Marine non-living resources

(with particular reference to gas hydrates)

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ABIOTIC RESOURCES

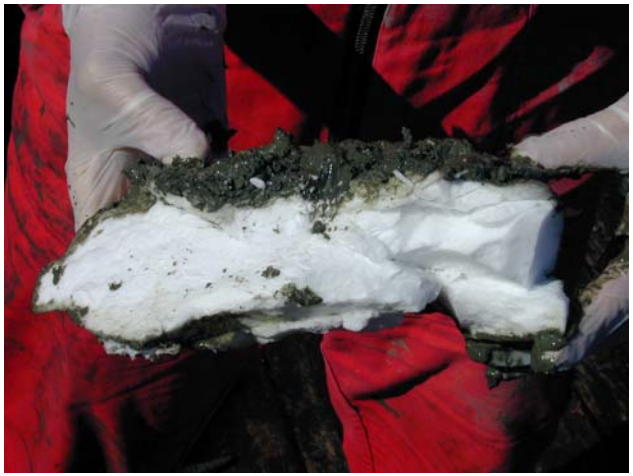
➢ **THE GEO-RESOURCES FORMED MAINLY BY NATURAL MARINE PROCESSES** (GEOLOGICAL, CHEMICAL, HYDROLOGICAL)

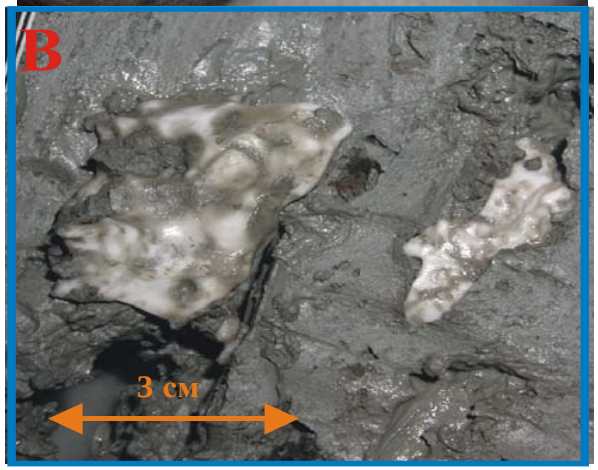
→ **MINERAL CONCENTRATIONS (PLACERS)**
→ **HYDROTHERMAL FLUIDS**

→ **GRAVEL and SAND MINING**

→ **GAS HYDRATES**

Gas Hydrates





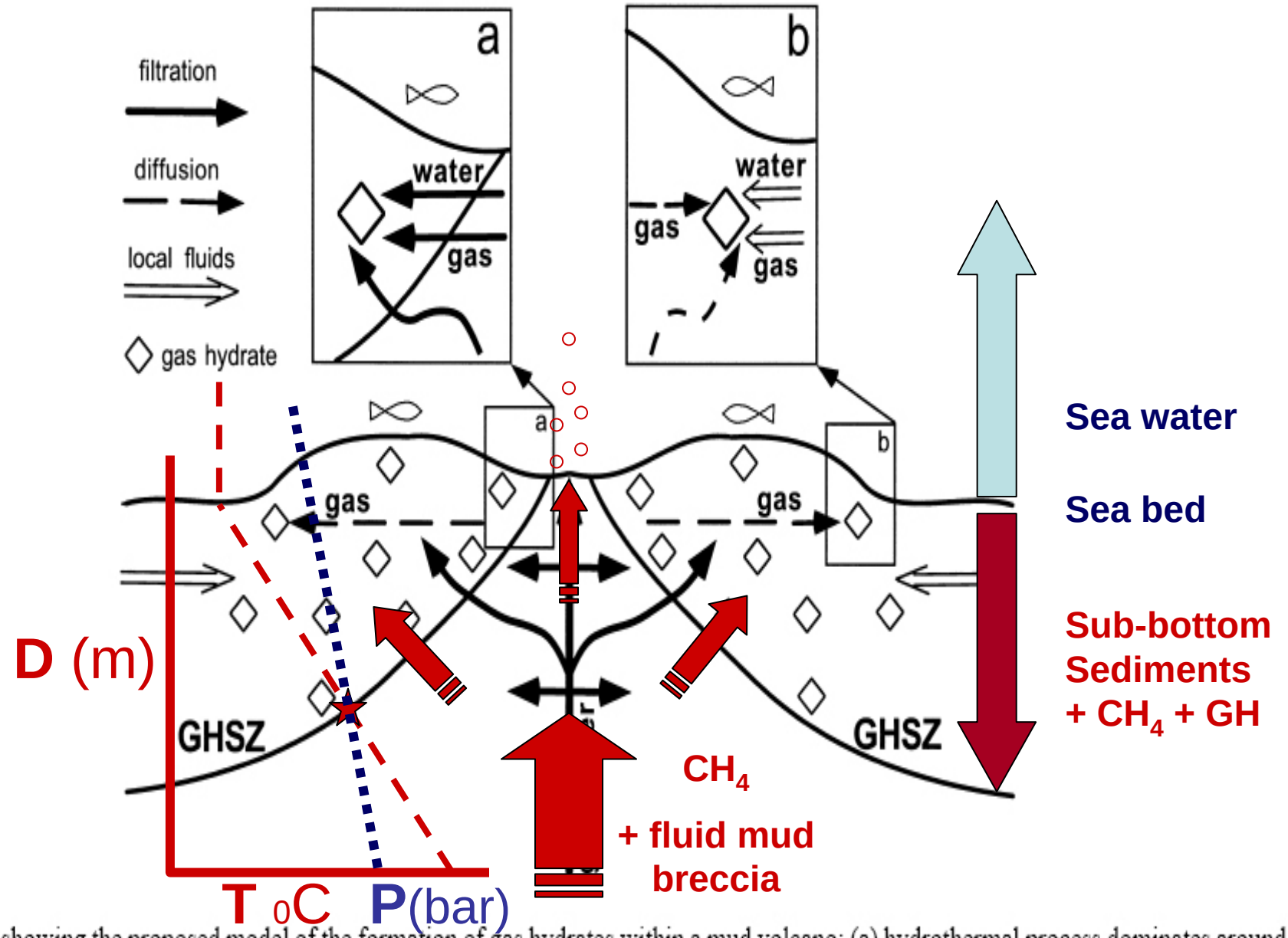


Fig. 3. Cartoon showing the proposed model of the formation of gas hydrates within a mud volcano: (a) hydrothermal process dominates around the central part of the mud volcano; (b) metasomatic process dominates at the peripherical part of the mud volcano.

PARAMETERS OF G.H.

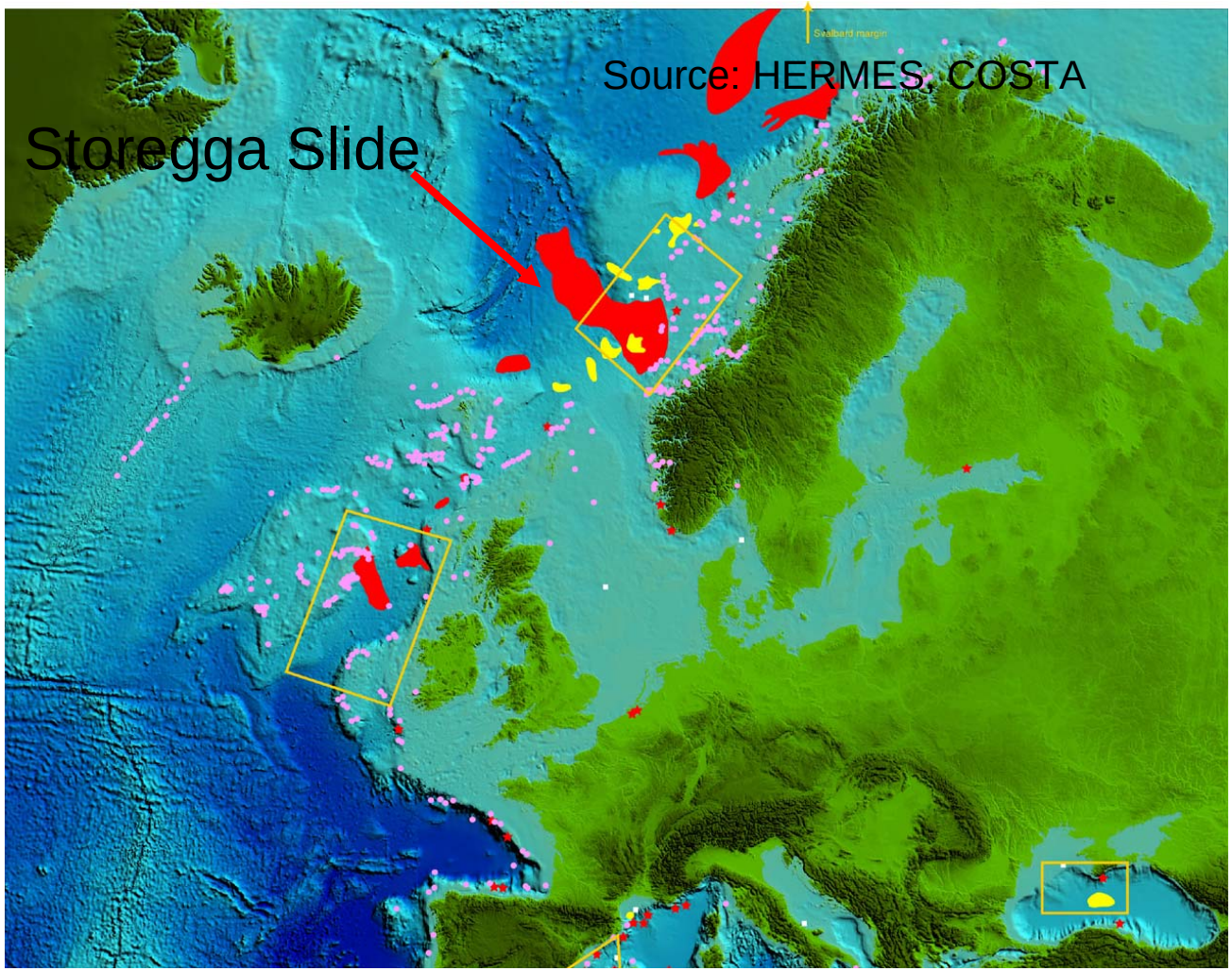
- **AREAS OF OCCURRENCE:** SEA 99,8%, LAND 0,20%.
- **CHARACTERISTIC:** PRESENCE OF BSR (NOT ALWAYS).
- **SEA WATER DEPTH:** 130 –3000m.
- **OCCURRENCE BELOW SEA BOTTOM:** 0-1100 m.
- **THICKNESS OF GH BED:** Unknown.Generally less than 250m
- **QUANTITY OF CH_4:** 3.000–10.000 TRILLION m^3or 55% OF WW Org C
- **EXAMPLE OF RESOURCE VOLUME:** Methane from GH in Blake Ridge, U.S. can meet the natural gas requirements in USA for next 105 yr, (at 1996 consumption level)
- **ORIGIN:** Mainly Thermogenic

