CHAPTER III

THE STUDY OF AMMONOIDS AND FUSULINIDS

The Study of Ammonoids

Ammonoidea is an Order of Class Cephalopoda, Phylum Mollusca. This molluscan invertebrates has bilateral symmetry, soft body and undivided in segment. Its body is covered by two fold of tissue (the mantle) which secretes calcium carbonate to form shell and enclose the gill cavity. Mollusca have a muscular "foot" which is used for movement and is modified in various groups. Most of mollusca have an external calcium carbonate shell. The shell may be external univalve, external bivalve, internal or absent. More than 40,000 species have long been extinct but about 80,000 species are survived. Their habitats are usually marine, fresh water or terrestrial.

Cephalopoda is a class of highly organized marine mollusca, characterized by a head with 8, 10 or more tentacles around the mouth. They have a high developed nervous system. They consist of the head and part of foot to form the so call head-foot is characteristic of this class, though its name (Greek word : kephale = head + podos = foot) appendage are used for crawling. The one important organ of this class is the developed siphuncle. Ammonoidea is one of Order of this Class.

Furthermore, Cephalopods are comprised of both living and fossil forms. The living forms are nautiloids, octopus, cuttlefishes, and squids. The fossil forms are ammonoids, belemnites and nautiloids. All cephalopods are exclusively marine. They are widely distributed in the present oceans, and from the fossil record, they had a comparable distribution in the past as evidenced. They are most abundant in the shallow sea but occur also in the intermediate and even the abyssal depth of ocean. The fossil form indicated that they were in shallow-water habitat. Many fossil and living forms in Order Ammonoidea have the life habit as nektonic.

Although ammonoids have long been extinct but their fossilized shell are common in all continents and many oceanic islands. Ammonoids were widespread and abundant in the past. There are two lines of thought concerning the origin of this group of cephalopods. Some investigators assumed that the ammonoids evolved from some coiled nautiloid genus.

Nautiloids range from the Late Cambrian to Recent but the first ammonoids have the record that they were first found in Lower Devonian. Other investigators believed that the ammonoids evolved from the bactritoids by a gradual coiling of the straight shell. It is very difficult to solve this problem. However, the distinguished characters of ammonoids are tightly coiled in planispiral, with a bulbous calcareous protoconch, septa that form angular and curve, suture flexure, and a small marginal siphuncle (morphology of Ammonoidea will be explained in the next chapter.). Ammonoids have rapid evolution. They have evolved in the great number of genus within Lower Devonian to Upper Cretaceous (Figure 3.1).

