11th International SedNet Conference Hotel Dubrovnik Palace, Dubrovnik, Croatia,
3-5 April 2019

Acceleration of sedimentation rate in the Black Sea revealed in radiometrically dated by 210Pb sediment cores

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Portsmouth University, UK

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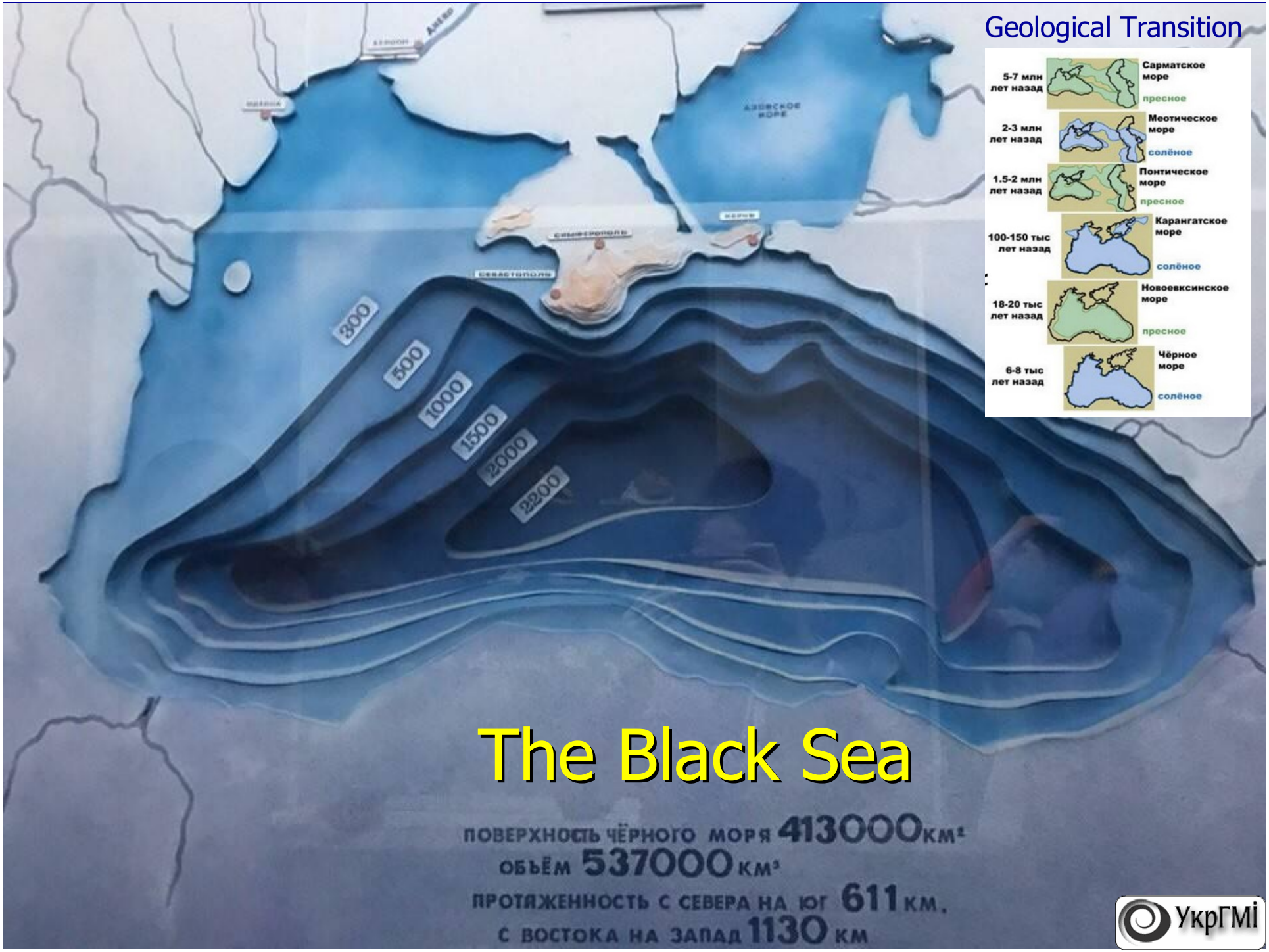
The Black Sea



Geological Transition

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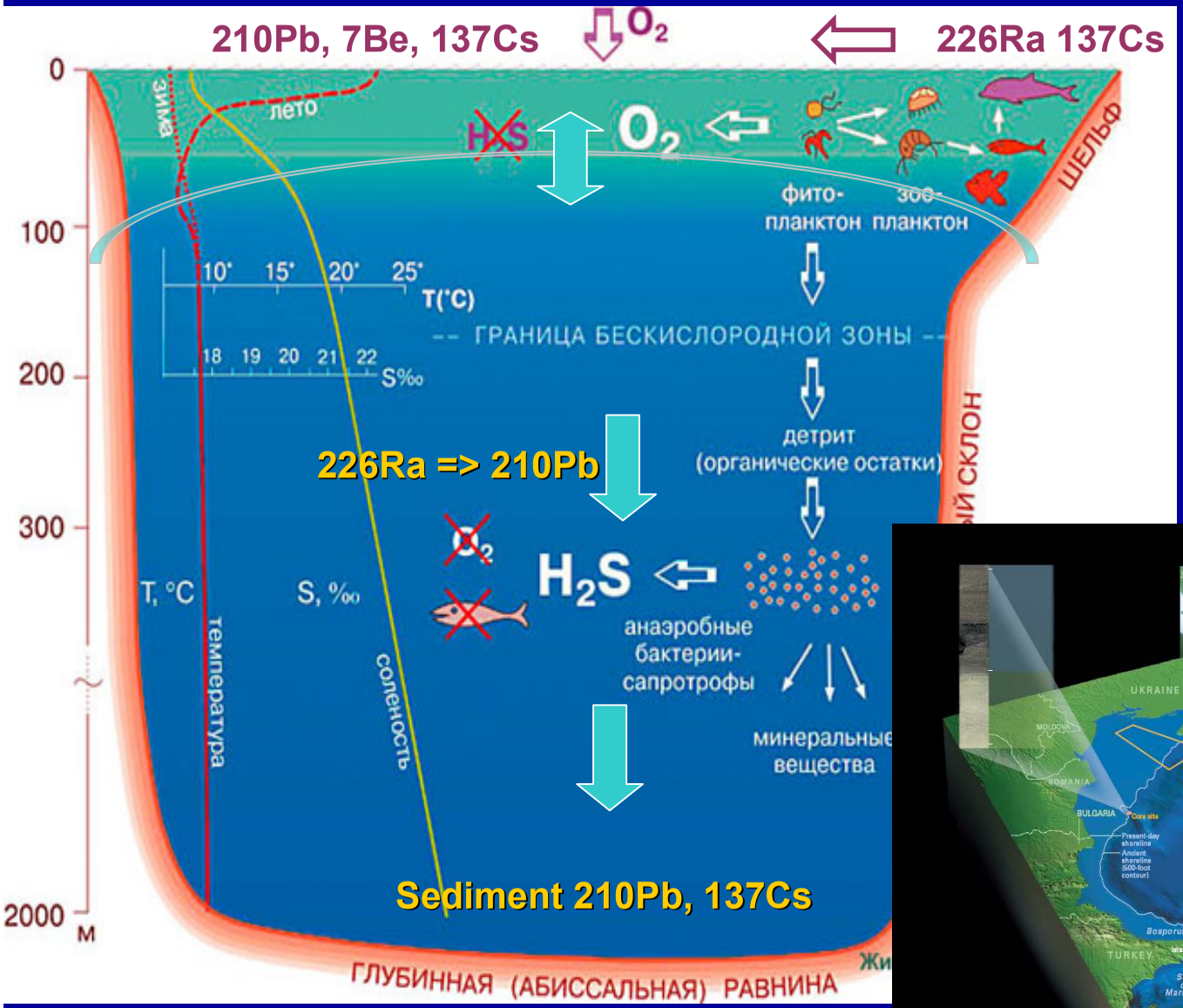
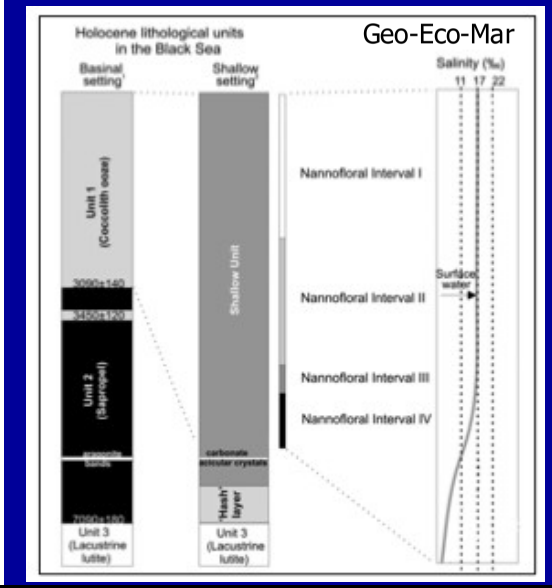
Main Processes in the Black Sea





William Ryan & Walter Pitman, 1997

Radioisotope Technique in Sedimentation Study

- Bottom sediment – natural archive of environmental chronological records
- Source and geochemical behavior of radioisotopes well defined
- Natural spatial and temporal smoothing data filter (*in contrary to instrumental measurements*)
- Nondestructive analytical method
- Tolerance to present lack of knowledge – lookout into the past

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Radioisotopes Used in Sedimentation Study

- U-Th Series:
  ^{226}Ra – Halflife 1600 y
  (*River Inflow, Groundwater seepage, Desorption from Sediment*)

  ^{210}Pb – Halflife 22.3 y
  (*Atmospheric Flux, ^{226}Ra Production via ^{222}Rn, Suspended Solid Transport*)

- Cosmogenic
  ^{7}Be – Halflife 53 d
  (*Atmospheric Flux, Suspended Solid Transport*)

- Artificial – ^{137}Cs, ^{90}Sr, ^{241}Am, Pu, Eu etc.

