GEOLOGY OF THE GHUNDAI SAR AND VICINITY, JAMRUD, KHYBER AGENCY

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ABSTRACT

The area of investigation lying in the eastern part of the Khyber Pass, between Jamrud and Waran Ghundai, is covered by the formations of the Lower and Upper Palaeozoic ages. They are represented by the Landikotal Slate(?Ordovician-Lower Silurian), the Shagai Limestone(?Middle to Upper Silurian) and Ali Masjid Formation (Upper Silurian to ? Lower Carboniferous).

All of these are marine, and clastic sedimentary rocks account for more than two-third of the total thickness of the strata exposed in the area. The Landikotal Slate constitutes as much as ± 6000 feet of clastic sedimentary rocks.

Of all the formations the Ali Masjid Formation is the only fossiliferous formation. It is reefoid, and extensive reef deposits occur in it.

Thamnopora, Cladopora, *and* Favosites *are the important tabulate corals. Other fossils present are stromatoporoids, orthoconic cephalopods, byrozoans, brachiopods, and abundant crinoidal stems and columnals. The fossil assemblage indicates an age between Upper Silurian and Lower Devonian. Large scale metamorphism and dolomitization has occurred, which has resulted in the obliteration of the details of fossils. This has rendered difficult to indentify many fossils even at generic level. The effect of metamorphism increases towards north and the reef limestones are converted to marble.*

Late Cretaceous and Early Tertiary igenous activity is indicated by the dolerite, gabbro, and (?) microgranite intrusive bodies. Most of these are sills. Dolerite and gabbro sills have mineralized the calcareous phyllites and reef limestones. Extensive and large deposits of soapstone occur within calcareous phyllites and reef limestones (converted to marble).

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The area is traversed by NS and NW-SE striking thrust faults. In the northeastern part of the area the rocks are folded into a NE plunging syncline. Recent movements have occurred in the area as indicated by elevated terraces and alluvial valleys.

INTRODUCTION

This paper is an edited account of a M.Sc. thesis presented to Geology Department, University of Peshawar. The area investigated covers approximately 17 square miles located between latitude 34°1′ 12′′-34°4′ 16′′ N; and longitude 71°18′5′′-71° 23′20′′ E on the western fringe of the Peshawar valley.

The field work for this paper was conducted during April and May, 1970. Survey of Pakistan topo sheet No. 38 N/8 with a scale of 1 inch to 0.789 miles and contour interval of 50 feet was enlarged four times and used as a base for mapping the geology of the area.

The rock outcrops in the area form low foot hills, which rise from the alluvial plains of the Peshawar valley and form the eastern front of the main mountain chain covering most of the Khyber Agency. On a regional scale, this main mountain chain is a part of the Hindukush Mountains which fan out in a westward direction into Afghanistan. It extends into Pakistan in a southern direction from north and makes a series of anticlines and synclines which are clearly observed in the main Khyber Pass.

The highest point in the area investigated is Sangaral. It rises to an altitude of 2755 feet above the sea level. It is approximately 1707 feet above the Peshawar valley floor. All the high peaks and ridges make steep slopes which dip in a northeastern direction.

The investigated area lies entirely to the east of the main drainage divide of the Khyber Agency. The majority of the drainage systems of the area are ephemeral. During the periods of winter rains, and torrential storms during July and August, when streams receive sufficient quantities of water to cause flowage, they join the Sur Kamar Khwar, the main ephemeral trunk stream flowing generally northwards.

Four major drainage systems have developed in the area. All of the main tributaries have cut moderately deep to shallow valleys and their innumerable tributaries have reduced the part of upper reaches to late youthful stage. The following form the major drainage system of the area. 1. Marzai Khwar, 2. Sre Khule Khwar, 3. Dando Khwar, and 4. Lashora Khwar. In addition to above mentioned four major drainage systems, many other small streams drain the area.

A thick cover of alluvium extends all along the eastern front of the region. This thick cover of alluvial deposit has developed because of coalescing of several alluvial fans. Recently uplifted river terraces occur near the southern boundary of the area. These are made up of horizontally deposited layers of gravel, sand and silt, and are seen at much higher level than the present level of the main river which flows nearby. Recent movements have uplifted the area which still shows a youthful topography. Stauffer (1968) estimates a recent uplift between 600 to 1000 feet.

The area of investigation falls in the semi-arid zone, and is characterized by sparse vegetation, reflecting a short rainy season. The annual amount of downpour varies between 15 to 20 inches. However, this is not fairly uniformly distributed throughout the year. The area receives considerable rainfall during the monsoon and winter.

The maximum temperature during the summer is 110°F and minimum temperature in winter is about 35°F. The average minima and maxima for winter and summer are 40°F and 105°F, respectively. Both the summer and winter are longest season and severe as well. The spring, which sets in late February or early March, is short lived.

The areas is thinly populated, Afridis, Kukis, Dadu, and Mullagori are the dominant tribes inhabiting the area. Besides agriculture and transit trade, marble excavation and soapstone mining are the main mineral supported professions within the area.