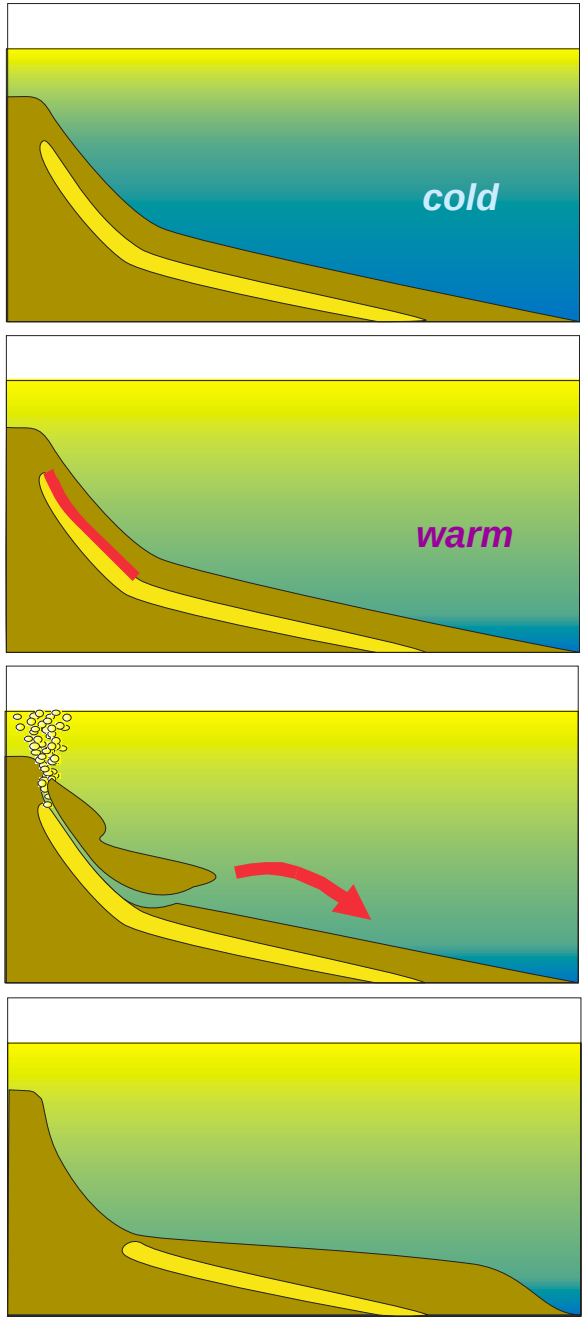
GH, slope stability and tsunamis:

Example: 8,000 years ago

3,400 km^3 submarine land slide

10-15 m high tsunami wave

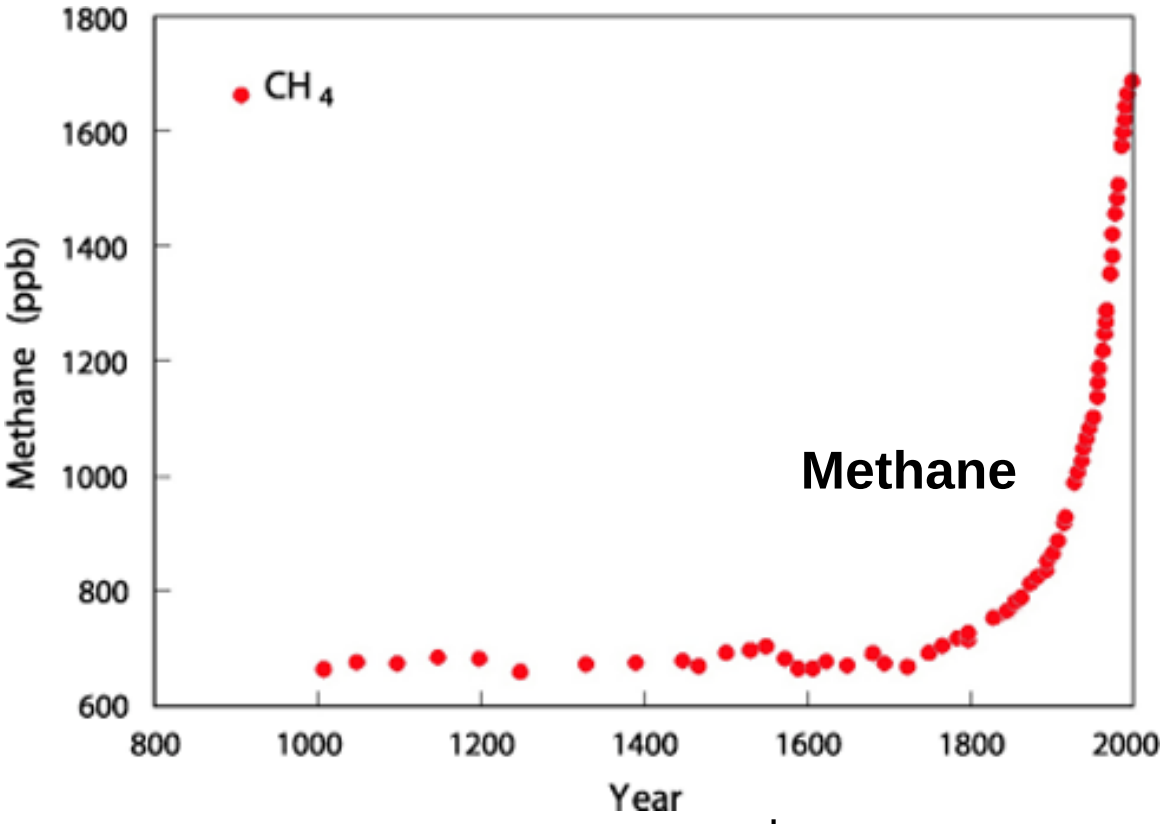




Methane concentration in the atmosphere:

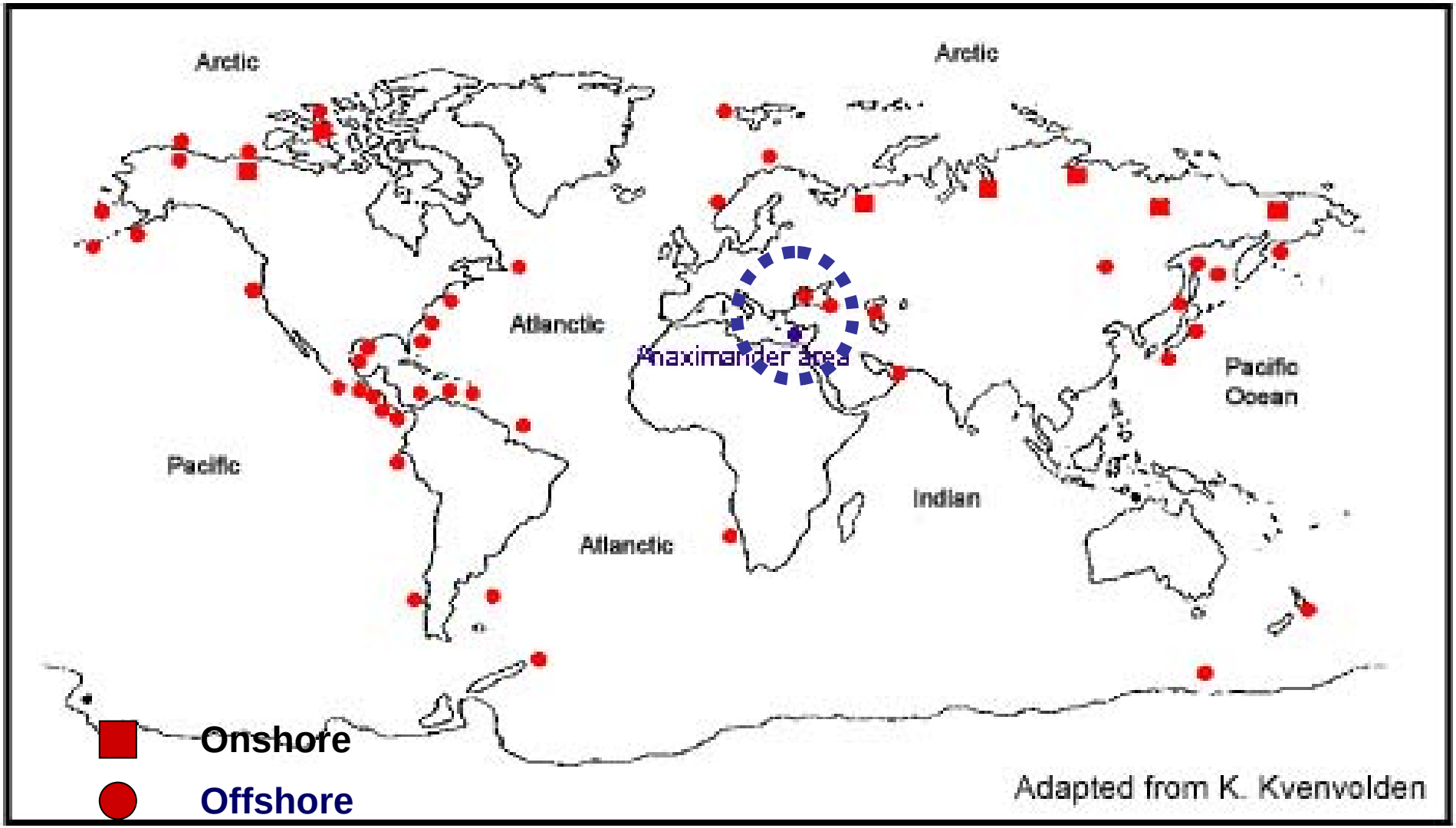
from ice cores (since AD 1000) and air samples

