ECONOMIC USE OF PALAEONTOLOGY WITH SPECIAL REFERENCE TO THE OIL INDUSTRY

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ABSTRACT—Economic applications of palaeontology have found their greatest development in the exploratory work of the oil industry. Micropalaeontology especially has been widely used as a basis of correlation between outcrop sections and the sequence revealed in wells drilled in the search for new oilfields. The smaller foraminifera have been most useful, but ostracods and some other groups are sometimes helpful. Techniques have been described for extraction and study of micro-fossils, and the results are most conveniently shown by range tables.

INTRODUCTION

For a long time after William Smith first established the principle that fossils can be used as a basis of correlation, palaeontology, although accepted as an important branch of geology, did not find much direct application by geologists working in the economic field. The economic geologist was of course profiting by the palaeontological work of the various national geological surveys, by the researches of academic geologists, and by the extremely valuable work of many enthusiastic amateurs, but it was not until the development of oil geology that economic palaeontology became of importance. In India outside the oil companies very little palaeontological work of direct economic importance has been done.

The oil industry is constantly concerned with the search for new oilfields ; oil wells do not maintain their initial productivity, and the steadily falling output necessitates constant drilling of new wells until the oil-field is fully developed, after which the output of the oilfield itself rapidly declines. Without the discovery of new oilfields it would be quite impossible to provide even the world's present requirements of oil, quite apart from meeting any increase there may be in the future.

The discovery of new oilfields depends on the work of the geologist and geophysicist. They must make their plans on a basis of studies of regional geology, so as to ensure that the campaign of exploration thoroughly covers the oil possibilities, and in this regional study palaeontology must play an important part. After making these regional studies, the oil geologist decides where it would be best to drill test wells to find out whether the apparently favourable areas do in fact contain oil in commercial quantity or whether they are barren or productive of only traces of oil.

It is not however the help given in regional studies that especially connects palaeontology with oil exploration. Many other regional studies, not necessarily directed towards economic ends, must equally make use of palaeontological evidence. Where palaeontology has a special part to play in the oil industry is in helping to solve problems of detailed correlation, especially between the sequences found in test wells and those studied at the outcrops. It may also be of great use in finding the correlation between test wells drilled many miles part. Furthermore, there may be scope for the use of palaeontology in correlating from one well to another within a single oilfield, but evidence for this kind of correlation is more usually provided by geophysical methods, especially the measurement of the electrical characteristics of the beds drilled through. This electrical logging has proved a much more delicate tool or correlations within the oil-fields.

The oil industry is the one which, on its exploration side, is making the fullest use of palaeontological knowledge, and it is also the one which by so doing has contributed most to our present knowledge of palaeontology. Certain groups of organisms have been shown to be much better than others, both in their reliability as a basis of correlation and in the ease with which they can be utilized. The groups which have been most successfully used in economic work are foraminifera, ostracods, spores, pollen, and conodonts. In coalfield work marine bands have in many cases, proved helpful, correlation being based on the presence of distinctive lamellibranchs. Some groups, such as ammonites and echinoids, which have been of great value in zoning outcrops, have proved of much less value in bore-holes because of the comparative infrequency of good specimens.

WORK ON FORAMINIFERA

Within the oil industry the foraminifera have received the greatest attention from palaeontologists, and of the foraminifera it is the smaller forms which in general have proved most useful; so much so, that micropalaeontology has become a recognised branch of oil geology. Fossil foraminifera have been known for almost twenty-five centuries : some occur near the Egyptian pyramids and one of the early ideas was that they were petrified food akin to *dhal* that had been dropped by the workmen who built the pyramids. The Swiss naturalist, Conrad Gesner, included foraminifera in his palaeontological work of four hundred years ago, and since then they have from time to time attracted the attention of scientists. Little serious work was possible before the advent of the microscope, and indeed t was not until d'Orbigny's time, a hundredi years ago, that the foraminifera were studied in detail, and it was still later when the word micropalaeontology appeared in print.

Foraminifera were used to determine the age of rock cuttings brought up from a well as far back as 1877, but their regular use is little more than 30 years old. One of the pioneers of this work was Professor J. A. Cushman who in 1925 established the first periodical for publishing the results of micropalaeontological work. Since then the studies of foraminifera have increased rapidly until the oil companies are now employing over 2,000 palaeontologists on foraminiferal work alone.

The smaller species of foraminifera tend to have a wider dispersal than the larger species; there are some pelagic forms (e.g. *Globotruncana*) with a limited vertical range which are known from many areas in both hemispheres and consequently have become the basis of an almost world-wide correlation. The larger foraminifera, although more restricted in their occurrence and tending to show a greater degree of variation, have their counterparts in such wide correlations. The Fusulinids in the Permo-Carboniferous marine facies, the Orbitoides and related genera in the Upper Cretaceous, and certain types of Nummulites in the Eocene and Oligocene are well known from Europe across the Mediterranean and through the Middle Eastern countries, and India, Burma, and Indonesia, as far as Japan. Similar forms are known in the Americas too.