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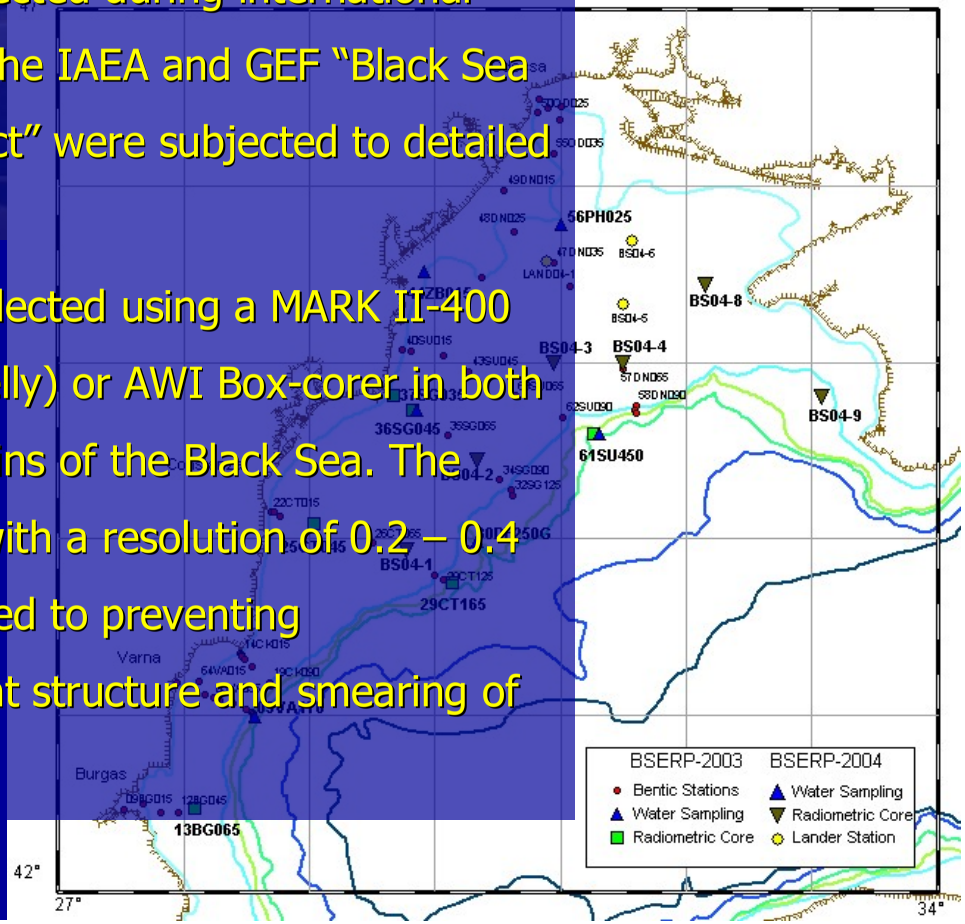
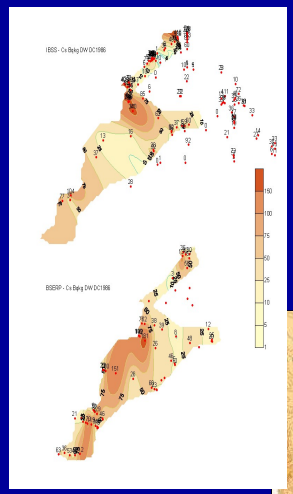
Radioisotope Sediment Study in Marine Research

- Sediment cores from shelf area, continental slope and abyssal (deep-sea) plain collected during international cruises in the framework of the IAEA and GEF "Black Sea Environment Recovery Project" were subjected to detailed radiometric analysis.

- The sediment cores were collected using a MARK II-400 multi-corer (Bowers & Connelly) or AWI Box-corer in both Western and Eastern subbasins of the Black Sea. The cores were sliced on board with a resolution of 0.2 – 0.4 cm using an extruder designed to preventing disintegration of the sediment structure and smearing of collected material.



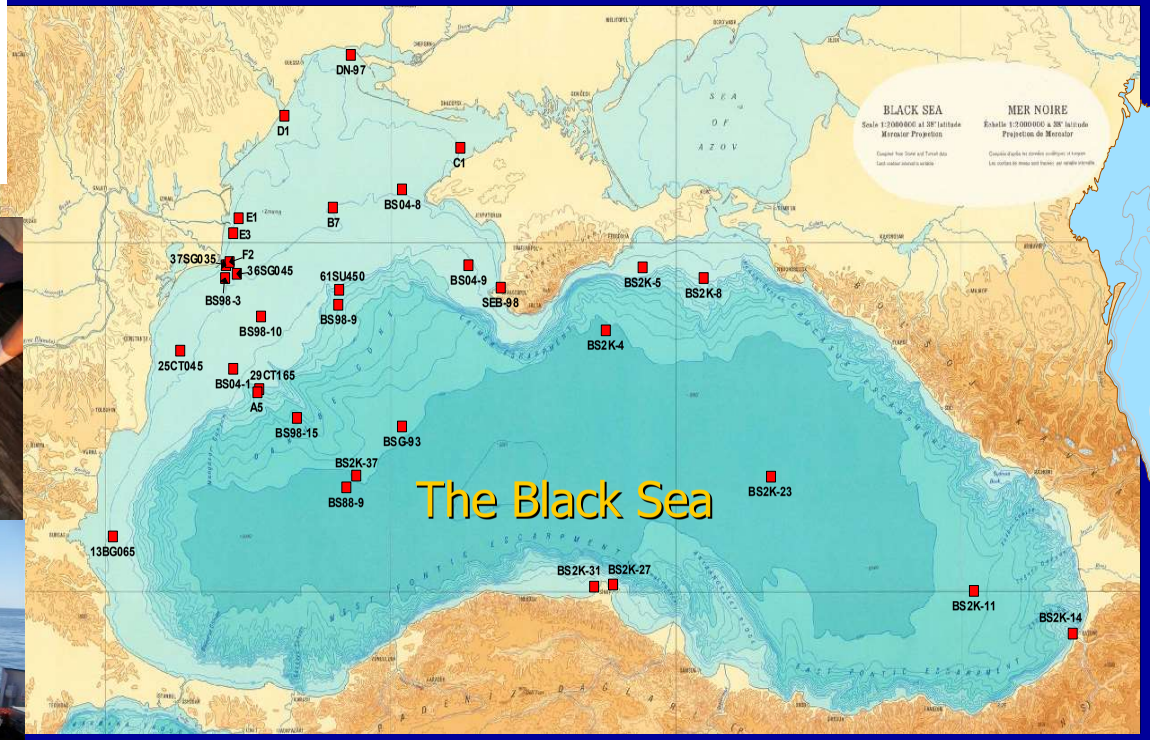


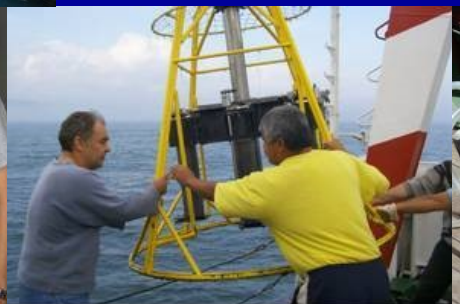
Radioisotope Methods Applied For

- Undisturbed Sediment Cores collected on shelf, continetal slope and abbysal ravine
- Dissolved and SS radionuclides

Timeline:
Black Sea
1993-1995, IAEA RC 7330/R1/R2
1998, 2000, IAEA RER/2/003 RADEUX
2003, 2004 and 2006,GEF BSERP
2010 – 65th Cruise RV Vodyanitskyi, NASU
2012 – MHI, CarbCycle

Caspian Sea:
2006 IAEA
2008, 2009 - CEP





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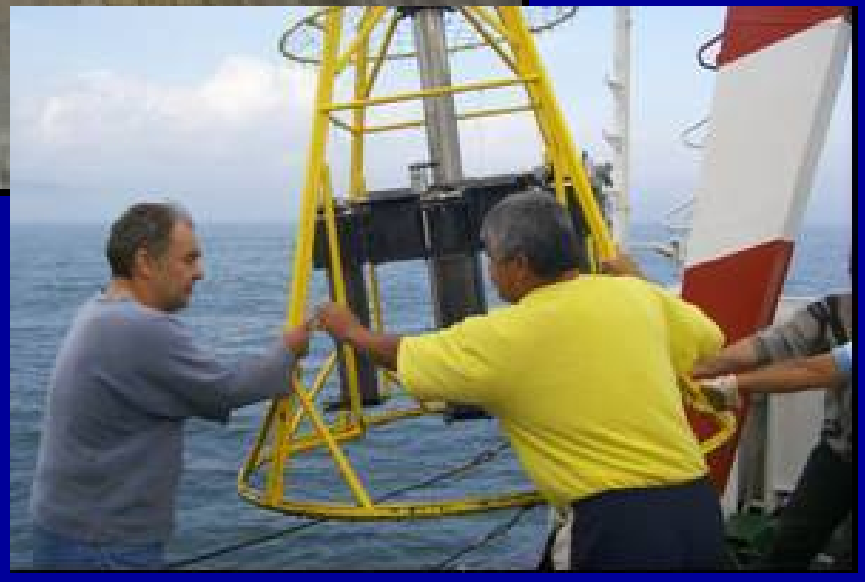
Sediment Core Sampling



