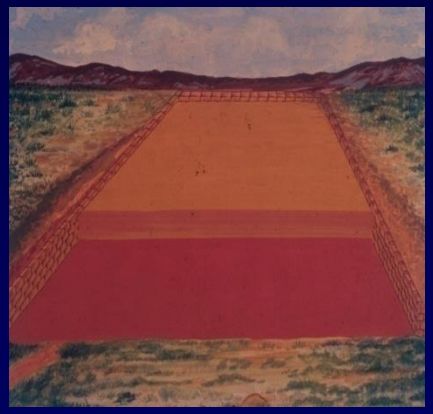
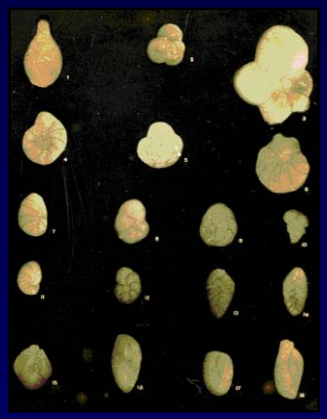
NIO
understanding the seas

4th conference on Science and Geopolitics of Himalayan-Arctic-Antarctic
Focusing Climate Change
1st Dec.2017

FORAMINIFERA IN MARINE SEDIMENTS OFF WEST COAST OF INDIA - A TOOL FOR PALEOCLIMATIC RECONSTRUCTIONS



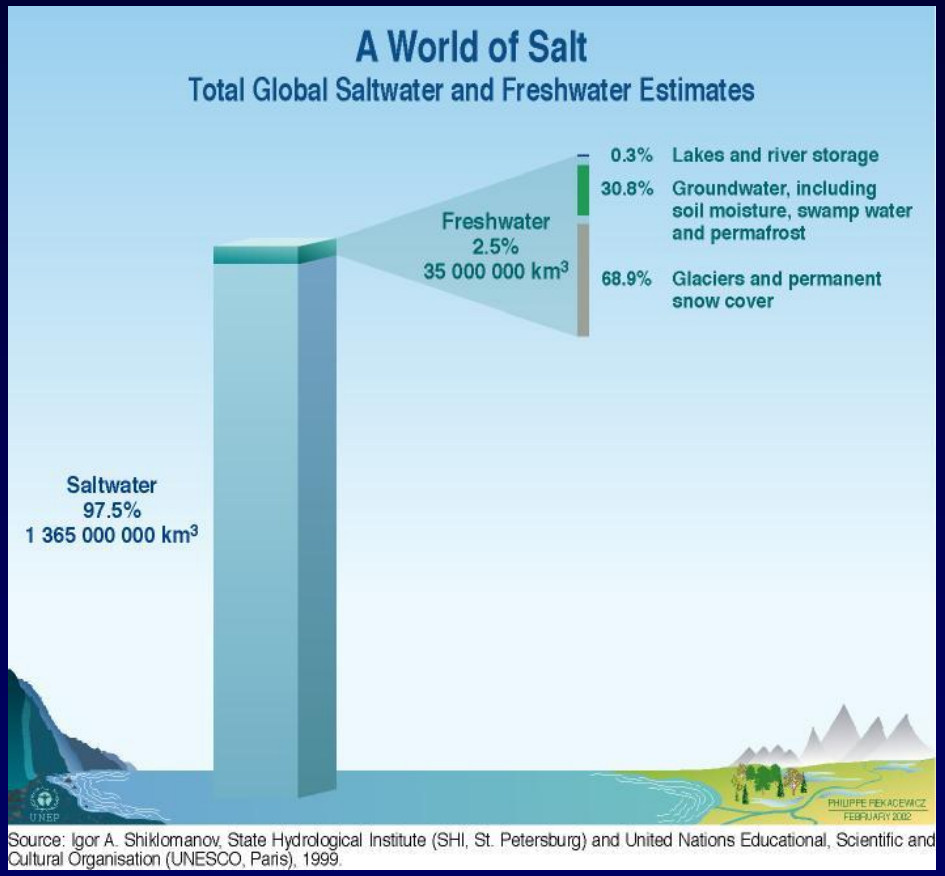
Rajiv Nigam
National Institute of Oceanography
Dona Paula, Goa-403004
nigam@nio.org; rajivnigam1954@gmail.com

Global Warming

Consequences :

- Accelerated rise in Sea Level
- Change in monsoon pattern
- Increase in intensity and frequency of storms
- Fisheries

NIO



Fluctuating waters

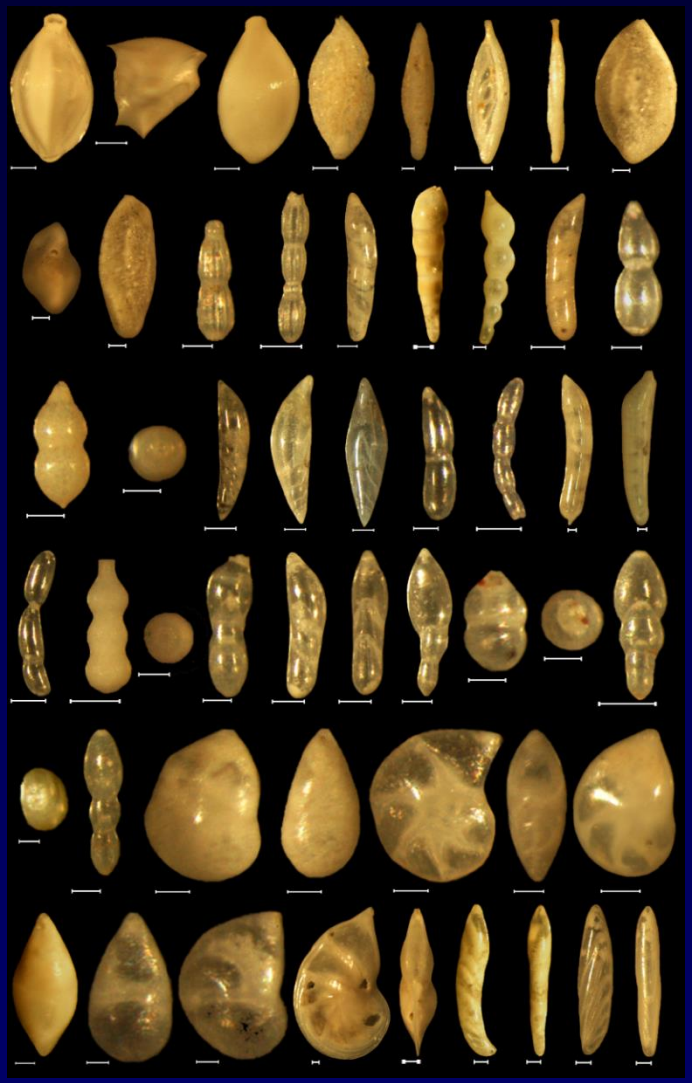
"**Archaeology** may be subtly defined as the systematic study of antiquities as a means to reconstruct past"

[Grahamclark, Prof. Archaeology, University of Cambridge]

"The unique contribution of the marine sediments has been for deciphering the Changes in oceanographic conditions due to climatic variations in the past -Paleoclimate"

Since the common aim of oceanography and archaeology lies in the illumination of the past, it is obvious to bring coherence between the two.

Marine Archaeology – Marine Sediments and sea level changes

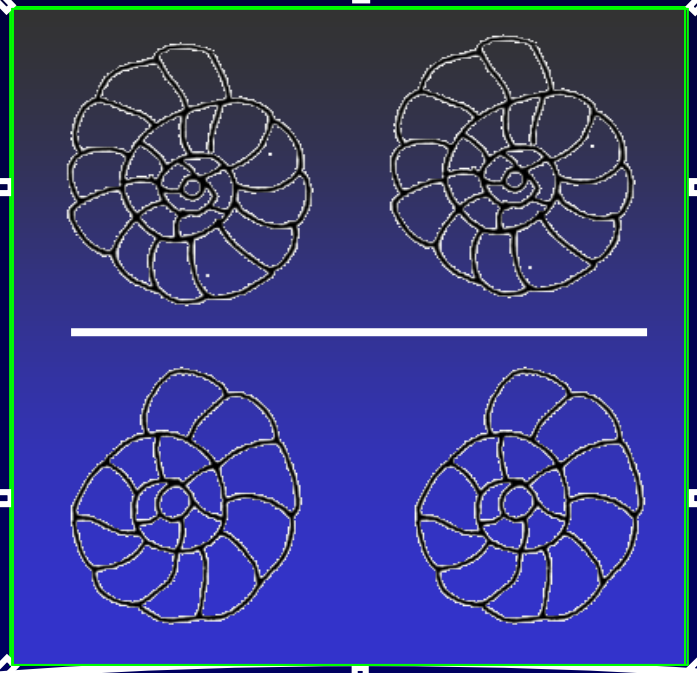


Applications of Foraminifera

- Paleoceanography
- Sediment Transport
- Petroleum Exploration
- Monsoon Variation
- Paleoclimatology
- Sea level Changes
- Marine Archaeology
- Pollution Monitoring

NIO

Foraminiferal Parameters used as Tool



Total Foraminiferal Number

Assemblages

Abundance

Coiling Direction

Benthic: Planktic

Elemental Composition

Isotopic Composition

Mean Proloculus Size

Mean Diameter

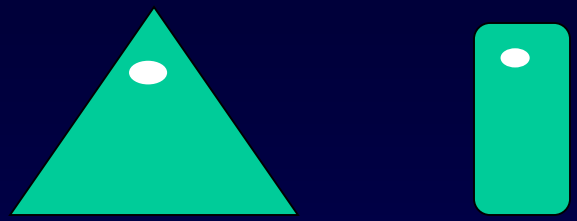
Average Number of Chambers

Mode of Reproduction

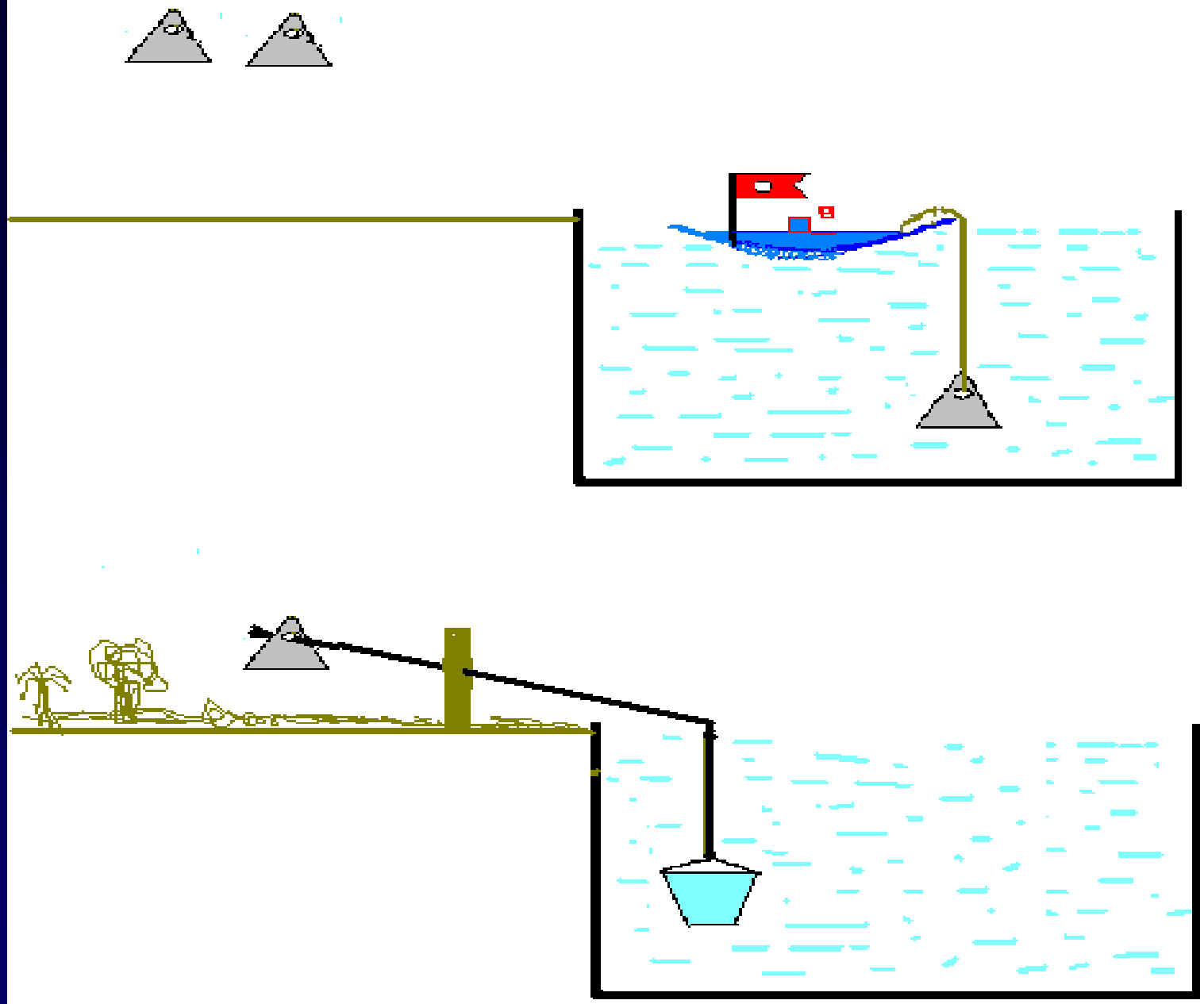
NIO


Dholavira
Surkotada
Bhuj
AHMEDABAD
Goladhoro
GOLFO DEL KUTCH
LOTHAL
Vadodara
Nageshwar
Porbandar
Surat
Prabhas Patan
(SOMNATH)
MARE ARABICO
GOLFO DI KHAMBHAT
100 km

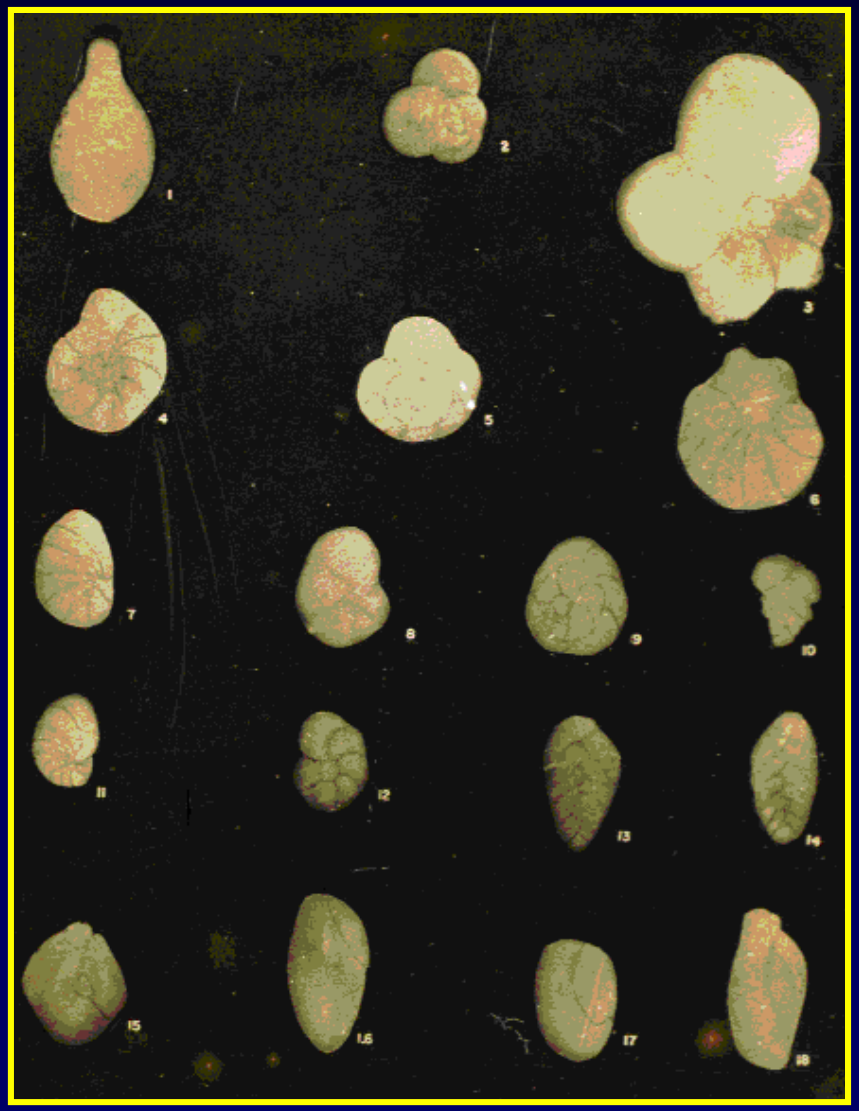
The Key-question is to Understand whether Lothal was a Port Town or not …



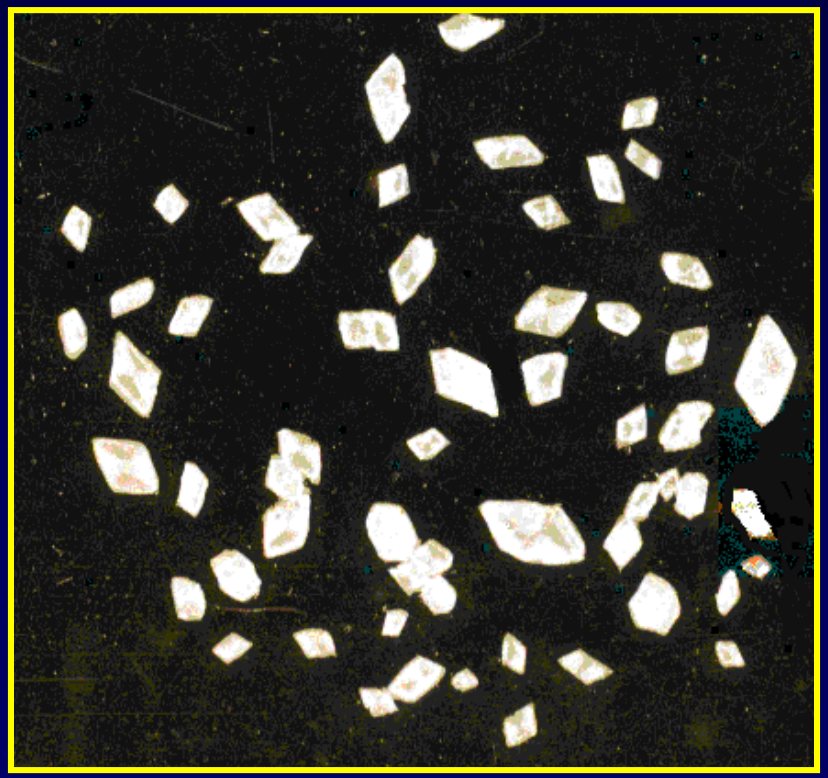
TIDAL-DOCKYARD
OR
FRESH WATER TANK
?



