Università di Trieste
LAUREA MAGISTRALE IN GEOSCIENZE SM62
Percorso Esplorazione Geologica

Anno accademico 2022 - 2023

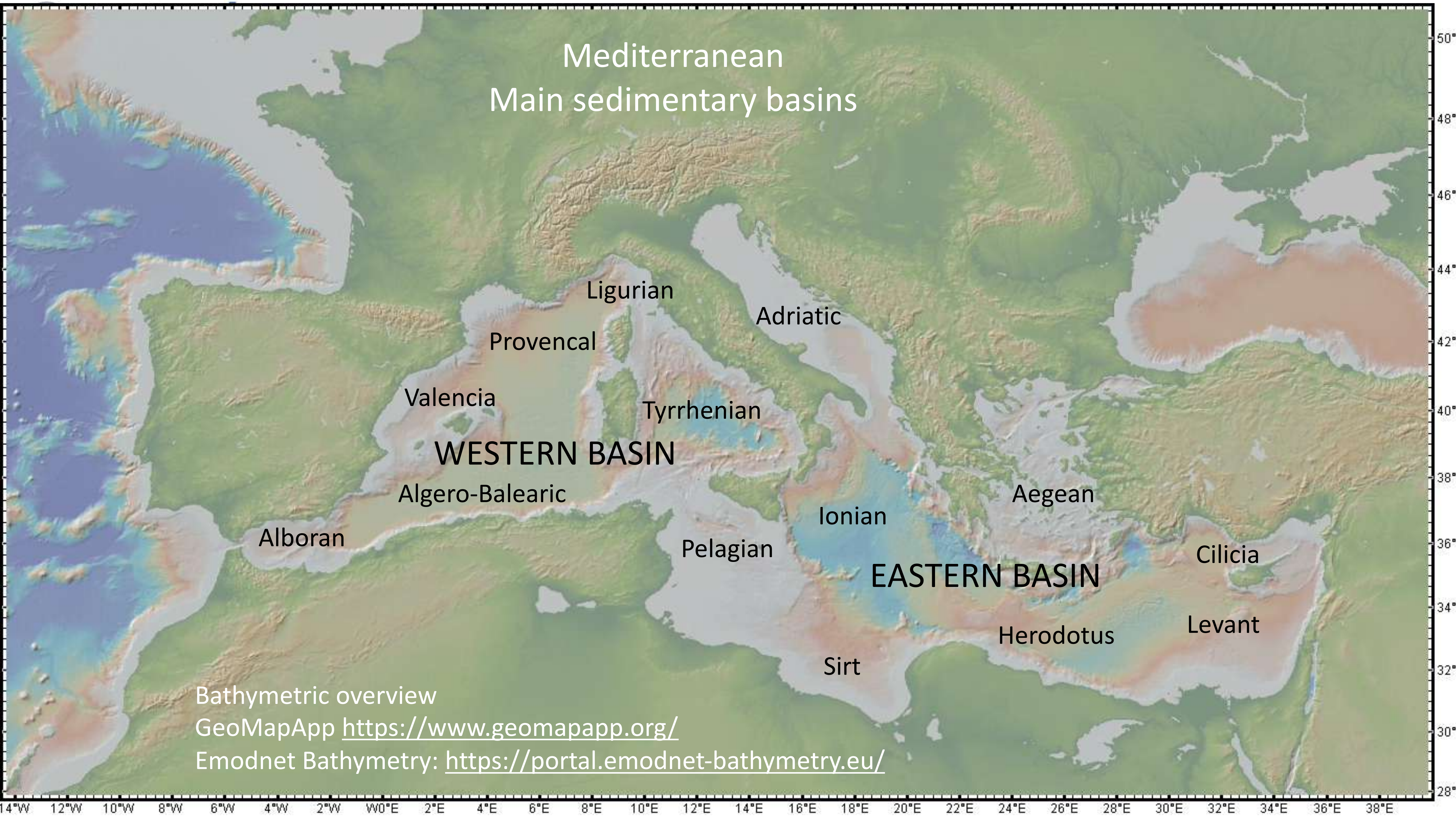
Geologia Marina 953SM

Modulo 5 - Geologia marina del Mediterraneo

Docente
Angelo Camerlenghi

Marine geology of the Mediterranean basin

Bathymetric overview
GeoMapApp https://www.geomapapp.org/
Emodnet Bathymetry: https://portal.emodnet-bathymetry.eu/
Geophysics
Seismicity
Stratigraphy
Mud volcanoes and olistostromes
Subduction systems and rifted margins
Golfo di trieste
Synthesis


Mediterranean
Main sedimentary basins
Ligurian
Adriatic
Provencal
Valencia
Tyrrhenian
WESTERN BASIN
Algero-Balearic
Aegean
Ionian
Alboran
Pelagian
Cilicia
EASTERN BASIN
Levant
Herodotus
Sirt
Bathymetric overview
GeoMapApp https://www.geomapapp.org/
