VI. *On the Geological Evidence of the Advance of the Land at the Head of the Persian Gulf.* By CHARLES T. BEKE, Esq., F.S.A.

To the Editors of the Philosophical Magazine and Journal.

GENTLEMEN,

I HAVE now to trouble you with the following observations on the *Geological* evidence of the advance of the land at the head of the Persian Gulf, which you will oblige me by inserting in the next Number of the *Philosophical Magazine*, as a continuation of my paper on the *Historical* evidence on the same subject contained in the number of that Magazine this day published*.

Almost eighteen centuries have now elapsed since it was remarked by Pliny, in the passage which I have already cited†, that “in no part of the world did the land advance so greatly or so rapidly upon the sea” as at the head of the Persian Gulf. In making this observation that ardent and careful investigator of the phenomena of nature at the same time expressed his wonder (to use Mr. Lyell’s paraphrastic translation‡,) “that the fluvatile matter was not swept away by the tide which penetrated far above the tracts where great accessions were made. This remark” (Mr. Lyell proceeds to say,) “proves that he had considered the different condition of rivers in inland seas, and those discharging their waters into the ocean.” I may add that it proves even more evidently that the subject of the growth of land at the mouths of rivers was entirely familiar to the natural historian, who (it is to be remembered,) was a native of Verona, a city at a short distance only from the shores of the Adriatic, and who, in the course of his active life, visited various countries bordering upon the Mediterranean—than which “no other inland sea affords so many examples of accessions of new lands at the mouths of rivers within the records of authentic history§”—

* Lond. and Edinb. Phil. Mag., vol. vi. p. 401.

† Lond. and Edinb. Phil. Mag. for February 1834, vol. iv. p. 109; and *Origines Biblicæ*, p. 21. “Nec ulla in parte plus aut celerius proficere terræ fluminibus invecitæ. Magis id mirum est, æstu longe ultra id accedente, non repercussas.” *Hist. Nat.* lib. vi. cap. xxvii.

‡ Principles of Geology, first edition, vol. i. p. 291. The passage here cited is repeated by the author in the second edition of his work, vol. i. p. 332; but in the third edition, published in August 1834, the paragraph in which it is contained, together with the above quotation from Pliny, which is also given in the former editions, are omitted, without any cause being assigned by the author for their suppression.

§ Principles of Geology, vol. i. p. 231; first edition.

and it further demonstrates that special attention had been devoted by him to the particular subject of the changes at the head of the Persian Gulf, since he pointedly contrasts what he conceives ought to have been the effect of the tide there, with the consequences of the absence of tides within the Mediterranean.

From the examination, therefore, of what is ascertained to have occurred at the mouths of the principal rivers flowing into this latter sea, resulting from the continuation of the process which was going on in Pliny's time and to his knowledge, we shall obtain the best means of forming an approximate idea of what also have been the actual changes at the mouths of those rivers which discharge themselves into the Persian Gulf. For the present means of this examination we are greatly indebted to the talents and research of the accomplished President of the Geological Society. It is, in fact, substantially effected in his able work to which I have so frequently referred*; and in citing that work once more as my authority, I shall content myself with adducing the single instance of the rapid formation of new lands at the mouths of the Po and Adige, as being that with which Pliny himself may, from the place of his birth, be presumed to have been better acquainted than with any other. We learn, then, that "from the northernmost point of the Gulf of Trieste, where the Isonzo enters, down to the south of Ravenna, there is an uninterrupted series of accessions of land, more than one hundred miles in length, which, within the last two thousand years, have increased from *two to twenty miles in breadth*†; that is to say, a formation of new land has within that period taken place, extending over an area of not less than *one thousand square miles*. Hence, even if we attach no importance whatever to Pliny's express reference to the *extraordinarily* rapid growth of the land in the Persian Gulf, we may, at all events, be permitted to calculate that during the same period the accession of new lands in that locality has at least been of equal magnitude with that which has taken place within the Adriatic; and if, further, we reckon that during the previous ages the rate of increase was no greater than during the last two thousand years, we shall have about 2300 square miles as the amount of the new lands which have been formed by the alluvial deposits of the Tigris and Euphrates since the date of the erection of the tower of Babel‡.

* Principles of Geology, vol. i. pp. 232—239; first edition.

† *Ibid.*, p. 236; first edition.

‡ According to Dr. Hales, the birth of Peleg, to which epoch I refer the dispersion of mankind (see *Orig. Bibl.*, p. 68), took place in the year 2745
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It would, however, be most unreasonable to imagine that the quantity of detritus brought down by the rivers which flow into the Persian Gulf was not of far greater amount than that of the rivers of the Adriatic, when we consider that the Po itself is surpassed in size by many of the tributaries of the Tigris, whilst "the great river, the river Euphrates*," exceeds it at least five times in length.

