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**Course code: GEY402(Micropalentology and palaecology)**

1. **Discuss the morphological classification of pollens and spores**

 **SPORES:**

1. Spores are reproductive haploid structures that is adapted for dispersal and surviving for extended periods of time in unfavorable conditions.
2. Spores form part of the life cycle of many plants, algae, fungi and some protozoans.
3. A chief difference between spores and seeds as dispersal units is that spores have very little stored food resources compared with seeds.
4. Spores are usually haploid and unicellular and are produced by meiosis in the sporophyte.
5. Once conditions are favorable, the spore can develop into a new organism using mitotic division, producing a multicellular gametophyte, which eventually goes on to produce gametes.

**POLLEN:**

1. Pollens are produced from the microspore mother cells, but female spores are produced by the megaspore mother cells.
2. Pollen grains have two outer coats extine and intine and female spores do not have the extine or intine.
3. Pollens are dispersed by various mechanism, but female spores are retained within the ovary. Pollens are found inside the pollen sac, and female spores are found inside the ovule.
4. In other words, all pollens are spores, but not all spores are pollens.

**NPC CLASSIFICATION:**

1. NPC is an artificial system of classification of pollen and spore based on the three features of aperture only, i.e. number, position and character.
2. Erdtman and Straka(1961) proposed NPC classification and palynologists all over the world accepted it.
3. According to NPC system each pollen grain has an arithmetic cardinal number consisting of three digits
4. The first digit reveals the absence or presence of aperture, and when present it mentions the total number of aperture(s) present in a pollen grain
5. The second digit illustrates the position of aperture(s) i.e. digital, proximal, and latitudinal, meridonial, equatorial.
6. The microscope reveals the position of aperture(s) with full clarify when they are in tetrad.
7. The third digit explains the character of an aperture, i.e. circular/oval or elongated, simple or compound etc. ‘N’from number, ‘P’ from position and Ç’from character of aperture compose the NPC- classification.

 **CLASSIFICATION OF APERTURE BASED ON NUMBER**

1. In NPC system ‘N’denotes the number of apertures present in a pollen grain.
2. Aperture pollen, i.e pollen having apertures are divided into seven groups
3. The groups are mentioned as N1 to N7.
4. Each group has characteristic number of aperture, i.e N1 has one aperture and N2 has two apertures and so on. The N7 group has seven or more apertures.
5. N1 to N7 groups are also referred to respectively as monotreme, ditreme, tritreme, tetratreme, penatreme, hexatreme, and polytreme.
6. There are pollen grains where apertures are absent.
7. Such pollen grains are termed as inaperturate or atreme and they are placed on N0 group.
8. Anopther special group N8- termed nomotreme is created where the pollen grains and spores have one or several irregular or irregularly spaced apertures.

**CLASSIFICATION OF APERTURE BASED ON POSITION**

1. In NPC system ‘P’denotes the position of aperture in a pollen grain and spore.
2. The position may be proximal, distal and equatorial.
3. There are seven groups of aperture based on position namely- P0-P6. Pollen grains having P0 group have uncertain or unknown position or aperture.
4. P1 groups of pollen and spores are catatreme
5. Catatreme pollen grains have one aperture that occurs on the proximal part of a grain.
6. The proximal part is the face of a pollen grain or spore that faces inward/nearest or towards the centre of tetrad.
7. P2 groups of pollen and spores are anacatatreme
8. Anacatatreme pollen and spores have two apertures
9. One aperture with its centre occurs at the proximal pole. The other aperture with its centre occurs on the distal pole
10. The distal part is the face of a pollen grain and the spore that faces outward i.e away from the center of tetrad and opposite the proximal part.
11. P3 groups of pollen and spores are anatreme, i.e. the aperture is distal in position.
12. P4 groups of pollen and spore are zonotreme
13. A zonotreme pollen grain is characterised in having apertures on equator or sub-equator.
14. The equator is the part of the pollen grain or spore that runs midway between the proximal and distal poles and perpendicular to polar axis.
15. P5 groups of pollen and spore are dizonotreme
16. Dizonotreme pollen grains have apertures arranged in two or more zones
17. The apertures occur parallel to equator. P6 groups of pollen and spore are pantotreme
18. Pantotreme pollen grains have apertures scattered over the whole surface uniformly. As a rule, pantotreme pollen grains are spheroidal.

