UNIT - 4

Micropalaeontology

Cynobacteria

- Cynobacteria are among the most ancient known organisms dating back some 2800 – 3500 million years.
- The are involved in the formation of stromotolite which is geologically very important.
- It is rounded to cylindrical cells upto 25microns in diameter.
- It is found in early Pre-Cambrian sedimentary rocks

Bacteria

- It is diverse prokaryotic organisms occurring single or as aggregates.
- Fossils are found in oil shales, Iron ore deposits, L.st and chert from early Pre-Cambrian rocks

Diatoms

- Diatoms are microscopic siliceous algae.
- They posses siliceous, discoidal, elliptical, rectangular or rhombic shaped skeletons.
- They are found in all latitutes in ocean as well as in fresh water.

Cocoliths

- Cocoliths are minute dominantly marine, plantonic, unicellular and flagalate organisms.
- The spherical cell wall is covered with minute calcareous plate.
- They are common in upper Jurassic L.st and Marl and ranges fro Jurassic to recent

Silicoflagallates

- Silicoflagallates are microscopic marine, plantonic, flagellate, algal organisms related to cocoliths but the skeleton is composed of hollow bars of siliceous materials.
- They ranges from Lower Cretaceous to Recent

Dinoflagallates

- Dinoflagallates are minute, plantonic, placed in flagellate algae.
- They posses thick, often spiny cell wall consisting of organic matter and divided by furrows and angular plates.
- The live in upper 50mts of photic zone.
- The range from Silurian to recent

Phylum Protozoa

Class Sarcodina

- Protozoa (primitive-life) are unicellular organism occupying the lowest level in the classification ladder of animals.
- It is divided into two major orders which are Foraminifera and Radiolaria.

Micropaleontology

1. The study of micro fossils are known as Micropaleontology. These fossils must be examined under the microscope.
2. Micropaleontology involves study of unicellular protists like foraminifera, radiolaria, pteropods and diatoms. They are also includes the study of spores and pollens.
3. Most are unicellular but others are multicellular or microscopic parts of microscopic form.
4. The practical values of marine microfossils is enhanced by their minute size, abundant occurrence and wide geographic distribution in sediments of all ages and in almost all marine environments.

- Microfossils occur in sediments of Precambrian to recent ages and in every part of the stratigraphy column.
- One or more group always be found, useful for **biostratigraphy and paleoecology** interpretation.
- In Microfossils, foraminifera were the first fossils studied under microscope.
- In 1758 Linne made a biological taxonomy to 15 species of foraminifera. Then in the following years discovery and description of Silicoflagellates, Dinoflagellates, Nannoplanktons and Radiolarians were done.
- In recent times, micropaleontology is back with a bang with the advent of deep sea drilling projects and its utility in the petroleum industry.

Commercial micropaleontology is associated with foraminifera and the oil industry. Though the other forms cannot be neglected the biostratigraphy utility of foraminifera in petroleum industry enhanced its utility.

Foraminifera:

- Foraminifera belongs to phylum Protozoa.
- They are unicellular organisms
- The cell of a foraminifera is a protoplasmic mass encapsulated in a agglutinated or secreted covering called the test.
- Since they possess the streaming pseudopodia they are placed in class sarcodina.
- Foraminifera are as small as a few hundred microns in size.

They are predominantly marine and are classified into

1. Planktonites-found in 200m water depth
2. Benthics - >200m water depth
    1. Benthic may be Epibenthics which is lives on sea floor
    2. Inbenthics within the sea floor

Classification of Foraminifera

Loebheh and Tappan estimated about 100 families, over 1200 genera and some 27000 species of foraminifera.

Over 35 schemes of classification based on the following criteria.

1. Wall composition and microstructure
2. Chamber arrangements and septal addition
3. Apertural characters and modifications
4. Chamber form
5. Life habits and Habitats
6. Ontogenetic changes
7. Reproductive processes
8. Geologic ranges

Wall Structure

1. The distinguishing feature of one foraminifera from another is its wall type.
2. The primary foraminiferal group are the agglutinated, the calcareous and the micro granular foraminifera.
3. Wall structure is considered to be genetically stable of the test and hence to be relatively unaffected by environmental fluctuations.

