V. *An Account of some recent Researches near Cairo, undertaken with the view of throwing light upon the Geological History of the Alluvial Land of Egypt.— Instituted by* LEONARD HORNER, *Esq., Vice-President of the Royal Society, Fellow of the Royal Society of Edinburgh, and Vice-President of the Geological Society.*

PART II.

Received January 25,—Read February 11, 1858.

CONTENTS:—

AT the conclusion of the first part of this memoir*, I stated that, besides the operations at Heliopolis therein described, researches on a more extensive scale had subsequently been undertaken in the district of ancient Memphis and in the valley on the western

* Philosophical Transactions, 1855, Part I. p. 105. It may be useful for the reader to refer to the Introduction in Part I., where I describe the geological object of these researches, and the means by which I hoped that it might be accomplished.

side of the Nile in the parallel of Heliopolis. These researches I now proceed to describe.

In accordance with the opinion I entertained, when I undertook the inquiry, that excavations should be made in the vicinity of some very ancient monument, the age of which is known, I chose the site of the long extinct city of Memphis, now covered with the date groves of the modern village of Metrahenny, twenty miles above the parallel of Heliopolis, and about thirty miles above the apex of the Delta. All testimony appears to concur as to its very remote antiquity; in assigning its foundation to MENES, the first king of the first dynasty which reigned over Egypt, and who, according to LEPSIUS, the latest and very able expounder of Egyptian chronology, began his reign 3892 years before the Christian era.

HERODOTUS relates*, that MENES turned the course of the Nile eastward, by an embankment 100 stadia higher up the river, to dam out the inundations which then annually covered the land on which he proposed to erect his seat of government. Sir G. WILKINSON says†, that though we may still trace the spot where the diversion of the river was made, owing to the great bend it makes about fourteen miles above the site of Memphis, the lofty mounds raised there are no longer visible. This ancient city was thus built on land which, from its vicinity to the Nile, must have been annually overflowed, doubtless for many previous ages, and which, consequently, must have been covered with the sediment deposited by the annual inundations. It presented, therefore, a peculiarly fit situation for prosecuting this inquiry, by sinking pits to the greatest practicable depth beneath the level of the existing foundations of buildings or other monuments. As at Heliopolis the Obelisk is all that remains above ground of that city, so at Memphis there is one solitary monument of its former greatness, which has, in recent times, been uncovered, a fallen colossal statue of the great king RAMESSES II., MIANUN, the SESOSTRIS of the Greeks, which stood in front of one of its temples.

Supported by the powerful influence of our then Consul-General in Egypt, the Honourable CHARLES AUGUSTUS MURRAY, with the late Viceroy ABBAS PACHA, and encouraged by the intelligent zeal and energy shown in the researches at Heliopolis by my very able coadjutor, the Engineer HEKEKYAN BEY‡, my wish was accomplished. The Pacha placed at the disposal of the Bey all the requisite means for carrying on the operations in the most effective manner; and directed different departments of his government to cooperate with him. There were appointed to assist him OMAR EFFENDI, Adjutant of Artillery, two subaltern officers of the corps of Engineers of roads and bridges, a civil engineer to have special charge of the excavations and borings, and other officers to superintend the labourers. HEKEKYAN BEY had also the advantage of being assisted for some time by a German gentleman resident in Cairo, Herr ERBEN, whose scientific acquirements rendered his services of great value. The whole expenses of the researches, carried on during three seasons, of some original surveys, and the preparation of several

* Book ii. s. 99. † Ancient Egyptians, First Series, i. 89. ‡ Note A. Appendix, pp. 78, 79.

maps on a large scale, and many drawings, amounting altogether to a very considerable sum, have been, with great liberality, defrayed by the Egyptian Government.

Nature of the Alluvial Soils.

In the first part of this memoir I have entered fully into the nature of the solid matter held in suspension in the inundation water, and deposited on the land, from the samples then in my possession. I have found no essential difference between them and the samples I have since received from the later excavations and borings. There is very little variety throughout the whole valley from Memphis to the sea; an argillaceous earth or loam of different shades of colour, black, grey and brown, more or less mixed with fine sand, constitutes the chief part, often associated with quartzose sand of different degrees of coarseness, and of various shades of colour. This coarser sand is for the most part blown into the valley by violent winds from the deserts on both sides.

THE RECENT RESEARCHES IN THE MEMPHIS DISTRICT.

I intimated to HEKEKYAN BEY my wish that the first object of his attention should be, to sink a shaft close to the colossal statue at Metrahenny. This statue, which had fallen or been thrown down from its pedestal, is said to have been discovered by Signor CAVIGLIA, about thirty years ago. He had found some indications of buried sculpture between the modern villages of Metrahenny and Bedreshin, and on making an excavation around it to a depth of about 5 feet, he uncovered a statue in its whole length. HERODOTUS says* that SESOSTRIS erected two statues, each 30 cubits high, before the temple of Vulcan in Memphis, representing himself and his queen, and four statues of his sons, each 20 cubits high. The existing statue has been proved to be that of RAMESSES II., the SESOSTRIS of the Greeks†. Dr. LEPSIUS, in a letter with which he has favoured me, says,—"If we may assume that the Memphis statue represents RAMESSES while a young man, of which the absence of the beard would not be, of itself, a decided proof, we should then be justified in assigning it to the beginning of the fourteenth century before Christ. According to my estimate, RAMESSES MIANUN reigned from about 1394 to 1328 B.C."

I requested that, in making the excavation in this place, the following particulars should be attended to:—

To ascertain the height of the surface of the ground at the edge of CAVIGLIA's excavation above the low water of the Nile;

To search for the pedestal on which the statue had stood;

To measure the depth of soil from the surface of the ground down to the upper surface of the pedestal, if found;

To sink a vertical shaft close to one side of the pedestal;

* Book ii. 110.

† See a description of this statue by J. BONOMI, Esq., in the Transactions of the Royal Society of Literature, Second Series, vol. ii. p. 297.

To mark the depth from the surface of the ground to the lowest part of the pedestal;

To ascertain carefully the nature of the ground on which the pedestal rests;

To continue the sinking of the shaft, so long as the soil passed through should consist of alluvial deposit;

If no pedestal were found, that the shaft should be made close to the statue, and that a specimen of each variety of soil passed through should be carefully preserved.

By the middle of April 1852, the engineers had begun their preparations for the work, and on the 10th of May the researches commenced. Several shafts were sunk, which I shall notice hereafter, besides that at the colossal statue, for the operations were continued without interruption to the 3rd of October, and then, in spite of every effort to close the breaches in the embankments around the district in which the works were carried on, the Nile inundated all the pits, and compelled the party to take refuge on the neighbouring mounds.

Inequalities in the surface of the ground.

The surface of the ground for some distance around the colossal statue being uneven, it became necessary, in order to ascertain the variable depth of water during an inundation at the mouths of the pits in various parts of the area, now intended to be sunk, that the level of the highest rise of the water over that ground at a given time should be determined. Accordingly the Salibe level * of the flood of 1851 on the Libyan dyke of the river to the east of the village of Bedreshin was accurately ascertained, and was found to be $\frac{11}{24}$ths of a cubit (9·922 inches) above the twenty-fourth cubit mark on the Nilometer on the island of Rhoda near Cairo †. The line of the twenty-fourth cubit covers the entire surface of the valley, leaving above it artificial elevations, such as dykes, mounds of rubbish, and buildings. The inequalities of the ground are such that, in any section under the said twenty-fourth cubit level, the surface varies from where it coincides with that level to nearly twenty feet in the deepest part; so that while in one part of the district there might be a depth of nearly twenty feet of turbid water, in another it might be less than an inch; a circumstance of great importance to bear in mind in this inquiry. M. TALABOT, in the report of the operations of the French Brigade in 1846–47, states that, in the latter year, the inundation rose to the twenty-fourth cubit mark of the Rhoda Nilometer, and that that mark is 71 feet 5½ inches above the mean level of the Mediterranean ‡. The Nile having risen in 1851 ten inches above the twenty-fourth cubit mark, the distance by the river from the Nilometer to the parallel of Bedreshin being 13 miles, and the ascent of this part of the river being estimated at about 5½ inches in a mile, the level of the inundation water of 1851 over the site of the colossal statue, was thus 78 feet 3 inches above the mean level of the Mediterranean.

* The Salibe is the stationary level occupied by the inundation water at the autumnal equinox.

† Estimating the cubit at 55 centimetres, and 1 centimetre at 0·39371 of an inch, 24 cubits are nearly 43 feet 3½ inches.

‡ Mémoire de la Société d'Études de l'Isthme de Suez.

It will be observed on examining the sections of the pits hereafter described, that the further progress of sinking the shafts was stopped by water of filtration, and at very different depths from the surface of the ground; but in the most important of them the penetration of the soil was continued by boring. The remarkable circumstance of the very different depths at which the filtration water was reached, and that within a very limited area, will be best considered after the soils passed through in each pit have been described.

The Excavation, Shafts, and Borings at the Colossal Statue.

The excavation originally made by CAVIGLIA was enlarged by HEKEKYAN BEY, and, when completed, it measured 110 feet by 85. At a depth of 5 feet 8 inches from the surface of the ground, they came upon the upper surface of a platform on which the colossus had stood, composed of two courses of cyclopean masonry, a considerable portion of which still remains. The upper blocks are 31¼, the lower 35½ inches thick, and they lie perfectly horizontal. The lower course of blocks was found to rest upon a bed of sand 38 inches in thickness, which, from the section of the adjacent ground, appears to have been brought to the spot in order to form a more firm foundation for the platform. It is a grey quartzose sand, identical with that found at a depth of 16½ feet on the left bank of the Rosetta branch, at the apex of the Delta*. This foundation sand rests on Nile sediment.

The surface of the ground, at the margin of the excavation, was ascertained to be 3 feet 6½ inches under the inundation level of 1851, and thus, according to the measurements of M. TALABOT, 74 feet 8½ inches above the mean level of the Mediterranean.

When this excavation was commenced in August 1852, no part of the platform was visible; and after it had been continued down to the inferior surface of the lower course of masonry, all around the statue, it was deepened on the eastern side, and at a distance of 25 feet from the platform, a shaft was sunk to the depth of 16 feet 4¾ inches from the surface of the ground. At that depth, filtration water put a stop to further digging, and, on this first occasion, artificial means were not resorted to to draw it off. But borings were made in three places, in one to the depth of 7 feet, in another to the depth of 8 feet, and in a third to the depth of 23 feet 8 inches; that is, to a depth of 40 feet from the surface of the ground. In the latter case, the boring instrument was drawn up fourteen times, each time bringing up a core of soil, specimens of which were sent to me. Throughout the excavation and sinking of the shaft and the borings, there was no indication of a laminated structure in the soils, no trace of quietly deposited successive layers.

* Specimen I. Memoir, Part I. page 128.

Section of the first Shaft and deepest boring at the Statue of RAMESSES II.

Layer*.	Thickness of layer†.	Depth of the bottom of the layer from the surface of the ground.	Nature of the soils.
	inches.	inches.	
I.	7·875	....	The surface layer at the superior ridge of the excavation, a brown sandy argillaceous earth, with a mixture of white sand, and small fragments of limestone and burnt brick. It closely resembles the standard specimen E, described in Part I. of this Memoir, page 127.
II.	23·625	31·500	Undistinguishable from I., except in being of a lighter colour.
III.	15·750	47·250	Scarcely distinguishable from I., except in being more indurated, like dried clay, and containing fragments of pottery.
IV.	31·500	78·750	Similar in all respects to III.
V.	35·375	114·125	Scarcely distinguishable from II. and III.
VI.	27·520	141·645	Almost identical with V., with fragments of limestone and brick.
VII.	15·730	157·375	Very similar to III. and VI., with fragments of burnt brick.
VIII.	39·375	196·750	Nearly identical with VII.
			16 feet, 4¾ inches. Filtration water, 4 August, 1852.
Boring layers.			
IX.	8·000	204·75	Light brown sandy argillaceous earth, with fragments of burnt brick.
X.	48·000	252·75	Dark brown argillaceous earth, with fragments of burnt brick and particles of pottery.
XI.	48·000	300·75	Similar to X., with fragments of limestone.
XII.	24·000	324·75	Similar to X., with fragments of burnt brick and pottery.
XIII.	12·000	336·75	Similar to IX., with fragments of burnt brick, pottery and limestone.
XIV.	12·000	348·75	A mixture of IX. and transparent quartzose sand.
XV.	12·000	360·75	Similar to XIV., but the earth of a lighter colour.
XVI.	24·000	384·75	Shining black sand, composed of rounded and crystalline grains of magnetic iron, and a few round grains of transparent quartz.
XVII.	12·000	396·75	Same as preceding, with a mixture of argillaceous earth.
XVIII.	12·000	408·75	Same as XVI.
XIX.	12·000	470·75	Same as XVII.
XX.	12·000	432·75	Same as XVII., with darker-coloured argillaceous earth.
XXI.	24·000	456·75	Same as XX., *but with fragments of burnt brick and pottery.*
XXII.	24·000	480·75	Same as XVI.
			40 feet from the surface of the ground.

It will thus be seen that, from about 2 feet 8 inches from the surface, indeed almost from the present surface of the ground, to the depth of 30 feet, there is very little difference in the nature of the soils. All the specimens sent to me consist of a sandy argillaceous earth or loam, of various shades of colour, from dark to light brown, differing somewhat in texture, some friable, some having more the character of clay, and some hardened into concretions.

Throughout this excavation and shaft, various objects of art and some bones of domestic animals were met with; the former of these may, at first sight, appear foreign to a geological treatise, but it must be remembered that the object of this inquiry has been to endeavour to trace back the history of the formation of the alluvial land from the present time, and therefore they have a bearing upon the question of the gradual

* By the term "layer" is to be understood merely certain distinctions adopted by HEKEKYAN BEY, founded, in the case of the argillaceous earths, chiefly on differences of colour, and partly on admixtures of sand.

† The measurements in English inches, in this and other sections, are those given by HEKEKYAN BEY; the minute decimals arising from his conversions of French metres into our measures.

accumulation of the sediment upon the area of Memphis. They have also a bearing upon an opinion I venture hereafter to express, that the evidence collected during these researches afford a strong presumption of the existence of man in Egypt, in a certain degree of civilization, long prior to all historical records. I have therefore made the following selection of these objects, as instances, showing the depths from the surface at which they were found:—

Fragment of a jar of coarse unglazed pottery . . .	6 feet
Lower half of a small human figure in baked clay .	6 feet
Cover of a jar of limestone	7 feet
Back part of the skull of a dog or large jackal . . .	7 feet
Left metacarpal of an ass	7 feet
Small vase of coarse unglazed pottery	8 feet
Right metacarpal of a dromedary	9 feet
Valve of *Iridina rubens* *	10 feet
Saucer of coarse pottery	10 feet
Hinder half of a small lion in baked clay	10 feet
Fragment of a jar with a stamped ornament . . .	11 feet
Small fragment of coloured mosaic	12 feet
Valve of *Iridina rubens*	12 feet
Valve of *Spondylus gaderopus* †	12 feet
Blade of a copper knife ‡	13 feet
Small vase of white pottery	14 feet
Small pot of brown unglazed pottery	15 feet

The boring instrument could not bring up large objects, but it will have been seen by the preceding section, that, at the depth of 38 feet, the sand contained small fragments of burnt brick and pottery.

In the summer of 1854 another pit was sunk at the colossal statue, midway towards

* Caillaud found *Iridina rubens* in considerable abundance in the Nile, and Sowerby describes a species under the name of *Iridina nilotica* obtained from Sennaar by Caillaud.

† On showing this marine shell to the late Professor Forbes, he remarked that it had probably been carried thus far inland by a large bird.

‡ This blade has been analysed in the Metallurgical Laboratory in Jermyn Street, under the direction of Dr. Percy, by Mr. Charles Tookey, and yielded the following results:—

Copper	97·12
Arsenic	2·29
Iron	0·43
Tin, with trace of gold	0·24
	100·08

Phosphorus was sought for, but no trace was found.

The arsenic may have existed in the copper ore; but the Ancient Egyptians may have known the art of hardening copper by adding a small proportion of arsenic.

the western side of the platform. In digging the former pit, when they reached the filtration water, no artificial means were resorted to to draw it off, in order to carry the shaft deeper, the further examination of the soils being made by borings; but in this new pit, shadoofs (buckets with levers) were employed, and the shaft was continued to a depth of 24 feet, by which means the nature of the soil was better shown at that greater depth than was possible by the borings.

The summit ridge of the excavation was the same as in the former pit, that is 3 feet 6½ inches below the inundation level of 1853, which was ascertained to have been the same as that of 1851. Although, as might be expected, there is a considerable resemblance between this pit and that already described, there still is a sufficient difference to induce me to give a detailed description of it, the more especially as it proved to be the most important of all the pits that were sunk.

Section of the second Shaft and Boring at the Statue of RAMESSES II.

Layer.	Thickness of layer.	Depth of the bottom of the layer from surface of the ground.	Nature of the soils.
	inches.	inches.	
I.	77·4334	....	Light brown, sandy, argillaceous earth, with an admixture of transparent quartzose sand.
II.	30·4334	107·4334	Similar to I., with fragments of red brick.
III.	60·4334	167·4334	Similar to I., with fragments of limestone, brick and pottery.
IV.	125·1158	292·5492	The same as III.
			24 feet 4½ inches. Filtration water.
Boring layer.			
V.	36·1158	328·5492	Light brown argillaceous earth, with fragments of pottery.
VI.	84·1158	412·5492	Same as II., but without fragments of brick.
VII.	36·1158	448·5492	Dark brown argillaceous earth, with fragments of pottery.
VIII.	24·1158	472·5492	Blackish, compact, fine-grained argillaceous earth, with a few fragments of pottery.
IX.	24·1158	496·5492	Fine greenish-grey sand, mixed with argillaceous earth.
			41 feet 4½ inches.

Throughout this excavation also, objects of art and bones of domestic animals were met with, of which the following is a selection:—

Lower molar tooth of a small variety of Ox, } between 13 and 20 feet
Molar tooth, and end of the humerus of a Hog, } from the surface.

Neck of a vessel in coarse unglazed pottery at 21 feet.

Fragment of a small glass vessel, at the bottom of the shaft.

Cube of coarse sandstone, smoothed, as if used for polishing, ditto.

And from the lowest part of the boring, the tool brought up a fragment, about an inch square, of unglazed red pottery.

