C. Morhange

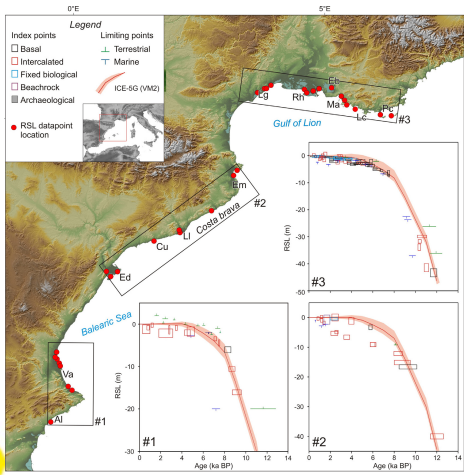
Géoarchéologie des ports antiques

Quo vadis ?

OINIADAI, Patras gulf, III BC

Delta de l‘Acheloos

Landsat 7 ETM+ Intensity Layer, 1999



Histoire des impacts de l'anthropisation

Histoire du niveau marin et archéologie littorale

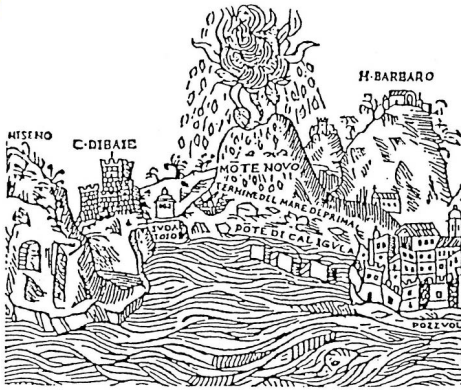
Paléo-environnements et archéologie des paysages

Histoire des environnements Archéosciences

Histoire des rivages et mobilité des ports

Histoire des risques et néo-catastrophisme

Préservation du patrimoine archéologique sous-marin et côtier



Benoit
Gouvernet
Mars

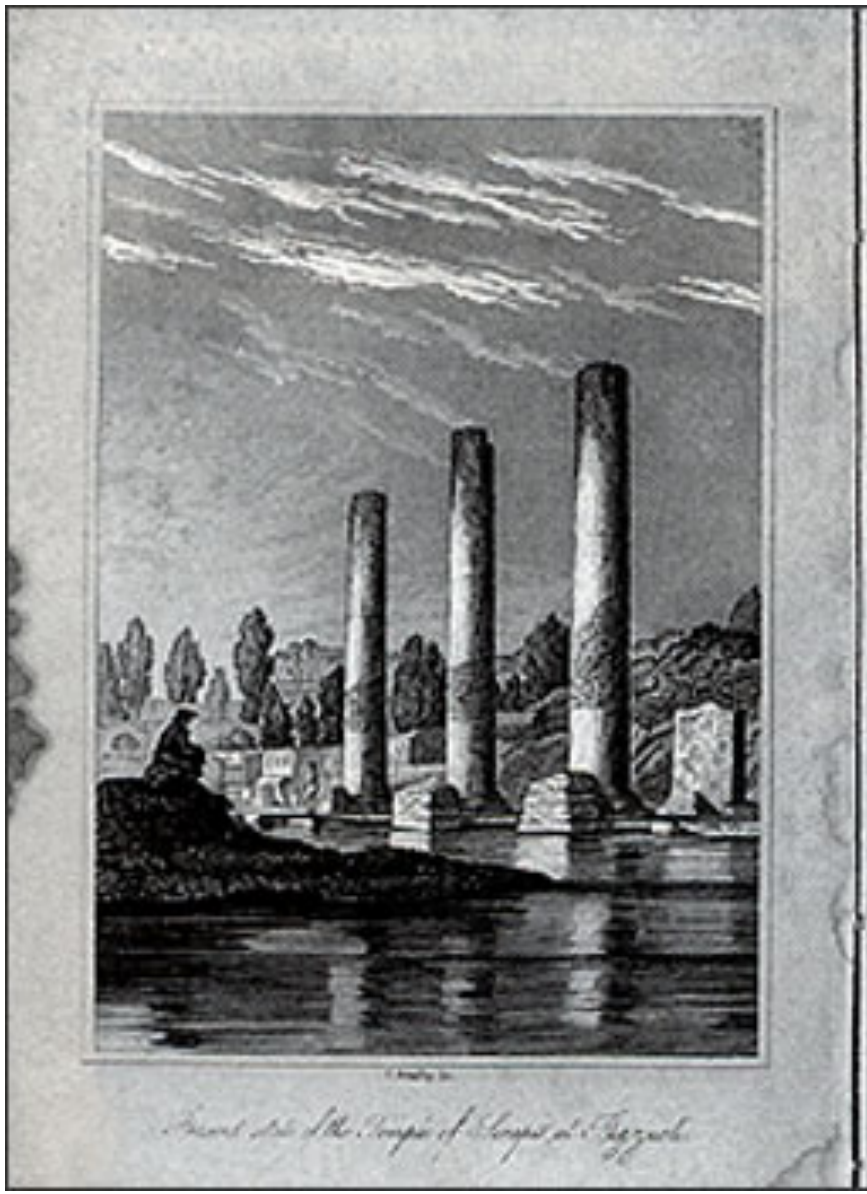
Vue des destructions et des zones en cours de fouilles archéologiques.
Cliché: Collection F. Benoit, SRA, Aix.

Outline

- Relative sea-level changes since 6.000 years / water columns (fishpond, Magdala)
- Coastal deformations and sedimentary budget / Harbour location / palaeo-geography (Akko, Gizzeh)
- Sedimentary processes/energy/hazards (Aquileia, Tipaza, Yenikape). Neocatastrophism /factoids
- Anthropogenic impacts (Napoli, Alexandria…)

1. Relative sea-level changes since 6.000 years / water columns

Rapid sea-level movements and noneruptive crustal deformations in Pozzuoli (Italy)



PRINCIPLES

OF

GEOLOGY,

BEING

AN ATTEMPT TO EXPLAIN THE FORMER CHANGES OF THE EARTH'S SURFACE,

BY REFERENCE TO CAUSES NOW IN OPERATION.

BY

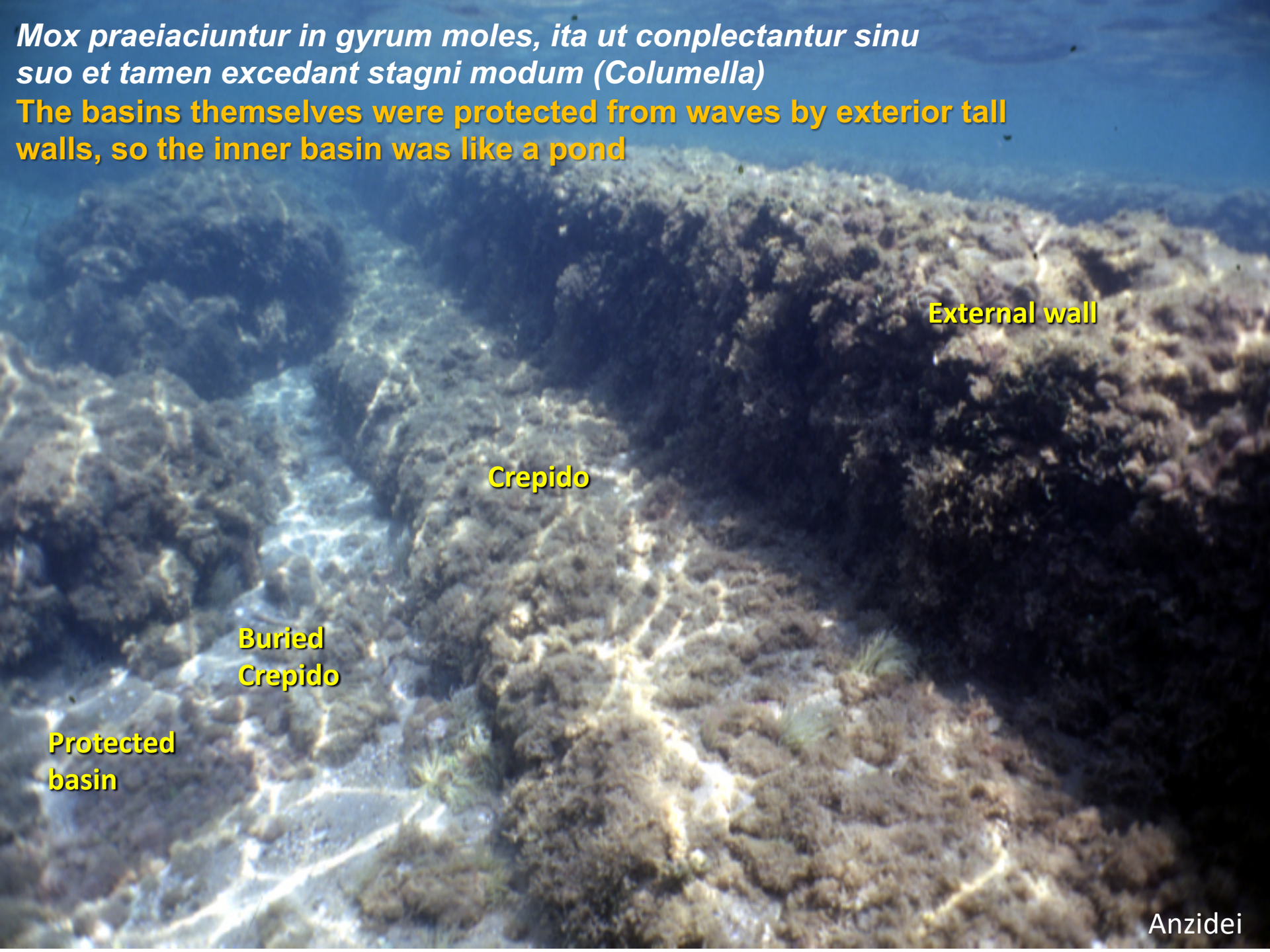
CHARLES LYELL, Esq., F.R.S.

IN TWO VOLUMES.

Vol. I.

LONDON:

JOHN MURRAY, ALBEMARLE-STREET.


Mox praeiaciuntur in gyrum moles, ita ut conplectantur sinu suo et tamen excedant stagni modum (Columella)
The basins themselves were protected from waves by exterior tall walls, so the inner basin was like a pond
External wall
Crepido
Buried Crepido
Protected basin
Anzidei

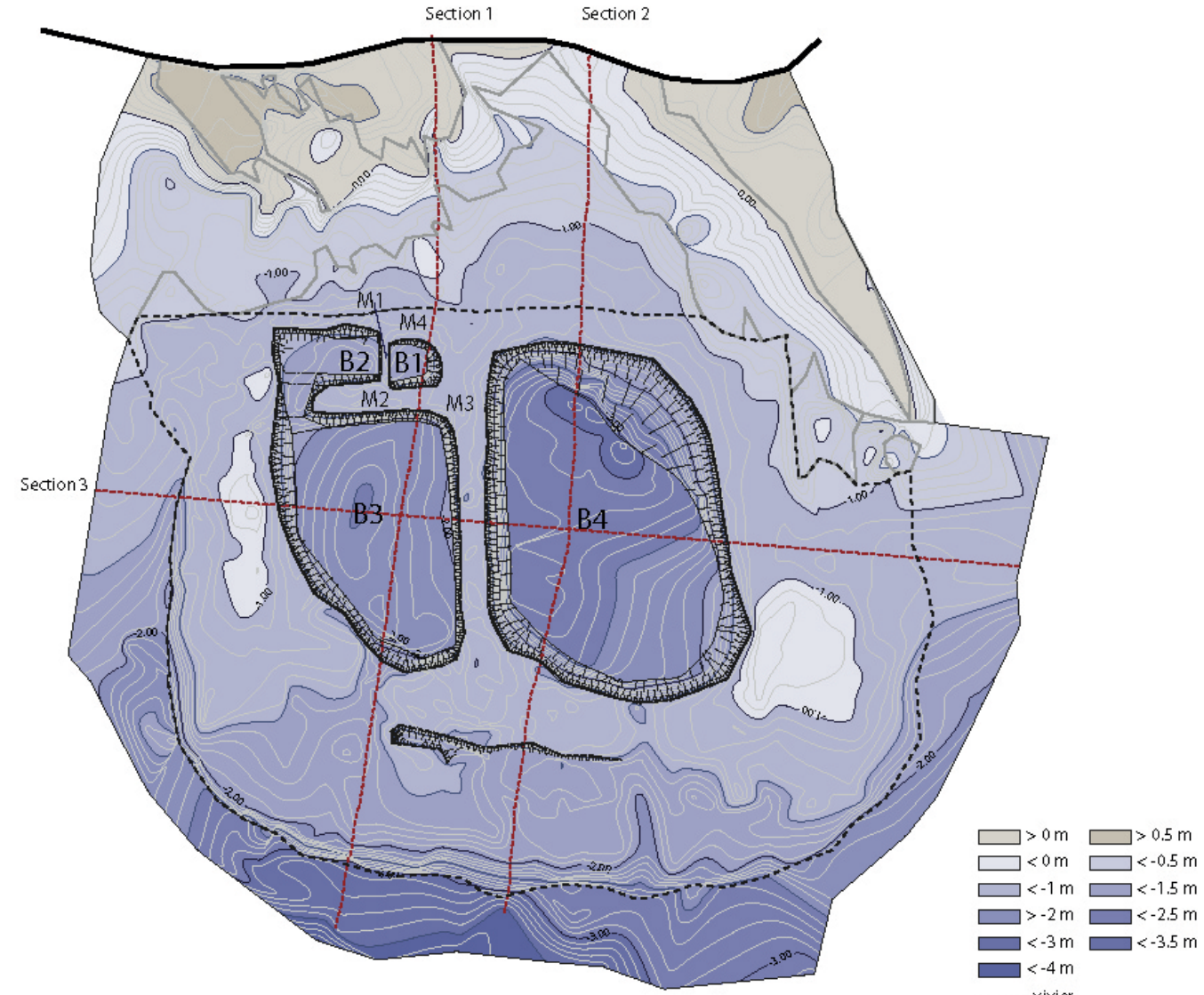

ITALIE
Aquileia
Tergeste
SLOVENIE
S. Bartolomeo
Fisine
Catoro
Viviers sumergés
de l'Istrie
Kupanja
Busuja
Parentium
CROATIE
Programmes Ministère des Affaires étrangères
dir. M. B. Carre
Brioni
Pola

San Bartolomeo (SLO)

VIVIERS	*Dim. Max (m)*	*Dim. Min.*	*Sup. Totale (m2)*	*Sup. interne*	*Nb bassins*
Kupanja	**100**	**95**	**7500**	**2500**	**4**
Katoro	**65/70**	**60/65**	**4000/4500**	**1200**	**4 dt 2petits**
S. Bartolomeo	**135**	**80/50**	**6750/ 8550**	**2200**	**2**
Fizine	**65**	**28/36**	**3036**	**1432**	**2**
Svršata	**35**	**30**	**1050**	**600**	**1**
Busuja	**L :48**	**L : 18,8**	**900**	**400**	**5 + 5 (?)**

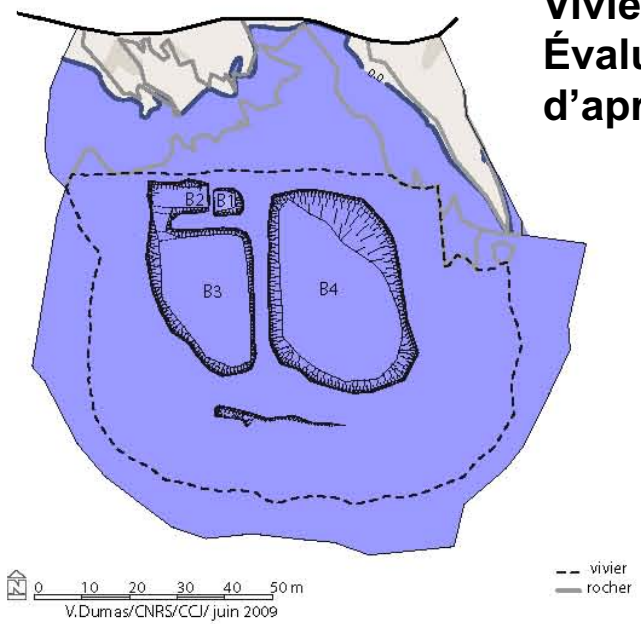
Dimensions très différentes, deux types différents

KATORO - Planimétrie (3 juillet 2009)

