THE GENESIS OF THE QUATERNARY DEPOSITS OF THE VALE OF PESHAWAR, SOUTH OF KABUL RIVER

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This study is dedicated

to

my father

LATE MALIK NASRULLAH KHAN AZIZ

who always loved the vale and its people, and inspired me to undertake the present study.

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ABSTRACT

The vale of Peshawar is located in the world's youngest collision zone in the north-west of Pakistan. It remained a locus of various tectonic and geomorphological activities throughout its geological history.

The present basin which was filled in with a variety of sediments, during the Quaternary period has been carved out of Tertiary mountain system as a result of long phases of erosion which lasted for about 15 to 19 m.y.s.

The study area which is located south of the river Kabul forms an integral part of the vale and possesses a complete record of such tectonic and geomorphological episodes which are preserved in various litho-stratigraphic units and exposed in different sections along the channels of present torrents draining the northern slopes of the Attock-Cherat range.

The study shows that the Pleistocene glaciation had a direct influence over the climatic and geomorphological pattern of the vale, which resulted in the establishment of such morphogenetic conditions that remained in tune with the changing climatic pattern of the nearby glacial Himalayas.

On the basis of interpretation of lithological chacracteristics of different beds, it was possible to identify four major facies, e.g. lacustrine, flood plain, alluvial fan and aeolian (loess).

The oldest sediments (Lower Pleistocene) of the vale, are exposed on the eroded bed rock of Murree formation of Miocene age at Garhi Chandan, south of Peshawar city. These sediments are composed of lacustrine and over-bank and channel facies of Kabul river. Vast deposits of volcanic ash, dated as 2.7+-0.3 m.y. are embedded in these sediments and considered contemporaneous to the Soan Formation of the Potwar plateau. These deposits are overlain by the material of Older fans with an erosional unconformity which, on the basis of lithological similarities are considered homotaxial to the "Lei Conglomerate Complex" of the Potwar plateau.

Evidence suggest that the vale was transformed into lakes at least four times during the Pleistocene due to different causes. In the first two phases, lakes were formed as a result of the effect of tectonics, while the latter phases seem to occur due to the northward prograding Younger alluvial fans in two phases which blocked the flow of Kabul river. The various erratic blocks lying along the northern foot-slopes of the Attock-Cherat range are suggested to be deposited on the lake bed by the floating ice blocks during one of the 'stades' of the Middle Pleistocene.

The geomorphological behaviour of Kabul river appears to be controlled by the oscillating climate as well as by the tectonic events which also resulted in the draining of the lakes. Due to the lowering of local base level, Kabul river started aggradation by building its flood-plain. Near its

outlet from the mountain, it behaved like a braiding stream. In the main vale, water in excess of channel capacity resulted in over-bank deposition while the migrating slow moving meandering channel developed 'point bar' facies during which huge amount of sand was deposited in the vale on a very large area.

Besides the deposition of glacio-fluvial material, the vale also received a large amount of sediments, released by the slopes of the Attock-Cherat range deposited as facies of alluvial fans. Their formation seems to be triggered by suitable climatic conditions as well as by rapid uplift of the Attock-Cherat range. Their deposition appears to be contemporaneous with climatic amelioration as is evidenced by the formation of different soil horizons and growth of rich vegetation on the fan material. It may be noted that each of these phases of deposition in the vale was followed by a phase of erosion in order to achieve a 'profile of equilibrium.'

There are evidence to believe that during the Pleistocene, loess was deposited in the vale in three phases. The earliest two loess are found embedded in the first and second lake phases, while the third (Youngest) loess appears to blanket the entire topography during the late phase of the upper Pleistocene. The detailed analysis of mineral and physical characteristics of the loess of Peshawar vale, suggest it to be as 'rock flour,' produced by the grinding action of glaciers in the northern provenance during glacial

advances. This material was deposited by the winds during deglaciation phase in warm dry/semi-dry climatic conditions with occasional wet spells. This is indicated by the development of soil horizons, the deposition of recent gravels and lenses of sand within the loess.

The Holocene is marked by a large scale erosion of loess, the peidmont and the development of 'badland' topography. There is also evidence to suggest that the vale is presently passing through a phase of aggradation.

CHAPTER 1

INTRODUCTION

1.1 SCOPE

This study deals with the genesis of the Quaternary deposits in the Peshawar vale, south of Kabul river. Although a number of studies, e.g, geological, hydrological and pedological, have been carried out in the area but unfortunately, the Quaternary deposits of the vale have been ignored or dealt with only very casually. These studies were too generalized and had their own specific aims. None of these investigations have dealt with the Quaternary deposits in their lithological and morphogenetic context. Thus in the Peshawar vale and particularly in the study area, there exists a big gap in our knowledge of Quaternary period, which requires a systematic study. The work carried out in the present study, is therefore, an addition to our knowledge of geomorphology of this area.

1.2 AIMS AND OBJECTS

The present study is aimed at the following:-

1. To carry out a systematic survey of the exposed material and to investigate all possible factors which have contributed to their deposition.
2. To evaluate the agencies of transportation and deposition, the provenance where the material was produced,

the environments of deposition and to understand the operation of post-depositional processes by examining its lithological and chemical properties.

3. To determine a possible chronology of landform evolution in the vale of Peshawar by establishing stratigraphic position of each component unit.

1.3 METHODOLOGY

To achieve the objectives outlined, the following procedure was adopted:

In order to have a comprehensive view of the physical set up of the area, a geological frame work dealing with lithology, structure and stratigraphic evolution of the vale was prepared, from the available published works and personal communications. A geomorphological review of the published material regarding landforms, soils, hydrology, archaeology and surface deposits was carried out. Field work was conducted to survey geomorphological characteristics of the various litho-stratigraphic units exposed in the sections. This was followed by laboratory examination of surface deposits. Finally, to determine the genesis of surface deposits interpretation of sections was made which became the basis of a detailed chronology.

1.4 FIELD AND LABORATORY TECHNIQUES

A reconnaissance of Peshawar vale was carried out to get acquainted with the area. Important geomorphological

observations were recorded in their geological setting. The study area was thoroughly examined and observations were made along the numerous torrents. After a thorough study of these beds a detailed examination of the selected sections was carried out on the following pattern:

1.4.1 Field Examination of Sections

Each section was thoroughly examined and its various beds were identified. The thickness of each bed was measured and all characteristics recorded. These included, colour, texture, structure, worm and roote-holes, fossils and organic material, formation of soil and weathering zones. Each bed of the section was numbered for identification. About 1/2 kg of sediment samples were taken from at least 1 foot depth of each bed for detailed examination and laboratory analysis. This way, 100 sections were examined, out of which 40 sections were studied in detail. About 240 samples collected from sections were studied in detail. About 140 samples collected from sections were analysed in the laboratory. For correlation purpose, some samples of loess and river sand were also collected from the Harro basin.

1.4.2 Laboratory Examination of Deposits

1.4.2.1 Colour Identification

In laboratory, the samples were air dried for colour identification. The colour was matched and noted with the Munsell chart, and identification made in terms of hue,

value and chroma.

1.4.2.2 Grain size Analysis

Grain-size analysis of samples was carried out to understand the textural composition of the material which helped in determining the source and the processes involved in the transportation and deposition. Pure sand samples were examined through sieves, while finer material was analysed by hydrometer method. Shape of the gravels was determined on Zing's model.

1.4.2.3 Chemical Analysis

Fourteen samples were examined for determining calcium, magnesium, organic matter and iron to understand their characteristics in relation to the processes and their environments. The following methods were used to get their percentage:

a. Ca++---by titration against EDTA (Ethylene diamine Tetra-Acitic Acid) solution.

b. Ca+Mg---by titration against versenate (EDTA) solution.

c. Mg++---by subtracting the Ca values from Ca+Mg values.

d. Organic matter---by Walley and Black method (by titrating against ferrous ammonium sulphate solution).

e. Total iron content---determined on an Atomic Absorption Spectro-Photometer after digesting the soil in a tri-acid mixture of H_2SO_4,

value and chroma.

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HNO_3 and 70% $HClO_4$ in the ratios of 1:10:4.

1.4.2.4 Microscopic Study of thin Sections

A thin section microscopic study was carried out to find out the general mineral composition of the material. It was supplemented by taking 275 times enlarged photographs of the grains. Thus the individual shape of the grain was determined.

1.4.2.5 SEM Analysis of grains of material

Samples from loess (Section Nos. 15 and 22) were examined through SEM (Scanning Electron Microscope) to see the shape and surface texture of the individual grains at high magnification (upto 3000). Firstly the samples of air-dried loess were treated with 50% HCL to remove the carbonates, (Pye, 1983). Secondly, these samples were coated with aluminium to produce a conductive layer. Some samples were also polished to make the surface smooth to see the difference. Micrographs were taken at different magnifications.

1.4.2.6 Dating through Fission track and Thermo-luminescence methods

Two samples each of volcanic ash (V1, V2, Section 4) and loess (Section Nos. 15 & 22) were sent to Japan, for dating through fission track and T.L. (thermo-luminescence) methods respectively. Only the dating results of two volcanic ashes have been received so far (Table-23). This helped in establishing the age and the stratigraphic nature of the deposits containing volcanic ash. It also helped in estab-

lishing its correlation with the some of the upper Siwalik rocks of Potwar.

1.4.3 Facies Identification

To establish the true nature of sedimentation and the processes involved, it was necessary to identify different facies. This identification helped in understanding the geomorphic processes operating in time and space.

The following four facies were recognized after the criteria established in the following works:-

a. The lacustrine facies, by Picard and High (1972).

b. The alluvial fan facies, by Beaty (1963), Bull (1972), Wasson (1979).

c. The fluvial facies, by Leopold, et al., (1964), Allen (1965, 1979) and Visher (1977).

d. The aeolian facies (Loess), by Flint (1961) Smalley (1966, 1971) and Pye (1983).

1.4.4 Interpretation of Sections

a. After collecting the necessary data from the field and laboratory, each section and its beds were described in detail to evaluate its geomorphological characteristics.

b. The events as recorded in the beds were described in order to understand their

occurrence in a chronological order.

c. An interpretation of sections was carried out on the basis of field and laboratory examination. The interpretation was supplemented by statistical and cartographic presentation of data.

d. Ultimately, conclusions were drawn with regard to the environments of deposition, the processes and the provenance.

1.4.5 Formulation of Geomorphic Chronology

On the basis of chronology of events a Quaternary history of the vale in general and the study area in particular has been prepared. The environmental conditions prevailing in the vale during different stages of the Quaternary period are correlated with the nearby Potwar area and Swat Himalayas.

1.5 THE PESHAWAR VALE

1.5.1 General

The Peshawar vale is located in the northwest of Pakistan between lat. 33°40' to 34°30' north and long. 71°15' to 72°30' East. (Fig.1.5.1.1.) It is situated in a zone of transition between the Hindukush and the Himalayan mountains. The vale, thus, shares the characteristics of the two ranges. It is semi-circular to oval-shaped basin, which has been filled in, by a variety of unconsolidated material of different sizes, ranging from clay, sand to gravels and boulders. (Fig.1.5.1.2)

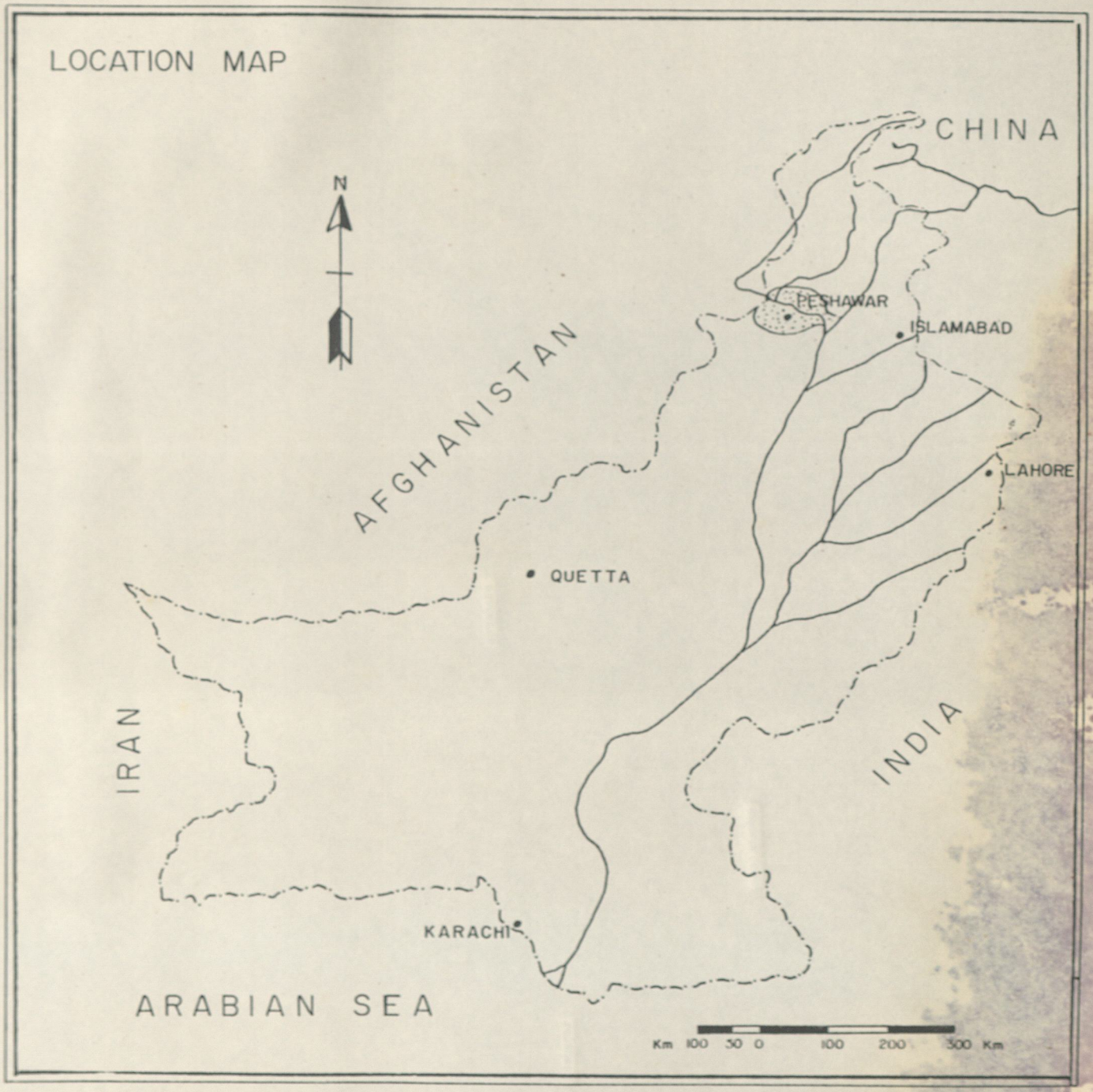
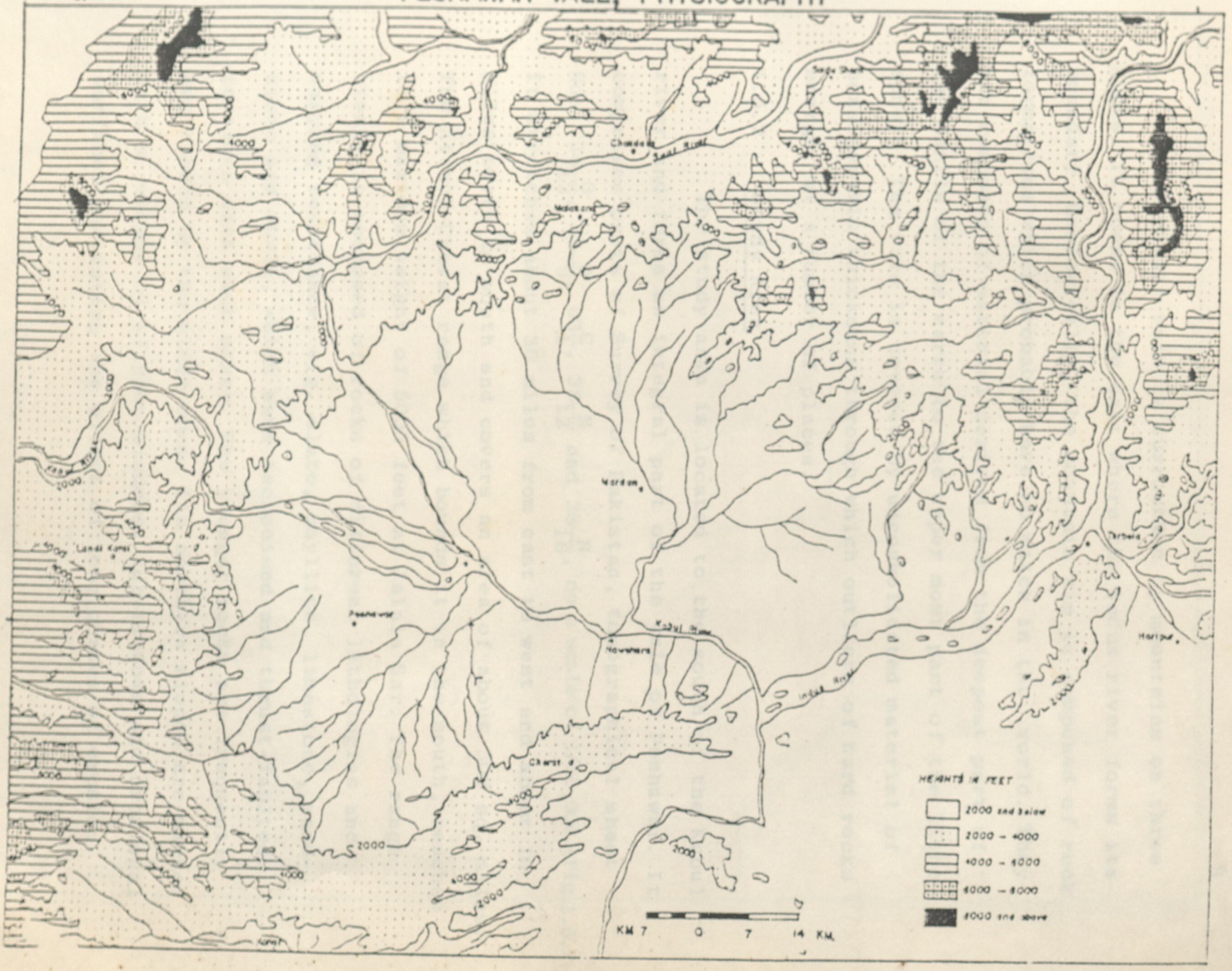

LOCATION MAP
CHINA
N
PESHAWAR
ISLAMABAD
AFGHANISTAN
LAHORE
QUETTA
IRAN
INDIA
KARACHI
ARABIAN SEA
Km 100 30 0 100 200 300 Km

Fig. 1.5.1.1

Fig. 1·5·1·2

PESHAWAR VALLEY PHYSIOGRAPHY



Peshawar vale is surrounded by mountains on three sides. It opens in the east where the Indus river forms its boundary. Geologically, the mountain rim is composed of rock formations which probably have no match in the world. They are composed of material derived from the deepest part of the mantle of the earth to the upper most part of the lithosphere. The vale is covered by unconsolidated material of considerable thickness through which outliers of hard rocks emerge at a number of places.

1.5.2 Study Area

The study area is located to the south of the Kabul river and forms an integral part of the vale of Peshawar. It comprises parts of Survey of Pakistan, topographical sheet Nos. $38\frac{O}{13}$, $38\frac{O}{9}$, $43\frac{C}{1}$, $38\frac{N}{12}$ and $38\frac{N}{16}$, on a scale of 1/50,000.(Fig.1.5.2.1). It stretches about 30 miles from east to west and about 10 miles north to south and covers an area of about 300 sq. miles. The Attock-Cherat range which bounds it in the south, reaches to a maximum height of 5033 feet at Jalala Sar. The range itself is composed of rocks of different lithologies and varying resistance, e.g. slate, phyllite, limestone, sandstone and shale, which have tectonised and thrust-faulted contacts with each other. The younger rocks are frequently overridden by the older ones. Its northern slopes are marked with a number of klippen/windows, sub-windows and erosional surfaces indicating the effect of long phases of erosion.

STUDY AREA AND LOCATION OF SECTIONS

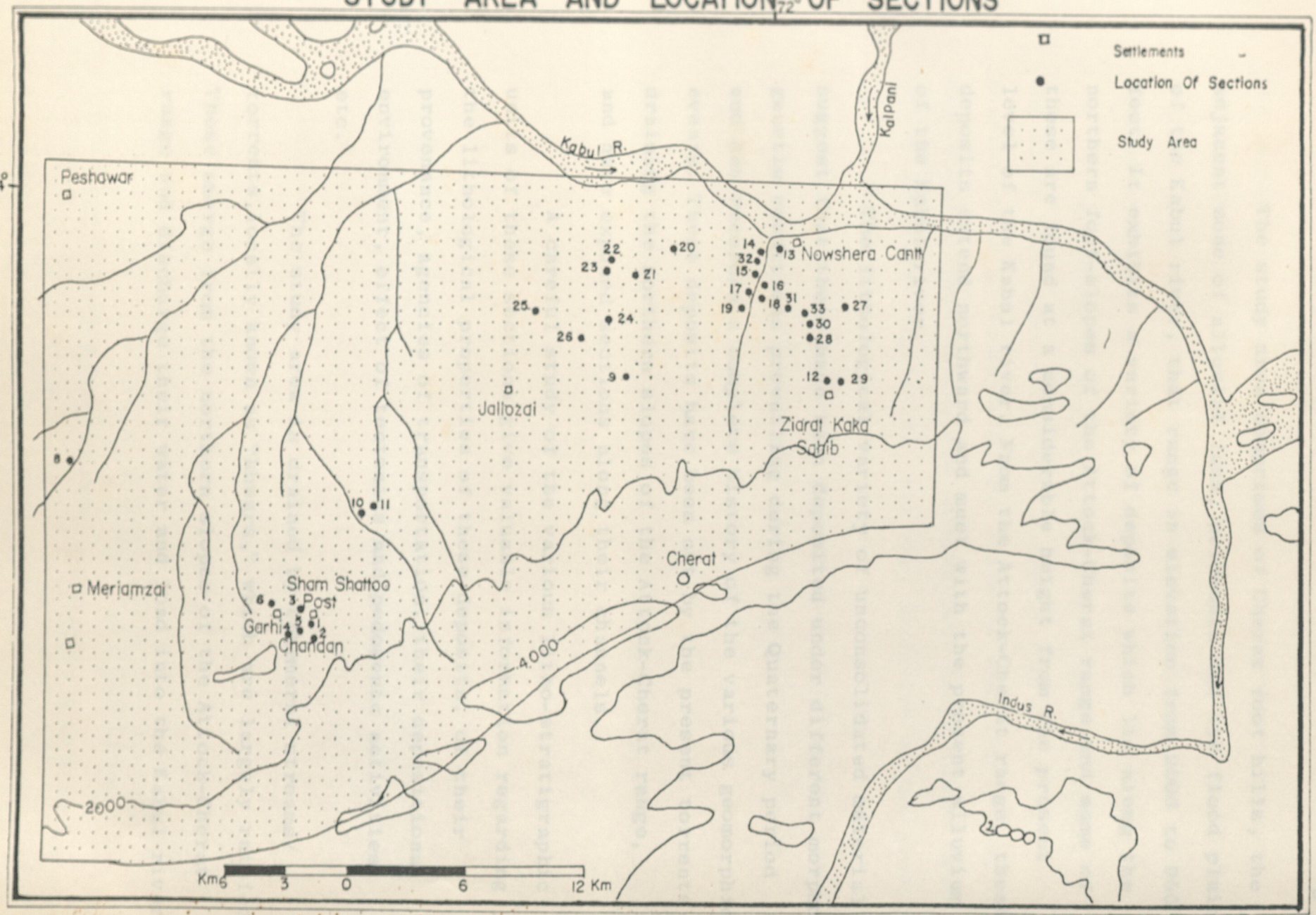


Fig. 1.5.2.1

The study area comprises of Cherat foot hills, the adjacent zone of alluvial fans, peidmonts and the flood plain of the Kabul river, that range in elevation from 2000 to 950 feet. It exhibits a variety of deposits which lie along the northern foot-slopes of the Attock-Cherat range and some of these are found at a considerable height from the present level of the Kabul river. From the Attock-Cherat range, these deposits extend northward and meet with the present alluvium of the Kabul river.

The lithological variety of unconsolidated material suggest that these have been deposited under different morpho-genetic conditions prevailing during the Quaternary period and has recorded a complete history of the various geomorphic events. These deposits have been cut by the present torrents draining the northern slopes of the Attock-Cherat range, and have exposed sections along their channels.

A careful study of the various litho-stratigraphic units of these sections give valuable information regarding the lithological properties of these deposits, of their provenance, agencies of transportation, their depositional environment, effect of tectonics and pedogenic activities, etc.

The study area is drained by ephemeral streams/ torrents, locally known as "khwars," which are largely rainfed. These emerge from the northern slopes of the Attock-Cherat range and discharge their water and load into the Kabul river.

The torrents are geomorphologically very important because in the past they have also brought great amount of weathered material from the Attock-Cherat range and spread it as alluvial fans and bajadas.

According to Koppen's classification of climate, the study area comes under Bsh climatic type which is characterised by "semi-arid, hot climatic conditions," having high range of temperature, low intermittent heavy summer downpours and sparse vegetation, all very conducive to the production and transportation of a large amount of weathered material by the ephemeral streams which deposit their load in the form of alluvial fans (Blissenbach, 1954, Langbein and Schumm, 1958; Beaty, 1963; and Allen, 1965, 1979).

CHAPTER 2

REVIEW OF THE GEOMORPHOLOGICAL STUDIES

Previous work concerning the geomorphological development of the Peshawar vale is restricted merely to the lithological reports of the Quaternary deposits without giving details of the processes concerned with their formation. In majority of descriptions, the litho-stratigraphic parameters have not been used as a guide to the provenance. However, brief reports, describing the Quaternary deposits in a genetic context, are not uncommon. Detailed accounts of the material of the deep mantle, covering the bed rocks within the vale, are given by the following authors:-

1. Vicary (1851) described alternating beds of clays, gravels and conglomerates in the vicinity of Kabul river near Akora. These deposits have been assigned a Pliocene age.
2. Wynne (1877) reported coarse conglomerate and gravely beds beneath the silt in the Peshawar plain which seems to be an extension of Hazara and Chuch plains.
3. Theobald (1880) described the Peshawar plain as Yousufzai plain and further concluded that it is formed of thick deposits of alluvium which is partly of lacustrine origin. He also reported large limestone blocks on the alluvium across Nowshehra. He considered these block to be ice-rafted during the Pleistocene period.

4. Waagan (1884) reported a vast plain, entirely composed of red sandstone and marl, mixed with fragments of black slate, quartzite, sandstone and limestone in the foothills of Attock-Cherat range.

5. Griesbach (1892) studied the surface deposits of the Peshawar valley specially the vast alluvial fans emerging from the foothills of Cherat and Afridi ranges.

6. Coulson (1937) suggested that the Quaternary deposits near Jehangira are of glacio-fluvial in origin, formed in a temporary lake.

7. Fraser (1958) carried out the landform survey of the Peshawar basin. The survey was aimed at establishing a landform-soil relationship for a better understanding of the processes involved in agricultural land-use and planning. With the exception of a few isolated outliers of the main mountain mass, the bedrock has been burried under a deep alluvial mantle and, therefore, landform distinctions have to be made primarily on the mode of alluvial deposition. Physiographically, the vale has been divided into five units; (i) the core of the vale which consists of a remarkably level basin plain (Mardan and Charsadda Tehsils), (ii) the younger riverain plain through which flow the braided channels of the Swat and Kabul rivers, (iii) the vast piedmont apron deposited by torrents from the ranges of Kohat district, (iv) the Sari-Maira ridge and (v) the plain of Indus-laid alluvium lying at the southern foot of this ridge.

8. Martin, et al., (1962) reported superficial deposits in the lower Swat-Buner area, generally consisting of river

alluvium, fluvio-glacial gravels and reworked loess.

9. During an archeological investigation of Sanghao Cave, north of Mardan, Allen (1964) and Allen and Dani (1964) found Palaeolith artifacts embedded in various deposits of Pleistocene origin. They considered Peshawar basin as a "structural depression" (probably formed during the orogenies of the upper Cenozoic) "which consists of a pre-Pleistocene topography filled with a several hundred feet hick accumulation of valley fill during the lower Pleistocene". The high alluvial terraces around the periphery of the Peshawar vale indicate that much of the older material has been removed.

10. Saleem (1979) carried out a grain size analysis of the cave deposits of Sanghao and found that sand and gravel fractions make up higher proportion of the three loess samples and a low percentage of silt. He is not in favour of calling Sanghao deposits as loess.

11. Elberson (1967) carried out a soil survey of the vale of Peshawar and studied various soil series in relation to their parent material. He identified major landorms and the associated processes. He considered the Peshawar vale as part of the Indo-Gangetic Synclinorium which, during Tertiary, was downwarped with the Himalayan orogeny. The bottom of the vale was considered to be uneven containing many fault blocks whose outcrops were protruding through the alluvium. He suggested that the Peshawar vale was transformed into a lake several times with the deposition of alternating silty and sandy beds. In the piedmont south of Peshawar, at least two loess

formations have been identified. These are separated by a red piedmont deposit. Holocene period is characterised by two erosion cycles, presumably linked with tectonic events affecting the local base levels.

12. Jan (1968) and Tahirkheli (1970) reported Pleistocene deposits exposed in the northern foothills of the Cherat range near Jallozai. These are composed of sandstone, shale and gritstone and together, described as the Jallozai Formation. The formation unconformably overlies the Manki Slate of pre-Cambrian age. From the lithological analysis of this formation, Jan (1968) inferred a possible link of the Cherat mountain with the northern mountains of the vale during Pleistocene.

13. Saif (1970) and Tahirkheli (1970) reported unconsolidated surficial deposits lying along the northern foothills of Cherat mountain. These deposits form broad alluvial fans in front of the escarpment while in the lowlands, they constitute valley fills, ranging from fine sand and clay to loose gravels and conglomerate.

14. Rehman and Zeb (1970) reported Quarternary alluvium spread over a large part of Shah Kabal Dheri (Swat), particularly the flat tops of low hills on the eastern side along the Swat river.

15. Ahmed, et al., (1969) reported Quarternary alluvium consisting of cobbles, gravels, sand and silt, lying on the flat tops of hills in Warsak area. This situation indicates the extent and height of the former flood plain of the Kabul river during the Quarternary period.

16. Khan, et al., (1970) reported a thick cover of Quarternary alluvium spreading in the form of alluvial fans all along the eastern slopes of the mountains near Jamrud. They also reported elevated river terraces composed of coarse material found at much higher level in the south-western area of Jamrud.

17. Kazmi (?) identified the following deposits in the Peshawar vale through tube-well logs: (i) the piedmont deposits which consist of a series of coalescing alluvial fans, some of which extend nearly upto the Peshawar city. (ii) the flood plain material, deposited in comparatively recent geological times by the Kabul river during its over-bank flooding, (iii) the aeolian deposits consisting of wind-blown silt which have been deeply dissected by torrents coming from the Cherat range.

18. Sayal and Afzal (1972) made a study of the land-forms of the Peshawar vale primarily for soil investigation. The description of main land forms starts with a brief account of the nature of parent material and its mode of deposition. A geomorphological history of the Quarternary period has been very briefly described. The subdivision of the Quaternary period is based on the degree of soil development and soil characteristics and not on their stratigraphic relationship. The Early Pleistocene is represented by large scale uplifts. The rejuvinated tributaries of Indus deposited fluviatile gravesls and boulders in the Peshawar syncline. During the Middle Pleistocene, the Peshawar syncline was transformed into a glacial lake in which deposition of alternate beds of

silt and sand took place. Due to deposition of loess, the Peshawar lake was converted into a marsh. It was suggested that during the middle part of the Middle Pleistocene, due to a large scale upheavel, the Kabul river was thrown into its present course. During later part of Middle Pleistocene, another uplift initiated a cycle of erosion during which most of the lake beds and loess deposits were eroded.

During the Late Pleistocene, the vale area was covered with another loess (second loess). The Holocene is represented by erosion of loess plains, piedmont plains and river terraces.

19. Gardezi, et al., (1976) reported alluvial terraces in the extreme southwest of Peshawar vale, and around Darra Adam Khel area. These terraces are composed, predominantly of silt, clay and coarse sand mixed with gravels.

20. Said and Majid (1977) investigated the Pleistocene history of terrestrial deposits of Bar Damman area, Peshawar valley, during which important physical characteristics of the surface deposits were statistically measured and studied in relation to their environments and geomorphic processes. On the basis of this study, a chronology of Pleistocene events was also established. It was suggested that during the second Himalayan glaciation, this area was covered by a fresh water lake in which "Azakhel siltstone", mainly consisting of older loess, was deposited. This lake was formed due to damming of the Kabul river by the formation of a huge alluvial fan by the Indus river that extended from Tarbela as far as Attock. According to these authors the early phase of the third

Himalayan glaciation is recorded by fan gravels i.e. "Daman gravels". A fossil soil reflects warm and wet conditions, perhaps, during an inter stadial. During third glaciation, a thick cover of "Sangrobi loess" was deposited. The last glaciation was recorded by the formation of fans, while Holocene is marked by large scale changes in the drainage of the study area.

21. Naqvi (1978) investigated surface and subsurface geological formations in Swabi-Gadoon area with the help of tubewell logs and divided the surface material into three units: (i) Piedmont, (ii) Rolling sand plain and (iii) cover flood plain.

22. Said (1978) carried out geomorphological study of Swabi-Gadoon area in which the genesis of the landforms in relation to material and their environments were traced out and the following landorms were recognized: Piedmont Plain, rolling sandy plain, cover flood plain, loess plain, infilled basin and local fans.

23. Ahmed and Khan (1980) described about 30 meters thick terrace deposits exposed along the principal streams in Barwar Khwar, Jandol Rud, Raingul Khwar and Shal-Kandai Khwar in Barwa-Jandol area.

24. Shah, et al., (1980) during their study of the geology of the eastern Khyber mountains, described some Quaternary terraces. The material lies unconformably over the pre-Cambrian slates of Landi Kotal Formation and the younger igneous rocks. These terraces are exposed near the eastern end of the Khyber Pass, (from Lala China to Ali Masjid),

and at Loe Shilman(Shenelle and Wazir Kor villages). Most of these terraces are titled. According to Stauffer (1968b) these terraces were uplifted during recent and subrecent times, while Shah, et al., (1980) considered the age of these terraces from Pleistocene to Recent.

25. Rendell and Thomas (1980) carried out a study of Pleistocene and Holocene deposits of Takhati-Bhai area near Mardan and identified a yellow coloured siltstone of lucustrine origin overlain by massive red silty beds. Both these beds have similarity in grain size distributions. It was also suggested that widespread erosion of the siltstone took place after its deposition. The Takhti-Bhai deposits were correlated with Pleistocene deposits of Bar Daman area south of river Kabul.

26. Aslam, et al., (1981) described Quaternary deposits in the Gandao area in Mohmand Agency.

27. Yeats and Lawrence (1982) while discussing tectonics of the Himalayan thrust belt in Northern Pakistan, discussed the effect of tectonics on the evolution of the Peshawar vale. The Peshawar basin is considered to have formed due to the southward migration of thrust faulting.

28. Burbank (1983) examined 25 meters thick graded beds exposed in a section in the Piran nala near Piran village. He concluded that at least 40 catastrophic floods of Indus river inundated the Peshawar basin in pre-historic times. According to his study the sediments at Piran are normally magnetized and belong to the Brunnes Chron and are less than 700,000 year old. It was suggested that the major portion of sediment

aggradation within the Peshawar basin commenced about 3 m.y. ago and continued till 60,000 years ago(Burbank and Johnson, 1982). The sedimentation in the vale terminated due to the accelerated uplift of the Attock-Cherat range.

29. A recent study by Burbank and Raynolds(1984) established chronologies for the Siwalik molass and intermontane basins along the southern margins of the Himalayas and Hindu Kush ranges. The intermontane basins such as the Peshawar and Kashmir are dominated by proximal alluvial fan facies,intermediate braided-river sediments, and extensive high sinousity fluvial and shallow lacustrine sediments. These sequences occur in tectonically ponded valleys that lie inside the deformational front of the Himalayan fold and thrust belt. Burbank and R ynold (Ibid) consider that it is the tectonic environment which controls the style and rate of sediment accumulation in the intermontane basins.

30. Burbank and Tahirkheli (1985) employed stratigraphy, fission track dates on volcanic ashes and stratigraphic data to define the chronologic and stratigraphic evolution of the Peshawar basin. According to them, a prolonged interval of folding, faulting, and erosion during the late Miocene and early Pliocene, was followed by accumulation of sediments along the southern margin of Peshawar basin at about 2.8 m.y. ago at the rate of about 15 cm/1000 years. At about 2.5 m.y. ago, alluvial fans derived from the uplift of Attock Range prograded northward into the Peshawar basin near Dag, while low-energy flood plain and flood pond sediments accumulated in the western part of the basin near Garhi Chandan. Extra-

basinal, explosive volcanism spread ashes in two clustors across the Peshawar basin. Accelerated uplift of the Attock Range after 0.6 m.y. ago resutled in folding and dissection of the sediments, filling the Peshawar basin.

31. Yeats and Hussain (1987) described the geology and structure of the Attock-Cherat Range in relation to various tectonic events. According to them, the Peshawar basin is formed as the Kala Chitta Range was faulted south on the Main Boundary Thrust (MBT). They also described deformation of the Quarternary deposits in the southern Peshawar vale due to recent thrust faulting.

32. Rendell (1988/89) studied the loess deposition during the Late Pleistocene in northern Pakistan. The thermo-luminescence (TL) dating method has been used to calculate the dates of loess deposition near Rawalpindi in the Potwar and around Nowshehra in the Peshawar vale.

As can be seen in the past no attempt has been made to carry out a systematic study of the deposits of Peshawar vale and to reconstruct its palaeogeography during the Quaternary period. The conclusions are very much generalized and not useful for stratigraphic correlation. The magneto-stratigraphy and fission-track dating too provide only a generalized view because details of the lithology of various deposits in relation to their morphogenetic characters are not available. In studying the surface deposits, many geo-morphic characteristics e.g. identifying the erosional uncon-formities, marking various fossil soil horizons, and signify-ing the environments of deposition in relation to the climatic

implications have been neglected. In general it appears that main emphasis has been on tracing the time of tectonic disruption in the Peshawar vale rather than identifying the morphogenetic characteristics of the vale during various stages of the Quaternary period.

From the previous work it is, however, clear that the bottom of the vale consists of a pre-Pleistocene topography, covered with a thick blanket of unconsolidated material which has been deposited as a result of a series of erosion of processes operating on the surrounding mountains. It is surprising to note that although there are good exposures of the component units of the Quaternary deposits, no attention has been given to their proper lithogeomorphic descriptions.

It is purely for this reason that in the present study, the chronology of the geomorphological events is based on a detailed field and laboratory examinations of material from various sections.

CHAPTER 3

GEOLOGY

3.1 INTRODUCTION

The Peshawar vale, covering an area of about 3440 square miles, holds a pivotal position in the tectonic framework of the Lesser Himalayas in Northern Pakistan. The Attock-Cherat range forms the southern boundary of the Peshawar vale and includes rocks, transitional between metasediments of the Lesser Himalayas and foreland - basin strata to the south (Yeats and Hussain, 1987). Surrounding the vale in the west, a sequence of sedimentary and low-grade metamorphic rocks with minor intrusions (mountain system of the Khyber Agency, Shah, et al., 1980) grades into a succession of schist and limestone beds with abundant acid intrusives in the Mohmand and Utmankhel territory in the north-west. Further north in the Bajaur Agency, the bordering rocks are dominantly of schistosic, acid plutonic, volcanic and volcano - sedimentary character (Kaker, et al., 1971, Chaudhry, et al., 1974, 1974(a), 1974(b), 1976 and Butt, et al., 1980). Adjacent to the Dargai, Rustam and Swabi plains, the Peshawar vale is truncated by the rocks of the lower Swat-Buner Schistose Group and Swat Granitic Gneisses (Martin, et al., 1962).

3.2 GENERAL GEOLOGY

General geology will be discussed under two sub-headings:- (Fig. 3.2.1)

- Geology of the area around the Peshawar vale.
- Geology of the Peshawar vale.

3.2.1 GEOLOGY OF THE AREA AROUND THE PESHAWAR VALE

Attock-Cherat Range

The range lies between the Peshawar vale on the north and the Nizampur basin to the south. Detailed description is given by a number of workers (Tahirkheli, 1970, Meisner, et al., 1974. Gardezi, et al., 1976, Lawrence and Ghouri, 1983, Hussain, et al., 1984 and Yeats and Hussain, 1987). The range consists of three east-trending fault-bounded blocks that contains folds verging to the south; these blocks are bounded by thrust faults that are folded but, in general dip to north. From north to south, these blocks consist of (1) argillite, slate, phyllite and subordinate quartzite of probable pre-Cambrian age intercalated with and overlain by limestone and intruded by diabase, (2) argillite and quartzite of possible pre-Cambrian age intercalated with subordinate beds of limestone and unconformably overlain by limestone and shale of Cretaceous, Paleocene, and Eocene ages and variegated sandstone and siltstone of the Murree Formation, at least in part of early Miocene age (Shah, 1977), and (3) limestone, quartzite, argillite, and local maroon shale, possibly of Paleozoic age,

MAP OF PESHAWAR BASIN AND ADJACENT AREAS

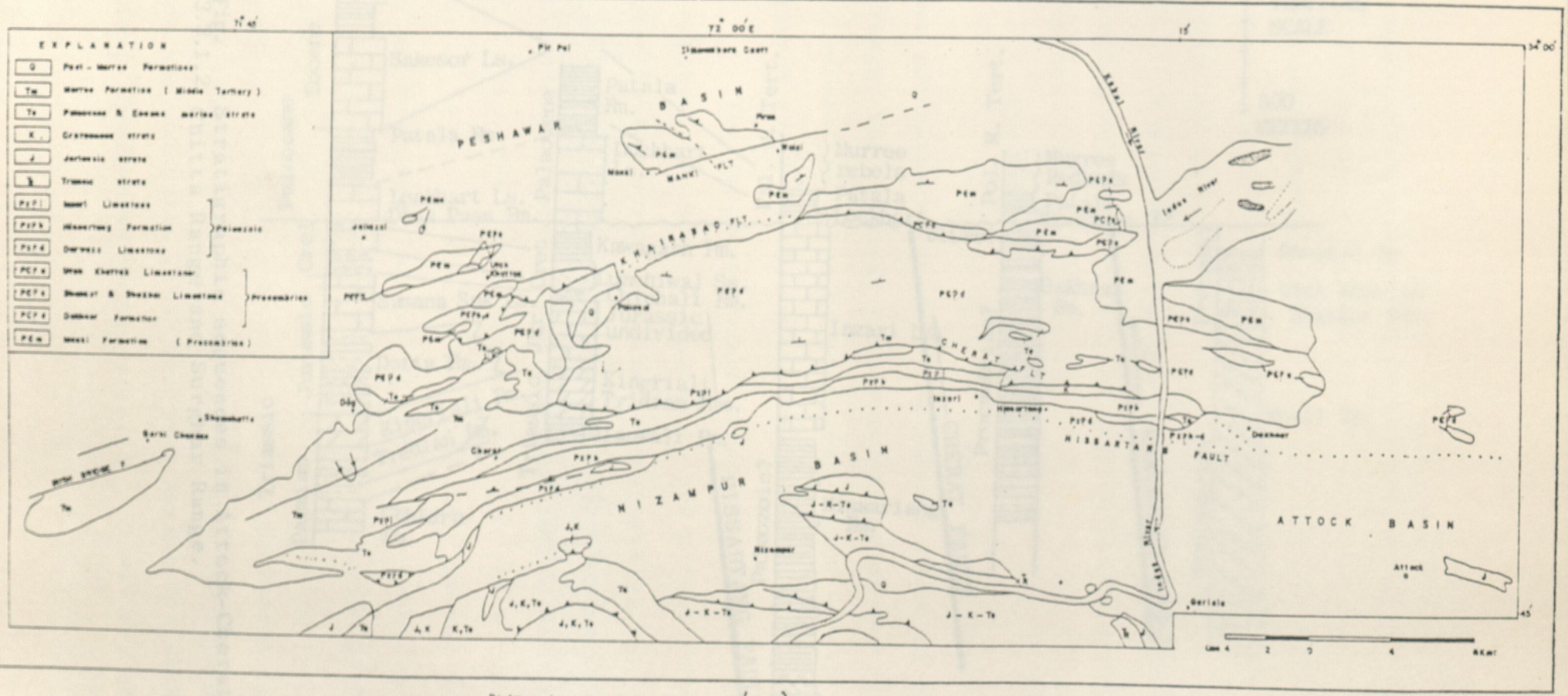


REDRAWN FROM BURBANK AND TAHIRKHELI (1985). GEOLOGY EAST OF TARBELA LAKE FROM CALKINS (1975). LOWLANDS SHOWN BY STIPPLE PATTERN

Fig. 3·2·1

GEOLOGY OF THE ATTOCK CHERAT RANGE

PAKISTAN



Re drawn from Yeats and Hussain et al (1987)

Fig. 3·2·1·1 .

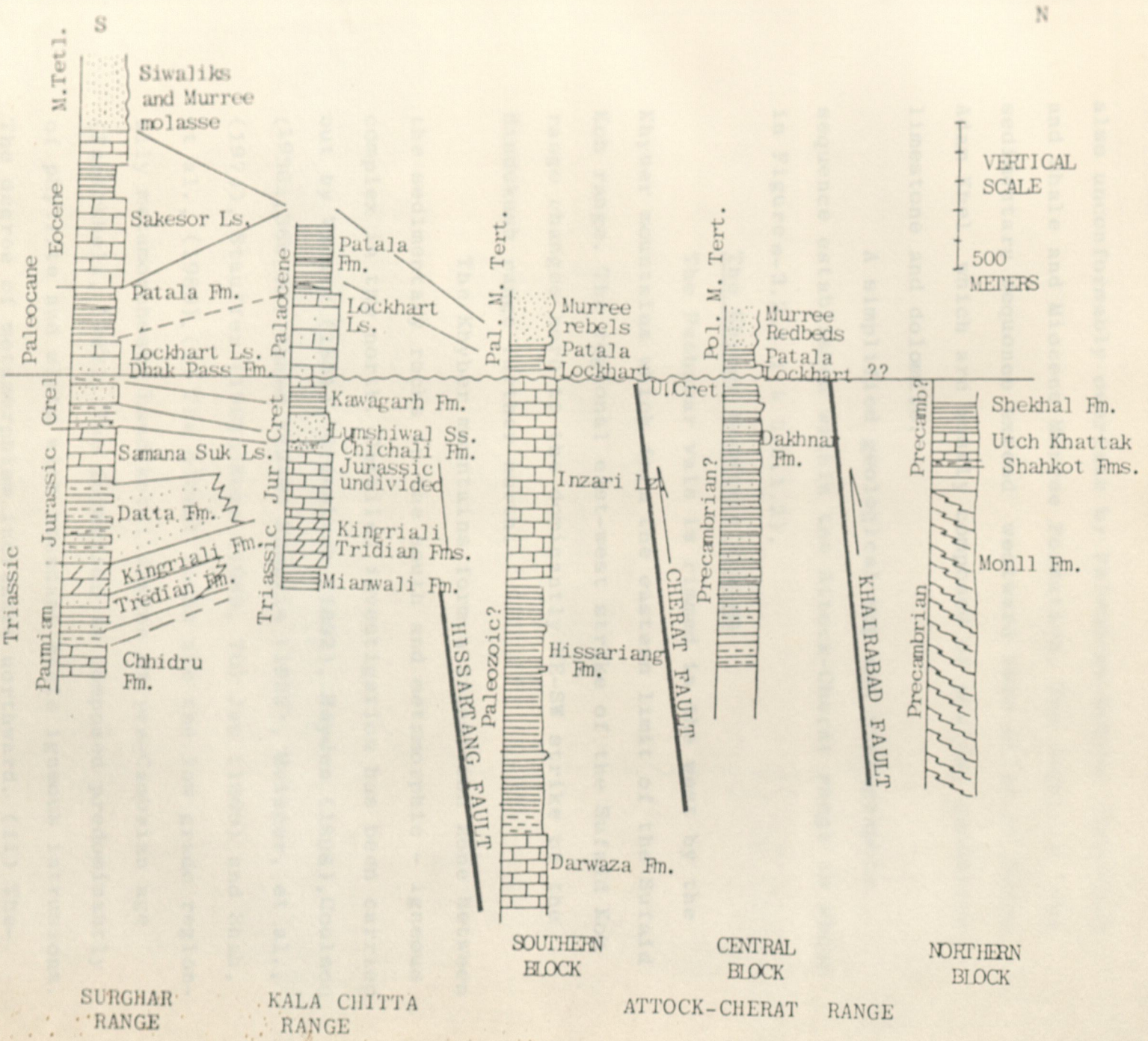


Fig. 3.2.1.2 Stratigraphic sequences in Attock-Cherat Range, Kala Chitta Range and Surghar Range.

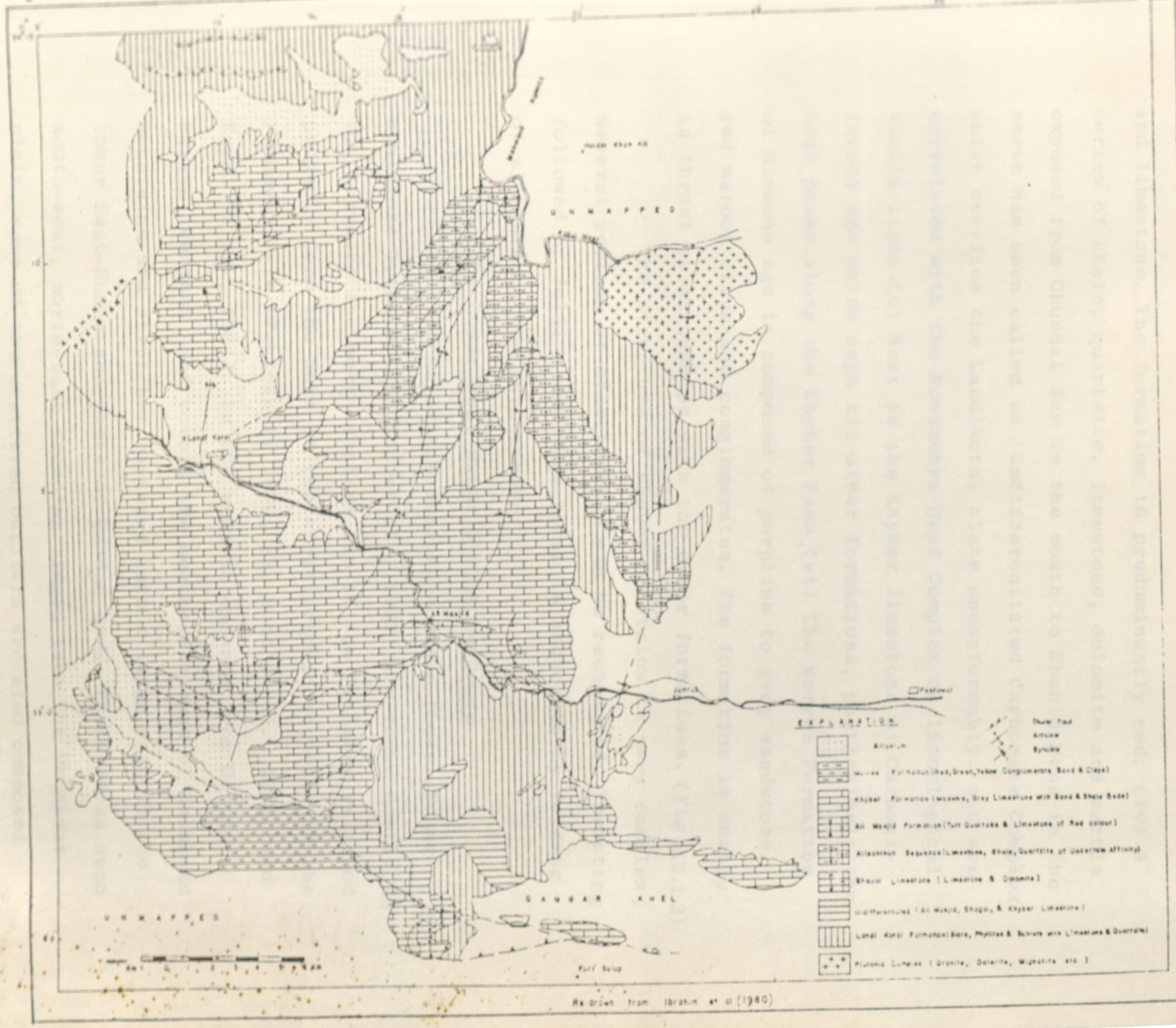
also unconformably overlain by Paleocene-Eocene limestone and shale and Miocene Murree Formation. The rocks of the sedimentary sequence extend westward into hills of Darra Adam Khel, which are mostly composed of shales, sandstone, limestone and dolomite.

A simplified geological map and starigraphic sequence established within the Attock-Cherat range is shown in Figures-3.2.1.1 & 3.2.1.2).

The Khyber Mountain System

The Peshawar vale is rimmed in the west by the Khyber mountains which form the eastern limit of the Sufaid Koh range. The regional east-west strike of the Sufaid Koh range changes here to the dominantly NE-SW strike of the Hindukush range further north.

The Khyber mountains form a transition zone between the sedimentary rocks in the south and metamorphic - igneous complex in the north. Detailed investigation has been carried out by Vicary (1851), Griesbach (1892), Hayden (1898),Coulson (1936a,36b,40) Ahmed (1949) Namazie (1952), Meisner, et al., (1974), Stauffer (1968b)Khan (1969, 70) Jan (1969) and Shah, et al., (1980). (i) The oldest rocks are the low grade regionally metamorphosed Landikotal slates of pre-Cambrian age (Tahirkheli, 1982). The formation is composed predominantly of phyllite and slate with abundant basic igneous intrusions. The degree of metamorphism increases northward. (ii) The-Shagai limestone is the next formation, represented by limestone and dolomite. (iii) The next is the Ali Masjid Formation, composed of shale,siltstone, sandstone, quartzite


UNMAPPED
AFGHANISTAN
PAKISTAN
Landi Kotal
Peshawar
EXPLANATION
Thrust Fault
Anticline
Syncline
Alluvium
Molasse Formation (Red, Brown, Yellow Conglomerate Sand & Clays)
Khyber Formation (Massive, Grey Limestone with Sand & Shale Beds)
Ali Masjid Formation (Tuff Quartzite & Limestone of Red colour)
Attockian Sequence (Limestone, Shale, Quartzite of Uncertain Affinity)
Shagai Limestone (Limestone & Dolomite)
Undifferentiated (Ali Masjid, Shagai, & Khyber Limestone)
Landi Kotal Formation (Basic, Phyllites & Schists with Limestones & Quartzite)
Plutonic Complex (Granite, Dolerite, Migmatite etc.)
GANDAR KHEL
UNMAPPED
Kurf Sirlup
Km 0 1 2 3 4 5 6 7 8 9 10
Re-drawn from Ibrahim et al (1980)

and limestone. The formation is predominantly red. (iv) A series of shale, quartzite, limestone, dolomite and marble exposed from Ghundai Sar in the south to Shahid Mena in the north has been called as 'Undifferentiated Carbonate Complex' which overlies the Landikotal slate unconformably and are correlated with the Nowshehra Reef Complex on lithological similarities.(v) Next is the Khyber limestone of Carboniferous age which caps all other formations, particularly the high peaks along the Khyber Pass.(vi) The Murree Formation of Miocene age is composed of purplish to grey sandstone, red maroon clays and conglomerates. The formation is mostly in thrust relationships with the older formations. (Fig.3.2.1.3)

The structure of Khyber mountains is very complex, several periods of diastrophism can be recognized. Thrusting followed by folding and vice versa is indicated by folding of allochthons and autochthons.

The Lower Swat-Buner Schistose Group

The rocks of the Schistose Group (Lower-Buner Schistose Group of Martin, et al., 1962) are found mostly in the northern and north-western rim of the Peshawar vale and probably form the base of the stratigraphic sequence of the Peshawar vale (Tahirkheli 1979, 82, Butt et al., 1980, and Kazmi et al., 1984). In the west it extends from Gandao, Warsak, Mohmand and covers the southern slopes of Malakand mountains and stretches eastward into a large part of the lower Swat-Buner and parts of Mardan area. These rocks send south-west, north-east trending ridges into the Peshawar plain, some of the scattered outliers are also composed

Geological Reconnaissance Map Of The Lower Swat-Indus Valley

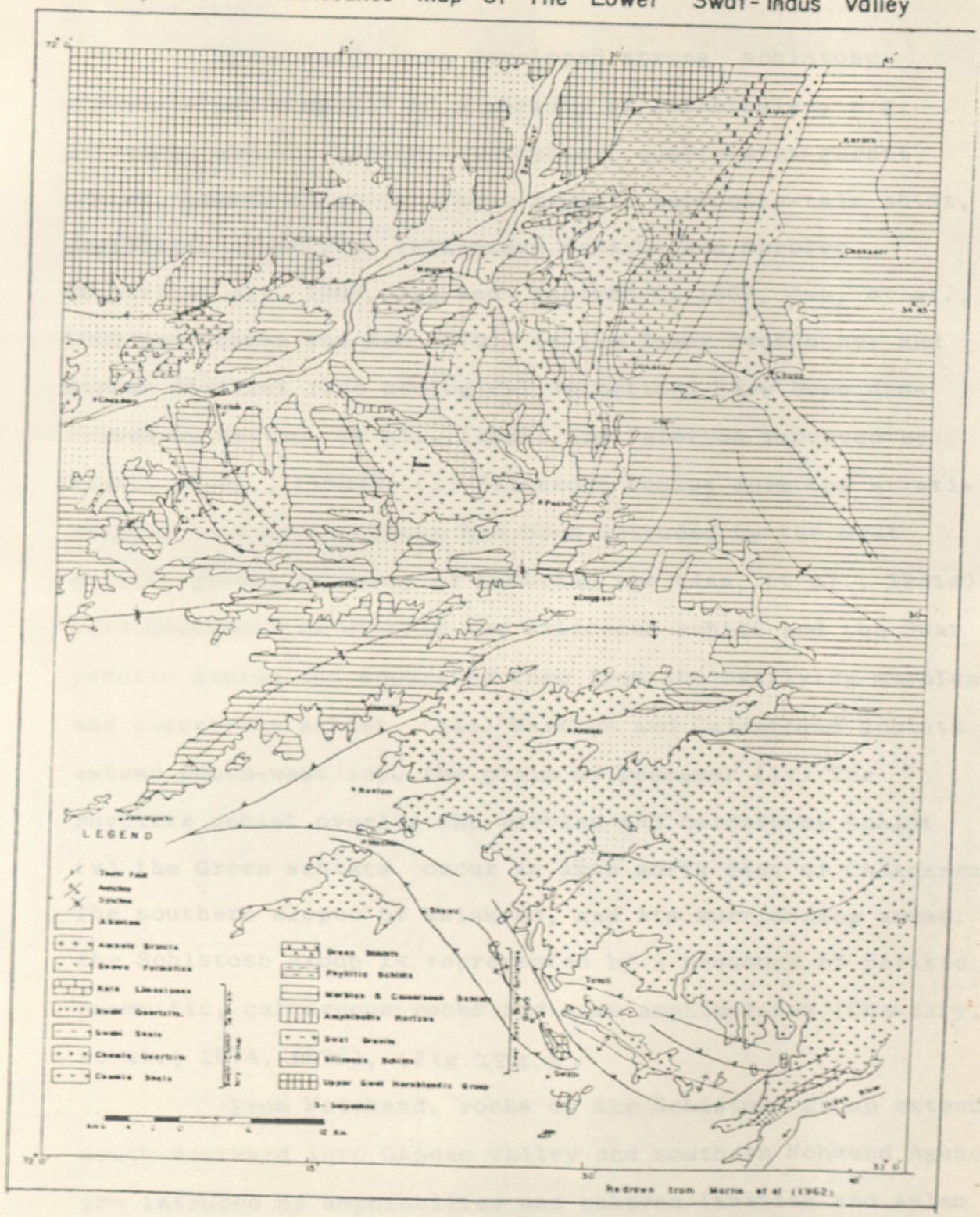


Fig. 3·2·1·4

of these rocks.

These rocks have developed strong schistose structure and composed of a variety of lithologies, e.g. siliceous schist, quartz-mica-schist, quarts-mica-garnet schist, quarts-chlorite albite schist, actionite-talc shist, phyllites, quartzite, calcarcous schists and marbles. (Moosvi,et al., 1966, Jan and Tahirkheli 1969, Jan, et al., 1969 and Rehman and Zeb 1970). In the lower Swat-Buner and Mardan district five geological formations have been described by Martin, et al., (1962) and later on improved by Kazmi, et al., (1984). (i) Siliceous schist form the stratigraphic base of the Group has been intruded by the Swat granite gneiss probably of Cambrian age (Jan, et al., 1981a). (ii) Amphibolites overlie the Siliceous schist and the Swat granite gneiss and separates them from the overlying marbles and calcareous schist. (iii) Marbles and Calcareous schists extend south-west into the plain of Peshawar (iv) The Phyllite schist overlie the marbles and calcareous schist (v) the Green schists occur in area north east of Chakdarra. The southern slopes of Malakand, and its surrounding areas, the Schistose group is represented by a sequence of pelitic, psammitic, calcareous rocks and some amphibolites (Chaudhry, et al., 1974, 1976), (Fig.3.2.1.4).

From Malakand, rocks of the Schistose group extend south-westward into Gandao valley and southern Mohmand Agency are intruded by amphibolites and gabbros (Khattak and Aslam 1974, Arbab and Siddiqui,1972 and Aslam, et al., 1981). Similarly, further south in Warsak and surrounding areas,

GEOLOGICAL MAP OF THE MALAKAND AREA

(Chaudhry et al, 1974)

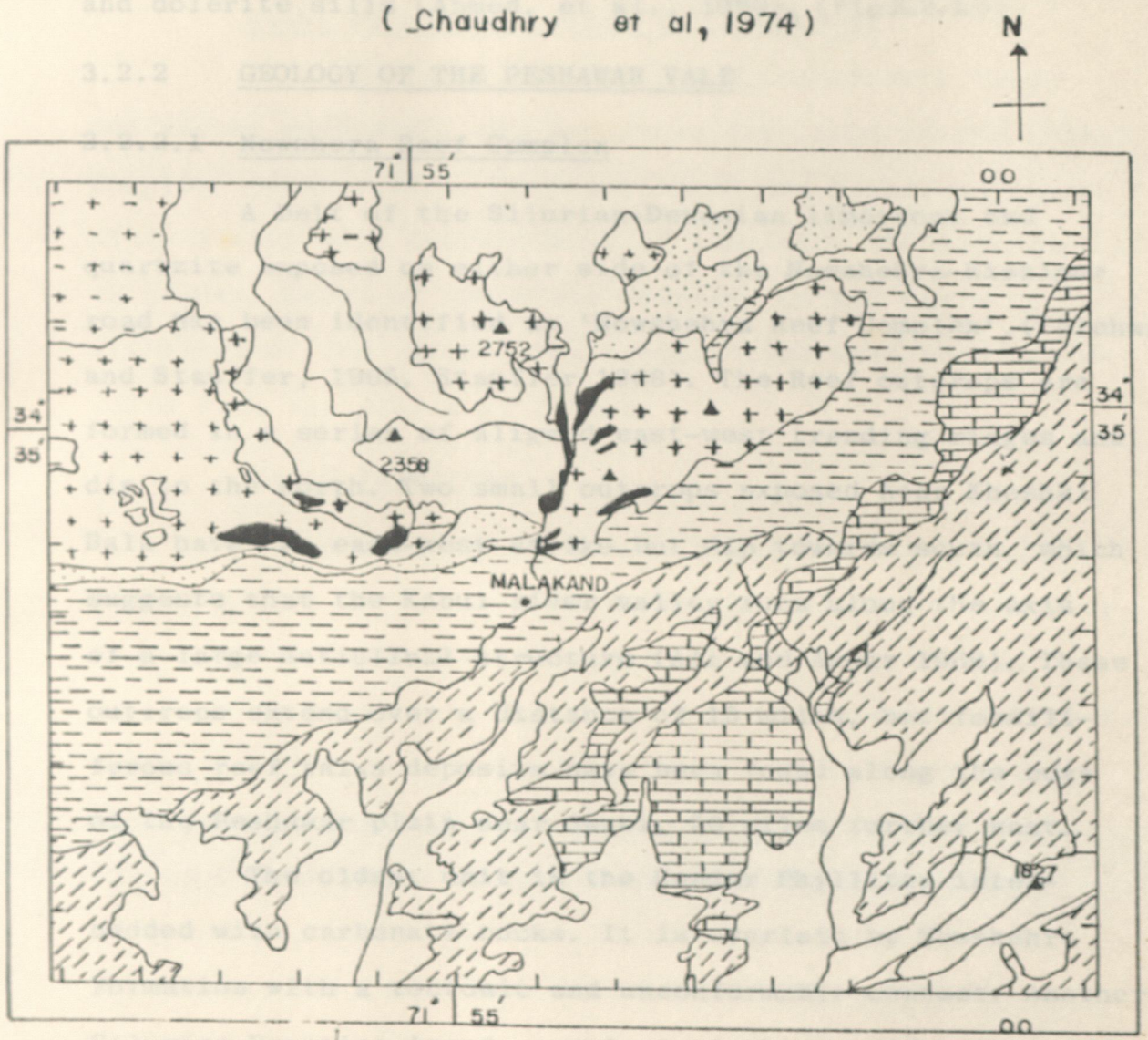


Fig. 3·2·1·5

ALLUVIUM

MALAKAND GRANITE

MIXED ZONE OF MALAKAND GRANITE

MALAKAND GRANITE GNEISS

MIXED ZONE OF MALAKAND GRANITE GNEISS

SCREENS IN GRANITE

BIOTITE CHLORITE SCHIST

CALCAREOUS SCHIST & MARBLE

GARNET MICA SCHIST

QUARTZITE & QUARTZ - MICA SCHIST

rocks of this group are represented by pelitic, psammitic and calcareous rocks which have also been intruded by granite and dolerite sills (Ahmed, et al., 1969), (Fig 3.2.1.5).

3.2.2 GEOLOGY OF THE PESHAWAR VALE

3.2.2.1 Nowshera Reef Complex

A belt of the Silurian-Devonian limestone and quartzite exposed on either side of the Nowshehra-Risalpur road has been identified as 'Nowshehra Reef Complex'.(Teichart and Stauffer, 1965, Stauffer 1968). The Reef outcrops are formed in a series of aligned east-west trending ridges and dip to the north. Two small outcrops exposed near Kheshki Bala have an east-west strike but dip towards south which suggests that the Kabul river valley runs along the axis of a large anticlinal structure (Ali and Anwar 1969). These outcrops extend over a distance of 15 miles, but fossiliferous reef talus deposits have been found along the edge of the Peshawar plain near Swabi, 20 miles further east.

The oldest unit is the Kandar Phyllites interbedded with carbonate rocks. It is overlain by Nowshehra Formation with a tectonic and unconformable contact. Another Silurian-Devonian 'reef complex' striking east-west and dipping northward is exposed to the north of Jamrud Fort (Khan 1969). The Silurian-Devonian reef of Charsadda, comprising seven isolated hillocks, is found at Tangi Ghar, a few miles north of the Peshawar city (Tahirkheli 1969).

3.3 STRATIGRAPHY OF THE PESHAWAR VALE

3.3.1 PRE-CAMBRIAN

Manki Formation/Landikotal Formation

Covering large part of the Attock-Cherat range and Khyber mountains, the rocks are described as the 'Slate Complex' (Shah, 1977). Dominant rocks are slate, phyllite, slaty shales with interbedding of limestone and quartzite at places. Rocks of the Slate Complex, on the basis of lithological and structural similarities have been correlated with the slates of Hazara.

Manki Formation

It is composed of slate, phyllitic slate and phyllite with lenticular limestone. The slate is dark-grey to black and shows weak cleavage parallel and oblique to the bedding planes. Hydrothermal quartz veins and dolerite sills and dykes are frequently found. It is extensively developed at Manki Ghar in the northern foothills of the Attock-Cherat range about six miles south of Nowshehra (Tahirkheli, 1970). No fossils have been found in this formation. The rocks have been tentatively assigned a pre-Cambrian age on the basis of their lithological correlation with Hazara Formation, which has been determined to be of pre-Cambrian age on the basis of radiometric dating by Rb-Sr method by Crawford and Davies (1975). The approximate thickness of the formation is 600 meters.

The Landi-Kotal Formation

The Landi-Kotal Formation comprises slates, phyll-

ites and schists with minor limestone and quartzites which are frequently intruded by dolerite dykes and sills and with some granites in the northern parts. In the northern parts of the Khyber mountains, due to high intensity of igneous activity, the slates have changed to biotite and garnetiferous schists. (Shah, et al., 1980, p.6).

Besides metasediments, limestone is embedded in Manki and Landikotal formations at various places. In the Attock-Cherat range, the limestone in the Manki Formation is yellowish grey, thin to medium bedded, finely crystalline and occurs as pockets and lenses. (Tahirkheli, 1970). In the Khyber mountains, limestone embedded within the slate is grey and exhibits light grey to buff colour on weathering. At Landikotal, the limestone is medium to thick bedded, crystalline and completely devoid of fossils.

Dakhner Formation

Dakhner Formation consists of thick sequence of argillite, quartzite, and subordinate limestone. It has got an extensive distribution in the Attock-Cherat range. The argillite is dark grey to greenish grey, thinly bedded to massive and irregularly stratified. The quartzite is light grey to dark grey, brownish, medium grained, hard and show poorly preserved cross-beddings. The basal part of the formation shows light grey to yellowish grey limestone with thin interbedding of chloritic material. The lower contact of the formation is faulted against Uch Khattak Formation. It is unfossiliferous and on the basis of the observed stratigraphic position and the structural affinity,

Hussain, et al., (1984) tentatively suggested a late pre-Cambrian age. The Dakhner Formation could be stratigraphically equivalent to the Manki Formation, differing only in degree of metamorphism (Yeats and Hussain, 1987).

Shahkotbala Formation

The Shahkotbaba Formation is composed of slaty shale overlain by limestone. Its maximum development is found in the north-western foothills of Attock-Cherat range between Shahkotbala village and Shaikhi nala. Towards east after a lapse of 30 miles it reappears in the hillocks around Khairabad village (Tahirkheli, 1970). The slaty shale of this formation is light greenish grey and brownish grey. It is hard, indurated and usually cleaved along more than one plane which results in splintry pieces.

The slaty shales are overlain by white, light to dark-grey and yellowish brown, thin to thick bedded, well-jointed finely crystalline dolomitic limestone. The formation has been intruded by dolerite sills and has been assigned a pre-Cambrian age (Tahirkheli, 1982, Hussain, 1984).

Utch Khattack Formation

In the Attock-Cherat range, it is predominantly limestone with subordinate shale. It overlies the Manki Formation with gradational contact, while its upper contact with the Shaikhi Formation is uncomformable. Khattak limestone is light grey to yellowish grey, thin to medium bedded, rubbly and contains dark grey argillaceous streaks and laminations (Hussain, 1984). Because of the occurrence of a boulder bed (e.g. at Sangrobi Ghundai and at Raja Hodi

Railway tunnel) similar to the Tanaki boulder bed of Hazara, the Khattak Formation is considered equivalent to the Tanawal Formation of Hazara (Tahirkheli, 1982).

In the Khyber mountains, the Shagai limestone is considered equivalent to the Khattak limestone on the basis of lithological similarities and its stratigraphic position (Tahirkheli, 1979, 82). The Shagai limestone is grey, weathering to light grey, black, brown and greyish yellow.

3.3.2 PALAEOZOIC

3.3.2.1 Cambrian

Shaikhi Limestone:

The Shaikhi limestone is composed of three lithologic units, limestone, quartzite and shale. It overlies the Khattak limestone with a well-marked unconformity(Tahirkheli, 1970). In the Attock-Cherat range, the formation is exposed between Shaikhi and Uch Khattack nala for a distance of about three miles with thickness ranging between 20 and 340 feet. It forms ridges and escarpment. Fossils have not been reported from this formation. Petrographic studies by Tahirkheli (1970) have shown this formation to be identical with the Abbotabad Formation (Hazara) of Cambrian age (Latif, 1974).

Ali Masjid Formation:

In the Khyber mountain the Ali Masjid Formation consists of shale, siltstone, sandstone, quartzite and limestone. It is pre-dominantly red in colour with subordinate bands of yellow, brown, white and grey colour. The basal part of the formation is composed of siltstone and calcareous

shale. These beds are followed by a series of quartzite layers, covered by an eighteen inches thick conglomeratic bed.

The Ali Masjid Formation lies between the Shagai limestone and the Khyber limestone. Its upper and lower contacts are slightly sheared. On the basis of the repetition of classic and calcareous material and other lithological characteristics it may be equivalent to the Abbotabad Formation of Hazara (Tahirkheli, 1982).

The Swabi-Chamla Sedimentary Group:

These rocks are exposed in Swabi and Chamla area of the lower Swat and extend upto Ambela in the north and upto the Indus river in the east. This group consists of the following formations:

a. The Chamla phyllitic shale: The Chamla Phyllitic shales are dark grey in colour and vary in composition from pelites to semi-pelites with quartzitic layers, and some gray wacks.

b. The Chamla quartzites: The formation consists mainly of pure quartzites, pebbly quartzites and quartzitic grit. In places, the quartzites are interbedded, with more argillaceous layers, while in the lower portions some fine thin-bedded mudstones and siltstones are found.

c. The Swabi pebbly shales: The Swabi Pebby Shales overlie the Chamla Quartzite with an erosional unconformity, (Martin, et al., 1962, Ali, 1962), and have close similarities with the Chamla shales. On the basis of lithology and structure, these rocks are correlated with the Tanaki boulder

bed of Hazara and Kashmir (Latif 1974, Ghorie et al., 1977 Tahirkheli 1982).

d. The Swabi quartzite: The Swabi quartzite which overlies the Swabi pebbly shales is composed of grey shaley sandstone, white quartzite and quartzitic grit, and brown honey-comb weathering grey calcareous sandstone.

e. The Kala limestones and dolomites: The Kala limestones and dolomites are named after the village Kala (34°b' 72° 29') where a complete succession is found. It dominantly consists of limestone, dolomitic limestone and shale.

3.3.2.2 Silurian-Devonian

Siluro-Devonian sequence is present in Nowshehra as "Nowshehra Reef Complex", in the Khyber mountains as 'Khyber Undifferentiated Carbonate Complex', and in Attock-Cherat range, rocks of Darwaza, Hissartang and Inzari Formations.

Nowshehra Reef Complex:

The rocks have been studied and described by Tiechart and Stauffer (1965), Stauffer (1968) and Ali and Anwar (1969) and divided into the following units:-

a. Kandar phyllites,- the oldest formation is composed of phyllites and interbeds of carbonate rocks. Crinoid stems and Nautiloids are present at places. Its lower contact is not exposed whereas the upper contact with Nowshehra Formation is tectonic and unconformable (Stauffer, 1968). It may be correlated with the slates of Landikotal and Manki Formations. (Khan 1970, Tahirkheli 1982).

b. Nowshehra Formation is reefoid and has been divided into following three units:-

i. Carbonate Rocks: These rocks are exposed only on the southern side of the western most out crop, north of the village Nawan-Killi. The carbonate rocks have been divided into (a) massive carbonate rocks lying at the base and (b) thin-bedded carbonate rocks which are marly in composition and contain abundant fossils (Ali and Anwar, 1969).

ii. Reef Core is made up of fossils in growth position with limestone and dolomite and fossil debris.

iii. Reef Breccia which includes crinoid banks, carbonate with dominant reef breccia or fossil debris. The age on the basis of canodonts is late Silurian to Early Devonian.

c. Misri Banda Quartzite: The quartzite of this formation is massive, medium grained and is characterized by dolomitized quartzite and orthoquartzites. It is non-fossiliferous and assigned a Devonian age on the basis of its lower conformable contact with Nowshehra Formation.

d. Pir Sabak Formation: This formation is represented by thick bedded dolomitic limestone at the base and thin to thick bedded limestone in the upper part. The lower contact with the Misri Banda quartzite is conformable.

Khyber Undifferentiated Carbonate Complex:

A series of shale, quartzite, limestone, dolomite and marble extends from Ghundai Sar in the south to Shahid Mena in the north, in the eastern parts of the Khyber mountains. The lithologies and colours of this unit are remarkably similar to the 'Nowshehra Reef Complex' and represents a facies complex associated with former reef development in the Peshawar vale area. The broad age may be considered as Devonian (Shah, et al., 1980).

Jamrud Reef Complex

A Siluro-Devonian reef complex striking east-west, dipping northward is exposed to the north of Jamrud Fort and the Warsak canal. Khan (1970) described four distinct units. From below upward these are: (i) phyllite and crinoidal limestone with intrusion of dolerite is the oldest unit which is equated with the Kandar phyllite of the Nowshehra Reef Complex. (ii) The reef core comprising pink to grey and dark grey silicious crystalline limestone, dolomitic limestone and dolomite (iii) the reef breccia overlain by (iv) grey and yellowish grey dolomitized quartzite which are equated with the Misri Banda quartzite of the Nowshehra Reef Complex.

Attock-Cherat Range

In the Attock-Cherat range three formations have been identified by Hussain, et al., (1983) and Hussain (1984), which on the lithological similarities have been considered equivalent to the Silurian-Devonian rocks of the Nowshehra

Reef Complex. Thus in this way a lower and middle Palaeozoic gap in the stratigraphic sequence of the Attock-Cherat range has been filled. These three formations are as follows:-

a. Darwaza Formation: The oldest lithological unit exposed on the southern slope of Attock-Cherat range is composed of limestone which is white to light greyish green, thin to medium bedded and contains manganese staining and denderities. It is overlain by shale of red maroon, dark grey colour. Small doleritic dykes and sills are common. The formation is without fossils. On lithological similarities it is correlated with the rocks of the Nowshehra Reef Complex of Silurian-Devonian age.

b. Hissartang Formation: It is composed of quartzite in the upper and lower parts and argillite in the middle part. The quartzite is white to light grey, fine, hard, well sorted and thin to thick bedded. It is correlated with Misri Banda quartzite of Silurian-Devonian age.

c. Inzari limestone: It is light yellowish grey to light greenish grey, finely crystalline and thin to thick bedded. Manganese stainings and denderites are common. The upper contact of Inzari limestone is faulted either against Dakher Formation of pre-Cambrian age or against the Tertiary sequence. It is correlated with the limestone of Nowshehra formation of Silurian-Devonian age.

3.3.2.3 Carboniferous

Khyber limestone: The formation named as Khyber limestone (Stauffer, 1968) is composed of thick bedded, fine grained, re-crystallized grey limestone with negligible

argillaceous and arenaceous partings. It is occasionally crystalline and rarely dolomitic in character. Basic dykes and sills are common mostly in the upper part of the formation.

3.3.3 MESOZOIC

3.3.3.1 Jurassic

Data, Samana Sukh Formation Undivided

It consists of limestone, calcareous sandstone, shale and marl and exposed in the south-western part of the Attock-Cherat range and in the Darra Adamkhel ranges.

Chichali Formation

It consists of dark grey to black and greenish grey sandstone and shale. Best exposures are found in the south-western slopes of Attock-Cherat range and parts of Darra Adam Khel ranges.

3.3.3.2 Cretaceous

Lumshiwal Formation

It consists of quartzose sandstone in lower part followed by upwards sandstone and limestone. The sandstone is greenish brown, greenish grey, medium grained, while the limestone is yellowish grey to brownish grey, and thin to medium bedded. It is assigned an early Cretaceous age (Fatmi, 1973).

Kawagarh Formation

The formation is exposed along the southern face of the Attock-Cherat range which skirts the Nizampur Valley. It consists of marl with subordinate interbedded limestone

and contains ferruginous encrustation along fractures and joints. The upper contact with the Lochart limestone is unconformable and is represented by the presence of laterite all over. It has been assigned a late Cretaceous age (Latif 1962, 1970).

Lochart Limestone

This limestone, (also known as Cherat limestone) is developed along the skyline of the Cherat range over which the Cherat cantonment is situated. It is exposed along the southern side of the Attock-Cherat Range forming prominent escarpment (Tahirkheli, 1970). The formation also extends into hill ranges of Darra Adam Khel (Gardezi, et al., 1976).

3.3.4 CENOZOIC

3.3.4.1 Palaeocene-Eocene

Patala Formation

It consists of alternate beds of shale and limestone with subordinate sandstone. The shale is dark greenish grey, thinly bedded and fissile. The limestone is dark grey to yellowish grey, hard and thin to medium-bedded. The sandstone is brownish grey thin bedded and shows poorly preserved cross-beddings. It has been assigned a late Paleocene to early Eocene age (Fatmi, 1973).

