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GEOLOGY AND TECTONICS OF THE AREA WEST OF ABBASABAD (SHAHRUD), IRAN

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ABSTRACT: A Geologic map and structural studies have been made in order to define the tectonic history and the orientation of the stress and strain diagrams in the Abbasabad area. Structural trends of faults, fold-axes, and shear joints of the area were compared by the strain ellipsoid and the proposed deformation diagram of Kupfer, 1968. The validity of each of these structural interpretation elements is checked with the actual facts of the area.

The results of this investigation show that the strain ellipsoid can not be used to explain all the structural elements of the area. On the other hand the deformation diagram of Kupfer is highly in accordance with the orientation of the major structural elements observed in the area.

Introduction

The area of study is located between SHAHRUD and SABZEVAR, about 130 km. east of SHAHRUD and 400 km. west of MASHAD (Fig. 1). Geographically, the Abbasabad area is located on 55 . 57′ east to 56 . 15′ longitude and on 36 . 10′ to 36 . 29′ with latitude in the northeastern part of the Iranian Plateau, covering approximately 1000 square kilometers, which is mapped on a scale of 1: 52000 (Plate 1).

The average elevation of the area is about 1200 meters above sea level, with a minimum elevation of 900 meters and a maximum elevation of 1470 meters. Most of the mountain ranges except one or two are located on the northeast-southwest structural trend.

The area is largely covered by andesitic rocks of Eocene age. These rocks are overlain by a younger sedimentary sequence of Late Tertiary in the north and southwestern part of the area. The extrusive rocks are andesitic to basaltic in composition and consist mainly of lavas, agglomerates and tuffs. The sedimentary sequences range from Middle Cretaceous (?) to Miocene in age. The clastic components of the sediments younger than Eocene are mainly derived from underlying andesitic-basaltic rocks. These sedimentary units are composed of sandstones, mudstones, nummulitic limestones, tuffs and conglomerates.

The area is covered by a series of gently folded single plunging anticlines and synclines with two major synclinal troughs in the southwest and north. The "Colored Melange" is limited to the fault blocks of the northeastern part of the area (Plate 1).

Geologic History

From a tectonic point of view, the Abbasabad region is considered to be part of the Central Iranian Plateau. This area is well as the other parts of Central Iran, passed through a quiet Phase of tectonic activity during the Paleozoic Era (STOCKLIN, 1968).

But, the area was tectonically active during Mesozoic and Cenozoic time. The major stages of the Alpine orogeny are believed to have been recorded in this area. During the Eocene time a series of submarine volcanic activities were active in Central Iran. In this period, the andesitic-basaltic rocks were formed simultaneously with lithic tuffs and

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some nummulitic limesones throughout the Abbasabad area. In Early Oligocene a major tectonic pulse uplifted the major mountains of Central Iran. The eastern part of Central Iran, as well as the Abbasabad area, were completely uplifted on Early Oligocene and sediments of non-marine origin predominate in these areas. However, in the western part of Central Iran, the sea was still covering part of this area depositing the marine sediments as the Qum Formation in the Qum Basin (Fig. 1).

The youngest tectonic movements in Central Iran (Pliocene-Pleistocene) caused the major reactivation of the older faults and folds. The presence of active young faults which cut the Quaternary terraces, offsetting some of the river channels, along with severe earthquake activities in this part of Central Iran suggest that the Alpine orogeny is still active in this area.