Evidences for higher sea level



Foraminifera and Marine Archaeology



Past records [in religions]

॥ राजोवाच ॥ भगवन् श्रोतुमिच्छामि हरेरद्भुतकर्मणः ॥ अवतारकथामाद्यां मायामत्स्यविडम्बनम् ॥१॥ यदर्थमदधाद्रूपं मात्स्यं लोकजुगुप्सितम् ॥ तमःप्रकृति दुर्मर्षं कर्मग्रस्त इवेश्वरः ॥२॥ एतन्नो भगवन्सर्वं यथावच्छुकुमर्हसि ॥ उत्तमश्लोकचरितं सर्वलोकसुखावहम् ॥३॥ ॥ सूत उवाच ॥ इत्युक्तो विष्णुरातेन भगवान्बादरायणिः ॥ उवाच चरितं विष्णोर्मत्स्यरूपेण यत्कृतम् ॥४॥ ॥ श्रीशुक उवाच ॥ गोविप्रसुरसाधूनां छन्दसामपि चेश्वरः ॥ रक्षामिच्छंस्तनूर्धत्ते धर्मस्यार्थस्य चैव हि ॥५॥ उच्चावचेषु भूतेषु चरन्वायुरिवेश्वरः ॥ नोच्चावचत्वं भजते निर्गुणत्वाद्धियो गुणैः ॥६॥ आसीदतीतकल्पान्ते ब्राह्मो नैमित्तिको लयः ॥ समुद्रोपप्लुतास्तत्र लोका भूरादयो नृप ॥७॥ कालेनागतनिद्रस्य धातुः शिशयिषोर्बली ॥ मुखतो निःसृतान्वेदान्हयग्रीवोऽन्तिकेऽहरत् ॥८॥ ज्ञात्वा तद्दानवेन्द्रस्य हयग्रीवस्य चेष्टितम् ॥ दधार शफरीरूपं भगवान्हरिरीश्वरः ॥९॥ तत्र राजऋषिः कश्चिन्नाम्ना सत्यव्रतो महान् ॥ नारायणपरोऽतप्यत्तपः स सलिलाशनः ॥१०॥ योऽसावस्मिन्महाकल्पे तनयः स विवस्वतः ॥ श्राद्धदेव इति ख्यातो

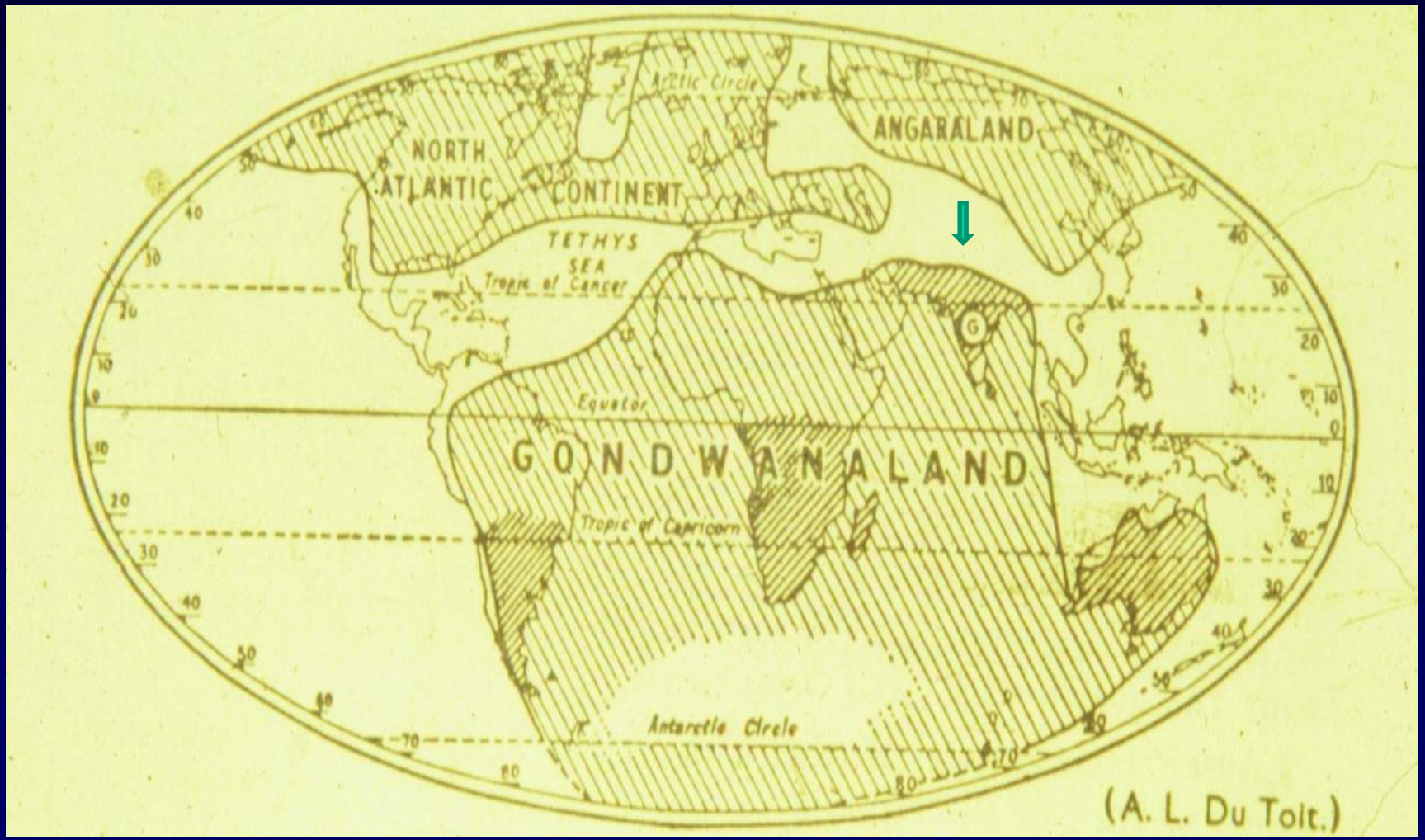
"At the end of the last Kalpa, there occurred a Pralaya caused by reason of Brahma's slumber, when all the worlds, the earth and the rest were deluged by the Ocean". (Srimad Bhagavatam, Book 8, Chapter 24, Shloka 4-9).

فَأَوْحَيْنَآ إِلَيْهِ أَنِ ٱصْنَعِ ٱلْفُلْكَ بِأَعْيُنِنَا
وَوَحْيِنَا فَإِذَا جَآءَ أَمْرُنَا وَفَارَ ٱلتَّنُّورُ فَٱسْلُكْ فِيهَا مِن
كُلٍّ زَوْجَيْنِ ٱثْنَيْنِ وَأَهْلَكَ إِلَّا مَن سَبَقَ عَلَيْهِ ٱلْقَوْلُ
مِنْهُمْ ۖ وَلَا تُخَٰطِبْنِى فِى ٱلَّذِينَ ظَلَمُوٓا۟ ۖ إِنَّهُم مُّغْرَقُونَ ﴿٢٧﴾

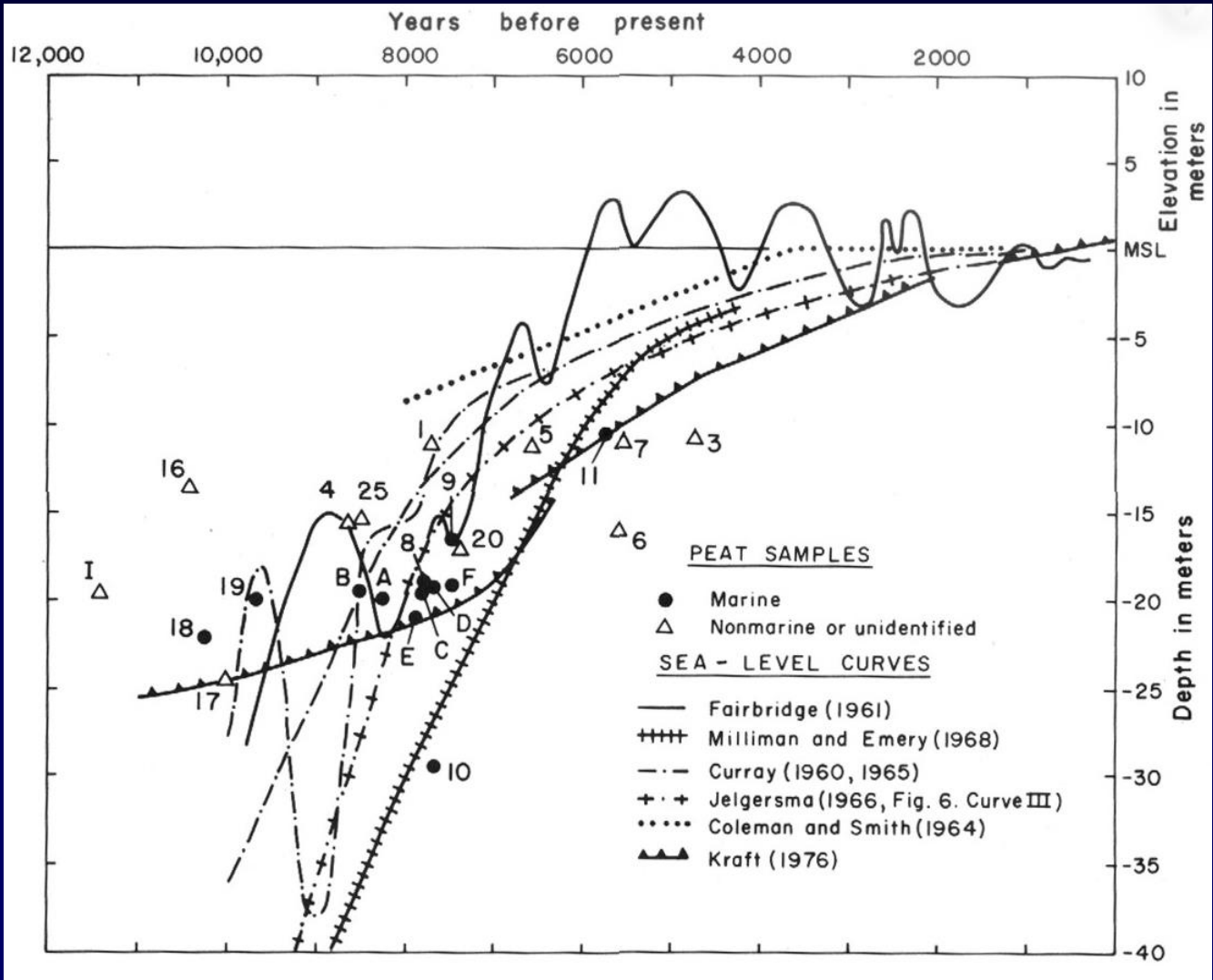
"So we inspired him (with this message) Construct The Ark within our right and under our guidance : then when comes our command and the fountains of the earth Gust forth, take thou on board pairs of every species, male and female and thy family".
(S xx 111, 27)

Then the Lord said to Noah, "Come into the ark …For after seven more days I will cause it to rain on the earth forty days and forty nights, and I will destroy from the face of the earth all living things that I have made." (Bible Chapter Genesis, 7)

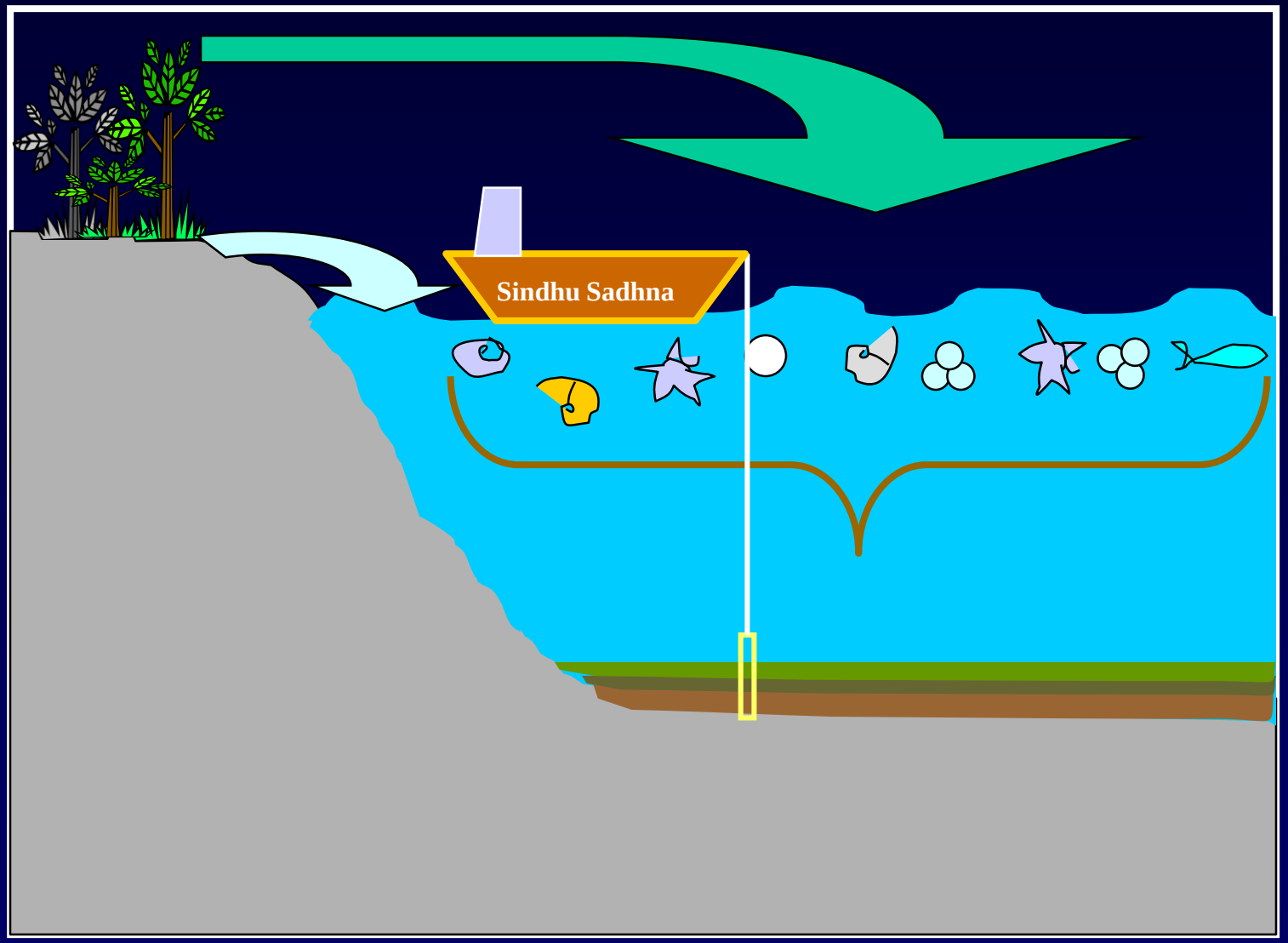
Past records [in Geology]



