THE USE OF THE MICROSCOPE IN THE STUDY OF SUBSURFACE STRATIGRAPHY

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For many years paleontology and lithology have been the bases for correlation of sedimentary rocks, but up to comparatively recent years only the grosser characteristics have been made use of for this purpose. It has also been customary to study the cuttings from wells for many years, but again it is only of late, with the stimulation of interest in the field of sedimentation, that a really critical examination of the lithology of cuttings has been at all extensively undertaken. With the closer study of the lithology of rocks has come either contemporaneously, or as a result thereof, the closer study of the minute or microscopic fossils.

The microscopic study of sediments, as has been implied, may be divided into two general classes, lithological and paleontological. The first concerns itself with the state of aggregation of a rock and the constituent minerals forming the aggregate. That is, it deals with the mineral composition of rocks, the size and shape of the mineral grains, the nature of the cementing material, and in some cases, with the chemical composition. If the rock is crystalline the nature of this phenomenon is also considered. Various methods are employed to determine these data, but at present the two most common modes of examination consist in the study of rock powders and of thin sections. The first, as the name implies, consists in the examination of the rock either as an artificially produced or natural powder. As the cuttings from wells drilled with a churn drill are commonly broken up rather finely, this method of study is especially applicable in such cases.

This detailed study of lithology has been used very satisfactorily in the case of well cuttings for separating one formation from another, as follows: Estimates are made of the percentages of sandstone, shale, and limestone in the various samples under a microscope, and these percentages are then plotted as a composite or synthetic log. The formational changes are shown by an abrupt increase or decrease of one or more of the three major sediments, the sandstone, limestone, or shale.

The second method of study, that of thin sectioning, gives more exact details than the first, and in the case of consolidated rocks, such as limestones and sandstones or unpulverized samples, is often the more satisfactory. It necessitates the making of a thin section which involves the expenditure of some little time but affords a detailed knowledge of the crystalline structure and mineralogical character of the specimen examined.

In the study of the paleontology of sediments with a microscope, the procedure consists in the examination of the rock as small fragments or thin sections. If the rock to be studied is a shale, it is soaked in water and washed under a strong stream of water until the fine shale particles have been removed and only the larger and heavier fragments of calcareous or siliceous material remain. This residue contains whatever minutia or small fossils the original shale contained. It is dried, sieved to various sizes, and examined under the binocular microscope.

Limestones, particularly shaly limestones, are treated in a somewhat similar fashion. They are soaked in water, then very carefully granulated with particular care that none of the finer chips be lost. The resulting fragments and powder are dried, sieved, and also examined under the binocular microscope.

As previously stated, this method is satisfactory with shales or shaly limestones, or even granular limestones, but its use with dense, fine-grained limestones is rather doubtfully successful. In studying this last kind of rock it may be necessary to resort to thin sections and from them determine, if possible, what diagnostic life forms the rock contains. If the fossils in the limestones are silicified, however, very satisfactory results can be obtained in some cases by breaking the specimen into small pieces and allowing them to etch in dilute hydrochloric acid. The etching removes the calcium carbonate and leaves behind whatever siliceous or argillaceous material was contained in the rock. In this residue the silicified minutia are found if present.

The minute fauna that is found in limestones and shales of different ages are varied. The unique character of some of these forms led earlier workers to consider them diagnostic of specific beds. As the evidence accumulates, however, it becomes apparent that only in rare instances is a single form diagnostic of a certain bed, and that rather an association of forms is the better diagnostic evidence. The search for horizon markers has been extensive and even skeletal parts have been made use of, not as wholly diagnostic in themselves, but as corroborative evidence.

Diminutive species of larger forms, such as brachiopods and pelecypods, are not uncommonly met with in the microscopic study of sediments. The forms which are more novel, however, and are receiving more attention at present, may be mentioned briefly.

Ostracods:—small crustaceans with a bivalved shell.

Foraminifera:—small protozoans with a skeleton of calcium carbonate. The tests are of varied design, some being coin-shaped, some like a grain of wheat, and others composed of a series of globular chambers arranged in regular or irregular patterns.

Bryozoa:—colonial or encrusting molluscoidea, some of which possess skeletons with intricately developed lace-like patterns.

Diatoms:—very small one-celled plants, with siliceous cell walls. These forms are not known in any of the Illinois rocks.

Other less common remains than those mentioned above, but forms which in combination with others are in cases of diagnostic significance, are sponge spicules, Echinois spines, Productus spines, worm casts, anelid jaws, and fish teeth.

