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CAPTAIN F. W. H. PETRIE, F.G.S., &c.

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1898.

ORDINARY MEETING.*

THEOPHILUS G. PINCHES, ESQ., M.R.A.S., IN THE CHAIR.

The Proceedings of the last Meeting were read and confirmed, and the following Elections were announced :—

ASSOCIATES :—Major G. MacKinlay, R.A., England ; H. B. Ford, Esq., D.D.S., Demerara ; D. B. Hewitt, Esq., B.A., L.R.C.P., L.R.C.S., J.P., Cheshire ; Rev. P. H. Cole, D.D., United States ; Rev. J. Hartley, D.D., United States.

The HON. SECRETARY (Captain F. PETRIE, F.G.S.).—I deeply regret to have to announce the death of the Institute's Honorary Treasurer, Mr. W. N. West. He added to his onerous duties as a banker the treasurer-ship of this Institute, which he held for upwards of 27 years. His name will ever be held in high esteem by those who were associated with him on the Council of this Institute, which owes much to that ripe and clear judgment which so specially distinguished him.

THE PROPOSED SCHEME FOR EMBANKING THE WATERS OF THE NILE AT ASSOUAN† IN UPPER EGYPT. By Professor EDWARD HULL, LL.D., F.R.S.

THE extraordinary fertility of Egypt, due to the periodic Nile floods, is an occurrence dating from the earliest period of Egyptian history, and in the days of the Roman Empire caused Egypt to become “the granary of Rome,” while it has placed Egypt at the head of fruitful countries. These periodic floods, utilized by a remarkable system of irrigating canals and minor channels, and worked by an industrious population, are now thoroughly understood, and need not be here described ; but it is to Sir Samuel Baker that we are indebted for a knowledge of their origin.‡ The thunderstorms which burst upon the highlands of Abyssinia in the early summer convert the wide channel of the Atbara from the condition of a chain of stagnant pools into an

* 3rd of 32nd Session.

† The works at Assouan and Silsileh were commenced in April, 1898, Mr. John Aird, M.P., having undertaken the contract.—ED.

‡ *The Nile Tributaries of Abyssinia.*

impetuous torrent. Descending towards the plains, the waters break down the high banks of alluvial mud, churning it into fine silt, and thus held in suspension, the solid matter is carried onwards towards the main stream of the White Nile, two hundred miles below Khartoum; and, impregnating the whole body of the river, passes onwards towards Lower Egypt and the Mediterranean, scattering fertility on either hand along its course. The White Nile rising in the Victoria Nyanza, although augmented by tributaries which descend from the highlands beyond Darfûr as well as the tributaries of the Albert Nyanza,* and other streams such as the Bahr-el-Azrak (or Blue Nile), contributes but little to the sediment which is so essential to the fertility of the Nile valley. The Atbara appears to be the most important source of this fertilising mud; and it is only by a visit to the valley of the Nile, that the traveller becomes impressed with the idea how essential are these annual floods of muddy water, utilised by means of the net-work of irrigating channels, to the fertility of the Nile valley and the great plain of Lower Egypt.† Should this process be interrupted only for a very few years these fruitful terraces and plains would be converted into the condition of the arid sandy deserts which border them on either hand.

In order to approach our subject it is necessary to recollect that under the existing natural system of "High" and "Low" Nile, Egypt is subjected to winter irrigation, which reaches its maximum height during the months of September and October. Early in June the river, which had fallen to its lowest level in March and April and for some weeks onwards, begins to rise; and this rise progresses somewhat rapidly during the months of July and August, reaching its maximum about the beginning of October as stated above, when the reverse process sets in, and after two or three periods of oscillation, the waters begin to fall during November and the following months. As the season of harvesting after the period of "High Nile" begins in December, it would be manifestly of enormous advantage if, with the high temperature which prevails all the year round,

* Which Baker claims as the source of the Nile, but being a smaller lake than the Victoria must give way.

