eddies in shoal water extending a great way from shore, so that vessels are frequently aground before they come within sight of land, or are caught in the indraft and driven upon the breakers. At the entrance of this gulf a promontory rises to the right, called Baráké, from the point of which the shore takes first a south-east direction, and then winds round to the west, encircling the bay and including the seven islands which lie off Baráké. Vessels which make this cape keep off from the entrance to the gulf to escape the danger; but if they are once embayed beyond the cape, there is no possibility of retreat. The soundings are as fallacious as the other dangers are imminent, for you have one instant an abrupt cast in deep water, and the next you are upon a rocky bottom, so broken and sharp as to chafe the cables carried out to steady the vessel, and finally make them part from the anchor." In this "bay" the Hakrá, through the Shagārā channel, formed its delta. It is of importance to note that the bay named Eirinos was shallow right across to the Cutch islands, and that the "indraft" setting eastwards would to a very considerable extent confine the deposit of Hakrá silt to the north of Cutch.

We cannot describe the gradual growth of the delta, for with the departure of Alexander and his army there followed a period of no less than a thousand years of "splendid isolation" on the part of India as a whole and of this portion of it in particular; but it may safely be assumed that an uninterrupted deposit of silt took place during this millennium. It has been calculated that the undivided Indus brings down 300 cubic feet of mud per second for seven months in the year, of which one half may well have come down the Shagārā channel. From these data it may be inferred that the delta advanced rapidly seaward, with an eastward trend.

Sind was invaded by the Arabs in 712 A.D., and the Arab historians of the conquest of that country furnish reliable information of the growth the delta had by their time attained. To have a correct conception of how far it extended when the Arabs landed in Sind we should draw a line from a few miles south of Debal and Badin towards Wangah, or even much further east towards Nowarkot. I have ventured, after studying the contours, to extend this line as far as Nagar. Thus, during the thousand years of silence which had passed in the history of the delta since the departure of the Greeks the coast-line had advanced as far southwards as a line joining Nagar with Debal.

For many hundreds of years after the Arab conquest of Sind the sea was still navigable, though doubtless shallower than in Alexander's time; and we find this period marked by the founding of a town named Pari Nagar, near the present village of Virāwāh, in Nagar. "To judge by the extent of the buildings and streets, many of which are traceable—the houses having been built of burnt bricks, some of which have since been excavated and used for the present village of Virāwāh—it would

appear to have been a large and flourishing town" (Raikes). The prosperity of this town can only have been due to its being a seaport. On the site of Pari Nagar are the remains of large Jain temples, most of them of white marble. They clearly demonstrate that at the time of their construction—and which, from dates engraved in some of the slabs, was probably in the middle of the eleventh century—the artisans were by no means behind those of after-times in the art of sculpture. This town must have been a port when the hinterland—prior to the periodical transitions of the rivers of Sind—was well watered, and supported a considerable population. Balmir, another town 100 miles north-east of Virāwāh, shows in its ruins similar evidence of wealth and population, and inferentially also of the Luni having been navigable for at least small craft for some centuries. Pari Virāwāh was destroyed by the Emperor's troops from Delhi in about 1226 A.D., but in any case its decline was imminent and inevitable. A great flood in the northern part of the Punjab territory had brought about a rearrangement of the waterways in the delta, for about the beginning of the fourteenth century the Hakrá lost the greater part of its volume, and for some four centuries continued only with some difficulty to be a perennial stream; it finally ceased to be one in A.D. 1739. Before its decline in importance, the river had, with some assistance from the Luni, and to a small extent from the streams in Cutch, silted up the sea-bed between the mainland and the Cutch islands; for although a channel was kept open for three or four centuries longer by the scour of the land-water from Cutch seeking the sea through the Khori creek, and another along the mainland preserved by the Luni, that the intervening area was a marsh (or ran) in A.D. 1361 we learn from the Arab historian who had accompanied the Sultán Firúz Sháh, when in that year he led an expedition into Guzarat. He describes the marsh as extending from the ocean between the provinces of Sind and Guzarat, in length 90 kuroh (157 miles), and breadth 8 to 30 kuroh (14 to 52 miles). It is "such a howling desert," he adds, "that no bird ever flapped its wings over it, not a tree was to be seen, not a blade of grass, not even a miserable noxious weed"—a description of the Ran five centuries ago which will do equally well for to-day.

