Major Tectonic Scars of Peshawar Vale and Adjoining Areas, and Associated Magmatism

R. A. KHAN TAHIRKHELI

Abstract: The Vale of Peshawar, spread in about 1800 sq. km area, constitutes an important tectonic zone in the northwestern margin of the Indo-Pakistan plate. It is surrounded by well carved mega-tectonic features, which originated during post collisional alpine orogenic episodes, starting from Late Cretaceous and lasting till Early Pleistocene.

The main tectonic evolutionary history of the Vale is syngenetic to these episodes, though some pre-alpine tectonic scars have also been distinguished.

Ten major fault tectonics have been described in this paper, out of which six are located within the Vale and the remaining four occur in the adjoining areas. An attempt has been made to decipher these tectonic scars and to delineate associated magmatism in the Vale of Peshawar.

INTRODUCTION

The Vale of Peshawar known as Gandhara in the ancient history, is located on important gateways to the Indo-Pakistan subcontinent on its northwestern terminus. It has glimmering past for craddling many cultures and civilizations.

Since pre-independence days, the Vale of Peshawar has evoked a keen interest among the geologists to bring this terrain within the fold of geological purview. Most of this work pertained to geological mapping to solve the regional stratigraphical riddles. However some efforts were also diverted to mineral exploration.

In the published work, little contribution has been made to cover the structural and tectonic aspects of the Vale. It is surrounded by well-defined major tectonic features, e.g. the Main Mantle Thrust and the Central Axial Belt lying to its north and west respectively; the syntaxial belt and the Hazara thrust system located to the east; the Main Boundary Thrust and the Marghala Thrust lying toward the south. All these maga-tectonic features are the products of various orogenic episodes emanating during and after continental collision, and thus in tectonic modelling of the Vale, their contribution has special importance.

The introduction of this aspect of geological features of the Vale of Peshawar was long due. In this paper the author has attempted to focuss upon this problem by deciphering the major tectonic scars of the Vale and indentifying various associated magmatism.

The exact geographical position of the Vale of Peshawar is still a debatable issue. The old timers consider it as a part of the Hindu Kush. Some divide it between the Himalaya and the Hindu Kush. On the basis of orographic trends of the ranges and geological settings, the author considers the Trans-Indus part of the Vale, incorporating the Lower Swat-Buner, Swabi and the Attock-Cherat ranges, as an extension of the Hazara Lesser Himalaya, whereas the western sector of the Vale consisting of Khyber mountain and its offshoots form the continuation of the Hindu Kush system — which extends into Afghanistan with south-westerly trend.

The Vale of Peshawar covers approximately 1800 square km of area. It is bounded on the east by the Indus river and on the west by the historical Khyber mountains. The Malakand-Lower Swat ranges on the north form its drainage divide with the Swat valley and Darra Adamkhel-Cherat range delimiting its southern extent.

The Swat and Kabul rivers after debouching into the Vale, bifurcate into several branches, e.g., Shah Alam, Naguman, Adezai, Khialai and Abazai, which are perrenial and thus constitute the major sources of irrigation to the Vale. Besides, there are several others, which emanate from the high alluvial fans, well developed on the foothill slope of the Malakand-Lower Swat ranges and become flooded during the rainy season. These streams together give a dendritic drainage pattern to the Vale.

The mountain ranges usually form steep slopes facing the Vale. There is a relief difference between the Vale and the two adjoining Valleys, e.g. Swat and Kohat lying on the north and south respectively.

This difference is about 300 meters along Batkhela-Dargai profile in the north and about 150 meters along Darra Adamkhel-Kohat profile in the south. This relief difference may be attributed to the tectonic factors rather than weathering and denudation.

Proc. Intern. Commit. Geodynamics, Grp. 6, Mtg. Peshawar, Nov. 23-29, 1979: Spec. Issue, Geol. Bull. Univ. Peshawar, Vol 13, 1980.

GENERAL GEOLOGY

Sedimentary, metasedimentary and igneous rocks are developed in the mountain ranges bordering the Vale. Some isolated outcrops emerge out of the alluvium and appear as haphazardly distributed dotts in the Vale. A summarized account on the general geological setup of the Vale of Peshawar is given below:

Sedimentary rocks

i. Siluro-Devonian reef outcrops exposed near Nowshera, Jamrud and Tangi (Stauffer, 1968; Khan, 1969; Tahirkheli, 1969).

ii. Devono-Permo-Carboniferous rocks developed in Lower Swat-Buner, Swabi and Khyber (Martin et al, 1962; Khan, 1969; Shah, 1969).

iii. Jurassic to Pliocene/Pleistocene sequences exposed in Darra Adamkhel-Cherat ranges (Meissner, 1973; Tahirkheli, 1970).