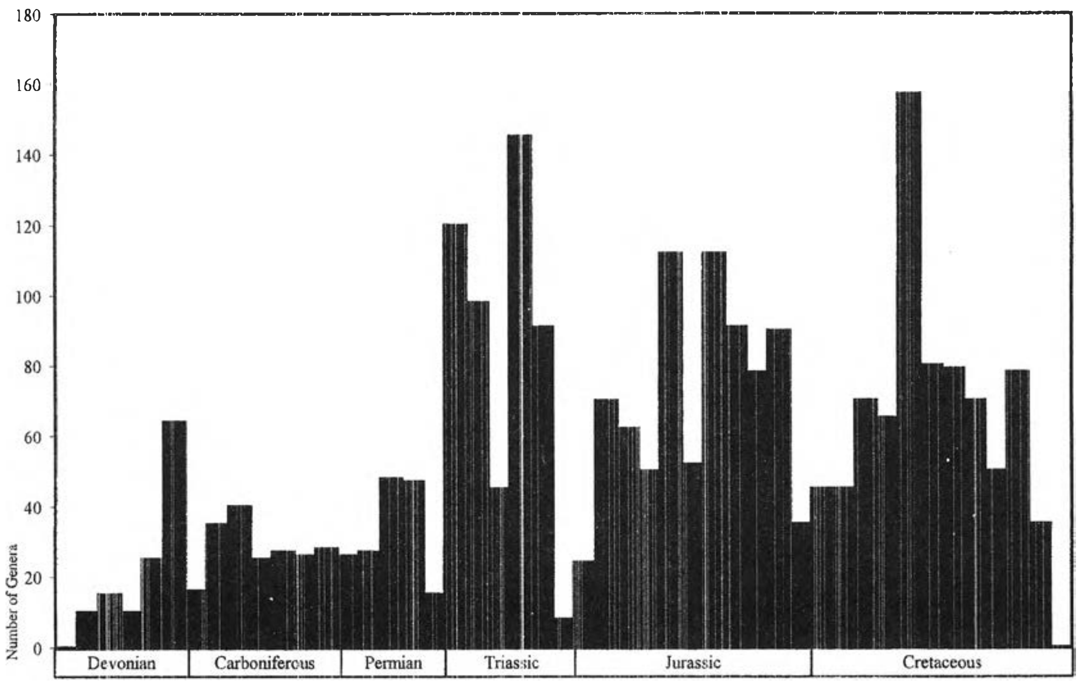

Figure 3.1 Diagram showing the change in number of genera of Ammonoidea during the whole periods of their existence (Ruzhencev, 1960).

Ammonoids are important as index fossils because of their rapid evolution and wide distribution in shallow marine waters. They became almost extinct at Late of the Permian and again at Late Triassic, then declined slowly during the Upper Cretaceous.

Ammonoid fossils are among the best index fossil because of their rapid and diverse evolution, widespread occurrence, abundance, and easiness of identification even when incomplete and when preserved only as internal mold. They, in particular, are good stratigraphic indices and marine strata of the Late Paleozoic and Mesozoic are zoned with reference to them. According to the rapid evolution, they have much more development in their morphology and ornament. The most important and dominant of them is suture system. They develop from simple suture (goniatitic) in the early form to be ceratitic suture and to the most advanced form in ammonitic suture found in the latter species of ammonoid (Figure 3.2) Goniatitic suture was found in ammonoids that have the age rang from the Early Devonian to the Triassic, ceratitic suture was found in ammonoids that range from the Carboniferous to the Triassic, and ammonitic suture was found in ammonoids that have age range from the Permian to the Cretaceous.

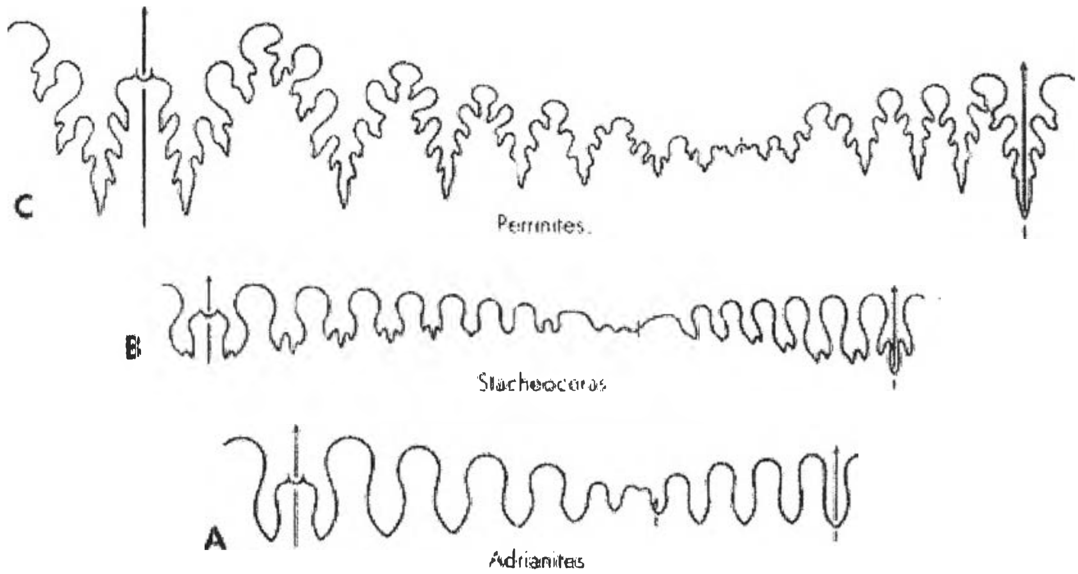

Figure 3.2 Diagram illustrating differences in type of ammonoid sutures, all based on Permian species : A, goniatitic suture type, *Adrianites defordi* Miller & Furnish, x1.3; B, ceratitic suture type, *Stacheoceras toumanskyae* Miller & Furnish, x2; C, ammonitic suture type, *Perrinites hilli* (Smith), x2.7 (110) (Moore, 1957).

