Università di Trieste
Corso di Laurea Magistrale in Esplorazione Geologica

Anno accademico 2021 - 2022

Geologia Marina

Modulo 6.2 Pericolosità dei fondali marini 2

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OUTLINE

I parte

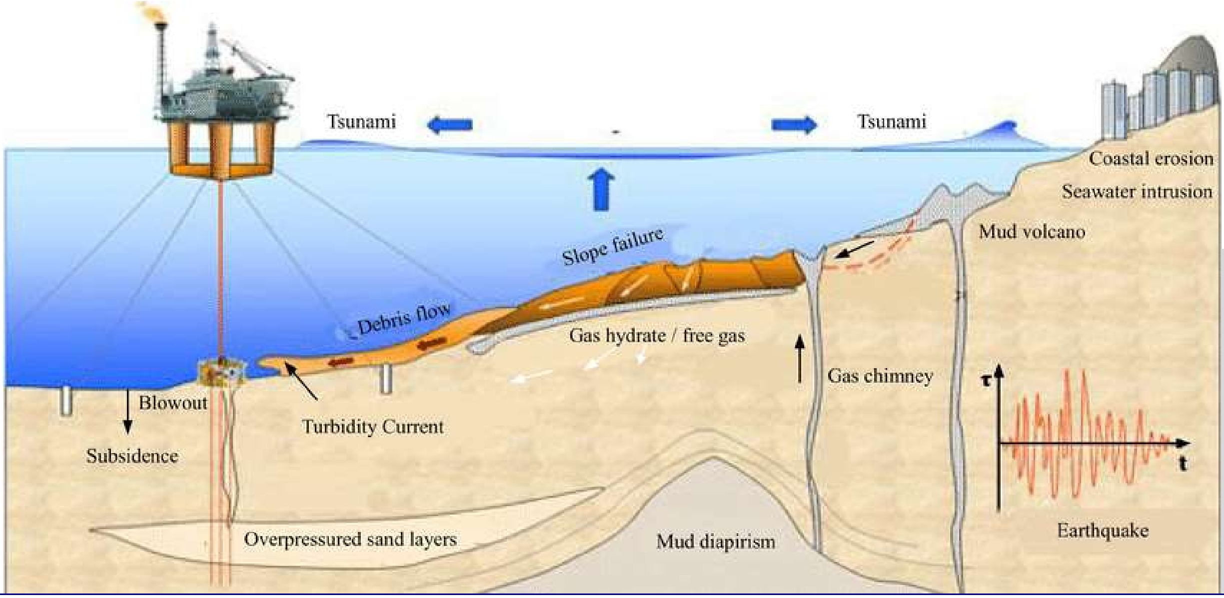
- The Seabed: Continental Margins and Physiographic Domains
- Geological Processes shaping the Seabed
- The role of Seabed mapping: Bathymetry and Geomorphology
- Concepts of Hazard, Vulnerability, Risk, Mitigation, Resilience
- Active Seabed: Natural Marine Geohazards
- Examples of Geohazards Assessment along the Ionian Seabed
- Natural Hazard Management of the Seabed

II parte

Marine geohazards

Geohazard Feature	Causative event	Effects	Consequences	Recent historical examples
Landslide scar and deposit	Sediment failure	Gravity flow	Cable break	Algeria 2003[7]
		Tsunami	Coastal inundation	Stromboli 2002[8]
		Retrogressive erosion	Coastal landslide	Finneidfjord 1996[9]
Canyon head	Seafloor erosion and sediment failure			Punta Alice 2006[10]
		Tsunami	Coastal inundation	Nice 1979[11]
		Gravity flow	Cable break	Gioia Tauro 1977[12]
Mud volcano, pockmark	Fluid escaping the seafloor	Fluidification of sediment	Weakening of soil	Patras Gulf 1993[13]
		Gas eruption	Navigation problems	Scoglio d'Affrica 2017[14]
Active faults	Earthquake	Submarine landslide	Cable break	Pingtung 2006[15]
		Land shaking	Structure collapse	Messina 1908[16]
		Tsunami	Coastal inundation	
Submarine and insular volcanoes	Eruption	Emissions in oceans and atmosphere	Navigation problems	Hierro 2011-'12[17]
	Caldera or sector collapse	Tsunami	Coastal inundation	Anak Krakatoa 2018[18]

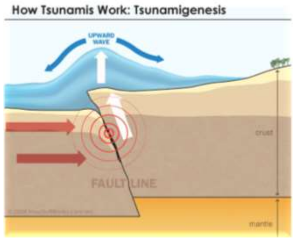
Wang et al 2018, *energies, MDPI*

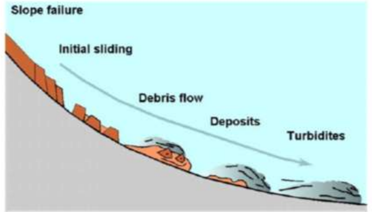


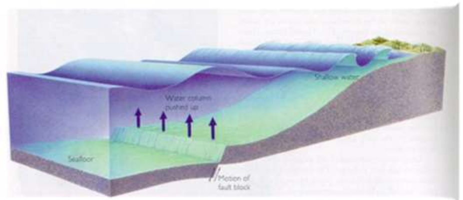
Marine geohazards are natural, real and complex and their occurrence can arm people and infrastructures

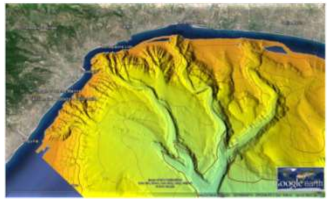
NATURAL MARINE GEOHAZARDS

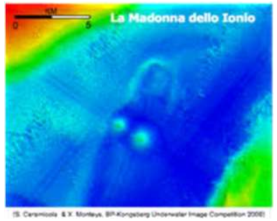
1. **SEISMOGENIC FAULTS** (earthquakes originated below the sea floor)
2. **SUBMARINE LANDSLIDES** including **VOLCANIC ISLAND ERUPTIONS** and **FLANK COLLAPSE**: sediment mass movements (turbidity currents, debris flows, slumps, retrogressive canyon headwalls
3. **TSUNAMIS** (originated by earthquakes and/or landslides)
4. **SUBMARINE CANYONS** (coastal erosion)
5. **FLUID EMISSIONS** (CH_4, CO_2 mainly)



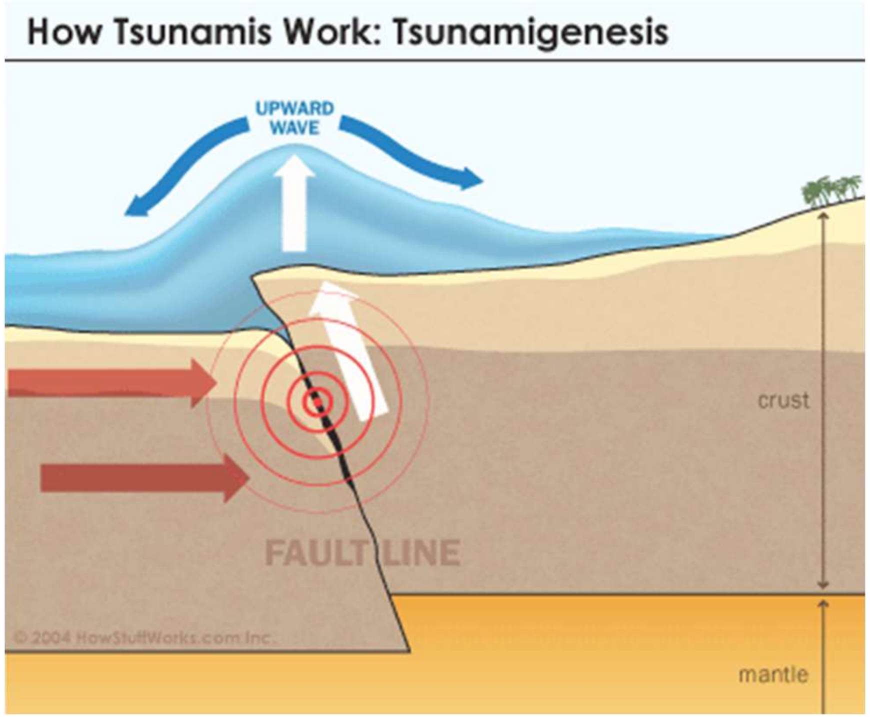








1) Faults and Earthquakes



When rocks break in response to stress, the resulting break is called a fracture. A fault is a fracture or zone of fractures between two blocks

Faults allow the blocks to move relative to each other. This movement may occur rapidly, in the form of an earthquake - or may occur slowly, in the form of creep.

Faults may range in length from a few millimeters to thousands of kilometers.

active Fault: is a fault which had displacement (or generated earthquakes) during the geologically recent period (20ka)

capable Fault : an active fault able to generate superficial displacement of the seabottom in recent period (20ka)

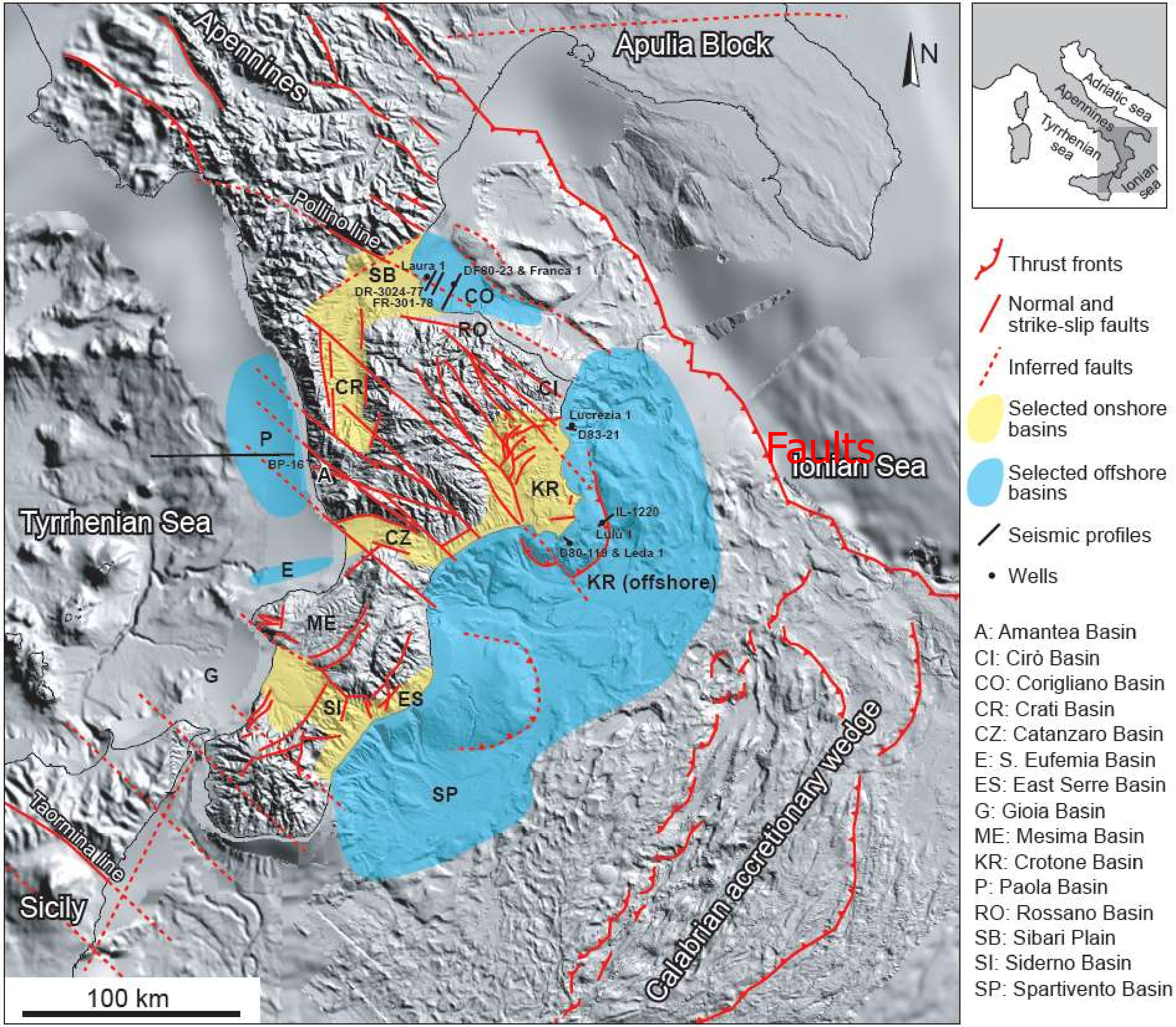
seismogenic Fault : an active fault capable of generating earthquakes in the upper lithosphere

aseismic Fault : faglia non attiva in tempi recenti con comportamento lento e continuo (crosta inferiore)

blind Fault: some faults do not break through to the sea bottom anywhere along their length

Using acoustic methods, it is possible to **identify** the faults that have displaced the seabottom (or below), to **map** them and thus **assess their hazard** but it is NOT possible to predict if and when they will be active again → **earthquakes are not predictable!**

‘Faults’ in the Calabrian margins

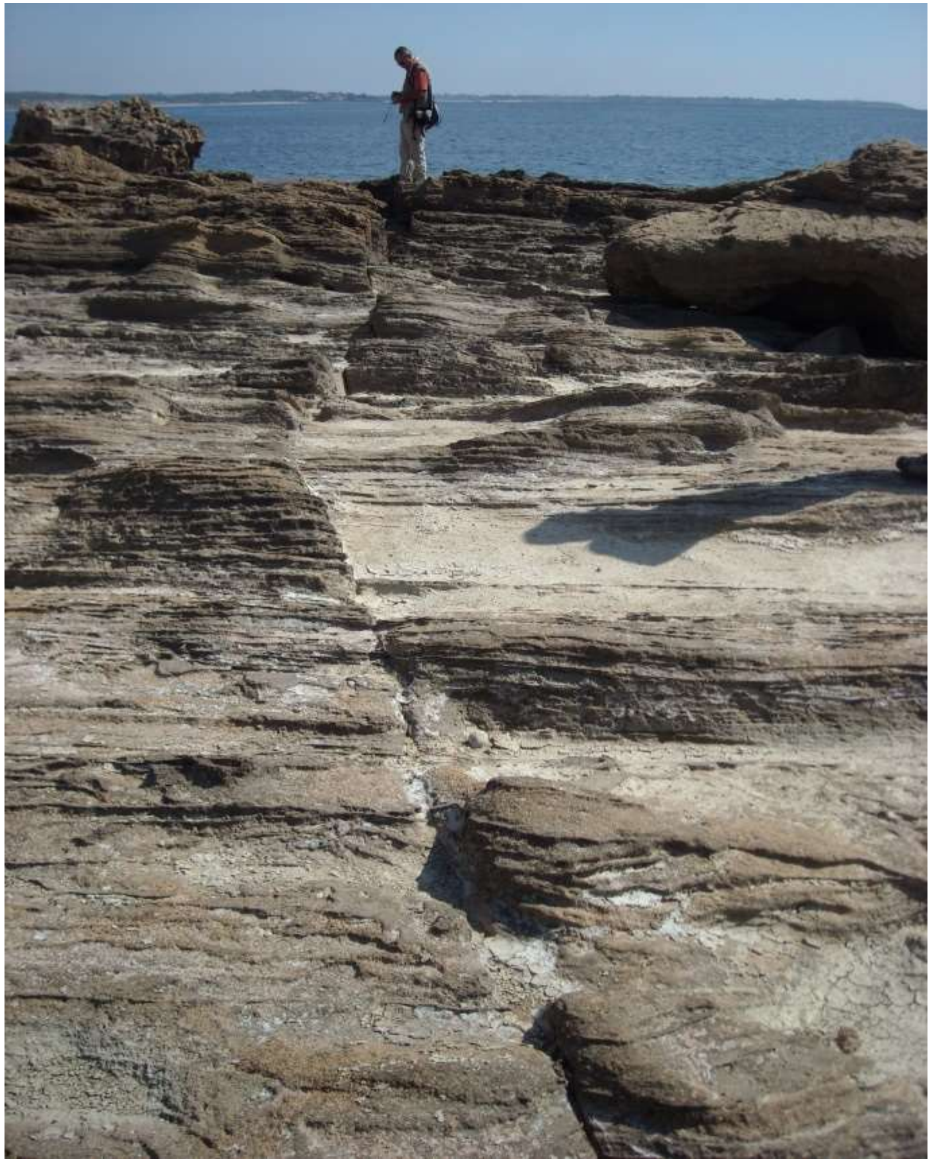


Zecchin et al. 2015

1) Fault systems do not stop at the coastline!!

2) Mapping fault systems allows to assess their distribution and characterise thier occurrence (lenghs, type, displacement....)

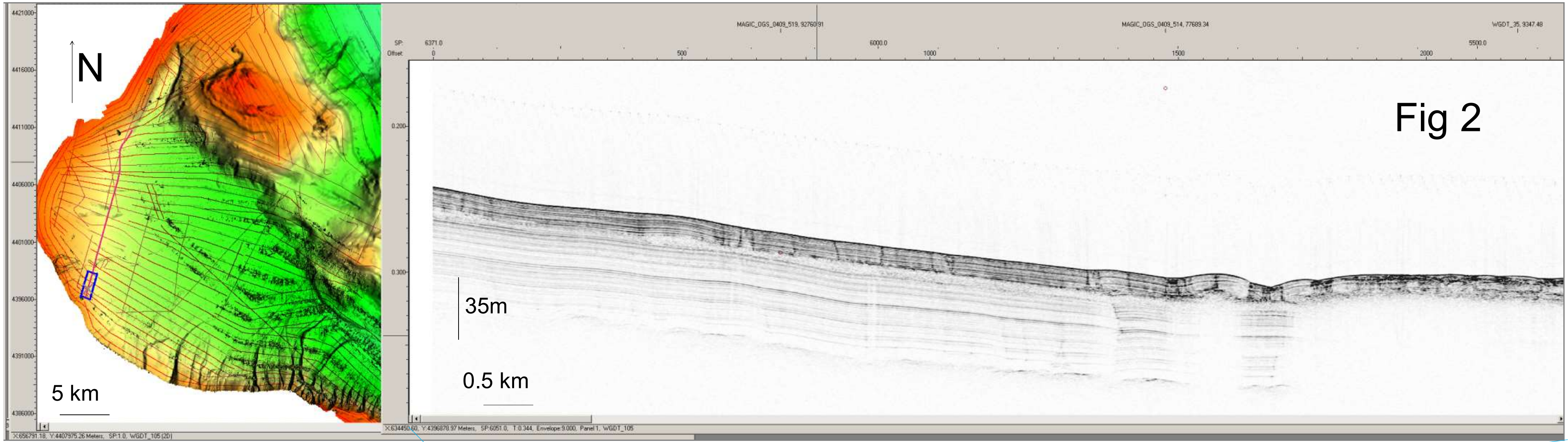
Onshore....



If there is no movement of one side relative to the other, and if there are many other fractures with the same orientation, then the fractures are called joints. Joints with a common orientation make up a joint set

Examples of joints oriented N100-120° and dissecting the deposits of the Le Castella marine terrace (Calabria, Italy)

Offshore....