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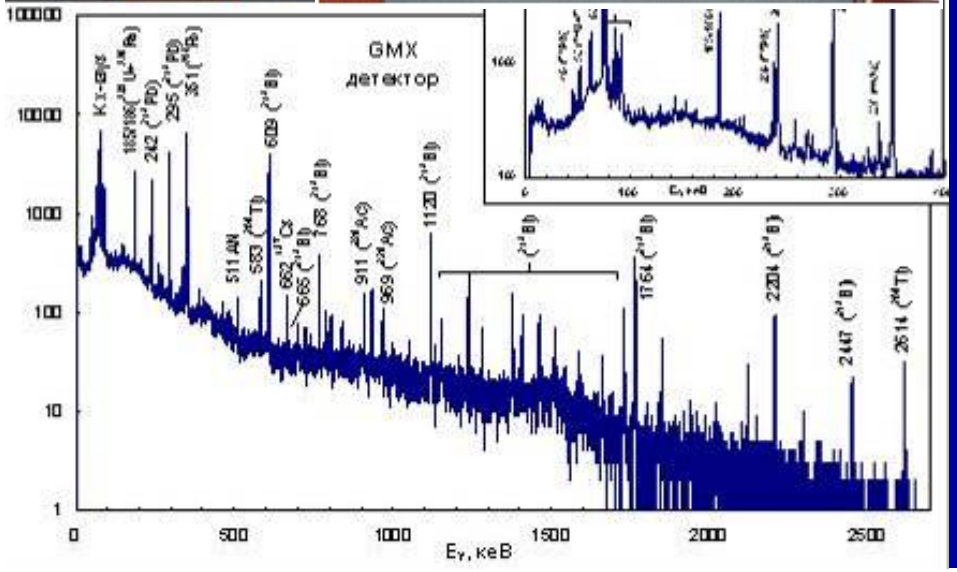
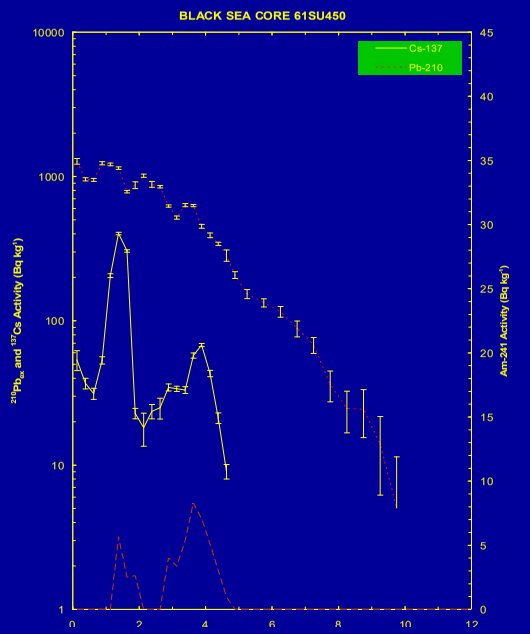
Sediment Core Processing

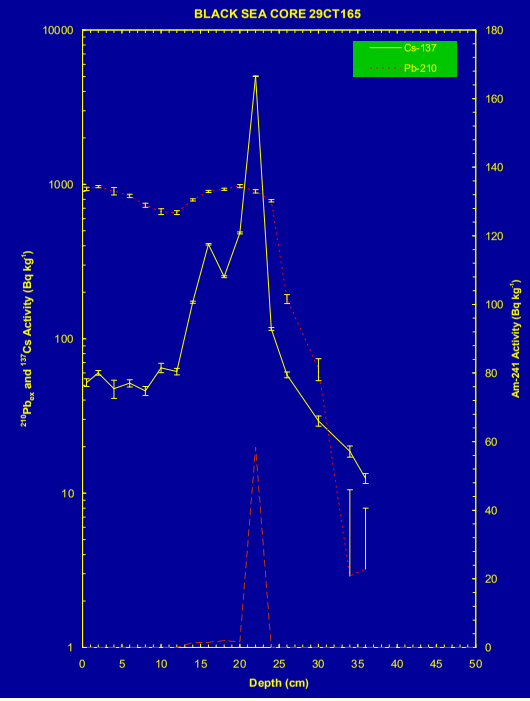
Analytical Facilities at UHMI

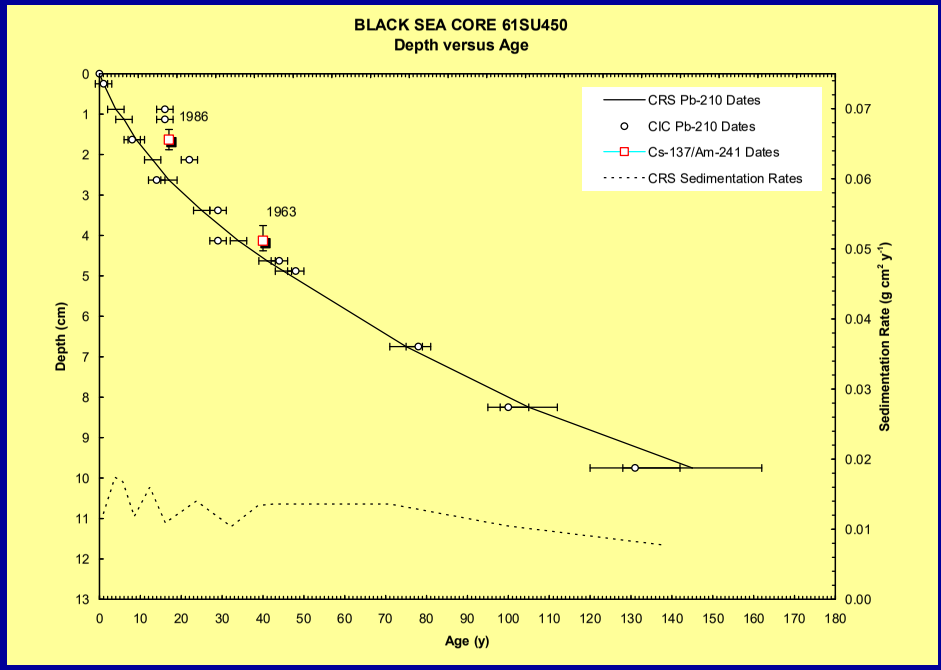


HPGe Gamma Systems
GEM, GWL, GMX – ORTEC,
BEGe5030 - CANBERRA
Alpha Spectrometry, LSC, XRFA
ICPMS (EcoCentre, Chornobyl)

$^{210}Pb_{ex}$, ^{137}Cs and ^{241}Am vs Depth







Basic Equations of the CRS ^{210}Pb dating model

$$A_x = A(0)e^{-\lambda t},$$

$$t = \frac{1}{\lambda}\ln\left[\frac{A(0)}{A_x}\right].$$

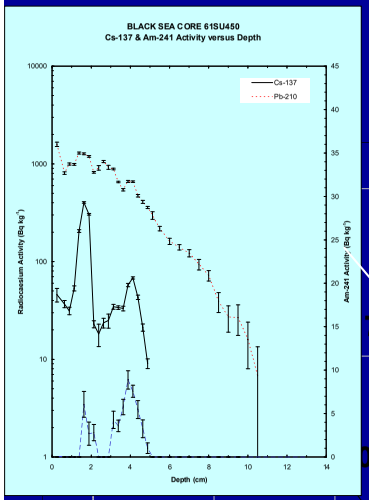
$$r = \frac{\lambda A_x}{C_x},$$

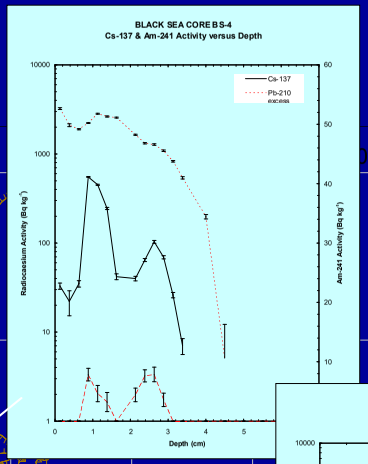
$$A(0) = \frac{P}{\lambda}$$

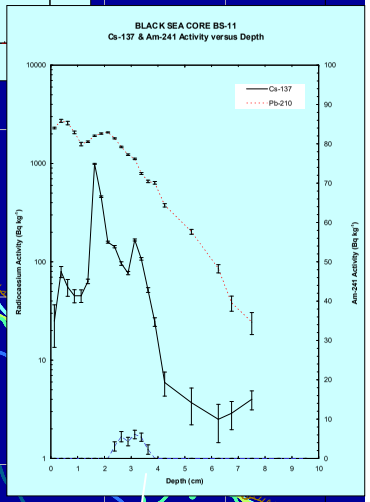
Basic Equations of the SIT ^{210}Pb dating model

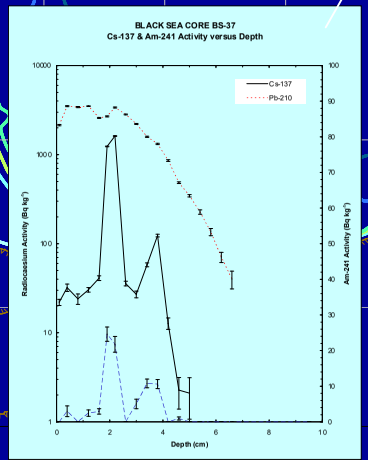
$$P(x) = P_0 \exp\left[\begin{array}{l}(-Bx + \sum_{n=1}^{N}\frac{a_n}{n\pi}\sin(\frac{n\pi x}{x_{\max}})) \\ +(\sum_{n=1}^{N}\frac{b_n}{n\pi}(1-\cos(\frac{n\pi x}{x_{\max}})))\end{array}\right]$$

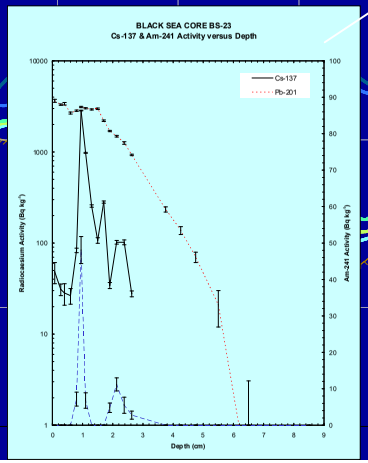
Pb-210 and Cs-137 in Bottom Sediment of the Black Sea, Bq m^{-2}











30°E
35°E
45°N
5°N
33°E
700
6 450
1 480
2 230
425
1 344
2 270
480
14 280
190
230
225
300
516
600
3 940
100
200
500
1500
2000

