along the foothills of the Attock - Cherat range reveals as if the ancient Kabul river was flowing in a more southerly direction, prior to the uplift of the Attock - Cherat range. Subsequent to the formation of the mountain range, the course of the Kabul river was perhaps blocked, and it diverted towards east, flowing in the foothills of the Attock-Cherat range.

7.2 PLEISTOCENE

7.2.1. Lower Pleistocene

First Glacial

The formation of the mountain range was followed by the beginning of the Pleistocene period. With the onset of glaciation in the Himalayas and Karakoram, pluvial condition prevailed in the Peshawar vale. It was favourable for the formation of soil and growth of vegetation on the Attock - Cherat range. As a result, a thick layer of regolith was prepared all over the mountain range.

Due to a change of base level, subsequent to the formation of the Attock-Cherat range, the valley as well as the mountain range may have undergone through a long phase of erosion by the Kabul river and the torrents. Rough topography, comprising mainly of hard and soft rocks may have developed on the floor of the valley, during the Lower Pleistocene.

First Interglacial

With a change of climate from glacial to warm dry interglacial, the vegetation cover decayed; loose material was released and accumulated at the foot of the Attock - Cherat range, as alluvial fans (Section No.1a). The regolith was perhaps eroded from the slopes due to intermittent torrential rain and rapid tectonic uplift of the Attock - Cherat mountains. Fans may be formed under all

climatic conditions, but intermittent torrential rainfalls are specially conducive to their formation (Czajka, 1958 and Allen, 1965, 1971).

The fan-gravels passed through a subsequent phase of dissection. Infact, every phase of the fan-formation in the Peshawar valley was followed by erosion. Tectonic uplift, climatic change and reduction in the torrent load may be the causes of the degradation, because the area is tectonically active and the removal of the weathered material from the Attock - Cherat range reduced the supply of the material in the torrents. Fan material was eroded from over a considerable part of the Peshawar valley, during a long phase of erosion (Section No Ia).

7.2.2 Middle Pleistocene

Second Glacial

The climate started to deteriorate again from warm dry interglacial to cold-humid glacial that paved the way for the second phase of vegetation growth on the Attock - Cherat range. Due to the penetration of roots, deep into the bedrock, a thick regolith was prepared. The material was, however, retained on the slopes, because of the network of roots.

Peshawar valley was ponded during the second glacial phase. It was perhaps, due to the blockade of the Indus river by tectonic uplift or an alluvial fan,

somewhere between Khwara basin and the Kalabagh gorge. Thick deposit of silt accumulated on the pre-existing fan gravels, in still water (Section Nos. 1b, IIa). Thickness of the facies reveals a long phase of the ponding of the valley. The extension of the lacustrine facies to Khwara basin as well as to the cis-Indus region of the Potwar plateau, shows that the lake was not only confined to the Peshawar Valley, but covered a considerable part of the Potwar and Khwara basins. The sedimentation of the facies occurred around 2.0 myr ago, because the overlying conglomerate and sand facies started to deposit around 1.9 myr ago (Rendell, 1980).

Siltstone was exposed after the lake was drained. The ancient Kabul river resumed its course over the siltstone. The accumulation of the siltstone in the lake changed the local base level. Kabul river and its tributaries started the degradation of the lake deposit in the valley. Consequently, siltstone was eroded from over a wide area.

It was followed by a long phase of deposition, during which, river gravels, containing huge erratics and sandstone facies of enormous thickness were formed. It covered considerable area of the Peshawar valley, south of the Kabul river (Section Nos. 1c, 1d, 2a, 2b, 3a, 3b, 5b, 8a, 9a and 9b). The deposit is exposed on the surface, in the vicinity of Jahangira, Shaidu and Akora Khattak,

forming low hillocks in the foot of the Attock - Cherat range. Lithology and mineralogical composition of the gravels and sand show, that they have been derived from the igneous and metamorphic formations of the mountains, north of the Peshawar Valley. Conglomerate and sand facies can be correlated with the Potwar Boulder Conglomerate, on the basis of stratigraphic position and lithological characteristics. Potwar Boulder Conglomerate has been dated by Rendell (1980) to be 1.9 myr old. A fossilised cervical vertebra of Bos (buffalo) from the sand bed south of Shaidu, and the camels bones from conglomeratic bed in the vicinity of Akora (Vicary, 1843), indicate the presence of Villafranchian fauna in the Peshawar valley during middle Pleistocene. The evidence of fauna also shows the development of soil profile on the siltstone.

