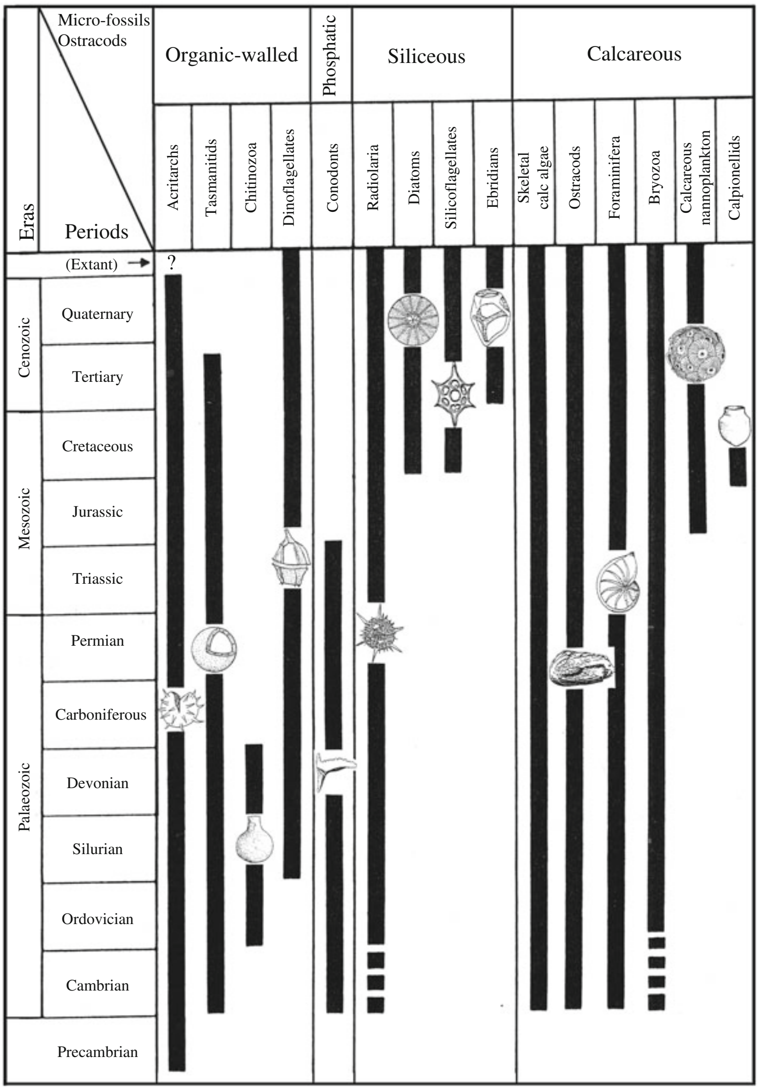

Fig. 7.3 Outline of the stratigraphic distribution of microfossil groups from Precambrian to present time, arranged according to skeletal composition (modified after Haq and Boersma 1978)

high potential for dispersal. (4) High degree of facies independence. (5) Small redepositional potential. (6) Presence of many distinct morphological features, increasing the precision level of taxon identification.

7.3.2.1 Mode of Life

The mode of life (*ethology*) of organisms is crucial for the regional distribution of their fossil remains. Living and fossil biota can be arranged into two ethological groups (Fig. 7.4). *Pelagic* organisms live freely in the water column and comprise the *planktonic* forms (passively floating) and *nektonic* forms (actively swimming). The *benthos* comprises bottom dwelling organisms belonging to *epibenthos* (living at the sediment/water interface) and *endobenthos* (living buried in the sediment). Foraminifera as a group reveal the widest environmental range by being represented in all the ethological categories except nektonic. Ostracods and diatoms also have a relatively wide range as they occur both in the benthic and pelagic habitats. Conodonts are regarded to have a nektonic origin. Acritarchs, dinoflagellates, calcareous nannoplankton, radiolarians and several minor groups are exclusively planktonic. Spores and pollen occupy a special position because they are the reproductive organs of terrestrial plants, but are dispersed principally as plankton (by air or water).

