

Comparative Study of Brachiopods of Chhidru Formation from Zaluch and Nammal Sections, Western Salt Range, Pakistan

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ABSTRACT

The Zaluch and Nammal sections are important reference areas of the marine upper Permian of the world. These sections are located in Mianwali District, Punjab, Pakistan. Specimens of brachiopods have been studied from Chhidru Formation in Zaluch and Nammal sections. The main results are summarized as follow;

Paleontological study resulted in the identification of the following 8 genera and 10 species from Zaluch as follow: *Nudauris diabloensis*, *Waagenoconcha abichi*, *Waagenoconcha purdoni*, *Linoproductus semisulcatus*, *Linoproductus angustus*, *Cleiothyridina pilularis*, *Composita crassa*, *Derbyia altestriata*, *Derbyia pannucia* and *Marginifera opima*. In addition 7 genera and 8 species from Nammal section as follow: *Nudauris diabloensis*, *Waagenoconcha abichi*, *Linoproductus semisulcatus*, *Linoproductus angustus*, *Cleiothyridina pilularis*, *Composita crassa*, *Derbyia pannucia* and *Marginifera opima*.

Based on the studies and research of the above-mentioned fauna, two-biostratigraphic zones have been established from both sections as: (A) *Waagenoconcha abichi* indicating Early Dzhulfian age and (B) *Derbyia pannucia-Marginifera opima* indicating Late Dzhulfian age.

Palaeoenvironments has been interpreted on the bases of the above-mentioned brachiopod fauna as inner sublittoral environment of deposition for the Chhidru Formation.

Chhidru Formation along Zaluch section shows comparatively well-populated brachiopod fauna and suggests deeper environment of deposition.

INTRODUCTION

The mass extinction of the animal kingdom along the Permian-Triassic boundary is one of the major interesting research subject for world historical geologists and paleontologists to solve this problem. It is important to make clear faunal distinction, which occurred throughout the Permian-lower Triassic, with an accurate age and correlation. The study area is located within the Survey of Pakistan topographic sheet # 38P/9 Zaluch section is located between the latitudes 32° 48' 00" to 32° 50' 30" N and longitudes 71° 37' 30" to 71° 40' 30", while the Nammal section is bounded by 71° 47' 38" E to 71° 47' 39" E longitude and 32° 39' 431" N to 32° 39' 393" N latitude (Figure 1) It constitutes a part of Western Salt Range and as an important reference place for the upper Permian

marine strata. Many scientists examined this area, but problems, such as age-assignment of the Permian rocks, the interpretation on the occurrence of the Permian-type brachiopods remained uncertain. The prime purpose of the present study is to present more accurate and detailed biostratigraphic data of the upper Permian strata (Chhidru Formation) and make a comparison of these data along Zaluch and Nammal sections based on brachiopod fauna.

The study area is easily accessible from the Mianwali-Kalabagh trunk road. From the village Paikhel it lies along Mianwali-Kalabagh road at 10 Km dirt track leads to the mouth of Zaluch Nala. Nammal Gorge section is located approximately 30km northeast of Mianwali along Mianwali-Musakhel road.

GENERAL GEOLOGY OF THE AREA

The Zaluch and Nammal sections have attracted the geologists since long time. The controversial Permo-Triassic boundary and occurrence of petroleum in nearby areas has further added to the attraction.

A few more Paleozoic species were described by Verchere and Albert (1866). Term "Productus Limestone" was used for the formation and indicated its thickness quite accurately to be 1100 feet (Theobald, 1854).

The Cis-Indus Salt Range can further be subdivided into Eastern, Central and Western parts. Salt Range with its Trans-Indus extension exposes the complete section from Precambrian to Quaternary. The Zaluch Gorge has the best-exposed sections for the study of Paleozoic-Mesozoic boundary (K/T boundary) in Pakistan. Moreover the Triassic rock exposures are excellently developed and well exposed by stream cuts. The Lower contact of the Triassic sequence i.e. the contact between the Mianwali and Chhidru Formation is marked by Paraconformity (Shah, 1977). The Tredian Formation conformably overlies the Mianwali Formation, which is overlain by the Kingriali Formation. The upper contact of the Kingriali Formation with the Datta Formation is marked by an unconformity a conglomerate bed i.e. at the top of the Kingriali Formation.

STRATIGRAPHY

The rocks exposed in the Salt Range in age from Precambrian to Eocene. Details of stratigraphic sequence are as follow:

The Paleozoic rocks of the Salt Range include Jhelum Group of Cambrian age including continental to shallow marine sandstone. Also include limestone and dolomite (Fatmi, 1973). The younger Paleozoic rocks include Nilawahan and Zaluch Groups of Permian age composed of continental to marine origin mostly sandstones and limestones (Shah, 1977). The Mesozoic rocks of the Salt