Lakhrai Claystone

This formation is exposed along the northern foothills of the Cherat ridge. It consists of sandstone, shale, loose and soft clay. The Lakhrai formation unconformably overlies the Cherat limestone. It is assigned a lower Eocene

age (Meisner, et al., 1974).

Bakhtai Formation

Bakhtai Formation of lower Eocene age is developed on the northern slope of the main Cherat ridge. The formation consists of medium to dark-grey thin-bedded, at places sandy limestone, which contains interbedded soft splintry greenish grey shale and slaty shale. The shale contains pockets and lenses of interior coal near Jaba Khattak, Shaikhi and Bakhtai villages (Tahirkheli, 1970).

3.3.4.2 Miocene

Murree Formation

The Murree formation is exposed in and around Dag and Bakhtai villages and unconformably overlies the Bakhtai formation. It is isoclinally folded and forms low and sharp ridges along the Attock-Cherat range. Towards west, it extends into hills of Dara Adamkhel, where Jurassic to Paleocene sequence in the middle have faulted contacts in the form of low angle thrusts with Murrees. This area consists of two allochthonous nappes resting upon the autochthonous Murree sediments (Gardezi, et al., 1976). It is also extensively exposed in the south-western part of the Khyber mountains. The Murree Formation is composed of alternations of sandstones, siltstone, shale, and conglomeratic at places.

3.4 IGNEOUS ROCKS OF THE PESHAWAR VALE

Igneous rocks of the Peshawar vale are discussed with reference to the development of similar rocks in the

TABLE- 3.4.1. IGNEOUS ROCKS OF THE INDO-PAKISTAN PLATE

Igneous Rocks group		Tectonic episode in the Himalayan Orogeny	Age	Examples
IV.	Ultramafic Association	Tectonic emplacement of solid mantle peridotite	Early Tertiary emplacement	Harzburgite - peridotite - dunite - serpentinite association of Sakhakot Qila area.
III.	Granites and related igneous rocks of the Peshawar plain Alkaline igneous province.	Rifting	(41-50 M.Y) Early Tertiary	Ambela granitic complex, Loe-Shilman Carbonatite, Complex, Malakand granite, Shewa - Shahbazgarhi porphyritic microgranites
II.	Granites of the Lesser Himalayan granitic belt	Crystal strike and slip movement giving rise to a thermal corridor and/or to a zone of crystal thining with simultaneous arching of the crust.	515 m.y. Cambro-Ordovician	A, Mansehra granite B, Swat granitic gneisses C, Besham granitic gneiss
I.	The Nanga Parbat granitoids	Crustal thining and arching event.	(1.8 billion years)	Nanga Parbat - Haramosh granitic gneiss.

Indo-Pakistan plates portion of the north-west frontier, which are broadly distinguished into four age groups (see table-3.4.1).The first three groups comprise mostly granitic rocks, while the fourth group includes an harzburgite peridotite - dunite - serpentinite association in the Sakhakot Qila area. Each group belongs to a distinct mineralogical and chemical variety and exhibits regularly in its spatial disposition. The older igneous rocks are developed at the leading edge of the Indo-Pakistan plate in the north, while the comparatively younger plutons are abundant around the northern boundary of the Peshawar vale.

Igneous rocks of group IIB and III concern the Peshawar vale and are described in some detail:-

3.4.1 (IIB) The Swat Granite Gneisse

These rocks occur in an area west of Batkhela in Swat and occupy an extreme west position in the approximately 1600 kilometers long Lesser Himalayan granitic belt. In Swat they occur as a massive concordant sheet like body which has been tightly folded in an antiform. Major minerals are quartz, albite-oligoclase, K-feldspar, biotite and epidote. A tourmaline bearing granite/gneiss is, however, a minor marginal variant of these rocks (Jan, et al., 1981b). An age of 515 m.y. has been assigned to these rocks. (Maluski pers. comm. to M.Q. Jan., 1981b).

3.4.2 (III) Granites and related igneous rocks of the Peshawar plain alkaline province

These granites are distributed in a semi-circular belt around the northern half of the Peshawar vale and belong to an alkaline igneous province which stretches for a dis-

tance of more than 200 km, from Tarbela in the east, to the Afghan Border. The province includes the following complexes:-

a. Loe Shilman Carbonatite Complex (Majid 1976, Jan, et al., 1981b, Butt, et al., 1980).

b. Warsak granite (Coulson 1936, Ahmed, et al., 1969, Khan, et al., 1970).

c. Malakand granite (Chaudhry, et al., 1974, 1976, Badshah, 1979).

d. Ambela granite complex (Martin, et al., 1962, Siddiqui, et al., 1968, Ahmed and Ahmed 1974).

e. Shewa - Shahbazgarhi porphyritic. Microgranites (Irshad, 1986).

f. Tarbela alkaline complex (Jan, et al., 1981).

Important rock types are alkaline granites and microgranites, syenites, alcitites and carbonates. Only two reliable radiometric ages (50 m.y. for Koga syenite of Ambela granitic complex and 41 m.y. for the Warsak alkaline granites) are available (Kemp, 1973) which suggest that the constituent rocks are of Eocene age.

3.4.3 (IV) Rocks of ultramafic association of the Sakhakot Qila area is described as Alpine type by Asrar ullah (1960), Ali and Amin (1963) Qaiser, et al., (1970) and Uppal (1972). Its western extension in the Utmankhel, Mohmand Agency is studied by Rafique (1984). The entire complex covers an area of more than 225 km^2. Malinconico (1982) has described the complex as a Klippe over the Indo-Pakistan plate.

Dominant rocks are dunite-peridotite-serpentinite and gabbro, while alteration to serpentinite, asbestos and talc carbonate is conspicuous along sheer zones.

Besides these four groups of igneous rocks, there are basic dykes, intrusive into the Manki slates, Landikotal slates, Utla granites and Ambela granites. These granites are dark grey in colour but exhibit a brownish appearance on weathered surfaces.

3.5 STRUCTURE OF THE PESHAWAR VALE

Because Peshawar vale is an integral part of the world's youngest full-scale continental collision zone, its structure cannot be presented in isolation from the Himalayas in northern Pakistan. In the following discussion, therefore, an integrated account of the overall picture of the Himalayas in northern Pakistan is given in general, followed by a discussion on the structural pattern of the Peshawar vale in particular. Fig-3.5.1 shows the major structural features of the north-west frontier region (Peshawar vale and adjoining areas) in northern Pakistan. Like the rest of the north-west Himalayas, this area is characterised by three principal tectonic blocks that are separated by two major crustal sutures.

An established sequence of the structural elements from north to south is as follows:-

1. Asiatic Mass or Karakoram plate.
2. Northern Suture or Main Karakoram Thrust (MKT).

Tectonic Map Of Northern Pakistan

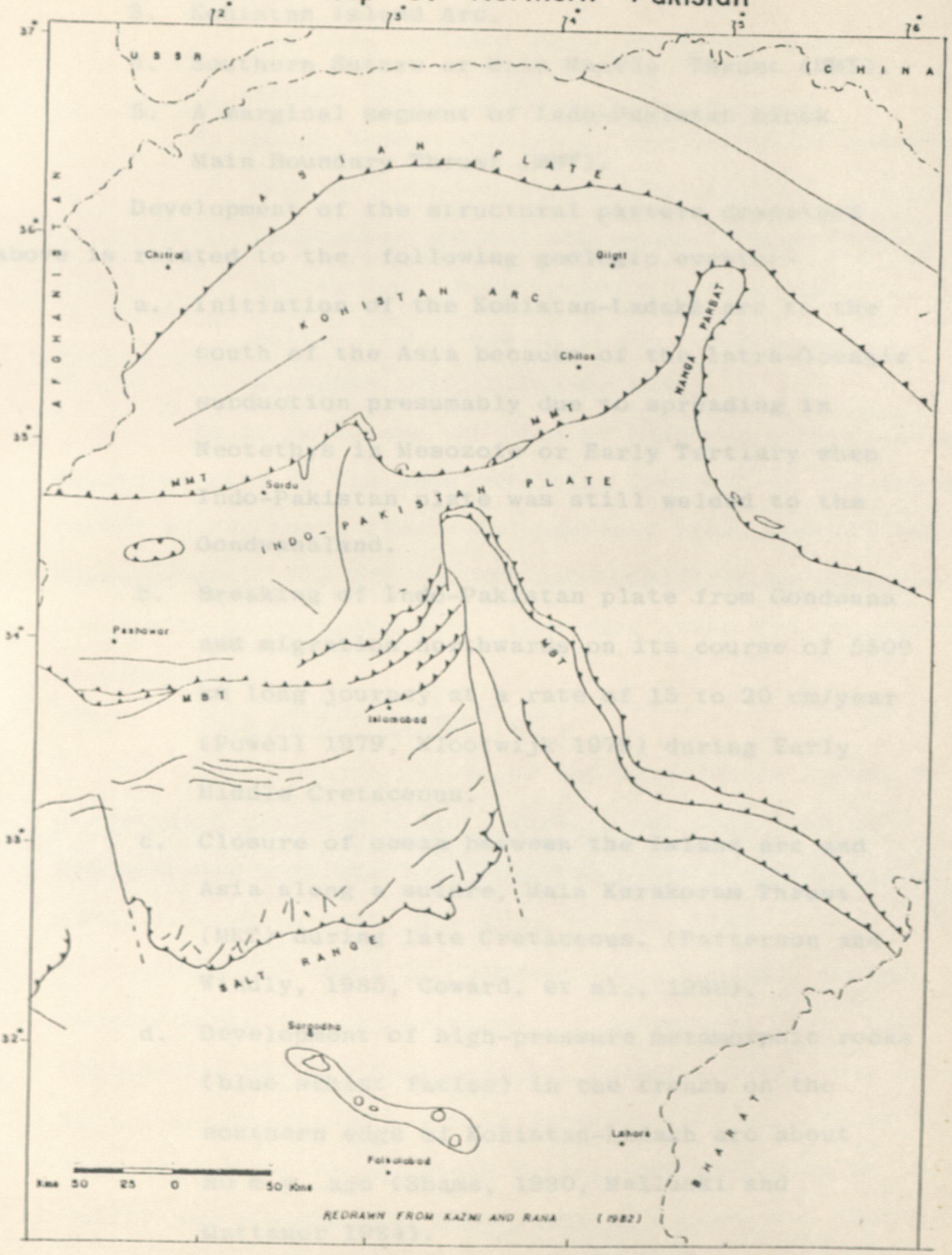


Fig. 3·5·1

3. Kohistan Island Arc.
4. Southern Suture or Main Mantle Thrust (MMT).
5. A marginal segment of Indo-Pakistan block Main Boundary Thrust (MBT).

Development of the structural pattern described above is related to the following geologic events:-

a. Initiation of the Kohistan-Ladakh arc to the south of the Asia because of the Intra-Oceanic subduction presumably due to spreading in Neotethys in Mesozoic or Early Tertiary when Indo-Pakistan plate was still welded to the Gondwanaland.

b. Breaking of Indo-Pakistan plate from Gondwana and migration northwards on its course of 5500 km long journey at a rate of 15 to 20 cm/year (Powell 1979, Klootwijk 1979) during Early Middle Cretaceous.

c. Closure of ocean between the Island arc and Asia along a suture, Main Karakoram Thrust (MKT) during late Cretaceous. (Patterson and Windly, 1985, Coward, et al., 1986).

d. Development of high-pressure metamorphic rocks (blue schist facies) in the trench on the southern edge of Kohistan-Ladakh arc about 80 m.y. ago (Shams, 1980, Malluski and Mattauer 1984).

e. Closure of the Neotethys in Eocene (Powell, 1979, and obduction in arc on to

the Indo-Pakistan Plate along the Main Mantle Thrust (MMT).

f. After Eocene collision, the continued displacement of Indo-Pakistan plate resulted in crustal shortening and was accounted through thrust system e.g. Main Boundary Thrust (MBT) within Indo-Pakistan plate. (Powell and Conaghan 1973, Mattauer 1986).

As it is clear, the vale of Peshawar constitute an essential part of the area extending from MBT in the south to MMT in the north (Yeats and Lawrence 1982, Burbank and Raynolds1984). The MMT and MBT are considered as tectonic boundaries of Peshawar vale, therefore these are described in some detail.

3.5.1 MAIN MANTLE THRUST (MMT)

The southern suture or the Main Mantle Thrust is a northward directed thrust, marking the obduction of Kohistan arc onto the Indo-Pakistan plate (Tahirkheli, et al., 1979; Tahirkheli 1980, 82; Bard, et al., 1980).

In the north of Peshawar vale, the MMT, besides metasediments and crystallines, is associated with the 'Ophiolites and tectonic melanges (Ganseer 1964). The overthrust can be traced north of Peshawar vale in a NE-SW direction from Jijal in the Indus Valley through Zullam in Dir valley and extends into South-east of Afghanistan (Tahirkheli 1979, 79b, 1980; Tahirkheli, et al., 1979; Jan, 1980).

Due to this thrust fault, the various lithological segments from MMT towards south have thrust faulted contacts with each other, while over-folding and nappe formation are common. The strata have been bodily sliced off and carried to far off areas of the vale, and the younger rocks have been frequently overriden by the older.

The following examples may be considered as the surface expression of the impact of this thrust:-

a. The Dargai Ophiolite is considered as a nappe/klippe emplaced onto the Indo-Pakistan plate (north western part of the vale), some 25 km to the south of MMT.

b. Rocks of the Kohistan Complex of Jan and Mian (1971) has a thrust faulted contact with the rocks of the Schistose Group of Martin, et al., (1962), while the Schistose Group has also a thrust faulted contact with the Swabi-Chamla Sedimentary Group and Shewa Formation in Mardan.

c. The Nowshehra Reef Complex has also a thrust faulted contact with the underlying Kandar Phyllite, equivalent to the Manki Slates (Tahirkheli, 1980).

d. The three blocks of the Attock-Cherat range are bounded by thrust faults, e.g. two narrow belts of Utch Khattak Formation occur as Klippe of the northern block faulted into the Dakhner Formation east of the Indus River (Yeats and

and Hussain 1987).

e. In the hill ranges of Darra Adam Khel, the Jurassic and Paleocene sequences have a low angle thrust faulted contact with the younger Murree Formation (Gardezi, et al., 1976).

f. In the Khyber mountains area, thrusting followed by folding and vice versa is indicated by folding of the allochthons and autochthons (Shah, et al., 1980).

3.5.2 THE MAIN BOUNDARY THRUST (MBT)

The Main Boundary Thrust (MBT) passes south of the Peshawar Vale and constitute a well-established tectonic contact between the Murree Formation and the older rocks running all along the frontal part of the Himalayas. This contact is a thrust. The Murree Formation of Mid-Miocene age is overridden by the various older rocks along this tectonic line (Tahirkheli 1980). In northern Pakistan, west of the Hazara Syntaxis, the Murree Thrust-Kohat Thrust are considered as extension of the Main Boundary Thrust (Tahirkheli and Jan 1979).

3.5.3 CONTEMPORARY TECTONICS

3.5.3.1 Gadun Fault

It is considered as one of the oldest faults located in the north eastern part of the vale of Peshawar (Tahirkheli, 1980) and involves rocks which are pre-Cambrian.

3.5.3.2 The Reef Thrust Belt

The Reef Complexes of Nowshehra, Jamrud and Tangi are developed within an east-west elongated belt bounded by

alluvium both in the north and south. The Manki Slate dips under the reefoid bed with an unconformable contact. North of the Nowshehra reef out crops, near Takhatbai at a distance of 35 km, an isolated out crop of slates and phyllitic slate dipping northward has lithological similarities with the Manki Slate emerges out of the alluvium. This out crop seems to be part of the dominantly pelitic rocks of the Malakand range which is separated by 8-10 km wide alluvial belt. This sequential disorder in the stratigraphy of the vale points to an existence of a thrust fault (Tahirkheli, 1980).

3.5.3.3 The Vale Rift Zone

An east-west elongated alkaline igneous province, forms a semi-circular belt along the northern margins of the Peshawar vale. Details of the component rocks have already been described. Rocks of this zone are considered to be associated with an episode of rifting during Late Paleozoic and Triassic when the Indo-Pakistan plate was still a part of the Gondwanaland.

3.5.3.4 Dargai Klippe

An ultramafic body, about 300 sq. km. in dimension, is emplaced on the north-western part of the vale, flanking the Malakand range to its south. It forms a linear belt striking east-west, thus corresponding with the general strike of the metasediments with which it is associated. In the north it has a tectonic contact with metasedimentary rocks mainly pelitic.

Dargai ultramafic forms a nappe zone in the vale and is considered to be emplaced as a result of large scale thrusting from the Main Mantle Thrust (Tahirkheli 1979). Its exposure as a klippe has great geomorphological significance which indicates that after its emplacement, a very long cycle of erosion prevailed over the vale during which rocks of the upper sheet were stripped off to form it as Klippe.

3.5.3.5 The Lakrai-Tarbela-Durband Fault

The Lakrai thrust is located on the north western margins of the Attock-Cherat range, where the Mamikhel claystone of lower Eocene age is thrust over by the pre-Cambrian Shaikhi limestone. (Tahirkheli 1970, 1982). This thrust dips to the north and extends eastward along the northern margin of the Attock-Cherat range upto the Kund village. Beyond Kund, upto Topi, this fault is concealed under alluvium but reappears near Tarbela and extends upto Darband in the Indus valley.

3.5.3.6 Marghalla Thrust

This thrust belongs to the latest phase of the Himalayan orogeny, when Murrees were disrupted, and the Siwalik mollasse deposited along the frontal part of the Himalayas, were thrust over by the Murrees or overlain directly by the lower Tertiary limestone (Tahirkheli, 1980). This thrust which is northward directed has its contribution in supplementing the compressive forces in producing young structure reminiscent of the southern part of the vale. Some of these are located in the vicinity of Jallozai, Shahkotbala and Jabba Khattak where the folding of Pliestocene age

can be differentiated. During the course of present study, it was found that tilting, folding and overfoldings and formation of silty dykes are most pronounced in the Pleistocene lake beds exposed in various sections. A recent fault in the piedmont deposits has also been located in Manki-Walai area showing deformation and tilting of the piedmont deposits. (Hussain, 1984) All these may be attributed to the effect of Marghalla Thrust during some part of the Pleistocene period.

3.5.3.7 Minor Structures

In the Attock-Cherat range, Ahmed (1952, p.38) has described numerous windows/semi-window structures in various parts of Bakhtai, Jabba Khattak and Shahkot Bala villages. Similarly, rocks of the Utch Khattak Formation of northern block of the Attock-Cherat range are shown in two Klippen, down folded into the Dakhner Formation, east of the Indus river (Yeats and Hussain, 1987, p.170).

In hill ranges of Darra Adam Khel area, the structure consists of 'two allochthonous nappes resting upon the autochthonous Murree sediments', (Gardezi, et al., 1976, p.101).

In the Khyber mountains, Shah, et al., (1980, p.25, 21) described four main thrust faults. Thrusting followed by folding and vice-versa, is indicated by folding of Allochthons and autochthons. A Kilippen has been reported south of Lala China (p.27).

3.5.3.8 Geomorphological Considerations of the Nature of Faults

It has been noted that almost all the faults of the Peshawar vale have E-W to NE-SW direction with mostly northerly dip. These characteristics are closely similar to the rocks with which these are associated.

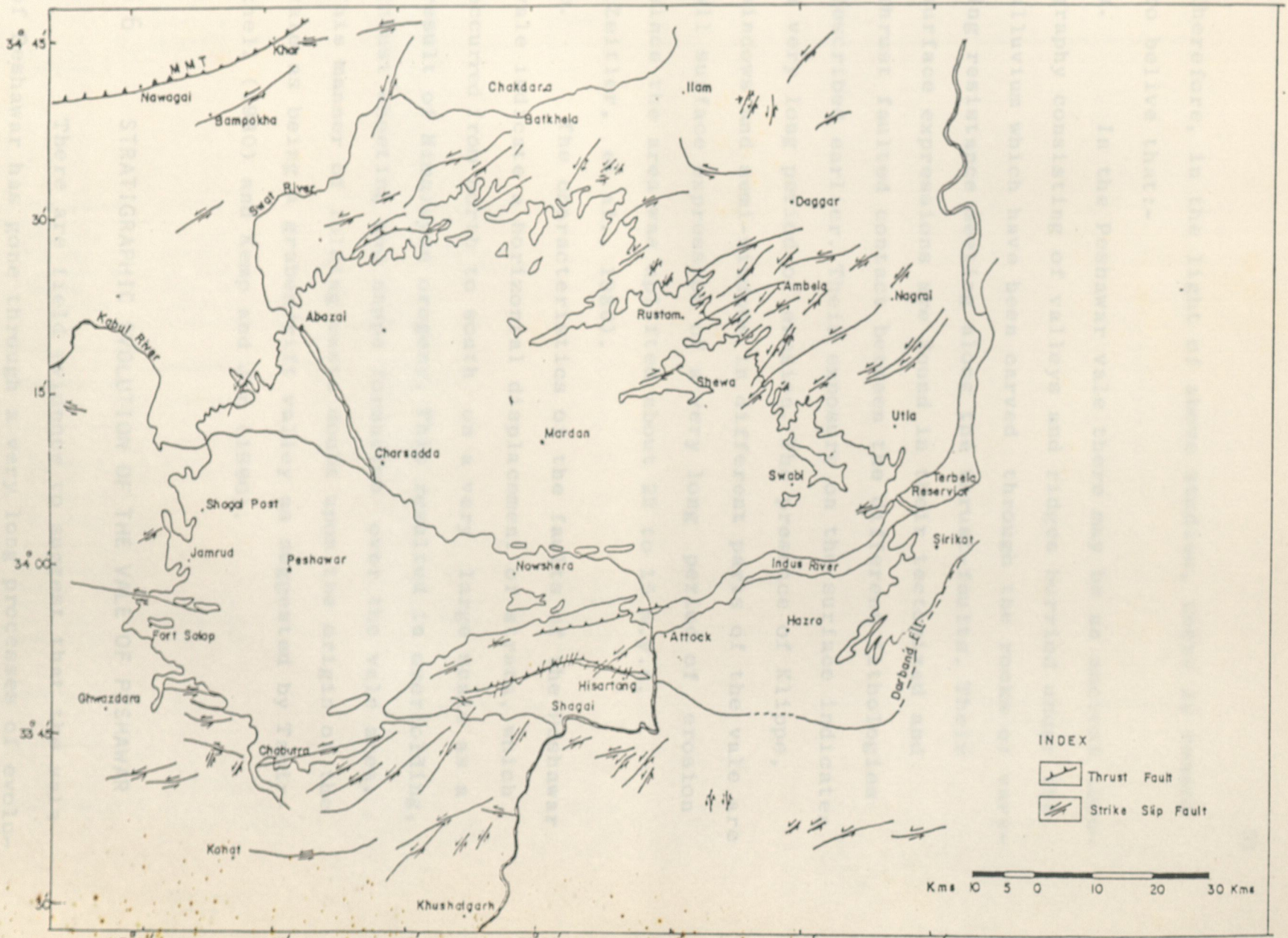
It has also been found that the faults of the Peshawar vale are either thrust faults or strike slip faults which result in large scale horizontal displacement of strata. No normal fault has been reported in the main vale as yet. This is also confirmed by Kazmi (1979) and Rafique, et al., (1984), who have shown major faults and lineaments of the Peshawar vale after making a study of aerial photographs and the landsat imageries (Fig.3.5.3.8.1).

According to Billings (1979), the lineaments appearing on the aerial photographs may actually be a long depression or a ridge. Many of the depressions are the result of erosion along line of weakness, either faults, or set of joints in strata of varying hardness. Therefore the lineaments may be easily confused with ridges and valleys.

It has been previously discussed that in the Peshawar vale, the various lithological segments have thrust-faulted contact from north to south. Strahler (1981), suggested that thrust-faults commonly separate rocks of varying lithologies with contrasting resistance to erosion. And along the thrust faults, the rocks are shattered, crushed and mylonitized thus making it a weak zone very susceptible to the processes of weathering and erosion (Whiten and Brooks 1986, p.31).

MAJOR FAULTS OF THE SURROUNDINGS OF THE PESHAWAR PLAIN

Fig. 3·5·3·8·1



RE DRAWN FROM RAFIQ et al (1984)

Therefore, in the light of above studies, there is reason to belive that:-

a. In the Peshawar vale there may be an ancient topography consisting of valleys and ridges burried under the alluvium which have been carved through the rocks of varying resistance meeting along the thrust-faults. Their surface expressions are found in their tectonized and thrust faulted contact between the different lithologies described earlier. Their exposure on the surface indicates a very long period of erosion. The presence of Klippe, windows and semi-windows in different parts of the vale are all surface expression of a very long period of erosion since the area was uplifted about 22 to 15 m.y.a, (Zeitler, et al., 1980).

b. The characteristics of the faults of the Peshawar vale indicate a horizontal displacement of strata, which occurred from north to south on a very large scale as a result of Himalayan orogeny. This resulted in overfolding, thrust sheeting and nappe formation over the vale area. This manner of folding casts doubt upon the origin of the vale as being a graben/rift valley as suggested by Tahirkheli (1980) and Kemp and Jan (1980).

3.6 STRATIGRAPHIC EVOLUTION OF THE VALE OF PESHAWAR

There are field evidence to suggest that the vale of Peshawar has gone through a very long processes of evolu-

TABLE-3.6.2

PROPOSED STRATIGRAPHIC CORRELATION OF DIFFERENT AREAS SURROUNDING THE PESHAWAR VALE

			Attock-Cherat range Tahirkheli, 1970-82, Hussain et al.,1984, Yeats and Hussain 1986	Hill Ranges of Dara Adam Khel Gardezi et al., 1976.	Khyber Mountains Shah et al., 1980.	Nowshehra Reef Comp. Stauffer 1968, Ali and Anwar 1969.	Swabi-Mardan Sedimentary Comp, Martin et al., 1962	Lower Swat Buner Schistose Group Martin et al., 1962, Kazmi et al., 1984	Malakand Range Chaudhry et al., 1974	Proposed Correlation with Hazara area
CENOZOIC	QUATERNARY	Holocene								
		Pleistocene	Jallozai Fm	Alluvium	Quaternary Terraces				–	–
		Pliocene	Er. Uncon							
		Miocene	Murree Fm	Murree Fm	Murree Fm					
		Oligocene	Er. Uncom	Discon.	Unconformity					
		Eocene	Patal Fm	Patala Fm.						
		Paleocene	Lochart Limestone Uncon--Laterite-	Lochart Fm. Discon with laterite					–	–
MESOZOIC	Cretaceous	U	Kawagarh Fm	Kawagarh Fm -Minor Disconformity						
		L	Lumshiwal Fm	Lumshiwal Fm						
	Jurassic	U	Chichli Fm	-Disconformity-						
		M	Samana Sukh Fm	Samana Sukh Fm.						
		L	Data Fm							
	Triassic	U	-							
		L	-							
PALEOZOIC			-		-Unconformity					
	Carboniferous				Khyber L.S.					
	Permian		-	-		Pir Sabak Fm	Kala Limestone			
	Devonian		Inzari Fm	-	Khyber Undif-	Misribanda-				
	Silurian		Hissartang Fm	-	ferentiated	Quartzite				
	Ordovician		Darwaza Fm	-	Carbonate Complex.Also (Jamrud Reef Complex)	Nowshehra-Formation	Swabi Quartzite			
	Cambrian		Shaikhi L.S	-	Ali Masjid Fm	-	-	Green Schist	Calcareous rocks.Marbles & Calc Schist	Abbottabad Fm
	Pre-Cambrian		Raja Hodi and Sangrobii Ghundi-Boulder bed	-	-	-	Swabi Pebly shale	-	-	Tanaki Boulderbed
			-un-conformity Khattak limestone	-	- Shagai limestone	-Un-con- -	-Un-con- Chamla Quartzite	-Un-con- x x Swat granite gneiss Marble & Calc.Schist. Amphibolite Silicious Schist	- Psammitic rocks(Qtzite & Q.Mic-Schist Amphibolite Pelitic Rocks	-Uncon- Tanawal Fm. Hazara granite
			Shahkot and Shaikhi Fm Dakhner Fm Manki slate	-	Landikotal Slate	Kandar Phylite	Chamla Phyllite			

tion to achieve its present form since the pre-Cambrian times. On the basis of previous work as well as the present study, the stratigraphic evolution of the Peshawar vale is described in the following order:- (See table-3.6.1)

3.6.1 THE PRE-CAMBRIAN PERIOD

The basement complex of the Peshawar vale exposed along its northern rim is composed of granite gneisses and schists. Identification and separation of individual lithology is, however, difficult because of the alteration (Martin, et al., 1962, Kazmi, et al., 1984). The oldest rocks deposited on the basement complex are composed of sediments mostly pelitic, with some intercalcation of psammitic and calcareous beds. These include: Shahkotbala formation and the Manki slates in the Attock-Cherat range (Tahirkheli, 1970, 1980, Hussain, 1984), and Landikotal formation in the Khyber mountains (Shah, et al., 1980).

Further north and northwest, due to increase in the grade of metamorphism, these sediments have been changed mostly into Schistose group. Examples are slate, phyllites, paragneisses, various schists, crystalline limestone and marbles, occur in the following areas:-

a. Schistose rocks of Lower Swat-Mardan-Swabi area (Martin, et al., 1962).

b. Pelitic and Psammitic rocks of the southern slopes of Malakand ranges (Chaudhry, et al., 1974, 1976).

c. Metasedimentary rocks recorded in the core of the Ghalanai anticline (Tahirkheli, 1980)

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TABLE-3.6.1

STRATIGRAPHIC SECTION, PESHAWAR VALE SOUTH OF RIVER KABUL

CENOZOIC	QUATERNARY	Holocene	For detail see section on Quaternary stratigraphy
		Pleistocene	Chandan Garhi Fm/Jallozai Fm
	PLIOCENE	.....	Erosional Unconformity .....
	MIOCENE		Murree Formation
	OLIGOCENE	.....	Eorsional Unconformity .....
	EOCENE		Bakhtai Formation Patala Fm/Lakhrai Fm
		.....	Unconformity ....
	PALAEOCENE		Lochart limestone/Cherat limestone
		.....	Unconformity marked with laterite.....
MESOZOIC	CRETACEOUS		Kawagarh Formation
		.....	Disconformity .....
			Lumshiwal Formation
	JURASSIC		Chichali Formation
		.....	Disconfomrity .....
			Data, Samana Sukh Formation
	TRIASSIC	.....	Unconformity....
PALAEOZOIC	CARBONIFEROUS		Khyber Limestone. Rifting, Tectonic activity, Intrusion & Mountain building.
	PERMIAN		——————— ? ———————
	DEVONIAN		Inzari Fm x Khyber x Nowshehra
	SILURIAN		Hissartang Fm x Undifferentiated x Reef
	ORDOVICIAN		Darwaza Fm x Carbonate Complex x Complex
			——————— ? ———————
		.....	Unconformity .....
	CAMBRIAN		Shaikhi limestone/Ali Masjid Formation
	PRE-CAMBRIAN		Raja Hodi & Sangrobi Ghundai Boulder Bed
		.....	Erosional Unconformity ....
			Khatak Formation
			Shahkot Bala Formation
			Dakhner Formation
			Manki Formation/Landikotal Formation
		.....	ERODED .....
			BASEMENT COMPLEX

and in the Gandhao valley, Mohmand area (Aslam, et al., 1981).

It should be noted that the deposition of pre-Cambrian pelitic rocks have been considered equivalent to the 'Flysch' of Europe by Mark and Ali (1961) and Tahirkheli (1970) but inclusion of limestone and sandstone as subordinate beds in the slates of Cherat range and Khyber mountains suggest a regression and transgression of shorelines resulting in relatively shallower conditions of the sea at different times (Calkins, et al., 1975).

Examples of the shallowing of sea and the deposition of quartzite in the north and north-east and limestone in south and south-western parts of the vale are:-

a. The crystalline limestone of Khattak Formation in the Attock Cherat range (Tahirkheli 1970, 1982), limestone and dolomite of the Shagai formation in the Khyber mountains (Shah, et al., 1980).

b. Ortho-quartzite of Middle Series in the Warsak area (Ahmed, et al., 1969).

c. The quartzite and quartzitic schist of the Malakand mountains (Chaudhry, et al., 1974, 1976).

c. The Chamla quartzite in the Mardan-Swabi area (Martin, et al., 1962).

e. The Misribanda quartzite of Nowshehra Reef Complex (Ali and Anwar 1969).

f. The Spinrag quartzite in the Jamrud Reef Complex (Khan, 1970).

g. The Manglaur crystalline schist near Mingora, Swat (Kazmi, et al., 1984).

All these rocks are the facies changes of the Tanawal Formation of the Hazara.

Following the deposition of Tanawal Formation, large granitic bodies (batholithic size) were emplaced in the pre-Cambrian rocks homotaxial to the Tanawal formation in the northern half of the Peshawar vale (Calkins, et al., 1975, Kazmi, et al., 1984). Le Forte, et al., (1980) and Jan, et al., (1981 b) consider these granites as part of a discontinuous belt of granitic rocks of late pre-Cambrian age which stretches from Mansehra towards west into the Peshawar vale and extend upto the Khyber mountains.

These bodies of granites are tightly folded alongwith the country rocks and have developed a strong gneissosic fabric having a foliated or banded structure. Included within this group of granite are the Swat granites and granite gneiss (Martin, et al., 1962, Jan and Tahirkheli 1969, Jan, et al., 1981a),Malakand-Chakdarra granites (Chaudhry, et al., 1974, Butt, et al., 1980, Jan, et al., 1981b), Kalangai granite gneiss of Mohmand area (Badshah, et al., 1979, Spinkai granite gneiss of Tirah Tahirkheli, et al., 1975, Jan 1975, Jan, et al., 1981b).

Glaciation and large scale erosion produced erosional unconformities on regional scale. The Tanawal Formation or its equivalent rock facies are therefore overlain

by a boulder bed in Peshawar vale; in Hazara some of these boulder beds also contain pebbles of pre-Cambrian granite which confirm their erosion during the preceeding cycle of erosion. These boulder beds have been correlated with the Tanaki boulder bed of Hazara (Tahirkheli, 1982). Tanaki boulder bed has been deposited as a result of fluvio-glacial action during a pre-Cambrian glaciation (Latif 1974, Ghorie,et al., 1977). Therefore, it is inferred that the Peshawar vale having many paleogeographic similarities with the Hazara mountains might have also been glaciated in some parts during the pre-Cambrian period and during the coming warm inter-glacial period the morainic material was released by the melting ice, carried by the glacial streams and deposited as boulder and now found at the following places in the vale:-

a. On the top of Raja Hodi tunnel in the Attock-Cherat range, at the Sangrobi Ghundai West of Jabba Khattack on the road to Manki (Tahirkheli, 1970, 1982) and in a road cut on way to Katti Miana, southwest of Khairabad civil rest house.

b. Pebbly quartz schist and meta - Conglomerate of Warsak area (Ahmed, et al., 1969).

c. Conglomeratic bed on the Ghalanai anticline in the Mohmand area (Tahirkheli, 1982).

d. Swabi pebbly shale (Martin, et al., 1962).

e. Meta - Conglomerate exposed in various nullahs in the Swat and Indus Kohistan (Jan and

Tahirkheli, 1969, Ashraf, et al., 1980).

f. Quartzose conglomerate at Tarbela Calkins, et al., 1975).

3.6.2 PALAEOZOIC

3.6.2.1 Cambrian

A rising of the sea had resulted in the deposition of the rocks equivalent to the Abbotabad group of Hazara (Latif, 1974, 1976). In Peshawar vale such rocks are exposed at the following places:-

a. Shaikhi formation in the Attock-Cherat range (Tahirkheli, 1970), Ali Masjid formation in the Khyber mountains (Shah, et al., 1980).

b. Phyllitic and calcareous schists, quartzites and marbles of Warsak area (Ahmed, et al., 1969) calcareous schists and marbles of Malakand range (Chaudhry, et al., 1974, 1976) Swabi quartzite, Kala limestone and marbles (Martin, et al., 1962), and Baghdarra limestone and quartzites of Gandgarh range (Tahirkheli, 1971).

3.6.2.2 Siluro-Devonian

It seems that after the deposition of Cambrian rocks, the sea receded from the vale area. There was a very long period of hiatus (Tahirkheli,1980) which probably extended upto the Silurian during which a large part of the vale was exposed to subaireal processes and the vale was once again planned off. This resulted in the transgression of sea, which occupied the vale area from the Silurian to the

end of Carboniferous.

It is suggested that during this period, the Peshawar vale entered a zone of warm waters of a tropical sea. This is evident from the existence of coral reef rocks of the Silurian-Devonian age found at Nowshehra (Tiecart and Stauffer 1965 1968; Ali and Anwar, 1969), Jamrud (Khan,1968); Tangi (Tahirkheli,1969); and undifferentiated carbonate rocks in the Khyber mountain (Shah, et al., 1980). Such carbonate rocks are also found beyond Swabi in the east and extend as far as Batkhela in the north. In the south the Silurian-Devonian sea extended upto the southern edge of the Attock-Cherat range where three formations e.g. the Darwazai, Hissartang and Inzari limestone have been deposited, (equivalent to the rocks of Nowshehra reef complex of Silurian-Devonian age (Hussain,1984).

It is important to note that the reef rocks are resting unconformably over the Kander phyllite. Either Kandar Phyllite is Cambrian or it may be equivalent to the Manki Slate of pre-Cambrian age (Tahirkheli,1982). In either case, the contact between the Kandar phyllite and the overlying coral reef rock is unconformable which may be considered as an erosional unconformity. There is also indication of dolomitization and regional and thermal metamorphism leading to the crystalization of the limestone. The evidence of tectonic activity is found in the tight folds in the phyllite and more gentle folds in the carbonate layers. There is a tilt of about 50° to the north in the rocks of

the Nowshehra Reef Complex. There are also intrusion of dykes of dolerite (Ali and Anwar, 1969). All these events suggest occurrence of an orogenic episode which may be considered equivalent to the Caledonian Orogeny of Middle Ordovician to Middle Devonian times.

The cross-beddings found in the Misribanda quartzite of the Reef complex suggest that the source of the sand was in the land area located north east of Nowshehra (Stauffer, 1968). Ali and Anwar, (1969) suggested that this quartzie is formed of beach sand which indicates that the shoreline might have been situated along Nowshehra and extended in east-west direction. The present study also favours the idea that the streams were flowing along the strike in a NW-SW direction and due to erosion of pre-Cambrian granites and metasediments located in the north of Nowshehra, brought sediments to the Nowshehra beach. The clay/shale provided a sea bed as favourable environment upon which the reef growth took place which later on metamorphosed as chlorite rich Kandar phyllite, while the sand was metamorphosed into Misribanda quartzite (Stauffer, 1968; Khan, 1970).

3.6.2.3 Carboniferous

In the vale of Peshawar, the Siluro-Devonian sea lasted upto the end of Carboniferous. Rocks of Carboniferous age (mostly carbonate) are widespread in the Khyber mountains (Khyber limestone, Stauffer 1968, Shah, et al., 1980) and in Swabi area (Kala limestone and marble, Latif, 1970). There is evidence of igneous activity as can be seen from the

basic dykes and sills intruded in the Carboniferous limestone of the Khyber mountains.

During late Paleozoic and Early Triassic, the north western part of the Indo-Pakistan plate (the area presently covered by the Peshawar vale, eastern Hazara and Kashmir) experienced an episode of rifting. This is reflected in the emplacement of granitic and sub-alkaline to alkaline plutons around the northern edge of the Peshawar vale (see discussion on igneous rocks).

3.6.3 MESOZOIC

The Mesozoic stratigraphy of the Peshawar vale is not very clear. It appears that the vale is devoid of these sediments and remained an area of emergence and tectonic activity during this period.

According to the tectonic framework of northern Pakistan, the Axial Belt of Pakistan folded mountain which extends west to east passes through Peshawar vale and Hazara (see Fig-3.6.3).This area is believed to be tectonically active towards the close of the Early Jurassic and developed into a pre-orogenic geanticlinal structure which contributed sedimentation on either side of the Axial Belt (Fatmi, 1977). This state of affair suggests that the Mesozoic sea surrounded the northern and southern areas of the Peshawar vale, while the vale area itself had been going through a phase of large scale erosion. The following stratigraphic succession is traced from the exposed lithologies:-

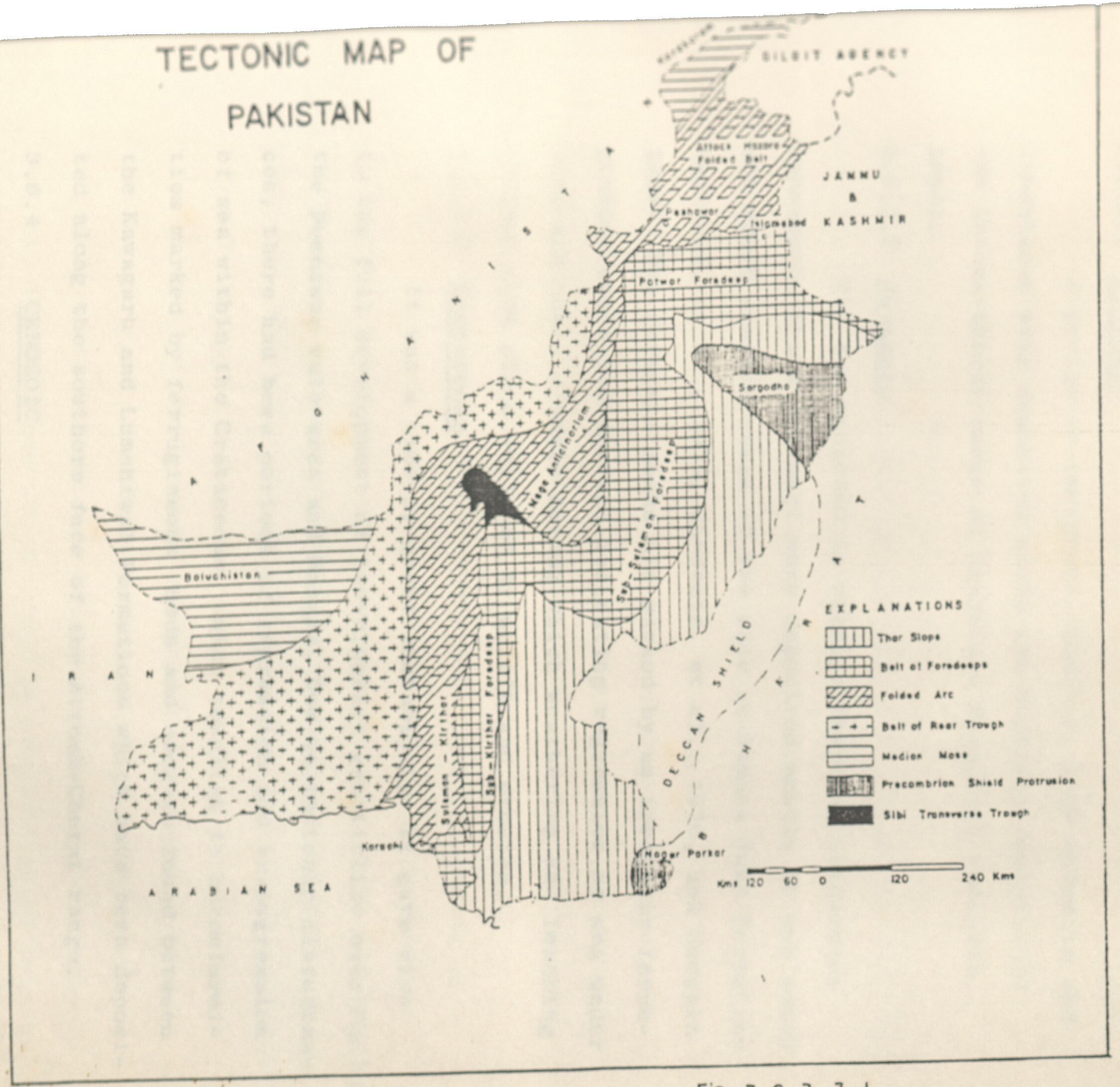

TECTONIC MAP OF
PAKISTAN
GILGIT AGENCY
Attock Hazara Folded Belt
JAMMU & KASHMIR
Peshawar
Islamabad
Potwar Foredeep
Sargodha
Mega Anticlinorium
Sub-Suleman Foredeep
Baluchistan
IRAN
Suleman - Kirthar
Sub-Kirthar Foredeep
DECCAN SHIELD
Karachi
Nagar Parkar
ARABIAN SEA
EXPLANATIONS
Thar Slope
Belt of Foredeeps
Folded Arc
Belt of Rear Trough
Median Mass
Precambrian Shield Protrusion
Sibi Transverse Trough
Kms 120 60 0 120 240 Kms

Fig. 3·6·3·3·1

3.6.3.1 Triassic

A period of emergence. However, some dolomite and limestones were deposited along the southern margins of the Attock-Cherat range as Kingriali Formation (Hussain, 1984).

3.6.3.2 Jurassic

The sea expanded in which limestone, calcareous sandstone, shale and marl were deposited mostly in the south and south western areas of the vale as Samana Sukh Formation (Meisner, et al., 1974, Gardezie, et al., 1976, and Hussain 1984). The Jurassic rocks are marked by an irregular ferrugineous weathered surface indicating regression of sea under warm and humid climate during which weathering and leaching of iron took place followed by uplift and erosion.

3.6.3.3 Cretaceous

It was a time of great instability. It gave rise to the full development of pre-orogenic geanticline over(Fig.3.6.3.3.1) the Peshawar vale area and Hazara. Due to tectonic disturbances, there had been periods of regression and transgression of sea within the Cretaceous which resulted in unconformities marked by ferrugineous beds and erosion found between the Kawagarh and Lumshiwal Formations which have been deposited along the southern face of the Attock-Cherat range.

3.6.4 CENOZOIC

3.6.4.1 Palaeocene

During the Paleocene, parts of the vale area submerged under the shallow sea with the deposition of Cherat limestone/Lochart Formation (Tahirkheli, 1970, Gardezi,

et al., 1976, and Hussain 1984). A foeted smell is typical of the Cherat limestone. It is related to the decay of the enclosed organic matter and signifies the prevalence of conditions favourable for vegetation growth at the time of deposition of the Cherat limestone.

It appears that the Paleocene sea extended far into western Dir in the north-west, where Paleocene/Eocene fossils have been found in the calcareous bands of shale embedded in the volcanic rocks (Kaker, et al., 1971). This indicates out-pouring of lava in great quantities in marine environments and formed numerous volcanic islands to the north of the Peshawar vale which are now known as the 'Kohistan Basic Complex' (Jan and Mian 1971).

As a result of tectonic activity, regression of sea took place for some time leaving behind a prominent unconformity marked with weathering and erosion found between the Cherat limestone and the Lakhari claystone (Tahirkheli, 1970).

3.6.4.2 Eocene

The sea once again expanded and covered a vast area of the vale and expanded into north-western areas. During this period Lakhrai claystone deposited unconformably over the Cherat limestone followed by deposition of Bakhtai Formation which is composed of limestone and slaty shale. The Bakhtai Formation contains pockets and lenses of thin seams of inferior coal which indicates deltaic conditions in the south western areas of the vale with favourable

conditions for the growth of vegetation (Tahirkheli 1970).

The Eocene was also a period of great tectonic instability and volcanic activity in the vale and the surrounding region. As a result of subduction of the Indo-Pakistan plate under the Volcanic Islands/Asian plate, the collision between the plates began to occur resulting in the first Himalayan Orogeny. During this orogeny, either due to rifting in the crust (Kemp and Jan,1980) or due to development of tensional fractures during an orogeny, the pressure released through these fractures gave rise to highly alkaline magma (Strahler, 1981) which are now found as a belt of alkaline igneous rocks in the northern half of the Peshawar vale (Kemp and Jan 1980). At the end of Eocene, the sea completely left the Peshawar vale (Tahirkheli, 1980).

3.6.4.3 Oligocene-Miocene

Oligocene is considereed as a great period of erosion which previaled over the Peshawar vale and the surrounding areas in response to the uplift of the Himalayas. Due to migration of the sea southward, the southern and south western areas of the vale were replaced by a few east-west alongated narrow depressions which served as the basin of deposition for the vale and the surrounding areas. As a result of erosion,the streams brought great amount of sediments from the northern areas which are comprised of 'Ophiolites', volcanic and ultramafic rocks rich in iron. These rocks had already developed a laterite soil due to weathering and leaching of iron on a regional scale, in a warm humid climate during the later part of Cretaceous-

Paleocene (Rossman, 1976). The eroded material from the north was deposited as rocks of the Murree Formation. During the second Himalayan Orogeny which was the most severest, (Wadia 1966), the Murrees were uplifted and tightly folded and also overriden by the older rocks as a result of thrustsheeting from the north.

The thrust was so powerful that the strata was bodily sliced-off and carried southward to far off distances overriding the younger rocks forming nappes over the vale area. During this orogenic episode, the vale and the entire area to its north was uplifted about 22 to 15 m.y.a. (Zeitler, et al., 1980) and a new topography was evolved in the vale. In response to the uplift, a new cycle of erosion began to operate over the newly formed topography of the vale. This process of erosion accelerated with intermittent uplifts and fall of base levels at different times and continued for about 19 to 15 m.y.s., till the vale area was deeply dissected into deep valleys and ridges thus forming a 'pre-Quaternary topography'.

The process of erosion is believed to stop at a time when due to southward migration of the thrust belt, the southern rim (the Attock-Cherat range) of the Peshawar vale was uplifted about 3 m.y.a. (Yeast and Lawrence, 1982, Burbank and Raynolds 1984, Burbank and Tahirkheli 1985, Yeast and Hussain 1987). As a result, the local base level was raised, the direction of drainage changed and aggradation replaced erosion and the vale area was deeply filled by a variety of clastic material during some part

of the Quarternary period.

During the Quarternary period, the geo morphological processes were controlled by climatic changes resulting in many periods of erosion and deposition which gave the vale its present form. The origin and the stratigraphic chronology of the Quaternary deposits in the vale is discussed in the next pages which is the main discourse of the present study.

LEGEND USED IN THE SECTIONS

1. Lake bed
2. Sandy bed
3. Silty bed
4. Flood Plain
5. Loess
6. Gravels
7. Gravels of igneous and metamorphic rocks.
8. Cross beddings
9. Lenses of silt
10. Lenses of gravels
11. Concretions of $CaCo^3$
12. Calichie of $CaCo^3$
13. Seams of Iron Concentration



14. Warping of beds
15. Tilting of the bed
16. Silty dykes in the lake bed
17. Fault
18. Erosional unconformities
19. Paleosol
20. Weathered zone and eroded soil.
21. Dessication cracks
22. Mud balls
23. Worm holes
24. Roote holes
25. Erratics
26. Bed rock

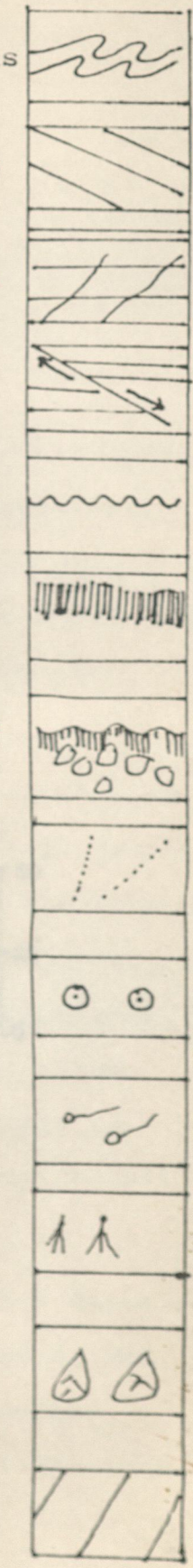


Table.4.1

SECTION I

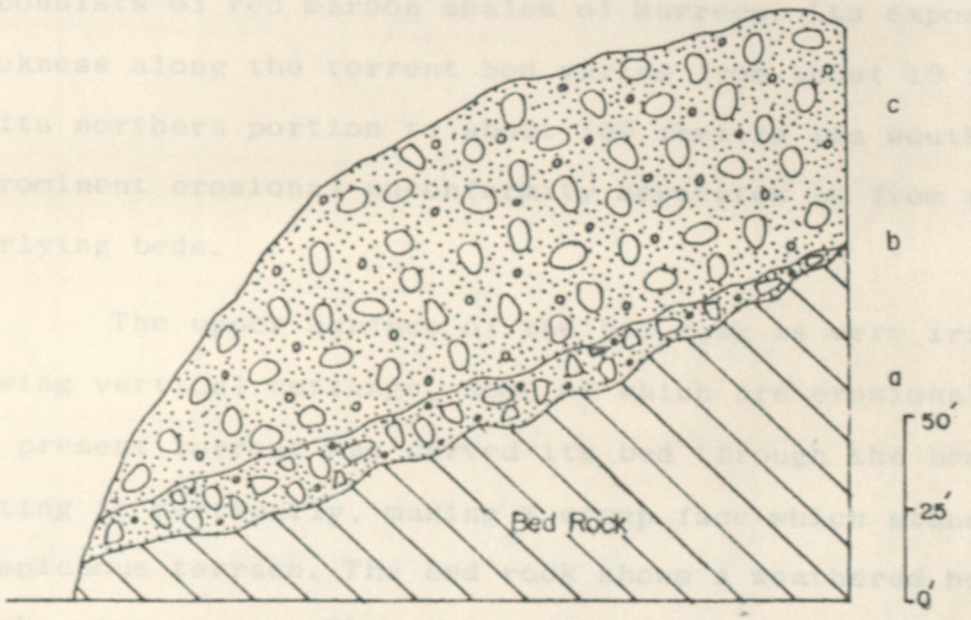


Fig. 4·1·1

CHAPTER-4

SECTIONS IN THE QUATERNARY DEPOSITS

4.1 SECTION 1

4.1.1 Field Description

This section is located in Garhi Chandan area along the right bank of a torrent (GR 763674)* coming from the Cherat foot hills. The following beds are exposed:-

Bed a:

The bed rock is exposed at the bottom of the section. It consists of red maroon shales of Murrees. Its exposed thickness along the torrent bed varies from about 10 feet in its northern portion to about 100 feet in its southern end. A prominent erosional unconformity separates it from the overlying beds.

The upper surface of the bed rock is very irregular, showing vertical cuttings, some of which are erosional channels. The present torrent has carved its bed through the bed rock by cutting it vertically, making a steep face which stands as a conspicuous terrace. The bed rock shows a weathered horizon, in the upper parts. This mass of weathered material makes a steep slope, dipping towards north, which shows that the southern part of the bed rock has been uplifted considerably.

Bed b:

This bed is composed of a 5 to 15 feet thick deposit of weathered bed rock, lying over the eroded surface of the bed rock. The material is mostly composed of very coarse angular fragments to coarse sand size particles. It is loose,

* For location of section see Fig. 4.1.1.1.

LOCATION OF SECTIONS

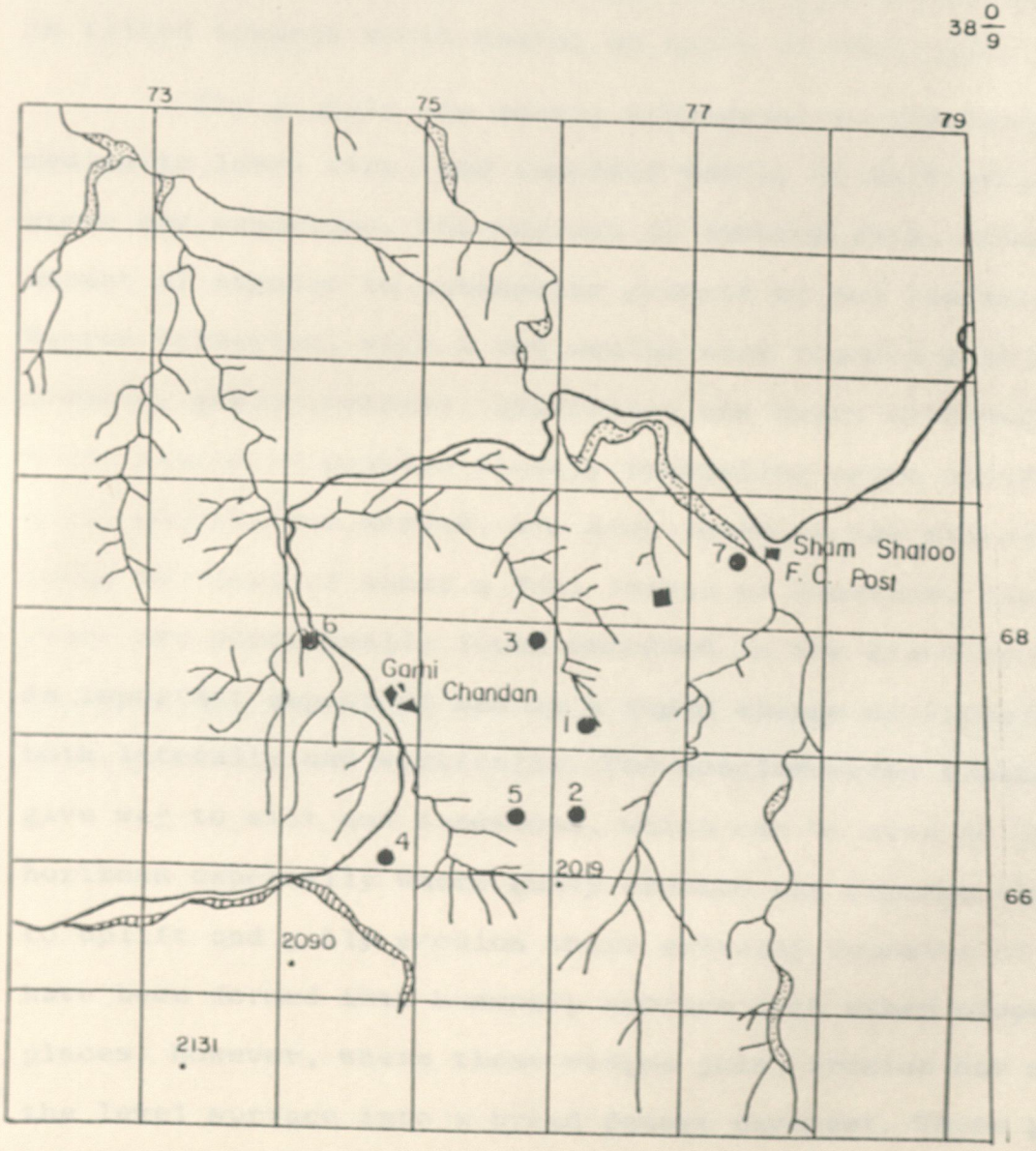


Fig. 4.1.1.1

uneven and at places has been eroded completely.

Bed c:

Gravels and unconsolidated material, composed of sand, silt and clay, more than 100 feet thick overlies the bed rock and the weathered bed b unconformably. The whole bed is tilted towards north making an angle of about 25°.

The gravels are mostly subangular to subrounded, medium to large size, and composed mostly of dark-grey limestone and sandstone. The surface is covered with, considerable amount of angular to subangular gravels of red shales of Murree Formation, with a few medium-size rounded pebbles of granite, gneiss,schists, quartzites and heavy ultramafic rocks. A few quartzite pebbles closely resembling crude artifacts of early Paleolithic period, are also found in the gravel bed. Large boulders of about a foot length of limestone and sandstone are occasionally found embedded in the gravelly matrix. An important aspect of bed is a rapid change of lithology, both laterally and vertically. The conglomerates rapidly give way to silt and sandstone, which can be seen at different horizons especially where gully erosion has exposed them. Due to uplift and gully erosion these gravelly deposits of bed c have been formed into hummocky surface with steep slopes in places. However, where these ridges join, erosion has made the level surface into a broad desert pavement. These gravelly deposits are spread over a very vast area, and in places are so thick that some of the high foot-hills are buried

under them.

4.1.2 Discussion

The bedrock which is composed of rocks of Murree Formation of Miocene age is the youngest solid rocks of the Peshawar vale, that were involved in the most vigorous Himalayan orogeny. The northern rim of the Peshawar vale comprising the mountains of the Swat were uplifted about 22 to 15 my.b.p. (Zeitler, et al., 1980). As a result, the sediments were uplifted, folded and thrust faulted, to form nappe/schupen structure over the whole of the Peshawar vale. The rocks of Murree Formation were particularly overriden by the older rocks (Tahirkheli 1979, Meisner, et al., 1974, Gardezi, et al., 1976, Shah, et al., 1980). Their exposure bears considerable geomorphological significance. There are field evidence which suggest that a very long period of erosion prevailed over the vale during which, firstly, the upper plate of the thrust sheet comprising older rocks were stripped off, and secondly, the rocks of Murree Formation at the lower plate of the thrust sheet were exposed and then subjected to a long period of erosion. It is inferred, that during this period, most of these rocks were eroded and planned off, from a large part of the vale, till the present depression of the vale was carved. This cycle of erosion lasting more than 15 m.ys. came to an end about 3 m.y.a. (Burbank and Tahirkheli, 1985) when the first deposition began to take place on the eroded surface of the bed

rock as Garhi Chandan Formation, which has been dated as 2.7 and 2.8 m.y. from the volcanic ash deposits (Table-23).

After the planation of the bedrock, another spell of rapid uplift of the bedrock and the surrounding mountains took place, due to the subduction and underthrusting of the leading edge of the Indo-Pakistan plate. This phase of uplift was very prominent in the southern area of the vale, particularly in the Cherat mountain, because the thrust was gradually prograding southward. The bed rock was, therefore, uplifted more in its southern part which resulted in the tilt towards north. Also due to this uplift, bedrock was exposed to weathering.

Simultaneous with the uplift, the climatic conditions, deteriorated and very cold conditions prevailed over the vale area. This phase may have been initiated by the beginning of a glaciation in the high Himalayas surrounding the vale.

The freez/thaw activity during this cold climate resulted in the intense physical disintegration of the surrounding mountains, which are mostly composed of fine grained, moderately permeable rocks such as shales, slates, schists, limestone and some sandstone. All these rocks are especially susceptible to frost action (Leopold, et al., 1964, Briggs, 1977). Not only the shales and sandstone were subject to physical disintegration, but the entire surrounding mountains, were also subject to severe frost action. During this period, slopes of the surrounding mountains particularly the Attock-

Cherat range were thickly covered with the weathered material as found in the bed b, and was a source of sediments for torrents.

The lithological compositions of graveliferous bed is varied, which suggests that this bed has been deposited under a variety of environments, which can be summarised as follows:-

1. The preceding cold phase changed into warm and sub-humid environments, as a result, the slopes began to release weathered material. Also the glaciers over the surrounding high Himalayas began to melt and released large amount of morainic material which was carried away by the streams draining into the Peshawar vale.

2. The inclusion of limestone and granite gravels have special geomorphological significance. The limestone bearing gravels record unusual conditions which permitted the erosion of limestone as gravel rather than its removal by solution. This implies a sharp uplift best achieved along a fault scarp.(Pettijohn, 1975; Krumbian and Sloss, 1963). Similarly, the granite bearing gravels of the bed c, have been derived from the rapid erosion of the tectonically active crystalline base (Ibid) which lies to the north of the study area. Therefore, inclusion of limestone and igneous gravles in the bed c, show that they are the product of a very rapid uplift, which may have been syndepositional.

3. The lithological composition of the bed c indicates that its material has been mostly derived from the local rocks, while inclusion of gravels of igneous and metamorphic rocks suggest that these gravels were deposited along the northern foot-slopes of the Cherat range at an earlier phase. This material was derived from the erosion of the tectonically active crystalline basement located in the northern rim of the Peshawar vale. These gravels were picked up by torrents alongwith the weathered material, at a later stage from the foot-slopes of the Attock-Cherat range. Their mode of deposition may represent an alluvial fan facies, (fanglomerates of Lawson, 1915). The scattered beds of sandstone and cemented gravels, and pink and green silt at different levels are deposits of a braided stream, frequently shifting its channel and resulting in lateral accretion. This also explains the numerous erosional unconformities within the stratigraphic section.

4. At present, these deposits have been considerably eroded, but some of the adjacent ridges and hills are still burried under them, giving some idea of the thickness when they were first deposited. These deposits are found upto a height of 2019 feet; more than 1000 feet above the present Kabul river. It may be suggested that the relief of Peshawar vale fluctuated between few hundred feet since the gravelly bed was deposited. Their tilted position however, suggest that they may have been considerably uplifted, after their

deposition, while the main valley of the Kabul river subsided under the weight of the sediments.

4.1.3 Summary of the Major Events Recorded in the Section

i. The erosion and planation of the bed rock for a very long period.

ii. A long period of mechanical weathering of the bed rock.

iii. A period of uplift of the surrounding mountains.

iv. The deposition of gravelly deposits as bed c.

v. A period of uplift.

vi. The erosion of gravelly deposits for a very long time, till the torrent carved its present channel.

vii. A period of aggradation during which the torrent deposited gravelly material in its bed upto the present level.

SECTION 2

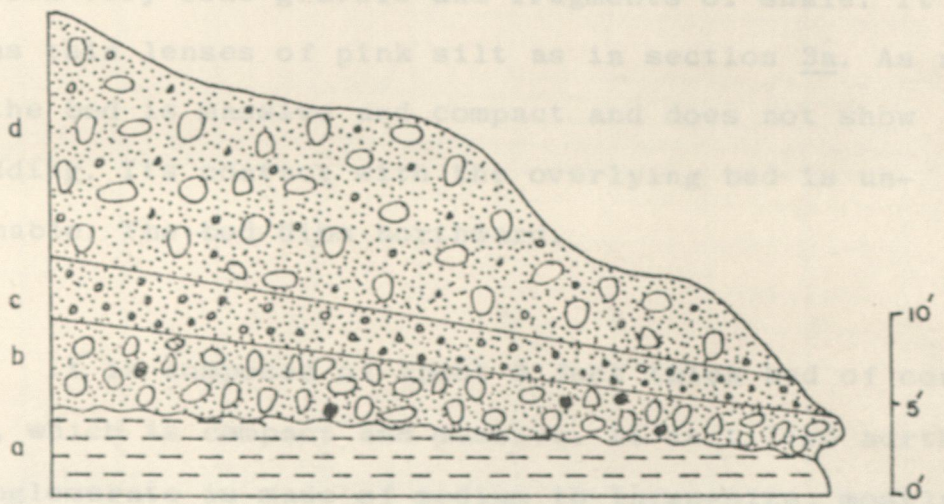


Fig. 4·2·1

4.2 SECTION 2

4.2.1 Field Description

This section is located along left bank of an unnamed torrent (GR 762666)* about 1 km south east of the main village of Garhi Chandan. The following beds are exposed:

Bed a:

This bed, 3 to 5 feet thick, is composed of pale yellow to pale olive, (5Y 6.2/3) sandy silt. It is frequently mixed with very fine gravels and fragments of shale. It also contains thin lenses of pink silt as in section 3a. As a whole the bed is massive and compact and does not show any bedding. Its contact with the overlying bed is unconformable. The bed dips northward.

Bed b:

It is composed of about 5 feet thick bed of conglomerate, which is compact and massive. It is tilted northward. The conglomerate is made of medium to large-size, mostly, sub-rounded gravels and pebbles of limestone and sandstone, which have been cemented together. Embedded are some well-rounded, small-size, gravels of granite and quartzite. It has an unconformable contact with the bed a.

Bed c:

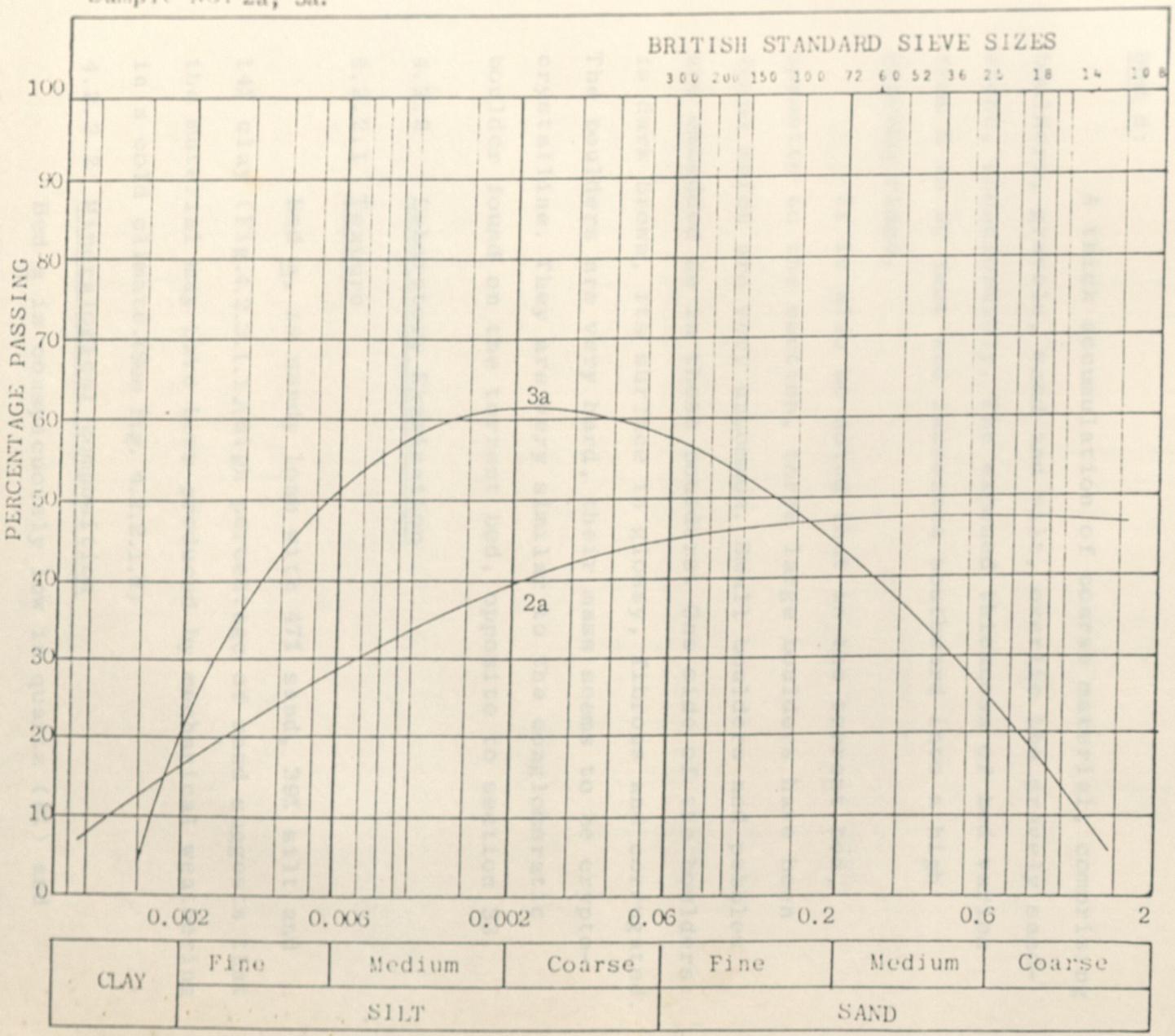
This bed is composed of 3 feet thick, compact, hard, gravelly sandstone in which lenses of fine gravels are found. The bed also shows minor cross-beddings. In places the sandstone is porous and very soft and shows small cavities

* For location of section see Fig.4.1.1.1.

PARTICLE SIZE DISTRIBUTION

Sample No. 2a, 3a.

Fig:4.2.2.1.1



of different shapes and size. It has also unconformable contact with lower as well as upper bed.

Bed d:

A thick accumulation of coarse material, comprising boulders, gravels, sand and silt, overlie the gravely sandstone, unconformably. The exposed thickness of bed varies from 5 to 20 feet and increases southward into a high gravelly ridge.

It is also be noted that in the torrent bed, opposite to the section, three large boulders have been found which are very uncommon. Small boulders and pebbles are embedded on in these boulders. One side of the boulders is dark brown, its surface is glossy, fibrous and corrugated. The boulders are very hard, their mass seems to be cryptocrystalline. They are very similar to the conglomeratic boulder found on the torrent bed, opposite to section 33.

4.2.2 Laboratory Examination

4.2.2.1 Texture

Bed a, is sandy loam with 47% sand, 39% silt and 14% clay (Fig.4.2.2.1.1.A high percentage of sand suggests that the material may have been produced by mechanical weathering in a cold climate.(See fig. 4.2.2.1.2)

4.2.2.2 Mineralogical composition

Bed a is conspicuously low in quartz (8%) and feldspars (5%), while it shows a higher amount of carbonates (25%) and biotite (20%) followed by muscovite (12%), clays (10%) and amphiboles (9%), opaques(2%) chlorite (3%) and rutile

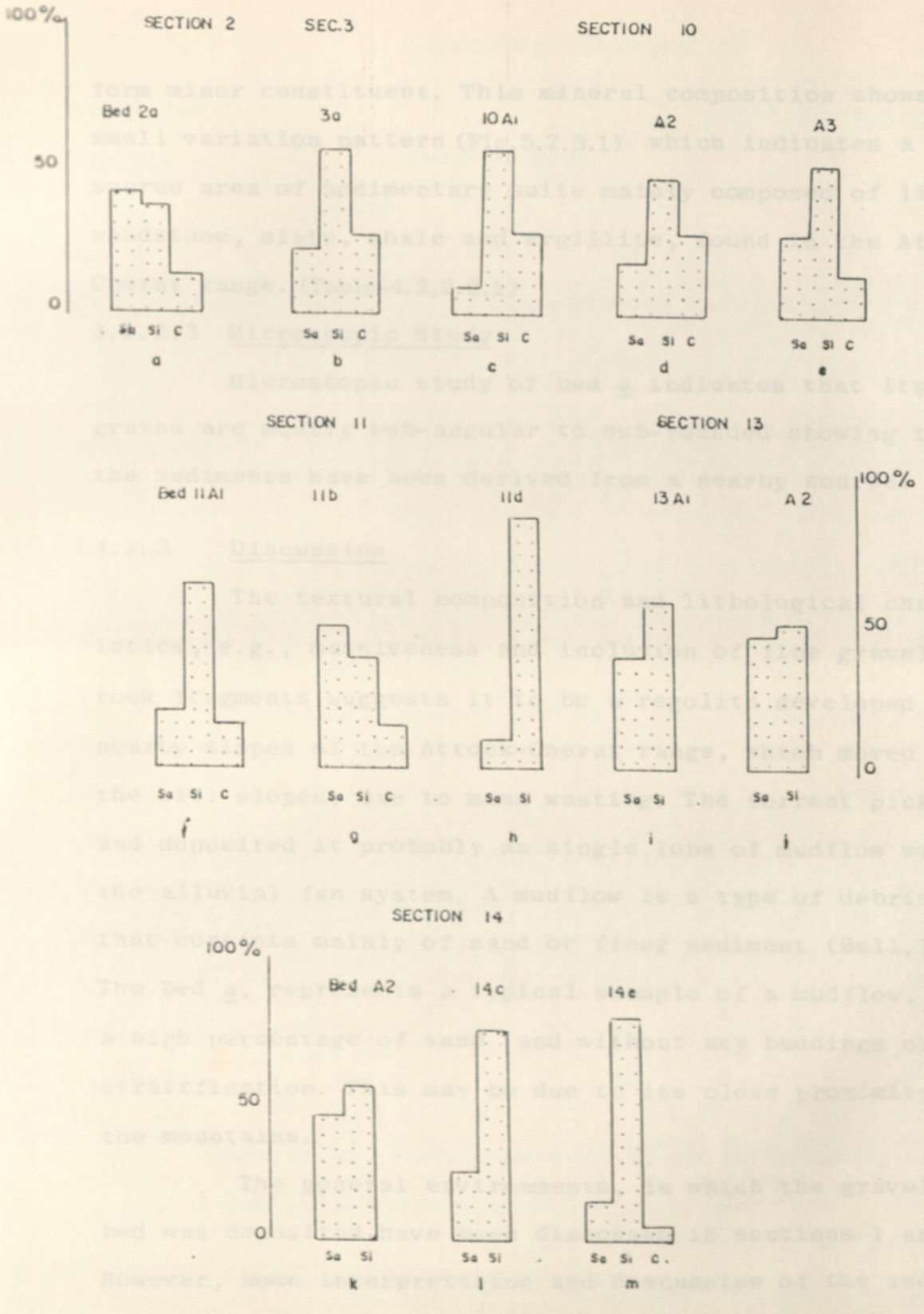


Fig. 4.2.2.1.2. Histograms showing Textural Composition of various beds

form minor constituent. This mineral composition shows a small variation pattern (Fig.5.2.3.1) which indicates a single source area of sedimentary suite mainly composed of limestone, sandstone, slate, shale and argillite, found in the Attock-Cherat range. (Table-4.2.2.2.1)

4.2.2.3 Microscopic Study

Microscopic study of bed a indicates that its grains are mostly sub-angular to sub-rounded showing that the sediments have been derived from a nearby source.

4.2.3 Discussion

The textural composition and lithological characteristics, e.g., massiveness and inclusion of fine gravels and rock fragments suggests it to be a regolith developed on the nearby slopes of the Attock-Cherat range, which moved down the hill slopes, due to mass wasting. The torrent picked up and deposited it probably as single lobe of mudflow within the alluvial fan system. A mudflow is a type of debris flow that consists mainly of sand or finer sediment (Bull,1972). The bed a, represents a typical example of a mudflow, with a high percentage of sand and without any beddings or stratification. This may be due to its close proximity to the mountains.

The general environments, in which the gravelly bed was deposited have been discussed in sections 1 and 3. However, some interpretation and discussion of the individual bed has been made for further understanding of the environments.

LABORATORY EXAMINATION

Section-2 TABLE NO. 4.2.2.2.1

Texture (Percentage)

	Sand	Silt	Clay
Bed a	47	39	14

Mineral Composition (Approximate Percentage)

	Bed a*
Quartz	8
Feldspars	5
Clays	10
Opaque	2
Biotite	20
Muscovite	12
Carbonates	25
Amphibole	9
Chlorite	3
Rutile	2
Tourmaline	1
Epidote	-
Zircon	Tr
Sericite	2
Apatite	Tr

*Grains are mostly subangular to subrounded, few grains are angular.

The conglomeratic bed b, was deposited as gravel bar, within the channel of a braided stream, across an alluvial fan as a result of repeated channel shifting. It seems that after its deposition the channel migrated to other area. The gravels were exposed and cemented firmly due to the solution of limestone under warm humid environments.

The deposition of gravelly sandstone (bed c) on the conglomerate (bed b) indicates a stream channel following its old course under a subsiding water level which may have occured due to changes in the environment of provenance. With relatively low water discharge, sand was deposited in the channel and with intermittent high water flow, lenses of fine gravels were deposited as 'lag deposits.'

The deposition of bed d, as widespread gravels show a rejuvination of the stream, with a high flow of water, for a very long time, during which gravelly material was deposited over a large area. In this section, the alternating beds of gravels and sandstone suggest aggradation of stream under different transporting power due to high and low water discharge.

As has been suggested the thickness of the graveliferous material in section 1 was very high in the vale at the time of its deposition. In the present section, the bed d, also continues southward and ends in a gravelly ridge, 2019 feet high. Originally, it was very thick, with considerable height but it has been greatly reduced by erosion, which also resulted in carving the present channel of the torrent. Many of the foot hills and ridges are still buried under

these gravels, while some of them have been exhumed by the later phase of erosion.

The three boulder blocks, exposed on the torrent bed, seems to be contemporaneous to the bed a. One such boulder has been described in section 33. Their origin is unknown. However, their typical appearance and composition suggest that probably these boulders have been silicified alongwith a portion of trunk of a tree at an earlier time.

However, these silicified boulder blocks and the one found along section 33 south of Nowshehra have some geochronological significance. According to Wadia (1966), such silicified wood and other such material is very commonly found in the Lower Siwalik rocks. If this is so, it is possible that Lower Siwalik/Lower Middle Siwalik rocks are present some where in the Peshawar vale.

4.2.4 Summary of Major Events Recorded in the Section

i. The deposition of silty sand as bed a.
ii. The uplift of the whole area.
iii. The partial erosion of bed a.
iv. The deposition of conglomerate bed b.
v. A period of hault in which gravels were cemented.
vi. The deposition of gravelly sandstone and bed c.
vii. A period of hault.
viii. The deposition of gravelly material as bed d.
ix. An episode of uplift of the whole area.
x. A long period of erosion during which deposits of this section were dissected. The torrent carved its present channel and exposed the conglomeratic boulders.

