The major subdivisions of the Palaeozoic exposed in the area under study are the fossiliferous rocks of upper Ordovician, Silurian, Devonian and Carboniferous systems. In addition, ? Cambrian and older Ordovician formations also occur, but their exact age is speculative.

The complete stratigraphic sequence is as follows:

- **Panjal Traps**
  - Upper Agglomeratic Slates
  - Middle Fenestella Shales
  - Passage Beds
  - Lower Syringothyris Limestone

- **Carboniferous**
  - Upper Unfossiliferous Muth Quartzite
  - Middle Fossiliferous Muth Quartzite
  - Lower Unfossiliferous Muth Quartzite

- **Devonian**
  - Upper Naubug Beds
  - Middle Harpatnar Beds
  - Lower Unfossiliferous shales

- **Silurian**
  - Upper Fossiliferous sandy shales, shaly sandstone and limestone.
  - Middle Thinly bedded siliceous shales yielding Gruptolites
  - Lower Unfossiliferous shales

- **Ordovician**
  - Upper Gauran Beds
  - Lower Siliceous shales yielding Bryozoans, Brachiopods and Cystoids

- **Older Ordovician and ? Cambrian**
  - Unfossiliferous shales
The thickness of these formations varies from one area to another, being maximum in the Lider and minimum in the Naubug valley.

**Older Ordovician and ? Cambrian**

The beds underlying the fossiliferous shales have been provisionally referred by the author to older Ordovician and ? Cambrian. The exact age of these formations, however, is speculative. The rocks are for the most part unfossiliferous though at places indeterminable outlines of shells are visible. Lithologically the rock consists of thin-bedded siliceous and argillaceous shales of dull pale colour, which here and there becomes of varied shades of purple, blue, grey and pale greenish. A considerable cement, often micaceous, is frequently found mixed with the argillaceous type. There are some calcareous layers in the upper parts, sometimes white and crystalline. Near Gugaldar and Margan Pass these limestones attain considerable thickness.

**Upper Ordovician (Gauran Beds)**

The beds immediately overlying the unfossiliferous shales of older Ordovician and ? Cambrian ages contain some well preserved bryozoans, brachiopods and cystoids near the village Gauran. Lithologically these are similar to underlying shales. Most of these bryozoans are in the fragmentary state of preservation and their identification is difficult. Three forms could be easily identified from
the huge collection made by the author. These forms are *Diplotrypa boersensis* sp. nov., *Praeopora simulatrix* Ulrich and *Orbigryrella* sp. and they indicate upper Ordovician age for these strata. This is supported by brachiopods and cystoids. The beds yielding these fossils are now named Gauran Beds since they are exposed near Gauran village.

**LOWER SILURIAN**

The strata immediately overlying the Gauran beds and underlying the Harpatnar beds consist of an enormous thickness of unfossiliferous thinly bedded siliceous and argillaceous shales. The Gauran beds have been referred by the author to Upper Ordovician and the Harpatnar beds to Middle Silurian, so the intermediate strata can be provisionally assigned to Lower Silurian.

**MIDDLE SILURIAN (Harpatnar Beds)**

The author discovered graptolites in the soft, easily weathered shales exposed near the village Harpatnar (Fig. 8). The succession yielding graptolites is as follows:
European Equivalents (Type Succession)

<table>
<thead>
<tr>
<th>European Equivalent</th>
<th>(Type Succession)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monograptus cf. dubius Suess</td>
<td>Ludlow</td>
</tr>
<tr>
<td>Monograptus cf. chimaera Barrande</td>
<td></td>
</tr>
<tr>
<td>Monograptus cf. tumenscens Wood</td>
<td></td>
</tr>
<tr>
<td>Monograptus cf. vulgaris Wood</td>
<td>Salopian 3'</td>
</tr>
<tr>
<td>Monograptus cf. colonus Barrande</td>
<td></td>
</tr>
<tr>
<td>Wenlock 27'</td>
<td></td>
</tr>
<tr>
<td>Unidentified Graptolites</td>
<td></td>
</tr>
</tbody>
</table>

The lowermost beds of the Harpatnar sequence contain graptolites, the identification of which is somewhat speculative, there being difference of opinions as to whether they are cidymograptids of monograptids.

