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STRATIGRAPHIC STUDIES OF THE NOWSHERA REEF COMPLEX, NOWSHERA TEHSIL, WEST PAKISTAN

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ABSTRACT

A belt of Siluro-Devonian limestone and quartzite, pink or yellowish-pink in colour, is exposed on either side of the Nowshera-Risalpur road. This belt was identified as a 'Reef Complex' in 1965, *and is the first of its kind to be discovered in the Indo-Pak sub-continent. Prior to this discovery, the limestone belt had been erroneously assigned a Precambrian age and regarded as part of the Attock Slates.*

The entire belt unconformably overlies the Kandar Phyllite and is divisible into four definite units: 1. *Carbonate Rocks,* 2. *Reef Core,* 3. *Reef Breccia, and* 4. *the Misri Banda Quartzite. The first three collectively are known as the Nowshera Formation. With the exception of the last, these units represent the characteristic structural layers of a reef.*

The age of the reef complex on the basis of its fossil assemblage ranges between Upper Silurian and Devonian. However, there is no fossil present which may pinpoint an exact age. The uncertainity about the precise age of the reef is largely due to the destruction of many organisms by the process of dolomitization.

In the opinion of the writers, the Nowshera Formation and the Misri Banda Quartzite were deposited in the southernmost extremities of the basin in which the Muth Quartzite, of Siluro-Devonian age, was formed.

In their opinion, the Nowshera Formation and the Misri Banda Quartzite can be correlated with the middle and upper parts of the Muth Quartzite.

INTRODUCTION

The area investigated includes approximately 16 square miles located between latitudes 34°0′ and 34°3′N, and longitudes 72°0′ and 72°8′E, in the alluvium plains of the Peshawar valley. The east and west extremities of the area are marked by the towns of Nawan Killi and Akora Khattak.

The reef outcrops in the area are exposed as low scattered hillocks, extensively modified by quarrying, rising out of the immense alluvial plains of the Peshawar valley. The base contour of the map is 960 feet, while the highest point in the area is

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the 1252 foot ridge along the Tangai nullah in the Misri Banda area. The general relief of the area is of the first order, and the rocks form exposed ridges, with varying degrees of slope. The slopes are mostly covered either with alluvium or rock debris.

All the outcrops studied and described in this paper lie on the northern bank of the Kabul River. They strike nearly east-west and dip dominantly towards the north. Two small outcrops exposed near Keshki Bala have the same strike direction but dip towards the south. It is concluded, therefore, that the Kabul River valley runs along the axis of a large anticlinal structure and is thus not simply an erosional valley but also a structural feature (Teichert and Stauffer, 1965).

The area was originally mapped and described by Teichert and Stauffer (1965) and Stauffer (1968). Prior to this work, the reef complex had been considered a part of the Attock Slates and assigned a Precambrian age.

The field work for this report was carried out during the spring of 1969. The project was selected by the Chairman of the Department of Geology as a partial requirement for the Master of Science Degree and as a part of an extensive programme organized to map the former North Western Frontier Province region.

ACKNOWLEDGEMENTS

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The assistance in the field work by S. M. Saqlain is greatly appreciated.

STRATIGRAPHY

Introduction: The rock strata in the area of investigation represent deposition from pre-Silurian and Silurian to Devonian times.

The oldest unit in the area, the Kandar Phyllite, originally shales and marls before metamorphism, developed in a marine environment; abundant remains of crinoids and nautiloids confirm this interpretation.

It is most likely that the argillaceous rocks forming the Kandar Phyllite contributed the sea bed on which the reef developed unconformably by the

growth of encrusting organisms like stromatoporoids and interlocking tabulate corals. This marine environment contined until the deposition of the Misri Banda Quartzite.

Apart from local faulting and folding, the succession is undisturbed, the Nowshera Formation, followed conformably by the Misri Banda Quartzite, lying unconformably on the Kandar Phyllite Formation.

?PRE-SILURIAN

KANDAR PHYLLITE

The Kandar Phyllites are the oldest unit in the sequence of deposition and were so called after the village of this name. The Phyllites are well developed to the south of Kandar village on both sides of the Nowshera - Risalpur road. The only other locality where these phyllites are exposed is to the northwest of Misri Banda village.