† On the subject of irrigation of Egypt see Three Lectures by Sir Colin Scott-Moncrieff, *Professional Papers of the Corps of Royal Engineers*, vol. xix (1893).

and especially in the valley of the Nile itself, a second period of irrigation, extending from the beginning of March to the middle of July, could be ensured. By such a system the slack season of "Low Nile" might be turned to profitable account, and a second crop might be secured either of the same kind of produce, or different varieties, overlapping one another. Major R. H. Brown, Inspector-General of Irrigation for Upper Egypt, has shown how this result might be achieved,* and it can only be done by means of regulating weirs.

The advantages of such regulating weirs as that now proposed had for several years become apparent to those acquainted with the physical conditions and requirements of Egypt; and in 1873 the distinguished French engineer, Linant de Bellefonds, suggested the Silsileh "Gate of the Nile," a narrow gorge twenty-five miles below Assouân, as a suitable site for such a weir. Somewhat later, another Frenchman, Count de la Motte, further developed the idea, and proposed a reservoir at the same site.† Owing, however, to financial difficulties, nothing was done until 1889, when Mr. Prompt, Member of the Railway Board, pressed upon the Government the necessity of studying the subject; and in consequence, Mr. W. Willcocks, who, in conjunction with Sir Colin Scott-Moncrieff, carried out the reconstruction of the *barrage* for regulating the Nile floods in Lower Egypt, was instructed to investigate the whole question. The report of Mr. Willcocks embodies the result of four years' examination, extending from the Second Cataract to Cairo, and includes a survey of the remarkable basin known as the Fayûn, the advantages of which had been repeatedly urged upon the Government by an American engineer, Mr. Cope Whitehouse. Finally, Mr. Willcocks fixed upon the rapids of Philæ as, under all circumstances, the most favourable for the site of a regulating dam for Upper, Middle, and, to some extent, Lower Egypt; and in this decision he had the support of Mr. Garstin, the Head of the Public Works Department. It is unnecessary here to discuss the relative advantages of

* *Report on Perennial Irrigation and Flood Protection for Egypt.* By W. Willcocks, Director-General of Reservoirs, with note by W. E. Garstin, Under Secretary of State (1894).

† At Silsileh the ridge of the Nubian sandstone is cut through by the Nile, and the rocks terminate on either hand near the banks. The quarries from which the stone used in the construction of most of the ancient temples north of Assouân has been obtained, are situated on this ridge.

the various proposed sites, which are fully detailed in the reports issued by the Egyptian Government; but it should be mentioned that before the site at Philæ was finally adopted it was considered desirable to refer the subject to a commission of engineers of acknowledged eminence in matters of this kind. Accordingly Sir Benjamin Baker, M. Auguste Boulé, and Sig. Giacomo Torricelli, representing three countries which have strong interests in Egypt, were, on the recommendation of Sir Colin Scott-Moncrieff, appointed to visit and report on the various sites recommended from time to time. The Commissioners carried out their examination during the winter of 1894, and on returning to Cairo drew up their reports.* Unhappily the Commissioners were not unanimous in their conclusions; for while Sir B. Baker and Sig. Torricelli concurred in recommending the site at Philæ, M. Boulé was unable to take a similar view, and has drawn up a separate statement containing his objections as regards several particulars connected with the Philæ site. Great weight is justly due to M. Boulé's objections; but regarded from a practical standpoint, they seem capable of being fairly met; and it will be seen in the sequel that one of M. Boulé's chief objections, namely, the threatened submersion of the Temple of Philæ and other monuments, has been removed by the modified project which now holds the field.

The proposed site of the embankment at the First Cataract is one which commends itself for several reasons. Here the newer Tertiary and Cretaceous formations which follow the course of the Nile up as far as Assouân give place to granitic rocks of extreme geological antiquity, from which the huge monoliths that adorn the cities of Ancient Egypt, and now, to some extent, those of modern Europe, have been hewn. At the Isle of Philæ, the Nile enters this granitic region, which extends down the stream to Assouân, a distance of seven miles, and pursues its course along a channel interrupted by numerous rocky islands. Here, indeed, seem to be all the essentials for the construction of an embankment of the largest dimensions; namely, a granite foundation,† abundance of building stone capable of yielding blocks of any required size, and a channel not very deep and

* *Reports of the Technical Commission on Reservoirs*, with note by W. E. Garstin (1894).

