ASSIGNMENT ON THE MORPHOLOGICAL CLASSIFICATION AND APPLICATION OF POLLENS AND SPORES IN GEOSCIENCE

Submitted to

DR AFOLABI

By

ANITA AMARACHI ANYAJI

16/sci14/002

The department of Geology, college of science

Afe-Babalola university Ado-Ekiti.

June, 2020

In general the spores of bacteria, fungi, algae and protists are rarely preserved but those of terrestrial plants are very common fossils. Terrestrial plants produce extremely resistent spores and pollen which are easily transported by wind and water. Most fossil spore and pollen grains are studied in a dispersed state. Spores are produced by the so-called "lower plants" or cryptogams, and within this group the pteridophytic vascular plants and bryophytes (mosses, liverworts and hornworts) are the most commonly studied. Pollen of seed plants, both angioperms and gymnosperms increasingly dominate palynological assemblages of Mesozoic and younger nonmarine deposits.

The fact that spores and pollen are normally retrieved from their host sediments as disjunct entities, separate from the original parent plant means that their natural affinities are often obscure. The free sporing plants including the Bryophyta e.g. mosses and liverworts, and the Pteridophytes which, although not a natural classification, encompassess all the seedless vascular plants, including the palaeontologicaly important ferns and fern allies, are primarily classified using the gross morphology, wall structure and the type of wall sculpture, if present. The important feature of homospory in terms of the fossil record is the four fold division involved in spore production, this takes the form of either a tetrahedra which gives a trilete spore or a tetragon which gives a monolete spore. The trilete and monolete marks imparted on the individual spores are the marks where each of the spore tetrad once abutted each other.

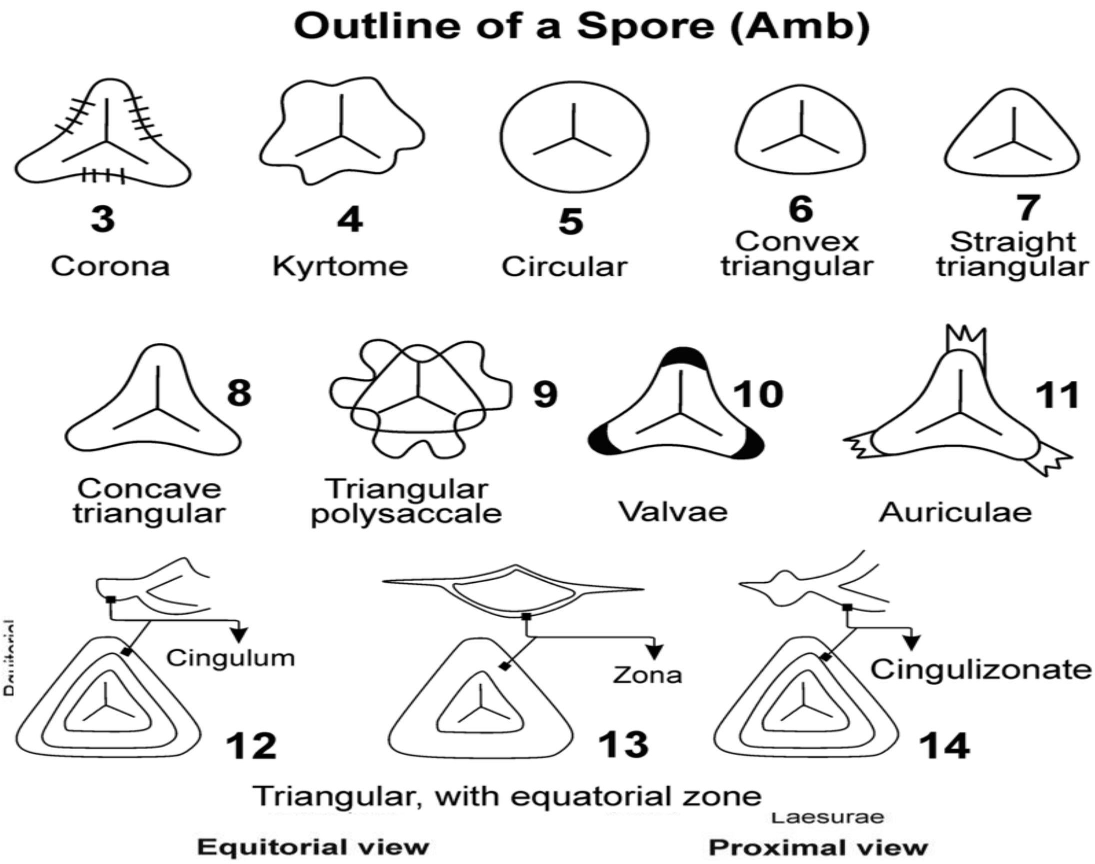
Classification of pollen, like that of spores is based on the morphological trends observed among various groups of fossils which may be primarily but not entirely reflections of evolution within the groups of plants which produced the pollen. It should also be remembered that higher plants have charcteristics of reproduction which permit them to utilise modes of evolution unavailable to animals. Because of their relatively simple genetic systems plants may utilise hybridisation and self fertilisation. The early gymnosperms produce prepollen, differentiated from true pollen by germination from the proximal rather than the distal side. Recent gymnosperms may produce very distinctive saccate pollen, i.e. pollen with one, two or rarely three air sacs attached to a central body (colpus) or monosulcate pollen as in the cycads and ginkgos. The angiosperms produce pollen with the greatest morphological variation, but typicaly with either a tricolpate or monosulcate form.

