PROCEEDINGS

OF THE

COTTESWOLD NATURALISTS' FIELD CLUB

VOLUME XI

PRINTED BY JOHN BELLOWS, GLOUCESTER

1895

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VOL. XI PART I

PROCEEDINGS

OF THE

Cotteswold Naturalists' FIELD CLUB

For 1892—1893

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(CHELTENHAM)

THE COUNCIL OF THE CLUB WISH IT TO BE DISTINCTLY UNDERSTOOD THAT THE AUTHORS ALONE ARE RESPONSIBLE FOR THE FACTS AND OPINIONS CONTAINED IN THEIR RESPECTIVE PAPERS.

Contents

PUBLISHED BY JOHN BELLOWS, GLOUCESTER.

ANNUAL ADDRESS

TO THE

COTTESWOLD NATURALISTS' FIELD CLUB

AT GLOUCESTER, MAY 5th, 1893

BY

W. C. LUCY, PRESIDENT

Our Annual Meeting took place on Tuesday, April 26th, at the School of Science and Art, Gloucester.

The Accounts of the Hon. Sec., Mr J. H. Jones, shewing a balance in hand of £33 9s. 7d., were duly passed and the President, Vice-Presidents, the Hon. Secretary, and the Hon. Treasurer were re-elected.

The Field Meetings for the year were fixed :—

Woolhope - - -	23rd June
Bath - - - - -	21st July
(Left open) - - -	August
Neighbourhood of Newent	15th Sept.

The Members adjourned to the Bell Hotel to dine.

It is with deep regret I have to refer to the death of an old member of the Club—Mr John Hooke Taunton, C.E.,—which took place at Stroud on 31st January last. I gather from an obituary notice in the local newspaper that Mr Taunton was born at Totnes, Devon, in 1821, and his family had resided in the West of England as far back as the reign of Henry the First.

His great-grandfather, William Taunton, was Vicar of Ipplepen, Devon, from 1723 to 1783, and his son Joseph married Margaret, daughter of Mr Benjamin Babbage, of

Totnes, and aunt of Mr Charles Babbage, the Mathematician, and inventor of the Calculating Machine, which bears his name, and whose son is, I am glad to say, one of our Members.

Mr Taunton was, through life, actively engaged as an Engineer—was for a time in Mr I. K. Brunel's office in London, and afterwards employed by him in making the Oxford, Worcester, and Wolverhampton Railway, in the neighbourhood of Moreton-in-Marsh.

For thirty years he was Engineer of the Thames and Severn Canal, and was often called in as an Hydraulic Engineer in the construction of various water works.

He was a frequent attendant at the Field and Evening Meetings, and contributed to our Proceedings the following papers:—

"Remarks on the Watershed of the Cotteswolds in connection with the Water Supply to the Metropolis."	Vol. IV, 249.
"Sapperton Tunnel on the Thames and Severn Canal."	Vol. V, 255.
"Description of the Malmesbury Water Works."	Vol. VI, 301.
"Notes on the Hydrology of the Cotteswolds."	Vol. IX, 52.
"Visit to the Boxwell Springs."	Vol. IX, 70.
"Notes on the Dynamic Geology of Palestine."	Vol. X, 323.

The paper "Notes on the Hydrology of the Cotteswolds," contains an unusually large amount of valuable information, illustrated by beautifully executed diagrams.

WOOLHOPE

On June 23rd a large party proceeded by Great Western Railway to Ledbury, to examine the area not visited last year. The weather, as on that occasion, was extremely unsettled, but it afterwards cleared up, and in the intervals of sunshine the beautiful scenery came out to great advantage.

Our kind friend, Mr G. H. Piper, of Ledbury, accompanied by Mr Moore, the Hon. Sec. of the Woolhope

Club, were our guides, and brakes were taken at the Station for the day's excursion.

In ascending the hill to the Cockshot, at Kynaston, in the parish of Much Marcle, the celebrated landslip, called the "Wonder," was pointed out, and its history given by Mr Piper,

Quoting from Camden who says: "Near the conflux "of the Lugg and Wye, eastward, a hill which they call "Marcley Hill, in the year 1575, roused itself up, as it "were, out of sleep, and for three days together shoving "its prodigious body forward with a horrible roaring noise, "and overturning all that stood in its way, advancing "itself (to the great astonishment of the beholders) to a "higher station: by that kind of earthquake, I suppose, "which Naturalists call Brasmatia."

Science now enables us to give a more simple explanation. The Ludlow formation here consists of a series of beds of clay and limestone; and as the clay is of an unctuous character, after heavy rain the water percolates until its progress is arrested by one of the clay bands which it softens, reducing it to a soapy state. The limestone which rests upon the clay, owing to the great weight of the beds above it, is forced forward, and in slipping down the hill formed the uneven tumbled ground which we now see.

A halt was made at the Cockshot, where Mr Piper gave a graphic description of the geology of the district, and just before reaching the village of Woolhope a fine quarry of the celebrated Woolhope limestone was examined.

After luncheon at the "Crown" a visit was made to the Church, which has been carefully restored. On a tombstone in the Churchyard are the following quaint lines:—

All you that pass this way along,
Pray think how sudden we was gone;
God does not always warning give,
Therefore be careful how you live.

Carriages were again taken, and in passing through the village, I recognised, at the Lodge of Wessington Court, a large mass of coral, which, on examination, proved to be Cyathophylleum truncatum (Wenlock) which I am glad to say is now in the Museum at Hereford. It is one ft. ten in. high with a maximum circumference of about five ft.

On reaching Scutterdine an inspection was made of a fine section in the Woolhope limestone, shewing its peculiar nodular condition, more particularly of the lower beds, some specimens of which were taken away by the Hon. Secretary, from whom we hope to have the result of his microscopic examinations.

It was in this quarry the late Rev. W. S. Symonds found some noble trilobites, and large specimens of Rhynchonella Stricklandi.

A return was made to Woolhope, and as the programme did not admit of time for dinner the members were well satisfied with an excellent tea at the "Crown."

During the day a fine specimen was found of "Astragalus glycyphyllos"—Sweet Astragal, Milk Vetch, a plant new to many of the members. Bentham, in his "British Flora" remarks: "this plant occurs in rather "dry, open woods and bushy places, over the greater part "of Europe and Russian Asia, except the extreme North. "Not common in Britain, although it ranges over a great "part of England, especially the Eastern Counties, and "Southern Scotland; rarer in the North; not recorded in "Ireland."

Near Woolhope Church, Mr Moore pointed out the Anthyllis vulneraria—Kidney Vetch—Lady's-fingers—also Melilotus arvensis—Field Melilot, and close to Scutterdine, Cynoglossum officinale—Hound's Tongue, was found.

The weather was beautiful for the drive back to Ledbury, and as the Country was new to the members they appreciated the glorious view in descending the Cockshot Hill. The long ridge of the Malverns shewed grandly, and in our front was the familiar range of the Western escarpment of the Cotteswolds, of which all the prominent points could readily be distinguished.

I confess I am not satisfied with the general explanation in the text books of Geology on the denudation of the Woolhope Dome; but the complicated character of the subject forbids my hoping for sufficient leisure to work it out.

BATH, 21st JULY, 1892

A large party of members left by Midland Railway at 10.38 a.m., and on arrival at Bath they were met by one of our Vice-Presidents—the Rev. H. H. Winwood—who conducted us to the celebrated section at Weston in the Rhætic and Lower Lias, and called attention to each of the beds in the section before us. He also gave a very clear explanation of the general Geology of the Bath area.

The members were much interested in the old Roman Baths, which are now the property of the Corporation.

The modern Baths were also visited, their various uses explained, and they appear well adapted to the requirements of the age, being probably as complete as any in Europe.

I refer those who wish a full description of the Roman Baths and a history of their discovery, to an excellent paper by Major Charles E. Davis, F.S.A., in the Transactions of the Bristol and Gloucestershire Archæological Society, Vol. VIII, part I.

The Museum was visited, and its fine contents, mostly collected by our late colleague, Mr Chas. Moore, explained by Mr Winwood.

A short time was spent at the Abbey, the leading features of which were pointed out by Mr T. Brown, the Architect; after which the members dined at the Pump Room Hotel.

I have not thought it necessary to enter fully into the details of the Meeting as Bath was visited by the Club on the 14th September, 1865, when the British Association met there; also in July, 1866, June, 1873, and again in August, 1881, all of which meetings are referred to in the Annual Address of the time, by our late President, Sir W. Guise, who contributed a paper in our Proceedings, Vol. II, page 176, "Notes on the Inferior Oolite in the Neighbourhood of Bath."

I must, however, place on record how much we were indebted to Mr Winwood for the valuable information he gave us, and for his admirable arrangements of the day's excursion.

CLEEVE HILL, 26th AUGUST

Carriages were taken from the Cheltenham Station to the "Rising Sun," from whence the members walked to the quarries, where a halt was made, and the Hon. Sec., Mr Wethered, gave a lucid description of the three divisions of the Lias in front of us, and referred to the difference of opinion which existed as to the top bed of the Upper Lias, or basement bed of the Inferior Oolite; and mentioned that in a paper on the subject which he contributed to the Quarterly Journal of the Geological Society he had given them the name of "Transition beds."

He then passed to the beds next in succession in the series, and exhibited some beautiful photographic prints of their Oolitic structure, as seen under the microscope, shewing tubules growing round a nucleus, generally a fragment of a calcareous organism—in some cases an entire one, as a Foraminifera—but whether the tubules were of animal or vegetable origin he was not prepared to say.

BOULDER FROM CLEEVE CLOUD

A short walk brought the members to the ancient camp, one of the many formed as a defence against the Silures. On a flat surface below, a large cubical stone, known as "Huddlestone's table," was pointed out. It was placed there about 300 years ago in lieu of an earlier stone which marked the spot where in 811, Kenulph parted from Eadbert, a priest, and Siren, a famous noble, after they had been to the dedication of Winchcombe Abbey.

I conducted the party to a small opening in a sand pit, near the eleventh golf hole on the hill, to which my attention had been called by Mr J. W. Gray, of Stockport, who was induced to write to me in consequence of having once accompanied the Cotteswold Club to Sharpness, when I gave an exposition of the Drifts there.

In the summer of 1891, when Mr Gray was staying at Cheltenham, he made an excursion to Cleeve Cloud, and in his letter he mentioned having found a pit in which were about three feet of sandy clay and some masses of hard white rock, some rounded on the under side. There was some brown sand which appeared to pass or become consolidated into, a hard rock. Underneath this rock was a white sand which, on analysis, was found to contain ninety-seven per cent. of silica. The white fragments, some of which had the appearance of boulders, contained sixty-three per cent. of silica; but a brown one, only one per cent.

In May, accompanied by our Hon. Sec., I went in search of the pit which we found with some difficulty. In it, near the surface, was a large boulder resembling in shape a hog's back, measuring three ft. ten in. in length, and four ft. ten in. in girth, which is now in the Gloucester Museum. (See plate).

I at once recognised the sand as belonging to the quartzose series, described in my paper in the Proceedings: "On the Gravels of the Severn, Avon, and Evenlode, and their extension over the Cotteswold Hills," published in Vol. V, page 71; and in a supplementary one, "On the extension of the Northern Drift and Boulder Clay over the Cotteswold Range." Vol. VII, page 50.

On June the 17th I again visited the section with Mr Gray, and Mr Percy Kendall, a distinguished glacial geologist, when the accompanying section was made.

On one side of the pit was a hard rock dipping at an angle of 45°, and upon the upper part of it were imperfect fossil impressions, and the joints in the section were filled with clay.

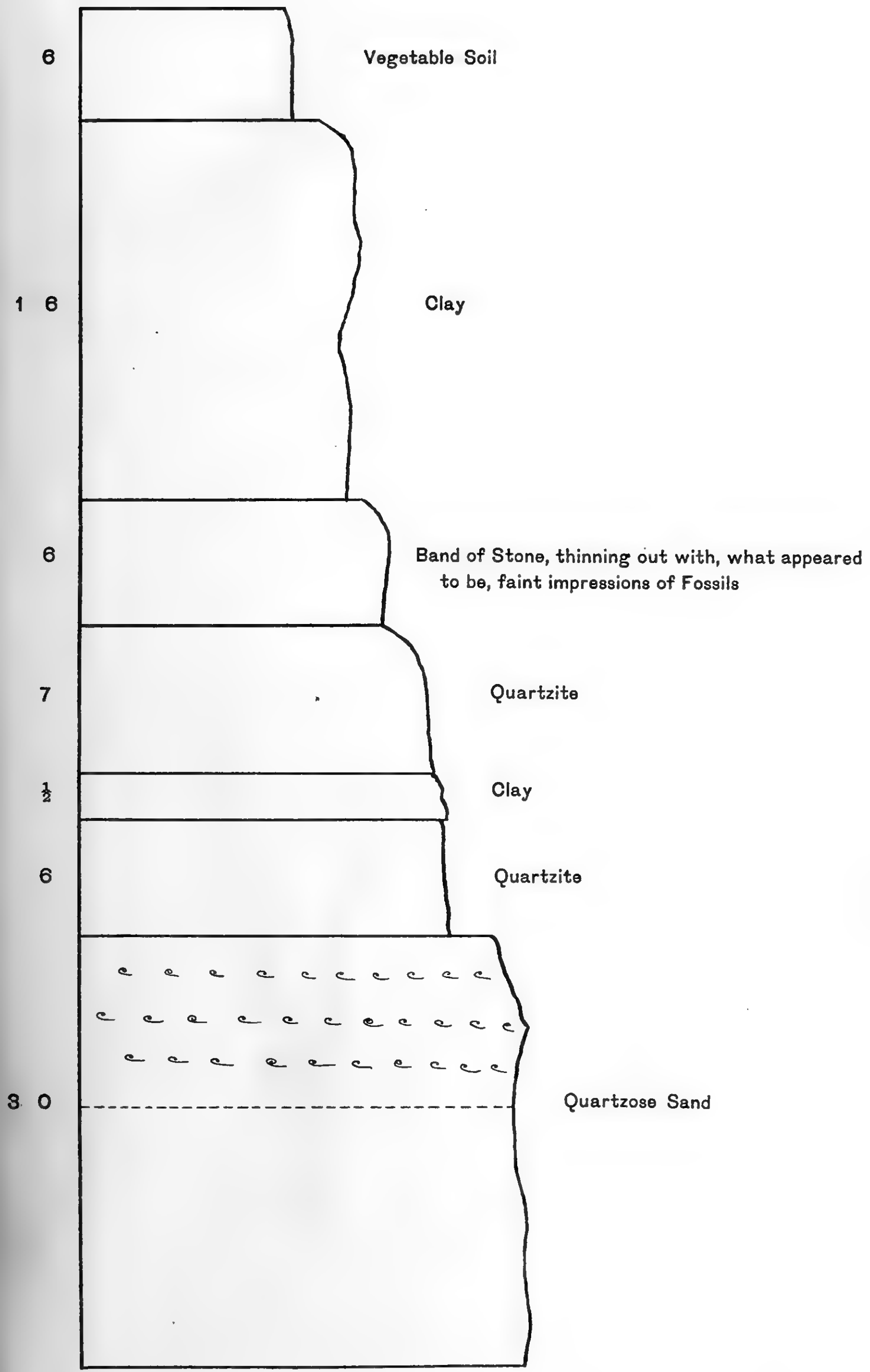
Near there Mr Kendall picked up, on the surface, a small boulder of old Red Sandstone.

On the way to the "Rising Sun," crossing a valley about a quarter of a mile distant from the pit, Mr Gray, Mr Kendall, and I saw, underneath some Oolitic detritus, a small cavern which had been made to get out the same quartzose sand, and in it were small pieces of quartzite.

Prior to our Club Meeting, men were obtained who increased the size of the opening, and the first section given above was no longer applicable. A further excavation shewed a foot of the same quartzose sand, then it gradually became reduced more to a clay, from attrition, in which were found some impressions of Oolitic shells, a thin seam of blue clay, afterwards a like clay to that above it, and near the bottom a small piece of quartzite; and at a total depth of four feet below the section made with Mr Gray and Mr Kendall water came in.

The presence of some Oolite slabs apparantly in situ, in the section made with Mr Gray and Mr Kendall, rather puzzled me; but after the wider opening and deepening had been made the explanation became clear.

The hole is a depression in the Oolite and the quartzose sand, with the large boulder in it, belong to the period of the great submergence. The same sand also appears in several other places on the hill side.


6
Vegetable Soil
1 6
Clay
6
Band of Stone, thinning out with, what appeared to be, faint impressions of Fossils
7
Quartzite
½
Clay
6
Quartzite
3 0
Quartzose Sand

The form of the boulder is due to attrition during its transportation. From its being so coated with the quartzose sand which is cemented round it, it is evident that the boulder must have travelled a long way in the sand.

The Oolite slabs were really detached by the same force which brought the boulder into its present position; the finding of fairly good impressions of Oolitic fossils shewing the same history; and the large quantity of silica in the clay proves that it was derived from the quartzose sand reduced by attrition.

In my paper on the gravels I have recorded boulders of Carboniferous limestone, Millstone grit, Coal Measure Sandstone, &c., &c., in the Northern Cotteswolds, but not at so great an elevation; and I have shewn that Northern Drift pebbles and boulder clay are found at the greatest altitude of the Cotteswold range.

In Volume IX, p. 393, will be seen a description of two Carboniferous pebbles attached to Great Oolite found on Minchinhampton Common by Mr A. E. Smith, of Nailsworth.

It is, I know, very difficult to those who are not students of this part of the Earth's history to realise the changes which then took place; and after more than a quarter of a century's work upon the subject, the general principles seem to me established, although there is much difference of opinion as to what occurred during the intervals between the great disturbances.

We have been taught that the Northern and Eastern parts of England are the districts for the study of Glacial action; and it is true in these areas striation occurs more frequently and is better seen, as the hard rocks retain the impression of the striæ, which our soft Oolites would not, since they would be crushed from the want of density to resist the pressure; and I therefore claim, the top of Cleeve Cloud as a fine example of Glacial denudation.

From it can be traced boulders from the North, red chalk from Lincolnshire, the presence of Northern Drift on the West of the Severn mingled with the Oolite; the Jurassic outliers which have been detached by denudation from the main body of the formation, and the widening of the valley now separating the secondary formation on the East from the primary on the West.

From the pit I made the following short address on the subject:—

There is every reason to believe that, towards the close of the Pliocene period, a gradual lowering of temperature took place, which increased as the Glacial period set in.

Now I will endeavour very briefly to describe what I think was the aspect which the country before us then presented to the eye.

The Cotteswolds formed a higher range of hills than now, and extended far into the valley, to the then slopes of the Malverns; the latter range probably coming somewhat further eastward.

The evidence of the Cotteswold extension is shewn in the numerous outliers of Oolite in the Lias valley, as seen at Bredon, Oxenton, Robin's Wood Hill, Meon; and those rather lower outliers of Alderton and Churchdown, which are capped with Upper Lias, the Oolite having been denuded. The connection with the table-land of the Cotteswolds is evident from a comparison of the heights:

Bredon - - - - -	975 feet
Leckhampton - - - -	978 ,,
Birdlip - - - - -	955 ,,
Painswick Beacon - - -	929 ,,

I am disposed to think the Severn, which you will observe on the map is considerably West of the Cotteswolds, has not materially changed its course.

We are now to consider the Glacial period, in which there is strong evidence of a great submergence. The current came from the North, bringing down with it

Icebergs, which, acting on a soft formation like the Oolite, would in course of time wear it away, forming a large valley, though not of the size we now see it.

It was during this epoch that the rocks we find in our gravels and on the highest point of the range were derived from Scotland and the North of England; and the boulder lately discovered at Cleeve confirms this.

This Drift doubtless reached as high as the present high-level terraces, and the Severn was probably filled with it, remains of which were found in its bed after the great storm in which the "Royal Charter" was wrecked, when a strong south-westerly wind occurred which swept away a good deal of sand in the lower part of the River above Sharpness, exposing a great quantity of large rounded pebbles of Northern Drift; and when sinking the cylinders in the deep water for the Severn Bridge, Northern Drift was also met with in considerable thickness. The boulder clay probably belongs to the later period of this Drift, and was deposited on the hills, most of it afterwards being swept away; and the enormous thickness it once attained is evident from the way in which it is forced into the fissures of the Oolite quarries not only vertically, but many feet down, *laterally*.

From an examination of the boulder clays taken at distant points in this area, it may not be uninteresting to show how their identification is traced.

In my papers on the "Gravels of Severn, Avon, and Evenlode," I mentioned I had not then been able to find Northern Drift pebbles higher than seven-hundred-and-fifty feet. Professor Phillips in his "Geology of the Thames Valley," says of the Drift:—

"It may have covered those highest hills (Chalk and "Oolite) but proof fails at seven-hundred-and-fifty feet "according to the careful researches, which I am happy "to confirm of Mr Hull and Mr Lucy."

In a note, however I said the clay partings at Woodchester, in which quartz pebbles occur, might belong to the Boulder period. The clays were found on analysis to be the same:—

Woodchester gave - -	70·50	of silica
Cleeve Cloud, taken from the surface - - - -	67·2	,,
Symonds Hall Farm (ridge) -	69·58	,,
Painswick Hill - - -	68·2	,,

In walking over the field at Symonds Hall Farm, with the late Mr G. F. Playne, he picked up a piece of boulder clay which, on examination, contained quartz pebbles; the clay, as mentioned above, containing 69·58 of silica.

Sometime afterwards I found in a gravel pit of Oolite at Frampton some pieces of the same clay with 69·60 of silica, which shewed the great denudation which had taken place as the gravel and clay were derived from the top of the Cotteswold Range five to six miles distant.

A gradual upheaval of the land occurred with some amelioration of temperature, and after it was raised above the sea, to about its present height, rather colder conditions occurred and another kind of denudation in the form of frozen snow, or land ice set in.

The summers then are thought to have been very like those of Greenland now, which often reach a high temperature. The melted snow would carry large masses of the soft friable Oolite, upon which it rested, into the valleys; and in their progress they would be much broken up, and deposited in large heaps.

Another much smaller subsidence subsequently occurred and the water came up the Severn Valley, levelling down the masses of rock, reducing them much by attrition; which explains how the gravels were formed, now some distance from the foot of the Cotteswolds, as at Barnwood, Coaley Junction, Frampton, and elsewhere. There is little doubt that such was the case, as there is no agent known but water which would level gravel in this manner.

The water then receded, leaving the land probably some fifty feet higher than it is now, and it was during this period the present submerged forests and peat beds, like those at Sharpness, grew. A rise of one-hundred-and-twenty feet would be sufficient to make nearly the whole of the Bristol Channel dry ground, with probably a river running through it of much the same size as the Severn is now at Gloucester.

A distinguished French writer—M. Belgrand—believes that when the Glacial period was brought suddenly to a close, it was succeeded by the peat deposits, owing to the diminished rain-fall leaving the rivers clearer, and under conditions favorable for the growth of peat, which, he shews, never takes place in river valleys subject to frequent and heavy floods; but always in valleys where springs abound, and the floods are few and not turbulent.

The ground afterwards sank, and although there may have since been some oscillations in level they have probably been unimportant.

In looking at the valley before us few persons are, perhaps, aware of how great a change would be effected by a depression of the ground to the extent of one-hundred feet. The present level at the Gloucester Gaol is only thirty-six feet above the sea—at St. Michael's Church at the Cross, about the highest point in the City, sixty-six feet—at the Lunatic Asylum, eighty-nine feet—Upton-on-Severn Church, fifty-one feet, and Worcester Cathedral, eighty-seven feet. Instead of the present fertile plain, there would be a large inland lake, which it once was.

May we not say with Tennyson—

> There rolls the deep, where green the tree,
> O earth what changes hast thou seen!
> There where the long street roars hath been
> The stillness of the central sea.

The hills are shadows, and they flow
From form to form, and nothing stands;
They melt like mists, the solid lands.
Like clouds they shape themselves and go.

NEIGHBOURHOOD OF NEWENT

15th September

The fourth and last Meeting was largely attended—and on arrival of the train at Newent carriages were taken.

A halt was made at the Railway Bridge outside the town, where I indicated the spot in the Waterstones, suggested by Mr Etheridge, to ascertain by boring whether a supply of water could be obtained for the City of Gloucester; explaining by the aid of the geological survey map, the various New Red Sandstone formations or divisions, their thickness in this and other districts in England, and the nature and character of the beds, dwelling somewhat in detail upon the Salt beds or rocks at Droitwich, which have been worked for upwards of a thousand years. It must in very early times have been an important industry, as in 816 a grant was made of the then working by Kenulph, King of the Mercians, as a source of revenue to Worcester Cathedral.

Mr Taunton, C.E., who had considerable experience as a Water Engineer, and who contributed many valuable papers in our Proceedings on the water question, remarked: "from the absence of hills in the neighbourhood he doubted if there was sufficient gathering ground to give any great quantity of water."

I also pointed out that only a small quantity of the water of the area finds its way into the Severn—the only river being the Leadon. This is shewn by the absence of springs, which arises from the porous character of the beds affording rapid filtration to the rain, which passes down to a considerable depth in the rocks.

Within three quarters of a mile, at the coal shaft, is a large quantity of water—and that underground reservoirs are not uncommon was shewn during the construction of the Severn Tunnel, which was flooded more than once by land springs being cut when the approaches to it were made.

Reference was made to the cause of the red oxide of iron which gives the colour to the New Red Sandstone, of which the following explanation in Professor Phillips' book on the "Geology of Oxford and Valley of the Thames," page 99.

The sea received at successive times the spoils of different lands by currents arriving in different directions. There was first a pre-Cambrian land, which yielded one set of materials; next a pre-Silurian land, whose mineral constitution was not the same. Then Silurian land appeared, followed by Devonian and Carboniferous land.

Twice in this flow of time came the red deposits, which may be called exceptional, and whose origin is not explored. We may indeed suppose the sesquioxide of the Poikilitic series to have been derived from the red hæmatites of the carboniferous limestone (this hæmatite is often of Permian age) or, as has been sometimes conjectured, from the old red rocks; but in each of these cases remains the question: "Whence came originally the red oxide?" Perhaps, we may answer, from decomposed minerals of volcanic or metamorphic origin; silicated peroxides altered in an immensity of time by the slow action of the elements. In this point of view it is worth calling to mind that enormous physical changes—great displacements of land and sea—preceded, in each case, the deposition of the only two extensive and abundant stratified deposits of red oxide of iron known in Europe. One later case occurs, indeed, at the base of the chalk of Yorkshire, Lincolnshire, and Norfolk, and for that a similar supposition has been proposed.

To complete the retrospect, we have only to call attention to the well-established fact of the paucity of fossils in the purely red beds; their comparative rarity, or even total absence, in the purple beds; and their abundance (even contemporaneous abundance) in the grey beds. Was marine life very rare in the directions from which the red streams flowed? Was the fine red mud hostile to the growth of mollusks and corals by impeding the action of the respiratory organs? Or, finally, were the sediments brought down by great rivers like the Mississippi and its branches, and so necessarily almost devoid of ocean life? We may adopt such a conjecture as the last with no great hesitation, and it agrees in some degree with the ingenious supposition of Mr Godwin Austen, without requiring, as he does, that the sediments should have been deposited in a lake of fresh water.

The Members went to Oxenhall Church, and afterwards to the once celebrated Newent Coal Field, where I shewed the accompanying section given me by Mr Fox, C.E.

Some discussion took place as to whether the coal was, as suggested by Mr Hosköld, a lagoon deposit in the old Red. To this view Mr Wethered and I expressed our dissent, believing that the evidence was decidedly in favor of its being merely an out-crop of the Carboniferous series which was also the opinion of the late Rev. W. S. Symonds.

Thence to the Castle Tump, from the summit of which I gave a brief explanation of the Geological formations to be seen from there, ranging from the Silurians of the Malverns to the Oolites of the Cotteswolds.

On arriving at Dymock a substantial dinner was done ample justice to, and afterwards the Church was visited, and its leading features explained by Mr F. W. Waller.

Carriages were resumed to Pauntley, whose interesting Church was also described by Mr Waller.

Rudge, in his "History of Gloucestershire," says of this parish:—

"The Manor appears, by the Sheriff's Return, 1281, to have been in William de Whytington. By the Inquisition taken 1311, William, son of the last, was found to be the next heir of John, son of Thomas de Solers, then 24 years of age, in whom the Manor and Estates were probably united.

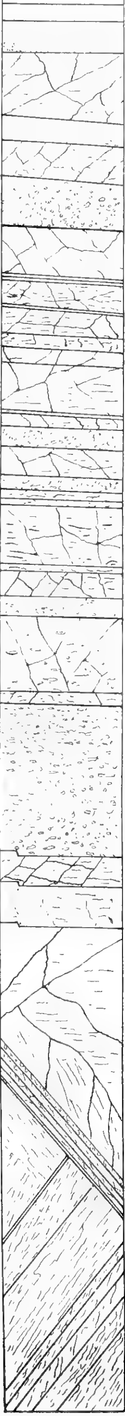
"The family of Whittington were proprietors from this period till the year 1546. Richard de Whittington, the celebrated Lord Mayor of London, was the younger son of William."

Red Sandstone	1	0	3	

SECTION OF COAL FIELD NEAR NEWENT

SHAFT B.

EAST | WEST



Strata	Thickness Yds.	Ft.	Ins.
Raised Ground	1	1	0
Soil and Sand	2	2	0
Sandstone	5	0	0
Clod	2	0	0
Sandstone	3	0	0
Clod and Conglomerate	4	0	0
Sandstone	4	0	0
Red Marl			6
Light Sandstone			6
Red Sandstone	2	1	0
Marl Partings			1
Red Sandstone	2	0	0
Red Rocky Marl	1	0	6
Red Sandstone	1	0	6
Red Sandstone	4	0	0
Rocky Marl			9
Red Sandstone	1	0	0
Dark Pebbly Ground	1	2	0
Sandstone	2	1	0
Sandstone Conglomerate	1	0	6
Rocky Marl		2	0
Red Marl		1	6
Red Sandstone	4	2	6
Rocky Marl		1	6
Strong Dark Sandstone Rock	2	0	4
Conglomerate	1	1	8
Red Pebbly Sandstones	6	0	9
Red Sandstone	1	0	3
Conglomerate	12	0	0
Red Sandstone	2	1	6
Marl and Sandstone	3	1	0
Sandstone	11	0	3
Sandstone full of Pebbles		2	3
Soft Red Marl		2	0
Light Rocky Marl		2	3
Dark Rocky Marl		2	6
Light Blue Rock			3
Rocky Marl	9	1	11
Light Blue Rock			8
Soft Red Marl	5	0	6
Brown Binds	5	2	0
Dark Grey Binds	4	0	6
Dark Binds	1	0	6
Dark Fire Clay	1	1	6
Dark Blue Binds	1	2	9
	118	1	2
Blue Binds and Fire Clays			

Scale 20 feet to an inch.

The Arms of the Whittingtons are to be seen at the East end of the Church.

In the churchyard at Dymock is a very large handsome yew tree, the branches not having been cut; and at Pauntley is one of larger girth, but it is too much trimmed to be graceful.

As Mr Waller has treated very ably of these Churches in his paper at our Evening Meeting on the 20th February, no further remark is necessary here.

A long, but pleasant, drive to Gloucester terminated our last Field Meeting.

THE FIRST EVENING MEETING

Was on November 22nd, 1892, when Professor Allen Harker read a paper on "The History of a great Physiological Discovery, and its bearing on Agriculture and Economics."

The second Meeting took place on January 17th, 1893, the paper, "On the Origin of the Names of Places," with special reference to Gloucestershire, its Folk-lore and Traditions; and a short account of thirteen parishes in Gloucestershire, by way of illustration, by the Rev. A. R. Winnington-Ingram.

The third Meeting on February 20th, when a paper was read by F. W. Waller, Esq., "Some Notes on Dymock and Pauntley Churches, with illustrations of the buildings as they now are, and a reference to certain structural alterations which have been effected at different times."

Mr H. G. Madan afterwards exhibited some specimens of the curious volcanic product called "Pélé's hair," from the crater of Kilanea, on the side of the great volcano of Mauna Loa, in Hawaii. This consists of a mass of fine filaments of lava, bearing a very close resemblance to brown hair, believed by the natives to belong to Pélé, the goddess presiding over the volcano. It is formed in the following way:—The crater is always half-full of an unusually fluid kind of lava, in a state of constant agitation, owing to the outburst of gases. Waves of this fiery liquid are shattered against the rocky sides of the crater; and the drops as they break away from the mass carry away with them one or more fine threads of the material, which float away in the wind and collect in tufts on adjacent rocks. (See an account by Prof. Moseley in the "Narrative of the Challenger Expedition," Vol. I, part 2, p. 768).

Specimens of the so-called "slag-wool" were also shewn: a product manufactured in a very analogous way, *viz.:* by blowing jets of high-pressure and super-heated steam through liquid blast-furnace slag. This is now extensively used for covering boilers and steam-pipes, owing to its being an extremely bad conductor of heat, and quite incombustible.

Mr Etheridge, F.R.S., gave the fourth and last paper, taking for his subject, "Rivers of the Upper Region of the Thames."

That the closing lecture during my Presidency should have been given by my old friend, Mr Etheridge, was a real pleasure to me, and it is a very valuable contribution to our Proceedings.

As all these papers will be published in the usual course no extract from them here is necessary.

And now Gentlemen, as President of the Club for the last six years, it is with deep regret that I tender you my resignation.

To be no longer your leader—to give up a position of which I have been justly proud—is indeed painful.

I shall always be grateful for the aid I have received from my colleagues—your Vice-Presidents, your very able Hon. Secretary, upon whom much of the work has devolved; and your excellent Hon. Treasurer.

But, however good the executive may be, it is to the Members themselves that a President of a Club like ours must mainly rely for support—a support you have always so fully, and so kindly, given me.

Since the Club was established in 1846, I have only had two predecessors—both men of distinguished ability.

My great wish has been to maintain the reputation of the Club, and should it have suffered during my Presidency I can only plead that I have done my best: and in bidding you farewell as President I assure you that I am deeply thankful for the kindness you have ever shewn me, and which I shall never forget.

A PAPER

READ BEFORE THE COTTESWOLD CLUB AT GLOUCESTER

JANUARY 17th, 1893

BY

THE REV. A. R. WINNINGTON-INGRAM

(RECTOR OF LASSINGTON)

ON THE ORIGIN OF NAMES OF PLACES WITH SPECIAL REFERENCE TO GLOUCESTERSHIRE, ITS FOLK-LORE AND TRADITIONS; AND A SHORT ACCOUNT OF THIRTEEN PARISHES IN GLOUCESTERSHIRE BY WAY OF ILLUSTRATION

The science of the derivation of names, whether of places or of men is very interesting, and one which provides the student of it with continual entertainment and instruction. As he travels about he is furnished, as it were, with a lantern to illuminate the dark and obscure meaning of the names of the places and of the people that he meets, and what is mere senseless jargon to others becomes to him full of signification.

Wherever he goes he traces with delight indications of the former appearance of the country, of the original dwellers in it, of their faiths, of their modes of life, and of their achievements. But in order to see all these things a light is necessary, and that light is a knowledge of the origin of names.

To enter the better into our subject, let us turn our thoughts back many centuries, and behold with the mind's eye the country in its early state, when it was frequently invaded by foreigners, when it was clothed with vast forests full of wild animals, with here and there a clearing which was inhabited by a few rude and unlettered men, whose habits and ideas were of the most primitive description; when scattered over the country in commanding situations were the Castles of Chieftains or of the great Barons, who kept all around them beneath their sway; when the wealthy monasteries served as schools, hotels, and poor-houses; when the towns were in their infancy, and the industries in them were for the most part carried on by hand.

Still in our researches we must not confine ourselves entirely to the earlier periods, but must follow the course of the great river of time till it loses itself in the absorbing ocean of modern days.

Having said thus much by way of preface, I will now proceed to give a few of the chief origins of the names of places, and through places sometimes of men.

Ton was used to signify a farm and its surroundings, and has become part of the name of many villages, which, as the population increased, sprung up around the original farm. To illustrate the ancient use of the word *Ton* I may quote from Wycliff's Bible. In the parable of the Prodigal Son his rendering is: "And he wente and drough him to one of the cyteseynes of that country and he sente him into his toun to feed swyn." This word *ton* is used in combination with some other word, as Nor-ton, North-town. In Scotland there is Tong, and in Yorkshire Tonge, probably from the same origin.

Ham, Saxon, meant a private estate with a village on it—a manor. *Wickham* was a superior farm-house, and took the place of the Roman Villa, and came to be the manor-house. The German form is *hiem*, the English *home*. The old form *ham* continues in local names, Examples—Cheltenham, Newnham; but in general English it has come to bear the meaning of *home*.

Leys were open forest glades were the cattle loved to lie. And in some cases *Ley* was applied to land that lay fallow for a year or two. We may find this word in Cowley, Berkeley.

Dens were deep wooded valleys, often used as swine pastures. As these *Dens* afforded shelter to various animals so they had various prefixes, as Hare-den or Harden, Sow-den or Sugden, Hog-den or Ogden.

Worth is a common suffix in Gloucestershire, and means a sufficiently warded place, but came to denote a small homestead or an enclosure. *Worth* is connected with an old verb, which we find in our Bible; we read in Ezekiel, Ch. 30, v. 2: "Woe worth the day." This verb is the same as Werden in German, which signifies to be and to become, so *Worth* is a place where people *are* in residence. Examples—Ashleworth, Wallsworth, Brockworth.

Dole is sometimes found in connection with the names of fields. *Dol* is a British word for a meadow. But it probably means an allotment, that is a piece of ground cut up among a number of persons; just as we say a *dole* of food. In Bulley parish we find Shewell's Dole and Tucker's Dole; in Huntley there is Gingell's Dole.

Load, or *Lade* is often found in Gloucestershire in connection with rivers. It is derived from the verb to lead, and used to mean a place where the cattle could be led over. But now it often signifies a ferry. Examples—The Lower Load at Tewkesbury, Framiload, St. Mary de Lode, Lechlade.

Croft was an inclosed field for pasture, but has given rise to such combinations as Ban-Croft or Beancroft, Bere-Croft or Barley Croft or perhaps Bare-Croft. Example—Lao Croft in Dymock, Lao Croft means Hill Croft.

Hurst was a name for a wood. Hazle-hurst a wood where there were hazles. Lyndhurst a wood where lime trees were. Brocklehurst a wood where there were badgers. Local example—Sandhurst.

Shaw was a shelter for game. The surname Bagshaw means Badger's Shaw.

Holt was a small thicket; which word may be found in Aldershot: that is, Alder's-Holt.

Slad is said to be derived from the Saxon word *slidan* to slide, and so is applied to a landslip. Several places in Gloucestershire on the slopes of hills are thus named, for instance, *Slad*, between Painswick and Stroud. Sometimes Slad is applied to a small green plain within a Wood-land.

A *Knowle* was a gently rising slope. Examples—Tuffley Knowle, Knibley Knowle—The surname Knowles.

Borough, *Barrow*, and *Bury* or *Pury*. Some draw a distinction between "*Beorh*" whence Bury a hill, and "*Burh*" whence "*Borough*" a town. It seems probable that when the names were separated, *Bury* signified an earthwork or camp, while *Borough* meant a more regularly fortified town. But it is wonderful how the strict meaning of *shelter* is preserved in all the terms founded upon the root of *Beorgan* to hide. Is it a repository to guard the ashes of the dead? It is a *Barrow*, the act of sepulture itself being the *burial*. Is it a refuge for the conies? It is a *burrow* or beare as in Conebeare. Is it a raised mound for the security of man? It is a Bury, Borough, Brough, or Burgh. Examples—Hartpury, Rodborough.

Pills. All along the Severn Estuary are a number of Pills, that is to say little creeks or outlets of water. The word *Pill* is British, and is much the same as the Welsh *Pwll* whence Pwllheli. From this word Pwll we get our word Pool. In Gloucestershire we find Garden Pill, Bullo Pill, etc.

Coombe is a ridgy hollow on a hill-side, and is allied to the Welsh *Cwm*. Coombe is very common in Devon, Sussex and Surrey. In Gloucestershire we have Coombe Hill and Stinchcoombe.

Clough is a narrow fissure between hills. Hence *Cleeve*.

Among other origins of names, the Danish invasions gave rise to such words as *Ravenhills* Raffnals. This is owing to the Danish standard having been a Raven. This mysterious banner which consisted of a Raven with open beak and extended wings on a ground of white silk was embroidered by the three sisters of King Sweyn in one night with magic incantations. Date 1004 to 1006 A.D. There are people of the name of Ravenhill in the neighbourhood of Gloucester.

Cester—Chester. This termination showing the site of a Roman town is too well known to need much comment. In this county we have Gloucester, Cirencester, Woodchester.

Toot-hills. Some derive this from the Saxon word *Teotan* to look out, others from the Saxon god Teutates, who was said to be the guide over hills and track ways.

Teutates was the same as the Thoth of the Egyptians, whom Eusebius mentions as the same as Hermes. When the Cimmerian Druids migrated from Asia into Europe, they carried with them their paternal traditions of Chaldean lore, and the name Theu Tate. There is no language into which this name is more easily resolvable than the British.

Theu Tate is no more nor less than Dhiu-Tad, the Universal Parent or God the Father. The Celts popularly worshipped Mercury. The Druids secretly taught the immortality of the soul. The secret worship was of one infinite God, whose representation was the circle Thoth, Taute, Toute, Tot, Tut Tad, Ted, Tet are probably derived from the same Celtic root, and are names of places in England indicative of some tumulus or conical hill, dedicated to the great Celtic god Taute or Mercury, when there were "Ubique per Angliam, plurima simulacra," according to the testimony of Cæsar. But I may mention that in the *Gentleman's Magazine* for January, 1829, doubts are stated as to the identity of the Egyptian Thoth with Hermes or the Gaulish Mercurius Teutates, and arguing that Taut or Teutates was the Egyptian Hercules, a symbol of the sun.

In Gloucestershire we find Mythe, Toot or Tute near Tewkesbury and Tetbury.

Sarn hills, *Sern* hills, *Yarn* hills and *Darn*-hills. The British word Sarn means a pavement, and it seems to indicate that there was a Druidical *Seat of Judgment*, where such names are found.

Among the Romans also the places of Judgment were paved. We are told by St. John that Pilate sat down on the Judgment Seat in a place that is called the pavement, but in the Hebrew Gabbatha—Gabbatha means elevated place.

Near Bushley there is Sarn hill. In Wales there is Sarn Hellen. In Wales Sarn is used for a road—which is a *paved* way.

Tan. The origin of this syllable which is sometimes met with in conjunction with some word as Tan-field, Tan-wood. Tan hill is derived from the Celtic god, Tanaris, the god of thunder; an altar was once dug up in Cheshire with D.O.M. Tanaro on it. The metal *tin*, from its brightness, and tinde from its connection with fire, are from the same source.

FOLK LORE

It is probable that an ancient belief in fairies has had a considerable influence in forming the names of places and of fields.

The *Ignis Fatuus* has given rise to many names, for instance Hob, Hoberdy's Lantern, Hobany's Lantern, Jack o' Lantern, Will o' the Wisp.

As a matter of fact the *Ignis Fatuus* is Carburetted Hydrogen, if it is caused by decayed vegetable matter, or

Phosphorated Hydrogen if caused by decomposing animal matter—by either of these gases coming into contact with the oxygen of the air.

Hob is from the Gothic word Hoppe, a horse. There are several legends in which fiend-horses play a prominent part, and indeed the undulating movements of the *Ignis Fatuus* resembles the cantering of a horse, which may have been the reason why the names in question have been given to it. And here we appear to have the true meaning of the word hob-goblin, that is a fiend-horse, which afterwards became a very general name for sprites, in whatever form they might appear. Horsemen who were stationed in particular places to give notice of the approach of the enemy were called "*Hobelers.*"

There is Hob's Hole Coppice in Aston in Blockley. Hob Well in Great Malvern, and Hoberdy Hill in Kempsey.

Dobbie. The name of this species of fairy, like the words Hobby and Hob, are from the Gothic *Hoppe* a horse. The word Dobbin is to this day a provincial name for a horse.

Dobbies were demons who attached themselves to particular farms and houses, like the *Brownies* in Scotland, and though generally lazy, sometimes assisted with the work, and sometimes played mischievous tricks.

There is Dobbin's Hill in The Berrow, Dobb's Hill in Eldersfield, and Lower Dobbins in Mathon.

Puck or Robin Good Fellow was a frolicsome, night-loving rogue. See "Midsummer Nights' Dream." The Irish Puck, or Pooka was a malignant spirit. *Hob thrush* was a Hob Goblin, called sometimes Robbin Good Fellow. In the North Hob-thrush or rather Hob o' t' hurst was a spirit supposed to haunt woods only. It has been said that the village of Dorsington derives its name from a word very similar to this, meaning a bushy place.

In Gloucestershire we have Puckle Church Hundred and Parish Puckmere in Dymock, and Puck pit in Maisemore.

Will o' the Wisp, a personification from the Saxon *Wile*, meaning deceit, and *Wisp* a small bundle of straw ignited. The Will o' the Wisp or *Ignis Fatuus* has been seen in the Leadon Meadows at Lassington. There is Will's Field in Gloucestershire, and Wilkin's Field in Pendock.

Mab, Tom Thumb, Patch, Grim Tib, Pin, Trip, Tick, etc., are all names of Fairies.

In Herefordshire there is Mabbled Plock, that is a field in which one would be liable to be Mab—led. I have myself heard country people say of a man who was stupified that he was Mambled or Mombled—clearly from Mab—led.

In Gloucestershire there is Pinswell Camp, and Triphurst. In Madresfield there is Drypshill. And in Handley Castle, Tickridge.

A Short Account of Thirteen Parishes in Gloucestershire by way of illustration

Lassington, formerly Lassingdon and Lessedune or Lesser Down, or elevated spot in opposition to Churchdown, which was the greater Down, both of which were at one time held by the same proprietor.

In the reign of Edward the Confessor, Ulchatel held Lessedune in Langebridge Hundred, a manor of two hides. Roger held it of Thomas, Archbishop of York, in the time of the Conqueror. The family of Musgros, was possessed of two-thirds of it for many generations, one of whom, (Walter) gave to the Hospital of St. Bartholomew, in Gloucester, two cranocs (eight bushels) of oats, payable out of his barn at Lessedune, on Michaelmas Day, for ever.

Names of places and fields in Lassington, Twin Hedges, Hawk's Hill, Leg of Mutton, Butts, Inage, Portway, Weatherley Hill, Cuckoo Pen (Wood), Reddings (Wood), Brimstone Meadow, Upper Yells, Rodway, Pope's Meadow, Upper Peter's, Lower Peter's, Lonkridge.

Maisemore, or Mayesmore, or Mazemore, does not occur in Domesday, it being a member of St. Mary de Lode, in Gloucester. Derivation from "Maes," a field or place; and "Mor," which in composition means water, which well describes its situation. Some, however, say that it is from Maes—More, the great field. Several places in Wales bear this name.

This parish was inclosed in 1793. The Church is dedicated to St. Giles, and the Feast of the Patron Saint is celebrated on the 1st Sunday in September.

Within the memory of living men there used to be held on Feast Sunday, games of wrestling, cudgel playing, sack-racing, and smock-running. A muffled peal is rung on Innocents' Day.

At Christmas time the villagers sing a kind of carol or wassailing song, of which the following are the words:—

THE WASSAILING BOWL

We've been a wassailing all over the town,
Our bread it is white, and our ale it is brown,
Our bowl it is made of the sycamore tree,
And a wassailing bowl we drink unto thee.

Chorus—

Wassail, wassail, our jolly wassail,
And joy shall go with our jolly wassail.

Here's a health to the ox, and to his old head,
Here's wishing our master a good loaf of bread,
A good loaf of bread that we may all see,
And a wassailing bowl we drink unto thee.

Chorus—

Wassail, wassail, our jolly wassail,
And joy shall go with our jolly wassail.

Here's a health to the ox and to his right eye,
Here's wishing our master a good Christmas pie,
A good Christmas pie that we may all see,
And a wassailing bowl we drink unto thee.
Chorus.

Here's a health to the ox and to his old horn,
Here's wishing our master a good crop of corn,
A good crop of corn that we may all see,
And a wassailing bowl we drink unto thee.
Chorus.

Here's a health to the ox and to his fore leg,
Here's wishing our master a good fat pig,
A good fat pig that we may all see,
And a wassailing bowl we drink unto thee.
Chorus.

Here's a health to the ox and to his old tail,
Here's wishing our master a good tap of ale,
A good tap of ale that we may all see,
And a wassailing bowl we drink unto thee.
Chorus.

There was an old woman who had an old cow,
To keep her cow warm she did not know how,
So she builded a barn to keep her cow warm,
And a drop of good liquor will do us no harm.
Chorus.

Come butler now bring us a bowl of your best,
And we'll hope that your soul in heaven may rest,
But if you don't bring us a bowl of your small,
Down will go butler bowl and all.
Chorus.

Our carol's done we must be gone,
We'll stay no longer here,
God bless you all, both great and small,
And send you a happy New Year.

Names of places and fields in Maisemore, Puck Pit, Farmer's Horn, Slough Wash Hill, Sinklose, Woodcroft Hides, Swingley, Wabblidge Hill, Highridden Hill, Crockley.

Hartpury, or Hardeper, or Hardepury; anciently Merewent.

Offa, King of Mercia, gave the manor of Merewent to the Nunnery established at Gloucester, when Eva was Abbess, 769 A.D.; and it continued a parcel of the possession of the Abbey of St. Peter's till the Dissolution.

The Manor House was anciently called Abbot's Place.

At the time of the French Revolution some French Nuns found refuge here, and are still remembered by some of the old inhabitants for their kindness and liberality.

The Hamlets are Moor End, Corse End, Blackwell's End, Butter's End, Morrell's End.

At Blackwell's End there is a dark stone well or spring.

A decisive skirmish was fought at Hartpury in the Civil Wars, when Colonel Myn of the Royal Forces suffered great loss. There is still a house called the King's Standing. A high bank which overlooks the Severn Valley is called Woolridge.

A Muffled Peal is rung on the Church Bells on Innocents' Day.

Names of places, fields, etc., in Hartpury, Elver Tump. *Woods:* Limbury, Catsbury, Wixlip, Darley, Mount Oliver, Rugley.

The Elver Tump is said to be so named from the inordinate quantity of elvers caught in the Severn and brought home to the Tump. Names of fields: Burleys, Colespen, Stanage, Curleys, Billy Close, Patus, Bun Hills.

A VILLEIN'S SERVICES IN THE MANOR OF HARTPURY

SERVICES OF A VIRGATE—

	s	d
A. B. holds 1 virgate of 48 acres (in the Manor of Hartpury), with messuage, and 6 acres of meadow land. From Michaelmas till August 1st he has to plough 1 day a week, each day's work being valued at	0	3½
And to do manual labour 3 days a week, each day's work being valued at	0	0½
On the 14th day to carry horse-loads if necessary to Preston and other Manors, and Gloucester, each day's work being valued at	0	1
Once a year to carry to Wick, valued at	0	3
To plough one acre called Eadacre, and to thresh the seed for the said acre, the ploughing and the threshing being valued at	0	4
To do the ploughing called "*beneherthe*," with one meal from the lord, valued "*ultracibum*" at	0	1
To lift the lord's hay for 5 days	0	2½
To hoe the lord's corn for one day (besides the customary labour) with one man valued at	0	0½
To do 1 "*bedripa*" before autumn with one man valued at ...	0	1½
To work in the lord's harvest 5 days a week, with 2 men from August 1st to Michaelmas, valued per week at ...	1	3
To do 1 bedripa, called Bondenebedripa, with 4 men valued	0	6
To do 1 harrowing a year, called Londegginge, valued at ...	0	1
To give at Michaelmas an aid of	3	3
To pay "pannage," *viz.:* for a pig of a year old	0	1
For a younger pig that can be separated	0	0½

If he brew for sale, to give 14 gallons of ale as toll.

To sell neither horse nor ox without license.

Seller and buyer to give 4d. as a toll for a horse sold within the Manor.

To redeem son and daughter at the will of the lord.

If he die, the lord to have his best beast of burden as heriot, and of his widow likewise, if she out-live her husband.

Rudford. Rodesford, anciently Rudeford. Derives its name from the redness of the soil, and from a ford over the Leadon. Highleadon is a hamlet. Highleadon House was held for the King during the Civil Wars by Colonel Myn. There was a skirmish at Rudford, and when the Canal was being dug several skeletons were unearthed.

Some of the Welshmen killed in the battle of Highnam were buried at Barber's Bridge, in Rudford, where their bodies were found by the late W. P. Price, Esq., who erected a Monument to their memory. See Article in Cotteswold Club Proceedings.

Names of places and fields in Rudford: Snow's Close, Little Martins, Big Martins, Rowet, Puggle Hole, Pinch Field, Far Heel, Home Heel.

Newent, anciently Noent. Said by Leland to mean New Inn, there being only a single house when communication was first opened up with Wales by this way.

There was anciently an Alien Priory at Newent, of which very little now remains. John Horne was burnt in the yard belonging to the Priory in the persecution in Queen Mary's reign.

In Cugley is Crocket's Hole, where one Crocket and Horne hid themselves in the reign of Queen Mary. Afterwards in 1665, one Fairfax, a disbanded soldier, advised by Lilley, the astrologer, came down from London, and opened this Hole in hopes of finding great riches therein, and drew many people thither. Some of them went into the hole and told incredible things concerning it; at last one Witcombe going in drunk and dying there put an end to all further examination. Crocket's Hole has recently been opened by Major How, of the Stardens, but nothing very remarkable has been discovered.

Tythings and Hamlets of Newent: Newent, Nellfields Farm, Compton and Court Orchard, The Scar, formerly Water's or Athlord's Place, Hays, or Heges, as in Domesday, Stardens, Ford House, Waterdine, Callow Hill, Malswick, Wyndham's, Cugley, Boulesdon, Kilcote.

At Kilcote there formerly stood a Chapel, dedicated to St. Hilary, the site of which is called St. Hilly's Nap or Tump.

Newent Church is dedicated to the Virgin Mary, the top of the Spire was blown down in 1662, and the whole of the roof fell in after service in 1673. It was repaired in 1679.

Names of places, fields, etc., in Newent: Mantley House Farm, on which is Woe Field, where local tradition says that people was burned.

Porter's Top, Corswall's Farm, Hides Croaks, Conegar, Fatlands.

NOTE ON MAY HILL

It was the custom of the youth of Newent and of the neighbourhood to meet upon Yartledon Hill, on May Day, and contend in mock battle for the possession of it. May Day was considered as the boundary day between summer and winter; in allusion to which one party of youths fought for the continuance of winter, the other for the bringing in of the spring. The party of spring was always victorious, and returned triumphantly, carrying flowers and green branches, and singing that they had brought the summer home.

Pauntley, anciently Pantelie. There was an ancient custom in Pauntley intended to prevent the smut in wheat, in some respects resembling the Scotch Beltein (or Fires of Baal).

On the eve of twelfth night, all the servants of every farmer assembled together in one of his fields that had been sown with wheat. At the ends of twelve lands they made twelve fires in a row with straw, round one of which, larger than the rest, they drank a hearty glass of cider to their master, and success to the future harvest, then returning home they feasted on cakes, made with carraways soaked in cider, which they claimed as the reward of their past labours. It has been said that these fires refer to Christ and his Twelve Apostles, who were the lights of the world. And it seems probable that a Christian meaning has been given to a custom of Pagan origin.

There is a spring of mineral water in Pauntley, a little above Paveford Bridge, called the Spa, to which it was the custom of the Newent people and others to repair on the evening of the 30th April, in order to be ready to drink the waters early on May Day. They used to light a fire to warm the water, which is of an aperient nature, and having drunk a number of horns full of it, they used to run round a field of the shape of a figure of eight, until the desired result was obtained.

This custom is falling out of use, owing to the farmer being offended at sticks being pulled out of his hedges to light the fires.

Names of places and fields in Pauntley: Paveford (*i.e.* Paved-Ford), Paveford Coppices, Harwich Coppice, Harwich Quabbs, Harwich Field.

Dymock, anciently Dimock. Derivation from Dim, dark and Ac, awoak.

On the south side of the parish there is an elevation called the Castle Tump, it is said that one of the Bohuns built a Castle here, but as there are no vestages of it remaining, and as the Tump is too small for such a building, it was probably a fort constructed during the Civil Wars.

John Kyrle, the Man of Ross, was born at the White-house, in Dymock, A.D. 1637.

Names of places and fields in Dymock: Gamage Hall, The Boyce, The Old Grange, Ryton, Ockington, The Lynch, Ketford Farm, Great Lintridge, Rowshill, Wincross, Dorlow, Berrows, Castle Meadow, Crews Field, Round Hill, Puckmore, Puckmore's Hitch, Yestlers, Quabbs, Quabb Ground, Shaice Field, Hell Piece, Hell Bridge, Dotchlo, Stanberrow, Stitch, Stitchells, Lao Croft, (from the Saxon, Hlaew a Hill) Amberley, Cob's Hole, Bow Field, Hardings, Pink's Field, Harcombe, Knaphead.

Huntley, Hunteley, anciently Huntelie. William, son Baderon, held Huntelie at the time of the Conquest in Botelaw Hundred, taxed at two hides. The Manor of Huntley was afterwards held by John Talbot, famous for his victories in France, and created Earl of Shrewsbury.

There is an immense Yew Tree in Huntley churchyard, more than 20 feet in girth. Our forefathers were careful to preserve the yew, whose branches it was usual for the mourners to carry in the funeral procession to the grave, and then to throw under the body. The branches cut off, by shooting next spring, typified the Resurrection, as the perpetual verdure did the immortality of the soul.

Names of places and fields in Huntley: Handkerchief Meadow, Stoney Hayes, Stanley, Gingell's Hole, Broom Hill, Hell Pit, Byford, Lanks, Starve Crow.

Taynton, formerly Tetington. Maud de Teynton gave the Church of Teynton to the Abbey of St. Peter's, Gloucester, to find lights. The old Church which stood at the Northern end of the parish was burnt down in the Civil Wars. The present Church, dedicated to St. Lawrence, was built during the usurpation of Cromwell, principally through the interest of Mr Thomas Pury, Lord of the Manor; it stands almost North and South.

Names of fields and places in Taynton: Fatlands, Lemans, Blakemore, Black Patch, Moors, Horn's Hill, Cinders, Charmeadow, Rylands, Ploddy House, Ireland's Hill.

Tibberton, Tybreton, anciently Tibriston. In Domesday, William, the son of Baderon, held Tibriston in Botelau hundred containing five hides, and a wood three miles long and one broad.

Names of fields and places in Tibberton: Longney, Pedners, Barton Meadow, Moor, Gillan, Steven Hay, Croft, Muzzle Patch, Cinders, (where search has been made for iron).

Bully, Bolay, anciently Bulelege. Walter Balistarius is recorded in Domesday as proprietor of Bulelege, in Westbury Hundred, taxed at four hides. The Church, which was for some time in ruins, has been recently restored. It is annexed to the living of Churcham. There is a fine Yew Tree in the Churchyard.

Names of places and fields in Bulley: English Hill, Does, Losle Field, Bisle Field, Harry Field, Handilow, Shewell's Dole, Tucker's Dole, Lake Farm. Woods: Sparke's Gutter, Pedner's Pits, Demesne Hood.

Churcham, anciently Hamme. Being the part of the *Ham* where the Church was built, to distinguish it from the other Hamlets. This was in 1281 A.D.

Highnam, Over, and Linton were hamlets forming one tithing, but lately formed into the parish of Highnam, they are in the Hundred of Dudstone and King's Barton, but anciently Tolangbridges. The two manors of Churcham and Highnam were given by mandate of the Pope to the Abbey of Gloucester, as an atonement for the murder of seven monks on their way to this place by Wolphin de Rue, the proprietor, 1048. The Abbey continued the possession till the dissolution.

Highnam. During the Civil Wars the old mansion was occupied in turns by both parties, and was reduced to ruins, but soon after the Restoration it was rebuilt, on a plan by Inigo Jones, by a pupil of that Architect, the proprietor being William Cooke, Esquire.

Over lies on the Western channel of the Severn, and communicates with Gloucester by a bridge, with a fine single span by Telford. The old bridge gave the name to the old hundred of Langebridge. *Over* is derived from

"*Ofer,*" that the bank of a river. A battery was erected on Vineyard Hill, at Over, during the Siege of Gloucester.

Names of places and fields in Churcham: Hester's Hill, Toomey's Hill, Colt Pound, The Speak, The Salt, Solomon's Tump, Clauses, Oxleys, Little Hedges, Lobstocks, Big Cockshot, Little Cockshot.

SERVICES OF A LUNDINARIUS

A.B. holds one Lundinarium (in the Manor of Highnam) to wit, a messuage with curtilage, 4 acres of land, and a half acre of meadow, and has to work one day a week, (probably Monday, Lunæ-dies, Lundi, whence the title of the holding) from Michaelmas to August 1st, and each day's work is valued at:—

	s	d
To mow the lord's meadow for 4 days if necessary, and a day's mowing is valued at	0	2
To aid in cocking and lifting the hay for 6 days at least, and the day's work is valued at	0	0½
To hoe the lord's corn for one day valued at	0	0½
To do 2 bederipoe before August 1st, valued at	0	2
From August 1st to Michaelmas to do manual labour 2 days a week, and each day's work is valued at	0	1½
To gather rushes on August 1st, valued at	0	0½
And in all other conditions he shall do as the customers.		
The total value of the service of a lundinarius is	6	8
To give 4d. as aid at Michaelmas, 15 other lundinarii hold on a like tenure.		

Minsterworth, anciently Mortune. From Mor, British for Sea, in composition water only. So Mor-tune means the Town on the water or river.

The name Minsterworth is of later date, and was given when the parish came into the possession of the Abbey of St. Peter.

Hamlets—Morcote or Boyfield. The former derived from Mor-water and Coed a wood. The latter from Bois-wood and field.

Hampton, situate in the middle of the parish, adjoining the great Ham or meadow, now inclosed.

Dunney or *Duni* is not mentioned in Domesday, but is said to be that half hide of land held by William de Goizanboded, with half the fishery in Westbury Hundred.

Roger de Staunton gave a yardland called Duni in Minsterworth to Gloucester Abbey in the 14th Century.

The Manors of Minsterworth and Rodley were granted to Simon de Montfort.