The colour of the phyllites on fresh surfaces is greenish-grey, while on the weathered surfaces it is yellowish-grey. In both localities, the phyllites are interbedded with limestone beds ranging in thickness from a few inches to 3 feet. In the Kandar village area, two limestone beds of more than 10 feet in thickness are interbedded with the phyllites. The limestones are fossiliferous and abundant crinoid columns occur in them. It is for this reason that the limestone is named 'Crinoidal limestone'. In Misri Banda, nautiloid cones were found in this limestone.

The base of the phyllites in the type locality (Kandar village), as well as those lying exposed in the Misri Banda area, are covered with alluvium. Therefore, the lower extent of the phyllites and the nature of the underlying rocks cannot be determined. However, the exposed thickness of the phyllites in the type locality is about 200 feet, while in the Misri Banda area it varies between 500-700 feet. The exposure of phyllites towards the northern extremity of Tangai nullah (Misri Banda) is about 200 feet. Igneous intrusions of doleritic composition, as shown in the maps (1 and 2), have been noted in both the localities.

The Kandar Phyllite is unconformaby overlain by the Nowshera Formation.

SILURO-DEVONIAN SYSTEM*

NOWSHERA FORMATION

The stratigraphic name was first given by Teichert and Stauffer (1965) to the reef complex in the main section (western extremity).

According to Krumbein and Sloss (1963), a reef complex is the product of organisms that precipitate, bind or retain carbonate and show a potential of upward growth

* Conodont studies by Barnett *et at.* (1966) indicate an age between uppermost Silurian or lowermost Devonian.

towards the surface of the sea. On reaching the surface, the growing reef exerts a strong influence on its own environment and those adjacent to it. This reef growth establishes an environmental complex and depositional setting termed a 'Reef Complex' (p. 575).

According to Mac Neil (1954), a reef complex includes the whole body of organic deposits, both in growth position and produced by erosion.

The writers during their investigation differentiated the following three units in the reef complex on the basis of superposition and fossil content. They are:

3. Reef Breccia
2. Reef Core
1. Carbonate Rocks

This sequence is well exposed near the village of Nawan Killi on both sides of the dirt road.

1. Carbonate Rocks.

The Carbonate Rocks are exposed only on the southern side of the westernmost outcrop, north of the village of Nawan Killi (map 1).

The colour of the Carbonate Rocks varies from yellow to dark grey; on weathered surfaces, it is yellowish-grey to greyish-black. The Carbonate Rocks have been reported to be unfossiliferous or containing only a few fossils by Teichert and Stauffer (1965). These observations do not hold true for all the Carbonate Rocks, as the writers have observed certain exposures containing abundant fossils notably along the western side of the dirt road.

The Carbonate Rocks have been divided into two parts on the basis of their fossil content:

(*i*) *Massive Carbonate Rocks* — containing very few fossils and lying at the base.
(*ii*) *Thin-bedded Carbonate Rocks* — marly in composition and containing abundant fossils.

The massive Carbonate Rocks are dark in colour, while those having a marly appearance are yellow in colour on fresh surfaces. On weathered surfaces, the colour is greyish-black (massive Carbonate Rocks) and yellowish-grey (thin-bedded Carbonate Rocks).

The fossils present in these rocks are brachiopods, mainly *Atrypa*, *Spinella* and *Spirigerilla*. A tabulate coral, *Favosites*, both in the form of massive round elliptical colonies and dendroid, is the characteristic fossil of the Carbonate Rocks. Beside brachiopods and tabulate corals, abundant crinoid columns are also found in the Carbonate Rocks.

The thickness of the thin-bedded Carbonate Rocks, measured on the western side of the dirt road, is 22 feet; a partial chemical analysis of these rocks showed a carbonate content of 89%.

2. Reef Core.

Pettijohn (1957) and Krumbein and Sloss (1963) have defined the reef core as the central, massive, thick carbonate rock on which the organisms start the growth or reproduction of their colonies.

The Reef Core lies stratigraphically above the Carbonate Rocks and is the most widely distributed unit exposed in all the outcrops. The type locality is exposed on both sides of the Nowshera-Risalpur road, where all the characteristics of the Reef Core are found.

The rocks in the Reef Core are composed of limestone and dolomite; at places lenses of argillaceous material were also observed.

The Reef Core strata are characteristically buff to pinkish-white in colour on fresh surfaces, except where dolomitization and recrystallization has been extensive, when the colour is white. The colour of the weathered surfaces is dark grey.