Morphology

A shell is the only fossil record of Ammonoidea; no imprints of the soft body have been found (Orlov, 1974). The shell can be visualized in the uncoiled state as a very long widening tube composed of three totally different parts (Figure 3.3). Posteriorly, the shell begins with a microscopic initial chamber, the protoconch. Next comes the phragmocone, a long tube divided by numerous septa into air chamber. Anteriorly, there is a shorter cavity tube, the living chamber, containing the soft body. Also inside the shell is the siphuncle which extends from the protoconch to the living chamber, traversing all the septa. The protoconch of the regularly coiled Ammonoidea is situated in the center of the planispiral shell and is surrounded by the spiral phragmocone. An important morphology of Ammonoidea are described as followed:

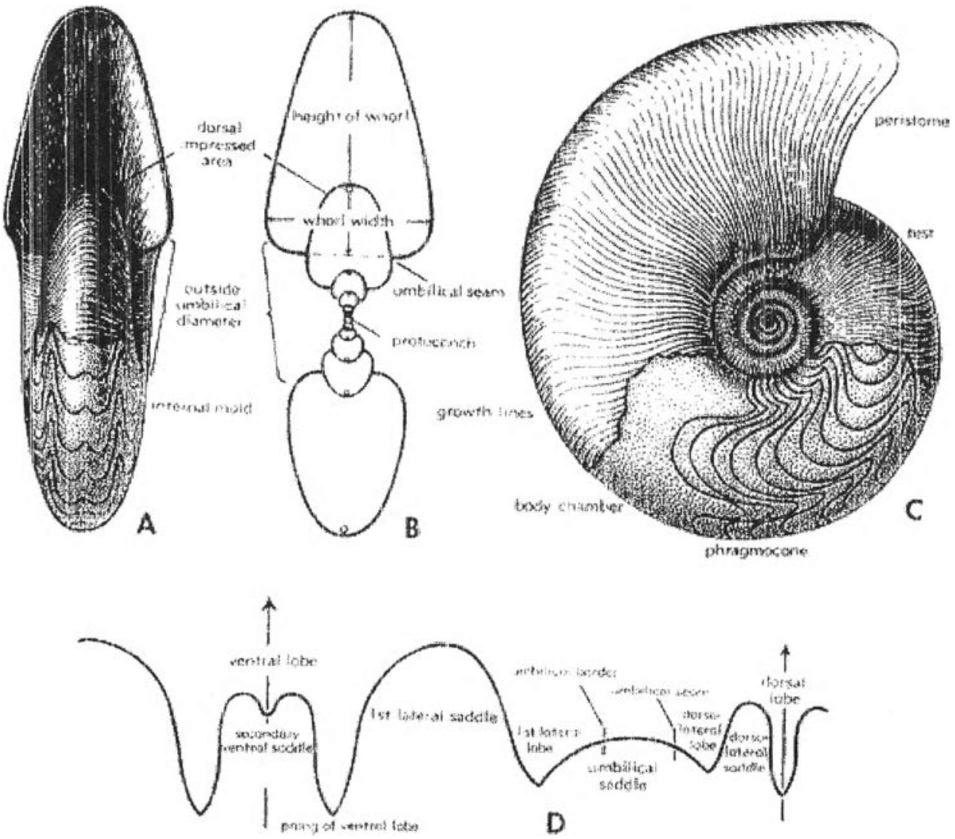

Figure 3.3 General morphology of the shell in the Ammonoidea (Miller & Furnish, 1957, with modifications).

Protoconch

Protoconch is the first chamber of shell of ammonoids, closed by proseptum (Figure 3.4). It is sometimes called initial chamber or apical chamber. The ammonoids shell consist of a small protoconch and a much larger conch, both of which were calcified and were therefore commonly preserved as fossil. Typically, the conch consists of a circinate spiral tightly coiled about the protoconch, and it is involute as the whorls are impressed dorsally by the ventral portion of the preceding volution (Figure 3.3).