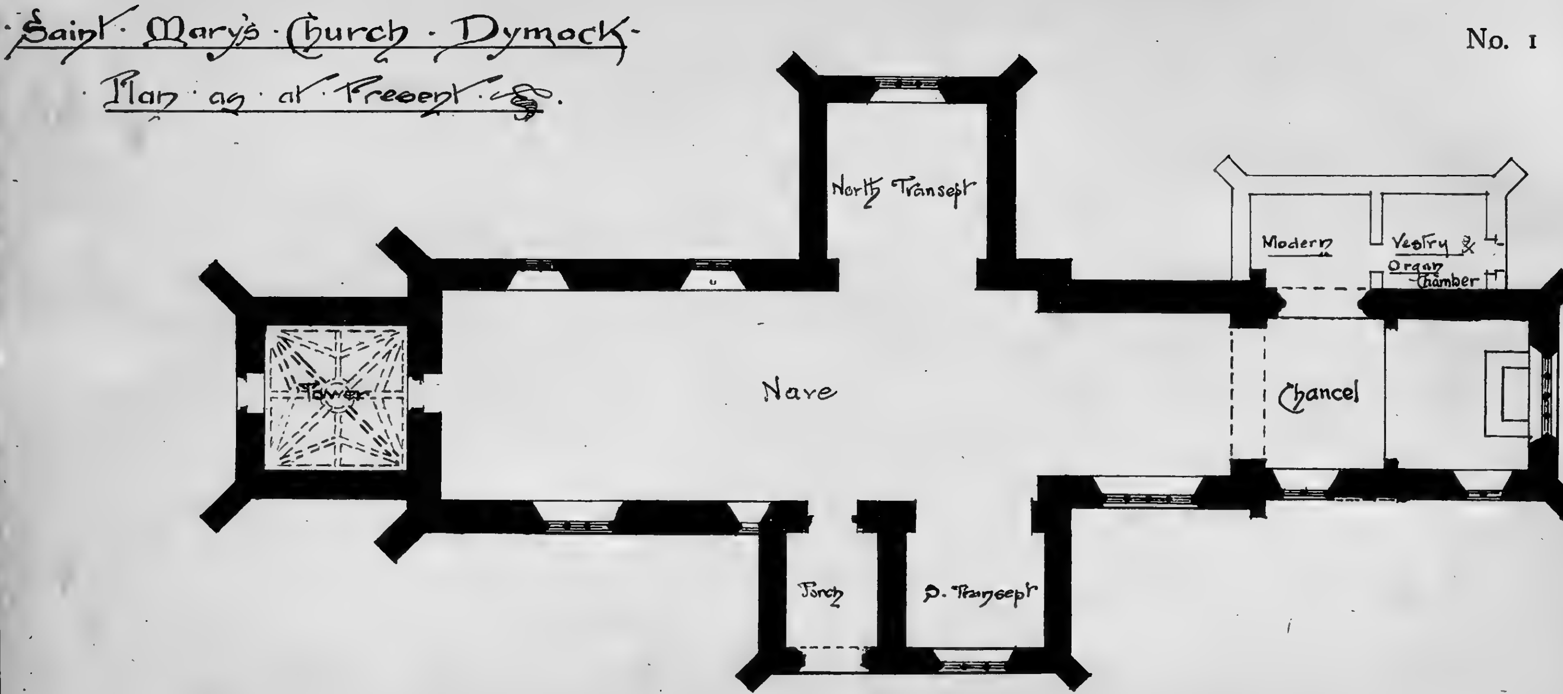
In Minsterworth Manor acknowledgments were paid to the Lord of the Manor for the liberty of fishing in the Severn, under the name of Prid-Gavel.

Atkins derives the name from *Lampreyd* and *Gavel*—A *tribute* for fishing for *lampreys*. Rudder from "*Pride*" a wicker "*put*" or poucheon used in taking lampreys.

The Church is dedicated to St. Peter, the tower is low, the steeple, which once stood on it, was destroyed by lightning and the bells melted in 1702.

Names of places and fields in Minsterworth: Foxwell, Inhenacre, Pollis, Hoppithorn, Garden-Barton, Stoney-Barton, Lime Paddock, Islay.

No. 1


Saint Mary's Church Dymock
Plan as at Present
North Transept
Modern
Vestry &
Organ Chamber
Tower
Nave
Chancel
Porch
S. Transept

NOTES ON

DYMOCK CHURCH

BY

F. W. WALLER, Esq.

READ ON FEBRUARY 20th, 1893.

Much of the history of this most interesting Church, dedicated to St. Mary, can be gleaned from the building itself as it now stands, by a careful study of the plan, and the details of the structure.

Such study will also bring to notice a number of points which suggest yet further links in the historical chain, which may not be so fully capable of proof, but which I shall mention in order to give the members present an opportunity of discussing and expressing their views thereon, whereby more light may be thrown on a subject so well worthy of exceptional care in investigation.

I called this a "*most interesting*" Church, and I did so because I think that it well merits such a description,—the original plan in the first instance being somewhat unusual for this district (if I read it correctly), and the changes which have been effected from time to time being not only numerous but in some instances very remarkable.

The original structure was without doubt Norman, and there are certain features which would appear to have more in common with the French source from which such work was derived than with the English variety of it.

Bearing in mind the origin of the building it may be well for one moment to digress, and consider its position and the locality in which it is situated, and the exigencies to which it was likely to have been subject owing to that position, as such a course may enable us the better to appreciate some of the earlier changes in the structure.

This particular view of the subject was ably dealt with by the late Mr Gambier Parry in a description he gave of the building on the occasion of a visit paid to it by the Bristol and Gloucestershire Archæological Society, September 30th. 1885, an account of which is given in their volume of Transactions for 1885-1886. Mr Gambier Parry pointed out that Dymock was situated in the heart of the country, where much disturbance took place between the inhabitants of England and Wales, before the two countries were united—that the position of the Church, and its surroundings, is such as to have made it a vantage ground for defence, and that much of the land about here is said to have been held by Norman Barons, the chief of whom (in the reign of Henry III, 1216-1272) was Humphry de Bohun, to whom the Manor of Dymock appears to have belonged, through his wife.

It is evident from the condition of the walls that the Church had fallen into a more or less ruinous condition previously to the 14th. century, and subsequent works were for the most part carried out at this period, very possibly, as Mr Gambier Parry points out, by the owners of the Manor.

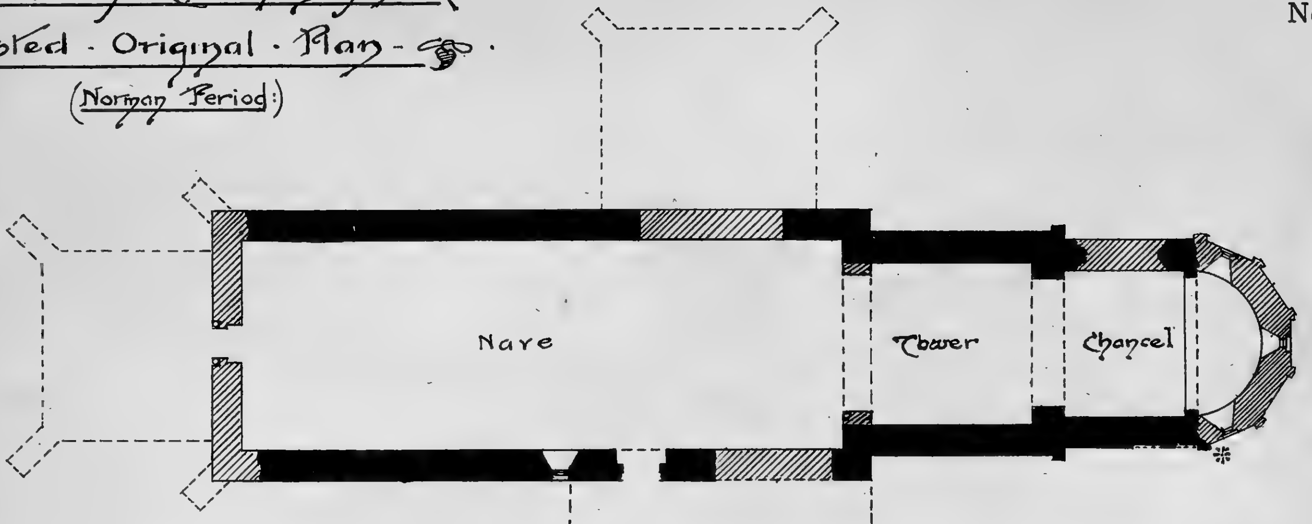
Be that as it may, we have before us a Norman Church which within a comparatively short time after its erection seems to have needed extensive repairs, and, looking to the solid and substantial way in which Churches at this period were constructed, we may perhaps assume that the dilapidation would not necessarily have been occasioned by neglect or lapse of time, but might also be due in part to the causes already suggested: that the repairs and

No 2.

Saint · Mary's · Church · Dymock ·

Suggested · Original · Plan ·

(Norman Period:)



Note: The dotted lines indicate additions made at a subsequent period -

Start of the Apse at ❋ Scale 1 inch to 1 foot:

the extensive alterations and additions were effected in the 14th. century is indicated by the work itself.

These are points more or less conjectural, with which we have to deal, and which certainly appear to me to range themselves strongly on the side of probability when all the circumstances are considered.

Our first task will be to trace out the form of the Norman Church and sever from it the later styles of architecture with which it is surrounded. This is a comparatively simple matter as regards certain parts, but as regards others we soon come to debateable ground.

PLAN No. 1. Shews a Nave 93 ft. x 24 ft. North and South Transepts 19 ft. x 18 ft. and 16 ft. x 13 ft. respectively. South Porch, Western Tower and Chancel, 17 ft. 6 in. x 31 ft. The Vestry and Organ Chamber are modern.

To arrive at what remains of the Norman Church we have to remove the Eastern compartment of the Chancel, the Transepts, the South Porch, the Tower and West end of the Nave, the later windows which have been inserted, the roofs, a considerable portion of the South Wall of the Nave and some of the upper parts of the remaining walls.

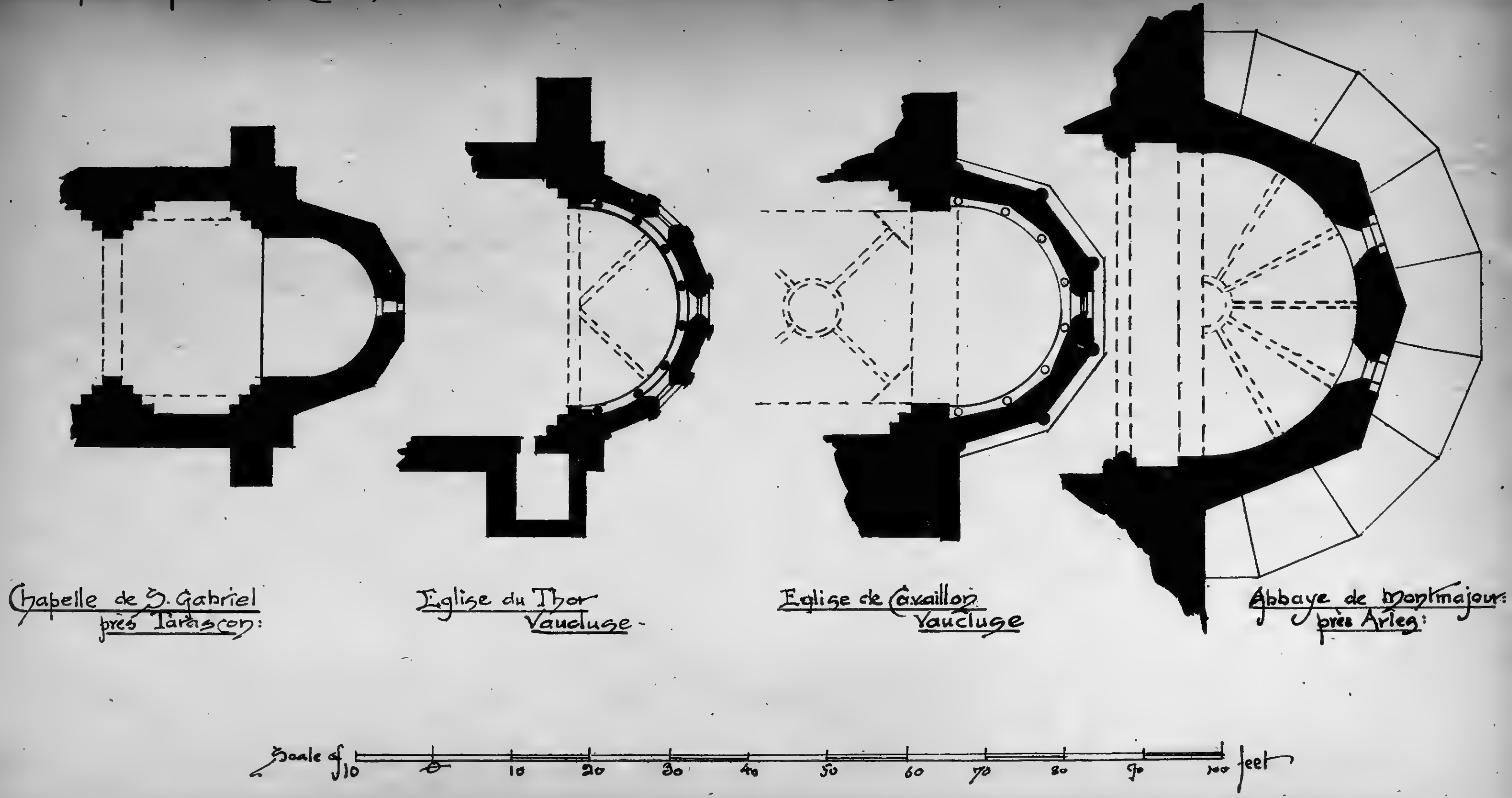
After such a wholesale demolition a very natural enquiry would be, What is there left to work upon in tracing out the old Church? I think that plan No. 2 will approximately indicate this. There are considerable portions of the North and South walls of the Norman Nave with a fine South Door and window, and the remains of a plainer doorway in the North wall. The number and position of the remaining windows it is impossible to determine. This Nave would have been 71 ft. x 24 ft., that is if the Norman West Wall stood where the present West Wall stands. Now you will observe that I have given this Norman Nave as 22 feet shorter than the present one, which is stated as being 93 feet long; the reason being that the compartment between the end of the Nave and the Chancel is taken separately on the supposition that a tower stood over this portion, and this space is 19 ft. x 19 ft. within the walls, and the thickness of the arch removed from between the Tower and Nave was 3 ft. Beyond this was a Chancel with an apsidal termination, and so far as one may judge from working out the dimensions from that portion which remains of the Apse, the Chancel would have been 17 ft. 6 in. wide, and about 23ft. from the Chancel Arch to the furthest point (internally) of the Apse.

The reasons which have led to the foregoing conclusions are these:

1st—The extent of the Norman work. This can be traced by the character of the masonry; the peculiar flat buttresses so common to this style, and which appear rather to be intended to divide the walls into a series of compartments and to break up the surfaces than for strength; again, the undoubted evidence of the doorways and windows, the string courses and mouldings, though great care must be observed even in an analysis such as this; for some of the walling, in the South Wall of the Nave for example, seems to have been rebuilt at a later date with Norman masonry, and the Rector pointed out to me what was evidently a piece of moulding from the interior of the Chancel, which had been used externally.

2nd—The Central Tower. If we examine the plan we shall find that the Nave is complete in itself at a length of 71 feet, and that beyond this point eastward there is a narrower compartment of building intervening between the Nave and Chancel. This compartment is 19 ft. x 19 ft., and at its junction with the Chancel there is a large archway, the bases, jambs, and caps beneath which are unquestionably Norman, the arch above being of later date, the original arch (?), (the springers of which remain), having been apparently removed to allow of the later additions.

Examples of French Churches with Apsidal Eastern Terminations: No. 3



If we examine the corresponding part of this compartment westward, very distinct traces may be observed of the lines where return walls have evidently been removed. They have been entirely cut away and the stonework has been left flush with the adjoining wall. Still the lines are unmistakable, and indicate the former existence here of an archway similar in all probability to that which existed eastward. It is evident the Nave could never have terminated here, and what other purpose could these return walls have served?

Another point worthy of note in connection with this is the ceiling beneath the Tower, and the awkward way the Nave roof drops below it.

These facts seem to point to the existence, or at all events the intention, of a Tower here, but it is of course quite impossible to say whether it was ever completed.

A Tower in this position in a Norman Church was a very common arrangement. We may cite Gloucester Cathedral and Tewkesbury Abbey as examples in the immediate neighbourhood, and many others might be mentioned. What the Tower may have been, supposing it ever existed, I cannot say, but judging by analogy, probably such a Tower would have been somewhat low and square in appearance, and rising about one square above the roof of the Church: the treatment may have been, and probably was in a Church of this size, plain and simple; or on the contrary, it may have been enriched with arcading like that of Tewkesbury, or of Burford or Iffley in Oxfordshire.

3rd—The Norman Chancel. Here, if I interpret the plan correctly, was an arrangement much more common in France than in this country with Churches of this size. viz.: a polygonal apsidal termination; and the reasons for arriving at this conclusion are these:—

On the plan it will be noticed that there is what is technically known as a respond of Norman work on either side of the interior of the Chancel some 14 feet from the Chancel Arch. These just correspond with one another and mark off as it were the first compartment of the Chancel. Outside there is some flat Norman arcading, and at a point which just corresponds with the responds within, this arcading commences to cant inwards and sufficient is left of the turn, or cant, to make it evident and undoubted; and the later masonry of the square-ended Chancel is butted up against the old arcade.

The filling in of the arches of this arcading should be noticed. The return or canted portion of the arcade is so short that it is difficult to say with any degree of accuracy what the form of the Apse may have been, except that it was polygonal; and from careful measurements taken of the old work it is possible that the building may have been somewhat as indicated on the sketch plan.

In a letter to my father on the subject of the plan of the East end of the Cathedral and of the Chapels at Gloucester, the late J. Fergusson says:

"It is curious that polygonal forms should be used in "this country in the 11th century, whilst, at Caen and on "the Continent generally, circular forms prevailed well into the 12th century"; and in Parker the following occurs:

"On the continent apses were more universally em-"ployed, and continued in use much later than in England, "where the practice of making the East ends of Churches "square began early in the Norman period. In the pointed "styles the form of the apse was soon changed from semi-"circular to polygonal, and this form was, with very few "exceptions, universally given to the Continental "Churches.

"In England many Norman apses still exist, and traces "of their former existence may be found in many cases "where the Choirs or Chancels have been subsequently "enlarged, or otherwise altered."

In some of the French examples the apses take various forms, of which a few are given to illustrate the plan which may have been adopted here. Of the roof there is no record. It would have been vaulted probably, either quite plainly or with ribs—a rough sketch of the Norman Chancel of Lenchars Church is given as an example of a rib treatment.

There are certain points connected with the Norman work which are difficult to explain. There is a small doorway (now blocked) in the North wall of the Tower; some arches in the same wall; and a piece of flat pitched drip mould over the Transept, to which it obviously does not belong. There were probably buildings on that side of the Church, and I would ask you to note the peculiar straight joint in the N.E. angle of the North Transept and the general treatment of the end of this building.

So far we have been engaged in tracing the original form of the Church, and supposing for the sake of argument that we have arrived at a general conclusion on this head, it now remains to fill in the details of the later additions.

To commence with the Nave. The West end was evidently rebuilt previously to the erection of the Western Tower, the West Door and Window indicate this; the ruined side walls were built up, partly with the old masonry, and an oak roof placed thereon, the timbers being of large size and framed. This roof is now continuous from the West end to the Chancel as regards the external ridge, but not so as regards the interior; the difference of level between the ceilings of the Nave and Tower has been previously noted.

New windows were inserted in the walls, the pointed Chancel arch was introduced in place of the Norman arch, and it may have been during this time that the Western arch of the Tower was removed altogether, and the insertions made in the walls.

The Transepts were also built; plain semi-circular headed openings being drawn in the Nave walls to give access to them.

The Chancel was extended from the responds before noted, and finished with a square end (in place of the Apse), and an oak roof put on. All the important part of this was probably 14th century work. Subsequently the Western Tower was built; and this was intended to be groined, as the starting point of the ribs can evidently be seen; whether the intention was carried out is not clear. There are squinches across the angles as though a spire had been contemplated.

Externally the Tower is very picturesque with its conical roof, and the buttresses are worth examination, as they appear like a buttress upon a buttress, though all built at one time, as the bonding of the stones show. The work on the slopes is also noteworthy.

There are many points of detail within the Church which merit notice, but a mere description would be of little avail; they must be examined on the spot and carefully considered.

ON THE

RIVERS OF THE COTTESWOLD HILLS

WITHIN THE WATERSHED OF THE THAMES AND THEIR IMPORTANCE AS SUPPLY TO THE MAIN RIVER AND THE METROPOLIS

BY

R. ETHERIDGE

READ TO THE COTTESWOLD CLUB, FEBRUARY 20th, 1893

The series of strata comprising the structure of the upper portion of the Thames extends from the line of the Watershed separating the Valley of the Thames from that of the Severn, in places 800 to 1000 feet above the sea. North of Sevenhampton the divide is between 800 and 900, and near Snow Hill 1000.*

The Stratified Rocks occupying this elevated tract of country consist of eight divisions of the Jurassic series, ranging from the Lower Lias to the Portland sands and Limestone.

The impervious strata occupy nearly 800 square miles, and the pervious series 650 square miles. The retentive or argillaceous rocks thus occupy the larger area, but they contribute little directly to the springs that reach the Thames above Lechlade, or to the purer waters of the Windrush, Evenlode, or Cherwell, which latter river with the Ray drains an extensive area of nearly 450 square miles.

* This portion of the drainage area of the Thames is of great importance, having reference to the general geological structure of the eastern and north-eastern watershed; from the several divisions of the Jurassic rocks there is a great supply of pure spring water daily passed into the Thames to supply the metropolis.

The Rocks more immediately concerned in my paper occupy the high eastern and broadly speaking long sloping ground of the western Cotteswolds. They range from the steep escarpment of Broadway and Snow Hill to Charlton Abbots, Dowdeswell, Leckhampton Hill, and Birdlip, &c., on the west; and Moreton-in-the-Marsh, Little Compton, Chipping Norton, and up to the heights of the source of the Cherwell on the N. From this large tract of country between the western, N.W. and N.E. portion of the Watershed and Oxford is derived daily over 100,000,000 gallons of spring water supplying the Thames. The entire volume of the river that helps on its way to supply London passes over Bensington Weir, south of Dorchester and the Thame.

The series of stratified rocks represented or occurring over the western and north-western Cotteswolds comprise the following 13 divisions:

Jurassic	Lias - - - -	The Lower Lias
		,, Middle Lias
		,, Upper Lias Sands
		,, Upper Lias Clays
	Lower Oolite -	,, Inferior Oolite
		,, Fuller's Earth
		,, Great Oolite
		,, Forest Marble
		,, Cornbrash
	Middle Oolite -	,, Oxford Clay
		,, Corallian Beds
	Upper Oolite -	,, Kimmeridge Clay
		,, Portland Beds

All these range in the order of their succession from the north-western and northern portion of the Watershed to the Oxford area on the south-east, and with a gradient or dip so gentle that the rise from Oxford to the Thames and Severn divide is scarcely perceptible.

Four of the above-named strata, viz.:

The Lower and Upper Lias Clays
,, Fuller's Earth
,, Oxford Clay
,, Kimmeridge Clay

are impervious, and as a rule are valueless as spring water producers, the rain water falling on their surfaces flows over, rather than from, these clay beds.

Although few or no springs rise or have issue from these retentive clays, they are, however, of significant importance to the supply of water in the Thames basin.

The drainage area of the Thames comprises two distinct basins, an upper and lower, outwardly connected by a well-defined area or space of about 4 miles between the eastern and western escarpments of the Chiltern range; this plain or space is occupied by the Thames from Moulsford and South Stoke, to Streatley, Goring, Basildon, Pangbourne and Reading.

The strike of the south-western and north-eastern Chalk and Greensand escarpment ranges from Swindon and Wallingford to Wendover and Tring.* The strike of the lower tertiary beds ranges from Hungerford to Newbury, Reading, Windsor, Rickmansworth, and Watford to Hertford.†

The space between these two almost parallel lines is occupied by the chalk, averaging 16 miles in width, and determines the upper part of the lower basin of the Thames above noticed, or between Dorchester and Reading. To the north of the strike of the Lower Cretaceous series, the rocks of the Cotteswolds occupy an area of nearly 1,640 square miles.

* Within the Thames Watershed.

† This line is nearly parallel to that of the Cotteswold Jurassic or Upper Thames Basin, the drainage and slope of which is towards and under the great spread of the chalk to Reading, Hungerford, and Windsor, &c.

The lower basin of the Thames is entirely occupied by the Lower Tertiary series, viz.:

The Thanet Sands
,, Woolwich and Reading Beds, and
,, London Clay.

All occur in their true succession, resting upon the chalk, and extending from Windsor, under the Metropolis, to near Southend and the German Ocean, a distance of nearly 70 miles.

This constituting the London Basin, or within the Watershed.

The nine divisions of the Jurassic Rocks constitute the source of a large water system, and four of the Rivers which drain them on the north side of the Thames are above St John's Weir, and have their confluence at Cricklade and Lechlade, viz.:

The Upper Thames or Swill Brook
,, Churn
,, Coln
,, Ampneys (2)

The great volume of water derived from these rivers passes over St John's Weir at Lechlade, and is augmented by those streams which rise within the Swindon Basin, viz.:

The Ray
,, Dance
,, Highworth Streams
,, Cole

Their united volume has been ascertained by gauging the River at St John's Weir below Lechlade.

Few Catchment Basins are richer in springs than the Thames, and those rising in and from the Oolitic rocks above Oxford and Abingdon, and the extensively developed cretaceous series south of Abingdon to Wallingford and Mongewell, constitute a large proportion of the pure water supplied to the middle basin of the Thames.

The total length of the chief tributaries to the Thames is about 700 miles, the secondary feeders being considerably more; there are therefore about 1800 miles of waterway within the area of the Thames watershed, or about one mile of water-channel in every 3½ square miles.

The Great Oolite comprises the most important group of permeable strata, representing or occupying a catchment area of about 250 square miles, and giving rise to a number of fine and constant springs, among which are those of Boxwell and Baunton on the Churn above Cirencester, the Thames Head, and the Ewen Springs, west of Cricklade, and Siddington, the numerous and copious springs constituting the Boxwell group rising from the east and west fault between the Cornbrash and Oxford Clay, and the variable but fine springs of the two Ampneys.

The great and constant spring at Bibury, those of Foss Bridge, Winson, Coln St Dennis, Coln Rogers, Ablington, Coln St Andrews, and Quenington, are all on the Coln. These prolific springs are all thrown out by the impermeable clays of the Fuller's Earth, which underlie the Great Oolite and Forest Marble, and they furnish a large proportion of the spring water flowing into the Thames above Lechlade, and the Windrush below.

The Inferior Oolite extends over an area of about 106 square miles. The head of underground waters drained from these porous rocks is great and constant, furnishing several important perennial springs, those of Syreford and Dowdeswell on the Upper Coln, yielding from 3,000,000 to 4,000,000 gallons per day. These springs are thrown out by the underlying impervious clays of the Lias—which extend from the watershed at Charlton Abbots to Withington, entirely draining the extensive spread of the Inferior Oolite.

In 1867 Mr Taunton gauged the volume of water in the Thames, passing over St John's Weir near Lechlade.

This was done twice a day for twelve days, (between October the 18th and 29th) for the purpose of ascertaining the quantity passing over the Weir, gathered from the springs feeding the several rivers confluent to the Thames above Lechlade, viz.:

N. side of the Thames	The Thames Head and Swill Brook
	„ Churn
	„ Ampney and Marston Waters
	„ Coln
S. side of the Thames in the Swindon Basin	The Dance Brook
	„ Ray
	„ Shire Ditch
	„ Byde Mill Brook
	„ Cole

The result of his experiments showed that the mean flow of the 24 gaugings gave 3,242 cubic feet per minute, and the mean of the flow 29,092,468 gallons per day.

Mr Taunton, again twice a day, (morning and evening) from November 22nd to December 1st inclusive, completed the 36 gaugings, "which gave him the mean of 2,135 cubic feet per minute, with the mean flow of 19,165,041 gallons per day, or showing a minimum flow of about 20,000,000 gallons per day from the drainage area of 323 square miles." (Mr Taunton's measurement.)

"This flow gives nearly 7 cubic feet or 44 gallons per square mile per minute. Possibly the ordinary summer flow may exceed this to the extent of from 50 to 100 per cent. or 30,000,000 to 40,000,000 gallons per day, ordinary summer flow."

"Assuming, however, 12 cubic feet or 75 gallons per square mile per minute for the 323 square miles of drainage above Lechlade, this would give a flow of 34,884,000 gallons per day."

But taking the smaller flow of 7 cubic feet, or 44 gallons, per square mile per minute this would fairly represent the minimum flow of 20,000,000 gallons per day passing over St John's Weir from the area drained by the 5 basins *above Lechlade*, or

The basin of the Upper Thames
" " Coln
" " Ampney and Marston
" " Cole and
" " Swindon Basin

or prior to the large accession of water derived from the Leach, the Bampton Streams, the Windrush and Evenlode, which join the Thames below Lechlade, and before reaching Oxford; and finally uniting with the Cherwell immediately below the City.

Bensington Weir above Wallingford receives and passes over the entire volume of water of the Upper Thames and its tributaries. This extensive weir separates the derived waters of the Jurassic rocks from those of the Cretaceous or the Middle Thames Basin.

From the Jurassic Rocks alone above Lechlade we have reason to believe that the ordinary flow may be at least from 30 to 50,000,000 gallons per day, and this must be greatly exceeded during the winter and early spring months.

The loss by percolation through the Cornbrash, Forest Marble, and Great Oolite is largely compensated by the great discharge of water from the Fuller's Earth, which is thrown out by the Baunton, Boxwell, Siddington, and other springs on the Churn, the Forest Marble and Great Oolite of the Ampneys, the many and fine springs from nearly the entire length of the Coln, notably those of Syreford, Bibury, and Coln St Andrews to the Thames at Lechlade.

As above stated the chief loss in the upper part of the watershed is through the Great and Inferior Oolite, and that from an area of nearly 350 square miles.

Probably the highest effective drainage or contour line giving a reliable supply is about 400 feet, although prolific springs issue at a much higher elevation. The Syreford Spring on the Coln issues at 665 feet above the sea, and often yields 4,000,000 gallons per day.

The Churn at the Seven Springs, half-mile E. of the watershed, is 750 feet, and Sevenhampton 600 feet. It is from this long and extended easterly slope of the Cotteswolds that the powerful springs of the lower Jurassic rocks rise, and constitute the head waters of the Thames.

The larger springs such as those of Bibury, Ablington, Boxwell, the Ampneys, Foss Bridge, and Syreford, &c., quite characterise their respective areas, distinguishing it from those localities where the waters rapidly pass off and down surface channels, broad flats, or plains, as those composed of the Lias, Oxford, and Kimmeridge Clays, and the Gault.

The highest issue of these springs and rivers is that of the Coln at Charlton Abbots, south of the Winchcombe Valley, the Windrush at Taddington, two miles north of Guiting Power, and the Evenlode at Moreton-in-the-Marsh, and each of these Rivers rises close to, and nearly breaches the line of the watershed—where the tributaries to the Thames and Severn nearly meet, the Coln nearly uniting with the Isborne, a little south of Winchcombe, the Churn almost joining the Chelt at Dowdeswell, the Seven Springs or Wells east of Leckhampton, and the Cubberley branch at Ullen Farm. The steepness of the escarpment on the western or Severn side of the line of the watershed giving rise to no less than 20 streams which traverse the Lower Lias Plain to the Severn.

Rivers confluent to the Thames above Lechlade

Basin of the Churn

The Churn rises at the Seven Springs, within a quarter-of-a-mile of, or south of the Thames and Severn divide, a small feeder from Ullen Farm and Wood, joining the Churn at Cubberley. The Shurdington and Yanworth Fault passes the Seven Springs a little south of them, and is undoubtedly the cause of their issue, which at times is very considerable.

From Cubberley the Churn traverses the Upper Lias Clay and Sands to Colesbourn and Rendcomb. The Cubberley and Postcombe Fault, at Upper Cubberley and north of Colesbourn where the two tributaries meet, largely contributes to the variable, and at times large quantity of water passing down the Coln to North Cerney, Baunton, and Siddington, here much influenced by the system of rectangular faults between the Forest Marble and Cornbrash. The Siddington and Ampney Crucis Faults on the north, and the Boxwell Fault to the south, fully accounts for the fine springs that issue from or between the Forest Marble and Cornbrash Fault at Boxwell, at times to the extent of 2,000,000 gallons per day.

The springs in the Churn Basin below North Cerney are sometimes lost from the river, but reappear below South Cerney, or Cerney Wick, after receiving the artesian Boxwell supply from the Fault. The numerous springs lost from the upper part of the Churn in traversing the Inferior Oolite between Colesbourn and North Cerney, a distance of 4 miles, is known to amount occasionally to 267 cubic feet per minute, or at the rate of 2,403,000 gallons per day.

These subterranean waters are retained *pro tem* between the impervious clays of the Upper Lias and the overlying Inferior Oolite, the former throwing out the absorbed or percolated waters as springs—and where the Fuller's Earth Clays occur they retain and release all rain water received through the Great Oolite and Forest Marble above.

In 1849 Mr Taunton measured the flow of water from the Seven Wells, when it reached 3,780,000 gallons per day. In 1859 during the dry Autumn the discharge was only 100,000 gallons per day, clearly showing that this great difference of the flow is due to or dependent upon the rainfall of the season.

On its way from its sources, the Churn runs about 5½ miles over the Upper Lias, receiving continued additional water from the springs of the Inferior Oolite above at the Cubberley and Cowley Faults, at Cockleford and the Fault at Colesbourn. In 1859 Mr Simpson, C.E., measured the stream which was found to have considerably increased, the discharge of the spring head, being 11 cubic feet per minute, or 99,000 gallons per day.

After	¼	of mile	the flow	was	31	cubic ft. per min.	or	279,000	gals. per day
,,	¾	,,	,,	,,	61	,,	,,	549,000	,, ,,
,,	1	,,	,,	,,	73	,,	,,	657,000	,, ,,
,,	2	,,	,,	,,	105	,,	,,	945,000	,, ,,
,,	2½	,,	,,	,,	165	,,	,,	1,485,000	,, ,,
,,	4¾	,,	,,	,,	312	,,	,,	2,808,000	,, ,,
,,	5½	,,	,,	,,	320	,,	,,	2,880,000	,, ,,

At this distance (5½ miles) the Upper Lias Clay terminates, and the Churn traverses or runs over the Oolitic Rocks. A reduction in the flow immediately took place, and the result of the gaugings was as follows:—

After	6½	miles	the flow	was	290	cub. ft. per. min.	or	2,610,000	gals. pr. dy.
,,	7	,,	,,	,,	235	,,	,,	2,111,000	,, ,,
,,	7⅜	,,	,,	,,	179	,,	,,	1,711,000	,, ,,
,,	8⅛	,,	,,	,,	113	,,	,,	1,017,000	,, ,,
,,	8⅞	,,	,,	,,	45	,,	,,	405,000	,, ,,
,,	9¾	,,	,,	,,	33	,,	,,	297,000	,, ,,
,,	12½	,,	,,	,,	30	,,	,,	270,000	,, ,,
,,	14½	,,	,,	,,	10	,,	,,	only 90,000	,, ,,

Thus after a run of nearly 15 miles *less water* was delivered than at its source, and at 20 miles from its source, where it joins the Thames at Cricklade, the river only delivered 110 cubic feet per minute, or 1,000,000 gallons per day. This incontestably shows the influence of underground drainage and flow, due to the nature of the underlying impervious clays of the Upper Lias, which here on passing Colesbourn and Rendcomb, ceased to throw out springs where their presence terminated: the waters of the succeeding Great Oolite and Forest Marble from this point were retained by the underlying Fuller's Earth, and delivered at Trinity Mill and Baunton, north of Cirencester.

Thus south of Baunton much of the water of the Churn is lost, becoming subterranean, being here held up by the Fuller's Earth, thus separating two distinct underground flows, until brought into communication with the east and west Faults that intersect the valley above and below Cirencester to Siddington and South Cerney, and doubtless influencing the prolific springs at Boxwell.

Ampney, Marston, and Marston Maisey Basin and Springs

The drainage area of this prolific water district is about 40 square miles—these springs rise in the Forest Marble four miles east of Cirencester, and after receiving many small tributaries during a course of 10 miles, both the Ampney and Marston Streams cross the Cornbrash, the Ampney at Eastington and Poulton, the Maisey at Maisey Hampton. They both then flow over the Oxford Clay to the Thames east of Cricklade, the Ampney at Eisey Chapel, the Maisey one mile west of Castle Eaton. The chief supply of these streams is from five springs issuing from the Great Oolite and Forest Marble at Ampney Crucis, Ampney Park, Hunt's Hill, and Ampney

St Peter or Eastington. These springs rise from the Fuller's Earth through the influence of the east and west King's Mead, Preston, and Ampney Crucis Faults. Occasionally they release their waters to the extent of from 10 to 12,000,000 gallons per day; at the same time after wet weather the Winterwell Spring is capable of delivering 3,000,000 gallons per day to feed the Ampney basin. Of the entire drainage area of 40 square miles, about 28 occupy permeable strata, the remaining 10 or 12 being over or upon the Impermeable Oxford Clay.

Basin of the Coln

The Coln rises at Charlton Abbots close to the divide issuing from a fault near the base of the Inferior Oolite, in a group of springs a little south of Charlton Abbots, it then flows over the Upper Lias, draining the sands of the Inferior Oolite as far as Sevenhampton, Syreford, Andoversford and Shipton to Withington, all in the Upper Lias Clay, it then immediately enters and drains the Inferior Oolite as far as Foss Bridge and Coln St Dennis. No less than nine east and west parallel Faults traverse the Lias and Oolite between Charlton Abbots and Stowell, north of Coln St Dennis; these govern and greatly affect the water system of the Upper Coln, between or from the water parting to Stowell. Between Stowell and Lechlade the only known Fault of importance throws out the copious spring of Bibury. From Bibury to the Thames at Lechlade the Winterwell and Quenington Fault much influences the flow to Fairford.

The water parting between the Basins of the Ampney and Coln lies a little east of Winterwell, whose variable spring largely feeds the Ampney and Marston streams.

The Coln from Foss Bridge to Bibury flows over the Fuller's Earth, which is here lost: the Great Oolite and Forest Marble absorb all rainfall, but it is doubtful if any of this water passes into the Thames, being lost by underground drainage in a south-easterly direction. A curved line drawn from Trinity Mill, commencing two miles above Cirencester, through Barnsley Park to Bibury, thence north to Aldsworth, Sherborne Lodge, Windrush Camp, Little Barrington and Burford, will probably determine the southern limit to the Fuller's Earth within the Thames watershed, between the extreme points at Trinity Mill, above Cirencester, and Burford; south of this line I believe most, if not all, the spring water is lost to the Thames.

On its way south, over the Upper Lias, as far as Withington, the Coln receives springs from Brockhampton, Sevenhampton, and the fine springs of Syreford, frequently yielding from three to four million gallons per day. For six miles from its source the Coln flows over the Upper Lias Clay to Withington, draining the sands above, and the extremely faulted Inferior Oolite receiving feeders from the springs of Andoversford, Frog Mill, and Withington, it then occupies the Inferior Oolite as far as Foss Bridge and Coln St Dennis. From Foss Bridge to Coln Rogers, Winson, Ablington, and the great spring at Bibury, the river flows through the deep valley in the Great Oolite and Forest Marble, which is denuded down to the retentive clays of the Fuller's Earth, over which the Churn runs.

From Bibury to Coln St Albans, Hatherop, and Quenington, and as far as Fairford the Fuller's Earth is lost at the surface, nevertheless it influences the water system as far as Fairford, where all springs cease.

From Fairford to Lechlade the Coln occupies the argillaceous plain of the Oxford Clay, and enters the Thames close to the Round House, at the junction of the Thames and Severn Canal, one mile west of Lechlade.

The Coln in its course drains an area of 70¼ square miles from the following eight Jurassic Rocks:

The Upper Lias	3	square	miles
„ „ „ Sands	1¾	„	„
„ Inferior Oolite	13½	„	„
„ Fuller's Earth	3¼	„	„
„ Great Oolite	18½	„	„
„ Forest Marble	13¼	„	„
„ Cornbrash	6	„	„
„ Oxford Clay	11	„	„
	70¼	„	„

North Side of the Thames and below Lechlade and St John's Weir

Basin of the Leach

The source of the Leach is at Seven Springs, 570 feet above the sea, half-a-mile west of Northleach, and in a small valley composed of Inferior Oolite and Fuller's Earth. The river leaves the Fuller's Earth at Sherborne Lodge, three miles south of Northleach, and flows entirely over the Great Oolite to Coat Mill, immediately below East Leach Martin. At Fyfield it enters and crosses the Cornbrash to Lemhill Copse, its remaining course to a mile east of Lechlade, being over the Oxford Clay, joining the Thames half-a-mile east of St John's Weir.

From its source to the Thames the Leach falls over 300 feet, and conveys to the Thames about 500,000 gallons of water per day, and most of this is derived from its source; much of the water from the Great Oolite is lost below Sherborne Lodge, the Fuller's Earth being probably too deeply seated to throw out the superincumbent or absorbed waters of the overlying Great Oolite and Forest Marble. The Leach drains an area of 30 square miles. Of this amount the Great Oolite occupies 17¼ square miles; the Forest Marble nearly 7, and the Cornbrash and Oxford Clay 4½.

Basin of the Windrush

Including the Sub-Basin of the Dickler*

The Windrush is one of the most important tributaries or confluents to the Upper Thames, having a drainage area of 147¾ square miles, including in this its tributary the Dickler.

The Windrush receives in its course of 30 miles a large supply of water from four groups of the Jurassic Rocks—ranging from the Lower Lias to the Oxford Clay, viz.:

Group 1	The Lower Lias	9	square miles
	,, Middle ,,	4¼	,, ,,
	,, Upper ,, Clay	8¼	,, ,,
	,, ,, ,, Sands	7	,, ,,
,, 2	,, Inferior Oolite	59	,, ,,
	,, Fuller's Earth	5¾	,, ,,
,, 3	,, Great Oolite	24¾	,, ,,
	,, Forest Marble	8	,, ,,
	,, Cornbrash	5½	,, ,,
,, 4	,, Oxford Clay	16¼	,, ,,
		147¾	,, ,,

The Windrush has its source on the north-eastern slopes of the high ground, south of Snowshill, immediately below the line of the watershed, rising at Taddington, one mile above Cutsdean; a second and lower branch rises at Bradwell s Head, a third branch rises at the divide in Pinnock Wood. The junction of these streams meets at Guiting Power, passing over a broad

* The rapidly running stream of Eyeford, a branch of the Dickler, rises in a Lias Valley amidst the faults east of Naunton, unwatering a large expanse of Inferior Oolite above Swellwold Farm and Condicote. The Dickler rises at Campoden Ashes, falling south to Upper Swell in a well defined Lias Valley for five miles, then entering the Lower Lias Valley to Newbridge (five miles) then joining the Windrush from Bourton-on-the-Water.

spread of Upper Lias to the Vale of Naunton, and the faulted ground at Harford Bridge and Harford Hill, and over the Lias to Bourton-on-the-Water. A large system of rectangular Faults occur north and south of the extended Naunton Valley Fault, and from the equally disturbed ground at Stow-on-the-Wold and Upper Swell, from the divide between the Dickler and the Evenlode issues the large addition of water drained by the Dickler over the Lower Lias, and meeting at New Bridge, west of Rissington, half-a-mile below Dodd's Mill. A tributary which rises in the Inferior Oolite at Under Camp Farm, north of Farmington, passes over the Lias by Sherborne, to the village of Windrush and Little Barrington to Burford.

The head springs at Donnington, Upper Slaughter, Eyeford, and Bourton-on-the-Water deliver to the lower part of the Windrush at Bourton nearly 20,000,000 gallons of water daily.

The collected waters of the Windrush and the Dickler, after a winding and intricate course from Cutsdean, Temple Guiting, Guiting Power, and Naunton to Bourton-on-the-Water, supply the large Mills above Burford, and pass to Witney, finally entering the Thames at New Bridge.

Springs rise in the Inferior Oolite near Stow-on-the-Wold at an elevation of 700—800 feet, and they supply both the basin of the Dickler and Evenlode.

The Bampton District

BETWEEN THE RIVER LEACH AND THE WINDRUSH

This area is drained directly from the Oxford Clay into the Thames by the Broadwell Brook, the Langhat Ditch, Spill Brook, and numerous small streams.

This extensive district between the Leach and the Windrush contains about 66 square miles, is conspicuous for its flatness, paucity of streams, and barrenness generally. The few and separate streams discharge their waters into the Thames over the Oxford Clay, at four or five points from north of "Old Man's Weir" to Standlake. The Charney Brook rises at Black Bourton, and after passing Bampton enters the Thames at Charney Ford.

There does not appear to be any definite system of drainage over or from the Oxford Clay on either side of the Thames, which is almost a part of the Bampton area, from the confluence of the Cole near Lechlade, to near Oxford. The extreme flatness of the Oxford Clay hardly admits of a determinable watershed for the Bampton waters, but which, nevertheless, at times must be considerable.

The Watersheds of the Ock and the Thames run parallel, that of the Ock on the south side of the River ranges from Faringdon to High Woodbridge and Longworth. The escarpment south of the Thame is composed of the Corallian Rocks which release or pass to the Thames over the Oxford Clay the waters of the few streams that rise along the well defined belt and low lying plain of the Oxford Clay. North of the Thames the higher ground and escarpment of the Cornbrash ranges from Broughton to Broadwell, Alvescott, North Brize and Witney; the broad plain for the entire distance being composed of Oxford Clay.

As near as can be determined the following Rocks occupy the Bampton area:

The Great Oolite - -	8¼	square	miles
,, Forest Marble - -	13½	,,	,,
,, Cornbrash - -	9¼	,,	,,
,, Oxford Clay - -	35½	,,	,,
	66½	,,	,,

THE BASIN OF THE EVENLODE

WITH THE SUB-BASINS OF THE GLYME AND DARNE

The Evenlode is confluent to the Thames 1¼ miles north-east of Swinford Bridge and half-a-mile south-west of Cassington. One of the sources of this important affluent rises in the Lower Lias, close to the northern side of the watershed, at Upper Lennington, the second or western and probably the most important rises at Moreton-in-the-Marsh; these two branches unite to form the main stream at Coldicote and Heathen Farm; above this, two or three tributaries enter the Moreton or Western branch. From its source to Shipton, three miles north of Burford, the Evenlode flows entirely over the broad plain of the Lower Lias, it then turns to the north, and enters the narrow and deep Liassic Valley of Ascot for six miles, to Charlbury, excavating its course through the three divisions of the Lias and the Inferior and Great Oolite, beyond which it partly drains the Great Oolite of Wychwood Forest to the south, and Stonesfield and Ditchley Woods to the north-east. Near Bladon the Evenlode is joined by its chief tributary the Glyme from Woodstock and Kiddington, and three other tributaries from Enstone.

The Darne rises at Dunstew, and unites with the Glyme near Wootton, after draining the Great Oolite and Forest Marble by a western tributary from Little Tew, by Sandford to Westcot Barton, where it unites with the main stream, finally crossing the Cornbrash between Woodstock and Bladon, and the Oxford Clay between Burley Wood and Cassington; then entering the Thames half-a-mile south of Cassington, opposite Wytham Wood and Hill, on the south side of the river.

The three following groups of the Jurassic Rocks are drained by the Evenlode:

The Lias - - -	63½	square miles
„ Inferior and Great Oolite Forest Marble and Cornbrash - -	93¾	„ „
„ Oxford Clay - -	9½	„ „
	166¾	„ „

Little or no alluvial deposit occurs over the Evenlode watershed.

Owing to the excess of the Lower Jurassic Rocks comprising the Valley of the Evenlode, and their importance to the Thames, I append the areas occupied by the nine following divisions, and draining 167¼ square miles:

The Lower Lias - - -	39	square miles
„ Middle Lias - - -	12	„ „
„ Upper Lias Clay - -	11¾	„ „
„ „ „ Sands - -	¼	„ „
„ Inferior Oolite - -	11¼	„ „
„ Great Oolite - -	73½	„ „
„ Forest Marble - -	5½	„ „
„ Cornbrash - - -	4½	„ „
„ Oxford Clay - - -	9½	„ „
	167¼	„ „

At Woodstock the Evenlode receives the Glyme, which rises in three small Liassic Valleys north-east of Chipping Norton. These three sources or feeders form quite a system of their own, cut out of the Great and Inferior Oolites, and down to the Middle Lias, and drain an area of 10 square miles; with this exception the Glyme and the Darne chiefly unwater or drain the Great Oolite Rocks only.

Basin of the Cherwell*

AND ITS THREE SUB-BASINS, THE SWERE, SOR BROOK, AND THE DEDDINGTON STREAM ABOVE OXFORD

The Cherwell is the most important river supplying the Thames above Oxford, draining a diversified district of no less than 334½ square miles.

The Pervious Rocks drain 159 square miles, and the Impervious 175½ square miles.

The chief source of the Cherwell is in the Middle Lias, near Cherwell House, south of Helidon. The river then flowing through the sandy series as far as Telford Bridge, turns west, and flows over the Lower Lias between Edgecott and Chipping Warden to Banbury.

Below Banbury the Cherwell becomes a large and important stream, the country on both sides yielding tributaries which flow through east and west Valleys, denuded down to the Upper and Middle Lias as far south as Aston Bridge. West and south of Banbury, and north of the Swere, the Sor Brook or Broughton Stream is an important feeder, rising near Blackwell Wood, north of Alkerton, and flowing to Shutford, Broughton, and Alderbury. The rivers occupying the basins of the Sor Brook, the Swere, and the Deddington Streams all rise and drain the extensive district chiefly occupied by the Middle and Upper Lias on the western side of the Cherwell, and are parallel to each other; the Swere and the Sor Brook are affected by extensive faulting to the west, entering the Cherwell above Somerton and north of Aston Bridge. The Ray, east of the Cherwell, joins the River at Islip, rising near Marsh Gibbon, and flows over the Oxford Clay for 10 miles, from whence the river

* The Cherwell drains the most northern portion of the Watershed of the Thames, and is one of the chief sources of flood water in the neighbourhood of Oxford, and often to the extent of 300,000,000 gallons per day.

passes over the Great Oolite and Cornbrash to near Hampton Grey. From Hampton to Kidlington, Islip, and Water Eaton, the Cherwell runs over the Oxford Clay, and half-a-mile below the City of Oxford enters the Thames.

The accompanying table of the 13 divisions of the Jurassic Rocks drained by the Cherwell are, for the sake of clearness, arranged under their Impervious and Pervious groups.

Impervious Rocks 236½ sq. ms.	The Lower Lias - -	47¾	sq. miles
	„ Middle „ - -	61¼	„
	„ Upper „ - -	30¼	„
	„ Oxford Clay - -	93½	„
	„ Kimmeridge Clay -	3¾	„
Pervious Rocks 97¾ sq. ms.	The Inferior Oolite -	6¼	„
	„ Great „ -	52½	„
	„ Forest Marble -	2¾	„
	„ Cornbrash - -	26½	„
	„ Lower Calc. Grit -	6¾	„
	„ Coral Rag - -	1¾	„
	„ Portland Oolite and Sands - - -	¾	„
	The Lower Green Sand	½	„

SUB-BASIN OF THE SWERE

This well defined area is drained by the Swere, which is a considerable tributary to the Cherwell on its western side. One branch rising near Hook Norton, in the Middle Lias, close to the watershed, and the second near "Over Norton," in the Upper Lias. The course of the Swere is due west, lying between two east and west Faults, as far as Swereford. From this point the stream is confined between the Great Rollwright and Swereford

Faults, as far as the Post House, south of Great Rollwright; these entirely bound the tributaries whose sources are doubtless due to these parallel and extended lines of disturbance.

The Swere and its many small streams drain an elongated basin in the Great Oolite and Forest Marble, from Swereford to the south of Great Rollwright, as above stated.

East of Swereford to Wiggington, South Newington, to Barford St John and Barford St Michael, to its confluence with the Cherwell near the Paper Mill, the river runs entirely between the two faults, the area between them being little more than half-a-mile wide. This complicated district is drained by another feeder to the Cherwell from the west, parallel to the Swere, and enters the main stream below Deddington, rising in the Great Oolite at Pomfret Castle, close to the southern water-parting of the Swere.

This Deddington stream drains a well defined but small basin in the Lower, Middle, and Upper Lias, bordered on the south side by a narrow belt of Great Oolite, which defines the area between it and the basin of the Dorne.

The numerous streams west and south of Banbury from the Faulted district of Epwell, Tadmarton, Edgehill, and Broughton, with those of Bloxham and Adderbury, flow almost entirely over and drain the sandy beds of the Middle Lias to the south of the Swere Valley, and the long valley of Lower Lias drained by the Deddington Stream is defined by the watershed between Dunstew, Great Tew, and Pomfret Castle, close to the southern water parting of the Swere; all south of this line, to the Cornbrash, between Witney and Woodstock, including the sub-basins of the Darne and Swere, is occupied by the Great Oolite and Forest Marble as far as Bladon.

SUB-BASIN OF THE SOR BROOK

OR THE SHENINGTON, BROUGHTON, BLOXHAM AND ADDERBURY STREAMS

The northern or Broughton, and most of the important tributaries, rise near Blackwell Wood, close to the north-western Watershed, draining the southern part of the Edge Hills, then ranging by Shenington and Shutford to Broughton, Bodicot, and Adderbury, entering the Cherwell opposite, or west of Aynho. North-west of Banbury the Ratley, Horley, and Drayton Streams rise immediately south-east of the Edge Hills, uninterruptedly traversing the Lower Lias Valley to Horley, when a stream from the west meets the north and south stream at Moore Mill, which continues its course by Drayton to Broughton, and enters the Sor Brook. The Sor Brook then flows entirely over the Lower Lias, and drains the Middle Lias along its narrow bed for nine miles.

The Great Copready and Long Compton Fault extends for 17 miles, ranging from north-east of Banbury to Broughton, Whichford, and Long Compton. The area drained by the Sor Brook and its tributaries is about 60 square miles, 55 of which are occupied by the Middle Lias, the remaining small portion being chiefly composed of the Great Oolite, but much faulted.

THE DEDDINGTON BASIN AND STREAM

This considerable tributary enters the Cherwell from the west, and runs parallel to and south of the Swere. It rises due west at Pomfret Castle, and continues in a direct line to its union with the Cherwell, between North Aston and Somerton. Nine-tenths of the drainage in this basin is from the Lower, Middle, and Upper Lias; a strip of Great Oolite along the southern side, from Pomfret Castle by

Great Tew, and Dunstew to the Cherwell, defining its watershed. All south of the divide as far as Woodstock is on the Great Oolite, which is drained by the Darne and the Glyme. The line of the southern Watershed of the Deddington Basin and Stream marks the southern termination of the extensive development of the Middle and Lower Lias, occupied by the Deddington, Swere, and Sor Brook Basins above Banbury, to the extent of 70 square miles.

The Cherwell below North Aston occupies a narrow valley cut out of and down to the Lower Lias, as far as Northbrook Bridge. East of this the Lias entirely ceases to appear, being overlaid by the Great Oolite.

Basin of the Ray (Cherwell)

The Ray enters or is confluent with the Cherwell at Islip, after draining about 114 square miles, and yields a considerable but variable supply of water. The northern part of the watershed of the Ray includes part of the main watershed of the Thames Basin, and extends along its northern boundary from Somerton on the west, to Stoke Lyne, Sutton Audley, and Edgcot to Quainton to the east; the divide between the Ray and the Thame rapidly turning south to Westcot and Weston Underwood, a little north of the Corallian and Neocomian outliers of Brill and Woodbury Wells to Islip. The western line or side of the Basin corresponds to the eastern divide of the Cherwell up to Somerton again. I give this area watered by the Ray and its tributaries as being almost an exceptional geological district of considerable extent, and draining only three Jurassic groups of rock: the Great Oolite 8 square miles, the Cornbrash 21¼, and the Oxford Clay 75; the remaining strata being fragmentary remains, composed of the Lower Calc. Grit, Coral Rag, Kimmeridge Clay and Portland Beds; with the

Neocomian or Lower Greensand, not exceeding 8 square miles. Put in tabular form they are as follows:

The Great Oolite and Forest Marble	- 9¾	sq. mls.
„ Cornbrash	- 21¼	„
„ Oxford Clay	- 75	„
„ Corallian Beds	- 4	„
„ Kimmeridge Clay	- 3	„
„ Portland Oolite and Sands	- ¾	„
„ Neocomian	- ¼	„
	114	„

The Cornbrash crosses the basin of the Ray in two parallel banks; the western portion averaging three miles in width, occupying the county between Kirtlington, Bicester, and Stratton Audley, along the eastern escarpment. Parallel to this unbroken range in the Oxford Clay are the three conspicuous outlying masses of Cornbrash, ranging from Islip to Marsh Gibbon, each having its small village, viz.: Noke, Oddington, Merton, and Ambrosden: and a smaller patch at West-stan Hill.

These outliers and the eastern escarpment of the Cornbrash have much influence upon the water system of the Ray Basin; no less than eight spring tributaries drain the Cornbrash between Stratton Audley and Weston on the Green, along its south-eastern escarpment, all passing over the Oxford Clay.

The Basin of the Ray yields a considerable but variable supply of water from the flat plain of Ott Moor, being situated on the wide spread of the Oxford Clay. This "Ott Moor" forms an extensive lake, and becomes after heavy rains a "flood regulator."

The tributaries to the Ouse meet those of the Ray close to the northern and western sides of the watershed.

The Ouse drains more than one-hundred square miles of Great Oolite north of the Cornbrash, which ranges from the Ray Watershed at Fringford to Tingewick, Buckingham, and Stow.

Many of the tributaries that feed the Ray from the north and east have a course of nearly ten miles, but entirely over the wide expanse of the Oxford Clay.

The strata drained by the Ray range through nine divisions of the four groups of Jurassic Rock before mentioned are

Jurassic	The Great Oolite	8	sq. mls.
	„ Forest Marble	1¾	„
	„ Cornbrash	21¼	„
	„ Oxford Clay	74¾	„
	„ Lower Calc. Grit	3¾	„
	„ Coral Rag (too small to name)		
	„ Kimmeridge Clay	3	„
	„ Portland Oolite and Sands	¾	„
Cretaceous	„ Lower Greensand	½	„
		113¾	„

Rivers on the South Side of the Thames

Swindon Basin

THE SWINDON BASIN SOUTH OF CRICKLADE

This district lies south of Cricklade, extending on the west from Lurker's Wood, along the south-west line of the watershed to Quiddington, thence due east along the water parting of the Basin, south of the escarpment of the Chalk and Greensands, to Overton and Wroughton, Chiseldon, Liddington, Charlbury Hill, and along the "Ridge road" to a little south of Ashbury, then ranges north along the divide between the Cole and the Ock, passing Little Coxwell and Buscot Park to the Thames at Buscot below Lechlade and St John's Weir, draining an area of about 125 square miles; and is partly separated on its western side from the basin of the Upper Thames, and Swill Brook, by its water system draining in a different direction to that of the Churn, the Ampneys, and Coln, or from south to north; the waters of the Dance, Ray, Cole, and Highworth Streams flowing from the Cretaceous, Kimmeridge Clay, and Corallian Rocks of Swindon and Highworth on the south, over the Oxford Clay to Cricklade and Lechlade.

This broad Basin is drained chiefly by the Ray and Cole, both of which rise in the Chalk, and receive their waters through numerous tributaries flowing from the Chalk and Upper Greensand escarpment of Chisledon, Liddington, and Bishopstone, and over the broad plain of the Gault and Kimmeridge Clay to the Thames.

Basin of the (Swindon) Ray

The Ray rises in the Upper Greensand at Wroughton, a western branch uniting at North Lanes, a third to the west at Elbro Bridge and Haydon, where the main stream passes to and enters the Thames near Water Eaton House, east of Cricklade.

The supply of water during heavy rainfall is large, rapidly draining the surfaces of the Impervious Oxford and Kimmeridge Clays which occupy the chief area of the basin.

The Ray drains 36½ square miles from six divisions of the Jurassic Rocks, but chiefly from the Oxford Clay, Coral Rag, and Kimmeridge Clay, and from the Cretaceous escarpment along the southern divide of the basin; its direct course to the Thames is between eight and nine miles, one half being over the Oxford Clay; neither the Kimmeridge or Oxford Clays yielding any springs.

The diversity of the strata comprising the structure of the drainage area of the Ray may be gathered from the following table:

Jurassic 29¼	The Oxford Clay	7¾	sq. mls.
	" Lower Calc. Grit	¼	"
	" Coral Rag	5½	"
	" Kimmeridge Clay	15	"
	" Portland Sands and Purbeck	¾	"
Cretaceous 7¼	" Lower Greensand	½	"
	" Gault	1½	"
	" Upper Greensand	¼	"
	" Chalk	5	"
		36½	"

As before stated the waters collected from the southern Cretaceous escarpment drain or flow north, whilst the rocks dip south-east, and the probable underground line of parting between the Basin of the Swill Brook and the Dance and Ray is nearly coincident with the western and local watershed of the Dance Brook.

Area between the Rivers Ray and Cole, (the Highworth Streams)

These streams drain directly into the Thames by the Shire Ditch, the Byde Mill Brook and small streams. The drainage area between the Ray and the Cole occupies eighteen-and a half square miles, fifteen of which is upon the Oxford Clay: the remaining or Corallian Beds (Calcareous Grit and Coral Rag) supply water from the united drainage of 3½ square miles.

This district supplies the Thames at Blackford, through the western branch, or Shire Ditch tributary, and the eastern or Byde Mill Brook near Inglesham, a north-west and south-east Fault ranges between Hannington and Highworth, nearly reaching to Sevenhampton.

Nearly two square miles of alluvial soil covers the Oxford Clay a little south of the Thames from Blackford to Inglesham.

The Oxford Clay occupies nearly 15 square miles, and the Corallian nearly 3½. The small amount of drift or alluvial soil resting upon the Oxford Clay does not exceed 2 square miles.

BASIN OF THE RIVER COLE

The Cole enters the Thames half-a-mile east of Lechlade Bridge, and a little above or west of St John's Weir.

The Cole is the chief stream in the Swindon Basin, rising both in the Portland Sands of Swindon and the Chalk and Upper Greensand of Chisledon and Liddington flowing for two-and-a-half miles over the Gault and Lower Greensand to Foxbridge. Another set of tributary streams rise in the Upper Greensand between Wanborough, Bishopstone and Ashbury, flowing over the Kimmeridge Clay to where the roadway crosses the Wilts and Berks Canal, there becoming the main stream at Warneford Place, a branch of which drains the Sevenhampton Valley in the Oxford Clay and Calcareous Grit and unites at Warneford Place. The Cole then winds its way into, and over the Oxford Clay Valley to Coleshill, five miles north of which it reaches the Thames at St John's Bridge and Weir. The tributaries of the Ray and Cole rise and nearly meet at Great Copse, each rising on either side of the main road to and from Swindon.

The Cole like the Ray chiefly drains from the surface of the Oxford and Kimmeridge Clays and Gault, which during heavy falls of rain release from their surfaces large volumes of water.

The Cole drains an area of about 56 square miles from five divisions of the Jurassic and four of the Cretaceous Rocks, viz.:

Jurassic Rocks 37 sq. miles	The Oxford Clay -	13	sq. mls.
	„ Lower Calc. Grit	2¼	„
	„ Coral Rag - -	8	„
	„ Upper Calc. Grit	2½	„
	„ Kimmeridge Clay	11¼	„
Cretaceous 18¾	„ Lower Greensand	1¾	„
	„ Gault - -	8¾	„
	„ Upper Greensand	1	„
	„ Chalk - -	7¼	„
		55¾	„

These four Rivers, the Shire Stream, the Byde Mill Brook, the Ray, and the Cole, with their numerous tributaries, collectively drain 123½ square miles, and this chiefly from the Oxford and Kimmeridge Clays.

The direction of the flow of the streams is contrary to the dip of the strata, which may not be conducive to perennial supply, yet during heavy rain-fall they largely contribute to the flood waters of the Upper Thames Valley above Lechlade.

Physical Conditions and Geological Deductions

The clays of the Lower and Upper Lias cease to appear below a line drawn from Rendcomb on the Coln to Hampnet near Northleach, and on to Sherborne, Little Barrington and Burford on the Windrush; thence to the Valley of the Evenlode near Charlbury, turning north between Enstone and Kiddington to Nethercot on the Cherwell, and then to Fawler: all below this line to the Thames is occupied by the Great Oolite and Cornbrash to the outcrop of the Oxford Clay. The Evenlode joins the Thames one mile south-west of Cassington.

This defined line or range of the Lias below the overlying Oolitic Rocks to an unknown depth and spread to the south-east, has an important bearing upon the water system of the Cotteswolds, and equally so upon the construction of reservoirs on any of the several rivers above Oxford. Again, to better understand the flow of water in the Churn, the Ampneys, Coln, Windrush, and Evenlode, it is important to notice where the Lias disappears both along the beds as well as sides of the Rivers.