 **CLASSICATION OF APERTURES BASED ON CHARACTER**

1. In NPC system ‘C’ denotes the character of an aperture in a pollen grain and spore.
2. The character groups of pollen and spore are seven and they are mentioned as C0 to C6 groups have apertures whose character cannot be established with certainty.
3. C1 groups of pollen and spore have leptoma.
4. Leptoma is a thin area, aperture like and functions like an aperture.
5. Pollen grains having one leptoma are termed as monlept.
6. The leptoma may occur on either proximal or distal face of pollen grain and spore and accordingly termed as catalept or analet.
7. C2 groups are trichotomocolpate
8. Trichotomocolpate is a three-branched aperture, the branches of which are more than two times longer than breadth.
9. Trichotomocolpate pollen and spores having aperture on proximal face are termed as trilete.
10. The group C3 has colpate grains
11. The group C4 comprises porate pollen grains
12. The group C5 comprises colporate pollen
13. The group C6 comprises pororate pollen C3, C4, C5 and C6 groups of aperture are previously discussed under aperture.

 **MERITS OF NPC CLASSIFICATION**

1. It is a simple system of classification and illustrstes apertures of a pollen grain and spore.
2. With the aid of NPC pollen grains and spores of ptridophyta, monocotyledon and dicotyledon, to some extent, can be differentiated
3. Most of the spores of pteridophyta are monolete or trilete.
4. Monocots are characterized by inaperture, monosulcate and monoporate pollen grain s.
5. Dicots, with a few exceptions, have pollen grains that are mostly with three meridonial furrows and polyaperturate.
6. Thus NPC narrows the search list of identification of unknown sporomorphs
7. NPC makes the description of apertures precise.
8. NPC is supposed to be of primary classificatory character because apertures are most conservative
9. It is supplemented by the surface ornamentation, size and shape, etc. of a pollen grain.
10. Sometimes it becomes possible to identify the family or genus or even species of a pollen grain with the aid of NPC in combination with other morphological characters.
11. Palynologists all over the world accepted NPC classification as it is basically simple and consistent where pollen grains and spores could be arranged easily.
12. This helps to identify unknown sporomorphs.
13. NPC, sporoderm, exine patterns, size and shape etc, of a pollen grain are genetically stable.
14. This property is utilized for various purposes and the followings are a few illustrations.
15. With the aid of NPC and other characters a key can be formulated that helps to identify unknown poleen and spores.
16. NPC and the various types of exine patterns and ornament provide characters of taxonomic significance and thus become one of the sources of alpha taxonomy.

 **DEMERITS OF NPC CLASSIFICATION**

1. It is an artificial system of classification.
2. Syncolpate and parasyncolpate pollen grains do not fit neatly in NPC system.
3. Pollen grains that are characteristically present as aggregates in tetrads, e.g Ericacae, Typhacae and polyads, e.g Orchidaceae, Mimosa, etc are not grouped in NPC system.
4. NPC system of classification is always compared with Linnaeus’s system of classification, because the latter is also an artificial system of classification.
5. The characters of stamen were the basis of classification.
6. Linnaeus accepted the weakness of his classification but claimed that it was propounded mainly as an aid to identification.
7. **APPLICATIONS OF POLLENS AND SPORES IN GEOSCIENCES**
8. **Marine geosciences:**

In marine geosciences, pollen and spores from sediment cores have been particularly useful to document the vegetation and climate over terrestrial areas adjacent to study sites and to establish land-sea correlations.

