

# Caspian Sea levels in the last 2000 years and current changes

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Forest remains on the beach near Astara (NW Iran)  
drowned by the 1995 highstand

Photograph taken in 2009. Plastic shoe for scale

Source: S.A.G. Leroy

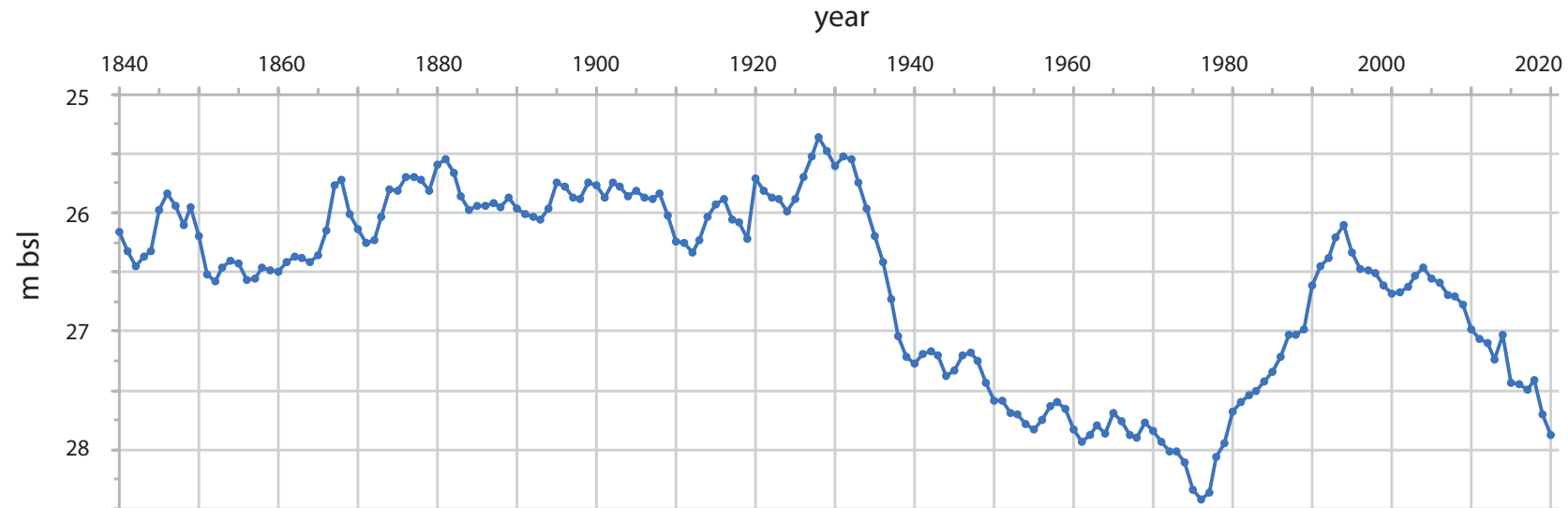
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3. Past Caspian Sea levels
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  3. The Sasanian wall
4. Current and future Caspian Sea levels
  1. Instrumental record
  2. Forecasts



# 1 Introduction and setting

## Caspian Sea level



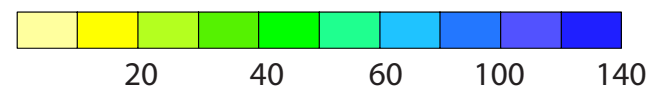
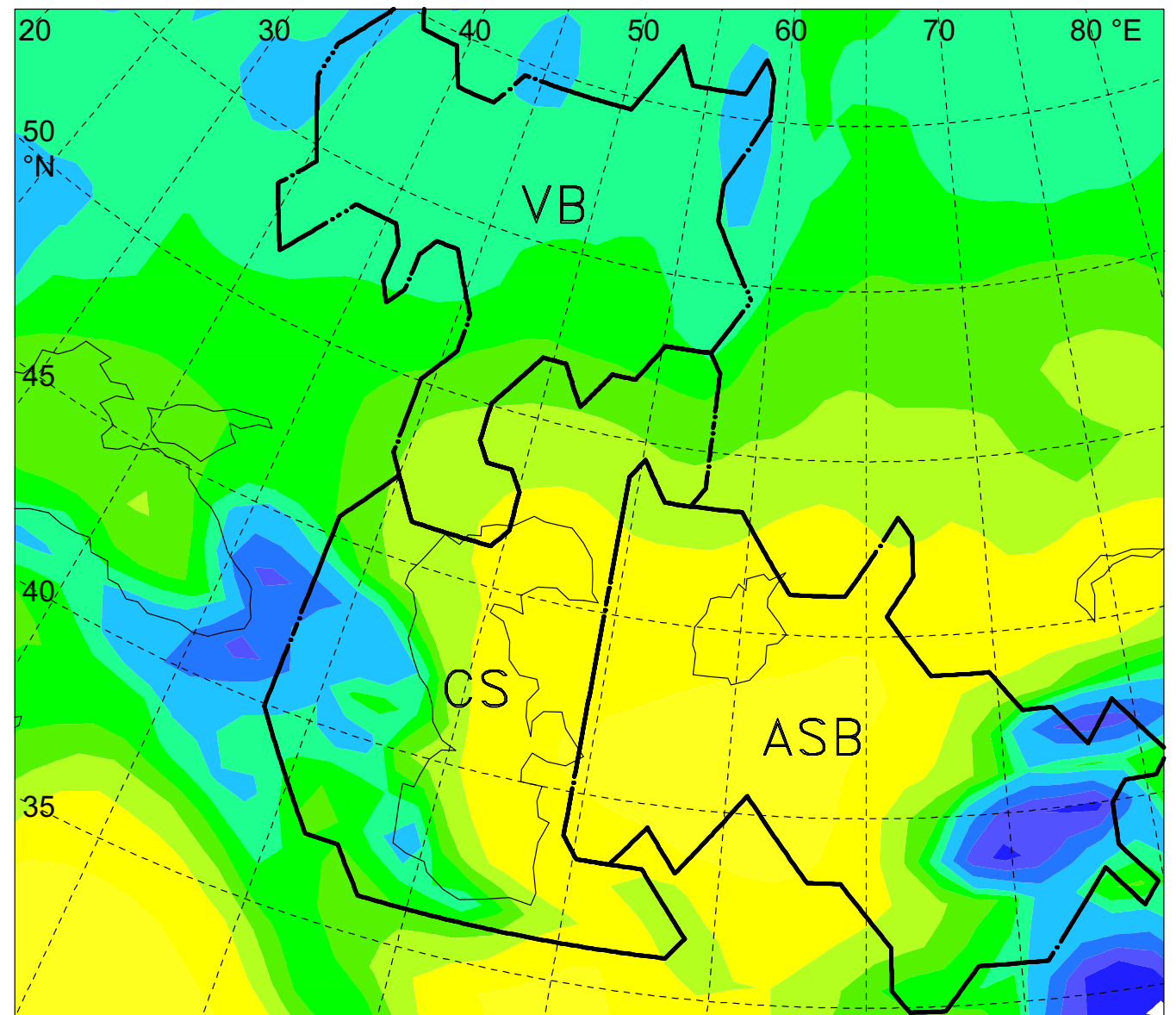
Caspian Sea level curve from 1840 to 2020 in m below sea level, combining gauge and satellite data

- Data from 1840 to 1992 from Golitsyn (1995)
- Data from 1993 to 2020 from Hydroweb (2021)

# Precipitation of the CS drainage basin

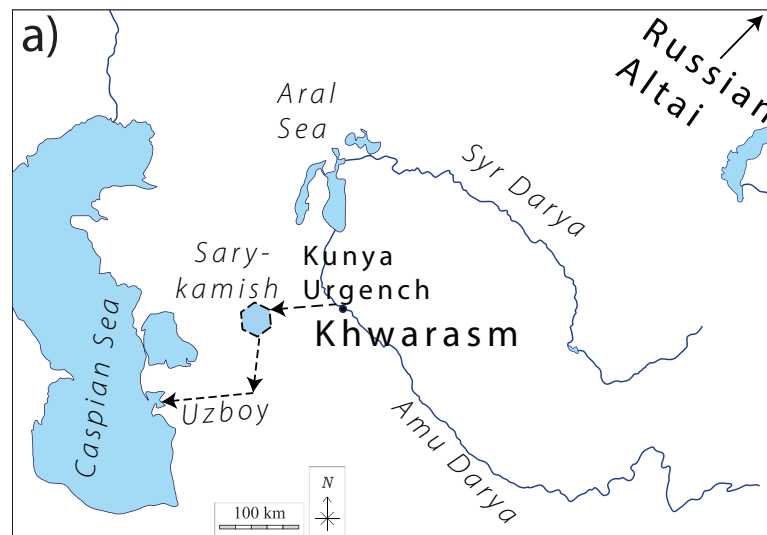
Uncertain limit east of the CS, bec. deserts

Amu-Darya and Syr-Darya at times belonged to the CS drainage



mm/month

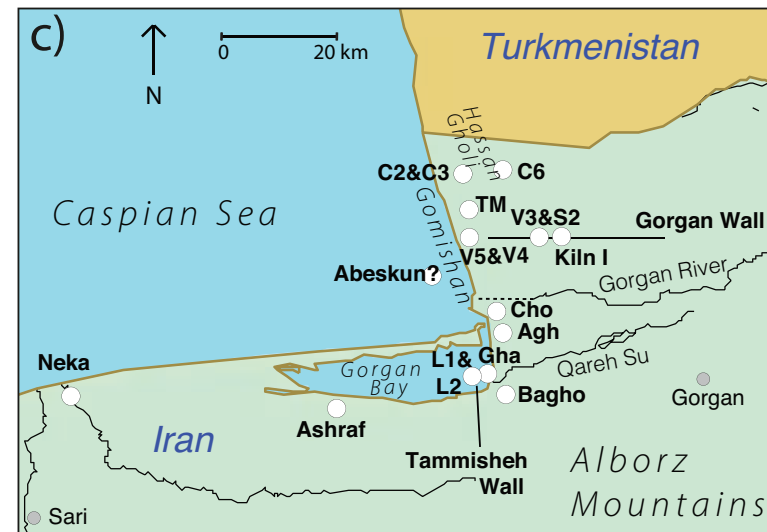
Arpe, pers. comm.



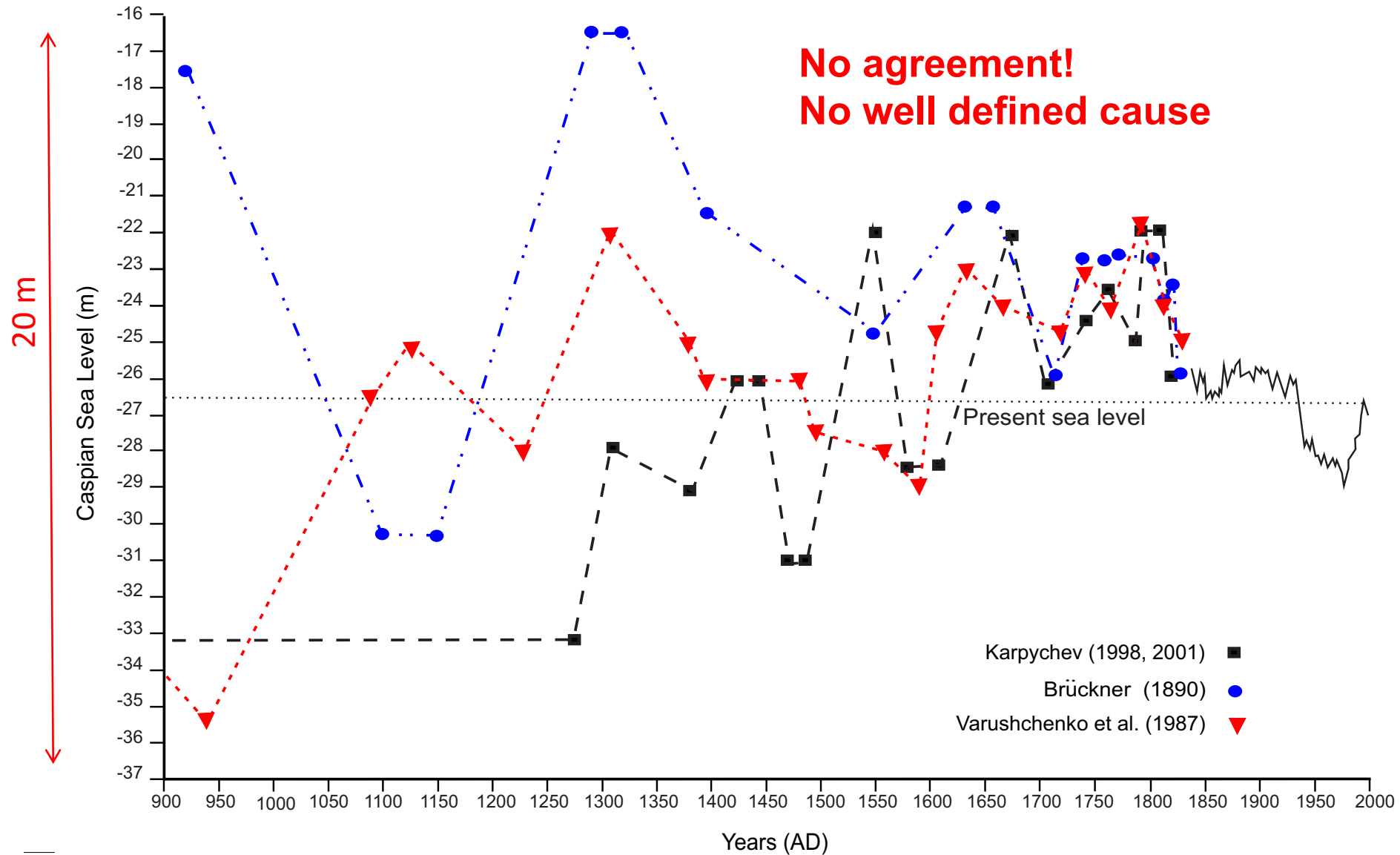


# Maps of the sites used for past CSL reconstruction

Geological data  
and  
Archaeo-historical data

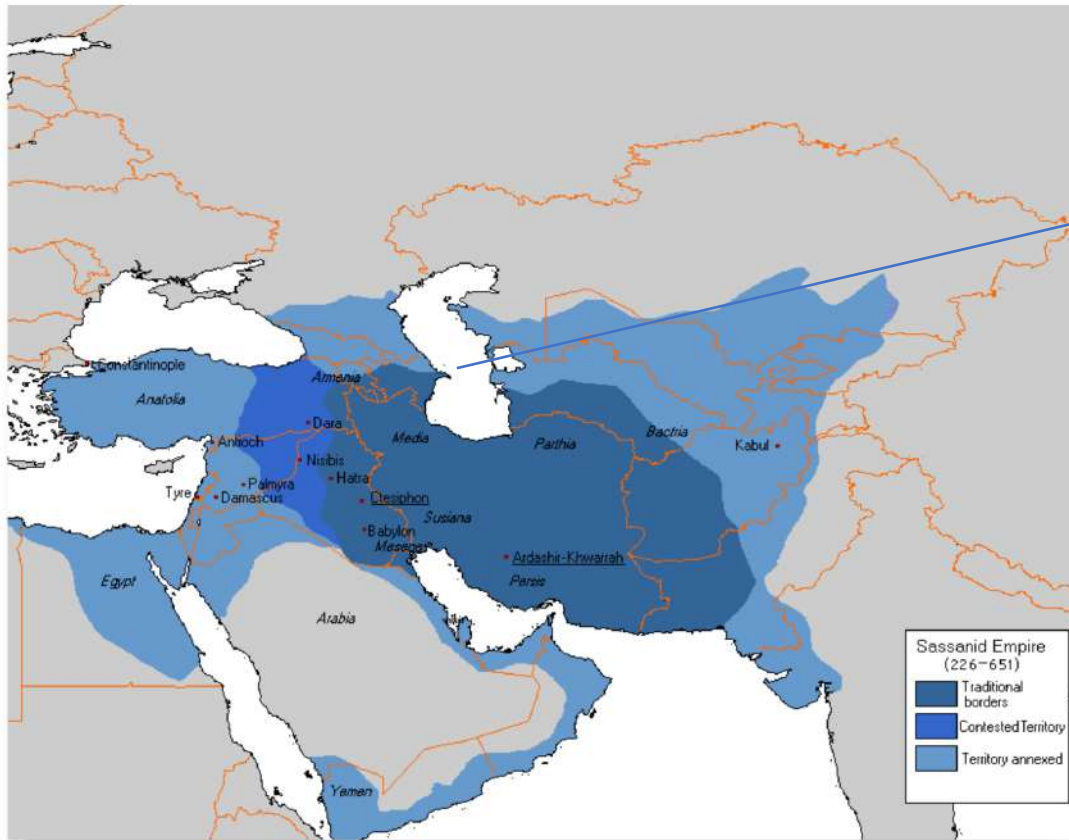


# Water levels in the last 1000 years



# The five Sassanian walls

Derbent Wall  
And the Iron Gate  
Attributed to  
Alexander The Great



This map shows the territorial expansion of the **Sasanian Empire** from 226 to 651 CE.