A line drawn from Rendcomb on the Churn to between Compton, and Yanworth on the Coln, Hampnet, north of Northleach, and Farmington, thence by Sherborne and Little Barrington to Burford, nearly determines where the Impervious Lias ceases to occupy the beds of the rivers named; throwing out the confined waters in the form of springs, this water being derived from the overlying porous and jointed beds of the Inferior Oolite south-east of this line. The surface area is occupied by the Impervious Fuller's Earth, Great Oolite, and Forest Marble.

The absorbed rainfall over the two latter rocks is held up below them by the Fuller's Earth, which releases through the agency of numerous east and west Faults the accumulated drainage from its watertight underground surface.

The limit of the area occupied by the Fuller's Earth between the loss of the Lias at Rendcomb on the Churn, Compton on the Coln, Farmington, Sherborne and Burford on the western side of the Windrush is clearly defined by this line, below which all water accumulated upon the Lias is lost to the Thames.

The springs of Yanworth, Stowell, Foss Bridge, Coln St Dennis, Coln Regis, Winson, Arlington, and Bibury, are entirely governed and thrown out by the underlying Fuller's Earth Clays, which occupy the bed of the Coln from the Stowell fault, to the fault and great spring at Bibury, south of which all traces of the Fuller's Earth cease to appear; the picturesque basin of Coln St Aldwyn and Hatherop to the Quenington Fault being the receptacle for the very large volume of water brought down to Fairford, and thence flowing into the Thames at the Round House, opposite Inglesham, and finally passing over St John's Weir at Lechlade.

The importance of the Fuller's Earth upon the water system over the north-western Cotteswolds is scarcely appreciated. Its first appearance is on the western side of the basin of the Windrush, and first seen surrounding the isolated and rectangularly faulted area east of the Upper Lias Valley of Guiting Power, and north of the Vale of Naunton, composed of the Great Oolite and Stonesfield slate. This highly faulted district is undoubtedly an important feeder to the Windrush, and empties its gathered waters on to the surface of the Lower Lias at Upper Slaughter and Bourton-on-the-Water. The extensive fault from Stow Gate close to the watershed, to Harford Bridge, separates the Rowell, Guiting Power and Naunton rocks from the highly faulted region of Hawling and Aylworth Downs. The waters of the Salperton and Notgrove Great Oolite plateau are *entirely released* by the Fuller's Earth, the Inferior Oolite being drained at Hasleton and Turkdean by a small Upper Lias stream.

The drainage area of nearly 90 square miles occupied by the Churn, Coln, and Windrush is thus governed by the Fuller's Earth; upon the underground south-eastern dip-slope of which, all water not thrown out by springs or faults, north of the line I have indicated on the three rivers, (or between the Fuller's Earth, north of Naunton and the Bibury fault and spring to Burford) is lost to the supply of the Thames. The waters received by the overlying pervious Great Oolite, Forest Marble and Cornbrash pass down through the fissured and jointed rocks until probably arrested by the lower-lying clays of the Lias.

The Fuller's Earth is lost east of the watershed of the Windrush. It is cut off by the north and south fault on the western side of the sub-basin of the Dickler, ranging from one mile south of Condicote to Wagborough Huish, a little south-west of Upper Slaughter.

No Fuller's Earth is known east of the watershed that divides the Windrush from the Evenlode.

This may be accounted for by the complicated system of west and east Faults of Donnington, Upper Swell, Stow-on-the-Wold, and Lower Swell, the waters from which enter the Lower Lias Valley near Lower Slaughter, there meeting the main stream from Bourton-on-the-Water at New Bridge, opposite Rissington.

The Evenlode largely depends upon its supply from the numerous tributaries flowing over the broad plain of the Lower Lias from Moreton-in-the-Marsh to its entrance into the narrow valley of Ascot and Charlbury, along which it drains the Inferior Oolite, and also the spread of Great Oolite to the north and east, entering the Oxford Clay at Blaydon, over which it traverses for four miles, joining the Thames half-a-mile south-west of Cassington.

The south-west and north-east strike of the well-defined and parallel groups of the Jurassic Rocks ranging from the Lias to the close of the Great Oolite series, including the Cornbrash, is a marked feature in the physical structure of the Upper Thames district between the south-western and north-eastern sides of the watershed.

This Calcareous Zone is succeeded by the parallel and Impervious Oxford Clay, the outcrop of which uninterruptedly ranges from Crudwell, nine miles west of Cricklade, close to the western divide, to Stratton Audley, north of Bicester. Along this defined outcrop are placed the towns of South Cerney, Fairford, Witney, and Bicester. The southern outcrop ranges from a little west of Purton to Highworth, Faringdon, Oxford, and Quainton, 18 miles east of Oxford. This Argillaceous Zone occupies an unbroken area of nearly 420 square miles, averaging about eight miles in width by fifty, between the extremes of the south-west and north-east sides of the watershed and is probably 150 feet thick. The Corallian Oolites are parallel to, and occur between the Oxford and Kimmeridge Clays, but more or less interrupted along their strike. Swindon, Highworth, Faringdon, Thame, and Aylesbury are placed upon these uppermost members, which terminate the *Calcareous* series, or second Zone, of the Jurassic Rocks within the watershed. These beds may be between 60 and 70 feet thick. The third Impervious Zone, parallel to the Corallian, comprises the Kimmeridge Clay, which cannot be less than 300 feet thick, occupying about 220 square miles, between the extremes of the western and eastern sides of the watershed. The southern outcrop of the Kimmeridge Clay terminates the visible mass of the Upper Thames Jurassic Rocks, so definitely marked by the six parallel groups of strata occupying the elevated tract of country nearly 1200 square miles in extent. These six groups are the Lias, Inferior Oolite, Great Oolite, Oxford Clay, Corallian Oolites, and Kimmeridge Clay.

The Jurassic Rocks are succeeded by the unconformable yet parallel outcrop of the Cretaceous series, or the lower Greensand and Gault; the former being about 400 feet thick, and the Gault from 130 to 150 feet; averaging 3 miles in width by 56 from W to E, or 168 square miles.

The fourth Impervious Zone, or the Gault, ranges south-west and south-east from Wroughton, Wanborough, Wantage, Wallingford, Princes-Risborough and Wendover to Irvinghoe, between the western and eastern sides of the watershed. This strike also defines the northern outcrop of the Chalk basin, the exposed area of which between the above line and the parallel strike of the Lower Eocene series, from Hungerford on the south-west to Reading, Windsor, Uxbridge, Watford, Hertford, and Bishop Stortford to Dunmow occupies an area within the watershed of 1560 square miles. The area south-east of this is occupied by the Woolwich and Reading Beds and the London Clay, or *Lower Tertiaries series* of the London Basin.

The surface soil of the Oolitic Rocks of the Cotteswold district, unless drift-covered, is seldom more than a few inches thick, and little or no *true boulder* clay occurs. Quaternary Gravels of variable thickness rapidly absorb the rainfall, rendering the surface-flow small, except in heavy rains; the rivers being mostly supplied from springs, thrown out by faults, and gathered from the impermeable floors of the Lias and the Fuller's Earth, according to their geographical distribution, both at and below the surface; the Lias receiving and throwing out those waters after percolation through the Inferior Oolite above; the Fuller's Earth constituting the second natural reservoir from rainfall, percolating through the Great Oolite and Forest Marble, and in places the Cornbrash.

These two impermeable rocks are therefore the important factors in the development of springs, over the eastern flank of the Cotteswolds, supplying eight streams, draining 320 square miles, and contributing to the Thames above Lechlade and St John's Weir from 30,000,000 to 50,000,000 gallons per day, ordinary flow.

The Inferior Oolite extends over an area of about 120 square miles, furnishing many important perennial springs; notably those of Syreford and Dowdeswell, which yield from 3,000,000 to 4,000,000 gallons per day from the surface of the retentive Lias below.

From the impermeable rocks, the rainfall, after allowing for evaporation and vegetation (or absorption), flows away at once, and whenever in excess gives rise to the extensive floods in the Upper and Middle Thames, whereas the rainfall on the porous Limestones, is at once stored upon or between (in the case of the Upper Thames district) the Lias and Fuller's Earth Clays, and its ultimate delivery through springs to the streams and rivers, is or may be spread over weeks and months.

To this cause we owe the permanence and regularity of the flow of the Thames, thus draining the permeable rocks, both of the Upper and Middle Basins; the former only however being here under description. As compared with the irregular delivery from an impermeable area this is a consideration of great importance in the question of water supply, and it is well to notice the value of the impervious rocks, as affording copious supplies of water to the Thames, which at once receives them either as flood or otherwise. The following seven groups of strata show that the large proportion of rain falling upon their surfaces is not absorbed but runs off towards the river:

From (1) the Lias—A great portion passes off the surface, except where covered with alluvial or gravelly soil.

,, (2) Fuller's Earth—Where *exposed* nearly all runs off, but the area is usually very small.

,, (3) Forest Marble—Part absorbed by sandy beds, but owing to bands of clay, about ¼ of the remainder runs away.

,, (4) Oxford Clay and (5) Kellaways Rocks—Part runs off and part is absorbed, but the whole of the water of the Oxford Clay passes off and reaches the Thames.

,, (6) Kimmeridge Clay—A considerable portion runs off.

,, (7) Gault—The greater portion runs off, but is partly absorbed again by the Lower Greensand.

The proportion of rainfall that may be expected to be absorbed or run off from a given drainage area, the consequent supply yielded to the rivers, the quality of the water, the additions received to the surface supply by springs, and the seasons of maximum and minimum and mean flow, are all influenced by the nature of the rocks over which the water flows, the character of the country where the river takes its rise, and the physical features of the surface along its course.

Of all these conditions, the permeability of the rock, whether due to a soft or spongy and porous nature, or to the presence of numerous fissures into which water freely passes is necessarily the most influential. In absorbent rocks it rarely happens that under heavy rainfall, in a wet season the pores do not become choked, and the absorbency checked; but in fissured and cavernous rocks communicating with the interior by large crevices, which condition is so common in the tumbled and broken Lower Oolitic Rocks of the Cotteswolds there is practically no limit.

The waters in the several Catchment basins where they traverse the Great Oolite often lose much of their surface character, as developed by the Fuller's Earth, passing down out of sight into absorbent beds in the Great Oolite. They become imprisoned until arrested by faults, in which case they ascend as Artesian springs, overflowing into the surface channels. Such peculiarity is conspicuous in the Churn, which after passing over the impervious Upper Lias for nearly 6 miles from its source, (the Seven Wells) attains a volume of from 300 to 400 cubic feet per minute. Six miles lower down, after traversing the porous beds and fractured freestones of the Inferior and Great Oolite, near Cirencester, the volume diminished to 30 cubic feet per minute, or 270,000 gallons per day. The lost surface water, however, was still under the Valley of the Churn at the depth of 91 ft. 0 in., as determined by Mr Taunton in 1872, and forcibly ascended through the bore and overflowed. These facts cannot be overlooked where faulted ground, in some cases, so completely governs the immediate loss, or, in others, an excess of overflow.

Drainage areas are not necessarily basins, in the ordinary sense of the term, and lines of water-parting are not always those of greatest elevation. The term river-basin therefore although commonly used and convenient does not apply strictly, except in a few instances.

Geologically, rivers more frequently run across the dip of the rocks than along their strike. This is a marked feature within that portion of the Thames watershed, occupied by the numerous rivers that pass down the eastern slope of the Cotteswolds, where *all the strata from* the Lias to the Kimmeridge Clay strike from the south-west to the north-east. The rivers, however, traverse them *nearly at right angles*, flowing from the north-west to the south-east.

The geological conditions that affect water supply to rivers are similar over a wide extent of country, when the direction of the axis of the basin corresponds with the line of strike of the rocks; but the rocks that form the surface at any place may be quite unrecognisable, owing to the presence of a coating or deposit of comparatively modern transported material of which clay, boulders, or rolled fragments of rocks, sand, and gravel, (glacial or river-drift or otherwise) are the chief or constituent parts.

It is well known that the number and magnitude of streams is much less in districts where the underlying *rock is absorbent* than in those where it is impermeable and compact. The extreme of this condition is seen in the Chalk, and parts of the Red Sandstone approach it.

The daily flow of the Thames above Oxford with a drainage of about 600 square miles, and a rainfall of 30 inches, varies from about 73,000,000 to 200,000,000 gallons, the former being the dry summer weather flow, and the latter the flow during floods, but of which we know little or nothing.

As regards the Upper Basin above Lechlade, Mr Taunton in 1867 ascertained by gaugings that the *maximum* flow of the Thames at Lechlade is 28 times the summer flow, which may be calculated at about 26,000,000 gallons per day.

The floods of the upper parts of the Thames naturally accumulate above Goring, where the narrow or contracted passage through the Chalk Hills commences, and should heavy rains in the Middle Basin, below Wallingford, continue to fall while the accumulated waters from above, or north and north-west of Oxford, are coming down freely, it at once causes a large addition spreading over the alluvial bottom at the foot of the Chalk Hills, and over the alluvial land bordering the Thames to and far below Reading.

The extended and varied watershed of the Upper Thames determines it to be a "river of floods," almost from its source, increased by flood and land drainage brought down by the Ray and Cole and other smaller water courses above the navigation or to Lechlade. The Lower Oolitic Rocks which rise from beneath the outcrop of the Oxford Clay to the north of the Corallian beds, which again crop out from beneath the Kimmeridge Clay, in the Valley of the Ock, rise at so low or slight an angle from beneath these Clay beds, that in wet seasons these calcareous strata become so charged with water as to throw it from their surface, either as floods or by land drainage. These pervious beds then assume the drainage character of non-retentive strata, and in addition to this the Fuller's Earth and Clays of the Forest Marble in the higher parts of the watershed produce the same effect, as also the flood-waters from the largely exposed surface of the Lias Clays in the upper Valleys of the Windrush, the Evenlode, and Cherwell. The large tract of Oxford Clay within the watershed of the Ray (Cherwell), and from the Kimmeridge and Gault Clays in the Valleys of the Ock and Thame all throw great volumes of water into the Thames above Wallingford, for which the geological structure of this extended area at once accounts. We must not, however, forget to notice that in many localities these clays are covered with drift gravel and sand, the depth of which is often so considerable that percolation through them to the underlying Oxford, Kimmeridge, and Gault Clays, results in the issue of large springs, which become perennial. These complications make it almost impossible to always *identify* the respective sources of flood and perennial waters, or even to limit them to certain strata.

From eight miles west of Cricklade to Oxford the Thames runs over the Oxford Clay, and is the mere carrier of waters derived from its tributaries; those which run from north to south and from north-west to south-east, as the Churn, Coln, Leach, Windrush, and Evenlode, cut their way across the strike of the Lias, the Oolites proper, and the Oxford Clay to the Thames. The Cherwell has a *direct* north and south course also directly flowing across the strike of the Lias, and Lower and Middle Oolites to Oxford, and is the source, or cause of extensive floods.

Those streams which flow from south to north have their sources in the Chalk Hills, from the escarpment of which, they receive the back drainage, slightly augmented by that of the Upper Greensand, and then pass over the Gault and Kimmeridge Clays either by the Ray or Cole, or as affluents of the Ock and Thame, which are the main sources of the water carried by these tributaries into the Thames from the south and east, or the Swindon and Thame Basins.

The Thames as before stated is the great carrier of water, whether perennial or flood, brought into it by its tributaries, but we know nothing of the aggregate of the water it carries. There are no available existing data on this point, the tributaries are so numerous and their watersheds so various that any estimate of their volume at different seasons would be difficult, and in flood almost defy calculation.

The geological condition of the sources of the Churn which rises just within the western escarpment, is *the type* of most of the streams which derive their head waters from these Jurassic strata. It is from the aggregation of such streams and springs that the Churn, the Coln, the Windrush, the Evenlode, and Cherwell, etc., derive their supply, and in this way become perennial. The Churn and the Coln with their affluents specially come within this general description, and in detail more so than any of the Cotteswold streams.

The Swindon Ray and Cole receive their waters from a different source, and are types of streams flowing from south to north. They rise at the foot of the escarpment of the Chalk Range, flanking the Vale of the White Horse to the south and flowing over the Upper Greensand Gault and Lower Greensand, thence running over a very large surface of Kimmeridge Clay, cutting their courses through the Corallian Oolites of Shrivenham and Highworth, then passing over the wide expanse occupied by the Oxford Clay. The Ray reaches the Thames near Water Eaton, east of Cricklade; and the Cole opposite St John's Bridge and Weir, east of Lechlade. The volume of perennial waters received from the cretaceous rocks by these rivers is shown by several mills near their sources and they largely contribute to the amount of flood-water from the Kimmeridge and Oxford Clays in the Swindon Basin.

HYDROLOGICAL CONDITIONS, &c.

The Thames well illustrates the condition of river flow, its water supply being derived from numerous sources or feeders, and this from an area of known physical or geological conditions, in no place mountainous, and having a generally even slope or fall throughout.

The flow of the river is not interrupted in any part of its course by rapids or falls, beyond the numerous weirs which greatly add to its purification, through the process of more rapid oxidation through passing over the weirs. The rainfall is fairly equal throughout the year, the mean being about 28 inches.

The porous rocks of the Cotteswolds carrying down the percolated rainfall may be regarded as underground conduits, the depth of which is the thickness of the permeable rock, the width being that of the extent of the strike, or its horizontal extent, and the inclination that of the dip of the rock.

Examples of such conditions of water-bearing horizons or planes exist in the Upper Thames Basin, throughout the area occupied by the Lias from west to east, up to 900 feet above the sea. The Inferior Oolite is at times only fully saturated at its base, and the water following the dip escapes—as at the large Syreford spring, 600 feet above the sea.

Still further eastward the water contained in the Great Oolite is supported by the non-porous Fuller's Earth, and does not rise to the top of that rock until it passes beneath the Forest Marble, east of Northleach. Eastward still the Fuller's Earth thins away, and the two permeable rocks or water-zones formed by the Inferior and Great Oolite unite and pass under the thick impermeable Oxford Clay, between the Windrush and the Thames; these again underlying the Corallian Oolites, which in their turn pass under the Kimmeridge Clay east of Oxford.

The intervention of faults, loss in continuity, or thinning away through deposition, or undulations in the strata all seriously affect the value of the springs governed by the Fuller's Earth over the northern half of the eastern slopes of the Cotteswolds.

The exact proportion of the rainfall absorbed by the different permeable strata, and which is given out again in the form of springs, has yet to be determined, varying as it does according to the lithological character of the water bearing strata.

In a district like that of Cricklade, Lechlade, Bampton, etc., where the impermeable strata (Oxford Clay) predominates, the total deliveries will be large, following close upon rainfall; whereas where the permeable strata predominate as they do north of the strike of the Cornbrash, over the Upper Cotteswolds, so will the rainfall be stored in the jointed and broken nature of the Limestones, and its delivery through springs due to the retentive Clays of the Lias and Fuller's Earth below will be spread over a greater length of time. Hence the *summer flow* which, in a dry season, consists almost entirely of the supplies from deep-seated springs, such percolated waters being retained and upheld by the two impervious Clays above mentioned.

Doubtless the loss of water that takes place where the streams run over the fractured and faulted Oolitic Limestones, especially the Great Oolite, is for the time very great, but there can be little doubt that a considerable portion of what appears to be lost, enters the river at a lower point by bottom and lateral springs.

We know little or nothing of the nature of the deeply seated water area occupied by the Lias below the Inferior Oolite; neither do we know anything of the extended underground surface or strike of the Fuller's Earth which upholds the thick and widely spread Limestones of the Great Oolite and their large water supply, neither have we any evidence of the dying out or thinning away of the Inferior and Great Oolites, or where they may come together through the loss of the intermediate Fuller's Earth; it may be between Burford and Witney, or deep under the thick Oxford Clay towards Oxford.

Few trials by *deep* boring or deep well sinking have been made beyond those at Cirencester, etc., by Mr J. H. Taunton, C.E.,[1] and the researches by Professor Allen Harker,[2] the two Buckman's, and Mr Witchell, whose admirable papers should be consulted for Cotteswoldian Geology.

The deep and important well at Swindon, 7 miles south-east of Cricklade, was commenced in the Kimmeridge Clay and ended in the Forest Marble at the depth of 736 feet. The sinking was abandoned through the large per centage of saline matter in the water derived both from the Corallian and Forest Marble beds.

(1) [a] Remarks upon the Watershed of the Cotteswolds in connection with the water supply to the Metropolis.—Vol. IV., p. 249.

[b] Notes on the Hydrology of the Cotteswolds.—Vol. IX., p. 52.

[c] Sapperton Tunnel on the Thames and Severn Canal.—Vol. V., p. 255.

[d] Visit to the Boxwell Springs.—Vol. IX., p. 70.

(2) [a] On the Kellaways Rock, near Cirencester.—Vol. VIII., p. 76.

[b] On the Sections of the Forest Marble and Great Oolite formation exposed in the new Railway from Cirencester to Chedworth.—Vol. X., p. 82.

[c] On the Geology of Cirencester Town.—Vol. X., p. 178.

Buckman, S. S.—Two papers of much interest: the first upon the Inferior Oolite between Andoversford and Bourton-on-the-Water, 1886-7, p. 108. The second on the Sections exposed between Andoversford and Chedworth, &c.—Vol. X., 1889-90, p. 94.

Amongst the numerous papers by Mr Lucy, I must not omit to mention six at least, which more or less bear upon the subject of my paper:

(1) On the extension of the northern Drift and Boulder Clay over the Cotteswold Range.—Vol. VII., p. 50, 1877-8.

(2) Gravels of the Severn and Avon.—Vol. V., p. 71.

(3) Notes on the Jurassic Rocks of Crickley Hill, Vol. VIII., p. 289.

(4) Remarks on a Boring for Water near Birdlip.—Vol. VIII., p. 161.

(5) Remarks on the Dapple Bed of the Inferior Oolite at the Horsepools, and on some Pebbles from the Great Oolite at Minchinhampton.—Vol. IX., p. 388.

(6) On Sinking a Well in the Lower Lias at Gloucester.—Vol. VIII., p. 211.

Two papers by Mr Witchell, one in 1867, On the Denudation of the Cotteswolds.—Vol. IV., p. 214. A second, On the Forest Marble and Upper Beds of the Great Oolite between Nailsworth and Wotton-under-Edge.—Vol. VIII., p. 265.

These able papers should be consulted by all interested in the Physical History of the Cotteswold Hills.

The evidence as to the occurrence of saline waters in the vicinity of Swindon is not however new, and the Swindon Well was confirmation of the fact, where at the depth of 112 feet the water from the Forest Marble contained 144 grains of saline matter per imperial gallon, and at the greatest depth (736 feet) over 2000 grains per imperial gallon. This deep boring confirmed the fact of the great thickness of the Oxford Clay, south of the outcrop of the Cornbrash, extending between South Cerney, or Somerford Keynes, Cricklade, and Swindon, a distance of 12 miles, and in the direction of its true dip it was found 570 feet thick in the Swindon sinking.*

At Melksham also mineral springs have been met with during sinking in search of coal. The water here contained 552 grains of saline matter per gallon, chiefly sodium calcium. Other localities may be mentioned, but important evidence of saline water was furnished by an Artesian well made at Oxford in 1832, where the well was carried to a depth of 420 feet, through Oxford Clay 265 feet, and to the Great Oolite below.

"The conclusions drawn from these records are that in certain localities, as at Melksham and Trowbridge, Swindon and Oxford, where the Great Oolite series have been reached, the prevalent salt is chloride of sodium—and that while saline water has been found at higher levels in the Corallian beds, the water obtained is less saline, and the prevalent salt is in several cases sulphate of soda."

"The saline waters, however, found in the district vary considerably, so that if the mineral matter be originally derived from Triassic rocks below, the water must be diluted and modified by other waters with which it has come in contact, in rising towards the surface."

It is important here to notice the presence and position of the Triassic Rocks (the New Red Marls and Sandstones)

* H. B. Woodward, Q. Jour. Geol. Soc., Vol. 42. Account of a well sinking, G. W. Railway Co. Swindon.

ascertained through the deep boring for coal at Signet, 1½ miles south of the Windrush at Burford, about 17 miles north-west of Oxford, and about the same north of Swindon.

In this trial the following strata were penetrated (all but the coal measures):

The Great Oolite and Forest Marble -	148	feet
,, Lias and Rhætic Beds - -	608	,,
,, Red Marls - - - -	291	,,
,, Red Sandstone - - - -	137	,,
,, Coal Measures and Coal Plants -	225	,,
	1409	,,

The importance of deep boring is greatly exemplified by the Burford or Signet trial, as illustrating the presence, thickness, and thinning away of deeply seated strata, and was little expected; proof, however, has been obtained of the presence and thickness of the Triassic Rocks at the depth of 1184 feet, and the continuity of the Rhætic and Lower Lias at 608 feet, and the still deeper coal measures ascertained to be rich in coal plants,* and thin coals below the New Red Sandstone, or from 1184 feet to 1409 feet. Possibly no spot could have been selected between the northern escarpment of the Cotteswolds and Burford that could have so well illustrated the thinning away of the Inferior and Great Oolites and the scarcely expected occurrence of the Triassic and Coal Measure Rocks in the Upper Thames area.

At Leckhampton, or a little east of the escarpment, the thickness of the strata intervening between the base of the Great Oolite and the base of the Lias is about 1200 feet, but at Burford the total thickness is probably much under

* I named all the specimens brought up during the progress of the boring, the coal plants and shales being of much interest.

200 feet. There is therefore a difference in thickness between Leckhampton and Burford of about 1000 feet of Lower Jurassic strata. Possibly it would be plainer if both geological horizons are referred to the sea level. The base of the *Great Oolite* at or immediately east of Leckhampton would be 1000 feet above sea level, at Burford 20 miles distant, and nearly due east, it is 400 feet above the sea; therefore the loss of Strata on the dip of the Great Oolite, etc., from north-west to south-east is 600 feet in the 20 miles.

Central or Middle (Cretaceous) Basin

I have no intention of entering into particulars relative to that portion of the Thames Basin termed the "Middle Basin."

The extensive area below Abingdon, Dorchester, and the mouth of the Thame to Wallingford, and on to Reading, Windsor, and Eton, are entirely upon the Cretaceous Rocks, but it is important to notice the so-called Middle or Cretaceous Basin as distinguished from the Upper or Jurassic. The geological structure of the Cretaceous area is much less complicated than the Jurassic, which occupies or ranges from the highest part of the western or north-western Watershed to Oxford and Abingdon.

The area occupied by the Cretaceous rocks may be included in that part of the Thames Basin south of Swindon, Abingdon, Thame, and Aylesbury; which line determines their strike from the south-west to the north-east. All to the south-east comprises the spread of the Upper Greensand and Chalk, with an average breadth of 16 miles, to where it is overlaid by the Lower Tertiaries, which trend or range parallel to the strike of the Cretaceous series above named. This extensive area occupies 1050 square miles.

Between Abingdon and Reading the course of the Thames is entirely over the Lower Greensand, Gault, Upper Greensand and Chalk,* falling from 179 feet at Abingdon to 67 at Eton, or 112 feet.

Between Culham and Dorchester the Thames flows between the sharply defined beds of the Lower Greensand and Gault, the former on the north side as far as Burcot, thence to Day's Lock and the mouth of the Thame over the Gault—from the Thame to Bensington Weir *between* the Gault and Upper Greensand and from the Great Bensington Weir to Mongewell, three miles *over* the Upper Greensand; thence for four miles to the Gap in the Chiltern Hills between Streatley and Goring and on to Pangbourn.

Reservoirs

The question of obtaining suitable sites or localities for the construction of reservoirs, either for the reception of pure spring, or pure spring-flood waters of the Upper Thames district, is now a question of great importance to the supply of water to the metropolis.

None of the tributary valleys of the Cotteswolds above Lechlade, owing to the porous nature of the Oolitic Rocks, can be utilized; few, if any, possess either the proper configuration of the ground or condition of rock-structure enabling embankments of sufficient size to be constructed, and watertight reservoirs ensured.

The Churn, the Coln, and the Windrush, which are typical examples of the Cotteswold Rivers, and the country they drain, would seem at first sight to have all the elements necessary for the construction of watertight reservoirs through embankments thrown across their valleys. The difficulty however arises from the physical nature of the rocks on which such reservoirs would be

* The Lower Greensand two miles, Gault four, Upper Greensand five.

placed or constructed in the extended and winding river valleys, the sides of which are largely composed of porous jointed limestones, in places much faulted, and often with no continuous watertight bottom along them.

There are many localities and areas to any extent in the great flats of the Oxford Clay between Cricklade and Lechlade, but reservoirs here must be constructed by excavation, which probably would not be entertained on many grounds; great superficial extent and necessary depth being an objection to such a mode of construction.

The courses of the rivers above Lechlade named in the previous pages, the nature of the valleys through which they flow, and the almost universally porous character of the Oolitic Rocks on the eastern slope of the Cotteswolds (or west of the Evenlode) does away with the chance of constructing reservoirs of sufficient capacity to receive for storage the very large volumes of water from an area teeming with pure and inexhaustible springs.

It is impossible to examine the extensive plain of the Oxford Clay over the wide expanse of country east and south of Lechlade, and bordering the Thames on both sides, from the mouth of the Churn near Cricklade to Castle Eaton and Kempsford, and on to the confluence of the Coln, west of Lechlade, and thence to Buscot Weir, Kelenscott, and Eaton Hastings, without believing that much of the *lost water* to the Thames from the high ground to the north-west must continue its underground drainage upon or over the Lower Oolite Rocks underlying the Oxford Clay of the plain in an easterly direction. No trials by deep boring or wells west of Oxford, along the Valley of the Thames, have ever tested the nature or condition of the Upper Cotteswold Rocks that range below the Oxford Clay,* for doubtless they spread or extend under the wide plain to the Valley of the Ock.

* The nearest is that near Burford, which penetrated the Lias, Oolite, and Triassic, and 225 feet of the Carboniferous Rocks.

The construction of storage reservoirs in the upper reaches of the Valley of the Thames would in addition to the present flow of the rivers secure or allow of the abstraction of probably twice the maximum quantity being now drawn from the river for the supply of the metropolis without reducing the dry weather flow past Teddington Weir below the desired 200,000,000 gallons per day.

It has been proposed by Messrs Martin & Rofe to construct eight reservoirs north of the Thames, and above Oxford. Two on the Windrush (one of them on the sub-basin of the Dickler), three on the Cherwell, one north-east of the Cherwell at Moreton Pinckney, near the extreme north-east side of the watershed, and an extended one above Woodstock, embracing the lower part of the sub-basins of the Darne near to, and the Glyme above, Woodstock; these last between the Evenlode and the Cherwell. No other scheme for reservoirs above Oxford was submitted to the Royal Commissioners on the Water Supply of the Metropolis. The proposed acreage of the first reservoir on the Windrush above Burford, in the Valley of the Dickler is 43,776 square acres. The second, west of Sherborne, or stream above junction with the Windrush, 11,668 square acres. The third, west of the Cherwell, or stream near Deddington, 8,480 square acres. The fourth, or River Swere, near Adderbury, 13,196 square acres. The fifth, the Sor Brook, Broughton, near Banbury, 22,176 square acres. The sixth, near Moreton Pinckney, north-east of the Cherwell, 14,000. The united acreage of these 8 proposed reservoirs amounts to 140,796 square acres, capable of holding some 20,302,000,000 gallons of water. These are the only localities in the Upper Thames area, above Oxford, where sites *have been* definitely proposed for reservoirs, hence I give them—most of them are believed to be watertight.* No such reliable sites can

* The geological sections across the Valleys where it has been proposed to construct these reservoirs were prepared by Mr H. B. Woodward, F.G.S.

be obtained anywhere on the Churn, either above or below Cirencester, or on the Coln above Lechlade, owing to their geological construction.

It was the opinion of Mr Bravender, of Cirencester, that a reservoir could be constructed at the mouth of the Coln, into which could be conducted at once the pure spring waters of the river, and doubtless the waters of the Churn and the Ampneys could also be readily conveyed to any reservoir so placed.

Mr Bravender also stated his opinion as to the construction of a large reservoir at or near the confluence of the Windrush with the Thames at Newbridge, or Langley Weir, near Appleton, nearly opposite to where the Windrush joins the Thames.

Referring to the question of reservoirs being constructed in the Oxford Clay *by excavation in* the Lechlade and other areas, it was proposed by Messrs Hunter and Fraser in their report to the Royal Commissioners, to construct as many as nine large storage reservoirs at Staines, through *excavation* in gravels 20 feet thick resting *above* the London Clay, and *excavating* into the London Clay to the depth of 20 feet, the impervious condition of the London Clay being even more tenacious than that of the Oxford Clay above-mentioned in the Lechlade area, and the conditions much the same. Their scheme is highly important, and commands careful consideration.

DESCRIPTION OF TABLES

The accompanying table, No. I, exhibits the stratigraphical arrangement of the Jurassic and Cretaceous Rocks occupying the Upper Basin of the Thames above Bensington Weir (or Wallingford), and embraces the drainage of 23 areas, or 18 tributaries to the Thames.

These 18 streams drain 16 divisions of the Jurassic Rocks, and 4 divisions of the Cretaceous.

Each of the rivers shows the drainage of the groups of strata in square miles, and it is expressed by the horizontal lines of figures, their totals being given on the right hand.

The totals of the drainage of the stratigraphical rocks are given in square miles at the foot of the table, thus each river and each division of the periods represent both the river and stratigraphical drainage in square miles. For example: the Windrush drains 147¾ square miles of area from 10 of the Jurassic Rocks; and the Great Oolite is drained to the extent of 256½ square miles by 10 of the rivers. The totals of all are given both ways.

							sq. miles
The	Lias	is drained by	6	rivers to the extent of			230¾
,,	Lower Oolites	,,	12	,,	,,	,,	559¾
,,	Middle ,,	,,	20	,,	,,	,,	492¾
,,	Upper ,,	,,	8	,,	,,	,,	159¾
							1443

The Cretaceous Rocks by 3 Rivers,* (the Ray, Cole, and area between the Cole and Ock) 27½ sq. miles.

* I cannot include the Ock and Thame in the true Cotteswold area although in the Upper Thames division. The Ock is below or south of the Thames, and enters the River at Abingdon, after draining 57½ square miles of Jurassic Rocks and 38 square miles of Cretaceous. The Thame lies to the east of and enters the main river above Bensington Weir (Wallingford), and drains 11 geological horizons to the extent of 265½ square miles, 157½ of which are Cretaceous—and as before stated both feed the Thames above the Great Bensington Weir, which separates the waters derived from the Jurassic Rocks from those of the Cretaceous or Middle Thames Basin—the total drainage of the Cretaceous Rocks given in the table is 224 square miles.

The 4 Rivers, the Upper Thames, Churn, Ampney, and Coln on the north side of the Thames *above* Lechlade and St John's Weir drain 8 geological horizons to the extent of - - -	291¾ sq. miles
The 14 Rivers on the north side of the Thames between Lechlade and Oxford drain 13 geological horizons to the extent of - - - - -	977¾ sq. miles
The 6 Rivers on the *south* side of the Thames above Lechlade, and in the Swindon Basin, drain 8 geological horizons to the extent of only - -	174½ sq. miles
	1444 ,,

The 3 Rivers (Ray, Cole, and area between the Cole and Ock), and areas between them in the Swindon Basin drain 4 divisions of the Cretaceous Rocks to the extent of 27½ sq. miles.

Table No. II shews the geographical distribution of the Jurassic Rocks of the Cotteswolds, showing the individual and united thickness of the 10 horizons or divisions of the Oolitic Series. It is not given as or intended to be complete, but as far as the individual thicknesses go they may be depended upon: omissions may be supplied by those who know the Cotteswold Rocks and their local stratigraphical history. The right hand column gives the thickness of the strata on their dip, mainly from west to east.

Table No. III shews the distribution of the permeable and impermeable strata of the Upper Thames Watershed.

Table I—Table showing the areas occupied by the Jurassic & Cretaceous Rocks of the Upper Thames & drained by the Rivers N. & S. of the Thames above Oxford

	Rivers of the Upper Thames Basin or within the watershed of the Cotteswold Hills	Lias: Lower Lias	Lias: Middle Lias	Lias: Upper Lias	Lower Oolite: Sands	Lower Oolite: Inferior Oolite	Lower Oolite: Fullers Earth	Lower Oolite: Great Oolite	Lower Oolite: Forest Marble	Lower Oolite: Cornbrash	Middle Oolite: Oxford Clay	Middle Oolite: Lower Calc Grit	Middle Oolite: Coral Rag	Middle Oolite: Upper Calc Grit	Upper Oolite: Kimeridge Clay	Upper Oolite: Portland Beds	Upper Oolite: Purbeck Beds	Cretaceous: Lower Greensand	Cretaceous: Gault	Cretaceous: Upper Greensand	Cretaceous: Chalk	Area of River Drainage in sq. miles	
Rivers on the N side of the Thames above Lechlade	Upper Thames				1¾	13½	3¼	3¾	8¾	3½	9¾											44¼	291¾ N. side of the Thames and above Lechlade and St. Johns Weir
	Churn			½	2½	16	4	20	8½	3	5											59½	
	Ampney			2			5	30	6	3												46	
	Coln			2¾	1¾	13½	3¼	18½	13¼	6	11											70	
Rivers on the North side of the Thames and below Lechlade to Oxford	Leach					½	¾	17¼	6¾	1½	3											29¾	977¾ N. side of the Thames below Lechlade, or between Lechlade and Oxford
	Between the Leach & Windrush							8¼	13½	9¼	35½											66½	
	Windrush	9	4⅛	8¼	7	59	5¾	24¾	8	5¼	16¼											147⅜	
	Between the Windrush & Evenlode										13¾											13¾	
	Evenlode	40	12	12	½	11¼		73½	5½	4½	9½											168¾	
	Between the Evenlode & Cherwell									1¼	9½											10¾	
	The Glyme																						
	The Darne																						
	Cherwell	47¾	6¼	30¼		6¼		52½	2¾	26¼	93¾	6¾	2		4	¾						334¼	
	Swere																					21	
	Ceddington Stream																					16	
	Sorbrook																					50	
	Ray							8	1¾	2¼	75	4			3	¾						94¾	
	Between the Cherwell & Thame										1⅛	2½	2½		5½	3¼						14⅞	
Rivers on the South side of Thames above Lechlade in the Swindon Basin	The Swill Brook								5¾	¾	18½											25	299¾ S. side of the Thames & above Lechlade & St. Johns Weir Swindon Basin
	Between the Swill Brook & Ray										13½											13½	
	Ray										7¾	¼	5½		15			½	1¼	¼	5	35½	
	Between Ray & Cole										15	1½	2¼									18¾	
	Cole										13	2½	8	2½	11¼	¾		1¼	8¾	1	7¼	56¾	
	Between the Cole & Ock										29	6¼	5½		9½			1¾				52	
Below Oxford	The Ock											12¼	19¾	½	27			3¼	18¼	6	10½	97½	S of Thames
	Between the Ock & Thame																						
E of Thames	Thame										8¾	13¼	1¾	4⅛	53¼	24¼	1½	6¼	92½	17¾	42	265⅜	E of Thames
	Stratigraphical Drainage by the Rivers in sq miles	96¾	77⅜	55¾	13½	120¾	22	256½	80½	66½	388⅝	49¼	47¼	7⅛	128½	29¾	1½	13½	120¾	25	64¾	1931¼	TOTAL
		230¾ LIAS			156¼ LOWER OOLITE			403½			492¾ MIDDLE OOLITE				159¾ UPPER OOLITE			224 CRETACEOUS					

Jurassic Rocks drained by the Rivers

Lias	230¾	sq miles
Lower Oolite	559¾	"
Middle "	492¾	"
Upper "	159¾	
	1443	sq miles

Area of River Drainage

North side of the Thames above Lechlade	291¾	sq miles
" " " below " to Oxford	977¾	"
South " above " & St John's Weir from the Swindon Basin	299¾	
	1569¼	
South side of the Thames — the Ock	97½	
East " the Thame	265¼	"
	1932	sq miles

Cretaceous Rocks

Lower Greensand	13½	sq miles
Gault	120¾	
Upper Greensand	25	"
Chalk	64¾	
	224	sq miles

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Table II— Table of the thickness of the Jurassic Rocks of the Cotteswold area as far East as Burford, or from the Western Watershed to Burford

Dedington	34	400	70		105	55	110					740
Stroud	34			30	40	150	70D					299
Fromehall	34	460	54	78	168	120						880
Minchinhampton	34					230	70	120				420
Cam Long Down	35		200	80	200	110						590
Uley Bury	35		180	70	200	100	110					660
Between Uley Bury and Kingscote	35					110	140					250
North Nibley	35		105									105
Wotton-under-Edge	35		186	10	133	96	128					553

A. In the hills further N. 80 to 100 feet decreases in thickness, towards Oxfordshire in S. Cotteswold at Wooton-under Edge 10 feet, Stroud about 30 feet, Nailsworth 105 feet.

B. None E. of Stow-on-the-Wold

C. S. E. Limit of these beds.

D. In the valleys of Rendcombe and Miserdene, 30 to 40 feet.

E.F. Thins away S.E. of Ebrington and Chipping Campden, and all the formations from the marlstone (Mid Lias) to base of Great Oolite diminish in thickness to 50 or 60 feet.

Table II—Table of the thickness of the Jurassic Rocks of the Cotteswold area as far East as Burford, or, from the Western Watershed to Burford

LOCALITIES Gloucestershire	Sheet Geol. Survey Map	Lower Lias	Middle Lias	Upper Lias	Upper Lias Sands	Inferior Oolite	Fullers Earth	Great Oolite	Forest Marble	Cornbrash	Oxford Clay	Thickness on Dip or Deposition FEET
Pewsdown	44			200	20	220	65	110				615
Bredon Hill	44		280	250	25	105						640
Chipping Campden	44		150E	90	30F							270
Bibury	44							70				70
Stanley Hill	44		230	280	15	70						595
Cleeve Cloud	44	550	?	290		200						1040
Cheltenham	44	600	115		30	236	30					1121
Leckhampton	44		115	230A	28	264						637
Stow-on-the Wold	44			40	10 B							50
Chastleton	44			60								
Sherborne	44	215	22	50	C	45						332
Turkdean	44	250	30	45	30	90						445
Tainton	44			20								
Burford	44	100	18	6	0	20		100				244
Nr. Shipton Downs	44		24	20		20		10				74
Compton Abdale	44		220	200	20	220	65	225				950
Coln Rogers	44			140		80	45	200	40			505
Painswick Hill	44			80								80
Tetbury	34								60		15	75
Dedington	34	400	70		105	55	110					740
Stroud	34			30	40	150	70D					299
Fromehall	34	460	54	78	168	120						880
Minchinhampton	34					230	70	120				420
Cam Long Down	35		200	80	200	110						590
Uley Bury	35		180	70	200	100	110					660
Between Uley Bury and Kingscote	35					110	140					250
North Nibley	35		105									105
Wotton-under-Edge	35		186	10	133	96	128					553

A. In the hills further N. 80 to 100 feet decreases in thickness, towards Oxfordshire in S. Cotteswold at Wooton-under Edge 10 feet, Stroud about 30 feet, Nailsworth 105 feet.

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E.F. Thins away S.E. of Ebrington and Chipping Campden, and all the formations from the marlstone (Mid Lias) to base of Great Oolite diminish in thickness to 50 or 60 feet.

Table III—Shewing the distribution of the Permeable

	GEOLOGICAL FORMATIONS
	LOWER JURASSIC OR OOLITIC
The Waters from the drainage of the Lower Jurassic or Oolitic division are conveyed to the Thames by the Thames Head and Ewen Springs, the Churn, Ampney, and Coln rivers above Lechlade and St John's Weir, and by the Leach, Windrush, and Evenlode to Oxford and Wallingford.	Middle Lias or Marlst Sands - - - Inferior Oolite - Great Oolite - - Forest Marble - Cornbrash - - Fuller's Earth - Lower and Upper Lia
	MIDDLE AND UPPER JURASSIC
Most of the Waters of this division, or the Oxford and Kimmeridge Clays, Corallian Rocks, and Portland and Purbeck are collected by the Ray and Cole, &c., of the Swindon Basin above Lechlade.	Lower Calcareous G Coral Rag - - Upper Calcareous G Portland Oolite - Purbeck - - Oxford Clay - Kimmeridge Clay
	CRETACEOUS DIVISION
All the Cretaceous Waters are gathered from the Swindon Basin and conveyed to the Thames above St John's Weir from four divisions, the Lower and Upper Greensand, Chalk, and Gault.	Lower Greensand Upper Greensand Chalk - - Gault - -

Permeable JURASSIC strata drained by the Tributaries to the
Impermeable ,, ,, ,, ,, ,, ,,
Permeable CRETACEOUS strata drained by the Tributaries of th
Impermeable ,, ,, ,, ,, ,, ,,

Impermeable Strata of the Upper Thames Watershed

			Permeable sq. miles	Impermeable sq. miles	Totals sq. miles
VISION					
- - -	77 sq. miles	Permeable	**614¾**		**789¼**
- - -	13½ ,,				
- - -	120¾ ,,				
- - -	256½ ,,				
- - -	80½ ,,				
- - -	66½ ,,				
- - -	22 ,,	Impermeable		**174½**	
- - -	152½ ,,				
VISION					
- - -	49¼ sq. miles	Permeable	**134¾**		**652**
- - -	47¼ ,,				
- - -	7 ,,				
- - -	29¾ ,,				
- - -	1½ ,,				
- - -	388¾ ,,	Impermeable		**517¼**	
- - -	128½ ,,				
- - -	13½ sq. miles	Permeable	**103¼**		**224**
- - -	25 ,,				
- - -	64¾ ,,				
- - -	120¾ ,,	Impermeable		**120¾**	

r Thames - -	760¼ sq. miles	Total Jurassic sq. miles, 1452
,, - -	691¾ ,,	
per Thames - -	103¼ ,,	Total Cretaceous sq. miles, 244
,, ,, - -	120¾ ,,	
Total	1676 ,,	

ON THE HISTORY

OF A

GREAT PHYSIOLOGICAL DISCOVERY

AND ITS BEARING ON AGRICULTURE AND ECONOMICS

BY

PROFESSOR J. ALLEN HARKER

(ROYAL AGRICULTURAL COLLEGE, CIRENCESTER)

READ 22nd NOVEMBER, 1892

The most important of the indispensable constituents of plant food, (neglecting carbon and water, which under ordinary conditions Nature supplies gratis) are Nitrogen, Potash, and Phosphoric Acid. If we average in a very rough and general way all food plants, the proportions in which these three substances are required are to each other as 10, 5, and 4. In continuous husbandry they have largely to be artificially supplied to the land. Of these Nitrogen is the most costly. Forming, as this element does, about four-fifths of our atmosphere, surrounded as plants are by millions of cubic miles of it, why cannot they obtain it as they do the carbon dioxide they need, or as they, and animals too, obtain their needful oxygen, from the air?

Fifty years ago it was generally supposed that they did so, but this view of the matter, a mere supposition, gave place on the institution of direct experiments, to the opposite opinion, to wit, that Nitrogen was not in any case obtained by plants from the free Nitrogen of the air. The experiments leading to this end are classical. They were conducted by Boussingault, who admitted known quantities of gaseous plant foods into closed receivers in which healthy plants were growing, and analyzed the residues. His conclusion was that plants used none of the Nitrogen of the air. A similar conclusion was arrived at in this country by the experiments of Lawes, Gilbert, and Pugh, carried out at Rothamsted. Such remained the opinion of Botanists up till a few years ago. We find all authoritative text books accepting this view. I quote from one or two:

"It is certain from a great number of experiments on "vegetation, especially those of Boussingault, that plants "have no power of using the free Nitrogen of the atmos-"phere for the production of their nitrogeneous compounds. " . . . . although the Nitrogen of the atmosphere "is at the command of the plant in such great quantities." (Sach's Text Book of Botany, English Ed., 1882.)

"It was once supposed that there was a power in the "living plant to fix free Nitrogen from atmospheric air; "but this is conclusively negatived." (Henfrey's Botany, 4th Edition, 1884.)

The researches of Hellriegel and Wilfarth which have now conclusively demonstrated the fact that plants *can*, under certain conditions, draw upon the free Nitrogen of the atmosphere, for some of their supplies of that element have been considered worthy of detailed attention in our Proceedings. They may be described without euphuism, as truly epoch-making, and their inductive thoroughness and exactitude merit historical treatment.

The experimenters themselves attribute the inception of their enquiry rather to accident than to design. It has been so in the history of many great discoveries.

As early as 1862, at the Research Station at Dahme, Hellriegel and Wilfarth were making observations of great agricultural interest, on the action of certain manures, and on the actual quantities taken up by plants. The experiments in which nitrogeneous manures were used were what Priestley used to call "bad experiments;" they showed varying results and thus proved nothing.

Where the plants experimented with were Cereals (Gramineæ) a correspondence was found to exist between the amount of Nitrogen supplied in the manure and the amount absorbed by the plant, but where the plants experimented with were Leguminosæ no such correspondence appeared to exist.

Already as early as the year 1862, Red Clover had been observed to flourish without any Nitrogen at all; but in other years, under apparently precisely similar conditions, all the plants had died.

Again and again the repeated experiments failed to show any relation either between the Nitrogen supplied as manures or between the Nitrogen in the soil and that in the dried plant.

The failure of these experiments led Hellriegel and Wilfarth to the determination to institute a careful and prolonged enquiry into this separate question of the behaviour of both Gramineous and Leguminous plants in relation to Nitrogen, which their preliminary experiments had so clearly shown to exhibit varying phenomena hitherto unexplained. The complexity of the factors to be controlled renders such an experiment one of great care and labour. The soil and its quality, the amount of light and heat, the degree of humidity and temperature of the air by which the plants are to be surrounded, and kept in as nearly as possible natural conditions, as well as a complete command of the food they are to have, are among the chief of these factors.

As various methods of securing the desirable conditions were tried and found capable of improvement, or highly suitable, the years led on to 1873, when Hellriegel published some preliminary record of the results already achieved in a work, "Beiträge zu den naturwissenschaftlichen Grundlage des Ackerbaus."

From this date the experiments were unavoidably interrupted for so long a period as ten years by the removal of Dr Hellriegel from Dahme, and by other pressing occupations. In 1883, however, at a new experimental station at Bernberg the collaboration was resumed and our experimenters returned to their old task.

It should here be noticed that the attention of other observers had about this time been called to the same subject, and much was being done to its elucidation in various parts of the world, but we may with advantage to the narrative, follow to its conclusion and completion the work of Hellriegel and Wilfarth, and return later to the contemporary results of other original workers in the same field.

The years 1883-5 were employed in picking up the threads of the old work, and repeating again with such additions and precautions as experience suggested the old experiments on barley, oats, and peas.

Some brief account of the methods employed will aid us in appreciating the subsequent course of the important investigations. The difficulties of conducting with absolute thoroughness an extended series of observations of this nature are manifold and serious, the factors to be estimated and valued are so numerous.

The medium in which the plants were grown was a fine quartzose sand from Tertiary Beds at Oberlausitz, in Saxony. The sand was not quite chemically pure, containing traces of lime, magnesia, potash, soda, and phosphoric acid. But the amount of Nitrogen present was always most carefully determined, and was found to be almost infinitesimal, and "negligeable" in the estimation of results.

Glass jars of two sizes made of white glass with larger or smaller holes in the bottom were employed for growing the plants in. We may use the term "pots" for them. In the bottom of each pot were placed for drainage purposes a layer of three centimetres of rough pieces of quartz, which had been heated to redness, and then well washed. Then a pad of unglazed cotton wool: and lastly the soil composed of the sand referred to.

It is at once apparent that this soil contains nothing whatever (if we neglect the mere traces of the substances mentioned above) that can contribute to the food and growth of any vegetable life.

This sand was, however, previously watered with a nutritive solution hereinafter described, to bring it into a suitable condition of "tilth," found to be most advantageous for the plants, and to provide the necessary food for the plants sown. Each jar held about 4 kilogrammes of this soil.

The so called nutritive solution employed was a mixture of

	Grammes per Kilos of the sand
Potassium phosphate - - -	·136
Potassium chloride - - -	·075
Magnesium sulphate - - -	·060
Calcium nitrate - - - -	·492

This mixture had been found by long experience to be the one best suited to the amount and area of the sand in each jar, and to the healthy growth of the experimental plants. The three first ingredients of the above mixture may be passed over without remark: it is the fourth the calcium nitrate, which is the determinative factor in the experiments, as it is the only one containing any nitrogen. No less care was exercised in the selection of the seeds to be grown. Each seed was weighed, and fair average specimens were selected, neither the heaviest nor the lightest, but those of a mean weight. The germinating power was also previously tested, so that those only were taken which shewed fair average character. In each pot was sown a double quantity, so that when they appeared above ground half might be pulled up, and again a selection of the healthiest and most equally grown seedlings were left to continue the experiment.

The amount of nitrogen in each set of seeds was carefully calculated, and due allowance therefore subsequently made.

In order to give the plants, so far as humanly possible, natural conditions to grow in, a situation in the garden was chosen for them, where a free current of air was to be found, and protection against heavy rain and storms was afforded by screens made of glass with iron frames. During the hours of the day when the sun's heat was excessive, the pots were transported on rails specially constructed to facilitate quick movement from the sun to suitable shade, improvised for the purpose, of frames, covered round with card-board, but open at each end, and all admitting free currents of air.

Distilled water (first third rejected) was alone used for watering the plants, and the humidity of the soil was regulated within the limits, 8-18%.

Different species of plants require different degrees of humidity, and the same plants at different ages or periods of growth similarly flourish best in soils of varying states of moisture.

It should be noticed that four grammes of Carbonate of Lime were added to each pot, but this does not affect in any way the chemical results.

We now come to the consideration of the general results obtained during the years 1883-5.

The plants cultivated were Hordeum distichum var. Chevalier Barley, ordinary oats, and field peas (var. printanier), the two first belonging to the Gramineæ and the last to the Leguminosæ. Taking first the barley: in 1883 fourteen pots were devoted to this crop, and fourteen grains were sown in each pot, seven were taken out after germination, leaving seven to grow to maturity.

Each pot received as plant food the first three ingredients of the mixture given above, namely:

	Grammes
Potassium phosphate - - - -	·5444
Potassium chloride - - - - -	·1492
Magnesium sulphate - - - -	·2400

and at the same time a quantity of Calcium Nitrate varying with each pot or set of pots as follows:

	Grammes
1 pot received - - - - - -	1·968
3 pots ,, - - - - - -	1·312
1 pot ,, - - - - - -	·984
3 pots ,, - - - - - -	·656
3 pots ,, - - - - - -	·328
1 pot ,, - - - - - -	·164
2 pots ,, - - - - - -	·000

In brief, while two of the pots had no Nitrogen whatever given to them, the rest had varying quantities, duly noted by the numbering of the pots. This plan was followed throughout and need not be again described in detail.

For the first week all grew equally well, but then it was noticed that in the pots receiving no Nitrogen the plants were suddenly checked in their growth, and as the days went on this retardation became more marked. In a fortnight the four pots which had received the smallest quantity of Nitrogen exhibited a similar sudden retardation of growth, and by the end of the third week the effects of the varying quantities of Nitrogen were quite plain, not only in the vigour of the plants, but in the quantity of leaf, stem, ear and grain produced. It was clear that the growth was directly proportional to the amount of Nitrogen supplied in the Calcium Nitrate. The most thorough and careful analyses were made of the produce from each pot, and the results duly tabulated.

The year 1884, though a bad year, gave similar results.

In 1885 full corroboration of the experiments of 1883 was obtained. The experiments on oats in the years 1883, 1884, and 1885 were conducted in a precisely similar manner, and the results obtained were confirmatory of those on barley. In the first week those pots not supplied with any Nitrogen were checked, and in three weeks the condition of all reflected the amount of Nitrogen supplied them. The conclusion as to the growth of oats and barley is plainly that they respond in growth with regularity to the smaller or larger amount of Nitrogen given them in their food.

PEAS, 1883

The pots in which the peas were grown were similar as to the soil and food supplied to those of the Cereals, with the exception that a fewer number of seeds were germinated and allowed to grow in each pot; six seeds were germinated of which three were removed. Three pots were devoted to those receiving no Nitrogen, in the rest the quantities of Calcium Nitrate supplied was similar to that given to the barley and oats.

All grew well for two weeks without any apparent difference; in the third week the influence of the Nitrogen revealed itself in the increased depth of colour of the leaves. The plants poorly supplied with Nitrogen or with none shewed of a pale yellow colour, and with much smaller leaves. So far the behaviour of the peas resembled that of the Cereals. "But soon a wonder did appear," for in the seventh week *the plants which had had no Nitrogen at all began to revive,* and in time caught up their Nitrogen-supplied brethren, one pot with the smallest quantity, ·164 gr. of Calcium Nitrate, surpassing in size, vigour, and quantity of produce all the rest.

These were, before the end of the season, attacked by plant lice, and the results somewhat vitiated thereby. In 1884 some slight modifications were made in the quantities of Potassium and Phosphoric Acid supplied, but the results not only confirmed those of the preceeding year, but were more pronounced. The plants with little or no Nitrogen after growing well for a few days passed through a period which the experimenters call a period of *inanition*, then proceeded by leaps and bounds and passed all the rest.

In 1885 a greater number of pots was taken with no Nitrogen supplied to them, but the same results followed, though with some irregularity as to the time when the inanition period terminated.

Analyses and tabulations of the results no less elaborate and thorough than in the case of the Cereals corroborate the deductions from the appearances of the growing plants, and support the general conclusions arrived at by Hellriegel and Wilfarth. These were:

1st—The quantity of dry produce in oats and barley is in strict relation to the Nitrate supplied, for

(*a*) Without any Nitrogen in the soil the produce is Nil.

(*b*) Maximum growth is only reached with large doses.

(*c*) There is an oscillation in the growth with a variation in the quantity of Nitrate.

(*d*) Each dose of Nitrate produced proportionate results.

2nd—There is no indication whatever in oats and barley of any other modes of obtaining Nitrogen.

3rd—Peas showed no relationship whatever between their growth and produce and the amount of Nitrogen supplied to them, for

(*a*) Luxuriant vegetation was shown with no Nitrogen at all. In 1883 one pot of peas with no Nitrogen supplied showed 5·233 grammes in the dry substance of the leaves and stem, and in 1884-5 certain pots showed 28·483 grammes, 33·147 grammes, etc.

(*b*) There was an entire absence of equality in the pots.

And finally it was clear *the peas had found some other source of Nitrogen.*

These conclusions closed the year 1885. The problem which now remained for solution was, where and how did the peas obtain their Nitrogen?

Four hypotheses presented themselves, as indicating the direction in which the solution might be found.

1.—The Nitrogen, as in the case of Carbon Dioxide, might be absorbed direct from the atmosphere. Boussingault had satisfactorily settled this in the negative.

2.—The larger amount of foliage and the length of the growth period in the case of peas might enable them to absorb a large quantity of the combined Nitrogen of the air, small as it is in percentage quantity.

3.—The profound depth to which the roots penetrate might enable them to reach hidden stores of Nitrogen. Lawes and Gilbert had given some support to this hypothesis, but Hellriegel and Wilfarth's experiments negatived this idea.

4.—The Nitrogen might be obtained from the soil indirectly, the soil obtaining it by absorption of Meteoric Nitrogen, or by other well known causes, whereby it is set free in the soil. The method of obtaining it on the part of the peas was not explained by this hypothesis.

Atwater, in the United States, had grown peas which gave twelve times more Nitrogen than had been given them.

E. Wolff had cultivated oats, potatoes, and four species of Leguminosæ, and found in the two former less Nitrogen than was supplied, but in the latter very considerably more than was supplied. Other observers, Frank, Joulie, Strecker, etc., had attained similar results. Atwater and Joulie concluded that the supply of Nitrogen was from the free element in the atmosphere, but how obtained remained an open question. Others gave hypothetical explanations.

Hellriegel and Wilfarth felt that their experiments compelled them to reject the several hypotheses advanced in explanation of the phenomena furnished by peas and other Leguminous plants, and to look for the true solution of the problem in the relationships now known to subsist between certain lowly-formed organisms in the soil and the roots of the higher plants with which they appeared to be symbiotically associated. The unexplained but constant irregularity exhibited by the peas which had found new sources of Nitrogen might be accounted for on the hypothesis that very greatly varying numbers of micro-organisms engaged in the work would by the law of probabilites be present in the experimental pots. The possession by the Leguminosæ of tubercules on their roots, already well known to botanists, and the relationship between these tubercules and certain Bacteroid organisms contained in them suggested a line of enquiry, and a hypothesis that the tubercules and their contents were associated with the absorption of the Free Nitrogen of the air.

On this line Hellriegel and Wilfarth carried out a new set of experiments, with both cereals and Leguminous plants of various species during the years 1886 and 1887. The methods were precisely as before, except that the sand in one set of pots was carefully sterilized, and in another set was watered with a solution of soil extract. This extract was prepared by taking some ordinary soil in which Leguminous plants were healthily growing, and washing it thoroughly with distilled water, the supposition being that the solution, after filtration of large particles would contain certain micro-organisms natural to the soil, and in watering pots with this solution an *inoculation* of the pot would take place. The result of these two years experiments was no less remarkable than those of 1883—1885.

In the perfectly sterilized pots the behaviour of the Cereals and Leguminosæ was the same.

In the case of oats and maize no appreciable increase of growth took place even in the watered pots, but in the case of the Leguminosæ the addition of the soil extract invariably stimulated the growth of the plants, and a large absorption and assimilation of Nitrogen took place, evidenced by the subsequent analysis of all parts of the plants. Furthermore, the formation of tubercules on the roots of the plants proceeded pari passu with the supply of soil extract. No tubercules were formed where sterile conditions prevailed, and where Nitrogen was supplied, [but under sterilized conditions] the same result appeared. Hellriegel felt justified in communicating to the German Association in 1887 that the "tuberosities were in direct relation with the assimilation of Nitrogen."

The "period of inanition," exhibited by the earlier experiments was explained satisfactorily by the new facts, for supposing a soil containing no Nitrogen to hold a few living micro-organisms, capable of entering into symbiosis with the plant roots—some time must elapse before they could be sufficiently developed to set up the chemical action now demonstrated.

Such is but a bare and meagre outline of the labours which have been so fruitful in physiological advances of the highest importance. A study of the original papers of Hellriegel and Wilfarth can alone convey a notion of the multitude of laborious analyses by which these results have been arrived at. It should be noted too that subsequent investigations by other workers in the same field, by (principally) Schlœsing and Laurent, and by

Lawes and Gilbert at Rothamsted, have abundantly corroborated the facts discovered by our experimenters, that Leguminous plants by means of the symbiotic organisms which form the tubercules on their roots, *can and do obtain a supply of Nitrogen from the atmosphere.*

What is the bearing of this great Physiological Discovery on Agriculture? Liebig said long ago: "The pole star "of all progress in Agriculture is the knowledge of "Natural Sources on which we can draw for the Nitrogen "we want."

Here is a demonstrated source of Nitrogen, new—so far as exact knowledge goes. For when a crop of clover or other Leguminous plant is taken from the land the soil is left richer in Nitrogen than it was, and we now know, thanks to Hellriegel and Wilfarth, how and why this is.

It remains for our farmers to apply this great discovery to the exigencies of their calling. There is a race of British farmers, a steadily though slowly increasing one, the true descendants in spirit of Townsend and Jethro Tull, who watch for and are prepared to accept whatever help may come to them from German laboratory or Rothamsted plot, and who will alone maintain with success amid what seems an impending chaos, the highest practises of their Art modified and regulated by every new advance in our knowledge of the Laws of Nature.