The Reef Core is strongly dolomitized, causing almost total destruction of the fossil content, leaving only white blotches representing largely destroyed stromatoporoids and *Favosites*. On weathered limestone surfaces traces of these skeletal structures can be seen in detail. The other important fossils which characterize the Reef Core are *Thamnopora* and *Cladopora*, which are the most abundant, and nautiloid cones. The nautiloid cones are well preserved and at places large cones, ranging up to 1½ feet were seen. The nautiloid cones are straight (orthoceroid) and no coiled forms were seen. The *Favosites* colonies are massive as well as dendroid and other fossils found are *?Streptelasma*, *Mucophyllum*, *Hexagonaria* and coiled gastropods.

No lateral variations were observed in the faunal content of the Reef Core; however, some vertical variations could be seen. On the basis of *Thamnopora* and *Cladopora* two layers could be distinguished. One had an abundance of these fossils, while the other contained only rare concentrations. On the basis of its *Thamnopora* content, Stauffer (1968) subdivided the Reef Core into several layers.

Solution cavities are well marked in the Reef Core; also the fossils have been dissolved out leaving their outlines on the surface. Leaching of lime has resulted in the accumulation of secondary carbonates which resemble kankar in form. The western extension of the Reef Core at two distinct places consisted of crinoid fragments only, which have been named by Stauffer (1968) the 'Crinoidal Banks'. The writers, however, consider them to be part of the Reef Core.

Though the Reef Core is massive in character, the bedding planes can be distinguished at places.

The Reef Core is being quarried for various purposes at different places.

(*i*) *Pir Sabak Area:* The Reef Core is exposed to the east and west of Pir Sabak village in the form of four ridges (map 2).

The colour on fresh surfaces varies from white to brown, while on weathered surfaces it is dark grey. The Reef Core is massive, fractured and jointed, as a result of which slumping has occured.

The exposures in the east of Pir Sabak village, especially the easternmost outcrop known as the Pir Sabak Ki Dheri, have been more dolomitized when compared to the outcrop west of Pir Sabak village. In these outcrops stringers of quartzite are present locally and thin quartz veins were observed at a few places.

The fossils found in the Reef Core are the characteristic stromatoporoids and colonial *Favosites*, along with crinoid columns and some gastropods.

The peak of Pir Sabak Ki Dheri towards the southern part is entirely composed of pelecypods with a few stromatoporoids. This part of the Reef Core is about 600-700 feet thick and it is only here that pelecypods are found in much abundance.

Thin-bedded layers of light grey to yellow-brown limestone with intercalations of argillaceous material were found to occur at a few places. They are about 15-35 feet thick and contain dendroid *Favosites*, crinoid columns, and some brachiopods. Chemical analysis of samples from this area shows 69% carbonate content. The decrease in carbonate content suggests the inflow of clastic material from time to time. This is also evident from interbedded quartzite within the Reef Core.

(*ii*) *Misri Banda Area:* In the Misri Banda area, the Reef Core is exposed in the west and north-west along the Tangai nullah. The exposure in the west is in the form of a small patch which was probably left after the erosion of the Reef Core from the middle part.

The colour is light grey to yellowsish-brown. The Reef Core has been completely dolomitized and only the outlines of stromatoporoids and crinoid fragments could be seen. The Reef Core is massive, highly fractured and well jointed.

3. Reef Breccia.

According to Stauffer (1968), "the reef breccia consists of angular pieces of carbonate rocks and some building skeletons broken off from the reef core. The reef breccia contains one or more types of fossil fragments found in the reef core."

The Reef Breccia is the uppermost unit of the Nowshera Formation and is well developed towards the western extremity north of Nawan Killi graveyard. The only other locality where it is exposed is near Kandar Village, where it forms a small bed.

The writers observed abundant fossil fragments in some parts, whilst others were sparsely fossiliferous.

The Reef Breccia can be sub-divided into two parts:

(*ii*) Thin bedded Reef Breccia — containing abundant fossil fragments.

(*i*) Thick bedded Reef Breccia — containg few fossil fragments.

The colour of the Reef Breccia on the weathered surfaces is dark grey, while on fresh surfaces it is pinkish white.

The fossil fragments found in the Reef Breccia include *Thamnopora*, *Cladopora*, dendroid *Favosites*, *Mucophyllum*, *?Streptelasma*, *Hexagonaria*, crinoid columns, and many brachiopods.

