

***Geology of the
Mediterranean Basins***



Talk outline

Brief introduction of the Mediterranean geological provinces

Pre-Mesozoic and Meso-Cenozoic Tectonic evolution

– Continental vs. oceanic crust

– Subduction

– Collision

Development of the Mediterranean basins

Western basins

Eastern Basins

The seas surrounding the Italian Peninsula

Tyrrhenian Sea

Ionian Sea

Sicily Channel

Adriatic Sea

Gulf of Trieste

Two main paleo-geographic episodes

•Messinian salinity crisis

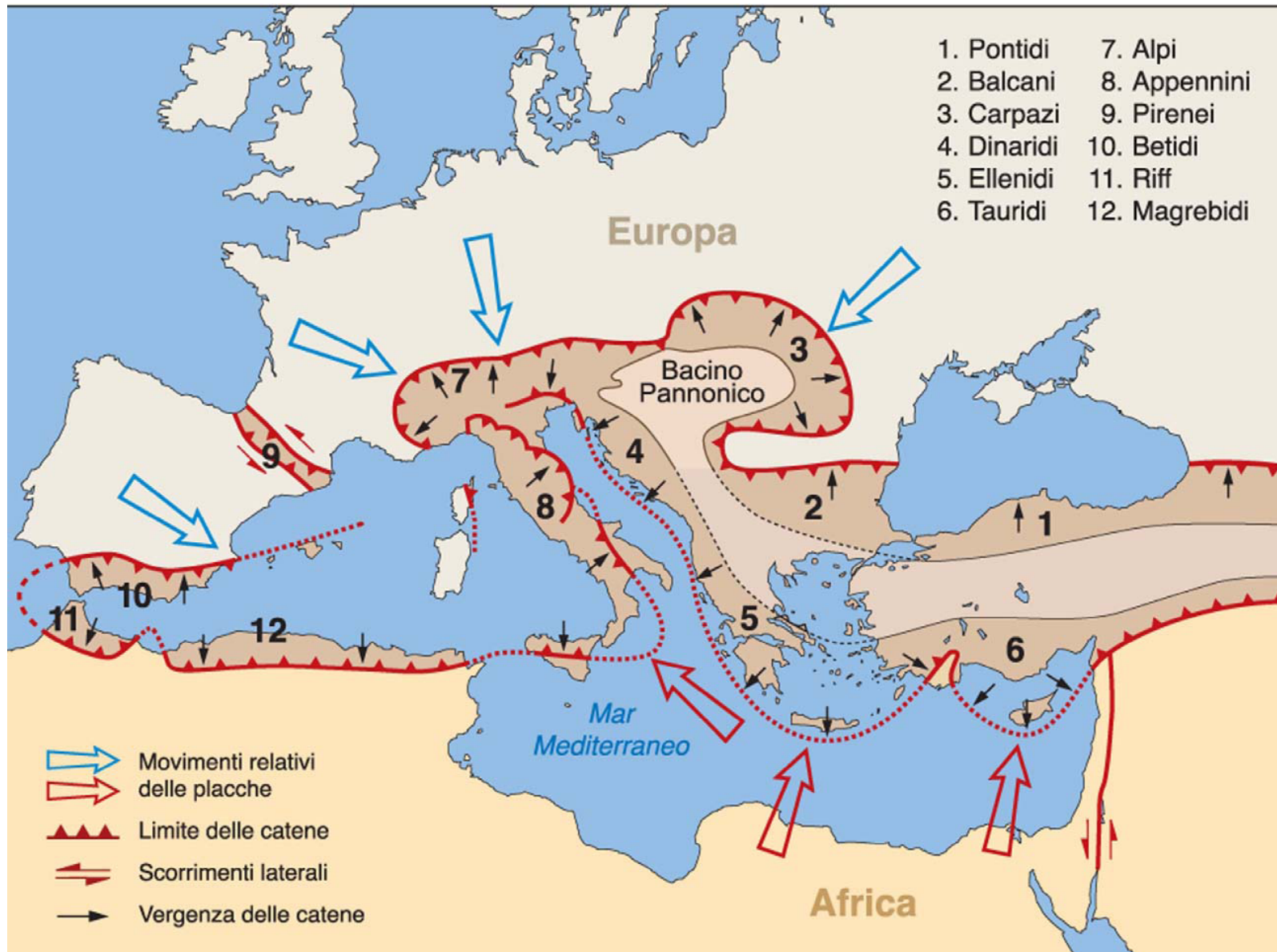
•Post-LGM sea-level rise

Organization of lessons (2016)

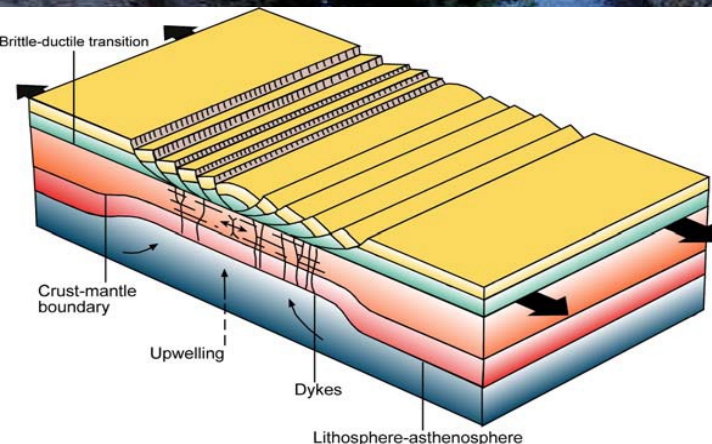
- **20 April** – Mediterranean basins (general) + Eastern Mediterranean + Aegean Sea + Tyrrhenian Sea + Sicilian Channel (*E. Lodolo*)
- **21 April** – Western Mediterranean + Alboran Sea + Ionian Sea (*S. Ceramicola*)
- **27 April** – Adriatic Sea + Gulf of Trieste (*M. Buseti and V. Volpi*)

CIRCUM-MEDITERRANEAN OROGENIC CHAINS

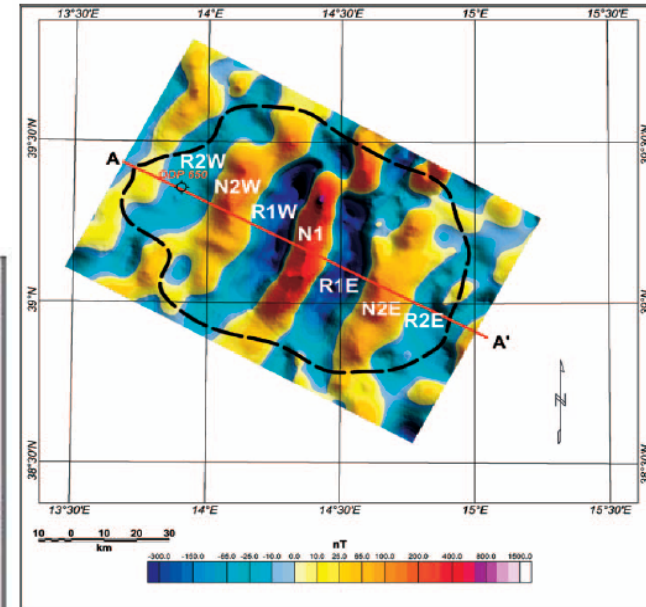
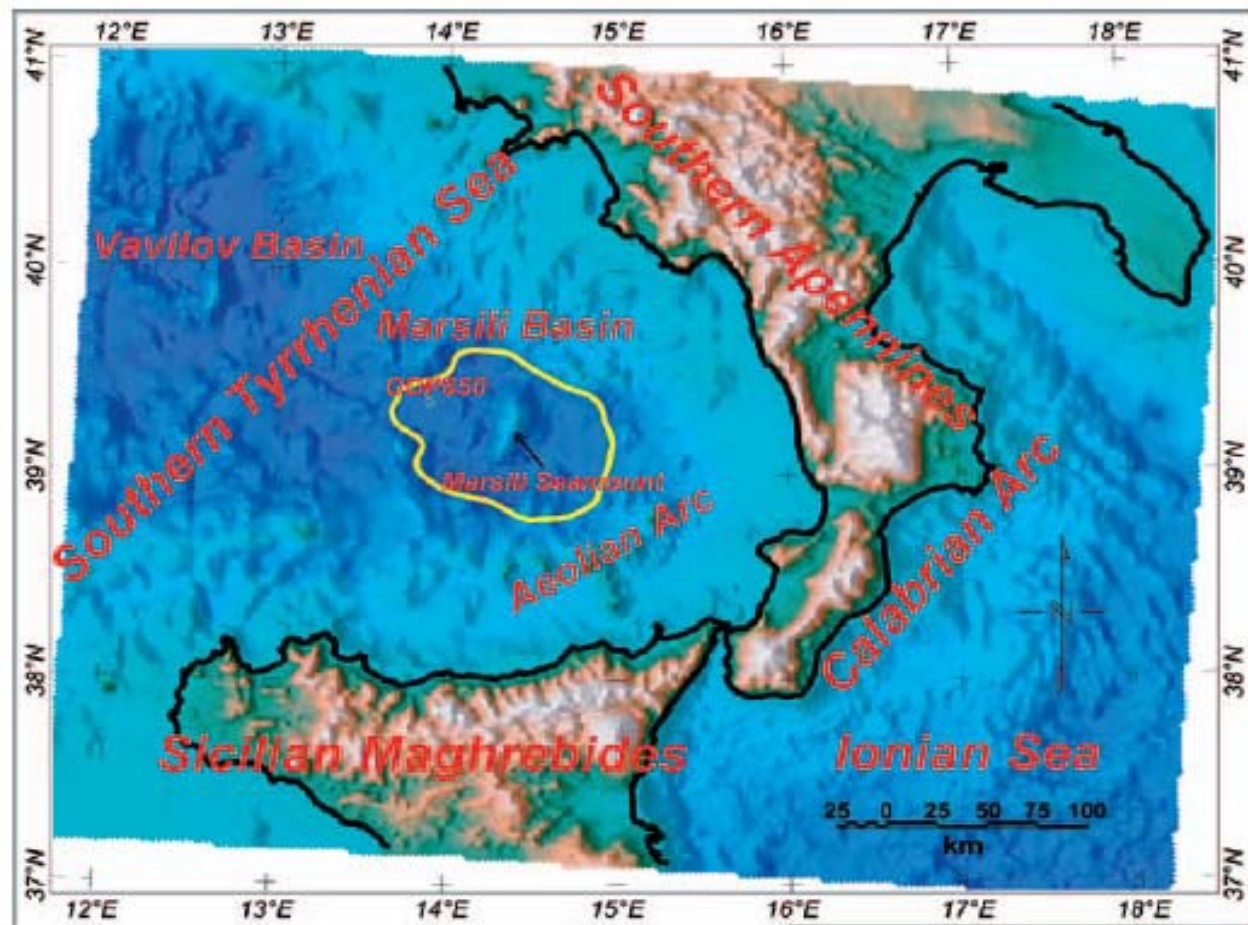
Alpine – Himalayan collisional system (Mesozoic-Present)



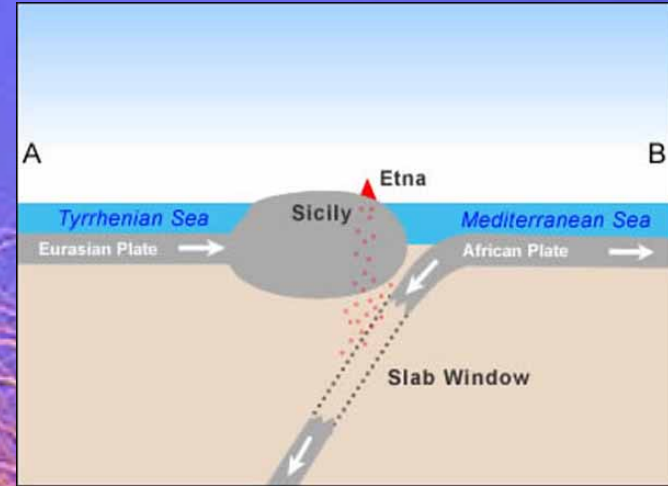
Rifting (Corinth, Sicilian Channel)



Back-arc opening (Tyrrhenian Sea)



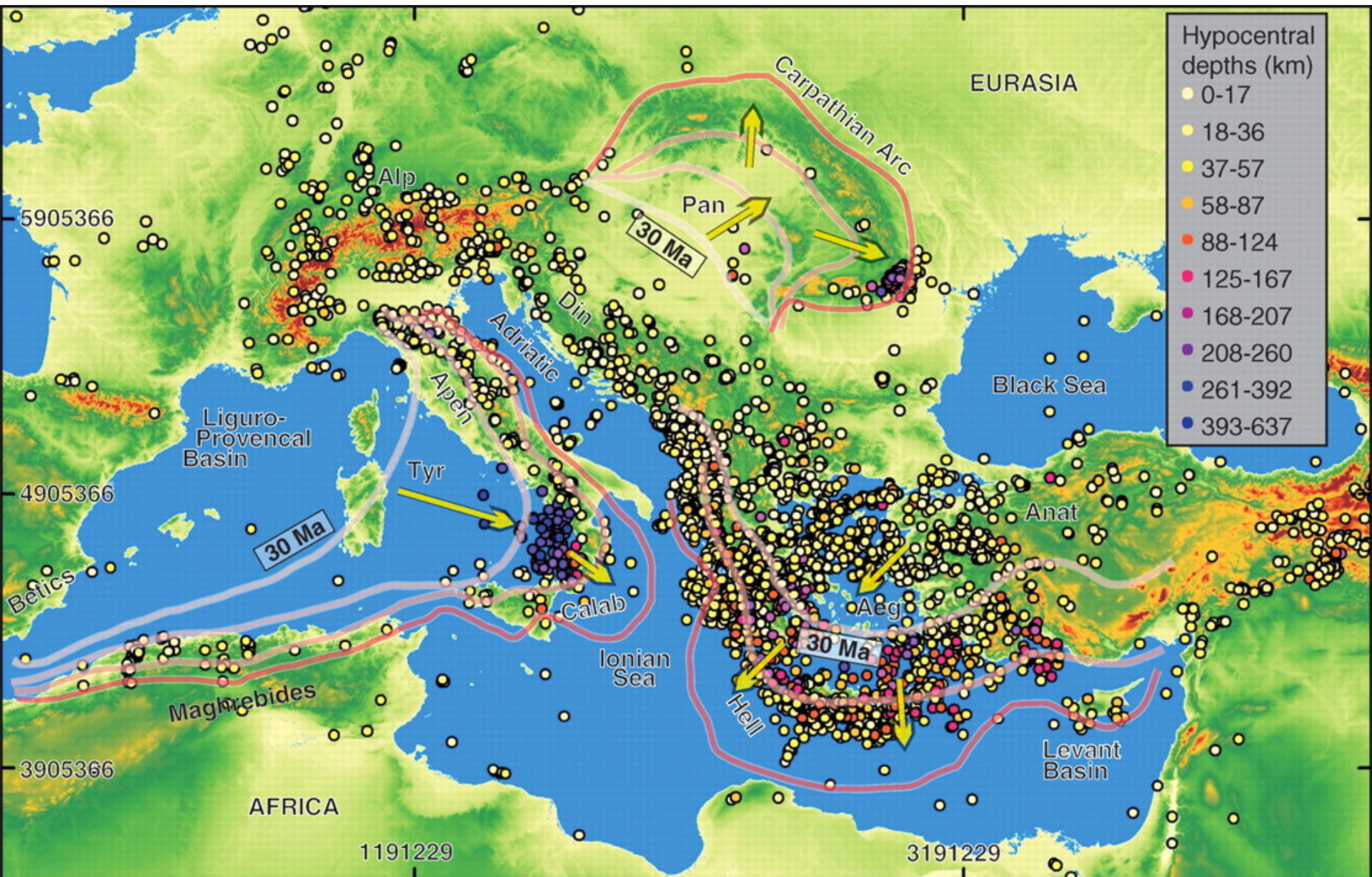
Subduction (Calabrian Arc, Aegean Sea)

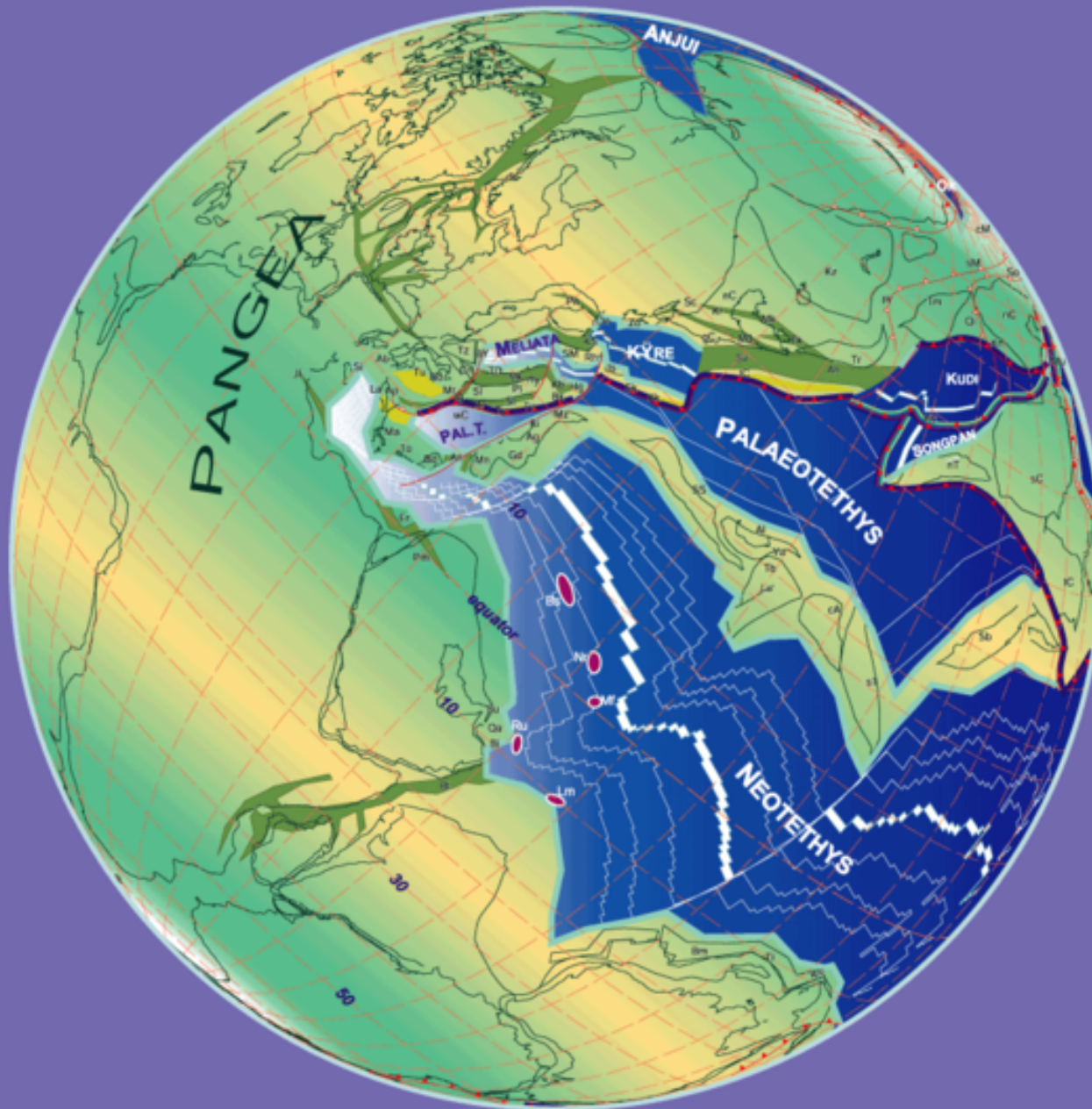


Continent-continent collision (Alps)



MEDITERRANEAN SEISMICITY AND PLATE BOUNDARIES



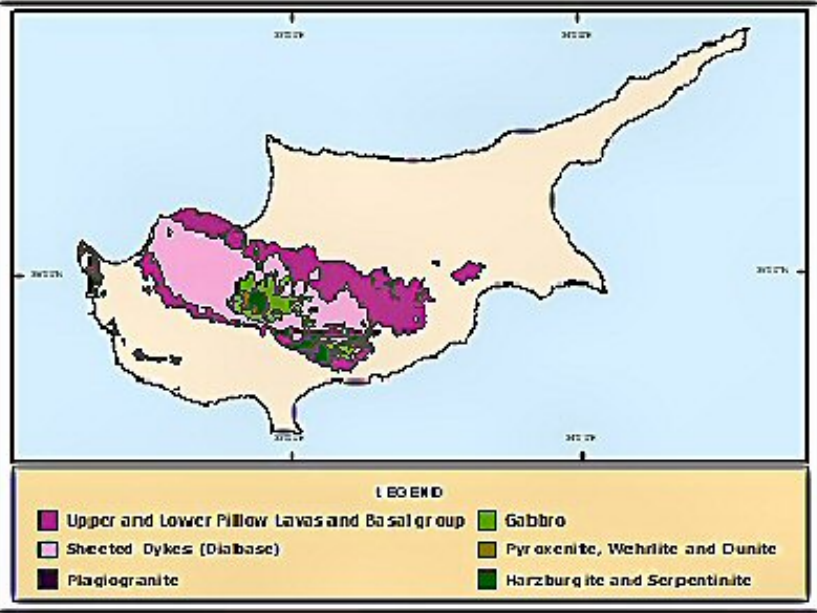


Ladinian

Stampfli & Borel 2001

Neotethys ~220 Ma

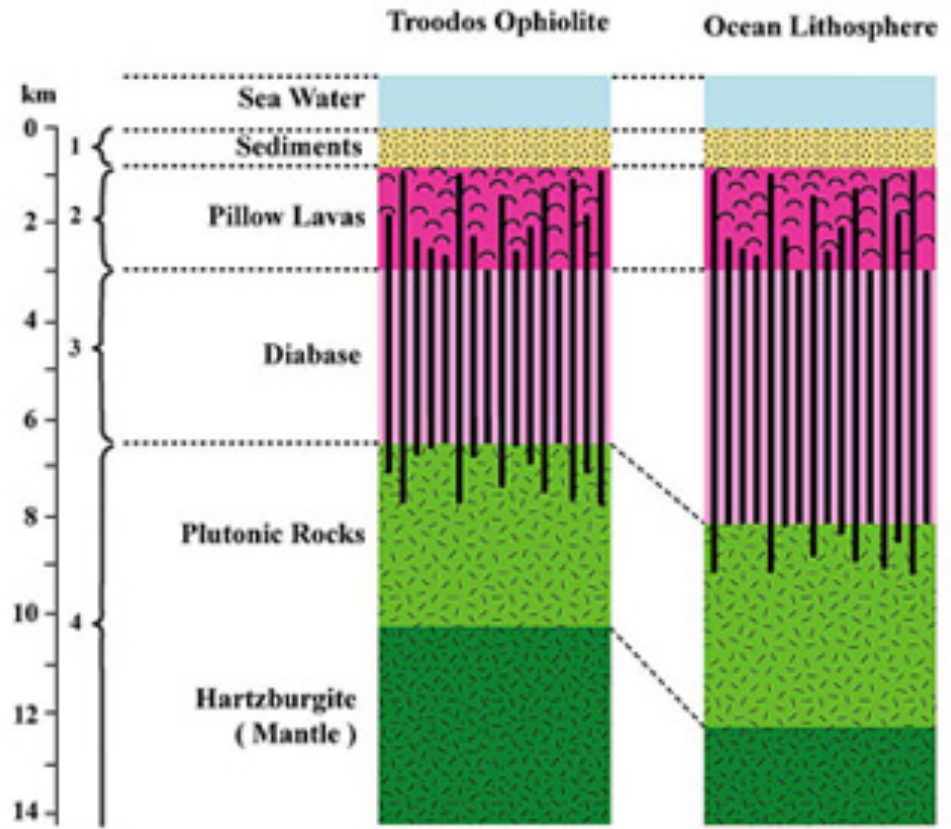
Evidence from Sicily to the eastern Mediterranean (followed the Variscan orogeny, resulting from the collision of Laurussia with Gondwana to form Pangea supercontinent)

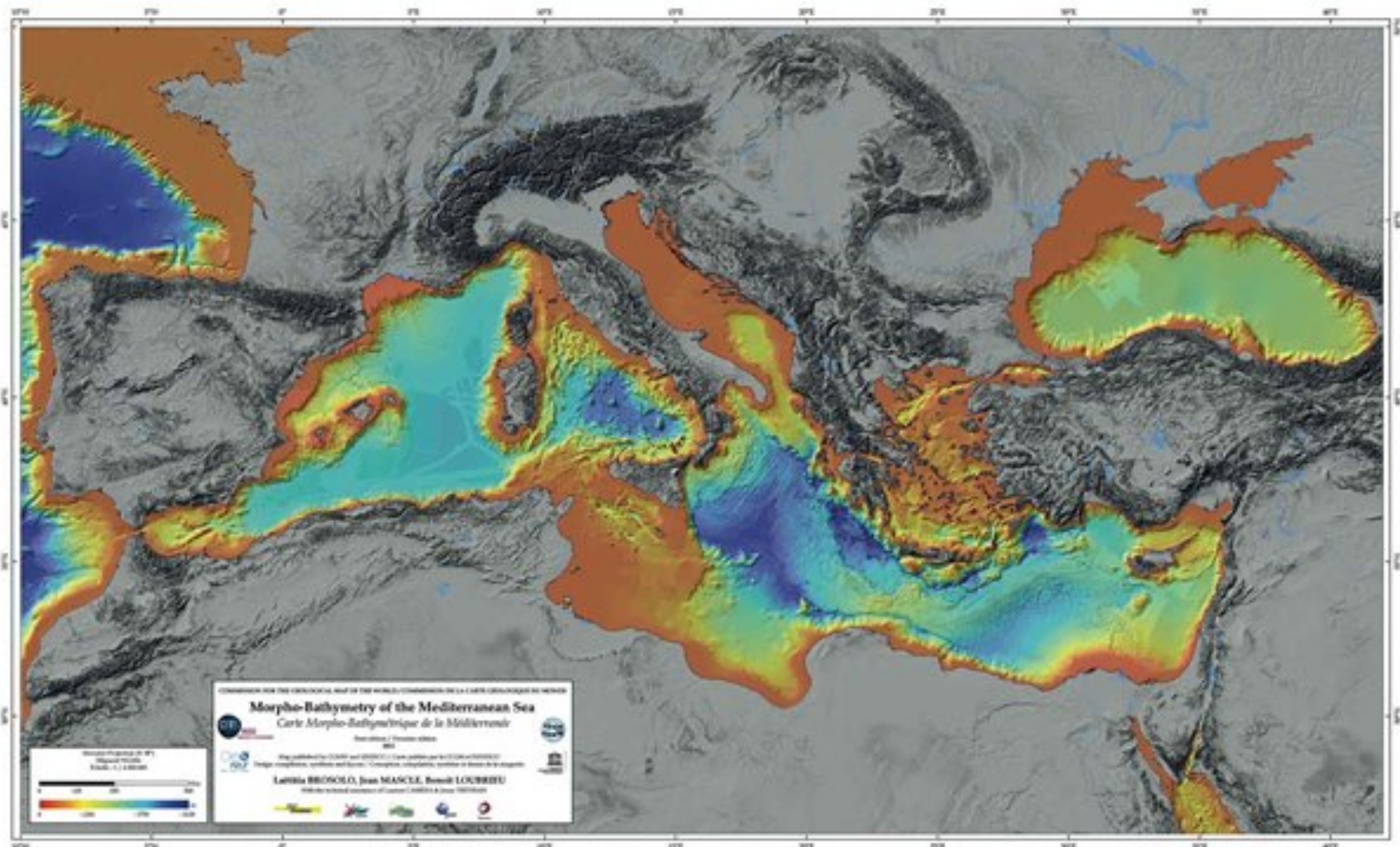


The Troodos Ophiolite complex dominates the central part of the island. It was formed in the Upper Cretaceous (90 Ma) on the Tethys sea floor, which then extended from the Pyrenees through the Alps to the Himalayas. It is regarded as the most complete, intact and studied ophiolite in the world. It is a fragment of a fully developed oceanic crust, consisting of plutonic, intrusive and volcanic rocks and chemical sediments. It was created during the complex process of sea-floor spreading and formation of oceanic crust and was emerged and placed in its present position through tectonic processes related to the collision of the Eurasian plate to the north and the African plate to the south. The stratigraphy of the ophiolite shows a topographic inversion, with the stratigraphically lower suites of rocks outcropping in the highest points of the range, while the higher units appear on the periphery of the ophiolite. The uplift of the island took place during episodes of abrupt uplift up to the Pleistocene (2 Ma).

Troodos Ophiolite Complex (Cyprus)

The Troodos Ophiolite consists of the following stratigraphic units, in ascending order: Plutonics (mantle sequence and cumulates), Intrusives, Volcanics and sediments.





Updat
 Ce document constitue un document de travail. Il est susceptible d'être révisé et mis à jour en fonction des nouvelles données et des progrès de la recherche. Les informations contenues dans ce document ne constituent pas une recommandation officielle de l'IFREMER.

Legend
 Les couleurs indiquent les profondeurs en mètres. Les contours de profondeur sont indiqués en mètres. Les contours de profondeur sont indiqués en mètres. Les contours de profondeur sont indiqués en mètres.

Depuis le début
 Ce document constitue un document de travail. Il est susceptible d'être révisé et mis à jour en fonction des nouvelles données et des progrès de la recherche. Les informations contenues dans ce document ne constituent pas une recommandation officielle de l'IFREMER.

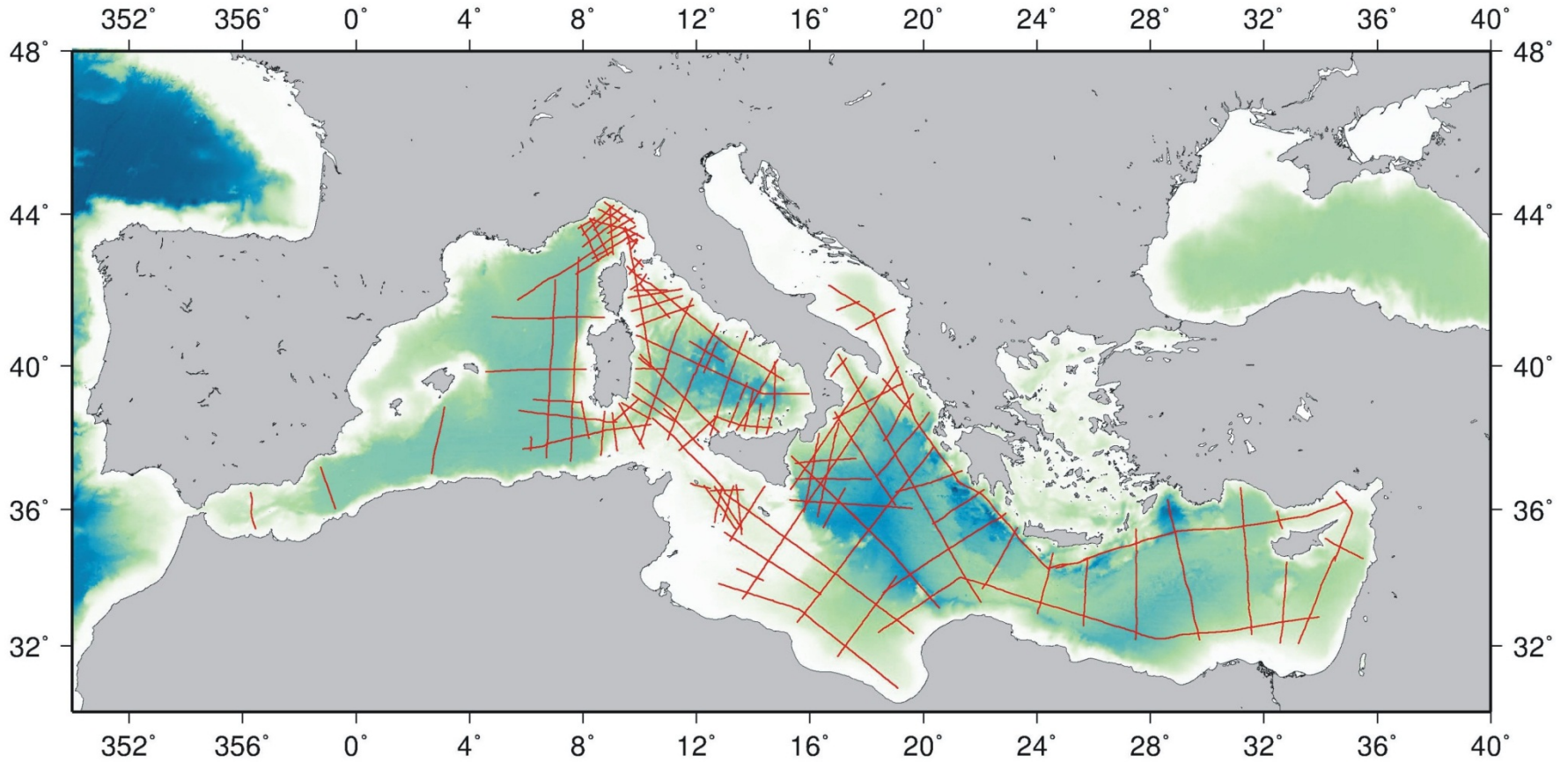
Commission for the Geological Map of the World - Commission de la Carte Géologique du Monde
 Institut Français de Recherche pour l'Exploitation de la Mer (IFREMER)
 Institut National de la Mer et de la Pêche (INMPE)
 Institut National de l'Environnement Industriel et des Risques (INERIS)
 Institut National de la Santé et de la Sécurité du Travail (INRSST)
 Institut National de la Statistique et des Études Économiques (INSEE)
 Institut National de la Recherche Scientifique (INRS)
 Institut National de la Recherche Scientifique (INRS)
 Institut National de la Recherche Scientifique (INRS)
 Institut National de la Recherche Scientifique (INRS)

Détails
 Ce document constitue un document de travail. Il est susceptible d'être révisé et mis à jour en fonction des nouvelles données et des progrès de la recherche. Les informations contenues dans ce document ne constituent pas une recommandation officielle de l'IFREMER.