VOL. XI PART II

PROCEEDINGS

OF THE

Cotteswold Naturalists' FIELD CLUB

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ANALYSES OF WATERS FROM THE RIVER SEVERN

At various points of its course between Llanidloes and Tewkesbury, and from its Chief Tributaries near their Junctions with the Main River

Date of Collection	[illegible]	State of River	[illegible]	H	A[illegible]	Total Solids	Chlorine as Cl	Nitrates as HNO3	[illegible]	A[illegible]	[illegible] absorbed in 4 hours at 80° F	Nitrites
					in grains per [illegible]				in parts per million			
[illegible]	[illegible]	[illegible]		2·5		3	1	15	[illegible]	[illegible]	[illegible]	[illegible]
Jan 27th	Newtown just above town	[illegible]		1·5	[illegible] neutral [illegible] 9	4·	1	15	·01	[illegible]	2·12	[illegible]
Jan 27th	150 yards [illegible]	[illegible]	[illegible]	4	2·1	7	·9	23	·01	·05	1·53	[illegible]
[illegible]	[illegible]	Ditto		4·5	2·1	[illegible]	1·1	23	·01	·05	1·3	[illegible]
Feb 14th	[illegible]	[illegible]		4·5	2·0	5	1·2	30	[illegible]	·09	1·53	[illegible]
Feb 14th	[illegible]			4·5	2·0	5	1·2	30	[illegible]	·09	1·53	Trace
[illegible]	[illegible]	[illegible]	[illegible]	5·5	2·0	7	1·3	25	·03	·05	2·40	Small trace
Jan 27th	at Ferry [illegible]			6	2·0	8	1·3	·30	·08	·09	2·20	[illegible] trace
Jan 27th	Tap at Shrewsbury Waterworks		[illegible]	5·5	2·5	7	1·3	25	[illegible]	[illegible]	1·53	[illegible]
Feb 14th	At ham [illegible]	[illegible]	[illegible]	5·5	2·2	9·	1·2	30	·04	·11	2·13	[illegible]
Feb 14th	[illegible]	[illegible]	[illegible]	6·5	3·0	11	1·3	30	·04	·14	2·25	Large trace
[illegible]	Tap at W[illegible]	[illegible]	[illegible]	7·0	3·5	9	1·3	30	[illegible]	·06	·90	Very [illegible] trace
Feb 16th	[illegible] the bridge and [illegible]	Nearly full, or [illegible] fresh	[illegible] turbid, or what [illegible] termed [illegible] at Tewkesbury	5·0	3·4	13·	1·5	·30	[illegible]	·11	1·86	[illegible]
Feb 16th	One mile below [illegible]	Ditto	[illegible]	6·0	3·5	15·	1·8	35	[illegible]	·12	1·73	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	7·0	3·5	10·	3·0	[illegible]	[illegible]	·16	2·04	Large trace
[illegible]	[illegible]	Ditto	Ditto	7·0	3·5	10	2·4	[illegible]	[illegible]	·16	2·53	[illegible]
[illegible]	[illegible]	[illegible]	[illegible] wash of [illegible]	6·5	3·5	[illegible]	1·9	32	·01	·07	1·63	None
[illegible]	[illegible] 100 yards above mouth of Teme	[illegible] recent floods	Colour [illegible], but very turbid	5·0	2·0	18	1·4	[illegible]	[illegible]	·28	5·20	Large trace
Feb 6th	[illegible]	[illegible]	[illegible]	8·0	3·8	11	1·8	35	·04	·10	2·07	[illegible]
Feb 6th	[illegible] a short distance above the bridge [illegible] Severn	[illegible]		..	4·1	11·	1·8	42	·04	·13	2·00	[illegible]
Feb 6th	[illegible]	Full, and very [illegible]	[illegible]	11·0	6·0	[illegible]	1·9	·62	·07	·14	2·30	Slight trace
Feb 16th	[illegible]	[illegible]	[illegible]	5·5	3·5	15	1·5	30	·03	·15	2·26	Trace
Feb 16th	Tewkesbury Waterworks	Ditto	Clear straw [illegible]	5·5	3·4	7·5	1·5	·30	·02	·07	1·73	[illegible]
Jan 12th	Tewkesbury Waterworks [illegible]		[illegible]	10·5		.	2·5 Supernatant water after standing to subside [illegible]		·13 ·14	·11 ·09	.. ...	Trace
[illegible]	[illegible]		Clear [illegible]	10·5	8·0	20	3·7	·45	[illegible]	·06	1·25	None
Dec 6th	Tewkesbury at intake of W[illegible]	[illegible]	[illegible]	8·0	.	19	3·4	·40	·13	·13	2·54	[illegible] trace
Dec [illegible]	[illegible] house tap	Ditto	[illegible]	7·5	.	11·	2·5	[illegible]	·02	·06	1·70	None
March 11th	One mile above [illegible]	No recent rain, three-quarters full	Yellow, with tinge of green, turbid "Milky"	11·5	7·0	18·	2·1	·40	·07	·09	1·15	Small trace
March 11th	[illegible]	Ditto	[illegible]	11·0	6·6	17	2·0	45	·01	·07	1·05	None
[illegible] 12th	[illegible] filtered water	River low, no rain for [illegible] "Bright" in [illegible]	[illegible]	14	10·5	27	4·0	70	[illegible]	·06	·75	None
Feb. 14th	Vyrnwy, 100 yards above junction with [illegible]	[illegible] flood, water now [illegible]	[illegible] yellowish [illegible] turbid, but [illegible]	4·5	2·0	7	1·0	[illegible]	·01	·10	1·42	None
Feb 14th	[illegible] from [illegible]	Full, recent heavy rain	Strong brown-yellow colour, slightly turbid	24	11·5	32	1·7	·92	·06	·22	5·03	Large trace
Feb 14th	[illegible]	Full, recent heavy rain	[illegible] yellow colour, slightly turbid	24·	12·0	34	1·4	[illegible]	·06	·10	3·22	Large trace
Feb 14th	[illegible] Ledwyche	Full, recent heavy rain	[illegible] green colour, slightly turbid	23	12·5	31	2·3	1·00	·05	·10	..	Large trace
Feb 16th	[illegible]	[illegible]	[illegible] ochry, very [illegible]	14	10·0	44·	5·0	·90	·48	·24	1·78	Largely present
Feb 13th	Salwarpe at Hawford Mill, above [illegible] Severn	[illegible]	[illegible] very [illegible]	95	14·0	155·	45·0	·35	·16	·12	1·07	Large trace
[illegible]	[illegible]	Very [illegible]	[illegible] of [illegible]	[illegible]	5·0	11·	1·1	28	·03	·14	2·45	Small trace
[illegible]	[illegible]		[illegible]	30	13·7	10	2·6	[illegible]	·14	[illegible]	2·03	Largely present

THE RIVER SEVERN

CONSIDERED AS A SOURCE OF DRINKING WATER

WITH SOME REMARKS UPON THE

QUALITIES OF WATER IN GENERAL

BY

J. H. GARRETT, M.D., F.L.S.

READ TO THE COTTESWOLD CLUB, FEBRUARY 19th, 1894

I. The Qualities of Water

By the ignition of the carefully prepared component gases of water it is possible that absolutely pure water may be obtained, but it is safe to say that in Nature no such thing exists. Whether water occur in its gaseous, liquid, or solid form, it is mixed with, or has taken into a closer associateship matters gaseous liquid and solid in greater or lesser proportion. When water takes the form of vapour it passes into the gases of the air and is mixed with them, and though it leaves all non-volatile matters behind, it carries with it matters volatile. In its condensations into the liquid form it washes the air, and brings down gaseous and suspended matter, so that as rain it is impure before it touches the ground. In its liquid state it is Nature's great solvent and carrier, and although some of the foreign material is shut out from its ice crystals when it freezes, its impurities are never all so shut out, but the resulting ice even after repeated freezings is still impure water. Water as we commonly know it therefore, is an aqueous solution of the various soluble materials with which it has been brought into contact, and swimming in and upon it is also matter living and unliving which is not capable of being actually dissolved.

Its Natural Impurities

The natural impurities of water then are such as the earth and the air are capable of yielding to it, and consist of inorganic or mineral material, of material of organic origin, of actual organisms, and of gases. As water passes hurriedly over the surface of the ground, or rushes down its natural channels after heavy rains, it bears with it much sand and clay and such like gross material diffused through it in a more or less fine state of division, and giving the water a turbidity, which, however, is lost by deposition of the suspended matter as soon as tranquility is restored. But limiting ourselves to what we call clear water, we may find the main inorganic impurity to consist of lime salts and particularly of carbonate of lime, whilst magnesia and soda salts take a secondary place, and silica alumina and iron occur only in very small quantity; the mineral acids in combination being chiefly sulphuric hydrochloric and nitric, besides carbonic. When water is brought into contact with deposits of soluble salts that lie here and there in the crust of the earth, relatively large quantities are sometimes taken into solution, and we get what is called a "mineral water." In such excessive mineralization of water the salts of magnesia and soda—sulphate, chloride and carbonate—are mainly concerned, and iron in the form of carbonate and chloride enters into solution in the creation of what are known as "chalybeate waters." Sulphate of lime or gypsum is a common impurity in water, being readily dissolved wherever it occurs, but the lime in most ordinary waters is as before said mainly in the form of carbonate, in fact in many waters more than 90 per cent. of the entire impurity is carbonate of lime. The carbonate is of itself quite insoluble in water, but is taken into solution by the aid of free carbonic acid gas and exists in the water as bicarbonate. If the gas be driven off by boiling the water the carbonate of lime is at once thrown out of solution. Carbonic acid gas assumes the same rôle towards iron, enabling it to enter into solution as an acid carbonate, and most "chalybeate" waters are such solutions of carbonate of iron. What is known as the hardness of water is due mainly to the impregnation of the water with lime salts, the major portion of the hardness being generally due to carbonate of lime. Magnesia salts produce the same effect in a greater degree. A large proportion of lime in water renders it unsuitable for drinking. It undoubtedly tends to produce dyspepsia, is productive of skin affections, or at least propitious to their production, and has been credited with causing goitre. Sulphate of lime in water is thought to be more harmful than carbonate, and magnesia salts more objectionable in a drinking water than salts of lime.

The impurities in water that are of organic origin are no doubt numerous, but are of unknown composition, and have to be considered in the mass for want of any known means of separating them. They are derived from decaying vegetable and animal tissues, or are the more direct products of living creatures. They include organic acids, alkaloidal, gumlike, and other substances that result from the breaking down of cellular tissues and other material, in its passage from very highly complex to simpler forms. In this degradation of organic material the number of compounds formed is probably innumerable, but the minute proportions in which they exist in water prevent their particular and individual examination. Their decomposition when carried to its ultimate end results in gases such as carbonic acid gas and marsh gas, the nitrogen they contain passing through the form of ammonia to nitric acid. They serve as food substances to living organisms, and their decomposition is dependent upon the growth in the water of bacteria. These micro-organisms in appropriating a portion of the organic material to their own sustenance, cause a general breaking up of such material, and the process commonly bears the title of fermentation. Some of the substances produced during the growth of bacteria are of a highly poisonous nature, but in natural waters the solutions of these are infinitely too dilute in a general way to produce any effect. As to other living organisms besides bacteria, water is of course liable to contain all those species of animals and plants that find their natural habitat in the fluid.

Differences in Quality due to Geological Origin

All the fresh water of the earth being derived from rain, has to pass over or through the various rocks upon which the rain falls, and is affected in different degrees according to the solubility or general nature of the rocks and the soils that cover their surfaces. Thus a knowledge of the geology of a district allows of a fair estimate being made of the quality of the water likely to be found there. We know that very little is likely to be yielded to water by granitic rocks, or by the slates, shales, and grits so conspicuous in the Primary Systems, but in the Jurassic and Cretaceous Systems vast areas of carbonate of lime are found, pervious to water, and ready to enter into solution in the presence of carbonic acid gas. One might expect magnesia in the water on the Permian and Triassic Systems, or wherever magnesian limestone rocks are known to occur, and the possibility of strongly saline waters would be associated with the New Red rocks, the sulphate of lime so esteemed by brewers is also likely to be found in waters obtained by sinking wells through the Keuper Marl. In water derived from peaty springs and boggy uplands, and from the rich alluvial soils of fenland, we may expect to find much organic matter, peat generally giving the water a strong brown tint, and an unpleasant flavour. Water from the lias rocks is almost invariably hard, and no harder water is met with than that from the drift sands upon the lias. Such sand is probably often capable of charging water with a large amount of carbonic acid gas. This gas being derived by decomposition of organic material near the surface, and contained in the interstices of the sand, charges the water as it passes, and thus charged, it readily dissolves the particles of lime carbonate that it touches.

THE EFFECTS OF MOVEMENT AND STAGNATION UPON WATER

The quality of water is considerably affected by movement as in streams and rivers. In the first place, after flowing for a long distance, it is often brought into contact with a succession of rocks, from the qualities of each of which it takes a little. It also takes up, carries and redeposits insoluble matters, and exercises a maximum effect in the destruction of organic impurities. In this process of destruction the oxygen of the air is a very important factor, and movement aids the aëration of the water to a very pronounced extent. When fresh organic pollution is received into a running stream, the micro-organisms stimulated by the extra amount of food afforded, increase in numbers, and under their influence the organic matters recently received by the water are quickly broken up and reduced to simple compounds, but the micro-organisms are aërobic, i.e., they can only effect their purpose by the aid of oxygen, and the oxygen by which the water is saturated is rapidly reduced. In stagnant water it takes a comparatively long time for fresh aëration to take place, and the process of destruction is correspondingly slow, but in running water fresh oxygen is rapidly absorbed, and the process is as quickly completed. It has long been known that streams, however polluted, are capable of recovering their purity after a flow of a few miles, and originally the fact was attributed to the simple effect of oxygen, but it is now universally recognised that the process is effected through the mediation of bacteria. It is a vital process, and is precisely analagous, or one might say identical to what is constantly going on in soil. In soil, as in water, complex organic material is being constantly reduced by bacterial action to simple salts and gases, the ubiquity of micro-organisms preventing the permanence of organic filth. An example might be given in the contents of a dry-earth closet, which in an incredibly short time is reduced to an absolutely homogeneous soil, differing only from the original earth in containing a slight addition to its soluble salts. The action of micro-organisms upon organic matter in water is similar, but proceeds at a faster rate. The micro-organisms are not permanently increased in a river by its temporary pollution, although in a general way their numbers accord with the amount of pollution present in any particular portion of the river. In short their numbers are regulated by the amount of material that is presented to them for destruction, and in examining an untreated river water both chemically and bacterially the same information is obtained, for one is quite sure by experience that when the water is less pure than usual there is likely to be found a greater number of bacteria contained in it. When water has been purified, however, by filtration, or by boiling or distillation, and thus wholly freed from the bacteria that it previously contained, fresh bacteria being introduced will now grow in it with great rapidity, a fact which at first sight appears contradictory to the assertion that the number of bacteria and the amount of organic pollution in a natural water correspond with each other. In purified water, however, the conditions are not the same as in the water of a river where a keen competition is ever in progress between the several species of micro-organisms and where the growth of one is probably preventive of the growth of another. But the fact mentioned above points to the possible dangerous infection of a water of whatever origin and purity by the organisms of disease, and in fact their chance of multiplying is evidently greatest in a water free from other bacteria.

When flowing water is brought to rest as in a reservoir, subsidence of suspended matters begins at once to take place, and after standing for some days a considerable improvement is effected in the water, both as to a diminution in the quantity of organic matter shown by chemical analysis, and in the number of bacteria present. The water of streams in times of flood or after heavy rains is less pure than usual, the water becomes turbid with silt washed from the banks and bottom, and this silt contains micro-organisms and organic matter, so that the number of organisms and amount of organic matter is increased in the water at such times. If such turbid water be allowed to stand for a week or ten days the silt subsides and carries down with it a very large proportion of the organic matter and the bacteria, and the resulting water is now far purer than the ordinary water of the river, in fact this process of subsidence has almost as great a purifying effect as filtration.

After standing for several weeks the water begins to deteriorate again, such deterioration being brought about by what may be called the pollution of stagnation. Vegetable and animal growths that belong rather to stagnant than to flowing water begin to develop, multiply, die and decay, and the organic matter, and the micro-organisms in the water again reach a maximum. At certain seasons of the year stagnant water is liable to get particularly foul on account of the extraordinary development of certain members of the lower algæ which literally swarm in the water and give it a peculiar unpleasant odour and flavour. For these reasons it is a decided disadvantage to keep water intended for drinking purposes in store for many weeks or months together. The accidental introduction of the bacteria of disease into such a store of water might lead to results altogether overshadowing any possible evils resulting from the use of the purified water of a river such as the Severn.

The Chemical Analysis of Water

The suitability or otherwise of a water for drinking has for long been judged by chemical analysis alone, but the connection of bacteria with the origin of diseases has led to the necessity of bacterial examination of water as well as of its analysis. It must not, however, be for a moment supposed that the value of chemical analysis is in any way lessened by the recent innovation; on the contrary, the examination of water for bacteria is but an adjunct mode, and its main value at the present time is rather to determine the efficiency of the purification of water, rather than as yielding more direct information upon the general suitability of any water for potable use. In the analysis of water it is usual to make the following estimations:—

(1) The total solid matter contained in the water, obtained by evaporating a measured quantity to dryness and weighing the residue.

(2) The hardness, which is equivalent to the quantity of salts of lime contained in the water, one grain of carbonate of lime, or its equivalent in sulphate or other salt of lime representing one degree of hardness, the hardness of water being sometimes also partly due to magnesia, &c.

(3) The Chlorides. Urine contains chloride of sodium and a large quantity of chloride in the water, taken with other circumstances may be indicative of sewage.

(4) Nitrates. The presence of nitrate in water is indicative of matter that has at some time near or far existed in the form of nitrogeneous organic matter. A large quantity of nitrate is often found in shallow wells, and affords evidence of the existence, or previous existence, of decomposing organic matter situated at no great distance from the well.

(5) Nitrites. The existence of any considerable quantity of nitrite is reliable evidence of recent pollution, nitrite being an intermediate product in the reduction of organic material.

(6) Free or Saline Ammonia, which is a first product of the decomposition of nitrogeneous material such as is contained in sewage.

(7) Albuminoid or organic ammonia, which is ammonia formed in the process of analysis from the nitrogeneous organic compounds of varied composition contained in the water, and gives a relative measurement of the quantity of such compounds present.

(8) The amount of oxygen absorbed by the water from an acid solution of permanganate of potash. The oxygen is absorbed to oxidize organic matter present and of such readily oxidizable matter the process is a measure. It is indicative rather of carbonaceous than of nitrogeneous compounds, and taken together with the albuminoid ammonia found, enables the analyst to determine whether the organic matter present be of vegetable or of animal origin.

(9) The amount of oxygen dissolved in the water. This estimation is sometimes made and indicates the activity of the oxidation of organic material in the water that is going on as a result of bacterial growth.

(10) Exact estimations of the lime and magnesia and of carbonic and sulphuric acids, &c. are made when specially required, and the water is tested for iron and lead, the latter being dissolved from lead pipes by certain peculiar waters.

The Bacteriology of Water

The organic material contained in water may be living or unliving, chemical analysis does not distinguish between the two, but in the process for estimation of albuminoid ammonia the living and the unliving organic material yield the same result. The living organic material of water, however, carries a portent of greater significance than that which is not alive, owing to the possibility of the living organisms including those that are capable of setting up disease in the human body. It is true that a large amount of organic material in water, particularly that of a nitrogeneous nature, is always indicative of the elements of bacteria, and when such material exists in large amount, the greater is the likelihood of the bacteria of disease being present. Sometimes bacteria increase through the influence of temperature or through some circumstances as yet not well understood, but which apparently has no relation to the amount of food material present. It is possible, however, to arrive at an approximate idea of the actual number of living micro-organisms present in a water, and also to some extent to separate them into their individual species. The vast number of bacteria in all ordinary waters and their minute size precludes the possibility of actually counting them in a drop of water placed under the microscope, but when a drop of such water is mixed with a gelatinous preparation which is found to be highly nutrient to bacteria, and which has been itself entirely freed from bacteria by exposure to heat, each individual bacterium begins to multiply and in doing so causes a liquification of the nutrient gelatine preparation, the presence of the "colony" being indicated by a liquifying spot in the gelatine. The nutrient preparation has sufficient gelatine in it to form a solid jelly at temperatures below 100°F. and the modus operandi is to melt a sufficient quantity in a test tube, add the measured drop of water, and before the mixture sets pour it out in an equal layer into a covered glass plate. In the course of two or three days, the time varying according to the temperature, the liquifying spots in these plate cultivations begin to appear, each spot represents one bacterium in the added drop of water; the spots grow in size rapidly and soon the whole of the gelatine is involved and has become entirely liquified, but before this has occurred, whilst the spots are still distinct, they are counted and a portion of nutrient gelatine in a test tube may be innoculated from any one of the spots, by touching the spot with the point of a needle and conveying what adheres to the needle to the gelatine in the tube, this being afterwards kept free of other microbes by plugging with cotton wool, which is found to act as a perfect filter for the bacteria of the air, allowing none to pass it. In this way a crop of the individual species of bacteria is prepared, though sometimes it may be necessary to make several successive plate cultivations in order to get an undoubted separation of species. Different species of bacteria behave in different ways towards various cultivating media, such as milk, cooked potatoes, and the like, many of them in their cultivations also exhibit a colour and mode of growth peculiar to themselves, and such differences together with slight differences in size and shape enable many of them to be distinguished.

Bacteria exist in all exposed waters in amazing numbers. They are too numerous to be mentioned in connection with the gallon or the pint, but one cubic centimetre, which is about one thirtieth part of an ounce, is the measure of water which it is usual to quote as containing so many bacteria. This small quantity of water may contain any number from zero to 100,000 or more. It is said that as many as 200 distinct species of bacteria have been distinguished in river water, but their separation and study is so surrounded with difficulties that no extensive and reliable classification has yet been made of them. There are many points in connection with their life and death, nature and growth that have yet to be made clear. It is a well established fact, however, that certain species of bacteria are invariably developed in certain environments in preference to other species, also, that various food materials are affected differently by different species, a preference sometimes being given to one species which upon that particular nourishing medium, or under those particular circumstances entirely overgrows and puts out of existence all other species. In fact every set of conditions is conducive only to the development of those organisms which belong to it, and the organisms which do not belong to it are as little likely to flourish when accidentally introduced as a fish upon dry land. Thus there are undoubtedly a number of species of bacteria that are peculiar to the waters of streams and rivers and which may be particularly referred to as river bacteria. As rivers proceed in their course they become capable of supporting other species of bacteria than those originally contained in the head waters, owing to additions of salts and other materials to the water, but it should be particularly remembered that the water of a river is not rendered progressively impure so far as organic material goes, but varies locally to a very great extent, and to an equal extent varies in regard to its bacteriology. Not only is there the competition between different species of bacteria which results in the survival only of the fittest, but in the flowing water of a river destructive influences are at work upon all bacteria and one of the strongest of these is direct sunlight, all parts of the water at one place or another in the river being liable to exposure to this most destructive agent.

THE QUALITIES REQUIRED IN A GOOD DRINKING WATER

Let us now review the qualities required in a good drinking water—

As to total solid matter a water that contains more than 30 grains in the gallon, however pure it may be organically, cannot be placed amongst first class drinking waters. Nearly the whole of the solid matter present should consist of lime salts and be mainly carbonate of lime. A water containing 30 grains to the gallon of total solids is sure to be a too hard water. Though it has been argued that lime salts in water are essential to bone-formation, and to good health, it has been also pointed out that populations who drink very hard waters are not particularly remarkable for well-formed bones, whilst the natives of Aberdeen and its neighbourhood, where the water is almost devoid of lime, are remarkable for their development of bone. Certainly a hardness exceeding 6 or 8 degrees is a superfluity best dispensed with where possible on account of health, comfort, and general utility. Chloride when exceeding 2 or 3 grains of chlorine in the gallon requires explanation and the origin of the water that contains nitrate equivalent to more than a grain of nitric acid in the gallon should be enquired into, whilst nitrite beyond the smallest trace cannot be allowed to have existence in a good water. Water from a deep well, a deep spring, or freshly filtered water from a river or a reservoir that yields no more than ·002 of free ammonia and ·006 of albuminoid ammonia per 100,000 is certainly wholesome unless the bacteria of disease have been accidentally introduced into it subsequently to its filtration.

The bacteria of disease must of course be absent from a good drinking water, and the water should contain few bacteria of any kind. It is absolutely impossible however to serve out water that is sterile or free of bacteria, but when quite fresh from the spring, well or filter a good and safe drinking water must not contain more than 100 bacteria per cubic centimetre. The French and German water analysts have fixed upon this as a safe maximum number, and have proved it by experience of some length. A good drinking water in short should not be hard, should not contain organic material or nitrate which is its resultant in such quantity as to suggest pollution by dangerous filth, and should when fresh contain no more than 100 bacteria per cubic centimetre.

Water Supplied to Towns

The origin of the water of public supplies to towns is various and depends chiefly upon the character of local resources. In some neighbourhoods springs are plentiful in number and sufficiently copious in yield to afford a supply. Failing natural springs recourse is sometimes had to sinking deep wells, or making artesian borings from the bottom of shallower wells through impervious rocks to the water bearing strata below. Larger natural stores of pure water as in certain lakes have been requisitioned for water supplies, the supplies to Glasgow and Manchester being of this kind, whilst Liverpool by throwing a dam across the Vyrnwy Valley has created such a lake for its own use and Birmingham is following the example. About 25 years ago a Parliamentary Commission sat to enquire into the Pollution of Rivers and in one of the reports issued by it is contained a classification of waters according to their supposed wholesomeness. This has been very frequently quoted and copied into most books dealing with the subject of water supplies, in fact it has hitherto influenced opinion in a very decided way, and it is unfavourable to untreated river water. In the light of more modern knowledge however this table requires revision and rearrangement, and the next classification of drinking waters will have to be made with due considerations to circumstances of purification into which I will presently enter. Notwithstanding however that so strong a bias has existed against river water for drinking, the water of rivers and smaller streams has after all formed the chief supply to towns. There are a great many towns in England supplied with water from small streams many of which are subject to sewage pollution, but I will make mention of some places that are supplied by rivers of larger size. Oxford is supplied from the Thames, Reading from the Kennet, York from the Ouse, Hereford from the Wye, Durham from the Wear, Newcastle in part from the Tyne, Doncaster from the Don, Worcester and Tewkesbury from the Severn, and other towns, in part, from the same river, Chester from the Dee, Carlisle from the Eden, Exeter from the Exe, Ely from the Great Ouse. On the continent the following large cities are partly or wholly supplied with drinking water from the rivers upon which they stand, Paris, Berlin, Vienna, Antwerp, Ghent, Warsaw, Buda Pesth, Hamburg, and Altona, Amsterdam, Rotterdam, Dortrecht, and many others. In America I am informed on good authority that 1500 towns are supplied with water from rivers and that upon all the great rivers, such as the Hudson and Mississippi, town after town takes out water for drinking. Philadelphia, Cincinnati, Boston, Washington, Springfield, Jersey City, New Orleans, San Francisco, Allegheny, Pittsburg, St. Louis, Albany, being amongst those using river water. From none of these numerous towns comes news of disease caused by properly purified river water.

Artificial versus Natural Purification

It was stated at the commencement that all water is impure, that rain washes impurities out of the air, and out of the soil. Water which has received contamination in this way can be purified by filtration, and the natural filtration of water is constantly in progress, the water sinks through beds of gravel and sand, chalk or oolitic rock, and issues from their base as springs, or collects into wells that may be sunk through the porous rocks. The water is much purer than was the rain after washing the Earth's surface; it has lost the greater part of the organic material it contained as well as its bacteria. This natural purification of water can be imitated artificially by passing water through prepared filters. Gravel and sand are generally employed as the filtering media for artificial filtration and the result of passing water through a well prepared filter of this kind is very satisfactory, a large proportion of the organic matter as well as all or nearly all of the bacteria present in the water being removed. In some respects artificial filtration is superior to natural filtration inasmuch as one knows exactly what is being done with the water, and the purification is so to speak in one's own hands, at all events it may be made superior and more efficient than some natural filtration, and it is not necessary for the purification of water to have filters of such vast thickness as is afforded in nature by beds of chalk, oolite, or sand, measuring hundreds of feet. The same practical results can be obtained with not more than 4 or 5 feet of sand and gravel if the filtering process be not hurried. Professor E. Frankland who formerly had little faith in artificial filtration, after making a very careful investigation of the action of sand filters has stated in effect that it is possible to purify water by sand filtration to as great a degree as if it had been obtained from a deep well after passing through hundreds of feet of chalk. Professor Koch, of Berlin, has recently shown that the efficiency of artificial filters does not depend upon the thickness of the filter, but upon the formation upon its surface of a slimy mud, which is deposited from the water, and which is loaded with bacteria. The purification of the water is mainly effected in passing through this layer by a vital rather than by a physical process, although by stopping up the pores of the filter it also increases the straining effect and so prevents the bacteria from passing. By a vital process is meant the fermentative effect of the bacteria in the slimy layer upon the organic matter in the water causing its destruction, or reduction to harmless products.

There are several patented processes for the purifying of water on a large scale by special means, they mostly comprise the use of iron in one form or another, the several compounds recommended being stated to greatly aid the purification of water by filtration. One such compound is termed polarite, and another magnetic iron carbide. A third process, and one the use of which appears to be extending, is the agitation of the water with pieces of metallic iron by allowing the water to flow through a revolving cylinder containing the pieces of iron, such as iron punchings or any small pieces of the metal, which are caused to fall through and through the water as the cylinder revolves. A small portion of iron is taken up as carbonate, and on after exposure to the air is precipitated as oxide, carrying with it some of the impurity of the water, which along with the iron is then removed by filtration. Dr Swete, the Worcestershire Analyst, strongly advocates the process after given it an extended trial. By the careful management of ordinary sand filters however such excellent results are obtained as to allow of any extra process being dispensed with.

The Danger of Drinking Polluted Water with Examples

Ample evidence has been obtained to prove that drinking water may become the medium for the conveyance into the human body of the bacteria which cause Typhoid Fever and Cholera. Under certain favourable conditions there is little doubt that these specific organisms are capable of multiplication outside the body, and that such multiplication has taken place in water intended for drinking, and thus become the cause of epidemics. So far as is known the only two zymotic diseases that are ever thus conveyed in water are Typhoid and Cholera, although there are some whom Professor Koch terms "Water Fanatics," who attribute far greater powers to water as a carrier of disease germs, or who argue that the infection of Typhoid and Cholera is never borne by any other means than by water. To most persons who have had experience of the matter, however, the last assertion appears an undoubted fallacy. There is little doubt that Typhoid Fever, for instance, is frequently set up and conveyed from person to person irrespective of drinking water; faulty drainage being probably an initiating cause as well as water supply, and a crowding together of the healthy and the sick also resulting in the spread of the disease. The germs of these two diseases are also very likely to be introduced by other articles of food and drink besides water. In both Typhoid and Cholera the bacteria of the disease, are contained in great numbers in the bowel evacuations and are consequently liable to pass into drains and sewers and possibly into streams, rivers, and other sources of drinking water, where they may under favourable conditions multiply. Experience of epidemics of Typhoid that have been traced to water supplies in England have proved that the danger is almost limited to supplies or collections of water as in wells or small brooks, where it is possible that a comparatively high degree of pollution by matter containing Typhoid bacilli may be reached. When such matter is poured into a great stream such as the Thames or Severn the possibility of the multiplication of its bacilli is of the remotest. The dilution is in the first place enormous, the conditions are exceedingly unfavourable to these specific bacteria as compared with the river bacteria and it has been proved by actual experiment that the two kinds cannot go on living side by side, and it would be absurd to suppose that the river bacteria could be displaced from their natural element by weakly strangers. Unless the cultivating material be suitable, the bacteria of disease do not multiply in it, and river water unless grossly polluted with sewage material is certainly not a medium suited to the development of Typhoid bacilli. The evidence that we have at present goes to prove that Typhoid bacilli may be expected in rivers near the mouths of sewers, and that if they multiply in river waters it is only in situations where the pollution by the material in which they have been developed in the body is at a maximum, and that dilution and exposure to flowing water very quickly destroys them. The same thing holds good of Cholera, of which however we have but little experience, but one cannot suppose that Cholera bacteria are at all likely to multiply through the waters of our larger streams in face of the natural difficulties presented. In small collections of water, however, there is greater danger, the pollution reaches a far greater intensity, and in the water of wells and small stagnant stores there is evidence to show that disease organisms may multiply and continue through a prolonged existence. Any water of whatever origin, that contains unaltered sewage material, is absolutely unfit for drinking until such material has been destroyed or removed, and previous to such destruction or removal its use is reprehensible in the highest degree. Lately the subject of water-borne diseases has been much to the fore, and some extraordinary examples have been placed on record. The Local Government Board, through their Inspectors, have made many inquiries into the origin of outbreaks of

Typhoid Fever, and have sometimes been able to attribute the cause with great reason to water supplies. The recent experience at Hamburg has also shed light upon the origin of Cholera from water. In England the water that has been the cause of Typhoid has always been a small local supply, if we make the one exception of the water of the River Tees which was reported to have caused a prevalence of Typhoid in the Tees Valley. The report of this outbreak made by Dr Barry has led to a controversy with a doubtful result up to the present time. That the water may have caused the disease by some accidental fouling is possible or even probable, but that the whole of the water of the Tees was affected by Typhoid bacteria derived from a very small amount of possible pollution at a point nearly 20 miles above where the water was removed for drinking as suggested by Dr Barry is an idea that cannot be entertained. Professor Koch has attributed an outbreak of Typhoid Fever at Altona to imperfect filtration of the waters of the River Elbe, which, however, is known to be in a very highly polluted condition at the intake of the Water Company. The recent Cholera Epidemic at Hamburg no doubt had origin in the water of the Elbe, which is a tidal river at Hamburg, and receives the whole of the sewage of that large city and its suburbs. The history of the Cholera Epidemic at Hamburg and the escape in this instance of Altona proves at one and the same time the danger of drinking the strongly polluted water of a river, and also the saving efficacy of filtration in removing the organisms of disease from water. The story may be told in Koch's own words:

"The three towns of Hamburg, Altona, and Wansbeck "are contiguous to each other, and really form a single "community, and only differ in so far as each has a "separate and a different kind of water supply. Wansbeck "obtained filtered water from a lake. Hamburg obtained

"its water in an unfiltered condition from the Elbe above
"the town, and Altona obtained filtered water from the
"Elbe below the town. Whereas Hamburg was notori-
"ously badly visited with Cholera, Wansbeck and Altona—
"if one excepts the cases brought thither from Ham-
"burg—were almost quite free from the disease. . . . . .
"In one street forming a boundary of Hamburg and
"Altona, Cholera occurred on the Hamburg side, whereas
"the Altona side was free of it. . . . . Altona resorts
"to the Elbe after it has received all the liquid and fœcal
"refuse of 800,000 people, the Elbe being relatively little
"contaminated where Hamburg takes its water."

Here we have an instance of Cholera bacteria living and probably multiplying in a river constantly, and enormously polluted with sewage. The Cholera bacilli were actually detected in the water—we see the disease set up by it in the one town, and in the other where the water is originally at its worst we see the disease prevented by simple sand filtration.

The Caterham Well may be quoted as a notorious example of a pure water that caused an epidemic of Typhoid Fever through an accidental contamination from a workman, who whilst employed at work inside the well was seized with Typhoid Fever. This water was of course not filtered, being derived from a deep well.

Typhoid and Cholera Bacilli

The mode of the artificial cultivation of the Typhoid bacillus and its separation as recently described by Professor Percy Frankland is of interest, as showing the different behaviour of bacteria towards different nutrient material. Carbolic acid and dilute mineral acids are very fatal to the existence of most bacteria, but the Typhoid bacillus is comparatively insusceptible to their influence. A cultivation of the suspected water is therefore made in a nutrient fluid to which a little carbolic acid and hydrochloric acid has been added the Typhoid bacilli increase in this fluid enormously, whilst ordinary river bacteria are killed or their growth greatly retarded. The Cholera bacillus may be similarly cultivated in a nutrient fluid containing peptone and salt, which is a form of nourishment it particularly affects.

The majority of bacilli produce spores by which they are reproduced with renewed vitality, and these spores are more difficult of destruction than the bacteria themselves. The Typhoid bacillus produces no spores, which is an important fact in connection with the life history and destruction of these bacilli. Both the bacilli of Typhoid and Cholera refuse to grow in ordinarily pure river waters containing the common river bacteria, and only upon very rare occasions has either been detected in river water, even in the most polluted places.

The Royal Commission on Metropolitan Water Supply, 1893

In September of last year was issued the Report of the Royal Commission appointed to inquire into the Water Supply of the Metropolis, and it is the most important document in connection with the use of river water ever yet printed. In mentioning some towns that were supplied with drinking water from rivers I made omission of London. Over 5,000,000 of people in greater London are supplied with river water for drinking, and about 3,000,000 are supplied from the River Thames, the water being taken from the river very near its entry to the London area in the neighbourhood of Hampton Court. The object of the Inquiry as set out in the preamble of the Report is "to ascertain whether the sources available in the Watersheds of the Rivers Thames and Lea are adequate in quantity and quality for the Water Supply of the Metropolis." All the evidence of any value that was obtainable upon the subject was brought before the Commissioners. The question of the suitability of a river like the Thames that is known to receive pollutions in hundreds of places was discussed in all its bearings. The evidence of Chemists, Bacteriologists, Medical Officers of Health, Engineers, and others was taken, and all went to show that as to quantity there is available from the rivers at present supplying London sufficient at least for a population of 12,000,000, and as to quality the Commissioners report: "We are strongly of opinion that the water as supplied to the consumer in London is of a very high standard of excellence and purity, and that it is suitable in quality for all household purposes. We are well aware however that a certain prejudice exists against the use of drinking water derived from the Thames and Lea, because these rivers are liable to pollution, however perfect the subsequent purification either by natural or artificial means may be; but having regard to the experience of London during the last 30 years, and to the evidence given on this subject, we do not believe that any danger exists of the spread of disease by the use of this water, provided that there is adequate storage, and that the water is efficiently filtered before delivery to the consumers."

All that the Commission is able to suggest in regard to the improvement of the quality of water as supplied to London is that a little greater care should be taken in regard to the purification of the water by increasing the areas of the filters and the subsidence reservoirs, and the idea of going 150 or 200 miles away into Wales to bring water for drinking purposes into London is entirely waived so long as such an excellent supply can be obtained from the noble river upon which the metropolis stands. In the course of the Inquiry many interesting items of information were elicited. It was shown for instance that the mortality from Typhoid Fever in London notwithstanding the vast and close aggregation of people that lives upon its limited area was less than in 10 out of 14 other great English towns which are supplied with water to which no such pollution as that which finds its way into the Thames has access. This surely ought to be sufficient to prove to the satisfaction of most people that the production of Typhoid Fever is no more connected with the filtered Thames water than with any other water wherever supplied and of whatever origin.

II. THE SEVERN AND ITS TRIBUTARIES

Let me now direct your attention to our own river, the Severn. It rises as you know on the sides of Plinlimmon by several small streams. These have united at the town of Llanidloes, somewhere about 160 miles above Gloucester, to form a stream quite worthy of the name of river and which contains a fair volume of water at all times of the year. It flows on with many winds past Newtown, and within 2 or 3 miles of Montgomery, to Welshpool receiving additions to its volume by small tributaries from the hill country on either side. Ten miles from Welshpool as the crow flies it is joined by a most important branch the Vyrnwy which is hardly second to the main stream at this point. The river has so far flowed in a North Easterly direction, or in a direction opposite to its mouth. It now turns due East and after a very wide detour reaches Shrewsbury whence its general direction is Southerly. The next town it passes is Ironbridge, and afterwards Bridgnorth, Bewdley, and Stourport, and so it flows to Worcester, Tewkesbury, and Gloucester.

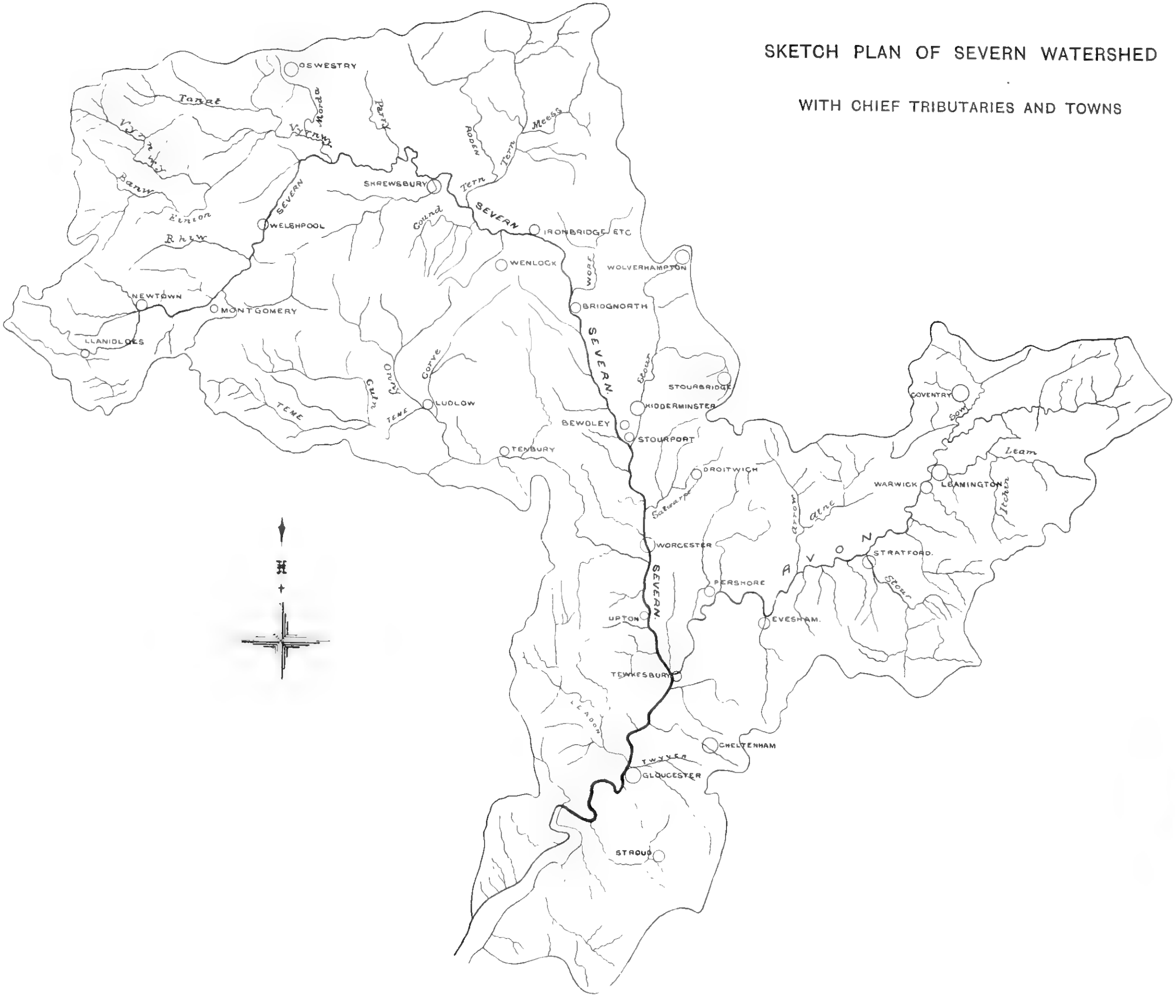
The great head waters of the river come chiefly out of Montgomeryshire, almost the whole face of that hilly county being drained by innumerable small streams eastwards. Between the junction of the Severn and Vyrnwy and Shrewsbury the river receives the Perry which drains

TCH PLAN OF SEVERN WATERSHED

WITH CHIEF TRIBUTARIES AND TOWNS

SKETCH PLAN OF SEVERN WATERSHED

WITH CHIEF TRIBUTARIES AND TOWNS



North-West Shropshire, and after passing Shrewsbury it receives the Tern, and the Worf from the North-East and East of the same county, the Tern extending for some miles along the border of the county of Stafford. The Meol Brook and the Cound are small streams from Mid-Salop, but a large district in the South and South-West of this county including, the Wenlock Edge and Clee districts, and extending over the borders of Herefordshire, is drained by numerous brooks into the Teme, which forms a large tributary to the Severn below Worcester. On the other side at Stourport is the Stour which comes out of Staffordshire, its branch the Smeston extending nearly to Wolverhampton. On the same side before reaching Worcester is the Salwarp from the neighbourhood of Droitwich, and besides the Teme already mentioned below Worcester we have the Upper or Warwickshire Avon, a tributary 85 miles in length, which rises beyond the borders of Northamptonshire and drains a tract of country over 1000 square miles in area.

Up to the junction of the Severn and Vyrnwy the geological character of the river basin is that of impermeable Silurian and altered rocks that yield very little to water. The rainfall in Montgomeryshire averages 36 in. per annum, but at the head of the Vyrnwy it is 76 inches, and the result is a very large yield of very pure water to the river. After 2 or 3 days heavy rain in these upper stations the river above Shrewsbury rises rapidly to a flood, but it requires a very large local rainfall to materially affect the height of the river at Worcester and Tewkesbury, as the effect of local storms in Montgomeryshire is, so to speak, spread out over the whole river. Thus about a week ago the storm of wind which was experienced throughout the West of England was accompanied by a very heavy rainfall in the Upper Severn Basin and resulted in the water rising 9 feet over the river banks below the junction of Severn and Vyrnwy, no such flood having occurred for over 2 years previously. No indication of such an excessive fall however was noticed at Tewkesbury.

A short distance below the junctions of the rivers the Severn comes on to the Bunter beds of the Trias, and at Shrewsbury passes over a patch of Permian. (These rocks here overlie the coal measures.) It is afterwards in contact with the lower Trias again, the Middle Silurian Sandstone in the neighbourhood of the Wrekin and the Wenlock Shale for a few miles, and at Ironbridge is on the Coal Measures which crop out here. It is afterwards on the New Red Rocks until it reaches the lias which forms one bank of it near Tewkesbury whilst the Keuper Marl forms the other.

The Perry 10 miles long, the Tern 23 miles long, with its branch the Roden 20 miles long, as well as the Worf 13 miles long, and the Stour 20 miles long, all flow chiefly over the mottled sandstones and conglomerates of the Bunter, with occasional touches of the Permian and Keuper.

The Salwarp comes entirely from Keuper Marl. On the other side the Teme passes successively over Upper Silurian Rocks, old Red Sandstone and New Red Marl receiving tributaries from the same Rocks. The (Upper) Avon differs from all the other tributaries previously mentioned in draining large areas of Lias formation as well as considerable areas of Keuper. The Lias Rocks give the waters of the Avon a totally different quality to any water that has been received by the Severn hitherto, the water of the Avon being much less pure organically, owing partly perhaps to the slowness of its flow. It has also a far greater hardness than the Severn itself or either of its other tributaries.

The Pollution of the Severn

Throughout its course the Severn receives numerous pollutions from the towns and factories that stand on its banks and on those of its tributaries, or rather its one tributary the Stour, for above the Avon the Stour is the only tributary that receives any very large amount of pollution, excepting such as may be called natural pollution. In Montgomeryshire flannel and cloth manufacture is carried on to some considerable extent and is a source of pollution. The first flannel mills are above Llanidloes.

The population of Llanidloes is 2574. It is irregularly drained, several drains discharging into the river. There is no public water supply and cesspits and wells abound. There are several flannel and woollen mills in the town. Above Llanidloes are lead mines the washings of which flow into and it is said pollute the Severn with lead when the mines are in work. At present they are idle. The lead is reported to have poisoned the fish, but it would be a chemical impossibility for lead to be borne any considerable distance in the water of the Severn.

NEWTOWN AND LLANLLWCHAIRN population 6610, distant from Llanidloes by river about 16 miles. Here there are several flannel and cloth mills. The town bears the appearance of good public management and possesses a sewage farm and public water supply, the effluent goes into the river. The river here is a large deep stream 25 or 30 yards wide with a strong current and bottom of gritty stones.

MONTGOMERY, population 1098, a dozen miles by river below Newtown is Montgomery station, but the town lies over two miles from the river and cannot be said to pollute it.

WELSHPOOL, population (urban) 3100, 10 miles from Montgomery station by water. In the town is one flannel factory employing 60 or 80 hands. Welshpool has a water supply and its houses are pretty generally drained. Its sewage goes straight into the river which at the point of discharge exhibits no apparent sign of receiving it. The volume of sewage seen discharging is insignificant compared to the volume of the river. A brook upon which the flannel mill stands also brings in some pollution.

SHREWSBURY, population 26,967, about 40 miles by river from Welshpool, the river being very tortuous between the two towns. The Shrewsbury sewage is poured into Severn by several sewers without treatment. The town has a small supply of spring water, which is supplimented by a large supply from the Severn.

IRONBRIDGE, COALBROOKDALE, COALPORT and JACKFIELD, a cluster of small manufacturing places, population about 5,250, 20 miles by river below Shrewsbury. Ironbridge is situated on the side of a steep cliff, and with the other places mentioned, drains irregularly into the river. Lime kilns and blast furnaces are here, and pottery, bricks, &c. are manufactured; no public water supply. Clinkers, &c. are tipped on river bank.

BRIDGNORTH, population 5,350, 9 miles by river below Ironbridge, drains straight into the river. It has a limited supply of stored spring water, with a supplimentary supply from the Severn.

BEWDLEY population 2,870, 17 miles by river below Bridgnorth, drains irregularly into river, and has no public water supply.

STOURPORT, population 3,548, five miles below Bewdley by river. Sewer discharges straight into the river. Water from the Kidderminster Public Supply is conveyed into Stourport. Carpet manufacture is carried on here.

THE RIVER STOUR. Kidderminster stands on the Stour, population 24,830. Its sewage irrigates 548 acres of land. The effluent goes into the Stour. The Stour is greatly polluted by dye stuffs and other trade refuse from carpet factories; also iron and hydrochloric and sulphuric acids from tin plate works, and refuse from paper mills. The iron has, no doubt, a purifying rather than a harmful affect upon the water, acting as a precipitant.

The pollution from the factories is soon deposited, and only a portion of it ever reaches the Severn. In summer time very little water passes from the Stour at all.

WORCESTER, population 42,900, about 14 miles below Stourport by water. It, at present, passes its sewage directly into the river, but a mandamus has been issued which compels the Corporation to treat the sewage within the next two years. Water supply wholly from the Severn, the water being subjected to sand filtration.

UPTON-ON-SEVERN, population 2,000 (about), 10 miles below Worcester, drains some sewage into the river. Privies are here in common use, and there is no public water supply.

TEWKESBURY, population 5,269, 17 miles by river below Worcester, turns sewage into the river. Has a public water supply of filtered Severn water.

THE CANALS OPENING INTO THE SEVERN discharge an occasional lock-ful of their water into the river.

There are a few outlying places such as OSWESTRY, LUDLOW and TENBURY, and solitary houses and hamlets on the Severn or its branches, which also add their pollution or such of it as can ever reach the river.

THE SELF PURIFICATION OF THE RIVER

The total town population that drains its sewage, treated and untreated, into the Severn and its branches above Tewkesbury, is less than 150,000. So far as the sewage goes it is nowhere sufficient in quantity to have any marked effect upon the quality of the water in the river, and the small effect it does produce is very transient. The fact is, however, the volume of the water coming down the Severn is too vast, in proportion to the actual solid material of the sewage discharged into it, for the latter to be appreciable. However unpleasant this list of pollutions may sound to the ear, if we come to calculate the average mass or weight of the solid polluting material of animal origin discharged into the river, as related to the amount of water in the river, supposing at the same time that, notwithstanding its organic nature, it suffers no destruction, and the river is at its lowest, even so, its relative weight is infinitesimal. When we come to consider the undeniable fact that this organic matter is destroyed in the water with great rapidity, so that after a very few miles flow from the place of reception as we have plenty of evidence to show, the material is entirely destroyed, the degree of pollution becomes lessened to a vanishing point. No doubt it is quite possible to pour more sewage into a river than can be destroyed; such was the case when the whole of the London sewage went untreated into the Thames, and in such a case we have all the dangers of a permanent pollution; but no such condition obtains anywhere in the Severn. I have satisfied myself by my own examinations and analysis, that all the sewage received by the Severn makes no appreciable difference to the water at Tewkesbury. Dr Swete, the Worcestershire Analyst, has proved to me, by the result of his examinations, that the process of destruction of the Worcester sewage is complete five miles below Worcester. I have satisfied myself of the same thing, by analyses and bacteriological examination, having collected water for the purpose on the same day above Worcester and at points below the town at increasing distances. The bacteria in the water of the river increase in numbers opposite and immediately below the town, but three or four miles lower down have come back to their normal numbers. The oxygen in the water, as Dr Swete has shown is at saturation point above Worcester, and is reduced opposite and below the town by the oxidation of the organic matters discharged into the river; but five miles below Worcester the water has returned to its nominal saturation by oxygen, and also to its nominal yield of ammonia.

The organic material brought in by the little slow-flowing river, The Perry, notwithstanding that this comes off what may be called a clean country, so far as sewage is concerned, appears to bear a high proportion to that contained in all the sewage that finds its way into the Severn. It may be said that the danger does not lie in quantity of organic material, but in the likelihood of the water containing the bacteria of disease; but the answer may be given that a sluggish water containing a permanent amount of decomposable impurity is more likely to breed disease bacteria than a water as naturally pure as the fast-flowing Severn. There would be more danger in using the water of the comparatively stagnant river Avon for a drinking supply, though it should be proved that it receive no sewage from any town upon it than to use the water of the Severn with all its known pollutions.

THE RIVERS POLLUTION PREVENTION ACT

You have heard that Worcester has been ordered to desist from pouring its raw sewage into the river. Under the Rivers Pollution Prevention Act, which dates from so long ago as 1876, all the towns on the Severn can be compelled to the same course as is Worcester. All that is required is for some person, or corporate body to cause the Act to be put in force. Possibly some one will put the Rivers Pollution Prevention Act into force against those towns now carelessly pouring their pollutions into the Severn.

THE QUALITY OF THE WATER IN THE SEVERN AND ITS CHIEF TRIBUTARIES

I have appended to this paper tables of the analyses I have made of the water of the Severn and its chief tributaries, and the results are interesting as showing the changes that take place in the composition of the water of the main river during its flow from Llanidloes to Tewkesbury. The river, which, at its commencement, contains water with only 3 grains of total solids in the gallon, gradually picks up a little carbonate and sulphate of lime, and so increases in hardness as it progresses. The tributaries it receives between the Vyrnwy and the Avon, excepting the Teme, bring in water containing a comparatively large quantity of solid material, but they are all quite small compared with the main stream, and the water consequently remains pure and soft in the Severn until it arrives at Tewkesbury. Some people appear to entertain the idea that the water of the Severn must contain a large quantity of solid impurity after so long a flow. The fact of the country through which it passes being cultivated, it has been hinted, must add material to it. This is a great fallacy. The green meadows of Severnside are not a source of pollution, and the actual amount of solid material in the Severn at Tewkesbury only appears to average about 12 grains in the gallon, which is a far smaller amount than that contained in any other natural water in the neighbourhood. The average hardness is about 8 degrees, but varies some degrees on either side of this. The last sample obtained only a few days ago, had 5½ degrees only. Even when the water is very turbid, as after long continued rains, the material which causes the turbidity has very little weight, the whole solid material rarely exceeding, under these conditions, more than 20 grains per gallon. The turbidity of the water at Tewkesbury is caused by fine particles of sand and red marl, and there is more of one or of the other according to the locality where the greatest rainfall has occurred to disturb the banks of the tributaries. The Teme, when in flood, brings in more red marl than any other tributary, and this causes thick redness in the water of the Severn. The waters of the upper Severn have a slight turbidity after rain, which is said to be due to kaolin; the suspended material is impalpably fine, and when the rains have been confined to the

Montgomeryshire district, a slight milkiness is often imparted to the whole of the Severn by the kaolin. The Vyrnwy, after very heavy rains, and especially at certain seasons of the year, brings down peat. It is described as sometimes being black with peat. Very little of the actual particles of peat appear to reach Tewkesbury unless on very rare occasions, but the water of the Severn often has a rather strong yellow-brown colour due to staining by vegetable material, though I question whether this colour comes altogether from the Vyrnwy, for, having on the same day collected water from the Vyrnwy and most of the other tributaries, I found the waters of the Perry and of the Tern had much the strongest colour. The Stour is commonly turbid.

A record is kept at Tewkesbury of the appearance of the Severn water on every day of the year, and the Water Engineer has obliged me with the following information concerning the appearance of the water during the last two years. When the water is chiefly turbid with sand it is called "thick," and when turbid with marl "red," and when it has the fine turbidity due to kaolin and very fine particles of light coloured sand it is termed "milky," and it is "bright" when it has no turbidity.

	1892	1893
Bright - - - -	187	249
Milky - - - -	104	60
Thick - - - -	34	44
Thick and red - -	24	12
Red - - - -	9	—
Record interrupted -	7	—
Days	365	365

I have said that the greater bulk of the water of the Severn comes from its two great heads, the Vyrnwy and the Upper Severn, in Montgomeryshire. The water of these two main sources do not differ very much in quality, but unless much disturbed and peaty the Vyrnwy is the clearer water, the river having a harder bottom of sand, whilst the Severn, in places, has a soft alluvial clay, which is, in fact, what gives the water its milkiness, and which appears to be of the nature of China clay, or Kaolin. The waters of both the Vyrnwy and the Severn bear evidence of containing vegetable organic material in considerable quantity from the commencement. Probably it is peat, and the quantity of such vegetable material in the main stream is largely added to by the highly-charged waters of the Perry and Tern. The material of this kind contained in the water of the Severn, where lower down it comes to be used, is readily discovered on analysis by the large amount of oxygen it is capable of absorbing from permanganate of potash, it also gives a yellowish tint to the water, much stronger at some times than at others.

The chief characteristics of the waters of other tributaries may be briefly mentioned. The Perry, Tern, and Worfe are all off the Bunter beds, and contain similar water excepting that the Worfe does not contain so much of the brown-coloured vegetable matter as the other two streams. They all three contain about the same amount of solid material with a hardness of 24°, i.e., they are decidedly hard waters. Nearly half the lime that they contain is sulphate of lime, which is sufficient of itself to characterize them and the rocks from which they drain. Of the three the Perry had the least degree of organic purity on the day of collection of the water when all three of the streams were full to the tops of their banks.

The water of the river Stour gave signs of considerable pollution. It contained a very appreciable quantity of iron; in fact it was brown with iron oxide, no doubt derived from the tin plate works. It also contained excessive quantities of sulphate and chloride evidently combined with sodium in great part, and too much organic material.

The water of the Salwarp gave interesting results. It contained 150 grains cf solids in the gallon, and chlorine equivalent to 74 grains of sodium chloride (common salt), and had a hardness of 65 degrees. It will be remembered that this river comes over the red marl from the Droitwich neighbourhood, and evidently receives water from salt springs. The river was brimming full when the sample was taken, and must have consisted in part of local surface water, so that it is likely in dry weather, when the water will consist of more spring water and less surface water, that the water will be much stronger in salt. The 3 or 4 grains of chloride in the gallon, sometimes detected in the water at Tewkesbury, might have been attributed to a less desirable source had one not known the character of the water brought in by the Salwarp.

The river Teme, which joins the Severn below Worcester, brings in a large volume of water of very excellent quality, which, when the river is not in flood, is of great organic purity. So large an adjunct of such pure water as that of the Teme is of great advantage to Tewkesbury, and it is well the positions of the Teme and Avon are not reversed. The Teme drains 633 square miles of country, mainly consisting of impervious rocks, which is equal to two-thirds of the whole Severn Watershed above Shrewsbury. The water of the Teme receives very little pollution.

In the 15 miles of river between Worcester and Tewkesbury the water is altogether greatly improved in quality, partly no doubt through natural purification and partly by dilution with the pure waters of the Teme. The water in the middle of the river at Tewkesbury after a spell of quiet weather is wonderfully pure, far purer than the water either below or above Worcester, it in fact compares favourably with the water of the river anywhere below Shrewsbury. The turbidity of the water caused by storms renders it less pure in all ways for the time being, but if such water be allowed to stand for a few days for subsidence to take place, the sand and marl, and kaolin in subsiding carry down much of the other impurity. In the experiments I have made with the Tewkesbury water I find that allowing the turbid water to stand for a week entirely clears it and reduces its organic impurity by just one half, generally rendering it sufficiently pure to use without further treatment.

COMPARISONS WITH THE THAMES

The Severn water is on the whole superior to that of the Thames, and the Severn water above Tewkesbury compares favourably with that of the Thames above Oxford. I had a sample from the Thames one mile above Oxford last year and compared it with a sample taken from the Severn above Tewkesbury under similar conditions of weather, there having been no rain for several weeks. The result in the organic constituents I give—

	Thames	Severn
Free Ammonia	·05	·05
Albuminoid Ammonia	·14	·09
Oxygen consumed in 4 hours	·84	1·15

In parts per million.

Of course Thames water is much harder than that of the Severn, being derived from the Oolitic limestone, the hardness being the one disadvantage of London water. The filtered water of the Tewkesbury supply has just about the same degree of organic purity as the water supplied by the more careful of the London Companies to their consumers, but the raw Severn water at Tewkesbury averaging a much higher degree of purity than the Thames at Hampton Court it is easier to arrive at as good a result. The population of the polluting towns on the Severn and its tributaries is less than of those on the Thames and its tributaries, whilst the flow of water in the Severn is greater than that in the Thames on an average, and the minimum flow of the Severn above the Avon at Tewkesbury is fully equal to the minimum of the Thames at Teddington.

The Quality of Water the Severn is Readily Capable of Yielding

The Severn an Excellent and Inexhaustible Supply for Drinking and All-Round Purposes

There can therefore be no possible difficulty in producing as good a water from the Severn as from the Thames. The only argument that can be adduced as against the use of river water is the possibility of the germs of typhoid fever being spread in the supply, but supposing that the water at the intake ever contained such germs, by a careful treatment by subsidence and slow filtration it is perfectly easy to get rid of them, and considering that absolutely pure but unfiltered waters have been the cause of typhoid epidemics it would seem most safe to use a freshly purified water. It is better sometimes to trust rather to art than to nature. The experience of London and the many other places for so many years proves beyond doubt the safety of purified river water for drinking and the safety is now further assured by the fresh knowledge we have gained. The highly sensational cry "Is sewage fit to drink" as applying to river water such as that of the Severn is meaningless. The water of the Severn is not sewage, but a good natural water of unusual purity. It is no more sewage than the springs of the Cotswolds are sewage, because the surfaces of the fields upon which that same spring water fell were subject to innumerable pollutions and even covered with the manure of animals and men. As that water is purified by a natural purification so the Severn water can be purified with quite as great a certainty and to quite as great a degree by an artificial purification. There is no reason why the Severn water should not be served with as great a degree of organic purity as the water of the oolite springs which in certain other qualities it excels under any circumstances.

The springs are not inexhaustible but the Severn cannot be run dry. The supply of water to such a place as Liverpool from one of its small tributaries has made no perceptible difference to the water in the Severn or even in the Vyrnwy, near its mouth, unless it be a difference of advantage in the driest weather by reason of the 10,000,000 gallons of compensation water that has to be turned daily from the reservoir into the stream. For all towns in the middle Severn basin at least, no better supply for drinking and all-round purposes is required than that from the Severn, and none can be obtained.

		Model Drinking Water	Tewkesbury Water as supplied
Hardness in Clark's degrees, up to		10°	7·5°
In parts per 100,000	Total solids ,,	15	16
	Nitrite ,,	·00	·00
	Free Ammonia ,,	·002	·002
	Albuminoid Ammonia ,,	·006	·006
	Oxygen consum'd in 4 hrs. ,, (when water is of peaty origin)	·15	·17
Bacteria		Practically sterile when fresh	Practically sterile when freshly filtered

ON THE

PAST IN THE PRESENT, IN ASIA

BY

JOHN BELLOWS

(WRITTEN FOR THE AMERICAN ANTIQUARIAN SOCIETY)

READ TO THE COTTESWOLD CLUB, JANUARY 19th, 1894

During the closing days of 1892 I was travelling from Moscow to Tiflis with an English friend. The last 130 miles of this journey was taken up in crossing the great mountain barrier of the Caucasus, from Europe into Asia: or rather from Russia, where Asia overlaps Europe, to the Transcaucasus, where the European tide of change is very slowly wearing its way into the cliff of oriental thought and customs accumulated from a distant past.

