Geol. Bull. Univ. Peshawar, Vol. 33, pp. 87-95, 2000

Imprints of transpressional deformation on the southern Kohat Plateau, Karak area, NW Himalayas, NWFP, Pakistan

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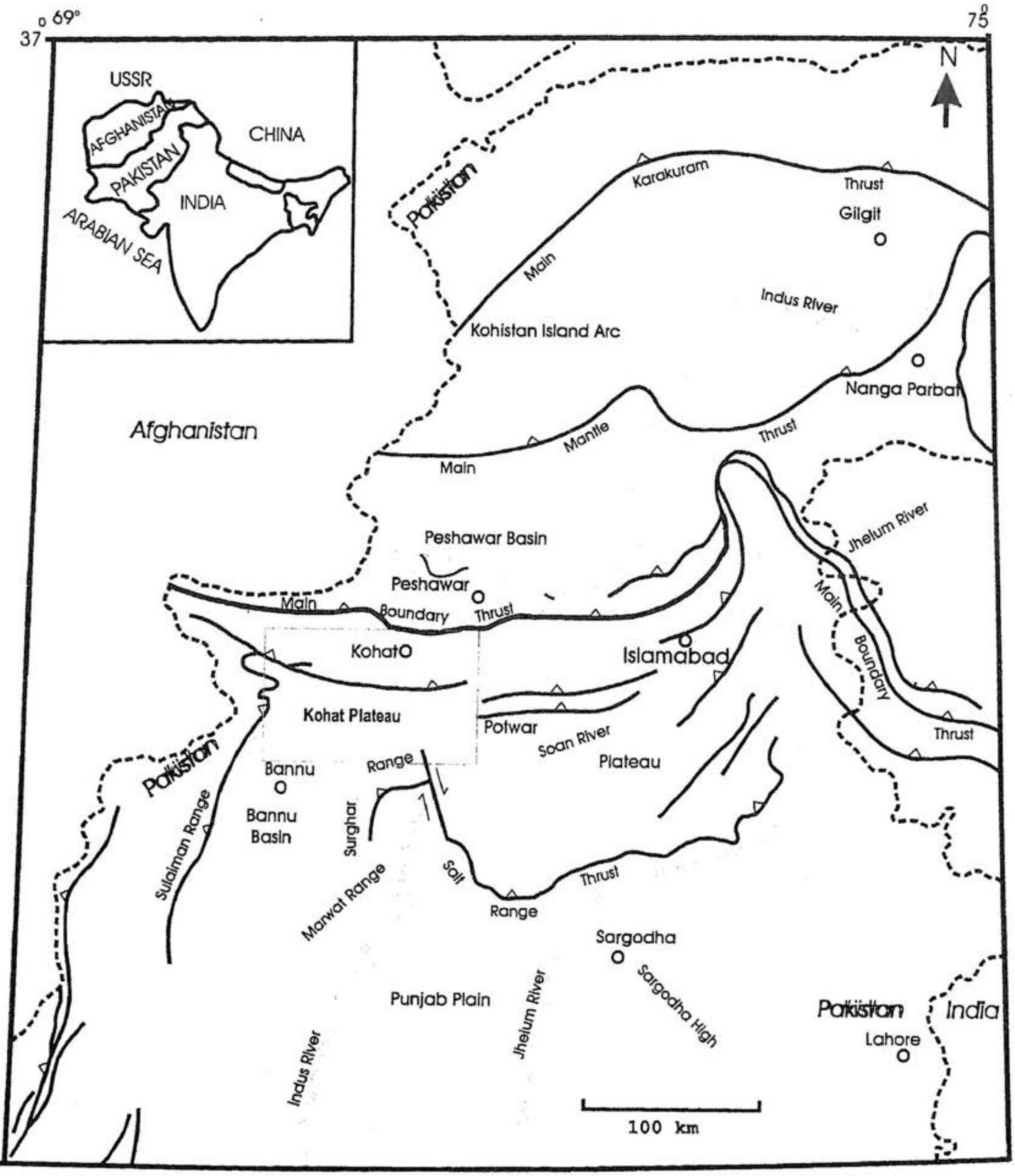
ABSTRACT: *A suite of evaporite deposits, shelf sediments and mollase sequence of Early Cenozoic age from Karak area marks a part of southern Kohat Plateau. Structurally the area is interpreted as east-west trending positive flower structure, which is exposed for about 20 km along strike with widths varying from 3-5 km laterally. It is bounded by the north dipping Karak Fault in the south and south dipping Nari Panos Fault in the north and internally subdivided by the south dipping Banda Kunghara Fault. All these faults trend east-west and have moderate surface dips. A right lateral component of deformation along the Karak-Nari Panos structure is indicated by: 1) the north-east directed trend of the Daggar Syncline in the footwall of the Nari Panos Fault, 2) the local scale thrusts in the core of this syncline and 3) east-north east trending right stepping folds located south-east of Banda Charpara in the footwall of Banda Kunghara Fault. The idea of transpressional deformation is also supported by the seismic data, which shows that all the major fault structures become steep, converging at deeper level and the presence of horizontal to sub-horizontal slicks on different fault surfaces. The region has experienced an early phase of compressional deformation overprinted by later phase of transpressional deformation of Plio-Pleistocene age.*