It appears as if the Kabul river, flowing at the foot of the Attock - Cherat range, was pushed towards north, due to a slow tectonic uplift, and the conglomerate exposed on the surface. The torrents emerging from the mountains, were sediment - free, because of the vegetation cover. Slow epeirogenic uplift of the area, accompanied by a decrease in the load of torrents, caused rejuvenation. The torrents severely eroded the conglomeratic bed. In areas, where the torrents were bigger, the sand and conglomerate were totally eroded, while smaller torrents only reduced the thickness of the beds. Narrow, and deep

channels were cut in the material, as can be seen, south of Jahangira, Shaidu and Akora Khattak. Erratic boulders, incorporated in the conglomerate, were left on the underlying lacustrine facies, as they could not be transported by torrents. A number of such erratic boulders can be examined in the area under study. Some of the erratics are entrapped in the siltstone, because of the accumulation of the redeposited silt, while a number can still be seen either on the siltstone, or in the conglomeratic beds, in the vicinity of Jahangira and Shaidu. Rough, undulating topography of the low, isolated hillocks of conglomerate and sand was formed, because of erosion. The underlying siltstone was also exposed over a large area. This seems to be the end of the second glacial phase.

Second Interglacial

The second interglacial started with a change of climate from cold humid to warm and dry, over the Himalayas and Karakoram. In Peshawar valley, it was a warm-dry interpluvial phase. Change of environmental condition brought drastic changes in the ecological set up of the valley. The vegetation-cover on the Attock - Cherat range decayed in the semi - arid environment. The underlying deeply weathered soil, prepared during the pluvial phase, was exposed on the surface. Torrential rainfall and the

occasional floods, accompanied by mass-movement, removed the weathered layer. The material was deposited in the foot of the range, forming alluvial fans. The pre-existing torrent channels, incised in the siltstone, were filled with the fan-gravels and the old topography over a large part of the area under study was covered by fan material (Section Nos. 4b, IIc). The fans extended as far as Nowshera. The maximum thickness of the gravels west of Manki, is 9 m, revealing a long phase of fan formation. This was the second phase of fan formation in the valley.

It appears as if this was also an episode of rapid tectonic uplift of the Attock-Cherat range. Due to the uplift of the mountains, the processes of weathering and erosion were accelerated, and deep valleys were cut in the mountain range, by torrents. The eroded material was deposited in the foot of the mountain range, forming alluvial fans.

The fan material suffered erosion after the development of drainage on it. This was perhaps, due to the slow tectonic uplift. The material was reduced in thickness, while from several localities, it was totally removed.

Third Glacial

With the deterioration of climate from warm dry to cold dry, a third phase of glaciation, began in the Himalayas and Karakoram. This was characterised by a cold

dry climate and the deposition of older loess, over a wide area in the Peshawar vale, including the Attock - Cherat range. The loess is exposed in several sections in the study area (Section Nos. 5a and 12a). The basal portion of the older loess i.e. brown silt, consists of the featureless, massive fine silt, with abundant calcium carbonate concretions. The loess seems to have been derived from the older floodplains of the Indus and Kabul rivers. In a few places, the loess also rests on the well - developed laterite zones.

Third Interglacial

Laterite zone beneath the loess reveals a change of climate from a cold dry glacial to warm humid interglacial, with sufficient rainfall. The valley as well as the Attock - Cherat range seem to have been covered by vegetation. Rhizoconcretions i.e. the fossilised parts of the branches of plants, recovered from the brown silt (Pl. 5.12.2) shows the development of soil profile on the older loess. Chemical changes, during the pedogenic processes, oxidised the loess, and its colour was changed to red and brown. Lenses of fine gravels, occasional rounded gravels of foreign origin, and the fossilised roots also indicate that the bulk of the material is a part of the redeposited older soil, eroded from the Attock - Cherat range, consequent on the deterioration of climatic conditions, in

the early cold dry stade of the fourth glacial phase. Dani (1964) has given a tentative date of 400,000 to 600,000 years, to the laterite zone at the base of the loess. The loessic silt and the laterite zone may be older than 600,000 years, because the loess is overlain by the siltstone, deposited during the second phase of lake formation. The siltstone has been correlated with the brunhes chron of the megnetic stratigraphy (Burbank, 1980), and hence could have been deposited around 700,000 years. The loess, accumulated earlier than siltstone would be older than 700,000 years.