Sir C. J. Stubblefield after studying the material expressed the following opinions:

1. The figured graptolite is Monograptus cf. dubius Suess; Wenlock to Lower Ludlow age. (pl. 7, fig. 2).
2. The other monograptids on the slab are Monograptus cf. vulgaris Wood and Monograptus cf. colonus Barrande; both of Lower Ludlow age (pl. 7, fig. 3).
3. The fossil on the third slab looks like a tuning fork Llanvirn graptolites but the
sicula region is damaged and we should be cautious because Llanvirn to Wenlock, Lower Ludlow is a great time hiatus, especially as there is no real evidence that the two graptolite stipes were ever joined together. Among the photographs, certainly three look like tuning fork Didymograptids but one had on the same slab a graptolite looking like Monograptus prionodon."

The above mentioned slabs were sent to Sir C. J. Stubblefield and he expressed the following view:

"............... I am not satisfied that the graptolites are really tuning fork didymograptids, as one slab appears to have a Monograptus sicula on the back of it..........."

The author had the opportunity of discussing these varying views with Sir C. J. Stubblefield in New Delhi during the International Geological Congress Session. He showed him a number of specimens containing what appeared to be tuning fork didymograptids. After studying the material he agreed that these specimens might be tuning fork didymograptids.

Specimens of these were sent to Prof. William B. N. Berry of California University. According to him (April 17, 1965):
The tuning fork specimens do seem to be didymograptids, although proximal ends are not clear on those in which they are preserved........

In a subsequent communication however (April 23, 1965) Prof. Berry modified his opinion and observed:

"I have spent some time studying the graptolites you sent to me. I have been paying particular attention to the biserial appearing forms, and I think you might be interested in my opinion of them. Of the five specimens you sent that appeared to be biserial, only two gave any evidence of a join. The others, although they appear to have stipes that taper towards each other, are broken at the critical place. I have noted on the specimens with what may have been a join, that in reality to me, the stipes appear to have crossed and not to have joined. Also, no sicula is present nor is any structure that might have been a sicula and is now distorted. Also none of the stipes taper in the slightest toward the area in which they cross, and all the pendent didymograptids do show at least a little tapering near the point of join. The theca
also seemed to me to be unlike those of any known pendent didymograptid - being more free and overlapping less: further, there was no real demonstrable similarity of the thecae on the stipes that are parallel. In one case the thecae number 3 in 5 mm and on the stipe parallel with it, they number 4 in 5 mm. This and the fact that the thecae appeared somewhat different in form on the two stipes made me think that the two stipes were not parts of the same rhabdosome. These factors made me think the seeming pendent forms were not tuning fork didymograptids but were just fragments of different forms.

In view of the above it is difficult to assign a definite age to the lowermost horizon yielding tuning fork didymograptids.

In case these specimens prove to be definite tuning fork didymograptids, then their age would correspond to Llanvirn to Arenig series. The overlying horizons yielding Monograptids corresponds to Wenlock and Lower Ludlow of Europe. The great time hiatus between Llanvirn to Wenlock, Lower Ludlow is explained by the fault which separates the two horizons yielding monograptids and tuning fork didymograptids.
The beds yielding monograptids are now named Harpatnar Beds since they are exposed near Harpatnar village.

UPPER SILURIAN (Naubug Beds)

The Harpatnar beds are overlain by unfossiliferous shales which vary in thickness from 200' to 450'. These unfossiliferous shales are overlain by 100' or so of strata containing well preserved fossils (pl. 3, figs. 1, 2) of Upper Silurian. The rock consists of blue grey, rusty weathering sandy shales, occasionally calcareous and full of casts and impressions of Brachiopods, Trilobites, Corals, Gastropods, Crinoids etc. coated yellow with limonite. The fossiliferous horizon can be easily traced out by keeping in mind that it forms the topmost portion of the limestone bands coming below the more siliceous shales and finally quartzites.