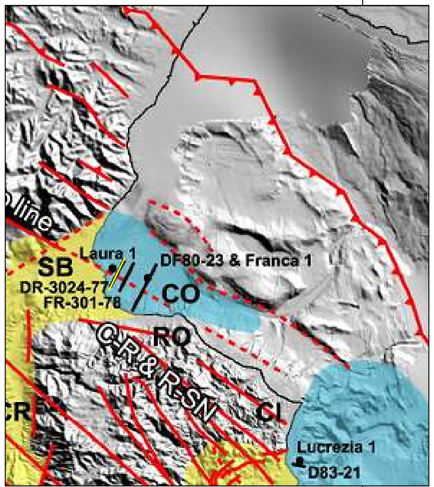
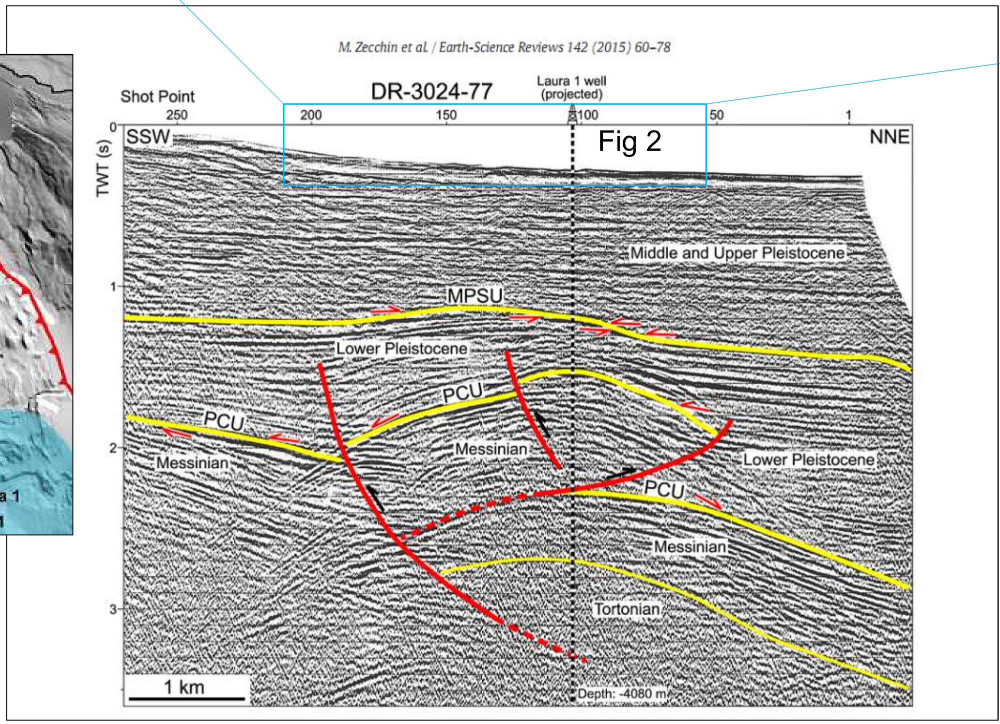


Fig 1



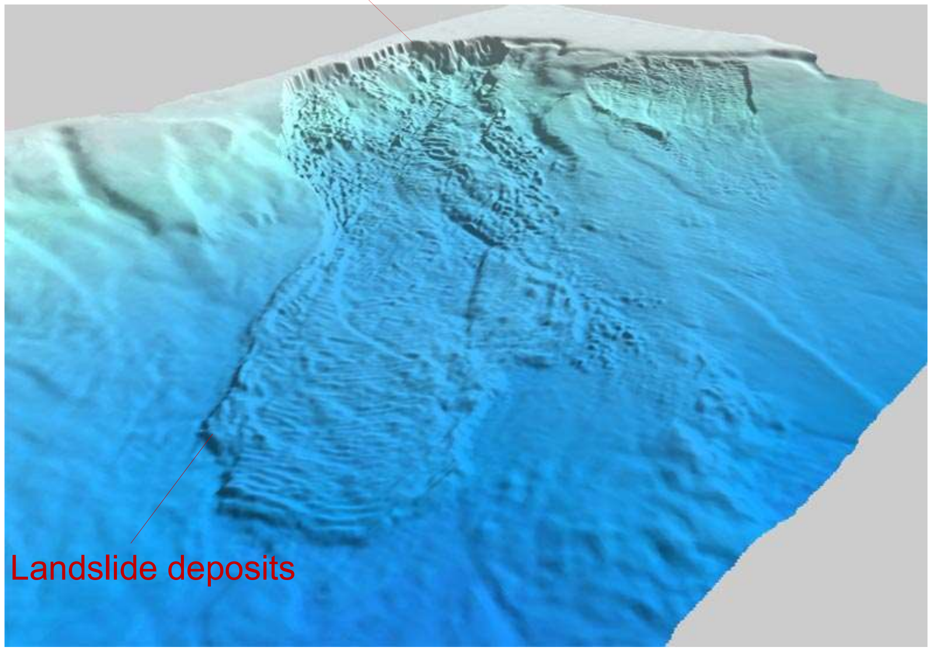
...things are more complicated!

possible problems:

1) Do we have the good **data resolution**?

2) Are we investigating **the right portion of seabed**?

2) Submarine landslides



are able to **transport sediments** across the continental shelf and into the deep ocean.

A submarine landslide can be initiated by different **trigger mechanisms** such as:

- i) presence of weak geological layers,
- ii) overpressure due to rapid accumulation of sedimentary deposits,
- iii) earthquakes,
- iv) storm wave loading and hurricanes,
- v) gas hydrates dissociation,
- vi) groundwater seepage and high pore water pressure,
- vii) glacial loading,
- viii) volcanic island growth,
- ix) oversteepening.

When a pile of near-seabed marine sediments is **subjected to external stresses** or **looses its internal strength, it fails under the effect of gravity producing a range of deposits** that are collectively referred with various terms such as submarine landslides, mass-transport complexes, mass-transport deposits, or slump complexes

Huge landslides are able to mobilize up to **hundreds to thousands of km³** of sediment and rock. They take place in a variety of different geological settings **including planes as low as 1°.**

They can **cause significant damage** to life (human and/or marine ecosystems) as well as coastal and deep sea infrastructures

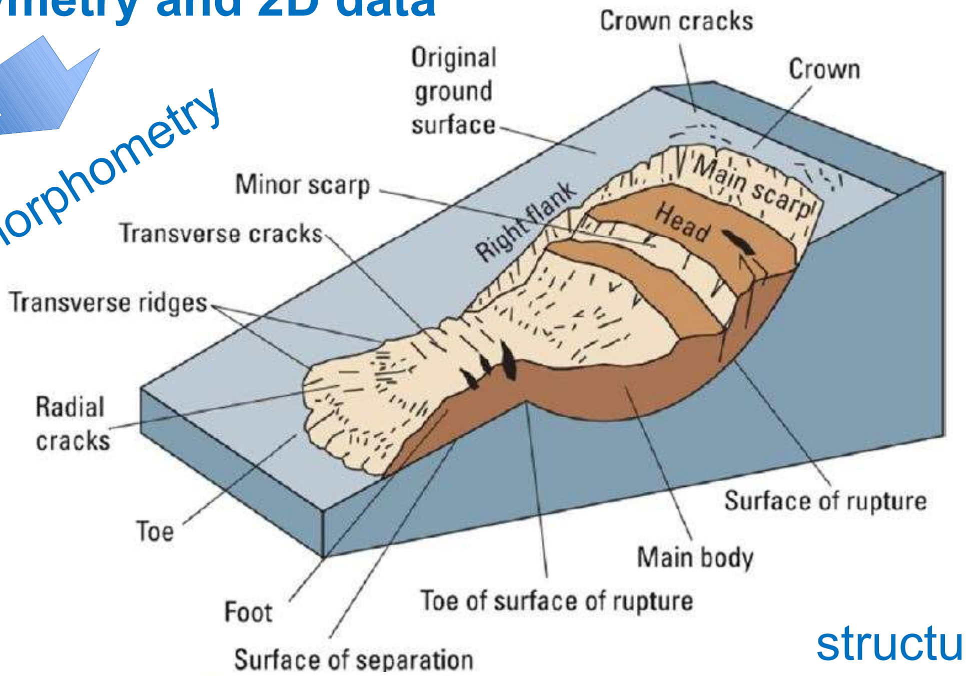
Velocity class	Description	Velocity (mm/s)	Typical velocity
7	Extremely rapid	5×10^{3}	5 m/s
6	Very rapid	5×10^{1}	3 m/min
5	Rapid	5×10^{-1}	1.8 m/h
4	Moderate	5×10^{-3}	13 m/month
3	Slow	5×10^{-5}	1.6 m/year
2	Very slow	5×10^{-7}	16 mm/year
1	Extremely Slow	$< 5\times10^{-7}$	< 16 mm/year

Tabella 1.1: Tabella che mostra gli ordini di grandezza della velocità delle frane [da Hungr et al., 2013]

2) Submarine landslides

Bathymetry and 2D data

morphometry

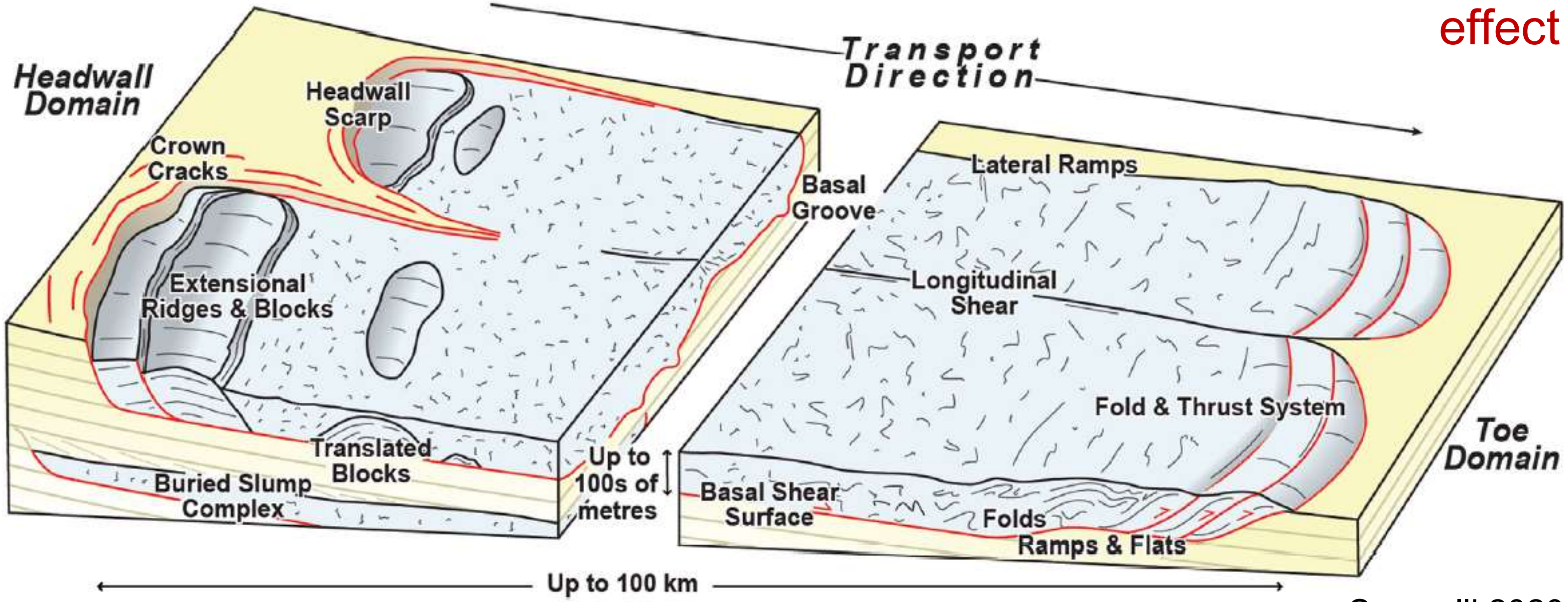


Kinematic indicators

3D data

structural architecture

Submarine landslides are a broad term for indicating the phenomena of failure of near-seabed sediments under the effect of gravity.



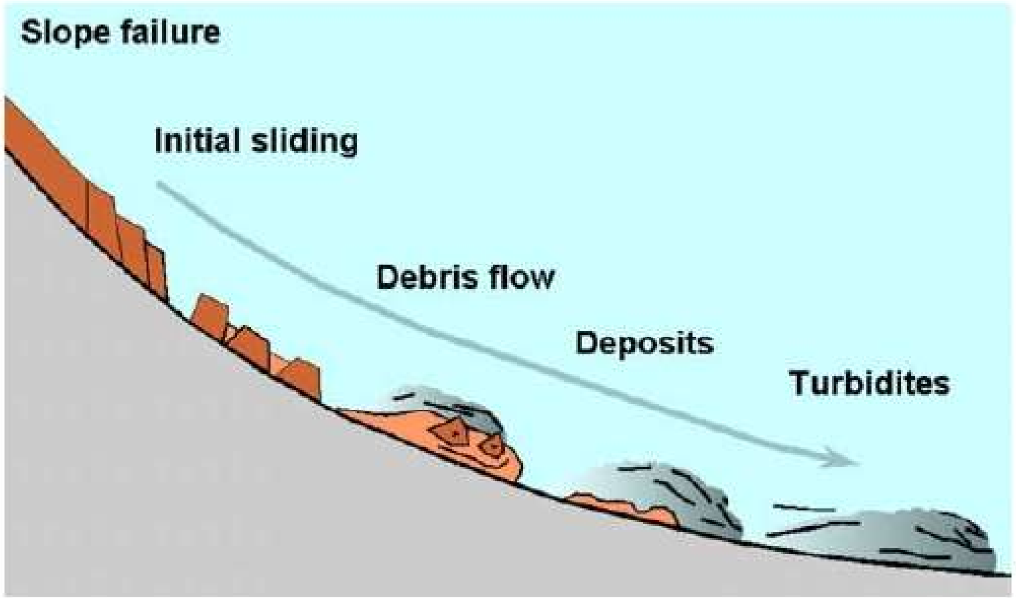
Submarine landslides remobilize and displace metres to hundreds of metres of sediments producing deposits that exhibit a basal shear surface above which material is translated downdip from a proximal headwall domain to a distal toe domain

Scarselli 2020

FIGURE 16.1 Schematic illustration of the morphology and structures of a submarine landslide. Source: *Compiled from Prior, D.B., Bornhold, B.D., Johns, M.W., 1984. Depositional characteristics of a submarine debris flow. J. Geol. 92, 707–727 and Bull, S., Cartwright, J., Huuse, M., 2009. A review of kinematic indicators from mass-transport complexes using 3D seismic data. Mar. Pet. Geol. 26, 1132–1151. https://doi.org/10.1016/j.marpetgeo.2008.09.011.*

2) Submarine Landslides – classification

Types of deformation brittle - plastic- fluid



Bryn et al., 2005

Frontally confined vs. emergent landslides

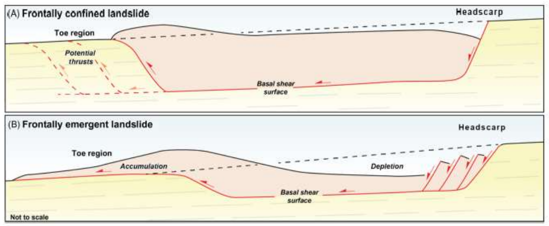


FIGURE 16.5 Schematic diagram of the classification of submarine landslides according to their frontal emplacement. (A) Frontally confined landslides abut against a frontal ramp and do not abandon their basal shear surface. (B) Frontally emergent landslides ramp up their basal shear surface and overrun the adjacent undeformed downslope strata. Source: *Modified from Frey-Martínez, J., Cartwright, J., James, D., 2006. Frontally confined versus frontally emergent submarine landslides: a 3D seismic characterisation. Mar. Pet. Geol. 23, 585–604. https://doi.org/10.1016/j.marpetgeo.2006.04.002.*

Attached vs detached

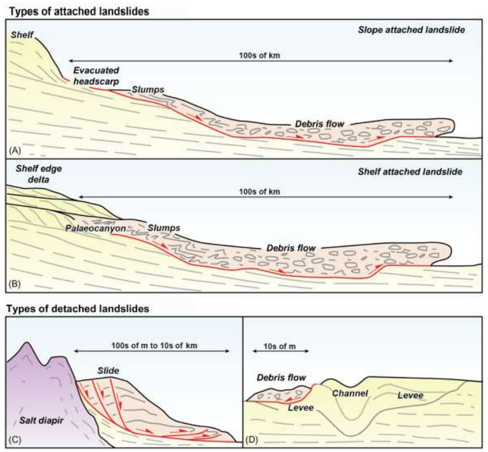


FIGURE 16.6 Schematic illustrations of attached and detached landslides. (A) Slope-attached landslides have their source region in the slope portion of a margin. (B) Shelf-attached landslides result from the failure of shelf-edge deltas. (C) Detached landslide created by the collapse of steep strata at the flanks of a salt diapir. (D) Detached landslide originating from the steep flanks of a channel-levee complex. Source: *Modified from Moscardelli, L., Wood, L., 2008. New classification system for mass transport complexes in offshore Trinidad. Basin Res. 20, 73–98.*

Gravity driven processes at continental margins occur at **different scales** producing a wide spectrum of products and styles (Butler and Turner, 2010). These vary from **margin-scale megaslides** that can involve thicknesses of stratigraphy of several kilometres **to shallow submarine landslides** that produce mostly incoherent deposits.

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DOI: https://doi.org/10.1016/B978-0-444-64134-2.00015-8

2) Submarine landslides

A submarine landslide initiates when the driving stresses applied to a sediment column exceeds its shearing resistance (e.g. Hampton et al., 1996; Locat and Lee, 2002; Lee et al., 2007). Slope failure is therefore favoured by:

(1) an increase in the driving stresses (gravity),

(2) a decrease in shearing resistance or

(3) a combination of the two (Lee et al., 2007).

There are several natural factors that can increase the driving stresses and reduce the shear strength of sediments. These factors can be either seen as **triggering factors**, if they act in a relatively **short period**, ultimately triggering failure, or **preconditioning factors**, if they are **acquired during the deposition of slope sediments,** favouring their instability (Canals et al., 2004; Leynaud et al., 2009; Masson et al., 2010).

TABLE 16.1 Causes of submarine slope failure and environments where they are likely to have relevance in causing landslides.

