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Early Jurassic Vegetational Analysis Based on Palynological: Data from Khisor Range, Pakistan.

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Abstract

The study has focused on palynological analysis regarding the early Jurassic rock sample that was retrieved from Datta Formation, Khisor Range Pakistan. The study represents initial report of palynological investigation form Khisor Range Pakistan. Samples contained medium to significantly well preserved palynoflora. Palynological data retrieved from this study was used to reconstruct the previous vegetation, climate and environment of deposition during early Jurassic in the Kishor Range Pakistan.Palynomorphs are recovered in good identifiable condition, and the sample included pollen and spores in yellowish brown, dark brown and reddish brown color. This represented different thermal maturity levels. Other obtained groups included Bisaccate pollen and Monolete spores, Monosaccate, pollen, Alete/Inaperturate & Colpat/Sulcate pollen. Presence of Bisaccate pollen was lower than Trilete spores.A fluvial to shallow marine environment in Khisor Range, Pakistan included the Datta formation as represented by the discovery of Pteridophytic spores.

Keywords: *Jurassic Vegetational Analysis, Palynological, Khisor Range, Pakistan*

1. Introduction

Palynology is a naive discipline that is introduced by Hyde and Williams (1944), As the study of spores and pollen, according toTraverse (2007), palynology concerns the study of organic microfossils that range from 5 µm to 500 µm with respect to their size, these contain sporopollenin, pseudo-chitin and chitin as major constituents in the walls and are produced as a result of maceration. Generally, palynology is the Study of fossil and contemporary palynomorphs, that include spores, pollens, dinocysts, orbicules, chitinozoans, acritarchs and scolecodonts All in one along with particulate organic matter and kerogen that is available in the sedimentary sediments and rocks. It does not include foraminiferans, organisms with siliceous or calcareous exoskeletons or diatoms. Palynomorphs are the fossilized, wall bearing resistant structures that present whole organism or some part of the

organism.Formation includes body of strata unified with the help of lithological characteristics that can be distinguished in field from other strata and are traceable as well. Datta Formation can widely be observed in western part of salt range and in the Trans-Indus ranges. And the level of thickness is 212m and enhances by 230m towards Punnu Nala, moving towards the west and over 400 m towards Shaikh Budin Hill. Name of Datta formation was first presented by Danilchik (1961) and Danilchik and Shah (1967) for the purpose of replacing "Variegated Stage", the formation can be significantly observed in the full developed form around Trans-Indus range and the salt range. Around Kohat, same name is adopted from similar rocks as well. Type section is present in Datta Nala around Surghar range.Datta formation Involves continental origin and includes variegated shale, sandstone, siltstone and mudstone, including irregularly present dolomite, fireclay horizons, cancerous, ferruginous glass and carbonaceous. Fireclay is mostly found in the lower areas, whereas, there is thick bed present on the upper part, including maroon shale, that can be recognized easily. Palynology can be applied over various disciplines including Zoology, Botany, Geography and Botany. This data can be utilized in various hydrocarbon research organizations, oil and gas development corporations and geological survey of Pakistan as well. Moreover, the fields of geology in which there is a possible application of palynology include, Biostratigraphy, paleoecology, geochronology and quaternary palynology. The major objective of this study is to investigate paleoclimate, depositional environment and vegetational history of Datta formation present in the Khisor range of Pakistan, with the application of palynological analysis. This research also involves previous palynological work and analysis on Datta formation, present in Khisor range of Pakistan. The study includes five different sections, consisting upon introduction of the study, literature review of the study, methodology of the study, data analysis and interpretation of the study and discussion and conclusion of the study.

2. Literature review

Pattemore (2000) investigated and studied the botanical formations in a vast manners and they have also studied the palynological and preserved it fairly. From the fine grained argillaceous sand stone the open catkin-like bisteriate in the upper landscape and they took the sand from the southern Nambour Basin in queens-land southeast and Australia and are of likely the age of Toarcian.Olivera et al (2014), as far as the fructification is concerned it was examined as Knezourocarponnarangbaensis and it was also discovered that it belongs to the