Emodnet Bathymetry: https://portal.emodnet-bathymetry.eu/
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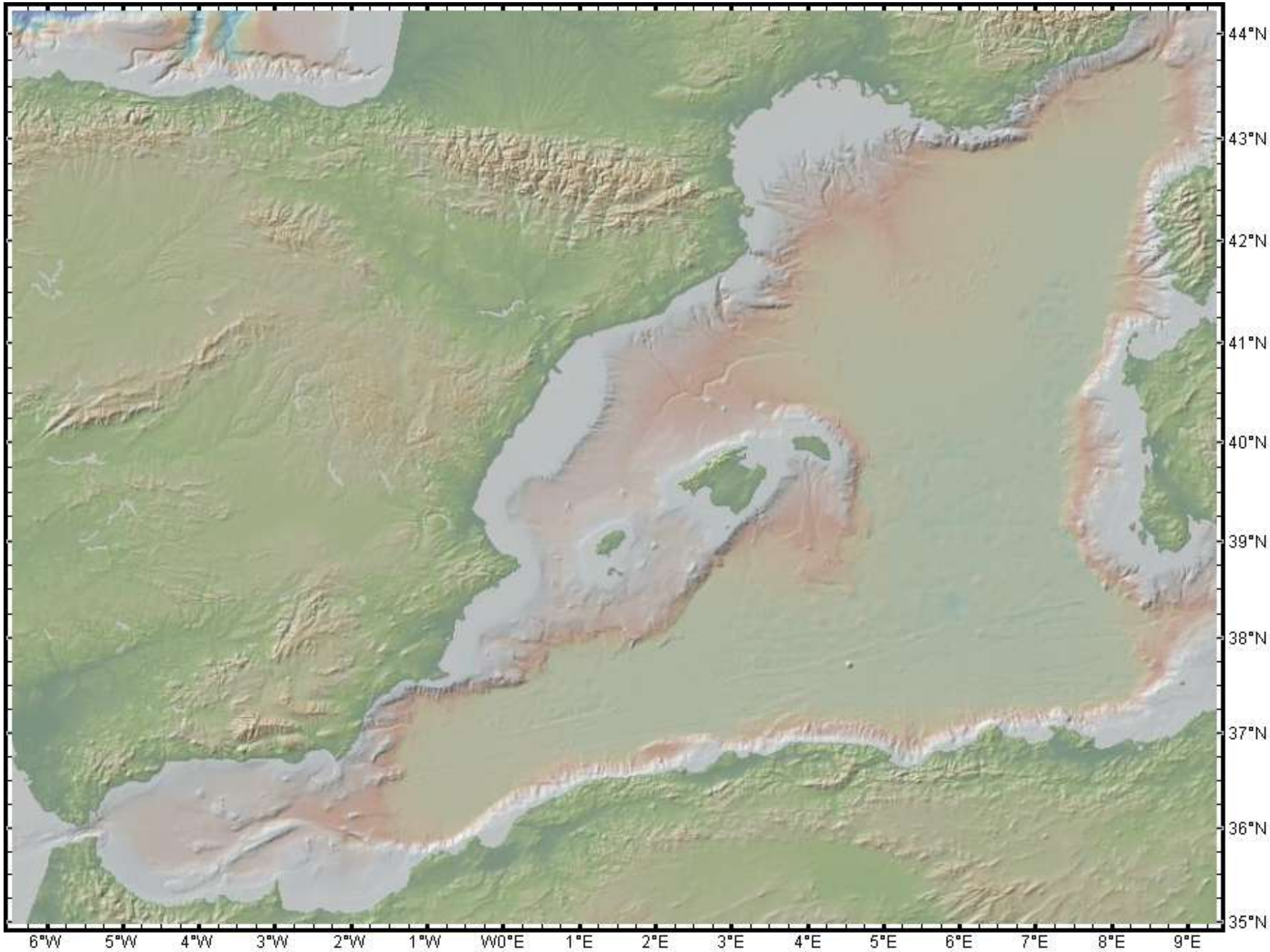
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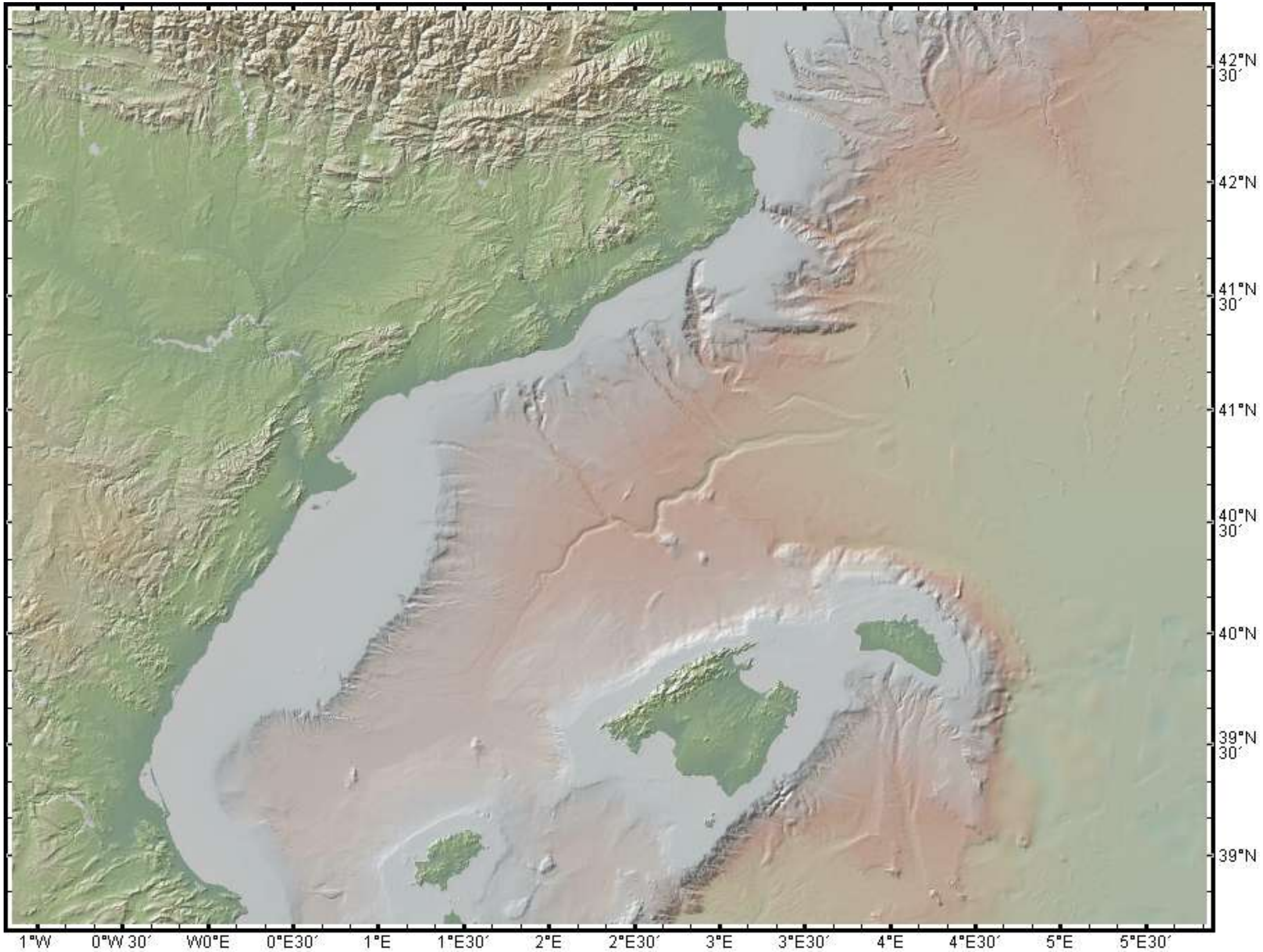
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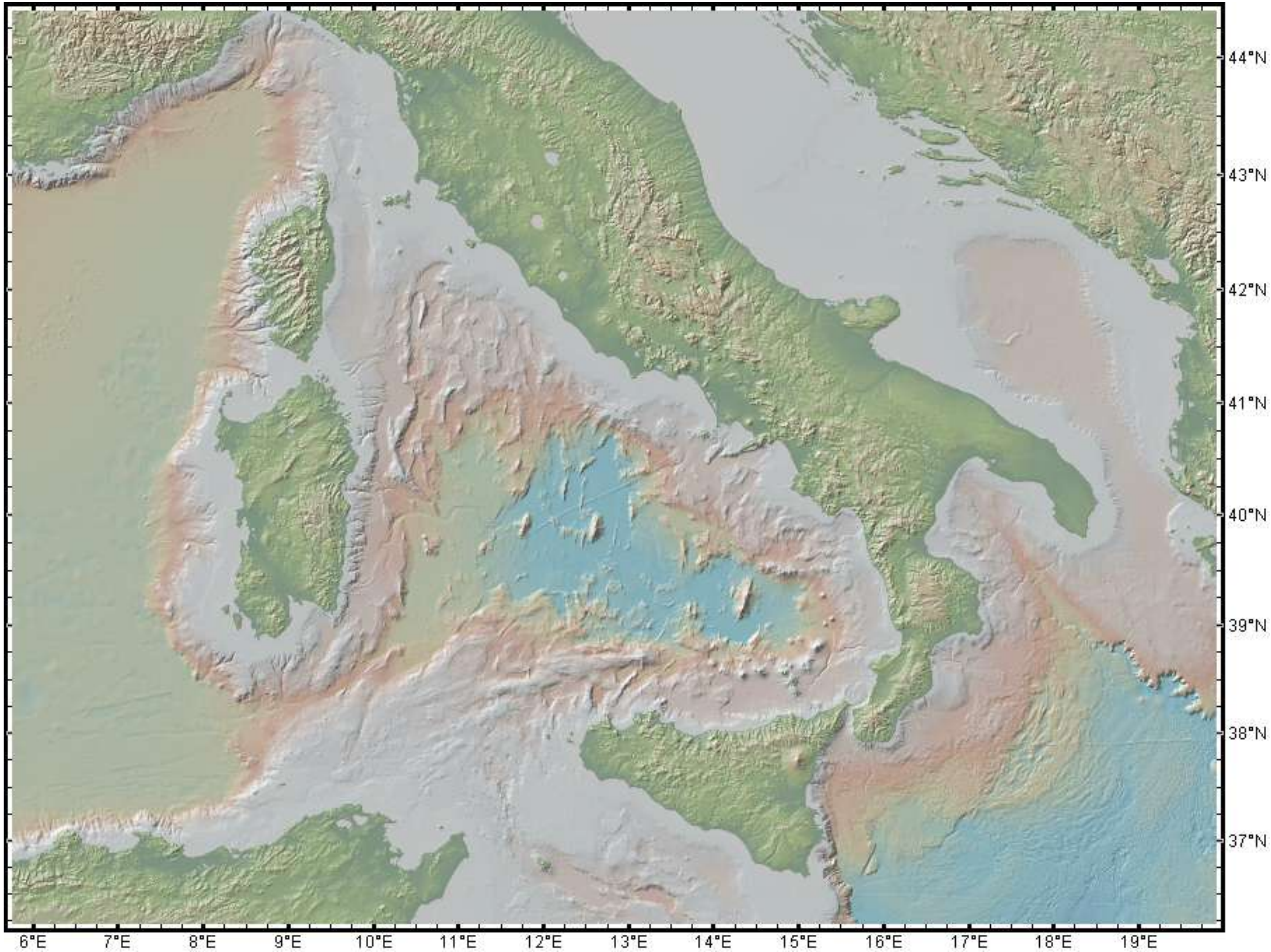
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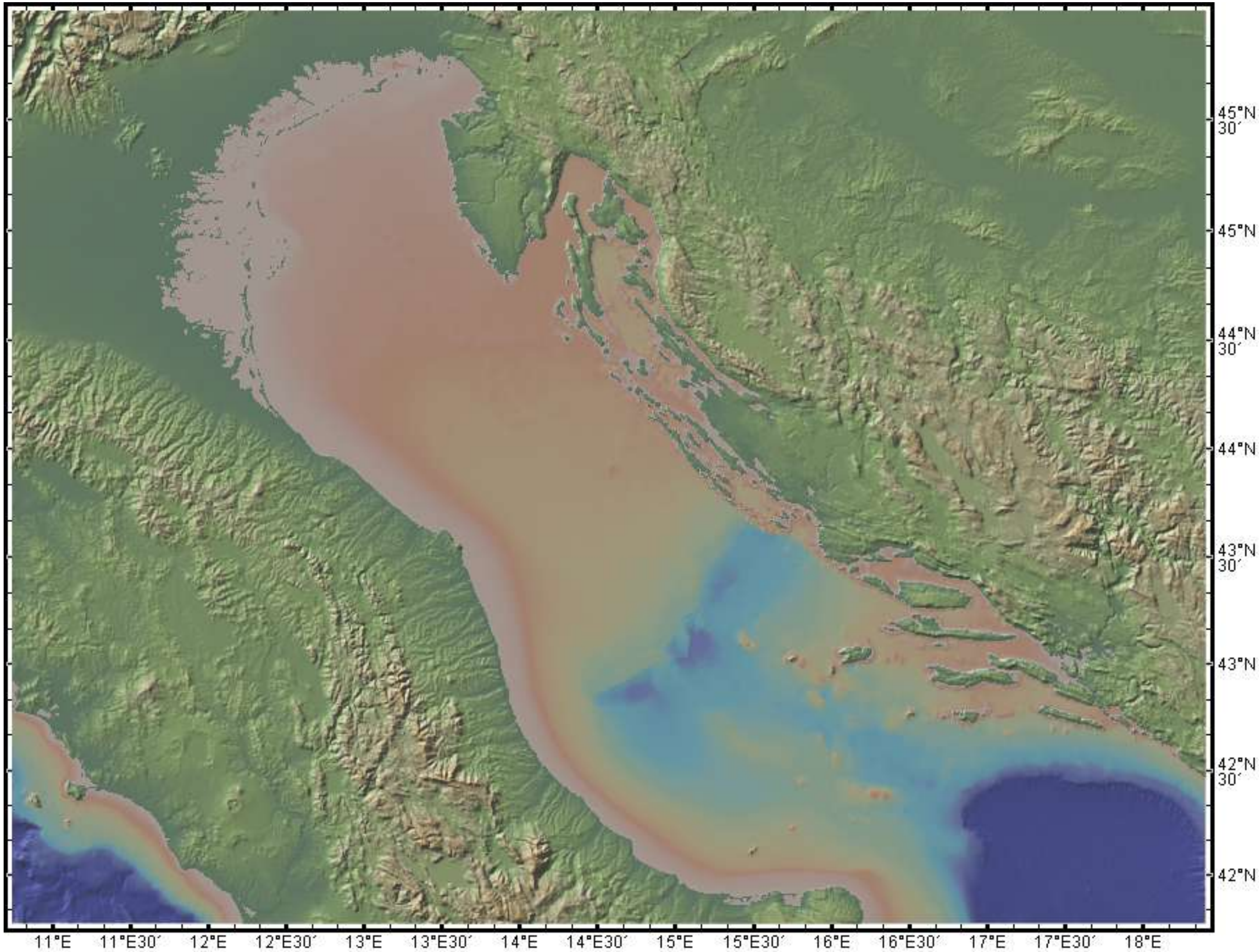
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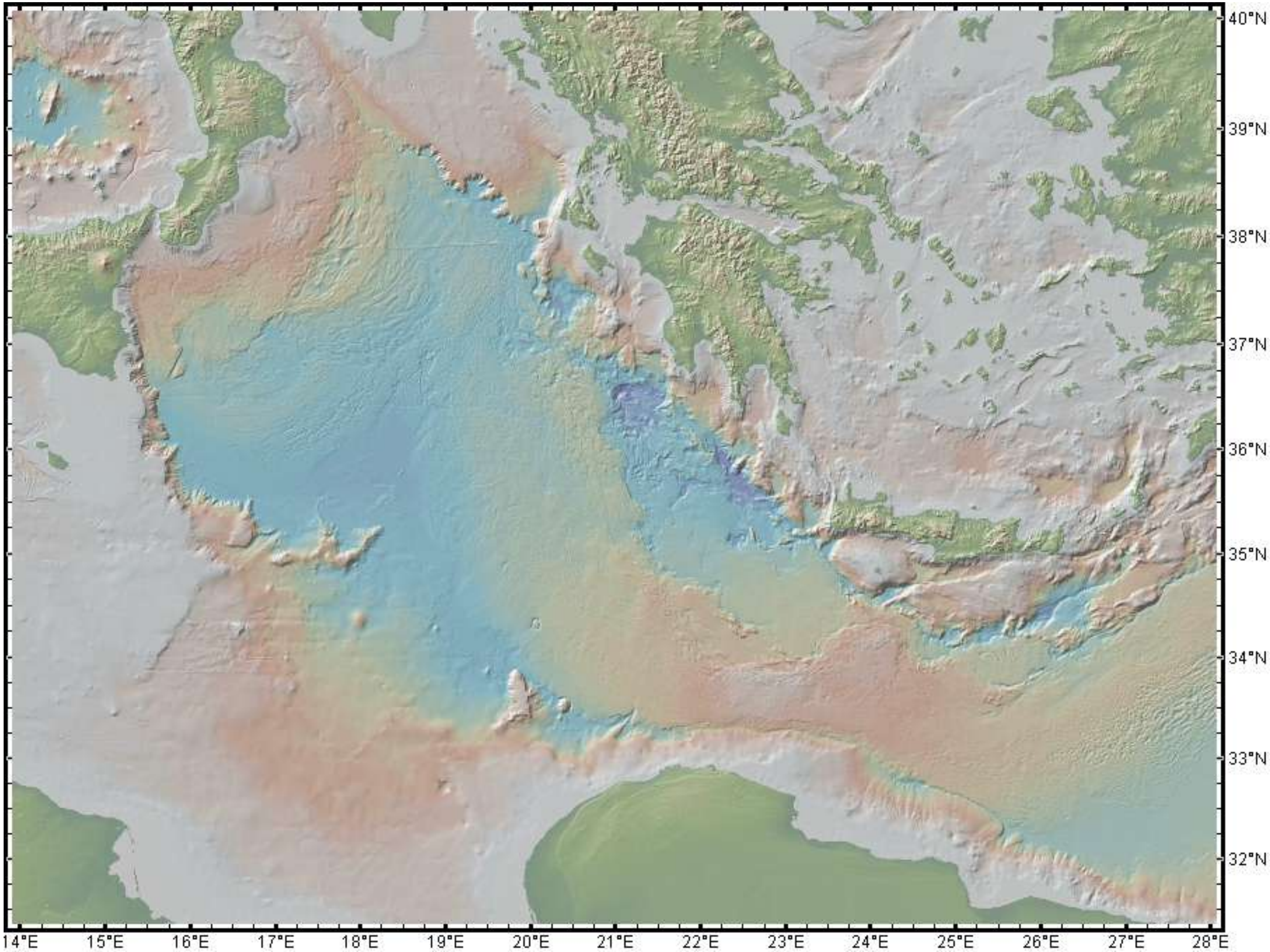
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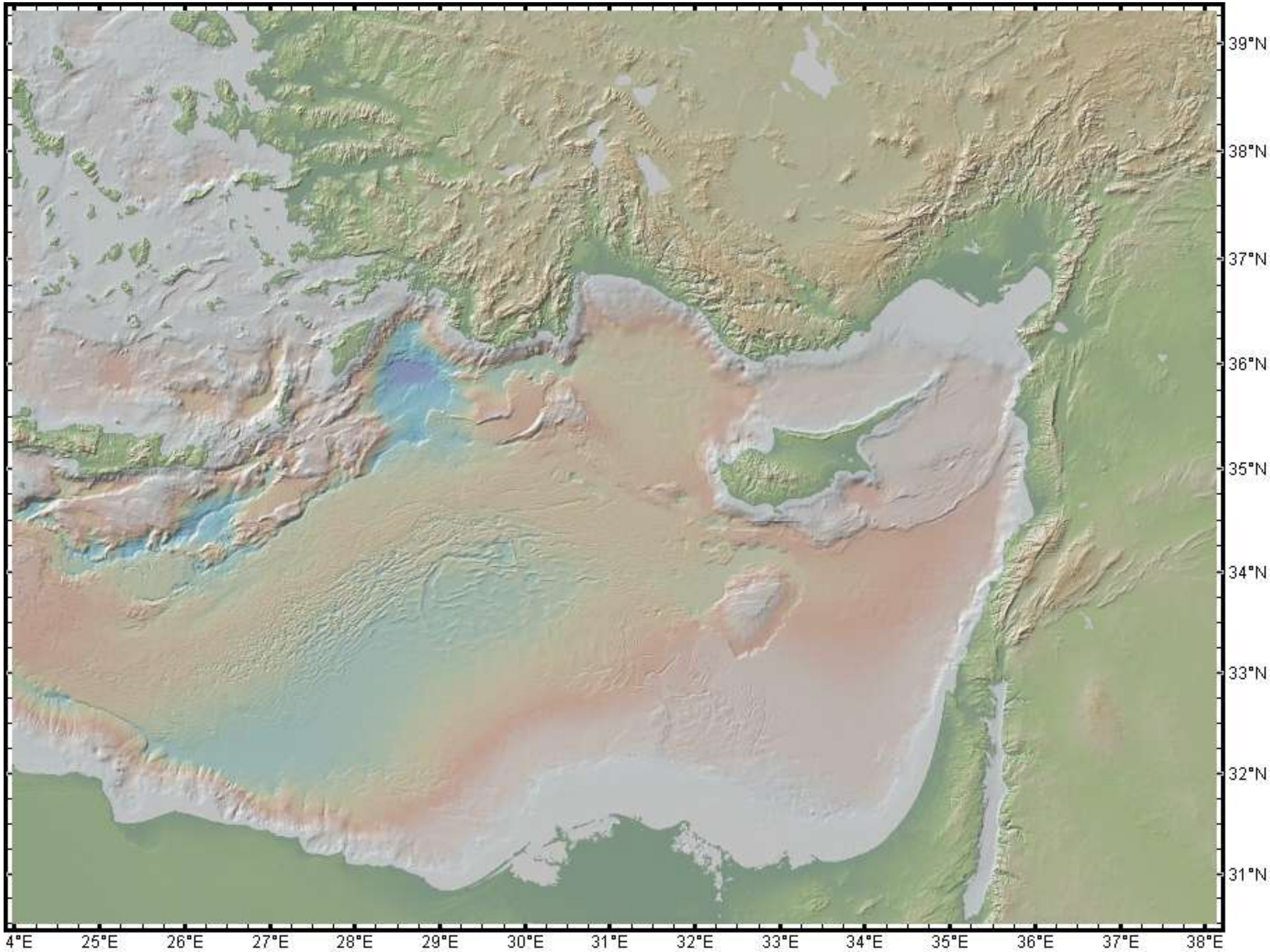
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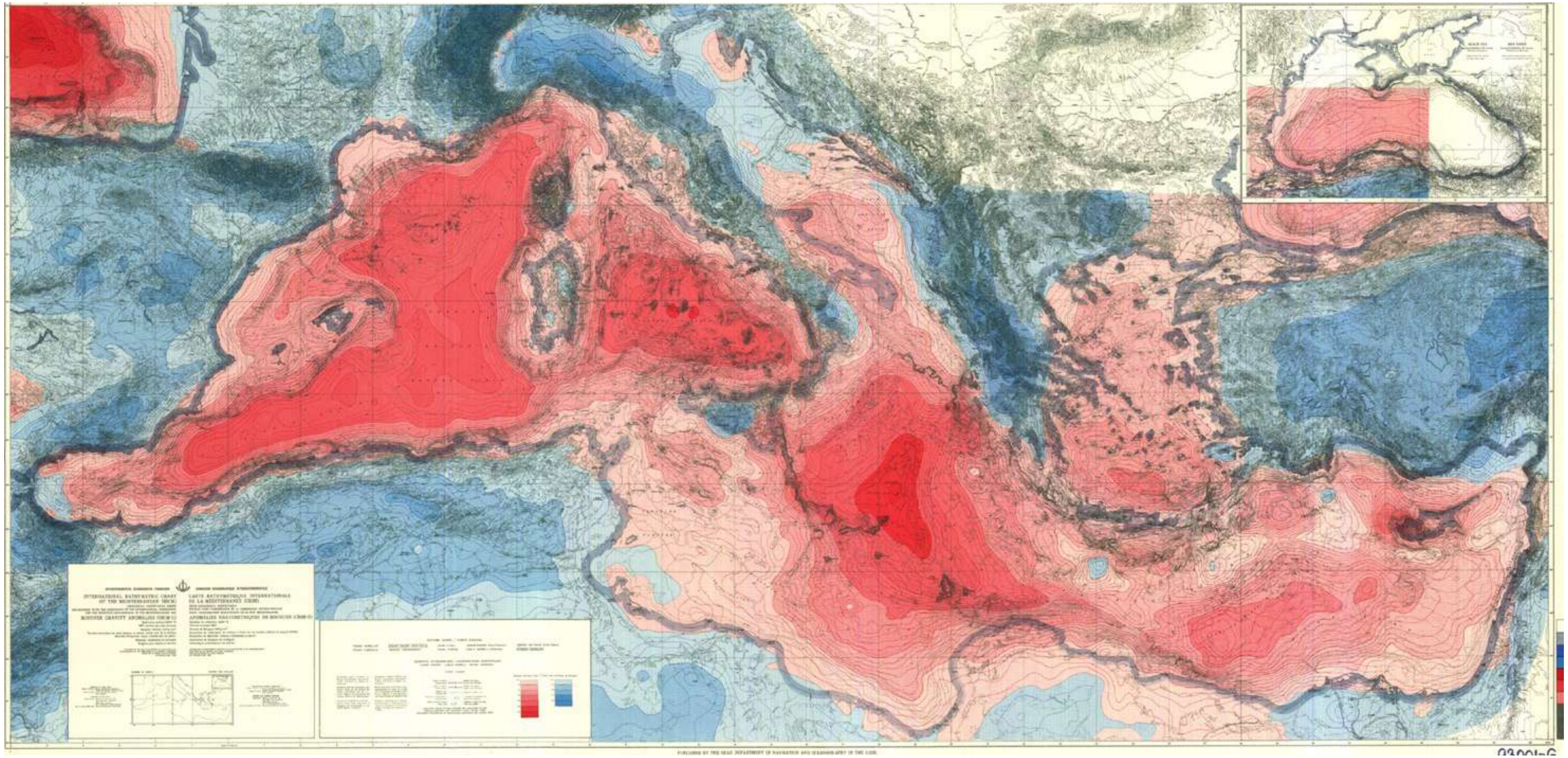
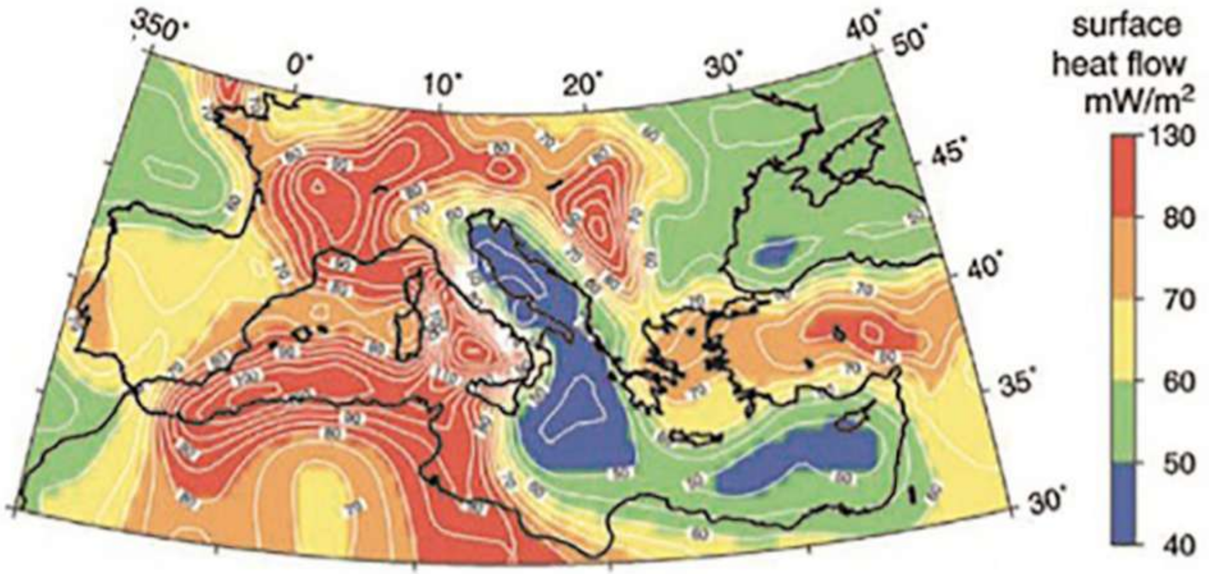
Bouguer gravity anomaly