		Factors causing slope instability	***Environments and geological settings***
Increasing stress	*Slope steepening*	Faulting, folding and diapirism	*Passive and active margins, salt provinces*
		Sediment accumulation	*Continental slopes, deltas, fjords*
		Erosion	*Continental slopes and canyons*
	Seismic shaking	Earthquakes	*Active margins, glaciated margins, fjords (passive margins)*
	Wave loading	Hurricanes	*Deltas and continentals shelves (water depth < 100m)*
		Tsunamis	
		Storms	
Reducing strength	*Excess pore fluid pressure*	Dissociation of gas hydrate	*Continental slopes (water depth < 500m)*
		Decay of organic matter	*Deltas, fjords*
		Fluid seepage and migration	*Fjords, continental slopes*
		Earthquakes	*Active margins, glaciated margins, fjords (passive margins)*
		High sedimentation rate	*Fjords, deltas and continental slopes*

Triggering factor Preconditioning factor

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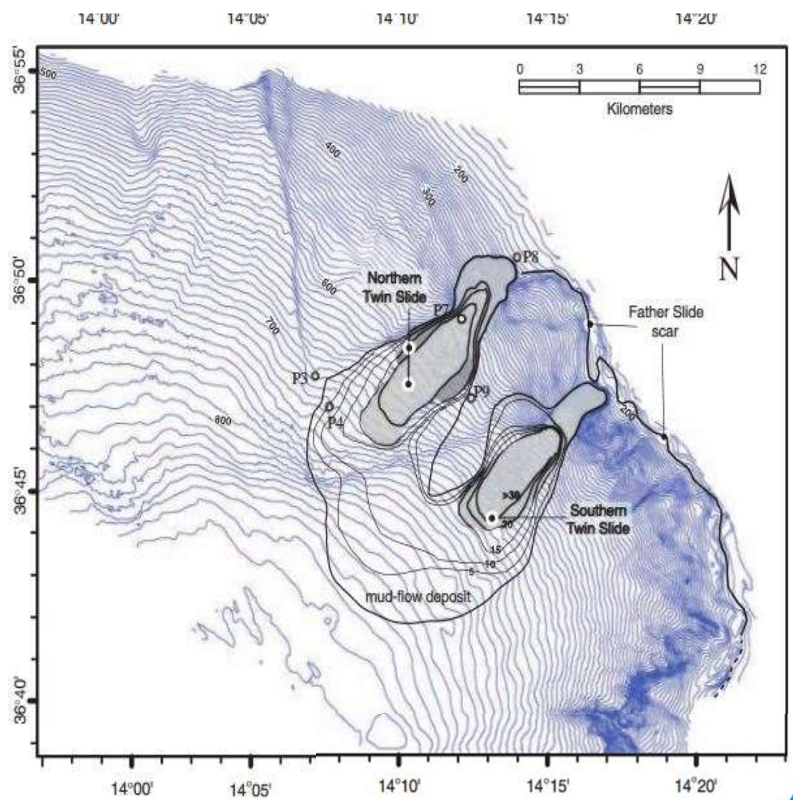
2) Submarine landslides hazard

- Characterise occurrence: identify morphometry and kinematic indicators to be able to recunstract → failure dynamic, assess mechanisms and frequency
- Statistical analyses are important to correlate between morphometric parameters (watch out for standardiation of measurement and description!!)

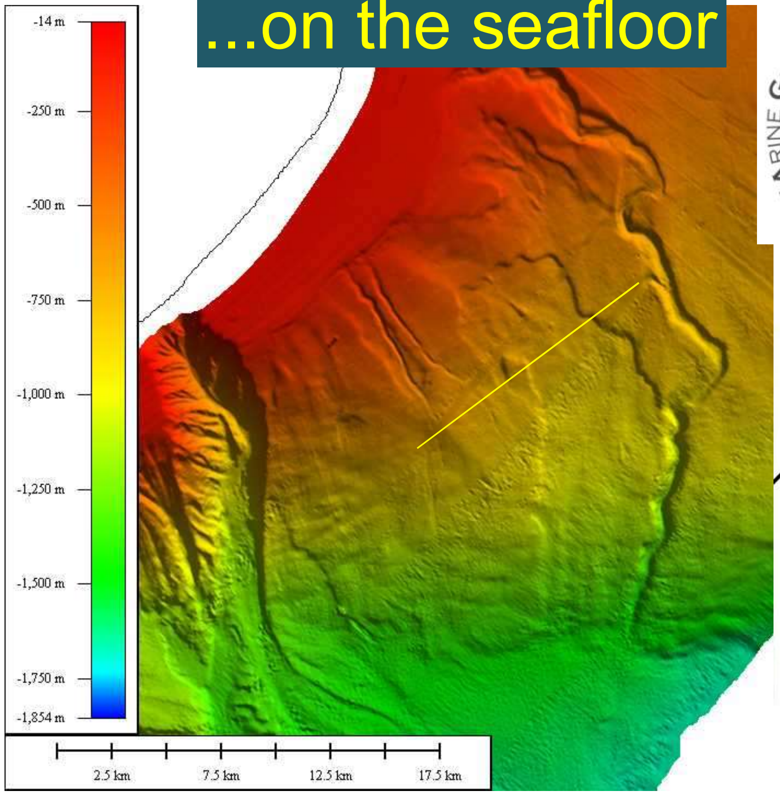
Being able to evaluate the recurrence of sediment failures on continental margins is important to better understand the evolution of margins and to assess the geologic hazard of slope failure. This will help to model tsunami hazard



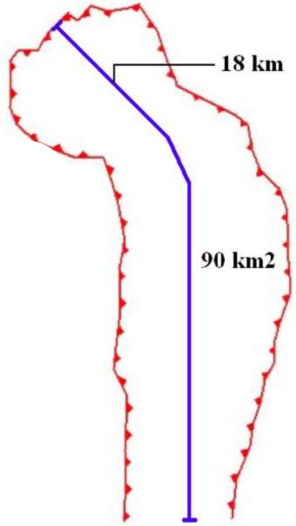
Minisini and Trincardi 2009

The Assi Failure

...on the seafloor

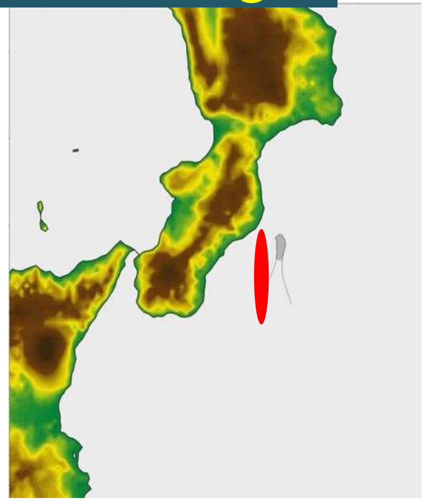


MARINE GEOHAZARDS ALONG THE ITALIAN COASTS
PROGETTO MAGIC



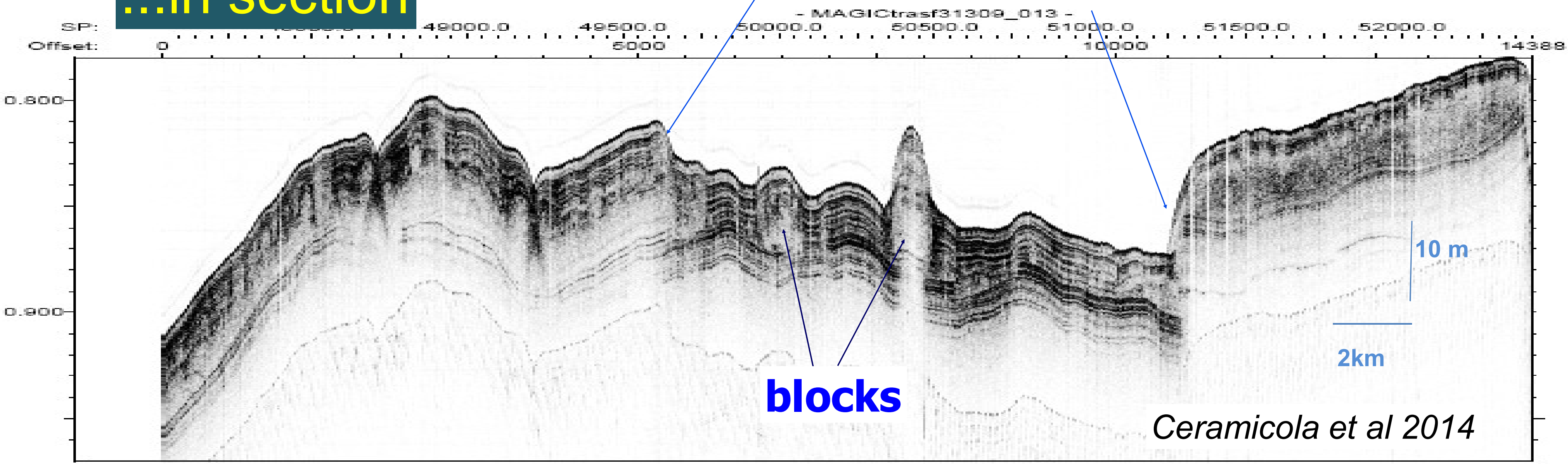
...the Calabrian margin

Volume of sediments of the failure is about 2km^3



...in section

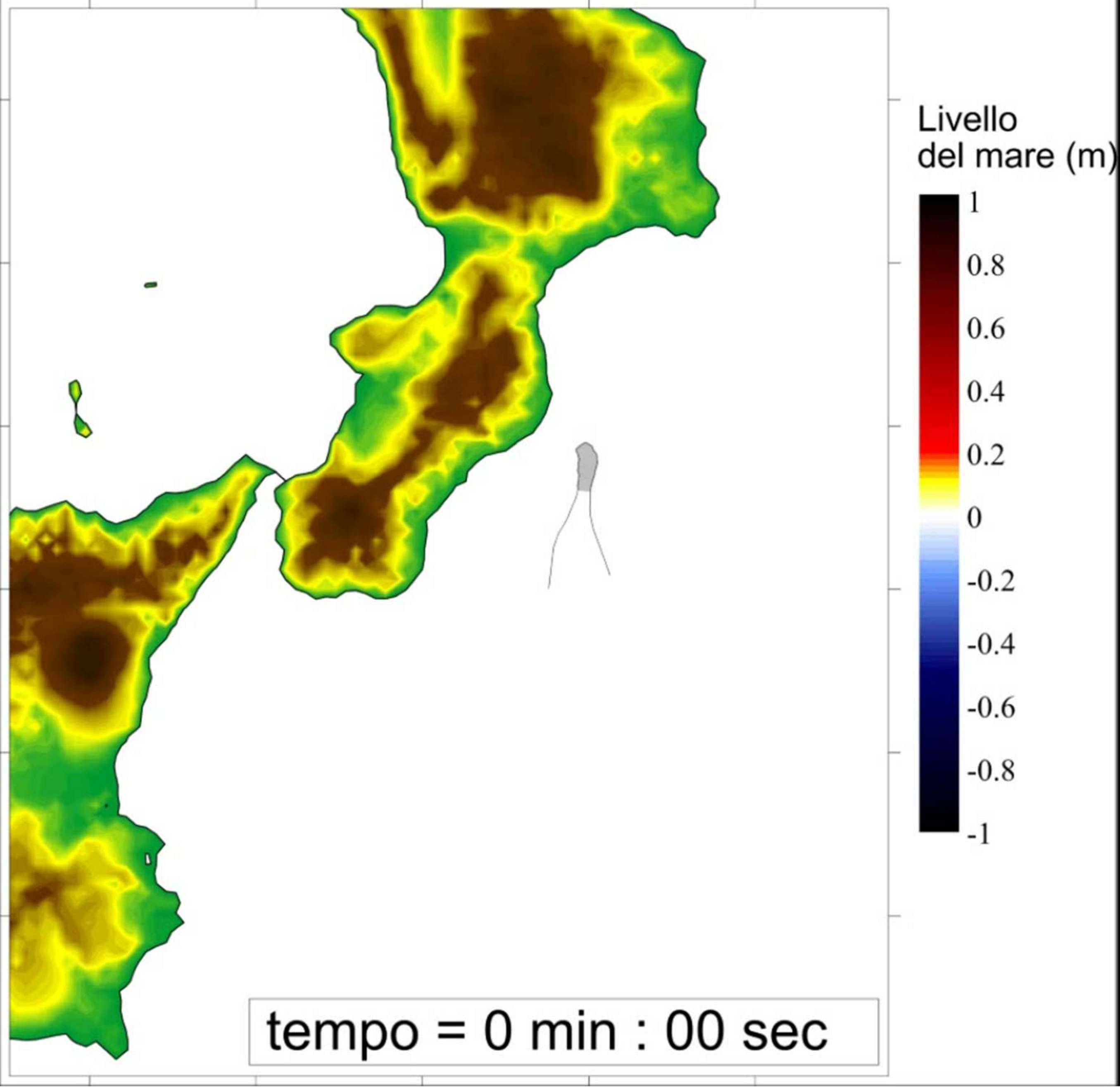
Side scarps or lateral ramps



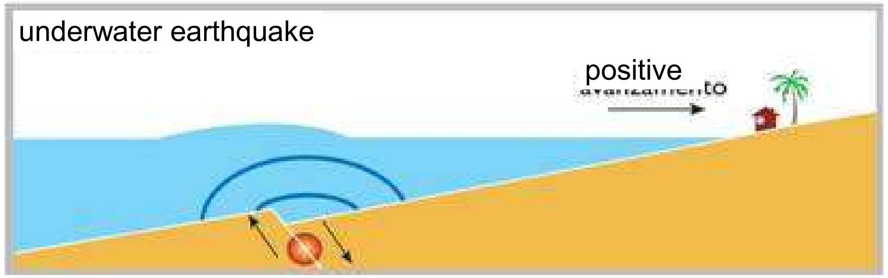
Ceramicola et al 2014

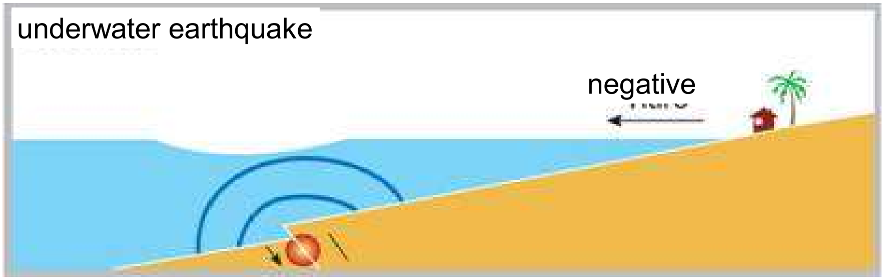
Maremoto dalla frana di Assi

Gruppo di Ricerca Maremoti - Università di Bologna

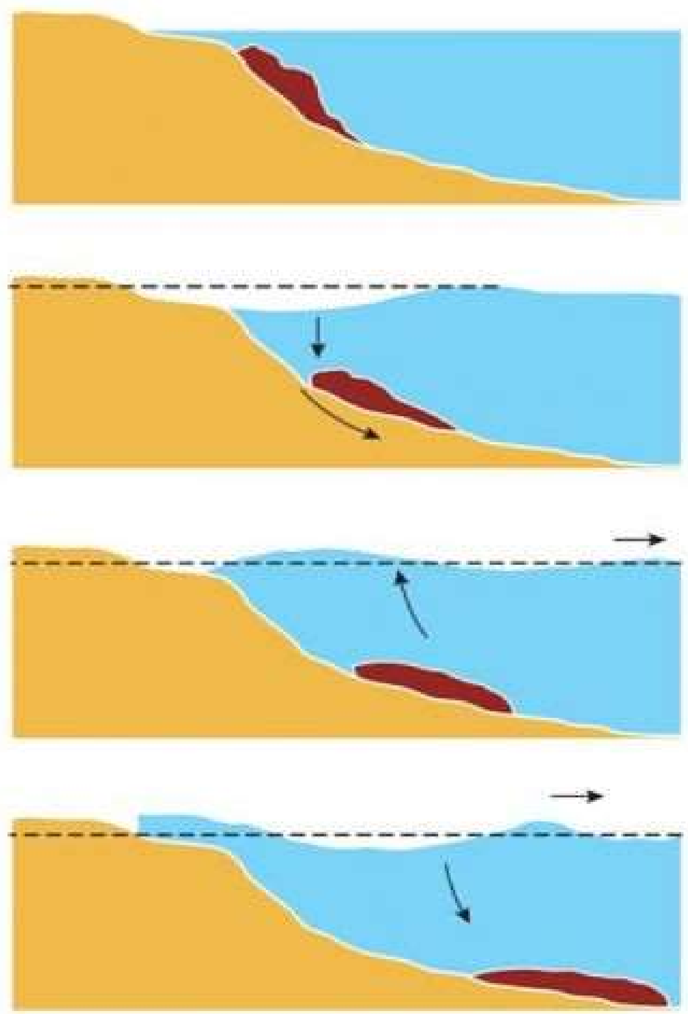


3) Tsunamis



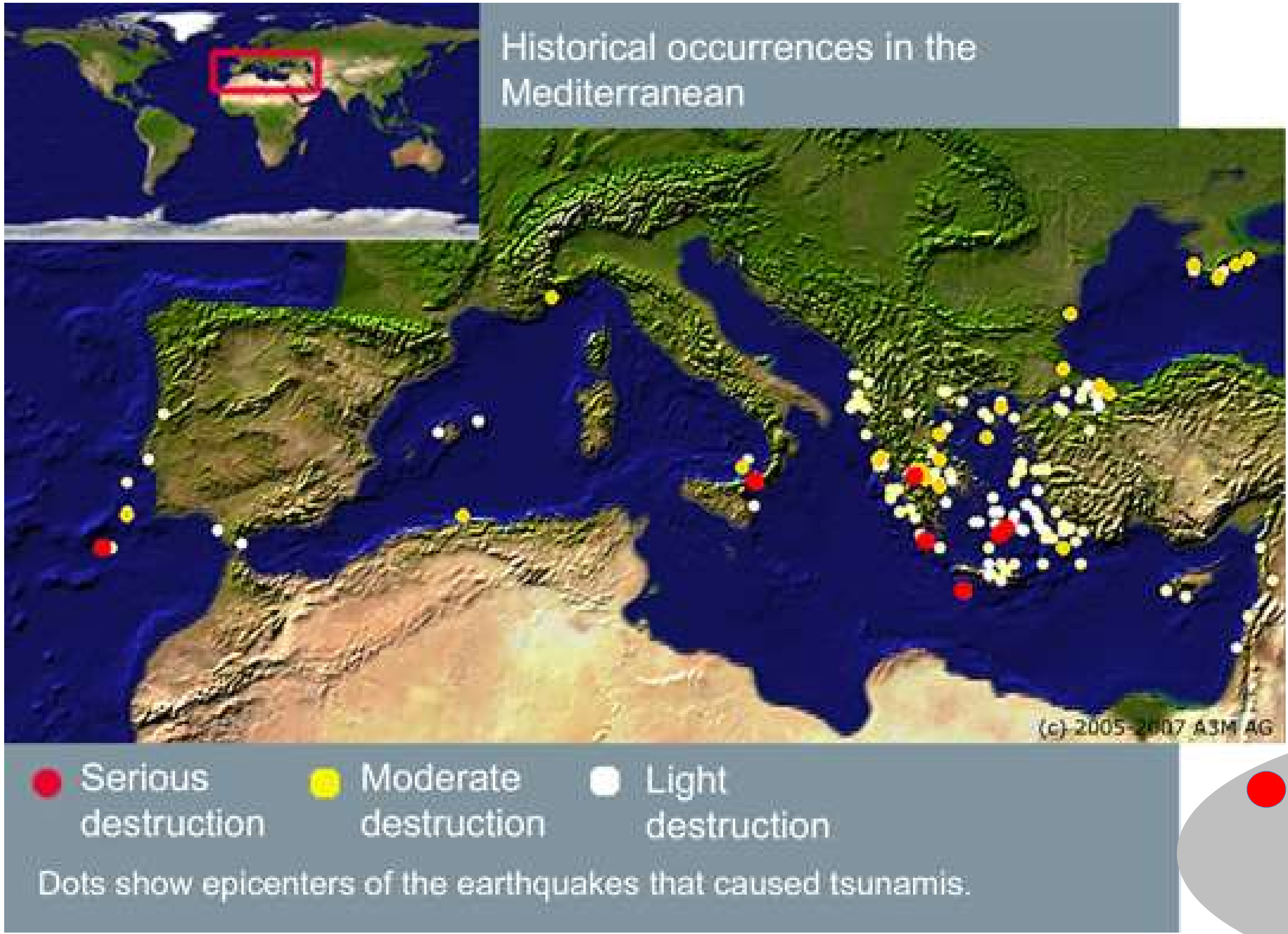


submarine landslide



A tsunami is a series of **ocean waves** that send **surges of water**, sometimes reaching heights of over 30 meters, onto land. They are different from waves generated by storms as they involve the entire water column. These walls of water **can cause widespread destruction** when they crash ashore.