If the finer part of the surface layer be compared with the argillaceous sediment brought up by the boring instrument from the deepest part, they appear identical, with the exception of a slight difference in colour, and in a somewhat greater proportion of sand in the latter. Mr. BRAZIER, who analysed the standard specimens of Nile sediment, as described in Part I. of this Memoir (page 125), undertook at my request analyses of the surface layer (A) and of the lowest part of the boring (B), which yielded the following results:—

		A.	B.
Soluble in hydrochloric acid.	Moisture .... per cent.	3·24	3·36
	Organic matter	1·72	1·60
	Carbonate of lime	10·40	1·92
	Sesquioxide of iron..............	5·20	7·68
	Sesquioxide of alumina	2·81	2·46
	Magnesia...........................	0·08	traces
	Sulphuric acid	0·16	0·02
	Phosphoric acid	traces	none
	Chlorine	traces	none
	Potassa	0·57	none
	Soda.................................	0·85	none
Insoluble in hydrochloric acid.	Silica	64·55	74·96
	Sesquioxide of iron..............	6·45	5·83
	Sesquioxide of alumina	3·85	2·53
		99·88	100·36

Per-centage composition after deducting moisture.	A.	B.
Silica	66·80	77·28
Sesquioxide of iron..............	17·05	13·93
Sesquioxide of alumina	6·89	5·14
Carbonate of lime	10·76	1·98
Magnesia...........................	0·08	traces
Potassa.............................	0·59	none
Soda.................................	0·88	none
Sulphuric acid.....................	0·17	0·02
Phosphoric acid	traces	none
Chlorine	traces	none
Organic matter	1·78	1·65
	100·00	100·00

The chief differences are in the proportions of carbonate of lime and of silica: the former was likely to predominate in the surface layer from the admixture of particles of limestone, and the silica in the lower layer from the admixture of sand.

With the exceptions mentioned above, not a trace of a shell was found in these excavations and borings; but I would not have it inferred from this that no remains of Mollusca exist in the places excavated. That shells, either whole or in fragments, should not have been found far below the surface is not surprising: freshwater and land shells are in general fragile, and if left on the ground by the inundation water, they would not only soon fall to pieces by exposure to the air, but would be destroyed in the stirring up of the soil by the husbandman. In the Appendix* will be found an account of microscopic organisms, not visible except with the aid of a powerful instrument and by a practised eye, which were found in some of the soils.

Pits sunk in the vicinity of the Colossal Statue.

In addition to the examination of the soil by the excavation, shafts or pits, and borings, close to the statue above described, seventeen pits were sunk within the space that may be considered to be the area of ancient Memphis. Their relative situations will be seen by the following ground plan.

* Note B. Appendix, p. 79.

Local Names of the Pits.

R.	Ramesses II.	9.	Shimbab, No. 3.
1.	Pit XIII.*	10.	Erben's.
2.	Omar's.	11.	Mekias il Rod.
3.	The Palms.	12.	Bedreshin†, No. 1.
4.	Cæsareum or Serb.	13.	Bedreshin, No. 2.
5.	Tel Moukalid.	14.	Bedreshin, No. 3.
6.	Three Colossi.	15.	Bedreshin, No. 4.
7.	Shimbab, No. 1.	16.	Bedreshin, No. 5.
8.	Shimbab, No. 2.	17.	Bedreshin, No. 6.

Distances from the Pits R, *in yards.*

Pits, No.			Pits, No.		
1.	25 East	6 South	10.	779 East	40 North
2.	21 West	45 South	11.	758 East	627 North
3.	24 East	52 North	12.	875 East	595 North
4.	80 West	260 North	13.	983 East	537 North
5.	151 West	326 North	14.	1150 East	491 North
6.	35 East	354 North	15.	1325 East	490 North
7.	115 East	565 South	16.	1470 East	404 North
8.	198 East	854 South	17.	1690 East	388 North
9.	291 East	1250 South			

The sections of these pits will be seen in Plate II. The alluvial soil being divisible into two principal kinds, in the one of which argillaceous earth enters largely into the composition, while the other consists mainly, or altogether, of quartzose sand,

* Of the line of pits across the valley in the mound district of Memphis, described hereafter.

† Nos. 1 to 5 of the Bedreshin Pits were in the Summer Road, north of the cross embankment leading from Metrahenny to Bedreshin. No. 6 is west of the Bedreshin burial-grounds.

I have considered it sufficient in the illustrations of all the sections of the soils, given in this second part of my memoir, to distinguish these two main kinds by two shadings, the varieties of them by letters, and the accidental mixtures of fragments of limestone, brick and pottery by subordinate marks. I have prepared a list of the varieties of the soils, which precedes the explanations of the Plates of the Sections. To have given the Sections according to a true scale was obviously impossible within a moderate space, but I have shown, in the explanation accompanying each Plate, the distances, in yards, that intervene. By this method the variety of the soils that occur in the same plane will be more readily seen than by mere verbal descriptions.

In the Pit No. 2, there were met with, at a depth of 13 feet from the surface, a fragment of Assouan granite, sculptured, and an architectural carved ornament of limestone.

In No. 3, at a depth of $12\frac{1}{2}$ feet, a female foot, carved in white limestone, and an ornamental vase of red pottery.

In No. 4, at a depth of 7 feet 2 inches, they came upon the surface of a course of large blocks of a red sandstone, resting upon pure sand, succeeded by a layer of sediment; at 9 feet 2 inches, a second course of large blocks of the same sandstone; and at 11 feet 8 inches, a third course of the same kind.

In No. 6, at depths of $8\frac{1}{2}$ feet and 15 feet, several small statuettes in stone and bronze; at 26 feet, a fragment of wrought limestone; at $27\frac{1}{2}$ feet, several bones of a hog; at $33\frac{1}{2}$ feet, a tablet of calcareous sandstone, with portions of an inscription in hieroglyphics; and at 35 feet, fragments of pottery.

In the lowest part of No. 17, between 11 and 12 feet, the right humerus of an adult man; but this pit, it will be observed, was sunk on the west of the Bedreshin burial-grounds.

Pits across the Valley in the Parallel of Memphis.

Twenty-seven pits were opened in ground below the inundation level of 1851, in a line across the valley from the foot of the Libyan Hills on the west to the skirt of the Arabian Hills on the east of the Nile, nearly in the parallel of the colossal statue of RAMESSES II., and embraced within an area extending about five miles from west to east, and one mile from north to south. Each pit was 5 feet square, and the excavation was continued until stopped by the filtration water. Sections of these pits are given in Plate III., accompanied by the necessary explanations.

Pits across the Valley in the Parallel of Heliopolis.

Extensive as the researches had already been, I was desirous of having further trials, made lower down the river, in the parallel of Heliopolis; and the consent of the Pacha having been obtained, through the kind and zealous intervention of Mr. MURRAY, and afterwards of his successor, Mr. BRUCE, HEKEKYAN BEY, with unabated energy, undertook to conduct the further operations in the year 1854, partly by excavations, but chiefly by borings.

The first sinking in this line was in ground below the inundation level of 1853, which was very nearly the same as that of 1851, at a distance of fifty yards from the eastern slope of the Libyan Hills, and nearly eight miles from the left bank of the Nile. In this distance twenty-six trials were made. Passing over to the right bank, twenty-five trials were made in a space about eight miles westward. Thus fifty-one penetrations of the soil were made at intervals in a line across the valley of about sixteen miles, and sections of them are given in Plates IV. and V., with accompanying explanations. In each instance the boring terminated when the filtration water was reached. The operations were carried on in the month of July, except in four instances.

I would draw particular attention to the sections 24, 25 and 26, in Plate IV., and to section No. 1, in Plate V., on account of the great depths to which the borings were there continued.

The instrument employed was an iron graduated rod, having a deep threaded screw to work into the soil. The screw was conical, and the samples of soil were brought up from the several depths given without turning it; and in separating the sample, great care was taken to keep it clear of any soil adhering to the exterior of the screw, and the instrument was washed each time that it was drawn up, before the next descent.

The Boring No. 24 was made at the distance of fifteen yards from the left bank of the Nile, near the village of Sigiul, about ten miles below Cairo, the surface of the ground being 3 feet 10 inches below the inundation level of 1853. The operation was carried on from the 13th to the 17th of November 1854, and was continued to the depth of 50 feet. The soil consisted of 35 feet of argillaceous earth (Nile sediment), of various shades of brown, and 15 feet of bluish- and greenish-brown quartzose sand. The tool brought up particles of "rubbish"* from depths of 26, 28 and 32 feet.

The Boring No. 25 was in the same locality, at a short distance from No. 24, on the north side of the village, and was also continued to the depth of 50 feet, the surface of the ground being 3 feet above the surface at No. 24. The soil consisted of the same Nile sediment, to the depth of 32 feet, and of 18 feet of quartzose sands. Particles of "rubbish" were brought up from a depth of 32 feet, and the sand at 46 feet contained particles of limestone.

The Boring No. 26 was at the south-western extremity of the same village, 1330 yards above the intersection of the parallel of Heliopolis with the great Libyan dyke of the Nile, the surface of the ground being 4 feet above the surface at No. 24. It was made on the 21st of September, 1st and 5th of October 1854, and was continued to the depth of 50 feet. The soil penetrated consisted exclusively of Nile sediment, with some varieties of colour. From the last five feet, the tool brought up particles of "rubbish."

The Boring No. 1 in Plate V., was on the right bank of the river, at the north-western extremity of the village of Bessousse, nearly opposite to the village of Sigiul, and 722

* Hekekyan Bey, in using the term "rubbish," means particles and very frequently morsels of baked clay, usually red, and of limestone.

yards above the intersection of the parallel of Heliopolis with the great Arabian dyke of the Nile, the surface of the ground being 2 feet 5 inches below the inundation level of 1853. The boring was made from the 14th to the 17th of October, and from the 2nd to the 11th of November 1854, was carried down to the depth of 59 feet 10 inches, and yielded the following remarkable results:—

ft.	in.	
20	0	of ordinary Nile sediment.
8	4	of grey quartzose sand.
5	0	of Nile sediment.
2	0	of sand.
1	0	of Nile sediment.
11	0	of sands.
1	0	of Nile sediment.
11	6	of sands.
59	10	

Out of thirty-seven times that the boring tool was brought up, in twenty-one instances the soil contained particles of "rubbish," even at the lowest depths. Of the sixteen instances in which the "rubbish" was not found, the soil consisted of sand.

This boring had reached to within 7 feet $4\frac{1}{2}$ inches of the mean level of the Mediterranean:—

	ft.	in.	ft.	in.
Level of the inundation water at Bedreshin, above the mean level of the Mediterranean			78	3
Deduct:—1. Fall from Bedreshin to the island of Rhoda	5	6		
Fall from Rhoda to the parallel of Heliopolis, 10 miles, at the rate of $3\frac{3}{4}$ inches in a mile (Memoir, Part I. p. 114)	3	$1\frac{1}{2}$		
Surface of ground at the mouth of the boring below the inundation level	2	5	11	$0\frac{1}{2}$
Surface of the ground at the boring			67	$2\frac{1}{2}$
Depth of the boring			59	10
			7	$4\frac{1}{2}$

In this boring, the samples of soil down to the end of the 53rd foot from the surface of the ground, were extracted by turning the screw in the soil exactly a foot deep each time. The remainder of the depth was jumped through, and the samples brought up were estimated from the contents of the bottom tube in the screw.

Review of the chief facts made known by the Excavations, Shafts and Borings.

On examining the results of the ninety-five probings of the alluvial land which I have described in this second part of my memoir, we find,—

1st. That the alluvium is of two principal kinds; first, and chiefly, an argillaceous earth or loam, more or less mixed with fine sand, of various shades of colour, being the true Nile mud or sediment; and secondly, pure quartzose sand, derived in a great measure from the desert, being swept by violent winds through the gullies in the hills on either side, but chiefly from the Libyan range.

2ndly. That the Nile sediment found at the lowest depth reached is very similar in composition to that deposited by the inundation water of the present day.

3rdly. That in no instance did the boring instrument strike upon the solid rock, that which may be presumed to form the basin between the Libyan and Arabian Hills that contains the alluvium accumulated through unknown ages, from the time when this depression in the earth's surface was formed, and the waters of the Nile first flowed through it.

4thly. That, except minute organisms discoverable only by a powerful microscope, few organic remains were met with, and that those found were recent land and river shells, and bones of domestic animals.

5thly. That there has not been found a trace of an extinct organic body.

6thly. That at the same levels great varieties in the alluvium have been found in adjoining pits, even when the distances between them are very moderate. This will be at once seen by referring to the Sections.

7thly. That there is an absence of all lamination in the sediment. When I first undertook these researches, I expected that sediment, slowly deposited on the land from nearly tranquil water, would present, in sections, a laminated structure; more especially as an able observer, the late Captain NEWBOLD, has told us that he had met with such an arrangement of the alluvial soil*. It was therefore with no small surprise that I learned, when I received the account of the excavations at Heliopolis, that no such laminæ had been found; and in none of the excavations or borings since made has such a structure been met with in a single instance. There can be no doubt that a layer of sediment must be deposited upon the land, but so soon as the waters have subsided, the sun, the wind, and cultivation combine to break it up. From the earliest times when the Nile valley was inhabited by man, the alluvial land, fertilized by the sediment from the annual inundation, must have been cultivated in the returning seasons. The next following flood softens the hardened mud of the preceding year, and it is considered that this softening of the soil is one of the most fertilizing effects of the inundation. The very primitive and simple system of cultivation of the present day is most probably the same which had been followed for unknown ages, for it is said that in Egypt nothing changes. As the subsiding inundation level continues to expose to air and light

* Quarterly Journal of the Geological Society, vol. iv. 1848, pp. 343 and 344.

the surface on which the sediment has been deposited, in insulated patches of the uneven ground, the fellah, wading in mud, begins to throw seed upon them, in contour lines, his light boat bringing to him his seed corn. As the retreating waters expose more land, so soon as it is sufficiently drained, another zone of ground is sown, and so on until the lowest parts have received the seed, which must be cast before the surface begins to crack; and after it has been cast, it is beaten down into the mud with a flat piece of wood at the end of a pole. During the dry season, when vegetation withers, and the underground water has subsided, the ground cracks into numerous and deep fissures, forming the usual polygonal fissures we see in dry mud or clay, affording receptacles for the flying sand. For three or four months in every year the surface of the valley, stript of vegetation, in the state of a dry powder, is swept by violent winds, raising storms of dust. By these combined causes, therefore, every trace of the deposited layer must be effaced*. Instances of lamination and alternations of clay and sand, such as those mentioned by Captain NEWBOLD, are not unfrequently met with in the banks of the river, and at the entrances of canals; but they are local occurrences caused by eddies and currents. I have in my possession specimens of such laminated sediment from the right bank of the river near Helwan, a few miles above Cairo.

8thly. That there are occasional accumulations of soil, the materials of which are only remotely derived from the inundation water and the storms of desert sand. In the neighbourhood of old buildings, and on the sites of former buildings, where these have been constructed of crude bricks, the soil, to a considerable depth, may have been derived from the disintegration of these bricks. The soil, thus derived, would have nearly the same aspect as the natural deposit of Nile mud. In the Heliopolis excavation B (Memoir, Part I. p. 132), crude bricks were seen to have been the origin of the soil there by visible rectangular lines chequering the sides of the pit. This last appearance, however, must be a rare occurrence, for the action of the inundation water softens the bricks and causes them to melt, as it were, into a homogeneous mass.

9thly. That, in nearly every part of the ground penetrated, artificial substances have

* I have stated in Part I., p. 108, that, "with an inclination so slight as that of the land over which the inundation spreads, the solid insoluble matter must in great part remain where it is deposited." I did not then take into account the violent winds which swept over the parched land, and transport the soil in vast clouds of dust. Neither did I take into account the great absorption of the constituents of the soil by the grain crops which succeed the inundation. In JOHNSTON'S 'Elements of Agricultural Chemistry,' p. 71, we find the following statement:—"1000 lbs. of the ash of the straw of wheat, barley, oats, rye, and Indian corn have been found to contain respectively,—

	Wheat.	Barley.	Oats.	Rye.	Indian Corn.
Silica	654 lbs.	676 lbs.	484 lbs.	645 lbs.	270 lbs.
Lime	67	85	81	90	83
Magnesia	39	50	38	24	66
Oxide of iron	13	10	18	14	8
	773	821	621	773	427"

been found, such as fragments and particles of burnt brick and pottery, and in the area of Heliopolis and Memphis, fragments of statues and other sculptured stones.

Circumstances which modify the deposition of the sediment in different parts of the valley.

When the Nile first enters Egypt at Assouan, it is loaded with its greatest amount of solid matter, and with that which is coarsest and heaviest. In its progress, the heavier particles must be first deposited, and the solid matter thus becomes finer and finer as the river flows downwards, until at length it is in the state of an impalpable powder, which discolours the water, and is perceptible in the sea at a great distance from the land. As a proof of the more rapid deposition of the heavier particles, even so low down as Cairo, I may mention, that at the ebb of the river, after the inundation of 1853, it was found that the deposit on the Mastaba, or landing-place, of the Rhoda Nilometer, that is at the ninth cubit mark on the column, was 6 inches in thickness; on the fourth step above it, about $2\frac{1}{4}$ inches, and on the sixteenth step not more than $1\frac{1}{4}$, each step being rather more than 9 inches deep.

The deposition of the sediment must further be hastened in the upper parts of the river by two causes, the small amount of the fall and the evaporation under a burning sun. The course of the stream between Assouan and Cairo, according to the observations of RUSSEGGER, is 555 statute miles*, and Assouan being 300 feet above Cairo†, the mean fall of the river is thus 6·486 inches according to RUSSEGGER, 6·175 according to HEKEKYAN BEY, in a mile. The inundation of 1851 rose to the height of 78 feet at the parallel of Memphis, and to $63\frac{1}{2}$ feet at the apex of the Delta, difference $14\frac{1}{2}$ feet, and the distance between the two points being thirty miles, it gives a fall of 5·8 inches in a mile. From Assouan to Cairo, the river has nowhere a sufficient fall to be used as water power‡. The evaporation by the great heat in those latitudes from the broad surface of the river must be very great. M. GIRARD states§, that on plunging a thermometer into the sand that covers the surface of the desert, it rose to 56° of REAUMUR, or 158° of FAHRENHEIT; and Sir G. WILKINSON says‖ that "so rapidly does the ardent sun of Egypt, even in the months of November and December, dry the mud, when once deprived of its covering of water, that no fevers are generated, and no illness visits those villages which have been entirely surrounded by the inundation." The evaporating water, thus parting with its solid contents, must greatly accelerate the deposition in the higher parts of the river's course. There is also a constant source of irregularity in the amount of deposition at different parts of the valley from this cause, that the Nile frequently undermines its banks, and a vast quantity of the sediment of former years falls

* Reisen, Band ii. Theil i. 271, 120 German geographical miles, one mile=$4\frac{5}{8}$ and 25 yards, English. HEKEKYAN BEY considers RUSSEGGER's estimate to be under the truth, and that following the chief line of current of the Nile (say its line at low water), the total distance from Assouan to the point of Rhoda Island must be 583 miles.