It is through the Tartar influence in its history, and the Tartar element in its population, that Asia overlaps European Russia. A Western European is at once struck in Petersburg and other Russian towns, with the "Dvors" or Markets, where the shops are built round a cloistered square: that is, they are a modified form of the Oriental "Bazaar." This Asian influence is more marked in Moscow than in Petersburg. Moscow is European in its railroads and steam-engines, its factories and tram-lines, its telegraphs and telephones: Asiatic in its "Kitai Gorod" or Chinese town, as the Kremlin is called: in the quaint old-world style of the Kremlin's battlemented walls,* in

* These walls were anciently of timber: a stockade such as still surrounds some of the minor towns, and many villages, in China. The Comte de Kergaradec (Consul-General for France, and an experienced antiquary), who resides in Moscow, has also remarked the Chinese character of the Kremlin.

the gorgeous coloring of its bulbed domes: in its multitudinous bells, and in a variety of minor matters, of which I will instance two. The Chinese Abacus or counting frame, is used in every bank and shop in Moscow, and throughout Russia. The Chinese influence is curiously shewn in the ornaments painted even on the brewers' drays: where we constantly meet with the chrysanthemum pattern on a scarlet ground. The same ornament is used on the wooden spoons made here, and sold all over the Empire for the use of the peasantry. I bought some of these Muscovite spoons in the Armenian bazaar at Tiflis. The wood is varnished, and ornamented with bronze, as in Chinese and Japanese work: while the shape itself is the European bowl with "fiddle-pattern" handle! I may mention that the Armenian of whom I bought them put them up in a paper bag of his own making. It was covered with text in an alphabet of Phœnician origin; and over pictures in this text, might be deciphered the words,

"PUNCH, OR THE LONDON CHARIVARI"!

My English friend and I had for travelling companions over the mountain, a Russian interpreter, a Georgian wine-grower, who was on his way home from Stavropol to rejoin his wife and children at his vineyard in Kakhetia, and a Jew, homeward bound to Tiflis. Our conveyance over the snow on the summit was a covered sledge drawn by four horses. It allowed us each but cramped space, and it was no small relief, after fifteen hours' continuous rise, to find we had surmounted the pass, rather over eight thousand feet in altitude, and were beginning to run down on the Asian side of Mount Kazbek, which here towers more than 8,500 feet higher still above us.

The Russian Government has built substantial stations all along this military road, and our Georgian fellow-traveller took some refreshment at the first of these in descending the mountain, Lars. When he had resumed his seat in the sledge, he threw himself back, closed his eyes, and struck up a strange wild melody in his own tongue. He was a very remarkable-looking man: tall, powerfully-built, and with a face so exactly of the type of the Assyrian Kings that he might just have stepped off one of the Nineveh slabs in the British Museum.* "Was the wine good?" asked our interpreter, as soon as he had come to a pause in his song. "Nay," replied Belshazzar, "It is my heart that is good, because I shall now soon be with my wife and children;" and then he closed his eyes again, and continued his song. The notes were strange and wild: unlike anything European; but they struck me as the more strange because I had heard them once before. Four years previously curiosity had led some members of my family into the great Synagogue at Frankfort, near the old historic house of the Rothschilds. Part of the service consisted of a chant by a youth of fifteen: a strange, wild, high-pitched wailing, rather than what would be classed as music by a European ear. And here, under Mount Kazbek, was an Asiatic, of kindred type with the Jew, if not himself a Hebrew, singing the same notes; the same "motif" intonation I had heard in the Synagogue at Frankfort.

What could be the clue to this riddle? Asia certainly had not borrowed this music from Europe; but an Asiatic people who at this day form a colony 30,000 strong in a great European city, must have carried it there. Further: this people, "scattered and peeled" from their own land for eighteen hundred years, were five-and-twenty hundred years ago dwellers on the banks of the Euphrates, at no very great distance from here. They must have carried the tune from the same source from which our Georgian's ancestor's brought it.

* The persistence of the type is wonderful. If I believed in the transmigration of souls, I should say that I have seen two of the old Assyrian Kings, dressed in the uniform of Russian officers, sitting down at a table in the hotel at Elizabethpol, drinking a bottle of wine together! I only wish I could have photographed them, to enable the reader to appreciate the uncanny feeling that crept over me at the time.

Among the Caucasian Jews I followed up this enquiry on the identity of the Synagogue music at Frankfort with Asiatic music of to-day. The idea was new to them ; but after a little reflection they said they believed I was right, and that the sounds had come down from the Babylonish captivity. It is even possible, in a land where " rien ne commence : tout se continue " that the motif or style of this singing may go back to before the days of Abraham, when he " dwelt in Haran," in the same valley of the Euphrates.

There are tribes of Jews in the Transcaucasus, especially about Kutaïs, (the ancient Colchis from whence Jason brought the Golden Fleece,) who claim that they have been settled there ever since the Babylonish captivity. They are dark in complexion, and resemble the Georgians, yet retaining the unmistakable type which leaves no doubt as to their ancestry.

Besides these there are 21,000 Jews scattered through Daghestan, (Dagh = mountain : Stan = country) — the region to the east and north-east of the Georgian Pass. Most of these live in Aouls, or villages, and are engaged in agriculture. Mahometanism has so far repressed them that they have but little knowledge of the Talmud, though in one of their villages they have a parchment MS. of the ten commandments, two or three centuries old.

Some years ago a Hebrew inscription was found at Mzhket, the station at the southern end of the Georgian Pass, through which we have been journeying. The following translation is by the proprietor and editor of the " Kafkaz," the leading journal of the Caucasus, and a remarkably able writer :—

" Year 131 from the Captivity. Rechabin.
" * * to the palace of those who rest eternally.
" with the just
" the follower of the law
" of the Ancient High One

* * * * *

" the weak will be exalted "

We must not forget that the Israelites were transplanted by Shalmanezer, the Assyrian king, close to the borders of the Caucasus; that is, "to the cities of the Medes." That Media at one time included the valley of the Kurus, or Kur, on which Tiflis stands, is shewn by "Cyrus the Mede" having been named from this river. This removal of the ten tribes was more than a century earlier than the Babylonian Captivity of the tribes of Judah and Benjamin. (See II Kings, 17, 6.)

My own impression is strong that the Armenians who still inhabit the Armenian Plain, and the north-west of Media—the present Persian Province of Aderbijan—as well as the Caucasus, are the descendants of these people. It is impossible to travel among them without being struck with many little things in their daily life that recall manners and customs touched upon in the Bible.* I have many photographs of Armenian types of feature—very suggestive of a Hebrew origin—one of which, a group of school-girls, especially, shews several strongly Jewish faces. Add to this the similarity of the Armenian chant-music to that of the Synagogue, the abstinence of the Armenians from eating pork, and the presence of Hebrew words in the speech of Aderbijan,† and the evidence of this origin seems to me clear.

It was late on the afternoon of the second day of our journey over the mountain before we emerged on the

* Dr Baedeker, who has returned from the Caucasus since our journey in it, tells me he had been ascending a mountain-side near Shemaka one night during last summer, when just as the dawn was breaking his guide and himself were hailed by an Armenian shepherd. The man was followed by a flock of 60 or 70 sheep, and carried a lamb in his arms. Suddenly he stood still and bent his head in a listening attitude for some moments, as some distant sound fell on his ear. Then gently laying the lamb on the ground, he summoned the dog, and gave the flock into his charge to keep it together till his return; and started off among the rocks. Dr B. waited to see the upshot. In about an hour the shepherd came back, bringing with him, lame and halting, the lost sheep whose bleating he had heard from the wilderness.

† Most of the Armenians of North Persia speak two languages: their own, and "Aderbijansky" (Tartar, or Turkish).

great plain of the river Kur. The soil along many parts of the bank is a rich deep loam, resulting from the decomposition of volcanic deposits. As we were jolting wearily along—for 26 hours of continuous sitting in the cold, wonderfully damps one's enthusiasm—my attention was suddenly caught by a shovel with which a labourer was digging near the roadside: for it was of the form used in the Cornish mines.

Some years before I had seen in Germany the same long-hilted triangular shovel in use: and as German miners were brought to Cornwall, I believe in Queen Elizabeth's time, to instruct our countrymen in improved methods of deep mining, I at once concluded that the Cornish shovel must have been introduced by them; if not indeed during a still earlier visit of German tin-miners to Cornwall, under an ancestor of the Godolphins. But here was the same instrument in Asia: and the problem needed further examination; for it was not solved.

We had to make a stay of some weeks in Tiflis, and during this interval I had opportunity for frequent visits to the bazaars, and to examine the tools and methods used in some of the handicrafts. Tiflis is a great centre of commerce between Persia and the Central Asian provinces on the one hand, and the Black Sea, with Constantinople and Odessa on the other; and the variety of types, tribal and national, one meets with in the streets, is as great as perhaps in any city in Asia. Besides some sixty different peoples that make up the population of the Transcaucasus, now, as in the days of Strabo, and representatives of whom may from time to time be encountered in the city, Tiflis itself has more than 100,000 souls, of six different nations, each of which retains its individuality, and holds somewhat aloof from the rest. There are the Russians, constituting the official and upper classes, as well as Cosacks and other military; Georgians; Armenians; Tartars (some of them descendants of the soldiers of

Ghengis Khan)—a German colony; and about 10,000 Persians. Most of the masons in Tiflis are Persians, and the tools they use are Persian—i.e., of course of definitely Asian types. Among those to whom I turned for information about the Georgian pointed shovel to which allusion has been made, was Samuel Rooks, an English engineer long resident in the country. He told me that it was the ancient native pattern, and that it was an excellent digging tool, especially in the hands of the Tartars, who are remarkably clever at well-sinking and other earthwork. A Tartar will dig a well for a small sum, turning round and round as he works, in a circle scarcely larger than gives him standing room; drawing up the earth in a skin bag, and leaving the hole beautifully round and true as he finishes it.

Samuel Rooks advised me to go to the smiths' shops just above the Persian bazaar, and see a shovel forged for myself. I did so. Entering a shop where shovels were hung up at the door, I told the smith (a Georgian) that I wanted two made specially, one-half the usual size, but exactly of the sort used by farmers. My reason for getting new ones made, was that quite lately the Town Authorities have imported steel shovels from Germany, for use by the scavengers, on account of their lightness, and I wanted to be certain of getting the real native implement, and not a foreign one.

The smith was a bright, intelligent fellow, and after a sketch with chalk, to show that he had grasped my meaning, he took a lump of iron the size of one's hand, and perhaps an inch thick, and placed it in his fire. All the smiths and metal workers in Tiflis use charcoal: I think they are obliged to do so, to avoid smoke in so densely crowded a town. One of the picturesque sights of the bazaars is the number of donkeys that bring in the charcoal from the forests. They are loaded so as to form a hump or peak, that makes them look like little dromedaries, mingling with the camels and buffalo teams that throng the narrow streets.

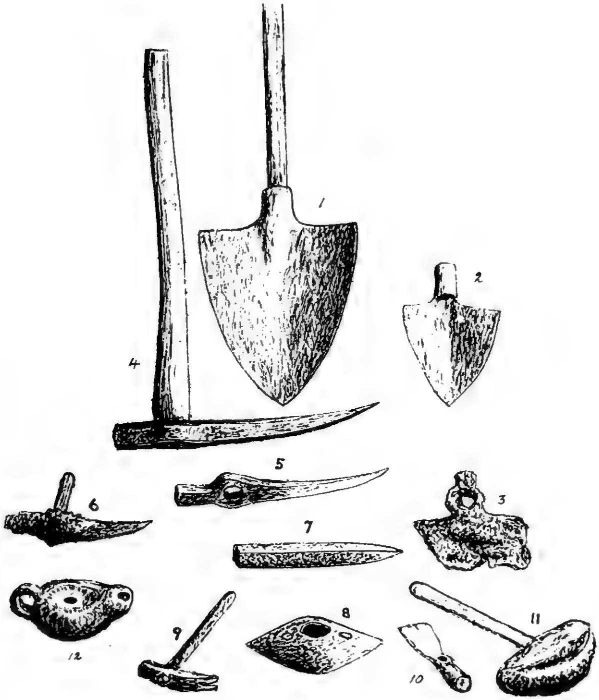
The Georgian signalled to his strikers, and in swift succession his hammer and their two sledges rang on the little mass of iron till one side of it was beaten to a plate, the other being shaped at a second heat for the socket. The edges were trimmed, and the whole dressed with a rough file, till it took the form here shown (fig. 2). A second shovel I left to be finished, and called for next day, when I paid for the pair. I think the whole sum charged was a rouble (say half a dollar, or two shillings English).

I noticed that the anvil in this smithy, as in others we visited, was beaked, like those we are accustomed to, and that the swages and other tools were of the familiar types. The beaked anvil is shewn on a Roman painting in Pompeii, so that the shape was the same in Italy 1,800 years ago as that we are using to-day.

I went to another smith to get a pick and gad made such as miners use in the Caucasus. (See figs. 5 and 7).

In masons' tools I had noticed the same forms as those with which we are familiar in the west: the lozenge-shaped building trowel; the oblong square plastering float with the handle attached to the plate. A similar form, made of wood, has been found in Egypt, used by the earliest Pyramid-builders.

Stone-cutters' tools were also identical with ours. Noticing that these seemed rather a specialty in one of the forges in the Persian quarter, I went in and asked the smith if he could make me a double-pointed pick, somewhat smaller than those generally used, but of the usual shape. This man I found was a Greek, named Nikola, an immigrant, but as he had, of course, to conform to the usual patterns of tools used in the Caucasus, his nationality made no difference for my purpose. He could not speak Russian, however, and I had to hold converse with him



1 Cornish Mining Shovel

2 Caucasian Shovel drawn half scale of the Cornish

3 Ancient Hoe found at Rio Tinto

4 Cornish Pick

5 Caucasian Pick, forged at Tiflis

6 Roman Pick from Rio Tinto

7 Gad from Tiflis

8 Masons Pick, Tiflis

9 Claw Hammer from Shusha

10 Caucasian Adze

11 Ancient Hammer, Rio Tinto

12 " Lamp, Ditto

through two interpreters. Our Russian attendant gathering my meaning in English, passed it on to a Persian, who turned it into "Aderbijansky," as it is here called; that is, the dialect of Turkish or Tartar spoken throughout the Persian Province of Aderbijan, and largely used by Armenians and Tartars in the Caucasus. It is to Western Central Asia what French is in European travelling: a general medium of intercourse.

Nikola seized the idea at once, and searching among his stock brought out the pattern of pick I wanted, as well as two others used in dressing stone by the Persians. One was a hammer with two perpendicular edges cut into teeth about a quarter of an inch long; the other shewed a flat of 2″ square, cut with deep V grooves at right-angles, so as to leave the whole surface covered with sharp points a quarter of an inch asunder. Both these forms are used in England for granite.

Selecting a piece of steel, the smith placed it in the fire and signalled to his boy—an Armenian—to blow. The hearth was a low square block of masonry in the middle of the shop. The bellows, which stood at the back of it, consisted of two pig-skins, or calf-skins, placed perpendicularly on the ground, with a board between them, and two others on the sides with handles. The boy grasped one in each hand—his arms being wide apart, and began to sway himself from side to side two or three feet left and right alternately, so that as one skin was emptied the other was filled, keeping up a strong continuous blast. Here was clearly the origin of the term "a pair" of bellows: the word bellows itself probably being from Pellis, a skin, of which the Saxon form is Fell (as in Fellmonger).

I was struck as I watched the Greek skilfully hammering the dazzling hot steel to its shape, by noting how without any gauge or template he wrought it not only to the form we still use in Europe, but drew its point to about the same angle that our masons employ. (See fig. 8).

The persistance of even so fleeting and evanescent a thing as a set of sounds has been already instanced in the Georgian wine-grower's song, reproducing notes that resounded in the Psalms in Solomon's Temple; if not a thousand years before that on the Plains of Chaldea. In this matter of a cutting tool, experience has no doubt established a model which has been kept to, for probably as long a period. Similarly, I have found the angle of the piers in the Roman bridge at Newcastle, identical with that of cutwaters I have measured in modern bridges.

At a certain point in the forging, the assistant, or striker, laid down his sledge for his master to finish off the work with the hammer. Our Persian interpreter leaned towards him and said something, when the man left the shop; presently returning with a European chair which he had borrowed for my use, as I had still some little time to wait before my pick was completed. I am sure I shall be excused for mentioning this, for it is but one instance out of many of the little acts of courtesy we received from the people among whom we travelled in different parts of the Russian Empire.

I had paid for the pick—a rouble—and was taking it up to depart, when Nikola asked to have it back for a moment, and putting it again on the anvil held a tool to it, which he ordered his man to strike with a light blow. "I always like to put my mark on my work," he remarked by way of apology; and I saw he had struck a neat N on the steel.

The artizans in the Bazaar all seemed marvellously industrious. In the smithies they filled up odd moments between the execution of orders by making little things for stock, especially horseshoes, nails, and currycombs. The Asiatic currycomb is a bit of sheet iron bent over in section to three sides of a square ⊏, the two edges being filed into teeth. Three stays are fixed crosswise, on which are placed loose rings, the jingle of these being supposed to please the horse or camel while he is being groomed. If we place this instrument alongside one of our own currycombs, we shall see at once that the latter is simply a combination of three of the Asiatic ones placed side by side, and fixed to a plate at the back. This multiplication necessitated a handle, as the whole became too broad to grasp by the back, and the teeth had to be made smaller. Still, for a shaggy beast, like a camel, or an unclipped horse or mule, the ancient form is better, as being more elastic.

The horseshoe is a plate of iron with a small hole in the centre, and the European shape is only a modification of this into a rim of iron. Many antiquaries have fancied that the Romans did not shoe their horses, but this is a mistake.* The very fact of their paving their roads shows they must have shod their horses; and besides this, horseshoes have been found in Roman remains in many places. Professor Church tells me that he has examined the equestrian statue of a Roman Emperor at Orange, in France, and on the upturned foot of the horse, little points are marked in the marble, shewing the nails.

* This error is based on the assumption that a horse-shoe is not mentioned by any classical writer. Negative evidence is very dubious at best; but even this negative evidence cannot be admitted: for in Suetonius' "Life of Vespasian" there is a capital story of the Emperor's muleteer stopping to have his mule shod in order to give some friend of his an opportunity of presenting a petition to Vespasian. The latter saw through the trick: and when they were ready to start again he remarked that the petitioner ought to pay half the smith's charge, seeing it was as much on his account as the Emperor's that the work had been done!

A similar error has been fallen into by Antiquaries with regard to the supposed absence of camels in Egypt, anciently, on the ground that they are never shown on Egyptian monuments. Even Dr Mommsen, the most fascinating writer on Roman antiquities, asserts that the camel was unknown in Egypt until the third century of the Christian Era. The narrative in Genesis, of the camel caravan that took Joseph to Egypt, would alone disprove such a statement; besides the fact that the camel *is* figured on one of the monuments. But Flinders Petrie, in his "Ten Years Digging in Egypt," gives a figure of camels that are scratched on stones older than any of the monuments in that land!

From Tiflis we visited the great copper mines at Kedabek, on the east of Lake Goktcha. These mines, which have been worked from ancient times, now belong to the firm of Siemens Brothers, the well-known electricians who constructed the Indo-European line of telegraph. Some two thousand hands are employed in all: most of them Armenians and Tartars. The best European methods and appliances are used in the working: yet I noticed among the implements the same pick and shovel I had made in Tiflis; but how could it be decided whether these were imported by the German firm or had been previously used by the natives? One of the managers suggested that I might satisfy myself on this head by cross-examining the oldest man in the place—an Armenian who had worked in Kedabek before the Siemens came to it. He was sent for, and before long made his appearance: a venerable old man of eighty-four (if I remember rightly), with snowy hair and beard, and a considerable difficulty of hearing. Our interpreter asked one of the clerks in Russian, who passed on the query in Armenian, Whether the pick and shovel sketched on the bit of paper before him had been brought here by Siemens Brothers, or whether he remembered them before the Germans came to the mine? Before the reply had time to sift through its double delivery, I saw from the old man's action what it was. "No: that pick and that shovel were "the old tools of the country before the Siemens ever "came to Kedabek."

The "old tools of the country:" and what a country! A day or two after, we were driven to the summit of the mountain above the mines by William Bolton, the general manager (who is of English descent). Near the top we left the sledge to examine an old and decaying oak in the forest, which is considered a holy tree by the Armenians at the mines. "They come here on Sundays," we were told, "and burn candles to the Virgin at the foot of that tree." Close against it, and almost buried in the root was a stone slab, completely covered with wax, and black with the smoke of tapers burned for generations! Here then we were in the presence of such an oak as had been worshipped in some of the "high places" in ancient days, and the worship of which, thinly veiled by the name of Christianity, was going on yet; and of the stone that was probably an object of adoration for many generations earlier still: all three eras overlapping, so to say, and co-existent.

Few spots could be more calculated to excite the imagination. From the summit above us, five thousand five hundred feet in height, we look westward over a wild abyss of Armenian mountains to a great volcanic barrier, thirty or forty miles in length, and in one part eleven thousand feet high, which shuts in the Lake of Goktcha. This lake is a thousand feet higher than the summit we stand on: a storm-beaten and desolate sea, the thunder of whose billows dashing against the tremendous cliffs, is often heard for twenty versts away in the valleys below.

In the Kedabek Valley we had our first opportunity of examining the Asiatic turbine, which as a mill-wheel is universal in the Caucasus. In all that relates to hydraulics, Asia has an incontestable lead in antiquity. This is partly due to the necessity which makes irrigation a condition of cultivation over so large a portion of the continent: India, Turkestan, Persia, for example. Palmyra we now know to have been supplied with water from an underground canal across the desert; and the vast earthworks that remain in Mesopotamia give us some idea of the scale on which the canals were made from the Tigris and Euphrates. My friend Col. Holland, who preceded Gen. Gordon in China, tells me that the embankments in that Empire surpass the whole work of the railways in Europe; while the light bamboo water-wheel employed there for irrigation, though probably in use for ages, is, I venture to say, a better contrivance than any we use, for the lifting of water to such heights as 30 feet. A Roman dipping-wheel found lately in the Rio Tinto Mines in Spain, is not so good an appliance.

Of the turbine, my friend Wilson Sturge, who has been for some years British Consul at Poti, writes:—"Early "in the century a Frenchman, I believe, introduced the "turbine. When I was a boy they were rare in England: "in fact hardly known. But the turbine, or horizontal "water-wheel from which the turbine is developed, is the "ordinary water-wheel in use here, and has been no doubt, "for centuries."

The principle was known in France in the last century, but its practical application has only been made, as Wilson Sturge says, within our own era; if we except what is known in Scotland as Baker's Mill, which is, I think, older. The oldest water-mill mentioned in history, was one at Pontus, described by Strabo; that is, on the Black Sea, not far from the Caucasus.

At Kedabek we were taken about half a mile down the valley to a mill belonging to a Tartar. The old man promptly and courteously shewed us the mechanism. First, a stream was led along an artificial channel, to get a head of about twelve feet. From this the water came down a shoot made by hollowing a tree, which was placed at a slant of 45 degrees: the open or upper side of the hollow being secured by a plank nailed lengthways over it. At the bottom was a horizontal wheel about three feet in diameter, set round on its upper side with stout float-boards, diagonally placed, to receive the impact of the water. The shaft or axle of this wheel went up through the mill-stones, of which the nether one was made fast to it. The foot of this driving shaft rested in a bearing on a beam of oak, arranged as a lever, so that by tightening a wedge under one end of this lever, the Turbine with the nether mill-stone could be lifted nearer the top stone, or vice-versa; thus determining the fineness or coarseness of the meal. On the wooden framing above the hopper was pasted a written prayer in Arabic, from the Koran, for luck. The old miller told us he could grind about 36 poods of meal a day (a pood is $\frac{1}{3}$ of a cwt). It is a pleasure to mention an instance of refined feeling on the part of this old Tartar, for he was so grateful for the 20 kopeks I gave him, that when we came away he ran on in front of us for some hundred yards in order to place better stepping stones in the brook we had to cross, and save us the chance of wet feet on a very cold day.

In the city of Tiflis itself, the whole of the corn is ground in stream mills, that is, mills worked by the rush of the River Kura against flat floats on wheels of large diameter. When these were invented I do not know; but they were first used in Rome by Belisarius during the siege by the Goths, in the 6th century.

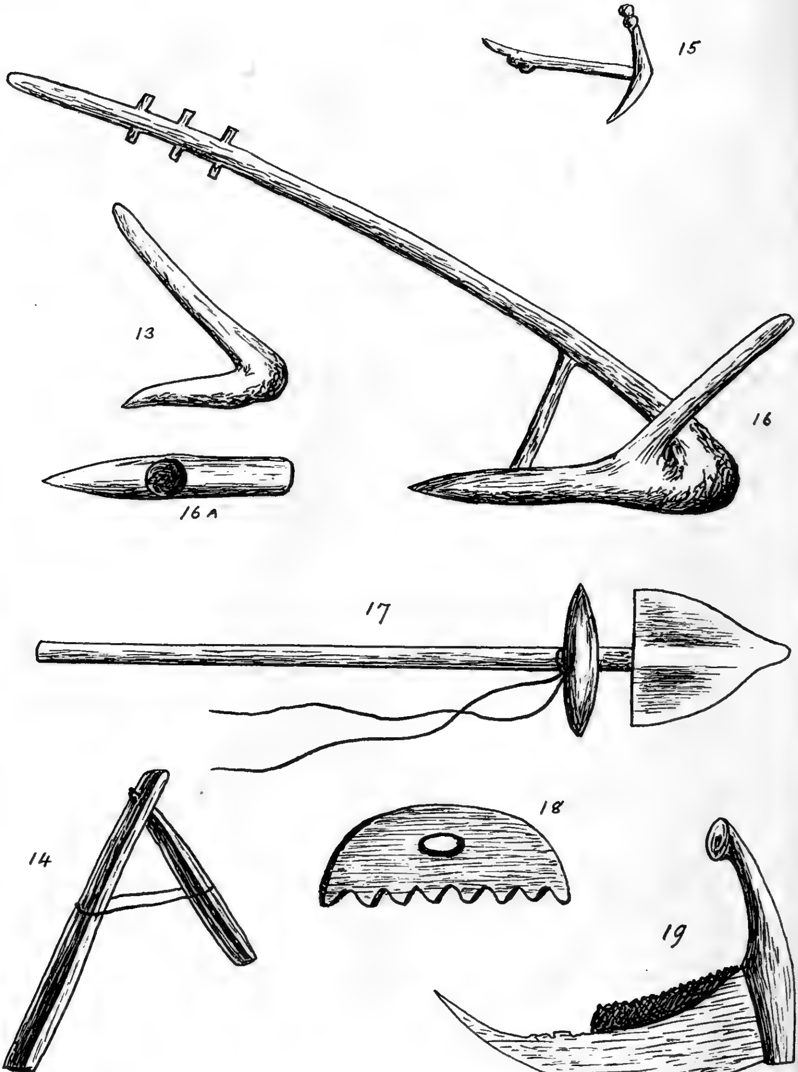
But grinding by water power implies a certain degree of civilised and settled life. If we go back for a moment from this to the family life of the nomad Tartars in the Steppe, we find ourselves at the beginning of things; and it was to me very interesting to trace from that beginning the development of the bread-oven which fills so important, though humble, a place in our daily existence.

The original oven is a pit dug in the ground, and lined with clay. I brought home a photograph, taken in the wilderness, of some Tartar women making bread for baking in one of these pits. An upper guard, standing out of the ground, is made of wattle-work, the clay lining being carried to the top. When the oven is hot, the cakes of dough are wetted and stuck perpendicularly all over its sides, and the top is covered with cloths until the bread is baked. Now mark the evolution from this. If, in moving from one pasturage to another halting ground, the clay lining of the oven could be carried away in one piece, it would save a good deal of labour in making the next oven. By making the lining as a large jar or amphora, this was done; and the common oven of Western Asia is simply an amphora of 6 or 7 feet high, let half way into the ground, and filled from the top in the way I have described. To us it is a startling thing to see an Armenian baker, or a Syrian, take a cake in his hand, and swing himself over the fire in this jar, to stick it on, while his feet are kicking acrobat-wise in the air! And not altogether appetising is the sight of an unwashed boy, with a dingy cloth tied to the end of a stick, dipping it in whitey-brown water, and then flapping the cakes in the pit-oven to keep them from burning: or the sight of the baker's ragged coat stretched over the orifice to keep in the steam, and loaded down with an old camel-cloth, or donkey-cloth, and other unsavoury fabrics, on the top of which some passing Lazarus may lie down for a nap in the warm. I made a vow never to eat of that bread . . . but "necessity knows no law"!

We have only to go a few steps in the same street to find a Turkish oven. This is the Asiatic one turned on its side: the lower side being flattened to lay the loaves on, and a door placed at the mouth, so as to work it horizontally instead of acrobatically! The Turkish oven is that of all western nations; and anyone  who is familiar with the dome-shaped clay ovens used in country cottages will be able to trace every step of the evolution from the Tartar pit in the desert, up to Huntley and Palmer's newest patent.

Now let us return to the agricultural tools. In the Museum at Tiflis there is a plough-share which gives us a clue to another very interesting evolution: that from the iron hoe to the shovel; and from this again to the iron plough.

A little thought would show, even if we had no historic evidence of it,  that the earliest instrument of tillage is a hooked stick drawn towards the worker: for if



13 Natural Hoe from Illahun

14 Broad Hoe Ditto

15 Wooden Plough from an ancient coin

16 " Mysia

16a Iron Share or point for Ditto

17 Shovel used in Palestine

18 Wooden Rake, Illahun

19 " Sickle, with flint teeth, Ditto

either of us were set down in a forest to begin farming without capital of any sort—and the simplest tool is capital—we should have to sow seed of some kind: and to do so we must make a furrow. If we picked up a stick and pushed it, we should find it harder than if we dragged it towards us; and a hooked stick is easier to drag than a straight one. A shovel, be it noted, is a pushing tool; a hoe is a pulling tool; and therefore a hoe was used earlier than a shovel. A rake is a multiple hoe: also used before shovels. Now for the historical confirmation of this:

The oldest tools after flint implements, that have yet been found in the world, are some that were unearthed by Flinders Petrie in Egypt, in 1890. They were in the ruins of a town that was erected for the workmen who were to build the pyramid of Illahun, during the 18th dynasty—i.e., 2,700 years B.C.—say a thousand years before Joseph was Viceroy in Egypt: or eight centuries earlier than Abraham.*

In the illustration of some of the objects turned up, we have flint implements, wooden sickles set with flint teeth, and two hoes, of which the first is a natural fork of a tree, while the second is an improved form, with a broader edge, made by setting a board at an angle with the handle, similar to the angle of the natural hoe. This is nearly the pattern of the mamooty, or hoe, used all over the south of India at the present day, of which a sketch was lately given me by my friend Col. Carleton.

Now let us compare this hoe (fig. 13) with the wooden plough still used in Mysia, as figured by Sir C. Fellows, (fig. 16), and in Syria, and we see at once that this original plough is simply a contrivance for making horses or oxen, instead of men, drag the hoe. We must bear in mind that

* A useful mnemonic in Egyptian dates is that the Exodus of the Israelites took place as far before Christ, as Columbus' discovery of America is after: i.e., about 1,492 years. Bronze came into general use about the time of the Exodus.

iron was not in common use, so far as we can gather from Egyptian remains, until about 800 B.C.—or nearly 2,000 years later than the wooden hoe found at Illahun. Copper was known, for a workman's frail was found, with copper tools, at the same time as the wooden implements.

After the discovery of iron it not only replaced wood, but led to improved patterns of tools; and the hoe took, in Western Asia, the form of a triangle ▽ as shewn in this Syrian pattern* (like fig. 17). By setting back the socket at a different angle on the hoe, a new digging tool could be made—and this is the evolution of the iron shovel such as I had forged at Tiflis (fig. 2).

An amusing instance of the way in which the Asiatic people cling to old ideas, even in the use of a newer instrument, was given me by a friend who has been a good deal in Lebanon. The Friends have a school there, at Brumana, near Beyrout; and Henry Newman, with Eli Jones of Maine, were visiting it. They noticed the smallness of the shovels, and to improve the agriculture, they sent to England for spades of larger size. A few days after the arrival of these, Henry Newman was taken aback at the way the Syrians worked them. A man drove the spade into the earth: then stood still, and called "Hi!" on which two young fellows, each with a rope fixed to the neck of the tool, dragged it up, lifting the mould, ready for the next dig! But this is the universal plan in Palestine. (See Journal of the Palest. Explor. Fund, April, 1890).

As the first wooden plough, then, was the wooden hoe, dragged by an animal, so the first iron plough is a shovel dragged by a horse, or oxen, instead of by a man. In proof of this may be instanced a plough-share from Daghestan, in the museum at Tiflis, which is exactly like my Caucasian

* It will occur to some readers that the "spades" on playing cards are of this triangular shape; but I believe the cards themselves were introduced into Europe from the East.

shovel, except that the socket alters its pitch; and three plough-shares from Syria, all lent me by friends who obtained them in the country. The first is a model only, but precisely matching my shovel: the second and third are actual implements taken from field-work. But these two plough-shares from Palestine have a curious spike forged in front of each, and the rudiments of the same projecting point are visible on the Syrian hoe and the Syrian shovel pictured in the Quarterly Statement already cited. What is this? Evidently it is nothing more or less than the imitation, by the maker of the first iron plough,—the slavish imitation of the pointed stick of the wooden plough that went before it, and that remained, and is still used in Asia, alongside of it. It is in fact a survival, which the more revolutionary blacksmiths of the Caucasus rightly discarded, as unavoidable in wood, but needless in metal.

In conclusion: In what way can we account for the identity which we have shown to exist between the mining tools used in Germany and Cornwall, and the Caucasus, and between the hoe and shovel of the Caucasus, with the like tools of Palestine?

They must have come, originally, from one centre; and in endeavouring to trace where this was, we instinctively turn in the first place to the sources of two of the great civilizations of the East—Egypt and Assyria. But I am assured by the Authorities of the British Museum that hitherto we have no evidence of the shovel having been used either by the Egyptians or the Assyrians. In representations of brick-making on Egyptian Monuments we find the broad hoe used for working the clay, similar to the No. 14 at Illahun, much as the mamooty is used in India, and the hoe (fig. 3) is employed by the Spaniards in the Rio Tinto mines, instead of the shovel.

On the other hand, we not only find that both the hoe and the pointed shovel are now employed in Syria; but the latter was used anciently in countries, like Italy, that came strongly under Phœnician influence,* and is used to-day, as well as the pick in Germany and Cornwall, where that influence affected the mines.

I cannot find the same shovel at the Rio Tinto Mines, which are near the Phœnician colony of Gades (Cadiz), but Capt. Rich, the manager there, has favoured me with the gift of an ancient pick found in the workings (fig. 6) which corresponds in form to the one I brought from Tiflis, and to some ancient Cornish ones in the Truro Museum.† The hole for the handle in each of these is round. In the modern Cornish pick it is made oval to prevent the haft from twisting round in the head.

That the Syrian pattern of the triangular hoe and shovel is the oldest is proved by the survival, in them, of the spike imitating the preceding wooden hoe.

I therefore think Syria the original centre from which these implements came.

The Phœnician commerce will account for their being met with in Italy; and Phœnician Mining explains their use in Germany, Spain, and Cornwall. I believe the Hebrew migration under Shalmenezer to Armenia and Aderbijan, and the exile of Phœnicians under Nebuzaradan, will account for the presence in the Transcaucasus of these Syrian tools, the Syrian chant-music, as well as perhaps of the Syrian oven.

In ancient times not only were the Phœnicians the best artisans in the world, in metals, but both they and

* The pointed shovel with the Syrian Crossbar is still met with in Italy, and appears on an ancient Tomb in Rome.

† Suspecting that the cloths made by the peasantry in so Phœnician a district, might still show some similarity to Western Asian fabrics, I asked Capt. Rich whether certain striped patterns are used near Rio Tinto. He has sent me some interesting specimens of native cloths: one of them from a bolt that has been in the same family for 150 years. Some of these are almost identical with the woollen cloths woven and dyed by the Armenians among whom I travelled. But this is too wide a subject for the present paper.

their near kinsmen, the Jews, took the lead in jewellery and gold and silversmith's work: as the Jews do at the present day. Thus at Tell Defenneh (the Tahapanes of the Bible, or Daphne of the Classic writers)—the border town of Palestine and Egypt, Flinders Petrie records the discovery of goldsmiths' and jewellers' work on a considerable scale.

Similarly at the present day these arts in the Caucasus and Northern Persia are mainly followed by the Armenians. Homer says that the very finest silverwork in the world was wrought by the Sidonians: and the finest needlework and embroidery. At this moment some of the most beautiful silversmith's work in the world is in the Armenian bazaars in Tiflis and Northern Persia, and the finest work of the needle and the loom is found in the same district.

I may mention that I bought a hammer from an Armenian silversmith, which he had used for years. It has the claw, for nail-drawing, exactly like that with which we are familiar in Europe (see fig. 9).

I do not dogmatise on these facts—but simply lay before the reader, for what they are worth, my own impressions on them, which are briefly these:

1. We know that the Israelite tribes, and some of their kinsmen, the Phœnicians, settled in the districts now occupied by the Armenians; and we have no historic reason for supposing that they have since migrated to any other part of the world.

2. We find among the Armenians old national Israelitish airs in music: old Syrian tools: the same oven that is used in Palestine: the same aptitude for fine metal-work and jewellery which distinguished the Jews and Phœnicians: the same ability in textile manufacture (as displayed in "Persian" and "Turkey" carpets, silk-work, and shawls): the same talent for commerce:* abstinence from eating

* The Russians assert that "it takes three Jews to outwit an Armenian"!

pork: the employment, in a Non-Semitic language, of several Hebrew words; and a very general and very striking Hebrew type of features.

It seems to me more likely, then, that the present Armenians are descendants of the Israelite exiles, than that the latter are "lost." In any case, as we turn from this most interesting country and people, we shall feel the force of the Frenchman's words—

"Nothing begins, but all things go on."

Yours sincerely

Edward B. Wethered

ANNUAL ADDRESS

TO THE

COTTESWOLD NATURALISTS' FIELD CLUB

AT GLOUCESTER, MAY 4TH, 1894

BY

M. W. COLCHESTER-WEMYSS, PRESIDENT

The Annual Meeting of the Club was held at the Bell Hotel, on Friday, May 5th.

The resignation of Mr Lucy as President of the Club was accepted. The unanimous regret of the Members at Mr Lucy's decision was no merely formal act, but a most genuine expression of the sincere feeling of the whole Club. Mr Lucy's intimate acquaintance with the County, his many scientific attainments, and his unvarying and genial courtesy, fitted him in a peculiar degree for the office which he had so ably filled.

So fully have I felt this to be the case that I was certain I should only be anticipating the wish of the Members, if I asked our friend John Bellows, who was more intimately acquainted with Mr Lucy than any other Member of the Club, to write a few paragraphs to insert in this report bearing upon Mr Lucy's resignation. He most kindly consented, and I this morning received from him the following interesting communication :—

WILLIAM LUCY

AND

HIS FRIENDS OF THE COTTESWOLD CLUB

FIVE AND THIRTY YEARS AGO

I had intended to sketch some reminiscences of our retiring President: but when it comes to putting them on paper, they present the difficulty of being for the most part rather such as relate to a private friendship than to our intercourse as members of the Club. If, however, I broaden my ground so far as to permit of its being covered by the title of " William Lucy and his friends of the Cotteswold Club," the objection will cease to apply: and this I propose to do.

My acquaintance with William Lucy goes back to the middle ages: not as European history reckons them, but according to the true chronology accepted by one of the most scientific societies in this country, and which takes for its point of departure the first meeting of that Society at the Black Horse, at Birdlip. In the middle period to which I refer many of the original Members were still living and vigorous: for we used to do our fifteen-mile walk upon occasion at a Field Meeting, winding up with a dinner at some village hostelry, or old-town inn like the Ram at Cirencester; followed by a debate on a Quarry section, in which Dr Wright and Edwin Witchell bore the brunt:* or a pleasant chat on British Birds—sometimes on British Jail Birds—for our Vice-President, Barwick Baker, was a specialist in both ornithologies. A most genial, as well as able man, was the first President of the Cotteswold Club: full of fun to boot, and given to little piquant sayings which were made the more telling by a slight hesitation in his speech. I remember being a good deal tickled at the advice he gave to a visitor who had accompanied him in one of our Club tramps across country. The stranger was a tall dignified North country squire, who had had troubles from a habit of the colliers in his neighbourhood, of opening up new paths across his fields in all directions, to get to their pits. Barwick Baker advised him to put thorns at the two ends of the field, in the gaps, and a bull in the middle: explaining that "some Village Hampden" might pull up the thorns, but that the bull discouraged trespassers effectually. "Well," said the North countryman, "but they can pull you up for the bull!" "Ye-s," replied Barwick Baker, with a provoking drawl—"they C A N: but they DON'T!"

This was on my first outing with the Club. I had been invited by John Jones, at that time the Secretary, and whose acquaintance I had recently made by asking him a question on some Philological matter, as I met him in the street: for he enjoyed a wide reputation as a savant in Anglo-Saxon and other languages, as well as in Geology. I don't remember what the word was, about which I was curious, but he asked me to come to his house and refer to Bosworth's Anglo-Saxon dictionary to determine it. Then, with the remark "I see you take an interest in Philology: can you tell me what this word means?"—taking out his pocket-book, and turning over a few leaves, he showed me this:—"Skiln."

* I am reminded that the historical quarry debate in which Professor Buckman was a principal, was some five years earlier than this.

"I could not tell what its exact meaning is," I replied, "unless I saw the context: but it must be something connected with division, because the Norse skilja [pr. skil-ya] means to divide."

"You are right. It means the division of a barn: the 'bay' of a barn. I was up at Sherston lately,—a curious old place: and there is a public-house there with the sign of the 'Rattlebone,' and a figure of a warrior with a drawn sword. I asked a labourer who was passing, who this man was. 'John Rattlebone,' he replied. 'He was a Sherston man that fowt with the Danes in old times; and he killed a whole skiln 'vul of 'em wi' his own hand!'" Sherston, I may remark, formed the subject of a paper by John Jones, some years after, in the Proceedings of the Club; and an excellent paper it is, although I will not say that all the writer's conclusions are right.

John Jones introduced me to several Members of the Club with whom it was afterwards my privilege to form close friendship; and among them to the most intimate friend I have had for now between thirty and forty years: William Lucy. Geology had been the pursuit that had drawn him to John Jones, from whom he derived a good deal of his earlier knowledge of that science. Jones was at that time a shipbroker in Gloucester, and I am not sure that he did not make the mistake of giving up too large a portion of his time to the scientific pursuits which ought to have been always subordinate to the business by which he gained his livelihood. But if ever a man was specially exposed to this temptation it was he: for no one of larger or more varied natural ability has ever been connected with the Cotteswold Club. I have myself been present when he has been in the company of such men as Professor Owen, and witnessed the marked degree of respect in which he was held by them, and their acknowledgment of his right, in his own specialty, to parler en maître.

Many other figures rise before one in looking back at the Cotteswold Club during its mediæval period, besides those already named. Foremost, of course, was the President, W. V. Guise, a born captain of men, who, to his position as a Baronet of old family united a very remarkable power of description of whatever came under his observation: then Dr Paine, George F. Playne, Edwin Witchell, Canon Lysons, and J. D. T. Niblett. The last two often enlivened the Field Walk or the Meeting by their friendly sparring: for both were enthusiastic, both highly original, each amusingly intolerant of the other: and each, like the chief subject of this sketch, eminently lovable.

"I say Niblett—you know the Iron Well at Matson. Well, they worked iron on Robins' Wood Hill in the middle ages!"

"How do you make that out?" replies Niblett, with a politely incredulous grin.

"I can show you a deed in which the Abbot of Gloucester is entitled to work iron on the Hill."

"Well—let us see it. Seeing is believing: and when I see it I'll believe it."

"Here it is! . . . so and so . . . *Ferrum!*"

"Let me get my glass to bear on it." . . .

This was a magnifying-glass the size of a cheese-plate, which he carried with other items in a leather bag slung at his side. He usually prefaced its employment with an aside—I always carry this glass, you know. It is very useful in making out old documents and coins. It has a large field, and my eyes are not so good as they were . . .

A little squaring up: and then, with a triumphant smile: "*Ferrum!*"—it isn't *Ferrum!* It's Foenum, as plain as a pikestaff: and you always jump to conclusions like that, Lysons! The Monks of the Abbey had the right to cut hay there: they were not such fools as to work iron, for it wasn't there!"

And, thereafter, sudden collapse of the Canon: great roaring, merciless laugh of the President, and unconcealed delight of the squire, who had "scored," and who carefully put the *Ferrum* into his pocket, to be used as a rod of iron in future controversy, if needed, whenever the Canon seemed verging on to a state of cocksureness!

I have said that they each had a real regard for the other—but subject to the right of search, and to unlimited banter, if occasion offered.

"My cousin, Sam Lysons, is a very good fellow, you know, but he's always wild when he gets on to Antiquarian subjects: he's as mad as a March hare about the Ancient Britons. Then there's the Iron Well at Matson. Lysons will have it that the Monks worked iron on Robins' Wood Hill. He brought me a deed, you know, that he said gave them the privilege: and then he pointed to a word that he said was *Ferrum*. I got my big glass to bear upon it—This glass: I always carry it to make out old deeds and coins. Well, when I came to look, it wasn't *Ferrum* at all. It was Foenum. That's just like Sam Lysons: he's a very good fellow you know, but you can't trust him a bit in such matters."

—"John Niblett has a wonderful fund of knowledge, if you can only get at it," said his old friend one day: "He's a capital well, but with no pump to it."*

And then changing the metaphor, the Canon added—"Niblett always puts me in mind of a schoolboy that you want to borrow a pencil from. He dives his hand into his pockets and pulls out a heap of all sorts of things. First he picks out a button: then a bit of string: and then a peg-top. He tells you all the history of the top: where he got it: how many other tops he has split with

* "I once had to give a lecture, and before it began, —— asked me a lot of questions about it, till he had got it all off by heart. Then he got up to introduce me to the audience, and made a long speech, in which he said everything I had prepared down to the very details—so that when it came to my turn I really hadn't a mortal thing left to talk about, for he had pumped me completely dry you know!"

it, pitching the peg into their heads: what the boys said who owned the other tops:—and then he puts the whole lot back into his pocket, and changes the subject. He has forgotten all about the pencil."

"It's just the same, you know, with Niblett. You ask him some question about the Fairford Windows. He goes off into the question of Albert Dürer: and tells you that some mark they take to be Albert Dürer's was only meant for a sign to ward off the effects of the Evil Eye—and then he goes off into the history of the Evil Eye, and you hear no more about the Fairford Windows."

Yet on the Fairford Windows John Niblett was no mean authority. He had studied them as few men besides have done. "Can you tell me where John Niblett is?" asked John Jones one day, of Barwick Baker, as he met him in the street in Gloucester—"I've been enquiring of his father: and he said the last they had seen of him was when he went to dress for dinner at Haresfield several days ago. They waited for him: but he didn't come: and then they found he had gone out. He hasn't been seen since." "Dear me, I said—but that is very extraordinary!" "Not at all," says the old squire, "There's nothing extraordinary about it. There might be if it was anyone else: but it's just exactly what John would do!"

"No," said Barwick Baker, "I don't know where he is: but if you will direct a letter 'J. D. T. Niblett, Esq., East Window, Fairford Church,' I haven't any doubt it will find him, for he's been there a good deal lately!" The hint was taken, and that letter, John Jones assured us, was delivered to him by the postman half way up a ladder, in the window!

Personally, I am greatly indebted to John Niblett for many facts in our local archæology, of which he had made a thorough and life-long study. He was the most painstaking man, and one of the most unselfish I have ever known. Ask him a question about—say a pedigree: and after a little chat he would go away saying he would "look into it and let you know." In a week he would come with a sheet of foolscap ruled and tabulated with all the family tree from the time of Charles the Second, if not from that of Edward the Third, "from whom, you know, my cousin Yates says we are all sprung. Edward had a lot of daughters that married among the nobility: and their descendants married into all the families in the country—so that my cousin will have it there is not even a peasant, of English blood, who is not of Royal descent. It is a fad of Yates's, you know. He once wrote to my mother a letter beginning 'Madam—you are descended from Charlemagne!' She read as far as this, and laid down the letter, and said 'I don't care whether I am or not!'"

I have somewhere in my possession the life-sized portrait of a still older sovereign of this country than Edward III., drawn by John Niblett from a likeness found in Gloucester: and had it been done during the life-time of the monarch, I feel sure he would have complimented the Cotteswold Club on having such a member, and would not improbably have invited the Club to lunch at the palace to see their colleague invested with equestrian rank.

"That's a sketch of Vespasian that I took from a coin, for a lecture I gave. It shows better on the large scale. You see his bull-neck: you know those fellows—those early Emperors—generally had great bull-necks like that."

Twice only, in the long period during which it was my privilege to receive help from John Niblett in archæology, it was my fortune to find him wrong. He used to come daily while we were opening up the Roman Wall at Eastgate, to examine the pottery, &c. that turned up: but he insisted that the masonry itself could not be Roman, because there was no pounded brick in the mortar. He was, as it proved, mistaken: for we eventually found that all the walls, from Cirencester to Chester inclusive, left by the Romans, are without pounded brick: and that there is none in the original portions of Hadrian's Wall. They only began to use it at a late period: for no brick or tile was made in Britain before their arrival.

The other occasion on which I had the gratification of finding him wrong, as against the innumerable times in which he was right, was apropos of Haresfield Camp, which was on his own property: and in referring to which he rarely failed to add, "You know, the Standish people will persist in calling it Standish Beacon, while the whole of it is in Haresfield Parish! It's simply absurd. It's HARESFIELD Beacon, and nothing else!"—I am satisfied that if any Standish man could have seen the withering look of contempt that always accompanied this assertion of the right, he would not lightly have ventured to repeat his groundless claim.—John Niblett had been telling me of the Beacon-fire station at the southern end of the Roman Camp: when I remarked that there must also have been one at the opposite end, because they would not care to light a large fire, when the South wind blew, in such a position as to send the smoke into the camp itself. "Well," said he, "but there is no trace of such a pit at the other end": and then he added "If you will come over to Haresfield, we will try whether there is or not." We got a labourer with a spade: mounted the hill, and walked along the northern rampart. Near the end towards Painswick there was a suspicious depression in the grass: "Do you think this was used for a fire? Well, we'll dig here." He was as delighted as I was, when in five minutes after removing the turf we came upon the ashes and fire-pinked Oolite that proved the point at issue.

It has happened during the period to which this sketch relates that the leading Members of the Club have been mainly,—some of them exclusively—devoted to Geology, although the Cotteswold Club embraces in its aims several other branches of human knowledge. Charles Lamb once tried to excuse himself, when charged by his chief at the India House, with being late in the mornings, by the plea that he went home early in the afternoons: and on the same principle it might be urged as a counterbalance to the too-exclusive attention paid to the one science by the best men in the Club, that many of us who made up the rank and file knew almost nothing about it.

We were one beautiful summer day wending our way up Haresfield Hill, when John Niblett pointed out the manner in which the British Camp had been partly utilized by the Romans, who built their square encampment in one end of it. Reaching the Quarry at the top of the hill, one of the Geologists pecked out some specimens from the rhynconella cynocephalus band that occurs in the section, and called John Niblett's attention to the position and thickness of the layer: handing him a type of the fossil. Niblett assented to the doctor in an absent dreamy fashion: took the shell between his finger and thumb, and drawing me a yard or two aside, said "Cynocephalus, you know, is from the Greek Kuon—a dog, and Kephale—a head: because the shell is so like the head of a dog. You see, there are his ears." Then after a absent look—changing the subject to another which the mention of dogs had probably suggested, he added in a lower tone—

"There are a great many rabbits just below there, and some of the idle fellows of the neighbourhood come here poaching. The policeman that takes the round in the early morning overtook one of them in this Quarry—old John Smith: old Jackey they called him. Jackey had a shooting jacket on, with the sides bulged out in a most suspicious way: and the policeman stopped him to ask what he'd got in his pockets. 'What I got in my pockets aint nothin to do with *you*,' says Jackey. The policeman wouldn't take that for an answer, and he says 'You just turn them pockets out.' When the pockets were turned out, there were a whole heap of rabbits—so the policeman walks old Jackey off . . . . "

"Mr Niblett—do you hear what Dr Wright is saying?" asks the President.

"O—y-e-s, Sir William—about the—a—a—'m : and a vacant gaze confirms the President's suspicion that he had not been paying that close attention which he ought to have done, to the doctor's exposition of the Quarry.

I wish here to make a clean breast of it, and confess how this and similar wasted opportunities came home to myself: for several years afterwards a lady called on me at Gloucester, handing me a card, "Miss . . . Newnham College, Cambridge," and saying she had been referred to me as a likely person to give her some information about the Geology of the district. I ought at once to have told her that I had practically no acquaintance with Geology: but I yielded, instead, to the temptation of piecing together the few scraps I had picked up, and trying to make them serve the turn: so I talked about the lias formation, and some of the oolitic beds above, but in so vague a way that what was offered to the lady's notice might almost have applied to any period, from the beds of the glacial epoch down to the beds in the Bell Hotel. Then, hinting that as her time was limited she might like to begin at once with some section easy of access, I told her that one of the most interesting I could think of was that of the Quarry on Haresfield Hill, in which she would find the rhynconella cynocephalus, with which she was doubtless familiar—and taking out my watch I discovered that she would just have comfortable time to catch the next train to Haresfield: which she did: and, as John Bunyan said of the Pilgrim, after he was safely landed—I saw her no more.

I beg the lady's forgiveness, if these lines should ever meet her eye: for after all, the information I gave her was sound as far as it went: and I can but hope she found the palæontology of the Quarry as attractive as its more recent fauna proved to old John Smith.

Haresfield is rich in Roman remains, and it was worth listening to John Niblett's story of his first search after them. His brother had come home from Oxford, fired with antiquarian zeal; and he said one morning "John, let's come up on to the Camp and have a dig to see if we can find something."

"Nonsense. You may dig your life out, and never find anything there!"

"Well—suppose we don't: there's no harm in trying. Come along!" So they shouldered a spade each, and went up the hill, where they worked away for about an hour, with the result of turning up a piece of black pottery the size of one's hand, and some scores of coins of the Constantine period—say of the Lower Empire: most of them struck at Trèves.

Twenty years after this, the farmer who had the ground ploughed it for the first time since the Roman occupation: for it had been a rough pasture field. In doing so he turned up a pot, with a sherd broken from its side: the very sherd that had been taken off by the spade in the experimental digging just described. About 3,000 coins—say "third brass," were found in it. John Niblett fastened the broken piece on to the pot, and sorted up the coins into the several reigns to which they belonged: perhaps ten in all, beginning, I think, with Constantius Chlorus. I have some of them in my own possession, by favour of Arthur E. Niblett, who has succeeded his uncle in the Haresfield Estate.

When I asked him how he could account for this large find, all of coins of small value, he said he surmised it might have been on the site of the paymaster's tent. This officer, he thought, might have buried the money in his tent, ready for the pay of the troops; and then he had gone out and got knocked on the head: so that nobody ever knew anything about it till it turned up thus accidentally.

I have reason to believe that he was unaware, when he said this, that the very spot on which the coins were found corresponds with what is marked in a Polybian Camp as the Quæstorium: although the Roman Camp at Haresfield, so far from being Polybian, is of very late form. I may remark, apropos of the abundance of coins of the Constantine era, that I have seen an exactly similar lot of 700 found at Kingsholm: and another 700 odd found in one heap on Mount Lebanon.

But John Niblett's best find at Haresfield was a silver coin. "This is a denarius of Theodosius. It is valuable, because it belongs to just the last period of the Romans in Britain. I found it on the site of a Villa on one of my farms. I don't mind telling you where it was: but I don't want it to get out, or we shall have all the antiquaries here. They are dreadful thieves: they have an idea that what is old belongs to everybody. You know there was So and So. He came to see me, and got me to show him a coin he had coveted. When my back was turned he slipped it into his pocket, and of course I never saw it again.—Ask him for it, you say? I have asked him, but he declares he knows nothing about it.—No. I shan't tell them where the Villa is.—Why they'd steal the eyes out of your head. I know them of old!"

It is time I should draw this chat to a close: for I hope it may be enough to give an idea of the sort of men who were prominent in the Cotteswold Club five and thirty years ago: the rest of the picture being made up of country squires and clergymen of the old school; one or two Professors with spectacles, and a bagful of gryphites and pygasters and pectens, and a vocabulary that would frighten owls: and last, not least, a contingent of old Indian officers from Cheltenham, tanned by the sun, and touched on the liver: and whose talk was of elephas orientalis, cholera morbus, and the Nizam.

I have alluded to William Lucy as our "retiring" President. It is precisely because he is such a retiring man that there is so little to say of him in a sketch like this: but very different is the area he occupies in the thoughts of one who has enjoyed his intimate friendship for thirty years, and his company in hundreds of miles of walking over the Cotteswolds and the Severn Valley, the moors of West Cornwall, and the Volcanic district of South Central France: the latter area being described in one of his papers in the Transactions of the Club.

I am able to testify of him, as a friend of mine did sometime ago of the late Alfred Lloyd Fox, of Falmouth, "He is the best man to travel with I ever knew!" "Why?"—"Because he can go anyhow: he can sleep anywhere: and he can eat anything!" Even now a cold shiver comes over me at the recollection of the dirty hovel we went into at Thuyets, a few leagues from Vals, close under the slope of a volcano that unfortunately became extinct before it had had time to swallow up and melt the establishment in question. Your respected ex-President forthwith made a convention with the unkempt hostess to prepare us an omelette—which the present writer declined as promptly as he would a slice of the cold missionary said to be on the King of Timbuctoo's table every day at two o'clock: producing instead, from his own pocket, a pot of Liebig, and modestly asking for "un peu de pain" and a kettle of hot water. Kettles were not known at Thuyets: and a damsel, unkempt, to match the mistress, brought in a vast saucepan of boiling water, which she managed to splash over the basin on to the table, and to the raw back of a mangy dog—(who became a minus quantity, all but a shriek)—forming a steaming puddle in the mud floor. One ate, under such circumstances, simply to keep soul and body together: not for enjoyment; but your leader held on his way, and made the best of things,—praising the omelette as excellent! As we left the house, he looked back with a smile, and said:

"What do you think of that for the Knight of Elmore to spend the night in? for Sir William and I slept in this inn when we were here last year!"—a place, it occurred to me that the Knight of Elmore would not have put his dogs into, if he could have helped it. I believe he tried to get some amelioration by giving the landlady a hint that he was "somebody" when he was at home: though I don't know that he told her he was President of a learned society. All that he got by it, however, was a heavy bill in the morning: and a hint to the man who drove the visitors, to be sure and charge them enough, as they were "distingués" foreigners, well able to pay! a hint upon which he faithfully acted.

It is, however, mainly in our innumerable country walks in Gloucestershire that William Lucy's memory is enshrined to me: hours of quiet conversation, in which his singularly gentle and unobtrusive manner has left a mark that no time can efface—walks generally refreshed by a quiet cup of tea at some roadside inn, or cottage: or it might be at a friend's house en route—such as Anthony Fewster's at Nailsworth: Bussage House: or the Rectory at Littledean, or the like.

And now I must ask the Members of the Club to forgive me for the light style in which I have written of men dear to us all, and of each of whom, in turn, we are forced to say: "We ne'er shall look upon his like again!" Most of them have crossed the dark river whose banks we too are nearing, and their memory, both in what they did rightly and in what they fell short, should impress us with the thought: "Whatsoever thine hand findeth to do, do it with thy might: for there is no knowledge or device in the grave whither thou goest."

Mr Colchester-Wemyss was elected President in Mr Lucy's place, and the other officers of the Club were re-elected.

The Treasurer presented his report, showing a balance in hand in favour of the Club amounting to £86 13s 3d.

The First Field Meeting of the season was held on Thursday, 25th May, when an expedition was made to the Wick Rocks.

The Members assembled on the platform at Warmley Station, where they were met by the Rev. H. Winwood, one of the Vice-Presidents of the Club. A break was in readiness to convey them to Naishcoombe Hill. Mr Winwood here showed some excavations made in the fields on both sides of the road to Quarry Ochre.

A visit was then paid to a quarry on the left of the Bristol and Bath road, the first exposure of the Millstone Grit, which was seen dipping at a high angle. Several specimens of the grit, which assumed the character of a quartzite, were taken as illustrative of its general appearance in the Bristol district.

After lunch, the Members, under Mr Winwood's guidance, followed the left bank of the Boyd, until they came to a section of the Millstone Grit on the right hand, where Mr Winwood, with the aid of a geological map, gave a lucid explanation of the geology of the district. The arduous climb up the steep left slope of the ravine led to a large quarry of the massive limestone dipping at a high angle in the same direction as the overlying Millstone Grit already passed, and to a projecting spur of rock from whence a fine view up and down the gorge was seen. Mr Lucy here pointed out an instance of Slickensides on the face of a bed of limestone. This gave rise to a discussion as to the evidence of ice-action on the Cotteswolds and elsewhere in the district, until time warned the Members to return to Warmley.

Before leaving for home, the President expressed the very cordial thanks of the Club to Mr Winwood for the able manner in which he had contributed to the success of the day's proceedings.

The Second Field Meeting may be described as a thoroughly Cotteswold day. The Members assembled at Gloucester Station on Thursday, the 23rd June, and drove to the Brick Works lately opened on the Western slope of Robins' Wood Hill. The clay used belongs to the Middle Lias, which is divided into six zones, each zone marked by a characteristic Ammonite. Dr Smithe pointed out the geological features of the hill, and laid special stress upon the fact that the six zonal divisions hold good for Belgium, Switzerland, Germany, Austria, and Italy, demonstrating the great area covered by the ocean in which Middle Lias beds were deposited. Half way up the hill the Common Henbane (Hyoscyamus Niger), the only British species of this germs. The name probably comes from the Celtic word "Hen," which means "sleep."

The name Robins' Wood Hill is a modern one, owing its origin to the fact that in the 16th century a family of the name of Robins resided on the Northern slope.

The original name was Mattesdon Hill, which may be derived from the Teutonic "Matte," a meadow, and "Düne," a down.

The party then drove to the old Manor House at Brookthorpe, the scene of some stirring incidents in the great Civil War, close to which stands the little church dedicated to St Swithin, which possesses a beautiful small Early English window, and a nearly perfect staircase to the rood loft. Its distinguishing feature, however, is a pack-saddle tower, a type which occurs in only one other church in the County, Duntisbourne, near Cirencester. There is certain documentary evidence which tends to show that these churches were built by the Monks of St Peter's, Gloucester, and that these peculiar towers were part of the original design.

A short walk took the party to Mr Lucy's beautifully situated residence, where the hospitable owner had with kindly forethought provided a most sumptuous luncheon.

He further earned the gratitude of the Members by exhibiting some of his geological treasures, including an immense boulder of black limestone covered with the striations of glacier action which had been obtained some years ago from a railway cutting in the North of England. A walk through the grounds of Judge Hutton led the party to the summit of the Horsepools Hill, where the Upper Lias Sands, and nearly all the beds of the inferior Oolite are well exposed. In a quarry on the brow many specimens of Coral were extracted by the Geologists' hammers from beds which for some time were only known at Crickley Hill, but which have now been traced for a considerable distance along the escarpment in a Southerly direction.