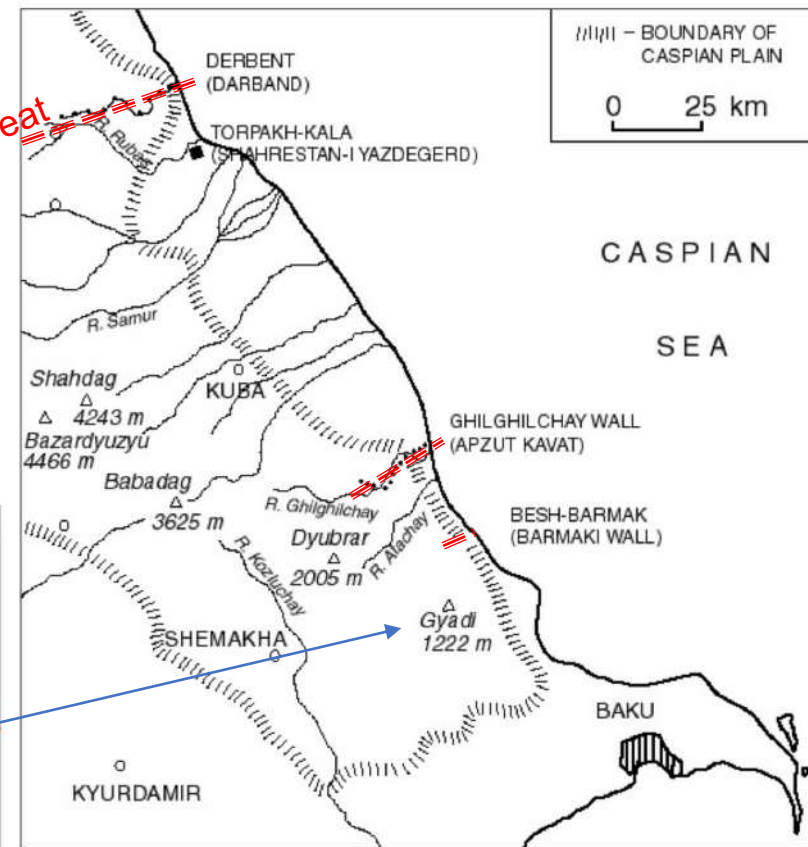
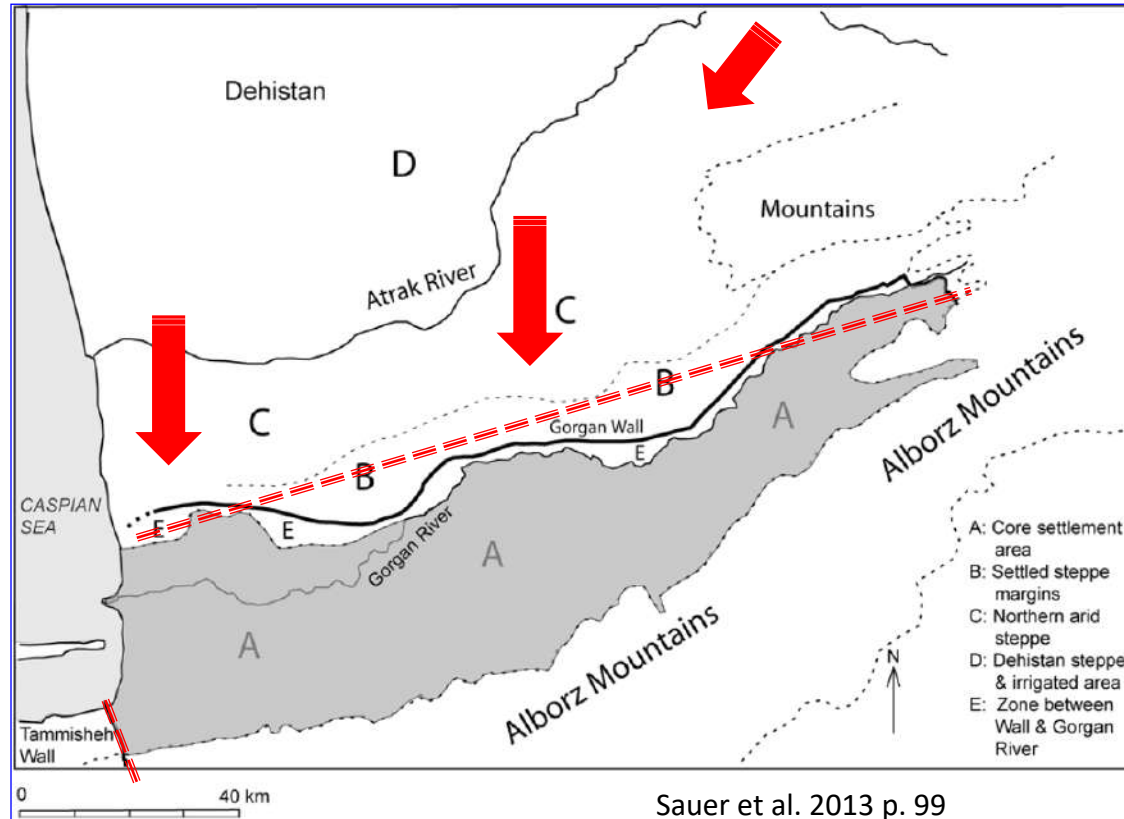


Fig. 1. A map of the eastern Caucasus with a designation of strengthening of Derbent, fortified settlement Torpakh-kala, Ghilghilchay long defensive wall and Besh-Barmak fortifications.

The walls were built when the water levels were at the lowest

# The walls of Gorgan and Tammisheh



In N Iran,  
The walls of Gorgan (c. 170 km, W-E)  
Tammisheh (12 km, N-S)

**=> The 5 walls were built to protect the Sasanian rural and town people from the attacks of the White Huns coming from the N and NE**

Made of cooked bricks around the 5<sup>th</sup> c. AD and 1<sup>st</sup> half of 6<sup>th</sup> c. and occupied until the 1<sup>st</sup> half of 7<sup>th</sup> c.



# The Red Snake = the Gorgan Wall

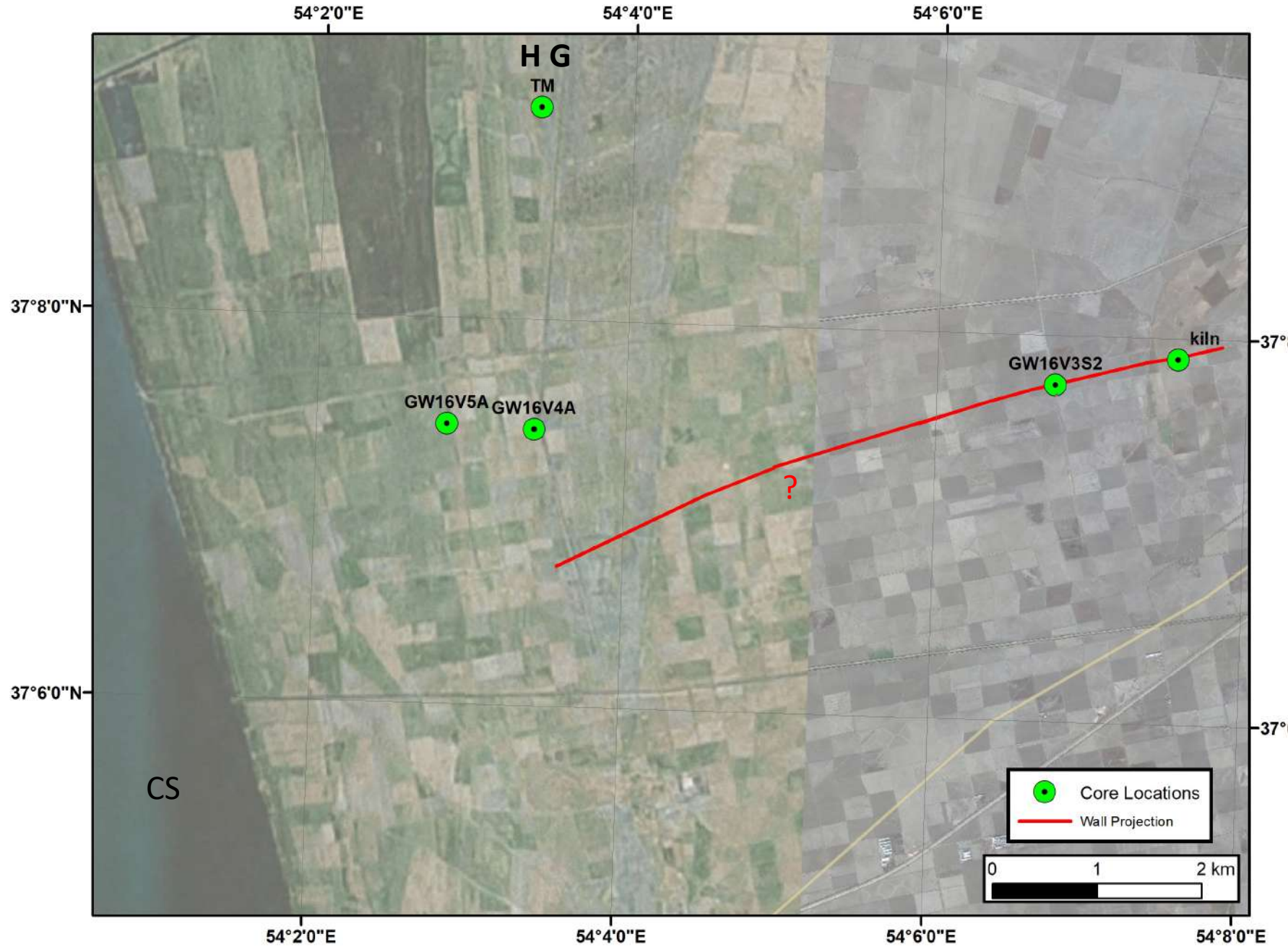


Wall and forts

# Gorgan Wall

The wall ends in multiple walls near the coast

Note Hasan Gholi Lagoon (HG)





# Tammisheh Wall ends under water



Wall and moat  
(S. Leroy Jan. 2013)

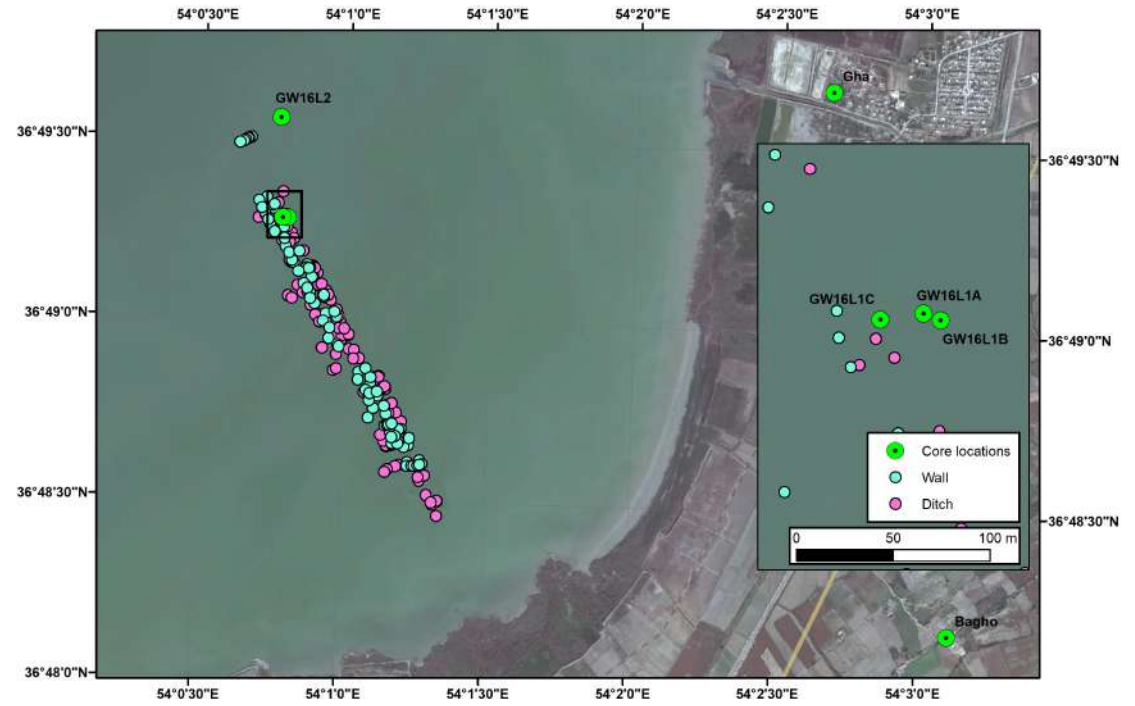


Google Earth

# Tammisheh Wall ends under water



Diver bringing a wall brick up



2 m long cores taken from small boat + geophisic



## 2: Methods percussion coring





# Coring in Gorgan Bay



# The palynological method

- Past **climate** is reconstructed owing to pollen and spores, amongst other **terrestrial proxies**.
- **Water**: reconstruction of past salinity, from which water levels are derived, is made from dinocyst assemblages (protists)
- Other possible information : temperature, nutrients, ...