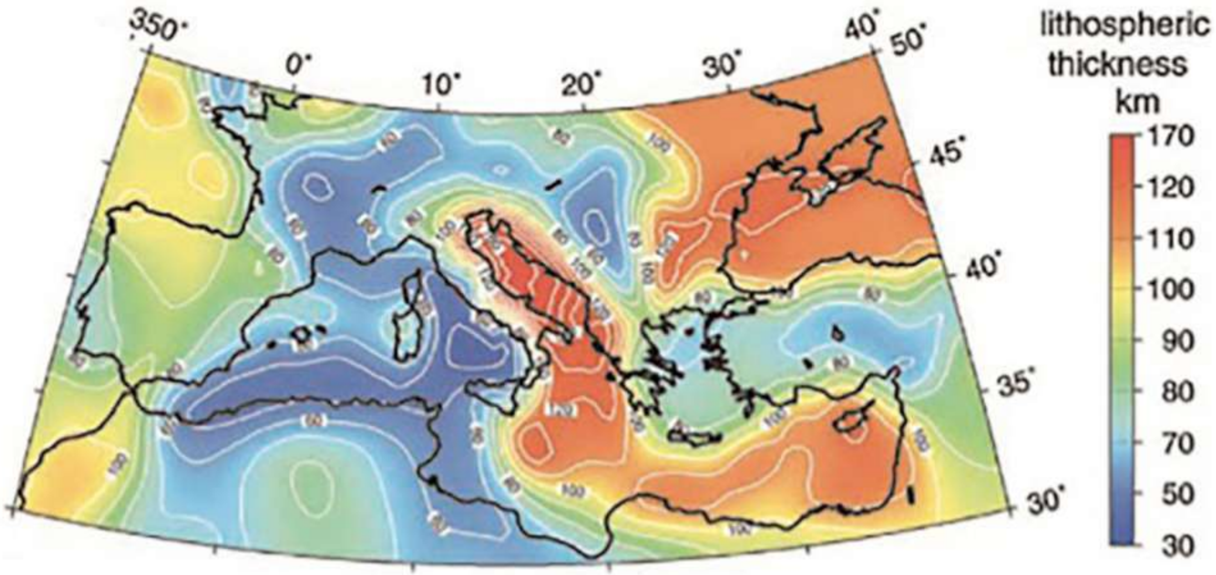


Heat Flow

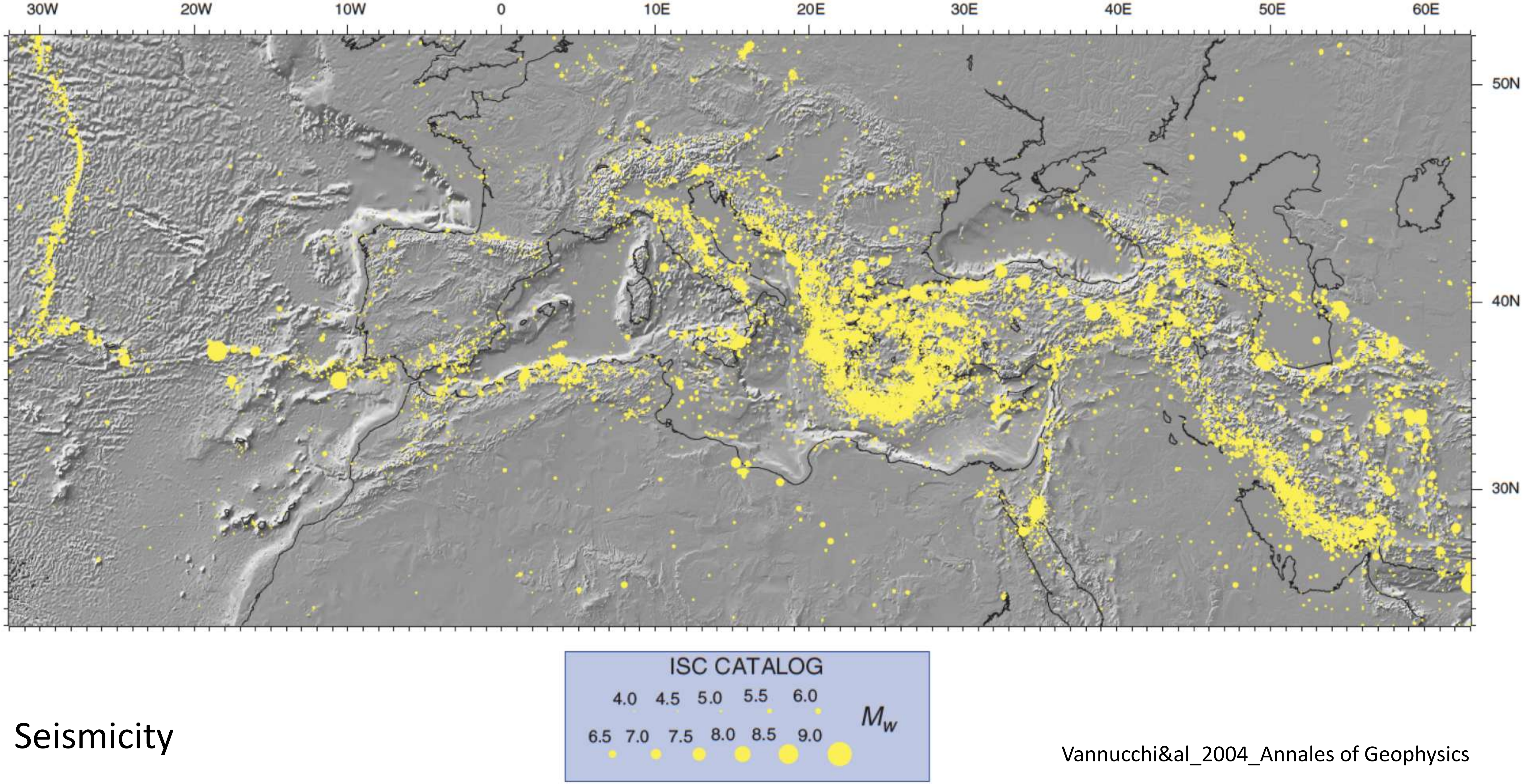


Poort et al., 2020

Lithospheric thickness

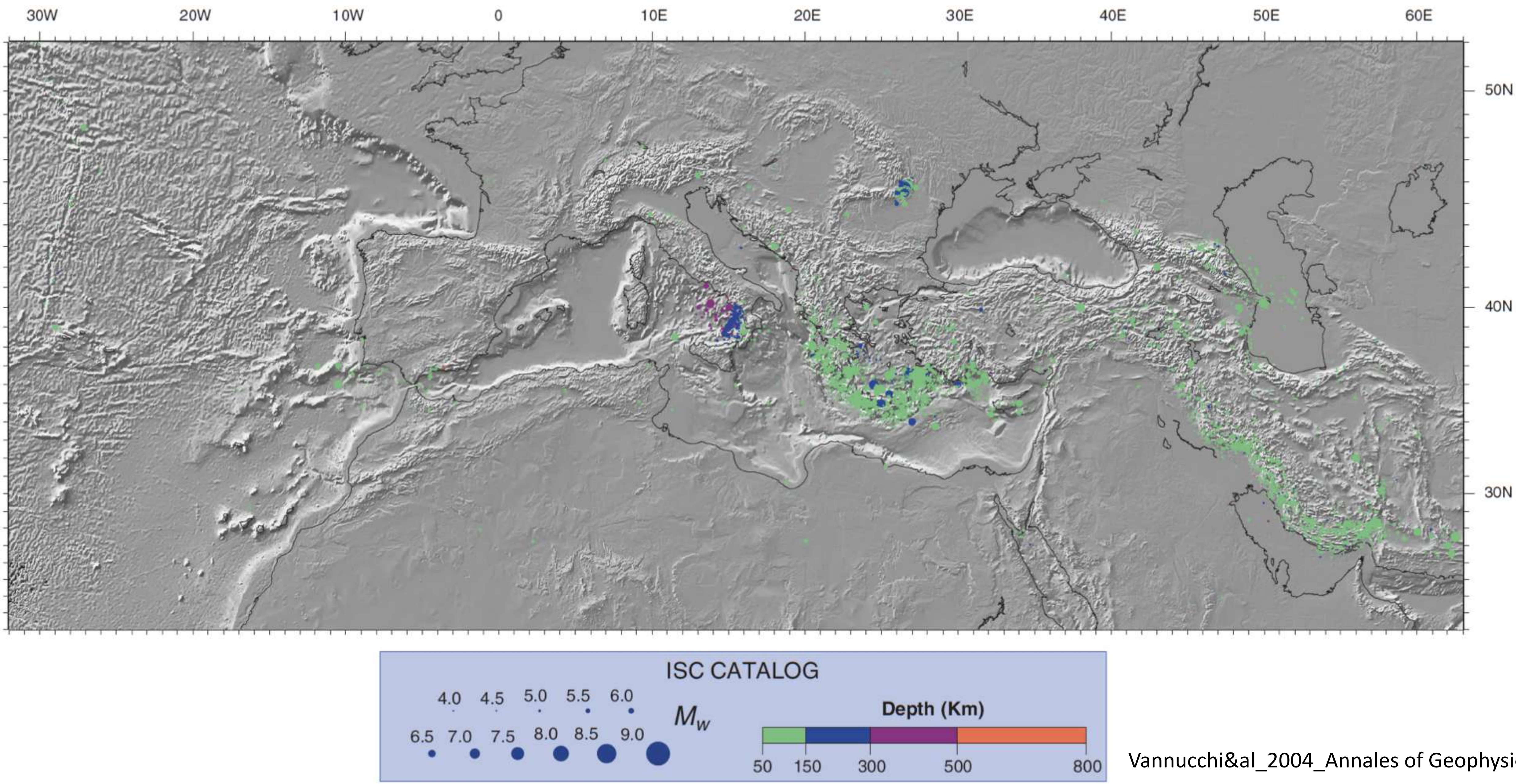


Poort et al., 2020

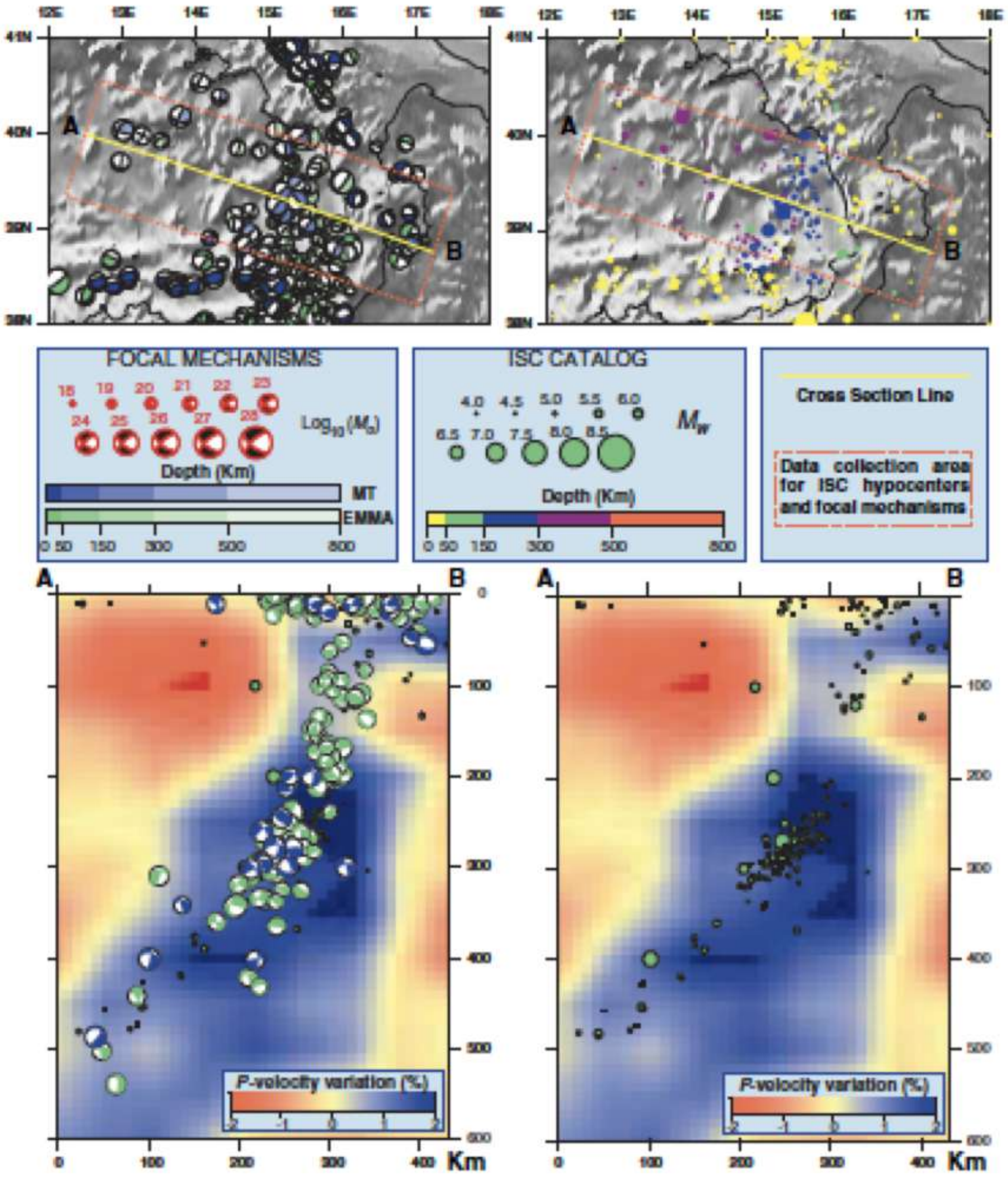


Seismicity

Vannucchi&al_2004_Annales of Geophysics

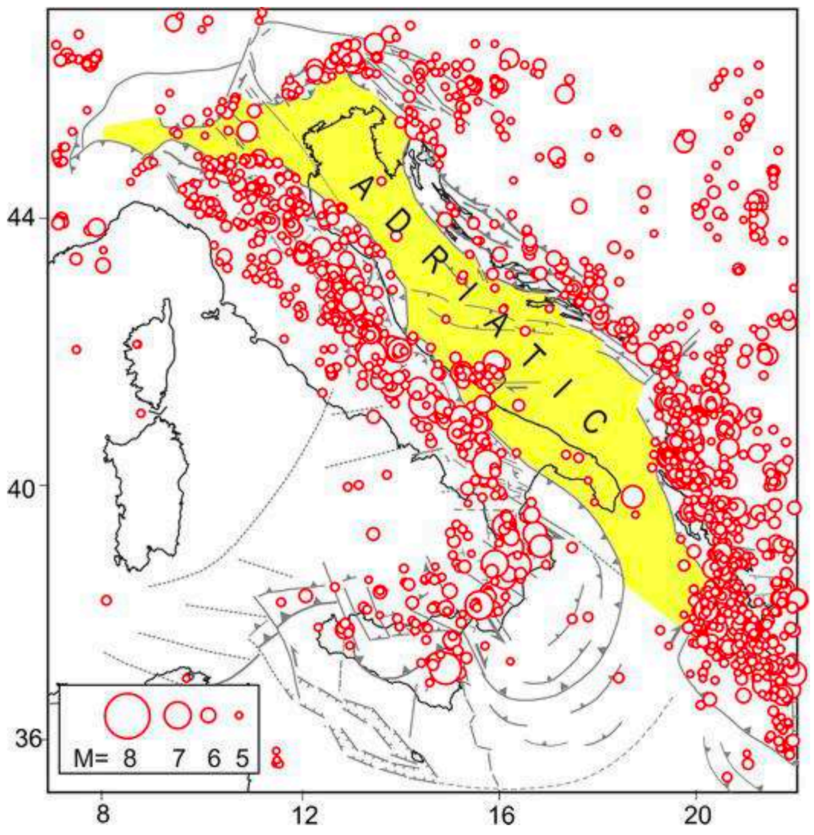


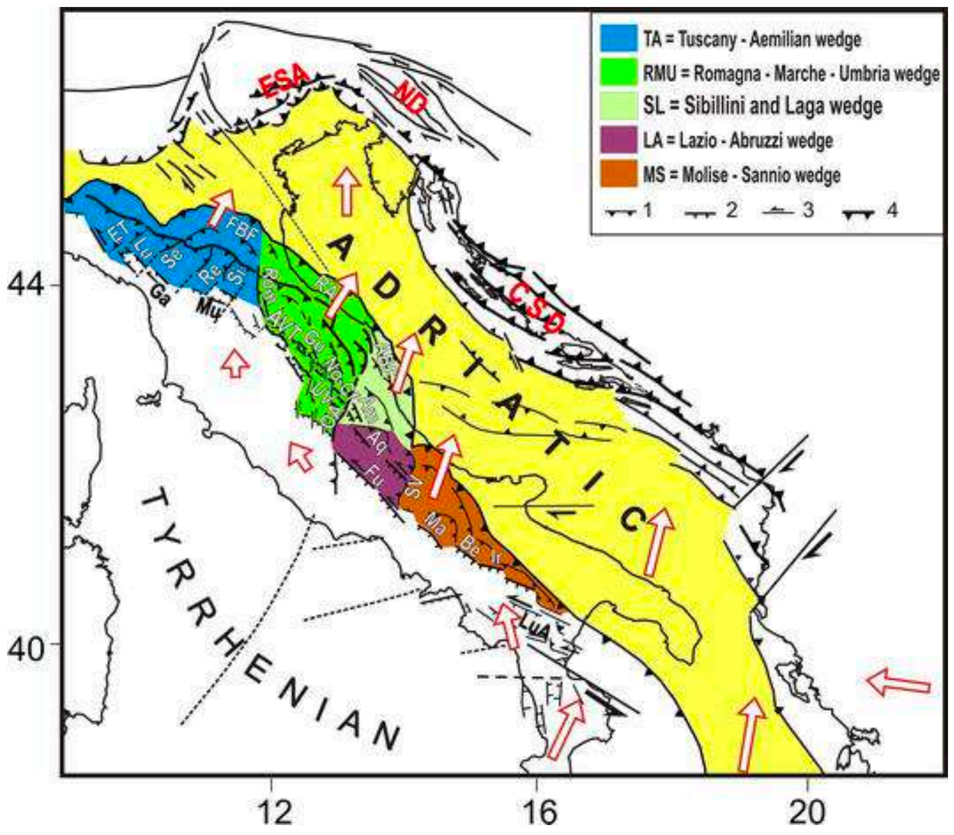
Vannucchi&al_2004_Annales of Geophysics



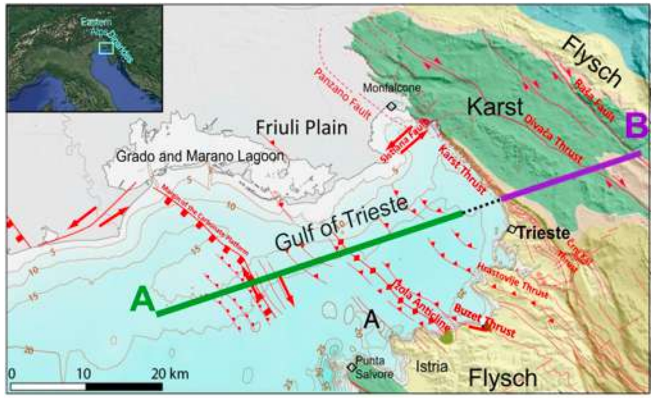
Vannucchi&al_2004_Annales of Geophysics

Adria plate



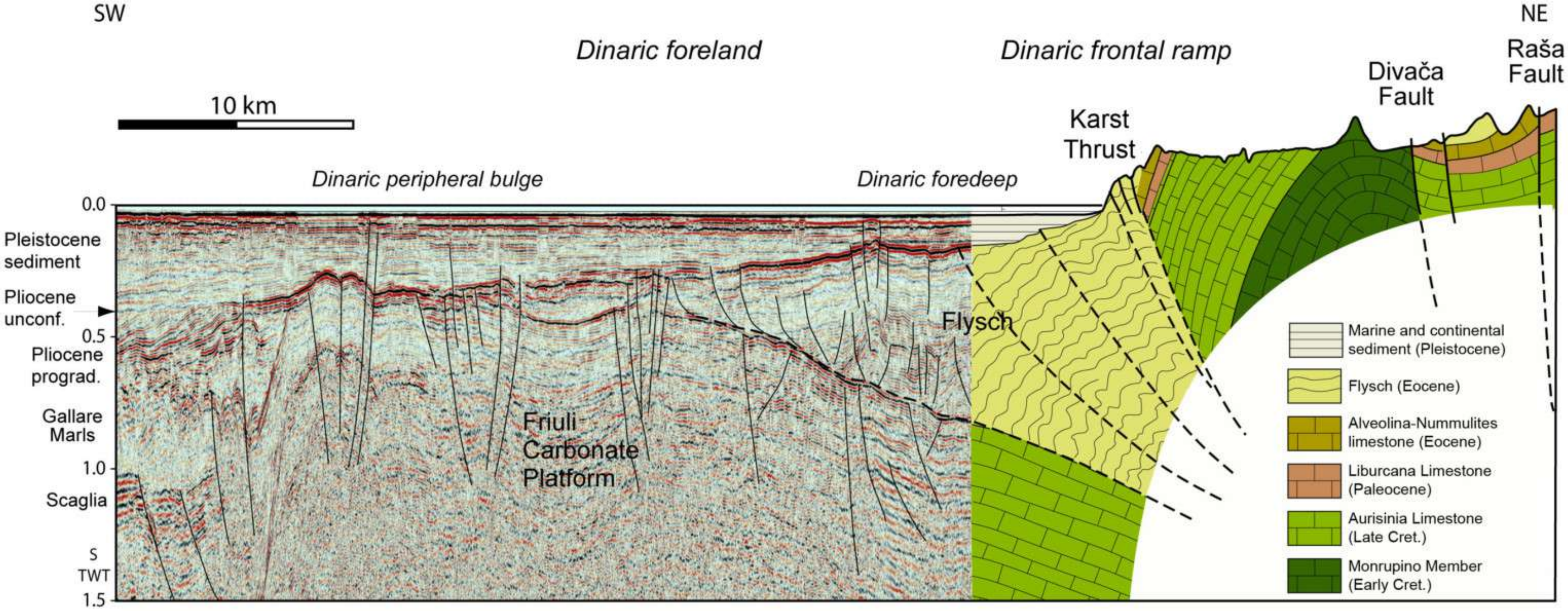


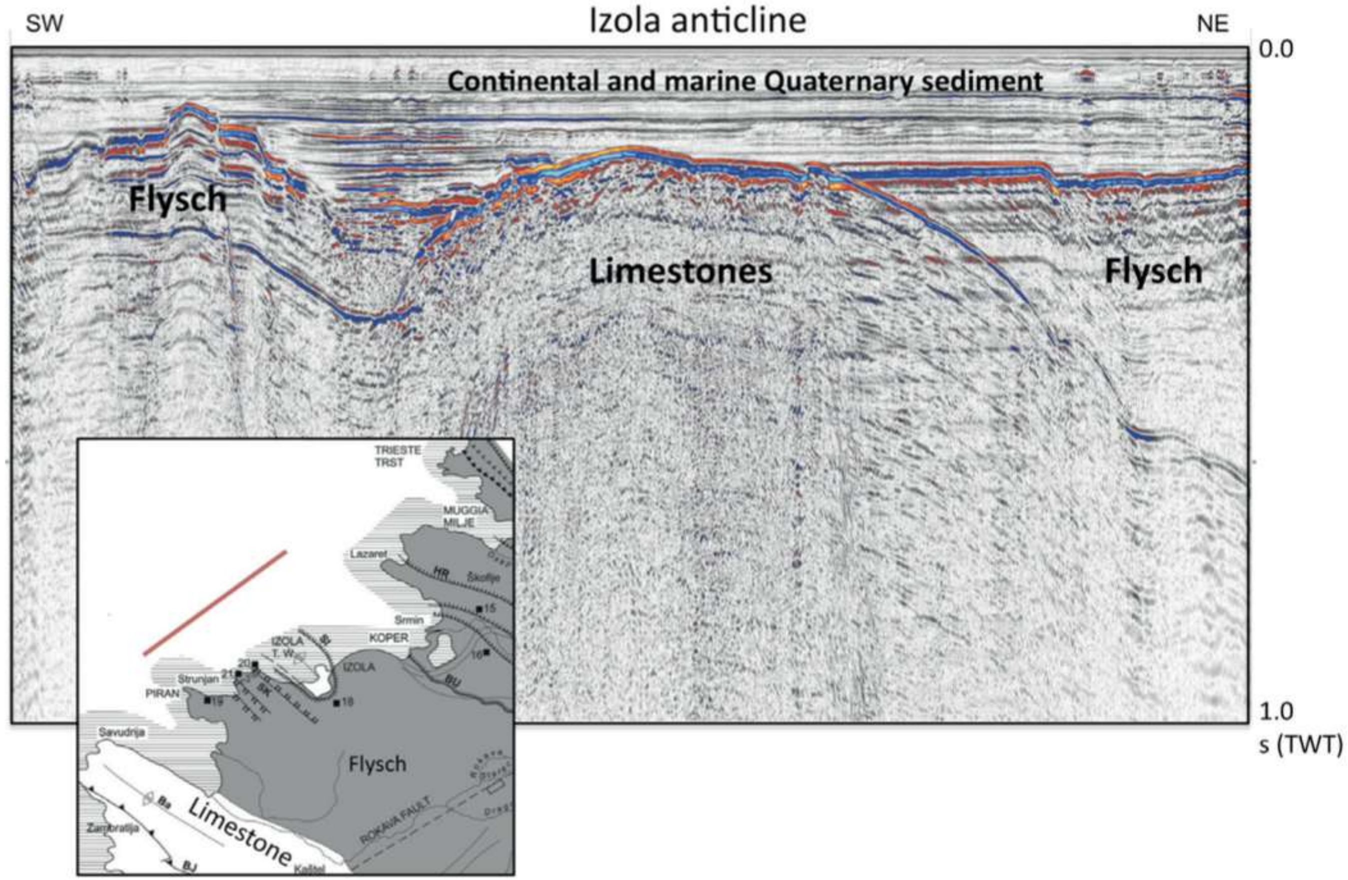
Mantovani et al., 2020.



Simplified geological map of the Gulf of Trieste. The A-B line represents the position of the cross-section in Figure 4. The green part corresponds to the seismic data, the purple part corresponds to the schematic cross-section. Trieste lies above Eocene flysch, at the front of the NW-SE Karst Thrust that delimit the Karst plateau. Offshore, the Karst's carbonate platform is repeatedly thrusted and folded until the margin of the platform. Courtesy of Martina Busetti.

https://blogs.egu.eu/divisions/ts/2019/10/16/trieste-where-the-word-karst-originates/





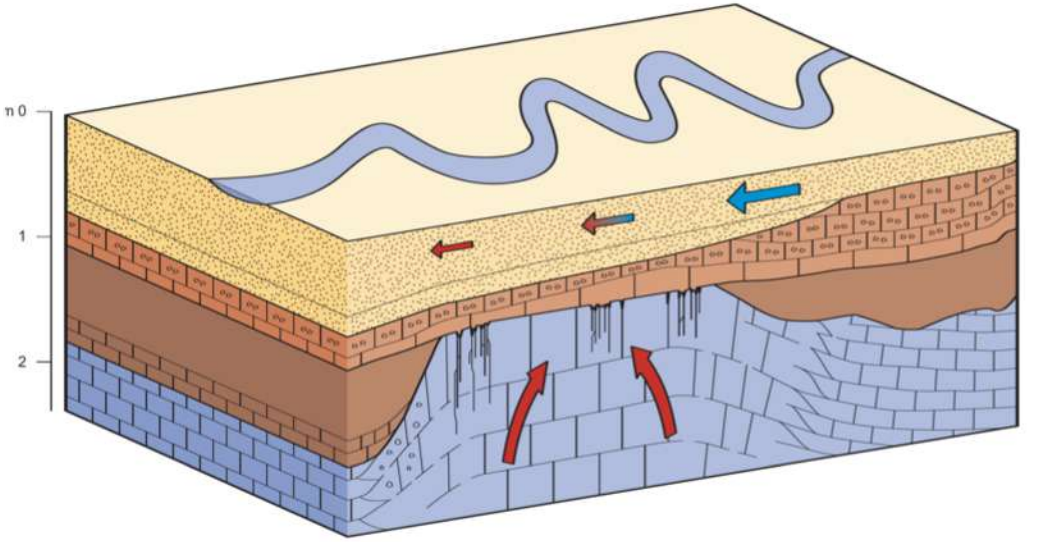


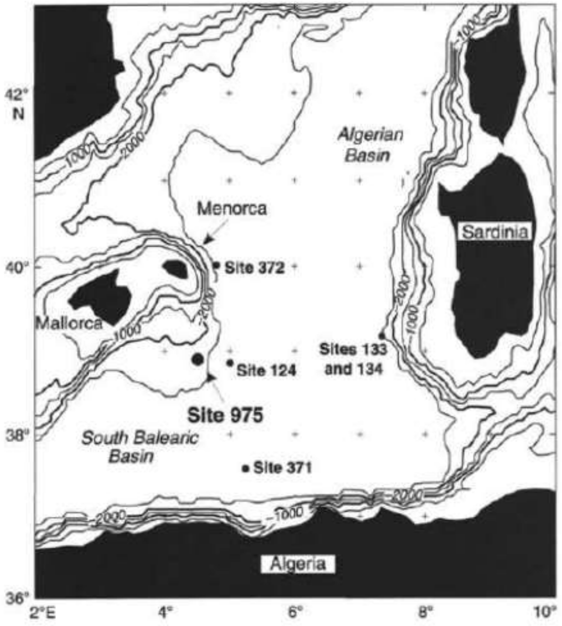
Fig. 5: modello geologico schematico di circolazione delle acque entro i carbonati della piattaforma

