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Palaeozoic Stratigraphy of Kashmir, Kishtwar and Chamba (Panjab Himalayas)

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(with 3 Figures, and 1 Plate)

Schlüsselwörter
Himalaya
Kashmir-Chamba
Paläozoikum

Contents

Zusammenfassung

Die Arbeit gibt einen Überblick über die Schichtfolge des Paläozoikums von Kashmir und der im SE angrenzenden Gebiete von Kishtwar, Pangi und Chamba. Der Fossilinhalt der einzelnen Formationen wird, soweit dieser aus verschiedenen Arbeiten bekannt ist, eingehend referiert und so eine Übersicht über unsere derzeitige Kenntnis gegeben.

Die tieferen Teile der Schichtfolge werden von mächtigen, schlecht gliederbaren Geosynklinalablagerungen aufgebaut (Grauwacken-Fazies). Ihr Alter reicht vom Jung-Präkambrium bis ins Silur, wie vereinzelte paläozoische Fossilhorizonte zeigen. In den Tanawals (Ordoviz — Ob. Karbon) setzt die flyschoide Fazies weiter fort, sie wird nur etwas sandiger. Sie ist mit der Seichtwasserfazies des Muth-Quarzits (Devon) und örtlich mit dem Syringothyris-Kalk (Unt. Karbon) sowie den Fenestella-Schiefern (Mittel-Karbon) verzahnt. Der stratigraphische Umfang der Tanawals ist in den äußeren, südwestlichen Gebirgszonen größer als im NE. Mit dem Agglomeratic Slate werden die Ablagerungsbedingungen einheitlicher (Oberkarbon). Diese Formation erhält ihren besonderen Charakter durch das Zusammentreffen klimatischer Faktoren (Südkontinent-Vereisung) mit dem Beginn vulkanischer Tätigkeit. Es folgt die Bildung mächtiger Lavadecken (Panjal Trap). Die Eruptionen klingen örtlich erst in der Trias aus. In anderen Teilen Kashmirs kommt es noch im Perm zur Ablagerung der Gangamopteris Beds und der marinen Zewan-Serie auf dem Trap.

Abstract

The paper gives a review of the Palaeozoic successions of Kashmir and the region adjoining in the SE (Kishtwar, Pangi, Chamba). Special reference is given to the diverse notes on fossil contents of the beds.

The basal formations show a distinct geosynclinal (greywacke) facies. They range up from the Late Precambrian to the Silurian as shown by rare fossil horizons. The Tanawals (Ordovician-Upper Carboniferous) indicate a persistence of flyschoid deposition which has become more arenaceous. This facies is intertonguing with the shallow water facies of the Muth Quartzite (Devonian) and partly with the dark Syringothyris Limestone (L. Carb.) and the Fenestella Shales (Mid. Carb.). The stratigraphic range of the Tanawals becomes larger when followed from the inner to the outer (southwestern) zones of the mountains. Facies becomes more uniform with the deposition of the Agglomeratic Slates (Up. Carb.). This formation has its unique character from climatic (glacial) influence and the beginning of volcanic activity. Thick lava flows follow — the Panjal Traps. In the Permian the Gangamopteris Beds and marine Zewan Series are deposited on the trap. Locally, however, volcanicity persists into the Upper Triassic.

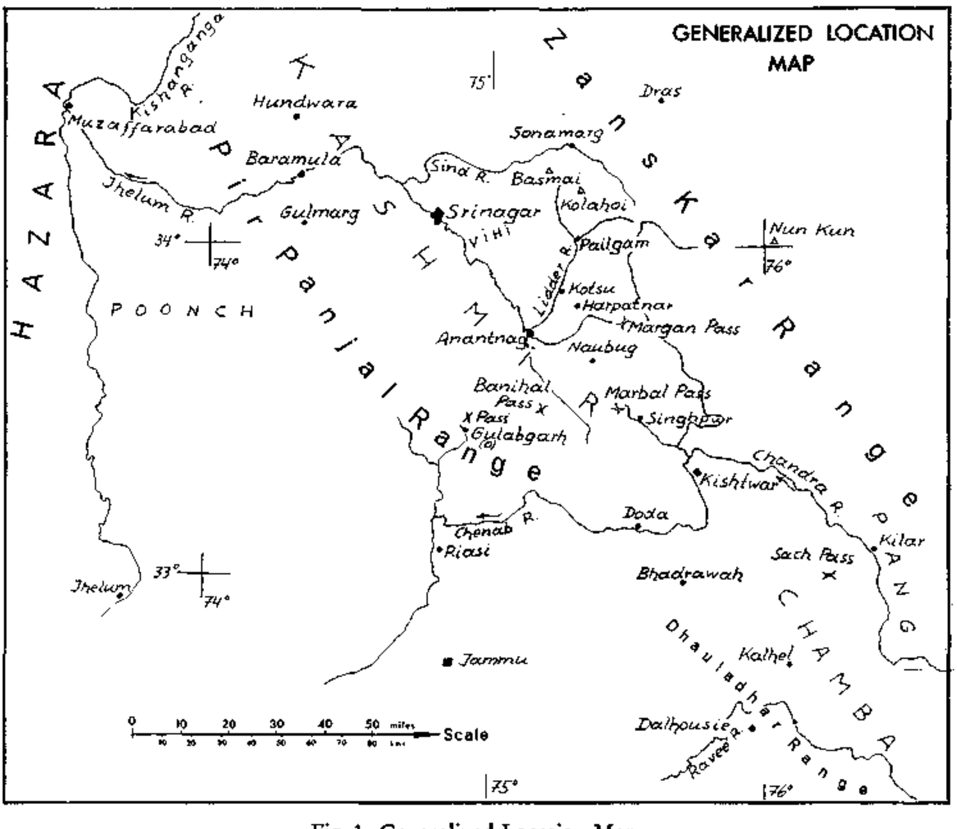


Fig. 1: Generalized Location Map.

Introduction

The Kashmir Valley lies between the two arms of high and rugged mountain ranges: Dhauladhar-Pir Panjal Range in the SW and Zanskar Range or Great Himalayan Range in the NE. It has a unique position in the Himalayan Geology for its complete Cambro-Trias sequence with patches of Jurassic rocks. This succession has individual character. The western part of the Kashmir Valley is bordered by the Draba and Karnah mountain ranges of Muzaffarabad District, whereas the northeastern part is bordered by Hundwara Tehsil. The Kishtwar and Chamba areas lie to the SE of Kashmir.

The earliest references to the Palaeozoic Stratigraphy of the Kashmir Himalayas date back to 1866 when DAVIDSON described the fossil collections of GODWIN AUSTEN and STOLICZKA reported on his geological observations. A year later DEVERNEUIL (1867) reported a few Upper Palaeozoic fossils from the Kashmir Valley. The first systematic attempt to work out the stratigraphy of the Kashmir Himalayas was by LYDEKKER (1883) who subdivided the Palaeozoic rocks into Metamorphic, Panjal and Zanskar Systems. A detailed account on the stratigraphy of the Anantnag area, was published by MIDDLEMISS (1910) and fossil collections made by him were later described by REED (1910). MIDDLEMISS divided the Silurian-Trias sequence into following divisions:

Older Silurian and ? Cambrian
Upper Silurian
Muth Quartzite
Syringothyris Limestone
Passage Beds
Fenestella Series
Panjal Volcanic Flows and Agglomeratic Slates.

The north-western part of the valley was worked out in detail by WADIA (1934) who recorded the presence of richly fossiliferous Cambrian rocks for the first time from the valley. This area differs from the south-eastern part of the valley in having a complete fossiliferous Cambrian succession and a poorly developed Ordovician-Devonian sequence. The importance of the Mid-Palaeozoic unconformity is emphasized by WADIA. Contrary definite Cambrian rocks are not known so far in the south-eastern part of Kashmir whereas the Ordovician-Devonian succession is very well developed there. The Devonian rocks in the Baramula District are overlapped by the Panjal Volcanics whereas in SE-Kashmir (Anantnag District) they are followed by the Syringothyris Limestone, Fenestella Shales etc. Varying lithology, difference in faunal and floral assemblages, and different stratigraphic sequences in the two parts of the valley are due to facies variations within the Kashmir Valley during the Palaeozoic times.

In 1963, GUPTA undertook the work to revise the Palaeozoic stratigraphy of the south-eastern part of the valley. On the basis of new fossil collections he proposed (1969) a new classification of the Palaeozoic rocks of the area.

After a first visit in 1964 G. FUCHS studied the sequences of Kashmir, Kishtwar, Chamba, and Hazara in 1969. Aim of his investigations was to correlate the fossiliferous sequences with the unfossiliferous ones of the Lower Himalayas to find out their age.

The results of the authors which are in fair agreement are given in a joint paper.

In addition there are several papers dealing with different aspects of Kashmir Geology which have been published in several journals in India and abroad. These have been referred at appropriate places in the text.