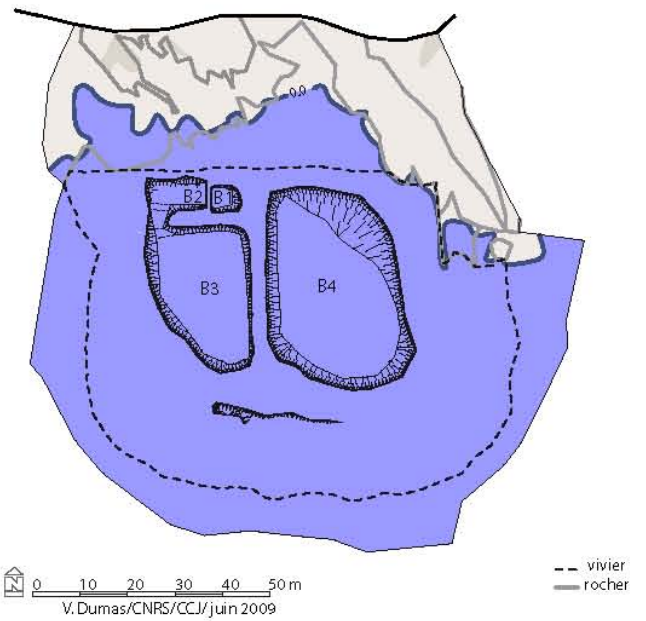


V. Dumas/CNRS/CCJ/ juin 2009

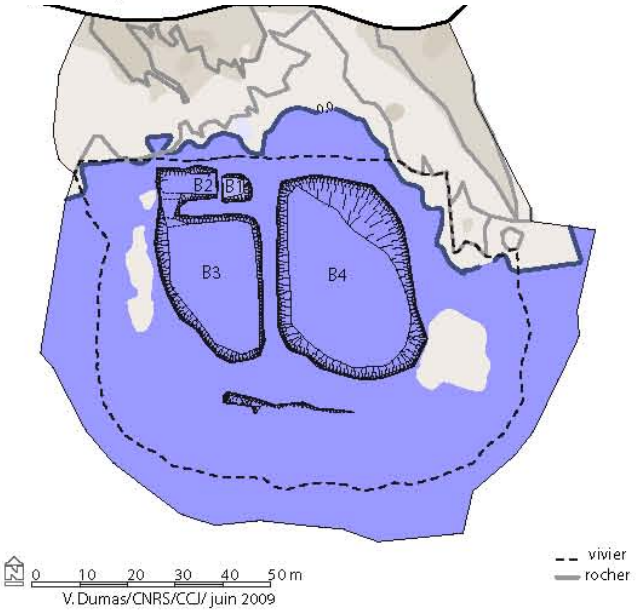
Vivier de Katoro, Évaluations d'après le MNT



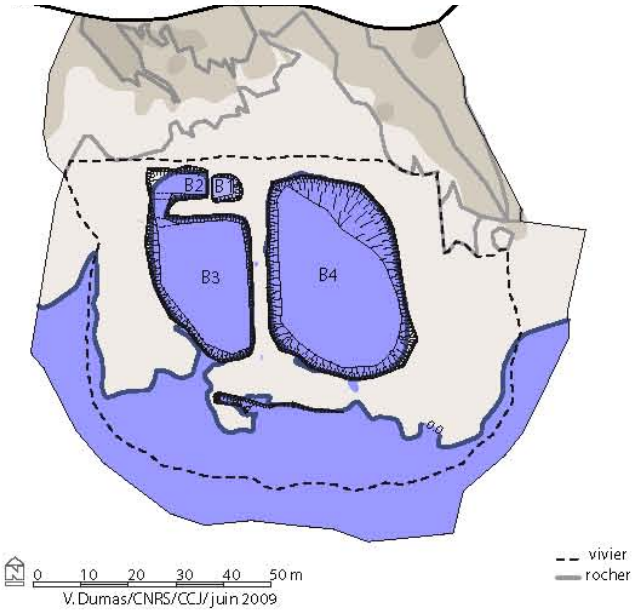
niveau moyen actuel de la mer Adriatique : Marégraphe de Trieste



-0.70 m du niveau moyen actuel de la mer Adriatique

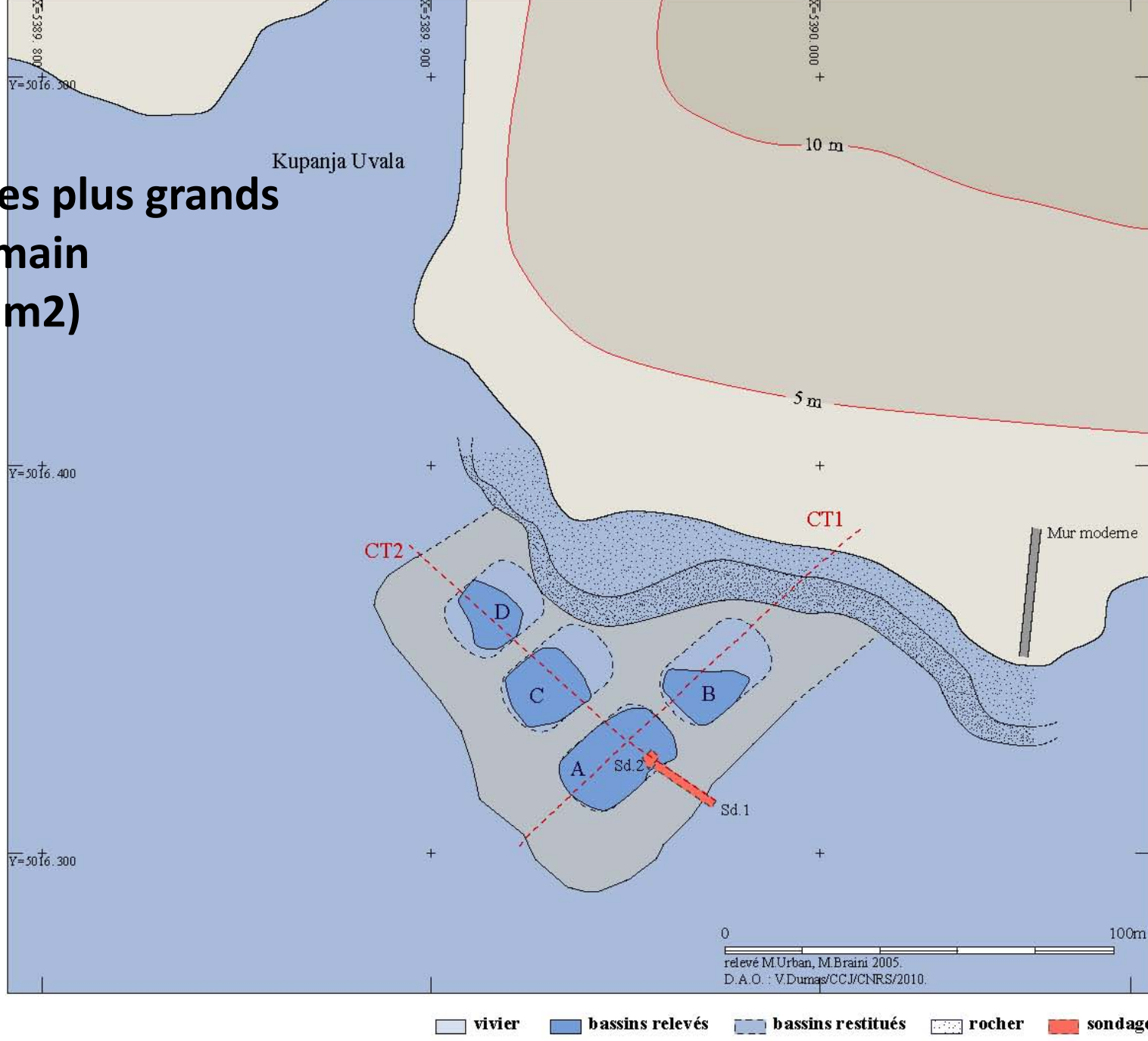


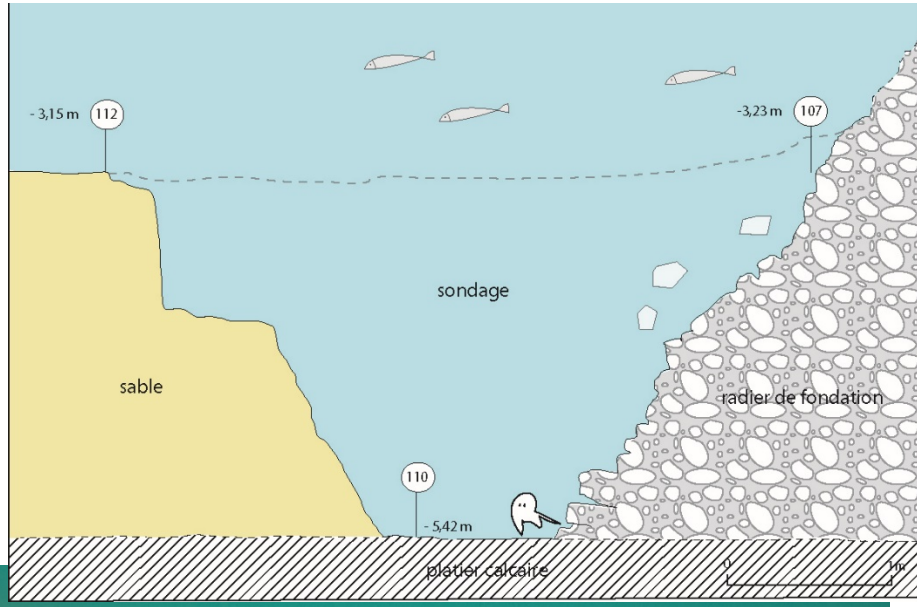
-1 m du niveau moyen actuel de la mer Adriatique



-1.5 m du niveau moyen actuel de la mer Adriatique

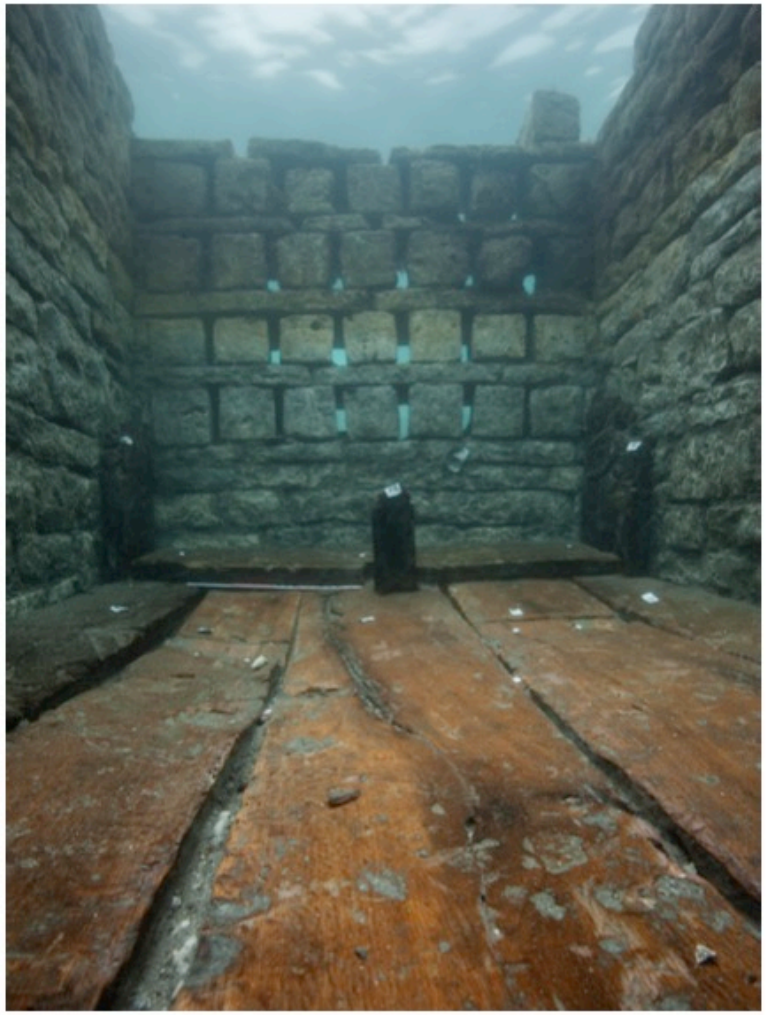
Kupanja, un des plus grands du monde romain (près de 7500 m2)





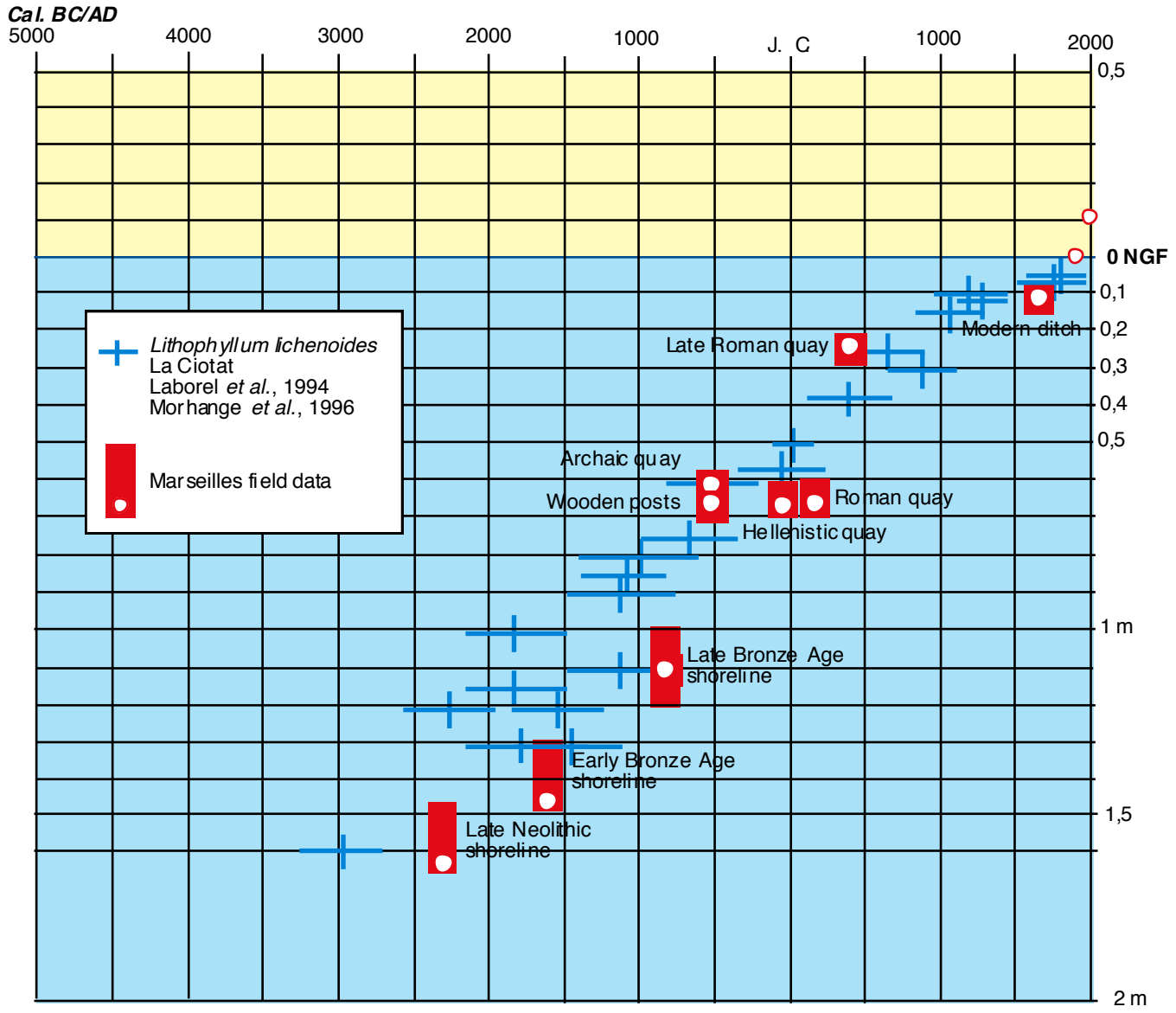
KUPANJA
Une fondation
de blocs jetés en vrac

Busuja, vivier à anguilles ?