Pterospermatophyta. Along with the fructification the poor quality if fern which were preserved and equisitalean leaves were also found. Within the levee complex the likely sedimentary setting was associated. And it was also related with the braided river system.Moreover, the study of Wang et al (2001), has discovered that, of a common early Mesozoic the palynologically investigated the in situ ultrastructure. This mesozoic was fern and it has also included the Marattia asiatica, and techniques were SEM and TEM was the same of analysis of the study. Barbacka et al (2014), on a thin external layer, the exposure was composed of and a homogenised thick outer layer was also present and there was a middle layer as well which was further composed of thick sheets of sporopollenin. In the case of investigation of spores there were no perispore elements were found. It was further investigated that extant spores of Marattiaceae resembled with the ultrastructure while comparisons of spores. But these spores were less similar to the fossil Marattialeans it was because there was less favourable presence there of preservation of Palaeozoic spores.Form the lower of member of Gravelbourg formation the study of White et al (2002), has discovered that, there is a rich variety of marine and terrestrial palynomorphs and southern Saskatchewan. Under the Watrous formation the Gravelbourg lies which has mud stones of middle Triassic age and had spares palynoflora while on the other hand, middle Jurassic age was rich in palynomorphs described by the Gravelbourg formation. Another study ofSernaa et al (2003), critically analyzed the importance of Bata formation in the context of Jurassic unit of Colombia. They concluded that, the upper part of unit and trinoids which are also collected form the upper part are in terulobites triangularis, Cyctusphaerapsilata, and Balmeiopsis. It was the sign that, the section was late VlanginuHauterivian in age and assemblage.A newly discovered plant fossils was investigated by the study of Wang et al (2010), they discovered the plant fossils assemblage in Albian Eschucha formation, this was located at Spain.Peterffy et al (2015), this study was similar to the classical study being done by US researchers in USA. It was comprised of different concepts and summarized that, possible mixing of European and provinces of Potomac in early Cretaceous within the peninsula in a semi arid climate and subtropical as well.Research of Wang et al (2005), has studied the solar clusters and palynologically investigated that, Weichselia reticulate exposed the solar clusters and opened the casting near the village of Aragon located in Spain. This has provided the new formation and new information on the concept of morphology. Elena I. Kostina et al (2015), the information regarding anatomy of the fern and distribution was also discovered in this study. The spore content and solar clusters were also documented by their

studies. Within the sporangia before the maturity the distribution of the spores were also documented by their study. The cuticular anatomy of the fossil foliage was studied and investigated by palynologically by the study of Tripathi et al (2006), and these fossil foliage includes the SphenobaieraHuangiofrom upper Triassic to lower Jurassic. There were two layers in both upper and lower cuticle in the ultrastructure cuticle. The study of Ruckweid et al (2009), explained that the other layers were having fibrils. These layers were heterogeneous by nature as well. The comparison of Sphenobaiera with the different species suggested that Shuangii was the best and well known taxon in the genus with relevant to morphology of the leaf and cuticular anatomy. Furthermore, the study of Sajjadi et al (2007) have critically examined the palynologically lithology and summarized that there are comprehensive things available in the review of lithology. The study has also reviews of the megafloras and palynology of the Dubrajapur Formation of the Basin Rajmahal which is situated in the eastern side of India. This study has historical importance as this study was conducted by tar-getting the sample of historic planation by differ emperors. S. Akram (2015), the Dubranjpur Formation was the age range which concluded the Triassic Indian to early Cretaceous which was totally based on the palynological evidences. These can be proved by various researches as well.Another study of L. Sender Palomer (2008), was conducted in the Iran where the palynologically investigation was held and diverse and moderately well persevered which were at the senjedak section of middle Jurassic sediment of Kasahfrud formation. From the diverse palynoflora the miospores were derived and they were from the Pterophyta and Gymnosperms which were grown under the warm humid conditions during the Jurassic middle. The study has also indicated the open marine which was associated with the marine fauna and this was collectively indicated scenario and depositional near shore deposition setting for the Formation in Mashhad Iran.Peinkowski et al (2009) has contributed towards the literature on underlying topic very significantly and disclosed the fact that the palynomorphs were fairly low and preserved equally with low diversity. By slightly woody organic material the residue was dominated. Elena I. Kostina et al (2013) Dinoflagellate cysts were common and Trilete spores and rimulates were abundant as well. The hot climate can be indicated through the abundance and the organic material indicated a storm influx of debris which is continental and it has also its effects on the invaded platform during the Toarican whereas, the cold climate can be expressed with the common rimulates in the environment. L. Sender Palomer (2008) have expressed that the palynologically it was investigated that, in the flood basin siltstones the Jurassic flora which