INTRODUCTION

The Kohat Plateau lies in the north-western indentor of the Indian Plate of a major oroclinal deflection with structural trend from EW to NS within the Himalayan chain and associated mountain ranges (Fig.1). The plateau represents a typical foreland fold and thrust belt of the Himalayan collision zone, about 100 km south of the main foothills of Himalayan range. The plateau was the main depocentre of the Himalayan shed during Early Miocene time (Wells, 1984; Pivnik 1992), now uplifted and deformed, preserving clues about the south progression of Himalayan deformation.

Previous structural interpretations for the tectonic evolution of the region implies the propagation of foreland fold and thrust belt along blind and partially emergent thrust faults from an upper detachment at the base of Eocene sequence underlain by passive roof duplex geometry within Mesozoic rocks (Abbasi & McElory, 1991; McDougal & Hussain, 1991). An alternate interpretation was proposed by Pivnik et al. (1993, 1995, & 1996), suggesting transpressional deformation instead of compressional deformation. According to them the Kohat Plateau is charectarized by narrow anticlinal hills, which are cored by high angle reverse faults converging to a single strike-slip zone



1. Tectonic map of north Pakistan (After Kazmi & Rana, 1982).

at depth. They believed that virtually every anticlinal structure within the plateau is a pressure ridge representing the surface expression of a positive flower structure at the depth.

The Karak-Nari Panos area is believed to be very important as far as the understanding of tectonic evolution of Kohat Plateau is concerned. It is located at the southern edge of Kohat Plateau and is bounded toward west by the left lateral Kurrum Fault (and right lateral Kalabagh Faulit in the caste). It is believed that the opposing motion along these regional structural discontinuities is responsible for the complex structural style of the Kohat Plateau. The study area has well preserved imprints of the transpressional deformation superimposed upon earlier contractile structures.

GEOLOGICAL SETTING

Four tectonic features delineate the tectonomorphic terrains of north Pakistan i.e., 1) the Main Karakurum Thrust (MKT) that separates the southern Eurasian Plate from Kohistan arc (Fig.1, 2) the Main Mantle Trust (MMT) separates Kohistan arc from the northern Indian plate, 3) the Main Boundary Thrust (MBT) separates the Hill Ranges and Hazara Himalayas in the north from the deformed foreland basin in the south, and 4) the Salt Range Thrust, Surghar Range Thrust and the Khisor Range Thrust forming the southern boundary of the deformed foreland basin in Pakistan along which Mesozoic rocks are thrust over the un-deformed Punjab foreland basin.