Thus far I have dealt with the advance of the coast-line immediately to the north of the Cutch islands, and the silting up of the sea area between by the Hakrá and subsidiary streams; now the advance southward of the delta of the Indus west of the 68° 30′ meridian can be rapidly followed.

The ancient town, Debal, 15 miles below Thathah (Tatta), was the first place in that territory attacked by the Arab leader Muhammad early in 93 H. (711 A.D.), a fact recorded by the Arab historian which enables us to fix the position of this portion of the coast-line at the beginning of the eighth century, for Debal was then a seaport. Like

Thathah (which, however, was not founded till some six centuries later) it was on the Bhágar branch of the Indus, but at its mouth; and even as late as the seventeenth century the Bhágar branch was a very great stream, and navigable for vessels of 200 tons as far as Láhrí Bandar, which place was then some 20 miles from the sea. Moghul Bin, now 50 miles from the sea, was, in the reign of Queen Elizabeth, on the sea-coast. Accordingly, a line joining Karáchi with a point 20 miles south of Láhrí Bandar, through Moghul Bin, to about 20 miles north of Lakhpat, will give the approximate coast-line of the Indus delta three hundred years ago. The delta to the south of this line has been formed since. The conclusion to be formed is that, subsequent to the transition of the drainage of the Punjab rivers from the Hakrá into channels further west, the advance seawards of the delta became more rapid, and that its development has caused the silting up of the Khori channel and its permanent closing as an access for the sea into the western portion of the Ran. But this desertion of the Hakrá channel was not completed until the 'bay,' as it was known to the Greeks, had been silted up by that river to the sea-level and in parts above it.

There are no writings to aid us in an attempt to fix the easterly confines of the bay as described in the Periplus; in the accompanying map I have shown the 100-feet and 200-feet contours of the country to the east as they exist at the present day, and from a consideration of the probable rate of accumulation of Æolian deposits under the conditions obtaining, a suggestion that the present 100-feet contour approximates to the coast-line 2000 years ago appears tenable. The two areas of Jurassic formation in the district now called Chorar would then have been islands, as would the province of Cutch named Wagir, and the seven islands of the old geographers are accounted for.

The small rainfall in Cutch, under 15 inches a year, and the very limited catchment areas of the streams discharging into the Ran, indicate an insignificant deposit of silt through their agency; nor can the Luni have brought down much, as it is not a river liable to freshets. Further, it rises in a lake at Ajmere; its chief tributary is the Sarsuti, which also has its origin in a lake (the Pushkar), and, though fed by numerous tributaries, these have their origin in the well wooded Aravalli hills.

I believe that so long as the easterly current, referred to by the Greek writers, circled round the Cutch islands the deposit of silt into the Lesser Ran from Chorar to the present head of the Gulf of Cutch by the Banas and the rivers of Kathiawar cannot have been considerable; but on the silting up of the Greater Ran by the Hakrá, and with the simultaneous heading off of this current by the southward extension of the Indus delta, the conditions became more favourable. The Lesser Ran would then become a quiet and almost land-locked bay, where silt might be expected to accumulate with rapidity.

The very marked difference between the composition of the alluvium of the Greater and Lesser Ran at once points to different sources of origin. The silt of the Greater Ran is unmistakably an Indus valley deposit; that of the Lesser Ran is as easily recognizable as the black cotton soil of its source of origin in Kathiawar. The Greater Ran, when it dries, becomes hard sand overlaid by salt, varying in thickness from a mere layer to as much as 4 feet. The Lesser Ran, were it not for a slight powdering of salt, resembles that rich dark loam, composed of mineral *débris* and organic matter, which is known as "black cotton soil," or regar; such salt-beds as occur owe their existence to the Banās, the one river flowing into the Lesser Ran comparable to the Luni. This silt, when wet, becomes clayey; the Indus silt—the "hour-glass sand," as it has been described—does not. Neither ever forms marshland. The Greater Ran is mainly indebted for its salt to the Luni, the bed of which river and its tributary streams are encrusted by saline deposits. The river has now silted up its mouth, and a salt-bed of great extent has been formed east of Nagar by the evaporation of such water as has in recent times filtered through the sand-drifts which have choked it up. Some salt was also brought to the Ran by the Indus inundations subsequent to its diversion from the Hakrá channel. Nearly all the rocks of Cutch are strongly impregnated with salt, many of the river pools are lined with it, and this occurs so generally that a stream of fresh water is rarely found in the country except in the stratified trap area, and these, as will be seen from the map, discharge without exception into the Indian ocean. The Jurassic rocks are the most saline, and these are drained into the Ran. The Cutch salt has a slightly bitter taste.