Regional Setting

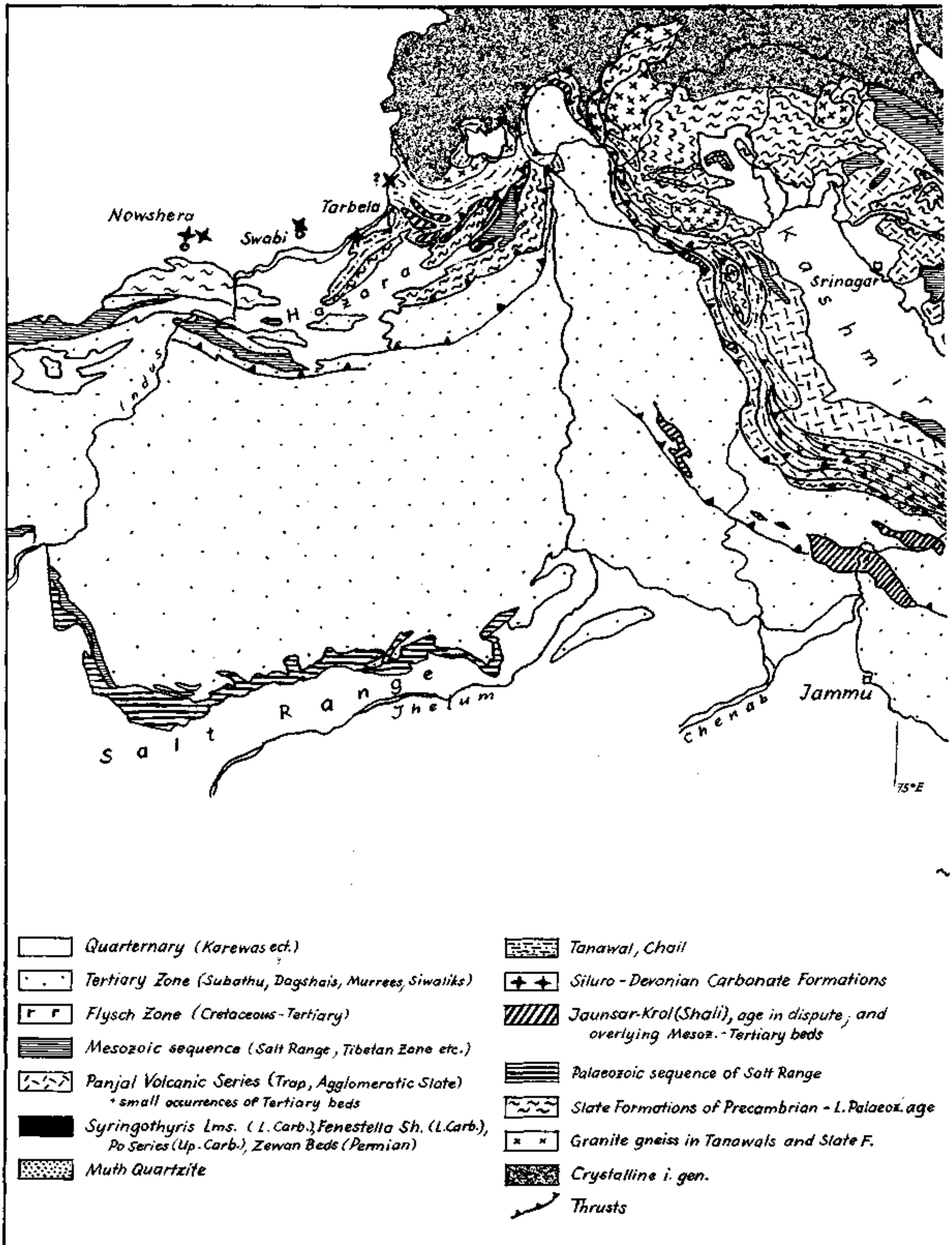
In his 1934 paper WADIA discerned the Kashmir Nappe which has its roots in the Zanskar Range. The Palaeo-Mesozoic succession of the Kashmir Valley is part of this unit. The oldest rocks of the sequence, Dogra Slates and metamorphic rocks come to rest on Permo-Carboniferous and even Eocene formations of a lower structural unit, the Autochthonous Fold Belt. The Kashmir Nappe which overrides the lower units along a low angle thrust (Panjal Thrust) comes in contact even with Murrees of the Tertiary Zone at one point.

The structural picture given by WADIA was proved by recent work. The discovery of the window of Kishtwar by one of the authors (FUCHS) is clear evidence for the existence of the Kashmir Nappe. In this window epimetamorphic rocks of the Chail Formation intruded by stocks of granite (Chail Nappe) are surrounded by overthrust high-grade metamorphic rocks (Crystalline- or Kashmir Nappe). The strongly altered crystallines form the base of the Kashmir- and Chamba Synclinoria.

The crest of the Pir Panjal Range is built of rocks of the Kashmir sequence. The south-western slope of the range shows complicated structure. Immediately over the Murrees there is a thrust sheet consisting of Dogra Slates, Chandpurs, Agglomeratic Slate, Panjal Trap, Infra Trias, and local Eocene rocks. This nonmetamorphic unit (Autochthonous Fold Belt, WADIA) is overthrust by epimetamorphic rocks of Chail-Tanawal type and Dogra Slates. There are also deformed intrusions of granitic rocks. The topmost Tanawals grade into the Agglomeratic Slate, e. g. at Gulabgarh. Within the metamorphic sequence, however, major structural complications are to be expected.

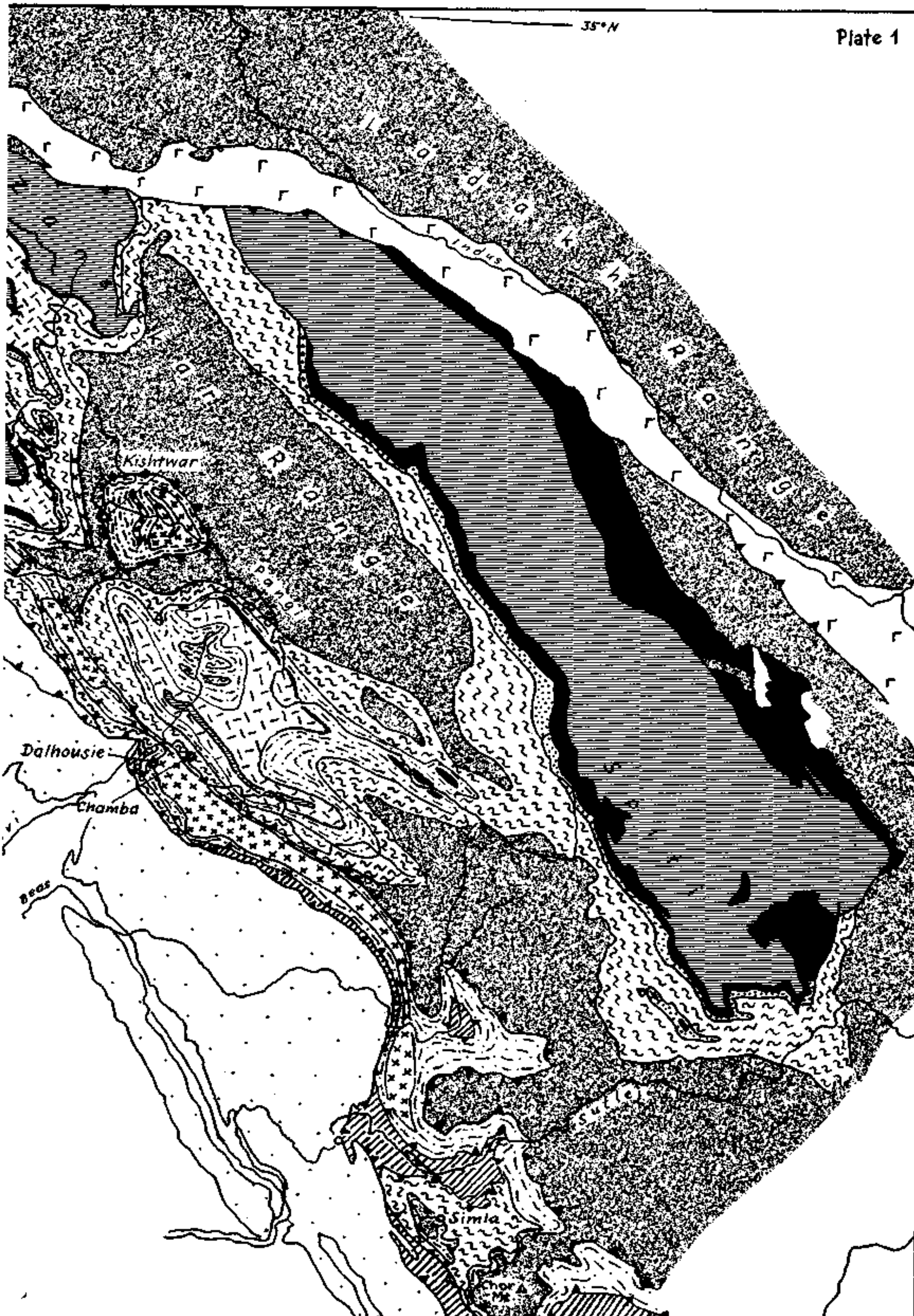
The Chamba Synclinorium is the south-eastern continuation of the Kashmir Basin only separated by the deeply eroded valley of the Chenab. It is there that the less metamorphic rocks of the Kishtwar window are exposed. The series of the Chamba Synclinorium range up from gneiss or Dogra Slate respectively to Lower Triassic rocks. Thus the younger Triassic — Jurassic beds are not preserved here. Similar to the Pir Panjal Range we find a sequence of Chail — Tanawal rocks and granite-gneiss in the Dhauladhar Range.

Also here they dip beneath the Chamba Synclinorium the continuation of the Kashmir Nappe. It is interesting to note that like in Kashmir, the high-grade metamorphic rocks which form the base of the Kashmir Nappe in the N, e. g. in Pangi or NW Kishtwar, are missing along the south-western rims of the nappe. As in the Pir Panjal Range we find a narrow zone of unmetamorphic rocks below



Pl. 1. Geological Map of the NW-Himalayas by G. Fuchs, 1970.

Plate 1



35° N
Ladakh Range
Indus
Zanskar Range
Kishtwar
Pangi
Dalhousie
Chamba
Beas
Sutlej
Simla
Chor Mt.