Tsunamis in the Med



Tsunamis threaten the coasts and beaches **all over the world.**

They occur in all oceans and **seas**, including the Mediterranean, the Atlantic, the Indian, the Pacific and in **large lakes**.

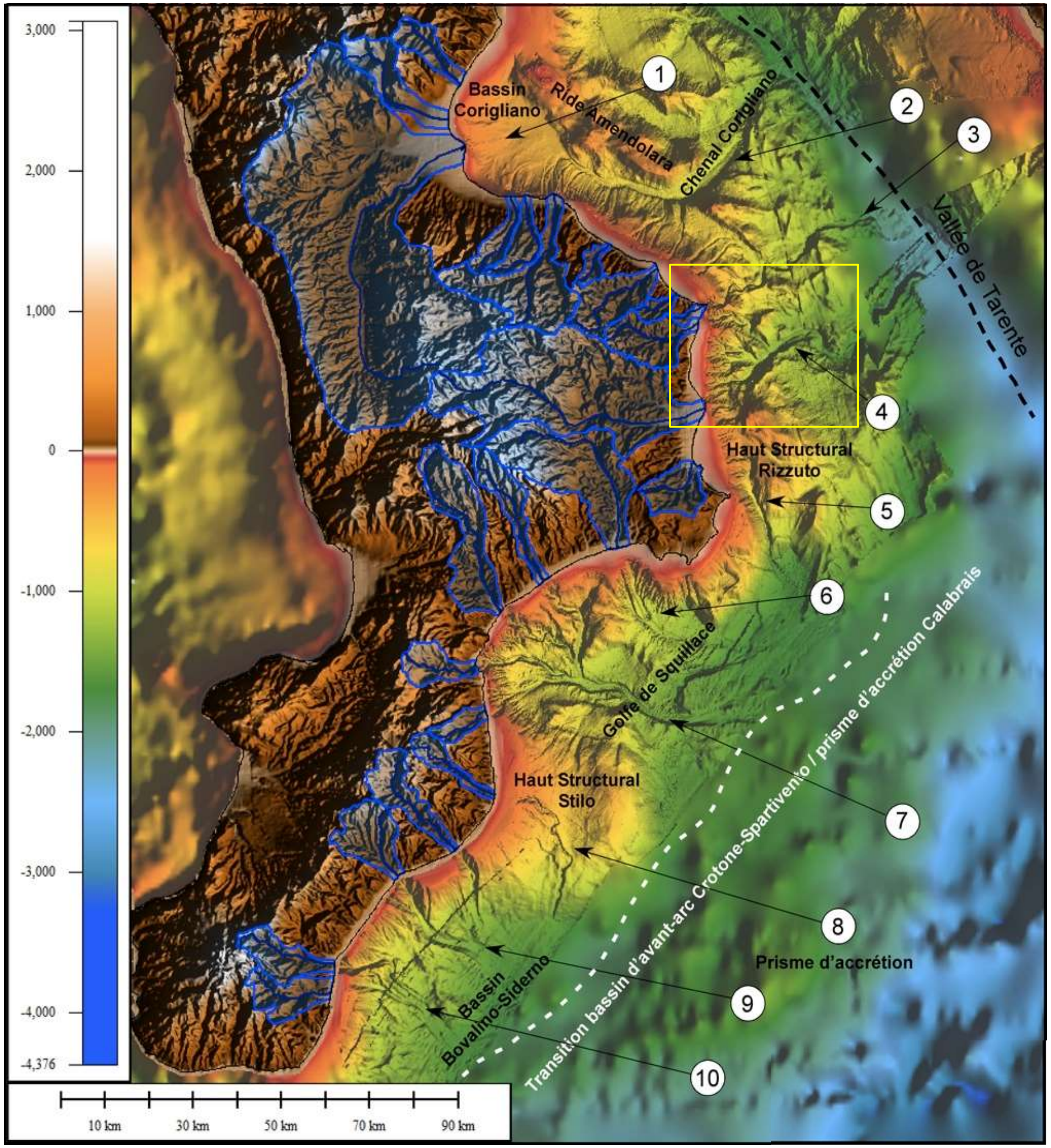
About **10%** of all tsunamis reach the beaches of the **Mediterranean Sea**.

1 nov 1755 Lisbon!

28 December 1908: Due to an earthquake and the ensuing tsunami, the city of Messina in Italy was almost completely destroyed. More than 75 000 people were killed.

Tsunamis in the Med travel quickly from cost to cost (in hours) and so it is difficult to settle an efficient **warning system!**

3) Coastal erosion and the role of canyons



The Calabrian Ionian continental margin is incised by numerous 'young' (<2,5 Ma) submarine canyon systems:

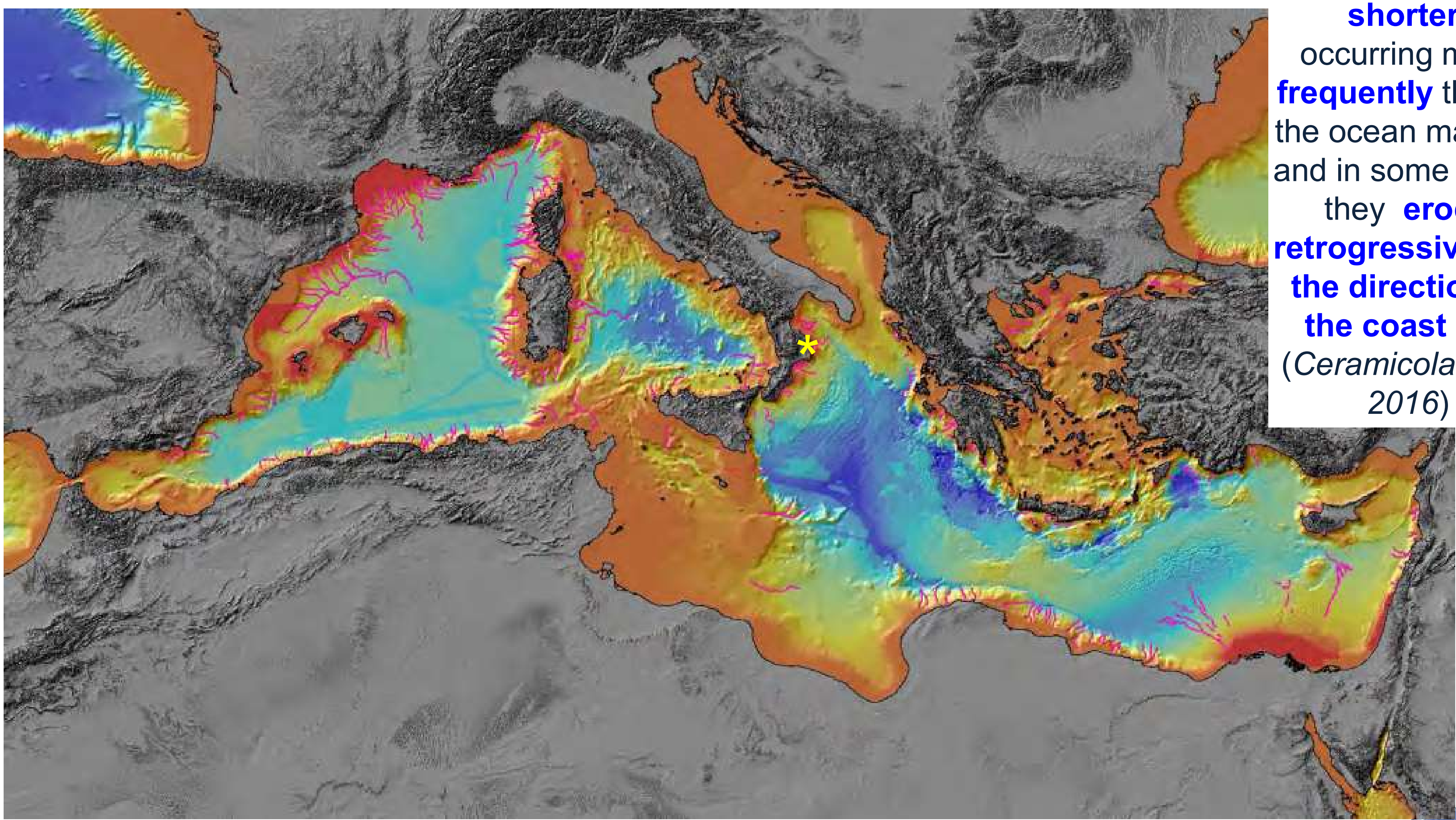
- The biggest headwall is 50km
- The longest body is more that 150km
- Very densely spaced
- Retrogressive character of the headwalls (mostly in the south)
- High activity of 'fiumare' flash floods

terrestrial drainage system

Ceramicola et al 2016

Shaded relief of the Calabrian continental margin Italy (DEM max resolution 15 m). The MaGIC Project http://magicproject.it

4) Submarine canyons in the Med

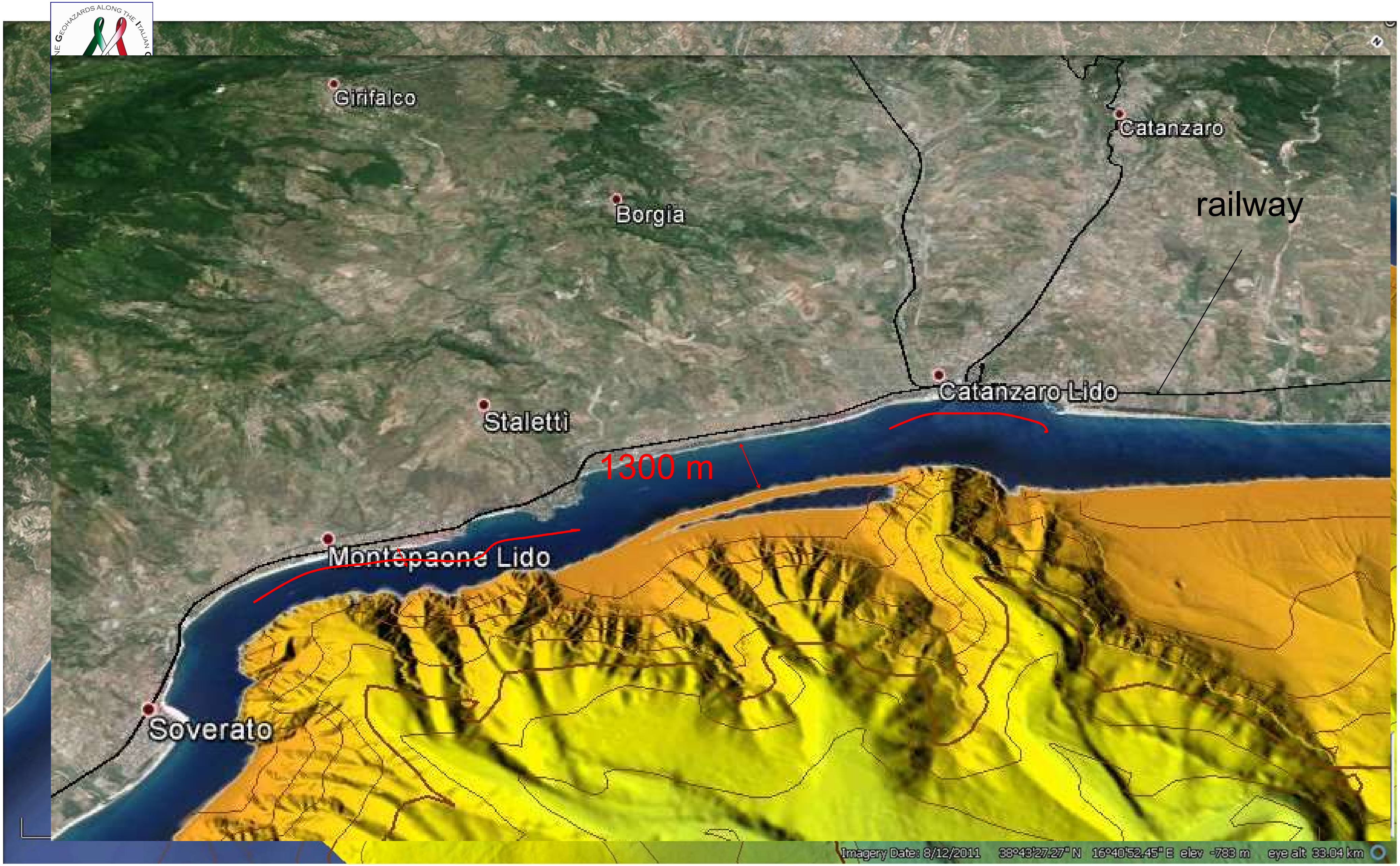


...they are **shorter**, occurring more **frequently** than in the ocean margins and in some cases they **erode retrogressively in the direction of the coast line** (*Ceramicola et al. 2016*)

The Ciro' submarine canyon


Porto di Cirò Marina
Ore 11:00 del 01 Dicembre 2013
Foto by Sergio Marino

Canyon headwall hazard



Canyon di Catanzaro (Golfo di Squillace), Calabria Ionica

ERODOTO - EROsive Dynamics Of The squillace submarine canyOn

WHY?

Test the hypotesis that the heads of the Squillace canyon are controlled by multiple gravitational events driven by flash floods (*fiumare*) activity onland.

WHERE?

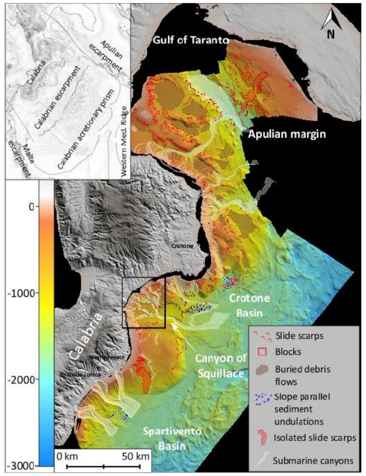
Squillace Gulf, Calabria, Italy
(both onshore and offshore)

HOW?

- ❑ MBES and CHIRP from **AUV**
- ❑ imaging and sampling from **ROV**
- ❑ onland topography from **Drone**
- ❑ set a **Mooring** (record 1 year)

WHO?

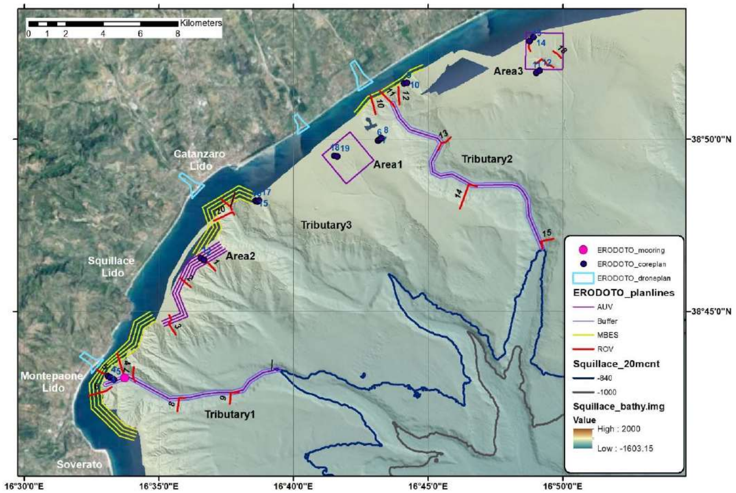
- ✓ Principal investigator: **OGS, I**
- ✓ **NOC**, UK
- ✓ **University of Durham,** UK
- ✓ **IFREMER**, FR
- ✓ **Università La Sapienza**, I



Ceramicola et al 2014

AND SO WHAT?

ERODOTO proposes to analyse and quantify the active dynamics of a shelf-incising, close-to-shore submarine canyon heads to set a model for geohazards assessment, monitoring and risk management in coastal areas (in collaboration with the Italian Department of Civil Protection)



Survey in May 2023

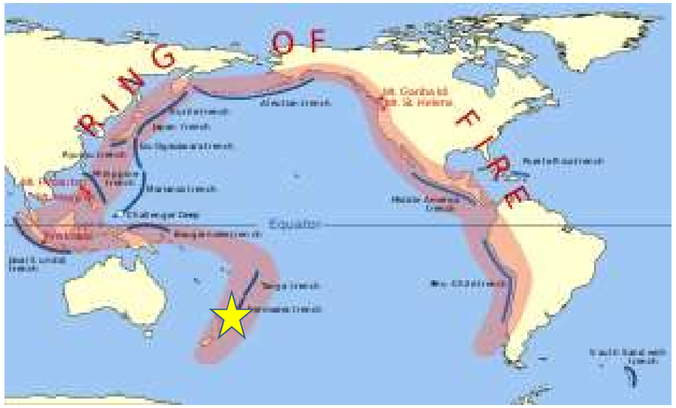
3) Submarine Volcanic hazard

Over 75% of the volcanic activity on Earth occurs underwater (Nomikou, MDPI 2018)

Submarine volcanic hazard includes:

volcanic eruptions,
volcanic earthquakes,
submarine landslides,
hydrothermal emissions and
volcanogenic tsunamis

(Nomikou, MDPI 2018)



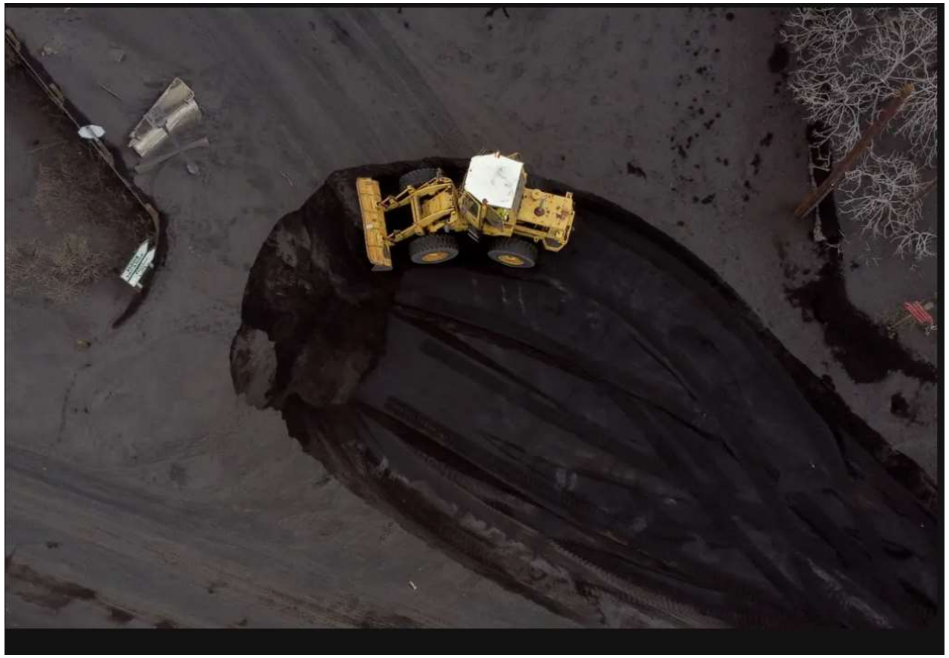
2009 Tonga submarine eruption

The initial March 16–17 eruption sent ash and smoke up to 20 kilometres into the atmosphere and the volcano has breached the ocean surface forming an island.