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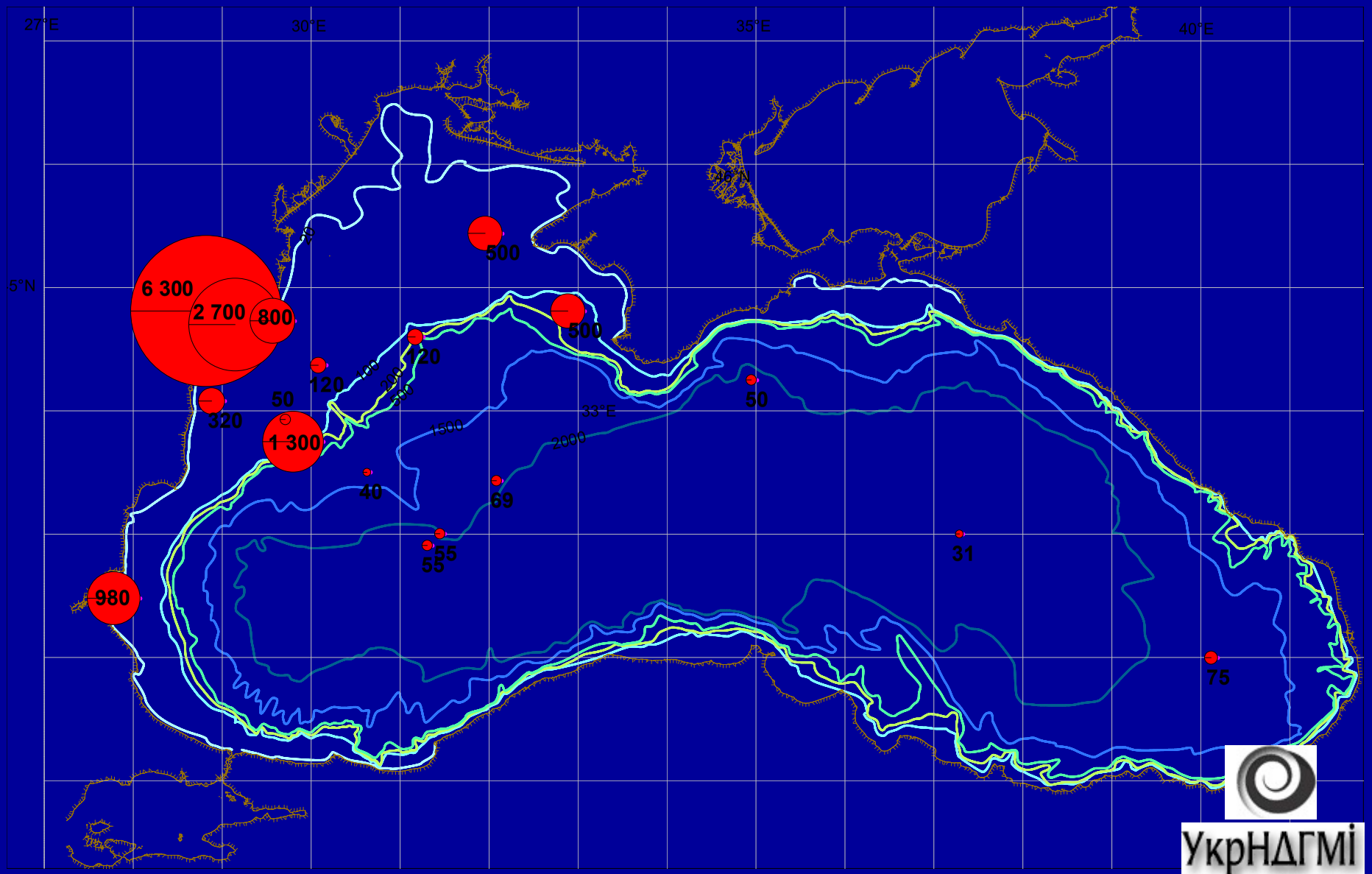
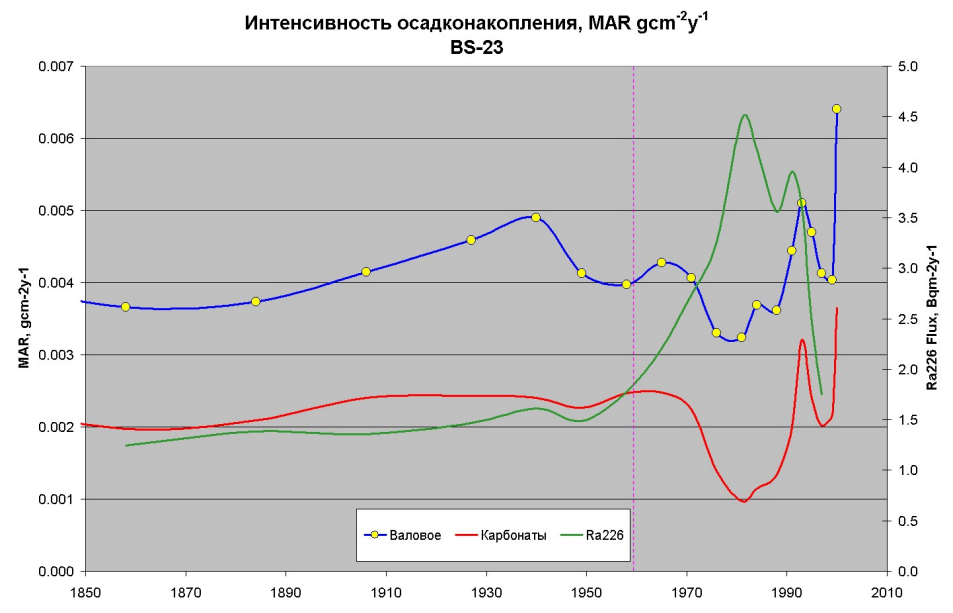
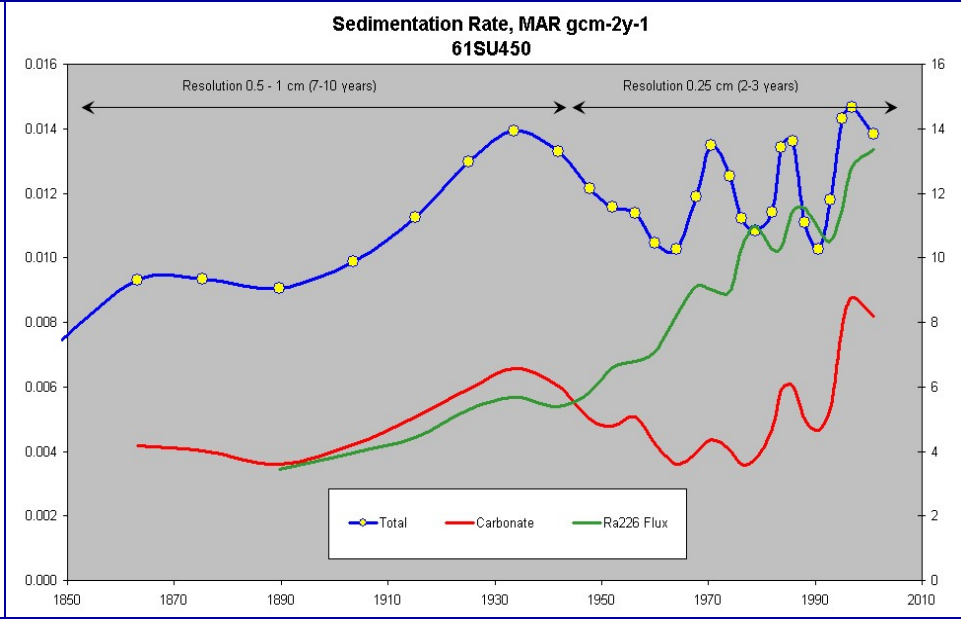
MAR in Bottom Sediment of the Black Sea,

g m^{-2} y^{-1}



MAR Abyssal Sediment, Black Sea
Variation over the last 100 years





MAR show significant variability and apparent cyclicity in the second half of the XX century