The geological usefulness of this sort of work is appreciated readily when it is considered that in many places the bed rock is concealed beneath a covering of later sediments, wind-blown material, or glacial drift, and it is therefore impossible to determine its nature. The bed rock may come to the surface at some distant place and an examination of the outcrops be possible there, but in some cases the beds at the outcrop are so different from those which are concealed that what is true of them at one place is not true at the other. It is obvious that only a detailed, careful, and extensive study of the cuttings from wells drilled in such covered areas will enable the geologist to know the formations underground. The geologist desires to know, however, not only what the formations underground are like, but also what their structure is, whether they are flat-lying or folded. Where it is possible, the structure may be determined from a key bed of some particular sort which is encountered in the wells. In case there are no such beds, however, it is necessary to rely on some other means of identifying beds other than by gross lithological similarity. This is where the microscope finds its usefulness, and with its aid an attempt is made to determine what characteristics, either lithological or paleontological, can be used to identify certain horizons from which the structure of the beds may be interpreted.

Aside from the purely scientific value of the information obtained bearing on the subsurface structure of beds, a practical worth is apparent. Oil and gas are found associated with certain rock structures, and in the scientific prospecting for oil and gas and the successful exploitation of known deposits, it is desirable to know the structure of the rock from which the oil or gas is obtained. If the microscopic study of sediments, either lithological or paleontological, aids in securing such data, it renders a valuable service.

The study of cuttings, however, particularly the lithologic study, is not confined to the identification of beds of like stratigraphic position. The increase in the amount of sand in a shale formation from well to well may indicate the approach to an old shore line, where sand lenses, possible oil reservoirs, may be expected. Of a somewhat different nature are the determinations of porosity and the state of aggregation of oil- and water-bearing sands, which have, in cases at least, had a definite bearing on successful and maximum oil production.

In the oil fields of the southwestern part of the United States the microscopic study of cuttings has been found to be of great value in determining many of the above factors. The large oil companies have established laboratories and employ men to study the cuttings not only after they have been brought to the laboratory, but also to collect and in some cases study them as they come out of the wells. It is of interest to note that perhaps the greatest impetus has been given to this work by commercial enterprises. It seems to be a paying proposition with them on a dollar and cents basis.

The problem which presents itself in Illinois and the need for microscopic study are understood readily when it is considered that the bed rock of at least two-thirds of the State is obscured by glacial drift or loess, and the determination of structure is therefore very difficult and unsatisfactory. The rocks that do outcrop occur along the margins of the State, along the Mississippi and Ohio rivers and the adjoining territory, and in the northern part of the State along the larger streams and in artificial exposures. In some cases these beds continue into the central part of the State with the same lithological characters they display at the outcrop, but in others they change very markedly, due to differences in position with reference to the shore lines of the seas in which they were deposited. One group of rocks in particular, which outcrops in the southern part of the State, exhibits this phenomenon. This is the Chester group, one of the important oil-producing groups of rocks in Illinois. In outcrop, the sequence of the Chester formation has been well established, but as the rocks pass to the north and into the central part of the State they become covered and also change markedly. In this central area key beds are not numerous, and such phases as red rocks and colored shales are used for the lack of better evidence on which to base correlations.

It is obviously impossible to use the same large fossils in identifying the cuttings from wells that it is possible to use in identifying the beds at the outcrop, but it may be possible to identify in the cuttings from wells the same small fossils which may be used to identify the beds at the outcrop. With this in mind approximately 1,800 samples of the Chester rocks have been obtained very carefully from typical outcrops. These samples were taken from every different layer of the exposure being sampled, and in some cases this has meant a sample every six inches or less. The samples of the limestones were blocks about 3 by 6 by 1 inches, and in case of the shales, sufficient fragments to make up a corresponding amount.

The microscopic study of Illinois sediments is just beginning. The washing of shales has been tried with both satisfactory and unsatisfactory results. The sandy shales of the Chester formations seem to be practically barren of minutia and so do also some of the dense siliceous limestones. On the other hand granulated samples of some of the coarser grained, more fossiliferous limestones have yielded a number of small forms which, though they have not been and may not be established as diagnostic, at least hold out a hope for such results with further work. Up to the present time the thin sections made are mainly from the lower Chester formations, and it is quite possible that some of the bryozoa and foraminifera which appear therein may prove later to be diagnostic of these formations.

As yet no definite course has been pursued with reference to the detailed study of the lithologic characteristics of the samples. This feature is so variable from place to place in many of the formations that at the present time its use for "long distance" correlation is looked upon as corroborative rather than determinative.

The amount of work done on the minutia of the Paleozoic rocks such as are being studied here in Illinois is not so extensive as that devoted to the younger and less consolidated sediments. However, the fact that so much of the bed rock of the State is obscured by drift rather urges an attempt to make use of all possible means of subsurface correlation, and it is hoped that the future work will show results as worth while as those from the younger formations.