The Kohat fold and thrust belt is the western most deformed part of the Himalayan foreland basin which rims the entire Himalayas with an east-west trend from Ganges delta in the east up to Kohat area in the north Pakistan and changes to north-south orientation in the vicinity of Bannu depression stretching up to Karachi. The Main Boundary Thrust lies north of the Kohat Plateau whereas the left lateral Kurram Fault flanks its western periphery and toward southeast it is flanked by the right lateral Kalabagh Fault (Fig.1).

The Kohat Plateau is underlain by a complex assemblage of shale, limestone, gypsum and sandstone of Eocene age and is unconformably overlain by the thick alternating sequence of sandstone, shale and conglomerate of the mollase sediments.

In the study area the oldest rocks belongs to Eocene age which include Bahader Khel Salt and Jatta Gypsum at the base followed upward by shelf sediments of Kuldana and Kohat formations. These units are unconformebly overlain by mollase sediments of Miocene to Pliocene age, which include Rawalpindi and Siwalik groups (Fig.2).

STRUCTURAL GEOLOGY

The area is dominated by regional scale folds and thrust faults trending east-west (Fig.3). The folds are open, asymmetric and have shallow plunge angles. Various local scale folds oriented NNE are mapped as well. These bear an oblique relationship with the regional scale folds and faults.

A geological cross-section along line A-B of Figure 4 has been constructed and the structures are projected by combining surface data with the subsurface data. The subsurface data was acquired from OGDCL of Pakistan (line #. 906-NSK-47). On a north to south traverse along the geological cross-section three major faults i.e., Nari Panos, Banda Kunghara and Karak faults control the structure of the area (Fig.4). At the outcrop the Nari Panos Fault moderatly dips southward and brings Bahader Khel Salt and