SECTION 3

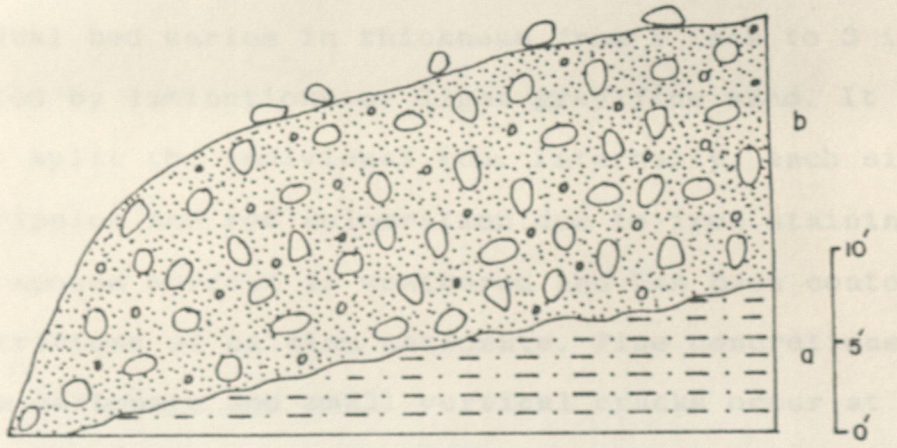


Fig. 4·3·1

4.3 SECTION 3

4.3.1 Field Description

This section is located in Garhi Chandan along the right bank of an un-named torrent (GR 759679)*. The following beds are exposed from below upward:-

Bed a:

It is composed of about 8 feet thick, pink silty clay (5 YR 7/3.5). The whole formation is formed of compact and semi-hard beds which can only be broken with hammer. Each individual bed varies in thickness from 1 inch to 3 inch, separated by laminations of light grey fine sand. It is very easy to split the individual bed. Internally, each silty bed shows ripples and red colouration due to iron staining. Its outer exposed surface is weathered and has been coated with encrustrations of calcium carbonate. Fine concretions of calcium carbonate and small vertical cracks occur at different levels. It breaks into blocky structure. Interestingly the silty clay is slightly saltish in taste. Its upper surface shows a prominent erosional unconformity.

Bed b:

The bed a is overlain by a thick deposit, ranging from medium size pebbles, to coarse sand and silt. Its exposed thickness varies from 15 to 20 feet. The bed has been eroded in different parts and makes an irregular surface. Due to erosion it shows internal stratification. Three to four

* For location of section see Fig. 4.1.1.1.



Plate No. 4.3.1.1 Section 3.

SECTION 3b

Zingg's diagram showing gravels shape

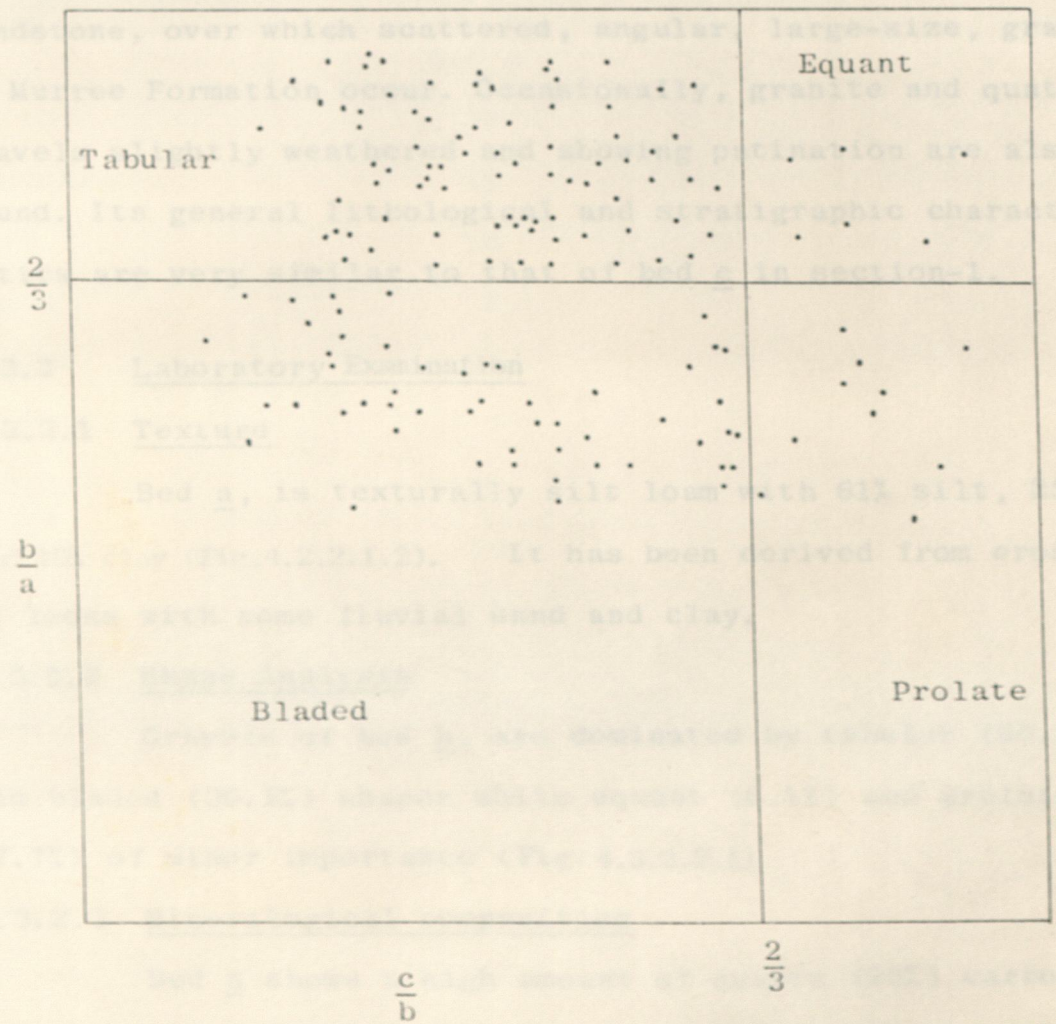


Fig: 4.3.2.2.1.

gravelly beds separated by thin beds of sandstone can easily be recognized, which have formed into terraces. In places small beds or lenses of pink silt are exposed due to gully erosion. The gravels are generally loose, but some are consolidated and make a conglomerate.

The gravels are mostly composed of limestone and sandstone, over which scattered, angular, large-size, gravels of Murree Formation occur. Occasionally, granite and quatzite gravels slightly weathered and showing patination are also found. Its general lithological and stratigraphic characteristics are very similar to that of bed c in section-1.

4.3.2 Laboratory Examination

4.3.2.1 Texture

Bed a, is texturally silt loam with 61% silt, 23% sand and 16% clay (Fig.4.2.2.1.2). It has been derived from erosion of loess with some fluvial sand and clay.

4.3.2.2 Shape Analysis

Gravels of bed b, are dominated by tabular (50.1%) and bladed (36.1%) shapes while equant (6.1%) and prolate (7.7%) of minor importance (Fig. 4.3.2.2.1)

4.3.2.3 Mineralogical composition

Bed a shows a high amount of quartz (25%) carbonates (20%) and clays (15%). Feldspars are significantly low (12%) as compared to clays and quarts. Amphiboles and muscovite contribute 10% and 7% respectively, with chlorite as 5%, while biotite rutile and tourmaline are present in very small proportion. (Table-4.3.2.3.1)

LABORATORY EXAMINATION

Section-3 Table No. 4.3.2.3.1

Texture (Percentage)

	Sand	Silt	Clay
Bed a	23	61	16

Mineral Composition (Approximate Percentage)

	Bed a*
Quartz	20
Feldspars	12
Clays	15
Opaque	5
Biotite	3
Muscovite	7
Carbonates	20
Amphibole	10
Chlorite	5
Rutile	1
Tourmaline	1
Epidote	Tr
Zircon	Tr
Sericite	-
Apatite	-

* Grains are mostly rounded.

These minerals show a high variation pattern (Fig.5.2.1.1) which suggests that its material has been derived from a variety of sources. One of the most important source may be the Hornblendic Group of rocks located in the north, while high amount of carbonates suggest that some of the material may have been derived from the limestone of Attock-Cherat range.

4.3.2.4 Microscopic study

Microscopic study of the material suggests that grains are mostly sub-angular to subrounded, indicating a wide range of transportation from different sources.

4.3.3 Discussion

Bed a at the base of section appears to be a lake bed but it could also be an over-bank deposition of a flood plain facies. Its lithological characteristics indicate that its material was deposited in a shallow, still water, perhaps a lake or a slow moving meandering stream channel. It seems as if excess water of channel capacity has flown over-bank, inundating parts of flood plain and fine material of the bed a, was deposited. The fine sandy laminations within the silty beds indicate periodical overflowing of the channel.

It is suggested that fine material of the bed a, was probably derived from the erosion of a soil profile developed during a warm phase and carried down slope, due to soil creep and picked up by the streams. The small vertical cracks, at different levels are interpreted as 'dessication cracks.'

The orange colour stainings within the beds indicate leaching of iron in a warm humid environments, while the development of fine concretions of calcium carbonate suggest its leaching during warm dry spells. All these characteristics suggest the development of a B horizon of a soil. It appears, that due to a change in the pedogenic environments, the upper surface of the bed a and its A horizons were eroded, forming erosional channels.

The deposition of bed b, indicates the rejuvincation of a high energy stream with a steep gradient, the result of a rapid uplift of the Attock-Cherat ridge. The entire bed b, probably represents the ramnants of islands and bars of gravels, generated as channel segments formed, which migrated latterally and disappeared under a regime of rapidly changing, braiding stream within an alluvial fan system.

The internal stratification of the gravels and exposure of small beds or lenses of silt, indicate its deposition in different stages by high and low energy stream. During the shifting of the channel, the gravels were consolidated, while at low discharge the stream could deposit only fine material like silt in its channel.

It is likely that the entire bed b was later on eroded, during a very long period of erosion. Probably the erosion took place in three or four stages. As a result of erosion the gravels were formed in various terraces. The erosion in stages may have occurred due to the falling of the

local base level as a result of intermittent uplifts. After the torrent formed its present channel, the lower bed a was exposed. The leaching of calcium carbonate and its encurstation on the outer surface of the bed a, suggests a very dry period, during which the silty bed was exposed to weathering processes.

4.3.4 Summary of Major Events Recorded in the Section

i. The deposition of silty clay as bed a.

ii. The erosion of bed a.

iii. The uplift of the Attock-Cherat range.

iv. The deposition of gravelly material as bed b.

v. A long period of erosion during which these gravels were eroded in different stages.

vi. A post exposure weathering of the silty clay.

SECTION 4

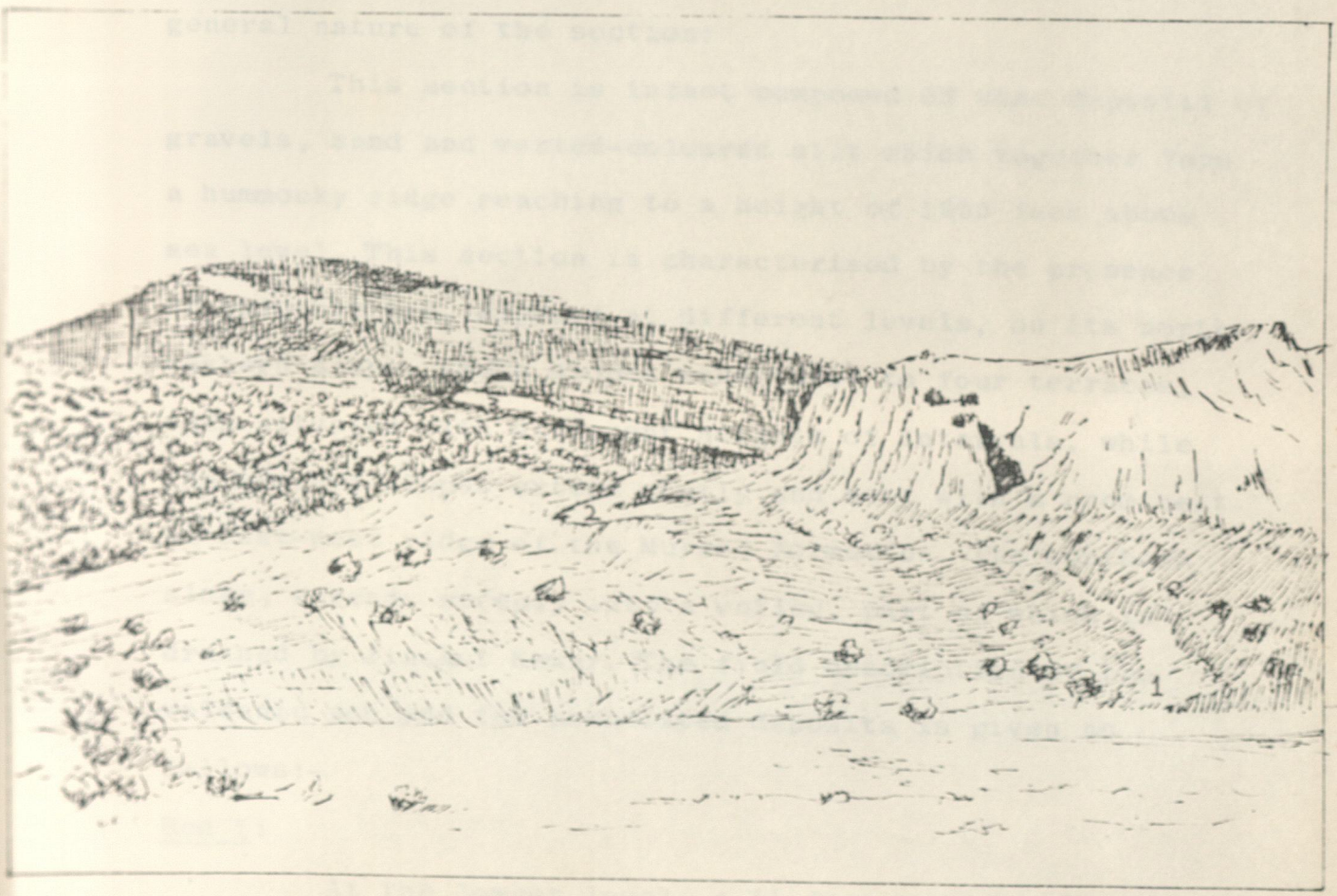


Fig. 4·4·1

4.4 SECTION 4

4.4.1 Field Description

This section is located along a shingle road, about ½ km south of Garhi Chandan village (GR 747662)*. A general description is given as follows to understand the general nature of the section:

This section is infact composed of vast deposits of gravels, sand and varied-coloured silt which together form a hummocky ridge reaching to a height of 1950 feet above sea level. This section is characterised by the presence of volcanic ash, exposed at different levels, on its north-eastern slope. These slopes make three to four terraces, each situated with different heights of intervals, while the western slopes extend gently and meet with a prominent an east-west ridge of the Murree Formation. Its southern slope, extends steeply into a valley, part of which is drained by Jinakor Khwar. The field description of the volcanic ash and the associated deposits is given as follows:-

Bed 1:

At the lowest level, a 1½ feet bed of volcanic ash is exposed, along a thin bed of light-grey sandstone overlain by a massive conglomerate, which in places is broken and weathered. Its gravels and boulders are scattered all over the area. The gravels are sub-rounded and composed of dark grey crystalline limestone, grey brown sandstone with a large number of medium-size gravels of igneous and metamorphic

*For location of section see Fig.4.1.1.1.



Plate No: 4.4.1.1.a. Section 4



Plate No: 4.4.1.1.b Section 4

rocks. Some large-size gravels of greenish black and brownish black colour, being very heavy are also embedded in the conglomerate. It may be noted that, this type of sandstone and conglomerate is also found along with a pocket of volcanic ash of pure white colour, located at a higher level, about 300 meters west of this bed. A sample of volcanic ash from bed 1 (V.1) has been dated through fission track method as 2.7 m.ys ± 0.3 m.ys (Table-4.4.1.1).

Bed 2:

About 100 feet above bed 1, another bed of volcanic ash (3 feet thick) is exposed. It lies over a bed of pale green silt, similar to that of section 2a. Its upper part is fine, white and porous, but the lower part is mixed with the underlying silt and is a little greenish, more heavier and massive.

Bed-3:

About 100 feet upslope from the bed 2, another bed of volcanic ash is found, which is the largest exposure of the area. Its horizontal extension is more than 50 feet while its thickness may vary from 2 to about 10 feet. Due to erosion, the underlying deposits of ash is exposed at two places. At one place, the volcanic ash seems to be overlying a bed of pink silty clay showing fine beddings and stratification like a lake bed, while at others the volcanic ash is underlain by a bed of whitish grey soft micaceous sandstone, similar to the one exposed in section 12. In both beds, the silt and sand of the respective beds have been mixed with the ash at contacts and has become harder and heavier than the pure ash.

TABLE --4.4.1.1.

Result of the fission-track ages of volcanic ashes from Garhi Chandan (Sample Nos. V1&V2

1. Specimen V1 — 2.7 + -0.3 Ma

2. Specimen V2 — 2.8 + -0.4 Ma

Both of the age values were obtained by grain by grain and EDM-1 Method about 30 grains of Zircon crystals. The calculation of the age values carried out through the GGPT Calculation Method. Precise data are as follows:

1.	V1	Number of spontaneous fission-tracks	74
		Number of induced fission-tracks	751
		Uranium content	346 ppm.
		Measured square	2.39 x 10 cm
		Value	4.54 x 10
2.	V2	Number of spontaneous fission-tracks	72
		Number of induced fission-tracks	702
		Uranium content	348 ppm.
		Measured square	2.2 x 10 cm
		Value	4.57 x 10

3. B value = 6.23 x 10

value = 7.03 x 10/year

These two volcanic ashes may be the same.

Prof. T. Yoko Yama
Department of Earth Sciences,
Doshisha University,
Kyoto Japan 602.
Date: 1986.1.27.

The beddings are prominent, which vary from ½ an inch to 3 inch. The surrounding surface is covered with gravels of limestone. A sample of volcanic ash from this bed (V.2) is dated through fission track method as 2.8 m.ys. ± 0.4 m.ys (Table- 4.4.1.1).

Bed 4:

Near the top of ridge 1950 feet above sea level, a 2 to 3 feet thick deposit of volcanic ash is exposed on a very steep slope. The surface is covered with loose gravels of limestone, while below the ash, the material is sandy and silty having red brown colour.

4.4.2 Discussion

Due to repeated action of tectonics and the resulting erosion, the whole formation of the Garhi Chandan is very much disturbed. In order to understand the true stratigraphic nature of these deposits, dates for two volcanic ash deposits were obtained by fission track method. On the bases of these dates and field description, the following interpretation of the section is given as:-

i. The dates of the two ash beds is closely related which suggests that these and all other exposed beds may be one and the same (Yokoyama, 1986, written communication). The exposure at different levels may be due to the rapid uplift of the whole formation making a steep tilt to the north.

ii. The purity of the ash beds also suggests that it was directly and spontaneously deposited over Garhi Chandan area during a volcanic ejecta. However,

the varying thickness of the individual beds suggests that the ejects may have been intermittent with varying intensities at very short intervals. Also, there is no indication that the ash was reworked by torrents as the ash beds are pure and without clastic contamination. The purity of the ash beds also suggests that during its deposition there was neither a fluvial deposition nor erosion.

The source of the volcanic ejecta is not clear. These ashes represent the primary air-fall, while no Pliocene to Quaternary volcanic rocks have been noted in and around the vale area. However, a number of Pliocene and Quaternary volcanic centers have been reported in Afghanistan of which the Dasht-e-Nawar volcanic complex, about 175 km south west of Kabul seems a plausible source of this volcanic ejecta (Johnson, et al., 1982a).It may also be noted that the volcanic ash dates of Garhi Chandan are similar to the volcanic tuffs found in various areas of Potwar and the Salt Range. On the basis of these dates, the formations in which the ash is embedded in Garhi Chandan may be considered homotoxial to the Upper Siwalik rocks of Potwar.

It seems that the volcanic ash was deposited on the varied coloured silt of lacustrine facies which is the oldest lithological member of Garhi Chandan area. After the deposition of volcanic ash, the environments changed to warm humid and the Kabul river being a slow meandering stream, frequently overflooded its channel, began to form its flood plain.

The pink and green silt, are interpreted as deposits of overbank while the whitish grey sandstone may be considered as its 'channel facies'.

It appears that a significant change occured in the sedimentary character of this area, when petromictic conglomerate with a clear crystalline aspect began to be deposited over the older stratigraphic units. It indicates a braided stream morphology, which implies that the Swat-Kabul and Bara rivers achieved a steep gradient as a result of a rapid uplift of the surrounding area, particularly the crystalline belt lying to the west and north-west, of the study area. Secondly, an environmental change had also occured in the northern provenance leading to a warm/interglacial climate, releasing a large amount of coarse material which was produced under the previous regime of cold/glacial environments. Thus this material which is mostly composed of gravels and boulders of variety of crystalline rocks was picked up by high energy streams, and formed very large alluvial fans from their outlets, which spread south-eastward as far as the northern foothills of the Attock-Cherat range. It is suggested, that this way, much of the vale might have been filled with the material, referred to as the First valley fill.

Probably, in order to achieve a profile of equilibrium the petromictic conglomerate and its associated deposits were eroded, from much of the Peshawar vale. The only exception is those lying along side the mountain on the higher slope, as found in the Garhi Chandan area or along the

northern foot hills of the Attock-Cherat range referred to in the sections 12 and 27.

The deposition of limestone, bearing graveliferous material, over the ash beds, as facies of an alluvial fan indicates a rapid uplift of Attock-Cherat range, and the weathering of its rocks, under freez/thaw cycles in a cold climate contemporaneous with a glacial phase over the Northern Areas. The weathered debris in great quantity streamed out north-ward from the Attock-Cherat range, as Older alluvial fans and covered a large part of the Peshawar vale south of river Kabul. This has been referred to as the Second valley fill of the Peshawar vale.

The deposition of the Second valley fill was followed by another tectonic episode, during which whole of the Garhi Chandan formation was considerably uplifted and tilted to the north. Consequently, the actual stratigraphic position of various beds in this area was greatly disturbed. This uplift also initiated another phase of erosion, during which these deposits were eroded and shaped into hummocky ridges. The torrent carved its present channel by exposing the ash beds.

4.4.3 Summary of Major Events Recorded in the Section

i. The formation of a lake and the deposition of varied colour silt and clay as lacustrine facies.

ii. The onset of very cold conditions in the vale.

iii. The uplift of the Himalayas. The weathering and erosion of crystalline rocks of the northern provenance of the vale.

iv. The deposition of volcanic ash over the lake beds.

v. The formation of flood plain by the ancient Kabul river and the deposition of overbank facies, and sand as its channel facies. Contemporarily, volcanic ash was also deposited in this part of the vale.

vi. Another phase of tectonics; the gradient of Kabul becomes steeper and the river begins to transport and deposit coarse material like gravels and boulders of igneous and metamorphic rocks of the northern provenance. The material is referred to as the First valley fill of the Peshawar vale.

vii. A cold phase during which the gravely material of the First valley fill and the underlying beds were eroded from over a large part of the vale.

viii. Rapid uplift of the Attock-Cherat range and the weathering of rocks.

ix. A long phase of erosion.

x. Deposition of graveliferous material from the Attock-Cherat range as Older fans, in great thickness, referred to as Second valley fill of the vale.

xi. Another phase of tectonics. The uplifting and tilting of deposits in Garhi Chandan area.

xii. A phase of erosion during which most of the Older fan material was eroded; the torrent carved its present channel.

SECTION 5

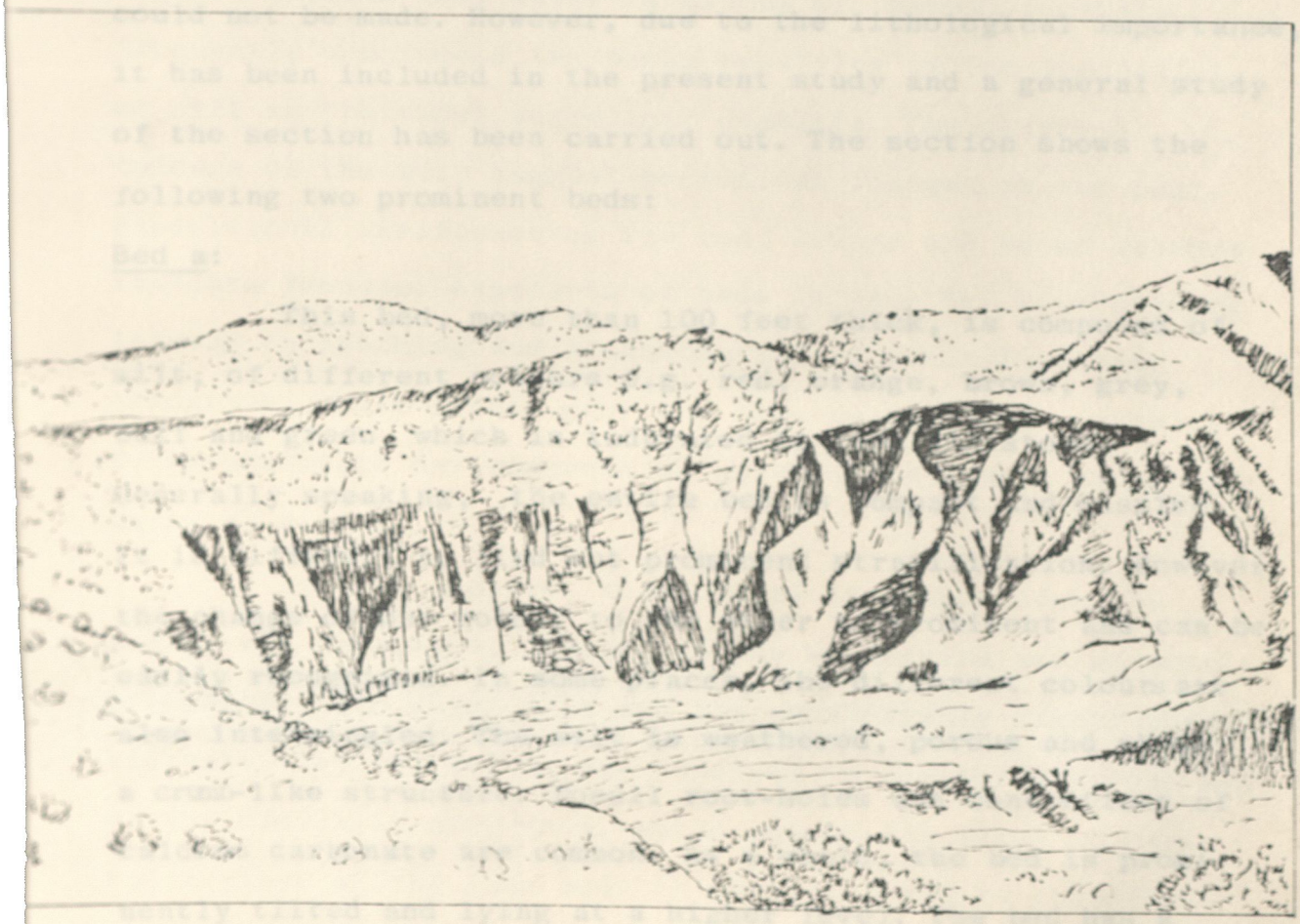


Fig. 4·5·1

4.5 SECTION 5

4.5.1 Field Description

This section is located on the right bank of an un-named torrent in the Garhi Chandan area (GR 757665)*. Due to the law and order situation, detailed field investigation could not be made. However, due to the lithological importance, it has been included in the present study and a general study of the section has been carried out. The section shows the following two prominent beds:

Bed a:

This bed, more than 100 feet thick, is composed of silt, of different colours e.g. red, orange, brown, grey, buff and green, which is indurated to form siltstone. Generally speaking, the entire bed is compact and massive. It is difficult to find out prominent stratification. However, the change of one colour to the other is prominent and can be easily recognized. In some places, the different colours are also intermingled. The silt is weathered, porous and shows a crumb-like structure. Fossil root-holes and concretions of calcium carbonate are common. As a whole, the bed is prominently tilted and lying at a higher level. The bed has a non-conformable contact with the overlying gravelly bed.

Bed b:

It is composed of thick gravelly material, which is an extension of the gravelly deposits exposed in sections 1,2 and 3 and also possesses similar lithological characteristics. A number of terraces are developed in bed b.

* For location of section see Fig. 4.1.1.1.

4.5.2 Discussion

The deposition of bed a, indicates that normal fluvial conditions existed in this area during its deposition. The varied coloured silt of bed a is interpreted as "an over-bank facies" of a flood plain formed by the ancient Kabul river. It seems that water in excess of channel capacity, frequently overflooded its banks resulting in the deposition of silt as "vertical accretion" deposits. The different colours of the silt suggest periodical changes in the post-depositional environments. The red, orange and brown colours indicate frequent exposures of beds in warm dry environments leading to leaching and concentration of minerals during oxidation, while green, grey and blue colours show presence of an aneorobic environments of marshes and swamps along the banks of stream.

It also appears, that during its deposition the bed a, was frequently exposed to the weathering and pedogenic processes. The steep tilt and its considerably higher position indicate that the bed a, was involved in tectonics during one of the Himalayan orogenies, while subsidence seems to have taken place at the lake beds in section 6 due to the over-loading of the sediments. However, due to the rapid uplift of the Attock-Cherat range, there was a change in the environments. The torrent now deposited huge alluvial fans, (bed b) that extended northward from the Cherat mountain.

4.5.3 Summary of Major Events Recorded in the Section

i. The deposition of varied coloured silt as the bed a. A period of uplift.

ii. The erosion of bed a.

iii. The deposition of gravelly material as the bed b.

iv. The uplift of the northern foothills of the Attock-Cherat range; tilting of bed a and b.

v. The erosion of gravelly deposits and formation of terraces. Due to continued erosion, the torrent also carved its present channel in these beds.

vi. The exposure of the bed b, which was subject to gully erosion.

SECTION 6

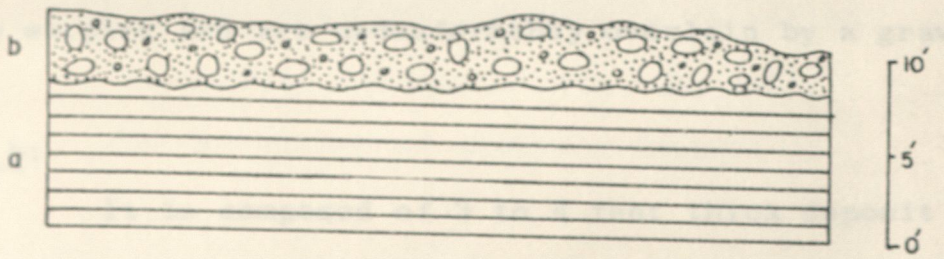


Fig. 4·6·1

4.6 SECTION 6

4.6.1 Field Description

This section is located adjacent to Garhi Chandan village (GR 743679)* along a water course. It exhibits the following beds:-

Bed a:

The lowest bed a, about 8 feet thick is of varied coloured, thin beds, of lacustrine facies. Each bed is about one inch thick and composed of hard silty clay of grey, red, yellow, green, blue, brown and pink colours. These colours are repeated, but without any systematic order. The beds show warping and are unconformably overlain by a gravelly bed.

Bed b:

It is composed of 3 to 4 feet thick deposit of gravelly material. Its upper surface is convex which rises gradually towards south. Its lithological composition is very similar to the gravelly deposits exposed in other sections of Garhi Chandan.

4.6.2 Discussion

The bed a, was deposited in a lake which was probably formed due to the damming of the Kabul river, by the uplift of the Attock-Cherat range at Khairabad-Kund. Here the eroded parts of the uplifted ridge, comprising Manki Slate, was crossing the Kabul river channel at right angle. It is suggested, that this may be the oldest (First) lake

* For location of section see Fig. 4.1.1.1.

phase of the Peshawar vale in which silty clay of bed a was deposited. It seems that due to their involvement in tectonics, these lake beds have been warped and uplifted.

It may be noted that the varied colours of these lake beds closely resemble with the bed a of section 5, suggesting similarities of the environments of deposition. The gravelly bed b of this section is the same as found in other sections of the Garhi Chandan areas.

4.6.3 Summary of Major Events Recorded in the Section

i. The formation of a lake and the deposition of varied-coloured silty clay.

ii. The lake beds are involved in tectonics.

iii. The partial erosion of the lake beds.

iv. The deposition of gravelly deposits.

SECTION 7

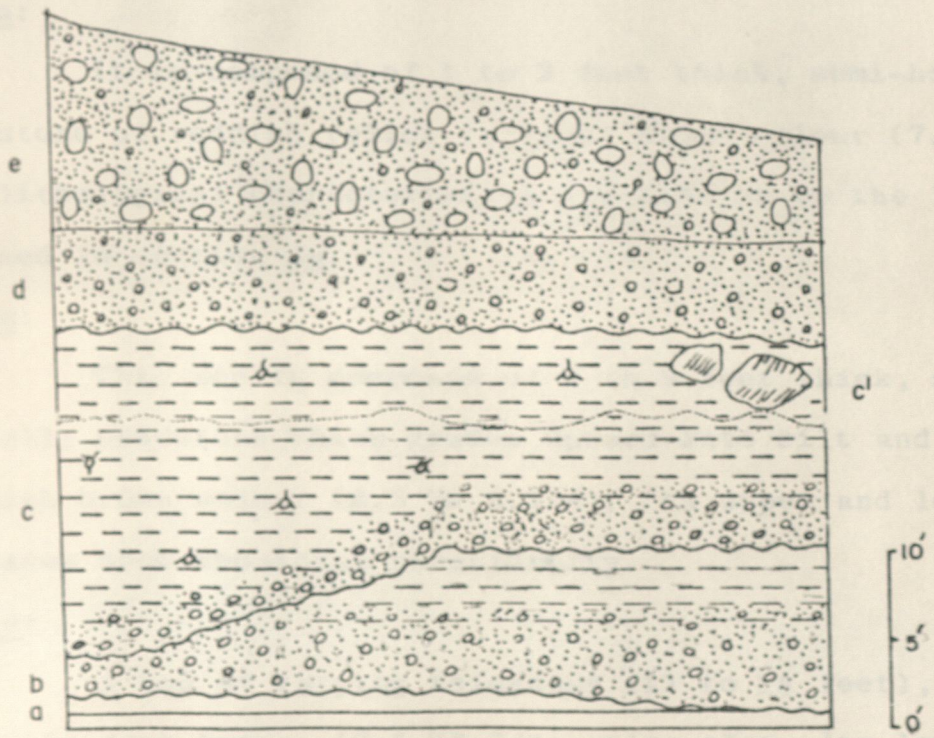


Fig. 4·7·1

4.7 SECTION 7

4.7.1 Field Description

This section is located about 100 meters west of Shamshattoo Frontier Constabulary post, along the lef bank (GR 775685)* of an un-named torrent. The whole section, about 40 feet high, exhibits the following beds:-

Bed a:

It is composed of 1 to 2 feet thick, semi-hard siltstone of reddish yellow to light brown colour (7.5 YR 6.5/5). Its lithological characteristics are similar to the lake beds exposed in section 6a.

Bed b:

This bed is composed of 2 to 9 feet thick, semi-hard gravelly sandstone which grades upward into silt and clay of reddish brown colour (2.5 YR 4.5/4). Its upper and lower surfaces show erosional unconformity.

Bed c:

A bed of varying thickness (11 to 18 feet), massive, brown to dark brown, (7.5 YR 5/4) silty clay, Its lower 2 feet, at one end is composed of coarse material, consisting of angular to sub-angular, fine to medium-size gravels. In the middle part, it shows very dark brown patches, which extends horizontally. Nodules of calcium carbonate are frequently incorporated. In its upper part (c1), at one end, two large-size boulders are firmly embedded. Its contact with the overlying bed is unconformable.

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* For location of section, see Fig. 4.1.1.1.



Plate No. 4.7.1.1 Section 7.

Bed d:

A 5 feet thick bed of gravelly, coarse sandstone, of grey brown colour, overlies the silty bed unconformably. The sandstone is semi-hard, pourous and shows numerous weathering pits of different sizes and shapes.

Bed e:

Bed e is 6 to 12 feet thick. It is predominantly gravelly and lithologically very similar to the gravelly beds in other sections of the Garhi Chandan area.

4.7.2 Discussion

This section is important because in addition to the different lithologies shown, it exhibits two soil horizons. The lake bed in this section is an extension of those exposed in section 6a. It appears that after the lake bed was eroded, it was occupied by a stream channel in which material of the bed b, was deposited as 'Channel lag deposit.' Subsequently the channel shifted its position and due to frequent over-flooding, fine silt was deposited over the channel lag deposits. The whole deposit was exposed to pedogenic processes for a long time during which a soil horizon was developed. Later on, due to a change in the environment, the upper part of the bed, including its A horizon, was completely eroded.

The lithological composition of bed c, suggests it to be the mud flow facies of an alluvial fan which was deposited by one of the braided channel of a stream. Its deposition is favoured by the presence of clay bearing rocks (Allen 1979,

p.145) such as shale and slate which are found in abundance in the Attock Cherat range. These rocks were subjected to physical disintegration due to 'slacking' in an alternate drying and wet conditions. This resulted in the development of a thick mantle of regolith over the entire Attock-Cherat range. During wet conditions, as a result of mass wasting the slopes began to release the weathered material to braiding channel. The presence of the coarser material and a few large boulders suggest, high viscosity and steep gradient which facilitated the mud-flow. The material was probably deposited, down the fan channel in two phases (c and c1). The material of the bed c, remained open for the pedogenic processes, which lead to the development of another soil horizon.

Bed d, represents 'channel bar deposit' of one of the braided channels of an alluvial fan. During a warm and wet period, solution cavities and weathering pits were produced as a result of chemical weathering. A period of rapid uplift of the Attock-Cherat range supplied huge amount of gravels and coarser material which was deposited as the bed e.

4.7.3 Summary of Major Events Recorded in the Section

i. The formation of lake and deposition of siltstone as bed a.

ii. The erosion of the lake bed.

iii. The deposition of gravelly sandstone as bed b.

iv. The erosion of gravelly sandstone.

v. The deposition of silty material as the bed c.

vi. The erosion of the bed c.

vii. The deposition of gravelly sandstone as the bed d.

viii. The deposition of gravelly bed as the bed e.

ix. A period of long erosion during which the present section was exposed.

SECTION 8

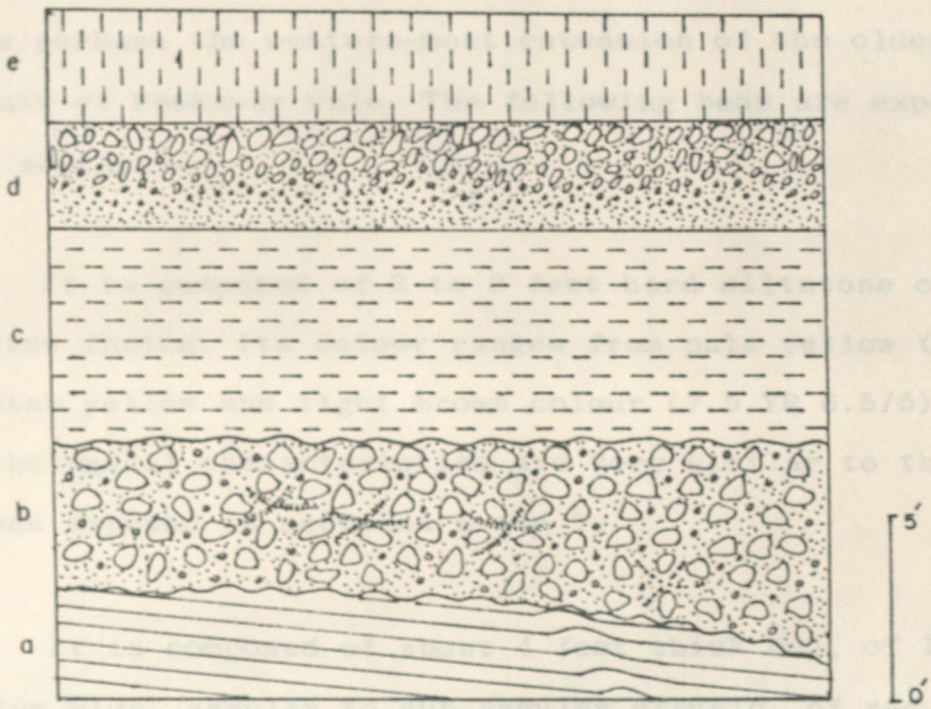

Fig. 4·8·1

4.8 SECTION 8

4.8.1 Field Description

This section is located on the left bank of Zindai Khwar, about one km, north of a point where the North-West Frontier road crosses the Zindai Khwar (GR 605723).* It has been included in this study because it exposes a lake bed, which is perhaps the western-most extension of the oldest lake phase of Peshawar vale. The following beds are exposed in this section:-

Bed a:

It is composed of 2 to 3 feet hard siltstone of lacustrine facies. Its colour ranges from pale yellow (5Y 7.5/3) to reddish yellow and light brown colour (7.5 YR 6.5/5); while its lithological characteristics are very similar to the lake beds exposed in sections 6 and 7.

Bed b:

It is composed of about 4 feet thick bed, of large to medium size, angular to sub-angular gravels, of red sandstone and shale, of Murree Formation. Occasionally, large gravels of limestone are also embedded. The matrix which is composed of coarse sand and fine gravels show cross-beddings.

Bed c:

About 6 feet thick bed of coarse to fine silt of reddish brown colour (2.5 YR 4.5/4) overlies gravels unconformably. A band of (about one foot thick) of very dark-red colour, extends horizontally, throughout the bed.

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* For location of section, see Fig.4.8.1.1.

LOCATION OF SECTIONS

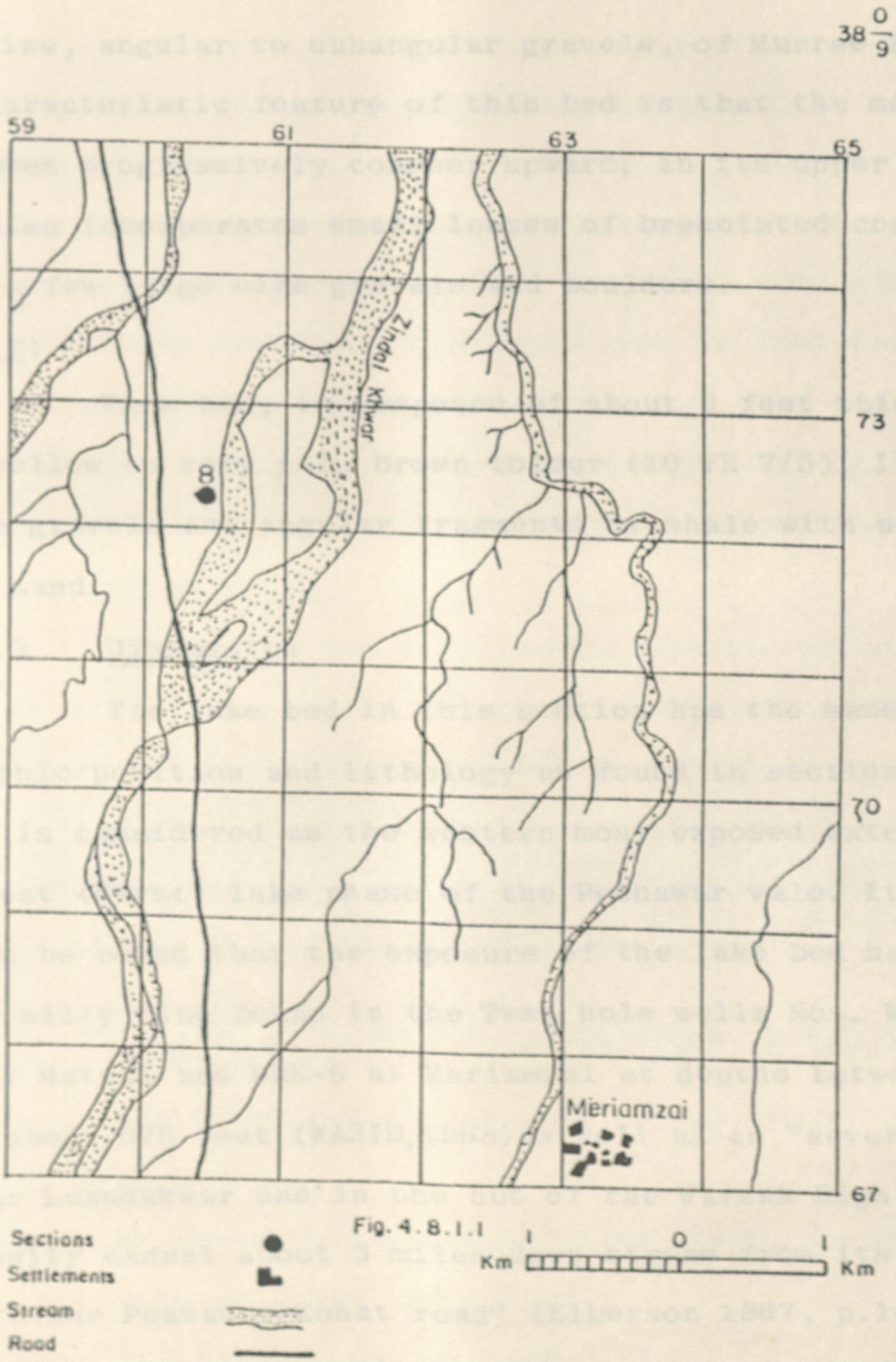

Fig. 4.8.1.1

It contains very small hard nodules of iron rich material. Its contact with the overlying gravelly bed is unconformable.

Bed d:

It is composed of 3 feet thick material of medium of fine, angular to subangular gravels, of Murree Formation. A characteristic feature of this bed is that the material becomes progressively coarser upward; in its upper parts it also incorporates small lenses of brecciated conglomerate and a few large size gravels and boulders.

Bed e:

This bed, is composed of about 3 feet thick loess of yellow to very pale brown colour (10 YR 7/5). It contains fine gravels and angular fragments of shale with small lenses of sand.

4.8.2 Discussion

The lake bed in this section has the same stratigraphic position and lithology as found in sections 6 and 7, and is considered as the western most exposed extension of oldest (First) lake phase of the Peshawar vale. It should also be noted that the exposure of the lake bed here and the silty clay found in the Test hole wells Nos. WRK-5, near Matani and WRK-6 at Mariamzai at depths between 100 to about 575 feet (WASID,1968)as well as in "several gullies near Luandkhwar and in the cut of the Warsak High Level Density cannal about 3 miles down stream from its crossing with the Peshawar-Kohat road" (Elberson 1967, p.104) are similar in their lithological characteristics and indicate that at one time the lake must have been deep and very

extensive, which perhaps covered a vast area of the Peshawar vale, south of river Kabul. There is an evidence which suggests that these lake beds have been intrupted by the deposition of brown silt loam like material very similar to loess (Elberson 1967, p.104). This loess may be considered as the earliest phase (First loess) of loess deposition in the Peshawar vale.

The tilting and warping of the lake bed, and its subsequent erosion, suggest that the whole area was involved in a Himalayan orogeny during which due to lowering of the local base level and also steeper gradient, the lake beds were removed from a large part of vale, except those protected by gravelly material as found in the Garhi Chandan area and along the foot-hills.

The beds c and d, represent profile of an 'inverted soil.' Their lithological characteristics and environments of deposition have been discussed in detail in section 30a.

The deposition of silt over here suggests that it is a redeposited loess which has been washed down from the nearby slopes of the surrounding mountains.

4.8.3 Summary of Major Events Recorded in the Section

i. The formation of lake and deposition of siltstone as bed a.

ii. An event of tectonics during which the lake beds were uplifted and warped.

iii. The erosion of lake bed.

iv. The deposition of torrent gravels as bed b.

v. The erosion of torrent gravels.

vi. The deposition of red silt as bed c.

vii. The deposition of torrent gravels as bed d.

viii. A period of hault.

ix. The deposition of loess as bed e.

x. A very long period of erosion during which all these sediments were dissected.

SECTION 9

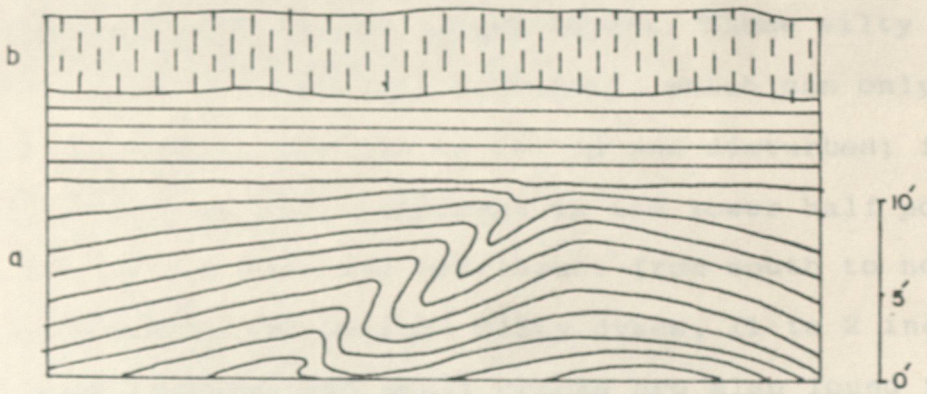

Fig. 4·9·1

4.9 SECTION 9

4.9.1 Field Description

This section is located on the left bank of Lakarai Khwar near Spinkana road (GR 029794)*. This section with a total thickness of 20 feet, exposes 16 feet of lake bed, overlain by a 4 feet thick bed of loess. The detailed description of the section is as follows:-

Bed a:

It is 16 feet thick lake bed, which is composed of numerous individual silty layers mostly 1 inch to 2 inch thick, that are separated by hard sandy layers. These silty bands are hard, and indurated into siltstone, which can only by broken by a hammer. The bed is tilted and disturbed; folding and overfolding is very prominent in its lower half portion, where some of the beds are overthrust from south to north. Numerous vertical and oblique silty dykes, (1 to 2 inch thick) open fissures and small cracks are also found in the silty beds.

As a whole, internally, the individual bed shows fine laminations. Small worm-holes, mostly perpendicular to the bedding planes are also very common. Texturally, it is different from the lower lake beds, exposed in the Babu, Talab and Baringar Khwars as it has a high percentage of clay than the latter. Besides, horizontal concretions of calcium carbonate, are frequently, found at different levels. On the basis of colour, three types of silty beds are repeated as a cycle of yellow, red and green can be easily recognized.

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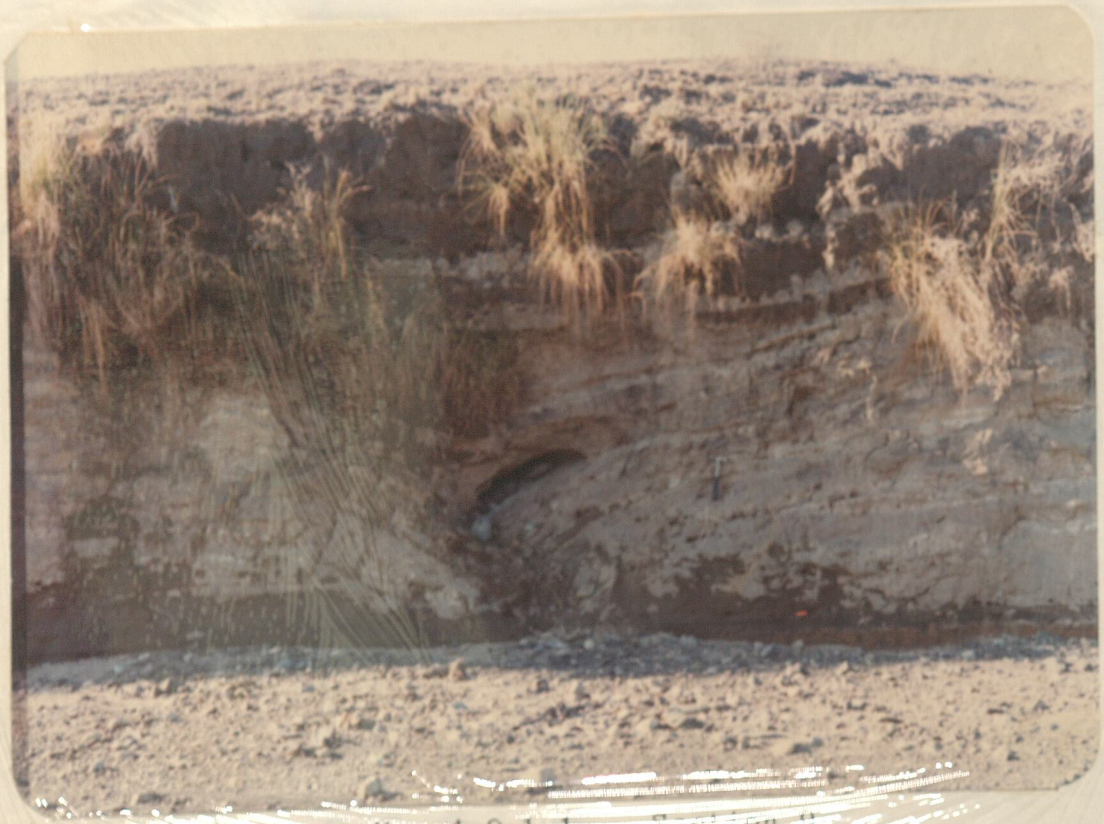
* For location of section see Fig. 4.20.1.1.



The detail of these beds is as follows:-

Bed a1:

The lowest part of the lake bed is composed of about 1 to 2 inches thick, silt loam, of reddish yellow to light brown colour (7.5 YR 6.5/5). It is hard; is sticky, when wet. It contains horizontal concentrations and small nodules of calcium carbonate. Also incorporated are small, angular fragments of slate and shale.

Bed a2:

Bed a1 is followed by a bed of reddish brown to red colour (2.5 YR 4.5/6). It is also very sticky, but is devoid of concretions of calcium carbonate.

Bed a3:

This bed is composed of light olive grey to olive colour (5 Y 6/2.5) sandy loam.

It should be noted that these individual beds of varied coloured, mostly overlie alternately each other, usually separated by thin sandy layers. The bed a3 is massive as compared to the others and reaches upto the top, with a thickness of 4 feet. This bed is conspicuous by having lenses of hard sand and reddish brown clay. The lake bed has an unconformable contact, with the overlying loess bed b.

Bed b:

This bed, is composed of a 4 feet thick loess of yellow to very pale brown colour (10 YR 7/5). Fine gravels and angular rock fragments of shale are occasionally found.

4. 9.2 Laboratory Examination

4. 9.2.1 Texture

Bed a, is silty clay, composed of 61% silt, 28% clay, with a low percentage of sand (11%). Bed a2, also shows high percentage of clay (30%) with 49% silt, and 21% sand. As compared to beds a and a2, bed a3, has a higher percentage of sand (31%) with 55% silt and 14% clay (Fig.4.9.2.1.1). Textural composition of these beds show a considerable contribution of loess mixed with fluvial sand and clay. High amount of clay in beds a and a2, suggests contribution by chemical weathering while higher percentage of sand in bed a3, may be due to mechanical weathering during cold environments.

4. 9.2.2 Mineralogical Composition

All beds exposed in the section have a uniform and similar mineral composition e.g. quartz 18% to 20%, feldspars 20% to 22%, carbonates 18% to 22%, clays 10% to 12% and biotite 10% to 12%, with amphiboles 4% to 5% and chlorite 3% to 4%. This composition suggests that most of the material has been derived from igneous and metamorphic rocks of northern provenance.(Table-4.9.2.2.1)

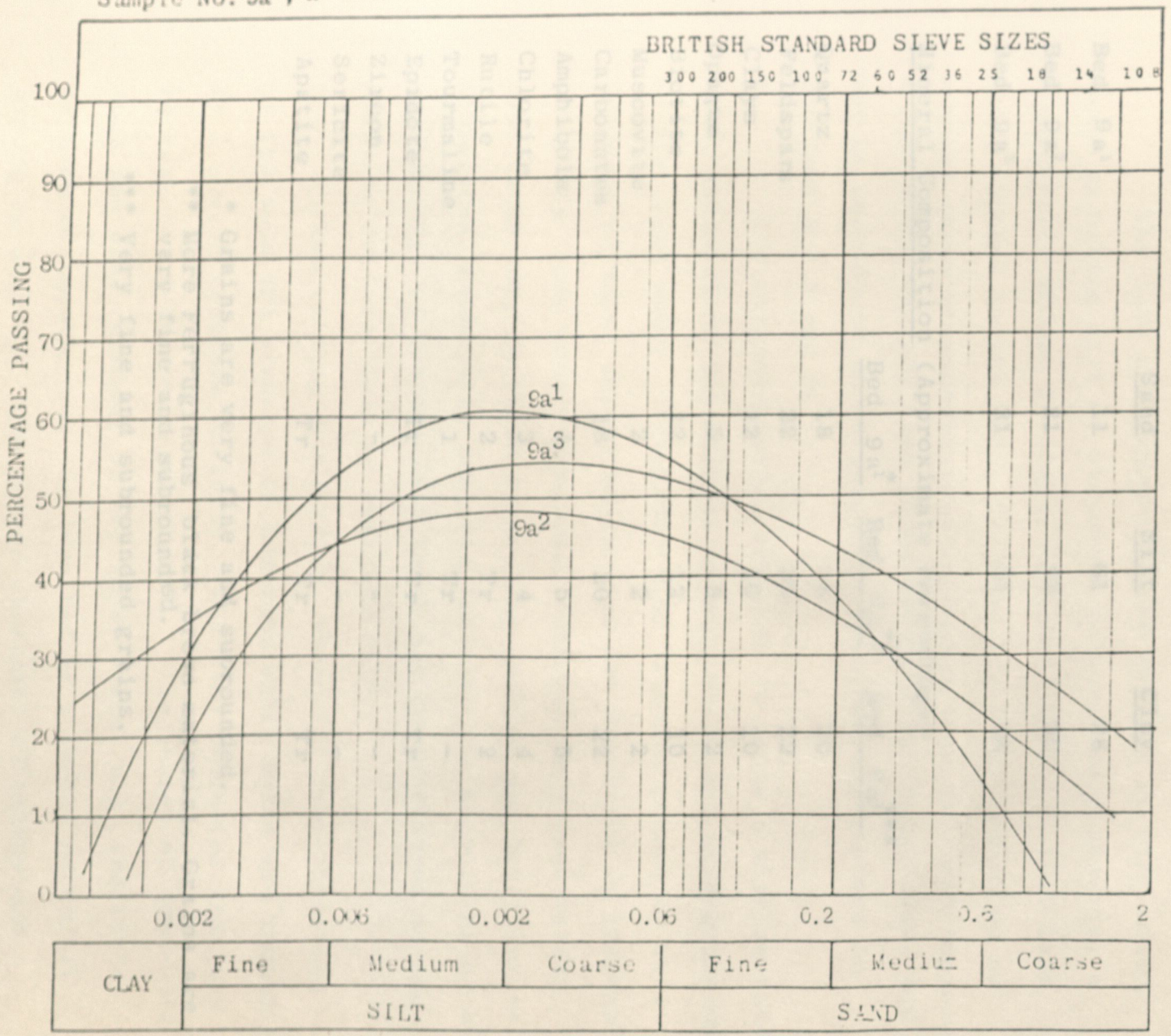
4. 9.2.3 Microscopic study

Grains of all beds are very fine and sub-rounded showing a long distance of transportation. Bed a2, also shows dark brown ferruginous material which indicates post-depositional weathering during warm humid period. The loess is soft and much weathered. Concretions and nodules of calcium carbonate frequently occur. The surface of the

PARTICLE SIZE DISTRIBUTION

Fig.4.9.2.1.1

Sample No. $9a^1$, a^2 & a^3



LABORATORY EXAMINATION

Section- 9 — Table No.4.9.2.2.1.

Texture (Percentage)

	Sand	Silt	Clay
Bed $9a^1$	11	61	28
Bed $9a^2$	21	49	30
Bed $9a^3$	31	55	14

Mineral Composition (Approximate Percentage)

	Bed $9a^1$*	Bed $9a^2$**	Bed $9a^3$***
Quartz	18	18	20
Feldspars	22	20	22
Clays	12	10	10
Opaque	5	8	2
Biotite	12	12	10
Muscovite	2	2	2
Carbonates	18	20	22
Amphibole	4	5	5
Chlorite	3	4	4
Rutile	2	Tr	2
Tourmaline	1	Tr	-
Epidote	Tr	Tr	Tr
Zircon	-	-	-
Sericite	-	-	-
Apatite	Tr	Tr	Tr

* Grains are very fine and subrounded.

** More Ferruginous black brown material. Grains are very fine and subrounded.

*** Very fine and subrounded grains.

loess is disturbed due to cultivation.

4. 9.3 Discussion

1. The lake bed exposed in the section is very conspicuous by having silt of different colours and possessing a considerable amount of clays. It should be noted that lake beds, exposed in the Babu, Baringar and Talab Khwars do not exhibit these characteristics. Probably this lake bed represents a lake phase earlier than those found in the Babu Khwar, and may be considered an extension of the lake bed exposed in sections 6,7,8 and 9.

2. Its characteristics suggests it to be a shallow water lake, whose floor was subject to regression and transgression of the shore water. There were also frequent phases of over-flooding of water during which clay was deposited in suspension after the flood water subsided. There may have been marshy conditions too, in which worms like leaches and their larvae flourished. Laboratory analysis indicate the deposition of considerable amount of loessic silt which may be considered as the Earliest (First) loess of Peshawar vale.

3. The tilting and folding, alongwith over-thrusting of the beds and presence of numerous silty dykes are indicative of a severe tectonic activity. This also indicates that the tectonics were syn-depositional. The lenses of semi-hard sand and clay embedded in the upper lake bed indicates erosion of chunks from the lake bed as a result of uplift during on orogeny. The cyclic character of colour and texture of the sediment suggest continuous denudation of

the source area. The minerological investigation suggests that the material has been derived from igneous and metamorphic rocks.

4. The various characteristics of loess suggest it to be a redeposited loess, which was subject to pedogenic process.

4. 9.4 Summary of Major Events Recorded in the Section

i. The formation of a lake and the deposition of silty clay as bed a.

ii. The exposure of lake beds due to a regression of the shore water.

iii. Tectonic activity which resulted in the tilting and folding of lake bed.

iv. The erosion of lake beds.

v. A long period of erosion during which the sediments were dissected and exposed. The present channel of torrent is formed during this period.

SECTION 10

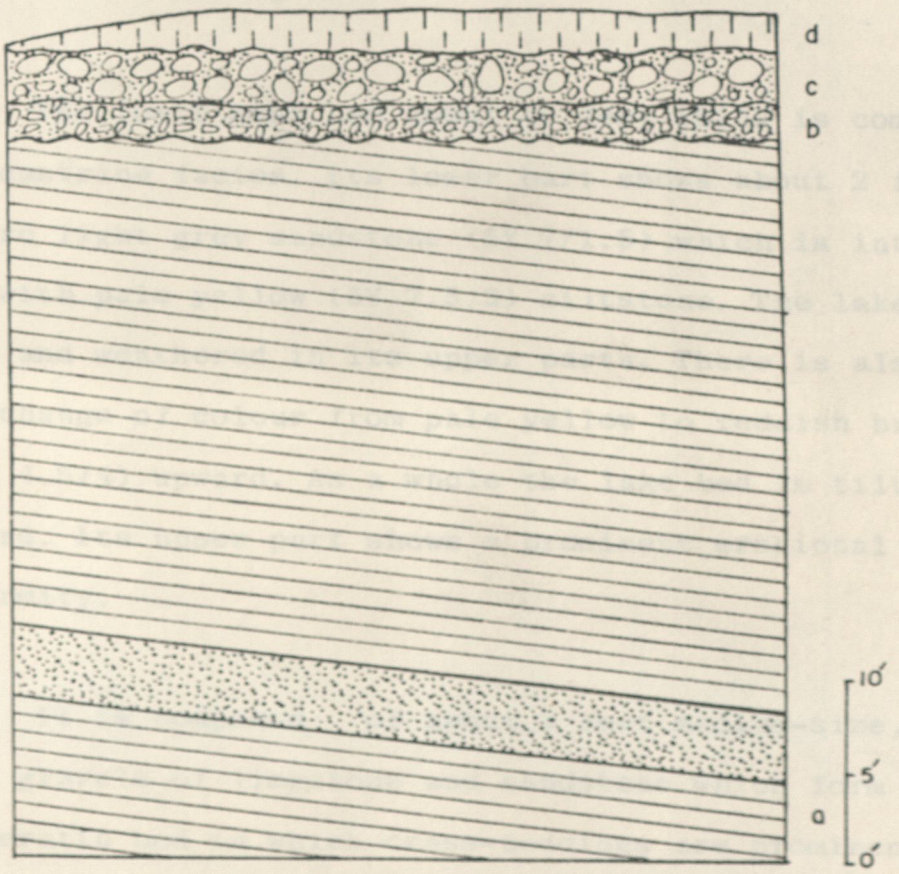


Fig. 4·10·1

4.10 SECTION 10

4.10.1 Field Description

This section is located on the right bank of Nakki Khwar, about 2 km north of Spin Khak (GR 921729)*. It exhibits the following beds:

Bed a:

The lower most bed about 40 feet thick is composed of a lacustrine facies. Its lower part shows about 2 feet semi-hard light grey sandstone (5Y 7/1.5) which is inter-bedded with pale yellow (5Y 7.5/3) siltstone. The lake bed is friable and weathered in its upper parts. There is also a marked change of colour from pale yellow to reddish brown (2.5 YR 4.5/4) upward. As a whole the lake bed is tilted northward. Its upper part shows a prominent erosional unconformity.

Bed b:

It is composed of about 2 feet medium-size, sub-angular gravels of limestone and sandstone which form a conglomeratic bed in which cross-beddings are prominent. Its upper contact with tne overlying bed is unconformable.

Bed c:

It is a 3 feet thick, consolidated bed, composed of sub-rounded to rounded, large-size river gravels and boulders of light red quartzite, white marble, dark grey limestone with some dark brown heavy ultramafic rocks. Its upper and lower contacts are unconformable.

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* For location of section see Fig. 4.10.1.1.

LOCATION OF SECTIONS

38 0/13

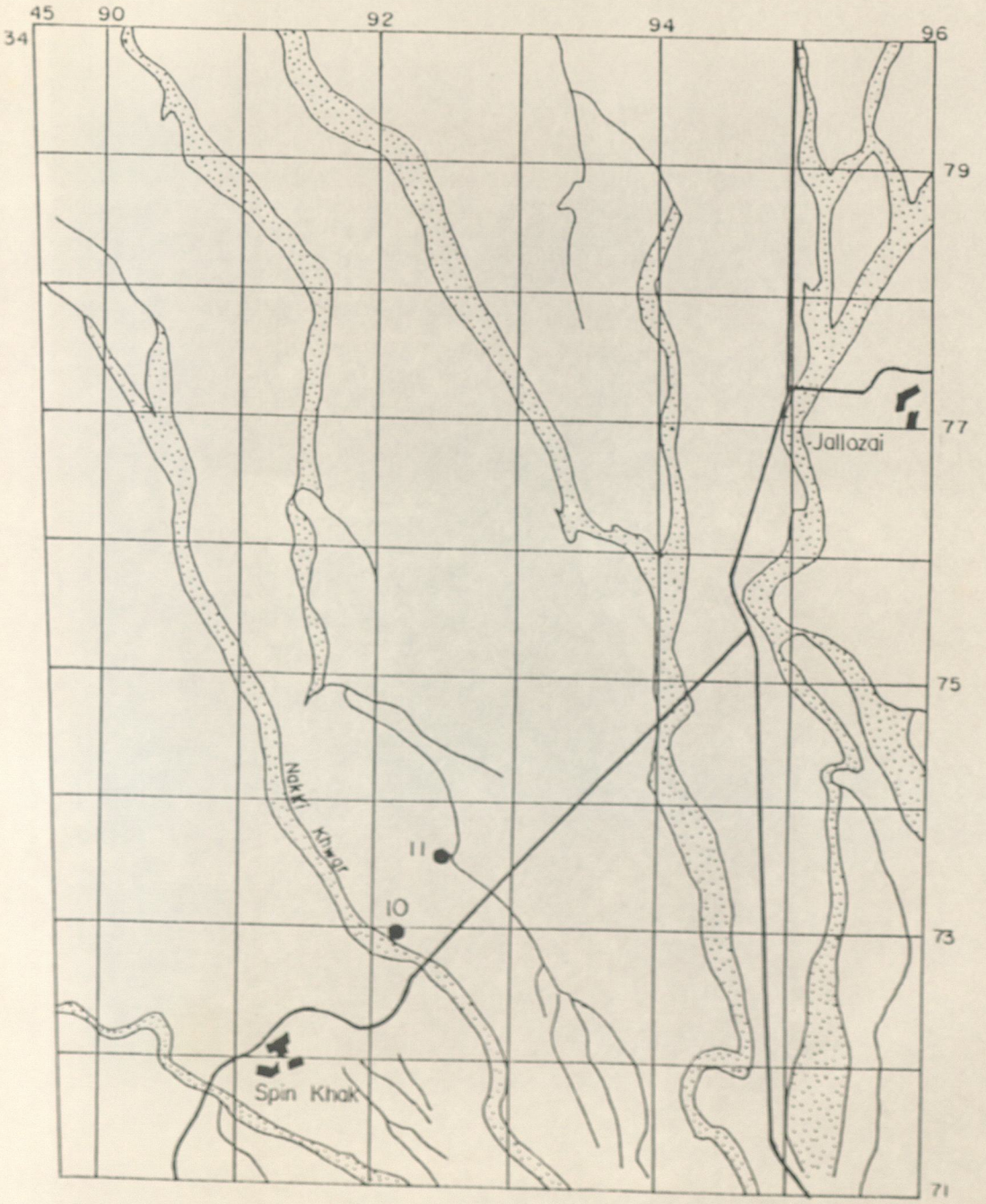


Fig. 4.10.1.1

Sections
Settlements
Stream
Road

1 0 1 Km

Km



Plate No. 4.10.1.1 Section 10.

Bed d:

It is composed of about 2 feet thick bed of pale yellow (7.5 Y 7/4) loess, similar to other loess deposits referred to in previous sections.

4.10.2 Discussion

The lake bed a, is very similar to the lake beds discussed in sections 8,7 and 6 and reflects similar environments during deposition.

The bed b, represents facies of an Older alluvial fan, the material of which was derived by the torrent from the Attock-Cherat range. Its deposition as an alluvial fan indicates a turbulent stream with a high water discharge during periods of torrential rainfall and a steep gradient as a result of the rapid uplift of the source area.

The bed c, represents "channel deposit" of the ancient Kabul river. The lithology of gravels and boulders of the bed c shows that they are not of local origin but have been derived from the northern provenance of the vale by the ancient Kabul river during some warm/inter glacial period. Their deposition also indicate that as a result of uplift, the gradient of the Kabul river also became relatively steeper and during more warm and humid environments, the river behaved like a high energy stream which could transport gravels and boulders, and deposited them in its channel by developing a braided stream pattern which extended upto this part of the vale. The bed c, also indicates that besides deposition of Older fan material from the Cherat mountain aggradation was also taking place contemporarily

on a very large scale in the main vale by the ancient Kabul river. Their much higher position than the present kabul river suggest that due to aggradation, the main floor of the vale may have been raised high enough to burry some of the valleys, hills and ridges along the northern foot-slopes of the Attock-Cherat range.

4.10.3 Summary of Major Events Recorded in the Section

i. The formation of lake and deposition of lacustrine facies.

ii. A phase of uplift.

iii. Partial erosion of lake beds.

iv. The deposition of torrent gravels as bed b.

v. The deposition of river gravels and boulders as bed c.

vi. The erosion of the bed c.

vii. The deposition of loess as the bed d.

viii. A long phase of erosion during which these beds were dissected by the torrent and the present section was exposed.

SECTION II

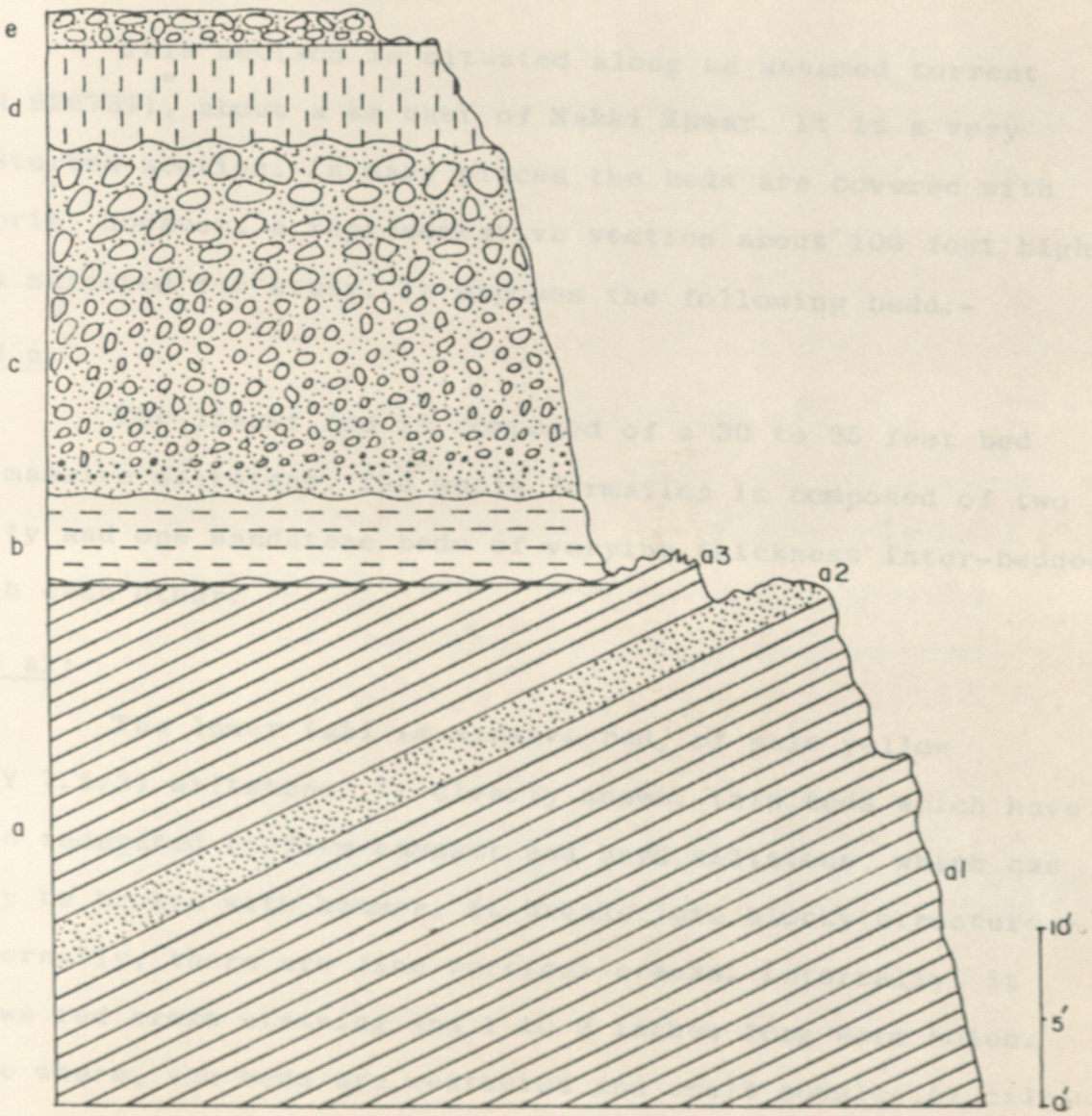


Fig. 4·11·1

4.11 SECTION 11

4.11.1 Field Description

This section is situated along an unnamed torrent (GR 926735)*, about a km east of Nakki Khwar. It is a very disturbed section. In many places the beds are covered with debris. However, a representative section about 100 feet high was selected for study. It exposes the following beds:-

Bed a:

The lowest bed is composed of a 30 to 35 feet bed of massive siltstone. The whole formation is composed of two silty and one sandstone beds of varying thickness inter-bedded with each other.

Bed a1:

The lower (a1) is massive bed, of pale yellow (5 Y 7.5/3) siltstone. It clearly shows, thin beds which have been indurated to form compact and hard siltstone, which can only be broken with hammer. It breaks into blocky structure. Externally, there are fine vertical cracks. Internally, it shows red brown staining and 1 to 2 inches long worm holes. Some where, the beds are weathered and small nodules of calcium carbonate are found at different levels.

Bed a2:

A, 2 feet thick bed of semi-hard white to light grey (5 Y 7.5/1.5) medium to fine (Appendix - 1) sandstone lies conformably over the bed a1. The sandstone is micaceous

* For location of section, see Fig.4.1a1.1.

and shows fine beddings and ripple marks. It also shows red brown staining.

Bed a3:

Sandstone (a2), is overlain by a 3 feet thick bed of siltstone. It has characteristics similar to the bed (a1), except that it is of reddish colour. It is separated by an erosional unconformity from the overlying silt bed b. The whole formation is tilted steeply.

Bed b:

It is a 5 feet thick, bed of coarse silt, of (2.5 YR 4.5/4) reddish brown colour, which lies unconformably over the siltstone. Its contact with the overlying gravely bed c, seems to be gradational. Occasionally, it contains small subangular rock fragments. At places, it shows hard iron nodules and bands of dark red colour.

Bed c:

Bed c, about 20 feet thick is composed of, large to medium-size, angular to subangular gravels of red sandstone, and shale, of Murree formation. These gravels are embedded in a sandy matrix, which shows crossbeddings. The whole bed gradually coarsens upward, where it comprises mostly large gravels and occasionally cobbles and boulders. These have been cemented together in places as conglomerate. Besides, it also contains patches of brecciated conglomerate. Its upper surface shows an erosional unconformity.

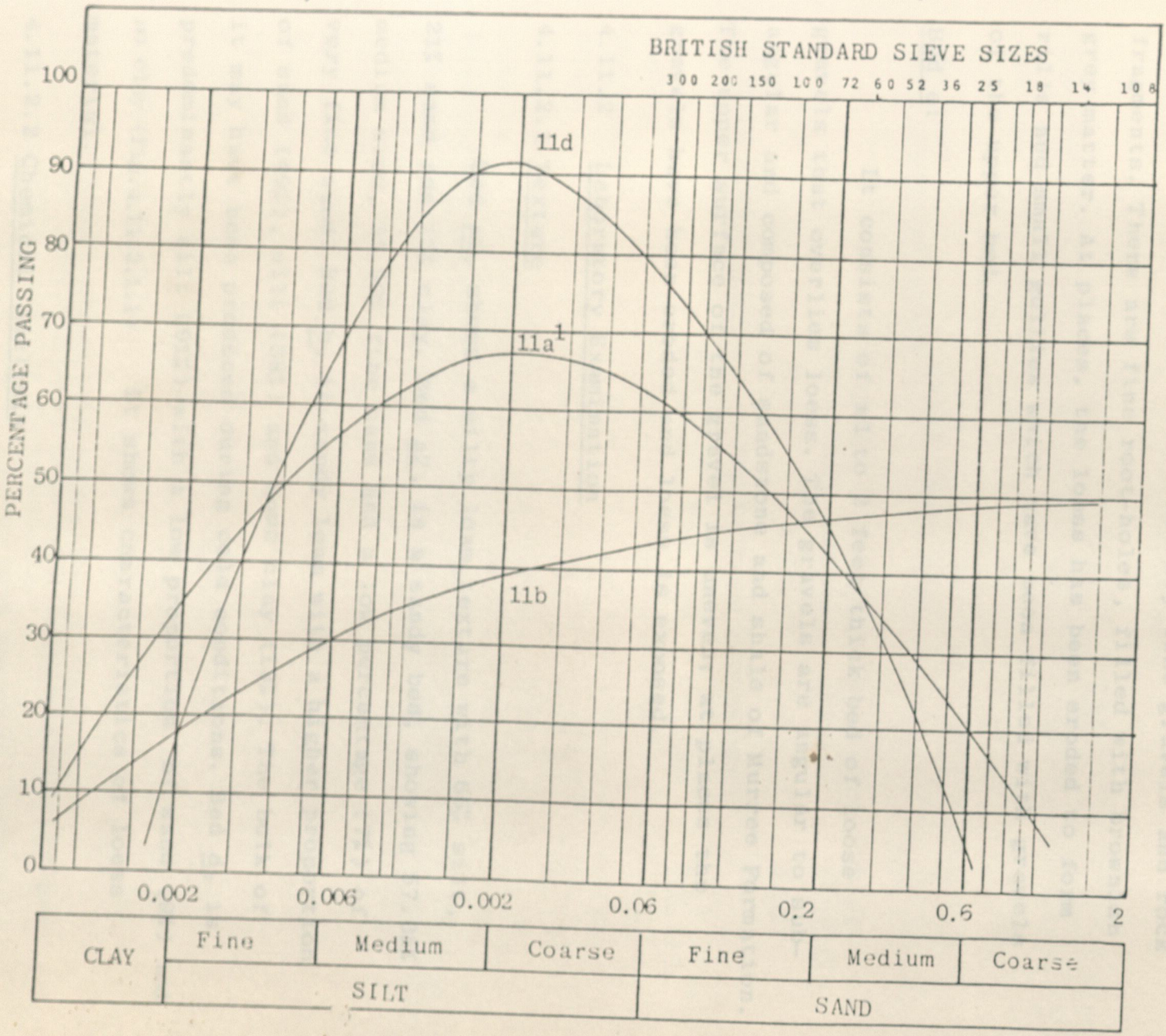
Bed d:

It is composed of about 6 feet thick bed of (7.5 Y 7/4)

PARTICLE SIZE DISTRIBUTION

Sample No. 11a[1], b&d.