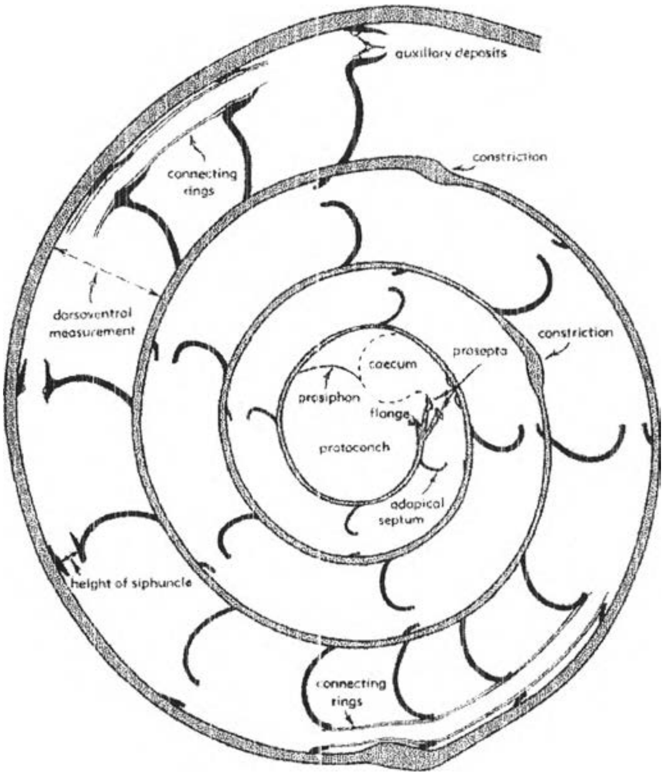

Figure 3.4 Enlarge median dorsoventral section of the adapical portion of the shell of a typical ammonoid, showing diagrammatically the various internal structures (Moore, 1957).

Conch

The conch comprises all of the complete shell except the Protoconch. In typical mature individuals it has several volutions. It consists of a phragmocone and a body chamber. The shells of ammonoids consist of numerous chambers which are separated by septa and communicated with one another solely by means of the siphuncle. The chambers are also called camera. In general, their length increased progressively during development of coiling. The surface of conch tend to be rather smooth and the growth lines are generally fine and not very prominent. Furthermore, in many cases the conch bears transverse constrictions, the depression encircling the whorl which are prominent on the internal mold than on the exterior of the conch and which tend to be more or less parallel to the growth lines and to strengthen the shell. On both sides of ammonoids shell usually show the external depression on each side of shell axis of coiling, it is called umbilicus (Figure 3.3).

Body Chamber

Body chamber of living animal is the last chamber house the body of the animal, Ammonoidea. Posteriorly it borders on the last septum, while anteriorly it ends at the aperture.

Siphuncle

Siphuncle of ammonoid is a narrow longitudinal tube passing through camerae or septa from protoconch to the base of body chamber. Nevertheless, because at maturity it is marginal in position, it serves to differentiate the ammonoids from the nautiloids. (Figure 3.4).

Orlov (1962) reported that the siphon performed an important function during life. It is assumed that it served to alter the gas pressure in the chamber. When the ammonoids diving down into the water, an increase of the intracameral gas pressure, which increased the specific weight of the animal and at the same time counteracted the external water pressure on the hollow shell. When the animal rose, the intracameral pressure was decreased, which lowered the weight of the animal and protected the shell from internal strains resulting from the abrupt reduction of hydrostatic pressure.

Septa

The shell of the ammonoid are divided by traverse septa. The first two septa near protoconch, often termed prosepta. The number of septa per volution, though variable, tended to increase during growth. There could be several hundred septa in the adults. All septa have a perforation for the passage of the siphuncle, extends from the protoconch to the body chamber.

Thus, the main function of the septa of ammonoid was to increase the strength of the conch without adding unduly to its weight and to protect any mechanism influences threatening to damage the shell.

Suture

The suture is the high taxonomic value of Ammonoidea. Suture line is the line of contact between septum and shell wall. The suture line is invisible to study until the shell wall is scraped off by some instrument. In involuted forms, the portion of the suture that extends across the ventral and lateral area to the umbilical seams is termed the external suture, and its continuation across the dorsal impressed area is called the internal suture. Suture line consists of separate curves directed backward and forward in relation to the position of aperture, and termed respectively lobes and saddles. During evolution, the suture line of ammonoid underwent progressive complication and become extraordinary intricate in some phylogenetic branches.

