FLOW
Energy & Environmental Operations

Teresa Fokianou

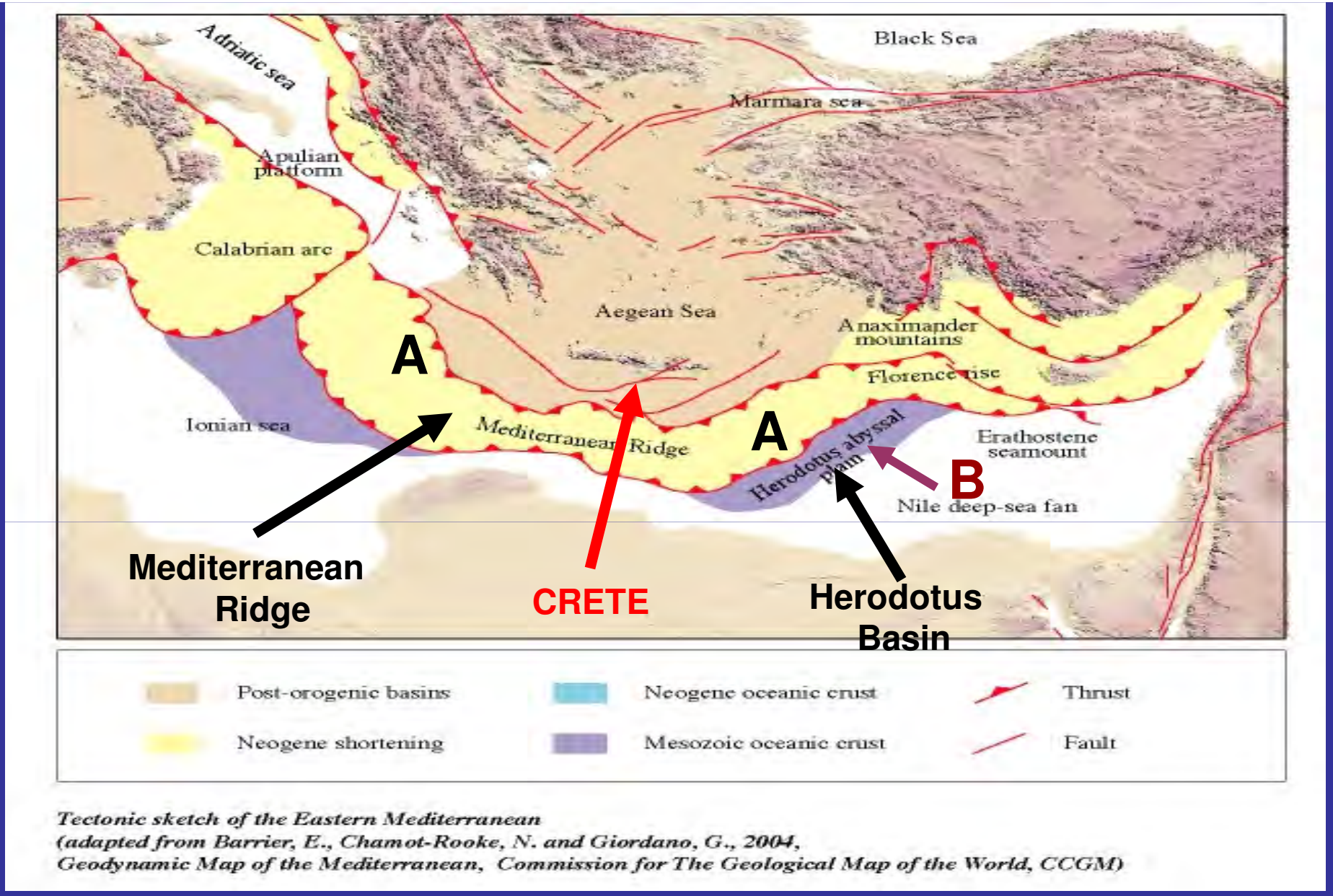
TUC

CANADA 1842
GEOLOGICAL SURVEY - COMMISSION GÉOLOGIQUE

Anthony FOSCOLOS

HYDROCARBON POTENTIAL OFFSHORE CRETE

A NEW PERSPECTIVE FOR GREECE'S OIL AND NATURAL GAS RESOURCES.



Tectonic sketch of the Eastern Mediterranean
(adapted from Barrier, E., Chamot-Rooke, N. and Giordano, G., 2004,
Geodynamic Map of the Mediterranean, Commission for The Geological Map of the World, CCGM)

Fig. 1. Tectonic sketch of the Eastern Mediterranean showing: A The Mediterranean Ridge and B The Abyssal Herodotus basin, Barrier et. al., 2004

- **GEOLOGICAL INDICATORS POINTING TOWARDS THE EXISTENCE OF HYDROCARBONS OFFSHORE CRETE.**

- **A. THE EXISTENCE OF CONVERGING PLATES**

- **B. THE EXISTNCE OF A RIDGE WITH ACCRETIONARY PRISMS.**

C. THE EXISTENCE OF ACTIVE MUD FLOW VOLCANOES EMITTING $^{13}CH_4$

D. THE PRESENCE OF HUMOUNGOUS GAS HYDRATE DEPOSITS DERIVED FROM PYROLYSIS OF LIQUID HYDROCARBONS

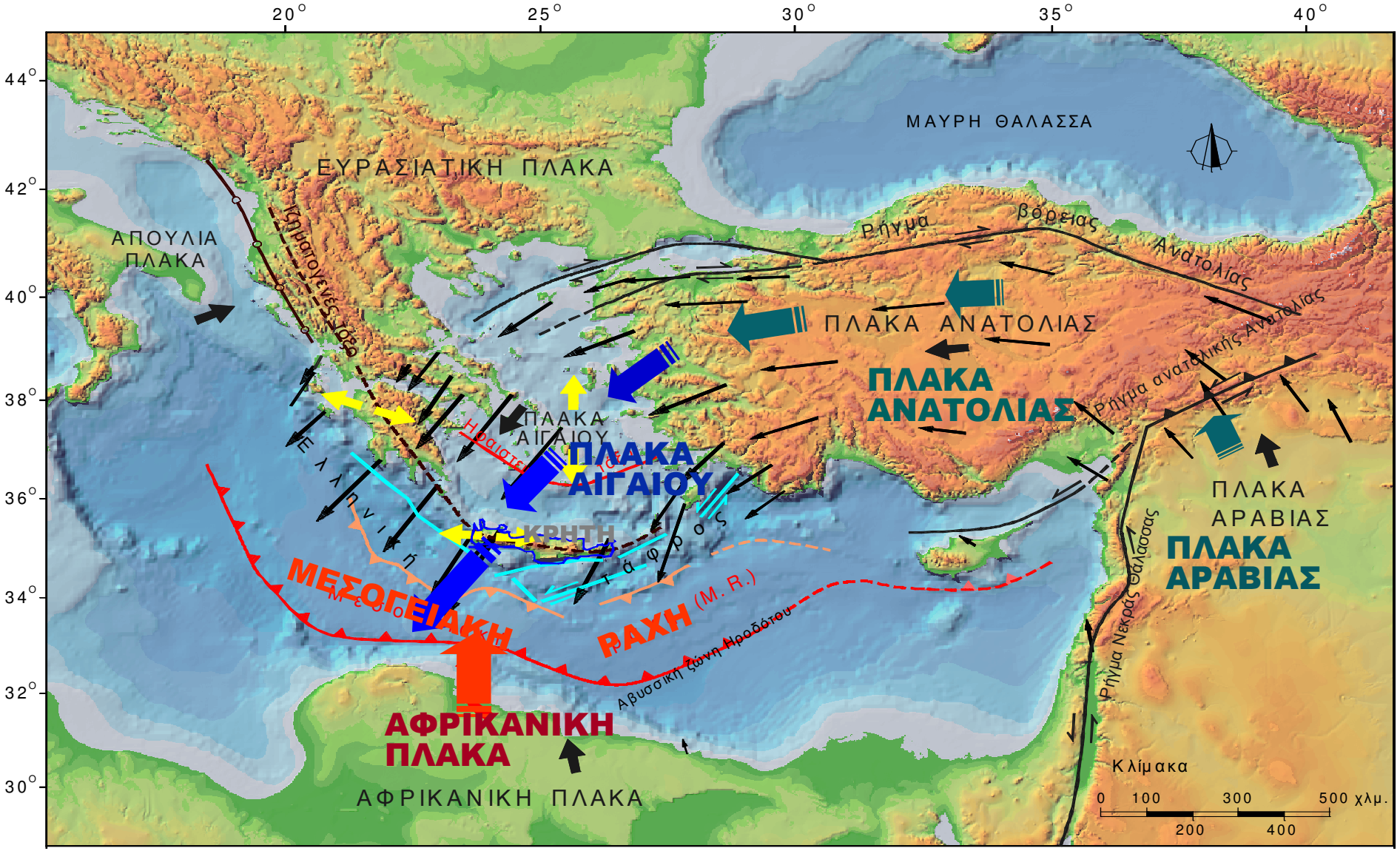
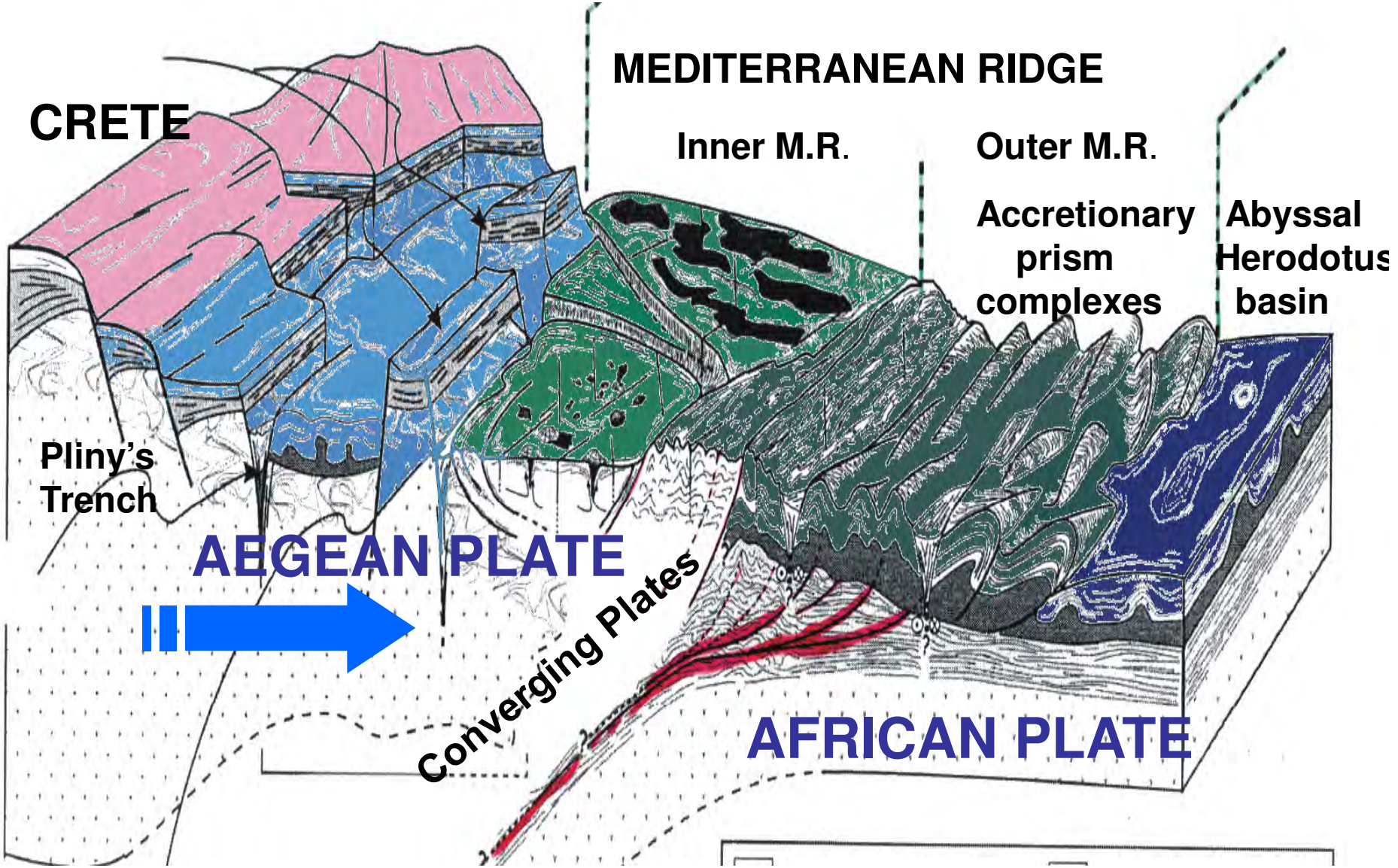


Fig. 2. The geodynamic regime of the wider area of Crete and Eastern Mediterranean. Arabian plate pushing counterclockwise the Anatolian plate which in turn pushes sideways the Aegean plate. The latter overrides the African plate which subducts under the island of Crete, Pavlaki, 2006



Fig, 3. Conversion of the African plate with the Aegean plate south of Crete in the region of Eastern Mediterranean. Distortion of the wider sub-Sea region. Formation of trenches and the Mediterranean Ridge, Pavlaki, 2006

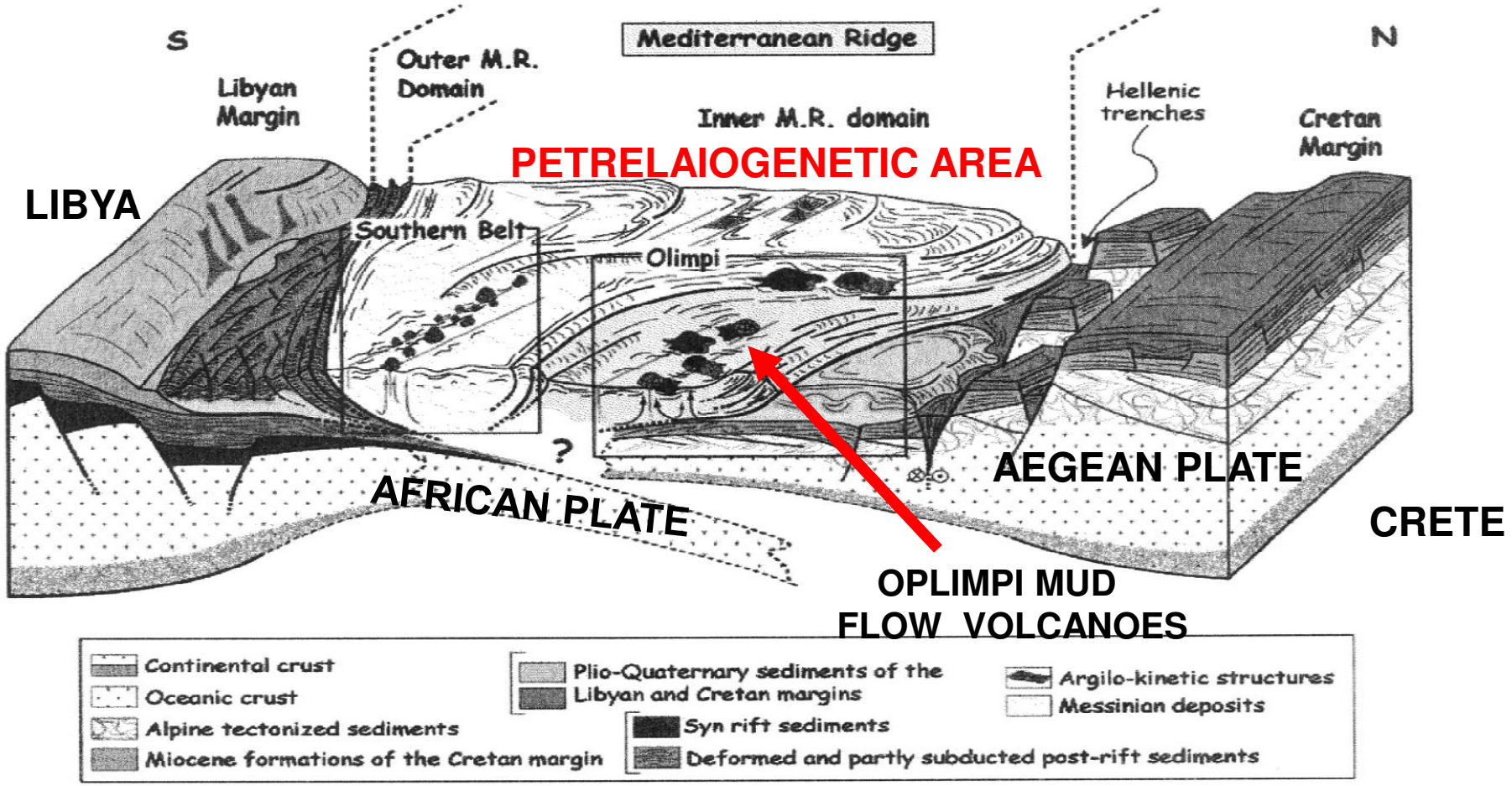
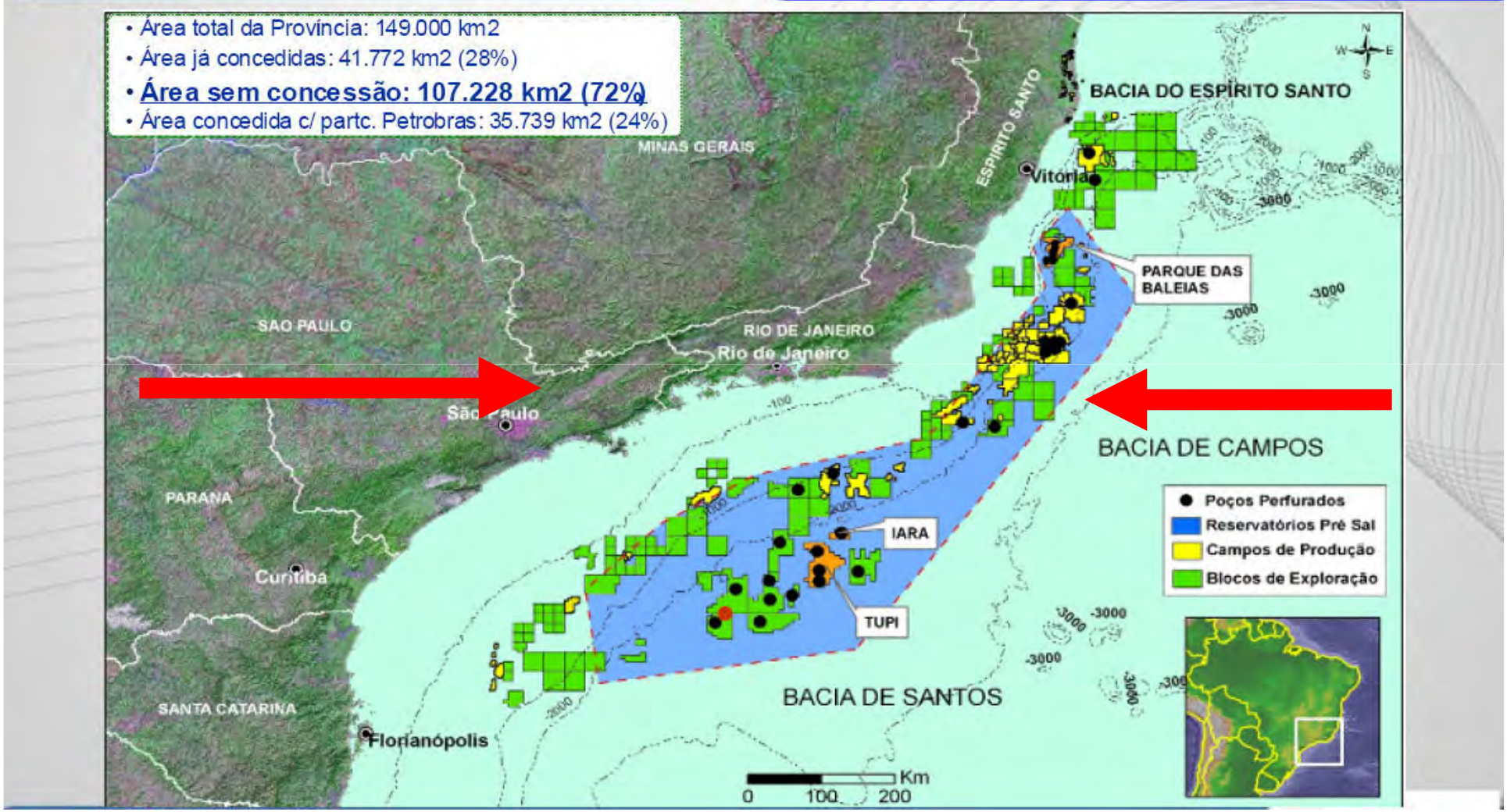


Figure 4. Interpretative 3D tectonic sketch of the Central Mediterranean Ridge and the Olimpi and the Southern Belt mud fields. Two different source levels are proposed for the two mud fields, the Olimpi field being related to relatively shallow mud formations, with high fluid contents and the Southern field being connected to deeper mud sources with lower fluid contents, Huguen, et. al., 2005

Converging plates between the South Atlantic Plate and South American Plate Santos Basin, Brazil

A grande área em azul indica a ocorrência prevista para o Pré-sal, com potencial para a presença de petróleo

No Campo de Jubarte (Parque das Baleias) está sendo realizada a antecipação da produção e, na área de Tupi (Bacia de Santos), o teste de longa duração

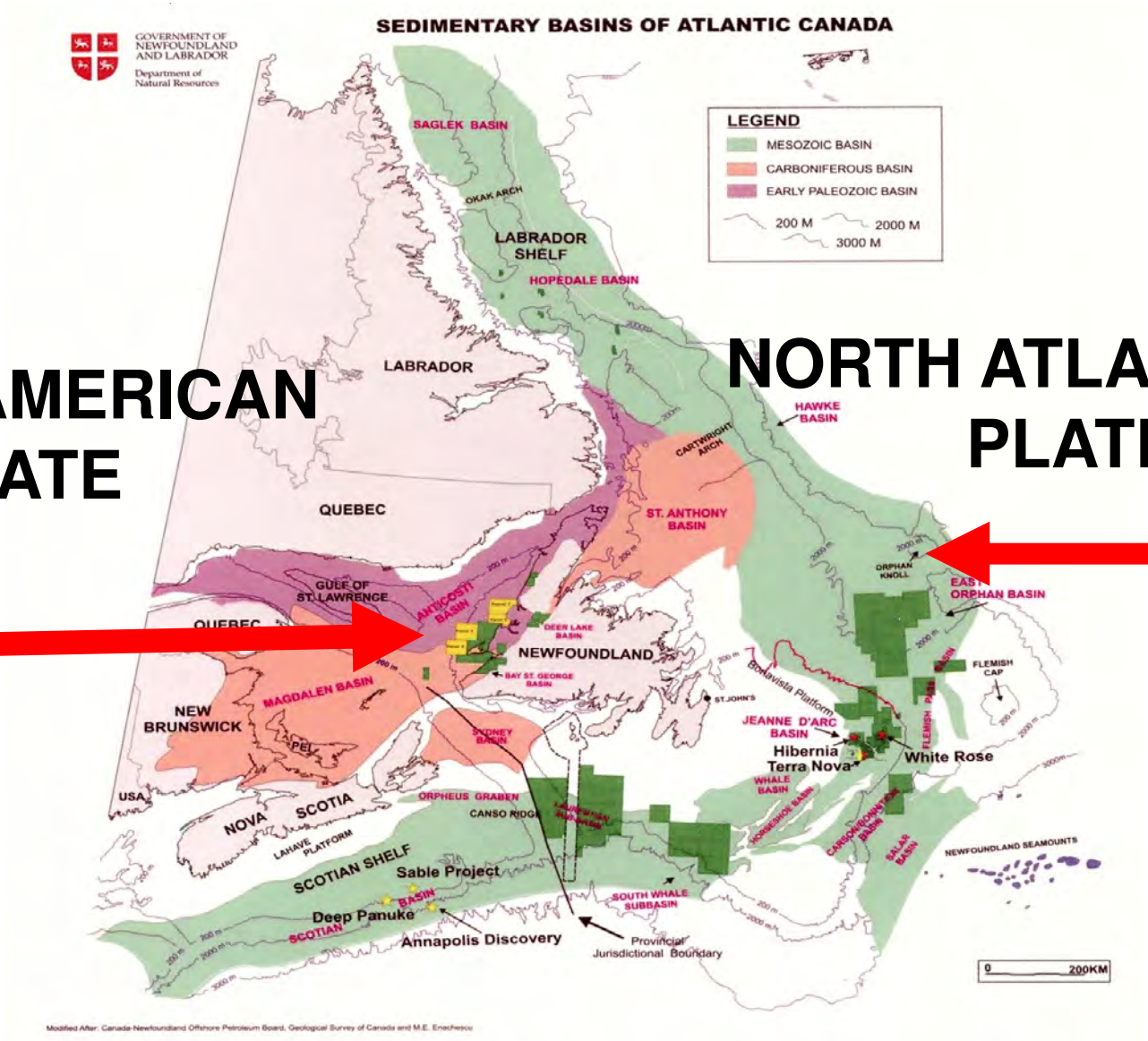


Oil and gas fields in De Campos and De Santos Basins offshore Brazil.

CONVERGING PLATES

NORTH AMERICAN PLATE

NORTH ATLANTIC PLATE



Modified After: Canada-Newfoundland Offshore Petroleum Board, Geological Survey of Canada and M.E. Enachescu

Figure 1
Atlantic Canada Basins with Petroleum Rights. The NL05-01 Call for Bids parcels are shown in yellow.

Κοιτάσματα υδρογονανθράκων στις συγκλίνουσες λιθοσφαιρικές πλάκες του Ατλαντικού με αυτήν της Βόρειας Αμερικής ακτή Labrador και Newfoundland

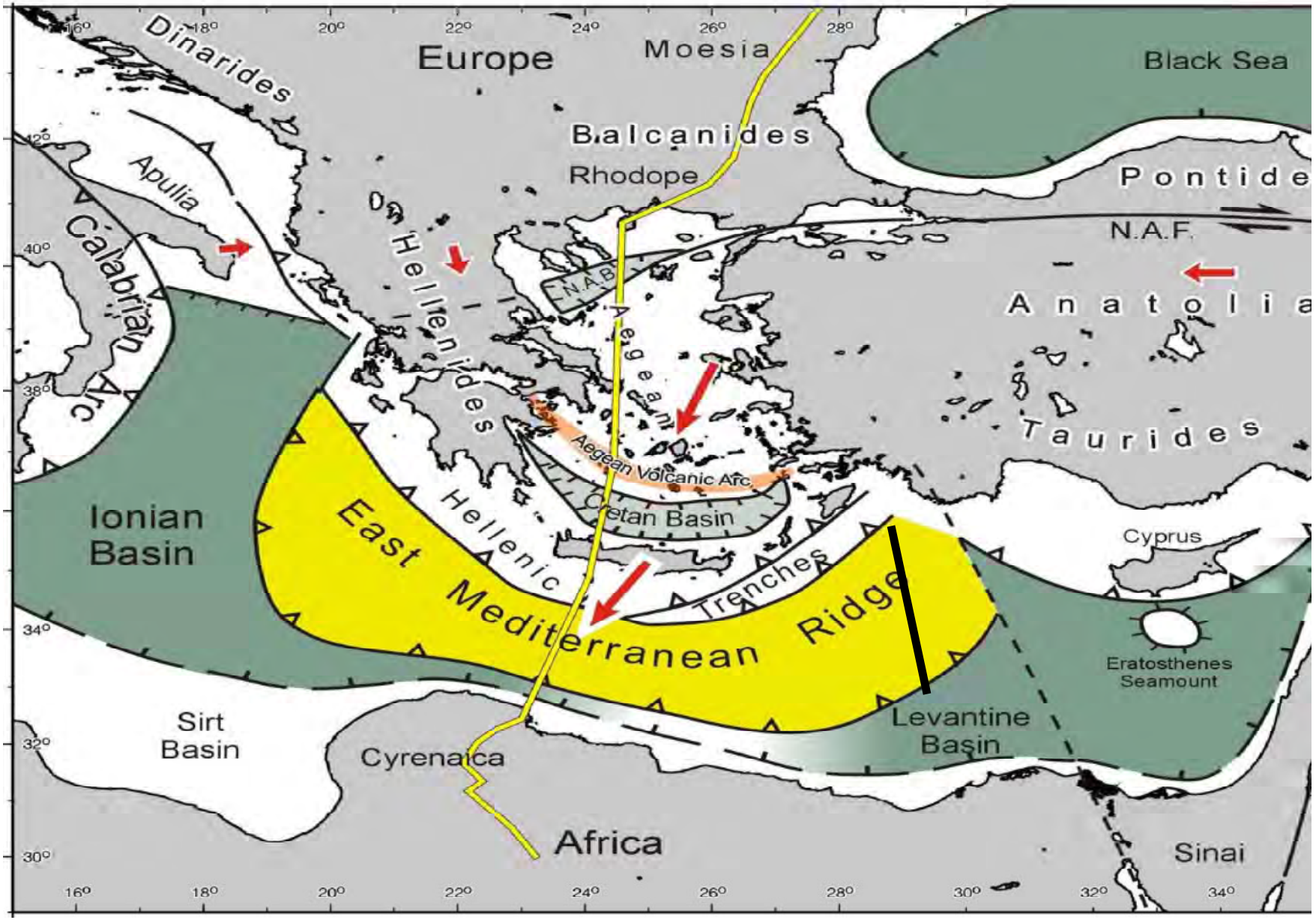


Figure 5. The Mediterranean Ridge and the main geotectonic features in Eastern Mediterranean and its wider area of the Transmediterranean section (Transmed. VII) from Moesia till Cyrenaica, Papanicolaou et. al., 2004

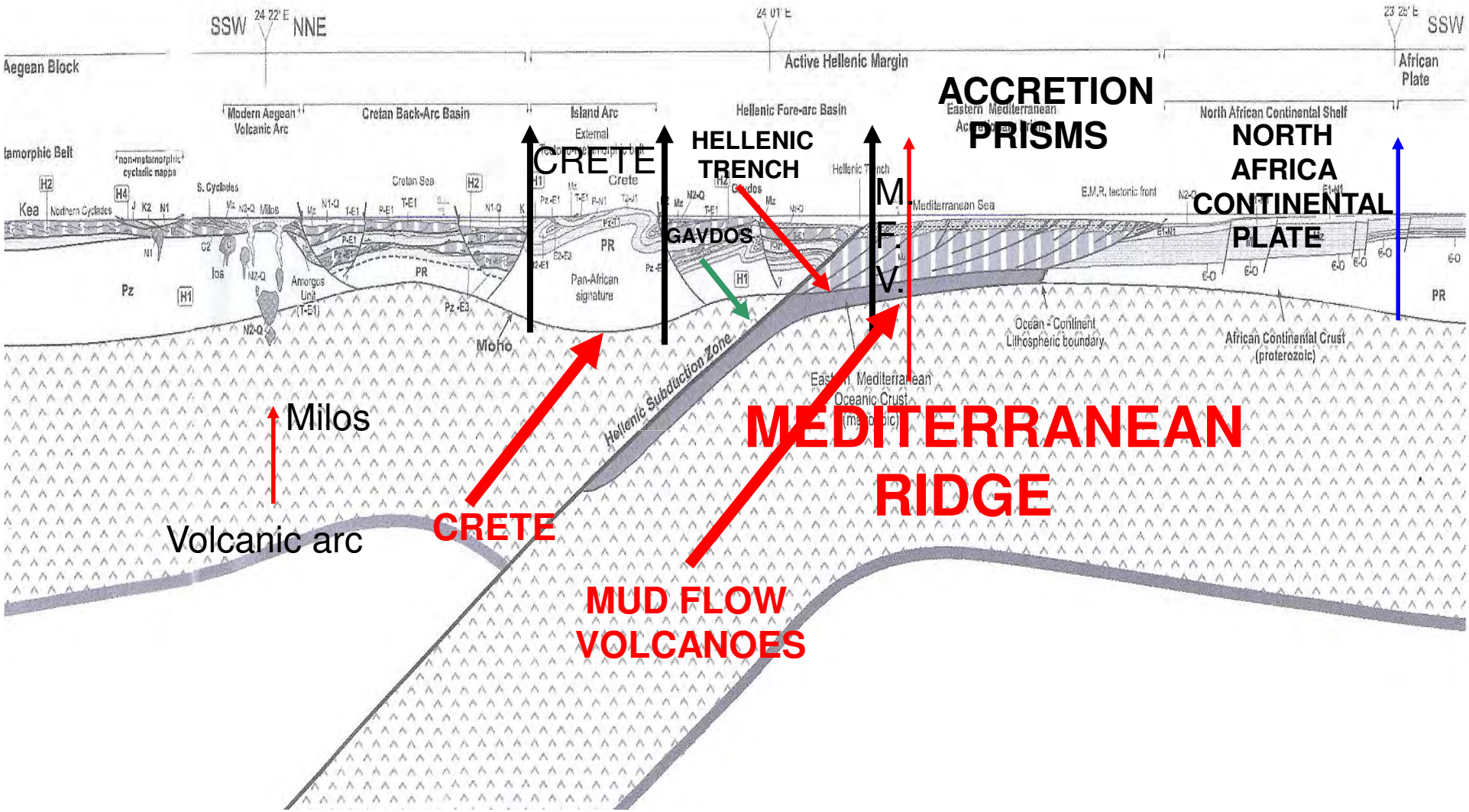
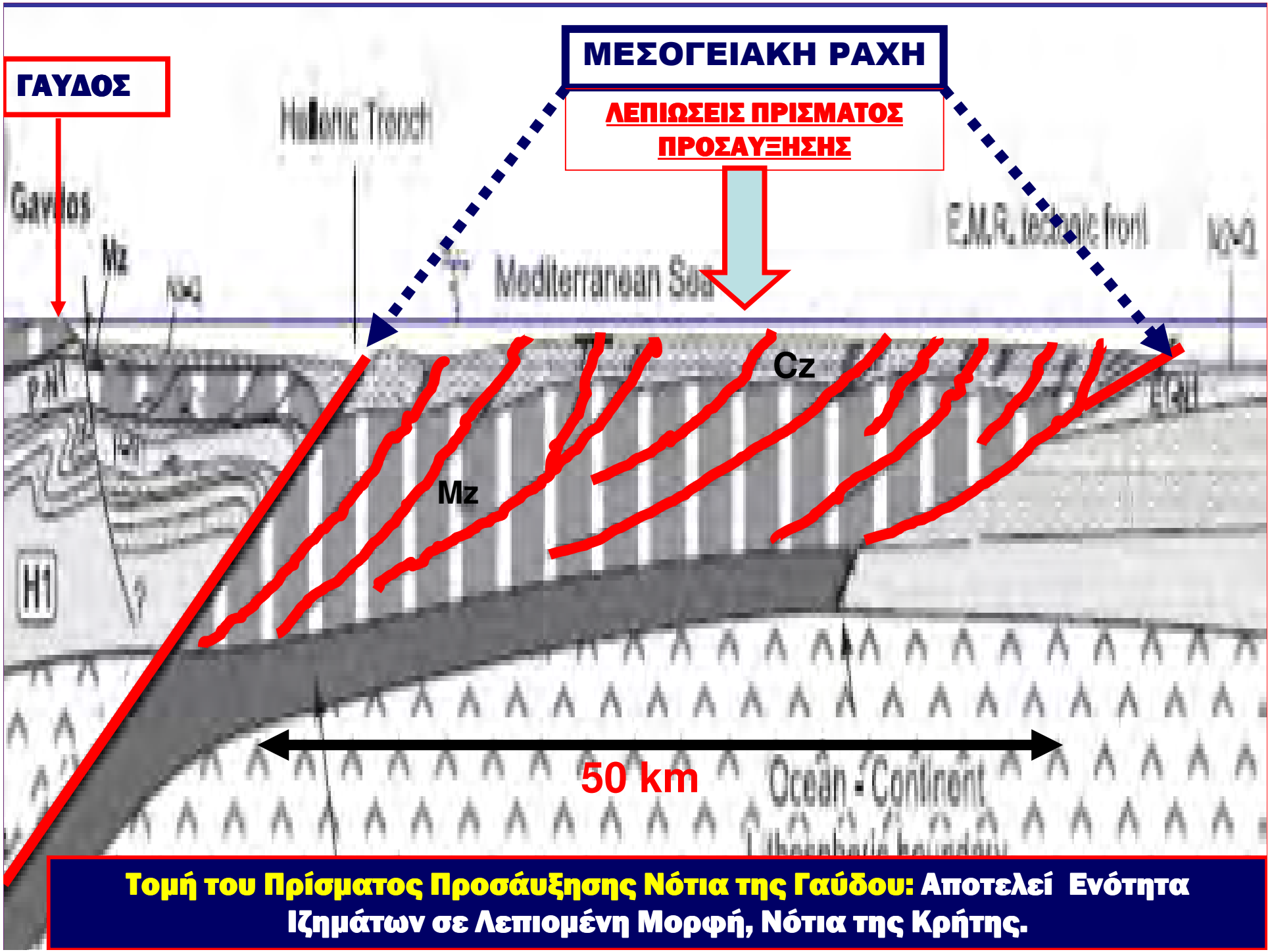


Figure 7. Portion of the Transmediterranean section, (Transmed. VII), starting from Cyrenaica and ending in the Aegean volcanic arc. Papanicolaou et. al., 2004 from Gavazza et. al., 2004



Τομή του Πρίσματος Προσάυξησης Νότια της Γαύδου: Αποτελεί Ενότητα Ιζημάτων σε Λεπιομένη Μορφή, Νότια της Κρήτης.

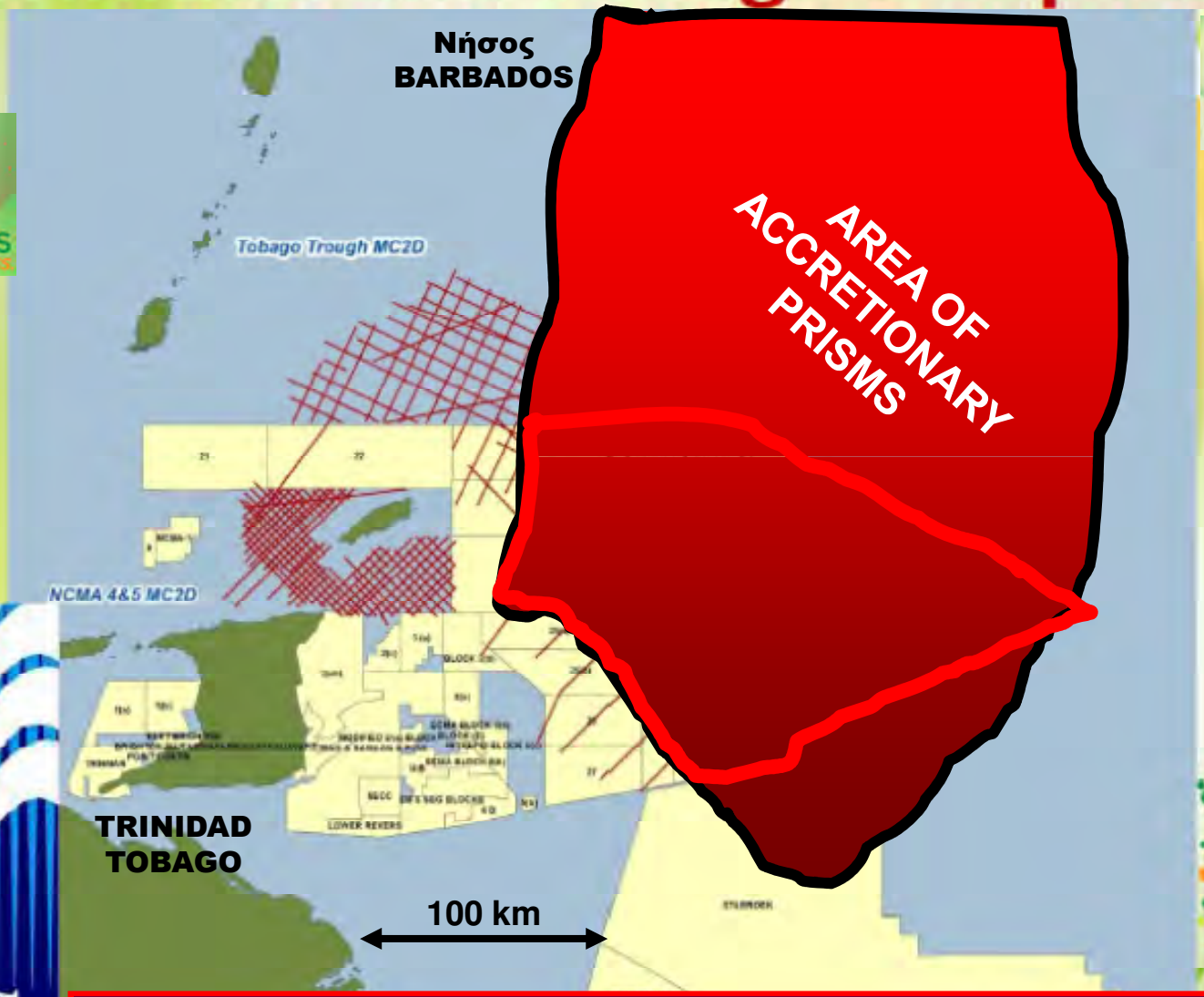
Exploration Opportunities for Trinidad and Tobago Deep Atlantic

THE GOVERNMENT OF THE REPUBLIC OF TRINIDAD AND TOBAGO

MINISTRY OF ENERGY AND ENERGY AFFAIRS
POWER. PROSPERITY. PROGRESS.

