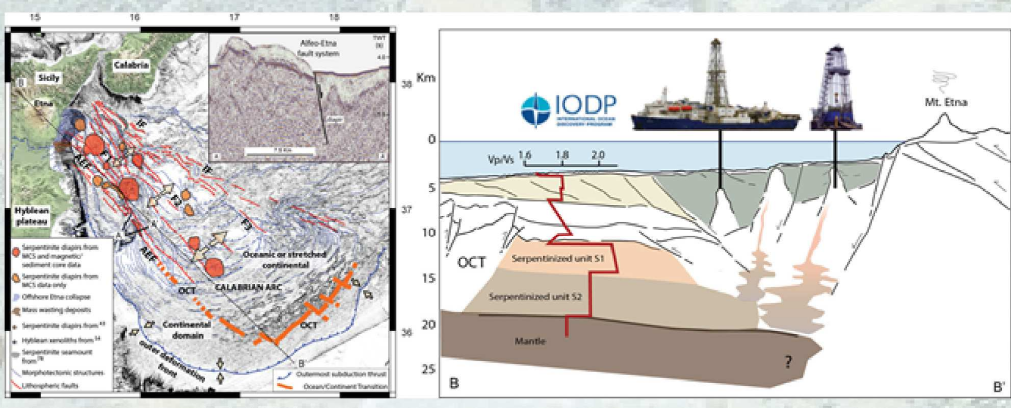
MagellanPlus Workshop

SCYLLA

Serpentinite diapirs in the **C**alabrian Subduction s**Y**stem return **L**ower plate mant**L**e from E**A**rth's oldest ocean

Bologna, September 21-23, 2022, Institute of Marine Sciences (CNR)



The SCYLLA workshop aims to discuss the rationale to submit an IODP proposal to drill and core underplated serpentinite diapirs in the Calabrian Arc subduction system (central Mediterranean Sea) derived directly from the oldest in situ ocean in the world. It tackles fundamental questions on the structure and nature of subducting slabs and their implications for material recycling, mantle evolution and seismogenesis in subduction zones. This workshop aims to involve a broad scientific community, ranging from sedimentologists, geophysicists, geochemists, volcanologists, and seismologists to microbiologists.

Gasperini L., Polonia A., National Research Council, Institute of Marine Sciences, Bologna, Italy, **Bonatti E.**, Lamont-Doherty Earth Observatory of Columbia University, Palisades, NY 10964, USA, **Hensen C.**, GEOMAR Helmholtz Centre for Ocean Research, Kiel, Germany, **Morgan J. P.,** Department of Ocean Science and Engineering, SUSTech, China, **Ruffine L.,** Unité des Géosciences Marines, IFREMER- Centre de Bretagne, Plouzané, France, **Vannucchi P.,** Department of Earth Sciences, University of Florence, Italy

WORKSHOP PURPOSES AND OUTCOMES

The SCYLLA MagellanPlus workshop was designed to discuss the rationale to submit an IODP proposal to drill and core underplated serpentinite diapirs in the Calabrian Arc subduction system (central Mediterranean Sea) derived directly from the oldest *in situ* ocean in the world. The proposal tackles fundamental questions on the structure and nature of subducting slabs and their implications for material recycling, mantle evolution and seismogenesis in subduction zones. The workshop involved a broad scientific community, ranging from sedimentologists, geophysicists, geochemists, seismologists to microbiologists.

The workshop was planned to discuss the 968_Pre SCYLLA IODP proposal submitted on October 2019, in the frame of other IODP initiatives in the Mediterranean region. Following SEP recommendations (January 2020), the workshop program was conceived to discuss among a multidisciplinary community the questions and concerns raised by SEP on the 968_Pre SCYLLA proposal. The proponents were, in fact, encouraged to pursue alternative strategies to investigate and ground truth the existence of serpentinites in the Ionian Sea prior to proposing a full drilling expedition. SEP recommended to discuss alternative strategies such as non-drilling approaches (e.g. coring, dredging) or a limited drilling operation (e.g. APL).

The information provided by Joides Resolution Facility Board Chair and the Science Manager of ECORD Science Operator were particularly fruitful to understand which of the alternative strategies can be pursued for SCYLLA. An APL cannot be scheduled while the JOIDES Resolution is in the North Atlantic and Mediterranean over the next few years, because the vessel's schedule is already set, and there is no way that more projects can be added to it.