Fig: 4.11.2.1.1



pale yellow colour loess. It is soft and deeply weathered showing concretions and nodules of calcium carbonate. It also shows fine beddings and contains very fine gravels and rock fragments. There are fine root-holes, filled with brownish grey matter. At places, the loess has been eroded to form rills and small gullies which have been filled with gravels of the upper bed.

Bed e:

It consists of a 1 to 2 feet thick bed of loose gravels that overlies loess. The gravels are angular to sub-angular and composed of sandstone and shale of Murree Formation. The upper surface of the gravel is uneven; at places the gravels have been eroded and loess is exposed.

4.11.2 Laboratory Examination

4.11.2.1 Texture

Bed a1, shows a silty loam texture with 66% silt, 21% sand and 13% clay. Bed a2, is a sandy bed, showing 57.35% medium sand, 35.50% fine sand and a low percentage (7%) of very fine sand. Bed b, is sandy loam with a higher proportion of sand (49%), silt (38%) and some clay (13%). The bulk of it may have been produced during cold conditions. Bed d, is predominantly silt (91%) with a low proportion of sand (9%) and no clay (Fig.4.11.2.1.1) It shows characteristics of loess material.

4.11.2.2 Chemical Analysis

The loess bed d, shows a very low percentage (0.13%) of organic matter, which indicates arid to semi-arid conditions

LABORATORY EXAMINATION

Section-11

Table No.4.11.2.3.1

Texture

(Percentage)

	Sand	Silt	Clay
Bed 11a[1]	21	66	13
Bed 11b	49	38	13
Bed 11d	9	91	0
bed 11a[2]	(Sand Table 22)		

Soil Characteristics

	Organic matter(%)	Calcium (Meq/1)	Magnesium (Meq/1)	Total Iron(%)
Bed 11d	0.13	0.09	1.41	0.227

Mineral Composition

(Approximate Percentage)

	Bed 11a[1]*	Bed 11a[2]**	Bed 11b+	Bed 11d++
Quartz	25	22	6	25
Feldspars	20	18	5	20
Clays	8	2	9	3
Opaque	2	3	10	2
Biotite	12	15	20	10
Muscovite	3	18	16	2
Carbonates	18	12	16	33
Amphibole	8	5	8	4
Chlorite	Tr	2	3	-
Rutile	2	1	2	1
Tourmaline	-	Tr	2	-
Epidote	Tr	-	1	-
Zircon	Tr	Tr	Tr	-
Sericite	Tr	-	Tr	Tr
Apatite	Tr	-	-	Tr

* Grains are mostly subangular to subrounded.

** It contains very fine rock fragments. Grains are sharp, angular to subangular.

\+ Contains abundant ferruginous material. Grains are subangular to subrounded.

++ Grains are mostly subangular.

during which only sparse vegetation like low shrubs and grasses could grow.

4.11.2.3 Mineralogical Composition

Bed a, is composed predominantly of quartz (25%) and feldspars(20%) with some carbonates (18%) and biotite (12%). Bed a2, is dominated by quartz (22%), followed by feldspars and muscovite, (18% each) with biotite (15%) and carbonates (12%). Mineral composition of the beds shows that their material has been derived from a provenance which is composed of igneous and metamorphic rocks.

Bed b, shows a relative low quartz (6%) and feldspars (5%) and a high percentage of biotite (20%) muscovite and carbonates (16% each), with opaques (10%) and clays (9%). It is very similar to the bed a of section 2. Its material has most probably been derived from the Attock Cherat range. Inclusion of tourmaline (2%) suggests that some of its material may have been derived from Murree Formation.

Bed d, is dominated by carbonates (33%) followed by quartz (25%), feldspars (20%) and biotite (10%). Amphiboles, clays and ores form minor constituents. Its texture and minerals suite represent a typical loess material, having many affinities with the loess deposits of Potwar (De Terra and Patterson 1939, Rendell 1988-89). It is important to note that quartz and feldspars are primary constituents derived from a quartho-feldspathic parent rocks found in the granite belt of North and northwestern areas, while carbonates, however, are of secondary nature formed in situ after deposition. (Table-4.11.2.3.1)



Plate No. 4.11.1.1. Section 11.

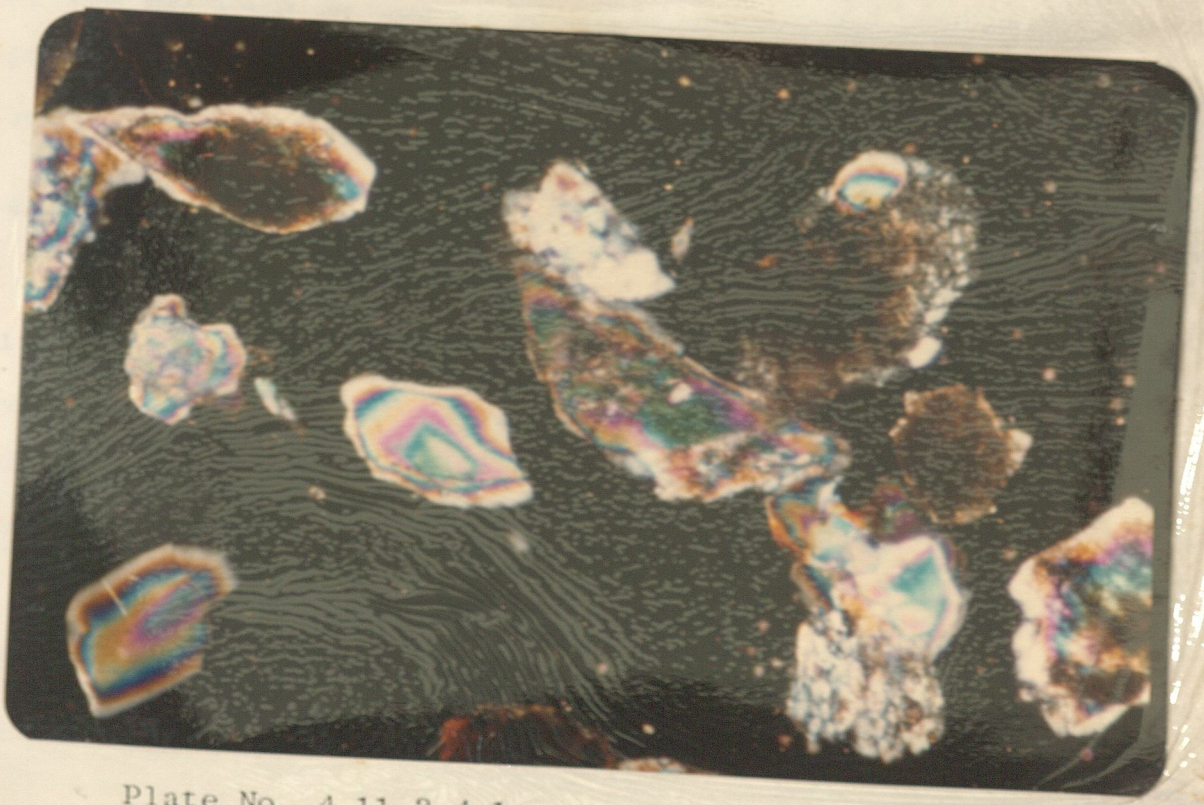


Plate No. 4.11.2.4.1 Loess (11a).

4.11.2.4 Microscopic Study

In bed a1, the grains are mostly rounded to sub-rounded, indicating a long distance transportation. The sand of bed a2, contains very fine and sharp grains which are angular to subangular. These characteristics suggest that the material of bed a2, may have been produced by frost shattering during a cold/glacial phase. Bed b, contains abundant ferrugineous material, which indicates a post deposition weathering of haemetite rich Manki and Murree Formations. Its subangular to subrounded grains also suggest a short distance of transportation from the Attock-Cherat range.

In Bed d (loess) the grains are angular to subangular, which indicate that it has been produced as rock flour by the grinding action of glaciers during the Pleistocene period. These were later on picked up by winds and deposited as loessic silt. (Plate No.4.11.2.4.1)

4.11.3 Discussion

Bed a1, is a lacustrine facies that was deposited in the lake, which formed due to damming of the Kabul river, probably due to the uplifting of the south-eastern rim of the Peshawar vale. This lake bed also seems to be an extension of the earlier lake phase, discussed in sections 9,8,7 and 6.

Mineral composition of the siltstone (a1) and the overlying sandstone (a2) is very similar, which would suggest that their material has been derived from the same provenance, which is composed of igneous and metamorphic rocks of the

northern vale. The high percentage of quartz as compared to feldspars and the angularity/sub-angularity of the grains suggest that the material is produced due to frost shattering and grinding action of glaciers, during the Pleistocene.

The deposition of sandstone (bed a2) suggests that at one time, the lake was filled and the river channel occupied the lake bed temporarily in which sand was deposited as bed a2. The ripple marks and laminations suggests it to be a shallow water deposition. The deposition of sand may have taken place due to a change in the environments of the provenance, where more sand was produced due to very severe climatic conditions. Similarly, the absence of clay and inclusion of fine rock fragments also indicate that it was produced in a very cold environment.

Later on, may be due to aggradation in the down valley, the river channel choked and water again began to overflow its channel and lacustrine conditions were restored in which the siltstone of bed (a3) was deposited as a lacustrine facies. Its reddish colour indicates the supply of fine weathered material from Murree Formation.

The presence of fine worm-holes and mottling suggest that it was a shallow water lake with marshy conditions and beds were frequently exposed to weathering. This frequent exposure of beds to evaporation and drying process, resulted in the formation of mud cracks.

The subanugalrity of the grains of siltstone also suggest that during the course of fluvial deposition, consider-

able amount of wind-blown silt may have been deposited directly into the lake converting it into a marsh in which small worms, leaches and their larvae could flourish.

The highly tilted position of the lake bed indicates that these were involved in one of the severest phases of the Himalayan orogeny. As a consequence of uplift, the lake beds were eroded from a large part of the Peshawar vale.

The deposition of bed b, with all its characteristics e.g., its stratigraphic position with the overlying gravelly bed c, its progressive increase in the size of material upward, its loam texture, with occasional angular rock fragments and dark bands within the bed, all indicate it to be a profile of an inverted soil, which was deposited over the lake bed as a result of erosion from the slopes of the Attock-Cherat range. The inclusion of tourmaline and abundant ferruginous material suggests that the parent material of the soil may have been rocks of Murree formation which are iron rich and also contain abundant tourmaline (Wadia, 1966).

It seems that the regolith on which the soil developed, was produced due to the weathering of rocks, under freez-thaw conditions during a cold phase, and followed by a warm humid phase in which pedogenic processes operated and soil developed on the northern slopes of Attock-Cherat range. Probably, during another cold phase the vegetation died, and as a result of masswasting the soil from the slopes moved down and picked up by torrents and deposited in the lake as bed c. After its deposition, the accelerated erosion reached

the weathered bed rock, the torrent reworked and deposited it as bed c over the soil in a reverse order. The deposition of breccia in the upper part of the gravelly bed also indicates that it was produced by frost shattering and carried by the torrent as 'colluvial material'. The cross-beddings and the large size of the gravels and inclusion of boulders and cobbles in it indicate a high flow of water in the torrent, which was turbulent and frequently changing the direction of current. The environments during this period may have been warm and sub-humid.

The deposition of bed d as loess, indicates similar environments as found in other loessic beds in the different sections, discussed previously. Here the loess is overlain by another gravelly bed c, which is considered to be very young and of recent age. These gravels indicate another frost shattering of the Murree rocks, during a cold phase and released to the torrent in the next warm phase (inter glacial/ recent). Laboratory examination suggest that it has been derived from igneous and metamorphic rocks located in the north of the Peshawar vale. The subangularity of the grains suggests that it may have been produced by the grinding action of glaciers during the Pleistocene period.

Probably, either due to the uplift or falling local base level, another phase of erosion began to operate for a long time, during which the beds were dissected and the present section was exposed.

4.11.4 Summary of Major Events Recorded in the Section

i. The formation of a lake and the deposition of siltstone as bed a.

ii. The Himalayan orogeny; the lake beds are uplifted and tilted steeply.

iii. The erosion of lake beds.

iv. The deposition of red silt as bed b.

v. The deposition of the gravels as bed c.

vi. The erosion of the bed c.

vii. The deposition of loess as bed d.

viii. The erosion of loess.

ix. The deposition of recent gravels as bed e.

x. A period of long erosion during which these beds were dissected and exposed, and the torrent carved its present channel.

SECTION 12

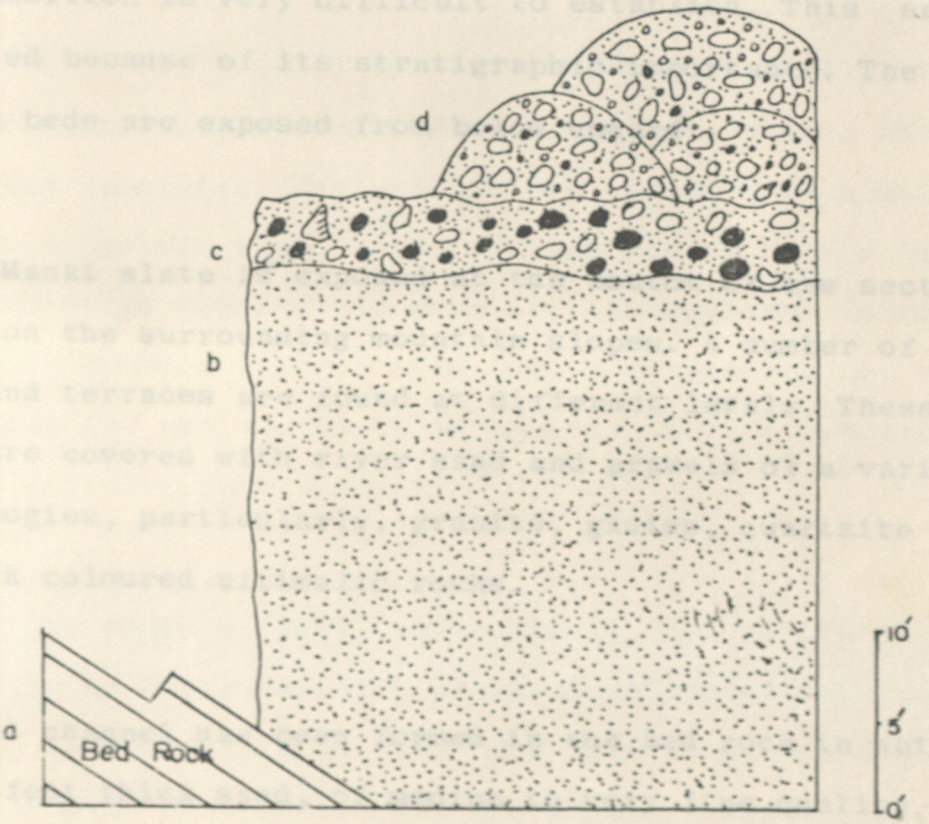


Fig. 4·12·1

4.12 SECTION 12

4.12.1 Field Description

This section is located north east of Tarakai Ghar near Ziarat Kaka Sahib (GR 078816)*. The whole area exhibits a variety of complicated geomorphic features, and their stratigraphic position is very difficult to establish. This section is selected because of its stratigraphic importance. The following beds are exposed from below upward:-

Bed a:

Manki slate is exposed at the bottom of the section and also on the surrounding mountain slopes. A number of eroded benches and terraces are found at different levels. These benches are covered with river sand and gravels of a variety of lithologies, particularly, granite, gneiss, quartzite and heavy dark coloured ultimafic rocks.

Bed b:

A channel has been formed in the bed rock in which about 30 feet thick sand, of medium to very fine quality (Table-5, 22) has been deposited. It is white to light grey (5 Y 7.5/1.5) in colour, and is highly micaceous. The whole deposit shows fine beddings. The sand is mostly loose and incoherent, however, there are however occasional hard layers of sandstone at different levels, which are usually 1 to 2 inches thick. The bed also exhibits fine worm holes. Its upper contact with the overlying gravelly bed is unconformable.

* For location of section, see Fig.4.27.1.1.

There is field evidence to show that previously, the sand was much more widespread but now a considerable amount of sand has been removed for construction purposes. About a few hundred meters south-east of this section, another body of semi-hard white sandstone is exposed along the left bank of Maile Khwar.

Bed c:

The sandy deposit is overlain by a 2 to 4 feet thick bed of gravels, mostly composed of sandstone, slate, gneiss, granite and quartzite. The gravels are embedded in a matrix of coarse micaceous sand, cemented together to form a conglomerate, which is compact and hard. It is important to note that on the exposed part of this bed, a pebble tool of early Plaeolithic age was found. It is made of white quartzite and exhibits yellow-orange varnish.

Bed d:

The whole section, particularly, its northern side is overlain by thick deposits of un-consolidated material, generally composed of silt, sand and fine to medium gravels, of local rocks. Included in it, are also gravels of igneous and metamorphic rocks which are scattered over a very large area. Subsequently, they have been eroded and shaped into hummocky surface, m ng low and high ridges. At places, these ridges have faulted contact.

4.12. 2 Laboratory Examination

4.12.2.1 Texture

Bed b, is sand, mostl composed of medium (41.25%) and fine (44%) sizes with a low amount (14.75%) of very fine

LABORATORY EXAMINATION

Section-12

Table No.4.12.2.2.1

Texture (Percentage)

	Sand	Very Coarse	Coarse	Medium	Fine	Very Fine
Bed 12b		-	-	41.25	44.0	14.75

Mineral Composition (Percentage)

	Bed 12b*
Quartz	20
Feldspars	25
Clays	1
Opaque	1
Biotite	25
Muscovite	10
Carbonates	10
Amphibole	3
Chlorite	3
Rutile	-
Tourmaline	-
Epidote	-
Zircon	1
Sericite	-
Apatite	-
Garnet	Tr

* Grains are subrounded.

grains (Appendix 1). This would reflect a sufficiently long distance of transportation from its provenance.

4.12.2.2 Mineralogical Composition

Bed b, predominantly composed of feldspars (25%), biotite (25%) and quartz 20% followed by carbonates (10%) with a low amount of amphiboles and chlorite. (Table-4.12.2.2.1)

4.12.2.3 Microscopic Study

Micrscopic examination of the material in bed b, shows that the grains are mostly sub-rounded. This would indicate a long distance of transportation.

4.12.3 Discussion

The geomorphological characteristics of this area are very similar to what has been described in section 27 which indicates that the two areas have a common geomorphic history.

In this area, the eroded slopes and erosion terraces suggest that a master stream was flowing along the Attock-Cherat range. As a result of erosion, its northern slopes of the Attock-Cherat range were eroded; while due to intermittent uplift, erosional terraces were also formed at various levels.

The location of section 12, in an uneven topography, indicates that a deep channel had been formed here, in which white to light-grey micaceous sand had been deposited in the lower part of the stratigraphic column, during an aggradation period. The circumstances of its deposition have been discussed in section 27. The fine beddings and lamination suggest swift stream with shallow channel.

The deposition of white sand in this part of Peshawar vale has great geomorphological significance. Burbank and Tahirkheli,(1985) reported a distinctive white sandstone, at Dag, near to the base of the Pliocene-Pleistocene sequence, which according to them, had been derived from the northern provenance. During the course of present study at Garhi Chandan two deposits of valcanic ash bearing ages of 2.7 MY and 2.8 MY were found, which are also associated with either pink clay or white sandstone. Its details have been discussed in section 4. Raynolds,(1981) also reported, that white sand, is being produced presently, at Attock by the Indus river.

There may be two possibilities. (i) There existed a possible link between the Attock-Cherat range and the northern areas of Peshawar vale (Jan, 1968). The drainage was flowing in the general direction of the strike of the vale, i.e. in NE-SW. The clastic material from the north was deposited on the floor of the ancestral valleys, which may have crossed the ancestral Attock-Cherat range obliquely before it was uplifted to the present height, (ii) the Indus river might have been flowing over the ancestral Attock-Cherat range and deposited its load, over the fossil peneplain, of the range during sometime in the Pleistocene.

It seems that after the deposition of white sand, the graveliferous material, derived from igneous and metamorphic rocks was released in great quantity and deposited as First valley fill of the Peshawar vale. The gravelly material on the upper slopes of this section, gives us some idea of the height of this valley fill.

The conglomeratic bed c, may be considered as the lowest part of the graveliferous material, whose upper parts have been eroded, during a subsequent cycle of erosion. The presence of a quartzite pebble tool on the bed c, indicates the presence of an early man during the deposition of the First valley fill, the material of which particularly the quartzite pebbles were used as suitable raw material for making intentional fracturing (Wadia, 1928). The dark yellow patination on the artifact indicates a very early age of manufacturing. As discussed in section 27, this valley fill was deposited during a warm/interglacial period, a great part of which was subsequently eroded, during another cycle of erosion, except those which are resting in enclosed places, or lying scattered on higher slopes. At present the residue of this valley fill are found lying along the northern foot-hills of Attock-Cherat range, from Ziarat Kaka Sahib westward as far as Tangi, Spinkana, Jabba Khattak, about 2 km east of Jalozai, and Garhi Chandan.

During another warm/interglacial period, the slopes of the Attock-Cherat range released weathered material in great quantity, which was picked up by the fast moving torrents and deposited as huge fans in places encroaching on to the main vale, as the Second valley fill.

Stratigraphically, these fans overlie the material of the First valley fill. They are composed of material, derived from the local rocks, however, gravels of granite, gneiss and quartzite derived from the residue of First valley fill lying along the foot hills, have also been incorporated sparingly,

which makes it conspicous from the early material.

Probably, they are the oldest alluvial fans of the Peshawar vale, which extend from the Attock-Cherat range in response to its rapid uplift and can rightly be called as an Older fans. Due to severe weathering and erosion, the material has been piled up in great thickness burrying much of the older topography along the foothills. During a post-fan orogeny, the fan material along the foot-hills has been uplifted and faulting within the fan has taken place. This has resulted in a widespread erosion of the fan material along the foot-hills, shapping them into uneven ridges, with very steep slopes. These are represented as bed d in the present section. It has also been found during the course of present study that such low and high ridges extend westward all along the northern foothills of Attock-Cherat range, and even beyond Garhi Chandan to the west.

4.12.4 Summary of Major Events Recorded in the Section

i. A very long period of erosion, during which this area and the northern slopes of the Attock-Cherat range were eroded.

ii. The deposition of white sand of bed b as channel facies.

iii. The deposition of a conglomeratic bed c, in great thickness as part of the First valley fill of the Peshawar vale.

iv. A long period of erosion, during which much of the First valley fill, was eroded,except patches laid in depressions or along the mountain walls.

v. Himalayan orogeny resulting in an uplift of the northern slopes of Attock-Cherat range.

vi. An uplift resulting in severe weathering and erosion of the Attock-Cherat range; the eroded material spread out as the Older alluvial fans or the Second valley fill of the Peshawar vale.

vii. A period of erosion during which the deposits of bed d, were eroded and shaped into hommocky surface.

SECTION 13

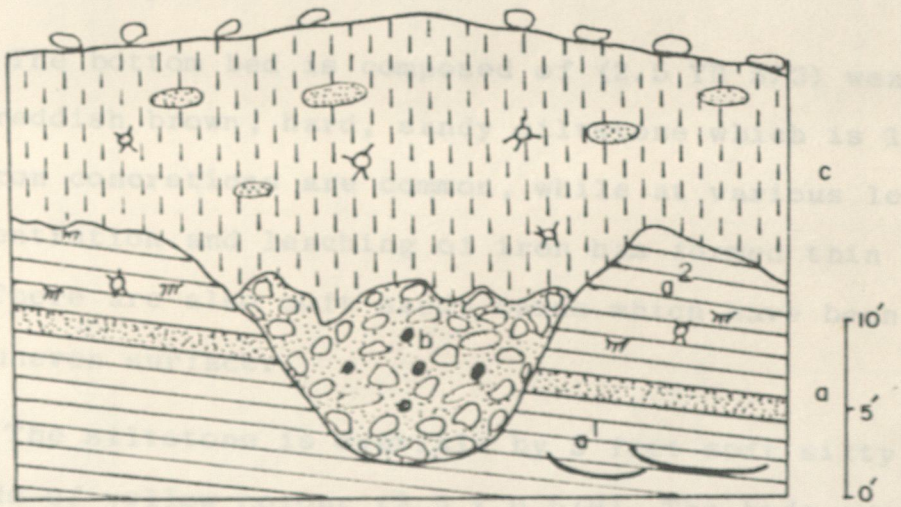


Fig. 4·13·1

4.13 SECTION 13

4.13.1 Field Description

This section is located on the left bank of the Nur Gul Baba Khwar, Nowshehra Cantt:, about 50 feet south of the railway line (GR 102874).*The following beds are exposed:-

Bed a:

From base to top it is about 15 feet thick, and consists of two parts:

i. The bottom bed is composed of (2.5 YR 5/3) weak red to reddish brown, hard, sandy siltstone which is 10 feet thick. Iron concretions are common, while at various levels the concentration and leaching of iron has formed thin hard sheets. There are also soft sandy bands which have been eroded to form uneven surface.

ii. The siltstone is overlain by 5 feet soft silty sandy beds of yellow colour (2.5 Y 6.5/6). The beds are also separated by 4 to 6 inches thick layer of sand from the lower bed (i). It is relatively soft and shows weathered layers at different levels resulting in uneven surface. It contains a large number of hard nodules of calcium carbonate, while calichie of different sizes and shapes (ring shape) are not uncommon. Individual beds also show lamination. There is marked erosional unconformity at its upper contact with the overlying bed c. The bed shows fine worm holes and short worm

* For location of section, see Fig.4.13.1.1.

LOCATION OF SECTIONS

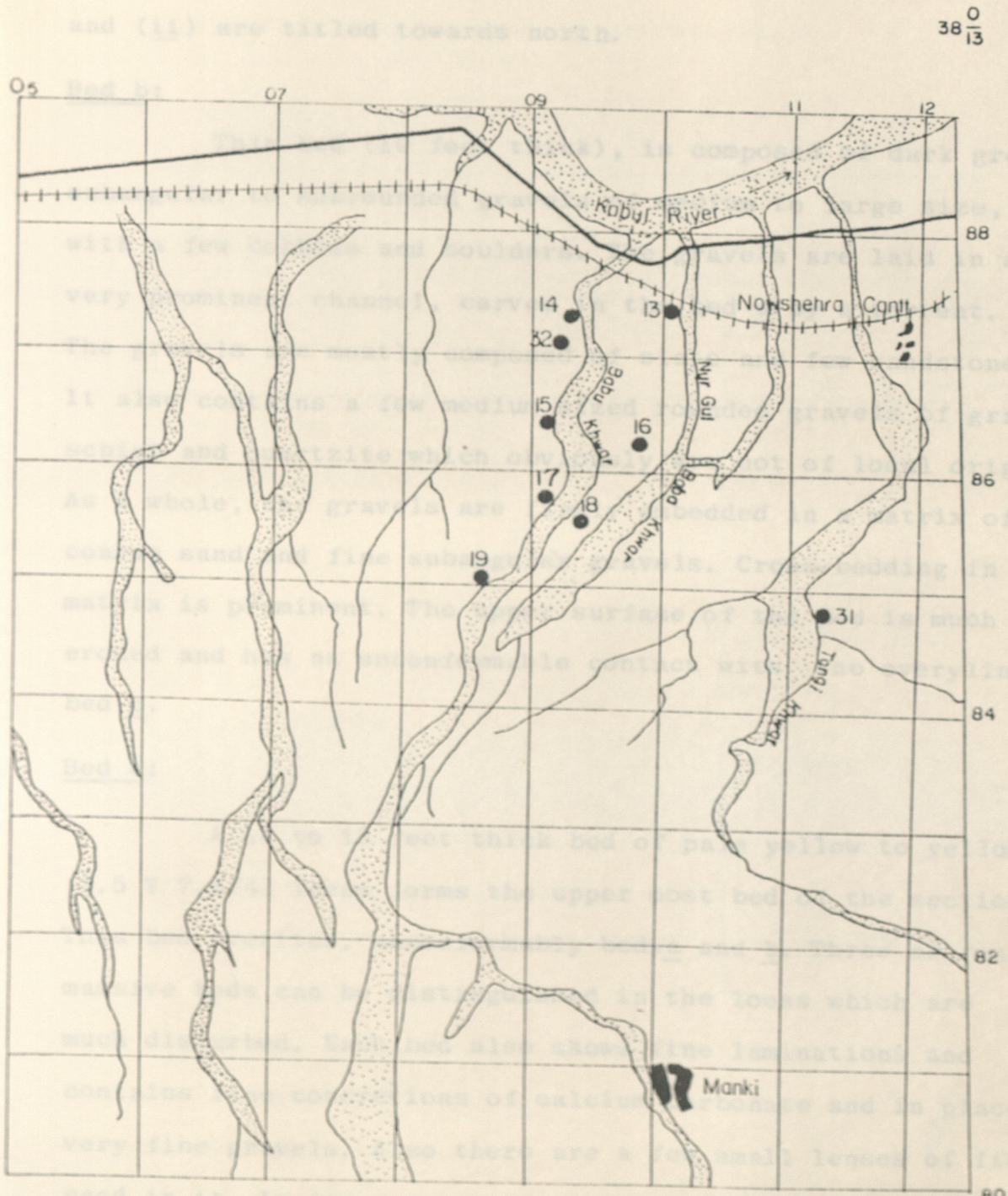


Fig. 4.13.1.1

tracks. There are fine roote holes filled with decayed organic matter. On the whole the whole formation of bed (i) and (ii) are titled towards north.

Bed b:

This bed (10 feet thick), is composed of dark grey, subangular to subrounded gravels of medium to large size, with a few cobbles and boulders. The gravels are laid in a very prominent channel, carved in the bed a by a torrent. The gravels are mostly composed of slate and few sandstone. It also contains a few medium sized rounded gravels of granite, schist and quartzite which obviously are not of local origin. As a whole, the gravels are firmly embedded in a matrix of coarse sand and fine subangular gravels. Cross-bedding in the matrix is prominent. The upper surface of the bed is much eroded and has an unconformable contact with the overyling bed c.

Bed c:

A 10 to 15 feet thick bed of pale yellow to yellow (2.5 Y 7.5/4) loess forms the upper most bed of the section. This bed overlies, unconformably beds a and b. Three or four massive beds can be distinguished in the loess which are much disturbed. Each bed also shows fine laminations and contains fine concretions of calcium carbonate and in places very fine gravels. Also there are a few small lenses of fine sand in it. In its upper part, a few medium to large gravels of slate are embedded. It should also be pointed out that due

SECTION 13b

Zingg's diagram showing gravels shape

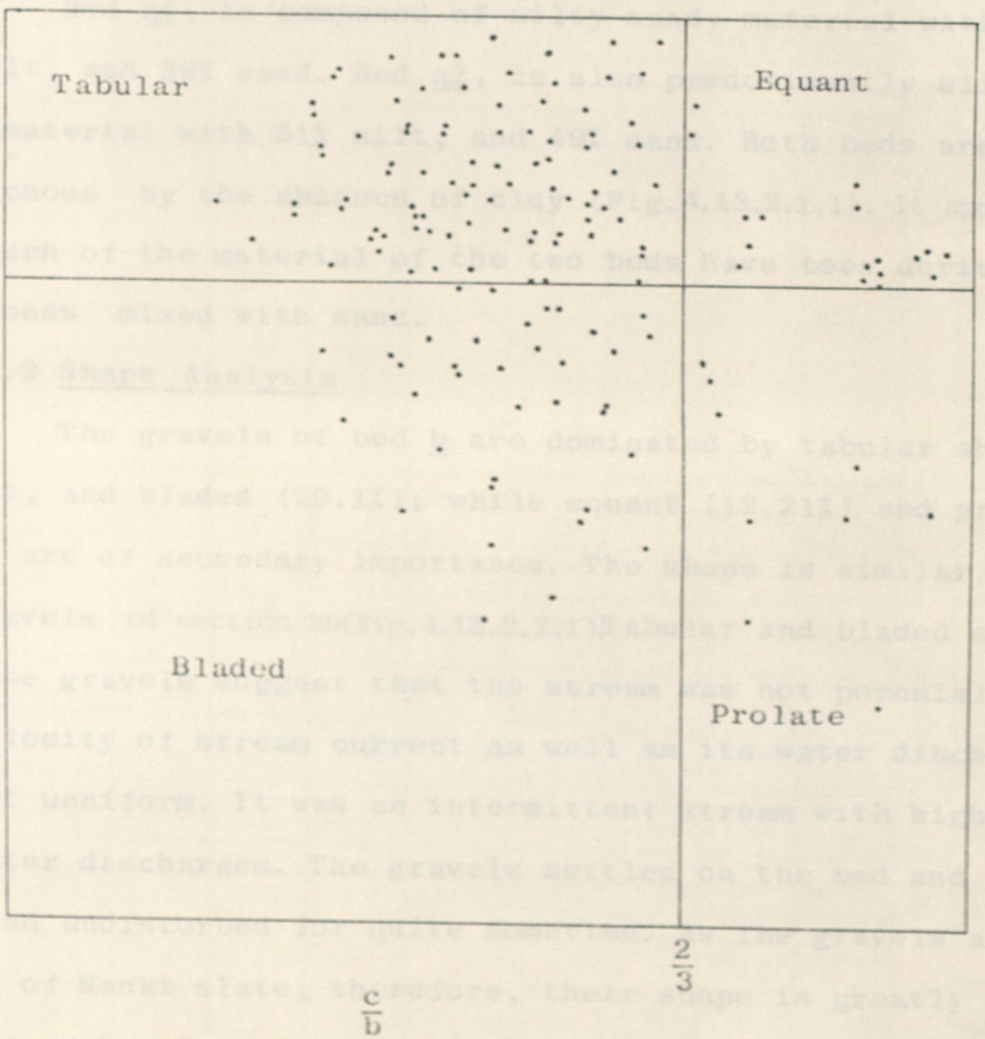


Fig: 4.13.2.2.1

to its use as graveyard, its upper surface has been very much disturbed.

4.13.2 Laboratory Examination

4.13.2.1 Texture

Bed a1, is composed of silty sandy material with 61% silt, and 39% sand. Bed a2, is also predominantly silty sandy material with 51% silt, and 49% sand. Both beds are conspicuous by the absence of clay (Fig.4.13.2.1.1). It appears that much of the material of the two beds have been derived from loess mixed with sand.

4.13.2.2 Shape Analysis

The gravels of bed b are dominated by tabular shape (51,5%), and bladed (29.1%); while equant (12.21%) and prolate (7.2%) are of secondary importance. The shape is similar to the gravels of section 3b(Fig.4.13.2.2.1).Tabular and bladed shapes of these gravels suggest that the stream was not perenial. The velocity of stream current as well as its water discharge was not unniform. It was an intermittent stream with high and low water discharges. The gravels settled on the bed and remained undisturbed for quite sometime. As the gravels are mostly of Manki slate, therefore, their shape is greatly determined by the structure of the rock.

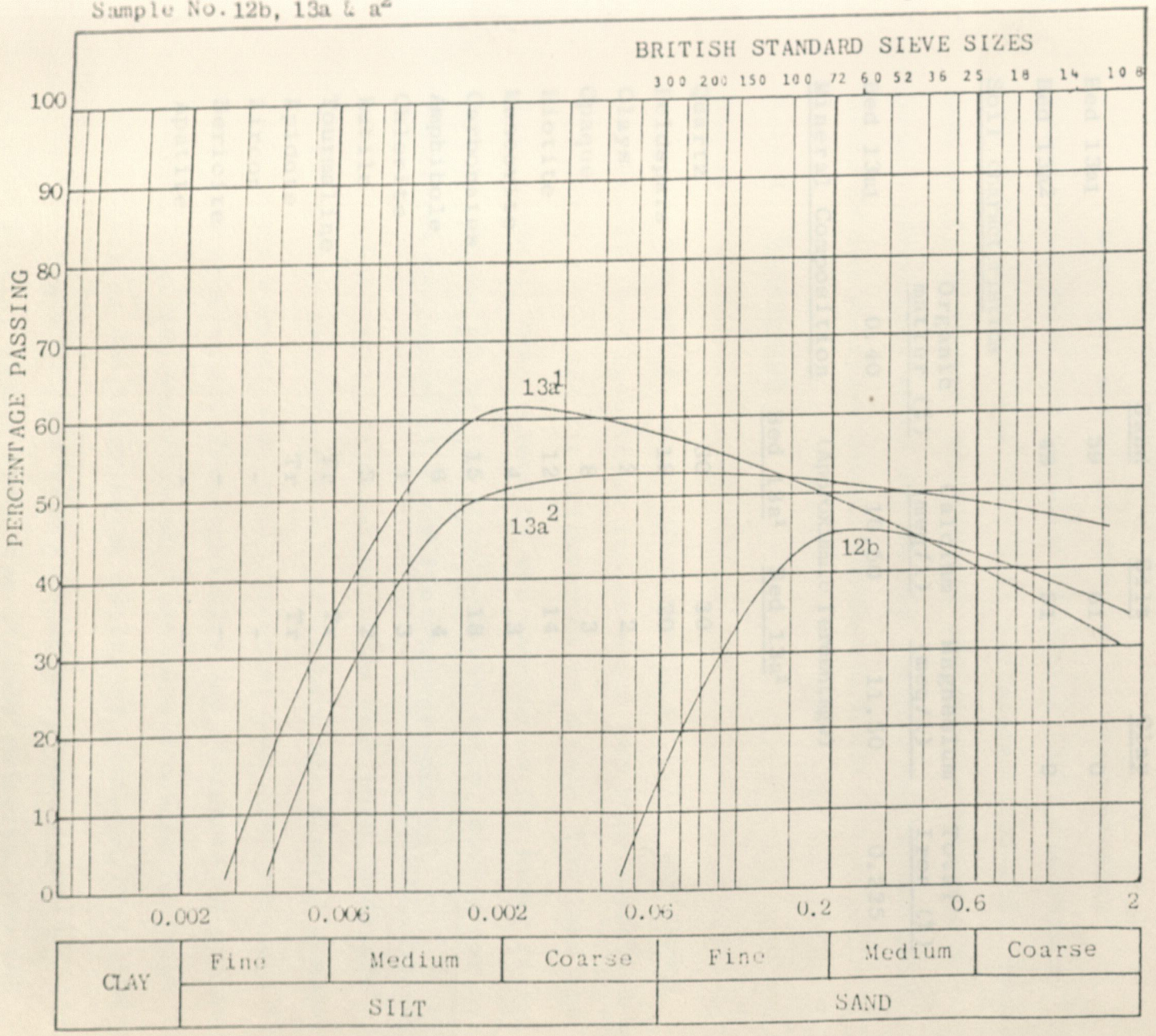
4.13.2.3 Chemical Analysis

Bed a1, shows a very low percentage (0.40) of organic matter, with a high amount of calcium (maq/1) 10.50 and magnesium (meq/1) 11.50. These characteristics indicate a hot, arid

PARTICLE SIZE DISTRIBUTION

Fig.4.13.2.1.1

Sample No. 12b, 13a & a^2



LABORATORY EXAMINATION

Section-13 Table No. 4.13.2.4.1

Texture (Percentage)

	Sand	Silt	Clay
Bed 13a1	39	61	0
Bed 13a2	49	51	0

Soil characteristics

	Organic matter (%)	Calcium (meq/1)	Magnesium (meq/1)	Total Iron (%)
Bed 13a1	0.40	10.50	11.50	0.225

Mineral Composition (Approximate Percentage)

	Bed 13a[1]	Bed 13a[2]
Quartz	30	30
Feldspars	18	20
Clays	2	2
Opaque	8	3
Biotite	12	14
Muscovite	4	3
Carbonates	15	18
Amphibole	6	4
Chlorite	1	3
Rutile	3	2
Tourmaline	Tr	Tr
Epidote	Tr	Tr
Zircon	-	-
Sericite	-	-
Apatite	-	-

to semi-arid environment with a sparse vegetation cover and a high rate of leaching of salts.

4.13.2.4 Mineralogical Composition

Beds $\underline{a}^1$, and $\underline{a}^2$ are similar in their mineral composition. Both are composed of quartz (30%), feldspars (18%-20%), biotite (12%-14%) with carbonates (15%-18%). Their similarity in texture and mineral composition suggests a common provenance which may be the igneous and metamorphic rocks of the Northern Areas. (Table-4.13.2.4.1)

4.13.3 Discussion

Bed a:

The bed a, is composed mostly of silty and sandy layers. It is a lacustrine facies which has been deposited by the Kabul river and its tributaries in a lake. The lake has most probably been formed by the damming of the Kabul river, due to the uplift of the Attock-Cherat range, during one of Himalayan orogenies of early Pleistocene age.

Laboratory examination shows that both, beds are without clay and very similar in texture and mineral composition. This would suggest that their material have been produced from the same provenance. The angularity and sharpness of grains suggest that the material may have been produced by frost shattering or due to grinding action of glaciers, (Pye, 1983).

The silt and sand has probably been deposited during a cold glacial phase, when the streams emerging from the

glaciers had a low water discharge and could carry only finer material like sand and silt.

The presence of very fine worm holes and their short tracks also suggest it to be a cold water lake, probably having marshy conditions during which only fine worms or their larvae could grow.

The lower siltstone, (a1) with its reddish brown colour, suggests that its material might have been derived from ultramafic rocks. Its unusual hardness and presence of iron concretions and thin seams of iron at various levels, confirm leaching and concentration of iron during a warm climate, following a cold phase.

The warm climate may have been associated with periods of alternate dry and wet. This is indicated by mottling, calcium noduless and calichie formation of different sizes and shapes especially ring shaped found in the lake bed. Such distinctive features supply evidence of the original soil forming conditions (Leopold, et al., 1964, p.469) and may be considered as marked horizon for high temperature and moderate to low seasonal rainfall (Pettijhon 1975, p.472). Therefore it is suggested, that this bed (a2) represents the B horizon of a paleosol; while A horizon has been eroded. Further interpretation indicates that the environments may have lead to the development of a 'Pedocal' type of soil, followed by a period of humidity during which calichie nodules were leached, leaving solution holes and cavities in them

(Bryon and Albritton 1943, p.438). Such soils have also been reported in paleosols of western United States. (Leopold, et al., 1964).

A change from warm to cold environment may have resulted in withering of the vegetation. The dipping beds reflect involvement in an uplift. It is suggested that the lowering of the local base level may have been a response to the uplift. These factors resulted in the widespread erosion of the lake bed, particularly the A horizon. The torrent coming from the local mountains eroded and formed channels in the lake bed upto the new base level.

Bed b:

The gravels have been deposited in a channel carved in the lake bed by the local torrent as "water laid deposit" (Bull 1977, p.67). The dark grey slate which constitute the bulk of the deposit has been derived from the pre-Cambrian Manki Slate of the Attock-Cherat range. Prior to their deposition, and during very cold phase, the rocks of Attock-Cherat range were subject to intense physical weathering, but the debris was frost jammed and could not be released (King, 1975, p.4). With a change in climate from cold to warm and further uplift, the slopes began to release the weathered debris which was picked up and reworked by torrent and deposited in the channel.

The cross-bedding of the matrix further suggest that it was a highly turbulent stream, the channel of which was

frequently changing its course. The deposition of silty lenses within the gravels indicates simultaneous erosion and deposition (Allen, 1965, 1979).

After their deposition, the gravels were subject to erosion by torrent, because the supply of the clast was stopped and the torrent had to erode and lower its bed in order to maintain an equilibrium profile.

Bed c:

Stratigraphically the (bed c) loess overlies unconformably the gravel bed b, and the lower lake bed a. After the erosion of the gravel bed b, a period of loess deposition began to occur. The environment of the deposition of loess is very much controvertial (Russel 1944b,Zeuner 1949, Berg 1964, Ollier 1969, Smalley, 1970, 1971). The examination of the physical characteristics of the loess bed c, however suggests that, it may represent a warm and interglacial period having intermittent dry and wet phases. (Alford, 1982, p.139).

The deposition of loess in various beds with small rocks fragments and fine gravels alongwith small lenses of fine sand, suggest that it was redeposited during a wet phase while the presence of concretion and nodules of Ca Co3 indicates a dry warm phase. The inclusion of recent gravels embedded in the upper surface of the loess is indicative of another wet phase, during which the torrent was probably rejuvinated and deposited recent gravels on the upper part of the loess.

4.13.4 Summary of Major Events Recorded in the Section

i. The formation of a lake due to the daming of the Kabul river.

ii. The deposition of silt and sand in the lake as bed a.

iii. An event of tectonics during which the lake beds were uplifted and titled.

iv. The draining of the lake and the exposure of the lacustrine beds to weathering and pedogenic processes.

v. The development of soil on bed a; the leaching of iron and its concentration at lower level. The concentration of the calcium carbonate in the form of nodules and calichie in the upper parts, as the two levels of B horizon.

vi. The erosion of A horizon and the upper parts of the lake bed. The emergence of a torrent from the Attock-Cherat range and formation of a channel in the lake bed by the torrent.

vii. The deposition of local and few foreign gravels by the torrent as channel deposits.

viii. The erosion of the torrent bed.

ix. The erosion of torrent bed was followed by the deposition of loess.

x. The deposition of some recent gravels over the loess.

SECTION 14

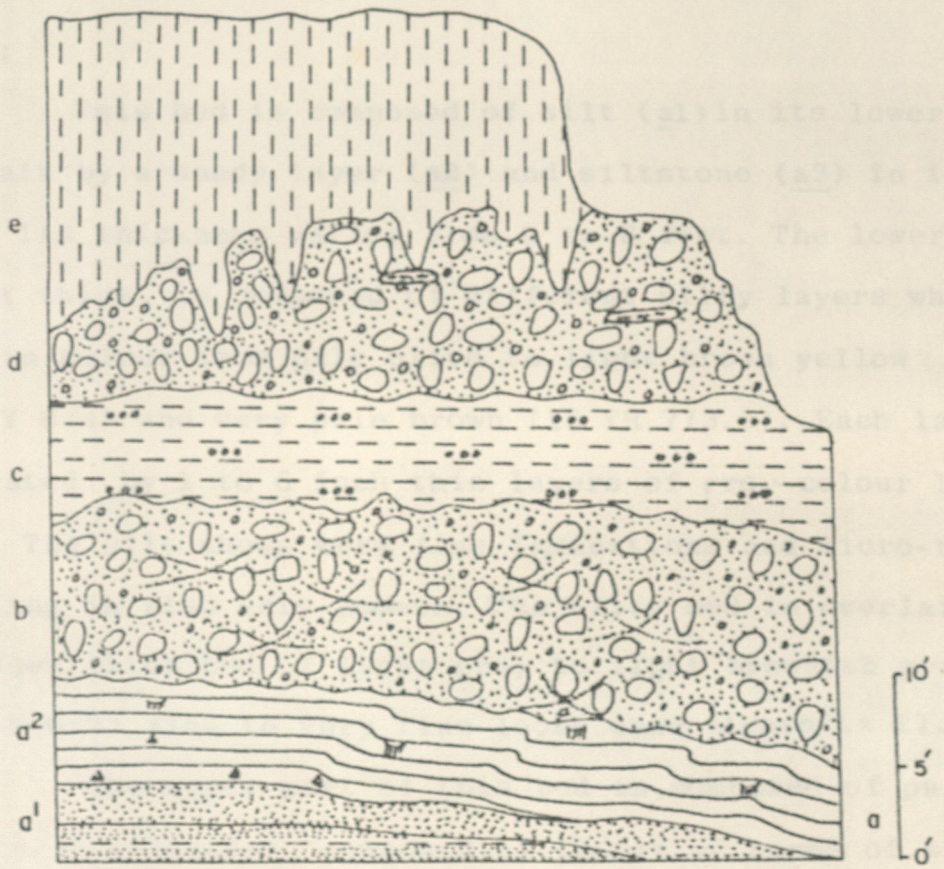


Fig. 4·14·1

4.14 SECTION 14

4.14.1 Field Description

This section is located in the Babu Khwar along its left bank (GR 093874)* and is composed of the following beds:-

Bed a:

This bed is composed of silt (a1) in its lower part, overlain by a sandy layer (a2) and siltstone (a3) in its upper part. Its thickness varies from 5 to 8 feet. The lower part, 2 feet thick, is composed of different silty layers which vary in colour from pale olive to light brown yellow (7.5 Y 6/4) and very pale brown (10 YR 7/3.5). Each layer is separated by 1 to 6 inch thin layers of grey-colour loose sand. The silt shows very fine laminations and micro-ripples. Mottling is also very common. The silty bed is overlain by a 3 feet thick bed of light gray to light brownish gray (7.5 Y 6/2) fine to very fine loose sand (Appendix 1).

The upper part of this bed is composed of pale olive (5 Y 6/4) siltstone, composed of indurated seams of silt, interbedded with thin sheets of soft sandstone and shows orange colour staining with tiny wormholes about 1 mm wide and 2 to 3 mm long, normal to the bedding planes. Its upper part is titled and warped. Fine gravels of slate are embedded in the lower part of the siltstone. It has an uncomformable contact with the overlying bed.

Bed b:

This bed, 10 to 12 feet thick, is composed of dark

* For location of section, see Fig. 4.13.1.1.



Plate No. 4.14.1.1 Section 14.

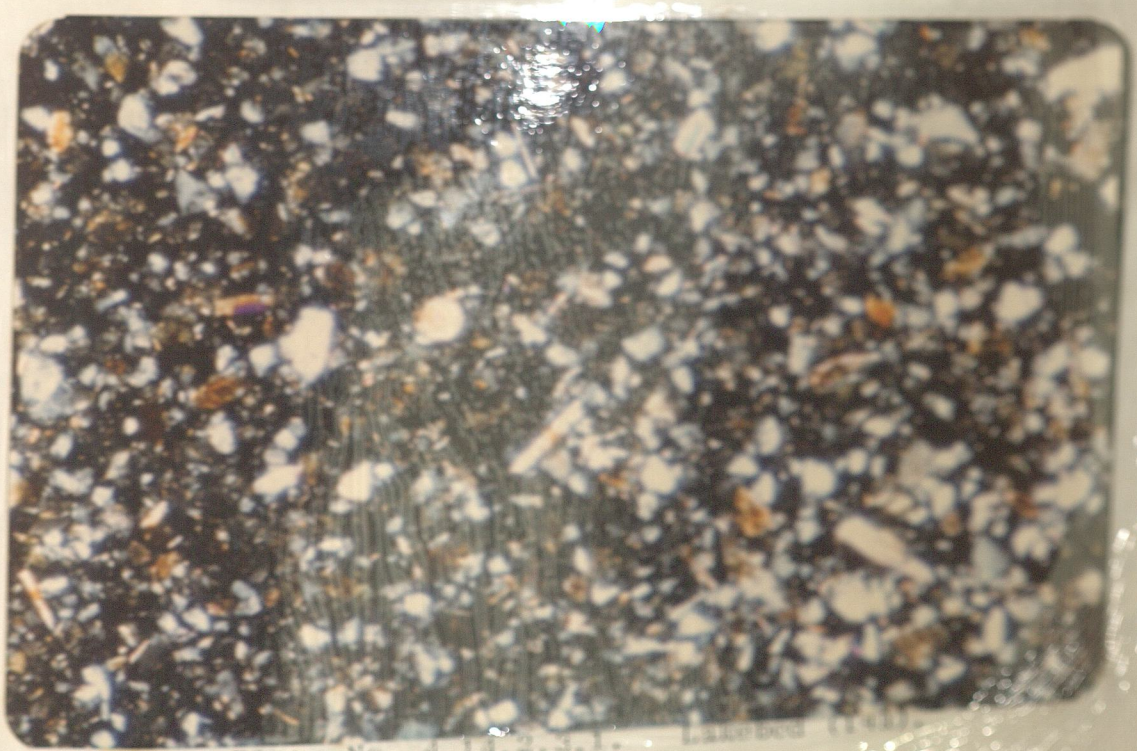


Plate No. 4.14.2.3.1. Lakebed (Top)

gray, medium-sized gravels, of slate and sandstone. The gravels are sub-angular to sub-rounded, firmly embedded in a dark matrix of fine gravels and very coarse sand, showing cross-bedding. Occasionally, cobbles and boulders of 8 to 10 inch size are also embedded in the bed. It also contains 6 inches to one foot thick lenses and horizontal layers of silt. The upper part is very much disturbed, due to the frequent intermixing and interfingering of gravels and silty material. An erosional unconformity separates it from the overlying bed.

Bed c:

About 6 feet thick pale yellow (5 Y 7/4.5) silty bed unconformably overlies the gravely bed. Apparently, it is structureless and massive, but from the bedding planes, two to three layers can be recognized. It also contains thin bands of fine gravels and angular fragments of slate/shale. At one end, it stands out as vertical columns due to gully erosion.

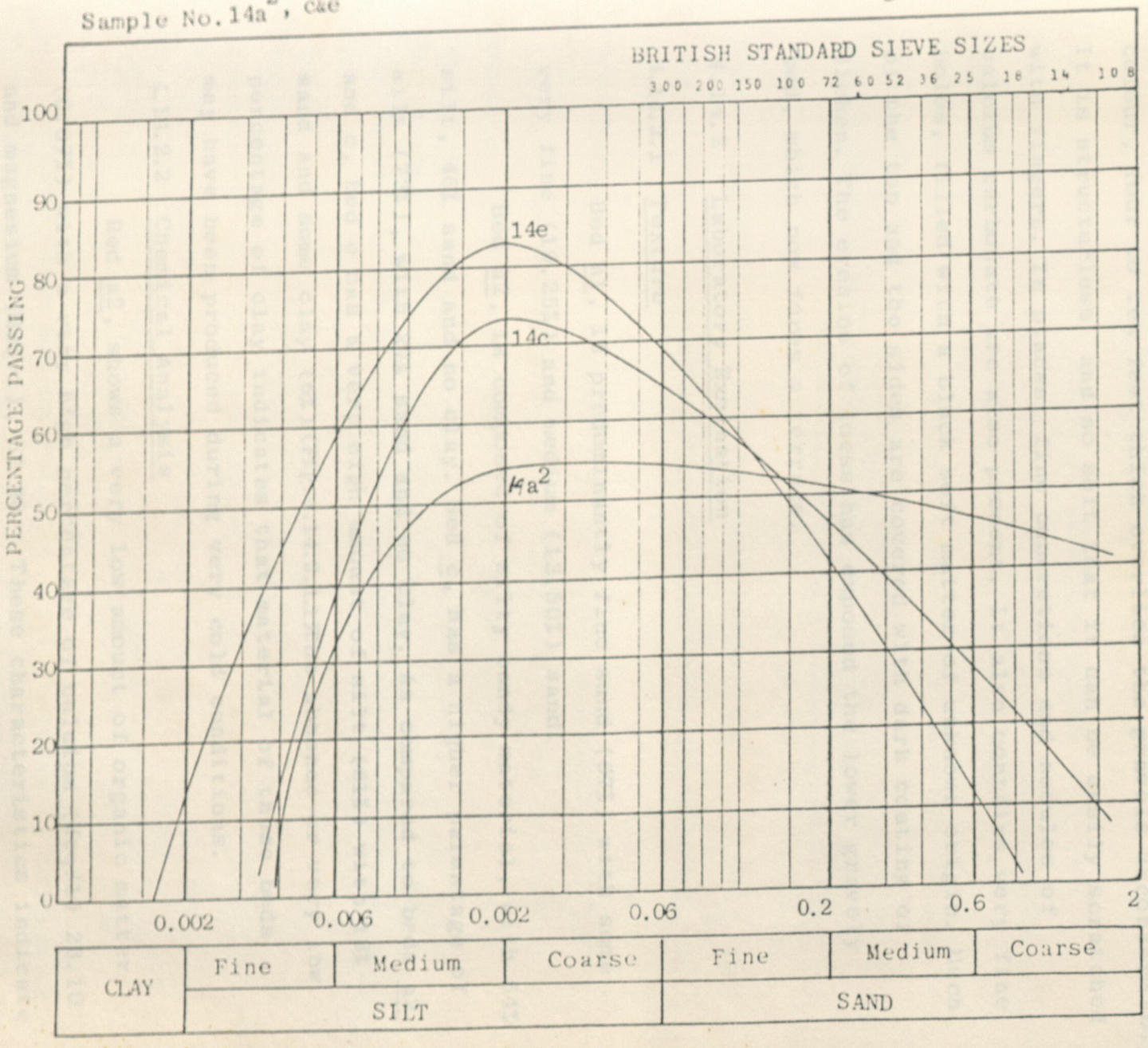
Bed d:

It consists of six to ten feet thick irregular bed of sub-angular to sub-rounded coarse gravels of dark gray slate and sandstone, embedded in a dark matrix of fine gravels and coarse sand. It also incorporates lenses and thin beds of silty clay and a large number of cobbles and a few boulders. The bed is very much disturbed and dissected by gully erosion. It has an unconformable contact with the overlying bed.

PARTICLE SIZE DISTRIBUTION

Fig.4.14.2.1.1.

Sample No. $14a^2$, c&e



Bed e:

A bed of loessic silt of pale yellow (7.5 Y 7/4) colour, four to ten feet thick overlies the gravels unconformably. It is structurless and so soft that it can be easily scratched with fingers. In places, fine concretions and nodules of calcium carbonate are also present. It also contains very fine holes, filled with a black soft matter of unknown origin. Much of the top and the sides are covered with dark coating of lichen. The erosion of loess has exposed the lower gravely bed, which now forms a terrace.

4.14.2 Laboratory Exmination

4.14.2.1 Texture

Bed a1, is predominantly fine sand (67%) with some very fine (19.25%) and medium (13.50%) sand.

Bed a2, is composed of silty sandy material, with 54% silt, 46% sand and no clay. Bed c, has a higher parentage of silt (73%), with 27% sand and no clay. As compared to beds a2 and c, bed e has a very high amount of silt (81%) with 13% sand and some clay (6%) (Fig.4.14.2.1.1) The absence or very low percentage of clay indicates that material of these beds may have been produced during very cold conditions.

4.14.2.2 Chemical Analysis

Bed a2, shows a very low amount of organic matter (0.07%) with a very high percentage of calcium (Meq/1) 23.10 and magnesium (Meq/1), 32.90. These characteristics indicate a hot and arid to semi-arid conditions with very low growth of vegetation and a very high rate of leaching of salts.

LABORATORY EXAMINATION

Section-14 Table No.4.14.2.2.1

Texture (Percentage)

	Sand	Silt	Clay
Bed 14a^2	46	54	0
Bed 14c	27	73	0
Bed 14e	13	81	6
Bed 14a^1	(Sand, Appendix-1)		

Soil Characteristics	Organic matter(%)	Calcium (Meq/1)	Magnesium (Meq/1)	Total Iron (%)
Bed 14a^2	0.07	23.10	32.90	0.228

Mineral Composition (Approximate Percentage)

	Bed 14a^1*	Bed 14a^2**	Bed 14c$^+$	Bed 14e^{++}
Quartz	35	31	6	16
Feldspars	15	18	4	28
Clays	2	5	9	2
Opaque	4	3	10	1
Biotite	16	17	12	8
Muscovite	3	2	9	1
Carbonates	10	12	24	38
Amphibole	9	8	9	4
Chlorite	-	-	4	1
Rutile	2	Tr	2	Tr
Tourmaline	2	Tr	-	Tr
Epidote	Tr	-	1	-
Zircon	-	Tr	-	Tr
Sericite	-	Tr	-	-
Apatite	Tr	Tr	-	Tr

* The shape of the grain is mostly subangular. Few angular.
** The shape of the grain is mostly angular to subangular.
+
++

4.14.2.2 Mineralogical Composition

Bed a1 (sand) is predominantly composed of quartz (35%) with some feldspars (15%), biotite (16%), carbonates (10%) and amphiboles (9%). The composition suggests that this sand has probably been derived from Ambela granite (Raifique Personnel communication).

Bed a2, is similar to bed a1 and has a higher percentage (31%) of quarts as compared to feldspars (18%), with biotite (17%) while carbonates (12%) and amphiboles (8%). Bed e, is dominated by carbonates (38%) followed by quartz (16%), feldspars (28%) and biotite 8%. Amphiboles (4%), clays (2%), opaques muscovite and chlorite (1% each) form minor constituents and is similar to other loess be . Bed c, has a low percentage of quartz (6%) and feldspars (4%) with opaques(10%) and clays (9%). It is dominated by carbonates (24%) which would suggest that it has been derived locally from the sedimentary suite of the Attock-Cherat range. It is very similar to the bed a of section 2 and bed b of section 11. (Table 4.14.2.2.1)

4.14.2.3 Microscopic Study

It is important to note that shape of the grains of bed a1 and a2 are mostly angular to sub-angular which would suggest that the material was originally produced either by frost action or by grinding action of glaciers, during very cold/glacial conditions. (Plate No.4.14.2.3.1)

4.14.3 Discussion

The lower part of the bed a, seems to be a facies of the flood plain which was deposited during vertical accretion

(Walker and Cant, 1979). The channel of the river may have been overflooded to deposit a thick bed of sand before the Kabul river was dammed to form a lake.

After the lake was formed, the Kabul river and its traibutaries deposited, silt and sand in it as a lacustrine facies, which formed into siltstone. The deposition of lenses of fine gravels from the local rocks indicate either temporary periods of retreat of lake, during which torrent from the local mountains deposited fine gravels on the lake bed, or perhaps the torrents formed small delta in the lake.

Fine laminations and the micro-ripples suggest that the lake was shallow and its level was fluctuating during different climatic conditions. The weathering of the siltstone and concretions, in layers, at different levels also indicate the exposure of lake beds at different times. The mottling and formation of concretions also reflect oscillation of climate between wet and dry periods, while mottling suggests leaching of iron during warm conditions.

Field and laboratory examination suggest that the material of the lake has been derived from the erosion of the morainic material produced during the Pleistocene period from the areas, north of the Peshawar vale which is composed of igneous and metamorphic rocks. The angularity and subangularity of the grains of siltstone also suggest that besides fluvio-glacial sand and silt, a considerable part of the silt has been deposited directly in the lake as "wind blown loessic silt." The field evidence further suggests that due to the deposition of loessic silt, the lake might have been filled, and boggy

and marshy conditions prevailed. The presence of fine worm-holes also indicates that only small worms and leeches or their larvae could survive in such environments. Different colours of the siltstone indicate that their material may have been derived from a variety of sources and laid by different streams.

The tilting of the lake bed indicates that they were uplifted and warped during one of the phases of the Himalayan orogeny. Consequently, the local base level was lowered resulting in the erosion of the lake bed from a large part of the Peshawar vale. It may be pointed out that after the uplift, the climate became cold and semi-dry. This deterioration of climate initiated a cycle of erosion, which prevailed for a long time, while the physical disintegration of rocks, e.g. slates, shale and sandstone took place over the Attock-Cherat range due to intense frost action (Briggs,1977), but the weathered material was not released by the slopes because it was frost jammed (King 1975, p.4). With a change of climate to warm and wet, the slopes of the Attock-Cherat range began to release the debris, triggering the mountain torrents to deposit their material in the form of alluvial fans. Therefore, the deposition of beds b, c and d, have been recognised as the various facies of the alluvial fans which have been deposited by the torrent in different phases. It seems, that the torrent picked up the weathered material, released by the slopes, reworked it and deposited it on the eroded parts of the lake bed, as a facies of the "water laid/debris flow" deposits as bed b (Wasson, 1977 b, p.784). The presence of occasional

cobbles, boulders and with prominent cross-beddings indicate a powerful, swift and braided stream having a moderate year round rainfall which was frequently changing its channel (Thornbury, 1954, Allen, 1979). The deposition of lenses of silt within the gravels suggests that erosion and deposition were taking place simultaneously. After a long period of aggradation the torrent started eroding its bed probably in order to maintain a profile of equilibrium.

The bed c, with its silty texture and massive structure, hving a sharp and distinct contact with the underlying bed b, suggest that it may have been deposited as a facies of the "mudflow deposit" (Blissenbach 1954, Fisher 1971, Allen 1979, Rachocki, 1981). It should be pointed out that the material of the bed c, may have been derived from the fine regolith released by the slopes of Attock-Cherat range as a result of mass wasting/soil creep. With changes in environments, the torrents with low water discharge probably in a dry semi-dry climate, became more heavily laden with silt/mud, moved as a high concentration mixture and deposited the sediments as "slurry flows" (Wasson,1979, p.30). Its three prominent massive layers suggest that it may have been deposited in three lobes during three phases (Blissenbach,1954). It may further be added that this type of deposition is very common in the alluvial fans of dry/semi-dry environment (Blissenbach 1954, Bull 1962, 1972, 1977). According to Langbein and Schumn (1958) an average precipitation of 10-14 inches may be considered optimum for promoting fan development. Such conditions reduce vegetation cover to its minimum and ensure

an adequate supply of water to erode the soil cover during torrential/intermittent rainfall in a semi-desert environments. Allen (1979, pp.144-145) also suggested that intermittant but intense rainfall of dry regions and the presence of clay bearing rocks in the source area may be considered conducive for the occurrences of mud flow in the formation of an alluvial fan. It should be noted that climatically, the Peshawar vale falls under semi-dry, sub-tropical, continental zone, with an annual average rainfall 10-14 inches, and having a lot of clay bearing rocks, in the Attock-Cherat range, e.g. slate, shale, and argillite, possesses ideal conditions for the formation of alluvial fans.

The deposition of bed d, over the silty bed c, is indicative of a rejuvination period of the same torrent which due to a change in the environments regained enough energy and picked up the weathered debris and deposited the coarse sediment as a turbulent and swollen stream. This may have been in response to a revival of the frost climate followed by a warm wet climate. The aggradation of these gravels may have been followed by its degradation in order to achieve a profile of equilbrium. The erosion of the gravely bed d, was followed by the deposition of loess (bed e). The presence of nodules of CaCo3in the loess suggests that it was deposited during a warm climate with alternate wet periods. The very fine holes filled with some black matter suggest it to be some decayed organic matter formed as a result of growth of vegetation during wet spells.

The exposure of gravels of the bed d, as a terrace, suggests that loess was subjected to severe gully erosion, as a result of which it was removed from over a large area. The gully erosion may have progressively developed as a new phase of erosion, which continued for a long time. It was during this period that torrent carved its present channel, and the present section exposed.

4.14.4 Summary of Major Events Recorded in the Section

i. The deposition of silt and sand by the Kabul river as part of its flood plain.

ii. The formation of lake due to damming of the Kabul river.

iii. A temporary retreat of lake phase is recorded by the deposition of fine gravels by the local torrent.

iv. A phase of uplift and warping of the lake beds.

v. A very long phase of erosion of the lake beds.

vi. The deposition of torrent gravels as bed b.

vii. The erosion of torrent gravels.

viii. The deposition of pale yellow silt as bed c.

ix. The erosion of bed c.

x. The deposition of torrent gravels as bed d.

xi. The erosion of gravels as bed d.

xii. The deposition of loess as bed e.

xiii. A period of long erosion during which loess and other beds were eroded and the present channel of the torrent was formed.

SECTION 15

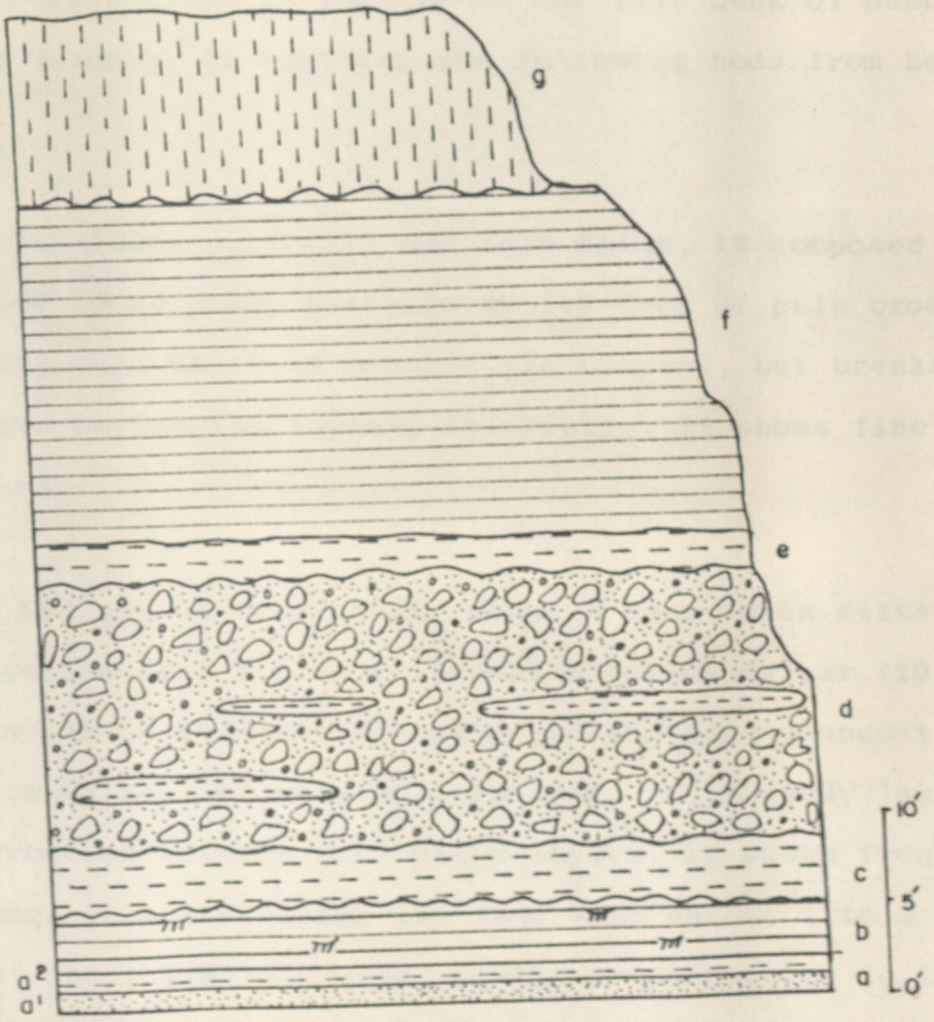


Fig. 4·15·1

4.15 SECTION 15

4.15.1 Field Description

This section is located on the left bank of Babu Khwar (GR 093865).* It exhibits the following beds from below upwards:-

Bed a:

Its lower part (a1) one foot thick, is composed of grey-colour loose sand, overlain by 1.5 feet of pale brown silty clay, (a2) which is massive and compact, but breaks easily into horizontal layers. Internally, it shows fine laminations.

Bed b:

Bed a2, is overlain by about 8 feet thick siltstone of pale yellow (2.5 Y 5/4) to brownish yellow colour (10 YR 7/6). The siltstone is sufficiently hard and contains abundant horizontal concretions of calcium carbonate. Thin sandy layers are interbedded between hard silty layers. It shows frequent red organge colour staining and fine worm holes, 1 to 2 inches long and about 1/8 inch wide, mostly prependicular to the layers. Traces of very short worm tracks can be seen on the surface. There is an unconformity between this bed and the overlying silty bed c.

Bed c:

Bed c is pale yellow (5 Y 7/3) hard silt, 4 feet thick, is massive and structureless. It contains very fine angular fragments of slate and small nodules of calcium carbonate which breaks into platy structure. It has an unconformable contact

* For location of section, see Fig.4.13.1.1.



Plate No. 4.15.1.1. Section 15.

with the overlying gravely bed.

Bed d:

It is a 15 feet thick bed of torrent gravels, of dark grey slate and some sandstone. The gravels are sub-angular to sub-rounded, medium-sized and embedded in a dark matrix of fine gravels and coarse sand, showing cross-beddings. The bed is very disturbed, lenses of silt are interbedded within the gravels. The contact with the overlying bed is also unconformable.

Bed e:

A 2 feet thick bed of yellow to brownish silt (10 YR 6.5/6), lies unconformably over the gravelly bed. It is massive and semi-hard, but internally it shows fine beddings and small roote holes. It contains very fine angular gravels of slate and rock fragments.

Bed f:

It is about 20 feet thick bed of laminated silty clay of pale yellow colour (5 Y 7.5/3). The silty clay has become massive and internally it is cross-laminated and frequently shows fine dessication cracks. At places it is soft and weathered and breaks easily into thin horizontal sheets. Occasionally, it contains dark colour fossil rootes. Mottling and leaching of iron is common.

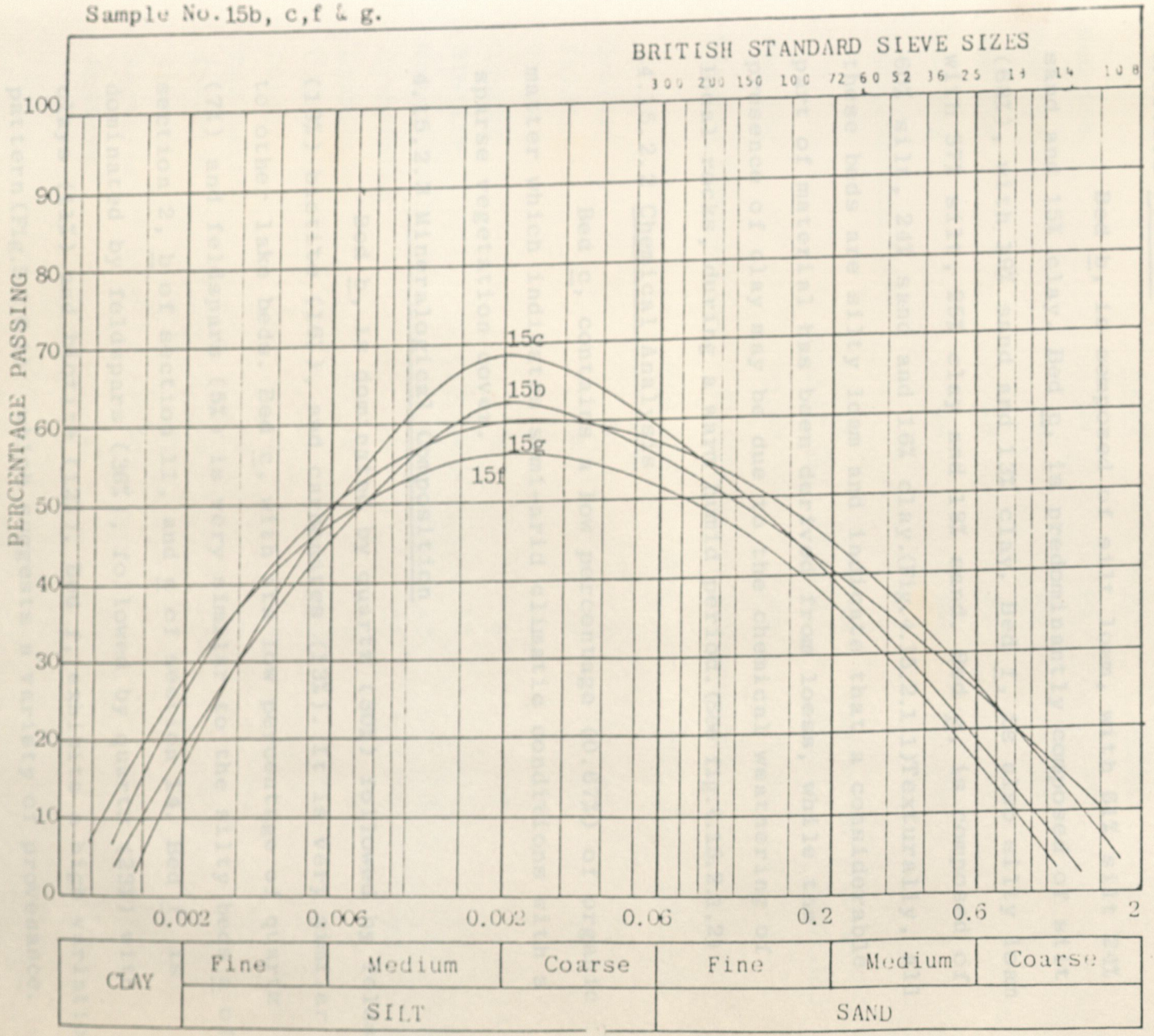
Bed g:

The top bed of the section is composed of about 10 feet thick bed of massive but soft loess. It is pale yellow to yellow colour (2.5 Y 7.5/4). It contains about 1/8 inch wide holes, filled with dark colour, soft matter. Internally, it shows dark spots and occasionally contains fine concretions

PARTICLE SIZE DISTRIBUTION

Fig.4.15.2.1.1

Sample No.15b, c,f & g.



of calcium carbonates. It lies unconformably over the lower bed f.

4.15.2 Laboratory Examination

4.15.2.1 Texture

Bed b, is composed of silt loam, with 61% silt 24% sand and 15% clay. Bed c, is predominantly composed of silt (68%), with 19% sand and 13% clay. Bed f, is also silty loam with 57% silt, 25% clay and 18% sand. Bed g, is composed of 60% silt, 24% sand and 16% clay.(Fig.4.15.2.1.1)Texturally, all these beds are silty loam and indicate that a considerable part of material has been derived from loess, while the presence of clay may be due to the chemical weathering of local rocks, during a warm humid period.(See fig.4.15.2.1.2)

4.15.2.2 Chemical Analysis

Bed c, contains a low percentage (0.67%) of organic matter which indicates semi-arid climatic conditions with a sparse vegetation cover.

4.15.2.3 Mineralogical Composition

Bed b, is dominated by quartz (30%) followed by feldspars (18%) biotite (16%), and carbonates (13%). It is very similar to other lake beds. Bed c, with its low percentage of quartz (7%) and feldspars (5%) is very similar to the silty beds a of section 2, b of section 11, and c of section 14. Bed f, is dominated by feldspars (36%), followed by quartz (23%) with clays (11%) and biotite (12%). Bed f, exhibits a high variation pattern(Fig.5.2.6.1) which suggests a variety of provenance.

LABORATORY EXAMINATION

Section-15

Table No. 4.15.2.3.1

Texture (Percentage)

	Sand	Silt	Clay
Bed 15b	24	61	15
Bed 15c	19	68	13
Bed 15f	18	57	25
Bed 15g	24	60	16

Soil Characteristics

	Organic matter (%)	Calcium (Meq/1)	Magnesium (Meq/1)	Total Iron (%)
Bed 15c	0.67	1.00	0.80	-

Mineral Composition (Approximate Percentage)

	Bed 15b	Bed 15c	Bed 15f	Bed 15g
Quartz	30	7	23	27
Feldspars	18	5	36	15
Clays	6	10	11	2
Opaque	4	8	2	2
Biotite	16	13	12	10
Muscovite	2	16	3	2
Carbonates	13	26	7	38
Amphibole	6	8	4	3
Chlorite	1	5	Tr	Tr
Rutile	1	1	1	-
Tourmaline	1	-	Tr	Tr
Epidote	-	-	Tr	-
Zircon	Tr	-	-	-
Sericite	Tr	-	-	-
Apatite	-	-	-	-

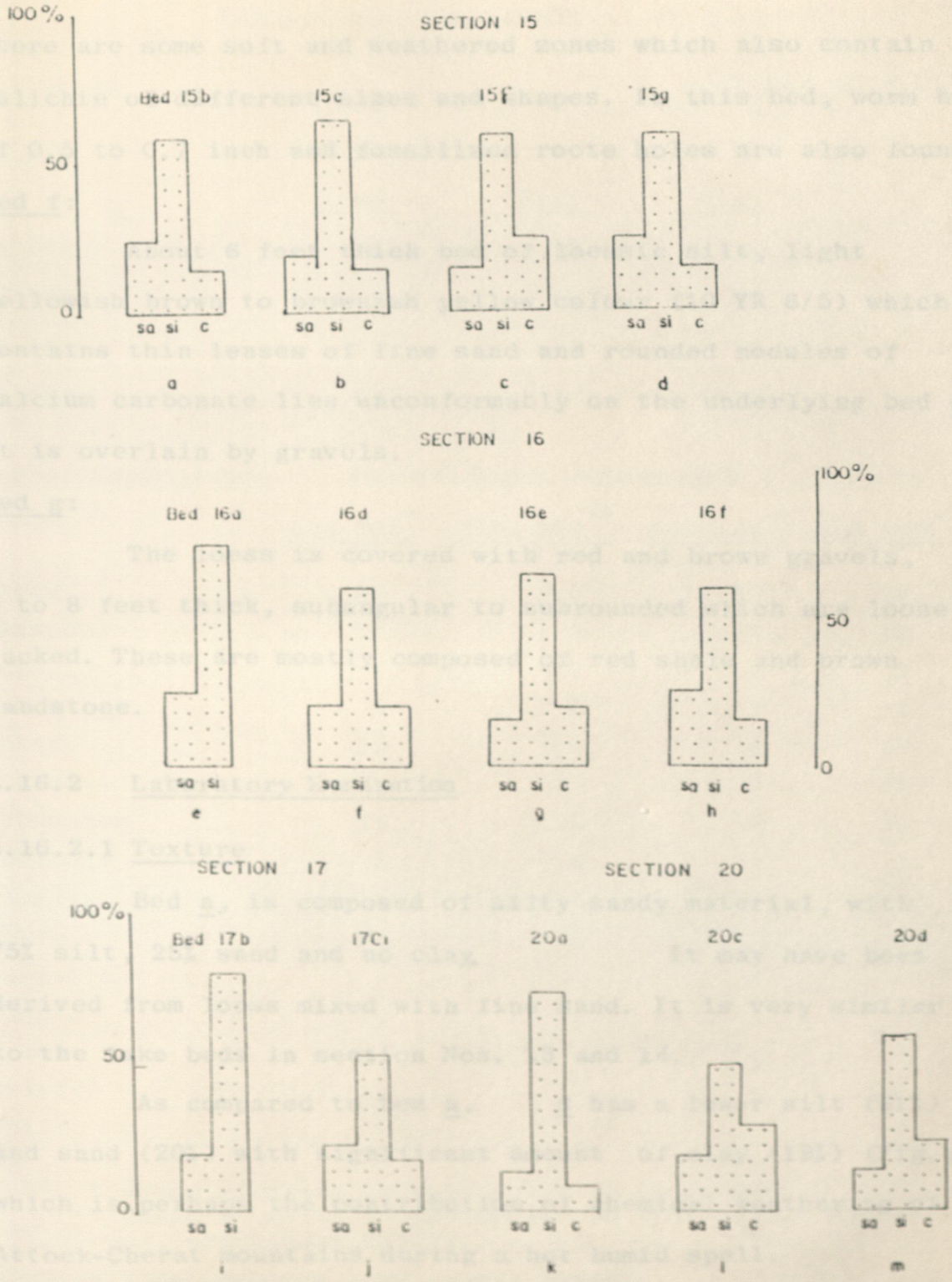


Fig.4.15.2.1.2: Histograms showing Textural Composition of various beds.

there are some soft and weathered zones which also contain calichie of different sizes and shapes. In this bed, worm holes of 0.5 to 0.7 inch and fossilized roote holes are also found.