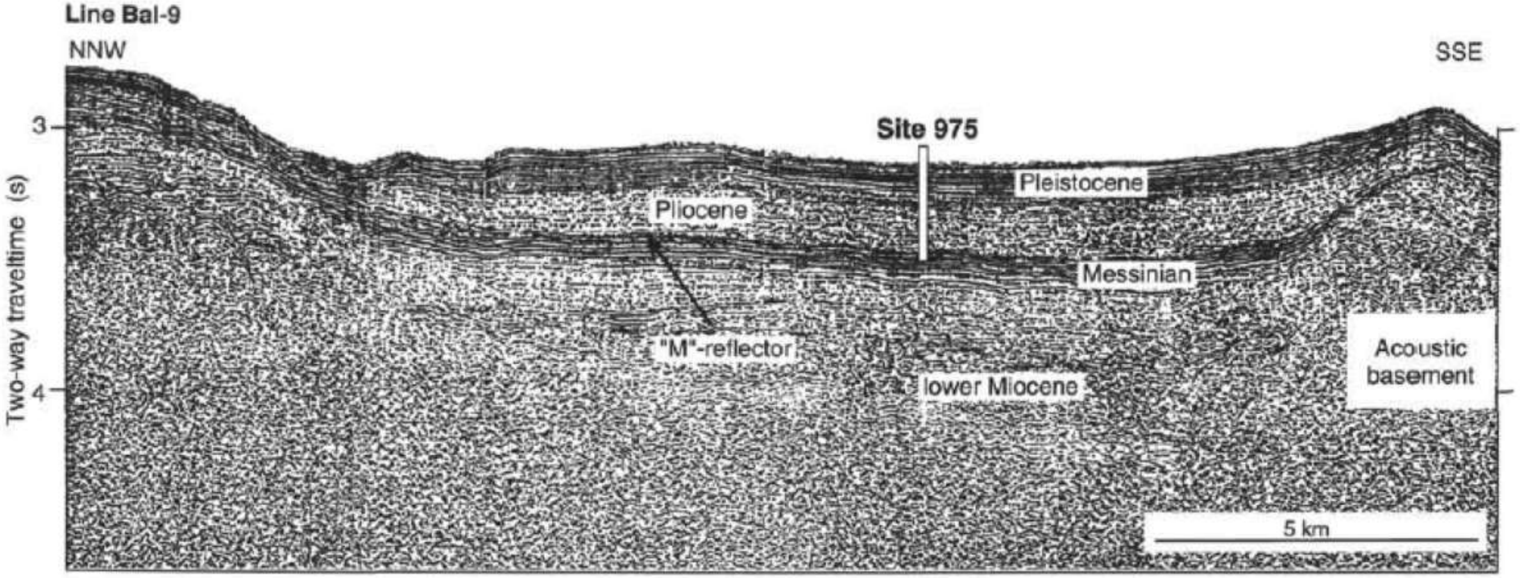
Nicolich et al., 2007

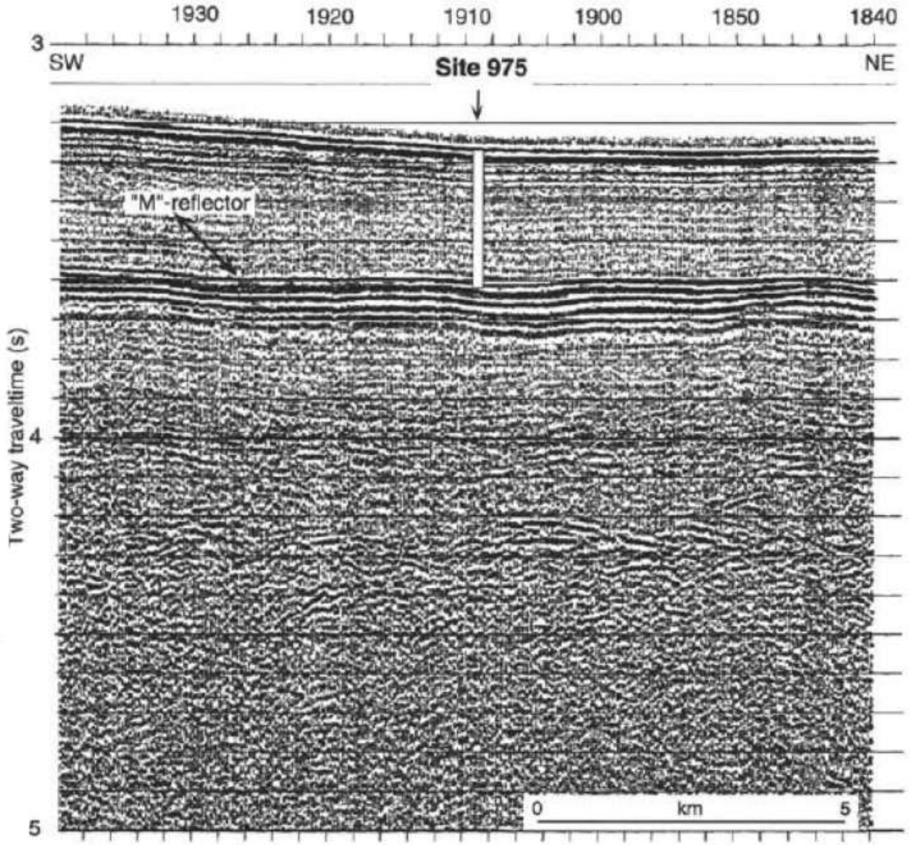
Busetti_et al., GNGTS2013

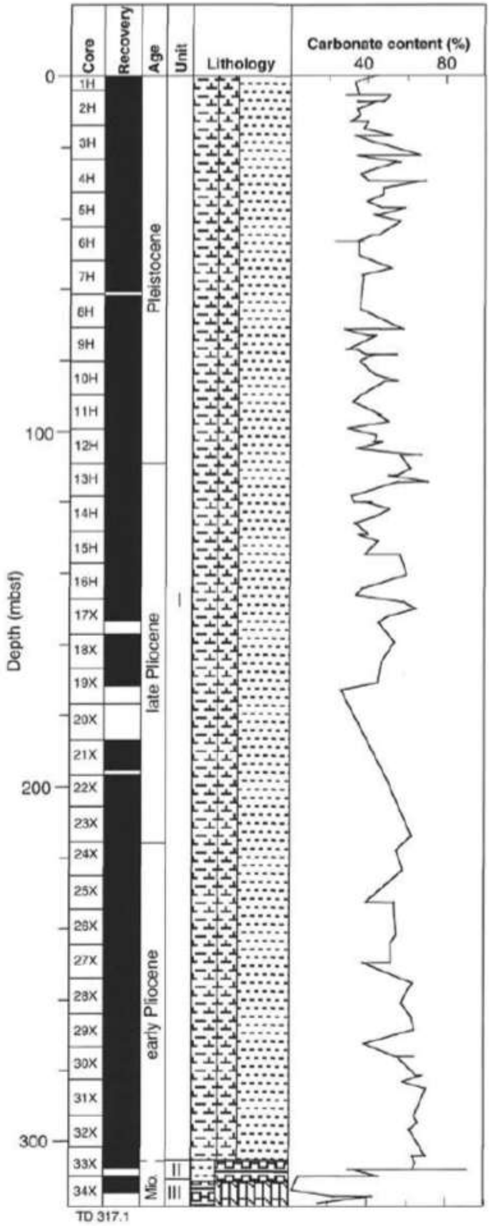
Stratigraphy

ODP Leg 161 – Western Mediterranean
Site 975





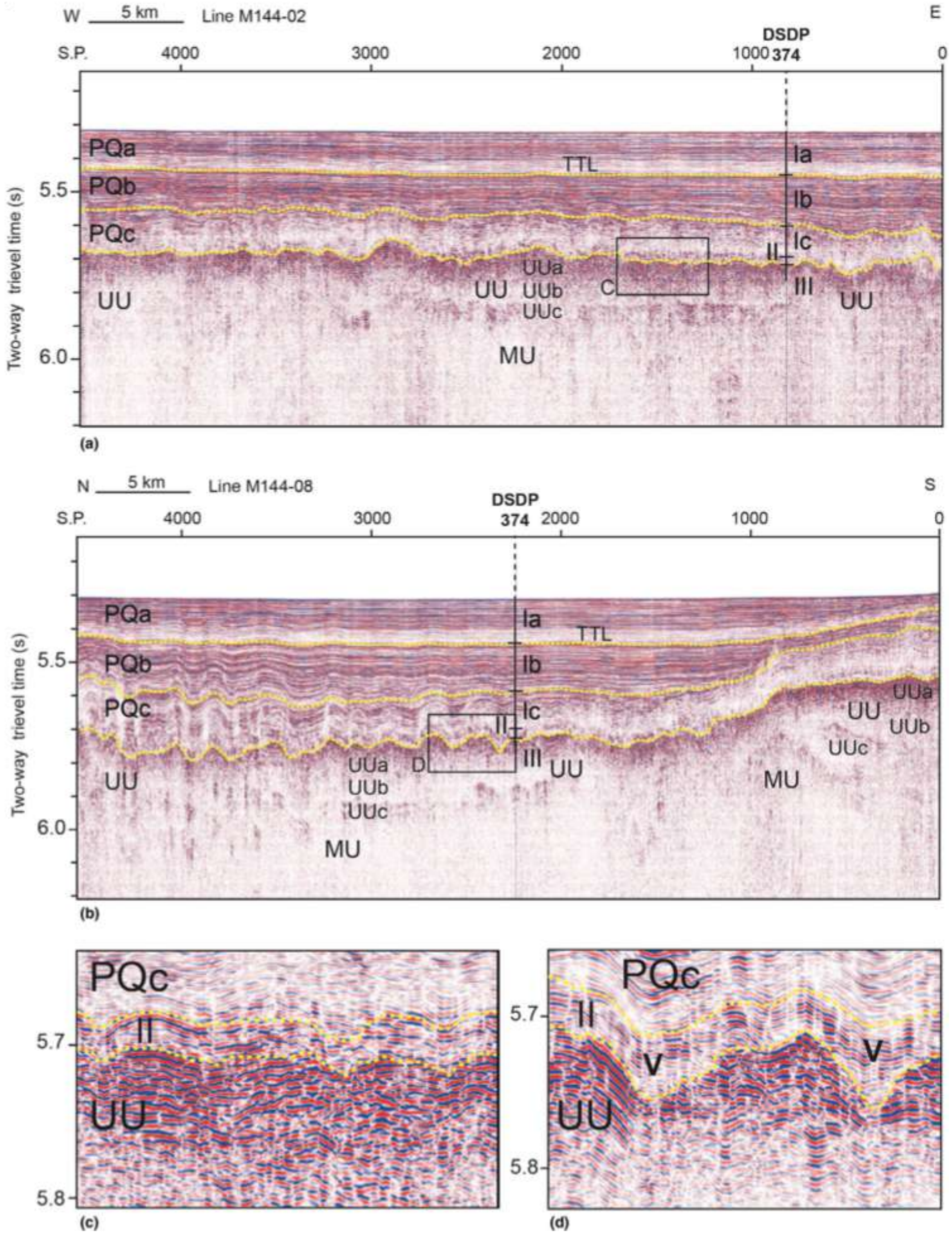


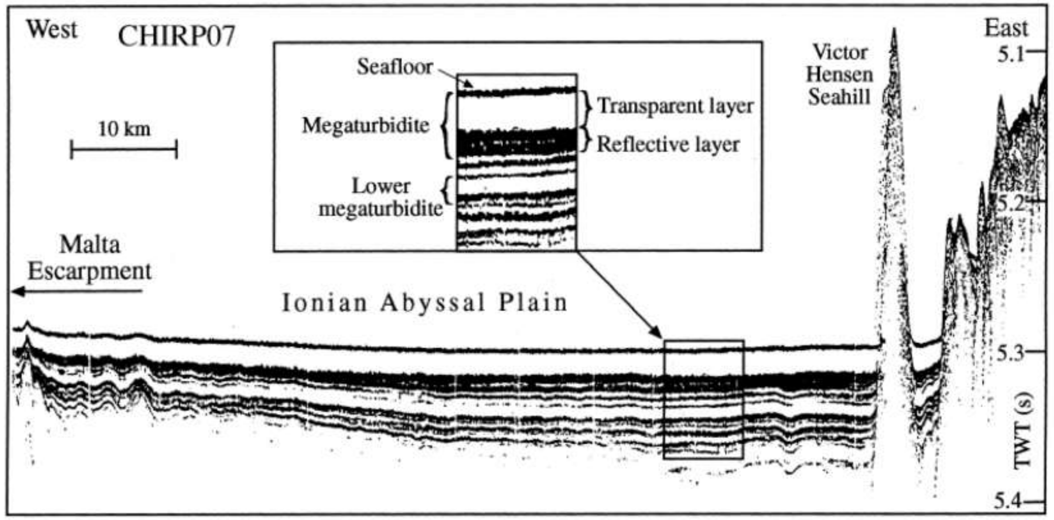


ODP Leg 161 – Western Mediterranean
Site 975

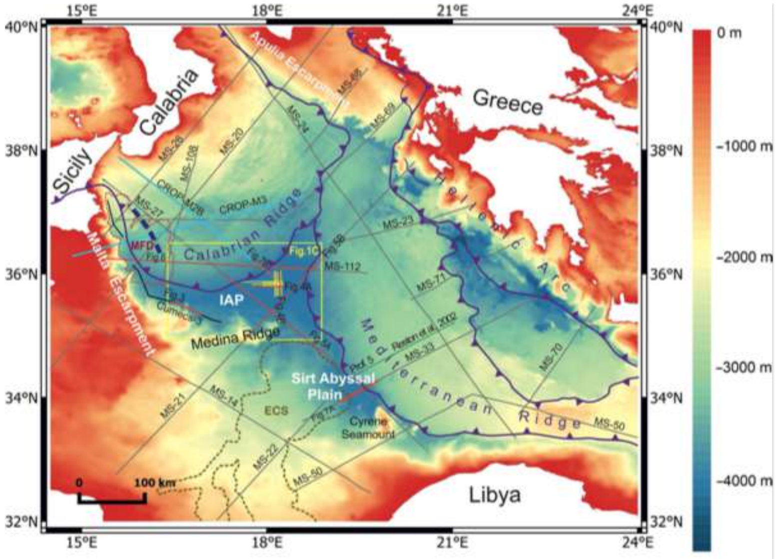
Table 2. Summary of lithostratigraphic units for Site 975.

Unit	Age	Lithology	Sedimentary structures	Occurrence	Interval (mbsf)
I	Pleistocene to Pliocene–Miocene	Major:			
		Nannofossil or calcareous clay and silty clay	Alternating dark and light bands, through Core 975B-18X	Core 975A-1H	0.0–9.5
				Core 975B-1H to Section 975B-33X-2, 131 cm	0.0–305.2
		Nannofossil ooze	Foraminifer-rich silt laminae, through Core 975B-18X	Core 975C-1H to Section 975C-33X-4, 110 cm	0.0–306.3
				Core 975D-1H to 16H	0.0–149.9
			Bioturbation, common throughout; large burrows especially noticeable in Cores 975B-18X through 33X		
			Slumps in Cores 975B-13X and 975C-13X and 26X		
		Minor:			
		Organic-rich layers	Color banding		
II	Pliocene–Miocene?	Major:			
		Micrite and micritic silty clay	Thinly interbedded and finely laminated	Section 975B-33X-2, 131 cm, to Section 975B-33X-CC, 11 cm	305.2–307.0
		Minor:			
		Calcareous silty sand	Thin beds; graded or laminated	Section 975C-33X-4, 110 cm, to Section 975C-33X-CC	306.3–306.9
III	Miocene	Major:			
		Gypsum and gypsiferous chalk	Finely laminated, nodular, and coarse grained with micrite matrix	Section 975B-33X-CC, 11 cm, to Section 975B-34X-CC	307.0–317.1
		Minor:		Section 975C-34X-CC	310.7–313.7
		Clay to micrite-rich clay	Thin beds		
		Foraminifer-rich gypsum silty clay	Thin laminae in Section 975B-34X-CC		
		Anhydrite	Thin laminae in Section 975B-33X-CC		



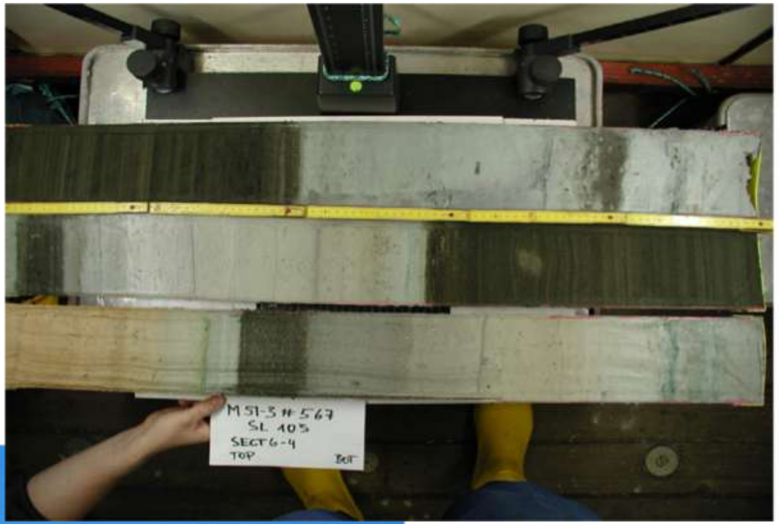


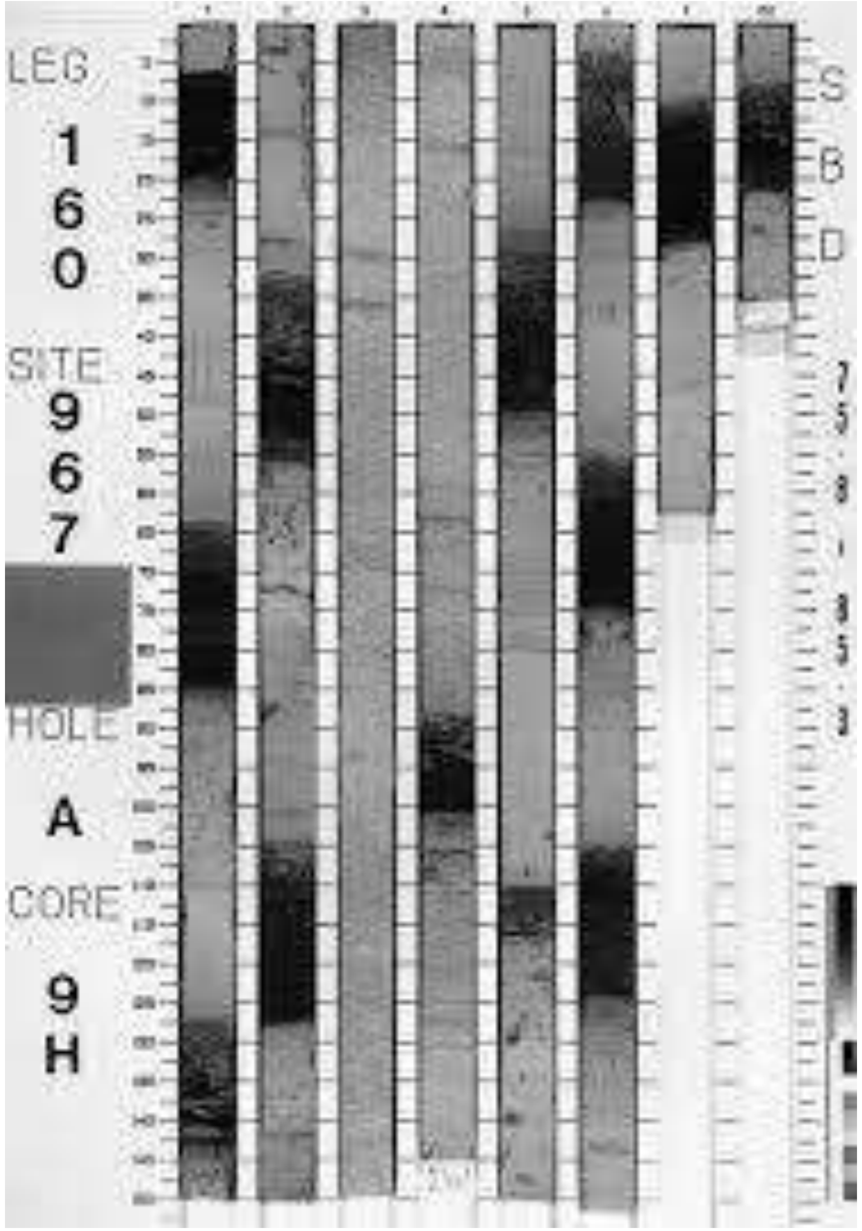
Rebesco&al., 2000



camerlenghi&al., 2019

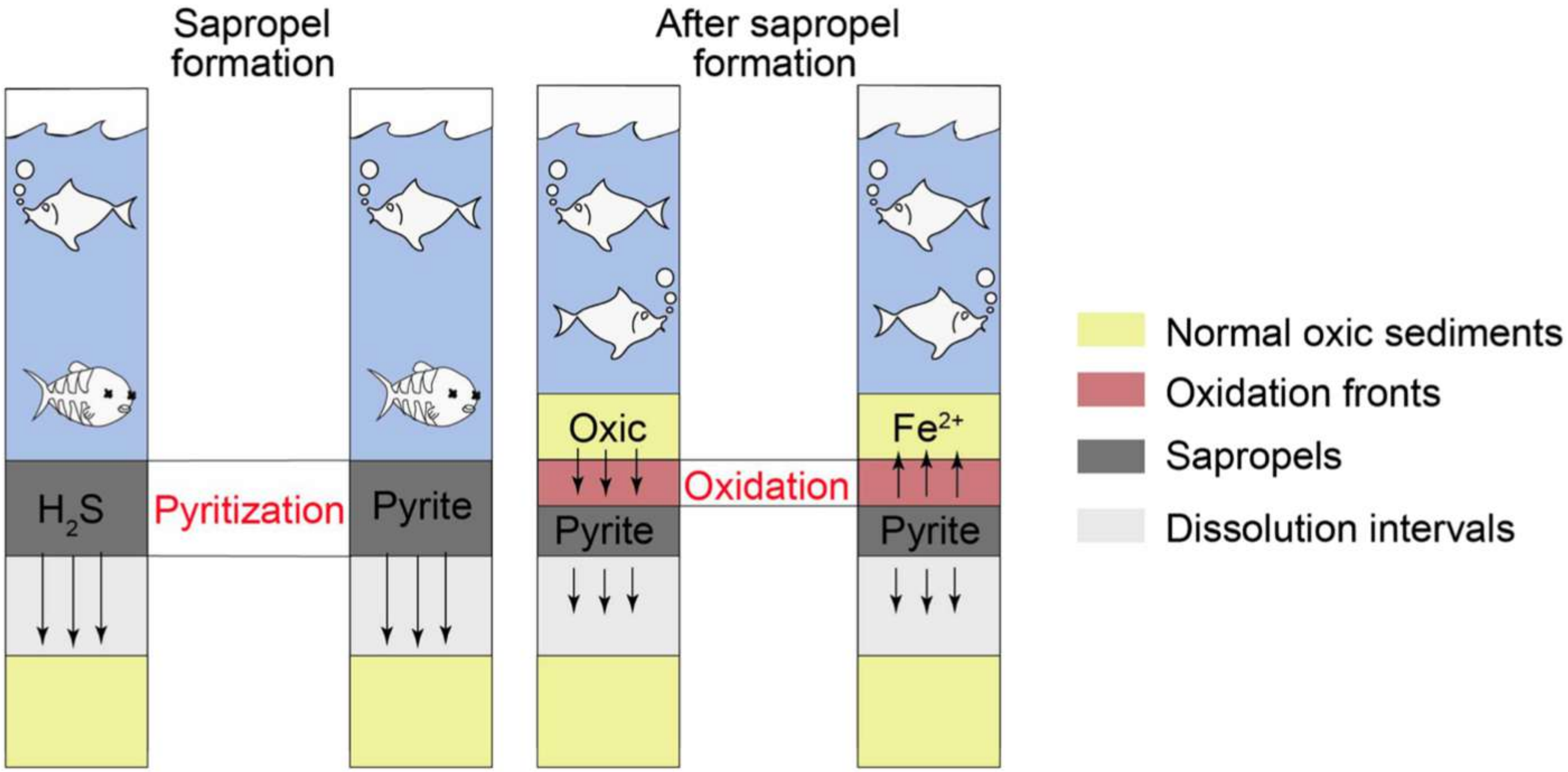
Sapropels. sediments rich in organic carbon (>2%) occurring cyclically in the Mediterranean marine records and whose origin has been matter of great debate during the last decades.





Rohling et al., 2015

Sapropels



Qian et al., 2019

Two main models to explain sapropel deposition:

stagnation/anoxia

anoxic bottom conditions are caused by a strong stratification of the water column that prevents vertical mixing and oxygen supply to the bottom waters.