The Ministry of Energy and Energy Affairs

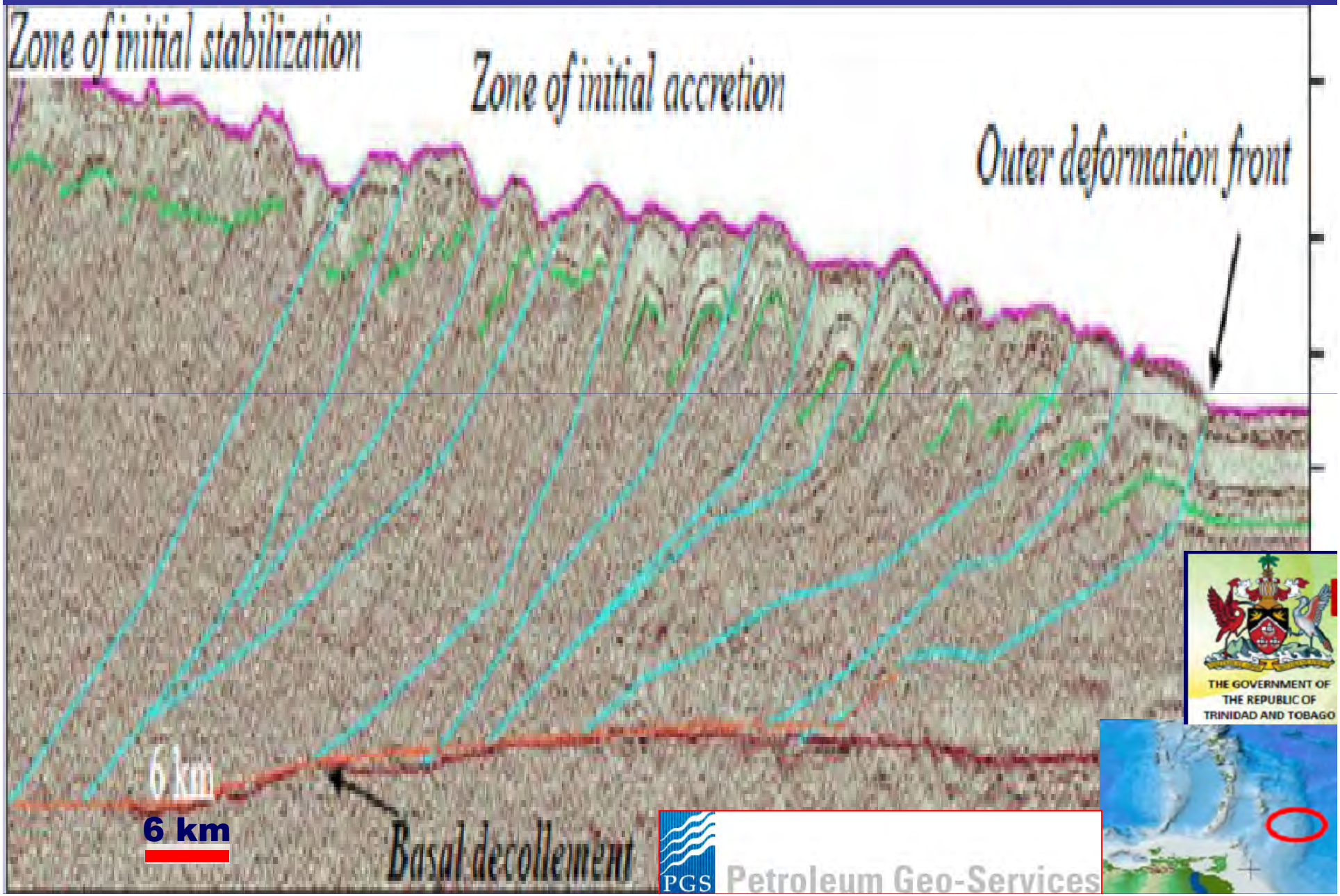
2012



PGS

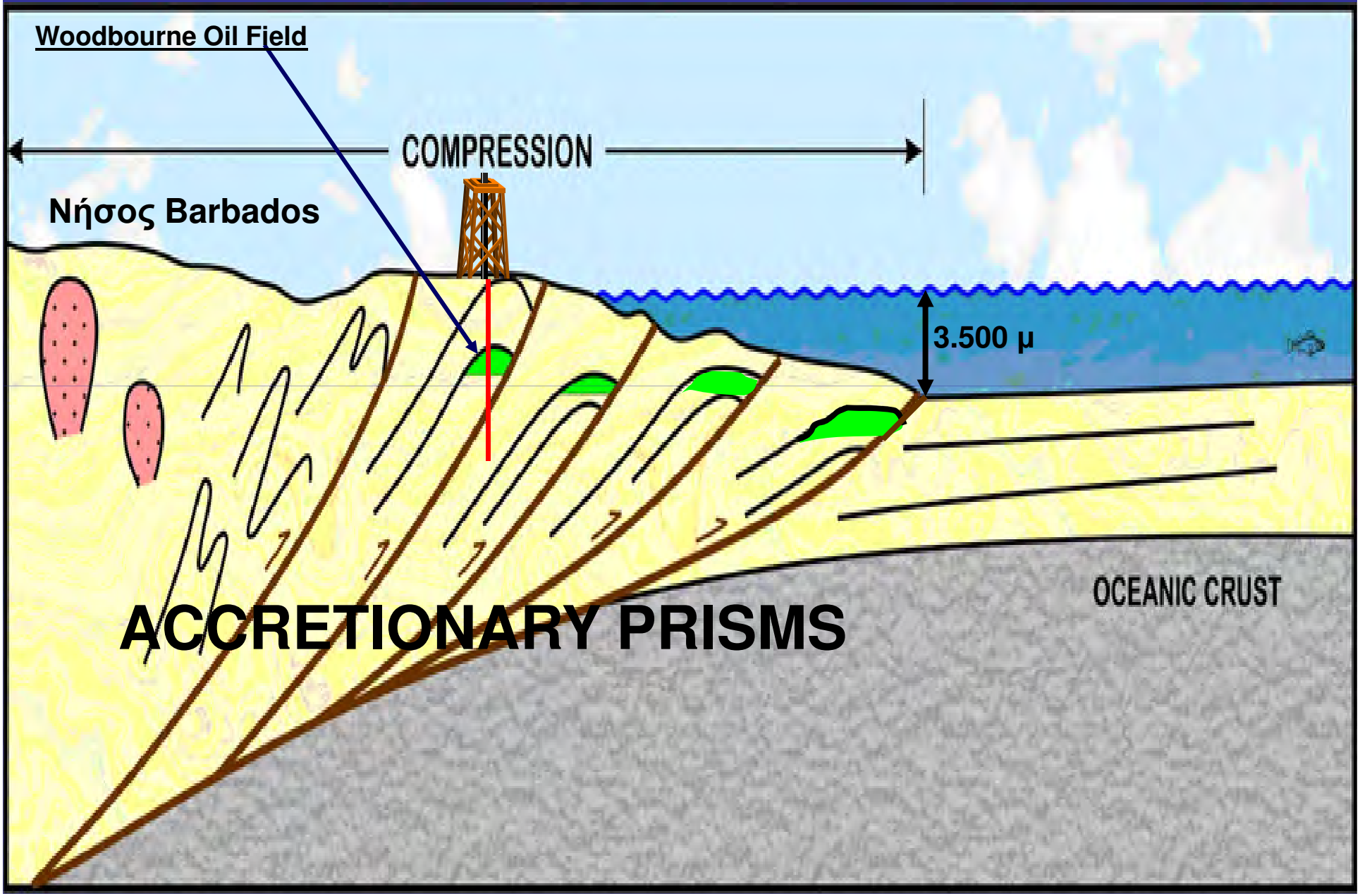
Trinidad & Tobago Licensing Round on 40,000 km2 Blocks, waters depths ranging from 1.000m to 3.500m.

ACCRETIONARY PRISM COMPLEX – OFFSHORE TRINIDAD TOBAGO



BARBADOS RIDGE – WOODBOURNE OIL FIELD & OFFSHORE PERSPECTIVES

EXPECTED FIELDS -Geometry of Sandstones Reservoirs on the Accretionary Prism Complex

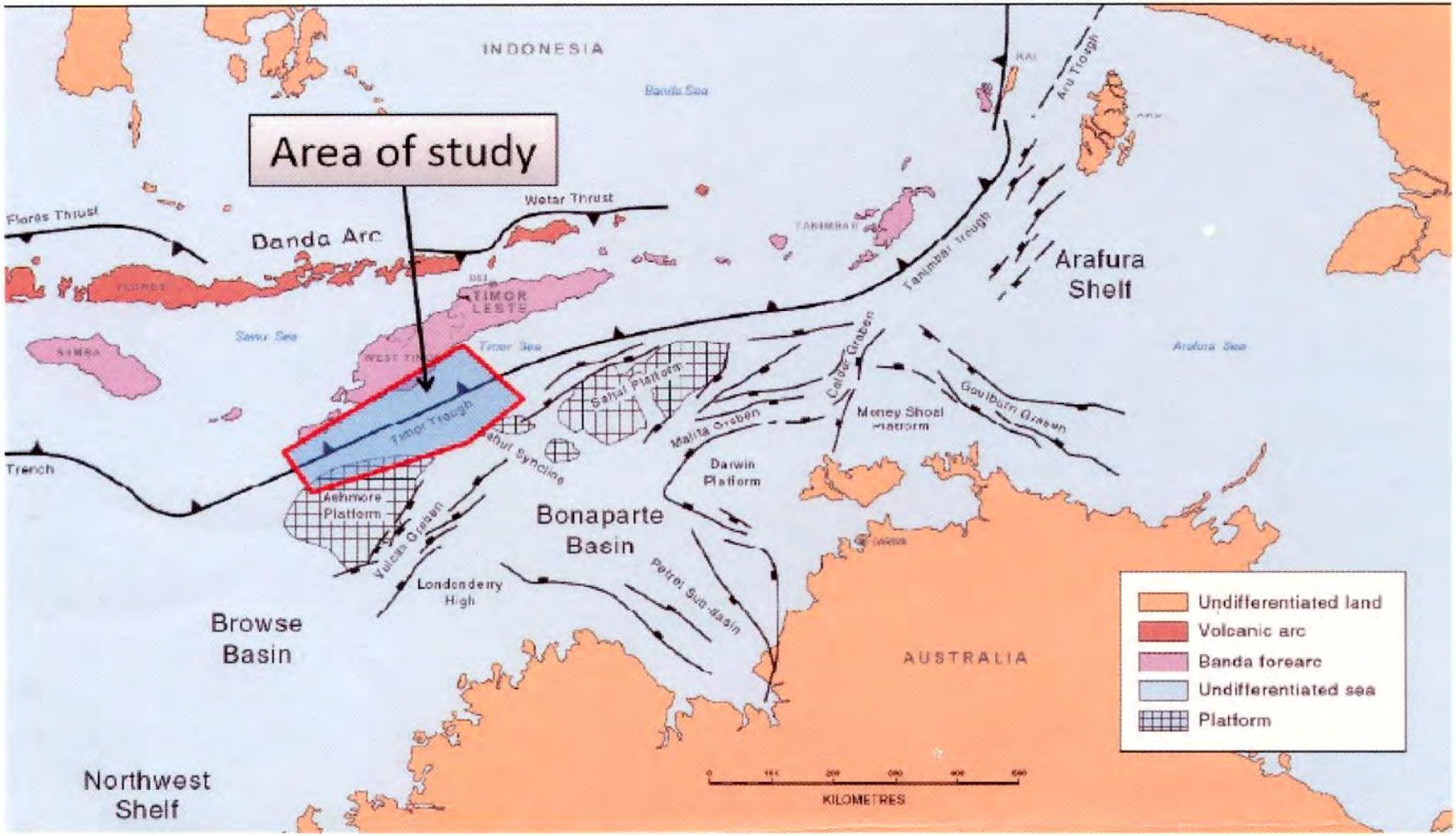


Accretionary Prisms-Plate tectonics-Hydrocarbons

PGS- Similar to South Crete Petroleum Prospectivity

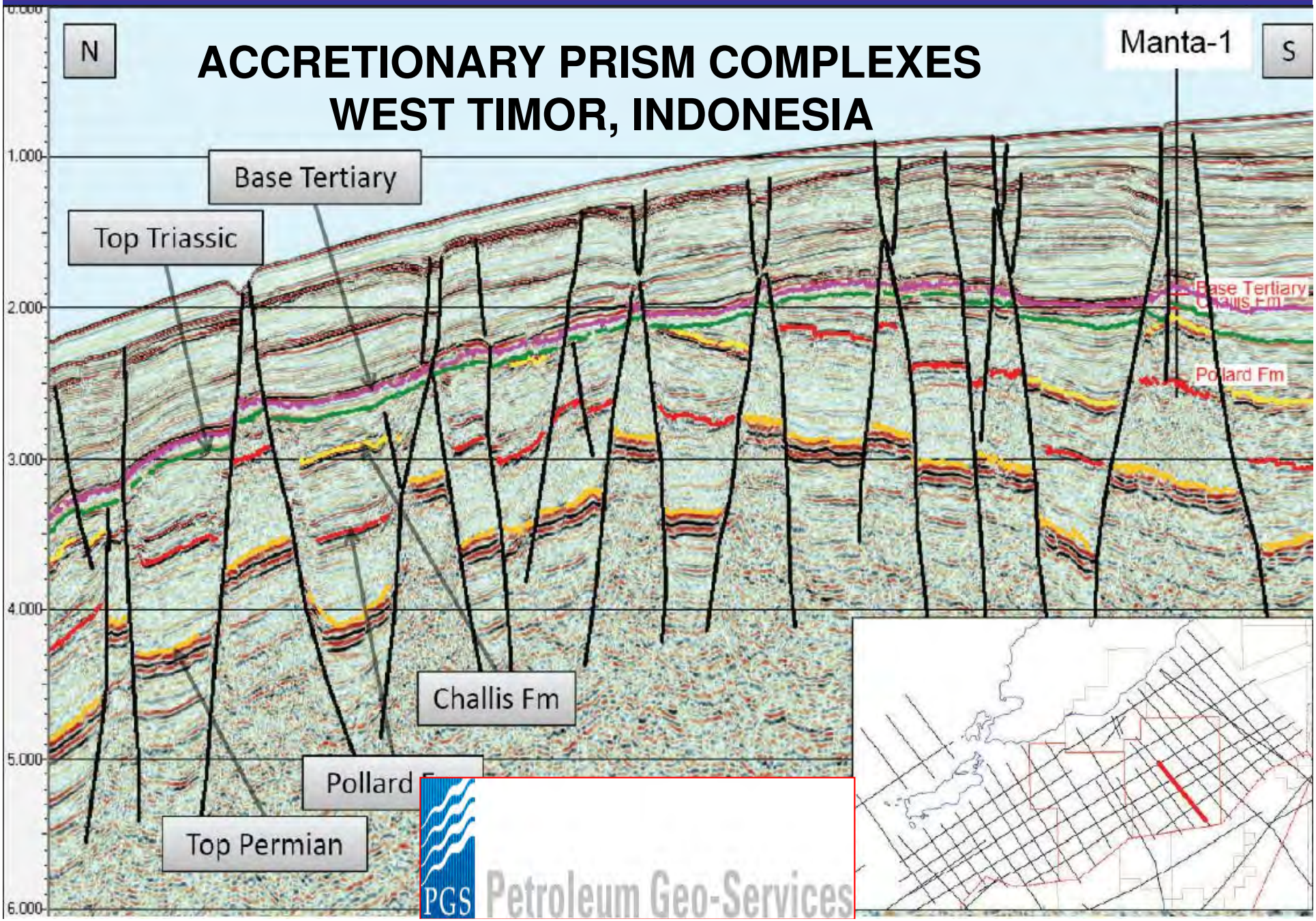
Paper Title: Petroleum Prospectivity Of The West Timor Trough

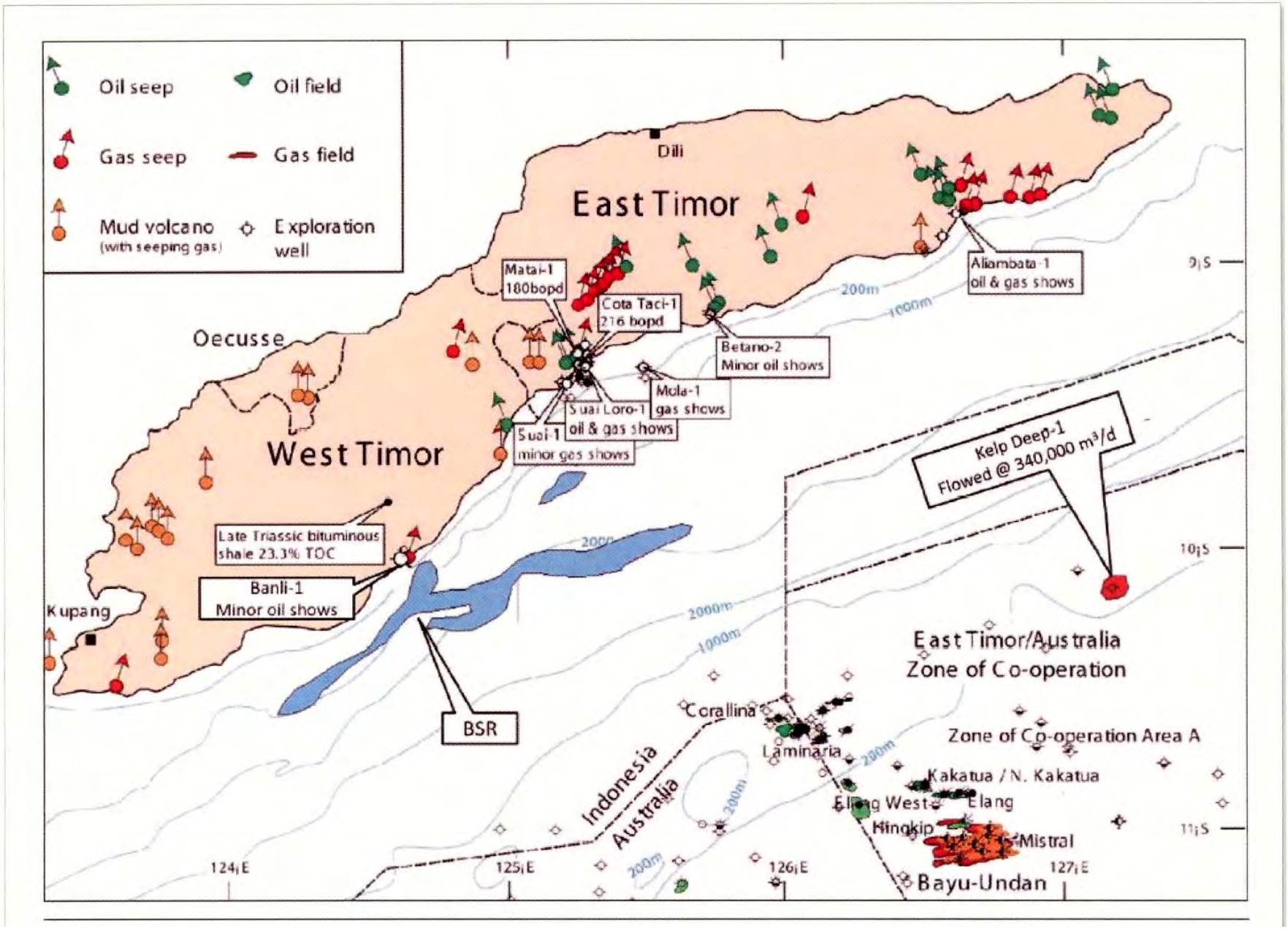
Will Jones, Anand Tripathi, Rajesh Rajagopal and Adrian Williams, PGS Reservoir



Σύγκληση της Αυστραλιανής Πλάκας με την Πλάκα του Ινδικού Ωκεανού στην νήσο Τιμόρ, Ινδονησία. Δημιουργία Ράχης. Ομοιότητα με Κρήτη

ΛΕΠΙΩΣΕΙΣ ΣΤΗΝ ΠΕΡΙΟΧΗ ΠΡΙΣΜΑΤΟΣ ΕΠΑΥΞΗΣΗΣ ΤΟΥ ΤΙΜΟΡ





Oil and gas fields in East Timor, Indonesia. (Κοιτάσματα Υδρογονανθράκων στη νήσο Τιμόρ, Ινδονησία)

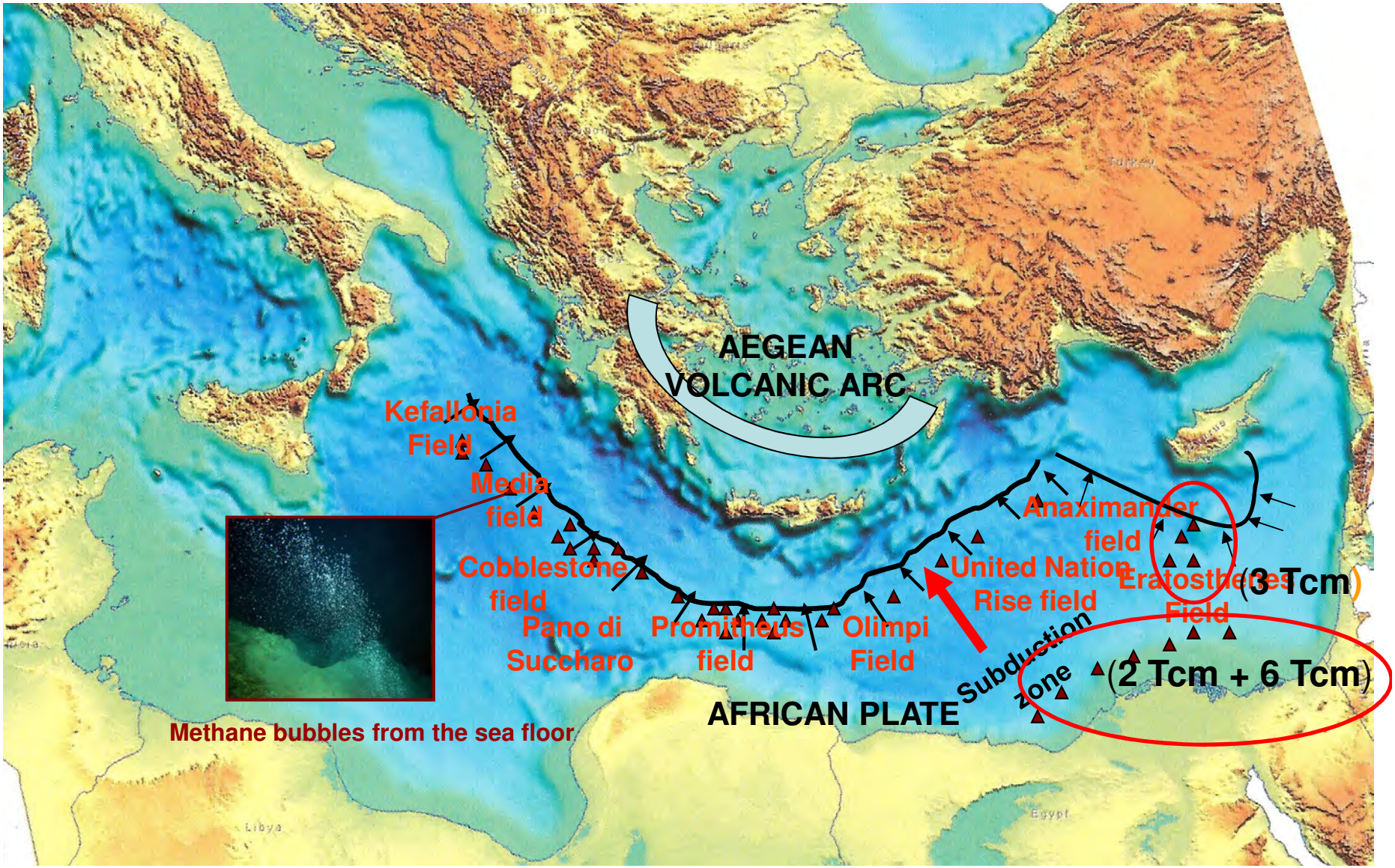


Figure 6. Location of mud flow volcanoes in the subduction zone along with the location of the Aegean volcanic arc. Location of the mud flow volcanoes in the Nile cone and the EEZ of Cyprus. In parenthesis the anticipated amount of natural gas to be found. Modified after Dimitov, 2002

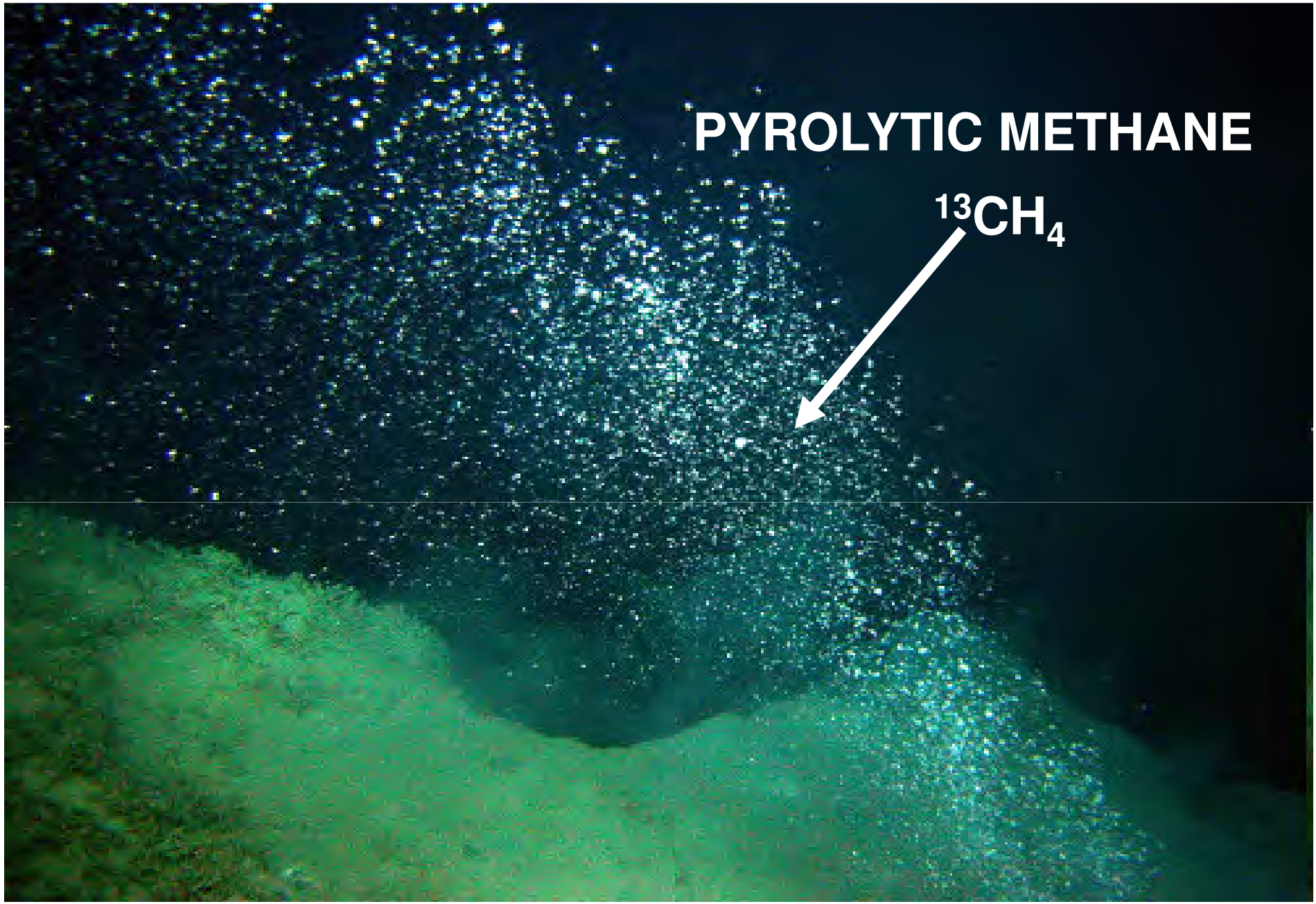


Fig. 9. Methane bubbles from the bottom of the Mediterranean Sea.
www.energybulletin.net/node/51517 **- Cached - Similar**

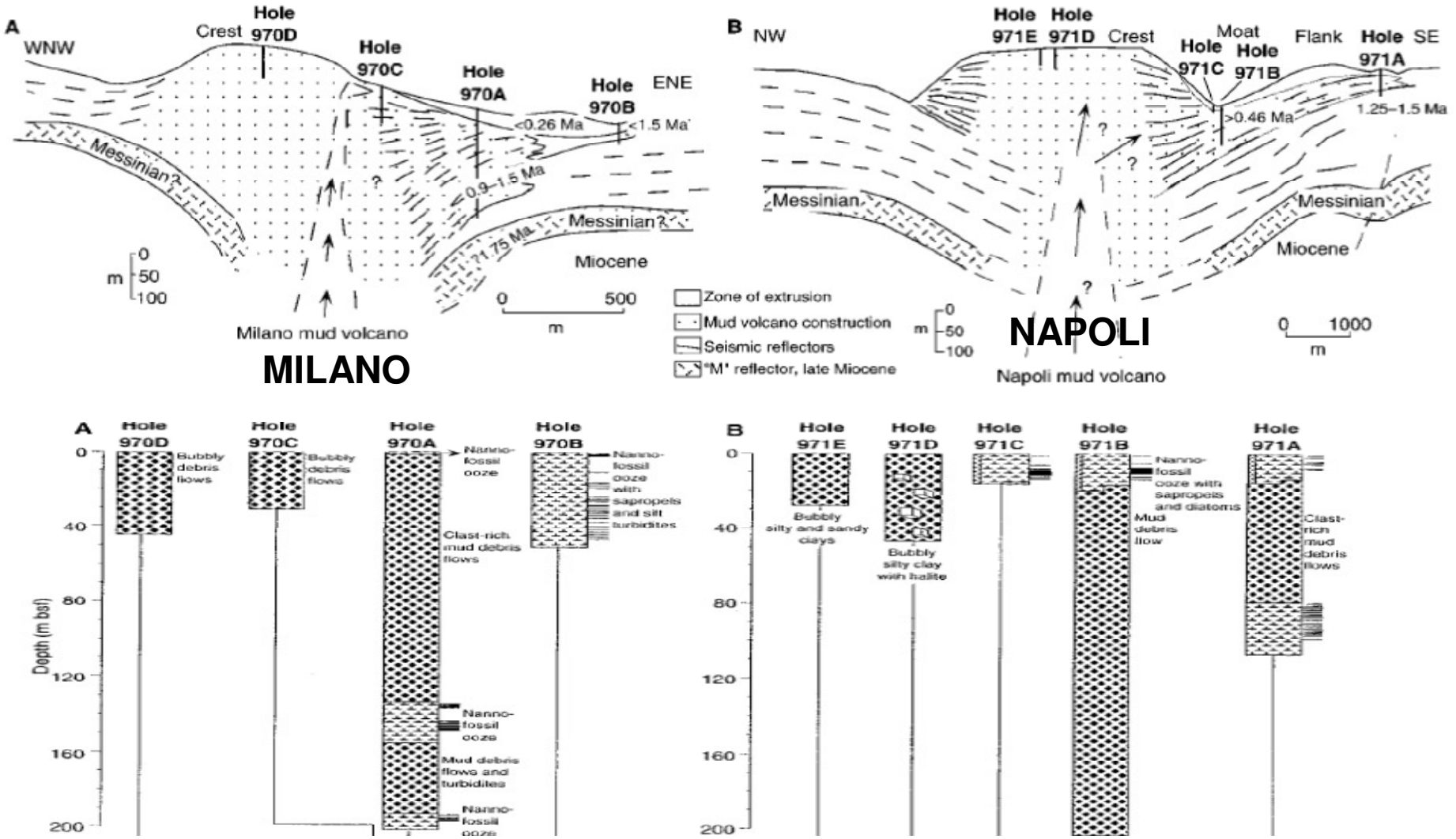


Figure 12. Pockmarks, gas seeps, and the discovery of gas hydrates indicate that the surrounding area is also actively degassing through a vent zone, of which the mud volcanoes are a part. The presence of thermogenic gas is inferred from the ratio of methane to heavier hydrocarbon gases, indicating a deep source of origin, Cronin et al., 1997; Robinson et al., 1996

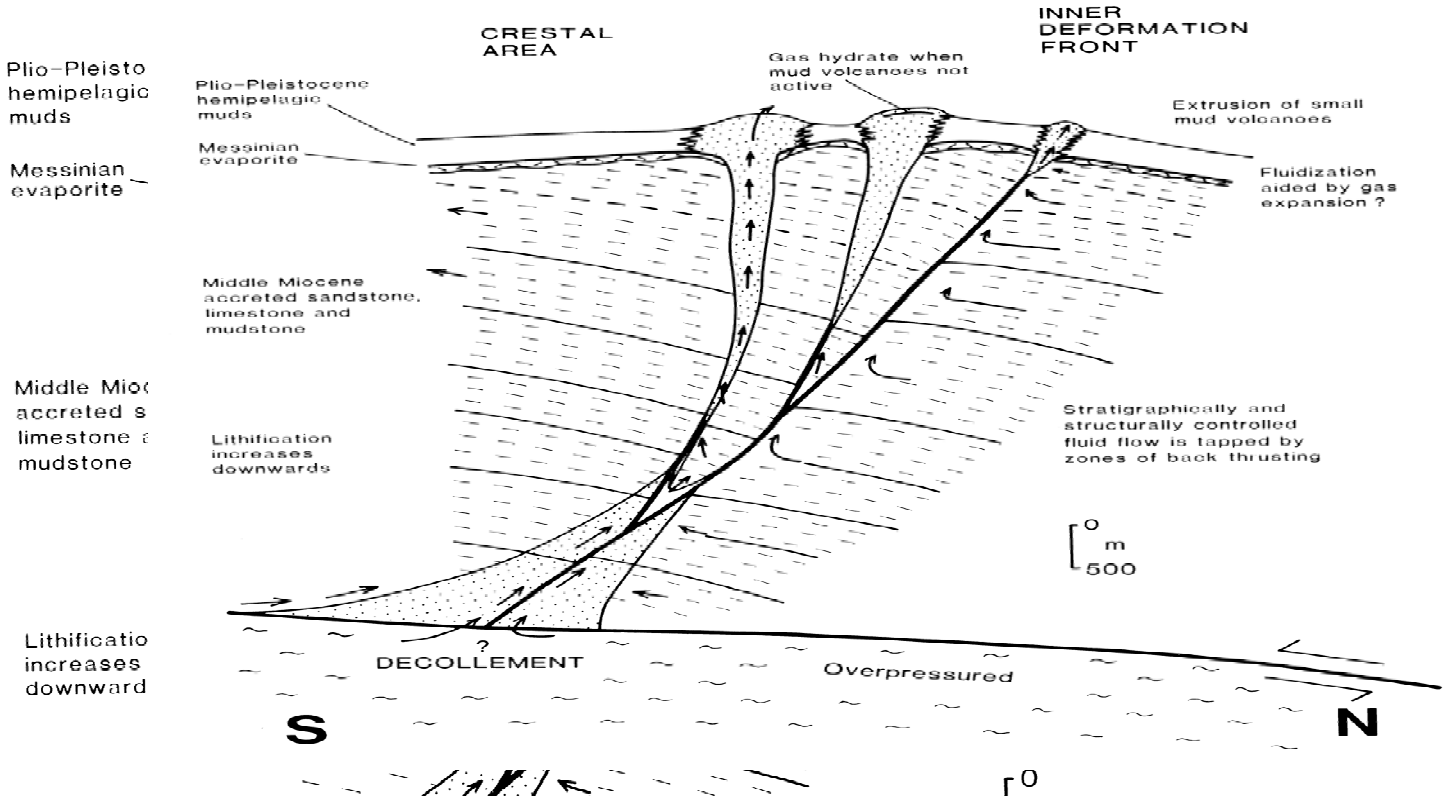


Figure 13. Revised model of mud volcanism on the Mediterranean Ridge accretionary complex, supported by petrographic and mineralogical data from Leg.160. Mud volcanism was initiated >1 Ma ago, following collision following collision of the to the Mediterranean ridge accretionary complex with a promontory of the North African passive continental margin, Robertson and Kopf, 1998

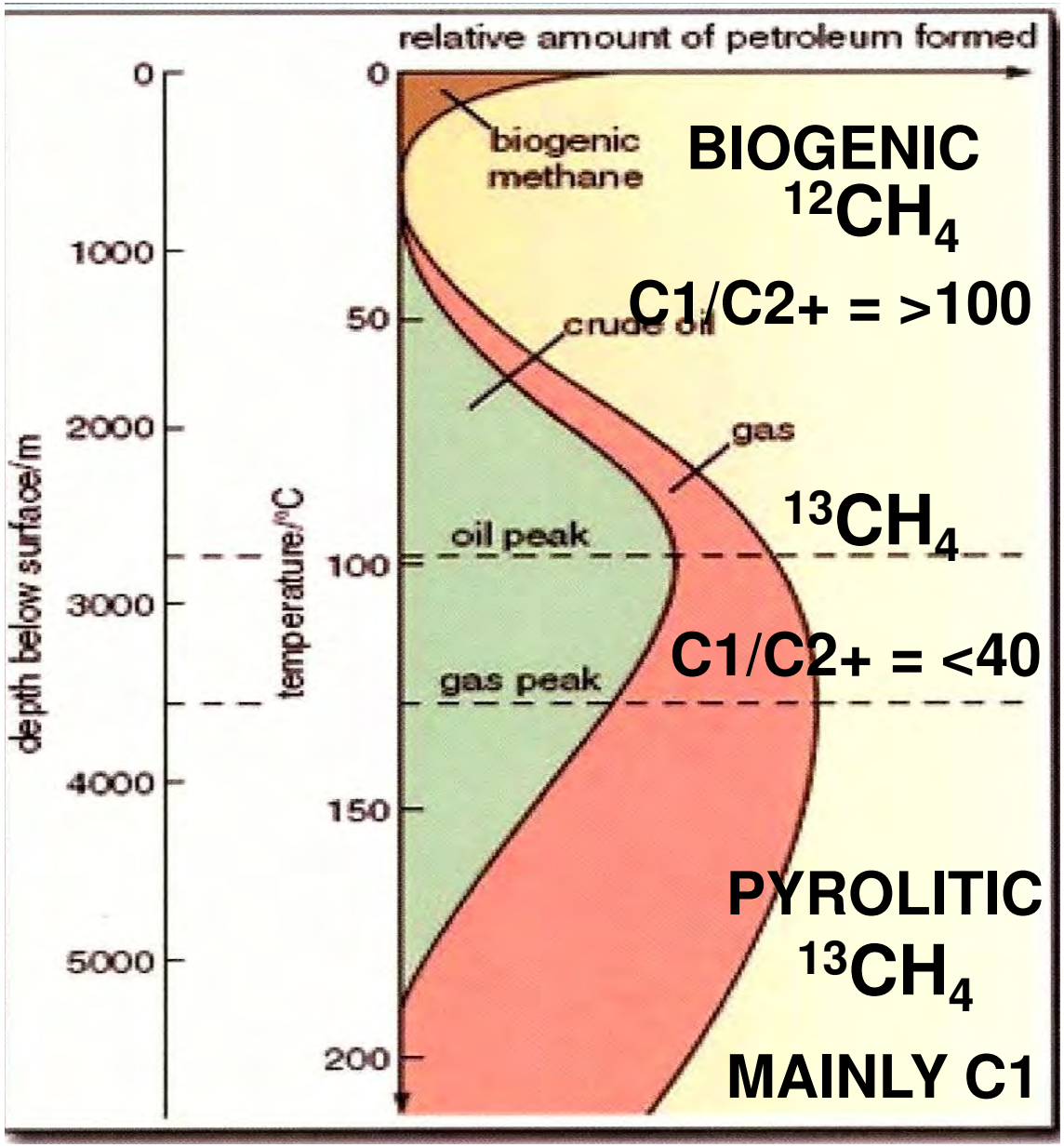


Figure 15. Generation of gases from organic matter with increasing temperature Buruss, and Laughrey, 2009