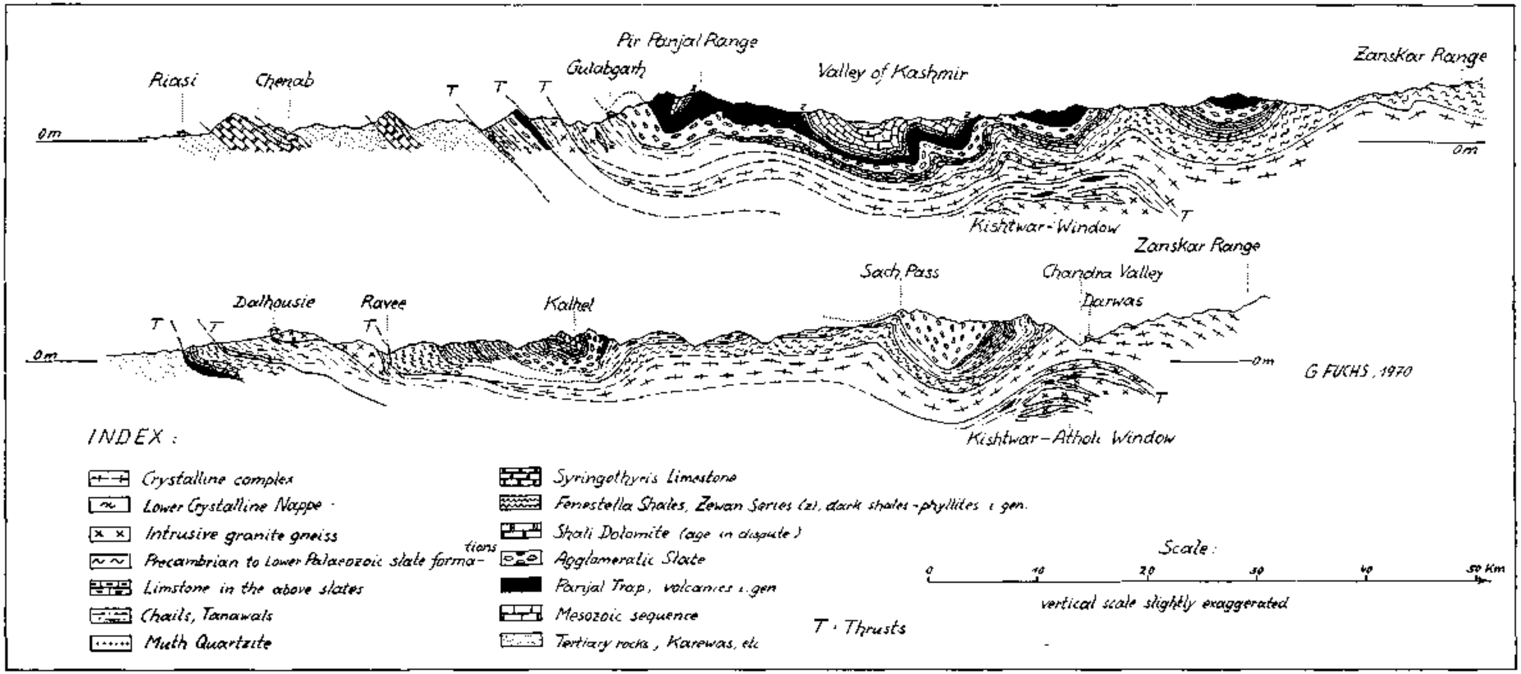


Fig. 2: Sections across Kashmir and Chamba, by G. Fuchs, 1970.

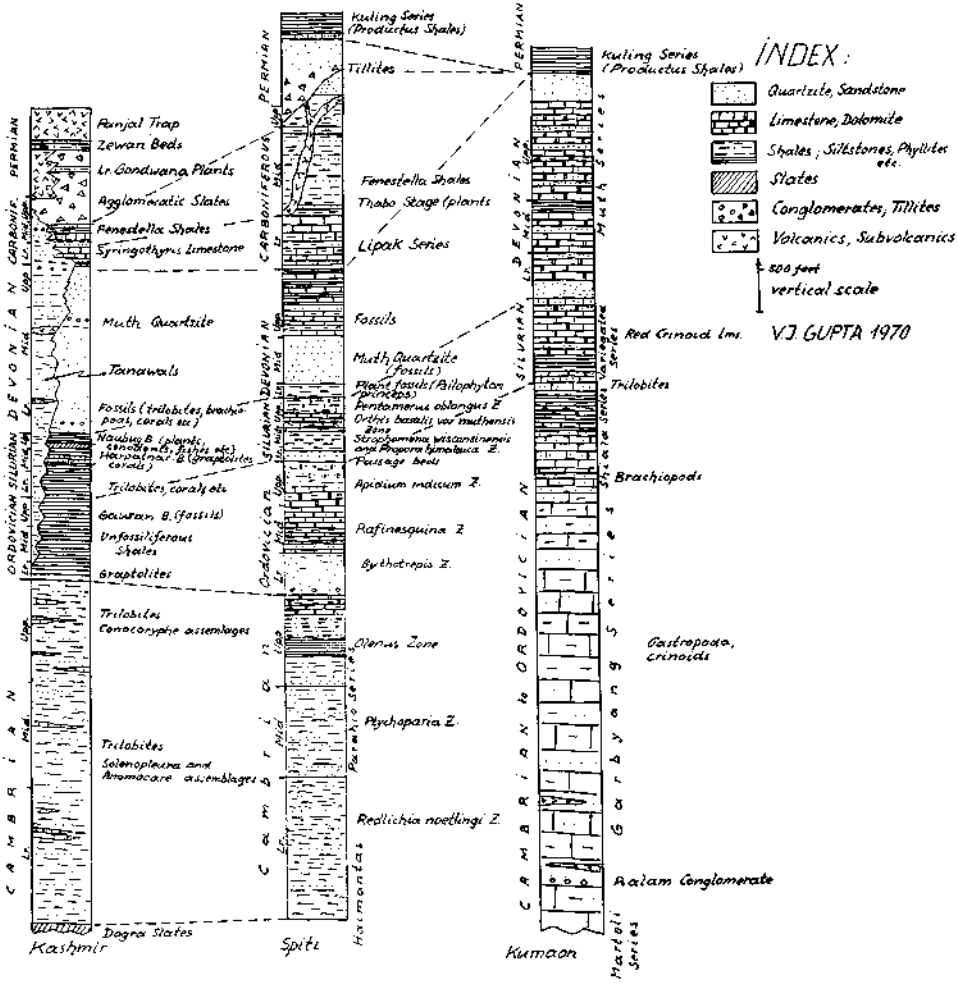


Fig. 3: Generalized stratigraphical columns of the Palaeozoics in the Himalayas, illustrating the possible correlation across the region (V. J. GUPTA, 1970). 1. Kashmir; 2. Spiti Valley (modified after HAYDEN, 1904); 3. Lipu Lekh at the head of the Kali Valley, Kumaon Himalayas (based on GANSSER, 1964; HEIM and GANSSER, 1939).

the Chails and granite-gneiss. This is the continuation of the Autochthonous Fold Belt which is overthrust by the Chail Nappe.

Thus apart from some individual features the regions under consideration fit well into the structural pattern of the Himalayas.

When we describe the Palaeozoic successions of Kashmir-Chamba, which is the topic of the present paper, we have to point to several facies differences across as well as along the strike.

Stratigraphy

Dogra Slates

The name Dogra Slates was proposed by WADIA (1928) for a thick pile of argillaceous sediments in SW-Kashmir and Poonch which he regarded as equivalent of the Simla Slates of the Simla area (PILGRIM and WEST, 1928). The Dogra Slates have almost monotonous lithology of black greenish slates and greenish phyllites though rarely a few quartzitic bands and altered lava flows are also met with in the series. These rocks have prominent oblique cleavage developed. At places where the rocks have registered higher grade of metamorphism the rocks show prominent foliation oblique to the bedding.

In the western parts of the Kashmir Valley, Dogra Slates form the base over which fossiliferous Palaeozoic rocks have been deposited as evinced in exposures of Baramula and Banihal areas.

Generally the contact of the Dogra Slates and the underlying Salkhalas is a gradational one. Where the Dogra Slates are missing the fossiliferous Palaeozoic rocks directly overlie the Salkhalas. In these cases the Dogra Slates seem to have been altered to form part of the metamorphic complex.

The age of these rocks (Slates and Salkhalas) is just a speculation because of their azoic nature. The lower portion of the overlying thick sequence of slates, clays, sandstone, greywackes etc. has yielded Lower Cambrian fossils, on the basis of which the Dogra Slates have been assigned to Precambrian or in some parts Lower Cambrian age. The lithology of the Dogra Slates and the overlying beds is rather similar. In absence of fossils it is difficult to discern.

The correlation of the Dogra Slates with the Attock Slates, Hazara Slates and Simla Slates is very probable from the comparison of sections, however, there may be some differences in stratigraphic range. Simla Slates and Dogra Slates were deposited in two different basins of deposition.

Cambrian System

The best known exposures of fossiliferous Cambrian System are found in the Baramula District of Kashmir although unfossiliferous shales, clays, sandstones etc. underlying the Ordovician-Trias sequence in other areas in parts be considered equivalent.

In Baramula District, the Dogra Slates are conformably overlain by the fossiliferous Cambro-Silurian succession and have wide distribution in the northwestern parts of the Kashmir Valley and parts of Banihal. The best known example of a continous succession from Dogra Slates through Lower, Middle and Upper Cambrian to Ordovician-Silurian sequence is met with in a traverse across the Jhelum-Kishenganga (Jumegand to Marhaum). Dogra Slates come in direct contact with the fossiliferous Middle and Upper Cambrian to Ordovician-Silurian sequence at some places, e. g. in the Jhelum-Kishenganga section (Jamegand to Marhaum).

The Lower Cambrian consists of annelid slates, sandstones, and quartzites yielding poorly preserved organic remains ((Tubicolous, Vermes etc.). SUNEJA (Personal communication) has recently found a few specimens of *Microdiscus* and *Agnostus* in addition to annelid remains from these slates and has suggested a Lower Cambrian age for the beds immediately overlying the Dogra Slates in a conformable sequence.

