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Paleontology
First Geology

المحاضرة الاولى و الثانية

Palaeontology

Palaeontology is the science which deals with studying life of past geologic ages (fossils).

Paleo = ancient onto = life logy = science

Fossils: are remains or traces of organisms (animals and plants), which inhabited the globe since the beginning of life.

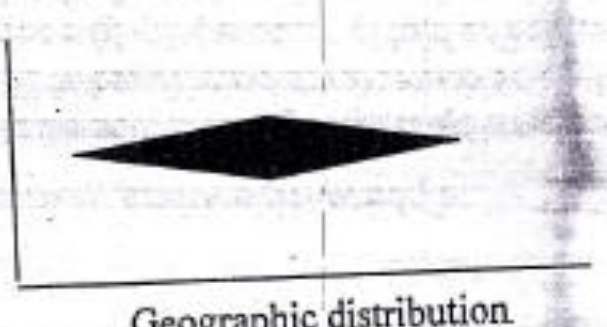
Kinds of fossils:

1- **Body fossils:** are fossils that represent remains of the actual organism or its skeleton. They occur in many ways, including: unaltered preservation, recrystallization, replacement, permineralization, carbonization, impressions, casts and molds.

2- **Trace fossils:** Unlike body fossils, where a portion of the actual organism or its skeleton is preserved, trace fossils are the remains of an organism's activity or behavior. Examples include tracks, trails, burrows, and borings.

3- **Pseudofossils:** unusual structures formed inorganically that, by chance, resemble body or trace fossils. examples dendrites. These are inorganic precipitates of manganese oxide that were described originally as fossil algae.

Fossils in general may have long range and these are called **Range fossils,** these fossils can't be used as time indicators. Other fossils are characterized by wide geographic distribution and short range; these are called **Index (guide) fossils** and are useful in designating the age of strata.



Fossils which are washed out from the original beds and re-deposited in younger strata are called **Derived (drifted) fossil.**

Example: Cretaceous and Eocene fossils deposited in the Miocene basins of the Gulf of Suez.

Nature of fossil record:

All fossils should occur in sedimentary rocks being abundant in limestone and limy shale but rare in sandstone?. Fossils never occur in igneous rocks except when volcanic ash falls, or nearly cooled lava have overcome plants and animals. In Metamorphic rocks they are also absent except when these rocks were originally fossiliferous and subjected to very low grades of metamorphism.

In Nature fossils are found scattered in the rocks, in some cases they are accumulated in layers or patches. Those accumulated in layers or beds are called **Biostroms** whereas those accumulated without any distinctive layering are called **Bioherms.**

Conditions of preservation:

1-possession of hard skeleton:

In order to be preserved as fossil, the organism must have a hard skeleton. The soft parts decay after death and only the hard parts are preserved.

2-Rapid burial:

After death, the organism should be directly covered with sediments to prevent its destruction by waves or winds. On land, rapid burial is not common and hence land organisms have little chance of preservation than marine organisms.

Chemical and mineralogical composition:

The following minerals are the main constituents of fossil skeletons:

1. Aragonite: Aragonite ($CaCO_3$) is a form of calcium carbonate that is fairly unstable and commonly dissolves away. Skeletons made originally of aragonite are commonly recrystallized to calcite and preserved as molds. Aragonite is easy to recognize. It is usually (not always!) milky white and has no luster.
2. Calcite: Calcite ($CaCO_3$) is the more common form of calcium carbonate. It is more stable than aragonite and therefore does not dissolve as readily. Calcite usually has a grayish color and a slight vitreous (or glassy) luster when found as a skeletal mineral. It can be found as an original skeletal material, or as a recrystallization product.
3. Silica: Silica (SiO_2) is easy to distinguish from the carbonate minerals since it will not react with acid. Skeletons composed of this mineral will commonly have a brown, earthy color, with or without a vitreous luster, and can have a granular texture. Silica is rarely found as an original material and most commonly occurs as a replacement product.
4. Pyrite: Pyrite (FeS_2) or "fools' gold" is a golden colored mineral with a metallic luster and is therefore identified easily. It always appears as a replacement product.

