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Research Paper

SEDIMENTOLOGICAL AND PALYNOLOGICAL STUDIES OF SUB-SURFACE SAMPLES OF KOYAGUDEM AREA, KYG-451, GODAVARI VALLEYCOAL FIELD, LOWER GONDWANA, ANDHRA PRADESH, SOUTH INDIA

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Sedimentological and Palynologicaldata from the subsurface samples from the bore-hole # KYG-451, located in the southwestern margin of Godavari sub-basin and Northern part of Kothagudem sub-basin of Koyagudem area, Lower Gondwana, Andhra Pradesh. Present study has been chosen to depict the relationship between sedimentological and palynological data based on the mineral assemblage with palynoassemblage. Present study is for ten core samples from bore-hole which are sandstone, shale and shally coal. The objective of the study is to identify the minerals and its grain size, shape analysis, sedimentation character and nature of source rock, palynoassemblage study and age assessment. Thin section study reveals shape of the grains which discloses the source rock relationship for the sediments during deposition and also some heavy minerals like zircon, garnet, hematite, chlorite are also identified and the source rock potential identified. Cementing materials areidentified which flows through inter granular space between adjacent minerals of sediments which reveals the deposition environments of the sediments. Palynological data applied to understand distribution pattern of floral remains. Palynological study reveals fifteen well preserved palynoformsarerecovered.Based on the dominance and sub-dominance of palynoforms Scheurangipollenites palynoassemblage identified and possible to assign the age for the sediments under consideration.

Keywords: Sedimentology, Palynology, Koyagudem, Bore-hole sample, Lower Gondwana.

INTRODUCTION

Gondwana sedimentary basin is a unique system largely with fresh water sediments with fairamount of floral remains. Gondwana stratigraphy in India has attracted many earth scientists to understand more about its distribution and evolution aspects of flora. Gondwana research supports to understanding more about coal deposits and floral distribution in India. From past several decadessedimentological and palynologi-

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cal research were carried out on various Gondwana coal basins of India (Jacob 1952, K Jacob, *et al.,* 1958, P G Adyalkar 1964, Sengupta 1970, Singh IndraBir 1975, Lakshminarayan 1995, R C Tewari and M Chandra Das 1996, Suresh C Srivastava and NeerjaJha 1989, Suresh C Srivastava and NeerjaJha1996, Pauline Sabina K S *et al.,* 2007, Nagamadhu C J *et al.,* 2012, NehaAggarwal, NeerjaJha, 2013). Gondwana sediments are characterized by cyclic nature of deposition. Lithostratigraphicallythe Gondwana sediments were classified into Lower and Upper Gondwana as bipartite division. Present sedimentological and palynological data are from Lower Gondwana Formation, south western margin of Godavari sub-basin Godavari valley coal field of Permian period. Present study an attempt has been bring out the possible relationship between sedimentological data with palynological data. Sedimentological and palynological study gives an ample of scope to understand the mineral assemblage, grain size and shape, nature of source rock, palynoassemblage andfloral distribution.

GEOLOGY OF THE STUDY AREA

Godavari valley coal field is the one of the largest coal producing area in southern Indian Gondwana basins.The coal field is extends NNW-SSE direction and located in betweenlatitude N 16º 38' and 19º 35' and longitude E 79º 12' and 81º 39' which covers an area about 17,000 sq.km.According to Raja Rao, 1982, the valley is structurally divided into four sub-basins Godavari, Chintalpudi, Kothagudem and Krishna-Godavari tract. The present Sedimentological and Palynologicalinvestigation for the core samples from subsurface bore hole No.KYG-451, Koyagudem area,Kothagudemsub-basin of Andhra Pradesh. Koyagudem area located in the southwestern margin of Godavari sub-basin andNorthern part of Kothagudem sub-basinand situated under Lingala-Koyagudem coal-belt. This coal-belt is situated between the two active mining centers of Ramagundem area in the North West and Kothagudem in the South Western part. This Lingala-Koyagudem coal belt extended by 50km long unbroken stretch of Barakar Formation occurring between Lingala in the NW to Koyagudem in the SE on western margin of Godavari graben. The coal belt bounded by N 17º 35' to 18º latitude and East longitude 80º 03' to 80º 30' on GSI topo sheet number 65 $^{C}/_{5}$, $^{C}/_{6}$ and $^{C}/_{10}$ and it covers an area