Morphological types of suture line. In the morphological sense the suture line are divided into the following types: goniatitic, ceratitic, and ammonitic (Figure 3.2). These type can be characterized as followed:

1. Goniatitic suture (Figure 3.2 A) the elements are more numerous, the lobes and saddles simple, undivided (except the ventral lobe), often peaked.

2. Ceratitic suture (Figure 3.2 B) the lobes are serrate at the base and the saddles are simple.

3. Ammonitic suture (Figure 3.2 C) the lobes and saddles are strongly and fully divided.

The terms of suture line are still useful in broad way, as well as in a very restricted sense for identification of genera, from which each genera has a specific character of suture system. Goniatites are often appeared in the Early Devonian to Triassic, Ceratites in the Carboniferous to the Triassic and Ammonites in the Permian to the Cretaceous.

Size and Measurement.

The size of the Ammonoidea varied considerably. Shells of definitive size are rare in the collections, but it is evident from a large numbers of observations that the minimum and maximum sizes of ammonoids were 1 cm and 2 m. Records of the occurrence of even larger shells (to 3 m.) have not been verified.

The main measurements of the shell of ammonoid are also measured in shell diameter, whorl height, whorl width and umbilical diameter. The four number of measurements are usually recorded in the data about ammonoids (Figure 3.5).

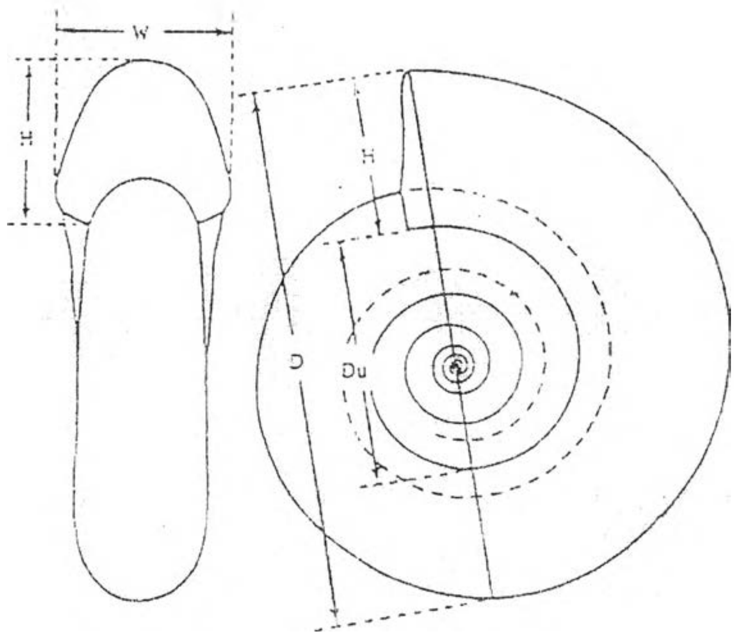

Figure 3.5 Diagram showing the main measurements of the shell in the Ammonoidea : D : shell diameter, H : whorl height, W : whorl width, Du : umbilicus diameter (Orlov, 1962).

Paleoecology

The Ammonoidea were exclusively marine animal like all cephalopods. Recent studies show believable evidence that the Paleozoic ammonoids lived in relatively shallow waters of normal salinity and were largely confined to the littoral zones (Miller and Furnish, 1936-1937; Teichert, 1943; Maksimova, 1950; Ruzhencev, 1950, 1952, 1956). The Devonian Ammonoidea were particularly abundant in neritic and oceanic zone (Westermann, 1987). They also lived near reefs, sometime on them, if they near sheltered from heavy waves. Bay and inlets with calm water and with a vegetation of algae provided an especially favorable environment for all cephalopods. Ammonoidea also lived in the shelf zone.