Metasedimentary rocks

An assemblage of pelitic, psammitic and calcareous rocks ranging in age from Silurian to Precambrian form the base of the stratigraphical sequences in the Peshawar Vale. These rocks are being considered to be homotaxial to the Hazara Slate, Tannawal Quartzite and Abbottabad Formation, constituting Lesser Hazara Himalayan sequences east of the Vale. In metamorphic grade they range from epi to meso.

The pelitic sequence near the northern Indo-Pakistan plate margin, also incorporates amphibolite, paragneisses and other high grade metamorphic rocks, indicating progressive increase of metamorphism towards north and northwest where tectonized zones become more frequent in occurrence.

Some of such sequences, so far differentiated in the Vale of Peshawar are: Gadun Quartzite, Lower Swat-Buner schistose group, Manki Slate and Shakhai Limestone in Attock-Cherat Range, and Landikotal Slate in Khyber. Beside, there are several undifferentiated and unnamed slates, quartzites and limestones, having widespread distribution in Malakand, Mohmand and Bajaur which are considered homotaxial to the earlier stated metamorphic sequences which are awaiting stratigraphic formalization.

Igneous rocks

Among the igneous rocks, granites predominate and form large scattered bodies. Their emplacement is mainly confined to the northern and western corners of the Vale. Others include, Dargai ultramafics forming a klippe on the southern flank of the Malakand range and extending westward into Mohmand area; a volcanic to sub-volcanic alkaline body exposed in the vicinity of Shewa-Shahbaz Garhi and several minor acid and basic bodies intruding the granites, ultramafics and metasedimentary rocks.

The granites and alkaline rocks of the Vale are variously named as Utla granite (Khan *et al,* 1978) in Gadun area, Ambela granitic complex and Swat Granitic Gneisses (Martin *et al,* 1962), Koga alkaline complex (Siddique *et al,* 1968), Shewa Formation (Martin *et al,* 1962), Salai Patai alkaline complex (Ashraf *et al,* 1977), Malakand Granite (Khan 1965), and Warsak granite (Ahmad *et al,* 1969).

These granites form isolated bodies and belong to different orogenic episodes. Under broader textural and structural context, the granites of Vale may be grouped into three categories:

i. Foliated, medium grained, light grey to yellowish brown with frequent intrusions of minor acid and basic bodies, having difused contact with the country rocks;

ii. Leuco-type, which are light coloured, medium to coarse, massive and having well defined contacts with the country rocks;

iii. Soda-rich alkaline granite, light coloured medium to very coarse and incorporate carbonatite plugs, which in some sections predominate.

Age-wise, the first mentioned category is the oldest, next in order may be placed the second and the last one is the latest.

Most of the above mentioned igneous rocks have been studied in detail by several workers from different organisations and for an exhaustive digest on their petrology, age and economic significance, the readers are referred to Siddique (1965, 1967), Chaudhry *et al,* (1976), Kempe and Jan (1970), Majid (1976), Jan (1979), Tahirkheli (1979) and a pile of unpublished data lying in the Geological Survey of Pakistan.

FAULT TECTONICS: VALE OF PESHAWAR AND ADJOINING AREAS

The major faults deciphered in the Vale and described in this paper were studied in the exposed rock outcrops. As most of the Vale is camouflaged with thick apron of the alluvials, their extension demands a thorough geophysical probe to confirm their subsurface behaviour. Thus, till such results are made available, their surficial trace marked in the alluvials may have to be considered as tentative.

Ten major faults have been differentiated, six of these are located within the Vale and four occur out-