Lower Cambrian slates, sandstones, and quartzites are conformably overlain by an enormous thickness of Middle and Upper Cambrian strata of fossiliferous clays, slates, limestones, and arenaceous beds. The Middle and Upper Cambrian strata have yielded trilobites and brachiopods respectively and are characterized by the presence of *Ptychoparia-Solenopleura-Anomocare* and *Conocoryphe* assemblages respectively. The trilobites are found mostly in form of head shields and pygidia. Complete specimens are rare and where present are difficult to extract because the rocks break along cleavage on hammering which is oblique to the bedding.

The characteristic fossils from the Cambrian of Kashmir are (REED, 1934; KOBAYASHI, 1934; GUPTA, 1967; SUNEJA, 1970):

Irania spp., *Ogygopsis klotzi, Wenkchemnia sulcata, Conocoryphe frangtengensis, C. sejuncta, Tonkinella breviceps, T. quadrifida, T. stephensis, Dolichometopus subtuberculatus, Anomocare hundwarense, A. novatum, A. suspectum, A. dimotum, Chuangia wadapurensis, C. subangulata, Solenopleura lydekkeri, Ptychoparia dardapurensis, P. memor, Agnostus* cf. *rakuraensis, Microdiscus* sp., *Saukia vagans, Prosaukia middlemissi, Hundwarella personata, H. remota,* and several species of brachiopods, gastropods and cystoids.

The occurence of *Irania* and *Chuangia* in the Kashmir collection is important in that the former indicates upper Middle Cambrian and the later lower Upper Cambrian and thus the boundary between the Middle and Upper Cambrian can be defined on the basis of these two forms. Both these forms are common to Iran, Kashmir, and Indo-China and therefore the Kashmir region forms a definite link between Iran on one hand and Indo-China on the other. KOBAYASHI (1934) has described a species of *Agnostus* from the Hundwara basin and has compared it with *A. rakurdenses* from Chosen in China. The form described by REED (1910) from Spiti as *Ptychoparia memor* has also been found in Kashmir though referred by KOBAYASHI to *Anomocorella* and is compared with *Anomocare megalurus* DAMES (SAHNI, 1940) from Tonkin. More important still, the characteristic Indo-Chinese genus *Tonkinella* is now recorded in the species *Tonkinella breviceps* KOBAYASHI. The occurence of species of *Anomocare* and *Conocoryphe* in Kashmir which are closely allied to Indo-Chinese species is likewise of great interest and emphasizes marine connections between these regions.

The bulk of the fauna from the Cambrian of Kashmir comprises such forms as are known to occur in deep, turbid, muddy ocean bottoms and obviously it is only such genera that are preserved as complete skeletons. Shallow water and shelf forms, are fragmentary and occur in the form of headshields and pygidia.

The separation into headshield and pygidia may also be due to the process of moulting or by the sorting action of waves.

The fauna from the Cambrian of Kashmir is endemic and is not related to the forms reported from the corresponding formations of Spiti and the Salt Range. The absence of *Redlichia* from the Cambrian of Kashmir is conspicuous as this genus is known to occur in the Salt Range, Persia, Yunnan, and Spiti. This diversity in the Kashmir, Salt Range, and Spiti Cambrian faunas may be due entirely to the change of the environmental factors in the three depth zones. WAKHALOO and SHAH (1965) suggested that the central part of the Cambrian sea in this region showing the deepest zones are those of Kashmir and Indo-China, whereas the margins of this sea are represented by the Salt Range in the south and by China and South Korea in the north. The Spiti region is of intermediate nature. The Kashmir region represented the extra-cratonic (euxinic) biofacies and the Salt Range the cratonic biofacies. Spiti region represents miogeosynclinal biofacies.

The lithological evidence also seems to support this fact. In the Salt Range the trilobites are entombed in sandstones and light shales, in Spiti are found in quartzites, sandstones, and limestones whereas in Kashmir they are present in typical blue muddy shales and siltstones which are elsewhere associated with greywackes (WADIA 1934).

Ordovician System

In India, the rocks belonging to the Ordovician System are found through the entire stretch of the Himalayas from Kashmir to Bhutan. The recognition of Ordovician rocks in the Kashmir Himalayas was first done in the Baramula and Anantnag Districts by WADIA (1934) and GUPTA (1966) respectively.

In the Baramula District WADIA (1934) recognized the occurrence of Ordovician (?) fossils from a series of ferruginous slates, quartzose greywackes, and limestones. They conformably overlie the fossiliferous Upper Cambrian shales and are well exposed in the northern limb of the Shamsh Abari Syncline near Trehgam, Hundwara Tehsil. REED (1934) identified the following forms out of the poor collection submitted to him for identification:

Orthis marahumensis, O. cf. calligramma, Orthis (Nicolella?) sp., *Leptelloidea* (?) sp. and crinoid stems and joints.

SUNEJA in 1968 and the Austrian Geological Expedition 1969 made fresh fossil collections from the Lower Palaeozoic rocks of this area and one of us (V. J. G.) had the opportunity to study both the collections. The collections include several forms in addition to those recorded by REED (1934) and the fauna definitely indicates Ordovician age for the beds yielding brachiopods.

In the Lidder Valley of Anantnag District GUPTA (1966) referred the beds underlying the fossiliferous shales to the Lower Ordovician and (?) Cambrian. The exact age of these formation, however, is speculative. The rocks are entirely destitute of organic remains and are constant in lithological character as we go from the Lidder Valley to the Margan Pass. Lithologically, the rocks consist of thin-bedded siliceous and argillaceous shales of dull pale colour, which, here and there, become of varied shades of purple, blue, grey, and pale greenish. A considerable amount of silt 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. As these beds conformably underlie the Gauran Beds (Upper Ordovician), the possibility of their being part of the Lower Ordovician cannot be ruled out.

In the Naubug Valley of Anantnag District the beds immediately overlying the fossiliferous shales of Lower Ordovician and (?) Cambrian contain some well-preserved bryozoans, brachiopods, and cystoids near the village Gauran and the fossiliferous beds have been named Gauran Beds after the name of that village. Among the fossils identified from these beds are:

Diplotrypa boardensis, *Prasopora simulatrix*, *Orbignyella* sp., *Monotrypa* sp., *Orthis (Dinorthis) flabellulum*, *Orthis (Dalmanella) chaungzonensis*, *Cheirocrinus* sp., *Carycrinus* sp.

The forms listed above are identical or closely allied to those from the Naungkangyi Beds (Ordovician) of Northern Shan States, Burma.

The discovery of graptolites in the Anantnag District was of considerable interest to the geologists studying the history of the Himalayas. The graptolites described by Berry & Gupta (1966) from the Harpatnar Beds indicate a Ludlow age. The stratigraphic succession beneath the Harpatnar Beds is in contrast with the layers above. A unit of red mudstones and shales bounded by faults can be recognized as a slice beneath the Harpatnar Beds. The graptolites recovered from this slice are poorly fragments. The following forms can, however, be recognized among them (Berry & Gupta, 1967):

Climacograptus sp., *Didymograptus* sp., *Glossograptus* (?) sp.

The association of these extensiform didymograptids with a climacograptid and glossograptid indicates an age span of late Early (Midcaradoc) Ordovician. The association of these graptolites is known in the British and the continental European Ordovician graptolite successions from the British *Didymograptus hirundo* Zone and strata correlative with it into the *Climacograptus bicornis* Zone. This association of graptolites is known in the American-Australian-Asian Ordovician graptolite succession to range from beds, considered correlative with the basal part of the British Llanvirn, into those correlative with the British *Climacograptus bicornis* Zone.

The presence of an extensiform didymograptid, similar to *D. compressus*, suggests that the fauna may have had connections with the American-Australian-Asian Ordovician graptolite faunas rather than with the British-European faunas. This didymograptid species is restricted to the American-Australian-Asian Ordovician graptolite fauna where it occurs in faunas considered to be correlated with those of British Llanvirn.

Silurian System

Fossiliferous Silurian rocks form a conspicuous horizon below the Muth Quartzite through the entire stretch of the Himalayas from Kashmir to the border of Nepal. In Kashmir, the rocks belonging to this system are exposed in the Baramula and Anantnag Districts.

In the Baramula District, the occurrence of Silurian rocks was first reported by WADIA (1934) from Ganganagar, Marhaum, and Shamsh Abari areas. Lithologically the rocks consist of sandstones, slates, and greywackes. The Austrian Geological Expedition 1969 made fossil collections from the Silurian rocks of Sind Valley and submitted them to V. J. G. for palaeontological investigations. One of the samles from north of Marhaum has a fairly well preserved specimen of *Pycnactis mitrata* — a definite Middle Silurian form.

BION (1928), while working in the area around Nagmarg recorded the presence of the Old Slate Series with rusty coloured limestone bands containing obscure brachiopods and some trilobite fragments, ? *Cheirurus, Asaphus* etc., and suggested Silurian age for them. The Silurian rocks are unconformably overlain by the Agglomeratic Slate.

In the Anantnag District a well developed succession of the Silurian rocks is exposed at several localities (Harpatnar, Gugaldar, Gudrammen, Naubug, Margan Pass and Lutherwan) and has yielded rich and varied faunas. The fossiliferous succession in this region has been classified as follows (GUPTA, 1969):

Muth Quartzite	Middle and Upper Devonian
Naubug Beds	higher Upper Silurian to Lower Devonian
Harpatnar Beds	Upper Silurian
Unfossiliferous shales	Lower to Middle Silurian
Gauran Beds	Upper Ordovician

The unfossiliferous strata immediately overlying the Gauran Beds and underlying the Harpatnar Beds consist of an enormous thickness of unfossiliferous thinly bedded siliceous and argillaceous shales. These strata have been provisionally referred to Lower and Middle Silurian.