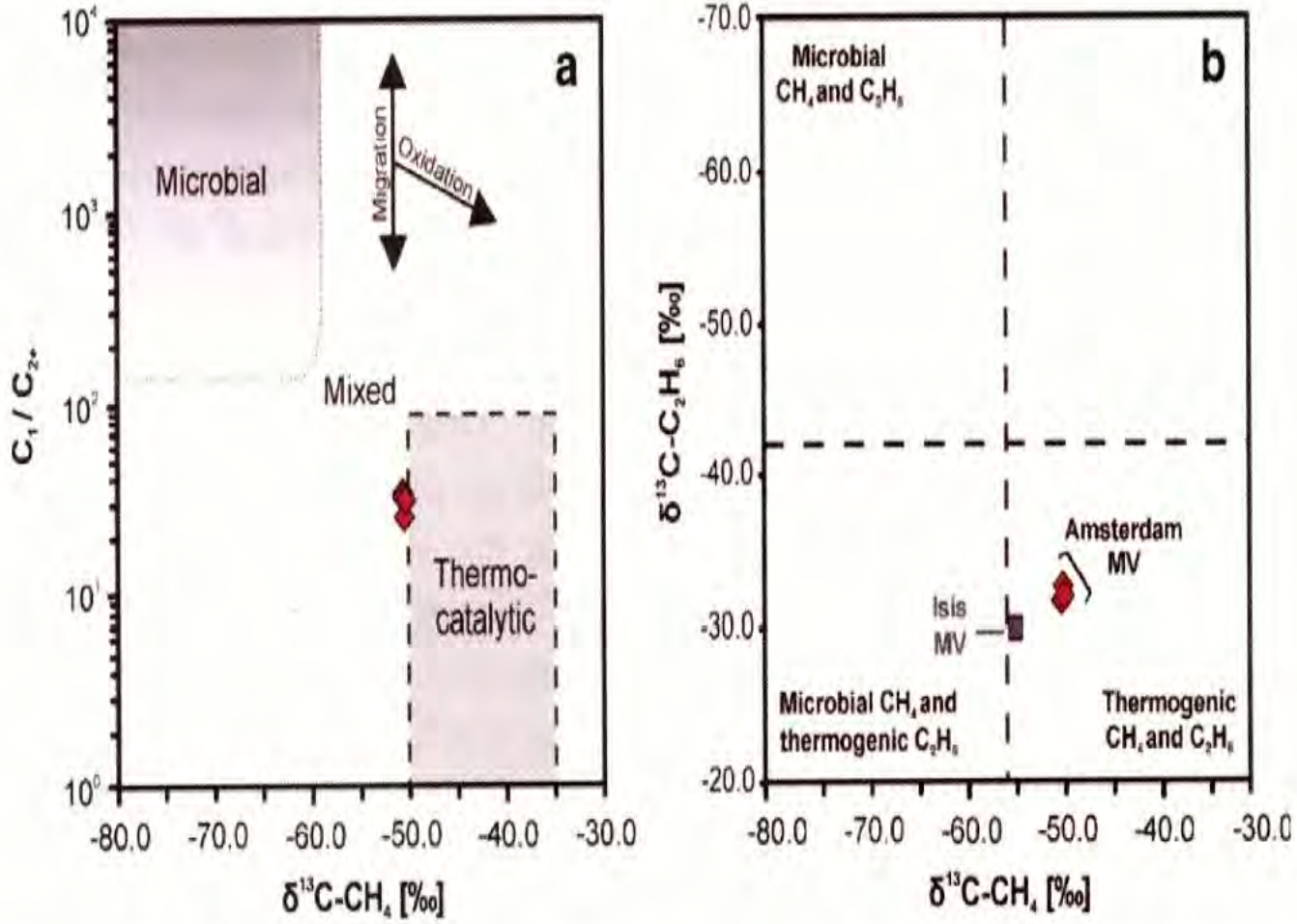


Figure 14. The relation of C_1/C_{2+} vs $\delta^{13}C\text{-}CH_4$ ($^0/_{00}$) and $\delta^{13}C\text{-}C_2H_6$ ($^0/_{00}$) vs $\delta^{13}C\text{-}CH_4$ ($^0/_{00}$) in Amsterdam Mud Flow Volcano, Anaximander Mountain, indicating the thermogenic origin of methane bubbles, Pape et. al., 2010

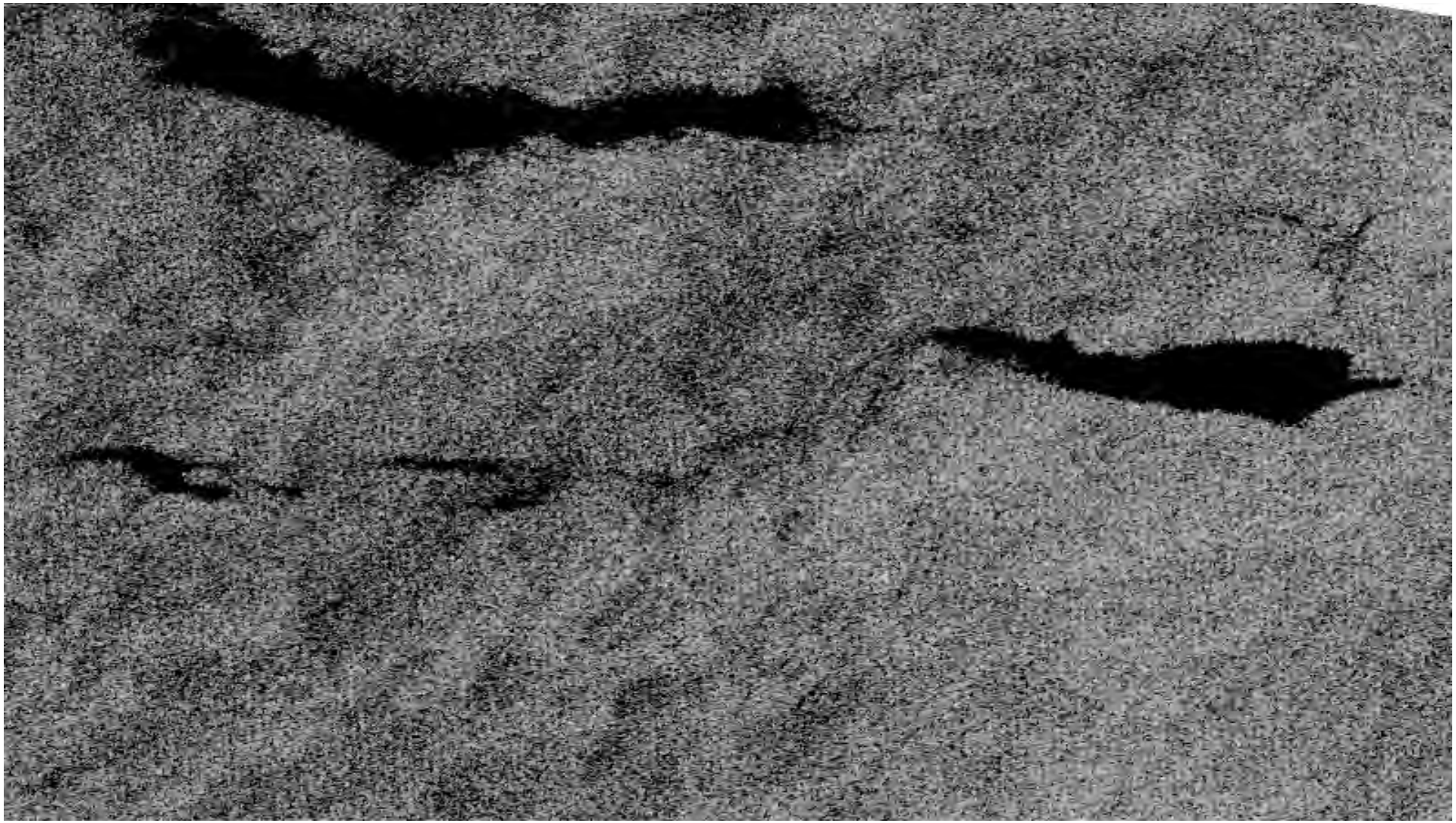


Figure 16. Oil films resulting from escaping gas bubbles which are coated with oil. Gas bubbles are derived from Active Mud Volcanoes. in offshore Nile Cone, Egypt. Picture taken from satellites. Roberts and Peace, 2007

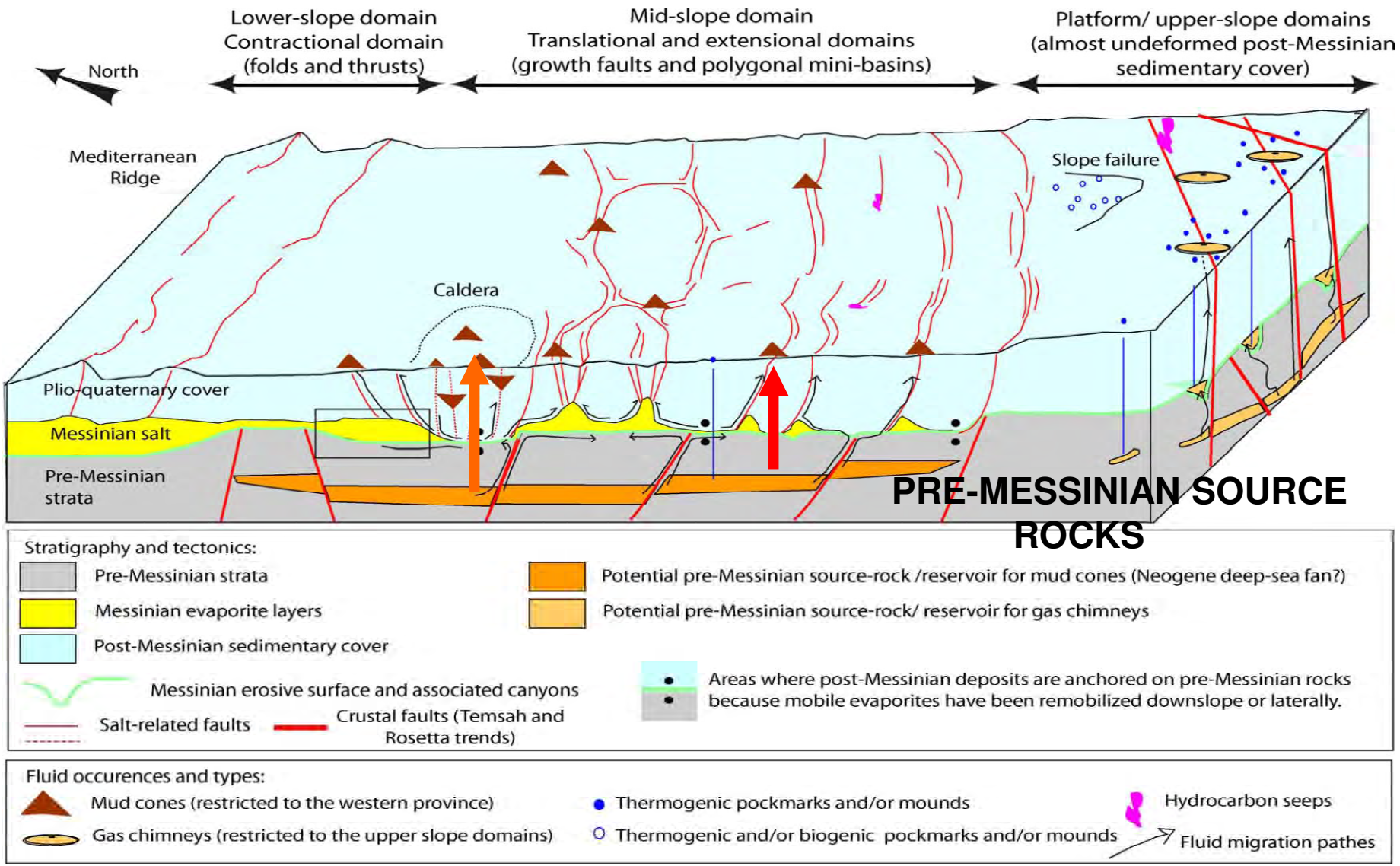


Figure 17. Active Mud Flow Volcanoes (brown triangles), Gas chimneys (brown discs), Thermogenic Pockmarks and Mounds offshore Southern Crete. The pre-Messinian source rocks/ reservoir for the mud cones (brown), are highly visible as well as the reservoir/source for the gas chimneys (light brown), are also visible, Loncke et al., 2004,

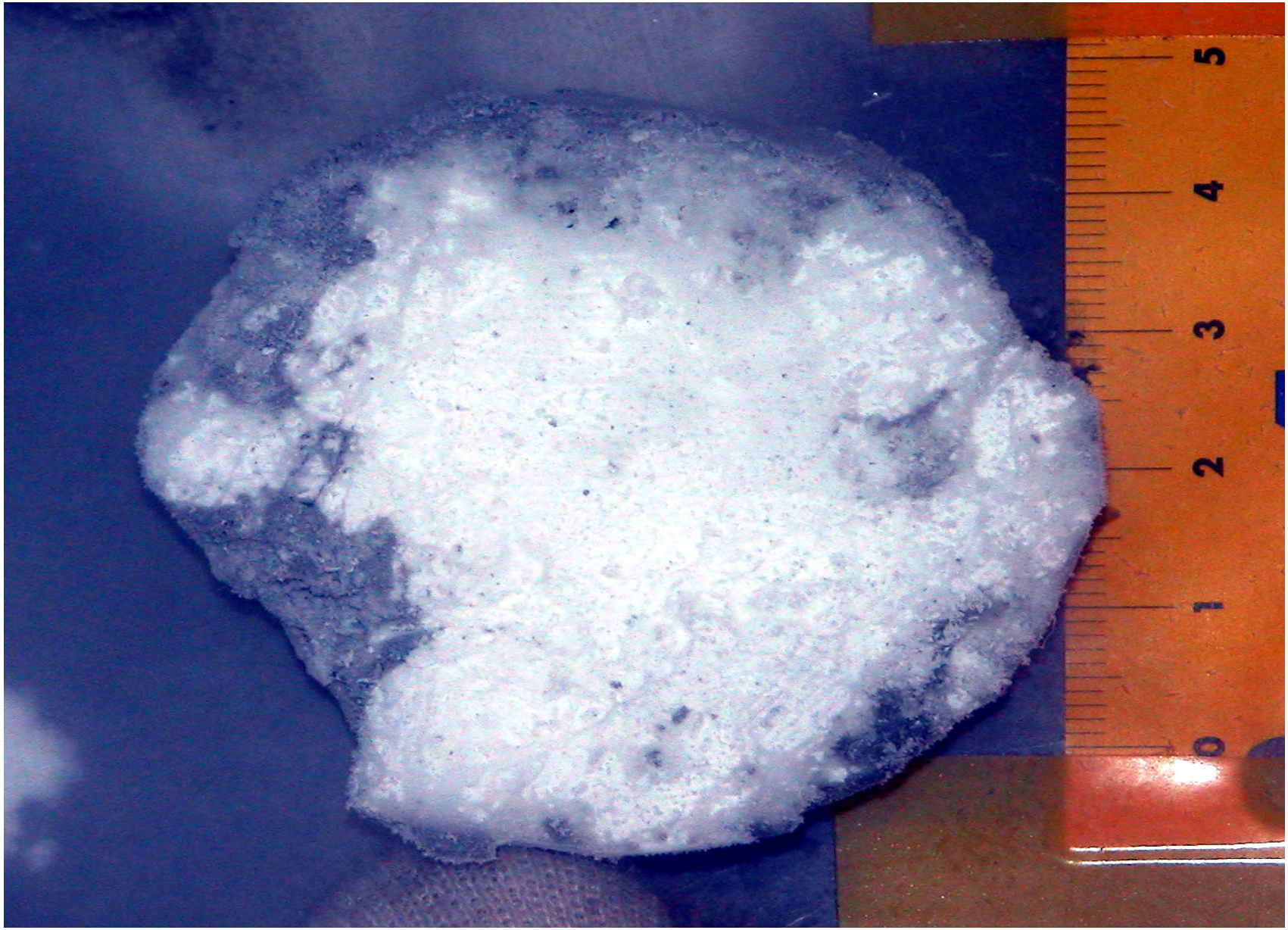


Figure 10. Hydrate from the Thessaloniki mud flow volcano of Anaximander mountains, Eastern Mediterranean, Lykousis et. al., 2004.

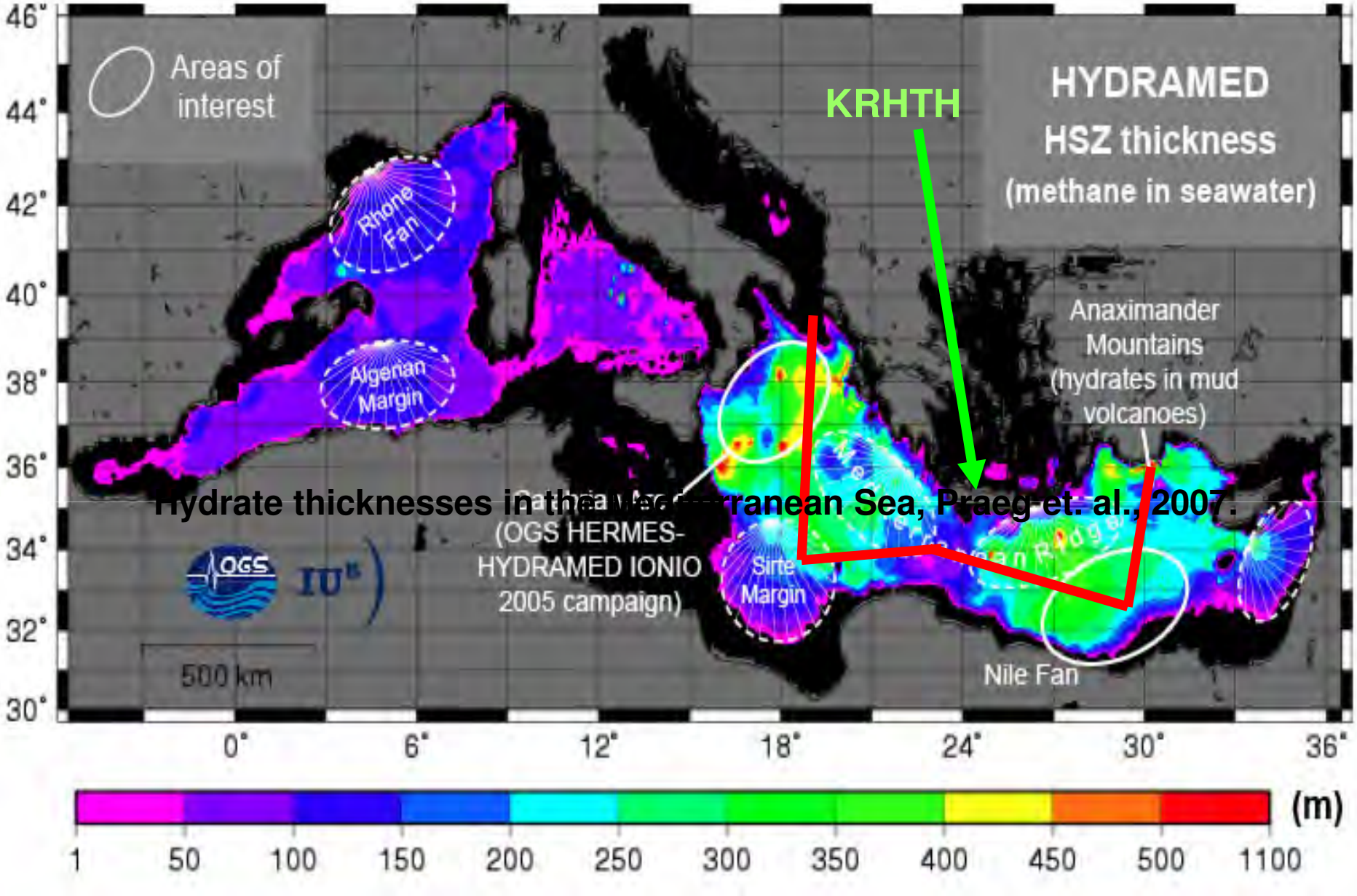


Figure 11. Hydrate thicknesses in the Mediterranean Sea, Praeg et. al., 2007.
Red line — denotes Greece's EEZ

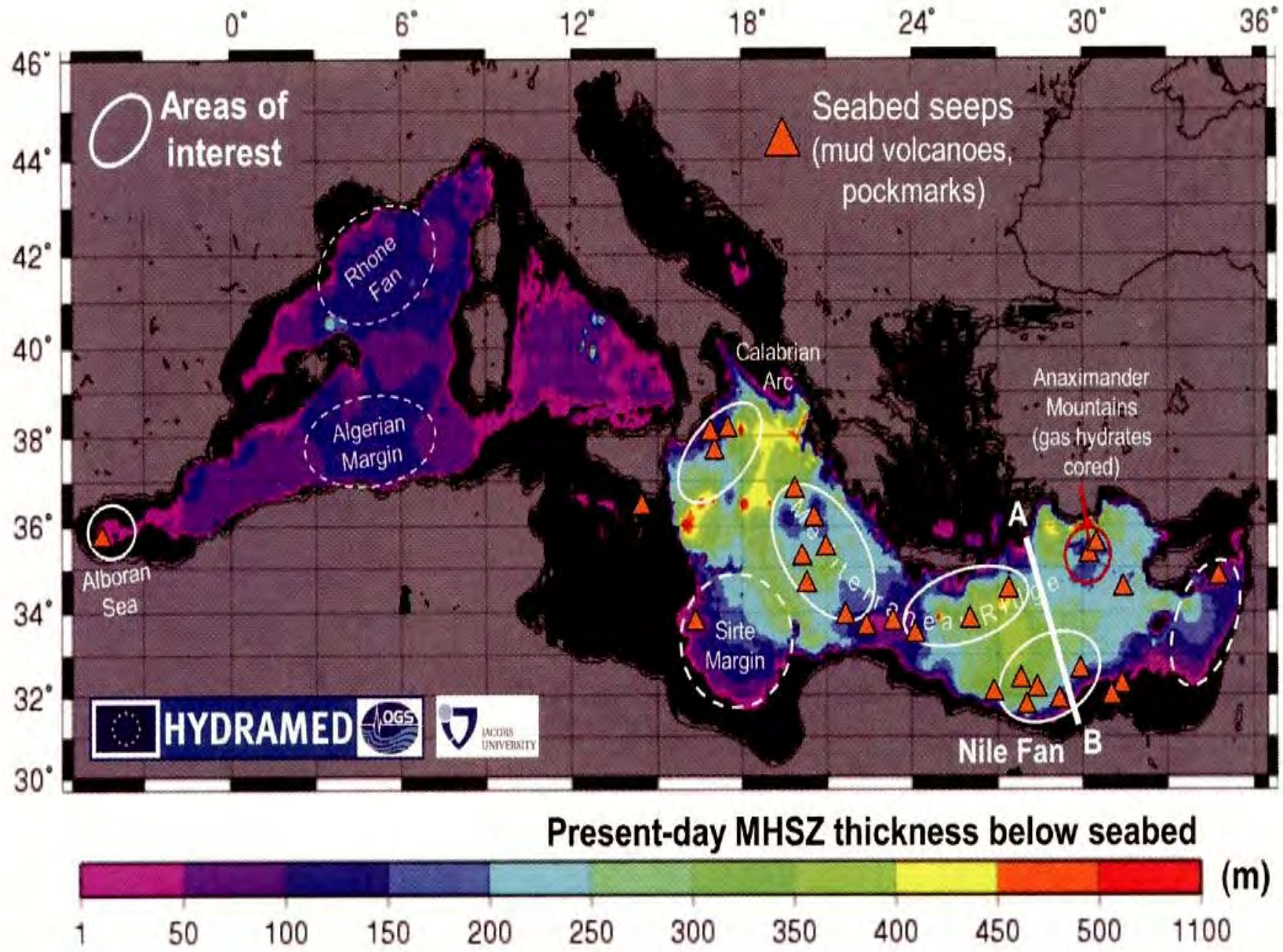
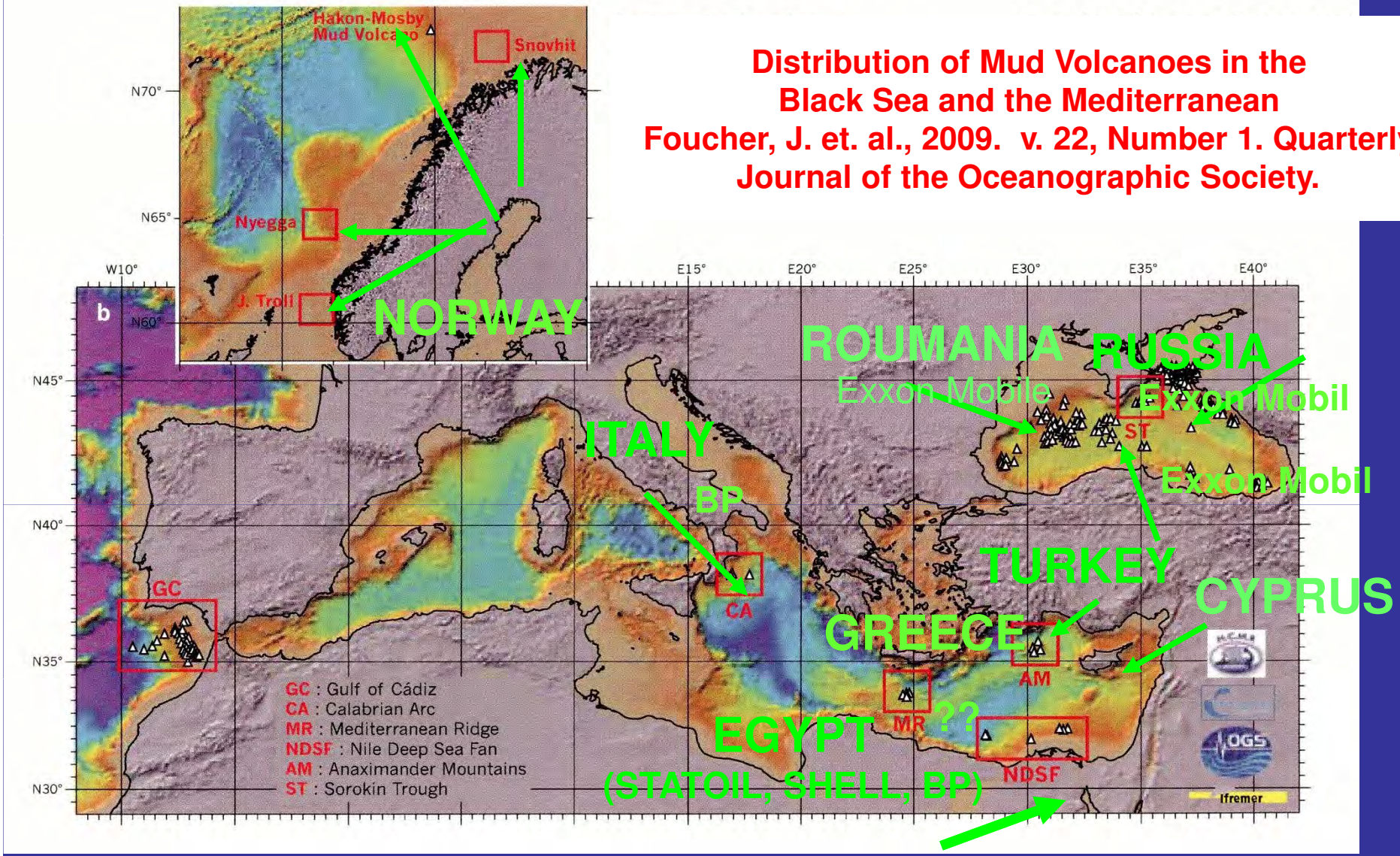


Figure 2. Modelled methane hydrate stability zone for present-day conditions, with areas of interest for hydrate occurrence; orange triangles indicate the general locations of known seabed seeps (various sources).



Εικόνα 26. Κατανομή των ενεργών λασποηφαιστείων στον Βόρειο Ατλαντικό, Μαύρη Θάλασσα και την Μεσόγειο, Foucher, et. al., 2009. Τα πράσινα τόξα υποδεικνύουν περιοχές έρευνας και εκμετάλλευσης υδρογονανθράκων γύρω από τα λασποηφαίστεια.

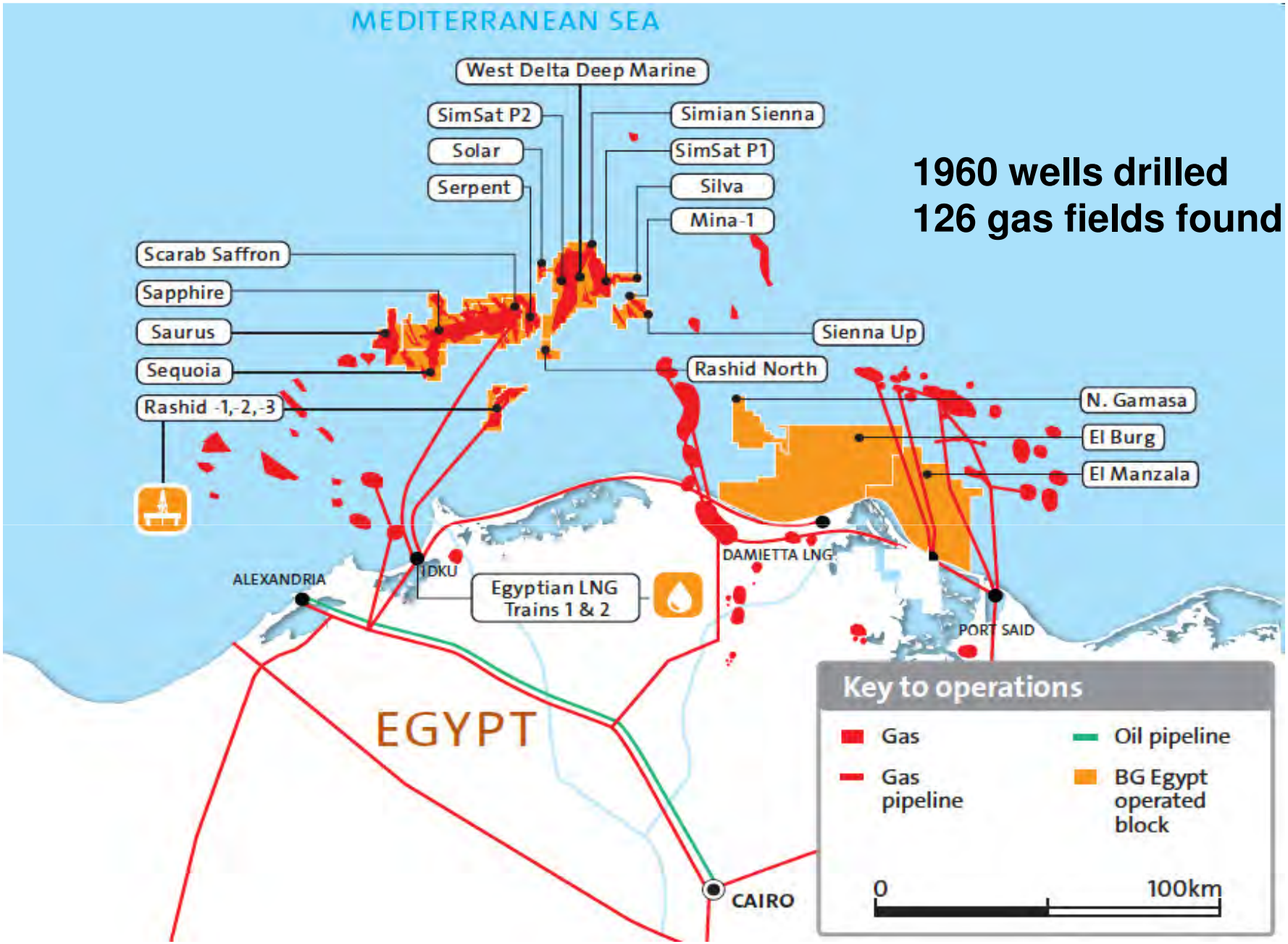


Figure 23. Distribution of natural gas reservoirs offshore Egypt, Neftegaz, EU, 2010 Rigzone, 2010

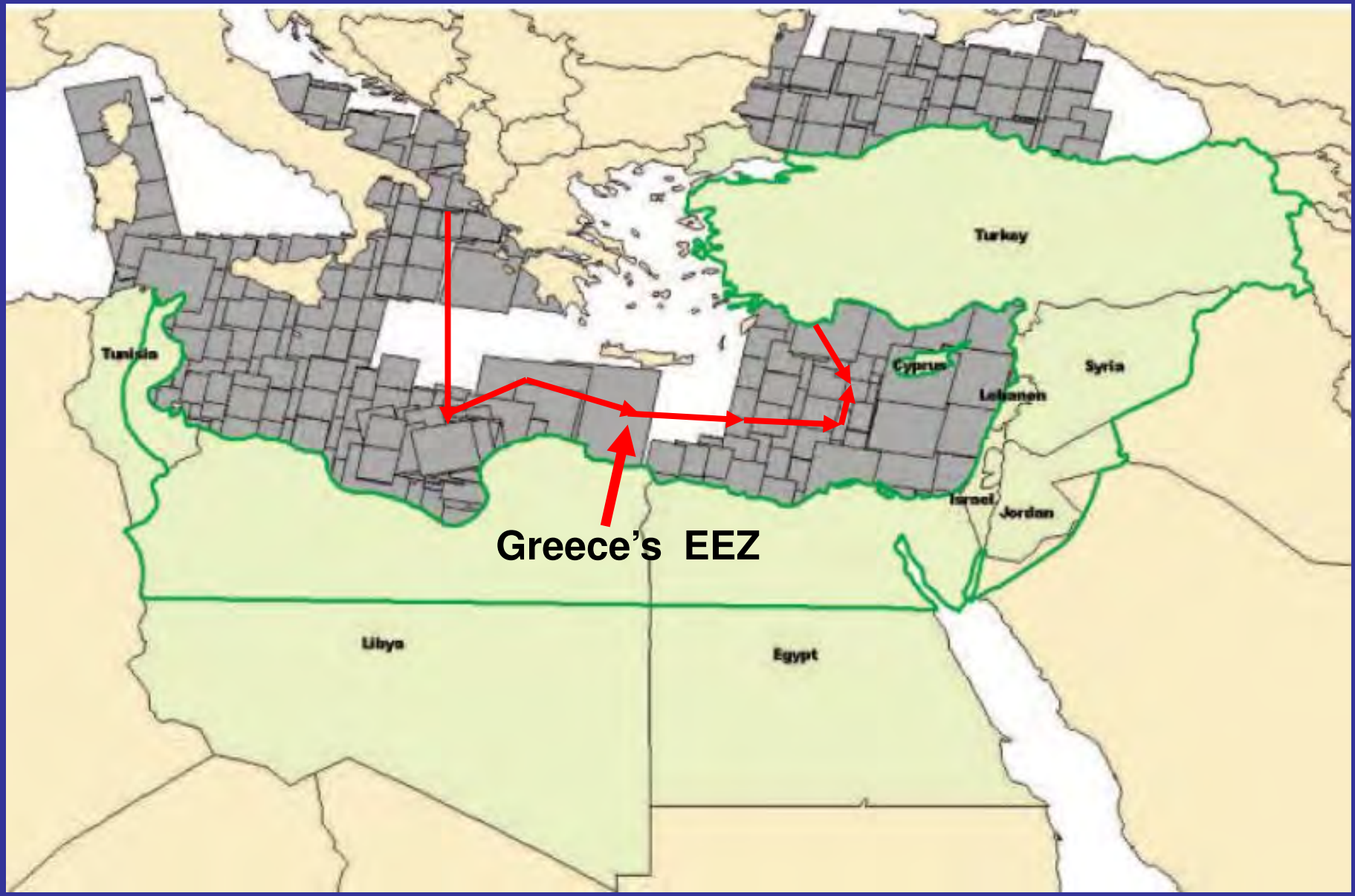
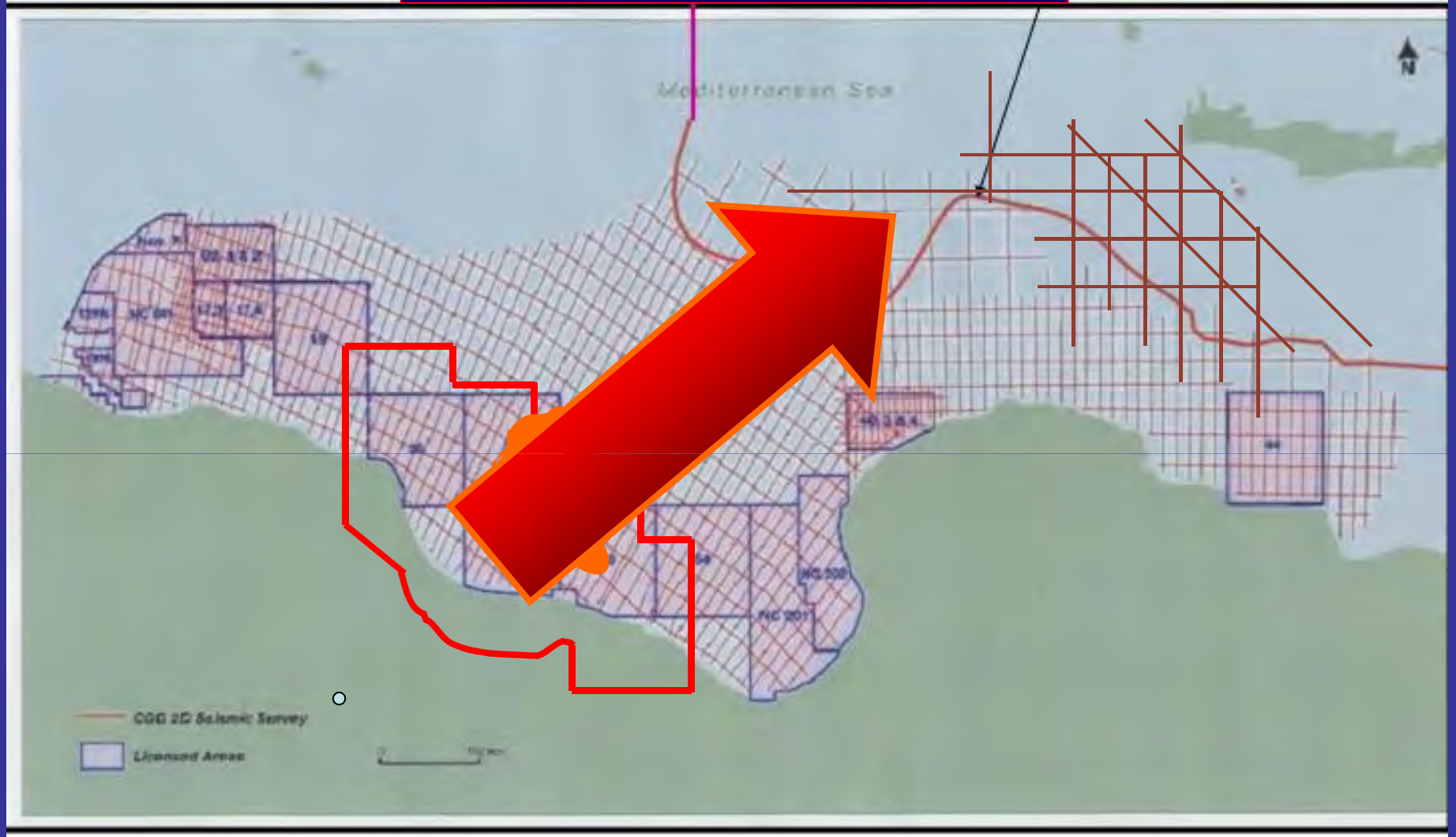