Bed f:

About 6 feet thick bed of loessic silt, light yellowish brown to brownish yellow colour (10 YR 6/5) which contains thin lenses of fine sand and rounded nodules of calcium carbonate lies unconformably on the underlying bed d. It is overlain by gravels.

Bed g:

The loess is covered with red and brown gravels, 6 to 8 feet thick, subangular to subrounded which are loosely packed. These are mostly composed of red shale and brown sandstone.

4.16.2 Laboratory Examination

4.16.2.1 Texture

Bed a, is composed of silty sandy material, with 75% silt, 25% sand and no clay. It may have been derived from loess mixed with fine sand. It is very similar to the lake beds in section Nos. 13 and 14.

As compared to bed a, d has a lower silt (61%) and sand (20%) with significant amount of clay (19%) (Fig. 4.16.2.1.1) which is perhaps the contribution of chemical weathering of Attock-Cherat mountains during a hot humid spell.

Beds e and f are texturally similar, relatively non sorted, with 57% to 64% of the material in silt, 15% to 28%

LABORATORY EXAMINATION

Section-16 — Table No. 4.16.2.2.1

Texture (Percentage)

	Sand	Silt	Clay
Bed 16a	25	75	0
Bed 16d	20	61	19
Bed 16e	15	64	21
Bed 16f	28	57	15

Mineral Composition (Approximate Percentage)

	Bed 16a*	Bed 16d**	Bed 16e+	Bed 16f++
Quartz	29	5	18	26
Feldspars	20	4	31	18
Clays	7	11	14	2
Opaque	2	6	1	1
Biotite	19	18	10	12
Muscovite	2	11	5	1
Carbonates	14	30	15	36
Amphibole	5	8	4	2
Chlorite	-	4	Tr	-
Rutile	Tr	1	1	-
Tourmaline	-	-	-	-
Epidote	Tr	Tr	-	-
Zircon	-	-	Tr	-
Sericite	-	-	-	-
Apatite	-	-	-	-

* Shape of grain is subangular to subrounded.
** Shape of grain is subangular to subrounded. Presence of ferruginous matter.
\+ Also contains ferruginous matter.
++ Shape of grains is mostly angular.

in sand and 15% to 21% in clay. Both appears to be primarily wind blown material mixed with sand and clay.

4.16.2.2 Shape Analysis

Bed c is dominated by gravels of tabular shape (53.8%) followed by bladed (30.8%); while equant (6.2%) and prolate (9.2%) are of minor importance. (Fig.4.16.2.2.1)Their shape is very similar to gravels of section 3b and 13 b.

4.16.2.2 Mineralogical Composition

Bed a is composed of quartz (29%), fieldspars (20%), biotite (19%) and carbonates (14%). Its mineral composition is similar to the second lake beds. Its material is derived from igneous and metamorphic rocks. Bed d, with its low percentage of quartz and feldspars is similar to the silty beds in section nos. 2, 11, 14 and 15. Bed e, is composed of feldspars (31%), quartz (18%), clays (15%), biotite (10%) and carbonates (15%). The high percentage of feldspars as compared to quartz is similar to the bed f of section-15. Bed f, with (26%) quartz, (18%) feldspars (12%) biotite and higher percentage of carbonates (36%) indicates that it is similar to loess beds, examined in other sections. (Table-4.16.2.2.1)

4.16.2.4 Microscopic Study

In beds a and d, the grains are sub-angular to sub-rounded. Bed d and bed e contain ferruginous material, which indicates post-depositional weathering. The shape of grains is mostly angular in bed f, which is characteristic feature of the wind blown material. (Plate Nos. 4.16.2.4.1 & 2)

SECTION 16c

Zingg's diagram showing gravels shape

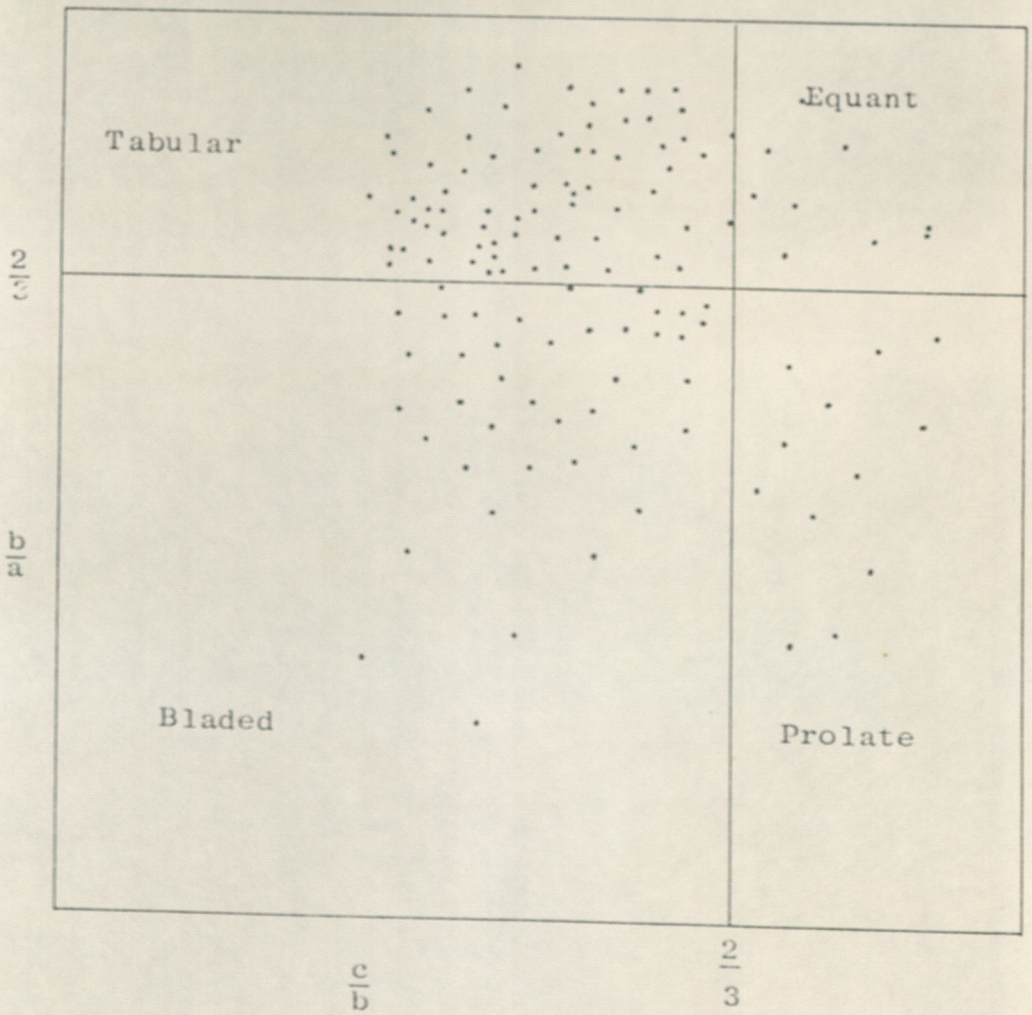


Fig:4.16.2.2.1



Plate No. 4.16.2.4.1 Lakebed (16a).

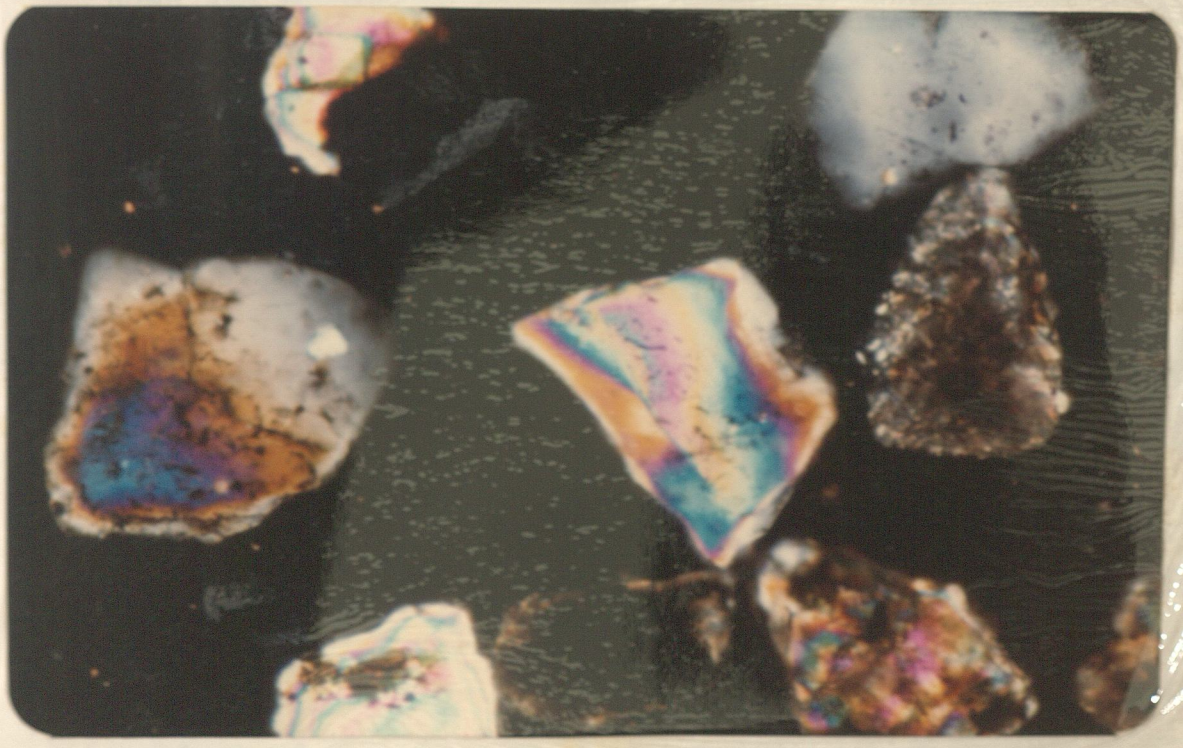


Plate No.4.16.2.4.2 Loess (16f).

4.16.3 Discussion

The phsycial characteristics and environment of deposition of the lake beds are closely similar to the section nos. 14 and 15, discussed previosuly. However, there are two other events recorded in the lake bed a, which are different and need explanation.

(i) In bed a, the segment a^1, suggests that there was a temporary retreat of lake shores during a cold phase, when due to short supply of water the lake receded. During this cold period, weathering of slate in the Attock-Cherat range occurred. The weathered fragments from the slopes were washed down and picked by the local torrent and deposited on the exposed lake bed as a^1. The lake appears to have expanded again. The presence of silty dykes indicate that the lake beds were involved in the uplift, during one of the Himalayan orogenies. The presence of concretionary zones at different levels also confirm frequent exposures of the lake bed leading to the leaching of $CaCo^3$. As a result of uplift, the lake beds were eroded from a large parts of the Peshawar vale.

(ii) Field evidence suggests that after the erosion of lake beds, the Kabul river was flowing past this area of the lake bed and deposited sandy gravels as bed b. It is suggested that these sandy gravels were deposited immediately above the surface of erosion, swept out by the meandering channel of the Kabul river during the course of its lateral movement. (Allen, 1979, p.141, Leopold, et al., 1964, p.323). The

inclusion of igneous and metamorphic gravels also suggests that they were deposited by the Kabul river at a much earlier time and during lateral shifting of its channel, these were picked up and deposited as the "Channel lag deposits." The inclusion of the subangular gravels derived from the surrounding rocks suggests, the presence of local torrents draining into the Kabul river and depositing torrent gravels interfingering with the river gravels.

After the deposition of the "lag deposits," the channel of the Kabul river which may have been in high flood began to shift rapidly because the recession of banks is usually most rapid in the case of loose sand and gravels. This sudden shifting of the channel may have occured by "Avulsion", which is the sudden shifting of a whole stream course built up by deposition to a disadvantageously low gradient to a new site, in an adjacent and more favourable area. (Allen, 1979). It is a very common feature of semi-arid regions during catastrophic rare floods (Leopold, et al., 1964). With the shifting of river flow from this area, its channel was occupied by torrents which eroded the channel deposits because it had steep gradient and high discharge.

(iii) The disposition of gravelly bed (d) is a facie of an alluvial fan. The environments and its mode of deposition has already been explained and discussed in sections 14 and 15. The bed c with all its characteristics suggest it to be a profile of a soil which developed over the gravelly

bed (c). It appears that after the deposition of gravels, the torrent migrated to some other area, leaving the gravels open to weathering and pedogenic processes to operate for a very long time. Its brownish yellow colour indicates leaching of iron in a warm humid environment. The low percentage of quartz and feldspars suggests that its parent material is derived from the local rocks.

(iv) Bed e, is an extension of the lake bed exposed in section 32c. The concretionary layers at different levels in this bed indicate repeated emergence and submergence of water, with consequent deposition and exposure to evaportion at different time intervals. This also suggests, that this part of the lake bed remained open for pedogenic process to work and to form soils in semi-arid environment. These conditions permitted, only grasses and bushes, having fine rootlets to grow and encouraged concentration of calcium carbonate as concretions. The lacustrine conditions also encouraged growth and development of very small insects like leaches and worms as is clear from their holes.

(v) The deposition of loess as bed f, with its brownish colour indicates warm and semi-dry environments. The lenses of sand in it suggests fluvial action during intermittent humid spells and temporary deposition in ponds and as a rainwash was deposited where the slope permitted. It is interesting to note that during the course of this study, loess deposits around Lawrencepur and Harro river have also

been studied for correlation. It was found, that one of the loess deposits contained a small rounded gravel of gneiss of about 1 x ¼ inch size, which obviously suggests, that this part of loess, including the gneiss gravels, was deposited by fluvial action.

(vi) The gravel bed g, covering the loess bed indicates another period of rock weathering in the Attock-Cherat mountains. It appears that after the deposition of loess, the environments became humid for sometime and the rejuvinated torrent picked up the weathered debris, reworked and deposited them on the loess bed as recent gravels.

(vii) After the deposition of the recent gravels at bed g, another period of erosion occured, either in response to another Himalayan uplift or to achieve a profile of equilibrium, the Kabul river started degrading its channel bed. Due to lowering of the local base level, it initiated another cycle of erosion. The local torrents following the new base level eroded the previously deposited material by carving their present channels. During this period of erosion, loess was also removed from a large part of the study area and gullies were formed, making typical "badland" topography.

(viii) Field evidence also indicate that the present channels of torrents are being aggraded, probably the vale of Peshawar is again acquiring profile of equilibrium. The present beds of the torrents are again being filled with gravelly material, while Kabul river is behaving like a

braided stream by raising its bed.

4.16.4 Summary of Major Events Recorded in the Section

i. The formation of a lake and the deposition of the siltstone in the lake as the bed a.

ii. The weathering of the local rocks.

iii. A temporary retreat of the lake shores and the deposition of the subangular gravels of slate by the torrent as a^1 of the bed a.

iv. The lake begins to fill to its full capacity.

v. An event of uplift and formation of the vertical and oblique dykes in the lake beds.

vi. A long period of erosion during which lake beds from a large part of the Peshawar vale were eroded.

vii. The deposition of channel deposits as bed b.

viii. The erosion of channel deposits by the torrents.

ix. A period of weathering of the local rocks.

x. The deposition of torrent gravels.

xi. The erosion of torrent gravels.

xii. The deposition of silt as bed d.

xiii. The erosion of bed d.

xiv. The formation of another lake and the deposition of silty clay as the bed e.

xv. The erosion of the bed e.

xvi. The deposition of loess as the bed f.

xvii. The erosion of loess and gully formation.

xviii. The weathering of the local rocks, e.g. shale and

sandstone.

xix. The deposition of recent gravels as bed g.

xx. A long period of erosion during which the torrent carved its present channel and the beds along the torrent in this section were exposed.

xxi. A period of recent aggradation during which the torrent again deposited gravels in its bed upto the present level.

SECTION 17

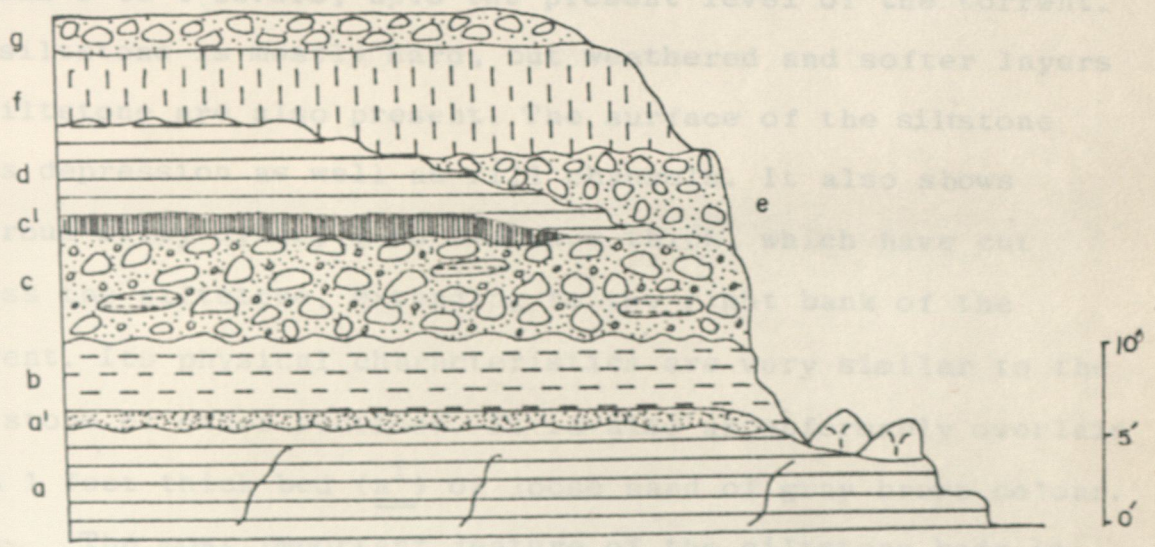


Fig. 4·17·1

4.17 SECTION 17

4.17.1 Field Description

The following beds are exposed along the left bank of the Babu Khwar (GR 091858).*

Bed a:

This bed consists of a pale yellow (5 Y 7.5/4) lake material composed of about 7 feet hard siltstone. It is exposed horizontally forming a broad terrace along the present bed of the torrent. The siltstone is not found at a uniform height, but has 3 to 4 levels, upto the present level of the torrent. The siltstone is mostly hard, but weathered and softer layers of siltstone are also present. The surface of the siltstone shows depression as well as rill channels. It also shows numerous silty dykes, 2 to 4 inches thick, which have cut across the siltstone, extending to the right bank of the torrent. Its physical characteristics are very similar to the siltstone of other sections. It is also unconformably overlain by a 1 foot thick bed (a^1) of loose sand of gray brown colour.

The most important feature of the siltstone beds is the presence of a few large size subangular erratic blocks of gneiss, diorite (?) and quartzite rocks, which are firmly embedded in the siltstone. The exposed size of the two blocks is 4 x 5 feet (Gneiss) and 3 x 4 feet (diorite).(Plate 4.17.1.1)

Bed b:

This bed, 4 feet thick, is composed of yellow to very pale brown (10 YR 7/5) silt. It is massive and structureless, and has an unconformable contact with the underlying

* For location of section, see Fig.4.13.1.1.



Plate No. 4.17.1.1.

View of two erratics embedded in the lakebed.



Plate No. 4.33.1.2

Conglomeratic erratic embedded in the lakebed.

sandy bed (a^1). It has a well-pronounced erosional unconformity with the overlying grafely bed c. A few lenses of fine gravels are also embedded in it.

Bed c:

It is composed of about 6 feet thick bed, subangular to subrounded gravels, 2 to 3 inches, of dark grey slate and sandstone. The bed also contains a few medium-size pebbles of granite, gneiss and quartzite. These gravels are firmly embedded in a matrix of fine gravels and coarse sand. Occasionally, cobbles of 5 to 6 inches, are present. Also contained are lenses of silt at different levels. The upper part (c^1) of the bed c is much weathered and grades into silt of reddish yellow to strong brown colour (7.5 YR 5.5/6). It also contains, frequently, very fine angular fragments of slate and some fine nodules of $CaCo^3$ and iron. It breaks into crumb structure. It shows occasionally long root-holes filled with a grey colour matter of unknown origin. Its upper surface is irregular, indicating as erosional unconformity.

Bed d:

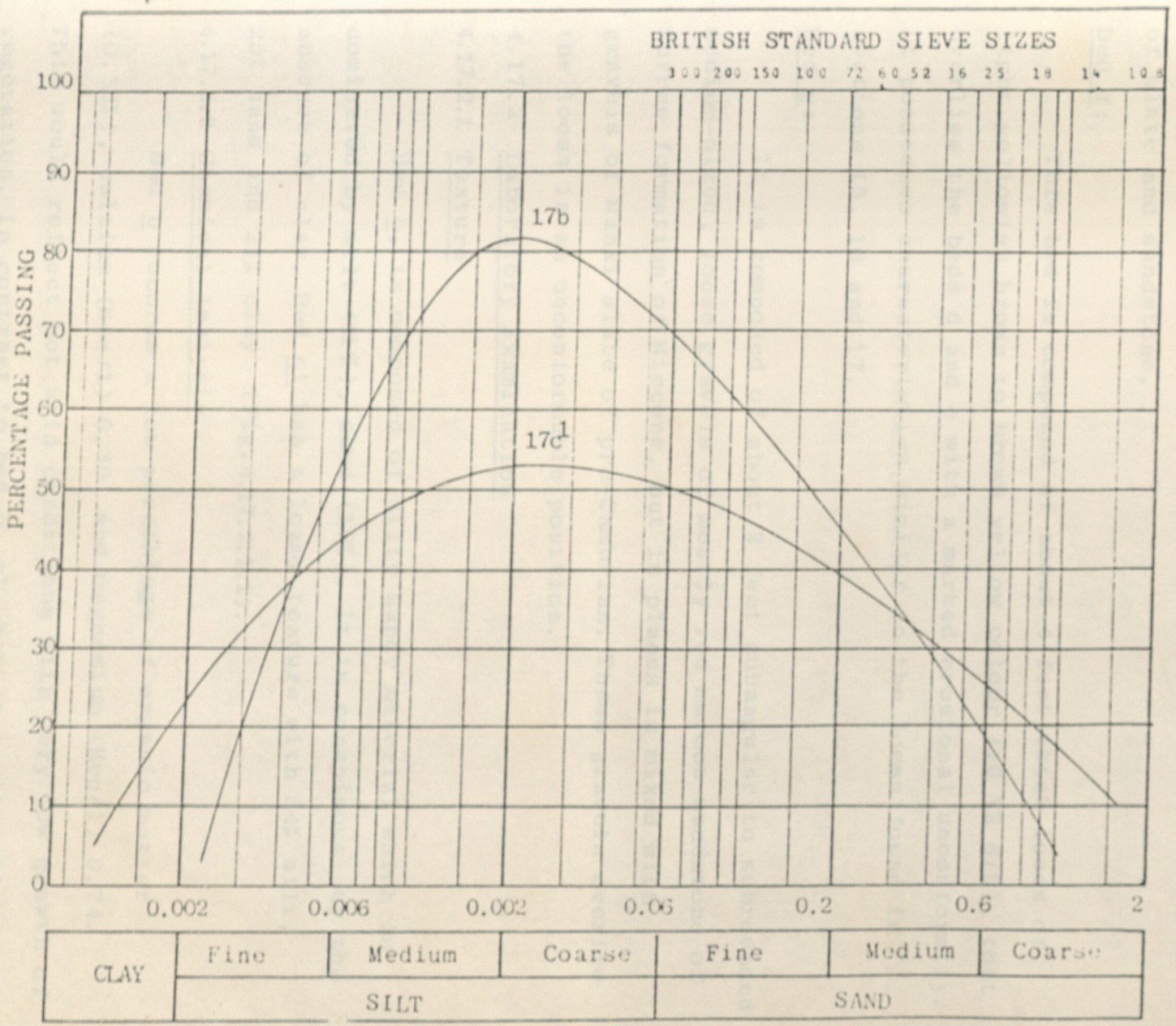
It is about 5 feet thick, composed of thin layers of clay and silt of pale brown colour (5 Y 7.5/3). Internally, it shows fine laminations and red brown staining. Occasionally, the bed is crossed by vertical cracks. The bed is soft and easily breaks into platty structure. Its upper surface shows a prominent erosional unconformity. This bed extends discontinuously northward, where it is overlain by the gravel bed e, unconformably.



PARTICLE SIZE DISTRIBUTION

Fig.4.17.2.1.1.

Sample No. 17b & c^1



Bed e:

Adjacent to the bed d, is 2 to 4 feet thick, gravelly bed e, composed of subangular to subrounded medium-size gravels of slate and sandstone.

Bed f:

This bed is composed of about 4 feet thick loess of light yellowish brown to brown yellow colour (10 YR 6/5), that overlies the beds d and e with a marked erosional unconformity. It possesses characteristics similar to the loess found in sections 15, 16 and 17.

Bed g:

It is composed of about 2 feet subangular to subrounded medium-sized, loose gravels of mostly red maroon sandstone of Murree formation of Miocene, but in places is mixed with gravels of Manki slate of pre-Cambrian. These gravels overlie the loess in an unconformable position.

4.17.2 Laboratory Examination

4.17.2.1 Texture

Bed b, is composed of silty sandy material which is dominated by silt (81%), sand (19%). It is conspicous by the absence of clay. Bed c1 has a loamy texture with 54% silt, 25% sand and 21% clay (Fig.4.17.2.1.1).

4.17.2.2 Chemical Analysis

Bed b records a low percentage of organic matter (0.33%), calcium (Meq/1) 0.30, and magnesium (Meq/1) 0.74. This would reflect hot arid conditions with very low growth of vegetation. In contrast to bed b, c1, has an appreciable amount of organic matter (1.74%) which would suggest a dense

LABORATORY EXAMINATION

Section-17 Table No. 4.17.2.3.1

Texture (Percentage)

	Sand	Silt	Clay
Bed 17b	19	81	0
Bed 17c[1]	25	54	21

Soil Characteristics

	Organic matter (%)	Calcium (Meq/1)	Magnesium (Meq/1)	Total iron (%)
Bed 17b	0.33	0.30	0.74	0.230
Bed 17c[1]	1.74	0.50	0.30	0.233

Mineral Composition (Approximate Percentage)

	Bed 17b*	Bed 17c[1]**
Quartz	7	15
Feldspars	4	6
Clays	13	17
Opaque	5	8
Biotite	14	15
Muscovite	18	20
Carbonates	23	10
Amphibole	9	4
Chlorite	5	2
Rutile	2	1
Tourmaline	Tr	1
Epidote	Tr	-
Zircon	Tr	-
Sericite	-	-
Apatite	-	-

* Grains are mostly angular to subangular.

** Ferruginous material in abundance. Grains are subangular to subrounded.

growth of vegetation, during a warm humid climate.

4.17.2.3 Mineralogical Composition

Bed b has a low percentage of quartz (7%) and feldspars (4%) with 13% clays and 23% carbonates. Its composition is similar to the bed a of section 2, bed b of section 11, bed c of section 14, and bed d of section 16. As compared to bed b, the bed c1 is composed of quartz (15%), feldspars (6%) opaques (8%), carbonates (10%), biotite (15%) and muscovite 20%. It has an appreciable amount of clays (17%) which suggests that a considerable amount of feldspars may have been chemically decomposed into clays after deposition during a warm-humid phase. (Table-4.17.2.3.1)

4.17.2.4 Microscopic Study

In bed b, the grains are mostly angular to subangular very similar to the material in section nos. 2,11,14, and 16 indicating a short distance transportation from its source in the Attock Cherat range. In bed c1, the grains are mostly subangular to subrounded. It also contains abundant ferruginous material indicating a phase of post-depositional weathering, during which leaching of iron and other ores concentrated in its B horizon. It should also be noted that the parent material of this bed is Manki formation which is rich in haemetite (Tahirkheli, 1970).

4.17.3 Discussion

The bed a, is a lacustrine facies found at the bottom of various sections discussed previously. The bed a1, represents channel sand, which was deposited after the erosion of the lake

bed, when the Kabul river began to form its flood plain as a meandering stream.

In this section, the lake bed is very significant from others, that it contians a few large erratic blocks of igneous and metamorphic rocks. It should be noted that such erratic blocks are also found outside the Peshawar vale, particularly in the Attock basin and along the Indus from Attock to Kalabagh. Their origin has been discussed from time to time (Vicary 1851, Verchere 1867, Weller 1928, Wynne, 1877, 1878, 1881a, 1881b, Theobald 1877 and 1880, Hayden 1898, Cotter 1929, de Terra and Teilhard, 1936, Coulson, 1937, and de Terra and Patterson 1939), and it has been suggested that these may have been deposited in response to the conditions prevailing during the Pleistocene period, but their origin is still doubtful.

The erratics of Peshawar vale may be considered, contemporary to the erratics of the northwest Punjab, as both are very similar in lithology, which would suggest that both have similar origin and mode of deposition. However, the erratics of the Peshawar vale are unique and conspicuous as these are mostly found on the lake bed south of the river Kabul along the foothills of Attock-Cherat range e.g. south of Shaidu and Nowshehra, Manki foothills, Jabba Khattak, and Zao Koruna, near Jallozai. However, there are also some, which are found at a higher elevations on the Attock-Khairabad slopes. Their huge size, location at different levels and their association with the Peshawar lake bed points out that these could have been the huge ice blocks which were detached

from the glaciers, floating here and there, like ice-bergs in the lake which deposited their load, on melting, either on the floor of the lake or rafted on to the higher slopes by occasional flash currents.

As yet, there is no evidence that the nearby hills of the Peshawar vale were ever occupied by glaciers during the Pleistocene and whether there was a Great Indus Glacier (Theobald, 1880), the snount of which extended to Tarbela is also a matter of conjecture. But there seems to be no doubt, that their lithological association with the erratics of northwest Punjab, indicates that these blocks have been transported by the Indus river and driven onto the Peshawar lake, which perhaps then stretched beyond the borders of the Peshawar vale, upto the Attock basin.

It is further pointed out, that during one of the glacial maxima of the Pleistocene, the snowline may have come down to a limit much below the present. Glaciers of Himalayas and the Karakoram could have descended a few thousand feet, below their present position, (Porter 1970, Desio and Orombolli 1971, Desio 1974, and Ambrasseys, et al., 1981). The Indus valley with a number of tributary streams, may have been fed by numerous tributary glaciers forming a Great Indus Glacier (Theobold,1880). However, the possibility, that the Indus Glacier might have acted like a surging glacier by blocking its valley and building a temporary dam, later on bursting thereby releasing ice blocks and morainic material, cannot be ruled out. The area where from these erratic blocks were derived, clearly lies outside the skirts of the Peshawar

vale. Davies (1965) suggested that these boulders have been derived from the Hornblendic Group of Martin, et al., (1962) renamed as Kohistan Complex of Jan and Mian (1971) which is located in the north and north-east of Peshawar vale and mainly drained by the Indus river. However, Said and Majid (1977) have the opinion that probably these boulders have been derived from the mountains of Tirah and Afghanistan, because some of the large genissic boulders had actually been reported by Hayden (1898). Their close association with the erratics of north west Punjab however suggest that they may have originated at the Kohistan Complex drained by the Indus as suggested by Davies (1965). Under these circumstances there might have been a reversal of drainage in the Peshawar vale, during which the waters of the Indus river may have started flowing towards the vale temporarily driving the ice rafted boulders to the far off western areas of the Peshawar vale.

The lake beds were eroded from a large part of the Peshawar vale in response to the uplift of the southern mountains. The bed $\underline{a}^1$ represents channel sand, which was deposited after the erosion of the lake bed, when the Kabul river began to form its flood plain as explained in section 16b.

Beds b and c indicate that these are facies of an alluvial fan, which were deposited by the braided stream of the fan coming from the Attock-Cherat range. The growth of fan, its mode of deposition and behaviour of the stream channel is clearly evident from the deposition of the beds b and c.

Bed b is composed of silt and represents a profile of an 'Inverted soil'. Its environments and mode of deposition has already been explained in sections 14 and 15. It seems that, here, the torrent was very turbulent, which rapidly changed its course. After the deposition of silty bed b, probably with high discharge and steep gradient, it eroded the silty bed and formed a broad channel on it and deposited gravelly material as bed c. The presence of lenses of silt in it suggests that erosion and deposition was taking place simultaneously (Allen 1965, Bull 1962). The presence of granite and gneiss gravels in it, indicates that these were deposited along the Cherat foothills earlier and later on picked up by torrents and deposited alongwith the local gravels of bed c.

The bed c1 represents B horizon of a fossil soil. Field and laboratory examinations indicate it to be a well-developed soil, which formed under a warm humid climate in which leaching of minerals took place. The long root-holes filled with grey colour material, having a high percentage of organic matter suggests that the area was blanketed with a forest cover. The low percentage of feldspars as compared to the quartz and clays also suggests that much of feldspars have been chemically decomposed into clays during, warm and humid environments. Texutrally, bed c1 is a loam with a high percentage of clay. It would suggest a thorough homogenization of material, in a warm humid climate, during which clay was formed, while the absence of clay in the silt bed b, also indicates that its material was deposited as regolith from the up-slopes in a cold climate in which clay could not be formed. Moreover, the pedogenic process did not work long enough to produce

enough humus. However, during a dry and warm phase, leaching of iron and its concentration lended it dark-red colour. Later on either due to a change in the environments or removal of forest cover, the upper horizon of the soil was eroded. This cycle of erosion may have spread over a large part of vale resulting in the lowering of the local base level.

Bed d represents another lacustrine facies which was deposited in a lake that was formed due to the daming of the Kabul river by the younger alluvial fans which prograded northward from the Attock-Cherat range as far as Nowshehra Reef hills.

The deposition of gravel bed g, over the loess bed f indicates that, after the deposition of loess, there occurred another period of gravel deposition. Their deposition indicates a temporary hault in the deposition of loess and establishment of wet conditions during which torrents transported gravels and deposited them over the loess.

4.17.4 Summary of Major Events Recorded in the Section

i. The formation of lake and the deposition of silty beds.

ii. The deposition of erratic blocks in the lake bed.

iii. An event of tectonics in which the lake beds were involved and dykes were produced.

iv. A period of very long erosion, during which lake beds were eroded from a large part of Peshawar vale, probably upto the level of erratic blocks.

v. The Kabul river occupied its channel and deposited "Channel sand" (a^1) over the lake bed.

vi. The deposition of silt by torrents as bed b.

vii. The erosion of bed b by the torrents which had formed a channel in this bed.

viii. The deposition of gravels by the torrent as bed c.

ix. A period of hiatus, during which the gravels were weathered. The pedogenic processes began to operate and a soil was formed as C^1. A thick forest cover spread over the soil C^1.

x. The removal of vegetation and erosion of the upper horizons of the soil.

xi. The formation of another lake and the deposition of silt as bed d.

xii. The partial erosion of lake bed.

xiii. The deposition of gravels by the torrent as bed e.

xiv. A period of erosion during which part of the lake bed and gravels were eroded.

xv. The deposition of loess as the bed f.

xvi. The partial erosion of bed f.

xvii. The deposition of the younger gravels as bed g.

xviii. A long period of erosion during which the torrent carved its present channel.

SECTION 18

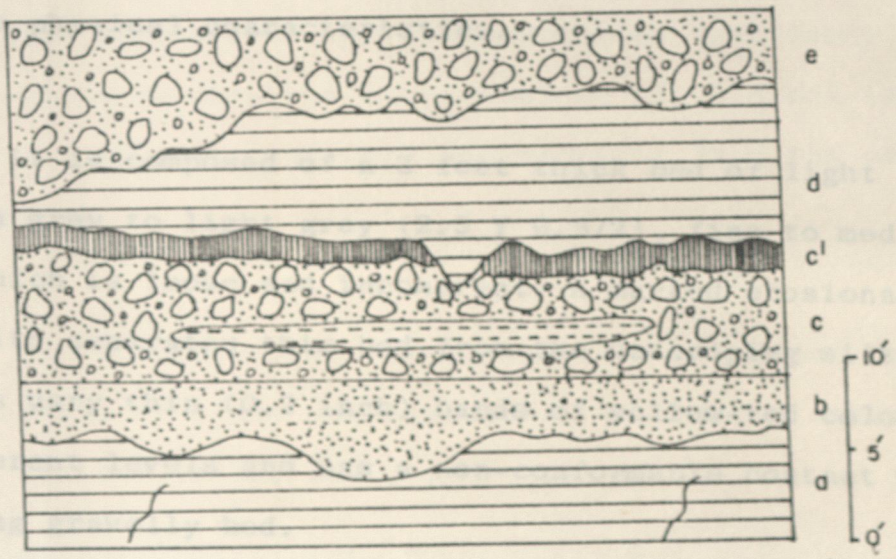


Fig. 4·18·1

4.18 SECTION 18

4.18.1 Field Description

This section is located on the right bank of Babu Khwar (GR 095857).* From bottom to top the following beds are exposed:-

Bed a:

This bed is composed of pale yellow (5 Y 7.5/4), siltstone, about 6 foot thick. It is an extension of the siltstone, exposed in sections described earlier, and has almost the same physical characteristics.

Bed b:

It is composed of a 3 feet thick bed of light brownish grey to light grey (2.5 Y 6.3/2), fine to medium size sand, which is loose and incoherent. A marked erosional unconformity separates this bed from the underlying siltstone. It shows very thin (0.2 inch) bands of yellow-red colours, at different levels and has a non-conformable contact with the overlying gravelly bed.

Bed c:

This 7 to 9 feet thick bed is composed of subangular to subrounded, medium sized gravels, of dark grey slate and sandstone. A few cobbles are also embedded in it. The matrix which is composed of very coarse sand and fine gravels also shows cross-beddings. A silty bed of red brown colour one foot thick and 22 feet long, is interbedded between the gravelly bed. It is massive and structureless.

* For location of section see fig. 4.13.1.1.

The upper surface of the gravel is much weathered and overlain by about a foot thick silt of reddish yellow to strong brown colour (7.5 YR 5.5/6). The upper surface of this silty bed is much eroded. In one place a torrent channel has been formed.

Bed d:

It is a silty clay bed, 1 to 9 feet thick that unconformably overlies the gravelly bed b. It is very pale brown to yellow in colour (10 YR 7/5), is deeply weathered and breaks into crumb like structure. It shows horizontal bedding and lamination and also possesses fine sandy nodules of calcium carbonate. The upper surface of this bed is separated by a very prominent erosional unconformity from the overlying gravelly bed.

Bed e:

It is composed of subangular to subrounded, medium sized gravels of slate and sandstone, 4 to 7 feet thick and is very similar to the lower gravelly bed.

4.18.2 Discussion

The bed a, is a continuation of the lacustrine bed found at the bottom of the various sections explained earlier. The bed b is also similar to the beds found in sections 16 and 17. Its mode of deposition has been explained in section 16.

The bed b, represents facies of an alluvial fan and has also been dealt with in other sections. The period of non-deposition may be due to migration of the torrent channel for a long time (Bull, 1974), during which the weathering and

pedogenic processes may have taken place under warm humid climate. The formation of soil and its erosion has been explained in the section 17.

The bed d, represents another phase of lake development when the Kabul river was dammed due to northward growing alluvial fans. Its horizontal beddings and fine laminations suggest that the lake was shallow and the deposition of silt was slow. The presence of crumb-like structure and sandy nodules of calcium carbonate indicate a period of soil formation.

The gravel bed e represents a facies of the second phase of younger alluvial fan which was deposited after the erosion of the younger lake bed.

4.18.3 Summary of Major Events Recorded in the Section

i. The formation of a lake and the deposition of the siltstone as bed a.

ii. The erosion of lake bed and formation of a river channel.

iii. The formation of flood plain by the ancient Kabul river and the deposition of sand as channel deposit in the bed b.

iv. The deposition of torrent gravels as bed b.

v. A period of non-deposition, during which weathering of gravels and development of soil took place as the bed c^1.

vi. The erosion of upper soil horizones and the formation of river channel in the gravels.

vii. The daming of the Kabul river and the formation of a lake in which silty bed d, was deposited.

viii. The erosion of the lake bed by the mountain torrent.

ix. The deposition of another gravel bed e by the torrent.

x. A long period of erosion during which the torrent dissected all these beds and carved its present channel.

xi. A period of aggradation during which the torrent filled its channel upto the present level.

SECTION 19

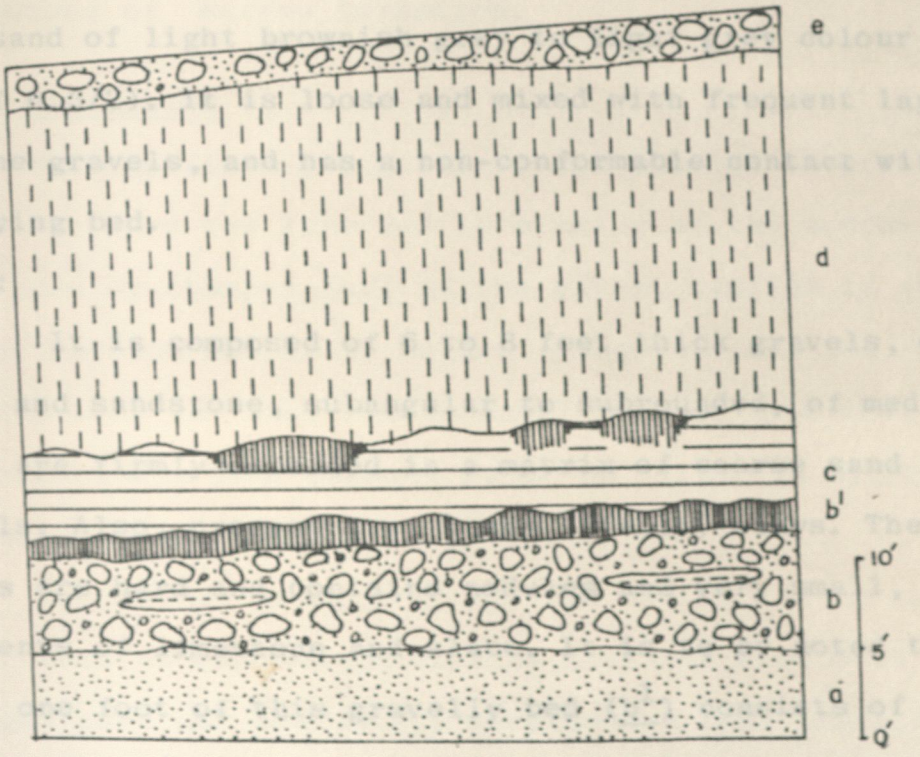


Fig. 4·19·1

4.19 SECTION 19

4.19.1 Field Description

This section is located along the left bank of the Babu Khwar (GR 08685).* It is composed of the following beds from below upwards:-

Bed a:

This bed, 5 feet thick, is composed of fine to medium size sand of light brownish grey to light grey colour (2.5 Y 6.3/2). It is loose and mixed with frequent layers of fine gravels, and has a non-conformable contact with the overlying bed.

Bed b:

It is composed of 6 to 8 feet thick gravels, of slate and sandstone, subangular to subrounded, of medium-size, which are firmly embedded in a matrix of coarse sand and fine gravels. Also, present are, lense of silty clays. The silty layers are hard and contains nodules and very small, angular fragments of limestone and slate. It is to be noted that the upper one foot of this gravelly bed (b^1) consists of very fine weathered material of red brown colour.

Bed c:

This 5 feet thick bed is composed of silty clay of very pale brown to yellow colour (10 YR 7/5), showing beddings that are formed of fine laminations. The beds are soft and contains abundant concretions of $CaCo^3$ and fossil roots. It has a non-conformable contact with the overlying bed. Its upper part is weathered.

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* For location of section, see fig. 4.13.1.1.

Bed d:

It is composed of about 20 feet thick loess having characteristics, similar to what has been described in section nos. 15,16 and 17.

Bed e:

This bed is composed of about 2 feet thick, subangular to subrounded, loose gravels of red colour mostly composed of sandstone of Murree formation.

4.19.2 Discussion

This section is similar to the section 18 with a few exceptions. Here the lake bed is missing at the bottom, and is replaced by channel sand of the river, similar to the bed b of section 18, which is overlying the lake bed. This indicates that the lake bed is deeply eroded from here and a deep channel has been carved, later on filled in by thick deposits of channel ,sand.

The bed b, is an alluvial fan facies and is similar to such beds as exposed in various sections discussed previously. Its upper part had previously developed a soil profile, it has now been completely eroded and is now represented by its weathered C horizon (b^1). The bed c represents a lacustrine facies similar to sections 17e and 18c. The presence of a weathered zone in its upper part and rootholes as well as nodules of $CaCo^3$, indicate a period of non-confomrity during which a soil profile developed. It is important to note, that unlike section 18, the lake bed here is directly overlain by loess, which is missing in the section 18. The physical

characteristics of the loess suggest that it was mostly deposited under warm dry environments with intermittent wet spells. The presence of a gravel bed c over the loess in this section suggest that after the deposition of loess (bed d) there was another wet spell during which torrent carried weathered material from the foot hills and deposited them on the loess as the recent gravels.

4.19.3 Summary of Major Events Recorded in the Section

i. The deposition of sand and gravels in the river channel as the bed a.

ii. The deposition of torrent gravels as the bed b.

iii. The weathering of gravels and the formation of soil.

iv. The erosion of the upper horizon of soil.

v. The formation of another lake.

vi. A period of non-deposition during which the upper surface of the lake bed was exposed to weathering and pedogenic processes.

vii. The erosion of upper horizon of soil.

viii. The deposition of loess.

ix. A period of non-conformity.

x. The deposition of recent gravels.

xi. A very long period of erosion during which the torrent carved its present channel and the various beds of this section were exposed.

SECTION 20

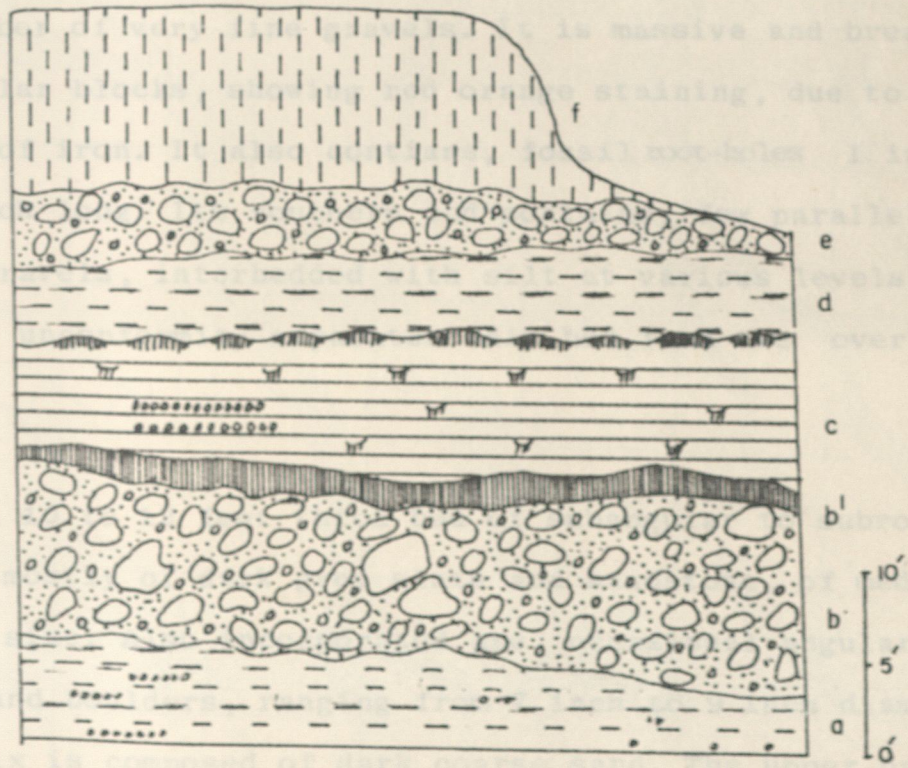

Fig. 4·20·1

4.20 SECTION 20

4.20.1 Field Description

This section is located on the left bank of Baringar Khwar (GR 045866).* The following beds are exposed:-

Bed a:

It consists of three to six feet thick, hard silt of very pale brown colour (10 YR 7/4), which incorporates a large number of very fine gravels. It is massive and breaks into tabular blocks, showing red orange staining, due to the leaching of iron. It also contians, fossil root-holes 1 inch to 1.5 inch long. Its southern end contains, few parallel bands of fine gravels, interbedded with silt at various levels. An erosional unconformity separates this bed from the overlying gravels.

Bed b:

A 10 to 12 feet thick bed of subangular to subrounded gravels, mostly of dark grey slate and sandstone, of medium to large size. Also incorporated are, occasional angular cobbles and boulders, ranging from 7 inch to 9 inch diameter. The matrix is composed of dark coarse sand. The upper part shows one foot thick weathered bed (b^1) of gravels that shows red orange colour.

Bed c:

This bed 6 to 8 feet thick, is composed of silty clay, showing prominent beddings, which is finely laminated. The silty clay is very pale brown (10 YR 7/4). It is mostly soft

* For location of section, see fig. 4.20.1.1.

LOCATION OF SECTIONS

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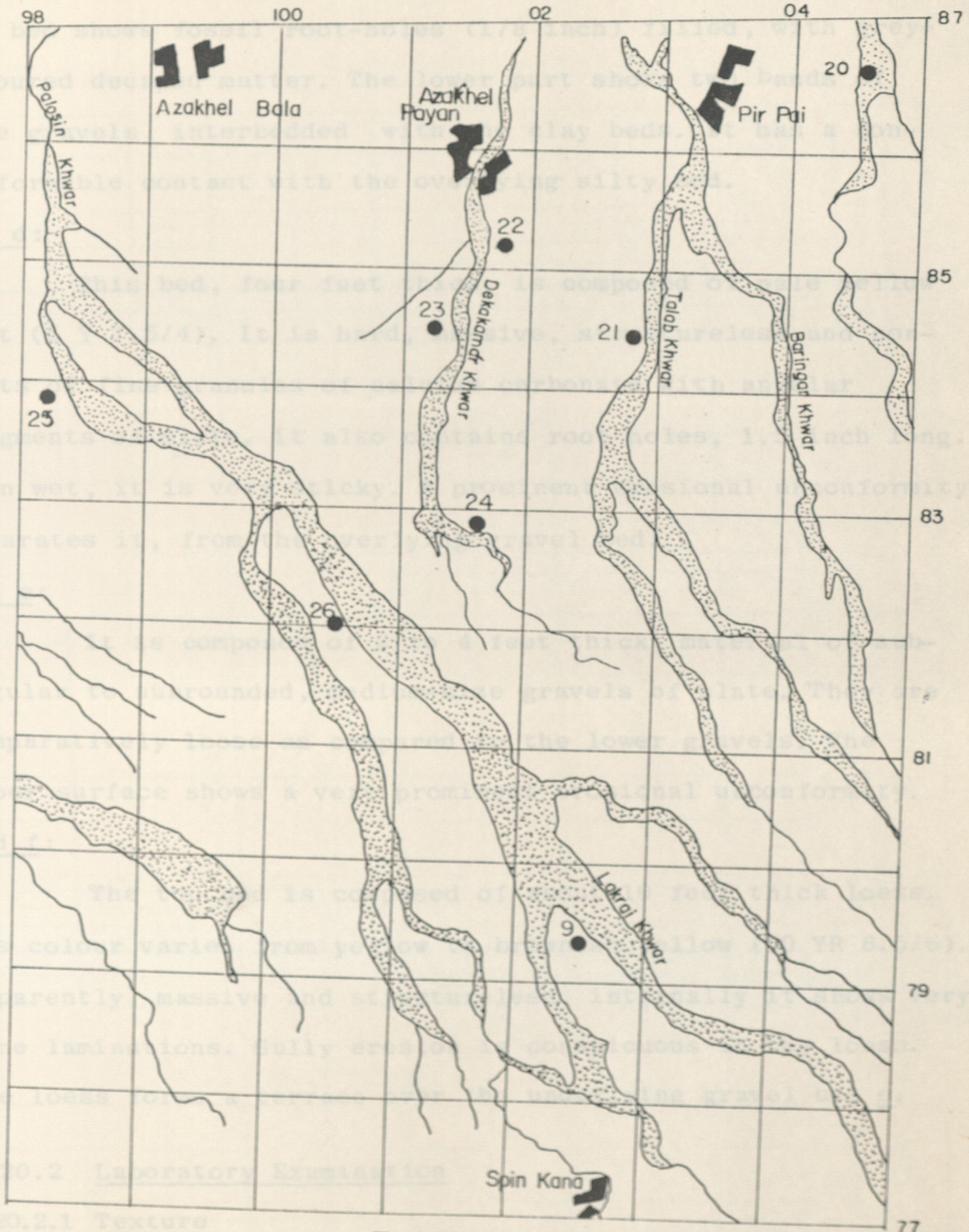


Fig. 4.20.1.1

and contains nodules and fine concretions of calcium corbonate. The bed shows fossil root-holes (1/8 inch) filled, with grey-coloured decayed matter. The lower part shows two bands of fine gravels, interbedded with the clay beds. It has a non-conformable contact with the overlying silty bed.

Bed d:

This bed, four feet thick, is composed of pale yellow silt (5 Y 7.5/4). It is hard, massive, structureless and consists of fine granules of calcium carbonate with angular fragments of slate. It also contains root holes, 1.5 inch long. When wet, it is very sticky. A prominent erosional unconformity, separates it, from the overlying gravel bed.

Bed e:

It is composed of 2 to 4 feet thick, material of sub-angular to subrounded, medium-size gravels of slate. They are comparatively loose as compared to the lower gravels. The upper surface shows a very prominent erosional unconformity.

Bed f:

The top bed is composed of about 10 feet thick loess. Its colour varies from yellow to brownish yellow (10 YR 6.5/6). Apparently, massive and structureless, internally it shows very fine laminations. Gully erosion is conspicuous in the loess. The loess forms a terrace over the underlying gravel bed e.

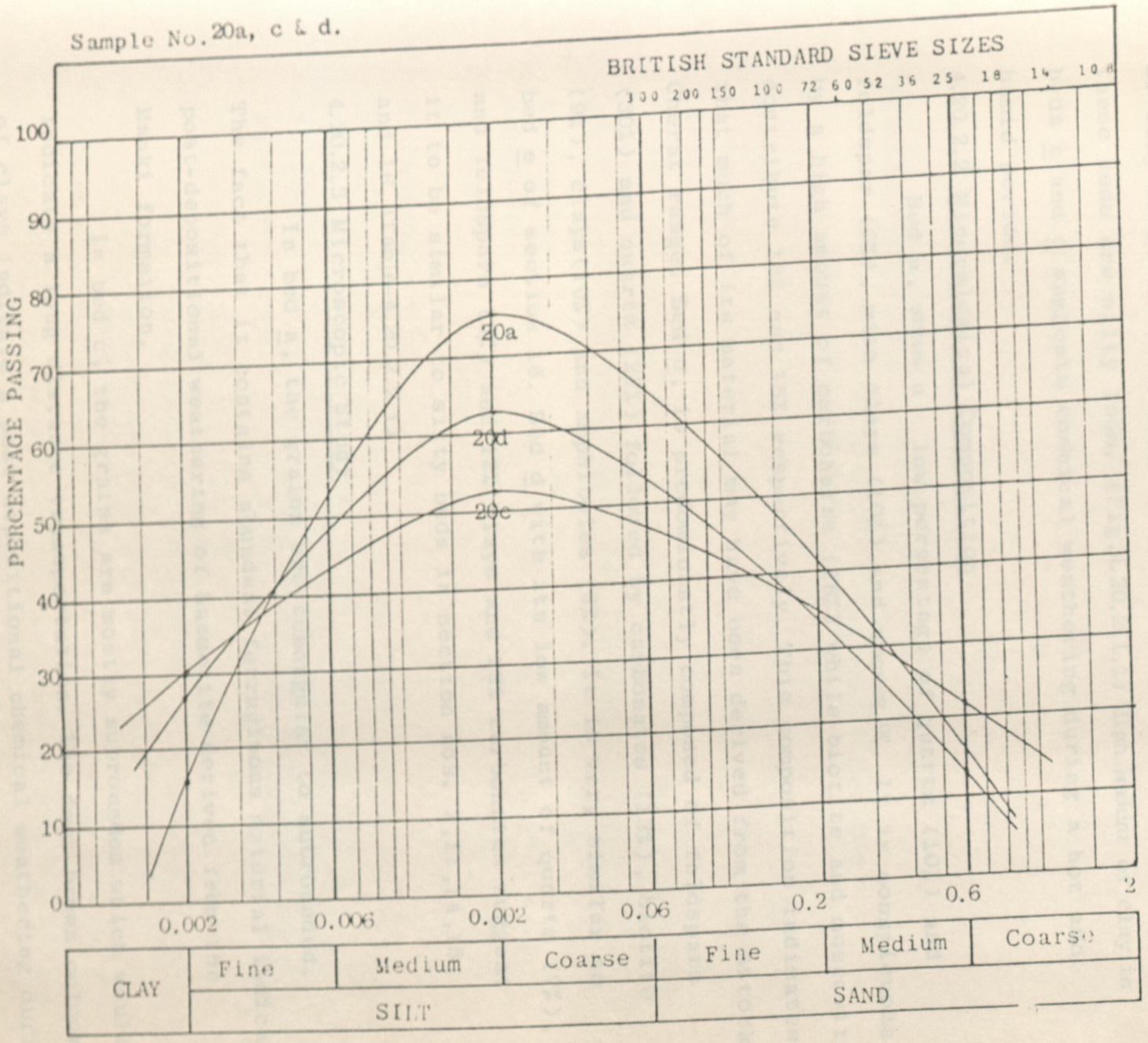
4.20.2 Laboratory Examination

4.20.2.1 Texture

Bed a, is predominantly composed of silt (75%), clay (10%) and sand (15%). In contrast to bed a, bed c has

PARTICLE SIZE DISTRIBUTION

Fig:4.20.2.1.1.



a higher percentage of clay (27%) while silt and sand form 52% and 15% respectively. Bed d, has also considerable amount of clay (25%) with silt (62%) and sand (15%). Texturally all these beds are silty loam. (Fig.4.20,2.1.1) High amount of clay in beds c and d suggests chemical weathering during a hot and humid period.

4.20.2.2 Mineralogical Composition

Bed a, shows a low percentage of quartz (10%) and feldspar (6%), with clays (10%) and opaques 9%. It is conspicuous by a high amount of carbonates (28%) while biotite and muscovite contribute 12% and 15% respectively. This composition indicates that much of its material may have been derived from the Attock-Cherat range. Bed c, is predominantly composed of feldspars (30%) and quartz (22%) followed by carbonates (13%), biotite (9%), clays(10%) and amphiboles (6%). It is very similar to bed e of section 16. Bed d with its low amount of quartz (7%), and feldspars (5%) and 12% clays and 22% carbonates suggest it to be similar to silty beds in section nos. 2,11,14,15, and 16. (Table-4.20.2.2.1)

4.20.2.3 Microscopic Study

In bed a, the grains are subangular to subrounded. The fact that it contains abundant ferruginous material indicates post-depositional weathering of haemetite derived from the Manki formation.

In bed c, the grains are mostly subrounded which would indicate a long distance transportation. The dark brown colour of clays indicate a post depositional chemical weathering during a warm humid phase.

LABORATORY EXAMINATION

Section 20

Table No. 4.20.2.2.1

Texture

	(Percentage) Sand	Silt	Clay
Bed 20a	15	75	10
Bed 20c	21	52	27
Bed 20d	13	62	25

Mineral Composition (Approximate Percentage)

	Bed 20a*	Bed 20c**	Bed 20d+
Quartz	10	22	7
Feldspars	6	30	5
Clays	10	10	12
Opaque	9	3	5
Biotite	12	9	13
Muscovite	15	3	21
Carbonates	28	13	22
Amphibole	4	6	8
Chlorite	4	2	5
Rutile	1	1	1
Tourmaline	Tr	-	-
Epidote	Tr	-	-
Zircon	Tr	-	-
Sericite	-	-	-
Apatite	-	-	-

*/+ Ferruginous material in abundance. Grains subangular to subrounded.

** Grains are mostly subrounded. Clays are brownish black.

4.20.3 Discussion

This section has preserved two very clear phases of the younger alluvial fans which are separated by an interval during which another lake was formed, in which the bed c was deposited. The mode of formation of the lake has already been explained in section 17. The bed c with its loamy texture, concretions of $CaCo^3$ and fossil roots indicate that a soil was formed on the lake bed during a long hiatus. Later on, due to lowering of the local base level as a result of further uplift of the Attock-Cherat range, the soil and the lake bed were eroded. Consequently, the rejuvinated torrent deposited its second phase of the younger alluvial fan.

The beds a and d, represent profile of an "inverted soil." It was produced when the regolith of the uphill slopes moved down as a result of soil creep, picked up by the torrent and deposited slowly, at its low discharge of water. This may have followed by accelerated erosion when the weathered bed rock approached by the torrent during torrential rains of a warm climate. The swollen torrent carried the weathered bed rock, reworked and deposited it over the soil in an inverted order. It seems that after the deposition of the bed b, the torrent shifted its channel to some other area for a sufficient long time (Bull, 1977), and its upper part remained exposed to weathering and pedogenic processes developing into a soil profile. Due to change in the local environments the soil was eroded from here, leaving behind b^1 and its C horizon of the parent material.

It should be noted that texturally bed a, and the bed d are different but, similarity in their mineral composition indicates that these may have been derived from the same parent material which may be the Attock-Cherat range while their great difference in percentage of clay suggests difference in environments during which the pedogenic processes seem to have operated for a much longer time on the bed d than the bed a.

4.20.4 Summary of Major Events Recorded in the Section

i. The deposition of very pale brown silt as bed a.
ii. The partial erosion of the silty bed a.
iii. The deposition of torrent gravels as bed b.
iv. A period of non-deposition during which the gravels were exposed to pedogenic processes and a soil developed.
v. The erosion of soil of bed b.
vi. The formation of a lake due to damming of the Kabul river.
vii. The deposition of silt as bed d.
viii. The deposition of torrent gravels as bed c.
ix. The partial erosion of the gravels.
x. The deposition of loess as bed f.
xi. The partial erosion of loess, leading to gully erosion.

SECTION 21

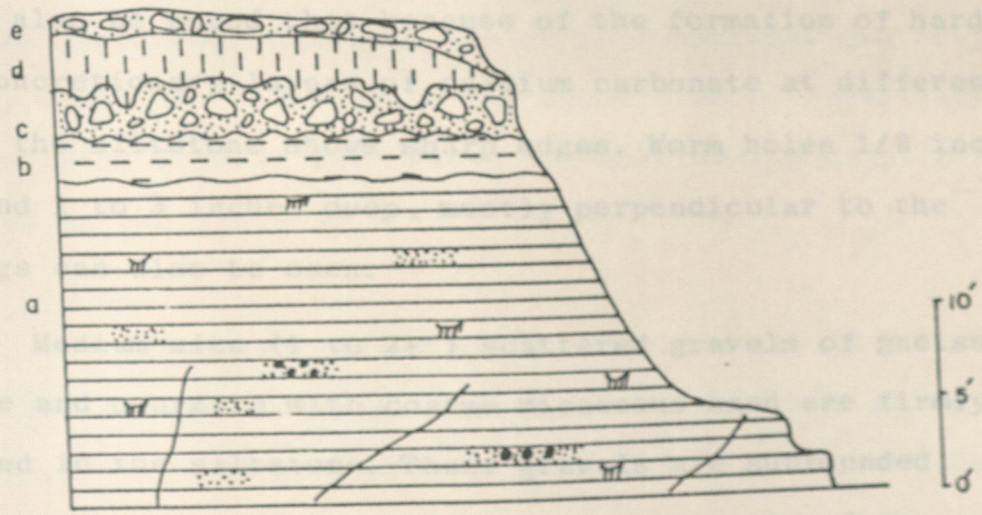


Fig. 4·21·1

4.21 SECTION 21

4.21.1 Field Description

This section is located on the left bank of Talab Khwar (GR 028845).* The following beds are exposed:-

Bed a:

It consists of a lake bed about 18 feet thick, composed of layers of hard siltstone, varying in colour from pale olive to light brown yellow (7.5 Y 6/4). The siltstone also contains soft bands of sand, 3 to 6 inches thick. Due to its erosion the siltstone shows "corrugated" surface. It should also be noted that because of the formation of hard thin concretionary layers of calcium carbonate at different levels the siltstone shows sharp edges. Worm holes 1/8 inch wide and 1 to 3 inches deep, mostly perpendicular to the beddings can also be seen.

Medium size (1 to 2½") scattered gravels of gneiss, granite and quarzite with coarse micaceous sand are firmly embedded in the siltstone. These gravels are subrounded, mostly weathered, and breaks easily on extraction from the bed. One gravel of gneiss is subangular and faceted. The siltstone beds contain numerous dykes of silt which are vertical as well as oblique, showing an angle of 60° to 75°. There are also some vertical open cracks or fissures. The upper surface shows an erosional unconformity.

Bed b:

The siltstone is overlain by a 2 feet thick bed of silt, the colour of which varies from yellowish red to strong

---

* For location of section, see fig. 4.20.1.1.

brown (6.5 YR 5/8). It is massive, structureless and very hard, and can be broken only by a hammer. It also contains very fine angular fragments of slate. Fossil root-holes of 1/8 inch length and fresh roots are also common. A marked erosional unconformity separates it from the overlying gravelly bed.

Bed c:

It consists of a gravelly bed, 1.5 to 3 feet thick, composed of subangular to subrounded, medium-sized gravels of slate and red sandstone of Murrees. It also contains numerous large, angular to subangular, cobbles of slate. The bed as a whole is disturbed. Cuttings and gully formations are very common, which are filled with the deposition of loess from the overlying loessic bed. There are also lenses of silt embedded in the gravels.

Bed d:

Bed d is a yellow to brownish yellow (10 YR 6.5/6) loess; its thickness varies from 1.5 to 3 feet. It is covered by a few patches of grey colour lichen. In places, it also contains fine nodules of calcium carbonate. Generally, it is massive and structureless but is soft, and can be easily broken by fingers. Internally, it exhibits fine beddings and minor laminations. It also contains very fine angular fragments of slate. The bed d has an unconformable contact with overlying gravelly bed.

Bed e:

The loess is covered with, about one foot thick, subangular to subrounded, loose gravels, of slate and sandstone,

LABORATORY EXAMINATION

Section 21

Table No. 4.21.2.2.1

Texture (Percentage)

	Sand	Silt	Clay
Bed 21b	21	60	19

Soil Characteristics

	Organic matter (%)	Calcium (Meq/1)	Magnesium (Meq/1)	Total Iron (%)
Bed 21b	1.34	0.16	2.24	-

Mineral Composition (Approximate Percentage)

	Bed 21b
Quartz	7
Feldspars	5
Clays	8
Opaque	12
Biotite	13
Muscovite	19
Carbonates	22
Amphibole	5
Chlorite	5
Rutile	2
Tourmaline	-
Epidote	-
Zircon	-
Sericite	-
Apatite	-

with occasional gravels of Murree sandstone.

4.21.2 Laboratory Examination

4.21.2.1 Texture

Bed b, is texturally silty loam, composed of 60% silt, 21% sand and 19% clay. (Fig. 4.21.2.1.1)

4.21.2.2 Chemical Analysis

Bed b, records a considerable amount of organic matter (1.34%) which indicates a thick growth of forest during a warm humid climatic phase.(Table-4.21.2.2.1)

4.21.2.3 Mineralogical Composition

Bed b is similar in mineral composition with silty beds in section nos.2,11,14,15 and 16 and 20.

4.21.3 Discussion

The lake bed a in this section is lithologically very similar to the lake beds exposed in sections 14,15,16 and 17. The presence of numerous dykes indicate that it was heavily involved in one of the Himalayan orogenies.

The deposition of stray lenses of gravels of igneous and metamorphic rocks with coarse micaceous sand on the lake bed indicate that these have been derived from the northern provenance and dropped on the lake bed by small ice rafted blocks as described and discussed in section 17.

The beds b and c represent facies of an alluvial fan as explained in sections 15,17 and 20. The laboratory examination of silty bed b suggests that after its deposition the pedogenic processes operated for a considerable period of time. It is believed that the climate was warm and humid,

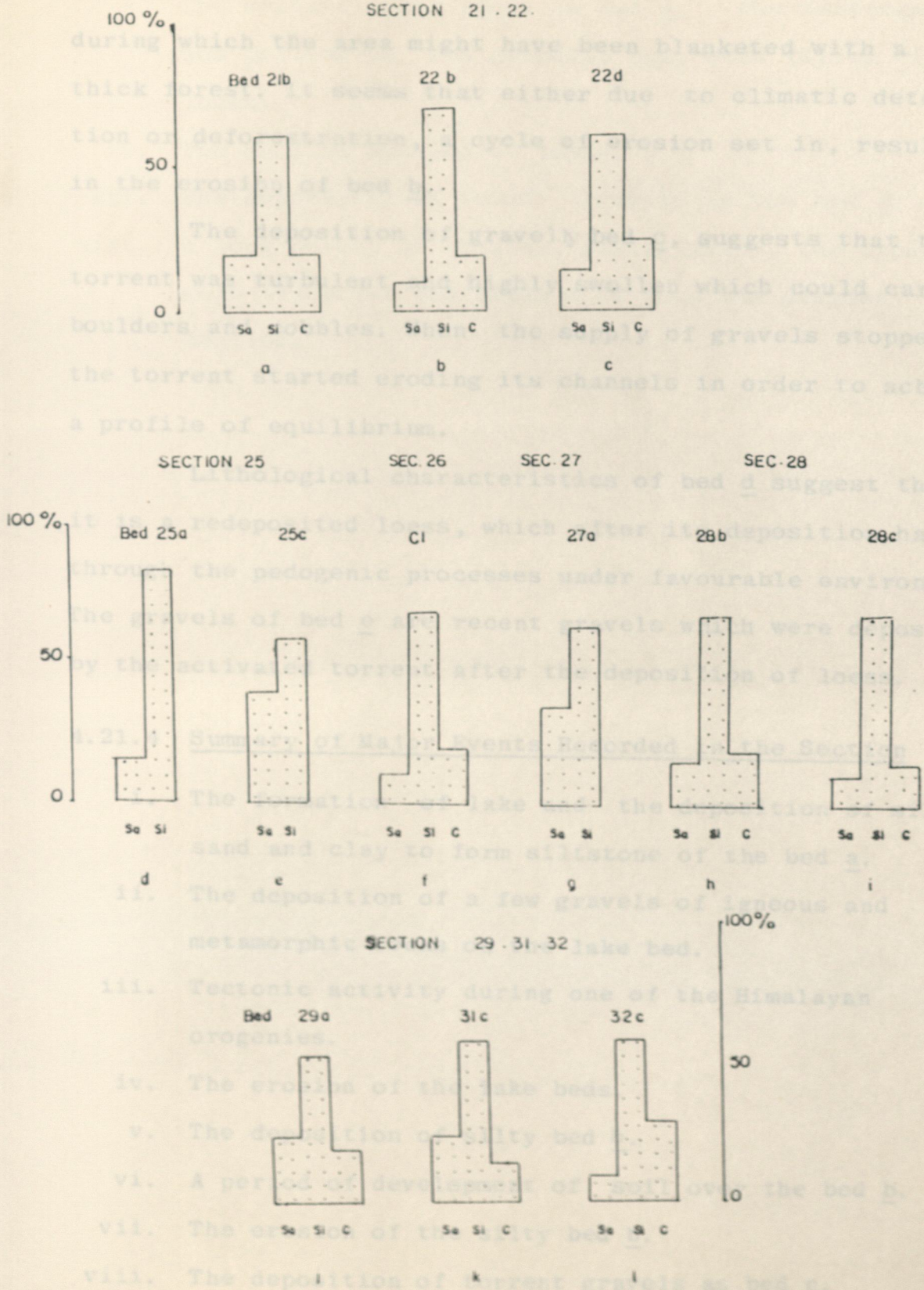


Fig. 4.21.2.1.1 Histogram showing Textural composition of various beds.

during which the area might have been blanketed with a thick forest. It seems that either due to climatic deterioration or deforestration, a cycle of erosion set in, resulting in the erosion of bed b.

The deposition of gravelly bed c, suggests that the torrent was turbulent and highly swollen which could carry boulders and cobbles. When the supply of gravels stopped, the torrent started eroding its channels in order to achieve a profile of equilibrium.

Lithological characteristics of bed d suggest that it is a redeposited loess, which after its deposition has gone through the pedogenic processes under favourable environments. The gravels of bed e are recent gravels which were deposited by the activated torrent after the deposition of loess.

4.21.4 Summary of Major Events Recorded in the Section

i. The formation of lake and the deposition of silt, sand and clay to form siltstone of the bed a.
ii. The deposition of a few gravels of igneous and metamorphic rocks on the lake bed.
iii. Tectonic activity during one of the Himalayan orogenies.
iv. The erosion of the lake beds.
v. The deposition of silty bed b.
vi. A period of development of soil over the bed b.
vii. The erosion of the silty bed b.
viii. The deposition of torrent gravels as bed c.
ix. The erosion of the gravelly bed, with intense cuttings.

x. The deposition of loess as bed d, the cuttings and gullies in the gravelly bed, were filled with loess.

xi. The partial erosion of loess.

xii. The deposition of recent gravels as the bed d.

xiii. A long period of erosion, during which, the deposits were dissected and exposed to form the present section.

SECTION 22

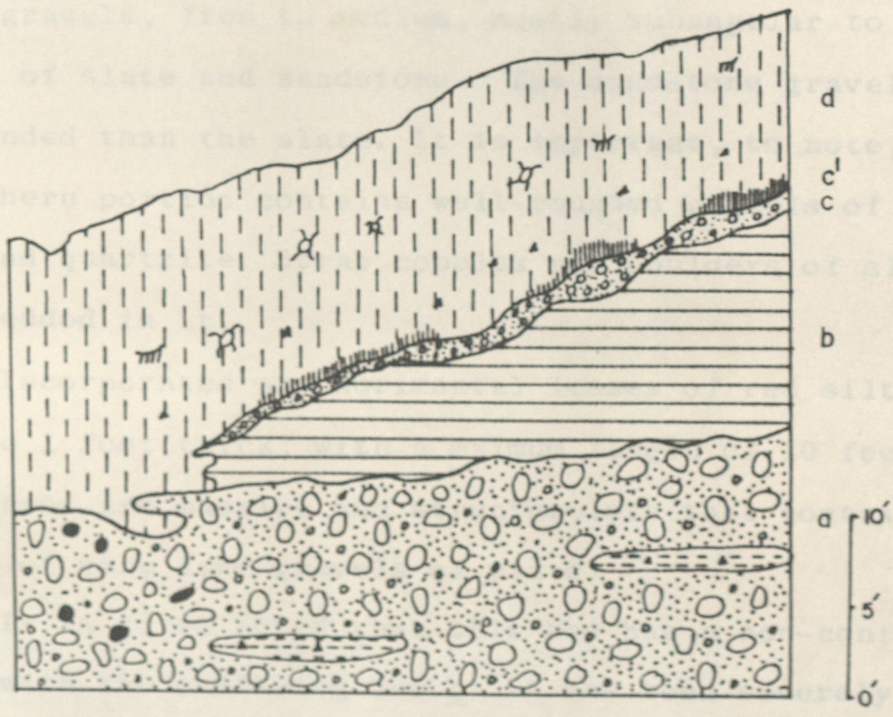


Fig. 4·22·1

4.22 SECTION 22

4.22.1 Field Description

This section is located on the right bank of Dakamar Khwar, near Gul Masti Dhand, (GR 016853).* The following beds are exposed:-

Bed a:

The lowest bed is composed of 12 to 15 feet thick torrent gravels, fine to medium, mostly subangular to subrounded, composed of slate and sandstone. The sandstone gravels are more rounded than the slate. It is important, to note, that its northern portion contains well-rounded gravels of granite, gneiss and quartzite. Stray cobbles and boulders of slate are also embedded in it.

Incorporated are horizontal lenses of red silt, 6 inches to 1 foot thick, with a mximum length of 10 feet. These silty lenses are massive and structureless that contain quite a number of very fine gravels of slate.

It is to be noted that this bed has a non-conformable contact with the overlying bed b. It has been severely eroded in the northern parts, and many small channels have been cut in it. As a result, gravels have a direct contact with the bed d.

Bed b:

This bed 3 to 12 feet thick, is composed of pale yellow (5 Y 7.5/6), finely laminated, soft silty clay beds. When wet the bed as a whole is very sticky. It also contains fine worm holes. However, the upper surface of this bed, shows

* For location of section, see fig. 4.20.1.1.

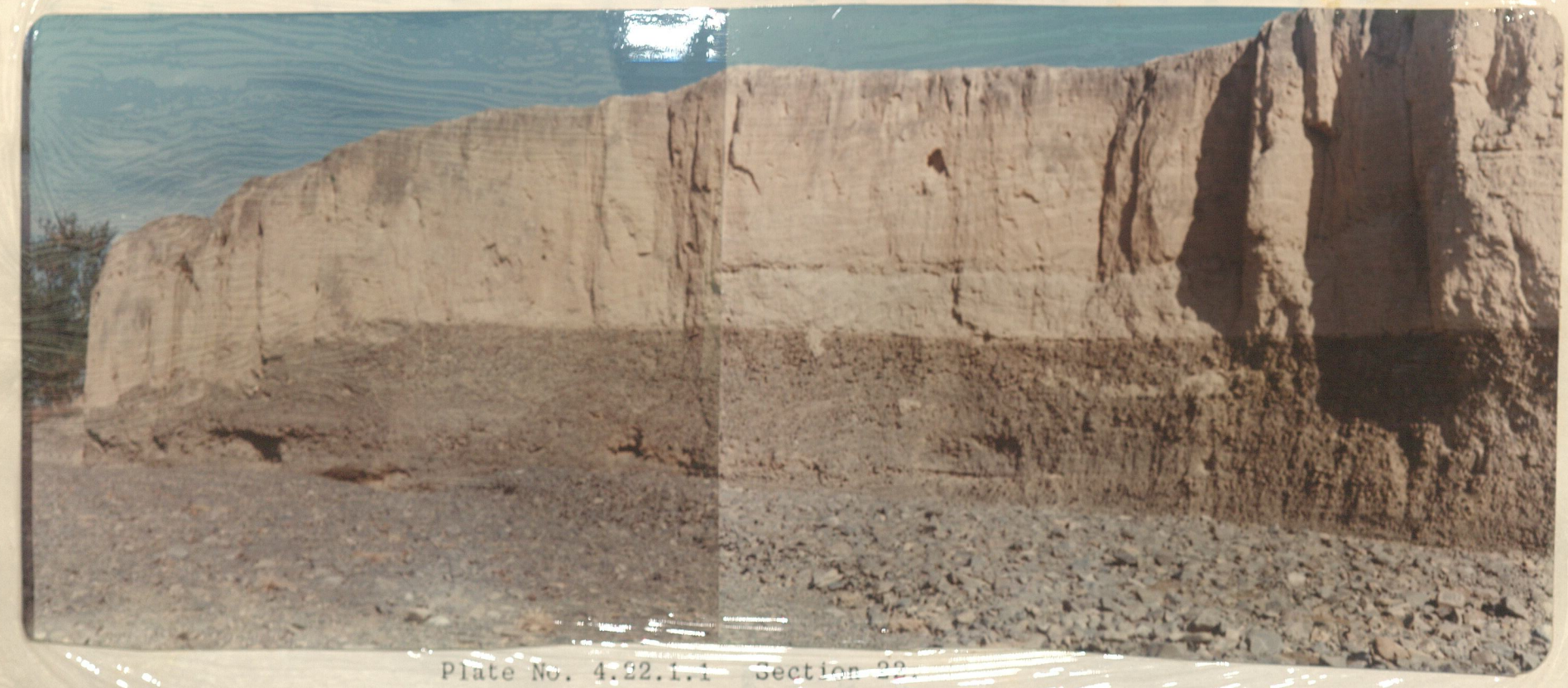


Plate No. 4.22.1.1 Section 22.

a very prominent erosional unconformity, which is overlain, by a thin bed of fine gravels mixed with coarse sand.