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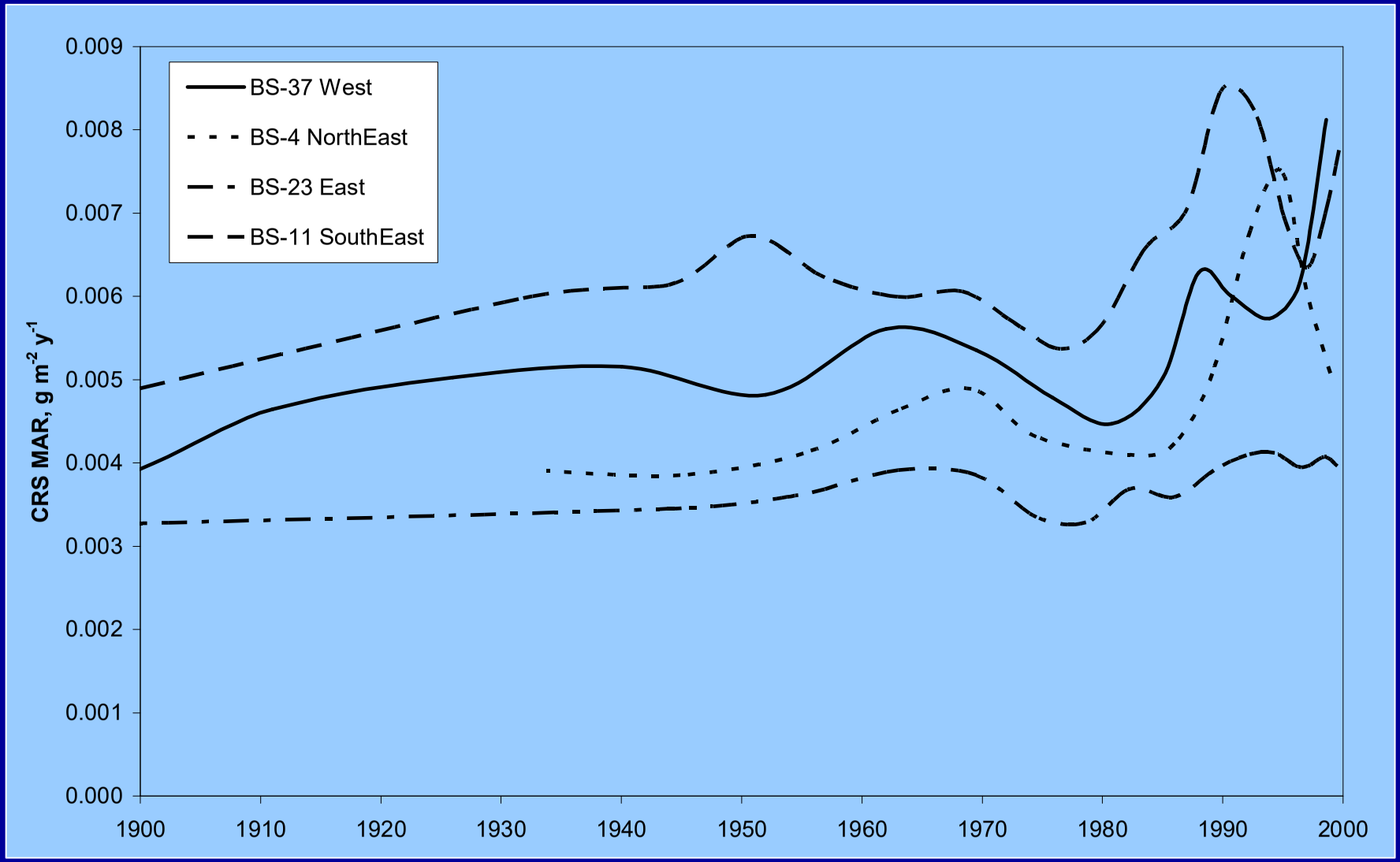
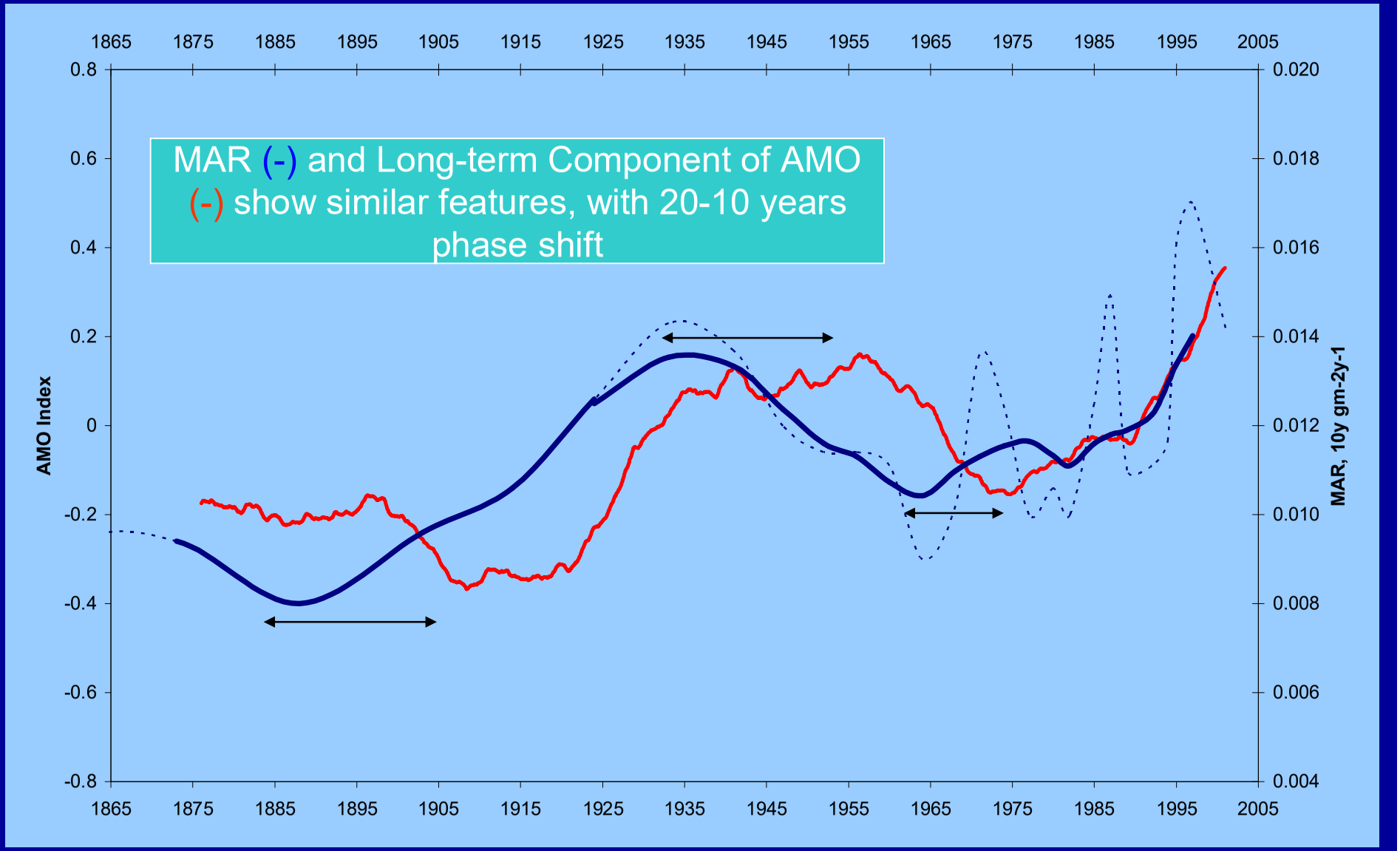
MAR Abyssal Sediment, Black Sea (cont.)



Black Sea MAR and AMO



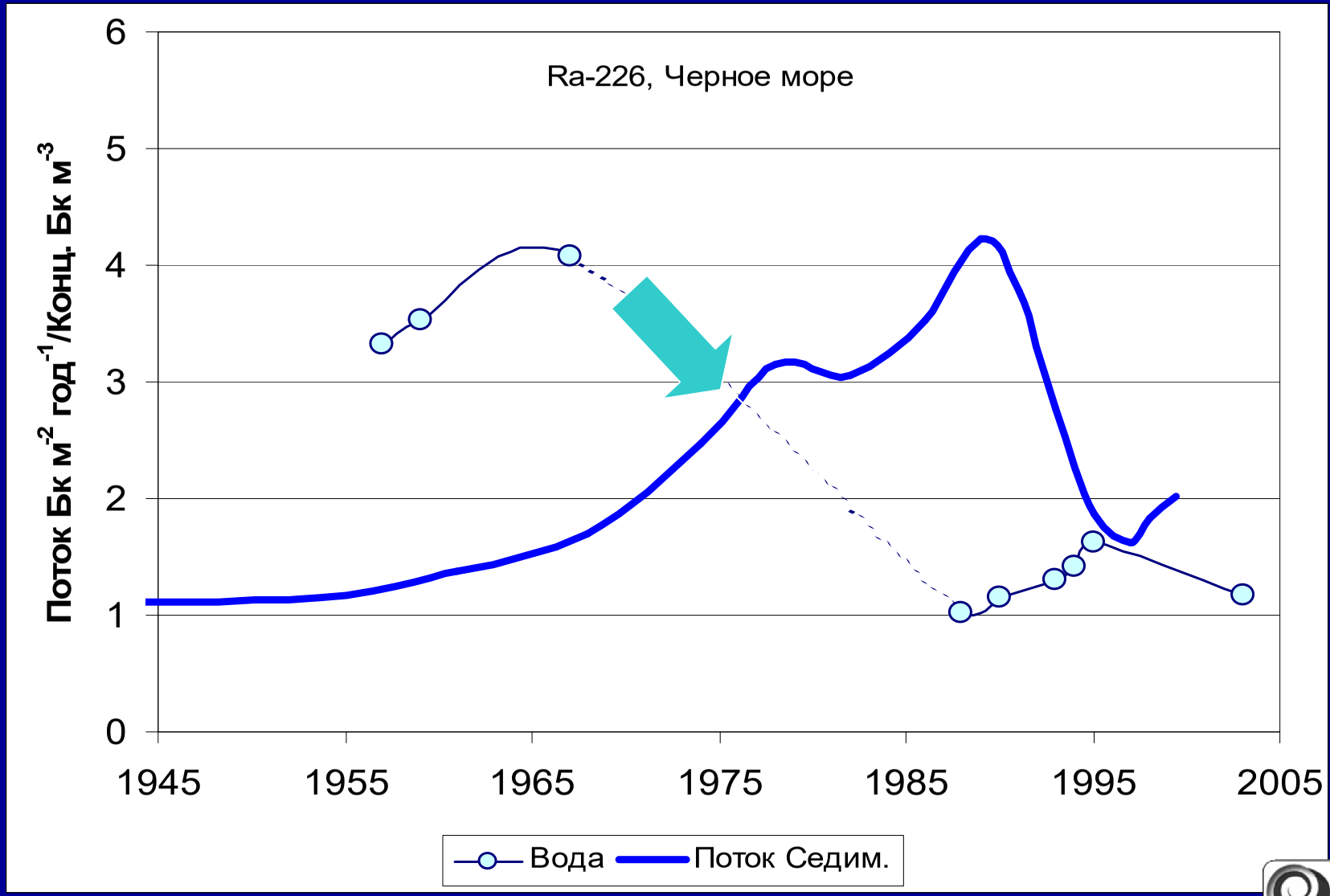
^{226}Ra Disequilibrium – Historical Background

- Early measurements of ^{226}Ra in the Black Sea –

  RIAN (Russia) 1957-59 (Lazarev et al., 1960 – *Surface Water*)

  1967 – RV Oceanographer (Moore, 1969)
- 1988 – Joint US-Turkish BS Expedition (ONeill et al., 1992 – *Water Column Profile*)
- 1988-1990 – Falkner et al., 1991(*Chronological Records*)
- 1991-1995 - Moore et al., 1999 (*Rivers and Sea*)

Does ^{226}Ra Disequilibrium pose a reaction of the Black Sea geochemical system on increased eutrophication only, or reflects the climate change?