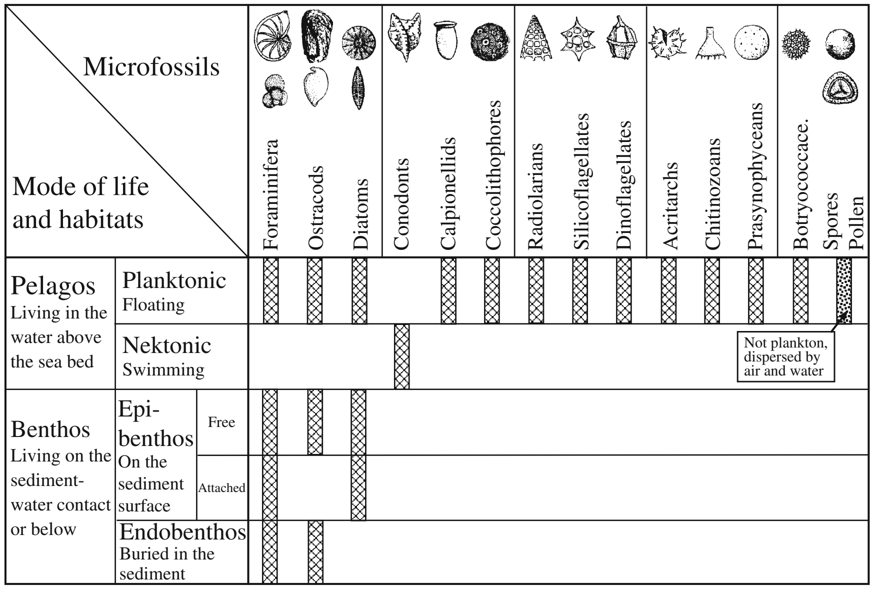

Fig. 7.4 Mode of life and habitats of major microfossil groups in aquatic environments

It is obvious that the pelagic group contains microfossils with particularly high stratigraphic applicability, owing to their relative independence of facies, e.g. planktonic foraminifera, calcareous nannoplankton, dinoflagellates and the nektonic conodonts. Benthic biota usually have less stratigraphic potential, although they are also commonly used for this purpose, particularly in marginal marine deposits where planktonic biota are rare. On the other hand, benthic forms are commonly excellent facies indicators, e.g. benthic foraminifera and ostracods.

7.3.2.2 Environmental Distribution

The life habitat of biota is of prime importance both for stratigraphical purposes and biofacies analysis. In non-marine subaquatic environments important fossil groups include diatoms and ostracods (Fig. 7.4). In marginal marine brackish environments low diversity assemblages of foraminifera, ostracods, and diatoms are dominant. Shallow shelf to bathyal environments are typified by their high diversity assemblages of benthic and pelagic biota. In abyssal environments, below the compensation depth of calcium carbonate, microfossils are exclusively siliceous, arenaceous or organic-walled.

The members of the ubiquitous group of organic-walled microfossils are produced in a wide range of contrasting habitats (Fig. 7.4). Pollen and spores are produced by land and freshwater flora. They are transported far out into the marine realm but show decreasing frequency with increasing distance from source. They are commonly used in the stratigraphy of terrestrial and marginal marine deposits in the absence of other fossils, although they provide a low age resolution. Chlorophyte freshwater algae (as Bothryococcus) are also prone to be transported to marine areas. Prasionophyte marine algae and acritarchs are common in brackish marginal marine and shallow shelf settings. Dinoflagellates are most common in marine shelf and oceanic waters, and are widely used for stratigraphical purposes.

Foraminifera occur in a wide variety of environments ranging from open ocean to estuarine waters, and are extensively used in stratigraphic and facies analyses. Marginal marine environments (such as tidal marshes, estuaries and lagoons) are typified by low diversity benthic assemblages composed of agglutinated and mixed calcareous-agglutinated components. The low species diversity restricted nature of these assemblages reduces their stratigraphical applicability. Normal marine shelf areas are typified by high diversity calcareous faunas and increasing frequency of planktonic species toward the shelf break.

The planktonic component reaches its maximum in bathyal areas. Shelf and bathyal assemblages form an excellent basis for age determination and stratigraphic correlation. The amount of calcareous benthic and planktonic foraminifera decreases downslope through the lysocline and they disappear below the compensation depth of calcium carbonate. Below this level the sea bed is populated by agglutinated species, usually of a cosmopolitan nature, which provide an adequate basis for stratigraphic application.