The Reef Breccia is interbedded with marly and sandy layers at various stratigraphic levels. The maximum thickness of individual strata varies from 3 inches to 1 foot.

The massive Reef Breccia on fresh surfaces resembles the Reef Core, but the characteristic fossils like massive stromatoporoids and large orthoceroid nautiloid cones are missing. The rocks are coarsely crystalline and thoroughly dolomitized.

The Reef Breccia is comparatively thicker towards the northern side, which shows that it was the leeward side.

UPPER DEVONIAN SYSTEM

MISRI BANDA QUARTZITE

The term Misri Banda Quartzite was first used by Teichert and Stauffer (1965) to describe a new group of rocks from a locality near Misri Banda village.

At the type locality, the Misri Banda Quartzite is composed of well bedded dolomitic quartzites. These are evidently of both marine and fresh water origin and are probably of uppermost Devonian age.

The quartzites are well developed in Kandar village area and Misri Banda area. From Misri Banda village, the formation extends eastwards up to Ali Mohammad village under a thin blanket of alluvium. Their further extension eastwards was not traced.

In the area covered by this report, the Misri Banda Quartzite is characterized by two types of lithology, i.e., dolomitized quartzites and orthoquartzites. The entire

formation consists of very evenly bedded marine and partially marine quartzites.

The quartzites show very faint shades of buff, pink, red, and cream colour. The cream-coloured dolomitized quartzites are exposed near the northern extremity of the outcrop (no. 2), north of Kandar village. Elsewhere, as in Misri Banda village, the quartzites are mainly orthoquartzites. The Misri Banda Quartzite is both ripple-marked and cross-bedded, indicating deposition in shallow marine to partially fluvial environments.

The thickness of the Misri Banda Quartzite is variable in various localities and ranges from 300 to 1200 feet. It conformably overlies the Nowshera Formation.

In the area investigated, the Misri Banda Quartzite is the youngest solid formation, and is locally covered by recent Kabul River alluvium.

Age and Correlation.

The Misri Banda Quartzite Formation has not yielded any organic remains, so that assignment to an exact age, and correlation, is not possible. As it conformably overlies the Nowshera Formation and is transitional from calcareous facies to arenaceous facies, it is probable that sedimentation occurred uninterrupted under shallow water conditions. On the basis of field evidence, the writers are inclined to assign an uppermost Devonian age to this formation.

In their opinion, the Misri Banda Quartzite and the older Nowshera Formation are the equivalent of the Muth Quartzite. The Nowshera equivalent of the dominantly clastic facies in Spiti, Kashmir, and Chitral may have been dominantly calcareous in the early stages, becoming clastic later. If so, then the Misri Banda Quartzite should have a lenticular or diachronous relationship with the Nowshera Formation.

ECONOMIC GEOLOGY

MARBLE DEPOSITS

The Nowshera reef complex is of considerable economic importance and at present this area is playing an important role in the economic progress of this part of the country.

Quarrying of marble has been in progress on a large scale for several years. Limestone is quarried for building purposes as well as for calcining. The kilns are fed mostly with the blocks and fragments not suitable for constructional purposes.

The marble deposits, which are only associated with the Reef Core (partially metamorphosed), are quarried in two localities:

(*i*) Nowshera deposits (outcrop nos. 1 and 2).

(*ii*) Pir Sabak deposits (outcrop nos. 5 and 6).

(i) Nowshera Deposits.

These deposits lie exposed along the Nowshera-Risalpur road and are quite extensive in size.

The marble is pink in colour with streaks and patches of red and grey ferruginous material. Calcite in the form of veins is present and also fills the numerous cavities present in the rock.

The marble is of inferior quality. According to the Geological Survey of Pakistan, the reserves may amount to 3,84,000 cubic feet.

(ii) Pir Sabak Deposits.

The Pir Sabak deposits are exposed near the village of this name. The marble is pink and grey in colour with little or no impurities. These deposits are of better quality than the Nowshera deposits.

Large scale quarrying is carried out by well organized private enterprise. Large flawless blocks are taken out and transported to the nearest railway station for onward transmission, mostly to Karachi. According to the quarrymen, the large blocks measuring $6 \times 2 \times 2$ feet are sold for the highest prices.

The estimated reserves are 9,70,000 cubic feet, down to a depth of 50 feet.