The following is a list of localities whence fossils belonging to these ages have been collected:

1. Near Ougaldar. (In the Harpatnar valley.)
2. One mile north of Naubug.
The most important fossils from Upper Silurian age for these beds are:

- **Favosites spitiensis** Reed, **Stylarea sp.**
- **Streptelasma sp.** **Calymene kashmiricus** sp. nov.,
- **C. blumenbachi** Brongniart, **Encriurus kashmiricus** sp. nov., **E. punctatus** Brunnich,
- **Ileasurus kashmiricus** sp. nov.,
- **Acidaspis kashmirica** Reed, **Leptaena rhomboidalis** Wilckens, **Pentamerus oblongus** Sowerby, **Tripectia insularis** Eichwald, etc.

The beds yielding above mentioned fossils from the five localities are now named as **Naubug Beds,** after the village Naubug, where they are best exposed.

**LOWER, MIDDLE AND UPPER DEVONIAN**

In normal sequence, above the fossiliferous Upper Silurian horizons, comes a vast thickness of massive quartzites (Pl.3,5, figs 1,2) of granular texture, and of generally white colour with spots and patches of ferruginous matter. This quartzite is lithologically and petrologically similar to the Muth Quartzite of Spiti and Kumaon.

The outcrop of this formation follows round that of fossiliferous upper Silurian and makes a broad belt between it and the succeeding strata. The lower and upper portions of this quartzite are
ufossiliferous while the middle portion is fossiliferous. These three horizons are now referred to Lower, Middle and Upper Devonian respectively.

The Muth Quartzite had been considered to be unfossiliferous since its first description by Stoliczka over a century ago. It overlies the fossiliferous division referred to by Middlemiss (1910, p. 213) as Upper Silurian and underlies the Syringothysis Limestone of Lower Carboniferous age. Stoliczka assigned an Upper Silurian age to it whereas Greisbach regarded it as Carboniferous. Hayden and Burрад considered it to be probably partly Silurian and partly Devonian. Middlemiss regarded its limits between Upper Silurian below and Lower Carboniferous above. According to him it may be either of these two or it may be Devonian or represent any two or all three of them.

The fossils now found by the author from the middle horizon of the Muth Quartzite exposed one mile north of Naubug are well preserved and occur in profusion though extraction is difficult. The fauna indicates the Middle Devonian thus proving the age of a part at least of the quartzite. This view is supported by the recent fossil collection made by the author from the corresponding horizon during the geological investigations of the Spiti valley itself— the type area of Muth Quartzite.
The Lower and upper parts of the Muth Quartzite (which have not yielded any fossils so far) may be assigned to the lower and upper Devonian respectively. The Upper part is underlain by the fossiliferous Middle Devonian quartzite and overlain by Syringothyris Limestone of Lower Carboniferous age. The lower part of the Muth Quartzite is overlain by the fossiliferous Middle Devonian quartzite and underlain by Upper Silurian fossiliferous shales.

The Middle Devonian fossils collected, from the quartzite includes:

Crathophyllum caespitosum Goldfuss,
C. bathycalv Frech, Hallia striata Schlüter,
Endophyllum acanthicum Frech, Calceola sandalina Lamarck, Microplasma f. rectum Schlüter,
Pachytera reticulate De Blainville, Polypora sp.
Goniophora hamiltomesis Hall, Athyris spiriferoides Eaton, A. concentrica von Buch
Cystina heteropolyta Defrance, Nucleospira lens Schur, Meristella atokes Girty, Rhynchonella subsignata Schur,
Camarotrychus seppho Hall, Atrypa reticularis Linn, Pentamerus (Gypidula) brevirostus Phillips, Schizophoria striatula Schlotheim, Stropheodonta interstrialis Phillips, Str. demissa Conrad
The upper (so far) unfossiliferous part of the Muth Quartzite is succeeded by the Syringothyris Limestone (Lower Carboniferous) except where it is unconformably overlapped by the Panjal volcanics. This horizon can be traced over a large area in the north eastern part of the Silurian anticline from Kotsu in the Lider valley to Hairbal Gali while on the side it cuts across the ridge between Paisan and Tangmarg. In the Naubug valley and Mangan Pass areas this horizon is unconformably overlapped by the Panjal volcanics.