PREVIOUS WORK

Prior to 1965, very little work has been carried out in the Khyber Agency. This was mainly due to inaccessibility of the tribal areas. Therefore, little literature is available on the geology of the area in particularr and the Khyber Agency in general, and most of it is mainly concerned with the economic aspects of the region, *i.e.*about the marble deposits, railroad surveys, and dam-site explorations and investigations.

The latest available record of detailed geological work, in this part of the Khyber Agency, is an unpublished master's degree thesis by Badshah and Rehman (1969) and a published report on the 'Ghundai Sar Reef' by Khan (1969).

Prior to this work, a few reconnaissance type surveys were carried out in the Khyber Agency.

The very first survey was made by Lord (1838), an officer of British India Army. It is reported that he made a traverse from Attock to Kabul through the Khyber Agency.

Falconer (Wynne, 1879, p. 121) has reported the occurrence of Lower-Silurian fossils from Khyber Agency. However, the location and identification of these fossils could never be ascertained. As such, it is safe to disregard this report (Stauffer, 1967).

Among many other geologists, besides Lord(1838) who ventured to investigate the geology of the Khyber Agency, Griesbach (1892), Hayden (1898), Wynne (1879), Coulson (1936 and 1937), and Fox (1920's and 1930's) are noteworthy.

Griesbach (1892) distinguished the following lithologic units while working out the geology of the Safed Koh mountain ranges:

(v)	Complex of shales and earthy beds	Triassic?
(iv)	Limestone and alum shale series	)
(iii)	Metamorphic strata with graphitic layers ..	) Carboniferous
(ii)	Phyllites and schists	)
(i)	Gneissic series ..	) Older Palaeozoic

Fox, who visited Khyber pass in 1920's and 1930's, described the various types of rocks and structures of the main Khyber Pass.

Coulson (1936) described the Warsak granite and compared it with the 'Shahbazghari prophyries' (the Shewa Formation of Martin *et al.*, 1962) and considered them to be consanguineous (Ahmad *et al.*, 1969).

Coulson's work of 1937 is mainly confined to the marble resources of the N.W.F.P. However, he incorporates various reports and informations from other geologists about the occurrence of Palaeozoic fossils in the Khyber Agency.

Stauffer (1968) established the following stratigraphic succession in the main Khyber Pass. He coined names for all the major formations.

(iv) Khyber Limestone-massive grey unfossiliferous limestone	Carbonifeours to Jurassic (?)
(iii) Ali Masjid Formation—white tuff and quartzite with calcareous sandstones ..	Devonian (?) to Permian ?
(ii) Shagai Limestone—limestone and dolomite ..	Ordovician? to Carboniferous
(i) Landikotal Slates	Ordovician? to Carboniferous?

Stauffer failed to report any fossil from any of the units differentiated by him. However, he considers that the Shagai Limestone might be of algal origin.

Ibrahim Shah (1969) practically follows the same pattern as put forward by Stauffer. He reported a number of index fossils from Khyber Agency during his investigations. A detailed report, being prepared by John A. Talent, on the taxonomy of these is still awaited.

Ibrahim Shah (1969) assigns an Upper Devonian age at least to the upper part of the Ali Masjid Formation, on the basis of the occurrence of *Platyclymenea* in the upper part of the formation. On the basis of the occurrence of *Productus* and fusulinids, he also assigned a Carboniferous to Permian age to a part of the Khyber Limestone. This formation was previously correlated with the Carboniferous Limestone of Hindukush and Himalayas on lithological grounds, by Griesbach (1892).

It is to be noted that Ibrahim Shah failed to take note of the Ghundai Sar Reef and three kinds of igneous intrusions so prominent in the area.

M. I. Ahmad (1951) investigated the geology of Warsak Dam site.

Abbas and others described the soapstone deposits from the area of this report in 1967.

Ahmad *et al.* (1969) gave a detailed account of the geology of the Warsak area along with the petrography of the basic and granitic rocks.

STRATIGRAPHY

The strata in the area of investigation represent deposition from (?) Ordovician to Permian. No Tertiary deposits of sedimentary origin are exposed. However, Early Teritiary is represented by mafic and silicic intrusions.

The rocks of the Khyber area as a whole mark a transition in the regional strikes. "The regional east-west strike of the Safed Koh Range.....changes here to the dominantly northeast and southwest strike characteristic of the Hindukush Range farther to the north. Farthermore, the sedimentary rocks of the south give way to the metamorphic and igneous rocks farther north" (Re. CENTO, 1966, p. 47).

The oldest strata in the area, the low-grade regionally metamorphosed sediments (the Landikotal Slates), developed in deep marine conditions probably on the floor of gradually subsiding geosyncline. This formation is represented dominantly by pelitic and psammitic rocks. At places, the psammitic strata, interbedded with pelitic strata at various stratigraphic levels, show markings resembling flute casts and load casts. The slates are intruded by dolerite, gabbro, and granite sills. The Landikotal Slates extend deep into Afghan teritory where they have yielded lower Silurian fossils. Waagen and Wynne correlated the slate formation of Khyber with the Attock Slates on lithological and structural similarities.

