

26. *On the Rocks of the Essex Drift.* By the Rev. A. W. ROWE, M.A., F.G.S. (Read May 11, 1887.)

THE rocks of the drift in Essex are of such great variety that it is very difficult to get a really representative collection; but I have selected some two hundred specimens out of a much larger number, and these, I think, may fairly be called representative, at any rate of the rocks in the western and north-western parts of Essex. Some of these are chips from large boulders, others are rolled pebbles. I have gathered them from the surface of the land within a radius of about four miles from Felstead, taking them chiefly from the open fields, the lanes, ditches, and bye-roads, and avoiding the main roads for obvious reasons, although no imported road-metal is used in the immediate neighbourhood. A considerable number have been taken out of the Boulder-clay, and some few from the gravel-beds which underlie it. The village of Felstead stands upon high ground overlooking the valley of the Chelmer, about six miles to the north-west of Braintree and just off the highroad between Braintree and Dunmow. The general appearance of this part of Essex is that of a tableland which has been carved out into valleys, with gently sloping rounded hills. On the slopes of these hills there are at all levels, even to the very tops, beds of loamy gravel, alternating with a considerable thickness of stiff yellow loam in some parts, and in others with chalky Boulder-clay, patches of which lie on the tops of the hills and along the upper slopes, sometimes reaching down to a considerable depth, while here and there the London Clay comes to the surface. The way in which the superficial deposits lie was clearly shown a short time ago by a section which had been made in the railway-cutting near Dunmow. Unfortunately this has become covered up again; but at the time it was made a small photograph of it was taken for me by a friend. The section showed that there were between six and seven feet of chalky Boulder-clay, part of which only was uncovered, resting upon a layer of red and yellow laminated clays, a few inches thick, overlying some twelve feet of reddish loamy gravel, consisting of large and small subangular flints, quartzites, quartz-rocks, sandstones, and lumps of hard chalk, these last being very plainly striated. Between the chalky clay and the laminated clays a large block of Jurassic limestone could be seen sticking out, and, upon examination, it was found to be deeply grooved with striae upon more than one face. I had previously found a similar block sticking out from under the Boulder-clay, about a hundred yards away from this section in the same cutting, and this also was striated in a similar manner. But besides the numerous beds of gravel, the surface is everywhere strewn with fragments of rocks, rounded pebbles, and flintstones; and in cutting open grips for surface-draining, or in deepening ditches and ponds, large masses of flint, rounded boulders of quartzite and sandstone, and great blocks of dolerite and other rocks are thrown

out upon the land or into the lanes, or are carted off to the farmyards to repair walls or to serve as mounting-stones, or to fill up holes in front of the doorways. And upon comparing those which I know have been taken out of the Boulder-clay with the rocks which lie upon the surface, I have found them to be, as a rule, so precisely similar in character as to leave no room for doubt that the great majority of them belong to the same series. On the other hand, there are certain fragments of rock found upon the surface whose presence there is doubtless due to other causes than the glacial drift, such as fragments of Jurassic limestone and of hard chalk rock (used in earlier times for building churches and priories), and pieces of a trachytic rock closely resembling that which the Romans imported from Germany for use as millstones. Yet, making all allowance for such fragments, there still remain the facts that an immense number of boulders and fragments, some of very large size and nearly all polished and smoothed and rounded in a remarkable manner, are found lying on the surface, which cannot conceivably have come so far from where they are found *in situ* in any other way than as having been included in the drift; and that, wherever the surface of the ground is being broken up at the present day, exactly similar boulders and fragments of rock are being dug up and left lying on the surface. These do not, however, appear to belong to the same period as the beds of gravel; for not only is the general appearance of the stones in the gravel-pits very different from the appearance of those found on the surface, but also, though quartzites, sandstones, and quartz-rocks abound both in the gravels and on the surface, yet I have not found any fragments of hard crystalline limestone or of Jurassic limestones in the gravel-beds, and only two or three fragments of dolerite, and these so decomposed that only a very small core was still crystalline; whereas, among the stones on the surface, blocks of hard crystalline limestone and of Jurassic limestone are most abundant, and there are a very great number of boulders of dolerite, some of considerable size, of which the crystalline components are as sharp and fresh as if they had just been struck off from an almost unweathered mass. The very great variety in these rocks makes it very difficult to classify them at all satisfactorily; so much so, that after having examined several hundred pieces, and having made microscopic sections of at least one hundred and fifty, I find that I can do little more than form them into groups, and point out the common features of each group, making special mention of any specimen which seems to require it.