The workshop successfully identified main synergic research lines that will be developed as Mission Specific Platform (MSP) proposals to be submitted in the near future.

Three options will be taken into consideration during proposal writing, depending on the total penetration needed to sample piercing features:

- 'Standard' MSP using a geotechnical vessel (if total pipe <3000m).
- Deep-water MSP using a deep-water drillship.
- Seafloor drill from a research vessel or hired vessel if track record may be limited up to 150-200 mbsf.

SCYLLA Magellan+ workshop hosted 31 scientists (4 remotely connected) proceeding from 7 Nations, that represented 18 Research Institutes and Universities, covering a wide range of expertise. The workshop working group particularly benefitted by the presence of a consistent group of Early Career Scientists that actively participated to the scientific discussion and the definition of the new proposals working hypothesis and objectives.

WORKSHOP FINANCIAL SUPPORT AND EXPENSES

COSTS	Total cost €
AGENCY: HT EVENTI E FORMAZIONE SRL: including	
PINSA SRL _Social Dinner (21 Sep, 18 people)	€ 693,00
JUSTCONVO SRLS _Social Dinner (22 Sep, 19 people)	€ 731,50
COMPASS GROUP ITALIA SPA_Coffee Break & Buffet (20-21-22 Sep, 30 people)	€ 2.775,30
TRAVEL (Fly, Train, Taxi)	€ 3.308,22
AMB SRL_ Accomodation (20-21-22 Sep.)	€ 2.428,00
HT EVENT AGENCY FEE	€ 1.500,00
CNR CONFERENCE ROOM (21-22-23 Sep, 2 Rooms)	€ 425,00

TOTAL	**€ 11.861,02**
VAT	**€ 2.011,95**
TOTAL WITH VAT	**€ 13.872,97**

icdp

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Consiglio Nazionale delle Ricerche
Area Territoriale di Ricerca di Bologna

CNR ISMAR ISTITUTO DI SCIENZE MARINE

CNR-ISMAR Bologna (Italy)
September 21-23, 2022
https://area-new.bo.cnr.it/en/

LIST OF PARTICIPANTS

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Mediterranean paleoceanography, geodynamics, seismology and modelling					
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Microbial activity by deep subseafloor serpentinization					
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Available data, site survey, IODP projects					
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*: Remotely connected

^: Early career scientists

WORKSHOP PROGRAM

Day 1- Wednesday, September 21, 2022 - (*remotely connected)

12:00-14:00 Icebreaker and lunch

14:00-14:30 **Gasperini** L.	Welcome, introduction, IODP Pre-proposal P968 and workshop goals

Session 1	**The Ionian subduction system: geodynamic and tectonic background to address SEP criticism on the SCYLLA pre-proposal**

14:30-14:50 **Polonia A.**	Do Calabrian Arc diapirs return lower plate mantle from the oldest ocean on Earth?
14:50-15:10 **Muttoni G.**	Adria in Mediterranean paleogeography, the origin of the Ionian Sea, and Permo-Triassic configurations of Pangea
15:10-15:30 **Dannowski** A.	Deep structure of the Calabrian Arc from wide-angle seismic data and gravity
15:30-16:00	DISCUSSION

16.00-16:30 Coffee break

Session 2	**Geodynamic context and Mesozoic paleoceanography: implications of serpentine occurrence in the Mediterranean region and how these can be incorporated in the new pre-proposal**

16:30-16:50 **Vannucchi P.**	How serpentine peridotites can leak through subduction channels
16:50-17:10 **Ranero C.**	The Tectonic structure of the Calabria Arc system
17:10-17:30 **Govers R.**	A Probabilistic Assessment of the Causes of Active Deformation in the East Central Mediterranean Using Spherical Finite Element Models
17:30-17:50 **Chiarabba** C.	Fluids in geodynamics and seismogenic processes defined by tomograms
17:50 -18:30	DISCUSSION

20:00 Dinner at restaurant 2 CUOCHI, Via Giovanni Francesco Barbieri, n.56

Day-2 Thursday, September 22, 2022

Session 3	**Mantle peridotites from continental rifts to ocean basins to subduction. What the Ionian Sea serpentinites can tell us about the oldest in situ ocean on Earth?**