Figure 1: Geological Map of Godavari Valley Coal Field

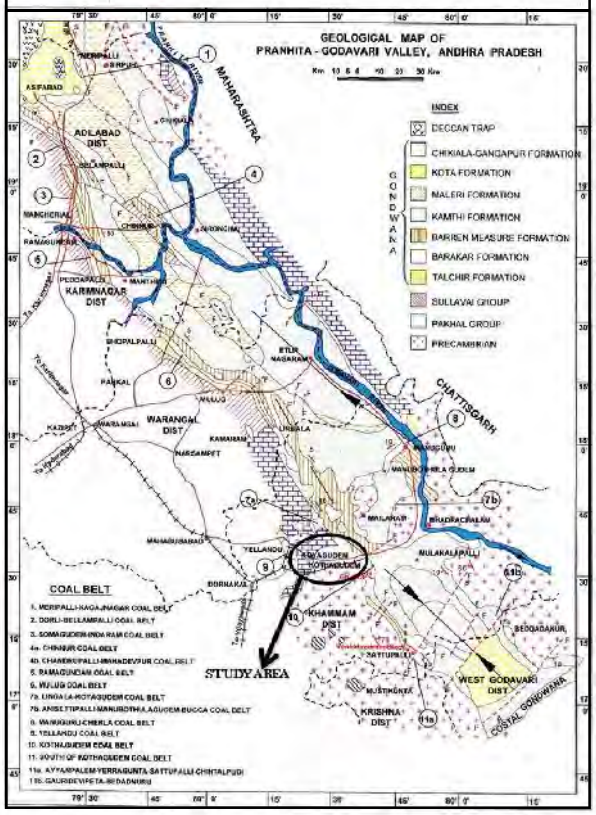


Table 1: General Lithostraigraphy of Lingala - Koyagudem Coal belt

Age	Group	Formation	General Lithology
Recent			Reddish and reddish yellow sandy soil
Permian	Upper Gondwana	Upper Kamthi	Alternating sequence of pebbly sand stone, pebble bed, medium to coarse grained yellowish ferruginous sand stone, fine to medium grained white quartizitic sandstone, pink and purple laminated sand stone with intervening pebble beds and micaceous reddish brown hematite bands beds.
	Lower Gondwana	Middle Kamthi	Alternating sequence of red, green, white and grey clays, shales and siltstones, inter bedded with fine to coarse grained argillaceous and ferruginous sandstone
		Conformable contact	
		Lower Kamthi	Coarse, Pebbly, feldspathic, highly Kaolinated sandstone with alternating thick clay and sandy clay beds.
		Barren Measures	Alternating sequence of grey immature feldspathic sandstone. Mg to Cg. Ferruginous sandstone hard and compact reddish brown to brown iron stone bands with green and grey clays and shales.
		Conformable contact	
		Barakar	Coarse to very coarse, pebbly poorly sorted grey white sandstone, alternating with siltstones, grey and white clays, shale and coal seams.
		Conformable contact	
		Talchir	Fine grained Greenish sandstone, siltstone, greenish and brown clays and dark green needle shalesinterbedded with dark grey, parallel bedded compact fine grained andstone (Rhythmites).
		Conformable contact	
		Pakhal	Quartzites, Phyllites, slates, Dolomitic limestone with quartz vein.
		Conformable contact	
Pre-cambrian Archean			Granite gneisses, Biotite gneisses, amphibolites, quarts, Chlorite Schists. BASEMENT

about 192 km^2 in Khammam district of Andhra Pradesh.The rocks of Archean gneiss, Pro terozoic Pakhalsuper group and Phenerozoic Gondwana sequence are exposed in the Koyagudem area. The Koyagudem area in Lower Gondwana sequence represents by parts of synformal structure and the area is traversed by repeated faults. Lower Gondwana sediments in the Koyagudem area belonging to Talchir, Barakar and Kamthi (sensu Raja Rao 1982). Formations have been established by surface and subsurface data. The bore hole KYG 451 located in the Lingala-Koyagudem coal belt Koyagudem area bounded by N 17º 37' 465" and E 80º31' 631" and falls in the survey of Indiatopo sheet No. 65 $^C/_{10}$ and $^C/_{11}$, 1:50000 scale respectively (SCCL 2011). TheGeological map of the study area shown in Figure 1 and lithostratigraphy of the area shown in Table 1.