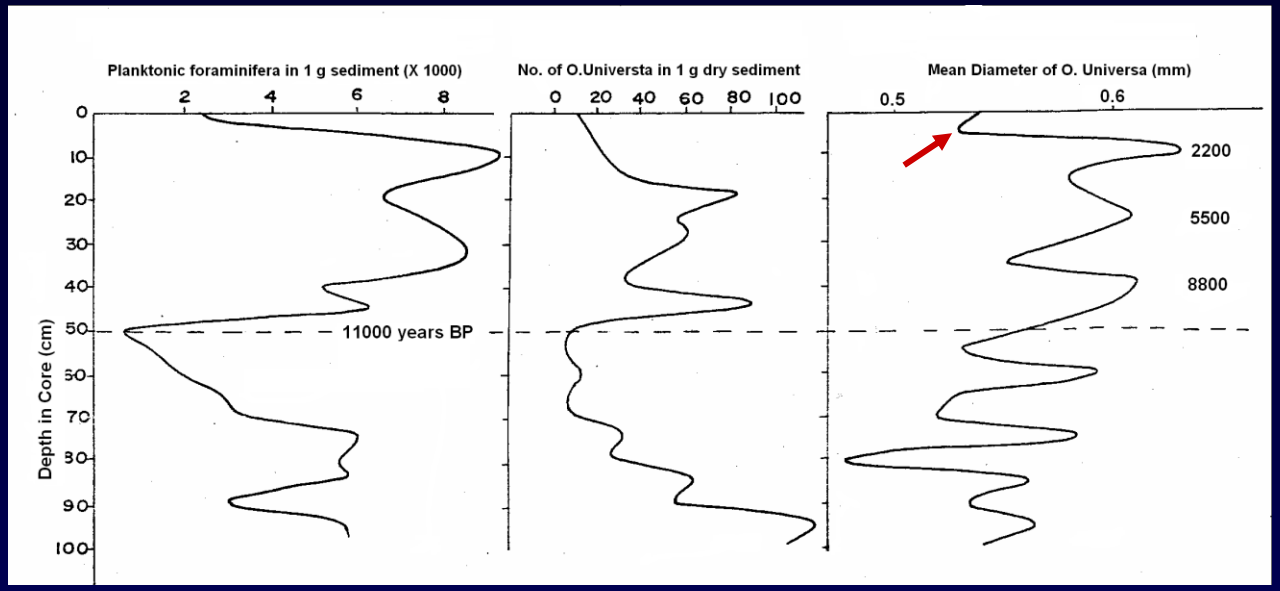
Past records [in Oceanography]

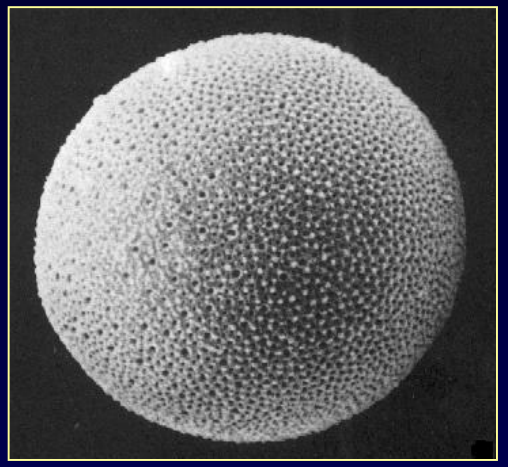


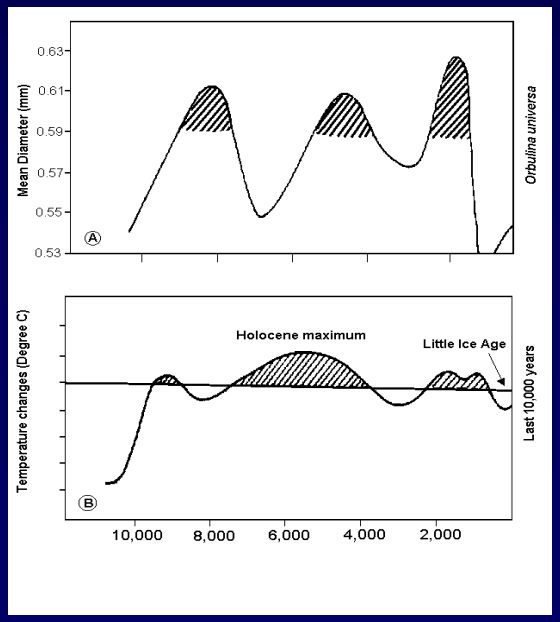
Past Climate: From where?

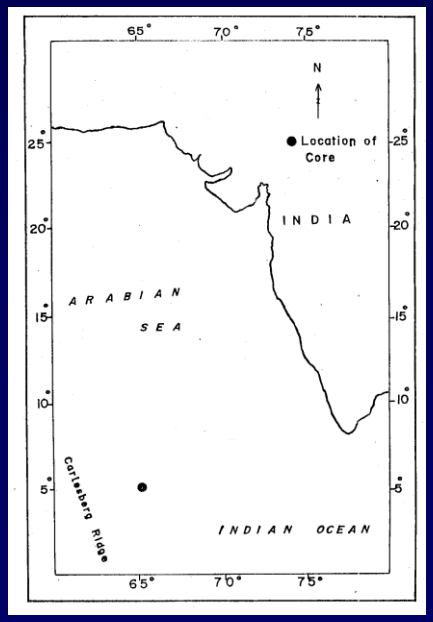


Paleo Sea Levels









Morphology of species

Mean diameter of *Orbulina universa* is

(i) directly proportional to temperature

(ii) inversely proportional to salinity and density

(Coughan and Neyenzi, 1991)

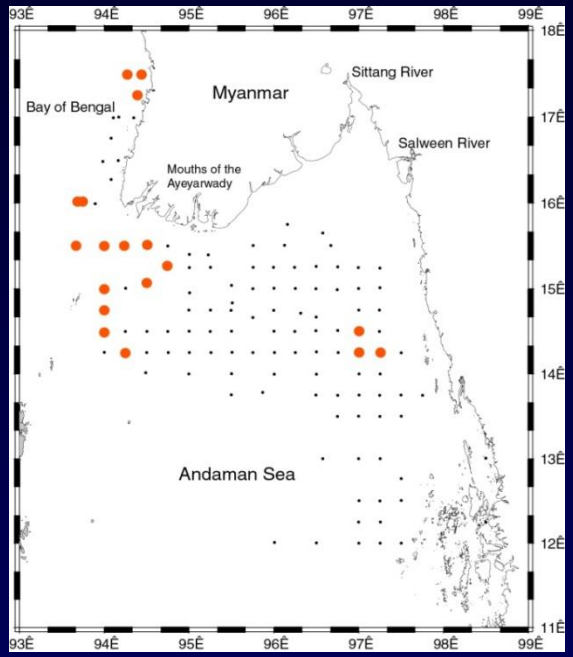
Evidences for sea level higher than today

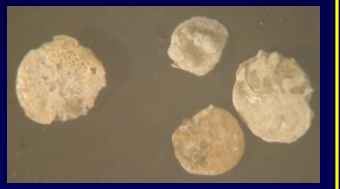
Erosional features

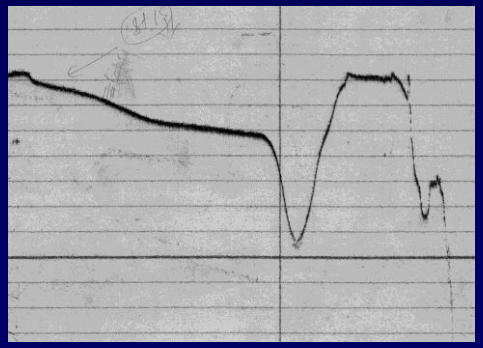
Depositional features

NIO

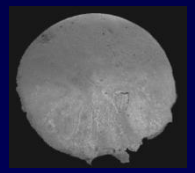
Evidences for sea level lower than today