The hard parts of **vertebrates** include bones (largely calcium phosphate and carbonate).
Invertebrate skeletons are mainly calcium carbonate (either calcite or aragonite), some skeletons are composed of silica (siliceous). The composition of major invertebrate groups is as follow:

Foraminifera: Calcareous ($Ca\ CO_3$) or agglutinated (sand grains, sponge spicules or mica flakes).
Sponge: calcareous ($CaCO_3$) and siliceous (silica).
Coelenterates: calcareous.
Bryozoa: calcareous.
Brachiopods: Calcareous and chitinophosphatic.
Mollusca: calcareous.
Echinoderms: calcareous.

Modes of preservation:

After death, the organisms are preserved in different forms as follow:

I. **Unaltered remains:** the hard skeleton of the organism or its soft part or both remains unchanged.

A) **Soft part (organic compounds):**

1- Mammoth: in the Pleistocene glaciers of Siberia.
2-Insect in Amber: the insects are preserved in the resin (Amber) such as those found in the Oligocene deposits of Baltic province.

B) **Hard skeleton (inorganic compounds):**
This is characteristic for Cenozoic shells which underwent little or no alteration of the original mineral substance.

II. **Altered remains:** The soft parts decay and the hard skeletons are completely altered. This takes the following forms:

1- **Carbonization:** This is the removal of volatile constituents such as oxygen, hydrogen and nitrogen from the organic compound leaving only carbon as a thin black film.
Ex. Graptolites, fishes and plants

2- **Recrystallization:** is the alteration of less stable inorganic compounds (e.g. aragonite) into more stable ones (e.g. calcite) without any chemical change.
Aragonite (less stable) ™ calcite

3-**Permineralization:** is the deposition of minerals in the interstices of skeleton.
Ex. Bone vertebra

4-**Replacement:** The original skeleton is removed and replaced by other mineral substances such as silica (silicification), pyrite, iron or carbonates.
Ex. Silicified wood (stone forests)

5 -**Imprints, casts and Moulds:**

Imprints (external molds): are impressions produced when something is pressed into soft sediment. They show only external detail, and they are negative in relief.

Cast: is the infilling of cavities of shells (external mold) by minerals or other sediments. It shows only external features, but will be positive in relief, not negative like an external mold.

Mould (internal): moulds form when sediment infills a shell or skeleton, hardens, and the shell is worn away. What is left is a mould showing internal features and will most likely have positive relief.

6-**Evidence of the activity**: here we don't have anything of the body fossil itself but only traces of its movement. This branch of palaeontology is called Ichnology, which deals with traces of organisms.

Tracks: These are the traces of feet made by quadrepedal or bipedal vertebrates during moving on soft sediments.

Trails: These are the traces made by animals during crawling on sediments.

Burrows: are pathways made up by animals in soft sediments as a normal way of life (worm burrows).

Borings: are holes made by animals in hard rocks and shells either for protection or as parasites in search for food.

Excrements: these are called coprolites and they indicate the kind of food, which the organism had eaten.

Rules of species nomenclature

To write the name of a species we should follow the following:

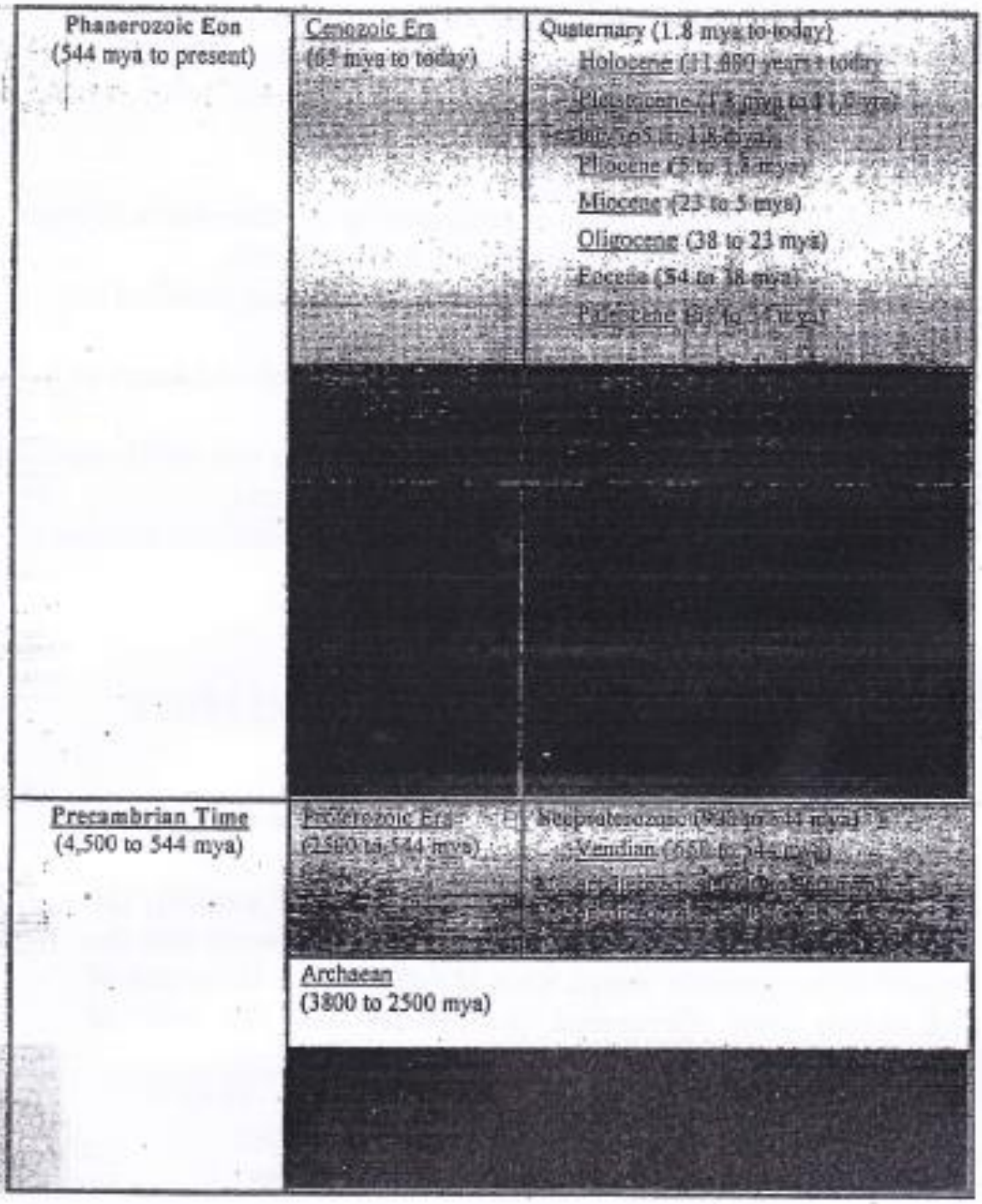
1- **The species name must be binomial (two names); the first is the generic name to which the species belongs and the second is the specific name. This is followed by the name of the author who discovered the species and the year of discovery.**

Ex. ***Ostrea khargensis*** **Abbass, 1962.**
Generic name specific name author name year

2- **The generic and specific names must be written italic or underlined.**

3- **The first letter of the generic name must be capital letter but the specific name not.**

Geologic Time Scale
(mya = million years ago)



Environment

As mentioned before, fossils are mostly found in marine rocks rather than continental ones since they had a better chance of preservation.

The marine environment (sea or ocean) is divided into zones, each has its own physical and chemical characteristics.(fig.1)

This is the zone of water between highest and lowest tide. Living conditions are difficult because of alternate covering and exposure of the bottom materials and organisms due to tidal effect. In spite of that; some organisms adapt themselves to live in these conditions. These are mainly attached or burrowing organisms such as corals, worms, pelecypods, burrowing crustaceans together with lime-secreting algae.

(2) Neritic zone:

It is the zone of water between lowest tide and 200 m depth (edge of the continental shelf).

Organisms are abundant due to excellent light, oxygen and agitated water. This allows plants to grow and produce food by photosynthesis for animals living in this zone.

The majority of invertebrate fossil assemblages appear to have flourished upon the bottoms of the neritic zone. Also much of invertebrate evolution is thought to have take place upon the continental shelves of ancient seas.

(3) Bathyal zone:

It is the zone of water between 200 m and 4000 m.

Only the upper part of this zone has some light and so there is little or no plant life.

The inner part of this zone contains remains of neritic and even continental organisms transported by turbidity currents.

(4) Abyssal zone:

It is the zone of water between 4000 m and 5000 m.