Faults

Based upon the orientation of the strikes

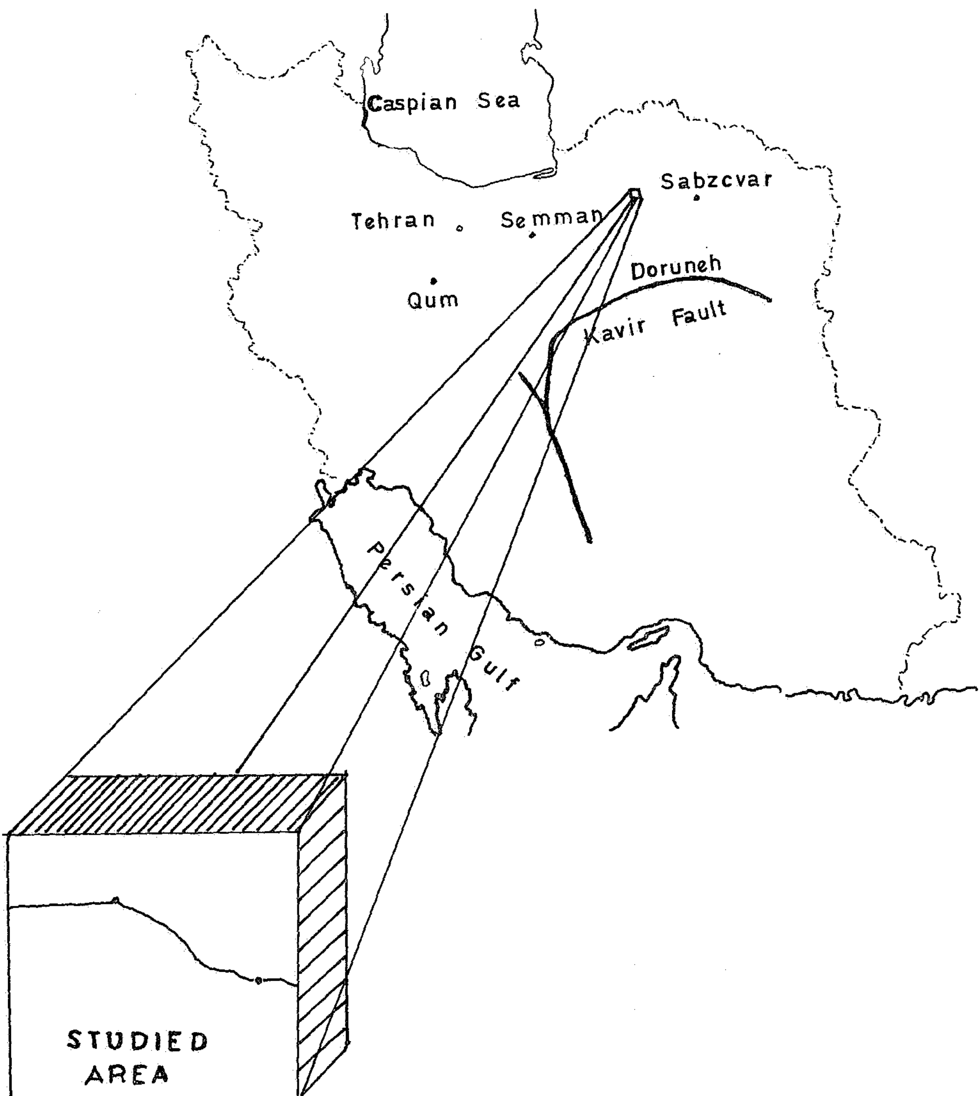


Fig. 1. Index map showing the locality of mapped area.

GEOLOGICAL MAP OF WEST OF ABBÄS-ÄBÄD

BY: V. BAROYANT

SUPERVISED BY:
A. IRANPANAH Ph.D.

LEGEND

0 1 2 3 4 5 Km

QUATERNARY

NEOGENE
- N — UNDIFFERENTIATED ALTERNATION OF REDDISH CONGLOMERATE, MARL AND SANDSTONE
- ml/ss — ALTERNATION OF MARL & SANDSTONE (DARK RED)
- cg — BASAL CONGLOMERATE

UNCONFORMITY

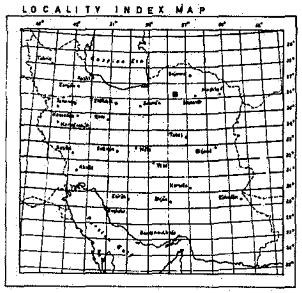
EOCENE
- BASALT
- ANDESITIC BASALT DIKES
- UNDIFFERENTIATED AGGLOMERATE & TUFFBRECCIA
- TUFFBRECCIA
- TUFF
- NUMMULITIC & ALVEOLINA LIMESTONE
- ALTERNATION OF ANDESITIC BASALT AND TUFF
- ANDESITIC BASALT (PORPHYRITIC)
- INTERFINGERING ANDESITIC BASALT AND AGGLOMERATE