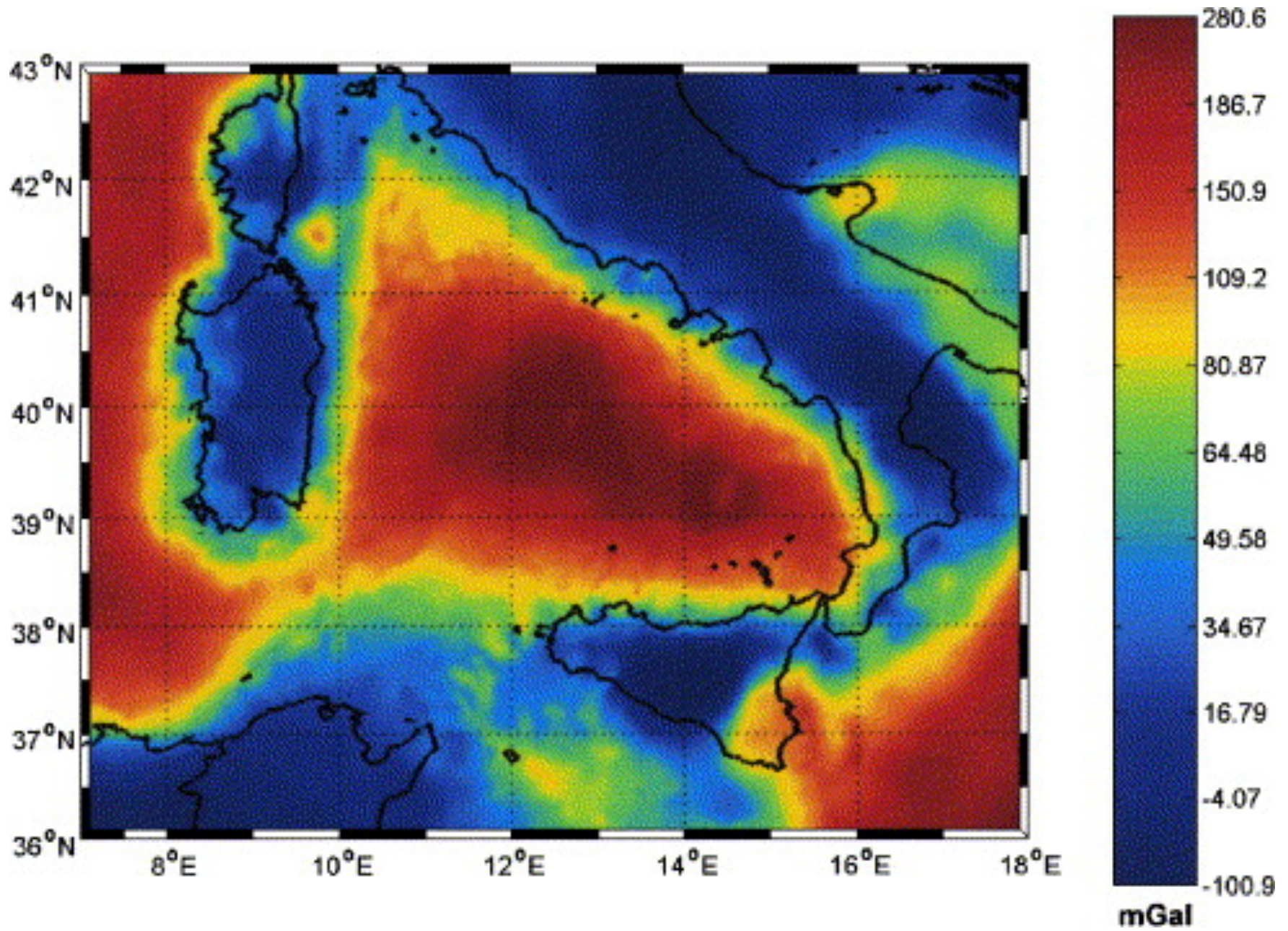
Commission for the Geological Map of the World - Commission de la Carte Géologique du Monde
 Institut Français de Recherche pour l'Exploitation de la Mer (IFREMER)
 Institut National de la Mer et de la Pêche (INMPE)
 Institut National de l'Environnement Industriel et des Risques (INERIS)
 Institut National de la Santé et de la Sécurité du Travail (INRSST)
 Institut National de la Statistique et des Études Économiques (INSEE)
 Institut National de la Recherche Scientifique (INRS)
 Institut National de la Recherche Scientifique (INRS)
 Institut National de la Recherche Scientifique (INRS)
 Institut National de la Recherche Scientifique (INRS)

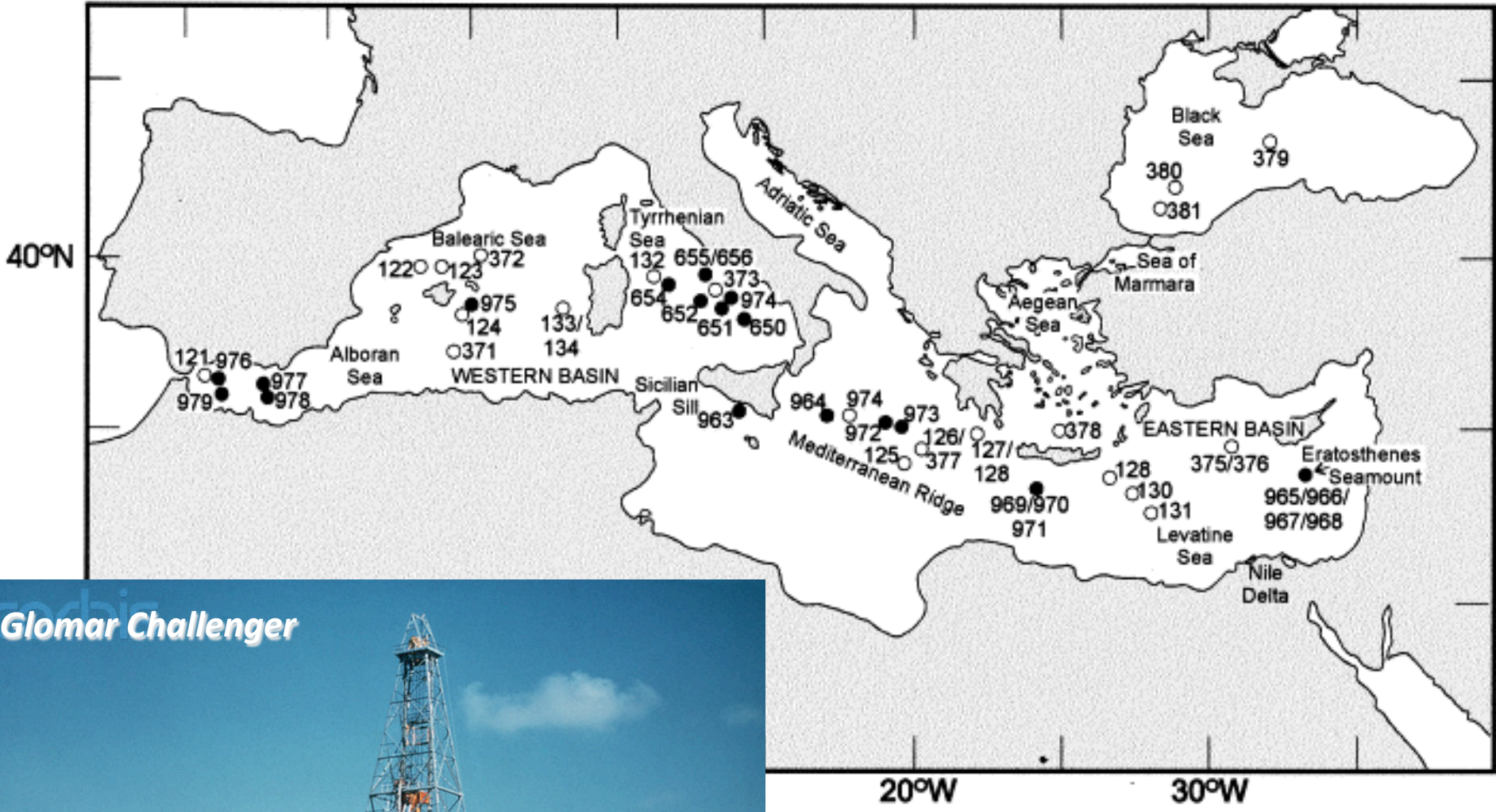
MS map

(seismic profiles collected from 1968 to 1982)



Bouguer gravity anomaly map of the Central Mediterranean

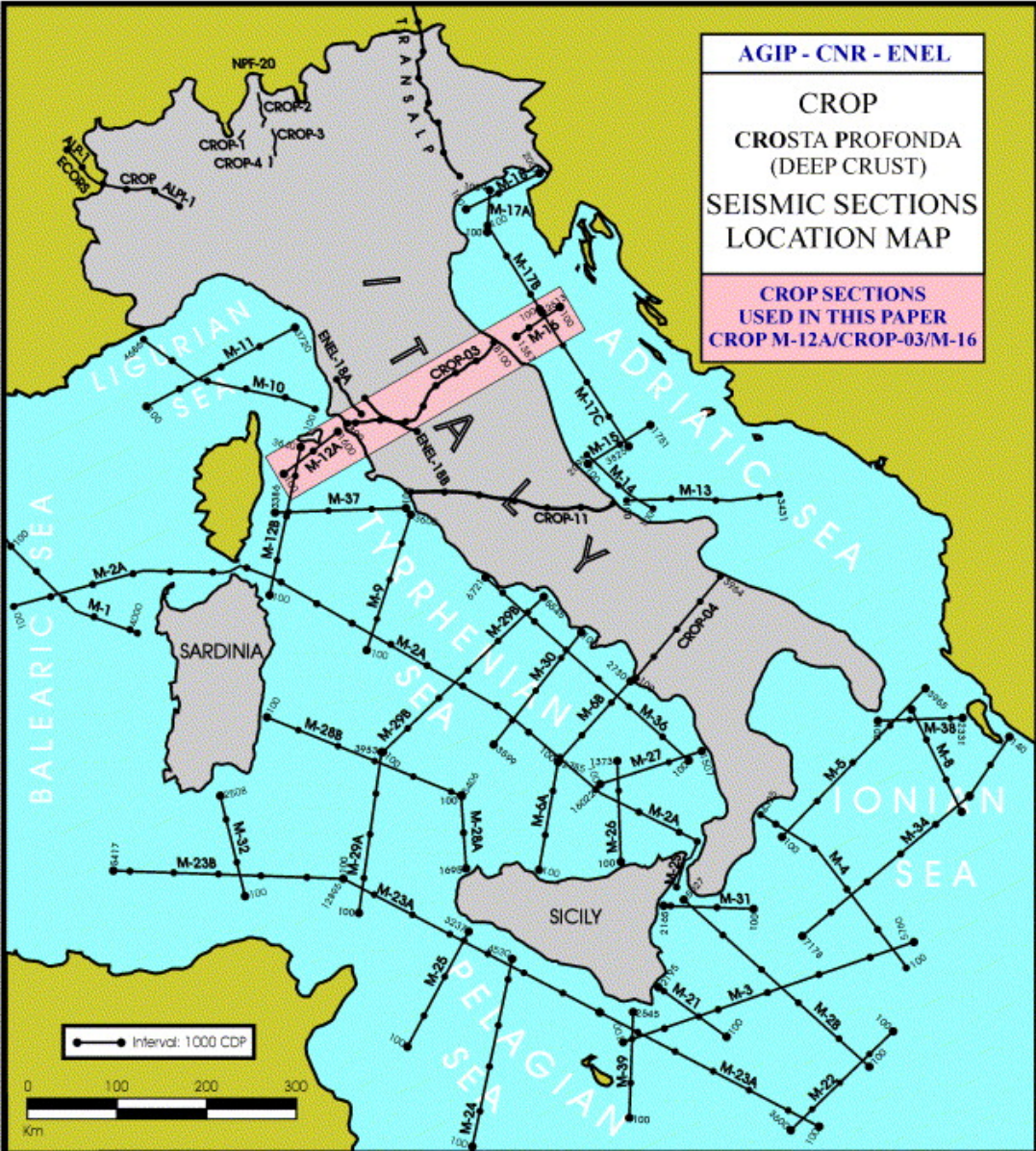




Glomar Challenger



DSDP and ODP program



CROP map
 (Seismic profiles collected both onshore and offshore)

<p>FRENCH (ECORS) - ITALIAN (CROP) COOPERATION -WESTERN ALPS (ALP-1/ALPI-1) -BALEARIC SEA (GULF OF LYON/SARDINIA, M-1)</p>	<p>GERMAN (DEKORP) - AUSTRIAN (OEKORP) - ITALIAN (CROP) COOPERATION - EASTERN ALPS (TRANSALP)</p>
<p>SWISS (NPF-20) - ITALIAN (CROP) COOPERATION -CENTRAL ALPS (CROP-1, 2, 3, 4 AND NPF-20 CONTINUATION TO NORTH)</p>	<p>GREEK - ITALIAN (CROP) COOPERATION - NE IONIAN SEA (EAST - EXTREMITIES OF M-34 & M-38)</p>



PUBLIC DOMAIN DATA BASE

Composite Wells downloading for over 2000 released wells are available at the web site
<http://unmig.sviluppoeconomico.gov.it/unmig/sta/pozzidisponibili.htm>

Paper copies of the reports for the expired Licences are available for consultation at the BAST library of Roma 3 University in Rome (Via della Vasca Navale 79/81)
http://host.uniroma3.it/biblioteche/page.php?page=Archivio_9

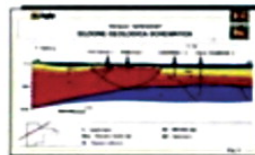
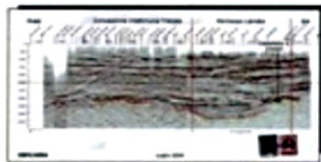
Seismic Data collected from the documents filed by the Operators to UNMIG are available at the web site
<http://www.neogeo.unisi.it/assomin/>

All public data will be available at web site:
www.videpi.com

ViDEPI

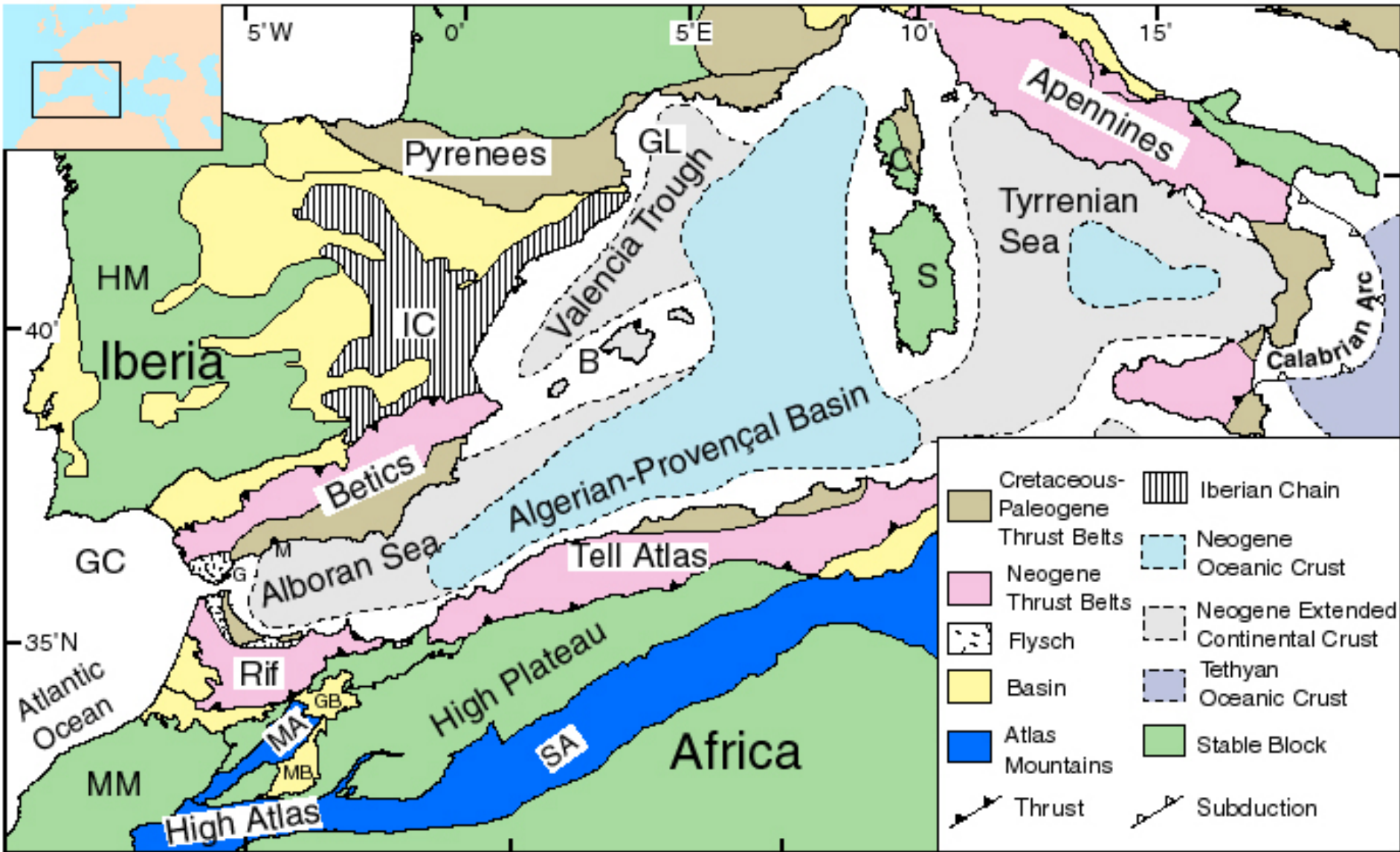
Visibilità dei dati afferenti all'attività di esplorazione petrolifera in Italia

<http://unmig.sviluppoeconomico.gov.it/videpi/>



- **The present-day geological configuration of the Mediterranean region is the result of the creation and ensuing consumption of two major oceanic basins—the Paleotethys and the Neotethys.**
- **The overall tectonic regime was (and it is) the regime of prolonged interaction between the Eurasian and the African-Arabian plates.**
- **The Mediterranean domain provides a present-day geodynamic analog for the final stages of a continent-continent collisional orogeny. Over this area, the oceanic lithospheric domains originally present between the Eurasian and African-Arabian plates have been subducted and partially obducted (ophiolitic terranes), except for the Ionian basin and the south-eastern Mediterranean.**
- **The modern marine basins of the Mediterranean Sea are variably floored by: (i) remnants of the Tethyan oceanic domains (Ionian, E Mediterranean); (ii) Neogene oceanic crust (Algero-Provençal basin and Tyrrhenian Sea); (iii) extended continental lithosphere (Alboran Sea, Valencia Trough, Aegean Sea), and (iv) thick continental lithosphere (Adriatic Sea).**

WESTERN MEDITERRANEAN BASINS

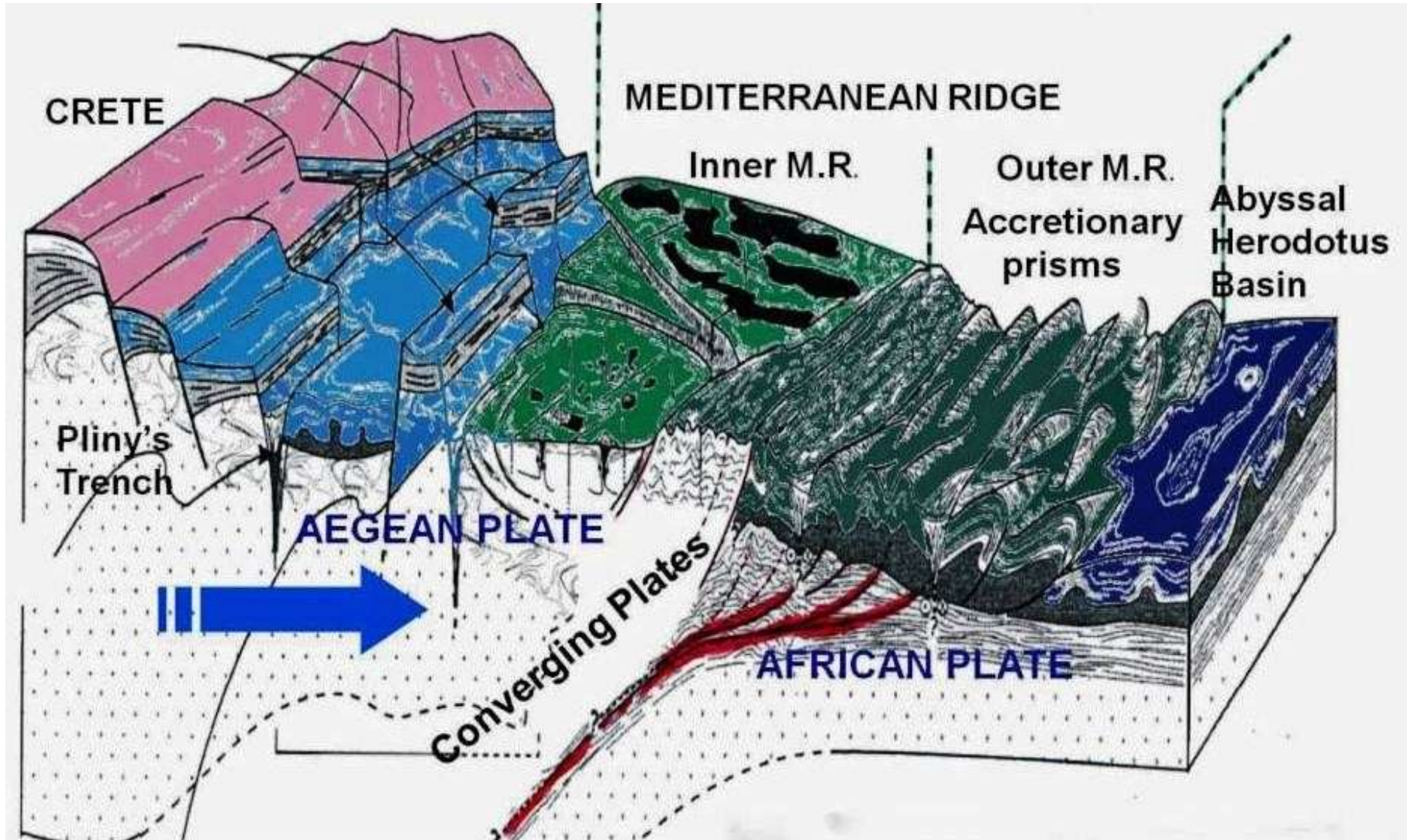


- **The western Mediterranean is the younger part of the Mediterranean (late Oligocene to present). It consists of a series of sub-basins: Alboran, Valencia, Provençal, Algerian and Tyrrhenian seas. These generally rejuvenate moving from west to east. They are partly floored by oceanic crust (Provençal and Algerian basins, and two smaller areas in the Tyrrhenian Sea). The remaining submarine part of the western Mediterranean basin is made of extensional and transtensional passive continental margins.**
- **The Algerian Basin is a deep basin (around 3000 m) located between the Balearic Promontory and the North Africa margin. The crust in the Algerian Basin seems to have an oceanic character. In most of the basin the Moho depth is less than 14 km and the crust is 4 to 6 km thick.**
- **The Liguro-Provençal Basin comprises the Ligurian Sea, the Gulf of Lions as well as the portion of the Mediterranean Sea located West of Corsica and Sardinia, and East of Menorca. It is the oldest Western Mediterranean basin and has a maximum water depth of 2800 m. The lithosphere beneath the Liguro-Provençal basin is thin (less than 30 km) the crust decreases in thickness to about 5 km beneath the central part of the basin where it is oceanic, dated as late Aquitanian to late Burdigalian-early Serravallian. Rifting in the Provençal-Ligurian basin started during latest Eocene-Early Oligocene (34-28 Ma) and ended in the middle Aquitanian. Subsequently, the central oceanic portion of the basin was generated between the late Aquitanian and late Burdigalian (21-16 Ma) associated with the counter clockwise rotation of the Corsica-Sardinia Block. Before drifting, this block of the Iberian plate was located close to the Provençal coast and the present-day Gulf of Lions. The Liguro-Provençal Basin is considered to be a back-arc basin generated from the south-eastward roll-back of the Apennines-Maghrebides subduction.**

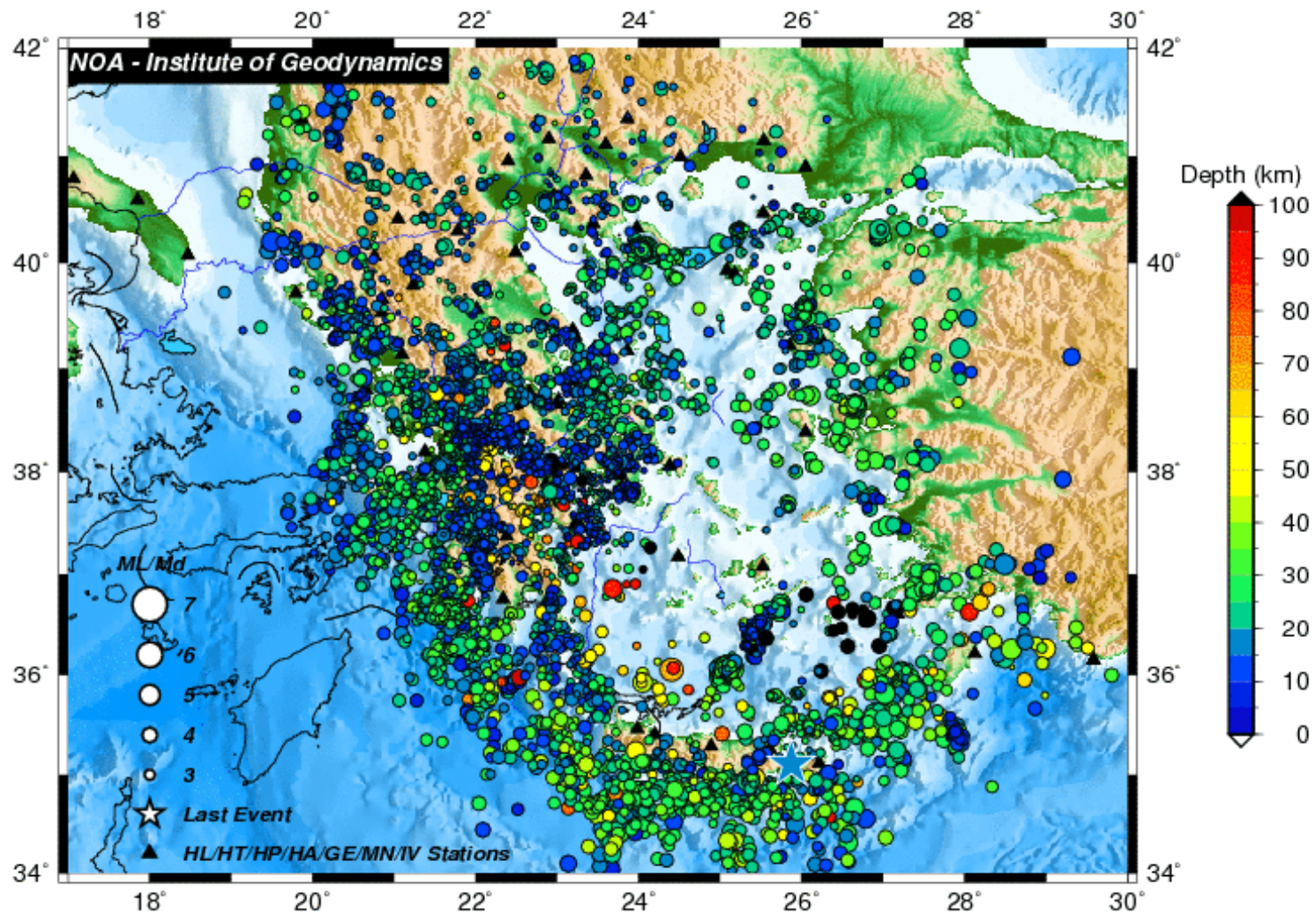
Aegean region



Aegean region cross-section

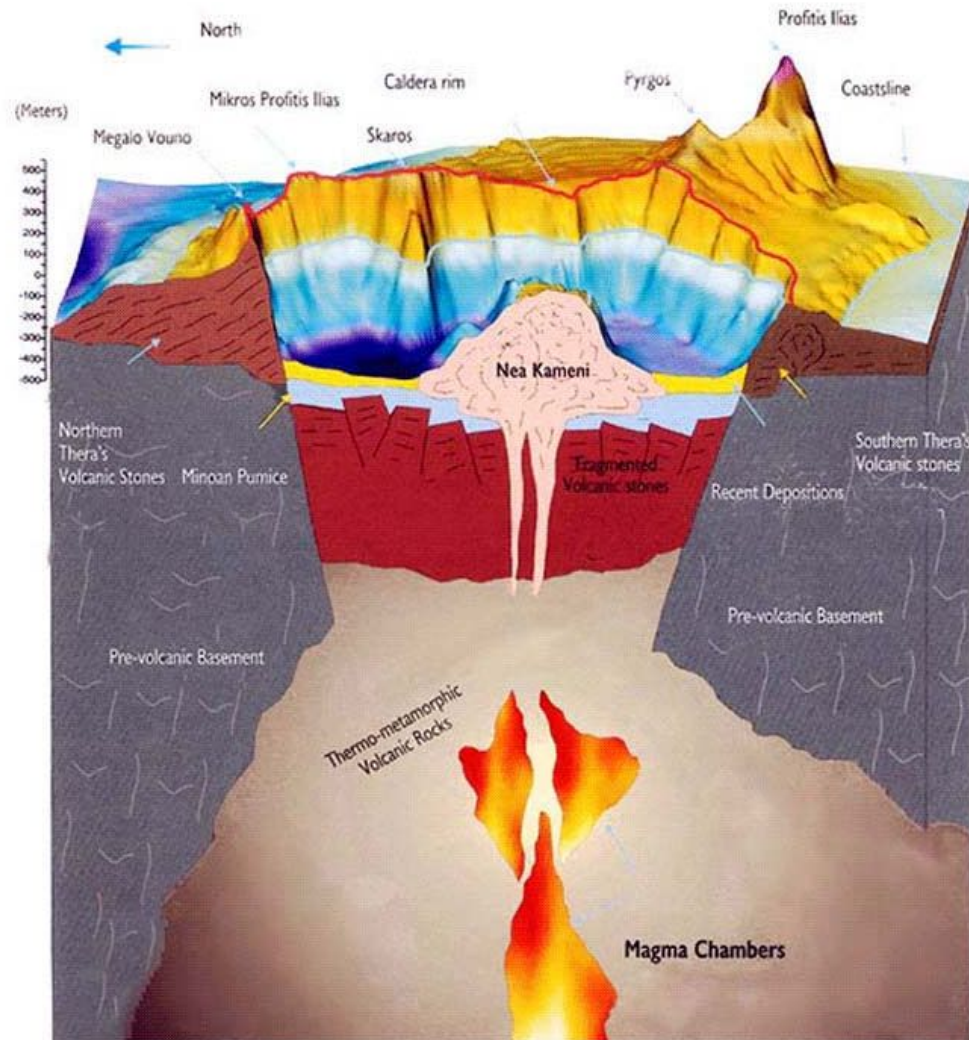


Aegean Sea seismicity



The volcanic complex of Santorini is the most active part of the South Aegean Volcanic Arc. It is about 500 km long and 20 to 40 km wide and characterized by earthquakes at depths of 150-170 km that mark the subduction of the African underneath the Eurasian plate, at a rate of up to 5 cm/year in a NE direction.