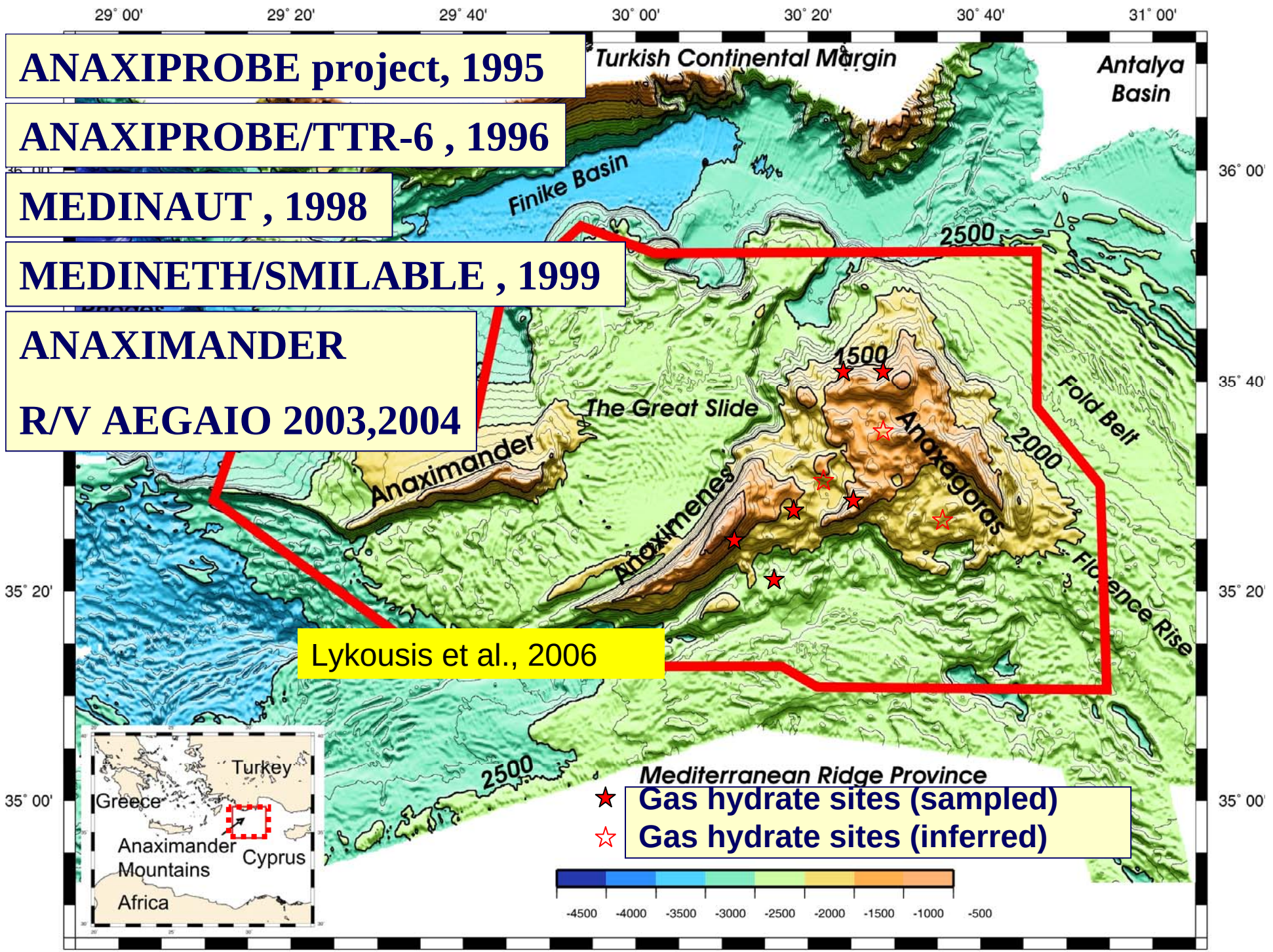
- **Methane:** 140% increase since 1800
- **Carbon dioxide:** 30% increase since 1800