is early was preserved. And the Marburg were in Sub groups. Moreover, there was very low diversity of flora because in Australia it is seen to be most common thing. By Cheirolepidian the flora was dominated and pollen which was attributed to upper parts of the torosa zone of the Corollina in the early age of Torcian. Cuticular characteristics and sedimentological features of conifer leaves and abundance of the free sporing plants has indicated in the study of Ruckweid et al (2009) , that has been humid and paleoclinate of the Clearance Moreton Basin in early Jurassic age as well.Research study of Jansson et al (2008), palynologically investigated and suggested the fossil rich sire within the AlbuanEscucha formation in the Oilerer and in the sub basin. This study was also in the age of Spain and located in some villages of Spain as well. Including the leaf remains and seed cones the great abundance of the impression of Coniferales and leaves of Caytiniales and Ginkgoales. In the upper limit of the gymnosperm remains were fairly abundant and it was built up of sediment deposited into levels of swaps environments and fluvial without the marine influence as well. In the outcrop of different gymnosperm associations, it indicated a wide variety of circumstances in a sub-tropical environment and there was a mixture which studied by various past studies. The climate was the mixture of the taxa and American including European in the Liberian plate in the middle of Albina Spain during that plate.The Oliviera et al (2007) have discussed the plant life at European context and US context into various forms of understanding and they discovered the three aspect of the Jurassic and emphasized on the some of the groups of plants that were British sediments. Usually the studies have included the Rhaetian floras of the early Jurassic.Moreover, researchers Cirilli et al (2009), have disclosed and studied the concept of stratigraphic relation by investigating the palynologically and discovered that the relationship between stratigraphic and position of CAPM basalts and the Triassic Jurassic Boundary in the basin of fundy. Afsaneh et al (2013) has investigated the palynologically JurassicTriassic boundary and saw that the interval of the Furnasja section with respect to a major climate change is having greater significance. By terrestrial particles the palynofacies were dominated and which were also indicated by the shallow marine depositional environment or climate. These can be fairly preserved by changing its characteristics. This shift can be interpreted to display a sudden increase in the humidity of the underlying environment.The study of Wang et al (2010) looked the fertile organs of Hausmannia in the middle of Jurassic in the area of Mongolia China. With compression the specimens were well preserved. The leaves which were completely preserved were including the sori, sporangia and annuli. These leaves were fan by shapes and broad with margin of entire leaf. There were

primary and bilateral veins and branched which were forming a mesh(Bharadwaj,1996). There were two circular sori upon the each mesh. To the dispersed genera Bacatisporites the spores were trilete and comparable in a simple way. Wang et al (2010) has analyzed in the Himalayan Tethys the Jurassic early Cretaceous succession. The fossils including ammonites and belemnites were also found out around the area. The latest Jurassic studies were also contained such areas as well.

3. Geological setup

The Jurassic system is majorly presented with shale, limestone and sandstone including ferruginous beds and subordinate dolomite. Close of Triassic is represented with emergence in salt range, Hazara areas and Trans-Indus ranges with continuation of sedimentation. Lower Jurassic rocks are present either on the upper Triassic present in the salt range or in the old rocks in different parts of Hazara. Lower part of the Lower Jurassic or the Datta formation include arenaceous sediments and argillaceous sediments, related with calcareous rocks and argillaceous rocks, having lower toarcian fauna. The Jurassic present in the axial belt and the lower Indus basin is presented with great thickness including marine limestone and shale having subordinate sandstone in lower sections.Cephalopods has majorly been reported right from the lower and upper levels, whereas, other fossils like algae, bivalves, corals and crinoids are Present in various parts of the Jurassic sequence. The environment of deposition involves rocks that are deposited majorly in the shallow marine environment, and are also close to the early Jurassic axial belt, that are tectonically active. When it comes to the change in the environmental conditions, near the Callovian there is a widespread withdrawal right from the sea, from the Indus basin. The area is again submerged into the late Jurassic and early Cretaceous times. The evidence out of the lower index basin regarding the lower Jurassic faunas are scanty, however it is observed that main transgression, past the Callovian emergence happened in the Tithonian times. In axial Belt, the regressive phase cannot be seen to be well defined , but still there are evidence from specific parts of the post-Callovian disconformities and pre-Callovian disconformities. The thickness of the sequences of Jurassic present in Kohat province start from 820 m towards around 3000 m in the case of Lower Indus Basin. In case of the upper Indus basin, the Jurassic system of lower Indus basin is presented with Shinawari formation, Datta formation and chichali formation, Lumshiwal and chichali formation are Dealt with the Cretaceous system. Data formation was majorly introduced by Danilchik (1961) and Danilchik and Shah (1967), this formation can be