† Id. 282 Paris feet.

‡ Id.

§ Mémoires de l'Institut, 1817, p. 286.

‖ Ancient Egyptians, 2nd series, i. 37.

into the stream; and, moreover, in those parts which are opposite to gullies in the hills bounding each side, much sand, blown from the desert, mingles with the muddy water.

The spreading of the waters over the lands must have been controlled by embankments from a very remote historic period, for otherwise the inhabitants of the valley would have been exposed to great dangers from the floods. For how long a period, the river, when it rose above the natural limits of its channel, overflowed the adjoining country without any artificial check, how much of the alluvial land had been formed before the system of embankments was adopted, it is impossible to ascertain; but it is evident that the rate at which the soil accumulated would be different from what it became when the water was no longer allowed to flow in its natural course. The longitudinal embankments extend at present to the narrow pass in the river at Gebel Silsilis, about forty-two miles below Assouan. From that point, downwards, the longitudinal dyke, called the King's Road, extends all the way along the left bank of the stream. The extent of the deposit on the right bank is variable, covering considerable areas in some localities, where the slope of the desert skirt is gentle. The river, therefore, from Silsilis to Cairo, about 542 miles, is nowhere allowed to overflow its banks, that is, to have a free unimpeded access to the valley. The alluvial land on both sides above the apex of the Delta, and throughout the Delta, is intersected by canals, and each canal has its longitudinal dykes, over which the current of muddy water, flowing through it, is not allowed to pass, but is made to flow through certain apertures in the dykes at the proper time, and at the proper places, and thus, to use the expression of HEKEKYAN BEY, "the water is let out upon the land by rule and measure," regulated by the Rhoda Nilometer.

The higher level from which the inundation water is taken enables it to flow far into the interior, and sluices at the mouths of the canals prevent it from being excessive. These great canals feed smaller ones, which again are subdivided, so as to spread over the land a network of irrigation. About the middle of August, when the Nile has risen to about two-thirds of the height between its standard lowest ebb and its standard Salibe level, the water enters the Magrour or Joseph's Canal, about 326 miles above Cairo*. It is then charged with sediment, and continues to flow along it with an increasing volume as the inundation water rises, until that attains its maximum, when it runs in a contrary direction. By various artificial means the water in the Magrour is forced to rise at different places, so as to spread over the adjacent lands. In this operation overflowing eddies are created, which cause unequal rates in the deposit of the sediment,

* "The Magrour (or water-course) is the second and upper bed of the Nile in its natural state. It generally keeps close to the western limits of the cultivable area of the valley. Its average latitudinal distance from the river is about $6\frac{1}{4}$ miles; its greatest deviation about 13 miles; its closest approach, a little below Siout, about $1\frac{1}{2}$. It has been modified by works of art, particularly below Benisouef, where it gets the name of Bahr Jousseph or Joseph's Canal. Numerous cross canals make a connexion between the river and the Magrour. They claim for their origin certain natural water passages, as well from the river into the Magrour, as from the Magrour into the river. They are employed to drain the artificial inundation water from the grounds into the river, during the proper season, and to serve as canals of irrigation after the subsidence of the flood."—Letter of HEKEKYAN BEY, 8th January, 1858.

and these are also caused by irregularities in the surface of the ground. These eddies are often very wide, and according to their strength and velocity scoop out the ground, leaving sediment around the areas thus scooped out. Villages, dykes, plantations, and even solitary trees, together with the sinuosities of the valley, alter the direction, the extent, and the velocities of these inundation eddies, and consequently the quantities and areas of the deposits of sediment. Sometimes also the muddy water of the Nile is added to by torrents from the hills, which come down charged with clay and sand from the deserts. Hence some patches of land are of a dark brown argillaceous nature, others more or less yellow, and more or less sandy, in proportion to the matter suspended in the torrents, and according as their flow has been retarded. After the retiring of the flood, a series of lakes are found at different levels, produced by the eddies, and they are often filled up by the sand blowing over them being retained by the water. The removal of a plantation, the forming of a new one in another direction, a new dyke, a new hamlet, will all cause disturbances in the direction of the eddies, and consequent alterations in the nature and amount of the sediment deposited, causing also patches of land adjoining each other to fluctuate greatly in value to the cultivator.

The lands nearest the river which are irrigated by water, let in upon them direct from it, receive a greater amount of sediment, for the river water during the inundation has more suspended in it than that in the canals, especially those at a distance, and the river water must necessarily soon deposit the coarser and heavier matter. Thus the strips of land along the dykes that skirt the river, and the dykes of the great canals being irrigated by water holding the maximum of suspended matter, are generally higher than the rest of the valley; and, from the same cause, the strip of land between the river's ordinary channel and its embankment is higher than that on the other side of the embankment.

From the above description of the various circumstances which affect the distribution of the Nile sediment over the land, it is obvious that the depth of the annual deposit by the inundation must be very different in different parts of the valley, *and consequently the same lapse of time may be represented by different depths of the soil.*

The underground filtration Water.

On examining the sections of the pits, it will be seen that filtration water was reached at very different levels, at the same period of the year, even in the case of those separated only by a short distance. Thus, in Plate II.—

	feet.
In Pit R¹, on 4th August 1852, it was reached at	19
In Pit No. 2, 45 yards south, on the same day	16
In Pit No. 3, 52 yards north, on the same day	17
In Pit No. 4, 260 yards north, on 29th June	30

In Plate III.—

In Pit No. 1, on 22nd August 1852, at	10·9
In Pit No. 2, 66 yards east of No. 1, on the same day	15·9

	feet.
In Pit No. 3, 475 yards east of No. 2, on 24th July 1852 . . .	13·0
In Pit No. 4, 246 yards east of No. 3, on 24th July 1852 . . .	19·3
In Pit No. 5, 517 yards east of No. 4, on 24th July 1852 . . .	13·3
In Pit No. 6, 333 yards east of No. 5, on 25th July 1852 . . .	14·9
In Pit No. 7, 150 yards east of No. 6, on 25th July 1852 . . .	17·3
In Pit No. 8, 354 yards east of No. 7, on 25th July 1852 . . .	16·6

On all occasions when the soil was penetrated, the progress of excavation was stopped, except in the second shaft at the colossal statue, by filtration water, after which the further examination could only be made by borings. This impediment I did not anticipate; and I fear that it must ever be found a great obstacle to any satisfactory ascertaining of the nature and depth of the entire amount of Nile sediment in any section of the valley. It is a well-authenticated fact, that no wells can be sunk with any certainty as to the depth at which water will be found, in any part of the valley, even within a comparatively limited space. This irregularity in the levels must be caused to a great extent by differences in the degrees of permeability and power of retention in the soils; but it will be seen, on examining the sections in the instances quoted above, that the soils of the different pits are very much of the same kind, and it is not very likely that there would be great changes in the intervening spaces.

THE RATE OF SECULAR INCREASE OF THE ALLUVIAL LAND.

I shall now proceed to consider the geological conclusions which appear to me to be fairly deducible from the facts which these researches have disclosed, with reference to the object for which they were undertaken, viz. to endeavour, by digging deep into the soil at appropriate places, to ascertain how nearly we can determine the rate of secular increase of the alluvial land by the sediment left upon it annually by the inundation, and thence to form a probable estimate of the time that has elapsed since the lowest part of the sediment to which we could reach was deposited. But before entering upon this part of my memoir, it is necessary that I should draw attention to the inquiries of a similar nature which were instituted by the French Engineers who accompanied the expedition under General BONAPARTE at the close of the last century, as recorded in the celebrated work, the 'DESCRIPTION DE L'ÉGYPTE.'

In books that have appeared since the publication of that great work in 1809, when the formation of the alluvial land of Egypt is referred to, it is generally assumed as a settled point, that the mean increase of that land has been at the rate of 5 inches in a century, all over the valley from Assouan to Cairo*. The authority relied upon is the

* Thus, for example, M. ELIE DE BEAUMONT, in his 'Leçons de Géologie Pratique,' published in 1845, p. 480, says,—" dans la Vallée d'Égypte, l'exhaussement du sol est moyennement d'environ 126 millimètres (4·960 inches) par siècle."

memoir of M. GIRARD in the above work, afterwards published in the Memoirs of the Institute*. I have been naturally led to examine very carefully the data upon which the result arrived at by M. GIRARD was founded, and have seen reason to differ from his conclusion. In thus differing from an authority sanctioned, apparently, by the assent of subsequent authors for so long a time, although that assent may have been given without special examination, I should not feel justified in expressing my dissent, without stating the grounds of it, and without giving such extracts from M. GIRARD's memoir as will show the data on which his conclusion is founded. This must be my apology for a somewhat lengthened statement which I have given in the Appendix, Note C, p. 80.

The statement of a *mean* secular increase of the soil over a valley extending 580 miles, even if it were determined by the most accurate data, gives us no information of real value; for that mean may be inapplicable to any one particular part of the valley; and it is especially inapplicable in relation to the geological history of the alluvial land, when a depth of one foot of soil in one place and of three feet in another, might, according to circumstances, have been deposited during the same amount of time, the object of inquiry being to ascertain the probable age of the lowest layer of the Nile sediment. In every situation where the experiment is made, we must have *a fixed point in time* to start from, viz. the known age of a monument whose foundation rests upon Nile sediment, and upon whose sides it has accumulated by subsequent inundations. If there have been no local causes to disturb the probability that the sediment above and below the foundation has accumulated at the same rate, we divide the amount above the foundation by the number of centuries known to have elapsed from the erection of the monument to the present time, and then apply the same chronometric scale to the greatest ascertained depth of sediment below the foundation. If many experiments were thus made in different localities throughout the valley, where monuments of a known age exist, upon whose sides the sediment had accumulated and whose foundations were ascertained to rest upon the same kind of sediment, we should obtain reliable results, applicable to the valley generally. But in no one locality, however deep the sediment, could we affirm that we had reached the oldest layer, unless it rested on limestone (the rock foundation of the valley), because of the more than probable inequality of the surface of its bottom. We might arrive at a very high antiquity, but we could not say that we had arrived at the highest. To divide a depth of sediment above the foundation of a monument by *an assumed mean secular increase of it over the whole valley*, and thence to determine, as has been done, the age of the monument, is obviously, for the reasons stated, a fallacious inference.

* Sur la Vallée d'Égypte, et sur l'exhaussement séculaire du sol qui la recouvre; Mémoires de l'Académie Royale des Sciences de l'Institut, année 1817.

How far a local secular rate of increase of the alluvial land may, with probability, be estimated from these recent researches.

The Obelisk at Heliopolis and the colossal statue of RAMESSES II. on the site of Memphis, are the only monuments of high antiquity, and of a known age, upon and around which the sediment of the inundations has accumulated, in that part of Lower Egypt where alone it was practicable to undertake the researches described in this memoir, viz. in the vicinity of Cairo.

In the excavations made around the Obelisk of Heliopolis, it was found in that nearest to it (A)* that the surface of the pedestal on which the obelisk stands was reached at a depth of 5 feet 6 inches, and that the pedestal measured 6 feet $10\frac{1}{2}$ inches in height, making together 12 feet $4\frac{1}{2}$ inches from the surface of the ground to the foot of the pedestal. But we may presume that the pedestal, at the time of its erection, would be sunk somewhat below the then surface of the ground, and if we allow for that 1 foot $4\frac{1}{2}$ inches, we have an accumulation of sediment of 11 feet from the present surface of the ground to the level where the pedestal first appeared above the surface, at the time of the erection of the obelisk.

The obelisk is believed to have been erected 2300 years B.C.†, and adding 1850, the year when the observation was made (June 1851, *i. e.* before the inundation of that year), we have 4150 years in which the 11 feet of sediment were deposited, which is at the rate of 3·18 inches in a century.

But entire reliance cannot be placed on this conclusion; and this very ancient monument of known age, apparently so well calculated to solve the problem, from unforeseen circumstances in the nature of the ground on which it was erected, has failed to afford the true chronometric scale which it was hoped it would have done. For there is great uncertainty whether the 9 inches of "disturbed ground" is entirely true sediment, and also whether the sand that was reached before coming to the base of the pedestal was deposited by the Nile, or was original desert ground, that had been sunk into for the foundation. I have already stated‡ that the appearances round the obelisk render it probable that the site originally chosen for the temple and city of Heliopolis was a portion of land somewhat raised above the level of the rest of the skirt of the desert, and advancing into the low grounds then inundated by the Nile. This view is supported by the differences in the nature of the soils passed through in the excavations to the west of the obelisk, that is, nearer to the Nile, from those to the east of it, especially the excavation H, which was due east, and therefore on the supposed offshoot from the desert land. Thus,

In the excavation B, 100 yards west of the obelisk, there was found 13 feet 3 inches of mud (argillaceous sediment); in C, 784 west, 14 feet 3 inches of mud, which in neither pit was gone through, as the filtration water prevented further progress.

In the excavation D, 270 yards south-east, there was found 12 feet 5 inches of mud,

* These excavations are described in Part I. of this Memoir, from page 131 to 136.

† Id. page 123.

‡ Id. page 123.

and then 2 feet 10 inches of quartzose sand. In E, 100 yards north-east, 12 feet 6 inches of mud, and then 1 foot $7\frac{1}{2}$ inches of quartzose sand, which was probably blown sand, as below it there was a repetition of 3 feet 7 inches of mud. In F, 383 yards north-east, there were 8 feet $1\frac{1}{2}$ inch of mud, and then 2 feet $2\frac{1}{2}$ inches of sand. In G, 1215 yards north-east, there were 6 feet 8 inches of mud, and 8 feet 4 inches of sand. In H, 615 yards due east, there were only 2 feet 10 inches of mud, and then 11 feet 8 inches of sand.

The Colossal Statue.

In the excavation at this statue in the area of Memphis in 1852, the level of the upper surface of the platform on which the statue had stood was ascertained to be 5 feet 8 inches below the surface of the ground; but as there were 8 inches of a sandy earth, there remained 5 feet of true Nile sediment. The upper blocks of the platform are $31\frac{1}{4}$ inches thick, and the lower $35\frac{1}{2}$ inches, together 5 feet $6\frac{3}{4}$ inches. If we allow the lower part of the platform to have been $14\frac{3}{4}$ inches below the surface of the ground at the time it was laid, we have a depth of sediment from the present surface of the ground to that level of 9 feet 4 inches. Ramesses, according to Lepsius, reigned from 1394 to 1328 B.C., and if we suppose the statue to have been erected in the middle of his reign, *i. e.* in 1361, we have between A.D. 1854 and that time 3215 years, during which the above depth of 9 feet 4 inches of sediment was accumulated; and supposing that no disturbing cause had interfered with what may be termed the normal rate of deposition *in this locality*, and of which there is no evidence, we have thus a mean rate of increase within a small fraction of $3\frac{1}{2}$ inches in a century.

The depth of ground excavated in the second pit, close to the statue of Ramesses II., in 1854, was 24 feet, and the additional depth examined by boring was 17 feet $4\frac{1}{2}$ inches, together 41 feet $4\frac{1}{2}$ inches. Of this total, 9 feet 4 inches have been assumed to have been deposited between 1361 B.C. and the year 1854, and thus we have a remainder of 32 feet of the total depth penetrated. But the two lowest feet consisted of sand, below which it is possible there may be no true Nile sediment in this locality, and we have thus 30 feet of the latter. If that amount has been deposited at the same mean rate of $3\frac{1}{2}$ inches in a century, it gives for the lowest part deposited an age of 10,285 years before the middle of the reign of Ramesses II., 11,646 years B.C., and 13,500 years before A.D. 1854.

The deeper parts of this accumulation of 30 feet of sediment are probably more compact in structure from the long-applied superincumbent pressure, and therefore their age is probably greater, on that account, than that arrived at by the application of the chronometric scale of $3\frac{1}{2}$ inches in a century, obtained by measuring the superior and specifically lighter part of the accumulated mass.

The other excavations and pits, both those in the parallel of Memphis and those in the parallel of Heliopolis, from the absence of a fixed starting-point of known age, with accumulations of Nile sediment above and below it, as in the case of the platform of the colossal statue, do not supply us with the requisite data for estimating the age of the lowest part reached, beyond a reasonable inference in each case, according to the circumstances of the particular locality. But they have supplied a large and valuable amount of evidence, showing the nature and alternations of the soils constituting the alluvial land; and, taken in conjunction with the researches of a similar nature made by the French engineers at the end of last century, a brief account of which I have given in the Appendix, p. 84 (Note D), they afford strong presumptive evidence that the whole of the land of Egypt between the bounding hills, from the first cataract to the sea, extending nearly 700 miles—that land which is associated in our minds with all that is most ancient in history or tradition—belongs entirely to the recent geological period. Remote as is the date of 13,500 years from the present time which these probings of the soil appear to have disclosed, they have not enabled us to attain the hoped-for object of discovering an approximate link between historical and geological time. No trace of an extinct organism has been turned up to take the formation of the alluvial land of Egypt beyond that modern epoch from which, in our artificial systems, we are used to carry back our geological reckonings; that period, which, although "characterized as the most recent, reaches to an infinitely higher antiquity than any contemplated by history or fable *." Evidence might possibly be found in the valley, by well-directed researches, which would approximatively determine the commencement of the recent period in this region, but all experience in geological inquiries hitherto would lead us to expect that the discovery would show a vastly remote antiquity. That the valley of the Nile in Egypt was formed by an internal movement in the earth's crust, which broke up horizontally deposited strata and produced the depression, scarcely admits of a doubt; and, from all that we have hitherto discovered, it is probable that the depression was partly filled up by sand, blown from the adjacent high lands, before the waters of the Nile were directed into it, and that these sands form the bed on which the sediment began to accumulate.