The Shagai Limestone is the next older formation in the area of investigation. This limestone represents deposition in marine environments. It is most probable that the limestone is of algal origin. It covers extensive areas in the Attock region and Hazara.

Partial continental environments of deposition prevailed during the accumulation of the Ali Masjid Formation. This formation is dominantly argillaceous, also containing white tuffaceous units. From the type locality, Stauffer reports a 400 feet thick tuffaceous bed within this formation.

White orthoquartzites and greyish-brown calcareous othoquartzite, which are profusely laminated and cross-bedded, form the base of this formation. Coral reefs and thin beds of crinoidal limestone occur throughout the calcareous part. The Ghundai Sar, located near the eastern extremity of the area, is entirely coral reef.

The upper part of the Ali Masjid Formation is dominantly pellitic. Interbedded with the pellites are lenticular beds of crinoidal limestone. However, the crinoidal columnals are considerably smaller than those found in the reefoid beds in the lower part of the formation. The Ali Masjid Formation may have deposited during Late Silurian to Late Devonian or even Early Carboniferous times (Khan, 1970).

The Khyber Limestone of probably Carboniferous to Permian or even Early Mesozoic age occurs as allochthonous blocks within the older formations. Outside the investigated area, it forms high peaks. The strata follow the general law of superposition, except near the western boundary where the Landikotal Slate is thrust over younger formations. Similarly, the Ali Masjid Formation has a thrust contact with the Landikotal Slate.

ORDOVICIAN-SILURIAN SYSTEM
(Upper Ordovician-Lower Silurian)

LANDIKOTAL SLATE

The Landikotal Slate crops out near the town of Landikotal which is the type locality. It continues westwards into Afghanistan, where it covers large areas. In the area of investigation, the Landikotal Slate is the most prominent and thick formation. It is exposed on either side of the Lashora Khwar. It continues from the northern bank of Sur Kamar Khwar towards north, ultimately passing out of the area (plate 1). It forms low rolling hills, however, where interbedded sillstones and sandstones occur at higher stratigraphic levels, escarpments and cliffs are formed.

Lithology and Thickness.

The Landikotal Slate consists of dark greenish-grey and dark grey slates, schists, phyllites, and interbedded sandstones and sillstones. The slate is fine-grained and

commonly weathers to long and thin splinters. Phyllites and schists occur more abundantly near the northern limb of the area, which is also the direction of increase in the grade of metamorphism. The entire unit is traversed by well-developed joints which cause the slate to breakup into rhomboid blocks, eventually weathering into long and thin pencil-like fragments.

At various stratigraphic levels, lenticular beds of siltstone and sandstone, showing sole markings, ball and pillow structure, flute casts, and convolute bedding, occur. Other features, such as lamination and graded bedding, are also observed.

It is most probable that the sediments were deposited in a deep marine basin, and the sillstone and sandstone beds represent turbidity deposits (Khan, oral communication). Khan also believes that the greenschist, which is often associated with the slates, may have been originally 'greenstone' or spilitic lavas associated with the 'flysch deposits'. The formation is extensively intruded by sills of dolerite, gabbro, and severely weathered granite. These intrusions occur on either side of the Lashora Khwar Valley. The individual sills sometimes measure upto 150 to 200 feet.

The writers think that the extensive igneous activity, besides the regional forces, might have contributed to the metamorphism of the rocks. Near the source of Lashora Khwar, thick veins of milky quartz traverse the slates. These veins have structurally deformed the surrounding rocks. The slates give way to phyllites and schists which are tightly folded in chevrons. Huge blocks of milky quartz, weighing a ton or more, are seen strewing the Lashora Khwar near its source.

The thickness of the Landikotal Slate is difficult to measure because of the structural complications. However, the continuous exposures in the investigated area might add up to $\pm$6000 feet.

Relation to Adjacent Formations.

The Landikotal Slate is the oldest formation in the area. Its true stratigraphic base is not exposed because of its faulted contact with the Shagai Limestone. It is overlain by the basal orthoquartzites of the Ali Masjid Formation. It is found nowhere in the investigated area to be overlain by the next immediate younger formation, the Shagai Limestone.

The upper contact of the slate, with the basal orthoquartzites of the Ali Masjid Formation, is sharp and truncated by a fault. The gouging of slates, and shearing and brecciation of the quartzites is suggestive of a thrust contact.

Age and Correlation.

In a regional correlation scheme, Stauffer (1967) correlated the Landikotal Slate with the Kandar Phyllite of Nowshera, the Lower Swat-Buner Schistose Group, major

part of the Swabi-Chamla Sedimentary Group, the Tanawal Formation, Lower part of the Abbottabad Formation, and Charun Quartzite and Muth Quartzite of Reshun (Chitral) and Srinagar-Muth respectively. However, recent field work (Khan, 1970) shows that the Landikotal Slate is much older than any of Stauffer's correlative units. According to Khan, the slates can be correlated with the Hazara Formation, the Manki Slate, and the Chitral Slate.