observed to be developed well in the trans-Indus ranges and the salt range.. The level of thickness is 212 m and enhances by 230 m towards Punnu Nala, moving towards the west and over 400 m towards Shaikh Budin Hill. Name of Datta formation was first presented by Danilchik (1961) and Danilchik and Shah (1967) for the purpose of replacing "Variegated Stage", the formation can be significantly observed in the full developed form around Trans-Indus range and the salt range. Around Kohat, same name is adopted from similar rocks as well. Type section is present in Datta Nala around Surghar range. There are no diagnostic fossils that are reported as a result of the formation, apart from the carbonaceous remains, the formation underlies from the shinawari formation Which has yielded lower toarcian ammonites in its lower parts, the age is inferred to be early Jurassic, specifically pre-toarcian.

4. Research methodology

The study on exposed sedimentary rocks is done for finding out the evolutionary history and the relative information regarding the palynomorphs. The first step involves the Isolation of the palynomorphs from the sedimentary rocks via maceration. Reactivities test is done, maceration is done with the help of demineralization, Preliminary microscopic analysis and post oxidization microscopic analysis is done. Furthermore, heavy liquid separation is done with the help of preparation of zncl2, preparation of plastic centrifuge tubes and the neutralization process. Then, mounting is done, with the help of preparation of cellusize, preparation of glycerin Jelly, cleaning of coverslips and slide preparation.

For reactivity test, small pieces of rock samples around 4-5mm taken on plastic tray and reacted with conc. HCL, HNO3 and HF, the noted relative rate of reaction of all of the samples, is as below:

- Vigorous = +++++
- Very fast = ++++
- Fast = +++
- Slow = ++
- Very slow = +

Carbon, silicates and organic compounds have been found to be predominant in sedimentary rocks, carbonates reacted with 50% of HCl, silicates reacted 50% with HF and organic compounds reacted 50% as well.

Table 3.1 Reaction of sample with inorganic acids

Sample no.	50% HCl	50% HF	50% HNO_3
DS: 05	++	++	++

Violent reaction with HCl represents high concentration of carbonates, violent reaction with HF represents presence of silicates and violent reaction with HNO3 represents organic compounds presence.

For maceration, sample was washed with water, and dried, after this it was crushed in 0.5 cm pieces, and the weight was recorded to be 50g. Then demineralization was done, resulting in removal of water soluble compounds including the removal of carbonates and silicates. For this process, the weighted sample was put into labeled and washed maceration jars, and for the treatment, HCl is applied to dissolve carbonates and then HF is applied to remove silicates. Then treatment with 10% HCl is done, by placing the jar of sample in the water bath at 80^{o}c, for around 20 minutes, and HClwas shaken at regular intervals. Jars were stood overnight for the settlement of the sediments, then supernatant was removed, then sample was neutralized with the help of water. After this, the sample was treated with 50% HCl.

Table 3.2 Reaction rate of sample with different grades of HCl

Sample no.	10% HCl	50% HCl
DS: 05	Very slow reaction	Slow reaction

Then, the sample is treated with 10% HF, as shown below:

Table 3.3 Reaction rate of sample with HF

Sample No.	10% HF
DS: 05	Slow reaction No fumes

Then, the sample was observed under microscope with the preparation of wet mount slide , so that the status of the sample can be observed.

Table 3.4 Results of Preliminary Microscopic Analysis

Sample no.	Observation	Recommended treatment
	Dispersion good, productivity good, mineral matrix frequent, fine-coarse	1. 30% HNO_3 overnight 2. 2% KOH.

DS: 05	grained, bisaccates, wood fragments and amorphogens observed	

After this, the sample is treated with 30% HNO3, for the dissolution of organic compounds, and then, the sample was treated with KOH. The former treatment is represented in the table below:

Table 3.5 showing results of 30% HNO_3 treatment.