There are some quicksands near the site of the now silted-up Sindree lake, but, unless local rain has fallen or river discharges have spread themselves over the Ran, its surface is hard and firm, and the heavy, cumbrous bullock-carts of the country pass easily over it. It was crossed in all directions at nearly all times of the year by troops of all arms, engaged in the suppression of the banditti who infested the deserts of Thar and Párkar. The effect of local rain on the Ran was considered in those days as the cause of the Ran being difficult to cross, but in the absence of this, rapid marches were made. Thus, on October 18, 1848, a company of European artillery, with a horse-battery of 9-pounders and two 24-pounder howitzers with waggons, marched in eighteen hours (including halts) from Misri Well to Vingur, a distance of 31 miles; and on September 30, 1832, a detachment of artillery from Bhuj, with a 12-pounder howitzer and a 6-pounder, marched across the Ran from Bela to Kasba, a distance of $27\frac{1}{2}$ miles, in twelve hours.

The silting up of the Greater Ran is still being continued by the Cutch rivers, but, as explained above, the quantity of alluvium brought down by them is insignificant. The Punjab drainage which entered the Ran by the Hakra river has formed fresh channels further westward,

and the Luni water now reaches the Ran as filtered brine; the sea never reaches this vast area, which has now become the dominion of dust-storms.

In the deserts of Thar and Párkar the air is seldom still, and in Cutch, where the rocks are generally remarkably friable, there is seldom a calm day. Though the prevailing wind is west, it blows for ten months in the year also from the south-west and north-west; one month may be allowed for easterly winds, and one month for variable winds. The monsoon sets in generally with great violence from the north-east before it settles in the south-west. In the desert, as in Cutch, a quiet breeze is enough to raise the dust, and a strong wind makes the air so thick with sand that a man fifty paces off would be invisible. Sir Charles Napier, writing from the Hyderabad district in January, when the climatic conditions would be at their best, says, "Our eyes are full of sand, ears full of sand, noses full, mouths full, and teeth grinding sand; enough between our clothes and skin to scour the latter into goldbeater's leaf—one might as well wear a sandpaper shirt. Our shoes are in holes from dryness, and we walk as if we had supplied their places with sand-boxes; our meat is all sand, and on the average every man's teeth have been ground down an eighth of an inch, according to his appetite." As might be expected, Æolian deposits in the Ran are being accumulated with great rapidity under the conditions which obtain. On the northern shores of the Ran, what was open water in the times of the Greeks is now occupied by parallel ranges of sandhills, having their crests from 6 to 8 miles apart, and in height some 50 to 80 feet above the hollows between them. These come right down to the shores of the Ran, on which they are encroaching, and which, it is safe to say, they will some day occupy, burying beneath them the alluvium whose origin I have been endeavouring to trace.

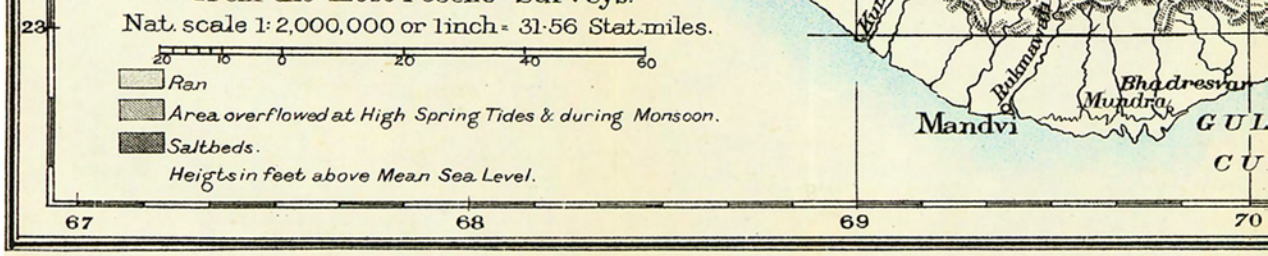
Very great changes within the last eighty years, through the agency of drifting sand, can even now be discerned by comparing Burnes' map of the Ran with the present conditions. Large areas which are shown as of Ran formation on it, and which are so described in contemporary notes on the most used crossings from Cutch to Sind and Nagar, are now areas of firm sand sustaining a scanty vegetation, while the formation of these sandy islands, or "bets" as they are called locally, is going on unceasingly.