3) Submarine Volcanic hazard

The Cumbre Vieja volcano (Canary Island) has been erupting since 19 September 2021, forcing more than 6,000 people out of their homes as the lava burnt its way across huge swathes of land on the western side of La Palma (Guardian).

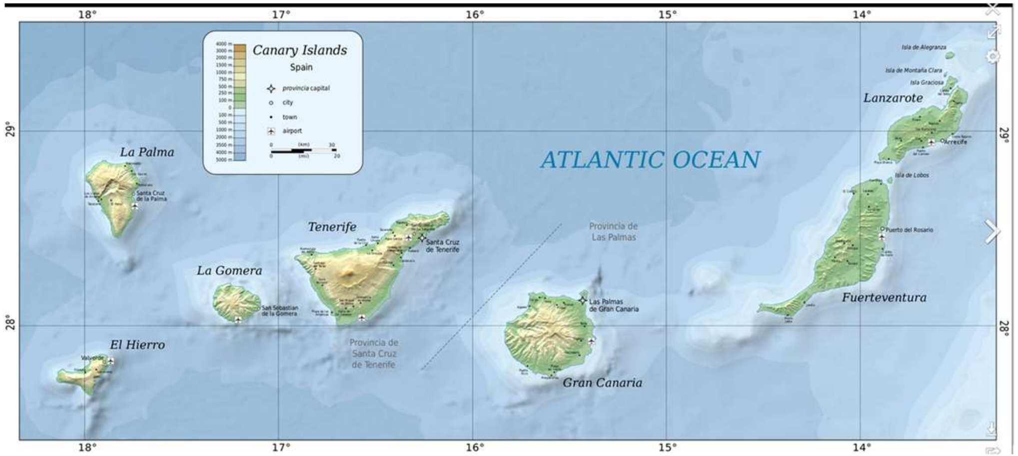
La Palma volcano comes to stop: Scientists consider it 'improbable' that it will reactivate, but are not ruling out that possibility for now (16 dicember 2021 El Pais)

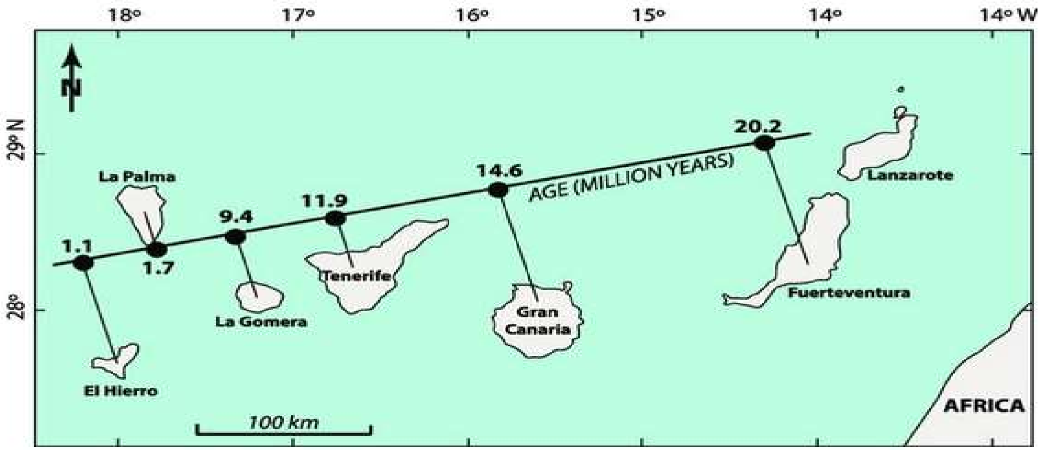


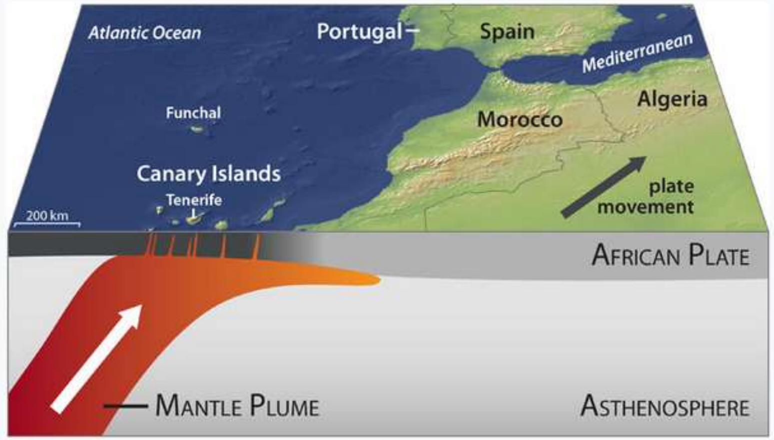
An excavator clears a road

Members of the Spanish army remove ash from houses covered with lava in Las Manchas.

The Canary Islands: The "Hawaii of Europe"







The Canaries formed when magma, rising from a hot spot deep in Earth's mantle, punched through the overlying oceanic crust. Credit: Kat Cantner, AGI

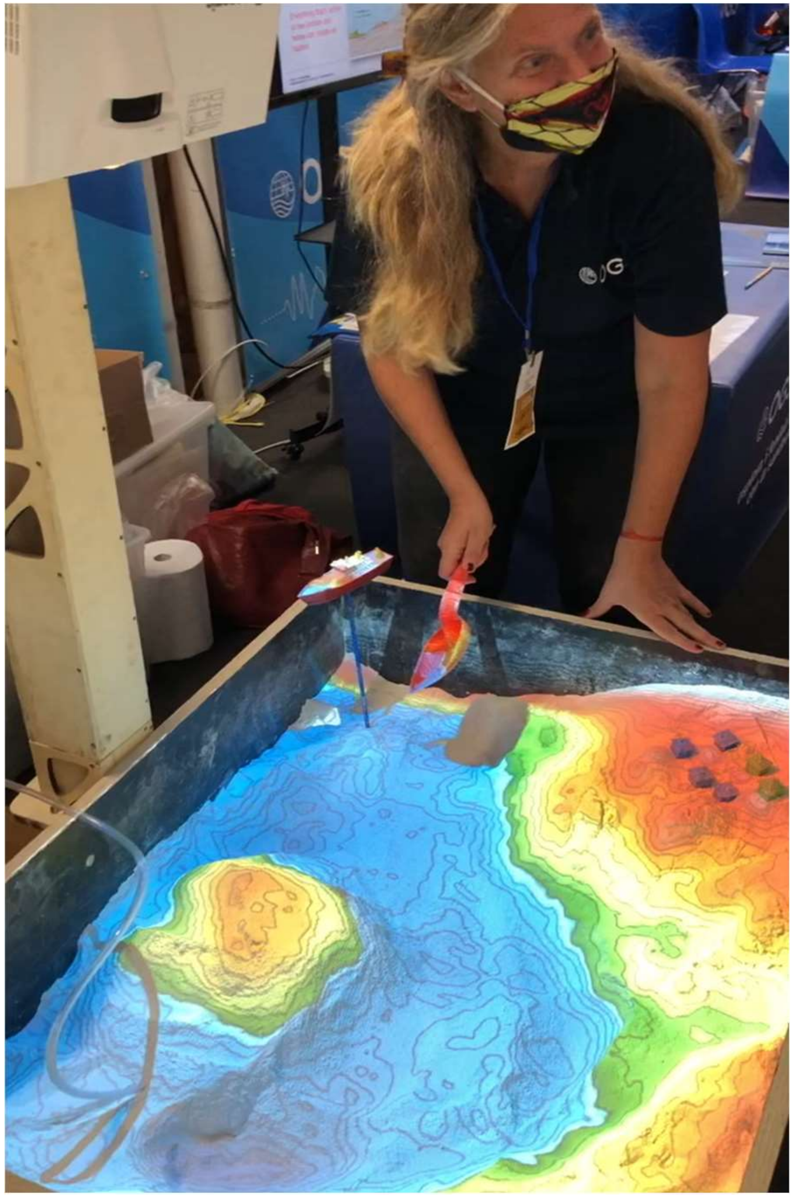
Figure 1. The Canary Islands with their respective geological age. Illustration by Erik-Jan Bosch, modified from Carracedo and Perez-Torrado 2013. (Jean Claessens et al. 2019)

A mantle plume is a proposed mechanism of convection within the Earth's mantle. Because the plume head partially melts on reaching shallow depths, a plume is often invoked as the cause of volcanic hotspots, such as Hawaii or Iceland, and large igneous provinces such as the Deccan and Siberian Traps.

The Canary Islands developed in a geodynamic setting characterized by Jurassic oceanic lithosphere formed during the first stage of opening of the Atlantic at 180-150 Ma and lying close to a passive continental margin on a very slow-moving tectonic plate – the African plate.

The origin of magmatism in the Canaries and its complicated space-time relationships have been a subject of debate for a long time. It is popularly believed that the origin of oceanic intraplate volcanism is related to mantle plumes.

3) Submarine Volcanic hazard



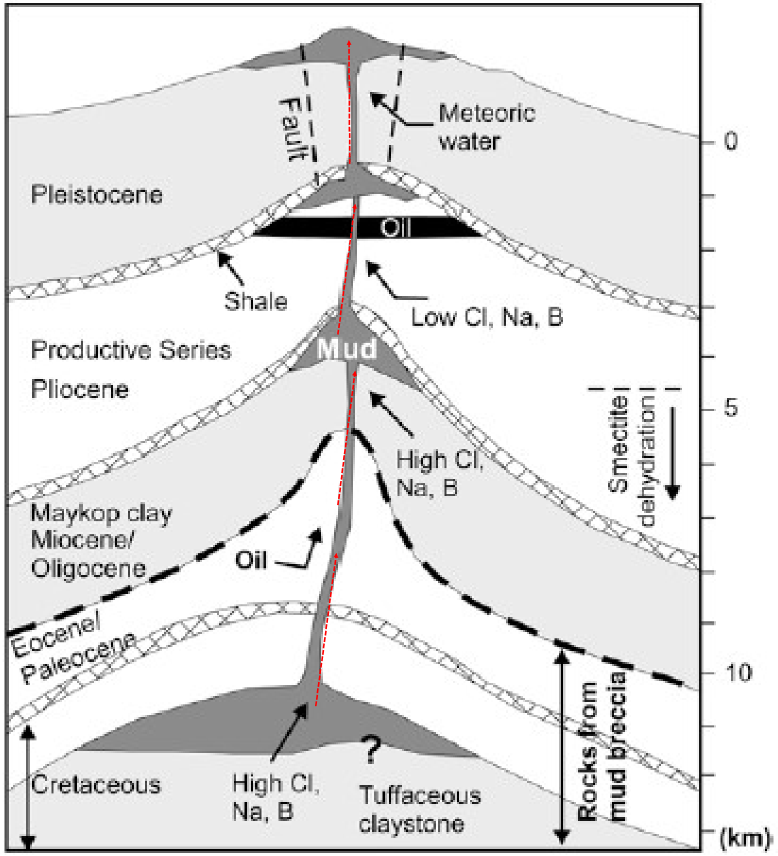
Sand box: I fondali marini in una scatola….. ovvero un laboratorio di sabbia per comprendere le morfologie dei fondali marini e i fenomeni e processi naturali geologici che li generano.

Sand Box as a tool for science outreach about marine geohazards @NEXT science festival in Trieste, 24-26 September 2021

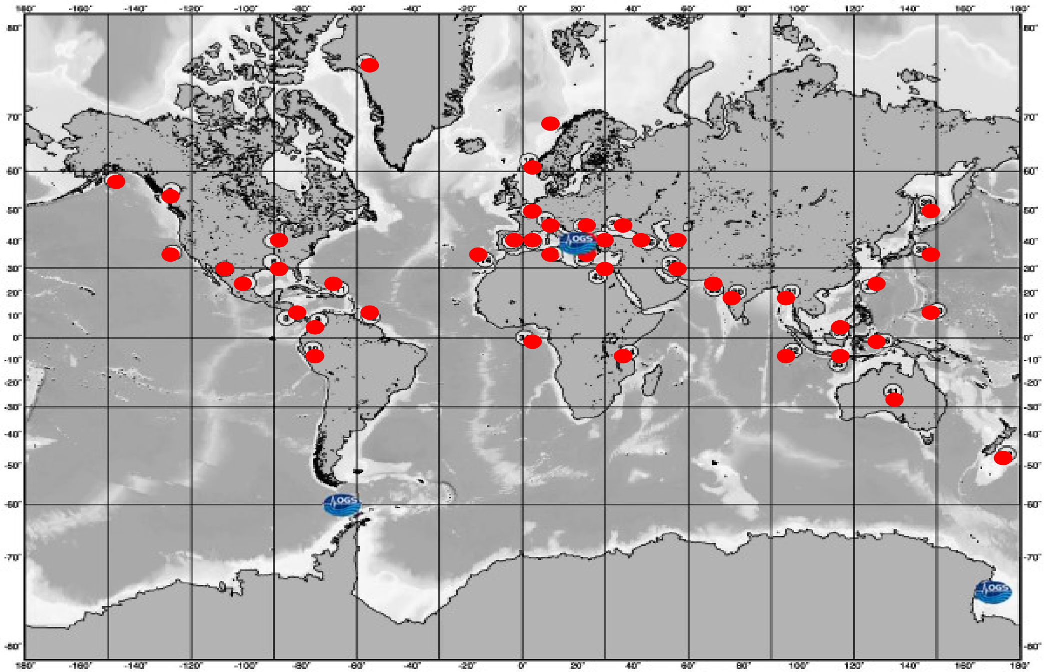
Fluid Emission hazard

Fluid flows, fluid venting, cold seeps, cold venting, seepage,

A cold seep is an area of the ocean floor where **H2S** hydrogen sulfide, **CH4** methane and other **hydrocarbon-rich fluid seepage** occurs.

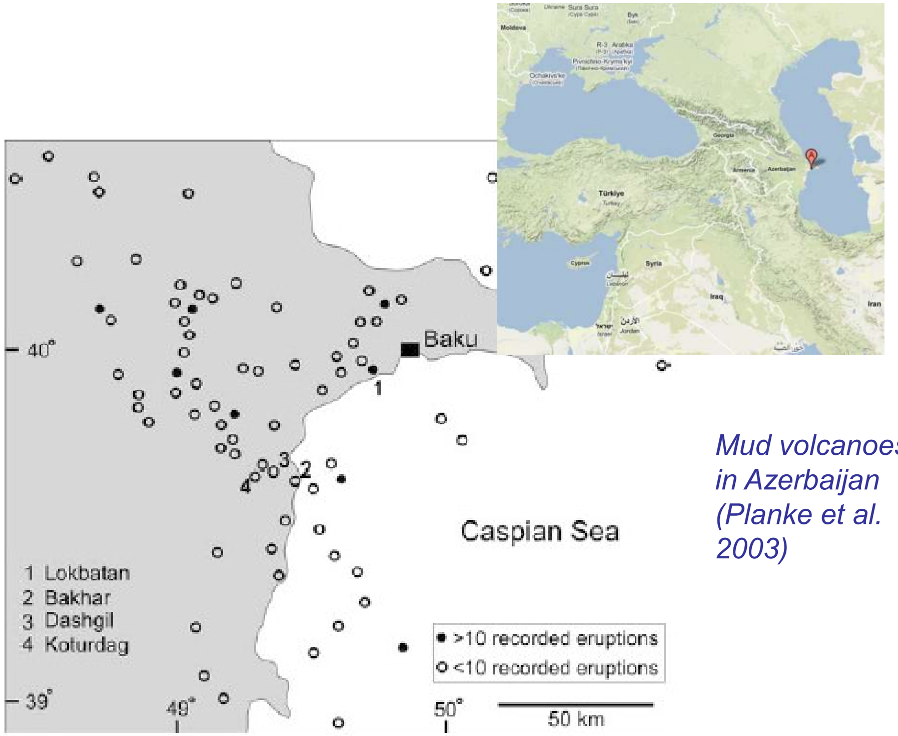


Conceptual model of Azeri mud volcanism - deep roots (12 km), multiple mud chambers (Planke et al. 2003)



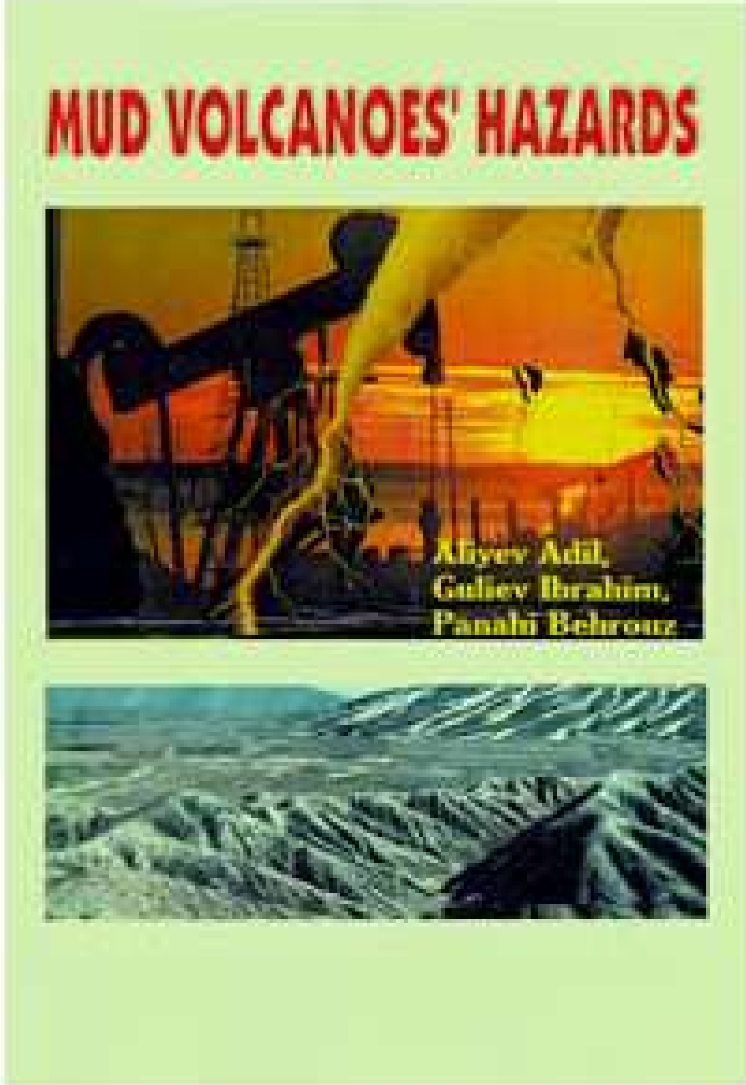
Distributions of mud volcanoes along the world's continental margins (Kopf 2002)

Fluid Emission hazard



Mud volcanoes in Azerbaijan (Planke et al. 2003)

Azerbaijan mud volcanoes (among world's largest)



Aliyev et al. (2000)

Lokbatan MV (B. Asbrink 2003 - Azerbaijan International)

Self-igniting supersonic gas blowout - height 750 m, distance 20 km from Baku (1958)

Fluid Emission hazard

Lusi Mud Volvano, W-Java, Indonesia (erupting since 2006)

It began erupting 16 years ago and hasn't stopped since.

