Palynology
Spore/Pollen Morphology

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What is Palynology?

- The branch of science concerned with the study of fossil and living palynomorphs
- The term Palynology was coined by Hyde and Williams (1944)

What are Palynomorphs?

- Palynomorphs include microscopic plant and animal structures composed of sporopollenin, chitin, or related compounds that are highly resistant to most forms of decay other than oxidation
- Palynomorphs are abundant in most sediments and sedimentary rocks, and are resistant to the routine pollen-extraction procedures including strong acids, bases, acetolysis, and density separation
- Most palynomorphs are between 5–500 µm in size
Common palynomorph categories:

- Acritarchs
- Chitinozoans
- Scolecodonts
- Microscopic Algae and Algal Parts
- Cryptospores
- Embryophyte Spores
- Pollen
- Dinoflagellates
- Chitinous Fungal Spores and Other Fungal Bodies
- Microforaminiferal Inner Tests
- Megaspores
- Palynodebris
- Varia
Embryophyte Spores are microscopic unicellular reproductive cells of certain vascular plants (those with special conducting tissues called xylem).

- These spores are extremely resistant and are easily transported by wind and water.
- They are useful biostratigraphic tools particularly in fresh-water environments, evaporitic deposits, and where marine and fresh-water facies interdigitate.
- They show variable surface sculpture (ornamentation).
Alternation of generations in some vascular plants

(http://www.geo.arizona.edu/palynology/ppfspor.html)
Leptolepidites psarosus  Crybelosporites pannuceus  Deltoidospora mesozoica
Pollen Grains

Stratigraphic range: latest Devonian–present

- **Pollen grains** are the containers of the male gametophyte generation of seed plants (both angiosperms and gymnosperms)

- They are produced in the male organs of the flowers (**anthers**)

- Pollen production is a strategy by which seed plants became free from dependence on standing water for **fertilization**

- **Pollination** occurs by transferring pollen grains from the anthers to the female organs by wind or animals

- Pollen are good biostratigraphic and paleoenvironmental tools
Reproduction in flowering plants

(http://www.geo.arizona.edu/palynology/polkey.html)
Tricolporopollenites kruschii  Cupuliferoipollenites sp.  Caryapollenites veripites

(Zobaa et al., 2011)
*Pinus echinata*

(http://www.geo.arizona.edu/palynology/pid00005.html)

*Pinus sp.*

Sample preparation for palynological analysis

Major components of a sediment/sedimentary rock sample:
- Carbonates
- Particulate Organic Matter (POM)
- Silicates
- Clays

- Carbonates: Removed by HCl
- Particulate Organic Matter (POM): Removed by HF
- Silicates: Removed by HF
- Clays: Removed by sieving

Our Target
Steps of work...

1- Crushing the sample in a mortar to the powder size

2- Transferring the crushed powder into a Nalgene plastic beaker that is resistant to high temperature

3- Conc. HCl treatment

4- Washing and neutralization

5- Conc. HF treatment

6- Washing and neutralization
7- Conc. HCl treatment

8- Washing and neutralization

9- Sieving the sample in a 125 µm brass sieve and collecting the residue in a 5-15 µm nylon sieve

10- Making permanent Kerogen slides

11- Oxidation if necessary

12- Making permanent oxidized slides
Microscopic examination of some slides

Try to recognize some pollen and spore specimens....
Morphology of Embryophytic Spores

**Trilete**
A spore with three *laesurae* (showing a trilete mark)

[![Trilete](http://www.pollen.mtu.edu/glos-gtx/332G.GIF)](http://www.pollen.mtu.edu/glos-gtx/332G.GIF)

**Monoletes**
A spore with a single *laesura*

[![Monoletes](http://www.pollen.mtu.edu/glos-gtx/211G.GIF)](http://www.pollen.mtu.edu/glos-gtx/211G.GIF)

**Alete**
A spore without a *laesura*
Schematic drawings illustrate the basic morphologic features of a trilete spore (Modified from Singh, 1964)

Basic morphology of a monolete spore
(http://www.ucl.ac.uk/GeolSci/micropal/spore.html)
Dictyophyllumites harrisii Couper 1958
(After Volkheimer et al., 2007)
Spore Amb (outline)
Spore/Pollen Wall Stratification

http://www.pollen.mtu.edu/glos-gtx/000G.GIF
Surface Sculpture of Spores

Psilate  Gemmate  Echinate  Rugulate
Scabrate  Baculate  Reticulate  Striate
Verrucate  Clavate  Foveolate  Cicatricose

After Tschudy (1969)
Spore Description

1- Spore type
   - Trilete
   - Monolete
   - Alete

2- Type of view
   - Polar (proximal – distal)
   - Equatorial

3- Amb
   - Circular
   - Triangular (straight – convex – concave)
   - Cingulate

4- Laesurae
   - Commissure (short – medium – long; reaching the equator)
   - Margo (present – absent)

5- Sculpture
Deltoidospora
Cicatricosisporites

(Nye et al., 2008)
Cingutrilletes
Leptolepidites

Sculpture: Verrucate

(Nye et al., 2008)
Gemmatrilletes

Sculpture: Gemmate
Sculpture: Baculate
Rugulatisporites

Gleicheniidites

Exinal crassitude

Crybelosporites

Perinate spore

Perine
Laevigatosporites
Morphology of Pollen Grains

1- Polarity

The **Polar Axis** is the straight line between the distal and proximal poles of a pollen grain or a spore.

