The second part of this book explains the characteristics of microfacies types (Chap. 11), discusses diagnostic features of paleoenvironmental conditions (Chap. 12) and the importance of integrated facies analysis (Chap. 13), examines the potential of generalized facies models and standard microfacies (Chap. 14), and illustrates the significance of microfacies in the recognition of depositional settings (Chap. 15) and specific sedimentation patterns (Chap. 16).

11 Summarizing Microfacies Criteria: Microfacies Types

Microfacies studies aim for the recognition of overall patterns that reflect the history of carbonate rocks, by means of a thorough examination of their sedimentological and paleontological characteristics. The previous chapters have shown which thin-section criteria are used in describing the microfacies of limestones. The evaluation of microfacies in the context of facies interpretation requires a synopsis of microfacies data observed in various samples into a microfacies type (MFT). Microfacies types and facies associations are fundamental to the development of models for carbonate sedimentation.

11.1 MFT Concepts

Microfacies, microfacies types and standard microfacies types

The microfacies recorded by a thin section is not necessarily identical to a microfacies type. The approach to microfacies is largely descriptive, and microfacies types should be defined by those microfacies criteria whose existence and abundance are determined by specific environmental factors and are linked to specific depositional settings. This requires careful selection of the textural and compositional criteria used.

Basic prerequisites for defining MFT are a clear-cut discrimination of grain categories discussed in Sect. 4.2, an understanding of limestone classifications based on textural criteria (Sect. 8.3), the recognition of depositional fabrics (Chap. 5) and the ability to attribute thin-section fossils to major systematic groups and taxonomic units.

Identical biota and comparable depositional environments give rise to time-specific microfacies types, some of which have been generalized, for example the facies types developed for Devonian shelf and reef carbonates (Hladil 1986; Machel and Hunter 1994). Similar or identical criteria in individual microfacies types from limestones not restricted to specific time intervals are used to define standard microfacies types (SMF types), which describe major depositional and biological controls and suggest major depositional settings (Wilson 1975). The SMF concept and its application in reconstructing depositional systems are discussed in Sect. 14.3.

Microfacies types, microfacies variability and facies hierarchy

Texture, as well as qualitative and quantitative microfacies characteristics, may vary considerably within a limestone bed, both laterally and vertically. Variability depends partly on sample size and sampling procedures (see Sect. 3.1.2.1), but may be real and reflect small-scaled depositional events or rapidly fluctuating environmental conditions. Several MFT may occur within a single thin section (Morrow and Webster 1991; see Pl. 127) or in samples taken within lateral distances of only a few tens of centimeters (Egenhoff et al. 1999). The evaluation of microfacies variability requires pre-
Microfacies types for allochthonous carbonates, defined by texture and composition and based on small-scale analyses (e.g. bed-by-bed studies), define the fundamental depositional unit and reveal the depositional dynamics that were operating during transport and deposition (e.g. storms). Facies analyses based on depositional lithofacies (e.g. wackestone, grainstone) and the comparison of MFTs from sedimentary sequences record both vertical and lateral changes. Vertical changes may indicate shallowing-up or deepening-up and reveal facies dynamics (e.g. regressive/ transgressive events). Lateral changes (e.g. following the dip of a ramp) may indicate differences in water depths and hydrodynamics. Associations of MFTs occurring within the same lithofacies and deposited in the same general environment (e.g. MFTs of grainstones) describe local sedimentary subenvironments (e.g. soft and firm substrates) or local processes.

11.2 How to Differentiate Meaningful Microfacies Types

Microfacies types for autochthonous limestones are defined by different criteria from those for other limestones.

Autochthonous limestones (Sect. 8.2) include both reef limestones and microbial carbonates.

Reef limestones: MFTs are differentiated according to the type of reef-building fossils. Generally, the most common reef-building taxa in combination with the dominant texture (framestone, bafflestone, bindstone or boundstone) and matrix type are used in defining a MFT.

The example shown in Fig. 10.36 (subsequently called sample A) is a sponge boundstone, or more precisely a coralline-sponge boundstone. Because the latter designation does not reflect the diversity of the coralline sponges contributing to the boundstone fabric, the MFT would be better characterized as ‘medium-diverse coralline boundstone’. The sample depicted on Pl. 81/1 (sample B) yields the same coralline sponge groups and corresponds to sample A in an inhomogeneous micrite matrix. The two samples represent the same microfacies type even though sample B exhibits spongiomorphs not shown in A. This additional constituent is of minor importance for the definition of the MFT because its consideration does not change the environmental interpretation of the two samples. Both samples reflect the existence of an organic reef framework formed by coralline sponges within low-energy environments. However, the depositional setting of each of these environments is different. Both samples are Late Triassic in age. Sample A comes from small patch reefs in the marly-calcareous Zlambach beds of the Northern Calcareous Alps which were formed in front of the large platform margin reefs represented by sample B which comes from the Dachstein limestones. The similarity in biotic composition and texture does not express congruent depositional sites, but does express similar nutrient controls in habitats that were comparable with regard to the ecological constraints of nutrient supply, available substrate and reduced water energy.

Another sponge limestone is shown in Fig. 10.34. This Late Jurassic sample differs distinctly from the sponge limestones discussed above in the sponge group (siliceous hexactinellid sponges), the association of sponges with microbial crusts at the top of the sponges, and the spotty matrix. The sample represents a specific MFT characterized essentially by biotic composition. The spotty and peloidal texture of the matrix indicates microbial controls. Other Late Jurassic sponge limestones may differ from the sample shown in growth forms of the sponges, the absence of microbial crusts, or matrix texture. These differences define specific MFTs that reflect differences in ecological and depositional constraints. Some criteria are of minor or no relevance for the characterization of the MFT. The existence of brachiopods (figure center) should be taken into consideration if the group is a conspicuous constituent of the limestone. Fracturing and differential compaction are not diagnostic criteria for definition of the MFT.

Plate 88 exhibits Cretaceous limestones with rudists. The term rudist limestone would be too general for establishing a defined MFT because different rudist groups prefer different habitats and environments and occur in different depositional settings. The definition of a MFT must take into consideration the major taxonomic groups (which can be recognized in thin section by specific microstructural patterns), their diversity (e.g. mono- or multispecific) and their association with other biota. Evaluation of diversity may be difficult or misleading on microfacies scale for this reef limestone, as well as for other reef carbonates, without knowledge of outcrop and field data.

Many reef limestones require a two-fold typification as demonstrated by the Figs. 11.1 (sample A) and 11.2 (sample B) which show Late Triassic coral lime-