THE LOWER PERMIAN AT ASHFIELD BRICK AND TILE WORKS,
CONISBOROUGH.

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(Read November 25th, 1915.)

This section has long been under observation by Yorkshire geologists, but no detailed record has hitherto been given of the Lower Permian beds as exposed here within the last few years. The chief interest has been centred upon the Upper Coal Measures upon which the Permian rests, beds which have yielded a rich harvest of fossil-plants. The top-most bed of the Coal Measures is a fine-grained micaceous sandstone deeply stained with hematite. The surface of this sandstone is undulating, and in the hollows are found deposits of Permian age, consisting of conglomeratic material. The largest pebbles in this conglomerate are in general not more than an inch in diameter, but during a visit to the section in September, 1915, some large boulders up to eighteen inches in diameter, were found, which had been taken out of the conglomerate by the workmen. These boulders consisted of sandstone, identical with the underlying Coal Measure sandstone, and a dense siliceous sandstone also possibly a Coal Measure type.

Intercalated with this conglomerate are beds of fine sand, which sand is in all respects, except colour, like the sand which occurs in similar stratigraphical positions along the edge of the Permian escarpment from North-east Durham to Yorkshire. As the section shows, this lowest bed is in its thickest part about 5 ft. 6 ins., but in a distance of 15 ft., it has thinned away to 15 ins. of fine sand with very few pebbles. Resting upon this bed and traceable right through the quarry is a bed of chocolate-coloured marl, the junction with the conglomerate being quite sharp. From this bed I obtained, some years ago, casts of *Schizodus* and these appear to be the only fossils present in the beds below the massive Magnesian limestone. The chocolate marl is succeeded by other thin bedded grey and brown marls, with some of which (as in beds E and H in section) are intercalated bands of buff-coloured limestones.

It will be noted from the chemical analyses given in the appendix that the intercalated limestones are highly dolomitised, while the insoluble residue in all the marls is very high, the kaolin reaching

Photo by] W. Odling.
The Lower Permian, showing the conglomeratic bed at the base and the thin bedded marls and limestones
above. The base of the conglomerate, about 2 ft., is obscured.
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38·58 per cent. in bed J, which is immediately below the massive Magnesian limestone.

These beds correspond, of course, in position with the Marl Slates of Durham, but have not yielded the fish fauna of those beds.

PETROLOGY OF THE CONGLOMERATE AND ASSOCIATED SANDS.

Among the pebbles the following have been noted :—sandstone, quartz, clay ironstone, hematite, chert and pink felspar. The material is not at all well compacted, but layers occur sufficiently indurated to yield sections for the microscope, and several have been made and examined with the following results.

The grains of hard material are all exceedingly well rounded, while the softer materials are somewhat flattened. The dominant constituent is quartz, the grains of which are chiefly of the complex type. Some of them show an extreme degree of mylonitisation, while others have “crenulate” and “mortar structure” well developed. Many grains of sandstone are present which are evidently from the under-lying rock. Chert-grains are numerous, but show no traces of organisms. Limonite and hematite are also common.

Felspar, other than microcline, is rather rare in the fresh condition, while muscovite is present in somewhat large flakes. A few pieces of micro-pegmatite have been noted, having in two cases lath-shaped feldspars associated with and penetrating the grain. The matrix is chiefly calcite.

HEAVY MINERALS IN THE SANDS.

These were separated by means of a Sollas bottle and Theulet's Solution :—

Cubic.—Garnet, Magnetite, Fluorspar.

Tetragonal.—Zircon, Rutile, Anatase, Xenotime.

Rhombohedral.—Ilmenite, Hematite, Limonite, Tourmaline, Apatite.

Orthorhombic.—Staurolite.

Monoclinic.—Biotite, Chlorite, Epidote, Monazite.

Triclinic.—None.

SECTION OF LOWER PERMIAN EXPOSED IN THE
ASHFIELD BRICK WORKS, CONISBOROUGH, Sept. 29th, 1915.

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In decreasing order of abundance these minerals would appear thus :—hematite, limonite, ilmenite, garnet, magnetite, zircon, tourmaline, rutile, staurolite. Only a few grains have been noted of the following :—fluorspar, xenotime, apatite, epidote and chlorite, while only one undoubted grain of monazite has been seen.

The heavy residue also contains a number of rounded grains with aggregate polarisation tints of the high orders. They possibly represent some altered mineral, and consist now chiefly of micaceous material, but they are never found in association with any other mineral so that their origin is obscure.

It is interesting to note that Mr. R. C. Burton found that the dominant heavy minerals of the Yellow Sands at the base of the Permian of Durham were :—garnet, zircon, rutile and tourmaline, while the sands also contained felspar and mica.*

Garnet.—This is a very abundant mineral, the grains being usually rounded or irregular with no crystal outline. In colour they vary from a deep red, through pink to colourless. Frequently they contain inclusions. The dodecahedral cleavage is well developed upon the surface of some of the grains, giving a zigzag appearance.

Magnetite.—A large number of rounded grains of this mineral are present, the crystal form of the octahedra being rarely seen.

Fluorspar.—A few isotropic grains showing the octahedral cleavage characteristic of this mineral occur, and its low refraction compared with garnet is very noticeable.

Zircon.—Excluding the iron ores, the greater part of the heavy residue consists of garnet and zircon. A fairly high percentage show a sharp crystal outline consisting of prism and simple pyramid. Others are rounded at the termination, due possibly to having had originally a number of pyramid faces developed. Zonal structure is common, especially in the short and stout prismatic forms. Inclusions also are numerous, usually arranged parallel to crystal faces. As is usual in the case of zircons occurring in detrital deposits the birefringence is very high.