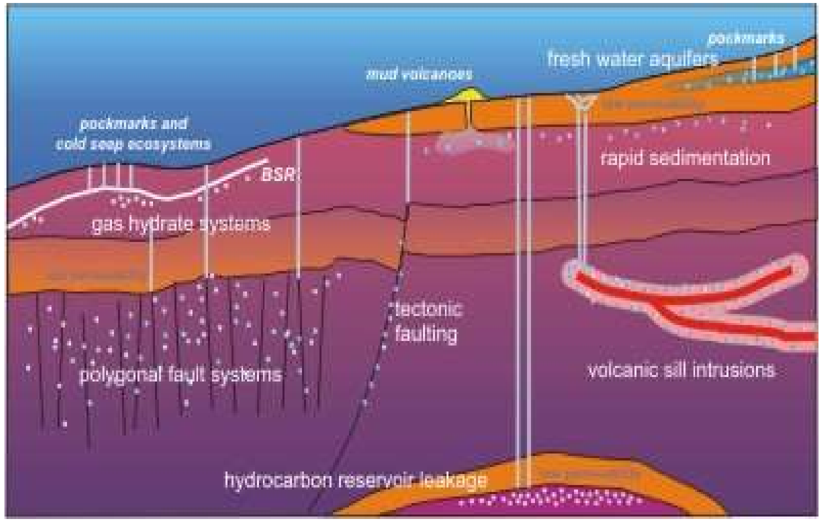
At its peak 180,000 m^2 of mud a day spewed to the surface.

Ikonos Satellite images (CRISP)

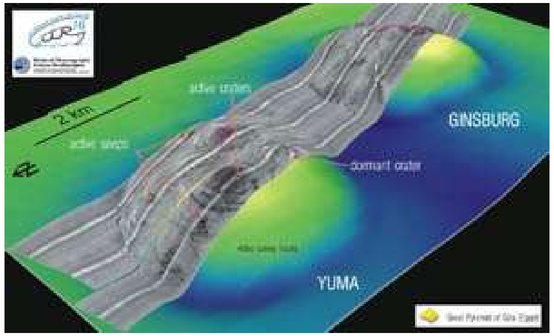
COLD SEEPS EXAMPLES

I COLD SEEPS

- MUD VOLCANOES, CONIC PIES, CHIMNEYS)
- POCKMARKS
- CARBONATIC CRUSTS
- BRINE POOLS
- GAS HYDRATES

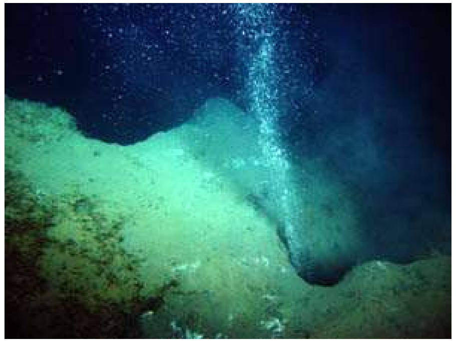


Schema della circolazione dei fluidi nei sedimenti, Berndt (2005)

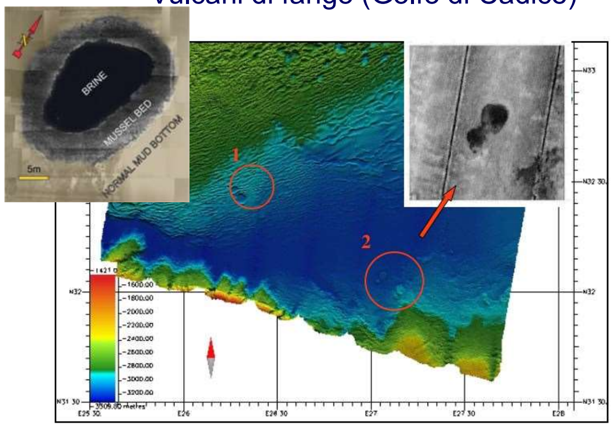


Vulcani di fango (Golfo di Cadice)

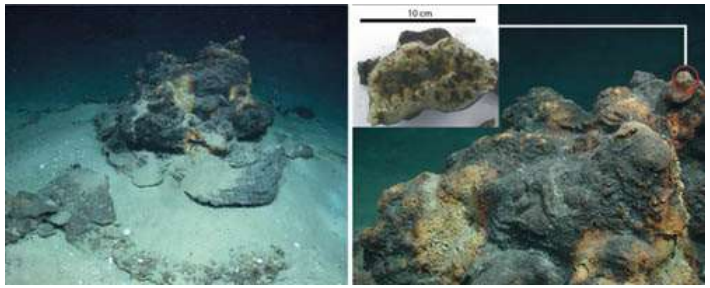
Pockmarks - Mar Adriatico



Fuoriuscite di metano
Hakon Mosby Mud Volcano



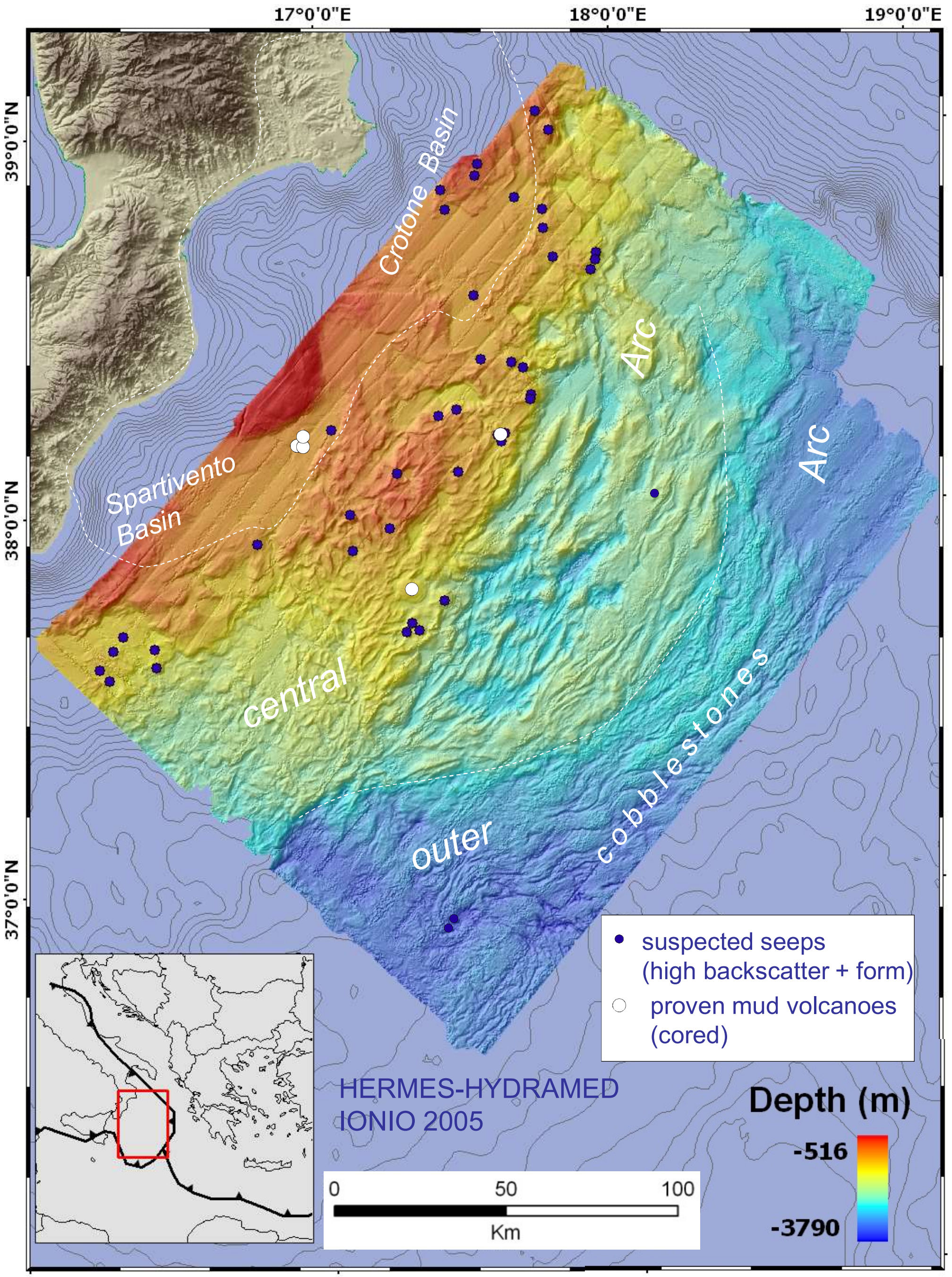
Brine salmastre (Delta del Nilo)



Croste carbonatiche - Vulcano di Fango Amon (Delta del Nilo)

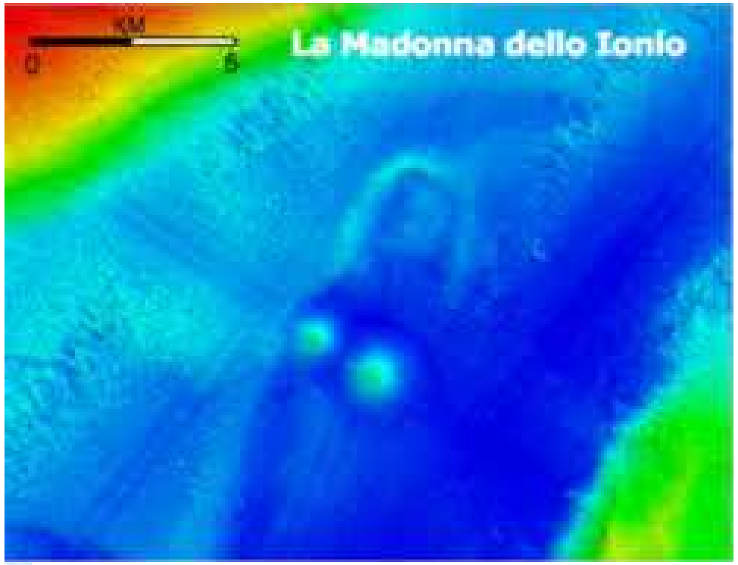
Le salse di Nirano (Modena)

OGS has discovered a new province of mud volcanoes in the Calabrian accretionary prism in 2005



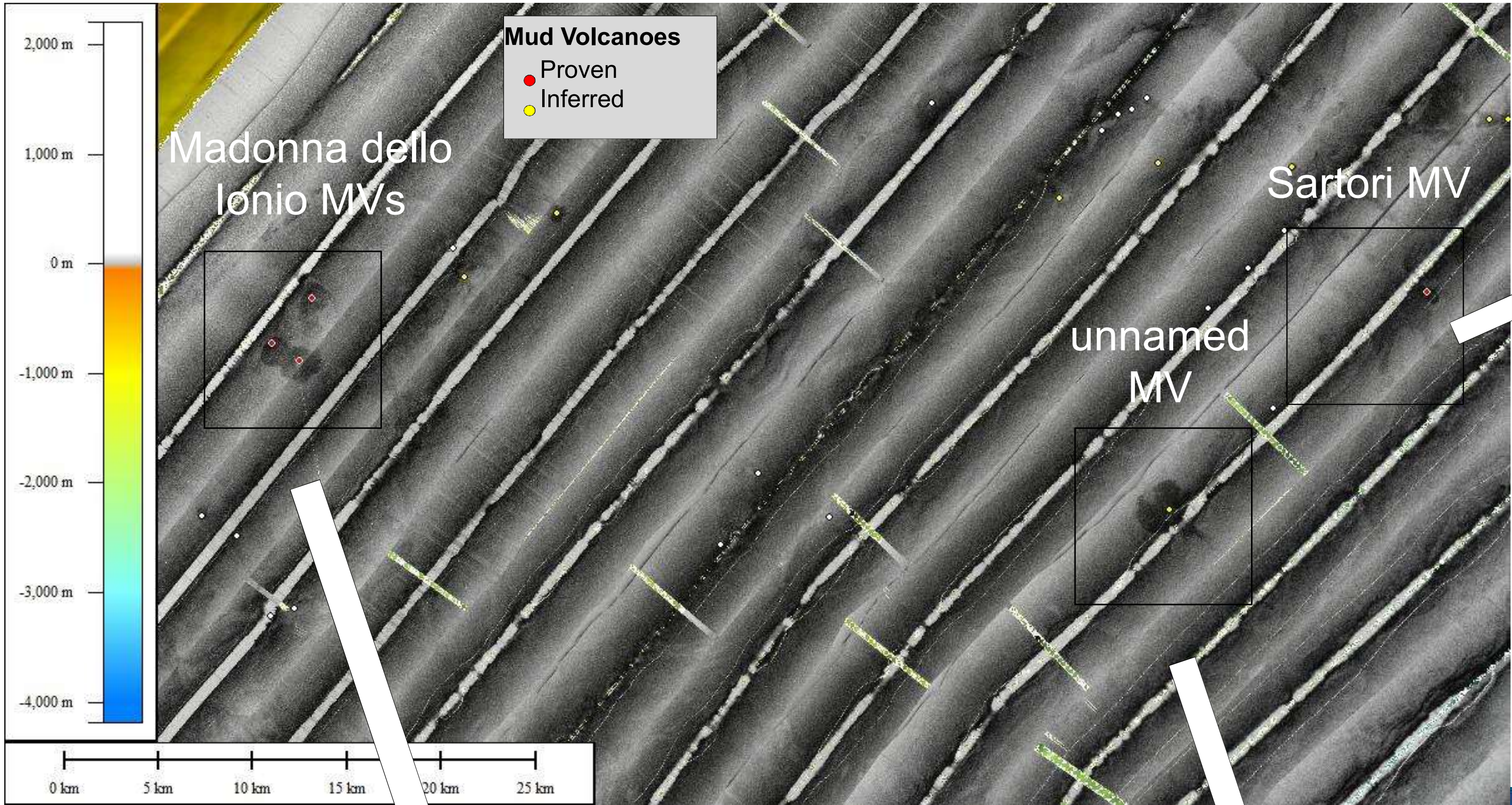
Ceramicola et al. 2014

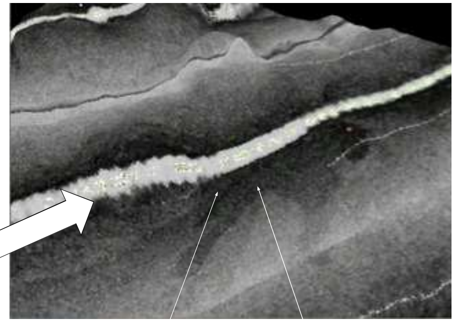
Using different geophysical and geological methods we have been able to identify 54 mud volcanoes, map their distribution, characterise their activity and assess possible geohazards

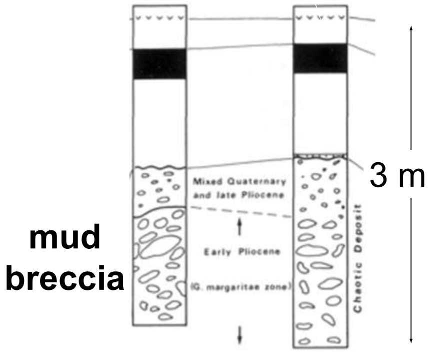


1° price at the BP Kongsberg Bathymertry Image Contest 2006 (500 £)

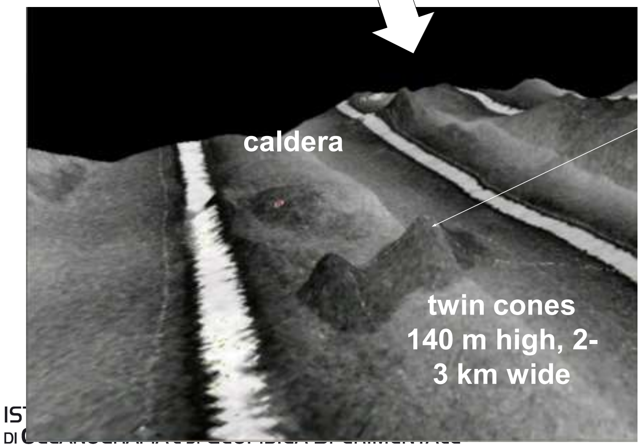
Use of multibeam morpho-bathymetry + backsca data to map mud volcanoes (Calabrian Arc)

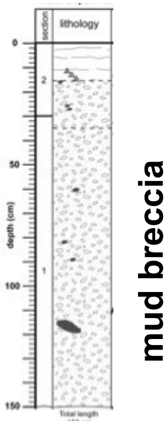


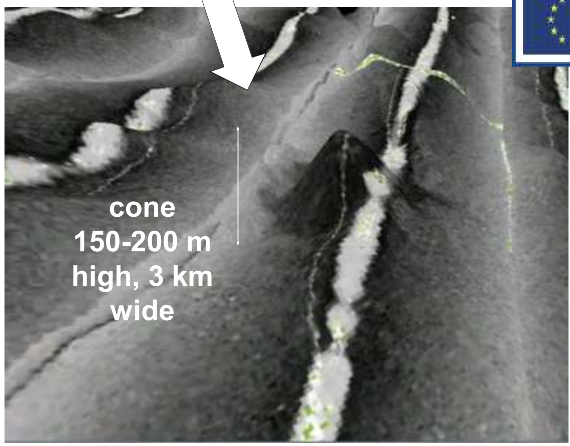




Morlotti et al. (1982)