Agglutinated Wall Structure

1. Agglutiated foraminifers cement particles onto a layer of tectin (an organic compound composed of protein and polysaccharaide).
2. Extra locular protoplasm, calcite, silica or ferruginious materials are used to cement particles causing grains to be loosely bound in place or permanently cemented within this mineralized zone.

Microgranular Walls

1. Microgranular walls evolved during the paleozoic and are considered the link between the agglutinated and the precipitated tests in foraminifera.
2. Microgranular particles of calcite cemented by a calcareous cement characterize this wall type and give it a sugary appearance

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Calcareous Walls – Hyaline Type

1. Calcareous walls may be composed of either low or high Mg calcite or Aragonite.
2. Hyaline calcareous test are characterised by the possession of minute perforations in the test walls.

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Calcareous Walls – Porcelaneous Type

1. The term porcelaneous derives from the shiny, smooth appearance of the test and is the result of the orientation of submicroscopic crystallites of calcite that forms the chamber.

Chamber shape and Chamber arrangemnet

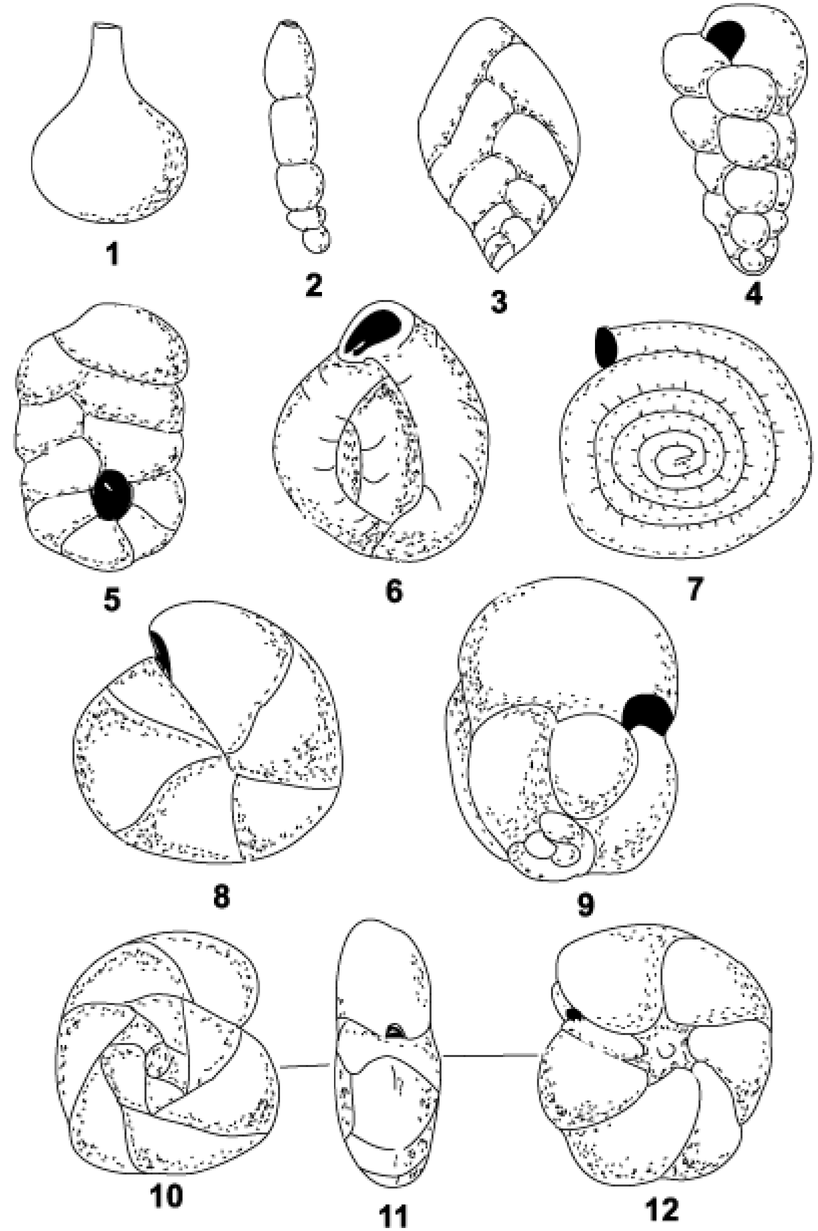
- Forminifera test may possess one or more chamber.
- The intial chamber is most often spherical or oblate with an aperture.
- Later chambers range in shape from tabular, spherical, ovate to the several others.
- Chambers may be arranged in a single roe, or uniserially, spirally around a series of coiling.
- The spiral lies in a single plane or in several planes of coiling.
- The chambers involved in one complete revolution are termed a whorl or coil.