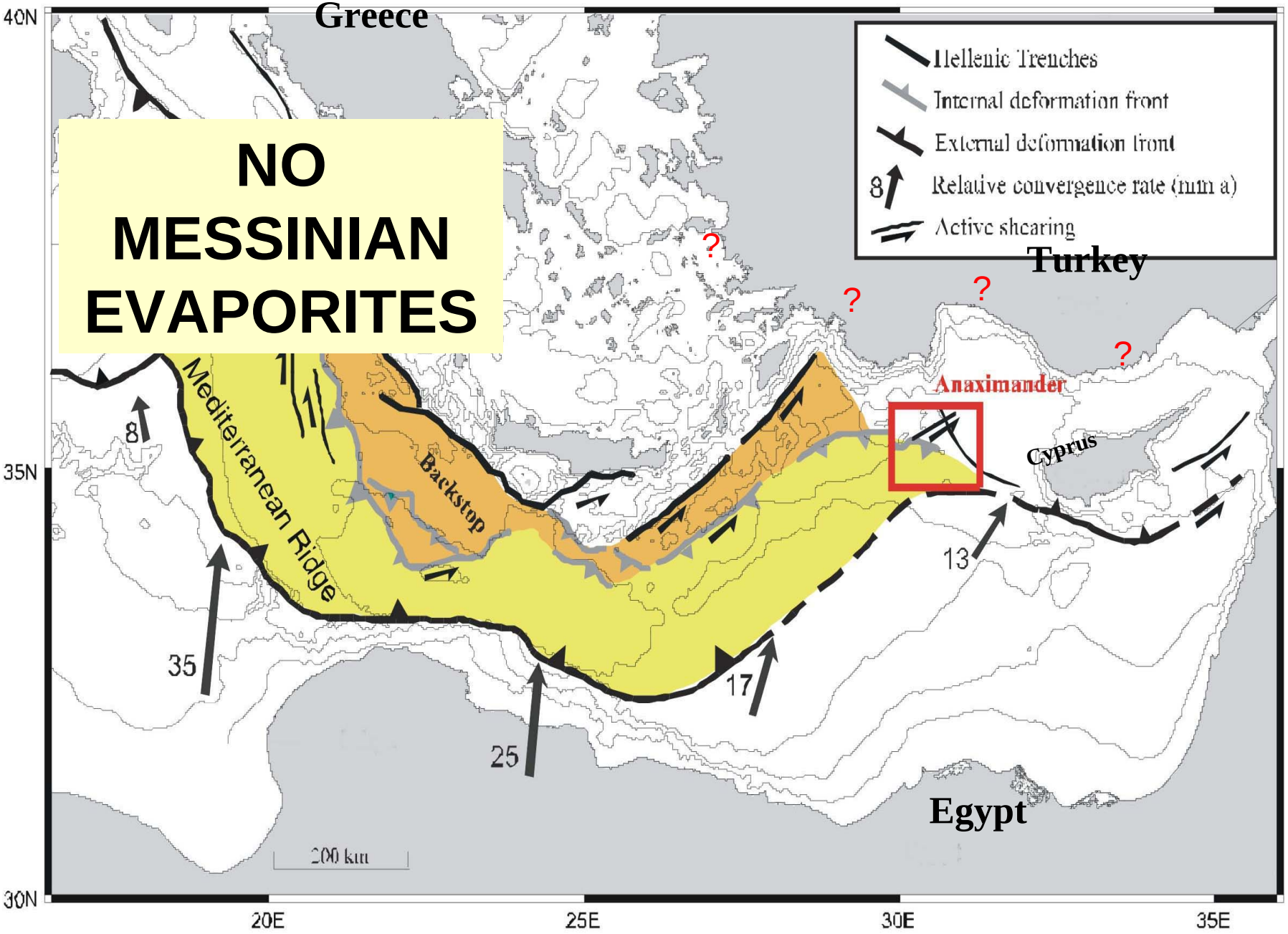


Source: CSIRO Atmospheric Research

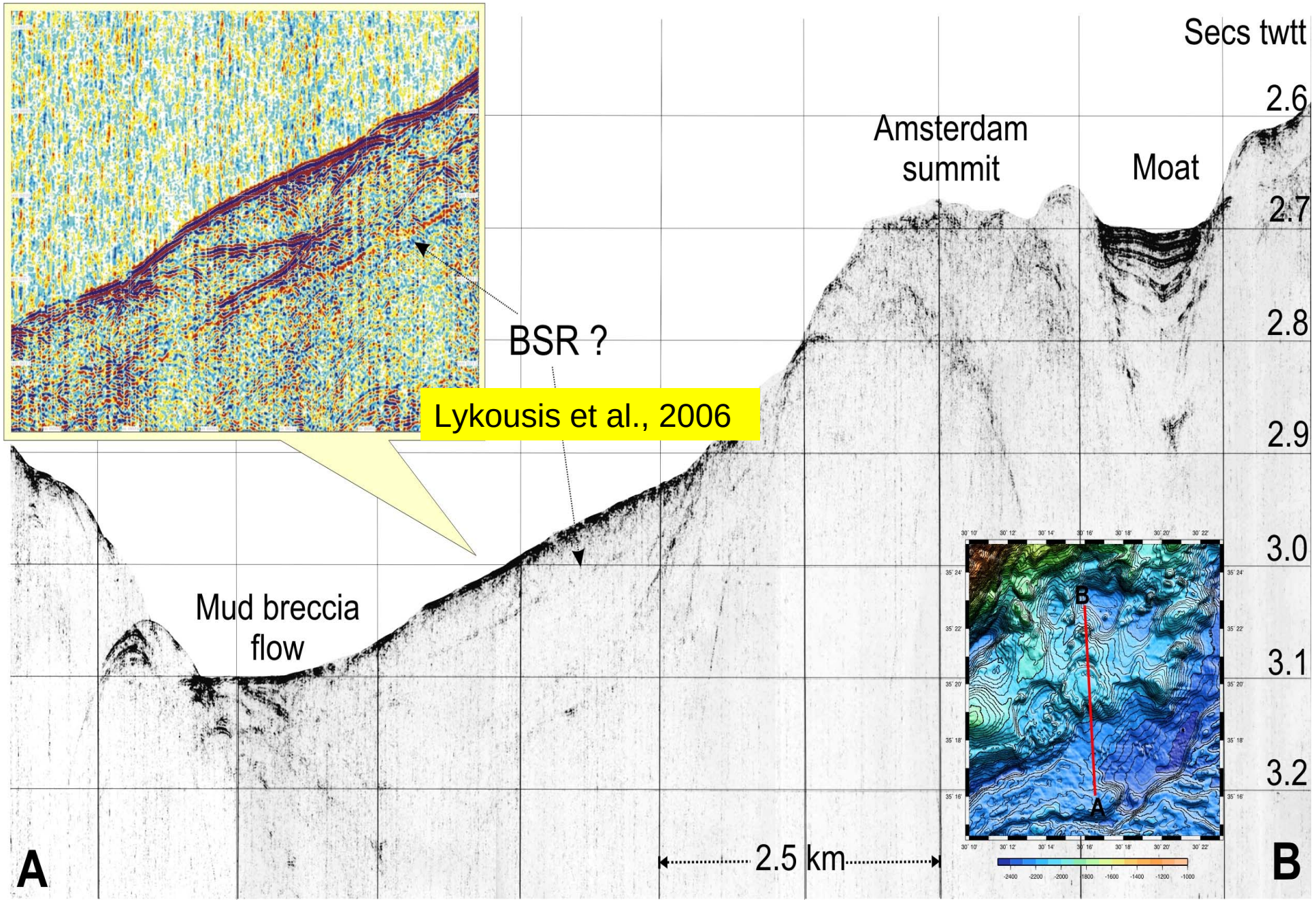
Gas Hydrate sites distribution (indicative)

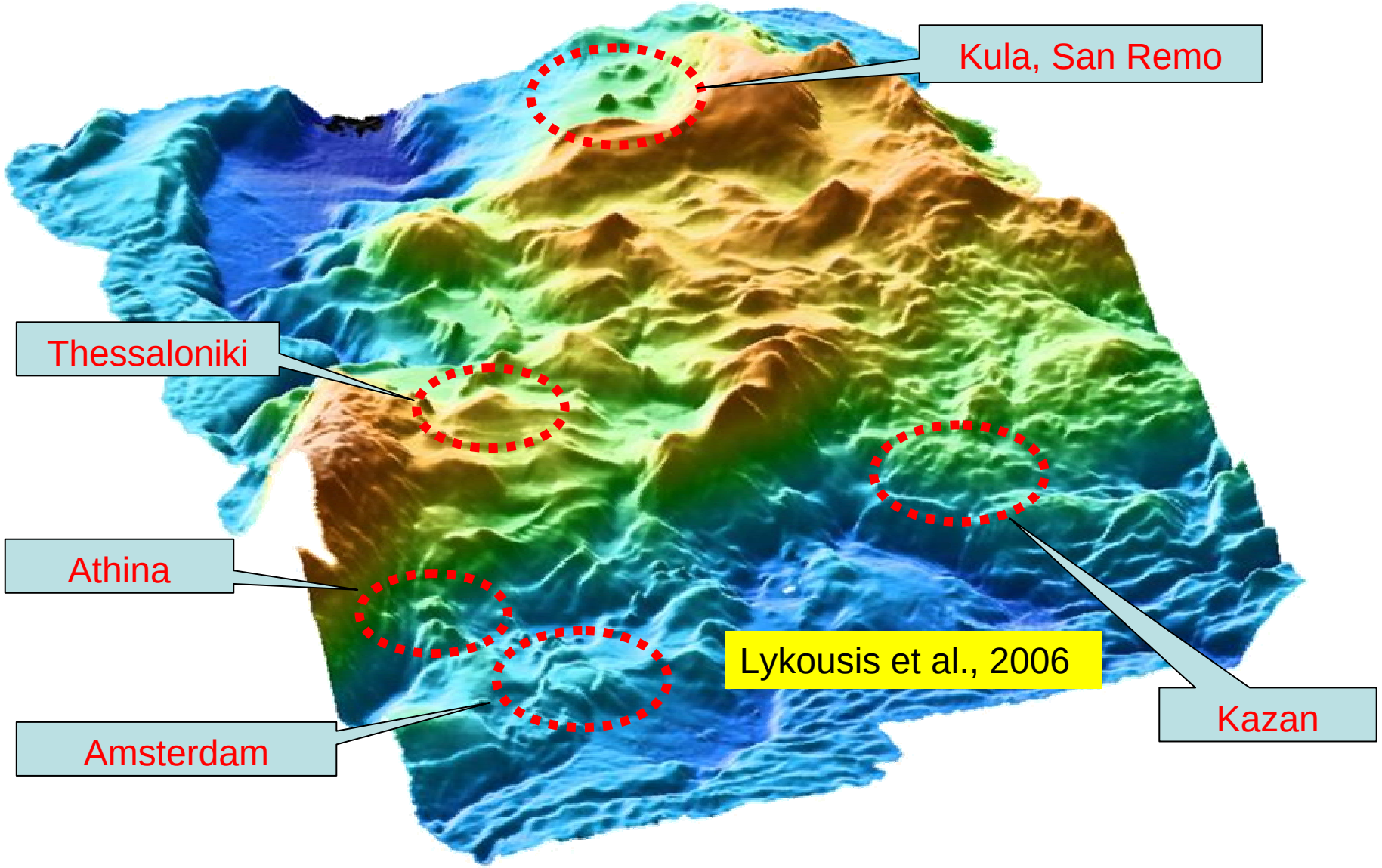



ANAXIPROBE project, 1995
ANAXIPROBE/TTR-6 , 1996
MEDINAUT , 1998
MEDINETH/SMILABLE , 1999
ANAXIMANDER
R/V AEGAIO 2003,2004
29° 00'
29° 20'
29° 40'
30° 00'
30° 20'
30° 40'
31° 00'
36° 00'
35° 40'
35° 20'
35° 00'
Turkish Continental Margin
Antalya Basin
Finike Basin
2500
1500
2000
The Great Slide
Anaximander
Anaximenes
Anaxagoras
Fold Belt
Florence Rise
Lykousis et al., 2006
Turkey
Greece
Cyprus
Anaximander Mountains
Africa
Mediterranean Ridge Province
Gas hydrate sites (sampled)
Gas hydrate sites (inferred)
-4500
-4000
-3500
-3000
-2500
-2000
-1500
-1000
-500


NO MESSINIAN EVAPORITES
Greece
Turkey
Egypt
Cyprus
Anaximander
Mediterranean Ridge
Backstop
Hellenic Trenches
Internal deformation front
External deformation front
Relative convergence rate (mm a)
Active shearing
8
35
25
17
13
?
?
?
?
40N
35N
30N
20E
25E
30E
35E
200 km


EIRELEC
4.0
KTJ
A-B
AUTO
AX 1 SGC1
Lykousis et al., 2006


Secs twtt
2.6
2.7
2.8
2.9
3.0
3.1
3.2
Amsterdam
summit
Moat
BSR ?
Lykousis et al., 2006
Mud breccia
flow
2.5 km
A
B



