

## 8.25 SALT RANGE

The Salt Range area is in Pakistan. It is situated at the southern side of the Potwar plateau. Here the Cambrian and Permo-carboniferous rocks are well exposed.

### 8.25.1. Cambrian Rocks

In the Cambrian succession of Salt Range, the "Saline series" is at the base. It is then conformably overlain by "Purple sandstone", "Neobolus shales", "Magnesian sandstone" and "Salt pseudomorph beds" (Table 8.18). The Neobolus shales have yielded fossils of brachiopod Neobolus and some trilobites (Redlichia) of Lower Cambrian age.

Table 8.18. Cambrian Succession of Salt Range

Formation	Lithology
Salt Pseudomorph Beds (105 m)	Shales with pseudomorphs of salt crystals.
Magnesian Sandstone (75 m)	Dolomitic sandstone
Neobolus Shales (45 m)	Fossiliferous grey shales
Purple Sandstone (75—140 m)	Fine grained purple sandstone
Saline Series (450 m)	Gypsum-dolomite, marls, and rock salt.

**Saline Series.** It is the basal member of the Cambrian succession. It is composed mainly of gypsum, marls and rock-salt with some decomposed lavaflores of basic composition. The Saline series has been subdivided into three parts : (i) the lower part, containing gypsum and gypsum-dolomite, (ii) the middle part, which is made up of red salt marls and beds of rock salt, and (iii) the upper part, containing gypsum and dolomite. The micro-fossils of Eocene age have been found in the beds of the Saline series.

**Purple Sandstone.** The beds of purple sandstones overlie the Saline series. They show current bedding and ripple marks and appear similar to the Upper Vindhyan sandstones.

**Neobolus Beds.** These are the fossiliferous beds of shales which contain brachiopods (Neobolus, Orthis, etc.), trilobites (Redlichia), and gasteropods.

**Magnesian Sandstones.** These are dolomitic sandstones which are up to 85 meters thick. The main fossil found in these sandstones is a gasteropod called "Stenotheca".

**Salt Pseudomorph Shales.** These shales occur at the top of the Cambrian succession of Salt Range. They contain cubic pseudomorphs of clay. These pseudomorphs are formed by the replacement of salt crystals by clay.

### 8.25.2. Age of Saline Series

The Age of the Saline series has been a matter of controversy among Indian geologists. According to the law of order of superposition, it may be regarded as of Cambrian age. However, the structural features, micro-fossils and other features indicate that it may be of Eocene age.



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**Views in Favour of Eocene Age.** B.Sahni, E.H. Pascoe, D.N. Wadia and L.M. Davies are of the opinion that the Saline series is of Eocene age and its present position below the Cambrian succession is due to thrusting. The evidences in favour of Eocene age are as follows.

1. The beds of the Saline series contain micro-fossils of plants and insects of Eocene age.
2. The contact between the Saline series and Purple sandstone is characterized by features which indicate structural disturbances.
3. In the Jogi Tilla and Diljaba areas, the Eocene beds are found thrust over by Cambrian rocks. Although here no salt marl is exposed, its presence at depth is indicated by the saline springs issuing from the fault plane.

**Views in Favour of Cambrian Age.** The Saline series is conformably overlain by the Cambrian succession. Hence it may be of Cambrian age. This view is favoured by E.S. Pinfold, C.S. Fox, E.R. Gee, E. Lehner and P.K. Ghosh. The evidences which are in favour of Cambrian age, are as follows.