MATERIALS AND METHODS

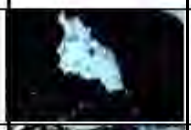
Ten bore hole samples are selected for sedimentological and palynologicalstudyfrom Koyagudem area, bore holeNo. KYG-451. The samples are collected according to referred depth and lithological wise. Total depth of the bore hole

is about 682m. From 002m to 308m and from 403m to 682m are non-coring sediments so that samples are unable to collected from these mentioned depth. From 95m thickness ten samples are collected and subjected to standard maceration technic for palynological study and thin section are made to sedimentological studies.For preparation of thin section study fresh bore hole representative samples are selected and section taken vertically by along the core samplesand mounted onglass slide with araldite fixed with canadabalsam and hand grounded and observed under the microscope and continued till all the mineral grain boarder clearly visible, when section attains to 0.03mm thickness. The thin section slides are ready for observation. This sedimentological thin section slides observed under the Leitz with digital camera attached optical microscope by selecting appropriate microscale.Thin sections are prepared in section cutting lab at Department of Earth Science, University of Mysore. The same samples are selected for palynological maceration procedure for the recovery of palynofossils. For palynological maceration analysis 50 grams of selected samples are washed with distilled water, burned with alchohol and crushed into pea nut size with ironpestel and mortar. The crushed samples are treated with 10% of HCl to remove the carbonate material, conc.HNO_3 to removehumic materials and finally treated with 40% of HF to remove silica contents, every acid treatment stage the samples are thoroughly washed with distilled water to remove the acid content if any. The collected organic material sieved by sieve cloth and centrifuged by taper ended test tube. The collected organic material mixed with a polyvinyl alchoholas a preservative and smeared on glass cover slip and mounted on palynological slide by using canada balsam and cooked and fixed,cleaned and labeled and palynological slides are ready to observe under palynological microscope and photographed digital camera attached Carl Zeiss microscope at VijanaBhavana, IOE, University of Mysore. Scanning Electron Microscopic study carriedout for the same rock samples was used to separate palynofossils and identified ultrafine morphic features of spores and pollens under Scanning Electron microscope and photographed at VijanaBhavana, UPE, University of Mysore, Mysuru.

SEDIMENTOLOGICAL STUDY

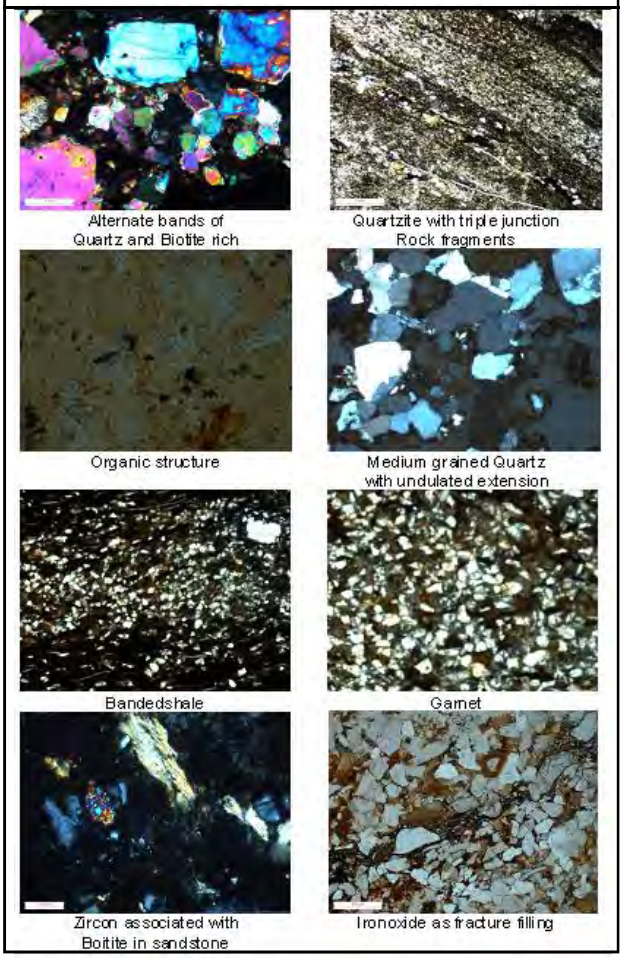
The investigation so far carried out for on aspects of sedimentology data from subsurface samples from Koyagudem area, KYG-451, Godavari valley coal field, Andhra Pradesh. Presentpaper contributes much about on sedimentological studies for ten core subsurface samples at different depth and for different lithology. The prepared thin section slides are analyzed under petrological microscope and identified different minerals, its character, and shape of the grains. After the detailed analysis of thin sections quartz grains are in abundance and are in sub angular to angular grain shape.The angularity of the quartz grains infers the immaturity of the sediments and also reveals the source rock is very near to the sediment depositional site. The presence of heavy minerals like zircon, garnet, hematite and chlorite are also identified from the thin section studies. The heavy mineral analysis depicts the source rock of the sediments for the deposition. The core sample and its corresponding optical thin section description for