*Pollen grains can therefore be:*

A- **Isopolar** (the proximal and distal faces of the exine are alike)

B- **Heteropolar** (the distal and proximal faces of the exine are different, either in shape, ornamentation or apertural system)

C- **Subisopolar** (the proximal and distal faces are slightly different)

Illustrations from: http://www.pollen.mtu.edu/glos-gtx/glos-int.htm
Spores and pollen are either **symmetric** or **asymmetric**

**Symmetric ones can be:**

A- **Radially symmetric** (with two or more vertical planes of symmetry)

B- **Bilaterally symmetric** (with a single, principal plane of symmetry)

Illustrations from: http://www.pollen.mtu.edu/glos-gtx/glos-int.htm
3- Shape

The shape of pollen grains and spores can be:

A- **Prolate** (the polar axis is longer than the equatorial diameter)

B- **Oblate** (the polar axis is shorter than the equatorial diameter)

C- **Spheroidal** (the polar axis and the equatorial diameter are approximately equal)
- The aperture is a specialized thin region of the spore/pollen wall that is generally different in ornamentation and/or in structure.

- Apertures can be in the form of **Pori** (pores) or **Colpi/Sulci** (furrows).

  - Grains with pori are called **Porate**.

  - Grains with colpi/sulci are called **Colpate/Sulcate**.

  - Grains with combined colpus and porus are called **Colporate**.
- Examples of apertures include:

- Monocolpate
- Monoporate

- Dicolpate
- Dicolporate
- Diporate

- Tricolpate
- Tricolporate
- Triporate
Apertures situated only at the equator:

- Zonocolpate (Stephanocolpate)
- Zonocolporate (Stephanocolporate)
- Zonoporate (Stephanoporate)

Apertures spread over the surface sometimes forming a regular pattern:

- Pantocolpate (Pericolpate)
- Pantocolporate (Pericolporate)
- Pantoporate (Periporate)
- Inaperturate
- Ulcerate (having an ill-defined pore in the polar area)

Illustrations from: http://www.pollen.mtu.edu/glos-gtx/glos-int.htm
• **Monosulcate**

• **Trichotomocolpate/Trichotomosulcate** (having three-branched colpus/sulcus)

• **Syncolpate** (having two or more colpi the ends of which anastomose at the pole)

Illustrations from: http://www.pollen.mtu.edu/glos-gtx/glos-int.htm
• **Fenestrate** (having large, window-like spaces lacking a tectum)

• **Lophate** (having a raised outer exine in a pattern of ridges (*lophae*) surrounding depressions (*lacunae*)

• **Heterocolpate** (having both simple and compound colpi)

Illustrations from: [http://www.pollen.mtu.edu/glos-gtx/glos-int.htm](http://www.pollen.mtu.edu/glos-gtx/glos-int.htm)
Other pollen types:

- **Saccate** (having at least one saccus/vesicle/bladder/wing)

A *saccus* is an expansion of the exine of a pollen grain that is at least partly filled with an *alveolate* infrastructure.

- **Polyplicate/Striate** (having more than three meridional ridges *(plicae)* separated by deep grooves *(striae)*)
1- **Polarity**
   - Isopolar
   - Heteropolar
   - Subisopolar

2- **Symmetry**
   - Asymmetric
   - Radially symmetric
   - Bilaterally symmetric

3- **Shape**
   - Prolate
   - Oblate
   - Spheroidal

4- **Type/Aperture**
   - Monoporate
   - Bisaccate
   - Tricolpate, etc.

5- **Sculpture**
Afropollis

(Doyle et al., 1982)
Retimonocolpites
Stellatopollis (Dejax and Masure, 2005)
Cretaceaeiporites
Asteraceae

(Zobaa et al., 2011)
Poaceae

(Joly et al., 2007)
Elaterosporites
Corollina
Pinus

(http://www.geo.arizona.edu/palynology/pid00005.html)

Spores and Pollen as Paleoenvironmental Indicators
Sedimentary Depositional Environments

- Continental
  - Aeolian
    - Fluvial
      - Lacustrine
    - Alluvial
    - Deltaic
    - Tidal
    - Lagoonal
    - Beach
    - Shallow marine
    - Deep marine
    - Reef
  - Transitional
    - Others
      - Evaporite
      - Glacial


Hyde, H. A. and Williams, D. W., 1944, Right word, Pollen Analysis Circular 8:6


References


http://www.geo.arizona.edu/palynology/

http://www.ucl.ac.uk/GeolSci/micropal/welcome.html

http://www.pollen.mtu.edu/glos-gtx/glos-int.htm