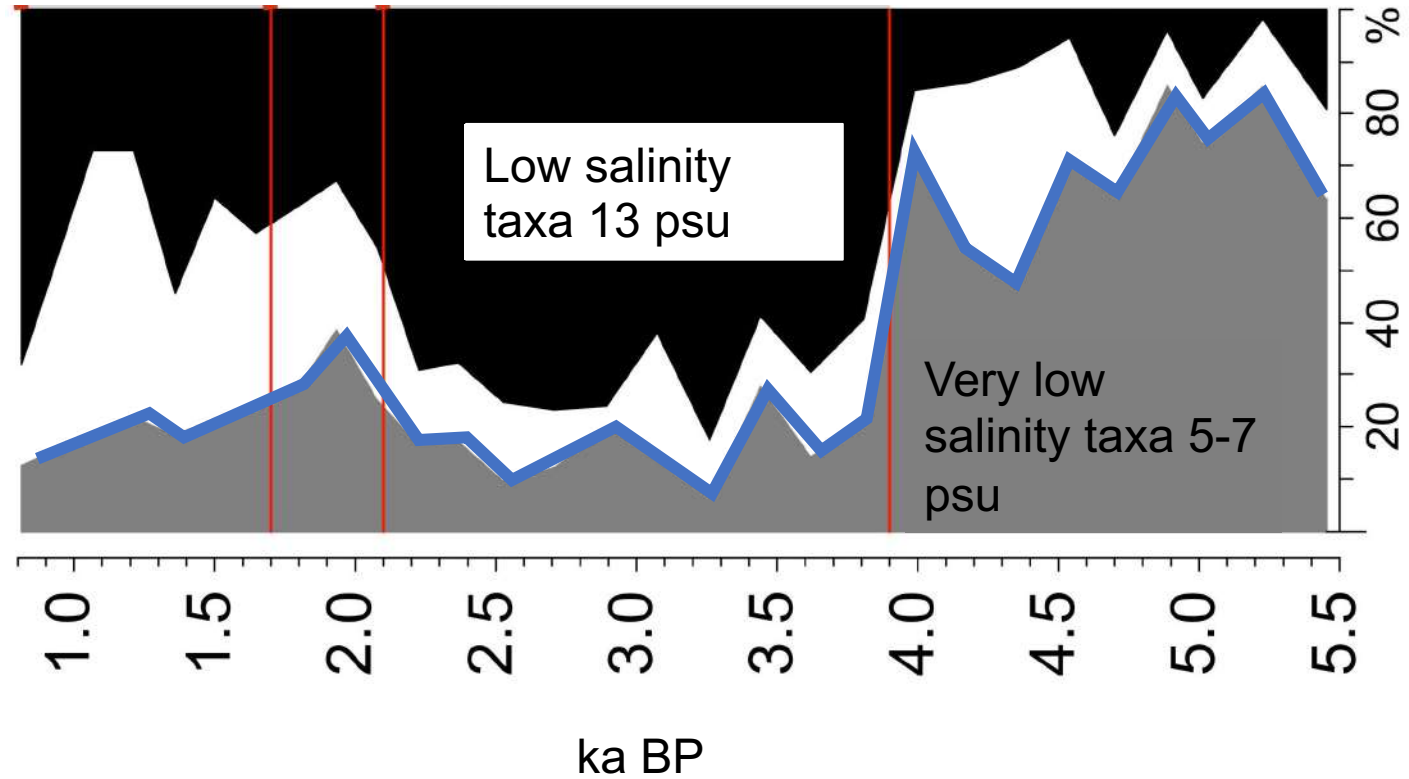


*Parrotia persica*,  
Endemic tree



*Pyxidinospis psilata*,  
Low salinity dinocyst

Dinocyst assemblages shown by cumulative curves  
as water level **indicators**



# Palynology

## Terrestrial signal



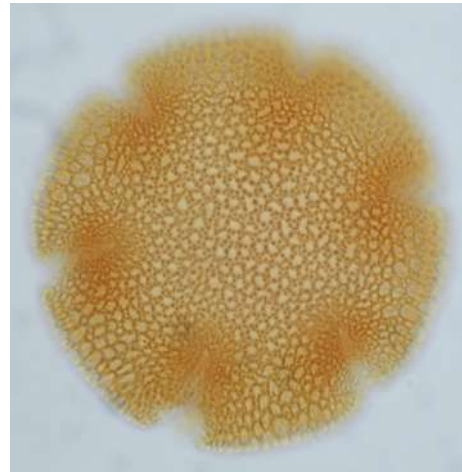
*Epilobium*, fireweed



*Pinus*, pine



Parasite egg



*Chroococcoid*,  
used as a dye

## Aquatic signal

Cyanobacteria  
*Gloeotrichia*

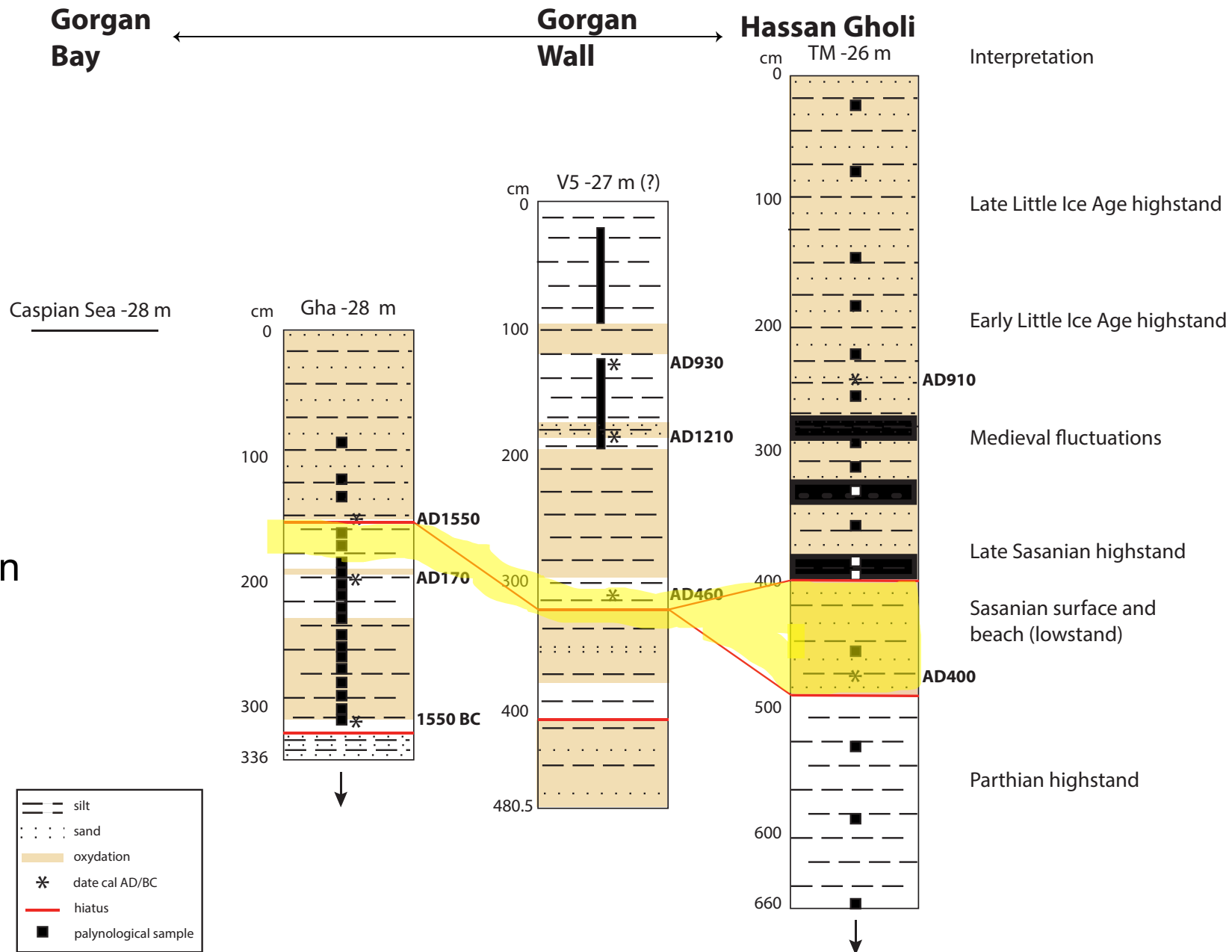


Dinoflagellate cyst



# 3: Past CSL N-S transect

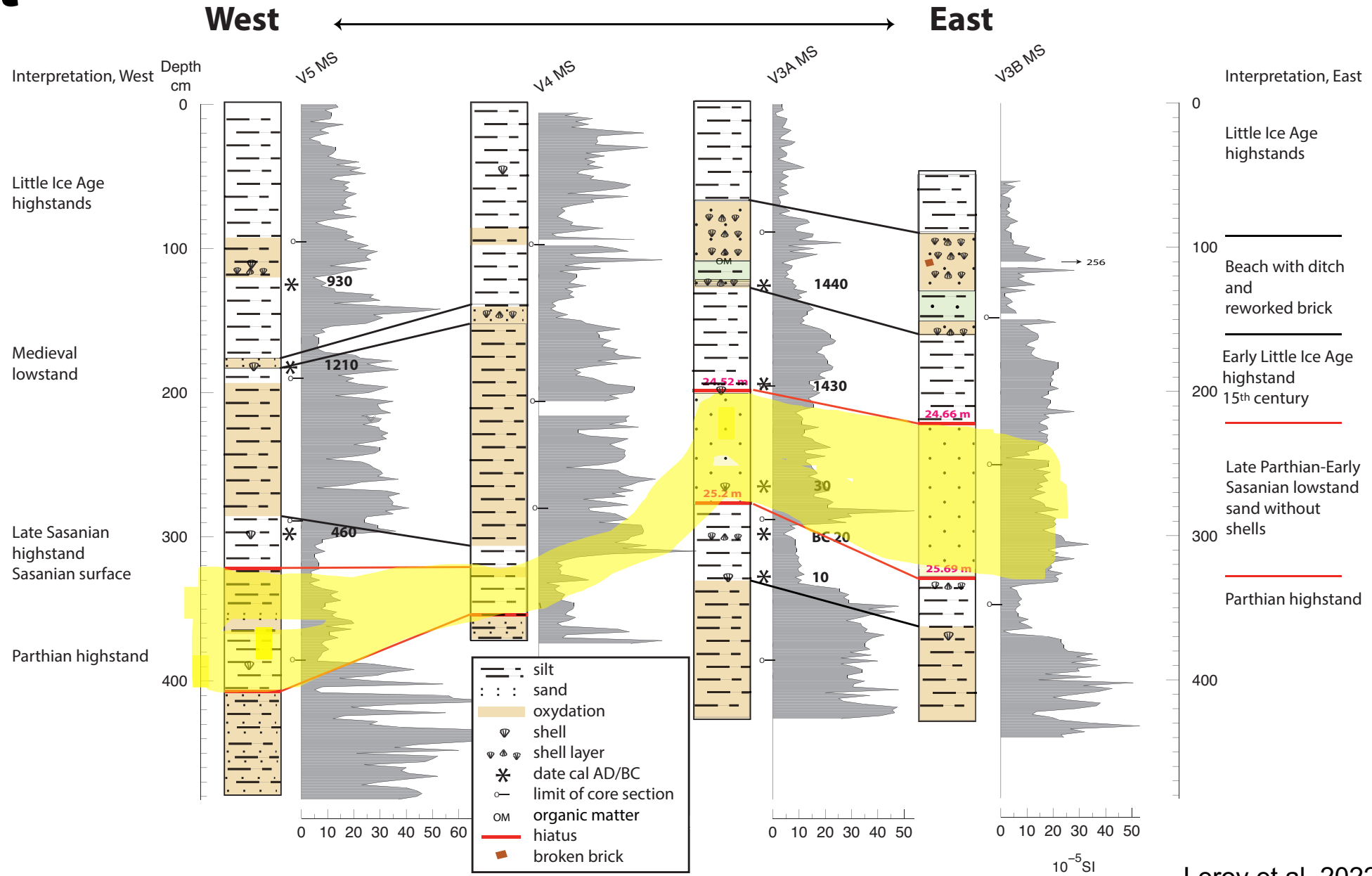
Sasanian period :  
 In the S: surface of erosion  
 In the N: beach by the lagoon





# W-E transect

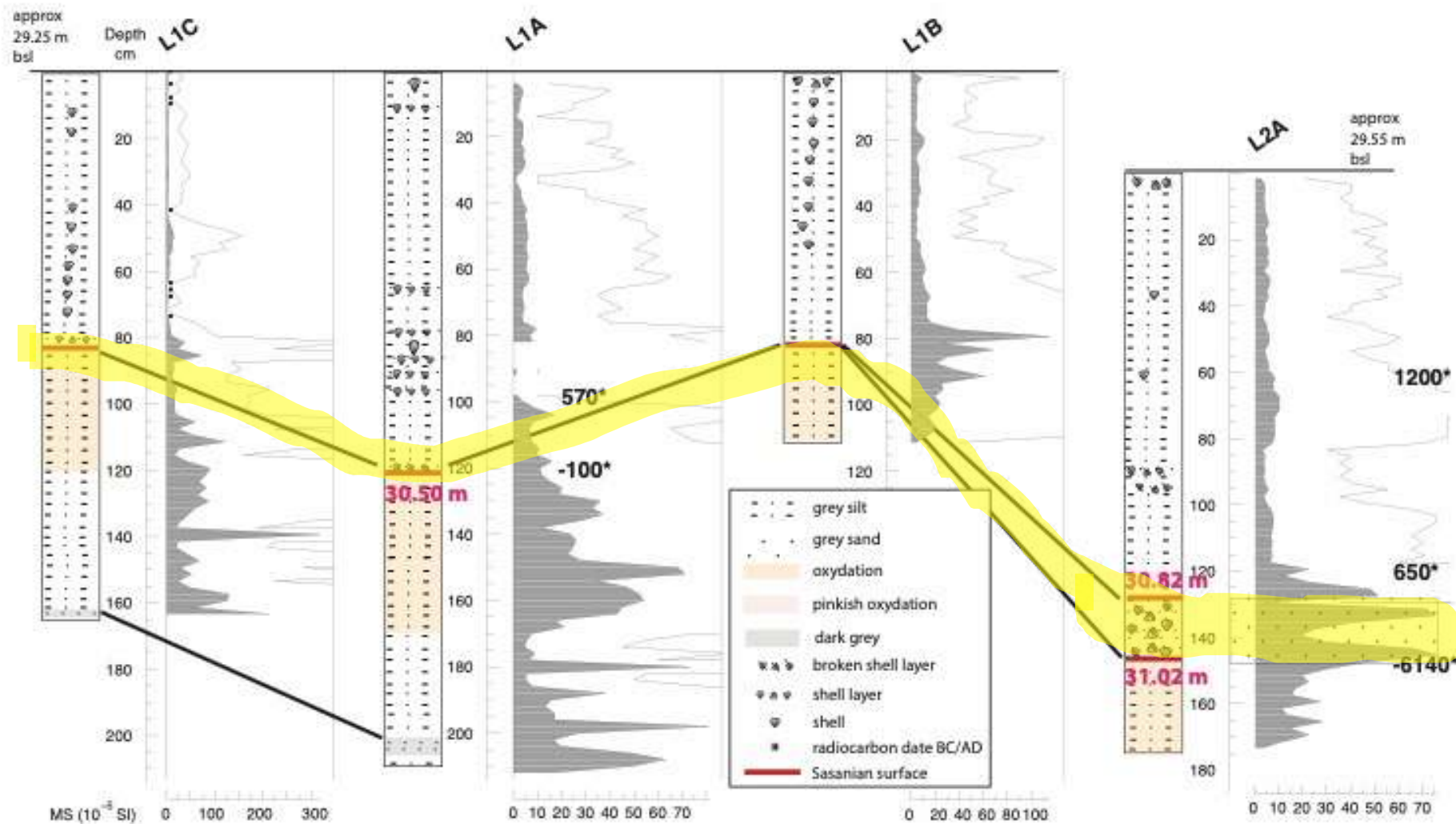
Western section of the Gorgan Wall, GW16V cores, logs and magnetic susceptibility



Sasanian lowstand or erosion surface

# In the G

Vicinity of the northern end of the Tammisheh Wall, cores GW16L: logs and magnetic susceptibility

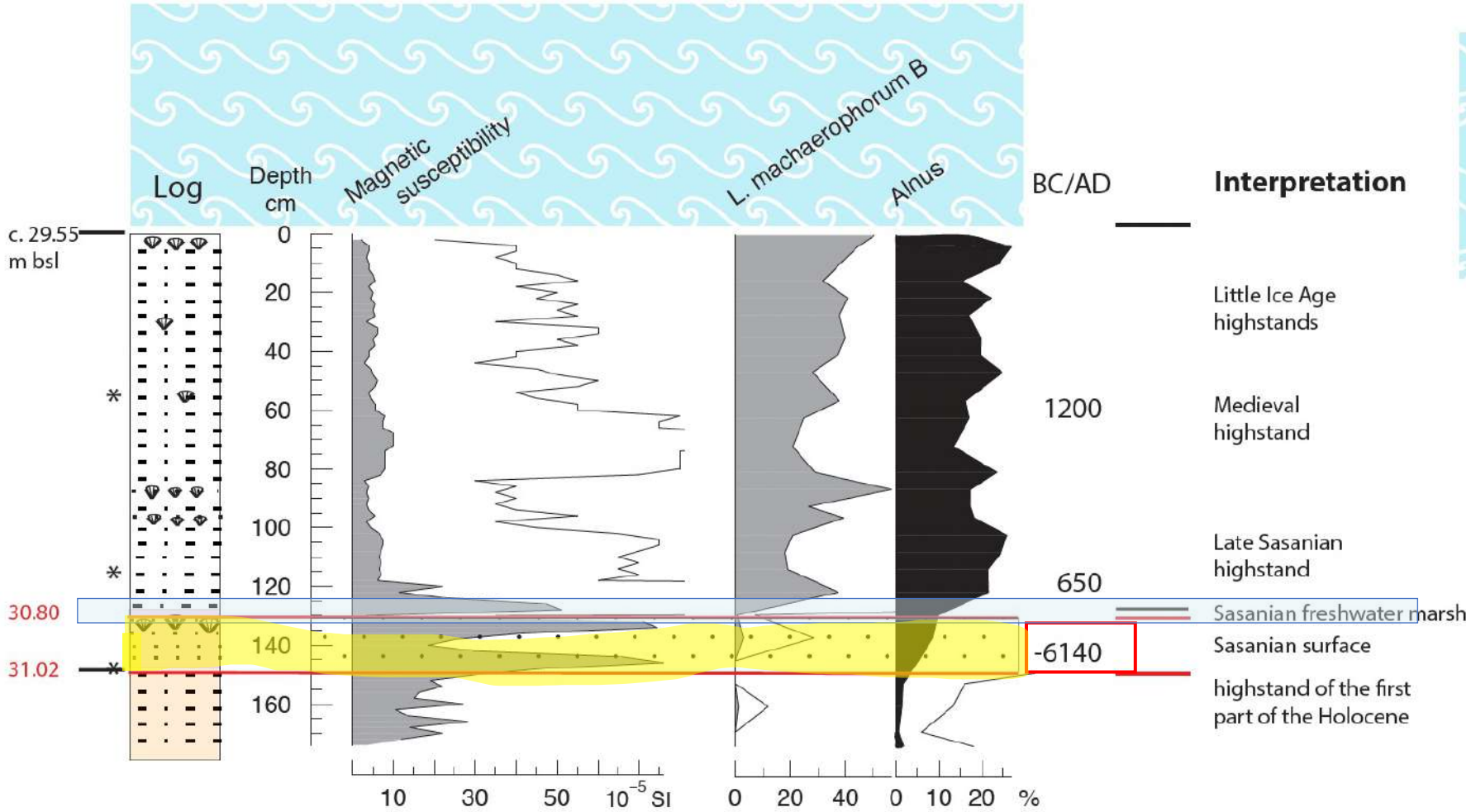


Sasanian  
erosion  
surface and  
sands

Possibly lower  
offshore

# Gorgan Bay results

Core GW16L2A taken in 2016 Near northernmost tip of wall  
 Caspian water level at 27.45 m bsl