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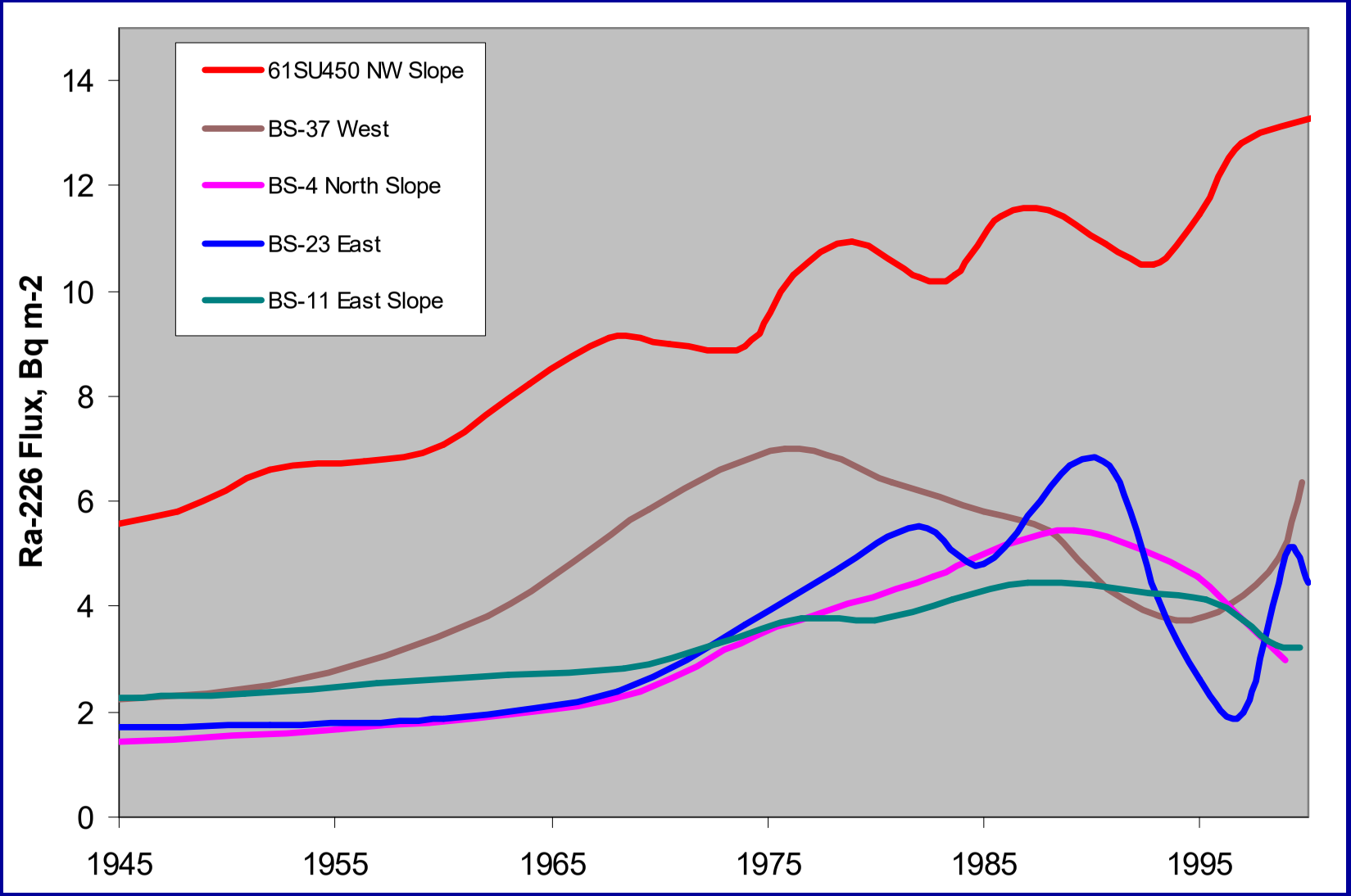
Ra226 Flux to Sediment, $Bqm^{-2}y^{-1}$



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Another feature of the Black Sea unstable condition revealed by radioisotopic marker – shoaling of the oxic/anoxic interface towards shoreline in last 30-40 years

Core BS-A5

Newly developed sedimentation pattern on shelf-continental slope boundary driven by rapid precipitation of possibly manganese hydroxides over the "older" Modiolus Phaseolina blanket – caused by likely establishing of permanent suboxic conditions near bottom due to lifting and advance (shoaling) of oxic/anoxic interface (Konovalov et al, 2004).

Powerful sink for contaminant and its present role in boundary scavenging of contaminants at shelf edge is needed to be further evaluated.

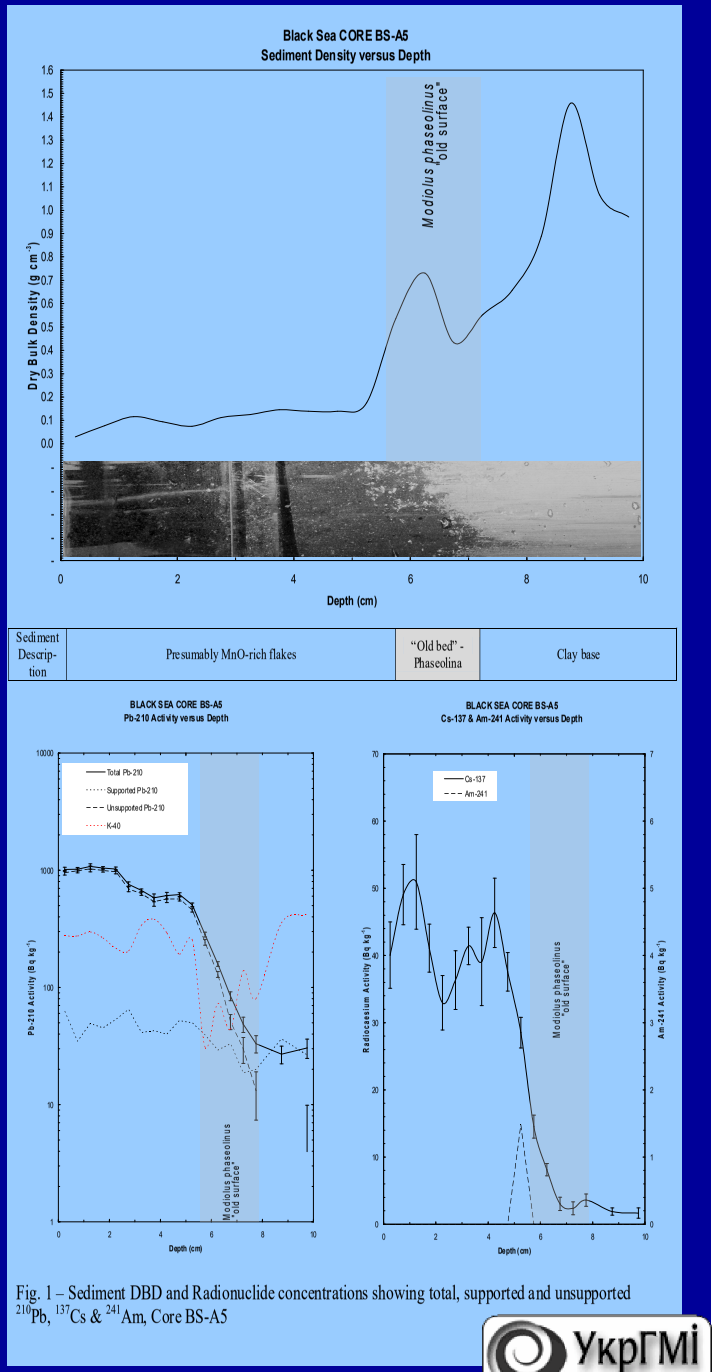

Fig. 1 – Sediment DBD and Radionuclide concentrations showing total, supported and unsupported ^{210}Pb, ^{137}Cs & ^{241}Am, Core BS-A5

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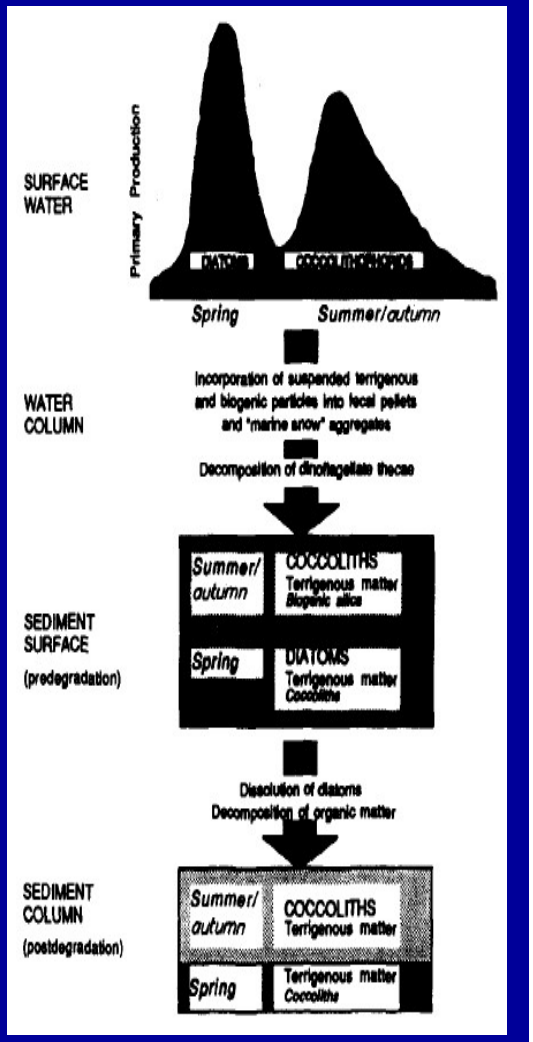
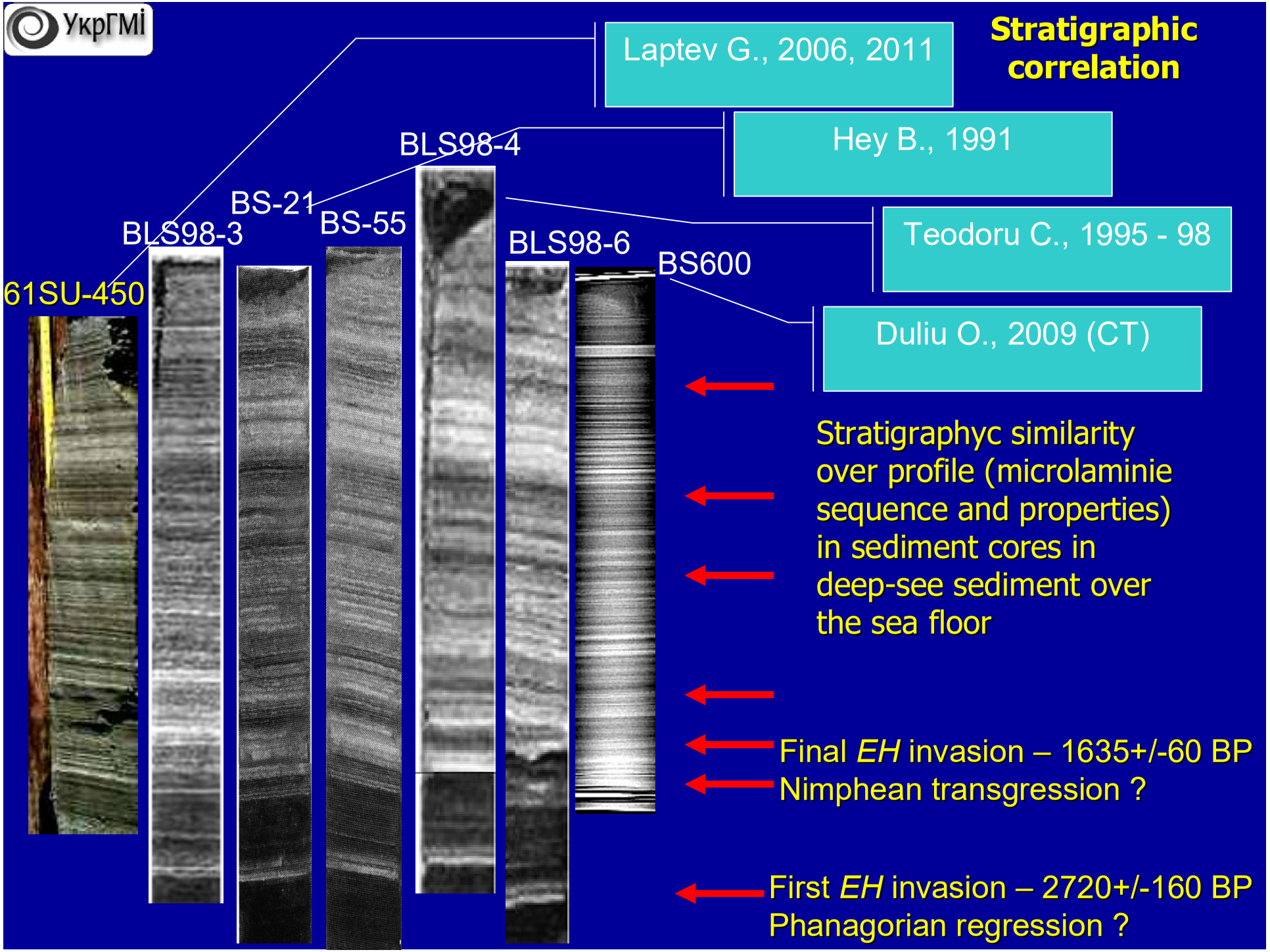
Laminated Sediment – paleoclimatic archive of high temporal resolution