- The degree to which one whorl covers or hides a previous one is known as the **degree of evolution**.
- When the majority of previous coils are hidden, a species is termed as **involute**, while **evolute,** if the majority of previous coils are seen.
- On coiled test the sides of the foraminifera showing the trace of the coil or spiral is termed the **spiral side**. The opposite side is termed **umbilical side**.
- The area where one chamber meets another chamber is the **suture area**.
- The aperture is the primary opening of the test to the outside environment and it varies in shape and size

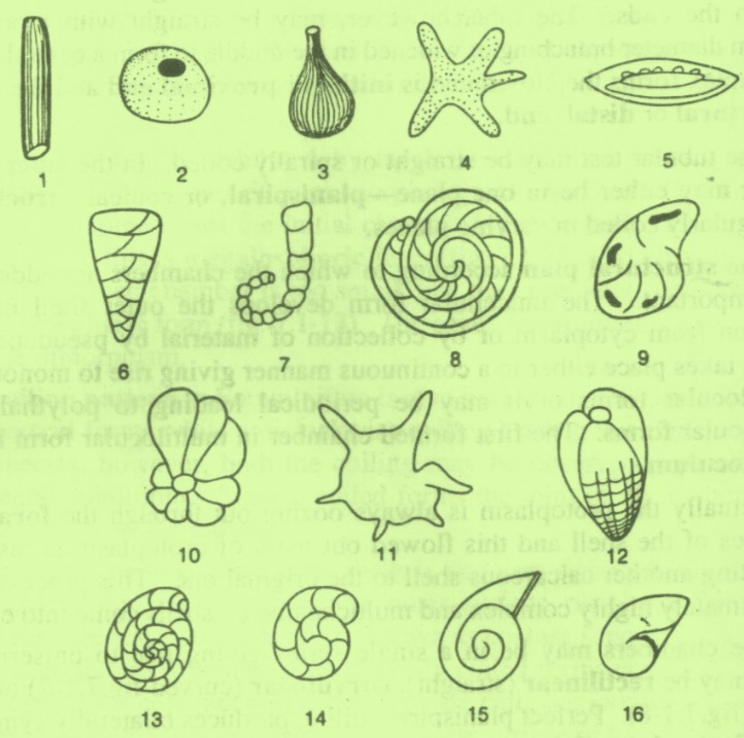
- Characteristically one aperture termed the primary aperture distinguished the apertural side of the foraminifera. There may be more than one aperture and they are termed as secondary aperture.

Ornamentation

Change in wall structure, pore density, inflational thickening of test resulting in protrusions. Thickenning or sharpening of chamber peripheris forming keels, these comprises ornamentation of foraminifera test.



Principle types of chamber arrangement. 1, single chambered; 2, uniserial; 3,biserial; 4, triserial; 5, planispiral to biserial; 6, milioline; 7, planispiral evolute; 8, planispiral involute; 9, streptospiral; 10-11-12, trochospiral (10, dorsal view; 11, edge view; 12, ventral view). Redrawn from Loeblich and Tappan 1964.



7.1.1. Cylindrical shell, monothalamus, uniserial with terminal aperture,
7.1.2. Shell globular, monothalamus,
7.1.3. Shell uniserial, fusiform, flask-shaped,
7.1.4. Shell stellate,
7.1.5. Shell fusiform,
7.1.6. Shell conical, biserial, multilocular,
7.1.7. Shell uniserial, curvilinear,
7.1.8. Spirally coiled, megalospheric,
7.1.9. Spirally coiled, peripheral aperture,
7.1.10. Spirally coiled, involute, umbilicus,
7.1.11. Spirally coiled, with spines development,
7.1.12. Costate shell,
7.1.13. Spirally coiled, microspheric,
7.1.14. Spirally coiled, megalospheric,
7.1.15. Spirally coiled, evolute coiling,
7.1.16. Spirally coiled, involute coiling.