Granite.—It is somewhat more convenient to take the igneous rocks first and to consider the sandstones and limestones afterwards. And the first group of igneous rocks should have included the granites or orthoclase-quartz-mica rocks; but though I have searched carefully for them, yet I have not been able hitherto to find a single specimen of granite. This is the more remarkable, because I understand that rocks of this class are not unfrequently found in the Boulder-clay both in Norfolk and in Lincolnshire.

Syenite.—The rocks of this class are also very rarely met with. At present I have found only two small specimens (nos. 1, 2). Of

these, the former consists chiefly of plagioclase and hornblende, with some good examples of magnesia-mica (biotite), and is therefore an orthoclase-plagioclase syenite, and the latter is a pinkish-grey rock with not much hornblende, and that in specks. It resembles a fine-grained granite, and appears to be like the rock described by Mr. Rutley in his article "On the Igneous Rocks of the Warwickshire Coal-field" (Geol. Mag. December 1886, p. 559), though there is not much plagioclase in the section which I have taken.

Quartz-porphyriles.—These rocks seem to abound in the drift. The specimens I have are numbered 3, 5, 6, 7, 110, 111, 112, 115: the character of the last four being so difficult to determine that I had at first placed them in another group; but upon the whole they appear to belong to the porphyritic quartz-rocks. Some of these specimens are very close-grained and compact; but in others the porphyritic crystals are very distinct, and in two or three cases they are so large and abundant as to give the rock the character of a conglomerate. The ground-mass varies from a distinctly felsitic character to a mosaic of small grains. The crystals of quartz are, in some cases, mere rounded blebs; while in others they are much larger, with more or less distinct outline, though usually rounded. They are frequently cracked, and, in almost all cases, are full of minute enclosures and lines of dust. Crystals of felspar also occur full of enclosures, much worn, and so decomposed as, in some cases, to present a mealy appearance. In no. 7 there is an appearance of fluxion-structure.

Quartz-tourmaline.—Rocks of this class also seem to be very abundant. The specimens are numbered 4, 8, 9, 10, 11, 12, 108, 109, 113, 114. The ground-mass is granitic; but the grains vary very much in size. They contain schorl in abundance, either in needles enclosed in other crystals, or in aggregates of grains with a decided tendency to a fan-shaped or radiate formation, or in spheroidal patches, or else in long lines passing irregularly through the section like thin threads. One of these sections (no. 113) seems to call for special mention, as it is in many respects a remarkable rock. The specimen is part of a large rounded boulder of very great hardness, which I dug out from the gravels; it is perfectly smooth and highly polished, and has very narrow almost parallel bands of yellow alternating with narrow bands of black, so as to give it a peculiar striped appearance. The fractured surface is quite dull and very compact. The microscopic section shows a microcrystalline mosaic of quartz, alternating with numerous dark bands composed of tourmaline with dark amorphous matter.

Felsites.—Of these rocks I have found only four specimens (nos. 14, 15, 16, 17), and these are all more or less devitrified. Nos. 14 and 15 are very dark compact rocks, of sp. gr. 2.65. The section of no. 14 shows a spherulitic structure and fluxion-arrangement; but that of no. 15 is entirely spherulitic, for the spherulites press so closely upon one another as to fill up the whole space. In no. 16 there is a fairly wide band passing through the section, in which crystallites are plainly discernible in long rods, and in many cases

radiating from centres; the spherulites are more apparent in the very microcrystalline portion. But no. 17 is an entirely different rock, of a pinkish-white appearance and not close-grained: the section of this rock reveals a remarkable perlitic structure, the small narrow bands being apparently composed of minute grains of quartz; the section also contains several circular aggregates of clear felspar. I have been informed that devitrified rhyolites of this character are stated to have been found in Sweden, at Elvedalen, in Hedemarken.