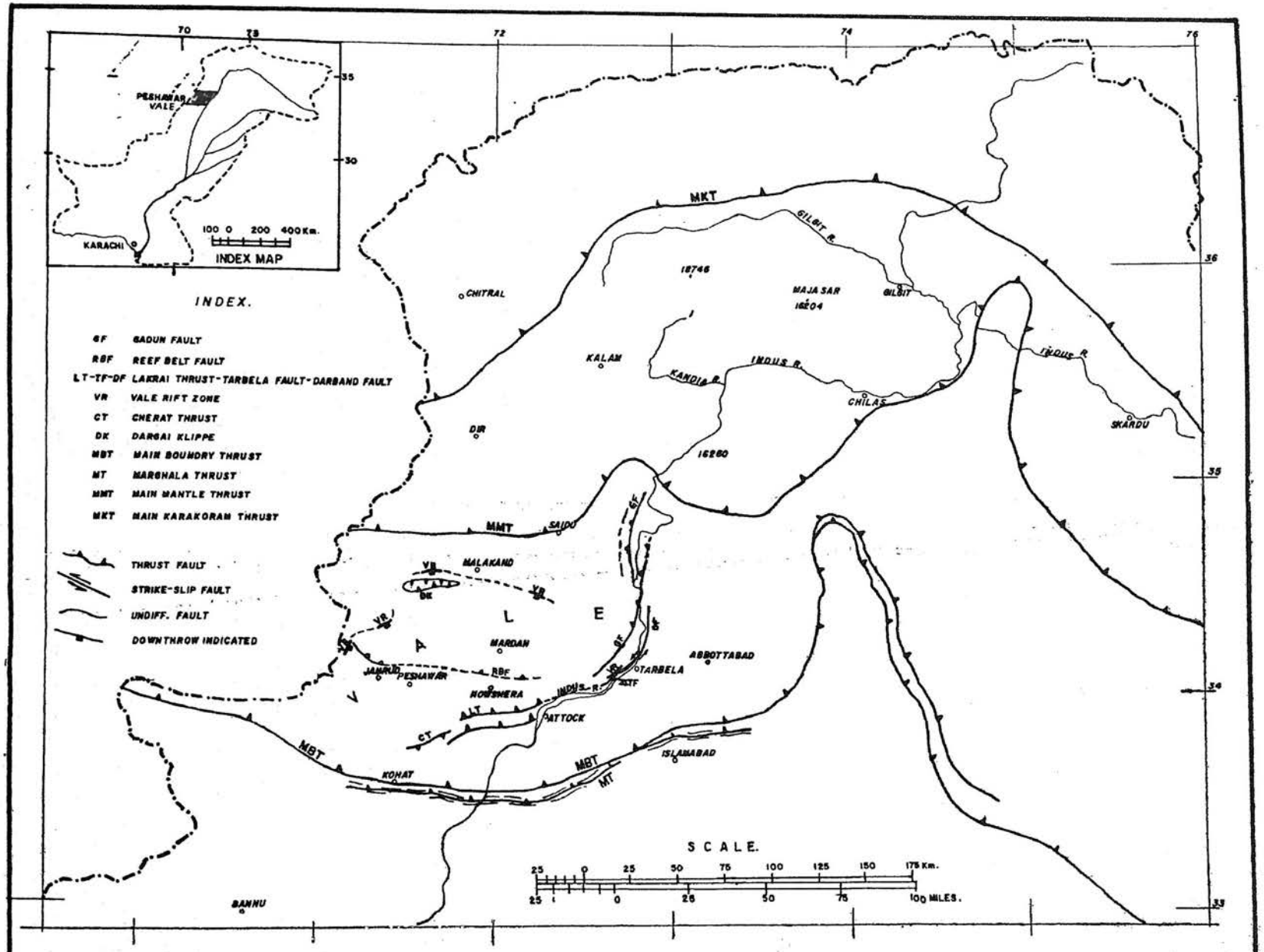

FIG-1. FAULT TECTONICS OF PESHAWAR VALE AND ADJOINING AREAS, PAKISTAN.

side, bordering the Vale on its north, northwest and south. These faults are enumerated below :

i. The Main Mantle Thrust located to the north of the Vale.
ii. The Central Axial Belt surrounding the Vale on the west and northwest.
iii. Gadun Fault.
iv. The Reef Belt Thrust.
v. Lakrai-Tarbela-Darband Fault.
vi. The Vale Rift Zone.
vii. The Cherat Thrust.
viii. Dargai klippe.
ix. The Main Boundary Thrust.
x. Marghala Thrust.

i-ii. The Main Mantle Thrust and the Central Axial Belt constitute two suture zones along which the Indo-Pakistan Plate has been juxtaposed with the Kohistan island arc on the north and Afghan Block of the Eurasian Plate on the west respectively.

The Main Mantle Thrust is a northward directed Thrust along which the Indo-Pakistan Plate margin (comprised of the crystalline rocks) has subducted under the Kohistan island are sequence.

The Central Axial Belt likewise marks a zone of subduction of the western part of the Indo-Pakistan continent under Afghan-Eurasian Plate. The contact is a westward directed thrust which has got a surficial expression of 10-15 km width. The former thrust constitutes the southern suture zone (Tahirkheli *et al,* 1979), whereas the latter after encircling the Kabul block on its east in Afghanistan reappears in Pakistan along Kuner river in the southern periphery of Chitral. It extends in the east as a part of the Northern Megashear (Tahirkheli *et al,* 1979), which has subsequently been named Main Karakorum Thrust by Mattauer *et al,* (1979), along which the ancient Kohistan island arc has been welded with the Eurasian plate.

