The Microstructure of Coal.

A VALUABLE and original paper on the economic selection of coal was contributed at the autumn meeting of the Iron and Steel Institute by Mr. A. L. Booth. The method usually adopted is to carry out a proximate chemical analysis, which at the best is very unsatisfactory and of little real use, to collate the results with practical experience, and to make a trial on some particular plant. Only too often it proves to be unsatisfactory, and trouble arises from the fact that two coals can have practically the same appearance and give the same analysis, and yet be totally different in behaviour. This occurs quite frequently, and does not seem to be realised by fuel-users generally. Sir W. G. Armstrong, Whitworth, and Co.'s works, with which Mr. Booth is connected, use some 250,000 tons of coal per annum for different purposes, and it was the unsatisfactory nature of chemical methods of classification which led to experiments being made with the microscope to ascertain whether a more trustworthy method could not be devised. The method adopted was as follows:

Sections were cut of a large number of typical pieces of coal from different sources. Some had been proved over a period of years to be suited to a particular class of work, while others had proved unsatisfactory for the same class of work. All were carefully examined under the microscope. It was soon seen that there were three main types, and that each type was suitable for certain classes of work. Further investigation rendered it possible to decide how far a departure from the typical member could be made without getting into difficulties.

The method of cutting sections is similar to that used in making rock sections, but is considerably more difficult and requires more patience. A piece of coal is selected and, if soft and cracked, treated with a transparent, colourless binder. One side of the coal is then ground down, using carborundum powders of finer and finer grades, finishing off with a water of Ayr stone. The result should be a smooth, flat face. The coal is then mounted in Canada balsam on a piece of glass, the face being well pressed against it. When the balsam is set, a slice of coal is cut off and ground down until it transmits light.

In his paper Mr. Booth considers only coals in commercial use in this country, and these fall into three main types: (1) "Humic," composed of leaves, stems, and broken-down woody tissue, together with some spores. (2) "Spore" coals, in which both "micro-" and "mega-" spores predominate. (3) Cannel coals.

The spores are the reproductive organs of the plants, and correspond with the pollen and ovules in present-day flowering plants. The micro-spores are very small, while some of the mega-spores are about $\frac{1}{8}$ in. in diameter. The cannel coals contain small, round, yellow bodies. It will be realised, of course, that these three classes merge into one another. Humic coals occur containing more and more spores, while spore coals become more cannellised as the yellow bodies merge with the spores. This is where microscopic work is necessary to enable a decision to be made as to what a particular sample of coal can be used for. The author shows sixteen coloured photomicrographs of thin sections of specimens of the three main types at magnifications varying from 50 to 560 diameters.

So far as the main economic uses of coal are concerned, the study of their microscopic structure has resulted in the following conclusions:

For steam-raising, humic coals which contain a fair proportion of spores are the most suitable. These coals coke fairly well, and give a good, hot fire without too long a flame. For town-gas manufacture humic coals are also suitable, and for this purpose those which swell on heating and burn with a long flame are the best. They give a good yield of gas and by-products. Some humic coals containing much yellow substance constitute the best coking coals, and should be reserved for that purpose.

For producer-gas work the spore coals are necessary. The best coals for non-recovery producers are those which have been partially cannellised. They do not soften, the coke is very fragile, and the fixed carbon is very high. This is a necessary feature in producer practice. If the ash is not very fusible it is possible to work these coals with a low blast saturation, and thus get a dry gas with a high carbon monoxide content, the flame of which has a higher radiating power than the hydrogen flame. In recovery work, coal containing more humic matter may be used, because here a primary low-temperature distillation takes place, and through the high saturation of the blast the tendency to swell is checked.

For direct-fired furnaces (*e.g.* reheating and reverberatory) the hard coals are used. These are almost true cannels, and are usually dull-looking. They are free-burning, having no tendency to coke, and unless iron be present through infiltration it is difficult to fuse the ash.

The microscope has not only been found helpful in the selection of coals, but in some cases it is also of use in deciding whether or no it would pay to wash them, and will explain why an apparently good and clean coal has, for instance, a high ash-content. In such a case a washing may be quite useless. In the event of a shortage of a particular class of fuel the more detailed knowledge of coal which the microscopic study gives will enable the best substitutes to be used; and to obtain satisfactory working with the substitute, any necessary alterations in the running of a plant can be made without waiting for adverse effects to develop.

The author states in conclusion that coal from the same seam is generally very uniform, and mentions that sections cut from a given seam, but delivered on dates twelve years apart, showed that the coal is of the same type. As he says, perhaps one day it will be possible to buy coal to specification as we now buy steel.

Mr. Booth's paper is very timely, and indicates what a considerable saving could be made if the present output of coal were scientifically utilised in the manner indicated.

The Cretaceous-Tertiary Boundary in North America.[1]

By PROF. A. C. SEWARD, F.R.S.

ONE of the most difficult problems with which American geologists and palæontologists are confronted is the correlation of the Later Cretaceous and Lower Tertiary strata in the different regions of the United States. The Professional Paper by Messrs. Lee and Knowlton is concerned with some of the Cretaceous and Tertiary rocks in the Rocky Mountains region of Colorado and New Mexico. A considerable area in the interior of North America was occupied by a Cretaceous sea, and it was part of this area which was afterwards uplifted as the Rocky Moun-

[1] Department of the Interior, United States Geological Survey. Professional Paper No. 101: "Geology and Palæontology of the Raton Mesa and other Regions in Colorado and New Mexico." By Willis T. Lee and F. H. Knowlton.

tains chain. This crust-folding was followed by the deposition of plant-bearing Tertiary strata. The Raton Mesa region is rich in coal-bearing beds containing a large number of flowering plants, with a few twigs of conifers and fragments of sterile fern-fronds. The flowering plants are, unfortunately, represented almost exclusively by detached leaves.