The Members then drove along the road leading to the foot of Painswick Beacon, stopping en route at the stone which has always been called "King Charles" stone, upon which, so says tradition, the King sat when retreating from the siege of Gloucester, and where, when asked by one of his sons when they were going home, replied: "Alas, my child, we have now no home to go to."

Near the stone are some entrenchments at the end of an old road leading up from the valley, forming a double line of breast-works in the shape of an irregular oval. Mr Lucy thinks they are of Roman date, were made to check incursions from the vale. This view is corroborated by the fact that there is a little lower down the slope of the hill a green lane called "Sandford," the original name of which was "Sarnfordd," or "Paved Way," Here are most evident proofs of the origin of the name, the pavement being traceable for a considerable distance, a Roman pavement, made probably in the Second Century.

The Members then drove through Upton St Leonards to Matson House, where they received from the Hon. Miss Rice a cordial welcome, and hospitable refreshment. Here Mr Bazeley was to have read some notes on the

History of the Parish, which three times at least has been visited by Royalty—by the Black Prince in 1355, by Charles I. in 1643, and by George III. in 1788; but the lateness of the hour deprived the Members of this pleasure, who hoped that the reading of the paper was only postponed to a more convenient occasion.

The Third Field Meeting of the season took place on Monday, 31st July, when a visit was paid to Monmouth and its neighbourhood. Mr Bagnall-Oakeley met the party at Monmouth, and most kindly and ably acted as guide during the day. A visit was first paid to the Castle, passing the remains of the old East Gate of the town. The Castle was built by William Fitz Osborne, Earl of Hereford, soon after the Norman Conquest. Henry V. was born within its walls, and it played an important part during the Parliamentary wars.

The old Norman tower on the Monnow Bridge, and the Church of St Thomas were then visited, and the party then drove up the Monnow valley to the village of Skenfrith. The remains of the Castle were here visited, a Castle which, with that of "Grosmont" and the "White Castle," formed the celebrated "trilateral" of Monmouthshire. The mound upon which the keep of Skenfrith Castle stands was probably in an earlier age one of a number which form a line of defence across the country. At the time of the Norman Conquest, Skenfrith is said to have been held by Bach, the son of "Cadivor ap Gwæthbold," who probably obtained possession of it in a campaign eleven years earlier. Of its history from that time until the 13th Century no trace has been found.

In the reign of John, the three Castles of the "trilateral" belonged to the King, and probably no part of the existing structure of Skenfrith is older than this date. Twice during the King's reign the three Castles passed into private hands, but in 1267 they were given by the King to his son, the Earl of Lancaster, and they afterwards merged into the possession of the Crown. After the Conquest of South Wales by Edward I., the trilateral ceased to be of importance for defensive purposes, and though Grosmont appears to have been a favourite residence of the Dukes of Lancaster, Skenfrith was allowed to gradually fall into ruin, and in the reign of James I. it was presented by a local jury as "ruinous and decayed time out of mind." There are no mural chambers, and no garde-roles in the Castle, but it was evidently built only to contain a small garrison, and not as a private residence.

The Church at Skenfrith has one striking and valuable feature in its freedom from modern restoration, for it does not seem to have been touched by the restorer since 1661, and Mr Waller congratulated the parishioners on their possession of a Church which had hitherto been unmolested by any modern architect. It was probably erected in the 13th Century, and the arcading between the North Aisle and Nave may be of this date. The tower is extremely interesting and picturesque, and is surmounted by an open lantern of timber, locally called a "Pigeon House Tower." The Church still possesses a Pre-Reformation Cope, a very good example of the embroidery of the 16th Century. It seems to have been used in the Church for many years as a pulpit cover, and its value was only detected some 40 years ago. The intrinsic evidence is sufficient to prove that we have here a genuine Pre-Reformation Cope; one of the chief subjects embroidered being the Assumption of the Virgin. On the collar the principal subject is the Virgin with the Holy Child. The costumes of many of the saints are fairly well preserved, and striking and distinct in every feature are the Cherubim and double-headed Eagles. One tradition is to the effect that the garment was worked by Queen Eleanour; another gives it a connection with King John.

A drive of some three miles brought the party to Pembridge Castle, built by Ralph de Pembridge, who at the beginning of the 13th Century was settled in this neighbourhood. The Castle is quadrangular, with a South entrance defended by two towers of unequal size. It is in fairly good condition, and the greater part of the moat still remains. The building is used as a farmhouse; the present kitchen and parlour were once the great hall, and a staircase in the projecting turret is, no doubt, original. In the reign of Henry VIII., Pembridge Castle seems to have belonged to the Knights of St John of Jerusalem, who had a preceptory at Garway, a few miles distant. After the dissolution it was granted to one Baynham, of Newland, who was attainted in the second year of Elizabeth. It was then sold to David Baker, who sold it to Sir Walter Pye, and the last Sir Walter sold it to George Kemble, who made it habitable. This family were members of the Church of Rome, and in the Castle may still be seen the desecrated Chapel where mass was wont to be celebrated. An aged priest of this family, named John Kemble, was betrayed, discovered at the altar, and arrested. He was tried and executed at Hereford, Aug. 22nd, 1679, one of the last victims of an intolerant age. It is said that the old priest asked to be allowed to smoke a pipe on his way to execution, and to this day the last pipe before a party breaks up is called, in Herefordshire, the "Kemble" pipe.

A pleasant drive back to Monmouth, and a dinner at the Beaufort Arms Hotel, brought a most interesting and enjoyable day to a conclusion.

The Fourth and last Field Meeting of the Club was held on the 25th and 26th August, when a large party travelled down to Wells and Glastonbury.

On arriving at Wells a visit was paid to the Cathedral. The capitals of the piers in the Nave and Transepts, the elaborate carving of the North Porch, the curious inverted arches inserted to support the original ones under the central tower, and the coloured glass, occupied much attention, as also did the quaint clock, the work of one of the Monks in the 14th Century. The East window of the Lady Chapel, and the exquisitely groined roof of the Chapter House were very much admired.

By kind permission of the Bishop a visit was then paid to the lovely grounds of the Palace, where an unusually fine specimen of the Ailanthus, said to be the largest in England, was seen. The Church of St Cuthberts was then inspected, and its tower, probably the finest example of perpendicular work in the County of Somerset, attracting special attention.

An agreeable evening was spent at the Swan Inn, and the next morning the party took an early train to Glastonbury, where they were met by Mr J. G. Bulleid, President of the Glastonbury Antiquarian Society, who had kindly undertaken to act as guide for the first part of the day. The old Manorial Building (1480) in which the Abbots formerly held their Court, and which is now used as an office by Mr Bulleid, was much admired. The Arms of Edward IV. are still to be noticed over the doorway. Mr Bulleid then took the party to the ruins of the magnificent Abbey, and explained most lucidly the many points of interest. His complete knowledge of all that can be ascertained of the history of the Abbey, and his love and veneration for the ruins which have been to him a life-long study, were evident in every passage of his most interesting description.

The party then proceeded to St John's Church, the tower of which is almost as beautiful as that of St Cuthberts, and from thence to the Abbots' kitchen, erected from 1303-1341. This edifice is built entirely of stone, with four fire-places and an oven. The Louvre system of ventilation is so excellent that it is said to have been copied in a recent laboratory building at Oxford. The roof has eight covered ribs springing from the octagon, and ending in the lantern. There are only three erections of the kind known, and one only resides thus in this country.

The Abbey Barn, 1420, a cruciform building, with the fine original timbered roof, and still occupied, with a farm just outside the Abbey walls, was also very much admired.

After luncheon at the "Pilgrims' Inn," a quaint building dating from 1475, the party visited the Museum, under the guidance of Mr A. Bulleid, and some time was spent in examining the various interesting objects it contains, especially those recently discovered in the ancient British village about a mile and a half from the town. Prominently among these was a flat-bottomed canoe, worked out of a single log of oak. This canoe was the cause of the discovery of the village. It was deeply bedded in the peat, and its prow projected out into one of the ditches used for draining the land. These ditches are periodically cleaned, and the men who did this work had long known of the existence of what they thought was a solid block of timber; one day, however, they happened to call Mr Bulleid's attention to it, when a short examination showed him it was no ordinary piece of timber, and he had the peat covering it dug away, and the whole canoe was thus exposed. This discovery led him to make further investigations, and his attention was attracted to some slight mounds in a field a few hundred yards away from where the canoe was found. Excavations revealed the fact that each one of these mounds was the site of a hut dwelling, and that the whole collection represented an encampment of very considerable extent. Each hut was built on logs laid flat on the morass, and coated over with clay. Embedded in this in the centre of each hut were several flat stones forming the hearth, and outside each hut were two or three stones still in situ, over which the original inhabitants stepped to their homes. Each hut is built round with wattle work, admirably preserved in the bed of peat, and the whole village was surrounded by a substantial stockade, formed of very strong wattle work; many of the piles used in its formation are most elaborately pointed and fashioned. Many relics indicating the occupation and habits of the dwellers in these primitive abodes have been discovered, but their history has yet to be written. It was with the greatest reluctance that the necessity to catch the home-bound train compelled the Members to leave a spot offering so much of unrivalled interest; and the whole country owes a debt of gratitude to Mr Bulleid, to whose energy the discovery and excavations are due.

The canoe discovered at Glastonbury reminds us of the boat excavated at Brigg some eight years ago, of very much larger size, but which was also fashioned out of a single log of oak. The inside measurement was 48 ft. long, 4 ft. 4 in. wide, and 2 ft. 9 in. deep. The tree from which it was cut must have been far finer than any now to be found in England. The diameter at the butt must have been about 5 ft. 3 in., and at the first branch, which was over 50 ft. from the ground, it was about 4 ft. 9 in., and throughout this length it was as straight and uniform as if turned in a lathe. Measured over the bark it would have contained nearly 1,000 cubic feet of timber.

There were three Meetings of the Club during the winter, at which papers were read:

1. By the President, on the 21st Nov., on "Refuse," the utilization of waste materials.
2. On the 19th Jan., by Mr John Bellows, on a recent journey undertaken by him in Western Asia.
3. On the 19th Feb., by Dr Garrett, on "The River Severn, considered as a Source of Drinking Water."

This last paper excited so much interest, and contained so much information, that it was decided to hold a special meeting on March 16th, to allow for a full discussion of the questions it raised. A great many speakers took part in this discussion, not only Members of the Club, but several other gentlemen interested in water questions, who had been specially invited to attend the meeting. The balance of opinion appeared to be in favour of the views advanced by the reader of the paper.

All three papers are printed with this Report.

REFUSE

THE UTILIZATION OF WASTE MATERIALS

BY

M. W. COLCHESTER-WEMYSS, PRESIDENT

READ TO THE COTTESWOLD CLUB, NOVEMBER 21st, 1893

I have always thought that one of the most beautiful revelations of science is the absolute indestructibility of matter. Do with any material what you will, it is impossible to obliterate its constituent elements. Burn it, dissolve it in water or acids, reduce it to powder and scatter it to the winds; the sum total of its atoms remains precisely the same as before, though they may have entered into new and entirely different combinations, and may have assumed fresh and altered forms. It therefore follows that Nature herself recognizes no such thing as waste. Some of her gifts may at times be poured forth in apparently lavish and wasteful profusion, but the surplus is either stored up for use in the ordinary course of the world's change, or by decaying and assuming new forms is again rendered available for immediate service.

As an illustration of my meaning, may I ask you to follow back with me the genealogy of that illuminating medium, to which we are indebted for so much of the artificial light we enjoy. Coal gas is a mixture of various chemical combinations of five of the elements. It is extracted, as is well known to all, by certain mechanical operations from coal. Now coal owes its origin to vast growths and accretions of vegetable matter in far-away prehistoric times, when the surface of this hemisphere was subject to a temperature and to atmospheric conditions very different to those we now possess. Then were formed either in great tracts of swamps, or on the deltas of deep and mighty rivers, those deposits which now constitute the coal-fields of the world. I must ask you to carry back your thoughts to the times when these accumulations were collected leaf by leaf and bit by bit; when giant ferns and reeds and sedges were living and growing, dying and decaying; when an almost tropical vegetation was daily and hourly extracting from the atmosphere of the preadamite world these very elements, and storing them up for use in succeeding ages. We here have the chain complete and perfect. These very atomic particles which now pass by combustion into the atmosphere, were once before, (and perhaps often before,) in countless ages past, floating in the air over a land very different to that we now inhabit; were extracted from that air by the hand of Nature, passed into various forms of vegetable life, were deposited in layers on the surface of the earth, submerged under the sea, and gradually covered over by the enormous weight of the superincumbent strata, were then drawn out of the bowels of the earth by the labour of man, and finally converted by his skill and ingenuity into that gas which, when it is burnt, pours back again into the atmosphere its constituent elements. Can we not clearly see, from this illustration alone, that waste is unknown in Nature, that nothing in her is lost, and that "refuse" means nothing else than that certain elements are for a time in a dormant condition, but only waiting until their time comes again to take an active part in the great economy of the world. It therefore behoves everyone to do all that in him lies, to convert this dormant condition into an active one, and thus, as it were, to assist Nature in turning over her capital as often as possible.

Much successful effort has already been devoted to utilizing so-called "waste" materials, but there are many natural products, as well as much refuse from manufactures, yet lying undeveloped, to which attention will one day be prominently turned, as new demands arise to be supplied. My desire is to press the importance of the prevention of waste, and I shall advert briefly to the utilization of the refuse of certain manufactures, and processes of domestic economy, with the hope of suggesting to others the profits which might accrue to themselves, and the benefits which would result to mankind from the useful application of many now worthless residues.

Man has necessarily long observed this absolute economy of Nature which turns every scrap to some ultimate account; and when compelled by circumstances (as in China) he has long put in practice. But our strictest economy in England is profuse waste compared with the assiduous care with which everything is turned by the celestials to the best account. The pressure of population which has brought this about in China, is beginning to tell upon Europeans; and hundreds of materials are now worked up, that not long ago were utterly unutilized. And thriftiness begets thriftiness, as waste begets waste. There are scores of manufactures producing by-products, which almost necessitate supplementary factories to use them up, and I shall presently refer to an instance where in one prominent article, an original factory is supplemented in this manner by two others, the one digesting the other's discarded waste. Scientific investigation has made "Arabian airs" from the most offensive refuse, and called forth splendid dyes from substances pitchy black. In this manner our stores are replenished, and it often happens that dearth, by the energy it gives to human research, is turned into plenty. Moreover, there are many materials which have long been subservient to mean purposes, and which cannot therefore be strictly called waste substances, that are yet capable of taking a much higher place in the world's uses; and some peculiar want may transform a comparatively worthless article to a high place in commercial estimation. In the arts vicissitudes of this kind are continually taking place. Other materials, again, are at present altogether undeveloped; they are visible to the eye, but we know not to what use to put them. They constitute a kind of available reserve upon which at any moment we may have occasion to draw.

The enormously increased production of wool of late years has not and never will do away with the using up of shoddy or reconverted woollen rags. Besides the large quantity of shoddy and mungo produced at home, we import 67,000,000 lbs. weight of woollen rags torn up to be used as wool. The use of shoddy of late years has assumed gigantic proportions. It has been well observed that the combination of shoddy with wool, together with the use of cotton warps, is the most valuable adaptation of materials in the history of the woollen trade which the ingenuity of man has discovered. By it multitudes are enabled to obtain useful and comfortable articles of clothing which were formerly beyond their means. Nor does the advantage stop here. An immense mass of materials, once thought all but valueless, has been rescued from the manure heaps and made subservient to the wealth, industry, and comfort of thousands. Shoddy may create a feeling of prejudice, or raise a smile of ridicule, but manufacturers and consumers owe more to it than they are ready to admit. The manufacturers of pure wool goods are indebted to it, for it has allowed them a full supply of wool, which, otherwise, they could not have procured except at ruinous prices. It often happens that the value of a thing is only discovered after its loss. Stop the supply of shoddy, and you may reasonably expect to double the price of wool and deprive millions of garments, warm and cheap for the winter, light and useful for the summer. Stop the supply of shoddy, and you will close one-third of the woollen mills in the kingdom, and bring distress upon the West Riding of Yorkshire.

Whilst on the subject of wool, I would call your attention to a discovery, the credit of which belongs wholly to our French neighbours, and which is one of the most singular in the history of Agriculture. Sheep draw from the land on which they graze a considerable quantity of Potash, much of which is ultimately excreted through the skin and adheres to the fleece. It was pointed out by a French savant, that this peculiar Potash compound, called by him "suint," forms no less than one-third of the weight of raw merino wool, whilst of ordinary wools it constitutes about 15 per cent. of the weight of the fresh fleece. As the suint may be extracted by mere immersion in cold water, it is easy for the manufacturers to produce more or less concentrated solutions from which the potash may be recovered by appropriate treatment; these are evaporated until a perfectly dry and somewhat charred residue is obtained. This is placed in retorts and distilled very much in the same manner that coal is distilled at gas works, and the result is that while much gas is evolved which is used for illuminating the factory, and much ammonia is expelled which is collected and utilized in many ways, there remains a residue consisting chiefly of carbonate, sulphate, and chloride of potassium. These three salts are separated by the usual method, and then pass into commerce. The wool manufacturers of Rheims Elbœuf and Fourmies annually wash the fleeces of nearly 7,000,000 sheep, and the amount of Potash which these fleeces would yield, if subjected to the new process, would represent a value of £80,000. It has been computed that there are in France seven times as many sheep as are included in this estimate, and this will enable us to judge of the enormous loss in potassic constituents which the soil of an agricultural district has to suffer; and besides teaching us, as agriculturists, this instructive lesson, it is one of the most complete and interesting instances of the utilization of waste with which I am acquainted.

In all civilized and densely populated countries it may be said that nothing is wasted of the animals used for the food of man; every part that is not eaten is turned to some useful purpose. The refuse fat is converted into tallow and soap, the greater part of the skin is made into leather; and the scraps with the hoofs, feet, and various membranes, turned into glue; the horns made into various useful articles, and the bones produce phosphorus and manure. But this is very far from being the case in more remote regions, where the abundance of animal life is almost inconceivable. Improved facilities of transport, consequent on the universal adoption of steam as a motive power by land and water, is doing much and will do more to remedy this, but it will be many a long year before all waste of this kind is obviated. In the Pampas of Buenos Ayres the wild oxen are slaughtered by hundreds of thousands annually, solely for the sake of their hides.

The enormous number of horses in some parts of South America renders them of little commercial value; but it is certainly odd to read of a country where the number of mares slaughtered merely for their hides and grease is so great, that it is found economical to light a large city with gas made from their fat.

In Russia, Moldavia, and Wallachia animals are slaughtered by thousands for the sake of their fat and horns; in the Australian colonies the price of cattle was until lately quoted at "boiling rate," in other words fat cattle would fetch no more from the butchers than could be realized from their hides, horns, hoofs, and tallow for exportation. Under the old and slovenly system of sending cattle to the melting-pot, it is certain that from one-quarter to one-half of what ought to have been profitably turned to account was wasted. The value of cattle and sheep in the colonies must now be measured, not by the local demand for butchers' meat, but by the price which can be obtained for the various constituents of the carcase in the different markets of the world. The utilization of this waste animal food has received of late years a large amount of attention, and various methods have been introduced both for transporting the animals themselves either alive or in carcase, and also for preparing the animal food in different forms, either as extracts of meat, tinned provisions, or dried and smoked goods.

There are two industries which have together constituted, to an incalculable extent, to render our commercial position what it is. I refer to the coal and iron trades.

Now in both of these there is an immense amount of waste material which is more and more being brought into utility.

Our colliery produce cannot last for ever, at the enormous rate at which we are working the pits, and as the quantity of small waste coal per annum in the United Kingdom has been estimated at 28,000,000 tons, the utilization of this refuse is a matter of national importance.

Many, more or less successful, efforts have been made to combine this dust with tar, pitch, and other inflammable substances, and then to press the mixture with bricks, which are used as fuel. At the Charleroi mines in Belgium over 250,000 tons of such an agglomerate are annually made; and so extensive is now becoming in our own country the manufacture of patent fuel, that we export yearly 400,000 to 500,000 tons of this commodity.

Much time, thought, and attention have of late years been devoted, both in domestic uses and in the production of steam, to minimize the consumption of fuel, and the urgent necessity there is for this is evident when we consider that our coal supplies are used once for all, and cannot be replaced, and that our annual consumption is ever on the increase. In 1855 the amount raised was 64 millions of tons; in 1860, 80 millions; in 1870, it was 110½ millions; in 1879, 140 millions; and now, 170 millions.

In the manufacture of coal-gas an immense bulk of tar is produced, and also a quantity of offensively smelling water, which used commonly to be called "Blue Billy" as it floated down the nearest river in ghastly blue patches. These two products were formerly thrown away as useless and deleterious, but now both are made to yield valuable commodities. From the water Carbonate of Ammonia to the extent of 2,000 tons, Sal Ammoniac 4,000 tons, Sulphate of Ammonia 5,000 tons, and also considerable quantities of Sulphuric Acid are annually extracted.

But it is the tarry matter which has been made to yield all sorts of extraordinary compounds. Such are Nitro-benyol, used on account of its sweet taste and almond-like odour to perfume soaps, and flavour confectionery; Aniline, the base of all the wonderful and brilliant dyes which have of late years been so much used; Carbolic Acid, now of such vast utility; but perhaps the most interesting of all the products of coal-tar is Solid Paraffin, a colourless crystalline fatty substance, which may truly be termed "Condensed Coal-gas." It is found in some places naturally, constituting the minerals known as fossil wax and ozokerit, but by far the greater bulk of Paraffin is obtained by chemical processes from Bituminous Shale or from Coal-tar.

Thus, Coal-tar is gradually refined upon and improved till the dirty mass becomes a liquid of glowing tints, ready to dye the most delicate silks, feathers, and other articles through endless gradations of colour; a few grains of Aniline suffice to dye many yards of fabric, and it is well it has this power, for two gallons of Coal-tar only yield 10 grains of Aniline. This same Coal-tar, formerly of so little value that it almost puzzled gas-makers to get rid of it, has become the basis of a most important industrial manufacture, and these by-products are now so valuable that factories are set up beside the gas-works for the purpose of working them up. On Bow Common a factory is thus located beside the Great Central Gas Company. From one of the products of Coal-distillation worked up at this factory, is prepared the impure Muriate of Ammonia in crystals, and in order to convert this salt into the "Sal Ammoniac" of commerce a Chemical firm has built another factory adjoining. Thus three laboratories, placed side by side, pass on from one to the other products, which, in the passage, suffer transformations as remarkable as any we read of in Arabian story.

There is hardly anything more wonderful than the development of the utilization of by-products from Coal-tar in the last 35 years. The value of the colouring matters alone is estimated at over £5,000,000 per annum.

The products which half a century ago were made in the laboratory with great difficulty and in small quantities, are now turned out by the cwt. and ton. To achieve these results the most profound chemical knowledge has been combined with the highest technological skill. The outcome has been to place at the service of man from the waste products of the gas manufacturers a series of colouring matters which can compete with the natural dyes, and in many cases have displaced them. From the same source we have been supplied with explosives, such as Picric Acid; with perfumes and flavouring materials, like Bitter Almond Oil and Banillin; with a sweetening principle, like Saccharine, compared with which the product of the sugar-cane is but feeble; with photographic developers, such as Hydro quinone and Eikonogen; with disinfectants, which largely contribute to the healthiness of our lives; with potent medicines, which rival the natural Alkaloids; and with stains, which reveal the innermost structure of the tissues of living things. Surely if ever romance was woven out of prosaic material, it has been in this industrial development of modern Chemistry.

Much more time might be occupied in discussing the various by-products which arise directly and indirectly from the use of Coal; great has been, too, the expense and ingenuity devoted to ensure their acceptance by the public. Take Ozokerit for an instance, which was first discovered as a natural product, very similar in appearance and composition to Solid Paraffin. I believe £20,000 was spent in posting the word on to every available dead wall, conspicuous rock, or high fence, and in advertising it in every language and in every country, until the curiosity of the whole world was raised to a high pitch in anticipation of the coming wonder; but I think we must now leave the coal pit, and work our way to the iron mine, or rather to the smelting furnace, and see what progress has been made in disposing of the enormous output of slag.

In the early days of Iron smelting the process was so crude and imperfect, that iron was left in the slag in such quantities that it has since been extracted with considerable profit from the old slag and cinder heaps.

Taking an average of all the districts in England, for each ton of iron made, 25 cwt. of slag is produced, and from the official returns of 1879 of the iron smelted, no less than 8,000,000 tons of slag were accumulated. The space occupied by this mass when loosely tipped is something like 170,000,000 cubic feet, whilst the bulk of the iron only occupies one-sixth of the same space. There is, however, this great difference between iron and its refuse; whilst the former is diffused and finds its way into every corner of the world, from the hook at the end of the fisherman's line, or the hair-spring of a watch, to the magnificent steam ship, or the abundant works upon the various railways; from the splendid roof of many of our public buildings, to the small but infinitely long rod of the telegraph wire; whilst iron has been diffused through all the beautiful branches of the Arts and Sciences;

its companion, slag, has been left behind at the smelting works, a hideous memorial, defacing the landscape, absorbing something like a quarter of a million sterling annually in its disposal, and destroying for ever hundreds of acres of valuable land; forming, as it were, a blot upon the face of the earth, and left as a landmark to show where the wonderful metal, iron, has been extracted, the development of which has contributed so much to bring the world to its present state of civilization.

The first use to which slag was devoted was road-making, but until the introduction of stone-breaking machinery, its extreme toughness rendered it so difficult to break, that it was not, I believe, very largely employed; now at many of the slag heaps, old and new, a machine may be seen constantly at work, breaking it up into road metal, and discharging it into railway trucks, to be conveyed considerable distances.

Another and simpler use has been to throw the rough blocks of slag into the sea in the construction of breakwaters. At the works at the Tees mouth enormous quantities have been used. The molten slag is simply run out, as usual, into cases placed upon the bogies, and the bogies are then run right out on to the breakwater. These blocks then serve an excellent purpose in breaking the force of the waves. Something like half a million tons have been annually used at the Tees works for some time past.

The next stage in slag utilization consists in the endeavour which has at various times been made, to run the liquid slag, as it flows in a stream from the furnace, into moulds, or in other words, to make slag castings. Such an idea would, at first sight, seem natural enough. Here, it may be said, is a material, flowing to waste in a liquid state, capable of being run into moulds, and of taking impressions almost equal to those of cast-iron. The castings, also, when successfully made, are exceedingly durable, and not unpleasing to look at. So alluring has been the idea of casting, that during the last 50 years the Patent Office has recorded almost annually the attempts of some inventor, impressed with the notion that he could treat the treacherous fluid successfully, or in some way or another make it useful in the Arts. Few people have any idea of the difficulties to be encountered.

The slag leaves the furnace at an excessively high temperature, not less than 3,000° F.; but when it is brought into contact with anything cold, such as a mould, it readily parts with its heat, and in so doing suddenly contracts. The surface contracting becomes covered with fine cracks, or flaws, and so much is this the case, that if allowed to become entirely consolidated in the moulds, these cracks will be found to penetrate completely through the casting, and upon exposure to the air it falls to pieces. This is the more vexing, as when slag is run into a large mass, say into a pit of sand 8 or 10 feet deep, and containing from 30 to 40 tons, there is such an enormous amount of heat accumulated, that it becomes self-annealing, the outside of the mass is kept at a high temperature, and if allowed to remain until cool, not a flaw will be found, and the slag becomes so excessively tough and hard that it may be quarried like granite, and used for street paving.

However, some extremely ingenious machinery, not long since introduced, has to a certain extent got rid of the difficulty, and at Tees mouth large quantities of paving blocks are manufactured direct out of the slag as it leaves the furnaces.

Mr Bashly Brittain has invented a process by which he converts slag into glass, for bottle-making, and for many purposes where a pure white glass is not essential. Quantities of Alkali and Sand, and of colouring or decolorizing material, are added to the molten slag, varying according to the quality of glass required: such as 50 per cent. of slag for champagne bottles, rather less for plate glass, and so on. Slag glass, owing to its toughness, is especially useful in the manufacture of tiles, cisterns, pipes, slates, and so on, and it has, I believe, been even used for railway sleepers.

By other ingenious machinery, slag coming from the furnaces is subjected to a process which turns it out in small-sized pieces, which are called "slag-shingle." These are largely used in certain localities in making concrete. Another machine, again, converts the molten slag into a sort of spongy sand, and this slag sand is much used to make slag bricks. The sand is simply mixed with selenitic lime, and a small proportion of iron oxides; it then passes into a particular kind of brick press; the bricks are taken out of the presses by girls, placed upon spring barrows and removed to air-hardening sheds. Here they remain a week or ten days, after which they are stacked in the air to further harden, and in five or six weeks are ready for the market. We have here a curious anomaly of bricks being made without burning, and of a wet season being favourable to the hardening process. They are very tough, do not split when a nail is driven into them, are easily cut, do not break in transit, the frost has no effect upon them, and they improve by age.

Slag sand mixed with other materials is converted into a first-rate cement; and some samples, rich in lime, have even been used with success as fertilizers for the land.

More than 20 years ago Sir Louthian Bell called attention to the fact that 20,000 lbs. of phosphoric acid were allowed to remain and injure 2,000,000 tons of pig-iron then produced in England annually. By the Thomas Gilchrist process this phosphoric acid is now abstracted from the iron by lining the converter with quick-lime. The large amount of phosphoric acid in the slag so produced, amounting as it does in some cases to over 18 per cent., at once attracted the attention of Agricultural Chemists, and numerous patents were from time to time taken out for the separation of that important manure from the oxide of iron with which it was associated. Experiments showed, however, that the oxide of iron in this so-called basic slag was completely innocuous and all that was necessary to make the phosphoric acid effective as a manure was to reduce the slag to an excessively fine powder.

The utilization of this waste product as a cheap and unfailing supply of phosphoric acid has been of enormous benefit to Agriculture. Over 400,000 tons of basic slag are yearly available, equal to one-sixth of the total amount of phosphate of lime used in agriculture.

I will mention just one other curious application of furnace slag; the so-called "slag wool," or silicate cotton. A jet of steam is made to strike upon the stream of molten slag as it flows from the usual spout into the bogies. The steam scatters the slag into shot. As each shot leaves the molten stream it draws out a fine thread, in the same way as if treacle is touched, a fine line can be drawn out. Each fine thread on losing its heat becomes set. The shot drops to the ground, but the thread is sucked into a large tube by an induced current of air caused by the steam jets, and the wool is discharged into a large chamber. It is of a snow-white colour, and attaches itself anywhere, almost as snow will adhere to every tiny twig of a leafless tree. The wool is taken up daily and packed away in bags. It is chiefly used for covering boilers or steam pipes, for which purpose it is peculiarly adapted, being a splendid non-conductor of heat and incombustible. About four tons of this wool are produced per week, and as only ¼ cwt. is made from each ton of molten slag operated upon, it will be seen that the process is not a rapid one.

There is no doubt that very much remains to be done in utilizing both the animal and vegetable products of the sea. Tons and tons of fish are weekly brought into the markets only to be there condemned as unfit for the food of man; a downright waste which we may well hope will ere long be at least considerably modified.

Independently of such waste as this, consider the millions of various fish which are caught in order to secure some particular part of their body, the remainder of the carcase being then cast into the sea. The Chinese have a partiality for the back fins of a kind of shark, or rather the back fins of two kinds of sharks, called respectively white and black fins, so discriminating is their taste that white fins are worth 60/- the maund, whereas the black have a value of 18/- only. In many parts of the Indian Ocean and especially at Kurrachee, many men are employed in providing this delicacy, and sharks are caught and slain by tens of thousands solely for the sake of their back fins.

Consider again the codfisheries, where the total take of the English, French, and Americans amounts to at least 250,000 tons. Of this at least one half is thrown away in cleaning and curing, and this reduced to a thoroughly dry state would represent about 50,000 tons of a manure probably at least as good as guano. As our annual importations of guano amount to 250,000 tons a year, and the supplies are being undoubtedly rapidly exhausted, this refuse alone, if properly utilized, would be a most valuable addition to the list of artificial manures.

For the same purpose much refuse from the seal and other fisheries might be used. The experiment has been tried in Norway with considerable success.

There large quantities of fish manure are made, less nitrogeneous than Peruvian Guano, but more rich in phosphates. Very much, however, remains to be done, for all over the world incalculable quantities of fish refuse are thrown away into the sea, which might be employed for this purpose. Moreover, the manufacture of these fish manures ought specially to be encouraged, because it conduces at the same time to the benefit of the fishermen, and of the cultivators of the land; and further it enables us to reclaim from the sea—that living reservoir of an ever-during and inappreciable fecundity, some portion of those fertilizing matters which are carried off by streams and rivers to the detriment of our fields.

Fish have been utilized for making paper, the process is a peculiar one, and the resulting product has a semi-transparent appearance, very similar to parchment.

Sea-weed is used in its natural state as a manure on lands bordering on the sea, and in the Channel Islands so valuable is it considered that special laws are enforced for its regular collection and fair distribution. There at regular seasons may be seen the "Vareck" collectors out at low water gathering in their marine harvest, men, women, and children all out together with large baskets, rakes, and hooks; taking their carts and horses as far below high-water mark as the stony beach will allow them. The air there seems to have a peculiar freshness, cooled by the breezes blown right off the Atlantic, and fragrant with the odour of the "Vareck." The bold precipitous cliffs scored by the tempests of ages, the fringe of golden sand skirting the bays, the glorious colouring of the sea itself, not so intensely blue, but more varied than that of the Mediterranean; the fishing boats lying idle at their moorings, and the busy Islanders conversing in their quaint old Norman-French dialect, together form a scene so picturesque, so full of beauty and life, that once seen it can never fade from the memory; it serves, moreover, to impress upon us the lesson of Nature to utilize, as far as we possibly can, such products of hers, as may be lying wasting within our reach.

Many chemical products are extracted from sea-weed, such as Iodine, Potash, and Magnesia; and in different parts of the world much sea-weed of different varieties is used for food, especially in China and Japan; and as the supply is practically unlimited we may look forward to seeing this abundant product of Nature even more and more utilized.

SAWDUST is a waste product which has many uses. That from Mahogany, Beech, and Rosewood is used in cleaning and dressing furs; and box-wood dust for cleaning jewellery. It is employed as a packing material, for use in wine cellars and ice-houses; sprinkling over floors and riding schools, sometimes instead of straw in stables; by many manufacturers, such as needle, nail, and screw-makers. Lately by a new process combining the hydraulic press with the application of intense heat, sawdust has been converted into a solid mass capable of being moulded into any shape, presenting a brilliant surface, and very durable. By another ingenious process a Norwegian Professor converts sawdust and wood into excellent flour, which mixed with certain small proportions of wheaten flour makes highly palatable gruel soup, pancakes, and bread. The Professor has, I believe, brought up a large family on this diet, and has had no reason to be dissatisfied with the result.

Until lately, after concentrating the colouring matter from dye woods, only a few shillings per ton could be obtained for the exhausted wood as a combustible material. Now, however, this is all utilized. Paper is made from it; a certain soda soap adapted for cotton printing, mastics for the joints of pipes, and other things.

The manufacture which of all others consumes the greatest amount of waste from other sources is Paper. The best materials are cotton and linen rags, and these are in constant demand: used alone they make the highest grade of paper, whilst in combination with varying proportions of paper stock they produce the different grades of paper found in the market.

To give you some idea of the importance of this industry, I may mention that we collect at home and import together about 120,000 tons weight of rags, that we are the largest paper makers in the world, turning out about 200,000 tons of paper annually. It has been computed that of the 1,300 millions of human beings inhabiting the globe, 360 millions have no paper or writing materials of any kind. 500 millions of the Mongolian race use a paper made from the stalks and leaves of plants; 10 millions use for graphic purposes tablets of wood; 130 millions (Persians, Hindoos, Armenians, and Syrians) have paper made from cotton, whilst the remaining 300 millions use the ordinary staple. The annual consumption of this latter number is estimated at one million tons, or an average of 6 lbs. per person. To produce this paper 10 million tons of woollen rags, besides large quantities of linen rags, straw, wood, and other materials are yearly consumed. The paper is manufactured in 3,960 paper mills, employing 90,000 male and 180,000 female labourers; and be it remembered this great and invaluable industry feeds chiefly on waste, and on what would be otherwise unemployed products.

It was imagined that in the opening of the China trade large supplies of cotton refuse would be obtainable from the teeming population of that country: but it was soon found out that all old rags, in this most provident empire, were used up in making the thick soles of boots.

In this utilizing age it cannot reasonably be expected that a waste product such as rags, which have been proved to possess a length of staple, when broken up, sufficient for the spinning of common-stuff, will be much longer permitted to find its way exclusively to the paper mill. Like flock and shoddy, linen and cotton rags will be taken more and more from the paper makers, and raw vegetable fibre will have to be sought for and cultivated. Moreover too the demand for paper is ever rapidly increasing, partly from the larger consumption of writing paper, more so from the extraordinary development of the cheap literature of the country, and the enormous augmentation in the issue and sale of newspapers; paper is used too now for an almost infinite variety of objects; paper collars are in constant use; paper shirts, and even paper waistcoats, bonnets, and hats; and not very long since a patent was taken out for the making of paper coffins.

Apropas of coffins a curious instance of an avoidance of waste came to my notice not long since. The Americans have, of late years, sent over great quantities of apples for sale in this country. It was found that the casks in which they were packed could not be sold and were wasted. At last an enterprising American has hit upon the device of having all his apple packing cases made up as coffins; these convey the fruit to this country, and, having served this purpose, are very readily sold.

Chemistry has taught us that the cellulose of all plants is the same as that contained in rags, and that in fact the fibre of some plants will give us a paper that cannot be made from rags.

An endless number of products have already been pressed into the service; and paper has been made out of the most diverse and varied materials; wood-shavings, nettles, hop-vines, bindweed, Indian corn, hemp, fish, beet-root, pulp, sea-weed, waste leather, and hosts of other things have been used with more or less success; but as yet only three or four new substances have been brought largely into requisition, straw, esparto grass, wood pulp, and the bamboo.

Of esparto grass alone something like 150,000 tons are annually imported as against 50 tons imported in the year 1856, and the useful employment of this hitherto waste product of nature has added enormously to the wealth and activity of many districts of Spain and Italy, and the North Coast of Africa.

There is a large French firm who have devoted their attention to the collecting of grease for all possible sources. They collect pickings and waste from the slaughter houses; greasy skimmings off the Seine; they remove the waste and pickings of vegetables from the Hospitals, and they buy up the old grease which has served for lubricating the axles of carriage wheels. The vegetable pickings are boiled and used for pig feeding, 3000 fat pigs being annually sold. They make oils, soap, and stearine, and the residues, liquid and solid are converted into manures.

RATS are considered by some to be a very objectionable product of the animal world, but they are turned to many useful purposes. The thumbs of most kid gloves are made of rat skin, it being more elastic yet tougher than kid. The fur of the rat is much used hy hatters; and there was an individual at Liskeard, in Cornwall, not long since who clad himself from head to foot in rat skins, using for the purpose the skins of 670 rats. In China rat-tail soup is considered equal to mock turtle, and indeed we eat the flesh of the pig, one of the dirtiest-feeding creatures of the whole creation, and why should not the flesh of a good fat corn-fed rat be palatable and good meat. I believe they sold for fabulous prices during the siege of Paris, and were much esteemed by connoisseurs.

Among various waste substances which have long been unutilized and of no value is scrap-leather. The quantity of hides and leather annually used in the United Kingdom amounts to over 70,000 tons. Some small proportion of leather parings and clippings are used in cementing iron cutting tools; some few more are worked up in the manufacture of Ferrocyanide of Potassium; in some places they are even allowed to accumulate, and are then burnt simply to economize fuel in warming the pipes. Many patents have been taken out for attacking these scraps and old leather with chemicals and special machinery, and reducing it to a pulpy mass, and then reconverting it into a species of artificial leather.

One or two of these processes, where a certain proportion of dissolved gutta-percha is added to the mass, have proved very successful. Other machines have been used for the conversion of odds and ends of leather into heels, by cementing them together, building them up layer by layer and then subjecting them to great pressure to secure cohesion; the resulting product is called, I believe, in the trade, "pasted-stock." Many and wonderful are the transformations by which old shoes and boots are converted into new ones, bright and resplendent, under the skilful manipulation of an individual called the "Translator."

Jelly has been made out of old boots, the maker averring that it was the purest gelatine. If the price of old boots should be so much advanced by this last discovery as to go towards paying for a new pair, what a start it will give to the boot and shoe trade.

A curious application is the utilization of the acicular leaflets of pine trees. Near Breslau, in Silesia, are two establishments, one a factory, where the pine leaves are converted into what is called "forest wool" or "wadding"; the other an establishment for invalids, where the waters used in the manufacture of this pine wool are employed as curative agents. Several cases of these products have been exhibited, containing specimens of the manufacture in the shape of wool for stuffing mattresses and other articles of furniture instead of horse-hair; wadded blankets and vegetable wadding: hygienic flannel for medical purposes; essential oil for rheumatism and skin diseases; cloth made from the fibre; articles of dress such as vests, hose, shirts, coverlets, &c. The liquid remaining from the decoction of the leaves is used for medical baths. The membranous substances and refuse are compressed into blocks and used for fuel, and from the resinous matter they contain sufficient gas is produced for illuminating the factory. It is asserted that articles made of this vegetable wool are not attacked by moths; it maintains an even degree of heat, is a sure preventive against humidity, and is especially recommended for rheumatic patients; and here moreover we have an instance of a factory which absolutely and entirely consumes and utilizes the whole of its waste.

There is in Paris a large manufactory where the cobs of maize or Indian corn are steeped in tar and resin and sold in bundles as fire lighters. They are sold at three or four a halfpenny, and the sales amount to £8,000 yearly.

Every waste of the precious metals is most carefully collected. A jeweller's leather, old and well worn, is worth a guinea, and what are called "sweeps" or the dust collected in the leathern receptacle suspended under every working jeweller's bench, form a regular article of trade. A worker in the precious metals can always obtain a new waistcoat for an old one, in consequence of the valuable dust adhering to it.

In the very centre of the large tobacco warehouses in the London Docks there is a large kiln, familiarly known as the "Queen's Pipe," which consumes as waste an enormous quantity of articles. The fire of the furnace never goes out, day or night, from year to year. Whatever is forfeited and is too bad for sale is doomed to the kiln, except the greater quantity of the tea, which having once set the chimney on fire, is now rarely burnt. Strange are the things that sometimes comes to this perpetually burning furnace. At one time there were 900 Australian hams, at another 13,000 pairs of condemned French gloves. The ashes of the kiln are collected and sold; in these gold and silver are often found; sometimes there have been numbers of foreign watches, which, professing to be genuine gold watches, but discovered to be impostors have been ground up in a mill and then thrown in here.

The waste paper, twine, old quills, &c., of the Government offices in London, sold under contract, realize £10,000 a year.

These are instances of the utilization of waste, which are not quite so commendable as some of those I have mentioned. The orange-peel is collected in some of the minor theatres and places of public resort where a good deal of this fruit is consumed: and sold, it is said, to the marmalade manufacturers.

The "Cincinnati Gazette" announced one day that pure essence of coffee is now made in that city out of the "cheapest, dirtiest molasses." The molasses are boiled, cooled, and when hard, broken and pulverised; ground rye is then mixed in, and a small box of the mixture labelled "Pure Essence of Coffee" is sold for 80 cents.

The dregs of coffee have been bought up in some of the Cafés in Paris, mixed up into paste with flour and water, shaped into berries, and then roasted and sold.

My subject would not be complete without a short reference to that extraordinary class of waste collectors, the Chiffonniers of Paris, where they form a peculiar type almost unknown elsewhere. They are a species of night birds of the human race; they sleep by day-light and spring out of the earth when twilight sets. Armed with hook, lantern, and basket they wander silently, solitarily from heap to heap, collecting cabbage leaf, rag, broken glass, anything, everything. They are as a colony most interesting to study. There are Categories of Chiffonniers. One class, the "sedentaires," have their own private clientèle of customers, their rubbish is reserved rubbish, and out of it they make about five francs a night. Many of the others are lodged, boarded, and employed by master Chiffonniers, who buy from them their produce, sort out the rubbish into divers departments, and send it off to different industrials. An idea may be formed of the importance of his trade from the fact that it is known that every Chiffonnier collects nightly at least four lbs. of rags. In 1872 the census showed that there were in Paris 22,500 individuals who live by collecting the refuse of the rest of the population. The whole contents of their baskets probably average £3000 a night. The master-chiffonniers are limited in number, there are not over 120 of them, they employ 300 workmen (independently of Chiffonniers) and their annual earnings are estimated at £450,000.

A curious class are they, these Chiffonniers, imbued with strong bellicose instincts. They wash their dirty linen among themselves, but they wash it with a vengeance; and they are the most egregious drunkards of creation. Cleanliness is not one of their attributes. "Sale comme un Chiffonnier," is one of the truest sayings of the French Dictionary of Proverbs.

They drink and sleep and fight alternately, when not busy, and hardly speak anything except a species of slang understood only by themselves. One good thing must be said of them, they are honest; many a necklace, many a jewel found among their rubbish has been handed to the authorities; and their roughness does not exclude a certain uncouth tenderness of heart. Many are the instances of lost children adopted by the commonwealth and instructed in the art of sorting broken glass and crusts of bread. Wonderful are the mysteries whereby the old clothes and hats collected by them are changed and transformed. A hat as long as it will hold together anyhow, be it never so shapeless, retains a certain value in the Chiffonnier's eyes. Marvellous is the transformation effected in it by a cunning manipulator; marvellous how his glue and brown paper, peach black, and dyed rabbit fur can stiffen and smarten the most battened old chimney-pot into a semblance of its glossy prime.

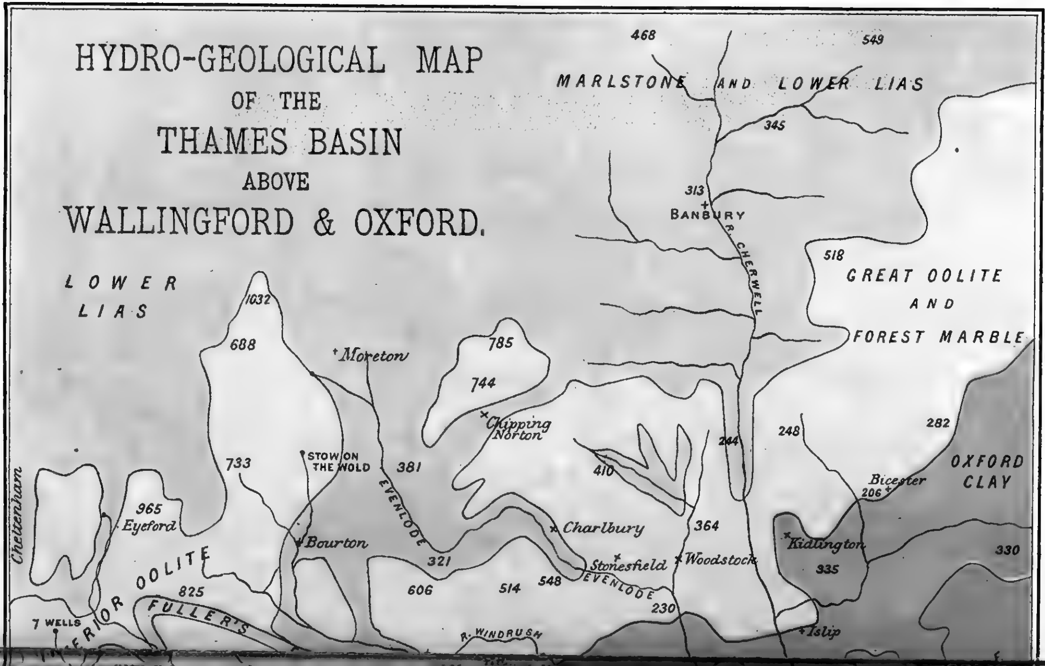
A thing of beauty it is, but not for long destined to be a joy to its sanguine purchaser. It bears fine weather well, but at the first downpour of rain, glue, paint, silk, and brown paper resolve into their original constituents, and the whole fabric collapses like a dissolving view.

In imitation of the Paris Chiffonniers, the Committee of the London Ragged Schools a few years ago set on foot a rag collecting brigade, with a few trucks to collect waste materials. In nine months with four trucks the boys had collected 82 tons of rags and refuse, besides 50,000 bottles. A most heterogeneous collection it was, cocked hats, hearse trappings, old aquariums, in one truck a million postage stamps, in another a Bank of England Cheque Book, in another a dozen pair of silk stockings, and so on.

It has only been possible for me to touch upon some of the more important examples of the use of refuse. There are many I have omitted to mention which might have been included with advantage, but I think I have given enough to show that civilization is every day adding enormously to the useful products of the world, both by economizing her resources and by calling new ones forth by the aid of chemistry. There is one matter which concerns us, as a manufacturing nation most nearly. Shall we ever discover and be able to utilize new combinations of the forces of Nature?

The world knows something of the triumphs already obtained in conquering electricity, that most subtle and mysterious force, but no one can foretell the future yet before the electrical engineer. Again, shall we ever be able to employ the more directly excited forces of Nature, among which may be named the rise and fall of the tides, and the tremendous manufactories and warehouses of heat that are situated in volcanic mountains. There are here boundless capacities of power, now dormant, but possibly some day to be controlled and utilized by man.

My subject is very far from being exhausted, though I fear I have sorely tried your patience and endurance; and I am satisfied you will already have thought that I have wished to give you a practical illustration of what rubbish really is. You may, perhaps, have never thought it possible that so much rubbish could pass through a man's mouth in the course of one hour. If this be so, I trust it may be like the two gallons of tar required to produce ten grains of aniline, and that you will be able from my mass of rubbish to extract at least a few grains of a more valuable commodity.


HYDRO-GEOLOGICAL MAP
OF THE
THAMES BASIN
ABOVE
WALLINGFORD & OXFORD.
LOWER LIAS
MARLSTONE AND LOWER LIAS
GREAT OOLITE AND FOREST MARBLE
OXFORD CLAY
FULLER'S
OOLITE
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549
345
313
BANBURY
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Moreton
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Stonesfield
Woodstock
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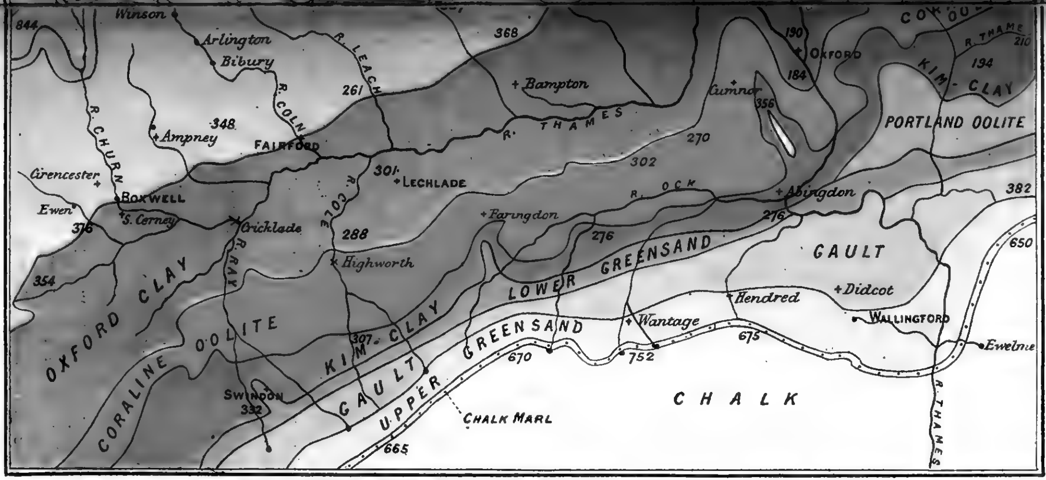
7 WELLS
R. WINDRUSH
Islip
Cheltenham



AFTER AND BY PERMISSION OF PROFESSOR PRESTWICH, F.R.S.

PERMEABLE STRATA { INFERIOR & GREAT OOLITE, CORALINE " ", LOWER GREENSAND, UPPER ", CHALK }

ARGILLACEOUS OR IMPERMEABLE STRATA { LOWER LIAS, UPPER ", FULLER'S EARTH, OXFORD CLAY, KIMMERIDGE CLAY, GAULT }

EXPLANATION OF THE HYDRO-GEOLOGICAL MAP

The accompanying map of the Upper Basin of the Thames, above Wallingford, or the area occupied by the Jurassic Strata between the northern edge of the map, and the strike of the Lias on the N. and N.W., and the parallel outcrop of the Chalk between Wallingford on the E., and S. of Swindon on the W., embraces nearly the entire area occupied by the Lias, Inferior and Great Oolite, Forest Marble, Cornbrash, Oxford Clay, Corallian Beds, Kimmeridge Clay, and Portland Oolite—or Jurassic group of Rocks.

These are again succeeded by the Cretaceous series, ranging through the Lower Greensand, Gault, Upper Greensand, and Chalk.

A sectional line drawn from the N.W. to the S.E. across the Cotteswold Hills from Cheltenham, through Syreford, Northleach, Burford, Witney, Wytham Hill and Oxford to Great Milton, passes nearly at right angles the outcrop of the several sub-divisions of the Jurassic series.

From Great Milton the Cretaceous group are also crossed by the same continuous line. Thus no less than 12 well-defined and characteristic divisions of the Oolitic series are exposed, and 5 divisions of the overlying unconformable and succeeding Cretaceous series above named, at Wallingford the extended range of Chalk indicates the position or commencement of the middle grouping of the Thames Basin.

These Jurassic and Cretaceous Rocks have been severally noticed in my paper. The rivers which have traversed them, both those that *cross* the strike of the several permeable and impermeable groups of strata and those that run with or parallel to or with them.

The position or sites of the more prolific springs are shown by dots at their issue; these springs and the courses taken by the streams are an important feature in the Hydro-Geology of the Cotteswolds, especially those that have their issue and course through the Oolitic Rocks N. of the Thames.

The Cretaceous Springs, although numerous, are less prolific and more uncertain in their supply, and chiefly enter the Thames from the S.

Probably 200,000,000 gallons per day passes over the Bensington Weir above Wallingford, where the whole of the water supplied by the springs from the S.E. slopes of the Cotteswold Range, and those passing from the higher Jurassic and Cretaceous Rocks defined by the Chalk outcrop or water-parting can be gauged.

VOL. XI PART III

PROCEEDINGS

OF THE

Cotteswold Naturalists' FIELD CLUB

For 1894—1895

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Contents

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ANNUAL ADDRESS

TO THE

COTTESWOLD NATURALISTS' FIELD CLUB

READ AT GLOUCESTER ON THE 7th OF MAY, 1895

BY

M. W. COLCHESTER-WEMYSS, PRESIDENT

The Annual Meeting of the Club was held at the Bell Hotel, on the 4th of May, 1894.

The Treasurer presented his financial statement, and was congratulated upon the very satisfactory balance of £92 10s. 11d. (exclusive of arrears of subscriptions) which appeared to the credit of the account of the Club.

Professor Harker was elected Secretary in the place of Mr Wethered, whose resignation in consequence of the pressing claims of municipal and political work was only very reluctantly accepted. A hearty vote of thanks was accorded to Mr Wethered for his conscientious and energetic services as Secretary during the last twelve years, and his name was added to the list of Vice-Presidents.

The other officers of the Club were unanimously re-elected.

It was arranged that the Summer Meetings for the year should be held at

Malvern,
Cirencester,
Clee Hill,
Evesham and Broadway.

It is with the deepest regret that I have to refer in this Address to the very great loss that the Club has sustained during the year in the death of the late Professor Harker, the Hon. Secretary. In 1881 he had been appointed to the chair of Natural History at the Royal Agricultural College, Cirencester, and till within a fortnight of his decease he continued his Lectures at the College. He had been for a long time suffering from an insidious disease; and this in the beginning of the winter developed the very gravest symptoms, which rendered an operation imperatively necessary. This was skilfully carried out, but the disease had obtained too firm a hold, and he passed away on the 19th December, retaining all his fine faculties to the end. His knowledge, scientific and practical, of all the subjects of his department, botany, geology and zoology, was of a very high order, and his teaching in lecture room, laboratory, on field excursions, or to outside audiences, was always as attractive and genial as it was sound. There will be present in the minds of Members of the Club the recollection of many a pleasant gathering at which his ripe and varied knowledge largely contributed to the interest of the proceedings; and it will be very long before his memory fades into oblivion.

The numbers of the Club have been well maintained during the past year. Six members have resigned,—Col. G. Fisher, E. Harford, Esq., Capt. Ross, Rev. G. F. E. Shaw, H. Waddy, Esq., and C. A. Witchell, Esq. Five new members have been elected,—Dr Ashton, Rev. W. Butt, W. L. Mellersh, Esq., Dr E. W. Prevost, and W. C. Wells, Esq.—and two candidates for election are announced.

The first Field Meeting was held at Malvern, on Thursday, 24th May. The first place visited was the Priory Church, a Norman Minster buried in perpendicular work. The pillars in the nave are early Norman, the remainder of the Church is mainly of 15th century date. The great glory of the edifice is its fine stained-glass windows. Formerly every window was filled with stained glass, but in the last century a good deal was destroyed, and it is even asserted that one Vicar had a dove-cot in the North Transept and broke some of the glass to enable the birds to get in and out. The party were most fortunate in securing the kind services, as guide, of Mr Nott, of Malvern, who has been for a long time an enthusiastic student of the windows. An hour-and-a-half passed only too rapidly as the party accompanied Mr Nott from window to window and with keen appreciation watched the apparently meaningless masses of colour resolve themselves into sacred and secular pictures under his clear and animated description.

After a substantial luncheon at the Foley Arms the party drove with Mr Dyke-Acland as guide along the western flank of the Malverns as far as Winds Point, dismounting here and there to study the geological problems everywhere presented.

As Mr Acland pointed out, the Malverns present two great problems to geologists. On the eastern side of the range you look over the great Triassic and Liassic plain which extends to the Cotteswold escarpment. On the western side are Silurian, Old Red Sandstone, and Carboniferous Rocks. Between these Palæozoic and Secondary formations rises the lofty chain of the Malverns, attaining at one point a height of more than 1,400 feet. How the chain came there, and when, is one geological problem.

Another problem concerns the constituent rocks of the range.* Professor Phillips held that they are mainly of igneous origin. In the second volume of the "Memoirs

* These problems were first attacked by Professor Strickland, Dr Hall, and the Rev. W. S. Symonds; all of whom, it may be noted, were distinguishedmembers of the Cotteswold Club.

of the Geological Survey of Great Britain," he discusses the origin and effect of the upheaval of the Malverns, and says:—"This upheaval appears to have been violent; "hence the abrupt truncation of the eastern face against "the New Red Sandstone plain, the striation and furrowing "of that face, the brecciated structures along it, and the "numerous lesser faults and cracks which traverse and "split the rocks in points adjacent to the surface of "greatest displacement. The vertical amount of this "displacement on the eastern boundary of the Malvern "chain cannot be less than some thousands of feet; and "to the various slidings of the broken masses of rock on "one another we may perhaps ascribe in part the short "pseudo-stratifications of the syenite, the glazing of many "surfaces with abraded hornblende, and possibly some of "the rude laminations which appear in the hills." And summing up the matter he adds:—"Upon the whole "there is no evidence in the nature and structure of the "Malvern rocks to justify the notion which the linear "character of the hill suggests, that they are to be "regarded as compounds crystallized by cooling from a "mass erupted in fusion along a particular fissure. On "the contrary, it is concluded that they are a mass of "varied and mingled rocks, in most of which an igneous "metamorphosis can be detected, and that they were solidi-"fied at some considerable depth in the sea, and thence "raised up along a great line of fracture passing through "them on the eastern side. With them were raised vast "piles of strata (palæozoic) which had been deposited "above and around them, and at a later time other strata "(mesozoic) were laid against their broken edges."

This "Memoir" was published in 1848. Subsequently a school of geologists arose who disagreed with Professor Phillips. Much that he attributed to igneous origin, they claimed to be the result of metamorphism, *i.e.*, the fusion of sedimentary rocks through which the admittedly igneous portion of the range had to force its upward way. Among these metamorphic rocks they classed the gneiss and schists of the chain. Later investigations, however, in which a microscopic examination of the rocks has had a prominent part, go to show that Professor Phillips was right, and the term "shearing" is used to describe the peculiar action of broken masses of rock on one another, which according to this theory has caused the short irregular veins that almost everywhere meet the eye.

In this explanation of some of the complicated phenomena of the Malvern chain, Mr Acland entirely concurs; and again and again in the course of the drive, he led the Cotteswold Club into quarry and cutting, in successful search of evidence to support the theory. In one quarry he caused a mild sensation. Solemnly asking the party to take off their hats, he silently pointed to a small mound. All anxiously awaited what was to follow. "This is the "spot," said Mr Acland in measured tones, "this is the "spot where Miss Phillips found the celebrated conglom- "erate." The geologists of the party at once appreciated the sanctity of the locality.

A long and systematic investigation had led Professor Phillips to think it probable that the Malvern ridge had not been erupted in a liquid state through all the Silurian strata, but that some parts of it, at least, were solidified at an earlier period. His sister, who shared his geological enthusiasm, sought diligently for evidence in proof, and one day her search was rewarded with success. From the middle of heaps of fallen stones, apparently all igneous trap-rock, Miss Phillips collected several masses of conglomerate, or breccia, full of Silurian shells associated with pebbles, and fragments of the Malvern syenite and other eruptive rocks.

The next thing to determine was the position of this conglomerate in relation to the crystalline mass of the hill. This was a work of much difficulty, owing to the great abundance of detritus on the slopes, but eventually the conglomerate was found adhering to the nearly vertical face of the trap mass. The inference, to quote Professor Phillips' words, "appears to be that the syenitic "and other associated rocks of the northern portion of the "Malvern Hills were accumulated and indurated previous "to the aggregation of the lower portions of the Caradoc "sandstone series, and that they were, with the whole "Silurian series, raised in a solid state." "Miss Phillips' "conglomerate," as it is often called, is therefore of great importance in the geological study of the Malverns.

Arrived at Wind's Point, the geologists would have liked to still further pursue their studies with Mr Acland's invaluable help, but some of the party had to leave to catch an early train for home, and the remainder climbed the grassy slopes of the ancient encampment, and listened to a brief description of it by Mr Nott. Of written record of this lofty and impregnable camp there is none. Tradition says it was a stronghold of the Silures in their long and sanguinary resistance to the Roman invaders, and tradition is probably correct.

The programme of the day's proceedings was certainly right in describing the camp as "one of the most perfect "existing examples of the hill-forts constructed by the "aboriginal inhabitants of Britain." Mr Nott pointed out the elaboration and strength of the works, crowned by a citadel on the actual summit of the beacon. The deep fosse, cut for the most part out of the solid rock, the double rampart, still continuous, except for a short distance on the north-west side (where a breach occurs, probably marking the spot where the last storming of the fortress took place), the remains of hut-dwellings, the chariot-gate, with its well-engineered road sloping down towards a ridgeway, in the direction of Eastnor, were all noted; and the party walked down to the southern end of the ramparts, from which the outline of the similar camp on Midsummer Hill is clearly traceable. The camp was left by the East gate, where the incurved and overlapping arms of the rampart on either side (intended to compel assailants to expose their flanks to attack) are still perfectly preserved; and a rapid descent was made down the steep slope to the water-works and filter-beds in the Snowdrop Valley, now approaching completion. In the excavations made for the foundations for the dam across the valley, a large mass of compact crystalline non-fossiliferous "archæan" limestone was exposed, traversed by several basaltic and felspathic dykes.

A short walk along a pretty country lane brought the party to Little Malvern, where Mr Berrington had kindly given permission to visit his gardens, containing some fine cedars, a magnificent Portugal laurel spreading over a space more than 300 feet in circumference, and an equally remarkable lime tree. After inspecting the ruins of the Priory on the south side of the Church the party entered the Church itself, of which only the tower and chancel are preserved, and used as a parish Church. Here Mr Nott called attention to the two hagioscopes, (connected, no doubt, with north and south side chapels, now wholly destroyed), to the well-carved rood screen, and to the remains of old stained-glass of the 15th century, including figures of King Edward IV and his Queen.