The closure of the ocean in the former suture zone is timed somewhere during post-Paleocene, whereas in the latter it is marked at an earlier stage, sometime during Late Cretaceous. This evidence is based on the fossils found in the Tethyan sedimentary remnants emplaced in the suture zones.

This collisional episode and subsequent stresses have left deep imprints in the Vale of Peshawar. Its location behind the zone of compression has very likely activated the tensional forces in the Vale, which were responsible for creating rifting, so pronouncedly marked incising the foothill zone surrounding the hill ranges.

iii. Gadun Fault is one of the oldest tectonic scars located in the Trans-Indus part of the Vale on its north-western corner. It lies between the Salkhala Series differentiated in Gadun by Calkins *et al.* (1975) and the slates-quartzites sequences representing Hazara Lesser Himalayan lithofacies and considered homotaxial to the Hazara Slate and Tannawal Quartzite respectively. The fault extends northward and its surficial trace corresponds to the graphitic schist horizon, developed in the vicinity of Khabbal and Kaya, and extending on the eastern bank of the Indus near Kharkot. This fault continues northward towards upper Swat and one of its branches extends into the Black Mountains (Middlemiss, 1896) which is traceable in the section along the road between Batagram and Thakot. Thus, this fault changes its course from west to east along the Indus river. Earlier Calkins *et al.* (1975) named this fault as Dangor Thrust.

Behaviour of this fault, as examined in varoius sections, is variable. In some sections it is a thrust, dipping west, northwest or southeast following the disturbed swings in the strike of beds. Elsewhere it may appear as reverse or a normal fault. In Gadun area, the slates overlie the Salkhalas, as the case may have been in a normal sequence, but with a distorted and tectonized contact.

This fault involves the rocks which are Precambrian, thus it does not appear to be younger than Cambrian. The Swat Granite Gneiss, which represents the oldest magmatic emanation of the Vale and having extension towards north in the upper Swat are associated with this generation of faulting.

South of Gandab in Gadun area this fault has lost its surficial trace underneath the alluvials.

iv. The Reef Belt of the Vale of Peshawar is developed in the three isolated outcrops located near Nowshera, Jamrud and Tangi. West of Nowshera, on the southern bank of Kabul river, two isolated low mounds concealed underneath the alluvials mark the extension of the Nowshera outcrop towards Jamrud in the west. Among them, the Nowshera and Jamrud reef complexes have large surficial expressions providing good sections for detailed geological studies to discern major tectonic features. On the basis of fossils, the reef complexes of the Vale have been dated to be Siluro-Devonian in age.

At Nowshera, the reef complex forms an isolated outcrop and is bounded by alluvium, both on the north and south. The Manki Slate of the Attock-Cherat range considered equivalent to the Hazara Slate, dip under

the reefoid bed. In case, the Hazara Slate is placed in the Precambrian, then their contact should be marked by a great hiatus, eclipsed underneath 12-15 km wide alluvial belt.

On the north of the reef outcrop, for over 35 km, the area is covered by alluvium till Takhtbai, where an isolated outcrop of slates and phyllitic slates, dipping northward and having lithological similarity with the Manki Slate, emerges out of the alluvials. This outcrop is a 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 out to an existence of a thrust fault between the Nowshera Reef Complex and the pelitic sequence in the north.

This east-west striking thrust dips towards north and places the Siluro-Devonian rocks underneath the Precambrian Slate of Malakand range. The northern face of the Nowshera outcrop does not have any visible indication supporting the presence of such a fault. Possibly this thrust lies further north of the reef complex and is marked beneath the alluvials of the Vale.

In Jamrud reef complex, there is a swing in the general strike of the bed. It is east-west in the eastern part and north-south in the western part of the outcrop. The beds dip to the north, northwest and east in the eastern, central and western parts of the outcrop respectively. A well marked thrust fault separates the reef belt from a metasedimentary assemblage consisting of slates and quartzitic sandstones, which are intruded by dolerite, gabbro and some granitic bodies.

The steep scarp on the southwestern margin of the Jamrud reef complex, slickening features, mylonitization and quartz veining along the thrust plane are some of the supplementary diagnostic surface evidences to authenticate this dislocation. This thrust appears to be the extension of the one, postulated earlier, on the north of the Nowshera reef complex.