Spore Morphology

The cryptospores (dispersed spores/spores produced by embryophytes; although recent data suggests that not all are produced by the latter), are the earliest evidence of the colonization of the Earth by land plants. The embryophytes (Bryophyta, Pteridophyta, and seed plants) are plants with true embryos in their life cycle. The earliest record (of an assemblage of monads and tetrads) comes from the Early Ordovician (~473–471 Ma).These are thought to be liverworts and predate the first vascular plants by almost 8–12 Ma. Previously, the earliest hilate and trilete spores came from the late Darriwilian age (Middle Ordovician; ~463–461 Ma) of Saudi Arabia (Steemans et al. 2009) and from the Czech Republic (Vavrdová 1990; Strother et al. 1996).

The trilete spore is the most basic spore type and is characterized by a Y-shaped “mark” or “suture” or “scar” (the Y-mark or trilete mark). These marks are called laesura and are in the form of raised ridges or fissures at the surface on the proximal face of a spore. The laesurae are formed by four equivalent reproductive cells (spore tetrad or tetrahedral tetrads) that are produced by the spore mother cell by simultaneous meiosis all four are in contact at a single point forming the Y-mark or the trilete mark.. The three laesurae radiate 120° from the proximal pole and thus, display radial symmetry; such spores are heteropolar, i.e., with differently formed polar faces. A laesura constitutes of a Commissure (a slit or line of dehiscence in the laesurae) and is bordered by a Margo, a distinct thinning or thickening of the ektexine (sometimes also referred to as ectexine) bordering the aperture. The equatorial contour is called the amb which displays varied shapes.

Morphology of a trilete spore



Amb shapes (spore outline). The equatorial contour of a spore is called an Amb, which displays varied shapes.

Pollen Morphology

The pollen morphology is very complex and exhaustive. It is briefly explained under the following subheads: Pollen Units, Shape, Symmetry, Size, Polarity, Apertures, Sporoderm stratification, and exine ornamentation.

Pollen Units

The pollen grains divide meiotically to form a tetrad that dissociates at maturity into a single grain called monad, into two, dyad, four tetrad and, eight, octad or many, polyad. The tetrads are formed when four pollen grains are united and are the unseparated product of meiosis (as in Acaciapollenites). Based on the arrangement of grains, they are of the following types—tetrahedral tetrad, tetragonal tetrad, rhomboidal tetrad, decussate tetrad, T-shaped tetrad, linear tetrad, and cryptotetrad or pseudomonad. In polyads as in Mimosaceae, the tetrad cell divides once or twice or more, yielding a group of 8–64 cells that remain together after maturity. In pollinia, the whole contents of an anther are released as one unit as in Orchidaceae.