Fourth Glacial

The beginning of the fourth glacial phase is marked by the deterioration of climate from warm humid to very cold and dry, destroying vegetation cover in the valley as well as on the mountain slopes, in the early stade. The soil exposed on the mountain slopes, was gullied, and the eroded material of the soil profile was redeposited on the older loess.

The degradation of the brown loessic silt and the underlying material initiated because of the change of ultimate base level, due to glaciation on the earth surface. It resulted in the development of an irregular topography in the valley. The brown loessic silt was also totally eroded from over a large part of the Peshawar

plain, as it is missing from a number of sections. The phase of erosion of brown loessic silt is also evident from erosional unconformities between the red brown silt and the overlying beds (Section No. 12). All these geomorphological and environmental changes have occurred during the initial phases of the fourth glacial period.

During the late stade of the fourth glacial phase, there seems to be a slight amelioration of climate, from cold dry to cold humid. Bulk of the older loessic silt had already been eroded from the Attock - cherat range during the early stade. The change of climate to cold and humid, resulted in the growth of vegetation on the mountain range. Due to vegetation cover, a deep zone of regolith started to develop.

Fine-layered silty material (Section Nos. 1e, 3b, 4c, 5c, 6b, 7a, 9c, 10b and 12c) reveal that it has been deposited in still water. It indicates a second phase of lake formation in the Peshawar valley, that also covered a large part of the khwara basin and the cis-Indus region of the Potwar. The lake seems to have been formed due to the blockade of the Indus river below khwara valley. It was perhaps, due to a short episode of severe tectonic changes that occurred from the mid-to-late Pleistocene, between 0.5 myr to 0.7 myr ago. During the same period, folding and faulting of the bedrock as well as the loose material has occurred, as is evident from several sections.

The silty material, brought by the Kabul river and its tributaries started to settle in the lake, forming thick deposits of siltstone, that is exposed in numerous sections in the Peshawar valley. In the vicinity of Jabba, the lake deposit contains occasional layers of red brown colour, particularly confined to the basal portion of the facies. It is perhaps, the red brown loessic silt of the previous interglacial and glacial phases, that was preserved on the slopes of the Attock - Cherat range, and on erosion, redeposited in the lake.

Textural properties, mineral composition and scanning electron microscopy of the silt indicate that the ultimate source of the lake deposit are the igneous and metamorphic rocks of the mountainous region, north and north-west of the Peshawar vale.

The lake drained, perhaps due to the tectonic changes or cutting a gorge in the rocks. The sediments, settled in the lake environment, were exposed. The recovery of fossilised parts of plants from the material reveal that a soil profile developed on the siltstone, during the subsequent period. The ancient Kabul river also re-established its course flowing on the lake sediments.

The mid-to-late Pleistocene short tectonic episode of the Himalayan orogeny, that had started prior to the lake formation, continued for 200,000 years i.e. from 0.5 myr to 0.7 myr ago. As a result, folds, joints, cracks,

dykes and warpings developed in the lake deposits. The lake sediments were subjected to severe erosion because of the tectonics and glacio-eustatic changes, during the glacial phase. It reduced the thickness of the formation, while from over a large part of the valley, siltstone was entirely eroded.

A new cycle of sedimentation began, when coarse rounded gravels of igneous and metamorphic origin were deposited on the lake beds (Section No. If). With the passage of time, gravel conglomerate was formed. This was the second phase of conglomerate formation in the valley. Roundness and composition of the clasts reveal a distant source of the material in the Himalayas and Karakoram. As the conglomeratic bed is confined only to the vicinity of Jahangira and Shaidu, it may have been deposited by the Indus river.