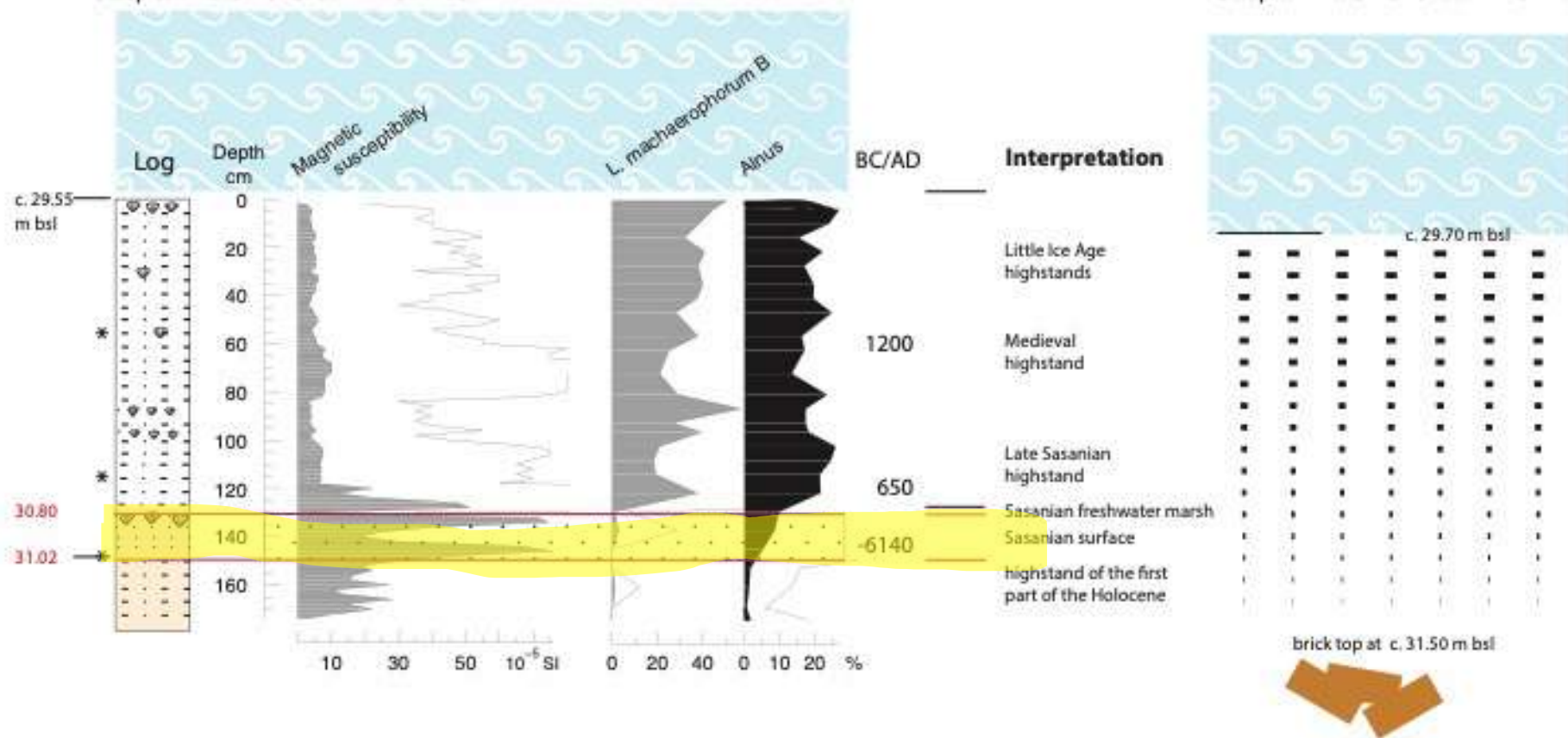


Possible beach with activity and mooring point

## Vicinity of the northern end of the Tammisheh Wall

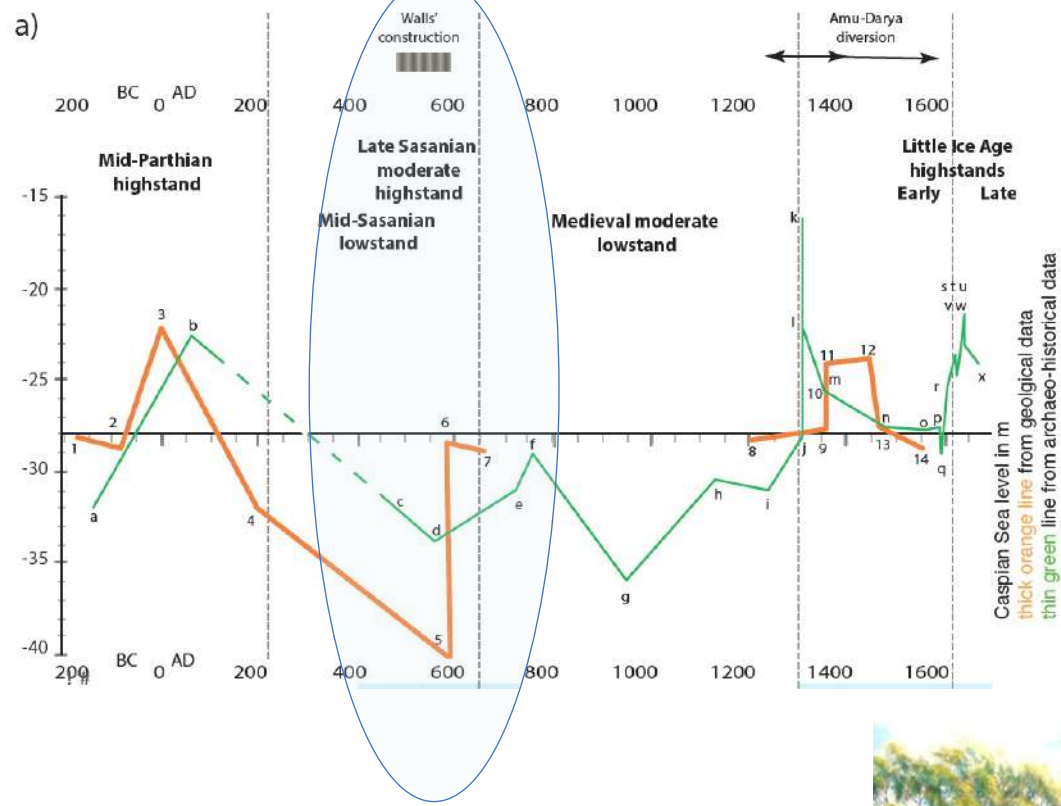
Core GW16L2A taken in 2016  
Caspian water level at 27.45 m bsl

Geophysical survey in 2015  
Caspian water level at 27.70 m bsl





# Walls and water level



Our work shows that the Sasanian surface at AD 570 at an elevation of - 31 m in the Gorgan Bay

This fits the construction period of the **Derbent Wall** (6<sup>th</sup> c. AD) near the Iron Gate (point d)

Leroy et al., 2022

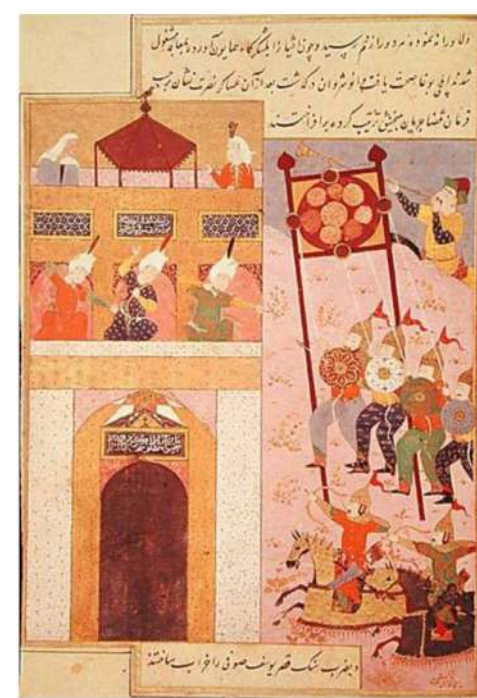


<http://www.heritageinstitute.com/zoroastrianism/caucasia/darband.htm>





## Ancient role of people



Impact of the siege of a town on the Amu-Darya by Mongols: Konya Urgench



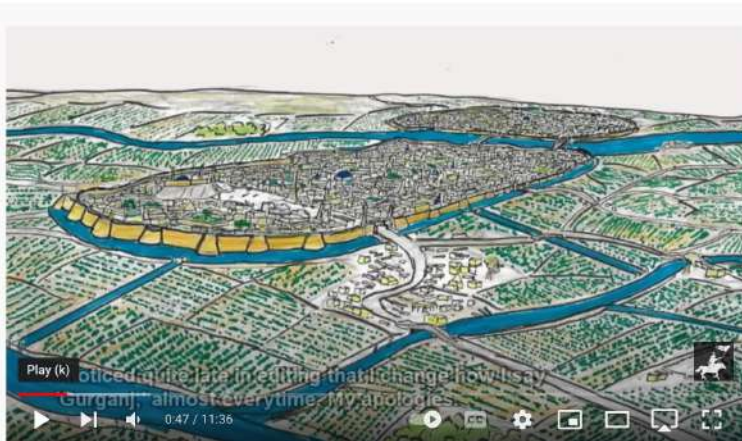
A Caspian port disappears: Abeskun

Inland flooding >12 km on Iranian coast: Langarud

# Ancient role of people

## Impact of the destruction of Kunya Urgench Capital of the Khârezm

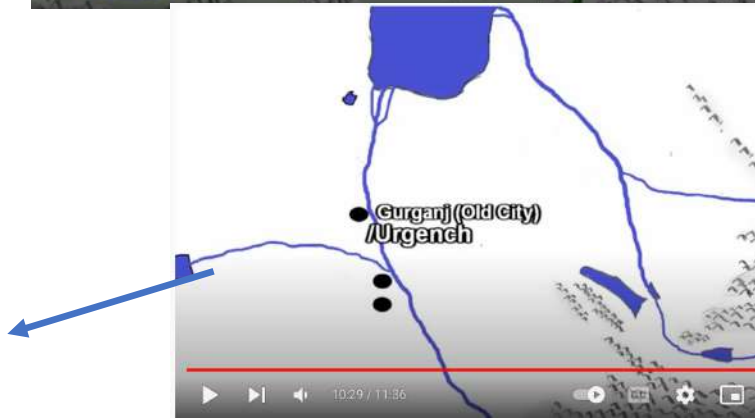
Important cultural and trading center on Amu-Darya  
Intensive agriculture



Attacked by Genghis Khan armies led by 3 of his sons  
In AD 1221, very long siege  
Napht used to set fire, destroyed town

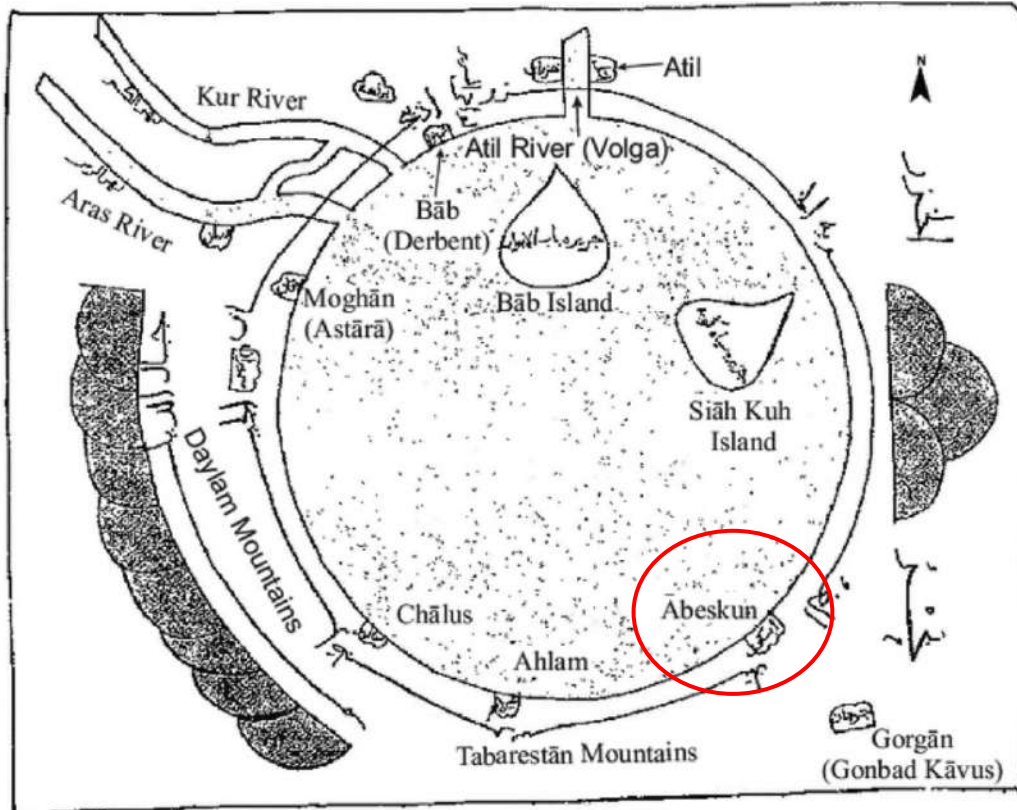


Destroyed dams and flooded town  
Destruction of irrigation canals  
Deviation of the Amu-Darya to the Caspian Sea



CS

# Abeskun = active commercial port



- One of the most important coastal towns , first known owing to Ptolemy as Socanda.
- Business across and beyond the Caspian: Transcaucasus and Volga.
- In the 9 and 10<sup>th</sup> c., several attacks-plunders by the Rus (Vikings).

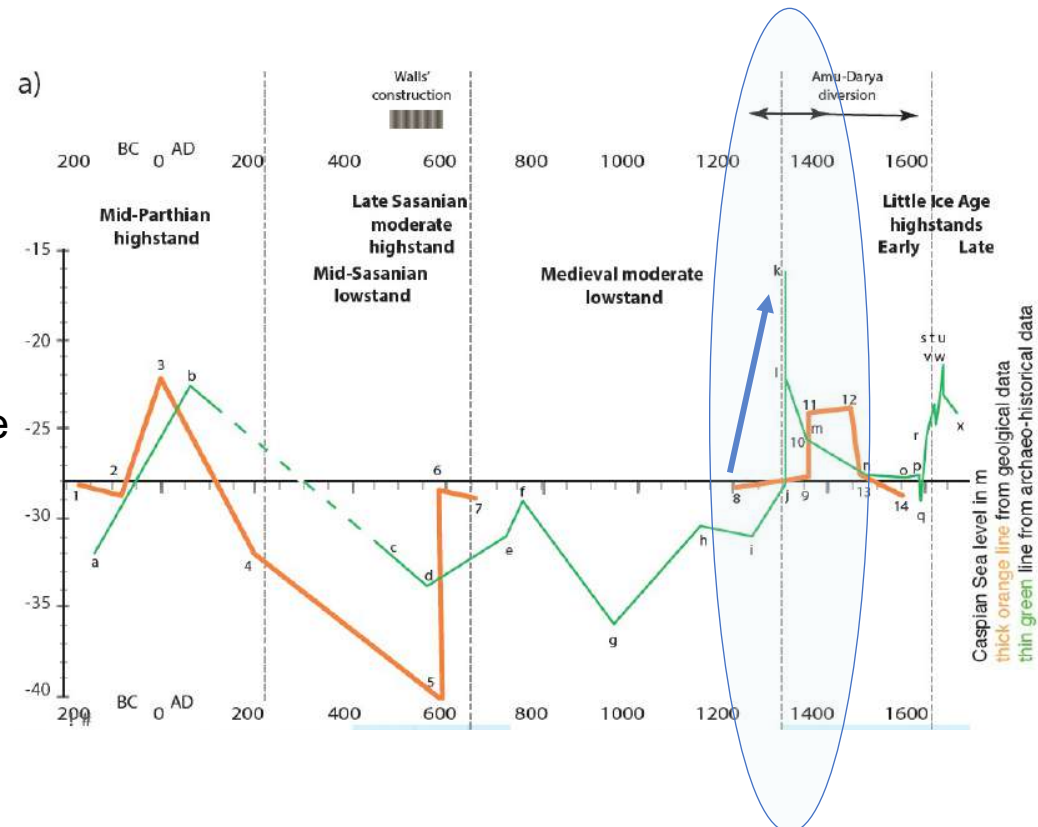
10<sup>th</sup> c. map by Ibn Hawqal (geographer)



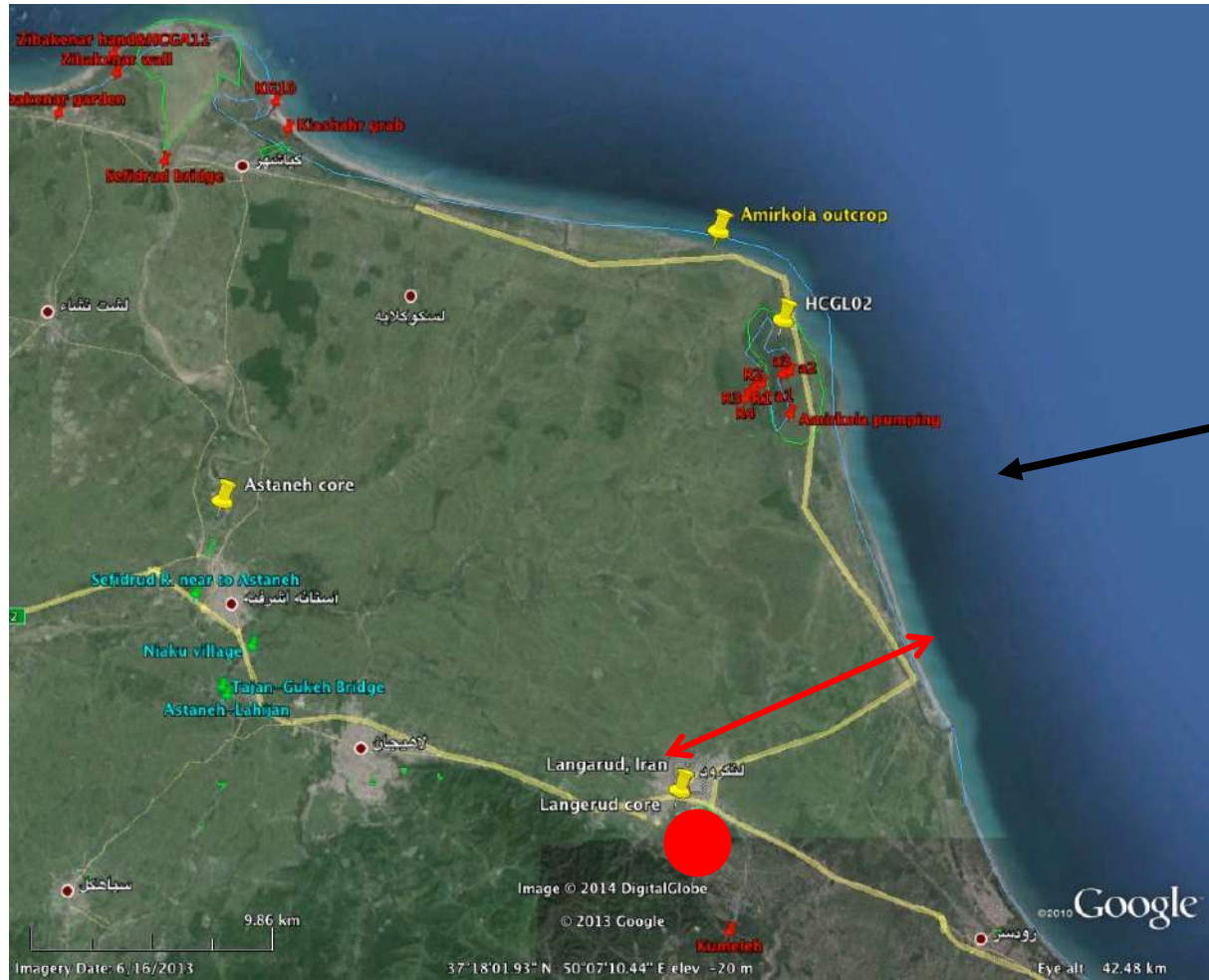
# Abeskun town, port or island?