All the recent data indicate that ammonoid shells were not transported great distance after the animal's death. For this reason, the sediments which contain these fossils as well as other organic remains buried together with them reflect to some extent their ecology, their mode of life. Ammonoidea are often found in sandstone, limestone, clay. They are absent in conglomerates and in black shales deposited in conditions of a low oxygen content. In other words, the ammonoids, living mostly in the neritic zone of the sea, require adequate aeration, without abundant sedimentation but could not tolerate such factors as eddy current, abrupt fluctuation of water temperature and salinity.

Invertebrates of other phylum are usually very rare in localities where contain abundant ammonoids. Among the forms which often occur in the group of ammonoids are radiolarians, sponges, bivalve mollusks and gastropods. Ammonoid and fusulinids are often found in the same formation (Orlov, 1962). As a rule, ammonoids did not live together with such group as corals, bryozoans or brachiopods, although they are buried together (Orlov, 1962).

The Study of Fusulinids

Fusulinids are the single-cell invertebrate fossil. They belong to Phylum Protozoa, Class Sarcodina, Order Foraminifera. Fusulinids occurred in upper Mississippian and extinct in late Permian. Many researchers called fusulinids as larger foraminifera. The suitable definition of larger foraminifera is the specimens, which can be identified only by eye without instrument aids or can be observed only by means of the thin-sections under the microscope. The shape of fusulinids shell is varied, although common type has fusiform, lenticular, and discoid. Sizes of fusulinids range from 1 mm. to 100 mm. Most of specimens are between 5 - 20 mm. in diameter. Many genera are the excellent index fossil because they have a rapid evolution and they were widely spread in many parts of paleo-marine of the world.

Morphology

Fusulinids shell are usually characterized fusiform in shape and coiled around the axis called axis of coiling. Even there are various form fusulinids but they have the same important features. Study of fusulinids usually consider on their significance morphologies as followed:

Proloculus

The proloculus is the initial chamber of the single-cell animal fusulinids. Proloculus is the original of axis of coiling (Figure 3.6). In most fusulinids the proloculus is spherical to subspherical in shape.

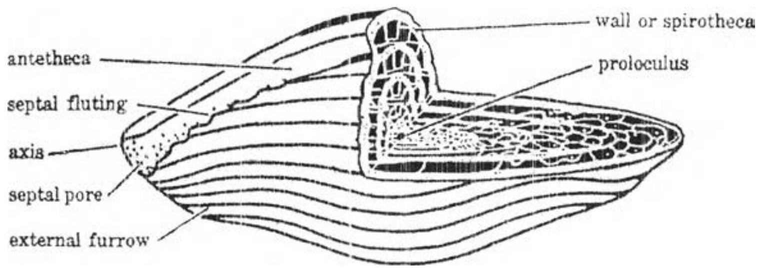

Figure 3.6 Diagram of a fusulinid test (*Triticites* sp.) showing structure features. A quadrant of the shell is cut away along planes of sagittal and axial sections so as to show internal structure (Moore et al., 1952).

Septa, Anthetica, and Spirotheca

The septa of fusulinids are partitions between chambers in the shell (Figure 3.6). For the primitive genera they usually have a plane surface septa, but for the advance genera, the septa become flute. Some genera, the septa may have aperture communication within the shell with numerous small opening; septal pores. The front wall of last chamber septa becomes anthetica, and outer wall of last volution called spirotheca. Furthermore, on the external surface of shell at the position of a septum usually show depression furrow is external furrow.

Tunnel

A central located at lowest part of septum like slit opening is tunnel, penetrates all septum except last septa (Figure 3.7). Opening beside tunnel called foramen.

Chomata, Parachomata, and Septula

The chomata is a cumulated calcium carbonate like a ridge between a couple sides of tunnel. Another cumulative calcium carbonate beside chomata throughout the shell termed parachomata. Some fusulinids have a calcium carbonated generated from wall downward at the same direction of parachomata call septula. (Figure 3.7)

Axial Filling

Dense deposit calcium carbonate accumulates in the axial region. Some fusulinids group may have heavy axial filling but some are very rare in axial filling. (Figure 3.7)