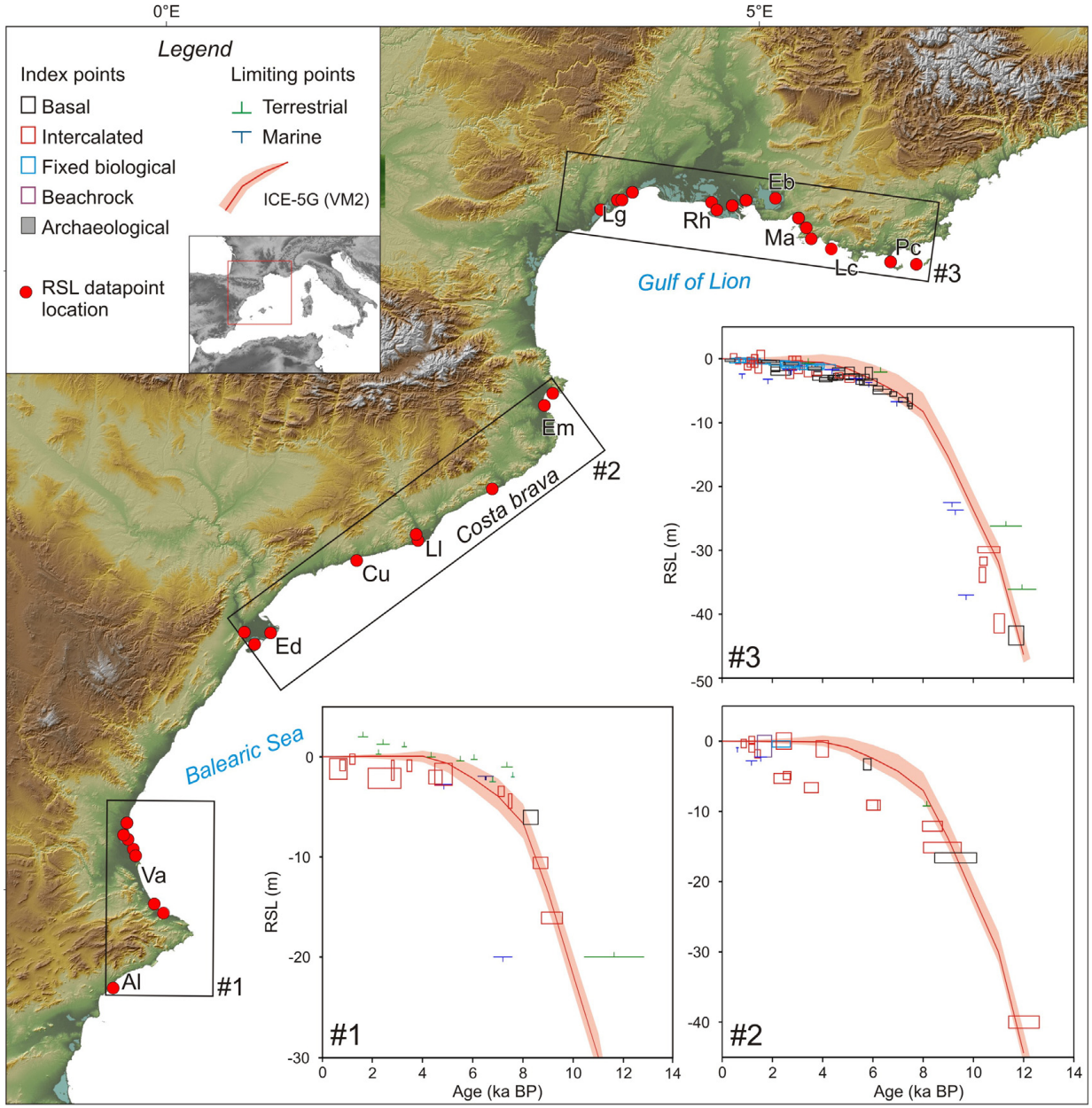
Pirazzoli
Science, 1974

Vue aérienne oblique des fouilles de la Bourse.
On remarque le quai romain délimitant la darse de
la corne du Vieux Port de Marseille.

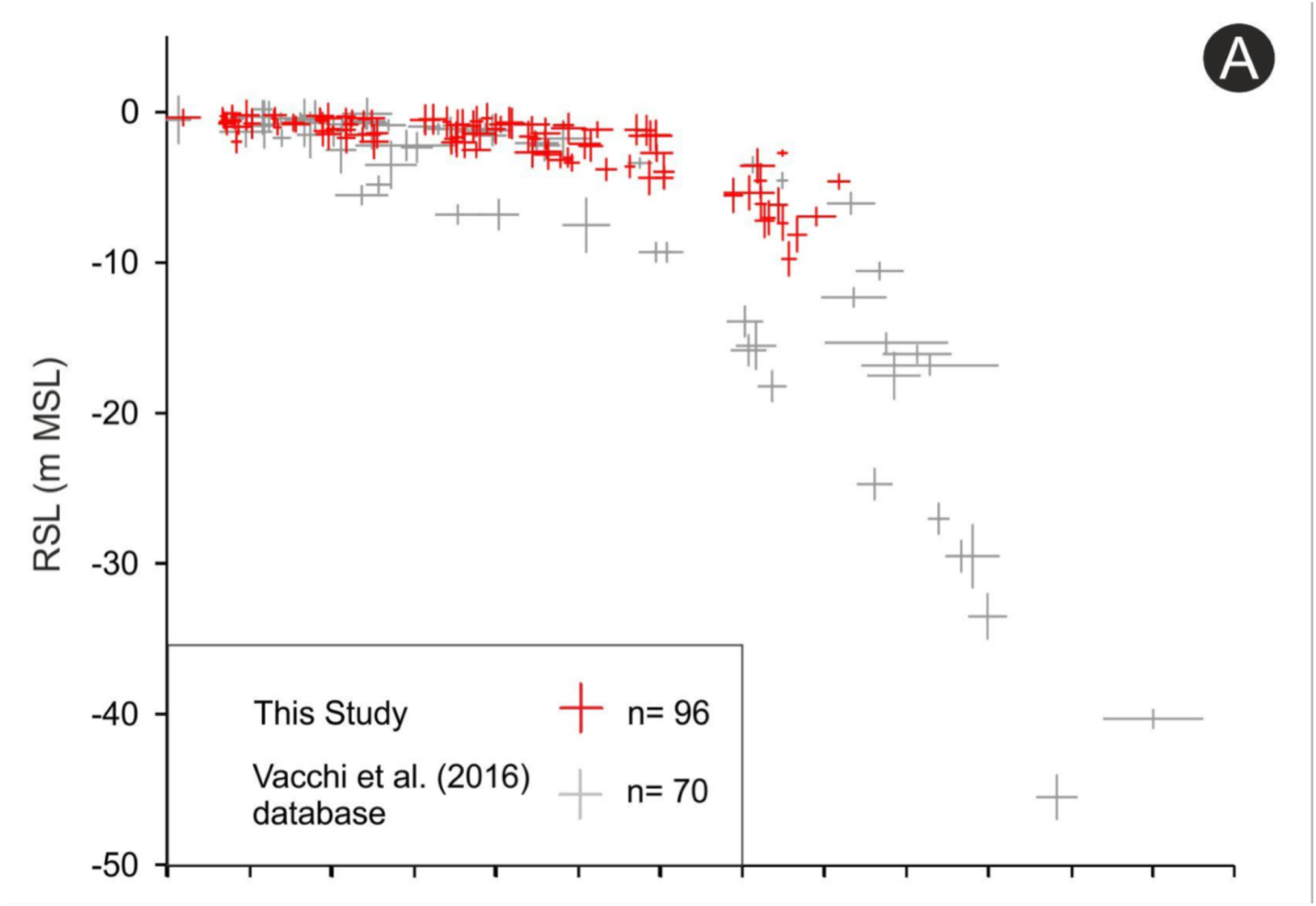

Relative sea level changes in Marseilles
Cal. BC/AD
5000
4000
3000
2000
1000
J. C
1000
2000
0,5
0 NGF
0,1
0,2
0,3
0,4
0,5
1 m
1,5
2 m
Lithophyllum lichenoides
La Ciotat
Laborel et al., 1994
Morhange et al., 1996
Marseilles field data
Modern ditch
Late Roman quay
Archaic quay
Wooden posts
Roman quay
Hellenistic quay
Late Bronze Age shoreline
Early Bronze Age shoreline
Late Neolithic shoreline

Phalasarna, uplift 10 m, 365 AD
Dendropoma

Lechaion, uplift 1,2 m, ca. 340 BC
Balanus



West Med.
Vacchi et al., 2016


A
0
-10
-20
-30
-40
-50
RSL (m MSL)
This Study
n= 96
Vacchi et al. (2016) database
n= 70
5000 cal. BP

Preliminary conclusions RSL

RSL variations are rarely a natural hazard

(except Pozzuoli, Phalasarna, Alexandria…)

Estimation of water columns

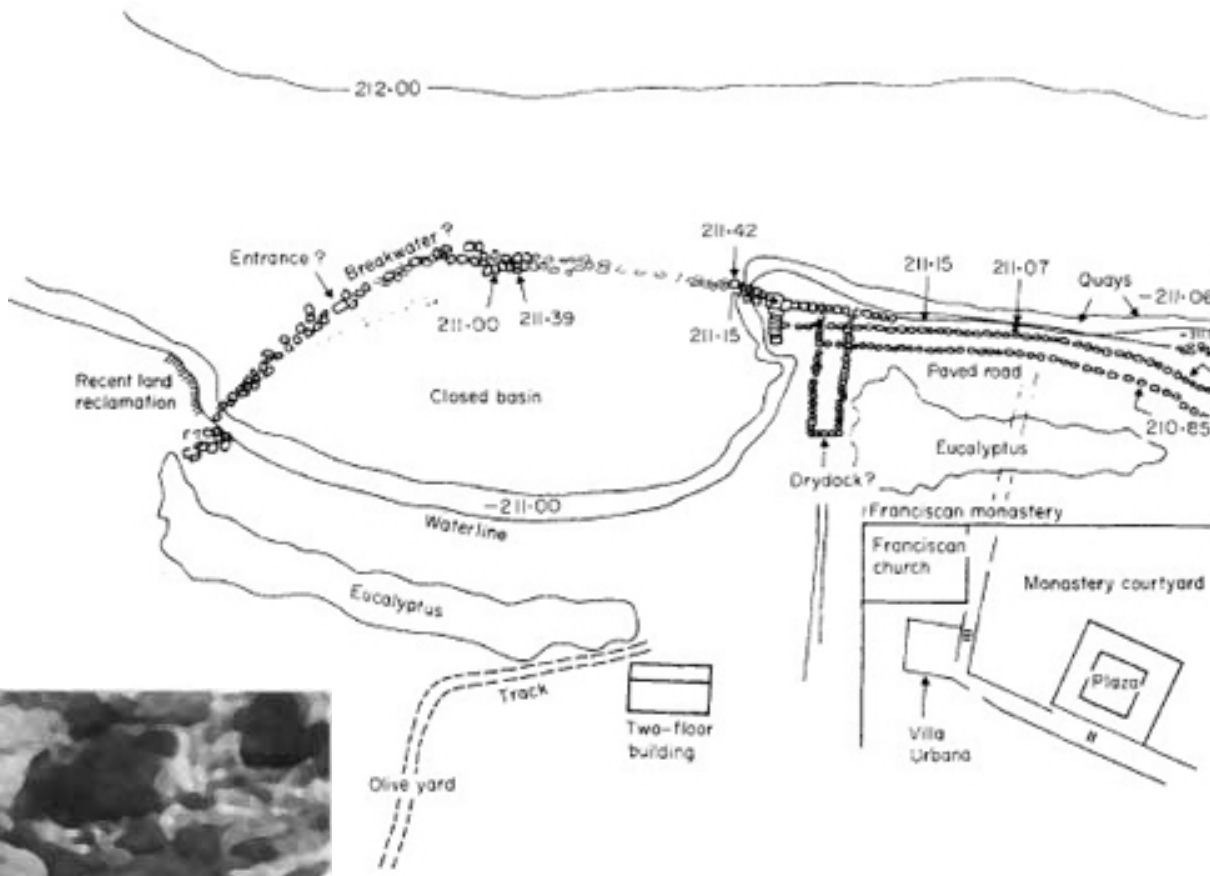
(60 cm ca 525 BC in Marseille ;
Roma, Claudius basin ca. 7 m)

centimetric precision cm with BSL indicators

2. Coastal deformations and sedimentary budget

Magdala Project
S. DE LUCA dir., A. LENA

Arbel : +180 m
Magdala : - 212 m

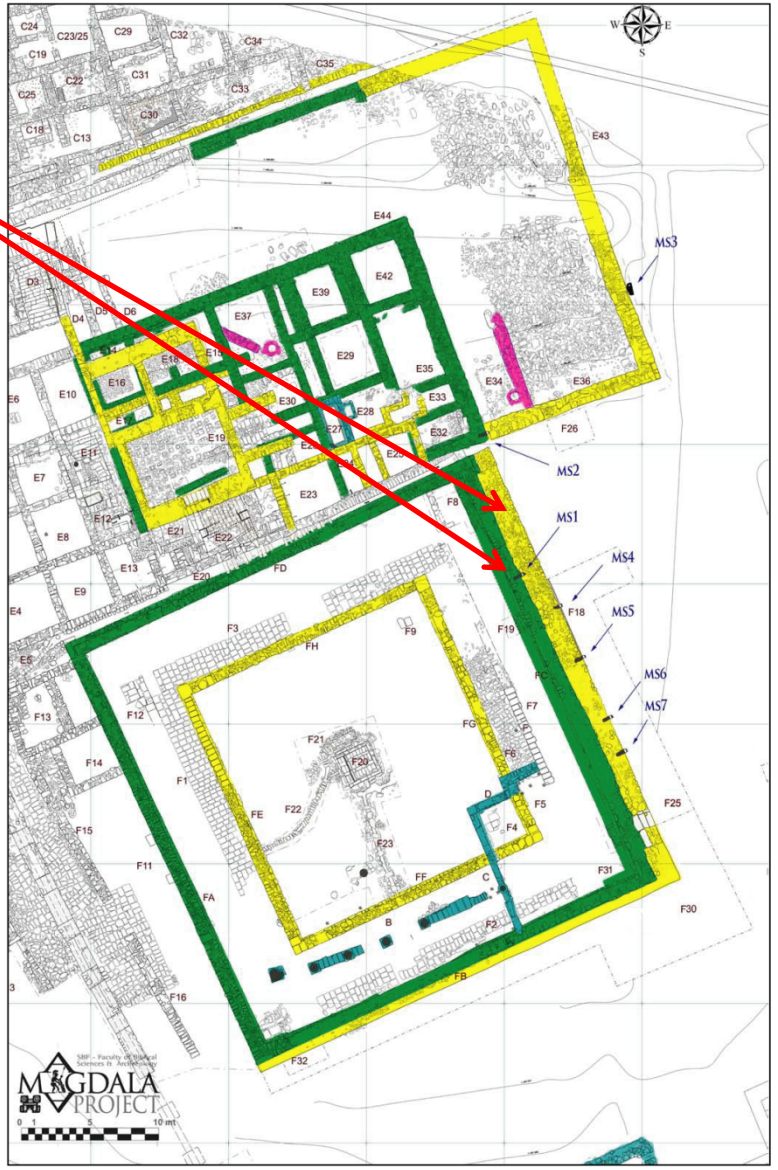


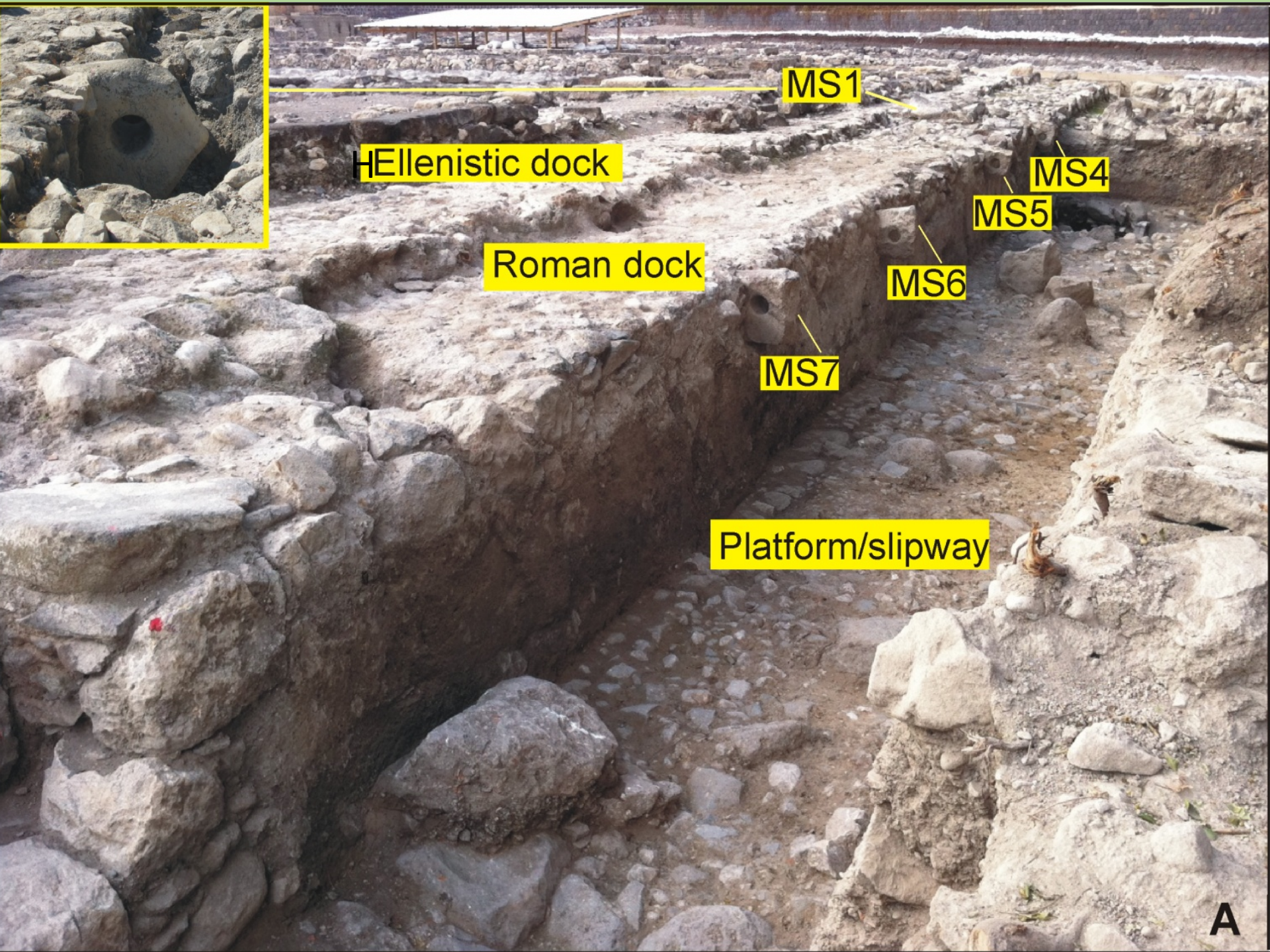
he coastal structures, the anchorage and the quays at Magdala (Migdal Nunia), based on IUES survey 19

Raban A., 1988
The boat from Migdal Nunia
and the anchorages of the Sea of Galilee
from the time of Jesus. IJNA, 17.