- Disappeared at beginning of 14<sup>th</sup> c caused by increase of water level. An ancient description says how Abeskun was flooded and swallowed by the sea in 1304.
- A high level of the CS is known for that time. This town till today has not been found. Maybe Gomishan? Or under the sea?
- Cause: avulsion caused by the Mongols at Konya Urgench?

1208	-24 m	Abeskun on the coast
↓		
1260	>-24 m	Abeskun flooded
↓		
1304	-19 m	Rapid water level increase



# Example of Langarud



In Iranian coast  
11.5 km from the sea

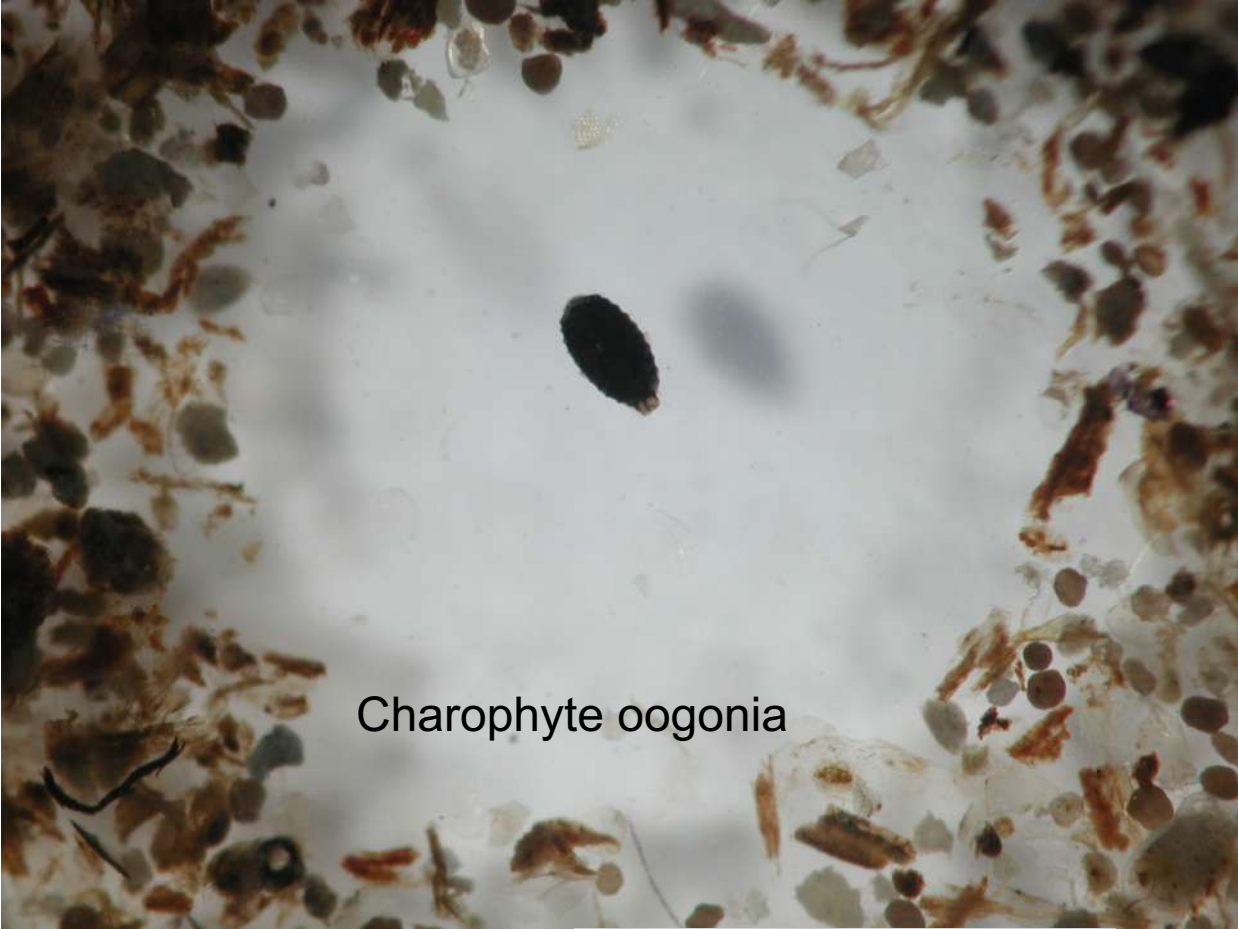
# View of Langarud towards the CS



Cores taken in the humid zone

Google Earth, Hadi Natureboy





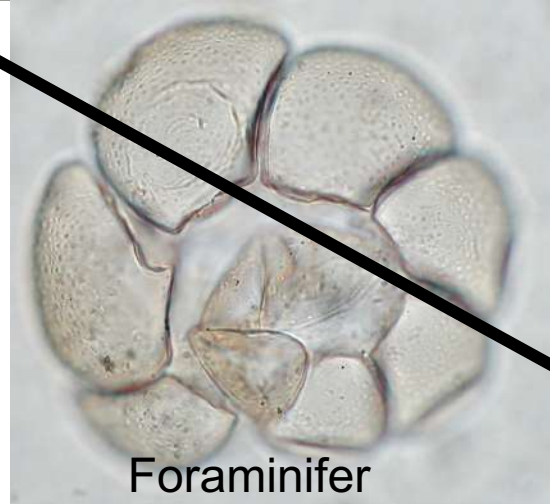
Charophyte oogonia



Head capsule of a Chironomid larva



Fish scale

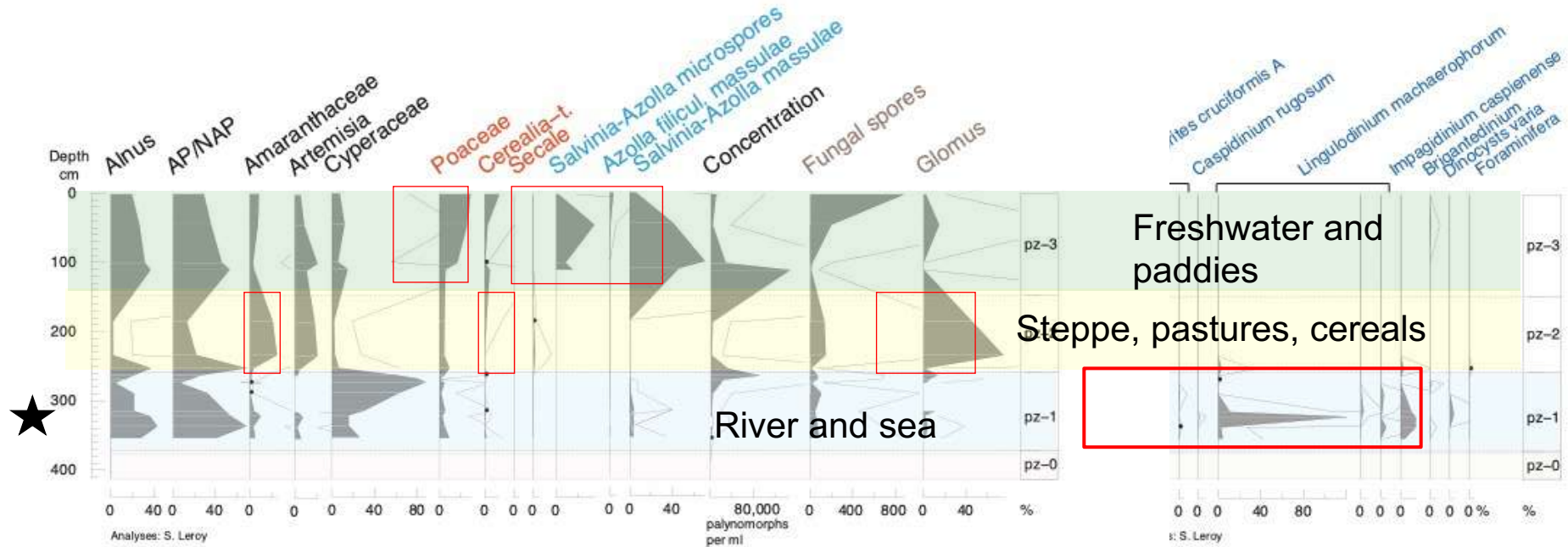


Foraminifer



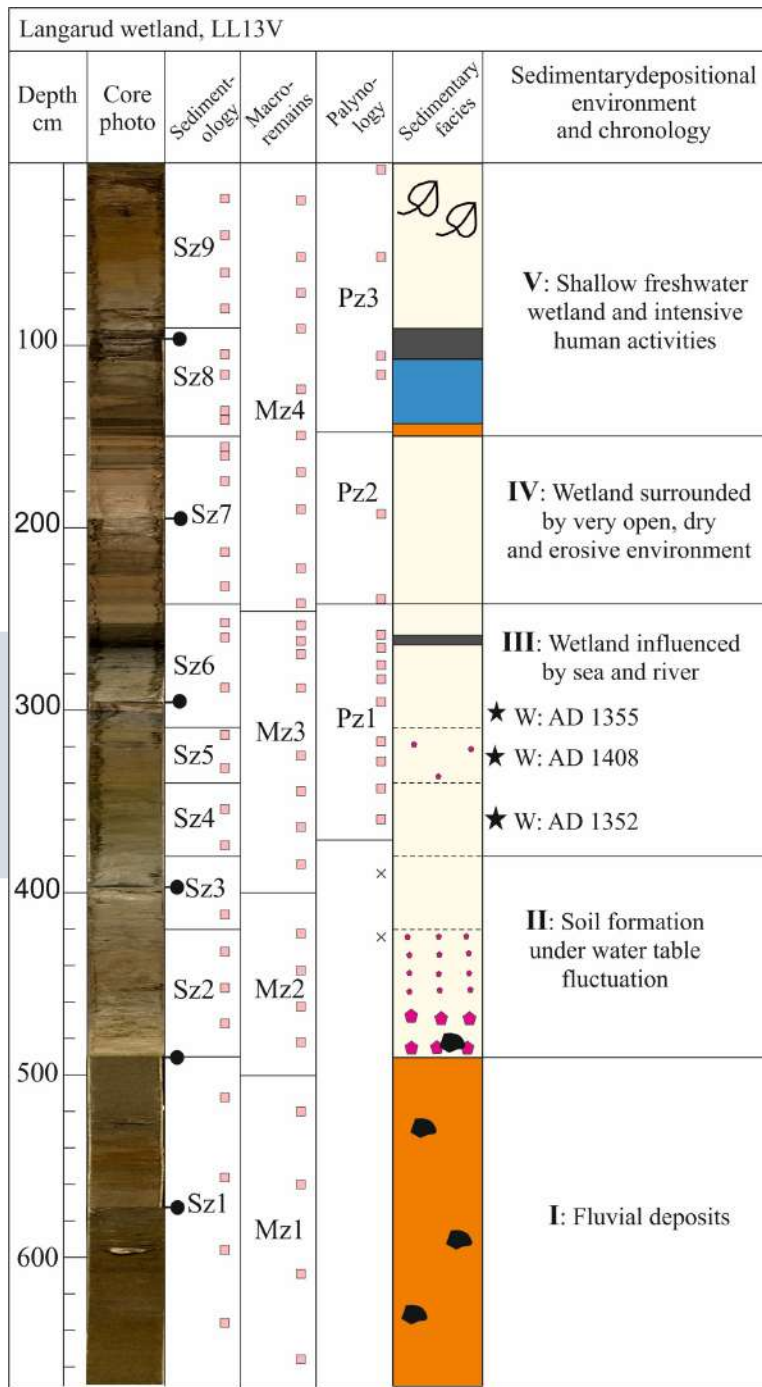
Gastropods

# Langarud: palynological diagram



During the high sea level in AD 1315-1418, the Caspian reached until -19 m (7.5 m more than at present!).