Schematic geological section of Santorini

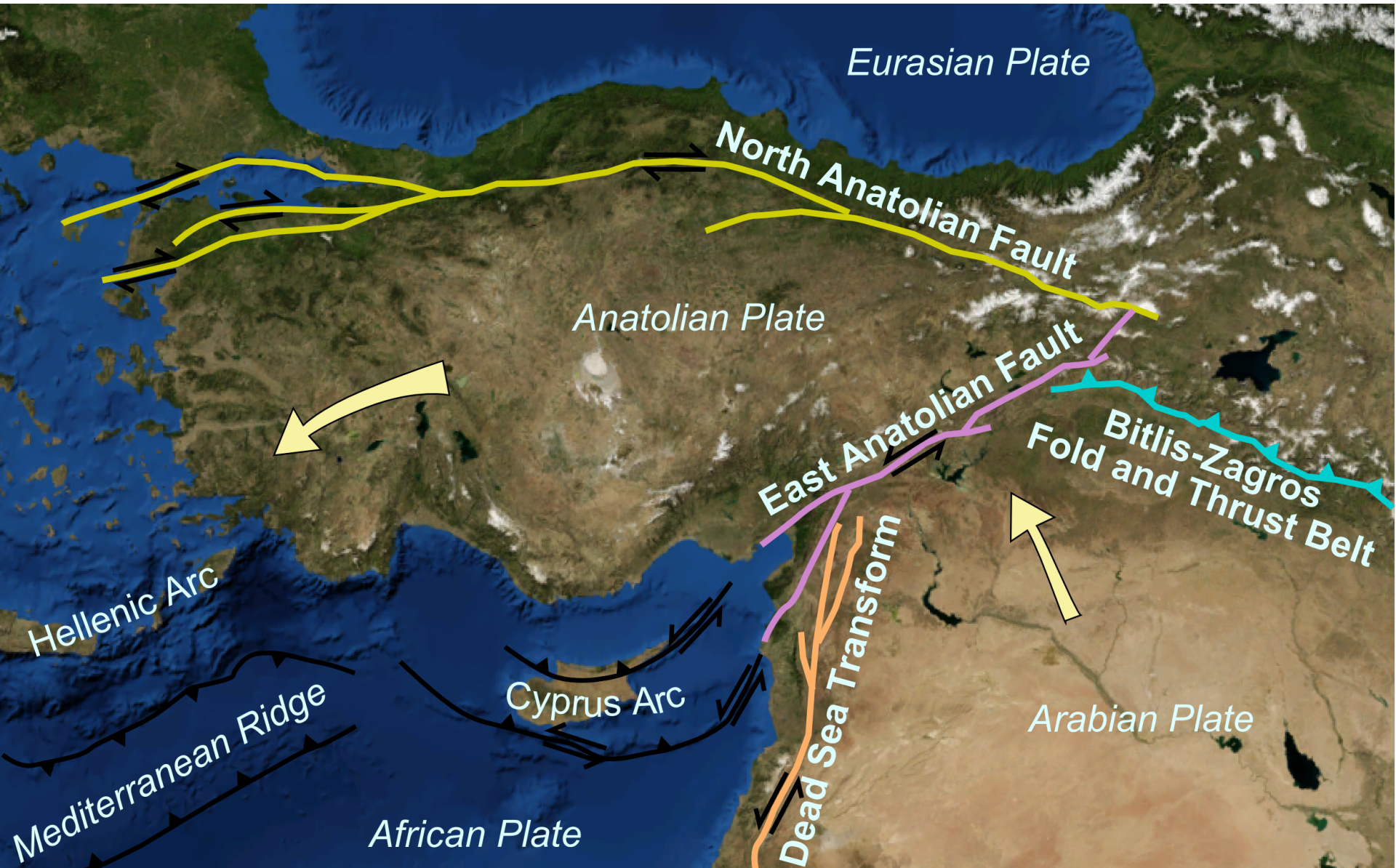


Santorini is what remains after an enormous volcanic eruption that destroyed the earliest settlements on a formerly single island, and created the current geological caldera. The island is the site of one of the largest volcanic eruptions in recorded history: the Minoan eruption, occurred some 3600 years ago at the height of the Minoan civilization.

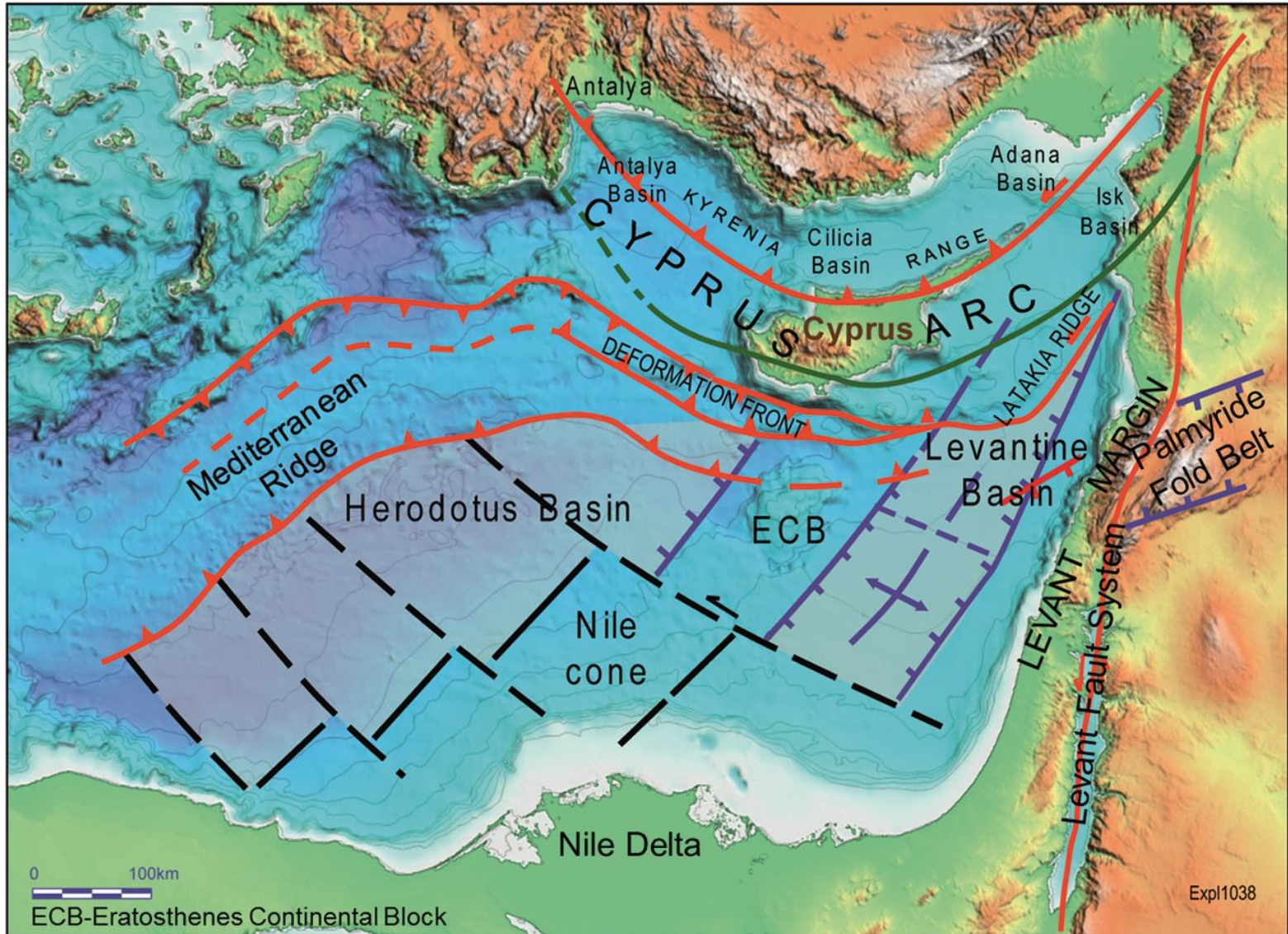
Santorini Is.

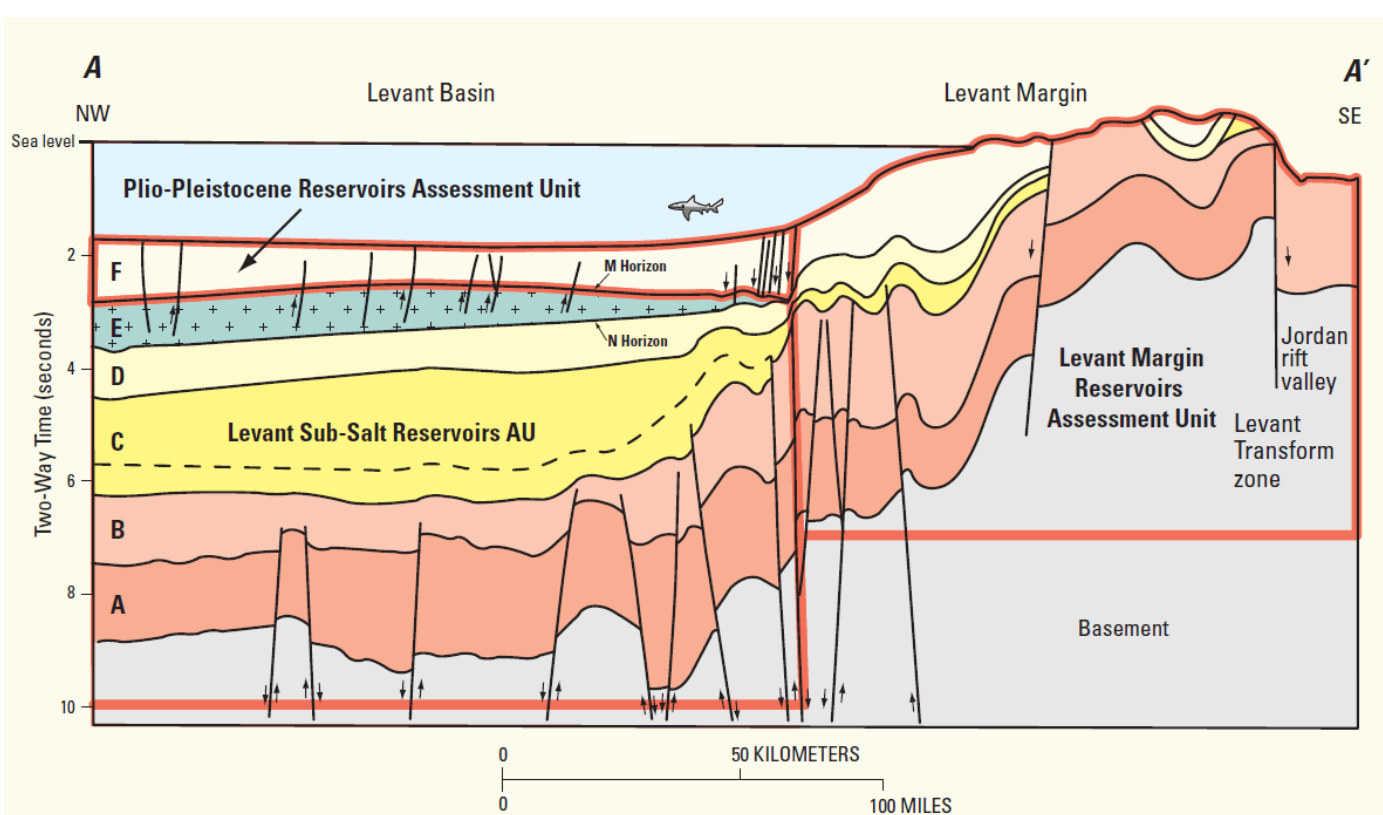
- **The Aegean is characterized by a relatively thicker crust (25-30 km) than a typical oceanic crust, which might be interpreted as a thinned continental crust**
- **The existence of a calc-alkaline inner volcanic arc, the spatial distribution of earthquakes and detailed tomographic studies indicate the existence of a northward-dipping subducted slab beneath this region (African plate beneath Eurasian plate).**
- **The Arabian plate is moving in a north-northwest direction relative to Eurasia at a rate of about 18 mm/yr, averaged over about 3 Myr. These models also indicate that the African plate is moving in a northerly direction relative to Eurasia at a rate of about 6 mm/yr.**

Middle East tectonic setting



Levant Basin

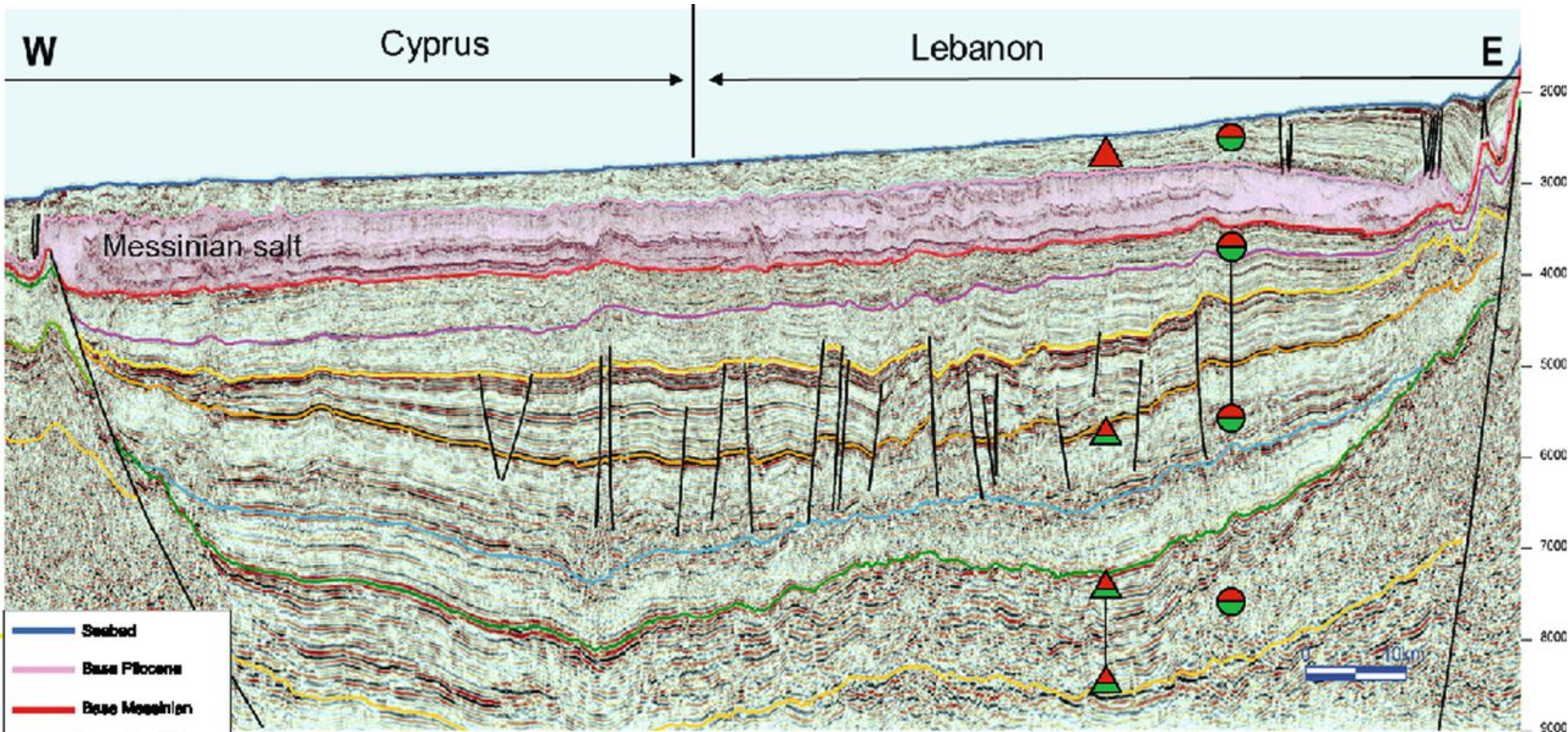




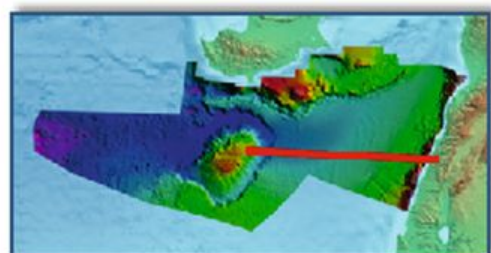
Oil and gas reservoir In the Levant Basin

Estimated total of 3.5 trillion (10^{12}) cubic meters of gas and 1.7 billion (10^9) barrels of oil

SEISMIC PROFILE ACROSS THE LEVANT BASIN



- Seabed
- Base Pliocene
- Base Messinian
- Intra Upper Miocene
- Base Middle Miocene
- Base Miocene
- Eocene Unc.
- Senonian Unc.
- Middle Jurassic



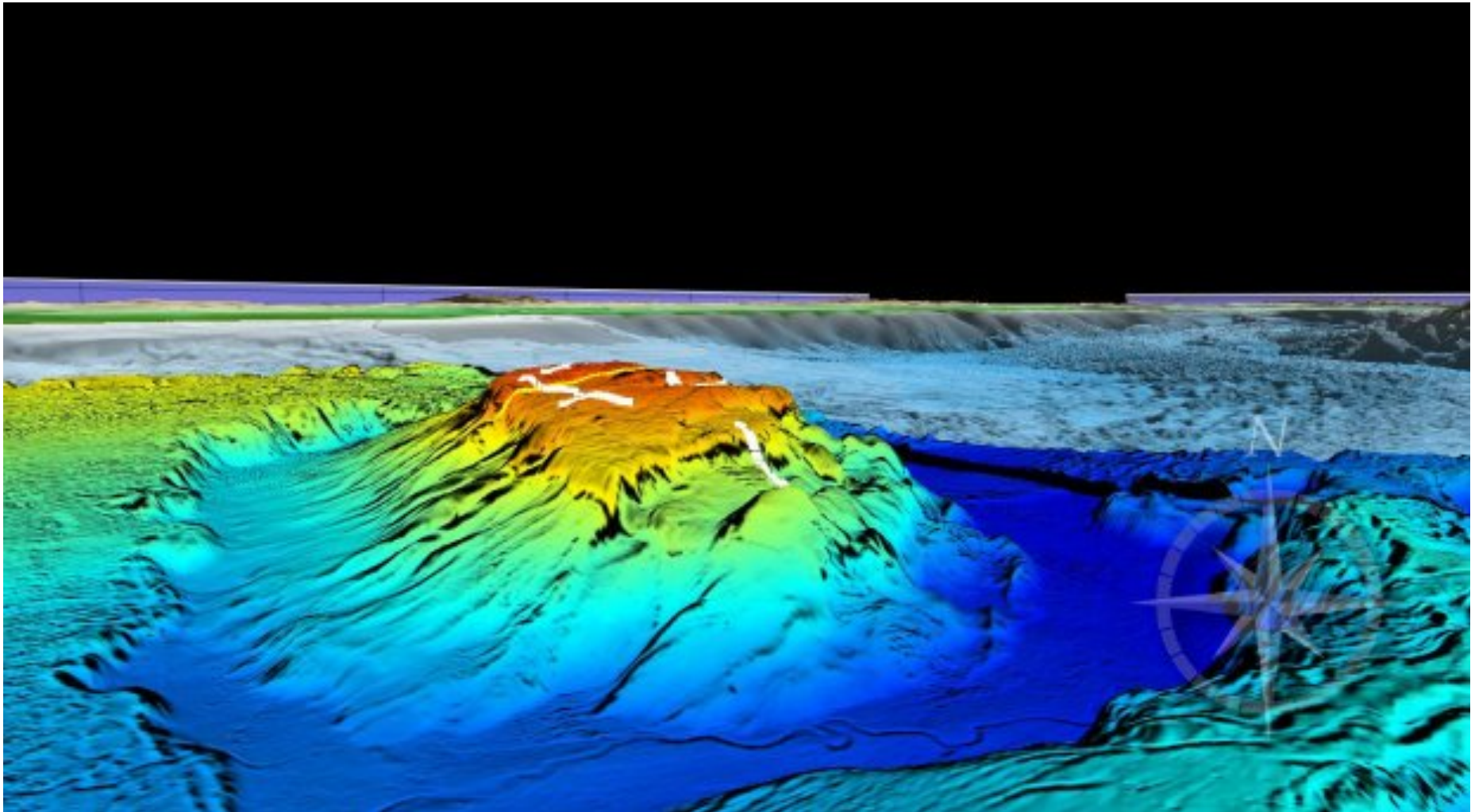
Gas	▲ Potential Source
Oil	
Gas	● Potential Reservoir
Oil	

10km

Heratostene Seamount

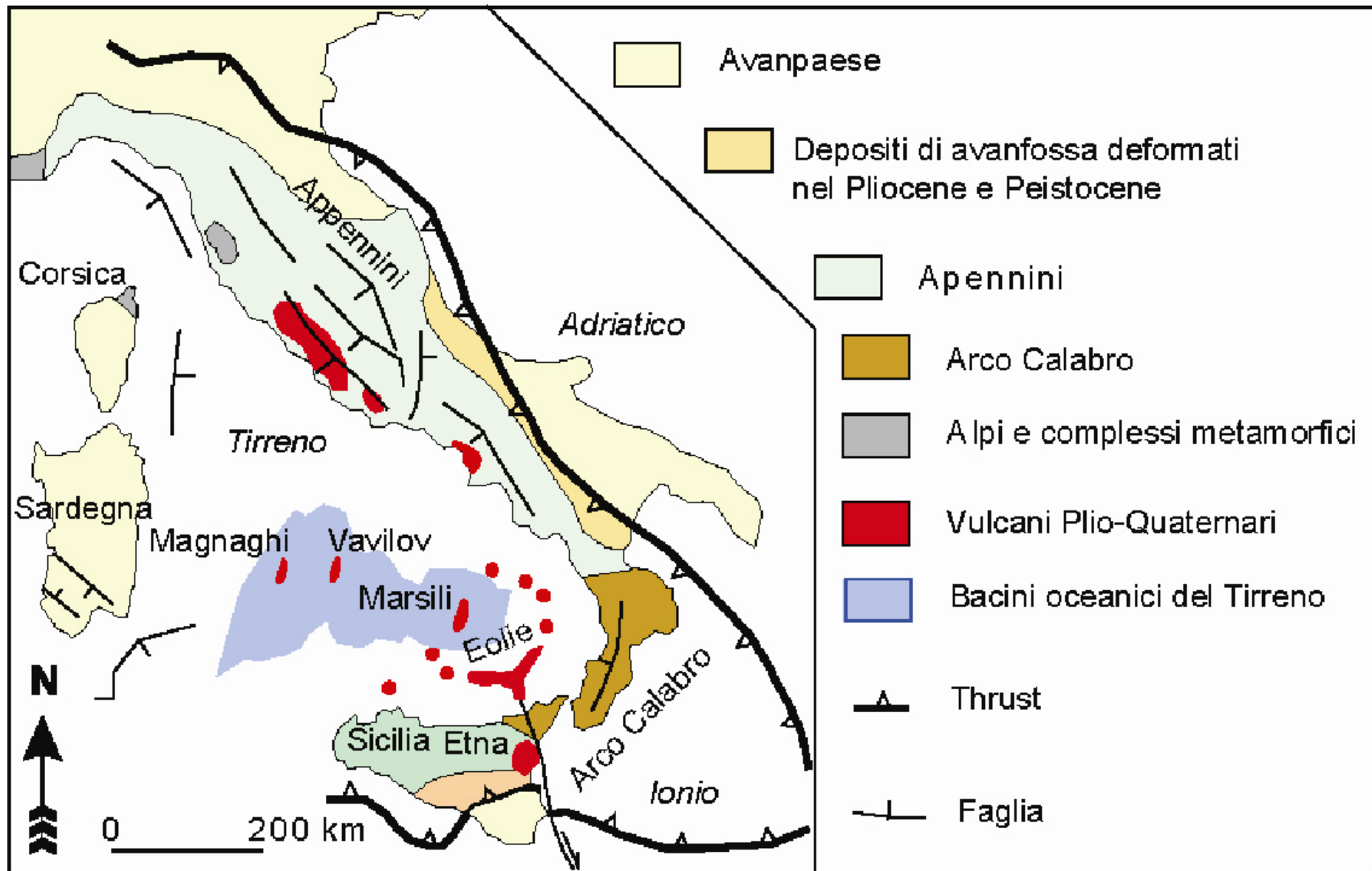
It is located about 100 km south of western Cyprus. It is a large, submerged massif, about 120 km long and 80 km wide. Its peak lies at the depth of 690 m and it rises 2000 m above the surrounding seafloor, which is located at the depth of up to 2,700.

It is capped by a carbonatic layer

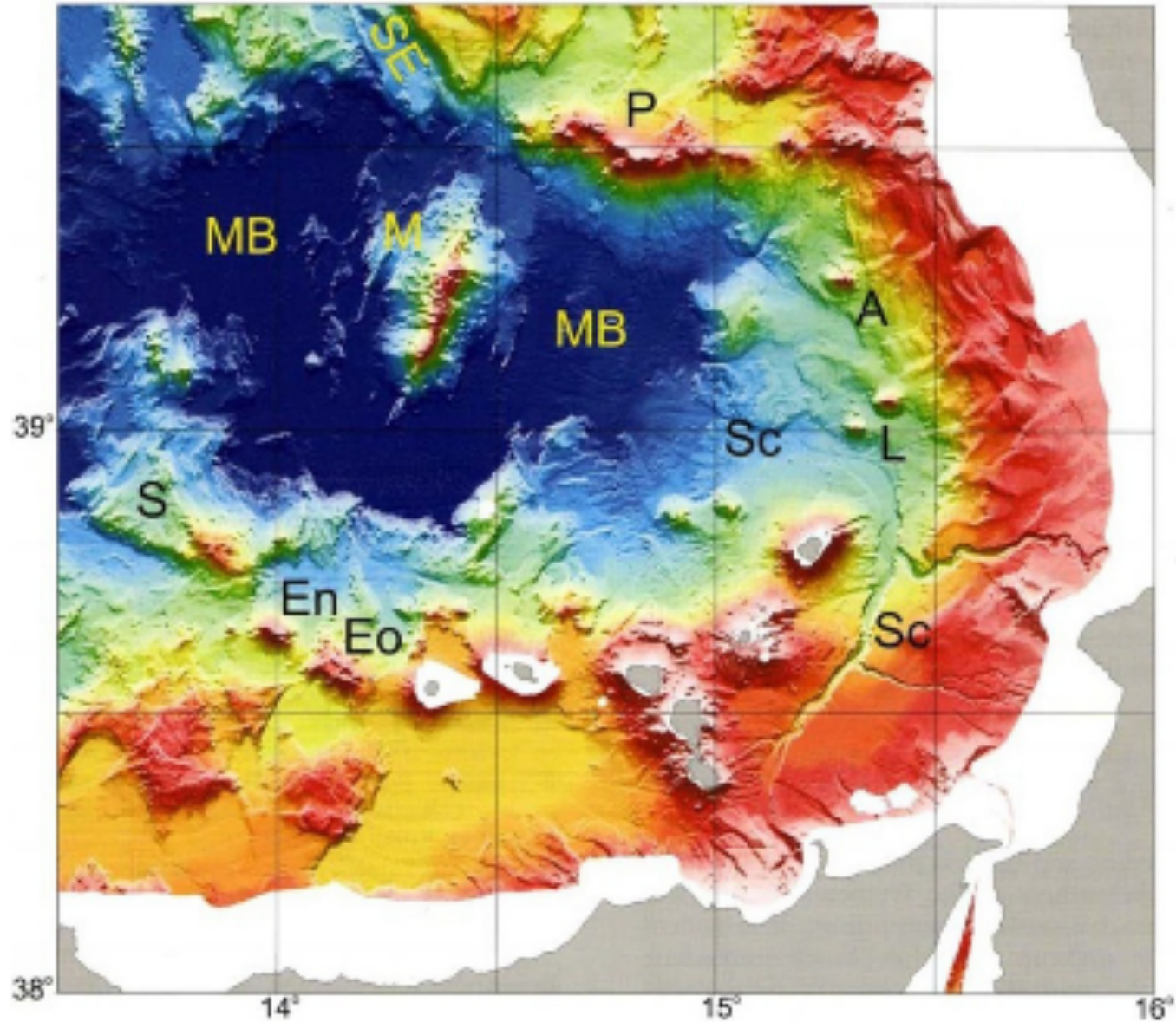


- **The formation of the Levant Basin was associated with the evolution of the Neo-Tethys ocean and its margins**
- **The tectonic framework of the eastern Mediterranean is dominated by the collision of the Arabian and African plates with Eurasia**
- **The sedimentary sequence reaches (in some places) a thickness of 12–14 km**
- **Data suggest the existence of oceanic crust under parts of the Levant Basin and continental crust under the Eratosthene Seamount**

Main geological provinces of the Tyrrhenian Sea region

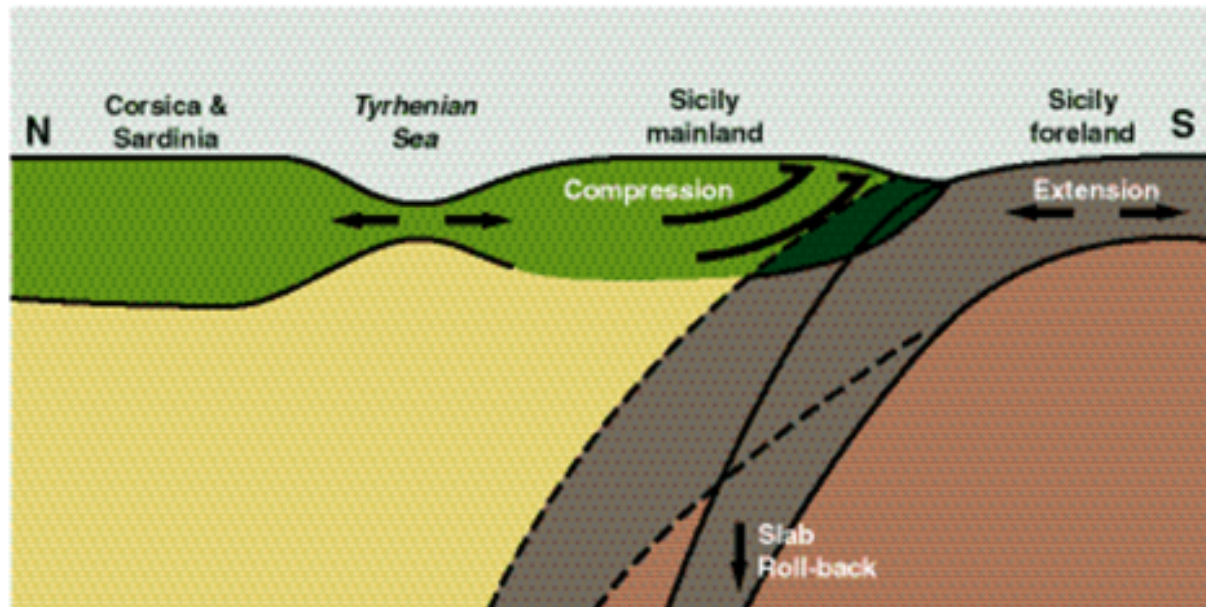


Tyrrhenian Sea bathymetry



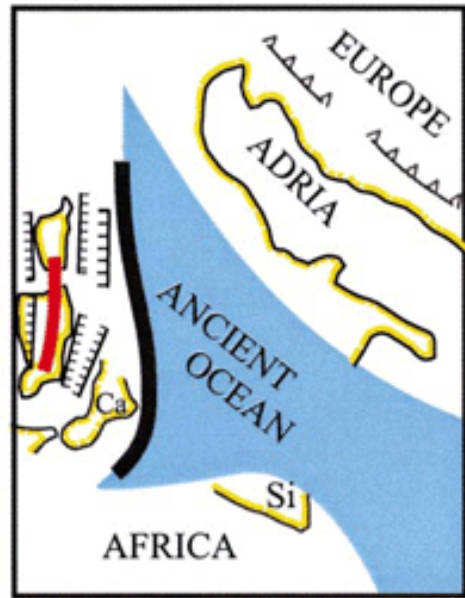
Mechanisms for the Tyrrhenian opening

- Extension in the Tyrrhenian has been explained by a SE rollback of the subduction hinge. If the subduction hinge migrates, or “rolls back” faster than the plates converge, extension will take place in the overriding plate.
- Another mechanism proposed for the Tyrrhenian extension invokes the extensional collapse of a pre-existing orogenic belt.
- Rollback and orogenic collapse are often presented as alternatives, but in the Tyrrhenian region they acted together.