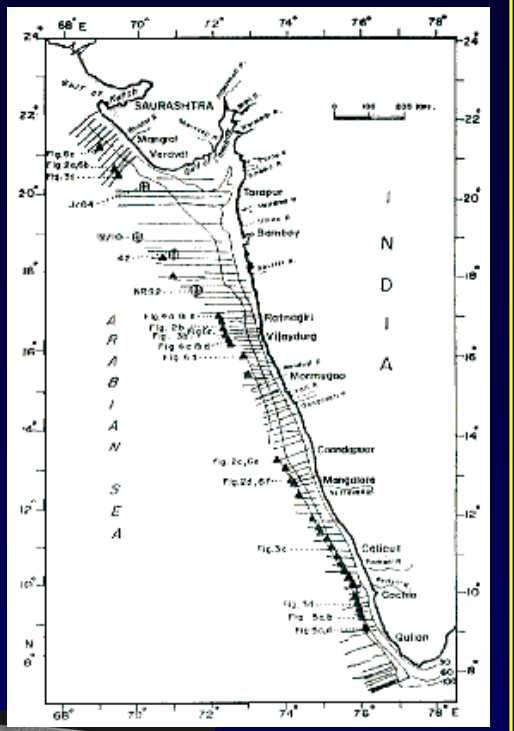


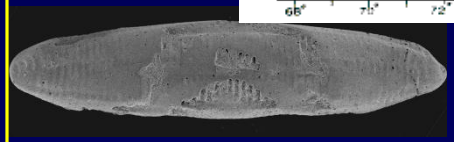


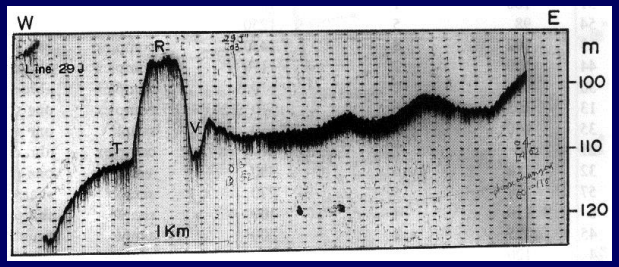


Myanmar

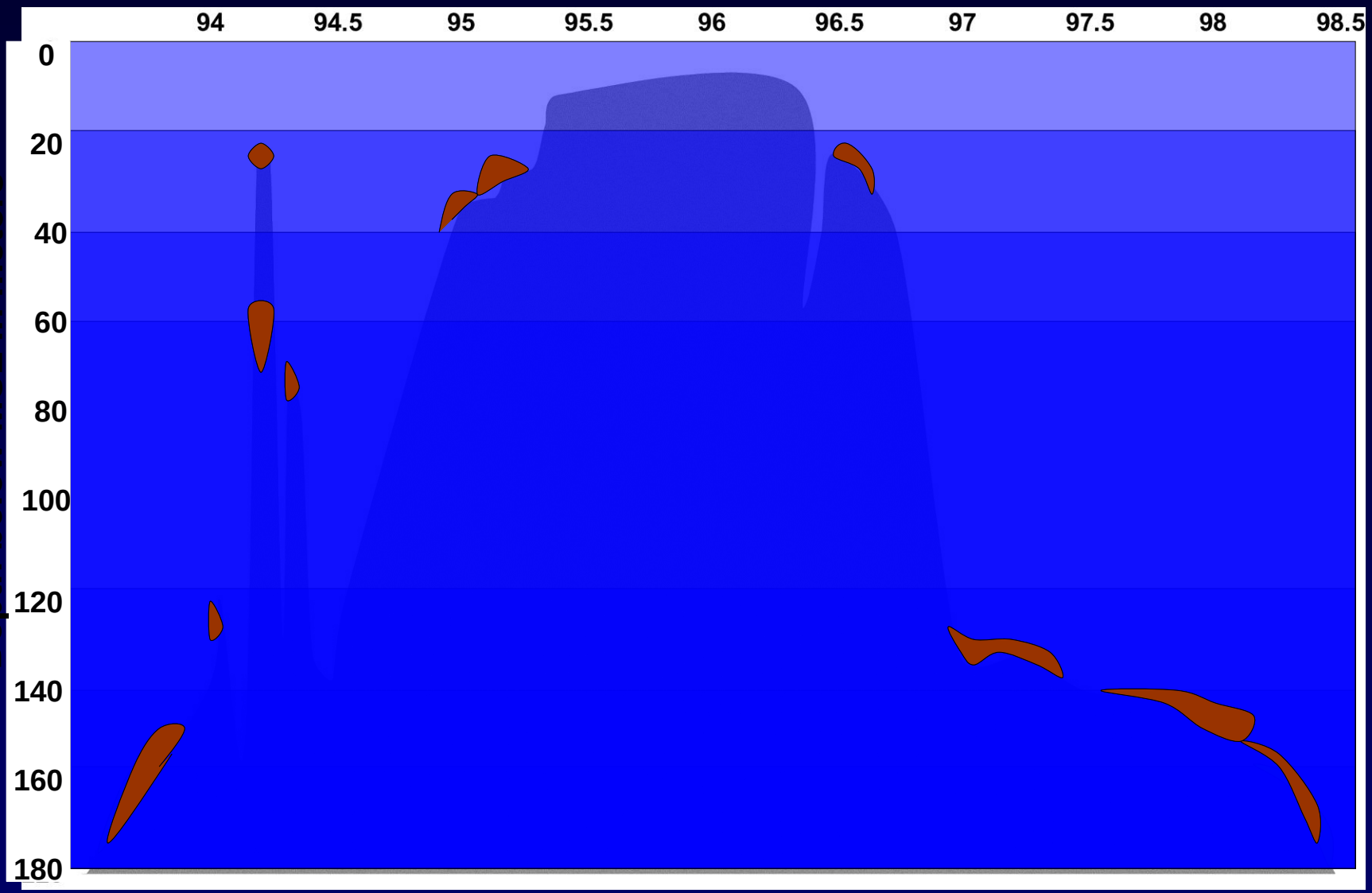








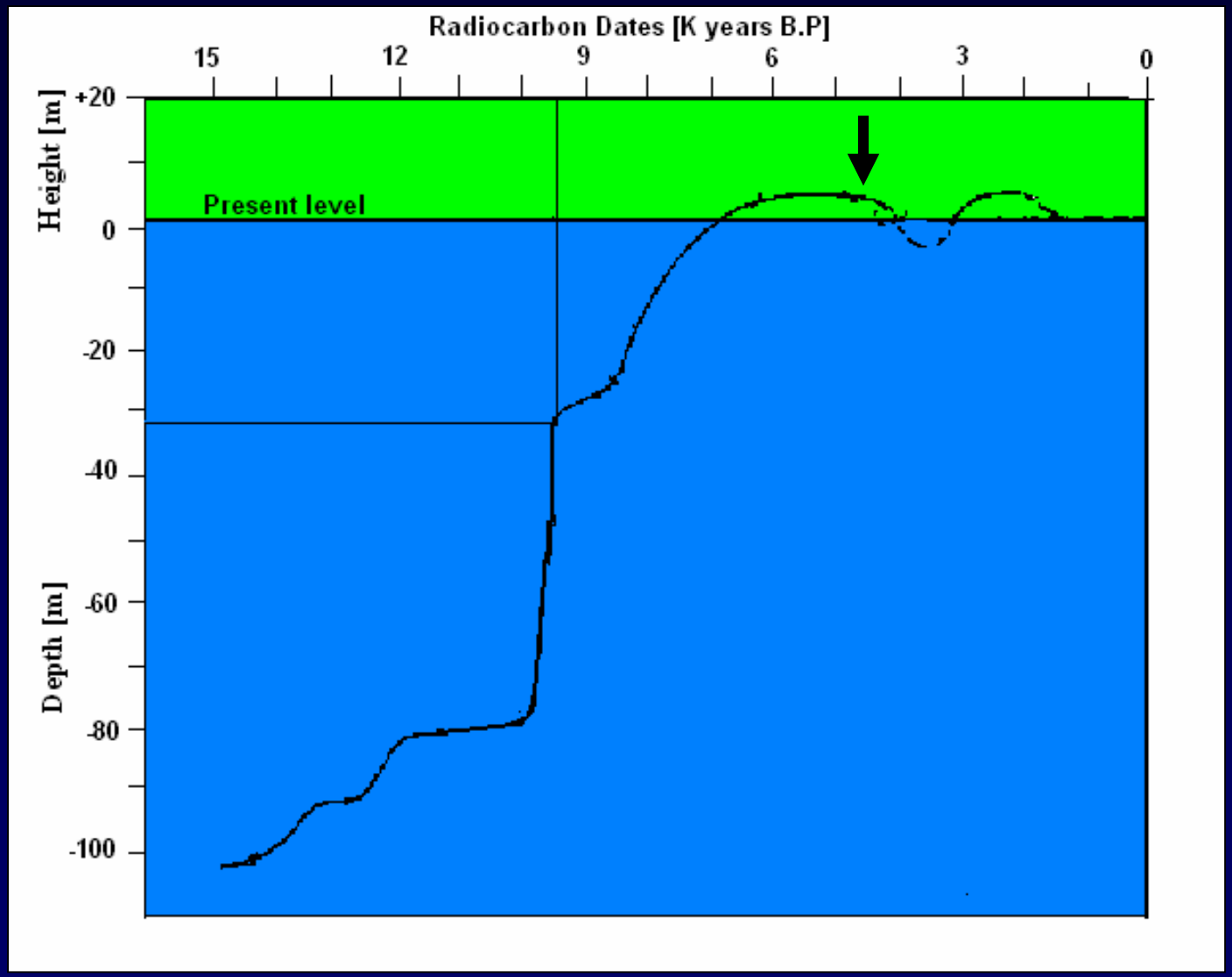
West coast of India



Conceptual Model

NIO

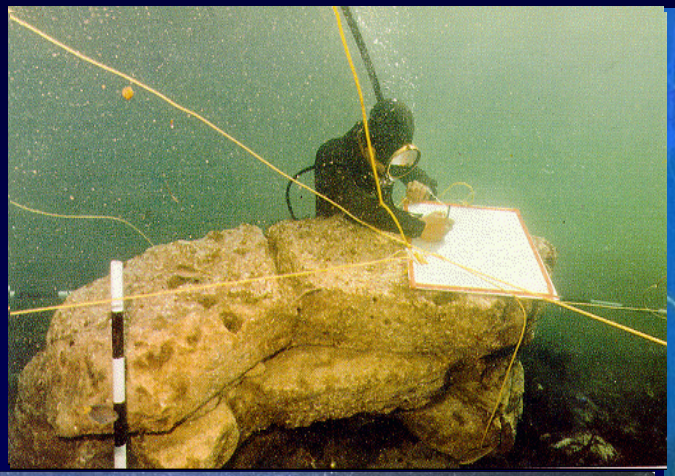
Lothal and Holocene Sea Level Curve

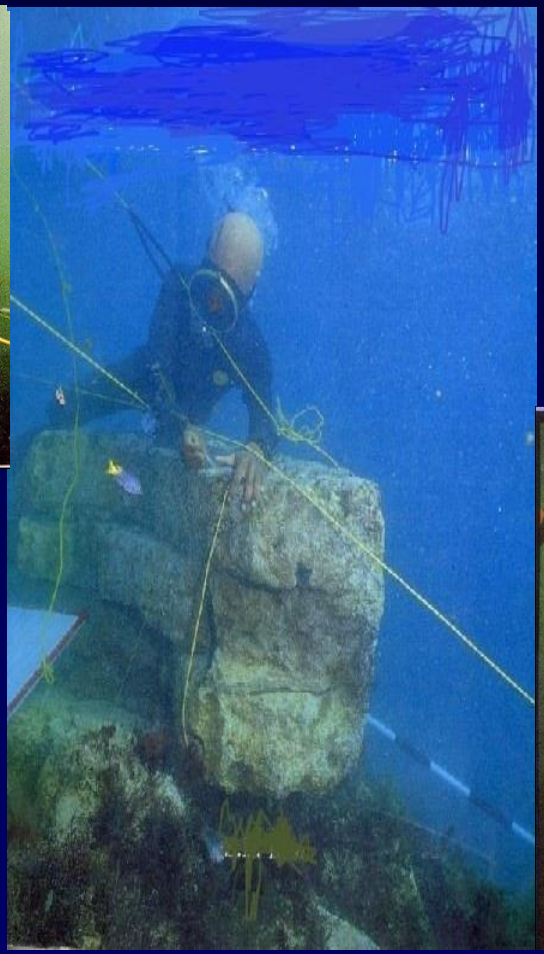


NIO

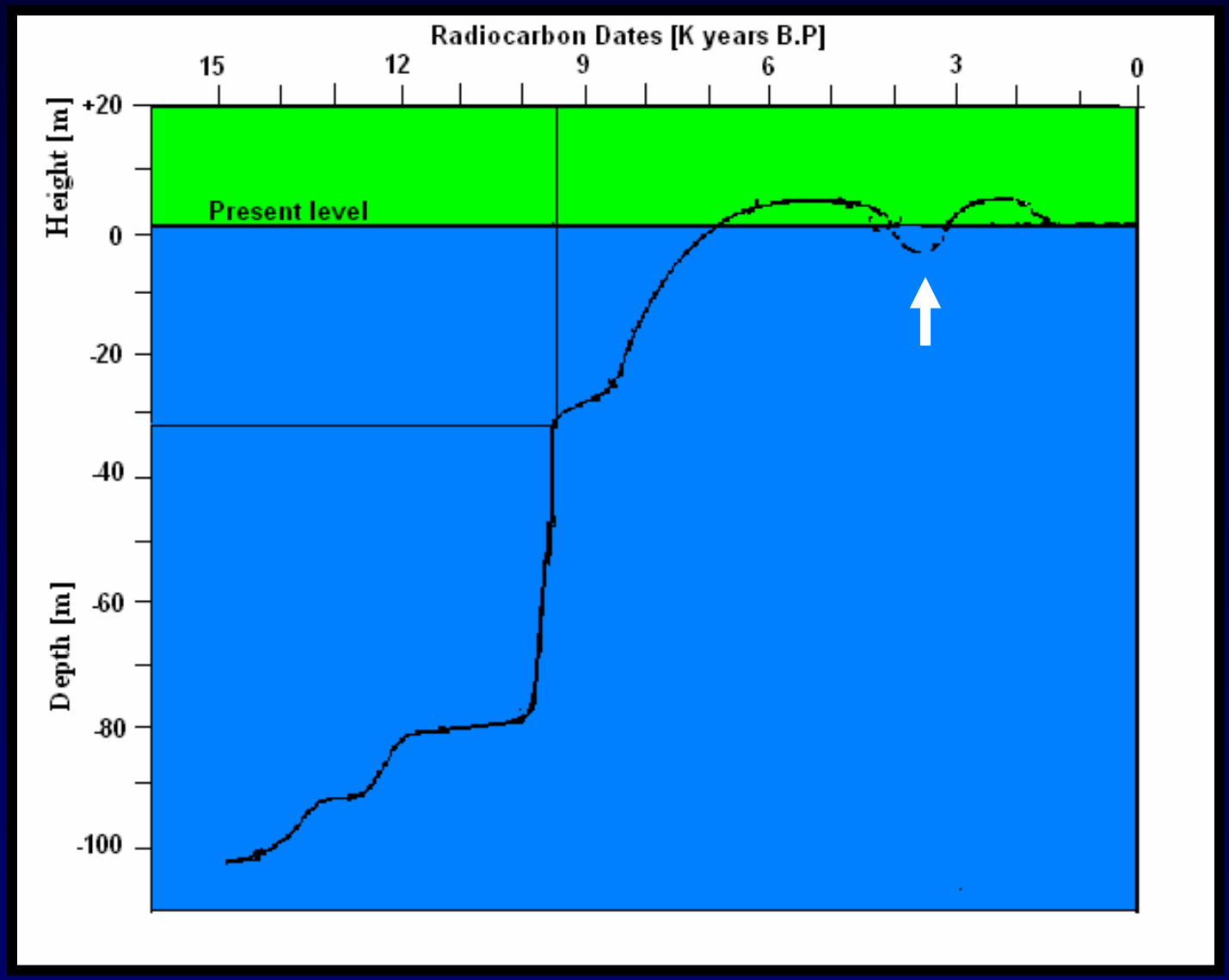
Marine Archaeological explorations at Dwarka

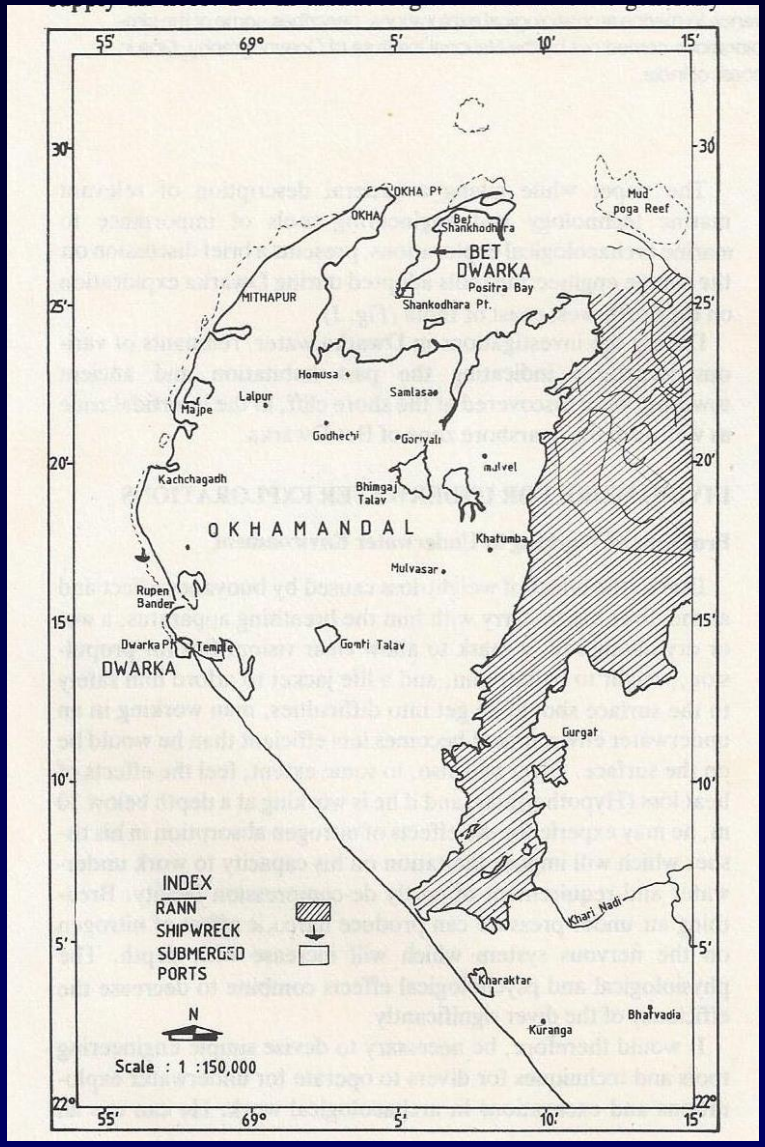
DWARKA: Underwater Stone structure





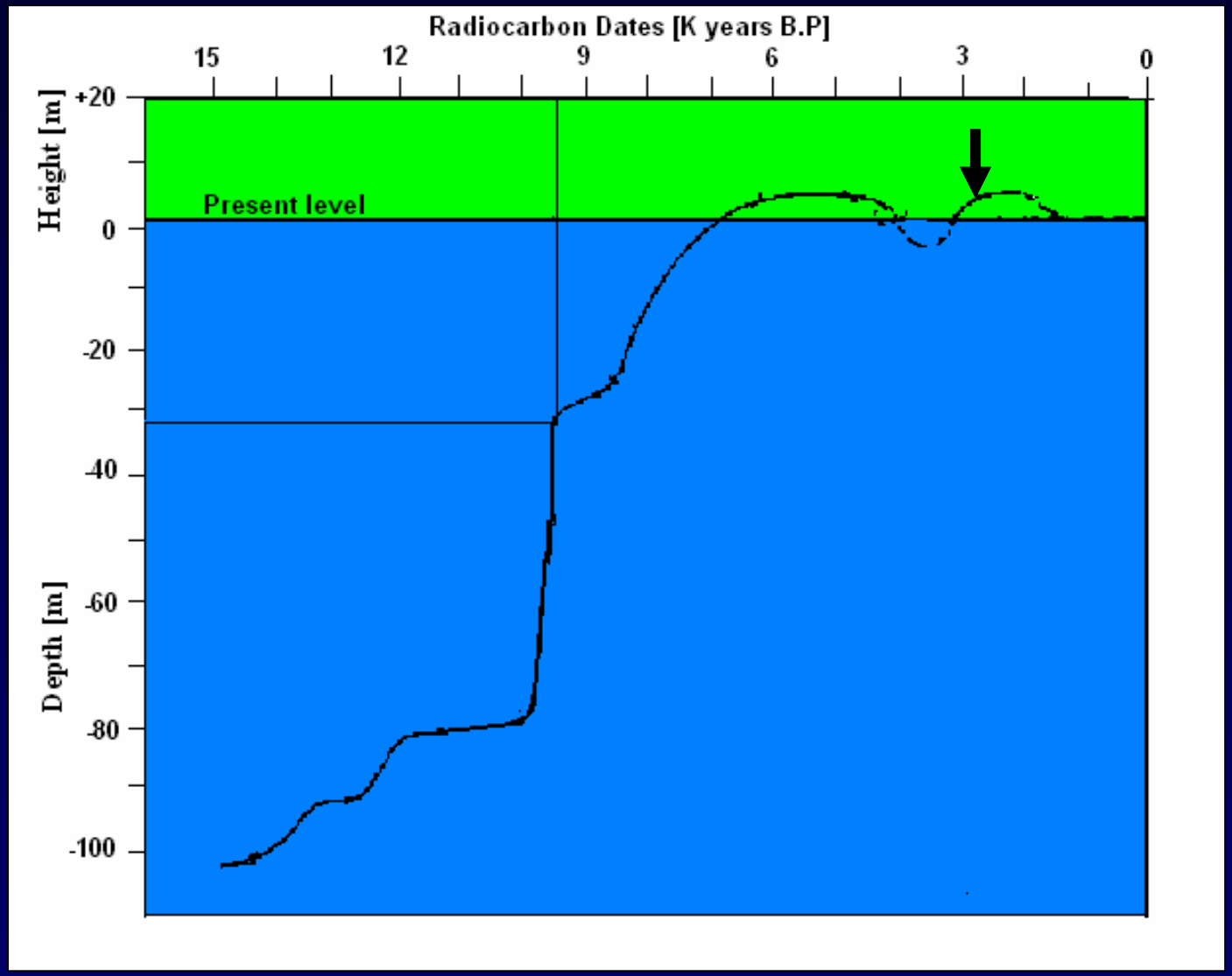
Dwarka and Holocene Sea Level Curve

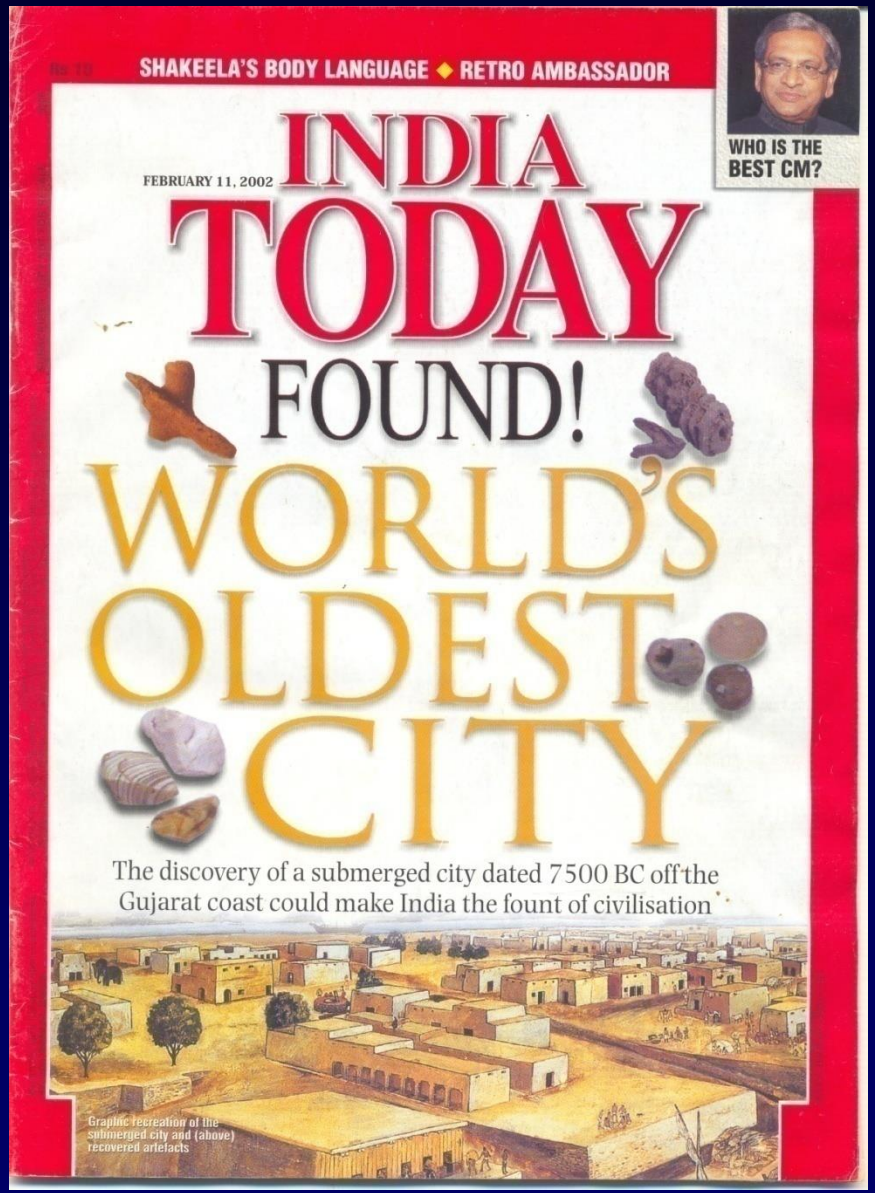



55'
69°
5'
10'
15'
30'
25'
20'
15'
10'
5'
22°
OKHA Pt
OKHA
Bet Shankhodhara
BET DWARKA
Positra Bay
Shankodhara Pt.
Mud poga Reef
MITHAPUR
Homusa
Samlasar
Lalpur
Majpe
Godhechi
Goriyali
Kachchagadh
Bhimgaj Talav
mulvel
OKHAMANDAL
Khatumba
Mulvasar
Rupen Bander
Dwarka Pt
Temple
Gomti Talav
DWARKA
Gurgat
INDEX
RANN
SHIPWRECK
SUBMERGED
PORTS
N
Khari Nadi
Kharaktar
Kuranga
Bhatvadia
Scale : 1 :150,000

Bet Dwarka

Bet Dwarka and Holocene Sea Level Curve



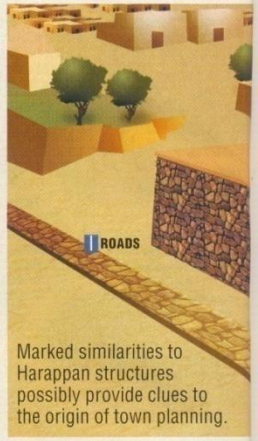


ARCHAEOLOGY

COVER STORY

LIFE IN CAMBAY CITY

FIRST CITY: Scientists found evidence of a citadel area and a 173-m-long granary apart from other mammoth structures stretching for as long as 9 km down an ancient river bed. There were signs that Cambay citizens had constructed a check dam across the river to harness water.