The Reef Belt Thrust is post-Devonian and is ranked as the second oldest in the Vale of Peshawar. Some of the basic magmatism, localized and occuring as minor bodies is associated with this episode of faulting.

v. Lakrai-Tarbela-Darband Fault: Lakrai Thrust is located on the southwestern margin of the Attock-Cherat range — where the Mamikhel Claystone, a Kohat lithofacies from the west is thrustover by the older Langrial Limestone which belongs to the unfossiliferous metasedimentary suite of the Hazara Lesser Himalayan sequence. The Mamikhel claystone is underlain by the Cherat Limestone of Paleocene age which in turn overlies the Attock Slaty shales containing Nerineids and has been dated to be upper Jurassic-Lower Cretaceous in age. This thrust dips to the north and extends eastward along the northern margin of the Attock-Cherat range and its last trace appears in the outcrops facing the Kund Village located at about 1½ km short of Kabul–Indus confluence. Beyond Lakrai, the Mamikhel claystone and the Cherat Limestone disappear as a result of faulting or may not have extended to that extent and thus the thrust is marked along the contact between the Attock slaty shales and the overlying older metasedimentary rocks.

The youngest sedimentary sequence involved in this thrust is Mamikhel claystone, which on the basis of fossils has been placed in the Lower Eocene, thus the Lakrai Thrust should be post-lower Eocene in age.

Beyond Kund till Topi village on the northeast in Swabi for a distance of about 40 km, this fault is concealed under alluvium. The reappearance of this fault in the northeast is marked in the outcrops located near Gala and Pihur, then extending towards the western abutement of the Tarbela Dam. Here the fault runs along the strike of the rocks, dipping west, and has vertically displaced the bed with a downthrow of about 200 m along the western bank of the Indus. Calkin *et al (1975)* in this section diagnosed it as a strike slip fault and have etended it further north and named it "Darband Fault". They had determined a left lateral movement along this fault and mentioned its association with the imbricate structures.

At the western abutment of the Tarbela Dam, alkaline rocks with carbonatite bodies have been mapped in this fault zone by Jan (1980). These intrusives elsewhere in the Vale, to be discussed subsequently, are associated with the rifting. The author considers the generation of this fault, (extension of Lakrai thrust) and rifting in the Vale, to belong to the same tectonic episode, thus placing the alkaline magmatism in Middle to Upper Eocene.

vi. The Vale Rift Zone: Rifting was first mentioned by Kempe and Jan (1980, this volume) and Jan (1979), while describing the mode of emplacement of the alkaline complexes in the Vale. Subsequent investigations by the author revealed that a rift zone forms a semi-circular bend from west to east around the Vale. The sections in the exposed outcrops which provide evidences in support of this view are located in Shilman, Khyber Agency, Warsak in Mohmand, Salai Patai in Malakand, Koga in Lower Swat and extending as far east as the western abutment of the Tarbela Dam.

Among the above mentioned five known sections Shilman rift zone has been studied in detail. Here

about 5000 m long east-west striking fault zone has been delineated, out of which 1800 m has surficial exposed trace in the outcrop. Four sets of faults are differentiated, three of them are longitudinal faults following the general strike of the regional structure.

Two of these faults are located along the northern and one along the southern margin of the alkaline complex. The fourth is of composite nature, relatively smaller in magnitude and cuts across the others. The three longitudinal faults dip northward at steep angles.

The faulting along the margins of the complex has produced a graben type structure in which the igneous mass indicates a downward slippage of scores of meters relative to the country rocks. The amount of downthrow appears to be rather higher along the southern margin adjoining the Vale, where fault gouge is distinctly marked and forms a well defined horizon.

The east-west rifting in Salai Patai, located on the southern flank of the Malakand range, corresponds to the general strike of the rocks. This rifting has also produced a graben structure along the northern margin of the Vale. More work is needed to establish the amount of downward slippage, but from the elevation differences of the Swat Valley and the Vale of Peshawar along Batkhela-Dargai profile one can deduce between 250 and 300 meters of downthrow of the Vale caused by this rifting.

Several magmatic episodes are associated with this tectonic event, specially along the northern margin of the Vale. The earliest are some of the granites of Buner with minor basic bodies and volcanic-subvolcanic alkaline rocks of Shewa-Shahbaz Garhi in Mardan district. The alkaline rocks with carbonatite bodies are related to later phases of development in rifting. Magmatism in the rift zone, as mentioned earlier is placed between Middle to Upper Eocene.

vii. Cherat Thrust: The Murree Formation of Mid. Miocene age extends to the Vale from Darra Adamkhel-Kohat side on the south-west. It is well developed on the northwestern flank of Cherat, a commanding peak located on the southern corner of the Vale. In this section the Murrees are thrust-over by the Cherat Limestone of Paleocene age. The thrust strikes east-west and dips towards south.