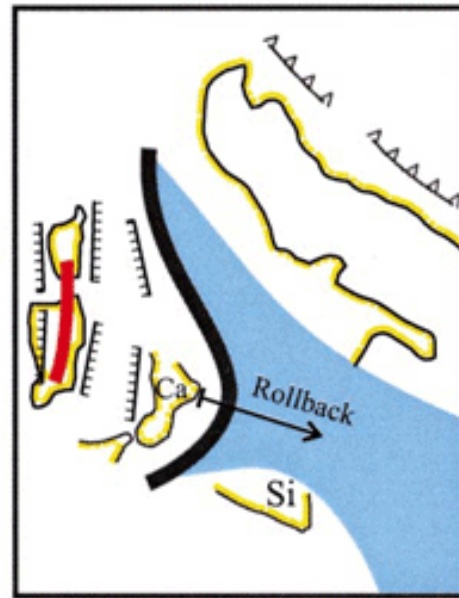


Evolutionary tectonic model showing the opening of the Tyrrhenian Sea and the formation of the Calabrian Arc at four different stages

Early Miocene



Middle Miocene



Early Pliocene



Present

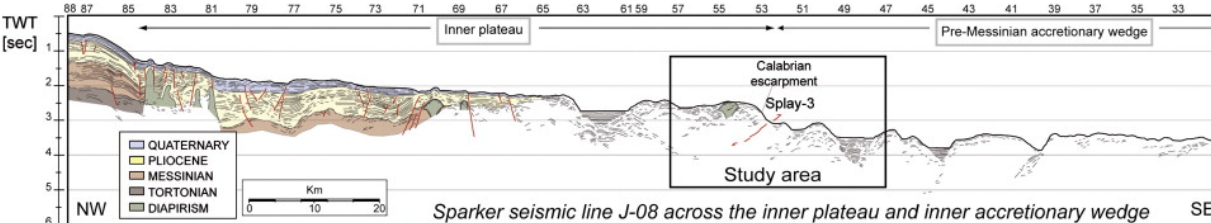
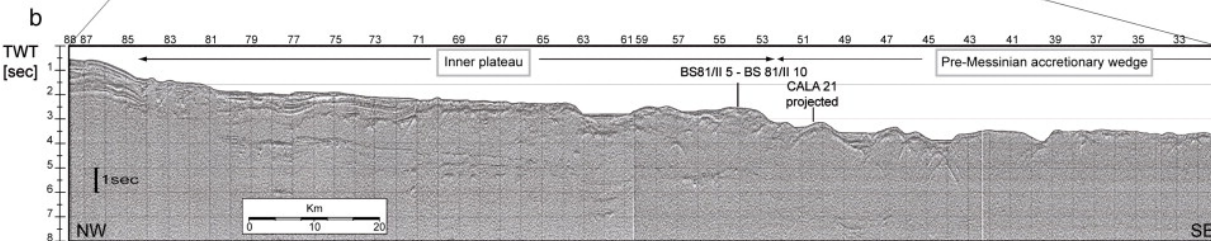
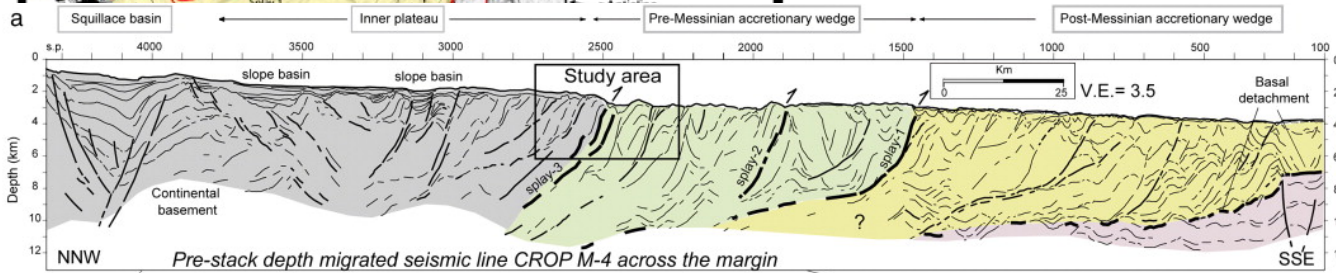
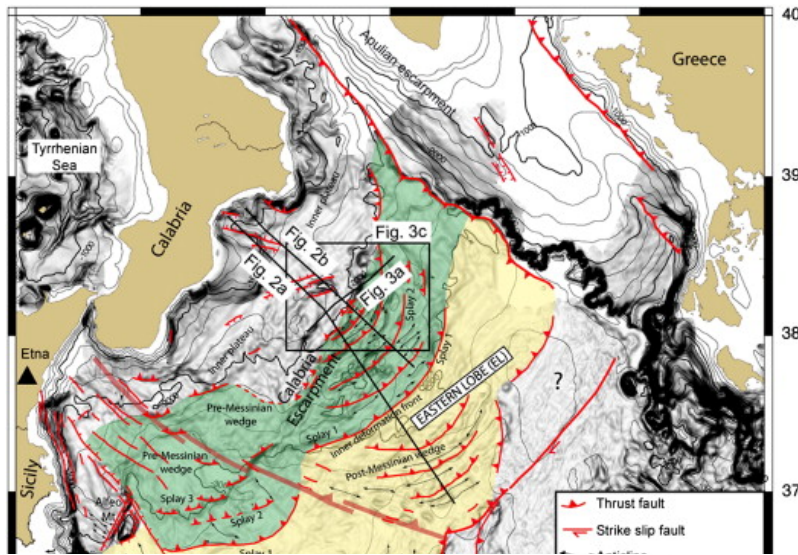


— Arc magmatism
 Active subduction
 ▲▲▲▲ Thrust belt
 ▬▬▬▬ Normal Faulting
■ Newly formed oceanic crust
■ Mesozoic oceanic crust

Sa - Sardinia; Si - Sicily; Ca - Calabria; Co - Corsica; V - Vavilov Basin; M - Marsili Basin

Calabrian Arc

Deformation is related to an imbricate fan within the post-Messinian salt-bearing accretionary wedge (yellow domain), out-of-sequence thrust faults in the pre-Messinian wedge (green domain) and normal faults in the Inner plateau (gray domain).



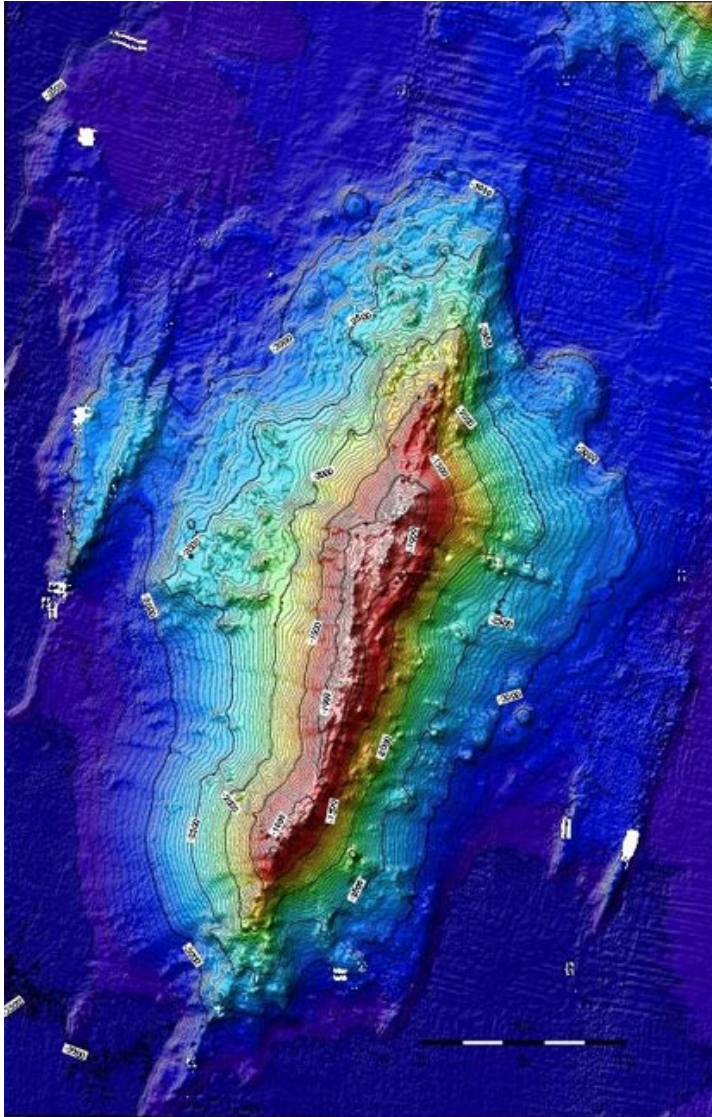
Sparker seismic line J-08 across the inner plateau and inner accretionary wedge

Tyrrhenian region volcanism

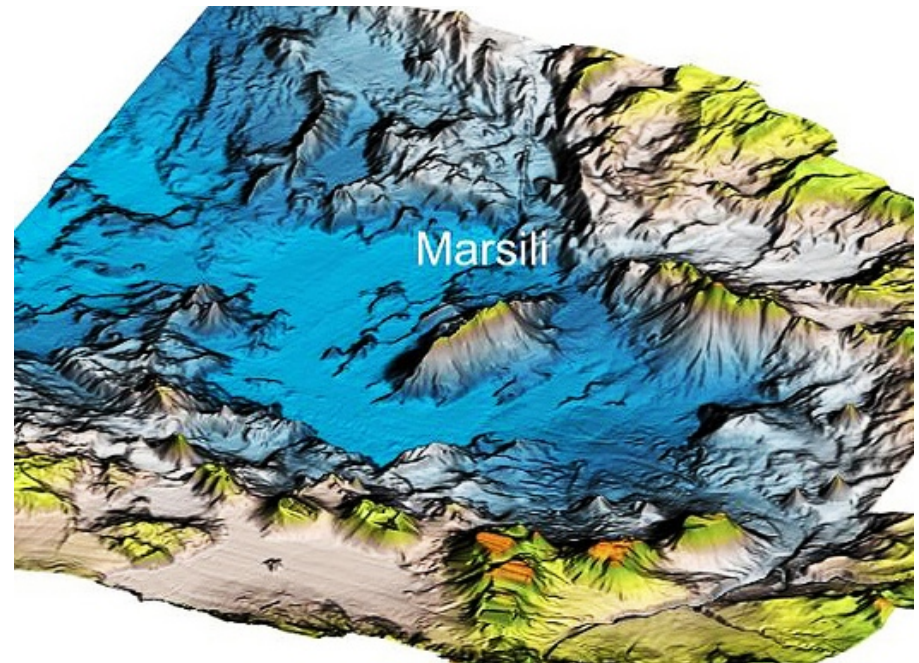


Marsili volcano

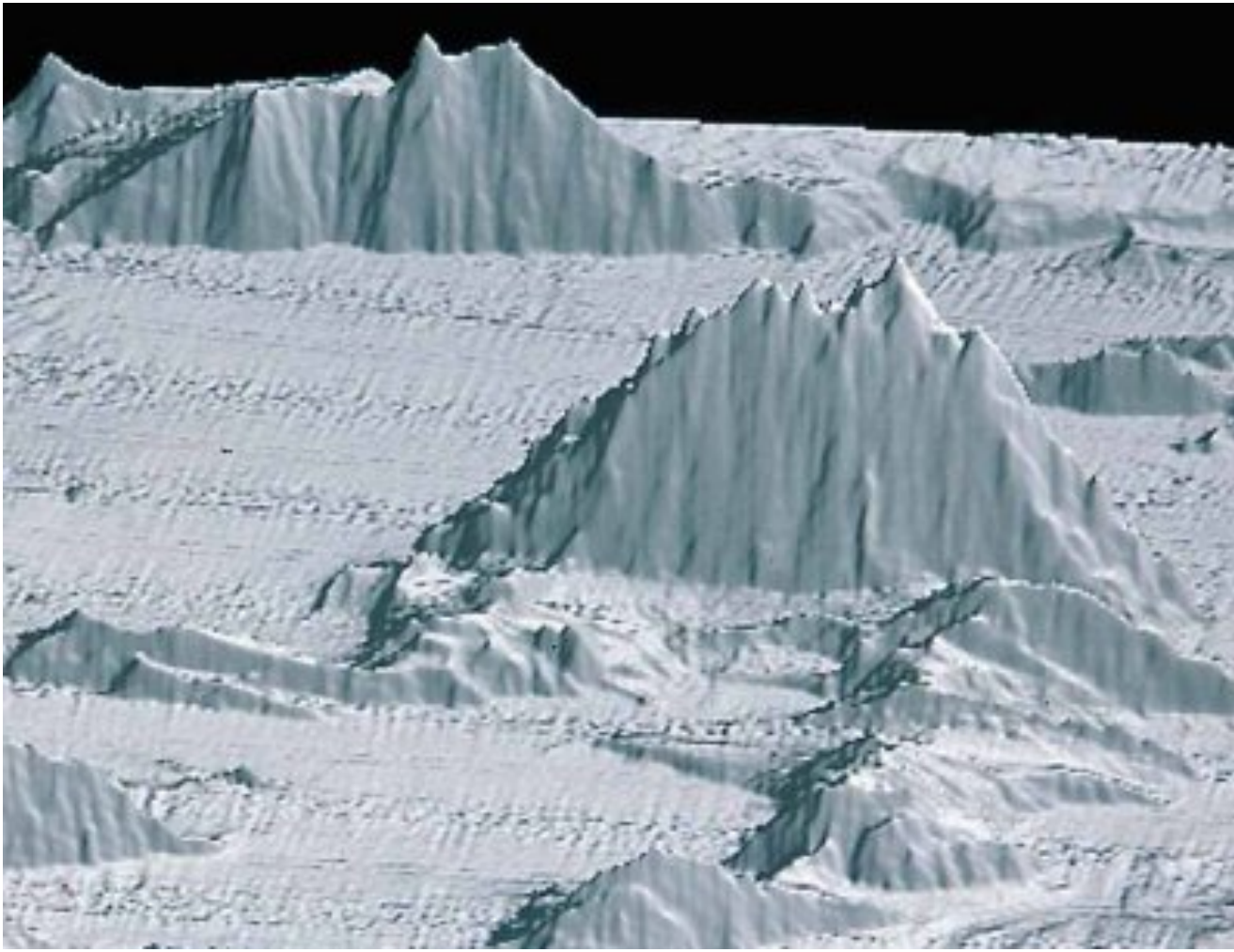
The Marsili volcano is 70 km long and 30 km wide, one of the largest in Europe. Rises to about 3000 meters from the seabed, with the top reaching the altitude of about 450 m below the surface of the Tyrrhenian Sea



K/Ar ages from the Marsili seamount suggest that the Marsili Basin opened at the remarkable full-spreading rate of ~ 19 cm/yr between ca. 1.6 and 2.1 Ma. This is the highest spreading rate ever documented, including that observed at the Cocos-Pacific plate boundary. Renewed but slow spreading during the Brunhes chron (after 0.78 Ma), coupled with huge magmatic inflation, gave rise to the Marsili volcano.

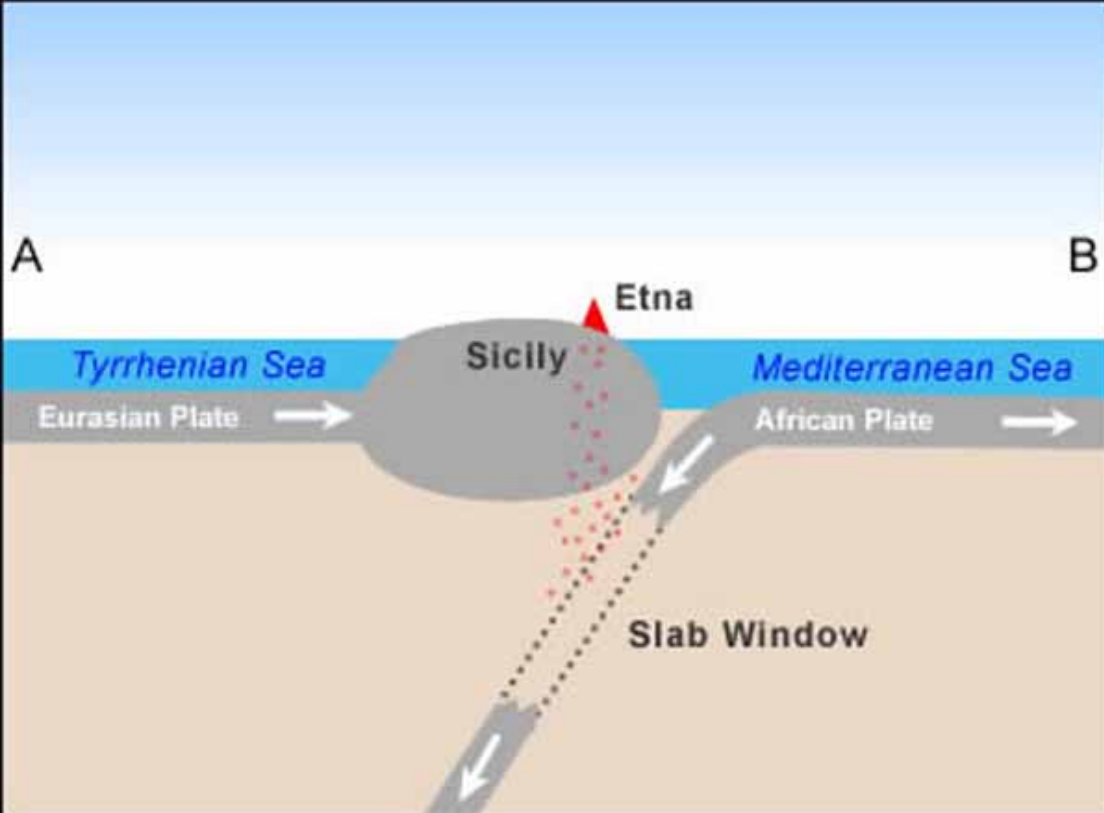


It is an extinct volcano (33 km in length and 17 km in width), which rises to about 2700 m from the sea bed reaching a total of about 800 meters below the surface of the Tyrrhenian Sea. The base of the Vavilov is at depths ranging from 3500 m to 3200 m. A distinctive feature of the volcano is a strong asymmetry between the two sides, with a steep slope on the western side and a slight incline on the eastern side. Its origin is dated from 7.6 to 2 Ma



Vavilov volcano

Subduction of the Ionian Sea



- The Tyrrhenian Sea is an extensional basin that formed in the last 10 Ma in the broad suture between the African and European plates. The convergent plate boundary is evident in the SE corner of the Tyrrhenian Sea, which contains a Benioff zone, a subducting slab imaged by seismic tomography, and the Aeolian islands Quaternary calc-alkaline volcanic arc.
- Backarc spreading of the Tyrrhenian Sea was episodic, with sudden rapid pulses punctuating relatively long periods of tectonic quiescence.
- Extension in the Tyrrhenian Sea took place at the same time as shortening in the arcuate Apenninic-Maghrebian thrust belt that surrounds the basin to the E and S. The maximum amount of extension is more than 300 km in a WNW-ESE direction between Sardinia and Calabria, and is matched by a similar amount of shortening in the Southern Apennines.
- Africa and Europe converged by only about 80 km in a NW-SE direction in the last 10 Ma.
- During the Tyrrhenian opening, the Apenninic deformation front migrated to the E and S and the sedimentary covers of the Adria and African margin were progressively incorporated in the orogenic wedge to form the southern Apennines and the Sicilian Maghrebides. Most of the shortening in the southern Apennines took place after 10 Ma, at the same time as extension in the Tyrrhenian basin. The deformation front moved the farthest to the southeast toward the subducting Ionian oceanic seaway. Sediments accreted or underplated from the Ionian basin formed a large accretionary wedge to the SE of Calabria.
- Extension rates averaged over the last 10 Ma are 40-50 km/Ma. If the Tyrrhenian started forming 10 Ma, this gives an average extension rate of 37 km/Ma, which matches the averages estimated by other authors.
- GPS data show that Calabria is not presently moving to the SE with respect to Sardinia, suggesting that extension in the Tyrrhenian domain is not active at present.

Belderson, 1974

Calabrian Ridge

Rossi and Sartori, 1981

External Calabrian Arc

boundary between the structural domains

Minelli and Faccenna, 2010

onset of the foreland domain

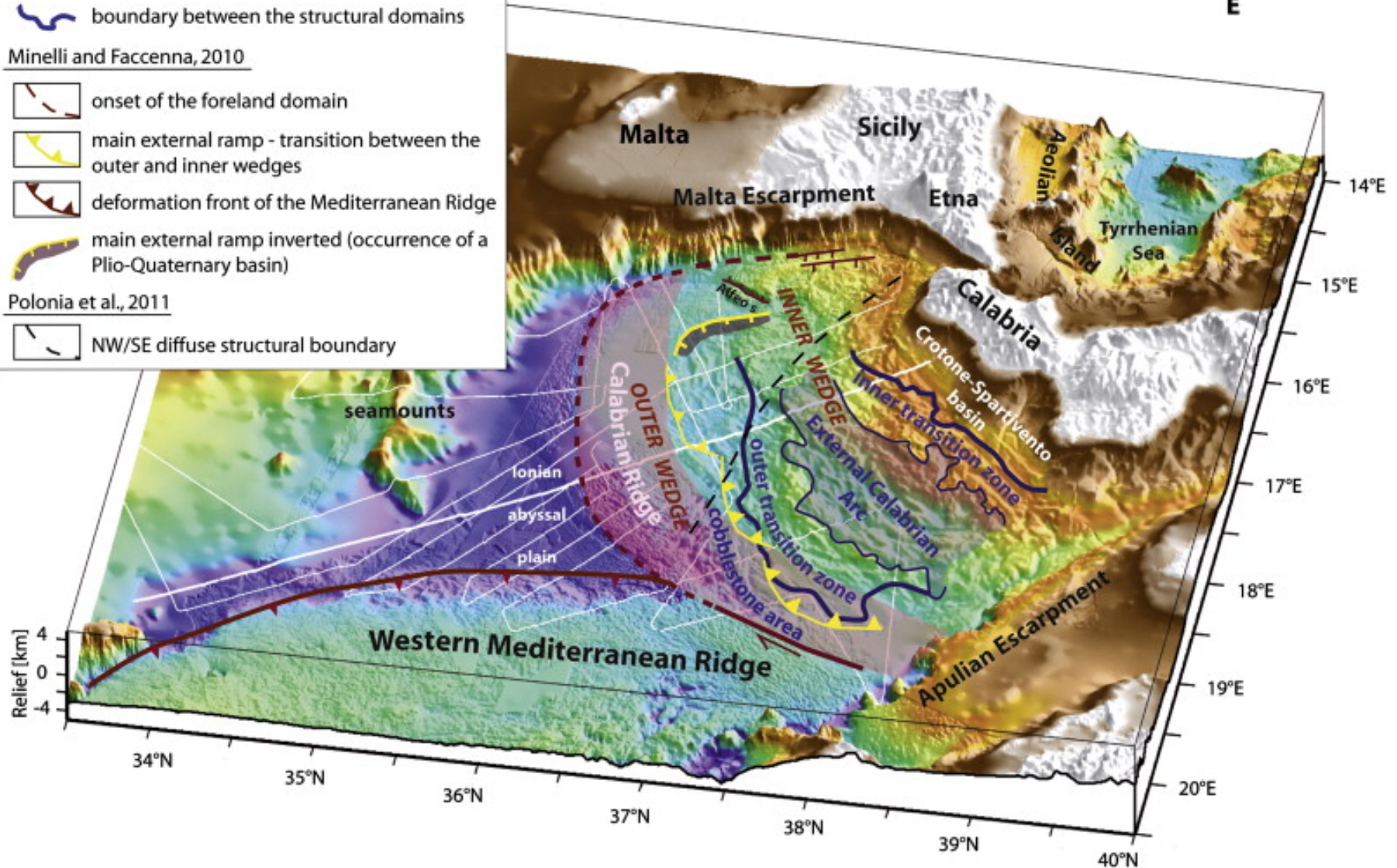
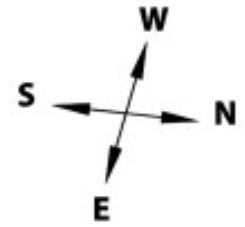
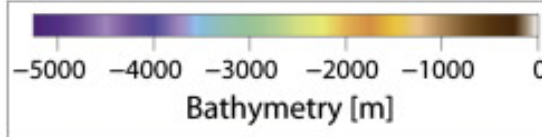
main external ramp - transition between the outer and inner wedges

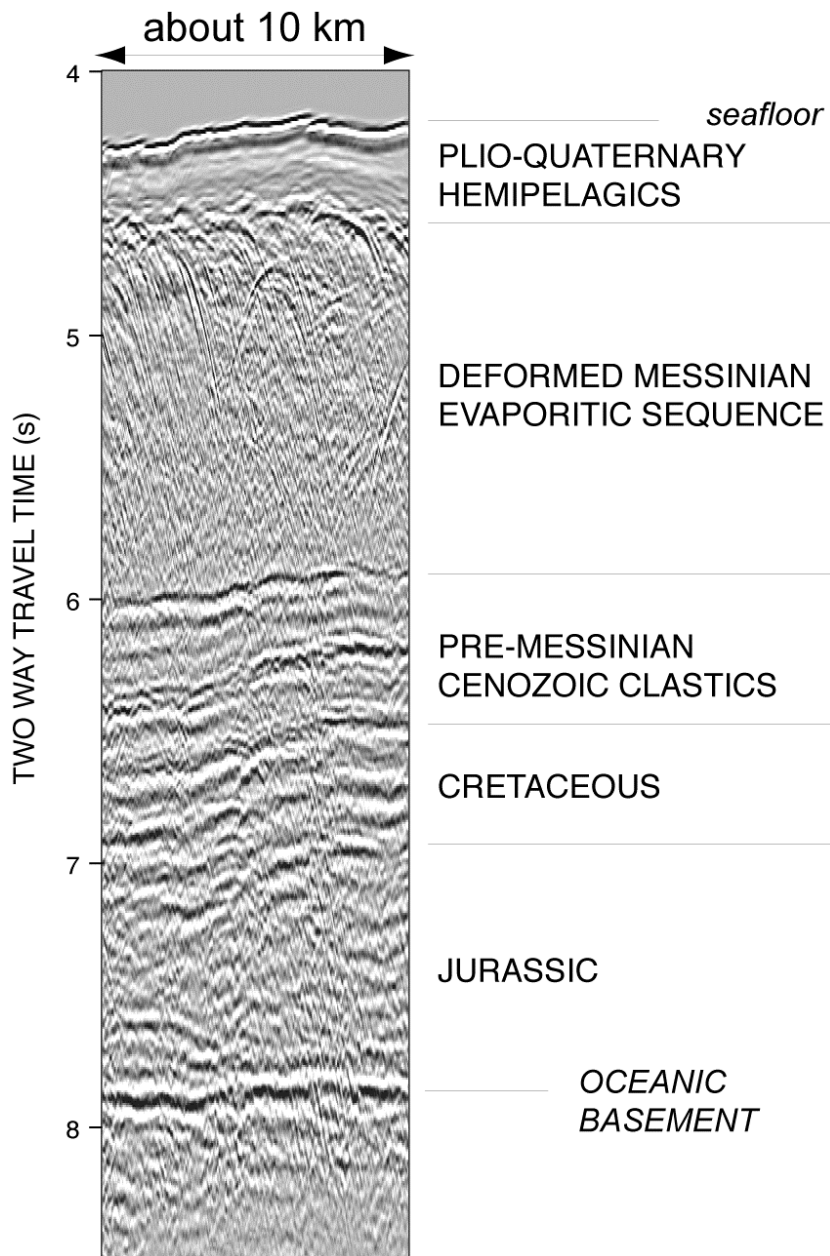
deformation front of the Mediterranean Ridge

main external ramp inverted (occurrence of a Plio-Quaternary basin)