Site of Magdala

2008 – Harbour structures (ca -208 m)




MS1
HEllenistic dock
MS4
MS5
Roman dock
MS6
MS7
Platform/slipway
A

Roman quay and slipway
of Magdala (Israel)

Kinneret-sea of Galilee

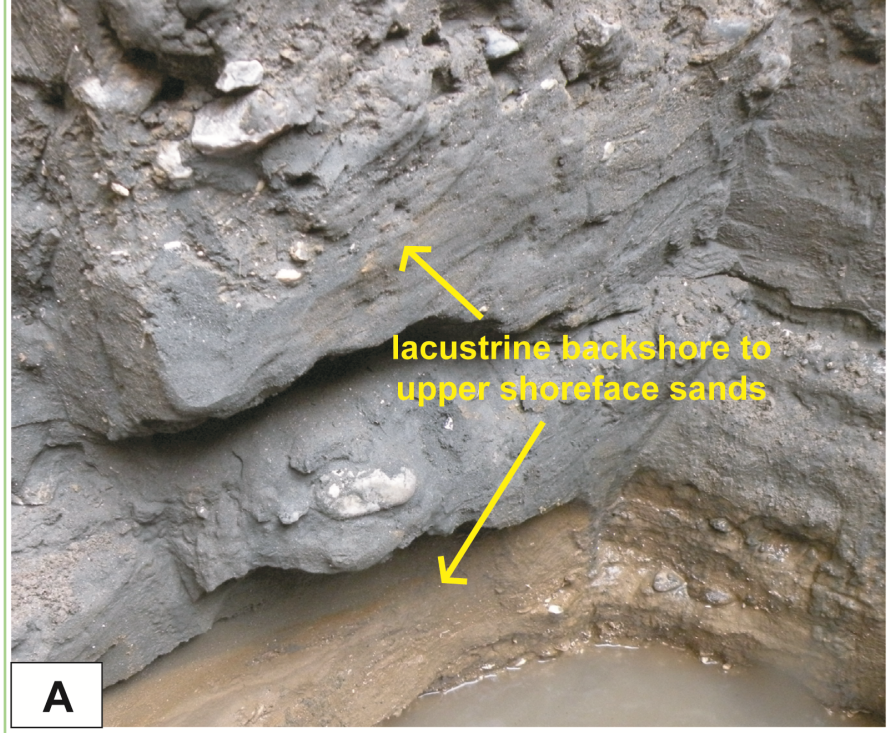
Annual oscillations ca 1.5m

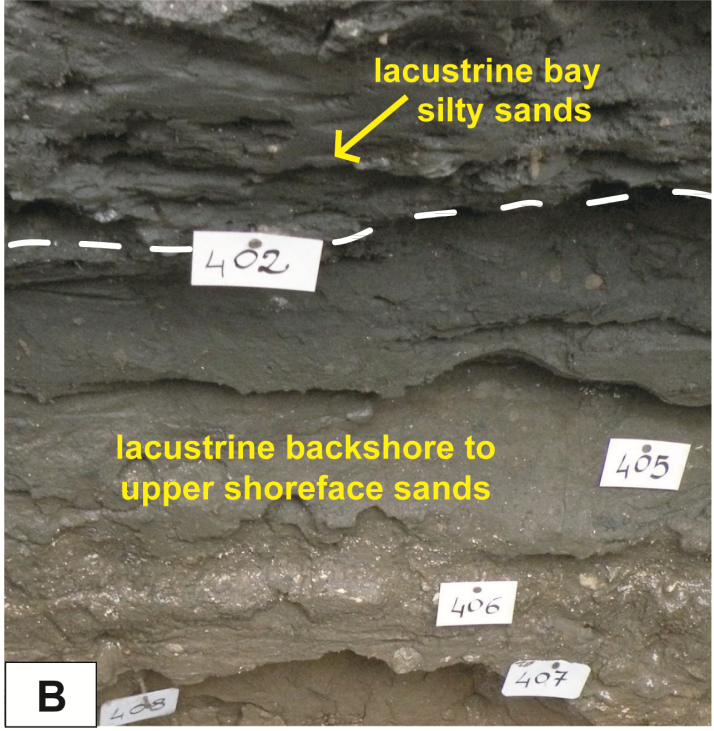
Med. Sea breeze from Arbel

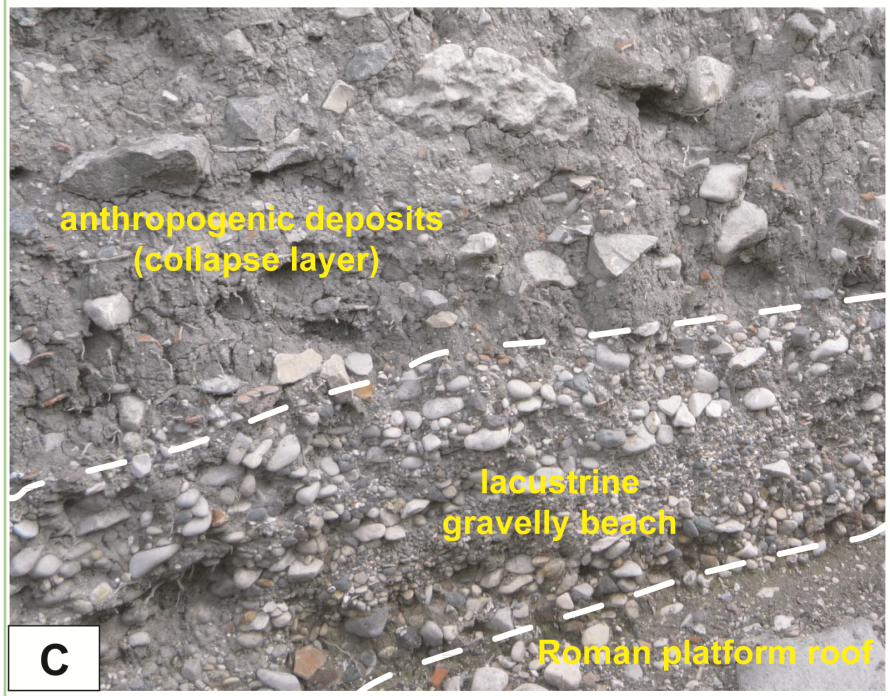
HIGH ENERGY **PRE-HARBOUR** LACUSTRINE FACIES

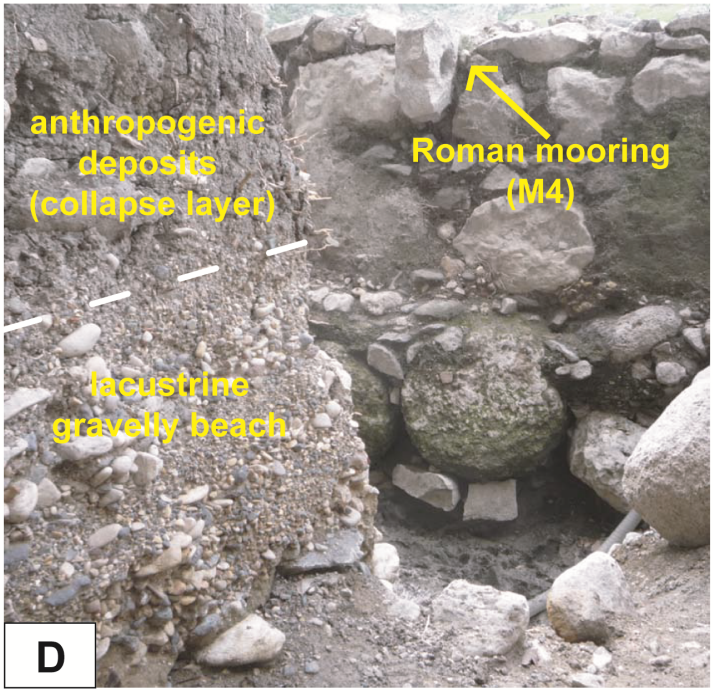
HARBOUR:
Silts
Pseudocandona albicans
Calm waters

POST-HARBOUR
Collapse layer.
Beach gravels



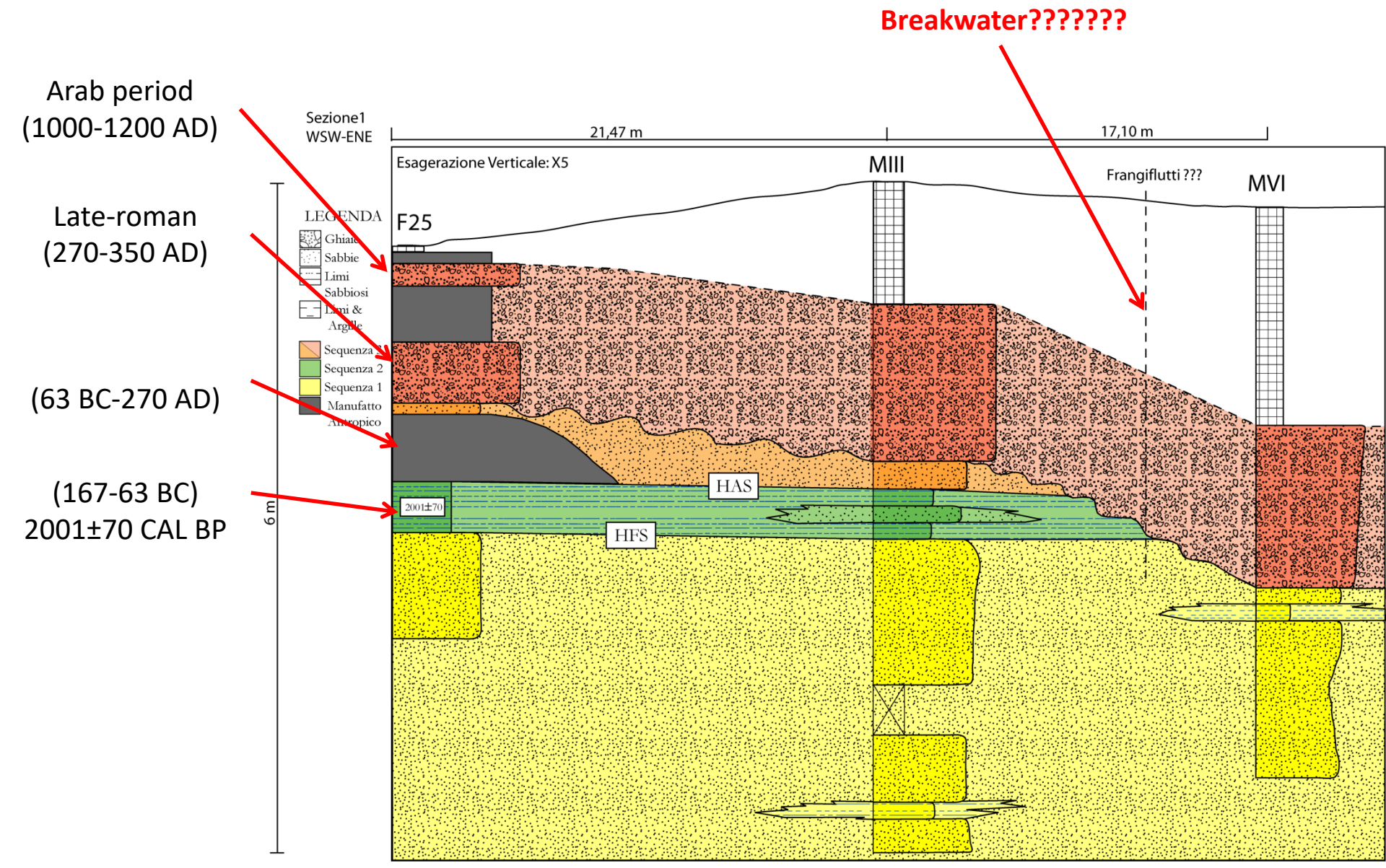






8 Corings (Rossi et al., 2015)

Section 1


Breakwater???????
Arab period
(1000-1200 AD)
Late-roman
(270-350 AD)
(63 BC-270 AD)
(167-63 BC)
2001±70 CAL BP
Sezione1
WSW-ENE
21,47 m
17,10 m
Esagerazione Verticale: X5
MIII
MVI
Frangiflutti ???
F25
LEGENDA
Ghiaie
Sabbie
Limi
Sabbiosi
Limi &
Argille
Sequenza 3
Sequenza 2
Sequenza 1
Manufatto
Antropico
HAS
HFS
2001±70
6 m

Conclusions concerning Magdala

- Importance of the Mediterranean sea-breeze and Arbel topography (sedimentary budget)

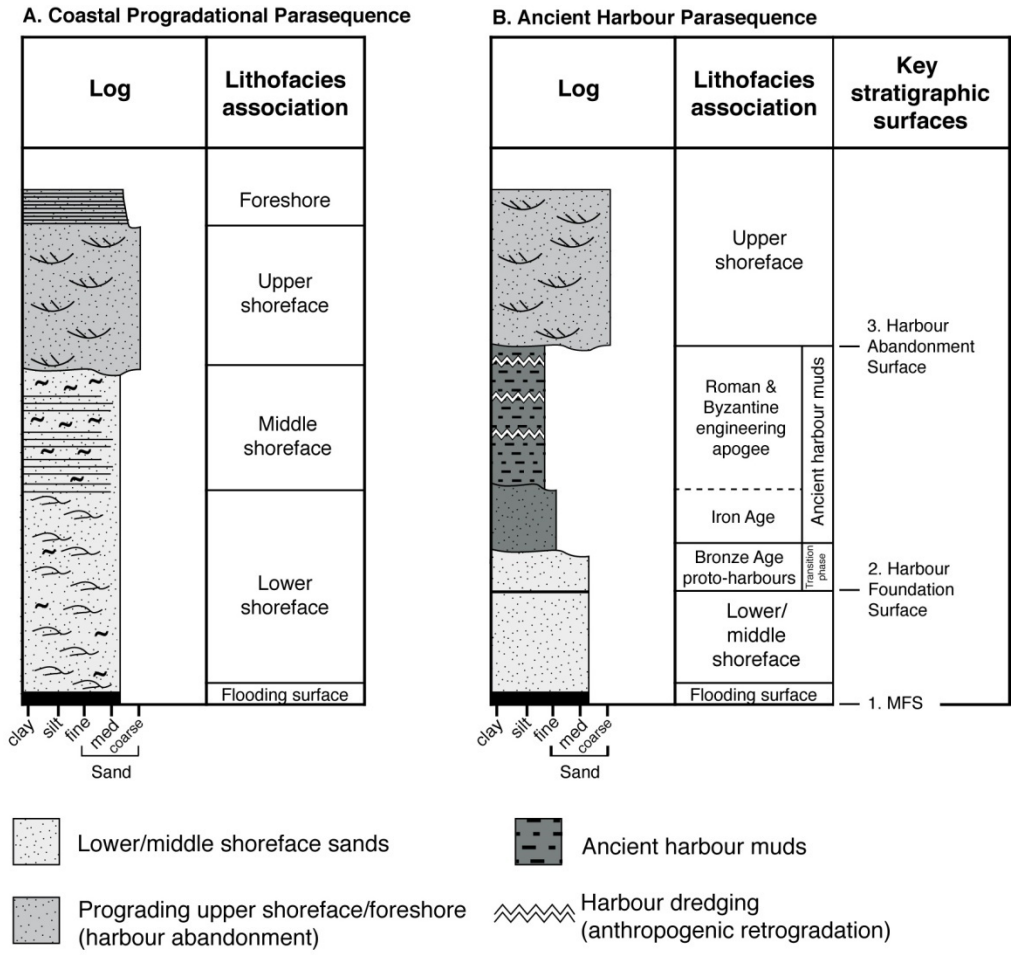
- Role of the pionners (M. Nun and A. Raban) in the (possible) over-interpretation of the ottoman (?) harbour structures.