This thrust is an offshoot of the Main Boundary Thrust running parallel to the Kohat Valley on the south. The MBT is northward directed, thus in the Cherat Thrust the change of the thrust inclination may be as a result of the post-Murree tectonics associated with the Marghala Thrust (discussed below) which have also affected the Vale.

Cherat Thrust is a relatively smaller tectonic scar of the Vale which has 10-12 km strike length. This thrust is associated with the post-Murrees events occuring during Pliocene-Pleistocene.

viii. Dargai Klippe: An ultrabasic body, about 300 square km. in dimension is emplaced on the northern corner of the Vale, flanking the Malakand range on its south. It forms a linear belt striking east-west, thus corresponding with the general strike of the metasediments with which it is associated. On the south it is covered with thick alluvials. In the north it has a tectonic contact with metasedimentary rocks, mainly pelitic. This contact is a shear zone which incorporates brecciated rocks and blastomylonitized bed. The eastern end of this body starts from Dargai in Malakand and extends westwards into Mohmand, where it spreads in a larger area.

Dargai ultramafics form a nappe zone in the Vale and its flight to its present site is postulated to be from the Main Mantle Thrust, with which small to large ultramafic bodies have associations. The largest body is located at Jijal which could be its place of origin, or otherwise it could be Dir district which lies further west. In the latter case, the Dir section lies relatively closer with respect to its present position, and it is possible that the whole mass including some stringers of the metasediments belonging to the subducted mass, has moved to the south and thrustover the Malakand metasediments near Dargai.

Dargai ultramafic nappe is considered younger to the rifting episode of the Vale. This large scale thrusting might have occurred during late Miocene–Pliocene, when the alpine orogeny had reached to its climax.

ix. Main Boundary Thrust: The boundary between the Murree Formation and the older rocks constitutes a well established tectonic contact which runs all along the frontal part of the Himalaya. This contact is a thrust, which among the older suite involves the Dogra Slate and Hazara Slate in Kashmir and Hazara respectively, representing the metasediments, and Mesozoic–Lower Tertiary sedimentary rocks in the Murree and Kala Chitta Hills and Kohat ranges. The Murree Formation of Mid-Miocene age constituting the youngest lithology in the sequence is overridden by the earlier stated older rocks along this tectonic line.

This fault has been assigned various names in different parts of the Himalaya. In Pakistan west of syntaxis, it used to be known as the Murree Thrust and in the westernmost sections it had been named as Kohat Thrust by some geologists.

The present author after studying its mode of

occurrence and its behaviour with respect to the older rocks, involved in Indo-Pakistan subcontinent, has come to the conclusion that the Murree Thrust–Kohat Thrust are the extension of the Main Boundary Thrust as shown in a recently published map of the northern segment of Pakistan by Tahirkheli and Jan (1979).

MBT passes south of the Vale of Peshawar and one of its small offshoots, discussed earlier, is noticed on the northwestern tip of the Cherat Range. It is a northward directed thrust and upheaving of the Vale on its southern border with Kohat is consequence of this thrusting — which has imparted it an elevation difference of about 150 meters.

x. Marghala Thrust: Subsequent to Miocene orogeny which created the Main Boundary Thrust, there occurred another important tectonic episode after the deposition of the Siwalik mollasse along the frontal part of the Himalaya. This episode has brought into existence another important tectonic scar alongwhich the rocks of the Siwalik Group of Pliocene–Pleistocene age were thrustover by the Murrees. This thrust runs more or less parallel to the MBT on its south. In many sections because of imbrication, the demarcation of the main tctonic line of this thrust some time becomes a problem. This thrust is also northward directed and in some sections has disrupted the continuity of the overriding Murree beds.

In the past many workers were confused to differentiate this thrust from the MBT. Many had actually mapped this thrust as MBT. Recently Valdiya (1979) had read a paper in an International Committee on Geodynamic, Group–6 meeting at Peshawar, in which this problem was limelighted. He differentiated the MBT as a thrust involving the Murrees with the older Mesozoic–Lower Tertiary formations, from the one which lies between the Murrees and Siwaliks.

At Marghala, the type section of this thrust, the Murrees are disrupted and do not extend as a continuous line. Here the Siwaliks are found directly overlain by the Lower Tertiary limestone. This thrust, belonging to the latest phases of the alpine orogeny, has special significance for migration, impounding and preservation of oil in the Potwar basin, because most of the major structures, for instance, Pabbi, Rohtas, Chambal, Mangla–Rohtas etc. have achieved their final structural configuration during the deformation produced by this thrust (Keller *et al,* 1977).

Marghala Thrust lies south of Peshawar and does not have direct approach to the Vale. However, this northward directed thrust has its contribution in supplementing the compressive forces in creating young structures, reminiscent on the southern part of the Vale and the ones readily recognised are located in the vicinity of Jallozai, Shahkotbala and Jabba Khattak where the folding of Pleistocene age could be differentiated.