Total active MV area 46km^2

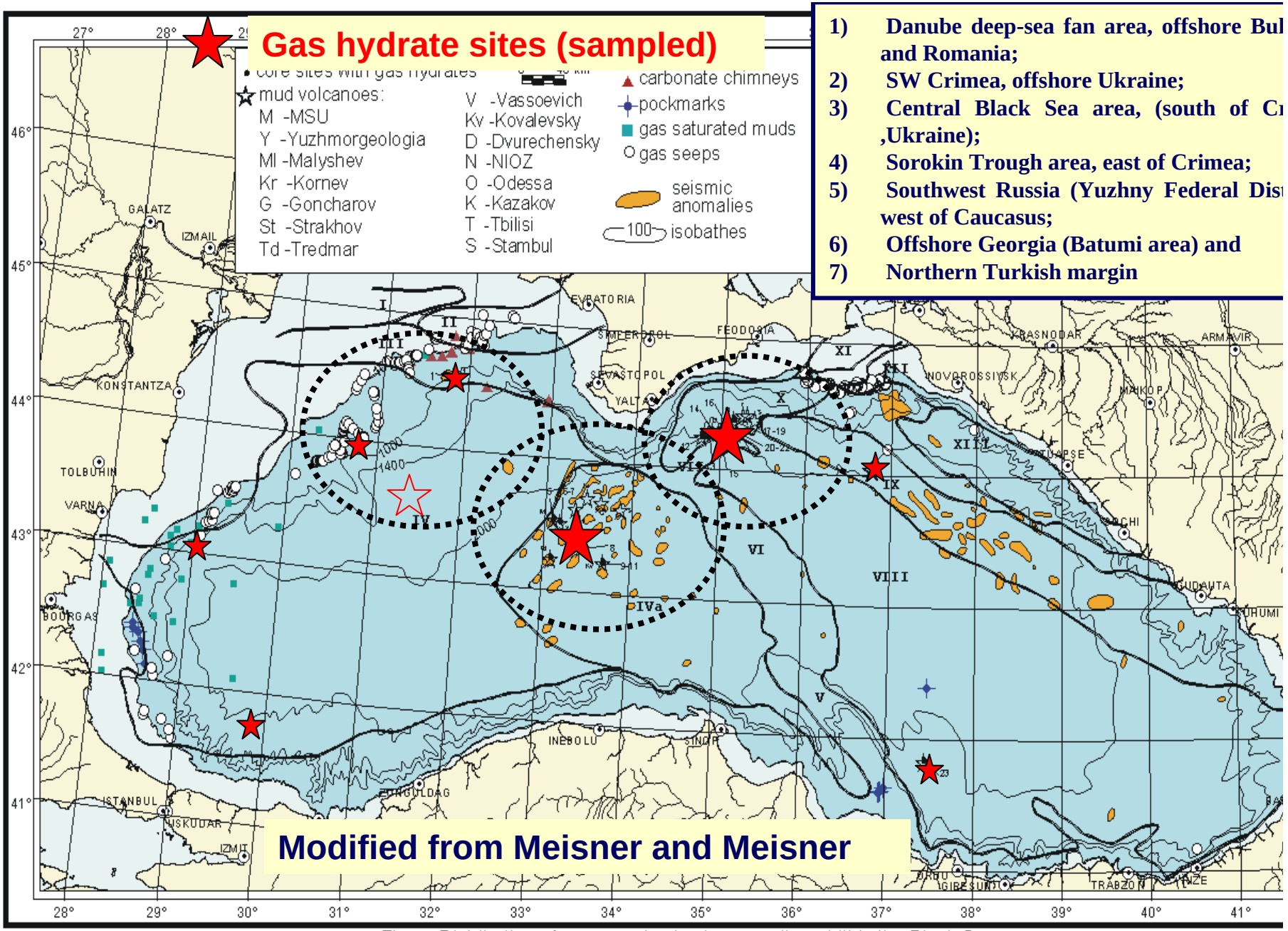
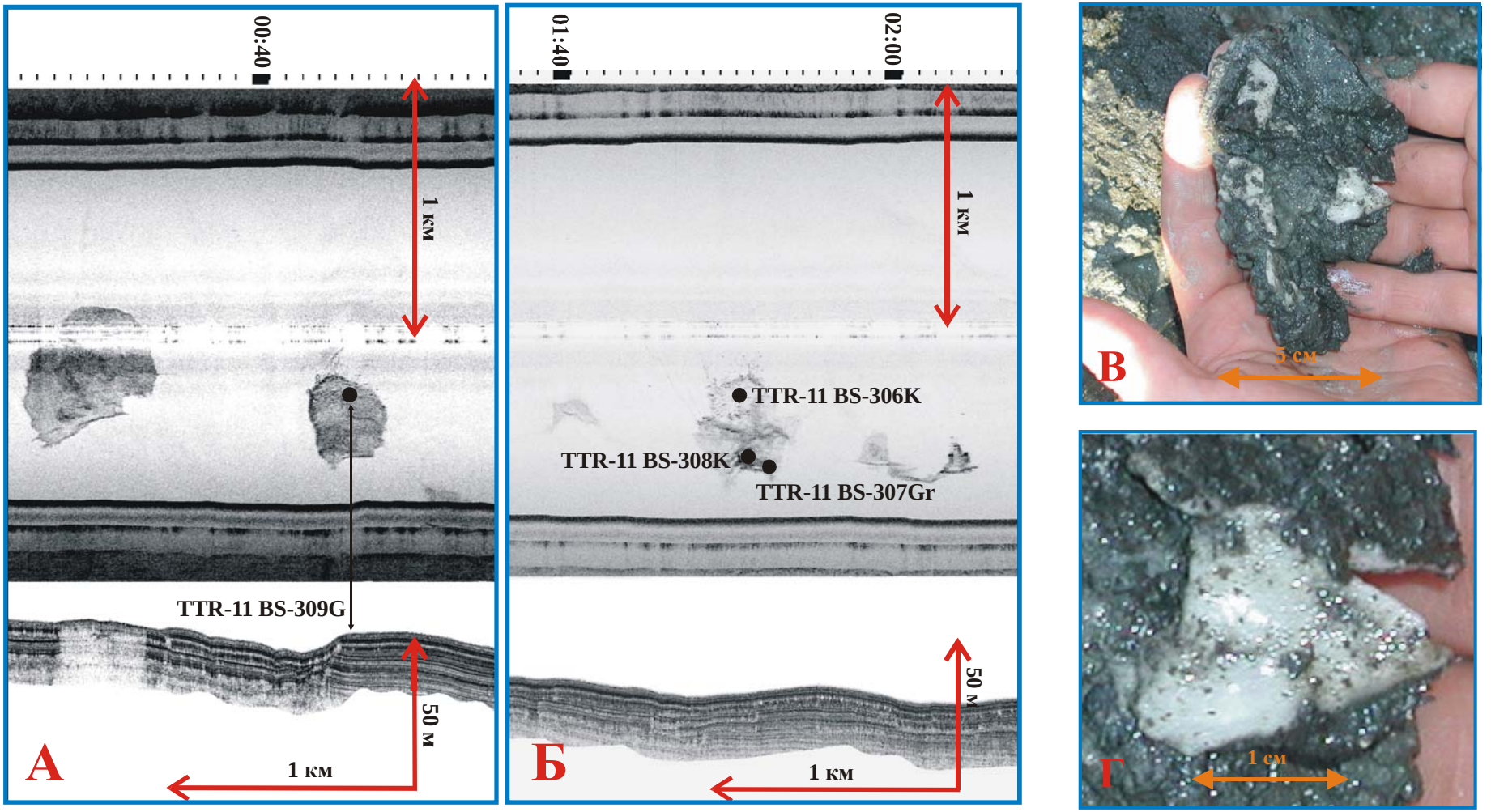


Fig. Distribution of seeps and seismic anomalies whithin the Black Sea

Compiled by Meisner T. and Meisner L.
Sources are Byakov et. al (2001); Glebov et. al. (2001); Ginsburg et. al. (1989); Ivanov et. al. (1994,1997,2002); Snyukov et. al. (1995, 2000, 2001, 2003); Dmitrov et. al. (1994)
Computer design by Prokoptsev V.