† Very different from that of the barrage of Lower Egypt, which is built on "fine river sand and alluvial mud." Sir C. Scott-Moncrieff, Lecture II.

broken by islets laid nearly dry in the winter season. The site itself is situated about a mile below Philæ at Bab-esh-Shellâl, where the eastern bank of the river approaches the western, reducing the breadth to about one kilometre.* As originally intended the level of the upper surface of the water was to have been 114 metres above Low Nile, requiring a structure of enormous dimensions, and one which would have submerged the Temples of Philæ as well as several important monuments in Nubia.†

On the promulgation of this project, it is not to be wondered at that a storm of indignation arose, not only from Egyptologists, but from the educated public of all countries. Philæ, the gem of Egyptian islands, decorated with the most picturesque, if not the largest or most ancient of the temples, and containing many works of art and inscriptions of great historical interest, was to be submerged in order to benefit the agricultural population and to bring fresh revenue to the Government! Protests and petitions against such an act of vandalism poured in on all sides; the Society for the Preservation of Ancient Monuments taking a leading part in the movement. But it is only due to the Egyptian Government to recognise the fact that it was not slow to admit the reasonableness of these protests. A general reconsideration of the whole question was undertaken, and the merits of the various suggested sites were carefully weighed; with the result that the First Cataract was found beyond all question to be the best for the supply of Middle and Lower Egypt. In order, therefore, to retain this site and to meet the wishes of those who deprecated the submersion of Philæ, a compromise was determined on, by which the advantages of such a reservoir would be largely secured and injury to the monuments averted. This compromise consists in the simple plan of diminishing the height to which the water is to be carried by 8 metres, or 26·24 feet.‡ As the project now stands the highest level of the water will be 106 metres (347·7 feet) above Lowest Nile surface. At this level the surface of the water will only reach

* 1,094 yards.

† *Note au Conseil des Ministres* (1894); Willcocks in his *Report* states, "105 or 106 metres," p. 22, para. 51.

‡ *Note au Conseil*, p. 5. The *Illustrated London News* lately contained some views of Philæ, with others showing the limit to which the water will rise when the reservoir has been completed.

the base of the columns, but by means of a wall of solid masonry even this amount of submersion will be avoided.

The æsthetical objections having been thus amicably settled, let us see what are the substantial advantages likely to accrue to Egypt from the proposed works. The works themselves will be of stupendous proportions, and will cost much money; but the experience of the benefits derived from similar works, though on a smaller scale, in Lower Egypt is regarded as fully justifying the expenditure. Let us recollect, as Sir Colin Scott-Moncrieff has stated as the result of his own observation, that no river approaches the Nile in the fertilizing properties of its sediment. For thousands of years this sediment has proved sufficient to keep the soil productive without recourse to artificial manures.

Major Brown, who is a high authority on this subject, estimates that the increased profit for Middle Egypt between Cairo and Assyût alone will be as follows:—

- (1) The value of the land will be increased from £20,426,400 to £43,575,240.
- (2) The rental, from £3,159,998 to £5,506,905.
- (3) The value of the annual yield from £5,178,786, to £9,864,429.