Table 2: Microscopic Description of Sedimentary Thin Section and Correlation with Palynological Data

Sl. No.	Core Samples	Thin Section	Depth in mtrs.	Identified Palynoforms through palynological study	Texture photo	Mineralogy	Grain Size Analysis
S-88			308	Unproductive		Garnet, Iron oxide, biotite mica, muscovite mica, quartz microcline, perthite, zircon and cholorite.	Iron oxide in solution flows in that fractures or intergranular space.
S-87			310	Unproductive		More no. of quartz with assorted and angular shape indicates immature sediments.	This indicates angular fragments of quartz reveals source rock is nearby the deposition.
S-80			328	Unproductive		Quartz rich with mica shows angular fragments more in number.	Source rock also nearer to the depositional sites.
S-76			337.5	*Scheuringipollenites Striatopodocarpites, Sulcatisporites Vesicaspora*		Quartz grains are dominant with more biotite.	Banded shale with coal layers.
S-74			340	*Scheuringipollenite Faunipollenites Lunatisporites Striatopodocarpites Rhizomaspora Striatites*		Medium quartz grains angular fragments.	Indicates immaturity of sediments.
S-65			364	Unproductive		Quartz with heavy mineral like garnet and hematite.	A palyno form observed in thin section.
S-62			388	*Scheuringipollenite, Faunipollenites,, Striatopodocarpites Striatites, Sulcatisporites Rhizomaspora, Ibisporites Primuspollenites Lahirites Ginkocycadophytus Vesicaspora Virkkipollenites Parasaccites Laevigatosporites*		Chlorite bands rich feldspars altered to chlorite.	Quartz biotite angular to medium texture, ferrous oxide noticed.
S-55			331	Unproductive		Quartz seen abundant alteration feldspars to clay.	Angular quartz suggests source is close to deposition.
S-50			400	*Scheuringipollenites Faunipollenites Striatopodocarpites Crescentipollenites*		Fine to medium grind texture. Feldspars alters to microcline.	Many triple junction marks indicates metamorphic events.
S-49			403	*Scheuringipollenites Faunipollenites Ibisporites Verticipollenites Virkkipollenites Striatopodocarpites Rhizomaspora*		Biotite, quartz muscovite mica.	Biotite banded alternate rich quartz grains.

each samples are tabulated in Table 2. In this table an illustrative account on samples, depth data, sedimentary minerals data, textures, mineral assemblage and palynoforms are provided. The palynological assemblage data are compared to bring out a comprehensive account on the sub-surface palynological aspects. The thin section are observed under the optical microscope by 10X objective micro photographs without cross Nichols and with cross Nichols. All optical properties studied in detail for identifying minerals. Colour of the minerals and outlines of mineral optical characters like shape, undulate extension and pleochrohic schemes are studies in detail. Size of grains are measured by micro ocular scale.The nature of cementing materials as observed as in the sections, where as to identify to decipher the deposition conditions. Sedimentological activity is to findout whether the sediments are deposited in reducing or oxidizing environment. Iron oxide solutions are observed as cementing material during the thin section study which flows through the inter space between the minerals which reveals the sediments are deposited due to chemical weathering and also deposited in oxidizing environment. To support thin section photos are shown in Figure 2.