Sample no.	Observation	Recommended treatment
DS: 05	Dispersion good, productivity good, mineral matrix frequent, cuticular fragments, trilete spores observed in good oxidation state, wood fragments blackish brown-jet black, tracheids observed.	Heavy liquid Separation Mounting

For the further cleaning of the sample, heavy liquid separation is done, as the specific gravity of palynomorphs is around 1.4 to 1.5, and the lightest mineral will have specific gravity of 2. For the separation of minerals and palynomorphs, $ZnCl_2$ Solution is prepared, having specific gravity of 1.975. Then the sample is centrifuged at 400 rpm for 20-30min. The ring of palynomorphs is decanted into glass centrifuge tube.100 g $ZnCl_2$, 10ml 50% HCl, 10 ml H2O is used for The preparation of the $ZnCl_2$ Solution.

Then in the neutralization process, the rings are neutralized with water and again centrifuged for 30 minutes. for the process of mounting, cellusize is prepared, with 100 ml of water in a beaker and 1 g of cellusize, in the Preparation of glycerin Jelly, 10 g gelatin powder in a beaker and 100 ml water is used. For the process of mounting, the glass slides are cleaned with rectified spirit and the coverslips are cleaned with KOH and detergent. Then the slides were prepared with small amount of glycerin Jelly and neutralized material. Microphotography was done with Meiji Trinocular Compound Microscope under 10X, 20X, 40X & 60X objectives with Lumina Infinity 1 digital camera.

4. Systematics and description

Anteturma SPORITES H.Potonie, 1893

Turma TRILETES (Reinsch) Dettman,1963

Suprasubturma ACAVITITRILETES Dettman, 1963

Subterma AZONOTRILETES (Luber) Dettman, 1963

Infraturma LAEVAGATI (Bennie and Kidson) Potonie,1956

Genus *CALAMOSPORA* Schopf (SchopfandWilson) and Bentall, 1944

Type species: *Calamosporahartungiana* Schopf

Cycathedites australis Couper

Pl. 8 Fig. 2

Dimensions: Equatorial Diameter: 55 µm

Description

Miospore, trilete, amb triangular, angles broadly rounded, sides slightly concaved, labra distinct, laesurae extending upto the angles, exine upto 1 µm thick, laevigate.

Affinities: Pteridosperm

Sample no.: D 5

Subturma AZONOTRILETES Luber emend. Dettmann 1963

Infraturma LAEVIGATI Bennie & Kidston emend. Potonié 1956

Dictyophyllidites sukhdevi Maheshwari 1974

Pl. 10 Fig. 1

Dimensions: Equatorial Diameter: 77 µm

Desccription

Miospore, trilete, amb rounded triangular to circular, laesurae distinct reaching upto the angles, exine infrapunctate to infragranulate 1 µm thick.

Affinities: Pteridosperm

Sample no.: D 5

Type species C*onvolutisporaflorida*Hoffmeister, Staplin and Malloy, 1955

Convolutispora sp.* cf. *C. florida Hoffmeister, Staplin and Malloy, 1955

Pl. 7 & 8 Fig. 1 & 1

Dimensions: Equatorial Diameter: 10 µm

Description

Miospore, trilete, amb circular, labra indistinct extending upto margins pointed lete extremities, exine 2-3 µm thick, infrapuntate to infrareticulate.

Affinities: Pteridosperm

Sample no.: D 5

Convolutispore sp.* cf. *C. formensisBalme and Hassell, 1962

Pl. 6 Fig. 3

Dimensions: Equatorial Diameter: 52µm

Description

Miospore, trilete, amb spherical to hemi-spherical, laesurae not visible, infrapunctate, exine upto 1 µm thick and infrapunctate to levigate.

Affinities: Pteridosperm

Sample no.: D 5

Suprasubturma ACAVATITRILETES Dettmann, 1963

Subturma AZONATI (Luber) Dettmann, 1963

Infraturma LAEVIGATI (Bennie et Kidston, 1886) Potonié, 1956

Genus *Calamospora*Schopf, Wilson & Bentall

Calamospora sp*. cf. *C.pedataKasanke 1950

Pl. 1 Fig.1

Dimensions: Equatorial Diameter: 78 µm

Description

Miospore, trilete, amb subcircular-oval, lete well developed extending upto the angles, labra distinct, exine 1 µm thick, psilate.