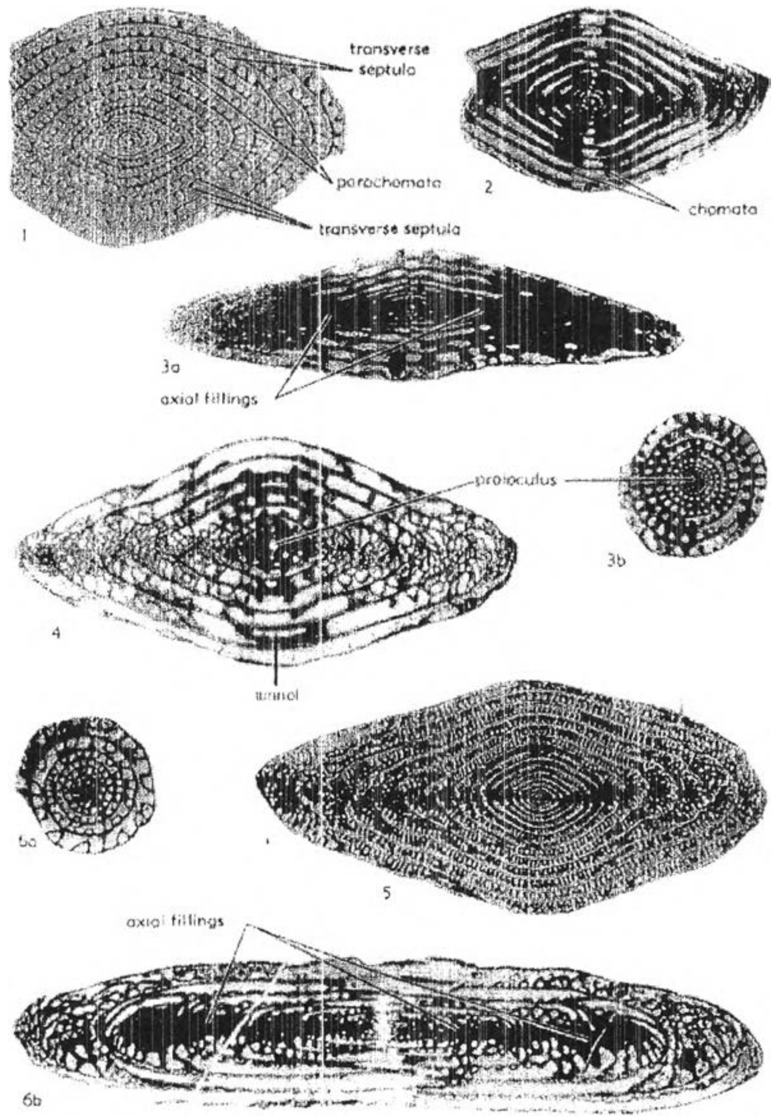

Figure 3.7 Axial, Sagittal, and Parallel Section showing internal structure of fusulinids: Tunnel, Chomata, Parachomata, Septula, and Axial Filling (Moore, 1964).

Wall Structure

The wall of fusulinids is composed of micro-granular calcium carbonate crystals. The wall structure of shell is complex. There are two main types; fusulinellid wall type and schwagerinid wall type, each type is well developed.

The fusulinellid type (Figure 3.8, A) is composed of four layers. The external layer is thin dark layer named tectum. Below the tectum is a transparent layer; diaphanotheca. Tectum and diaphanotheca area lying between tectoria. The outer one is upper tectorium and the outer one in inner tectorium. In the earlier volutions of fusulinids which have fusulinellid wall type there are completely four layers; upper tectorium, tectum, diaphanotheca, and inner tectorium. All layers are pierced by small mural pore. At outer volution, the wall may consist only three layers; tectum, diaphanotheca, and inner tectorium, and latest volution may consist only two layers of tectum and diaphanotheca.

The schwagerinid type (Figure 3.8, B) of wall structure is composed of only two layers; tectum and keriotheca. Tectum is the outer thin layer. Keriotheca is relatively thick layer shown by transverse dark line. Dark lines is wall of alveoli, which are deep cylindrical or prismatic cavities. Both tectum and keriotheca are pierced by small perforation of wall called mural pore.