Quartz-trachytes.—The only specimen that I have found of these rocks is numbered 18; the texture of the rock is fine-grained and compact, though vesicular in places; the section shows that the ground-mass is really vitreous, though so filled with minute grains of quartz as to give it an appearance of a finely granitic character; it contains some larger crystals of quartz and orthoclase with abundant enclosures and bubbles.

Felspar-porphyrites.—These rocks are exceedingly abundant in the drift; the specimens are numbered from 19 to 38. They vary very much in appearance, but in all of them the porphyritic felspar can be clearly seen in the hand-specimens, though none of the crystals are of any great size; the sections show generally a crypto-crystalline felsitic base, enclosing porphyritic crystals of orthoclase and plagioclase, but chiefly plagioclase—in some cases perfectly clear and transparent, in others in various stages of decomposition, much cracked and with outlines broken and indistinct; in some sections the felspar is altered into a mealy appearance, in others it has a pearly lustre. Augite is occasionally present in granular aggregates or in scattered crystals, and in some cases quartz. Some fine instances of zonal structure in felspar occur, notably in no. 21, and some sections contain tourmaline in abundance, especially nos. 22 to 32; this last-mentioned specimen is in many respects worthy of notice, and it is questionable whether it ought not really to be included among the quartz-tourmaline rocks. The hand-specimen is of a dark grey colour and very vesicular, the cavities being lined with minute pyramidal crystals of quartz and with minute crystals of tourmaline. In the section the porphyritic felspar seems to be made up of aggregates of minute crystalline grains corresponding with the ground-mass. The quartz is abundant, chiefly in aggregates; but one long and very clear crystal shows twinning under crossed nicols, one half remaining dark shot-grey, the other pale yellow; on rotation both extinguish partially and simultaneously; when the nicols are not crossed, the pale yellow part on rotation shows dark purplish blue changing to pale yellow, but the other half shows no colour at all. Nos. 33 and 34 are typical augite-andesites; in both the base is very vitreous and in 34 it shows great disturbance and fluxion-structure very clearly. The plagioclase is very clear, though much broken, and there are some good examples of zonal structure. The augite in 34 is, in most cases, either enclosed within the felspar, so that only a border of felspar is visible, or else attached to it, in some cases lying partly within the felspar, partly in the base; in 33 there are some good examples of a distinctly

pleochroic mineral of the enstatite group altering into bastite, the pleochroism being from pale green to brown. No. 38 contains a considerable amount of hornblende in irregular crystals, some of which is enclosed in the felspar.

Trachytes.—I have found a fair number of specimens of these rocks among the stones on the surface, but I am very doubtful whether they really belong to the drift or were imported, probably in very early times, for use as millstones; for I have found not only a curious small millstone made from this rock, but some other pieces also grooved and marked in an evidently artificial manner. A section from the millstone was kindly examined by Professor Bonney and pronounced by him to be very similar to the well-known Niedermendig rock. They are vesicular rocks of a dark grey colour approaching to black, and of a trachytic texture; the sections vary, no. 39 showing crystals of plagioclase and hornblende in a base composed of microliths of felspar and grains of hornblende. No. 40 has a vitreous base, enclosing abundant augite, but not much hornblende; in 43 the augite is again abundant and there are some fine instances of zonal structure: in all these rocks the crystals of augite and hornblende are surrounded by a distinct narrow border much lighter in colour and showing no pleochroism; under crossed nicols both crystal and border extinguish together, but in some cases appear to leave a narrow rim of light between the crystal and the border.

Dolerites.—Rocks of this class are exceedingly abundant in the drift, but they are all of a more or less fine-grained character; all the coarser dolerites and all those of a true ophitic character are remarkable for their absence. Moreover, I have not as yet found any specimens of columnar dolerites, though I understand that these rocks are of very common occurrence in the drift in the east of England; but of those which I have found, some are in very large blocks, much polished and rounded, but only a few retain any striae: one of these blocks, which was dug up out of a ditch some few years ago and taken to the farm where it now lies, measures roughly 3 ft. \times 3 ft. \times 1 ft. 4 in., it is much rounded and polished and in one small part of it the striae are very clear; another large block was lately dug from a depth of several feet in a clay-pit, in which the yellowish-white clay is full of whitened flints very plainly striated, like those numbered 173, one of which came from this clay; the block was found broken or, rather, cracked into several large fragments. The specimens of these dolerites are numbered 44 to 94, and may be divided into five groups:—The *first* group comprises nos. 44 to 52; these are of a fine-grained character and a dark greenish-grey colour, the crystals being just perceptible to the naked eye; under the microscope the texture is seen to be subophitic; they are plagioclase-augite-olivine rocks, the plagioclase being usually in microliths or else in lath-shaped crystals; the augite in aggregates or distinct crystals, in some cases rather highly coloured; the olivine varying very much, being sometimes so much altered that nothing but the outline remains the same, in other cases being very fresh and clear except along the cracks, and in some instances being in