Figure 25. Geological and geophysical data maps by ASTRIUM, an EADS Co.
https://webmail.isc.tuc.gr/exchweb/bin/redir.asp?URL=http://www.astrium-geo.com/en/222-east-mediteranean

CGG-Seimic Lines Libya

Μη Αποκλειστικα Σεισμικα Λιβύης - 2003

Όριο Οικονομικών Ζωνών

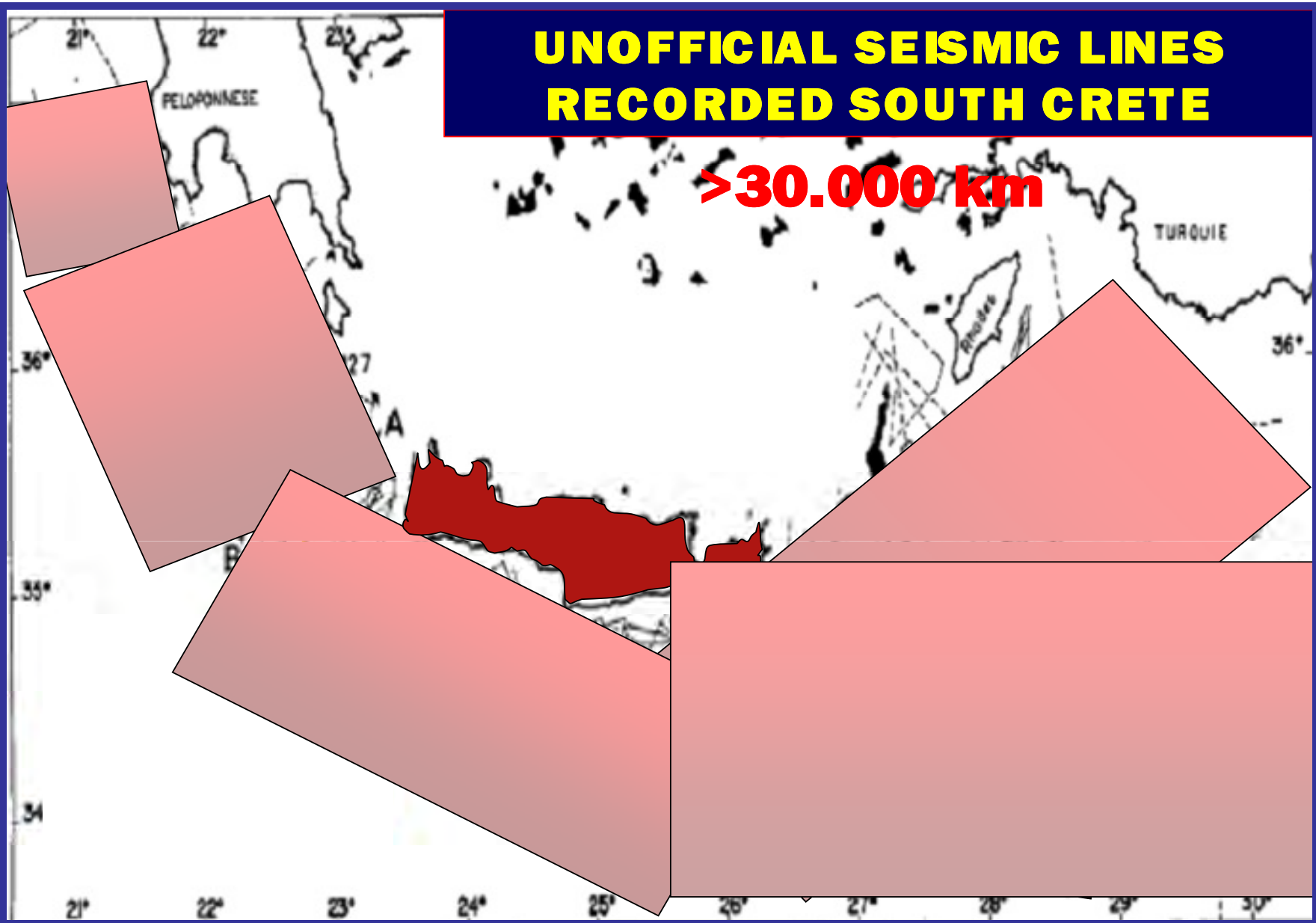


Εικόνα 34. CGG Veritas geophysical company Compagnie General de Geophysique, France

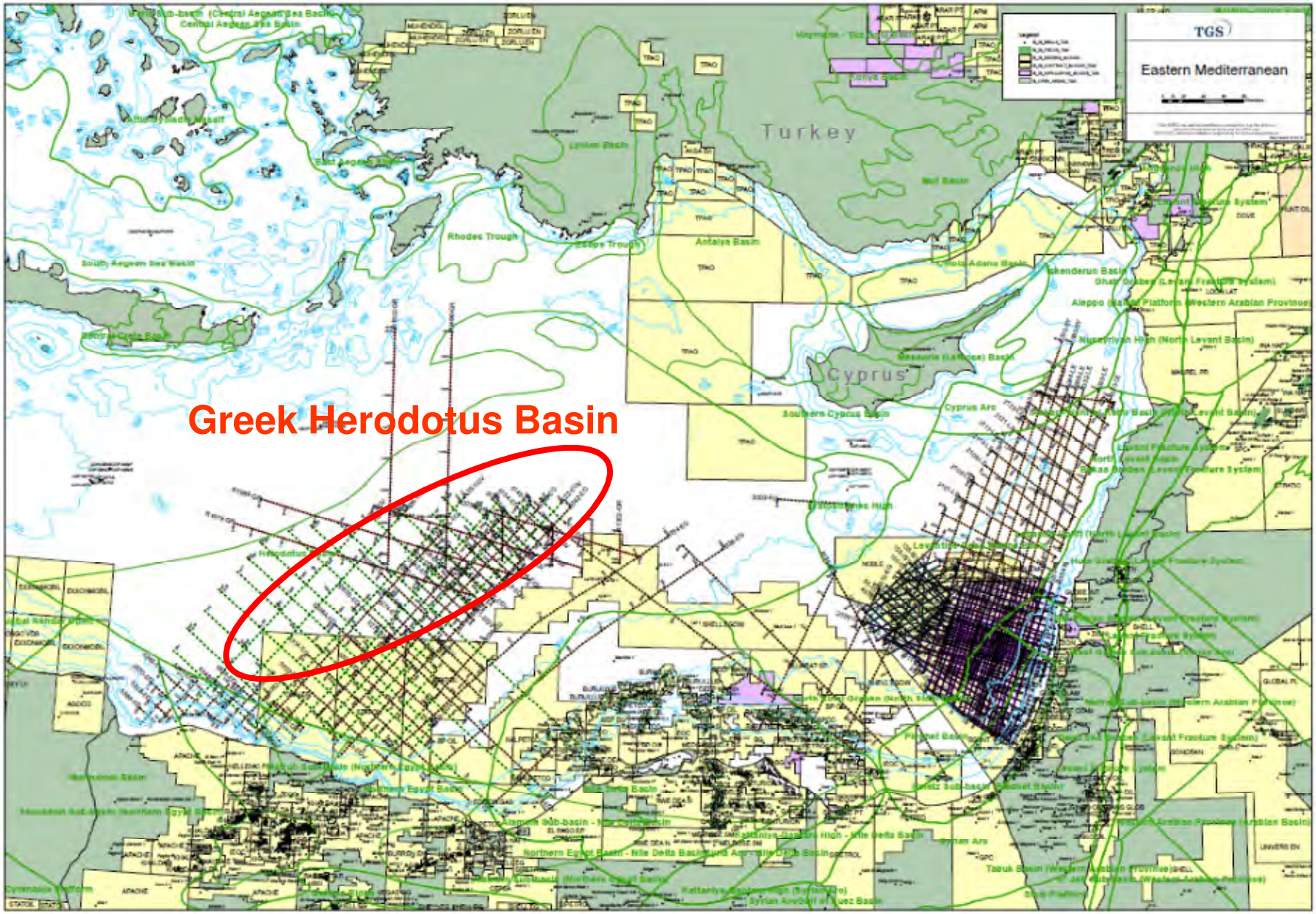
OIL SEARCH LIMITED

SIPETROL

HELLENIC PETROLEUM



ΑΝΕΠΙΣΗΜΕΣ 2D ΓΕΩΦΥΣΙΚΕΣ ΕΡΕΥΝΕΣ ΝΟΤΙΩΣ ΤΗΣ ΚΡΗΤΗΣ ΜΗΚΟΥΣ 30000 ΧΙΛΙΟΜΕΤΡΩΝ ΑΠΌ ΑΓΝΩΣΤΕΣ ΕΤΑΙΡΕΙΕΣ ΓΕΩΦΥΣΙΚΩΝ ΜΕΛΕΤΩΝ. ΟΙ ΜΑΥΡΕΣ ΓΡΑΜΜΕΣ ΔΕΞΙΑ ΕΙΝΑΙ ΑΠΌ ΤΗΝ TGS-NOPEC



Εικόνα 33. Οι Γεωφυσικές μελέτες της TGS-NOPEC, και η θέση της Ελληνικής λεκάνης του Ηρόδοτου, TGS-NOPEC, 2010

Multi- Client Promotional Presentation of PGS by J. Robinson at the ministry of Energy and Climatic Changes, Athens, Greece (ΥΠΕΚΑ), 2011

Summary of the South Mediterranean Sea offshore Crete

- **Hydrocarbon seeps** have been recorded adjacent to mud volcanoes

- **Interpretation of deep seismic data suggests** not only the presence of Messinian salt, but also pre-Messinian sediment

- Hydrocarbon analyses of mud from ODP cores **suggests the presence of an active hydrocarbon system at depth**

- Potential analogues to the Messinian facies in Libya and across the Mediterranean.

- High risks related to trapping mechanisms, however potential exists.

- **Accretionary prisms are productive across the world** i.e. (Barbados,Makran, Andaman Oceanic Island Arc system)

HYDROCARBON POTENTIAL IN GREECE

Play Name	Prinos	Ionian	S. Mediter.	Cretan Sea
Source	Miocene Shale	Neogene Shales	Cretaceous – Palaeogene Shales	Miocene Shale
Reservoir	Miocene Turbidites	Pliocene Turbidites	Miocene – Pliocene Turbidites	Miocene Deltaics
Seal	Miocene Evaporites	Pliocene Shales	Miocene Evaporites	Miocene Evaporites / Pliocene Shales
Trap	Structural	Stratigraphic	Stratigraphic	Combination
Type Basin	Prinos	Ionian	Levantine	Cretan

(3,45 Tcm ??)

Table 30. Source rocks, Reservoirs, Seals Traps and Type basin.
A promotional multi client presentation of PGS by J. Robinson at the ministry of Energy and Climatic Changes, Athens, Greece (ΥΠΕΚΑ), 2011

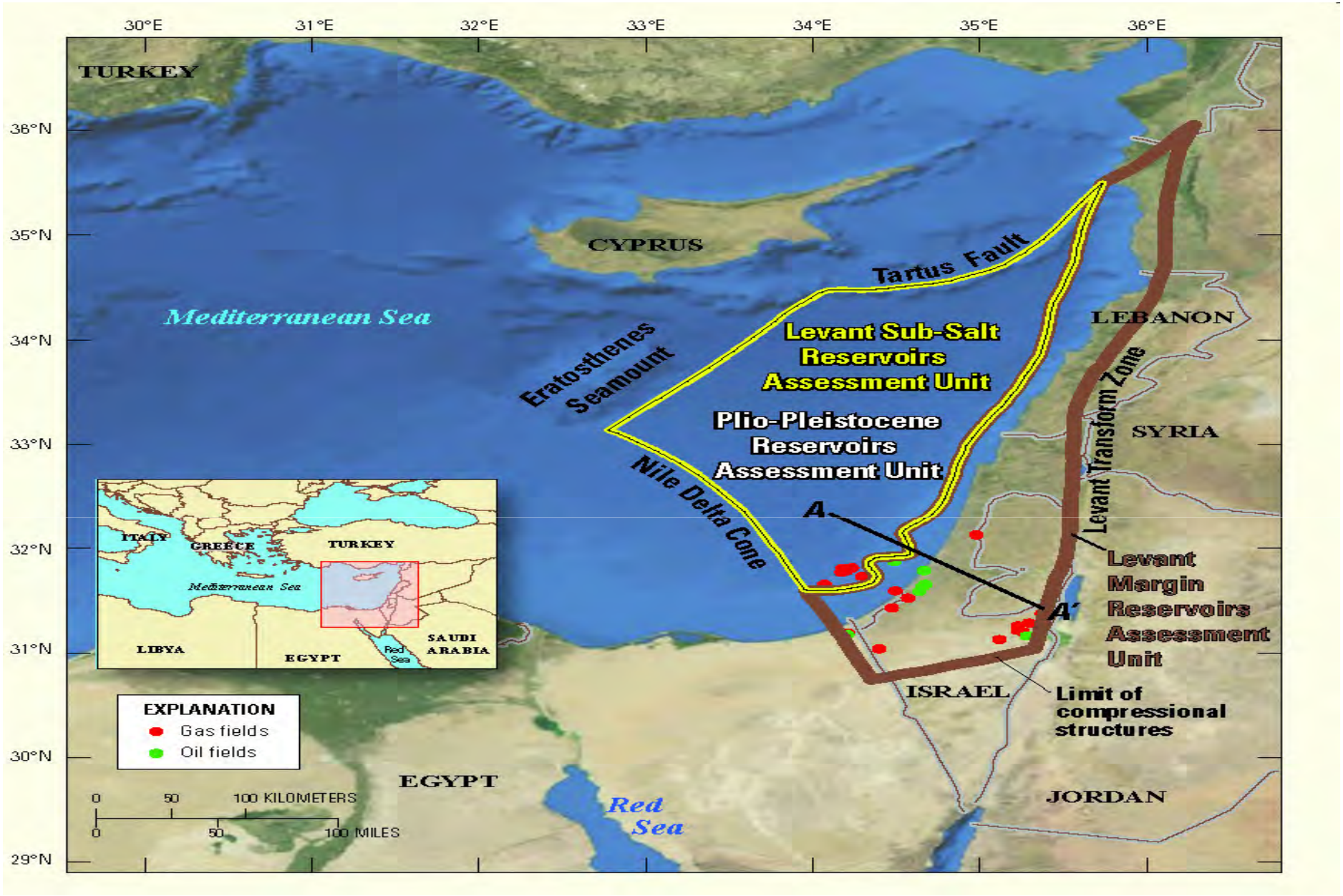


Figure 31. The Levantine Basin with its recent oil and gas discoveries. Assessed potential for further discoveries of natural gas 122 tcf (3,45 tcm) and oil 1,7 billion barrels, USGS Technical Report, 2010

ΑΠΟΤΕΛΕΣΜΑΤΑ ΑΝΑΛΟΓΙΚΗΣ ΣΥΓΚΡΙΣΗΣ ΠΡΙΣΜΑΤΩΝ ΕΠΑΥΞΗΣΗΣ

- **ΠΡΟΚΕΙΤΑΙ ΌΜΩΣ ΓΙΑ ΝΕΟΥΣ** ΑΝΕΞΕΡΕΥΝΗΤΟΥΣ ΑΚΟΜΑ ΣΤΟΧΟΥΣ – FRONTIER AREA

- ΑΠΌ ΥΠΑΡΧΟΥΣΕΣ ΚΑΤ' ΑΝΑΛΟΓΙΑΝ ΣΤΑΤΙΣΤΙΚΕΣ ΓΝΩΣΤΩΝ ΟΙΚΩΝ ΓΕΩΣΤΡΑΤΗΓΙΚΗΣ ΑΞΙΟΛΟΓΗΣΗΣ (**π.χ. ΟΙΚΟΣ STATFORD, ERGO SOLUTIONS**) ΤΑ ΑΝΑΜΕΝΟΜΕΝΑ ΣΥΜΒΑΤΙΚΑ ΑΠΟΘΕΜΑΤΑ Υ/Α ΝΟΤΙΑ ΤΗΣ ΚΡΗΤΗΣ, ΥΠΟΛΟΓΙΖΟΝΤΑΙ ΝΑ ΕΙΝΑΙ ΤΗΣ ΤΑΞΗΣ ΤΩΝ **20 - 30** Δις Βαρέλια Ισοδυνάμου Πετρελαίου - **δηλ. οι Ανάγκες της Ελλάδος για ~150 ΧΡΟΝΙΑ.**

Δρ. Ηλίας ΚΟΝΟΦΑΓΟΣ

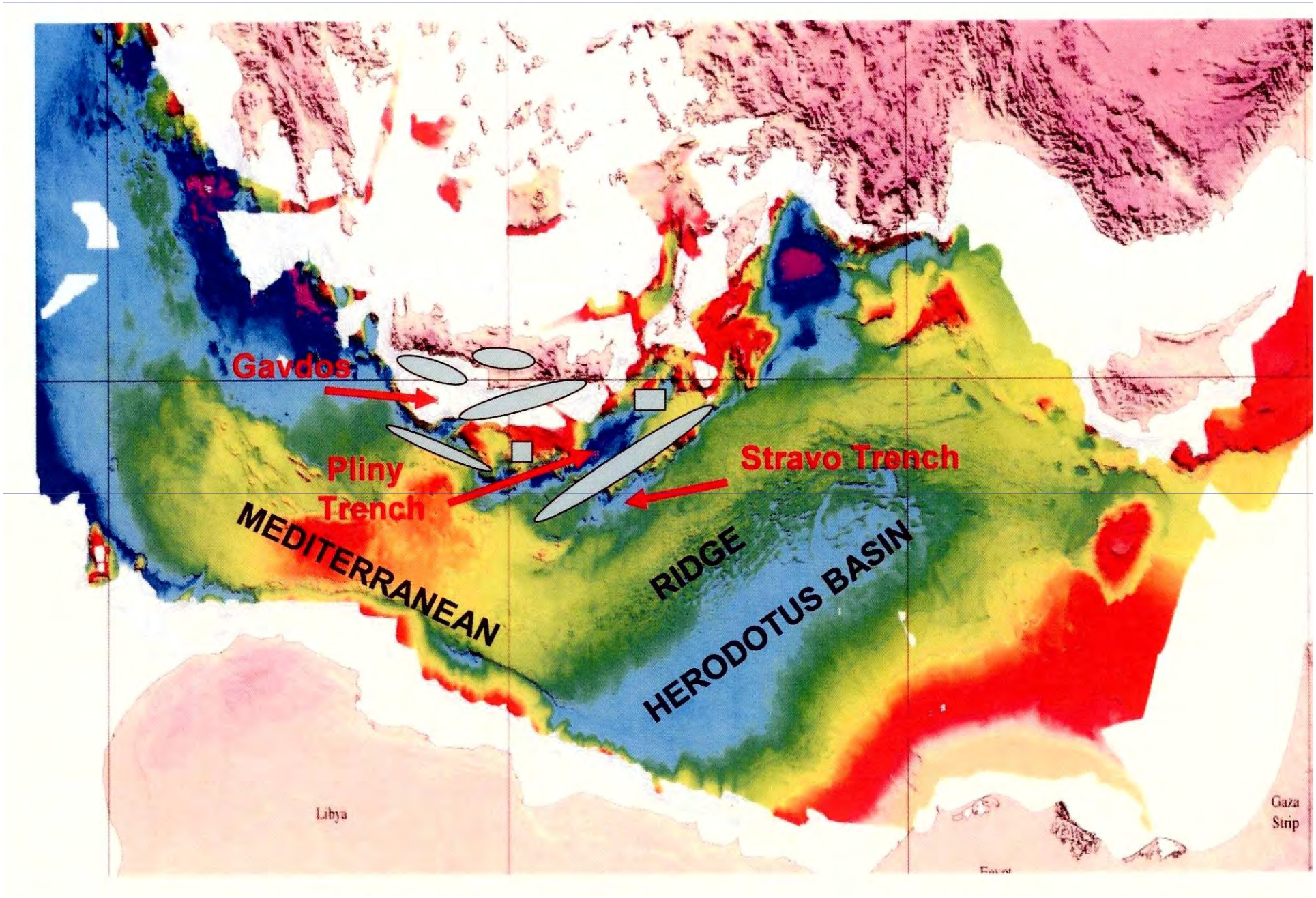


Figure 29. Suggested Hydrocarbon Fields, pale blue, ⬭ ,offshore Crete according to Maravelis et. al., 2012

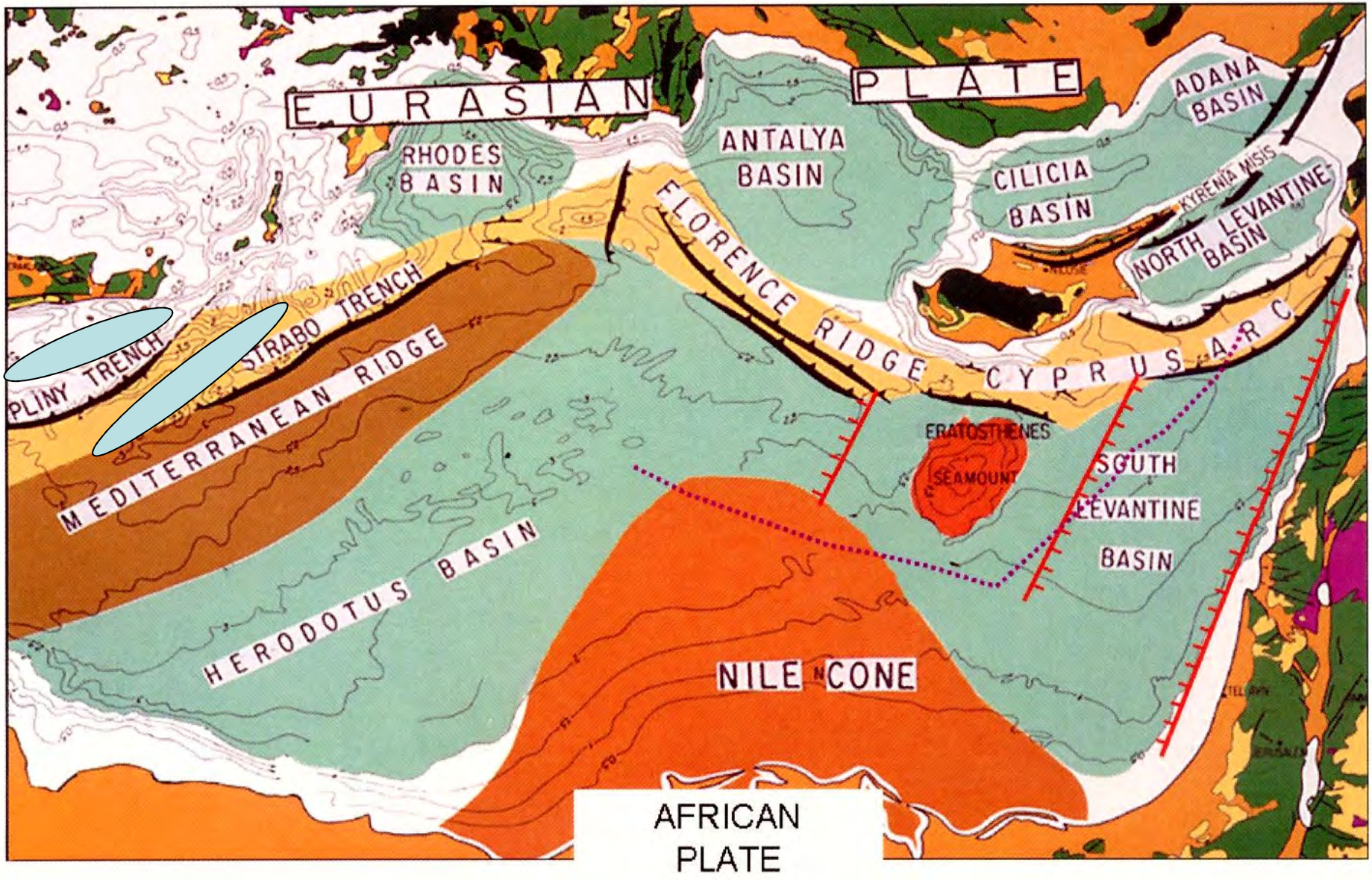


Figure 29. Suggested Hydrocarbon Fields, pale blue, ⬭,offshore Crete according to Maravelis et. al., 2012

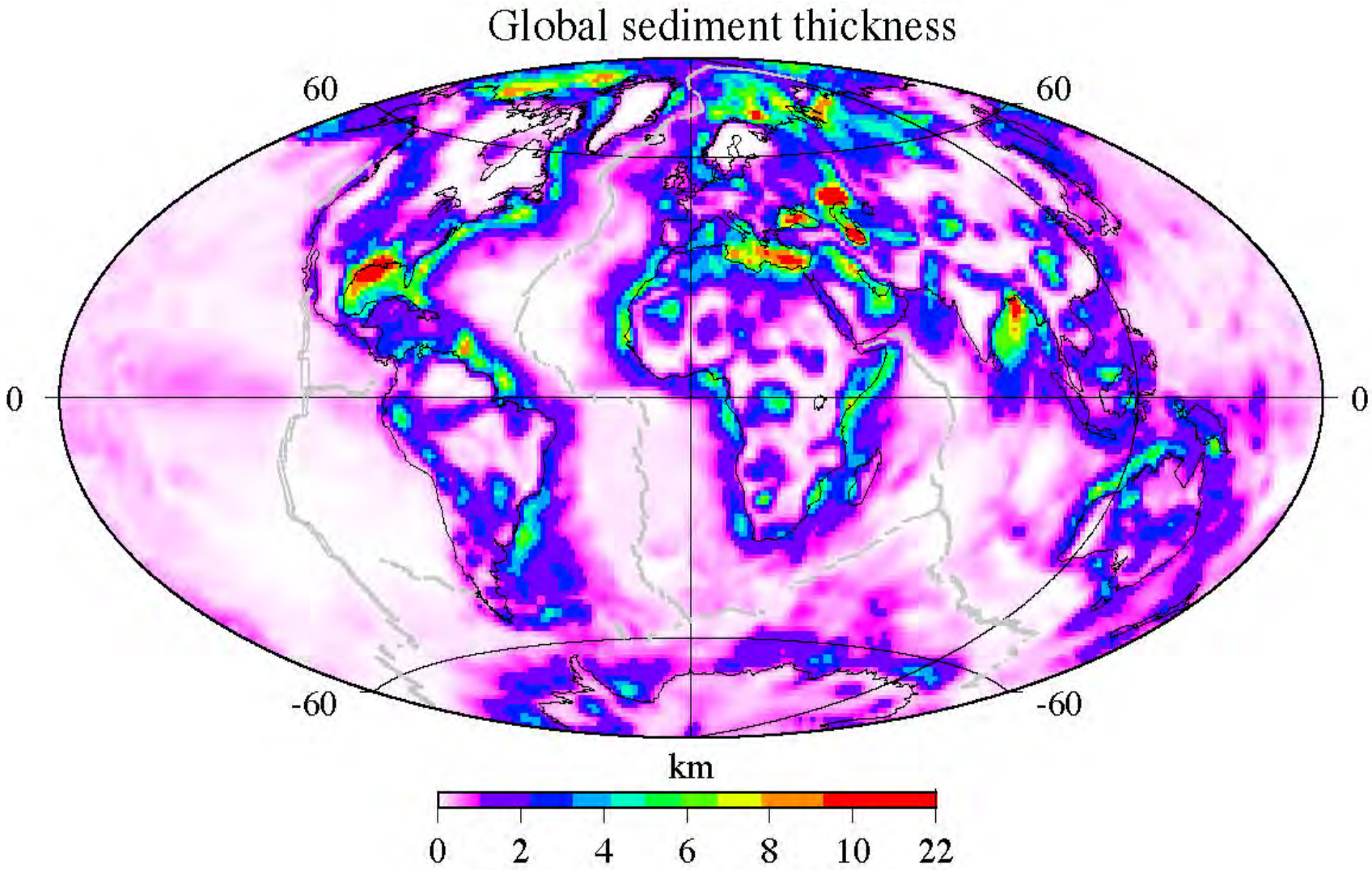
Εικόνα 17. ¨Ορια της προς έρευνα περιοχής που βασίζονται στην αρχή της μέσης γραμμής/γραμμή ίσης απόστασης μεταξύ όλων των εδαφών των εμπλεκόμενων κρατών..International Public Invitation for the participation in Non-Exclusive seismic Survey on the Continental shelf of Western and Southern Greece. June 7, 2011, www.maniatisy.gr/index.php?

- **THE NET RESULT FROM THIS INTERNATIONAL INVITATION BY YPEKA WAS THAT 8**

  GEOPYSICAL COMPAMIES HAVE ASKED PERMISSION TO CARRY OUT THE NON-EXCLUSIVE 2D AND 3D GEOPHYSICAL SURVEYS INDICATING BEYOND ANY DOUBT THAT HYDROCARBON FIELDS MUST EXIST OFFSHORE SOUTHERN CRETE.

THE FACT THAT 3 COMPANIES NAMELY, CGG VERITAS, SPECTRUM AND TGS-NOPEC, WHO DID ILLEGALLY GEOPHYSICAL SURVEYS OFFSHORE CRETE WANT TO PARTICIPATE IN THE COMPETITION PROVES BEYOND ANY DOUBT THE EXISTENCE OF HYDROCARBONS.


THANK YOU
CHANIA, CRETE



http://www.earth.ox.ac.uk/~tony/watts/basins.htm

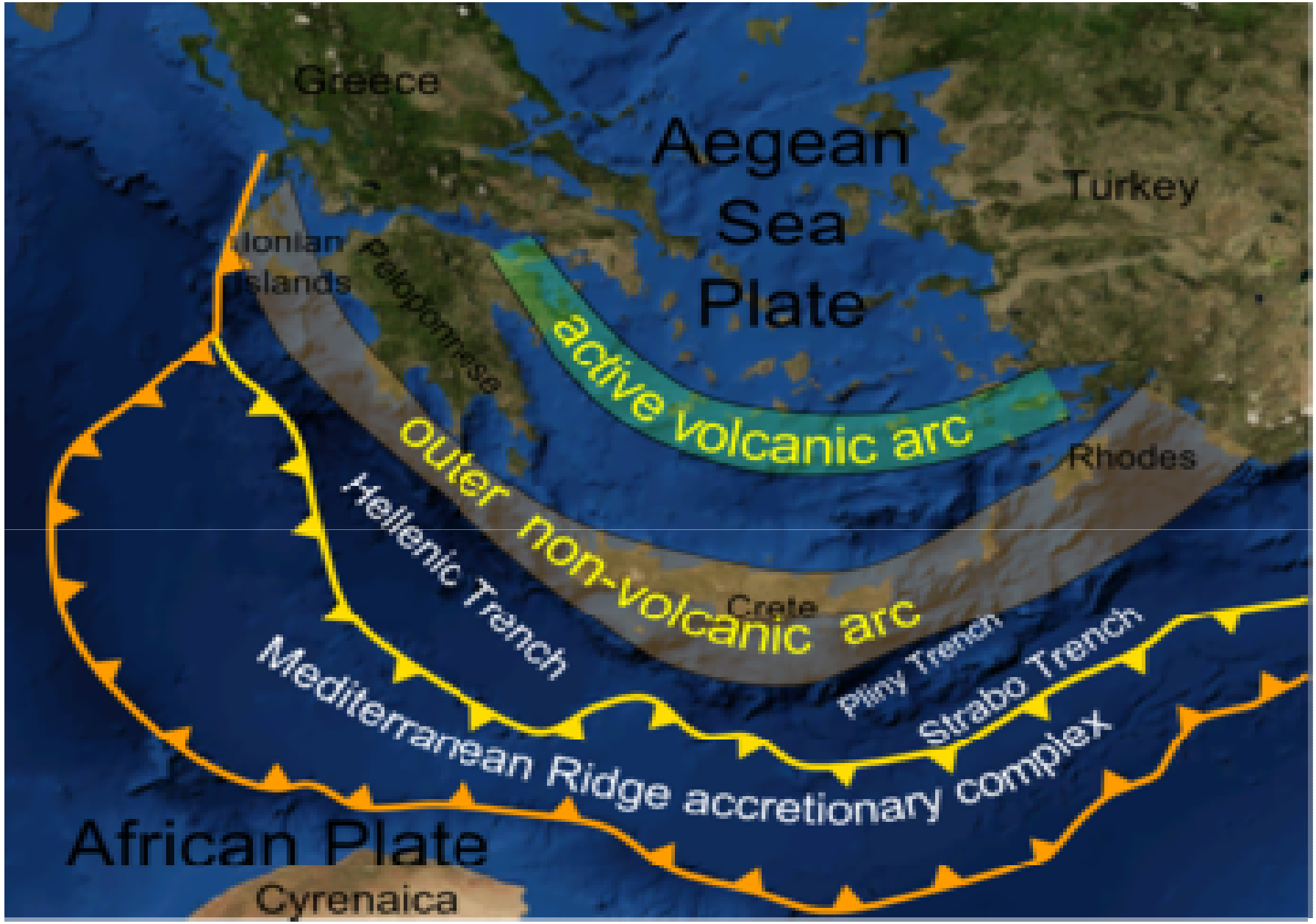


Figure 24. The Area covered by the Mediterranean Ridge accretionary prisms. Its implication for potential hydrocarbon reserves, en. Wikipedia org/…./Mediterranean Rid…

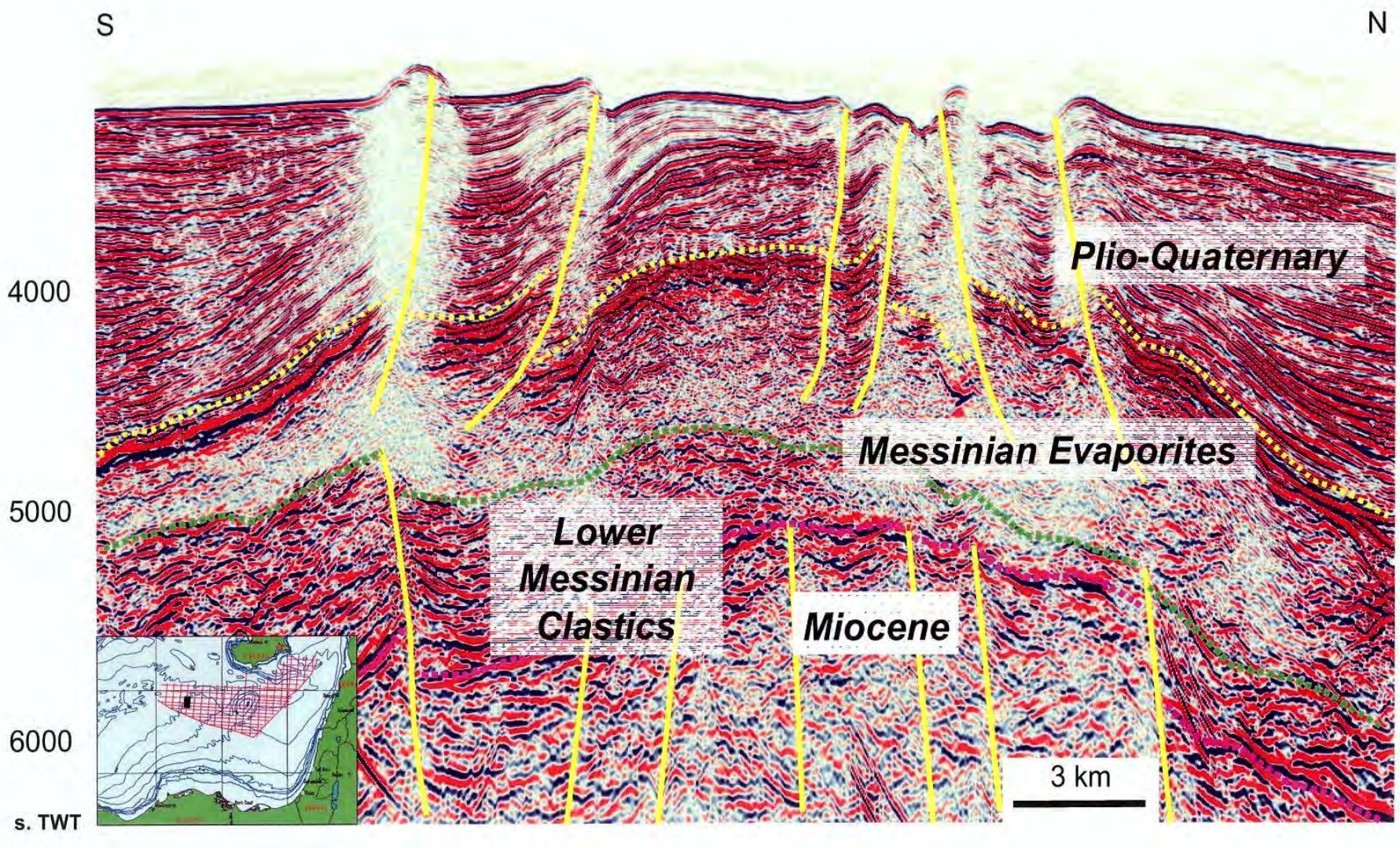


Figure 18. Large anticline on the toe of deep Nile delta fan with Messinian low-stand delta clastic sand faulted pre-Messinian. Gas chimneys are highly visible, Montadert and Nikolaides, 2010.