Figure 2: Some Selected Thin Section Microphotographs Showing Textures and Mineralogy



PALYNOLOGY

Palynological analysis data for the studied samples gives the ample of scope to assess the age of the sedimentary sequence. In the present study for analysis of ten samples at different depth and lithology. Based on the qualitative and quantitative analysis of the ten samples the monosacates, non-straiteddisaccates, striated disaccates are recovered and trilets are very rare. Based on the dominance and sub dominance of taxa one palynoassemblagemarked at a depth of 388m. The palynoassemblage zone reveals the dominanceof non-striatedpalynoform *Scheurangipollenites* (45%) along with sub-dominance of striated *Faunipollenites* (16%) and associated taxas like *Striatopodocarpites* (*6.2*%), *Striatites* (1.5%), *Sulcatisporites* (*3.1*%), *Rhizomaspora* (9.3%), *Ibisporites* (*4.6*%), *Primuspollenites* (*1.5*%), *Lahirites* (*1.5*%), *Ginckocycadophytus*(*1.5*%), *Vesicaspora* (4.6%), *Virkkipollenites* (*1.5*%), *Parasaccites* (*1.5*%), *Laevigatosporites* (*1.5*%). The other

samples are poor recovery of palynoforms. Some of the samples even afterrepeatedly checked which are unproductive may be due to mineral grain size control. It may be conclude that the samples like shally coal, shale are very much productive but sandstones unproductive sample from the present studies. The uneven distribution may be due to because of size of the grains in the sandstone which allows to percolation of water along with palynoforms. This is one of the valid reasons for uneven distribution of palynoforms in the study area. The distribution pattern of the spores and pollens at a depth 388m are shown in Figure 3. Some of the identified palynoforms are shown in Plate1 (Lightmicroscope photography) and Plate 2 for Scanning Electron Microphotograps. Scanning Electron Microphotographs are of high resolution showing all features of sacs, nature of central body with detailed ornamentation helps to identify the species.

RESULTS AND DISCUSSION

After detailed investigation of subsurface samples from the bore hole KYG-451 which gives a picture of mineral assemblage, source rock for deposition of sediments, depositional

Figure 3: Frequency Distribution Pattern of Spores and Pollens from B. H. KYG-451 at 388 m Depth

