Conglomerates, and those at Mincombe are succeeded by the rubbly breccias of the Teignmouth type. There is no reason for thinking that the Lower Trias beds of the Paignton and Torquay district are as old as the Watcombe Clays; they are very probably locally modified representatives of part of the Conglomerates.

Scenery.—For scenery alone Babbacombe Bay, Petitor, and Watcombe, may compare with and outvie any other part of the South Devon coast, and I know of no place where the influence of geology upon scenery can be more advantageously studied.

Pleistocene.—There is no necessity to allude to the Raised Beach of Hopes Nose, which will be pointed out to you by Mr. Pengelly. It indicates a subsidence of 50 or 60 feet, and its elevation, coupled with the Paignton forest bed, prove that the land was subsequently lifted much above its present level.

EXCURSION TO RADLETT.

SATURDAY AFTERNOON, 12TH JULY, 1884.

Director: JOHN HOPKINSON, F.L.S., F.G.S., &c.

(Report by the Director.)

Rain had been falling the greater part of the day, and was still falling somewhat heavily when a very small contingent of the Association arrived at Radlett Station, meeting there the Director and a considerable number of members of the Hertfordshire Natural History Society, most of whom (including several ladies) had driven from Watford, while others had come by train from St. Albans.

The road leading to Shenley was taken for a short distance, when, by permission of Mr. Thomas Bagnall, Newberries Park was entered. After walking through the grounds adjoining the house, a meadow near the park was crossed, and an opening in it, not easily found, revealed the only existing exposure of the Hertfordshire conglomerate. This spot has not before been visited by the Association, and on this occasion the conglomerate was examined under by no means favourable auspices. It was necessary to walk for a sufficient distance through wet grass to add materially to the discomfort of a walk in the rain, and moreover there was no one amongst the party well acquainted with the geology of the neighbourhood or with the strata of which the conglomerate forms a part—the Woolwich and Reading Series. The rain, however, now

ceased, and the Director, after expressing his regret at the absence of any "Tertiary" geologist, gave the following account of the conglomerate in its relation to the strata in which it occurs, in the course of which he repeated a few observations which he made to the members of the Hertfordshire Natural History Society at a former visit to Newberries.*

We are now, he said, as on several previous occasions when the two societies have met together in Hertfordshire, standing on the edge of the London Tertiary Basin. We have examined the beds forming the outcrop of the Tertiary strata to the south-west at Woodcock Hill near Rickmansworth,† and at Watford Heath and Bushey near Watford,‡ and to the north-east at Hatfield § and at Hertford.¶ All along this line of outcrop we have had the Chalk on the north-west of us and the London Clay on the south-east, while immediately beneath our feet have been the sands, mottled clays, and pebble-beds of the Woolwich and Reading Series, reposing on the Chalk and being overlaid by the London Clay, of which we could in some places see only the basement-bed.

Underlying the Woolwich and Reading beds, on the opposite side of our Chalk basin, south of London, are the Thanet Sands, but on this edge of the basin they are absent, the Reading beds here reposing immediately on the Chalk, which appears to have suffered some amount of denudation before their deposition. They are very different in character to their representatives south of London. In the neighbourhood of Woolwich especially, clays in thin layers predominate throughout, and fossils are frequent, and show that the beds are of fluvatile or estuarine origin. Here there is usually but one thick bed of mottled clay, with sands above and below, and quite at the base a bed of rolled flint-pebbles in sand, apparently a true shingle-bed. Fossils are seldom found, and the general character of the beds indicates a marine origin, though partly, at least, littoral.

It is this shore-deposit that we have now before us, for the Hertfordshire conglomerate is merely the lowest bed of the Woolwich and Reading Series—the shingle-bed of flint-pebbles consolidated by the infiltration of silica. At Watford this shingle-bed is 15 feet thick, the black, rolled flint-pebbles being in a matrix of

* See 'Trans. Herts Nat. Hist. Soc.,' Vol. i, p. 33.

† 'Proc. Geol. Assoc.,' Vol. vii, p. 397.

‡ *Ib.*, Vol. ii, p. 43; Vol. iii, p. 65; Vol. iv, p. 284; Vol. vi, p. 191.

§ *Ib.*, Vol. iii, p. 240; Vol. iv, p. 518.