As mentioned earlier, a thorough search for fossils in the area failed. However, the age assignment is based on superposition of the overlying formations, and lithological characters of correlative units of Hazara and Attock. Accordingly, an Ordovician to Lower Silurian age can be assigned to the Landikotal Slates (Khan, Ibid.)

SILURIAN SYSTEM

(Lower Silurian - Middle Silurian)

SHAGAI LIMESTONE

The name Shagai Limestone was assigned by Stauffer (1968) to the limestone overlying the Landikotal Slate in Khyber Pass. The type locality, the Shagai Fort, lies southwest of the outcrops. Here it is about 100 feet thick.

The Shagai Limestone demarks the westernmost extremity of the investigated area and is in thrust contact with the Landikotal Slate. In other localities within the area, it is mixed with the allochthonous blocks of the stratigraphically youngest formation, the Khyber Limestone.

Lithology and Thickness.

The Shagai Limestone consists of light grey, thinly laminated, apparently incipient nodular limestone weathering yellowish- and greenish-brown. The individual nodules range in size from two to three inches. The extremely thin laminations, which at places show crinkly boundaries, are suggestive of an algal origin for this limestone. Thin section study also reveals the presence of intraclasts — clot like objects with crinkly concentric layers (Stauffer, 1967, p. 548). The individual nodules (stretched into lenticular bodies) might represent the individual algal heads (Khan, oral communication).

The Limestone is traversed by abundant veins of white calcite. At places, it is severly crushed and brecciated, especially along the contact with the Landikotal Slate. The thickness of the unit is approximately ± 150 feet.

Relation to Adjacent Rocks.

The Shagai Limestone is in thrust contact with the older Landikotal Slate. It is nowhere seen in contact with immediately younger unit, the Ali Masjid Formation. Apparently, it is faulted out of the area.

Age and Correlation.

No definite organic remains were found in the Shagai Limestone. However, some unidentifiable (?) organic objects were seen west of the Lashora Khwar.

Stauffer (1967, p. 548) states: "no identifiable organic structures were seen.. ....although under microscope original textures such as interaclasts in sparry clacite and round clots of fine-grained carbonate with crinkly, concentric layers suggestive of algal growth, were seen." Hayden (1900, p. 110) described an outcrop of "..... a much crushed crinoidal limestone overlain by a dense coral limestone on the surface of which stands out silicified remains of many corals and echinodermata," some where in a valley five miles south of the Khyber Pass. This outcrop, probably, is the continuation of the crinoidal limestone of 'Jamrud reef complex' (Khan, oral communication). Neither the exact location nor the exact identification of Hayden's colcollection is known, and as such no definite palaeontological or stratigraphical conclusion can be dereived.

Ibrahim Shah (1969, p. 32) reports that the Shagai Limestone is unfossiliferous, but some where west of the Khyber Pass (? Hayden's locality) the formation contains highly recrystallized (?) brachiopods*. These could never be identified at generic level or even as brachiopods. On the basis of his finding(s) he opines that they might belong to Silurian/Devonian assemblages. Apparently, his conclusion is based on the occurrence of Upper Silurian and Lower Devonian brachiopods in the conformably overlying Ali Masjid Formation (Khan, oral communication).

From the above discussion, it is evident that the exact age determination of the Shagai Limestone is still in a state of flux. However, on the basis of superposition and its contact with the overlying Ali Masjid Formation (not in the mapped area), it can be safely assumed that the limestone represents deposition during the (?) Lower and Middle Silurian. The occurrence of the Upper Silurian fauna in the Ali Masjid Formation substantiates the assignment of this age to the Shagai Limestone (Khan, oral communication).

Lithologically similar limestone formations occur in Hazara and the Attock-Cherat Range of the N.W.F.P. In both of these localities, this limestone overlies slates of the same characters as the Landikotal Slate. As such, the Shagai Limestone can be correlated with the Khattak Limestone and Limestone of Attock-Cherat Range and Hazara, respectively.

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*The sample containing these (?) brachiopods was seen by the editor, although the collection site was never revealed by I. Shah. The preservation was so poor that the remains could only be called organic and nothing more. They could be bivalves, brachiopods, or remains of other shell-secreting organisms.

SILURO - DEVONIAN SYSTEMS
(Upper Silurian - Lower Devonian)

ALI MASJID FORMATION

The Ali Masjid Formation, consisting of white tuffaceous slaty shales (400 feet) and overlain by medium-grained quartzites (60 feet), was named by Stauffer (1967, p. 548) after the village of Ali Masjid (lat. 34°02′ N, long. 71°15′ E). The formation is well exposed in the investigated area, striking NW-SE, between the eastern bank of Dando Khwar and the eastern limits of the area. It practically covers more than ⅓ of the entire area mapped, and extends beyond Mulla Gori for a long distance.

