often to anchor at this harbour in order to hunt reindeer in the neighbouring fertile valleys; and this, too, was one of the first places visited by Professor Torell's Expedition in 1858. . . . During the winter of 1860–1861, the previously insignificant glacier descended upon the lowland and the grave-hillock on the shore, filled up the harbour and extended far into the sea. It now constitutes one of the largest glaciers of Spitzbergen, from which immense blocks of ice constantly fall down so that not even a boat can venture in safety beneath its broken border (Sketch of the Geology of Spitzbergen, pp. 8 and 9).

In the facts which I have collected in this paper I do not profess to have proved an absolutely conclusive case against the extension of a glacial age (other than the one now in progress) to the Arctic lands, but I do claim to have shown that the available evidence points very strongly in that direction, and it seems to me that those who have argued that because there was a large development of ice in the form of glaciers in more temperate regions there must also have been a corresponding development in much higher latitudes, have not only taken for granted what ought to be proved, but have confused the problem of discovering a true explanation of the so-called Glacial age itself. To this latter problem I hope to be allowed to devote a few sentences on another occasion.

IV.—THE GROWTH OF THE INDIAN PENINSULA.

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IT is one of the most fascinating of the recreations of a geologist to attempt to reconstruct the physical features of some past period; and though our essays in this direction have not been attended with complete success, and our maps of early epochs bear a striking resemblance to those of Herodotus and Ptolemy, yet these maps have their value and they are at least steps towards one of the goals of the science of geology.

But great though the value of a good map of some past period may be, its interest lies not so much in itself as in its relations to those of earlier and later periods. We wish to see how the geography of one period grew out of that of the preceding.

In some areas the geographical changes have been so numerous and so various that this is practically impossible; but in others the changes have been simpler, and we are able to trace with more or less certainty the evolution of the present geographical features.

The Peninsula of India is a case in point. Its growth—not from one, but from three centres—appears to have been nearly continuous; and the present peninsula has been formed by the final union of these three masses. Only along the western coast does there appear to have been any serious interference with the general plan of growth; for the complete absence of anything but gneiss, trap, and very late Tertiary beds on this coast, except in the north, seems to suggest that the coast itself is of very recent formation.

For our present purposes the rocks of the Peninsula, under which term is included the whole of India south of the Indo-Gangetic plain, may be divided into three great divisions, viz. :—

Post-Gondwàna.

Gondwàna.

Pre-Gondwàna.

The Pre-Gondwàna division includes the Gneissic, Dharwar, "Transition," and Vindhyan series, and as fossils are absolutely unknown, we are unable to correlate these series with European rocks. The Gondwàna formation probably ranges from Upper Carboniferous to Tithonian or Portlandian; and the Post-Gondwàna, which includes the marine beds of the coasts, the Deccan Trap, and the Tertiary and later beds, ranges from Upper Jurassic to the present day.

On the map accompanying the Manual of the Geology of India, there may be seen in the Peninsula three main areas of Gneissic rocks:— (1) the Southern Mass, bounded on the north by the Deccan Trap and the rocks of the Godâvari basin; (2) the Bundelkhand Mass, a semicircular mass immediately south of the Gangetic Plain; (3) the North-Eastern Mass, occupying a large area in Bengal and the Central Provinces, and separated from the Southern Mass by the Godâvari area of later beds. The positions of these masses are shown on the accompanying map.

Up to the beginning of the Gondwâna period each of the three masses had its own history, distinct from that of the others, and each must therefore be treated separately.

PRE-GONDWÂNA HISTORY.

Growth of the Southern Mass.—The greater part of India south of the Kistnah is composed of gneissic and granitoid rocks, but it is traversed by a number of nearly parallel bands of schist, together with conglomerates, haematite beds and lava flows, to which has been given the name of Dharwar Series.¹ Many of the schists seem to be altered lavas, and the whole series must have been largely volcanic. The direction of the bands is N.NW.—S.SE.; and it is clear that the Dharwars originally covered the whole, or nearly the whole, of the gneiss, and that they were afterwards thrown into folds running N.NW.—S.SE. (nearly parallel to the present west coast). Afterwards the whole mass was subjected to denudation, so that only remnants of the Dharwars were left, running as bands through the gneiss (see Woodcut-Section, Fig. 1).