Affinities: Pteridosperms

Sample no.: D 5

Sub-infraturma VERRUCATI,Dybova and Jachowicz, 1957

Genus *Verrucosisporites* Ibrahim, emend, Smith and Butterwort

Type species *Verrucosisporitesverrocosus.* *Ibrahim*, 1933

Verrucosisporites versus (Potonie and Kremp) Smith, Butterworth and Love, 1964

Pl. 1 Fig. 3

Dimensions: Equatorial Diameter: 61 µm

Description

Miospore, trilete, amb rounded tringular, lete mark distinct, infrapunctate, exine 1-2 µm thick, infragranulate.

Affinities: Pteridosperm

Sample no.: D 5

Verrucosisporites versus

Pl. 2 Fig. 1

Dimensions: Equatorial Diameter: 128 µm

Description

Miospore trilete, amb circular to oval, leasurae indistinct, exine 1 µm thick, levigate, infrapunctate.

Affinities: Pteridosperm

Sample no.: D 5

Turma ALETES Ibrahim

Subturma AZONOMONOLETES Luber

Infraturma PSILAMONOLETI Van der Hammen

SpheripollenitessubgranulatusCouper, 1958

Pl. 6 Fig. 2

Dimensions: Equatorial Diameter: 56µm

Description

Miospore, trilete, amb circular to oval distorted at one end due to compresison, lete distinct, exine 1-2 µm thick, levigate to slightyinfrapunctate.

Affinities: Pteridosperm

Sample no.: D 5

Infraturma MURORNATI Potonié & Kremp 1954

Genus *Lycopodiacidites*Couper1953 emend. Potonié 1956

Lycopodiumsporitescerniidites(Ross) Delcourt and Spermount

Pl. 8 Fig. 1

Dimensions: Equatorial Diameter: 115 µm

Desccription

Miospore, trilete, amb circular distorted due to compression, lete faintly visible, arms of lete extending upto 2/3 of the radius, exine upto 1-2 µm thick, infra-reticulate to infra-vermiculate.

Affinities: Pteridosperm

Sample no.: D 5

Turma MONOLETES Ibrahim, 1933

Suprasubturma ACAVATOMONOLETES Dettman, 1963

Subturma AZONOMONOLETES Luber, 1935

Infra turma LAEVIGATOMONOLETI Dybova&Jachovicz, 1957

Genus: *Laevigatosporites* Ibrahim, 1933

Type species : *Laevigatosporites vulgaris* Ibrahim, 1933

Laevigatosporites*sp. cf. *L. plicatusKar, 1968

Pl. 9 Fig. 1

Dimensions: Equatorial Diameter: 50 µm

Desccription

Miospore, trilete, rounded to sub-rounded, laesurae indistinct, exine infra-punctate to infra-granulate up to 1 µm thick seldom folded at certain places.

Affinities: Pteridosperm

Sample no.: D 5

Turma Kryptoaperturates Potonié 1960

Subturma Circumpolles Pflug 1953 emend. Klaus 1960

Genus *Classopollis*Pflug 1953 emend. Pocock & Jansonius 1961

TypeSpecies : *Classopollis torosus* (Reissinger) Couper 1958

***Classopollis classoides* (Pflug)** Pocock and Jansonius 1961

Pl. 4 Fig. 4

Pl. 5 Fig. 1, 2, 3, 4

Dimensions: Equatorial Diameter: 50 µm

Desccription

Miospore, trilete, amb rounded triangular, angles broadly rounded, lete distinct, exine upto 1-2 µm thick, wavy, infrapunctate to infravermiculate, seldom folds.

Affinities: Pteridosperm

Sample no.: D 5

Anteturma POLLENITES Potonie, 1931

Turma SACCITES Erdtman, 1947

Subturma MONOSACCITES (Chitaley) Potonie&Kremp, 1954

Genus Wilsonites Kosanke, 1959

Type Species*Wilsonitesvesicatus* (Kosanke) Kosanke, 1959

Wilsonitesdelicatus(Kosanke) Kosanke, 1959

Pl. 11 Fig. 1, 2

Dimensions:

Total breath= 130 µm

Corpus breath= 2 µm

Corpus length= 60 µm

Saccus length= 78 µm

Description

Pollen, monosaccate, overall amb spherical to hemispherical, exine of saccusupto 1 µm thick, infrapunctate, corpus distinct darker than saccus, wall of corpus 1-2 µm.