Two phases of conglomeratic sedimentation have also been reported from the Attock basin (Burbank & Roynold, 1984). It is suggested, that if the two conglomeratic beds in the Peshawar and Attock basins are contemporaneous, then they are part of a fan, formed by the Indus during the second and fourth glacial phases.

The second phase of the deposition of conglomerate has occurred in the last phases of the cold humid glacial period. It appears as if the change of climate to warm dry interglacial had begun. Glacio-eustatic

changes had occurred in the sea level by the return of water from the melting of ice-sheets and glaciers on the earth surface. The clasts were also readily available for onward transportation by rivers, because during the long glacial period, bulk of the eroded material had been produced by glaciers, forming moraines in the valleys of the Himalayas and Karakoram. Rise of sea level i.e. the ultimate base level and the availability of material at the source region, resulted in the sedimentation of the graveliferous deposits in the south-eastern parts of the Peshawar and Attock basins. This marked the end of the fourth glacial phase.

7.2.3 Upper Pleistocene

Fourth Interglacial

With the change of climate to warm dry interglacial, the vegetation decayed on the Attock - Cherat range, and the underlying soil was exposed. It was also, perhaps, complemented by episode of rapid tectonic uplift and erosion of the Attock - Cherat mountains, by torrents. A third phase of fan formation began in the Peshawar valley, south of the Kabul river. The weathered material was released with torrential rains and heavy floods, characteristic of the warm dry desert climate. Fans, developed at the emergence of a number of torrents from the mountains, coalesced, and formed a piedmont zone, covering

a large part of the Peshawar valley, south of the Kabul river. The maximum thickness of the fan deposit exceeds thirty metre in the foothills of the Attock - Cherat range. There was a sudden stop of the process of aggradation. Consequently the fan development came to end. The third phase of fan formation occurred in the early interstadial of the last glacial period. Cessation of the process of aggradation of the fan-gravels may be perhaps due to the beginning of a stadial, with mild climate, when the soil development on the Attock - Cherat range, stopped the further supply of the weathered debris to the plain area.

Sediment-free torrents, change of local base-level due to the formation of piedmont plain and the slow tectonic uplift, caused the degradation of the fan-gravels. Drainage pattern, developed on the alluvial fans and piedmont plain, resulted in an undulating topography with numerous low isolated hillocks of fan-gravels. The third phase was followed by a fourth phase of fan formation in the valley, during the late interstadial of the last glacial period. The vegetation cover, developed on the Attock - Cherat range during the stadial, perished in the warm-dry interstadial. The mountain range was also tectonically active, and the processes of weathering and erosion were going on. The release of the weathered material resumed, filling all the torrent channels and depressions. The older topography was buried under fresh

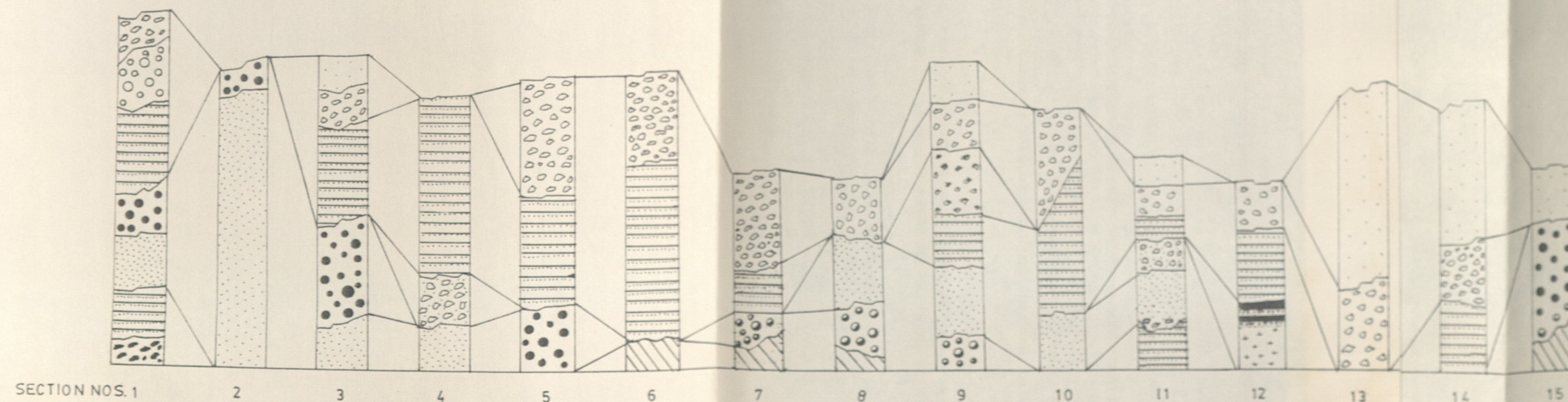
fan-gravels. A new piedmont zone was formed in the foot of the mountain range. Isolated low hillocks, comprising older fan material, stood above the new piedmont zone (Section No 9d). The thickness of the fan-gravels exceeds thirty metre in the vicinity of Ziarat Kaka Sahib and Jabba Khattak. The new piedmont plain occupied the entire south-eastern parts of the Peshawar valley.