Polonia et al., 2011

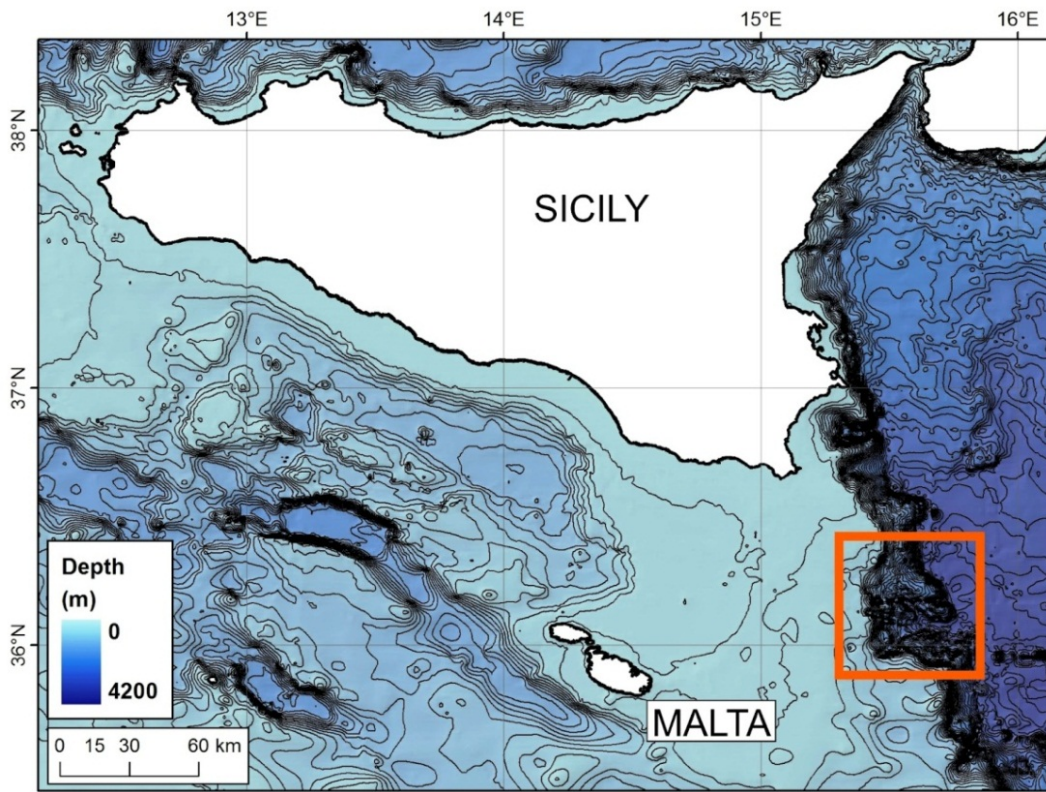
NW/SE diffuse structural boundary



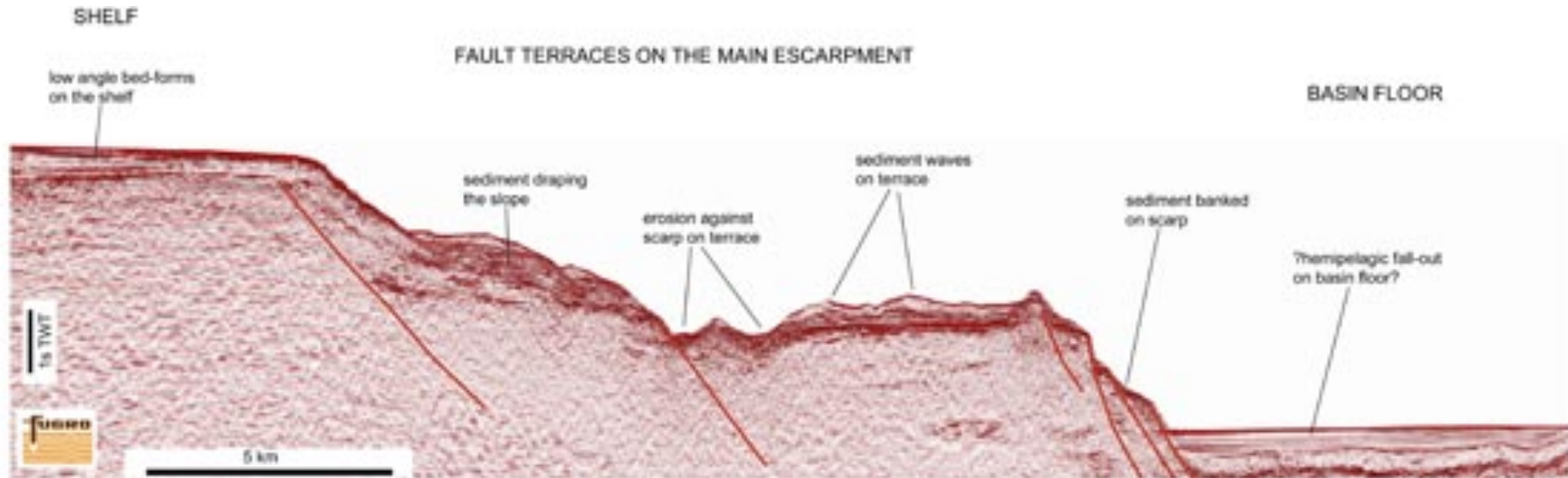


Ionian Sea

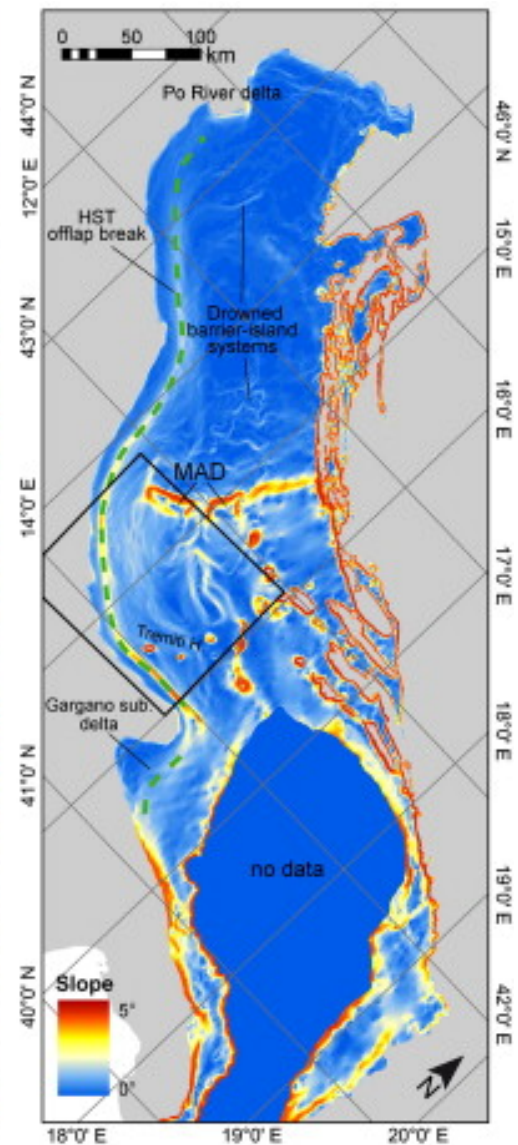
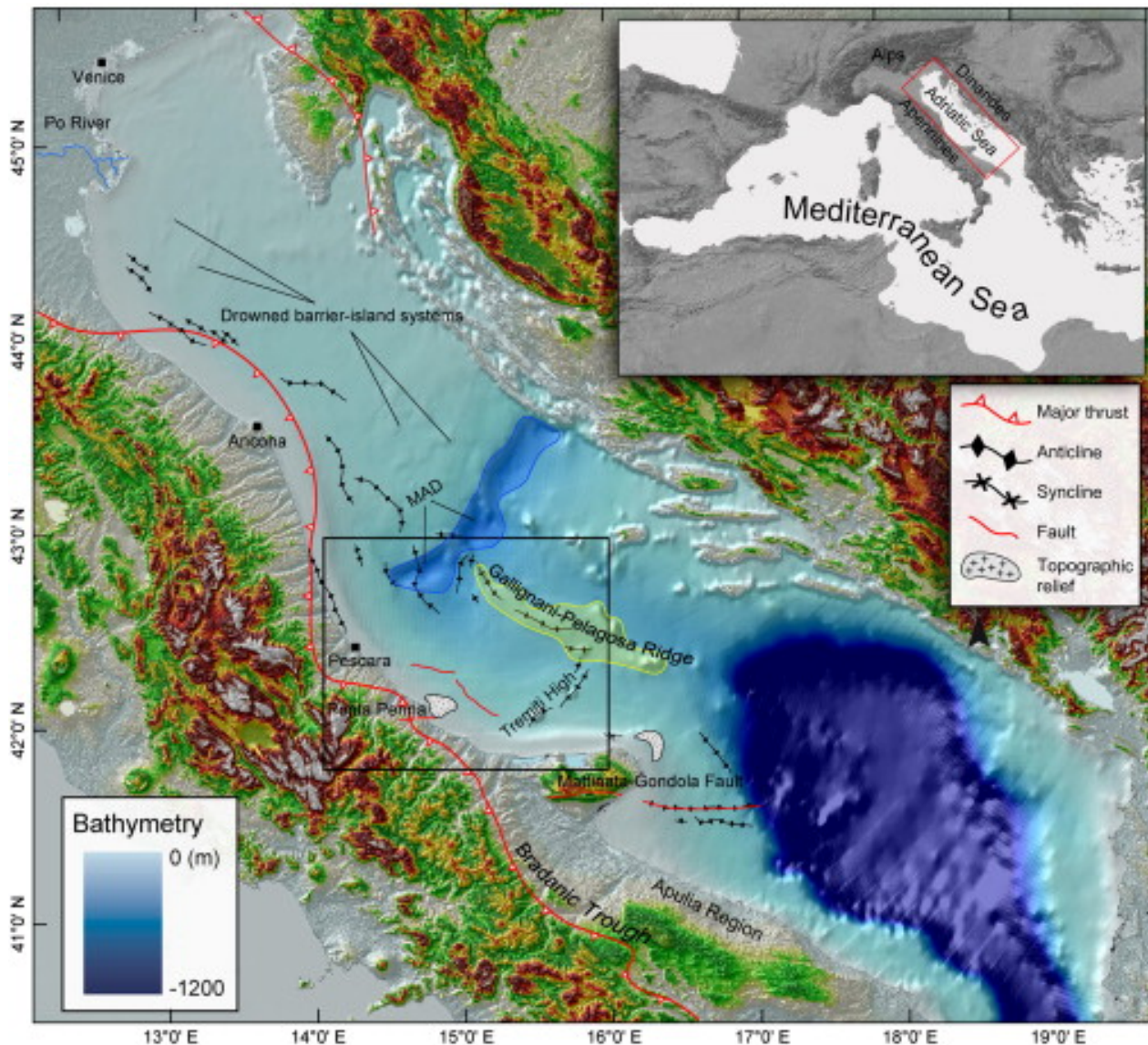
- As the last non-subducted sector of the Neo-Tethys ocean, the Ionian Sea turns out to be the oldest *in situ* ocean fragment of the world.
- It has been saved from subduction since locked within irregular S shaped continental margins of Africa and Eurasia.
- It is a 350 km wide x 600 km long abyssal plain lying at 3–4 km depth, locked between the continental platforms of northern Africa, Malta-Hyblean plateau, and Apulia, and active orogens of Calabria Arc and Hellenides.
- A thick package (5–7 km) of sediments overlying an extremely thin (8–11 km) crystalline crust.



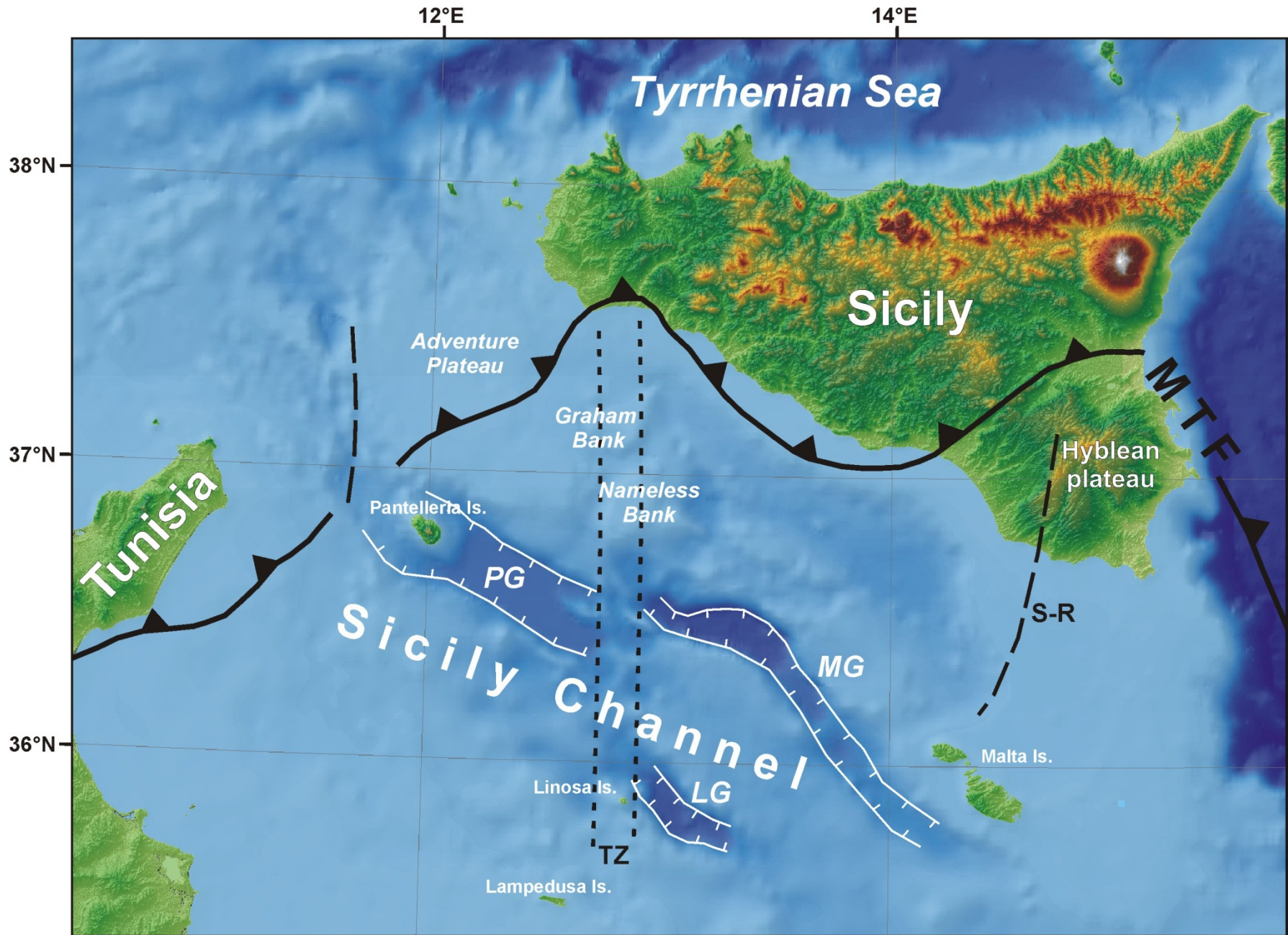
Malta Escarpment



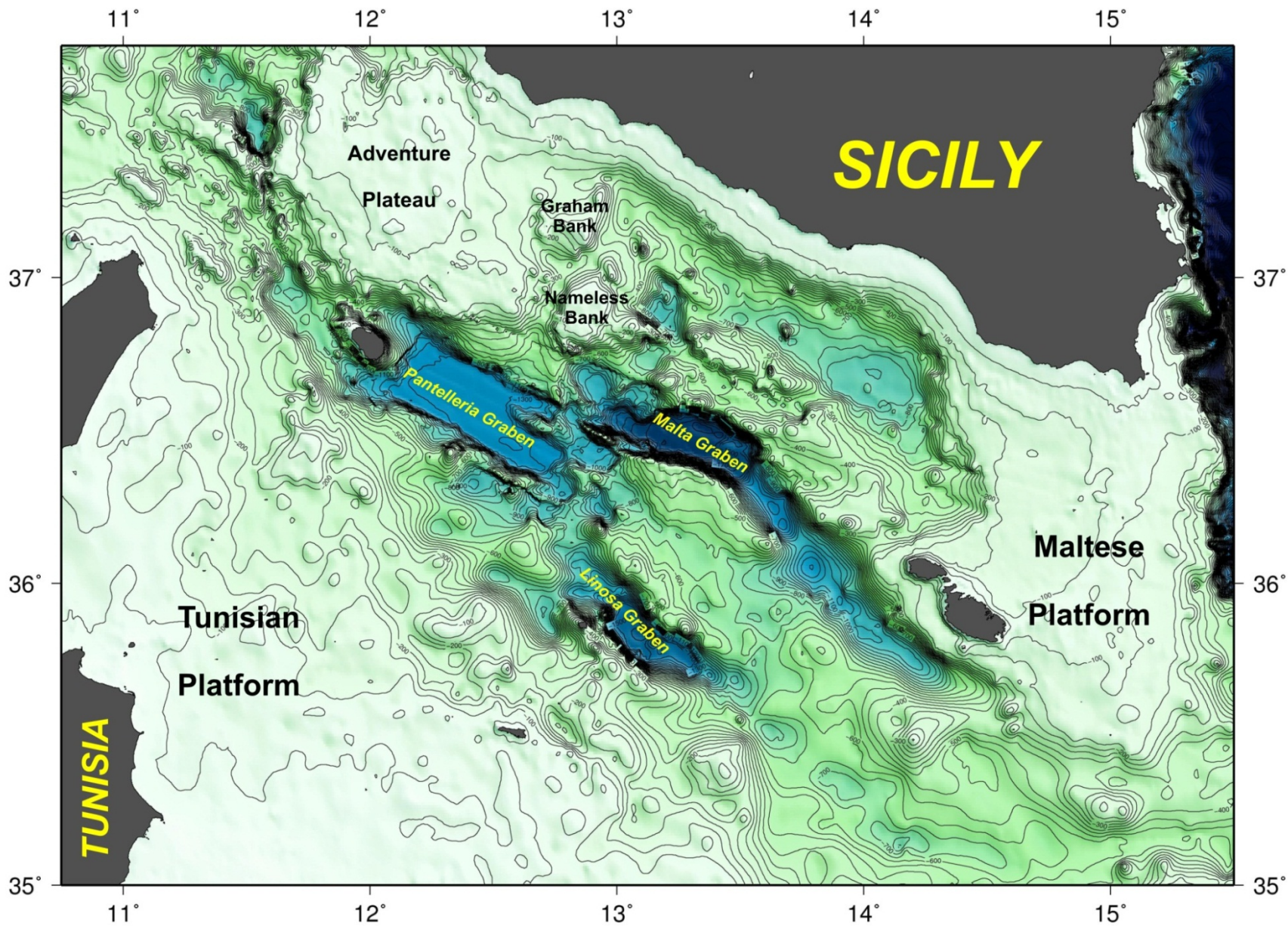
Adriatic Sea

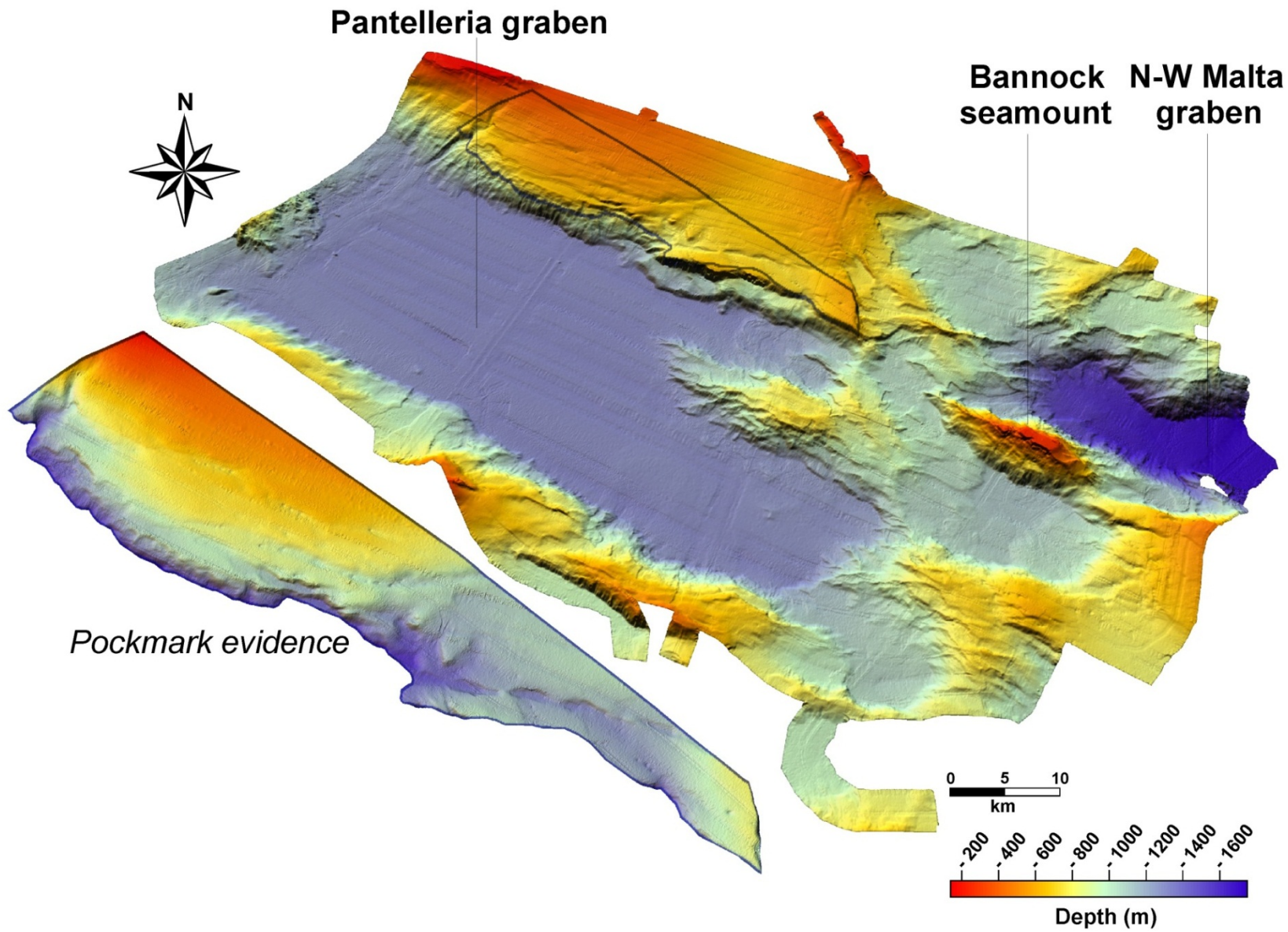


- **The Adriatic Sea and the Po Valley are associated with a tectonic microplate - Apulian or Adriatic Plate - that separated from the African Plate during the Mesozoic. This separation began in the Middle and Late Triassic, when limestone began to be deposited in the area. Between the Norian and Late Cretaceous, the Adriatic and Apulia Carbonate Platforms formed as a thick series of carbonate sediments (dolomites and limestones), up to 8 km thick. In the Eocene and early Oligocene, the plate moved north and north-east, contributing to the Alpine orogeny (along with the African and Eurasian Plates' movements) via the tectonic uplift of the Dinarides and Alps. In the Late Oligocene, the motion was reversed and the Apennine Mountains' orogeny took place.**
- **The Adriatic Basin was formed by the subsidence of the pre-existing foreland region into a basin (present since Pliocene time) and the subsequent eastward-thrusting movements of the Apennine mountain chain toward and into the western part of this Adriatic Pliocene basin.**
- **The most important structural elements are the Apennine overthrust chain in the west, the Dinarides overthrust chain in the east. The Adriatic Sea which is in the middle is being squeezed on both sides by both overthrust areas. The Adriatic comprises the folded foredeep region just to the east of the Apennines which have significantly folded and compressed the section and the central foreland or carbonate high region which runs roughly down the center of the Adriatic Sea from the east in the northern region offshore Croatia, to the west of the Adriatic in the south near the heel of Italy. This foreland region effectively splits the Adriatic basins into two main areas.**

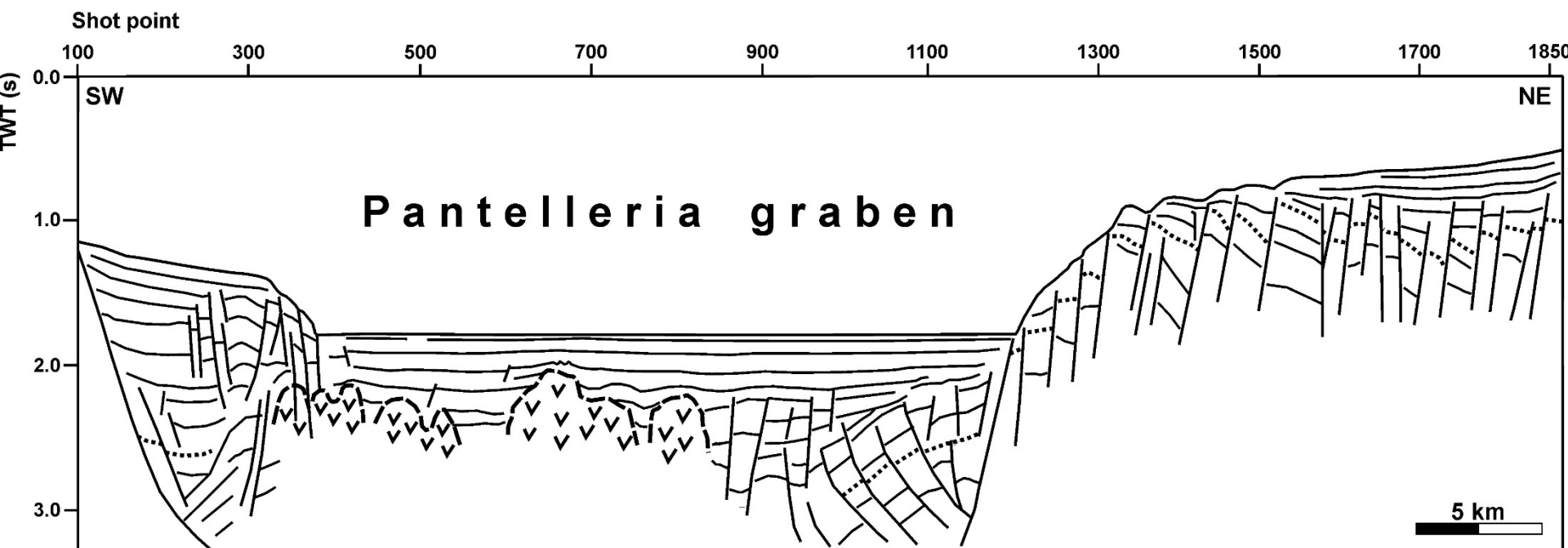
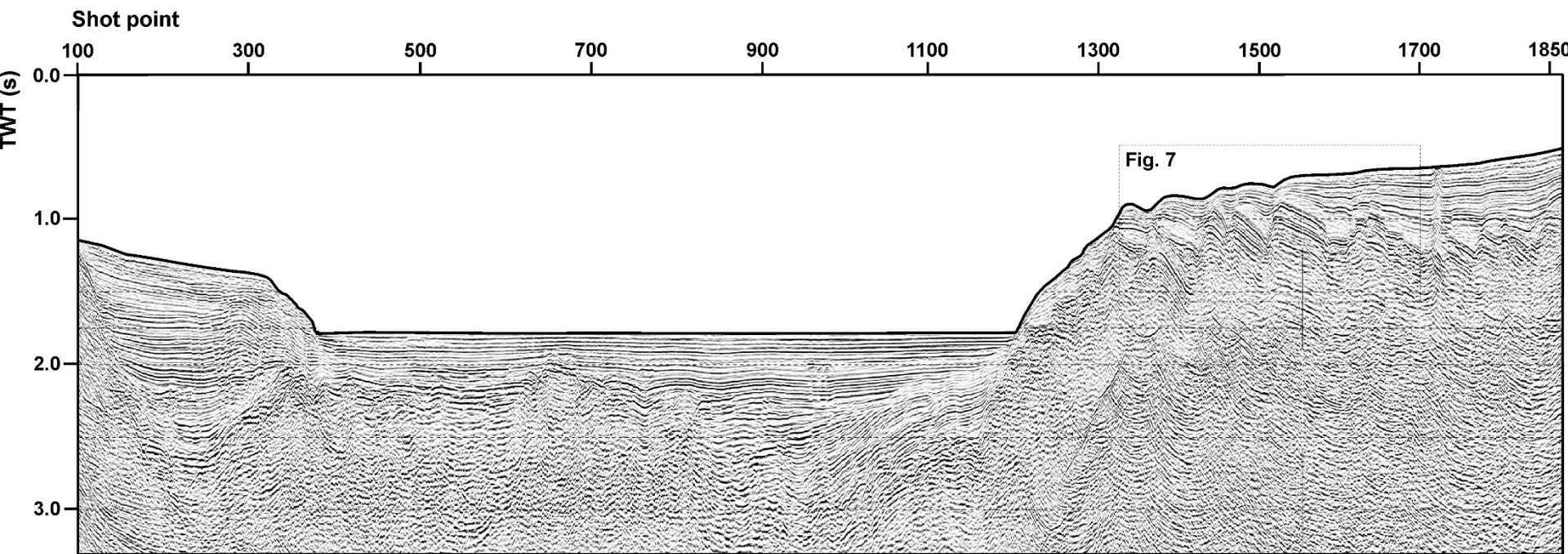


SICILIAN CHANNEL

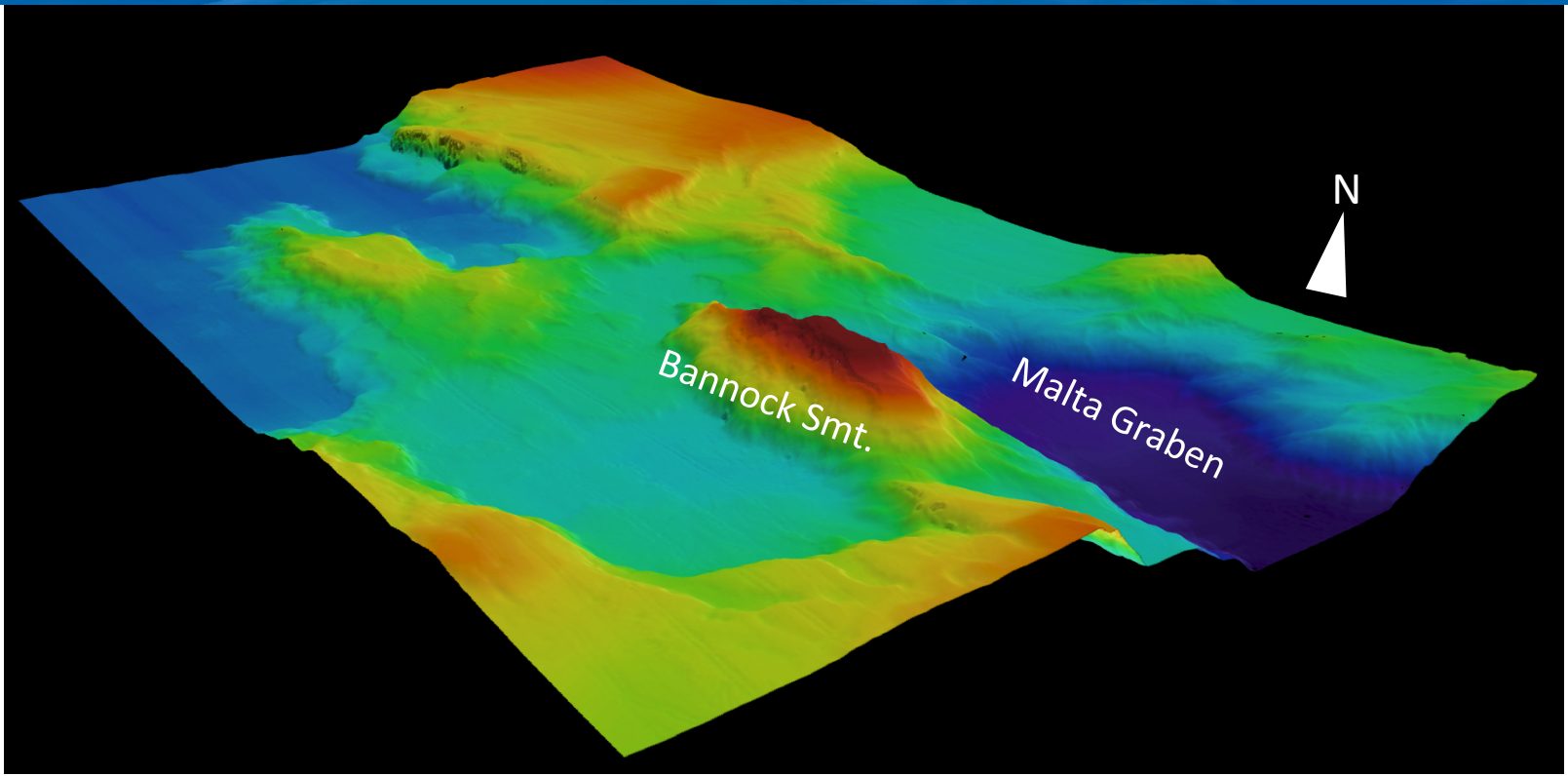
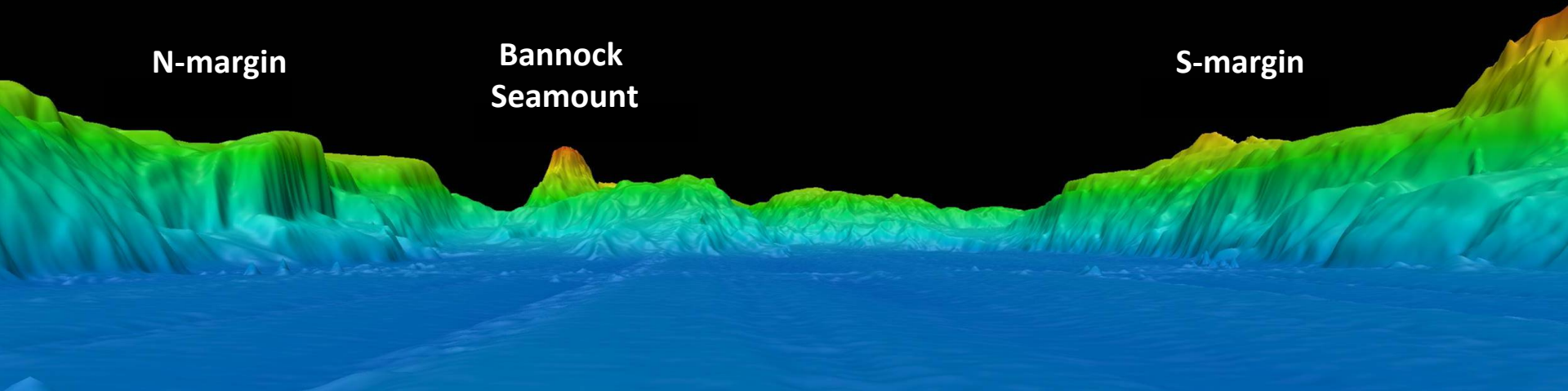