Besides being used in masonry and decorative work, low quality blocks and fist size pieces are used to make marble chips. A successful industry thrives near and around Nowshera. Enormous quantities of poor quality marble are used as railway line and road ballast.

Black banded crinoidal limestone.

Large quantities of this partially metamorphosed limestone are excavated from the Kandar Phyllites. It is dark grey in colour and is profusely banded. Well developed joints permit economical quarrying. It takes a high polish and is mainly used for interior and frontal decoration. On enquiry, the operators of the lease informed the writers that this limestone is in great demand in Karachi.

Quartzite.

The evenly-bedded Misri Banda Quartzite is quarried in Misri Banda village on a smaller scale than the marble and limestone. Its thin bedding and well developed joints permit easy quarrying. Blocks of this quartizite are used for masonry and paving purposes.

Other Economic potentialities.

Limestones of the same nature as the Nowshera reef limestones are found in Swat and Mardan districts. Here these "limestones are associated with extensive,

black, fetid, fine-grained limestones, and highly porous dolomites. The combination of reefs, fetid limestones, and porous dolomites has potential economic implications for the discovery of oil "(Teichert and Stauffer, 1965, p. 2, and Stauffer, 1968, p. 1349).

CONCLUSIONS

On the basis of this investigation the writers conclude that:

1. The Kandar Phyllite is the oldest formation exposed in the area, the age of which may be Lower Silurian to Middle Silurian.

2. The main reef complex is divisible into three definite layers. These three layers are collectively known as the Nowshera Formation:

   (*a*) *Carbonate Rocks:* dark grey to buff coloured limestones with abundant brachiopods, tabulate corals, and crinoid columns.

   (*b*) *Reef Core:* the central axial region of the reef: mainly spongy cavernous limestones and dolomites with cavities filled with silt and sand. Characterized by such organisms as massive *Favosites*, *Thamnopora*, *Cladopora*, *Mucophyllum*, *?Streptelasma*, brachiopods, large orthoceroid nautiloid cones, crinoid columns, and large, recrystallized, massive, encrusting *Stromatopora.*

   (*c*) *Reef Breccia:* a dominantly clastic carbonate rock formed by the accumulation of organic debris, mainly belonging to Crinoidea, dendroid *Favosites*, the fistulose or dendroid rugose corals *Thamnopora* and *Cladopora*, the solitary rugose corals *Mucophyllum*, *?Streptelasma*, *Hexagonaria* and brachiopods such as *Atrypa*, *Gypidula*, *Spirigerilla*, and *Spinella.*

3. The Misri Banda Quartzite is the youngest formation and was formed by the deposition of clastic material brought from land. Its textural as well as mineralogical maturity suggests it to have been beach sand.

4. The Misri Banda Quartzite is not a sedimentary body of uniform thickness or a blanket shape, but a lens. It interfingers with the carbonates of the reef. The clastic facies increases towards Misri Banda in the south.

5. The age of the Misri Banda Quartzite in this region is probably Upper Devonian.

6. The Misri Banda Quartzite Formation can be correlated with the upper part of the Muth Quartzite.

7. The purely clastic facies of the Muth Quartzite exposed in Spiti, Kashmir, and Hazara tends to become both the calcareous (the Nowshera Formation) and

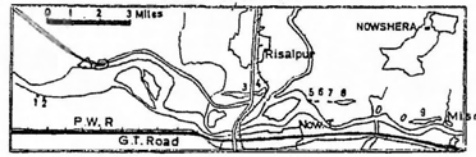
GEOLOGICAL MAP OF THE NOWSHERA REEF COMPLEX NO:- 1