Evidence which these researches would seem to afford of a very early existence of Man in Egypt.

In a large majority of the excavations and borings, the sediment was found to contain, at various depths and frequently at the lowest, small fragments of burnt brick and of pottery. In the lowest part of the boring of the sediment at the colossal statue in the year 1854, at a depth of 39 feet from the surface of the ground, consisting throughout of true Nile sediment, the instrument brought up a fragment of pottery, now in my possession. It is about an inch square and a quarter of an inch in thickness, the two surfaces being of a brick-red colour, the interior dark grey. This fragment, having been found at a depth of 39 feet, if there be no fallacy in my reasoning, must be held to be a record of the existence of man 13,371 years before A.D. 1854, reckoning by the before-mentioned rate of increase in that locality, of $3\frac{1}{2}$ inches in a century; 11,517 years before the Christian era, and 7625 years before the beginning assigned by LEPSIUS to

* Rev. BADEN POWELL, 'Christianity without Judaism,' p. 57.

the reign of MENES, the founder of Memphis; of man, moreover, in a state of civilization, so far, at least, as to be able to fashion clay into vessels, and to know how to harden it by the action of a strong heat *.

In the pit marked No. 6 in the Ground Plan at page 62, which was 354 yards north of the colossal statue, at a distance of 330 yards from the river, fragments of pottery were found at a depth of 38 feet from the surface of the ground.

Fragments of burnt brick and of pottery have been found at even greater depths in localities near the banks of the river, ten and sixteen miles below Cairo. In the boring at Sigiul, described in page 64 under the number 26, fragments of burnt brick and pottery were found in the sediment brought up from between the 45th and 50th foot from the surface, and in the boring at Bessousse, they were brought up from the lowest part, viz. 59 feet from the surface, but in this case in sand, the lowest sediment containing fragments of brick and pottery being at a depth of about 48 feet. I have also learned, from a communication with which I have been favoured by M. LINANT DE BELLEFONDS (LINANT BEY), that a few years ago he made a boring about 200 metres (656 feet) from the river on the Libyan side of the Rosetta branch of the Nile, in the parallel of the apex of the Delta, and that he had found fragments of red brick at a depth of about 72 feet below the surface of the ground. But in these cases there was wanting the fixed point of known age, the indispensable requisite for the formation of a chronometric scale. I may, however, state that M. DE ROZIÈRE † estimates the mean rate of the deposit of the sediment in the Delta, as not exceeding 2 French inches and 3 lines (60,907 millimetres=2·3622 English inches) in a century ‡.

The lowest water in the Nilometer of Rhoda in the year 1847, was determined by M. TALABOT to be 46 feet 2 inches above low water in the Mediterranean §. The fall of the river between Cairo and the apex of the Delta is $3\frac{3}{4}$ inches in a mile ||, and Sigioul and Bessousse being about 10 miles below the Rhoda Nilometer, the lowest water in the river in those localities would be about 43 feet. It is thus evident that the fragments of red brick and pottery found in the sediment brought up by the borings in those places, must have been, if not below, a very little above low-water mark in the Mediterranean, and that the fragments of brick found at so great a depth by LINANT BEY must have been considerably below that mark. It is therefore most probable that the fragments found in these localities were brought down by the river from the higher and inhabited part of the valley, at a time previous to the formation of the Delta.

There is every reason to believe that the whole of the area now occupied by the allu-

* For the opinion of the Baron VON BUNSEN as to the very early existence of man in Egypt, see Appendix, page 86, Note E.

† Description de l'Égypte, Hist. Nat., tome ii. p. 494.

‡ The question of the formation of the Delta is very fully examined by M. ELIE DE BEAUMONT, in his 'Leçons de Géologie,' tome i. pp. 405–492. The appearances in some parts of the coast, which have led some authors to suppose them to be indications of a depression of the land, are considered by M. DE BEAUMONT as insufficient proofs of such an event.

§ Memoir, Part I. p. 114.

|| Id.

vial land of Lower Egypt, the Delta, was at one time a bay in the Mediterranean, which in the course of ages was gradually filled up by deposits from the numerous branches of the Nile not confined by artificial embankments, and aided by sand blown from the adjacent high desert land *; and that at a time when the shore of the bay had advanced first to the parallel of Sigioul and Bessousse, and afterwards to that of the present apex of the Delta, by means of the accumulations at the embouchure of the Nile, the fragments of brick and pottery that had fallen into the river above were carried forward by it into the bay. This process appears to have continued as the shores of the bay gradually advanced northward, even to its present sea-line; for in borings made by HEKEKYAN BEY in 1854 at Sa-il-Hagiar, a village about 45 miles above Rosetta, the supposed site of the ancient city of Sais, and also in the neighbourhood of Rosetta itself, similar fragments were found at depths of 19 and 20 feet. He states that rubbish soil extends to considerable depths under the foundations of stone buildings below the lowest level of the Mediterranean, and quite close to the sea.

* "There must have been a time when the Delta was not only a marsh, but was even covered with water; and when the sea must have advanced so near to the site of Memphis, as to allow the annual flood to rise no higher than 8 cubits, or 12 to 14 feet at that place. HERODOTUS afterwards remarks, that it rose 15 or 16 cubits in his time, which was the natural progress of things, as the point of contact of the *land* waters with those of the *sea* was removed further out."—RENNELL'S 'Geography of HERODOTUS,' 112.

APPENDIX

Appendix.

Note A, page 54.

That a subject of the Grand Sultan, and one resident in Egypt, should be distinguished by attainments in science and literature is so rare an occurrence, that the Society may naturally expect me to give some biographical notice of my friend and coadjutor in this work, Hekekyan Bey. Had I not been so fortunate as to make his acquaintance, my object could not have been attained. Such extensive operations could not have been undertaken by a European, by any one not thoroughly inured to the climate of Egypt, nor by any one unacquainted with pursuits in physical science, and who was not familiar with the language of the numerous persons to be employed, of whom a large proportion must be common labourers. The researches had to be carried on under a burning sun, and they were continued during three years. My correspondence with Hekekyan Bey has been going on for more than five years; he writes English like a native, and it would be difficult for me to over-rate the value of his unwearied cooperation.

He is a native of Constantinople, of an Armenian Roman Catholic family. His father, Michirdiz, was in the service of Mehemet Ali, Viceroy of Egypt, in the capacity of translator of political or other useful dissertations for the personal use of the Pacha; being equally conversant with the Turkish and French languages.

Mehemet Ali having resolved on sending the sons of several of his officers to Paris for their education in the year 1817, Michirdiz solicited, as a reward for his services, that his son might be sent for the same purpose to England, and his request was granted. Hekekyan was then living with his family at Constantinople, and was only ten years of age. When he arrived in London, the only language he knew was the Turkish. He was placed under the care of Mr. Briggs, formerly British Consul at Alexandria, who had returned to England*; and to enable him to continue in the religion of his family, he was placed at the College of Stonyhurst in Lancashire. Here he received the first elements of an English education. After completing at the College the usual course of studies, as it was the desire of the Viceroy that he should be instructed in the management of steam-engines and machinery, he was placed by Mr. Briggs with Mr. Bramah, with whom he remained between two and three years. The Viceroy next desired that he should turn his attention to the machinery employed in cotton mills, as Mehemet Ali wished to establish that manufacture in Egypt, and he was, accordingly, a considerable time at Manchester and Glasgow. The Viceroy was not yet satisfied, but required him to be instructed in hydraulics, and an eminent engineer in London received him as a pupil, taking him with him while engaged in the formation of some canals and other works.

After a stay of twelve years in England, Hekekyan returned to Egypt in the autumn of 1830; but unfortunately he had forgotten his native tongue, and as he could only

* To this gentleman I am indebted for most of the particulars here given.

communicate with his patron the Viceroy through the medium of an interpreter, it proved, at first, a great obstacle to his advancement. For three years MEHEMET ALI employed him to superintend his cotton mills, but in 1833 he was appointed to a more congenial occupation, being entrusted with the organization of the Polytechnic School in Cairo, receiving rank as an Adjutant on the Staff, and in 1835 the advanced step of Major of Engineers. He established *l'École des Arts et Métiers*, which he continued to direct to the end of 1840, by which time he had obtained the rank of Lieut.-Colonel. During the seven years that he was attached to that school, he was more or less engaged in almost all the commissions appointed by his Government to examine the plans proposed for the construction of roads and bridges, fortifications and the working of mines; and he was further engaged to translate into Turkish, for the use of the Viceroy, the more important articles in the journals of England, France and India. He was now advanced to the rank of Bey in the Engineers, and after being engaged in several employments in the public service, early in 1850 he retired into private life.

Note B, page 61.

The existence of Microscopic Organisms in the Nile sediment.

I sent some specimens of recent sediment and of some brought up from a considerable depth, in all sixteen, to my friend the late Dr. MANTELL, requesting him to examine them under his powerful microscope. He did so, and his report was,—" Not a vestige of organisms of any kind have been detected. I never before found any fluviatile detritus free from animal or vegetable remains of some kind or other." Accidentally mentioning this to my friend Professor C. RITTER, then in England, he expressed much surprise, as Professor EHRENBERG had published some years ago an account of many forms he had found in Nile sediment, and he requested me to send some of the same which had been examined by Dr. MANTELL to Professor EHRENBERG. I did so, and the Professor kindly undertook a careful examination of them. The results he read at a meeting of the Berlin Academy, and they are published in their 'Monatsbericht' for 11 November 1852. He then describes his having found in the sixteen specimens, 67 organisms; viz. 10 Polygastrica, 47 Phytolitharia, 4 Polythalamia and 6 indeterminate forms. The details of forty-four examinations are given.

Two years afterwards, being in Berlin, I requested Professor EHRENBERG to show me some of the numerous organisms he had found; they are preserved in his collection, and are for the most part figured in his great work, '*Geologie des kleinen Lebens.*' Many of the plates I had then before me, and I selected, at a venture, those which I wished him to show me. He brought them out, and I saw, with a power of 300, with perfect distinctness, the following, which are figured in the above work:—

POLYGASTRICA.

Surirella Rhopala, Tafel xxxiii. I. 19. Taf. xxxv. A. x. 3.
Gallionella procera, Tafel xxxiii. I. 12. Taf. xv. A. 1.

Trachelomonas granulata, Tafel xxxv. A. 13.
Eunotia amphioxys, Tafel xiv. 31. Taf. xxxix. 29, 30.

PHYTOLITHARIA.

Lithostylidium rude, Tafel III. III. 21.
Lithostylidium quadratum, Tafel xxxiv. VI. 6.
Lithostylidium spinulosum, Tafel xxxv. A. XIV. 6.
Lithostylidium Trabecula, Tafel xxxiv. VI. 8.
Lithodontium nasutum, Tafel xxxix. 61, 62.
Lithodontium rostratum, Tafel I. III. 25.
Spongolithis acicularis, Tafel I. I. 16.
Spongolithis, Tafel xxxiv. V. B. 16.
Spongolithis, Tafel x. 22.
Spongolithis, Tafel xiv. 109.

Note C, page 72.

M. GIRARD'S *estimate of the Secular Increase of the alluvial land.*

His conclusions were founded on observations made at the ruined Nilometer on the island of Elephantina, near Assouan, and afterwards at the existing Nilometer on the island of Rhoda near Cairo.

He visited Elephantina towards the end of July 1799, and found at the shore a wall or quay 160 metres (525 feet) in length, and in a part of it a gallery and chamber, and from the latter a staircase leading down to the river. On cleaning the walls of this staircase, he observed upon them four vertical grooves cut into the stone to a depth of a centimetre (about $\frac{4}{10}$ths of an inch) with horizontal divisions, which proved to be marks of cubits, some of them having numbers annexed to them. He had thus no doubt that he had found the Nilometer. "The last cubit," says M. GIRARD, "of this Nilometer is marked in Greek characters with the number 24; that was, in effect, Egyptian cubits, the use of which was continued, as we know, under the Ptolemies, indicating the height of great inundations, as measured immediately below the last cataract. At the time, therefore, when the Nilometer was constructed, the inundations did not rise beyond that mark....... To compare the level of the twenty-fourth cubit of this Nilometer with that of the highest recent inundations, it was necessary to know the height to which the latter rise at this place, and fortunately the marks they leave are not obliterated from year to year, and we observed them very distinctly on the face of the wall of the quay, behind which the scale of the Nilometer is traced. The result of the levelings I took, to determine the space between the twenty-fourth cubit of the Nilometer and the level of the highest inundations of the present time, showed a difference of 2·413 metres (7 feet 11 inches). Thus, the bed of the Nile has risen by that amount, at least, between the time when the Nilometer was erected, for there is no reason to think that the quantity of water coming from Abyssinia is different now from what it was then. An inscription in Greek characters traced in the wall of the Nilometer has the date of the reign of SEPTIMIUS SEVERUS, and the object of it seems to have been to mark an inundation that had risen several palms above the twenty-fourth cubit. It is probable that the inundation referred to was not an extraordinary one, but that the Romans who formed the garrison at Syene in that reign, ignorant of the effect of the natural rise of the bed of the river, noted it as a remarkable event, supposing that the highest point of the twenty-fourth cubit was a fixed point, beyond which the annual flood of the river could never rise. Now admitting the highest inundations to have reached the mark traced above the twenty-fourth cubit, that is to say, that they had risen above it about 0·31 metre (12·205 inches) at the date of the inscription, it will be easy for us to fix the amount by which the bed of the Nile at Elephantina has been raised between that epoch and the present day. Thus, SEPTIMIUS SEVERUS became Emperor in A.D. 193, and died in 211, and supposing the inscription to have been cut on the stone in the middle of his reign, the bed of the Nile will have risen 2·11 metres (6 feet 11 inches) in 1600 years, which gives 0·132 mètre (5·192 inches in a century)."

M. GIRARD then gives the observations he made, with the same object, at the Nilometer on the island of Rhoda near Cairo, which he states to have been reconstructed about A.D. 847. "There can be no doubt," he says*, "that at the time when this Nilometer was erected, its 16th cubit by which it is terminated indicated a year of plenty, for it has always been of importance for the government to know the extent of the rise of the inundations, by which they could levy the largest amount of duty. If therefore the inundation had risen higher than the existing Nilometer, it is evident that they must have added to the height of the column, in order that it might show the inundations the most favourable to the exchequer. Now, in the present day, if the Nile does not rise above the 16th cubit of the Mekyas (Nilometer), it is considered unfavourable. That of 1799, for example, was considered to be one of the least favourable, and yet it rose to 16 cubits 2 digits. But the following year was one of plenty, and the water had risen to 18 cubits and 3 digits, thus making a difference of 2 cubits and 3 digits between the highest rise at the time of the erection of the Nilometer, and that to which it had risen in 1800, or 1·149 metre (45·237 inches) in 953 years, which is equal to 0·120 metre (4·742 inches) in a century." The difference between 0·132 at Elephantina and 0·120 at Rhoda may, he considers, be accounted for by possible changes in that distance, in the inclination of the bed, the amount and velocity of the stream, and its wearing power on the banks; but that it is so slight, that the secular rise of the bed of the river may be very nearly represented by the mean of the above sums, that is 0·126 metre, or 4·960 inches.

He then comes to a conclusion which I shall give in his own words:—"Quant à l'exhaussement moyen du sol de la vallée d'Égypte, il suffit d'une légère attention pour reconnaître, qu'il doit être exactement le même que l'exhaussement moyen du lit du Nil."

* *Loc. cit.* p. 264.

"Si donc il n'est point exact de dire qu'en un point déterminé de l'Égypte, le fond du lit du Nil et la plaine adjacente s'élèvent simultanément de la même quantité séculaire, il est constant que, depuis la dernière cataracte jusqu'à la mer, le fond du fleuve et le niveau des plaines qu'il submerge se sont élevés d'une même quantité moyenne, puisque ces deux surfaces tendent sans cesse au parallèlisme, et que la nature les y ramène quand des circonstances particulières ou les travaux des hommes les en ont momentanément écartées *."

The data upon which M. GIRARD founds his conclusion appear to me to be far too loose and indeterminate in their nature, and insufficient in number, to warrant the establishment of what may be termed a law of increase. Some observations are stated to have been made at Thebes, Siout, Heliopolis, and some other places, with the view of testing the accuracy of this rate of secular increase, by digging into the alluvial soil at the foot of ancient monuments, applying to remote antecedent periods the rate which had been founded upon observations which had reference only to comparatively recent times; but in none of those cases was any definite result obtained confirmatory of the assumed rate.

As regards the observations at the Nilometer of Elephantina, they are accompanied by some sources of uncertainty. In the more than 2000 years between its erection† and the time of M. GIRARD'S observations, it is far from improbable that the foundation of the building may have sunk, an occurrence by no means rare, and which, it is believed, has happened to the Nilometer of Rhoda. It is *assumed* only that the figure 24 marked the highest inundations at the time of the formation of the scale; it is *assumed* that the mark and inscription had been made by the Roman garrison with the intention of recording the highest flood at that period. The mark on the external wall is not a perfectly reliable proof of the height to which the inundations in recent times may have reached, as it may have been caused, so near the cataract, by some temporary and purely local accumulation of the water. After the river has attained its stationary salibe level, it sometimes continues to rise several inches higher, on account of occasional and sudden torrents falling into the Nile valley by some of the numerous side ravines, which bring down the rain-water from the Arabian or Libyan Hills; rain-clouds with thunder and lightning frequently cross the valley, coming generally from the west, and the rain falls very heavily.

As regards the Rhoda Nilometer, it is difficult to comprehend how there should have been so trifling a difference between the relative proportions of secular increase at Elephantina and Rhoda, viz. 0·132 metre and 0·120 metre, from which M. GIRARD makes the mean secular rise of the bed of the river 0·126. I have already shown how, from various causes, there must be a progressive diminution in the amount of sediment as the

* *Loc. cit.* p. 266.

† "Quant à la construction de cet édifice, je ne crois pas qu'on puisse en faire remonter la date au delà les Ptolemées. Les caractères numériques qui distinguent chaque coudée prouvent qu'il est l'ouvrage des Grecs."—GIRARD, Description de l'Égypte, Antiq. Mémoires, tome i. p. 11.

river descends, and in a distance of 580 miles the difference at the extremes of Cairo and Elephantina must be very great. Under such circumstances, that the rise of the bed of the river and the rise of the inundation water at the two places should relatively have so near an agreement, appears to me to be highly improbable.