Harpatnar Beds

The unfossiliferous shales referred above are conformably overlain by a thin succession of mudstone and shales and have yielded poorly preserved graptolites. The following forms have been described by BERRY & GUPTA (1966) from these beds:

Monograptus sp. (*M. colonus* type), *Monograptus* sp. (*M. uncinatus* type), *Monograptus* sp. (*M. vulgaris* type), *Monograptus* sp. (*M. leintwardinensis* type), *Monograptus* sp. (*M. dubius* type), *Monograptus* sp.

These graptolites are suggestive of an Early and possibly Middle Ludlow age for the Harpatnar Beds. The Harpatnar Beds have been named after the Harpatnar village in the Anantnag District where these beds are well exposed.

The graptolites referred above were collected from two stratigraphic levels. The lower one yielded *Monograptus* sp. of *M. colonus* type and *Monograptus* sp. of *M. vulgaris* type. Three feet stratigraphically higher, several specimens were obtained, and among them *Monograptus* cf. *M. leintwardinensis*, *Monograptus* sp. of *M. dubius* type, *Monograptus* sp. of *M. uncinatus* type, and *Monograptus* sp. bearing biform thecae were identified.

Yet a third horizon yielded graptolites. It is 27 feet stratigraphically lower than that from which the monograptids of the *M. colonus* and *M. vulgaris* type were collected. Some curved rhabdosome fragments of what appear to be monograptids were obtained at this level. *Cardiola* was found in the same beds. The widespread distribution of *Cardiola* in rocks of Late Silurian and possibly younger age, the discovery in the same beds of a sicula and first thecae similar to those of the monograptids of the *M. colonus* type, and the general resemblance of the fragments to distal portions of the rhabdosomes of *M. bohemicus* suggest a Late Silurian (possibly Early Ludlow in the British standard) age for these lower strata.

The presence of monograptids of the *M. colonus* and *M. vulgaris* types together in the medial stratigraphic position indicates a Ludlow, probably early, age for this horizon.

The presence of a *monograptus* closely comparable with *M. leintwardinensis* in the stratigraphically highest collection suggests a possible Middle Ludlow age for the beds at that stratigraphical level because *M. leintwardinensis* is found only in beds of Middle Ludlow age in Europe. The finding of monograptids of the *M. dubius, M. uncinatus,* and M. sp. (biform thecae) types together with *M.* cf. *M. leintwardinensis* is not inconsistent with a possible Middle Ludlow age for the beds bearing them. Members of the *M. dubius* type range through the Ludlow Series. Monograptids having biform thecae of the type in the Harpatnar Beds range from essentially Middle Ludlow into Skala Stage and possibly into Geddinian Stage. Monograptids that have the *M. uncinatus* type of thecae also range through the Ludlow into post-Ludlow rocks. The joint association of a form closely comparable with *M. leintwardinensis* and the form having biform thecae of the type found in the Harpatnar Beds indicates a slightly younger age for the beds bearing them than the beds bearing monograptids of the *M. colonus* and *M. vulgaris* types.

The graptolites obtained from the Harpatnar Beds thus suggest an Early, and possibly Middle Ludlow age. Berry & Gupta (1966) tentatively suggested that the older of the two levels may be correlated with the British *Monograptus nilssoni* and *M. scanicus* Zones and the younger could be correlated, at least in part, with the British *M. leintwardinensis* Zone.

Naubug Beds

The Harpatnar Beds are overlain by a thick succession of unfossiliferous shales followed by fossiliferous blue grey to dark rusty calcareous sandy shales and siliceous limestones. The unfossiliferous and fossiliferous strata overlying the Harpatnar Beds have been named as Naubug Beds after the village Naubug where these rocks are well exposed. The fauna from the lower level of these beds includes representatives of brachiopods, cephalopods, gastropods, corals, crinoids, cystoids, blastoids, trilobites and the fauna from the upper levels includes conodonts and fishes. The Naubug Beds are important in that the demarcation of the Silurian-Devonian boundary (GUPTA, 1969 a) can be made between the lower and upper stratigraphic levels found within these beds.

The most important forms from the lower stratigraphic level are (REED, 1912, GUPTA, 1966, 1969, 1970):

Favosites goldfussi, *F. spitiensis*, *Stylarea* sp., *Streptelasma* sp., *Heliolites* sp., *Stephanocrinus angulatus*, *Pholidops implicata*, *Orthotetes pecten*, *Strophomena corrugatella*, *Rafinesquina lineatissima*, *Leptaena rhomboidalis*, *Plectambonites transversalis*, *P. papilosa*, *Levenea* sp., *Plectatrypa* sp., *Leptoporella* sp., *Sphaerirhynchia* sp., *Hotedoklina* sp., *Reserella* sp., *Leptellina* sp., *Coelospira* sp., *Rhynchospira* sp., *Orthis (Plectorthis) spitiensis*, *O. (Dalmanella) basalis*, *O. (Dalmanella) elegantula*, *O. (Dalmanella) crassa*, *Dicoelosia biloba*, *Triplecia insularis*, *Nucleospira pisum*, *Retzina salteri*, *Atrypa marginalis*, *Cyclonema bilix*, *Diaphorostoma cornutum*, *D. niagarensis*, *Hormotoma* sp., *Dalmanites* sp., *Encrinurus punctatus*, *Calymene blumenbachi*, *C. kashmiricus*, *Flexicalymene* sp., *Illaenus kashmiricus*, *I. esmarki*, *Acidaspis kashmiricus* etc.

In addition to the above one of us (V. J. G.) has recently found a few foraminifera and ostracodes from the calcareous sandy shales.

The fauna mentioned above indicates a Middle or Late Ludlow age for the lower stratigraphic level of the Naubug Beds.

The stratigraphic level discussed above is conformably overlain by the dark calcareous shales and siliceous limestones which have yielded conodonts, fish remains etc. These beds have been referred to as of Lower to early Middle Devonian age by GUPTA (1969) and pass conformably into the Muth Quartzite of Middle and Upper Devonian age. near Margan Pass. The specimens were found in the dark calcareous shales that overlie the lower stratigraphic horizon of the Naubug Beds. The Kashmir specimens have been identified as species of *Dipterus*. One specimen has scales probably belonging to a crossopterygian of the family Osteolepididae, but cannot be identified more specifically (GUPTA & DENISON, 1966).

Conodont Horizons

A well preserved assemblage of conodonts was reported by GUPTA & RHODES (1967) from a sample of siliceous limestone, collected from a locality near Lutherwan, Anantnag District. The strata yielding conodonts lie just below the Muth Quartzite which has been assigned to Middle Devonian age on the basis of fossils.

The fauna is dominated by polygnathids although other individuals are also present. The following are the most important forms:

Polygnathus cristata, *P. ordinata*, *P. pennata*, *P. webbi*, *P. liquiformis*, *P. rugosa*, *Ancyrodella rugosa*, *A. rotundiloba*, *Bryantodus* cf. *Bryantodus paeckel-*

manni, *Icriodus* sp., *Lonchodina* sp., *Trichonodella* sp., *Bryantodus* sp., *Ozarkodina* sp., *Hindeodella* sp., *Panerodus* sp., *Ligonodella* sp.

The importance of the fauna mentioned above lies partly in the fact that the nearest known Devonian conodont faunas are those of Nepal (Fuchs & Mostler 1969), Europe, the Spanish Sahara, and Australia, and partly in the overall similarity of the faunal assemblages to those of other areas. Gupta & Rhodes (1967) suggested the age of this horizon in the *dubia-rotundiloba* Subzone, though there is possibility of differences in the ranges of individual species in such widely separated areas.

Fuchs collected a few poorly preserved plant fossils from the basal part of the Muth Quartzite in the Kotsu Hill, Anantnag District. According to Gupta these specimens seem to be identical with *Pseudoporochnus* known from the Early and Middle Devonian beds of Bohemia.

In the formations from the Dogra Slate up to the base of the Muth Quartzite the lithology shows littel variation. Slates and shales, graded siltstones, sandstones (quartzites), and greywackes predominate, calcareous beds being rare. Fossils are generally scarce and confined to isolated occurrences. The faunas described were not observed in one section. Thus in absence of fossils it is impossible to distinguish even the Precambrian from the Lower Palaeozoic part of the sequence.

Muth Quartzite

Muth Quartzite is the name given to a thick succession of snow white to greenish quartzites of Devonian age which form a conspicuous topographical feature from Kashmir virtually to the border of Nepal. These quartzites were first referred to as the Muth Quartzite by Griesbach (1891) after the village Muth in the Pin valley of Spiti.

The exact stratigraphic position of the quartzite formation was not known till 1964 when Gupta discovered a rich assemblage of fossils from these quartzites in eastern Kashmir. Stoliczka considered these quartzites as of Upper Silurian age whereas Griesbach (1891) assigned them to Carboniferous. Hayden (1910) regarded them as partly Silurian and partly Devonian. Burrard & Hayden (1934) in their table accepted a Devonian age for these quartzites. According to Middlemiss (1910) these quartzites may represent Upper Silurian, Devonian, or Lower Carboniferous or it may represent any two or all three of them. Das Gupta (1929) following Holland (1926) described the Muth Quartzite as an unfossiliferous sequence in the Kashmir, Spiti and Kumaon Himalayas, which includes beds ranging in age from Ordovician to Devonian. Gupta (1969) on the basis of fossils assigned Middle Devonian age for the fossiliferous portion of the Muth Quartzite and considered the upper unfossiliferous horizon as of Upper Devonian age.

This stratigraphic position holds good for eastern Kashmir. There is possibility, however, that the Muth Quartzite doesn't have exactly the same age in other areas. The relation of Tanawals and Muth Quartzite and between these formations and carbonate beds of same age shows that there are considerable variations of facies and stratigraphic range.

The Muth Quartzite consists of hard white to greenish quartzite which is generally massive and at places full of ferruginous spots. A thin band of conglomerate has been encountered at the base of the quartzite succession at several places.

But there are conglomerates intercalated also in higher levels of the Muth Quartzite (e. g. E Basmai). Though quartzite predominates there are also beds of siliceous limestone and argillaceous layers.