Water is dark and cold, pressure is very great. There is no green plant life beside little animal life.

Remains of pelagic organisms called oozes are dominantly accumulated on the bottom of this zone. There are two types of these oozes:

1- Foraminiferal (*Globigerina*) ooze: This consists of complete or broken tests of planktonic foraminifera.

2- Radiolarian Ooze: This consists of siliceous tests of Radiolaria beside other remains of siliceous composition such as diatoms.

(5) Hadal zone:

It is the zone of water below 5000 m depth (deep sea trenches).

Habit (mode of life) of marine organisms:

Organisms are classified according to their mode of life into three categories:

1- Planktonic: these are organisms which have no organs of locomotion and their movement is controlled by waves and currents. Upon death they sink to sea floor or may be washed ashore.

Ex. Diatoms, foraminifera, radiolaria and some ostracods.

2- Nektonic: are organisms which swim in water by their possession of organs locomotion, so they can control their movement.

Ex. Fishes and some mollusca.

3- Benthonic: are organisms which inhabit sea bottom. They are two types:

a) Epifaunal: living on sea bottom either sessile (fixed) or vagrant (free moving).

b) Infaunal: living buried within the sediments.

TAXONOMIC HEIRACHY

Kingdom Animalia (all animals)
Subkingdom Metazoa (all animals consisting of more than one cell)
Phylum Chordata (possessing in axil dorsal nerve cord)
Subphylum Vertebrata (nerve cord surrounding by a bony spin)
Class Mammalia (true hair ,nursing of young ,brain of advanced type)
Order Primates (mostly tree dwelling placental mammals)
Suborder Anthropoida (monkeys, apes and man)
Family hominidae (man and his immediate ancestors)
Genus Homo man
Species sapiens (sensible ,judicious, wise)

