Report (referred to in last week's NATURE) on application to the Hon. Secretaries, King Edward's School, Birmingham, or to the London Local Secretaries, Mr. C. W. Merrifield, F.R.S., South Kensington, and Mr. R. Tucker, University College School.

MR. I. LOWTHIAN BELL read a paper at the Institution of Civil Engineers on Tuesday evening, March 18, "On the conditions which favour and those which limit the Economy of Fuel in the Blast Furnace for Smelting Iron." A discussion on the paper was taken at the following meeting on Tuesday evening last.

MR. ALFRED SMEE, F.R.S., has in the press a volume entitled *My Garden*, in which he gives a complete description of his experimental garden at Beddington, in Surrey, and details the results of his experience in the culture of flowers and fruit: of these nearly 700 species and genera are described. The volume also treats generally of the natural history, geology, and antiquities of the neighbourhood. It is illustrated with about 1,000 wood engravings, executed expressly for the work. The volume will be published by Messrs. Bell and Daldy.

ANNUAL ADDRESS TO THE GEOLOGICAL SOCIETY OF LONDON, FEB. 16, 1872

BY J. PRESTWICH, F.R.S., PRESIDENT

IN looking at the labours of the Society during the past year, it is satisfactory to notice the same activity, the same wide range of subjects as ever, and the same independence of research for truth's sake which there ever should be. But, though good work has been done in special branches and the technical details of Geology, not so much progress has been made in its higher problems. I would, however, direct your attention to the steps made in grouping our volcanic rocks, and in the determination of the fauna of our Cambrian strata, which proves to be so much larger and richer than was anticipated a few years back. Both these subjects are in able hands, and cannot fail to yield important results, the latter especially in aiding to settle that interesting question—the true line of division between the Silurian and the Cambrian formations. On the subject of denudation and river-action, we have also had several excellent papers, and look forward with interest to the further development of the many original views which they have put before us.

The great question of the history of our globe during the Quaternary period seems also to be advancing towards more completeness. Many able observers, both in and out of our own Society, are engaged upon the subject, and various scientific periodicals and publications of our local societies are rich in contributions bearing upon this interesting subject. There is no more wonderful chapter in the earth's history than that which embraces the phenomena connected with the prevalence of great and exceptional cold immediately preceding our time,—the first dim appearance of man—his association with a race of great extinct Mammalia belonging to a cold climate—the persistent zoological characters of the one, so far as we have yet gone, in opposition to the variable types presented in geological time by the others—the search for connecting links, and the measure of man's antiquity,—all of which constitute theoretical problems of the highest interest, and are now occupying the attention of geologists of all countries. Allied also to this subject are the great questions relating to the form of our present continents—the elevation of the land—the origin of valleys and plains—and of all that which prepared this globe for the advent of man.

But while treating of these abstract and philosophical questions, geology deals also with the requirements of civilised man, showing him the best mode of providing for many of his wants, and guiding him in the search of much that is necessary for his welfare. The questions of water-supply, of building materials, of metalliferous veins, of iron and coal-supply, and of surface-soils, all come under this head, and constitute a scarcely less important, although a more special branch of our science than the palæontological questions connected with the life of past periods, or than the great theoretical problems relating to physical and cosmical phenomena. Looking at this triple division of geology, and seeing that the first, or applied geology, is, as it were, only incidental to our general studies, and therefore not often the topic of our discussions, notwithstanding its practical importance, I propose on this occasion to say a few words in connection with the two momentous subjects which, during the last few years, have been made the objects of investigation by two Royal Commissions,* on both of which the geological questions have received much and careful consideration. I shall here restrict myself to the more special geological bearings of the subject, extending them, however, in some directions beyond the scope of the original inquiries, and refer you to the Reports and Minutes of Evidence themselves for the many valuable economical questions and practical details which are there discussed.

Our Springs and Water-supply.

The site of a spring or the presence of a stream determined probably the first settlements of savage man; and his civilised descendants have continued, until the last few years, equally dependent upon like conditions—conditions connected first with the rainfall, and, secondly, with the distribution of the permeable and impermeable strata forming the surface of the country. Under ordinary circumstances, few large towns have arisen except where there has been an easily accessible localised water-supply, and where the catchment-basin on which depends the volume of the rivers has been large, and permeable strata prevail. Take, for example, London. Few sites could be more favourable in every respect. Beneath it are strata rich in springs, while at a distance there is that large development of those massive permeable strata so necessary to maintain a sufficient and permanent flow in our rivers. As the conditions exhibited in the London basin afford all the illustrations we need for our subject, I will confine myself in this address to that area alone.