More on Test Morphology

Most species of foraminifera build shells with multiple chambers (multilocular) but some species build shells with only a single chamber (unilocular). The most common types of chamber arrangements are:

Unilocular -- a single chamber

Uniserial -- chambers added in a single linear series

Biserial -- chambers added in a double linear series

Triserial -- chambers added in a triple linear series

Planispiral -- chambers added in a coil within a single plane. The center of the coil is called the umbilicus. The coil may be either involute (only the chambers of the last coil visible) or evolute (all chambers visible).

Trochospiral -- chambers added in a coil that forms a spire like a snail shell. The side on which all chambers are visible (evolute) is called the spiral side. On the other side only the final coil is visible (involute) and this is called the umbilical side.

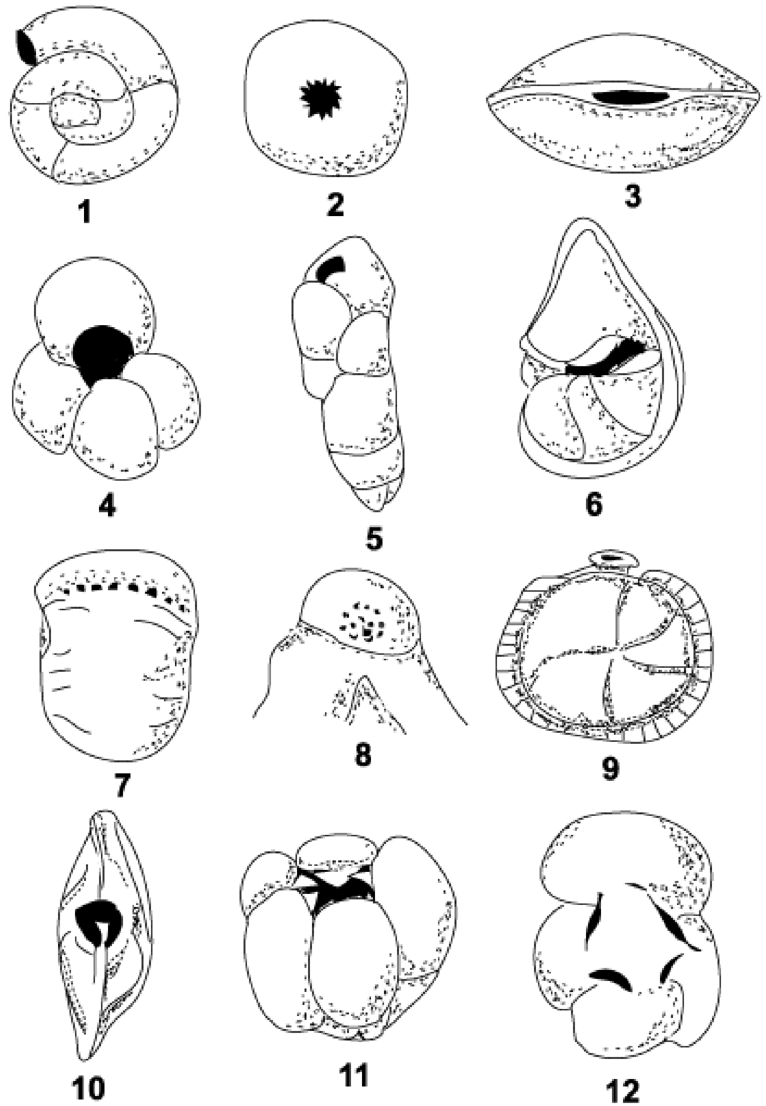
Milioline -- chambers arranged in a series where each chamber extends the length of the test, and each successive chamber is placed at an angle of up to 180 degrees from the previous one.

Fusuline -- a planispiral coil which is elongated along the axis of coiling. Typically each chamber is subdivided by a complex set of internal partitions.

Tubular -- a simple hollow tube.

Arborescent -- an erect, branching series of tubes. These forms may live attached to a solid surface or "rooted" in sediment.

Irregular -- without any definite arrangement of the chambers. These forms usually live attached to a solid surface.



Principle types of aperture. 1, open end of tube; 2, terminal radiate; 3, terminal slit; 4, umbilical; 5, loop shaped; 6, interiomarginal; 7, interiomarginal multiple; 8, areal crbrate; 9, with phialine lip; 10, with bifid tooth; 11, with umbilical teeth; 12, with umbilical bulla. Redrawn from Loeblich and Tappan 1964.