The rock is mainly calcareous with shales, quartzites and a few bands of trap which may be intrusive. The limestone is usually bedded, pale and dark grey in colour and the lowermost bands yield fossils. Collecting of fossils is naturally easier where the limestone is weathered.

This series is well exposed at the following localities and yield profuse faunas:

1. Kotsu an isolated hill in the Lider valley.
2. Aishuqam on two hill spurs.
3. Near Gugaldar
4. Grenard.
5. Ridge north of pass between Tangmarg and Paisan in Arpat valley.

This horizon is lithologically and palaeontologically similar to the Lipak series of
Spiti valley as described by Hayden. The two most characteristic species, namely, *Syringothyris cuspidata*, Mart. and *Chonetes hardrensis var. tibetensis*, Salt. are found in both sections.

The other fossils collected includes:
- *Productus core* d'Orb.,
- *P. longispinus* Sow, *Chonetes afi. kashmiriensis* Lyd, *Syringothyris cuspidata* Mart, *Spirigera subtilis* Hall,
- *Schizophrorie* sp., *Rhynchorelle* sp. etc.

The *Syringothyris* Limestone is overlain by a considerable thickness of unfossiliferous rock which have been classified as Passage beds by Middlemiss.

**PASSAGE BEDS**

The *Syringothyris* Limestone is followed by a considerable thickness of unfossiliferous strata, before the Fenestella series becomes signalised by organic remains. These rocks consist of quartzites, sandstones and shales. Petrologically they are similar to the overlying Fenestella series and are very well exposed at the following localities:

1. 1½ mile N.N.E. of Aishmuqam.
2. Between Liwapetur and peak No. 1.
3. S. E. of Kollur.
In the pitching anticline E. E. of Amantray, the Syringothyris Limestone is succeeded by the Fenestella series, except in the Nebbug valley where these beds are overlain by the younger, Panjal traps.

These beds comprise an enormous thickness of quartzites with intervening layers of slightly calcareous dark shales. The lower portion of these shales is highly fossiliferous, carrying a rich assemblage of Bryozoans, Brachiopods, Pelecypods and corals. In the middle portion of this series the shales become less conspicuous and are unfossiliferous.

The Fenestella series is in turn overlain by members of the Agglomeratic slates except where the latter are overlapped by the Panjal traps. Stratigraphically these are of older age than the Syringothyris Limestone.

These beds can be correlated with the Po series of Spiti (described by Hayden) as being in every way reasonable, on lithological, stratigraphical and palaeontological grounds. Their position between the Syringothyris Limestone beds and the Permo-Carboniferous is therefore in entire agreement with that of Po series, which in Spiti underlies Permian conglomerate and overlies the calcareous sandstones of Hayden. These calcareous sandstones in Spiti are overlain by the Products shales the real equivalent of the Permocarboniferous in Kashmir.
The Fenestella series is exposed at the following localities:

1. Lehindajjar valley and Bhugmore rasta.
2. Near Yanzar bridge.
3. Head of Kirram valley.
4. N.N.E. of Buru.
5. N.E. of Aimu, between Liwepatur and Krapri.

The fauna collected from the above mentioned localities includes the following species:

Griffithides sp., Phillipsia sp.,
Modiola lidarensis Diener,
Articulopecten middlemissii Diener,
Productus undatus Defr.; P. core d'Orb,
P. semireticulatus Mart, P. lidarensis Diener,
P. spitiensis Dien, P. dowhatensis Dien,
Derbyia dorsoplane Dien, Syringothyris Lydekkeri Dien,
Spirifer trigonalis Mart,
S. triangularis Mart, Camarophoria dowhatensis Dien,
Urdcinulus sp., Dielasma lidarensis Dien,
D. hastatum Sowerby, Fenestella sp.,
Proteretepora empla Lonsd. etc.

The Fenestella series passes upwards into the Agglomeratic slates which in turn are overlain by the great thickness of the Penjal volcanics. The Agglomeratic slates are at places fossiliferous and the fauna is identified with the Permocarboniferous of Zewan beds.