In Kashmir, the Muth Quartzite is exposed in the Baramula and Anantnag Districts. In the Baramula District it conformably overlies the Silurian rocks of the Shamsh Abari Syncline. At several places it comes in contact directly with the Upper Cambrian rocks with an unconformity in between. In the western part of the Kashmir Valley it is overlapped by members of the Panjal Volcanic Series.

In the Anantnag District, the Muth Quartzite conformably overlies the Naubug Beds. The lower and upper units of these quartzites are unfossiliferous whereas the intermediate units are richly fossiliferous. The fossils include representatives of brachiopods, corals, gastropods, pelecypods, trilobites, and cephalopods. Among the fossils described by GUPTA (1970) from these quartzites mention may be made of the following:

Cyathophyllum caespitosum, C. bathycalyx, Zaphrentis sp., *Hallia striata, Endophyllum acanthicum, Microplasma fractum, Calceola sandalina, Pachypora reticulata, Polypora* sp., *Pentamerus (Gypidula) brevirostris, Schizophoria striatula, Stropheodonta demissa, S. interstrialis, Athyris spiriferoides, A. concentrica, Cyrtina heteroclyta, Nucleospira lens, Rhynchonella subsignata, Pleurotomaria* sp., *Loxoplocus* sp., *Bellerophon shanensis, Nucula niotica, Palaeoneilo plana, Lunulicardium* sp., *Modiomorpha* sp., *Goniophora hamiltonensis, Phacops* cf. *rana, Orthoceras* etc.

The abovementioned fauna has definitely a Devonian aspect. The presence of *Schizophoria striatula* and *Athyris spiriferoides* supports Middle Devonian age. The occurrence of *Cyrtina heteroclyta* confirms a lower Middle Devonian age for these beds. The fossiliferous horizon is followed by a few hundred feet of unfossiliferous quartzites which can be assigned to Upper Devonian.

The Muth Quartzite is conformably overlain by the Syringothyris Limestone of Lower Carboniferous age.

Tanawals

The name Tanawals was derived from the word „Tanol“ which was proposed by WYNNE in 1879 to a thick sequence of argillaceous sandstones, arenaceous phyllites, quartz schists, massive quartzites, grits and conglomerates. He referred them to the Purana zone of Hazara. WADIA (1928), while working in the Poonch District of Kashmir, grouped these rocks as part of the Gondwanas and correlated the rocks of Poonch area with those of the Hazara-Himalayan syntaxis. He

(1934) further extended this term to the similar lithological units in parts of the Baramula District (WADIA, 1934).

The stratigraphic position of the Tanawals is uncertain because of their being unfossiliferous. They generally overlie the Dogra Slates and at places have anomalous relation with the gneisses and Salkhalas. The Tanawals conformably pass into rocks containing Gondwana (near Gulmarg) plant fossils like *Gangamopteris, Cordaites, Alethopteris* (WADIA, 1934; MIDDLEMISS, 1911) and vertebrates like *Phlyctaenichthys pectinatus* (GUPTA, 1970).

WADIA (1934) classified the Tanawals into „Lower" and „Upper" units suggesting the possibility of the former being Devonian and the later to be younger than the Agglomeratic Slate (Infra-Trias). WAKHALOO and SHAH (1967) reported the occurrence of boulders of Agglomeratic Slates within the Tanawal Boulder Bed from Poonch District and suggested Post-Agglomeratic age for the later. The Agglomeratic Slates and Tanawals are frequently repeated in the area as a result of a series of thrusts producing imbricate structure. Hence the presence of boulders of Agglomeratic Slates within the Tanawals may possibly be due to some structural complexities as a result of which a slice of the former might have been entrapped in the latter.

FUCHS found a sedimentary contact between the Tanawals and the Syringothyris Limestone in the Marbal Pass area. In Pangi he observed an intertonguing of Syringothyris Limestone and Tanawals between km. 12 and 11 of the trail NE of Sach Pass (Fig. 2). However, in the southern limb of the Sach Pass Syncline limestones are missing and the Tanawals grade into the Agglomeratic Slate. The same he observed in the Pir Panjal in the area of the village Gulabgarh. These observations are in agreement with the references above. The Tanawal facies may end at the top of the Devonian or may range up into the Upper Carboniferous.

There is more uncertainty concerning the lower boundary of the formation. In the 1967 paper FUCHS has assumed a Siluro-Devonian age for the Chails and Tanawals which are lithologically equivalent (Pl. 4). The observation of FUCHS that the Tanawals of Hazara are intertonguing with crinoid bearing carbonate rocks probably belonging to the Siluro-Devonian Nowshera Formation (STAUFFER, 1968) at Tarbela is in good agreement. At Turlandi (W of the Indus), however, quartzites of the Tanawal-Muth type interfinger with conglomerates which contain rare crinoids, and are overlain by the Nowshera Formation. Thus a Lower Silurian or even Ordovician age of the Tanawals is possible. Gradational contacts frequently observed between the Simla Slates and Chail-Chandpur-Tanawal type beds point in same direction (e. g. in Nepal, Chamba). Thus the authors regard the Tanawals as a Palaeozoic formation with a varying stratigraphic range between Ordovician and Upper Carboniferous.

A few years back (1964) one of us (V. J. G.) hurriedly tracked the Chamba-Bhadrawah route and on way collected a sample of calcareous sandstone from the basal part of the Tanawals NE of Sach Pass. On maceration it yielded a few Lower Devonian conodonts which have not been reported because of lack of details of the geology of the area. The author, however, proposes to take up this section again next year.

Intercalations of Muth Quartzite in the Tanawals (e. g. Apharwat area) and of Tanawals in Muth Quartzite (e. g. Sind Valley, Basmai Anticline) show that there are a quartzitic shallow water facies and an argillaceous-arenaceous facies of deeper water, mutually replacing each other. It is interesting to note that the latter facies is dominant in the SW, that means nearer to the Indian Shield. The shallow water facies, parts of the sequence being non-marine, is prominent in the NE, towards the Tethys. This indicates the existence of a swell area (Himalayan Ridge, FUCHS, 1967, 1968).

Syringothyris Limestone

The Muth Quartzite is conformably overlain by a succession of gray to dark bluish thinly bedded, hard flaggy limestone with bands of shales, quartzites, and traps which may be intrusive. The Limestone is rich in brachiopods, *Syringothyris* being the most common genus after which this series has been named. The formation is exposed at Kotsu, Ichnar, Grenard, Gagarpathari, Paisan, Gugaldar, Marbal Pass, Lehindajjar, Bhugmore Rasta, Dowhat etc. where fossil collections can be made.

The Carboniferous Limestone has attracted the attention of geologists for more than a century as the first mention of them is to be found in a writing of HUGH FALCONER (1838) who collected fossils from this series. This was followed by a number of investigators and large number of fossils were collected by LYDEKKER (1883) and MIDDLEMISS (1910). These fossils were later described by DIENER (1899, 1915). All the Syringothyris Limestone fossils which DIENER (1915) identified and described are brachiopods. On the basis of the study of these fossils DIENER supported MIDDLEMISS's view regarding the Lower Carboniferous age of the Syringothyris Limestone.

GUPTA (1970) after carrying out palaeontological and stratigraphical investigations in the Anantnag District has suggested the following classification for this limestone series.

	(b) Coralline Stage (best exposed near Ichnar)	
Syringothyris Limestone		(ii) *Productus* Zone
	(a) Brachiopod Stage (best exposed in the Kotsu Hill)	(i) *Syringothyris* Zone

The most characteristic fossils of the *Syringothyris* Zone are *Syringothyris cuspidata, Spirigera subtilita, Chonetes hardrensis,* and representatives of *Derbyia, Athyris, Rhynchonella* etc.

This Zone may be of Tournaisian age or may include parts of Strunian.

The *Productus* Zone is characterized by the presence of *Productus semireticulatus, P. cora, P. lineatus, P. scabriculus* etc. The fauna indicates Late Tournaisian to Early Visean age.

The Coralline Stage has yielded a rich assemblage of rugose corals. In addition to *Caninophyllum archiaci* reported from Kotsu (GUPTA, 1969) the following forms have been found near Ichnar (GUPTA, 1970):

Nemistium cf. *N. edmondsi, Palaeosmilia* cf. *P. regia, Lophophyllum* cf. *L. interruptum, Dibunophyllum* cf. *D. briestolense, Pseudocaninia* cf. *longisepta* and *Caninia* sp.

A general analysis of these forms shows that the rugose corals listed above are similar to those known from the marine deposits of Lower Carboniferous age of Nova Scotia and several parts of Europe. The coralline fauna is suggestive of Visean age for the upper part of the Syringothyris Limestone.

In the Sind Valley, this series is poorly developed and has yielded a few poorly preserved fossils. The formation borders tectonically to the Dogra Slate in the Banihal Valley of the Pir Panjal Range. In Sind Valley, Naubug Valley, and Margan Pass areas, the Syringothyris Limestone is overlapped by the Panjal Volcanics.

The Syringothyris Limestone is lithologically and palaeontologically similar to the Lipak Series of Spiti (HAYDEN, 1904) and the Lower Carboniferous Limestone of Sarchu, Ladakh (GUPTA et al., 1970). Several species of brachiopods, corals, and crinoids are common in these regions. MIDDLEMISS (1910) suggested Lower Carboniferous age for this formation because of its similarity to the Lipak Series and the association of *Syringothyris cuspidata* with species of *Phillipsia* in the latter, which is regarded as of Lower Carboniferous age.

Passage Beds

The Syringothyris Limestone is followed by a considerable thickness of unfossiliferous quartzites and shales before the Fenestella Shales become signalized by the characteristic *Fenestella* bearing strata. Petrologically these beds are similar to the overlying Fenestella Shales and are well exposed near Aishmuqam (1½ mile N. N. E of Aishmuqam) and between Liwapatur and Peak no. 1.