Bed c:

This bed of fine gravels, varies in thickness from 3 inches to a maximum 1 foot. Its upper and lower surfaces are very irregular, showing very prominent erosional unconformities. Incorporated are, thin bands of dark-coloured coarse sand. Its upper surface (C^1) is weathered and shows a prominent red brown colour.

Bed d:

It is a 10 to 15 feet thick deposit, of pale yellow to yellow (2.5 Y 7/5) loess. It is separated by an erosional unconformity from the underlying gravelly bed c. Its lower part also contains a large number of fine to medium gravels, scattered throughout the bed. In its northern end, the loess directly overlies the lowest bed a from where the beds b and c are completely eroded.

This bed of loess is massive containing nodules and concretions of $CaCo^3$. Due to gully erosion, it has been cut into vertical columns.

4.22.2 Laboratory Examination

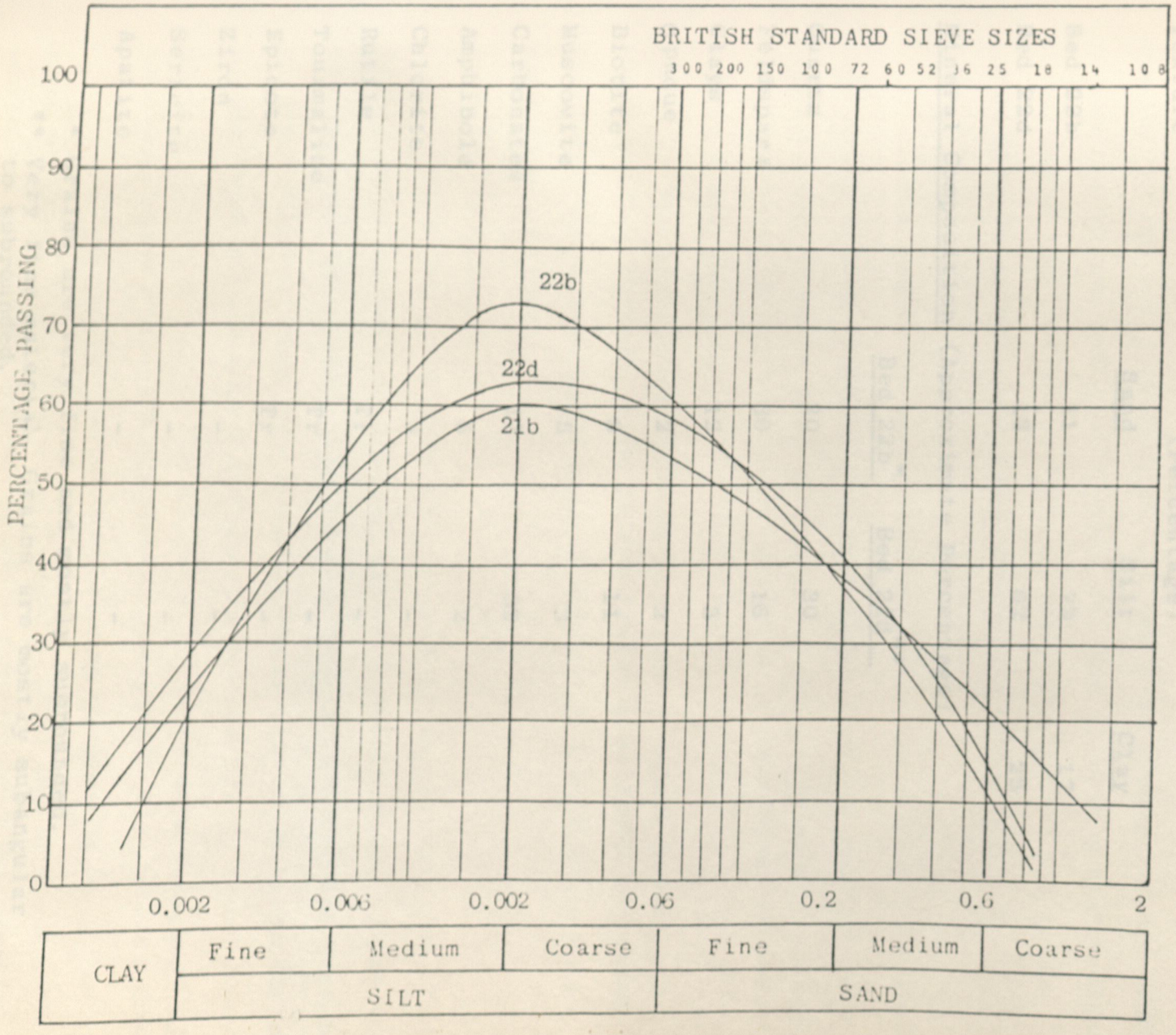
4.22.2.1 Texture

Bed b, is predominantly silty loam, with 72% silt, 17% clay and 11% sand. Bed d,is also silty loam, composed of 62% silt, 25% clay and 13% sand. (Fig.4.22.2.1.1) The texture of the two beds indicates that the bulk of the material is derived from the wind blown silt.

PARTICLE SIZE DISTRIBUTION

Sample No. 21b, 22b & d.

Fig: 4.22.2.1.1.



LABORATORY EXAMINATION

Section 22 — Table No. 4.22.2.2.1

Texture	(Percentage)		
	Sand	Silt	Clay
Bed 22b	11	72	17
Bed 22d	13	62	25

Mineral Composition (Approximate Percentage)

	Bed 22b*	Bed 22d**
Quartz	20	30
Feldspars	30	16
Clays	12	3
Opaque	2	2
Biotite	8	11
Muscovite	5	3
Carbonates	13	32
Amphibole	5	2
Chlorite	3	-
Rutile	Tr	-
Tourmaline	Tr	-
Epidote	Tr	-
Ziron	-	-
Sericite	-	-
Apatite	-	-

* Grains are very fine and mostly subrounded.

** Very fine material. Grains are mostly subangular to subrounded.

4.22.2.2 Mineralogical Composition

Bed b, is dominated by feldspars (30%). followed by quartz (20%), carbonates 13% and clays 12%, while biotite (8%) amphiboles (5%) and chlorite (3%) form minor constituents. It is similar to the bed f of section 15, bed e of section 16 and bed c of section 16 and bed c of section 20. Bed d, with a higher amount of carbonates (32%) and quartz (30%) is very similar to the other loess beds described previously. (Table-4.22.2.2.1)

4.22.2.3 Microscopic Study

The grains of bed b, are very fine and mostly subrounded, indicating a long distance transportation from its northern provenance. Bed d, shows very fine grains, which are mostly subangular to subrounded, exhibiting characteristics of wind blown material.

4.22.2.4 SEM Analysis

The individual grains of loess (bed d) shows broken and rough surface texture. Some of the grains also shows concoidal fractures and sharp angular edges. (Plate No. 4.22.2.4.1, 2, 3/Micrographs 2258, 2259 and 2262).

4.22.3 Discussion

The bed a, is part of a facies of an alluvial fan. The inclusion of gravels of igneous and metamorphis rocks in the torrent bed indicate that these gravels were deposited along the foot-hills of Attock-Cherat range, in a much earlier time from where the torrent picked them up, alongwith the weatehred material of local rocks and deposited as the bed a. The presence of silty beds indicates that the torrent was eroding and depositing simultaneously (Allen, 1965).

It seems that after the erosion of gravelly bed a, the Kabul river was dammed by the northward prograding alluvial fans as discussed in sections 14 and 15 and a lake was formed in which the bed b was deposited as lacustrine facies.

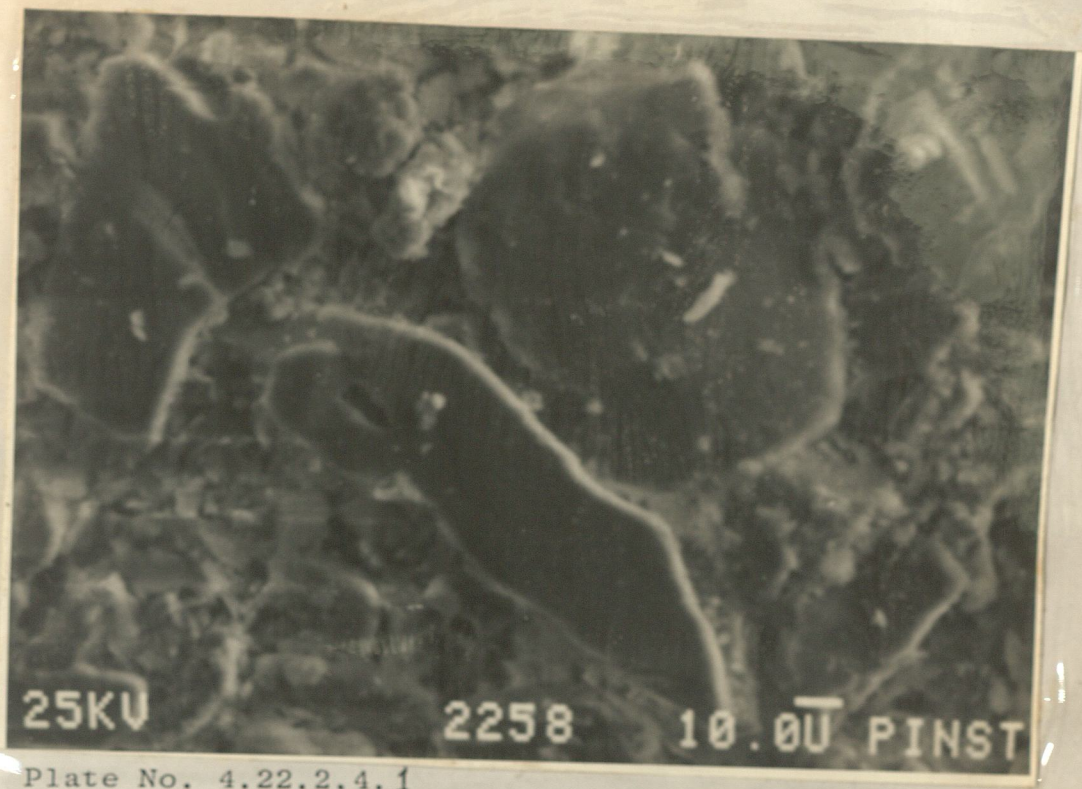


Plate No. 4.22.2.4.1

Micrograph showing shape of grains of loess.



Plate No. 4.22.2.4.2.

Micrograph showing surface texture of individual grain of loess.

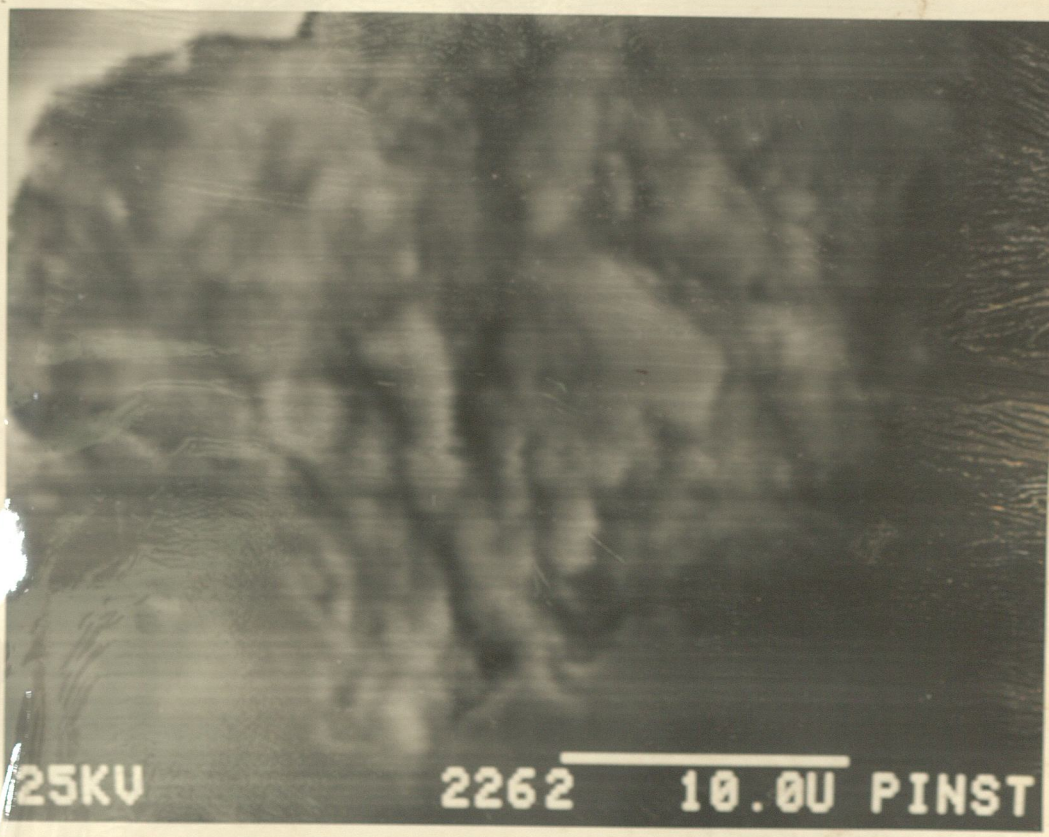


Plate No. 4.22.2.4.3

Micrograph showing surface texture of individual grain of loess.

As explained in section 20, due to the uplift of the Attock-Cherat range, the rejuvinated torrent deposited its second phase of younger alluvial fan on the eroded surface of lake bed. The bed $\underline{c}^1$ indicates that there was a long period of hault during which gravels of bed c were weathered and a soil horizon developed.

After the development of soil over the bed c, it appears that due to a deterioration of climate, another cycle of erosion operated for a long time, during which not only the soil and the gravelly bed c were eroded but also much of the lake bed (bed b) was removed from the northern part, so that the lower gravelly bed a was exposed. The weathered horizon of the upper surface of the gravelly bed c, indicates a post-erosion phase of weathering when CA horizon developed over the gravels.

The inclusion of quite a number of gravels of local slate in the loess suggest that it is redeposited, in which gravels and fragments of slate were washed down from the Attock-Cherat range during one of the wet spells.

4.22.4 Summary of Major Events Recorded in the Section

i. The deposition of torrent gravels as bed a.
ii. The erosion of bed a.
iii. The formation of a lake and deposition of bed b.
iv. The erosion of lake bed.
v. The deposition of gravels as bed c.

vi. A period of hault, in which the gravelly bed c was weathered and soil was formed.

vii. A long period of erosion during which not only the soil (C^1) was eroded but much of the gravelly bed c and part of lake bed (bed b) was eroded.

viii. The deposition of loess as bed d.

SECTION 23

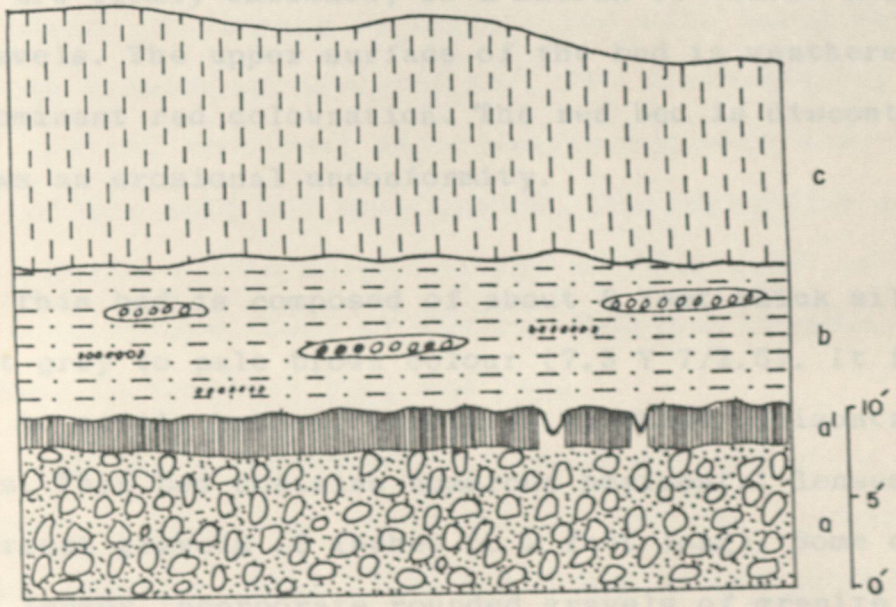


Fig. 4·23·1

4.23 SECTION 23

4.23.1 Field Description

This section is located on the left bank of the Dekamar Khwar (GR 012845).* It exhibits the following beds:-

Bed a:

This 10 feet thick bed, is composed of subangular to subrounded medium size gravels, of slate and sandstone. The gravels are firmly embedded, in a matrix of coarse sand and fine gravels. The upper surface of the bed is weathered and show prominant red colouration. The red bed is discontinuous and shows an erosional unconformity.

Bed b:

This bed is composed of about 8 feet thick silty clay, of light grey to pale brown colour (7.5 Y 7/2.5). It is soft and can be easily broken. In places it shows horizontal beddings. This bed contains numerous horizontal lenses of fine torrent gravels (6 inches to 2 feet long). Some of these gravel lenses incorporate rounded gravels of granite and quartzite. Fine fragments of slate, are distributed all over the bed. The bed has a non-conformable contact with the overlying bed c and the underlying bed a.

Bed c:

This bed 11 to 15 feet thick, is composed of pale brown to light yellowish brown (10 YR 6/3.5) loessic silt. It is soft and eroded easily. As a result it has been cut into vertical columns. In places the bed shows growth of grey

* For location of section, see fig. 4.20.1.1.

lichen. It also contains nodules of CaCo3. The whole bed is massive and structureless, but a closer examination reveals very fine beddings.

4.23.2 Discussion

It seems that after the deposition of gravelly bed a, the torrent's channel shifted its course leaving the gravels to the weathering and pedogenic processes, in a warm humid climate. As a result, a soil profile was developed. Later on, with a change of climate to aridity and with dying vegetation cover, the erosion of soil set in. The discontinuity of the red bed and the erosional unconformity suggests that the upper horizon of the soil has been eroded, leaving behind a part of the B horizon with concentration of iron oxide as the bed a1. A comparative study of various sections suggest it to be equivalent to sections 17c1 and 18b1.

The bed b represents facies of a flood plain which was formed by the Kabul river during vertical accretion as overbank deposit. This flood plain may be considered as contemporary to the lacustrine facies discussed in section Nos. 15,16,17 and 20. Due to periodical interfingering of torrent with the main stream, the gravels from the local rocks alongwith some gravels of granites and quartzites were deposited as lenses in the flood plain at different levels.

4.23.3 Summary of Major Events Recorded in the Section

i. The deposition of torrent gravels.

ii. A period of hault due to the shifting of the torrent's channel for a long time.

iii. The weathering of gravels and the formation of a soil.

iv. The erosion of soil from the gravel bed a.

v. The formation of the flood plain of the Kabul river and the deposition of silty clay, and its inter-fingering with the torrent gravels.

vi. The erosion of the flood plain.

vii. The deposition of loess.

viii. A very long period of erosion, during which the torrent carved its present channel in relation to the falling base level.

ix. A period of aggradation during which the torrent is currently depositing material in its channel.

SECTION 24

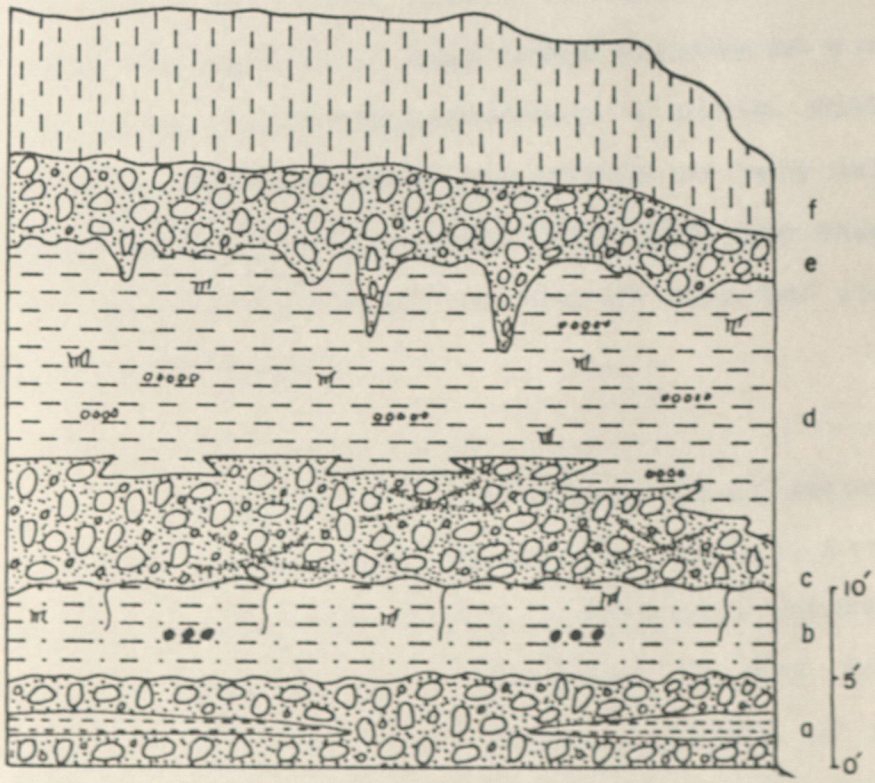


Fig. 4-24-1

4.24 SECTION 24

4.24.1 Field Description

This section is located on the right bank of the Dakamar Khwar (GR 016828).* It is a very complicated and disturbed section. The following beds have been outlined and studied from below upward:-

Bed a:

This bed 4 to 5 feet thick, is composed of medium to large size, subangular to subrounded gravels of a variety of local rocks, ranging from sandstone, to slate, shale and limestone. Two silty beds (one foot thick) of very pale brown to light yellowish brown colour (10 YR 6.5/8) are sandwiched between the gravels. The upper surface of this bed also shows an erosional unconformity.

Bed b:

Bed b, consistsof a 5 feet thick bed of alternate layers, of light grey to pale brown (7.5 Y 7/2.5) clay and sand. The clay is hard and contains horizontal concretion of $CaCo^3$ while the sand, on the other hand, is soft and loose. A prominant feature of the bed, is the occurence of rounded to well-rounded gravels, of gneiss, granite and quartzite, embedded in clay. Also, included in it are a few large aub-angular, dark coloured gravels, of ultramafic rocks. This bed, also shows, a few vertical cracks, filled with loose sand and silt. The upper surface of the bed shows an erosional unconformity.

* For location of section, see fig. 4.20.1.1.

Bed c:

This bed, 6 feet thick, is composed of subangular to subrounded, medium to large, gravels of sandstone, slate and limestone, that are embedded in a sandy gravelly matrix. Cross-beddings and channel cuttings are common. Also, found are large cobbles and boulders, of sandstone and limestone. As a whole, this bed is greatly disturbed. Its upper and lower surfaces show very prominent erosional unconformities.

Bed d:

A silty bed, 10 to 12 feet thick, overlies the gravelly bed c with an erosional unconformity. It contains concretions of $CaCo^3$ and fine gravels laid in parallel bands. The bed material has been cut into vertical columns by gully erosion.

Bed e:

It is a 2 to 5 feet thick bed, of fine to medium size, subangular to subrounded, loose gravels, of sandstone and slate. Its lower contact, with the silty bed, shows an erosional unconformity. Also, it has an unconformable contact, with the overlying bed.

Bed f:

A bed of loess 8 to 10 feet thick, pale brown to light yellowish brown (10 YR 6/3.5) which is massive and structureless, shows 3 to 4 beds which internally shows fine laminations. It also contains nodules of calcium carbonate. Fine fossil root-holes are frequently found which are filled with dark grey decayed organic matter. It is soft, and can

be easily scratched.

4.24.2 Discussion

i. This section shows two alluvial fan facies separated by a facies of the flood plain of the kabul river.

ii. The gravels of bed a, were deposited by a turbulent torrent which was rapidly changing its channel. The deposition of gravels and silt, suggest high and low water discharge of the torrent respectively. These conditions indicate oscillation of climatic conditions from wet to dry/semi-dry environments.

iii. The beds c, d and e also represent another facies of an alluvial fan which is separated by a facies of the flood plain of the Kabul river. The deposition of these beds indicate similar circumstances as explained above.

iv. The bed b, separating two facies of the alluvial fan is a flood plain facies of a slow moving meandering stream in which cutt-off channels, during floods a temporary lake was formed in which fine material was deposited. The parallel bands of concretions of calcium carbonate at different levels, indicate frequent exposure to evaporation and leaching. The vertical cracks are interpreted as dessication cracks (Allen, 1979) later on filled in by sand and silt, during overflooding. The inclusion of lenses of torrent gravels, alongwith rounded pebbles of granite and quartzite point out to interfingering of the torrent, with the bed b at different times.

v. The deposition of loess, shows warm dry environment with a few wet spells, during which it was washed down slowly from the up-slopes. Frequent fine fossil rootes indicate growth of grasses and bushes in warm semi-dry climate.

vi. It should be noted that in this section two very clear phases of (i) weathering and (ii) the formation of alluvial fans, separated by a period of flood plain can be recognized.

4.24.3 Summery of Major Events Recorded in the Section

i. The deposition of gravels as bed a.

ii. The partial erosion of gravelly bed a.

iii. The formation of a flood plain in which clay and sandy beds were deposited as bed b.

iv. The interfingering of torrent with the main stream and deposition of lenses of gravels and pebbles.

v. The partial erosion of torrent gravels (bed c).

vi. The deposition of gravels as bed c.

vii. The erosion of gravel bed c.

viii. The deposition of silt as bed d.

ix. The erosion of silty bed d.

x. The deposition of gravels as bed e.

xi. A period of non-deposition.

xii. The deposition of loess as bed f.

xiii. A very long period of erosion during which these beds were dissected and the present channel of the torrent was formed.

SECTION 25

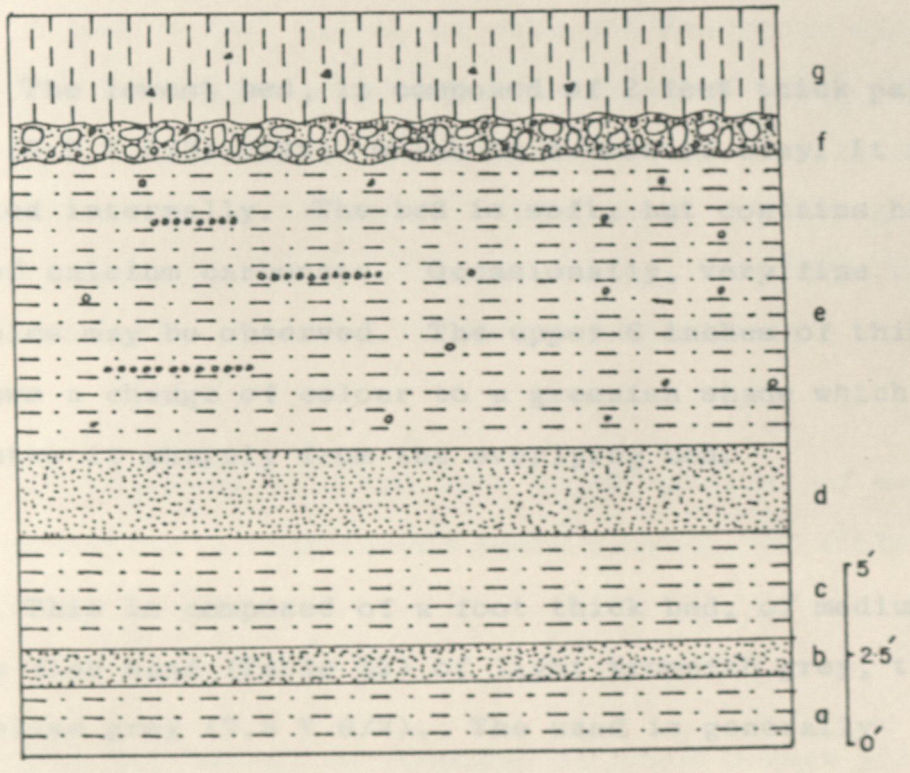


Fig. 4·25·1

4.25 SECTION 25

4.25.1 Field Description

Located on the left bank of Paloseen Khwar (GR 982836)*, this section, about 20 feet thick, is composed of silty and sandy beds, overlain by gravels and a loessic bed on the top. The section shows the following sequence of beds:-

Bed a:

The lowest bed, is composed of 2 feet thick pale yellow (5 Y 7.5/3) silt, which is devoid of clay. It is laminated internally. The bed is soft, but contains hard bands of calcium carbonate. Occasionally, very fine root-holes may be observed. The upper 6 inches of this bed shows a change of colour to a greenish shade which demarcates it sharply from the overlying bed.

Bed b:

This is composed of a foot thick bed, of medium to very fine sand (Table 22) of light brownish grey, to light olive grey (7.5 Y 6/2). The sand is generally loose and soft.

Bed c:

This bed, 3 feet thick, is composed of massive, hard silt of pale yellow colour (5 Y 7.5/3). It is also devoid of clay particles. It breaks into platey blocks and also shows an internal fine laminations. A

* For location of section, see fig. 4.20.1.1.

four inch thick bed of greenish shade, similar to bed b, overlies this bed.

Bed d:

This bed, 2 feet and 6 inches thick, is composed of incoherent, coarse sand, of light grey to light brownish grey colour (2.5 Y 6.5/2).

Bed e:

A bed, 8 feet thick, of pale yellow colour silt, (5 Y 7.5/3) is deposited over the lower sandy bed d. It is massive, hard and breaks into platty blocks. It also contains horizontal lenses (6 inches to 1 foot long) of fine gravels of slate, found at three different levels. There are also scattered gravels embedded in places in the bed.

Bed f:

It consists of a one foot thick material of medium size, subangular to subrounded loose gravels, of slate and limestone.

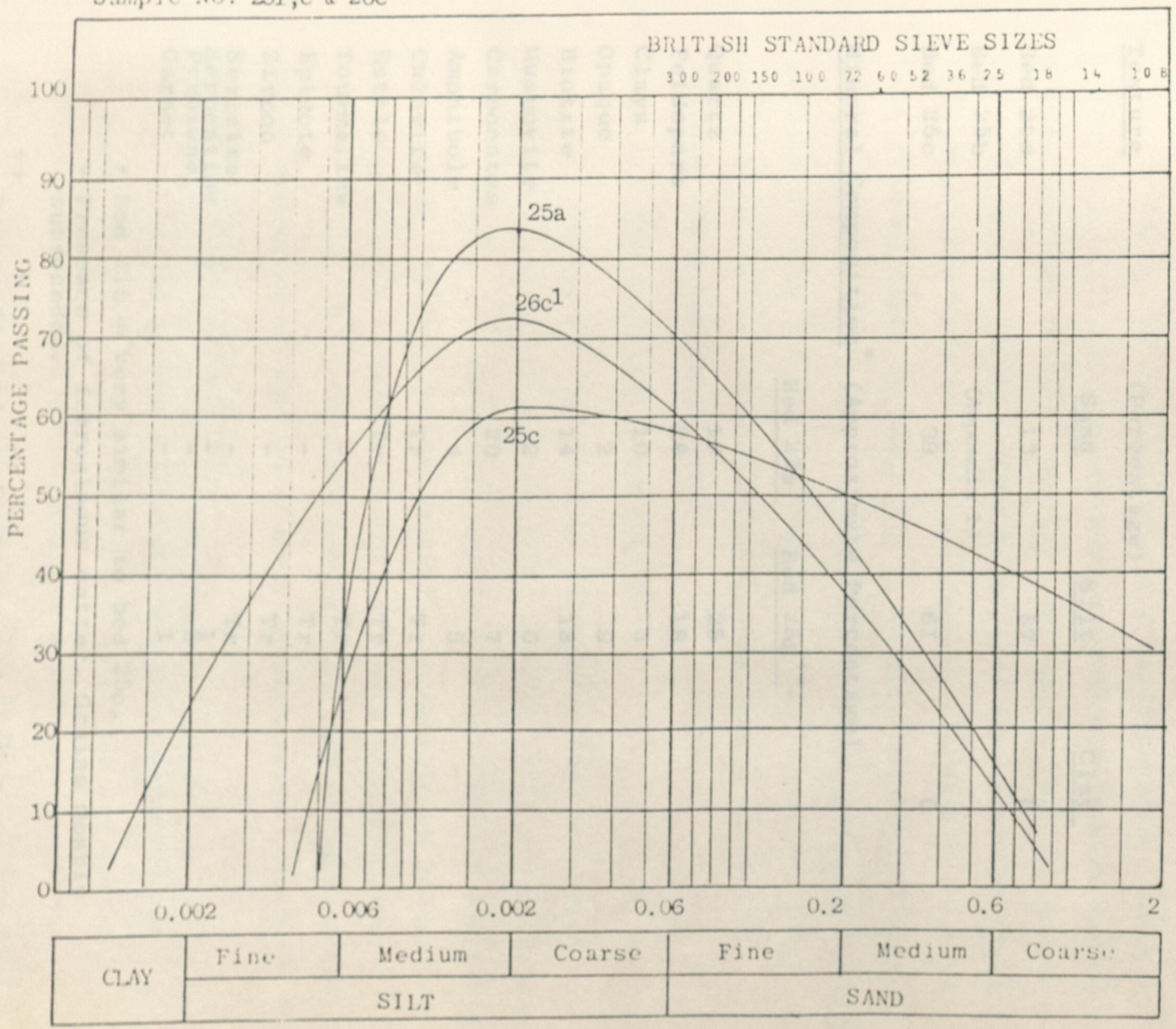
Bed g:

The top bed g, is composed of about 3 feet thick loess of pale brown to light yellowish brown (10 YR 6/3.5) colour. It is soft and can be easily scratched with fingers. In places, it contains quite a number of nodules of calcium carbonate and frequent fine gravels of slate. Fossil root holes one inch long filled with dark grey decayed matter can also be seen. The surface is covered with a few patches of grey lichens.

PARTICLE SIZE DISTRIBUTION

Fig.4.25.2.1.1.

Sample No. 251,c & 26c[1]



LABORATORY EXAMINATION

Section 25 — Table No. 4.25.2.2.1

Texture (Percentage)

	Sand	Silt	Clay
Bed 25a	13	87	0
Bed 25b	(Appendix 1)		
Bed 25c	39	61	0

Mineral Composition* (Approximate Percentage)

	Bed 25a+	Bed 25c++
Quartz	18	25
Feldspars	28	18
Clays	10	3
Opaque	2	9
Biotite	14	18
Muscovite	2	6
Carbonates	20	7
Amphibole	4	5
Chlorite	Tr	Tr
Rutile	Tr	Tr
Tourmaline	-	Tr
Epidote	-	Tr
Zircon	-	Tr
Sericite	-	Tr
Serpentine	-	1
Pyroxene	-	5
Garnet	-	1

* Bed 25b is very similar to bed 25c.

\+ Presence of ferruginous matter. Grains mostly subrounded.

++ Devetrified glass fragments and rock fragments present. Shape of grains is mostly subangular.

4.25.2 Laboratory Examination

4.25.2.1 Texture

Bed a, is composed of silty sandy material, dominated by 87% silt, 13% sand with no clay. Bed b is sand having a wide range of texture, showing very coarse (9.25%), coarse (15.5%), medium (21.1%), fine 21.00% and very fine 33% sizes (Appendix-1).Its wide textural arrangement suggests its derivation from multiple sources. Bed c, is also composed of silty material, with 61% silt, 40% sand and no clay. (Fig.4.25.2.1.1) The absence of clay and high percentage of sand indicates its derivation during a cold climatic phase from a variety of igneous and metamorphic rocks.

4.25.2.2 Mineralogical Composition

Bed a, is dominated by feldspars (28%) and quartz (18%) followed by carbonates (20%) biotite (14%) and amphiboles (4%). Bed b, is composed of quartz (25%), feldspars and biotite (18% each) followed by opaque (9%) with amphiboles and pyroxene (5% each). It also has traces of very hard minerals like rutile, tourmaline, sericite and zircon, indicating a provenance dominated by igneous and metamorphic rocks.(Table-4.25.2.2.1)

4.25.2.3 Microscopic Study

In bed a, the grains are mostly sub-rounded and contains ferruginous matter. In bed b, grains are mostly subangular. It shows devetrified glass and rock fragments. The material has probably been derived from glassy igneous rocks, found in the north and north-western areas, along Main Mantle Thrust.

4.25.3 Discussion

1. The beds from a, to e, represent facies of a flood plain formed by the Kabul river. It is suggested that these sedimentary facies were deposited in a generally well-developed meandering belt, of the Kabul river. The deposition of silt/sand apparently having a cyclic character in this section suggests, periodical overflooding of the channel, in which silt was deposited, as suspension load over the channel sand, at a time when the flood water subsided. This flood plain may be considered as contemporary to the third lake phase a little south which separated two phases of younger alluvial fans.

2. Bed e, suggests that the torrent began to deposit its load on the flood plain, during which scattered torrent gravels and their few lenses were deposited. It also suggests that the meandering stream shifted its course and replaced by a torrent.

3. The physical characteristics of the loess bed suggest that it was deposited in a warm dry phase, with intermittent wet spells, during which the silt was washed down, alongwith few fine gravels and very fine fragments of local rocks. Fine holes, filled with dark grey matter, suggest the growth of sparse vegetation like bushes or grasses, during a semi-dry and warm climate.

4.25.4 Summery of Major Events Recorded in the Section

i. Formation of the Kabul river flood plain.

ii. The inter-fingering of torrent gravel with the flood material.

iii. The deposition of torrent gravels.

iv. The deposition of loess.

v. A long period of erosion, during which the present section was exposed and the present channel of the torrent was formed.

SECTION 26

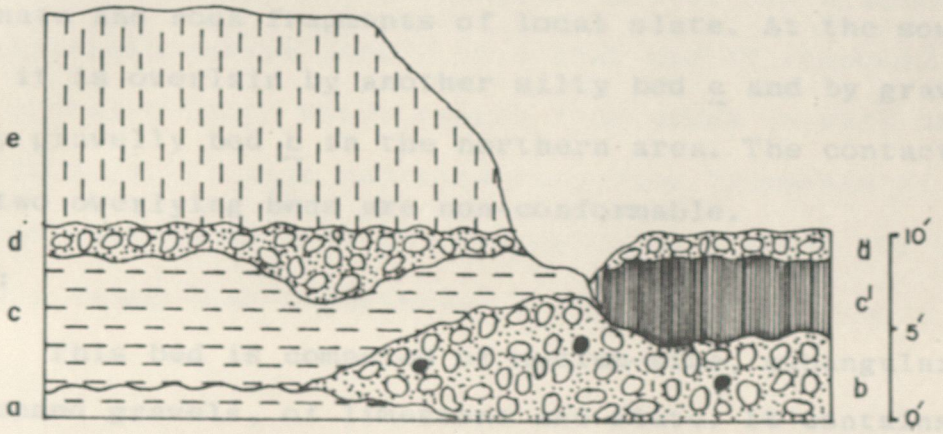


Fig. 4·26·1

4.26 SECTION 26

4.26.1 Field Description

This section is located on the left bank of Paloseen Khwar (GR 10582).* The following beds are exposed from below upward.

Bed a:

The lowest exposed bed is a 2 feet thick, bed of silt, of very pale brown to light yellowish brown colour (10 YR 6.5/8). It is hard, massive and can be broken only by a hammer. Incorporated are, fine concretions of calcium carbonate and rock fragments of local slate. At the southern part, it is overlain by another silty bed c and by gravelly and by gravelly bed b in the northern area. The contacts with two overlying beds are non-conformable.

Bed b:

This bed is composed of medium-size, subangular to subrounded gravels, of limestone and slate. It contains numerous well-rounded pebbles of granite and quartzite. Although, this bed is exposed right from the bottom of khwar channel and lies in the same horizon as the silty bed a, yet the erosional surfaces with overlying of gravels suggest, that its stratigraphic position is younger than the silty bed a, and that it was deposited on the bed a, after its partial erosion.

Bed c:

This bed, about 7 feet thick, is composed of silt

* For location of section, see fig. 4.20.1.1.

of very pale brown to light yellowish brown colour (10 YR 6.5/8). In places, it contains very fine gravels and angular fragments of slate. Fine concretions of calcium carbonate are also present frequently. It is hard and massive and breaks into platy blocks. It has a non-conformable contact with the overlying bed d as well as with the underlying bed b.

Bed c1:

The bed c, extends northward where it is burried under a thin cover of gravels. Its exposed part which makes the bed c1, is conspicuously different from the parent bed c. The bed c1 overlies an extension of gravel bed b,unconformably. Its thickness varies from 1 to 4 feet and is composed of a dark coloured silt, which ranges from brown to dark brown (7.5 YR 5/4). It also contains very fine fragments of slate and concretions of calcium carbonate. As a whole the bed shows a crumb like structure.

Bed d:

The bed c and c1 are overlain by an irregular and uneven bed of loose gravels of limestone and sandstone, which are mostly subangular to subrounded. Its thickness, varies from 1 to 4 feet. Its contact with the bed c and c1 clearly shows an erosional unconformity.

Bed e:

This bed is composed of 6 to 12 feet thick, loess deposits, of yellow to very pale brown colour (10 YR 7/5). Though massive, it shows two to three beddings. At places

LABORATORY EXAMINATION

Section 26 — Table No.4.26.2.3.1

Texture (Percentage)

	Sand	Silt	Clay
Bed 26c[1]	12	72	16

Soil Characteristics

	Organic matter(%)	Calcium (Meq/1)	Magnesium (Meq/1)	Total Iron (%)
Bed 26c[1]	1.54	1.00	0.60	0.234

Mineral Composition (Approximate Percentage)

	Bed 26c[1]*
Quartz	10
Feldspars	4
Clays	16
Opaques	10
Biotite	10
Muscovite	20
Carbonates	22
Amphibole	2
Chlorite	3
Rutile	1
Tourmaline	1
Epidote	-
Zircon	-
Sericite	-
Apatite	-

* Blackish brown ferruginous material is abundance. Grains are very fine and subrounded.

it is loose and weathered, as it shows nodules of calcium carbonate, which varies in size and shapes. Also, embedded in it, are fine fragments of slate and small lenses of sand. The loess has undergone severe gully erosion as a result it has been completely eroded from the bed d.

4.26.2 Laboratory Examination

4.26.2.1 Texture

Bed c1, is predominantly composed of silty loam with silt (72%) clay (16%) and sand (12%) (Fig.4.21.2.1.1).In fact it exhibits a well developed soil profile.

4.26.2.2 Chemical Analysis

Bed c1, contains a high percentage (1.54%) or organic matter which would suggest the presence of a thick forest cover.

4.26.2.3 Mineralogical Composition

Bed c1, is dominated by carbonates (22%) followed by muscovite 20%, clays 16%, and with biotite, quartz and opaque 10% each. Feldspars form low component (4%). Amphiboles, rutile and tourmaline form minor constituents. Mineral and textural composition suggests that it is a thoroughly homogenised material in which feldspars seem to be chemically weathered into clays during warm humid climate. Mineral composition also suggests that the material may have been derived mostly from rocks like Manki slate, limestone, and sandstone and shale of Murree Formation. (Table-4.26.2.3.1)

4.26.2.4 Microscopic Study

Microscopic examination indicates that grains are very fine and subrounded. It contains abundant blackish brown ferru-

It appears, that besides igneous and metamorphic rocks, some of the material from local sedimentary rocks have also been incorporated. A higher percentage of feldspars as compared to quartz indicate weathering of fedlspars by granular disintegration in cold arid climate either than its chemical decomposition. Glacial areas characterised by physical weatering provide feldspar-rich debris. Similarly, very rapid erosion of feldspars may also take place in response to rapid uplift in which the feldspars simply do not have the time to undergo weathering (Ollier, 1975, p.55). Bed g, with its high percentage (38%) of carbonates is very similar to the other loess beds (Table-4.15.2.3.1)

4.15.2.4 SEM Analysis

The individual grains in loess (bed g) shows irregular and rough surface texture and sharp edges (Plates No. 4.15.2.4.1 & 2) Micrographs 2251 & 2260).

4.15.3 Discussion

(i) Beds a^1 and a^2 indicate that these are "Overbank deposition" of a flood plain facies of the Kabul River. The bed a^1 was deposited as channel sand, while the bed a^2 was laid down, when the water in excess of the channel capacity of the Kabul river began to flow overbanks and inundated parts of the flood plain, and deposited finer material (silty clay of the bed a^2) from suspension over the channel sand a^1 (Leopold, et al., 1964, p.323).

(ii) Probably, after the deposition of the bed a^2, the Kabul river was dammed due to the uplift of south-eastern parts of the vale resulting in the lacustrine conditions, in which the siltstone of bed b, was deposited as lake bed. The enviromments of deposition of the siltstone (bed b) seems to be different from the deposition of bed a which

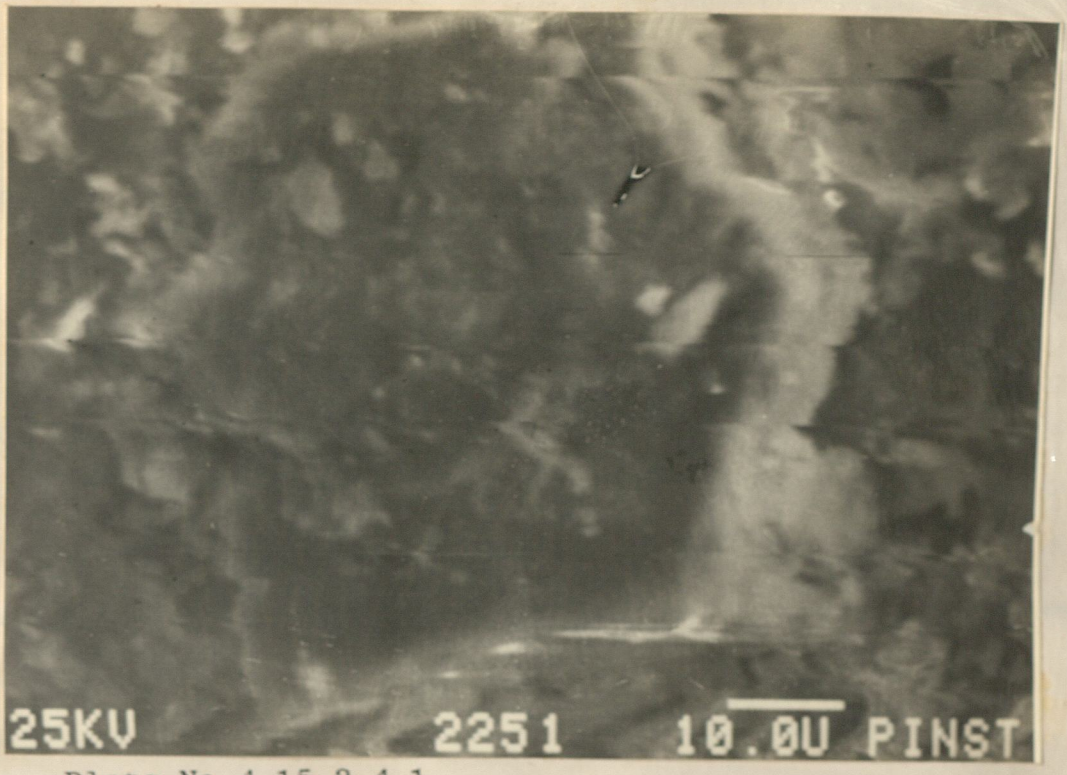


Plate No.4.15.2.4.1.

Micwograph showing surface texture of individual grain of loess.

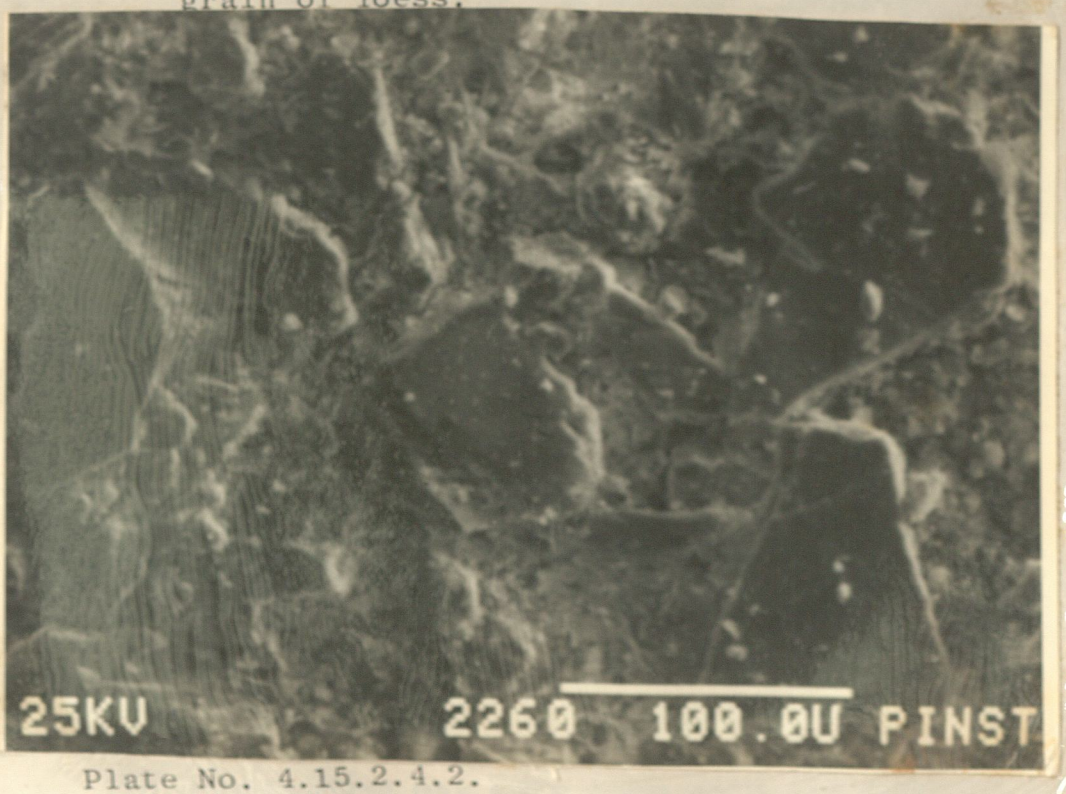


Plate No. 4.15.2.4.2.

Micrograph showing shape of grains of loess.

has been referred to as flood plain facies.

The laboratory examination of the beds b and g reveals that both are similar in texture and grain shape. This shows that the material of both these beds have been derived from same area and under similar environments. This analysis also indicates that a considerable amount of wind blown silt (loess) has been deposited directly into the lake as early loess. The cementation of silt into hard siltstone of the lake bed and the leaching of $CaCo^3$ also confirms the deposition of loess which has a high percentage of carbonates (38%). The deposition of the loessic silt turned the lake into boggy and marshy conditions, the only organism, that could flourish in such environments were small worms, leaches and their larvae etc. The fine laminations, presence of concretion of $CaCo^3$ at various levels indicate that at a time it was a shallow water lake, with wet and dry conditions, during which temporary fluctuation of lake surface and consequent exposure of the lake bed at different times resulted in leaching and concentrationsof $CaCo^3$ and iron in the B horizon of a pedocal soil.

The difference in the physical characteristics between the siltstone and underlying clay bed clearly indicates difference of facies and their environments.

From the above dicussion, it can be inferred that initially the lake was formed during a cold phase with a corresponding glacial stage in the Himalayas. During this period, the temperature may have been very low with a very restricted growth of organism. The deposition of loessic

silt in the lake, frequent exposure of lake bed and development of B horizon of the soil, all clearly suggest the occurence of a warm phase perhaps corresponding to an inter-glacial stage over the Himalayas.

(iii) After the lake was filled with sediments, the southern rim of the Peshawar vale was involved in one of the Himalayan orogenies. There are ample field evidence to indicate that lake beds were consequently uplifted and warped, resulting in the falling of the local base level. In response to the Himalayan uplift, a phase of erosion was initiated by the Kabul river and rejuvinated torrents draining the Attock-Cherat range. This resulted in a large scale erosion and removal of the lake beds from a very large part of the Peshawar vale. There were, however, lake beds which escaped erosion and are now exposed in various parts of the Peshawar vale. It is suggested that this phase of erosion may have been initiated during another cold phase.

It is further suggested that during this cold phase, while erosion was taking place in the main vale, the higher slopes of Attock-Cherat range were subject to intense frost action and repeated freeze and thaw, leading to mechanical disintegration of rocks. The Attock-Cherat range is mostly composed of slate, phyllite, shale and some limestone and sandstone. These rocks are highly susceptible to frost weathering (Leopold, et al., 1964, Ollier 1975, and Briggs,1977).

Field evidence also suggests that such areas of the Attock-Cherat range did develop a deep weathering zone during the cold climate due to freeze and thaw. Due to the freezing

temperature the weathered material, however, was frost jammed (King, 1975).

This was followed by an amelioration of climate during which vegetation, and a thick blanket of soil, covered the slopes of the Attock-Cherat range. Field evidence also indicates the development of soil cover, over favourable areas of eroded siltstone in the vale. This phase of soil and vegetation development was, generally speaking, a period of non-deposition.

It is suggested that due to the Himalayan orogeny and setting of a cold climate (Glacial over the Himalayas) the dying vegetation, iniitiated another phase of erosion. This accelerated erosion removed the soil cover from the Attock-Cherat range (Said and Majid, 1977) and deposited it in various parts of the vale as profile of an "Inverted Soil" as bed c.

After the removal of the soil cover, the deeply weathered parent rocks of the Attock-Cherat range was eroded with an increase in the discharge during wet conditions.It was easy for the swift and turbulent stream to carry away the weathered coarse debris, re-work it, and deposit it as a thick gravelly bed d over the inverted soil (bed c). The prominant cross-bedding of this bed suggest it to be a fast moving, swift and turbulent stream, whose channel was changing rapidly and frequently (Reineck and Sing, 1973). The presence of lenses of silt within the gravelly bed indicate change in the velocity of the transporting stream.

The deposition of beds (c) and (d) was followed simultaneously by aggradation in the main valley. This period is believed to be a warm inter-glacial, over the Himalayas in areas north of the Peshawar vale, when the rapid melting of the glacial ice exposed morainic debris. The abundant supply of glacio-fluvial material, resulted in an increase in the bed load of Kabul-Swat-Bara rivers. Their channels were widened and mid-channel bars formed leading to braiding (Schumm, 1960, Reading, 1980). Thus aggradation in the main valley closely followed by aggradation in the side valleys of the Attock-Cherat range. (Leopold, et al., 1964).

The inter-glacial was followed by another glacial period in the Himalayas. The streams were shrunken and the supply of morainic material was reduced. Therefore, aggradation was followed by a phase of degradation, in order to acquire a "profile of equilibrium." Consequently, the Kabul river began to erode its bed, which resulted in the lowering of the local base level, and consequently the local torrents followed the degradation process in the main Peshawar vale. This resulted in the erosion of the gravelly bed d.

The erosion of gravelly bed d was followed by the deposition of bed e. Its massive structure with few beddings, its silty texture and inclusion of fine gravels and angular fragments of slate/shale suggest, it to be a facies of the mudflow deposit. Its circumstances and environments of deposition has already been discussed in section 14c. The small roote holes suggest growth of fine vegetation like grasses while nodules of $CaCo^3$ indicate its leaching after

the deposition.

(iv) The bed f is interpreted as a lake bed which may be considered as an extension of the younger lake bed exposed in section 32c. The presence of dessication cracks and formation of nodules of $CaCo^3$, indicate drying at the surface, due to fluctuating water table in a warm semi-dry environments. Dark colour fossil roots suggest, growth of grasses and shrubs-like vegetation (Walker and Cantt , 1979, p.24, Allen 1979, p.137).

(v) The top most bed represents, a period of loess deposition during a warm dry period, with occasional humid spells during which pedogenic process were active.

4.15.4 Summary of Major Events Recorded in the Section

i. The deposition of sand and clay beds by the Kabul river.

ii. Damming of the Kabul river and the formation of a lake in which bed b was deposited as the siltstone.

iii. A very long period of erosion, during which lake beds were eroded from a large part of Peshawar vale.

iv. The weathering and development of soil over siltstone and the upper slopes of the Attock-Cherat range.

v. The erosion of upper soil from the siltstone and also from the Attock-Cherat range.

vi. The deposition of silty bed c by torrent over the eroded surface of siltstone.

vii. A period of non-deposition and partial erosion of the silty bed b.

viii. The deposition of gravels as bed d by the torrent.

ix. The erosion of gravelly bed d.

x. The deposition of another silty bed e.

xi. Partial erosion of bed e.

xii. The deposition of bed f.

xiii. The deposition of loess as bed g.

xiv. A long period of erosion during which the present section was exposed and the present channel of the torrent was formed.

SECTION 16

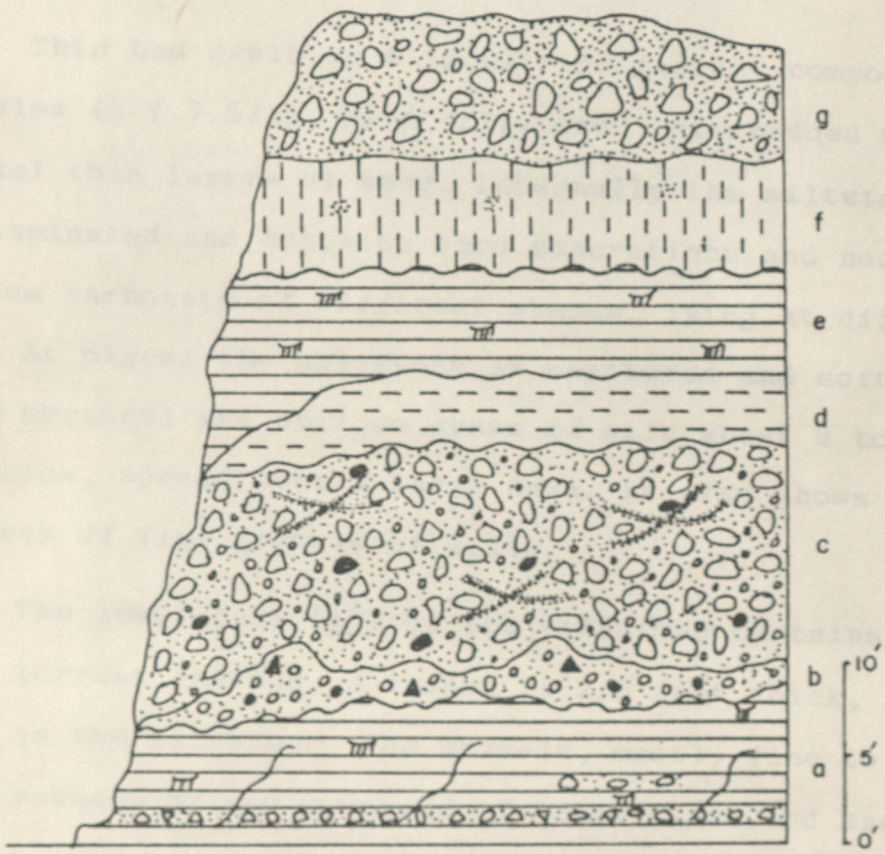


Fig. 4.16.1

4.16 SECTION 16

4.16.1 Field Description

This section is exposed along right bank of the Babu Khwar (GR 097863).* The following beds are exposed:-

Bed a:

This bed exhibits a lacustrine facies, composed of pale yellow (5 Y 7.5/4), hard siltstone, interbedded with occasional thin layers of sand. Internally the siltstone is finely laminated and contains hard concretions and nodules of calcium carbonate of different shapes, lying at different levels. At places the siltstone is weathered and soft. It contains vertical and oblique dykes of silt about 2 to 3 inches thick, spread over a large area. It also shows stray thin lenses of fine gravels of slate.

The lower part (a^1) of the siltstone contains a layer of torrent gravels, 6 inches to 2.5 feet thick, firmly embedded in the siltstone. The gravels, mostly fine to medium size are subangular and composed of local slate and sandstone.

Bed b:

The upper part of the siltstone abruptly gives way to an uneven and discontinuous (about 2 feet thick) bed of coarse sand, of grey brown colour, mixed with lenses of fine to medium gravels of slate, which are resting on the eroded surface of the siltstone. These lenses of gravels also contain a few well-rounded, medium-sized, gravels of granite, gneiss,

*For location of section, see Fig.4.13.1.1.



Plate No.4.15.1.1 Section 16.

quartzite and some dark colour heavy unltramafic rocks. The upper surface of this bed shows a well-marked erosional unconformity.

Bed c:

A 8 to 15 feet thick massive bed of subangular to subrounded gravels (2 to 3 inches) of dark grey sandstone and slate overlies bed b. The gravels are embedded in a matrix of coarse sand and fine gravels, showing prominent cross-beddings. This gravelly bed also contains a considerable number of rounded to well-rounded pebbles of granite, gneiss and quartzite. Besides, it also contains subangular cobbles and a few boulders of local rocks.

Bed d:

This bed is composed of light yellowish brown to brownish yellow (10 YR 6/5) silt, 2 to 3.5 feet thick, which is massive, structureless and hard. In places it contains very fine angular fragments of slate. If hit by a hammer it breaks into blocky structure. It is cut into vertical column due to erosion. It is separated by an erosional unconformity from the overlying bed e.

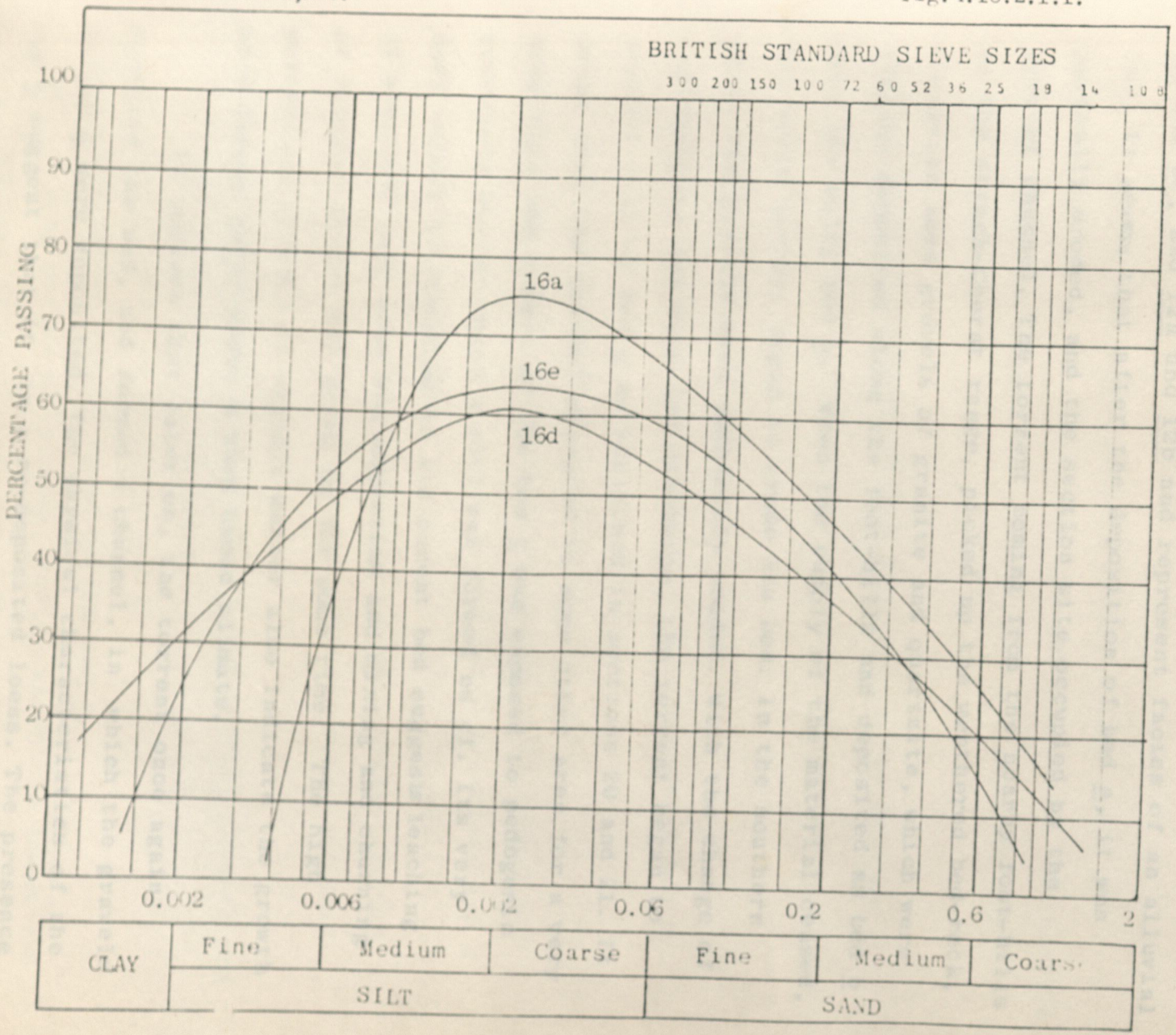
Bed e:

It consists of a pale yellow (5 Y 7.5/4), 6 to 10 feet thick bed of silty clay. The whole bed is arranged in prominent layers. Internally, each layer shows fine laminations. These layers are separated by hard concretionary layers of 0.3 to 1 inch thick, which can only be broken by hammer. These concretionary layers are found at different levels. Occasionally,

PARTICLE SIZE DISTRIBUTION

Sample No. 16a,d&e.

Fig.4.16.2.1.1.



ginous material which indicates chemical weathering during hot humid spell.

4.26.3 Discussion

The beds a and b are similar to the beds 4c and 4d, 8b and 8c, and 12a and 12b and represent facies of an alluvial fan. It seems that after the deposition of bed a, it was partially eroded, and the section site occupied by the torrent channel. The torrent coming from the nearby foot-hills of the Attock-Cherat range, picked up the weathered bed-rock, alongwith some gravels of granite and quartzite, which were already deposited along the foot-hills and deposited as bed b over the silty bed a. When the supply of the material ceased, the swift torrent began to erode its bed. In the southern part, the gravels were completely eroded. With the change of environments and with low discharge, the torrent began to deposit silt of bed c as explained in sections 20 and 21. It seems that the channel migrated to some other area for a very long time and a part of the bed c was exposed to pedogenic processes during which a soil was formed as c1. Its very dark colour is compared to its parent bed suggests leaching of minerals like iron and magnesium and mixing and churning of organic matter was going on for some time. The high percentage (1.54%) of organic matter also indicate the growth of a forest cover under a warm humid climate.

It appears that later on, the torrent once again occupied the bed, and formed a channel, in which the gravels of bed d were deposited. The physical characteristics of the bed e suggest that it is a re-deposited loess. The presence of noduls of calcium carborate with fine rock fragments of slate and lenses of sand indicate that loess was deposited

in a warm dry climate with intermittent wet spells during which it may have been washed down from the higher slopes of the Attock-Cherat range.

After the deposition of loess, a long phase of erosion set in as is clear from the gully erosion. The torrent cut the beds and carved its present channel exposing the present section.

4.26.4 Summary of Major Events Recorded in the Section

i. The deposition of silty material as the bed a, by the torrent.

ii. The erosion of bed a.

iii. The deposition of gravels by the torrent as bed b.

iv. The erosion of gravelly bed b.

v. The deposition of another silt as bed c.

vi. A period of non-deposition during which a part of bed c (c^1) was exposed to pedogenic processes and a soil was formed.

vii. The erosion and formation of a deep channel by the torrent, on the bed c, and partial erosion of soil at c1.

viii. The deposition of gravels, in the torrent channel and the formation of the bed d.

ix. The erosion of gravelly bed d.

x. The deposition of loess as the bed e.

xi. A long period of erosion, during which the loess was subject to gully formation. The beds were cut and exposed by the torrent and the present channel of the torrent was formed.

SECTION 27

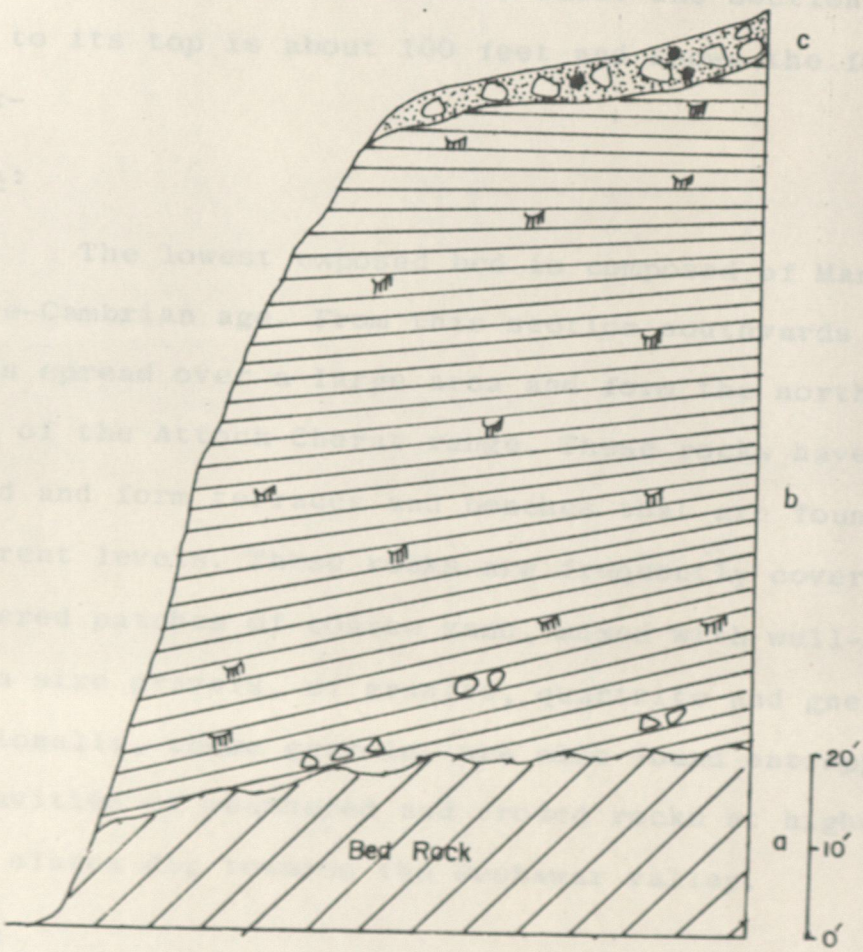


Fig. 4·27·1

4.27.1 Field Description

This section is located along Piran nala near Baitul Gharib (GR 077848).* It exhibits thick beds of lacustrine deposits along the incised nala. The section from the base to its top is about 100 feet and shows the following beds:-

Bed a:

The lowest exposed bed is composed of Manki slate of pre-Cambrian age. From this section southwards the Manki slates spread over a large area and form the northern foothills of the Attock-Cherat range. These rocks have been eroded and form terraces and benches that are found at different levels. These rocks are frequently covered with scattered patches of coarse sand, mixed with well-rounded, medium size gravels, of granite, quartzite and gneisses. Occasionally, these gravels, are also found entrapped in the cavities of weathered and eroded rocks at higher slopes. Manki slates dip towards the Peshawar valley.

Bed b:

The slates are overlain by a thick formation of silt, of pale yellow to pale olive colour, (5 Y 6.5/3.5) interbedded with, thin seams of grey brown sand.

The lowest bed, which rests on the eroded bench of the slate contains angular fragments of weathered slate. Similarly, there are occasional thin layers of such fragments,

* for location of section, see fig. 4.27.1.1.

LOCATION OF SECTIONS

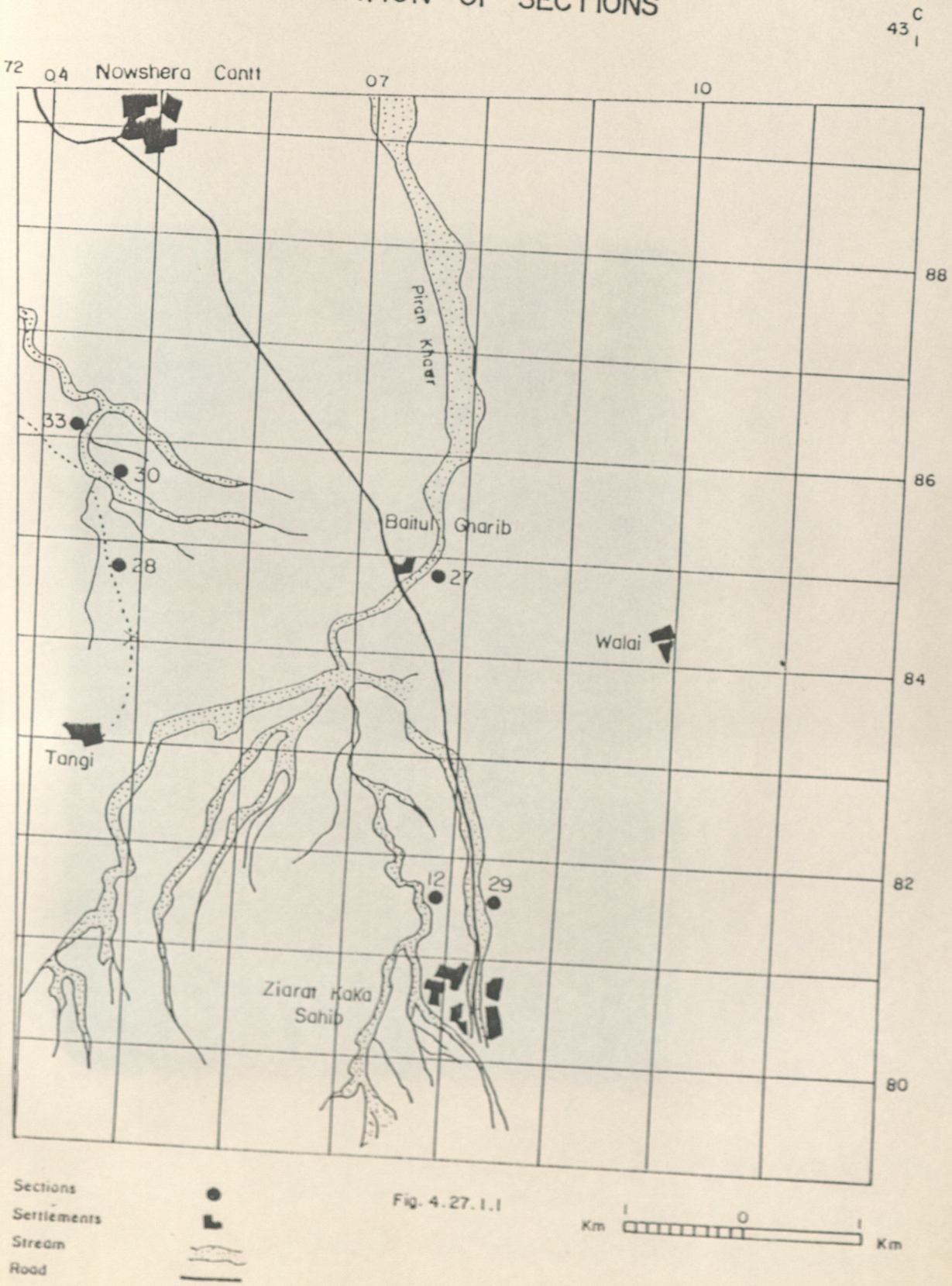


Fig. 4.27.1.1



Plate No. 4, 27-1-1 Section 27.

embedded in the silt at few other levels.

Although the whole formation is generally hard and indurated into siltstone, there are however, soft and weathered beds at different levels, which also contain horizontal concretions of calcium carbonate. These silty beds, also contain fine worm holes which are prependicular to the bedding plane, while a few worm-tracks are parallel to it. There are also numerous root-holes filled with a brown grey matter.

It is important to note, that the silt and sand of the siltstone are mostly repetitive and have graded strata. Comparatively, the lower beds are more sandy, while the thickness and massiveness of silty clay, gradually increases upward. It has also been observed that the lower half of the beds are titled, while the upper seems to be undisturbed. Beds of the upper part also contain mottling of red brown colour.

Bed c:

The lake beds are overlain by a thin bed of torrent gravels, mostly subangular, of slate and shale. The gravels contains pockets of loess..

4.27.2 Laboratory Examination

4.27.2.1 Texture

Bed a, is composed of silty sandy material with 67% silt, 33% sand and no clay (Fig. 4.21.2.1.1) It appears that most of its material has been derived from wind blown loessic silt.

4.27.2.2 Chemical Analysis

Bed b, contains a very high amount of organic matter (2.68%). It also contains an appreciable amount of calcium (Meq/1) 3.10 and magnesium (Meq/1) 3.86. These characteristics indicate growth of very thick vegetation, most like a dense forest which flourished in warm humid spell during which leaching of minerals and salts concentrated, in the B horizon, of a well-developed soil profile. (Table-4.27.2.2.1)

4.27.2.3 Mineralogical Composition

This bed is dominated by quartz (30%) and feldspars (21%), followed by biotite (15%) and carbonates (10%) with traces of epidote, sericite and zircon. This composition indicates a northern provenance of igneous and metamorphic rocks.

4.27.2.4 Microscopic Study

Its grains are subangular to subrounded, which would indicate it is most likely the product of frost shattering or glacial grinding during a cold/glacial phase. (Plate No.4.27.2.4.1)

4.27.3 Discussion

The erosion of Manki slates and the formation of erosional terraces and benches, at different levels suggest intermittent uplifts of the Attock-Cherat range, followed by a very cold climate which may have been a beginning of a glacial phase over the Higher Himalayas, north of Peshawar vale.

LABORATORY EXAMINATION

Section 27

Table No. 4.27.2.2.1

Texture (Percentage)

	Sand	Silt	Clay
Bed 27b	33	67	0

Soil Characteristics

	Organic matter (%)	Calcium (Meq/1)	Magnesium (Meq/1)	Total Iron (%)
Bed 27b	2.68	3.10	3.86	0.227

Mineral Composition (Approximate Percentage)

	Bed 27b*
Quartz	30
Feldspars	21
Clays	6
Opaque	3
Biotite	15
Muscovite	2
Carbonates	10
Amphibole	8
Chlorite	Tr
Rutile	3
Tourmaline	-
Epidote	Tr
Zircon	Tr
Sericite	Tr
Apatite	-

* Grains are subangular to mostly subrounded.

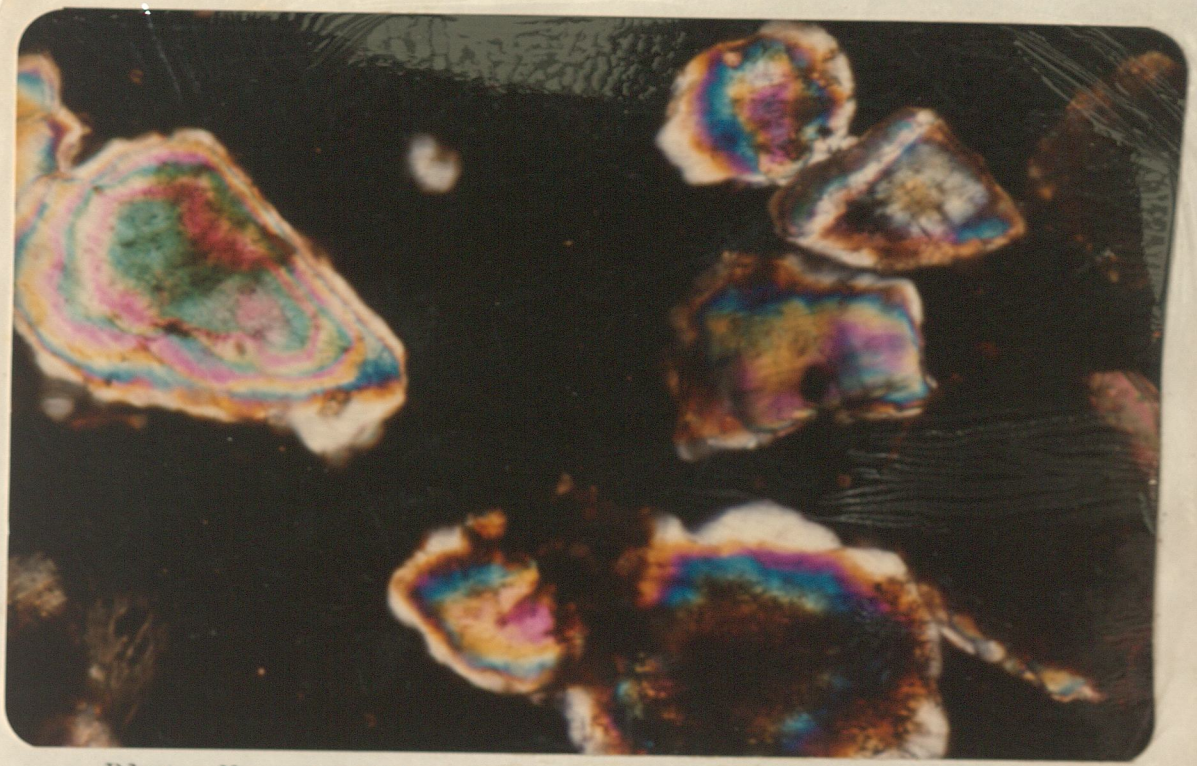


Plate No. 4.27.2.4.1. Lakebed (27b).

