the lip of the cataract without support. In this way great masses of the limestone are constantly breaking off along lines of jointing, and the Falls are gradually receding up the river, and the length of the ravine below the cataracts is constantly being increased. If the strata through which the river cuts were quite horizontal, there would be no limit to the recession of the Falls and to the length of the gorge which might be formed in this way. But, the strata have a slight dip in the opposite direction to that in which the river flows, or in the same direction as that in which the Falls are receding. It results from this that when the river has cut its way back for a certain distance, the conditions of the case must change. The hard and compact limestone which now forms the edge of the Falls will ultimately come to form the bed of the river; and as the strata which succeed this upwards are of a softer nature, the place of a single fall with a long ravine below it will finally be taken by a continuous rapid or a succession of minor cascades. As has been pointed out by Hall and Lyell, this is precisely the action which is going on at the Falls of Niagara, but upon a gigantic scale. I have endeavoured to show, however, that very similar phenomena may be produced under very different conditions; as is seen in Watkins Glen, where the strata through which the stream cuts are of a very uniform nature, but are regularly intersected by two sets of vertical joints cutting one another at right angles.

VII.—GROOVED BOULDERS IN DILUVIAL CLAY, WATSON'S HOSPITAL, EDINBURGH.

By W. T. BLACK, Esq.

THE excavations for the foundations of the new Infirmary in the grounds of Watson's Hospital, Edinburgh, have disclosed several Boulders, which appear lying in the Diluvial-clay. This is a marly clay, and has been dug to the depth of about five feet, in several horizontal terraces, down the slope from north to south. These Boulders were of sufficient size to be left behind *in situ* by the labourers, and about six large ones were found in the north and twelve in the south area of the grounds. They were of trappean rock chiefly, being rounded on the angles and sides, and of a dark green crystalline structure internally. A large one in the north area was of a metamorphic granitic character; one in the same area of a buff-coloured sandstone; and another in the south was composed of the same rock, and grooved also.

The grounds are in the form of an unequal quadrilateral figure, of the mean length of 850 feet and breadth of 750 feet, and are divided into two areas north and south by the buildings of the hospital.

The slope of the grounds of Watson's Hospital is towards the south, down to the Meadows, from Lauriston Street, on the north; and the angle may be about $2\frac{3}{4}^{\circ}$, or 1 foot in 20. In the northern area, the dimensions of the larger granitoid Boulder (No. 2) were 1ft. 8in. high, 2ft. 4in. long, and its horizontal circumference was 7ft. 6in., and the depth of the platform it was found on was 4ft. 8in.

The dimensions of the smaller trap Boulder (No. 1), in the north area, were 1ft. high, 1ft. 9in. long, the horizontal circumference was 5ft. 5in., and the depth of the platform 5ft. from the surface.

Both of these Boulders were grooved all over their upper surface, and the markings were all in one direction, except one or two streaks might be somewhat diagonally placed with respect to the others. The depth of the grooves was about $\frac{1}{8}$ to $\frac{1}{4}$ of an inch, and the breadth $\frac{1}{4}$ to $\frac{1}{2}$ an inch or more, and they extended right across the planes they scored, some being as long as 12 inches, and some as short as 2 inches.

Many of the grooves started abruptly into the surface of the boulder, whence they gradually shaded off to streaks, which some of them began with and ended, while the middle was deeply cut.

The Boulder (No. 3), without grooves, lying in the eastern cutting on the north area, was of the usual trappean description, with rounded edges and corners, and laminae on the surface, that peeled off in superficial cakes.

Its dimensions were: 1ft. 4in. deep, 1ft. 9in. broad at the larger end, 2ft. 9in. long, with a horizontal circumference of 7ft. 5in., and it lay loose on the platform.

A flat Boulder (No. 4), of buff-coloured sandstone, in the north area, lay loose on the surface, and had its upper surface scored with deep grooves more or less parallel.