The “gain to the state” from Lower Egypt has been estimated by Mr. E. W. P. Foster, Inspector-General of Irrigation for that province, as likely to vary from £278,000 to £300,000,* to which has to be added £8,000 per annum, the interest at 4 per cent. on the sale of cultivatable lands. It should be recollected that at the present day, notwithstanding their productiveness, certain tracts only enjoy perennial irrigation in good years of high Nile in summer, while other parts are irrigated only when the river rises to an exceptional level. In order, therefore, to obtain from the land its maximum supply of products, it is necessary that all the tracts should be insured a yearly irrigation; and the ultimate increase to the revenue and gain to the State, which may be eventually looked for on the completion of the works, are estimated by Mr. Garstin, for Middle and Lower Egypt as follows:—

* The former figure by Mr. Garstin (*Rep.* p. 13), the latter by Mr. Foster (Appendix xii, p. 19). In estimating the amount of enhanced value to the State, Mr. Garstin excludes Upper Egypt, on the ground that it is exceptionally poor, and distant from a sea-port. The fertile province of Dongola is, of course, not included.

1. Gain to the State £850,000 per annum.
2. Increased value of the crops from Upper, Middle, and Lower Egypt £16,000,000 per annum.

The above estimates are sufficiently remarkable, but may be accepted as resting on the authority of officials well acquainted with the conditions and requirements of the country. We have now to consider the mode by which the perennial irrigation is to be carried out.

The massive dam to be thrown across the river below Philæ is to be furnished with a large number of undersluices at short distances, and of sufficient size to allow the entire summer flood to pass freely as at present, and to carry off the sediment with which the waters are at that period so largely charged. This arrangement will prevent the deposition of the sediment over the bed of the reservoir and its ultimate silting up, as has been too often the case with reservoirs in India and elsewhere. After the flood waters have subsided towards the end of October, the regulating gates will be closed, and so remain during the three following months; and as the waters at this period are mainly drawn from their Central African sources and contain but little sediment, no silting is anticipated. By the end of this period they will have risen to their flood-level, and will be available for the second process of irrigation by means of the great lateral canals which will be carried down on both sides of the valley. There will, however, be a slight difference in the periods during which the water will be drawn from the reservoir for Upper and Middle Egypt. For the former the period is fixed as between the 1st March and the 15th July; whereas for the latter, the period will extend from the 1st April to the 31st July. This arrangement is necessary owing to the difference of climate in the two regions. The further south we go the higher is the temperature, and the earlier the demand for the increased supply of water. In addition to this it is to be recollected that the relief afforded by the arrival of the early flood is felt sooner in Upper, than in Middle, Egypt, which latter more nearly approaches the lower province in its agricultural conditions.*

* *Report*, pp. 9-16. In the history of Joseph we read, Gen. xli, that seven fruitful years preceded seven years of famine in Egypt. May not this have been brought about by periods of abundant Nile flood followed by short floods, each of seven years' duration?

The estimates of the engineers as to the requirements of storage in the proposed reservoir are as follows :—

For Upper Egypt ..	1,160,000,000	cubic metres.	
„ Middle Egypt ..	950,000,000	„	„
„ Lower Egypt ..	1,551,000,000	„	„
	<hr/>		
Total ..	3,661,000,000	„	„

Such in brief are the proposals, and such the expected advantages of the proposed scheme. Egypt has ever been the country of great public works, and the Assouân embankment, and the system of irrigation connected therewith, will not fall short of any hitherto attempted. By such an undertaking the British occupation will have conferred on the country an enormous benefit in addition to others already enjoyed. As regards ways and means there ought to be little difficulty in raising the money for carrying out the works; the financial condition of Egypt is sound, and its credit stands high. The amount required may be distributed over several years, and it has been shown that the profit returns will allow for a large outlay. The part played by irrigation in adding to the productiveness of the land-surface of the globe is little known outside the circle of experts. For many countries it is a question between irrigation or barrenness. Such are those of the valley of the Indus in India, the whole of Egypt, the great plains of Turkomania north of Persia and east of the Caspian, the plains of Northern Mexico, Colorado, Arizona, Kansas, and parts of California, the western coast of South America, and a great portion of the Australian continent. The rainfall in Cairo is about 1·4 inches per annum; yet agricultural land within a radius of twenty miles of its suburbs sells as high as £80 per acre, a price which may well call forth the envy of the British land-owner.* The ancient Egyptian flung a beautiful maiden to the crocodiles, when the time for the rise of the Nile waters began, in order to propitiate the god of the river for a full flood. The statesmen and engineers of these days adopt a more certain, as well as a more merciful, course for effecting the same object; namely, by building embankments and *tarrages*, and distributing the