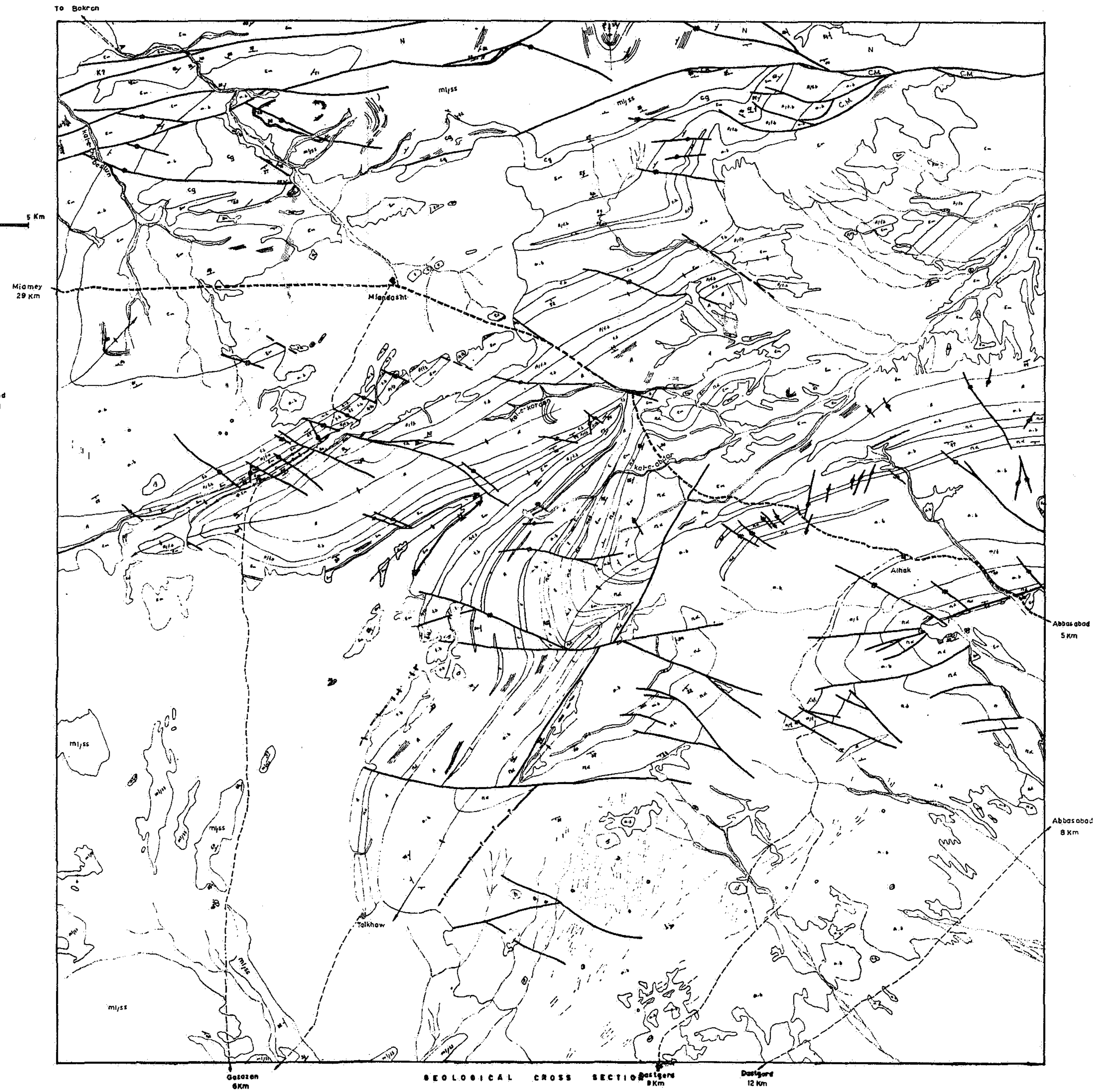
Em — Sandstone, tuff, and Nummulitic marl

CRETACEOUS
- C.M. — "COLORED MELANGE (UPPER CRETACEOUS)
- K? — LIMESTONE, HIGHLY RECRYSTALLIZED (MIDDLE CRETACEOUS?)

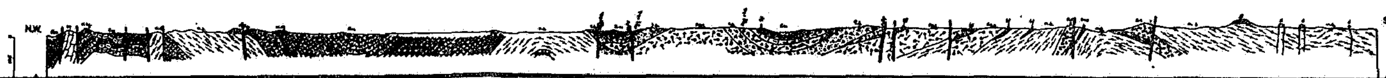
CONTACT-DASHED WHERE COVERED
FAULT-ARROWS SHOW THE RELATIVE MOVEMENT'
FAULT-LOCATED APPROXIMATELY
UNCERTAIN FAULT
PLUNGING ANTICLINE
PLUNGING SYNCLINE
STRIKE & DIP: MEASURED IN FIELD-INFERRED FROM AIRPHOTO.
TRACES OF BEDDING PLANES ON AIRPHOTO.
CANYON
MAIN ROAD
MOTORABLE TRACK