Fig. 19. The geology of North Africa and Southern Europe during Mid Miocene, Scotese, 2000

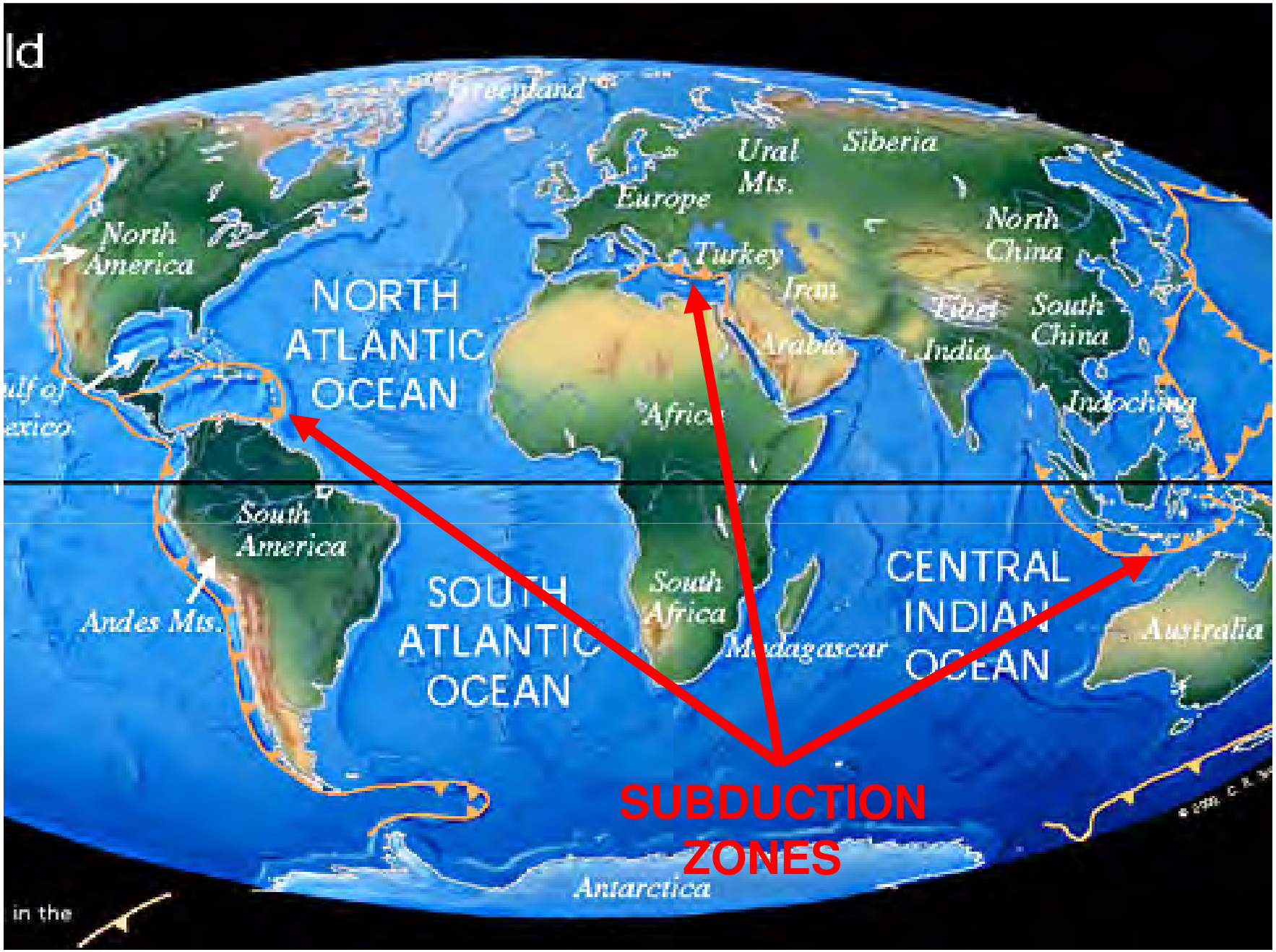


Fig. 20. Modern world, Scotese, 2000

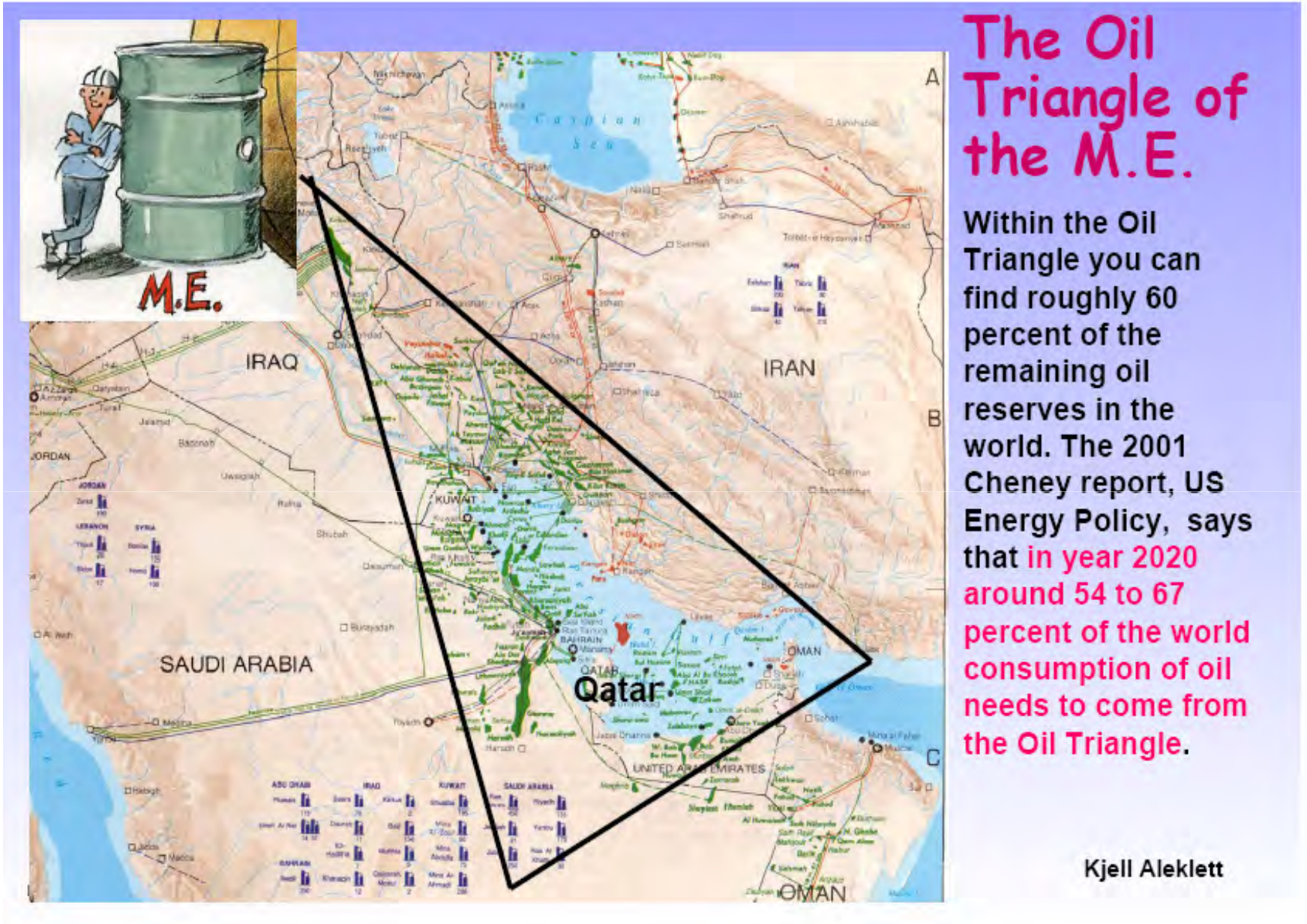
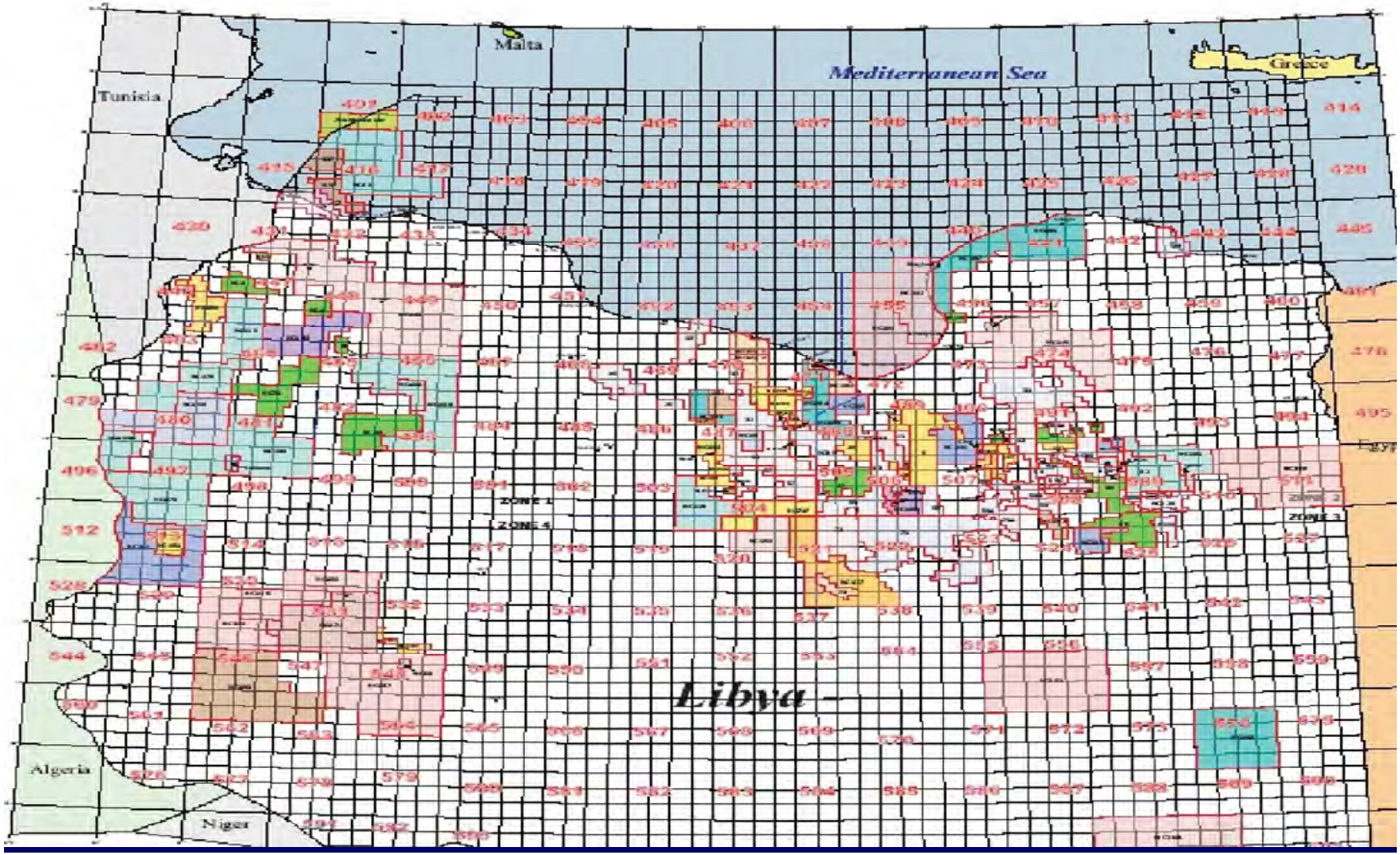


Fig. 21. The Middle East Oil Triangle Aleklett. 2004



ΧΑΡΤΗΣ ΠΑΡΑΧΩΡΗΣΕΩΝ ΤΗΣ ΛΙΒΥΗΣ

Εικόνα 34. CGG Veritas geophysical company
Compagnie General de Geophysique, France

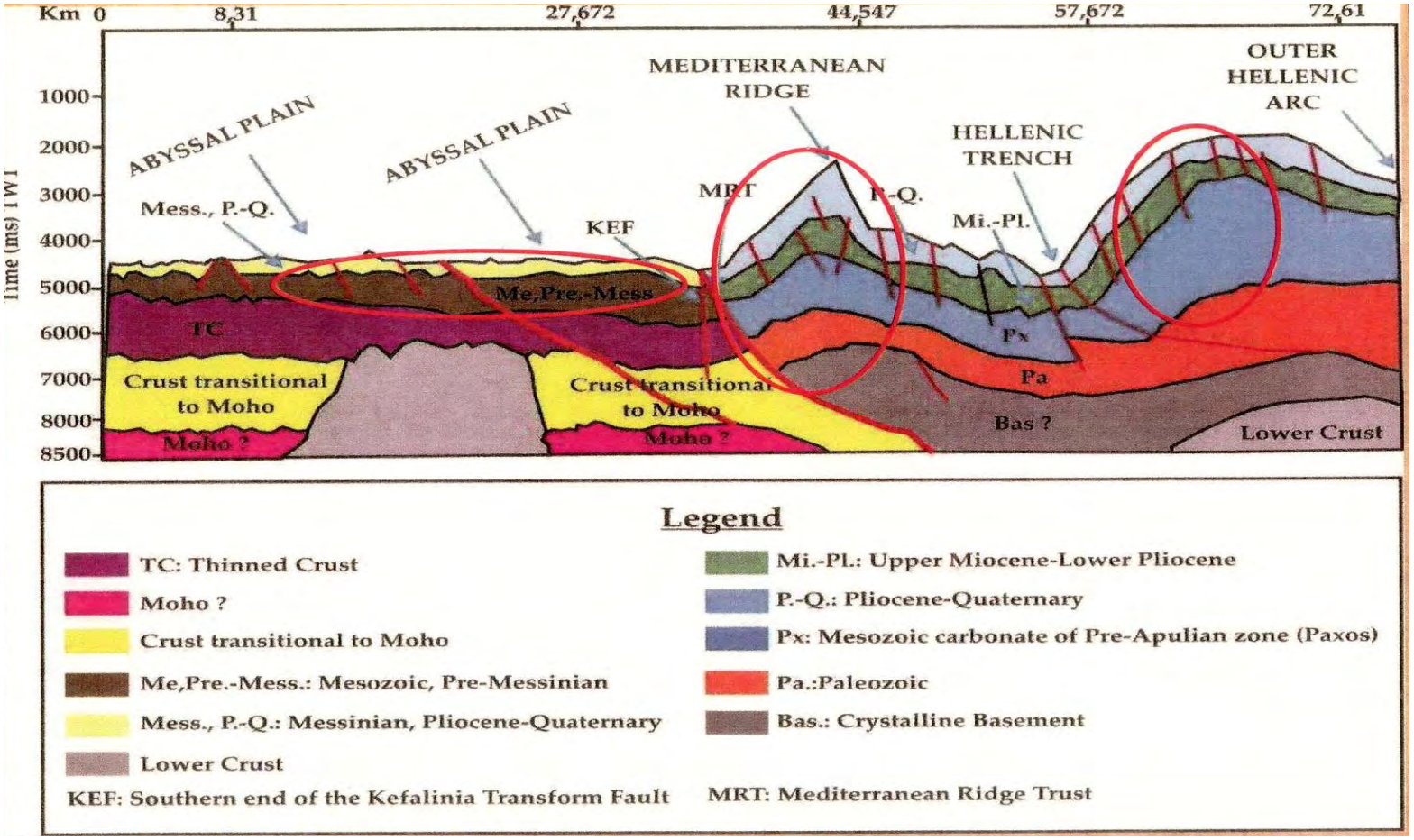


Fig. 27. Possible hydrocarbon plays offshore southern Crete. Two major anticlines (ellipsoidal red circles) and the Hellenic trench, 2 Km below sea level. 2. Abyssal Plain (Oval red Circle). Zelilidis, 2011.

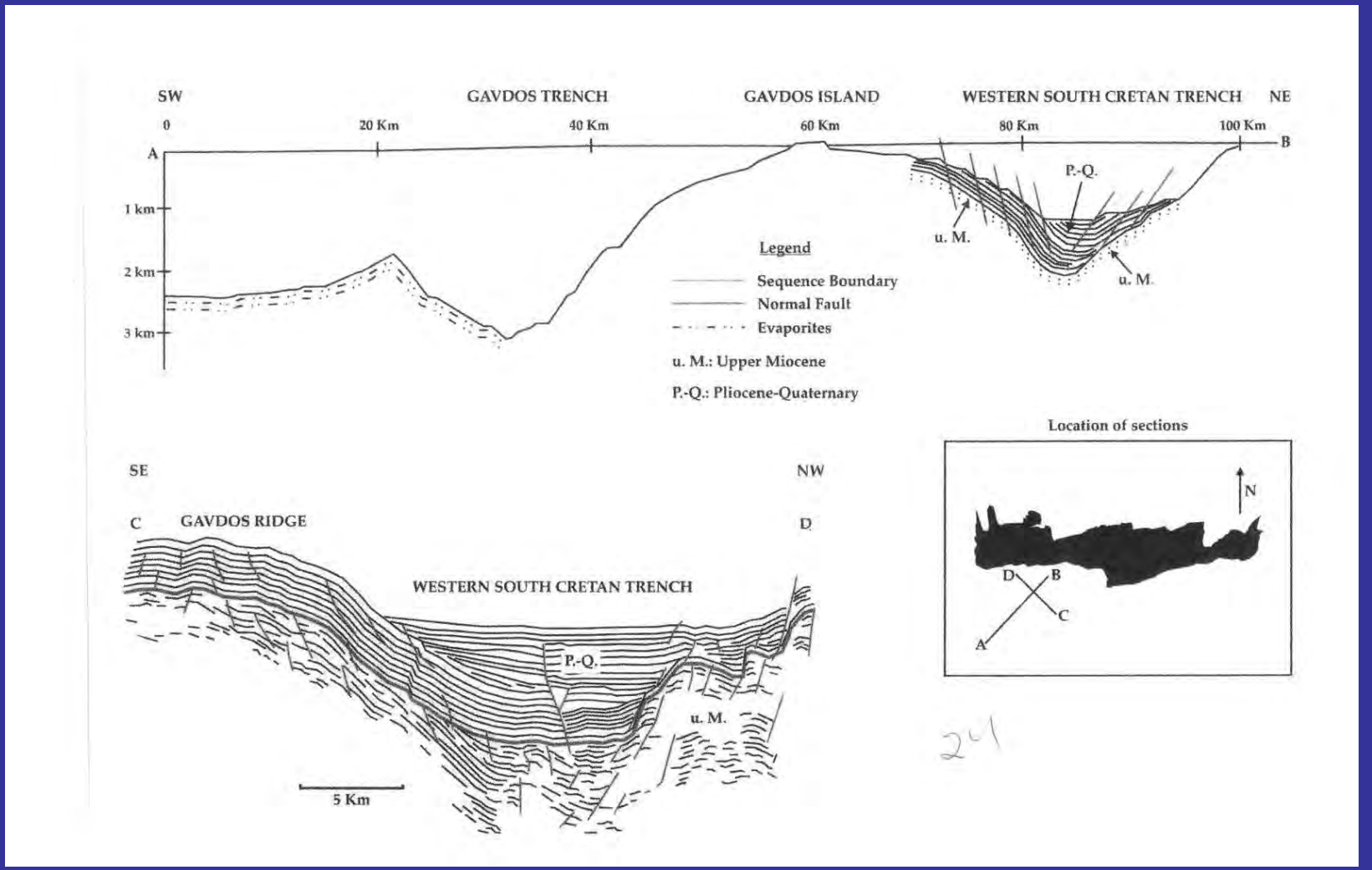
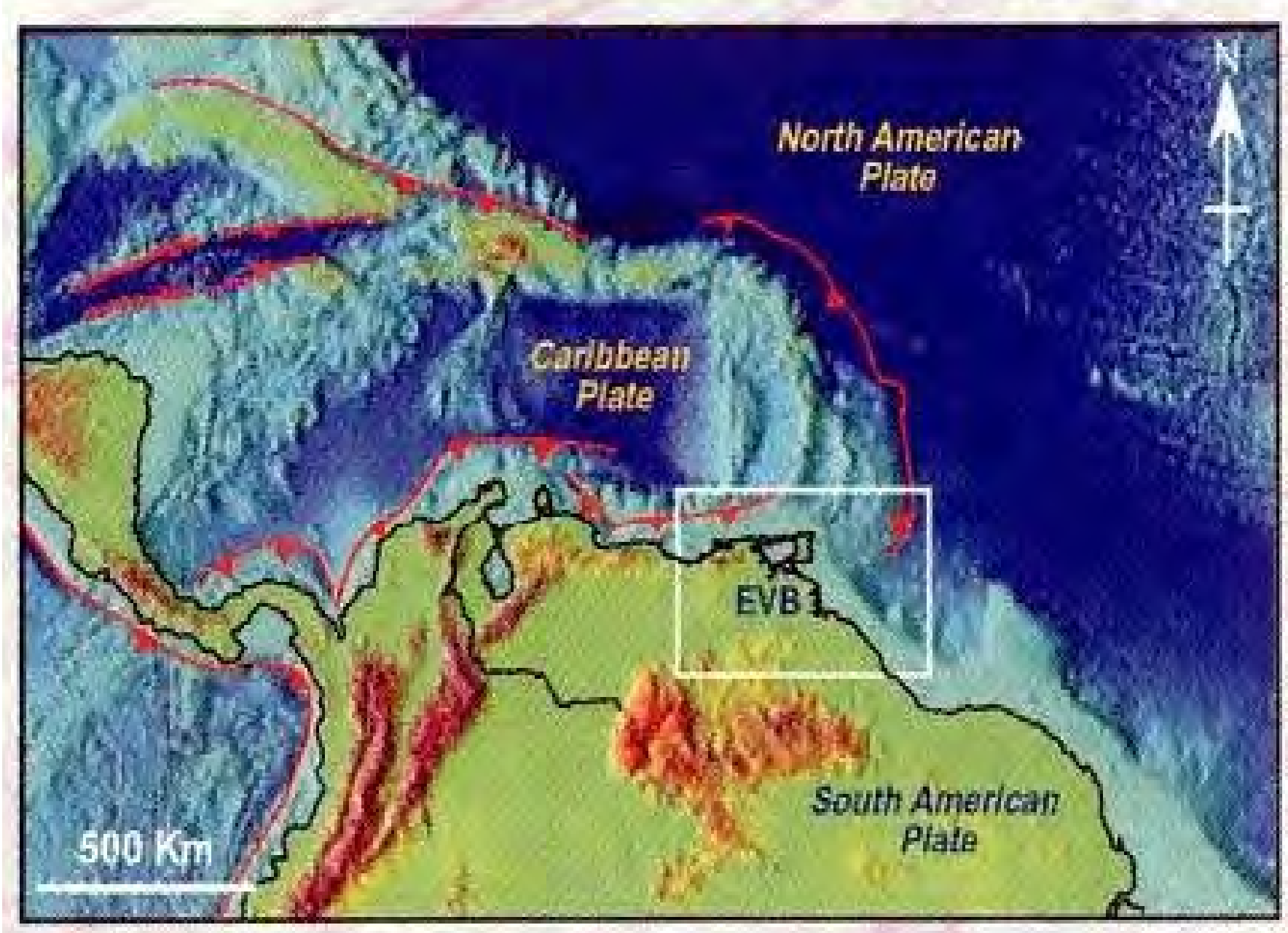
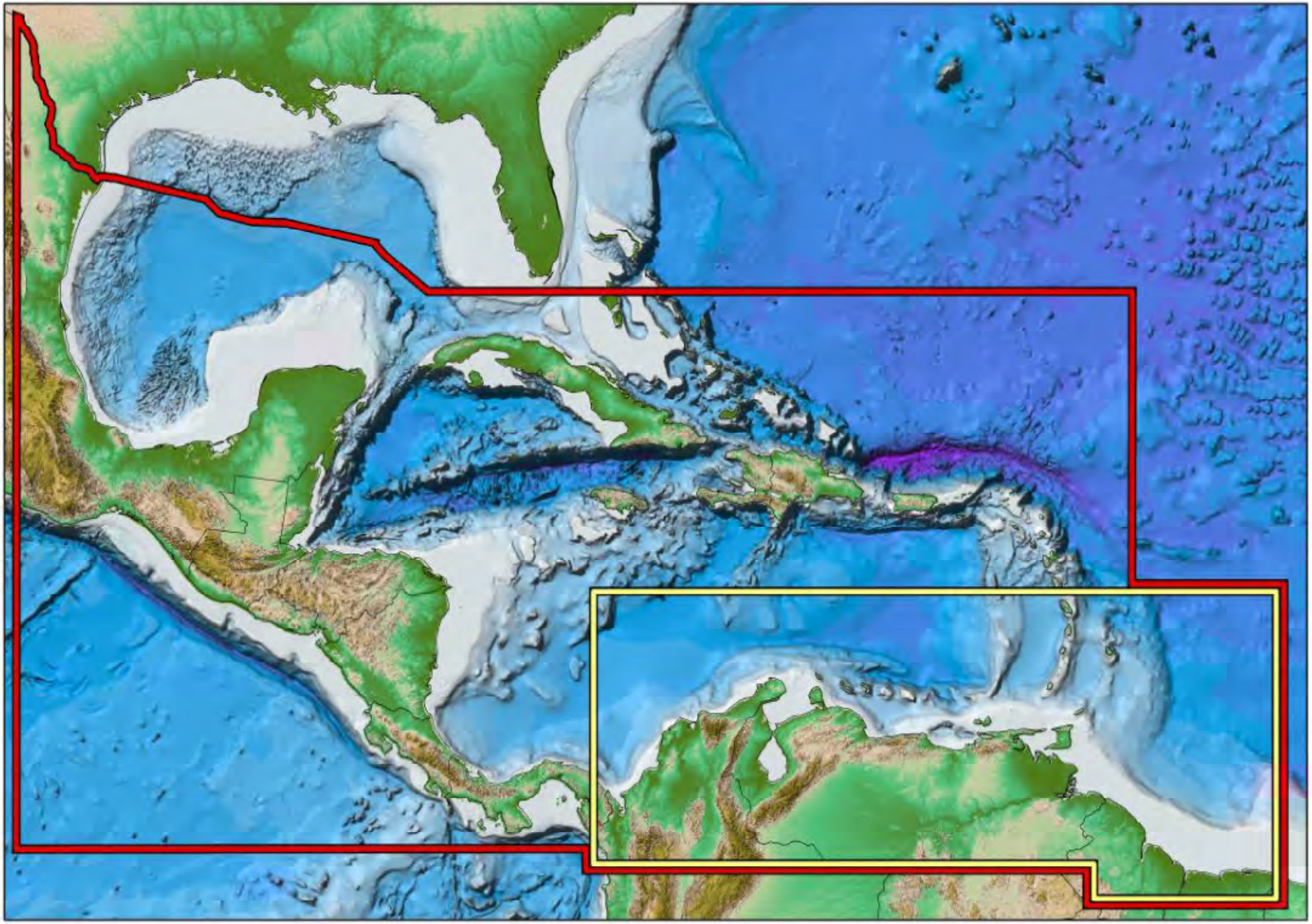


Fig. 28. Example from the six backstop basins southward of Crete (Gavdos, Gortys, Poseidon, Ptolemeus, Pliny and Stravon trenches). Interpretation of seismic reflection profiles across the western south Cretan trench. P.Q. recent sedimentary cover. uM, Miocene evaporite and related tectonics, Maravelis et al., 2012



Σύγκληση της Βορειοατλαντικής λιθοσφαιρικής πλάκας με την λιθοφαιρικη πλάκα της Καραβαικής. Δημιουργία της Καραβαικής Ράχης



MUD VOLCANOES EASTERN VENEZUELA

Figure 1-8. Mud Volcanoes as this one from the Orinoco Delta are small but frequently associated with gas and petroleum.Photo from BEG-UTexas Site.

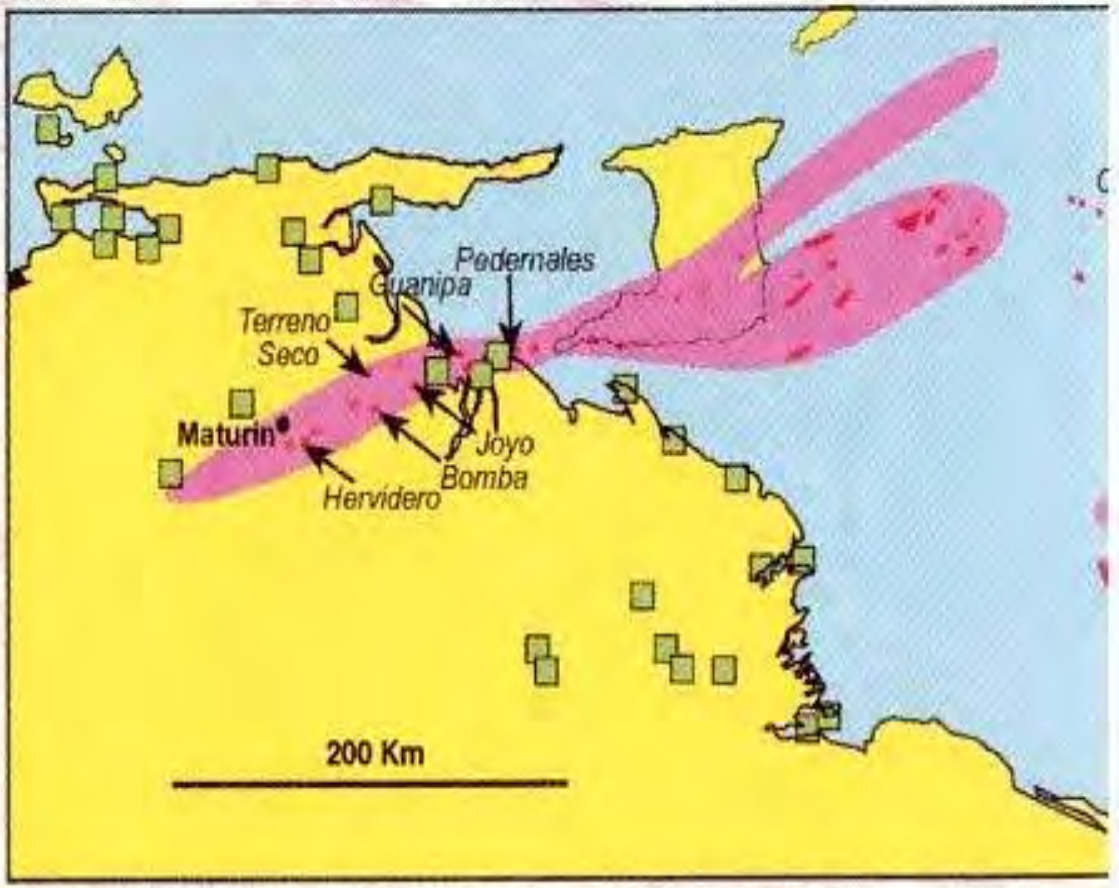


Figure 1-9. Location of mud volcanoes and gas seepages in the EVB. Note the convergenc in the diapir area

Τοποθεσίες των λασποηφαιστείων στην Ανατολική Βενεζουέλα. Λασποηφαίστειο στο δέλτα του ποταμού Ορινόκο

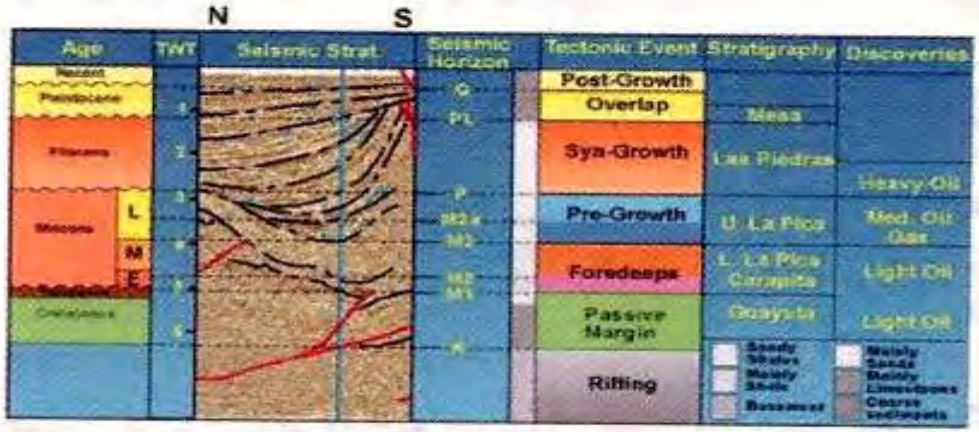


Figure 1-6. Seismic Stratigraphy. There are three growth sequences associated to the diapir evolution, the pre-growth unit with sediments controlled partially by the diapir, the syn-growth unit strongly affected by the diapir and the Overlap sequence.

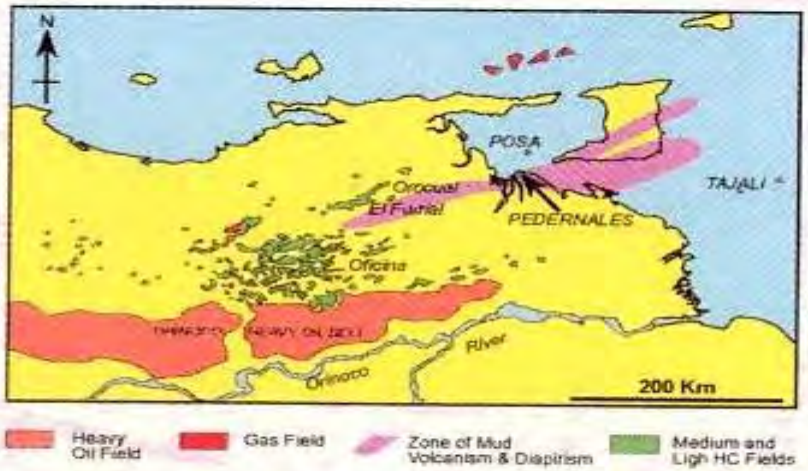


Figure 1-7. Location of the main gas and oil fields in the EVB. Note the location of the diapir strip in the basin and the main fields associated with Neogene reservoirs, i.e. Pedernales, Posa and Tajali.

MUD VOLCANOES EASTERN VENEZUELAN BASIN

Figure 1-8. Mud Volcanoes as this one from the Orinoco Delta are small but frequently associated with gas and petroleum.Photo from BEG-UTexas Site.

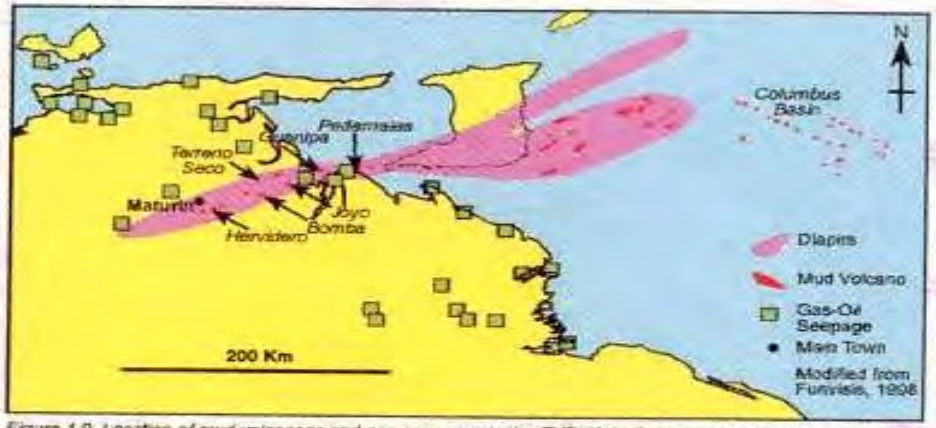


Figure 1-9. Location of mud volcanoes and gas seepages in the EVB. Note the convergence of mud volcanoes in the diapir area

Mud Volcanoes	N°	Gas	Oil
Herviderо	3	X	X
Terreno Seco	1	X	
Joyo	1	X	
Guanipa	3	X	
Pedernales	7	X	X

Table 1-1 Mud volcanoes and associated oil or gas shows. (Source Petito, 1979)

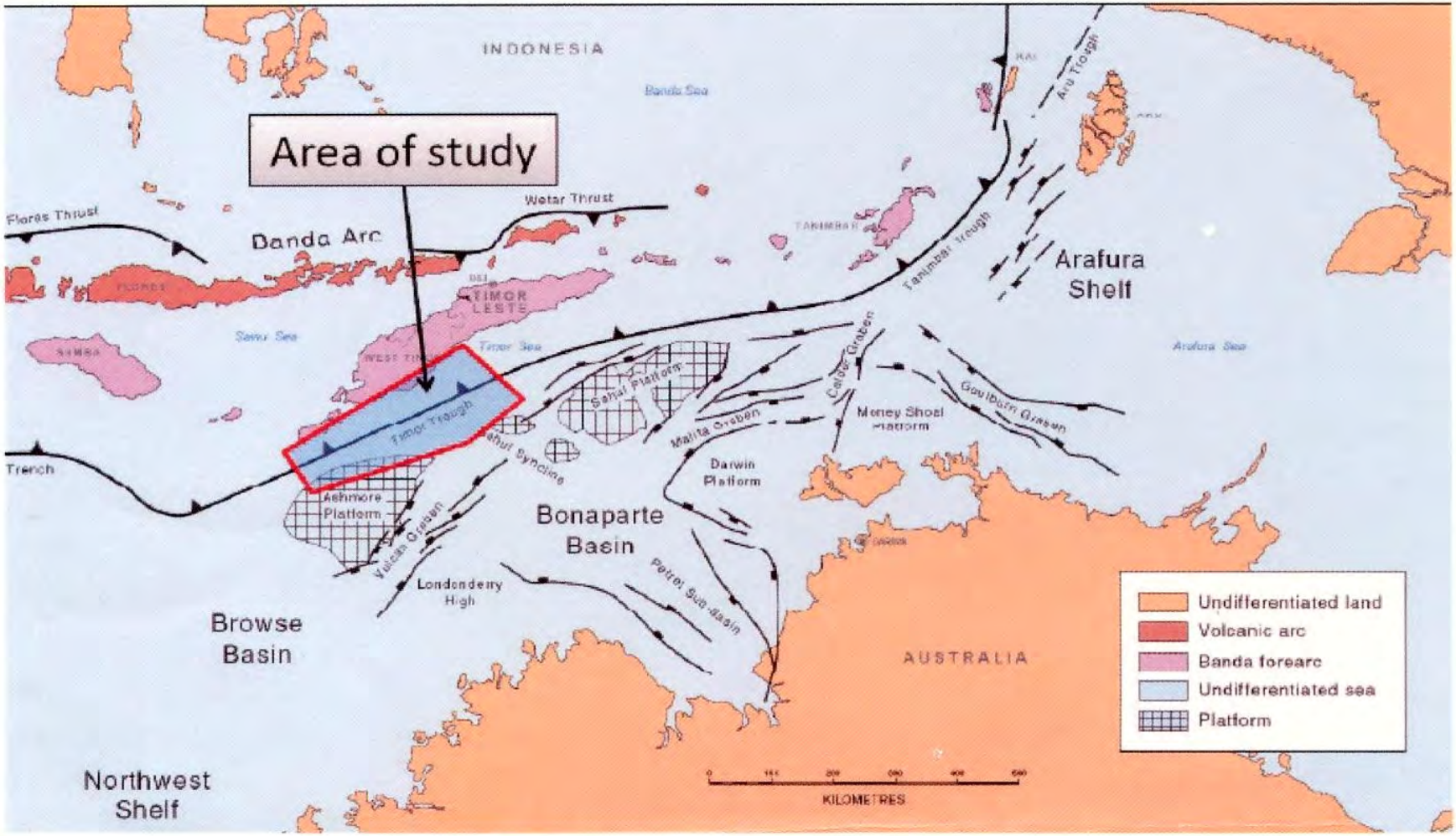
Συσχέτιση των λασποηφαιστείων και των κοιτασμάτων αργού πετρελαίου, φυσικού αερίου και κοιτασμάτων αμμόπισσας στην λεκάνη της Βενεζουέλας

Accretionary Prisms-Plate tectonics-Hydrocarbons

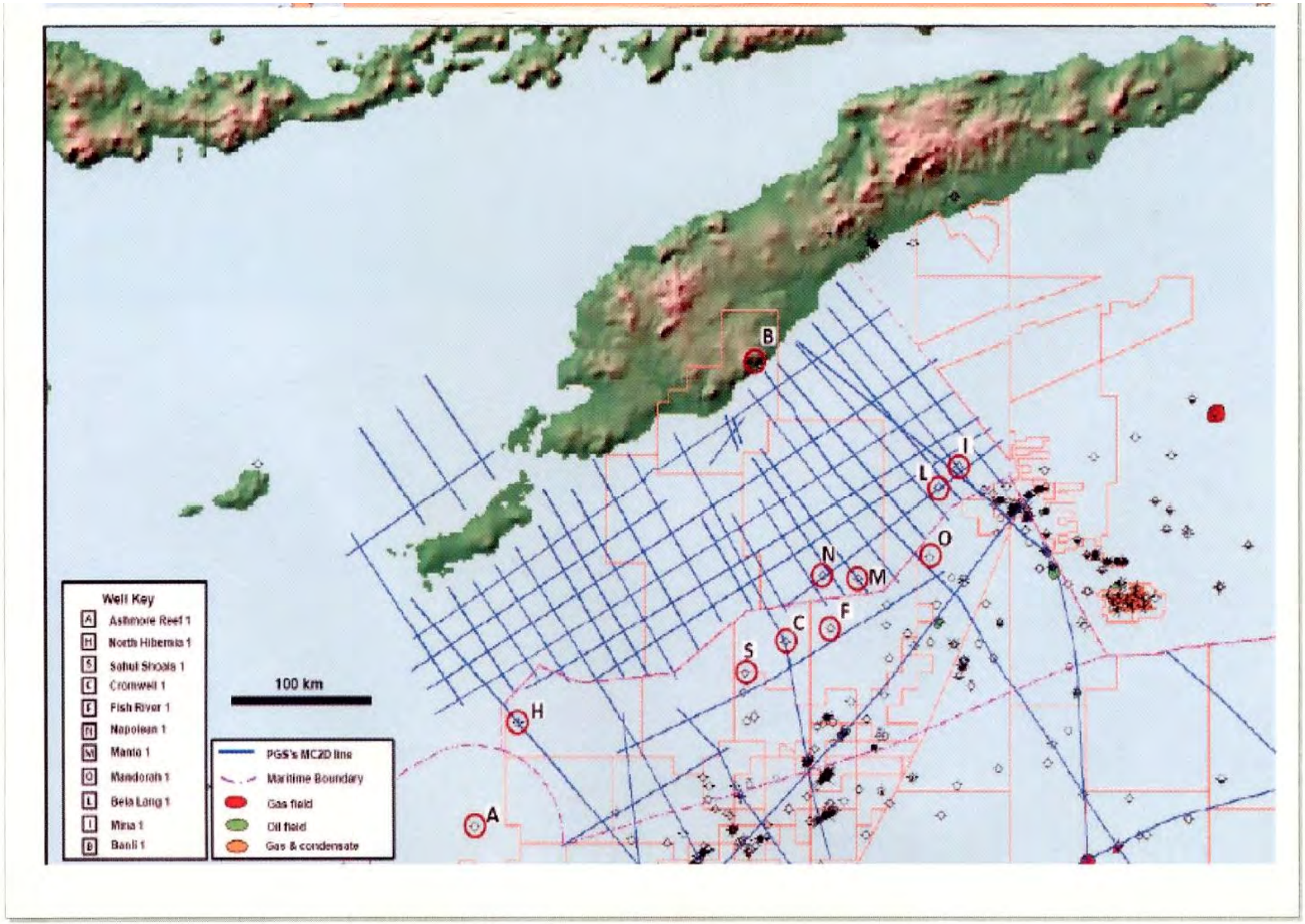
PGS- Similar to South Crete Petroleum Prospectivity

Paper Title: Petroleum Prospectivity Of The West Timor Trough

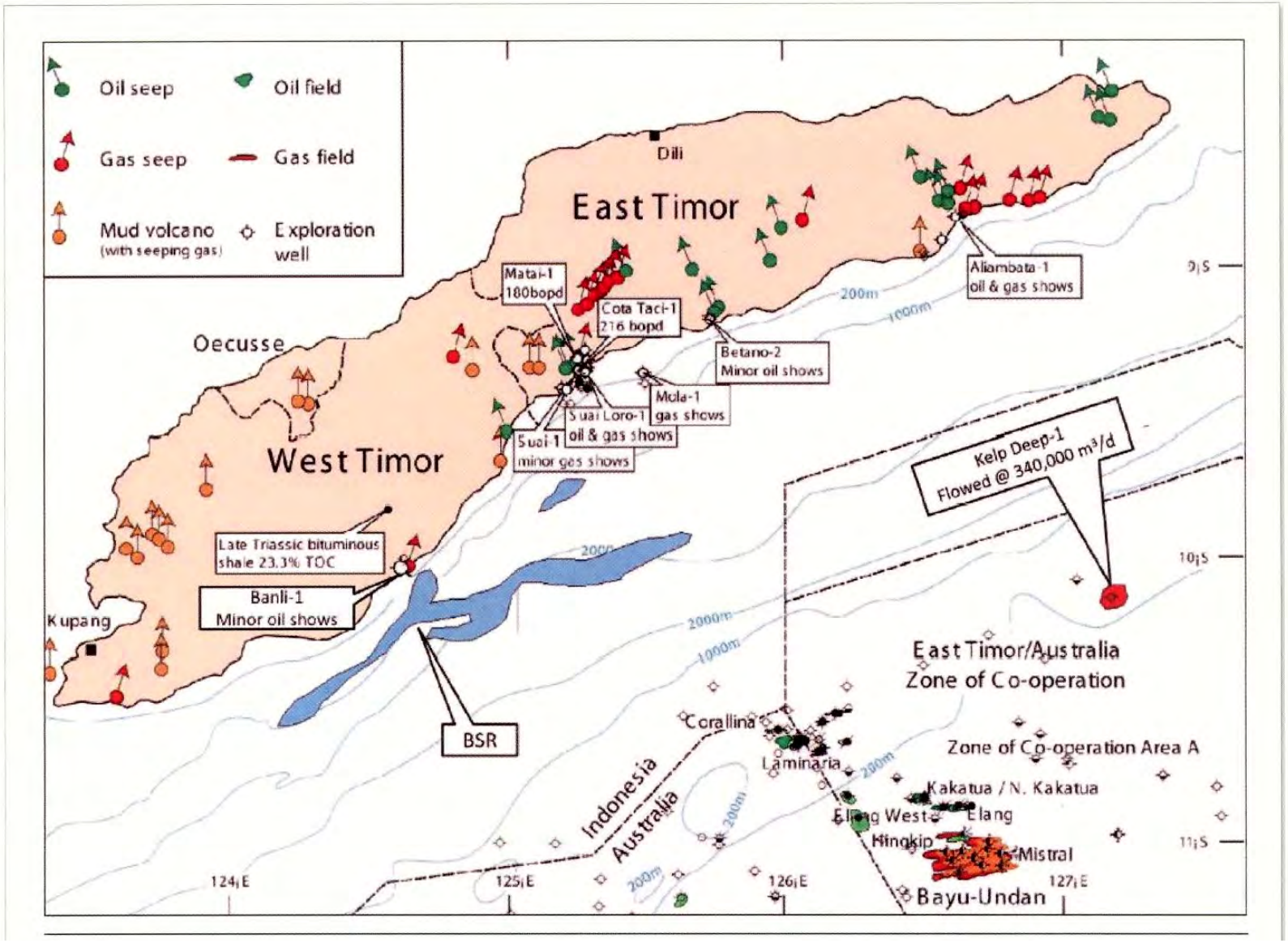
Will Jones, Anand Tripathi, Rajesh Rajagopal and Adrian Williams, PGS Reservoir



Σύγκληση της Αυστραλιανής Πλάκας με την Πλάκα του Ινδικού Ωκεανού στην νήσο Τιμόρ, Ινδονησία. Δημιουργία Ράχης. Ομοιότητα με Κρήτη



Η νήσος Τιμόρ Ινδονησίας με τις σεισμικές γραμμές.