Subturma DISACCATTES Cookson, 1947

Infraturma ALETIDISACCATES (Leschik) Potonie, 1958

Genus *ALISPORITES*Daugherty, 1941

Type species: *Alisporitesopii*Daugherty,1941

AlisporiteslandianusDaugherty

Pl. 12 Fig. 1

Dimensions:

Total breath= 90 µm

Corpus breath= 55 µm

Corpus length= 85 µm

Saccus length= 80 µm

Description

Pollen grain, bisaccate, haploxylonoid, overall amb spherical to hemispherical, corpus distinct, amb of corpus oval to elliptical, cappa 1.5 µm, cappula similar to cappa, exine of cappa infrapunctate to infragranulate, sacci hemispherical, exine of saccus reticulate.

Affinities: Gymnosperms

Sample no.: D 5

Cepdripites priscus Balme, 1970

Pl. 12 Fig. 2, 3, 4

Pl. 13 Fig. 1, 2

Pl. 14 Fig. 1

Dimensions:

Total breath= 130 µm

Corpus breath= 2 µm

Corpus length= 60 µm

Saccus length= 78 µm

Desccription

Pollen grain bisaccate, haploxylonoid to slightly diploxynoid, overall amb elongated oval, amb of corpus oval, cappa 1 µm thick, exoexine of cappa infrareticulate to infrapunctate, cappula distinct, sacci well developed, hemispherical darker than corpus, exoexine of saccus 1 µm thick infra-punctate to infra-reticulate.

Affinities: Gymnosperms

Sample no.: D 5

Turma PLICATES (Naumova) Potonie, 1960

Subturma MONOCOLPATES (Iverson and Troels) Smith, 1950

Genus *CYCADOPITES* Wodehouse, 1933

Type species: *Cycadopites follicularis* Wilson and Webster, 1946

Cycadopites follicularis Wilson and Webster, 1946

Pl. 13 Fig. 1, 2

Dimensions: Total length × Total breath: 49 µm × 23 µm

Desccription

Pollen grain, monosulcate, amb oval to oblong, sulcus discernnible, extending full length, boarded by intexinal folds, exine 1.5 µm thick, psilate to infra-punctate.

Affinities: Gymnosperms

Sample no.: D: 5

5. Discussion and conclusion

5.1. Discussion

Palynoflora has 27 species of 19 genera, 10 genera are trilete spores, 2 are monolete spores, 1 belongs to monosaccates, 2 are from bisaccates and 2 are from circumpolar pollen, Alete/Inaperturate pollen and 1 is fromcolpate/sulcate pollen.

Table 5.1Showing Palynomorph Diversity

Sr. no.	Palynomorph type	Number of genera	Number of species
1-	Triletes	10	15
2-	Monoletes	2	2
3-	Monosaccates	1	1
4-	Bisaccates	2	2
5-	Circumpolar pollen	1	4
6-	Colpates	1	1
7-	Alete pollen	2	2
8-	Wood and cuticular fragments	-	-

PalynomorphsRecovered are in good identifiable condition, the sample included pollen and spores in yellowish brown, dark brown and reddish brown color. This represented different thermal maturity levels. Miorpore assemblage represented Trilete spores. Another group wasBisaccate pollen and Monolete spores, Monosaccate, pollen, Alete/Inaperturate &Colpat/Sulcate pollen. Presence of Bisaccate pollen was lower than Trilete spores.

Table 5.2 Probable Botanical Affinities of the Palynoflora recovered from Datta Formation, Khisor Range, Pakistan.