Probably to be related to the historical high of AD **1304**



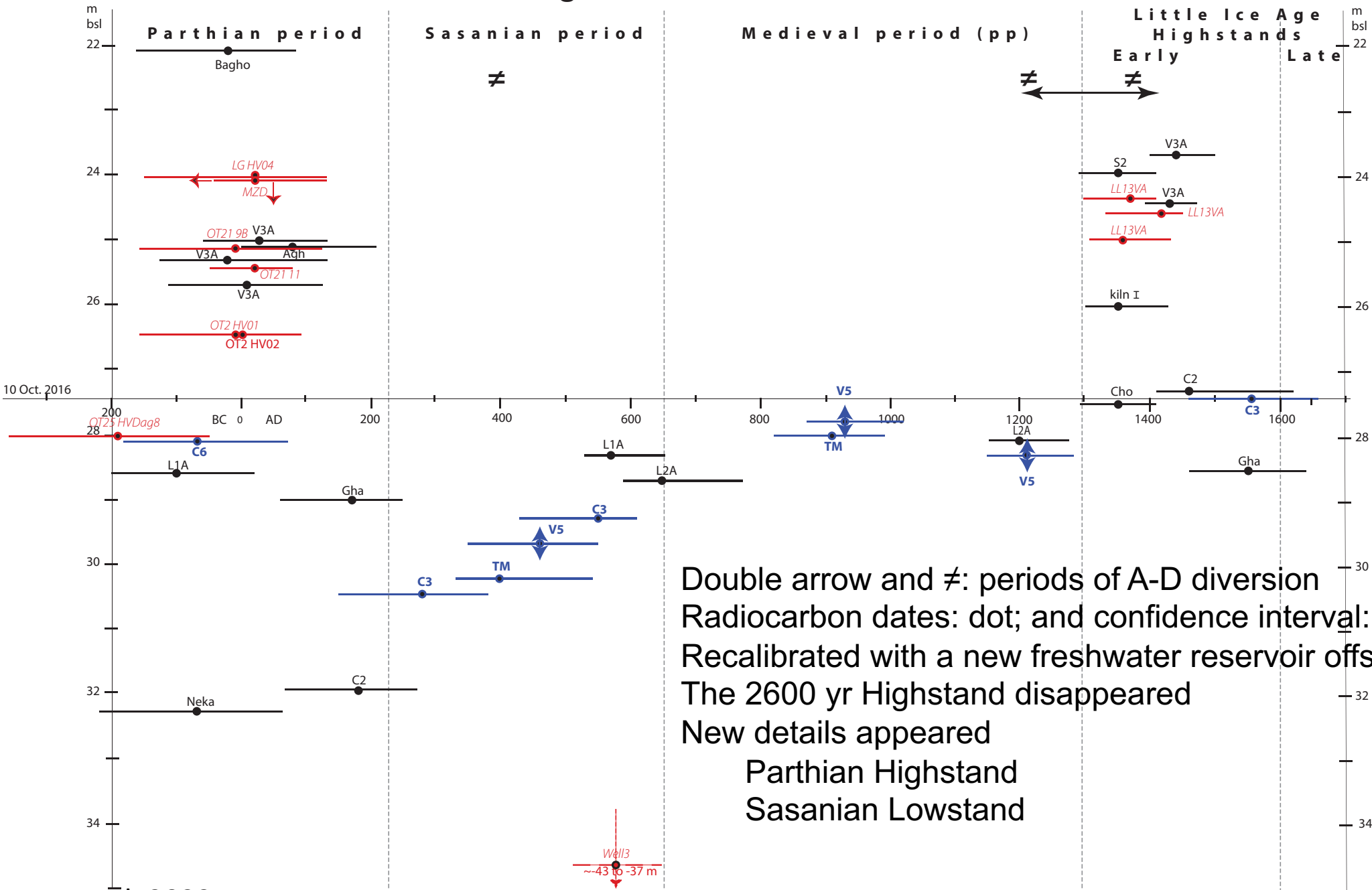
# Langarud : lithology

Altitude: -21,44 m

Distant marine invasion

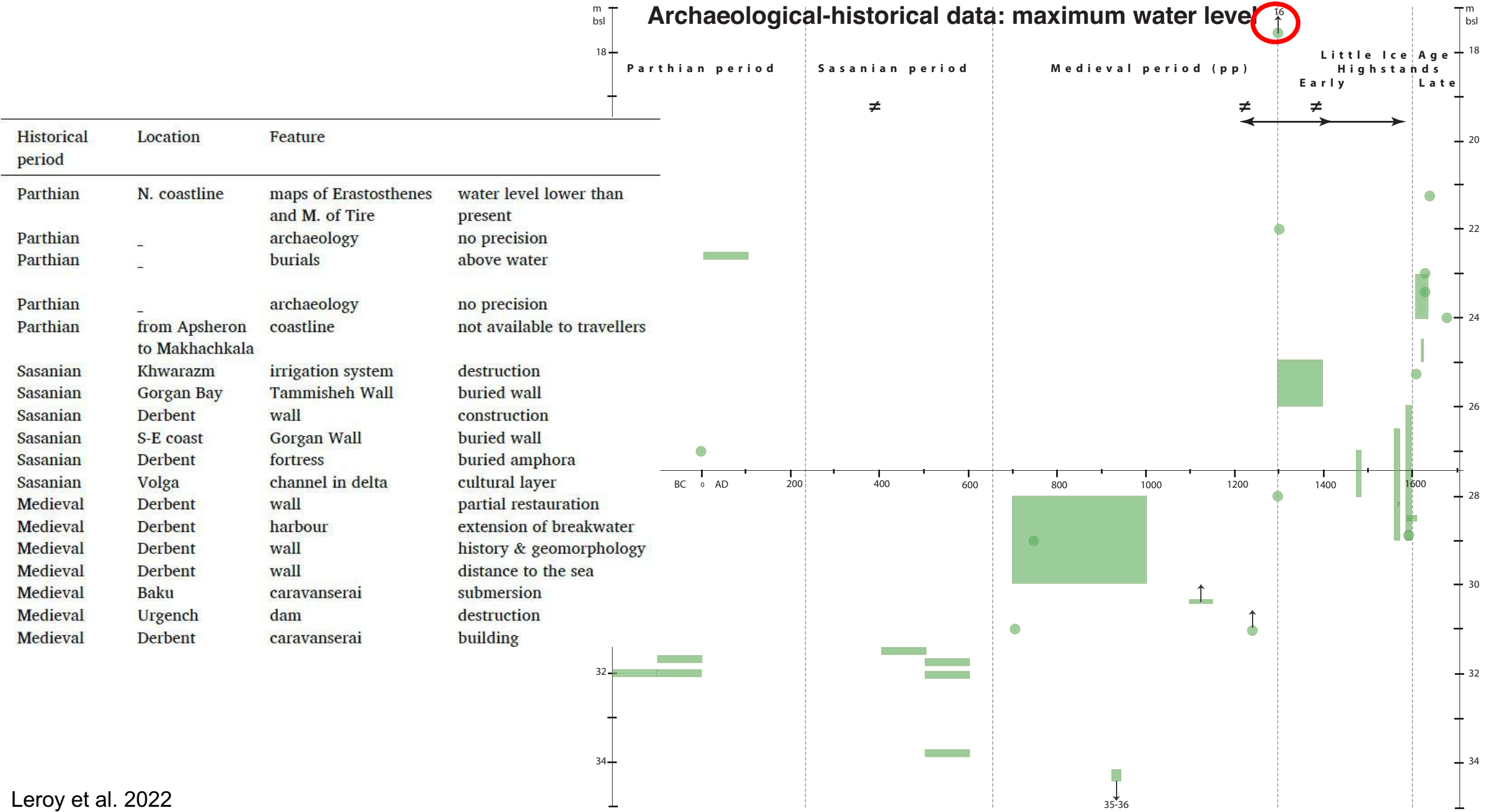


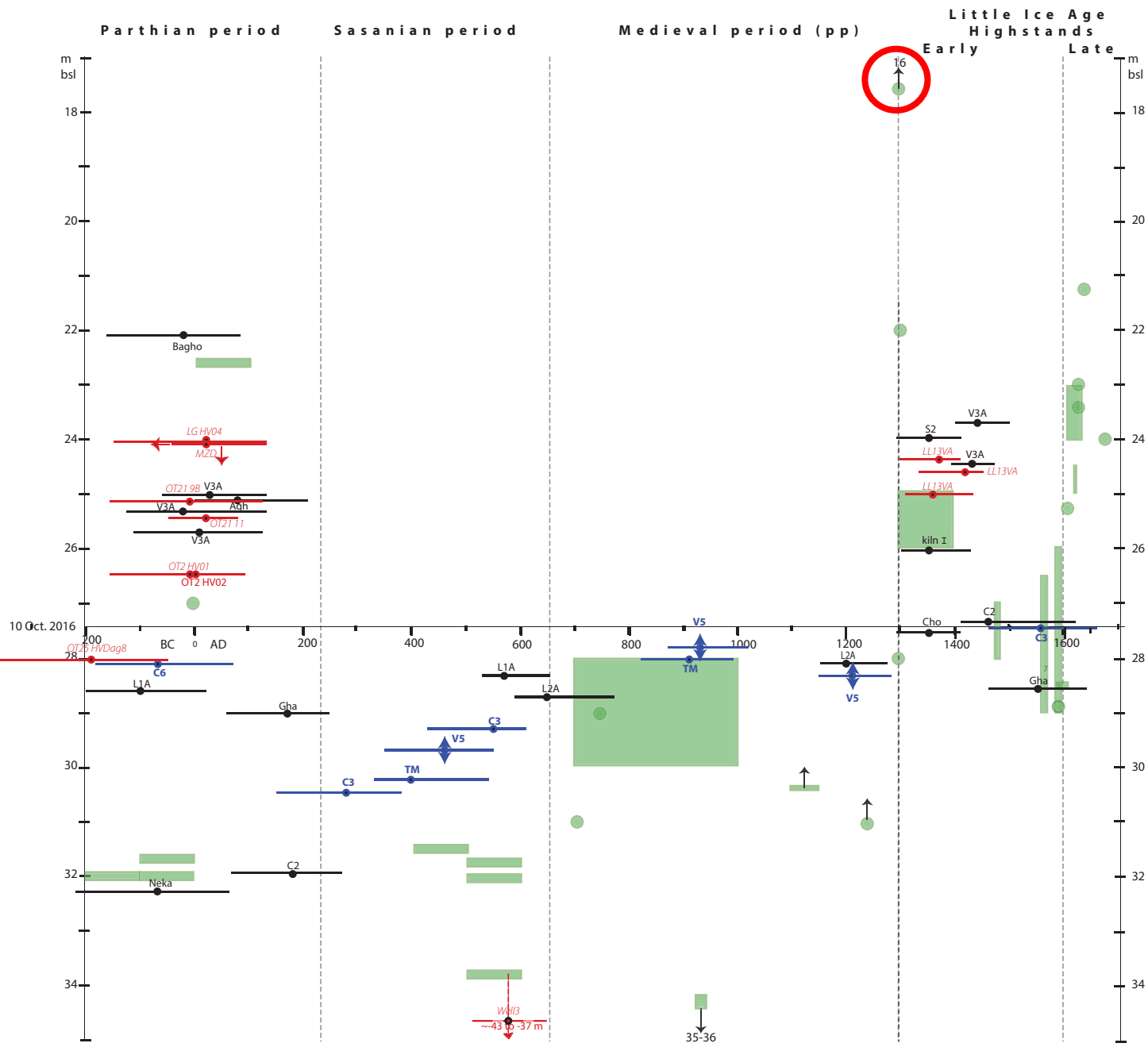
# Geological data: minimum water level



Double arrow and ≠: periods of A-D diversion  
 Radiocarbon dates: dot; and confidence interval: line  
 Recalibrated with a new freshwater reservoir offset:  $351 \pm 33$  years.  
 The 2600 yr Highstand disappeared  
 New details appeared  
 Parthian Highstand  
 Sasanian Lowstand

# Archaeological-historical data: maximum water level





# All together

Amplitude 15 m over last 2200 years  
 5x more changes than in the last century  
 Change rate: 14 cm per year  
 25% more than in the last century



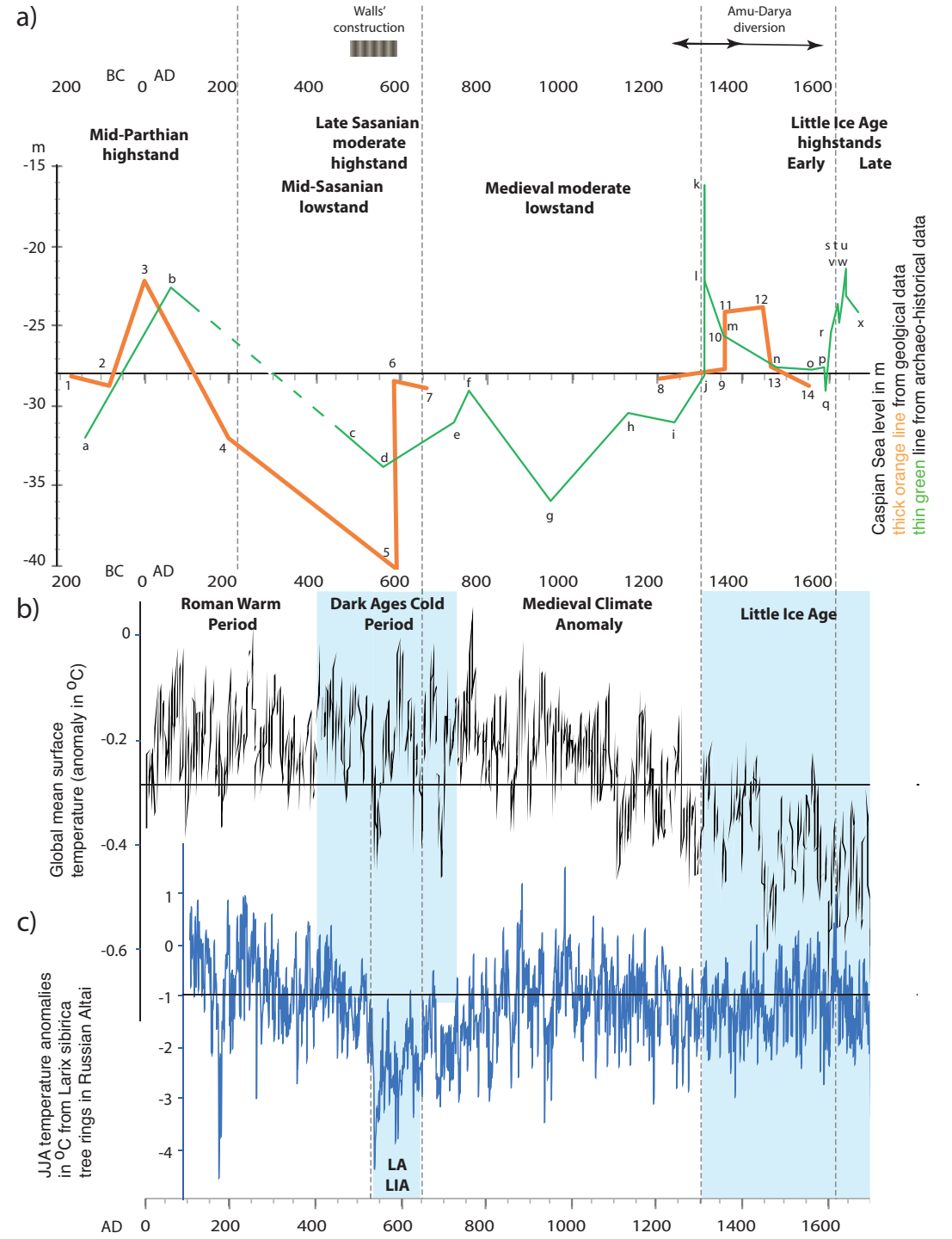
# Causes?

Causes?

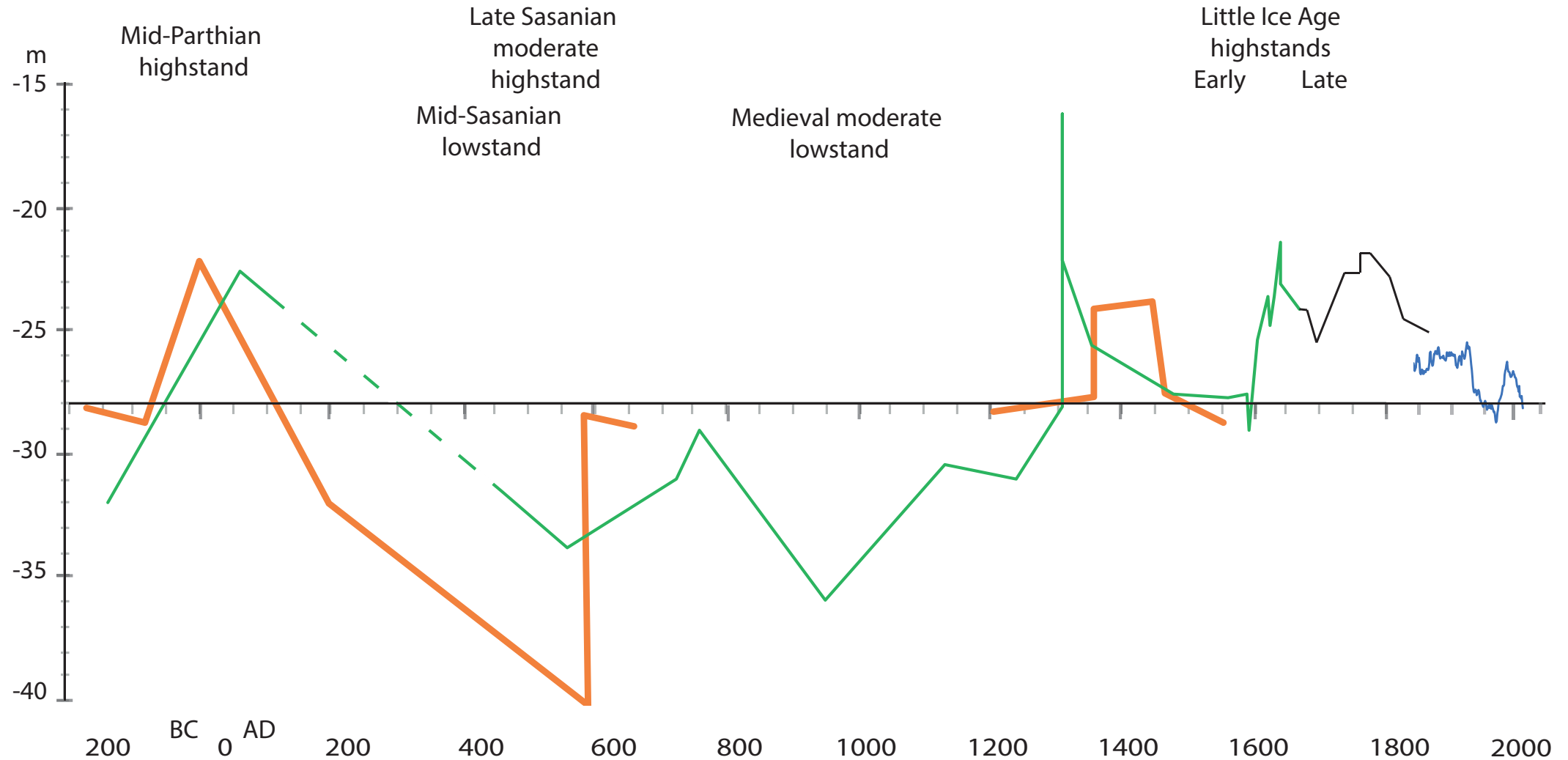
No direct link to global/regional temperatures

Role of A-D diversions?