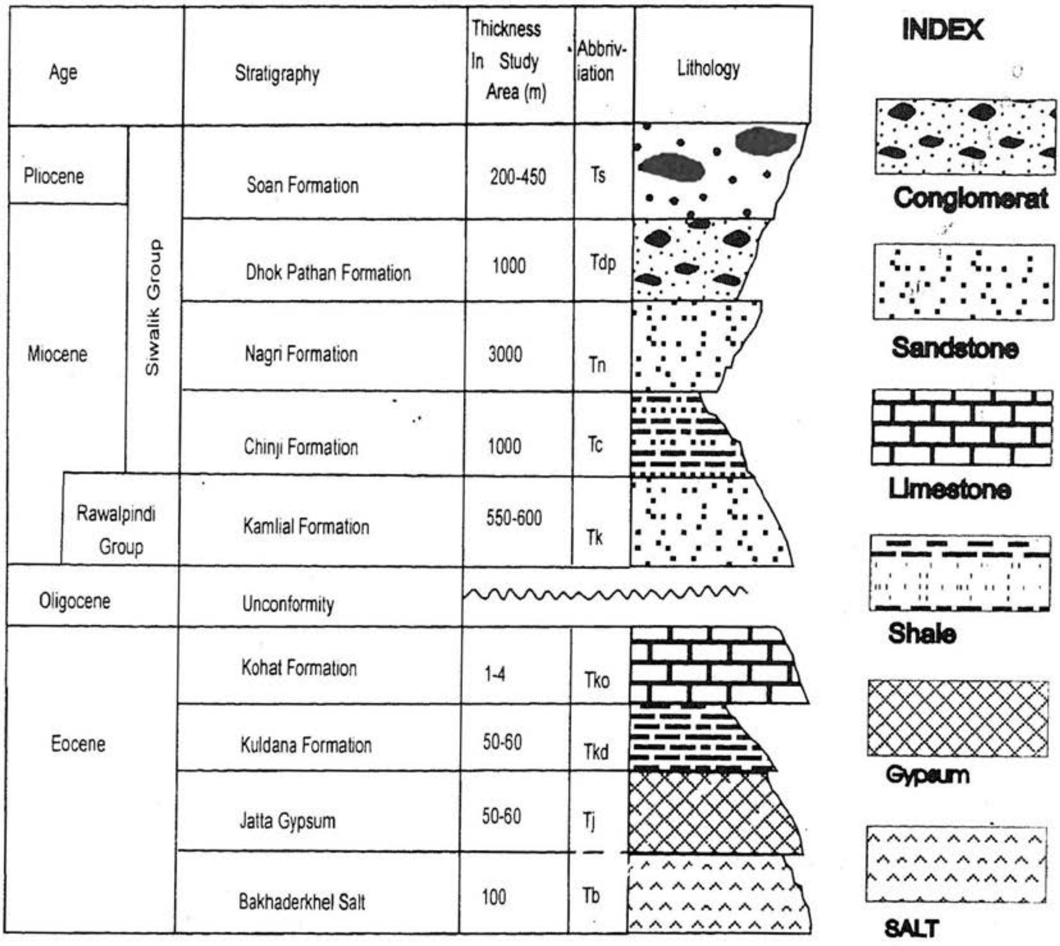


Fig. 2. Stratigraphic column of the study area.

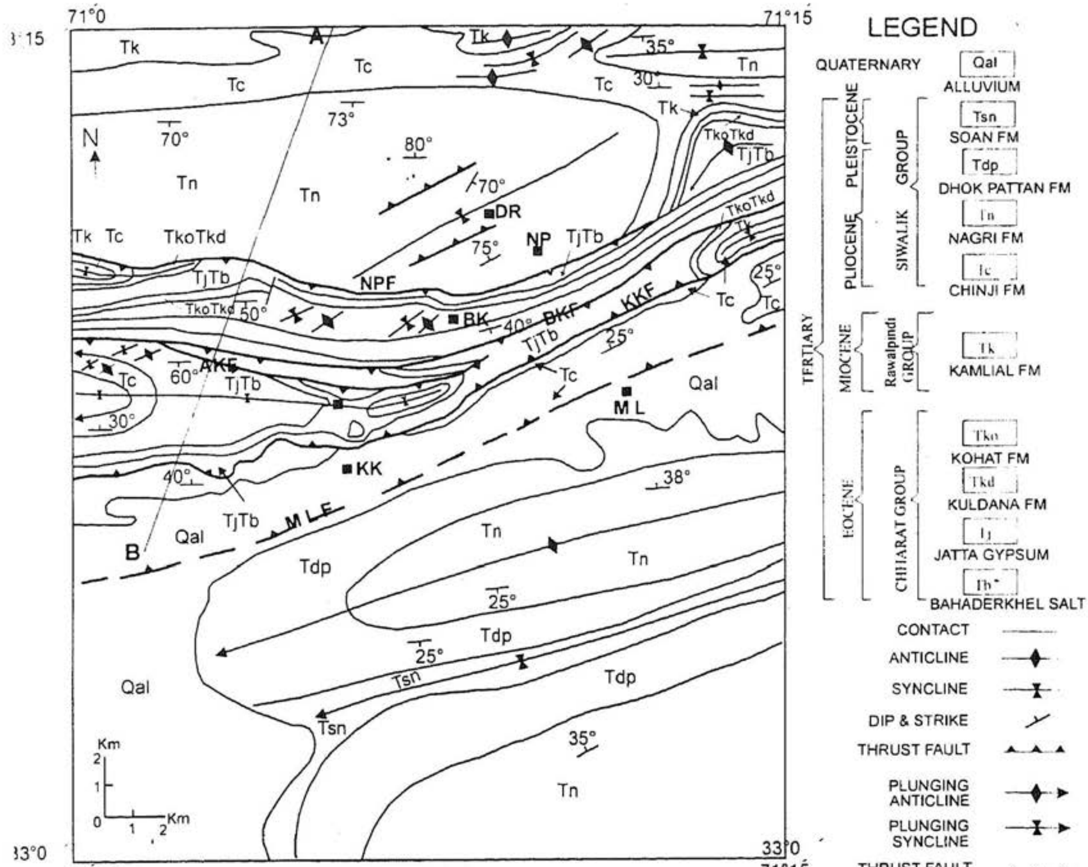


Fig. 3. Geological map of a part of southern Kohat Plateau, north of Karak. AKF=Andi Karak Fault, BKF=Banda Kunghara Fault, KKF=Karak Fault, MLF=Mitha Khel Fault, NPF=Nari Panos Fault, KK=Karak Town, DR=Daggar, BK=Banda Kungharat and NP=Nari Panost