Fenestella Shales

Fenestella Shales is the name given to a 600 meters thick succession of alternating thickly bedded fossiliferous shales (sandy, micaceous, and calcareous) and unfossiliferous quartzites with occasional bands of coarse thick conglomerates. The quartzites become thicker upwards in the succession. In its lower parts the succession is dominated by the shales whereas they become less conspicuous in the middle parts and pass into the Agglomeratic Slates in the upper part. These shales in the lower parts are full of *Fenestella* which gives the succession the name Fenestella Shales.

This series is well exposed in the Anantnag District and fossil collections can be made from near Buru, Lehindajjar, Bhugmore Rasta, Yanzar, head of Kirram Valley, Dowhat, Lur, and Ainu (between Liwapatur and Krapri). A few exposures of the series are met with near Banihal and Budil in the Pir Panjal Range. In the south-western part of the Valley the Fenestella Shales are missing.

The shales are full of bryozoans, brachiopods, pelecypods, corals, and a few representatives of trilobites and crinoids. Among the brachiopods important part is played by *Productus* and *Spirifer*.

Diener (1915) described 30 species of brachiopods, 6 species of pelecypods, and one species of trilobites from these shales. Gupta (1965) reported the occurrence of a *Griffithides* and Tewari and Singh (1967) recorded a few poorly preserved foraminifera (*Proteonina* cf. *P. cumberlandiae, Thuramminoides* cf. *T. sphaeroides, Hyperammina* cf. *H. clavata, Septammina kashmiriensis*). Verma (1969) discovered the presence of *Paraconularia* cf. *P. inaequicostata* from these shales exposed near Yanzar.

The opinions regarding the precise stratigraphic position of the Fenestella Shales differ. These have been regarded as Lower (Verma, 1969), Middle (Wadia, 1926; Fox, 1931; Burrard and Hayden, 1934) and Upper Carboniferous (Hayden in Burrard and Hayden, 1908).

The fauna from the Fenestella Shales has individual character and does not show any relationship with the faunas from other Anthracolithic formations. After discussing the Fenestella Shale fossils with the fossils of other areas Diener (1915) concluded by saying that: "It (the Fenestella Shales fauna) is certainly older than Permo-Carboniferous but its age correlation with Lower or Upper Carboniferous stages is still an open question." Middlemiss (1910) suggested Middle Carboniferous age for this series. According to Wadia (1926) "Fenestella shales can't be referred to any known Carboniferous horizons". Grabau (1926) suggested that the presence of *Syringothyris (S. lydekkeri)* shows affinities with the Dinantian, but the presence of *Aulosteges (A. percostata)* is suggestive of Upper Carboniferous age. The Productids *(Productus semireticulatus, P. cora, P. scabriculus, P. undatus)* and Spiriferids (*Spirifer trigonalis, S.* cf. *triangularis*), found elsewhere have a wide range and do not determine the age of these beds. The presence of *Vacunella curvata* indicates Upper Carboniferous age and the evidence on the basis of microfossils reported by Tewari and Singh (1967) also favors this. Contrary the conulariid reported by Verma (1969) suggests a Lower Carboniferous age for the series. Verma has supported his conclusions on the basis that *Dielasma hastatum* and *Syringothyris lydekkeri* which he found associated with his species of *Paraconularia* and all these forms indicate Lower Carboniferous age for this series.

The Fenestella Shales have been correlated with the Po Series of Spiti, the basal part of which (Thabo Stage) has yielded plant fossils indicating Lower Carboniferous age for at least lower part of the series. Gothan and Sahni (1942) after careful study of these plant remains are of the view that: "... the evidence at present available points as distinctly as possible Lower Carboniferous age for the Thabo Beds. If the overlying Fenestella shales are of Middle Carboniferous age, the Po Series should be regarded as covering a period from Lower to Middle Carboniferous."

The authors support Grabau (1926) in concluding that the fauna from this series lived in more or less isolated water bodies which favoured the development of provincial faunas which might have developed from the survivors of the beds underlying it (Syringothyris Limestone).

Observations made by FUCHS in the Marbal Pass — Singhpur area may be of importance for that problem. Near the pass the Fenestella Shales seem to be represented by the quartzites between the Syringothyris Limestone and the Agglomeratic Slate. W of Singhpur the Syringothyris Limestone is reduced to a few layers of limestone; the quartzites, however, alternate with dark Fenestella Shales full of Fenestellidae, Productidae, Spiriferidae, and crinoids. As in other sections the Fenestella Shales may be missing, it seems that the Syringothyris Limestone and the Fenestella Shales may replace each other, at least in part. On the other hand there is no sharp boundary to the overlying Agglomeratic Slate which, the typical tillites and tilloids excepted, is lithologically very similar. Thus the Fenestella Shales represent a facies which is frequent between the Syringothyris Limestone below and the Agglomeratic Slate above; the lower and upper formational boundaries, however, may rather vary.

The Fenestella Shales are conformably overlain by the Agglomeratic Slate. Locally it is directly overlapped by the Panjal Volcanics. The fauna from the lower fossiliferous zone of the Agglomeratic Slate has affinities with the faunas from the Fenestella Shales.

Agglomeratic Slates

The fossiliferous and unfossiliferous succession overlying the Fenestella Shales is known as Panjal Volcanic Series. This sequence of rocks can be divided into two parts; the lower part consists of slates, sandstones, quartzites, conglomerates, tilloids, agglomeratic slates and rare limestone constituting the "Agglomeratic Slate". The upper part comprising a thick succession of bedded andesitic and basaltic traps constitutes the Panjal Trap.

LYDEKKER (1883) classified the beds overlying the Fenestella Shales into Panjal Traps and Panjal conglomerates. MIDDLEMISS (1910) divided the Panjal Volcanic succession into Panjal Lava Flows and Agglomeratic Slates.

The exposures of this series are found in the Pir Panjal Range, parts of Baramula District, Lidder Valley in the Anantnag District, Kishtwar, and Chamba-Pangi (see Pl. 1, Fig. 2).

The Agglomeratic Slate has generally been regarded as unfossiliferous till BION (1928) reported a few fossiliferous beds from a number of localities within this series. In the Lidder Valley and parts of Panjal Range this series has not yielded any fossils so far. The best known exposures of fossiliferous beds belonging to this series are found near Nagmarg, Yal Nar, Apharwat, Kolahoi-Basmai Anticline, Marbal Valley, Gangangiyer, Traal, Bren spur etc. In Kishtwar, this series is developed near Singhpur, Senyar, and Sach Pass (Pangi).

MIDDLEMISS (1928) recognized the presence of two fossiliferous bands within this series. The lower zone is characterized by the presence of *Syringothyris cuspidata* var. *lydekkeri* and is found in the Marbal- and Kolahoi Anticlines about 800 feet above the base of the series. The upper zone which has *Syringothyris nagmarensis* as its characteristic fossil is exposed near Nagmarg, and Marbal Anticline about 100 feet below the base of the Panjal Trap.

The fossils from the lower zone are similar to those described from the Fenestella Shales. The most characteristic fossils of this zone are: *Syringothyris cuspidata* var. *lydekkeri, Camarophoria dowhatensis, Spirifer middlemissi, S. varuna, S.* aff. *niger, Derbyia* cf. *regularis, Productus* cf. *scabriculus, Eurydesma* sp., *Protoretepora* cf. *ampla* and *Fenestella* sp. BION (1928) has suggested Moscovian age for this zone.

The fauna from the upper zone is important in view of its individualistic character. BION (1928) has described a new species of *Spirifer-Spirifer nagmarensis* which he considered as index fossil for this zone. Stratigraphically this zone is much younger than the one referred above. The characteristic fossils of the upper zone are:

Spirifer nagmarensis, S. nitiensis, S. kimsari, S. cf. *keilhavii, S. fasciger, S. stockesii, Spiriferina* cf. *laminosa, Spiriferella* sp., *Productus scabriculus, P. cora* var. *lineatus, P. undatus, Dielasma, Streptorhynchus* sp., *Schellwienella* sp., *Lima* sp., *Protoretepora ampla, Fenestella* etc.

The Agglomeratic Slates of Nagmarg and Bren contain intercalations of Gondwana plants associated with the sandstones and shales containing marine forms like *Eurydesma*.

WATERHOUSE (1970) commenting on the fauna collected by R. D. THOMPSON from the Agglomeratic Slate at Bren Spur, Kashmir is of the view that the older horizon is characterized by *Eurydesma*, with *Deltopecten, Oriocrassatella* and other species. The younger horizon has *Taeniothaerus* as the characteristic form and includes *Palaeolima, Discina* and so called *Grantonia.* According to him *Polidevcia thompsoni, Neospirifer hardmani* and *Syringothyris nagmarensis* are common in both the horizons.

On the basis of the fauna discussed above it can be concluded that the slate series may range in age from Middle Carboniferous to Lower Permian.

The Agglomeratic Slate had been considered to have deposited as a result of ice action or volcanic activity. It has also been correlated with the Blaini and Talchir Boulder Beds and Talchir age has been assigned to it (FOX, 1931).

MIDDLEMISS (1910) after a detailed study of this formation has favoured the "Explosive Volcanic Theory" for the deposition of the lower members of the Panjal Volcanic series. According to him "... I regard it as an accumulation of clastic and sedimentary material formed around ruptured portions of the earth's crust which eventually became foci for the extrusion of lava flows". However, he did not completely rule out the other possibility of a glacial origin.

Certainly part of the Agglomeratic Slate has been deposited under marine conditions. This is shown by the fossils which are in part identical with those from the Fenestella Shales which are of doubtless marine nature. However, there are also horizons containing Gondwana plants. Thus a terrigenous origin of some sandstones or quartzites cann't be ruled out. We think that the volcanic influence was not as strong as might be expected from the name of the formation. Definitely there are tuffaceous, pyroclastic horizons and interbedded traps. But non-volcanic rocks predominate. Particularly the tilloids and tillites (?), — the "agglomeratic slates" — seem to be of glacial origin. Lithologically they are identical with the Blaini and Tanakki Boulder Beds. Striated and facetted boulders, however, hitherto haven't been found in Kashmir.