It is further assumed that the Rhoda Nilometer has undergone no alteration since A.D. 847; but M. MARCEL, a colleague of M. GIRARD in Egypt, in an elaborate dissertation on this Nilometer*, states, that it was erected in A.D. 715, that it had been injured by neglect, was restored in 814, repaired in 846, and again repaired in 861, 1092, and 1518. Sir GARDINER WILKINSON tells us "that it is certain no accurate calculations can be obtained from a column which has been broken and repaired in such a manner that one of the cubits remains incomplete†." How little reliance, for such an object, is to be placed on this Nilometer, is still more apparent from the following extracts from a memoir upon it sent to me by HEKEKYAN BEY, dated Cairo, 15 November, 1857.

"The chamber or deep basin in which the graduated column is erected, is an oblong space 21 feet 8 by 16 feet 9, having a flight of steps within it. The present column is formed out of the remnants of an older column of records, erected formerly on the same spot. According to some historians it was commenced and terminated in A.D. 715. The building has frequently required repair, effected at various intervals by Caliphs, Sultans, Beys, Pachas, and by the French General MENOU. It rests upon an isolated disk of sandstone 31½ inches thick, and by soundings it has been ascertained that the disk rests upon an arenaceous Nile alluvium, containing particles of limestone and pottery.

"In estimating the heights of the inundations by the column, the difficulty to surmount has been, the conception of some clear idea of the nature of the scale and the nomenclature used in the daily measurements and records of the water-levels. At the bottom of the flight of steps there is a landing-place, called the Mastaba, the surface of which is on a level with the 9th cubic mark on the column. The surface of the water at the commencement of the annual increase is measured down from the Mastaba, and when it has risen to that level, it is measured up from the Mastaba until it culminates. It is again measured down from its point of culmination to the Mastaba, and from that level down to its ebb, and again down from the Mastaba at the rise of the following year, circularly, without intermission; a process which has been going on from generation to generation every day at sunrise, and with extreme care at the precise times of the two solstices and equinoxes. These measurements are carried up and down the interior scarps of the walls of the chamber on the west and south sides. The measuring instrument is the Black Cubit, so called because it is made of ebony.

"The column has nothing to do with these measurements. MEHEMED ALI PACHA, observing the wide discrepancies between the numerical values assigned evidently to the same water-levels from year to year, ordered the Sheikhs of the Nilometer to send up the daily accounts of their observations, and to register them in government books.

* Description de l'Égypte, tome i. p. 29, and tome ii. État Moderne, p. 119.

† Topography of Thebes, p. 313.

"In 1852, the Sheikh of the Nilometer attending on me by order of the late Viceroy, informed me that the Mastaba was the 9th cubit, that he measured from it 7 cubits to obtain the 16th and three more to get at the 22nd, and two more to reach the 24th. Accordingly from the 9th to the 24th we have 12 cubits, and nine more below the Mastaba. I wished the Sheikh to afford me further information, which he declined, affirming that he was engaged by a sacred promise, like all his predecessors and ancestors,—the office is hereditary—to reveal the secrets of the Nilometer to no ear but that of the reigning Caliph of the Faithful. On my requesting, however, that he would show me how he measured up to the 24th cubit, he indicated a point on the parapet, which I measured, and found to be 254·209 inches above the Mastaba, which at 20·625 inches to the cubit, instead of 15 cubits, is only 12·325.

"The cubit divisions on the column do not at all correspond with the standard of 20·625, for on measuring the seven cubits between the 9th and 16th, I found it to be 155·20 inches, which gives 22·17 inches to the cubit. From the Mastaba to the upper surface of the sandstone disk on which the column rests, that is, the *nine* cubits, the distance was found to be 148·67 inches, which gives only 16·52 inches to each cubit. From the base of the column to the 16th cubit mark we have thus 303·87 inches, which gives an average of 18·99 to each cubit.

"The conflicting statements made by the Sheikhs of the Nilometer induced the French savans to give up the question of the scale used by the Ulema, and to adopt a new system of their own invention for future annual observations and records. The extraordinary high Nile of the 4th of October 1804 was quoted by the Ulema at 14 cubits and 17 digits; but the same water-level by the French measurement amounted to 18 cubits and 3 digits. On the 23rd of September 1799 the water-level was recorded by the Ulema at 12 cubits and 16 digits, and by the French at 16 cubits and 2 digits, and on the 8th of October 1798 the Ulema quoted 14 cubits, and the French 17 cubits and 10 digits."

Note D, page 75.

The researches undertaken by the French engineers, for the purpose of ascertaining the nature and depth of the alluvial soil in the Nile valley in Upper Egypt, are described by M. Girard, under whose special direction they appear to have been conducted *.

The first excavations were made in the early part of April 1799, in the nearly level plain in which Siout is situated, about 240 miles above Cairo. The valley here is rather more than six miles in width, the Nile flowing nearly two miles from the western or Libyan range of hills. Eleven pits were sunk in a continuous line from the Libyan Hills to the left bank of the river, and two, XII. and XIII., on the right bank, in a prolongation of the same line.

* Sur la Vallée d'Égypte, &c., Mémoires de l'Institut, 1817.

Pit.	Distance from the former pit.		Mud.		Sand.		Total depth of the pit.	
	yds.	ft.	ft.	in.	ft.	in.	ft.	in.
I.	....		13	0	....		13	0
II.	218	2	20	11½	4	1¼	25	0¾
III.	393	2	20	5¼	7	2½	77	7¾
IV.	142	0	11	0	6	0		
V.	153	0	11	0	9	3	20	3
VI.	437	1	4	3	6	6¾		
VII.	236	0	4	6¼	16	10	21	4¼
VIII.	235	0	4	11	13	0		
IX.	345	1	8	2¼	11	5¾	19	8
X.	332	1	7	8½	10	6½	18	3
XI.	393	2	7	4¼	20	10	38	2¼

In the pits X. and XI., at the level when the filtration water prevented further excavation, a boring tool was applied, and what it brought up showed that the same sand continued at a further depth of 16 feet.

The pits XII. and XIII. were sunk on the right bank; XII. at its edge, which rose above the highest inundation level. They first passed through 27 inches of pure mud (*limon*), which rested on 107 inches of micaceous sand mixed with a little mud, below which there were 85 inches of grey sand, and 4¼ inches of magnetic iron sand; lastly, 60½ inches of a mixture of sand and mud, when they were stopped by the filtration water. Thus—

Pit XII.

	ft.	in.
1. Pure mud	2	3
2. Micaceous sand. . . .	8	11
3. Grey sand	7	1
4. Iron sand	0	4¼
5. Sand and mud . . .	5	0½
Depth of pit . . .	23	7¾

Pit XIII.

Was sunk near to a broad canal 916 yards east of No. XII. They found—

	ft.	in.
1. Pure mud	20	9
2. Ferruginous sand . .	4	0
Depth of pit . . .	24	9

Being desirous of reaching, if possible, the rock which forms the base of the valley, they sank a pit in the same locality, but in the vicinity of the bounding hill, 304 yards from the cultivable land. They chose a projection of the base of the hill, which they conceived would be composed of the gravel that constitutes the soil of the desert land. The result of their excavation was—

	ft.	in.
1. Sand and gravel	6	10
2. Yellow sand mixed with clay, forming a very compact mass .	8	0
3. Whitish marl	0	8½
4. Pure incoherent yellow sand	1	10
5. Whitish marl	0	8½
6. Sand, gravel and rolled pebbles	3	11
	22	0

At this depth they struck a bed of limestone, the same as that in which the grottos of Siout are excavated, and they inferred that thus the limestone beds dip towards the river beneath the alluvium.

Their next excavations were in the vicinity of Queneh, about 140 miles above Siout; and here they sank two pits on the right bank of the river:

No. I. 554 *yards from the Nile.*

	ft.	in.
1. Mud	8	10
2. Grey sand	15	6
Filtration water at	24	4

No. II. 187 *yards from the Nile.*

	ft.	in.
1. Mud	4	7
2. Grey sand	24	$9\frac{1}{2}$
Filtration water at	29	$4\frac{1}{2}$

Their next excavations were at Esneh, about 90 miles above Queneh, and about 100 below Assouan. They sank three pits on the right bank, and three on the left, with the following results:—

Right bank.				Left bank.			
Pit.	Mud.	Sand.	Filtration water reached at	Pit.	Mud.	Sand.	Filtration water reached at
	ft. in.	ft. in.	ft. in.		ft. in.	ft. in.	ft in.
I.	16 $0\frac{1}{2}$	8 11	24 $11\frac{1}{2}$	I.	19 8	......	19 8
II.	18 $8\frac{1}{2}$	8 0	26 $8\frac{1}{2}$	II.	15 10	5 11	21 9
III.	24 6	......	24 6	III.	12 $5\frac{1}{2}$	7 $3\frac{1}{4}$	19 $8\frac{3}{4}$

Right bank:

I. 249 yards from right bank of river.
II. 1312 yards from I., nearer the Arabian Hills.
III. 1312 yards from II., further inland, and on the boundary of the cultivable land. Filtration water was reached before they had penetrated through the mud.

The plain rises about 3 feet 3 inches from the Nile to the foot of the hills, and the cultivable land extends $1\frac{5}{8}$ mile from the river.

Left bank:

I. 3609 yards from the Nile, at the outer edge of the cultivable land. No sand was reached.
II. 1640 yards from I., and so much nearer the river.
III. 656 yards from II., and so much nearer the river.

NOTE E, page 76.

The Chevalier BUNSEN, in his 'Egyptens Stelle in der Weltgeschichte,' has the following passage:—

"It may be assumed as a settled point in history, that Egyptian tradition, prior to MENES, admitted one dynasty of kings in Lower Egypt, and one at least, perhaps two, in Upper Egypt, during a period of from 2000 to 4000 years. The race of MENES succeeds three dynasties. They are perfectly distinct from the mythical kings, whose history is connected rather with that of the Gods. MENES united the Upper and the Lower Country."—English Translation, Book I. pp. 71, 72.

In the preface to the Fourth Book of the same history, published in 1856, there occurs the following passage:—

"An examination of the time from ALEXANDER to MENES, and of the vastly remote contemporaneous events of Asiatic life, leads us to documentary beginnings of a great development, more or less chronologically determinable. But when we come to consider more closely the unmistakeable purely historical time, before MENES, of separate kingdoms and particular provinces, we discover that those earlier ages belong to a period, when the foundation of that entire development rested upon the formation of language and mythology. The author believes that he is justified in maintaining this to be a fact in historical science."

"Records forming a documentary history of nations extend to about 4000 years before our era, and an early period of long duration must necessarily have preceded these. When, on the grounds set forth in our Fifth Book, we assign to that period a duration of from 6000 to 9000 years for Egypt, and from 15,000 to 16,000 years for man's existence, it is no arbitrary and presumptuous application of research, but an emancipation of ourselves from error which throws everything into confusion. The first epochs of the history of the human race demand, at the least, a period of this extent, and its commencement, 20,000 years before our era, is a fair starting-point in the earth's history." —Original edition, Vorrede, p. viii.

*Tables of the Soils**.

Signs in the sections.	Varieties.	Local names given by HEKEKYAN BEY.
A.	Blackish brown argillaceous earth, similar to sample I. Memoir, Part I. p. 130	Teane zebedi, butter soil or fine clay.
B.	Blackish, argillaceous sandy earth	Teane soda iblizi, or plastic clay.
C.	Light brown, argillaceous sandy earth, with scales of mica	Teane safra iblizi, yellow plastic clay.
D.	Blackish, compact, argillaceous sandy earth, with scales of mica	Teane zargha.
E.	Greenish brown, argillaceous sandy earth, with scales of mica	Teane khadra.
F.	Reddish brown, argillaceous sandy earth, with scales of mica	Teane houmra.
G.	Greyish brown, argillaceous sandy earth, with scales of mica	Teane beida.
H.	Transparent quartzose sand, rounded particles of various sizes, mixed with particles of black earth	Raml abiad, white sand.
I.	Fine, shining black sand, composed of rounded and crystalline grains of magnetic iron, with a small proportion of quartzose sand	Raml iswid, black sand.
K.	Transparent, fine-grained quartzose sand, of a light yellow tint, resembling the fine part of the sample X. Memoir, Part I. p. 130	Raml asfar, yellow sand.
L.	Very fine quartzose sand, with scales of mica	Raml azrak, bluish sand.
M.	Fine, transparent quartzose sand, composed of rounded particles	Raml Nili, clean river-sand.
N.	Gravel, composed of rounded quartz pebbles, coarse sand and angular fragments of flint	Zallat, quartz pebbles.
O.	Transparent, quartzose sand, similar to K	Raml gebeli, desert sand.
	Artificial substances.	
1.	Fragments and particles of limestone and red sandstone	Dabsh, stone fragments.
2.	Fragments of red burnt bricks	Tonb ah mar roufaiah.
3.	Fragments of pottery	Foukhhar roufaiah.
4.	Fragments of the rubbish of buildings, with lime mortar	Mouna binaiah.

The letters and figures within the sections in Plates II. and III. refer to the above Table.

The letters and figures which stand *first* in the divisions of the sections indicate the variety of the soil and of the artificial substance which predominates in the division.

* The specimens of the soils and of the objects of art found in the excavations, which are mentioned in this memoir, Parts I. and II., will be deposited in the British Museum.

Hekekyan Bey, in his anxiety to fulfil my instructions that every variety of the alluvial soil passed through in the pits should be noticed, carefully distinguished minute differences in composition and colour, and sent specimens of all the varieties he described. Although there are in fact only two classes, what may be termed *loams* and *sands*, I have thought it advisable to preserve in the sections Hekekyan Bey's minute distinctions. I have added to the above Table the local names which he has supplied, as they may prove useful, should future geologists, directing their attention, as I trust they will do, to the same subject, chance to see this memoir.

In the sections of the borings across the valley in the parallel of Heliopolis, given in Plates IV. and V., the letters used as signs of the different soils do not indicate the same varieties as in the preceding Table; they are as follows:—

Argillaceous earthy sediments, more or less mixed with sand.

A. Yellowish brown earth.
B. Light brown, argillaceous earth.
C. Light brown, sandy earth.
D. Brown sandy earth.
E. Dark brown earth.
F. Bluish dark brown earth.
G. Reddish brown earth.

Quartzose sands.

H. Yellow desert sand.
I. Yellowish brown sand.
K. Brown sand.
L. Light grey sand.
M. Grey sand.
N. Bluish sand.

Explanation of Plates.

PLATE II.

Sections of nineteen pits sunk in the area of Memphis, extending 2132 yards from west to east and 1576 yards from north to south, as given in the Ground Plan at page 62, showing the variations in the nature of the soils passed through at the same levels.

Pits.	Local names of the Pits, given by Hekekyan Bay.	Depths of the mouths of the Pits below the inundation level of 1851.		Distances in yards from the Pits R.	
		feet.	inches.		
R^1 R^2	At the colossal statue of Metrahenny	3	$6\frac{1}{2}$		
No. 1.	Excavation XIII. of the section across the valley	3	$6\frac{1}{2}$	6 S.	25 E.
No. 2.	Excavation of Omar Effendi	2	$11\frac{1}{2}$	45 S.	21 W.
No. 3.	Excavation of the Palms	6	1	52 N.	24 E.
No. 4.	Excavation of the Cesareum or Serb	8	$8\frac{1}{2}$	260 N.	80 W.
No. 5.	Excavation of Tel Moukalid	9	$10\frac{1}{2}$	326 N.	151 W.
No. 6.	Excavation of the Three Colossi	5	$11\frac{1}{2}$	354 N.	35 E.
No. 7.	Excavation of Shimbab, No. 1	1	$0\frac{1}{2}$	565 S.	115 E.
No. 8.	Excavation of Shimbab, No. 2	2	1	854 S.	198 E.
No. 9.	Excavation of Shimbab, No. 3	2	1	1250 S.	291 E.
No. 10.	Excavation of Baron Erben	8	$1\frac{1}{2}$	40 N.	779 E.
No. 11.	Excavation of Mekias il Rod, or Nilometer* of Memphis	7	0	627 N.	758 E.
No. 12.	Excavation in the Summer Road north of the cross embankment from Metrahenny to Bedreshin, No. 1	8	$3\frac{1}{2}$	595 N.	875 E.
No. 13.	Excavation of Bedreshin, No. 2	5	$10\frac{1}{2}$	537 N.	983 E.
No. 14.	Excavation of Bedreshin, No. 3	5	$1\frac{3}{4}$	491 N.	1150 E.
No. 15.	Excavation of Bedreshin, No. 4	8	$0\frac{3}{4}$	490 N.	1325 E.
No. 16.	Excavation of Bedreshin, No. 5	12	7	404 N.	1470 E.
No. 17.	Excavation of Bedreshin, No. 6	15	$10\frac{1}{4}$	388 N.	1690 E.

The letter F on the right of each section indicates the level of the filtration water reached in July and August 1852, except in the Pits R^2 and No. 6, which was in October 1854.

The letters within the sections indicate the varieties of the soils, as explained in the "Table of Soils" annexed, page 88.

The figures within the sections indicate the nature of the artificial substances contained in the soil.

The figures at the bottom of each section indicate, in feet and inches, its total depth from the surface of the ground.

* Diodorus Siculus speaks of a Niloscope constructed at Memphis by the ancient kings, divided by cubits and digits.

PLATE III.

Sections of a series of pits sunk across the Nile Valley, between the Libyan and Arabian Hills, in the parallel of the Memphis district, included within an area extending about 5 miles from west to east, and about $\frac{3}{4}$ of a mile from north to south.

Nos. 1 to 15 on the left bank, 16 to 26 on the right bank; the latter in a continuous line 490 yards south of the latitude of the excavation at the colossal statue of RAMESSES II.