The origin of stratification due to increased Nile river runoff linked to the periodic intensification of the African-Asian monsoons and, later, by increased rainfalls and river discharge along the northern part of the Eastern Mediterranean Sea.

increased productivity.

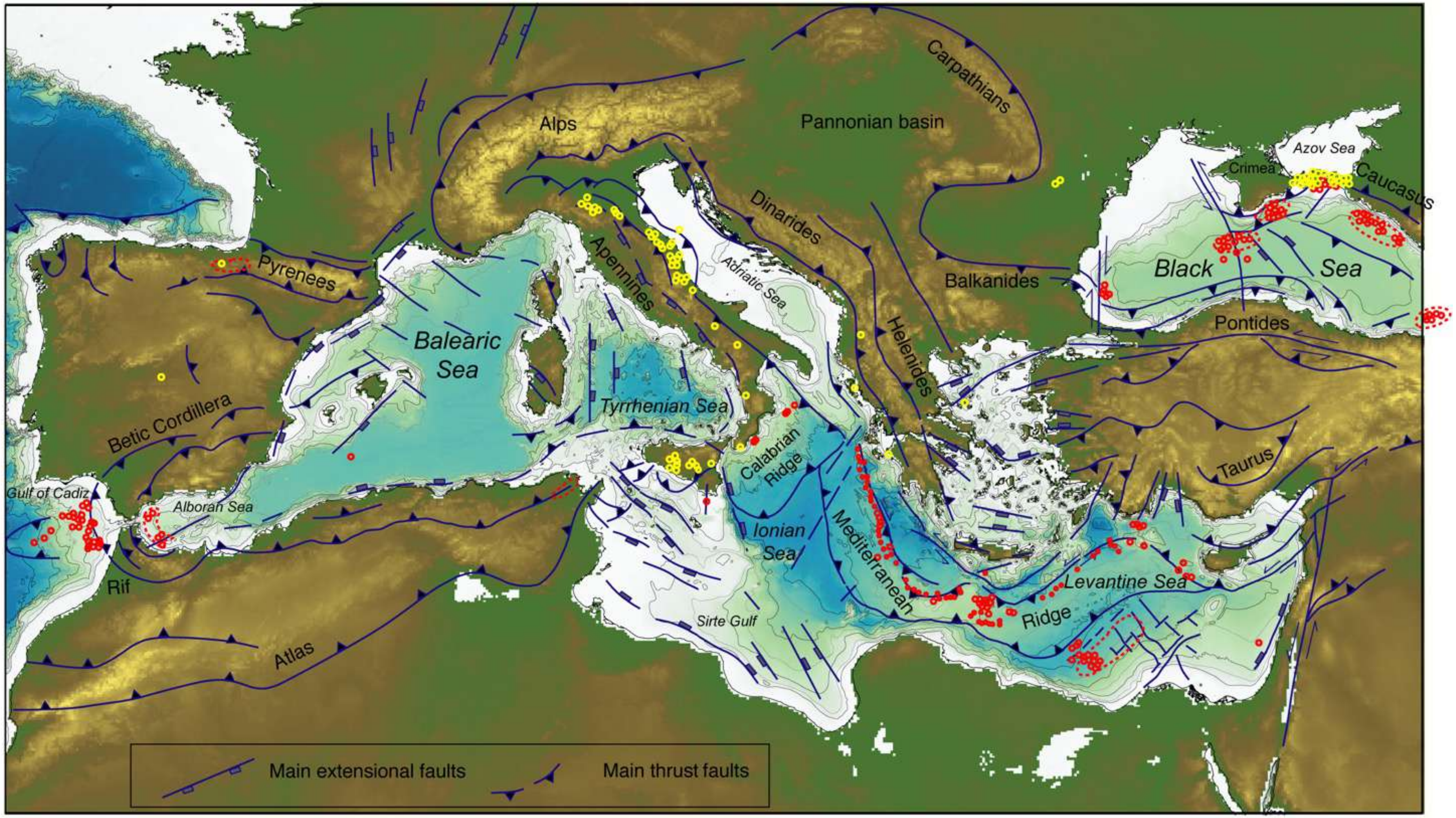
sapropel deposition was linked to enhanced organic matter flux, since the present production of organic matter in the Eastern Mediterranean cannot account for the high values of organic carbon (TOC) characterizing these layers.

Combination of the two:

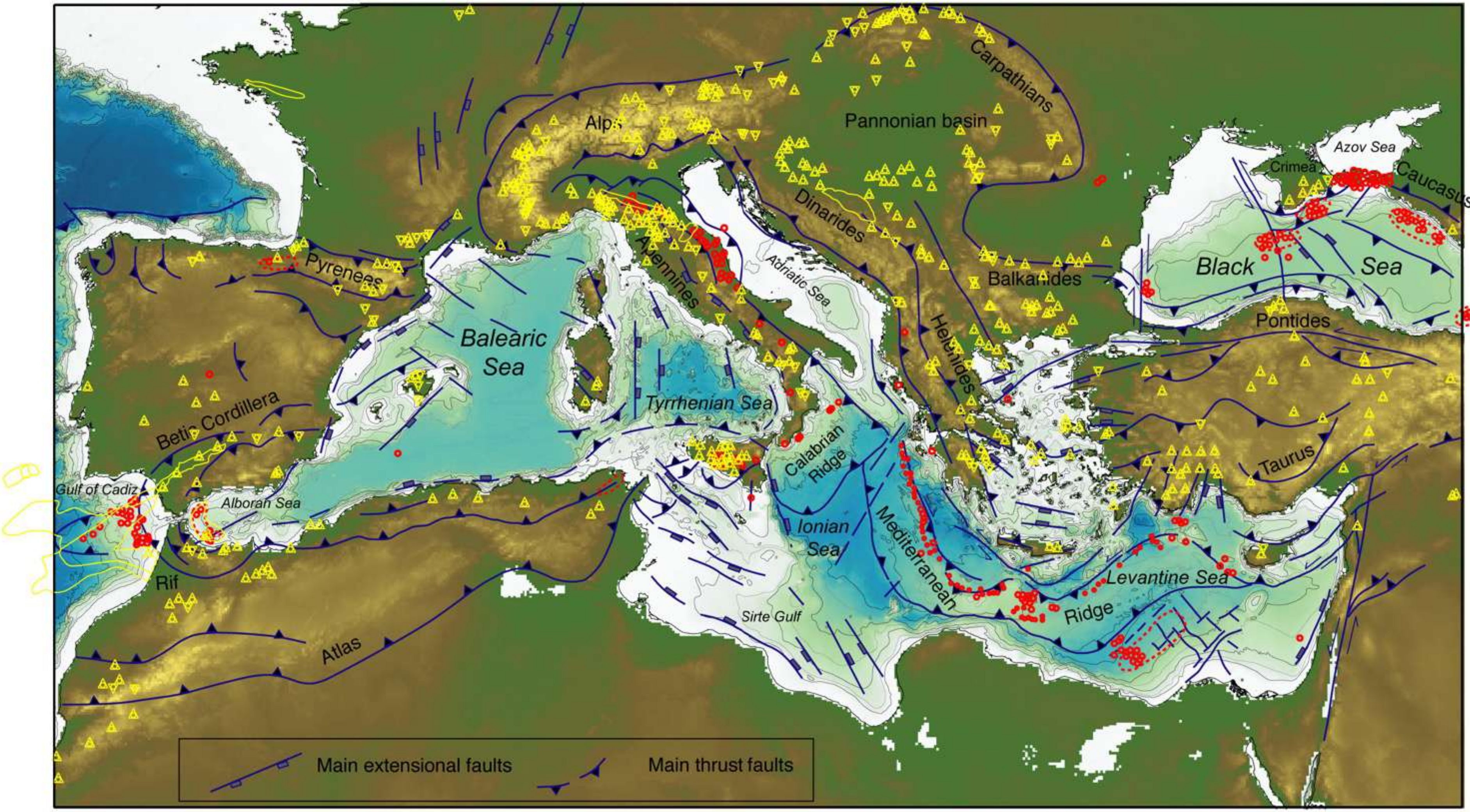
Stratification and productivity increase could have been caused by an overall increase of nutrient input via river runoff.

Negri et al., 2012

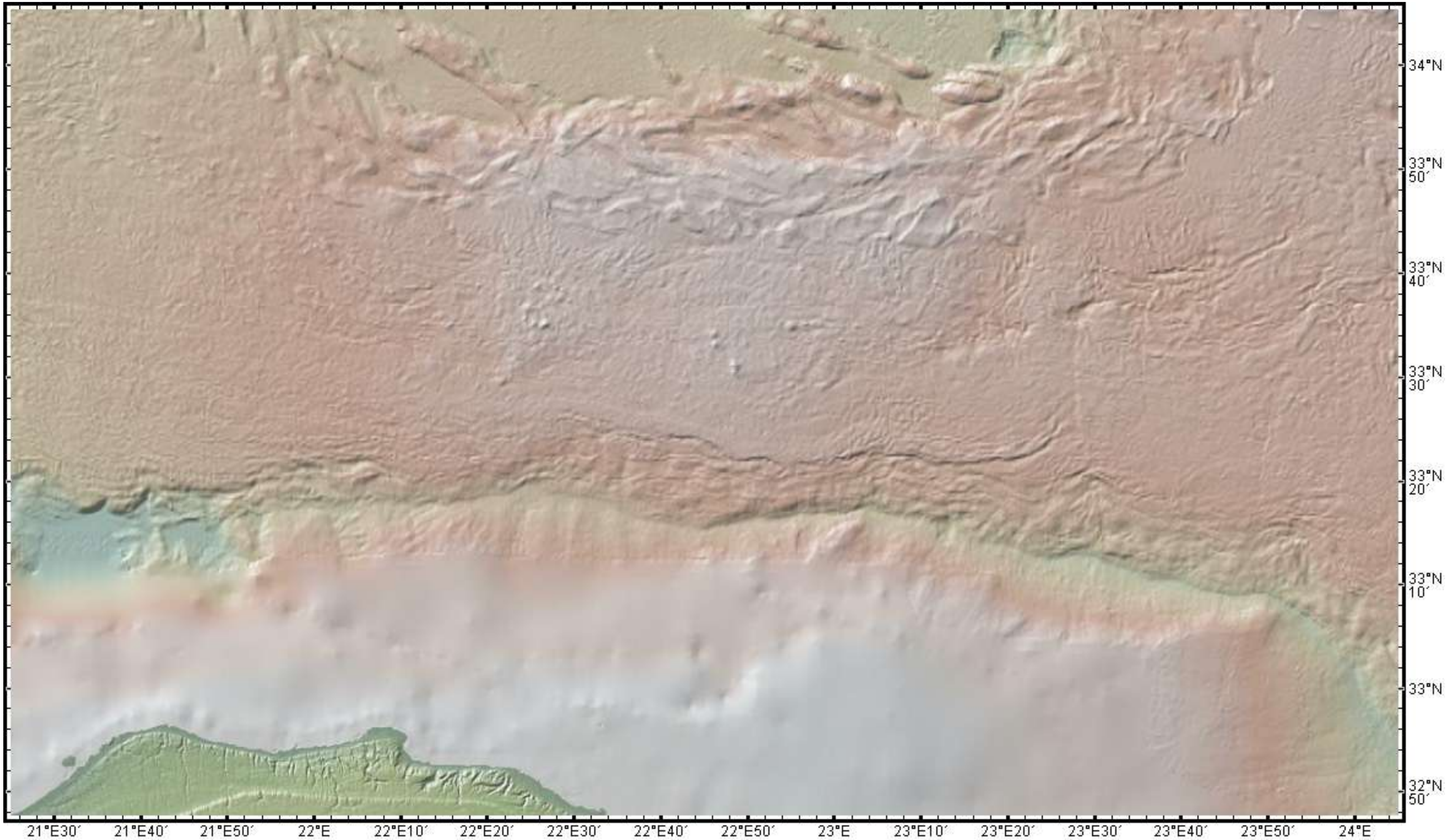
Mud volcanoes and olistostromes



Camerlenghi and Pini, 2009



Camerlenghi and Pini, 2009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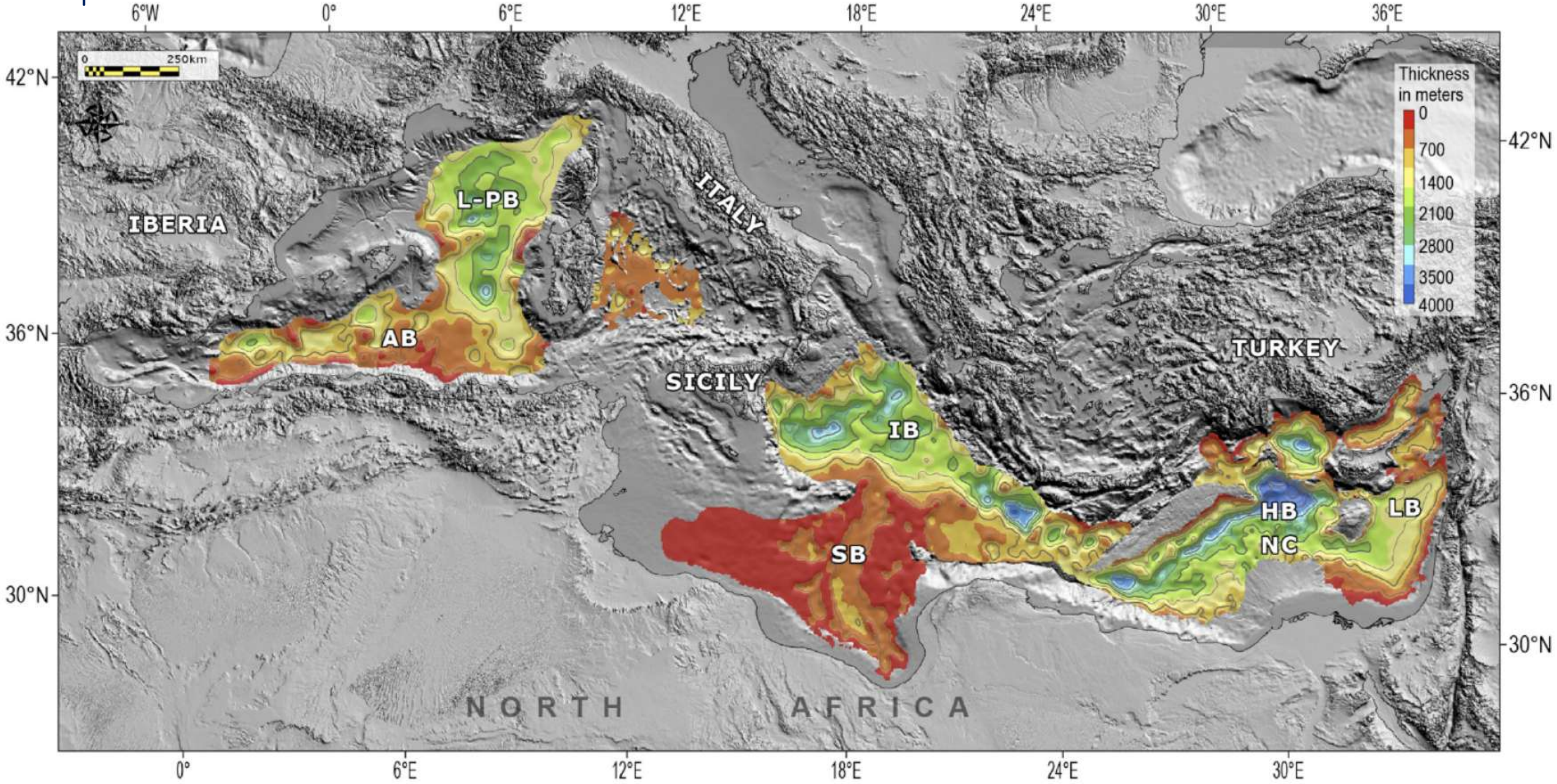
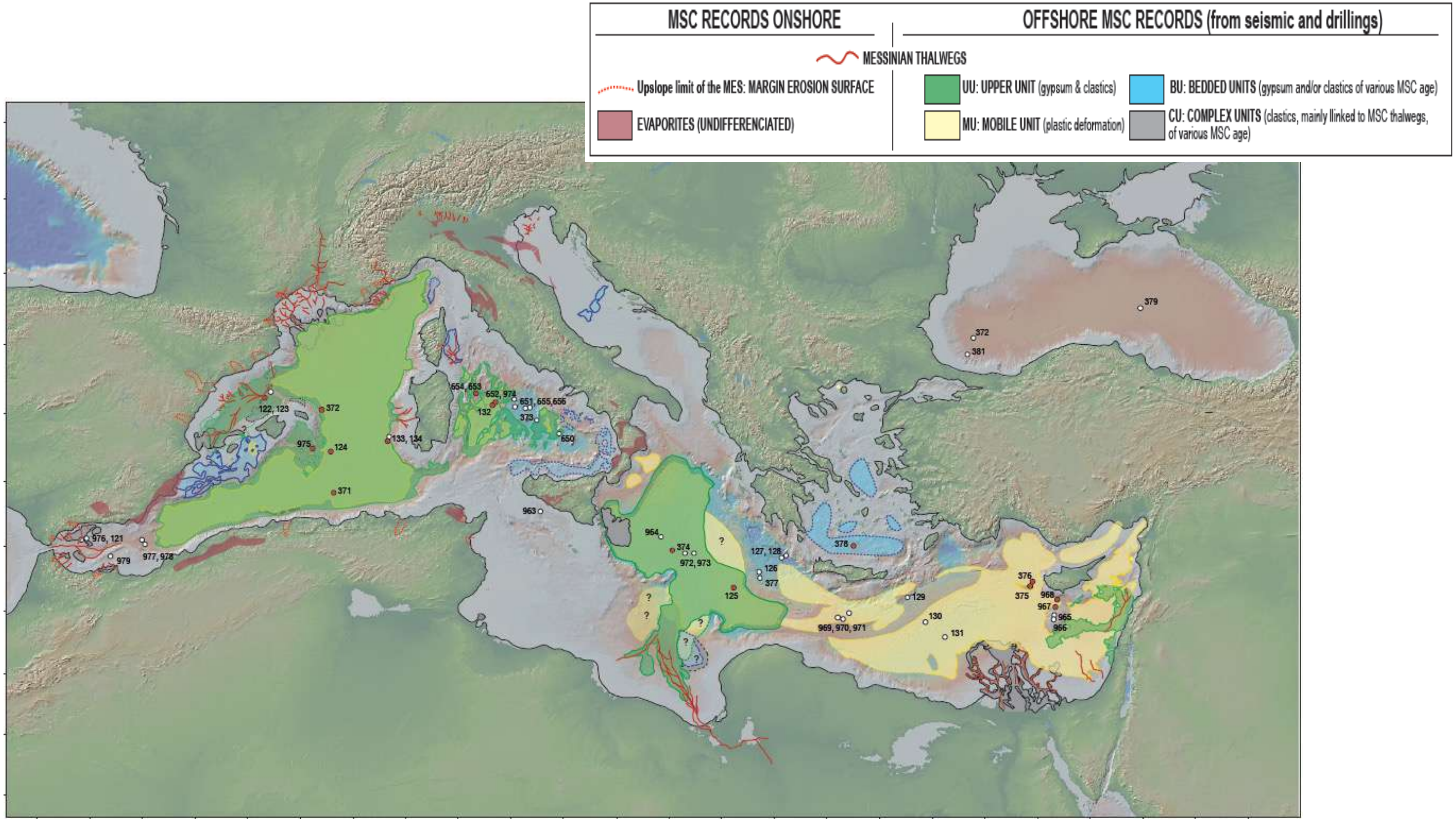
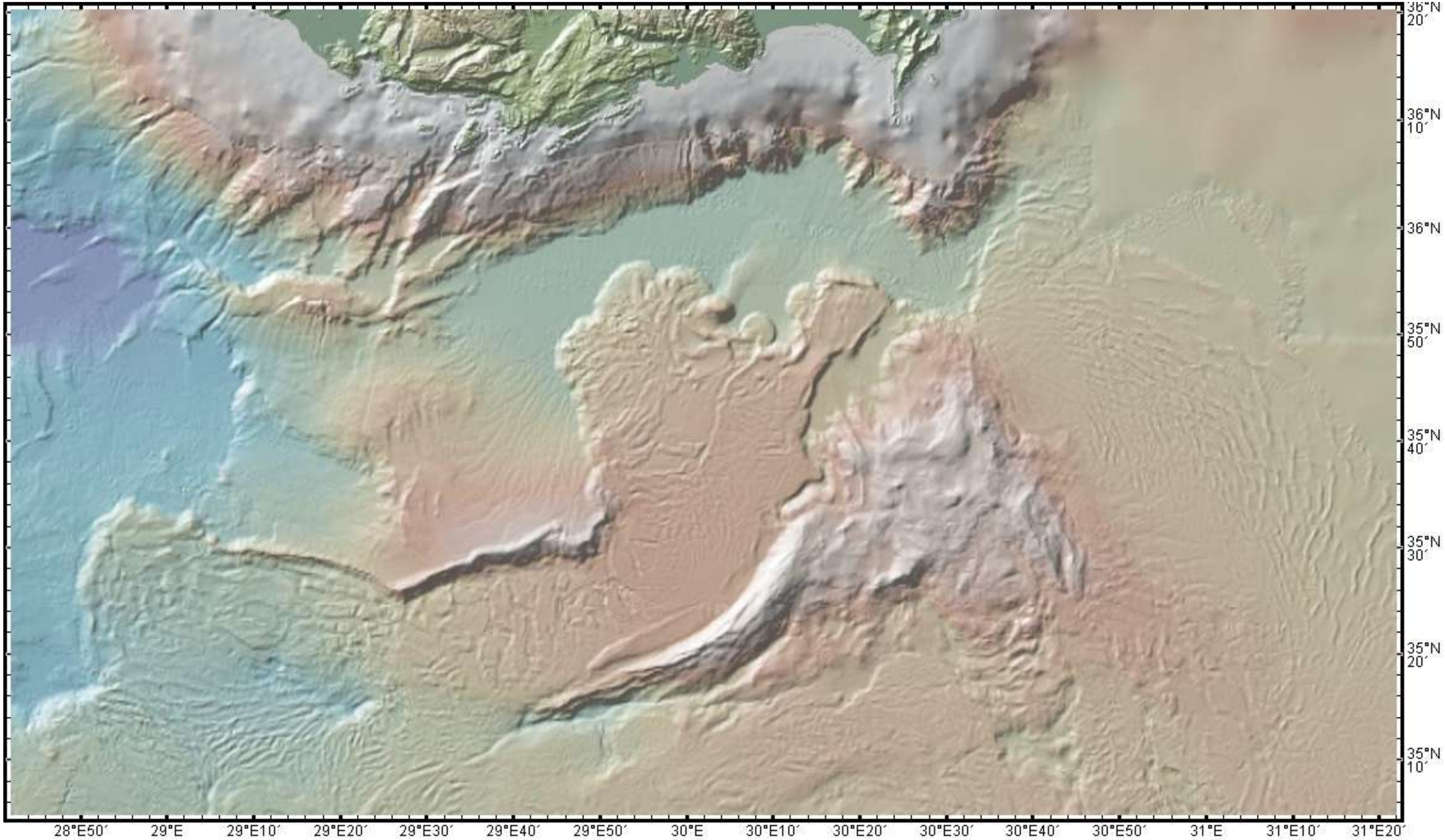
Messinian evaporites