¶ *Ib.*, Vol. v, p. 519.

ochreous clayey sand, but not consolidated ; and in fact it is only at this spot that the shingle-bed can now be seen *in situ* in the form of a conglomerate, or, as it is sometimes called, "plum-pudding-stone." Blocks of this conglomerate occur, however, here and there, over a considerable portion of Hertfordshire, and they have also been seen in Essex. We know that the Reading beds once extended over the greater portion of Hertfordshire, by the outliers which are seen at various places, and it seems more probable that the blocks we meet with are relics of these beds, of which the looser portions have been carried away by denudation, than that they have been transported in a northerly direction from the neighbourhood of Radlett. It is probable that the land over which flowed the rivers which deposited the clays, sands, and pebbles of the Woolwich and Reading Series was to the south of the London and Hampshire Tertiary Basin, where the English Channel now is, and on this supposition we should expect to see the beds to the north more marine in character than the more southerly portion of the series. From the very variable character of the whole of this series it may be inferred that in no locality where it occurs was it, or any portion of it, a deep-sea deposit. Littoral conditions may have prevailed over at least a considerable portion of Hertfordshire, so that there is no improbability in the shingle-bed having at one time been of considerable extent, and throughout this extent it may anywhere have been consolidated into a conglomerate.

We now, therefore, see before us a fragment of an old sea-shore which is usually seen as a bed of loose flint-pebbles in sand, sometimes clayey, the pebbles having been derived from the denudation of the Chalk. How is it, then, that it occurs here in the form of a conglomerate, not, as is most usual, with a matrix solidified by calcareous matter, but by siliceous ? Professor Prestwich, in his well-known paper on "The Woolwich and Reading Series," in the 'Quarterly Journal of the Geological Society,'* says that in 1846 the mottled clays of the "Argile Plastique" of the Paris basin were found to contain "a very considerable proportion of gelatinous or soluble silica, *i.e.*, silica in an active chemical state, and soluble in alkaline solutions without fusion." He then says that he has "recently tested the mottled clays from various places in the London District," and has found that "they also contain this gelatinous silica, which can be readily separated by boiling in a solution of caustic potash," the proportion being, however, very variable.

* Vol. x, p. 75.

As the stratum which immediately overlies our pebble-bed consists in this neighbourhood of mottled clays, it is probably the gelatinous silica from them which has converted the bed into a conglomerate, and which, in other places, where sands underlie these clays, has converted the sand here and there into a sandstone. As blocks of our conglomerate are found scattered far and wide, so are blocks of this sandstone, which are known as "sarsen-stones" "grey-wethers," and "Druid sandstones," and it is quite as rare to find this sandstone in position as it is to find our Hertfordshire conglomerate.

The conglomerate is here seen to be split up into blocks, showing that it has been subjected to considerable disturbance, either by subsidence or upheaval, after its consolidation, and the hardness and durability of the siliceous cement is evidenced by the splitting of the pebbles in the general lines of fracture. In some places the pebbles have become so soft that they can be cut with a knife, while the matrix preserves its hardness. Another point of interest is that here and there the surface of the conglomerate is seen to be smooth and rounded, as if it had been subjected to the action of ice. It is the only rock we have anywhere in this neighbourhood, and probably the only rock in our Tertiary basin, which is sufficiently durable to show any trace of glacial action.

A careful examination of the conglomerate was then made in different parts of the pit, and pebbles here and there were freely subjected to the action of pen-knives, a few being found which could be cut into. The splitting up of the conglomerate was observed, and its surface was seen to be in some places evidently moutonnéed. The beautifully white, fine sand seen reposing upon an unconsolidated portion of the pebble-bed also attracted attention.

The road leading to Boreham Wood was then taken for a short distance, and, turning off it towards Letchmoor Heath, a stream flowing out of Elstree Reservoir into the River Colne was crossed. The bed of this stream is frequently dry, and there was not much water in it now, but the proximity of the underground reservoir, the plane of permanent saturation in the Chalk, to which attention was soon to be directed, was evident from a stream of water running down the road, which was not merely surface-drainage from the recent rain, its source being beneath the surface.

The route was now past Kendall Hall, and then past Kendall Pound, between which place and Battler's Green the principal

"swallow-holes" in the district are to be seen, there being others near Letchmoor Heath and Bushey. On arriving at the Battler's Green swallow-holes no water was to be seen. There having been a long period of dry weather the recent rainfall would be speedily absorbed; but that sometimes a large quantity of water would be seen to disappear was evident from the amount of solid matter which had been carried away.

The following explanation of the occurrence of these swallow-holes was then given by the Director.

The average yearly rainfall for this part of Hertfordshire for the last 20 or 25 years may, he said, be taken roughly as 26 inches. Of this amount scarcely a quarter, or $6\frac{1}{2}$ inches, sinks through the soil, by far the greater portion being evaporated or absorbed by vegetation. The water which sinks through the soil ultimately finds its way to the rivers, usually appearing above the surface in the form of springs. In this neighbourhood the springs will be found where the London Clay, or a clay bed of the Reading Series, crops out from under a bed of gravel. Sometimes, as in clayey districts, percolation is very slow, and the water soon collects on the surface into streamlets or brooks, but over the greater part of Hertfordshire percolation is comparatively rapid, the subsoil being gravelly and the gravel reposing on chalk. The water, therefore, soon finds its way below ground, there are no small streams on the surface, and the rivers are dependent entirely on springs.