aggregates; in nos. 47 and 52 the magnetite is in skeleton crystals; the specific gravity of these rocks varies from 2·86 to 2·90. The second group comprises nos. 53 to 60, rocks of a greyish-brown colour and fine-grained; of these no. 59 is one of the few pieces that I have found in the gravels, and no. 60 is so much altered that it is somewhat difficult to distinguish its component crystals; they are plagioclase-augite rocks, of a subophitic texture and containing no olivine; the augite is in almost all cases in granular aggregates and the plagioclase in microliths. The magnetite in some cases is in large plates and skeleton crystals enclosing augite and plagioclase; they appear to contain a little biotite; the specific gravity of these rocks varies from 2·81 to 2·93. The specimens in these two groups have a general resemblance to the subophitic dolerites of Central England, some being very suggestive of the Rowley Rag, and others of the Tideswell Dale rocks; but upon comparing them with the sections which I have made of the Rowley Rag, the Tideswell Dale rock, and the Mount Sorrell dolerite, and with Mr. Allport's sections of the Central England rocks, I could not find any such definite points of resemblance as would enable one to say with any certainty whatever that they are different parts of the same rock. On the other hand, they do not appear to have any special points of similarity with the north of England dolerites; and upon comparing them with some few sections which I have of the dolerites of Southern and Eastern Scotland and with Dr. A. Geikie's description of these rocks in the Transactions of the Royal Society of Edinburgh, I could not discern any real points of resemblance. They may be found to be identical with some of the Scandinavian dolerites, but they are altogether different from the few specimens of those rocks which were sent me from Sweden.

The third group of dolerites, nos. 61 to 83, includes some remarkable specimens of plagioclase-augite-olivine rocks of trachytic texture, the magma in some cases being exceedingly vitreous. These are all very black-looking close-grained rocks, the crystals not being discernible with the naked eye, except the olivine: one of these, no. 69, is from the gravel; but the specimen was so decomposed that it was only from the core of it that a good crystalline section could be obtained. The magma of these rocks is vitreous, the plagioclase generally in minute microliths and, as a rule, not abundant, in some few cases in granular aggregates, but generally in well-formed crystals, sometimes porphyritically developed and of a fairly dark colour; the olivine usually porphyritic, in some cases remarkably clear and fresh, but occasionally altered, and in a few instances it is in granular aggregates. The magnetite is often in minute rounded grains, as if the section had been powdered with it; in some cases it partially or completely fills up crystals of olivine, and in a few sections it has a linear arrangement. The specific gravity of these rocks varies from 2·90 to 3·02. So far as I have been able to judge, these dolerites have neither any general nor any special likeness to the dolerites of Central England, except perhaps in these two respects, viz. that in nos. 76, 80, 81, the olivine is in granular aggregates, which, I think, is somewhat unusual, although I believe it occurs in some specimens

from the Rowley Rag; and that nos. 64, 65, 66 have some points of resemblance to a rock from Swinnerton Park and to a boulder found near Leicester which resembles that rock; but they differ in one most important point, viz. that nos. 64, 65, 66 contain porphyritic augite, remarkably well developed, whereas I understand that neither the Swinnerton-Park basalt nor the Leicester boulder contain porphyritic augite at all. These dolerites, moreover, are totally unlike any of the known dolerites of the north of England; they are, however, remarkably similar to some Scandinavian rocks, and this is especially so in the case of those very specimens, no. 64, 65, 66, which differ from the Central England rocks, and in that very point in which they so differ, viz. in their containing porphyritic augite; for upon comparing them with some specimens sent me from Sweden and labelled Pilahall (Scanie), Gustafsborg (Scanie), and Anneklef (Scanie), the general similarity between them is in itself striking; and besides this the sections show that they are almost identical in the following points:—the clearness of the olivine, the porphyritic development and sharpness of outline of the augite, the peculiar greenish appearance in the centre of many of the crystals of augite, the powdered arrangement of the magnetite, and the specific gravity 2.9.