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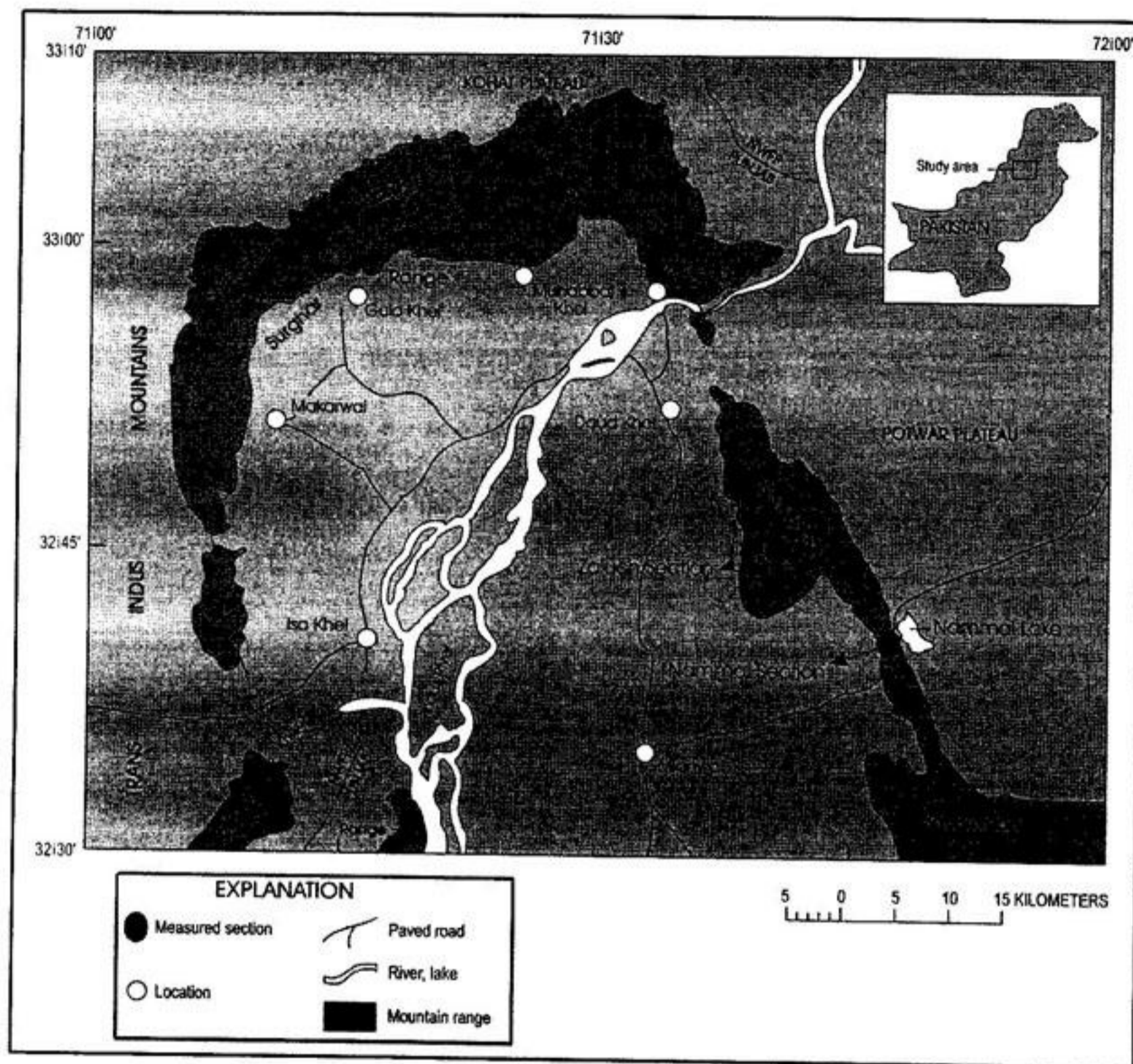


Figure 1- Location map of the study area. Black dots indicate the location of measured sections.

Range include rocks of Musakhel Group (Mianwali, Tredian & Kingriali Formations) of Triassic age, the Jurassic (Surghar Group) Datta, Shinawari and Samanasuk, Chichali, Lumshiwali and Kawagarh Formations of Cretaceous age. These rocks belong to a wide variety of environment including fluvial, deltaic, shallow marine and deep marine (Fatmi, 1973).

PERMIAN STRATIGRAPHY OF ZALUCH AND NAMMAL SECTIONS

The Permian sequence of the Salt Range is divisible in to two parts that is Early and Late Permian. The Early Permian stratigraphy of the Zaluch Nala comprises Nilawahan Group that includes from bottom to top the following formations.

3. Sardhai Formation
2. Warcha Sandstone
1. Tobra Formation

The Late Permian sequences in the Western Salt Range are represented by Zaluch Group, which includes Amb, Wargal and Chhidru Formations from bottom to top.

3. Chhidru Formation
2. Wargal Formation
1. Amb Formation

The Nilawah group is dominantly composed of clays of variegated color, sandstones, shale and tillites, demonstrating variety of depositional environments. While Zaluch group represent platform carbonate sediments with minor interbedded shales i.e. variety of limestones including massive, thick to medium bedded, nodular and sandy.

The Permian sequence exposed in Nammal section is Zaluch Group comprised of Wargal and Chhidru Formations. Rocks units include limestone, sandy limestone, interbedded shale and clays. The lower contact of these rocks is not exposed and the upper contact of Chhidru Formation with the Mianwali Formation of Triassic age is paraconformable.

CHHIDRU FORMATION

Chhidru Formation is the name given by Teichert (1966) after the type locality Chhidru Nala. (Lat. 32 31N; 71 48 E). The formation was previously named as Chhidru Beds (Waagen 1891).

The formation is widely distributed in the western Salt Range and Trans-Indus ranges (Kummel and Teichert 1970), (Pakistani-Japanese Research Group, 1981 and 1985) The lower contact of the Formation is conformable with the Wargal Formation. Whereas upper contact with Kathwai member of Mianwali Formation is regarded as para-conformity. There is considerable variation in stratigraphic thickness measured by previous workers, (Kummel and Teichert 1970) measured Chhidru Formation at Zaluch Nala, Zaluch Gorge and Chhidru Nala reported 58.4m, 63.63m, and 81.81m respectively. Rocks are predominantly composed of detritus, marked by variable influx of siliciclastic. Unlike the Wargal Formation. Chhidru Formation can be regarded as clastic dominated unit with rare intercalations of limestone beds. Dasycladacian algal fragments and spores and pollens rarely occur in certain beds. Paleontological studies were carried out by various workers including Pascoe (1964) and Japanese Research Group (1985). The issue of age assignment for Chhidru Formation has been addressed by various workers like; Furnish and Glenister (1970) considered it as post Guadalupian age on the basis of ammonoids genus *Cyclolobus*, while Kummel and Teichert (1970) pointed out the complexity of the controversial age assignment and demanded for more studies. Pakistani-Japanese Research Group, (1981) assigned Dzhulfian age to this formation on the basis of fusulinids and smaller foraminifera.