Homo sapiens

Hippurites bioculata Lamarck,1801

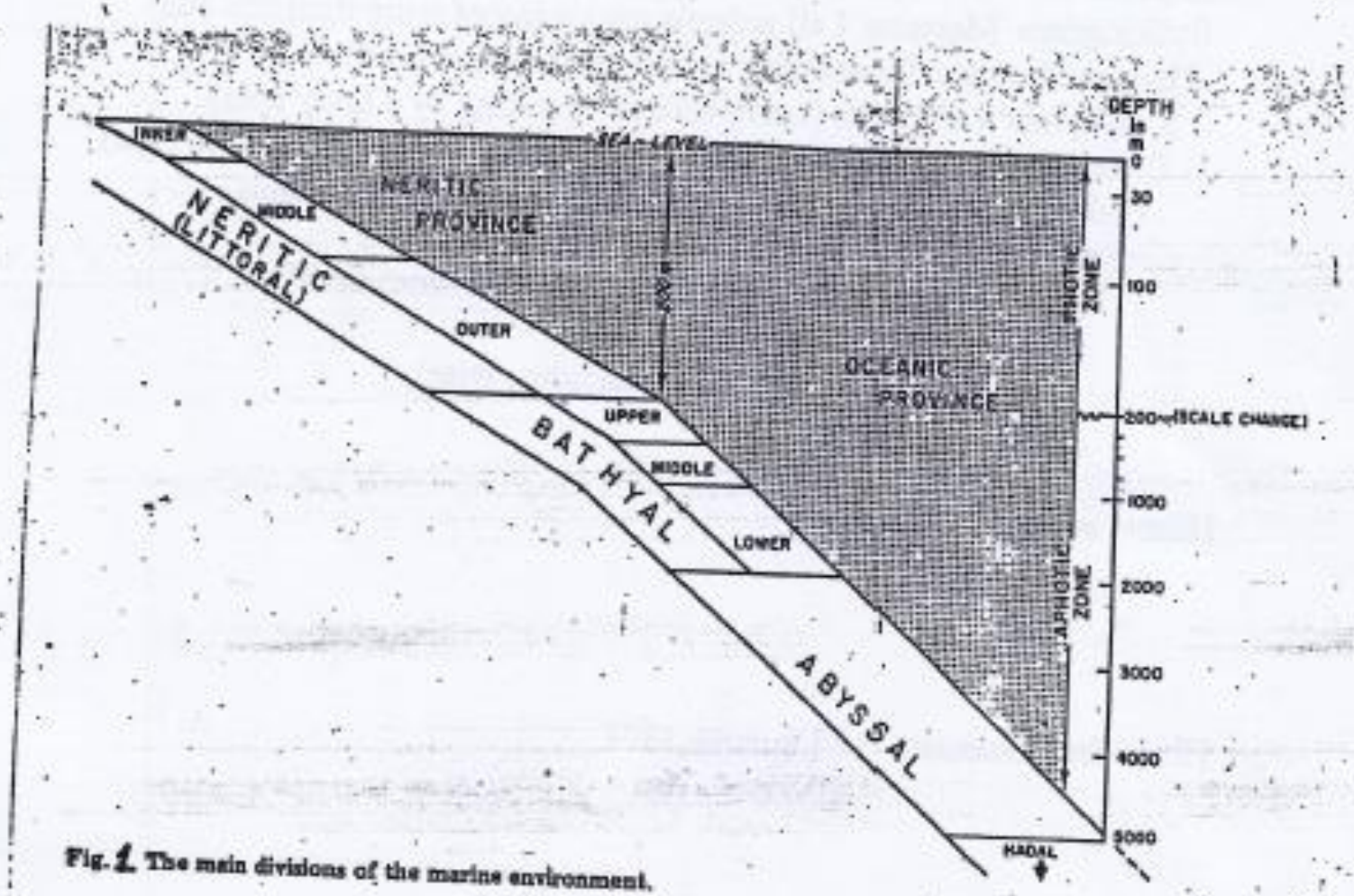


Fig. 1. The main divisions of the marine environment.

FORMS OF PRESERVATION

UNALTERED

This form of preservation is rare in most of the geologic column, but becomes more frequent in younger sedimentary rocks. Types of unaltered preservation where even the soft body parts are preserved include: (i) mummification, (ii) encasement in tar, (iii) encasement in amber, (iv) encasement in sediment, and (v) freezing. More frequently, however, only the hard skeletal material is preserved after removal of soft body parts.

Examples of unaltered preservation include the skeleton of a horseshoe crab, whose shell is composed of interlocking plates and jointed appendages which quickly disarticulate after death; cockle bivalved molluscs, whose outer-most shell layer has been removed by abrasion, yet the original shell material of the inner layers remains; an ammonoid from the Cretaceous period in which you should note the pearly luster which is original aragonite shell material; and an insect encased in amber .

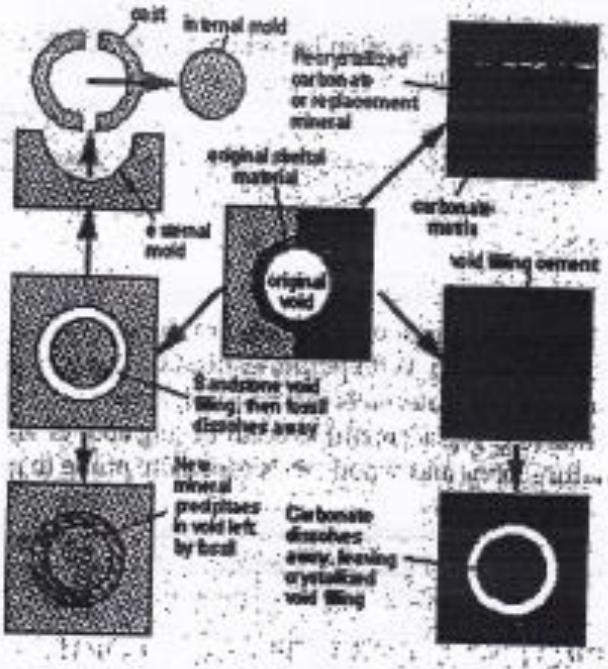
MOLDS & CASTS

This general class of preservation entails making "replicas" of the skeletal hard parts of organisms. In general, a **mold** is an impression in the sediment of a skeleton or shell. Once encased in lithified sediment, the dissolution of skeletal material leaves behind the impression or mold of original skeletal form. Thus, a mold is a "mirror image" of the original skeleton. An **internal mold** (sometimes called a steinkern) is the impression of the inside surface of skeletal hard parts. An **external mold** is the impression of the outside surface of skeleton or bone. An example of both types of molds can be seen in this image of a trilobite .