UTM projection
WGS-84
C. Long 39°

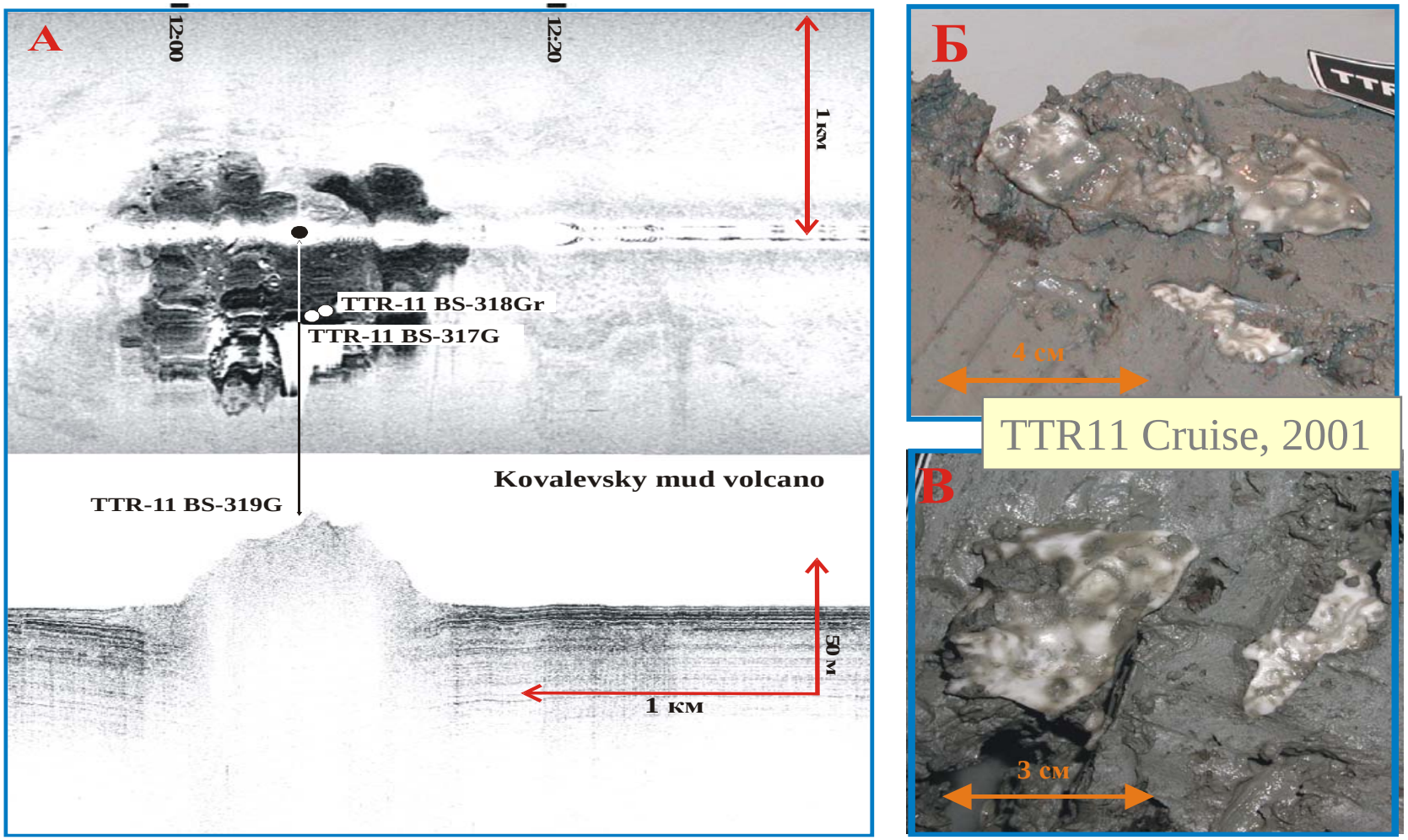
South-west slope of Crimean Peninsula



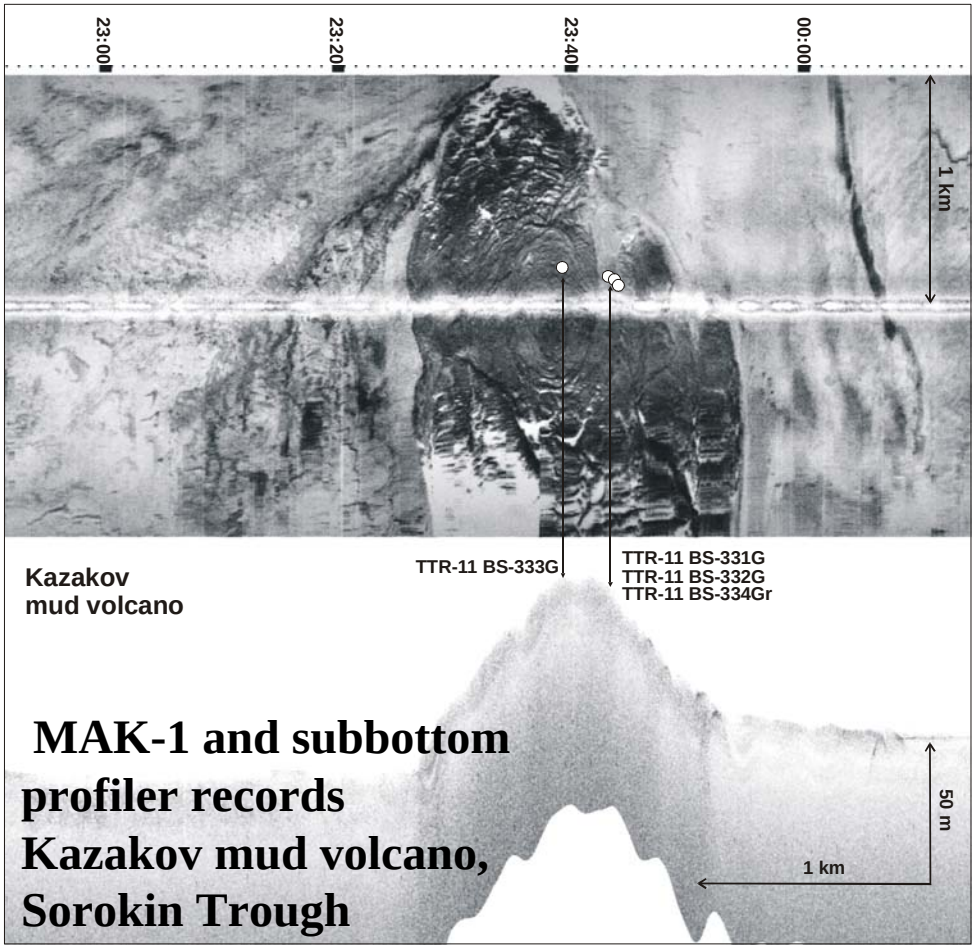
Sections of MAK-1 profile showing fluid discharge structures (left) and gas hydrates (right), South-west slope of Crimean Peninsula, Black Sea

TTR11 Cruise, 2001

Central Black Sea



Sections of MAK-1 profile showing Kovalevsky mud volcano (left) and gas hydrates (right), Central Black Sea



MAK-1 and subbottom profiler records Kazakov mud volcano, Sorokin Trough

Sorokin Trough

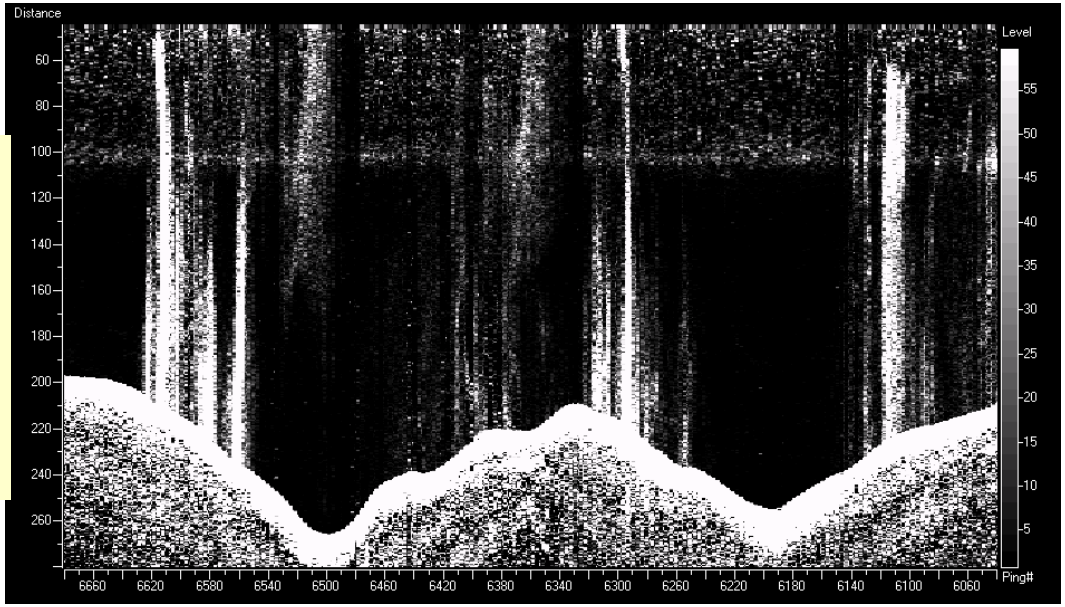
TTR11 Cruise, 2001

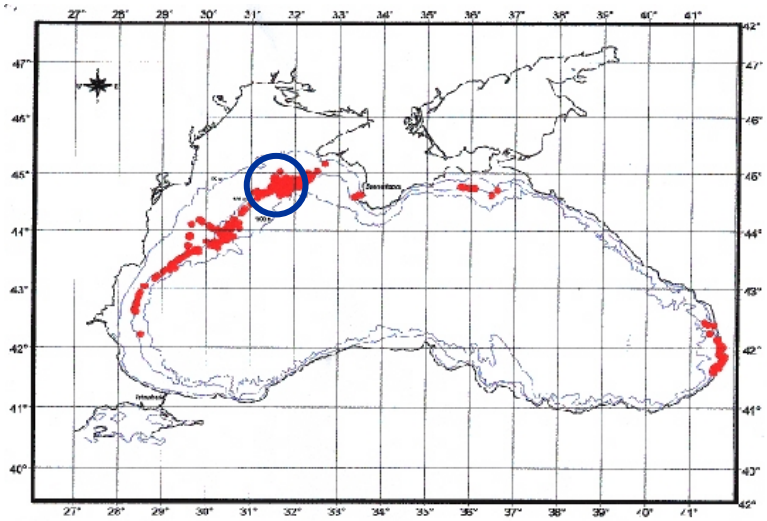
Gas ebullition from sea floor - NW Black Sea (**METROL**)

Top: Flares, echosounder profile

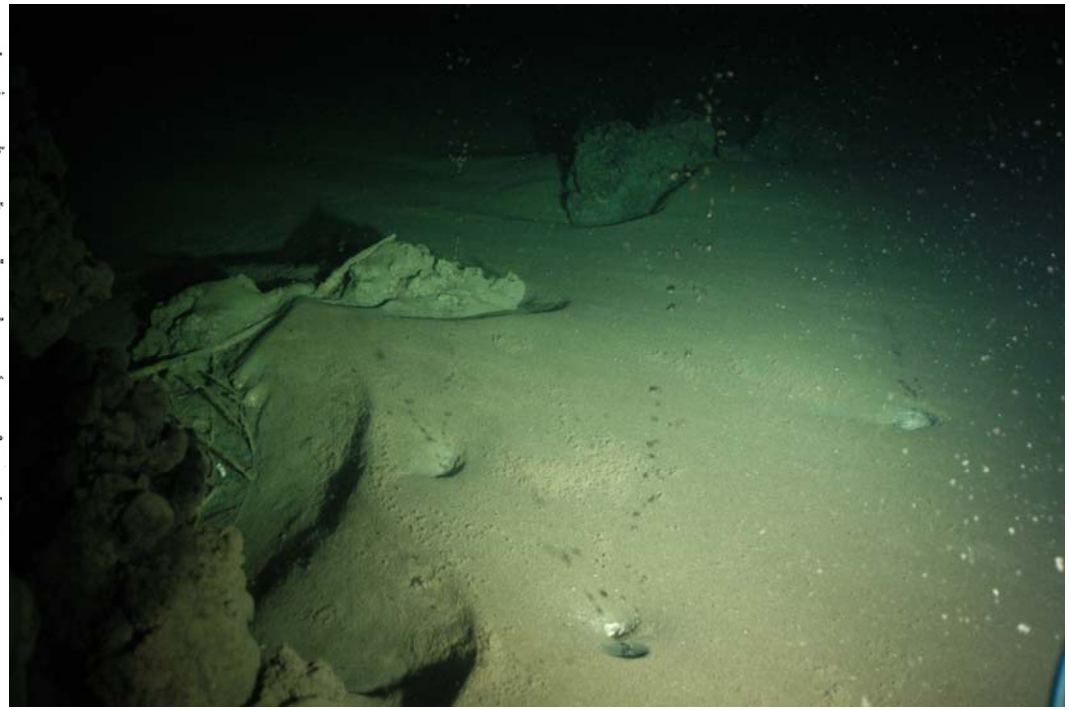
Bottom: Rising bubbles

Below: Sites of gas emission





Source: Egorov et al. (2003)