It may be impossible to determine the precise proportion between the quantities of detritus transported by the two classes of rivers respectively; but it will not be unreasonable to assume (as a first approximation only) that equal quantities of detritus have been produced from equal spaces of the countries drained. Looking, then, to the basin of the Po and its tributaries, which extends southward to the confines of Tuscany, from which country it is parted by the Apennines; westward to the extremity of Piedmont, where the chain of the Alps surrounds it; and northward to where the Ticino, the Adda, and the Adige bring down the waters from a portion even of Switzerland and the Tyrol, we cannot compute its area at more than 45,000 square miles. On the other hand, if we regard the vast countries watered by the numerous and widely spreading affluents of the Euphrates and Tigris and the other rivers which discharge themselves into the Persian Gulf,—from the Arabian and Syrian deserts to the westward, as far as Asia Minor and Armenia towards the north, and thence to Koordistan and Khusistan towards the east; and even yet further in that direction beyond the Baktiari range of mountains;—it will be an error in defect rather than in excess to reckon their area at 270,000 square miles; that is to

B.C., or 4589 years since. If we take the date of the erection of Babel as usually computed, it will differ about 500 years from this, making the quantity of new land about 250 square miles less than as stated above.

This result is, *of itself*, sufficient to occasion very strong doubts as to the identity of the site of the Babel of Nimrod with that of the ruins in the neighbourhood of Hillah, and to induce us to look for it further to the northward. Its real position was most probably in the north-western portion of the land of Shinar, or Mesopotamia: see *Orig. Bibl.*, pp. 25 and 66.

* Does not the fact that in the times of Abraham, of Moses, and of Joshua, the Euphrates was styled "the great river," κατ' ἑξοχὴν, (see Gen. xv. 18; Deut. i. 7, xi. 24; Josh. i. 4,) lead to the presumption that the Nile, a river far greater and much more remarkable than the Euphrates, could not have been known to the inspired writers at those early periods; thus further confirming the opinion advanced in *Origines Biblicæ* as to the original distinction between the *Mitzraim* of Scripture and the *Egypt* of Profane History? The former country, I will simply mention in this place, I conceive to have been altogether to the eastward of the Isthmus of Suez.

say, at six times more than the area of the countries drained by the rivers of the Adriatic.

If, then, in two thousand years a tract of 1000 square miles has been formed in the Gulf of Adria from the alluvium brought down by the rivers from 45,000 square miles of territory, it will (*cæteris paribus*) result, that at the head of the Persian Gulf the accession from 270,000 square miles of country will have been six times greater in amount; that is to say, a formation of not less than 6000 square miles of alluvial soil will have taken place within the last two thousand years: and if we compute the same rate of increase to have existed back from the building of Babel, this formation will have extended to 13,800 square miles of land.

In making the foregoing calculation it has been assumed that the circumstances are similar in both cases: this, however, is not precisely the case. The Adriatic is a gulf in a tideless (or almost tideless) sea: the rise and fall of the tide at the head of the Persian Gulf is (I believe,) as much as 8 or 9 feet at spring tides. From the effect, therefore, of the tide, and also from that of a current which sets across the head of the Persian Gulf from east to west, the accumulation at the mouths of the rivers would doubtless be checked, and a portion of the alluvium would be carried eastward and southward, and be dispersed in those directions over the bottom of the gulf. That such is actually the case is shown by the chart of this gulf lately constructed by the officers employed in its survey by the East India Company; from which it appears, that whilst along the north-eastern or Persian side of the gulf the depth, in great part, exceeds forty fathoms, along the whole of the Arabian or western and southern side it varies from twenty fathoms to shallows which are unnavigable, and which, to all appearance, will soon rise altogether above the level of the sea.

But, on the other hand, the much greater depth of the Adriatic, and of the Mediterranean generally, (which in many parts close to the shore is 2000 feet, and near Gibraltar even as much as 6000 feet deep*,) would tend very materially to reduce the rate of the *superficial* growth of the alluvial soil in that sea; and would thus—to a considerable extent, at least,—counterbalance the effects of the tide and current in the Persian Gulf.

On the whole, therefore, when we take into consideration the immense quantity of alluvial matter which is carried down into the Persian Gulf, we cannot hesitate to admit that Pliny

* Principles of Geology, vol. i. p. 237; first edition.

was not merely sincere in his belief, but also perfectly correct in his assertion that "in no part of the world* did the land gain so rapidly upon the sea;" and consequently we cannot, under any circumstances, be wrong in concluding that an accession of land very considerably greater than one thousand square miles has actually taken place at the head of that gulf within the last 2000 years. Hence it follows—and this is the point for which I need now principally to contend,—that the identifications of the various places mentioned by the ancients (and in particular by Nearchus) at the mouths of the rivers and along the coast at the head of the Persian Gulf, which have been made by geographers of modern times, and especially by the late Dr. Vincent and Major Rennell, must necessarily be erroneous †.

It is beyond the scope of the present paper to attempt to determine the correct positions of any of those places, or even to institute an inquiry into what may have been the direction of the coast line at the time when the voyage of Nearchus was undertaken, or at any other period of past history. I will, however, venture to offer the following suggestions, which may not be unworthy of the consideration of those who at any future period may feel inclined to devote their attention to the subject.

In the first place, then, it will be necessary to revert back to the time—whenever that time may have been,—when the Euphrates and Tigris discharged their waters into the Persian Gulf by entirely distinct and separate channels, each possessing its independent delta, as was formerly the case with the Po and Adige, the Ganges and Brahmapootra, and the Red River and Mississippi ‡.