Jatta Gypsum over the Nagri Formation in the footwall. Nagri Formation is about 4 Km thick in the mapped area (Meissner et al., 1974) suggesting a vertical displacement of about 3Km associated with Nari-Panos Fault. Along the Banda Kunghara Fault, Jatta Gypsum is in thrust contact with the Chinji Formation in the footwall and moderately dips toward south. The cutoff relationship along the fault shows about 3 Km vertical displacements. The Karak Fault moderately dips northwards and brings Jatta Gypsum in the hanging wall above the Chinji Formation in the footwall. Chinji Formation is about one Km thick; underlain by one and half kilometer thick sequence of Kamlial, Kohat and Kuldana formations. This implies about 3 Km vertical displacements.

The seismic data suggests that all the mapped faults have moderate dips at the surface and become steeps with depth (Fig.4). At as approximate depth of 4 km these faults appear to be converging towards each other and become almost vertical. The area in between Nari Panos and Karak fault is named as Karak-Nari Panos Positive Flower Structure. The marginal faults diverge upward in opposite direction having opposing vergence with a central structural discontinuity i.e. Banda Kunghara Fault (Fig.4). The Karak-Nari Panos structure is exposed about 20 Km along strike with widths ranging from 3-5 Km laterally (Fig.3).

Pivnik and Sercombe (1993), have well documented the role of transpressional deformation in the Kohat Plateau, however, the present work further enlighten the idea with the support of currently acquired field and seismic data. The following points can be put forwarded in favour of transpressional deformation. Slicks data was recorded and plotted on stereographic net. The dominant sets of data suggest horizontal translation along the faults in addition to dip-slip motion (Fig.5). Surface expression of the strike-slip motion is displayed by local structures as well. Two local scale thrust faults are mapped in the core of Dagger Syncline. These faults are oriented N65° E, and make an acute angle of 25° with east west oriented Nari Panos Fault (Fig.3). In addition, the orientation of the axis of the Dagger Syncline itself is parallel to these local scale faults and intersects the Nari Panos Fault at an acute angle of about 35°. Furthermore, in the hanging wall of the Nari Panos Fault, several northeast oriented local folds are mapped which bears oblique relationship with the Nari Panos Fault (Fig.3). South of Banda Charpara, in the hanging wall of Banda Kunghara Fault, several northeast oriented anticlinal and synclinal pairs are mapped. These also bear an oblique relationship with the Banada Kunghara Fault. All these local scale folds are believed to be the later manifestation of the oblique compression over printed upon the early-formed east-west trending contractile structures. The geometric relationship of the mapped folds and faults within the study area is quite comparable with the possible geometric array of structures developed in a right-lateral strike slip fault zone (Harding, 1974) (Fig.6). Thus a right-lateral sense of motion is believed to have occurred along Karak-Nari Panos structure.