Κοιτάσματα Υδρογονανθράκων στη νήσο Τιμόρ, Ινδονησία

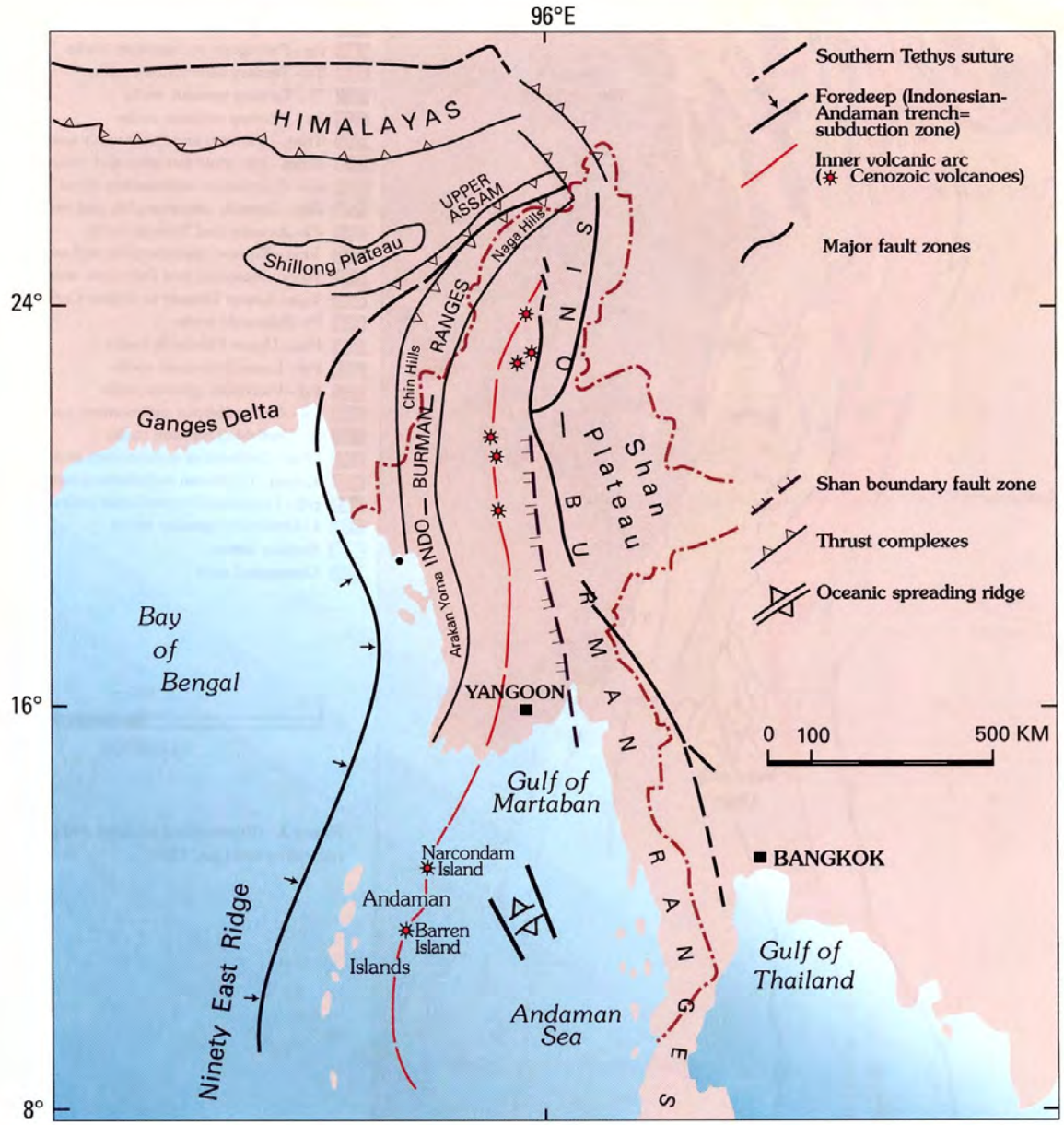
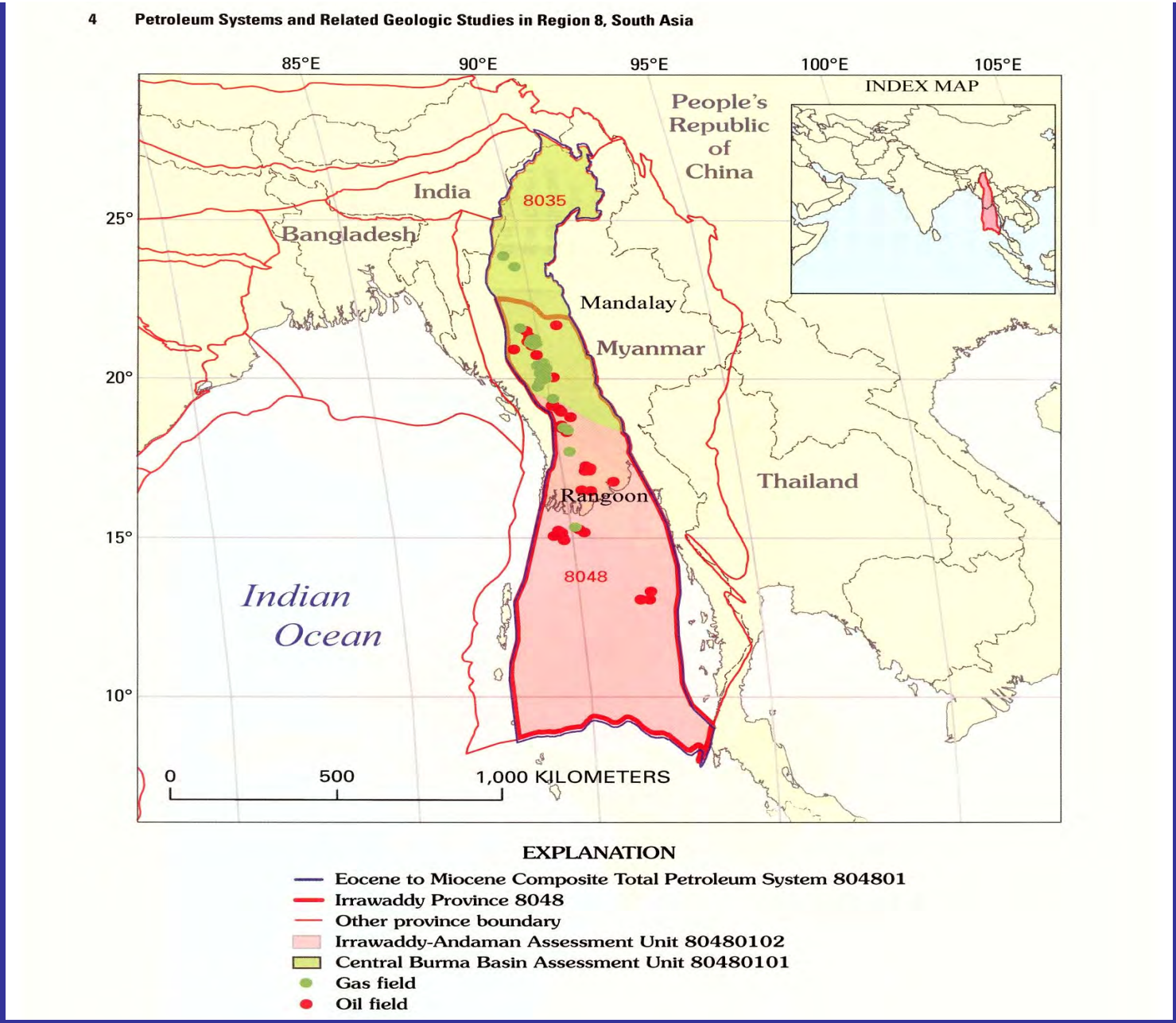


Figure 4. Tectonic map of Myanmar and Andaman Basin (modified from Bender, 1983).

Η Ράχη του Irrawaddy-Andaman



Κοιτάσματα υδρογονανθράκων στο Μυανμάρ

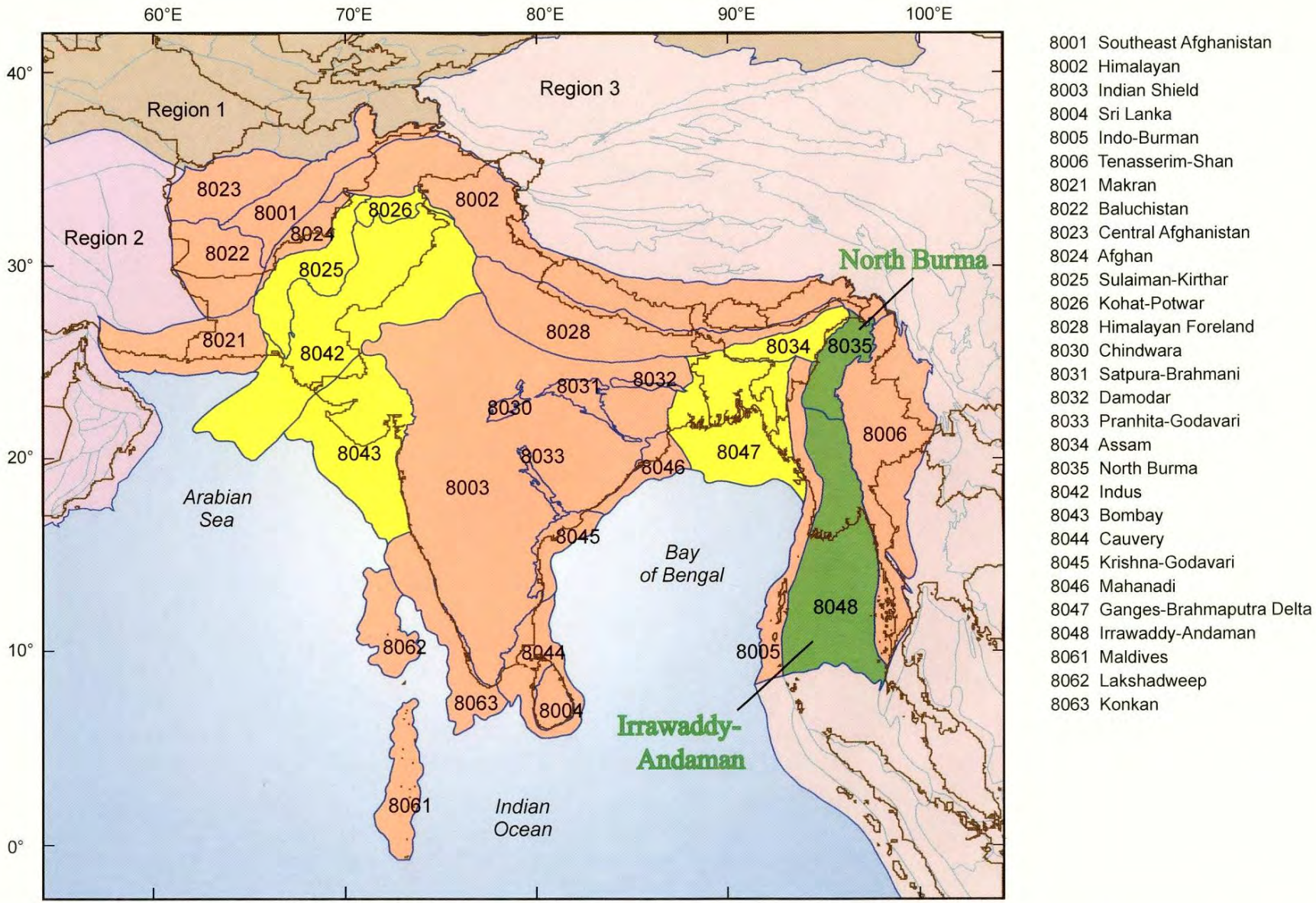
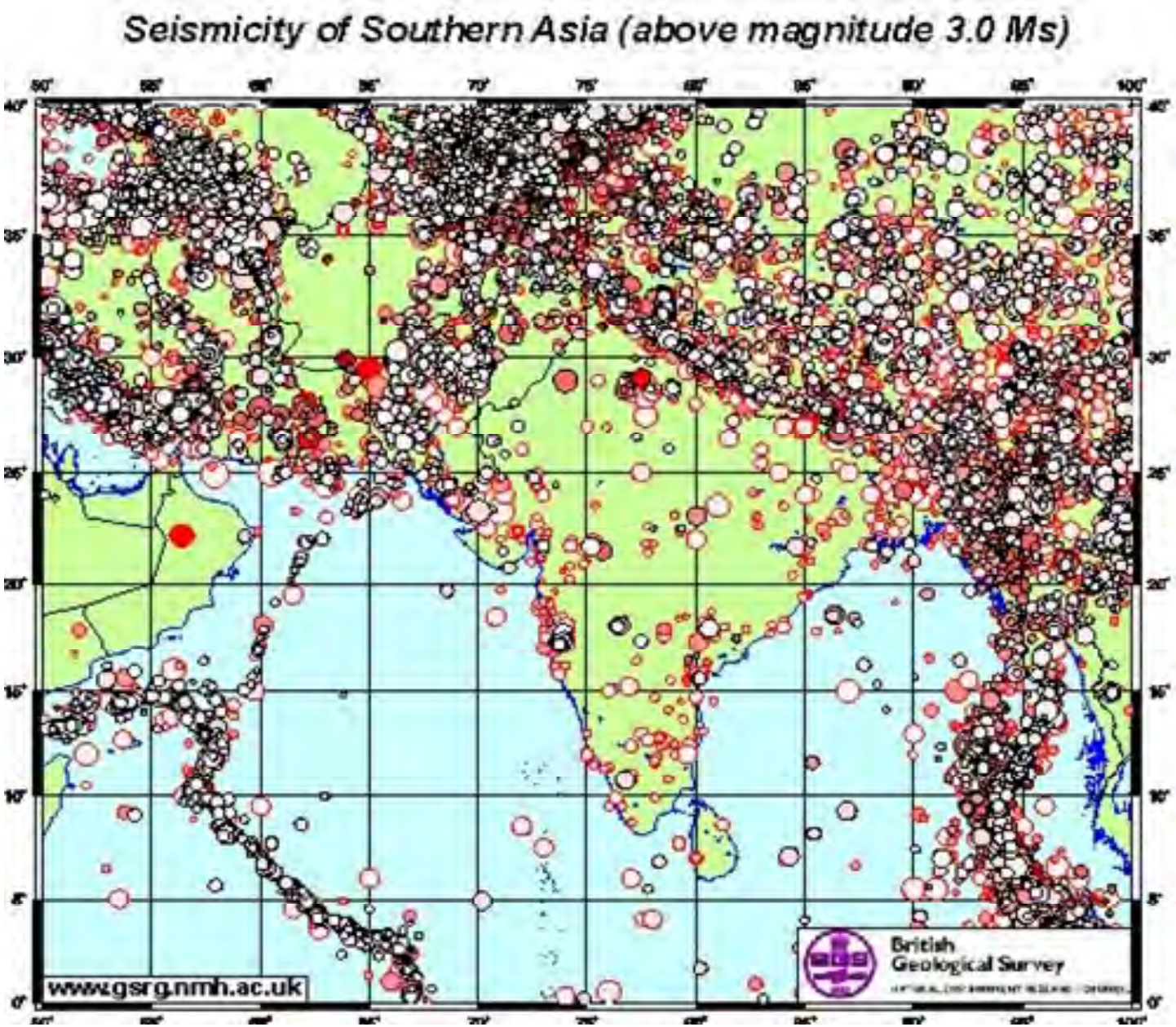


Figure 1. Location of Irrawaddy-Andaman (8048)and North Burma (8035) geologic provinces shown in green; other assessed provinces in region 8 shown in yellow.



Σεισμικότητα στην Νοτιοανατολική Ασία


Makran
accretionary
wedge

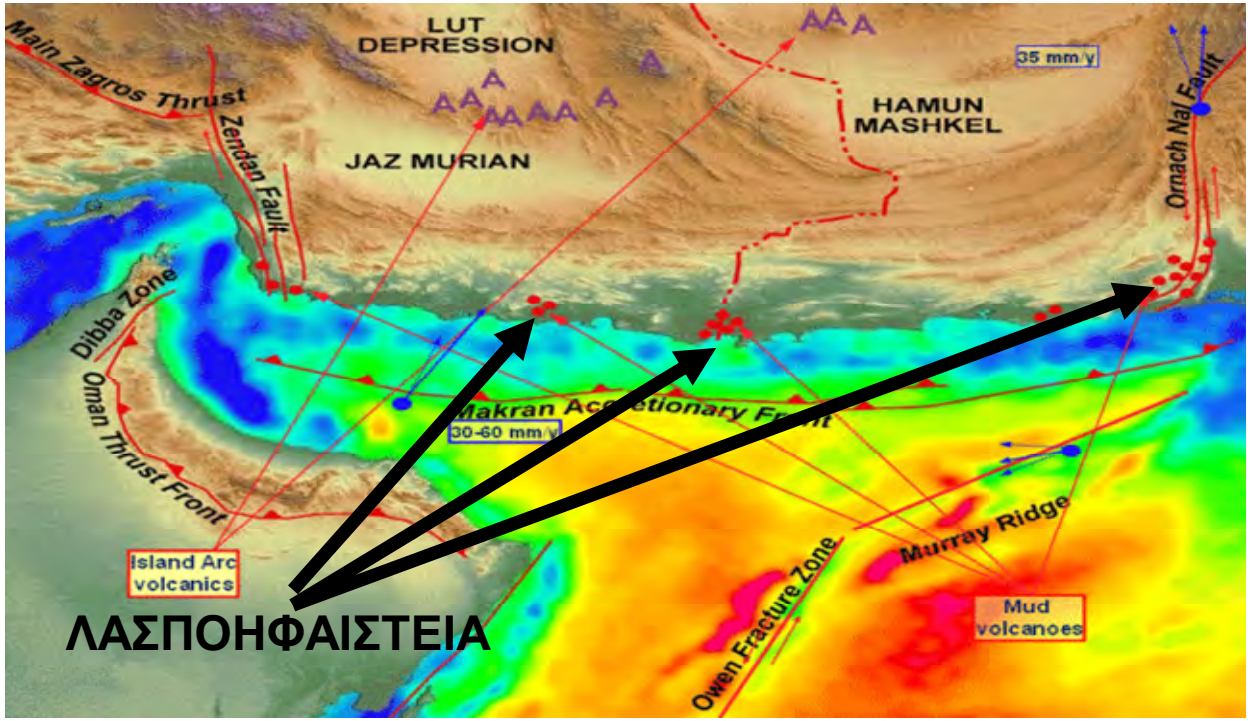
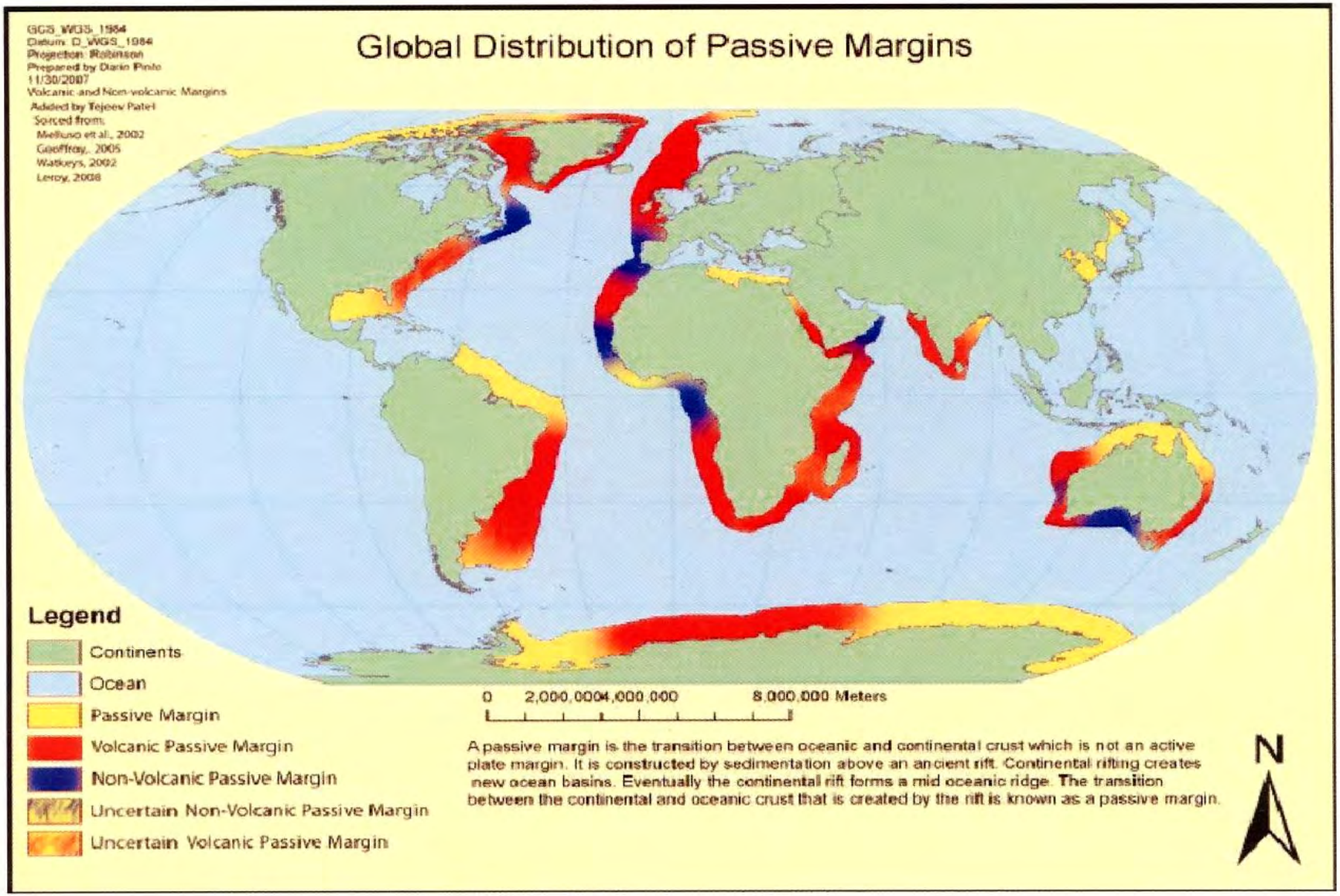


Fig. 6 The Makran Accretionary Prism and the Zone of Tectonic Subduction in the Northern Arabian Sea (Modified Dorostian graphic)

POTENTIAL OF TSUNAMI GENERATION ALONG THE MAKRAN SUBDUCTION ZONE IN THE NORTHERN ARABIAN SEA. CASE STUDY: THE EARTHQUAKE AND TSUNAMI OF NOVEMBER 28, 1945

George Pararas-Carayannis

Presentation at 3rd Tsunami Symposium of the Tsunami Society May 23-25, 2006, East-West Center, University of Hawaii, Honolulu, Hawaii.


GCS_WGS_1984
Datum: D_WGS_1984
Projection: Robinson
Prepared by Dario Pinto
11/30/2007
Volcanic and Non-volcanic Margins
Added by Tejeev Patel
Sourced from:
Melluso et al., 2002
Geoffroy, 2005
Watkeys, 2002
Leroy, 2008
Global Distribution of Passive Margins
Legend
Continents
Ocean
Passive Margin
Volcanic Passive Margin
Non-Volcanic Passive Margin
Uncertain Non-Volcanic Passive Margin
Uncertain Volcanic Passive Margin
0 2,000,000 4,000,000 8,000,000 Meters
A passive margin is the transition between oceanic and continental crust which is not an active plate margin. It is constructed by sedimentation above an ancient rift. Continental rifting creates new ocean basins. Eventually the continental rift forms a mid oceanic ridge. The transition between the continental and oceanic crust that is created by the rift is known as a passive margin.
N

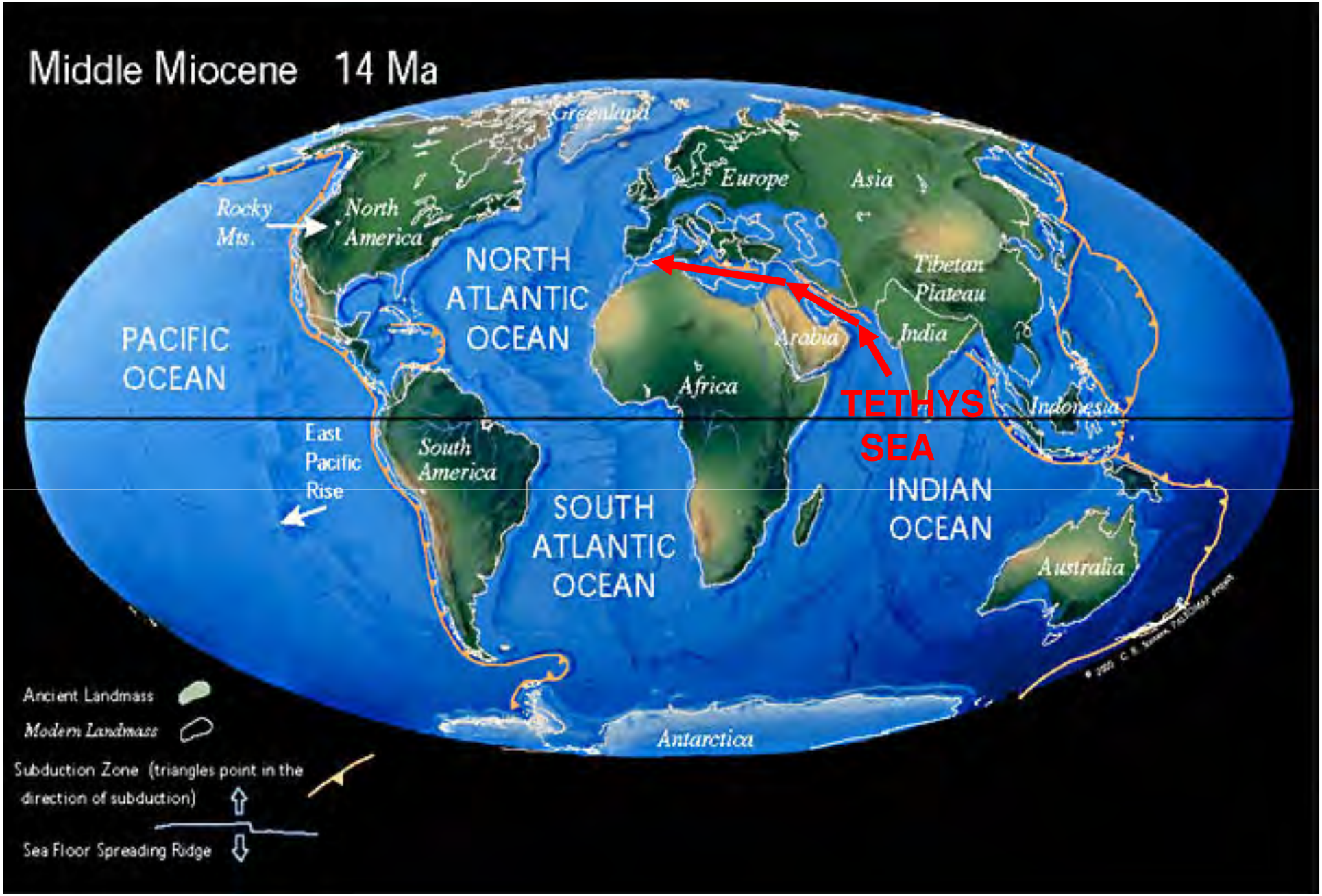


Fig. 17. The geology of North Africa and Southern Europe during Mid Miocene, Scotese, 2000

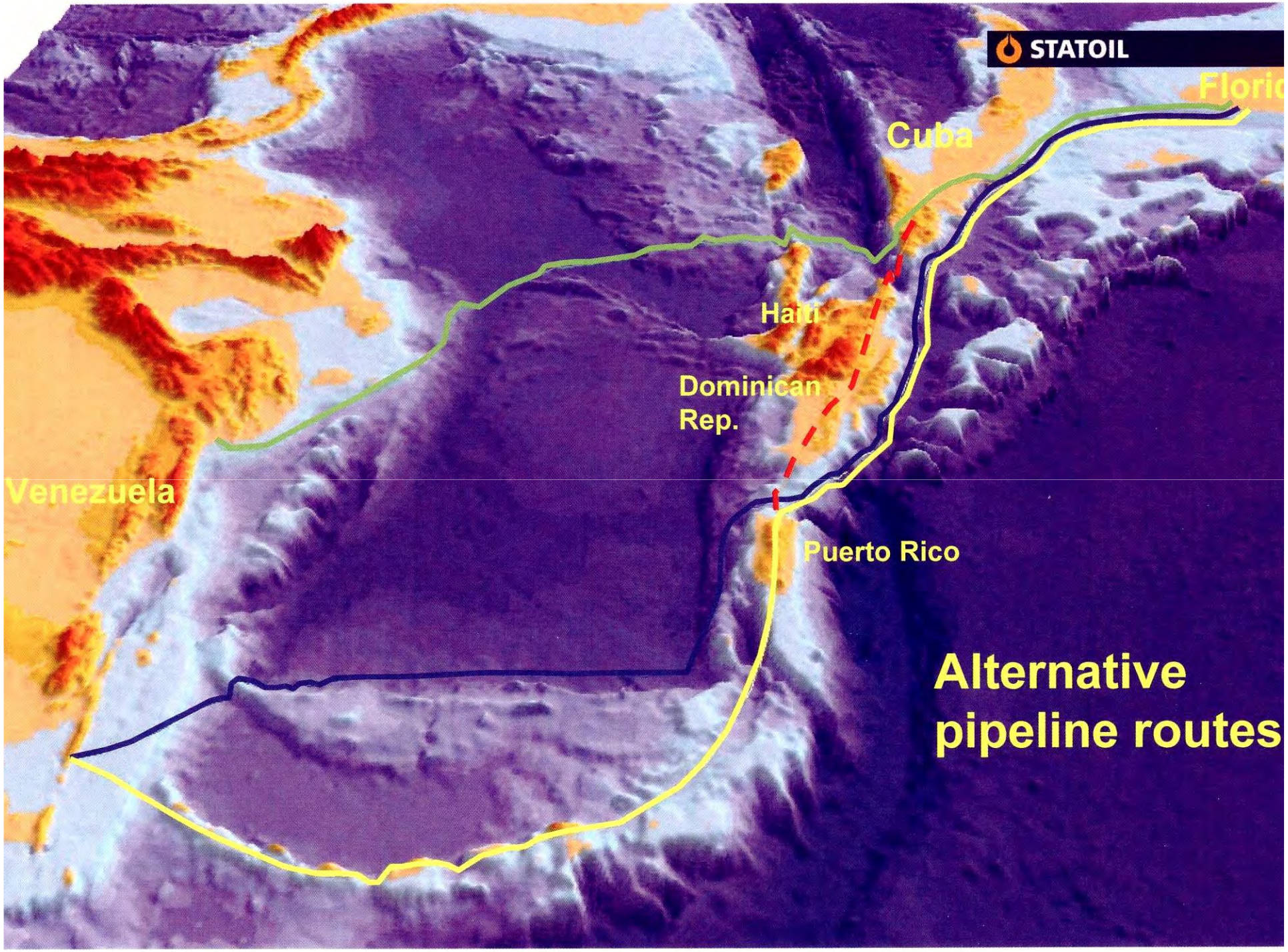

STATOIL
Florid
Cuba
Haiti
Dominican
Rep.
Venezuela
Puerto Rico
Alternative
pipeline routes

Fig. 17. Eastern Mediterranean Sea and its neighbouring countries

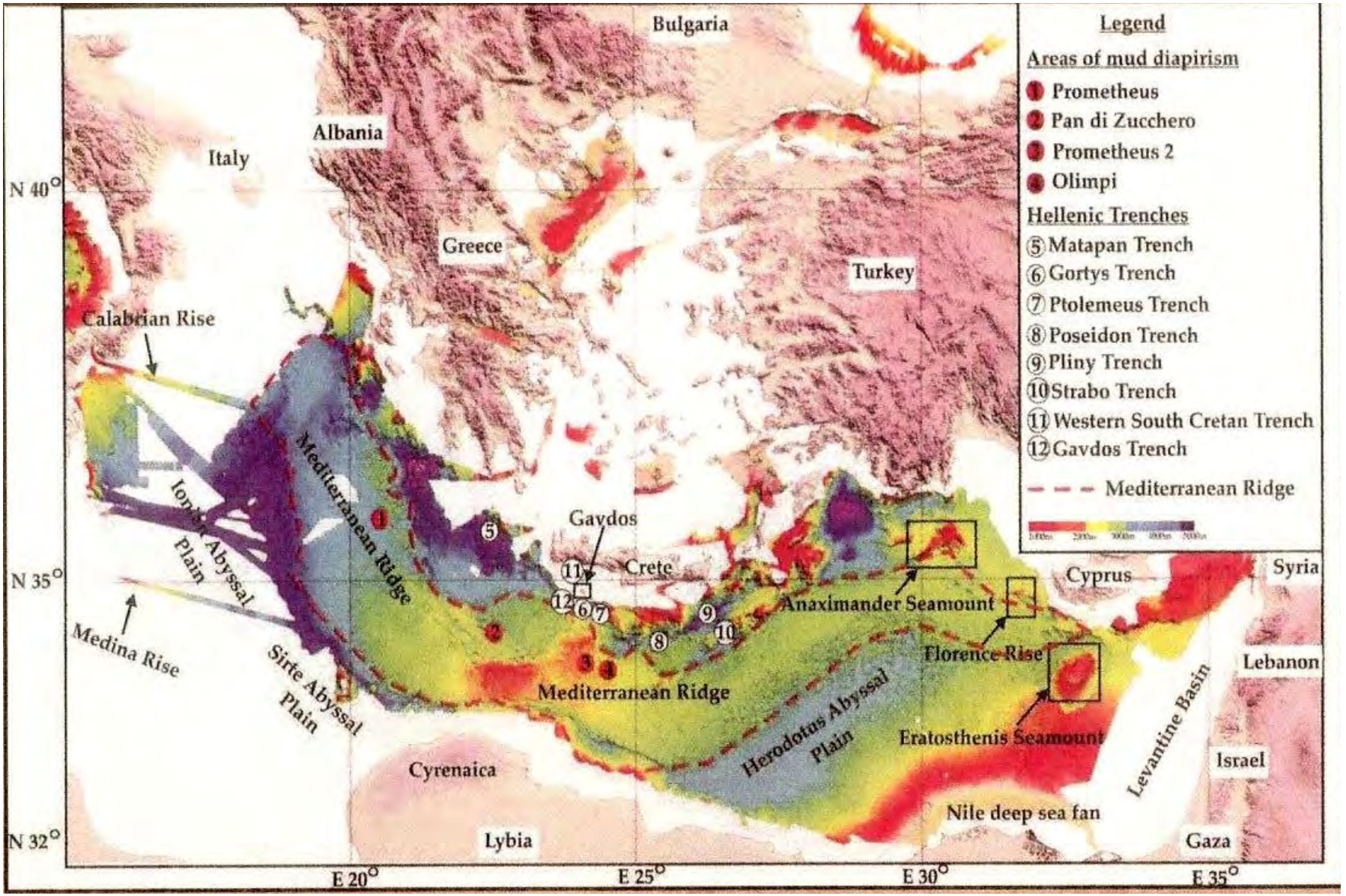


Fig. 26. Bathymetric map of the Mediterranean Sea with the Mediterranean Ridge, mud flow volcanoes, backstop and foreland basins, Maravelis et al., 2012