The cessation of regolith formation on the Attock - Cherat range, stopped, the further development of the fans, followed by a phase of dissection. The erosion of the piedmont zone was initiated, because the torrents were now free of the sediment-load and also due to a change of base-level in the southern parts of the Peshawar vale. Drainage pattern developed on the piedmont zone. In several places, fan material has been totally removed, exposing the underlying old fan-gravels and lacustrine facies. This marks the end of the interglacial and the beginning of the last glacial period.

Fifth Glacial

The last glacial phase in the Peshawar valley is characterised by the deposition of a thick mantle of loess, reflecting periglacial environment (Section Nos 3e, 9f, 11g, 13b, 14c and 15c). It had widespread distribution over the entire valley, filling channels, depressions and also in places burying the older topography of the Pleistocene period. Peshawar valley had a typical loessic landscape.

STRATIGRAPHIC CHRONOLOGY BASED ON THE CORRELATION OF SECTIONS



SECTION NOS. 1

2

3

4

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6

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8

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12

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14

15

FIGURE 7.1

CHRONOLOGY OF DEPOSITS

YOUNGER LOESS (135Ka-20Ka)	FIFTH GLACIATION
RECENT FAN GRAVELS	IV INTERGLACIAL
YOUNGER FAN GRAVELS	FOURTH GLACIATION
RIVER GRAVELS & CONGLOMERATE	
YOUNGER LAKE BEDS	
SOIL PROFILE	III INTERGLACIAL
OLDER LOESS	THIRD GLACIATION
MIDDLE FAN GRAVELS	II INTERGLACIAL
RIVER GRAVELS & CONGLOMERATE 1.9 myr	SECOND GLACIATION
SAND & SANDSTONE RIVER GRAVELS & CONGLOMERATE	
OLDER LAKE BEDS	
OLDER FAN GRAVELS	I INTERGLACIAL
BEDROCK, WEATHERING	FIRST GLACIATION

Its maximum thickness has been measured in Azakhel, where 19 m thick deposits of loess, overlies the sand bed. Rendell (1980) has dated the loess by thermoluminescence (TL) dating technique. It shows that the loess was deposited continuously from 135 ka b.p. until 20 ka b.p. However the rate of accumulation varied during the long phase of deposition.

As elsewhere in the world, the problem in the Peshawar valley is that of the distinction between primary and secondary loess. The later have been derived from the redeposition of the primary loess. The primary loess seems to have been re-worked several times during the last glacial phase. Another problem is that of layered structure in the loess, particularly in the Khairabad torrent. The layers have, perhaps, been formed either due to the redeposition of loess by torrents, or because of the rearrangement of the silt particles, as the rain water percolated in the deposit during post-glacial period.

The basal portion of the loess also contains a cultural stratum, (Section No.14), in the vicinity of Nowshera. It reveals settlements of neolithic age, prior to the deposition of loess. Loess still covers a considerable part of the Peshawar valley, presenting a badland topography.