London north of the Thames stands on a bed of gravel, varying in thickness from ten to twenty feet in round numbers, and overlying strata of tenacious clay from 100 to 200 feet. The former being easily permeable, the rain falling on its surface filters through it, until stopped by the impermeable London clay, where it accumulates and forms a never-failing source of supply to the innumerable shallow wells that have been sunk all over London from time immemorial, and which for centuries constituted its sole water-supply. Not only does it form an easily accessible underground reservoir, although of limited dimensions; but where the small intersecting valleys cut down through the bed of gravel into the London clay, a portion of the water in this reservoir escapes at the junction of the two strata, and gives rise to several springs formerly in much repute, such as those of Bagnigge Well, Holywell, Clerken-well, St. Chad's Well, and others.

The early growth of London followed unerringly the direction of this bed of gravel, eastward towards Whitechapel, Bow, and Stepney; north-eastward towards Hackney, Clapton, and Newington; and westward towards Chelsea and Kensington; while northward it came for many years to a sudden termination at Clerkenwell, Bloomsbury, Marylebone, Paddington, and Bayswater; for north of a line drawn from Bayswater by the Great Western station, Clarence Gate, Park Square, and along the north side of the New Road to Euston Square, Burton Crescent, and Mecklenburg Square, this bed of gravel terminates abruptly, and the London clay comes to the surface, and occupies all the ground to the north. A map of London, so recent as 1817, shows how well-defined was the extension of houses arising from this cause. Here and there only beyond the main body of the gravel there were a few outliers, such as those at Islington and Highbury; and there habitations followed. In the same way, south of the Thames, villages and buildings were gradually extended over the valley-gravels to Peckham, Camberwell, Brixton, and Clapham; while, beyond, houses and villages rose on the gravel-capped hills of Streatham, Denmark Hill, and Norwood. It was not until the facilities were afforded for an independent water-supply by the rapid extension of the works of the great water companies, that it became practicable to establish a town population in the clay districts of Holloway, Camden Town, Regent's Park, St. John's Wood, Westbourne, and Notting Hill.

On the outskirts of London a succession of villages grew up for miles on the great beds of gravel ranging on the east to Barking, Ilford, and Romford—on the north, following the valley of the Lea to Edmonton and Hoddesdon; and on the West, up the Thames-valley to Ealing, Hounslow, Slough, Hammersmith,

* Royal Commission on Water Supply, appointed April 1867. Report of the Commissioners and Minutes of Evidence and Appendix, June 1869. Royal Commission on Coal Supply, appointed June 1866. Reports of the Commissioners, Minutes of Evidence, Appendix, July 1871

and beyond; whereas, with the exception of Kilburn, hardly a house was to be met with a few years since between Paddington and Edgeware, or between Marylebone and Hendon; and not many even between the New Road and Highgate and Hampstead. As a marked case of the excluding effects of a large tract of impermeable strata close to a great city, I may mention the denuded London-clay district extending from a mile north of Acton, Ealing, and Hanwell, to Stanmore, Pinner and Ickenham, near Uxbridge. With the exception of Harrow (which stands on an outlier of the Bagshot Sands), and Perivale, and Greenford (on outliers of gravel), there are only the small villages of Northholt and Greenford Green. In the earlier edition of the Ordnance Maps, there was a tract of ten square miles north and westward of Harrow within which there were only four houses. Yet the ground is all cultivated and productive. But immediately eastward of this area, and ranging thence to the valley of the Lea, the ground rises higher, and most of the London-clay hills are capped by gravel of an older age than that of the London valley, and belonging to the boulder-clay series. On these we have the old settlements of Hendon, Stanmore, Finchley, Barnet, Totteridge, Whetstone, Southgate, and others.

There is yet another very common source of well-water supply from beds of gravel directing population to low sites in valleys, which is this. Everywhere on the banks of the Thames and its tributaries there is a lower-lying bed of valley-gravel or of rubble on, and often passing beneath, the level of the river. This bed is supplied with water both by rain falling on it, by springs thrown out from the adjacent hills or by the drainage from those hills and in places by infiltration from the river, when, from any cause, the line of water in the gravel falls below that of the adjacent river; while, on the other hand, the surplus land-supplies find their way direct and unseen, from the bed of gravel to the river. A great part of London south of the Thames, Westminster, Battersea, and a number of towns up the Thames, as Hammersmith, Brentford, Eton, Maidenhead, and others, together with Newbury and several villages on the Kennet, also the towns of Ware and Hertford on the Lea, have this shallow well-supply. A great many towns and numberless villages along most of our river-valleys all through England, and on whatever formation situated, are dependent on this superficial source of supply, a supply much more permanent than the other shallow well-supplies, in consequence of the outside aid from springs and rivers. It is, however, only in case of exceedingly dry seasons or of excessive pumping, that the supply requires to be supplemented by the river-waters. As, in ground of this description, the land-water is generally dammed back by the stream, the level of the water in the wells, which are always shallow, varies with the level of the water in the streams, rising and falling more or less with them.