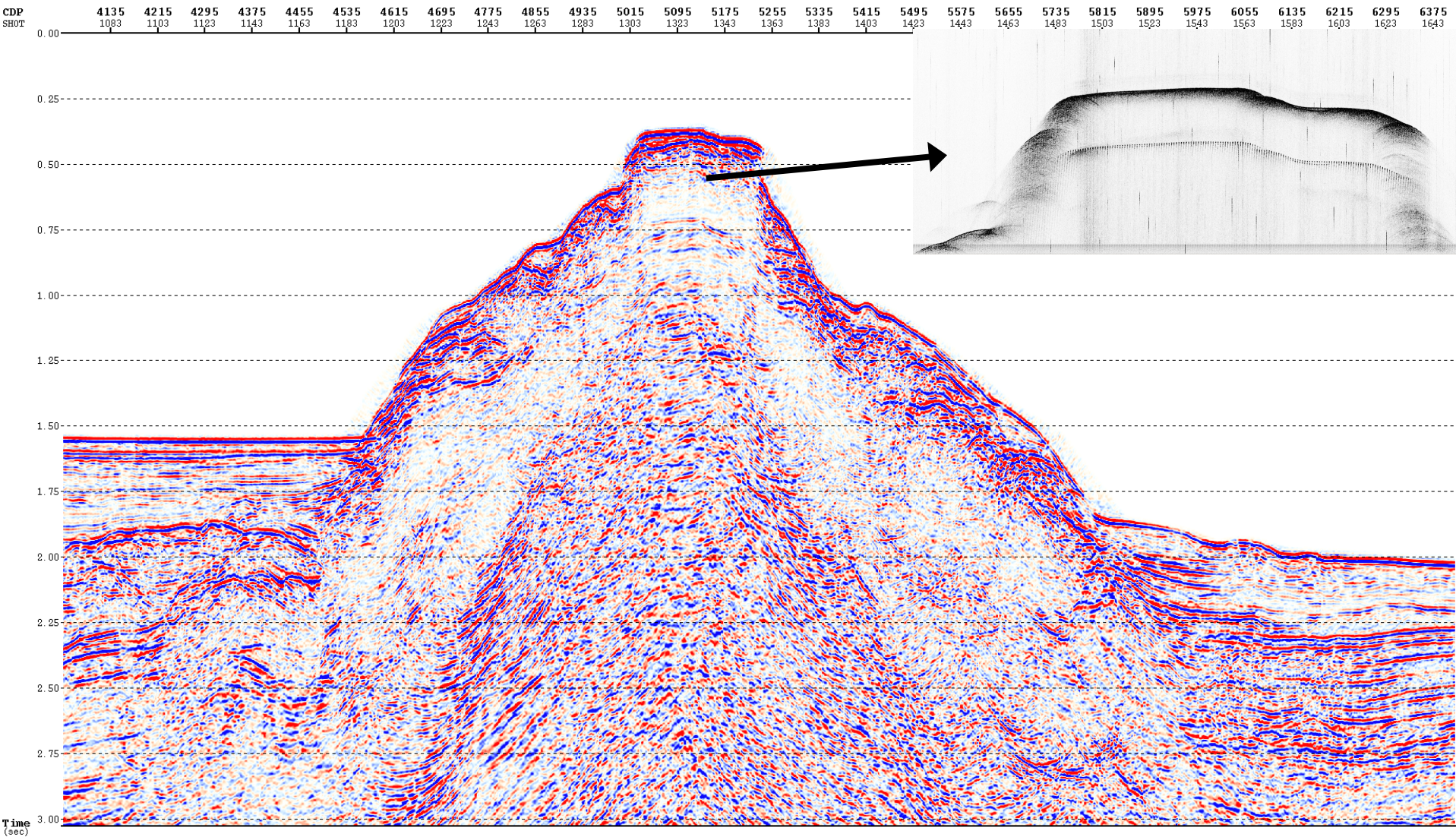
PANI - 3



The Pantelleria Graben from Pantelleria Is. (view toward S-E)



Bannock Seamount

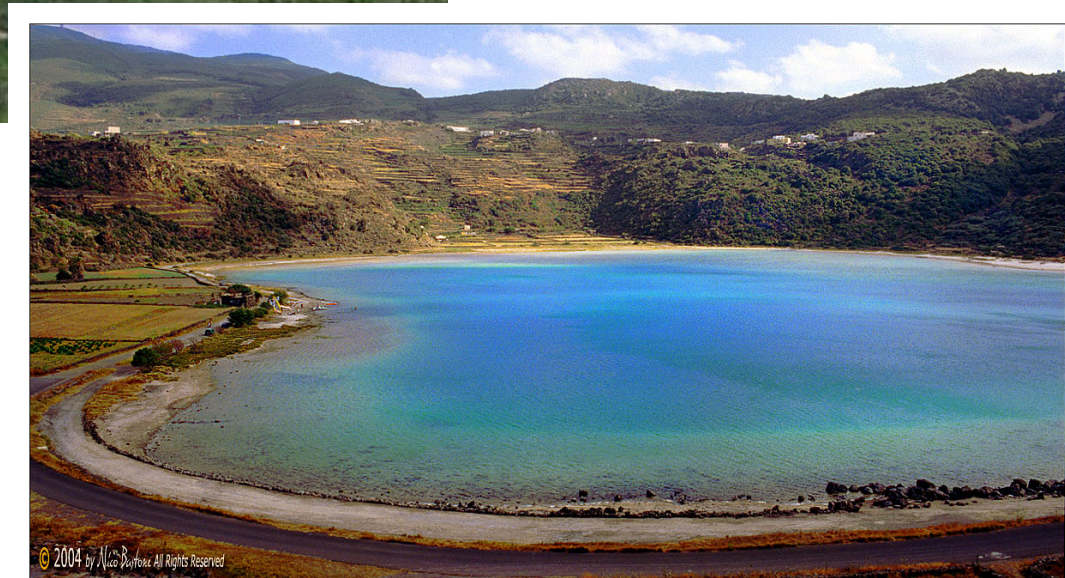


Time (sec)

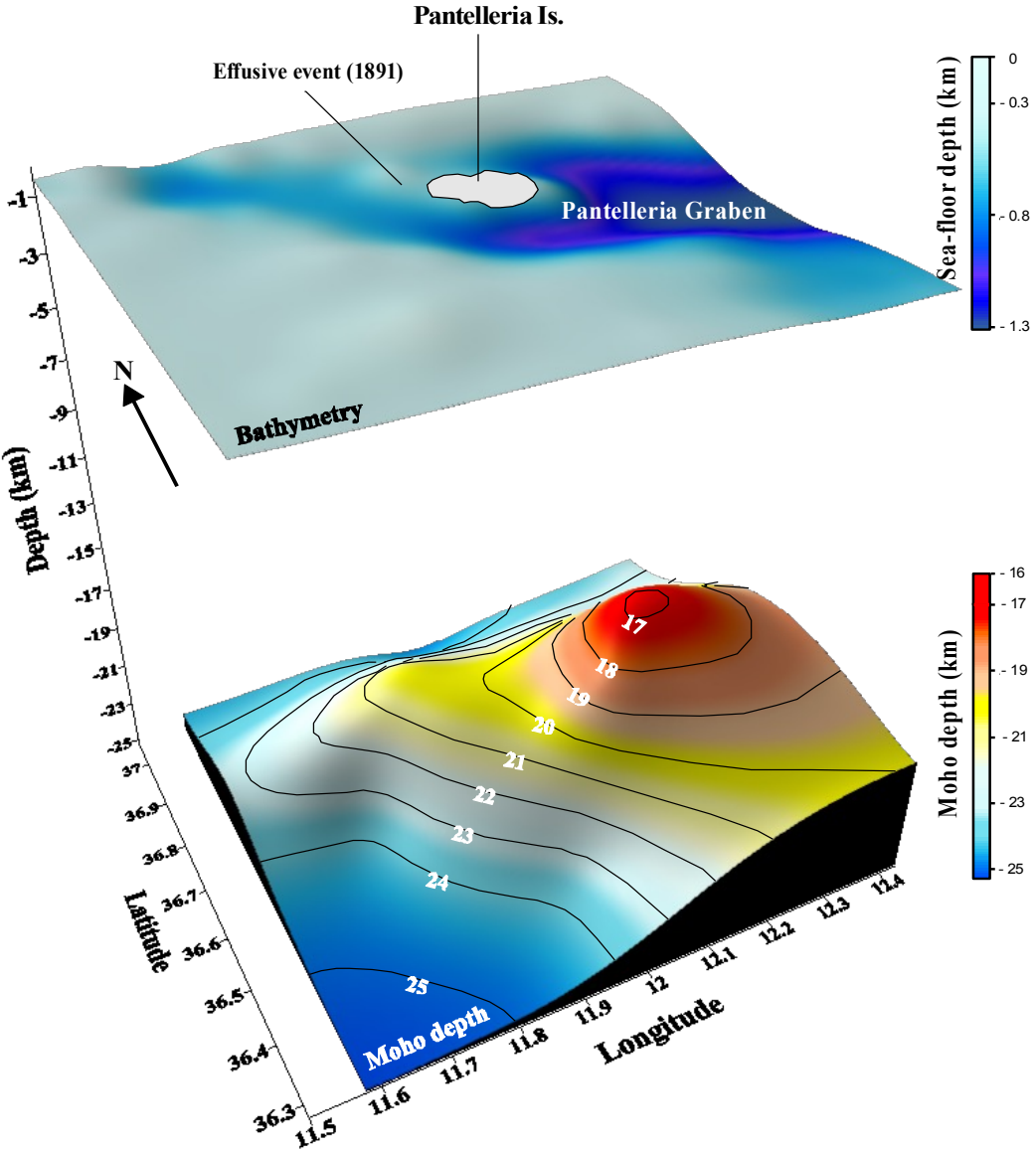


Montagna Grande

Lago di Venere



3-D Moho depth geometry beneath the Pantelleria Island



Emersion: July, 1831
(4 sqkm, 65 m high)
Disappeared: December, 1831



Ferdinandea Is.



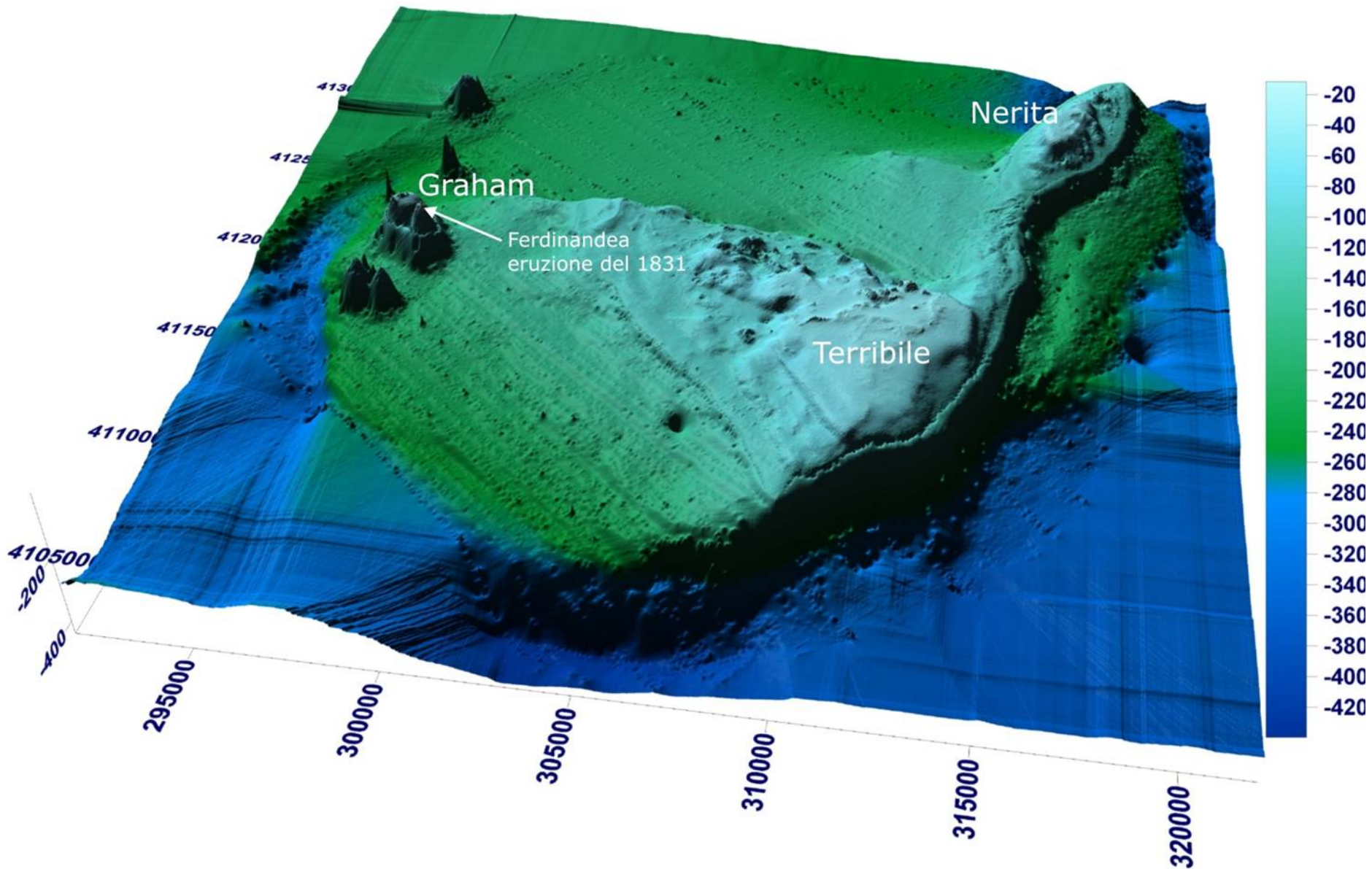
Claimed by:
UK, FRANCE, REGNO DUE SICILIE

Surtsey Island

(emerged on 1963)

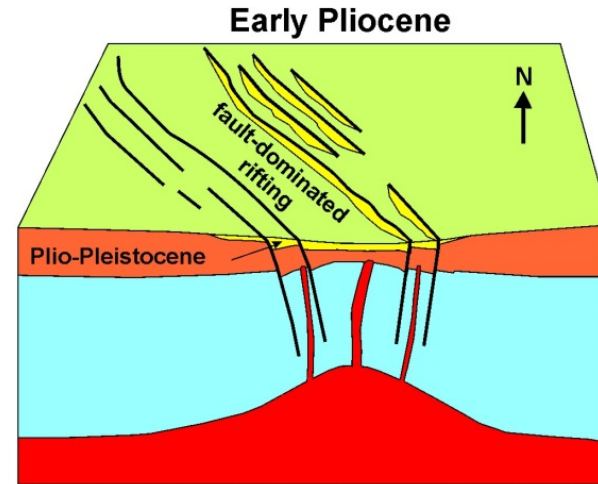
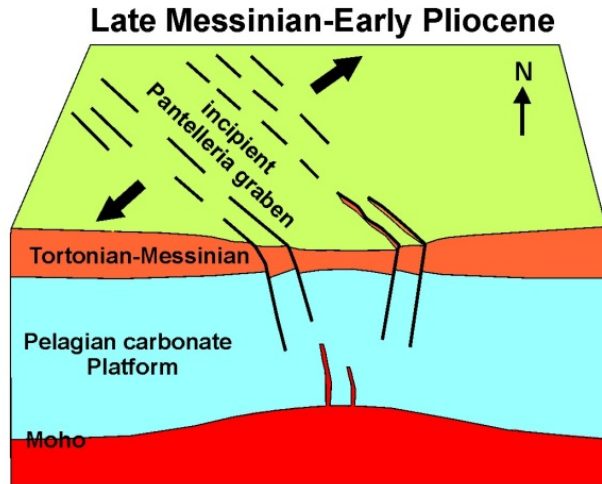


Ferdinandea Island

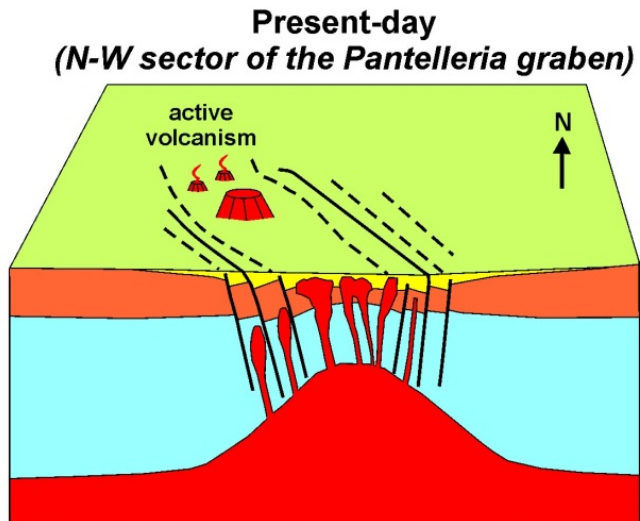
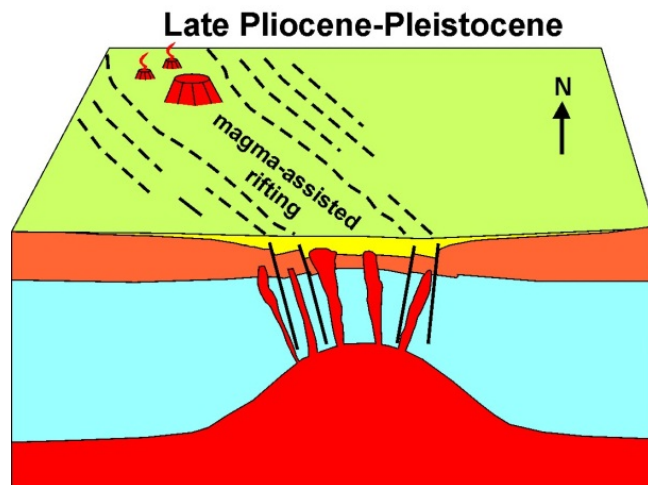


Pantelleria Graben development

Phase 1



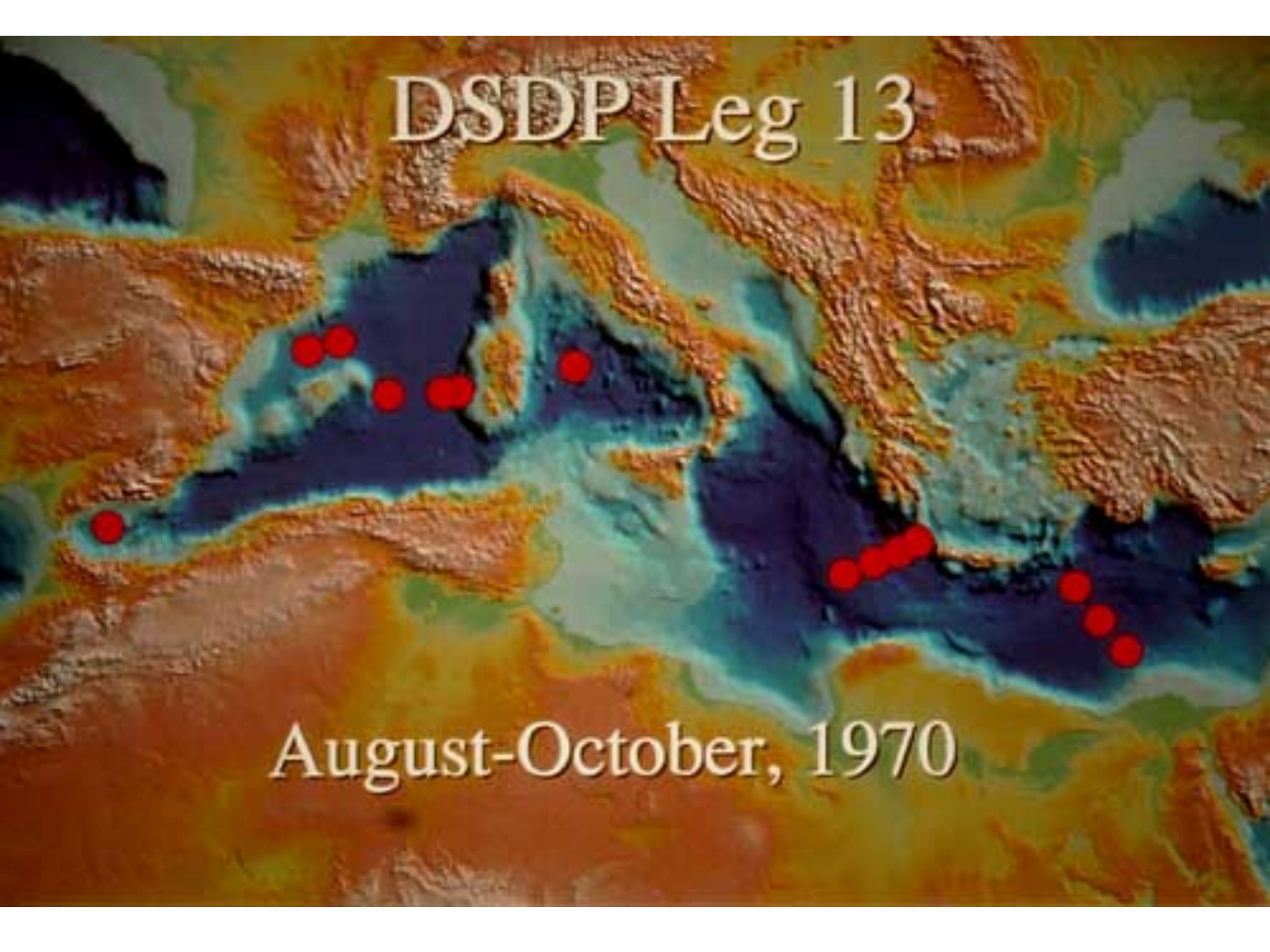
Phase 2



- **The Sicily Channel is a shallow-water platform located in the northern part of the African continental plate. It consists of a 6-7 km thick Meso-Cenozoic, shallow-water to deep-water carbonate succession, with intercalated volcanic rocks, and covered by Upper Tortonian-Lower Messinian siliclastic deposits.**
- **The Sicily Channel is cut through by three main, NW-trending, elongated depressions (Pantelleria, Malta and Linosa graben) formed by continental rift-related processes initiated since Late Miocene-Early Pliocene. Continental rifting is controlled by sub-vertical normal faults. These troughs, where water depths range from 1300 to more than 1700 m, are filled by Lower Pliocene-Pleistocene turbidites.**
- **Widespread volcanic activity accompanied the rifting process in the Sicily Channel. Volcanism is mainly concentrated on the islands of Pantelleria and Linosa, but a series of submarine magmatic manifestations have been identified in the Adventure Plateau, Graham and Nameless banks. The volcanic products consist mainly of alkali basalts and hawaiites, similar to that found in continental rift areas. The volcanism took place substantially during the Plio-Pleistocene, although some manifestations have occurred up to historical time, with the ephemeral emergence of the Ferdinanda Island in the Graham Bank (A.D. 1831), and the submarine eruption (Foerstner 'volcano') occurred about 5 km N-W of Pantelleria (A.D. 1891).**

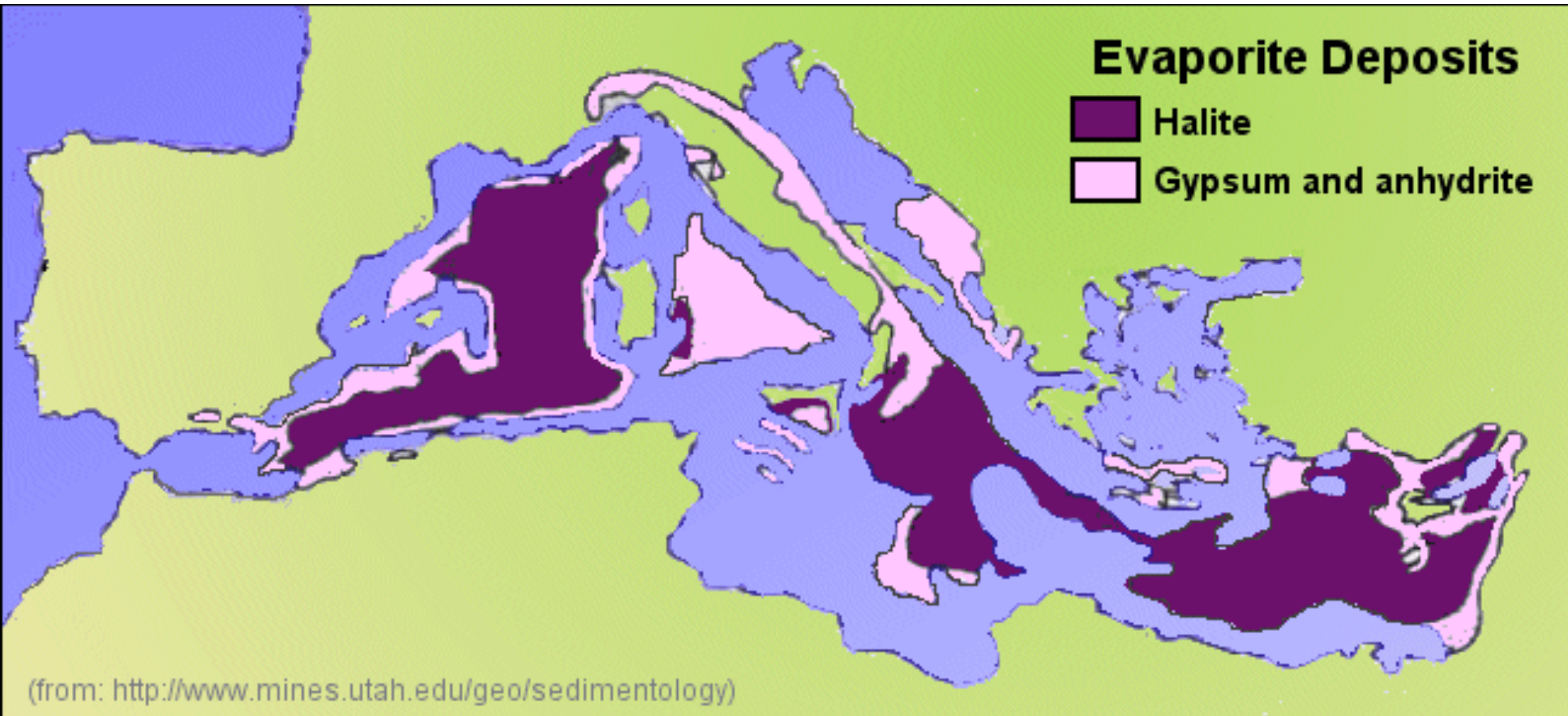
DSDP Leg 13

August-October, 1970

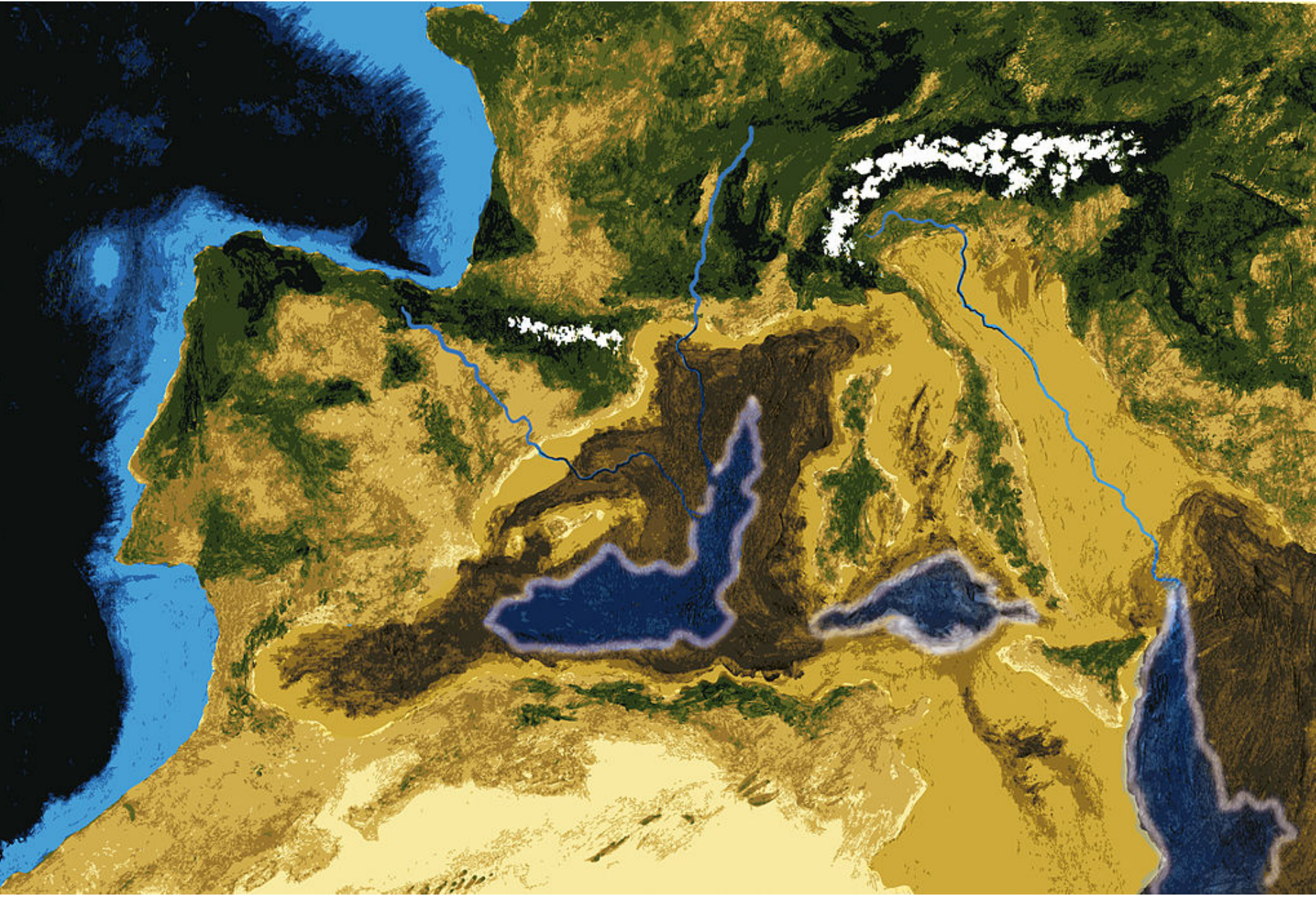


MIOCENE SALINITY CRISIS

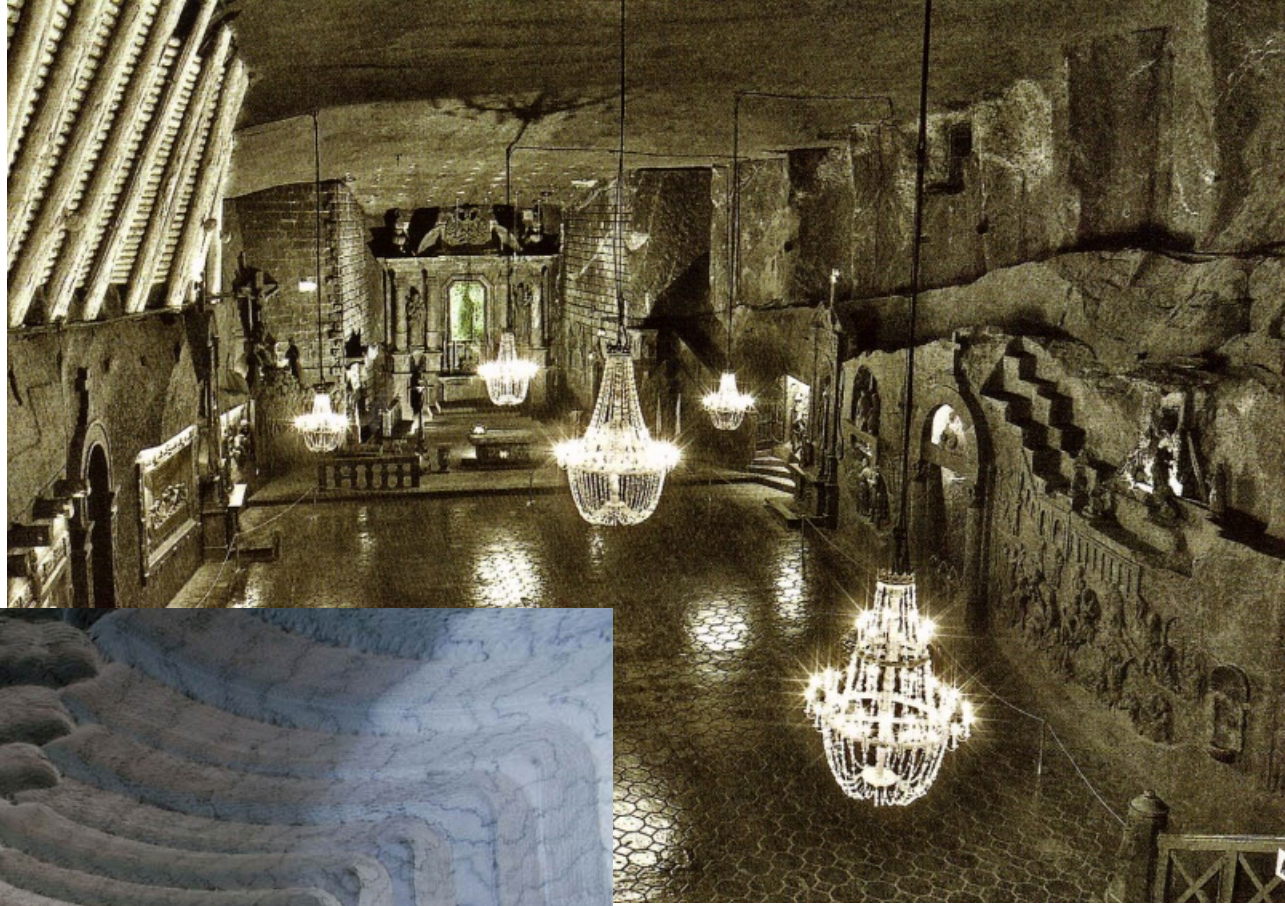
Miocene Sup. (5.9 - 5.3 Ma)