CONCLUSIONS

Pre- and syn-alpine orogenies, affecting the northwestern marginal mass of the Indo-Pakistan plate, have left deep imprints in the Vale of Peshawar. Out of the ten major fault tectonics deciphered in this paper, the Gadun Fault and the Reef Belt Thrust belong to the pre-alpine orogenic episodes. The former is dated to be Cambrian and the latter is placed as the post-Devonian.

Most of the mega-tectonic features surrounding the Vale have achieved their final configuration during the alpine orogenies emanating subsequent to collision and have contributed in creating the later eight faults which ranged in age from post Mid Eocene to Pleistocene (Marghala Thrust). Most of these faults have extensions into the Lesser and Outer Himalayan zones and form some of the major lineaments occurring on the northern margin of the Indo-Pakistan plate.

The magmatism in the Vale is associated with five of these fault tectonics, the oldest being the Swat Granite Gneiss associated with the Gadun Fault and the youngest is the ultramafics of the Dargai Klippe. Among the rest, the MBT and the Marghala Thrust have no associated magmatism, wereas the others have magmatic associations but are located outside of the Vale precinct.

The graben structure of the Vale is vivid and is distinctly differentiated tectonically by the amount of slippage encountered on the west, east and north of the four corners of the Vale. On the south the Vale shows upheaval with respect to the Kohat Valley which is due to the compressive forces affecting the Vale by the northward underthrusting along the Main Boundary and the Marghala Thrusts emanating during post-Mid. Miocene orogenies.

The drainage pattern and the steep slopes of the mountains facing the Vale are some of the supplementary evidences in support of graben structure of the Vale.

REFERENCES

Ahmad, M., Ali, K.S.S., Khan, B., Shah, M.A. and Ihsanullah, 1969, The Geology of the Warsak Area, Peshawar, W. Pakistan, Geol. Bull. Univ. Peshawar, 4, 44-70.

Ashfak, M. and Wakil, A. 1969, The study of joint patterns and the other structures of the Manki Slate and the Attock Shale, Geol. Bull. Univ. Peshawar, 4, 24-32.

Ashraf, M. and Chaudhry, M N., 1977, A discovery of carbonatite from Malakand. Geol. Bull. Punjab Univ. 14, 89-90.

Chaudhry, M.N., Ashraf, M , Hussain, S.S. and Iqbal, M., 1976, Geology of Malakand and part of Dir (Toposheet 38/4), Geol. Bull. Punj. Univ. 12, 17-39.

Calkins, J.A , Offield, T.W., Abdullah, S.K.M. and Ali, T., 1975, Geology of the Southern Himalaya in Hazara, Pakistan, and adjacent areas, U.S.G.S. Professional Paper 716-C, Washington, pp. C1-C29.

Davies, R.G asd Ahmad, R., 1963, The Orthoconic Nautiloids of the Kala Limestone and probably Age of the Swabi Formation, Geol. Bull. Punjab Univ. 3, 1-6.

Frank, W., Gansser, A. and Trommsdorff, 1977, Geological Observations in the Ladakh area (Himalayas) A Preliminary Report, Schweiz. Mineral. petrogr. Mitt. 57, 89-113.

Gansser, Augusto, 1964, The Geology of the Himalayas: New York, Interscience Publishers, 289p.

Gansser, A. 1964, The ophiolitic Melange, a world-wide problem on Tethyan Examples. Eclogea Geol. Helv. 67, 479-507.

Jan, M Q. 1979, Petrography of Shilman Carbonatite Complex, Presented in P.A.E.C. Seminar held at Peshawar.

Jan, M.Q. 1980, Geology and Petrography of the Tarbela Alkaline complex (in preparation).

Jan. M Q. and Kempe, D.R.C., 1973, The Petrology of the basic and intermediate rocks of upper Swat, Pakistan, Geol. Mag. 110, 285-300.

Khan, M.A., 1969, Siluro-Devonian Reef Complex of Ghundai Sar and vicinity, Jamrud, Khyber Agency, Geol. Bull. Univ. Peshawar, 4, 79-82.

Khan, W.M. 1965, The main Malakand granite, Geol. Bull. Univ. Peshawar, 2, 8 10.

Khan, B.A . Shah, Z.H. and Naeem, S.M., 1970, Geology of the Ghundai Sar and vicinity, Jamrud, Khyber Agency, Geol. Bull. Univ. Peshawar, 5, 115-130.