Polarity

Polarity is defined as the condition of having distinct poles in a pollen grain and best detected at the tetrad stage, i.e., prior to separation. The orientation of polarity is an important defining character in species identification and description and it is the polarity that distinguishes a spore from pollen. To understand polarity, it is important to first understand how a grain is viewed. The polar and distal views have varying focal planes; the darker plane represents the equatorial focal plane by examples of monolete and trilete spores and monosulcate pollen grains.

The spores have two poles, proximal and distal. The proximal face/surface is the one that faces inward/nearest or toward the center of the tetrad. The distal face/surface faces distal, i.e., away from the center of tetrad and opposite the proximal part. An imaginary straight line called the polar axis connects the proximal pole to the distal pole. The equatorial axis/equatorial diameter (=equator) is also an imaginary straight line that occurs perpendicular to the polar axis and runs through the middle of the pollen. The term meridional (or longitudinal) is used to indicate the surface of a pollen grain or spore that is oriented in the pole-to-pole direction, and at right angles to the equator.

In the polar view, the polar axis is directed toward the observer and the aperture is viewed centrally and the zonal aperture is then viewed in the circumference of the pollen grain. Whereas, in the equatorial view, the aperture is arranged meridionally (i.e., pole to pole), and at right angles to the equator. In this position, both the polar axis and the equatorial diameter can be viewed and measured.

A pollen grain can be either polar or apolar. Polar pollen grains can be isopolar or heteropolar, depending upon the demarcation between the two equal or unequal polar faces. In isopolar grains, the distal and proximal faces (above and below the equatorial plane) are mirror images (as in Calluna, Ericaceae), whereas in heteropolar grains, the two faces are distinctly different, either in shape, ornamentation or in the apertural system (as in Irlbachia, Gentianaceae). Thus, one face may have an opening (aperture) and the other would be marked by its absence (as in Lilium and Elaeis). The paraisopolar or subisopolar pollen grains; these are part of the polar grain category and intermediate between isopolar and heteropolar grains) are those that show minor differences between the distal and proximal faces such that one face (distal) is convex and the other is concave or plane (proximal) or vice versa (as in Diastella, Nivenia, and Ulmas).