Chhidru Formation was observed carefully in Nammal and Zaluch sections. The lithology is rather variable from place to place. It can be divisible into four units, showing unstable sedimentary environments of different thickness along both sections. Chhidru Formation is 59.2m and 54m thick in Nammal and Zaluch section respectively.

Unit 1. It is 10m and 12m thick in Zaluch and Nammal respectively, mainly composed of alternations of black sandy shale and fine-grained muddy sandstone.

Unit 2. is 12m and 19m thick in Zaluch and Nammal respectively. Lower part of the unit consists of alternations of calcareous sandstone or sandy limestone and fine-grained sandstone.

Unit 3. is 25m and 21m thick in Zaluch and Nammal respectively. Consisting mostly of alternations of medium-bedded sandstone and calcareous sandstone.

Unit 4. is 7m and 7.2m thick in Zaluch and Nammal respectively. This unit is composed of soft weathered white sandstone with interbeds of calcareous sandstone.

TAXONOMY OF PERMIAN BRACHIOPODS

Phylum: Brachiopoda

Class: Articulata Huxley, 1869

Order: Spiriferida Waagen, 1883

Suborder: Athyrididina Boucot, Johnson and Staton, 1964

Genus: *Composita* Brown and Thomas, 1849

Composita Brown and Thomas, 1849:131.-Hall and Clarke, 1892:93.-Buckman, 1906:324. -Weller, 1914:484.-Dunber and Condra, 1932:362.-Williams and Alwyn, 1965: H662.-Cooper and Grant, 1976:2140.

Description

Shell biconvex; outline subovate, or subtrigonal, commonly widest near midlength. Fold beginning far anterior, normally not standing high on brachial valve. Sulcus shallow, beginning some what earlier than fold on pedicle valve; costae absent. Growth line fine, closely and regularly spaced; growth laminae stronger, more widely and randomly spaced. Pedicle valve moderately to strongly convex transversely and longitudinally. Beak, thick, rounded, without well-defined beak ridges, foramen large, ovate. Pedicle valve interior having two knoblike hinge teeth. Brachial valve most strongly convex near umbo, beak short. Brachial valve with flat, nearly square hinge plate, and nearly square cardinal process. Characterized by narrow hinge; lack of interarea or beak ridges.

Species: *Composita crassa* Cooper and Grant, 1976

Composita crassa Cooper and Grant, 1976: 2149, pl. 655: figs. 1-39.

Composita persinuata King, 1931: 130, pl. 43: figs. 18-19.

Description

Moderately to strongly biconvex shell, outline sub triangular to sub-ovate, normally widest anterior to midlength. Commissure moderately to strongly uniplicate. Fold standing only slightly above flanks at anterior, crest broadly or narrowly arched, or slightly flattened, beginning anterior to brachial beak. Sulcus shallow, depressed below flanks only near anterior. Growth laminae moderately strong near margins of most specimens, weak on some. Pedicle valve most strongly convex near or in umbonal region; beak

thick, long, suberect to slightly incurved. Brachial valve inflated in umbonal region, beak is short, bluntly pointed, overlapped by pedicle beak. Costae absent. Narrow hinge, and lacking or very small interarea.

Genus: Cleiothyridina Buckman, 1906.

Cleiothyridina Buckman, 1906:324.-Hall and Clarke 1892:90.-Weller 1914:472.- Williams and Alwyn 1965:H662.-Carter 1967:342.- Cooper and Grant 1976:2134.

Description

Small to medium size, moderately strongly bi-convex to subglobose; outline sub circular to transversely subelliptical, greatest width near midlength; hinge narrow, without producing ends. Less commonly weakly sulcate; in some species fold beginning near beak and remaining prominent toward anterior, in some species absent. Sulcus shallow, gently rounded in most species, sharply outlined in some; Radial ornamentation absent. Pedicle valve moderately to strongly convex, greatest swelling normally just anterior to umbonal region; beak short, foramen small. Pedicle valve interior with rather large hinge teeth. Brachial valve slightly less strongly convex creates swelling in umbonal region; beak is pointed. Brachial valve interior with slightly concave hinge plate at beak, with small tooth-like cardinal process.

Species: Cleiothyridina pilularis Cooper and Grant, 1976

Cleiothyridina pilularis Cooper and Grant, 1976: 2137, pl. 650: figs. 50-83.

Description

Moderately to strongly biconvex, outlines are transversely sub elliptical to subpentagonal, greatest width near midlength; Commissure uniplicate. Fold low, broadly rounded, beginning on beak little anteriorly. Sulcus shallow gently rounded, which beginning of pedicle beak little anteriorly. Growth laminae concentric, strong, breaking slopes of valves, widely and irregularly spaced. Pedicle valve moderately convex, greatest convexity located in umbonal region; beak is short, thick, sub erect to erect, beak ridges rounded; foramen incomplete subcircular, perforating apex of beak. Brachial valve slightly less strongly convex longitudinally, beak is pointed obtusely. Radial ornament absent, narrow hinge area and lacking interarea or very small. Spiralia are observed.