Sr. no.	Name of palynomorphs	Types	Botanical

			affinities
1-	*Cycathedites australis* Couper	Trilete	Filicales
2-	*Dictyophyllidessukhdevi* Maheshwari, 1974	Trilete	Pteridospemic
3-	*Convolutispora sp.* cf. *C. florida* Hoffmeister, Staplin and Malloy, 1955	Trilete	Pteridospemic
4-	*Convolutispora sp.*	Trilete	Pteridospemic
5-	*Convolutispora sp. cf. C. formensis* Balme and Hassel 1962	Trilete	Filicales
6-	*Lycopodiumsporidescerniidites (*Ross) Delcourt and Spermount	Trilete	Filicales
7-	*Osmundacidites sp.*	Trilete	Filicales
8-	*Cyclogranisporites micaceous* Ingrund 1962	Trilete	Pteridospemic
9-	*Classopollis classoides* (Pflug) Pocock and Jansonius 1961	Circumpollen pollen	Gymnospermic
10-	*Punctatisporites sp.*cf. *P.pseudolevatus*Hoffmeister Staplin and Malloy, 1955	Trilete	Pteridospemic
11-	*Punctatisporitesnahanensis*Haquebard and Brass 1957	Trilete	Pteridospemic
12-	*Punctatisporitesvermiculatis*Kasanke, 1950	Trilete	Pteridospemic
13-	*Kewanesporites sp.*	Trilete	Pteridospemic
14-	*Verrucosisporites versus* (Potonie and Kremp)Smith, Butterworth and Love, 1964	Trilete	Pteridospemic
15-	*Calamospora sp. cf. C.pedata*Kasanke, 1950	Trilete	Pteridospemic
16-	*Laevigatosporites sp. cf. L.plicalus*	Monolete	Pteridospemic
17-	*Punctatisporites sp. cf. P.minutus* Ibrahim	Monolete	Pteridospemic
18-	*Spheripollenitessubgranulatus*Couper, 1958	Aletes	Pteridospemic

19-	*Inaperturopollenites undulatus* Weighland and Greifeld, 1953	Aletes	Pteridospemic
20-	*Wilsonitesdelicatus*(Kosanke) Kosanke, 1959	Monosaccates	Gymnospermic
21-	*Cedripstespriseus*Balme, 1970	Bisaccates	Gymnospermic
22-	*Alisporitesopii*Daugherty	Bisaccates	Gymnospermic
23-	Bissacate pollen Dyad	Bisaccates	Gymnospermic
24-	*Cycadopitesfilliculasis*(Wilson and Webster, 1946)	Colpates	Gymnospermic
25-	*Classopollis sp.*	Circumpolar pollen	Gymnospermic
26-	*Classopollis sp.* A	Circumpolar pollen	Gymnospermic
27-	*Classopollis sp.* B	Circumpolar pollen	Gymnospermic
28-	*Punctatisporites sp.*	Circumpolar pollen	Gymnospermic

Trilete spore included 15 species, 10 from Calamospora, Cyclogranisporites, Cyathedites, Dictyophyllidites, Convolutispora, Lycopodiumsporites, OsmundaciditesPunctatisporites, Kewanisporites and Calarnospora. Punctatisporites, Calamospora and Classoppollishave high presence. Monolete spores includedLaevigatosporites and Punctatosporites genera. Bissaccate pollen included Alisporites and Cedripites species. Monosaccate pollen included Wilsonites genus and monocolpates are represented from Cycadopites genus. Inaperturopollenites and Sphaeripollenites belonged to Alete /Inaperturate pollen represented by Inaperturopollenites undulatus and Spheripollenitessubgranulatus species. Prevailing early Jurassic palynoflora is dominated by the pteridophytes. Gymnosperms have Conifers, Cycads and Cheirolepidiaceae. Calassopollis grains That are spherical in shape, having encircling furrow, that is rimula.Pteridophytes are significantly strongly present, in comparison with the gymnosperms.Gymnosperms include Cycadaceae, Cheirolepidiaceae, Araucareaceaeand Taxodiaceae representation. Pteridophytes dominance represented Abundance of cool temperature towards sub temperate climate, including medium to high level of humidity. A

fluvial to shallow marine environment in Khisor Range, Pakistanincluded the datta formation as represented by the discovery of Pteridophytic spores.

5.2. Conclusion

From Datta formation the palynologically investigated the rock samples and the ranges were including the Khisor range Pakistan, which was most emerging and highly productive range. Because it was very preserved and rich assemblage of palynomorphs and wool fragments and dispersed cuticualrs.On almost twenty-seven forms of species the palynoflora were consisted upon. These were belonging to almost nineteen form of genera. With Trilete spores almost ten genera and fifteen species were belonged. To monolete spores there were almost two species and two same genera. To bisaccates there were two species and two genera were belonged. Four species and one genera was attached to the circumpolar pollen. Whereas, two species and two genera to alere pollen and at the end one species was belonging to the sulcate and colpate.Of the palynoflora the botanical affinities with the megaflora it is advised that the palaeovegetation that existed during the Jurassic time period which was early Jurassic. This was dominated during early ferns. The next dominant group was gymnosperms.The cool temperate to sun temperate the palynogical data clearly indicated and with moderate and high humidity as well.The environment is shallow for Datta formation of deposition and marine to fluvial as it was indicated by the palynoflora.

6. References

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Appendices