Haq et al., 2020 Thickness of Messinian evaporites


MSC RECORDS ONSHORE
OFFSHORE MSC RECORDS (from seismic and drillings)
MESSINIAN THALWEGS
Upslope limit of the MES: MARGIN EROSION SURFACE
EVAPORITES (UNDIFFERENCIATED)
UU: UPPER UNIT (gypsum & clastics)
MU: MOBILE UNIT (plastic deformation)
BU: BEDDED UNITS (gypsum and/or clastics of various MSC age)
CU: COMPLEX UNITS (clastics, mainly linked to MSC thalwegs, of various MSC age)

Lofi, 2018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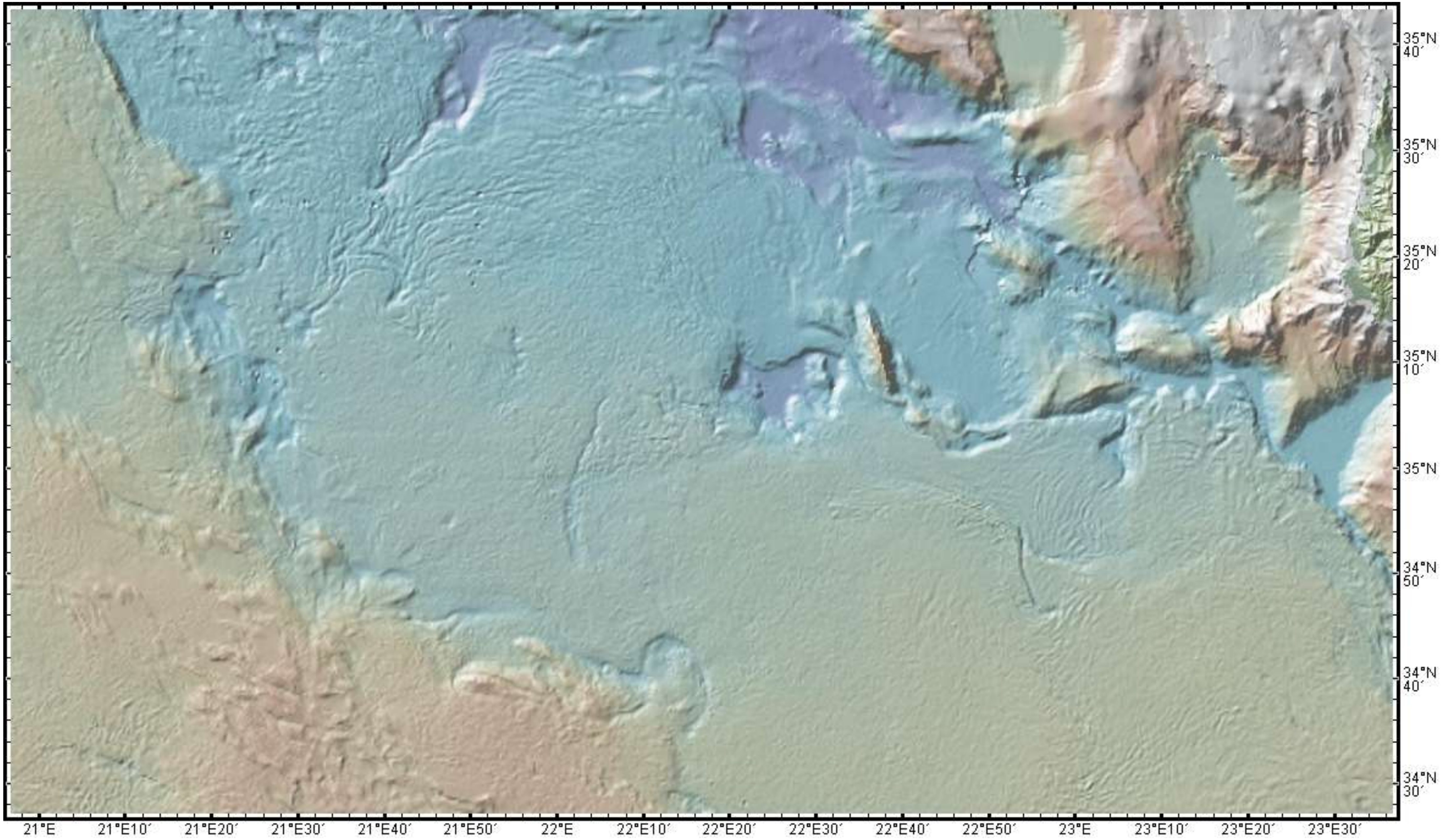
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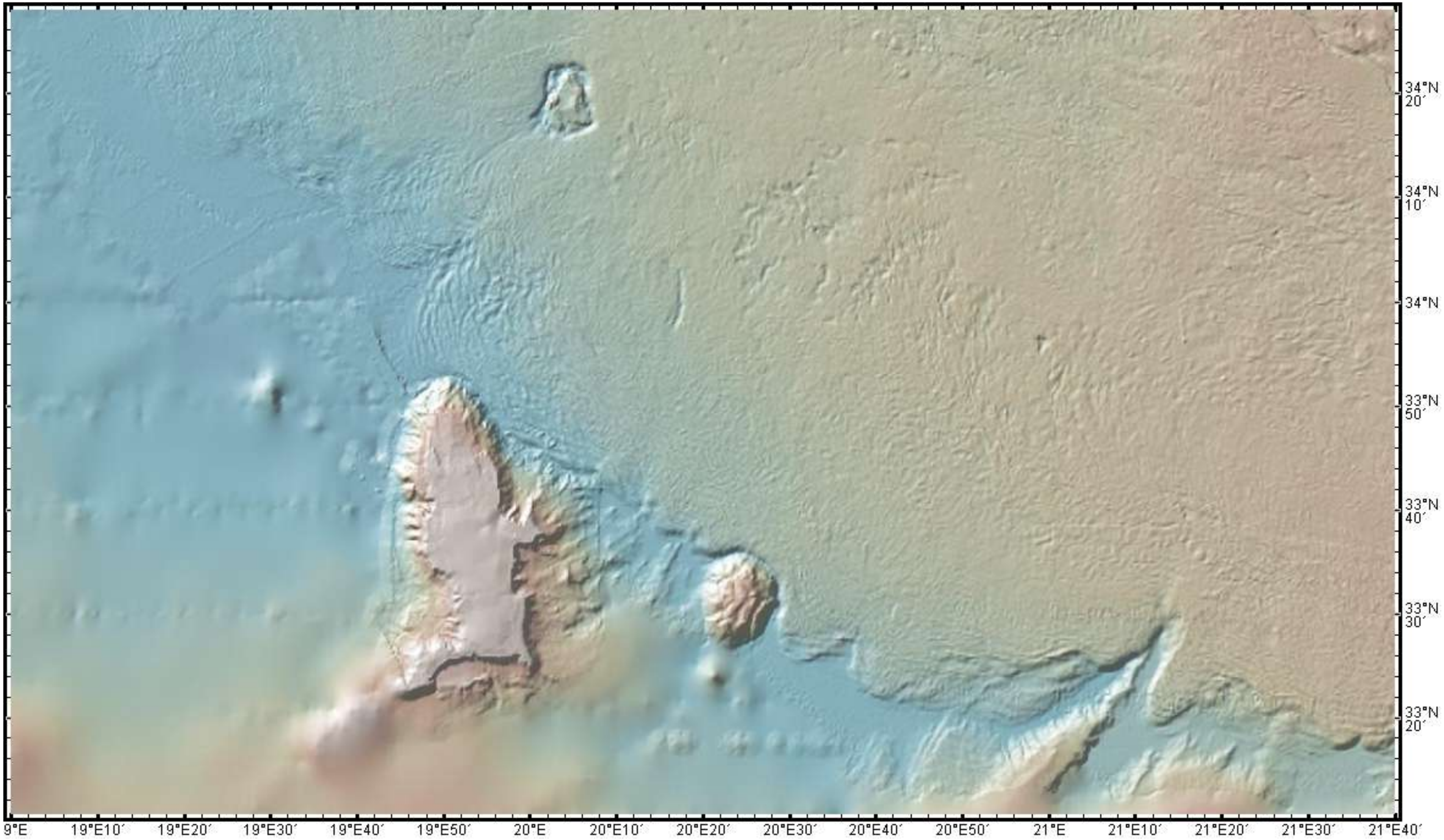
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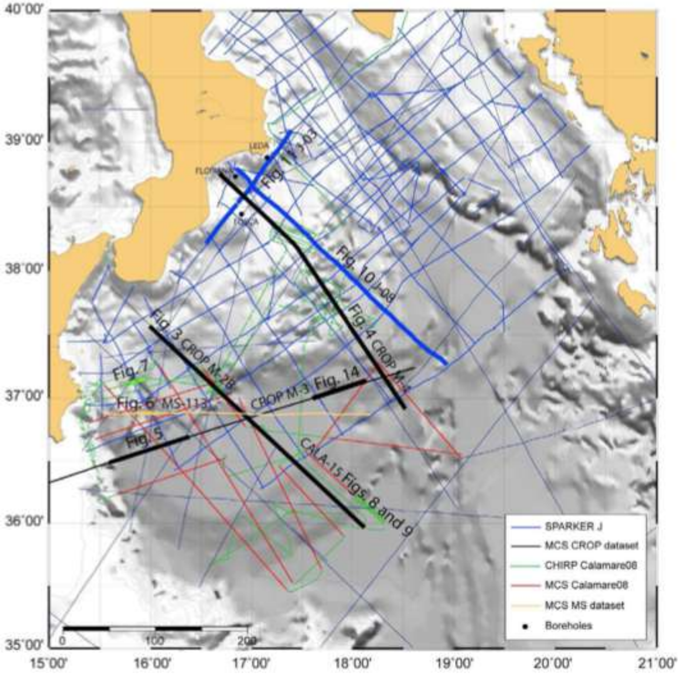
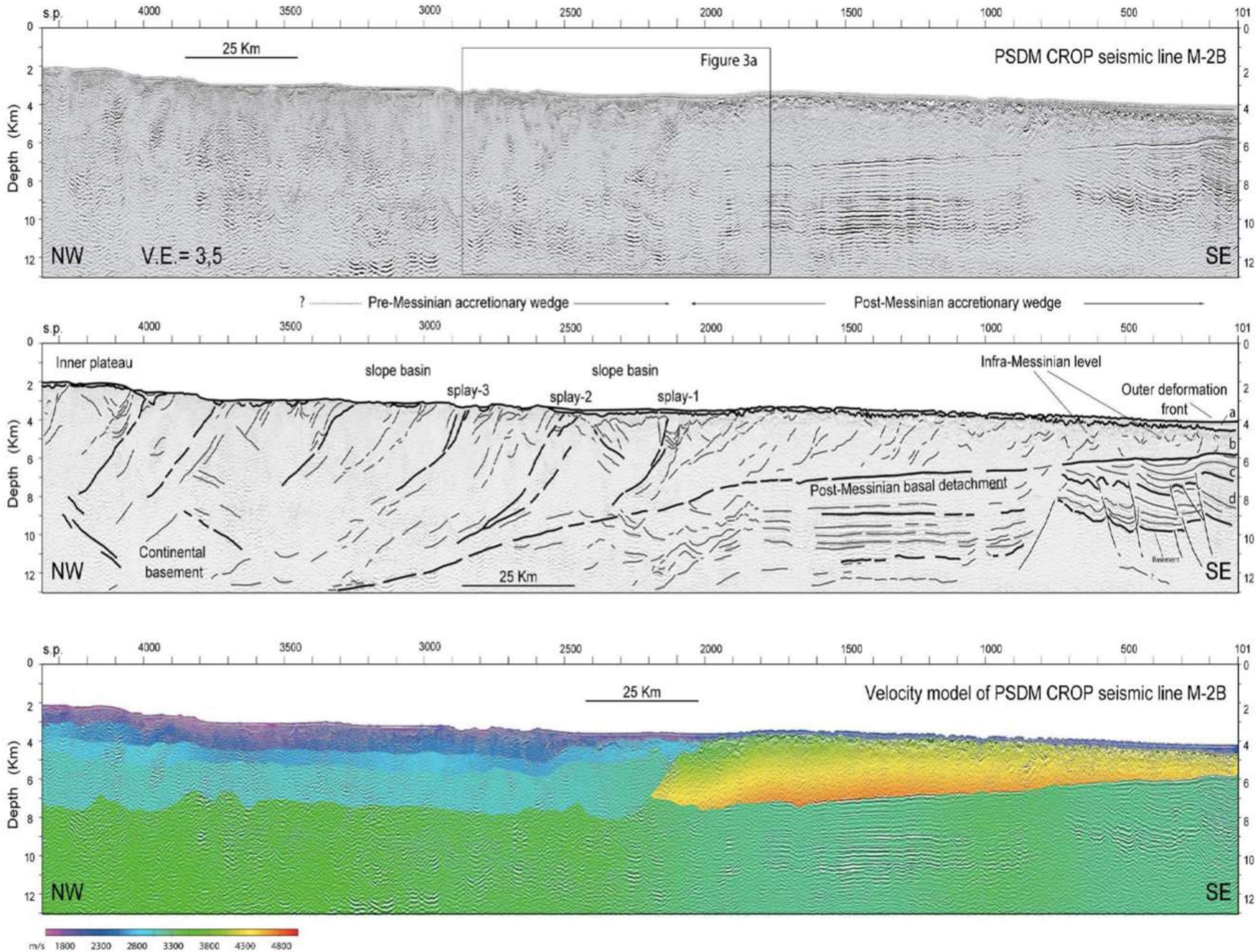
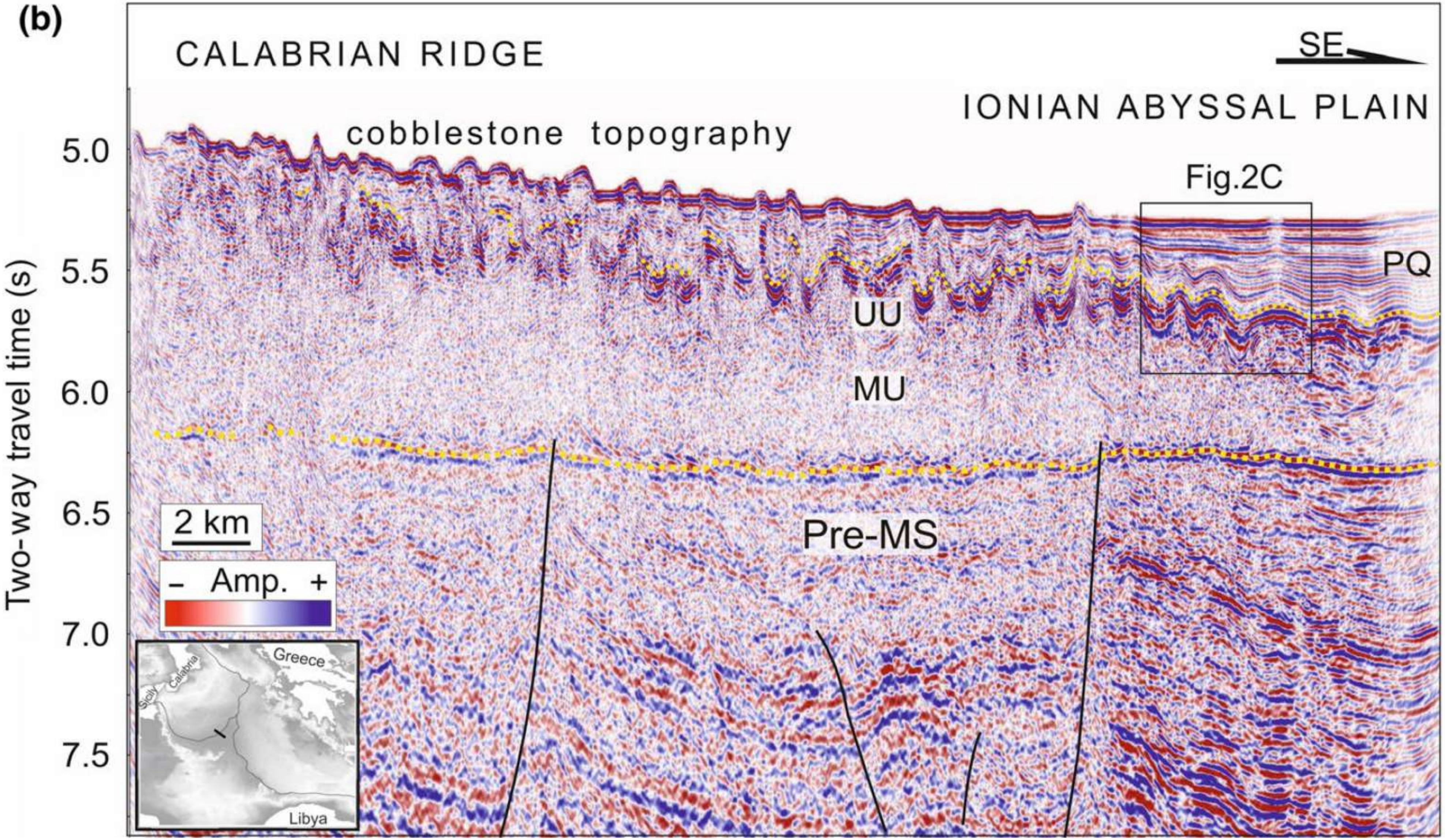
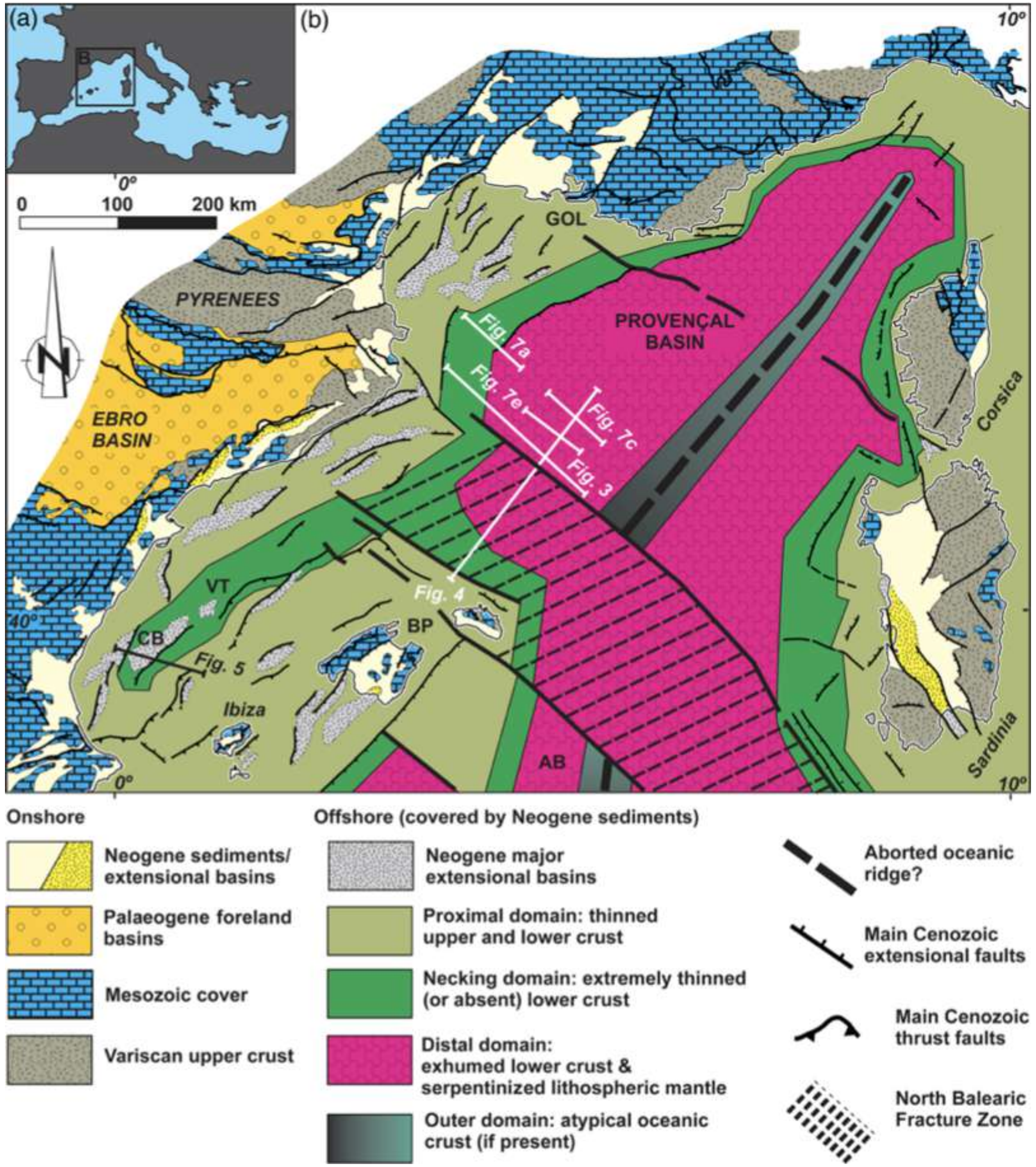