Lithology and Thickness.

Of all the formations exposed, the Ali Masjid Formation is the most diverse lithologically. From base to top, it consists of snow-white to grey quartzites, brecciated limestone, phyllite, reef carbonates, quartzite, and undifferentiated metasedimentary rocks. As each unit deserves a status of formation (Khan, Ibid., p. 90), it is fit to discuss them briefly.

1. *Snow white and grey Quartzite:* The quartzite bed constitutes the basal unit. It is massive to thick-bedded. The Lower part is snow-white in colour and is composed of well rounded, medium- to coarse-sized quartz grains. The Upper part is greyish-brown in colour and is composed of medium-fine to very-fine quartz grains. The cementing material is mainly silica, however, calcite is also present.

Cross-bedding is ubiquitous in the upper part. Extensive shearing, causing development of closely spaced joints and fractures, has occurred. The total thickness of the quartzite is 100 feet.

2. *Limestone:* This unit, which conformably overlies the quartzite, is well developed and is mainly composed of brownish-grey, dark grey, and brown, finely crystalline to lithographic limestone. Subordinate siltstone and shale also occur at various levels. The limestone weathers to sharply angular fragments which range in size from two to three inches.

Mafic intrusions (mainly sills) which occur profusely, have caused soapstone mineralization. Workable deposits of good quality soapstone occur throughout this unit. The total thickness of the formations is about ± 100 feet.

3. *Phyllite:* The phyllite conformably overlies the limestone. It "comprises mainly phyllites, chloritic phyllitic-schists, and crinoidal limestone, interbedded at various stratigraphic levels. The entire unit is yellowish-grey in colour, except where chloritic schists occur. The chlorite-bearing phyllitic schist is greyish-green in colour. The thickness of the unit is approximately 300 to 400 feet" (Khan, 1969, p. 79).

The phyllite unit is correlated with the Kandar Phyllite of Nowshera.

The phyllites are intruded by the sills of mafic rocks (gabbro, dolerite). These sills have also caused the development of soapstone in workable quantities.

4. *Reef Carbonate:* The Reef Carbonate unconformably overlies the phyllite. At Ghundai Sar they are well developed and form low hills of Ghundai Sar. These carbonate, which represent the Siluro-Devonian Reef, comprise mainly two distinguishable layers of a reef, the reef core, and the reef breccia. The reef core represents the main or axial part of the reef which grew in size due to vigorous organic activity, that is by the continuous upward growth of lime-secreting interlocking and encrusting organisms like corals and bryzoa.

The reef breccia represents the debris derived from the reef core by the disintegrations and uprooting of organisms due to wave action.

The strata comprising the reef core, converted to marble, are characteristically buff to pinkish-white in colour when fresh but brownish-grey when altered. "It is characterized by encrusting and interlocking fauna, mainly, stromatoporoids, tabulate corals, rugose corals, brachiopods, and abundant crinoid stems and columnals. Large orthoconic nautiloids are also present" (Khan, 1969, p. 80).

Athough most of the fossils have been obliteratcd or destroyed because of combined effect of dolomitzation and recrystallization, some of them can be recognized. Among the well-preserved fossils are massive or dendroid *Favosites, Cladopora*, and crinoid stems and columnal (Khan, 1969, p. 80). Stromatoporoids and orthoconic nautiloids are severely recrystallized, with the exception of greyish-white bodies and long conical calcitic bodies, nothing more can be inferred. Stringers of quartzite occur throughout the reef core.

The Reef Breccia is the youngest unit within the reef complex. It occurs in the form of lenses and pockets throughout the reef. Angular fragments and fossil debris derived from the reef core are the major constituents of this unit. The following fossils occur in the reef breccia:

Favosites, Cladopora, Thamnopora, Heliolithes. Hexagonaria,(?) *Streptelasma, Mucophyllum* and abundant fragments of stromatoporoids. Other fossils present are Fenestrenellid Bryozoa, and numerous brachiopods among which *Atrypa* is abundant.

The crinoid stems and columnals comprise the bulk of the reef breccia. It is noteworthy that the stems and individual columnals of crinoids are much larger than those found in the Nowshera Reef. The total thickness of the reef core and reef breccia is ± 900-950 feet.

The reef carbonates have yielded a number of fossils exactly similar to those of the Nowshera Reef Complex. On the basis of similarity of fossils and stratigraphic succession, Khan (1969, 1970) correlated the Ghundai Sar reef carbonates with the Nowshera reef carbonates.

5. *Quartzite:* The reef carbonates are conformably succeeded by a series of well-bedded dolomitized orthoquartzites which gradually become dolomitic and calcareous in the northern part of the investigated area. It is composed of well-rounded to moderately rounded quartz grains without frosting, pitting, or etching. The size of the particle ranges between 1/2 mm to 2 mm The thickness of the quartzite unit ranges between 300 to 600 feet.