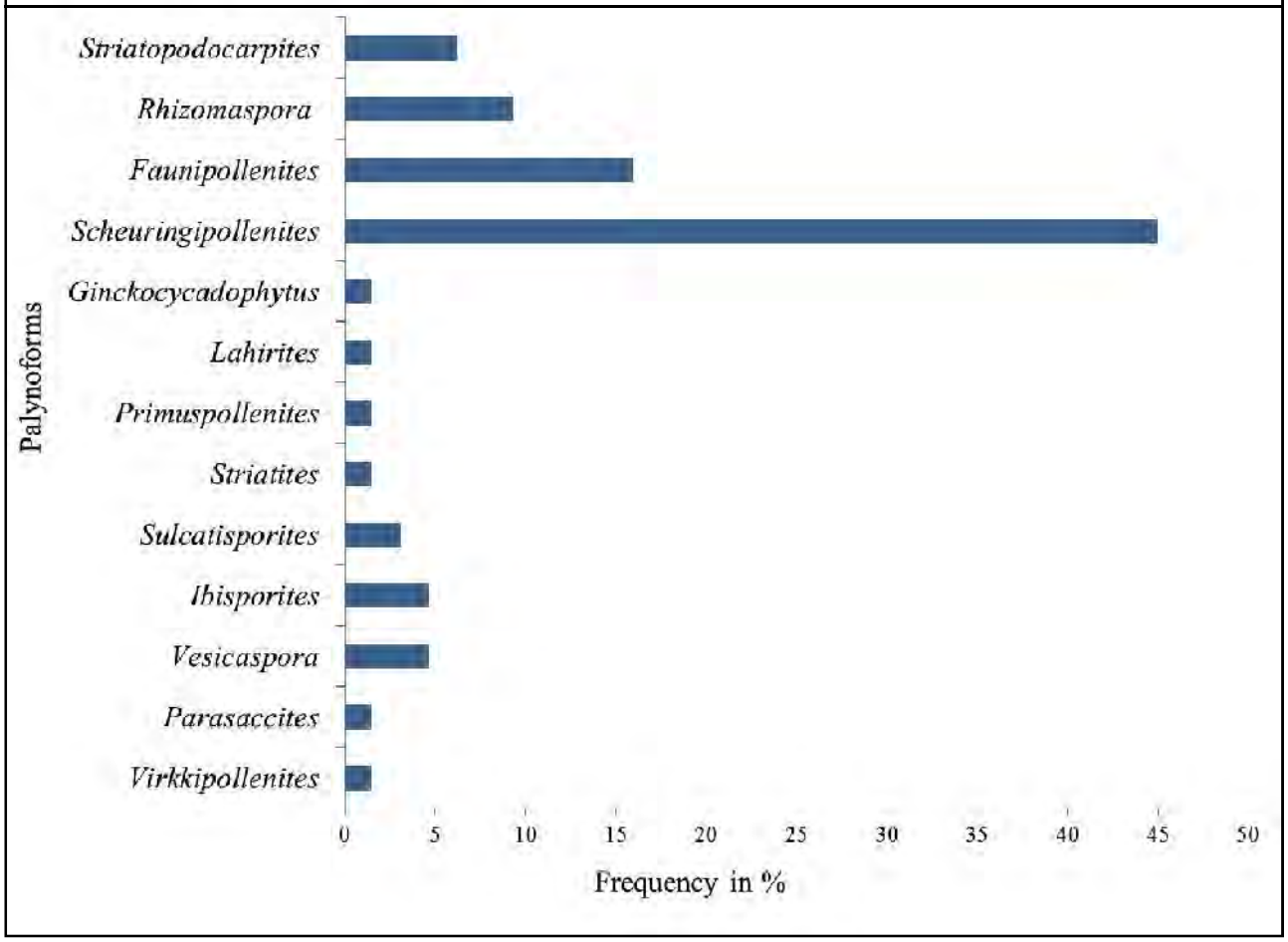
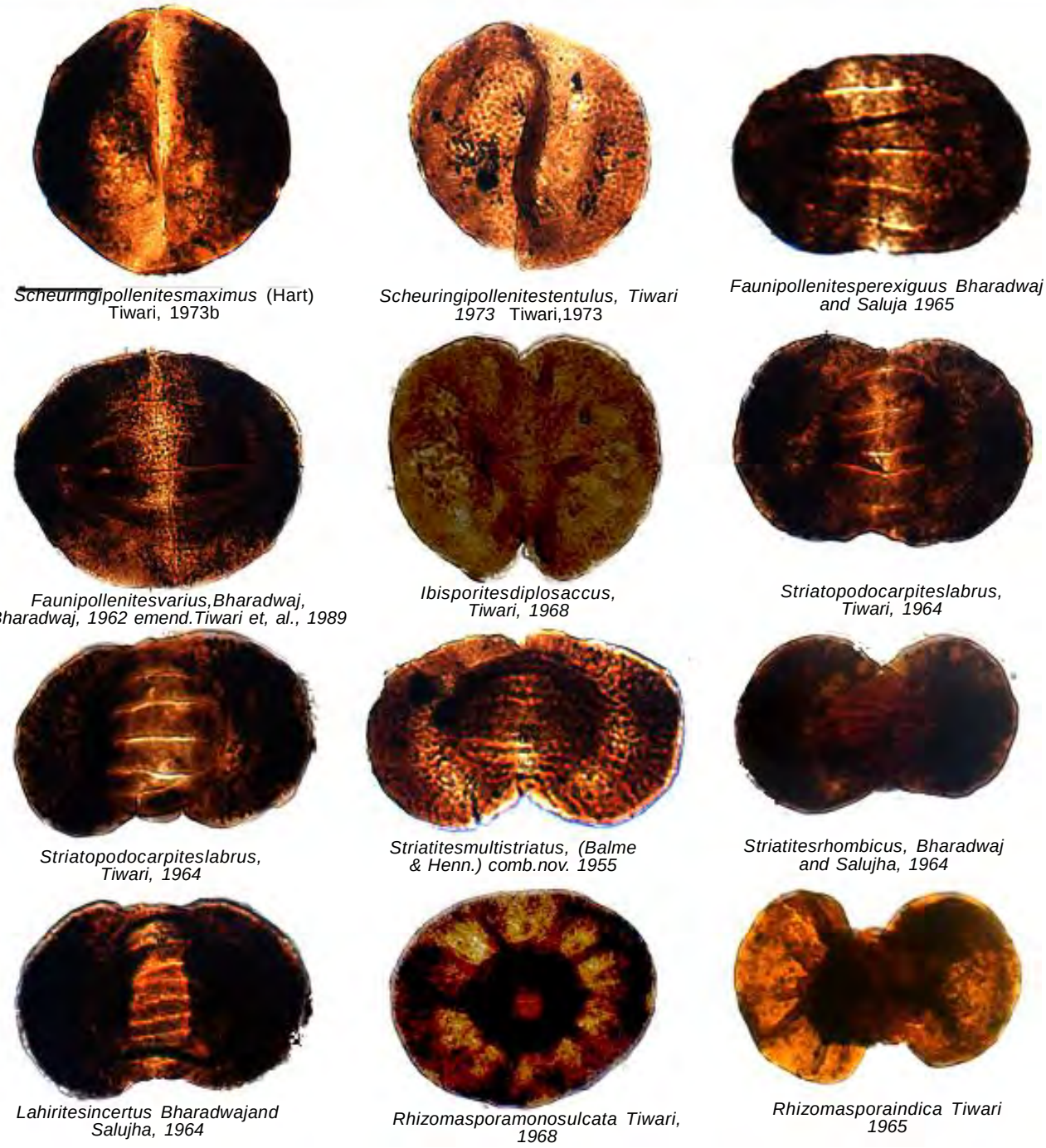