LOCALITY INDEX MAP





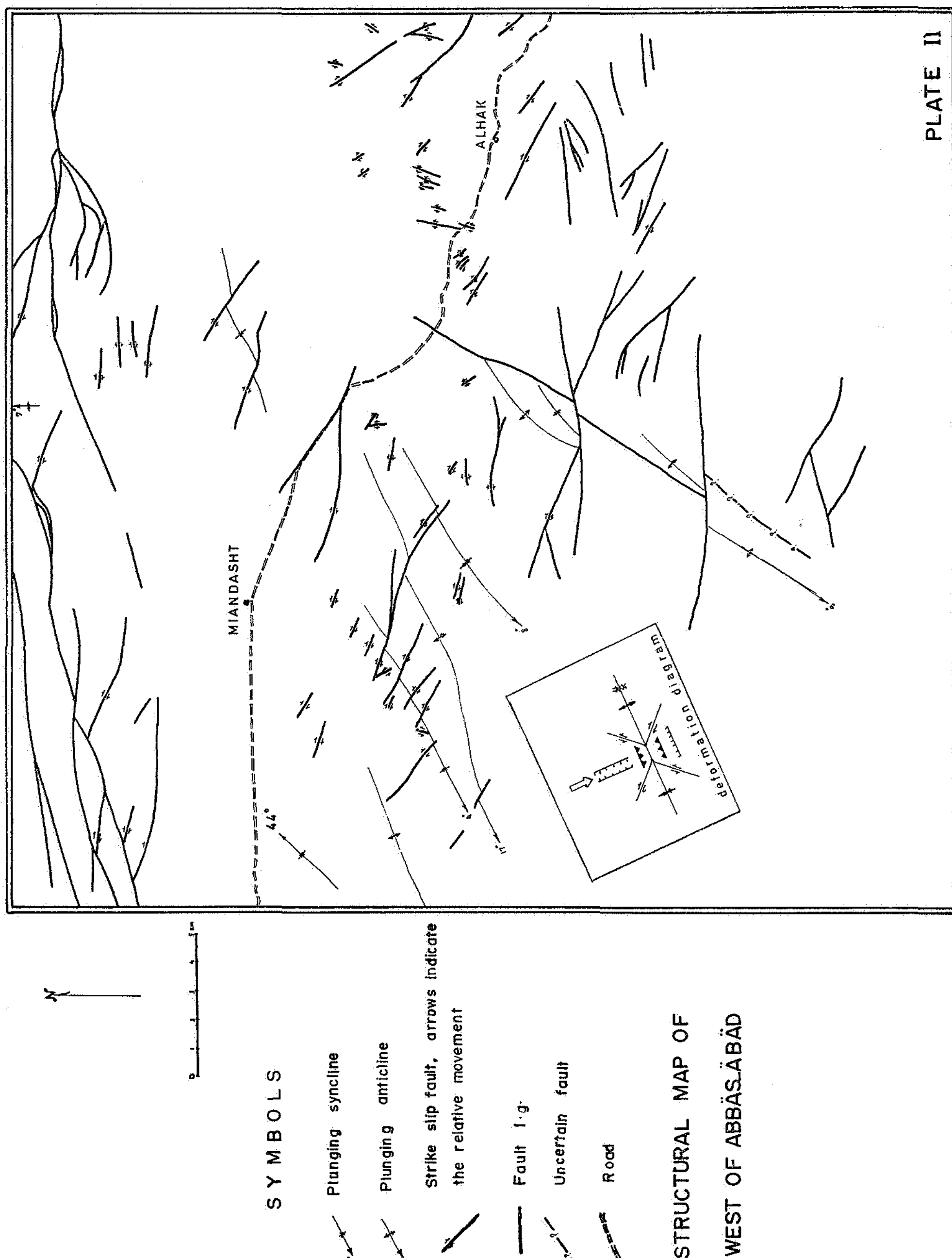
GEOLOGICAL CROSS SECTION



- ag — Agglomerate
- a.b — Andesitic basalt
- K? — Cretaceous (?) limestone
- t — Tuff
- ag/tb — Undifferentiated agglomerate & tuffbreccia
- tb — Tuffbreccia
- d — Dike
- B — Basalt
- pa — Porphyritic andesite
- Ncg — Neogene conglomerate
- Em — Eocene marl & sandstone
- Lm — Nummulitic limestone

PLATE I

of the faults, faults of the mapped area may be subdivided into three major sets. Strikes of these faults are northewest-southeast, east-west and northeast-southwest (Plate II). From a genetic point of view, these faults included left-lateral and right-lateral strike slips as well as normal faults. Except in a few localities the majority of faults have a dip measured greater than 80 degress. The leftlateral strike slip faults are limited to the west and especially to the north of the Kalat-e-Elhak (Plate I). These faults strike northeast-southwest, and



are less important when compared with the other faults from point of displacement and number of occurrence views. These faults appear to be contemporaneous with the formation of the right-lateral strike slip faults.