The fourth group of dolerites, nos. 84 to 91, includes some rocks of considerable interest. They are of a dark grey colour, as a rule very close-grained, some being less so and lighter in colour; they are plagioclase-augite rocks of a subophitic texture; the plagioclase is usually in microliths and the augite in granular aggregates, though in 88 and 89 it is in distinct crystals with fine examples of twinning bands; these specimens are so remarkably like the rocks of the Whin Sill as almost to establish an identity, for not only is there a very great general likeness in the hand-specimens, but the sections show that they are identical in several points: (1) the sections of the drift-rocks contain white colourless augite in long prisms, (2) they have some fine examples of a distinctly pleochroic mineral of the enstatite group (hypersthene?) altering into bastite, (3) they have many small grains of biotite scattered throughout the sections, and (4) the specific gravity of nos. 86 and 88 is 2.93. Upon referring to Mr. Teall's article upon the Whin Sill (in Quart. Journ. Geol. Soc. vol. xl. No. 160) it will be seen that the first three points are special peculiarities of this rock, and that in three out of the six specimens mentioned the specific gravity is 2.94. I understand, however, that in Central Scotland there are rocks allied to the Whin Sill, and that the Hunneberg rocks in Scandinavia have been shown to be very similar to these rocks; the two specimens from the Hunneberg which I have are of a totally different character, so much so that there is not even a general likeness between them and the specimen which I have of the Whin Sill.

The fifth group contains three specimens, nos. 92, 93, 94, each of which seems to call for special mention. No. 92 is a piece of an exceedingly hard boulder of dolerite, measuring about a foot each way; the boulder is completely rounded and polished, but scarcely

at all weathered; the section shows it to be an ophitic hypersthene-bearing dolerite, this being the only really ophitic dolerite that I have found in the drift; the plagioclase is abundant, but much of it is very cloudy; the augite fairly abundant, much cracked and broken; there are several very good examples of hypersthene both in grains and in distinct crystals, with the pleochroism from pale watery green to orange or brownish red fairly strong; some of the crystals are much cracked and some almost filled up with dark yellowish-brown alteration-matter; in one or two cases a fibrous structure has been developed. No. 93 is a remarkable rock, if it be a genuine rock specimen and not a slag; it has all the appearance of a slag, being very black and vesicular, and the magnetite is the great feature of the rock; but it is also composed of crystals which polarize in bright colours, have some distinct outline, extinguish on rotation, though not simultaneously, and have some appearance of cleavage; its specific gravity is 4.51. The remaining specimen, no. 94, is a plagioclase-augite rock of trachytic texture, of which the plagioclase is the great feature; for not only is it in abundant microliths with remarkably distinct fluxional arrangement, but some larger crystals are enclosed, which are of anterior consolidation to the ground-mass; the section reveals a structure evidently very similar to that of which Professor Judd speaks in his article on the volcanic rocks of the north-east of Fife (Quart. Journ. Geol. Soc. vol. xl. p. 428), where he says, "the minerals of the second consolidation consist of imperfectly developed microlites of felspar . . . the glassy base contains numerous trichites . . . the disposition of these and the felspar microlites of the second consolidation with respect to the larger porphyritic crystals reveals a most striking flow-structure; not only are these minuter elements of the rock arranged in irregular parallel bands, but they are crowded in front and along the sides of the porphyritic crystals, trailing off behind them."

Granulites.—As these rocks are classed by some authors with the eruptive rocks, and by others with the metamorphic rocks, I have placed them here between the dolerites and the crystalline schists. The only two examples which I have, nos. 95, 96, appear to be specimens of the same rock, although found at different times and in different localities. The rock is of a dark grey colour, of a holocrystalline granular texture, and of a slightly schistose structure; the sections show that the rock contains plagioclase and orthoclase in abundance, but chiefly the former, the crystals showing signs of considerable strain, for they are much broken and bent, and other crystals appear to have been forced between the broken parts; the hornblende is in granules, and there is much secondary hornblende in cracks passing through the sections, and in some cases through separate crystals, dividing them but not apparently displacing the parts; the rock also contains hypersthene in abundance, in grains and crystals, and some biotite. Mr. Teall kindly examined the sections for me, and he writes me that they are very interesting rocks belonging to a well-characterized type.