* Sir Colin Scott-Moncrieff: Lecture I, p. 5.

stored up waters through a system of canals and aqueducts. Let us hope that the commencement of the greatest of these works will be one of the events which will add lustre to the Victorian era, and render memorable the progress in arts and works of civilization of the nineteenth century. The victory of progress as against savagery, which we have witnessed with admiration in the Soudân, may have imposed a check upon this great work in the Nile valley; but it ought to be only a temporary check, and the early years of the twentieth century ought to witness its completion.

The CHAIRMAN (Mr. T. G. PINCHES, M.R.A.S.).—We are much indebted to Professor Hull for his very interesting paper, and shall all be glad to hear any remarks thereon.

A MEMBER.—Would the scheme described by Dr. Hull tend to interfere with the dwellings and possessions of the inhabitants of that part of the country or the preservation of any ancient monuments there?

The AUTHOR.—No, that is a question which has been carefully considered by the engineers, both as regards the ruins of Philæ and the possessions of the inhabitants.

[A discussion of a conversational character here followed upon this point.]

Mr. BALDWIN LATHAM, M.I.C.E., F.G.S.—Allow me to say I am much indebted to Professor Hull for having brought this paper to the attention of this Institute. I know the Nile very well and have seen it at flood and at low water. There can be no possible difficulty in getting rid of the question of flood, if the sluices are kept open, as they would have to be open during the whole of the year. It is only a question of regulating the sluices. When there is a superabundance of water coming down, you let out a sufficient amount of water for the practical purpose of continuing irrigation, and as the year goes on these

sluices still keep open, so there is no liability of the sluices themselves ever silting up. But what is intended by this impounding reservoir is to continue irrigation over the present area during the whole year, instead of part of the year, so as to give increased fertility to the land. From the fact that water is dammed up on this high ridge, it does not follow that you can irrigate it at this high level. It is simply to irrigate on the same area now irrigated, only for a longer period. And it is a simple matter, and easy to understand by those who are acquainted with irrigation works. I regret one thing being omitted from the paper, and that is an estimate of the cost of these works. We should then have been able to judge better whether the thing is likely to be a success or not. With reference to the Nile I may tell you this also, that it varies immensely from year to year in its floods, and that even Egypt often suffers from an excess of water. An impounding reservoir would therefore cure that evil by regulating the supply where many of the inhabitants of the plain run great risks of being sacrificed by an over-bountiful flow of the Nile.

The AUTHOR.—I am gratified to hear the remarks of so eminent an engineer as the last speaker, who has himself had so much experience in engineering work in Cairo. I think his words alone will help to dispel any such doubts as those expressed by the first speaker.

There are some tracts which at "high Nile" are flooded, but which are unirrigated when the waters fail to come up to that level by 4 feet or 5 feet. Some of these terraces are very flat, and their perennial irrigation will add considerably to the extent of ground that it will be possible to keep under cultivation, and so add enormously to the value of the often isolated lands along the valley of the Nile.

As regards the estimates, I have not thought it part of my subject to go into the question; the documents are public, and the reports and the representations to the Egyptian Government are accessible and exceedingly interesting to anyone who has had to do with works of this kind.

The Khedive himself, I understand, warmly approves of the project, and trusts that it will in due time be carried out.

The CHAIRMAN.—We are very much obliged to Professor Hull for his interesting paper. As an archæologist I should like to say

that I hope there will be no destruction of any ancient monuments, and one wishes, also, that the inhabitants may not sustain any damage on account of the works that have been referred to. I think we may trust the administration of Egypt, and the British officers there, to see that everything shall be done to protect both the monuments and the welfare of the inhabitants.

The Meeting was then adjourned.