

extraction of groundwater downstream one can create higher hydraulic potential difference between the percolation tank and water table, which in turn is responsible for greater percolation. Favourable

conditions exist at Kalwakurthy in contrast to Singaram because of greater number of wells downstream of the Kalwakurthy tank thereby enhancing the efficiency of the tank as explained above.

EVOLUTION OF THE WESTERN COASTLINE OF INDIA AND THE PROBABLE LOCATION OF DWARAKA OF KRISHNA: GEOLOGICAL PERSPECTIVES by R.N. Iyengar and B.P. Radhakrishna. Jour. Geol. Soc. India, 2005, v.66(3), pp.285-292.

V.S. Krishnaswamy, 409, S. Lexington Avenue, White Plains, NY-10606, USA comments:

The authors of the paper have once again demonstrated that modern tools of enquiry and ways of thinking can be useful in evaluating the ancient environments and long bygone events that have been so faithfully portrayed in the Sanskrit literature of India. However, I am unable to grasp the validity of certain of the observations and some of the conclusions presented in the paper, without some clarifications by the authors on the following points:

2. Three sets of evidences have been put forward by the authors in support of their/conclusions on the location of Ur-Dwaraka and Ur-Prabhava. However, they have not put forward any argument as to why the currently held views of archaeologists, like Sankhalia, S.R. Rao and other young scientists, all of whom accept the position as shown close to the western boundary of the Saurashtra peninsula, should be discarded. In this connection, the evidence and arguments put forward by Rao (1999, 2001) which are quite convincing, are very relevant to the current discussion. In particular, the illustrations portraying the sub-tidal and submarine finds of the ancient harbour lying close to the island of Bet Dwaraka offer in my view, impressive support to the existing opinion on the location of Dwaraka.
3. It appears to me that the three sets of evidences as put forward by the authors, are not unequivocal in support of the proposed new locations. The evidences cited appear to be equally applicable to the old locations as accepted by the archaeologists; hence, the need for changing the old in favor of the new locations is not clear. Also, using the new locations as suggested by the authors, the events, as portrayed in the *Bhagavatha Maha Purana* (referred to, hereafter, as BMP) do not

seem to be as well supported by the description of the events as recorded in the Sanskrit texts as the old locations, as, for example, the descriptions given when Krishna ordered the immediate evacuation of the city of Dwaraka in the 2nd millennium B.C. because he felt that Dwaraka was going to be threatened by an impending holocaust (vide BMP; Bk11: ch.30: ve.4-5: pp.660). The high ground of Sankhodara, as mentioned in the BMP, fits well with the Sankhodara of the present day, located in the Bet Dwaraka area. On the contrary, the Ur-Dwaraka, as now suggested for consideration by the authors, does not have a higher ground called Sankhodara, to the best of my knowledge. The Ur-Prabhava location, referred to in the ancient/Sanskrit text, is also on higher ground, to which Krishna had gone after he had abandoned Dwaraka, which is not the case at the location as suggested now. Lastly, it is relevant to recognize that while a submerged city's remains have been discovered underwater, close to Bet Dwaraka, such a find in support of the new location in the Cambay basin, although this area has also been archaeologically explored.

4. It is not clear from the presentation made by the authors whether or not the new locations suggested in Fig.2 have been adjudged necessary because of the comparative nearness of these locations to Hastinapur (close to present-day Delhi) in relation to the currently accepted locations, that lie further westwards. If so, this argument does not seem to be very strong, because, the route as shown by the authors on Fig.2 has to negotiate the high hills such as at Mt. Abu and probably also some part of the Thar desert, with no significant relay or support facilities available en route, for Krishna's entourage. This had a large number of chariots, palanquins and baskets, men, camels, horses, elephants and a contingent of soldiers for protection.