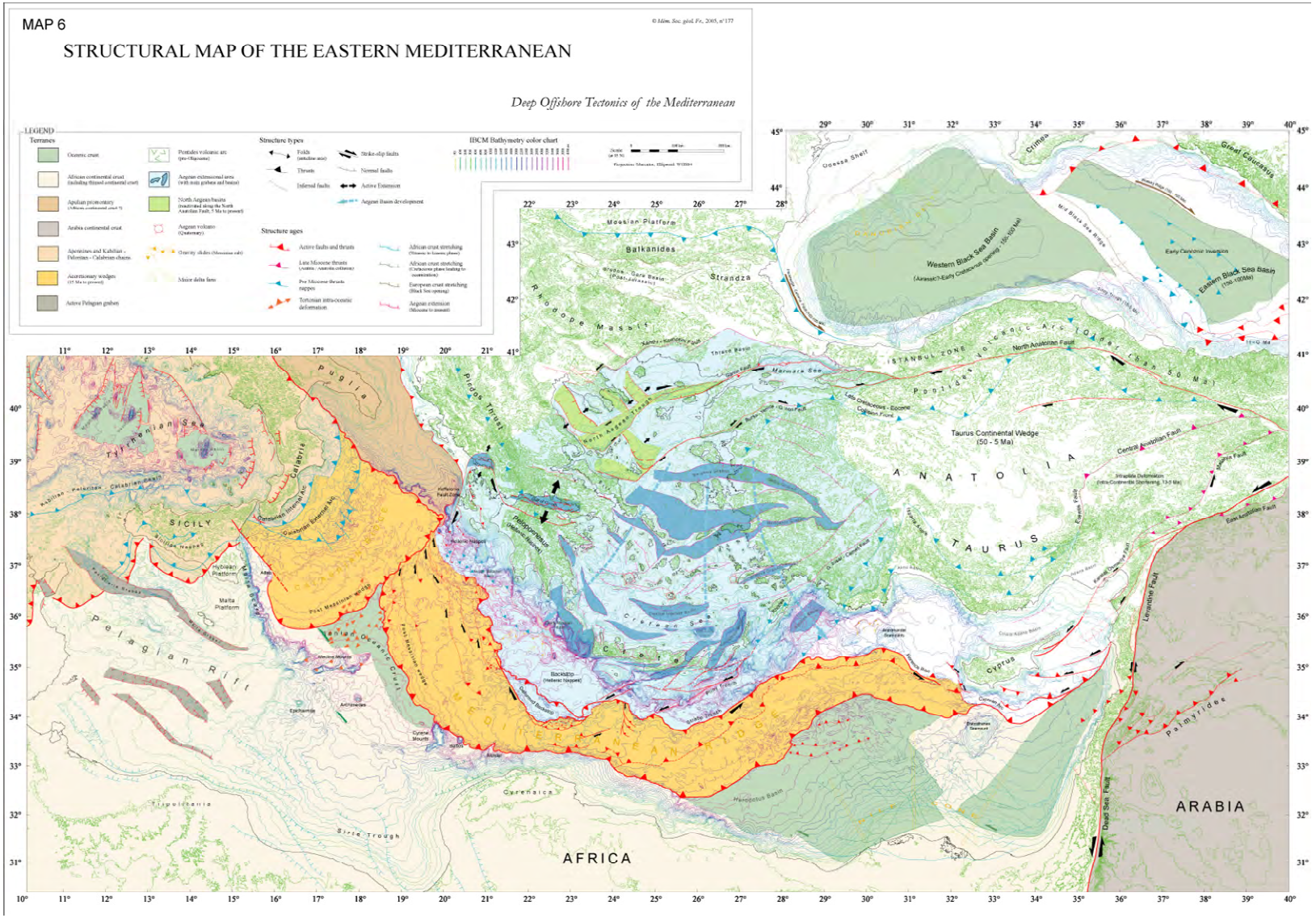
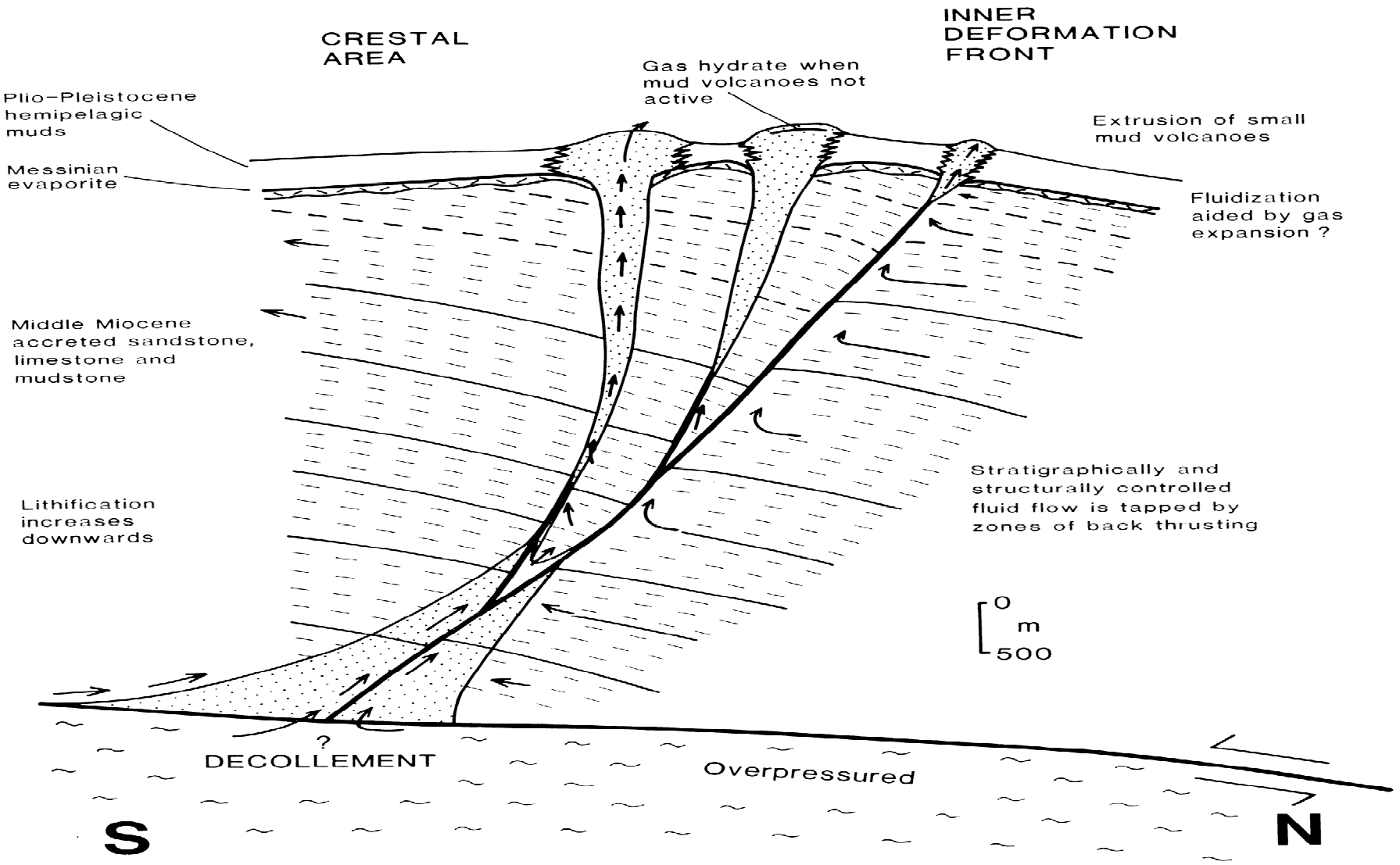
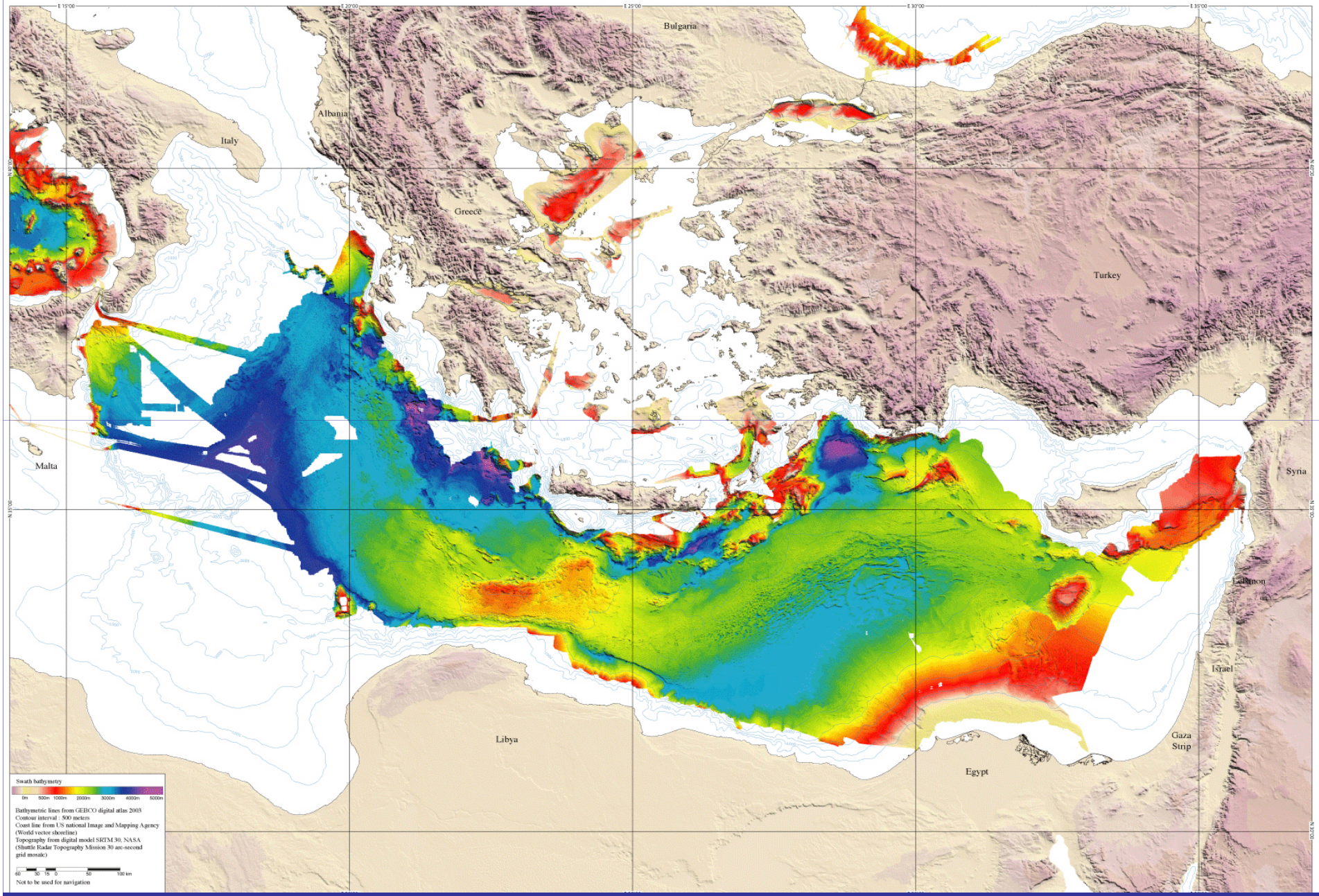


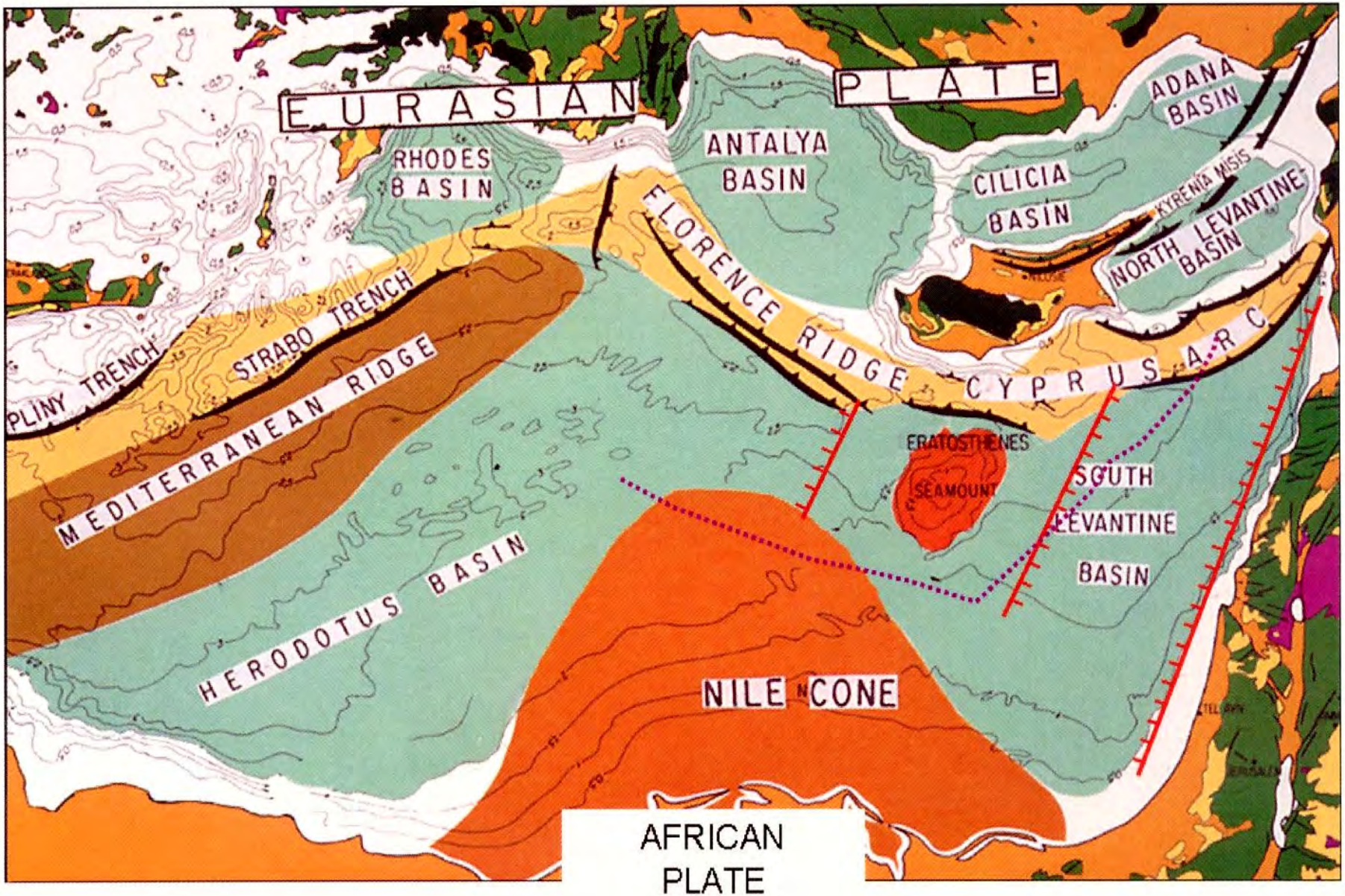
Figure 1a. Structural map of the Eastern Mediterranean showing the area of the Mediterranean Ridge, Chamot-Rooke et al., 2005

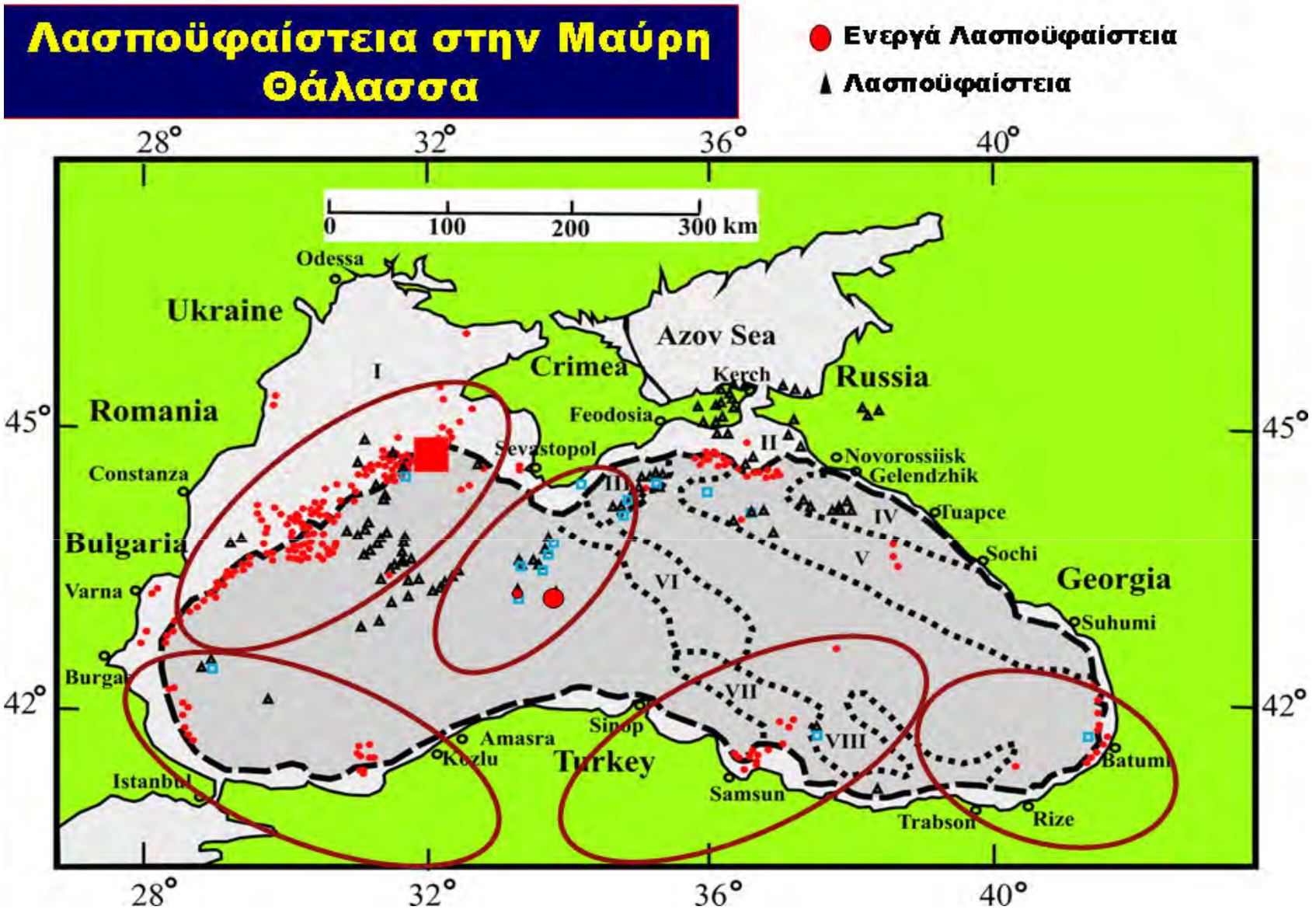


Εικόνα 9. Μοντέλο ενεργού λασποηφαιστείου που εμφανίζεται στα Συστήματα Επαυξητικών Πρισμάτων της Μεσογειακής Ράχης. Το διάγραμμα στηρίζεται σε πετρογραφικά και ορυκτολογικά στοιχεία, από το Leg 160. Robertson, A., H., F. and Kopf. A. *Proceedings of the Ocean Drilling Program, Scientific Results,* Vol. 160 Robertson, A.H.F., Emeis, K.-C., Richter, C., and Camerlenghi, A. (Eds.), 1998

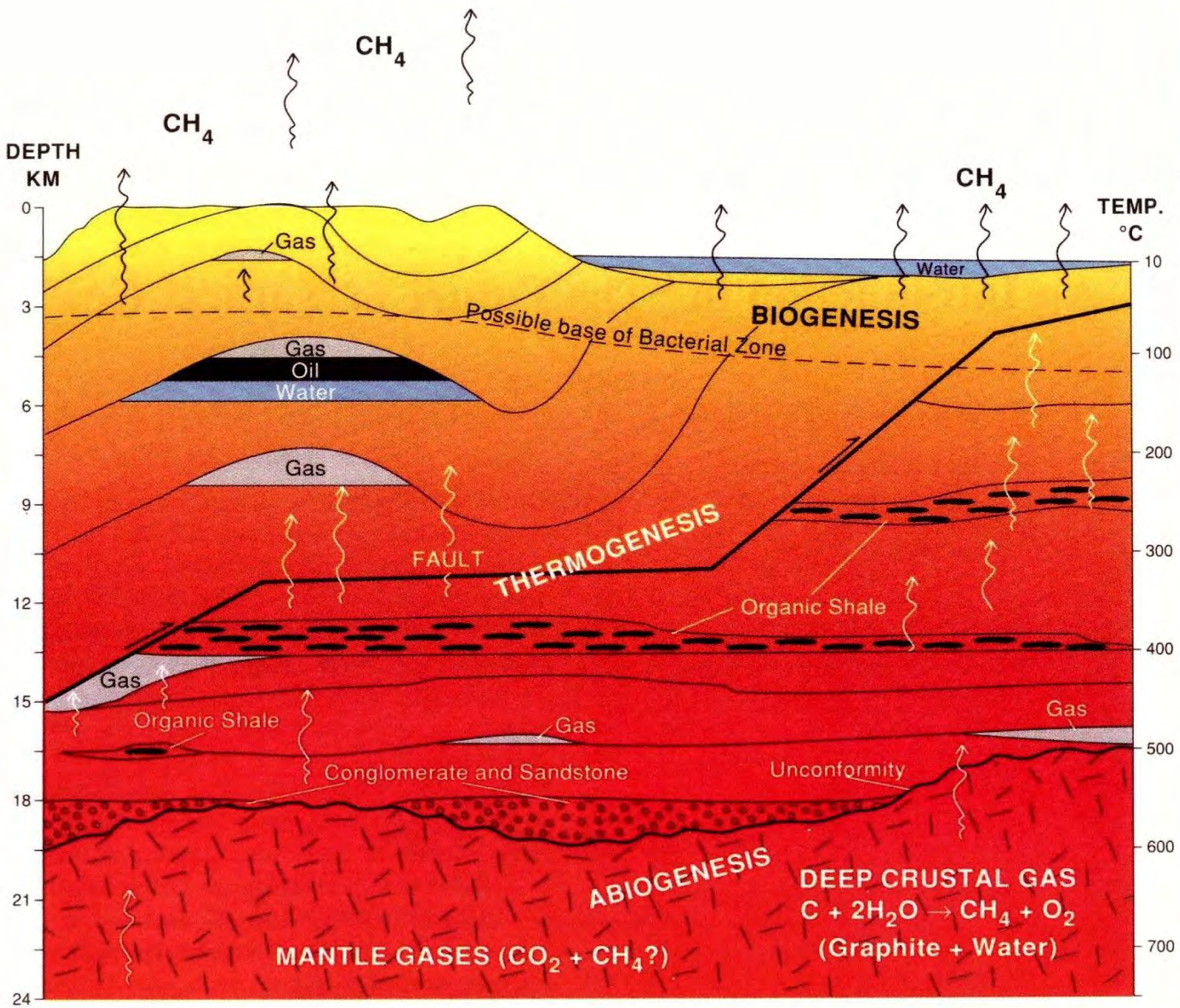
SWATH BATHYMETRY OF THE MEDITERRANEAN SEA : EASTERN MEDITERRANEAN



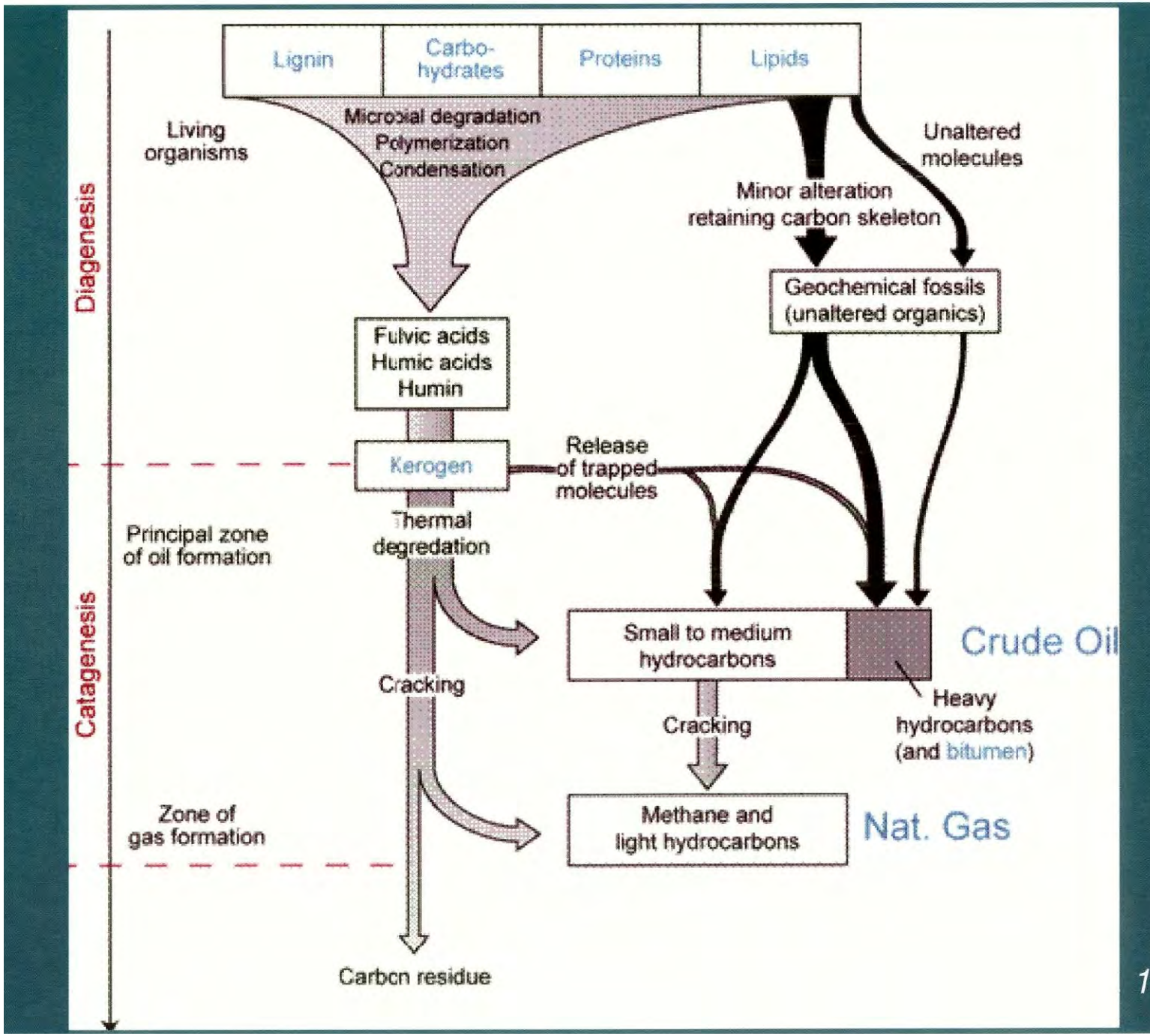

EURASIAN PLATE
RHODES BASIN
ANTALYA BASIN
ADANA BASIN
CILICIA BASIN
KYRENIA MISIS
NORTH LEVANTINE BASIN
FLORENCE RIDGE
CYPRUS ARC
PLINY TRENCH
STRABO TRENCH
MEDITERRANEAN RIDGE
ERATOSTHENES SEAMOUNT
SOUTH LEVANTINE BASIN
HERODOTUS BASIN
NILE CONE
AFRICAN PLATE



ExxonMobil's affiliate EMEPRL Corporation and OMV Petrom SA, the 51% subsidiary of OMV Aktiengesellschaft, confirmed a potentially significant gas discovery, Domino -1 well, in the Black Sea 170 kilometrs offshore Romania.

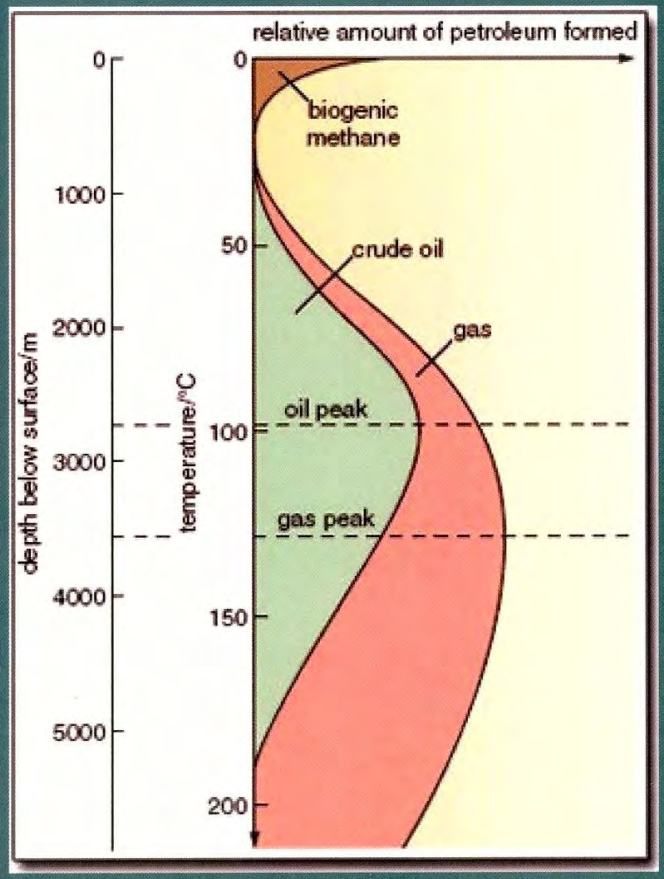


-Howell and others, 1993


Lignin
Carbo-hydrates
Proteins
Lipids
Living organisms
Microbial degradation
Polymerization
Condensation
Unaltered molecules
Minor alteration retaining carbon skeleton
Diagenesis
Geochemical fossils (unaltered organics)
Fulvic acids
Humic acids
Humin
Kerogen
Release of trapped molecules
Thermal degredation
Principal zone of oil formation
Catagenesis
Small to medium hydrocarbons
Crude Oil
Cracking
Heavy hydrocarbons (and bitumen)
Cracking
Zone of gas formation
Methane and light hydrocarbons
Nat. Gas
Carbon residue

Generation of gases from organic matter with increasing temperature:

- Diagenesis:
  - microbial methane generation up to ~ 50° C
  - ~ 20% methane in conventional reservoirs
  - Important in some shale reservoirs in the Michigan and Illinois basins
- Primary cracking:
  - thermal cracking of kerogen and coal to generate methane
  - ~25% to 40% of gases
- Secondary cracking:
  - thermal cracking of oil
  - ~40% to 55% of gases
- Metagenesis?



- Hunt, 1996

Buruss, R. C., Laughrey, C.D. 2009. Covariation of carbon and hydrogen isotopic composition in natural gas: separating biogenic, thermogenic and abiotic (inorganic CO2 reduction) source

po.water.usgs.gov/projects/energy/stray_gas/…/2_830_Buruss.pdf

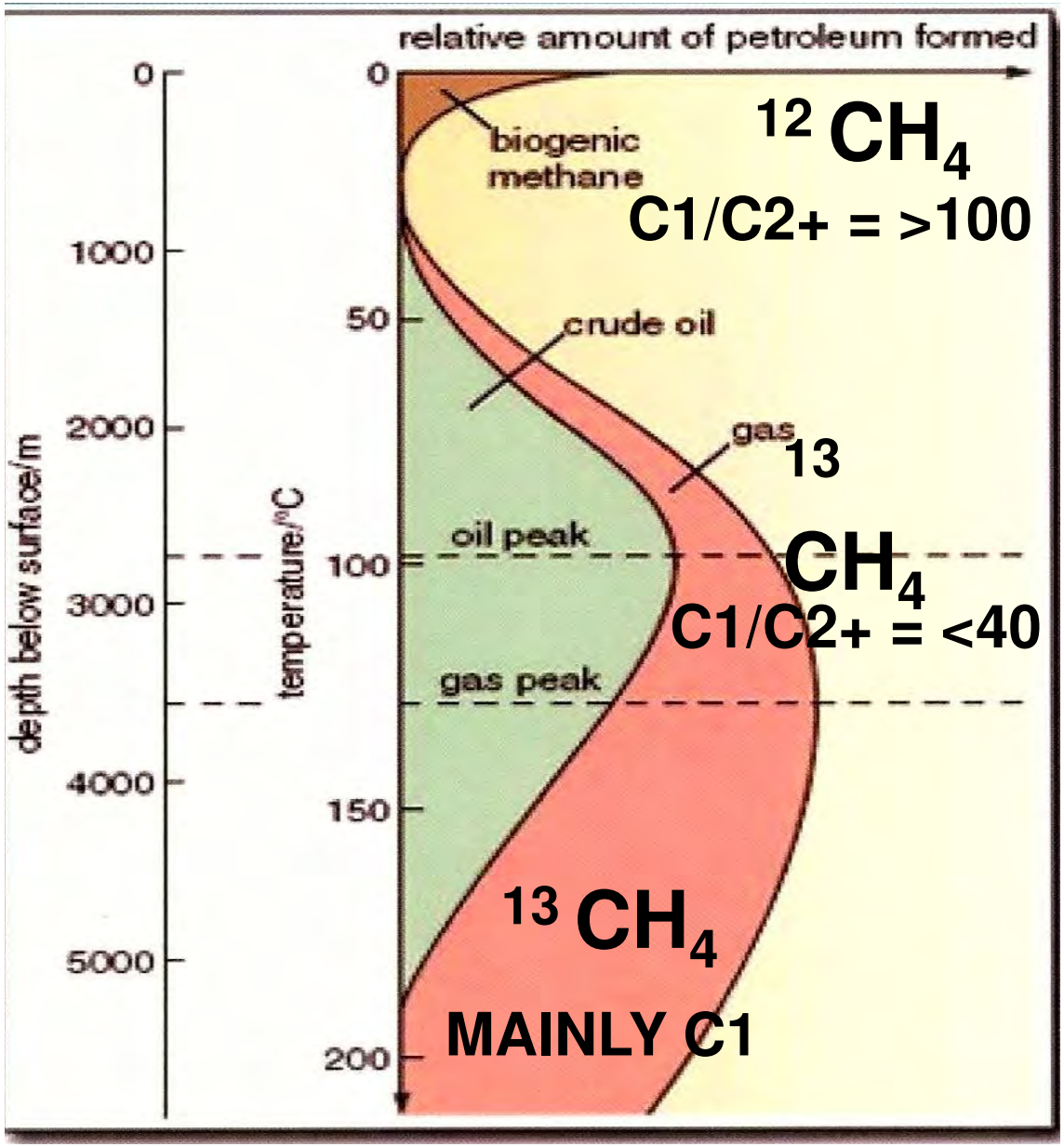
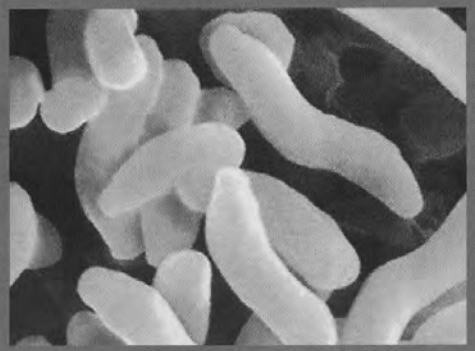


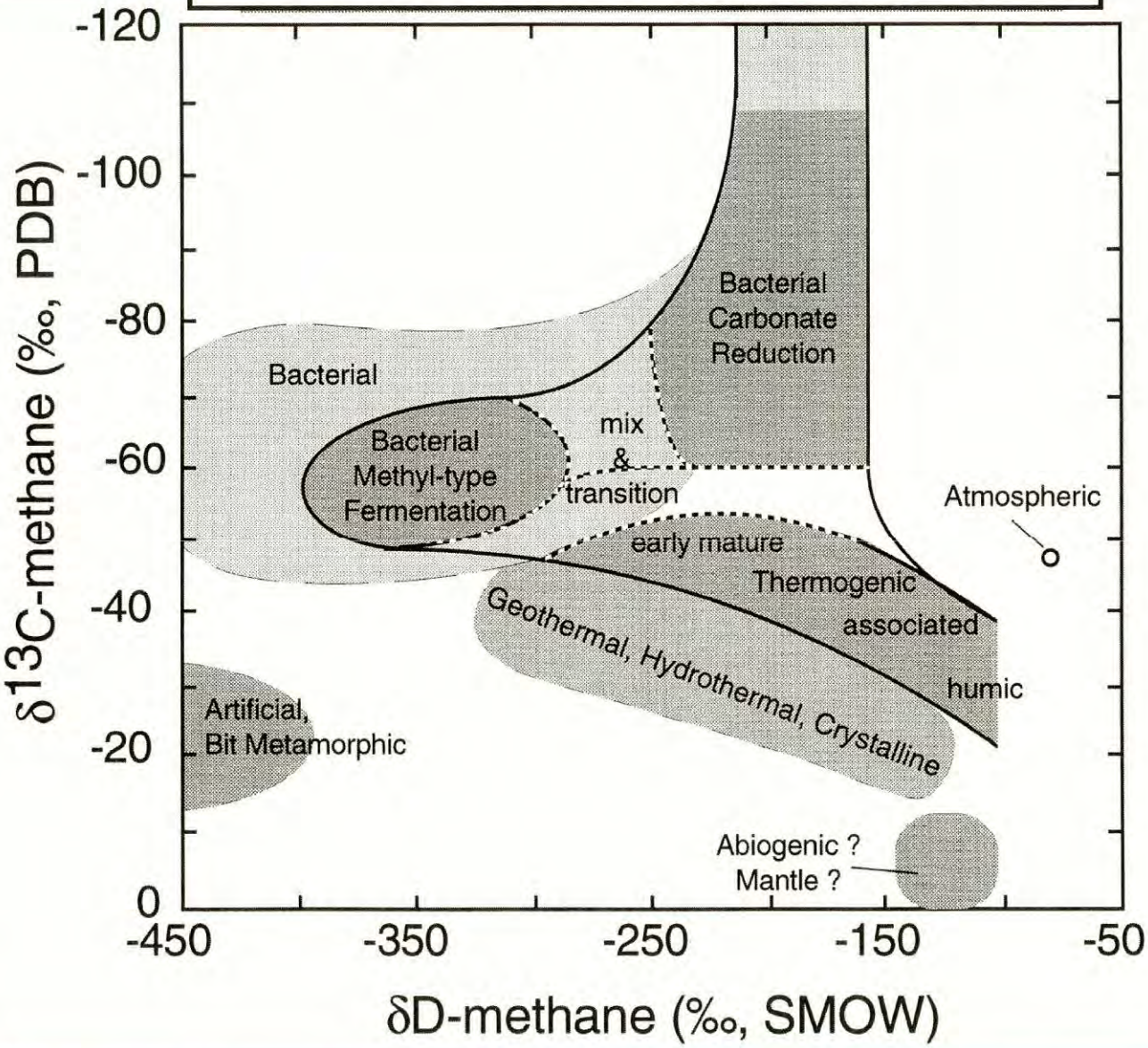
Figure X. Generation of gases from organic matter with increasing temperature
Buruss, and Laughrey, 2009