A cast is formed by the filling-in of a mold. It is thus a true replica (not a "mirror image") of the original skeleton or shell. By this definition, the cast one gets for a broken limb is not really a cast at all but an external mold.

A graphical representation of the formation of casts and molds is provided in Figure 2 below.

Figure 2 - Different diagenetic processes leading to different preservational styles in skeletal materials.



* Note that molds are produced directly as imprints of the shell and casts are produced from molds.

Modified from McRoberts (1998)

REPLACEMENT & RECRYSTALLIZATION

This common form of preservation involves chemical and/or physical alteration or replacement of original skeletal material. To properly identify replacement and recrystallization, one must know what the original constituents of the organism's skeleton were. These are provided in Figure 1.3. Replacement occurs often by the filling in (by various minerals) of the void space after dissolution of original skeletal material. Sometimes, the replacement occurs on a molecule by molecule basis. Common replacement minerals that you should be able to recognize include Silica (SiO_2) as shown in the coral, and Pyrite (FeS_2) shown in the ammonoid.

Recrystallization involves the physical re-arrangement of crystalline structure of skeletal material. This is a common phenomenon in shells which were originally aragonite and/or calcite (both forms of calcium carbonate- $CaCO_3$). Examples, both of which are now calcite, include a gastropod which was originally aragonite and a brachiopod which was originally calcite.

CARBONIZATION

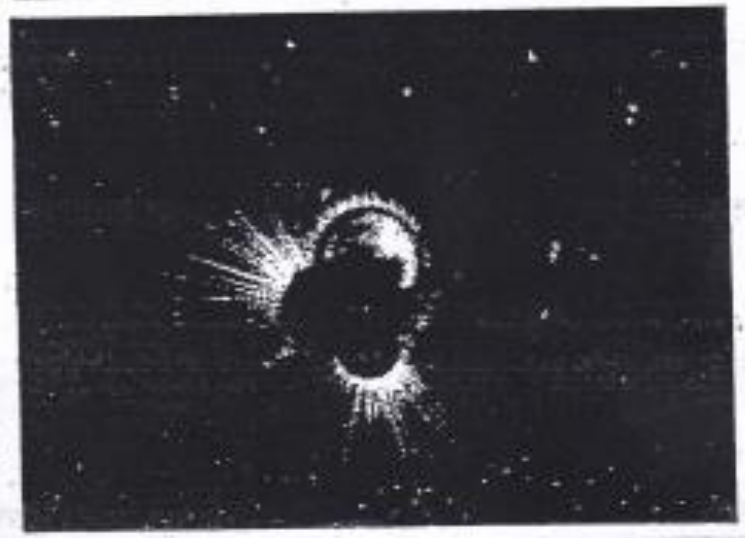
As organic remains decompose in sediments, volatile constituents such as oxygen, hydrogen, and nitrogen are slowly lost to the surrounding sediments frequently leaving behind a carbon film. This process is carbonization (or sometimes called distillation), and occurs most frequently in oxygen deficient, organic-rich environments such as basinal black shales, and coal swamps. The carbon films often show exquisite details of plants and soft-body parts of

animals not readily preserved, and can often be recognized by a dark gray or black film with a metallic sheen such as these fern-like fossil plants.

PERMINERALIZATION

Permineralization involves the filling-in of pore and/or void spaces in shell or bone by secondary mineral matter in solution. With permineralization, the tiny pore spaces in the fossil are filled and the original skeletal material is still retained. However, it is often common for other types of preservation (e.g. replacement) to occur during and/or after permineralization. Because of its porous nature, bone and wood is especially prone to permineralization.

PROTISTA, EUBACTERIA, & PORIFERA



From Stanley (1993)

Kingdoms EUBACTERIA and PROTISTA

Fossil organisms within the Kingdom Protista represent the earliest life forms known. These organisms are characterized by a single-celled body plan and are contrasted to members of the Kingdom Eubacteria (green and blue-green algae) by having a nucleus. This lab concentrates on the protist phyla Foraminifera and Diatoms because many of their constituents have mineralized skeletons and an extensive fossil record. Because of their wide-spread distribution and rapid evolutionary rates, many of the protists are excellent index fossils used in biostratigraphic studies. During this lab you will become familiar with the morphologic features and be able to identify each of the groups listed below, in addition to knowing their geologic ages.