Also, the actual route followed by Krishna, in one of the journeys he undertook to Hastinapur, has been described in the Sanskrit text of BMP (Bk 10 Ch 71 pp 418-421) The kingdoms of those days, crossed en route by the caravan have been shown on the political map given by S R Rao in the 1996 paper cited by the authors If the route as indicated is plotted out on a map of India, this passes by a number of sites of the Saraswathi and Indus Valley Civilizations of ancient India, which may have retained some of their glory in 1500 B C , when Krishna's caravan passed by Although much longer than the route shown on Fig 2 of the paper, this route as described in the text of the BMP seems to have better logistics of support, supplies and relay facilities

- 5 To me, it seems that we already have some evidence to believe that the marine incursions of the western part of India in the Pleistocene and, probably also in the early Holocene, as visualized by the authors, may have got drained off, because of the later uplifts of the middle and late Holocene so that, when Krishna came on the scene, in the late Holocene, much of the marshy terrain, that could have posed difficulties for travel, may have disappeared
- 6 Krishna's choice of Dwaraka, at the northwestern tip of the Saurashtra Peninsula, jutting out into the Arabian Sea, seems to have been dictated by strategic considerations, which have been described in the different Sanskrit texts, including the BMP, which indicate, how sorely pressed Krishna was by the attacks from his enemies than Mathura was, as was then chosen by him which, had better protection from enemy attacks due to the natural barriers of sea on all three sides and by a 30-40 m high, Raivataka hill on the fourth side These protective features, available at the existing site of Bet Dwaraka do not seem to be available at the alternative Patan location of the Cambay gulf as shown in Fig 2
- 7 It is relevant to point out that according to the BMP, when Krishna had directed his men to shift the capital from Mathura to Dwaraka (vide Bk 10, ch 50, ve 49, pp 323) he had instructed them to build a fortress in the sea The recent submarine explorations of S R Rao and his fellow workers have uncovered the existence of the under-sea remnants of a fortress wall with bastions, dated by thermo-luminescence studies of pottery fragments therein, as 1500 B C Therefore, in my opinion, the Patan site as favoured by the authors, does not seem to be the best fit for all the available information, while the currently accepted Bet Dwaraka

site appears to be so

- 8 In the geological evaluation of the environment of the past, as visualized by the authors, Kathiawar and Cutch, as well as several other islands like Pacchham and others have been considered by the authors to have been part of what can be described as an "island-archipelago" occupying the western part of India The available geophysical evidence from the one Deep Seismic Reflection Survey across the entire Saurashtra Peninsula from west to east crossing the Cambay area, carried out by the NGRI, the several gravity traverses and geophysical studies of the Saurashtra area by the GSI, and the regional geological mapping done by GSI and the detailed geological studies by the Universities and other agencies and the exploratory drilling done for oil by the ONGC does not seem to support the existence of deep dividing depressions other than those occupied by faults are by graben areas, therefore, available information do not seem to favour, unequivocally, the concept of the western island archipelago, in preference to the concept of a badly fractured and rifted Peninsular land mass, with several horsts and grabens, caused by the tensional forces implicit in the northward continental drift before the collision with the Asian Plate and also compatible with the concept of the subduction of the Indian plate under the Eurasian Plate, all along the Mekran coast
- 9 Figure 2 shows the extension of the Cambay graben into the Bombay offshore region, without any break The tectonic maps of ONGC (2004) as well as the earlier maps by Auden (1975, 1981) clearly show a break and the transformal shift of the Cambay graben to become the Bombay High graben It would seem, therefore, that the coast line in the Plio-Pleistocene period may not have been as unbroken as visualized
- 10 The tsunami generated by the 1945 Churie earthquake of the Mekran Coast can certainly be considered as the first, instrumentally recorded tsunami of the Arabian sea However, if the marine transgression and the sudden marine attack of 1500 B C , as has earlier been surmised (Krishnaswamy, 2005, In Press) is also considered, the Churie event would then become the second documented tsunami of the Arabian Sea and, if the suspected tsunami, following the invasion of India by Alexander's fleet, which got damaged extensively in 328 B C , is also taken into consideration, the Churie event will become the third possible tsunami event of the past, arising in the Arabian sea west and northwest of Dwaraka
- 11 The additional information on the nature of the

Arabian sea floor, made available since Wadia's book, written in 1957, does not support the existence of calderas in the ocean floor, off the Makran Coast, as surmised in the paper (Legget and Platt, 1984; Quittmeyer and Jacob, 1978) the currently available ocean floor maps of the world (U.S. Navy, 2002; National Geographic, 2004) also confirm the absence of caldera-like features in the Arabian sea. The subduction of the Mekran Coast, besides explaining the deep levels of the ocean floor here, as pointed out by the authors, also gives an understandable background to the occurrence of the mud volcanoes and the spectacular gas shows of 1945 that were recorded along the Mekran Coast