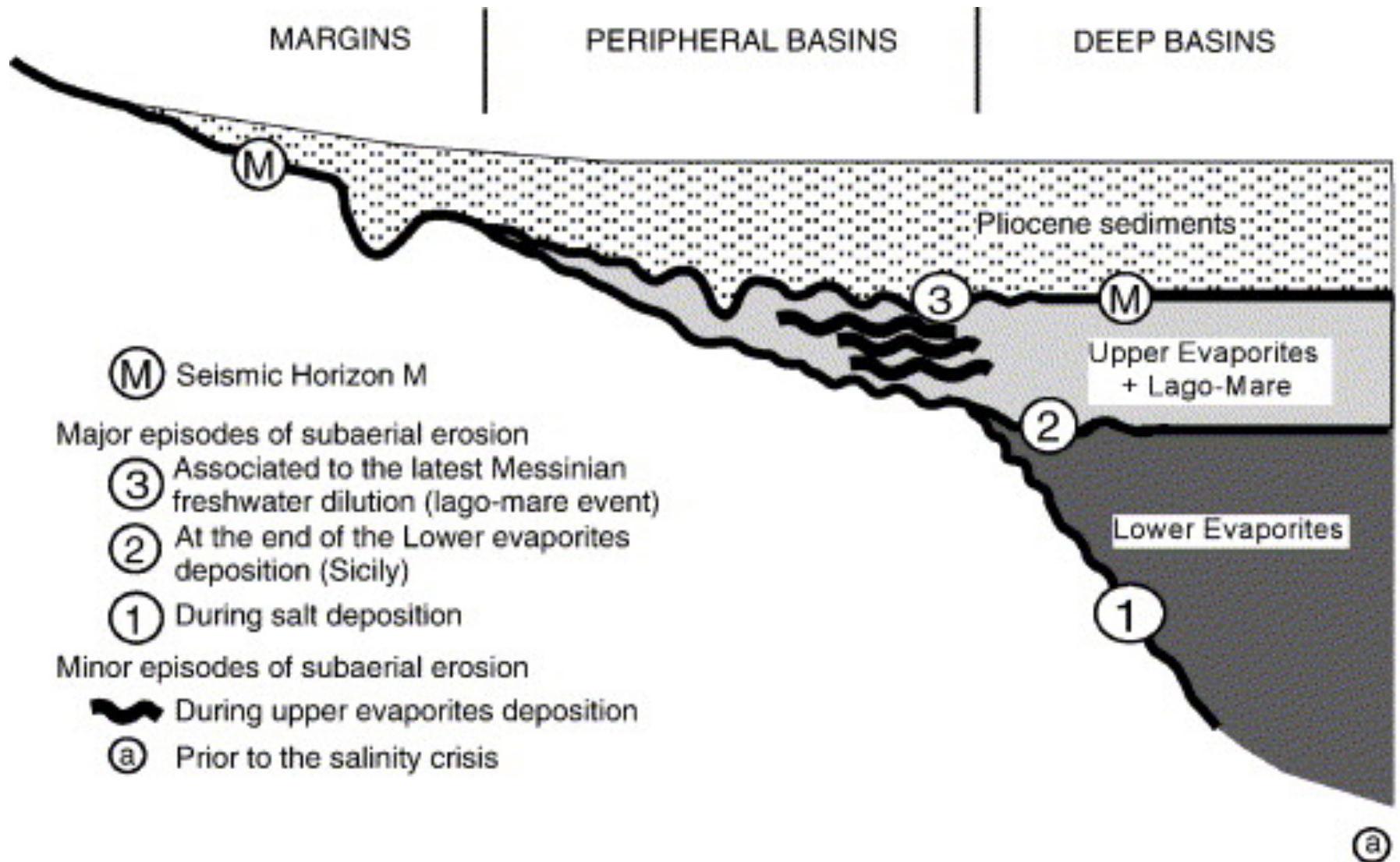


Messinian paleogeography



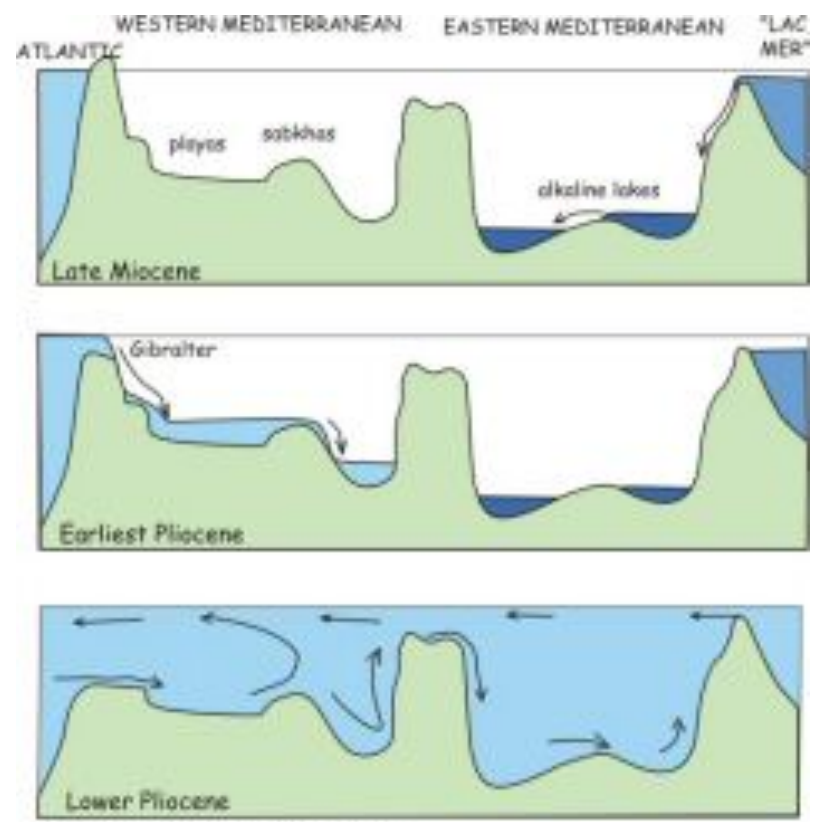
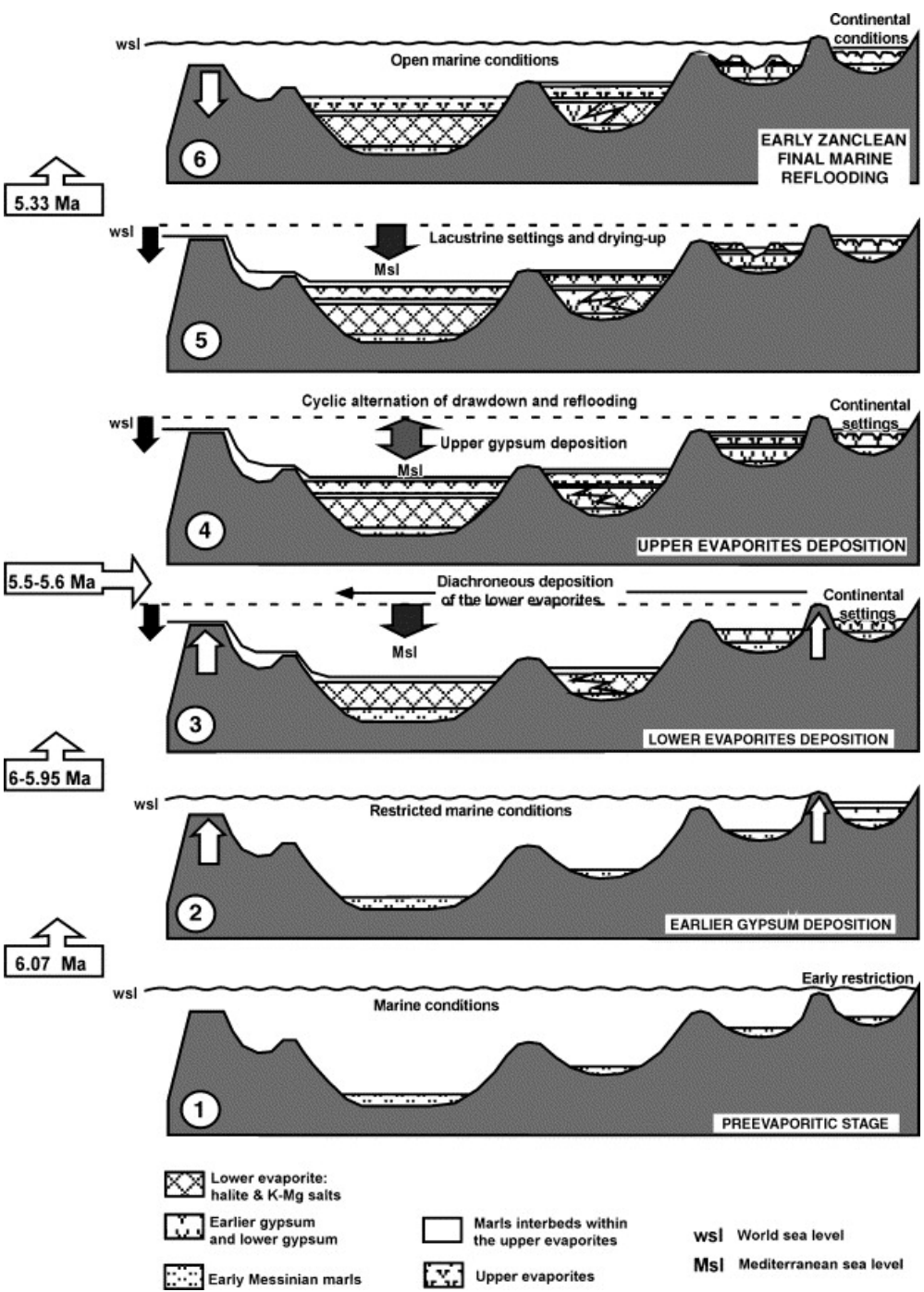
Salt mines in Sicily

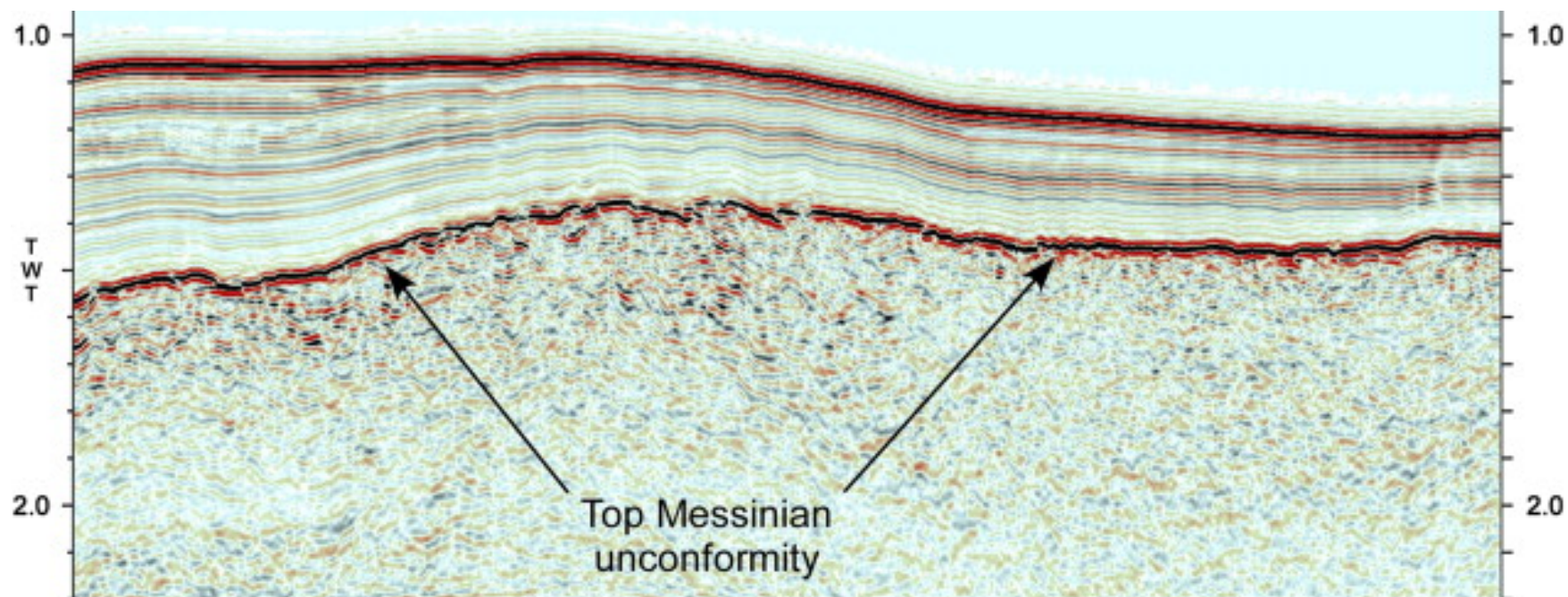
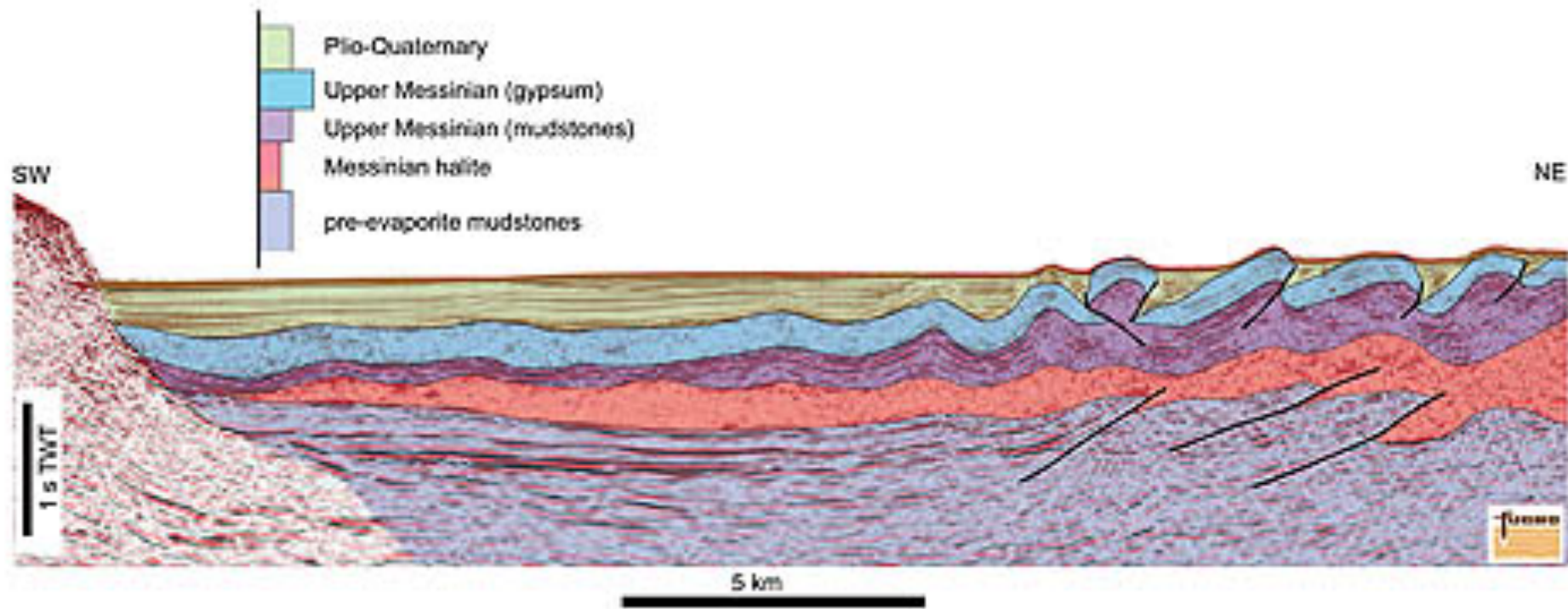




Correlation of the major erosional surfaces with the different evaporitic steps. The erosional surface that truncates the margins is interpreted as a polyphased surface resulting from the cumulated effects of several main episodes of erosion.

Summary of the sedimentary and hydrological changes that occurred in the Mediterranean during the Messinian





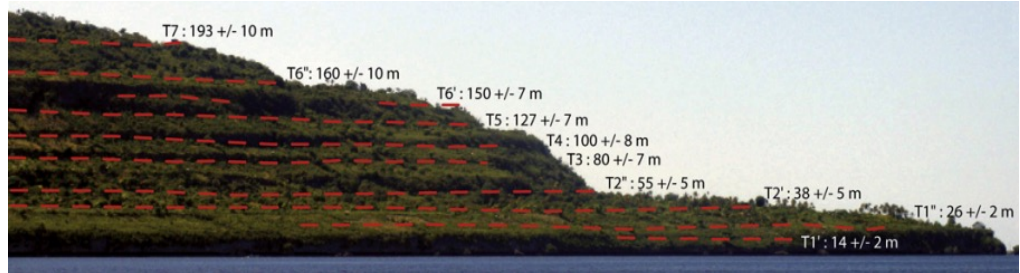
Artistic interpretation of the flood theorized to have refilled the Mediterranean Sea 5.33 million years ago (Zanclean flood) through the present-day Gibraltar Strait (discharge of about 1000 times the modern Amazon River)



PAST SEA-LEVEL RECONSTRUCTIONS

Emerged and near-the-coast areas

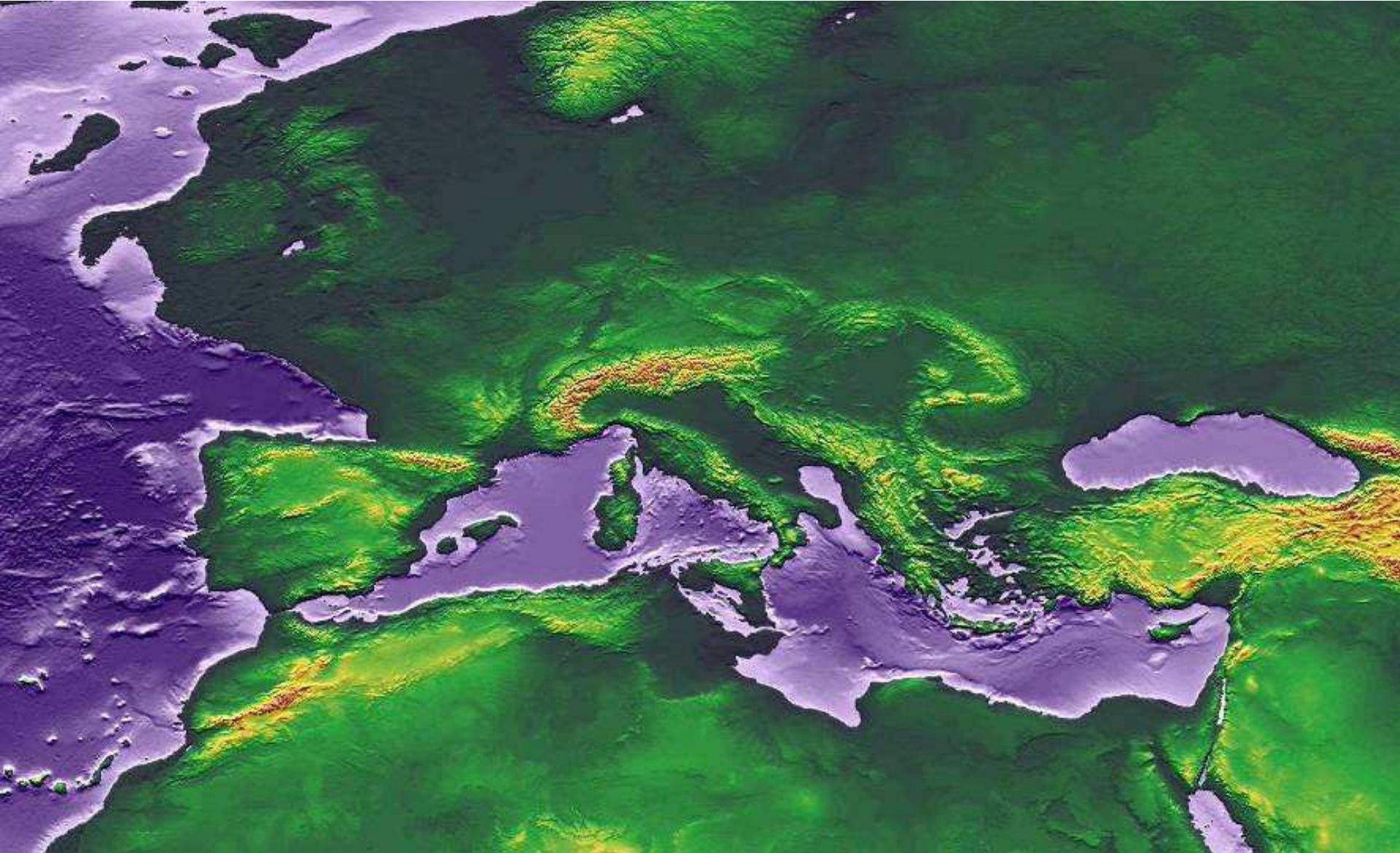
- Marine terraces
- Tidal and submerged notches
- Coral reef terraces
- Submerged speleothems
- Core analyses
- Archaeological remains
- ecc...



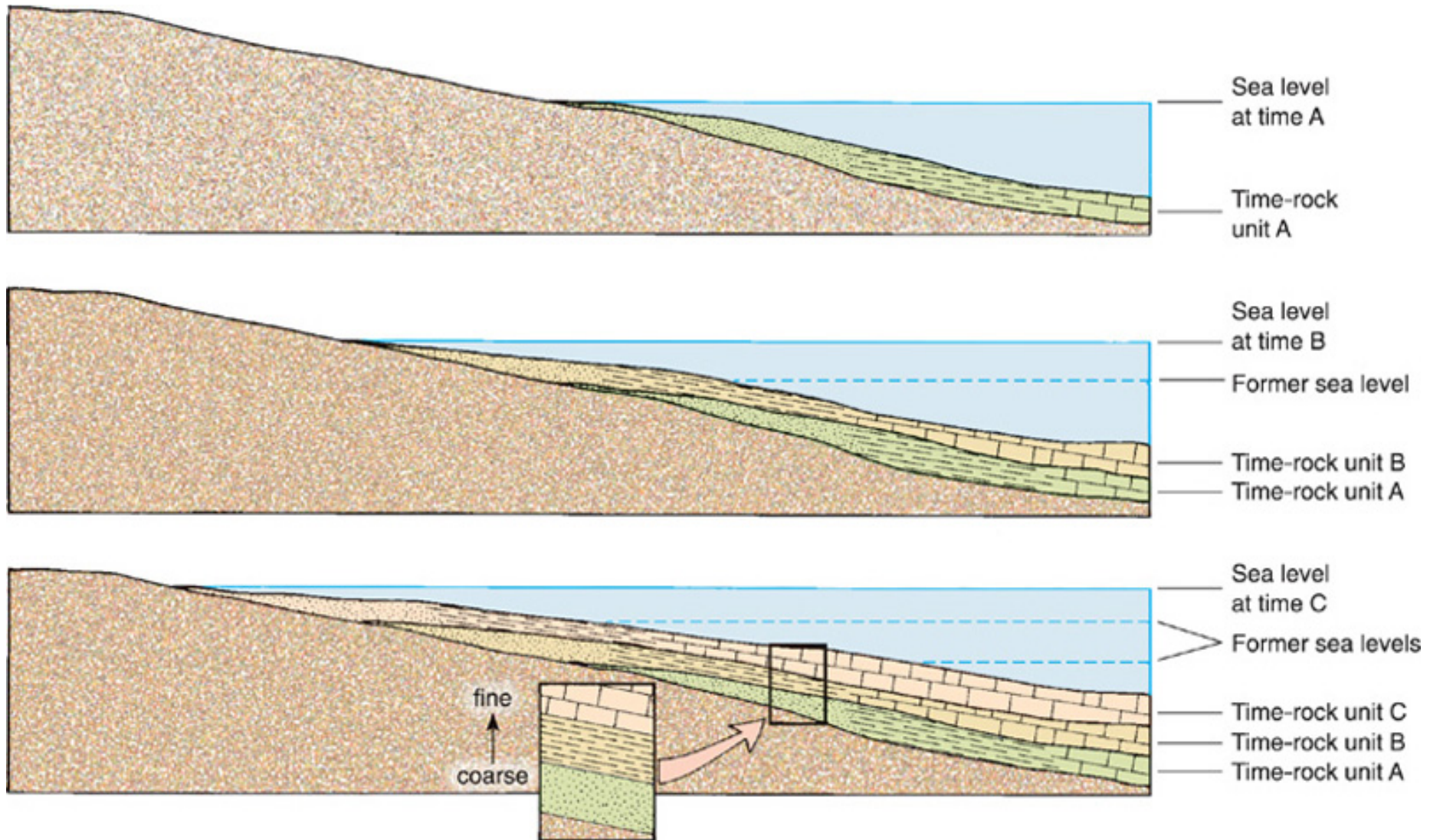
Submerged landscape areas (prehistoric sites)

In shelf areas (shallower than 100 m) far from the coast, the reconstructions of ancient sea-level are much more difficult, because the geomorphological markers are often covered by a more or less thick sedimentary layer, and adequate geophysical data are scarce

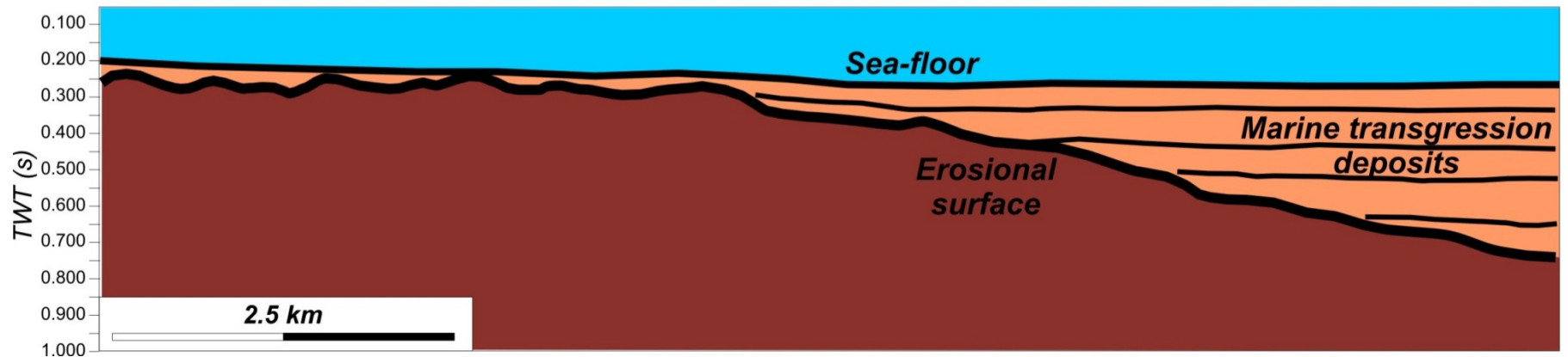
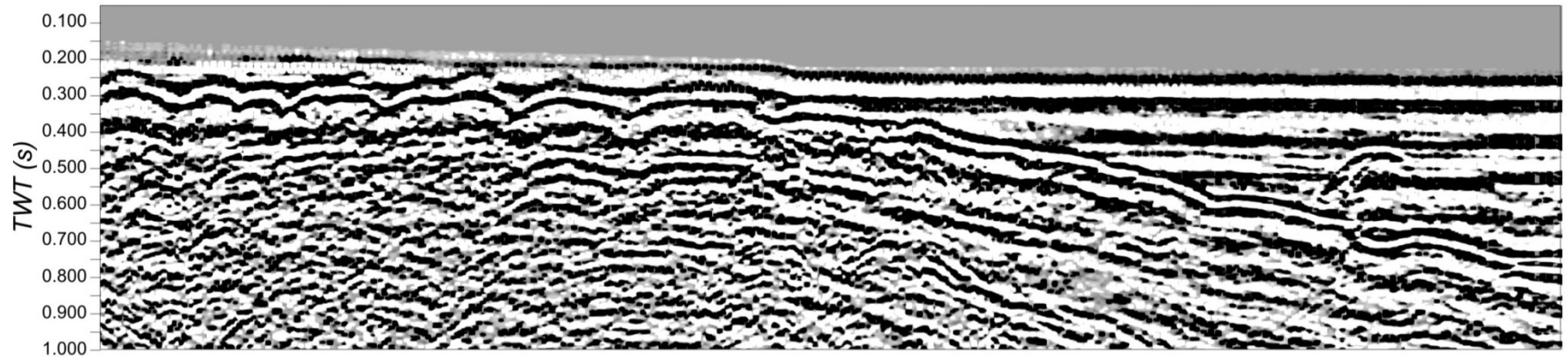
European and Mediterranean coastlines at about 18,000 yr BP (LGM)