The right-lateral strike slip faults striking northwest-southeast, cut mostly the Eocene volcanic pyroclasts and the sedimentary rocks throughout the mapped area. A few of these faults cut the Neogene sediments (Plate 1).

The normal faults are the most predominate faults occurring in this area. The apparent displacement along the faults can be observed in the northwestern part of the area (Miamy fault), along which the Cretaceous and the Neogene sediments are in contact. The amount of the apparent displacement decreases gradually to the south. It is impossible to observe the fault-plane of major faults where they cut through the Neogene marls, but one can observe the crushed zones in the andesitic rocks of Eocene age.

It seems that east-west trending faults are nearly subparallel to the Kavir fault in the south and have probably the same origin (Fig. 1). The Kavir fault (locally called "Doruneh") appears to have been originated during the Assyntic orogeny and since than reworked upwards during the later tectonic events. This is evidenced by the fact that the Kavir fault cuts the Neogene sediments and the Quaternary terraces.

The strike of 81 faults were measured in the study area and the results were plotted in a strike frequency diagram (Fig. 2). The diagram shows that the majority of the faults strike northwest-southeast. However, the maximum frequency, striking east-west, appears to be significant. From a theoretical point of view, it seems impossible to develop these two fault sets under one single stress ellipsoid. Slight variation in the strike of northwest-southeast trending faults is probably due to the differential competence of rock units involved.

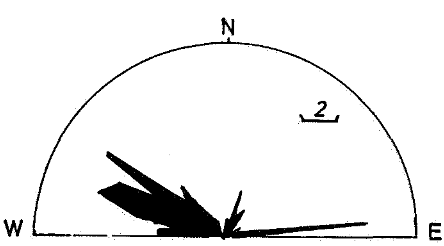


Fig. 2.

Colored Melange

The colored melange is limited to the faults of the northeastern part of the area (Plate 1). These are composed of a complex series of ultrabasic rocks in which the majority of the uplifted blocks are highly altered and serpentinized. The fragmentation and mixing of these melanges is probably due to tectonic deformation under overburden Pressures. Some blocks of Clabotruncans limestone and little radiolarites are present in the melange. Assignment of an age to these melanges on the basis of fossil occurrances alone can be incorrect. However, the melanges of the study area were mapped as tectono-stratigraphic units of probably Late Cretaceous age. The writers wish to point out that it may also be of Late Miocene in age as it cross-cuts the Neogene sedimentary sequence. The evidences gathered from the eastern part, outside of the mapped area show that the melanges have been injected upwards along the eastwest trending faults. The presence of abundant serpentinized blocks have probably caused the melanges to become more plastic as compared to the adjacent country rocks. Therefore, it made the plastic injection of the melanges possible along the fault planes. The injection of melanges was Probably contemporaneous with the development or reworking upwards of the east-west faults in Late Miocene time.

Joints

In addition to 100 joints measured in the andesitic-basaltic dikes from the southern part of the study area (Fig. 3), 500 joints were measured in two synclines south of Miandasht. The majority of the joints strike northwest-southeast and dip nearly vertical (Fig. 4).

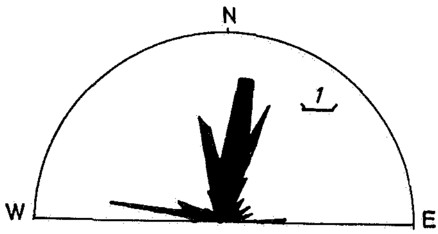


Fig. 3.

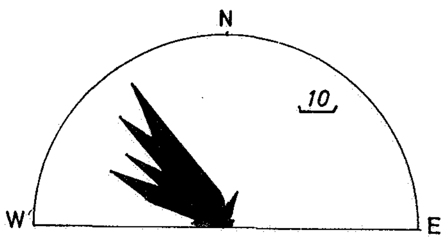


Fig. 4.

Almost all the joints measured throughout the area are shear joints. These joints can easily be measured in hard competent rocks, such as in lithic tuffs, limestones and sandstones. A large number of dikes are present in the southern part of the study area, in which several sets of subparallel joints are present. From these dikes, 100 joints were measured and pletted in a strike frequency diagram (Fig. 3). The majority of the joints were measured from andesitic-basaltic dikes striking NNE, NNW, and some striking WNW which appears to be perpendicular to the set of NNE.