Pits.	Localities of the Pits.	Depths of the mouths of the Pits below the inundation level of 1851.		Distances in yards from the excavation at the statue of RAMESSES II.	
		ft.	in.		
No. 1.	On the Montabesh * of the Western Desert	1	1	3162 W.	587 S.
No. 2.	On the Montabesh of the Western Desert	0	5	3096 W.	731 S.
No. 3.	In the Reef † of the Libyan Valley	0	$3\frac{1}{2}$	2621 W.	487 S.
No. 4.	In the Reef of the Libyan Valley	5	$7\frac{3}{4}$	2375 W.	362 S.
No. 5.	West of the Magrour or Joseph's Canal	5	1	1858 W.	210 S.
No. 6.	In the Magrour	4	10	1525 W.	220 S.
No. 7.	East of the Magrour	5	5	1375 W.	158 S.
No. 8.	In the plain west of Memphis mound district	4	6	1021 W.	81 S.
No. 9.	First pit on south side of the cross embankment on the eastern side of the mound district	6	10	1110 E.	42 N.
No. 10.	Second pit south of Metrahenny and Bedreshin cross embankment, and east of the mounds	5	$4\frac{1}{2}$	1721 E.	58 N.
No. 11.	South of the cross embankments from Bedreshin to Metrahenny.	4	8	2083 E.	69 N.
No. 12.	South of the cross embankments from Bedreshin to Metrahenny.	5	$11\frac{1}{2}$	2335 E.	80 N.
No. 13.	South of the cross embankments from Bedreshin to Metrahenny, and west of and close to the Nile dyke at Bedreshin Sahil ‡ ...	4	9	2930 E.	100 N.
No. 14.	East of Bedreshin Nile dyke, and on the Sahil	3	4	3177 E.	100 N.
No. 15.	On the edge of the river, at its ebb on 27th May 1854	25	9	3479 E.	475 N.
No. 16.	On the western scarp of Helwan Island	19	$5\frac{1}{2}$	4254 E.	490 S.
No. 17.	On the crest of the bank of Helwan Island	3	4	4505 E.	490 S.
No. 18.	On Helwan Island	2	$10\frac{1}{2}$	4583 E.	490 S.
No. 19.	On Helwan Island	3	$9\frac{3}{4}$	4754 E.	490 S.
No. 20.	In the bed of the Anaphora §, or branch of the river between the island and the Arabian valley	7	8	5049 E.	490 S.
No. 21.	East of the Arabian dyke	6	$0\frac{1}{2}$	5240 E.	490 S.
No. 22.	In the Arabian Reef, west of Helwan Canal	3	6	5407 E.	490 S.
No. 23.	On the Montabesh of the Eastern Desert side of the valley	3	5	5563 E.	490 S.
No. 24.	On the Montabesh of the Eastern Desert side of the valley	4	$2\frac{1}{4}$	5640 E.	490 S.
No. 25.	On the Montabesh of the Eastern Desert side of the valley	4	7	5794 E.	490 S.
No. 26.	On the Montabesh of the Eastern Desert side of the valley	0	10	5923 E.	490 S.

The letter F on the right of each section indicates the level of the filtration water reached in July and August 1852, except No. 15.

The letters within the sections indicate the varieties of the soils, as explained in the "Table of Soils" annexed, page 88.

The figures at the bottom of each section indicate, in feet and inches, its total depth from the surface of the ground.

* The Montabesh is the area that is inundated but not cultivated. It is good for camels and goats, and in times of peace and confidence the poor Bedouin cultivates this land, digging pits to water it.

† The Reef is the line separating the black soil from the sandy surface.

‡ The Sahil is the space of ground left by the ebbing river between itself and its dykes.

§ HEKEKYAN BEY has applied the term Anaphora to the passage of the swollen Nile, between an island in the river and the bank.

PLATE IV.

Sections of a line of borings between the Libyan range of hills and the left bank of the Nile, in the parallel of Heliopolis, about ten miles below Cairo, described in p. 63; Nos. 24, 25 and 26 are more accurately described in page 64. The length of the line is nearly eight miles.

1. In each instance the boring terminated when the filtration water was reached, No. 1 to 23 in July, 24, 25 and 26 from September to November 1854.

2. The figures immediately below the head line indicate in feet and inches the depth of the mouth of each boring below the inundation level.

3. The figures at the bottom of each section indicate in feet and inches the total depth of the boring from the surface of the ground.

4. The letters within the sections indicate the varieties of the soils, as explained in the "Table of Soils" annexed, page 88.

Section No. 1 was 50 yards distant from the eastern slope of the Libyan Hills.

5. The figures *between* the sections indicate in yards the distances between the borings.

PLATE V.

Sections of a line of borings between the right bank of the Nile at Bessousse and the Arabian range of hills in the parallel of the Heliopolis, in a distance of about eight miles from west to east, described in page 64, except No. 1, more particularly described, page 65.

The above explanations of Plate IV., numbered 1, 2, 3, 4 and 5, apply equally to Plate V.

The section No. 2 was 629 yards from the right bank of the Nile.

No. 9 was in the summer canal of Abou-Mounedgeh.

No. 10 was to the east of the winter canal of Sharkawiyeh.

No. 11 was in a small summer canal.

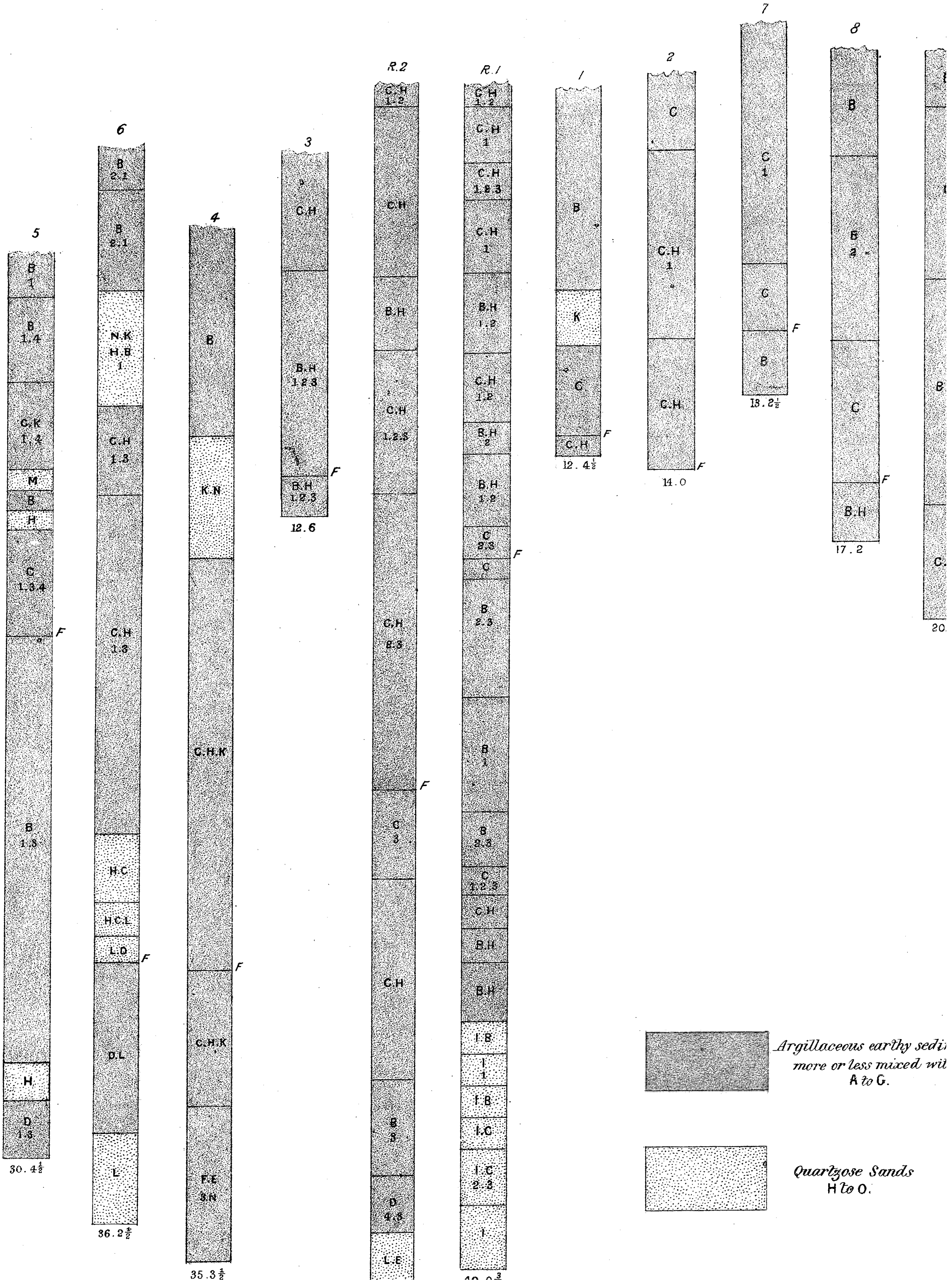
No. 17 was to the east of the Cairo Canal.

No. 18 was 87 yards west of the excavation C in the Heliopolis district. (Memoir, Part I., p. 124.)

No. 20 was 166 yards west of the Obelisk of Heliopolis.

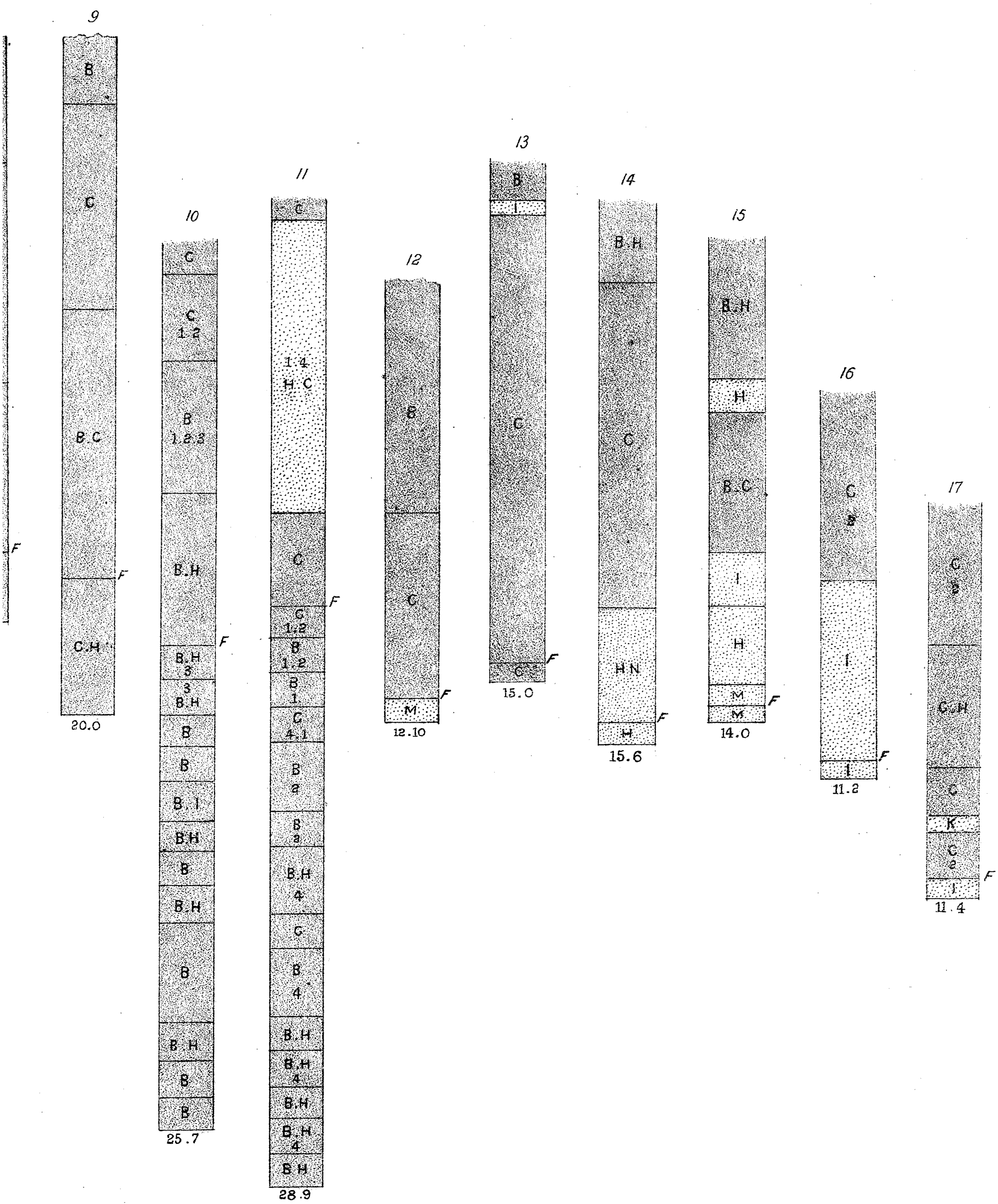
PITS SUNK IN THE AREA

INUNDATION LEVEL OF 185



AREA OF MEMPHIS.

'EL OF 1851.



arthy sediment
mixed with sand
G.

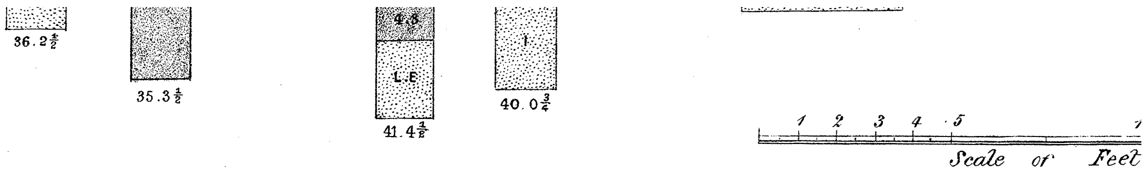
'ands

No. 1. Fragments of Limestone.

2. Fragments of burnt brick.

3. Fragments of Pottery.

4. Rubbish of buildings with lime mortar.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J. Basire, Lith.

PITS SUNK ACROSS THE NILE VALLEY, BETW
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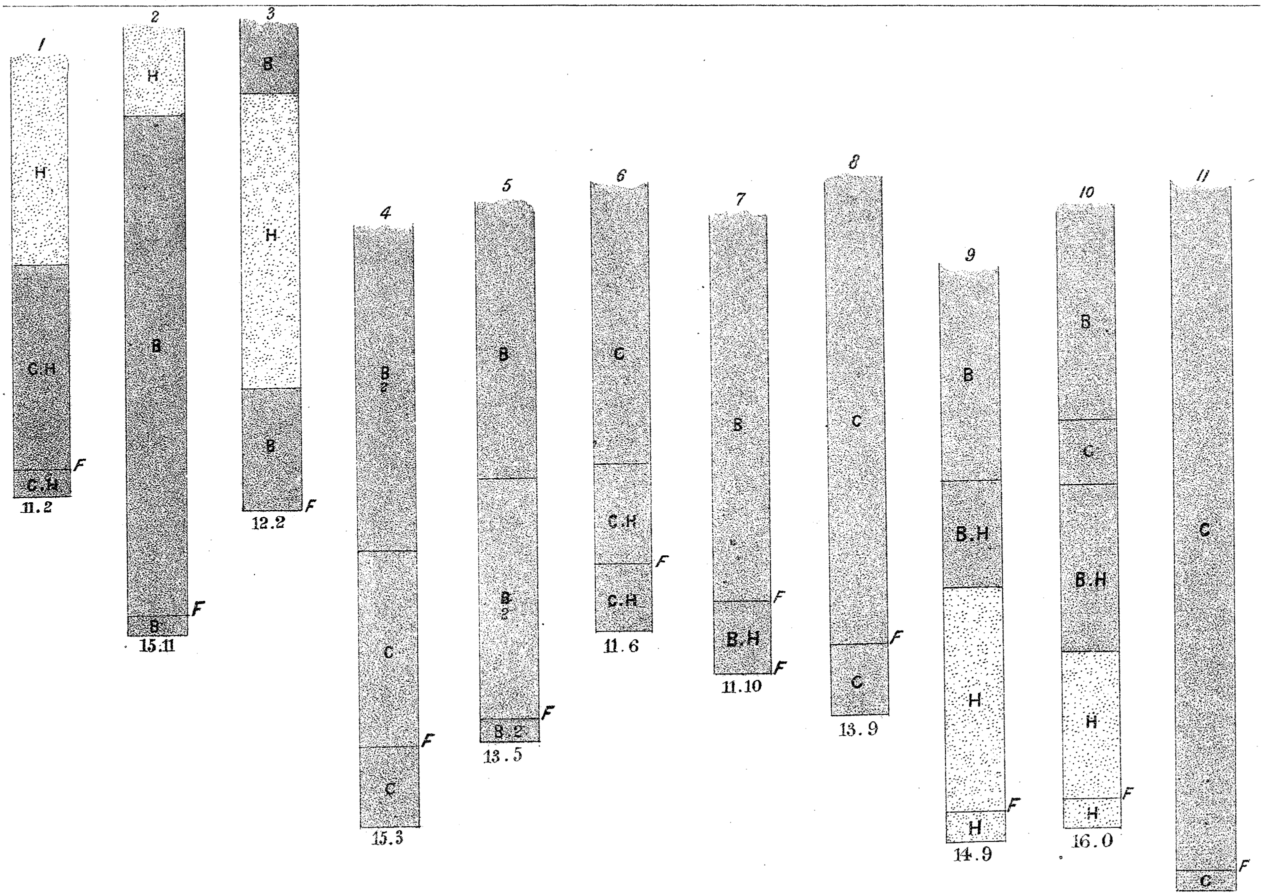
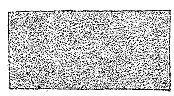
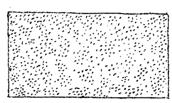
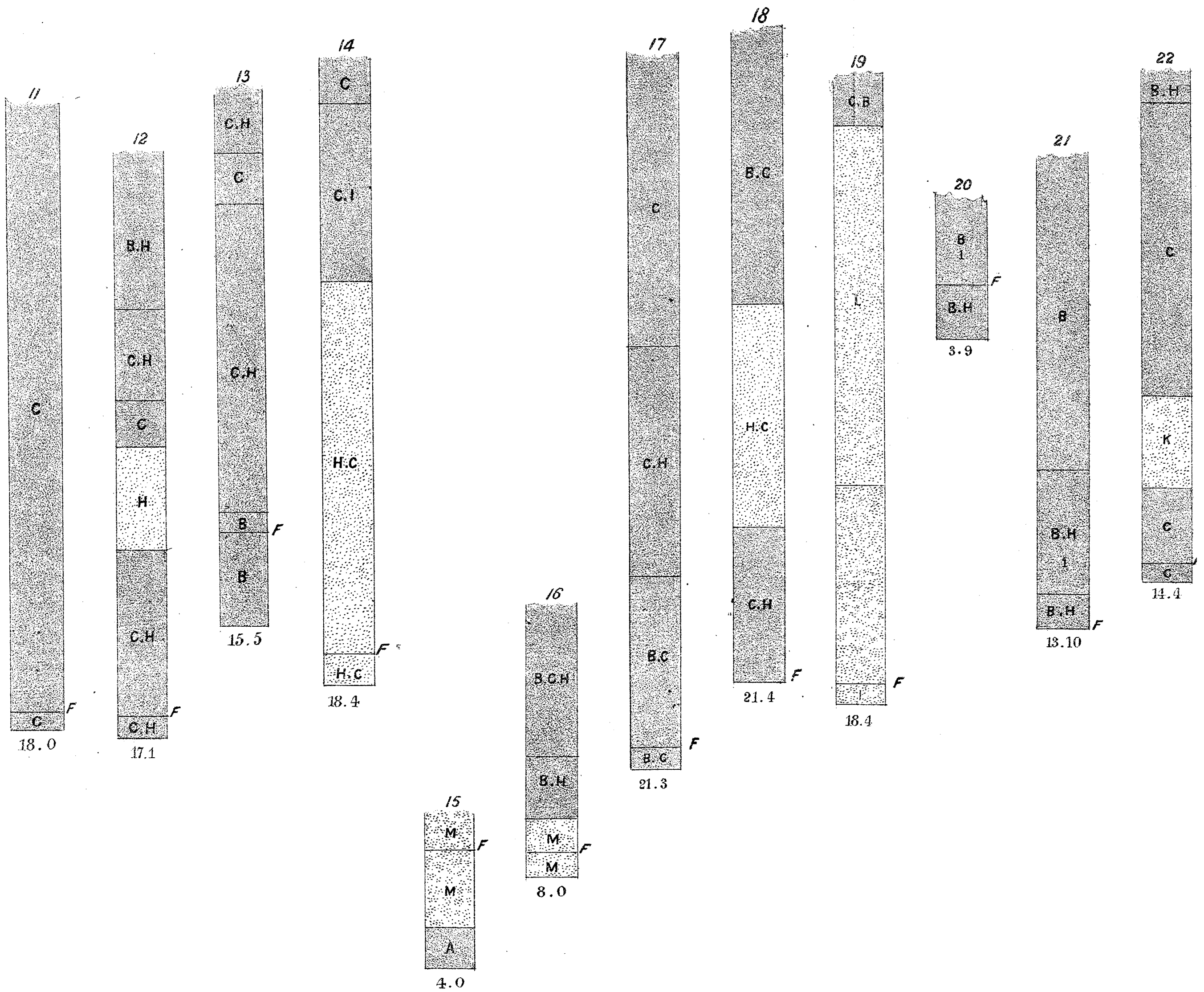






, BETWEEN THE LIBYAN AND ARABIAN HILLS, PARALLEL OF MEMPHIS.