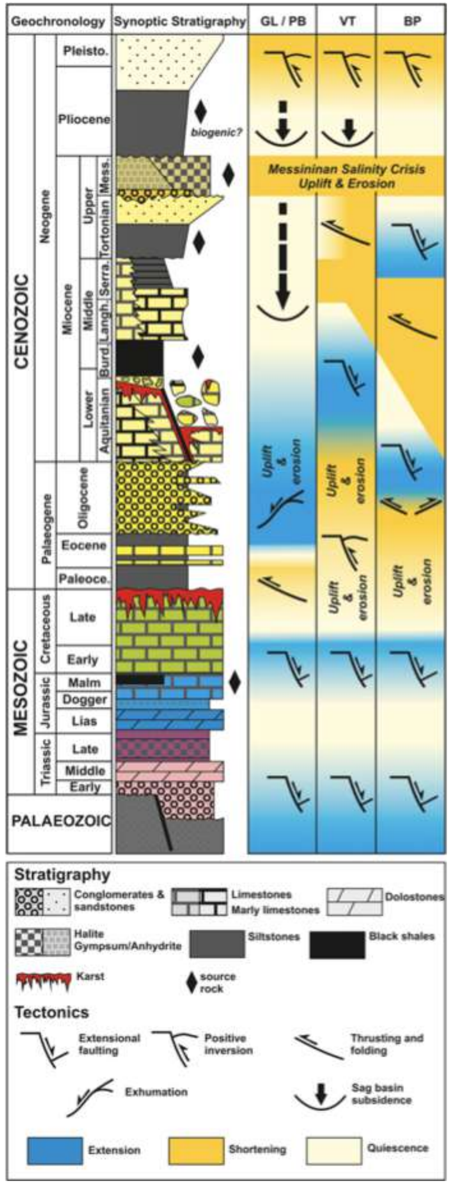


Polonia et al., 2011, Tectonics

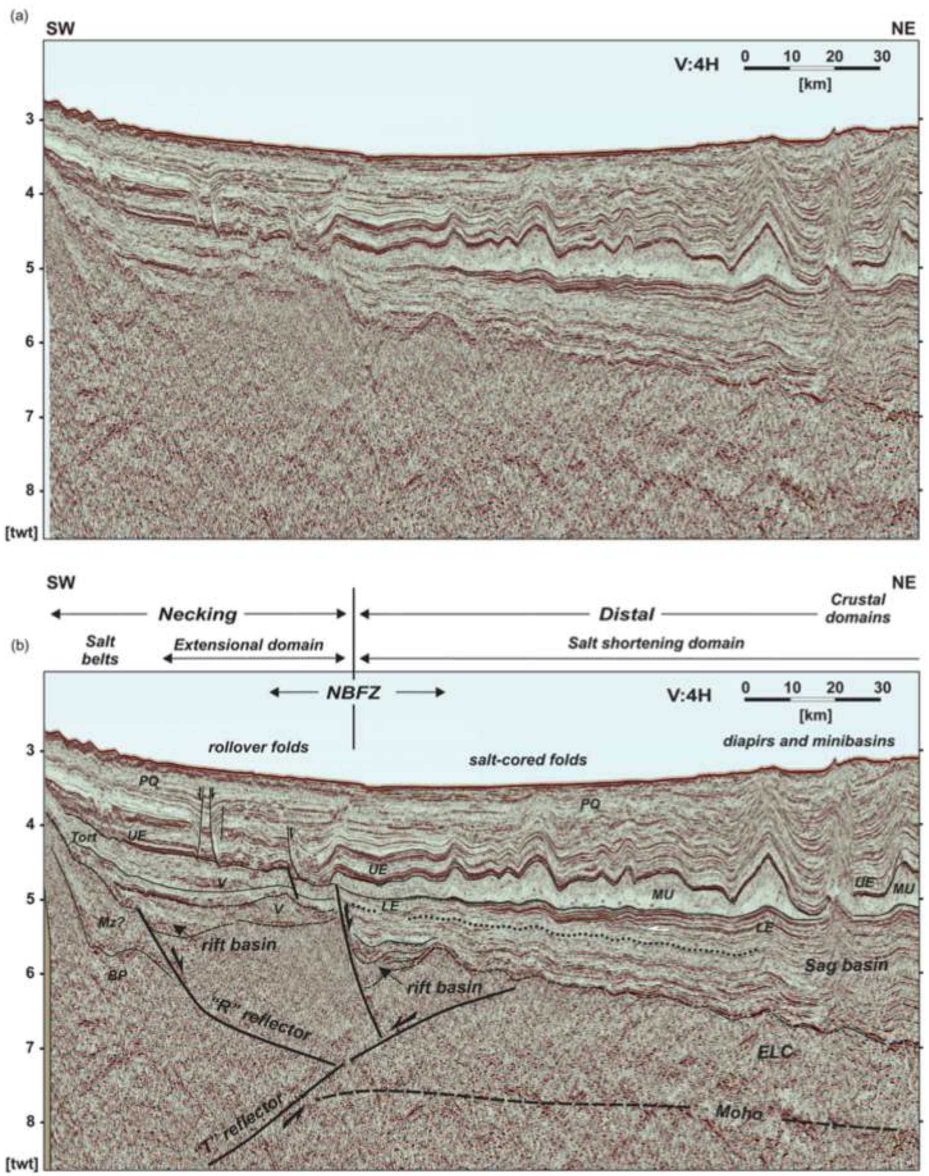


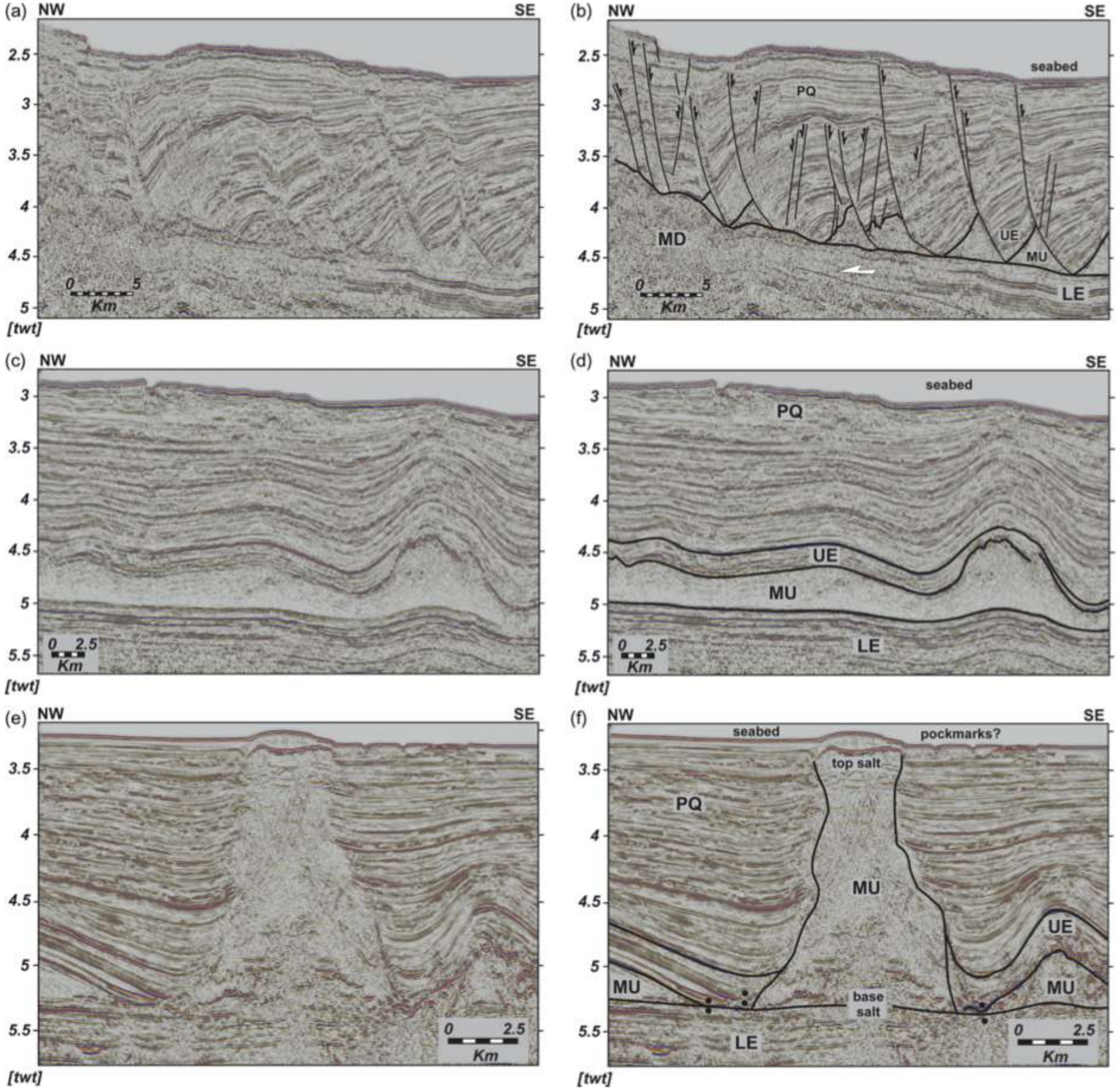
Camerlenghi et al., 2020



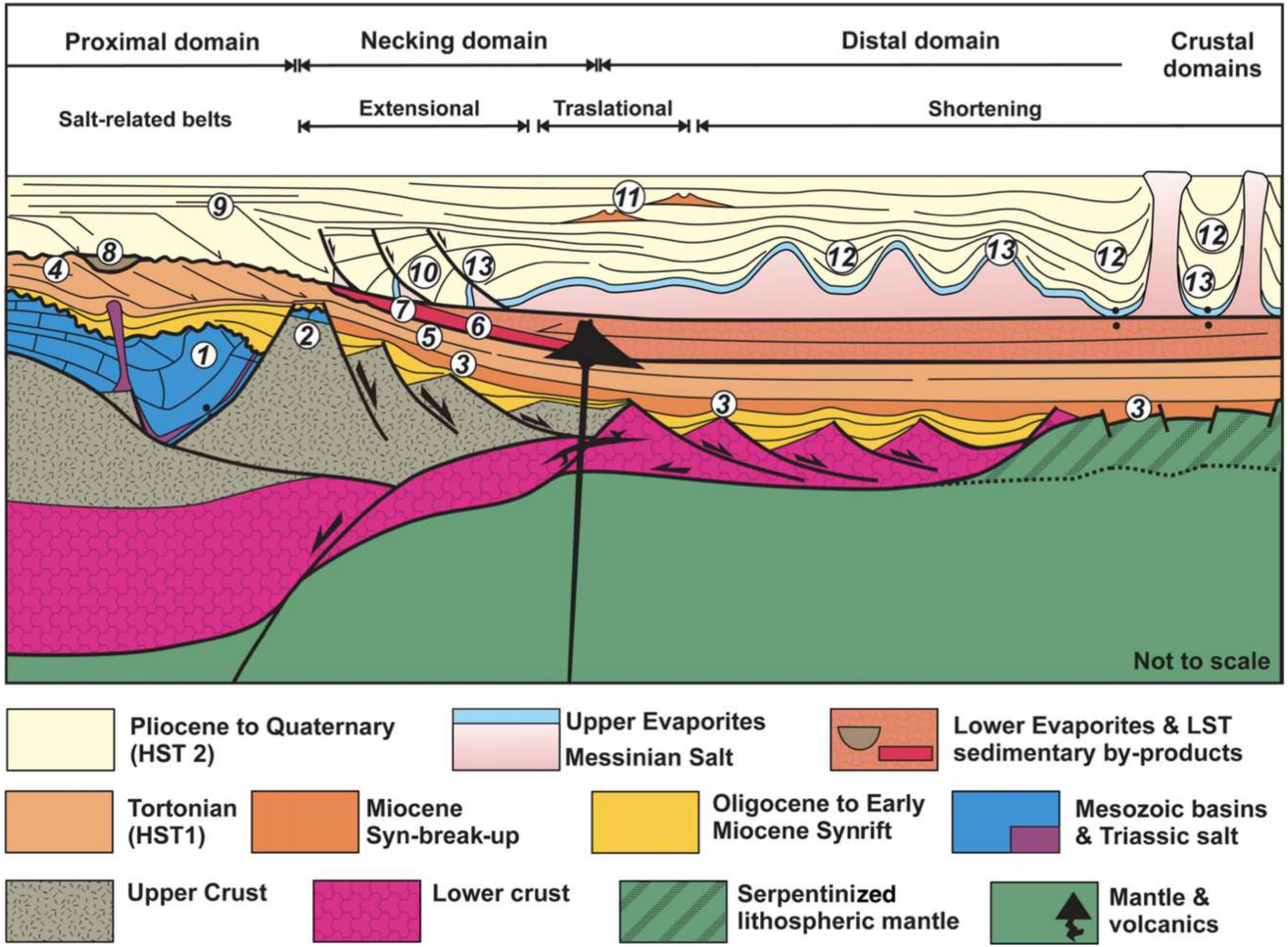


Granado et al., 2016

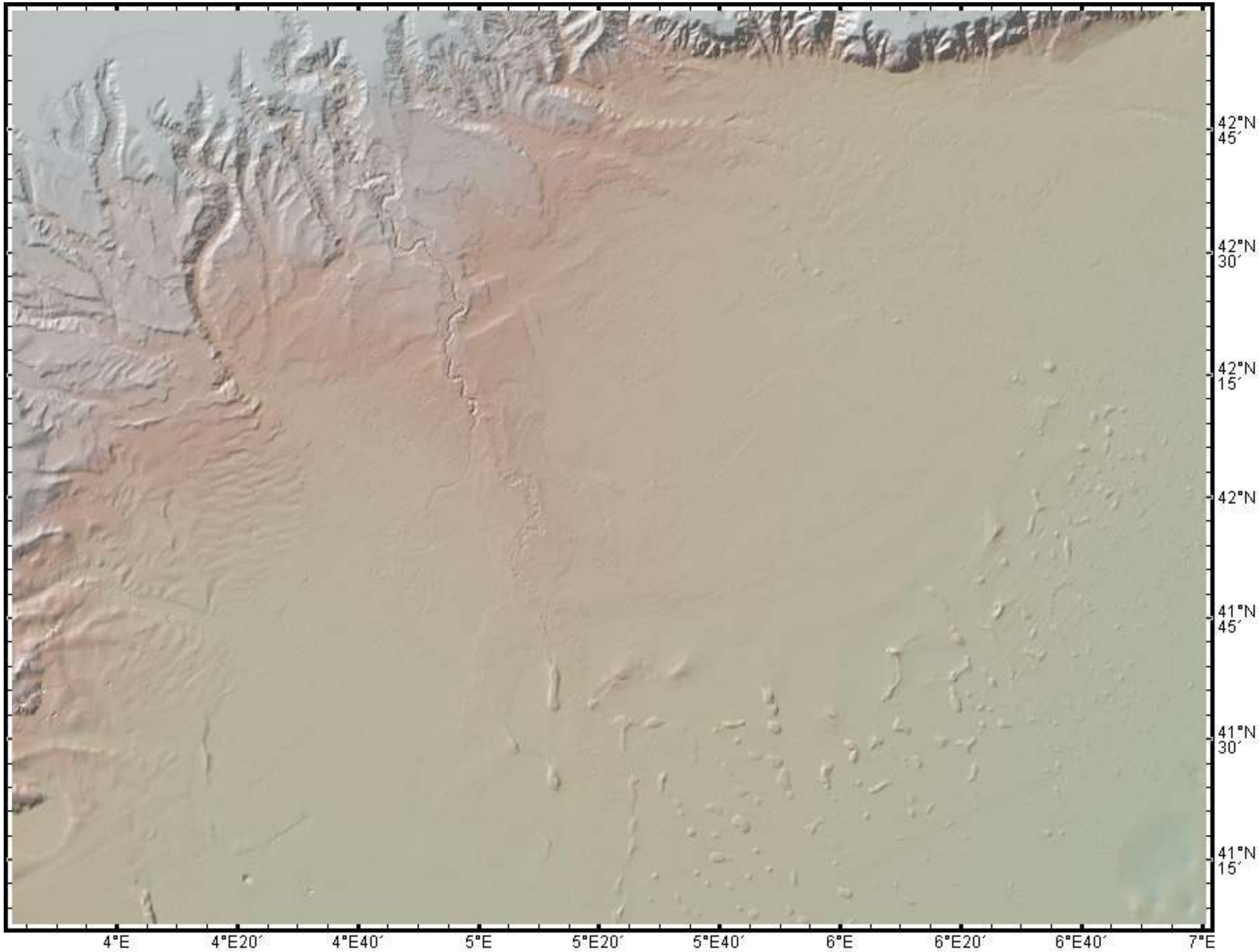




Granado et al., 2016



Granado et al., 2016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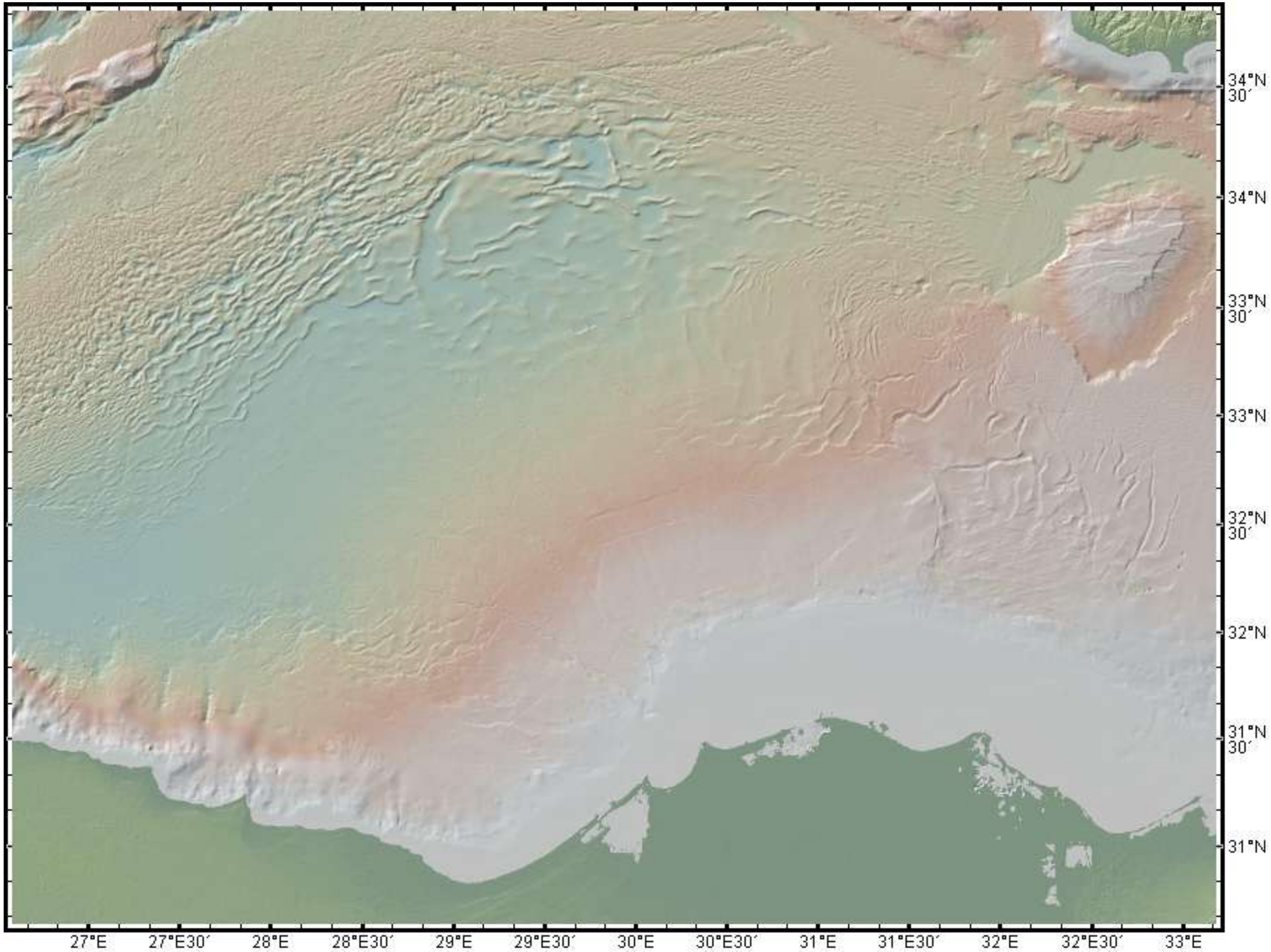
6°E20´
6°E40´
7°E