Microbial Gas Generation

- *Biogenic* vs. *microbial* or *bacterial* gas
- $C_1/(C_2 + C_3) >> 100$
- $\delta^{13}C_1 < 60$ permil
- $\delta DC_1 < 150$ permil
- Covariance of δD values of formation water and CH_4
- Alkalinity of associated formation water (> 10 meq/kg)
- Positive $\delta^{13}C$ of DIC (> 10 permil)
- Microbial fermentation
- CO_2 reduction

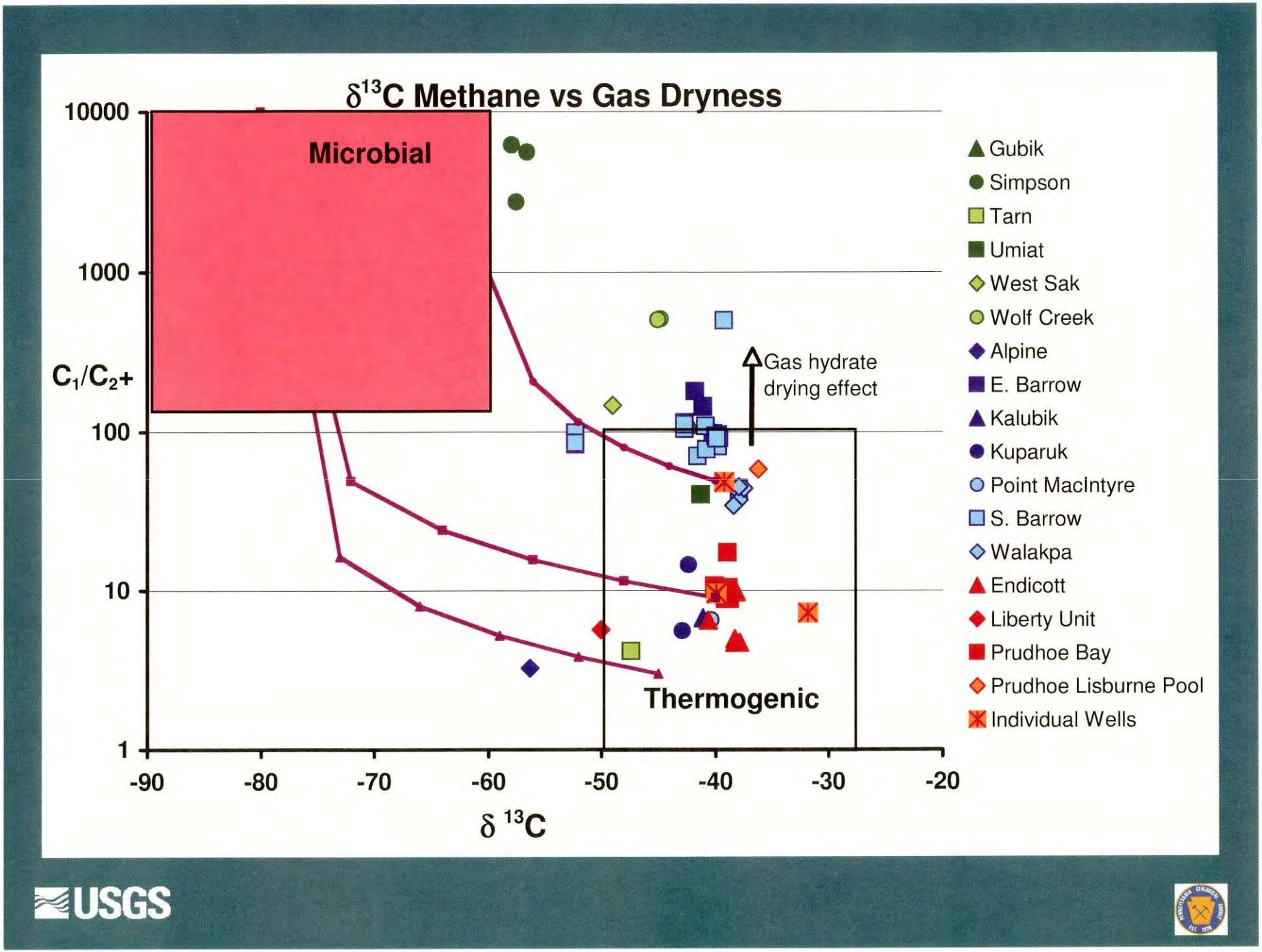


Schoell (Whiticar) diagram

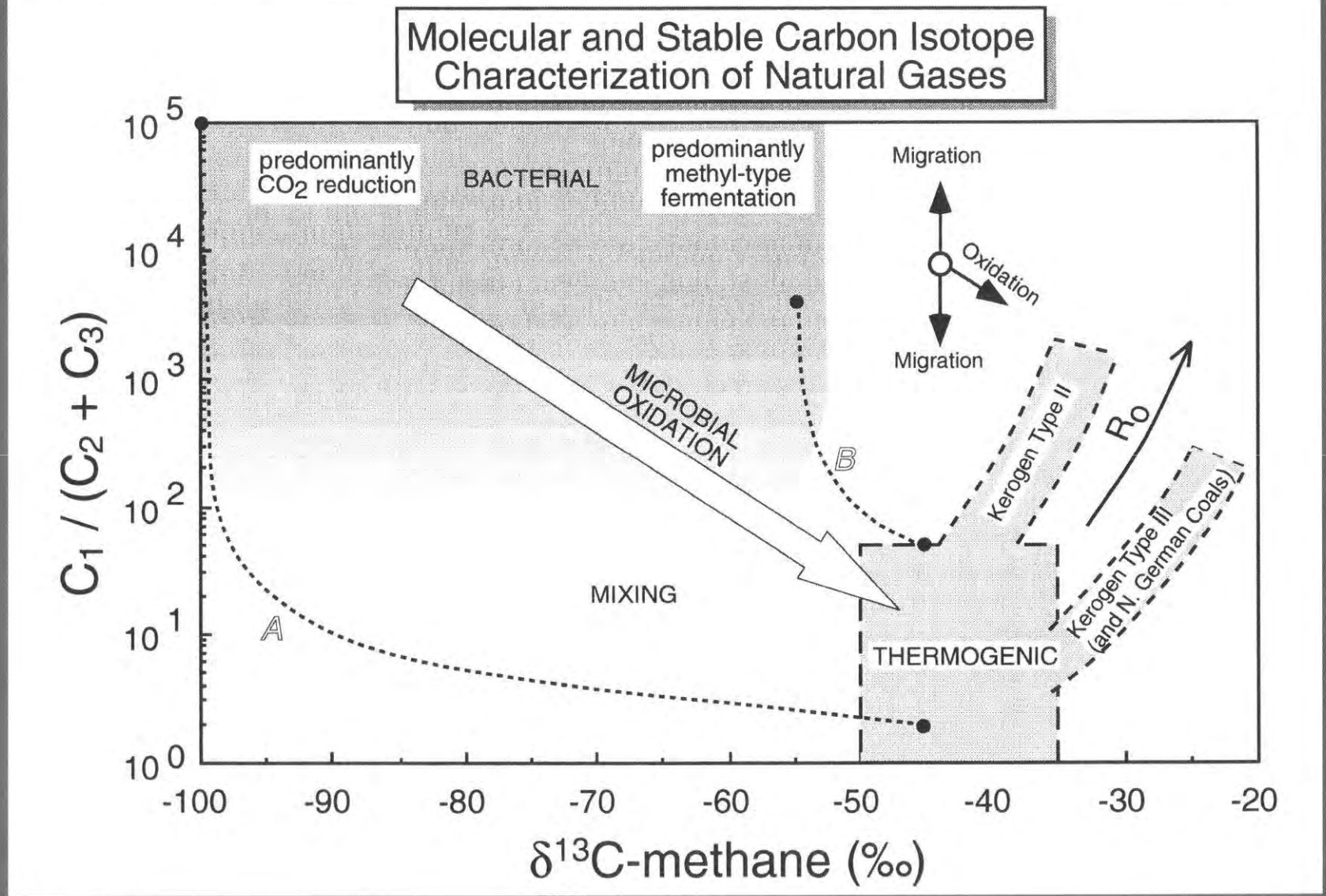


USGS

From Whiticar, 1999

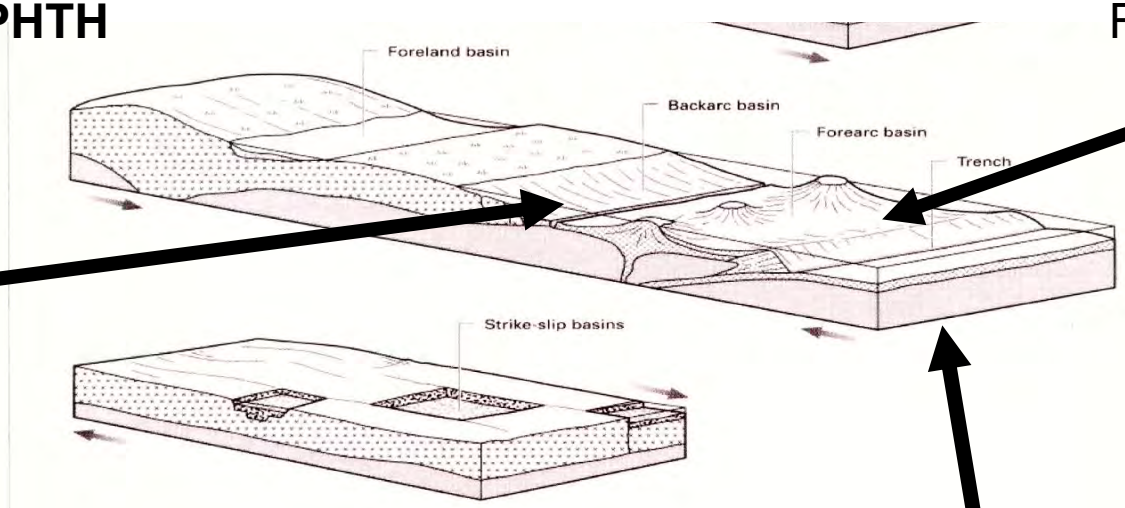

δ13C Methane vs Gas Dryness
Microbial
Thermogenic
Gas hydrate drying effect
C1/C2+
10000
1000
100
10
1
-90
-80
-70
-60
-50
-40
-30
-20
δ 13C
Gubik
Simpson
Tarn
Umiat
West Sak
Wolf Creek
Alpine
E. Barrow
Kalubik
Kuparuk
Point MacIntyre
S. Barrow
Walakpa
Endicott
Liberty Unit
Prudhoe Bay
Prudhoe Lisburne Pool
Individual Wells

Bernard diagram



USGS

KPHTH



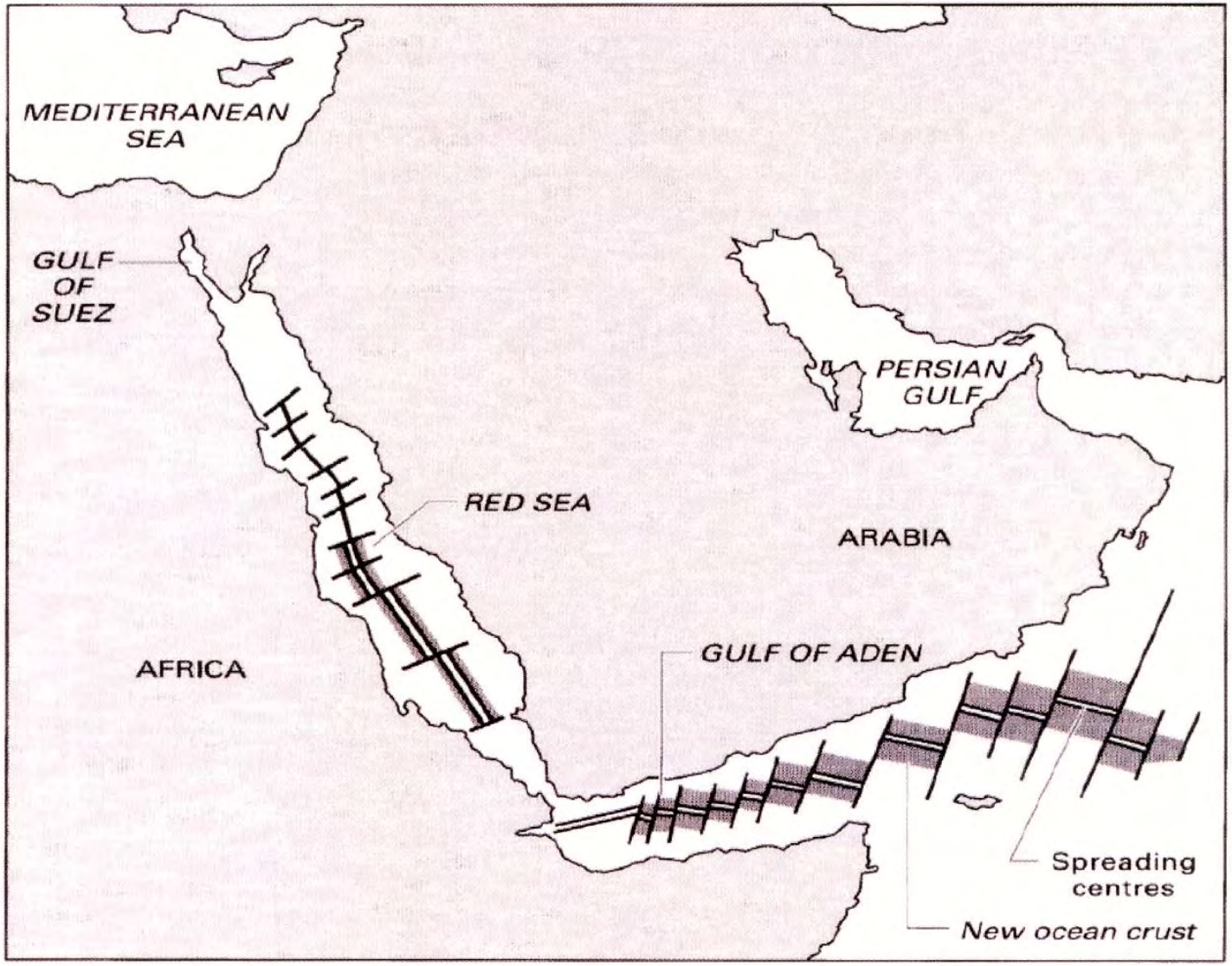
FOREARC BASIN

BACKARC BASIN

AFRICAN PLATE

Passive margin

•**A passive margin** is the transition between oceanic and continental crust which is not anactive plate margin. It is constructed by sedimentation above an


MEDITERRANEAN SEA
GULF OF SUEZ
RED SEA
PERSIAN GULF
ARABIA
AFRICA
GULF OF ADEN
Spreading centres
New ocean crust

Nomenclature

$$\delta = \left(\frac{R_x - R_{std}}{R_{std}} \right) \times 1000$$

δ units: parts per thousand, per mil or ‰

Where:
$R_x = {}^{13}C/{}^{12}C$ or ${}^{2}H/{}^{1}H$ (also D/H) in sample
and
R_{std} = ratio in standard: ${}^{13}C/{}^{12}C$, PDB; ${}^{2}H/{}^{1}H$, VSMOW

$$\alpha_{A\text{-}B} = \frac{R_A}{R_B}$$

$$\alpha_{A\text{-}B} = K^{1/n}$$

Where K is the equilibrium constant for the exchange reaction for n atoms exchanged

USGS

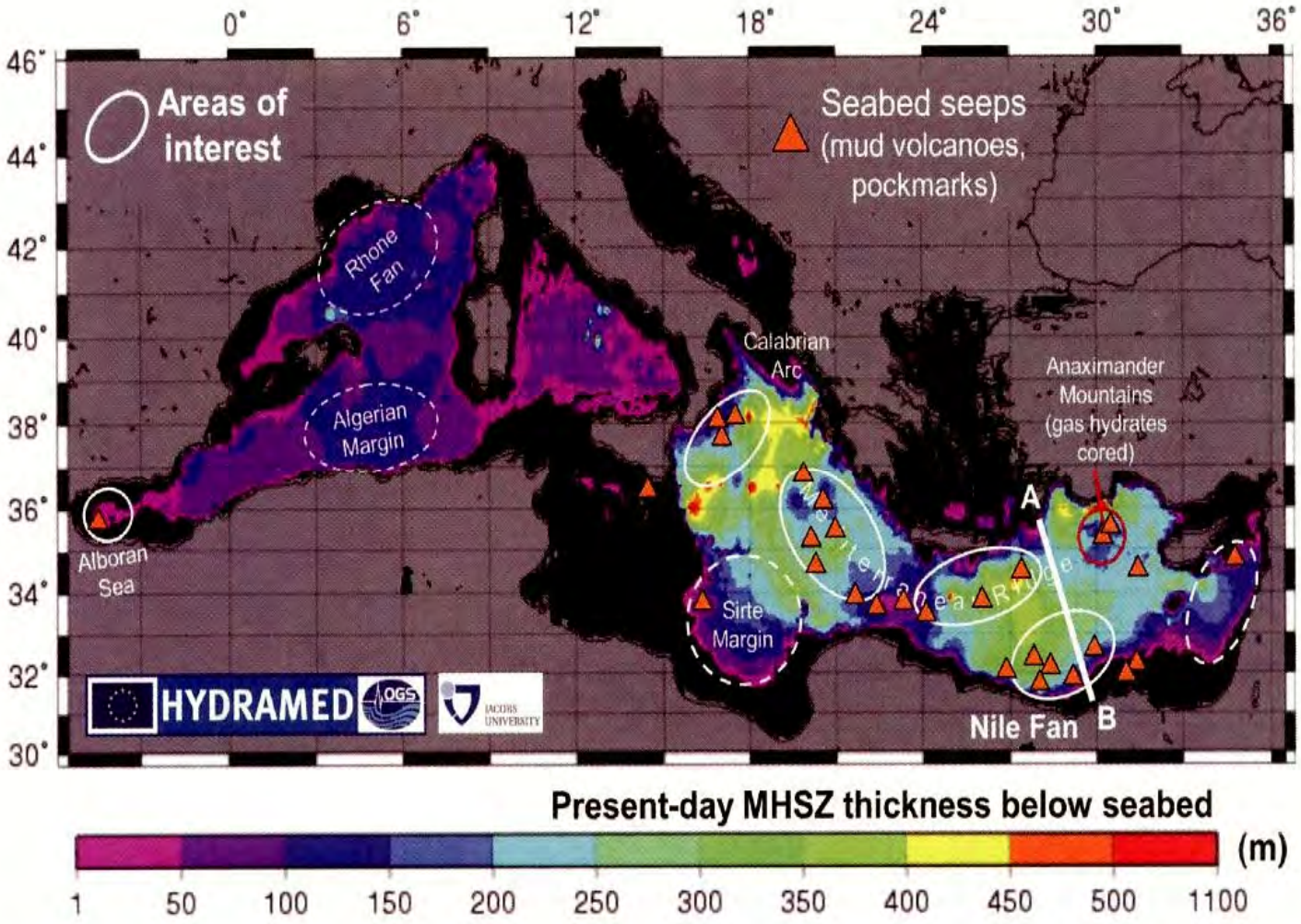


Figure 2. Modelled methane hydrate stability zone for present-day conditions, with areas of interest for hydrate occurrence; orange triangles indicate the general locations of known seabed seeps (various sources).

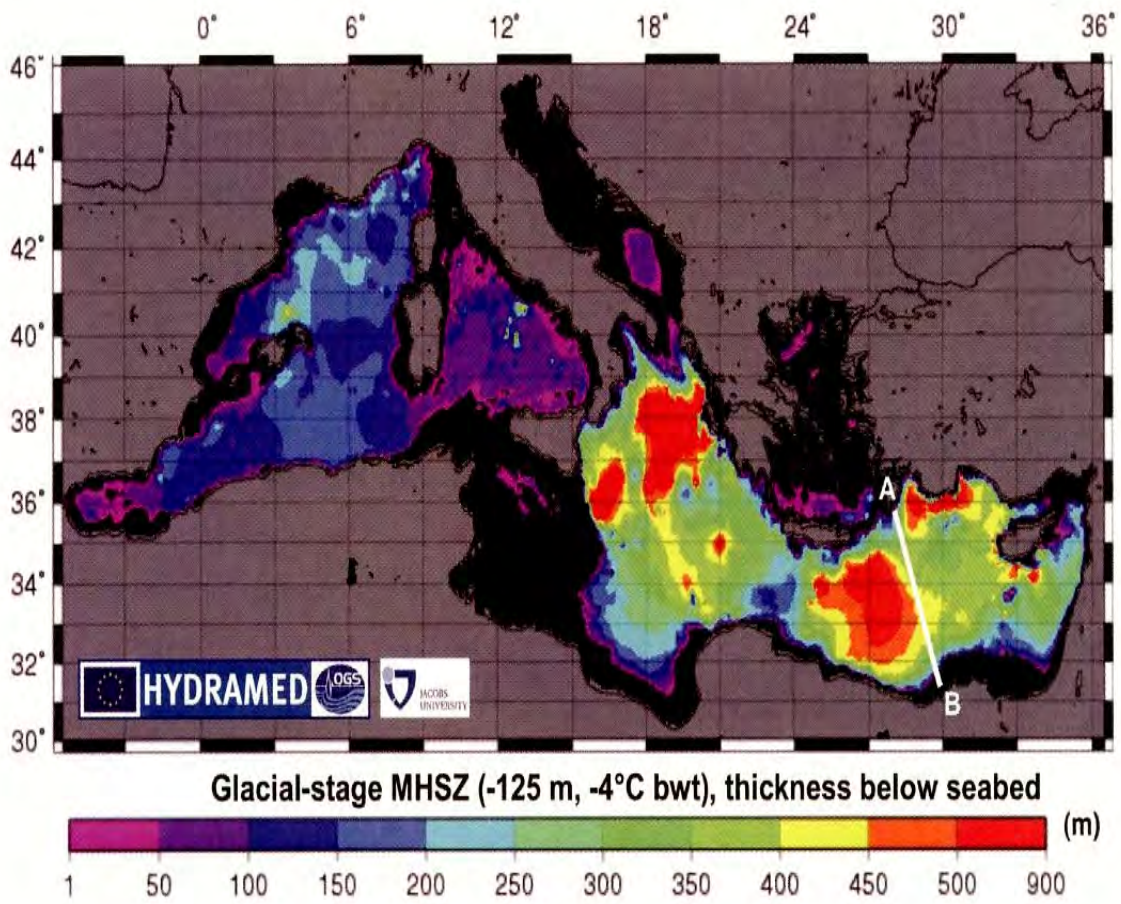
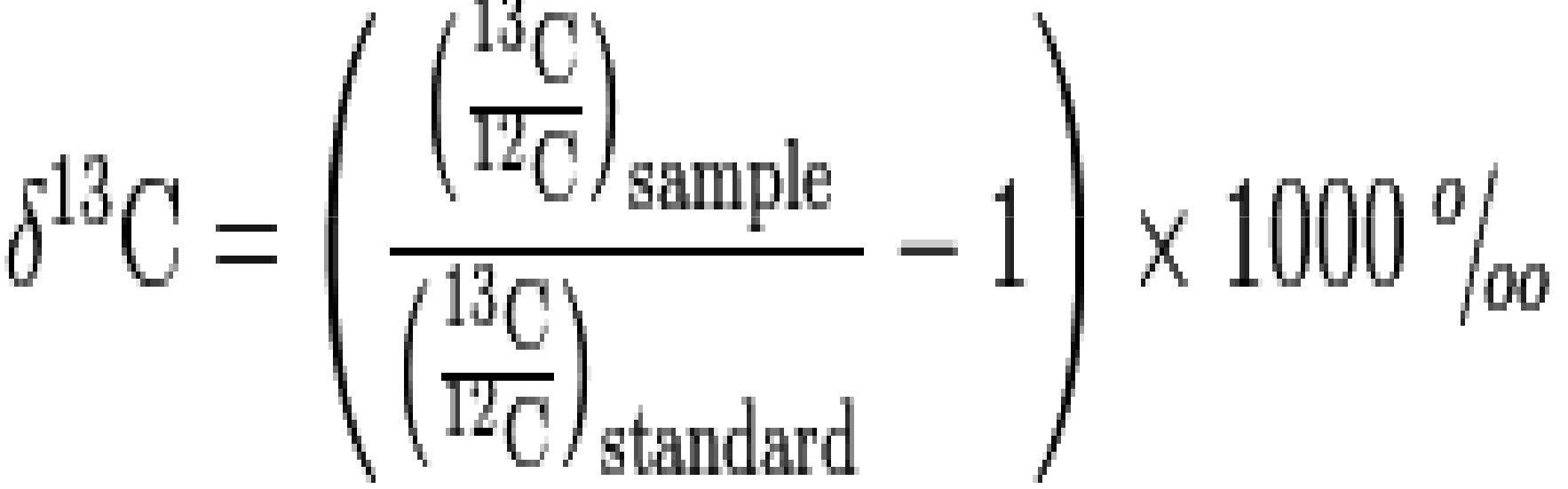


Figure 3. Modelled methane hydrate stability zone for glacial stage conditions.



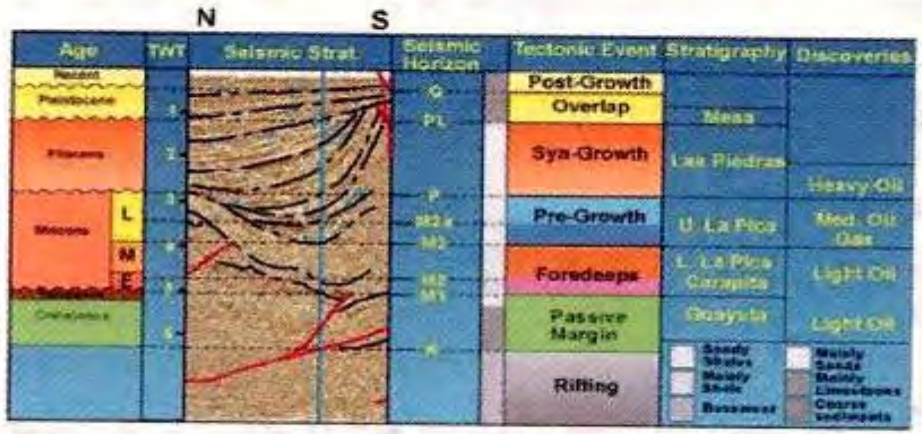


Figure 1-6. Seismic Stratigraphy. There are three growth sequences associated to the diapir evolution, the pre-growth unit with sediments controlled partially by the diapir, the syn-growth unit strongly affected by the diapir and the Overlap sequence.

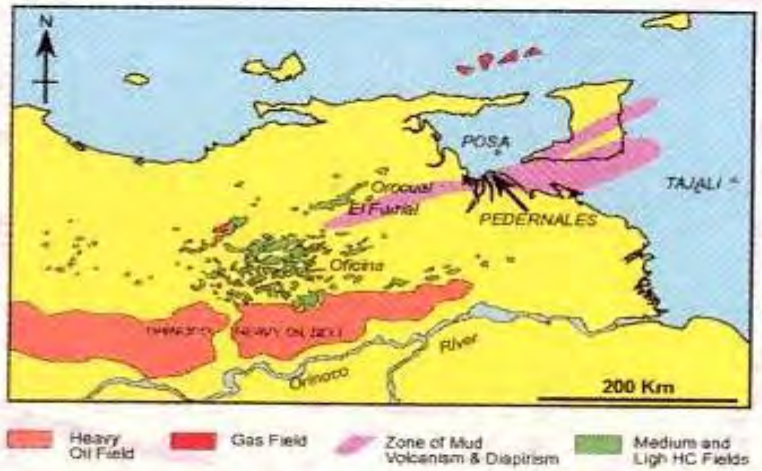


Figure 1-7. Location of the main gas and oil fields in the EVB. Note the location of the diapir strip in the basin and the main fields associated with Neogene reservoirs, i.e. Pedernales, Posa and Tajali.

MUD VOLCANOES EASTERN VENEZUELAN BASIN

Figure 1-8. Mud Volcanoes as this one from the Orinoco Delta are small but frequently associated with gas and petroleum.Photo from BEG-UTexas Site.

Figure 1-9. Location of mud volcanoes and gas seepages in the EVB. Note the convergence of mud volcanoes in the diapir area

Mud Volcanoes	N°	Gas	Oil
Hervidero	3	X	X
Terreno Seco	1	X	
Joyo	1	X	
Guanipa	3	X	
Pedernales	7	X	X

Table 1-1 Mud volcanoes and associated oil or gas shows. (Source Petito, 1979)

Συσχέτιση των λασποηφαιστείων και των κοιτασμάτων αργού πετρελαίου, φυσικού αερίου και κοιτασμάτων αμμόπισσας στην λεκάνη της Βενεζουέλας

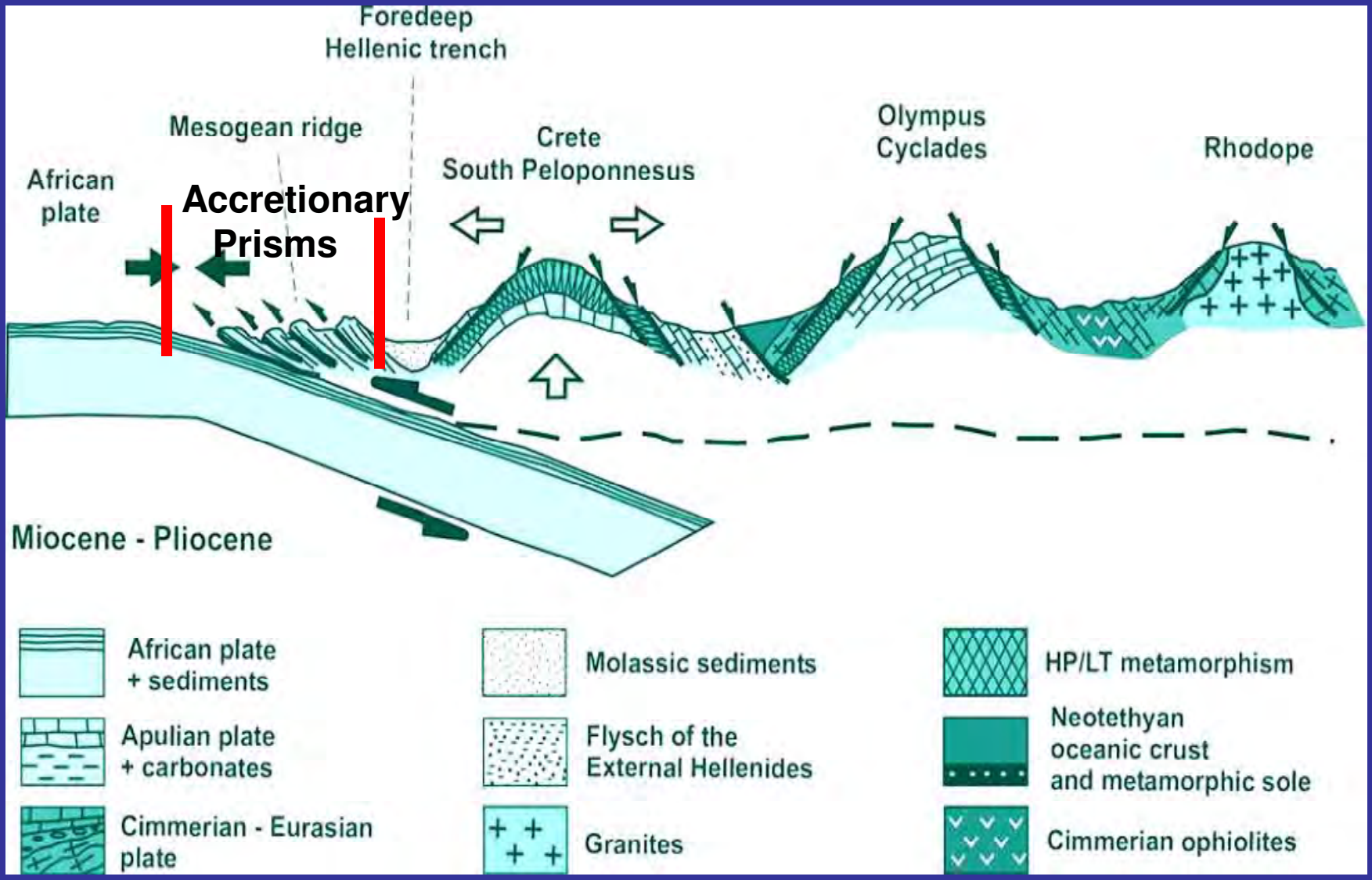


Figure 8, Schematic representation of the geodynamic process which created the Hellenides during the Mediterranean orogenesis and its tectonic migration impact which affected the new subduction zone underneath Crete, Mountrakis 2001, Pavlaki 2006

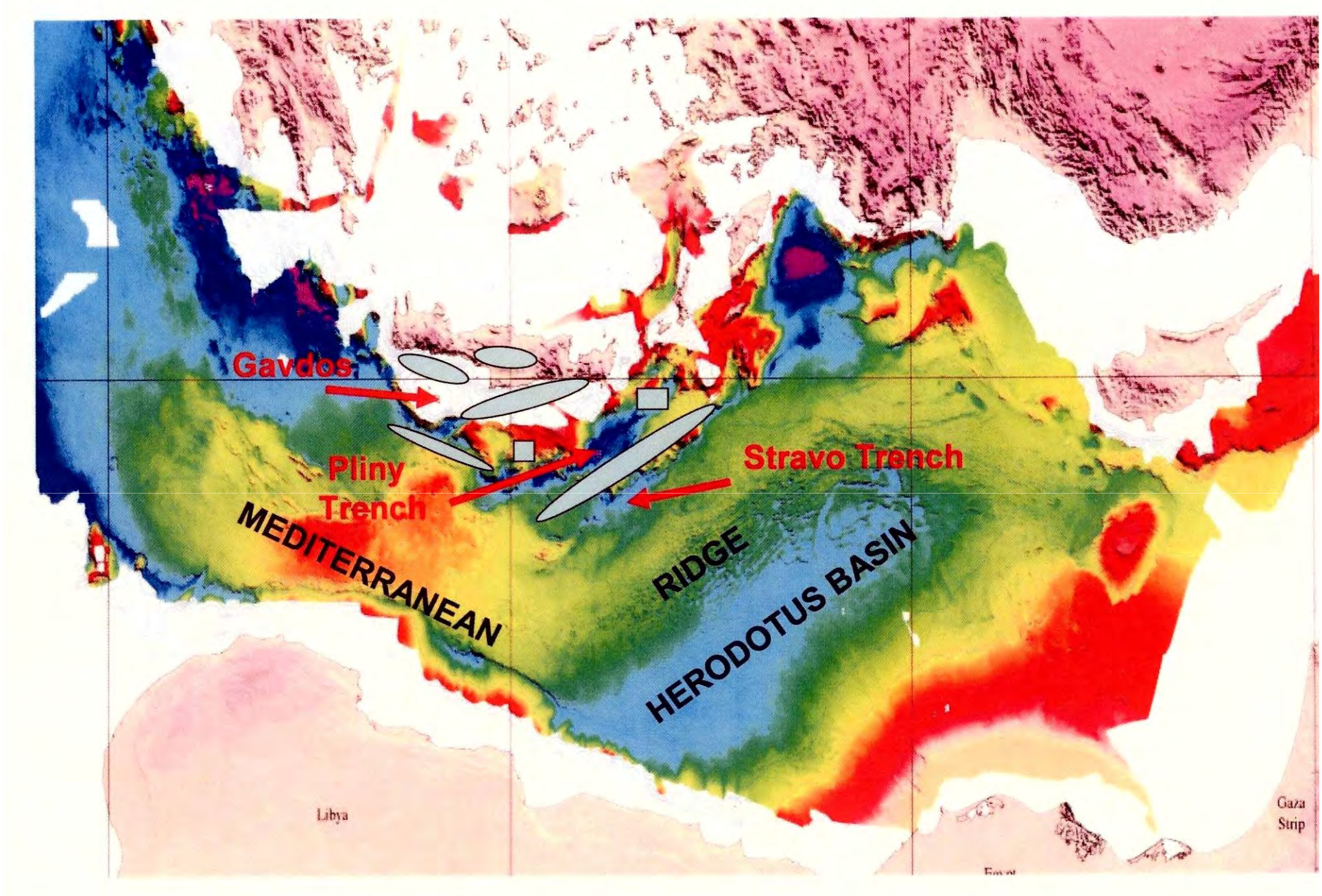
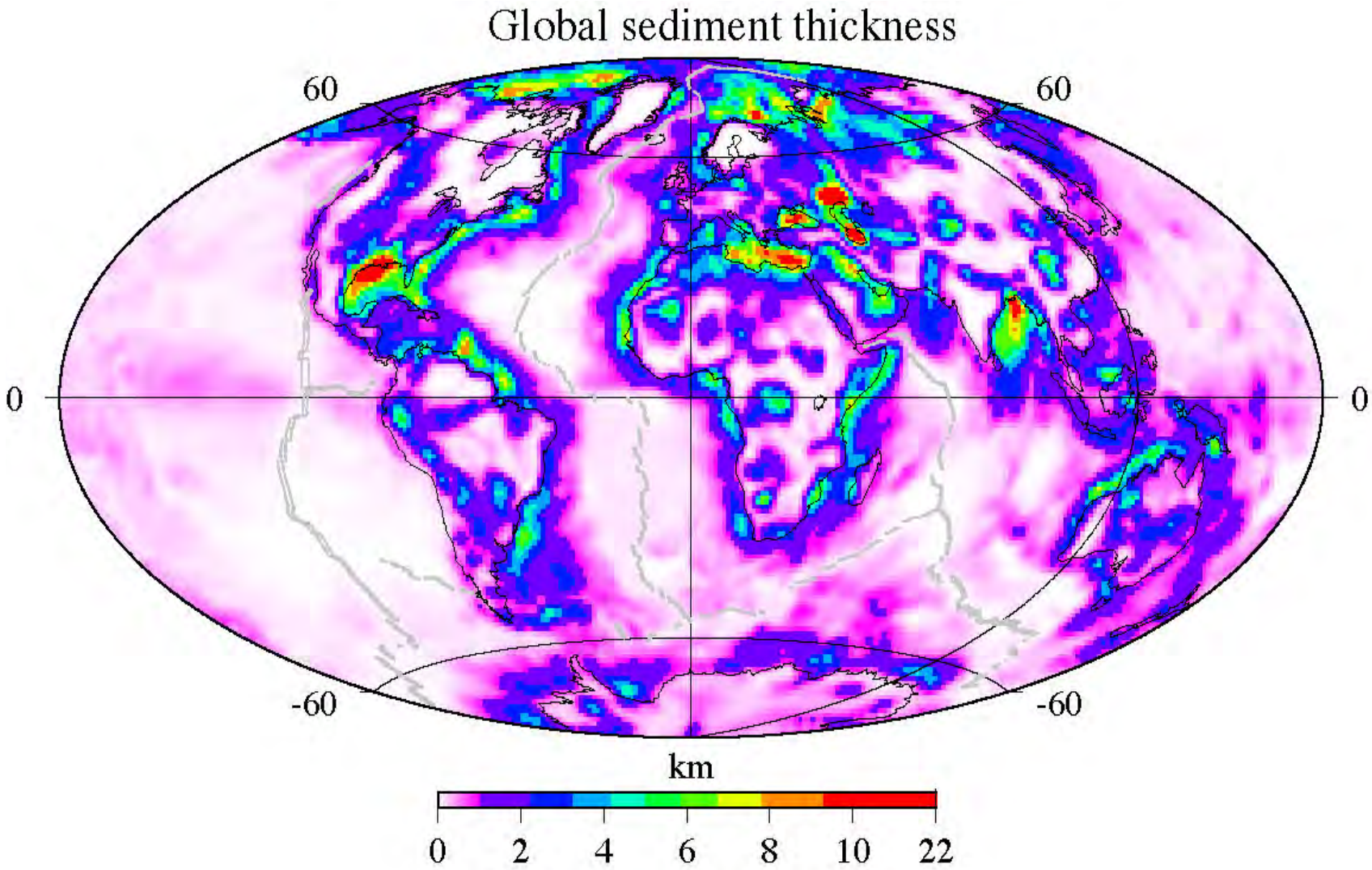


Figure 29. Hydrocarbon Fields, pale blue, ⬭ ,offshore Crete according to Maravelis et. al., 2012



http://www.earth.ox.ac.uk/~tony/watts/basins.htm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