Similar rocks occur in Saxony, where they are known as pyroxene-granulites, in Sweden (hyperite of Törnebohm), in Minnesota (augite-diorite of Streng), near Baltimore (gabbro or hypersthene-gabbro of Williams), and in Scotland, where they have not been described. The original minerals appear to have been augite, hypersthene, magnetite, and plagioclase; the plagioclase of the Baltimore rocks is bytownite; in most districts where they occur they show a considerable amount of variability in their mineralogical composition; felspar is sometimes abundant, sometimes absent; secondary hornblende is frequently present, and sometimes it entirely replaces both the pyroxenes*.

Crystalline Schists.—These rocks are not abundant in the drift. The specimens are numbered 97 to 105 with 171 and 180. Of these 97 to 103 and 180 are hornblende-schists, and are of a greyish-green colour and close-grained. In some cases they are evenly foliated and split with a very level fracture; in others they are very hard and much contorted, as in no. 100, a section which was taken from a large boulder, exceedingly hard, though rounded and polished. The sections show orthoclase, as a rule, cloudy and much altered, quartz not in any great quantity, and hornblende varying considerably. In nos. 97 and 99 it is in long prisms (actinolite), in 87 it is in irregular grains and prisms with good examples of transverse and longitudinal sections and with some instances of twinning. In 101, 102 it is not nearly so abundant, but in 103 it is most abundant in grains and prisms so minute that the hand-specimen shows a very compact structure of a silky appearance in which it is hardly possible to detect the separate crystals. But no. 98 is the most interesting of these sections; for besides the hornblende and some irregular grains of a colourless mineral showing weak tints under crossed nicols (zoisite?), it also contains abundance of dark blue tourmaline (indicolite), the prisms sometimes showing a tendency to gather into radiate or fan-shaped groups. The fact of the occurrence of tourmaline in this rock, when considered in connexion with the number of quartz-tourmaline rocks in the drift, makes it at any rate probable that they have come from the same locality, viz. from some locality where tourmaline-bearing granite is intrusive in hornblende-schists. Nos. 104, 105, and 171 are mica-schists, 104 being granatiferous; this section was from a block of considerable size, and the garnets are fairly abundant, though much cracked and broken.

Quartzites and Quartz-Rocks.—These rocks are most abundant in the drift; the quartzites occur in very large boulders as well as in numberless rolled pebbles. Sometimes they are very clearly banded, but in most cases they show no signs of banding. They are usually very fine close-grained rocks with a highly lustrous fracture. Quartz-rocks occur mostly as large, rounded, and highly polished boulders, often, especially in smaller pebbles, of a rose-red colour. The only specimens I have of these rocks are

* Lehmann "Die Entstehung der altkrystallinische Gesteine." Streng, Neues Jahrbuch, 1877. Williams, Bull. U. S. Geol. Survey, no. 28, 1886.

numbered 106, 107, 172, and of these the section of 107 is full of dark lines, apparently lines of fine dust, crossing and recrossing the crystals.

Silicified Wood.—Some few specimens of silicified wood occur in the drift; those I have are numbered 116, 117, 174; of these 116 was kindly examined for me by Prof. Williamson, of Victoria University, and he considered it to be coniferous and probably Jurassic; 117 is a section of a much larger fragment, and shows very clearly the medullary rays, separated by interlacing woody fibre.