Order: Strophomenida Opik, 1934

Suborder: Orthotetidina Waagen, 1884

Genus: Derbyia Waagen, 1884

Derbyia Waagen, 1884:576,591.-Hall and Clarke, 1892:261.-Schellwien, 1900:10.- Girty, 1909:81.-Dunbar and Condra, 1932:75.-Sokolskaya, 1960:219.-Cooper and Grant 1974:289.-Grabau, 1931:259, 262.-Thomas, 1937:13-18.-Derbyaconcha Licharew, 1934:507

Description

Shell large, Plano convex or biconvex nearly flat to deeply conical, commonly irregular and distorted. Usually have broad and flat interarea; in some other attached species it is twisted, concave, or convex. Usually ornamented by weak or strong costellae and growth lines. Pedicle interior with forward projecting teeth. Brachial valve interior with long or short cardinal process.

Species: Derbyia pannucia Cooper and Grant, 1974

Derbyia pannucia Cooper and Grant, 1974: 308, pl. 83: figs. 1-2, pl. 84: figs. 1-8, pl. 85: figs. 1-7, pl. 86: figs. 1-11.

Description

Shell is large moderately thick walled, flatly to moderately biconvex, normally irregular, shaped modified by attachment or spontaneously deformed. Outline transversally sub elliptical to nearly semicircular. Commissure is very irregular and wavy in detail. Growth laminae moderately well developed, radial ornamentation is weak to moderately strong, fine i.e. weak or strong Costellae. Pedicle valve flattish to strongly convex; profile may be concave, nearly flat, convex. Interarea wide, low to moderately high, edges irregular. Pedicle valve interior with hinge teeth projecting forward from underside of interarea. Brachial valve moderately to strongly convex may have strongly over-hanging beak.

Species: Derbyia altetriata Schellwien 1900

Description

Shell large, biconvex nearly flat to deeply conical, commonly irregular and distorted. Usually ornamented by weak or strong costellae and growth lines. Interarea wide, low to moderately high. Pedicle valve flattish, interior with hinge teeth projecting forward.

Suborder: Productidina Waagen, 1883

Genus: Waagenoconcha Chao, 1927

Chao 1927:24, 85.-Dunbar and Condra, 1932:190.-King, 1931:80.-Muir-Wood and Cooper, 1960:252.-Williams and Alwyn, 1965:H488.-Grant, 1966:660.- Fredericks and Georg, 1928:789.

Description

Large, elongate -oval shaped shell, with rounded sides, anterior may also broadly rounded. These are completely costate having a brush of haltered spines on the ears: Posterior region of both valves reticulated, regularly on the brachial valve but raggedly on the pedicle valve. This genus is not yet completely understood because it is rare or unusual at most places. This genus makes up a group of usually large to gigantic productids that are fairly widespread in the Permian and are especially common in arctic regions.

Species: *Waagenoconcha abichi* (Waagen)

Cf. *Productus abichi* Waagen, 1884, p. 697, pl. 74, figs. 1-6.

Cf. *Waagenoconcha abichi* (Waagen), Branson, 1948, p. 552 (includes extensive synonymy of species prior to 1948); Muir-Wood and Cooper, 1960, pl. 89, figs. 1-5; Grant, 1966, p. 1063, pl. 131, figs. 1-4; pl. 132, figs. 1-10.

cf. *Waagenoconcha sp.*, Nelson, 1961, pl. 29, fig. 4.

Description

Specimen is not in very good condition therefore very close observations were taken. Large, elongate-oval shaped shell, with rounded sides, anterior may also broadly rounded. Hinge is narrow than midwidth; ear small. Surface of shell consisting of numerous elongate spine bases, with crest facing anteriorly. Pedicle valve in lateral profile having fairly moderately curve except in umbonal region, there abruptly and narrowly curved. Anterior profile of pedicle valve show convex dome with nearly vertical sides, and deep medium furrow. Beak small and strongly incurved. Sulcus on pedicle valve is narrow and moderately deep near umbo, and widening and deepening anteriorly.

Species: *Waagenoconcha purdoni* Waagen 1884**Description**

Large, elongate-oval shaped shell, with rounded sides, anterior may also broadly rounded. Surface of shell consisting of numerous elongate spine bases, with crest facing anteriorly. Very prominent sulcus shallow starting from umbonal region and deepening anteriorly. Beak is prominent and strongly incurved. Brachial valve without spines.

Genus: *Linoproductus* Chao 1927

Linoproductus Chao, 1927:25,128; 1928: 63.-Muir-Wood and Cooper, 1960: 296.- Williams and Alwyn, 1965: H 500.- Cooper and Grant, 1975:1146.

Cora Fredericks, 1928:781, 790.

Description

Shell is large elongate-rectangular in outline, hinge is narrow and straight. Sides of shell are gently rounded, anterior margins narrowly rounded. This genus is one of the better-known productid brachiopods. It is more common in the early Permian. Considerable interest is the information obtained by Grant (1966) on the living habits, *L. angustus* R.E. King that indicates that this large brachiopod was attached throughout most, perhaps all, of its life?

Species: *Linoproductus angustus* King, 1931

Linoproductus cora angustus King, 1931:76, pl. 16: figs. 8, 9.

Linoproductus philocrinus Stehli, 1954:319, pl. 21: figs. 6-10.

Linoproductus angustus Cooper and Grant, 1975:1146, pl. 431: figs. 1-3, pl. 432: figs. 1-27, pl. 453: figs. 25-29.