Evolution of Foraminifera

- Forminifera evolved in evolving ocean.
- They evolved by adaptation which allowed them to survive with changing environments.
- Foraminifera have been found from Cambrian to recent.
- The evolution of early Foraminifera is viewed as a gradual process of change in the composition and structure of the test wall, starting from simple soft-walled unilocular forms that developed an agglutinated wall and later evolved into multilocular forms.

Evolution of Foraminifera…

- It has been proposed that the first agglutinated Foraminifera were either globular or tubular species that progressively evolved by development of a proloculus (initial chamber) followed by a rectilinear or coiled tubular chamber.
- Based on a literal interpretation of the sparse Cambrian foraminiferal fossil record and the recent identification of a proloculus in the early foraminiferan, Platysolenites antiquissimus, it has been suggested that all Foraminifera evolved from Platysolenites, either by losing the proloculus to become globular or tubular, or by the development of spiral growth.
- The evolution of spiral tests led to the formation of internal septae through the development of constrictions in the spiral tubular chamber and hence the appearance of multilocular forms.

Distribution of Living Foraminifera

- Foraminifera have been reported from marine environments extending from tide pools in a marsh to the abyssal plain. Each environment is characterized by its particular species and their diversity and densities.

Planktonics and Benthics distributions

- The distribution of planktonic may change diurnally or seasonally and it is considered to be a functions of the water density.
- The oceanic circulation patterns affect the distribution of planktonic foraminifera.
- Density drops markedly in water less than 300m

- Planktonic foraminifera species which characterize each geological epoch from cretaceous through Tertiary.
- Benthic foraminifera have cosmopolitan distributions both in the recent and in the past.
- Smaller benthic foraminifera are one of the primary contributors to the sediments of shallow carbonate platforms. Other environments include marshes, brackish, continental shell and open marine.

Distribution of Foraminifera with respect to ecological parameters.

Salinity: Foraminifera inhabit environment with salinities ranging from typical open ocean value of 35% to as high as 45%. The lower the salinity of an environment, the lower the diversity of the faunas there.

Alkalinity: Alkalinity is an expression of the capacity of the sea water to dissolve calcium carbonate. Alkalinity is governed chiefly by temperature, pressure and biological respiration.

When describing solution and precipitation of foraminiferal carbonate we use a geochemical term, the carbonate compensation depth, or CCD.

The carbonate compensation depth is the depth of effective solution of calcium carbonate sediment on the sea bottom.

Biotic Variables: Figures for the density of living benthic foraminifera vary from 1000 to 2000000 individuals per square meter of sea bottom.

When the density of the individuals becomes great, Foraminifera have been observed to migrate away from the crowded area.

The distribution of foraminifera is governed by all the physical and chemical variables discussed.

By studying the recent foraminifera and environment we can reconstruct the paleo environment by correlating foraminiferal fossil assemblages

Importance of Foraminifera in Paleoecology and age correlations..

Foraminifera have many positive characters that make them an indispensable tool in Paleoecological studies..

- Foraminifera are very sensitive to environmental changes. They are good pollution indicators.
- They are very good index fossil and have high resolution of age of the order of 1 million years.
- They show seasonal variations and they are good climatic indicators.
- In a stable environment the diversity is more. However in an unstable environment there is lesser diversity. Dominance of a species is observed because of survival of fitness.

- Sea level changes are also indicated by foraminifera. Marine regression and transgression are studied from foraminifera counts.

Application of Foraminifera in sequence Stratigraphy…

Sequence stratigraphy is powerful tool which allows stratigraphers to place a succession of strata into a chronostratigraphic framework that can be used for regional correlation.

A sequence boundary is an unconformity or its correlative conformity which acts as a bounding surface for a relatively conformable succession of genetically related strata.

- Sequence boundaries are controlled by changes in relative sea level..
- Relative sea level is an apparent rise or fall in sea level with respect to the land surface and is a function of the interaction between estuary and basin subsidence.