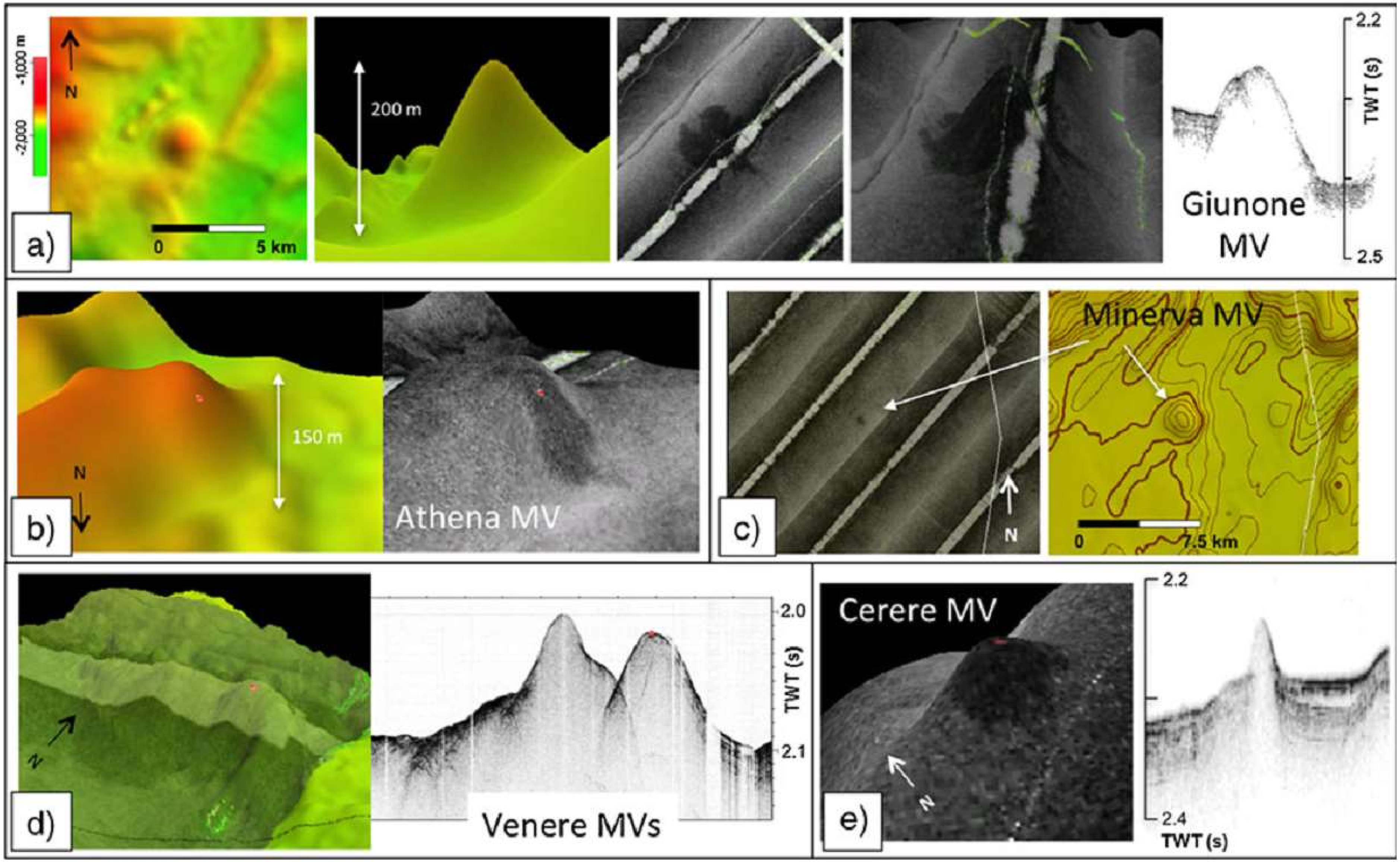


HYDRAMED

HERMES

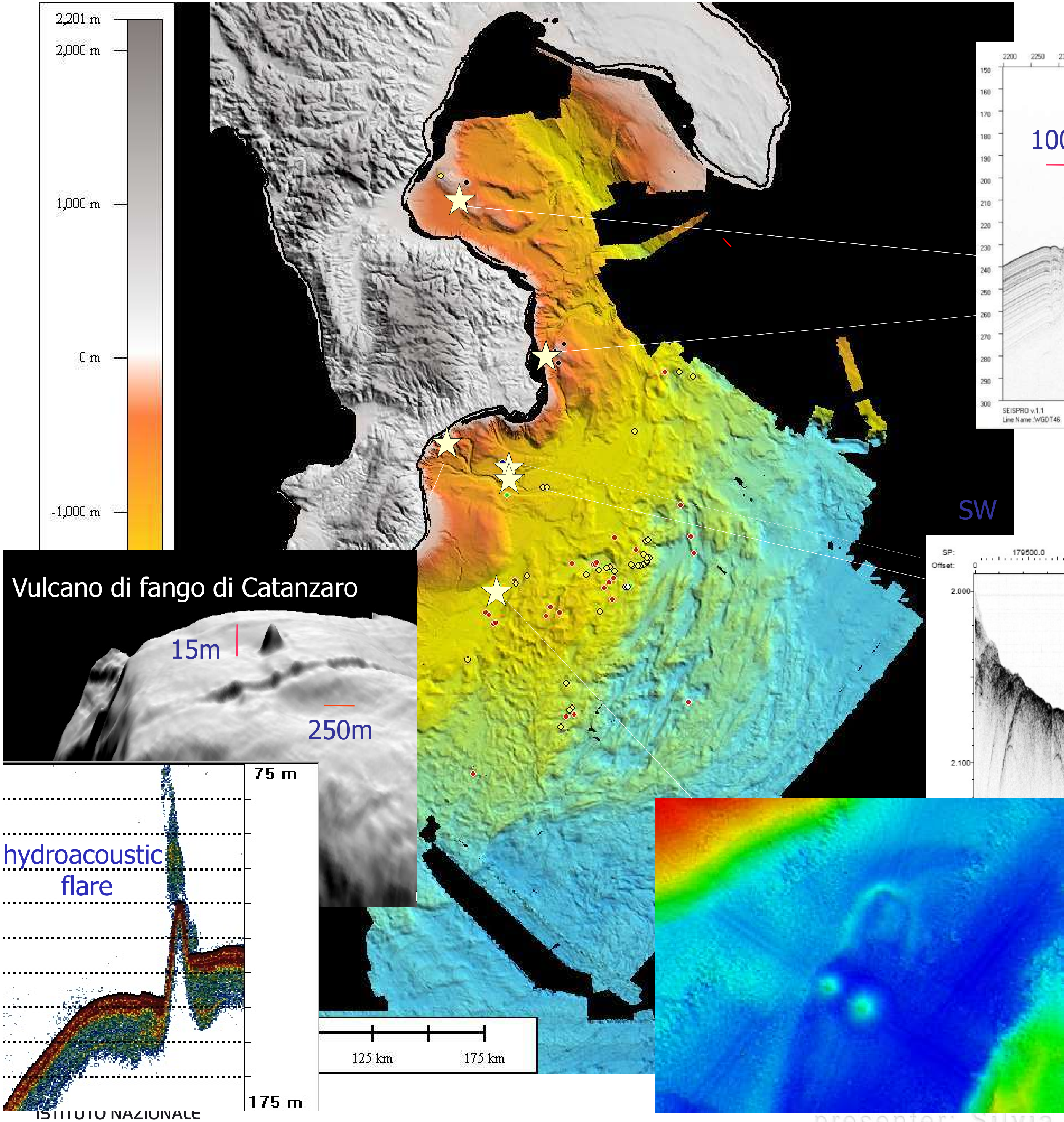
Ceramicola et al. (2014)

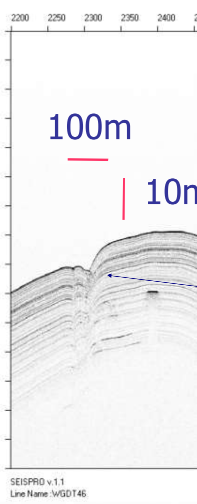
Morfologia | Riflettività | Facies acustica

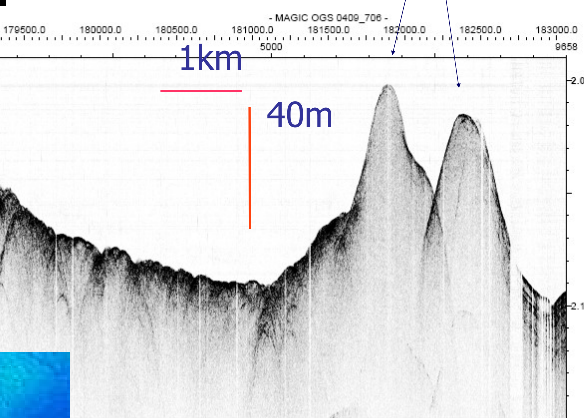


Ceramicola et al 2014

SEABED SEEPAGE MAPPING

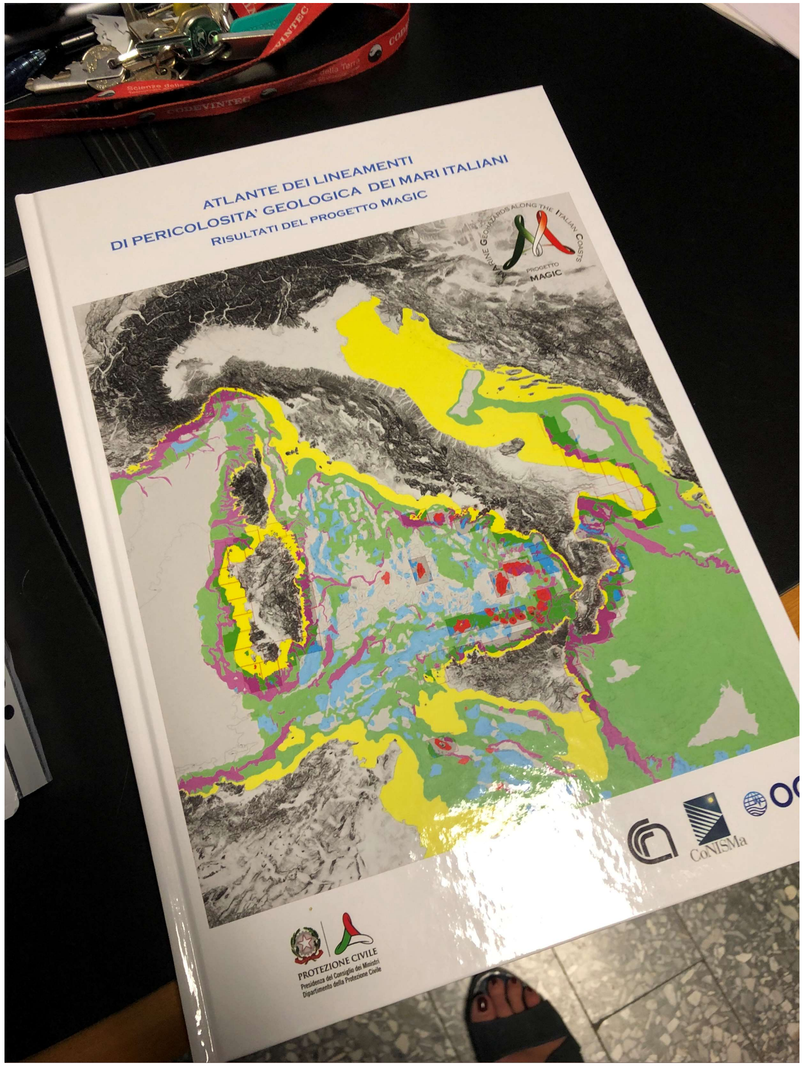






siti individuati nel
argine calabro ionico sottocosta,
olti di piu' sul prisma di accrezione

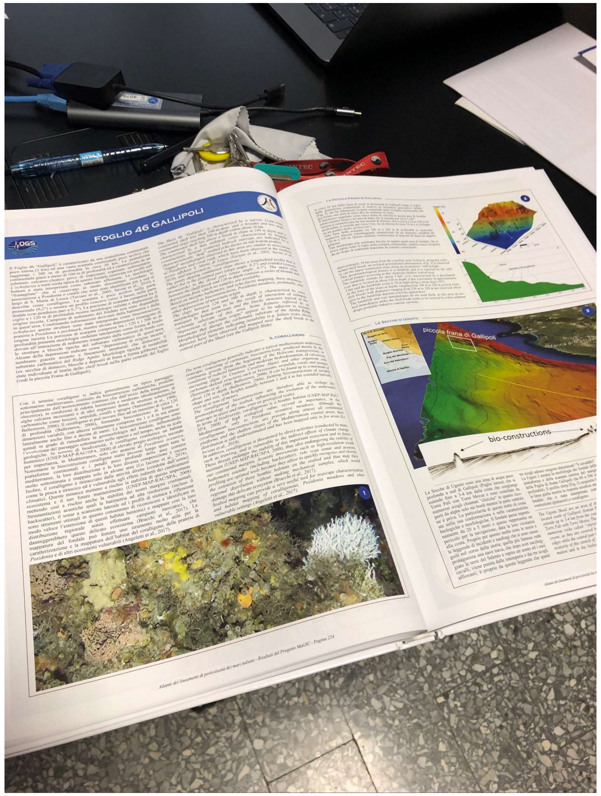
NATURAL HAZARDS MANAGMENT



ATLANTE DEI LINEAMENTI
DI PERICOLOSITA' GEOLOGICA
DEI MARI ITALIANI

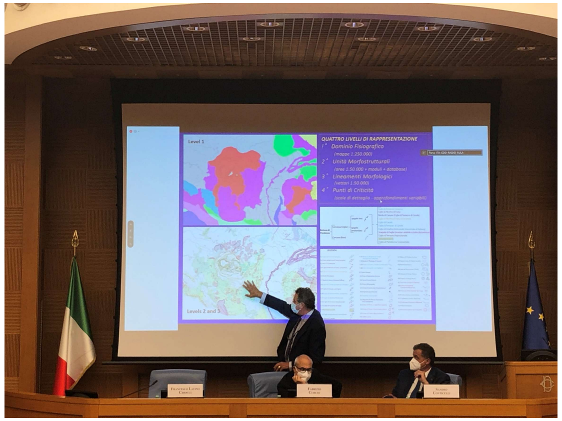
RISULTATI DEL PROGETTO MAGIC

I risultatai del progetto MaGIC in un atlante progetto



https://github.com/pcm-dpc/MaGIC

NATURAL HAZARDS MANAGMENT



Presentati l'Atlante degli elementi di pericolosità dei mari italiani e i risultati del progetto MaGIC presso la Camera dei Deputati, Commissione Ambiente, Territorio e Lavori Pubblici.

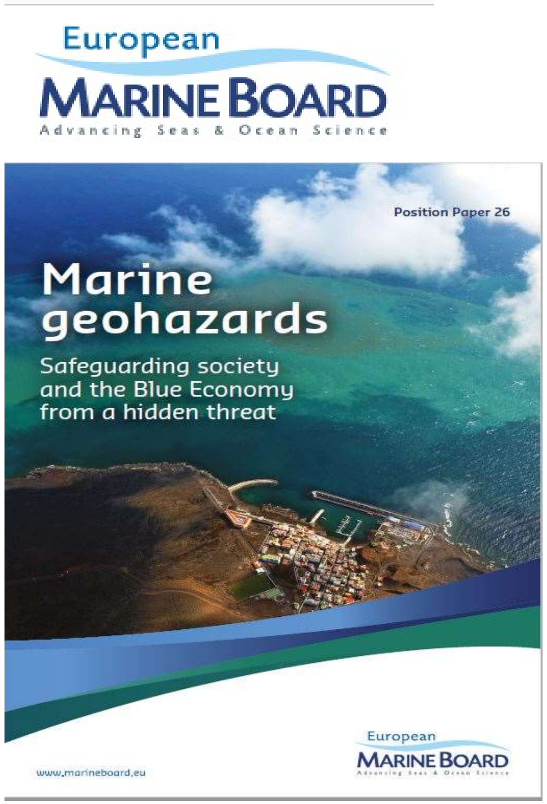
"La conoscenza scientifica è fondamentale per favorire la prevenzione e la previsione dei rischi nel nostro Paese. L'atlante rappresenta il prodotto finale del progetto e lo **strumento divulgativo**, **alla comunità scientifica** e **alle istituzioni competenti per la gestione del territorio costiero, delle informazioni raccolte e delle conoscenze raggiunte.**

La presentazione dell'Atlante degli elementi di pericolosità dei mari italiani e dei risultati del progetto Magic si è tenuta il 27 settembre 2021 presso la Camera dei Deputati, Commissione Ambiente, Territorio e Lavori Pubblici.

Alla presentazione hanno preso parte:
il Ministro delle Infrastrutture e mobilità: Enrico Giovannini,
Il Presidente della Commissione ambiente: onorevole Rotta,
il Direttore del Dipartimento della Protezione Civile, Fabrizio Curcio
Il Direttore del dipartimento Terra e Ambiente del CNR, Fabio Trincardi
Il Presidente di OGS: Nicola Casagli

Ulteriori informazioni al seguente link: https://www.cnr.it/it/nota-stampa/n-10590/
Rassegna stampa: https://new.ecostampa.net/rasimg/pdf_rs/clienti/CNRUS_10164505.pdf

Marine Geohazards and the Blue Economy



A geohazard (or geological hazard) is a geological condition which represents - or has the potential to develop into - a **situation leading to damage or uncontrolled risk.**

Hazardous marine geological events may occur **at any time** and the scientific community, marine industry, and governmental agencies must cooperate **to better understand and monitor the processes** involved in order to mitigate the resulting unpredictable damages.

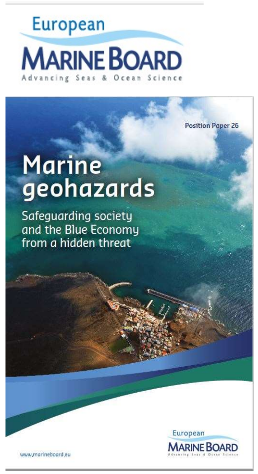
The **European Marine Board** has produce a foresight document to provide **a state-of-the-art** within this broad research field**, identifying the key issues**, and illustrating some examples of **how research in this area can improve the assessment of risks to the Blue Economy.**

Position Paper 26, Marine geohazards: Safeguarding society and the Blue Economy from a hidden threat (December 2021)

https://www.marineboard.eu/sites/marineboard.eu/files/public/publication/EMB_PP26_Marine_Geo_Hazards_v5_web.pdf

NATURAL HAZARDS MANAGMENT

Science needs to understand processes, triggers and precursors



1. Designate natural laboratories for marine geohazards
2. Promote a census of geohazard features in European seas
3. Integrate EU marine monitoring infrastructures
4. Promote innovative technologies to conceive and realize novel sensors and new methods
5. Data mining, virtual access and AI.