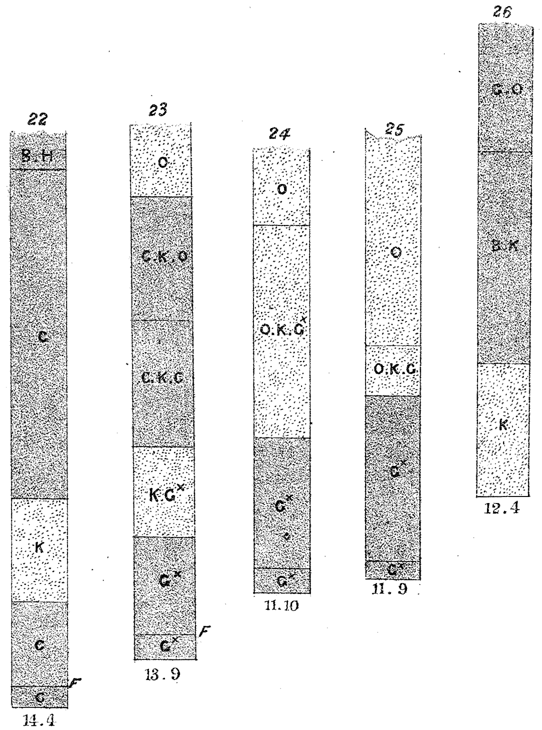
INUNDATION LEVEL OF 1851.



rgillaceous earthy sediment
more or less mixed with sand.
A to G.

Quartzose Sands.
H to O.

No. 1. Fragments of Limestone.
No. 2. Fragments of burnt brick.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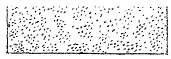

H 20 O

H̆ to O.

J. Basire Lith.

BORINGS BETWEEN THE LIBYAN HILL…

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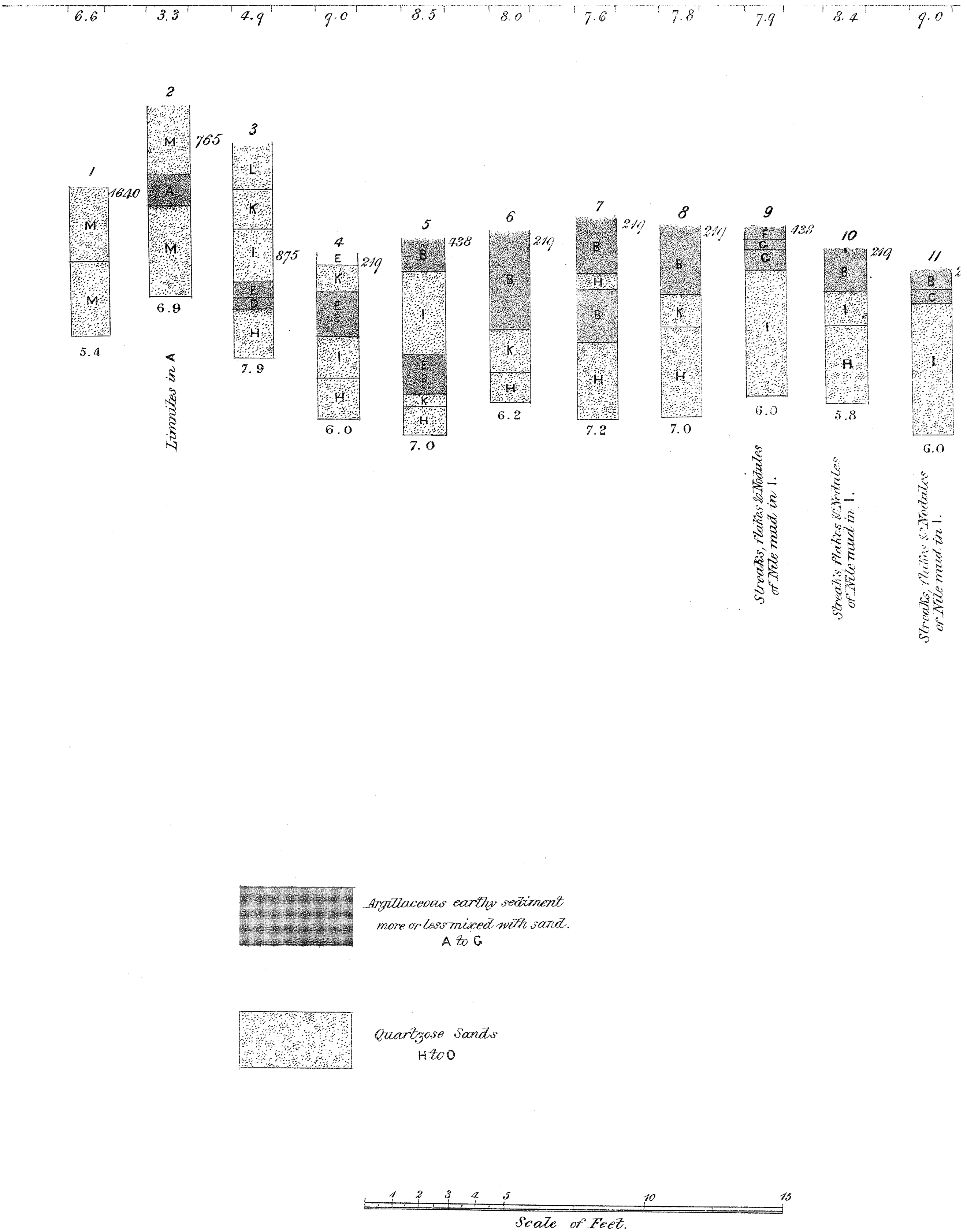
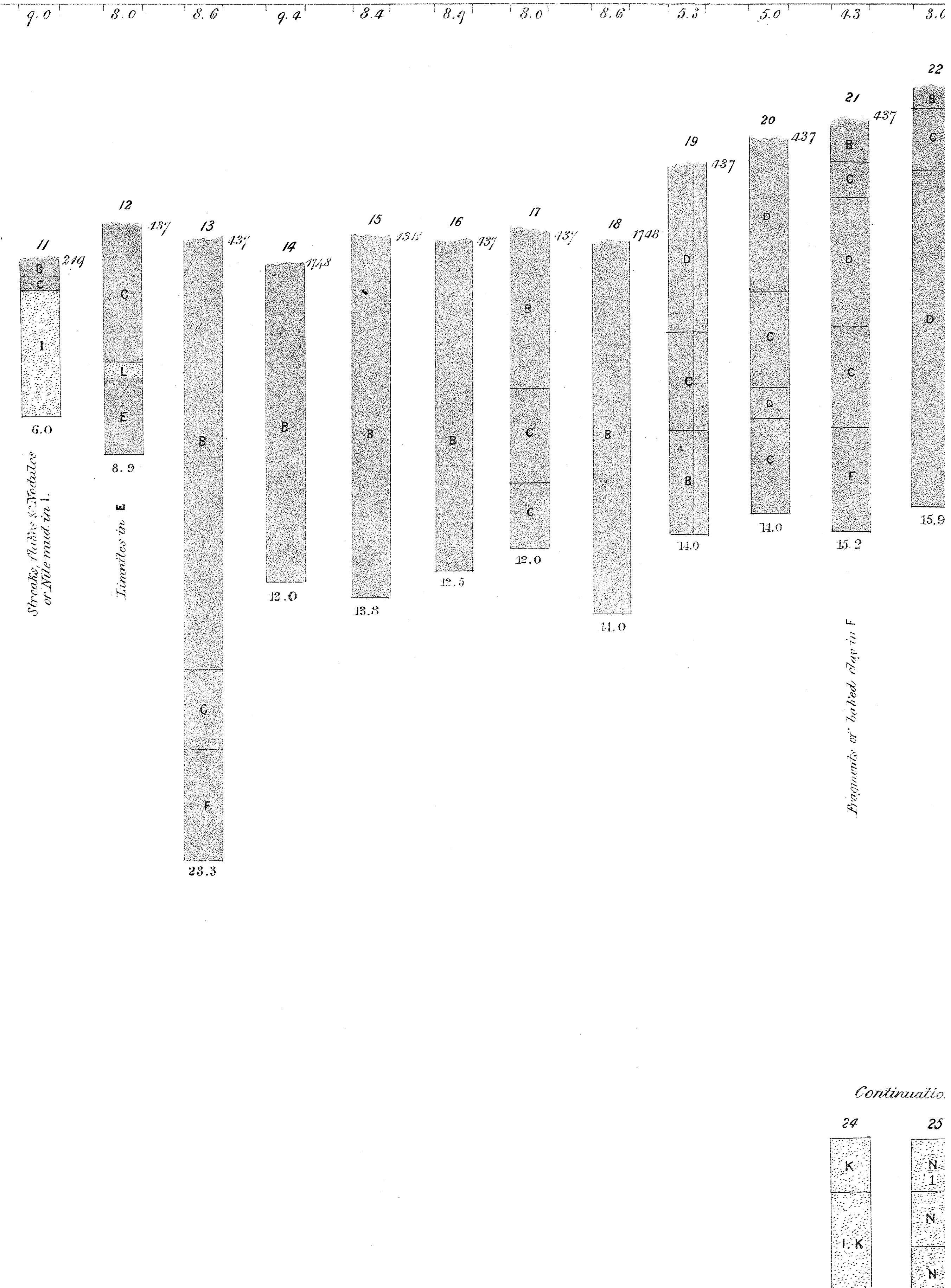
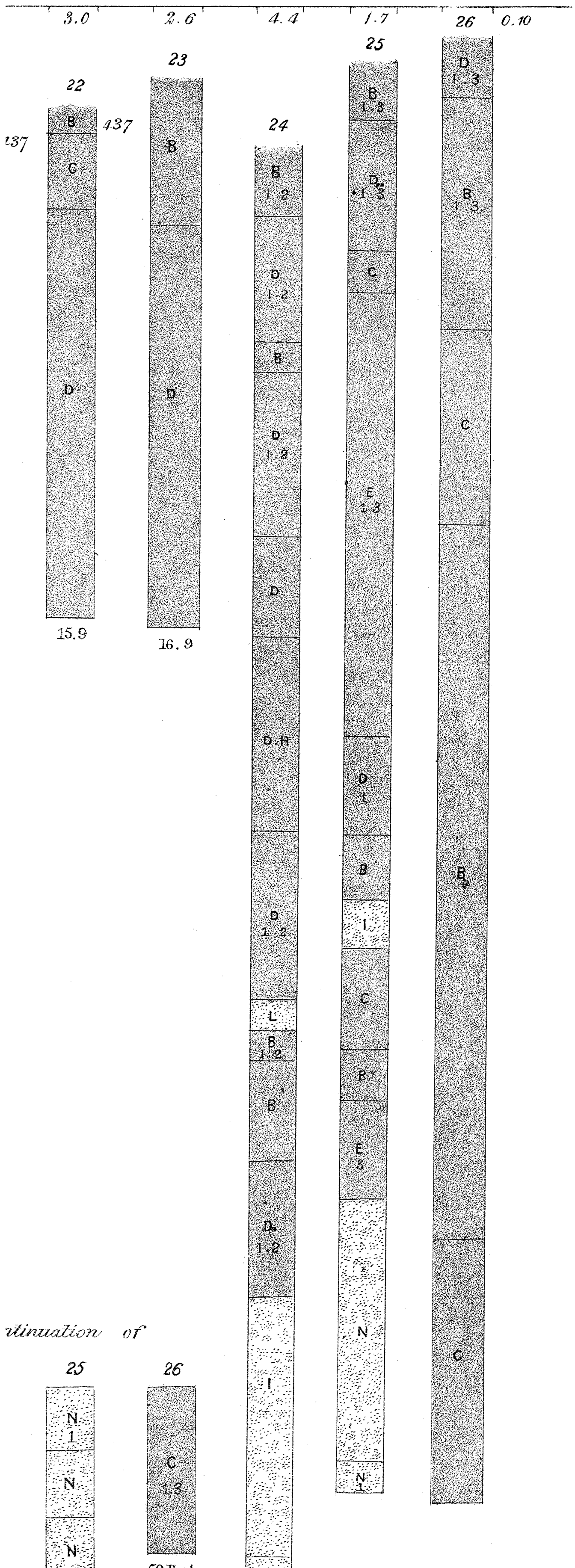


HILLS AND THE LEFT BANK OF THE NILE, PARALLEL OF HELIOPOLIS.
INUNDATION LEVEL OF 1853.

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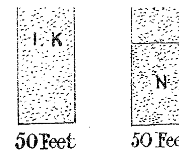
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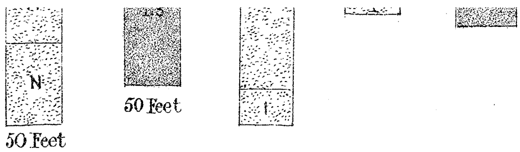
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BORINGS BETWEEN THE RIGHT BANK OF THE