Geological Distribution

- Foraminifera have a geological range from the earliest Cambrian to the present day.
- The earliest forms which appear in the fossil record (the allogromiine) have organic test walls or are simple agglutinated tubes.
- The term "agglutinated" refers to the tests formed from foreign particles "glued" together with a variety of cements.
- Foraminifera with hard tests are scarce until the Devonian, during this period the fusulinids began to flourish culminating in the complex fusulinid tests of the late Carboniferous and Permian times;

- the fusulinids died out at the end of the Palaeozoic.
- Fusulinids were single-celled organisms, about the size and shape of a grain of wheat.
- The miliolids first appeared in the early Carboniferous, followed in the Mesozoic by the appearance and radiation of the rotalinids and in the Jurassic the textularinids.
- The earliest forms are all benthic, planktic forms do not appear in the fossil record until the Mid Jurassic in the strata of the northern margin of Tethys and epicontinental basins of Europe.
- They were probably mesoplanktic (planktic only during late stages of their life cycle).

- The high sea levels and "greenhouse" conditions of the Cretaceous saw a diversification of the planktic foraminifera, and the major extinctions at the end of the Cretaceous included many planktic foraminifera forms.
- A rapid evolutionary burst occurred during the Palaeocene with the appearance of the planktic globigerinids and globorotalids and also in the Eocene with the large benthic foraminifera of the nummulites, soritids and orbitoids.
- The orbitoids died out in the Miocene, since which time the large foraminifera have dwindled.
- Diversity of planktic forms has also generally declined since the end of the Cretaceous with brief increases during the warm climatic periods of the Eocene and Miocene.

Sampling and Processing

- Samples can be collected from wells, river sections and quarry.
- After sampling, processing is very important in which the micro fossils are separated without any damage.
- Samples are collected in a china bowl with proper labeling like well number and depth of the sample.
- Larger caving are separated through the sieving method.
- To dissolve the organic wastes, the sample is treated with Hydrogen peroxide and water in the ratio of 1:3 and allowed to remain for six hours.
- In case of core samples, it is crushed before the H_2O_2 treatment.

- In case of hard samples in addition to the H_2O_2 further ammonia solution is added.
- Quato solution which is combination of ammonia and hydrogen peroxide is added to the rock samples and allowed to remain overnight.
- After six hours, the sample is boiled with water for twenty minutes.
- The sample is then washed in a standard sieve.
- This sieve is taken and immersed in methylene blue solution so as to colour any contaminants present in it.
- Then the sample is transferred and washed in the water.
- All very fine clay particles are washed away and clear samples are collected.

- The sample is then left in the oven at a temp of 125°C for about half hour.
- Sample dried, sieved through 200, 100 and 65u in size.
- The grains left in the 3 sieves are collected in to 3 different boxes with clear labelling.
- Size fraction is very important because foraminifera are greater then 500u in size while nanoplanktons are less than 65u in size.
- In case of grab samples from sea bottom and oozes, samples are treated with sodium carbonate.
- It is drying at over 100°C.

- Sorting under microscope
- The study generally starts with coarser samples.
- Samples are carefully separated and observed under microscope.
- Thin section preparation.

Scope of Micropaleontology

- Microfossils have many applications to petroleum geology.
- The two most common uses are biostratigraphy and paleoenvironmental analyses
- Biostratigraphy is the differentiation of rock units based upon the fossils which they contain.
- Paleoenvironmental analysis is the interpretation of the depositional environment in which the rock unit formed, based upon the fossils found within the unit.
- There are many other uses of fossils besides these, including: paleoclimatology, biogeography, and thermal maturation.

- The reason why Foraminifera are important in oil exploration and other subsurface work as index fossils (indicators of a particular geological age) lies not only in their abundance but equally in their range of size.
- This is generally between 0.10 mm and 1.00 mm in diameter and averages about 0.33 mm, equal to the fine sand grade of sediments.
- Although some are macroscopic and exceed 5.00 mm in diameter, "Larger Foraminifera", and some are smaller than 0.10 mm, "Micro foraminifera".

The reasons for the particular value of foraminifera in stratigraphy

- They are abundant in most marine sediments, in outer-shelf muds where several thousand specimens representing some fifty species frequently occur in a 10 ml volume sample.
- According to Levine (1962) they constitute 2.5% of the animal kingdom and more than half the known protozoa.
- A number of species belonging to different families also occur in brackish water but only members of the non-testate Allogromiida occur in freshwater.