Major contributior of biogenic carbonates in the Black Sea – phytoplankton Coccolithophorides, *Emeliania Huxleyi (Eh)*



Hay et al., 1990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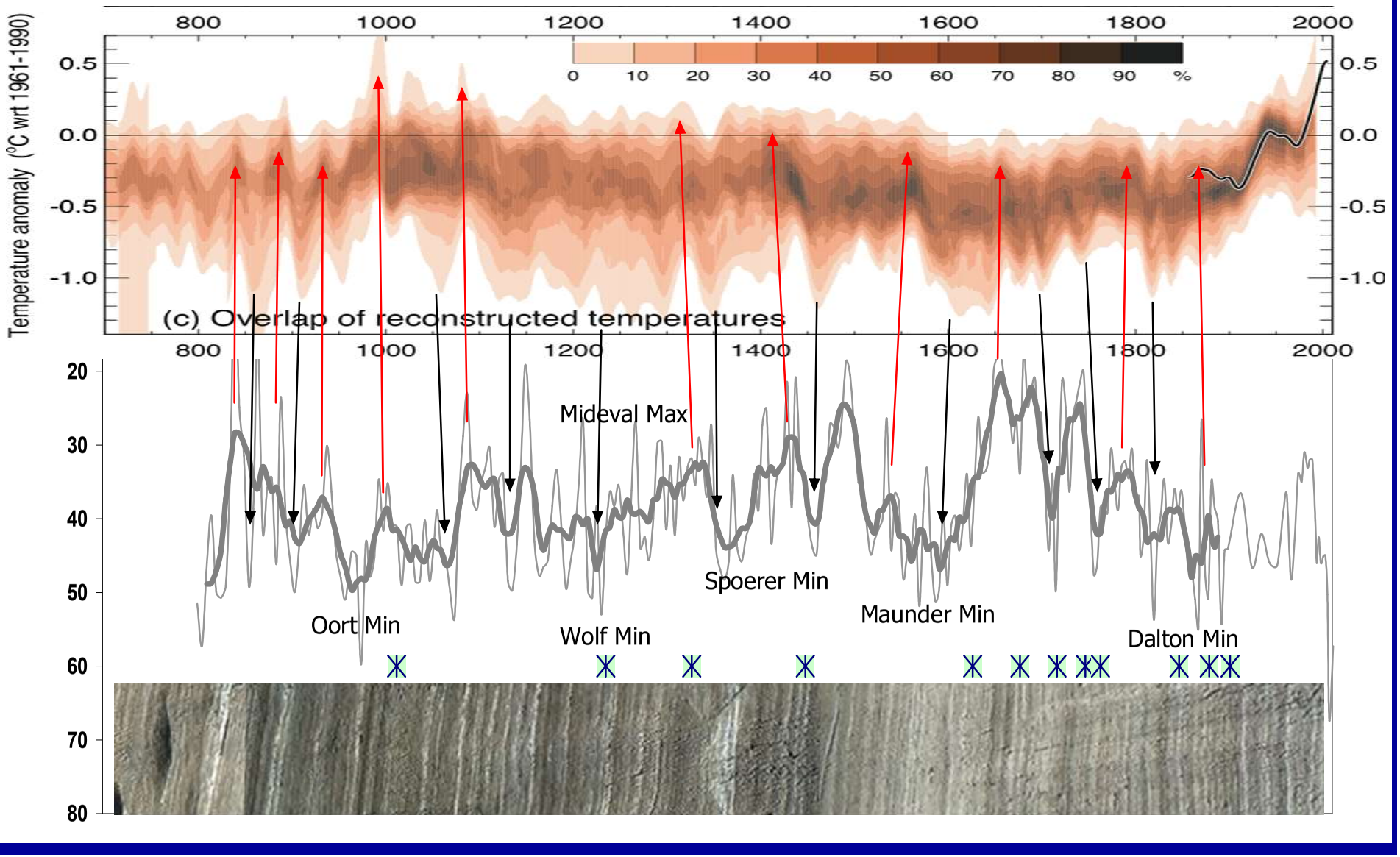
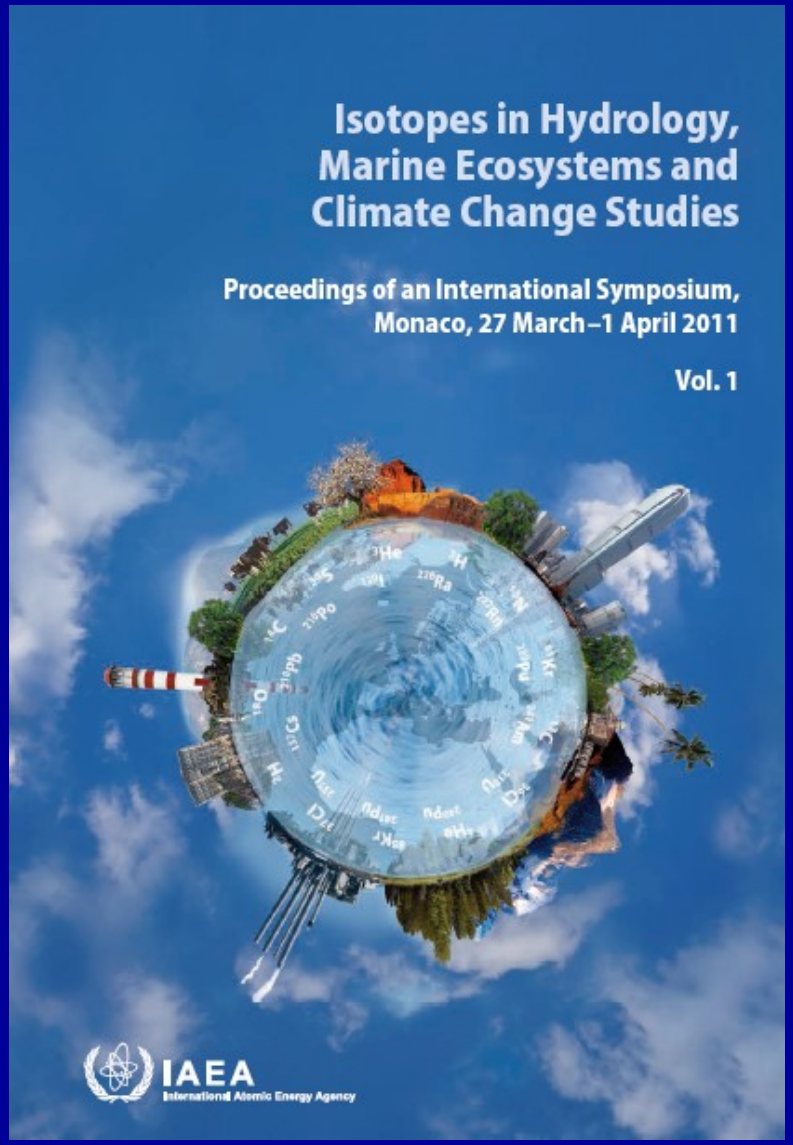
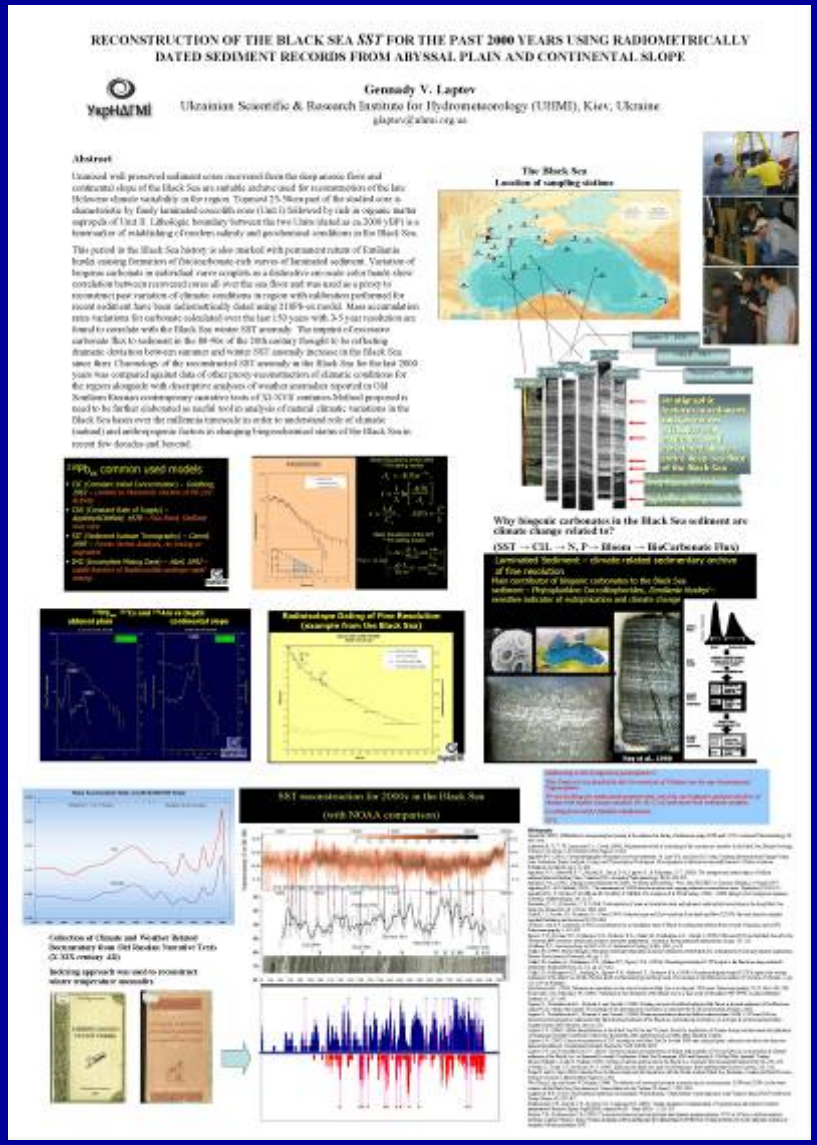
Laptev G., 2006, 2011
Stratigraphic correlation
Hey B., 1991
Teodoru C., 1995 - 98
Duliu O., 2009 (CT)
61SU-450
BLS98-3
BS-21
BS-55
BLS98-4
BLS98-6
BS600
Stratigraphyc similarity over profile (microlaminie sequence and properties) in sediment cores in deep-see sediment over the sea floor
Final EH invasion – 1635+/-60 BP
Nimphean transgression ?
First EH invasion – 2720+/-160 BP
Phanagorian regression ?