In the southern area of the hospital grounds were found, exposed in the excavations, about a dozen other Boulders, all of trappean character except No. 7, which was of a violet-coloured crystalline sandstone. Of these, eight were found scored with grooves of a similar character as those described on the boulders in the north area, and the sandstone block, No. 7, was also well marked with streaks.

The dimensions of one in the west cutting (No. 10) were: 1ft. high, 1ft. 7in. long, 1ft. 5in. broad, and it was 5ft. 6in. in circumference, oval in shape, and had grooves on two sides, all in the same direction, and the depth of the platform was about 2ft.

In the middle cutting was a large rounded one (No. 11), *in situ*, in the bank and near the surface of the soil, when the upper surface had only grooves, and these, like the last, tended all down hill.

Its dimensions were: length, 2ft. 3in.; height, 1ft. 4in.; and depth of platform, 2ft.; so that the soil above it was 8 in. deep, and of this half was of loam and the rest the marly subsoil.

None of the above-mentioned Boulders were seen to lie on the subjacent rock, but were all lying in the middle or near the top of the clayey stratum.

The rocky bed below this has only been exposed in one place in the south area, at about six feet below the surface, and this is a buff-coloured soft sandstone superficially, but of more densely crystalline structure deeper.

These igneous Boulders can be conjectured to have been carried by glacial or aqueous agency from numerous sources in the neighbourhood of Edinburgh; as the Castle Hill to the north, Corstorphine

Hill to the west, and Arthur's Seat to the east, which are greenstone eminences not far distant.

As to the agent producing the grooves, the general impression from their up and down hill course seemed to be that they were caused by the ploughshare in times gone by, when the locality might have been under cultivation for grass.

The probabilities against these grooves being due to glacial action rest chiefly upon their not being smoothened or polished, and their course curving over the rotundity of the upper surface of the boulders, and the starting of some channels by sudden indents in the stones. It may, however, be stated that the overlookers on the works think that some of the boulders lie too deep to have been marked by the old kinds of plough, and that these lie also in undisturbed subsoil, below the loam on the surface.¹

The evidence on this subject indicates that No. 1 grooved Boulder and No. 2 were both about three feet below the surface, No. 10 was one foot, and No. 11 was eight inches; while, again, Nos. 7 and 8 grooved Boulders just appeared on the level of the original slope of the ground.

The Secretary of the Institution has informed me that the grounds have not been used for agricultural purposes since the building of the Hospital in 1738. Previous to that event it was common land, called Heriot's Croft, and was probably meadow land when purchased by Watson's Trustees from those of Heriot's Hospital.

NOTICES OF MEMOIRS.

I.—MEMOIRS OF THE GEOLOGICAL SURVEY.

WE have much pleasure in stating that Part I. of the Memoir by Mr. W. Whitaker, B.A., F.G.S., on the Geology of the London Basin, has just been published. It occupies over 600 pages, and includes an account of the Chalk and the Eocene beds of the Southern and Western Tracts, lying in the counties of Berks, Bucks, Essex, Herts, Kent, Middlesex, Surrey, etc., with parts, by H. W. Bristow, F.R.S., Director, T. McK. Hughes, M.A., F.G.S., and notes from other members of the Geological Survey of England. We hope, in a future number, to give a more extensive notice of Mr. Whitaker's work, which, from the amount of detailed information on the Geology, together with the appendices on the Bibliography, Well Sections, and Fossils, cannot fail to be of great practical as well as scientific value.

¹ An eminent Scottish Geologist writes to the Editor that "the *true* glacial striae in the neighbourhood of Edinburgh all go from west to east; whereas the direction of the striae on the erratics, examined by Mr. Black, appear to go from north to south." This, he thinks, "looks like *the plough*." "Striated pavements of Boulders," he adds, "are *great rarities*; Hugh Miller has recorded a single instance."—Lyell's *Elementary Geology*, p. 147. Chambers' Papers, Proceed. Royal Soc. of Edinburgh, April 20th, 1857.