CHAPTER 5

The Organic Dimension: The Many Uses of Paleontology

by

Jürgen Schieber

Department of Geology, The University of Texas at Arlington, Arlington, Texas 76019, USA

Fossil hunters have long valued shale formations because the contained fossils are often exceptionally well preserved, on account of the fine-grained matrix that protects them from erosion, dissolution, and other destructive diagenetic processes. The enclosing shale matrix is often not cemented and beautiful specimens can be found that require little or no preparation. A number of shales are world famous as "Fossillagerstätten" (Seilacher, 1970; Seilacher et al., 1985) and have yielded specimens that were crucial for our understanding of earth history. Examples of such well known shales are the Burgess Shale (Conway Morris, 1985; Briggs et al., 1994) and the Posidonia Shale (Kauffman, 1979; Seilacher, 1982).

The fossil record is the backbone of stratigraphic correlations in sedimentary successions. Although application of sequence stratigraphy will likely help to refine correlations in shale sequences (see papers by Bohacs and Schutter in this volume), biostratigraphy is still indispensable. It is essential for long range correlation of cycles and for calibrating the sequence stratigraphic framework. A wide variety of fossils occur in shale successions, but the most useful ones for routine biostratigraphic work are microfossils, such as conodonts in the Paleozoic and Triassic, and foraminifers in the Late Paleozoic, Mesozoic, and Cenozoic. Macrofossils, such as trilobites and ammonites, can yield correlations that are almost as good as those obtained from microfossils. They are, however, typically much less abundant than microfossils, and thus the precise definition of biozones is not as accurate. The most precise biostratigraphic correlations are possible when they are based on evolutionary changes in a single lineage, such as for example the Upper Devonian biozones based on the evolution of Palmatolepis (Ziegler and Sandberg, 1990). A summary of fossils that can be used for biostratigraphic correlations, as well as relevant references, can for example be found in Boggs (1995), Blatt et al. (1991), Potter et al. (1980), and Geyer (1973).

Aside from providing correlation, fossils are also very useful as providers of environmental information. Constructional adaptations of fossils are reflections of their life habits and survival strategies, and indirectly they reflect type and abundance of food supply, consistency of the substrate, energy level of the environment, frequency of disturbances, and turbidity. Likewise, the quality of preservation of fossils (taphonomy) can say a lot about the amount of oxygen in the environment, speed of sedimentation, and energy levels (Allison and Briggs, 1991). Extracting this kind of information from the fossil record is the realm of paleoecology , and its application to shales and mudstones is summarized in the contribution by Brett and Allison to this chapter.

Basin topography, current systems, and climate zones can all influence the areal distribution of fossil species within a given stratigraphic interval, an area of research known as paleobiogeography. Although paleobiogeographic effects are probably minimal in many sedimentary basins, in very widespread cratonic successions, such as those of the Late Devonian inland sea of North America (see contribution by Ettensohn to this volume), the effects may be significant. Useful paleogeographic references are for example Hallam (1973), Middlemiss et al. (1973), and Gray and Boucot (1979)

Organisms that live in muddy environments interact with the accumulating sediment in a variety of ways. They leave tracks by moving over the surface and produce a large variety of burrows by tunneling inside the sediment in search of food and shelter. These trace fossils reflect the life habits and adaptations of the animals, and allow us to derive information about substrate consistency, food supply, turbidity, and oxygen supply. The study of these biogenic structures is known as paleoichnology. Its application to the study of shales and mudstones is summarized in the contribution by Wetzel and Uchman to this chapter.

Another, though non-paleontologic, aspect of the organic content of shales deserves mentioning in this context. Shales are the most significant hydrocarbon source rock in sedimentary basins, and the organic content of shales determines the production of natural gas and petroleum in sedimentary basins. There are two principal sources of organic matter, phyto- and zooplankton produced in the water column, and terrestrial plant debris brought in by rivers. Of these organic materials very little survives as recognizable parts of original organisms. Phyto- and zooplankton provide the building blocks for petroleum, whereas terrestrial plant debris is the raw material for the production of natural gas. Thus, the proportions of plant and animal matter accumulating in a shale succession have a strong influence on the relative proportions of gaseous and liquid hydrocarbons in a basin. The study of the nature and origin of non-skeletal organic matter in sediments is the realm of organic geochemistry. Texts by Tissot and Welte (1984) and by Engel and Macko (1993) provide thorough coverage of this topic. An interesting recent development was the realization that certain organic molecules, such as photosynthetic pigments, are stable enough to survive as “carbon skeletons” in the sedimentary record, and can give information about the original source of diagenetically altered organic matter in shales (Brassell, 1992).

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