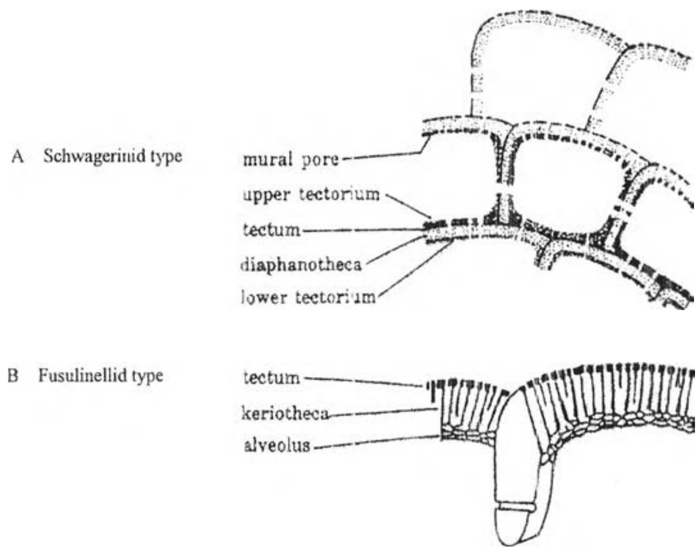

Figure 3.8 Comparison of fusulinellid and schwagerinid wall structure type: A, Showing outer part of fusulinellid type; B, Represents part of schwagerinid type. (Moore et al., 1952).

Sections for Fusulinids Observation

The study of fusulinids often observed under the microscope. The shells of fusulinids have many different characters especially in the internal character. Therefore, it is necessary to cut section of the shell in order to make a correct identification. A section parallel to the axis of coiling is named an axial section (Figure 3.9 A). A section cut perpendicularly with the axis of coiling and cut through proloculus is termed sagittal section (Figure 3.9 B). A section parallel to the axis of coiling but not through proloculus is a tangential section (Figure 3.9 C). The others section that not through proloculus and not parallel or perpendicular with the axis of coiling is termed oblique section.

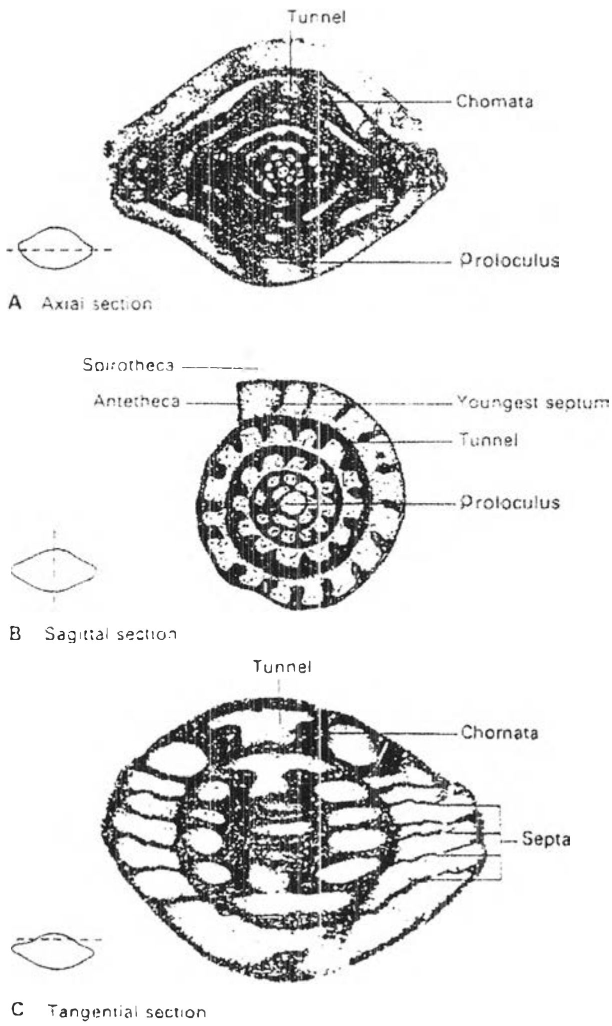

Figure 3.9 A section of fusulinids (*Fusulinella* sp.): A, Axial Section; B, Sagittal Section; C, Tangential Section. (Boardman et al., 1987)

Paleoecology

The environment in which fusulinids survived is interpreted from the study of rock in which they are preserved. Fusulinids usually lived in a shallow, clear, and marine water environment, shallow sea on the continental platform far from shoreline.