7.3 HOLOCENE

The climate of the Peshawar valley began to improve about 15,000 years ago (Rendell, 1980). Drainage pattern developed on the loessic plain; deep and wide torrent channels were cut in the area; loess was totally removed from over a wide area. Vertical and lateral erosion of the loessic plain and fan gravels, performed by the Kabul river and its tributaries, formed a broad flood plain in the valley.

Degradation of the Pleistocene deposits, was, perhaps due to the slow tectonic uplift, and because of the melting of glaciers that maximised the discharge of rivers.

Soil profile developed on the loess as well as on the flood plain of the Kabul river. Forest growth took place in and around the valley. It is on record, that the Mughal emperor, Baber, had killed a tiger in 1519 in the surrounding of Khairabad. Kabul river was sediment-free with clean water upto the middle of the 19th century (Hastings, 1869). Deforestation and overgrazing in the later half of the last century triggered a phase of erosion, and the rivers in the valley became choked with sediments. A new phase of aggradation began in the valley, during which, fine-sediments were deposited in the flood plains, while the redeposited fan-gravels, formed smaller alluvial fans near the banks of the rivers.

Even this geologically brief period has shown

TABLE I. PLEISTOCENE CHRONOLOGY OF THE SOUTH-EASTERN PART OF THE PESHAWAR VALE

Absolute Dates	Periods	Intervals	Climatic Conditions	Sequence of Significant Geomorphic Events	
				Attock Cherat Range	Peshawar Valley
0.015 myr (Rendell 1988) 0.135-20 myr (Rendell 1988) 0.5-0.7 myr 1.9 myr (Rendell 1988) 					

climatic variations. Roth Lisberger and Geyh (1985) has identified eight main Holocene phases of glacial expansion in the Himalayas, as having been around 7400 b.p., 4900 - 4600 b.p., 3700 - 3100 b.p., 2700 - 2100 b.p., 1700 - 1500 b.p., 1200 - 950 b.p., 800 b.p., and little ice age of 550 - 100 b.p. They have not been able to identify all the glacier advance of the Holocene period in the Himalayas. The impact of the Holocene ice advance and climatic variations, on the development of landforms in Peshawar valley is not known. This is a field, which requires detailed investigations. The environmental changes during the Holocene period present an interesting and a challenging task. It will be significant to examine as to what extent human and physical factors have contributed to the make-up of the present landscape during the later part of the Holocene period.

CHAPTER 8

SUMMARY AND CONCLUSION

1. The Peshawar valley achieved its final configuration during the Late Pliocene, as the Attock - Cherat range, marking the southern boundary of the valley, was uplifted in the later phases of the Alpine orogeny. The valley has passed through several phases of erosion and sedimentation during the past 2.1 myr.
2. Climatic changes, lithology and tectonic movements, have enormously affected the course of the geomorphological events in the valley during the Pleistocene period. Bulk of the deposit, in the south-eastern parts of the valley, has been derived from the Attock - Cherat range. Tectonic movements have played a dominant role in the deformation of the Quaternary deposits, processes of aggradation and degradation, change of drainage pattern, and perhaps in the damming of the Indus river, several times, between Attock and Kalabagh. It has resulted in the ponding of the Peshawar valley, and accumulation of siltstone deposits.
3. The area is tectonically active, and according to preliminary conclusions, there were four episodes of rapid tectonic uplift of the Attock - Cherat range. It resulted in the erosion and carving of wide and deep valleys, and gorges, in the mountains. The eroded material was deposited

in the foothills of the range, forming alluvial fans and piedmont plains, in the southern parts of the Peshawar vale.

4. On the basis of morphological and stratigraphical investigations, five pluvial and interpluvial phases have been identified in the south-eastern parts of the Peshawar valley, during the Pleistocene period. A brief summary of the climatic phases is as follow:

First Glacial

Due to the development of the soil profile and growth of vegetation cover, a thick layer of weathered material was prepared on the Attock-cherat range. Perhaps the valley has passed through a long phase of erosion by the Kabul river and its tributaries, which resulted in the development of an undulating topography.

First Interglacial

1. Due to rapid tectonic uplift of the Attock - Cherat mountains, and decay of vegetation cover in warm - dry climate, the loose material was eroded and accumulated in the foot of the Attock - cherat mountains, forming alluvial fans.