PORTUS LIVORNUS

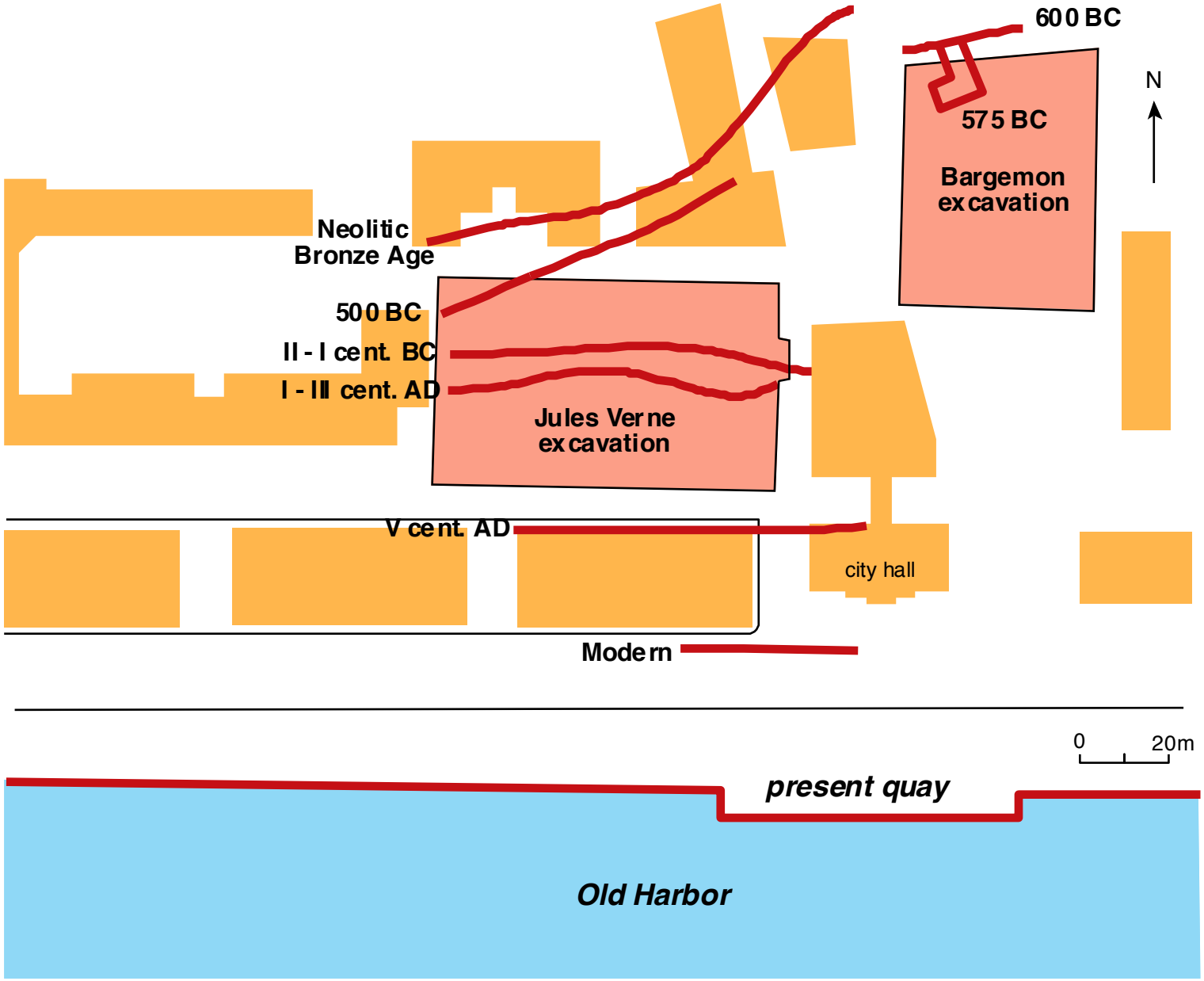
Posidonia silt

Programm Portus Pisanus
Università di Pisa.
Dir: M. Pasquinucci
L. Stefaniuk

Facies aberration



MARSEILLE HARBOUR

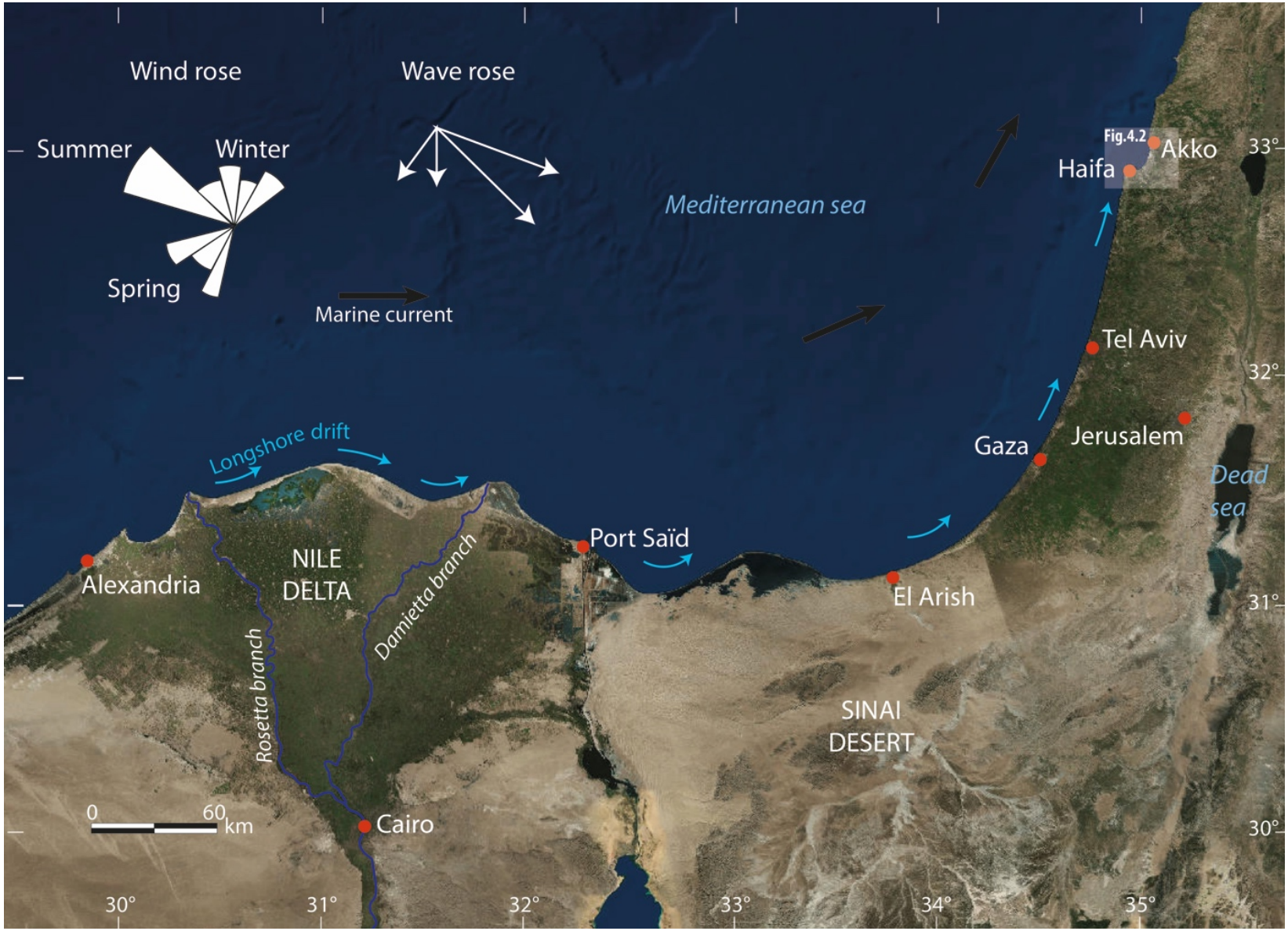


Ancient harbours of Akko since the Bronze Age

M. Artzy total archaeology project (Haifa)

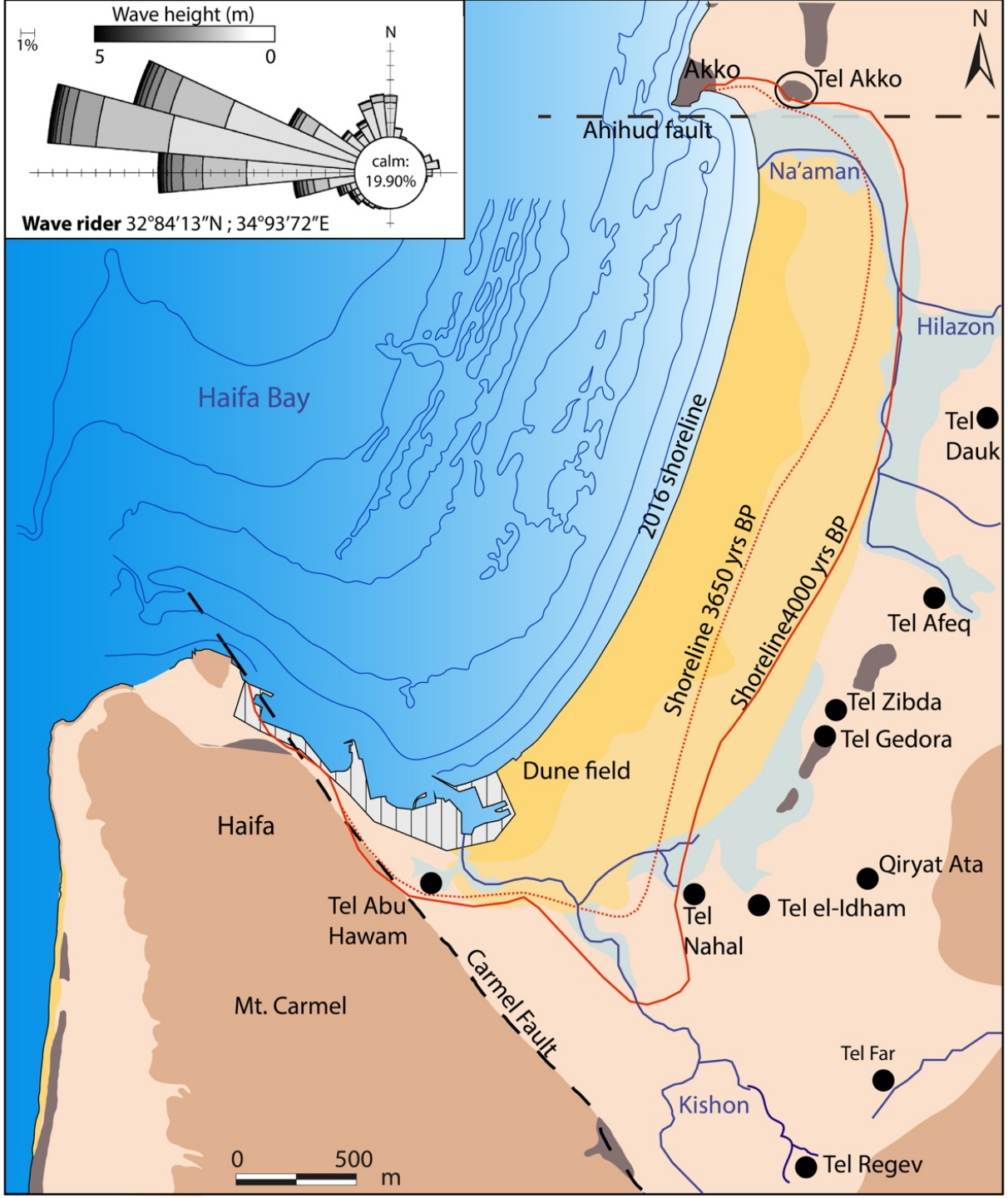
Aerial picture of Tel Akko (M. Artzy)

Regional context



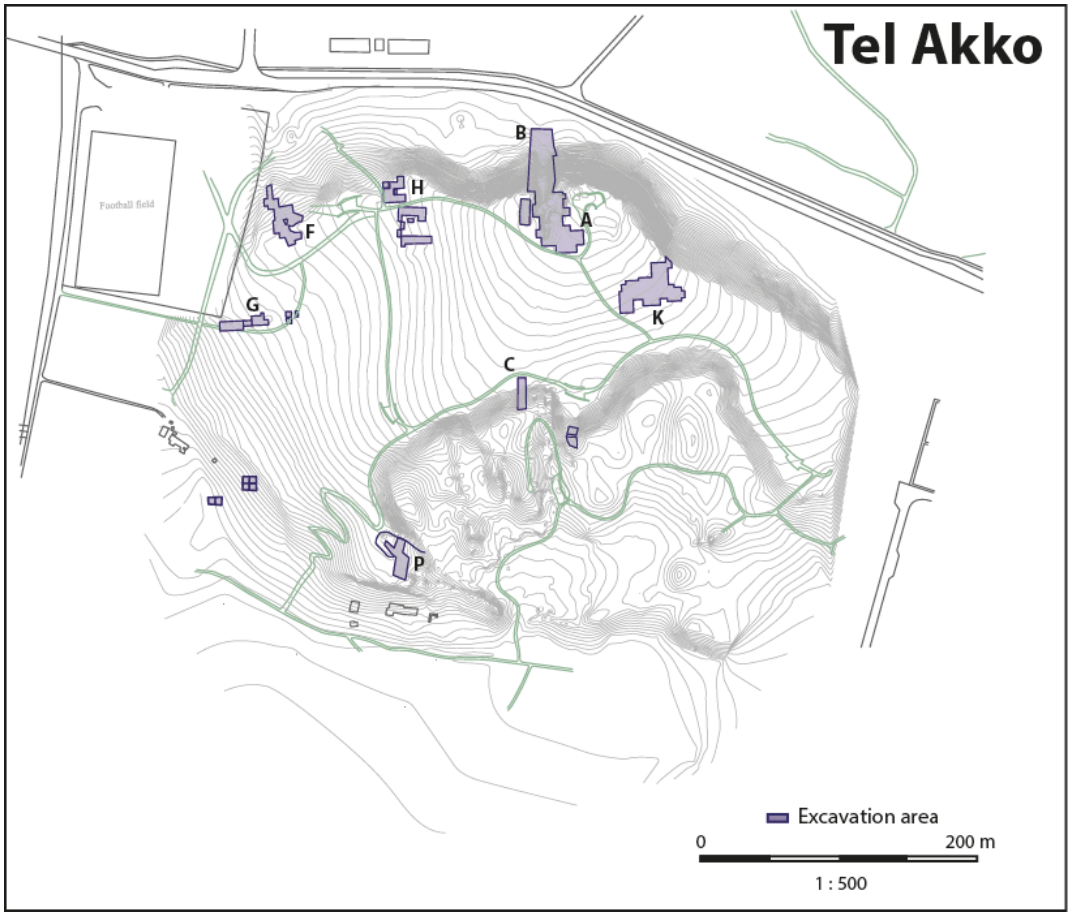
Location of Haifa Bay, on the northern limit of the Nile littoral cell (after Stanley, 2002; image Esri/CNES).

Geomorphology of Haifa Bay



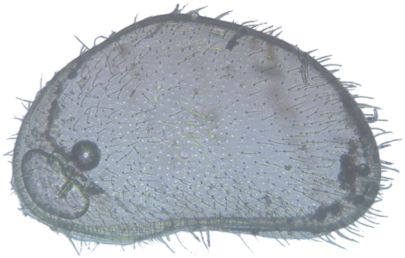
Geomorphological map of Haifa Bay. Localisation of the tells, 4000 years BP shore line position, bathymetry and wave rose after Zviely et al., 2007. 3650 years BP shoreline after Porat et al., 2008.