A few of the higher London-clay hills in the neighbourhood of London are also capped by outliers of the Bagshot Sands, as, for example, Harrow, Hampstead, and Highgate, all of which are sites of old habitations. The sands at these places attain a thickness of from 30 to 80 feet, are very permeable, and afford a sufficient water-supply by means of wells to a limited population. A number of well-known small springs are thrown out at the contact of the sands and the clay on the slopes just below and around the summit both of Highgate and Hampstead Hills. In some instances, owing to the presence of iron in the sands, they are slightly chalybeate. When the Baghshot Sands, further westward of London, attain their fuller development of from 300 to 400 feet, the depth to the water-level at their base becomes so great that the upper porous beds are left high and dry, and form uncultivated wastes, such as Bagshot Heath, Frimley Heath, and others; but on the outside of this area, where the sands become thinner, and the water-level more within reach, we find a number of villages, such as Englefield Green, Sunninghill, Brackwell, Wokingham, Alderstone, Esher, Weybridge, Woking, &c. There are also some thin subordinate beds of clay in the middle of the series which hold up a sufficient quantity of water for small local supplies, and give rise to small streams in the valleys of the Blackwater and of Chobham. The running nature of portions of these sands, and the presence of beds of ferruginous and green sands, often interfere much with the construction of deep wells, and the quantity of the well-water; and, externally, the mixed clay-and-sand character of the upper beds of the London clay fails to give any good retaining-line for the water, which therefore rarely issues as springs, but oozes out from the general surface of the intermediate spongy mass.

The 70 to 100 feet of sands and pebble-beds belonging to the lower tertiary strata under the London clay, and overlying the chalk, are also very permeable, and being intercalated with some beds of retentive clay, they give rise to one or two levels of water, affording wherever these strata form the surface, as at Blackheath, Bexley, Chiselhurst, and Bromley, a moderate water-supply to shallow wells. Where these sands dip under the London clay, and only present a narrow belt on the surface, a small valley is commonly formed into which the London-clay hills drain on the one side, and on the other the chalk dammed back by the Tertiary strata throws out its springs, and the sands are thus kept charged with water up to a short depth from the surface. As instances of the many places whose sites have been determined by these favourable circumstances, I may name Croydon, Beddington, Carshalton, Sutton, Cheam, Ewell, the villages between Epsom, Ashstead, and Leatherhead, to Guildford, and again between Old Basing and Kingsclere.

But besides furnishing a supply by ordinary wells to a number of villages on their line of outcrop, the Lower Tertiary sands have of late years contributed to the metropolitan supply, as well as to the supply of those adjacent districts where the surface is formed of tenacious clay, and water is scarce, by means of artesian wells. For along the line of country just named, and along a more irregular belt on the north of London, these sands pass beneath the London clay, so that the water they receive from rain and springs on the surface, passes underground, where it is prevented from rising by the impermeable superincumbent clay; consequently, as there is no outlet for the water below ground, these sand-beds are filled with water along their whole underground range, between their outcrop in Surrey and that in Hertfordshire.

I need not dwell here upon the constructions of Artesian wells, which have been explained by Hericart de Thury, Arago, Degousée and Laurent, Burnell, Hughes, myself, and others, beyond offering a few explanatory remarks on this particular case, which we shall also have to bring to bear upon the origin of springs.

The surface of the ground at the outcrop, just referred to, of the Lower Tertiary sands is about 100 ft. above the level of the Thames, whilst under London the sands are at a depth of from 100 ft. to 220 ft. below that level, thus forming the shell of a basin from 200 ft. to 300 ft. deep, the centre of which is filled with a depressed mass of impermeable clay. There is, however, a notch in the lip of the basin, where it is traversed by the Thames, at Deptford and Greenwich, which is at a lower level of 100 ft. than the rest of the rim. Below this level, as there is no escape for the water, the strata are naturally perpetually water-logged; and if any water is withdrawn from one part, it is, owing to the permeability of the strata, at once replaced from adjacent parts of the same strata. Early in the present century, bore-holes were made through the overlying London clay to the sands at depths of from 80 ft. to 140 ft., and the water from these deep-seated springs rose at once to a height of several feet above the level of the Thames, where it tended to maintain itself, and thus form, in the lower-lying districts, permanent natural fountains. But the ease and facility with which this abundant supply was obtained, led to the construction of so great a number of such wells that a time soon came when the annual rain outfall no longer sufficed to meet the demand, or, rather, it could not be transmitted fast enough to the central area of abstraction to replace the out-draught. The consequence was that, after some years, the water ceased to overflow, and the line of water-level has gradually sunk at London, until it now stands some 70 ft. or 80 ft. beneath the surface level. This, however, is not the case at a distance from London; and in many parts of Middlesex, and more especially in Essex, where Artesian wells are common, they have been found of very great service.