Different views have been held on the geological age of these sediments. Lesquereux referred them to the Tertiary period, and later geologists regarded them as Cretaceous. The evidence now brought forward points to the occurrence of two distinct formations, the Vermejo formation below separated by a well-marked unconformity from the overlying Raton formation. It is believed that this unconformity marks the boundary between the Cretaceous and Tertiary systems in Colorado and New Mexico. In the interval represented by the unconformity there was widespread erosion of the uplifted floor of the Cretaceous sea before the deposition of the Lower Tertiary Raton formation.

From a geological point of view the conclusions based on a considerable mass of information are of great interest as a contribution towards a more precise determination of the Cretaceous-Tertiary boundary. Both the Vermejo and Raton formations are rich in fossil plants, Dicotyledons being the most abundant in each flora; the Vermejo flora is correlated with the Montana flora, while the Raton flora is believed to be Eocene. A noteworthy feature of the Raton flora is the inclusion of some exceptionally fine specimens of palm-leaves, but, as Mr. Knowlton states, it is impossible to refer most of them to a definite position on leaf-characters only.

The palæobotanical portion of the volume is well illustrated and the specimens are concisely described. It is, however, unfortunate that little attempt is made to compare the plants with species other than American. The application of the names of recent genera to many of the specimens, though in accordance with a common practice, suggests a lack of appreciation of the difficulties of systematic work when leaves only are available. In many cases it is clearly impossible to accept the generic determinations of both fern fragments and dicotyledonous leaves without hesitation. Mr. Knowlton has done good service by rendering available much new material, and the excellent illustrations will enable students of palæogeography to institute comparisons between the American and other types. The absence of conifers in the Raton flora as contrasted with their comparative abundance in the older Vermejo flora is an interesting feature, though it is scarcely safe to assume, as Mr. Knowlton does, that the group was unrepresented in the contemporary vegetation of the district.

The greater part of the volume is devoted to Mr. Lee's extended researches, which include the results of field work in many districts and a very useful correlation of the formations in the Raton Mesa region with those in other parts of the continent.

The investigation of the later Cretaceous and earlier Tertiary floras has acquired a fresh importance in view of the recent work of Mrs. Reid, who is ably carrying on the researches initiated by the late Mr. Clement Reid on the younger Tertiary floras. The recognition of many Chinese types of flowering plants in the Pliocene beds of western Europe, as Mrs. Reid has shown, throws light on the interrelationships of floras that are now widely separated. A critical analysis of the older Tertiary floras in both the Old and the New World should enable us to obtain a deeper insight into the early history of the Angiosperms. One of the difficulties in the way of a comprehensive survey of fossil floras is that of correlation, and it is only by the co-operation of stratigraphical geologists and palæobotanists that this difficulty can be met. American investigators have realised the importance of such collaboration, and their example might with advantage be followed more closely in this country. It may be said that if the accurate determination of fossil leaves, especially those of Angiosperms, is impossible, why attempt it? The answer is that palæobotanists do not, as a rule, sufficiently avail themselves of the assistance of experienced systematists, and are too ready to be satisfied with resemblances based upon characters which are common to several recent genera. Though many fossil leaves referred to recent genera are valueless as accurate data, this is no reason for assuming that greater accuracy in the analyses of floras is unattainable.

Isle of Wight Disease in Hive Bees.[1]

By DR. A. D. IMMS.

ISLE OF WIGHT disease is the most serious menace to apiculture in Great Britain. The prevalence of this complaint and the present high cost of bee appliances and of stocks render it extremely doubtful whether any profit can be derived from the keeping of bees solely for honey production. Many bee-keepers find it more profitable to supply bees and queens, together with the necessary apparatus, and hundreds who take up bee-keeping relinquish it after a short time as being non-productive.

The disease has continued without interruption from about the year 1902 until the present time, and no epidemic of an equally permanent and extensive nature has so far been indisputably recognised outside the British Isles. The first preliminary investigation into its cause was carried out in the Isle of Wight in 1907 by the present writer, who described many of its symptoms, but was unable to discover any protozoa connected with it. In 1912 and 1913 Graham Smith and others put forward the theory that it was due to *Nosema apis*. More recent work by Anderson and Rennie and by Rennie and Harvey indicates that Isle of Wight disease and disease due to Nosema are two distinct complaints exhibiting different symptoms and pathological conditions.

In the first of the papers under review the causal organism of Isle of Wight disease is definitely stated to be a new species of mite, *Tarsonemus Woodi*. This Acarine was found in every one of 110 stocks reported by trustworthy bee-keepers, or certified by the investigators themselves, as suffering from Isle of Wight disease. The investigation involved an examination individually of at least 700 bees, and it was discovered that in every instance where symptoms of Isle of Wight disease were evident the mite was also present. No exception has been found. The parasite occupies

1 "Isle of Wight Disease in Hive Bees." (1) "The Etiology of the Disease." By Dr. J. Rennie, P. B. White, and Elsie I. Harvey (pp. 739-54). (2) "The Pathology of Isle of Wight Disease in Hive Bees." By P. B. White (pp. 756-64). (3) "Isle of Wight Disease in Hive Bees—Experiments on Infection with *Tarsonemus Woodi*, n.sp." By Elsie J. Harvey (pp. 765-67). (4) "Isle of Wight Disease in Hive Bees—Acarine Disease: The Organism Associated with the Disease—*Tarsonemus Woodi*, n.sp." By Dr. J. Rennie (pp. 768-79, pl. 1, fig. 2). Trans. Royal Soc. Edinburgh, vol. lii., part iv., No. 29, 1921.