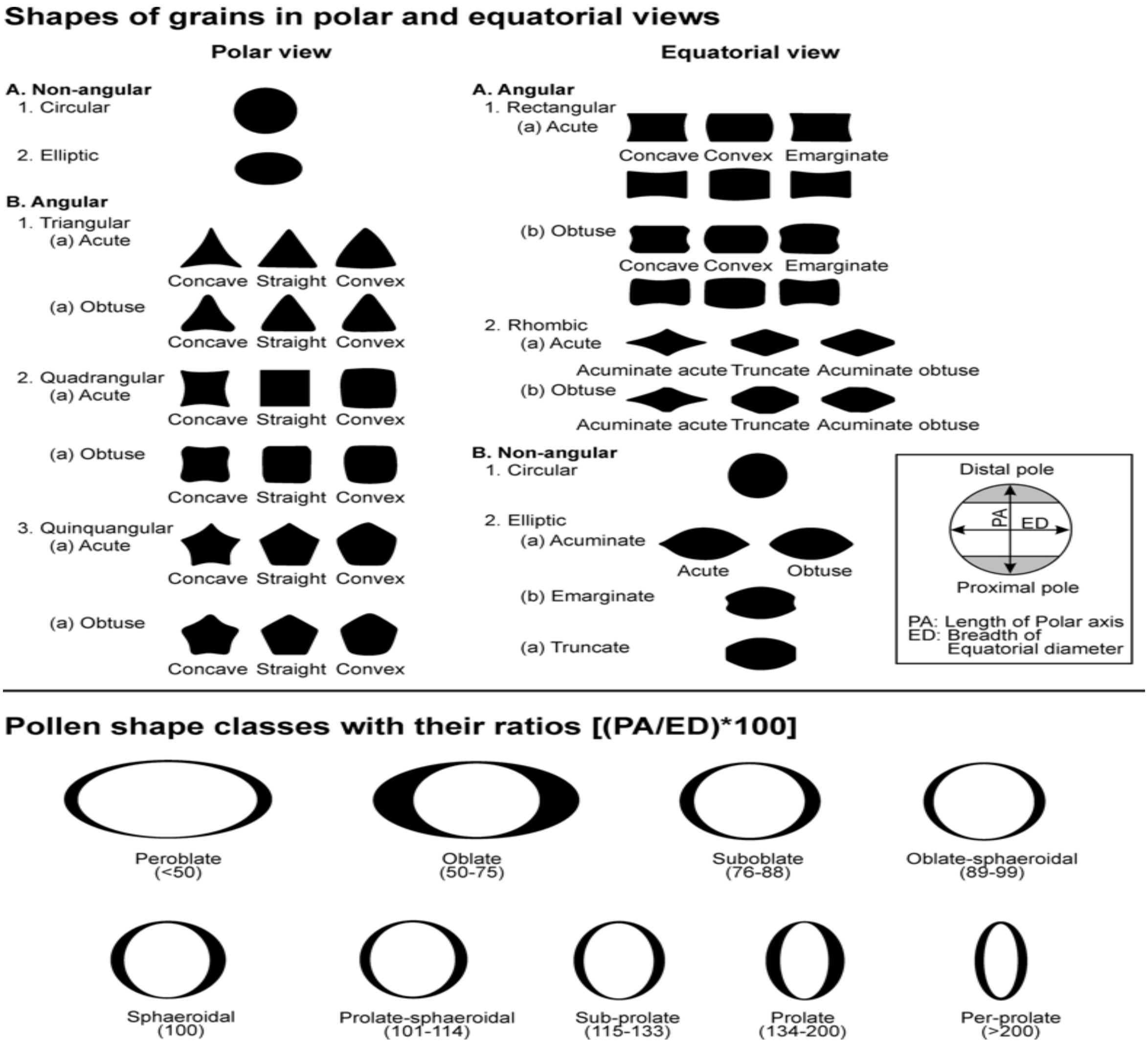
The polarity of a pollen grain forms the basis of the aperture terminology such that a circular aperture that occurs equatorially or globally is called porus. The circular aperture that occurs distally is termed as Ulcus. An elongated aperture that occurs equatorially or globally is called colpus (furrow is a common word for colpus). When an elongated aperture occurs distally it is called sulcus.

Apertures

An aperture (also treme—a Greek word for aperture) is an opening or thinning of the exine (outer layer); the intine (inner layer) is generally not affected and remains thick (Sporoderm stratification is detailed later in the chapter). In simple terms, it is a specialized region of the sporoderm that is thinner than the remaining sporoderm and differs in ornamentation and/or in structure. Based on the position of this opening, apertures can be grouped as polar, global, or equatorial. Polar types are either monopolar (positioned either in the proximal or distal pole) or bipolar (both in the proximal and distal face). The global apertures are uniformly distributed over the surface, whereas the equatorial ones are meridionally arranged. In some taxa, as in Canna spp. of Cannaceae, there are no special apertures and are thus called inaperturate or non-aperturate. But, in reality, most of them are actually "omniaperturate," i.e., the thin exine covers the grain with a thick intine (or at least as thick as the exine).

Shape

Shape is also a diagnostic character for species identification. But it varies greatly, from species to species, to within one grain type and even within one species. Pollen and spores are described by the shape of their outline, either as non-angular or angular. The outline or circumference in polar view is called Amb. Based on the ratio of polar axis (PA) and equatorial diameter (ED), eight shape classes are noted. In the equatorial view, the ratio between the PA and ED, multiplied by 100 gives the indication of the shape such as prolate, prolate–spheroidal, spheroidal, sub-prolate, perprolate, oblate, oblate–spheroidal, sub-oblate, and peroblate.