12. I am in total agreement with the wide-ranging but very valuable suggestions made by the authors on the needed efforts of the future, in connection with the multidisciplinary Project as conceived by them, which includes two items of basic research and six items of applied research. I wonder, however, whether the authors would consider the additional item of applied research work, for defining and exploring the deeply covered channel sections of the now extinct Saraswathi river of the Vedic Age, from the point of view of its likely utility in developing the groundwater potential therein for meeting the irrigation and water supply needs of the area.
13. In conclusion, I congratulate the authors, whose joint effort is a testimony to the type of very useful contributions that can be made, using the ancient Sanskrit texts as spring board for intellectual explorations, which the authors had done so remarkably well.

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Sri V.S. Krishnaswamy (VSK) has certain reservations about the validity of our observations and has sought clarifications. Replies are given point by point.

1. No comments
2. **The Location of Ur Dwaraka as being different from present day Dwaraka:** No final word has yet been said about the exact location of Dwaraka built by Krishna in second millennium BC. The findings of S.R. Rao are not so unequivocal as made out by VSK. There are

many dissenting views as those of K.M. Munshi and Kosambi among others. The marine archaeological group of NIOT, Chennai, have put forward the view that the ancient port city of Dwaraka lay at the mouth of the Gulf of Cambay (*JGSI*, v.60, pp.419-428). We are not aware of the work of other 'young scientists' who have accepted Ur-D as the town lying on the western boundary of present day Saurashtra.

We are not disputing the fact that a city belonging to 2nd millennium BC has been unearthed off Bet-Dwarka. What we question is its identification with Ur-D as presented in ancient texts connected with Krishna-lore. We do not claim to have located the place beyond doubt, but only point to the likelihood of Ur-D being located somewhere near present day Rann of Kachchh (ancient Irina) which would have been a navigable sea in mid Holocene.

3. **Evidence of Bhāgavata Mahā Purāna (BMP):** BMP should not be the sole basis for deciding the location of Ur-D. It is an accepted fact (in Krishna lore), that *Purāna* literature which depicts Krishna as an incarnation is later than other texts like the *Mahābhārata* (MB), and *Harivamśa*. Moreover, VSK has quoted only one half of the verse ignoring the second half which mentions Prabhāsa and Saraswati in addition. The full text in original reads:

*striyo bālāśca vrddhāśca śankadwāram vrajanvitāḥ |
vayam Prabhāsam yāsyāmo yatra pratyak Saraswati ||*

(Let ladies, children and elderly go to Sankadwara. We go to Prabhāsa where river Saraswati flows westwards)

Sankadwara is not an elevated land but an island around Oka subjected to long term erosion and lying close to the shore line (Mem. Geol. Soc. India, no.16, pp.122-126).

As far as topographical features of remote periods are concerned our stand is to construct, to the extent possible, the ancient coast line as it existed in 2nd millennium BC. This is where geology comes to our aid in fixing the probable location with greater reliability.

4. **Nearness to Hastinapura cannot be sole criteria:** MB and *Harivamśa* (HV) mention well known place names like Pushkara and Mt. Abu, which are certainly closer to Indraprastha than present day Dwarka located far away along the west coast and would have set no formidable barriers in crossing not only the Aravalli, but also the marshy ground represented by the Cambay

basin and the inhospitable dry stretch of Rann of Kachchh

The line marked in our Fig 2 is not claimed to be the precise route taken by Krishna. It is only indicative of what is mentioned in the Sanskrit texts as a possibility. Reaching any place on the eastern margin of Cambay would not have presented any difficulty.

- 5 **Conditions in Holocene:** The evidence of Sivewright (1907, *Roy Geograph Soc Jour* reference quoted in our paper) confirms that even in late Holocene the western coastline of India was close to the eastern margin of the Cambay Basin. The entire basin was slushy and marshy making the crossing a very arduous exercise.

It may be interesting here to recall the words of Pascoe who derives the term Gujarat from the tribe Gujjar who occupied a large part of the country drained by basins Saraswati and Mahi. In the more correct sense he states "*the term Gujarat includes neither Kathiawar nor Cutch*" (Manual of Geology of India, v 1, p 275). This implies the region occupied by Cambay basin was a slushy ground separating the mainland from the isolated islands located to the west.