Reconstruction of Temperature Anomalies for the last 1500y (NOAA *vs* the Black Sea)

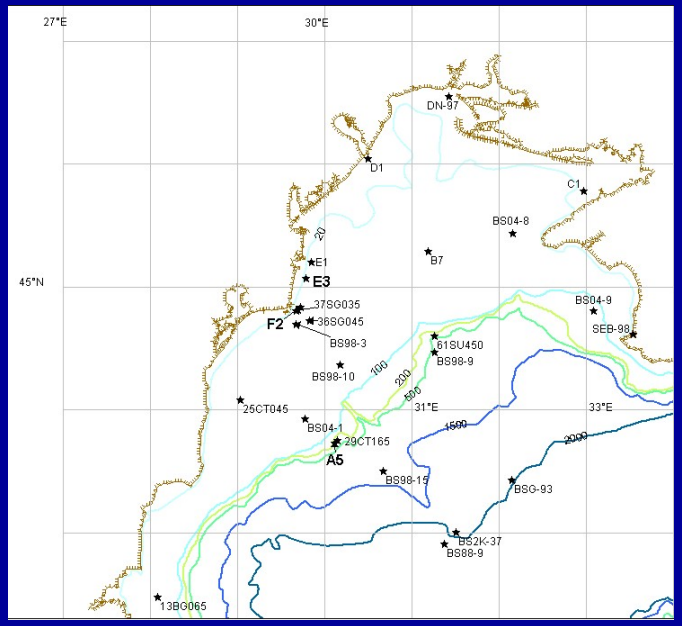


Isotope Symposium, Monaco, 2011

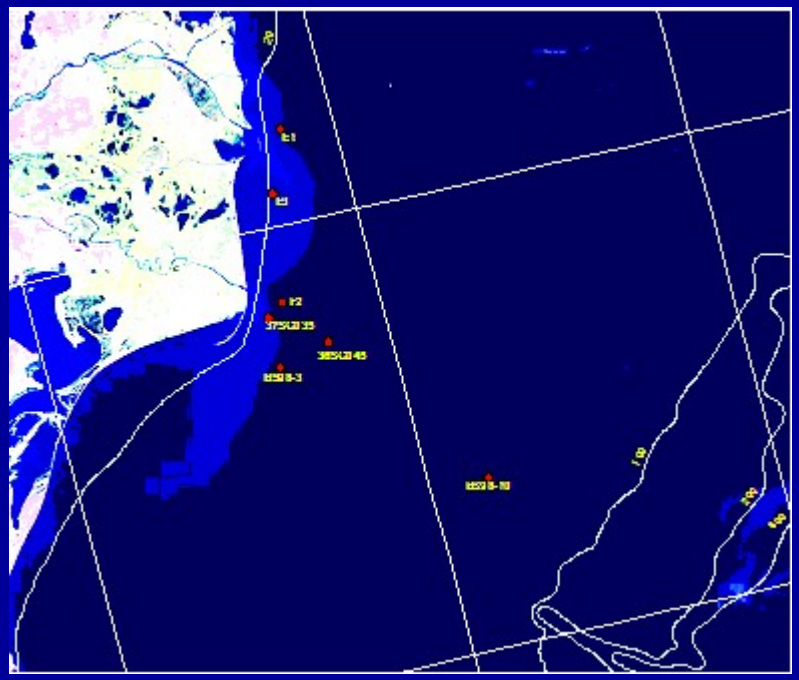


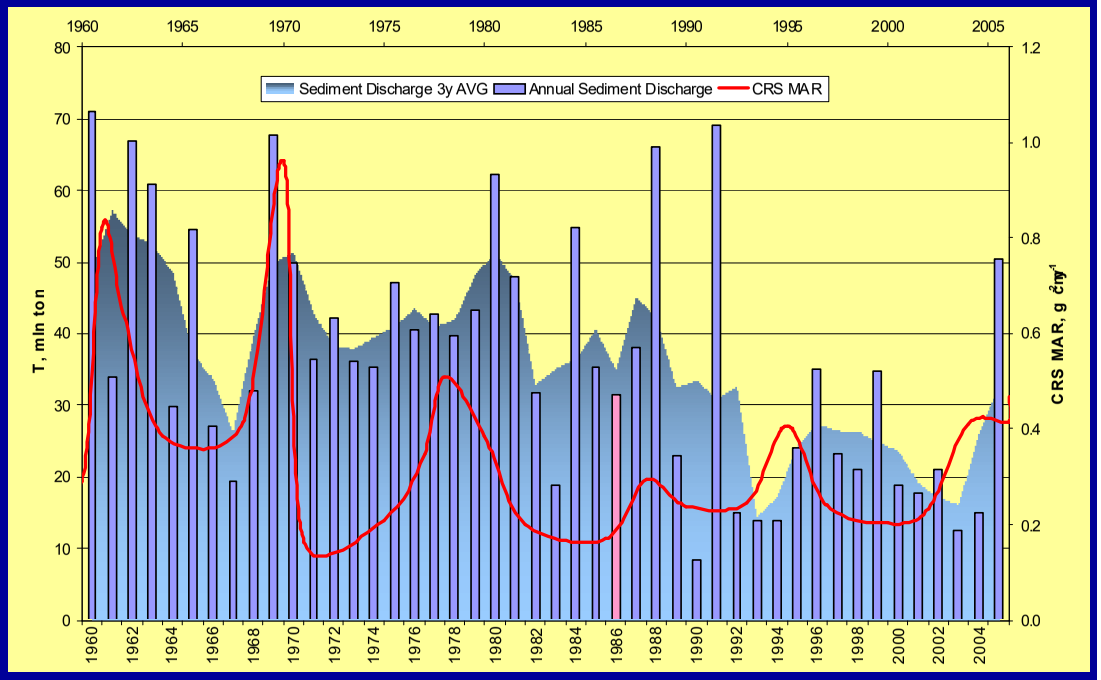


BSERP-2006, Study at Danube Delta



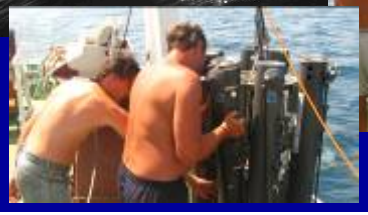
- sediment mass accumulation rate (MAR, g cm-2y-1) over the studied period of time in general follow **declining trend** in sediment supply by Danube after construction of Iron Gate Dam in 1970 inferred by hydrological observation data
- Danube sediment discharge (annual amount in mln.tons and 3year moving average) and CRS MAR for period of 1960-2005





Further Perspective Directions for Research

- Radionuclides in Atmospheric Aerosols (Pb-210, Be-7, Rn-222), pecularities of atmospheric circullation over open marine basin
- Modern structure of RN (Cs-137, Sr-90 etc) distribution in water column – can be used for calibaration of the model of vertical exchange in stratified marine system
- Paleoclimatic reconstuction in the Black Sea region in last 2000 years using biogenic carbonates and proxi-indicators δO_{18} и $U_{37}^{k,}$ (resolution 5-10 years), Pb-210, Ra-226, C-14
- Improvement of using sediment derived archives using modern instrumental observations by satelite (SeaWiFS, CZCS, MERIS и MODIS)
- Monitoring of Ecological Status (Health) by chemical and radioactive parameters (Coastal, Estuary, Deep)
- IAEA RCP 2018-2020 «Application of Nuclear Methods in coast management of the Black Sea and Adriatic Sea» - NW Shelf and Danube Delta



Selected Publications