Sandstones.—These occur in much greater abundance in the drift than any other rock except the flint. The specimens which I have selected are numbered 118 to 140 and have been for the most part struck off large blocks much rounded and polished. Some of these blocks are very large, one measuring 5 ft. 9 in. \times 3 ft. 6 in. \times 2 ft., and as this lies deeply imbedded in the soft clay ground, it must be nearly 4 ft. 6 in. in width. This mass was dug out some few years ago and dragged to its present position, where it forms part of a farmyard wall within a mile of Felstead; the specimen is numbered 132. In the village of Felstead there is a raised way, the outside border of which is formed of no less than thirty-six large blocks of sandstone, two of limestone, and one of dolerite; others stand near farmhouses and blacksmiths' forges and in front of inns. The majority of them are ferruginous, some being highly so; a fair number are completely siliceous; as a rule they are very fine-grained, some being specially compact and none that I have found being really coarse. They are also, with two or three exceptions, entirely unfossiliferous. I am indebted to Mr. H. Keeping, of the Woodwardian Museum at Cambridge, for having examined them, and he considered them to be for the most part Carboniferous Sandstones, two or three being pebbles of Millstone Grit; the exceptions, which are fossiliferous, are first a block of hard and compact reddish-yellow sandstone, no. 128, containing casts of *Aviculopecten* and some small fragments of crinoid stems; and next two large blocks of a greyish-yellow sandstone, no. 123, one measuring 3 ft. 3 in. \times 2 ft. 6 in. \times 1 ft. 5 in. One of these forms part of the raised way in the village, and consequently I cannot do more than just chip it. The other and larger block lies in a farmyard, and I have therefore been able to examine it; I have found in it fragments, but only fragments, of *Pecten orbicularis*; this sandstone has, however, a peculiar glazed surface when fractured, and Mr. Keeping recognized it as being of the same character as that which occurs in the Lower Greensand in Lincolnshire, and which he has described and figured in his paper on the Lincolnshire Neocomian (Quart. Journ. Geol. Soc. vol. xxxviii.). I have also found two or three smaller boulders of a glauconite sandstone, which probably belongs to the same series. In addition to these, there are here and there boulders of a rather soft argillaceous sandstone, but, so far as I have yet discovered, these are quite unfossiliferous; and boulders of the coarse conglomerate known as "Hertfordshire Puddingstone" are fairly abundant, some of them

being of considerable size. In connexion with the sandstones, it may perhaps be worth mentioning that an implement made from very hard sandstone was found on the surface close by Felstead, and brought to me by the gentleman who found it. It is, I believe, a Palæolithic implement, of a shape rarely found in England, and may have been lying in the clay; this seems the more likely from my having found two small implements and two abraded quartzite pebbles in the clay-pit mentioned above. They were taken out of a yellowish-white clay full of striated flints and resting on chalky Boulder-clay.

Limestones.—These are also found in considerable abundance in the drift; the specimens nos. 141–169 belong to the Carboniferous, Triassic, Jurassic, and Cretaceous series. Of the Carboniferous, there are boulders and fragments of all sizes, some being of considerable size, for one measures 2 ft. 3 in. \times 2 ft. \times 1 ft. 3 in., and another 2 ft. \times 1 ft. 6 in. \times 1 ft. They have become weathered to a light bluish grey and are smoothed and rounded, but I have not detected any striation. They are of a highly crystalline character, dark grey in colour, hard, and fine-grained. The sections under the microscope show some very perfect examples of *Valvulina*, *Endothyra*, *Trochammina*, &c., chiefly *V. bulloides*, *V. Youngi*, *E. Bowmani*, and *T. incerta*, and in some of the sections the rhombohedral plates of calcite are very perfect. In addition to these, there is one small piece containing *Lithostroton* (no. 160). Of the Triassic limestone there are two pieces from the Rhætic beds, nos. 162, 163, containing very good specimens of *Pleuromya crowcombeia*; one of these was taken from a railway-cutting at Castle Hedingham, considerably beyond my radius, the other I found near Felstead; I am indebted to Mr. H. Keeping for identifying them. They are somewhat interesting, because though I see that the Rhætic beds are said “to extend as a continuous, though very thin band at the top of the Trias, from the coast of Yorkshire across England to Lyme Regis on the Dorsetshire shore” (‘Textbook of Geology,’ A. Geikie, p. 766), yet I understand that no Rhætic beds come to the surface anywhere in the north of England, and in that case these must be remnants of a very early denudation. Of the Jurassic series, there is a great abundance of blocks of all sizes, but I have taken only a few specimens, of which one or two are from the Cornbrash, and the majority from the Oxford Clay and the Kimmeridge Clay, containing *Cardium*, *Trigonia clavellata*, *Ammonites serratus*, &c. There are also two or three pieces of Purbeck Marble, containing *Paludina fluviatorum*; but inasmuch as this rock was much used for church-building and building of priories &c., I feel that all of it that is not actually taken out of the Boulder-clay must be looked upon with suspicion, and this will necessarily apply to many of the Jurassic fragments besides the Purbeck. Of the Cretaceous series, I have found one or two blocks of glauconitic limestone of some size, one in particular, measuring 3 ft. \times 2 ft. 6 in. \times 2 ft., which lies in an inn-yard in Felstead, and is very much weathered and worn; the section is numbered