CONCLUSION

The present study leads to the conclusion that the Karak area has experienced an earlier episode of north-south compressional deformation overprinted by a north-west oriented oblique compressional deformation. The north-south phase of compressional deformation is responsible for the initial architecture of the area, which resulted in east-west oriented large-scale folds and faults. Whereas the later, north-west oriented

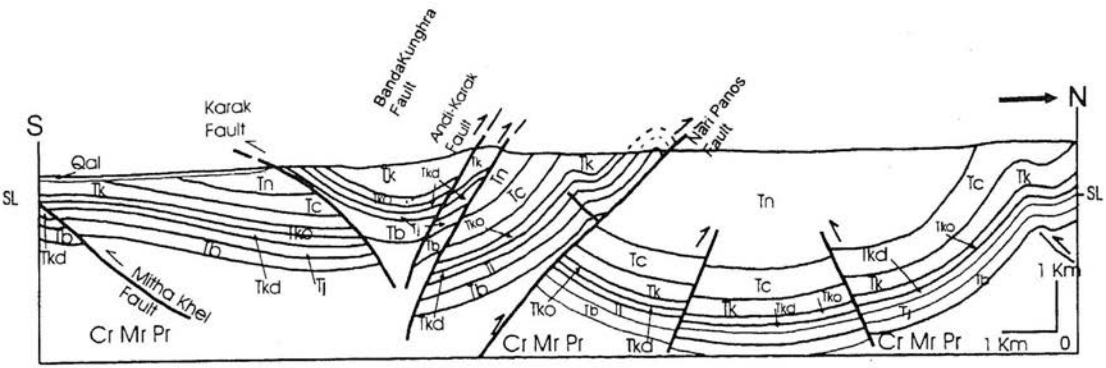


Fig. 4. Geological cross-section along line A-B of Figure 3 (Legend as in Fig. 3).
Cr Mr Pr=cretacious, Mesozoic and Paleozoic rocks undifferentiated.

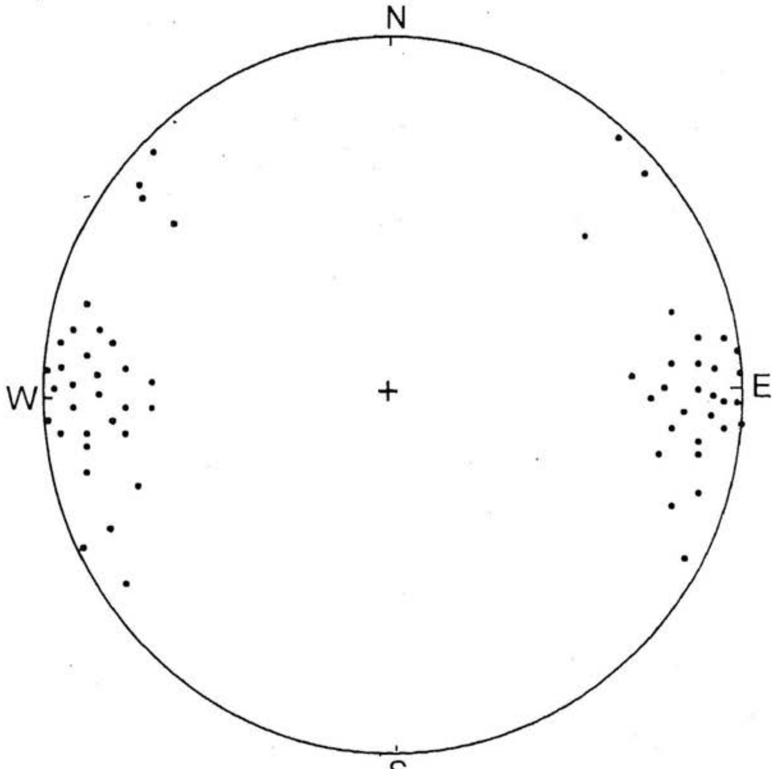


Fig. 5. Equal area plot of the slikeline data along different fault surfaces.

oblique compressional phase, has led to the development of the north-east oriented local scale faults and folds, observed in the hanging wall of the various faults mapped in the area (Fig.3). The local scale structures lie in en-echelon, right stepping fashion suggesting a right lateral component of horizontal translation along the Karak-Nari Panos Positive Flower Structure.

The timing of deformation is constrained by the age of youngest rocks involved in the later stage of deformation. A Plio-Pleistocene age has been assigned to the transpressional deformation as it involves the rocks as young as of Plio-Pleistocene age.