The environmental distribution of the various microfossil groups in the North Sea basin Mesozoic and Cenozoic succession is well known owing to the prevailing oil and gas exploration (Fig. 7.5). The dominance pattern in this area reflects the general bathymetric distribution pattern of the various groups. Abyssal deposits are dominated by radiolarians and cosmopolitan agglutinated foraminifera. Bathyal and outer shelf sediments are characterised by high dominance of planktonic foraminifera and calcareous nannoplankton. Mid-shelf sediments contain abundant calcareous benthic foraminifera and dinoflagellates. Deltaic deposits are typified by spores, pollen and agglutinated foraminifera. In non-marine deposits the most common fossils are spores and pollen.

7.3.2.3 Redeposition

Erosion of fossil-bearing sediments with subsequent transport and redeposition of microfossils can lead to serious problems for dating and correlation. Palynomorphs are particularly liable to redeposition owing to their small size and weight. Conodonts also have a high redeposition potential because their calcium phosphate skeletons are strongly resistant to corrosion by weathering and transport. Redeposition is suspected if microfossils appear at higher stratigraphic

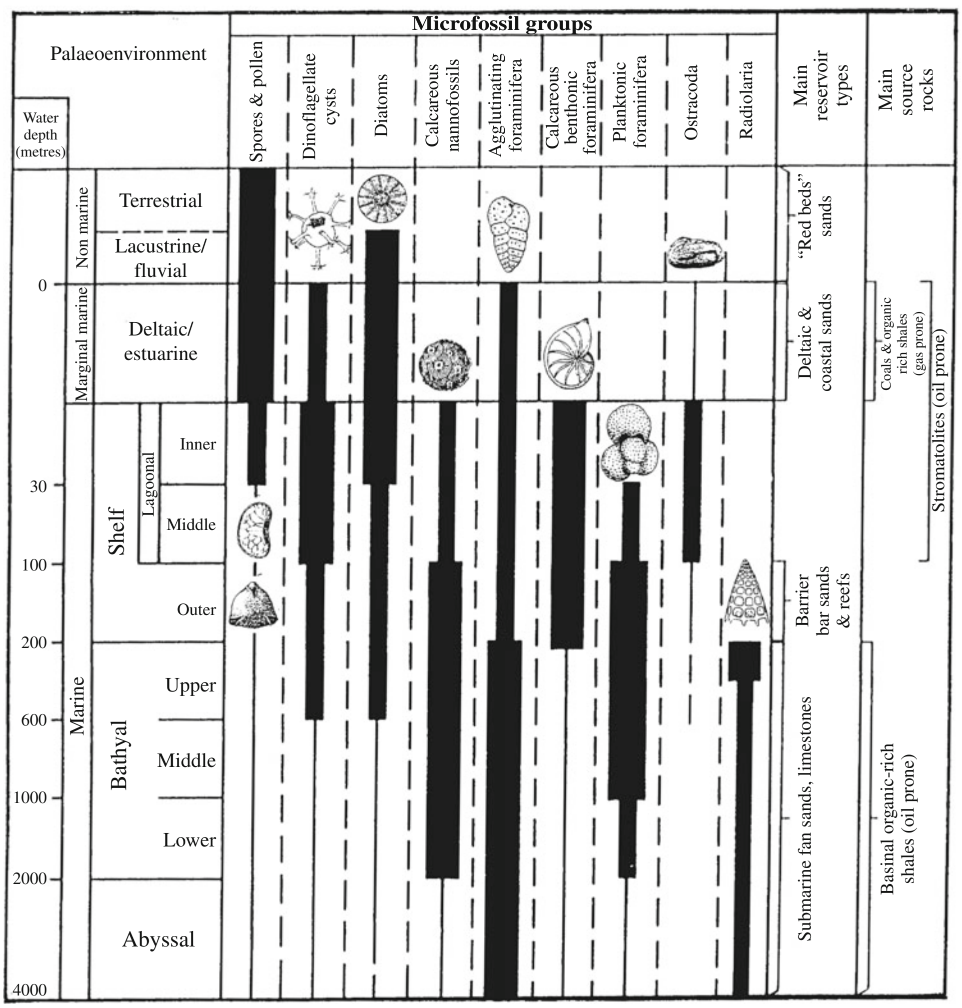

Fig. 7.5 Depth-related palaeoenvironmental distribution of major microfossil groups in the North Sea basin (Triassic to Tertiary), and position of the main reservoir and source rock facies (from Copestake 1993)

levels than expected. Reworked microfossils can be distinguished by changes in colour and traces of wear.