Description

Shell is large elongate-rectangular in outline, hinge is narrow and straight. Sides of shell are gently rounded, anterior margins narrowly rounded. Body spines bases are present. Surface of shell is costate, very finely, no growth lines. Pedicle valve unevenly convex in lateral profile, but at umbonal region flattened. Sulcus not noticeably developed on pedicle valve. In anterior profile pedicle valve nearly vertical sided dome with gently rounded crest. Ears large, deeply corrugated, undulations extending in concentric bands on lateral slopes but dying out medially. Brachial valve with flatly convex, umbonal region broadly depressed. The mid region anterior to umbo gently swollen to form a broad fold.

Species: *Linoproductus semisulcatus*, Cooper and Grant, 1975

Linoproductus semisulcatus, Cooper and Grant, 1975:1148, pl. 431: figs. 7-12.

Description

Shell is longer than width, longitudinally oval in outline. Hinge about equal to midwidth. Ears are present. Shell surface is finely costellate. Pedicle valve unevenly convex, anterior half gently convex in lateral profile, posterior half strongly convex. Umbonal region is strongly convex. Pedicle valve unevenly convex, anterior half moderately convex in lateral profile but posterior half strongly curved, anterior profile of pedicle valve is broadly domed with short, nearly vertical slopes. Median region of pedicle valve is swollen. Sulcus originating on anterior side of pedicle valve, broad and shallow, extends for about half valve length. Brachial valve is concave, umbonal region forming rounded depression. Cardinal process on brachial valve is visible. Fold on brachial valve is visible, broad, and dying as go towards posterior.

Genus: *Marginifera* King, 1931

Marginifera King, 1931:87.

Description

Medium to large, transversely subrectangular to subelliptical outline; deeply concavo-convex; hinge forming widest part; ears prominent; anterior margin broadly rounded. Surface poorly costate, radial elements most prominent. Anterior commissure with narrow, low fold. Spine confined to pedicle valve. Brachial valve without spines. Pedicle valve with minute beak; short and curved. The ears on some are smooth but in other species they are costate.

Species: *Marginifera opima*, King, 1931

Marginifera opima, King, 1931:87, pl. 22: figs. 20, 22, 23 [only].

Description

Shell is moderate in size, transversely rectangular in outline. Hinge forming widest part. Ear large, gently rounded anterior margin broadly and usually sulcate. Surface weakly

costate. Umbonal region of brachial valve is usually smooth. Spines bases are visible on brachial valve.

Pedicle valve narrowly convex at venter, anterior profile forming broad dome with steep slopes. Beak small, umbonal region swollen. Brachial valve closely fitting interior of pedicle valve, umbonal region shallowly depressed, greatest depth corresponding to venter of pedicle valve.

Genus: *Nudauris* Stehli, 1954

Nudauris Stehli, 1954:317.-Muir-Wood and Cooper, 1960:228.-Walliams and Alwyn, 1965:H482.-Cooper and Grant, 1975:1066.

Description

Shell large, transversely rectangular in outline, hinge forming widest part; ears large. Pedicle valve strongly sulcate, sulcus of the exterior makes a prominent ridge that runs from the umbonal region to the anterior margin. Ears of pedicle valve are deeply concave and large. Brachial valve with low fold, surface costate without regularity and variable in size.

Species: *Nudauris diabloensis* Stehli, 1954

Productus schucherti R. E. King, 1931:73, pl. 15: figs. 1, 2[not figs. 3-5].

Nudauris diabloensis Stehli, 1954:317, pl. 21: figs. 1-5.-Cooper and Grant, 1975:1068, pl. 372: figs. 1-5.

Description

Shell large, transversely rectangular in outline, hinge forming widest part; ears large. The pedicle valve is strongly convex; sulcus on pedicle valve is deep and originating near beak, extending anteriorly, beak is short and incurved, ears are prominent. Brachial valve is concave. Growth lines originating near umbonal region and dying soon posteriorly. Interarea is small and narrow, somewhat straight.

BIOSTRATIGRAPHY

To be useful, a zone fossil must be distinctive and easy to recognize, fairly abundant, and widespread. Few genera in the studied section (throughout the Chhidru Formations at Zaluch and Nammal sections fulfill these requirements (Figure 2 & 3).

Among the mega fossils, brachiopods are the most common fossils found at many horizons in studied section (Zaluch and Nammal sections). 10 species have been identified from studied sections as: *Nudauris diabloensis*, *Waagenoconcha abichi*, *Waagenoconcha purdoni*, *Linoproductus semisulcatus*, *Linoproductus angustus*, *Cleiothyridina pilularis*, *Composita crassa*, *Derbyia altetriata*, *Derbyia pannucia* and *Marginifera opima*.

Zone A: This zone is characterized by *Waagenoconcha abichi* suggesting Early Dzhulfian age (Branson, 1948).

Brachiopod assemblage of this zone includes *Nudauris diabloensis*, *Waagenoconcha abichi*, and *Linoproductus semisulcatus*.

Waagenoconcha abichi ranging throughout *Waagenoconcha abichi* zone.

Among these assemblages, *Nudauris diabloensis* is ranging from zone A in unit 1 to zone B in unit 3 of Chhidru Formation along both Nammal and Zaluch sections.

Linoproductus semisulcatus is ranging throughout zone A in unit 1 of Chhidru Formation in Nammal Section while reach to unit 3 along Zaluch section.

Zone B: This zone is characterized by *Marginifera opima* – *Derbyia pannucia*, suggests late Dzhulfian age (Pak-Japanese Research group, 1985). Brachiopod assemblage from this zone includes *Nudauris diabloensis*, *Linoproductus semisulcatus*, *Linoproductus angustus*, *Cleiothyridina pilularis*, *Composita crassa*, *Derbyia pannucia*, *Waagenoconcha purdoni* and *Marginifera opima*.