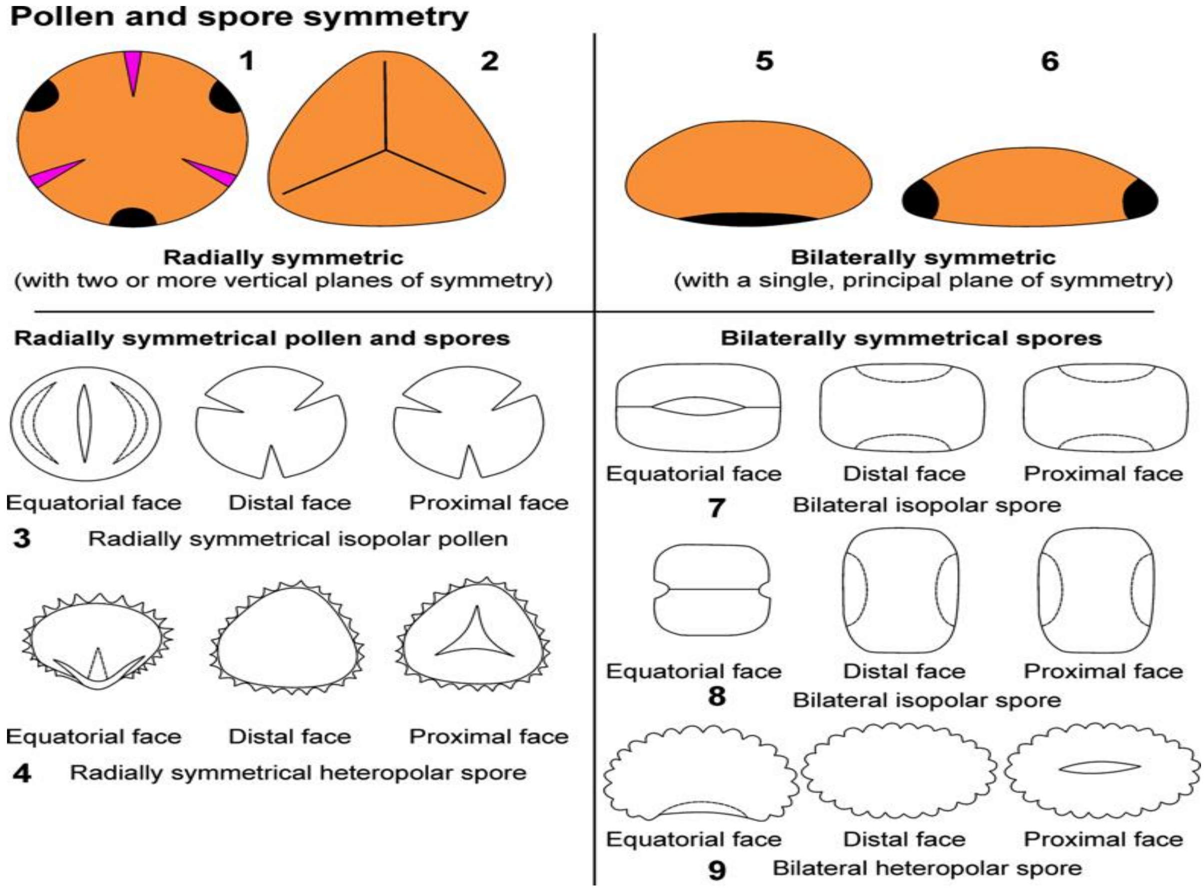
Pollen shapes. The pollen and spores are described by the shape of their outline, either as non-angular or angular.