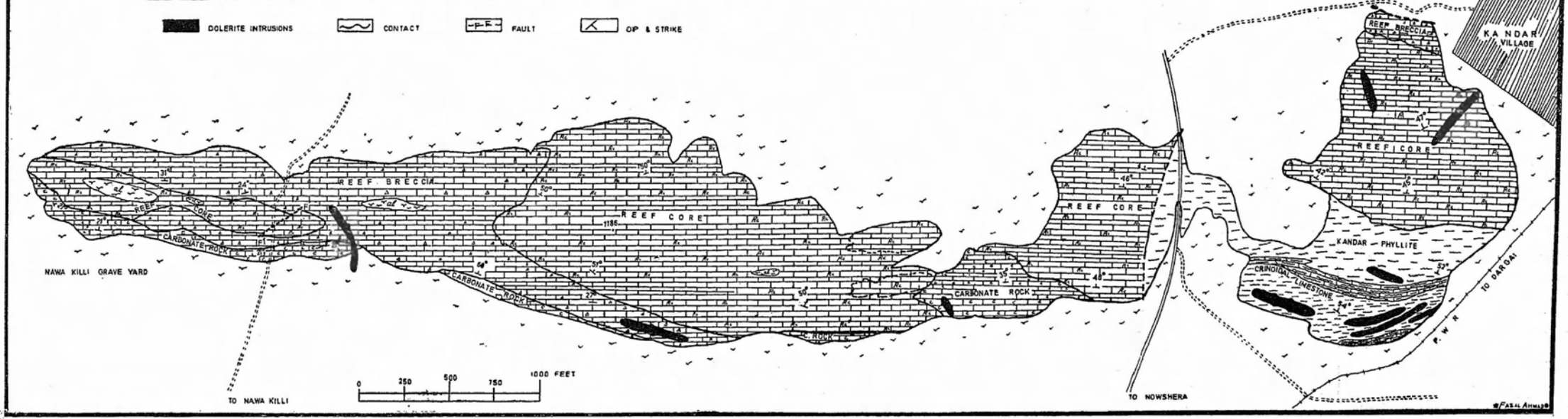
BETWEEN NAWA KILLI & KANDAR VILLAGE

INDEX

- REEF BRECCIA - WITH ABUNDANT FOSSIL FRAGMENTS, MAINLY THAMNOPORA, DENDROID FAVOSITES, & CRINOIDAL STEMS,
- REEF CORE - MASSIVE DOLOMITE & LIMESTONE WITH ABUNDANT STROMATOPORIDS, FAVOSITES, NAUTILOID CONES & OTHER RUGOSE CORALS; MAINLY MUCOPHYLLUM, & STREPTELASMA. PELECYPODS & GASTROPODS (BELLEROPHONTID (?) GASTROPODS IN PIR SABAK AREA,
- CARBONATE ROCK - MARLY LIMESTONE - WITH ABUNDANT BRACHIOPODS; MAINLY ORTHIS, ATRYPA, & SPIRIFER. FAVOSITES COLONIES ABUNDANT.
- ALLUVIUM & LOESS
- MISRI BANDA QUARTZITE
- NOWSHERA FORMATION
- PHYLLITE
- CRINOIDAL LIMESTONE } KANDAR PHYLLITE
- DOLERITE INTRUSIONS
- CONTACT
- FAULT
- DIP & STRIKE

LOCATION MAP





FAISAL AHMED

GEOLOGICAL MAP OF THE NOWSHERA REEF COMPLEX NO:-2

BETWEEN PIRSABAK & MISRI BANDA

INDEX.

- ALLUVIUM & LOESS
- MISRI BANDA QUARTZITE
- REEF CORE (NOWSHERA FM.) MASSIVE DOLOMITE & LIMESTONE WITH ABUNDANT STROMATOPORIDS, FAVOSITES, NAUTILOID CONES & OTHER RUGOSE CORALS; MAINLY MUOPHYLLUM & STREPTELASMA; PELECYPODS & GASTROPODS (BELLEROPHONTID(?)) GASTROPODS IN PIRSABAK AREA
- PHYLLITE
- CRINOIDAL LIMESTONE } KANDAR PHYLLITE
- DOLERITE INTRUSIONS.
- CONTACT
- FAULT
- DIP & STRIKE

N

MIAN KILI

MISRI BANDA MINOR

PIR SABAK

Reef Core With Quartzite stringers

QUARTZITE STRINGERS

QUARTZITE

PIR SABAK DHERAI REEF CORE

IGNEOUS INTRUSION

ZARA MIANA

TUR LANDI

REEF CORE

REEF CORE

PHYLLITE & LIMESTONE

QUARTZITE & SANDSTONE

QUARTZITE & SANDSTONE

MUSMAK

MISRI BANDA

KABUL (LANDAI) RIVER

0 2 4 6 8 FURLONGS

FAZAL AHMAD

clastic (the Misri Banda Quartzite) facies in the reef area of Nowshera.

8. The Nowshera Formation of Siluro-Devonian age can be correlated with the Muth Quartzite of Siluro-Devonian age.

9. The reef area marks the southernmost extension of the basin in which the Muth Quartzite of Siluro-Devonian age formed.

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