Among these *Nudauris diabloensis*, *Linoproductus semisulcatus* and *Linoproductus angustus* are extension of zone A into this zone.

Cleiothyridina pilularis, *Composita crassa*, *Marginifera opima*, *Derbyia altetriata* and *Derbyia pannucia* are among the abundant fossils of this zone and starting from zone B in unit 2 of Chhidru Formation and ending on last bed of unit 4 of Chhidru Formation.

PALEOENVIRONMENTS

The brachiopod assemblages (Strophomenida and Spiriferida) of the studied section are sessile benthos and show sublittoral environments (Hedgpeth, 1957).

The Chhidru Formation is rich in Strophomenida type brachiopod assemblages, this show inner sublittoral environment (Depths 100m, light of moderate to low intensity, wave action moderate to slight, water has low salinity and turbidity is moderate to low). The faunal dominancy from Zaluch section suggests comparatively deeper environment of deposition for Chhidru Formation.

COMPARASION OF BRACHIOPODS IN NAMMAL AND ZALUCH SECTIONS

Brachiopods along both sections almost of same resolution (Figure 4). The observed variations along both sections are;

- Zaluch section showing population dominancy of brachiopod fauna which suggesting comparatively deeper environment of deposition for Chhidru Formation than at Nammal section.
- Variation in faunal ranges along both sections suggesting close interaction of brachiopod fauna with its marine framework.

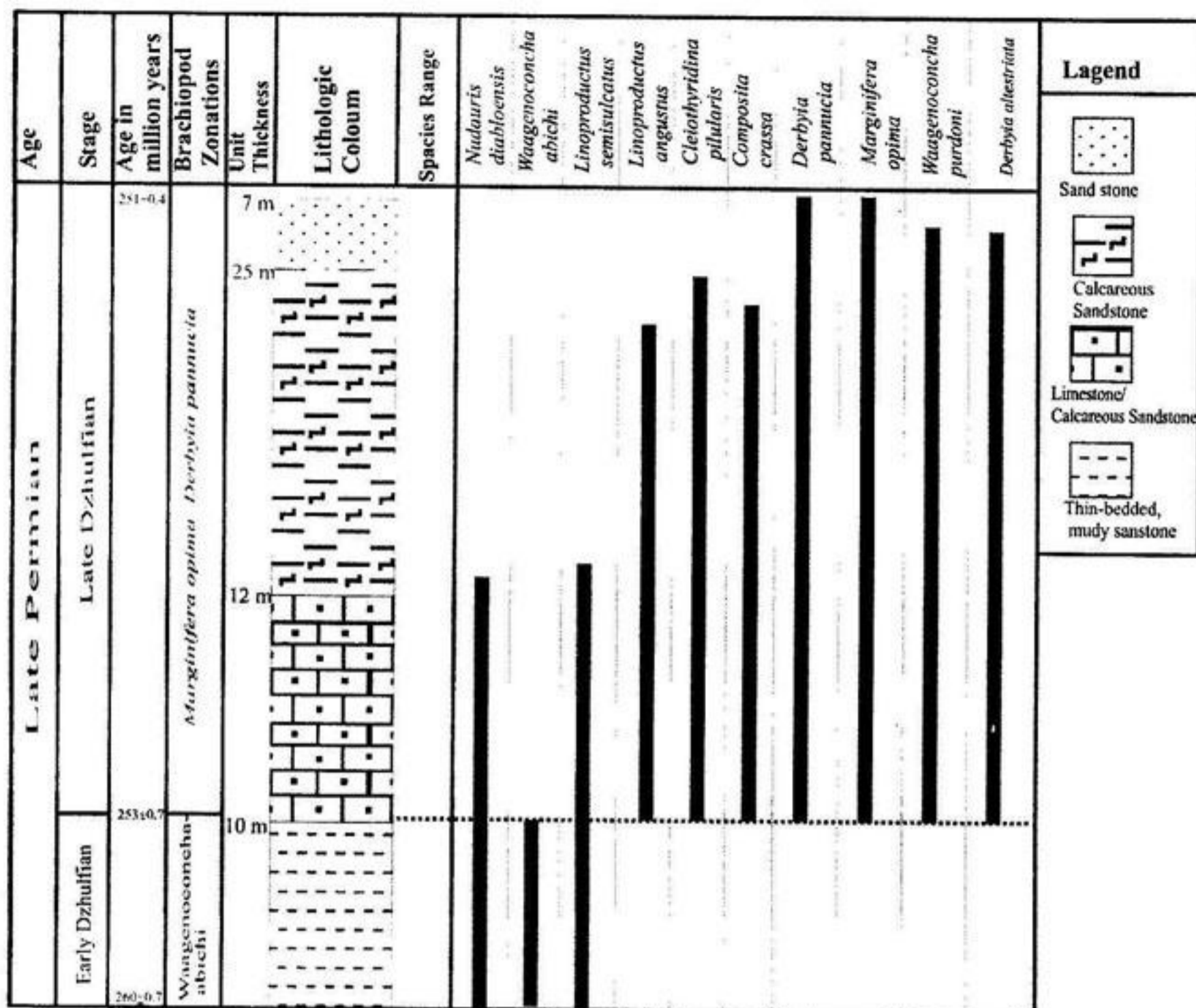


Figure 2- Schematic columnar section, species range chart and brachiopod zones from Chhidru Formation in Zaluch Section, Western Salt Range.

CONCLUSIONS

The Zaluch and Nammal sections have excellent exposures of upper Permian geology in Pakistan. Present paleontological studies resulted in identification of 8 genera and 10 species of brachiopods and two-biostratigraphic zones has been identified as follows:

Zone A: Waagenoconcha abichi zone of Early Dzhulfian age.