Tel AKKO : thousands of years occupation



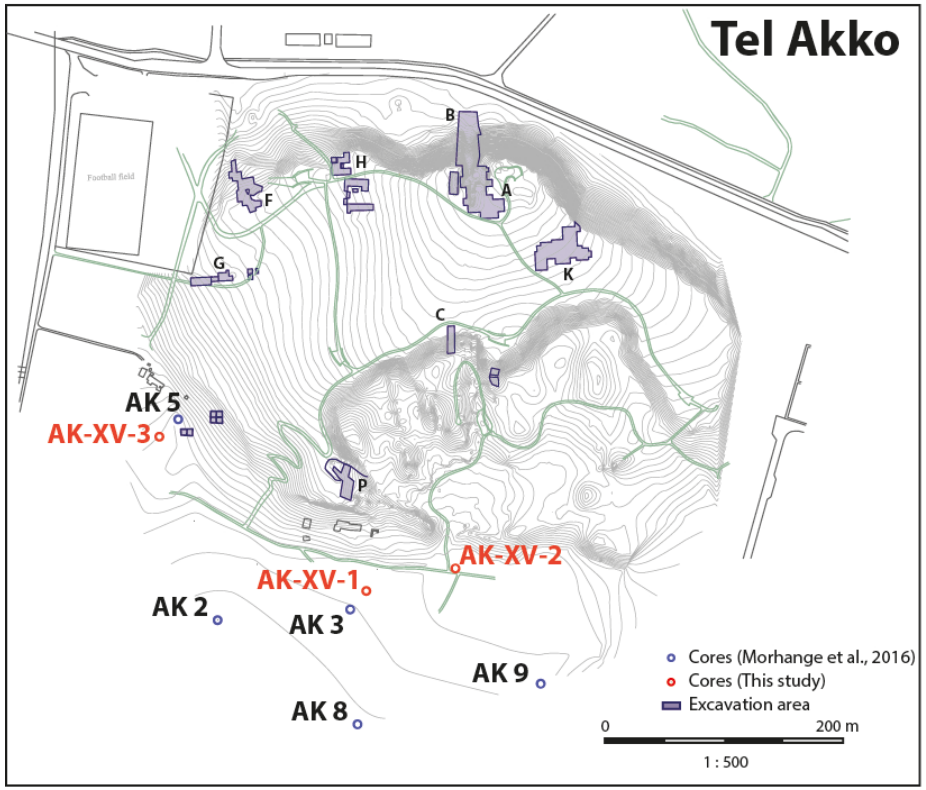
- **Akko mentioned in ancient text from 2400-2250 BC**
  + Amarna Letters (Pharaos of the 19th dynasty)
- Occupation attested since the MB II A (2000-1750 BC)
- Ceramics imported from Lebanon and Cyprus
  → important harbour activity

Methods



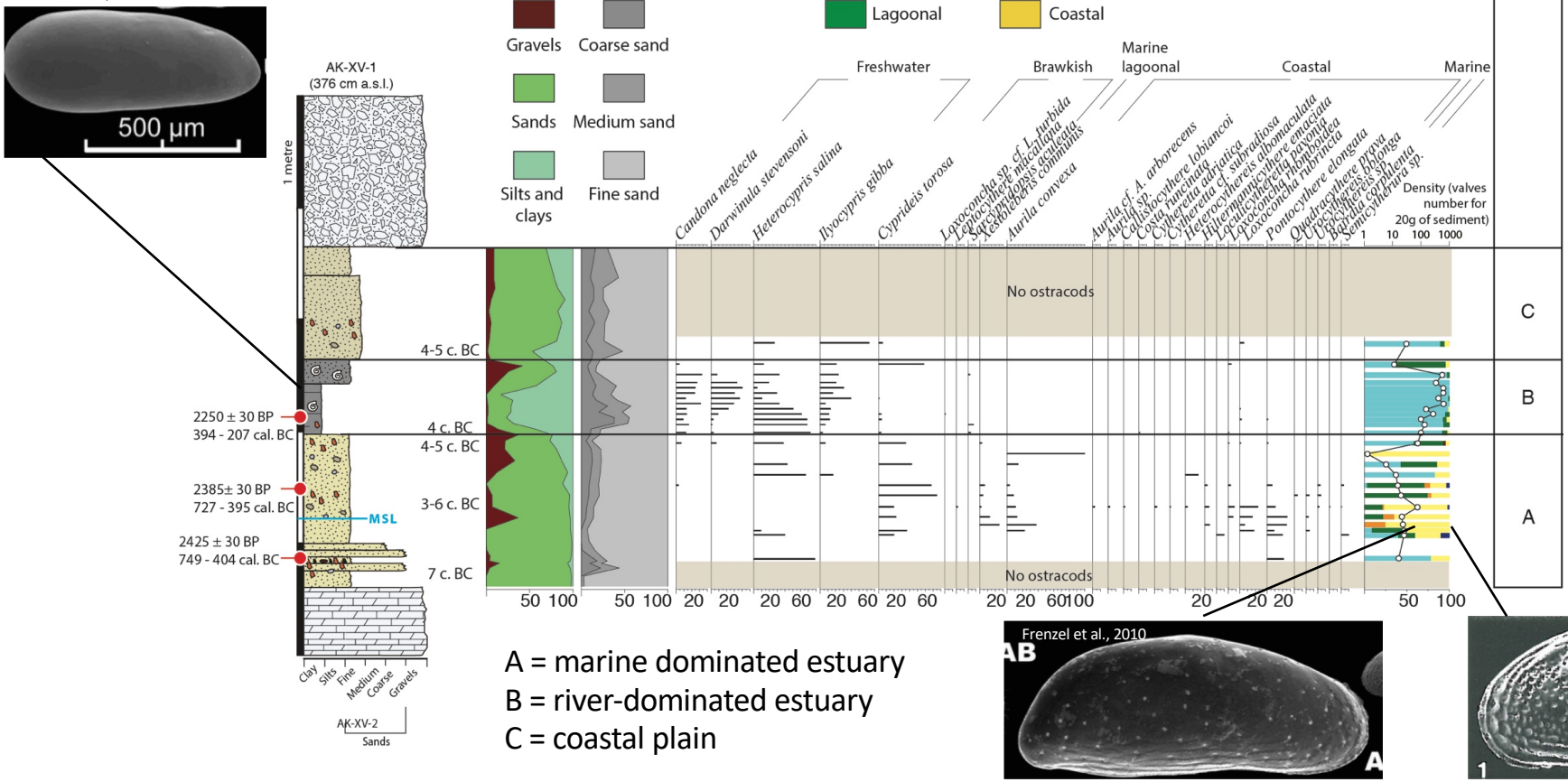
(1) Ubiquity of ostracods in both fresh and marine waters
(2) Small size
(3) Easily- preservable carapaces.

Location of the cores



Location of the cores, image Esri/CNES.

Southern façade, ostracods AK-XV-1

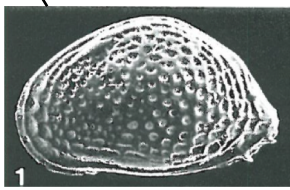


Frenzel et al., 2010

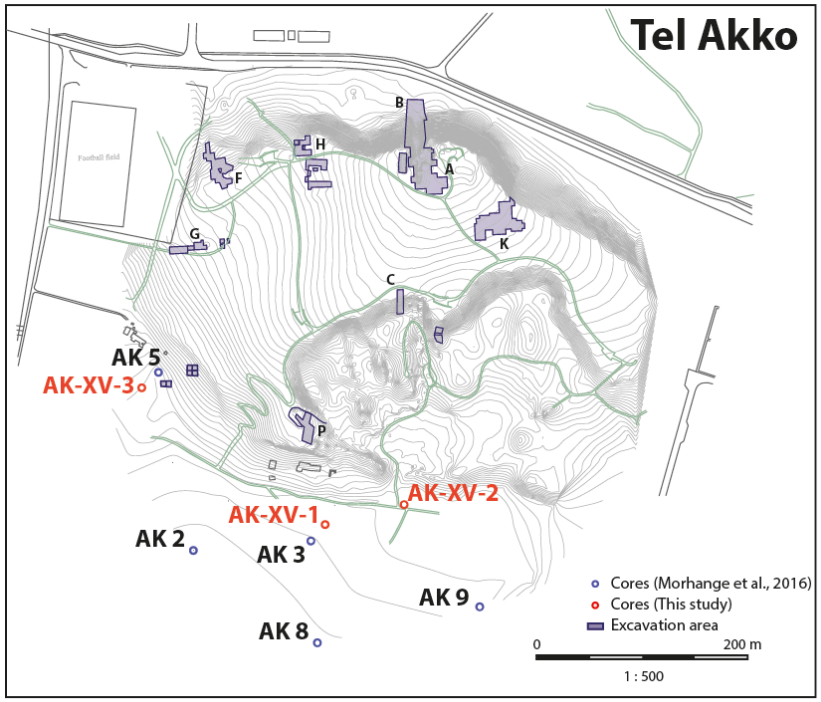
A = marine dominated estuary
B = river-dominated estuary
C = coastal plain

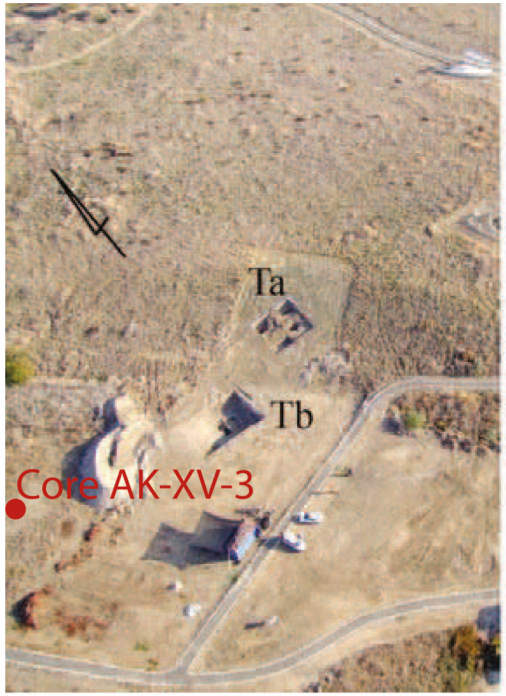
Frenzel et al., 2010

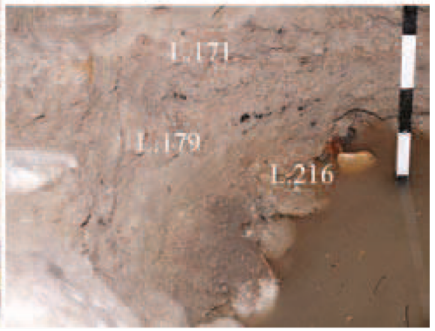
Athersuch et a., 1989



Western façade (AK XV 3)



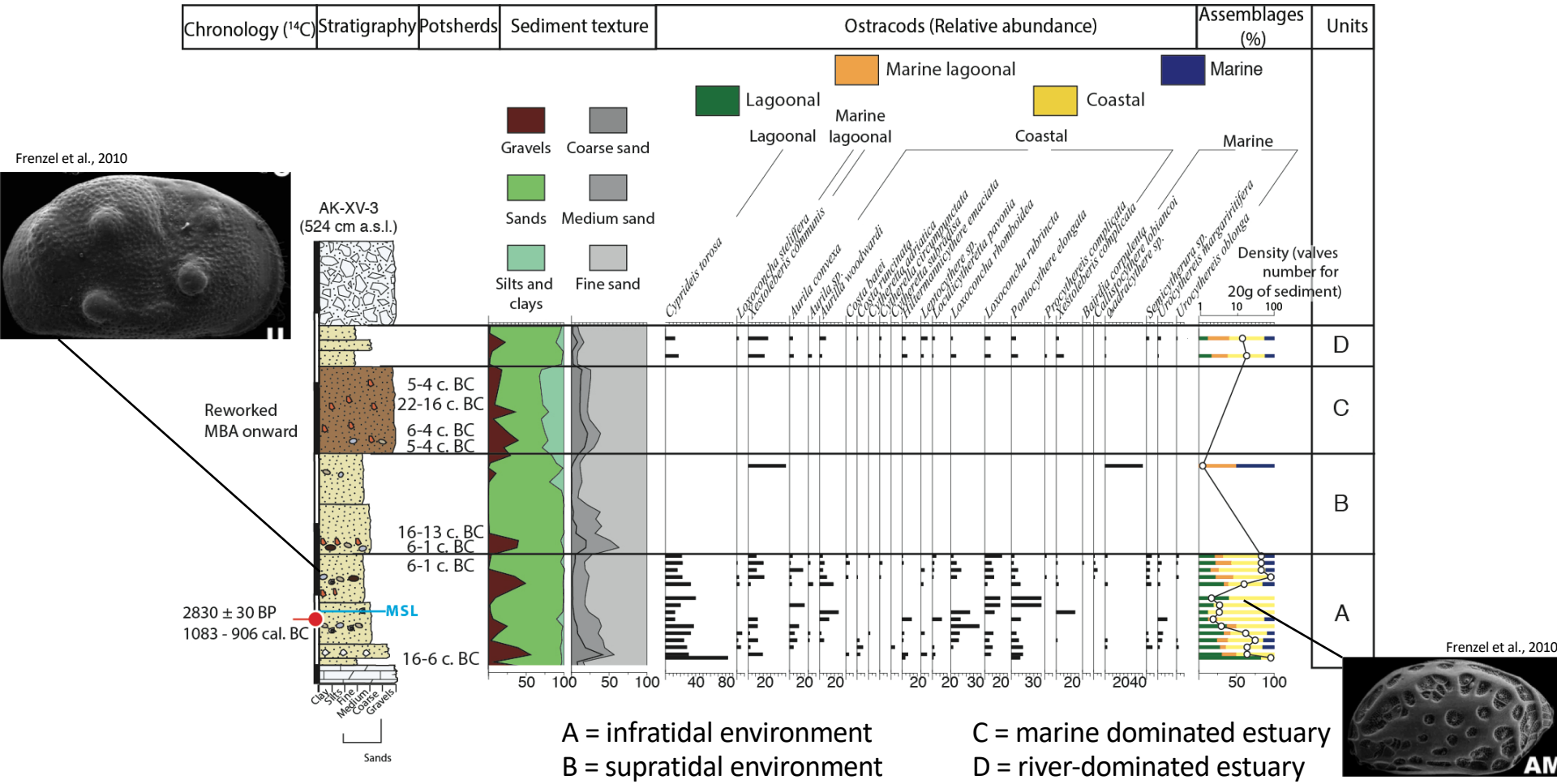




from Morhange et al., 2016).

Results of the salvage project (Artzy and Abou-Ahmed, 2012).

Ostracods AK-XV-3



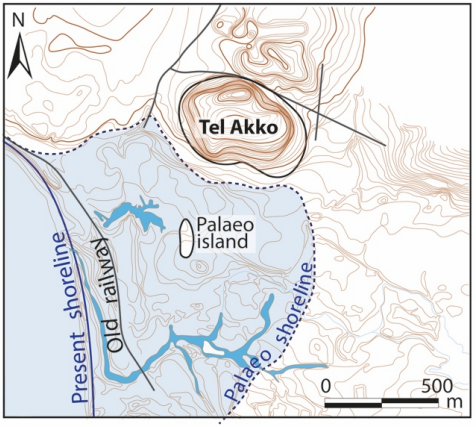
Frenzel et al., 2010

Frenzel et al., 2010

A = infratidal environment
B = supratidal environment
C = marine dominated estuary
D = river-dominated estuary

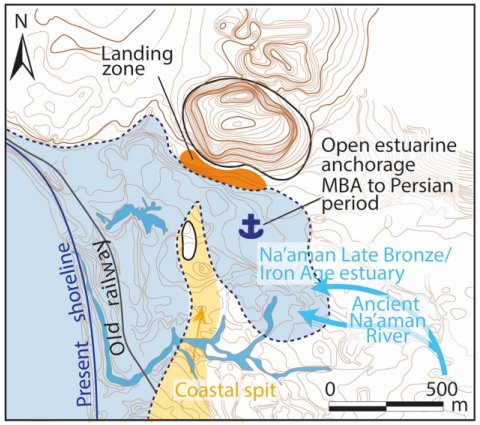
Akko total archaeaology research programm (Israel)

ca. 4000 BP



Maximum of the marine ingression

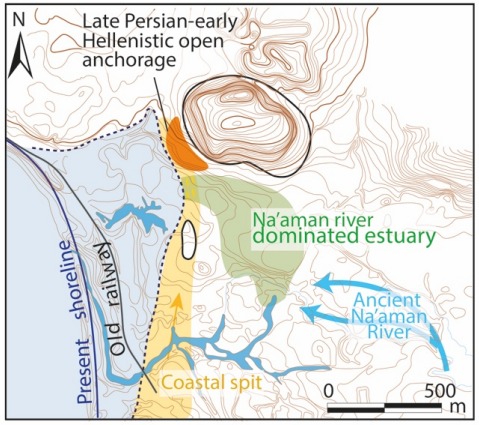
ca. 2800 BP



Growth of the sand spit

Infilling of the estuary

ca. 2400 BP



Final stage of the Coastal progradation

2016 AD

Coastline changes and location of Akko's ancient harbours through time

Topography adapted from Treidel map (1925-26).

Mobility of Akko ancient harbours

Hellenistic harbour

Late Persian/ Early Hellenistic harbour

Bronze/Iron Age harbour

Giaime et al. (2017) *GEOARCAEGEOLOGY*

3. Palaeo-processes and neo-catastrophism

high-energy events impacts
Vulnerabilities

Aquileia

MB CARRE and G ARNAUD F
D. COTTICA et al.