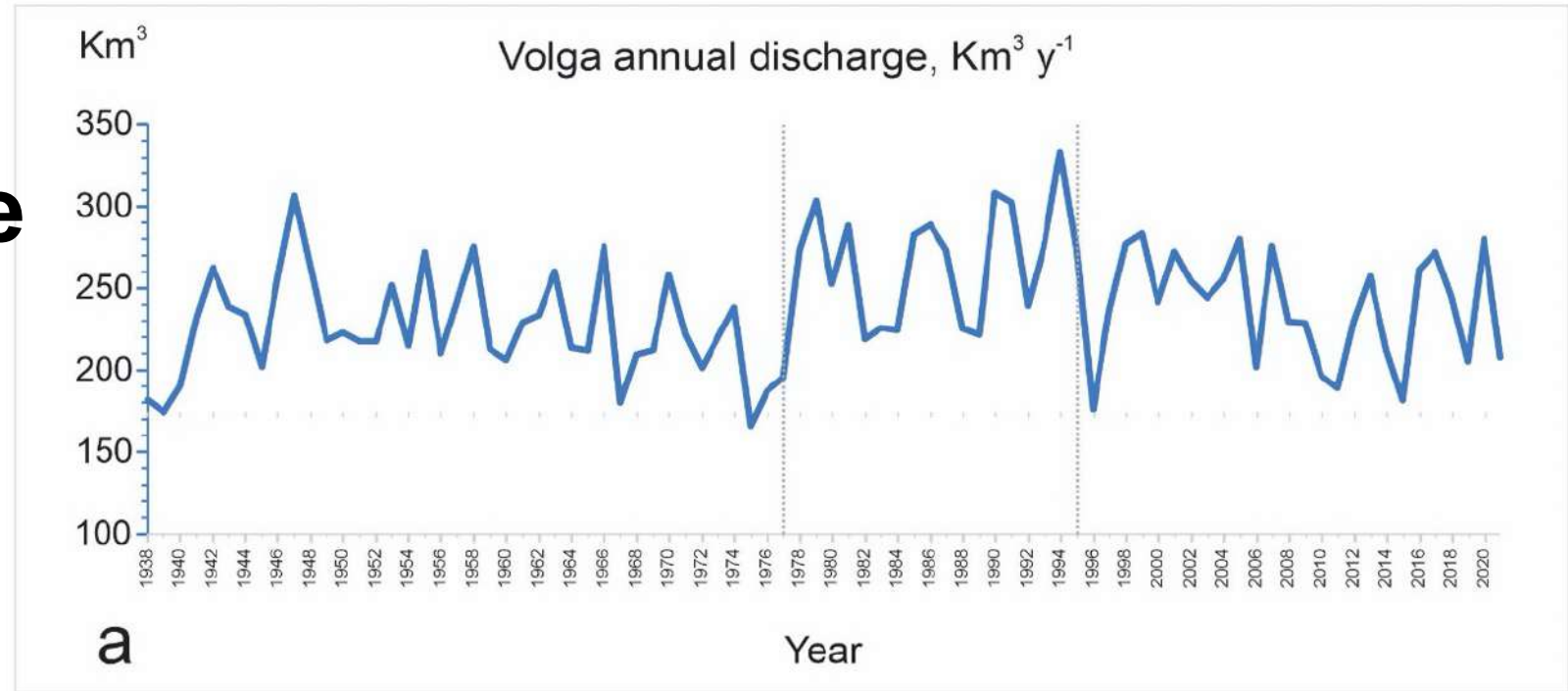
Perhaps a more prominent role of the El-Niño and river diversion caused by humans



# Part 4: the present in the perspective of the past



# Volga discharge

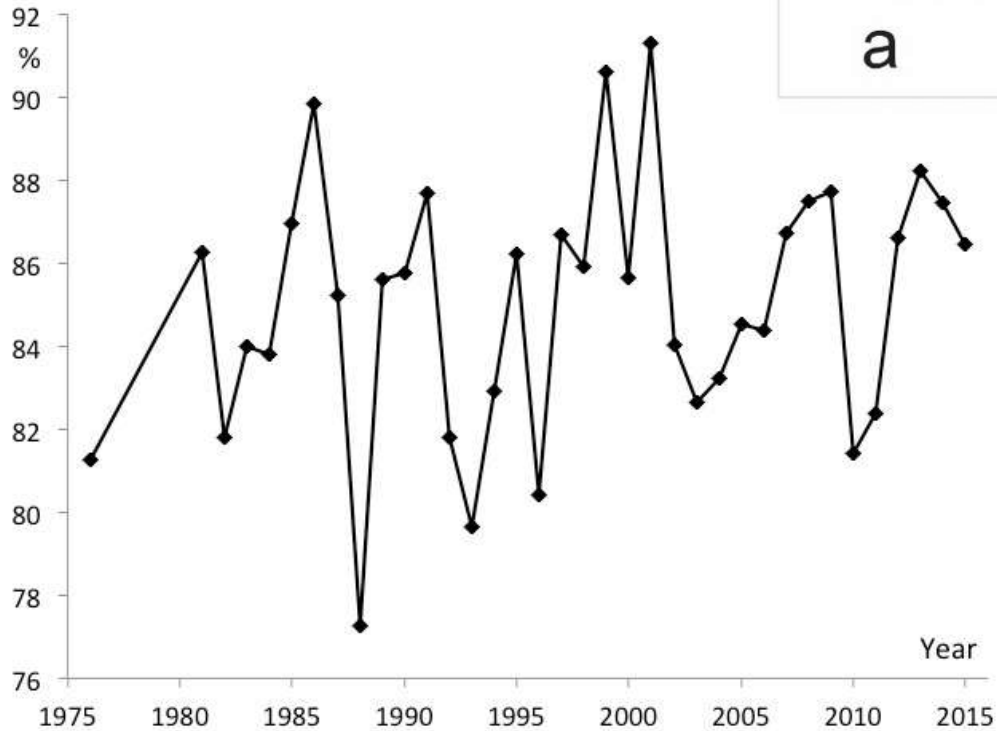


Lahijani et al. 2023

Dominant Volga inflow in the CS budget equation

Other important component of the equation:  
evaporation over the sea

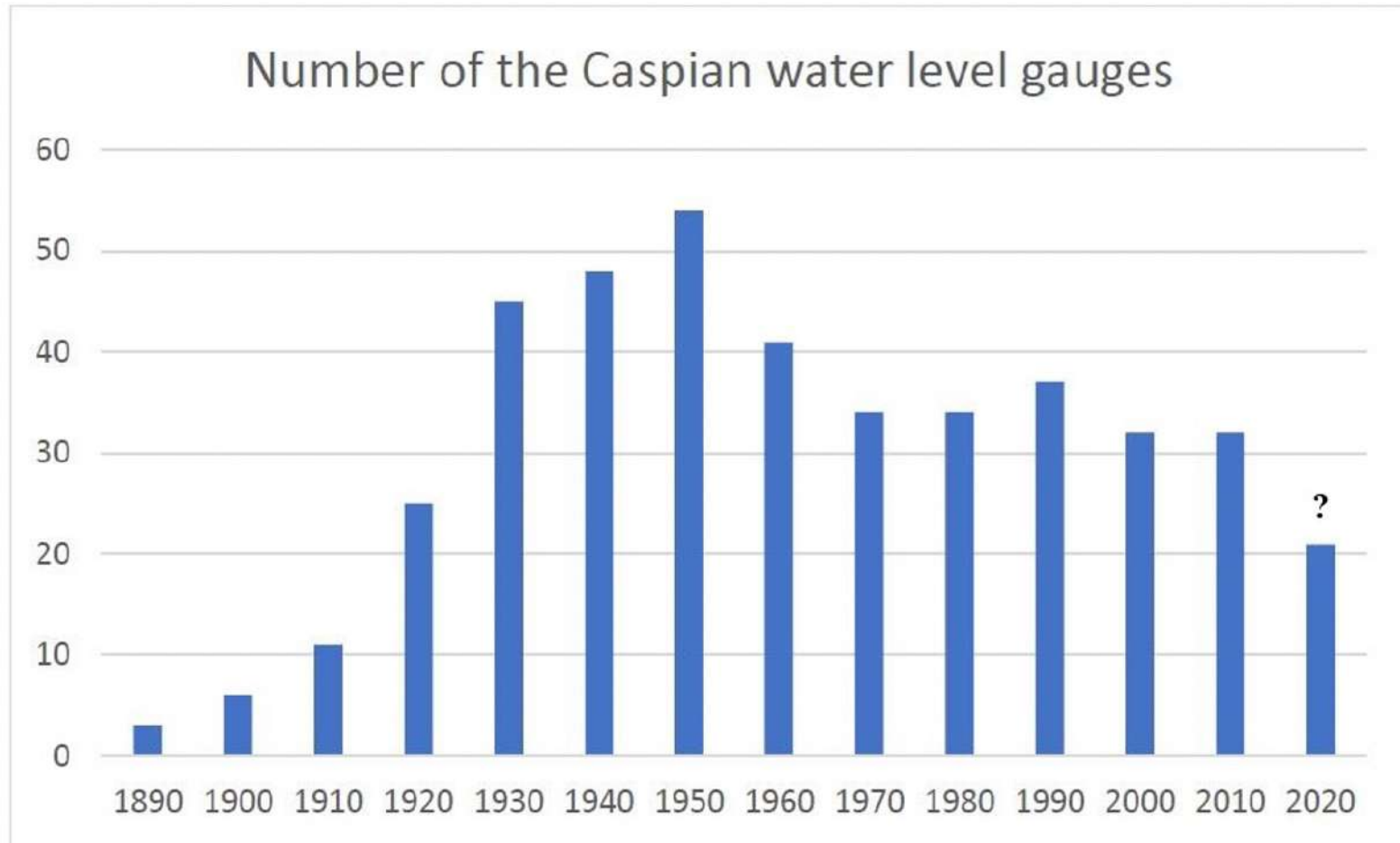
Not measured!  
Only modelled



Leroy et al. 2020



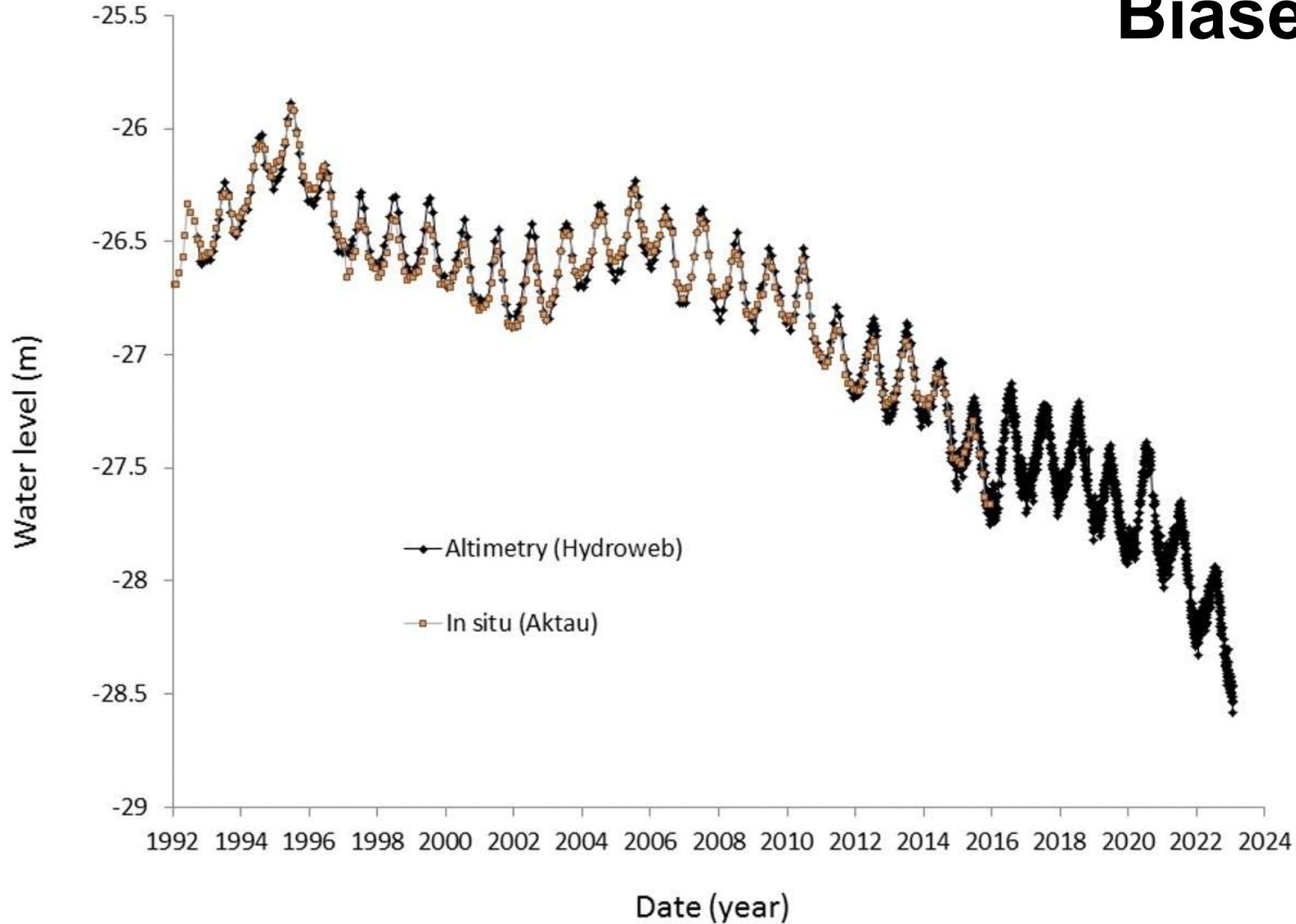
# Measurements of water levels



Gauges  
and  
Altimetric satellites

Fig. 4. Caspian water level stations based on Osmakov (2009) with the addition of some more recent data: i.e. for 2020 the number of gauges with data available at CASPCOM has been included as active stations. The interrogation mark indicates that due to rapid falling water level the number probably needs correction.