Zone B: Derbyia pannucia-Marginifera opima zone of Late Dzhulfian age.

The Chhidru Formation has been given the Early Dzhulfian to Late Dzhulfian age on the bases of current studies and research on brachiopods.

Paleoenvironmental study based on brachiopods suggests inner sublittoral environment for the Chhidru Formation while faunal dominancy in Zaluch section suggesting comparatively deeper environment of deposition for Chhidru Formation.

Brachiopods in Zaluch and Nammal sections show almost same faunal details but the only variation observed is the fossil range and population.

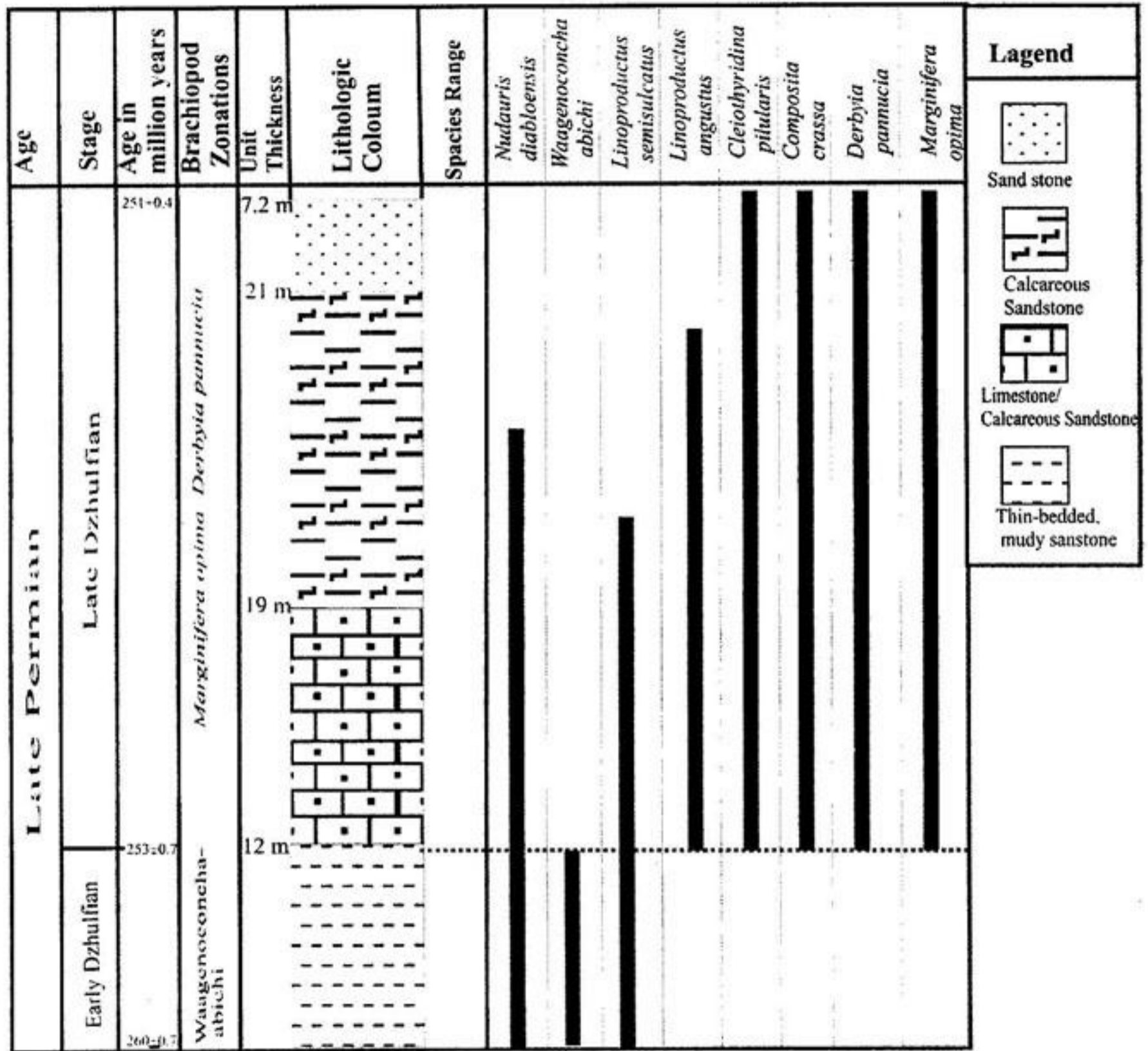


Figure 3- Schematic columnar section, species range chart and brachiopod zones from Chidru Formation in Nammal Section, Western Salt Range.