09:00-09:20 **Bonatti E.**	Mantle ultramafics in the oceanic lithosphere
09:20-09:40 **Menapace W.**	Origin and implications of serpentinite mud volcanism in the Mariana subduction zone
09:40-10:00 **Zitellini N.**	IODP Expedition 402: The Tyrrhenian Magmatism & Mantle Exhumation (TIME)
10:00-10:20 **Favali P.**	Long-term monitoring by fixed-point seafloor observatory contribution to the knowledge of the Ionian Sea geodynamics
10:20 -10:40	DISCUSSION

10:40-11:00 – Coffee break

Session 4	**The proxies we need: stratigraphic, geochemical and microbial signature of serpentinite/mud diapirism.**

11:00-11:20 **Boschi C.**	Fluid geochemistry and seismicity: What can we learn from our investigations along the North Anatolian Fault and the North Alfeo Fault?
11:20-11:40 **Hensen C. ***	Fluid geochemistry in marine sedimentary environments
11:40-12:00 **Bastianoni A.**	Subsurface microbial life and serpentinization: opportunities and open questions
12:00-12:20 **Erba E.**	Preliminary results of calcareous nannofossil investigation of sediment cores from the Calabrian Arc diapiric field.
12:20 -13:00	DISCUSSION

13:00-14:30 Lunch

Session 5	**Sampling the diapirs: testing the different hypothesis through drilling/coring. Drilling strategies under the present-day Scientific Ocean Drilling project**

14:30-14:50 **Polonia A.**	IODP Pre-proposal P968 – description and review results
14:50-15:10 **Camerlenghi A.**	Future perspectives of Scientific Ocean Drilling
15:10 -16:30	DISCUSSION

16.30-17:00 Coffee break

Session 6	**Scientific questions and aims/objectives for drilling; what drill sites are necessary to achieve proposal goals**

17:00-18:30	**Working group breakout**
	Group-1: Geodynamics, tectonics, seismology
	Group-2: Stratigraphy, geochemistry and microbiology
	Draft writing of Proposal

20:00 Dinner at restaurant NINO, Via Volturno, 9c

Day-3 Friday, September 23, 2022	

09:00-09:20 **Vitale Brovarone A.**	DeepSeep: an ERC-funded project to assess deep energy formation in subduction zone serpentinites

Session 7	**What is needed for writing a new drilling proposal? Site selection, site survey, drilling/coring.**

09:20-10:40	**Working group breakout**
	Group-1: Geodynamics, tectonics, seismology
	Group-2: Stratigraphy, geochemistry and microbiology
	Draft writing of Proposal

10:40-11:00 Coffee break

Session 8	**Workshop report: presentation of contributions, synthesis of open questions, distribution of tasks for proposal writing and definition of deadlines for proposal submission.**

11:00-11:20 **Gasperini L.**	Summary of Group-1
11:20-11:40 **Schmidt C.**	Summary of Group-2
11:00-13:30	FINAL DISCUSSION

13:30-14:30 Lunch

ABSTARCTS

Wednesday 21st September

MAGELLANPLUS WORKSHOP SERIES PROGRAM SCYLLA: INTRODUCTION AND GOALS

Gasperini L., Polonia A., Bonatti E., Hensen C., Morgan J., Vannucchi P., Ruffine L.

The SCYLLA workshop aims to discuss the rationale to submit an IODP proposal to sample underplated serpentinite diapirs in the Calabrian Arc subduction system (central Mediterranean Sea) derived directly from the oldest *in situ* ocean in the world.
To date, the presence of serpentinite in the Ionian Sea diapirs has been mainly inferred by indirect methods, such as seismic reflection images, quantitative modelling of potential field data, and observation of high Vp/Vs values. All mapped diapirs terminate too deep within the sediments of the overlying accretionary prism to be sampled with conventional piston-coring. This is the leading scientific motivation for the drilling project.
The workshop tackles fundamental questions on structure and nature of subducting slabs and their implications for material recycling, mantle evolution, and seismogenesis in subduction zones. This workshop aims to involve a broad scientific community including sedimentologists, geophysicists, geochemists, volcanologists, seismologists, and microbiologists. We will address how this ocean drilling can advance our knowledge of the Calabrian arc and forearc, and the styles and modes of potential seismogenesis in this 3D subduction system that is one of the most hazardous seismic environments worldwide.

DO CALABRIAN ARC DIAPIRS RETURN LOWER PLATE MANTLE FROM THE OLDEST OCEAN ON EARTH?