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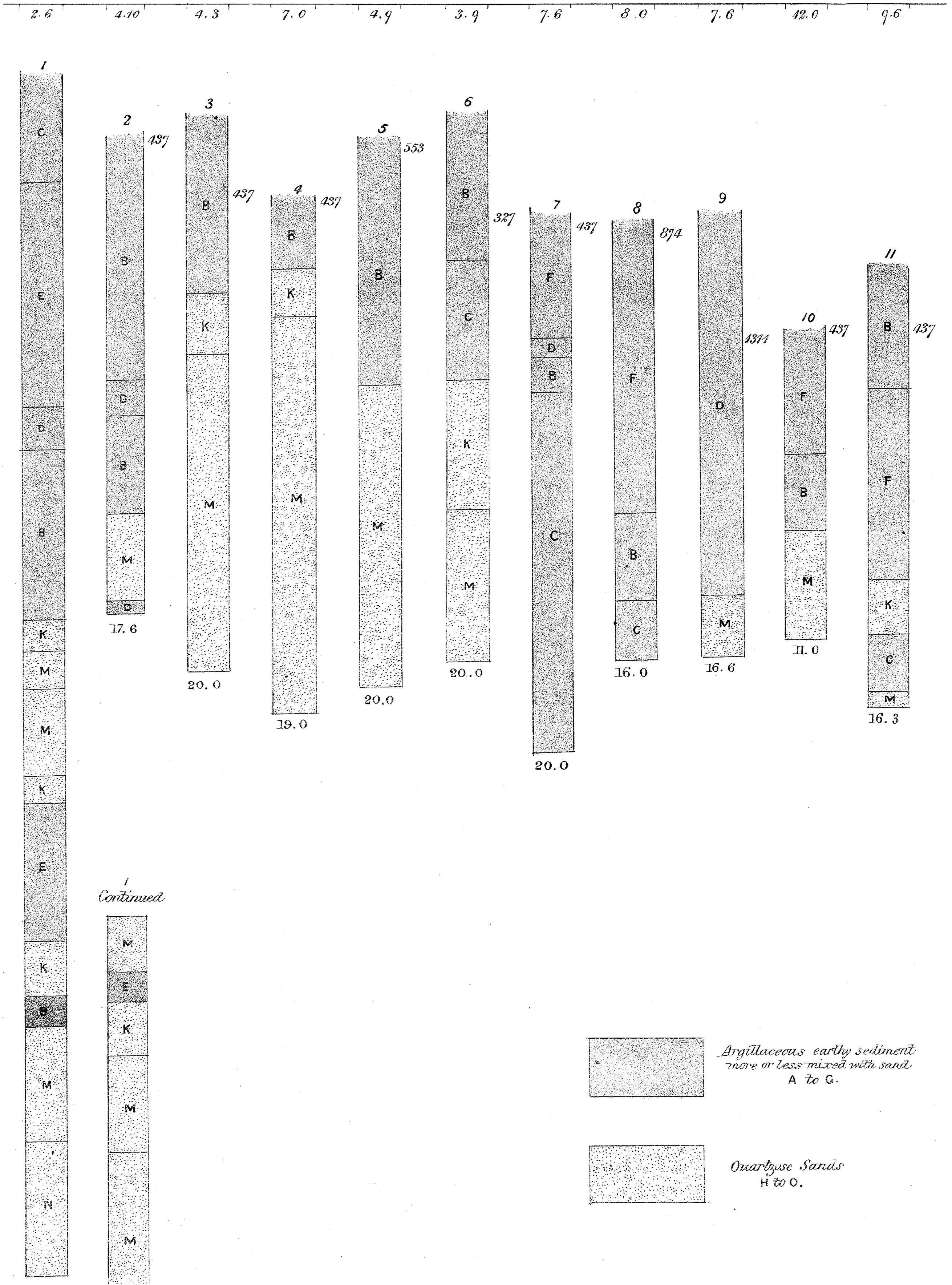
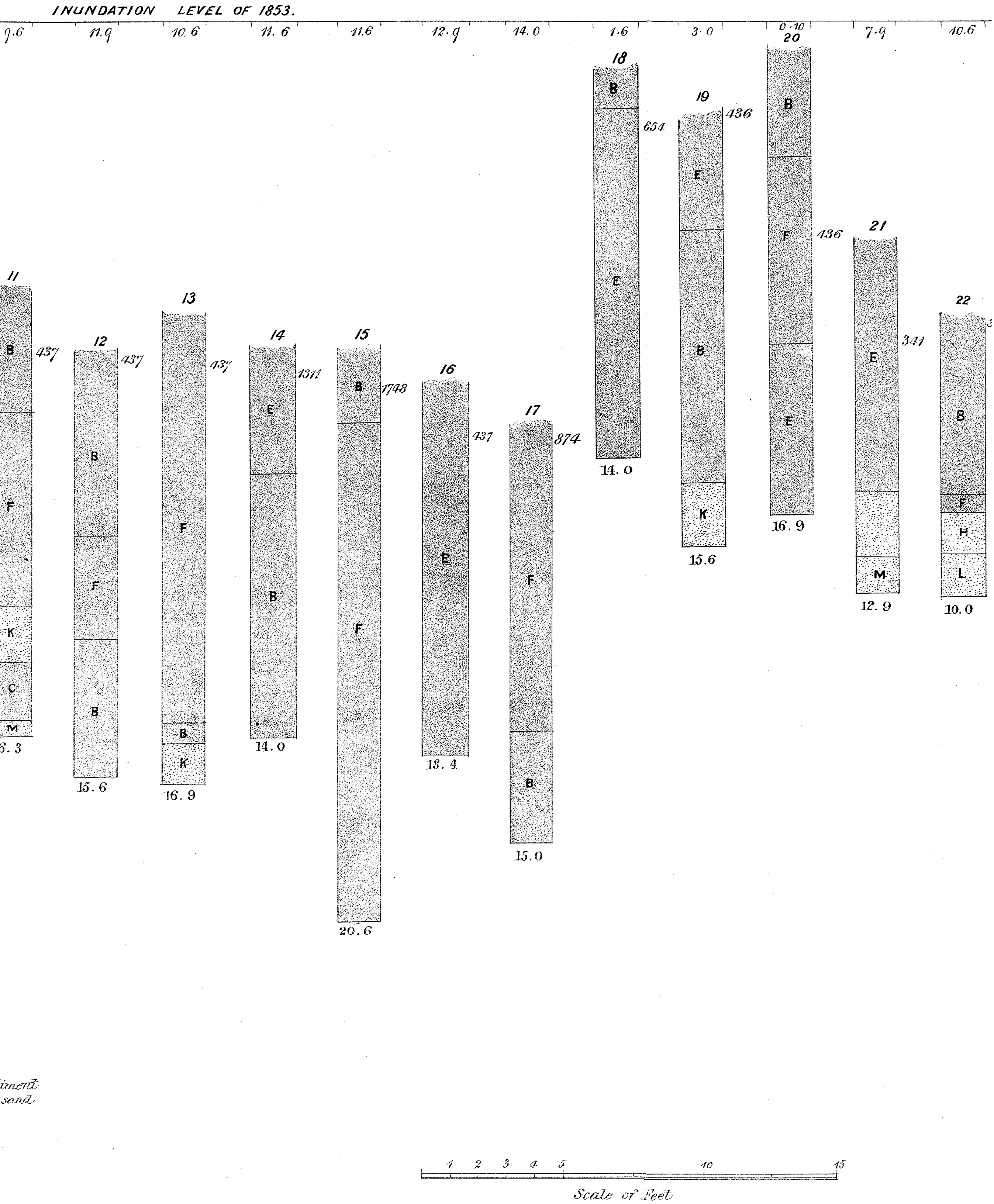
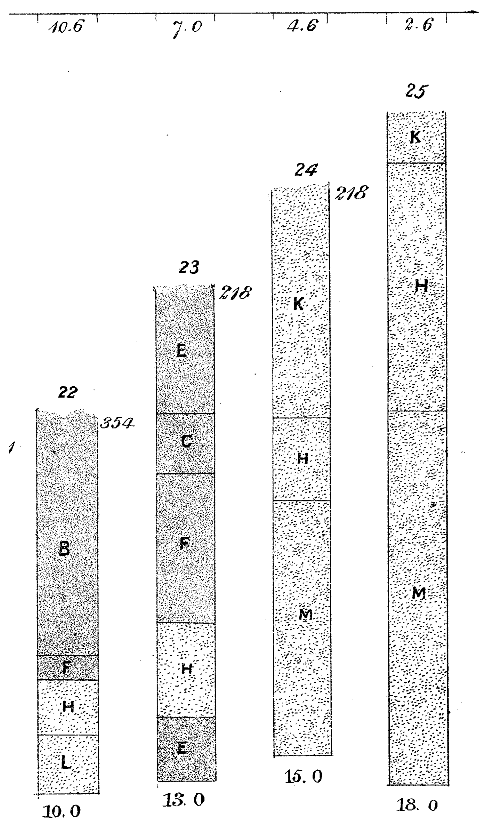


F THE NILE AND THE ARABIAN HILLS, PARALLEL OF HELIOPOLIS.





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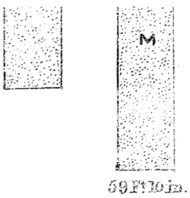
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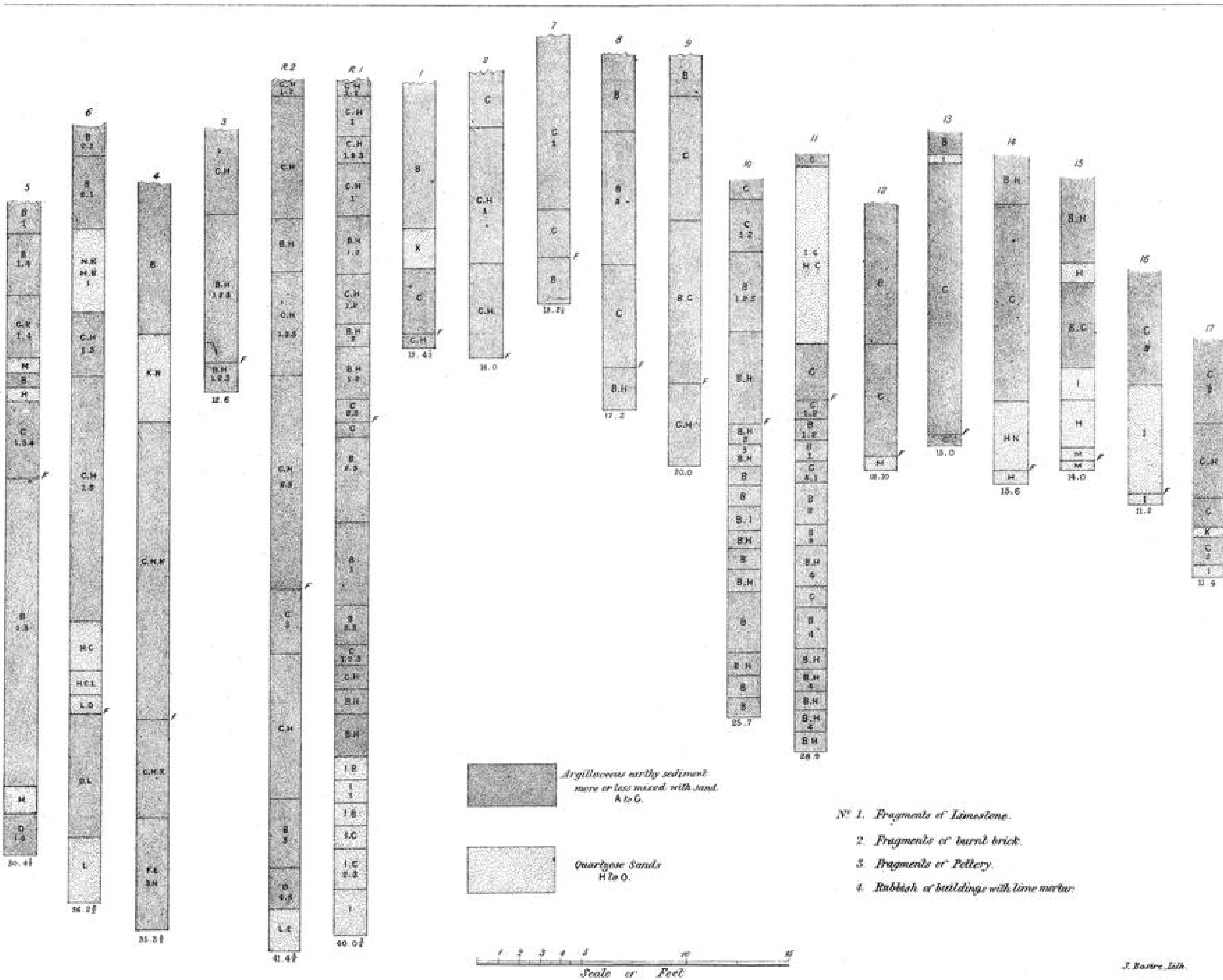
J. Basire, lith.

PITS SUNK IN THE AREA OF MEMPHIS.

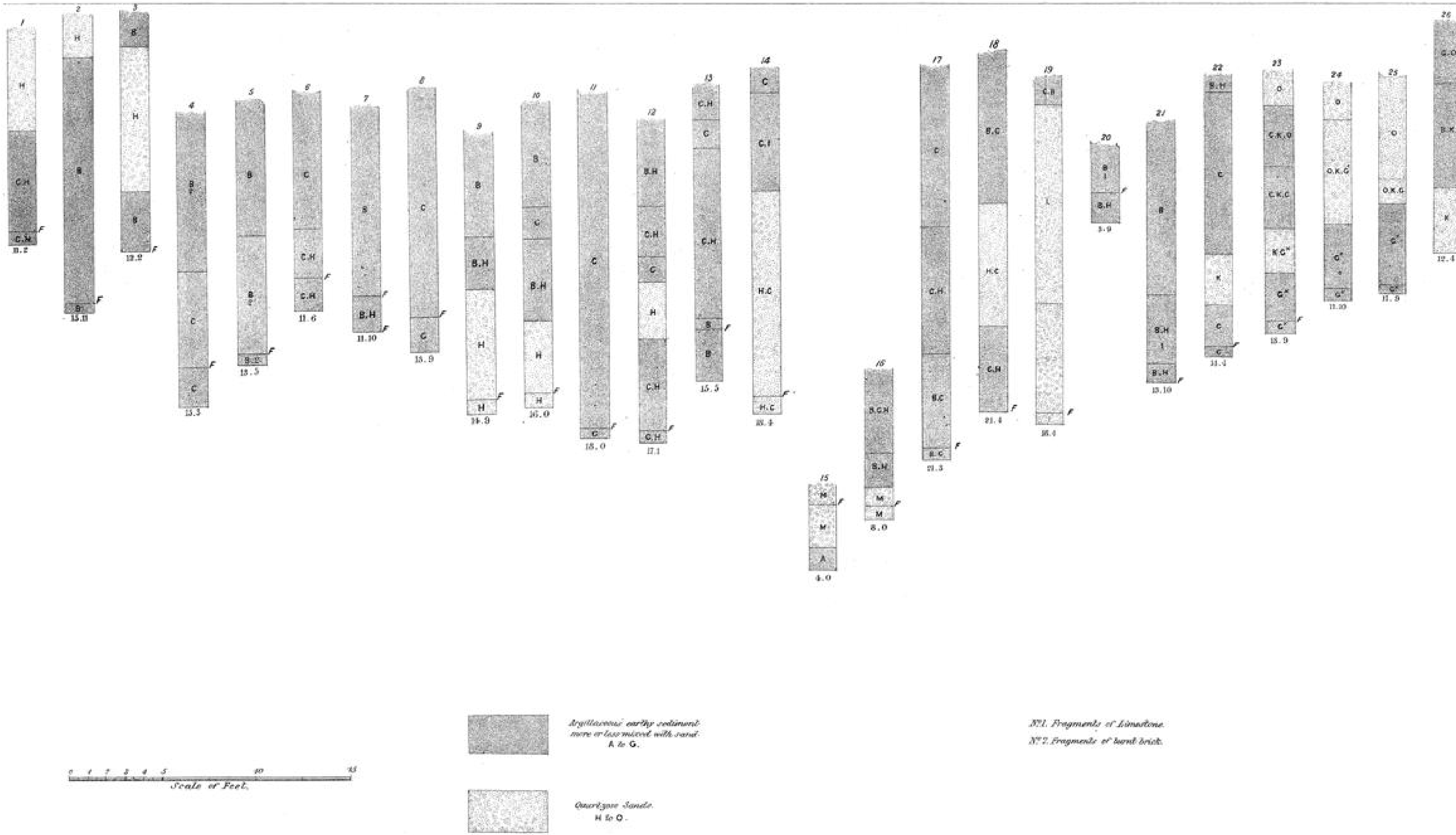
INUNDATION LEVEL of 1851.



J. Basire, lith.

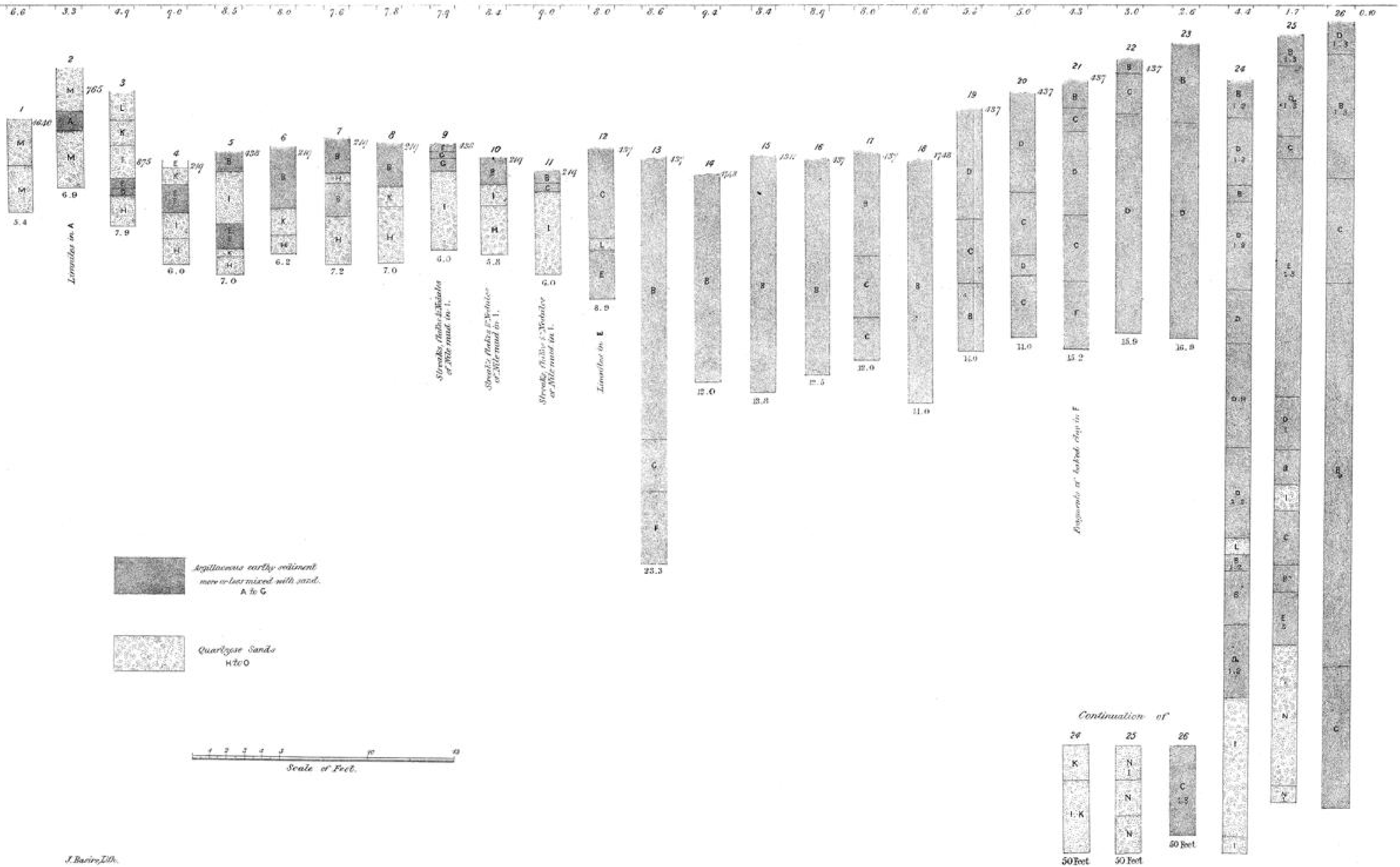
PITS SUNK ACROSS THE NILE VALLEY, BETWEEN THE LIBYAN AND ARABIAN HILLS, PARALLEL OF MEMPHIS.

INUNDATION LEVEL OF 1851.



BORINGS BETWEEN THE LIBYAN HILLS AND THE LEFT BANK OF THE NILE, PARALLEL OF HELIOPOLIS.

INUNDATION LEVEL OF 1853.



J. Basire, Lith.

BORINGS BETWEEN THE RIGHT BANK OF THE NILE AND THE ARABIAN HILLS, PARALLEL OF HELIOPOLIS.