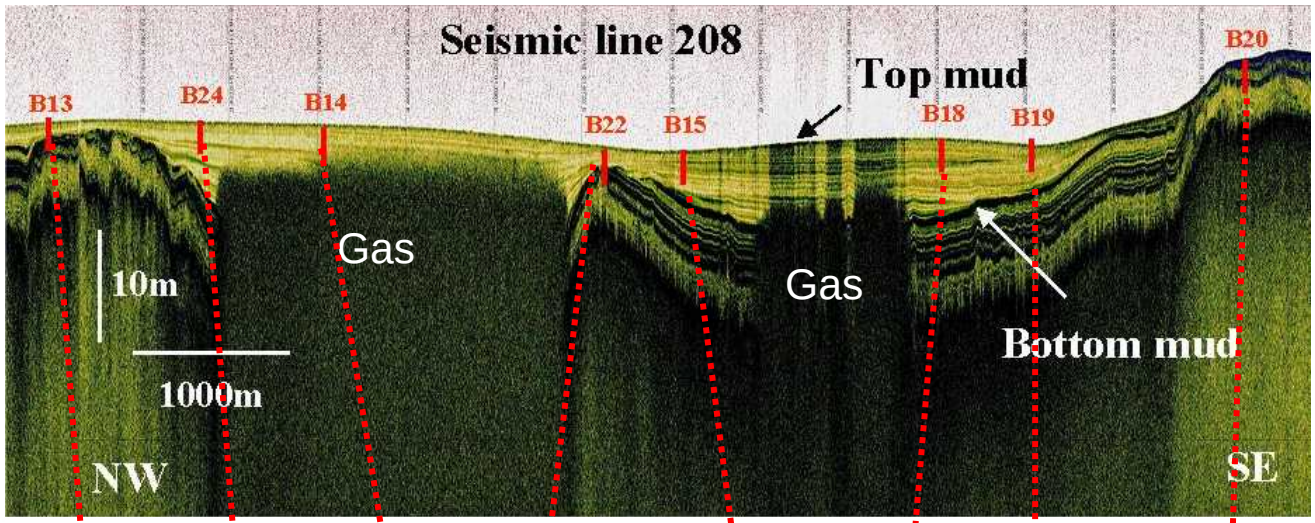


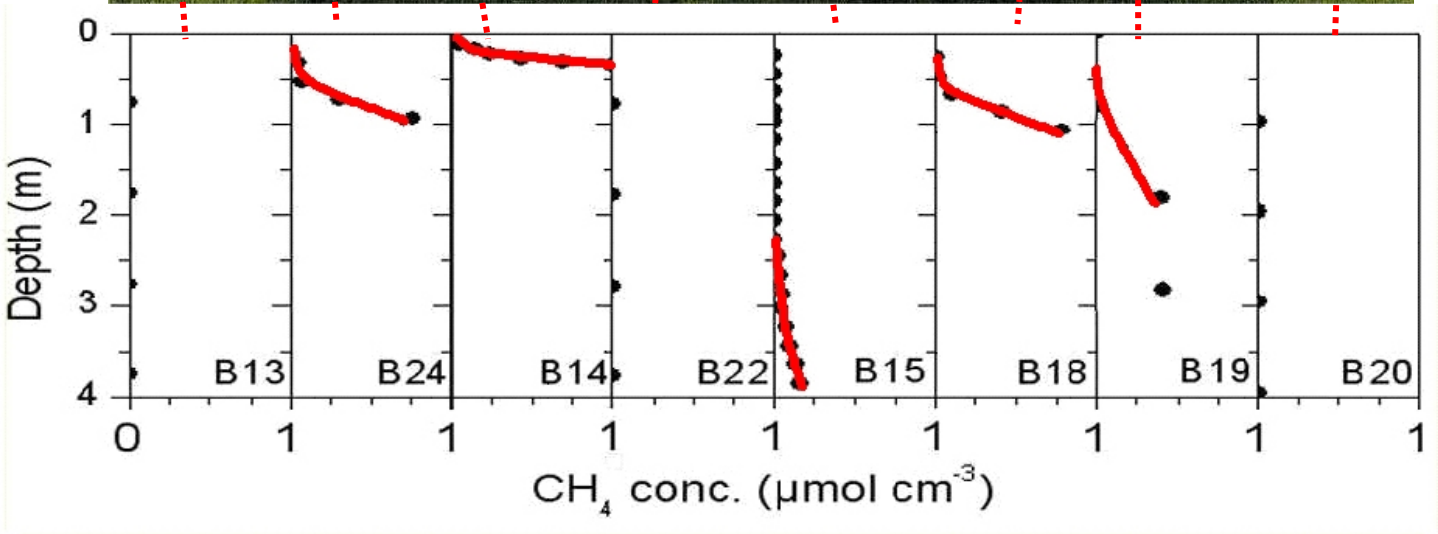
EU METROL PROJECT

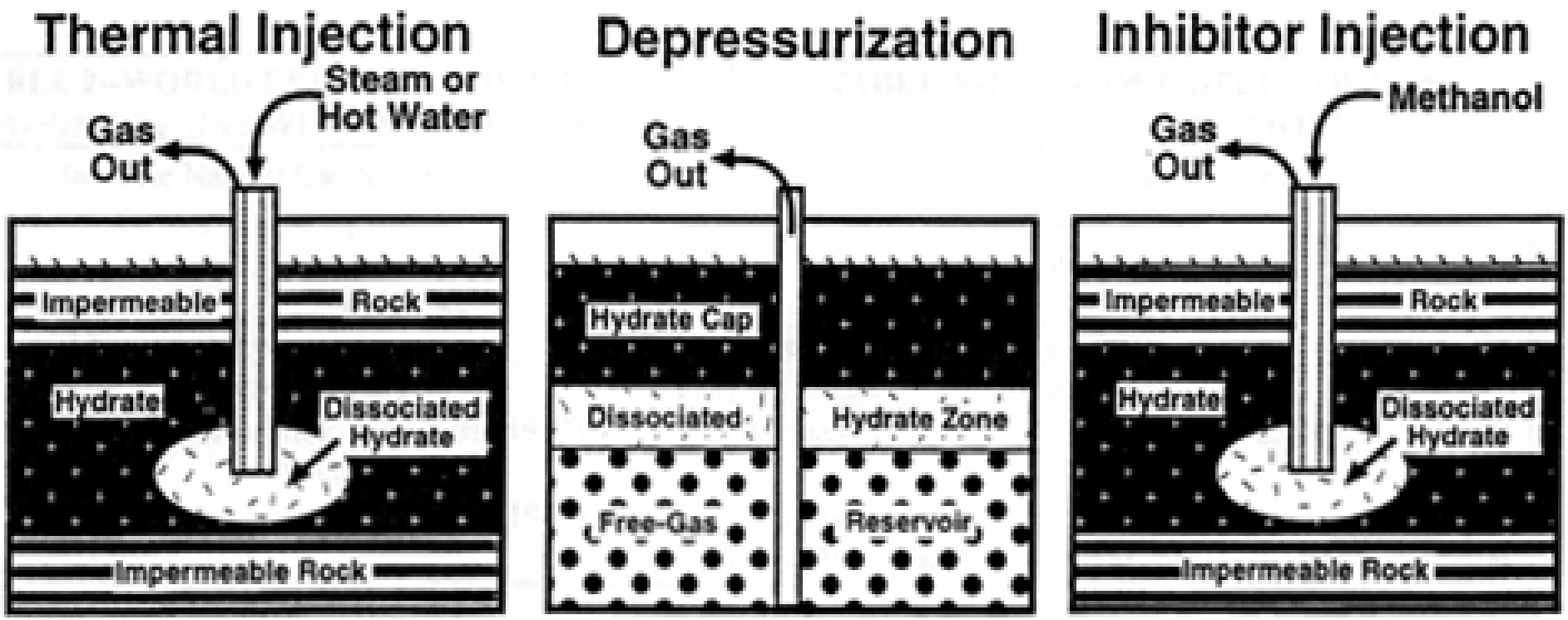
Top: Seismic profiles reveal hidden gas in the seabed
Bottom: Analyses in retrieved mud cores demonstrate hotspots of methane flux