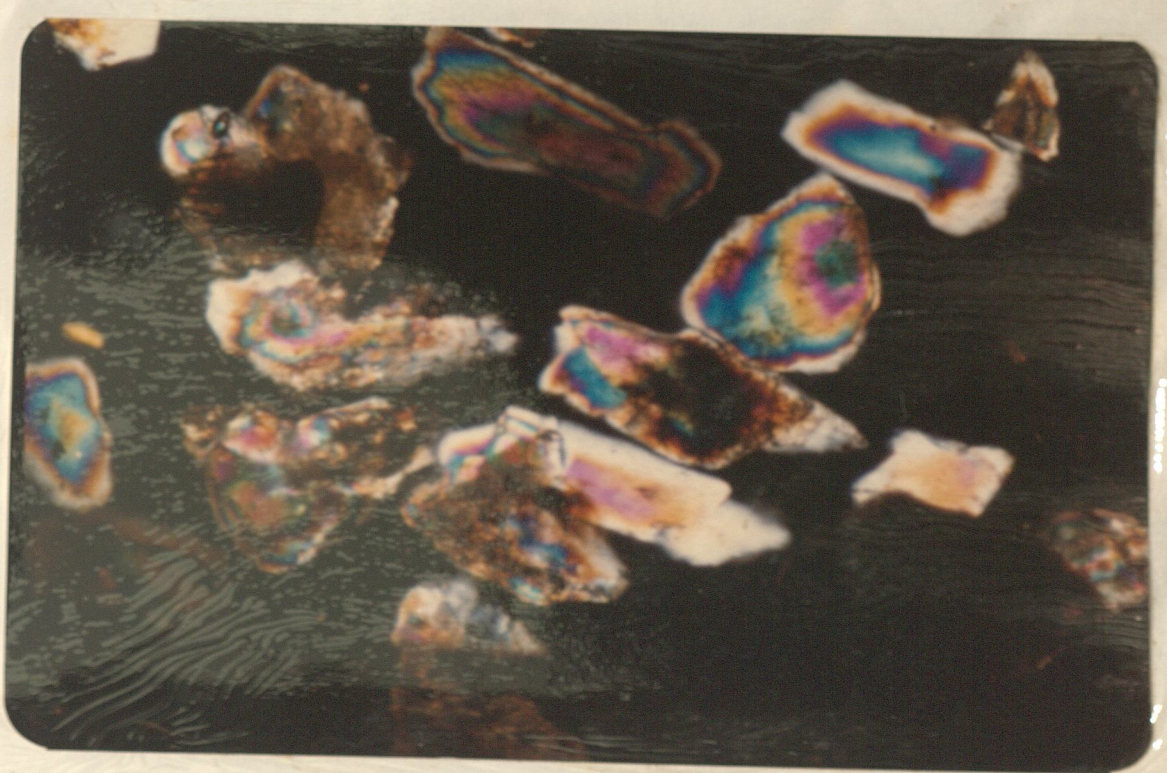


Plate No. 4.28.2.4.1 Loess (28c).

i. During a cold phase, the clay bearing rocks like slates, shale and phyllites, of the Attock-Cherat range were intensely weathered, during freez-thaw activities. It is suggested, that due to the uplift of the Attock-Cherat range, and with onset of a glacial phase over the Himalayas the base level may have fallen considerably, initiating a phase of erosion in the vale. It appears, that during this phase not only the northern slopes of the Attock-Cherat range were eroded and planned off, but the present depression of the vale was carved out. It is also suggested, that the present gorge of the Piran nala has also been carved, during this phase of erosion.

ii. After the glacial phase was over, a lot of morainic material comprising igneous and metamorphic rocks was released by the melting and retreating glaciers during the following warm interglacial phase, picked up by the tributaries of the Swat-Kabul rivers as glacio-fluvial material and deposited in the vale as a valley fill of great thickness, that the lower foot-hills of the Attock-Cherat range were burried. "Indeed the evidence of high terraces around the periphery amply indicates that the pre-Pleistocene topography was 'drowned' during the lower Pleistocene by the accumulation of valley fill to an elevation several hundred feet above the present valley surface." (Allen and Dani, 1964).

iii. The patches of sand and gravels of igneous and metamorphic rocks found on higher slopes and erosional benches indicate that they are the remnants of an older vally fill.

iv. Perhaps due to an uplift, or a glacial phase, another cycle of erosion set in during which, most of the valley fill was eroded, except, those resting on higher slopes, in between the foot-hills, or those gravels and patches of sand, now resting on the eroded benches. Their higher position also suggests that the area has since been uplifted.

v. The graded beds of silt and sand of the bed b suggests that they were deposited in a shallow water lake. The cyclic nature of the deposition, indicates a continuous supply of material from the source area under a cold/glacial phase. The soft and weathered beds at different levels containing concretions of calcium carbonate, with occasional mottling of red brown colour, indicate regressions and transgressions of lake water, during which the lake beds were frequently exposed, initiating, leaching of calcium carbonate and iron, in a dry and humid environments. This rise and fall of the lake level indictes a periodic oscilliation of climate during the lake phase.

vi. The presence of a thin bed of angular fragments in the lower portion of the lake bed suggests a minor cold phase during which due to freez/thaw, action and physical breaking of Manki slate, angular fragments were produced, which were washed down the slope and deposited on the lake bed.

vii. The repetitive and graded strata of the lake beds also indicate that there was no torrent activity.

viii. The tilt of the lower beds indicate that the tectonics were syn-depositional.

ix. The presence of fine worm-holes and worm-tracks are the only sign of life, which suggests that the boggy and marshy conditions of the lake could only support such burrowing organism as worms, leaches and their larvae. The marshy conditions in the lake may have been produced, at a time when besides the fluvial sediments, a considerable amount of wind blown silt (loess) had been directly deposited, in the lake during some warm/interglacial phase.

x. A high percentage (2.63%) of organic matter suggests a phase of thick growth of vegetation on the marginal areas of the lake.

xi. Texturally, the lower parts of the lake beds are predominantly silt (67%) and sand (33%) and devoid of clay while the upper beds contain more silt and clay; they are massive and hard, and contain less sandy layers. This would perhaps indicate that during this part of the deposition, the lake was much deeper, in which silty clay was deposited as suspended material. This also suggests that abundant clay was produced in the preceding warm humid climatic phase. The frequent mottling of the silty clay in the upper beds also confirm the above contention. After the lake was filled by sediment to a certain level aggradation stopped. Due to a change of environments from warm to cold, with dying vegetation or to falling base level, another cycle of erosion began to operate during which most of the lake beds were eroded from the vale and a new topography was formed. During this erosion phase, the Attock-Cherat range was subject to intense weathering due to freez-thaw cycle. After the erosion

of the lake beds, in the following warm and wet phase, the slopes released the weathered material and the torrents draining the Attock-Cherat range picked them, reworked and deposited it on the eroded surface of lake, as alluvial fans.

xii. The thin bed of gravels (c) over the lake bed suggests that much of the gravels deposited has been eroded, while thin patches of loess on the gravels also suggest that after its deposition a long phase of erosion set in during which most of the loess was eroded.

4.27.4 Summary of Major Events Recorded in the Section

i. The uplift of the Attock-Cherat range during one of the Himalayan orogenies.

ii. A very long period of erosion, and peneplanation during which the present basin of the Peshawar vale has been carved.

iii. A long period of deposition, during which the vale was filled, with a variety of sediments.

iv. A period of erosion during which most of the valley fill was eroded except those which rested along the higher slopes of the foot hills of the Attock-Cherat range. Probably, the Piran gorge was formed during this period.

v. A period of another uplift, during which the southern and eastern rim of the Peshawar vale were raised and blocked the drainage by transforming the vale into a lake.

vi. The deposition of silt and sand in the lake to form the siltstone of bed b.

vii. The weathering of local rocks.

viii. Regression and transgression of the lake water.
Exposure of lake beds.

ix. Syn-depositional uplift of the lake bed.

x. The erosion of the lake beds.

xi. The deposition of torrent gravels as bed c.

xii. The deposition of loess.

xiii. The erosion of loess, and lake beds.

SECTION 28

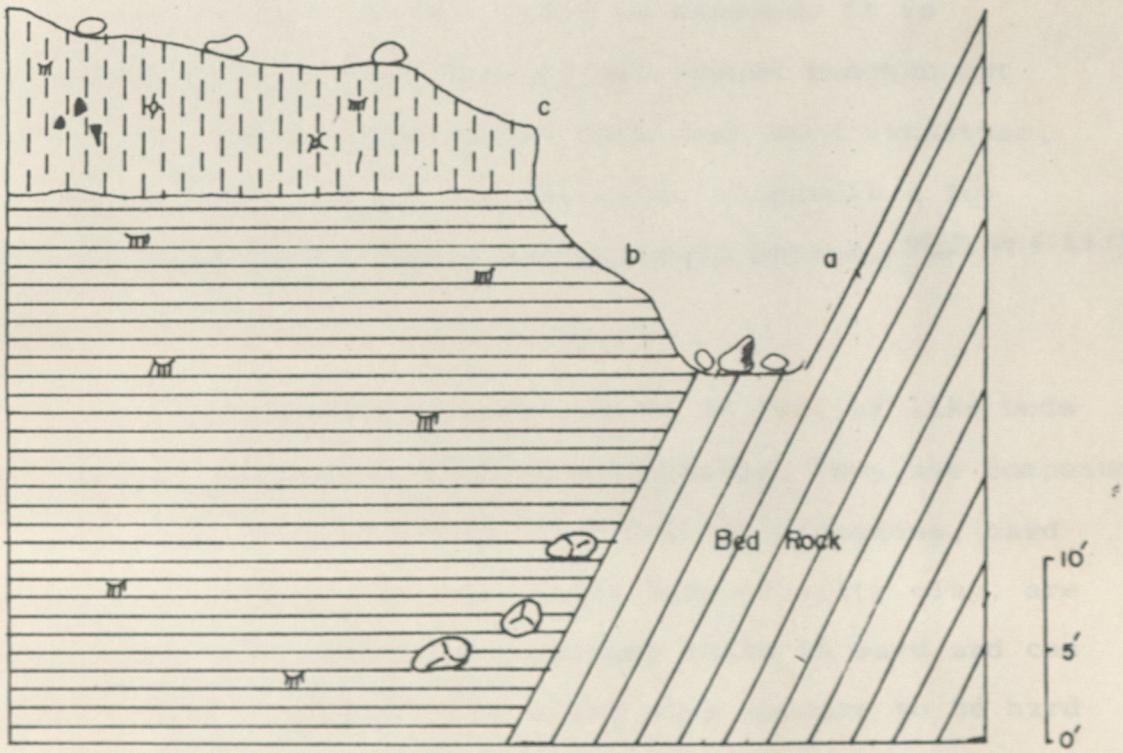


Fig. 4·28·1

4.28 SECTION 28

4.28.1 Field Description

This section is located north of Tangi Kandao (GR 047848).* The following beds are exposed from below upward:-

Bed a:

At the base, Manki slate is exposed. It is interesting to note, that some of the eroded benches cut across slate, contain gravels of dark grey hard sandstone, white quartzites, granite and gneisses, alongwith a few stone artifacts of the Early Palaeolithic Period. (Plate No: 4.28.1)

Bed b:

It is composed of about 20 to 30 feet of lake beds which overlie the Manki slate unconformably. They are composed of light grey to pale yellow (5 Y 7/1.5), micaceous, hard and soft silty clay. The individual beds of silty clay, are separated by thin layers of sandstone which is hard and can be broken only by hammer. The silty clay appears to be hard and compact, due to concentration of calcium carbonate, as horizontal concretion. However, in between these clay/sand beds there are some soft and weathered beds. The silty bed breaks into platty structure. Internally, the beds also show fine laminations.

This section is resting unconformably over the eroded surface of slate, while laterally it is also resting against the northern wall of Tangi Kandao, indicating the

* For location of section, see fig.4.27.1.1.

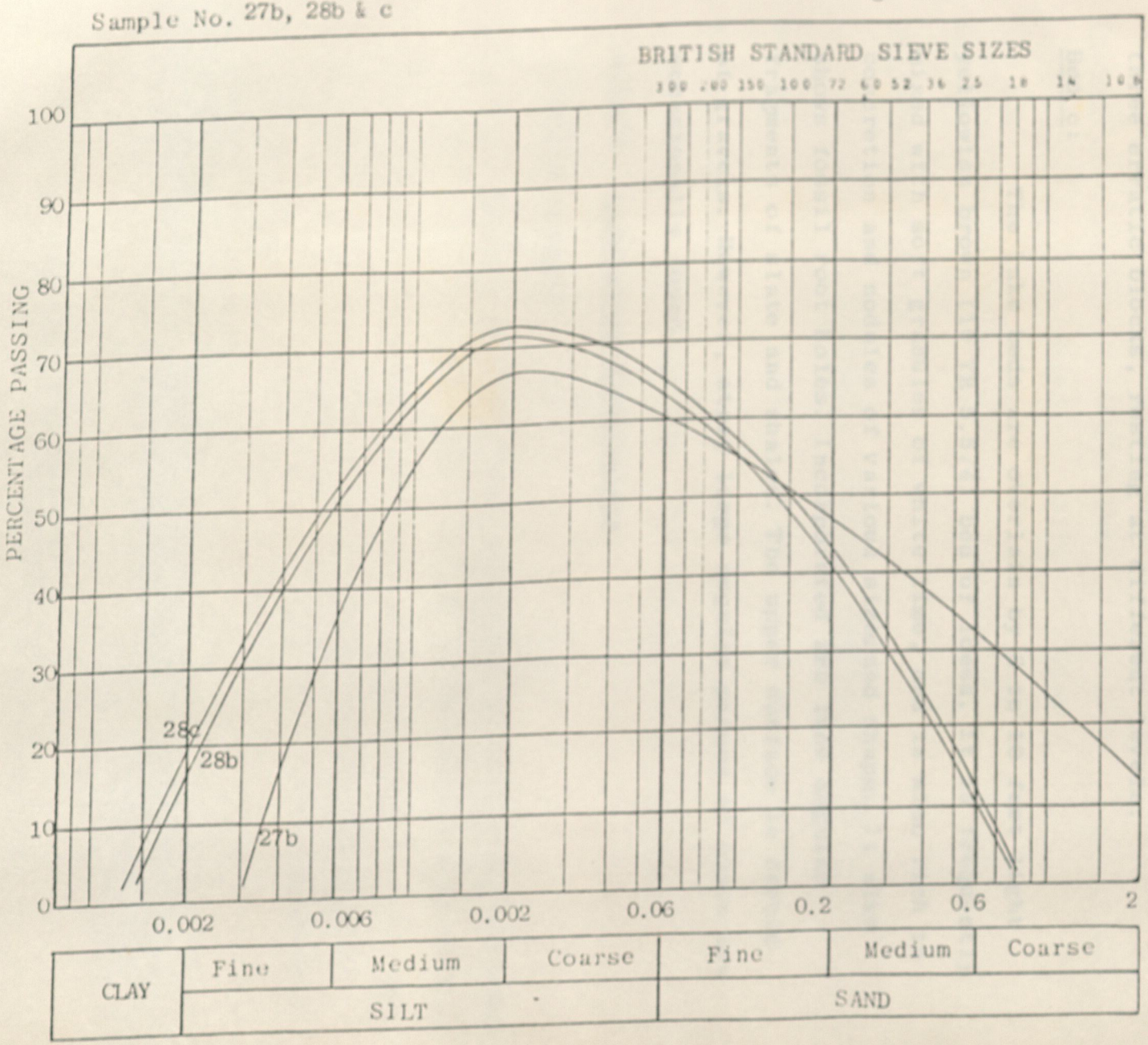


Plate No. 4.28.1. Pabble Tools from Verious Sections Under Study.

PARTICLE SIZE DISTRIBUTION

Fig: 4.28.2.1.1.

Sample No. 27b, 28b & c



boundary of lake. Here, the lake beds have been dissected and gullied by rainwash from the adjacent slope, and exposes three erratic blocks, resting at different levels.

Bed c:

The lake beds are overlain by 3 to 10 feet light yellowish brown (10 YR 5.5/4) bed of loess. It is frequently mixed with soft granules of white lime, and is also rich in concretion and nodules of various sizes and shapes. It also shows fossil root holes. Incorporated are fine angular fragments of slate and shales. The upper surface is devoid of gravels. However, stray large angular pieces of slate are occasionally found.

4.28.2 Laboratory Examination

4.28.2.1 Texture

Bed b, is silty loam, dominated by silt (73%) followed by clay (15%) and sand (12%). Bed c, is texturally very similar to bed b, and composed of 73% silt, 16% clay and 11% sand. (Fig. 4.28.2.1.1) Close similarity in textural composition suggests that most of the material of both beds have been derived from wind blown silt.

4.28.2.2 Chemical Analysis

Bed c, shows a high percentage (1.91%) of organic matter indicating thick vegetation, during hot humid spell.

4.28.2.3 Mineralogical Composition

Bed b, is predominantly composed of quartz (28%), feldspars (25%), clays (10%), biotite (10%) and carbonates

LABORATORY EXAMINATION

Section 28 — Table No. 4.28.2.3.1

Texture (Percentage)

	Sand	Silt	Clay
Bed 28b	12	73	15
Bed 28c	11	73	16

Soil Characteristics

	Organic matter(%)	Calcium (Meq/1)	Magnesium (Meq/1)	Total Iron (%)
Bed 28c	1.01	0.09	0.99	0.232

Mineral Composition (Approximate Percentage)

	Bed 28b*	Bed 28c**
Quartz	28	20
Feldspars	25	22
Clays	10	4
Opaque	5	2
Biotite	10	12
Muscovite	1	2
Carbonates	15	32
Amphibole	3	2
Chlorite	-	Tr
Rutile	1	1
Tourmaline	-	-
Epidote	Tr	-
Zircon	-	-
Sericite	Tr	Tr
Apatite	-	-
Pyroxene	1	-

* Grains are subangular to subrounded.

** Grains are very fine, subangular to subrounded.

(15%). Bed c, is dominated by carbonates (32%) followed by feldspars (22%) and quartz (20%) with biotite 12%. Both the beds are basically similar in mineral composition. However, small mineralogical variations may be due to the environments of deposition. (Table-4.28.2.3.1)

2.28.2.4 Micrscopic Study

In both the beds, the grains are subangular to subrounded, characteristics of wind blown silt. (Plate No.2.28.2.4.1)

2.28.3 Discussion

Most of the events are similar and also contemporaneous to those recorded in section 24. However, there are two new events recorded in this section which need special attention.

The igneous and metamorphic gravels on the eroded surface near Tangi Kandao and the presence of a few early pebble tools in them, suggest, the presence of an early man in this area. It is suggested, that these gravels are the ramnants of an early valley fill contemporaneous with the section 27. The early man who was roaming around this area picked up pebbles of grey hard sandstone and quartzite and made tools from these pebbles.

The location of these tools, on the higher slopes of Tangi Kandao, suggests, that they have been made 'in situ,' and are definitely associated with the period when these gravels were deposited in the vale. It also suggests that these pebbles represent a valley fill accomplished in one of warm interglacial. The presence of three erratics of igneous

rocks in the lake beds at different levels supports the idea that they were deposited by floating ice, the only agency that can carry such large blocks and deposit them on the lake floor.

In this section, the lake beds are partially eroded, and much of the beds escaped erosion, because of the protection, provided by the mountain, and also due to their location at a higher level.

The loess in this section, is soft and much weathered and possesses, concretions and calichie of different size and shapes in abundance with fossil roots. All these evidence indicate that the loess was deposited in a warm semi-dry environments, with occasional wet spells, during which cavities and solution holes in the calichie were formed due to chemical weathering. The presence of high organic matter also indicate growth of rich vegetation during a humid phase. The stray large angular pieces of slate, lying on the surface of loess, suggests, a short cold phase, during which slates were weathered and washed down from the adjacent slopes over the loess.

Rain and gully erosion indicate a dry or semi-dry period, during which intermittent but torrential rains started gully erosion which ultimately culminated in a new cycle of erosion, during which sediments were eroded from the lower areas to form the present channel of the Tangi Kandao Khwar.

4.28.4 Summary of Major Events Recorded in the Section

i. The weathering and erosion of the Manki slate.

ii. The deposition of gravels and pebbles of igneous and metamorphic rocks on the eroded surface of the Tangi Kandao as an early valley fill.

iii. A phase of erosion during which most of the gravels of an early valley fill were eroded.

iv. The formation of a lake.

v. The deposition of silt and sand as bed b.

vi. The deposition of erratics in the lake at different levels.

vii. The partial erosion of the lake beds.

viii. The deposition of loess.

ix. The development of soil over loess.

x. The erosion of A horizon of the soil profile.

xi. The weathering of the rocks of Tangi Kandao.

xii. A period of slope wash and the deposition of rock fragments over loess.

SECTION 29

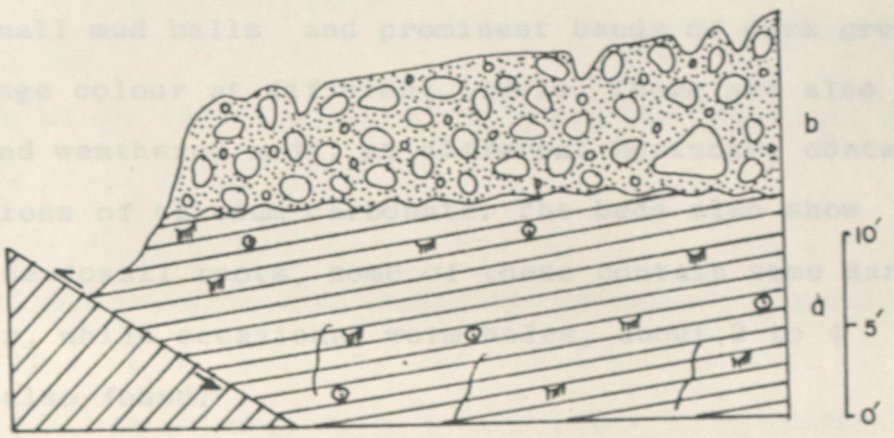


Fig. 4·29·1

4.29 SECTION 29

4.29.1 Field Description

This section is located along right bank of Maila Khwar, flowing south-east of Ziarat Kaka Sahib (GR 084815).* The following beds are exposed from below upward:-

Bed a:

Lake bed, 12 feet thick, composed of light grey to pale (5 Y 7/2.5) silty clay, separated by thin layers of white grey, hard sandstone, are exposed at the base of section. The whole formation is indurated, to form siltstone. The lake beds show small mud balls and prominent bands of dark grey and red orange colour at different levels. There are also some soft and weathered beds, at different horizons, containing concretions of calcium carbonate. The beds also show numerous fine fossil roots, some of these contain some dark-brown matter, while occasional worm holes, about 2 to 4 inches are also found.

The lake beds also show vertical and oblique silty dykes. These are generally tilted towards north, while at the northern end of the section, the beds are faulted, exhibiting steeper dips as compared to the rest of the beds.

It is to be noted that these lake beds have been deposited in a broad valley carved in the Manki slate. One of the original valley sides is along the Speen Salay mountain.

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* For location of section, see fig. 4.27.1.1.

Bed b:

A gravel bed, 6 to 10 feet thick, composed of subangular to subrounded, medium to large-size gravels of slate and sandstone, overlies the lake bed unconformably. These gravels are embedded in a semi-loose matrix of coarse sand and fine gravels, which shows prominent cross-beddings. Also, embedded in it are, some large-size subangular cobbles and boulders, mostly of slate. Its upper surface is irregular and shows cuttings, some of which are filled with silt and mud.

4.29.2 Laboratory Examination

4.29.2.1 Texture

Bed a, is composed of silty loam with 53% silt, 24% sand and 23% clay. (Fig. 4.21.2.1.1)

4.29.2.2 Chemical Analysis

Bed a, contains a considerable amount of organic matter (3.35%). It reflects hot and humid environment during which the area was covered with a very thick and luxuriant forest. (Table-4.29.2.2.1)

4.29.2.3 Mineralogical Composition

This bed is dominated by quartz (30%) and feldspars (15%), followed by muscovite (8%), biotite (15%), carbonates (12%) and clays 5%. The material is derived from the northern provenance.

4.29.2.4 Microscopic Study

Its grains are mostly sub-rounded indicating a long distance of transporation from its source.

LABORATORY EXAMINATION

Section 29 — Table No.4.29.2.2.1

Texture (Percentage)

	Sand	Silt	Clay
Bed 29a	24	53	23

Soil Characteristics

	Organic matter(%)	Calcium (Meq/1)	Magnesium (Meq/1)	Total Iron (%)
Bed 29a	3.35	0.80	0	0.232

Mineral Composition (Approximate Percentage)

	Bed 29a*
Quartz	30
Feldspars	15
Clays	5
Opqque	5
Biotite	15
Muscovite	8
Carbonates	12
Amphibole	3
Chlorite	4
Rutile	2
Tourmaline	Tr
Episode	-
Zircon	Tr
Sericite	Tr
Apatite	-

* Mostly fine grains, subrounded. Few prominantly coarse grains of quartz.

4.29.3 Discussion

Although this section is exposed along a torrent bed below which the bed-rock is not exposed, but Manki slate is exposed on opposite side of the section. This indicates that the torrent bed has been carved in the lake bed which in turn appears to have been deposited in a broad fluvial valley, which was carved during a long cycle of erosion as discussed in Sections 27 and 12.

There are field evidence which indicate that this valley was formed due to torrent erosion in a broad anticiline. The western part of its eroded link now stands high as Speen Salay which structurally is a synclinal mountain. This also suggests, that the original floor of the valley was very deep and Speen Salay has attained considerable height during various phases of uplift. This valley was later on inundated by the lake water.

On lithological similarities, this lake bed appears to be the southern most extension of the lake bed exposed at Piran Nala (section 27) deposited during the third lake phase of the Peshawar vale. It is also suggested that a braided channel of the Indus was flowing into the lake, along the northern foot-hills of the Attock-Cherat range. This is confirmed by the presence of whitish grey sand, in the lake beds. As already discussed in section 12, the Indus river has a reputation for the deposition of white sand in the past as well as in the present (Raynolds,1981)

The mode of deposition of siltstone is not uniform, because the individual bed varies in thickness. Similarly, the

interval of sandy layers interbedded between the silty beds is also not uniform. This indicates, that the supply of clast was also fluctuating, which may be due to oscillations in the climatic conditions of the provenance. The fluctuating water level is also indicated by the inclusion of mud balls in the lake bed. Either, due to a high flood conditions of syn-depositional uplift, some where in the lake area, rapid erosion and under cutting of the clay chunks was initiated which upon rolling down acquired a spherical shape (Pettijohn, 1975). As explained previously, the growth of mud ball is limited more by its structural strength acquired by accretion of clay and cementing particles.

Bands of different colours in the siltstone, and the presence of concretions of calcium carbonate at different levels, also indicate, that the deposition in the lake was taking place slowly and intermittently, and there were periods of high and low water. Perhaps there were also periods, when the lake beds were exposed to the weathering processes. The red orange beds, showing mottling are indicative of warm and wet environments, during which leaching of iron took place, while the dark grey bands are suggestive of marshy and boggy conditions and the decay of vegetation in an anaerobic environments. The laboratory examination shows a very high percentage (3.3%) of organic matter in it which reflects a very thick growth of vegetation. It should also be noted that like this lake bed, most of the marginal areas of Peshawar lake, too show a dense growth of vegetation as found in sections 28 and 27a. The

presence of worm holes is also indicative of marshy and boggy conditions.

The formation of concretions of calcium carbonate indicate exposure of the lake beds, during warm and dry conditions when leaching of calcium carbonate concentrated as concretions. Their occurence at different levels, also suggest frequent exposure of lake beds with their upward growth. This regression and transgression of lake water, with resulting exposure of the lake beds, were more conspicuous in this area, because it formed an extreme southern shores of the lake.

The presence of silty dykes and the tilting disposition of the lake beds with their faulted contact at the one end are all suggestive of the effect of syn-depositional tectonics during one of the Himalayan orogenies. The erosional unconfomrity at the top of the lake beds indicates a very long period of erosion, during which most of the lake beds were eroded from this valley and later on occupied by the present torrent. The present section, however escaped erosion partially. The various factors which lead to the erosion of the lake beds have been explained and discussed in various sections previously.

The cycle of erosion proceeded till the floor of the vale was lowered and another period of aggradation was initiated. During this phase of aggradation the slopes of Attock-Cherat range released the weathered material during a warm phase, picked up by the rejuvinated torrents and deposited the material as alluvial fans over the eroded surface of the lake as the bed b in this section.

Probably loess was deposited over the gravels. The cuttings in the gravel bed and some gully formation suggest that the loess was eroded during a semi-arid/arid period due to torrential/intermittent rains. During this period the torrent further eroded its bed and carved its present channel in the lake bed.

4.29.4 Summary of Major Events Recorded in the Section

i. A long period of erosion during which the rocks of this area were eroded and a broad valley was formed.

ii. The formation of lake, and the deposition of lacustrine facies in this valley as the bed a.

iii. An event of tectonics, during which lake beds were uplifted, tilted, and some of them are faulted.

iv. The erosion of lake beds.

v. The deposition of torrent gravels on the eroded surface of the lake bed.

vi. A period of erosion, during which a large part of gravels as well as the western part of the lake beds were eroded and the torrent carved its present channel.

vii. The deposition of loessic silt.

viii. A period of erosion, during which the loess was eroded from this area as well as from the upper surface of gravelly bed b.

SECTION 30

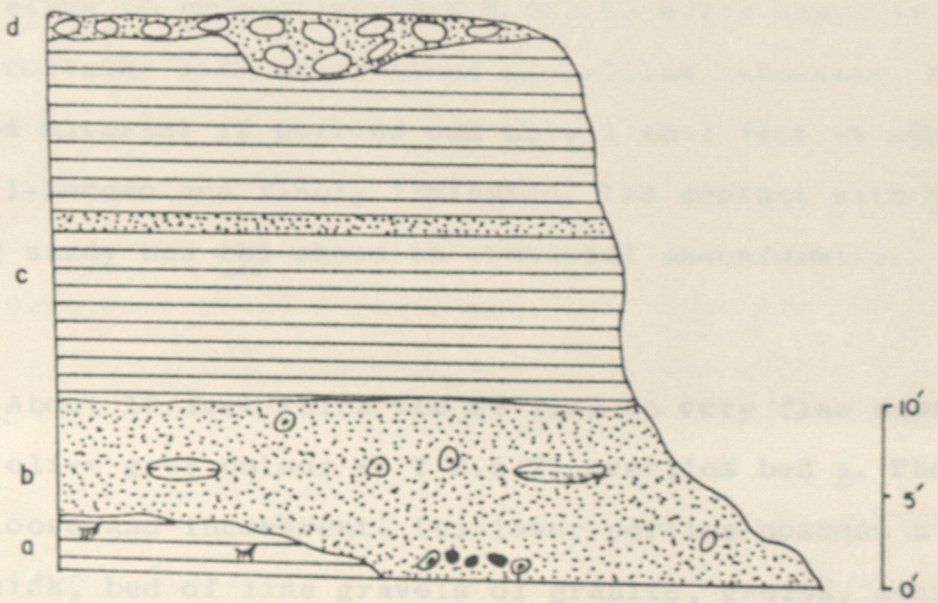

Fig. 4·30·1

4.30 SECTION 30

4.30.1 Field Description

This section is located in a tributary of the Tangi Kandao Khwar, about 1 km below, south of the section 28 (GR 046857).* The following beds are exposed from below upward.

Bed a:

Bed a represents a lacustrine facies which is composed of pale yellow to pale olive (5 Y 6.5/3.5) silty clay. It is hard and contains fine concretions of calcium carbonate. Much of the bed material is burried and only 1 to 2 feet is exposed. It is well-bedded and finely laminated. Its contact with the overlying sandy bed (b) shows an erosional unconformity.

Bed b:

About 10 feet thick bed of fine to very fine sand, of light olive grey colour (5 Y 6.5/2) overlies bed a. The sand is loose and incoherent. Its lower portion possess a 6 to 9 inches thick, bed of fine gravels of granite, gneiss, schist, quartzites, slate and shale. Some are well-rounded and weathered, while subangular to subrounded gravels are also present.

This sandy bed also contains a few lenses of clay and silt, with hard mud-balls, of medium-size, embedded in it. Occasionally, some pieces of fossil plants are also found. The bed also shows fine holes in different parts. There are a few horizontal red brown bands at different levels. In the northern

* For location of section, see fig.4.27.1.1.

end of the section, the sandy bed overlies the lake bed (a), but in the southern part, it directly overlies the torrent bed.

Bed c:

The sandy bed is overlain by a 20 feet thick bed of pale yellow, silty clay (5 Y 7/3.5). As a whole the bed is massive. Different bands of silty clay of varying thickness separated by thin layers (1 inch to 3 inch) of very fine sand are present. These are eroded to form cleavages between the silty beds. Each bed of silty clay is semi-hard, at places there are soft and weathered zones which contain concretions of calcium carbonate. At different levels it shows fine fossil roots. Its upper part also shows a few dessication cracks. The bed is conspicuous by the presence of coloured decayed organic matter. Its upper contact with the overlying gravelly bed, shows an erosional unconformity.

Bed d:

This bed is composed of 1 to 3 feet thick, subangular to subrounded, gravels of slate and shale. The gravels are loosely packed. Its upper surface shows evidence of severe erosion.

4.30.2 Discussion

Bed a, is a lacustrine facies, very similar to the other lake beds discussed previously. Its exposure below the sandy bed having a non-conformable contact, shows that lake beds have been eroded.

The sandy bed b, is a typical facies of the main channel of the meandering stream, which is maintained by the erosion of the outer banks and deposition on the inner side. Its depositional environments may be considered as the 'point bar,' which was migrating laterally and downstream across the flood plain. This can be termed as 'lateral accretion' deposit (Walker and Cantt 1979).

Thin bed composed of gravels of slate and pebbles of igneous and metamorphic rocks in the lower portion of the bed b, is considered as 'channel lag' deposits, which have been derived from the foot hills of Attock-Cherat range, during high floods and left behind on the bed when the flood subsided. It also indicates that these gravels were deposited, along the foot hills of Attock-Cherat range at a much earlier times, as discussed in section 27 and 28.

It was also found, that due to a rapid erosion and undercutting of the banks, the clay chunks rolled down to grow into mud balls. After attaining sufficient size, they were deposited on the channel sand (Pettijohn, 1975). The inclusion of a few lenses of clay and pieces of fossil plants also indicate that erosion and deposition was going on simultaneously (Allen, 1965).

The stratification and horizontal laminations of bed b, indicate that the channel was shallow with higher velocities (Walker and Cantt,1979, p.23), while the few bands of red brown colour suggest leaching of iron, during submergence and emergence, of surface of point bar, when due to lateral migration, its surface was frequently exposed to the sun.

The bed c, represents a lacustrine facies of another lake phase, which was formed due to the damming of the Kabul river just east of Nowshehra by the northward prograding of (early phase) the younger alluvial fans. The presence of fine concretions of calcium carbonate and fine fossil root at places, suggest occasional exposure of the lake bed during warm dry/semi dry period, while, the patch of dark coloured decayed organic matter suggest development of soil and growth of thick vegetation during a wet phase.

It is suggested that due to a change in the environments, a part of the upper surface of the bed c and soil was eroded, and a channel was formed by the torrent in the lake bed.

The erosion of bed c and deposition of gravels of slate and shale in it indicate torrent activity. It is suggested that piror to their deposition and during erosion phase of the lake bed, there was a cold phase in which Attock-Cherat range was subjected to intense weathering and erosion.

4.30.3 Summary of Major Events Recorded in the Section

i. The formation of a lake in the vale and deposition of silt as the bed a.

ii. The erosion of the lake beds.

iii. After erosion, the ancient Kabul river occupied its channel and deposited channel sand as the bed b.

iv. The formation of another lake and deposition of silt as bed c.

v. The partial erosion of lake bed and formation of torrent channel.

vi. The deposition of the torrent gravels.

vii. The erosion of the torrent gravels.

SECTION 31

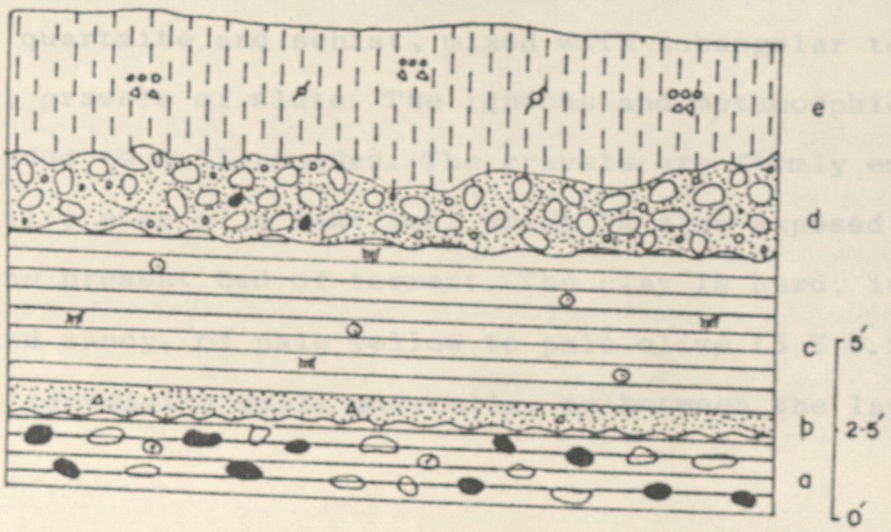

Fig. 4·31·1

4.31 SECTION 31

4.31.1 Field Description

This section is located along the right bank of the Tangi Kandao Khwar (GR 112849).* The following beds are exposed from below upward:

Bed a:

This bed is exposed along the torrent bed. It is composed of about 2 feet thick boulders and gravels of granite, gneiss, quartzite and schist, mixed with subangular to sub-rounded, gravels of slate. The igneous and metamorphic gravels are rounded to well-rounded. The gravels are firmly embedded in a silty clay of a lake bed, which is also exposed all along the present bed of torrent. The clay is hard, in places silty and sandy, of pale yellow to pale olive (5 Y 6.5/3.5) colour, containing small mud-balls, in between the layers.

Bed b:

The boulder bed is overlain by a 9 inch thick bed of light-grey to light olive grey (5 Y 6.5/2), medium to coarse, loose sand, which also contains subangular gravels of slate. The sandy layer has an unconformable contact with the boulder bed.

Bed c:

A pale yellow (5 Y 7/3.5) bed of clay, 4 feet thick, unconformably overlies, the lower boulder bed. The clay is hard, but well-bedded and laminated internally. It contains

* For location of section see fig. 4.13.1.1.

small-size, hard, mud balls. Horizontal, thin concretions of lime are also present at different levels. Its surface shows an erosional unconformity.

Bed d:

About 2 feet thick bed of subangular to subrounded, medium size, gravels of slate, overlies the clay bed unconformably. These torrent gravels, also contain a few rounded pebbles of granite and gneiss. The bed is much disturbed and shows numerous cuttings. It shows cross-beddings.

Bed e.

The top bed, about 3 to 4 feet thick, is composed of loessic silt. It is massive and structureless, and contains fine gravels and angular fragments of slate. Small nodules of calcium carbonate and fine fossil root-holes are common.

4.31.2 Laboratory Examination

4.31.2.1 Texture

Bed b, is composed of 21.46% medium, 60.20% fine and 18.33% very fine sand. Bed c, is composed of silt (59%), sand (25%) and clay (16%). It has a loamy texture which is similar to the lake beds discussed in section nos: 15,16,20, 22, and 29. (Fig.4.21.2.1.1)

4.31.2.2 Minerological Composition

Bed b, is dominated by fedlspars (30%) and quartz (22%), followed by clays and carbonates (12% each), biotite (8%) and opaques (4%) with traces of tourmaline and zircon. This composition indicates northern provenance, composed of igneous and metamor-

LABORATORY EXAMINATION

Section 31

Table No. 4.31.2.2.1

Texture	(Percentage)		
	Sand	Silt	Clay
Bed 31c	25	59	16

Mineral Composition	(Approximate Percentage)
	Bed b*
Quartz	22
Feldspars	30
Clays	12
Opaque	4
Biotite	8
Muscovite	6
Carbonates	12
Amphibole	2
Chlorite	2
Rutile	Tr
Tourmaline	Tr
Episode	-
Zircon	Tr
Sericite	-
Apatite	-

* Grains are mostly subrounded.

phic rocks. (Table-4.31.2.2.1)

4.31.2.3 Microscopic Study

Grains of bed b, are mostly sub-rounded indicating a long distance of transportation.

4.31.3 Discussion

i. The bed a, represents a lacustrine facies, which suggests, that at one time the lake was filled with sediments and a torrent coming from the Attock-Cherat range occupied its floor. The torrent, eroded gravels from an earlier deposit, lying along the foot-hills and deposited them along with the gravels of local rocks as its delta in the lake. The torrent deposition came to a hault when the lake began to expand.

ii. The beds b and c are extension of the beds b and c of section 30. Their mode of deposition has already been discussed.

iii. The torrent deposited its gravels, after eroding the lake bed, and making its channel over it. Numerous cuttings and cross-beddings in the gravel bed indicate a one time turbulent nature of the torrent.

iv. The deposition of loess took place in a warm dry environments with wet spells, during which some of the loess was washed down the higher slopes and deposited as bed e.

4.31.4 Summary of Major Events Recorded in the Section

i. The formation of a lake and the deposition of silt, containing gravels as bed a.

ii. The erosion of lake bed.

iii. Formation of flood plain by the Kabul river and deposition of sand as bed b.

iv. Formation of a lake and the deposition of silt and clay as bed c.

v. The partial erosion of the lake bed.

vi. The deposition of torrent gravels as bed d.

vii. The partial erosion of torrent gravels.

viii. The deposition of loess as bed e.

ix. A long period of erosion, during which the torrent carved its present channel.

Fig 4.32.1

SECTION 32

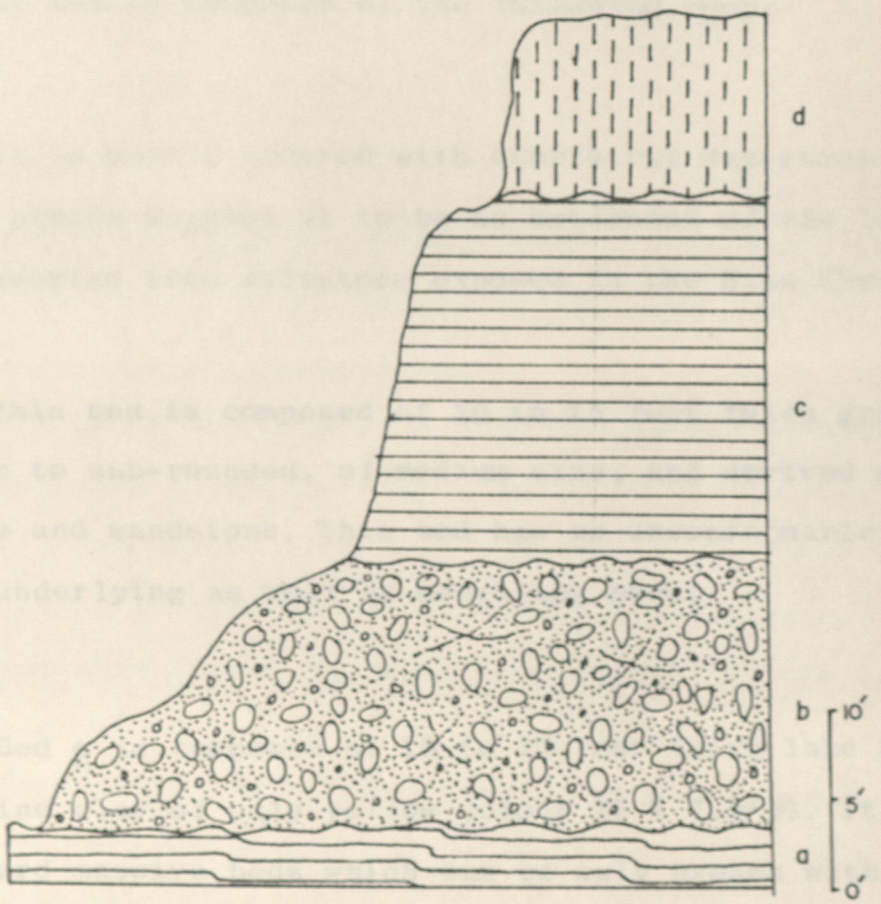

Fig. 4-32 1

4.32 SECTION 32

4.32.1 Field Description

This section is exposed along left bank of Babu Khwar, (GR 093872)* and is composed of the following beds:-

Bed a:

It is mostly covered with debris but exposures at different places suggest it to be an extension of the lacustrine facies converted into siltstone exposed in the Babu Khwar.

Bed b:

This bed is composed of 10 to 15 feet thick gravels, subangular to sub-rounded, of medium size, and derived mostly from slate and sandstone. This bed has an unconformable contact with the underlying as well as overlying beds.

Bed c:

Bed c is composed of 15 to 20-feet thick lake bed of very fine clay of pale yellow colour (5 Y 7.5/3). It consists of very hard massive beds which can be only broken with a hammer. However, there are occasional soft and weathered layers of clay. This bed is quite different from the lower siltstone beds of the lacustrine facies, and is also devoid of fine gravels or any fine rock fragments, commonly found in the siltstone at bed a. Mottling and red streaks are common. Worm holes are wider than the lower lake beds. Here the worm holes are upto 1/4 inch wide with a usual length of 2 inches.

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* For location of section, see fig. 4.13.1.1.

Bed d:

About 10 feet thick bed of pale yellow (6.5 Y 7/4) loess overlies bed c, in an unconformable position. The loess is soft and weathered. Concretions and nodules of calcium carbonate are common.

4.32.2 Laboratory Examination

4.32.2.1 Texture

Bed c, is composed of silt (60%), clay (28%) and sand (12%) showing a loamy texture of the lake beds. (Fig.4.32.2.1.1)

4.32.2.2 Mineralogical Composition

Bed c, is composed of a high percentage of feldspars (38%) as compared to quartz (20%), followed by biotite (13%), clays (10%), carbonates (8%) with amphiboles (5%) and rutile (2%) indicating an igneous and metamorphic provenance. Though this bed exhibits fourth phase of lake formation, the circumstances under which the material was produced and the environments of deposition are closely similar to the third lake phase discussed in section nos. 15,16,20,22,29 and 31. (Table-4.32.2.2.1)

4.32.3. Discussion

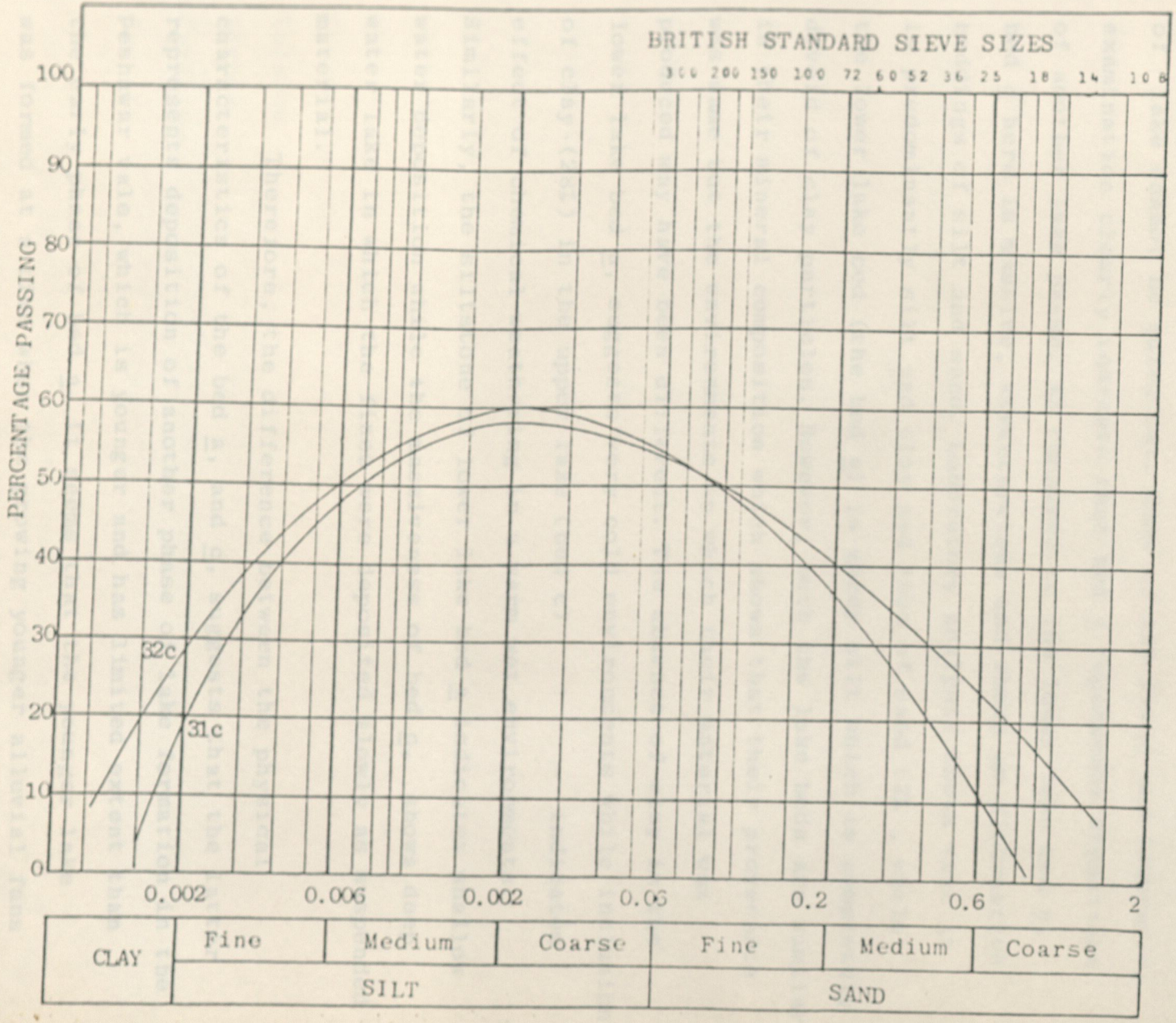
i. Bed c, a lacustrine facies, is an extension of the bed c of sections 13 and 14. The environments, of the deposition of siltstone of bed c and the circumstances which lead to its erosion, followed by the deposition of torrent gravels have already been discussed previously.

ii. The most important event recorded in this section is the deposition of bed c which is a lacustrine facies. It may

PARTICLE SIZE DISTRIBUTION

Sample No. 31c and 32c

Fig.4.32.2.1.1



be a vertical extension of the lower lake bed at bed a which escaped erosion. But the possibility of it being another phase of lake cannot be ruled out. Some of the field and laboratory examination clearly indicate that bed c represents deposition of another lake phase. As compared to the lower lake bed a, bed c here is massive, structureless and shows no alternative beddings of silt and sand. Laboratory analysis shows that it is predominantly silt and clay and less of sand 12% , while the lower lake bed (the bed a) is sandy silt which is completely devoid of clay particles. However, both the lake beds are similar in their mineral composition which shows that their provenance was same but the environments in which their material was produced may have been different. The absence of clay in the lower lake bed a, suggests very cold environments while inclusion of clay (28%) in the upper lake (bed c) indicates effect of chemical weathering in a warm wet environments. Similarly, the siltstone of lower lake bed a indicates shallow water deposition while the massiveness of bed c, shows deep water lake in which the fines were deposited slowly as suspended material.

Therefore, the difference between the physical characteristics of the bed a, and c, suggests that the latter represents deposition of another phase of lake formation in the Peshawar vale, which is younger and has limited extent than the early phase of bed a. It seems that the younger lake was formed at a time when the growing younger alluvial fans from the Attock-Cherat range may have extended upto the Reef hills, somewhere to the east of Nowshehra and blocked the

LABORATORY EXAMINATION

Section 32

Table No.4.32.2.2.1

Texture (Percentage)

	Sand	Silt	Clay
Bed 32c	12	60	28

Mineral Composition (Approximate Percentage)

	Bed 32c
Quartz	20
Feldspars	38
Clays	10
Opaque	2
Biotite	13
Muscovite	2
Carbonate	8
Amphibole	5
Chlorite	Tr
Rutile	2
Tourmaline	-
Episode	-
Zircon	Tr
Cericite	-
Apatite	Tr

waters of the Kabul river for some time. Consequently, the waters of the Kabul river ponded and entered the channels and gullies of some the torrents to its south in which the bed c was deposited. It is suggested that the environments of lake formation may have been almost contemporaneous to the alluvial fan formation which has been previously described as warm and sub-humid. The lake phase may have ended with the start of another cold period, when due to cold dry conditions the lake beds were eroded. It may be noted that a similar lake bed overlain by the younger loess at Nowshehra Tarakai, north of river Kabul has been dated as 124 Ka by thermoluminisence method (Rendell, 1988-89).

The younger lake phase was followed by the deposition of younger loess as the bed d under the same environmental conditions as discussed in section 14. The post-loess erosion removed much of the loess and the younger lake beds and exposed the gravels into terrace and formed the present channel of the torrent. It may be, that after degradation, the torrent once again began to aggrade perhaps in order to achieve a profile of equilibrium.

4.32.4 Summary of Major Events Recorded in the Section

i. The formation of lake and deposition of siltstone as the bed a.

ii. The erosion of the siltstone.

iii. The deposition of the torrent gravels as bed b.

iv. The formation of the younger lake and the deposition of silt as the bed c.

v. The erosion of the younger lake bed.

vi. The deposition of loess as bed d.

vii. A very long period of erosion, formation of the gravel terrace and dissection of the present channel of the torrent.

viii. Aggradation of the torrent channel.

SECTION 33

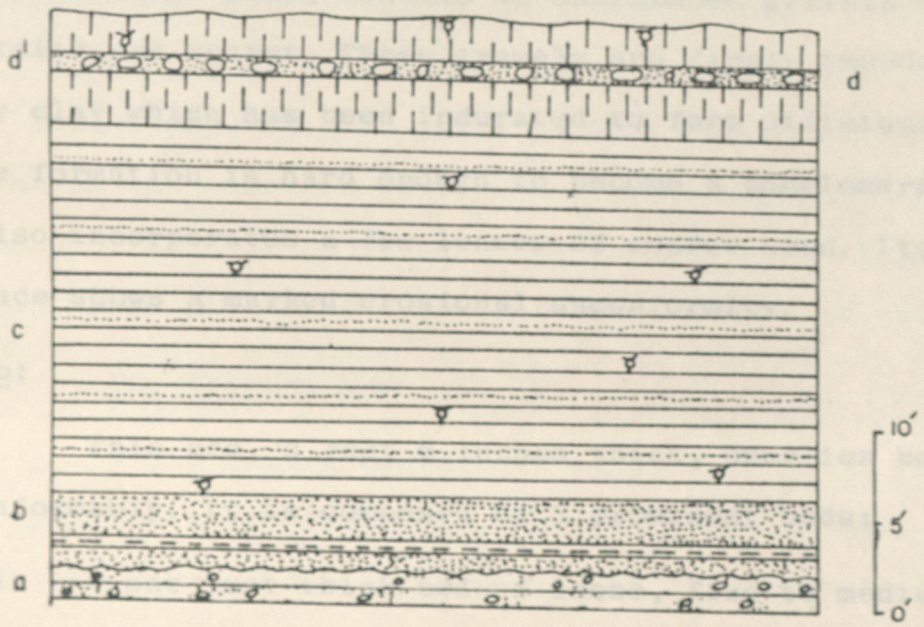


Fig. 4·33·1

4.33 SECTION 33

4.33.1 Field Description

This section is located along the right bank of a tributary of Tangi Kandao Khwar at GR (044862)*, and shows the following beds:-

Bed a:

The lower most bed, 2 feet thick, is composed of medium to large size, rounded to subrounded gravels of granite, quartzite and schist. These gravels are firmly embedded in the silty clay which has been indurated to form siltstone. The whole formation is hard enough to become a conglomeratic bed. It also incorporates a few lenses of coarse sand. Its upper surface shows a marked erosional unconformity.

Bed b:

This bed, 3 feet 6 inches thick, overlies bed a, unconformably. It is composed of 3 prominent beds:

i. a one foot thick bed of loose, fine to medium sand of light grey to light olive grey (5 Y 6.5/2) colour;

ii. a 6 inch thick silt of pink to reddish yellow colour (7.5 YR 7/5).

iii. upper part of bed b, is composed of 2 feet thick loose and incoherent sand of light grey to light olive grey (5 Y 6.5/2) colour.

Bed c:

It is composed of about 20 feet thick bed of fine

* For location of section, see fig. 4.27.1.1.

pale yellow coloured (5 Y 7/3.5) silt. The bed consists, layers of varying thickness, each separated by thin layers of semi-hard sand. The silty beds show fine rootholes and frequent bands of orange brown colour, at different levels. At places, the silt is soft and weathered and contains abundant concretions of calcium carbonate.

Bed d:

It is a loess bed, about 6 feet thick, of light yellowish brown (10 Y 5.5/4) colour. In the middle of the formation, it is interbedded with about a foot thick bed of torrent gravels of local slate (d1), which are loosely packed and mostly angular. The upper part of the loess is much weathered and contains nodules and concretions of calcium carbonate. It also contains a few patches of dark grey matter in its upper part. The upper surface of loess is eroded.

The Torrent Bed

A few meters downstream of this section, the torrent bed contains a few large-size erratics. The largest of the erratics is conglomerate; its exposed thickness is 5x5x3 feet. This conglomerate is composed of boulders and fine gravels of white, black and grey limestone, and red and pink quartzite. The boulders of the conglomerate erratic are well-rounded, closely packed, the whole mass seems to be solidified metamorphically. Its surface is smooth and glossy, which on rubbing shines like a porcelane. It is very difficult to break or detach a boulder from the erratics. At a few feet distance, another erratic of augen gneiss is found. Its exposed size is

nearly the same.

These erratics are presently lying on the torrent floor. The torrent has carved its channel in the lake bed and exposed these erratics which are lying about 50 feet lower than those found in section 28. (Plate-4.33.1.2)

4.33.2 Discussion

i. The formation of second lake, the deposition of siltstone and its erosion has already been discussed and explained previously. The deposition of a few erratics on the torrent bed, which are about 50 feet below, to those found in section 28, suggest that during the deposition of these erratics, the lake was sufficiently deep to allow the floatation of large ice blocks carrying the erratics. It is very difficult to locate the source and origin of the conglomeratic erratics. It is apparently composed of variety of limestone and red and pink quartzite but its immense hardness and compactness with smooth and glazed surface suggest that the conglomerate may have gone through a long process of silicification after its deposition.

It seems that the eroded surface of lake was occupied by a channel of the ancient Kabul river, which deposited its "lag deposits" in its channel. The lithology of gravels and boulders embedded in the siltstone suggests that these are derived from the northern provenance and deposited during a stage when the channel attained a steep gradient and became a high energy stream.

ii. May be due to avulsion the channel shifted to some other area and part of the bed a was eroded. Later on, the ancient Kabul river began to form its flood plain over the eroded surface of the lake and deposited alternate beds of sand and silt of bed b, as its vertical accretion/over bank deposition.

iii. The bed c, represents lacustrine facies of the third phase of the lake in which silty and sandy beds were deposited like varves. Its mode of formation has already been explained in previous pages. Leaching of iron and calcium carbonate is indicated by mottling of red brown colour and concretions of $CaCo^3$ during exposure of lake beds.

iv. The deposition of loess bed (d) in this section has great morphogenetic significance, as it indicates, that the phase of deposition of Younger loess in the vale was not continuous but intrupted due to a temporary climatic change in the regime of loess. Consequently, the torrent was activated and deposited its gravels on the surface of loess during more humid conditions. After sometimes, the environments again became conducive, and the loess resumed its deposition at about 22ka (Rendell, 1988-89).

4.33.3 Summary of Major Events Recorded in the Section

i. The formation of a lake and the deposition of siltstone as lacustrine facies.

ii. The deposition of erratics on the lake bed.

iii. The erosion of lake beds.

iv. The presence of a river channel in the lake bed and deposition of lenses of sand, and gravels of igneous and metamorphic rocks in the channel.

v. The erosion of gravels.

vi. The ancient Kabul river begins to form its floodplain over the eroded lakebed and the deposition of bed b, as its "vertical accretion."

vii. The formation of another lake phase and the deposition of silt and sand as lacustrine facies.

viii. A phase of the deposition of loess.

ix. Cessation of the deposition of loess and the deposition of torrent gravels on loess.

x. Resumption of the deposition of loess.

xi. Weathering and the development of soil in the loess.

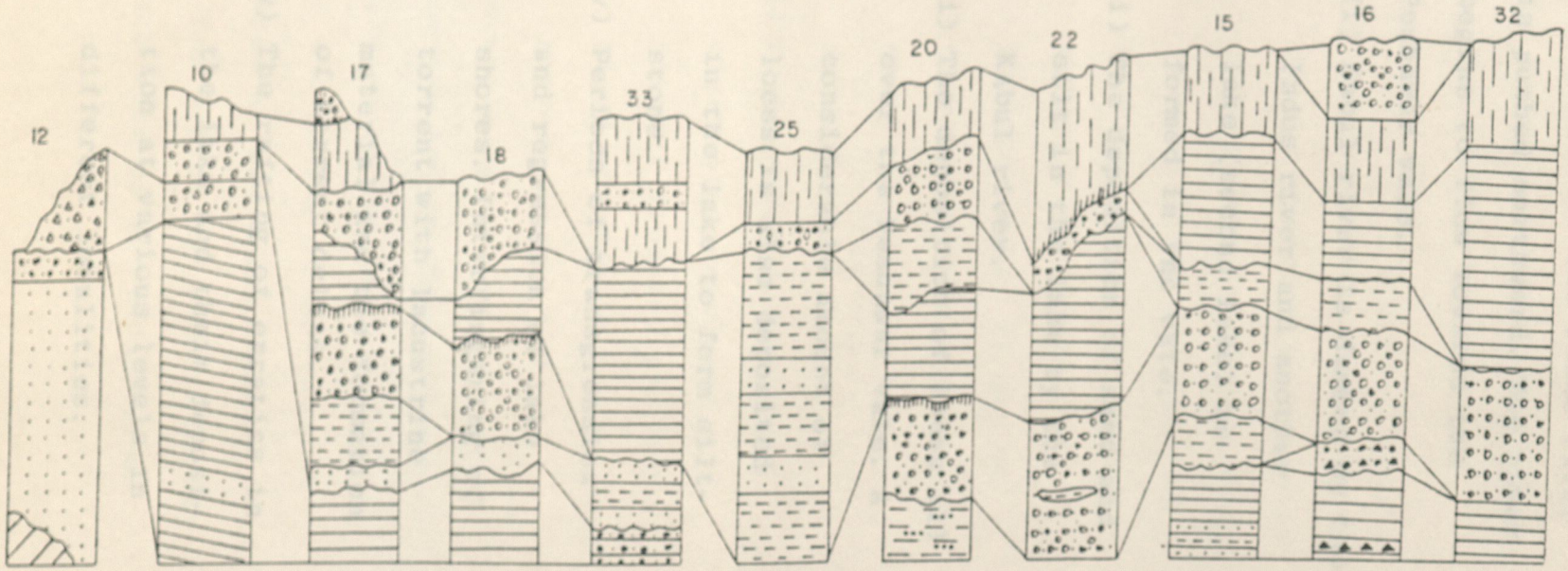
4.34 CHRONOLOGY OF EVENTS

	Reference/Sections
1. The uplift of the northern rim of the Peshawar vale at about 22 mya.	Zeitler, et al., 1980.
2. The extensive erosion of the bed-rock and the development of fresh relief in the vale.	Section Nos: 19a, 12a. 28a.
3. Uplift of the Attock-Cherat range at about 3 m.y.a.	Burbank and Tahirkheli, (1985).
4. The weathering of the Attock-Cherat range.	Section No. 1b.
5. The cessation of erosion; reversal of drainage and the formation of First lake phase in the south-western parts of the vale.	
6. The deposition of clay and silt of varied colour as lacustrine facies.	Section Nos: 4a, 6a, 7a, 8a.
7. The deposition of volcanic ash at 2.7±0.3 m.y./2.8±0.4 m.y.	Section No.4.
8. The ancestral Kabul river occupies the lake bed and begins to develop its flood plain; the deposition of overbank facies, which may be correlated with the Pinjor beds of upper Siwaliks	Section Nos: 3a, 5a, 7b.

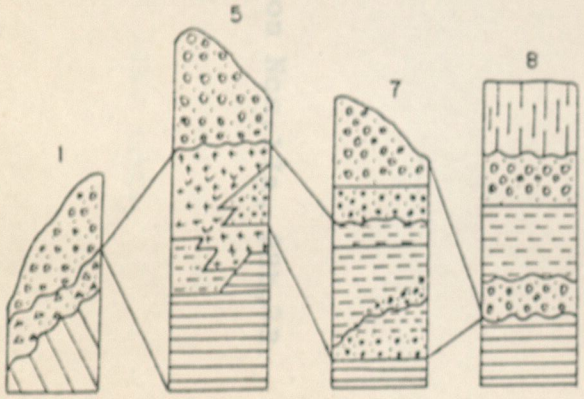
of Potwar, dated as 2.47 m.ys.	Opdyke, et al., (1979).
9. A period of hault; the development of soil.	Section Nos. 3a, 7b, 7c.
10. Partial erosion of soil, flood-plain and lakebeds.	Unconformities at: 1a, 3a, 5a, 7a, 7b, 8b.
11. Uplift of the Attock-Cherat range and the Khyber mountains.	
12. A cycle of sedimentation during which whitish-grey sand, gravels of igneous and metamorphic rocks, gravelly sandstone and conglomerate derived from the northern provenance were deposited in great thickness as First valley fill of the Peshawar vale. This may be correlated with the Upper Siwalik conglomerate of Potwar Plateau, dated as 1.9 m.ys.	Section Nos: 4, 12b,12c, 27. Keller, et al., (1977) Johnson, et al., (1979) Opdyke, et al., (1979)
13. A long period of erosion during which most of the material of first valley fill and the underlying floodplain and lake beds were eroded from over a large part of the vale.	Unconformities at section Nos. 6a, 8a, 12c, 27.
14. Kabul river begins to form its flood plain; the deposition of sand facies.	Section Nos:14a, 15a.

STRATIGRAPHIC CHRONOLOGY BASED ON

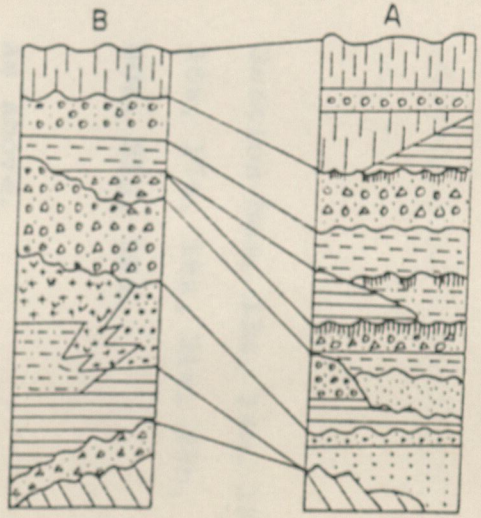
CORRELATION OF SECTIONS



A. From Ziarat Kaka Sahib To Nowshera



B. Garhi Chandan Area



Correlation Between B & A

Composite Section of A & B

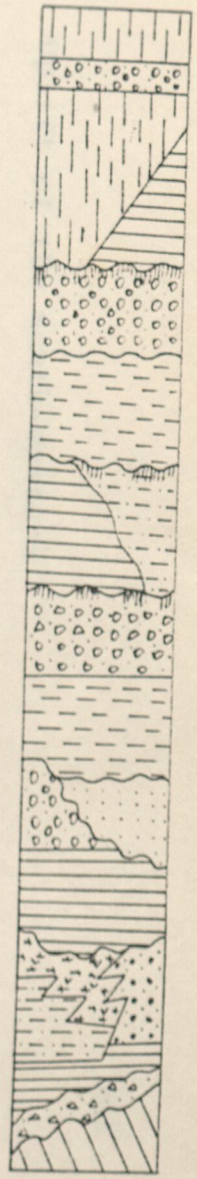


Fig 4.34.1

15.	Uplift of the south-eastern areas of the vale.	
16.	The course of the Indus river is pushed northward. The river begins to flow towards the Peshawar vale.	
17.	(i) Kabul river is dammed by the Indus river and another lake (second lake) is formed in the vale.	Section Nos. 13a, 14a, 15b, 16a, 17a, 18a, 21a, 28b, 30a, 31a, 32a.
	(ii) The deposition of sand and silt in the lake by the Kabul river.	As above.
	(iii) The deposition of loess all over the Peshawar vale. A considerable amount of loess is also deposited in the lake to form silt-stone.	As above.
	(iv) Periods of transgression and regression of lake shores. Interfingering of torrent with lacustrine material and the formation of torrent deltas.	Section Nos: 14a, 16a[1],
	(v) The rafting of erratics in the lake and their deposition at various levels in different localities.	Section Nos.17a, 28b,33.

18.	(i) Uplift of the Attock-Cherat range and the weathering of rocks.	
	(ii) Tilting and warping of the lake beds; formation of silty dykes.	Section Nos. 14a,16a,17a 18a,21a.
19.	(i) The deposition of graveliferous material by torrents coming from the Cherat mountain as Older fan material, referred to as the Second valley fill of the Peshawar vale. It may be correlated with Lei Conglomerate complex of Potwar, dated approx. 1.6 my.	Section Nos: 1c, 2b,c,d, 3b, 4,5b, 6b, 7c,d,e, 10b, 12d. (Johnson et al., 1979).
	(ii) Contemporarily the Kabul river also developed a steeper gradient and deposited rounded to sub-rounded gravels in its bed.	Section No. 10c.
20.	Overspilling of the lake water from the Attock-Cherat range. Incision of the Attock gorge and the making of the present course of the Indus river.	
21.	A long period of erosion during which most of the material of	Unconformities at the eroded lake beds.

the Older fan and underlying lake beds were eroded from a large part of the vale; the weathering of the Attock-Cherat range.

22. (i) The eroded lakebeds were occupied by the ancient Kabul river which began to develop its flood plain. The meandering channels of the Kabul river deposited sand "point bar" facies. The shifting stream also deposited gravels in its channel as "lag deposits".

Section Nos: 16b, 17a, 18b, 19a, 30b, 31b, 33b.

(ii) Occurrence of "avulsion". The Kabul river suddenly migrated its channel to its present course eroding most of the sand, some of which is still present at Zindai Khwar and also south of Nowshehra.

23. Regolith developed over the weathered rocks of the Attock-Cherat range.

24. The Attock-Cherat range is further uplifted.

25. Material from the Attock-Cherat range streamed out as the Younger alluvial fan (First phase) with deposition of the following facies:	
(i) The deposition of silt as "massive facies" on the lake bed.	Section Nos: 11b, 15c, 16d, 17b, 20a,21b,26a.
(ii) The erosion of the bedrock from the Cherat mountain and its deposition as "gravel facies".	Section Nos: 8b, 13b, 14b, 15d, 16c, 17c, 18c, 19b, 20b, 21c, 22a, 23a, 24a, 26b, 29b.
26. A period of weathering of the torrent gravels and the development of soil and thick growth of vegetation.	Section Nos:17c^1, 18c^1, 19b^1, 20b^1, 23a^1, 26c^1.
27. The erosion of soil and torrent gravels.	Unconformities at the above beds.
28. The formation of younger alluvial fans, along with the development of the Kabul river flood plain.	Section Nos.23b,24b, 25.
29. (i) Due to the development of alluvial fans, the Kabul river was dammed east of Nowshehra and a (3rd) lake was formed in the south and south west of Nowshehra at about 0.7 mya.	Section Nos: 17d, 18d, 19c, 20c, 22b, 23b, 27b, 29a, 30b, 31c. Burbank (1983).

(ii) The deposition of silt and clay as lacustrine facies;	Section Nos: as above.
(iii) Interfingering of the torrent gravels and the lake beds and parts of the food plain.	Section Nos: 20c, 23b, 24b, 25e.
30. (i) The formation of soil over the lake beds.	Section Nos: 19c, 22b.
(ii) Thick growth of vegetation over the marginal areas of the newly formed lake.	Section Nos: 27b, 29b.
31. A period of erosion of soil, parts of the flood plain and the lake beds.	Unconformities at 18d, 19c, 22c, 23b, 24b.
32. Uplift of the Attock-Cherat range at about 0.4 mya.	Burbank and Tahirkheli, (1985).
33. Formation of second phase of Younger alluvial fans and the deposition of:	
(i) silty beds as "massive facies" of the alluvial fans followed by,	Section Nos: 14c, 20d, 24d, 26c.
(ii) the deposition of torrent gravels as "gravel facies of the alluvial fans.	Section Nos: 14d, 17e, 18e, 20e, 22c, 24e, 25f, 26d, 29b, 30c, 31d.
34. The weathering of gravels and development of a soil horizon.	Section Nos: 22c1.

35.	(i) As a result of aggradation by the torrents as second phase of alluvial fans, the Kabul river was ponded again to form another phase of lake (Fourth Lake) around Nowshehra at about 124 ka.	Section Nos: 15f, 16e, 32c. Rendell,(1988-89).
	(ii) The deposition of very fine silt and clay in the fourth lake.	Section Nos: as above.
36.	A phase of erosion during which the soil, as well as torrent gravels and the lake beds were eroded.	Unconformities at: 14d, 15f, 16e, 27d&e, 20c, 21c, 22c1, 25f, 26d, 29b.
37.	The deposition of younger loess in the Peshawar vale at about 66 Ka.	Section Nos: 9b,10d,11d, 13c,14e,15g,16f,17f,19d, 20f,21d,22d,23c,24f,25g, 26e,28c,30d,32d,33d. (Rendell (1988-89).
38.	Cessation in loess deposition; the deposition of recent gravels by the torrent on the loess.	Section Nos: 11e,13c,16g, 17g,19e,21e,27c,33d1.
39.	The resumption of deposition of loess at about 22 Ka.	Section No.33d2. Rendell,(1988-89).
40.	The weathering and development of soil in the loess.	

41. A phase of uplift of the Attock-Cherat range.

42. Due to intermittent uplift of the Attock-Cherat range, a phase of erosion prevailed over the vale resulting in:-

(i) the erosion of loess, and the exposure of piedmont deposits.

(ii) the erosion of piedmont deposits and the formation of fan approns, and

(iii) the erosion of torrent gravels, the loess and formation of bad land topography in south and south west of Jallozai. The torrents formed their channels and the present sections were exposed.

All the sections under study.

43. A period of recent aggradation by the Kabul river and the torrents.

CHAPTER 5

QUATERNARY HISTORY

5.1 PRE-QUATERNARY PERIOD

The presence of klippen, windows and semi-windows in various parts of the vale indicates that erosion took place for about 19 to 12 m.ys, in response to the uplift of the northern rim of the vale about 22 to 15 m.ys.a, (Zeitler, et al., 1980). The erosion occurred in two phases and came to an end about 3 m.y.a. It resulted in the formation of two planation surfaces.

The first phase of erosion occurred after the end of Eocene, when the sea finally left the vale of Peshawar (Tahirkheli, 1980). The erosional terraces, now partly covered by alluvium near Shah Dheri and Kabal along the Swat river and at Warsak near Kabul river are the remanents of this phase of erosion (Rehman and Zeb, 1970; Ahmed, et al., 1969). As a result of the post-Eocene orogeny, the sediments derived from erosion in the northern provenance were deposited in a few shallow, left-over marine basins, in the south-western parts of the vale. These sediments were later on uplifted to form Murree formation during Miocene period.

The second phase of erosion started, after the vale and surrounding areas were uplifted, during one of the severe phases of the Himalayan orogeny resulting in the

41. A phase of uplift of the Attock-Cherat range.

42. Due to intermittent uplift of the Attock-Cherat range, a phase of erosion prevailed over the vale resulting in:-

(i) the erosion of loess, and the exposure of piedmont deposits.

(ii) the erosion of piedmont deposits and the formation of fan approns, and

(iii) the erosion of torrent gravels, the loess and formation of bad land topography in south and south west of Jallozai. The torrents formed their channels and the present sections were exposed.

43. A period of recent aggradation by the Kabul river and the torrents.

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rejuvination of streams. The younger rocks of Murree formation were overfolded, controrted and over-ridden by the older rocks from the north. This phase of erosion lasted throughout Pliocene, during which not only rocks of the upper plates were stripped off, but also those of the lower plates were exposed and eroded. During this period various klippen/windows and sub-windows were carved out in various parts of the vale, e.g. at Dargai-Utman Khel, Khyber mountains, Darra Adam Khel area and the Attock-Cherat range. Similarly Murree series were also truncated all along the northern foot-slopes of the Attock-Cherat range.

It should be noted that two such planation surfaces have also been found on the northern and southern slopes of Himalayas e.g. Qinghai Xizong plateau, eastern Hazara and the Potwar respectively, (Li Jijung, et al., 1979, Derbyshire, et al., 1984). This would suggest similarities of events on the two sides of the Himalayas.

5.2 QUATERNARY

5.2.1 Lower Pleistocene

Important changes took place in the vale during the Pleistocene period. The climate of the surrounding region began to deteriorate, culminating in widespread glaciation (Laikot Glaciation, Porter, 1970) in the Himalayas and Karrakoram. The vale being adjacent to it, experienced peri-glacial conditions, resulting in the physical dis-integration of rocks, due to repeated freez-thaw action.

QUATERNARY STRATIGRAPHY

LOWER PLEISTOCENE

	Stratigraphy, South of River Kabul	Environmental Correlation	
		Peshawar vale	Swat Himalayas
Late phase	The deposition of glacio-fluvial material from the northern provenance as the First valley fill	Warm, semi-dry to sub-humid	Deglaciation: Maximum wanning of Glaciers
	Further uplift of the northern mountains of the Peshawar vale	Himalayan Orogeny, Deglaciation	
	The erosion of soil and older lakebeds; weathering of the Attock-Cherat range	Cold, falling of local base level	Stadial
	The development of soil	Warm, sub-humid	Interstadial
Middle Phase	The deposition of flood plain facies	Cool, sub-humid	Neutral regimen of glaciers
	The deposition of volcanic ash	Volcanic eruption in Afghanistan	
	The deposition of older lakebeds in the south-western parts	Cold with intermittent warm spells	Stadial
	Uplift of the Attock-Cherat range	Himalayan Orogeny and Laikot Glaciation, Porter, (1970)	
	Widespread erosion of bed rock	Beginning of cold climate	
Early Phase	Uplift of the northern rim	Himalayan Orogeny	

LOWER PLEISTOCENE

The change in the climate alongwith the intermittent uplifts, accelerated the process of erosion. As a result, the older topography was dissected and a new relief emerged, comprising broad valleys separated by intervening spurs and ridges. The crests of some of these buried ridges can be seen today as isolated and scattered hillocks in various parts of the vale, at Swabi, Shewa, Shahbazgarhi, Jamalgarhi, Sakhakot, Tangi, Qarawai, Besai, Garhi Chandan, Jallozai, and Manki.

Shortly after, the process of erosion stopped due to the uplift of the Attock-Cherat range about 3 m.ys.a (Burbank & Tahirkheli, 1985), there was a reversal of drainage, and the newly born streams on the mountain range began to flow northward. While at the eastern end of the vale, the flow of the ancestral Kabul river was blocked due to the uplift of a ridge of the Attock-Cherat range at Kund, with a NE-SW strike, perpendicular to the river channel. This resulted in the ponding of the drainage, and the formation of a lake, (oldest phase) which extended as far as the south-western parts of the vale.