Marked similarities to Harappan structures possibly provide clues to the origin of town planning.

the diffusion theory of civilisation that proposes urbanisation spread from West Asia to the Indus and thence downwards to India.

CAMBAY could mean that the early Indians were not copycats and that civilisation arose in the subcontinent as an organic process that stemmed from the genius of its own people. Yet, as Lahiri points out, there are many interesting questions that still need to be answered: where, for instance, did the people of Cambay come from? Were they natives or did they come by sea from West Asia? When did they transit from hunter gatherers to agriculture and a mature urban settlement?

Jagat Pati Joshi, former director-general of the Archaeological Survey of India (ASI), thinks the answers to such questions could "provide the missing links" that historians have been searching fruitlessly for years. Historians have little evidence to show how a predominantly farming community in the Indian subcontinent took that giant leap forward in imagination and built some of the most well-designed cities in the world during the Indus period. Says Joshi: "Cambay opens for us the horizon of early settlements in the Neolithic Age in India that were hitherto known to exist only in West Asia which may have powered the phenomenal transformation."

For archaeologists the word certainty is an oxymoron. The origin of the glass bangle was initially believed to have been the result of Indo-Roman contacts in the 1st century A.D. Then bangles were found among the painted greyware of Hastinapur dating 7 B.C. The ornament's antiquity and origin was pushed further back when they were more recently found in Harappan settlements of 2000 B.C. As S.P. Gupta, chairman of the Indian Archaeological Society, says, "Nothing is static. Dates are constantly being revised by newer findings. The discovery of the Harappan site of Dholavira in Gujarat, for instance, pushed all our dates back by 1,000 years."

NIOT's findings has triggered tremendous interest and controversy among leading historians across the world. Harvard University historian Richard Meadow, an expert on South Asian archaeology, believes that a neolithic site in Cambay would "be very much in line" with developments in Mehrgarh and in West Asia during that period. But he thinks it is improper to take "wild guesses" as to whether it was the earliest known city and wants a well integrated research project to validate the findings. Says Meadow: "The discovery is

THE WORLD IN 7500 B.C.

The contemporaries of the Cambay dwellers were hunters, learning the art of cultivation

INDIA

Most relics of this period, like the one in Bhimbetka in Madhya Pradesh, indicate a primitive life.

PRITHVIPAL SINGH

AMERICA

Before the advent of the Olmecs 1200 B.C., the Mesoamerican people were villagers using simple tools.

CHINESE

Neolithic Chinese sites have yielded stone arrowheads and fish hooks. The silk fabrics and the decorated pottery indicate a well-developed sense of design

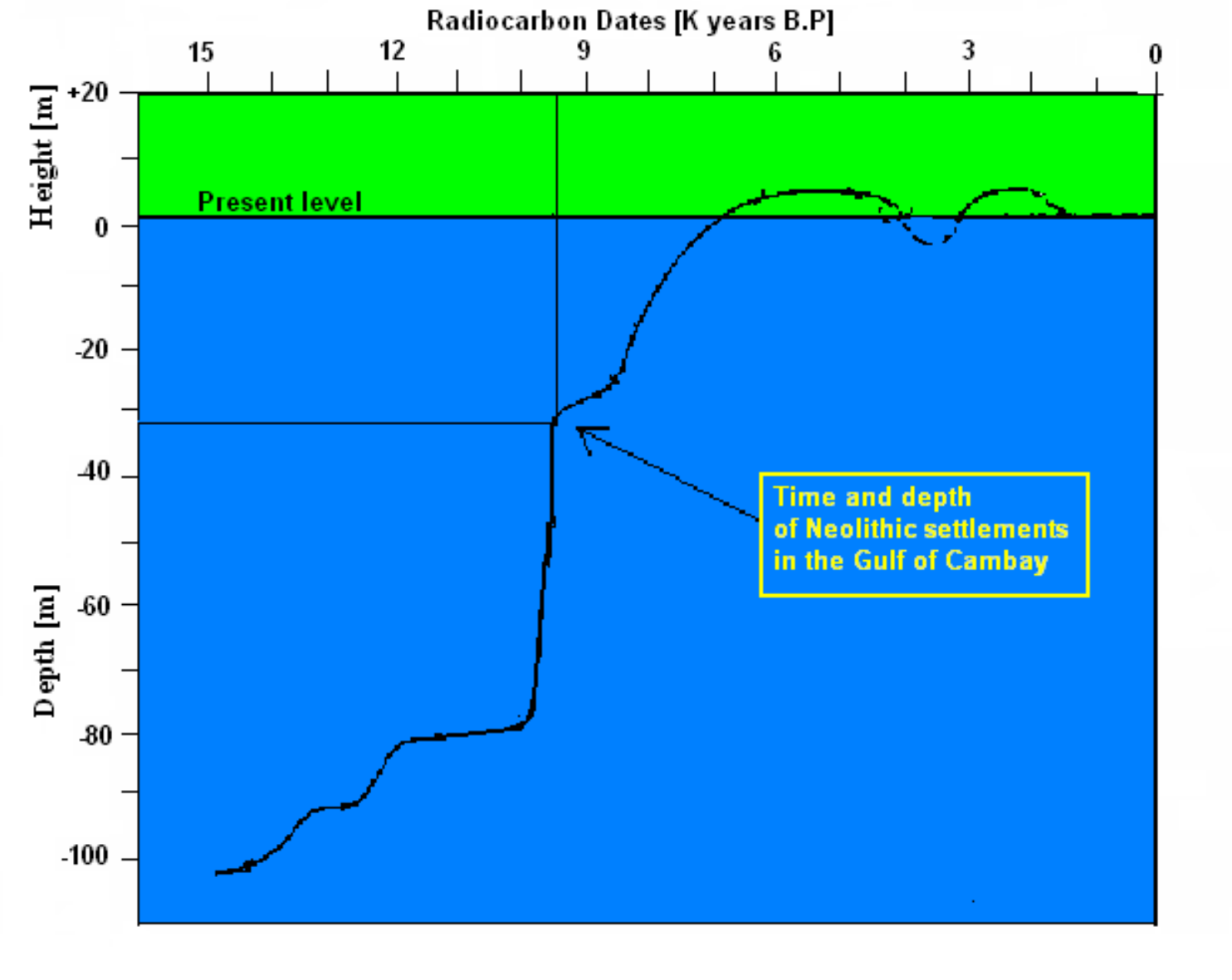
A BRIEF HISTORY OF TIME

20000 B.C. **PALEOLITHIC AGE** — **The Stone Age man led a nomadic life and survived by hunting and food gathering.**

8000 B.C. **NEOLITHIC AGE** — **Cultivation began but only stone was used for tools and weapons.**

4000 B.C. **COPPER AGE** — **With the discovery of metal, innovations began and so did agrarian townships.**

Neolithic settlement and Holocene Sea Level Curve



NIO

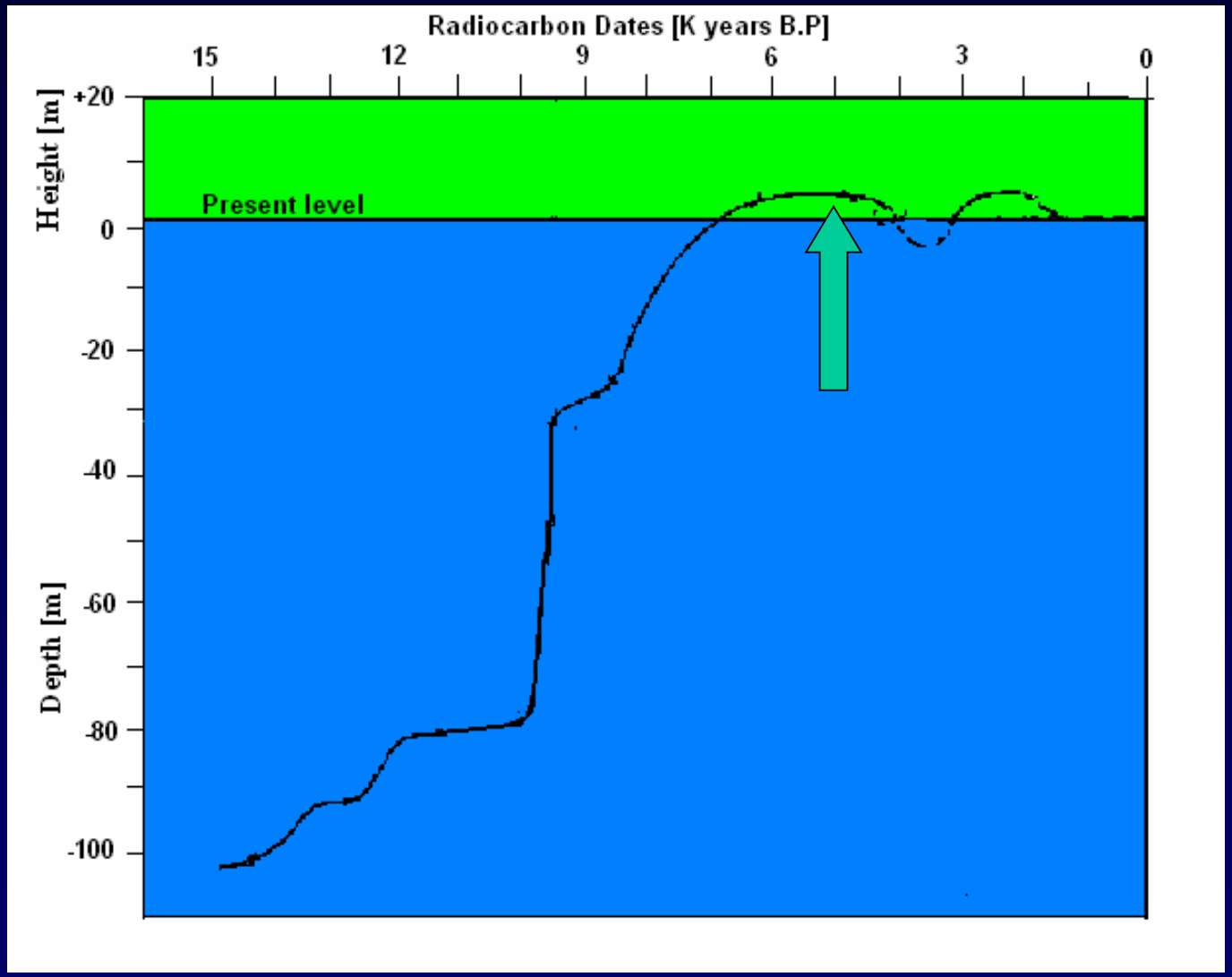
Location of Dholavira

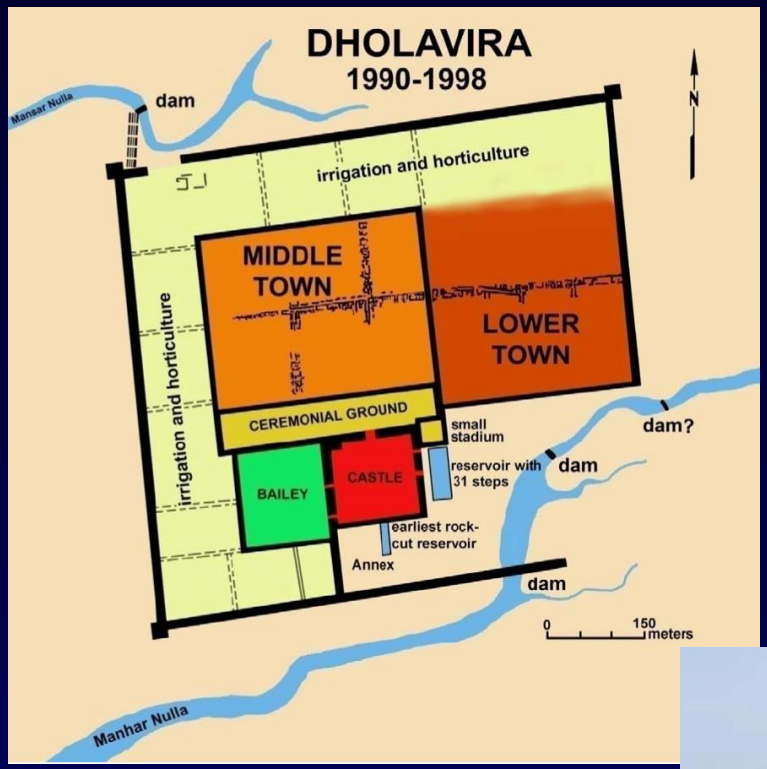
Proposed map of Rann of Kutch during 3rd millennium BC.

Dholavira

The famous water reservoir at Dholavira constructed about 5000 years back

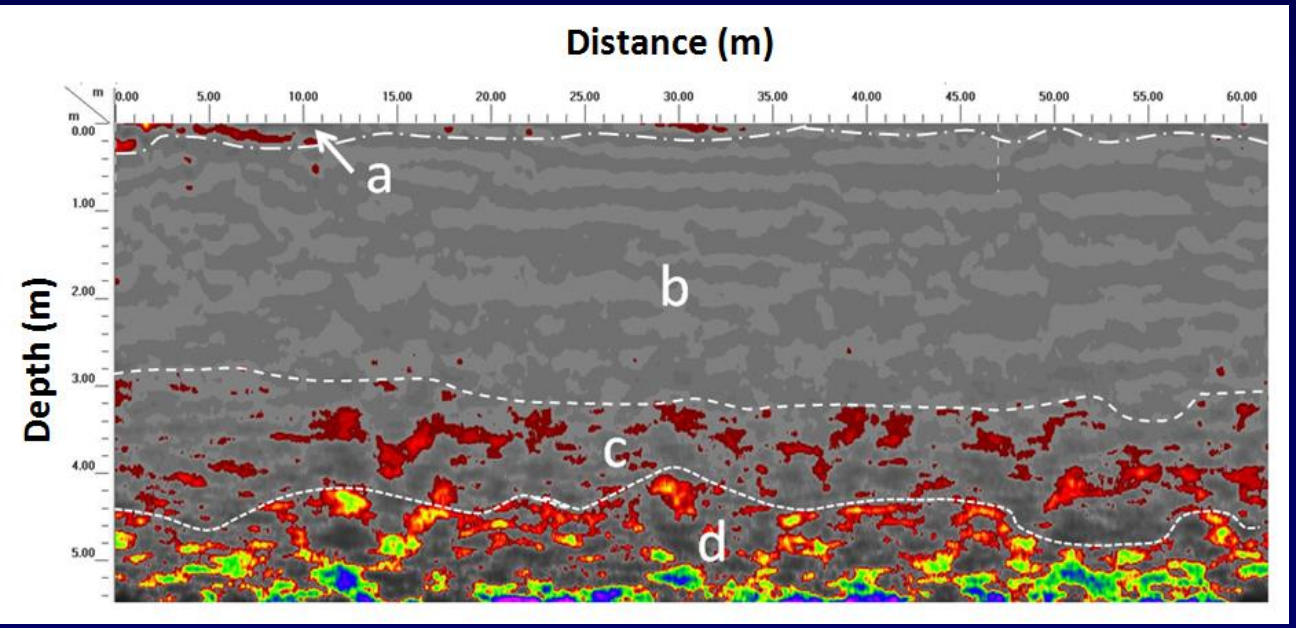
Dholaveera and Holocene Sea Level Curve

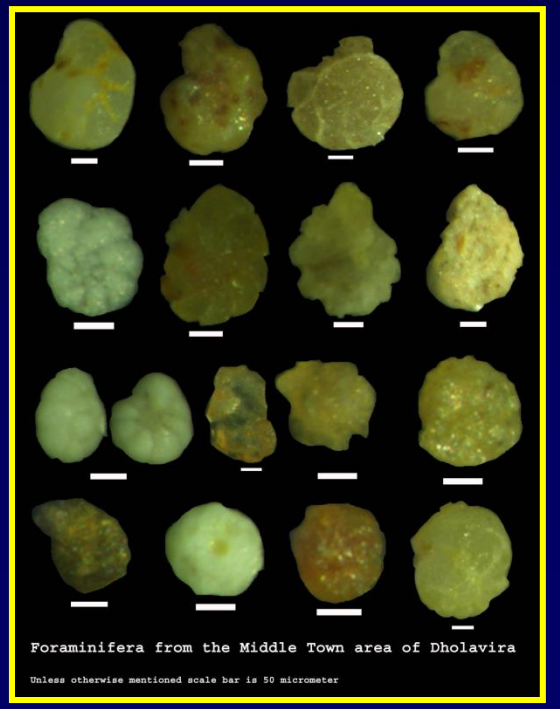




- J.P. Joshi - Discovered the site in 1967-68.
- R.S. Bisht - Excavation from 1989-90 to 2004-05. Excavation report came in 2015.
- Nigam et. al., 2016 - interpretation of walls which was not discussed in Bisht 2015