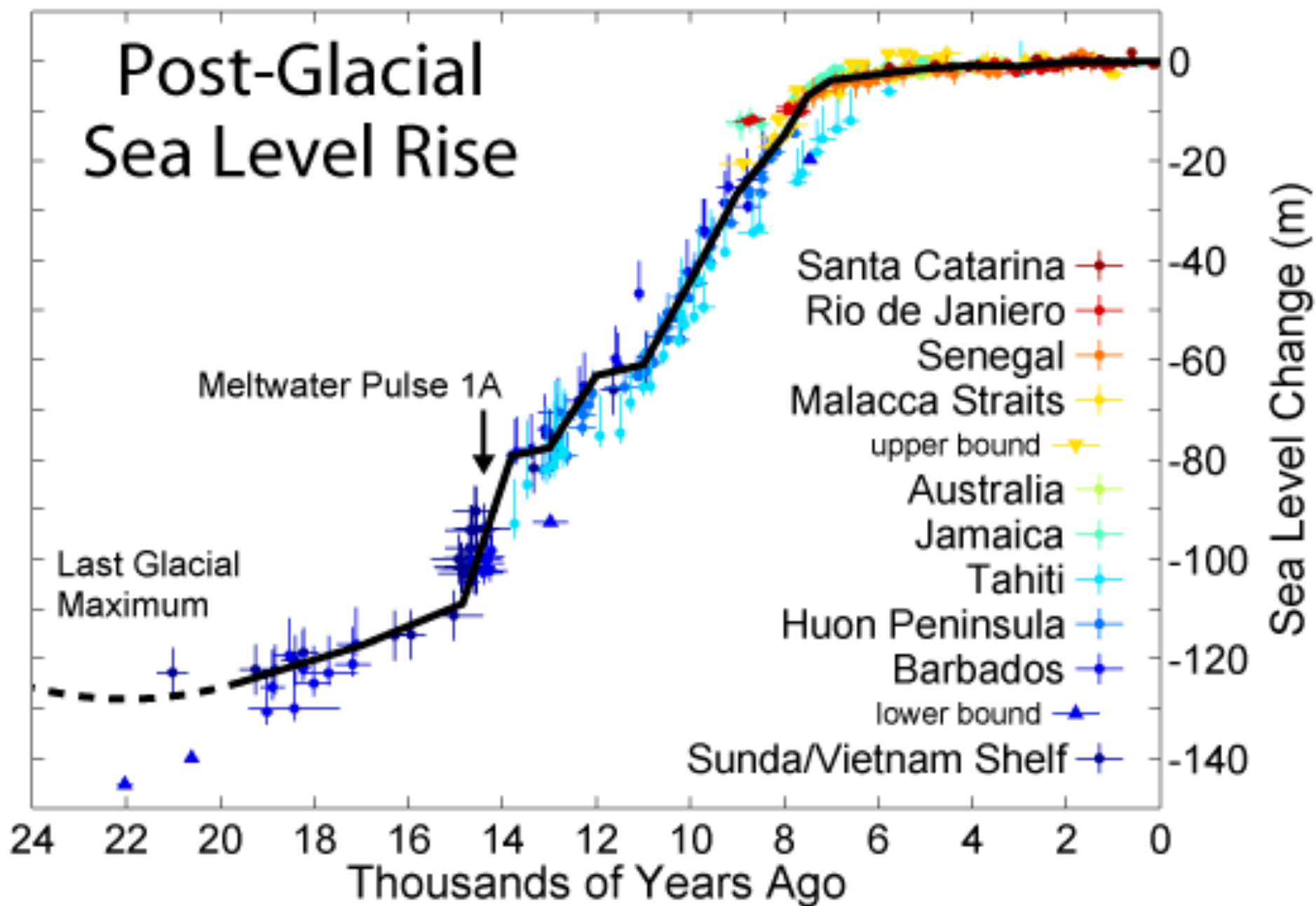
MODEL OF MARINE TRANSGRESSION



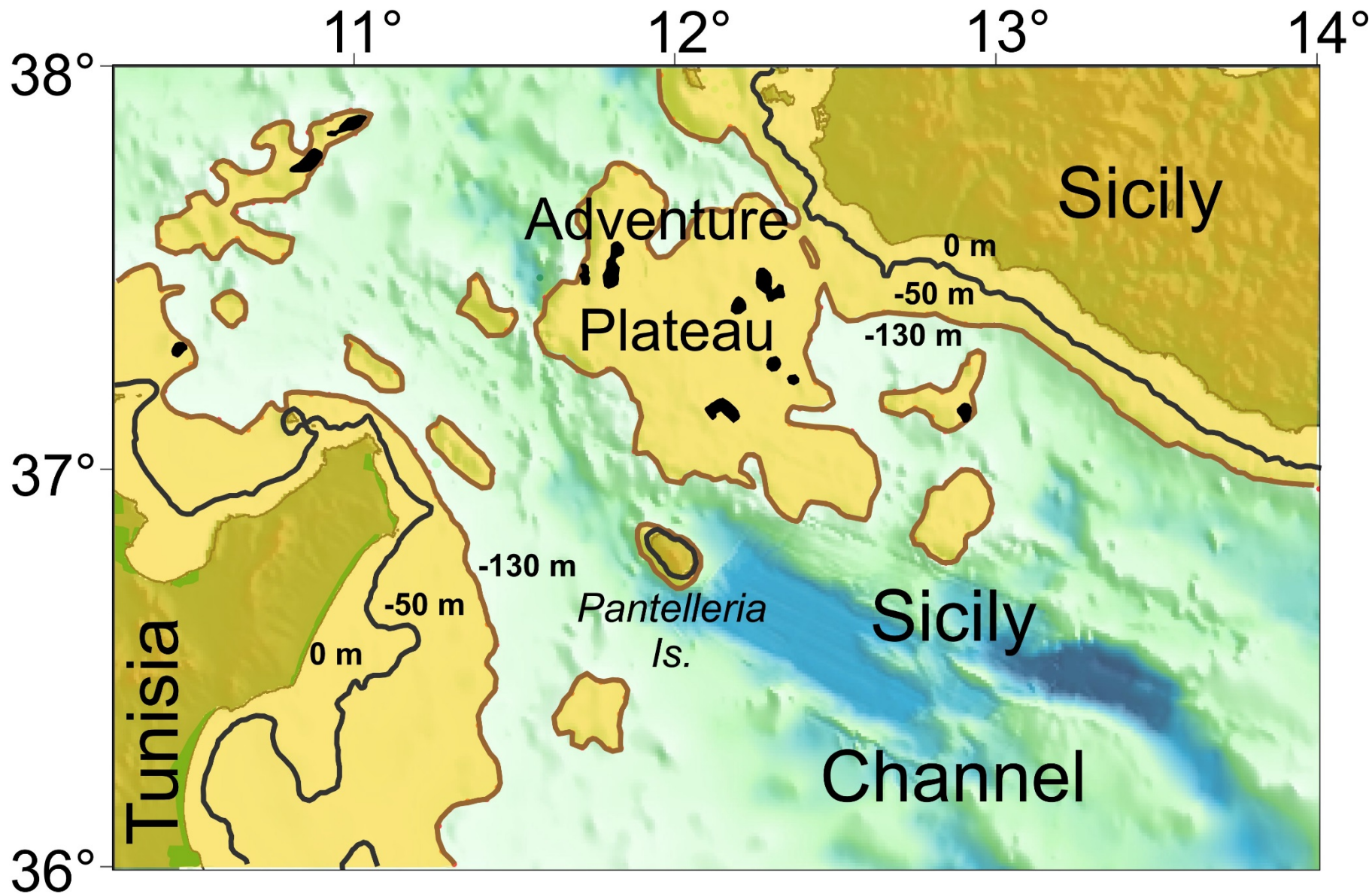
SEISMIC EXAMPLE OF MARINE TRANSGRESSION



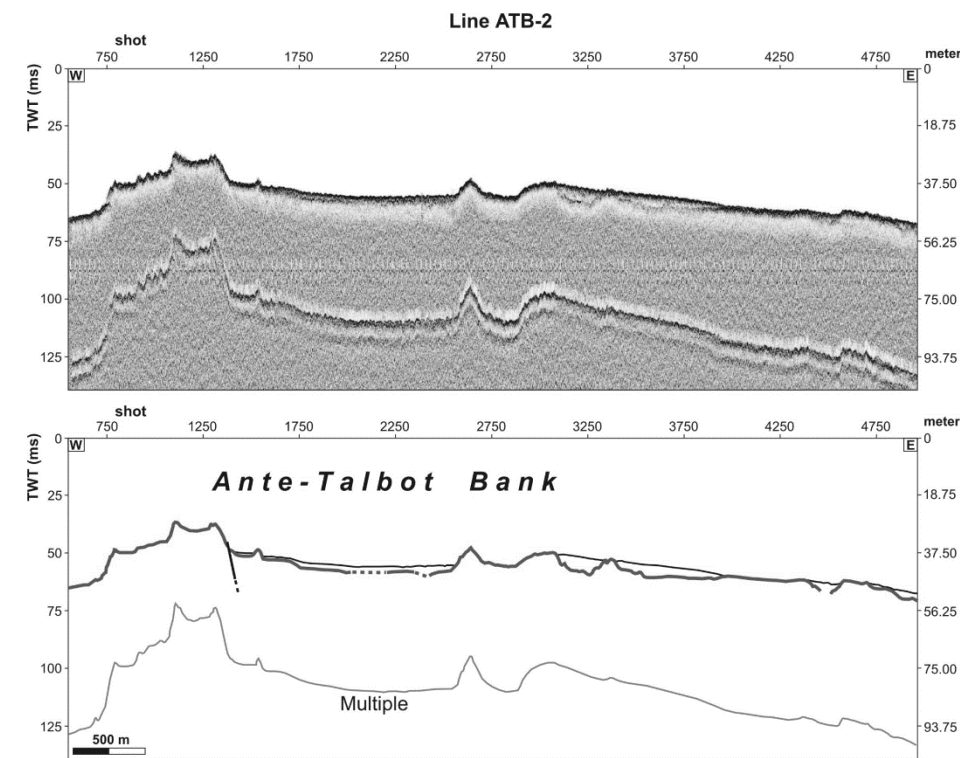
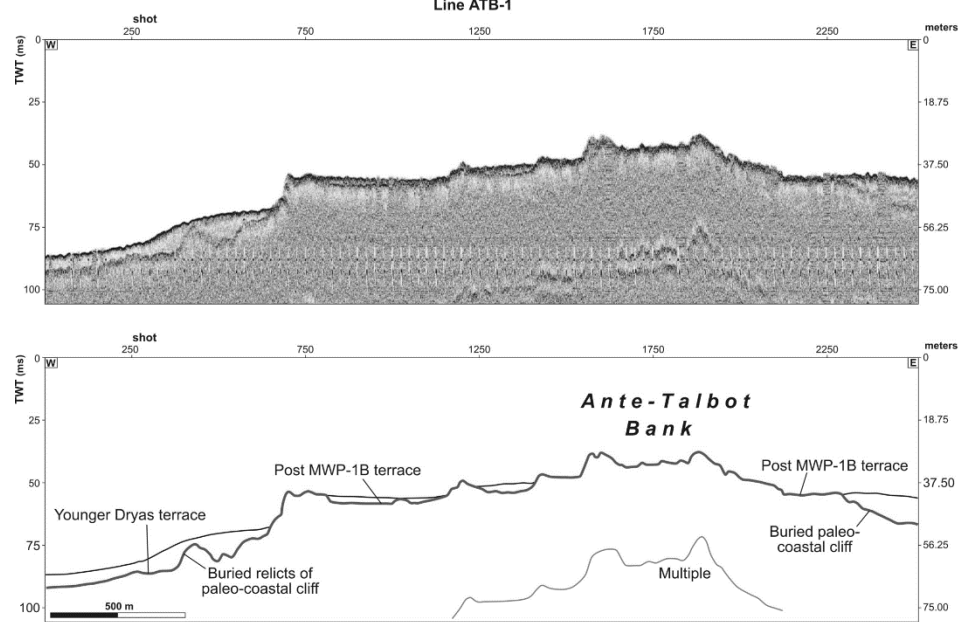
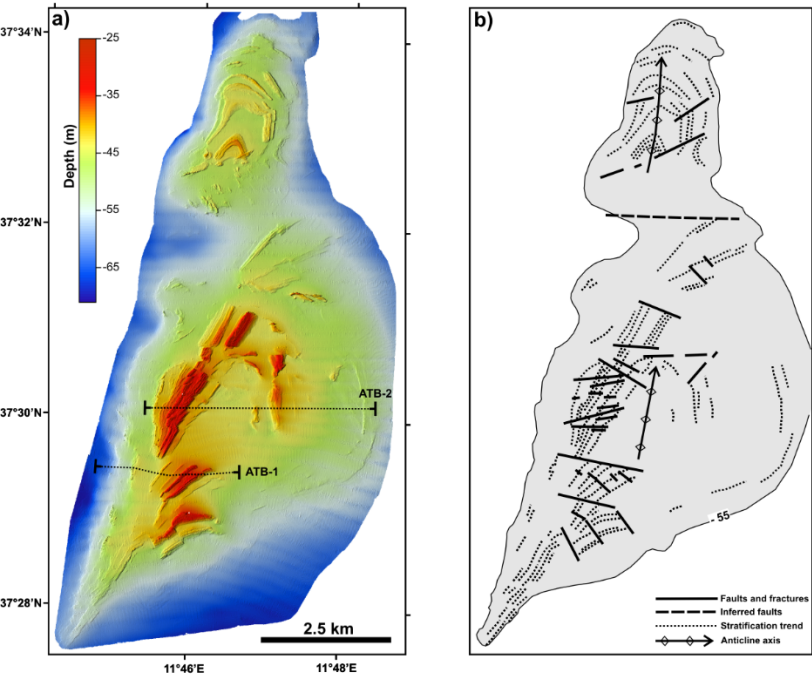
Post-Glacial Sea Level Rise



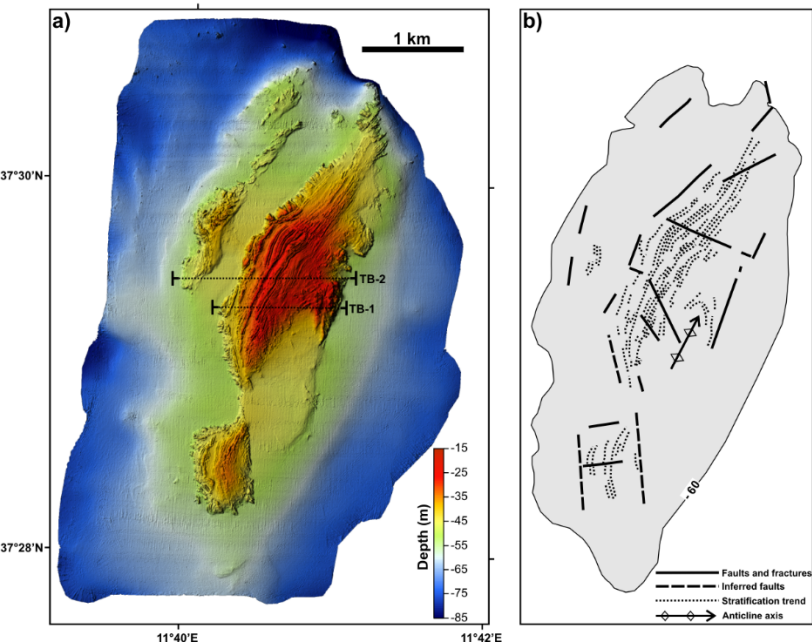
The Sicilian Channel at LGM



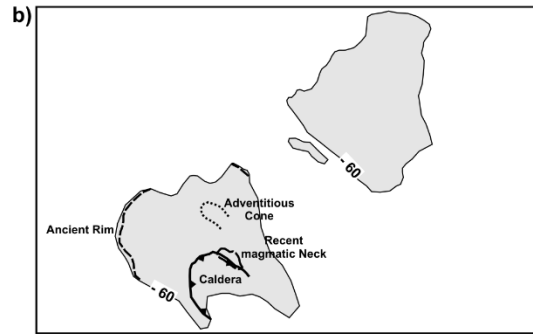
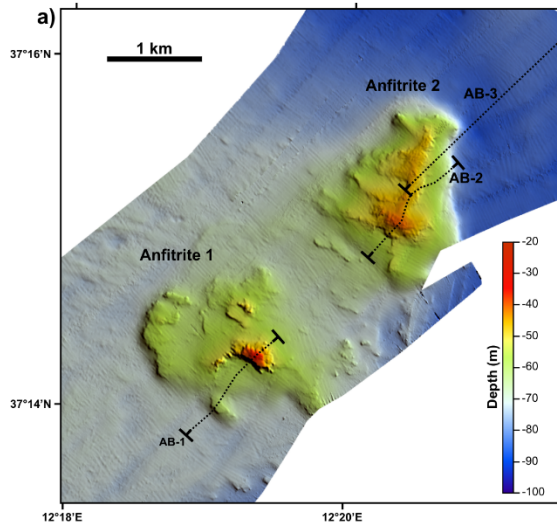
ANTE TALBOT



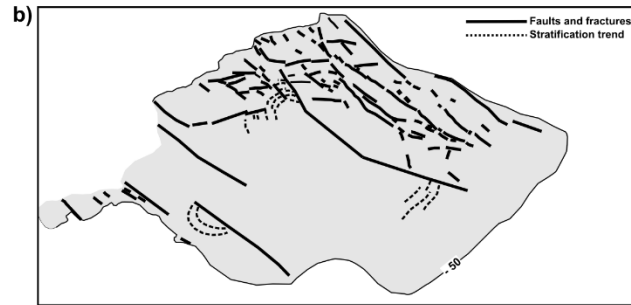
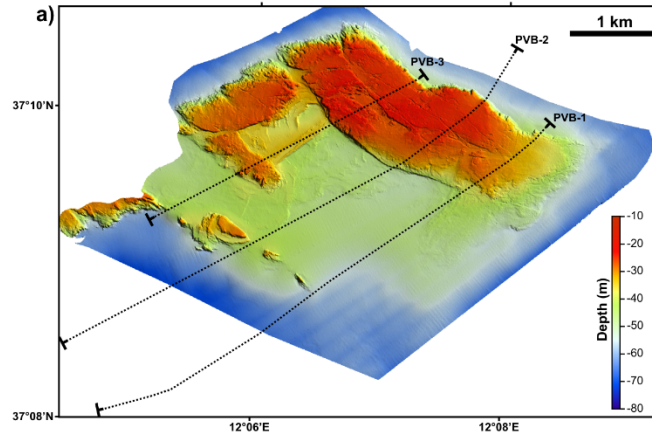
TALBOT



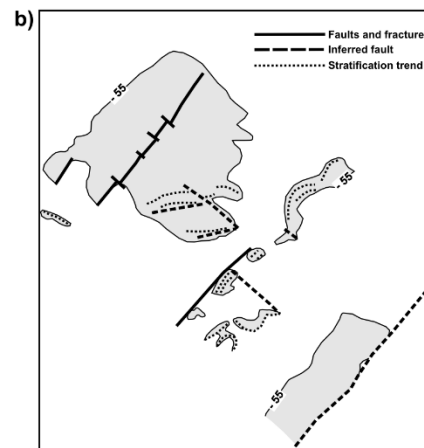
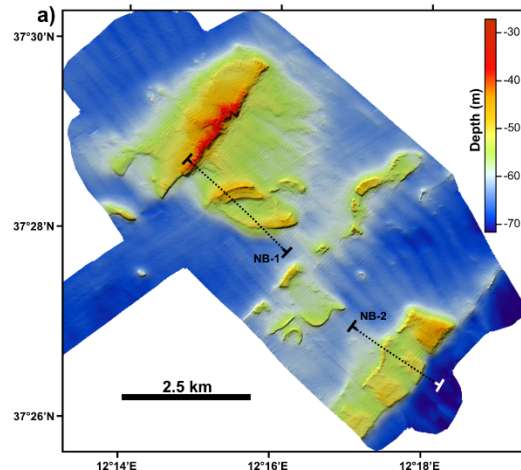
ANFITRITE

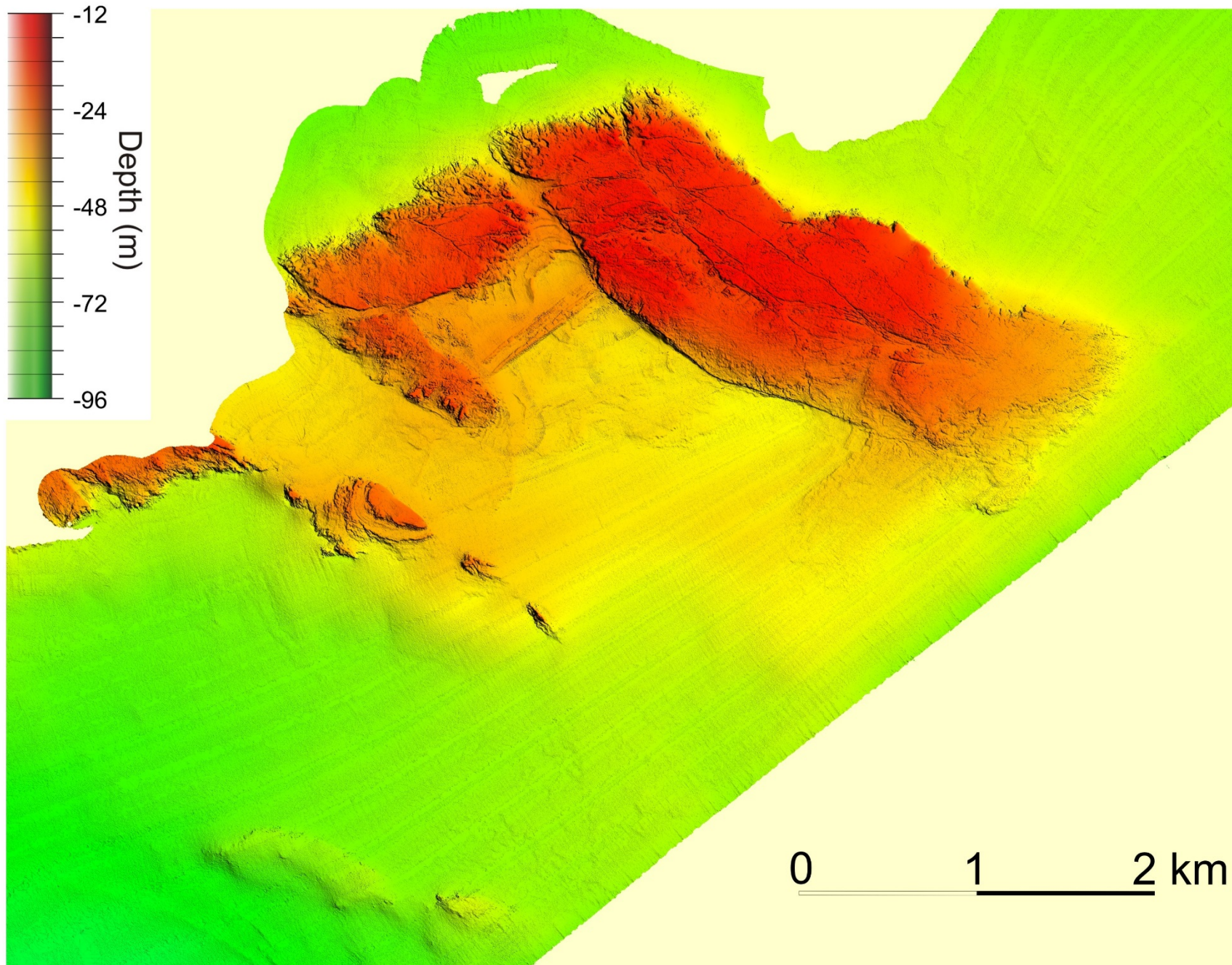


PANTELLERIA VECCHIA

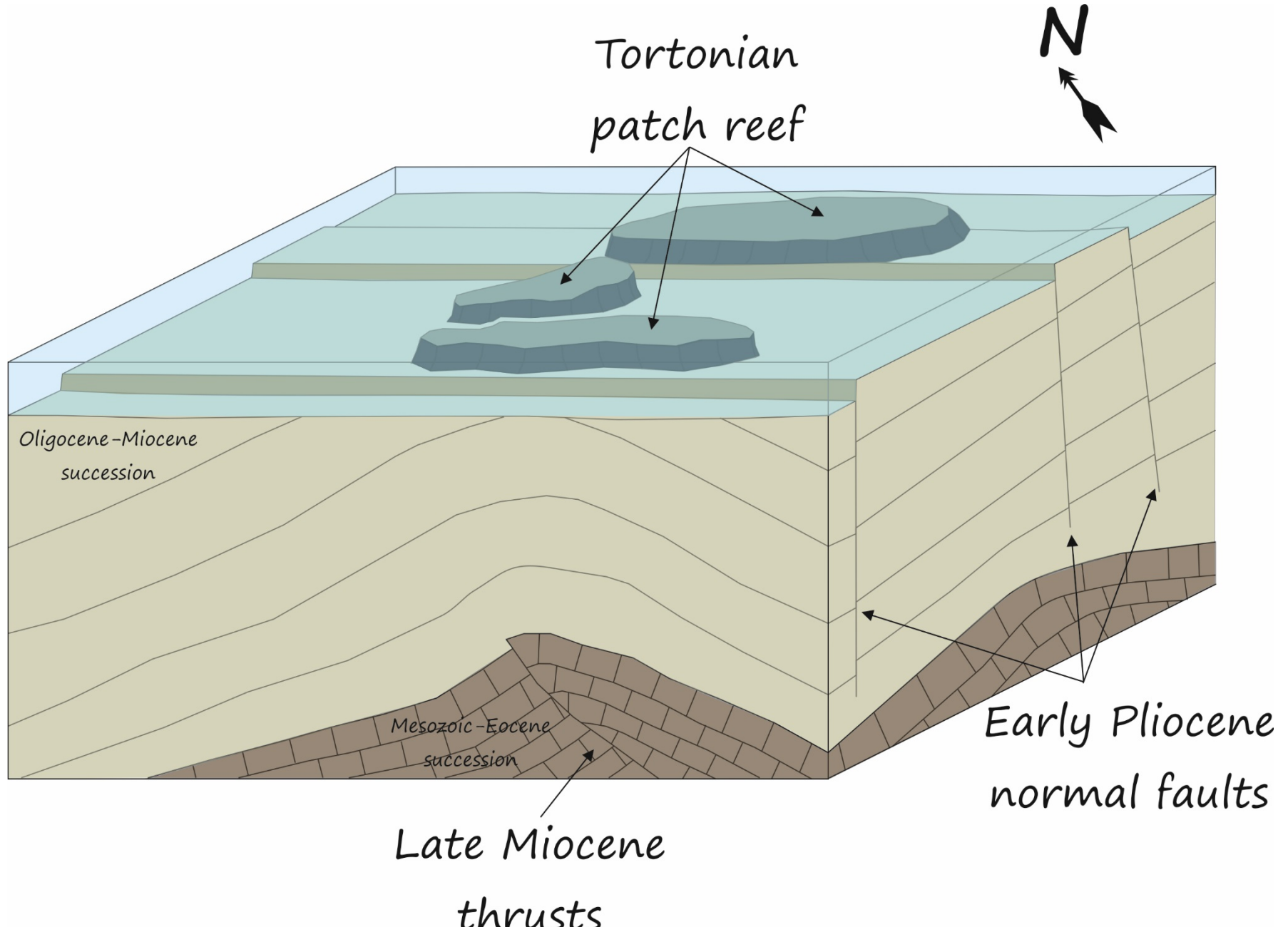


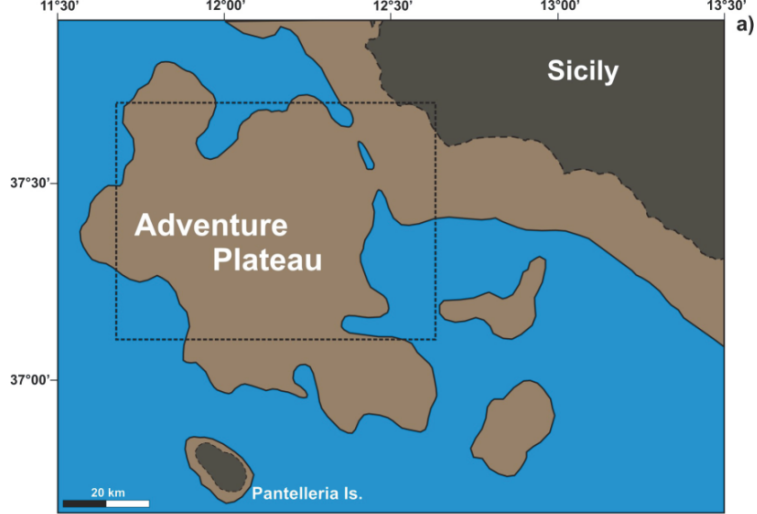
NEREO



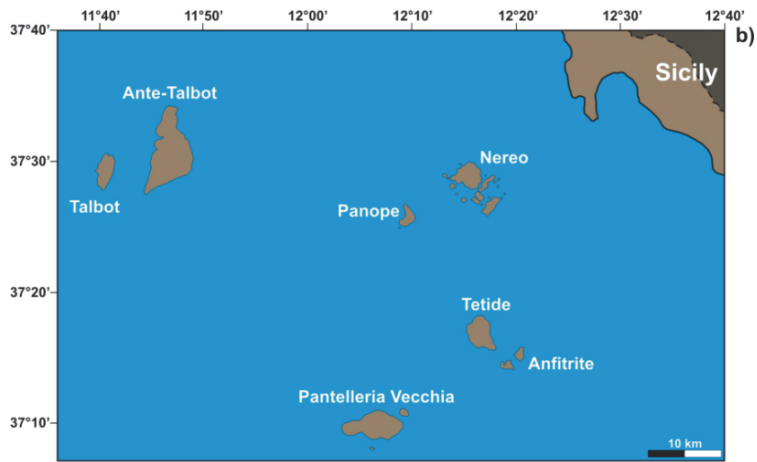


Pantelleria Vecchia Bank





**The Adventure Plateau at the LGM
(~18000 yr B.P.)**



**Adventure Archipelago at about
11,700 yr B.P.
Former sea level -60 m**



**Adventure Archipelago at about
11,200 yr B.P.
Former sea level -42 m**

CIVILIZATION IN THE MEDITERRANEAN REGION

PREHISTORY ← → *HISTORY*

12000 BC

10000 BC

8000 BC

6000 BC

4000 BC

2000 BC

> 36000 BC



Spain



Turkey



Malta



Egypt



Crete

SUGGESTED BIBLIOGRAPHY

Mediterranean region general geology

Stanley, J. and Wezel, F.C. (Eds.) (1985): Geological Evolution of the Mediterranean Basin, Springer-Verlag.

Crescenti, U. et al. (Eds.) (2004): Geology of Italy, Special Vol. of the It. Geol. Soc., 231 pp.

Western Mediterranean

Rosenbaum, G., Lister, G. S. and Duboz, C. (2002): Reconstruction of the tectonic evolution of the western Mediterranean since the Oligocene. *Journal of the Virtual Explorer*, 8, 107-130.

Carminati, E. et al. (2012): Evolution of the Western Mediterranean, In: Bally A.W. & Roberts D. (Eds): *Regional Geology and Tectonics: Phanerozoic Passive Margins, Cratonic Basins and Global Tectonic maps*, Elsevier.

Alboran Sea

Maldonado, A. and Comas, M.C. (1992): Geology and geophysics of the Alboran Sea: An introduction, *Geo-Marine Letters*, 12 (2-3), 61-65.

Lopez Casado, C. et al. (2001): The structure of the Alboran Sea: an interpretation from seismological and geological data, *Tectonophysics*, 118, 79–95.

Eastern Mediterranean

Robertson, A.H.F. and Mountraki, D. (Eds.) (2006): *Tectonic Development of the Eastern Mediterranean Region*, Geological Society Special Publication, 260.

Ben-Avraham, Z. et al. (2006): Eastern Mediterranean basin systems, *Geological Society Memoir*, 32, 263-276.

Le Pichon, X. et al. (2002): The Mediterranean Ridge backstop and the Hellenic nappes, *Marine Geology*, 186, 111-125.

Aegean Sea

Jolivet, L. et al. (2013): Aegean tectonics: strain localisation, slab tearing and trench retreat, *Tectonophysics*, 597-598.

Tyrrhenian Sea and Calabrian Arc

Rosenbaum, G. and Lister, G.S. (2004): Neogene and Quaternary roll-back evolution of the Tyrrhenian Sea, the Apennines, and the Sicilian Maghrebides, *Tectonics*, 23, TC1013, doi:10.1029/2003TC001518.

Malinverno, A. (2012): Evolution of the Tyrrhenian Sea-Calabrian Arc system: The past and the present, *Rend. Online Soc. Geol. It.*, Vol. 21 pp. 11-15.

Adriatic Sea

Bigi, S. et al. (Eds.) (2013): *The Geology of the Periadriatic Basin and of the Adriatic Sea*. *Marine and Petroleum Geology*, Special Issue, 42, pp. 1-214.

Sicily Channel

Civile, D. et al. (2010): The Pantelleria graben (Sicily Channel, Central Mediterranean): An example of intraplate 'passive' rift. *Tectonophysics*, 490 (3-4), 173-183.

Ionian Sea

Speranza, F. et al. (2012): The Ionian Sea: The oldest in situ ocean fragment of the world? *Journal of Geophysical Research, Solid Earth*, 117, B12, DOI: 10.1029/2012JB009475.

Mediterranean palaeo-geography and the Messinian salinity crisis

Lodolo, E. (2011): *La geografia del Quaternario*, Darwin, 44, 36-39.

Roveri, M. et al. (2014): The Messinian Salinity Crisis: Past and future of a great challenge for marine sciences. *Marine Geology*, 1-34.