152. Besides these, many lumps of hard chalk occur in the drift, some of them as rounded boulders with distinct striation. No. 169 is a section of this hard chalk, and is full of circular organisms of which little but the form can be detected. Mr. Keeping identified a specimen as being exactly similar to the hard chalk of Cambridgeshire. There remain only the flints and the Boulder-clay itself to be considered. The flints are by far the most abundant of the rocks in the drift, and sometimes are in blocks of very considerable size; two great blocks which were dug out of the Boulder-clay in making a very deep drain measure respectively 22 in. \times 11 in., and 19 in. \times 11 \times 7 in. In examining some Boulder-clay within two miles of Felstead in a disused clay-pit, I dug out several large flints, which were so highly polished on all sides that the surface was quite transparent; there were a great number of them lying in this clay at a depth of from four to five feet from the surface; but though apparently whole as they lay, yet, when taken out, they were all without exception found to be sharply cracked in one or two places without being at all splintered, and the clay itself was quite undisturbed. Of the chalky Boulder-clay itself three slides will be found numbered 170; they were taken from a mass of this clay exposed in an open grip close to Felstead, and they contain great numbers of very minute Foraminifera, many of them in perfect preservation, mixed up with particles of quartz-sand.

I fear that this investigation into the character of the rocks of the Essex drift has so far been productive of little, if any, practical result; but it is possible that the mere description of the rocks may lead to some important results as regards the general question of the glacial drift. In taking it up, I hoped to discover some of the localities from which the different rocks had come, and it is possible that further investigation may be productive of more definite results; but at present I feel that the difficulties of actually identifying these fragments with the rocks of any special locality are so great that I am not myself capable of coming to any definite conclusion upon such a question. I have to thank Professor Bonney and Mr. J. J. H. Teall for so kindly examining many of the specimens and sections, and for several valuable suggestions. My thanks are also due to Professor A. Geikie and Mr. Clement Reid for kindly inspecting the specimens, and to Mr. H. Keeping for identifying several of the sandstones and the fossils in the limestones.

DISCUSSION.

The PRESIDENT said the author of the paper had shown how much might be done by a petrologist even in so unpromising a region as Essex. Most geologists had experienced the difficulty of identifying rocks transported from a distance. Unless, however, the fragments are actually found *in situ* in the Boulder-clay, it is well to beware of concluding that they have not been brought to the spot. He related a case in which a Mexican carving was picked up in a Roman encampment in Devonshire.

Mr. WHITAKER said it was only by continual endeavours to identify the rocks of the Boulder-clay that any knowledge of their original derivation could be obtained. He also noticed the number of foreign fragments scattered over the country artificially. The sandstone, which he concurred with Mr. Rowe in regarding as Neocomian, was one of the commonest stones of the Boulder-clay in West Norfolk, but he had tried in vain to ascertain its origin. The paucity of granites was common in the Drift of the eastern counties, but the occurrence of Rhætic stone was new to him. On the Cromer coast there were boulders of rocks similar to those on the table, and many of the Cromer blocks were of Norwegian origin.

Mr. COLE mentioned the numerous pebbles of igneous rocks in the Bunter pebble-beds, and thought that their transference to the drift might complicate the question of the origin of the materials.

The PRESIDENT pointed out that Niedermendig beds were worked for mill-stones by the Romans, and fragments occurred all over Europe. The sandstone with glistening fractured surface was from the Spilsby Beds of Southern Lincolnshire, as shown by a fossil it contained.

Mr. ROWE said his specimens were from large boulders, and nearly all had been found in the Boulder-clay itself or could be traced to it.