In order to supply the deficiency thus caused in the Lower Tertiary sand, most of the Artesian wells in London have of late years been carried down into the underlying chalk, which also extends beneath London at depths of from 150 ft. to 280 ft. Both formations are permeable, but in different ways. On both the rainfall is at once absorbed, but the transmission of it is effected in different ways. Through the sands it filters at once; but not so with the chalk. A cubic foot of the latter will hold two gallons of water by mere capillary attraction; but it parts with this with difficulty. Still in time it finds its way through the body of the chalk, aided by the innumerable joints, fissures, and lines of flints by which this formation is traversed; and, when once under the line of saturation, the water in these fissures circulates freely. This line of saturation is governed in this as well as in all other permeable formations, by the level of the lowest natural point of escape, which is either the coast-line if near, or the nearest river-valley. Below these levels permeable strata are always charged with water; consequently under London the chalk is everywhere water-bearing; but as the Lower Chalk is more compact than the Upper, and is less fissured, especially when covered by other strata, and as the more compact water-logged chalk delivers its charge with extreme slowness, it is not until a fissure is met with that a free supply of water is obtained. Further, as there is no law regulating the position of the fissures, the depth to which the chalk has to be traversed before meeting with a free supply of water is quite uncertain. It is a question of probability depending upon meeting with a fissure sooner or later—10 to 15 feet have sufficed in some of the deep London wells, whereas in others it has been necessary to sink to a depth of from 100 to 200 feet or more before hitting on the necessary fissures. Large as this supply is, the same causes which have operated in the case of the sands have told also on the chalk supplies (and, no doubt, there is some community between the two), and the great demands on it have occasioned a similar lowering of the water-line. At the same time this line also remains unaltered at a distance from London, and as with Tertiary Sands the mass of the chalk beneath intersecting the level of the river valleys remains constantly charged with water. Ordinary wells, therefore, sunk below this line of saturation into the chalk where it comes to or near the surface, are capable of yielding very large quantities of water. More than seven million gallons daily are in fact now so obtained from the chalk on the south-east of London.

Numerous and useful as the London Artesian wells are, they sink into insignificance when compared with the application of the same system in Paris. Our deepest wells range from about 400 to 500 feet, and the water comes from the chalk hills at a nearest distance of from 15 to 25 miles from London; whereas in Paris the well of Grenelle is 1,798 feet deep, and derives its supplies from the rain-water falling in the Lower Greensands of Champagne, and travelling above 100 miles underground before reaching Paris. The well of Passy, sunk also through the Chalk into the Lower Greensands at a depth of 1,923 feet, derives its supplies from the same source. The level of the ground above the sea at the outcrop of the Lower Greensands in Champagne averages about 350 feet, and the water at Grenelle well rises 120 above the surface, which is nearly the level of the Seine, there 89 feet above the sea-level. The water-delivery is large and well maintained. These results were considered so encouraging, that in 1865 the Municipality of Paris decided on sinking two Artesian wells of unexampled magnitude. Hitherto the bore-holes of such wells have been measured by inches, varying from 14 to 4 inches, that of Passy alone having been 4 feet at the surface and 2 feet 4 inches at bottom. But it was resolved to exceed even the larger dimensions of this well.

One of these experimental wells is in the north of Paris, at La Chapelle, St. Denis, 157 feet above the sea-level. A shaft, with a diameter of of 6½ feet, was first sunk through Tertiary strata to a depth of 113 feet. At this point the boring was commenced with a diameter of 5½ feet, and carried through difficult Tertiary strata to a depth of 450 feet, when the Chalk was reached. A fresh bore-hole was here commenced in August 1867, which in September 1870 had reached the depth of 1,954 feet. The works were stopped on account of the war until June 1871, when they were resumed, and the bore-hole has now reached the great depth of 2,034 feet, with a diameter still of 4 feet 4½ inches. It is now in the Grey Chalk, and it is calculated that the Lower Greensands will be reached at a depth of about 2,300 feet.