By the time glaciation had set in completely, abundant morainic material was produced. Due to glacial conditions, however, it was ice-jammed and only very fine material like silt and clay, could be carried by glacial streams. It was deposited in the lake to form the oldest lacustrine facies of the Peshawar vale, (Section Nos. 4a, 6a, 7a, 8a). There is also an evidence of interuption of lake deposits by the deposition of brown silt loam like

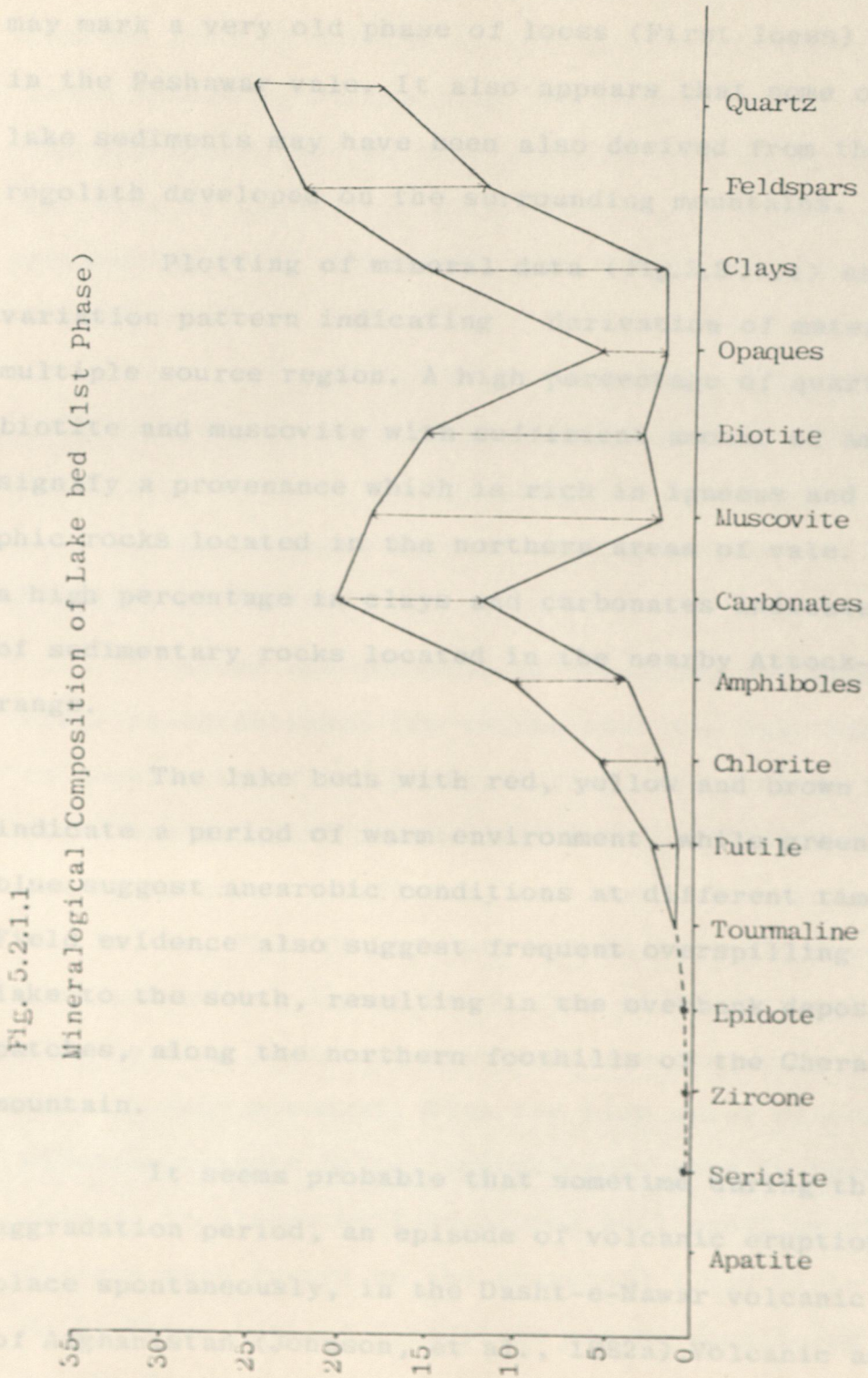


Fig. 5.2.1.1 Mineralogical Composition of Lake bed (1st Phase)

material similar to loess (Elberson, 1967, p.147), which may mark a very old phase of loess (First loess) deposition in the Peshawar vale. It also appears that some of the lake sediments may have been also derived from the fine regolith developed on the surrounding mountains.

Plotting of mineral data (Fig.5.2.1.1) shows a high variation pattern indicating derivation of material from multiple source region. A high percentage of quartz, feldspars, biotite and muscovite with sufficient amount of amphiboles signify a provenance which is rich in igneous and metamorphic rocks located in the northern areas of vale. However, a high percentage in clays and carbonates indicate a source of sedimentary rocks located in the nearby Attock-Cherat range.

The lake beds with red, yellow and brown colours indicate a period of warm environment, while green, grey and blue suggest anearobic conditions at different time intervals. Field evidence also suggest frequent overspilling of the lake to the south, resulting in the overbank deposition in patches, along the northern foothills of the Cherat mountain.

It seems probable that sometime during this aggradation period, an episode of volcanic eruption took place spontaneously, in the Dasht-e-Nawar volcanic complex of Afghanistan (Johnson, et al., 1982a). Volcanic ash was carried as far as the vale and deposited over the lakebeds

and overbank facies, that are now exposed at the Garhi Chandan area in section 4. The dates obtained by fission track method on zircon from two samples of the volcanic ash, (V1 the upper, and V2 the lower, section No.4), indicate the date of deposition as 2.7±0.3 m.y.a. and 2.8±0.4 m.y.a. respectively. It should also be noted that these dates closely coincide with those of the volcanic tuffs found in various parts of Potwar and the Salt range (Johnson, et al., 1979, Opdyke, et al., 1979, Raynolds, et al., 1980). These dates also confirm the fact, that the deposition of tuff in the Peshawar vale is contemporaneous with Upper Siwaliks of Potwar.

After the draining of the lake, the ancient Kabul river re-established its course over the lake bed, and began to develop its flood-plain. During this period, the Kabul river was sluggish meandering stream, building its floodplain due to frequent overflowing and vertical accretion. (Section Nos.3a, 5a, 7b). The climate around the vale may have been warm and humid, during which fine silty material from the clay-bearing rocks was supplied from the upper slopes through mass movement. With the high water discharge and widening meander belts, channel-cuts seem to have been common. In places well-developed soil profiles with B horizon were formed on the abandoned flood plain (Section No.7) These beds of floodplain may be considered homotaxial to the Pinjor beds of upper Siwalik of Potwar dated as 2.47 m.ys. (Opdyke et al., 1979).

There were also periods of high water discharge when the backsplash of the flood water eroded soil, while white sand and gravels derived from the northern provenance (Burbank and Tahirkheli, 1985) were deposited in the migrating channel as its lag deposits. These deposits of flood plain facies have been named as Jallozai formation by Tahirkheli (1970).

In the meantime, a change in the size of the sediments took place when besides channel sand, a large amount of gravels and boulders from the crystalline metasediments and igneous rocks of the northern provenance were supplied. Their deposition suggest a braided stream pattern, which indicate a rapid uplift of the surrounding mountains, resulting in the development of steep gradient and high energy streams, with relatively high water discharge. Contemporarily, this period may have been the culmination of deglaciation processes.

It was during a warm/inter-glacial phase, when large amount of morainic material was exposed and released by the retreating glaciers. The high energy streams (Bara-Kabul-Swat) derived a large amount of morainic material and formed large alluvial fans, at their outlets. These fans extended south-eastward, as far as the northern foot-slopes of the Attock-Cherat range. This fan material has been referred to as the First valley fill (Section Nos. 27, 12b & c, 4), Its deposition continued until the end of the First Glaciation. It should be noted that the lithological compo-

sition and mode of occurrence of the First valley fill is closely similar to the Upper Siwalik conglomerates of the Potwar plateau which are dated as 1.9 m.y.a. (Johnson, et al., 1979, Opdyke, et al., 1979 and Raynolds,et al., 1980).

5.2.2 Middle Pleistocene

With the onset of cold conditions, contemporaneous with the Second Glaciation in the Karakorams and Himalayas (Gabral Glaciation, Porter, 1970), it appears that a phase of erosion had set in, resulting in the incision of the earlier deposits, (Section Nos. 6a, 8a, 12a, 12c, 27). This phase of erosion probably ceased as a result of thrusting along the Main Boundary Fault which uplifted the south-eastern areas of vale and the Kala Chitta range in the south (Barbank and Reynolds, 1984). Consequently the Indus river which was draining the Attock-basin, was pushed to the north. It should be noted that prior to this event, Kabul river used to join the Indus near Lawrencepur. This is inferred from the mineralogical similarities between the Lawrencepur sand (sample L3) and a sand deposit (sample N1) at Nowshehra. These sand deposits appear to have a common source in the Ambela granite, (Rafique, personel communication). This is also confirmed by plotting of mineral data of both the samples which shows a very small variation pattern (Fig. 5.2.2.1 and Table-5.2.2.1)

As a consequence of the uplift, the Indus river began to flow slightly towards the Peshawar vale, which impeded the flow of the Kabul river, and another lake (second)

LABORATORY EXAMINATION

Section

Table No.5.2.2.1

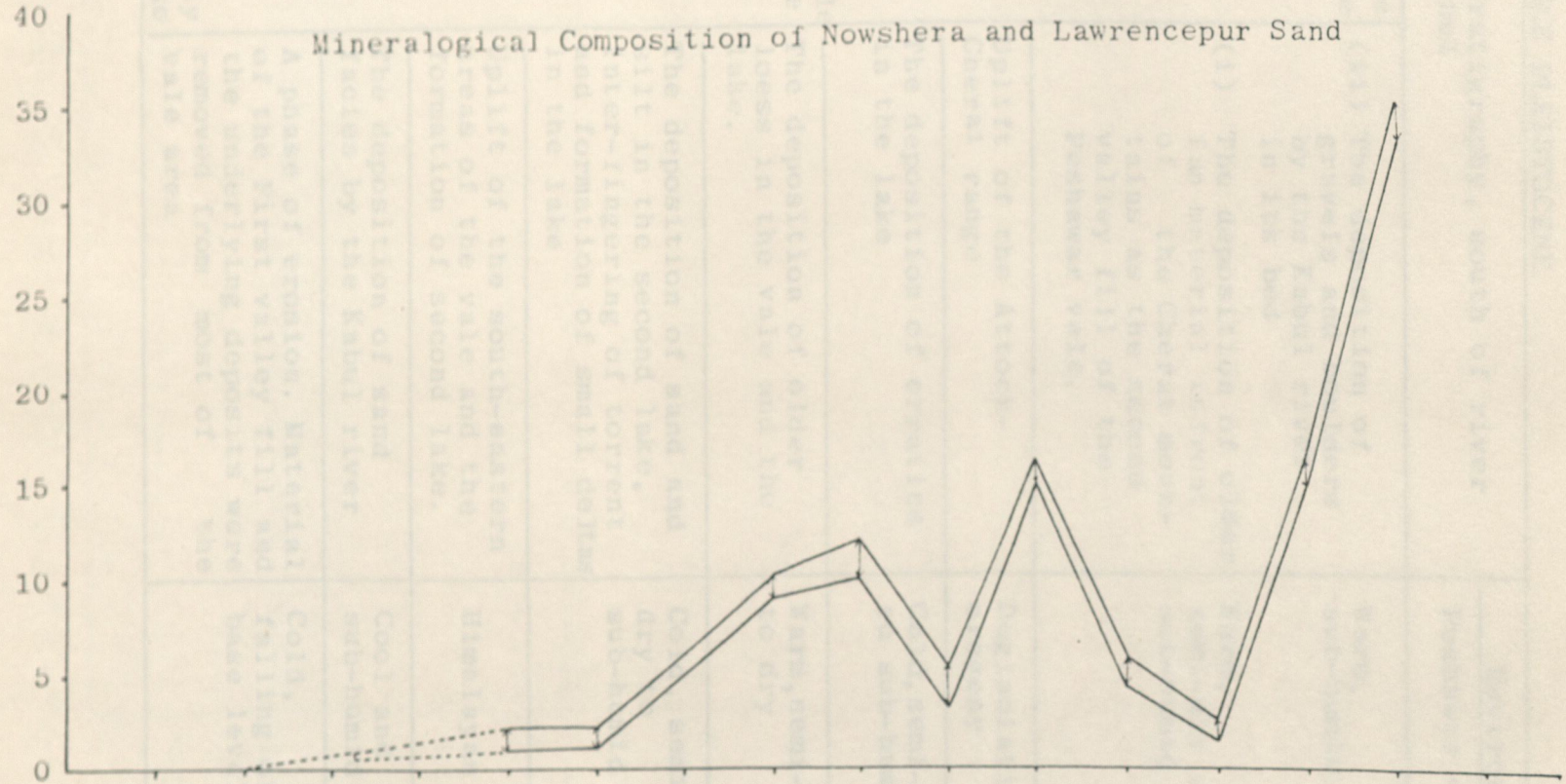
Mineral Composition (Approximate Percentage)

	Sample N1* (Nowshehra sand)	Sample L3** (Lawrencepur Sand)
Quartz	33	35
Feldspars	15	16
Clays	1	2
Opaque	5	5
Biotite	16	15
Muscovite	5	3
Carbonates	12	10
Amphibole	9	10
Chlorite	-	Tr
Rutile	2	1
Tourmaline	1	2
Epidote	Tr	-
Zircon	Tr	Tr
Sericite	-	Tr
Apatite	-	-

* Grains are mostly subangular, few are angular.
** Grains are subangular to sub-rounded few are angualr.

Fig.5.2.2.1

Mineralogical Composition of Nowshera and Lawrencepur Sand



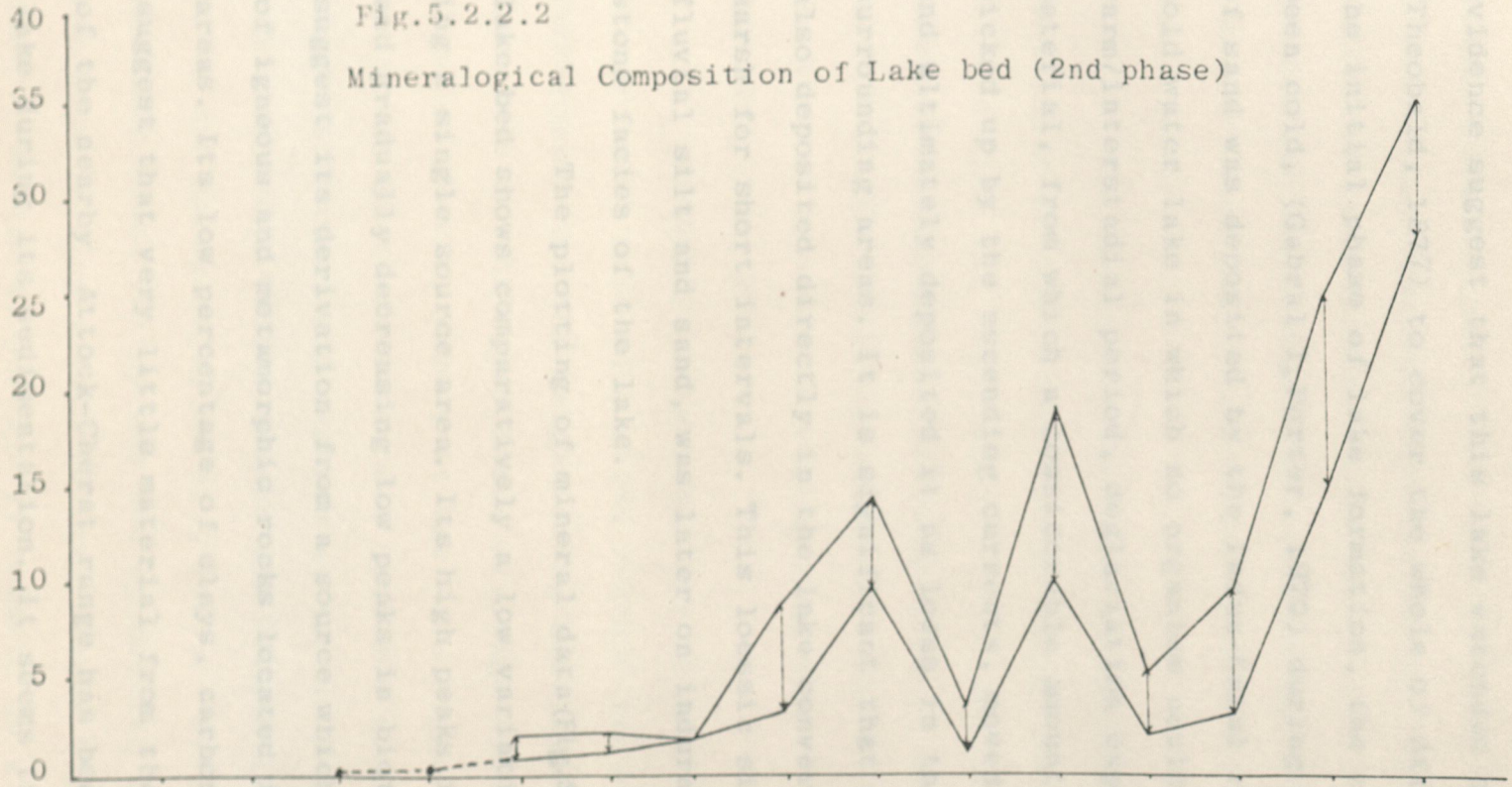
QUATERNARY STATIGRAPHY

MIDDLE PLEISTOCENE

		Stratigraphy, south of river Kabul	Environmental correlation	
			Peshawar vale	Swat Himalayan
MIDDLE PLEISTOCENE	Late phase	(ii) The deposition of gravels and boulders by the Kabul river in its bed	Warm, sub-humid	Deglaciation, maximum wanning of Glaciers
		(i) The deposition of older fan material infront of the Cherat mountains as the second valley fill of the Peshawar vale.	Warm, semi-dry to sub-humid	
		Uplift of the Attock-Cherat range	Deglaciation and Himalayan orogeny	
	Middle Phase	The deposition of erratics in the lake	Cold, semi-dry to sub-humid	Late stade (Gabral II) (Porter, 1970).
		The deposition of older loess in the vale and the lake.	Warm, semi-dry to dry	Interstade
		The deposition of sand and silt in the second lake, Inter-fingering of torrent and formation of small deltas in the lake	Cold, semi-dry to sub-humid	Early stade (Gabral II) (Porter, 1970).
		Uplift of the south-eastern areas of the vale and the formation of second lake.	Himalayan orogeny	
		The deposition of sand facies by the Kabul river	Cool and sub-humid	Neutral regimen of glacier
	Early phase	A phase of erosion. Material of the First valley fill and the underlying deposits were removed from most of the vale area	Cold, falling of base level	Gabral glaciation (Porter, 1970)

Fig.5.2.2.2

Mineralogical Composition of Lake bed (2nd phase)



was formed during the Middle Pleistocene. (Section Nos. 11a, 13a, 14a, 15a, 16a, 17a, 18a, 21a, 28b, 30a and 31a). Field evidence suggest that this lake extended beyond the vale (Theobald, 1877) to cover the whole of Attock basin. During the initial phase of lake formation, the climate may have been cold, (Gabral I, Porter, 1970) during which huge amount of sand was deposited by the Indus-Kabul rivers. It was a cold water lake in which no organism could grow. During a warm/interstadial period, deglaciation exposed morainic material, from which a considerable amount of fine silt was picked up by the ascending currents, moved across the mountains, and ultimately deposited it as loess in the vale and over the surrounding areas. It is significant that some loess was also deposited directly in the lake converting it into a marsh for short intervals. This loessic silt mixed with the fluvial silt and sand, was later on indurated to form siltstone facies of the lake.

The plotting of mineral data (Fig.5.2.2.2.) of this lake bed shows comparatively a low variation pattern signifying a single source area. Its high peaks in quartz, feldspars and gradually decreasing low peaks in biotite and amphiboles suggest its derivation from a source which may be composed of igneous and metamorphic rocks located in the northern areas. Its low percentage of clays, carbonates and chlorite suggest that very little material from the sedimentary rocks of the nearby Attock-Cherat range has been added in the lake during its sedimentation. It seems that the slopes of

Attock-Cherat range did not release their material as most of its was frost jammed during a long phase of the Middle Pleistocene.

The frequent exposure of the lake surface is indicated by mottling, while the presence of short worm tracks and small wormholes reflect marshy and boggy environment in which only leaches and their larvae-like organism could grow.

In the south, the lake extended as far as the foot-hills of the Attock-Cherat range. Numerous local torrents drained into the lake, which eroded weathered material prepared on the mountains and deposited it on the lake shores as deltas. The shifting courses of the torrent resulted in the torrent gravels interfingering with lake beds.(Section Nos. 14a, 16a, 20a)

Probably, it was another stadial (Gabral II, Porter 1970) when glaciation reached its maximum over the Karrakorams and the neighbouring Himalayas and filled nearly the whole of the Upper Indus drainage system with ice and glaciers (Norin, 1925). It has been suggested that the tributary glaciers descended upto 800 meters above sea level at Shatial and reached as far as Besham-Kamila in the main Indus valley (Desio and Oromballi 1971; Desio, 1974; and Ambrasseys, et al., 1981). It is believed that the main Indus valley was fed by several tributary glaciers which on joining formed a "Great Indus Glacier" (Theobald, 1880). At times, perhaps it behaved as a surging glacier,

the snout of which perhaps reached as far as Tarbela, during its maximum advance.

It was during this stadial that erratic blocks were deposited in the vale. (Section Nos. 17a, 28a, 33) Their mode of origin has been a matter of considerable debate. The present findings suggest that the erratics were deposited as ice rafted blocks detached from the snout of the Great Indus Glacier and driven into the lake, towards west in the Peshawar vale and east into the Attock basin. Their occurrence at various heights clearly indicate that they have been rafted in a deep water lake. It is also to be noted that erratics are mostly found along the northern foothills and piedmonts south of the Kabul river, which would also suggest that these came from the Indus valley.

Deglaciation process over the nearby Himalayas started under a warmer phase that culminated in the retreat of glaciers from the high altitude valleys, releasing morainic material later on to be reworked by fluvial processes.

It has been suggested that "during glacial phases, water loads were transferred from the oceanic 70% of the earth surface to the glaciated 5% which led to the depression of the earth crust, whilst the release of the weight of the melting ice leads to uplift" (Goudie 1979, p.185). The deglaciation phase in the northern Pakistan may have initiated a series of uplifts, in order to achieve isostatic balance.

There is also considerable agreement that glaciation, volcanicity and orogenic movements in the Quaternary are closely related (Charlesworth, 1957; King, 1965; Flint, 1971). It has also been suggested that orogenic activity has been relatively more intense during the Pleistocene at the margins of the various tectonic plates (Goudie 1979, p.188). The waxing and waning of the glaciation could therefore activate plate movement leading to orogenic activity. Tectonic studies pertaining to Peshawar vale indicate that due to its location near the marginal areas of the Indo-Pakistan plate it has been subjected to rather intense orogenic movement during Pleistocene. This is evident from the fact that the Nanga Parbat region has been uplifted at a phenomenal rate of 1 cm per year during the Pleistocene (Zeittler, et al., 1982).

During the following interglacial, the Peshawar vale was tectonically active, as can be seen from the tilted and warped lakebeds. On Attock-Cherat range the rapid uplift initated another phase of erosion. Under the warm-humid environment, its slopes began to release weathered material after reworking by the rejuvinated torrents. It was deposited in great thickness as "Older fans" referred to as the Second valley fill.(Section Nos. 1c, 2a,b & c, 3b, 4,5,6b, 7cde, 9b, 12b & d. Lithological examination of the Second valley fill shows that it is composed of subangular to subrounded, medium to large-size gravels, mostly of limestone and sand-stone. It also includes a few medium-size, well-rounded

gravels of granite, geneiss, quartzite, and ultramafic rocks, which have been derived from the material of the First valley fill, some of which are still preserved along the foothills of the Attock-Cherat range. Desert varnish on the sandstone and quartzite gravels is common, while gneiss and granites gravels are deeply weathered. There is also a rapid change of lithology both vertically and laterally. Silt of brownish and olive green colours are frequently interbedded with gravels, while in places gravelly sandstone is replaced by conglomeratic beds. Solution holes and cavities within the gravels are very common, suggesting chemical action during a warm and humid environment. The cementing of gravels into hard conglomeratic beds also indicate a warm humid interval. The detail morphology of the gravelly beds indicate that their material was deposited by a braiding stream in a well-developed regime of alluvial fan, nourished under a warm semi-arid to sub-humid environment and rapid uplift of the Attock-Cherat range. Due to the high degree of patination and the presence of gravels of local origin in the fans, it has been considered as material of the Older Fan to differentiate it from the Younger fan, which is devoid of any patination, or cementation. These may be correlated with the Lei conglomerate of Potwar.

The period of Older fan is also marked by aggradation in the main vale, as is clear from the rounded subrounded gravels and boulders exposed in section 9. These are derived from the moraines left over by the glaciers from

the northern provenance and deposited by the Kabul river and its tributaries on the lake bed. As a result, the vale was filled with a thick blanket of sediments, which buried many hills and ridges along the northern slopes of the Attock-Cherat range as discussed in section 1.

5.2.3 Upper Pleistocene

The upper Pleistocene started with the deterioration of climate, initiating another glacial phase (Kalam Glaciation, Porter 1970) over the Himalayas and Karrakoram. This is marked by a phase of erosion, starting at a time when the combined water of Indus and Kabul rivers began to drain over the crest of the Attock-Cherat range. By the process of backward erosion, the Attock gorge was incised and Indus started flowing in its present course. The rejuvinated streams incised and removed much of the gravels and lakebeds from the vale. During this period, the Attock-Cherat range was subject to physical weathering due to intense freez-thaw action. By the time the Third Glaciation completely established itself over the Himalayas, the floor of the vale had been sufficiently lowered to initiate another cycle of sedimentation. The Kabul and its main tributaries began to build up their flood plains. (Section Nos. 16b, 17a, 18b, 19a, 30b, 31b, 33b) During this period, the meandering and migrating channel of Kabul river deposited "point bar facies" on its flood plain. It appears that due to an increase of temperature there was accelerated melting

UPPER PLEISTOCENE

		Stratigraphy, South of Kabul River	Environmental Correlation	
			Peshawar vale	Swat Himalayas
PLEISTOCENE		Late phase: Resumption of deposition of younger loess	Warm, semi-dry	Deglaciation
		Cessation in the deposition of loess and the deposition of recent gravels	Warm, sub-humid	Deglaciation slows
		The deposition of younger loess	Warm, semi-dry	Deglaciation
		The erosion of soil, gravels and the lake beds	Cold, dry to semi-dry	Third stade (Kalam III) Porter, 1970)
		The deposition of clay and fine silt in the Fourth lake	Cool humid	Neutral regimen of glaciers
		Development of soil on gravels	Warm, sub-humid	Interstade
		Late phase of deposition of Younger alluvial fan from Cherat mountain	Warm, semi-dry to sub-humid	Interstade
	Middle Phase	Uplift of the Attock-Cherat range	Himalayan orogeny	
		A phase of erosion of soil, torrent gravels and parts of flood plain and the lake beds	Cold, dry to semi-dry	Middle stade (Kalam II) (Porter, 1970)
		Development of soil on gravels and lake beds	Warm, sub-humid	
UPPER		Formation of flood plain in the west and deposition of lacustrine facies in the third lake, south of Nowshehra	Damming of Kabul river by growth of an alluvial fan	
		An early phase of deposition of Younger alluvial fans from Cherat mountain	Warm, semi-dry to sub-humid	Interstade
		Uplift of the Attock-Cherat range	Himalayan orogeny Falling of local base level	
		Formation of flood plain and the deposition of sand facies	Cold, dry to semi-dry	Early stade (Kalam I) (Porter, 1970)
	Early phase	A phase of erosion. Material of the older fan and the underlying lake beds are removed from most of the vale area	Lowering of base level	Kalam Glaciation (Porter, 1970).

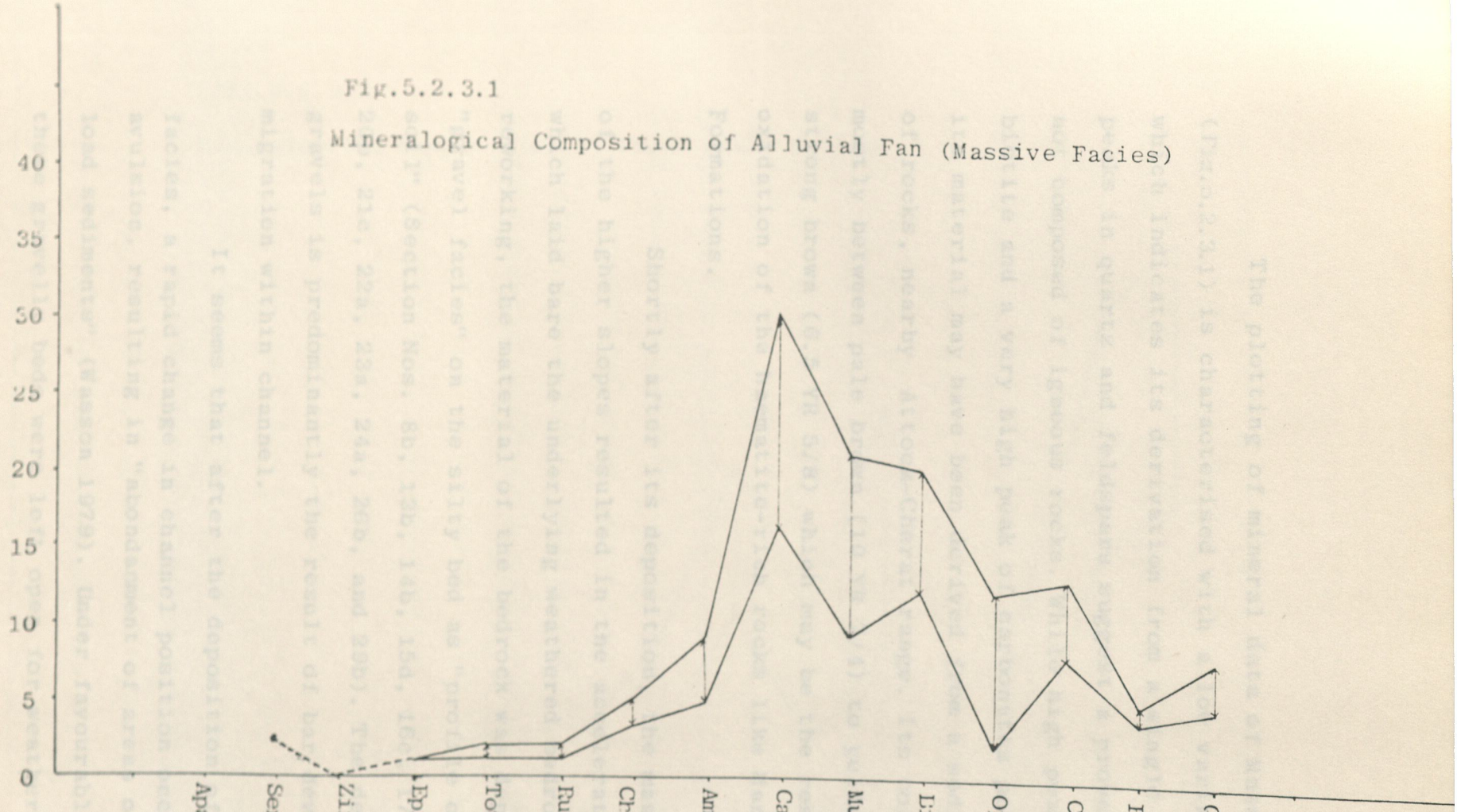
of ice. This resulted in periodic floods, during which lateral erosion was very rapid, in areas where loose sand was available. It was during this time, that the entire course of the Kabul river suddenly shifted, due to "avulsion" and acquired the present course. As a result, sandy material of the point bar facies was eroded except those found in the Zindai Khwar south of Peshawar, at Nowshehra and south of Shaidu.

Meanwhile, regolith developed over the slopes of Attock-Cherat range. The climate at that time was probably warm and semi-dry, with occasional humid spells. Simultaneously, the Attock-Cherat range experienced another phase of rapid uplift. Consequently, the rejuvinated torrents from the Cherat mountain deposited their material, as alluvial fans, referred to as Younger alluvial fans.

The younger fans seem to have been initiated by mass-movement on the higher slopes of the Attock-Cherat range, when fine regolith was directly deposited in the torrents channels. The fine sediments moved as high concentration mixture of sand and silt like "slurry flows" and deposited in one or more massive lobe-like body of varying thickness. These massive silty beds of younger alluvial fans closely resemble in lithology and mode of formation, the Mundi Mundi Alluvial Fans in Western New South Wales, Australia, which has been refered to as "Massive Facies," (Wasson, 1979, Section Nos. 11b, 15c, 16d, 17b, 20a, 21b and 26a).

Fig.5.2.3.1

Mineralogical Composition of Alluvial Fan (Massive Facies)



The plotting of mineral data of Massive Facies, (Fig.5.2.3.1) is characterised with a low variation pattern which indicates its derivation from a single source. Its low peaks in quartz and feldspars suggest a provenance which is not composed of igneous rocks. While high peaks of clays, biotite and a very high peak of carbonates point out that its material may have been derived from a sedimentary suite of rocks, nearby Attock-Cherat range. Its colour varies mostly between pale brown (10 YR 7/4) to yellowish red to strong brown (6.5 YR 5/8) which may be the result of strong oxidation of the haematite-rich rocks like Manki and Murree Formations.

Shortly after its deposition, the mass-wasting of the higher slopes resulted in the accelerated erosion which laid bare the underlying weathered bedrock. After reworking, the material of the bedrock was deposited as "gravel facies" on the silty bed as "profile of an inverted soil" (Section Nos. 8b, 13b, 14b, 15d, 16c, 17c, 18c, 19b, 20b, 21c, 22a, 23a, 24a, 26b, and 29b). The deposition of gravels is predominantly the result of bar development and migration within channel.

It seems that after the deposition of the gravel facies, a rapid change in channel position occurred, due to avulsion, resulting in "abondanment of areas of traction load sediments" (Wasson 1979). Under favourable environments these gravelly beds were left open for weathering and pedogenice processes (Bull, 1972), resulting in the

Fig.5.2.3.2
Mineralogical Composition of Flood plain facies

development of soil profile with a thick growth of vegetation which is indicated by a high percentage of organic matter(section Nos. 17c1, 18c1, 19b1, 20b1, 23a1, 26c1).

In the main vale, the Kabul river began to built its flood plain and through vertical accretion, overbank facies was laid along its southern bank, (Section Nos. 23b, 24b, 25). Plotting of mineral data (Fig.5.2.3.2) shows a high variation pattern which indicates its derivation from a variety of sources. Its high peaks in quartz, feldspars and low peaks in biotite and muscovite suggest a provenance which is composed of igneous and metamorphic rocks, while low peaks in clays and carbonates suggest that material has also been added from the local sedimentary rocks.

The development of alluvial fans northward, east of Nowshehra reef hills, facilitated the blocking of the Kabul's channel resulting in the formation of another lake phase (third lake) at Nowshehra, which extended as far as Ziarat Kaka Sahib in the south (Section Nos. 17d, 18d, 20c, 22b, 23b, 27b, 28a, 30b, 31c). It is to be noted that lake sediments exposed near Baitul Gharib are composed of alternate beds of silt and sand, that are formed in response to the seasonal fluctuation in the ablation of glaciers. Burbank (1983) however, has interpreted these beds as catastrophic flood deposits of the Indus river. These sediments are normally magnetized and belong to the Brunhas Chron and are about 0.7 m.ys old (ibid).

Fig.5.2.3.3
Mineralogical Composition of Lake bed (3rd phase)

The plotting of mineral data of third lake phase (Fig.5.2.3.3) exhibits a high variation pattern signifying differences in the mineralogy of the source area. A high peak in quartz and feldspars shows its derivation from igneous and metamorphic rocks, however, these beds are significantly marked by a higher percentage of feldspars than quartz. This indicates weathering of fedlspars under special conditions. It seems that the weathering of feldspars have taken place by granular disintegration in a cold arid climate rather than its chemical decomposition. It may also be noted that glacial regions too have much physical weathering and provide feldspar-rich debris. Similarly, very rapid erosion of fledspars due to rapid uplift may have taken place in which feldspars simply did not have time to weather (Ollier, 1975, p.55). It may be pointed out that the third lake was formed during an Himalayan orogeny when the Kabul river was dammed by the northward prograding Younger alluvial fans.

Frequent exposure of the lake bed is indicated by mottling, while vegetation growth is reflected in a high percentage of organic matter, particularly along lake shores. Similarly, on the flood plain, the abandoned overbank facies also developed a soil horizon with a vegetation cover. (Section Nos. 19c, 22b, 27b, 29b). These lake beds appear to have been involved in a tectonic activity by which the northern limb of the Attock-Cherat range was further uplifted about 0.4 m.y.a. (Burbank and Tahirkheli, 1985). This led

to the tilting of the lake beds toward the basin at Baitul-Gharib, while further south, at Ziarat Kaka Sahib they show tilting as well as normal faulting. It is also to be noted that deposits of Older fans lying between Ziarat Kaka Sahib and Tangi have also been faulted, along a line parallel to the Attock-Cherat range. It is likely that this fault is associated with pressure ridges that are the surface expression of left-lateral strike slip faults with a reverse-slip component (Yeats and Hussain, 1987).

This tectonic activity was following by another advancement of glaciers in the north, during the second stadial (Kalam II) that resulted in the erosion of soil, the torrent gravels, the lake beds and parts of the flood plain in the main vale, (Section Nos. 18d, 19c, 22c, 23b, 24b) while weathering of rocks prevailed over the Cherat mountains.

As a result, of the previous uplift and amelioration of climate, during warm and humid conditions (Lustig, 1965) material from the Cherat mountain streamed out as a late phase of the Younger alluvial fans (Section Nos.14c, 14d, 17e, 18e, 20d, 20c, 22c, 24d, 24e, 25f, 26c, 26d, 29b, 30c, 31d). It may be noted, that these two phases of Younger alluvial fans are stratigraphically separated either by the flood plain or the lacustrine facies of the third lake phase. The two facies are nevertheless contemporaneous. There are also indications, that soil and vegetation developed on the abandoned channels of the fans (Section No.22c1).

During the last stages of the development of Younger alluvial fan, Kabul river was dammed for the fourth time to form a lake. It covered much of the area, southwest of Nowshehra, and its water entered into some of the torrents channels. This time the lake had patches of deep water in which fine sediment like silt 60%, clay 28%, and sand 12% (Table-4.32.2.2.1)was deposited as suspended material. This mode of deposition in the lake is reflected in the enromous thickness of the beds which are devoid of varves or fine beddings. In the Babu Khwar the Youngest lake bed is clearly exposed (Section Nos. 15f, 16e, and 32c) and shows litho-logical and structural characteristics, which are very different from the lower (Second) lake beds composed of a higher percentage of sand and silt and is completely devoid of clay. Similarly, the upper lake bed (Fourth) has rela-tively bigger worm holes which are mostly vertical to the bedding plane. Perhaps it was a deeper lake, in which worms freely moved,vertically, instead of creeping horizontally along the beds of the lower shallow (Second) lake. This lake bed which is overlain by younger loess is also exposed in Nowshehra Tarakai, north of Kabul river and has been assigned an age of 124 ka (Rendell, 1988-89). During the third and last advance of glaciers in the Swat Himalayas (III Kalam), the climate of the vale deteriorated, to initiate another phase of erosion during which most of the previously developed soil, the gravel beds and much of the younger lake beds were eroded (Section Nos. 14d, 15f, 16e, 20c, 21c, 27c1, 25f, 26d,

27d & e 29b). This was followed by the deposition of loessic silt, which in places buried the earlier relief (Section Nos. 9b, 10d, 11d, 13c, 14e, 15g, 16f, 17f, 19d, 20f, 21d, 22d, 23c, 24f, 25g, 26e, 28c, 30d, 32d, 33d).

It may be noted that the deposition of loess during the Pleistocene period is a global phenomenon, but there is lack of agreement on its genesis. Various views have been put forward with regard to its definition and mode of origin (Smith and Norton, 1935; Russel, 1944b;Fisk, 1951; Berg, 1964; Smalley 1966; Smalley and Vita-Finzi, 1968; Kunen, 1969; Smalley, 1970, 1971). A discussion to its origin is beyond the scope of present study. However, a summary of some of the field observations and laboratory examination of loess of Peshawar, may be discussed in order to understand the circumstances in which the loess was produced and deposited in the vale.

1. The loess of Peshawar vale is generally unstratified, unconsolidated and structureless. It is dominantly composed of silt-size particles, with a low percentage (average)of sand (16%) and clay (12%). The deposits may vary from 5 to 20 feet in thickness.

2. Though commonly unstratified, in places loess shows two to three beds with internal laminations which indicate a temporary periods of haults in deposition. The laminations may be due to variation in wind velocity or direction.

3. Some of the loess also contains lenses of sand and fine gravels, while angular fragments of slate or shale are occasionally found. This would suggest that some of the loess is perhaps "redeposited" as slope wash from the Attock-Cherat range, during wet spells. In places, loess is interbedded with a thin bed of torrent gravels indicating a temporary hault in its deposition, due to a change in environment.

4. The loess tends to split along vertical joints, stands and maintains steep face, due to gully erosion. It also shows columner structure, which develops into bad land topography, particularly, in the vicinity of Jallozai village.

5. Most of the loess also contains concretions and nodules of various sizes and shapes, indicting leaching of calcium carbonate during a warm semi-dry climates while the ring-shape calichie indicate development of solution holes due to chemical action in humid conditions.

6. Some of the loess beds also contain terrestrial fresh water snails and mollusks, indicating wet conditions.

7. The fine root-holes, containing some decayed brownish-grey organic matter suggest the growth of vegetation, like low shrubs and grasses.

8. Mineralogically, the loess of Peshawar vale consists predominantly of quartz and feldspars with high concentration of carbonates, followed by a gradual decrease in biotite, muscovite and amphiboles.

Fig.5.2.3.4

Mineralogical Composition of Loess

9. Microscopic study shows that individual grains are mostly sharp and angular. Through SEM (Scanning Electric Microscope), the individual grains of quartz shows rough surface texture with clear marks of etching. The loess of Peshawar vale is therefore very similar to the loess studied in Europe, (Cegla, et al., 1971, Smalley and Caberera, 1970) West Germany and Poland, (Pye, 1983); Tajekistan, (Goudie, et al., 1984).

10. The colour of loess varies between pale yellow to yellow brown, and yellowish brown to brown yellow, suggesting development of ferric oxide. In places, where the surface is occupied by lichen, it shows grey shade.

In order to explain the formation and deposition of loess, Smalley (1971), formed a model, which consists of (i) a formation stage, (ii) a transportation stage and (iii) a deposition stage. These three stages form a mechanical system by which the genesis of loess of the Peshawar vale can also be vividly visualised.

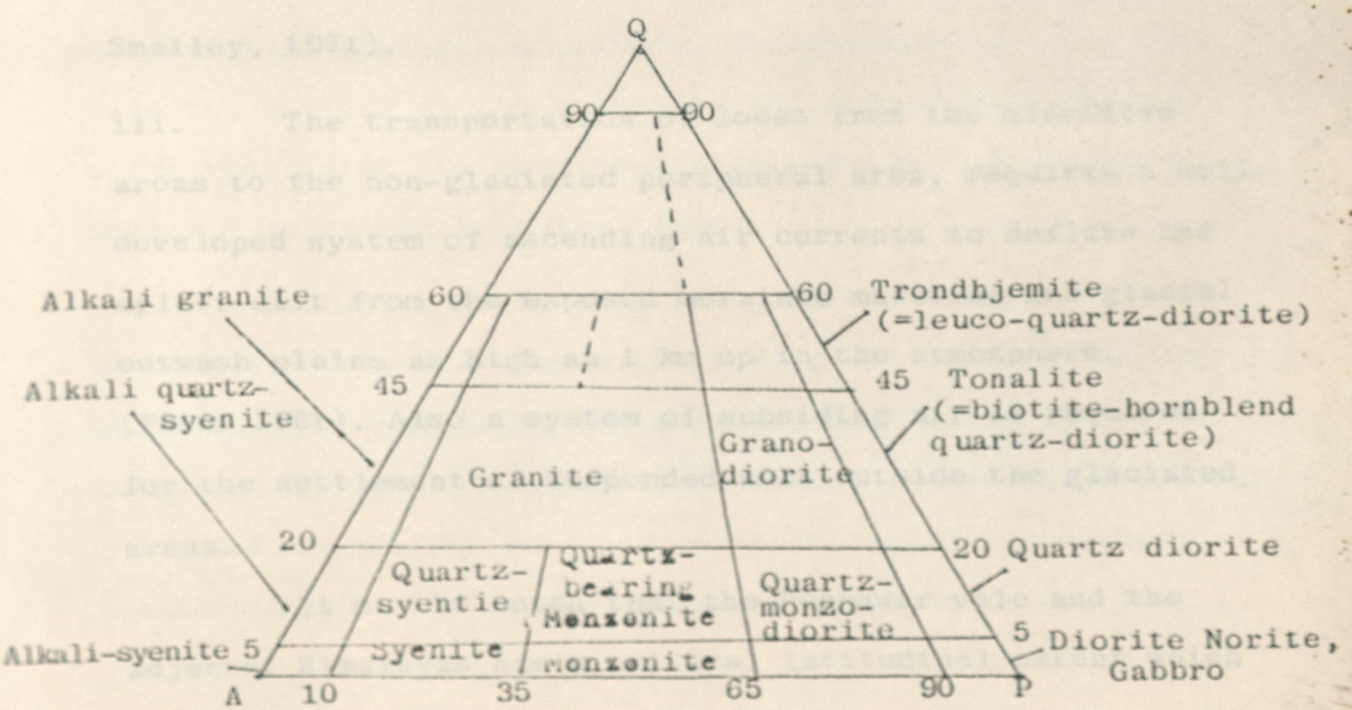
On the basis of lithological and physical characteristics of loess of Peshawar vale, the following views are suggested with regards to its origin and mode of formation:

i. The plotting of mineral data from various loess beds in(Fig.5.2.3.4) indicate a low variation pattern, signifying a single source. Loess of Peshawar vale are characterised by a high concentration of quartz and feldspars, suggesting their derivation from a quartho-feldspathic parent. The comparison of the average mineral composition of loess

TABLE-5.2.3.1

Comparison of the mineral composition (average of loess from the Peshawar vale with average granite

LOESS			GRANITE AS PER FIGURE BELOW
Quartz	37 (%age)	20-40	
Feldspars	30	15-30 }	alkali feldspar
Clays	4	10-25 }	Plagioclase and very commonly
Opaques	3		biotite and muscovite with
Biotite	16		accessary minerals including
Muscovite	9		apatite, zircon and
Amphiboles	4		magnetite.
Chlorite			
Rutile			



Q=Quartz; A=Alkali feldspar; P=Plagioclase.
Fig. Classification of Plutonic rocks in the triangle QAP.
Source: Streckeisen, Geotimes, Oct 1973, p.26 for final report of the IUGS.

(excluding carbonates which are of secondary origin) with an average granite/granite-gneiss in table - 5.2.3.1 suggest a daughter-parent relationship. (See the close correspondance between the concentrations of major minerals in both the composition). Therefore the loess has been formed in areas which are particularly composed of biotite-granite, granodiorite/gneiss which are distributed widely in the northern provenance, which were formerly very extensively glaciated.

ii. Loess may be considered as rock flour produced by glaciers (Smalley, 1971). The general angularity, irregular surface texture, and marks of etching on the individual grain suggest that glacial grinding is the only effective means of producing sufficient silt-size quartz to supply the loess deposits (Smith and Norton, 1935; Smalley, 1966b; Smalley and Vita Finzi, 1968; Smalley and Caberera, 1970; and Smalley, 1971).

iii. The transportation of loess from the glaciated areas to the non-glaciated peripheral area, requires a well-developed system of ascending air currents to deflate and uplift silt from the exposed morainic material and glacial outwash plains as high as 1 km up in the atmosphere. (Flint 1961). Also a system of subsiding air is required for the settlement of suspended silt outside the glaciated areas.

It may be noted that the Peshawar vale and the adjacent Himalayas has a critical latitudinal extent which

is climatically controlled by the Monsoons and the Westerlies. The belt of these winds migrates seasonally a few degrees north and south and has profound effect on the atmospheric circulation of low as well as high altitude areas.

Recently, Chinese scientists have demonstrated that the rapid elevation of Qinghai-Xisang Plateau (Tibet) and the Himalayan mountains during the Quaternary period has resulted not only in growth of glaciers but also changed the entire atmospheric circulation of the region. Glacier growth has responded to these changes in morphology and atmospheric circulation. The elevation of this mountainous region resulted in its powerful heating effect which has a strong impact on the atmospheric circulation. In summer, the Himalayas and the surrounding region, forms a special atmospheric situation, characteristics of a low near the surface of the mountains and a warm high above it, which punctuates the sub-tropical planetary high pressure zone (Li Jijun and Xushying, 1980).

Probably, it is this low pressure which is characterised by a system of ascending air currents during which the silt particles are deflated and lifted to a great height, till they are encountered with the upper high pressure zone, the descending currents of which facilities outward horizontal movement to some distance after which due to subsiding air of high pressure the silt began to settle

and deposit outside the glaciated region. It has also been found that the base of low pressure is sometime punctuated directly by subsiding air over the glaciated area during warmer phase. This also explains deposition of loess over the moraines in Swat Himalayas (Porter, 1970).

iv. The physical characteristics of loess as discussed in the previous pages indicate that during its deposition the climate was characterised by warm and dry conditions punctuated with occasional wet phases which may be due to incursions of Monsoons. It is inferred that wet conditions also facilitated the silt particles to settle down. Similarly, the general unstratified and massive nature of the loess deposits indicate that its accumulation occured slowly and continuously over a long period of time (Flint 1971, p.267) which probably spread over a period from 66Ka to 22Ka (Rendell, 1988-89).

The exact climatic provenance of glacial loess is uncertain. Although it is now recognised that most glacial loess have been derived from the outwash of streams acting as glacial sluice ways (Smalley, 1966), but whether the loess is indicative of waxing glacial or waning glacial time is a matter of contention (Alford, 1982). It was suggested by Woldsted (1967), Butzer (1971) and Fairbridge (1972) that loess deposits were formed at glacial maxima, while, Visher (1922), and Moran (1977), pointed out that loess was associated with retreat of continental glaciers

and accumulated when the climate shifted from glacial to an interglacial pattern. Smalley (1971, p.83) strongly advocated the latter views and remarked that "at the time of a glacial maximum, all the rock debris, apart from some in the end morain, will be covered by the ice sheet and traped. When the ice-sheet disappears, the bulk of the rock detritus is released and the fine material is eventually lifted by the wind and carried to become loess."

It may be noted that both physical characteristics of loess and its time of deposition which spreads over a span of about 44000 years (from 66Ka to 22Ka, Rendell 1988-89) suggests that the loess in the Peshawar vale is contemporaneous with the melting of glaciers in the nearby Swat Himalayas in the middle of the last glacial phase. The deposition of a gravel bed within younger loess indicates a short hault in its deposition (Section Nos. 11e, 13c, 16g, 17g, 19e, 21e, 27c, 33d1). It appears that perhaps the climate became a little more humid during which the torrents were activated and material from the Attock-Cherat range was deposited on the loess bed as "recent gravels." This however persisted for a short while and the deposition of loess was resumed at about 22Ka (Rendell, 1988-89 (Section No. 33d1.

5.2.4 Holocene

During the Holocene, the weathering of loess and the development of a pedocal soil all over the loess is indicated by the leaching and concentration of calcium

QUARTERNARY STRATIGRAPHY

HOLOCENE

Stratigraphy, south of river Kabul		Environmental Correlation	
		Peshawar vale	Swat Himalayas
Late phase	Recent aggradation of the Kabul river, and its tributaries	Warm, semi-arid to sub-humid. Release of more weathered material	Release of more morainic material
Middle Phase	Erosion of torrent gravels, loess and the formation of badland topography south and southwest of Jalozai	Warm,semi-arid, Torrential rainfall.	DEGLACIATION CONTINUES Intermittent Himalayan orogenies
	Uplift	Falling of local baselevel	
	Erosion of piedmont deposits and formation of fan approns, south of Nowshehra	Warm, semi-arid to sub-humid	
	Uplift	Falling of local base level	
	Erosion of loess and gully formation	Warm-semi-arid torrential rainfall	
	Uplift	Falling of local base level	
Early phase	Weathering and the development of soil in the loess.	Warm, semi-arid to sub-humid	

HOLOCENE

carbonate as nodules and concretions.

The presence of fine root holes suggest the growth of grasses and small shrubs in a warm semi-dry climatic conditions.

Due to intermittant uplifts of the Attock-Cherat range, the falling base level initiated a long phase of erosion which probably operated in three phases followed by a recent phase of aggradation:

i. During the first phase, the loess cover was eroded from the upper slopes and deposited lower down. This resulted in the exposure of piedmont in places. In the lower area, particularly along the torrent bed, gully formation began to take place. The exposed lake beds were further eroded by torrents to form an erosional terrace in the Babu Khwar (Section: 17a).

ii. During the second phase of erosion the Older fans were eroded and their material spread over the down-slope as fan apron. Some of the fine material was washed down, filling gullies and depressions. The torrent channels were further lowered and a second erosional terrace in the lake bed was formed (Section: 17a).

iii. It is likely that widespread deforrestration and overgrazing in the historical time accelerated the process of erosion and gully formation, leading to the development of badland topography, south and south west of

Jallozai. Due to erosion the torrent bed was further lowered and a third erosional terrace was carved on the lake bed (Section: 17a).

This phase of erosion came to a hault when climate became relatively more warmer and humid. Morainic material was supplied from the northern areas while torrent began to bring detritus from the slopes of Cherat mountains. All these events led to aggradation in the Peshawar vale. The Swat and Kabul rivers jointly built up the present braided plain at their outlets from the mountains, while torrents deposited gravels in their beds.

CHAPTER 6

SUMMARY AND CONCLUSION

6.1 PRE-QUATERNARY PERIOD

After a long period of erosion, lasting for about 15 to 19 m.ys, broad valleys separated by intervening ridges were carved in the Tertiary mountain system. Peshawar vale emerged as a broad basin, which was filled with a variety of deposits during the Quaternary period.

6.2 QUATERNARY PERIOD

6.2.1 Lower Pleistocene

1. The earliest sediments belonging to Lower Pleistocene are exposed in a few pockets along the northern foothills of the Attock-Cherat range. Garhi Chandan area, is an instance of such an exposure, where sediments unconformably overlie eroded Murrees. Their unconformable relationship reflects a long period of erosion of Murrees during the Pliocene period.

2. It appears that after the recession of sea, the vale emerged as a land mass much earlier than the Potwar region, and passed through a phase of erosion in Pliocene. The resulting eroded material was deposited in the Potwar. This perhaps is one reason why Pliocene rocks are not found in Peshawar vale.

3. Sedimentation replaced erosion at about 3 m.y.a., due to an uplift of the Attock-Cherat range. The NE-SW trending ridge near Kund, blocked the drainage and formed a lake in which varied coloured silt was deposited as lacustrine facies. This was followed by the deposition of volcanic ash from Afghanistan in about 2.7±0.3 m.ys to 2.8±0.4 m.ys.a. Soon after the draining of the lake, the area was occupied by a river, perhaps Kabul, which deposited over-bank and channel facies, on lake beds as well as volcanic ash.

4. The environment in which deposition occurred in the lake repeatedly changed, under cyclically fluctuating climatic conditions, from cold to warm and dry to humid as shown by the different colours of the lake beds.

5. The lake sediments as well as the flood plain material may have been derived from the fine regolith of the surrounding mountains, moving downslope under soil creep. Also, in places, there is an evidence of a very old loess, embedded in the lake beds.

6. Two profiles of paleosols have been noted in the flood plain and lake beds, recording periods of climatic amerlioration (inter stades over the Himalayas).

7. Deterioration of climate (stades over the Himalayas) heralded the decay of vegetation, and the initiation of a widespread erosion of the flood plain and lake beds.

8. Deglaciation over the Himalayas and Karakoram resulted in the release of morainic material which was deposited in the vale as glacio-fluvial material, and has been named as the First valley fill. There is evidence to suggest that during this period, Kabul river was flowing very close to the northern foot-slopes of the Attock-Cherat range.

9. On the basis of two dates of volcanic ash, from the First valley fill at Garhi Chandan, the embedded sediments may be considered homotaxial to the Upper Siwaliks (Soan formation) of Potwar region. Its gravel deposits consisting of igneous and metamorphic rocks may also be equated with the gravels of Upper Siwaliks.

6.2.2 Middle Pleistocene

1. The Second glaciation initiated another cycle of erosion, during which much of the First valley fill was removed resulting in the lowering of the valley floor. In order to achieve a profile of equilibrium, aggradation began to take place in the Kabul river basin and its tributary valleys. This is recorded in the form of flood plain material that incorporates sand deposits, in pockets, as one of its significant facies.

2. The second lake was formed due to the uplifting of the south-eastern part of the vale and the consequent blocking of the Indus river system at Kund. This lake phase was spread over a very long span of time. Initially, it was formed during an Early Stade (Gabral I) of the Middle Pleistocene, while the older loess (Second) was deposited during the long inter stade, having a warm and semi-arid climate. Floating ice blocks as suggested by Elberson (1967), was not an important factor in the blocking of the Attock gorge and the formation of the lake. In fact, it is more likely that the Attock gorge was incised at a later stage, after the lake water spilled over the Attock-Cherat range, resulting in its draining. There is evidence to suggest that during the Middle Stade (Gabral II) large blocks of ice containing erratic blocks broke off the Great Indus glacier and were rafted, to various places in the vale.

3. There is lithological similarities between the erratics of Peshawar vale and those of the North-West Punjab, indicating a common provenance. This could probably be the Hornblendic Group/Kohistan Complex drained by the Indus river.

4. The Attock-Cherat range experienced a rapid uplift and weathering due to frost action. During the following warm sub-humid climate, the weathered material, was carried down by torrents and deposited as Older fans.

5. Detailed study of the deposits at Garhi Chandan clearly shows the presence of two gravel beds, which are in places separated by an erosional unconformity. The lower gravel bed, composed of clast from igneous and metamorphic rocks, is associated with whitish-grey sand bed. It is a member of the First valley fill,which is mainly derived from the northern provenance. The upper gravel bed is mostly composed of limestone and sandstone, derived locally from the Attock-Cherat range and is the facies of Older fans. On the basis of lithology, the gravels of Older fans may be considered homotaxial with "Lei Conglomerate" of Peshawar.

6.2.3 Upper Pleistocene

1. The onset of cold conditions during the Upper Pleistocene are marked by frost weathering of rocks, decay of vegetation and widespread eorsion of the earlier deposits.

2. The Kabul river deposited huge amount of sand on the eroded surface of the lake bed by building its point bar facies. It is to be remembered that due to avulsion, the channel shifted suddenly and occupied the present course.

3. Intermittent uplift of the Attock-Cherat range resulted in the formation of Younger alluvial fans, in two phases, which are separated either by a lake phase or flood plain facies. The two facies of Younger alluvial fans, e.g. the "massive facies" overlain by the "gravel facies" represent an inverted soil profile. The massive facies represent fine regolith, which moved down the slopes of the Attock-Cherat

range, as mud flow and deposited in two to three lobes. The gravel facies mark the removal of weathered bed rock, due to accelerated erosion under a semi-arid to sub-humid climate. It indicates that slopes of the Attock-Cherat range were covered with a fine regolith, twice during climatic amelioration. Each time its erosion resulted in the deposition of material marking an inverted soil profile.

4. The gravels belonging to the latter phase of the Younger alluvial fans underlie Younger loess. This situation is very similar to the one present in the Potwar region. These may therefore be correlated with the gravels comparable to the Third Glaciation in Potwar (Patterson and Drummond 1962).

5. The development of soil on the torrent gravels, indicates frequent shifting of the torrent channels, exposing the gravels to weathering and pedogenic processes, under a warm sub-humid climate.

6. Two phases of lake (Third and Fourth) formation due to the ponding of the Kabul river by the prograding Younger alluvial fans have been recorded.

7. A high percentage (2.68 and 3.35) of organic matter recorded in the marginal areas of the third lake phase indicates warm and humid conditions during which these areas were covered with a thick cover of forests.

8. The erosion of soil and parent material indicates deterioration of climate during various stades over the nearby Swat Himalayas.

9. Younger loess was deposited during warm and semi-arid climatic conditions. There is a break in its deposition, marked by lenses of torrent gravels indicating a temporary change in its regime, during which torrents became active geomorphic agents. The presence of loess over gravels suggests a resumption of warm and semi-arid conditions, conducive to the deposition of wind blown material.

10. The angularity and rough surface of the grains of the Younger loess, suggests that it was produced as rock flour by the grinding action of glaciers during glacial maximum. It was picked up by winds during a wanning phase of the last glaciation and deposited across the Himalayas in the vale and the surrounding region.

6.2.4 Holocene

1. The amelioration of climate during Holocene resulted in the development of a pedocal type of soil over loess, while large scale erosion resulted in the removal of loess and the exposure of the underlying peidmonts. This was followed by erosion and the development of badland topography and the formation of low-angled fans, on the fringes of the peidmonts.

2. The area records a phase of recent aggradation in response to the supply of clast due to the erosion of morainic material from the northern provenance, and the weathered mantle of the Attock-Cherat range.

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Appendix 1

RESULT OF THE SCREEN ANALYSIS OF SAND

Sl. No.	Sample No.	Wt. taken in grams	Wt. of the Fraction/ % obtained	Mesh No. + 18 V.Coarse	+ 35 Coarse	+ 60 Medium	+ 120 Fine	-120 V.Fine
1.	30b	150	Wt. of the Friction	0.00	0.00	32.20	90.30	27.500
			%obtained	-	-	(21.46)	(60.20)	(150.33)
2.	25b	200	Wt. of the Fraction	18.50	31.00	42.20	42.00	66.00
			% Obtained	(9.25)	(15.5)	(21.1)	(21.00)	(33.00)
3.	L3	200	Wt. of the Friction	-	34.00	105.00	47.00	14.00
			% Obtained		(17.00)	(52.50)	(23.50)	(7.00)
4.	12b	200	Wt. of the Friction	-	-	82.50	88.00	29.50
			% Obtained			(41.25)	(44.00)	(14.75)
5.	N1	200	Wt. of the Fraction	-	-	52.50	126.00	20.30
			% Obtained			(26.25)	(63.00)	(10.15)
6.	14a[1]	200	Wt. of the Fraction	-	-	27.00	134.00	38.50
			% Obtained			(13.50)	(67.00)	(19.25)
7.	11a[2]	200	Wt. of the Fraction	-	-	114.70	71.00	14.20
			% Obtained			(57.35)	(35.50)	(7.1)

Appendix II

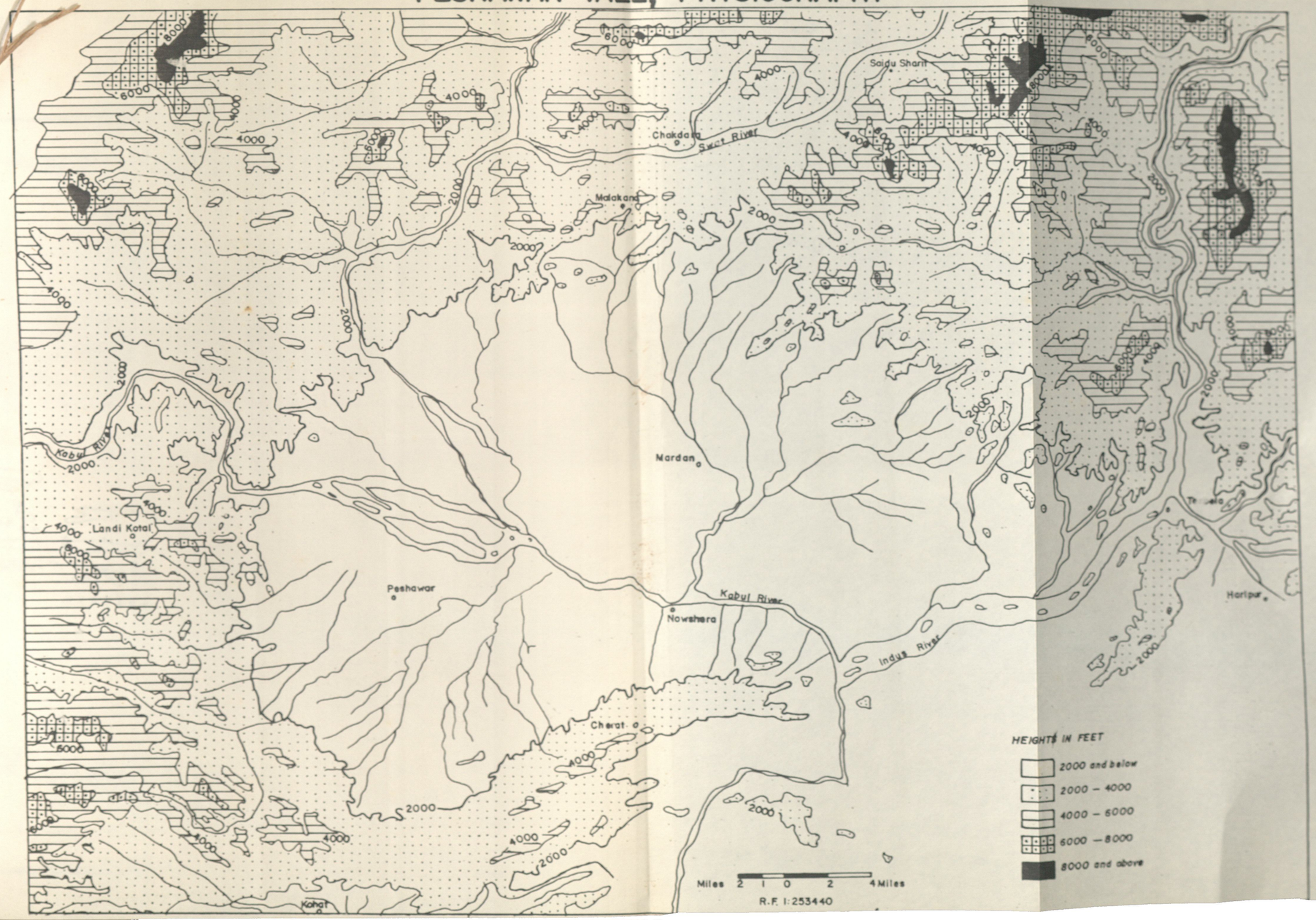
For location of sections following topographical sheets of Survey of Pakistan were used:-

1. Sheet No. $38\frac{O}{13}$, second edition. Metric Grid system. Scale 1/50,000.

2. Sheet No. $38\frac{O}{9}$, First Edition. Grid system in yards. Scale 1/50,000.

3. Sheet No. $43\frac{C}{1}$, First Edition. Grid system in yards. Scale 1/50,000.

PESHAWAR VALE, PHYSIOGRAPHY



GEOLOGY OF THE ATTOCK CHERAT RANGE
PAKISTAN

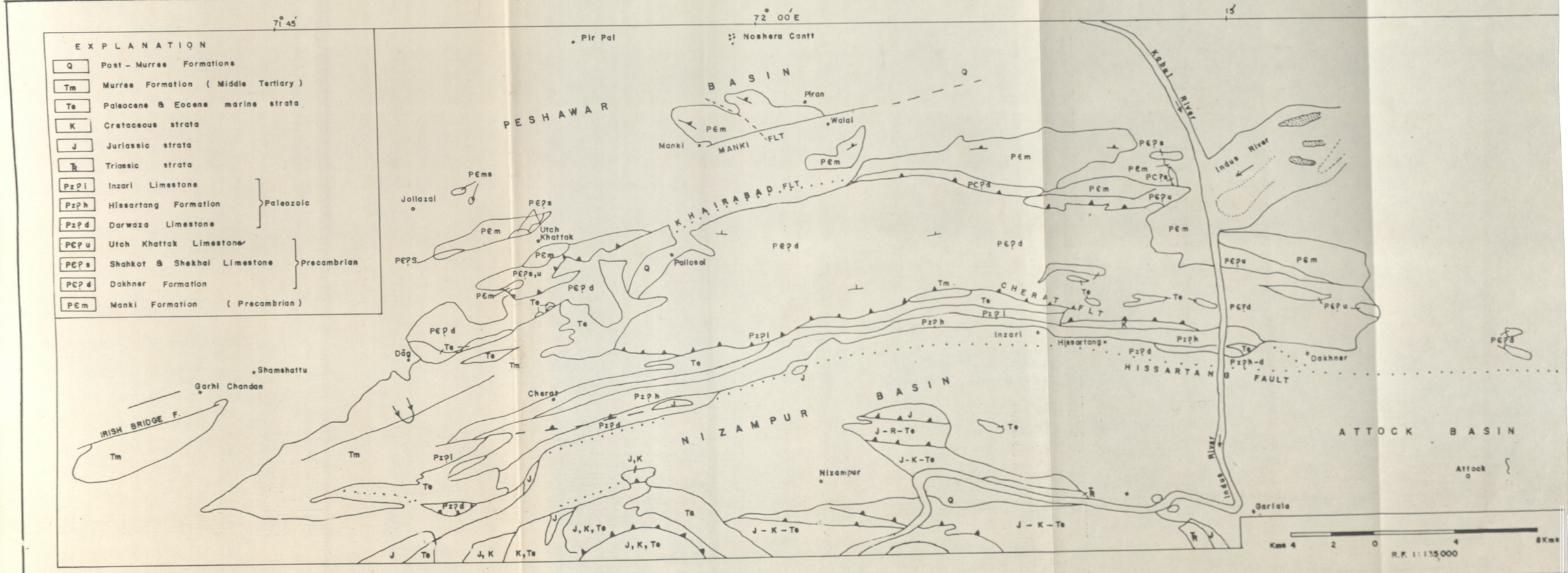


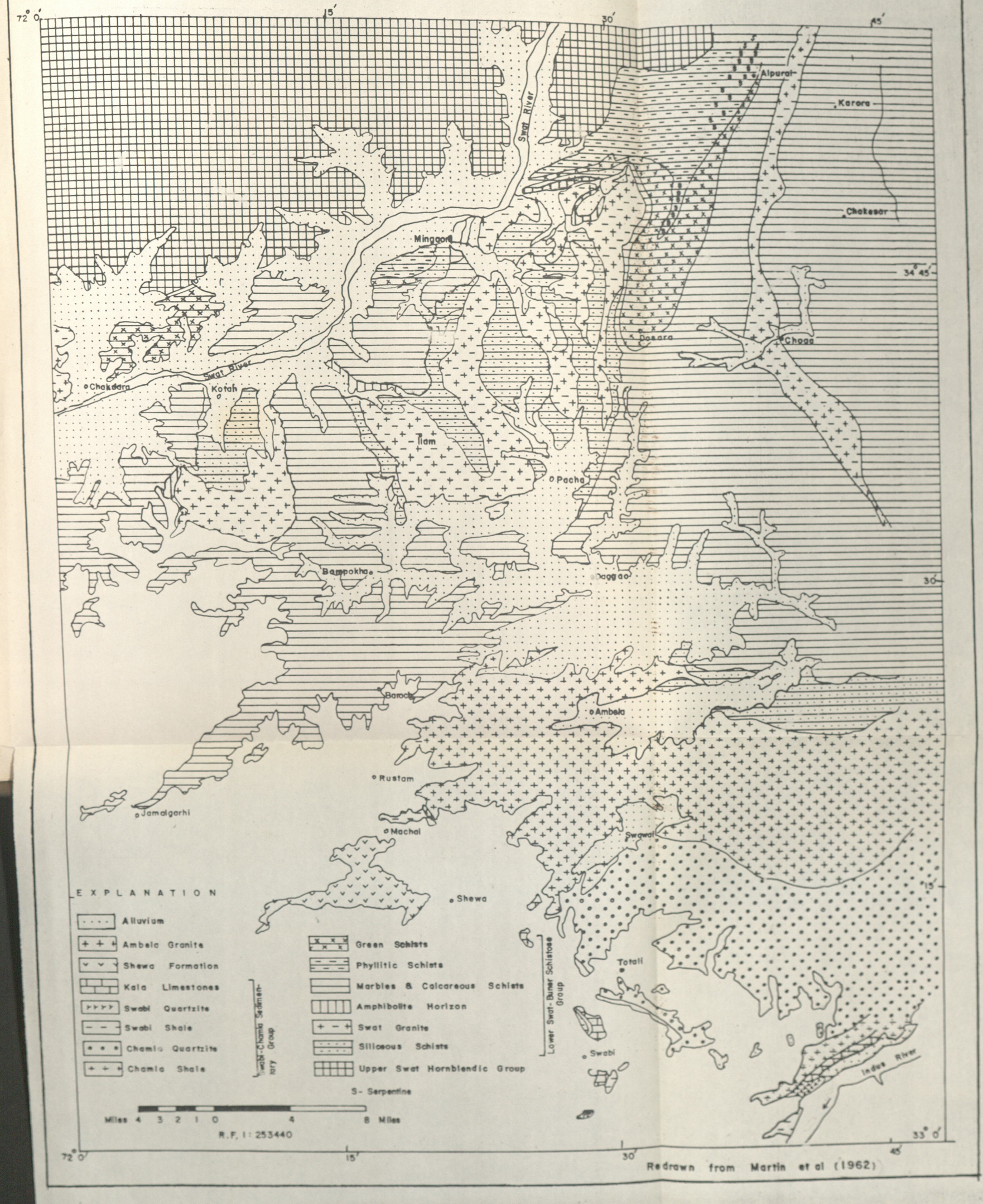
Fig 3.1 Re drawn from Yeats and Hussain (1987)

GEOLOGICAL MAP OF THE EASTERN PART OF KHYBER AGENCY, PAKISTAN



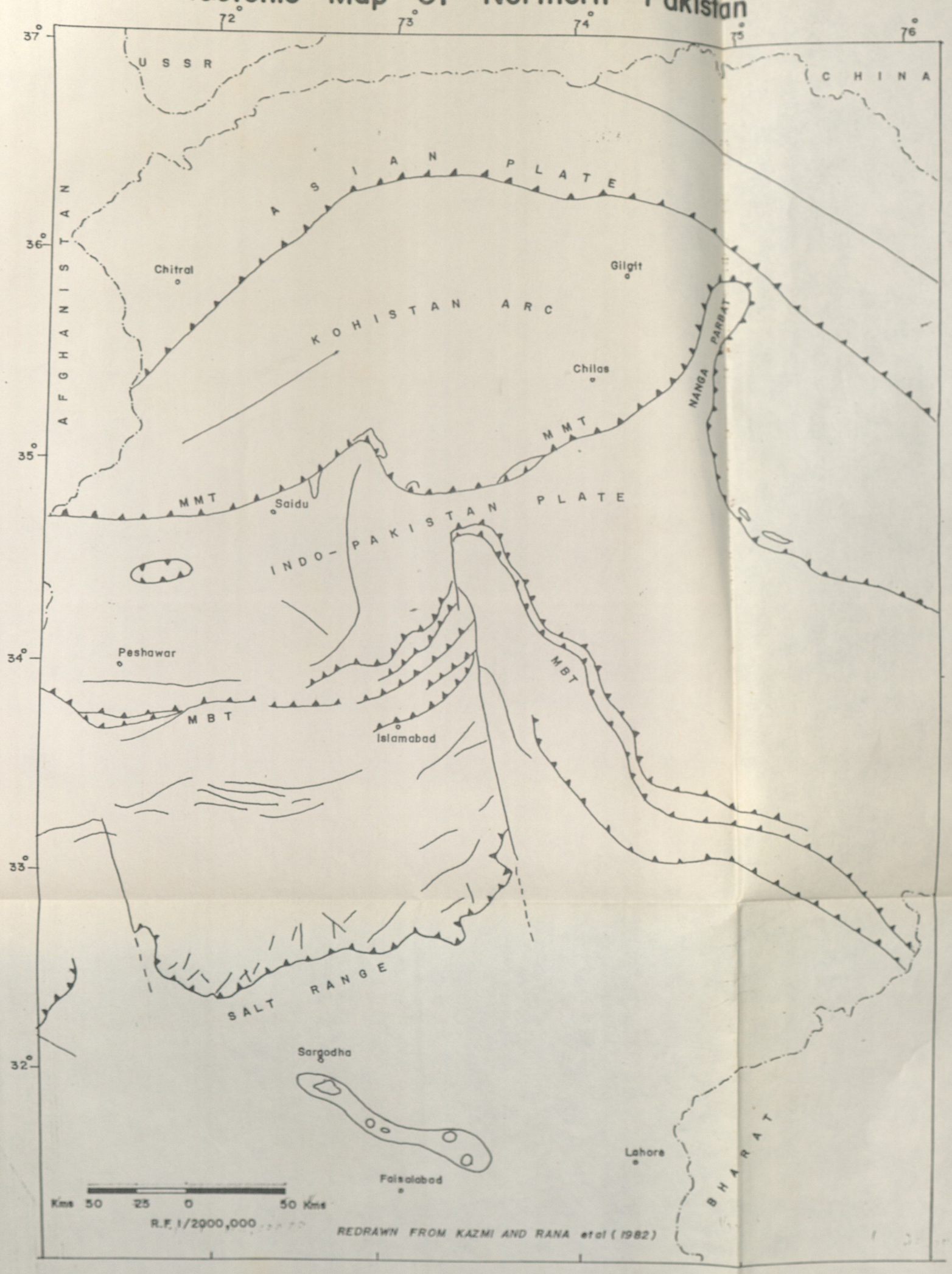
Re drawn from Ibrahim et al 1980

Geological Reconnaissance Map Of The Lower Swat-Indus Valley

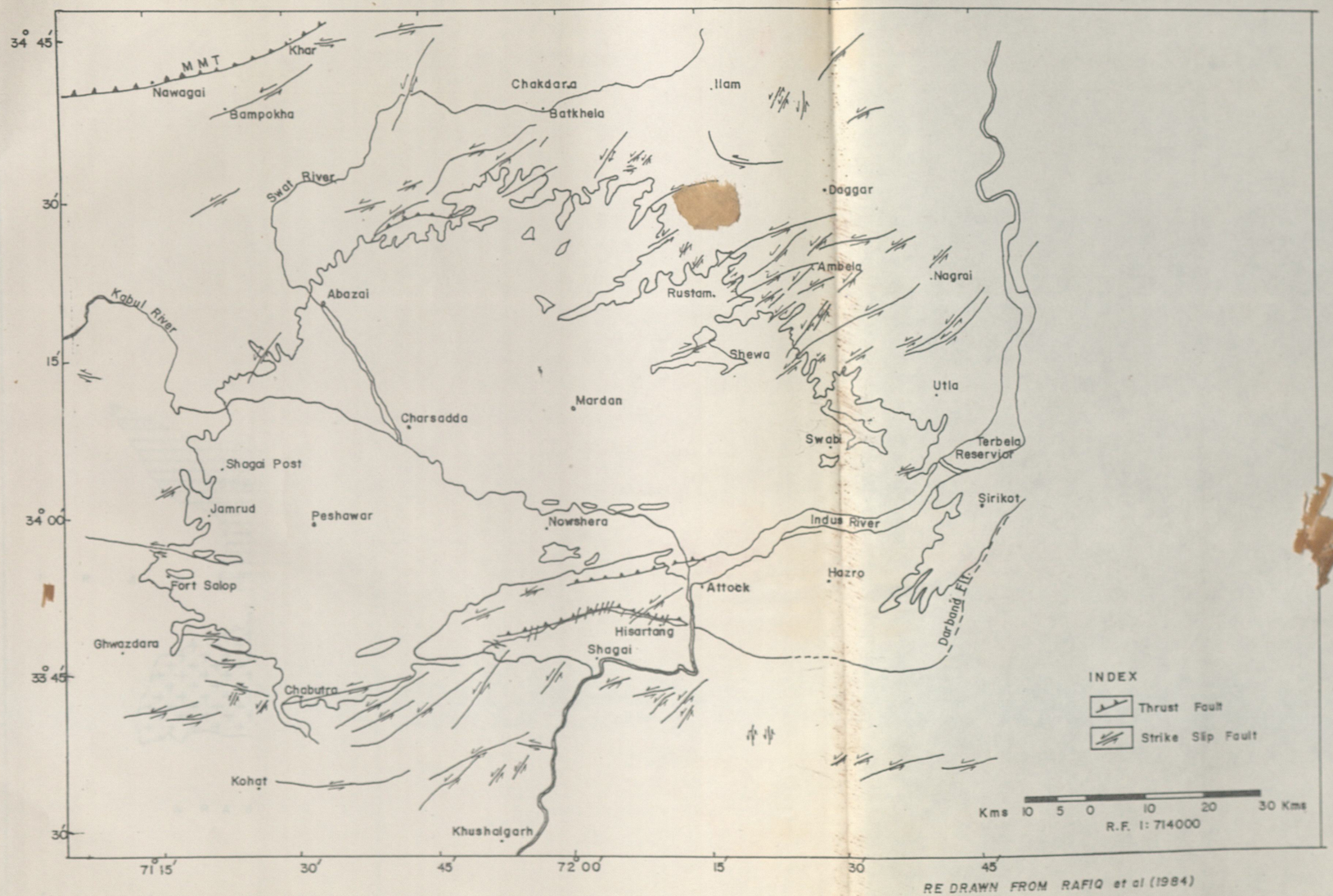


Redrawn from Martin et al (1962)

Tectonic Map Of Northern Pakistan



MAJOR FAULTS OF THE SURROUNDINGS OF THE PESHAWAR PLAIN



RE DRAWN FROM RAFIQ et al (1984)

TECTONIC MAP OF PAKISTAN