The second Field Meeting was held at Cirencester, on Thursday, the 28th of June. The day proved as enjoyable as it was attractive, and the twenty-five miles drive from Cirencester towards Somerford Keynes, thence through Siddington and Preston to Ampney, and thence to Fairford and back, was over a typical tract of Cotteswold upland.

Cirencester has frequently been visited by the Club, but Roman remains are constantly being turned up, and in a collection formed by Mr Wilfred Cripps, C.B., during the last few years, and also in one at Siddington House, where the party were most hospitably entertained at luncheon by Mr Christopher Bowly, fresh evidence was afforded of the mine of antiquarian wealth there is in the ancient Corinium. Mr Bowly has some large stone slabs, with deep wheel-ruts in them, which formed part of the pavement of the Roman streets; a number of pieces of face-coloured mortar from Roman houses, and the moulded bases and capitals of Roman columns; and in the grounds of his house is a tombstone to a Roman lady, and a votive altar of Roman date.

Mr Cripps' collection of relics of the domestic life of the Romans is exceedingly fine. Among the articles of Samian ware are upper and lower bowls used for heating spiced wine, evidently the property of a former wealthy resident. The lustred Castor ware, ornamented with tracery, also indicates great taste. Among glass vessels are a number of small bottles, often called lacrymatories. Mr Bellows smiled at the idea, asserting that the Romans were much more accustomed to make other people cry, than to cry themselves. Instead of the bottles being used to treasure tears, they were perfume bottles, the narrow necks of which enabled the perfume to be easily measured in drops.

Of hair-pins and bodkins in bone Mr Cripps has a large collection, and his series of coins represents nearly the whole of the period of the Roman occupation. Special attention was called to the design of the bottles in which the Roman soldiers carried sour wine. The handle is fluted so that the grip may be firm; the neck is funnel-shaped, which facilitates filling; and the orifice is small, thus minimizing evaporation. An interesting ornamental object is a statuette of bone representing a water nymph kneeling on the left knee and pouring water from a pitcher resting on the right knee. Another object indicated that the Romans had antiquarian tastes. This was a scarab, of Eastern origin, dating from 400—500 B.C., and Dr Budge, of the British Museum, reports that it is one of only some seven or eight objects of Phænician date that have been found in England. Some singular torus mouldings attracted attention, and it was pointed out that they were like patterns of mouldings found at Gloucester, Bath, and Silchester, indicating contemporaneity in certain buildings in all these towns.

The Forest Marble which is well developed, and now well exposed in the neighbourhood of Cirencester, was said in the circular calling the meeting to have "hardly "received the attention which it deserves at the hands of "the geologists of the Club." There is no excuse for further neglect. Very recently a memoir has been issued by the Geological Survey on the Lower Oolites, and in it Mr Horace Woodward treats in great detail of the Forest Marble, and gives numerous sections of the beds on the Cotteswolds. Under Professor Harker's guidance quarries were visited at Furzen Leaze, Siddington, and Poulton, in which the beds were seen in ascending order. Although the Forest Marble is classed among the Oolites the lower bed is not Oolitic at all. It is a hard, firm, blue stone which takes a very high polish, and is mainly made up of foraminifera, and broken particles of wood with occasional fishes' teeth, and iron pyrites. Professor Harker pointed out that geologists generally believe that the occasional blue colour of the Great Oolite and the blue of the Forest Marble beds is due to the presence of one of the lower oxides of iron, and that when exposed to the air the blue colour disappears. But in the Furzen Leaze quarry is a great heap of stone from the lower Forest Marble beds, which was quarried six or seven years ago, and which still retains its original deep blue colour. Professor Harker's explanation is that the iron in the stone is not protoxide or carbonate, but a sulphide, and hence not so susceptible to atmospheric influences as the lower oxides are. In a quarry at Siddington, said to be the largest Forest Marble quarry in England, the central beds are exposed and among them is a bed locally known as tile-stone, closely resembling the Stonesfield slate, and like it largely used for roofing purposes. The Poulton beds are higher still, and teem with fossils, indeed from one of these quarries Mr Phillips obtained much of the splendid collection of Saurians now in the Oxford Museum. The topmost beds are exposed in a quarry at Ampney, and overlying them is the Cornbrash, the thin bed of rubbly freestone pointed out many years ago by the late Professor Buckman as specially rich for corn growing. A discussion ensued as to the conditions under which the Forest Marble was deposited, Professor Harker showing that there is ample palæontological evidence, in the comminuted state of the fossil remains that the beds are a series of shore deposits. Mr Wethered said that around some fossil fragments microscopic tubuli have formed, and Mr Buckman pointed out that 75 per cent. of the fossil remains in the Forest Marble are also found in the underlying Great Oolite, indicating an unbroken sequence in the deposition of both formations.

Of the stained glass in Fairford Church I need say little, its glories and its teachings have been so ably chronicled in capital hand-books, and in papers in Archæological magazines, wherein is also recorded all that there is to be said for and against the theory that the windows are the work of Albert Dürer. The Vicar (the Rev. F. R. Carbonell) not only proved a competent and enthusiastic guide, but is also a painstaking and energetic custodian of his treasures; and had some of his predecessors been equally careful, the windows would have had far less of new glass than they now contain.

On the 26th July the Club paid a visit to the celebrated Clee Hill quarries, near Ludlow. The Mayor of Ludlow (Mr T. Roberts) met the members at the station, and they drove in breaks to the hill, where they were welcomed by gentlemen connected with the three Companies who work the quarries.

Professor Harker briefly explained the geological history and structure of the Clee Hills. Originally the whole of the district up to the level of the top of the hills was occupied by the carboniferous formation, consisting of strata of sand-stone, shale, coal, and limestone, resting on the beds of Old Red Sandstone, on which the town of Ludlow is built.

Then came a period of violent volcanic disturbance. The pent up energies below the earth's solid crust burst open a crack in the superincumbent strata, and a mass of liquid lava forced its way upwards through the opening nearly to the surface, lifting up the top layers and spreading out just below them into a vast sheet, which soon solidified and formed a compact mass of basalt covering a considerable area of the carboniferous strata. If a complete vertical section of the earth's crust could be made at this point, the mass of intrusive basalt would be seen as an irregular column rising from unknown depths through the lower rocks and spreading over the carboniferous strata like a gigantic mushroom. Then followed a period of destructive rather than constructive work. Air and water took the place of fire; rains descended and winds blew, and the whole of the district was by degrees carved into the beautiful diversified contours which are now seen. The softer strata yielded first to the attacking agencies, and were worn down into valleys. The harder rocks offered a more or less stubborn resistance, and have remained as rising ground and hills of varied height and outline. Thus, where the ancient town of Ludlow stands, the whole of the carboniferous strata, nearly 2,000 feet thick, have been worn away, and the buildings rest on the strata of the Old Red Sandstone below it.

One portion of the formation, however, has almost entirely resisted attack, not from its intrinsic hardness, but owing to the protection afforded by the roof of erupted basalt just mentioned, much in the same way as a hay-rick is protected by its cover, and the Clee Hills stand out proudly above the denuded country round, as an example of the success of nature in preserving her own handiwork from her own assaults. They are, in fact, gigantic examples of the curious structures known as "Earth Pillars," found in Switzerland, the Tyrol, and above all in Colorado and the Rocky Mountains, where columns of sandstone are seen a foot and upwards in diameter, some of them more than 200 feet in height, each capped with the large over-hanging slab of hard refractory material which has sufficed for hundreds of centuries to preserve it.

The Clee Hill stone is bluish, almost black in colour, hard and close-grained in structure, and composed of a mixture of small crystals of hornblende and felspar. Hornblende predominates and confers on the stone its valuable properties of hardness and durability. This excessive hardness would render the quarrying of it a work of very great difficulty, were it not for the fact that owing to the conditions of temperature and pressure under which solidification took place, the whole mass is "jointed" and traversed by a network of more or less minute cracks, like a piece of glass which has been suddenly cooled, and probably in part for the same reason. These cracks are often quite imperceptible at the surface, but by lighting a fire against the rock the water which it contains is converted into steam, which finds its way out through the "joints," and forms an easily visible edging of moisture along the line of the crack. The men then drive in wedges, and "prize" off large blocks which are afterwards cleft with sledge-hammers. Much work is also done by blasting, but as no steel drill can make much impression on the rock, boring regular holes for charges is almost impossible. By patient working however into and along a joint, an opening is made large enough to hold a cartridge of tonite or gunpowder sufficient to dislodge many tons at once. It is interesting to learn that the miner's old friend gunpowder is preferred to its smart modern rival tonite, since the latter almost pulverizes the rock from the suddenness and violence of its explosion.

The quarry proprietors most courteously entertained the Club at luncheon, after which an interesting paper was read by Mr Clarke, C.E., Chairman of the Clee Hill Dhu Stone Company. This paper is printed, by kind permission of the author, in the present number of the Proceedings, and is well worthy of the perusal of members, giving as it does a most interesting account of the growth of a special industry, much valuable information on the subject of material for road making, and a full description of the Clee Hill quarries and works.

The whole afternoon was spent in the quarries and on the hill-side, some of the members managing also to pay a hasty visit, on the way to the station, to the fine old Castle at Ludlow.

The fourth Field Meeting was held at Evesham and Broadway, on Wednesday, August 29th. The isolated tower, which is all that remains of its once famous Abbey, was the chief attraction in Evesham, but on the way a brief visit was paid to All Saints' Church, where Abbot Lichfield, the last Abbot of the Abbey, was buried, and to the Church of St. Lawrence, formerly a Monastic Church, which for a long period was in ruins, but has been restored during the present century.

The foundation of Evesham Abbey dates back to Saxon times. We are told that in the reign of Ethelred, Ecgwin "a humble Bishop of Wicci," whose diocese comprised the modern Sees of Worcester and Gloucester, was frequently favoured by visions, and greatly desiring to build a place to the praise of our Lord, besought the King to bestow upon him a place called Hethomme. The bishop's reason for requesting a gift of this particular place was that there the Virgin Mary had appeared to a herdsman named Eoves, and subsequently to Ecgwin himself. The King granted the request, and the Bishop at once built a Monastery there; and in consequence of the sanctity of Eoves he called the place Eovesham, whence the present name and spelling Evesham.

The town of Evesham therefore, as was the case at Tewkesbury, Winchcombe, Pershore, and Malvern, grew up round the Abbey, whereas at Gloucester and Worcester Abbeys were placed because those towns had existed from Roman times or earlier. In its early days Evesham Abbey was the home of the secular monks; in the middle of the 10th century the Benedictine rule was imposed on it, (as also on the Abbeys of Pershore and Winchcombe) by Oswald, Bishop of Worcester; but on the death of Oswald the secular monks were reinstated. We read that in 1075 "the seven Monasteries of Worcester, "Evesham, Pershore, Chertsey, Bath, Winchcombe, and "Gloucester, agreed to be as one Minster, with one heart "and one soul." In the 13th century too, the Monks of Evesham joined with others in developing their work of supplying trained teachers for the Ministry of the Church by availing themselves of the advantages of University Teaching; and when a Monk of Gloucester, first of all the Benedictine Monks in England, attained to the degree of D.D. at Oxford, the Abbot of Evesham was among the Abbots who were present at his inception, and who showed their regard for him by divers gifts. Another proof of the important position occupied by the Abbey of Evesham is the fact that in the middle ages it was one of the twenty-seven mitred Abbeys of England, whose Abbots enjoyed the privilege of a seat in the House of Peers. In the "Chronicle of Evesham," is the autobiographical record of Thomas Marlborough, who spent the greater part of his life there, and died as Abbot in 1236. His narrative is mainly occupied with two subjects: the claim of the Abbey to be exempt from episcopal visitation; and the deposition of an Abbot for gross misconduct. Having a knowledge of the law, Marlborough was appointed to plead the claim to exemption before Pope Innocent III, and he was successful. But the victory brought trouble with it, for the freedom of the Abbey was interpreted by the Abbot as freedom for himself to indulge further in his career of misconduct. For eight years Marlborough struggled for the deposition of his superior, and at last the Papal Legate listened to his cry and visited the Abbey. A sad story did he hear from the half-starved monks. Their meals were never regularly served, and for many days they had only the coarsest bread and water. They could not attend Church or Chapter or celebrate divine service, for want of sufficient clothing. They were forced to wander about against rule, and beg the means of living. Hospitality was wholly neglected, and some members of the household had died of actual starvation.

The lands of the Abbey were alienated, the buildings were suffered to fall into ruins, the property was wasted, and debts incurred. Meanwhile the Abbot disregarded the rules of the Order in living, dress, and discipline, and openly boasted that he had taken care to provide ample means of securing himself against any accusation. There were also graver charges of immorality behind, which Marlborough only brought forward under pressure. Again Marlborough succeeded, and the Abbot was deposed. This autobiography of Marlborough is an unconscious revelation of one of the chief causes of the fall of the Monasteries. Year by year they became more and more alienated from the national religious organization and from national feeling, and became as Professor Stubbs says "colonies of Roman partisans."

The surviving tower was in course of building at the dissolution of the Monastery, and it and a cloister arch are the only remains of the Abbey left standing. Simon de Montfort was buried in the Abbey, probably near the high altar, but all traces of his tomb have disappeared.

The town became possessed of the tower, and it is now a campanile for the two Churches near. Under the kind guidance of Mr Slatter and Mr Tomes the party saw a number of ancient objects connected with the Abbey, not the least interesting being the processional cross which hangs in the office of the Clerk to the Burial Board.

From Evesham the party drove to Broadway, where Mr Averill conducted them to some of the many quaint and picturesque cottages for which the little town is justly celebrated. Especially may be mentioned Pershore Grange, a Priory of the Abbey of Pershore, a curious old structure, until lately the studio of Mr Millett. After lunching at the Lygon Arms, an old Tudor building, the members drove to the ancient Church of Broadway, a cruciform structure of late 12th century date, with a richly carved but disused Jacobean Pulpit.

A concise little history of the Church is written in a book kept by the attendant, an example worthy of wide imitation.

A thick haze, which hid the distant scenery, deterred many of the members from climbing the hill to Broadway Tower, built by Lady Coventry a century ago, so that from Croome she might see the Broadway estate. Close to the tower is a camp, a bank and a ditch with their two ends resting on the declivity of the hill. On the tower is a notice board, stating that if visitors must scribble somewhere there is a vacant place on the board on which to do so. An inspection of some quarries on the lower slope of the hill yielded but little result; but more productive was a visit to the Bengeworth brickworks, close to Evesham, where there is an extensive exposure of the Lower Lias.

The day terminated with an inspection, far too hurried, of Mr Slatter's fine collection of fossils (including the horns of a rein-deer from the drift near Evesham) and the hearty thanks of the Club are due to this gentleman for the pleasure thus afforded to them, for his courteous hospitality, and for the kind attention he devoted to the members during the entire day.

There were three Meetings held during the winter, at which Papers were read on the following subjects:—

By Mr Madan on "The Geysirs of the Yellowstone Park,"
By Dr Prevost on "A Visit to the Andaman Islands."
By Dr Smithe on "The Geology of Churchdown," and
By Dr Garrett, "Preliminary Notes on the History of Bacteriology."

These papers were ordered to be printed in the next Part of the "Proceedings of the Club."

It will be in the recollection of the Members that Mr H. D. Hoskold, Director of the National Department of Mines and Geology, Buenos Ayres, (a paper by whom "On the Geology of the Forest of Dean" appears in the Proceedings of the Club for 1891-2) very generously presented to the Club a valuable collection of South American Indian Antiquities, collected by himself and his brother. Mr Bellows kindly took charge temporarily of the collection, but it was felt that the Club ought to provide amply for the security and proper display of the objects. Accordingly a Committee was appointed in the course of last year to consider what steps should be taken; and in accordance with their recommendations an estimate has been obtained and an order given for a substantial case of pitch-pine, with glass front, of sufficient size to contain the whole of the collection. Leave, moreover has been given for the case to be placed (for the present, at any rate) in the Price Memorial Hall at Gloucester: and before our next Annual Meeting it is hoped that Mr Hoskold's kind gift will be properly arranged and labelled in its new quarters. The catalogue, a very careful and elaborate one, made by Mr Hoskold himself, is printed *in extenso* in the present Part of the Proceedings.

M. W. COLCHESTER-WEMYSS.

ON THE

LIASSIC ZONES

AND

STRUCTURE OF CHURCHDOWN HILL GLOUCESTER.

BY

FREDERICK SMITHE, F.G.S., &c.

In the language of every-day life this upland and its slopes are generally called Chosen, which is the old name. It is becoming of late years superseded by the words Churchdown Hill, although it is, strictly speaking, more than a hill, as it really consists of several hills, forming a group, and several mounds undetached, bearing separate names well known to the older inhabitants; for example, some are called Far Hill, others Green Hill, and again Rabbits Hill, and Tinker's Hill. These eminences in any case, whether large or small, whether connected or almost isolated, were formed by the gradual erosion of a mass of high ground, which in this case was the range of the Cotteswold Hills. All such denudation was due not only to the action of running water, but also to the effect of rain, and especially to tropical rains. The shape and outline of Churchdown Hill can be well observed from Battle Down, overlooking the town of Cheltenham; from that point, the observer can clearly discern the peninsular character of our hill, and further that it resembles all the other outliers of the Vale of Gloucester as to formation.

Moreover, the geologist can by careful correlation of the strata, and identification of the fossil contents of the beds, explain the origin, structure, and features of these outliers with absolute certainty.

Churchdown Hill then is simply an isolated portion of the Cotteswold range of hills, and an examination of its fossil contents has a special interest, which is aided by the adoption of the Zonal divisions,—a system adopted by all the geologists of the Continent of Europe. The fossil contents of these sub-divisions, from the tiny Brachiopod to the vertebra of the huge Saurian, are of great importance; the more so, when we bear in mind the words of Sir Archibald Geikie, that "fossils are witnesses of early ages in the history of our planet, and few occupations possess greater power of fascination than to marshal these witnesses, and elicit from them the evidence which allows us to restore one after another the successive conditions through which the solid land has passed." The denuding agents which could scoop out valleys were able to model and shape the mounds and hills of our vale, from Bredon Hill to the neighbouring Hill of Churchdown.

On the summit of our hill, which is 580 feet in height, are to be seen many signs of old workings, such as pits, trenches, and excavations, which require some caution to distinguish from the work of modern quarrymen. The former are the ditches and ramparts of an ancient camp, whether of British or Roman work it matters not to the geologist, as his "quarry" is of far more ancient date; but it is well for him to remember that quarrymen when commencing their workings carefully wheel the top soil and stone in about equal quantity, to be out of their way, on each side of their excavation. On the contrary, the sapper, in making the trench of his field-work, threw up the earth and stone on one side only, to form a rampart, equally strong all along his line of defence. From the north of our hill, any one, standing at the porch of Chosen

Church, and looking straight to the east side of Wainlode Hill on the verge of the River Severn, will have under his eye the outcrop of the whole of the Liassic system, from the Upper Lias, forming the capping of the hill on which he stands, to the lowest beds of the Planorbis Zone. From the Communis Zone Quarry on the hill to the Planorbis beds at Wainlode would be a distance of six miles.

The principal sub-divisions of the Liassic Rocks are here appended:

(i)	The Midford Sands (passage beds)	Between Minchinhampton and Bath
(ii)	,, Upper Lias - - -	On Churchdown Hill
(iii)	,, Lower Lias - - -	Near Churchdown Railway Station

The junction of the last is with the Rhætic beds, a good walk but a pleasant one, as it ends with the Severn at Wainlode, where one may stand on the sub-formation named the Triassic, or rather the Rhætic, which reposes upon the Triassic system.

This outline of the sub-divisions will be naturally followed by a statement of the principal Zones in the Liassic Rocks, named after their characteristic Ammonites.

1.	The Upper Lias, comprising in descending order - - -	The Jurensis Zone ,, Communis Zone ,, Serpentinus Zone ,, Annulatus Zone
2.	The Middle Lias, comprising in descending order - - -	The Spinatus Zone ,, Margaritatus Zone ,, Capricornus Zone
3.	The Lower Lias, comprising in descending order - - -	The Jamesoni Zone ,, Oxynotus Zone ,, Bucklandi Zone ,, Angulatus Zone ,, Planorbis Zone

UPPER LIAS

Sections of the Communis Zone at Churchdown Hill.

NORTH QUARRY — DIP 8° N. — (F. SMITHE)

	No.	LITHOLOGY	Thickness ft.	Thickness in.	
Zone of Am. Communis, &c., &c.	1	Alluvial Soil	1	0	With Drift Pebbles
	2	Dark Marly Shale	1	6	
	3	Argillaceous Limestone (geodes)	4 to 6	0 / 0	Fish Bed
	4	Marly Shale	7	0	Alga Bed
	5	Fine Arenaceous Marl	1	0	Leptæna Bed
Zone of Am. Spinatus	6	Nodular Bed of Middle Lias with Belemnites and Terebratulæ	—	—	

SOUTH QUARRY — DIP 8° N. — (F. SMITHE)

	No.		Thickness ft.	Thickness in.	
	1	Alluvial Soil	1	6	
Zone of Am. Communis	2	Brown Marly Clay	2	0	Fish, Crustacea, and almost all of the Fossils of the List
	3	Concretionary Argillaceous Limestone	0 / 0	4 to 6	Fish Bed, Leptolepis concentricus, &c.
	4	Mottled Blue and Drab Clay	6	0	Fossils as in No. 2
	5	Fine Marly Shale	1	0	Leptæna Bed, Brachiopods and Nuculæ
	6	Blue and Yellow Clay	1	0	Ammonites { communis, serpentinus }; R. pygmæa, T. globulina { Bel. acuarius, and other Belemnites frequent }
Zone of Am. Spinatus	7	Light-coloured Marlstone (A. spinatus) and Nodular Bed of Marlstone Series	—	—	

UPPER LIAS—(A Third Quarry)

Section of Churchdown (called Chosen) Hill. (F. SMITHE)

		ft.	in.	
UPPER LIAS	Soil with Drift Pebbles -	1	6	
BASEMENT BEDS	Brown Marly Clay - -	2	0	Leptolepis concentricus Eg.
	Concretionary argillaceous Limestone (Fish Bed) - - -	0	6	
	Mottled Blue and Drab Clays (with Crustacea)	6	0	
	Brown Marly Shale (Leptæna Band) - -	1	0	
	Blue and Yellow Clay -	1	0	
MIDDLE LIAS	Yellow Marly Sands, with	1	0	
	ferruginous concretions and nodules with Ostracoda - -	6	0	
	Marly Stone Rock (impure ferruginous limestone, blue hearted) - -	10	0	

GENERAL SCHEME OF THE UPPER LIAS. (F. SMITHE)

UPPER LIAS	COMMUNIS ZONE	FISH BED			
		LEPTÆNA BED			
		LEPTÆNA CLAYS			

FOSSILS OF THE COMMUNIS ZONE OF CHURCHDOWN HILL

PISCES

Leptolepis concentricus Eg.
Pachycormus curtus. Ag. (common)
Dapedius dorsalis. Ag.
Tetragonolepis ovalis Eg.
——————— discus. Eg.

MOLLUSCA, CEPHALOPODA

Am. communis. Sow.
,, bifrons Brug. = raquinianus d'Orb.
,, crassus. Y. & B.
,, annulatus. Sow.
,, lythensis. Y. & B.
Aptychus of A. lythensis
Aptychi of the group "Cornei"—Pictet.
Am. serpentinus. Rein.
,, fimbriatus. Sow.
Belemnites tubularis. Y. & B.
Belemnosepia osselet, and pigment bags.

GASTEROPODA

Alaria angulata. Moore.
Turbo capitaneus. Münster.
Nucula inflexa. Quenstedt.
,, Hausmanni. Roemer.
Euomphalus minutus. (see Note.) Zieten.
Dentalium gracile. Moore.

CONCHIFERA

Ostrea ocreata. Desl.
Arca inaequivalvis. Goldf.
Inoceramus dubius. Sow.
Mytilus gryphoides. Schloth.
Monotis substriata. Goldf.
Posidonomya Bronnii. Voltz. (= Posidonia Bronnii. Münst.)
Plicatula spinosa. Sow.
Cucullæa Munsteri. Liet.
Nucula inflexa. Quenst.
Leda ovum. Sow.

BRACHIOPODA

Terebratula Lycetti. Dav.
Terebratula globulina. Dav.
Rhynchonella tetrahedra. Sow.
Rhynchonella pygmæa. Morris.
Lingula Moorei. Dav.
Lingula Beanii. Phil.
Leptæna Moorei. Dav.
,, liasina. Buch.
,, granulosa. Dav.

MISCELLANEA

Pterodactylus bone (coracoid).
Teleosaurus (tooth).
Fucoides Bollensis. Quenst. (= Chondrites)
Algæ (several sp. undetermined).
Drift wood.
Spongia and
Foraminifera, &c., &c.

Communis Zone

Additional note on the gasteropod, Euomphalus minutus (Zieten.)

As this minute fossil has been often a subject of misapprehension, it will be well to draw attention to its lineage. The geodes of the "Insect Limestone" course (Communis Zone) Upper Lias are often profusely studded with this tiny fossil, in fact, the whole of the blanched, weather-worn surfaces of the limestone seem to be covered with dark beads, more or less perfect; which, under a simple field lens, one might fancy were Liliputian Ammonites. This gasteropod is the Euomphalus minutus of Zieten, referred to by Quensted as a species of Natica. (See Jura, page 262). They were noticed also by Professor Tate, who believed he had met with a new species, and described it in the "Geological Magazine," vol. viii, page 8, 1871, as follows:—"Natica pilula, nov. sp. Very small, globose, spire depressed, slightly convex, whorls 4 to 5, ornamented with fine longitudinal lines, aperture narrow. Upper Lias, Dumbleton." I would add to "Dumbleton," "Gretton," since specimens have been found there by a member of the Cotteswold Club, as well as in the same zone at Churchdown. The fact is, these small gasteropods were first named Euomphalus minutus by Zieten in 1833, then it became the Natica pulla of Romer in 1839, followed by Tate's synonym of Natica pilula in 1871, and it could be traced onwards if it were worth while. The utility of extending our acquaintance with the gasteropods of the Lias is now acknowledged, and not too soon, by the monograph on the subject issued by the Palæontographical Society of London, which is now in course of publication.

The interesting character of our Leptæna Clays which lie above the top Zone of the Middle Lias, next to be treated, induces me to quote the following remarks of Mr Moore, F.G.S., referring to analogous beds.*

* Proc. Somerset Arch. and Nat. Hist. Soc. Vol. xiii, pp. 120, 132.

"In Somersetshire, N. of Ilminster, where the basement portion of the Upper Lias is exposed, the Leptæna Clays lie in immediate contact with the Marlstone, and consist of about 18 inches of green, yellow, and brown laminated clays, yielding *Leptæna* (*Koninckella*) *Bouchardi*, and *L. Moorei* at the base, and higher up *Thecidium rusticum*, *Alaria unispinosa*, *Spiriferina ilminsterensis*, and *Zellania liassica*. Foraminifera and Ostracoda likewise occur, as well as *Terebratula globulina*, *Rhynchonella pygmæa*, *Ammonites*, and occasionally remains of Fishes and Saurians."

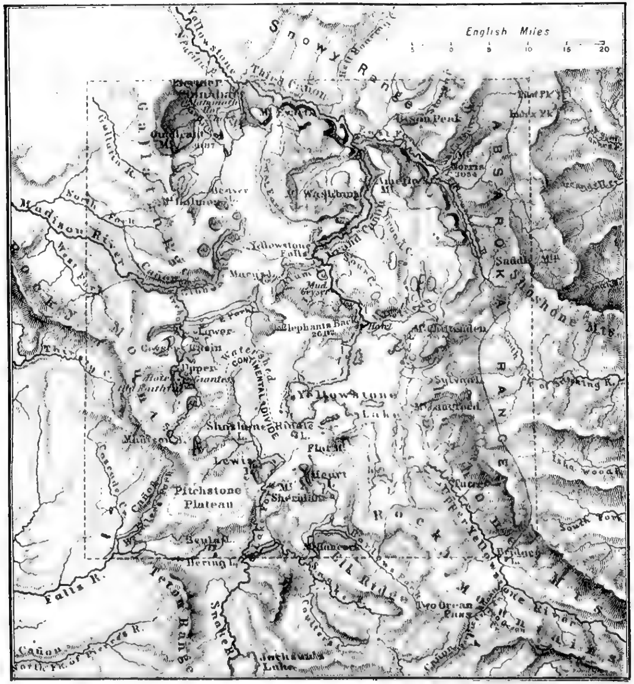
Middle Lias

We give on the next page such a scheme of the Middle Lias on which our capping beds repose, as may afford a general view of this portion of our Gloucestershire Lias, and the junction of the Upper Lias and Middle Lias with its Zone of Am. Spinatus.

BOUNDARY BEDS OF THE UPPER LIAS AGAINST THE MIDDLE LIAS, CHURCHDOWN HILL

[6 feet to the inch.]

	Unrepresented at Churchdown	ZONE of Ammonites Jurensis	UPPER LIAS
	Alluvium Brown Marly Clay Yellow Geodes of Argillaceous Limestone (Fish Bed) Leptolepis concentricus, &c.	ZONE of Ammonites Communis	UPPER LIAS
Leptæna Clays	Mottled Blue and Drab Clay with Crustacea. Leptæna Band with peculiar Fauna (Fredk. Smithe, 1860) Brown Marly Shale Blue and Yellow Clay	Frontier Line	UPPER LIAS
Marlstone of the older Geologists	Fine Yellow Marly Sands reposing upon ROCK BED (Lamellarian Shoal)	ZONE of Ammonites Spinatus	MIDDLE LIAS
Marlstone of the older Geologists	("Rock Bed" of Quarrymen) A dark Olive Blue impure Limestone, Blue in Middle, and weathering to Red Brown (ferruginous) "Belemnite Pavement."	ZONE of Ammonites Margaritatus	MIDDLE LIAS



MAP OF THE

YELLOWSTONE NATIONAL PARK, U.S.A.

(Inserted by the kind permission of H. M. Cadell, Esq., F.R.S.E.)

"OLD FAITHFUL"

Geysir in the Yellowstone Park. (See page 275.)

THE GEYSIRS

OF THE

YELLOWSTONE NATIONAL PARK, U.S.A.

BY

H. G. MADAN, M.A., F.C.S.

In these "globe-trotting" days I need not make any apology for asking the Cotteswold Club to transform itself temporarily into a "Rocky Mountains" Club, and visit "fresh fields and pastures new;" or, more strictly and less poetically speaking, to betake itself to regions where there is nothing at all corresponding to our ideas of a field, and where the pastures are such as every well-bred Cotteswold sheep would turn away from in disgust.

It was in the year of grace (and of rain) 1882 that the extension of the Eton School holidays to eight weeks enabled me to traverse rather more than 13,000 miles of the surface of this little planet, and to visit not only the civilisation and luxury of San Francisco, but also far more attractive regions where civilisation is unknown and where the only luxury is that of Nature in her wildest forms.

I shall not attempt to give any full account of my journey Westward Ho! The real scientific interest of it began when one afternoon as we were plodding across the great plain of the Mississippi at a steady rate of 25 miles an hour, I saw what seemed to be a stratum of dark heavy storm clouds on the horizon right ahead, which I could hardly believe at first to be the massive range of the Rocky Mountains.

We soon began to climb up the eastern side of them; and a very steep climb it was, the summit level of the Central Pacific railroad, at Sherman, being 8,200 feet above the sea. After this is reached there is, on the whole, a descending grade into the great central basin of which the Salt Lake is the lowest point, about 4,000 feet above sea-level.

It is a common mistake to consider the Rocky Mountains as a single, well-defined range of mountain summits, just as a traveller by the Midland line from Birmingham to Bristol, observing the escarpment of the Cotteswolds on his left hand, might think that they were a range of hills, narrow and isolated like the Malvern Hills on his right. He would soon find out his error if he left the Midland line at Stonehouse, and climbed by the Great Western Railway up the Stroud Valley to Swindon and Reading. He would then see that the Cotteswold Hills are really an elevated plateau, sloping gradually towards the E., but with no well-defined "other side." The same is true of the Rockies, on a very much larger scale. They consist of a high plateau, or rather, a series of plateaux, with an average elevation of 6,000-7,000 feet above sea-level, on which rise here and there immense rocky masses such as the range of the Wahsatch Mountains, Mount Washbourn (10,340 feet), and above all (in every sense of the words) the three gigantic Tetons (14,000 feet), which form landmarks visible throughout the whole region. Such prominences are strictly comparable to the Malverns, consisting as they do of volcanic materials forced up through the older sedimentary strata which flank them on all sides. But here the resemblance to our familiar district ends, for since the protrusion of these massive peaks and ridges, outbursts of lava have occurred on a scale to which we find no parallel in Great Britain, though in chemical characters and geological age we may compare them to the formations observed in the West of Scotland

and the Hebrides, where sheets of basalt 3,000 feet thick have been spread over the whole district during the Miocene period, sections of which are seen in Fingal's Cave, the Scuir of Eigg, and even so far off as the Giant's Causeway.

A closer parallel may be found in the district of Auvergne, where large basaltic plateaux occur, pierced through by masses of eruptive trachyte such as the Pic de Sancy and the well-known Puy de Dôme. The date of the outburst in Central France was probably nearly the same as that of one, at any rate, of the periods of volcanic disturbance in the Rocky Mountains, viz., the commencement of the Tertiary period; but in the Yellowstone district there have been at least two epochs of intense activity, the earlier flooding the region with sheets of andesitic lavas, the later characterised by lavas of the basaltic type. These latter seem to belong to the Pliocene period, but considerable eruptions must have taken place in still later times, and the existing thermal phenomena are the last expiring efforts of these volcanic energies; if indeed they are dying out, and not gathering strength for a fresh out-burst.

The latest period of activity, however, took place so long ago that not a single crater corresponding to the splendid row of symmetrical cones which astonish the traveller in Auvergne, has survived the destructive action of weather and water. Probably most of the lava issued from long narrow fissures, as in the case of the Pic de Sancy and the hills in the Cantal district. Glacial action and river erosion have ploughed out valleys in the basaltic plateaux until the original volcanic contours of the region are no more recognisable than the features of the youth can be traced in the wrinkled old man.

Many interesting evidences of the work of ice are observable; rocks polished and striated in the cañons, mounds of moraine in the valleys, and *blocs perchés* of granite even on the tops of hills 1,600 feet above the present river plain. Recent deposits are, however, gradually filling up and obliterating the older features of the country, and it is with these deposits that we are at present chiefly concerned.

They are of two kinds:—

1.—Calcareous: consisting of calcium carbonate in the form of travertine, corresponding to the well-known deposits in Auvergne and the Campagna.

2.—Siliceous: composed of almost pure silicon hydrates, to which, so far as I know, there is nothing of similar chemical character in Auvergne.

The origin of each is easily explained. The strata underlying the sheets of trachyte and basalt consist of cretaceous and jurassic limestones; and the water permeating these strata is highly charged with carbon dioxide, one of the principal gases emitted by volcanoes. Such a solution readily acts upon all calcareous rocks, the calcium carbonate which they contain being converted into calcium-hydrogen carbonate, a substance which readily dissolves in water.

Experiment.—Solution of calcium hydrate poured into a bottle of carbon dioxide; a white precipitate of calcium carbonate (chalk) is thus formed. This precipitate, suspended in the liquid, is transferred to another bottle of carbon dioxide and shaken up. The calcium carbonate dissolves, and a clear solution of calcium-hydrogen carbonate is obtained.

Thus the water which comes to the surface and issues in the form of springs contains large quantities of this calcium compound, which on exposure to the open air is decomposed with evolution of carbon dioxide and re-formation of insoluble calcium carbonate. This decomposition goes on much more quickly when the solution is heated.

Experiment.—The clear solution obtained in the last experiment is poured into a flask and heated to boiling. It becomes turbid owing to the precipitation of insoluble calcium carbonate.

It is in this way that the stony deposit or "fur" found in boilers and kettles containing hard water, such as is supplied to Gloucester, is produced.

From the same cause arise all the massive and beautiful travertine deposits of the Mammoth Hot Springs on Gardiner River, near the Northern boundary of the Park [lantern slide shown], which cover an area of several square miles, forming a series of terraces of great thickness, edged with stalactites in every variety of form.

But the Geysirs of the Firehole River form deposits of totally different chemical character, though equally beautiful and diversified in form, consisting of very pure silica; or rather, silicon hydrate, since they all contain the elements of water. The history of these formations is the following. The volcanic trachytes and basalts already described consist of various and complex silicates, containing silicon and oxygen united with the basic radicles aluminium, iron, potassium, and sodium. These compounds all break up more or less readily under the influence of heat and moisture into clay (aluminium silicate), iron oxide, salts of potassium and sodium, and silica. The clay, which is, for the most part, very pure, white kaolin, and might be used for making porcelain and china ware, forms the solid ingredient of the mud volcanoes or "paint-pots" as they are rather clumsily termed. The iron oxide contributes the colouring matters,—brown, red, and green,—which add so much to the beauty of the geysir deposits; while the silica under the influence of the subterranean heat and pressure, combines with the alkaline salts to form soluble potassium and sodium silicates resembling the common "water-glass" of which I exhibit a specimen. This latter dissolves in the hot water of the geysirs, and the silica is deposited, as the solution cools and evaporates, in very beautiful and often fantastic forms; giving not only the vast thick sheets, mounds, and spouts of the geysirs, but also the exquisite ornamentation of the hot springs and pools which abound along the Firehole River Valley. I brought away a few small specimens of this "geysirite" as it is termed, which are on the table before you; but I was not vandal enough to knock away any of the delicately-carved, flower-like forms which are seen everywhere glittering through the clear blue water in the pools. I preferred to leave this practice to vulgar tourists, who are now, I am glad to say, debarred from it by a strictly-enforced law.

The same deposit takes place, even without evaporation, when appropriate nuclei such as leaves, or sticks, or insects, are immersed in the water. Butterflies, for instance, which fall on the surface and are killed by the boiling water, are in a few hours encased in a thin film of silica, like the petrifactions of calcium carbonate which are so common at Matlock, and abound in greater beauty and profusion in Auvergne.

I must not omit to mention another cause which contributes greatly to the attractiveness of the deposits in the hot springs and geysir pools. Certain kinds of coloured algæ are found to flourish luxuriantly in water at temperatures as high as 90° C. (194° Fahr.); and several of these have, like the common marine corallines, the power of assimilating calcareous and siliceous materials from the water, and armour-plating themselves, as it were, with a thick covering of stone. Thus we have in water nearly hot enough to boil a cabbage for the table, masses of organic and inorganic vegetation wonderfully intricate and beautiful in form, coloured with every conceivable shade of green, yellow, pink, red, and brown.

With this short explanation of the chief physical characteristics of the Yellowstone district, I may pass on to describe what I saw myself during a too brief visit to it. [Diagram shown]. The general plan of the Park being an elevated plateau 60 miles square (about half the size of Wales), and averaging about 8,000 feet above sea-level, surrounded by mountain ranges rising about 3,000 feet above the plateau, the best way into it will obviously be that by which the rivers flow out of it; and that is on the N. and N.W. side. On the S. we have, as shown on the map, the great range of the Tetons and the Wind River Mountains. On the E. the Absaroka range forms a barrier rather difficult to get over; while the two chief rivers which drain the plateau, the Madison and the Yellowstone, have cut for themselves gaps through the Snowy Mountains and the Gallatin range on the N., which, like breaches in the walls of a strong fortress, afford a comparatively easy ingress to assailants. There is now, I believe, a branch line from the Northern Pacific Railroad running up the valley of the Yellowstone to Cinnabar, a settlement just within the N.W. boundary of the Park; and even stage-coaches (so-called) run from this point to the hot springs and Geysirs, where hotels, whisky saloons, and such-like products of American civilisation, are developing themselves in profusion. I am thankful to say that none of these nuisances existed in 1882. A traveller had really to "travail" then, more or less "heavy-laden" (I chose the latter and lighter condition). The nearest point accessible by railway was Beaver Cañon in Montana, on a branch line running from Ogden to Virginia City, a mining centre about 200 miles W. of the Park. As Ogden is on the main line of the Central Pacific Railroad, and as I was coming back from San Francisco, it was easy to take a ride on this branch line to the depôt at Beaver Cañon, from which a drive of about 140 miles would take me into the district I wished to see.

A few out of the many points of geological interest on the route from Cheyenne, where the ascent of the Rockies begins, to Beaver Cañon may be noted in passing.

1.—Iron Mountain, near Laramie, 1½ mile long, 1,200 feet high,—a solid mass of very pure magnetite, containing 72 per cent. of iron, [specimen shown]. This is not merely magnetic, *i.e.*, attracted by a magnet, but (perhaps in consequence of the N. and S. direction of the mountain) permanently magnetised; an enormous "lode-stone," in fact.

[Action of the specimen on a compass needle demonstrated.]

2.—The Buttes, and the sandstone pillars in Weber Cañon, near Ogden: curious examples of sub-aerial denudation. Buttes are flat-topped, table-like masses, usually of sandstone, which stand out above the level of the prairie plain, all the softer materials around them having been eroded away.

A similar selective erosion has taken place on a smaller scale along the sides of Weber Cañon. In several places there jut out tall, rounded, tower-like columns and pinnacles of bright-coloured red sandstone, which at a short distance off are hardly to be distinguished from the ruins of old castles. I need scarcely remind you of the precisely analogous examples of denudation in the carboniferous limestone, observable in "The Seven Sisters" and other rocks near Symond's Yat.

3.—The "Devil's Slides" in Echo Cañon:—two enormous parallel dykes of granite, about 10 feet apart, standing out like walls 20 feet high from the side of the cañon; their destruction having been given up by Nature as a hopeless task when she carved out the deep valley in the solid, but softer sandstone.

4.—The series of parallel, horizontal terraces, which are traceable all round the basin of the Great Salt Lake, and which are exactly analogous in appearance and origin to the well-known "Parallel Roads of Glen Roy" near Ben Nevis. The highest of them is nearly 1,000 feet above the present lake, and is found to correspond exactly in level with a gap in the northern boundary of the basin, through which the water of the lake must at one time have found an outlet into the Snake River. At this period it must have formed an immense inland sea of fresh water, like Lake Ontario, 300 miles long and 180 miles broad, fed by streams from glaciers which came down to the very edge of the water; and a flat beach was formed, as usual, all round the margin of the lake. As the water supply failed, evaporation reduced the size of the lake to its present level and limits; not continuously, but with pauses at regular intervals (caused by the relation between the rate of water-supply and loss by evaporation), each marked by formation of one of the lower terraces on the margin.

From Ogden I went northwards along a narrow-gauge line, newly made, to Beaver Cañon, a small settlement on the outskirts of civilisation, or perhaps (to speak truly) a little beyond them. The inhabitants of the place, when they were not eating, drinking, sleeping, or swearing, were engaged in "handling lumber"; *i.e.*, felling pines and sawing them up into logs and boards for building houses, and shingles for roofing them. From thence I started for a drive of about 140 miles to the Geysir Basins on the Firehole River in the National Park; my companions being a couple of the lumber-men, who turned out to be good guides, not very profound philosophers, and excellent friends. We went in a four-wheeled conveyance, drawn by *two* tough and active little horses, but realising in other respects that wonderful "one-horse shay" described by Wendell Holmes, more nearly than I thought possible in this imperfect world. Nothing could break that trap down; it was all good ash, lance-wood, and iron; and after any amount of knocking about over boulders and and pine-logs, into and out of ditches, and through rivers, it brought us back to Beaver Cañon as sound as ever, except a slight "set" in one of the axles.

The radiation through the pure dry air in those regions is remarkably free. By day the heat of the August sun was almost tropical: at night more than half an inch of ice was formed in a pan of water left exposed to the sky; and a good fire of pine-logs was not so much a luxury as a necessity. The main reason was, of course, as Tyndall's researches have proved, the absence of water-vapour in the atmosphere; but it must also be remembered that the whole region is more than 7,000 feet above sea-level, and we were within easy distance of the great Teton Mountains, with their summits covered with perpetual snow.

Our route lay along basaltic plains, covered with prairie grass and "sage-brush," under low ranges of trachytic buttes, and across the great Snake River teeming with excellent trout, from one to two pounds weight. About three cwt. of these are netted every day during the season, and sent off in waggons to the depôt at Beaver Cañon, there to be put on rail for Salt Lake City. At last we came to the summit of the Great Divide, and drank from a little moss-covered spring, the water of which is the first contribution sent down from that region to the vast Atlantic Ocean.

We followed it down to the Madison River, which was here formerly lost in an immense lake, until the water cut for itself a deep narrow gorge well known in those parts as the Madison Gap. No vestige of the lake now remains; its bed is covered with extensive pine woods, through which the track (I am sorry that I cannot call it a road) conducted us to the foot of a steep cliff, where a passable means of ascent had just been completed by the rough Engineers employed by the American Government. Almost as soon as we reached the top of this, I saw right in front of us a white cloud rising from a point about four miles off, resembling that which generally covers the top of Vesuvius. It was my first view of a real geysir in action, greeting us with a well-sustained royal salute; and though I watched several other eruptions of it before I left the district, none struck me so vividly as the magnificent out-burst seen from Look-out Cliffs.

The geysir was, as I afterwards learnt, the "Sheridan" or "Excelsior," in the middle Geysir Basin. It was the most recent addition to the group, having developed within the two previous years, from a quiet, inoffensive boiling spring into the largest and most violent eruptive geysir in the district. I shall allude to it again, and will now only express my regret at having learnt from recent visitors that it has quieted down again to its former condition, and is no longer an object of special interest.

We were now on the edge of the Valley of the Firehole River, overlooking the Lower Geysir Basin, and soon descended to a large log-hut, which was the nearest approach to a hotel then existing in the Park. It was built close to the Firehole River, and surrounded by boiling and spouting springs.

From this I had some interesting walks along the river to the Middle and Upper Geysir Basins, where all the first-class geysirs lie. This portion of the Valley of the Firehole River is about ten miles long and very variable in width, from half a mile to three miles; it is roughly divisible into the three districts already alluded to, called the Lower, the Middle, and the Upper Geysir Basins respectively. In the first-named of these there are no conspicuous geysirs, but boiling springs are numerous, one being close enough to Marshall's Ranch, the place where I was staying, to supply the house with all the hot water required for use in washing. Most of the adjacent springs are circular pools of exquisitely clear blue water, which from its strongly alkaline character (due to the large amount of sodium carbonate and silicate which it contains) is eminently suitable for laundry purposes. Indeed, hardly any "Sunlight" or other soap is required, and there is only one slight draw-back to the use of these pools for washing purposes, viz., that at uncertain intervals the whole of the contents of the basin are suddenly and without warning sucked down into unknown reservoirs below, carrying with them, of course, any articles which may be undergoing the process of cleansing at the time. It is true that the basin is certain to be filled again with scalding water almost as suddenly as it was emptied, but there is not as absolute a certainty that all the abstracted articles will re-appear with it.

At no great distance from these springs there is a group of pools which present the greatest possible contrast to them. I approached them over a plain consisting entirely of white geysirite, which formed a crust not by any means thicker than was required for safe walking. In several places there were holes with steam issuing from them, showing where a horse's foot had broken through, and I had carefully to follow the wheel tracks of a cart in order to minimise the risk of falling into unknown caverns below, containing boiling water, or worse. After about two miles of this, I came to one of the greatest curiosities (I cannot call them "beauties") of this wonderful region, a group of pools varying in diameter from four feet to eighty feet, and filled, not with clear blue water, but with gray or pink mud, having about the same consistency as thick paint or porridge. Through this semi-liquid mass numerous jets of steam were constantly forcing their way, raising the surface into bubbles about a foot or more in diameter, which just at the time of bursting had precisely the appearance of miniature volcanoes. It is hard to conceive a more lively and boisterous scene than the one presented by these "Devil's Paint-pots," as they are rudely but picturesquely termed; the whole surface spluttering and boiling up like pea-soup in a saucepan, each bubble bursting with a slight explosion, and throwing splashes of scalding mud several feet into the air. The material is a mixture of clay and geysirite, and when dried becomes a very friable white powder, otherwise I should have tried to transport one of these model volcanic cones to some museum in England.

From this busy scene I returned to the course of the Firehole River, and proceeded up it to the Middle Geysir Basin, a small plain containing only two objects of interest, one being a magnificent hot spring about 150 feet in diameter; the other being the finest specimen of a geysir in the district, and probably in the world, both in respect of size and of eruptive power.

It was this geysir which greeted us so warmly, not to say hotly, as we came over the Look-out cliffs and got our first view of the valley; and it has been called in a rather tame and cockney style, the "Excelsior." The life-history of it is pretty well known, and can be briefly given here. Dr Hayden, the director of the first scientific exploring party sent out by the Government, mentions in his Report, dated 1872, a large turbulent boiling spring, which had recently broken out near the left bank of the Firehole River and was pouring a large volume of hot water over its eastern edge into the river. A sketch of it is given in the Report, of which I exhibit a photograph. [Lantern slide.] Nine years later, in 1881, Mr Norris, the official superintendent of the Park, was surprised to find that this comparatively insignificant spring had become nearly treble its former size, by the breaking down of its margin, and was constantly emitting great volumes of steam and a regular river of boiling water, which rushed over its edge like a waterfall into the Firehole River about twenty feet below. I exhibit a photograph from Mr Norris's sketch, which shows the development which had taken place. [Lantern slide.]

A few months later still, this spring seems to have set up in business as a first-class geysir, eruptions attended with loud rumblings and earth-tremblings taking place every night, which, in the words of the official report by Mr Norris, "elevated to heights of from 200 to 300 feet, sufficient water to render the Firehole River (nearly 100 yards wide) a foaming torrent of steaming hot water;

while pieces of rock from 1 to 100 lbs. weight were hurled, as if from an exploded mine, over the adjacent country."

A little later still, the eruptions increased in frequency; and when I was there at least two occurred every day, and were perhaps the most astonishing things which I witnessed, though the actual rising column of water was provokingly obscured by dense clouds of steam. It was possible at times, and with caution, to approach within a foot or two of the yawning chasm which forms the outlet (there is no regular crater or nozzle here as in most of the other geysirs) and catch an occasional glimpse of the seething mass of water about 20 feet below, while far overhead there rose such a vast cloud of mixed steam and water as would do credit to Vesuvius itself.

The whole place certainly deserves most thoroughly the name of "Hell's half-acre," by which it is commonly known.

In striking contrast to this terrific display, there is, at a distance of only about 50 yards, a circular pool about 150 feet in diameter, filled to the brim with perfectly quiescent, though nearly boiling water of a most beautiful blue tint. The depth of the pool it was impossible to estimate, for as the thickness of the stratum of water increases, the blue deepens to a dark indigo, so that the actual bottom, if there be one, is practically invisible. The sloping sides of this spring are covered with masses of geysirite, showing the most curiously fantastic forms. Gigantic cauliflowers, columnar stalactites, growths resembling many known species of corals and sponges, all of the purest white material, appear through the water tinged with delicate shades of blue.

The existence of this tranquil spring in such close proximity to a violently-active geysir is only one instance of a general law observed in groups of geysirs,—that each individual acts quite independently of the rest, having its own separate subterranean source, its own times and peculiarities of eruption.

I proceeded four or five miles up the river before I came to any more prominent signs of volcanic activity. Then, emerging from a luxuriant pine-grove, I saw before me what I should be fully justified in calling the "Black Country" of the Rockies, if it were not for the fact that everything in it except the pines was brilliantly white, especially as seen through the clear mountain air and under the rays of an August sun; white plateaux of geysirite, white crater-mounds, white foaming river, white clouds of steam, white, or rather, crystal-clear columns of water. This was the Upper Geysir Basin of the Firehole River, a tract about three miles long and two miles broad, containing more geysirs and hot springs than any other area of the same size in the world. At least 50 of these are of the first rank, but I shall, of course, only attempt to describe a few, possessing characters of special scientific interest.

The flat bottom of the valley is wholly composed of a stratum of geysirite of unknown thickness, probably at least 40 or 50 feet, produced by the decomposition of the underlying lava sheet under the influence of heat and moisture. The silica, passing into solution, as has been already explained, has been brought to the surface by the geysirs and hot springs and then deposited from the water in sufficient quantity to form these thick and extensive layers. [Lantern slides.]

I noticed on the ground in several places large slabs of what looked so exactly like the semi-transparent, elastic, gelatinous flesh of fish (if I may say so) that I had to tear off a bit and taste it in order to satisfy myself that it was really nothing but colloidal silicon hydrate recently deposited from the water as it cooled. [Specimen shown.] Some of it, left for a while in the hot sun, soon gave off the elements of water and crumbled down into a friable mass of white nearly anhydrous silica, or geysirite. [Specimen shown.]

After crossing the river, the only bridge being the trunk of a young pine, not so large as a telegraph pole, casually flung across, on which I had to display my powers as an acrobat (with no one at hand, unfortunately, to see and appreciate them), I found myself in close proximity to three or four more or less active geysirs. One of these was of a very peculiar type. It is called the "Grotto" geysir, and is certainly a most fantastic piece of architecture. [Lantern slide shown.] It has two orifices very near together, and the two escaping jets of water are thrown slantingly against one another in the same way as the jets of gas in the "union" form of burner. Thus the regularity of the discharge is interfered with, the water being dashed about in several directions at once; and the deposit of geysirite had gradually assumed the curious forms here shown. When I saw it, the streams of boiling water seemed fighting with each other, as if from two rival fire-engines, splashing right and left through the holes in the grotto, until all was enveloped in a cloud of steam and spray.

A little south of this I came to one of the largest of the regularly-formed geysir-craters in the district,—the Giant Geysir. [Lantern slide shown.] Its cone is about 14 or 15 feet high, with a bore of 7 feet in diameter, and it sends up an unbroken watery column of this diameter to a height of 200 feet, maintaining the discharge for at least an hour. I was not fortunate enough to see an eruption of it (they occur at very irregular intervals), but as one side of the cone is broken down, I could look in and see the water surging below, sometimes rising quickly to the surface in a way that excited hopes of an explosion, but soon retreating again to a depth of 8 or 10 feet. Stones thrown in had no effect in making its "angry passions rise." I had no soap with me (I saw very little of that commodity in the Rockies), or I should certainly have tried the effect of administering some of it to the giant. This, I believe, usually acts as a very efficaceous emetic; owing, of course, to the viscosity it produces in the water. Engine drivers well know how quickly "priming" is brought on if a little grease or soap gets into the water supplied to the boiler.

About a quarter of a mile farther south, on a mound not far from the margin of the plain, there rises a structure which might easily be mistaken for the ruins of an old castle partly buried in débris. [Lantern slide shown.] This is another typical geysir-formation, showing the cone in an advanced stage of old age. It was probably at one time at least 25 or 30 feet high, built up by the deposits of numberless eruptions, each adding a brick (or more strictly, a film of silica) to the pile. Then, as the tube lengthened and the resistance to the passage of the water increased, the violence of its own discharges blew the structure to pieces, and left it as I saw it, a splendid wreck. It still emits much steam, and contributes a good deal of boiling water to the beautiful circular pool below; [Lantern slide shown] but it has retired from business as a real active geysir. The pool just mentioned (and shewn in the photograph) is a very fine one, perfectly circular, very deep and always full of magnificently-blue, tranquil water. I could almost fancy, while gazing into it, that I was looking down a hole bored right through the earth, upon the blue sky on the other side.

Perhaps I may note here, as a characteristic of nearly all the geysirs of the Rocky Mountains, and a point in which they differ from the Icelandic geysirs, that hardly any of them rise from the centre of pools. They almost invariably build up cones or short chimneys round the point where the water reaches the surface, and the discharge takes place from the top of these, instead of from a deep circular cup, like a volcanic crater. This peculiarity is undoubtedly due to the large amount of silica which the water holds in solution, and which is deposited as soon as any cooling and evaporation takes place. Indeed, in cases where there is great frequency of eruption and the volume of water emitted is considerable, the throat of the geysir is liable to become choked up by its own deposit; and several of the geysirs have actually committed suicide in this way. [Lantern slides.]

I must pass over a number of really magnificent geysirs in the Upper Basin, which have now, I believe, become the delight of dilettante tourists, and have received various trivial and tasteless names,—"Beehive,"—"Giantess"—"Grand,"—"Saw-mill,"—"Punch-bowl," &c. The Americans are undoubtedly excellent at inventing *things*, but not *names*: the names which they have scattered over their beautiful country are enough to disgust any respectable traveller from the offensive vulgarity and utter want of taste shown in their selection.

I must not, however, omit to describe, in conclusion, one other fine specimen of a geysir which is interesting as being actually the first of all the wonderful group of Yellowstone Geysirs discovered by the exploring party sent out in 1871 by the United States Government, and led by Dr F. V. Hayden, who has since done so much in his Reports to elucidate the physical geology of the district.

I cannot do better than quote a portion of the description of this discovery from the official Report, premising that the party entered the Firehole Valley near its upper end, and not from below, as I did.

"Hurrying down the Firehole River, thinking that the wonders of the Yellowstone country had been left behind, and anxious only to reach the settlements of the Madison Valley, we were startled and astonished to see at no great distance an immense volume of clear, sparkling water projected into the air to the height of one hundred and twenty-five feet. 'Geysirs! Geysirs!' exclaimed one of us, and spurring our tired horses we were soon gathered round an unexpected phenomenon,—a perfect geysir. [Lantern slide shown.] It stands on a mound thirty feet above the level of the surrounding plain, its crater rising five or six feet higher. The aperture through which the column of water is projected, is an irregular oval, three feet broad by seven feet long. The margin of sinter is curiously piled up, the exterior crust filled with little cavities or pockets full of water, some of them containing oval pebbles of a brilliant white colour, gathered round bits of wood and other nuclei. These cavities are irregular in shape, with margins of silica like frosted silver, in meshes as delicate as the finest lace. Diminutive yellow columns rise from their depths, capped with small tablets of rock, and resembling flowers growing in the water. This geysir spouted at regular intervals nine times during our stay, sending up a column of water about six feet in diameter to a height of 100 to 150 feet, and by a series of impulses holding it up steadily for the space of a quarter of an hour, the great mass of water falling directly back upon the crater, and flowing down the side in large streams. Its eruptions occurred once an hour, and from their extreme regularity we gave it the name of 'Old Faithful.'"

I can corroborate the above account in every particular. Since September, 1871, numbers of explorers and visitors have been to see this geysir, and every hour of the day and night (Sundays, I regret to say, not excepted) has "Old Faithful" treated them to a splendid display. I witnessed several of the eruptions, and I timed the interval between them as 63 minutes, as nearly as possible. This extreme and extraordinary regularity points, of course, to a remarkable uniformity in the supply of water to the subterranean boiler which is connected with the geysir. The feed-water comes, no doubt, from a very deep-seated spring, and not from any surface drainage which would afford an intermittent and very variable supply in summer and winter, drought and snow-time. The source of heat is probably constant in all cases, and the intervals between eruptions depend on the size of the reservoir and the quantity of water which enters it in a given time.

I have now brought you to the head of the Firehole Valley; and I should gladly, if the time had allowed, have crossed the great "Divide" or "Water-parting," which runs along the E. side of the Valley, and visited the fine sheet of water called the Yellowstone Lake, from which the Yellowstone River flows northwards through a magnificent cañon, [lantern slide shown,] forming falls more than twice as high as those of Niagara (350 feet, by line measurement), though not quite equal to the latter in volume. This "Grand Cañon," as it is termed, is one of the finest examples of river erosion in the world. [Lantern slide shown.] It is 20 miles in length, and averages about 1,000 feet in depth, and the same in width. The sides are not perpendicular as in some of the Colorado Cañons, but slope at an angle of about 30° from the vertical. Standing out from the sides there are numbers of rocky masses, like the "Seven Sisters" at Symond's Yat, carved by weather action into the most fantastic forms,—pillars, watch-towers, buttresses, pinnacles, all glowing in the sunlight with varied tints of yellow, orange, and red, from the quantity of iron oxide which the trachyte contains. The river has, in fact, cut its way through two distinct lava sheets, one overlying the other; its work being rendered easier by the disintegrating action of the steam and boiling water from the numerous hot springs which gush out from the sides of the chasm. Its course of destructive erosion was arrested by an immense vertical basaltic dyke, which crosses the cañon diagonally at the Falls, and forms a barrier like a weir, which the forces of Nature seem powerless to attack, and which will keep the Falls in their present condition for centuries to come.

I do not propose to give an account of all the objects of scientific interest in this wonderful region. I went there for the specific purpose of seeing and examining what, so far as I know, are not to be seen on such a scale anywhere else in the world, viz., the Geysirs; and I shall conclude my description with an endeavour to explain the causes of the very peculiar phenomena presented by these natural "water-rises" (which is surely as good an English word as "water-falls.")

A "Geysir" (the word is Icelandic and means a "gushing torrent") differs from other natural springs in the following respects:—

1.—The water issuing from it is nearly or quite at the boiling point, viz., 100° C., for the ordinary atmospheric pressure.

2.—The water is ejected with a force comparable to that which is developed in the explosion of a high pressure steam boiler.

3.—The water is ejected, in nearly all cases, at very irregular intervals, alternating with periods of complete repose.

The high temperature of the water is unquestionably due to the same cause as that of a volcano, viz.: the near approach to the earth's surface of some of the intensely hot materials of which the interior is composed. Hot springs are always, whether in Iceland, or in Auvergne, or in New Zealand, or in the Rocky Mountains, an accompaniment of volcanic action, and usually an indication of its decay.

The cause of the violence and the intermittent character of the eruptions of a geysir is readily understood by a consideration of one or two of the elementary laws of heat.

In the first place, a liquid is found to arrive at that critical point in its thermal history which we call "the boiling state," at a temperature which depends entirely upon the pressure to which it is subjected. "Boiling" is that condition of a liquid in which bubbles are formed, or capable of being formed, in all parts of the mass, and not merely at the free surface, as in the case of simple evaporation. In order that this should occur, the tension or pressure of the vapour must be at least equal to the pressure existing at the place where the bubble is to be formed; otherwise the cohesion of the molecules of the liquid prevents their disruption. Now, the communication of energy in the form of heat increases the pressure of a vapour, and if we raise the temperature of a liquid exposed to ordinary atmospheric pressure, we eventually reach a point at which the pressure of the vapour becomes as great as the pressure of the air upon it; and then boiling begins. If we now increase the pressure acting upon the liquid, either by forcing more air into the vessel containing it, or (more simply) by preventing the free escape of the vapour and thus making its pressure act in addition to that of the air, boiling cannot take place at the same temperature as before. But we can cause it to go on again by raising the temperature of the liquid still further, until the pressure of the vapour becomes so much greater that it counterbalances the existing pressure, great as the latter is. If, while the liquid is at this temperature and pressure, the supply of heat is stopped, boiling ceases; but it can be caused again to take place without supplying more heat, by simply diminishing the the pressure on the liquid.

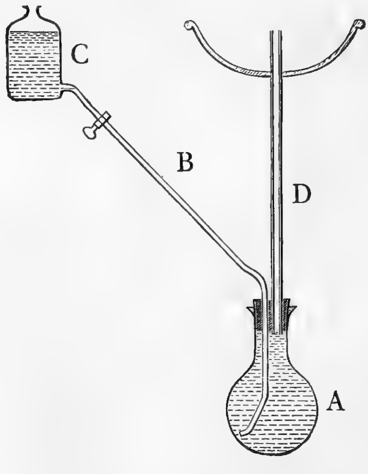
Experiment.—Water, nearly boiling, is placed in a globular flask connected with a pressure gauge and having a stopcock opening into the air. Heat is applied until the water boils, the pressure gauge then showing a pressure within the flask equal to the pressure of the external air. The stopcock is then closed; the gauge shows increase of pressure in the flask, due to the increased tension of the confined vapour; and the boiling is checked, though the temperature of the water rises several degrees above its previous boiling point. The lamp is taken away, and the formation of steam-bubbles soon ceases. The stopcock is then opened; steam escapes, the pressure within the flask is lessened, and the water again begins to boil violently.