Symmetry

Symmetry with relation to a pollen grain implies similarity of halves on either side of a median line or plane so far as aperture and ornamentation, etc., are concerned. The pollen grains or spores can be either symmetric or asymmetric. In asymmetric ones, there is no plane of symmetry (as in Berberis darwinii, Papaver argemone, and Myriophyllum alterniflorum). These may be with fixed shape, called fixiform or without any definite shape called non-fixiform. Asymmetric pollen and spores are very rare.

The symmetric ones can be either radially symmetrical (radiosymmetric or bilaterally symmetrical, i.e., having a single plane of symmetry). In radially symmetrical grains, any plane including the polar axis, produces identical halves. Hence, such grains possess more than two vertical planes of symmetry (as in Centaurea); one horizontal and two or more vertical. All the planes are of equal length. In radially symmetrical heteropolar spores, there is no horizontal plane of symmetry, but two or more vertical planes of symmetry (as in Osmunda regalis, Ophioglossum vulgatum, and Pteridium aquilinum). Most pollen and spores are symmetrical.

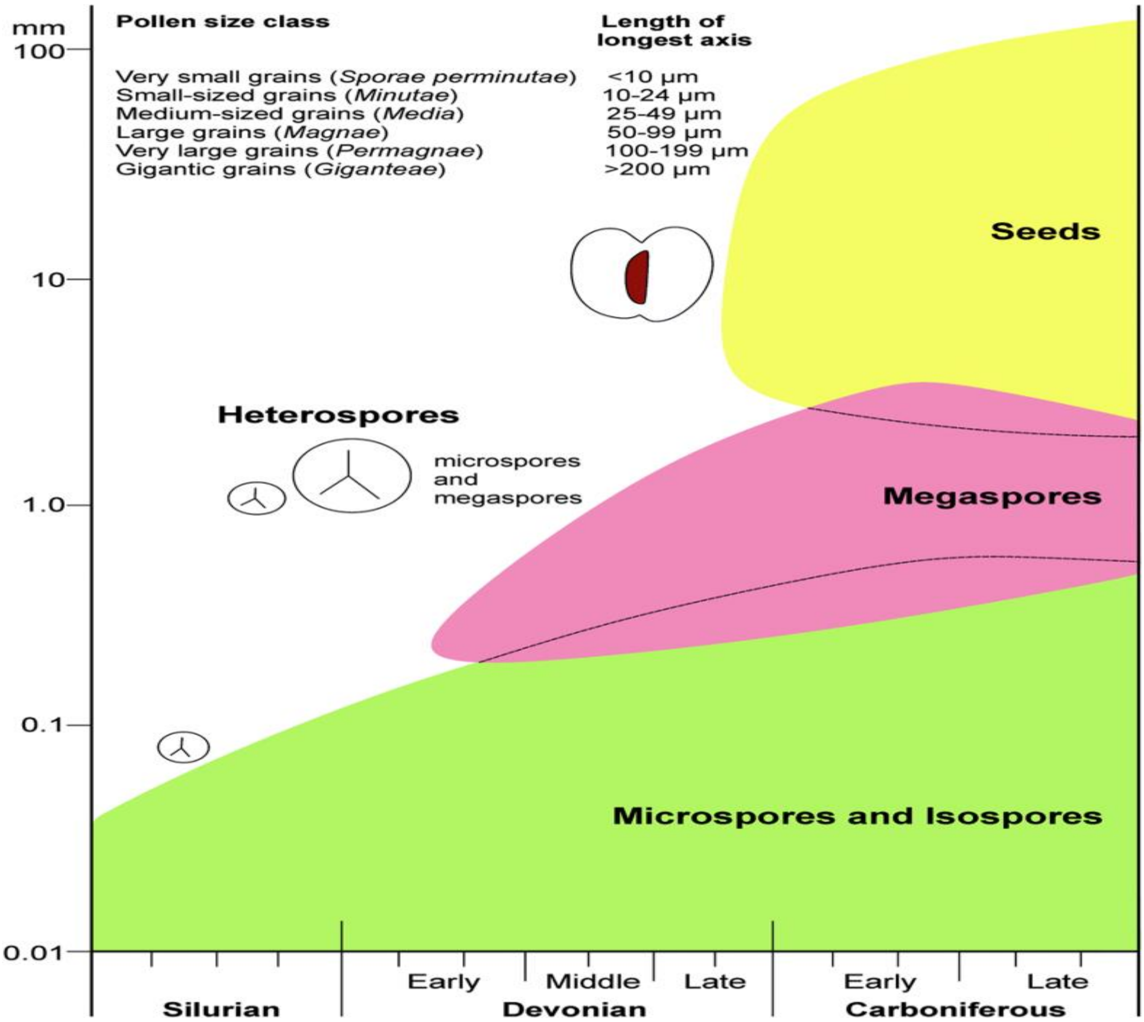
The bilateral isopolar spores exhibit two vertical planes and one horizontal plane of symmetry. All the planes are not of equal length (as in Rungia grandis). In bilateral heteropolar spores, there exist two vertical planes of symmetry. The planes are unequal in length and intersect each other at right angles (as in Ephemerum serratum, Picea abies, and Cycas revoluta).