Advancing hazard mitigation for policy making and the Blue Economy

1. Increase awareness of marine geohazards among public authorities and communities
2. Address marine geohazards in administrative management rules
3. Require industrial technology to be available for marine geohazard research.
4. Model the potential impact of marine geohazards
5. Enhance scientific research on marine geohazards at all levels

The **hazard management process** consists of a number of activities carried out before, during, and after a hazardous event in order to reduce loss of life and destruction of property. **Best practises** are a set of guidelines, ethics, or ideas that represent the most efficient or prudent course of action in hazard managment

1. Pre-event Measures:

   a. Mitigation of Natural Hazards:

      - Data Collection and Analysis
      - Vulnerability Reduction

   b. Preparation for Natural Disasters:

      - Prediction
      - Emergency preparedness (including monitoring, alert, evacuation)
      - Education and Training

2. Measures During and Immediately after Natural Disasters:

   a. Rescue
   b. Relief

3. Post-disaster Measures

   a. Rehabilitation
   b. Reconstruction

The natural hazard management processes can be divided into:

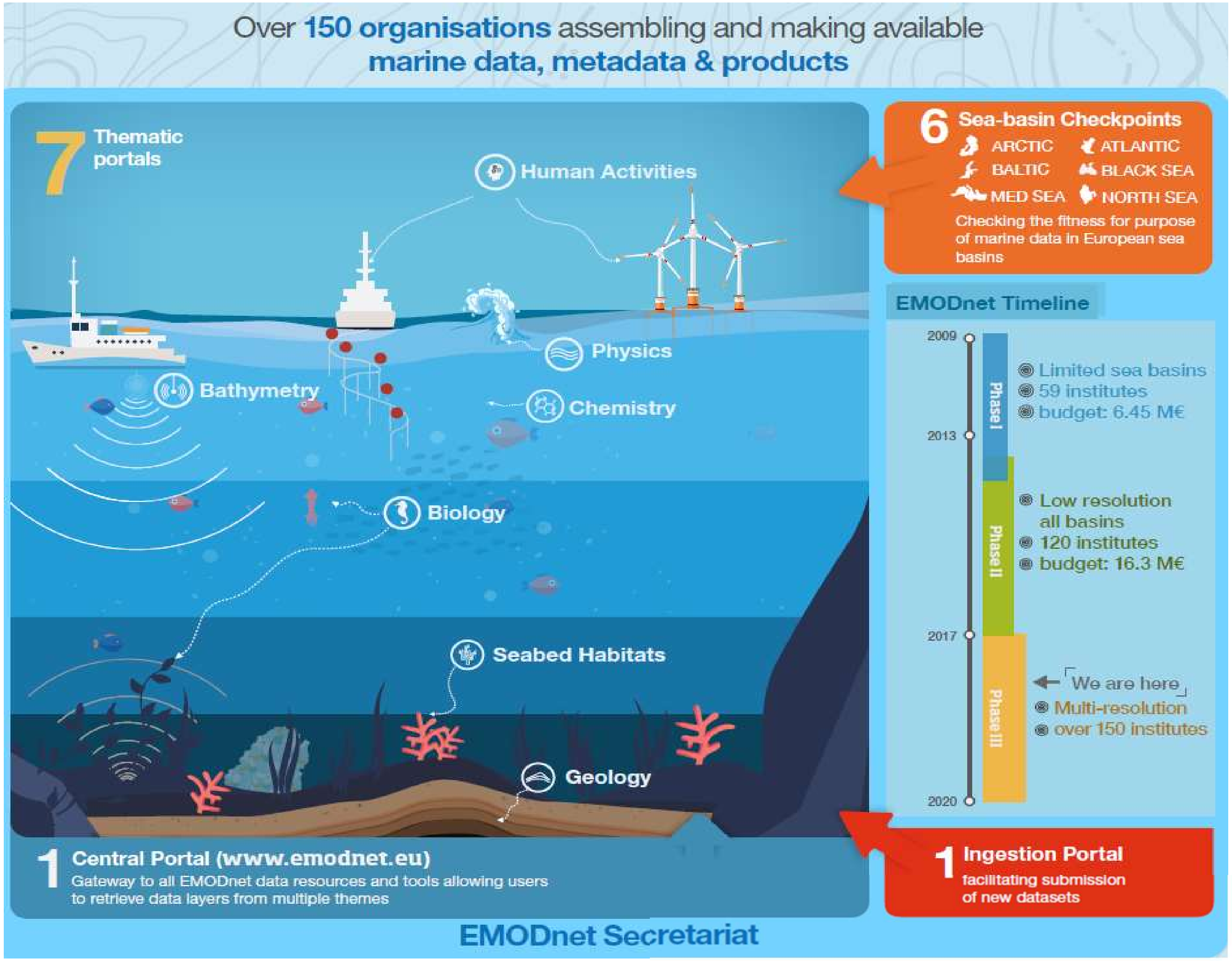
- **pre - event measures**,
- **actions during** and **immediately following an event**, and
- **post-disaster measures**.

OAS US regional forum for political discussion, policy analysis and decision-making

OAS More rights for more people

http://www.oas.org/en/

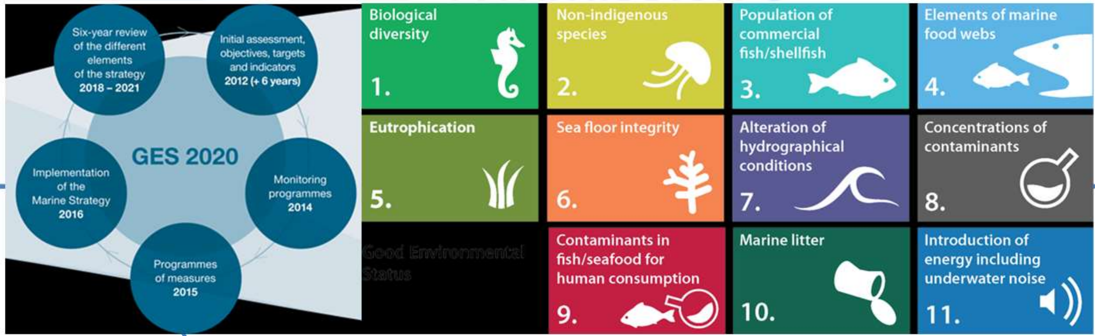
THE EUROPEAN MARINE OBSERVATION AND DATA NETWORK



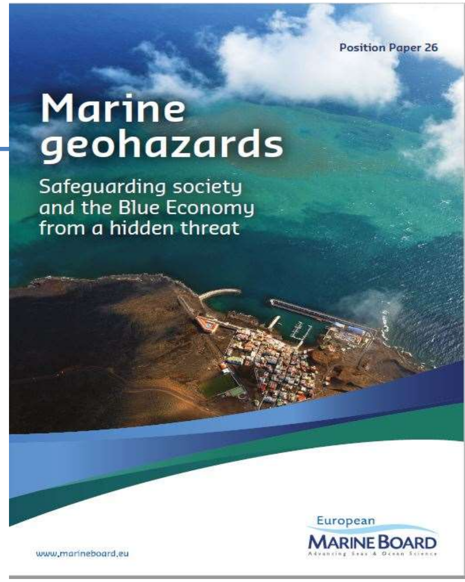
The **European Marine Observation and Data Network (EMODnet)** is a network of organisations supported by the EU's integrated maritime policy. These organisations work together to observe the sea, process the data according to international standards and make that information freely available as interoperable data layers and data products.

http://www.emodnet.eu/

European Commission



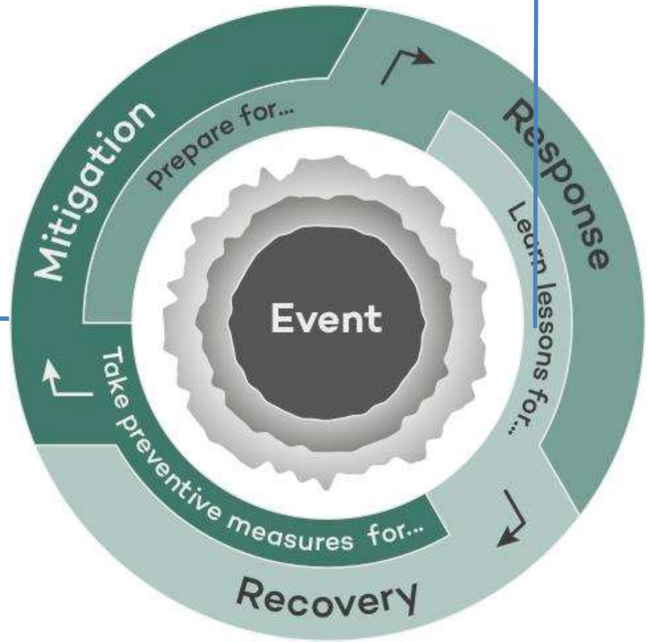
European MARINE BOARD
Advancing Seas & Ocean Science



https://www.marineboard.eu/new-position-paper-marine-geohazards

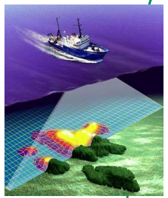
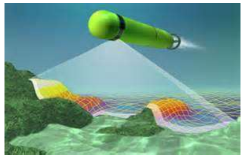
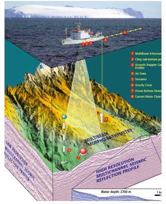
UNESCO
United Nations Educational, Scientific and Cultural Organization

2021 2030 United Nations Decade of Ocean Science for Sustainable Development



https://en.unesco.org/commemorations/disasterreductionday missing observations

80% OF THE SEABED IS STILL UNKNOWN

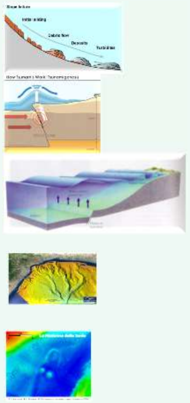




+ *ad hoc innovative methods*

GEOLOGICAL

KNOWLEDGE

Geohazard



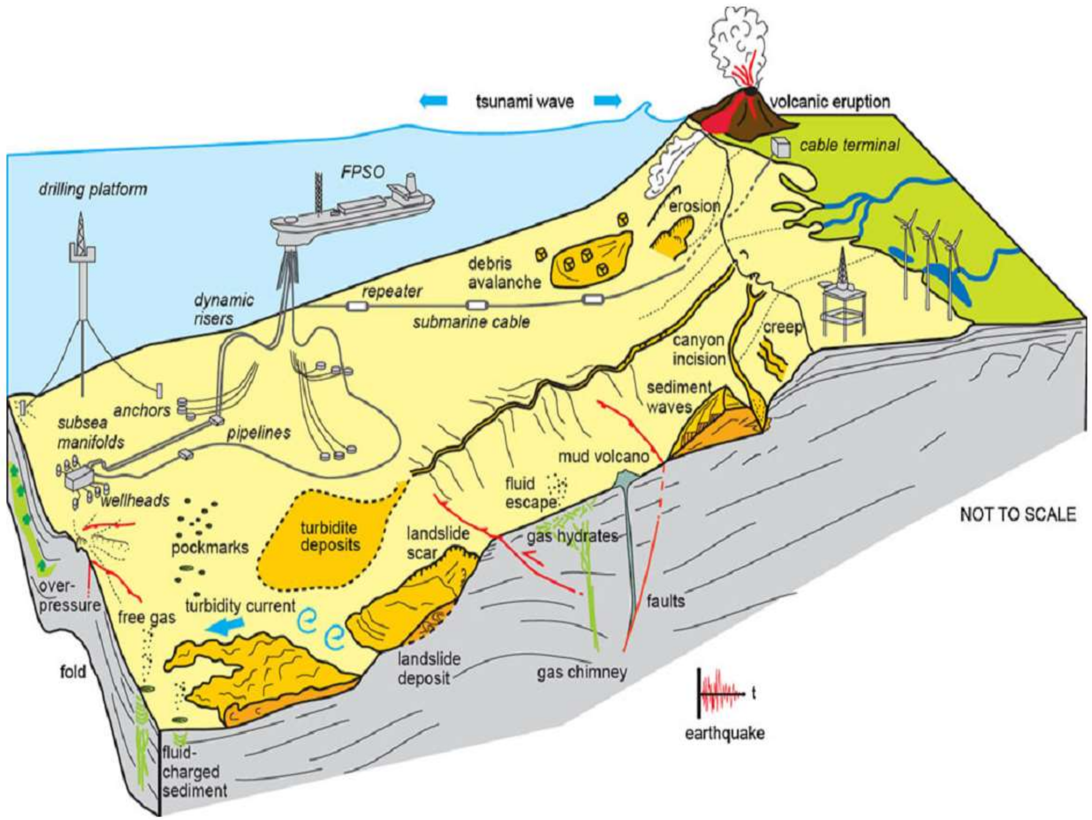
assessment

GeoHazard maps of the Mediterranean seabed

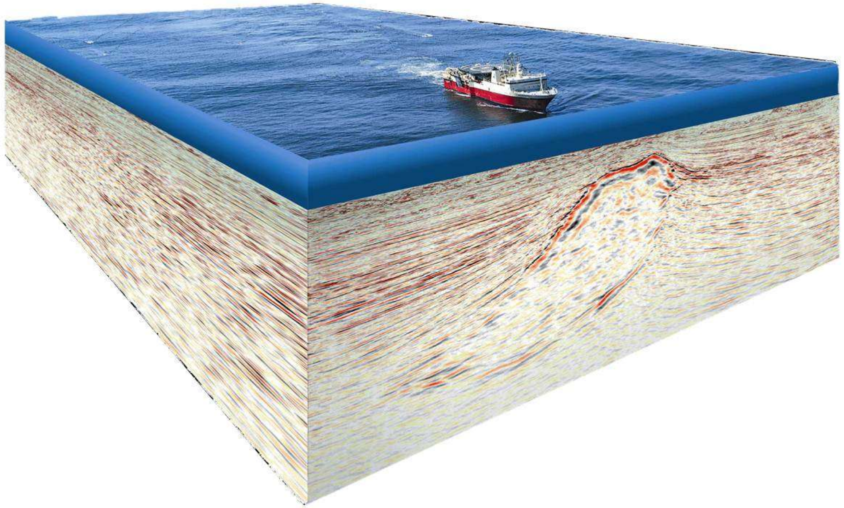
- set out strategy for hazard mitigation
- improve hazard crisis management
- increase general public awareness
- communicate geohazards to policy makers

Concluding…..

1) The submarine portion of continental margins can be 'disturbed' by ***natural geohazards: faults, landslides, retrogressive erosional canyons and fluid emissions...*** *Their activity at seafloor can damage humans and (costal and deep sea) infrastructures.*



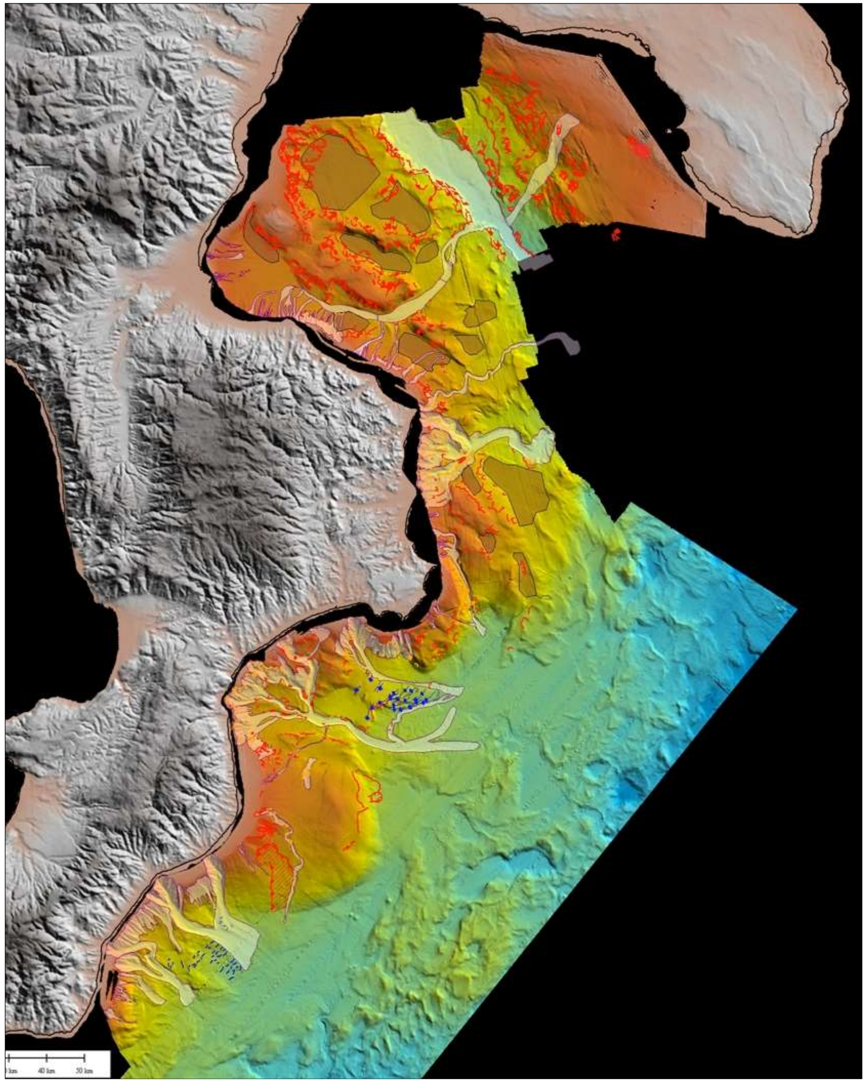
Concluding…..



2) Integrated ***marine geophysical methods (including robotics)*** *at different resolutions (up to cm) enable researchers to reach remote areas of our oceans and* ***identify marine geohazards***

Concluding.....

3) ***Marine geohazards assessment*** *is about identifying, mapping, and characterizing geohazards occurrence (their parameters and the processes that regulate their occurrence),*



4) ***Marine geohazard assessment*** *is a prerequisite to undertake successful risk managment and risk mitigation of coastal and deep sea areas*

Further reflections

- Assessment of submarine geohazards is of broad scientific and social importance notably in the densely populated Mediterranean region
- Seimogenic faults, failure, gas seepage, tsunami and their interaction (cascading effects)
- Understanding (mechanisms and locations) of the geohazards of our seabed: maps of geohazards of all European seas, eventually Mediterranean Sea
- Developing research/industry collaborative actions by means of the research vessels for sensitive infrastructures (nuclear power plant- submarine cable/pipelines)

Critical questions

1) What's the difference between hazard and risk?

2) Which are the most harmful marine geohazards in the Med in your opinion and why?

3) Why in the Med an alerting system could be not as efficient as in the Pacific ocean?

4) Why seabed mapping is important to assess marine geohazards?

Media and outreach

TWIST

TIDAL WAVE IN SOUTHERN

Salerno – 25 maggio 2013

Emergency exercise simulating a tsunami wave against the coast of Salerno, following a submarine failure along the volcano Palinuro

24 -25 -26 -27 October 2013

Croatia, France, Greece, Italy Malta, Portugal, Spain

Bibliography

Some books and papers on marine geohazards

- **Submarine geomorphology**. Ed. Springer, Editors: A. Micallef, S. Krastel A. Savini Ed. Springer
- **Submarine mass movements and their consequences**: international symposium (1st to 7th volume) . Springer Ed.
- **Regional-scale seafloor mapping** and geohazard assessment. The experience from the Italian project MaGIC (Marine Geohazards along the Italian Coasts)PrFL Chiocci, D Ridente - Marine Geophysical Research, 2011 – Springer-
- **Submarine mass-movements** in the Ionian Calabrian margin and their consequences for marine geohazards: S. Ceramicola, S., Praeg, D. Coste, M., Forlin, E. Colizza, F. Critelli, S. (2014).. In Submarine Mass Movements and Their Consequences, 6th International Symposium, Advances in Natural and Technological Hazards Research (Krastel et al., Eds); Springer Science + Business Media B.V. Ch. 26, pp. 295-306, doi:10.1007/978-3-319-00972-8_26.

- EMB PP26 Marine Geohazards – Safeguarding society and the Blue Economy from a hiodden threat

International projects on marine geohazards

SLATE: Projeect http://itn-slate.eu/project/

IGCP 640 S4Slide http://www.unesco.org/new/en/natural-sciences/environment/earth-sciences/international-geoscience-programme/igcp-projects/geohazards/project-640-new-2015/

Ackowledgments/Credits

- European Commission, Unesco, Department Civil Protection of Italy, Italian Ministry for the Research (MIUR)

Thank you for your attention…