7.3.2.4 Facies Barriers and Biostratigraphy

Sediment cores from deep oceanic settings usually provide undisturbed sections containing a continuous fossil record, commonly of high stratigraphic resolution. Based on this type of material, biostratigraphy combined with magnetostratigraphy and chemostratigraphy contributed heavily to development of a global biochronozonal framework. This framework has been extended to formations deposited in marine shelf, deltaic and coastal areas, where it forms an important basis for dating and correlation.

The basic unit of biostratigraphic correlation is the *taxon chronozone*, also called *biochronozone*. As defined below, a taxon chronozone represents all sediments deposited between the evolutionary appearance and extinction (total range) of its marker species (Fig. 7.8). In contrast, the *biozone* represents only those sediments at a given place that contain the one or several species. In the case of a single marker, the biozone can be defined by the local appearance and disappearance (local range) of the species. The time interval represented by the biozone may differ from place to place.

In deep oceanic regimes, the latitudinal distribution of each species is generally defined by the water mass temperature and chemistry. Therefore, the regional (lateral) extent of biozones and taxon chronozones is of restricted nature. Outside its optimal stratigraphic distribution area, the range of the marker species can vary considerably owing to environmental factors. At such sites the chronozone cannot be defined and the term biozone is used. Correlation between tropical and temperate oceanic regions is difficult, because of the low number of biota that include reliable zonal indicator species common to both areas. Interfingering of biozones (local ranges) and integration with magnetostratigraphy and chemostratigraphy is a useful approach to this type of correlation.

7.3.3 Biozones

The basic unit of biostratigraphy is the biozone which is a body of strata defined by its fossil content. During the history of biostratigraphy, a variety of names and definitions of units have been proposed, but there are only three basic types of zones: interval zones, assemblage zones and abundance zones. Zones defined in sedimentary successions are usually arranged into a zonal scheme, which can be developed for an extensive region and even for global application.

7.3.3.1 Interval Zones

These are the most commonly used type of zones, with boundaries defined by particular fossil events, specifically the first and last occurrence of taxa (usually species). Thus, the interval zone comprises the strata deposited between these two events. There are five types of interval zones (Fig. 7.6).

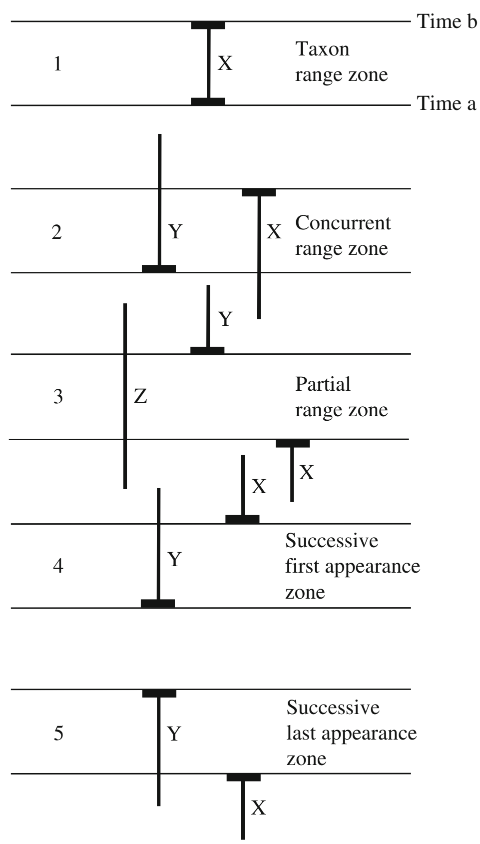

Fig. 7.6 Outline of the five types of biostratigraphic interval zones shown by occurrences of microfossils X, Y, and Z. *Vertical lines* are taxon ranges, *horizontal bars* are first and last occurrences