The reasons for the particular value of foraminifera in stratigraphy

- Therefore, the occurrence of Foraminifera is an indication of marine (high marine to brackish) conditions.
- The average about 0.33 mm in diameter (fine sand) with range from 0.10 mm to 1.00 mm. This means that they escape destruction during the ordinary process of rotary drilling.

- Stratigraphic markers "tops" based on the first appearance of species and assemblages in ditch cuttings can be applied in correlation which can be carried out without expensive coring.
- It has existed in abundance since the Cambrian, showing well-marked evolutionary changes useful in stratigraphy. Different families mark the Eras and major time Periods.
- Many species are planktonic and of worldwide occurrence. When this wide geographical range is combined with a short vertical time range they make excellent index fossils.

- Many species are restricted in their habit and confined to a particular ecological niche. They are thus particularly useful in interpreting the character of ancient environments.
- Foram-limestones (larger foraminifera) are well developed in the Upper Paleozoic, The Upper Cretaceous and in the Cenozoic.
- Classification is based on characters shown by the fossilisable test.

Foraminiferal Colouration Index

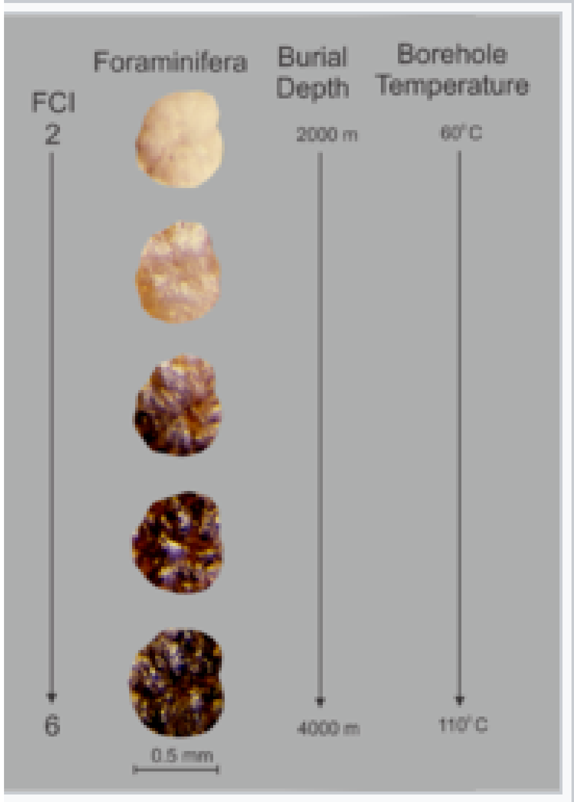
The Foraminiferal Colouration Index (FCI) is a tool for assessing the thermal alteration of organic matter buried in sedimentary rock.

It uses temperature-controlled colour changes in the organic cement of agglutinated foraminifera (microfossils) to estimate thermal alteration.

The method is empirical and based on determination of colour by visual comparison of fossil specimens to the Geological Society of America Rock-Color Chart (Munsell colour system) under a binocular microscope.

The FCI values 0 to 10 are indicated below:

FCI	*Munsell Notation*	*Colour Description*
0	7.5YR6/6	reddish yellow
1	10YR8/1, 10YR8/2	white
2	10YR6/1, 10YR7/2	light grey
3	10YR5/1, 10YR6/2	light brownish grey to grey
4	10YR4/1, 10YR5/2	grey to greyish brown
5	10YR3/1, 10YR/4/2	dark grey to dark greyish brown
6	10YR2/1, 10YR3/2	very dark grey to very dark greyish brown
7	10YR2/1, 10YR2/2	very dark brown to brownish black
8	10YR2/1, N2/0	very brownish black
9	N2/0	black (partially translucent)
10	N2/0	black



- Agglutinated foraminifera have a long geological history spanning the Paleozoic, Mesozoic, and Cenozoic.
- The FCI has many potential applications especially in the analysis of samples from hydrocarbon exploration wells.
- Significant colour changes (FCI 2 to 6) occur through a temperature range of ~60 °C to ~110 °C.
- The FCI is therefore an indicator of temperatures required to initiate petroleum generation (oil window).
- The onset of oil generation correlates approximately to FCI 5-6.