- 6 **Strategic importance of present day Dwaraka:** This has not much bearing on the present discussion.
- 7 We repeat that VSK is too much dependent on BMP ignoring other texts. We have to consider ancient textual geography collectively.
- 8 We dispute the current belief that Saurashtra and Cutch are part of the mainland. On the other hand they are islands. Our interpretation is that the rift which defines the west coast line of India from Kanyakumari to Tapti continues NNWwards traversing Gujarat and Rajasthan forming the eastern margin of the Cambay basin. Drilling exploration by the ONGC has shown that the area west of this rift line has been downfaulted by as much as 5-7 km and in the basin created by the rift a thickness of 5-7 km of sediments from Late Jurassic right up to Pleistocene and even Holocene accumulated. This is an undisputed fact proved by exploratory holes drilled by ONGC. Saurashtra and Kachchh were cut off from the mainland and occurred in the northern extension of the Arabian Sea as larger or smaller islands, some submerged and some uplifted above sea level. West of the line of rift, no part of the gneissic complex or the Aravallis and Delhis are exposed. Saurashtra and Kachchh were submerged initially receiving early Jurassic-Cretaceous sediments and were later uplifted in post-Cretaceous times, as supported by considerable patches of Jurassic and Cretaceous

sediments both in Kachchh and Saurashtra. Evidences indicate that the Deccan Trap activity in Kachchh and Saurashtra was of a distinctive kind marked by extensive ash beds and explosive volcanism. Mt Girnar and other plug like masses expose a wide variety of petrological rock types – a petrological bonanza not witnessed in any part of the mainland. Saurashtra has remained as an uplifted horst surrounded on all sides by the sea since upper Cretaceous and evolved independently with radial drainage, a pattern opposed to the westerly drainage of the mainland.

Dholavira was a port and the Rann of Kachchh was navigable, which again emphasises the fact that Kachchh and Saurashtra formed islands. Their connection to the mainland was established only in recent times by the extensive Indus and Saraswati alluvium. Based on literary accounts and field surveys, Sivewright has reconstructed a map of the Kachchh region as it existed in the time of Alexander which confirms our conjecture of the existence of the coastline coinciding with the eastern margin of Cambay basin. Subsurface connection may be present but this can be said for the whole series of islands lying off the Konkan and Karanataka coasts. They are to be recognized as islands.

- 9 All the recent maps of ONGC show Cambay and Bombay basin as continuous forming first order sedimentary basins with high hydrocarbon potential.
- 10 No comments.
- 11 We are not aware of the latest references quoted by VSK. The fact remains that the statement made by Wadia has not been corrected either by GSI or NIO. We are not aware of any bathymetric survey carried out by them of the coastal margin. The maps are not made available to us on request.
- 12 Our key arguments are that in 2nd millennium BC people
- & migrating westwards from the Kurukshetra region
- 13 would have met with a sea shore somewhere in the present day Rann of Kachchh. From the geological angle we think that this region could be an extension of the present day gulf of Cambay. As far as locating Krishna's Dwaravati is concerned the common features upheld by all the ancient texts are that it was west of Mathura, on the sea shore nearer to a place called *Prabhāsa* which in turn was where the sacred river Saraswati entered the sea. We feel our postulated location of Ur-D is a best fit for the above commonalities.

The historicity of Krishna and the probable location of

Dwaraka which is traditionally supposed to have been built around 2000 BC persuaded us to take a closer look at the evidence furnished, particularly geological by the ONGC in recent years and speculate on the evolution of the west coast line in general and the highly indented Gujarat coast in particular.

A greater part of the area lying to the west of the Saurashtra coast and the extensive tidal flats below the Great and Little Rann must have extensive spreads of Cretaceous

and younger sediments and would be worthy targets for hydrocarbon exploration.

We are grateful to VSK for the interest he has shown which have enabled us to reexamine our evidence and hope that our explanation is convincing and is at least worthy of further attention. The region in our opinion is insufficiently explored and a multi-disciplinary effort is required to trace the evolutionary history of the Western coast line of India with special reference to hydrocarbon exploration.

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