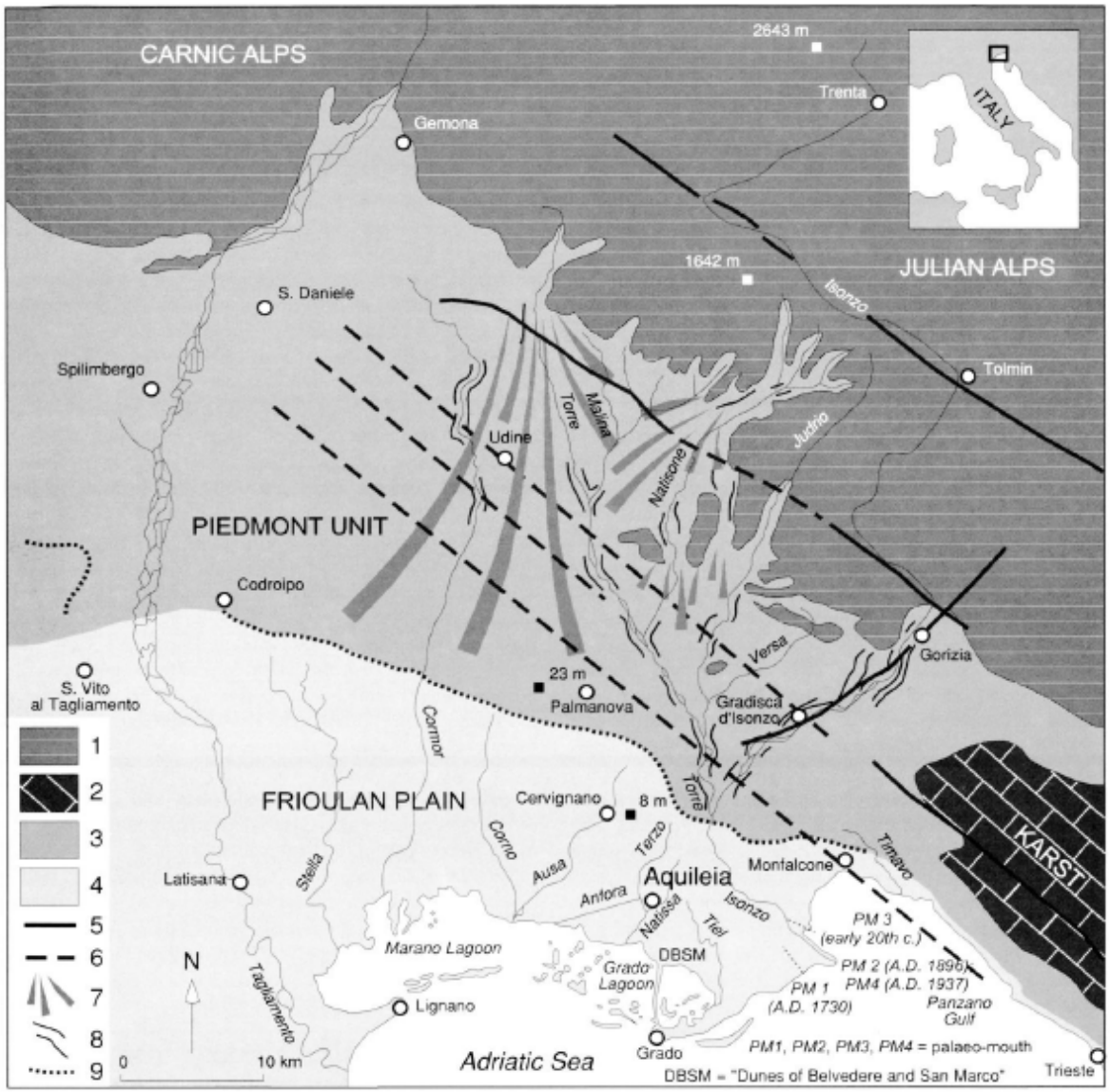
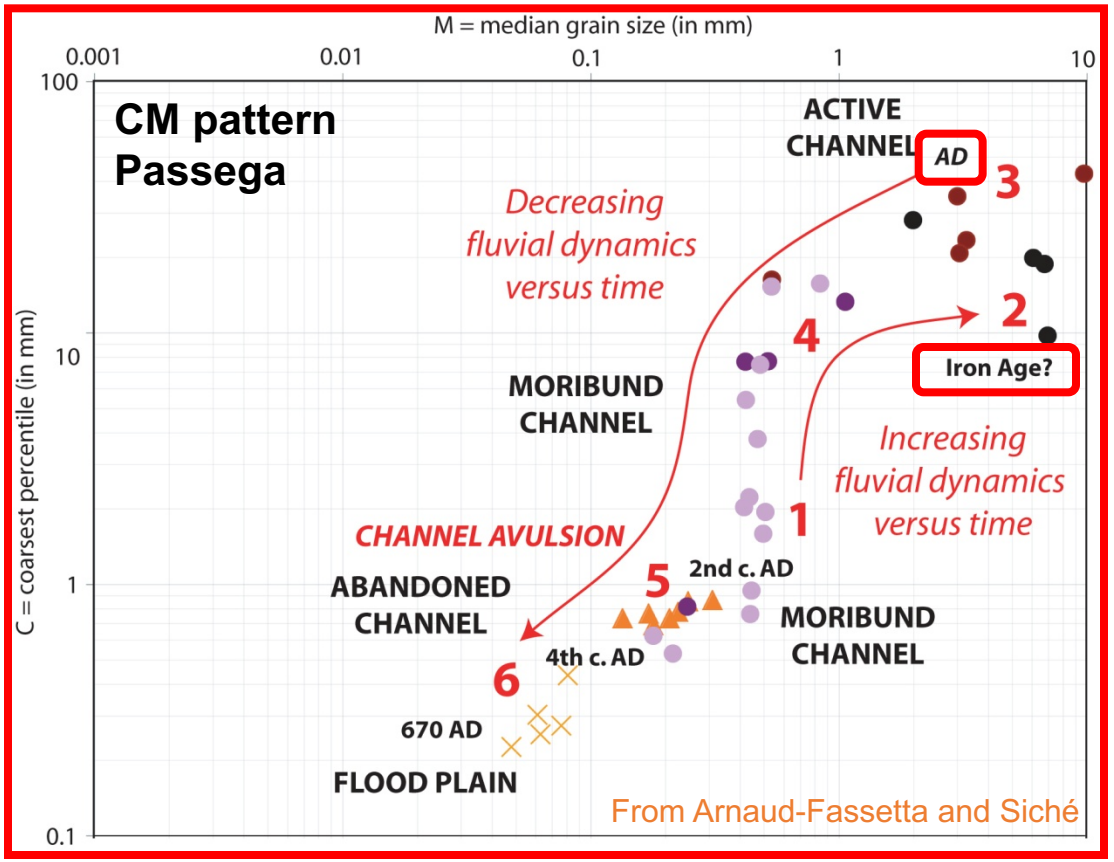


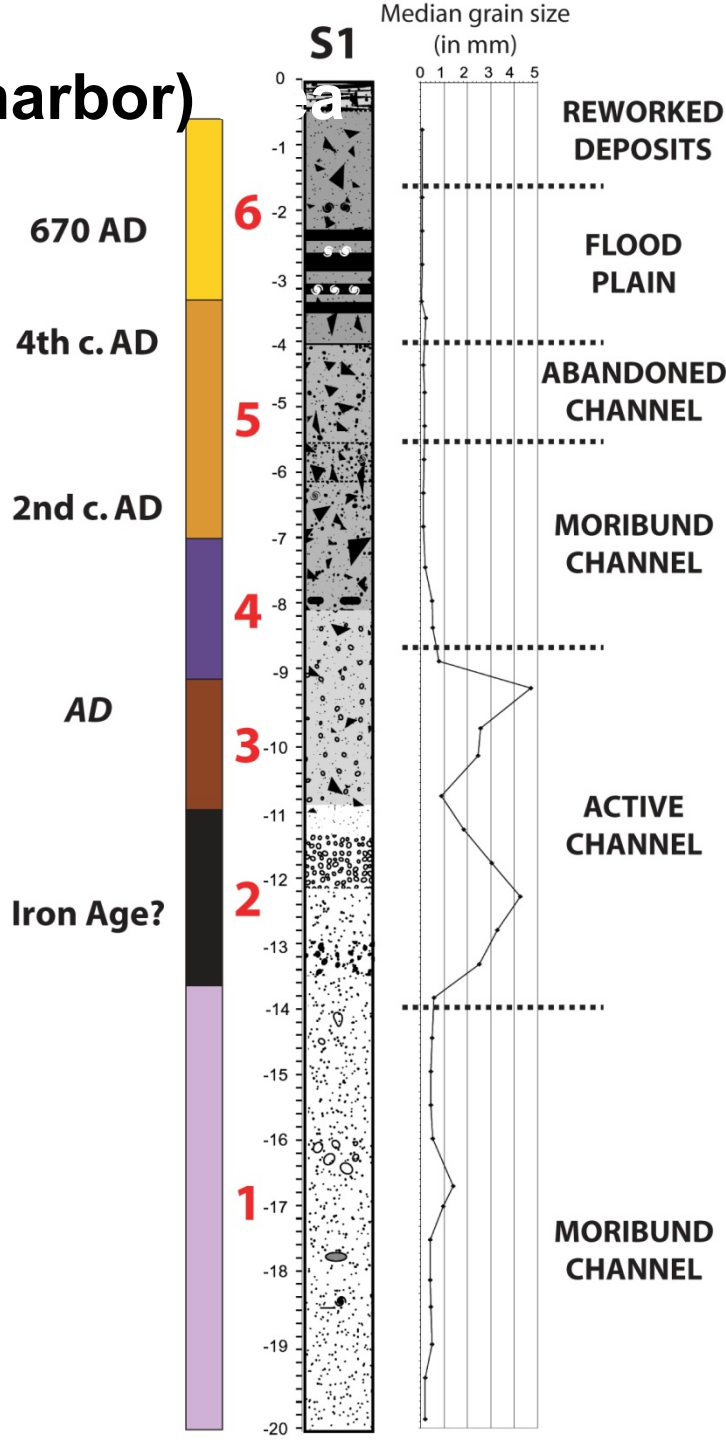
Fig. 1 – **Map of the Aquileia deltaic plain and its region**. 1: mountainous massifs (limestone, dolomite); 2: Karst plateau and massifs (limestone); 3: piedmont (calcareous marl, marly limestone, marly calcareous flysch); 4: plain unit (Quaternary fluvio-marine infill); 5: major fault; 6: possible fault (hypothetical trend); 7: alluvial fan; 8: enclosed valley (not represented in the mountainous units); 9: springs boundary.

*Fig. 1 – **Carte de la plaine deltaïque d'Aquilée et de sa région**. 1 : massifs montagneux calcaires et dolomitiques ; 2 : plateaux et massifs calcaires du Karst ; 3 : piémont (marnes calcaires, calcaires marneux, flyschs marno-calcaires) ; 4 : plaine (remblaiement fluvio-marin quaternaire) ; 5 : faille principale ; 6 : faille supposée (tracé hypothétique) ; 7 : cône alluvial ; 8 : vallée encaissée (non représentée dans les unités montagneuses) ; 9 : ligne de résurgence karstique.*

Aquileia
Western harbor

Fluvial dynamics in Aquileia (western harbor)

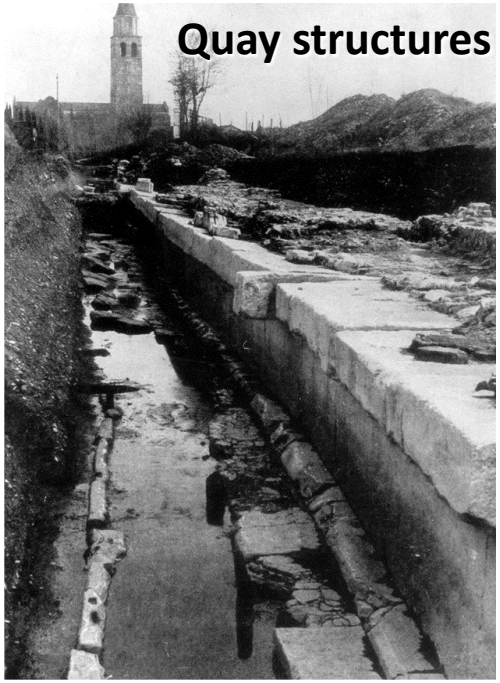




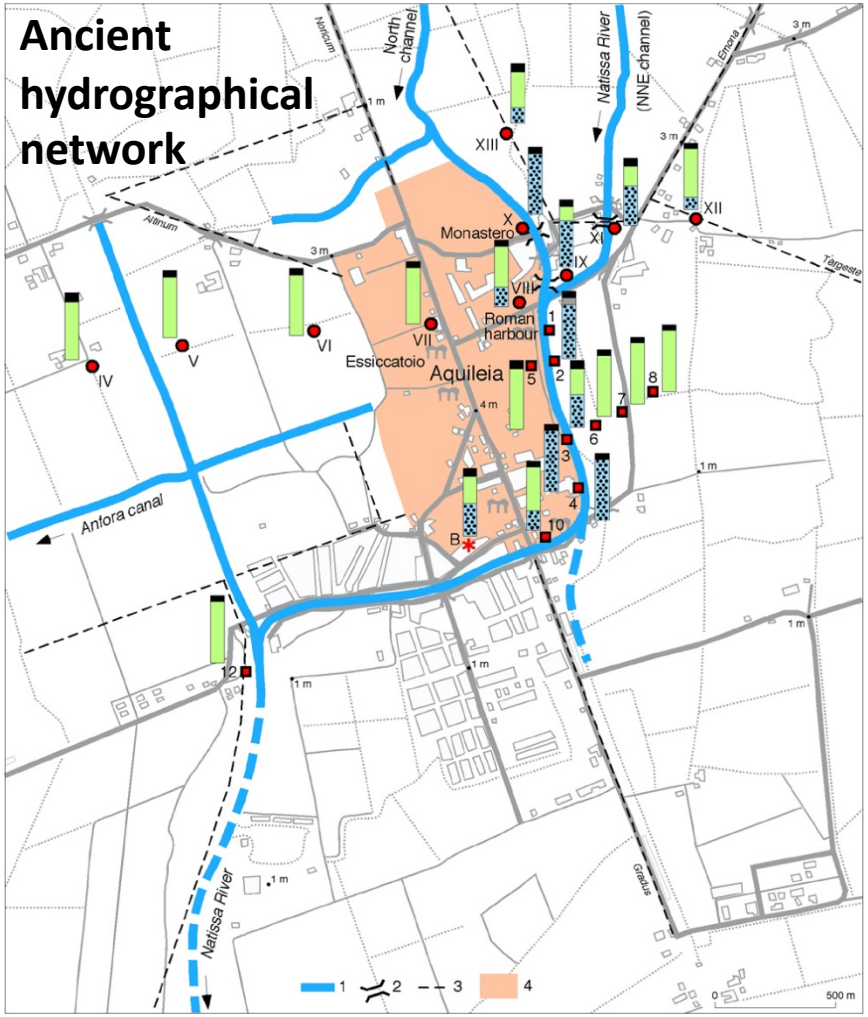
In Aquileia plain, CM patterns were useful to analyse fluvial channel activity since the Iron Age

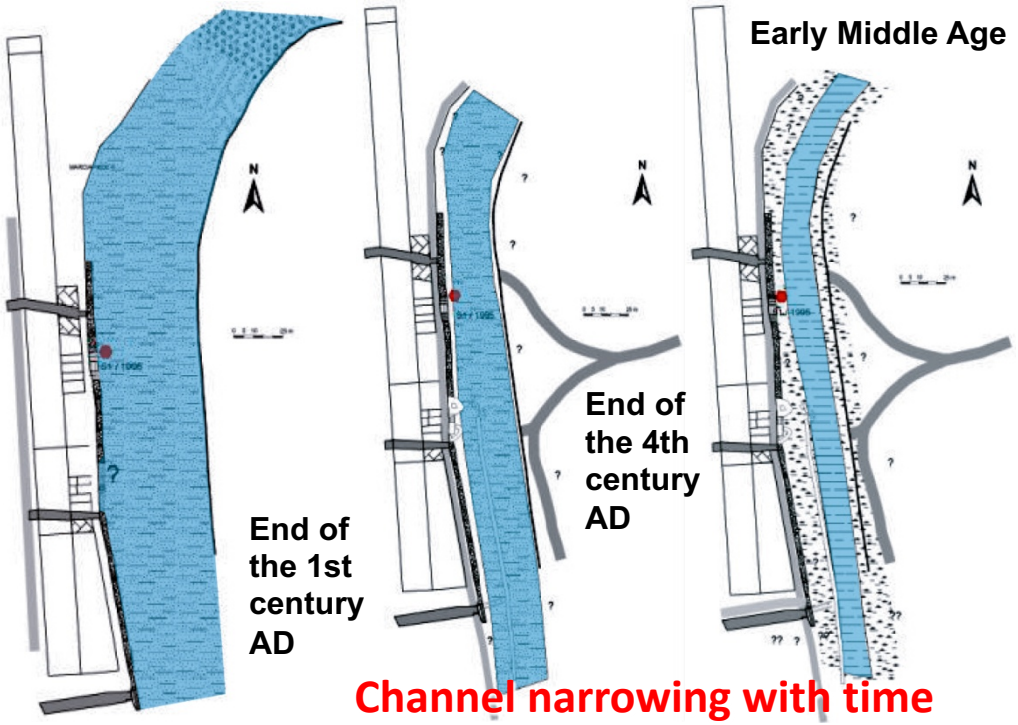
Increasing fluvial competence at the beginning of the antiquity