Polonia A., Torelli L., Gasperini L., Cocchi L., Muccini F., Bonatti E., Hensen C., Schmidt M., Artoni A.

Mantle-derived serpentinites have been detected at magma-poor rifted margins and above subduction zones, where they are usually produced by fluids released from the slab to the mantle wedge. Geophysical data in the external subduction system of the Calabrian Arc, show diapiric features rising through lithospheric faults caused by incipient rifting and the collapse of the accretionary wedge. Rising material in subduction complexes might be ascribed to different processes and we attempted to discriminate between these processes using magnetic and gravity field data, sediment samples and seismic data. Gravity/magnetic modelling best fit was obtained considering the intrusions as serpentine diapirs in agreement with the presence in the Ionian upper mantle of two layers with high seismic P-wave velocity, low S-wave velocity and high Vp/Vs values, interpreted as partly serpentinized peridotites. Mantle-derived diapirism is not linked directly to subduction processes. The serpentinites formed probably during Mesozoic Tethyan rifting and then were transferred from rifting to basin floor to subduction were they give rise to large-scale diapirism, enhancing shear processes and margin disruption during the final closure of the ocean.

These findings may lead towards a more complete understanding of the structure of the Ionian lithosphere and of the role of serpentinization in driving neotectonics. All mapped diapirs terminate too deep within the sediments of the overlying accretionary prism to be sampled with conventional piston-coring. Drilling, down-hole measurements, and sampling will be planned to clarify the nature and composition of the diapirs, and to reconstruct the mechanisms leading to their recent (incipient?) ascent.

ADRIA IN MEDITERRANEAN PALEOGEOGRAPHY, THE ORIGIN OF THE IONIAN SEA, AND PERMO-TRIASSIC CONFIGURATIONS OF PANGEA

Channell J. E. T., Muttoni G., Kent D. V.

The African affinity of the deformed Mesozoic continental margins surrounding the Adriatic Sea (a region known as Adria) was recognized in the 1920s. However, over the last several decades, the majority view of Mediter- ranean Mesozoic paleogeography has featured an ocean (Mesogea) that separated Adria and Africa in Mesozoic and early Cenozoic time. The presence of a Mesogea ocean has become an argument against the use of paleo- magnetic data from Adria as a proxy for Africa, which has been central to the controversy surrounding alter- native Permian configurations of Pangea (Pangea A or B). The rationale for Mesogea has been derived from the perceived need for oceanic lithosphere to feed Miocene to Recent subduction beneath the Tyrrhenian and Aegean seas, the apparent presence of Early Jurassic oceanic basement beneath the present-day Ionian Sea, and the presence of deep-water Permian and younger sedimentary rocks in Sicily. On the other hand, the presence of Mesogea is incompatible with the apparent continuity of Mesozoic sedimentary facies from North Africa and Sicily into Adria, and with increasingly well-documented consistency of paleomagnetic data from Adria and NW Africa.

We propose, rather than an early Mesozoic (Mesogea) ocean between Adria and Africa, a sinistral strike-slip fault system linked Atlantic spreading in the West to the Neo-Tethys in the East, during the Middle and Late Jurassic, and featured pull-apart basins that included the Ionian and Levant basins of the eastern Medi- terranean. In our modelling, Adria moved with Iberia during initial opening of the Central Atlantic in the Early and Middle Jurassic (after 203 Ma until 170 Ma). From mid-Jurassic time (170 Ma), Adria began to break away from Iberia with onset of rifting in the Piemonte-Ligurian Ocean, and, as the rate of southeasterly motion of Adria relative to North America lagged that of Africa, the Ionian-Levant basins formed as pull-apart basins along a sinistral strike-slip fault system parallel to a small circle about the 170–154 Ma Euler stage pole for motion of Africa relative to Adria. From marine magnetic anomaly M25 time (154 Ma), Adria moved in synch with Africa and therefore pull-apart extension in the eastern Mediterranean came to a halt.

DEEP STRUCTURE OF THE CALABRIAN ARC FROM WIDE-ANGLE SEISMIC DATA AND GRAVITY

Dannowski A., Klingelhöfer F., Kopp H., Dellong D., Gutscher M.A.