On the basis of lithological similarities and stratigraphic position, Khan (1969, 1970) correlated it with the Misri Banda Quartzite of Nowshera and Akora Khattak. However, the quartzite is considered older than Carboniferous. Stauffer (1968) considers the Misri Banda Quartzite to the Carboniferous in age.

6. *Metasedimentary Rocks:* A series of rocks consisting of phyllites with interbedded limestones, slaty shales, graphitic schists, biotite/muscovite schists, and crinoidal limestone conformably overlies the quartzite. Bands of greyish-white quartzite, 10 to 20 feet thick, also occur within the series. Igneous intrusions of granitic composition occur throughout. Thick veins of white and clear quartz traverse the series both along and across the bedding plane.

Of all the units within the metasedimentary series, the limestone bands are of great palaeontologic and stratigraphic significance. These limestone bands have undergone appreciable degree of recrystallization and structural deformation. Nevertheless, fossils are well preserved. Among these, crinoidal columnals and brachiopod shells are abundant. The individual crinoidal columnals are far more smaller than those found in the reef carbonate. No corals, either rugose or tabulate, or orthoconic nautiloids are found in the limestone bands. On this basis it is concluded that the metasedimentary series are much younger than Lower Devonian. Their age might range from Middle Devonian to Lower Carboniferous (Khan, oral communication).

Relation of the Ali Masjid Formation to Adjacent Rocks.

The Ali Masjid Formation is in thrust contact with the Landikotal Slate. According to the superposition of strata, the Shagai Limestone occupies intermediate position. However, it is faulted out here.

Age and Correlation.

As is evident form earlier discussion, the lowr part of the Ali Masjid Formation is correlated with the Siluro-Devonian rocks of North-Western Pakistan, particularly

those of the N.W.F.P. Consequently, it is given an age between Uppermost Silurian and Lowermost Devonian (Khan, oral communication). Stauffer (1967, 1968) considers the Ali Masjid Formation to be of Carboniferous age and has correlated it with the Misri Banda Quartzite. However, recent work by Khan (1969, 1970) and Ibrahim Shah* (1969) indicates that the Ali Masjid Formation, which is reefoid at various stratigraphic levels, represents deposition during Lower Silurian to (?) Lower Carboniferous.

RECENT DEPOSITS

Quaternary alluvium, which covers one-sixth part of the area investigated, occupies the northeastern, southwestern and southern portions of the mapped area. To the south, it lies on either sides of the Sur Kamar Khwar. Elevated river terraces and alluvial valleys are prominent in the southwestern corner of the area. In this part, the Wurmando Mela Caves which are excavated in the elevated terraces are inhabited by tribal people. A patch of alluvium is seen covering the axial region of the plunging syncline. The alluvium is mostly composed of angular fragments of slates, quartzite, and marble.

Near the mountain front where the streams emerge and wash the plain, the alluvium generally consists of unconsolidated boulders, cobbles, pebbles, and gravel. Sand and silt of fluvial origin serves as the embedding material. Most of the rock fragments in the alluvium are from various metasedimentary and igneous sources. The fragments are rounded which indicate transportation over a long distance. Without exception, the stream beds are covered by these partially rounded to well rounded pebbles and boulders.

ECONOMIC GEOLOGY

Many economical industrial rocks and minerals occur within the area of this report. They can be grouped as following:

a. Building and construction material
b. Ornamental material
c. Industrial material
d. Metallic mineral
e. Sand and gravel

a. Building and construction material.

Huge deposits of limestone occur within the area. Workable deposits of limestone are present in the Landikotal Slate, Ali Masjid Formation, and Khyber

* Shah considers an Upper Devonian age for at least the upper part of the Ali Masjid Formation. He supports this idea on the basis of the occurrence of *Platyclymenea*, *Hexagonaria*, and *Crytospirifer*.

Formation. The Shagai Limestone, which occurs along the western boundary of the investigated area, is entirely a dolomitic limestone.

The Limestone can be economically worked and used for masonary purposes, cement manufacture, road metalling, and as rail-road ballast. If a steel industry based on Haji Gak iron deposits of Afghanistan is ever established in Peshawar, the limestone will be an inexhaustable source of flux. The low percentage of silica in limestone makes it all the more suitable for both portland cement manufacture and steel. At present, the limestone is being mostly excavated for road metalling purposes. Locally, it is used for house building and lime manufacture. It is sold at a rate of Rs. 15.00 per 150 cubic feet (Badshah and Rehman, 1969, p. 17).

b. Ornamental Material.

Low grade regional metamorphism has caused the development of various banded marbles in the Ali Masjid and the Khyber Formations. Large workable deposits of white, pink, greyish-white, and pinkish-white marble occur in the Ali Masjid Formation, especially further north in Mulla Gori and Shahid Mina. From these localities, large quantity of marble is brought to Peshawar for onward export to the southern parts of West Pakistan.