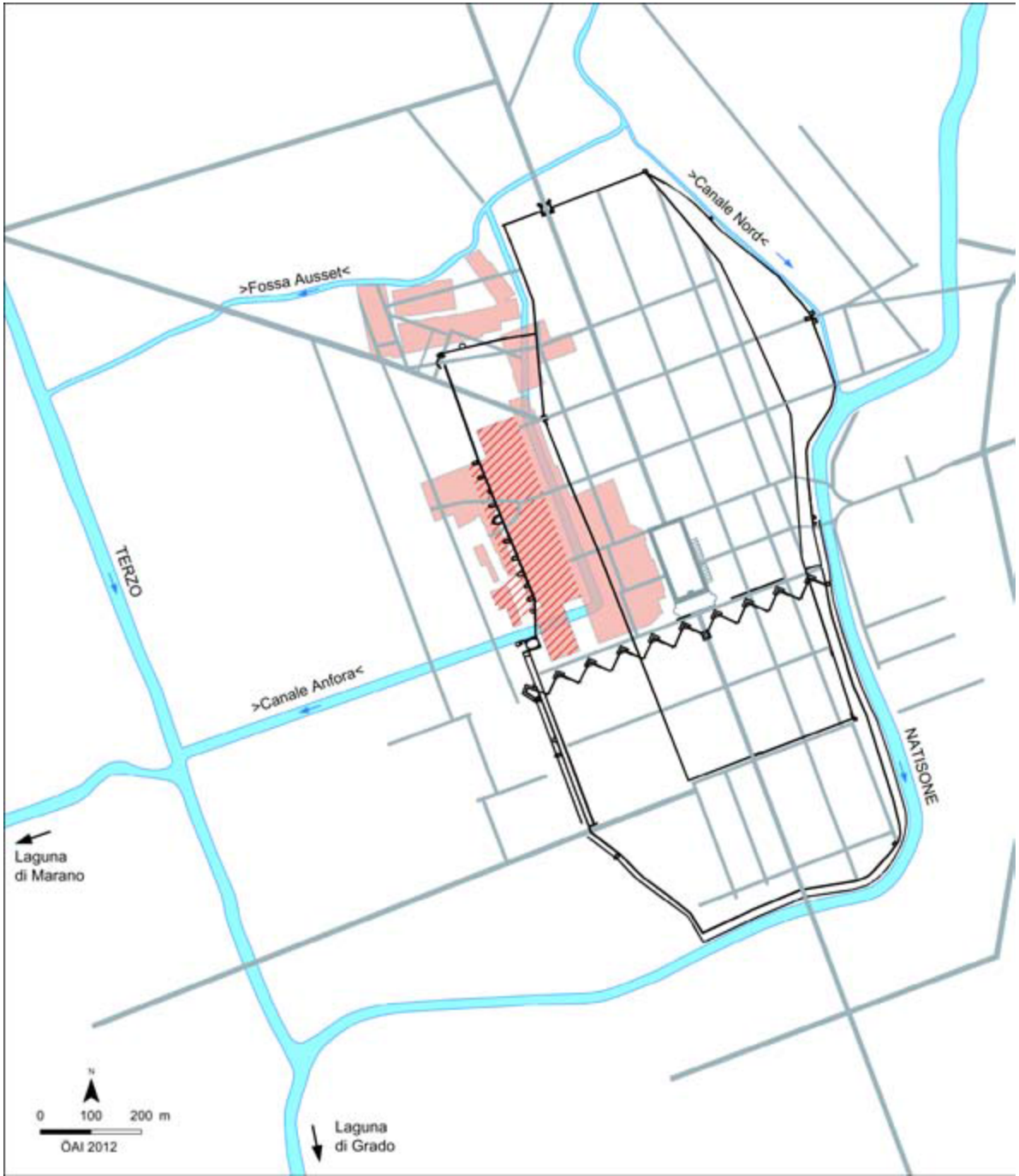
Land use had some influence on fluvial dynamics : Several active palaeo-channels were artificially infilled to increase the urbanised area ?



Hydraulic works led to river channelisation, as demonstrated in the sector of the Roman fluvial harbour





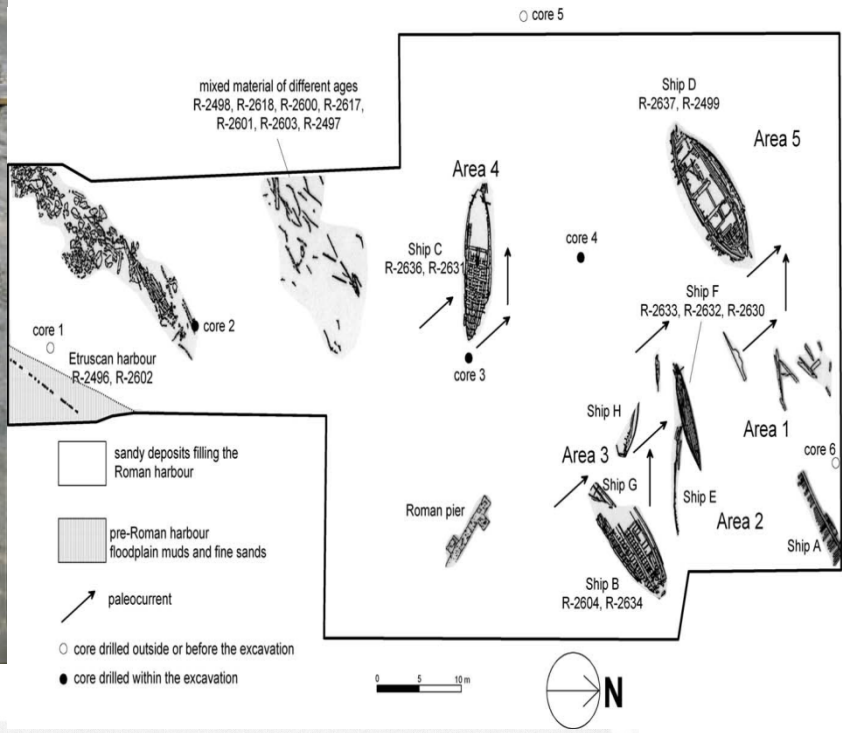


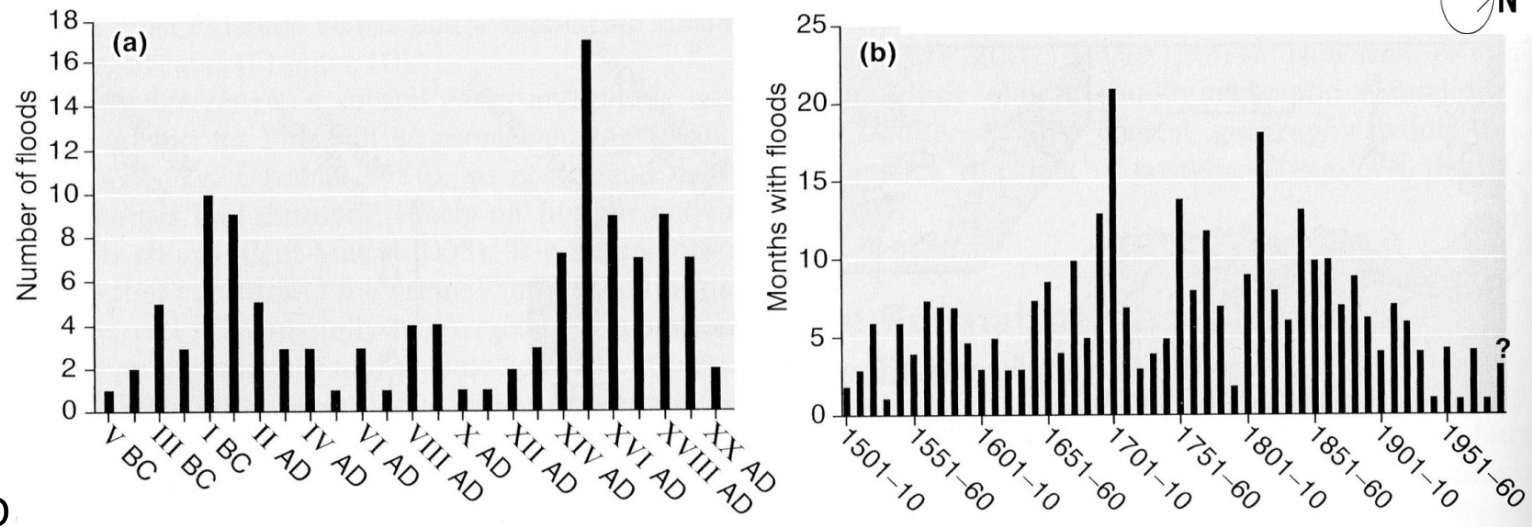
Research by S. Groh et al. (Austria), 2012

New harbour waterfront
Canale Anfora

Research in progress (D. Cottica)

Late-Holocene catastrophic floods in the Arno River





BERSANI
PICHARD

Fig. 13.15. Historical records of coastal flooding for (a) the River Tiber and (b) the River Rhône (see Chapter 18).

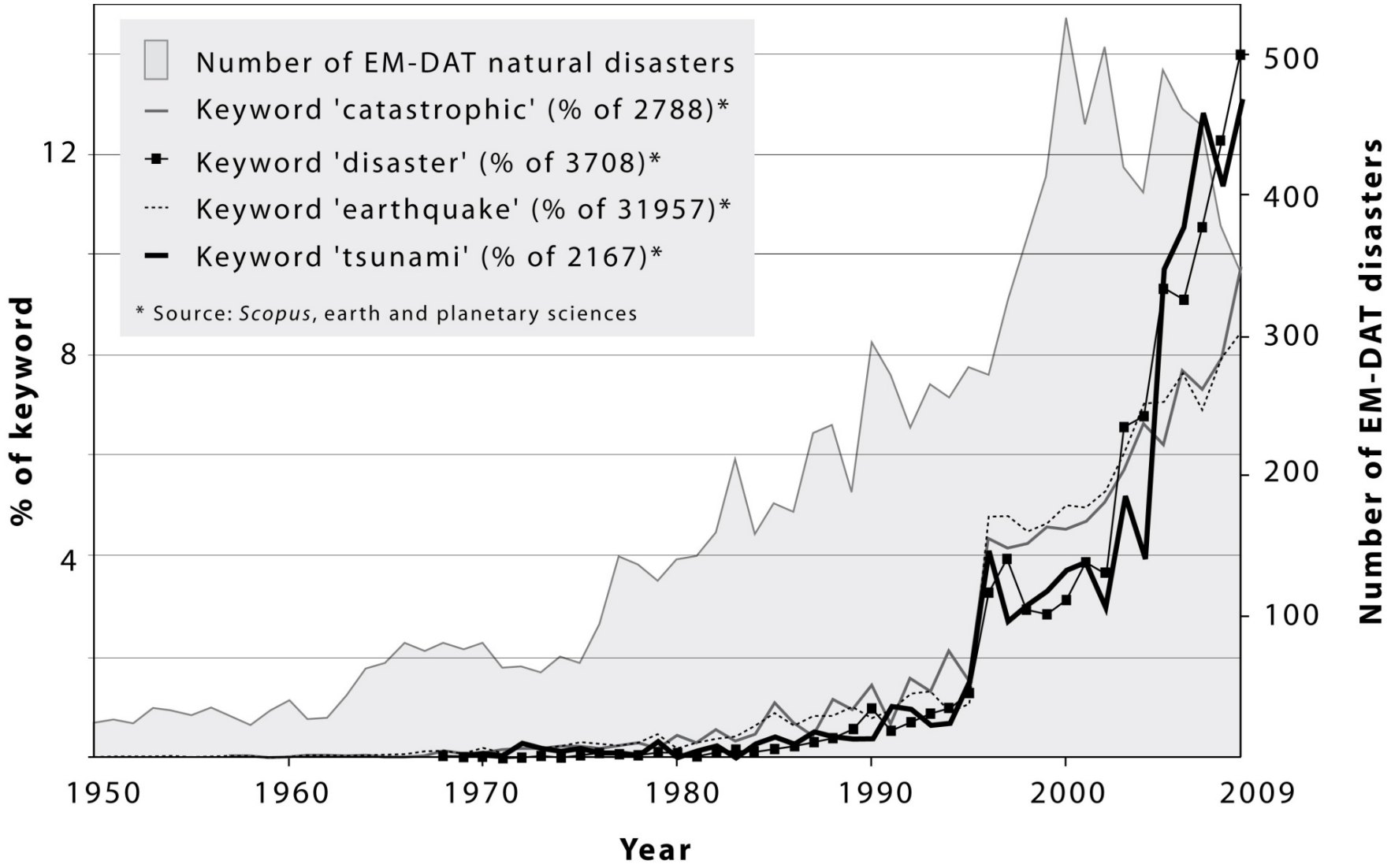
Painting of the frozen Lagoon in January 1789. (**Camuffo, 2014**)
The hinterland and the mountains in the background are covered with snow. (Correr Museum)


YENIKAPE, from Perincek, tsunami layer ca. V-VII° AD

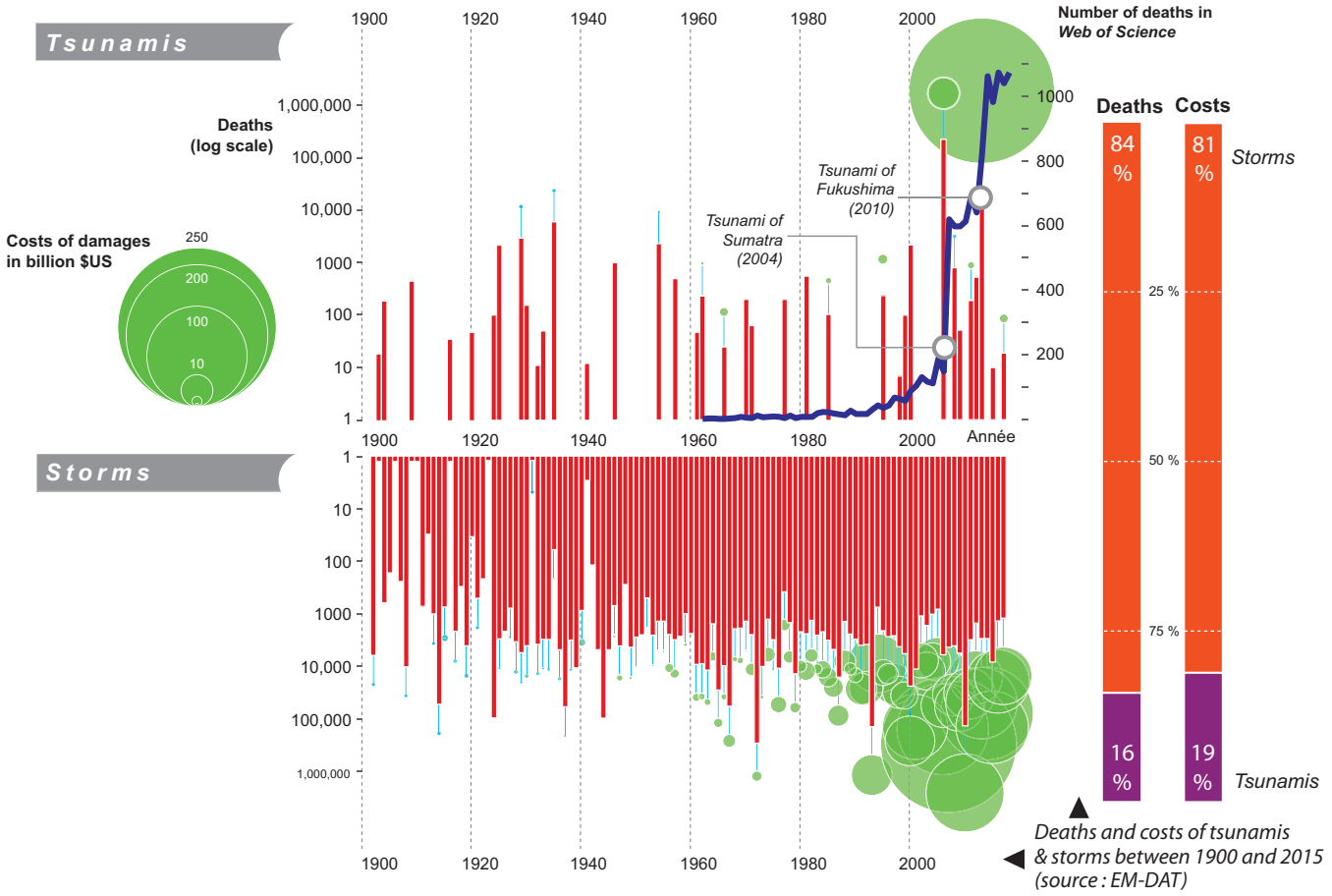
TIPAZA
ALGERIA

Maouche
Et al., 2009
Marine Geol.

Up to 200 tons


Number of EM-DAT natural disasters
Keyword 'catastrophic' (% of 2788)*
Keyword 'disaster' (% of 3708)*
Keyword 'earthquake' (% of 31957)*
Keyword 'tsunami' (% of 2167)*
* Source: Scopus, earth and planetary sciences
% of keyword
12
8
4
Number of EM-DAT disasters
500
400
300
200
100
1950
1960
1970
1980
1990
2000
2009
Year

TSUNAMIS: A DISCOURSE OF FEAR?



Deaths and costs of tsunamis & storms between 1900 and 2015 (source : EM-DAT)

Some explanations

« Impact factor race »
« media race »

Bases of geology
« risk society »

Social demand
Application opportunism
Funding

QUO VADIS ?

Progresses to be done in harbour geo-archaeology

- Dredging problem. From coring to sections…
- Integration of continental and submarine approaches. From watershed to base-level.
- Geoarcheology without archaological excavations is very fragile and naive.
- Neo-catastrophist fashion. Question of factoïds…
- Sea-level obsession.

Toward a stronger geographical (spatial) approach

Present-day destruction of coastal archaeological sites (coastal erosion and urbanization)