The Calabrian Arc is one of the narrowest subduction systems on Earth. Here, the remnant Tethyan oceanic lithosphere of the African plate subducts beneath Eurasia. Imaging the boundary between the downgoing slab and the upper plate along the Calabrian subduction zone is important for assessing the potential to generate megathrust earthquakes. Also, the nature of the Ionian Sea crust has been subject of scientific debate for a long time. We present 3 wide-angle seismic profiles spanning the complete subduction system, from the deep Ionian Basin and the accretionary wedge to northeast Sicily and the Malta Escarpment. The results of the seismic modelling were additionally constraint by 2D and 3D gravity modelling. The resulting velocity models document thin oceanic crust throughout the basin and therefore support the interpretation of the Ionian Abyssal Plain as a remnant of the Tethys lithosphere with the Malta Escarpment as a transform margin and a Tethys opening in the NNW–SSE direction. The slab dip of the subducting plate increases abruptly from 2–3° to 60–70° over a distance of ≤50 km underneath the Calabrian backstop and is likely related to the rollback geodynamic evolution of the narrow Calabrian slab.

Thursday 22nd September – morning session

HOW SERPENTINE PERIDOTITES CAN LEAK THROUGH SUBDUCTION CHANNELS

Vannucchi P., Morgan J. P., Polonia A., Molli G.

Serpentinized peridotites are weaker than other mantle rocks, with an internal friction coefficient μ_i~0.3 vs. ~0.6. Therefore they often promote strain localization. Serpentinite is also considerably lower in density (ρ=2.5-2.6 g/cm^3) than most rocks. In the presence of denser material, its buoyancy can mobilize upwelling masses and aid exhumation. Serpentinized peridotites can therefore influence the evolution of tectonic plate boundaries: their presence enhances shear processes, serpentinite-hosted faults can evolve into zones of permanent lithospheric weakness that can be reactivated during different tectonic phases, and control continental break-up, transform fault processes and subduction styles. Fault reactivation also provides paths for fluid infiltration and upward remobilization of serpentinized peridotites that can also interact diapirically with overlying rocks.

We have compiled observations that document the near-surface journey of serpentinized peridotites that are exhumed during rifting and continental break-up, reactivated as buoyant material during subduction, and ultimately emplaced as 'ophiolite-like' fragments within orogenic belts. This lifecycle is particularly well documented in former Tethys margins from the fragment that now subducts beneath the Calabrian Arc to those potentially preserved in the Northern Apennines. Transfer of serpentinized peridotites from the mantle lithosphere of the subducting slab to the overriding plate motivates the concept of a potentially "leaky" subduction channel. In addition to passing vertically through a shallow subduction channel, weak serpentine bodies may also rise into and preferentially migrate within the intraplate shear zone, leading to strong lateral heterogeneities in its composition, mechanical strength and seismic characteristics. Finally, as the movements of fluids through serpentinites are typically associated with extensive carbonation, the generation and subsequent migration of serpentinites may also be linked to significant carbon storage and transport within the subduction system.

THE TECTONIC STRUCTURE OF THE CALABRIA ARC SYSTEM

Ranero C.R., Sallares V., Prada M., Zitellini N., Grevemeyer I.

We will review the marine wide-angle seismic data and streamer seismic data collected across the Arc - Backarc of the Tyrrhenian Basin and in the Foreac in the Ionian contractional prism, both of them part of the Calabrian Arc System.
Seven wide-angle seismic profiles and numerous streamer lines cross the Tyrrhenian Basin which means that it is one of the best studied Backarc basins of the world. The seismic data were carefully located to cross the main tectonic units inferred from the high-resolution multi beam bathymetry map of the basin. The data show a complex opening history where continental rifting was followed by abundant back-arc magmatism. However, the latest opening stage was accomplished by mantle exhumation across a 100 km wide swath. These events of magmatic break up and subsequent mantle exhumation are at odds with classical models of continental rifting. Mantle exhumation may have been formed by large-scale formation of core-complex type of detachment faults. This region will be the lock of drilling in early 2024.

One of the wide-angle seismic lines and a coincident streamer profile extends further across the Calabrian tectonic arc and crosses much of the Ionian prim. An additional grid of streamer liens displays well the tectonic structure of the contractional prism. The seismic images display pronounced tectonic changes across the system from a western to an eastern domain. The western domain of the contractional prism is characterised by limited deep deformation and most lines display shallow deformation, fundamentally concentrated in the upper sediment section dominated by evaporites and terrigenous Plio-Quaternary turbidites. The eastern Domain displays a fundamentally different tectonic pattern, dominated by thick-skin tectonic that involved the entire sediment section and upper plate basement. We interpret the tectonic structure in terms of differences in the along strike subduction system.