The prevailing direction of the winds, and its distance from the deserts of Thar and Párkar, as well as the high state of cultivation of Kathiawar, render the Lesser Ran less liable to dust-storms than the Greater; wind-borne deposits are, accordingly, a less prominent feature of its present condition. Such as occur are in its eastern confines, but the Kathiawar shore is skirted by low hills of drift sand, and there is a well-marked series of dunes extending for 20 miles from Wawanya along the coast of the Gulf of Cutch.

I have throughout this paper adopted the simplest spelling of the name now given to this province. Cutch is, of course, merely a phonetic rendering of the Urdu word, whose nearest transliteration into Roman letters is "Kachchh," which means alluvium brought down by rivers. "Ran" means a marsh. Thus, when we talk of the Ran of Cutch, we say the Marsh of alluvium. It is out of the question that the rocky islands which lay off the mouth of the Hakra could have been called Kachchh at the time of the Greeks, or even for centuries later. It is probable that, as the islands formed part of the ancient province of Saurásthrá or Suráth, so they were named, until their identity was lost in the newly formed land surface connecting them with the mainland.*

After the paper, the CHAIRMAN (Sir T. H. Holdich): I am afraid that the time for discussion is rather short, but Mr. Sivewright has given us one or two very interesting points to think about. About the time that Mr. Sivewright must have been engaged in investigating the conditions of the Ran of Cutch, General Haig, R.E., of the Bombay Survey, issued a small booklet dealing with that very subject, and he, incidentally, pointed out the extraordinary changes that had taken place since ancient times in the course of the Indus. He traced out the old courses of the Indus, and he showed fairly, I think, what the growth of the Indus delta may have been from earliest times. As regards the Ran of Cutch, he distinctly affirms that the sea does occasionally enter the Ran and flood it. After what Mr. Sivewright has told us about the results of his levelling operations and the character of the silt which he examined at the bottom of the Ran, I think there can be no doubt that the Ran is deltaic, and I fancy that the saltness which pervades the water when the Ran is flooded has led people generally to suppose it was sea-water. But the stories of the changes that have taken place in the Ran belong to such ancient history that it is impossible really to say at which epoch these changes may have occurred, or whether they are gradual or sudden. So old are they that even in that ancient epic "The Mahâbhârata," there is a distinct allusion to the drying up of the Ran of Cutch, and the disaster is placed to the credit of the god Varuna. However that may be, it is quite certain that all along that coast, and westward from the Ran to Karrachi, as well as along the Makrán coast, changes have taken place with such rapidity that it is exceedingly dangerous to form any theory as to what the conditions of the country may have been at any particular time. General Haig, I think, has arrived at very fair conclusions as to the outline of the coast in the time of Alexander. I think myself, having gone over the ground, that the indications he gives are tolerably conclusive, but I have myself observed such extraordinary changes in the coast conformation even during the few years on which I was engaged in surveying it that I have long ceased to regard the process of transformation as continuous. I am certain that it has been more or less spasmodic, and that occasionally changes take place with exceeding rapidity, which normally would require very many years. You see that there are three large forces of Nature contending together to produce these changes. First, the wind and current action of the sea, which is most apparent during the south-west monsoon; then the silting action of rivers; and finally there are the periodic and intermittent results of earthquakes, and the action of such forces as Lieut. Headlam has just alluded to, *i.e.* that of mud volcanoes,

* At the same meeting Lieut. Headlam's account of "A New Island in the Bay of Bengal" (*G.J.*, vol. 29, p. 430) was read, and is dealt with in the discussion which follows.



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