The other Artesian well is at the Buttes-aux-Cailles, on the south-east of Paris, at an elevation of 203 ft. above the sea. The Tertiary strata are there only 205 ft. thick. This well is not quite on so large a scale as the other, and is still, at the depth of 1,640 ft., in the White Chalk.

The discharge from these great wells will probably be equal to that of a small river. At Passy, notwithstanding some defective tubage, and the circumstance that the surface of the ground is there 86 ft. above the Seine, the discharge at the surface is equal to 3½ millons of gallons daily; and it has been above 5 millions, or enough for the supply of a town of 150,000 inhabitants.

The question may arise, and has arisen, why, with a like geological structure, should not like results be obtained at London as at Paris; and, to a certain extent, it has been answered. At Kentish Town an Artesian well was, in 1855, carried through 324 feet of Tertiary strata, 645 ft. of Chalk, 14 ft. of Upper Greensand, and 130ft. of Gault. Instead of then meeting with the water-bearing Lower Greensands which crop out from beneath the Chalk, both on the north and south of London, unexpected geological conditions were found to prevail, to which we shall have occasion to refer presently; and not only were these Greensands found to be absent, but likewise all the Oolitic and Liassic series. The bore-hole passed at once from the Gault into a series of red and grey sandstones, probably of Palæozoic age, and not water-bearing. The Chalk has more recently been traversed at Crossness, near Plumstead, where its base was reached at a depth of 785 ft., and the bore-hole carried 159 ft. deeper into, but not through, the Gault, when, owing to difficulties caused by the small size of the bore-hole, the work had to be abandoned. Although we were mistaken in our anticipations as to the results of the first of these works, still it is evident—as the Lower Greensands, with a thickness of 450 ft., pass beneath the Chalk and the Gault in a line from Farnham, Reigate, to and beyond Sevenoaks—and they again occupy the same position north of London, on a line from Leighton Buzzard to Potton—that it is only a question of how far they may be prolonged underground towards London. They have as yet been followed only 4 miles from their outcrop under the Gault in Buckinghamshire, and 1 mile in Kent; and no attempt has been made to follow them under the Chalk. It is therefore quite possible that they may extend to under Croydon, or even to Sydenham, or still nearer London; but this depends upon the width of the underground ridge of Palæozoic rocks, which has not been determined. It is a matter for trial. As the sands are from 200 to 500 ft. thick, and show no sign of an immediate approach to the old shore-line, there is every probability that in Kent and Surrey they extend at all events some miles northward, and in Bucks some miles southward, before they thin off against the underground ridge of old rocks, so that they might still be found available, as a supplementary source, for the water-supply of London.

Such is the geological structure of the ground on which this large city is dependent for its first and immediate water-supply by means of wells. The highest seam of water, that in the drift-gravel, extends almost everywhere under the streets and houses of London, at depths of from 12ft. to 25ft., forming what is called ground-springs. The Lower Tertiary sands, with their greater thickness, and their larger and distant area of outcrop, contain the second and larger underground body of water beneath London. The third underground reservoir is the Chalk, which, from its large dimensions—500ft. to 1,000ft. thick—and extensive superficial area, forms a still larger reservoir, and source of water-supply.

With the increase of population, however, the need for larger quantities necessitated the recourse to river-supply; and this supply, equally with the other, is regulated by geological conditions, only that in this case the question concerns those conditions which affect the strata throughout the catchment-basin of the river itself above the town which needs its supply.

(*To be continued.*)

PROF. SCHIAPARELLI'S RESEARCHES

THE following address was delivered by the president of the Royal Astronomical Society, Mr. William Lassell, February 9, 1872, on presenting the Gold Medal of the Society to Signor Schiaparelli:—

You will have learned from the Report just read, that your Council have awarded the Gold Medal this year to Signor Schiaparelli; and I regret to have to inform you that we shall be deprived of the pleasure of presenting it to him in person; as by a letter received from him a few days ago, I learn that his duties of Professor and Director of the Observatory at Milan will prevent his being able to undertake so long a journey.

The first notice I find of Signor Schiaparelli's labours is his discovery of the minor planet *Hesperia*, at the Observatory of Milan, on April 29, 1861, an indication that, besides his mathematical attainments in Theoretical Astronomy, he possesses industry and practical skill as an observer.

In the *Astronomische Nachrichten* of August 13, 1864 (No. 1487), is a purely mathematical paper by him, entitled "Théorèmes sur le mouvement de plusiers corps qui s'attirent mutuellement dans l'espace." Of this paper, not bearing immediately upon those labours of Signor Schiaparelli which have more especially called forth the award, I will only express the opinion of a friend of high mathematical attainments, who