In the area of investigation, white, pinkish-white, and greyish-white marble occurs within the reef core of Ghundai Sar Reef. In the past, marble has been excavated from this locality, however, as better deposits occur further north, no more marble is quarried. The unfinished raw-blocks of marble are sold at a price of Rs. 20.00 to Rs. 25.00 per 150 cubic feet.

c. Industrial Material.

1. *Soapstone:* Extensive soapstone mineralization has occurred in the calcareous and dolomitized phyllites and reef carbonates due to the intrusions of dolerites and gabbros. North of Spin Rag, along the stream valley, many veins of white and pure soapstone occur. These veins show pinch and swell structures. Many more veins occur in the metasedimentary rocks. The thickness of the veins ranges from a few inches to about 10 feet. With a few exceptions, the soapstone is pure and white. Occasionally, it has a greenish tint due to the presence of chlorite and increases with the increase of chlorite content. On jointed surfaces, dendroids of manganese and iron ore are also observed.

The soapstone deposits are being exploited in a primitive style. As a result of this, large quantities of mineral are wasted and the total output is little. The soapstone finds markets in Peshawar, Lahore and Karachi and is sold at a rate of Rs. 700.00 per 150 cubic feet (Badshah and Rehman, 1969, p. 18). It is important to note that the soapstone deposits are located very close to Jamrud railway station.

If proper mining is carried out, the mineral can be exploited on a large scale and be shipped out to the main markets more regularly, and without much wastage and loss of time. This will greatly contribute to the economic development of the community inhabiting the area.

2. *Silica Sand:* The snow white quartzite forming the Spin Rag escarpment is a good potential source of silica sand. The quartzite is very pure and lacks any unstable minerals or impurities. Besides being a source of silica sand, it can be used for masonary purposes. The regional metamorphism has made it extremely dense and indurated, however, development of a rectangular system of joints permits easy quarrying.

d. Metallic Mineral.

No workable deposits of any metallic ore occur, however, an iron ore band, associated with the Landikotal Slate, was observed in Lashora Khwar. It has no economic significance but may warrant a thorough search for locating economic and workable deposits.

e. Sand and Gravel.

Large deposits of sand and gravel occur in the stream beds throughout the area. The gravel is being excavated from these for foundation concrete and aggregate, as well as for carpeting the highways, whereas the sand is being excavated for mixing with cement plasters.

In the past millions of tons of gravel and sand have been excavated and utilized in the construction of the Warsak dam.

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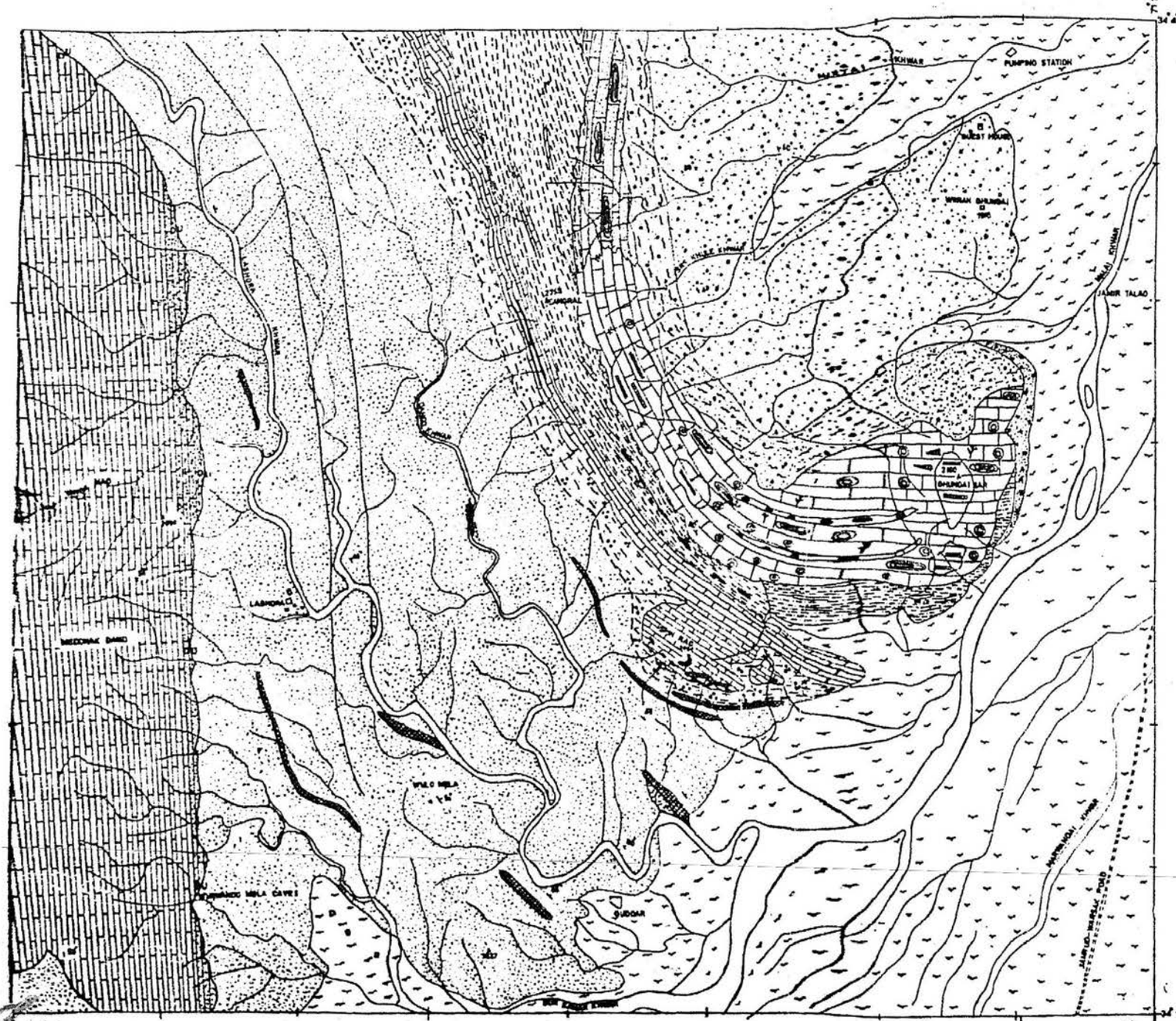