1. **Forensic applications:**

Palynological samples can be recovered from a wide range of sources, including people, such as on their clothes, in their hair or even in their nasal passage, vehicle tyres, air filters in cars, on objects and in mud. Because of the dispersal mechanisms of some plants, pollen can be readily picked up and transferred. A person can easily inadvertently pick up pollen from a crime scene, whether it be in mud on their shoes or on their clothes from directly brushing against a plant in the area. With this in mind, a primary use of palynology in a forensic investigation is to establish a link between two places, objects or people. For instance, it may be possible to link a suspect to an object, a vehicle to a crime scene, or even link two separate incident scenes. If a suspect was present at a particular crime scene at which pollen can be found (for instance a field or garden), they may have picked up pollen on their clothing or in their hair. Because pollen is so resilient, it can often stick to other objects even after that object has been washed. If the pollen recovered from the suspect matches pollen collected from the crime scene, this could suggest that the suspect was in fact present at that scene. However, it must be considered that although the presence of pollen may establish a link, the lack of pollen does not necessarily prove that there is not a link. Similarly, palynology may be able to determine the location of a crime scene if it is not known. For instance, a body that is believed to have been moved may carry pollen grains that can be analysed and traced to a likely location. This may particularly be suspected if the body carries large amounts of a particular pollen that is not found at the location in which the body was found.The study of pollen can also be used to determine the travel history of an item. In some cases, it may be necessary to ascertain where an item has originated from, especially illicit drugs, money, antiques and even food. By analysing pollen recovered from suspect items, it may be possible to trace that item to a particular country if the pollen grains identified are sufficiently distinctive. Although this application of palynology may not necessarily be able to establish an exact location, it may be least be possible to rule out certain geographical locations and point the investigation in the right direction.It may even be possible to estimate the time of year at which a crime took place. In the investigation of a somewhat older crime scene, pollen collected may actually be released at a different time of year, indicating the crime occurred during this period.

1. **Reconstructing past vegetation:**

Palynology can be used to reconstruct past vegetation and marine freshwater phytoplankton communities, and so infer past environmental and paleoclimatic conditions in an area thousands or millions of years ago.

1. **Limnology studies:**

Limnology  is the study of inland [aquatic ecosystems](https://en.wikipedia.org/wiki/Aquatic_ecosystems).[[1]](https://en.wikipedia.org/wiki/Limnology#cite_note-1) The study of limnology includes aspects of the [biological](https://en.wikipedia.org/wiki/Biology), [chemical](https://en.wikipedia.org/wiki/Chemistry), [physical](https://en.wikipedia.org/wiki/Physics), and [geological](https://en.wikipedia.org/wiki/Geology) characteristics and functions of inland waters (running and standing waters, fresh and saline, natural and man-made). This includes the study of [lakes](https://en.wikipedia.org/wiki/Lake), [reservoirs](https://en.wikipedia.org/wiki/Reservoir), [ponds](https://en.wikipedia.org/wiki/Pond), [rivers](https://en.wikipedia.org/wiki/River), [springs](https://en.wikipedia.org/wiki/Spring_%28hydrosphere%29), [streams](https://en.wikipedia.org/wiki/Stream), [wetlands](https://en.wikipedia.org/wiki/Wetland), and [groundwater](https://en.wikipedia.org/wiki/Groundwater).[[2]](https://en.wikipedia.org/wiki/Limnology#cite_note-Wetzel-2) A more recent sub-discipline of limnology, termed [landscape limnology](https://en.wikipedia.org/wiki/Landscape_limnology), studies, manages, and seeks to conserve these [ecosystems](https://en.wikipedia.org/wiki/Ecosystem) using a landscape perspective, by explicitly examining connections between an aquatic ecosystem and its [watershed](https://en.wikipedia.org/wiki/Drainage_basin). Recently, the need to understand global inland waters as part of the [Earth System](https://en.wikipedia.org/wiki/Earth_system_science) created a sub-discipline called global limnology.[[3]](https://en.wikipedia.org/wiki/Limnology#cite_note-3) This approach considers processes in inland waters on a global scale, like the role of inland aquatic ecosystems in global biogeochemical cycles. Freshwater palynomorphs and animal and plant fragments, including the [prasinophytes](https://en.wikipedia.org/wiki/Prasinophyte) and [desmids](https://en.wikipedia.org/wiki/Desmid) ([green algae](https://en.wikipedia.org/wiki/Green_alga)) can be used to study past lake levels and long term [climate change](https://en.wikipedia.org/wiki/Climate_change)

1. **Organic palynofacies studies:**

Organic [palynofacies](https://en.wikipedia.org/wiki/Palynofacies) studies, which examine the preservation of the particulate organic matter and [palynomorphs](https://en.wikipedia.org/wiki/Palynology#Palynomorphs) provides information on the depositional environment of sediments and depositional palaeoenvironments of [sedimentary rocks](https://en.wikipedia.org/wiki/Sedimentary).