Site plan of Dholavira showing prominent divisions (Bisht 2015)


Distance (m)
Depth (m)
m
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
45.00
50.00
55.00
60.00
1.00
2.00
3.00
4.00
5.00
a
b
c
d


Foraminifera from the Middle Town area of Dholavira
Unless otherwise mentioned scale bar is 50 micrometer

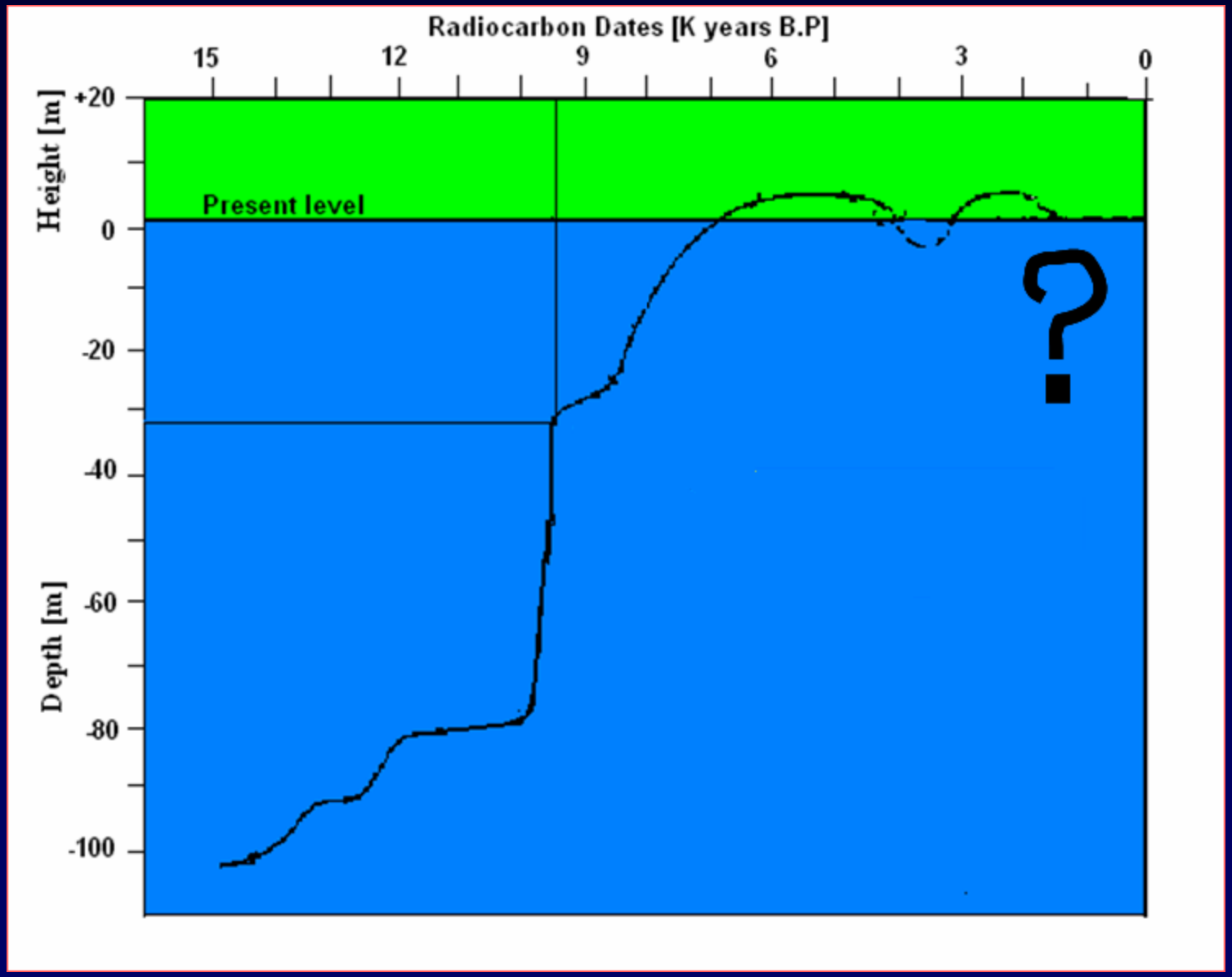
Gopakapattan

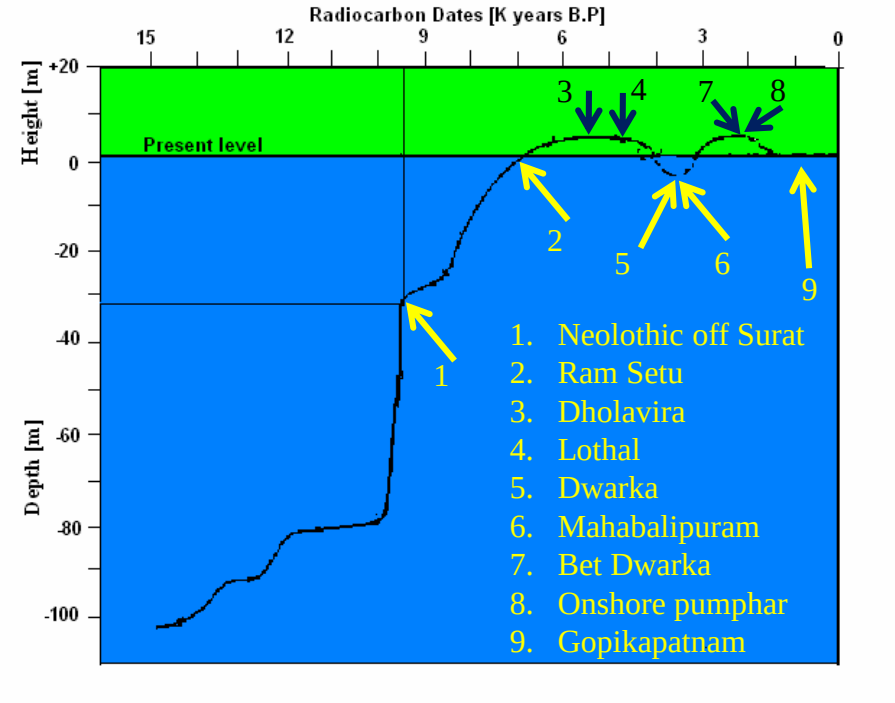
Ancient port of Gopakapattan of Kadamba period (10th – 13th century AD), is situated in the estuary of Zuari between present village of Aggasim and Pillar. Massive laterite brick structures have been observed running parallel to the coast for over a km. An attempt has been made to collect sample for OSL dating of these structures as we do not have any other supporting evidence to date these structures.


JCB


JCB

Gopakapattan and Holocene Sea Level Curve





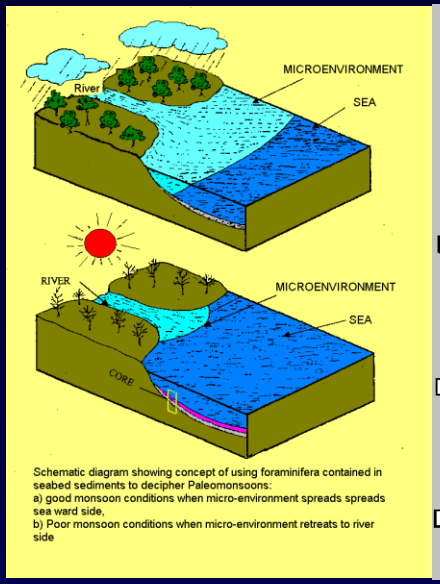
One who is proud of his/ her rich cultural heritage, always works hard to maintain the high level of civilization and tries to enhance the living standard of fellow citizens

CONCLUSION

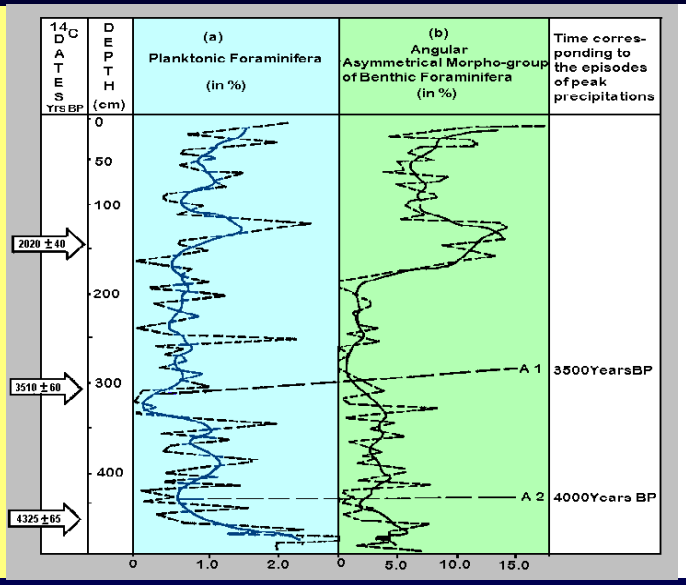
The above studies suggest a need for more efforts to compile historic / archaeological records of climatic changes on the one hand and reconstruction of Sea level fluctuations on the other hand. The coherent understanding of climate variability will help to develop better understanding of archaeology and futuristic climatic models. Foraminifera is an excellent tool for these studies.

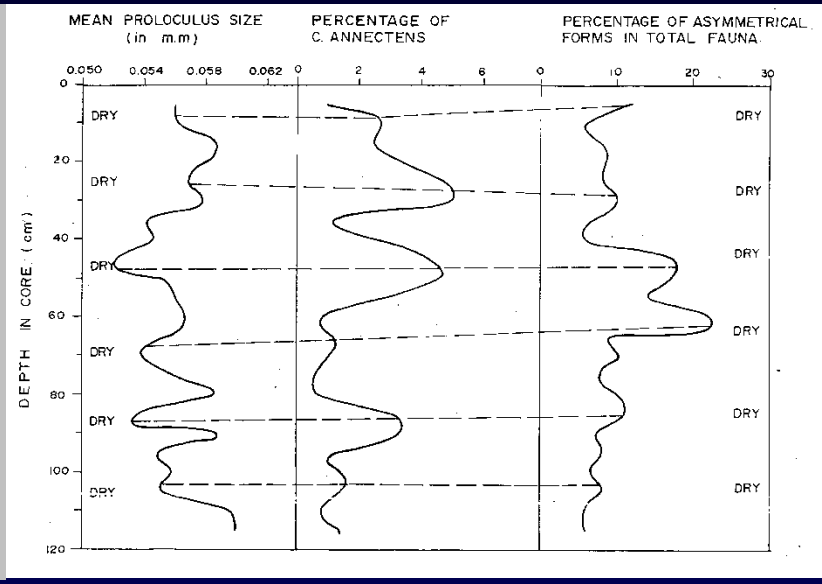

Thankyou

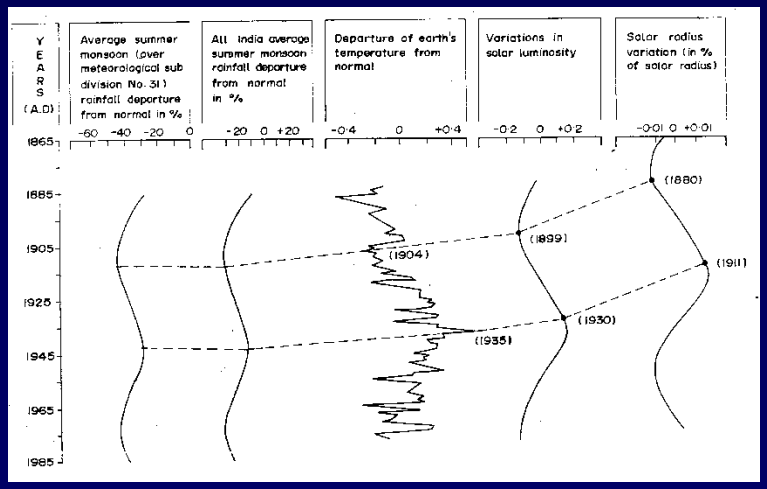
PALEO MONSOONS

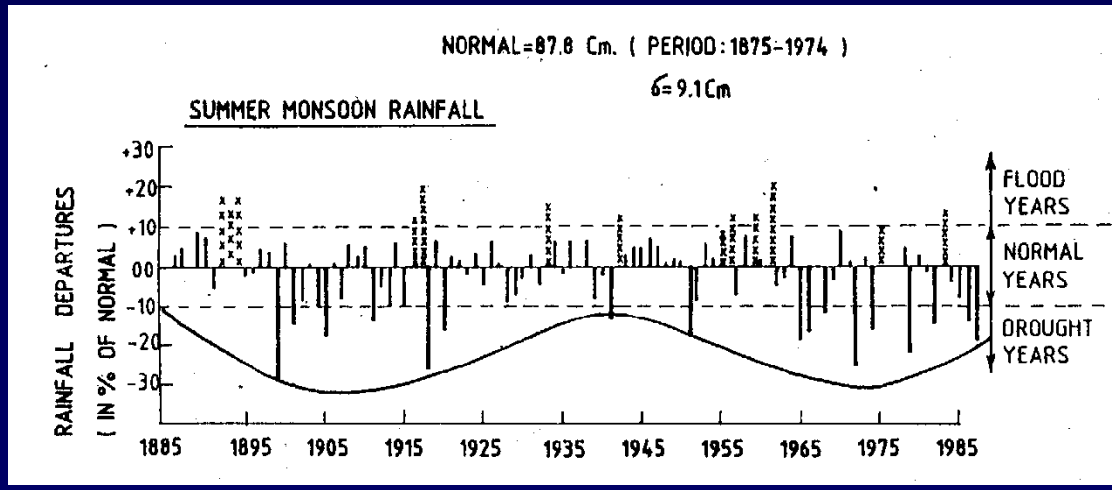


Schematic diagram showing concept of using foraminifera contained in seabed sediments to decipher Paleomonsoons:
a) good monsoon conditions when micro-environment spreads spreads sea ward side,
b) Poor monsoon conditions when micro-environment retreats to river side