From 500 joints measured in two synclines south of Miandesht, a frequency and a contour diagram has been made (Figs. 4 & 5). Figure 4 shows that the majority of joints strike northwest-southeast parallel to the main fault sets. A small number of joints strike in east-west direction. There is a submaximum orientation striking northeast-southwest which in turn appears to be perpendicular to the joints striking northwest-southeast. These joints may be explained as a series of parallel and perpendicular joint sets to the major structural elements of the area. Examination of the contour diagram (Fig. 5) shows that there is an orthorthombic symmetry in these joint sets. The maximum occurs along the circle of the equator on the lower hemisphere, indicating that the majority of joints have a dip close to 90 degrees. Furthermore, the contour diagram illustrates the fact that the maximum principle stress axis in two of the major synclines south of Miandasht is oriented northwest-southeast, probably at about N 40 W.

Folds

The Abbasabad region is covered by a series of plunging anticlines and synclines with their axes oriented northeast-southwest. With one exception, all the folds have a small angle of plunge. Geometrically, these folds are almost symmetrical, except one in the south (Plate 1). However, the asymmetry of the latter fold may have been due to the northeast-southwest trending fault. A disharmonic synclinal structure is present in the northern part of the mapped area, with its axis striking north-south and plunging to the north. This syncline is bounded by two strike slip faults in the east and west respectively (Plate I).

In order to determine and compare the angle of plunge of the folds, the strike and dip measurements were made in the nose of the anticlines and synclines, and the mean of the measurements were plotted in an stereonet (Fig. 6).

Conclusion

Petrological and structural studies of the Abbasabad area suggest that the area was covered by a shallow sea during the Eocene period. The sedimentary sequences are composed of sandstones, mudstones, marls and some nummulitic limestones, with submarine volcanic pyroclasts (lithic tuffs), which were deposited in a shallow marine environment. Alternating with the sedimentary sequences, the andesite-basalt extrusions were formed contemporaneously.