2. The fan-gravels passed through a phase of erosion, caused by tectonic uplift, climatic change and sediment-free torrents. Fan-material was also eroded from

over a considerable part of the study area.

Second Glacial

1. The growth of vegetation took place on the Attock - Cherat range, and a deep regolith was prepared.
2. Peshawar valley was ponded due to the damming of the Indus river below Khwara valley, and a thick deposit of silt was accumulated in the still water environment, around 2.0 myr ago.
3. Soil profile and open-grassland developed on siltstone, after the draining of the lake. Villafranchian fauna was thriving in the valley. At the same time, degradation of siltstone was also carried out by the Kabul river.
4. This was followed by a phase of deposition. Conglomerate and sandstone facies of enormous thickness was formed on the siltstone.
5. Kabul river was pushed towards north, due to the tectonic uplift of the area. Sandstone and conglomerate facies were subjected to severe erosion by torrents, emerging from the mountains.

Second Interglacial

1. The vegetation cover perished on the Attock-Cherat mountains, in the arid environment. Due to rapid tectonic uplift, and erosion, the weathered material was removed and accumulated at the foot of the mountain range, forming

alluvial fans.

2. In response to slow tectonic uplift, fan-gravels, passed through a phase of erosion.

Third Glacial

- I. Loess was deposited over a wide area in the Peshawar vale as well as on the surrounding mountains, in periglacial climate. The loess seems to have accumulated earlier than 700,000 years.

Third Interglacial

- I. It was a period of abundant rainfall. Vegetation growth took place on the valley floor as well as on the surrounding mountains. Loess was oxidised, because of pedogenic processes, and its colour was changed to red brown.
2. A well-developed laterite zone developed at the basal portion of the loess, due to the leaching of calcareous matter in a humid climate.

Fourth Glacial

1. During the very cold and dry stade of the early fourth glacial phase, vegetation cover was destroyed on the mountain range; soil was eroded, and redeposited in the plain area, overlying the red-brown loessic bed. During the late stade, cold and humid climate resulted in the

growth of vegetation on the Attock - Cherat range.

2. The valley was ponded for the second time, due to the blockade of the Indus river, below Khwara valley, and a thick deposit of silt accumulated in the lake.

3. Mid-to-late Pleistocene short tectonic episode disturbed the Quaternary deposits, in the southern parts of the Peshawar vale.

4. A second phase of the deposition of the rounded gravels of igneous and metamorphic origin began in the valley. These are preserved in the surrounding of Jahangira and Shaidu. Perhaps, they are remnants of a huge fan, formed by the Indus river.

Fourth Interglacial

1. The vegetation cover decayed on the Attock - Cherat mountains during the early interstadial. The weathered material was exposed and a third phase of alluvial fan formation began in the southern parts of the Peshawar vale. It was also complemented by rapid orogenic movement of the mountains.

2. During the mild stadial, soil development on the mountain range, stopped the supply of the fan-gravels to plain area. Alluvial fans suffered a phase of erosion, and an irregular topography developed in the area.

3. Due to change of climate and rapid tectonic uplift during the late interstadial, release of the fan-

gravels from the Attock - Cherat range, formed fresh alluvial fans in the southern parts of the vale. This was the fourth phase of fan formation. Subsequently, numerous torrent channels were cut in the fan-gravels, due to a change of base level.

Fifth Glacial

1. The phase is characterised by the accumulation of thick deposit of loess in the valley as well as on the surrounding mountains, in periglacial environment. It persisted continuously from 135 ka b.p. to 20 ka b.p.
2. The remains of settlements in the basal portion of loess, is the evidence of the neolithic man in the Peshawar vale, prior to the deposition of loess.

Holocene

1. Holocene in the valley is characterised by the erosion of loess and development of drainage pattern on the loessic plain in response to slow tectonic uplift. As a result of the erosion of loess, typical badland topography developed.
2. A broad flood plain was formed in the valley, because of the vertical and lateral erosion of the Kabul river and its tributaries.
3. Growth of forests took place in the valley as well as on the mountain ranges. Deforestation during the

historical period brought numerous geomorphological and ecological changes, that would require a thorough investigation.

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