1. E.R. Gee is of the opinion that the junction between the Saline series and the Cambrian succession is an undisturbed sedimentary contact and there is no evidence of large scale thrusting.
2. The features which suggest structural disturbances may have been produced due to disharmonic folding of the competent beds of Purple sandstone which rest over the highly incompetent beds of the Saline series.
3. The micro-fossils of Tertiary age which have been found in the Saline series, may have been introduced into it from outside by the groundwater.
4. Lehner (1946) points out that there are saline beds of two different ages in the Tethyan basin of Persia, one of Cambrian age and the other of Miocene age. The Saline series of Salt Range resembles to the Hormuz series of Cambrian age.
5. Schindewolf and Seiacher (1955) have suggested that the Salt pseudomorph beds which occur towards the top of the Cambrian succession indicate the recurrence of the evaporitic conditions which prevailed during the formation of the Saline series. This confirms the continuity in sedimentation from the Saline series to the Cambrian succession.

Thus the evidences given above are conflicting and therefore the problem of the age of the Saline series still remains unsolved. However, the evidences go more in favour of its Cambrian age.



### 8.25.3. Permo-carboniferous Rocks

In Salt Range, the rocks belonging to the Ordovician, Silurian, Devonian and Lower Carboniferous periods are missing and the Permo-carboniferous rocks are present. They rest directly over the Salt pseudomorph beds of Cambrian succession. The Permo-carboniferous succession of the Salt Range is shown in Table 8.19.

**Table 8.19. Permo-carboniferous Rocks of Salt Range**

Formation	Lithology	Description
Permian	Productus limestone (230 m)	Rich in marine fossils.
Upper Carboniferous	<ul style="list-style-type: none"> <li>Speckled sandstone (100 m)</li> <li>Olive Formation (100 m)</li> <li>Glacial boulder bed (3–65 m)</li> </ul>	<ul style="list-style-type: none"> <li>Shallow water deposits</li> <li>Rich in gasteropod (<i>Conularia</i>)</li> <li>Glacial deposits</li> </ul>

**Glacial Boulder Bed.** This bed rests unconformably over the Cambrian succession. It is composed of glacial boulders of different sizes. The total thickness of this formation is about 60 meters. The upper part of this formation contains plant fossils of Upper Carboniferous (Lower Gondwana) age.

**Olive Formation.** This formation is composed of olive shales and sandstones. This formation is also called the "*Conularia beds*" because it contains remains of gasteropods (*Conularia*) in abundance. The other fossils of this formation are lamellibranchs (*Eurydesma*) of Lower Permian age and plant fossils such as *Gangamopteris* and *Glossopteris*.

**Speckled Sandstone.** This formation is composed mainly of speckled sandstones of light red colour. In the upper part of the succession shales predominate. The rock beds exhibit current bedding and ripple marks which indicate that they are shallow water deposits.

**Productus Limestone.** The Productus limestone of Salt Range is regarded as one of the best developed Permian formation in the world. It is characterized by rich marine fossils. This formation has been subdivided into three parts.

(i) *Lower Products Limestone.* This part of the formation is composed of calcareous sandstones and carbonaceous shales. These beds contain fossils of Lower Permian age. The chief fossils are brachiopods (*Productus spiralis*, *Spirifer* and *Athyris*) and foraminifers (*Fusulinids*).

(ii) *Middle Productus Limestone.* This part is composed of limestones and dolomites. These rock beds are the richest in fossils. The chief fossils are brachiopods (*Productus indicus*, *Productus lineatus*, *Spirifer*, *Athyris*), lamellibranchs (*Pseudomonotis*), gasteropods (*Pleurotomaria*), and ammonites (*Xenaspis*).



(iii) *Upper Productus Limestone*. This part of the formation is composed of sandstones and marls. The chief fossils found in these beds are brachiopods (*Productus indicus*, *Productus spiralis*), lamellibranchs (*Schizodus*), gasteropods (*Bellerophon*), and ammonites (*Xenodiscus*, *Planetoceras*).

## 8.26. KASHMIR

### 8.26.1 Cambrian Rocks

The Cambrian rocks of Kashmir rest conformably over the fossiliferous "Dogra slates" of Precambrian age. The succession is composed chiefly of clays, impure sandstone and greywacks with a few lenticular bands of limestone. The clay beds are fossiliferous and they contain trilobites (*Ptychoparia*, *Solenopleura*), brachiopods (*Acrothele*, *Lingulella*), pteropods, crinoids, and sponges of Cambrian age.