# Biases

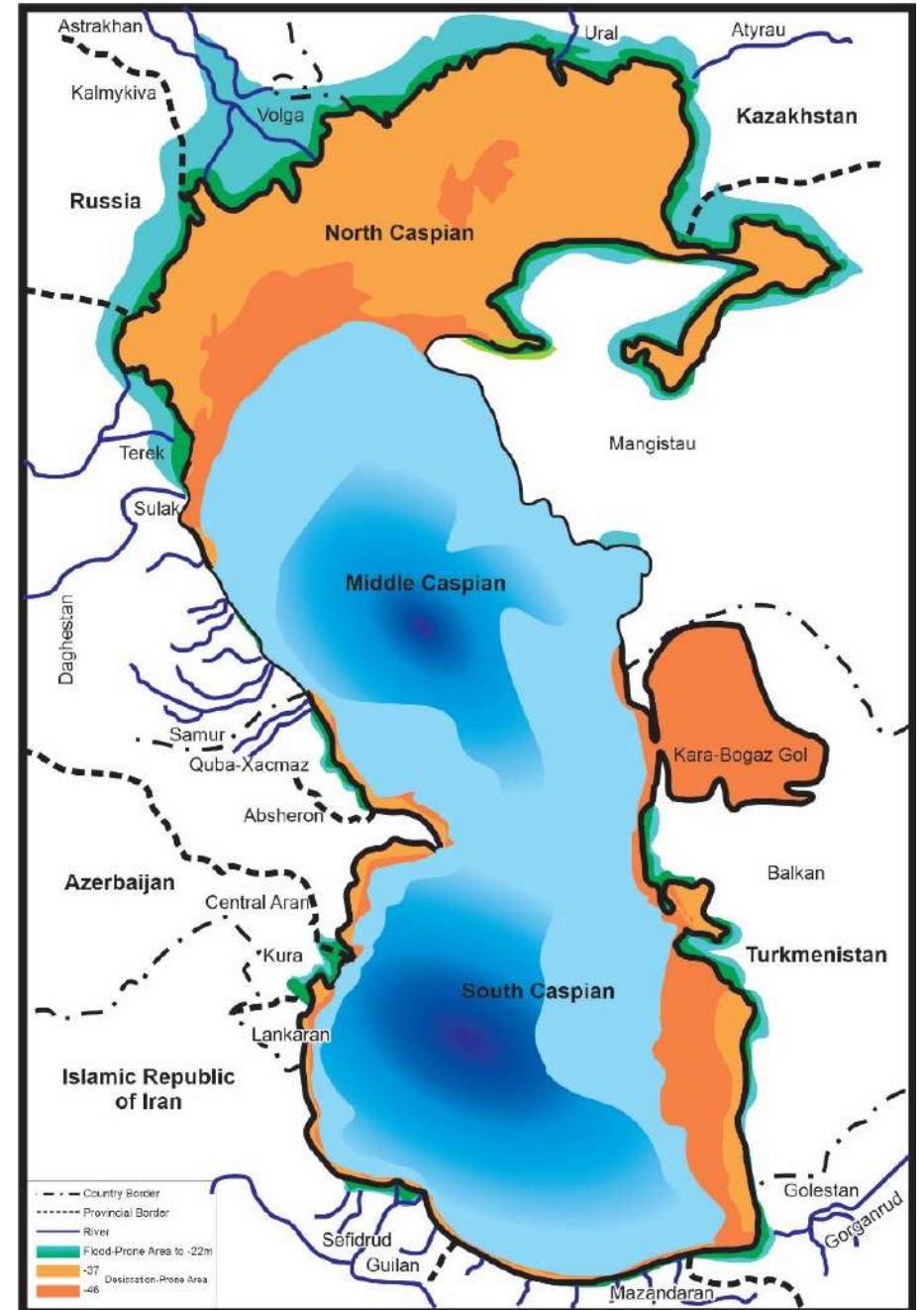


Need of calibration of the satellites

# Horizontal changes

Caspian coastal inundation in case of water level rise

Desiccation in case of water level fall

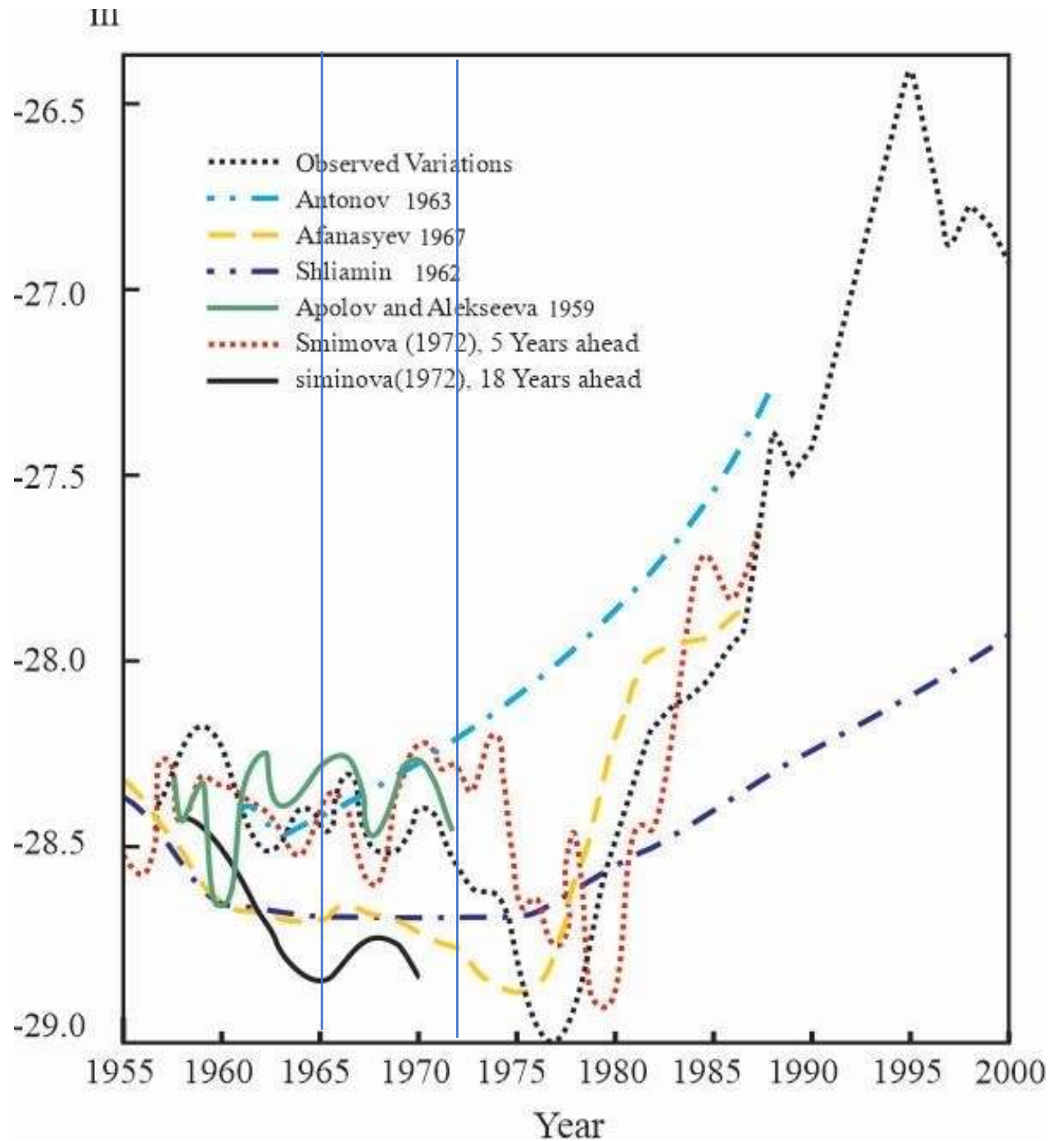


# Forecast

The Caspian Sea level forecasts and observed curves.

All of these forecasts were made when the Caspian Sea level was declining

No agreement



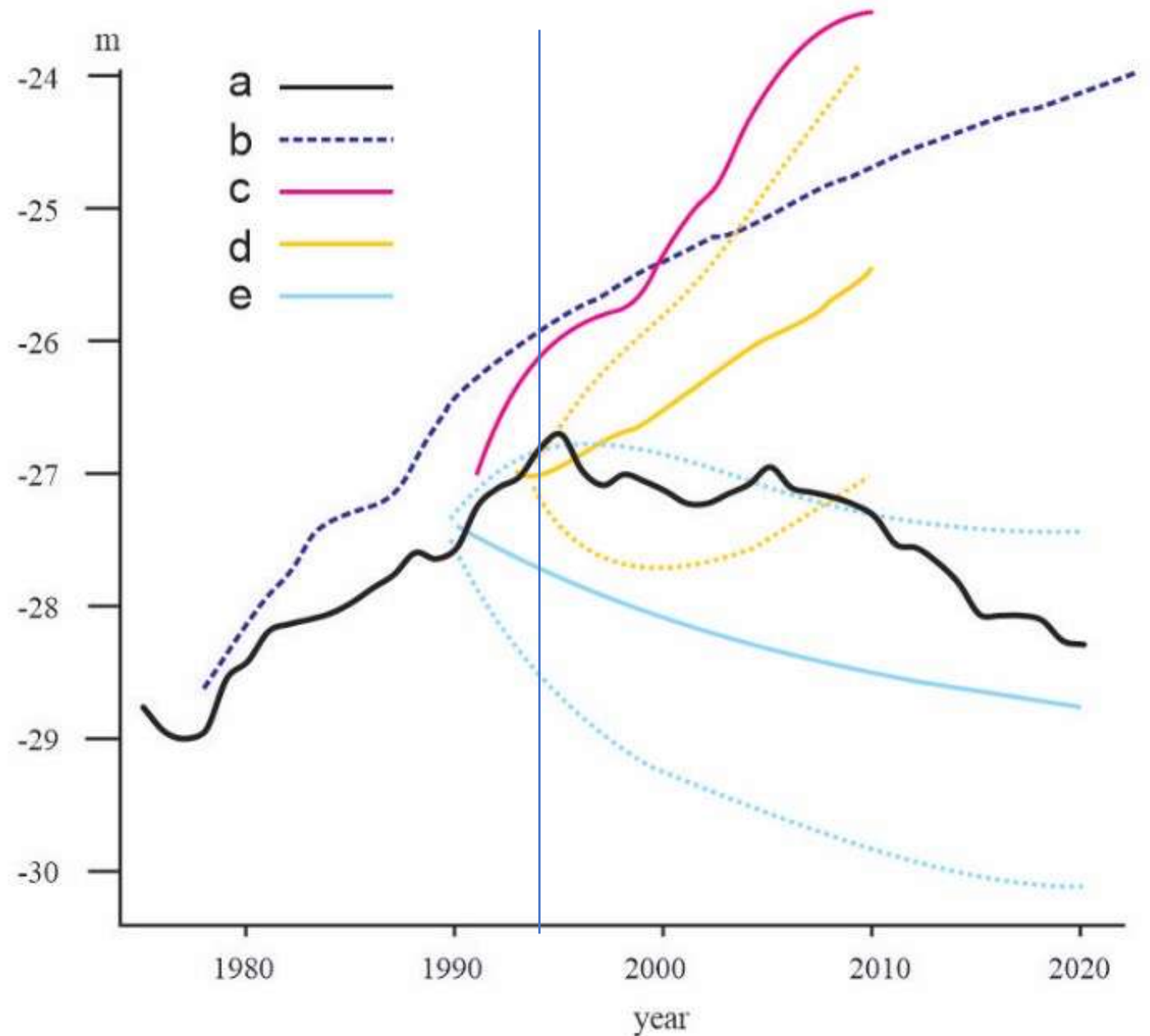


# Forecast

The Caspian Sea level forecasts and observed curves.

All of these forecasts were made during the period of CSL high stand.

- a) Observed
- b) Malinin, 1994
- c) Kazanskii, 1994
- d) Ratkovich and Bolgov, 1994
- e) Klige, 1994



# Forecast

Variability from 1900 to 2100

- a) observed
- b) reconstructed after Arpe and Leroy (2007)

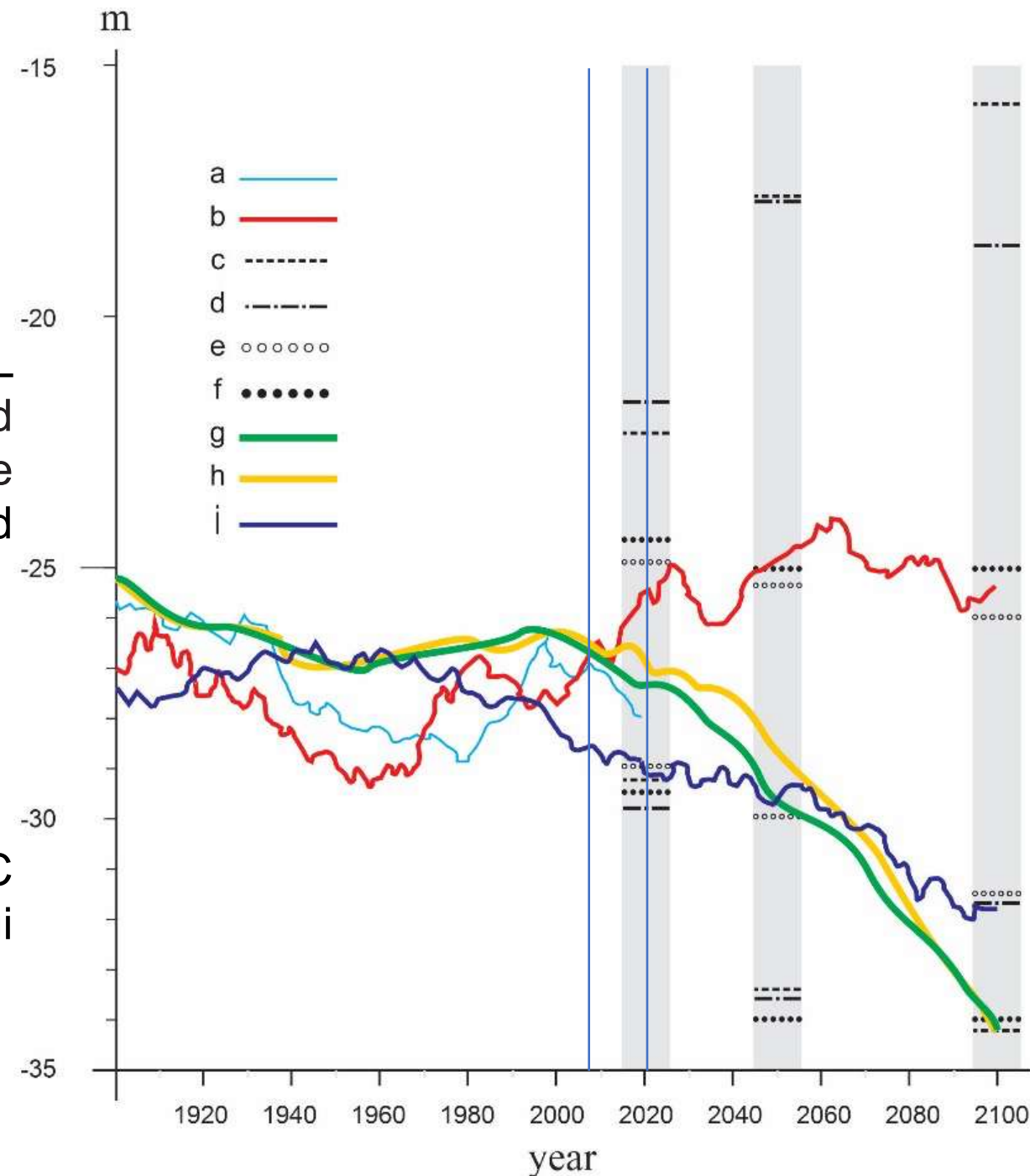
lowest and highest ranges for the forecast of the CSL using different models and scenarios of shared socioeconomic pathways (SSPs) and representative concentration pathways (RCPs) for 2021, 2050 and 2100 after Koriche et al. (2021a)

- c) RCP4.5,
- d) RCP 8.5,
- e) SSP245
- f) SSP585

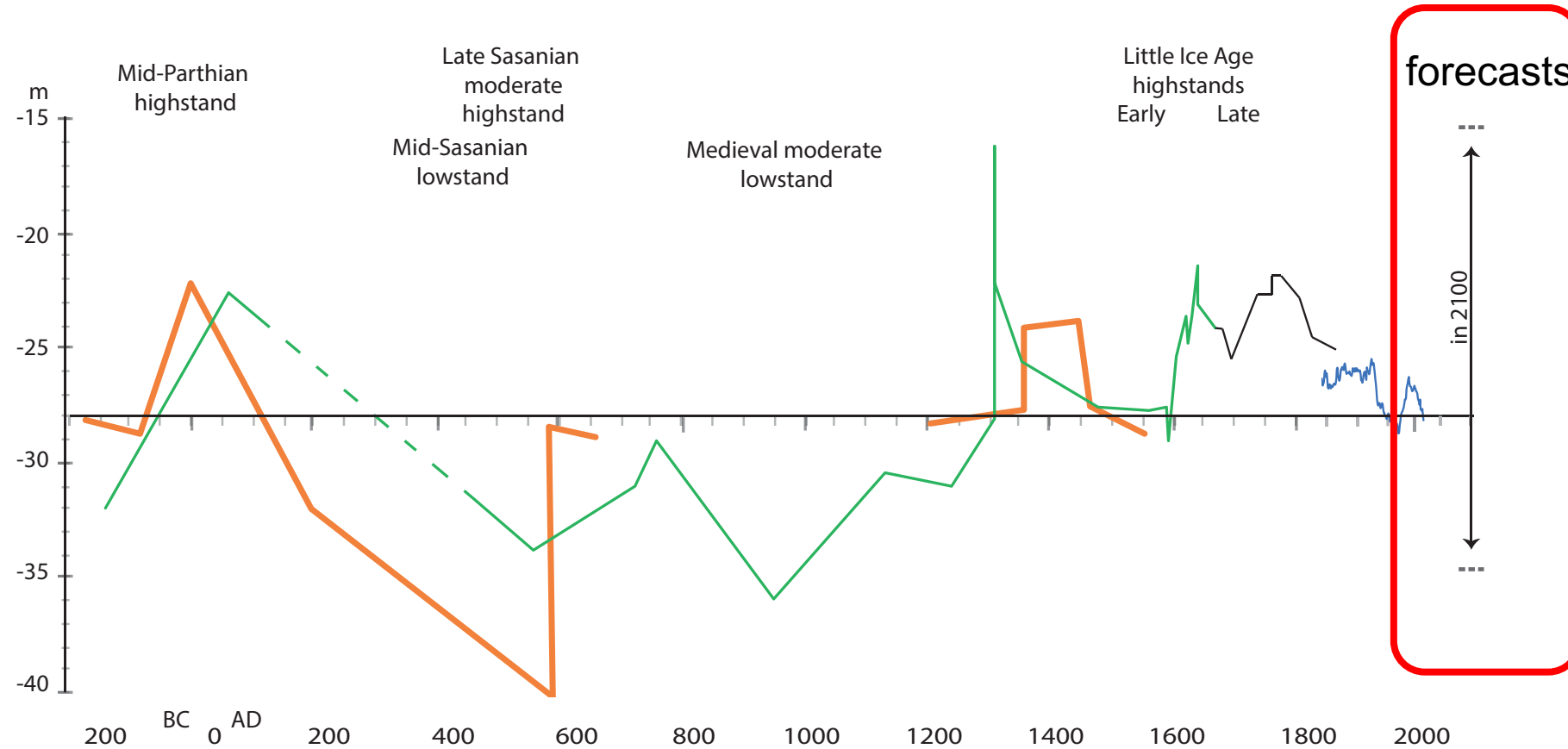
ensemble average CSL forecast based on the IPCC scenario emissions respectively, Elguindi and Giorgi (2006),

- g) A2
- h) A1b

i) Renssen et al. (2007)



# Conclusion: the past, now and the future



# References

- Lahijani H, Leroy SAG, Arpe K, Crétaux J-F, 2023. Caspian Sea level changes during instrumental period, its impact and forecast: A review. **Earth Science Reviews**
- Leroy S.A.G., Reimer P.J., Lahijani H.K., Naderi Beni A., Sauer E., Chalié F., Arpe K., Demory F., Mertens K., Belkacem D., Kakroodi A.A., Omrani Rekavandi H., Nokandeh J., Amini A., **2022**. Caspian Sea levels over the last 2200 years, with new data from the S-E corner. **Geomorphology** 403
- Leroy S.A.G., Demory F., Chalié F., Bates R., Bates M., Omrani Rekavandi H., Sauer E., **2022**. Palaeoenvironments at the Caspian terminals of the Gorgan and Tammisheh walls. 13: 425-441. In Sauer et al. “Ancient arms race, Antiquity’s Largest Fortresses And Sasanian Military Networks Of Northern Iran”. The British Institute of Persian Studies, Archaeological Monographs Series VII, **Oxbow book**.
- Leroy S.A.G., Lahijani H., Crétaux J.-F., Aladin N., Plotnikov I., **2020**. Past and current changes in the largest lake of the world: The Caspian Sea. In: Mischke S. (ed.) Large Asian lakes in a changing world. **Springer** 65-107.



THANK YOU



Iranian coast 2005 in Miankaleh