Plate 1: Microphotographs of Selected Spores and Pollens from the B. H. KYG-451. All Photo Graphs are Taken Under X1000 Magnification with Oil Immersion Until and Unless Mentioned, Bar Scale Indicates 50µm Size



Scheuringipollenitesmaximus (Hart) Tiwari, 1973b

Scheuringipollenitestentulus, Tiwari 1973 Tiwari,1973

Faunipollenitesperexiguus Bharadwaj and Saluja 1965

Faunipollenitesvarius,Bharadwaj, Bharadwaj, 1962 emend.Tiwari et, al., 1989

Ibisporitesdiplosaccus, Tiwari, 1968

Striatopodocarpiteslabrus, Tiwari, 1964

Striatopodocarpiteslabrus, Tiwari, 1964

Striatitesmultistriatus, (Balme & Henn.) comb.nov. 1955

Striatitesrhombicus, Bharadwaj and Salujha, 1964

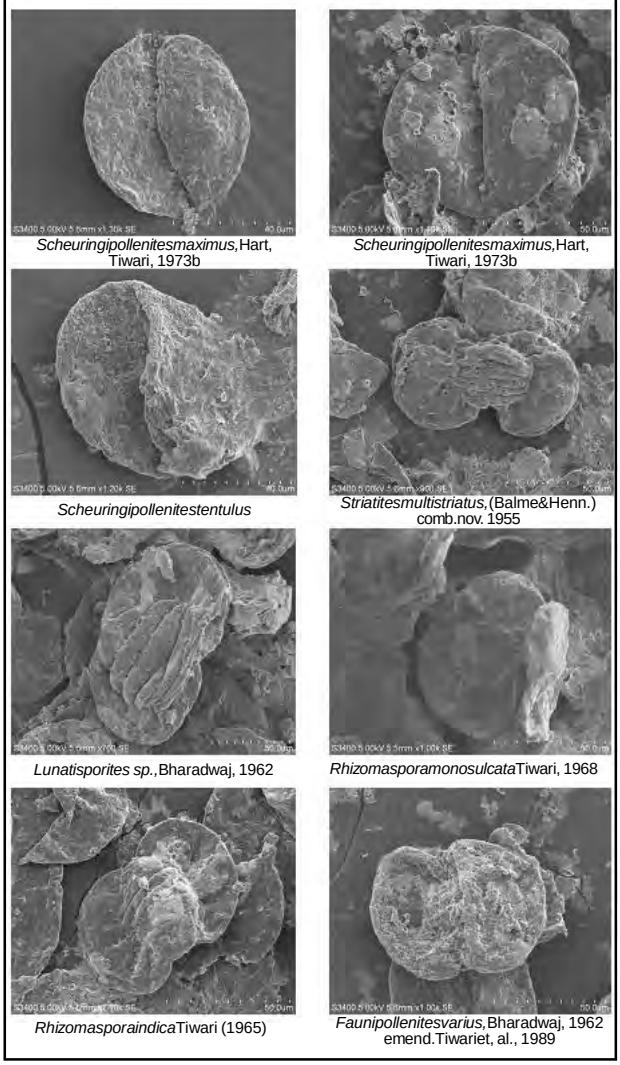
Lahiritesincertus Bharadwajand Salujha, 1964