### 8.26.2 Ordovician and Silurian Rocks

The Ordovician rocks of Kashmir and adjacent areas are composed of shales, silt and limestones. The shales have yielded well preserved bryozoans, brachiopods and cystoids. The Ordovician rocks are conformably overlain by a succession of sandstones, slates and greywacks which have yielded fossils of Silurian age.

### 8.26.3. Devonian Rocks

**Muth Quartzite.** In the northern parts of Kashmir, Muth quartzites of Devonian age are exposed. They constitute a thickness of about 650 meters. They rest either over the Cambrian rocks or over the rocks of Silurian age and are conformably overlain by the "*Syringothyris limestone*" of Carboniferous age. The Muth quartzites are mostly unfossiliferous.

### 8.26.4. Permo-carboniferous Rocks

The Permo-carboniferous succession of the Kashmir area has been divided into six formations : (i) *Syringothyris limestone*, (ii) *Fenestella shales*, (iii) *Agglomeratic slates*, (iv) *Panjal traps*, (v) *Gangamopteris beds*, and (vi) *Zewan formation*. These formations are shown in Table 8.20.

Table 8.20. Permo-carboniferous Rocks of Kashmir

Periods	Formations	Lithology
Permian	{ Zewan formation	Shales and limestones with marine fossils
	{ Gangamopteris beds	Slates and pyroclastic beds with plant fossils
Carboniferous	{ Panjal traps	Basaltic lavaflows
	{ Agglomeratic slates	Slates and greywacks
	{ Fenestella shales	Shales and quartzites
	{ Syringothyris limestone	Limestones
<b>Muth Quartzites (Devonian)</b>		



**Syringothyris Limestone.** The Muth quartzites are conformably overlain by the "*Syringothyris limestone*". This formation is composed of thin beds of grey and dark blue limestones with a few beds of shales, quartzites and traps. The limestones are characterized by the presence of the brachiopod "*Syringothyris*" of Lower Carboniferous age.

**Fenestella Shales.** The Fenestella shales are composed of a 600 meters thick succession of shales and quartzites with a few beds of conglomerates. The shale beds are fossiliferous and contain abundant remains of a polyzoa, called "*Fenestella*". These beds also contain bryozoans, brachiopods, pelecypods, corals, trilobites and crinoids ranging in age from Lower to Upper Carboniferous.

**Agglomeratic Slates.** This formation consists of a succession of slates, sandstones, quartzites and conglomerates. These rock beds are considered to be of volcanic origin. The fossils are generally absent in this formation.

**Panjal Traps.** The Agglomeratic slate formation is overlain by a thick succession of lavafloes of basaltic composition, known as the "*Panjal traps*". The maximum thickness of these lavafloes is up to 2300 meters. The lavafloes are intercalated with pyroclastic materials and intertrappean beds, and they may be of Upper Carboniferous to Lower Permian age.

**Gangamopteris Beds.** In some parts of Kashmir, the Panjal traps are overlain by beds of slaty and pyroclastic rocks. These beds have yielded plant fossils of Lower Gondwana (Lower Permian) age. The chief plant fossils are *Gangamopteris kashmirensis*, *Glossopteris indica*, and *Vertebraria*.

**Zewan Beds.** The Gangamopteris beds are overlain by a 240 meters thick succession of limestones and shales. These beds are rich in marine fossils of Middle and Upper Permian age. The chief fossils are brachiopods (*Spirigera*, *Chonetes*, and many species of *Productus* and *Spirifer*), bryozoans (*Fenestella* and *Protoretropa*), and corals (*Zaphrentis*).