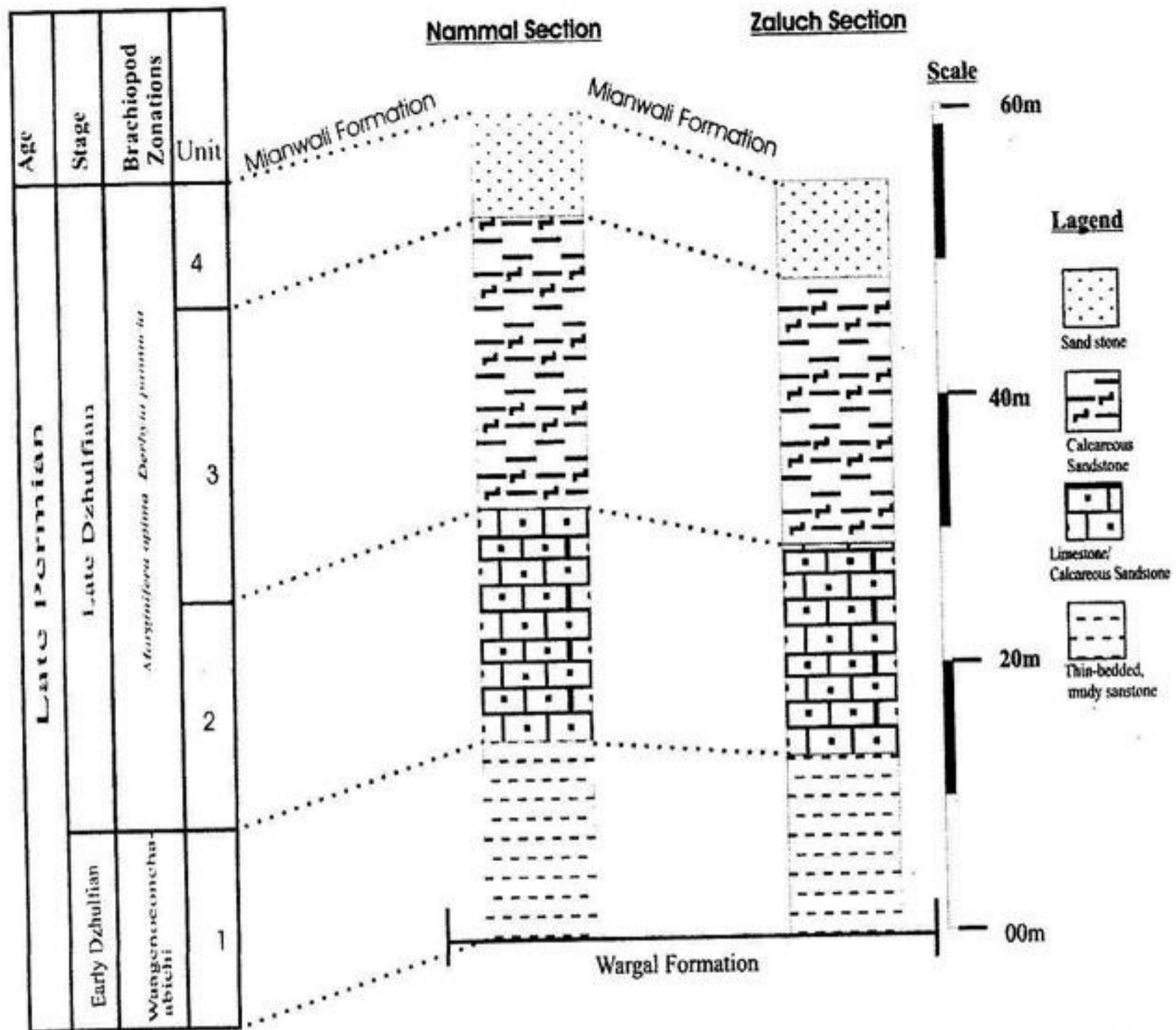


Figure 4- Schematic columnar sections and brachiopod zones from Chhidru Formation in Zaluch and Nammal Section, Western Salt Range.

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PLATES DESCRIPTION

PLATE 1:

- Figure # 1: *Cleiothyridina pilularis*, brachial view, Chhidru Formation, Nammal and Zaluch sections, Western Salt Range, Punjab, Pakistan.
- Figure # 2: *Composita crassa*, side view, Chhidru Formation, Nammal and Zaluch sections, Western Salt Range, Punjab, Pakistan.
- Figure # 3: *Derbyia pannucia*, pedicle view, Chhidru Formation, Nammal and Zaluch sections, Western Salt Range, Punjab, Pakistan.
- Figure # 4: *Derbyia altestriata*, pedicle view, Chhidru Formation, Zaluch section, Western Salt Range, Punjab, Pakistan.
- Figure # 5: *Waagenoconcha abich*, pedicle view, Chhidru Formation, Nammal and Zaluch sections, Western Salt Range, Punjab, Pakistan.
- Figure # 6: *Linoproductus angustus*, side view, Chhidru Formation, Nammal and Zaluch sections, Western Salt Range, Punjab, Pakistan.
- Figure # 7: *Waagenoconcha purdoni*, pedicle view, Chhidru Formation, Zaluch section, Western Salt Range, Punjab, Pakistan.
- Figure # 8: *Marginifera opima*, brachial view, Chhidru Formation, Nammal and Zaluch sections, Western Salt Range, Punjab, Pakistan.
- Figure # 9: *Linoproductus semisulcatus*, side view, Chhidru Formation, Nammal and Zaluch sections, Western Salt Range, Punjab, Pakistan.
- Figure # 10: *Nudauris diabloensis*, pedicle view, Chhidru Formation, Nammal and Zaluch sections, Western Salt Range, Punjab, Pakistan.

PLATE 1



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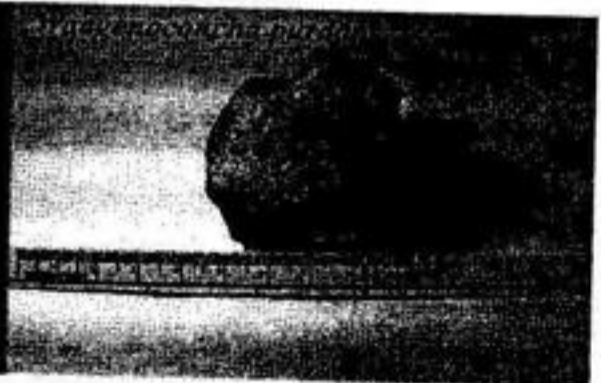
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