The folding and denudation of these rocks were completed before the deposition of the next set of beds, which were laid down as a fringe on the N., N.E. and E. sides of the gneiss mass, forming now the Kaladgi, Godâvari, and Kadapah basins. These basins were probably originally continuous with one another and their present separation is due to denudation.

The Kadapah basin is crescentic in shape and lies on the east side of the gneiss mass. The older ("Kadapah") rocks of this basin in the western part of the area, rest quite flatly on the gneiss

¹ See especially Foote, Rec. Geol. Surv. India, vol. xxi. p. 40; vol. xxii. p. 17. Mr. Foote gives a map of these bands.

FIG. 1.—DIAGRAMATIC SECTION OF THE SOUTHERN MASS.

a, Gneiss. b, Dharwar series. c, Kadapah series. d, Karnul series.

or slope gently away towards the east. The higher beds overlap the lower towards the west; and this, together with the fact that conglomeratic beds are not uncommon, leads one to conclude that the present western boundary of the basin is not far from the old coast-line.

Further east, as the distance from the old coast-line increases, these rocks become more and more folded; and on the eastern side of the basin are frequently reversed. The direction of the folds is nearly N.-S. (Fig. 1).

In the Godavari basin, which lies to the north of the Kadapah basin, similar beds are found, and here also in the west they are but little disturbed, while further east they are affected by the disturbances which folded the corresponding part of the Kadapah basin.

Hence we may conclude that a series of deposits (the "Kadapah" beds) was laid down on the eastern coast of the gneiss mass; and that ultimately these were crushed up against the gneiss. Near the old coast-line they remained almost undisturbed, whilst further out towards the east they were thrown into a series of N.-S. folds (see accompanying section).

Nearly the same course of events appears to have taken place on the north coast of the old gneiss mass, where we now have the Kaladgi basin of rocks similar to those of the Kadapah basin. The lowest beds, found at the south border of the basin, are conglomeratic, and evidently shore deposits, so that the coast of that time cannot have lain far south of the present boundary of the basin.¹ The beds of the Kaladgi basin have been thrown into folds running W. by N.—E. by S.; and the disturbance is greatest on the N. side of the basin, i.e. at the part furthest from the old shore—though this is not so well marked as in the Kadapah basin.

In the Kadapah the older (Kadapah) rocks which are affected by the folds already described, are overlaid by later rocks called the Karnuls, which serve to fill up the space between the great folds on the east and the old shore on the west (see section). They are but little disturbed and overlap on to the gneiss.

On the north of the gneiss similar beds are found in the Bhima basin near the Kaladgi basin. Here also they are little disturbed; but their relation to the rocks of the Kaladgi basin is nowhere shown.

After the deposition of these later beds (which are still pre-Gondwana) the Southern Mass has never received any further deposits, except close to the coasts, and it has remained land since that time.

Growth of the Bundelkhand Mass.—The Bundelkhand gneiss now forms a semicircular patch, bordered on the N.E. by alluvium, and elsewhere chiefly by the well-known Vindhyan rocks.

On the S.S.E. border, which runs from E.N.E.—W.S.W., there is a fringe of quartzites, limestones, etc., known as the Bijawars. These lie nearly horizontally on the gneiss and towards the south are covered by an extensive spread of Vindhyan beds; but before they disappear they begin to be crushed and folded. They were

¹ Cf. Foote, *Rec. Geol. Surv. India*, vol. xv., p. 191, and King, *Mem. Geol. Surv. India*, vol. viii., pl. ix., section i.

apparently shallow water deposits and never extended much further north than at present.

To the south of the Vindhyan spread they reappear in the Son-Narbada and Son areas; where they form a band running parallel to the Bundelkhand Bijāwar band. In the Son area especially they are strongly folded.

Here then again we have a series laid down upon the gneiss and subsequently folded. Close to the gneiss the beds are almost unaffected, while further away they are greatly disturbed.

To the north of the Bundelkhand gneiss we find very much the same thing. Close to the gneiss, at Gwalior, we have almost undisturbed Pre-Vindhyan beds; while further away, in the Arvali Hills, the Pre-Vindhyan beds are strongly folded, the folds running about N.E.-S.W.

Towards the S.W. the Bundelkhand gneiss disappears beneath Vindhyan beds and the Deccan Trap; but at intervals we find inliers of Bijāwars and similar rocks resting on gneiss, in the Dhar Forest, and at Narsingpur, Champanir, Bagh and Jobat.