Source: GEUS, MPI

Gravity corer





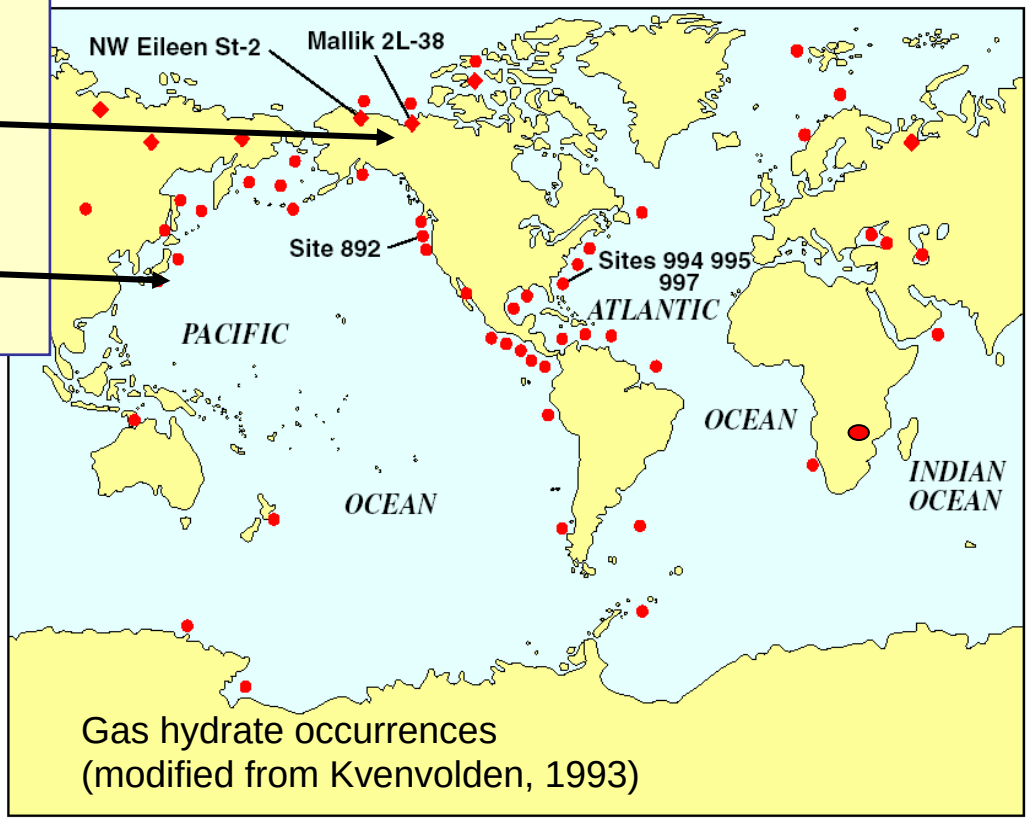


Proposed gas hydrates production methods.

Tests for exploitation:

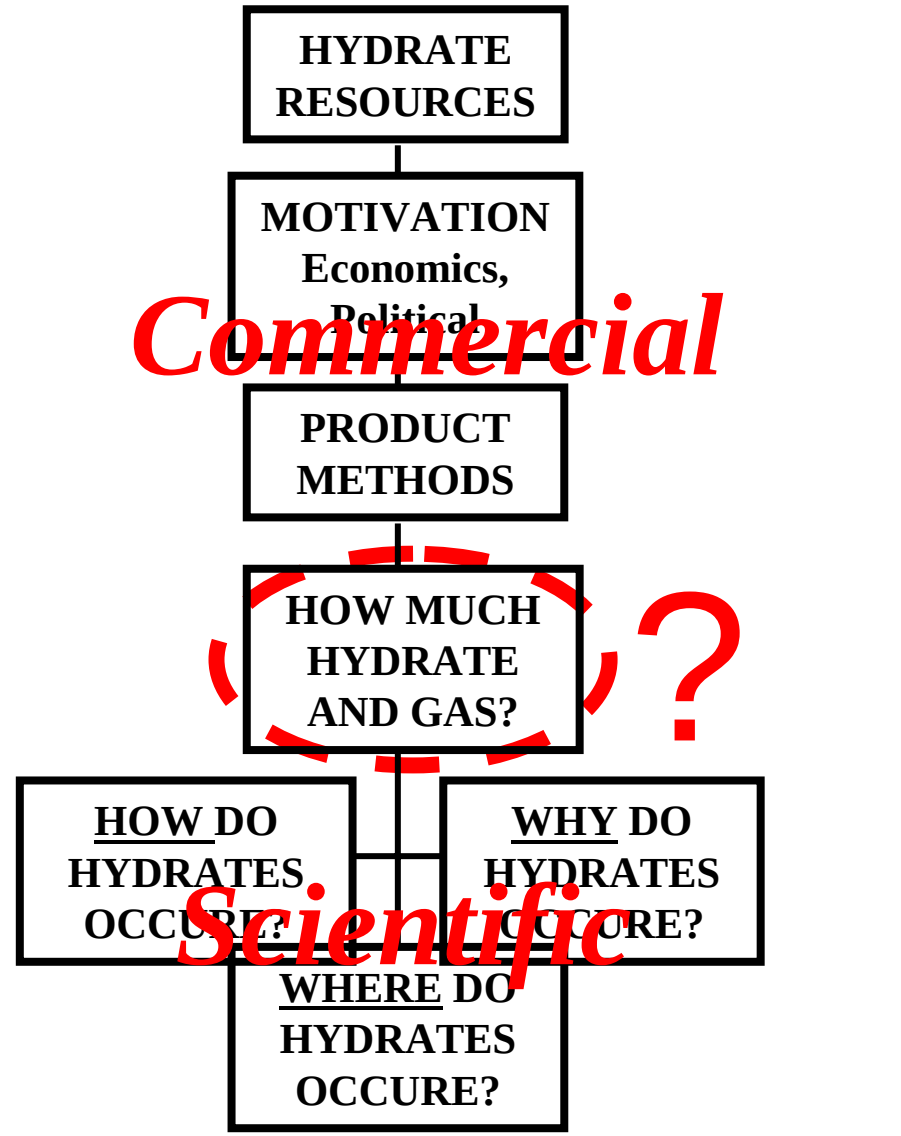
<u>On land</u>: Malik project
Mackenzie Delta, NW Canada
Gas hydrates at 1000 m depth

<u>At sea</u>: Nankai Trough project
SE of Japan



Gas hydrate occurrences
(modified from Kvenvolden, 1993)

Source: Energy Minerals Division,
American Association of Petroleum Geologists



Research steps for GH

-Thickness of GH bearing sediments?

-Base of GH (BSR) rarely distinguished/not continuous

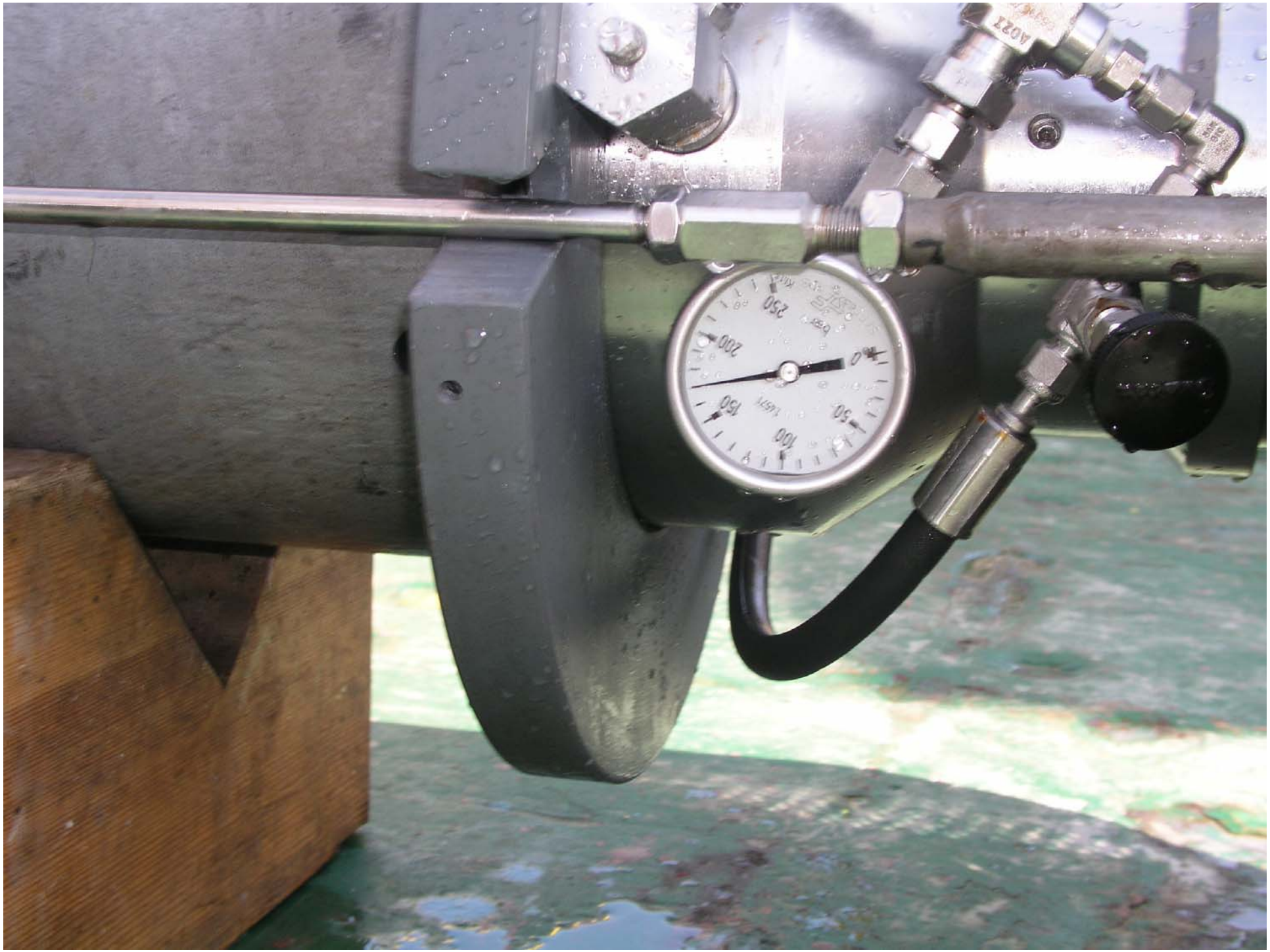
(3-D SEISMICS, MODELS)

-Vertical distribution of GH density

-Methane concentration per volume sediment?

Autoclave high pressure core (TUB)

ANAXIMANDER EXPERIMENT Nov 2004


250
200
150
100
50
0

Slow depressurization / dissociation of GH

CONCLUDING REMARKS

- **E. Med and Black Sea are promising CH_4 sources**
- **Need for further regional exploration** (multichannel,3-D seismics,ROV's...new techniques
- **Estimations of actual CH_4 concentrations and fluxes** (autoclave cores,bottom landers, in situ probes...)
- **Scenarios of method(s) production**

•Although… far away from exploitation