1 Introduction to Facies Analysis

“Every facies of a deposition shows well-defined petrographic, geognostic and paleontological properties which can be clearly differentiated from the properties of other facies in the same geological period.” The necessity for interdisciplinary studies is clearly expressed in this definition given by Amanz Gressly in 1838. In facies analysis paleontological, sedimentological, geological, and geochemical data provide the basic information about the sedimentary environment, the lithogenesis, and the biotopes of organisms preserved as fossils.

1.1 The Microfacies Concept

A. Name: The term “microfacies” was suggested by Brown (1943: 325): “In thin section the rock is seen to be composed of . . . microfacies.” In other words, microfacies refers to the criteria appearing in thin-sections under the microscope.

The various objections raised to the term microfacies have not gained a foothold: Calkins (1943 – a “microfacies” must be counterbalanced with a “megafacies”); Campbell (1944 – instead of “microfacies,” simply “under the microscope”); Alling (1945 – “microfacies” is difficult to define, therefore preferably “microlithology” as a result of quantitative microscopic studies).

Apparently without any knowledge of Brown’s suggestion, Cuvillier (1952, 1958, 1961) re-introduced the name microfacies to characterize paleontological and petrographic criteria in thin-sections. The International Sedimentary Petrographical Series, which first appeared, upon the request of Cuvillier, at the Third International World Petroleum Conference in Paris in 1951, contributed substantially to the rapid adoption of the term microfacies. The distinction between micro-lithofacies and micro-biofacies called for by Fairbridge (1954) has gained little support.

B. Definition: Microfacies is the total of all the paleontological and sedimentological criteria which can be classified in thin-sections, peels, and polished slabs.

C. Discussion: This definition assumes the following:
   a. Study of thin-sections, peels, and polished slabs at magnifications of up to approximately ×200.
   b. Equal consideration of paleontological and sedimentary criteria.
   c. Classification of data, taking into account the qualitative and quantitative criteria (e.g., organic associations, limestone classification, and modal composition).

E. Flügel, Microfacies Analysis of Limestones
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d. Testing of microfacies classifications by comparison with geological field data, paleoecological interpretations and, perhaps, geochemical criteria.

e. Application of small-scale observations to larger dimensions (outcrop: meter to kilometer range). The methodological relationship between thin-sections and outcrop areas comes from the use of limestone classifications based on textural and structural criteria (Dunham, 1962; see 6.2.2) and from the statistical evaluation of data (see 7.3). The definition presented here signifies a methodological refinement of Gressly's classical facies concept (see Teichert, 1958; Franke, 1963; Lützner et al., 1974). Because microfacies takes into consideration biological as well as lithological criteria, the arguments presented by W. Schäfer (1962: 546) opposing a “microbiofacies” (third order biofacies) do not seem to be applicable.

D. Development of the concept: Even the earliest thin-section studies of carbonates aimed for genetic interpretations (Sorby, 1879; Bornemann, 1886) as well as for stratigraphic evaluation and ecological interpretations of fossils (Gümbel, 1873). Probably the oldest microfacies studies originated from K. Peters at the University of Graz, Austria, where in 1863 he published a paper entitled Uber Foraminiferen im Dachsteinkalk (Foraminifera in Dachstein limestone); here thin-sections were evaluated to clarify paleoecological and paleogeographical questions. Hovelacque and Kilian (1900) published the first illustrated volume of thin-section photographs. The practical application of limestone structures in thin-sections was demonstrated by Udden and Waite (1927) for oil exploration in the Pennsylvanian of Texas.

Microscopic studies of carbonates were given substantial impetus by Bruno Sander (1936 – description of the depositional fabric; English translation 1951) and by Julius Pia (1933), who presented one of the first comprehensive general surveys of the Recent carbonates.

As illustrated in Fig. 1 by the Alpine Triassic, microfacies studies coupled with sedimentological and paleontological objectives did not begin in earnest until the 1960s. The rapid advances made in microfacies since then are a result of: (1) the exploration for oil in carbonate rocks (approximately 50% of the world's crude oil production); (2) creation of useful limestone classifications (Folk, 1959; Ham, 1962); and (3) paleontological problems (e.g., paleoecology of fossil reefs, biostratigraphy of “monotonous” limestone series by means of fossils in thin-sections). At the moment an increasing number of papers is available in which the multitude of microfacies criteria are compiled and interpreted in the form of “facies models” (J. L. Wilson, 1975, see Sects. 8 and 10). In addition, there are studies on the submicroscopic criteria of carbonate rocks (ultra-facies), on the possibilities offered by multivariate facies analyses, and on the mutual relationships between microfacies criteria and technological properties (see Sect. 9.2.3).

E. Divergent definitions: Gübler et al. (1967: 55) defined a “primary microfacies” on the basis of criteria observable in a sedimentation unit (= a rock lamina whose thickness does not exceed the largest diameter of the largest particle). According to this, the term is restricted to criteria which are determined in thin-sections parallel