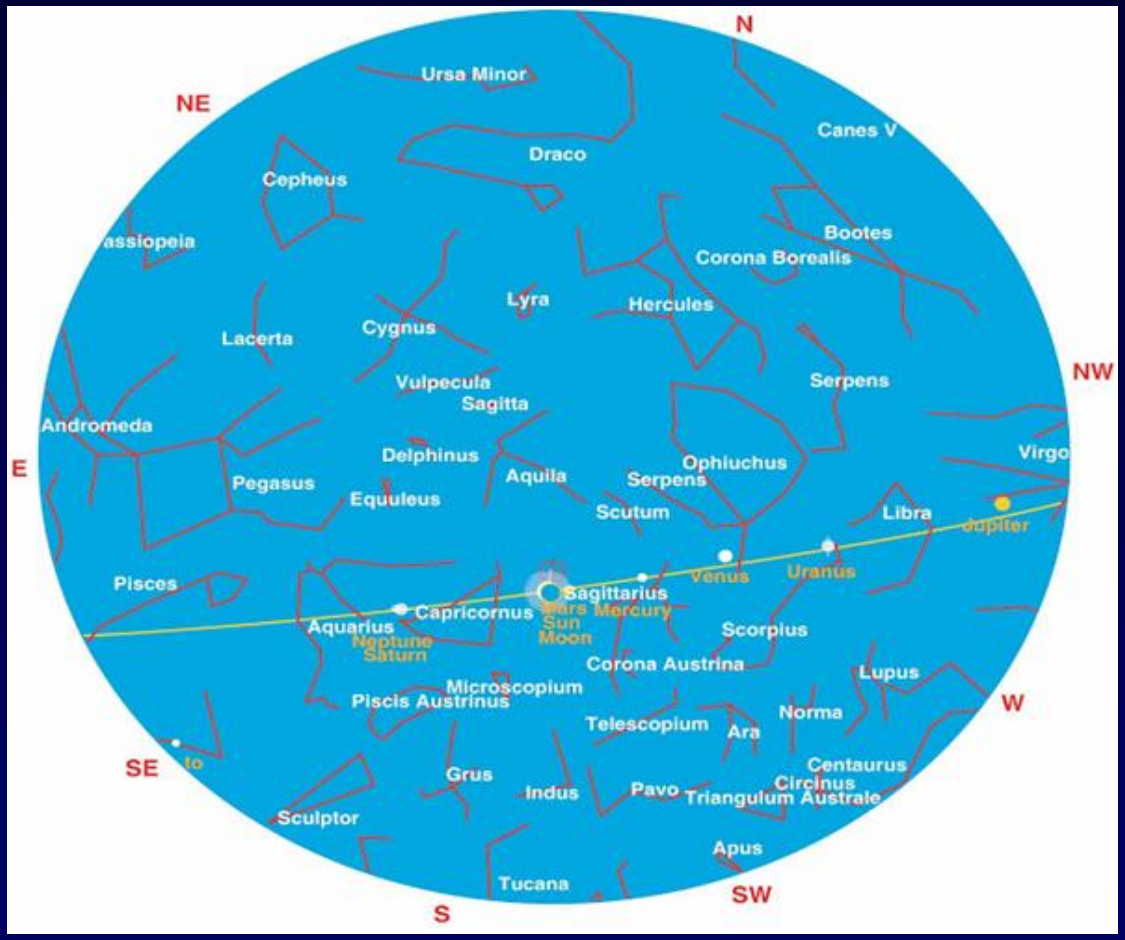


Ram setu

East Coast of India

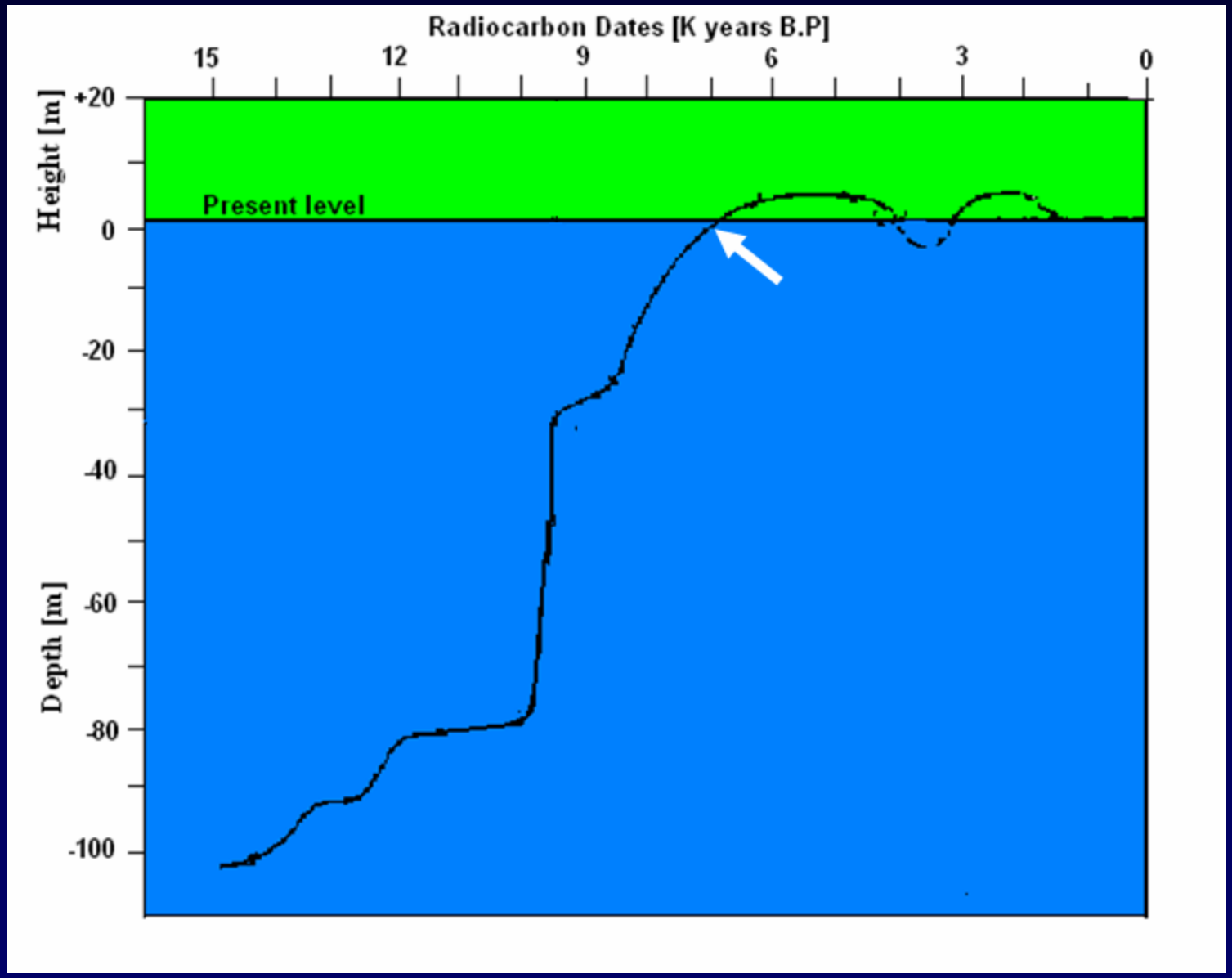
A big controversy

Saroj Bala and Kulbhushan Mishra, 2012, Institute of Scientific Research on Vedas



Astronomical dates of sky views depicted by Aadi Kavi Valmiki at the time of important events in Lord Ram's life match sequentially around 5100 BC.

Ram Setu and Holocene Sea Level Curve



Pride of Tamilnadu

Mahabalipuram

The traditional folk on submergence of Mahabalipuram was recorded by the European Travelers in 17th –18th century AD

There is no mention of submergence of Mahabalipuram in any Indian Literature unlike other ancient coastal towns.

Mahabalipuram

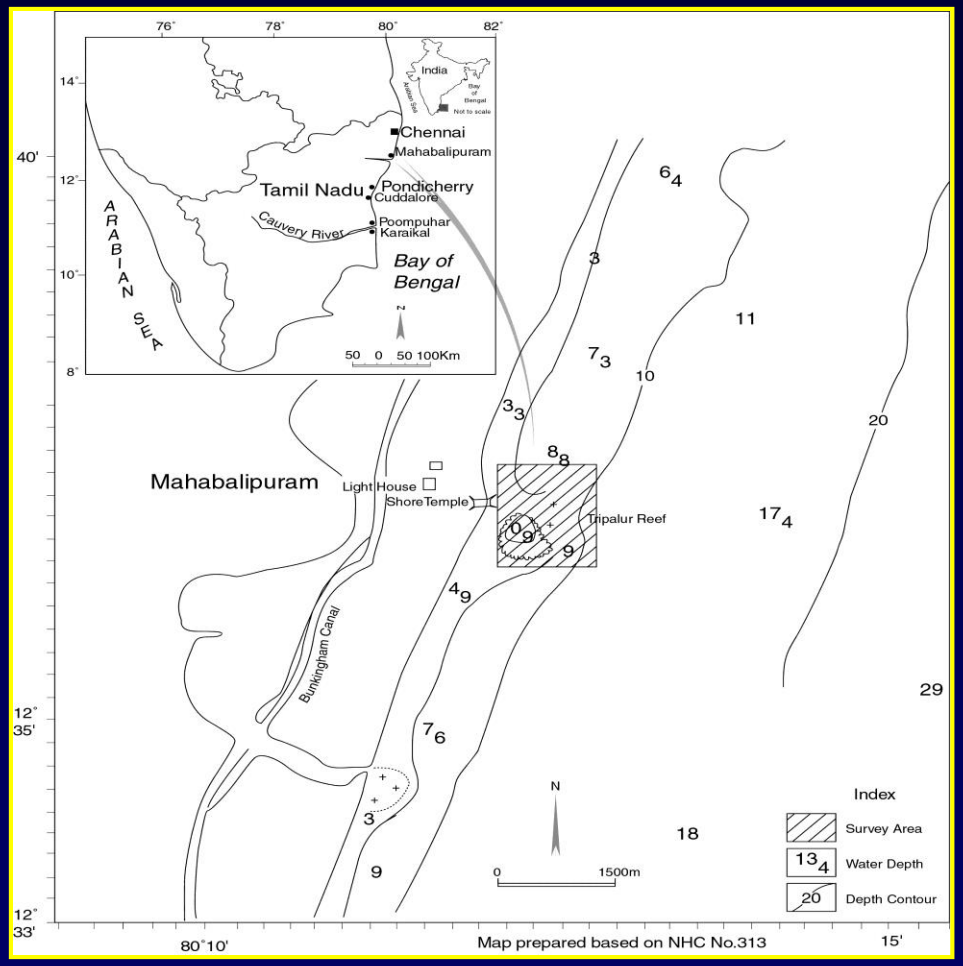
SaluvanKuppam

Explorations around Mahabalipuram

GPR survey to locate structures buried in north of the temple

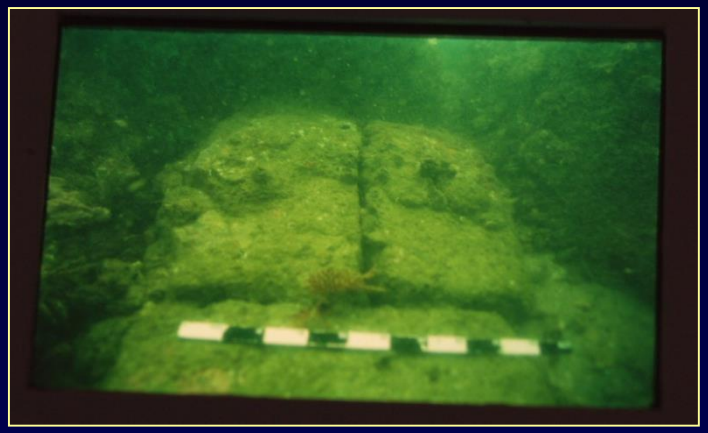
GPR survey to locate structures buried in south of the temple

There is no mention of submergence of Mahabalipuram in any Indian Literature unlike other ancient coastal towns.

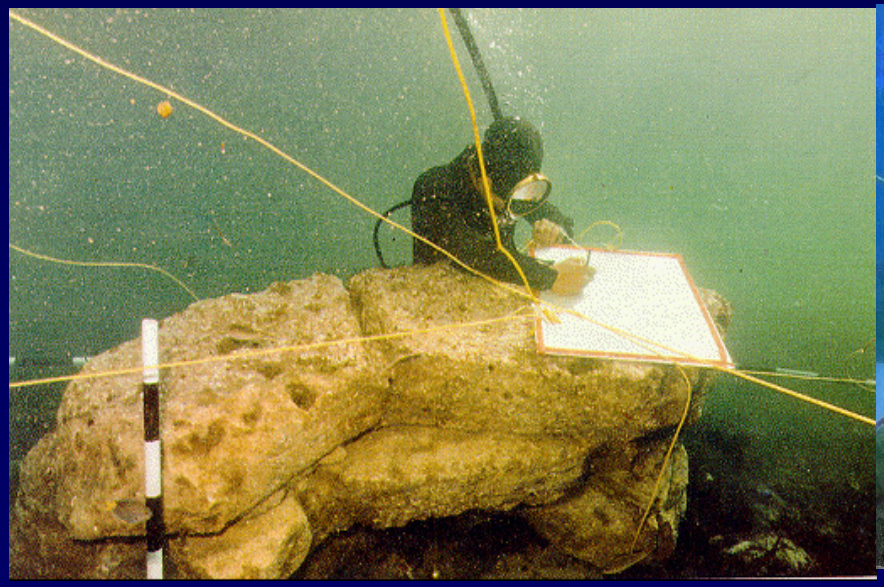


Underwater explorations off Mahabalipuram

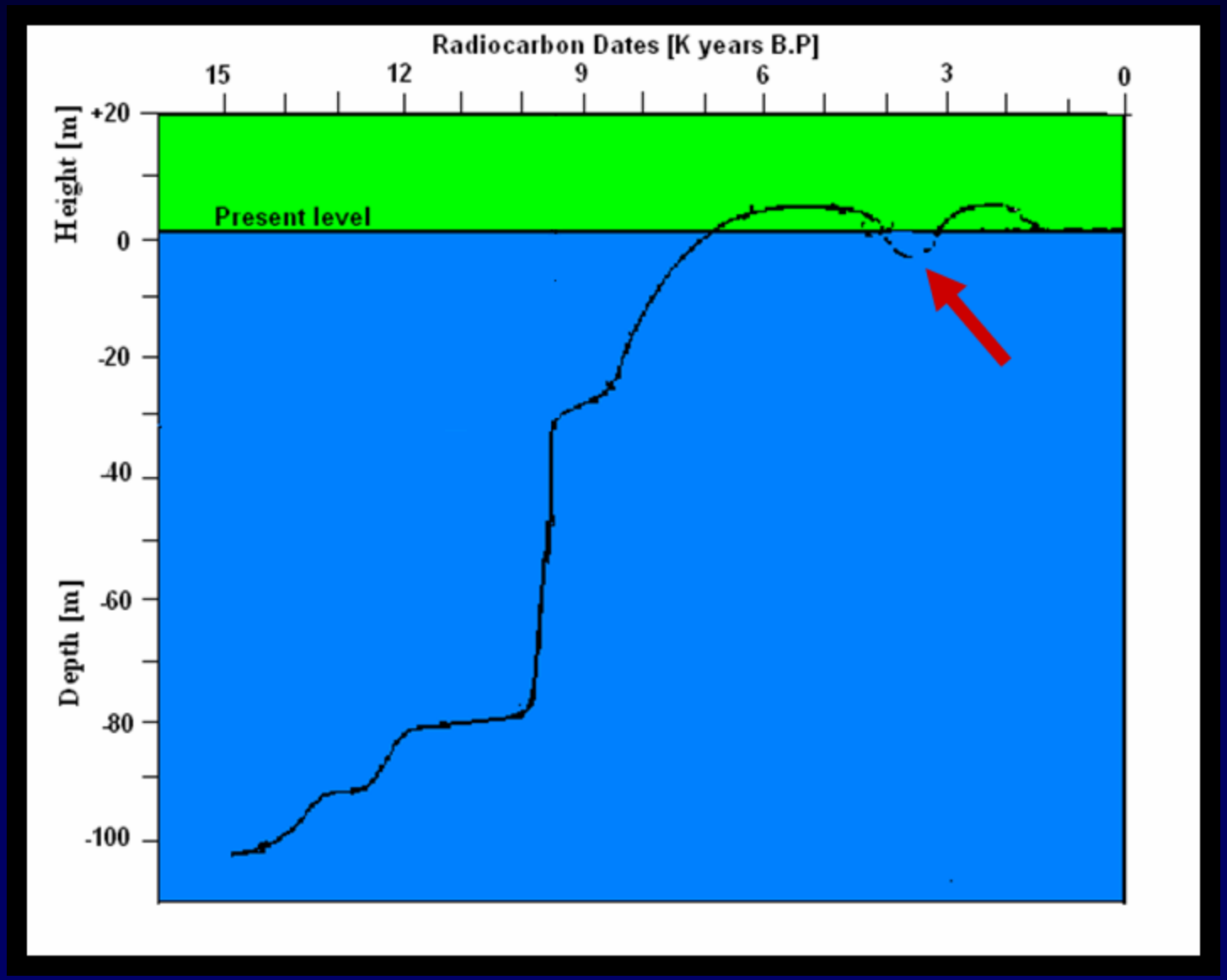
Underwater explorations off Mahabalipuram



