NEW TRENDS IN MICROPALAEONTOLOGY AND PETROLEUM EXPLORATION

M. F. GLAESSNER

University of Adelaide, Australia

ABSTRACT.—The most significant recent trends in micropalaeontological studies seem to be (1) the wide practical application of morphogenetic series in preference to arbitrarily selected purely empiric index Foraminifera ; (2) the investigation of facies—time relations as expressed in what has been termed "microfacies" in various areas, and the tracing of biostratigraphic time planes across changing facies ; and (3) the growth of palynology and palaeo-protistology as integrated fields of micropalaeontology. These trends are not, as they might seem to be, unconnected and autonomous developments, without direct relations to petroleum geology.

THE growth of micropalaeontology to its present position as one of the most active and important branches of palaeontology is closely linked with its undisputed value in petroleum exploration. Some new trends which distinguish its main present activities from those of 1945 reflect, therefore, the changing approach to oil finding.

Before attempting to produce proof of this view which is based on a personal study of micropalaeontology in parts of Europe and some other areas, some explanations concerning these trends are required. Some investigations are mentioned as illustrations but no judgment of the scientific or practical value of others is implied. No bibliographic references are given as they can be easily found in current bibliographies of micropalaeontology.

The *morphogenetic* method of foraminiferal studies was firmly established 25 years ago by the late Dr. Tan Sin Hok. It is now widely applied and had conspicuous success in the study of the rise and evolution of *Globotruncana* and *Miogypsina* which occurred in stages. In some instances mathematical definition has been attempted, in others it is impracticable. Many gaps in our knowledge have yet to be filled but the almost world-wide occurrence of stages in the evolution of certain characters (bioseries) has been definitely proved. The same method is now leading to the establishment of similar series in *Orbitoides*, *Nummulites*, *Assilina* and *Heterostegina* among the larger and *Neoflabellina*, *Bolivinoides* and *Uvigerina* among the smaller foraminifera, together with many others. The basic material for these studies has been carefully collected from stratigraphically well-placed localities so that the conclusions based on them can be used with confidence and compared with other biostratigraphic data.

This method also requires a profound understanding of the *morphology* of the foraminiferal test. The work of Reichel and his school has been outstanding in this respect. At the same time Hofker has made stimulating observations on the detailed structures of the smaller foraminifera. The discussion on many morphological characters to which he has drawn attention, such as toothplates, foramina and perforations, is proceeding. It is opening the way to the firm establishment of further morphogenetic series, which requires a full understanding, clear description, unequivocal documentation, and where possible quantitative analysis of morphological characters of successive populations.

The problem of *facies variations* between contemporaneous stratigraphic units continues to attract the micro-palaeontologists'

attention. Two recent contributions may be mentioned. One is a lexicography of microfossiliferous rocks of different ages from various sedimentary basins. It was initiated by Cuvillier, Schurmann and others and named, somewhat unfortunately, "microfacies study". These studies demonstrate by means of microphotographs of thin sections the existence of distinctive assemblages of microfossils in indurated rocks, some of which consist almost exclusively of such fossils. They are either similar though differing in age (*e.g.*, miliolid or *Operculina* limestones) or contemporaneous and strikingly similar but formed in widely distant areas (*e.g.*, *Globotruncana* or *Alveolina* limestones), or they illustrate the already well known facies differences of contemporaneous deposits of single sedimentary basins. Much unanalysed documentary material is thus being assembled which, although primarily intended as an aid to the recognition of microfossiliferous rock types in thin section, will eventually provide valuable material for later comparative studies of the distribution of facies types in time and space.

Another approach to the facies problem is the recognition of time-marking biostratigraphic horizons within diverse associated facies, *e.g.*, the appearance of the earliest Tertiary *Globorotalia* (currently but probably incorrectly designated as *Truncorotalia*), or of certain *Globotruncana* or *Globoquadrina* in different rocks throughout sedimentary basins or provinces. The important point here is the actual proof of the contemporaneous occurrence of the fossil in rocks of different adjoining facies. The placing of these horizons of first occurrence in terms of conventional units of the standard stratigraphic scale may still be problematic, as for example the placing of the first *Globorotalia* in relation to the conventional units Danian or Paleocene. The discussion on the earliest occurrence of *Orbulina* which was first proposed by Le Roy as a universal time marker for different rocks with pelagic fossils is still in progress. Though pelagic fossils may be expected to spread more rapidly over wider areas, they are by no means infallibly world-wide as they depend on temperature and other ecological factors which affect them particularly markedly at times of intense diversification of the pelagial by currents and climate.

As recently as a decade ago, *palynology* was considered a field for specialists, with only limited application to the practical problems of petroleum exploration. Today, we find it integrated with the work of many commercial or official survey laboratories. In addition to spores and pollen, other non-foraminiferal small microfossils such as dinoflagellates and hystrichospherids, tintinnids and discoasters and possibly even coccoliths, are now emerging from the field of pioneer "academic" researches to become increasingly common objects of micropalaeontological studies in what may be termed the new field of *palaeo-protistology*. The methods of palynology have now become more or less standardized. Those of palaeo-protistology have to be somewhat more refined as its objects are as a rule almost or altogether invisible to the naked eye and high-power microscopes, often of the phase contrast type, are required, with appropriate handling and recording devices, and occasional use of the electron microscope. Microphotography of these small objects is, however, often less problematical than that of foraminifera.

These trends in modern micropalaeontology seem at first glance quite unrelated with each other and with petroleum exploration. Actually they represent different responses to the current needs of oil exploration which has entered a new phase. Micropalaeontology served originally exclusively as a method of stratigraphic correlation, local (between the wells of an oil field), regional (between the fields of a province), or inter-regional (which includes age determination of the rocks). The obvious oil traps having been found, exploration has now turned to a more profound study in which micro-palaeontology is able to play a more substantial and essential part. The fundamental concept in the search for oil is today the *sedimentary basin*, and the formation and concentration of oil is considered as part of the history of sedimentary basins. The micropalaeontologist often holds the key to the explanation of field and subsurface observations in terms of chronology, ecology, and diastrophism of the sediments filling the basin. The morphogenetic stages of foraminiferal evolutionary series provide exact timing and can also indicate diastrophic breaks in apparently continuous sequ-

ences. Facies studies relate to each other the different rock complexes which make up the filling of each basin. Not only source, reservoir and cover rocks but also wedge belts of porosity, the nature of thickness changes and other phenomena related to facies are being studied by the petroleum geologist in their distribution in time and space. Palynology and palaeo-protistology extend palaeontological work into areas of seemingly unfossiliferous and stratigraphically intractable paralic (interbedded marine and nonmarine) and continental rocks which make up very large portions of sedimentary basins and in which much oil is yet to be found. A. I. Levorsen stated in the introduction to his "Geology of Petroleum" (San Francisco 1954, p. vi) "What in my opinion aids most in the discovery of new oil and gas pools or in the extension of old ones is an understanding of the geologic history of an area—its stratigraphy, its sedimentation, its deformation, and especially its fluid phenomena". Leaving the fluid phenomena to the petroleum engineer's attention, the micropalaeontologists have indeed in recent years turned their efforts to those investigations which will assist most in the modern approach to oil finding.