## 8.27. SPITI

Table 8.21. Palaeozoic Succession of Spiti

Periods	Groups	Formations
Permian	Kuling Group	{ Productus shales Calcareous sandstone Conglomerates and grits
Carboniferous	Kanawar Group	{ Po formation Lipak formation
Devonian		Muth quartzites
Silurian and Ordovician		{ Limestones, sandstones, quartzites and shales
Cambrian	Haimanta Group	Quartzites, slates and shales



In the Spiti area of Himachal Pradesh, a complete succession of rocks ranging in a age from the Precambrian to Cretaceous is exposed. The succession of the Palaeozoic rocks of this area is shown in Table 8.21.

### 8.27.1. Cambrian Rocks

**Haimanta Group.** The Haimanta group rests over the rocks of the Vaikrita group of Precambrian age. The Haimanta group consists of about 1500 meters thick succession of quartzites, slates and shales with some dolomite. The lower 600 meters thick rock beds are unfossiliferous while the rocks of the upper part of the succession contain a rich collection of trilobites (*Redlichia*, *Agnostus*, etc.) and brachiopods (*Lingulella*, *Obolella*, *Acrothele*, etc.). These fossils indicate that the age of the upper part of the Haimanta group ranges between Middle to Upper Cambrian. Hence some members of its lowermost part may be correlated with the Precambrian rocks.

### 8.27.2. Ordovician and Silurian Rocks

The rocks of the Haimanta group are conformably overlain by a succession of coarse red conglomerate, gritty quartzites, sandstones, shales, limestones and dolomites. The total thickness of the Ordovician and Silurian succession is about 750 meters. The Ordovician rock beds have yielded fossils of trilobites (*Asaphus*, *Iliaenus*), brachiopods (*Orthis*, *Leptaena*, *Strophomena*), and cephalopods (*Goniaceras*). The chief fossils of the Silurian rocks are trilobites (*Calymene*), brachiopods (*Orthis*, *Pentamerus*), and corals (*Zaphrentis*).

### 8.27.3. Devonian Rocks

**Muth Quartzites.** This formation of the Spiti area consists of about 100 meter thick succession of white and light green quartzites. The age of the Muth quartzites ranges from Upper Silurian to Devonian.

### 8.27.4. Permo-carboniferous Rocks

The Permo-carboniferous succession of the Spiti area has been divided into two groups : (i) the "*Kanawar group*", and (ii) the "*Kuling group*". These two groups are separated by an unconformity which is represented by a conglomerate (Table 8.22).

**Kanawar Group.** This group has been subdivided into two formations. The lower formation is called the "*Lipak formation*", and the upper one is called the "*Po formation*".

- (i) *Lipak Formation.* The Lipak formation consists of a succession of limestones and shales. This formation has yielded fossils of Lower Carboniferous age. The chief fossils are trilobites (*Phillipsia*), brachiopod (*Syringothyris cuspidata*), and coral (*Cyathophyl- lum*).



Table 8.22. Permo-carboniferous Rocks of Spiti

Group	Formation	Lithology
Kuling Group (100 m)		{ Productus shales Calcareous sandstone
	(Unconformity) Conglomerate	
Kanawar Group (1300 m)	{ Po formation	Shales and quartzites
	{ Lipak formation	Shales and limestone

(ii) *Po Formation*. This formation rests conformably over the Lipak formation. It is made up of a succession of quartzites and shales. The chief fossils of this formation are bryozoans (*Fenestella*), and brachiopods (*Spirifer*, *Productus*).

The Po formation is overlain by a horizon of conglomerate which may be of Upper Carboniferous age. This conglomerate represents an unconformity of a comparatively short interval.

**Kuling Group.** The "*Kuling group*" is composed of a succession of calcareous sandstones and shales. The calcareous sandstones have yielded brachiopods (*Spirifer*, *Productus*) of Middle Permian age. The carbonaceous shales of the upper part of the Kuling group are called the "*Productus shales*". These shales have yielded fossils of brachiopods (*Productus*), and cephalopods (*Xenaspis*, *Cyclolobus*) of Permian age.