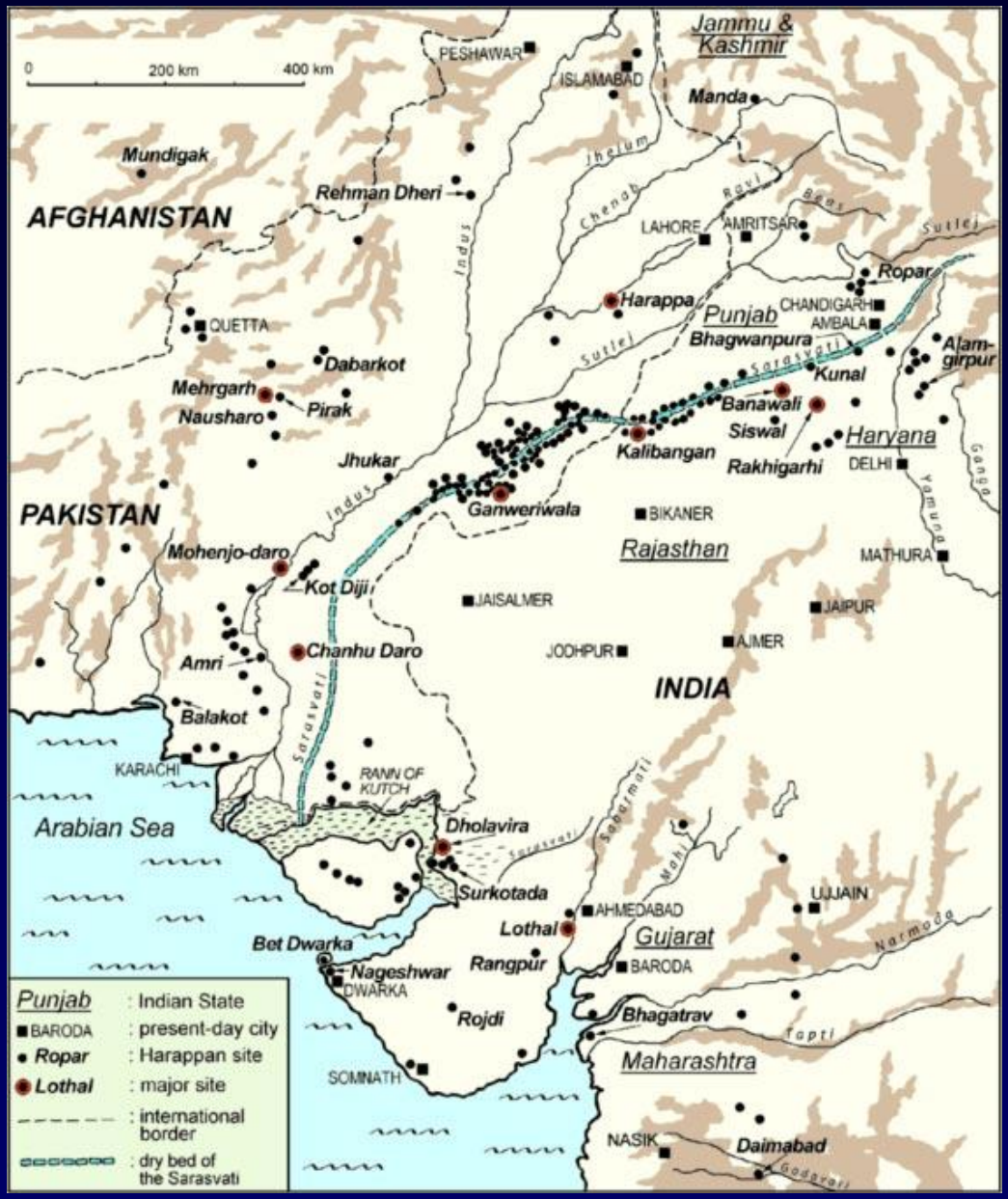
DWARKA: Underwater Stone structure

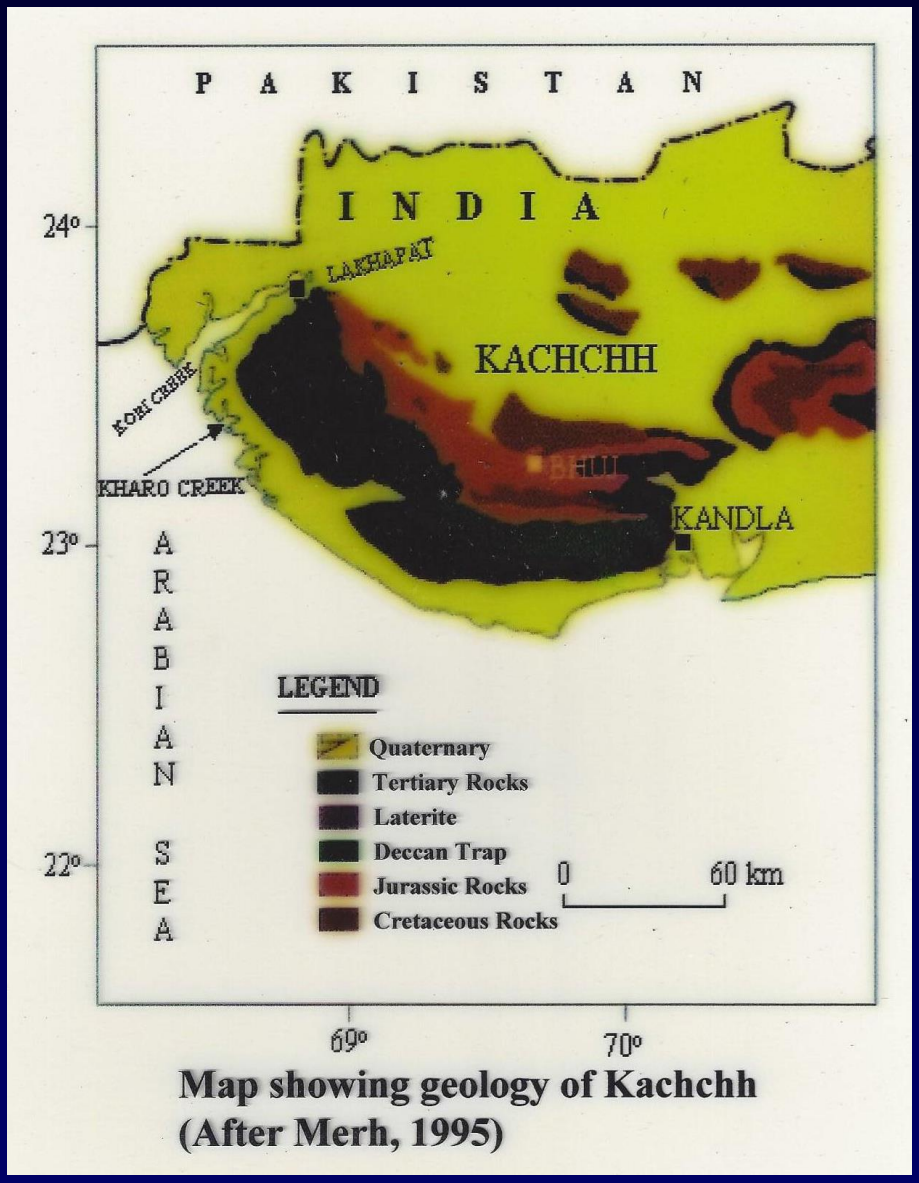


Underwater explorations off Mahabalipuram

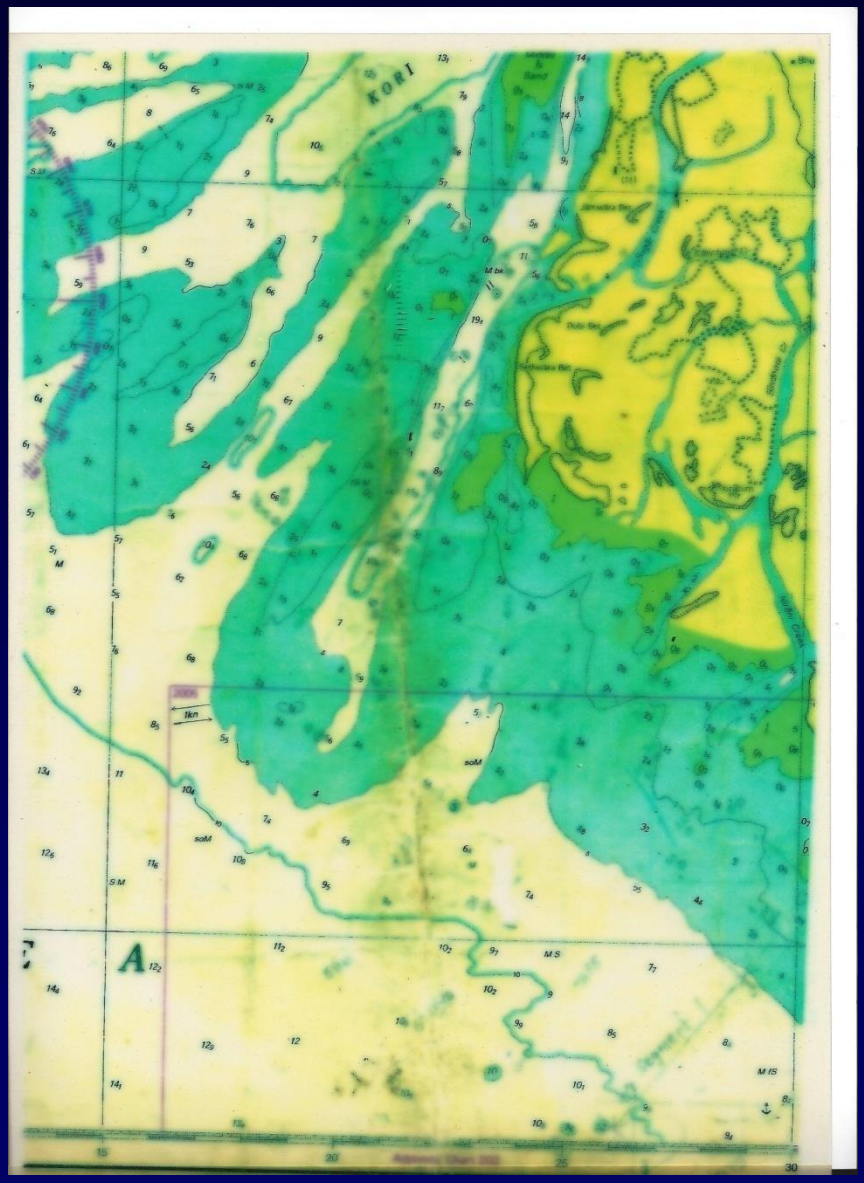


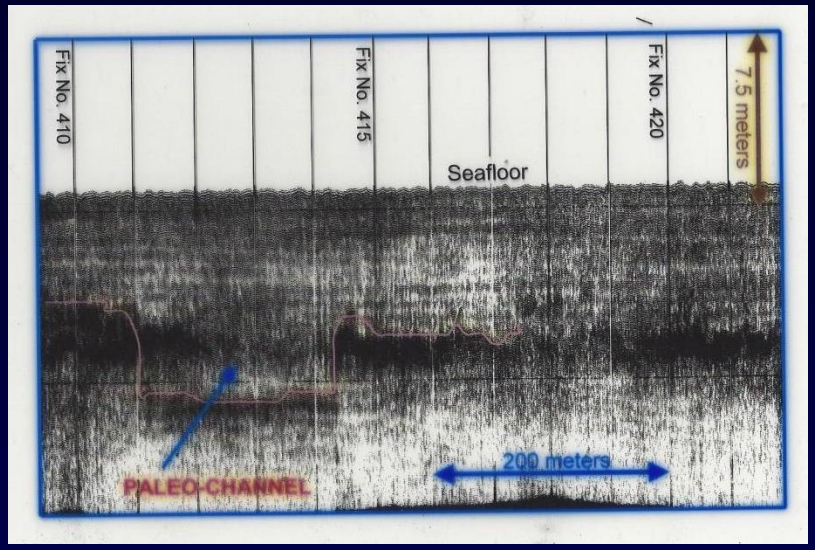
Tracking the ancient saraswati

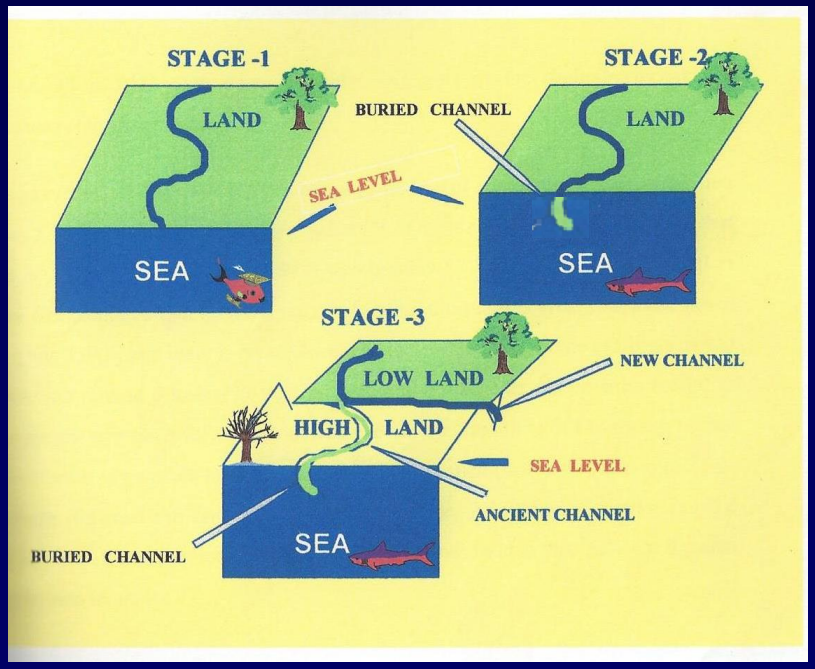

0
200 km
400 km
PESHAWAR
ISLAMABAD
Jammu & Kashmir
Manda
Mundigak
Rehman Dheri
AFGHANISTAN
Indus
Jhelum
Chenab
Ravi
Beas
Sutlej
LAHORE
AMRITSAR
Ropar
Harappa
Punjab
CHANDIGARH
AMBALA
QUETTA
Bhagwanpura
Alam-girpur
Dabarkot
Kunal
Mehrgarh
Pirak
Nausharo
Banawali
Siswal
Haryana
Kalibangan
Rakhigarhi
DELHI
Jhukar
Ganweriwala
PAKISTAN
BIKANER
Rajasthan
Mohenjo-daro
Kot Diji
MATHURA
JAISALMER
JAIPUR
Chanhu Daro
JODHPUR
AJMER
Amri
INDIA
Balakot
KARACHI
RANN OF KUTCH
Arabian Sea
Dholavira
Surkotada
AHMEDABAD
UJJAIN
Lothal
Gujarat
Bet Dwarka
Nageshwar
Rangpur
BARODA
DWARKA
Narmada
Rojdi
Bhagatrav
Tapti
Maharashtra
SOMNATH
NASIK
Daimabad
Godavari
Punjab : Indian State
BARODA : present-day city
Ropar : Harappan site
Lothal : major site
: international border
: dry bed of the Sarasvati



Map showing geology of Kachchh
(After Merh, 1995)




Fix No. 410
Fix No. 415
Fix No. 420
7.5 meters
Seafloor
PALEO-CHANNEL
200 meters


STAGE -1
LAND
SEA
SEA LEVEL
BURIED CHANNEL
STAGE -2
LAND
SEA
STAGE -3
LOW LAND
NEW CHANNEL
HIGH LAND
SEA LEVEL
ANCIENT CHANNEL
SEA
BURIED CHANNEL

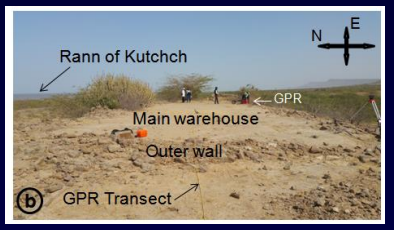
CSIR National Institute of Oceanography, Dona Paula, Goa

Underwater Heritage of India : Status of Research

Bet Dwarka, Dwarka, Gujarat

Structural remains at 6m water depth was found in Dwarka waters. It indicates the sea level was lower than today. Investigations were made during 1989-2001.

Dholavira, Saran, Gujarat



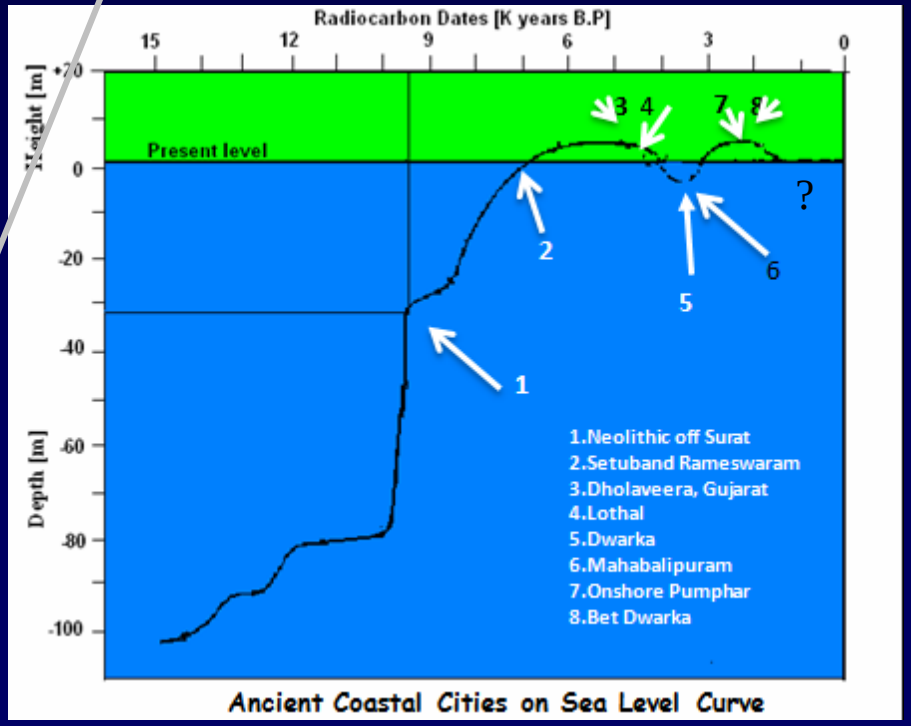
About 5000 years old fortified Harappan city (Tsunami protected?) which had maritime activities through Saran port is being explored through GPR subsurface survey. Funding awaited from Gujarat Government

Gopakapattanam, Goa

The remains of ancient structures documented. The research on this site is continuing. GPR survey has been initiated to map the buried structures. MoES funding

Mahabalipuram, Tamil Nadu

Geophysical and diving indicates the remnants of ancient structures at 6m water depth. GPR subsurface survey reveals buried structures on beach.

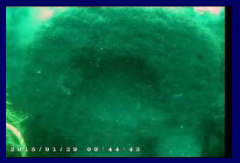


Ancient Coastal Cities on Sea Level Curve

Potential Sites for Detailed Studies

Poompuhar, Tamil Nadu (300BC – 300AD)

RamSethu , Tamil Nadu



Kollam, Kerala