Panjal Trap

In the Lidder Valley, Pir Panjal Range, and parts of Kishtwar the Agglomeratic Slate is conformably overlain by a thick succession of bedded and massive andesitic and basaltic lava flows. Such volcanics are also known from the Kalhel area of Chamba. In the north-western part of the Kashmir Valley the traps unconformably overlie the Muth Quartzite, Dogra Slates, or Salkhalas. In the Naubug and Margan Pass areas these traps successively overlap older rocks like Fenestella Shales, Syringothyris Limestone, Muth Quartzite etc. with a thin conglomerate bed between.

In addition to the bedded traps, MIDDLEMISS (1910) recorded the presence of dykes (what most likely was the same magma), cutting through the Fenestella Shales and Agglomeratic Slate near Kollur in Lidder Valley and Mandara and Batton in the Traal Valley. At places the presence of dolerite sills in between the lava flows and in the Agglomeratic Slate is also recorded.

It seems that the explosive volcanism began with the production of agglomerates and tuffs which attain great thickness and pass upwards into bedded traps. The rock representatives of this type are andesites without olivine and the massive and amygdaloidal compact varieties are also common. In the amygdaloidal varieties, the amygdules range in size from a pins head to several inches in size. They are filled generally with minerals of the chlorite group and quartz. At places thick bands of limestone (near Bandipura) are found within different lava flows.

Stratigraphically the Panjal Trap ranges in age from Upper Carboniferous to Upper Triassic. The best known exposures from the stratigraphical point of view are exposed near Khunmu, Nagmarg-Bandipura section, Gurais etc. According to WADIA (1934) western Kashmir can be regarded as the chief centre of the volcanic activity, where the eruptions persisted for the longest interval of time.

Gangamopteris Beds

As discussed volcanic activity in the western part of the Kashmir Valley continued till the close of the Triassic whereas in the eastern parts the sea returned in the Permian Period when the fossiliferous Zewan Beds were deposited. After the close of volcanic eruption and before the deposition of Zewan Beds there was a period of continental sedimentation during which 240 meters of novaculites, black tuffaceous shales, limestone, and sandstones were deposited.

The plant bearing beds which can be referred to the Lower Gondwana System are exposed near Khunmu, Pailgam, Nagmarg, Pir Panjal, Gulmarg ect.

The Lower Gondwana flora was first discovered in the Himalayas by NOETLING in 1902 and HOLLAND (1903) referred to the discovery of *Ganga-*

mopteris and a few other plant fossils at Khunmu in the Vihi Valley of Kashmir in beds apparently below the marine strata of Permian age. These fossils were later described by SEWARD and SMITH WOODWARD (1905). HANDLIRSCH (1908) reported the occurrence of the fossil insect *Gondwanoblatta reticulata* from the Risin Spur. Among the fossils described by these workers are representatives of Labyrinthodonts and fish. HAYDEN (1907) published a detailed account of these beds and the plant fossils collected by him were later described by SEWARD (1907). DAS GUPTA (1910) described a fossil fish from these beds. MIDDLEMISS (1909, 1910) defined the stratigraphic position of these beds and according to him the Kashmir Gondwana beds occupy a position below the Zewan Beds and he (1915) suggested Artinskian age for them. The plant fossils from the Golabgarh Pass were described by SEWARD (1912). BOSE (1925) reported a new locality of Lower Gondwana Plant Beds near Bren Hill. BANA (1964) recorded the occurrence of another fossil insect *Progonoblattina columbiana* from these beds exposed near Bren Spur. VERMA (1967) reported the presence of *Kashmiroblatta marahomensis* from Lower Gondwanas of Marahom. SRIVASTAVA & KAPOOR (1969) recorded the occurrence of *Lepidostrobus* BRONGNIART a fossil cone from the Lower Gondwana of Pailgam. KAPOOR (1969) reported a few lycopods from these beds exposed near Risin Spur, east of Zewan. GUPTA (1970) recorded the occurrence of *Phlyctaenichthys pectinatus* from the Lower Gondwana of Apharwat. The characteristic fossils from the Lower Gondwana of Kashmir are:

Gangamopteris kashmiriensis, Glossopteris indica, Vertebraria sp., *Cordaites hislopi, Psygmophyllum haydeni, Lepidostrobus kashmiriensis, Phlyctaenichthys pectinatus, Amblypteris* sp., *Archaegosaurus* sp. etc.

The Lower Gondwana deposits of Kashmir are of pre-Middle Permian age as the overlying Zewan Beds have yielded definite Middle Permian fossils.

Zewan Series

The novaculites and siliceous shales yielding Lower Gondwana plant fossils are succeeded by 240 meters of marine fossiliferous limestones and shales which have been named Zewan Series after the Zewan Spur in the Vihi District of Kashmir where this series is best exposed.

The beds of the Zewan Series are richly fossiliferous and fossil collections were made by HAYDEN and MIDDLEMISS. These fossils were later described by DIENER (1915). MIDDLEMISS divided the Zewan Series (his Zewan Beds) into a number of horizons but as it has been pointed out by DIENER the zone fossils cann't be, strictly speaking, considered as such. Thus, for example, the horizon of *Spirifer rajah* is followed by a horizon in which a predominance of the same species is also noticed. GRABAU (1926) proposed a zonal classification of the formation, and the relationship of these zones with the horizons of MIDDLEMISS (as modified by DIENER) are given below:

GRABAU (1926)	MIDDLEMISS (emend. DIENER, 1915)
4. *Xenaspis carbonaria* Zone	*Lammelibranch* Zone
3. *Marginifera himalayensis* Zone	*Spirifer rajah* Zone *Marginifera himalayensis* Zone *Productus semireticulatus* Zone
2. *Protoretepora* Zone 1. *Hemiptychina* Zone	*Protoretepora* Zone

The *Hemiptychina* Zone is characterized by the presence of *Productus cora, P. purdoni, P. gangeticus, Marginifera spinocostata, Spirifer fasciger, Spirigerella (Athyris) derbyi, Camarophoria purdoni* and *Hemiptychina himalayensis.*

The characteristic fossils of the *Protoretepora* Zone are *Lyttonia nobilis, Spiriferina zewanensis, Derbyia*? sp., *Protoretepora ampla* etc.

GRABAU (1926) subdivided the *Marginifera himalayensis* Zone into *Productus indicus, Marginifera himalayensis* and *Spirifer rajah* Subzones.

The *Productus indicus* Subzone has the following characteristic fossils:

Aviculopecten cf. *hiemalis, Productus indicus, P. spiralis, P. gratiosus, P. abichi, P. gangeticus, P. cancrini, P. cancriniformis, Marginifera himalayensis, M. vihiana, Spirifer rajah, Spiriferina cristata* var. *fastigata, S.* cf. *vercherii, Spirigera xetra, S. royssii, S. subexpansa, Camarophoria purdoni,* ***Dielasma biplex,*** *D. acutangulum, Hemiptychina himalayensis.*

The *Marginifera himalayensis* Subzone has the following species:

Eumicroites middlemissi, Productus waagenianus, P. abichi, P. gangeticus, Marginifera himalayensis, Chonetes lissarensis, Lyttonia nobilis, Spirifer fasciger, S. nitiensis, S. rajah, Spiriferina cristata, var. *fastigata, S. ornata, S. zewanensis, Spirigera* cf. *gerardi, S. subexpansa, Camarophoria purdoni, Dielasma latouchei.*

The only palaeontological difference between the abovementioned two subzones is that the *Productus indicus* Subzone is characterized by the predominance of *Producti* of the *semireticulatus* group which are absent in the latter, otherwise both are similar palaeontologically and stratigraphically.

The fauna of the third subzone (*Spirifer rajah* Subzone) includes:

Eumycrites sp., *Pseudomonotis* sp., *Aviculopecten* sp., *Pleurophorus* sp., *Schizodus* sp., *Productus* cf. *purdoni, P. indicus, P. spiralis, P. abichi, P. gangeticus, P. waagenianus, Marginifera himalayensis, M.* cf. *helica, Chonetes lissarensis.*

It may be remarked that the ammonite described from the topmost portion of the Zewan Series is *Xenaspis* cf. *carbonaria* and not *Xenaspis carbonaria* as stated by GRABAU (1926).

GUPTA suggests that a three fold classification will be more appropriate on the basis of the fossils found therein.

Upper	Lamellibranch Zone
Middle	Brachiopod Zone
Lower	*Protoretepora* Zone

The affinites of the Zewan Bed fauna with those of other Permian formations, e. g. Thini Chu Fn. (Northern Nepal), Kuling, Productus Lms. etc., clearly indicates a Permian age (see WATERHOUSE 1966, pp. 81—86).

The Agglomeratic Slate and traps of the Chamba Synclinorium are overlain by a succession of dark slates and phyllites which grade into a sequence of well-bedded blue to grey limestone (near Kalhel). The limestone has yielded crinoids (McMAHON 1883, p. 40), and a poorly preserved ammonite (GUPTA & BEDI 1970).

Whereas GUPTA & BEDI have suggested a Lower to Middle Carboniferous age, FUCHS from the fossils, the lithology, and the succession of the beds favours a Lower Triassic age for the Kalhel limestone. From Fig. 2 it may be seen that the limestone in question has a stratigraphic position higher than the trap and Agglomeratic Slate. Thus a Triassic age of the core of the syncline is indicated from the sequence of rocks. If this is accepted the dark phyllites and passage beds to the limestone could well represent Gondwanas and the Zewan Beds. Fossils, however, haven't been found hitherto in these rocks.

In Kashmir the Zewan Series is conformably overlain by beds of the Lower Triassic limestone.

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