34°N 30´
34°N
33°N 30´
33°N
32°N 30´
32°N
31°N 30´
31°N
27°E
27°E30´
28°E
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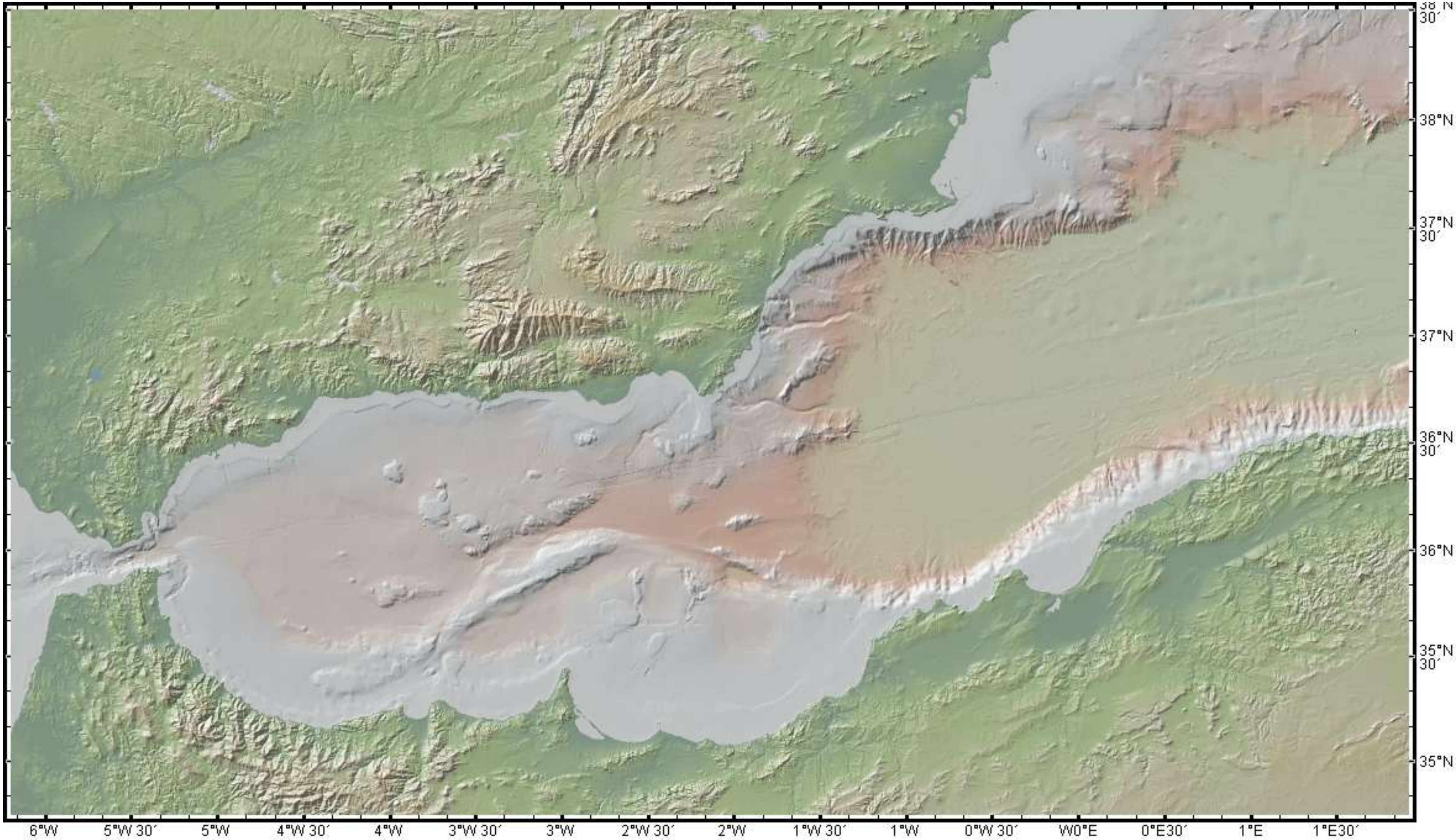
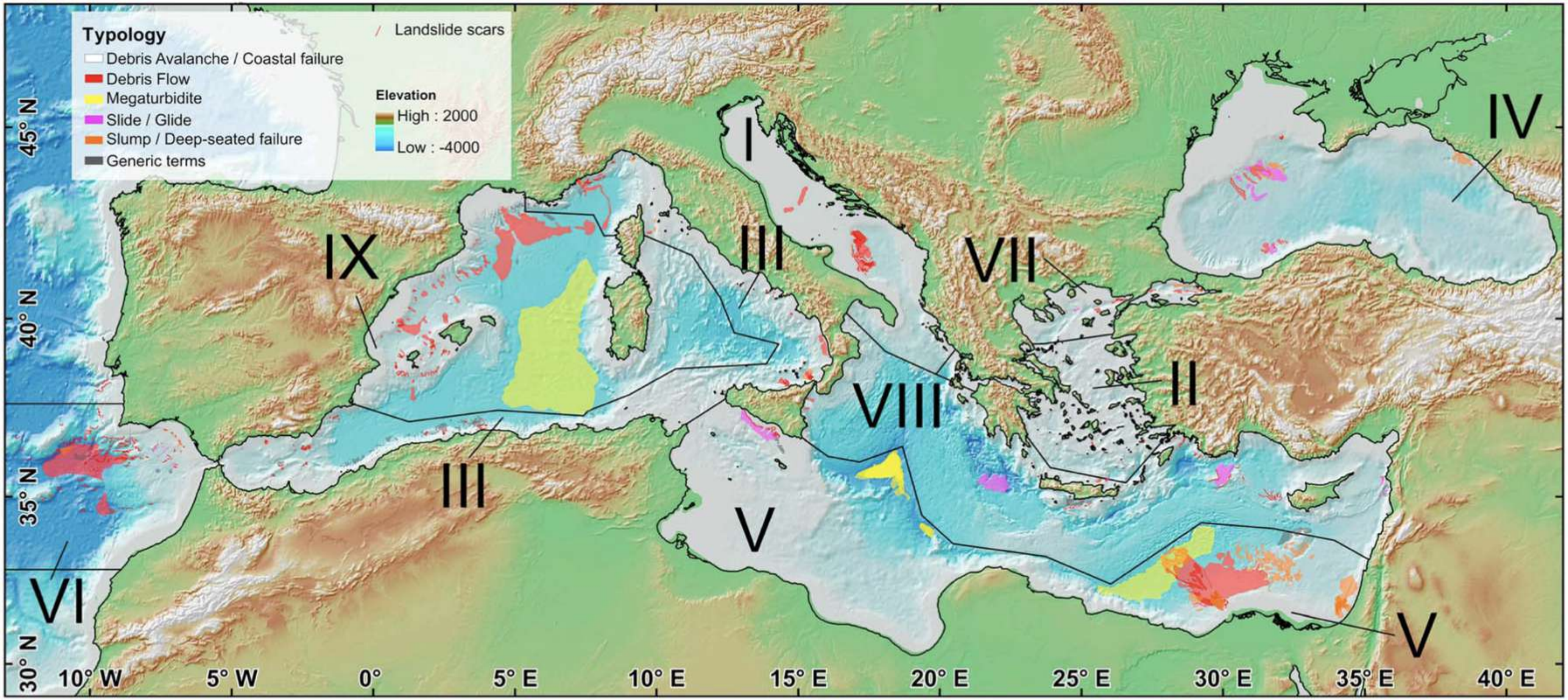
32°E
32°E30´
33°E


38°N 30´
38°N
37°N 30´
37°N
36°N 30´
36°N
35°N 30´
35°N
6°W
5°W 30´
5°W
4°W 30´
4°W
3°W 30´
3°W
2°W 30´
2°W
1°W 30´
1°W
0°W 30´
W0°E
0°E30´
1°E
1°E30´

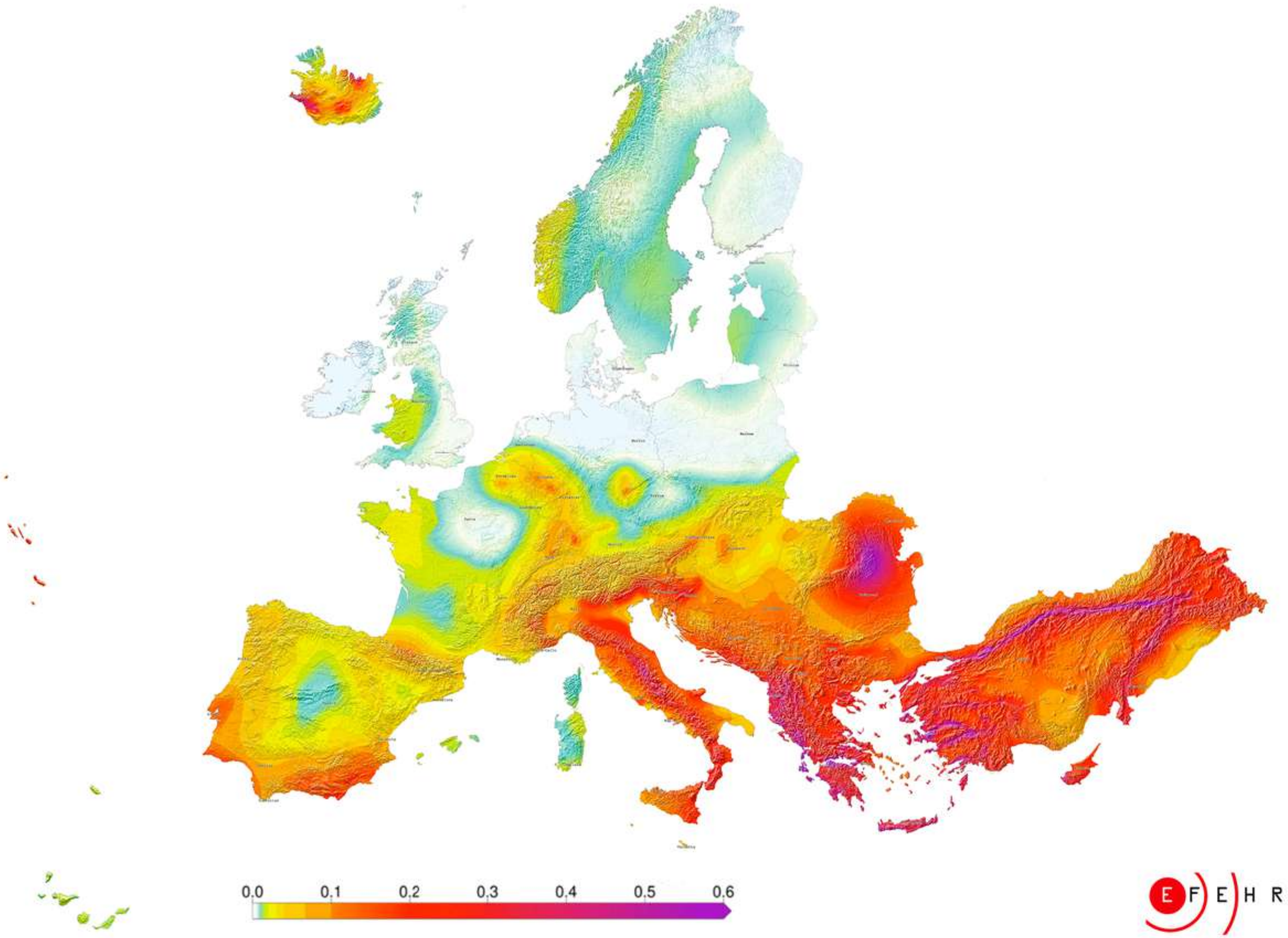
Pericolosità

Frane sottomarine



Urgeles and Camerlenghi, 2013

2020 European Seismic Hazard Model (ESHM20)



Peak Ground Acceleration PGA with 10% probability of exceedence within 50 years given in the percentage of "g", the Earth's gravitational acceleration

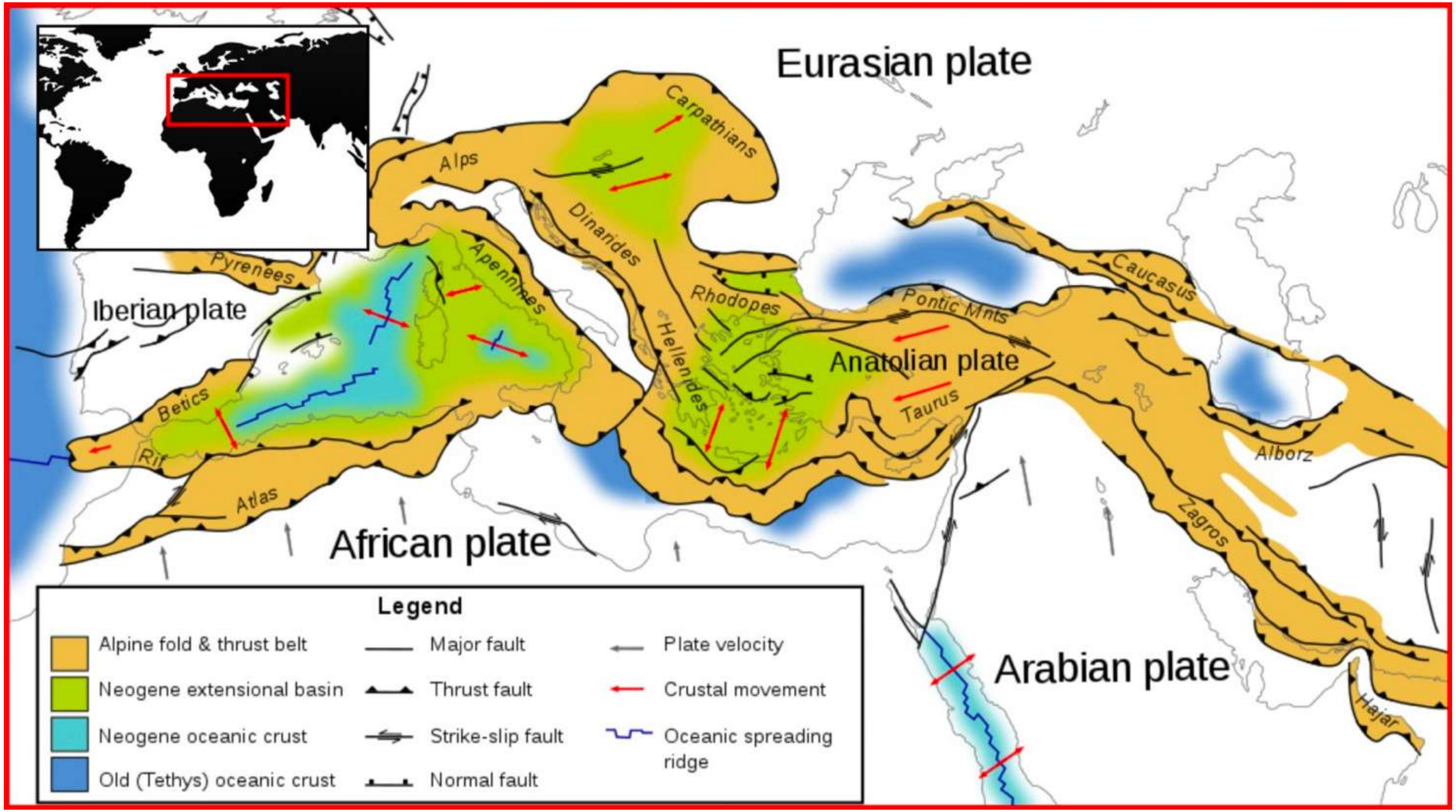


Figure 1: The Mediterranean region and its three major plates (Nubia, Arabia and Eurasia). Brown shaded areas indicate Alpine fold and thrust belts. Plate motions are indicated w.r.t. Eurasia by black arrows. Image credit: Modified by Anne Glerum from Woudloper (Own work) [CC BY-SA 1.0 (http://creativecommons.org/licenses/by-sa/1.0)], via Wikimedia Commons.

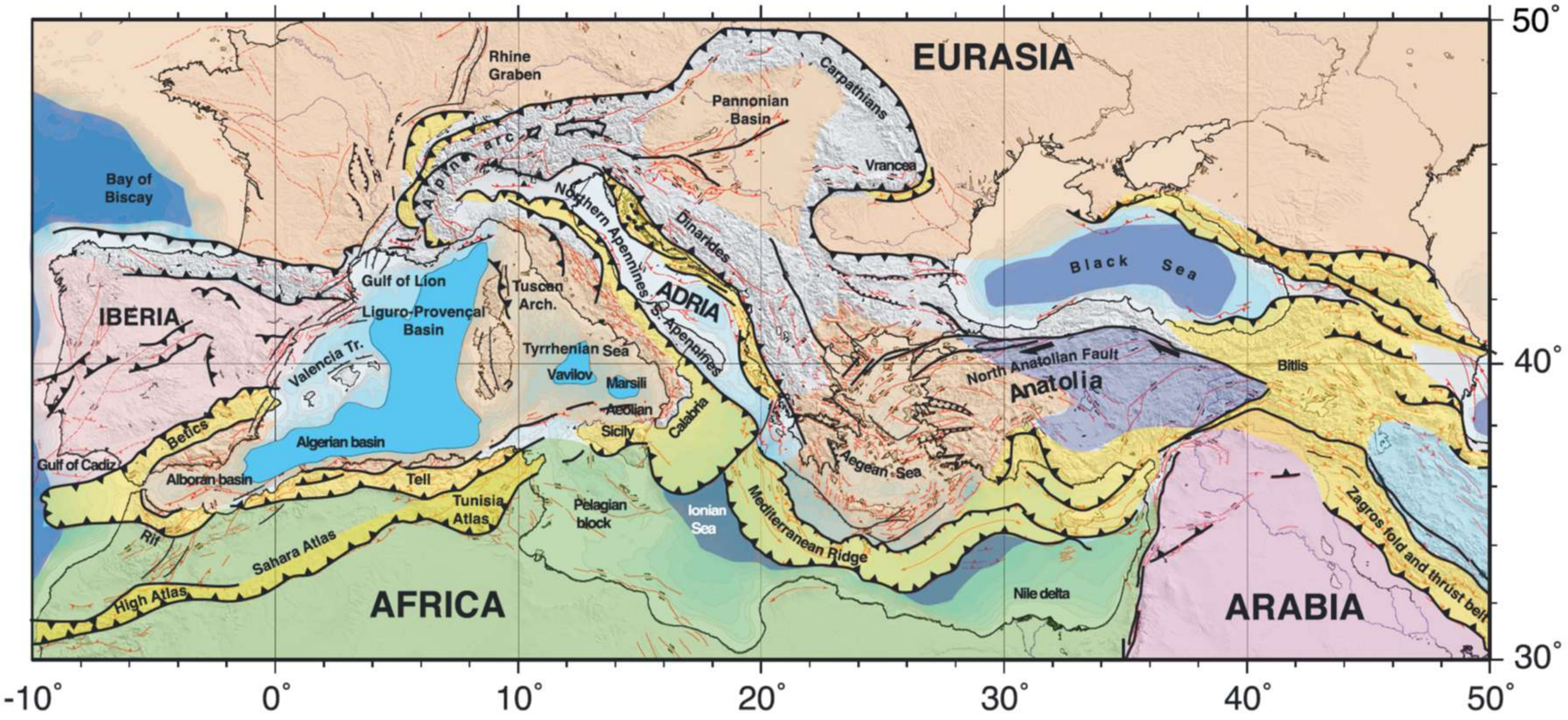


Figure 1. Plate tectonic setting of the Mediterranean.

Faccenna et al., 2014

Busetti, M., 2011. Structural and geological setting of the Gulf of Trieste (Northern Adriatic Sea). GNGTS Abstracts

Camerlenghi, A. and Pini, G.A., 2008. Mud volcanoes, olistostromes and Argille scagliose in the Mediterranean region. Sedimentology. 56. 319 - 365. 10.1111/j.1365-3091.2008.01016.x.

Camerlenghi, A., Del Ben, A., Hübscher, C., Forlin, E., Geletti, R., Brancatelli, G., Micallef, A., Saule, M., Facchin, L., 2020. Seismic markers of the Messinian salinity crisis in the deep Ionian Basin. Basin Research. DOI: 10.1111/bre.12392

Faccenna, C., et al. (2014), Mantle. dynamics in the Mediterranean, Rev. Geophys., 52, 283–332, doi:10.1002/2013RG000444.

Granado, P., Urgeles, R , Sàbat1, F., Albert-Villanueva, E., Roca, E., Muñoz, J.A., Mazzuca, N., and Gambini62016. Geodynamical framework and hydrocarbon plays of a salt giant: the NW Mediterranean Basin. Petroleum Geoscience, 22, pp. 309–321. doi:10.1144/petgeo2015-084

Haq, B., Gorini, C., Baur, J., Moneron, J., and , Rubino, J.L., 2020. Deep Mediterranean's Messinian evaporite giant: How much salt? Global and Planetary Change, 184, 103052. https://doi.org/10.1016/j.gloplacha.2019.103052.

Lofi, J. (2018). Seismic Atlas of the Messinian salinity crisis markers in the Mediterranean sea. Vollume 2 - Mémoires de la Société géologique de France, n.s., 2018, t. 181, and Commission for the Geological Map of the World, 72 p. + DVD. https ://doi. org/10.10682/ 2018M ESSINV2

Mantovani, E., Tamburelli, C., Babbucci, D., Viti, M., and Cenni, N., 2020. Tectonics and Seismicity in the periAdriatic Zones: Implications for Seismic Hazard in Italy. Intech Open Earthquakes - From Tectonics to Buildings. DOI: 10.5772/intechopen.94924

Negri, A., Colleoni, F., Masina, S., 2012. MEDITERRANEAN SAPROPELS: A MERE GEOLOGICAL PROBLEM OR A RESOURCE FOR THE STUDY OF A CHANGING PLANET? Alpine and Mediterranean Quaternary, 25 (2), 2012, 81-89

Nicolich, R, et al., 2007. Le ACQUE CALDE della PIANURA FRIULANA. Realizzazione della Carta Geologico-Tecnica della Risorsa Geotermica Regionale e definizione delle Linee Guida per il suo Utilizzo

Polonia, A., L. Torelli, P. Mussoni, L. Gasperini, A. Artoni, and D. Klaeschen (2011), The Calabrian Arc subduction complex in the Ionian Sea: Regional architecture, active deformation, and seismic hazard, *Tectonics*, *30*, TC5018, doi:10.1029/2010TC002821.

Qian, Y., Roberts, A. P., Liu, Y., Hu, P., Zhao, X., Heslop, D., et al. (2020). Assessment and integration of bulk and component-specific methods for identifying mineral magnetic assemblages in environmental magnetism. Journal of Geophysical Research: Solid Earth, 125, e2019JB019024. https://doi.org/ 10.1029/2019JB019024

Rebesco, M. Della Vedova, B.,Cernobori, L., and Aloisic, G., 2000. Acoustic facies of Holocene megaturbidites in the Eastern Mediterranean. Sedimentary Geology 135, 65–74.

Rohling, E.J., Marino, g., and Grant, K.M. , 2015. Mediterranean climate and oceanography, and the periodic development of anoxic events (sapropels). Earth-Science Reviews 143, 62–97. http://dx.doi.org/10.1016/j.earscirev.2015.01.008

Urgeles, R. and Camerlenghi, A., 2013. Submarine landslides of the Mediterranean Sea: Triggermechanisms, dynamics, and frequency-magnitude distribution. Journal of Geophysical Research: Earth Surface, 118, 1–19, doi: http://dx.doi.org/ 10.1002/2013JF002720, 2013

Vannucci, G., Pondrelli, S., Argnani, A., Morelli, A., Gasperini, P., and Boschi, E., 2004. An atlas of Mediterranean seismicity. Annales of Geophysics, sippl. N.1 vol. 47.