THE GEOLOGICAL MAP OF THE GHUNDAI SAR AND VICINITY, JAMRUD, KHYBER AGENCY. (N.W.F.P.)

MAY, 1970.

EXPLANATION

- SCREE. (MAINLY ANGULAR FRAGMENTS OF REEF LIMESTONE, QUARTZITE, AND IGNEOUS ROCKS (DOLERITE GRANITE AND GABBRO). — RECENT
- ALLUVIUM, RIVER BED GRAVEL, AND SAND. — RECENT
- UNDIFFERNTIATED METASEDIMENTARY ROCK MAINLY SLATES, PHYLLITES (INTER BEDDED WITH CRINOIDAL LIMESTONE), AND SCHISTS WITH INTER BEDDED LIMESTONE, QUARTZITE, AND INTRUDED BY THICK QUARTZ VEINS AND GRANITIC SILLS — ? LATE DEVONIAN
- DOLOMITIZED QUARTZITE (MISRI BANDA QUARTZITE).
- REEF LIMESTONE (NOWSHERA FORMATION) HIGHLY RECRYSTALLIZED AND MARMORIZED, WITH POCKETS OF BRECCIA. ABUNDANT FAVOSITES, THAMNOPORA, CLADOPORA, CRINOID STEMS AND COLUMNALS, RECRYSTALLIZED STROMATOPOROIDS, RUGOSE CORALS, AND ORTHOCONIC CEPHALOPODS, FENESTRELLOID BRYOZOA, BRACHIOPODS, AND GASTROPODS RARE.
- PHYLLITES WITH INTER BEDDED CRINOIDAL LIMESTONE, VERY FINE GRAINED AND LAMINATED QUARTZITE AT BASE INTRUDED BY DOLERITE SILLS WITH SOAPSTONE MINERALIZATION.
- LIMESTONE INTRUDED BY SILLS OF DOLERITE, GABBRO, AND ?GRANITE. NUMEROUS VEINS OF SOAPSTONE.
- QUARTZITE COARSE GRAINED AND SNOW WHITE IN COLOUR AT BASE, UPPER PART GRAYISH-BROWN, CALCAREOUS, FINE GRAINED, AND CROSS-BEDDED (NOT DIFFERENTIATED). — ? UPPER SILURIAN-EARLY DEVONIAN
- LIMESTONE, THIN BEDDED WITH QUARTZITIC BEDS ON TOP, INTERMIXED WITH ALLOCHTHONOUS BLOCKS OF YOUNGER FORMATIONS (NOT DIFFERENTIATED) IN FAULT COTACT WITH THE LANDIKOTAL FORMATION. — ? UPPER SILURIAN
- SLATES, PHYLLITES, IMMATURE SANDSTONE (GRAYWACKES), AND SCHISTS INTRUDED BY SILLS OF DOLERITE, GABBRO, AND ?GRANITE (NOT DIFFERENTIATED). — ? SILURIAN
- SILLS MAINLY DOLERITE, GABBRO, AND ? GRANITE (NOT DIFFERENTIATED)
- SOAP STONE DEPOSITS.
- DIP AND STRIKE

- CONTACT
- FAULT
- STREAMS
- PROBABLE THRUST CONTACT
- RECRYSTALLIZE STROMATOPOROIDS.
- ORTHOCONIC CEPHALOPOD (RARE).
- COLONIAL FAVOSITES
- THAMNOPORA AND CLADOPORA.
- CRINOID STEMS 4 TO 6 INCHES LONG AND 1 TO 1½ INCH IN DIAMETER
- INDIVIDUAL CRINOID COLUMNALS.