* This assertion is of course to be understood with reference to those portions only of the globe which were actually known in those times; for the growth of the land in the Persian Gulf will not bear comparison with that which takes place at the mouths of the great rivers of the New World, or even of Eastern Asia. It would be an interesting subject of research to investigate the changes which have taken place at the mouths of the Indus since that river was visited by Nearchus.

† Mr. Carter, in his paper in the *Philosophical Magazine* (present series, vol. v. p. 248.) before alluded to, relies upon the extraordinary and (as it would appear) unfounded opinion asserted by Dean Vincent that Captain Howe's chart "explains the journal of Nearchus as perfectly as if it had been composed by a person on board of his fleet;" (*Commerce and Navigation of the Ancients*, vol. i. p. 423;) and that "the pilot on board Nearchus's ship steered exactly the same course" (*along the coast of the Delta*) "as MacCluer's Karack pilot, 2000 years afterwards" (*ibid.* p. 466).

‡ See *Principles of Geology*, vol. i. 252, first edition. As I have mentioned in *Orig. Bibl.*, p. 19, Mr. Lyell observes that "the union of the Tigris and Euphrates must undoubtedly have been one of the modern geographical changes on our earth."

Next will have to be investigated the particular operation of the causes which have produced the changes in the coast line; the principal of which causes are the transporting action of the rivers on the one hand, and the counteracting influence of the tides and current on the other. By the simple operation of the former of those causes, a progressive deposition of alluvial matter would have taken place, which would have been even and regular throughout: by the operation of the latter cause, however, that deposition would not merely have been obstructed, but its regularity and equal character materially affected; and in the same way as it has been shown * that the current from the westward in the Mediterranean has occasioned a general declination of the waters of the Nile from east to west, and has obstructed, and indeed in some cases closed up, the more eastern branches of that river, so by the operation of the current at the head of the Persian Gulf, would the western branches of the Euphrates gradually have become impeded, and finally closed: and further, as in the progress of time the deltas of the Euphrates and Tigris became continuous, the current of the former river would gradually have become so obstructed, that, in the end, it would (like the Rhine†) have lost its separate course to the sea, and would be destined to form a tributary to its more favourably situated rival.

It will likewise be necessary to ascertain what islands originally existed in the Persian Gulf below the mouths of the rivers; as their presence will very materially have influenced the direction and the rate of the formation of new lands in their vicinity‡.

In considering the progress of the changes in the configuration of the new lands which will thus have been formed, but which, in many cases, will also have been subjected to destruction from the effect of the currents of the rivers and the shifting of their channels, as well as from the effect of the tides and currents of the sea, it may perhaps, under any circumstances, be impossible to determine anything decisive as to their geographical outline and character at any former determinate period; but we may yet be enabled to obtain the idea (however faint) of the mouths of the Euphrates having first been impeded by shoals and sand-banks formed along the base of the separate delta of that river;—next, of the formation of one or more lakes through which the branches of

* *Orig. Bibl.*, pp. 172, 173.

† *Principles of Geology*, vol. i. p. 286.

‡ These islands will now, of course, form part of the main land.

that river would have had to force their way;—subsequently, of a portion of the Euphrates finding a partial course to the eastward, through the less obstructed channels of the Tigris, and of the consequently easier and more rapid victory of the sands over the sluggish, and at times almost stagnant waters of the former river;—then of the formation of marshes which would have been alternately flooded and left dry, as the waters of the Euphrates rose and fell;—till at length the union of the two rivers being perfected, by which completion of the process the united streams would roll together to the ocean, the separate course of the now tributary river, the Euphrates, would gradually become obliterated, and all traces of its existence at length be lost.

When the chorography of the countries in question shall have been investigated with reference to the change above alluded to, we shall be enabled to understand more fully and more satisfactorily the statements respecting them of the geographers and historians of antiquity: under any other point of view it is an interminable and hopeless task to attempt to reconcile their conflicting, and in many cases apparently totally contradictory, assertions.

London, June 1, 1835.

CHARLES T. BEKE.

VII. *On the Silurian System of Rocks.* By RODERICK IMPEY MURCHISON, F.R.S., Vice-President of the Geological and Royal Geographical Societies, &c. &c.*

GEOLOGISTS having long felt that the older sedimentary deposits required a systematic examination, I have devoted the last five years to the study of this class of rocks, hoping thereby to fill up certain pages which were wanting in the chronology of the science†. A table published last year was the first attempt to convey to the geological student a correct view of the thickness, variety of strata, and fossil organic contents of a vast system, which, though arranged by nature in the most lucid order of succession, had not previously been pointed out. These rocks, rising from beneath the old red sandstone in Herefordshire, Shropshire, Radnorshire, Brecknockshire, Monmouthshire, and Caermarthen-shire, and each distinguished by separate and *peculiar organic remains*, were respectively named after those localities where each of them could be best studied, and their places in the series most clearly established. I have no change to an-

* Communicated by the Author.

† See Lond. and Edinb. Phil. Mag. 1832 to 1835, in the Proceedings of the Geological Society.