Rhizomasporamonosulcata Tiwari, 1968

Rhizomasporaindica Tiwari 1965

environment, and assessment of age. Sediments are analyzed sedimentologically and palynologically from bottom to top following order of superposition of the bore hole at various depths. According to Singh (1975), the presence of angular quartz grains and high feldspar content,

Plate 2: Scanning Electorn Microphotograps



*Scheuringipollenitesmaximus,*Hart, Tiwari, 1973b

*Scheuringipollenitesmaximus,*Hart, Tiwari, 1973b

Scheuringipollenitestentulus

Striatitesmultistriatus,(Balme&Henn.) comb.nov. 1955

*Lunatisporites sp.,*Bharadwaj, 1962

*Rhizomasporamonosulcata*Tiwari, 1968

*Rhizomasporaindica*Tiwari (1965)

*Faunipollenitesvarius,*Bharadwaj, 1962 emend.Tiwariet, al., 1989

pointing to textural and mineralogical immaturity of sediments. Microscopic study reveals that presence of sub-angular to angular fragments of quartz grains shows the immaturity of the sediments and it suggests that limited chemical weathering prior to transport and source is very near to the sediments deposition site in the study area. The angular fragments with undulose extension of the quartz which are dominant in sandstone which shows the source rocks are plutonic granites and gneiss. Presence of heavy minerals reveals that the different source rocks are contributed. Heavy minerals like garnet bearing rocks of Precambrian granitic might have deposited as input. Presence of heavy mineral zircon reveals that the mineral derived mainly from acid igneous and metamorphic rocks like granites or gneisses as source for these minerals. The presence of chlorite mineral indicatesthat they are derived from low to medium grade metamorphic rocks. According to Singh 1975, the abundance of presence of microcline along with feldspar also demands presence of significant amount of garnetic gneisses in the provenance. Iron oxide solution indicates the oxidizing environment. Triple junction marks are noticed in some of the thin sections which reveals metamorphic process taken place during the sediment deposition. According to Tiwari and Chandra Das (1996), the occurrence of cyclic sequence of sandstone reveals braided depositional environment condition. In the present study also similar cyclic sequence of sandstone occurrence suggests that the sediments under braided environmental depositional condition observed in thesub-surface bore hole KYG-451, Koyagudem area. Palynologically the palynoassemblage zone marked at 388m depth from the bore hole. The palynoassemblage reveals dominance of non-striated disaccates *Scheurangipollenites* along with striated disaccate *Faunipollenites*with other associated taxa shows the affinity towards Early Permian Lower Barakar age (Neerja 2006, Suresh Srivastava and NeerjaJha 1989, Mahesh Bilwa *et al.,* 2012). This result is at the depth of bore hole between 308m to 403m (95m is total depth). Sedimentological and palynological data can be well fitted with one another.

CONCLUSION

Present study conclude with aspects of sedimentology and palynology of the sub-surface bore hole samples. Sedimentological studyreveals mineralogy, grain size, texture analysis which depicts the source rock and depositional environment of the sediments. The mineralogical study suggests that the presence of heavy minerals like garnet, zircon, which indicates the sediments are from different source rock as material. Palynological study reveals identification ofpalynoassemblagesat 388m depth based on the dominance and sub-dominance of palynotaxa. Based on the qualitative and quantitative analysis of spores and pollens assigned palynoassembalage zone which reveals dominance of non-striated *Scheurangipollenites* and sub dominance of striated *Faunipollenites* along with other taxas which assigns Early Permian, Lower Barakareffinity.

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