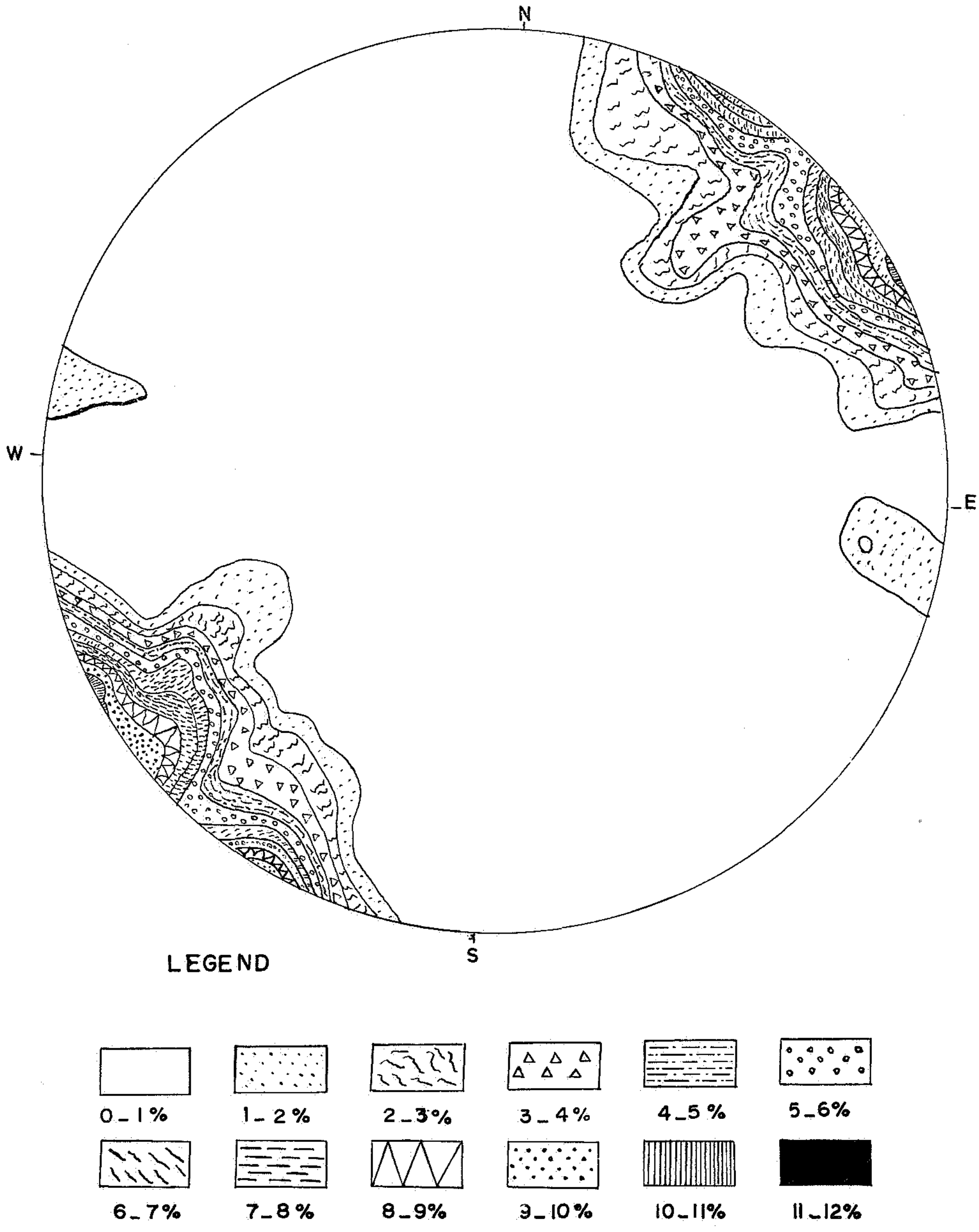


Fig. 5.

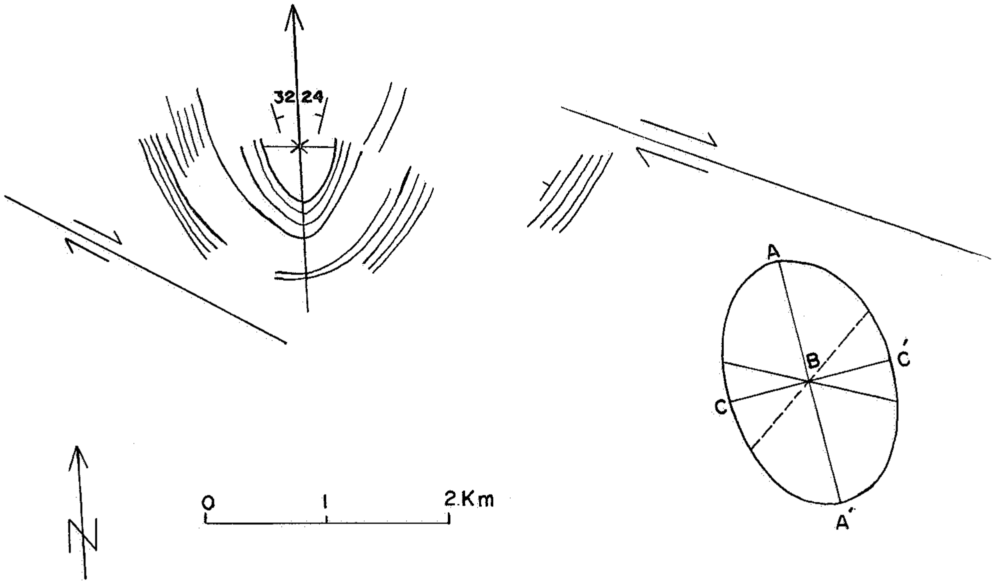

32
24
A
B
C
C'
A'
N
0
1
2 Km

Fig. 6.