I have thus shown that water, though at a temperature much above that at which it boils under ordinary conditions, is prevented from boiling by increasing the pressure upon it, and that, if the pressure is lessened without alteration of the temperature, violent boiling commences at once, and the temperature sinks (owing to the heat-energy abstracted in the formation of vapour) down to the boiling point corresponding to the reduced pressure.

We are now in a position to understand the mechanism of a geysir. Far below the surface of the earth, at a depth of 100 feet or more, there is a cave or reservoir into which water is continually flowing; the surface drainage making its way downwards through fissures in the rocks. One such fissure, however, serves, not so much to convey water down, as to form a free communication between the reservoir and the external air; and this, as water accumulates in the reservoir, becomes filled with a column of water reaching nearly or quite to the surface. The water in the reservoir, from its contact with intensely heated rocks, soon rises in temperature to what would be its boiling point in the open air; but it is prevented from actually boiling by the pressure of the column of water in the outlet-pipe, which acts in addition to the atmospheric pressure. Still the communication of heat goes on, until the temperature of the water in the reservoir and pipe reaches the boiling point corresponding to the pressure existing at the lower end of the pipe. Then a great bubble of steam forms there, and heaves up most or all of the column of water in the pipe, throwing it out at the top. Thus the pressure is relieved, large bubbles of steam are formed throughout the water in the reservoir, and nearly the whole of the contents is thrown up in huge masses, like projectiles from a gun, through the outlet-tube and high into the air.

The formation of the steam, and the mechanical work done in lifting the mass of water, absorb so much energy in the form of heat that the water remaining in the reservoir sinks to the ordinary boiling point and below it (as has been proved by actual thermometric observations), and the action of the geysir subsides. But in the course of more or less time new supplies of water percolating through the rocks again fill the reservoir and the vertical pipe, and new supplies of heat raise this water in temperature, until an explosion again occurs in the same way as before.

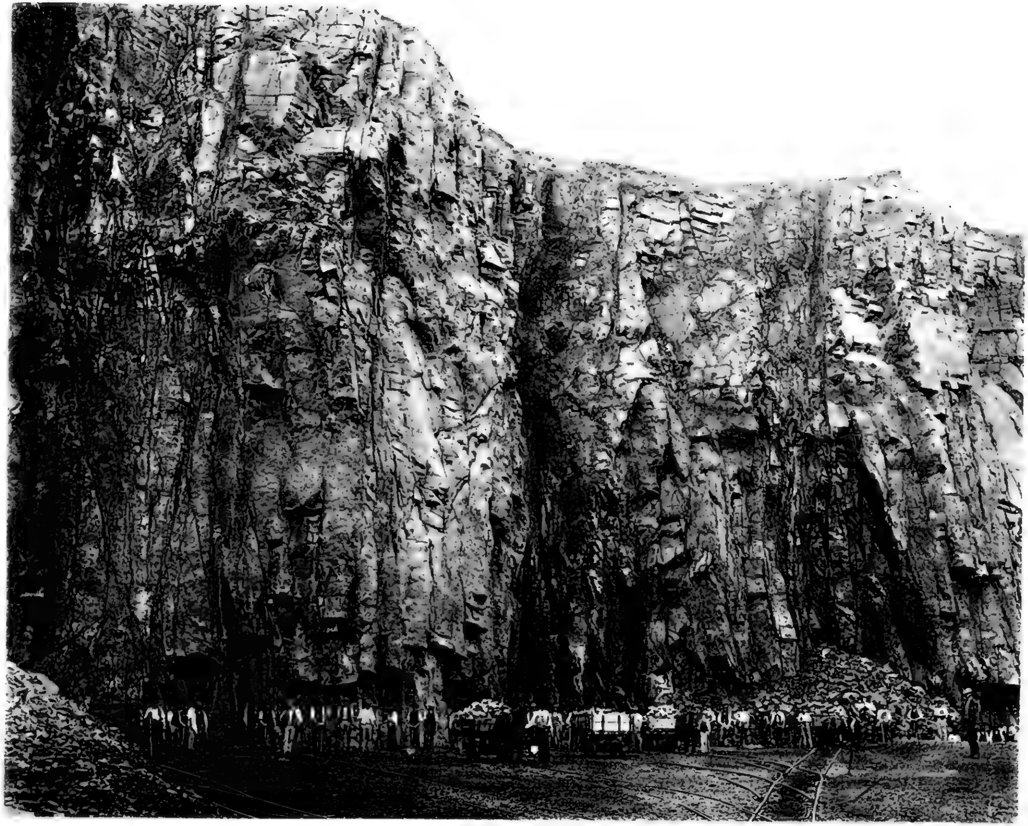
We have here, I think, a simple and adequate explanation of all the phenomena characteristic of geysir-action; and it is easy to show on a small scale that, given such conditions as those described above, results in every way similar to those observed in the immense laboratory of Nature must and will occur.



Experiment.—I have here a small glass model in which the above conditions are realized very simply. The glass flask, A, which represents the subterranean reservoir, is fitted with a cork through which two tubes pass;—one, B, corresponding to the course of the springs which feed the geysirs, reaches from the bottom of the flask to a bottle of water, C, placed on a high stand;—the other, D, larger in diameter, passes vertically upwards through the bottom of a basin. This latter tube represents the main outlet or shaft through which the discharge of the geysir takes place. A gas-burner, placed under the flask A, raises the temperature of the water, like the volcanic strata which underlie the whole of the geysir region.

Water is allowed to flow slowly from the reservoir C until the flask and the discharge pipe are filled. Heat is then applied until the contents of the flask reach the boiling point corresponding to the pressure of the column of water in the tube added to the pressure of the external air. Then a little further supply of heat causes a sudden formation of steam which drives out all the contents of the tube and some of the water in the flask, in the form of a fountain. The action then subsides until the flask and tube are again filled with water from the bottle, and when this has become sufficiently hot, another outburst takes place.

I have thus given a brief sketch of a small portion of what I saw myself during the necessarily limited time which I spent in the heart of the Rocky Mountains, and I will, in conclusion, strongly urge everyone of those who hear me to pack up his portmanteau this very night and start by the first train to-morrow morning, with or without the leave of the higher domestic powers, to explore for himself the natural marvels of that most wonderful region,—the Yellowstone National Park.



PORTION OF THE

CENTRAL QUARRY OF THE CLEE HILL DHU STONE COMPANY, LUDLOW

SOME OBSERVATIONS

ON THE

CLEE HILL BASALT

FROM A PRACTICAL POINT OF VIEW

BY

WILLIAM CLARKE, Esq., M. Inst. C.E.

(Chairman of the Associated Stone Companies of the Clee Hill, Shropshire.)

READ TO THE COTTESWOLD CLUB

ON THE OCCASION OF THEIR VISIT TO THE CLEE HILL QUARRIES

ON JULY 26th, 1894.

The geological history and the mineralogical structure of the Clee Hill formations have been so clearly and fully laid before the members of the Club by Professor Harker that I need not dwell further upon that part of the subject. But it may be, perhaps, in some sense a relief to us to come back from the far-off geological past to the immediate and living present, and to consider briefly the properties and uses of the so-called "Dhu" stone from which its great commercial value is derived.

The history of the quarries may not be uninteresting. Some 34 years ago, acting as Engineer for the construction of the Railway from Ludlow to this Hill, (a line made for the purpose of developing what was expected to be a large coal traffic, as well as the opening out of the quarries) I had my attention directed to the capabilities of the hill stone for road purposes, and in conjunction with my friend Major Patchett and others, we secured the hill running from the Railway to Limer Gate, a length of some 1½ miles, and at once commenced to open up the quarries.

Up to that time, the very small quantity of stone which was used for the roads in the immediate vicinity, consisted of the boulders taken from the slopes of the hill and from a few places which were little better than slight excavations, or burrow holes, here and there, upon the hill. The land carriage to Ludlow was necessarily expensive and, as a consequence, the stone had little more (in the commercial world at least) than a local reputation.

Mr Roberts (who was associated with me in railway construction in India), became our Manager, and thus, in the course of some years, we developed the stone trade of the Clee Hill. But Mr Roberts was ambitious, and from our nursery ground he developed into a proprietor, and opened up the collieries and works now constituting the Clee Hill Granite Company's quarries.

After a further period, my old and respected friend Mr Mackay (who had also been engaged upon this Railway) commenced the works at the Titterstone quarries, so that we are now three Companies, striving in friendly rivalry to develop to the utmost the stone trade of the Clee Hills. Our quarries, named the Clee Hill Dhu Stone Quarries, took the name from a word which I believe has for a very long time been used to describe the stone, the word "Dhu" being, I believe, the Celtic for "black," a not inappropriate name for the dark blue stone. Geologically the formation of the stone is shewn on the face of our quarries in vertical columns of very regular formation, and of a height of some 140 feet above our quarry bed, but we know that they extend some hundreds of feet below that surface; and although not as perfect as the columns to be seen at the Giant's Causeway, they are nevertheless strongly marked, and I think of very considerable interest.

Mr Bristow, of the Museum of Practical Geology, Jermyn Street, describes it as a basalt, chiefly composed of augite and felspar, "in the composition of which the augitic or hornblendic ingredient largely predominates."

For road purposes the stone is, quoting the words of a very impartial and central authority, *viz.*, the Home Office, "almost perfect as a road stone."

The material owes this high commendation to its extremely close texture and its consequent solidity, and above all things to its excessive toughness, due to its hornblende base giving to it a power to resist abrasion or friction, which I believe is not equalled by any other stone in the kingdom.

I have seen from time to time various methods proposed, whereby the capabilities of stone for road purposes may be tested, but, I am acquainted with none which will give satisfactory or even approximately reliable results.

To my mind, the only reliable test is that of constant use during a long period, exposed to all the uncertain elements of weather, rains, and frosts, and subject to the busiest, heaviest, and most constant traffic.

Some few years ago, I believe on the suggestion of a road authority, tests were made by Kirkaldy of Southwark to ascertain the stress, or load, which the stone would bear before fracture, and ultimately the stress required to crush it.

If the merits of a road stone are to be determined by such a test alone, then the Dhu Stone of the Clee Hill must win "hands down" against all competitors. It may be said, however, that the capability of withstanding an enormous (I may say a very exceptional) pressure whilst it marks the stone as one of great resisting power, does not by itself demonstrate that it is the most capable of fulfilling the other necessary requirements, such as ability to resist friction or the wear and tear to which coverings for roads must necessarily be subject under varying atmospheric conditions; although of course, other things being equal, the "crushing test" would determine the great superiority of the stone.

The ordinary weight of normal traffic upon roads may be taken at 1½ tons upon a pair of wheels, or only ¾ ton per wheel.

Now Kirkaldy establishes by scientific and therefore accurate tests that before a 3 inch cube of Dhu Stone cracked only slightly, it bore the enormous pressure equivalent to 1340 tons per square foot, and only crushed under a pressure of 1673 tons! One of three specimens failed only at 1808 tons per square foot crushing weight. If we consider by the light of these facts that the heaviest weight which can be brought upon a roadway is that represented by a steam roller of say sixteen tons on four wheels, or four tons per wheel, and remember the distribution of this load caused by the width of the broad tyres, it will be seen that the power of the Clee Hill stone to resist fracture is so pre-eminently great that the feather weight of four tons per wheel is out of all proportion to the ultimate strength of the stone. Nevertheless, it may be of some interest to compare the Dhu Stone with other hard stones, so as better to realise what the above tests mean.

		lbs. per sq. in.
CLEE HILL BASALT - - -	will crush at	**28,122**
Penmaenmawr - - - - - -	,,	26,837
Whinstone (Northumberland)	,,	25,702
Bardon Hill - - - - - -	,,	20,742
Llanbedrog (Carnarvon) - -	,,	20,711
Threlkeld (Cumberland) - -	,,	20,128
Markfield - - - - - - -	,,	19,096
Mount Sorrel - - - - - - -	,,	17,388
Dalbeattie (Kirkcudbright) -	,,	14,071
Cornish Granite - - - -	,,	14,000

		lbs. per sq. in.
Newry - - - - - - - -	will crush at	13,440
Aberdeen Granite - - - -	,,	10,900
Purbeck - - - - - - - -	,,	9,160
Limestone - - - - - - -	,,	7,700
Yorkshire Flag - - - - - -	,,	5,714
Derby Grit - - - - - - -	,,	3,100

These tests speak for themselves, and demonstrate the remarkable, almost extraordinary toughness of the Clee Hill Basalt, the highest, other than Clee Hill, being Penmaenmawr stone, crushing at 26,837 lbs. per square inch.

Granite, however, on roads is liable to have its component parts broken up by friction, and is not so tough as the more dense Dhu Stone, the specific gravity of granite being 2·62 as against 2·867 in the case of the Clee Hill Stone.

The toughness of the stone is due to the large proportion of hornblende it contains, and the absence of any approximation to brittleness is also proved by these tests.

Sandstones and Limestones are readily crushed, and in fact pulverized, and thus the metalling is no sooner laid than it begins to grind down; dust and mud follow, the latter has to be scraped off at great expense, and the road soon again renewed. Such like stones and inferior trap or igneous rock are frequently used, and more or less rapidly perish.

Although it is very enticing and apparently very economical to pick up the material for roads at your door, and so save expense of rail and road carriage, the ultimate cost becomes greater than would have been the case if a good and possibly expensive stone obtained from a distance had been used in the first instance.

Quite apart from the ultimate money saving, two other material benefits accrue, one that there is a good road for the money expended, where good material is used, and the other that the road once down is not disturbed again for years, and the great inconvenience to traffic by broken up roads is thus avoided.

Thirty years ago inferior stone, some of it utterly unfit for road metalling, was commonly used in many parts of this and the adjoining counties. Local bodies, however, have gradually learned wisdom by experience. I do not say this in any satirical sense, for Boards could do no less than ascertain by adequate trial which, amongst a choice of several local or other stones, was the best adapted for road purposes. I might venture to say that they have shewn abundant enterprise in this direction, and a sound discretion in the gradual introduction of Clee Hill Dhu Stone.

The opening of the Railway from Ludlow to the Clee Hill gave facilities for its more extended use at a reasonable cost. For traffic of the heaviest and most continuous character it became increasingly used, whilst statistics demonstrated in a marked manner its great economy as compared with many excellent stones, the first cost of which was much less than that of Clee Hill Dhu Stone.

In these and the Midland Counties, and indeed within a radius of 200 miles, Clee Hill stone after long trial under the most severe conditions, in London, Manchester, Preston, and other large towns, at Railway Station approaches of heavy and continuous traffic, has asserted its supremacy, and has largely supplanted the local stones formerly used, and daily continues to do so.

With gentlemen who now fulfil the position of County Surveyors, the ignorance which once prevailed as regards the uses of road stone in far away rural districts has been largely dispelled, and I am well satisfied that in a very short time hence financial statistics will have removed the prejudice of the most obdurate Highway Boards, and of individuals (if such there be), against the use of superior, but apparently expensive stone, and that they will recognise that true economy is not to be secured by the use of the local material because it is easy of access, however cheap it may appear to be.

The "crushing tests" referred to above are of course requisite in the case of material used in building construction,—but road stones have to do more than carry dead weight. Abrasion and its attendant dust and mud, in conjunction with rains and frosts, quickly break up a road made of unsuitable material.

The cleanliness of Dhu Stone, its capacity of maintaining the formation of its surface, if originally well put down, and the non-necessity of frequent repairs are so well understood that I will not longer dwell upon them, but leave others to make their own independent observations upon the subject. There is, however, one thing I should like, with your permission, to accentuate, in the interests of all road authorities, and that is the vile and pernicious system, once only too common and not yet quite dead, of throwing clay, loam, road siftings, and tufts of earth on to the newly spread metalling. I am well aware that the experienced gentlemen who now direct the construction and maintenance of roads will not knowingly permit this to be done, but nevertheless it *is* done in out of the way places, and done (as I suppose) through ignorance, or at least in the belief that it is a meritorious practice. The object, I presume, is to make the metalling set, and to render traction easier than it would be over the unset and irregular stones. It is true that for a time this system accomplishes its object, but in the meanwhile, and especially after rains, the stones find themselves on a soft bed, each piece carrying a plastic socket for the next stone to turn upon, and causing a movement under each passing load. Rains cause the mud to rise to the surface, more movement ensues, and ultimately that very great characteristic of the stone, its clean, sharp, angular, razor-like cleavage is destroyed, and with it the power it otherwise possessed of wedging itself into one solid impenetrable mass, the angles being rubbed off and rounded, and the setting of the stone rendered tedious, probably requiring some or all of the stones to be broken over again in order to regain their ability to set.

Its very hardness demands care in its setting, which is of little moment in inferior stones, which find a bed for themselves and upon each other only too quickly.

Indeed, just as the Builder should beware of quickly-setting cement so should the Road Surveyor be upon his guard against quickly-setting road stone.

I believe that too little attention is paid to this circumstance.

If a good stone be laid on in too thick layers at one time, the knife edges of the stone are made to bear upon each other, and the difficulty of setting is thus increased in something like the proportion in which the knife edges are destroyed.

Few country Highway Boards possess a steam roller, and newly laid-on metalling is indeed a severe strain upon the poor animals who have to drag heavy weights over it. Humanitarian grounds, are, I would submit, the only possible apology (for justification there otherwise cannot be) for applying clay, &c., in order to cause the metalling to set.

This difficulty, however, is one that it is within the power of any Road Surveyor to overcome, in a manner which, as my experience goes, is eminently satisfactory. I presume that if we had the power of converting the Basalt of the Clee Hill into its once liquid form and could apply it as we do Asphalte, so that in setting it regained its original toughness, we should possess a road surface made throughout, so to speak, of an impenetrable adamant, in which there could be no movement of its parts, and into which water could not find its way; and we should thereby avoid the, at times, disastrous and disintegrating effect of rain and frost.

We endeavour in road making to approximate to this ideal surface by breaking the stone into small portions or cubes in order that a concrete mass may be formed with as few and as small voids or interstices as possible.

The smaller the stone the more continuously solid is the resultant surface; but it is obvious that however small the pieces of metalling may be there will always exist interstices or voids; and to minimise such by a hard and binding substance, as hard as the metalling itself, ought to be the object of every one laying down a road.

This can be accomplished by the substitution of Clee Hill Dhu Stone Screenings for road siftings, clay, or earth. The voids are thus filled up and each cube is firmly wedged in position by an imperishable material: the surface is at once made flat and free from the roughness which would otherwise exist, and in a short time the road will be composed throughout of the one solid and unyielding Dhu Stone, possessing a watertight surface, the importance of which cannot be exaggerated. A road was so laid down giving access to these quarries some four years ago, and has not since been touched.

I can recommend the system on the ground of its economy, permanence, and ease of traction; such a road being superior to the one made in the ordinary way. The small vacant spaces otherwise filled up with earth, clay, or debris, become, in times of wet succeeded by frost, the equivalent of so many dynamite charges, which burst and disintegrate the road.

I may not be helping the Stone Companies by this recommendation, but anything which will tend to cheapen road construction and maintenance and to give better roads will, I believe, result in a still more extended use of the stone.

The output of the quarries is about 200,000 tons per annum. When I first became associated with the quarries there was no industry upon the hill; at the present time the men and boys directly employed number about 1,000, and indirectly of course a further number are beneficially affected by the Quarries. The stone goes beyond the local counties to London, Windsor, Ealing, Preston, Liverpool, Manchester, Crewe, Norfolk, Kent, &c., and as much as 20/- per ton has been paid for railway carriage alone, exclusive of after cartage, in a district where local stone, gravel, pebbles, &c., were available at a trivial cost.

A SHORT ACCOUNT

OF A

VISIT TO THE ANDAMAN ISLANDS

BY

E. W. PREVOST, Esq., Ph.D.

The Andaman Islands, concerning which the general public seems only to be aware that they are a convict station, lie in the Bay of Bengal, between 11° 25′ and 13° 35′ N. latitude, and just West of the 93rd meridian. Measuring about 140 miles long, with an average width of 10 miles, they form two groups, the Great and Little Andamans, and the former is again divided into the North, Middle, and South Islands; in addition there is a group on the Eastern coast, called the Archipelago, of which the individual islets bear the names of many of the heroes of the Indian Mutiny—Havelock, Outram, &c. On the Western coast lie the Labyrinth Islands, all uninhabited. The inhabitants of the Great Andaman are all friendly, except one tribe, the Jàrawàs; but it is only of late years, and after much patient toil, that Col. Cadell has succeeded in making friends with those who live on the Little Andaman. The size of this Island is 27 miles by 15. The Andamans form part of a chain which, starting with the Preparis and Cocos on the North, extends to Sumatra and the Sundas on the South, but with the exception of Barren Island, which is passed on the passage from Rangoon to Port Blair, there are now no signs of active volcanic action in the Northern section of the chain.

Barren Island, lying to the N.E. of Port Blair, is very nearly extinct, the last eruption having taken place in 1789; now only steam arises from its cone, and at the landing-place is found a hot spring, whose temperature in 1884 was 110 degrees, but it is now cooler. The cone, 1015 feet high, rises from a huge basin; at the top there is a crater 76 feet deep, and the floor measures 60 feet across. The island, consisting wholly of the walls of the basin, is covered from shore to summit with trees, and as this outer wall is 1100 feet high, nothing of the cone can be seen from the shore.

Before landing it may be as well to learn something of the history of these remarkable Islands, for remarkable they are as regards their inhabitants, both aboriginal and imported, as well as peculiar in regard to the paucity of variety of animal life.

Mention occurs of the Andamans in the writings of an Arabian historian in the 9th century; Marco Polo refers to them in the 13th, but not until the time of William III do we find any frequent mention of them, and in all reports the account of the inhabitants is greatly exaggerated.

It was not until Capt. Blair and Col. Colebrook made a survey that we got any trustworthy information. The name of the Islands seems to be of fairly ancient origin, though a variety of derivations have been proposed. The opinion of those most capable of judging is in favour of "Hanuman," the monkey god of India, and the Malays indicate the group by the name "Pulo Handuman."

There is no doubt that ships frequently called either under stress of weather, or in hopes of doing some trade, but the inhabitants refused to receive them under any conditions whatsoever, and it was not until 1789 that the first settlement at Port Cornwallis in the North Island was established. This was, however, soon abandoned, as it proved unhealthy, and nothing further was done until

Mouatt founded the penal settlement at Port Blair, after the Mutiny. Here at first the death rate was very high, amounting to 63 per cent., but in 1871 this had fallen to 1·2, and it is now stationary at 2 per cent.; and all this improvement has been obtained by draining the mangrove swamps, of which there are still plenty, but these are in progress of being cleared.

The passenger by steamer first sees the small Island of Ross, which lies at the mouth of the harbour of Port Blair, and though it is the smallest of the inhabited Islands, yet it is the most important, for on it lives the Governor, who possesses almost unlimited power. Here also are the Commissariat Stores, the Post Office, Barracks for European and Native troops, a Chapel and a Cemetery, and the houses of most of the European officials; so small is this Island and so tightly packed together are all the buildings, that I walked round it in 20 minutes. On the West side of Ross is a small jetty, but steamers and ships have to lie out in the harbour, and a boat lands the traveller at the jetty. Whoever wishes to land and stay on the Island must obtain leave of the Governor to do so, and this leave is freely granted to a British subject; but I believe I am right when I say that a foreigner must be provided with credentials of some sort. The Governor will apportion a bungalow for the use of those who desire it, and will in all probability cause the new arrival's name to be put up at the mess, and this is a very great advantage, for otherwise the very necessary subject of food will have to be discussed alone, as well as provided, which is here not too easy. From the mess-house or from the traveller's bungalow may be seen the whole harbour of Port Blair, with the Island of Chatham lying at the entrance to the creek. In front lies the mainland, the district of Aberdeen with the women's jail on the left, and Mount Harriet (the scene of Lord Mayo's massacre) on the right. Few prettier views can be seen anywhere; a native Bazaar and a tennis ground lying below in the immediate foreground, give life to the whole scene.

As I have before said, the object for which the Settlement was formed, was the imprisonment and forced labour of convicts from India and Burmah; the convicts are here to the number of 12,000, of whom 65 per cent. are Hindus, 25 per cent. Mahomadans, and the rest Burmese Buddhists. On their arrival, they are put to outdoor work and in the jail, for the caste principle prevents any combination for the purpose of mutiny; but lest there should be a mutiny or disturbance of any kind a company of British troops and some Madras infantry are always stationed in the barracks on Ross. In addition to this, there are 650 native police, principally Punjaubees; but these do not guard the convicts, they only keep watch on the many rowing-boats; and so well has this watch been kept that there has not been an escape by boat since 1880, and there are 130 boats and canoes kept at the Settlement. "Good conduct" men are selected to keep guard over the convicts.

For the first month, to impress the fact on their minds that they are not free, the convicts work in chains, but these are removed on proof of good conduct, and even when at work other than "hard" the prisoners are recognizable by a wooden tally suspended by a wire round the neck, on which is inscribed the date of sentence, the sentence itself, and the "code" number, so that at any time you may know the class of man with whom you may be brought in contact. It is not until a man has served 10 years, and has borne a good character that he is permitted to become a "jemadar," or petty officer, as already mentioned; or he may be, as many are (and women too) taken as a servant by any of the officials of the Settlement. It may be rather startling to learn that the best servants and the most trustworthy are the murderers, whilst the thieves are the worst; men frequently commit murder in a fit of jealousy, but do not make a business of murder, whereas the thief thieves as a matter of business, and "once a thief always a thief."

A convict may also become a "self-supporter," that is he is allowed to earn his own living as a petty shopkeeper, smith, &c.; of this class there are now 3,300. In addition to these privileges convicts are allowed to marry, if they can prove that they are unmarried; application is made to the womens' jail for any unmarried women who may be willing, and the man makes his choice. There are frequent small crimes, such as thefts, and these are dealt with by the several divisional police magistrates, but should the offence be a serious one, such as when a convict tired of his life attacks an officer, the case is tried in a more formal manner, and hanging is generally the result.

The labour of the convicts is not wholly lost, for they are employed in wood cutting, tea and coffee planting, vegetable growing, &c. The cost of the establishment amounts to 13 lakhs per annum; receipts from sale of wood, cocoa-nuts, &c., are about 4 lakhs, so that the net cost is £90,000 per annum. After 20 years servitude, good conduct men are allowed to return to their native country, and pardons are also granted for special deeds of gallantry, as when the women from the jail in the early hours of November 2, 1890, rescued the only survivor of the wreck of the "Enterprise."

The Europeans connected with the convict establishment as well as others, seem to enjoy life in these out-of-the-way parts, where at times the mails arrive but once in three weeks; one man I know told me he never meant to go home again, and I believe the late Governor came home with much regret. Life, excepting as regards the climate, is much as it is at home; tennis, boating, shooting, riding, are taken part in, ice is made, and special stores come out from England, whilst the country provides the mutton and beef. I should add, however, that though cattle can live healthily, sheep cannot do so, and hence it is necessary to import them from the mainland.

As regards the climate, I was informed that on the whole it was, though damp, healthy. The temperature varies from 67° to 91°, average 83°. The rain falls to an amount of 115 in., but unlike the mainland, the months of January, February, March, and April only are rainless. As regards the tides, the constants obtained from the gauge at Port Blair accord more nearly with theory than perhaps those of any other Indian station; the predictions agree very closely with the registered tidal curve.

Atmospheric disturbances of a fearful character are frequent in the Bay of Bengal, and according to the results of research in this matter, the cyclones (as the storms are called) originate near these Islands; but as no telegraphic cable is at yet in existence, warnings of the rise of such storms cannot be forwarded.

It was during the night of November 1, 1890, that a most serious cyclone arose, passed northwards, and wrecked many ships at the mouth of the Hugli, and in the Bay. At Ross the damage done was most remarkable, for it almost wholly destroyed the jetty, wrecked the Indian Marine Steamer "Enterprise," drove all except two of the boats from their moorings across to the mainland, and broke them up; the chaplain's bungalow was swept clean of its contents; as also was the bungalow of the Governor on Mount Harriet, but the exterior was untouched. On the Eastern side of the Islands the trees were stripped of all their beautiful creepers and reduced to the state of telegraph poles, and many were blown down, so that it was quite impossible for even the Andamanese to get through the jungle; but on the Western coast little or no damage was done.

As regards the geological features of the country, little of interest can be said. The rocks are chiefly serpentine and limestone; and a small quantity of iron and copper pyrites is found, but not in sufficient amount to make it worth while to work. Investigation has shown that the Islands are sinking, and a sunk forest has been discovered.

The forests of the present day cover the main portion of the land, down to the very water's edge, and many varieties of trees exist, the most valuable being the Gurjan (Bombax Malabaricum) which rises to a height of 200 feet, and the wood of which is hard, and straight in the grain; the growth is remarkable, as huge buttresses are formed stretching out several feet from the trunk. "Padouk" (Pterocarpus dalbergioides) is a hard wood, and red like mahogany, and is the best the Islands produce. All the wood is felled under the superintendence of the officials, and is shipped to Calcutta and London. The Fauna are small, and of carnivora there are only two species. The pig is peculiar to the Islands, and I am informed by an authority on the subject, that he differs from the ordinary pig in the following particulars:—tail very short, covered with somewhat long and shaggy bristles; molars much less complex; the hinder molar above and below shorter than the two preceding molars taken together. He is only 20 in. high at the shoulder. I did not have the pleasure of seeing a live specimen, though I saw a dead one being cooked, eaten, and disposed of, after their own fashion, by the aborigines.

Amongst the many fishes of these waters, one of the most curious is the "mud skipper," or jumping fish, (Periophthalmus Koelreuteri) having two pectoral fins, and great goggle eyes on the top of its head; it is only about three or four inches long, and lives as nearly out of the water as it is possible to do, appearing to be quite happy so long as a part of its tail is immersed. It is next to an impossibility to catch these fish, and "a naturalist in the Celebes" only succeeded in obtaining a specimen after hours of labour and by the use of numerous nets. The Andamanese are adepts in shooting fish with their curiously shaped bow, and their plain, straight, unfeathered arrow; I have watched them on the shore following by sight a fish in the water, until it came within bow-shot, and then with unerring aim transfix it, when the fish would float to the surface; I also saw another example of the wonderful accuracy of their aim. We were canoeing along shore, when suddenly the man at the bow jumped on to the gunwale, and threw his long bamboo punting pole at a "Pylaka," an ugly fish with a big mouth and teeth, which later on in the day made me a capital dinner.

I ought not to omit some mention of the shells for which this coast is famous; so much so that collections are made and sold in India for the benefit of the Andaman "Home." The varieties are numerous, beautiful in form and colour. Perhaps the largest is a Nautilus, which appears to be so common that I found them used as bailers for the boats.

One of the most interesting excursions that a stranger here can take is that over the Corals amongst the Labyrinth Islands. The forms and colours are glorious, though I believe that the corals are all of the ordinary kinds. The dexterity of the little Andamanese is marvellous; they propel and guide the long "dug-out" through narrow passages between rocks, which rise all round, intermixed with peaks of coral mountains, at low tide, without touching. Now and then circumstances in the shape of a very strong current are against the polers and the result is a bump; and the few bumps that I experienced made me feel uncommonly nervous, for had I been turned out into the water, either by capsizing of the canoe, or by dropping through a hole made in the bottom by the rock, nothing would have saved my life.

Having seen everything on the Western coast that was possible under the circumstances, I made my way by land and water to Kyd Island, which lies on the Eastern coast, and North of Ross.

A charming walk over a good road early in the morning took me past ferns and orchids, and beautiful trees to Mitha Kari. On my way I passed through a village inhabited, I suppose, by "self-supporters," and called in at the Telegraph Office to send off a message to one of the officials; messages must be written in Roman characters, and are sent to any part of the settlement for one anna the message, not by electricity, but by the heliograph, or when the sun does not shine, by flags. Official "wires" go free.

At Mitha Kari, a boat met me, and landed me on the Northern shore of the inlet, about half-way from the mouth, and then after a walk of six miles, past tea gardens and small farms, I arrived at Goplaka Bang, at the head of a narrow creek, where I found a canoe waiting for me; a wearisome journey was then begun on still water, past thick mangrove growth, under a blazing sun, and right glad was I to feel a little swell on, betokening the near approach to the open sea. Late in the afternoon I arrived at Kyd Island, or in the native tongue, Dura-tong. These boat expeditions are almost obligatory, for the jungles are too thick, and the roads too few, to allow of anyone travelling any distance by land.

At Dura-tong I found an excellent hut, and towards evening, a tribe of Andamanese arrived, having been out turtle fishing. With the tribe was a man, Joseph by name, who had been a servant to an Englishman, and had been to India, where he learnt to talk English very fairly, but like many aboriginals of other races, he could not avoid drink, and became a thorough drunkard, as well as a thief; he has therefore been brought back, turned out of the settlement, and now having taken to himself a wife he lives as he best can on turtle, pig, centipedes, beetles, and roots. I cheered him with a present of tea and sugar, and tobacco, and spent a long time talking with him that evening and next morning.

It was on this occasion that I saw the famous native pig; he had been freshly killed, and was now cut up, boiled in an old camp kettle, and then further cut up and distributed; previous to the cutting up he had been burnt and singed as is done here in Gloucestershire. This tribe that evening were not altogether happy, for though they were enjoying a good square meal, yet they had caught no turtle; for all turtle they catch are handed over to the Government who send them to Calcutta, and the proceeds of the sale are applied to the purchase of rice, for the use of all who choose to take advantage of the "Home."

The dress of the native is of the simplest. The men wear absolutely nothing, and the women a bustle, a leaf-apron, a necklace of bones, and a coronet of the same material; as ornaments the men wear an armlet made like the women's bustle, and a necklace of shells (Dentalium octagonum) and at times a coronet of human or other bones. Garters of shells and beads are also worn, but as a rule, if the man be married, his wife will reap the advantage of any beads which may be presented to her husband. This costume is what they wear when not in the settlement, which they visit at times; and then they are obliged to put on a little more, the women a skirt, which when over the dress-improver or bustle, produces a most ludicrous effect; the men wear drawers. All natives who choose to come, are taken care of at the "Home," which receives Rs. 200 per month from Government, and the funds are further aided by the sale of turtle, shells, bows and arrows, &c.; rice and a coarse woollen rug for use in the cold season are provided, but as a rule they never stay long at the "Home," preferring their wild uncontrolled life in the jungle, and they can always obtain tobacco, whilst spirits are strictly forbidden to them. Nearly all on the Great Andaman have been tamed and made friendly, but the Járawás still remain fierce, dangerous, and intractable; they seem to be somewhat different in race, for though their appearance is the same as that of the friendly tribes, their language is not.

The early reports of the Aborigines (9th century) made them hideous, with enormous hands and feet, 1 cubit long, and a writer in the "Sunday Magazine" also states that they are ugly, but I cannot say that this statement is correct, at all events with reference to the majority; there are always ugly people belonging to all races, and I certainly came across some who were quite good-looking, even according to European ideas, and well made, notably a man who was known as 'His Excellency.' Amongst the women, however, I did not find good looks; the hands and feet of all are small and neat, but then the average height of the men is only 4 ft. 10 in., and that of the women 3½ inches less. The origin of the race is unknown, but it is supposed to be closely allied to the Nigritos of the Philippines, and Professor Flower's opinion of them is that they are the least modified representatives of primitive inhabitants of a large portion of the earth, and verging on extinction. Whatever may be their origin, they are an unmixed race, for the Crania resemble each other, and they have not the projecting heel of the negro; their lips do not protrude excessively, and besides being intensely black, blacker than any negro, they have no smell, except what may arise from turtle-oil, or pig-fat mixed with ochre (koyob) with which at times they smear themselves. On gala days, and when they put on extra ornaments, they smear themselves with chalk.

The wool on the head does not grow as a mass, but in spiral tufts, and it is shaved to shape by the women with a piece of glass; all shave away from the forehead, but fancy, I believe, dictates further shaving, as for instance an alley-way down the centre of the scalp, while some cut it very short over the ears, &c. Wool or hair anywhere else on the body is rare, and not profuse. When some of these men were taken to the Calcutta Exhibition, their peculiar wool caused an excitement, and, as I was credibly informed, one man made about 20 rupees out of his head by selling the locks or tufts at R1 per lock!

Their distinctive manners and customs are few, and so are their manufactures; they depend on their bows and arrows for their main supplies of food, and the bow is very remarkable in shape, having a double curve, the one half of the bow bending from the string, the other toward the string. After a suitable piece of white wood has been chosen, the whole is fashioned by a sharp shell, or if possible by a bit of iron, then smoothed, and finally darkened in the smoke of a fire; the arrows are unfeathered, and have a point made of any piece of iron that can be found, such as an old nail, and I did see a bit of one of Fox's Paragon Frames acting in this capacity. The arrow used for pig shooting is, however, armed with a spear-shaped head, manufactured (I dare say) by hammering into shape a piece of a biscuit tin. This head is mounted on a short shaft, which in its turn is inserted loosely into a socket in a longer shaft, and the two are kept from separating by a short length of twisted fibre. The object of this arrangement is that when the pig is struck and runs away in the jungle, the head shall not be torn out of the wound, for the long shaft separating from the head hangs loose, being held to the head by the retaining strand. Nets are also made, and coarse pottery; twine or Betmo from fibre is laboriously prepared by the women, to provide lines and string generally. To make their canoes they employ an adze exactly similar to that which was used in pre-historic times, and the process of manufacture of such an adze has been carefully photographed in all stages by Mr Portman.

Of "fire-making" I could learn nothing, though I do not mean to imply that they know nothing of it, but I should judge that the practice has very much died out on account of the great ease with which matches can be obtained; and as the men have naturally no pockets, they carry the pipe fixed in the wool on one side of their head, the matches on the other.

The Andamanese appear to have no religious ideas at all. A few traditions concerning the population of the Islands are to be found in the Journals of the Anthropological Society, written by Mr Man, who has paid great attention to this, as also to their language, which he speaks like a native. They are monogamists, but take no care of their children, and are quite ready to hand the child over to the first person who may ask for it; few children are now born, and few survive birth, the natural result is, that the race is fast dying out, and their extinction is accelerated by death from measles and pneumonia. Boys and girls make excellent servants, and in the words of Col. Cadell, the late Governor, "they are such jolly merry little folk, and it is very saddening to live among them and to realize that they are fast dying out." As regards their jollity I can corroborate the Colonel, and no one with whom I came in contact had a bad word for them, though they have, like others, their faults.

They live in small tribes, but have no chiefs, though the strongest-minded amongst them takes the lead. The tribes are distinguished by tattoo-markings; these consist of a series of cicatrices formed by pinching up the skin, and then cutting it with a piece of glass; the patterns are somewhat of the herring-bone style, and are made on the chest; some have marks on their backs and arms, but I do not think that these have any especial significance.

Their amusements are few in number. They dance in a monotonous manner, and in their singing, the tune is restricted to three notes of our gamut, in the minor key.

They are fond of singing when they rest on their paddles, or just as they have laid themselves down for the night, but their music is rather weird and disagreeable.

The language is not unmelodious, with the accent on the last syllable, and the pitch of the voice is likewise raised on that syllable. The native word for bow is *ka-rama;* for pig arrow, *e-la;* for waist-belt, *bod;* for shell-belt, *gar-en-pe-'ta;* for North Andaman, *Aka-charria;* for South Andaman, *Bo-jig-ngiji.*

As a rule the dead are buried, but it is considered an honour to the dead to wrap the corpse in leaves, and place it on a platform in a tree; after a certain lapse of time, the remains are removed, and the bones worn as ornaments. During the period of mourning no turtle or pork is eaten, and the mourners smear themselves with white clay.

I had no opportunity of visiting the Little Andaman, neither would it have been altogether advisable for me to have gone there unaccompanied by some who knew the people and their language, for the inhabitants are not as tame as those on the Great Andaman, though as I have already said progress is being made, especially with the tribe of Ouges, who have accepted presents, and seem to be the most peaceful.

In appearance the inhabitants of the Little Andaman are the same as those of the other Islands, but they differ in language and habits. The huts on the Great Andaman are slight erections made of palm leaves, and will shelter only about six persons, whereas the huts of the Ouges are substantially built, bee-hived in shape, and will hold twenty persons; further, the women wear a tassel instead of a leaf apron, have many children, and the bows are like those of any other race, straight.

It may not unnaturally be asked, why does the Government of India take so much trouble to tame and support a moribund race?

The Andamans lie in the line of ships trading between the "Straits" Settlements and Europe, also many Malay crews trade between the Straits and Southern India. On account of the storms which suddenly arise, there are not unfrequent wrecks on these coasts, and when this happens few of the crew escape, being killed by the natives. If then the natives can be taught that those who land on their shores are not going to do harm, and should not be killed, many lives will be saved. A further and an important reason is found in the fact that at times convicts escape into the jungle; escapes by sea are very rare indeed, as it is almost certain death to put to sea on a raft. As soon as it is announced that a convict is in the jungle, the natives are sent out to track and bring them back, and to do this is not a laborious matter, for a convict has a healthy fear of an Andamanese bow and arrow. Col. Cadell thinks that it will be a few years yet ere ship-wrecked crews will be able to land on the Little Andaman with the safety which can be assured to them on the Great Andaman, but no trouble will be spared to thoroughly tame the Ouges and other tribes there.

There are several more points which I could have touched upon, but I have already kept you too long, and must now thank you for the attention which you have paid to me. The majority of the photographic slides which have been shown to you were taken on the spot, and the remainder have been lent to me for this purpose by the Scottish Geographical Society, and were prepared for a similar lecture given by Col. Cadell soon after his period of Governorship had expired. The objects which I have laid on the table are worthy of attention, as being in some respects unique; for instance, the bow is quite unlike any others made by any race.

SPECIMENS OF THE INDIAN ANTIQUITIES IN THE HOSKOLD COLLECTION

(THE NUMERALS REFER TO THE DESCRIPTIONS IN THE CATALOGUE)

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BY

H. D. AND C. L. HOSKOLD

No. 1. Vase painted red and black, with zig-zag lines, found in an Indian tomb in the neighbourhood of Gualfin, (Province of Catamarca).—On all the pottery and other objects of daily use in the time of the Incas, the sign of their Sun worship was invariably marked. When, however, the whole sign could not be employed, from want of space, portions of it, *i.e.*, the angular rays of the Sun, were adopted and made to traverse the object in a zig-zag manner; upon the pottery of the more ancient races, however, such signs are wanting. This vase must have belonged to a chief of a tribe, because it is of a good class: others, however, existed which were vastly superior.

No. 2. Vase found in an Indian tomb in the Province of Catamarca.—The markings upon this vase are indistinct, still there seems to be evidence that it belonged to a person anterior to the time of the Incas. If the signs upon it are correctly interpreted, they are serpent markings in an ornamental form. It does not seem to have been discovered that serpent worship or regard existed among the later Incas, but it is certain that the idea is an Egyptian one.

No. 3. Vase found at a depth of 8 feet below the surface at Copacabana, in the Province of Catamarca. It doubtless marked the site of an ancient grave.—This vase has two faces marked upon it very similar to an Egyptian type, and it is highly probable that it is much older than No. 2; but, although the neck part is broken off, it has the same shape. Nos. 2 and 3 may have belonged to different tribes; both, however, are very ancient.

No. 4. Vase found in an Indian grave in the Province of Catamarca.—This is of a different type, being a transition from Nos. 2 and 3. Probably it is a few centuries younger, or of the first Inca period. The Aztec sign of building predominates, but at the bottom part Sun-rays are visible.

No. 5. Vase found in an Indian grave in the Province of Catamarca.—This is of the same class and type as No. 4.

No. 6. Vase found in an Indian grave in the Province of Catamarca.—This has decided Sun-rays upon it, and is a little more elaborate, and possibly may have belonged to the period of the 2nd Inca, for as it was discovered at a considerable depth below the surface, and South of the principal seat of Government, the Sun worship had taken a firm hold upon the Southern tribes who had been conquered.

No. 7. Vase found in the grave of an Indian in the Province of Catamarca.—It is of the same form and type as Nos. 4, 5, and 6, but it has the serpent sign represented in an angular form. There is also a serpent's head over each of the handles, or if it should be proved not to be a serpent's head, then it may be a representation of the head of a diminutive species of Armadillo, an animal common in the provinces. Near to the bottom part Sun-rays appear. The superior part exhibits the outlines of the

Aztec sign of building, and appears to be an imitation of the Egyptian style. This and the serpent above, and the Sun-rays below, seem to indicate a conquered tribe, which, although subject to the Inca rule, still maintained and reverenced an older custom.

No. 8. Vase found in digging a water course near to La Troya, in the Province of Catamarca. It must have marked the site of an ancient tomb.—It has the same form and type as Nos. 2 and 3, but it is of ruder manufacture. The signs are difficult to read, but the presence of the face of a god or important personage on each side is sufficient to lead to the inference that an Egyptian type is indicated.

No. 9. Vase found in an Indian grave in the Province of Catamarca.—It is of the same type as No. 3, and seems to have belonged to a common family, who did not apparently much admire or advance the worship of the Sun, the signs of which are hardly more than straight lines.

No. 10. Vase found in an excavation in the Province of Catamarca. A blow from the pick broke it to pieces, one of which was lost. It can, however, be restored.—This is clearly of the character of No. 2, but the markings are better defined and finer. The entire absence of symbols of Sun worship confirms the idea that it belonged to a race prior to the time of the Incas.

No. 11. Vase found in an excavation in the Province of Catamarca, the neck part being broken.—It has the same form as No. 3, but is more modern, and is clearly of the Inca period.

No. 12. Water-bottle found in an excavation near Finogasta, in the Province of Catamarca.—It is well formed and must have belonged to a superior tribe, but as the sign of Sun worship upon it is not elaborate, the veneration for that cult could not have been very strong. A stroke from the pick during the process of excavation broke a hole in the bottom of the vase.

No. 13. Water-bottle found in the grave of an Indian at La Troya, in the Province of Catamarca.—It is of the same class as No. 12, but inferior in form; doubtless it belonged to one of the poorer families. The usual signs being double, Sun worship must have predominated. The date is about the time of the 3rd or 4th Inca.

No. 14. Water-bottle of a smaller size, for hand or table use, found in the grave of an Indian at La Troya, (Province of Catamarca).—It is of the same class and type as No. 13, and the same remarks apply to it.

No. 15. Water-bottle found in an excavation at Copacabana, in the Province of Catamarca, and doubtless marking the site of an Indian grave.—It is difficult to assign the period of this vase, but round the mouth or opening there may be seen the ears, nose, feet, and tail of an animal; possibly it may represent a Bat, but it is more likely that it is the Armadillo, referred to in the remarks to No. 7. The form of the animal is better seen if the bottom of the vase is held in the right hand out of the perpendicular with mouth pointing towards the person examining it.

No. 16. Vase or basin found in an excavation in the Province of Catamarca.—This object has lost its character, having been used for a considerable time by a modern family. The markings have been burnt off; probably it belonged to a race of older date than the Incas.

No. 17. Vase or basin found in the Province of Catamarca.—It has no special character, the markings being confused and inexplicable.

No. 18. Vase or basin found in an excavation near to the village of Belen, in the Province of Catamarca.—

There are no decided Inca markings upon this basin, but it is of superior workmanship, and made from a composition which may be called stone-ware. It is highly probable that it is one of the oldest in the collection. It is also a curious circumstance that it has the same form as the drinking cups of the Assyrians, carvings of which may be seen in that section of the British Museum.

No. 19. Lamp found in a grave in the Province of Catamarca.—It is very ancient and may date from the period of the 1st Inca, the Sun-rays being marked.

No. 20. Lamp found in a grave in the Province of Catamarca.—It is poorer in quality than No. 19, and without characters. It is difficult to assign its date.

No. 21. Lamp found in a grave in the Province of Catamarca.—The date of this lamp cannot be determined.

No. 22. Drinking cup.—It has the faces of Egyptian gods marked upon it, and may date from a period much anterior to the time of the Incas.

No. 23. Lamp found in an Indian grave in the Province of Catamarca.—This object has the parts of a small Armadillo marked upon it, but its age is not clear.

No. 24. Drinking cup found in the grave of an Indian family in the Province of Catamarca.—It is made of stone-ware. The Sun worship signs are numerous; the age is that of the Inca period.

No. 25. Paint-pot found in the Province of Catamarca.—It is made of stone-ware, of the time of the Incas.

No. 26. Common paint-pot.—Composition stone-ware, date uncertain.

No. 27. Small paint-bottle found in a grave near Finogasta, (Province of Catamarca).—It is made of stone-ware, and has the form of a beak in front, but its character and age are lost.

No. 28. Small paint-bottle found in a grave near Finogasta, in the Province of Catamarca.—Similar remarks apply to this as to No. 27.

No. 29. Small vase.—Appears to be a child's plaything. Age uncertain.

No. 30. Small vase.—Probably a child's plaything. Age uncertain.

No. 31. Small vase.—Probably a child's plaything. Age uncertain.

No. 32. Small vase.—Probably a child's plaything. Age uncertain.

No. 33. Call-whistle found at La Troya, in the Province of Catamarca.—Musical instrument in the form of a small Armadillo or Quilquincho. Age unknown.

No. 34. Whistle found at La Troya, in the Province of Catamarca.—Age of this instrument unknown.

No. 35. Instrument.—Use and age unknown.

No. 36. Instrument.—Use and age unknown.

No. 37. Strong-sounding whistle.—In the form of an animal. Age unknown.

No. 38. Pestle.—Apparently a child's plaything of the time of the Incas.

No. 39. Instrument obtained from a grave at La Troya, (Province of Catamarca).—Very ancient; probably of the time of the 1st Inca. Use unknown.

No. 40. Vase found in an excavation in the village of Belen, in the Province of Catamarca. Its handle was broken off by the stroke of a pick.—Probably of the date between the conquest of the Spaniards and the time of the expulsion of the Jesuits. Its use was that of a Maté, *i.e.*, a quantity of a certain herb of that name was placed in it, hot water poured upon it, and the tea sucked through a small tube. The class of instrument is still in common use, and is sometimes made of gold and silver.

No. 41. Vase found in an excavation in the village of Belen, (Province of Catamarca).—It was used for the same purpose as No. 40, but it is double and has the letters D.F.C. engraved upon it. Its date cannot be fixed, but it is not so old as No. 40.

No. 42. Vase found in an excavation in the village of Belen, (Province of Catamarca).—This has been glazed, and is comparatively modern. Its date cannot be fixed.

No. 43. An antique lamp, obtained from a grave at La Troya, (Province of Catamarca).—It has the face of an animal with the tail broken off. Probably it is an imitation of a land-tortoise. It is difficult to fix the date. It is not of the Inca period, but whether before or after is not clear.

No. 44. Part of a large vase, perfect when extracted from the excavation, but broken into many pieces by accident. From Fiambala, in the Province of Catamarca.—It has a well-defined face, probably of an Egyptian god in the act of crying for some departed favourite. It is of the time of the 1st or 2nd Inca.

No. 45. Part of the same vase as No. 44.

No. 46. Part of the same vase as No. 44.—The largest part saved of this beautiful vase.

No. 47. Vase obtained from La Troya.—Date and use unknown.

No. 48. Drinking cup obtained from the town of El Fuerte de Andalgala, (Province of Catamarca).—This drinking cup is much more ancient than any of the objects hitherto described in this catalogue. The characters engraved upon it are curious, and appear to differ one from the other. They may represent some ancient language now probably lost, or may be connected with some of those well known. This cup is worthy of the greatest attention and study. It was broken when obtained and since then it has been again broken, but all the pieces are present and it may be restored.

No. 49. Vase or basin of the common sort, found in an excavation at Finogasta, (Province of Catamarca).—Characters not well defined.

No. 50. A funeral image representing the face of a god lamenting the loss of some favourite friend.—Found in the grave of an Indian at La Troya, (Province of Catamarca).

No. 51. Bowl found in the Province of Catamarca. It was accidentally broken to pieces and some parts were lost.—Originally it had a perfect form, which appears to represent a high degree of civilization. It is difficult to determine its age, but it is probably of the same age as No. 18. The material is stone-ware.

Nos. 52 and 53. Pieces of a basin.—Source and age unknown.

No. 54. Pieces of different basins.—Source and age unknown.

No. 55. Square mortar used by the Indians for grinding substances to fine powder.—Obtained from Medianito, (Province of Catamarca).

No. 56. Face and arms of an Indian god.—Obtained from a small village called Medianito, situated at two days' journey South of the frontier of Bolivia, (Province of Catamarca).—It is carved in a very hard stone, probably Porphyry: owing to prolonged usage it is much worn. It was intended and was employed in modern times as a pestle to bruise Indian corn in a wooden mortar.

It is very old, but its age cannot be determined with exactitude. Probably it is older than the pottery described in this catalogue. The figure is carved in the attitude of adoration.

No. 57. Pestle obtained from a native or half-Indian at Anillaco, near the old Indian village now in ruins at La Troya, in the Province of Catamarca.—It has two faces of an Indian god carved on it, without arms. It appears to be of an Egyptian type. It is of the same age and was used for the same purpose as No. 56. It was obtained with great difficulty, and at last the Indian remarked, "Who knows that I shall not lose my good luck if I part with this object?"

No. 58. Hatchet obtained from the same neighbourhood as No. 57.—It has been so much worn by use that it is difficult to determine whether it originally had the face of a god upon it or not.

No. 59. An Indian god or effigy carved in slate. It is perfect in form, but the feet are broken off. It is clearly of an Egyptian type, and must have belonged to a race long before the time of the Incas. It seems to carry evidence that the memory of the form of things which existed in their mother country was preserved.—A history of this image was communicated, and it was searched for for several days and was ultimately found hidden under the pillow of an Indian girl.

No. 60. Face and arms of a small Indian god or effigy of the same type and age as No. 56. It has been much worn by use.—Obtained from a small village called Medianito, in the Province of Catamarca.

No. 61. Face of an Indian god or effigy of the same age, and obtained from Medianito, (Catamarca).

No. 62. A beautifully formed stone hatchet, but little used, of the same age as No. 56.—Obtained from Medianito, (Catamarca).

No. 63. Stone hatchet.—Obtained from Medianito, (Catamarca). Apparently it has not been used. It is of the same type and age as No. 56.

No. 64. Stone hatchet.—Obtained from Medianito, (Catamarca). It is of the same class and age as No. 56, but much worn by use.

No. 65. Pestle or grinding instrument in stone.—Obtained from Medianito, (Catamarca). Of the same date as No. 56.

No. 66. Worked stone, for grinding purposes.—Obtained from Medianito, (Catamarca).

No. 67. Round stone pestle used to rub up paint, of same age as No. 56.—Obtained from Medianito, (Catamarca).

No. 68. Round stone pestle, used to rub up paint, of the same date as No. 56.—Obtained from Medianito, (Catamarca).

No. 69. Indian instruments in stone, for arrow shooting practice of the young Indians.—Found at the Indian village La Troya, or Guatangasta, as it was anciently called, 8 leagues to the N.W. of Finogasta, (Province of Catamarca). It is of the time of the oldest Inca, as is indicated by its exterior form.

No. 70. Same as No. 69.

No. 71. Instrument in stone, probably Porphyry.—Obtained from an ancient Indian village now in ruins, in the Province of La Rioja. It was used by the Indians to engrave objects upon the rocks by percussion. Originally it had two well-made points at one end of the stone for this object, and these, although much worn, are still visible. The figures of animals upon the rocks were formed by dots made with the points of this graver.

No. 71*a*. Natural stone, ground flat on one side, probably employed for grinding paint and other things.—

Formerly this stone had the two sides alike. There exists an abundance of such stones in a natural condition, similar to a certain class of fossils, but their character is doubtful, the surface having been much worn by friction.

No. 71*b*. Stone ornament in the form of an animal.—This is of the same age as the stone hatchets previously described.

No. 71*c*. Stone Indian ornament.—Obtained from Guatangasta. Age and use unknown.

No. 71*d*. Stone ornament of the Indians. Age unknown.—Obtained from Guatangasta.

No. 71*e*. Blue coloured Indian ornament. Age unknown.—Obtained from Guatangasta.

Bronze Objects

No. 72. Bronze hatchet.—Found in the tomb of an Indian at Fiambala, (Province of Catamarca). It is probably of the time of the 1st Inca, or may have followed the stone implement age.

No. 73. Part of a bronze hatchet.—Found in the ruins of the Indian village Guatangasta or La Troya.

No. 74. Bronze hatchet.—From Guatangasta or La Troya. The blue oxidation has been cleaned off by the discoverer. Same age as No. 73.

Nos. 75, 76, 77, 78, 79, 79*a* and 79*b*. Bronze cutting instruments.—Found at La Troya. Employed by the Indians for carvings, &c. Same age as No. 72. Others of a similar nature exist with better cutting edges, but these are now in the possession of the writer. It would be interesting to make an analysis of all the bronze instruments so as to determine their constituents.

Nos. 80 and 81. Bronze Indian needles.—Found at La Troya. Of the same age as the other bronze objects.

No. 81*a* and 82. Bronze instruments.—Found in the ruins of the Indian village Guatangasta. They may have been used as pincers, or possibly as clasps for the ears for the support of pendants; but probably the former idea is more exact, because the Indians had a custom of extracting the hair from the face. They are of the same age as the other bronze objects.

No. 83. Bronze plate.—Found at La Troya. Age doubtful; it is probably not as old as the cutting implements, Nos. 76, 79*b*.

No. 84. Bronze bell of an oval form.—Found in one of the mountains in the Province of Catamarca. It is very ancient, and has fine faces cast upon it of the same type as the god No. 59, and part of the vase No. 54. There is, however, no sign of Inca Sun worship upon it; and it may consequently belong to an anterior period. Its exact use is unknown.

No. 85. Bronze bell.—Found in the mountains of Catamarca, where possibly it had remained since some war, which may have been instituted between the tribes or possibly at the Spanish conquest. It has four faces cast upon it of the same type as No. 84. If the surrounding ornamentation of zig-zag lines are Sun worship signs, it must have belonged to the time of one of the first Incas, but the faces point to ideas of things anterior to that worship.

Nos. 86 and 87. Bronze balls.—Obtained from the village of Belen, (Province of Catamarca). They may have been pendants, probably for the ears; since they are not worn they could not have been clappers of bells. Their age and precise use are unknown.

Nos. 88 and 89. Parts of ear-rings, having the form of birds. Age and source unknown.

No. 90. Bronze instrument.—Obtained from the vicinity of Finogasta, in the Province of Catamarca. This is cast in a very rough manner, and the discoverer has cut a large piece off it. It is an agricultural instrument, and if restored would have the form of an English hoe. It seems to be too roughly formed to have belonged to the period of the Spanish conquest. The inference is that it belonged to the Indians, who were employed in cultivating the soil. (See Garcilazo de la Vega and Prescott). An analysis of its constituents may produce evidence of age.

Nos. 91, 92, 93, 94, and 95. Bronze instruments.—Discovered in the ruins of an ancient Indian smelting furnace in the Province of Catamarca. It is difficult to discriminate between the ruins of the Indian smelting furnaces and those of the time of the Spanish conquest, but these instruments appear to be of the Indian period, and are of some interest as far as a determination of the constituents are concerned.

No. 96. Bronze handle.—Found near Finogasta, (Province of Catamarca). It appears to belong to a tea-caddy or small chest, of which it must have been the handle. It is probably of the time of the Spanish conquest or the Jesuits.

Skulls, &c., of Indians

Nos. 97, 98, 99, 101, 102, 105, 106, 107 and 108. Skulls and other bones.—Found in an ancient tomb, which had been made in soft micaceous schist between beds of inclined rock in a dry situation, near Anillaco, to the East of the ruined Indian village, La Troya, (Province of Catamarca). The tribe and age have not been determined. No. 99 is much older than the other two. Nos. 99 and 101 appear to belong to the same skeleton. Nos. 102 and 105 also appear to belong to the same skeleton.

Nos. 100, 103, 104 and 109. Skull and bones.—Found in an ancient Indian cemetery, near the small village of Medianito, in the Province of Catamarca. Evidently portions of the skeleton of a female idiot, much deformed. It belonged to a person about 30 years of age. The ribs of the chest were about the size of those of a child 9 or 10 years of age. This female seems to have walked in a doubled position.

No. 106. Lower part of spine.—Found in the same place as No. 97.

Nos. 107 and 108. Lower jaw-bone with teeth.—Age unknown. Found in the same place as No. 97.

Various Objects

Nos. 110 and 111. Shells.—Found in a mine in the N.W. portion of the Province of Catamarca. Apparently these were obtained from the West coast, indicating that the Indians of the interior had communication with the tribes inhabiting the extreme Western side of the Andes.

No. 112. Comb, made out of a hard piece of wood.—Found in a grave at the village called Sances, in the Province of La Rioja.

No. 113. Arrow heads, made out of hard siliceous stone.—Found in a grave at the village called Sances, in the Province of La Rioja.

No. 114. Arrow head, made out of bone.—Found in a grave at the village called Sances, in the Province of La Rioja.

No. 115. Implement, probably intended to be used for painting.—Found in a grave at the village called Sances, in the Province of La Rioja.

No. 116. Black coloured powder, used by the Indians for painting.—Found in a grave at the village called Sances, in the Province of La Rioja.

No 117. Sulphate of Sodium, almost pure.—Found in a grave at the village called Sances, in the Province of La Rioja. This chemical substance is found near Gualfin, at a distance of 85 miles to the N.E. of the grave in which this parcel was discovered. There is no indication of the purpose for which the Indians employed it. The determination of the elements of this salt was made by a chemist in Buenos Aires, but it would be interesting to have a particular and independent analysis made of it.

No. 118. Beans found in a grave at the village called Sances, in the Province of La Rioja.

No. 119. Part of an Indian garment used as grave clothes round the head of No. 99.—Found in the same Indian tomb as skull No. 99, in the Province of Catamarca. Probably it was made of the wool of the Guanaco or of the Vicuna.

No. 120. Two ropes made of twisted human hair; found in a grave at the village called Sances, in the Province of La Rioja.

No. 121. Small casket.—Found inclosed in the vase in the tomb of an Indian near the village of Medianito, (Province of Catamarca). It is beautifully made, having outline figures of Aztec or Egyptian temples marked upon it. It represents an epoch much anterior to the time of the Incas. After its discovery it was used by a woman belonging to a poor family for a period of 15 years, and so became mutilated. There has been a rude attempt made to repair the bottom part of it. Probably it is from 2000 to 3000 years old. It has been hermetically sealed in an earthen-ware vase, and hence time would have had but little effect upon it.

Nos. 122 and 123. Spikes of Indian Corn.—Found in the grave of an Indian at Sances, (Province of La Rioja). This proves that Indian Corn was indigenous, and the corns attached to the spike are smaller than they are at present found, indicating the natural condition or cultivation.

No. 124. Part of a basket, beautifully worked in different patterns, from a grave in the village of Sances, (Province of La Rioja).

No. 125. A beautiful piece of work with needles in it, probably not finished before the owner died.—Found in the grave of an Indian at Sances, (Province of La Rioja). It is one of the Inca books of knots and signs by which the Indians understood and recorded events, &c. It is an exceedingly rare object, and has great historical value, but it is doubtful whether anyone now living would be able to read its indications. (See Garcilazo de la Vega and Prescott: the first the best ancient, and the last the best modern historian).

The objects indicated in this catalogue were collected by H. D. and Carlos L. Hoskold, and are presented by them to the Museum of the Cotteswold Naturalists' Field Club, on the condition that the collection shall be preserved as long as that Club shall exist, and afterwards shall be placed in some permanent Museum in the County of Gloucester; but in either case the donors reserve to themselves the right to select two or three objects from the collection, supposing it were to be necessary.

H. D. HOSKOLD.

Buenos Aires, 15th January, 1892.

*** *The Collection is placed, for the present, in a case provided for the purpose by the Cotteswold Club, in the Price Memorial Hall, Brunswick Road, Gloucester.*