When water flowing over a bed of clay, whether as a streamlet on the surface of the land, or by percolation through gravel or sand underneath the surface, meets with a pervious bed such as the chalk cropping out from beneath the clay, it sinks into this pervious bed, usually almost imperceptibly, but occasionally, either from the stratum being exceptionally pervious, or the body of water being unusually large, the water may be seen to disappear in what are called "swallow-holes." This phenomenon is frequently observed in chalk and limestone districts. When once the water has made for itself a channel in a calcareous rock, by a chemical action due to the water holding carbonic-acid gas in solution, the channel is gradually enlarged, and, although this action is going on generally throughout the rock, as seen by all water derived from limestone districts being "hard," that is, containing bi-carbonate of lime, the more rapid action when a channel is formed frequently causes the surface of the land to sink, a considerable amount of matter being carried away either by chemical or mechanical action. In this way

the Peak Cavern in Derbyshire has been formed, and the Mammoth Cave in Kentucky, and in these cases the course of the water can be traced from its disappearance from the surface to its appearance again above ground at the mouths of these caves. Here we see the water disappear, and we only know for certain that it reaches the plane of permanent saturation in the chalk, and so finds its way to the rivers.

Some years ago the two societies visited a picturesque pool near Watford, known as Otterspool.* Looking into this pool of beautifully-clear water several distinct springs could be seen rising out of the chalk at the bottom, where the pool is about 10 feet deep. From these springs about 300,000 gallons of water a day now rise, and flowing out of the pool in a powerful stream, augment the volume of the River Colne, and they have been known to yield a million gallons a day. The Rev. James C. Clutterbuck, in his paper on the "Geology and Water Supply of the neighbourhood of Watford," in the 'Transactions of the Watford Natural History Society,'† says that it has been supposed that there is some connexion between the irruption of water at Letchmore Heath, referring to these swallow-holes, and the well-known copious issue of water at Otterspool. "There are," he adds, "stories of ducks having found their way thither by some subterranean passage; and measurements of the level at which the water stands in the wells thereabout, and in the direction of the pool, show a regularity not easily accounted for but by the existence of some fault or fissure in that direction." Although we may discredit the "stories of ducks," the springs at Otterspool evidently arise from fissures or channels in the chalk extending in this direction, and it seems extremely probable that these and other swallow-holes in the parishes of Aldenham and Bushey at least contribute materially to the volume of water discharged by the springs.

When swallow-holes occur in the bed of a stream the water may sometimes be seen to disappear entirely in dry seasons, while when a large amount of water flows they may take part of it only and the stream may flow on merely diminished in volume. In the carrier which conveys the water from the Elstree Reservoir to the River Brent there are some swallow-holes which have to be plugged when the water is discharged from the reservoir to prevent the waste of the greater part if not the entire volume of the water. This

* 'Proc. Geol. Assoc.,' Vol. iv, p. 284.

† Vol. i, p. 125.

carrier must there be above the plane of permanent saturation of the Chalk, but most of our chalk-streams flow at the level of permanent saturation. This plane is not horizontal, the rivers flowing at the bottom of the valleys being at its lowest point, while on each side of the rivers the plane forms an incline towards the higher ground of from about 12 to 24 feet to the mile, varying in different years and at different times of the year. If in this valley the inclination of the surface of the ground did not exceed the inclination of the surface of the underground reservoir, the saturated chalk, the water would flow over the surface at the same time that it was flowing beneath the surface, but much more rapidly, for there is a resistance in the chalk, provided there is no channel or fissure, and it is this resistance, the amount of which is determined by the rapidity with which the chalk can absorb and part with water, which causes the plane of saturation to be inclined from the horizontal.

Water will always try to find its level, but, in the chalk, although always trying to do so, it scarcely ever succeeds, there being, in wet weather at least, a constant accession from above. Thus by the accession of water by percolation from above, and the abstraction by springs, or wells, or by outlet into rivers below, an equilibrium in the plane of saturation is maintained which is represented in this neighbourhood by an angle of at least 12 feet to the mile.

After walking a short distance across the fields the party separated at Battler's Green, some walking to Radlett Station, and others driving to Watford.

EXCURSION TO SOUTH DEVON.

JULY 21ST, AND FIVE FOLLOWING DAYS.

Directors : ARTHUR CHAMPERNOWNE, Esq., M.A., F.G.S.;
WILLIAM PENGELLY, Esq., F.R.S., F.G.S.; and RICHARD
NICHOLLS WORTH, Esq., F.G.S.

(*Report by* R. N. WORTH, F.G.S., *and* A. CHAMPERNOWNE, F.G.S.)

The district chosen as the scene of the long excursion of 1884 is one of peculiar interest to the geologist. The greater part of South Devon is occupied by rocks of the Devonian system, as generally recognised, and nowhere can the Devonian limestones be studied to better advantage than at Plymouth and Torquay. On the north of the area is the wild granitic expanse of Dartmoor,