* Note by Dr. Woolacott to his paper on *The Geology of N.E. Durham and S.E. Northumberland.*—*Proc. Geol. Assoc.* Vol. XXIV. pt. 2, p. 93.

Rutile.—Present in relatively small quantity, compared with garnet and zircon. Usually it occurs as prismatic needles, pyramidal faces being extremely rare, while rounded grains are common. The colour varies from deep yellow to brownish red. No case of twinning has been noted.

Anatase.—Separate grains do not occur, but it is often associated with ilmenite and leucoxene.

Xenotime.—The clouded and purple crystals similar in other respects to zircon have been referred to this mineral.

Ilmenite.—This is a common constituent. Very frequently it is enveloped in the white alteration product leucoxene with outgrowths of anatase. It is more abundant than magnetite.

Hematite.—Rounded grains of bright red colour by reflected light occur plentifully.

Limonite.—This mineral is equally as abundant as hematite.

Tourmaline.—The grains of this mineral are usually rounded, though a few stumpy crystals consisting of prisms terminated by simple rhombohedra occur. The colour is most frequently brown, having in one case a blue border. Only one grain of distinctly blue tourmaline has been seen. The pleochroism of the brown variety is usually intense. Inclusions are somewhat rare.

Apatite.—A few crystals of this mineral have been noted.

Staurolite.—This mineral is of frequent occurrence. Usually it is quite fresh. The characteristic form is that bounded by cleavage faces, and presenting a “toothed” appearance. The colour varies from amber yellow to brown and the pleochroism is distinct.

Biotite.—Both the brown and green (chromium) varieties occur, though the latter is not abundant.

Chlorite and *Epidote*.—These occur as rounded grains, very similar in colour, but the high birefringence of the latter and the low birefringence of the former enable them to be separately identified. Both are somewhat rare.

Monazite.—Of this mineral, only one undoubted grain has been

DESCRIPTION OF PLATE XXXIV.

1.	<i>a</i>	Garnet	..	..	...	...	...	×	90
	<i>b</i>	„	...	...	...	...	...	×	95
	<i>c</i>	„	...	...	...	...	...	×	100
	<i>d</i>	Enlargement of part of surface of <i>a</i> .							
2.	<i>a</i>	Zircon	..	..	..	..	..	×	140
	<i>b</i>	„ (showing zoning)	..	..	..	..	..	×	115
	<i>c</i>	„ (showing zoning and inclusions)	..	..	..	..	..	×	125
3.	<i>a</i>	Staurolite	..	..	..	..	..	×	75
	<i>b</i>	„	..	..	..	..	..	×	130
	<i>c</i>	„	..	..	..	...	..	×	85
4.	<i>a</i>	Tourmaline	..	..	..	..	..	×	135
	<i>b</i>	„	..	..	..	..	..	×	65
	<i>c</i>	„	...	..	..	..	..	×	90
5.	<i>a</i>	Rutile	...	..	..	...	..	×	110
	<i>b</i>	„	..	..	..	..	..	×	75
	<i>c</i>	„	..	..	..	...	..	×	80
6.	<i>a</i>	Magnetite	..	..	..	..	..	×	140
	<i>b</i>	„	..	..	..	..	..	×	75
	<i>c</i>	„	...	...	...	...	...	×	140

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noted. It shows the rounded form and amber yellow colour with patches of alteration products. When tested spectroscopically it yields the characteristic spectrum.

SOURCE OF THE MATERIAL.

The writer must refrain from making any wide generalisation upon this subject, at this time, postponing such until the larger work which he has carried out in collaboration with Mr. H. C. Vessey, M.Sc., on the Permian Sands and Conglomerates of the North of England is ready for publication. It will be sufficient here to point out that, with the exception of the staurolite, all the other pebbles and minerals herein described have been found to occur in the Carboniferous Rocks of the Pennine area. The staurolite is interesting as being fairly common, and as having the same "toothed" or "frayed" outline which has been figured and described by Dr. H. H. Thomas as occurring in the New Red Sandstone of the West of England,* and by Mr. T. O. Bosworth from the Carboniferous Sandstones of Scotland.*

I am much indebted to Mr. J. A. Butterfield, M.Sc., for the careful drawings of the heavy minerals which he has made to illustrate this part of the work.

* *Petrography of the New Red Sandstone* (Dr. H. H. Thomas). *Quart. Journ. Geol. Soc.*, Vol. LXV., Pl. XII., fig. 4c.

* *Heavy Minerals in the Sandstones of the Scottish Carboniferous Rocks*. *Proc. Geol. Assoc.*, Vol. XXIV., Pt. 2.

SPECIMEN	B	C	D	E	F	G	H ¹	H ²	H ³	I	J	K
Insoluble Residue & Loss on Ignition	73.49	75.03	75.53	18.63	77.64	65.07	10.06	21.87	65.54	77.57	31.27	6.15
Kaolin	13.30	10.88	8.73	6.84	13.39	8.66	7.08	15.32	10.05	12.39	38.58	2.67
Total	86.79	85.91	84.26	25.47	91.03	73.73	17.74	27.19	75.59	89.96	69.85	8.80
Percentage of Kaolin in total Insoluble Residue	15	13	10	27	15	12	56	41	13	14	55	30

TABLE TO SHOW RELATIONS OF THE INSOLUBLE RESIDUE TO THE ALUMINA WHEN
THE LATTER IS CALCULATED AS KAOLIN.