Pollen symmetry. The pollen grains or spores are either symmetric (1–4) or asymmetric (5–9)

Size

Size, like shape, varies greatly. The smallest is about 5 × 2.4 µm (Myosotis palustris) whereas some are large, >200 µm in diameter, as in Boraginaceae, Curcurbitaceae, Nyctaginaceae, and Orectanthe ptaritepuiane (Abolbodaceae). Microspore is a term used to include all spores <200 µm in diameter. The wind pollinated and airborne pollen grains normally range from 10 to 80 µm. It is imperative to also measure exine elements (discussed in the next section) by considering the thickness of exine, sexine/nexine thickness ratio and the thickness of the exine projections >0.5 µm, if any. The different pollen size classes, based on the size expressed as the length of the longest axis.



Spore size- 0.1 mm = 100 µm.

APPLICATION OF SPORES AND POLLENS IN GEOSCIENCES

Identification of pollen and spore microfossils has greatly aided delineation of the geographical distribution of many plant groups from early Cambrian time (some 541 million years ago) to the present.

- **iostratigraphy and geochronology-**Geologists use palynological studies in biostratigraphy to correlate strata and determine the relative age of a given bed, horizon, formation or stratigraphical sequence.
- Because the distribution of acritarchs, chitinozoans, dinoflagellate cysts, pollen and spores provides evidence of stratigraphical correlation through biostratigraphy and palaeoenvironmental reconstruction, one common and lucrative application of palynology is in oil and gas exploration.
- **Paleoecology and climate change-** spores and pollens can be used to reconstruct past vegetation (land plants) and marine and Freshwater phytoplankton communities, and so infer past environmental (palaeoenvironmental) and palaeoclimatic conditions in an area thousands or millions of years ago, a fundamental part of research into climate change.
- Organic palynofacies studies, which examine the preservation of the particulate organic matter and palynomorphs provides

information on the depositional environment of sediments and depositional palaeoenvironments of sedimentary rocks.

- Geothermal alteration studies examine the colour of palynomorphs extracted from rocks to give the thermal alteration and maturation of sedimentary sequences, which provides estimates of maximum palaeotemperatures.
- **Limnology studies-**Freshwater palynomorphs and animal and plant fragments, including the prasinophytes and desmids (green algae) can be used to study past lake levels and long term climate change.
- **Taxonomy and evolutionary studies-**Involving the use of pollen morphological characters as source of taxonomic data to delimit plant species under same family or genus. Pollen apertural status is frequently used for differential sorting or finding similarities between species of the same taxa. This is also called Palynotaxonomy.
- **Forensic palynology:** the study of pollen and other palynomorphs for evidence at a crime scene.

- Archaeological palynology examines human uses of plants in the past. This can help determine seasonality of site occupation, presence or absence of agricultural practices or products, and 'plant-related activity areas' within an archaeological context. Bonfire Shelter is one such example of this application.