Keller, H.M., Tahirkheli, R.A K. Mirza, M.A., Johnson, G.D., N.M. and Opdyke, N.D , 1977, Magnetic polarity stratigraphy of the Upper Siwalik deposits, Pabbi Hills, Pakistan, Earth Planet Sc. Letters, 36 (1977), 187-201.

Khan, M.I. and Hammad A. 1978, Petrology of Utla Granite, Gadun Area, Unpubl. M.Sc. Thesis, Peshawar Univ. Geol. Department.

Kempe, D.R.C. and Jan, M.Q. 1970, An alkaline igneous province in the North-West Frontier Province, West Pakistan, Geol. Mag. 107, 395-398.

Kempe, D.R.C. and Jan, M.Q. 1980, The Peshawar Plain alkaline igneous province, NW Pakistan. In Proceedings of the International Committee on Geodynamics, Group-6 meeting at Peshawar, Centre of Excell. Geology, Peshawar University (This Volume).

Le Fort, P. 1975, Himalayas: The collided range, present knowledge of the continental arc. Amer. J. Sci. 275-A, 1-44.

Majid, M. 1978, Mineralogy and Petrology of the Shilman Carbonatite Complex, Khyber Agency, NWFP, Cent. Excell. Geology, Peshawar University, Inf. Release, No. 8.

Martin, N.R., Siddique, S F.A. and King. B.H., 1962, A geological reconnaissance of the region between the Lower Swat and Indus River of Pakistan: Geol. Bull. Punjab Univ. 2, 1-13.

Meissner. C.R., Hussain, M., Rashid, M.A., and Sethi, U.B, 1973, Geology of the Parachinar area, Pakistan. U.S. Geol. Surv. Prof. Paper 716-F.

Meissner, C R., and other, 1973, Stratigraphy of the Kohat quadrangle, Pakistan: U.S. Geological Survey Prof. paper, 716-D, 30p.

Middlemiss, C.S., 1896, The geology of Hazara and the Black Mountains: Geol. Surv. India. Mem. 26, 302p.

Powell, C. McA and Conaghan, P.J., 1975, Tectonic model of the Tibetan plateau, Geol. 3, 727-73.

Shah, I., 1969, Discovery of Palaeozoic rock in the Khyber Agency, Geonews, 1, 1-4.

Siddique, S.F.A., 1965, Alkaline rocks in Swat-Chamla. Geol. Bull. Punjab Univ. 5, 52.

Siddique, S F.A., 1967, Note on the discovery of Carbonatite rocks in the Chamla Area, Swat State, West Pakistan, Geol. Bull. Punjab Univ. 6, 85-89.

Siddique, S.F.A., Chaudhry, M.N. and Shakoor, A., 1968, Geology and Petrology of the feldspathoidal syenites and the associated rocks of the Koga Area, Chamla Valley, Swat, West Pakistan, Geol. Bull. Punjab Univ. 7, 1-30.

Stauffer, K.W , 1968, Silurian- Devonian Reef Complex near Nowshera W. Pakistan, Bull. Geol. Soc. America, 79, 1331-50.

Tahirkheli, R.A.K , 1969, Another Palaeozoic Reef discovery in Tangi Ghar, Peshawar Distt. Geol. Bull. Univ. Peshawar, 4, 90-9.

Tahirkheli, R.A K., 1971, The Geology of the Gandghar Range, Distt. Hazara, NWFP. Geol. Bull. Univ. Peshawar 6, 33-42.

Tahirkheli, R.A K., Mattauer, M., Proust, F. and Tapponnier, P., 1977, The India-Eurasia Suture Zone in Northern Pakistan: Some new data for an interpretation at plate scale. Geodynamics of Pakistan, Geol. Surv. of Pakistan, 125-130.

Tahirkheli, R.A.K , Mattauer, M., Proust, F. and Tapponnier, P., 1977, Some new data on the India-Eurasia Convergence in the Pakistani Himalaya. Colloq. Intern. C.N.R S. 268, Ecologic et Geologie de l' Himalaya, 209-212.

Tahirkheli, R.A.K., and Beg, I., 1979, An Economic Appraisal of Shilman Uraniferous Prospect, Khyber Agency, Pakistan, presented in PAEC Seminar held at Peshawar.

Tahirkheli, R A.K., and Jan, M.Q., 1979, Preliminary Geological map of Kohistan and adjoining areas, Geology of Kohistan, Karakorum Himalaya, Northern Pakistan, Geol. Bull. Univ. Peshawar, 11 (spec. issue).

Valdiya, K.S., 1979, Nature of the Main Boundary Thrust in the central sector of the Himalayan arc, presented in ICG, Group-6 meeting at Peshawar, Pakistan.