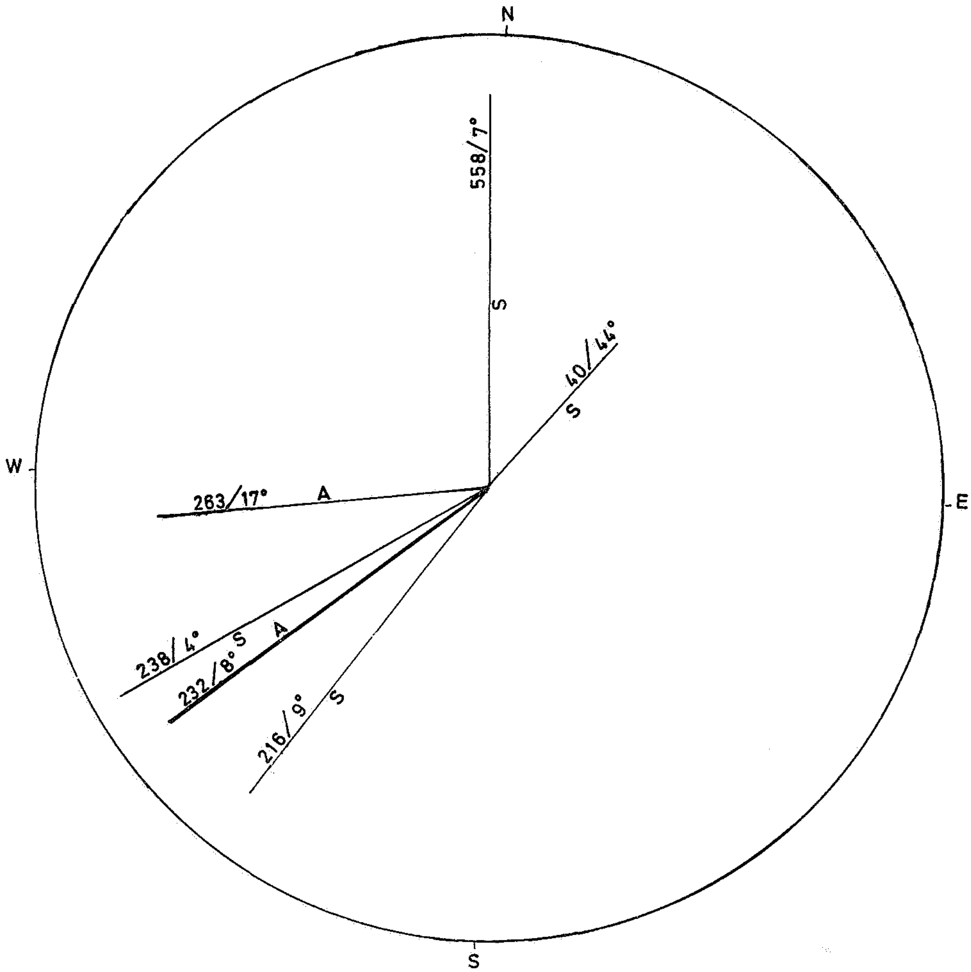

N
558/7°
S
40/44°
S
W
E
263/17°
A
238/4°
S
A
232/8°
216/9°
S
S

Fig. 7.

The tectonic pulses of Early Oligocene formed the major structural elements of the area. Part of the area was covered by shallow water during the Late Miocene period in which the Miocene red-beds were deposited. The Miocene sediments cover the troughs of major synclines of the area in north and southwest (Plate I) Post-Miocene, Pliocene-Pleistocene movements of the Alpine orogeny have disturbed the Neogene sediments throughout the area.

The strike slip faults have a dip exceeding 80 degrees. Furthermore, the examination of the contour diagram shows that the majority of the shear joints have a dip nearly vertical (Fig. 5). According to the stress-strain ellipsoids the greatest principle stress axis is horizontal striking northwest-southeast, and the intermediate principle stress axis lies vertical, and the least principle stress axis is horizontal and directed northeast-southwest. Such a stress diagram is highly compatible with the northeast-southwest trending fold-axes.

Except one, almost all the folds have a small angle of plunge. Based upon stress orientation of the area, the plunge of these folds should be nearly vertical. This is not ture however, in Abbasabad. The writers believe that the structural elements present in the Abbasabad region can not be interpreted under a single stress-strain ellipsoid. But, Kupfer's diagram could be used for interpretation of the stress-strain relation of the study area. (Plate II). This most probably suggests that the structural elements of Abbasabad region have been formed in shallow depths. Application of Kupfer's diagram Permits the interpretation of the northeast-southwest and northwest-southeast trending strike slip faults, as well as the east-west trending normal faults (Plates I and II). It is worthy to mention that although Kupfer's diagram was highly useful in interpreting the stress-strain relation of the Abbasabad region, there may feasibly be other regions foı which the strain ellipsoid is more applicable.

ILLUSTRATIONS

Fig. 1. Index map.

Fig. 2. Strike frequency diagram prepared from strikes of 81 faults measured throughout the mapped area.

Fig. 3. Strike frequency diagram prepared from strikes of 100 joints measured in the andesite-basalt dikes in the southeastern part of the mapped area.

Fig. 4. Strike frequency diagram prepared from 500 joints measured in two synclines south of Miandasht (Plate 1).

Fig. 5. Structural contour diagram prepared from 500 joints measured in two synclines south of Miandasht (Plate 1).

Fig. 6. A disharmonic fold (syncline) between two strike slip faults. The syncline has probably been formed due to movements of the couples along the faults. Note the orientation of strain ellipsoid in this area (see also the northern part of the geologic map (Plate 1).

Fig. 7. Axes of Anticlines (———A) and synclines (———S) plotted in the southern hemisphere in order to show the amount and the direction of plunge of folds throughout the mapped region.

Plate I — Geological map of the area.

Plate II — Structural map of the area.

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