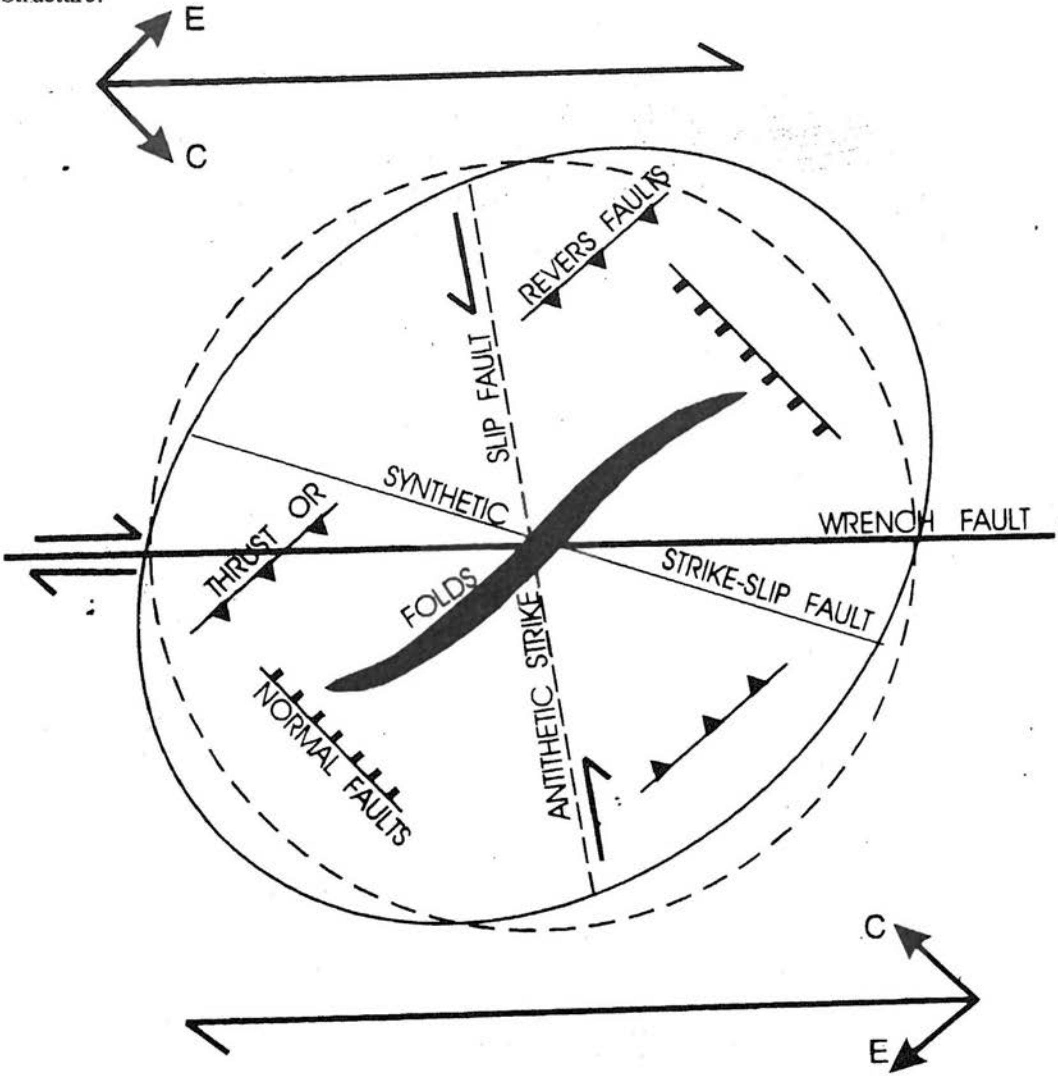


Fig. 6. Geometric relation of folds and faults to right-slip wrench fault combined schematically with strain ellipse and principal strain directions, contraction (C) and extension (E). (After Harding, 1974).

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