If the beds at Bijāwar and Gwalior are really shore deposits, close to the old coast-line, it is clear that the Bundelkhand Mass had a history very similar to that of the Southern Mass. Beds were laid down on its borders and afterwards crushed up against it, the most intense folding being at a considerable distance from the old shore.

In the space between these folds (the folds to the S.E. and the folds to the N.W. [see map] of this gneiss) we now find a large spread of Vindhyan rocks. These are little disturbed and may at one time have covered the whole of the gneiss mass.

Growth of the North-eastern Mass.—In the present state of our knowledge, it is impossible to trace the history of the N.E. Mass, even with the same degree of uncertainty as we have traced that of the others. Large areas are covered by Lower Vindhyan and older rocks, but these have not been examined in detail.

No rocks of later age than Lower Vindhyan are known between the Māhānadi and Godāvari Gondwāna basins; and the area has probably been land since Lower Vindhyan times.

GONDWĀNA HISTORY.

The Pre-Gondwāna history of the Southern and Bundelkhand Masses appears thus to have been nearly the same. Beds were deposited on their borders and afterwards crushed up against the unyielding gneiss. At a considerable distance from the shore this crushing caused intense folding, and no doubt elevation; and the space between the folds and the shore was subsequently filled by later rocks, which overlapped on to the gneiss and, in the case of the Bundelkhand Mass, perhaps covered the whole of the gneiss.

Somewhat in this fashion the three great masses appear to have grown outwards until, at the beginning of the Gondwāna period, only comparatively narrow spaces were left between them; and in these spaces the Gondwāna rocks were deposited. They now form strips between the Southern and North-eastern Masses (Godāvari basin); between the Bundelkhand and North-eastern Masses (Son

and Narbada areas); and on the north of the North-eastern Mass (Māhānadi, and perhaps Damuda, Gondwānas).

The complete absence of any trace of Gondwāna or later deposits on the Southern Mass (except near the coasts) and on the rocks of the Bundelkhand area, shows that these areas have been land since Vindhyan times. How much of the North-east Mass was land in Gondwāna times it is difficult to say. In the Godāvāri basin, the Lower Gondwānas appear along the S.W. border of the field, while higher beds abut against the N.E. border. This may be due to a fault, or to overlap of the higher beds on the N.E. side. In the former case the Gondwāna rocks extended over the North-east massif beyond their present limits; in the latter case the N.E. border of the basin must be near the original shore.

However this may be, some part of the North-east Mass was probably land in Gondwāna times; and the Gondwāna rocks were deposited in arms of water between this land and the Bundelkhand Mass on the N.W. and the Southern Mass on the S.E. They were also laid down on the northern border of the North-east massif (Māhānadi area, etc.).

The Gondwāna beds appear to be chiefly fluvial and to have been deposited under much the same conditions as the alluvial deposits of the Indo-Gangetic plain. These Indo-Gangetic deposits, it will be noticed, also fill up the space between two pre-existing land areas.

In this way the deposition of the Gondwānas completed the union of the three elements of the Indian Peninsula. Throughout the whole Peninsula no marine beds of later than Gondwāna age are found except near the coast, and the whole area has been land since that time.

POST-GONDWĀNA HISTORY.

But little now remains to be said. The outflow of the Deccan Trap must have greatly changed the configuration of the surface, and may perhaps have altered the northern part of the west coast; but beyond this it does not appear to have affected the general disposition of land and sea.

The presence of marine Jurassic and Cretaceous beds on the coasts, shows that the whole Peninsula has risen since Gondwāna times.

But the most important alteration is one of which we have only negative, and therefore doubtful, evidence. It will be noticed that up to very recent times no deposits of any kind were laid down on the west side of the Southern Mass, while rocks from the Kadapah period downwards were deposited on its northern and eastern shores. It is, therefore, not unlikely that the present west coast of the Southern Mass was not a coast till late Tertiary times; *i.e.* that the Southern Mass extended far to the S.W. of its present limits—and in this connection it is interesting to note that this would give us the “Lemuria” of Wallace, or Gondwāna land of Suess and Neumayr. In Tertiary times the western part of this land disappeared, and the remaining fragment now forms the southern part of the Indian Peninsula.