1. **Geothermal alteration studies:**

[Geothermal](https://en.wikipedia.org/wiki/Geothermal) alteration studies examine the [colour](https://en.wikipedia.org/wiki/Color) of palynomorphs extracted from rocks to give the thermal alteration and [maturation](https://en.wikipedia.org/wiki/Hydrocarbon) of [sedimentary](https://en.wikipedia.org/wiki/Sedimentary) sequences, which provides estimates of maximum [palaeotemperatures](https://en.wikipedia.org/wiki/Paleotemperatures).

1. **Explain the stratigraphical and paleoenvironmental applications and significance of pollens and spores in sedimentary and petroleum geology:**

 Palynology in the oil industry is a stratigraphic tool especially useful in the study of rocks deposited in continental, coastal, and shallow-marine settings . Palynological analyses are used mainly for chronostratigraphic correlations, paleoenvironmental studies, and the evaluation of potential source rocks. The integration of palynology with other geoscience disciplines, such as sedimentology, geophysics, geochemistry, and petro physics, is needed for geological modeling and petroleum system studies, which in turn are essential for planning and developing better exploration strategies and for optimizing reservoir exploitation . This also will enhance detection of hydrocarbon accumulation in subtle traps and permit better prediction of the lateral variability in quality of reservoir rock than is achievable only with the classical litho-seismic stratigraphic approach, thereby leading to increased oil reserves. The study of fossil flora record of sedimentary rocks has diverse range of applications in geology including biostratigraphy, geochronology (to correlate strata and determine the relative age of a bed, horizon, formation or stratigraphic sequence), paleoecology and climate change, organic palynofacies studies, geothermal alteration studies (to examine the color of palynomorphs extracted from rocks to give the thermal alteration and maturation of sedimentary sequences) . This is especially true because the floristic component of layered rocks occur in high abundance permitting the use of only little amount of sample and statistical analysis . Although a lot of bio stratigraphic studies have been carried out by several workers in the Niger Delta Basin ], the information they provide cannot be extrapolated over a long distance because of the very complex nature of stratigraphic architecture occasioned by the numerous synsedimentary faults which mainly deformed and compartmentalized the stratigraphic interval of interest, the Agbada Formation . Furthermore, the findings of some of these studies are kept private by the oil companies that did the research because of the rules of confidentiality and proprietary nature of basic information thereby causing a lacuna in the bio stratigraphic database of the Niger Delta Basin. It is the aim of this present study therefore to use palynology to establish the age, the paleoclimate and the paleodepositional environment of the stratigraphic interval penetrated by GBO-04 well in the western onshore Niger Delta. The role of palynology in the exploration for oil is essentially comparable to that of any other branch of paleontology. Advantages and limitations of spores, pollen, algae, miscellaneous protistans of uncertain or known affinity, and other similar-sized microfossils utilized in palynology as stratigraphic and paleoecologic indicators are briefly reviewed. The economic value of this relatively modern scientific field to the petroleum industry may be increased and hastened by avoiding some of the pitfalls which plagued micropaleontology in its earlier years of application. Information should be developed simultaneously on the biology, ecology and stratigraphy of these organisms.

Palynologists now being trained should be encouraged to develop their knowledge of both geologic and biologic fundamentals. Research in this field should be sponsored by industry, as well as by universities and government agencies, in both its own research laboratories and in private or university labs. The areas of this research should include: studies of the distribution and preservation of palynomorphs in modern sediments; relative significance of living assemblages or transported entities to other types of organisms with which they are found; development of methods and programs for mechanical classification of these micro-fossils and analysis, evaluation, storage and retrieval of data concerning them; improvement of techniques for separating these fossils from the rocks; development of environmental information by the study of types and conditions of preservation, origin and significance of reworked fossils, relative percentages of spores and pollen to other organisms, and characteristics of their role in sedimentation.