Investigations now in progress are yielding information about the relation of living foraminiferal populations to present-day marine conditions, and a better understanding of the dependence of foraminifera on the type of bottom, and on the salinity, depth, and temperature of water should considerably assist in interpreting fossil faunal assemblages. It is important to be able to distinguish more certainly between the time and facies elements in microfaunas ; the planktonic forms are less affected by the facies changes than are the bottom-living forms. A new line of inquiry which seems to be of some promise in correlation is the determination of the proportion of right and left-coiled forms in certain pelagic Rotalids.

MICROPALAEOBOTANY

The study of fossil spores and pollen now being carried out in various parts of the world has shown much promise and this new branch—now known as palynology—may well prove an important supplement to the evidence from foraminifera, especially in the sphere of economic palaeontology. Work on the use of plant fragments, spores, and pollen as applied to correlation is as yet in an early stage, but may well come to occupy an important place in applied palaeontology in India, not only in the coal industry, but also in the oil industry. Before this becomes possible it is likely that a great deal of fundamental work will be needed, as very little is known about the background against which individual problems must be viewed.

It is hoped that the extensive researches now being carried out in various centres in India (Birbal Sahni Institute of Palaeobotany, Geological Survey of India, and Bose Institute) will considerably assist in achieving this object.

TECHNIQUE OF MICROPALAEONTOLOGY

With progressively greater application of micropalaeontology to economic work, special techniques have naturally been developed for separating the smaller foraminifera from the rock. Though the division into smaller and larger foraminifera is purely arbitrary, it was designed for convenience of study arising out of the difference in the methods of preparation of specimens for examination.

The methods used in the palaeontological laboratory of the Assam Oil Company Ltd. at Digboi may be of interest to other workers in the subject. The softer rocks are the most likely to yield a rich suite of microfossils suitable for study, satisfactory extraction from hard rock being difficult and often impossible.

After extracting large foraminifera and other fossils, 50 to 200 grams of the sample, depending on what is available, is soaked in water for a few hours. If the rock disintegrates easily it is boiled for about ½ to 1 hour with a little detergent. Often this treatment is found sufficient to free the microforaminifera from small particles sticking on to the surface and to give clean specimens. Harder rocks may need a longer period of soaking and the addition of commercial sodium carbonate or even caustic soda while boiling. With gypseous shales, boiling with an excess of common salt is found useful in removing the encrustation on the fossils.

After boiling, the material is sieved through a bank of two sieves—100 and 200 mesh. This operation is carried out with a jet of water directed over the sieve and all the time the disintegrated material is gently rubbed against the metal sides. The fine silt passing through the 200 mesh is thrown away, not because there will be no fossils in this grade, but because the process of examining and determining the extremely small foraminifera present in this grade is time-consuming and laborious and therefore uneconomical.

Harder rocks such as hard marls and limestones are crushed between the jaws of a vice and when sufficient material is collected the same treatment as for softer rocks is followed. By this method the yield of microfossils is by no means large but some may be released, which is surely better than nothing at all !

RANGE TABLES

The foraminifera present in the material collected on the two sieves are hand-picked under a stereoscopic microscope and are transferred on to special slides. These slides are then examined and the various species recorded with an indication of their abundance. Distinction is made between occurrence of single individuals of a species, of 2-5 individuals, of 6-20 individuals, and of over 20; whenever flood occurrences are present in the latter category they are recorded separately. The results are then plotted on a range table. In the working range table the genera are set out in alphabetical order across the table, the stratigraphical sequence being drawn vertically. Each occurrence is represented by a symbol indicating the abundance of individuals. In this way the micropalaeontological evidence from a well or from a series of natural exposures can be shown compactly. For comparison with other areas it is convenient to re-draw the range table, grouping together species with approximately the same ranges, and preferably indicating the range by a vertical band of distinctive colour.

In material from surface sections equal attention may be given to the first and last appearances of a species, but if the samples are from a well the highest occurrence of a fossil is the important point, as lower samples may be contaminated by material from higher up the bore-hole. Contamination is especially likely when the material comes from cuttings brought up in the mud flush and not from cores. Range tables prepared from cuttings are consequently of far more value in showing the horizon at which a species becomes locally extinct than in showing its first arrival in the area. It has to be remembered that the "first appearance" in well samples is chronologically the "last appearance" of the fossil.

Once a range table has been prepared for a long sequence of beds in an area it is used as the basis of comparison; the oil geologist endeavours to have a reliable range table for the region in which test wells are being drilled so that, as samples become available, their content of microforaminifera may be compared with the assemblages of the range table and correlation established with the minimum of delay.

The evidence from the larger foraminifera and from other macro-fossils is recorded in the same way, either on the range table used for micro-fossils or separately, as may be most convenient. The range table has shown itself to be by far the best method of setting out palaeontological evidence from a number of sections, and has been widely employed in the work done by the palaeontologists of the Assam Oil Company and associated companies.