A PROBABILISTIC ASSESSMENT OF THE CAUSES OF ACTIVE DEFORMATION IN THE EAST CENTRAL MEDITERRANEAN USING SPHERICAL FINITE ELEMENT MODELS

Govers R.

Active deformation is well constrained by GNSS observations in the SW Balkans, Greece and W Turkey, and is characterized by variable extension and strike slip in an overall context of slow convergence of the Nubia plate relative to stable Eurasia. Diverse, and all potentially viable, forces have been proposed as the cause of the observed surface deformation, e.g., asthenospheric flow, horizontal gravitational stresses from lateral variations in gravitational potential energy, and rollback of the Hellenic slab. We use Bayesian inference to constrain the relative contribution of the proposed driving and resistive regional forces in spherical 2D finite element models with discrete plate boundaries and regional faults. The average viscosity of the overriding plate is well resolved 3-4 10^22 Pa.s, which is higher than published models without faults. Significant trench suction forces from the Hellenic slab act on the overriding Aegean Sea, including along the Pliny-Strabo STEP Fault. Slab pull and convective tractions have little imprint on the observed deformation of the overriding plate. Horizontal gravitational stresses are necessary to explain local features in the velocity field, particularly in the Aegean Sea, but are less important for fitting the regional pattern of velocities. Resistive tractions on most plate boundaries and faults are low. The best-fitting models compare well with paleomagnetic rotations and geological fault slip rates from previous studies.

FLUIDS IN GEODYNAMICS AND SEISMOGENIC PROCESSES DEFINED BY TOMOGRAMS

Chiarabba C.

Regional to local scale seismic tomography revealed heterogeneities in the lithosphere that control tectonic processes. We focus here on two main aspects: the role of fluids at different scales and the rheology of faults. First, we show that fluids drive tectonic processes from the long-term geodynamic scale to the short-term scale of singular earthquakes. We document examples of fluids-assisted processes that span from the subduction of the Ionian-Apennines system to the genesis of magma in the peri-Tyrrhenian area, to the Apennines extension, and seismogenesis of normal faulting earthquakes. The imaging of deep fluids at the base of the extensional fault system in the Apennines yield new vision on possible triggering mechanisms of large earthquakes. Significant changes in velocities defined by time-lapse imaging on faults revealed rapid fluid migration through the locked fault zone, leading to the catastrophic coseismic breaching of the fault seal. Then, we show that fault zones are objects where velocity heterogeneities play a crucial role in the evolution of instabilities like earthquakes. Low poisson ratio, high-Vs bodies represent high-strength barrier responsible for complexities during the rupture propagation. Such high velocity bodies are documented for the Apennines upper-middle crust and related to anomalies in the basement and the eventual presence of serpentinites.

MANTLE ULTRAMAFICS IN THE OCEANIC LITHOSPHERE

Bonatti E., Ligi M.

We will start with a brief account of when and where mantle-derived peridotites-serpentinites were first recovered from the ocean floor. We were in the decade 1960-1970, the years of the plate tectonics "revolution". The search for mantle peridotites in the oceans was stimulated by the ideas of Harry Hess. They were first recovered within the large fracture zones offsetting the equatorial mid Atlantic Ridge; then later at sites in the Mid Atlantic and Indian slow-spreading ridges. Mantle peridotites were found also in "pre-oceanic" areas, along the margins of the Atlantic, and in the Red Sea., as well as in subduction-related western Pacific trenches.
Going from pre-oceanic to oceanic to subduction-related ultramafics, the degree of melting undergone by the peridotites increases significantly. A spectacular 300 km long sliver of oceanic lithosphere, including basal mantle peridotites, is exposed along the Vema transform in the Atlantic. It represents 25 million years of generation of lithosphere at the Mid Atlantic Ridge axis. This exposure allows detection of temporal variations of thermal properties of the upwelling sub- ridge mantle; it also shows that serpentinization occurs mostly close to zero-age ridge axis.

ORIGIN AND IMPLICATIONS OF SERPENTINITE MUD VOLCANISM IN THE MARIANA SUBDUCTION ZONE

Menapace W.

Mud volcanoes are expulsion features ubiquitously present in subduction zones, whose fluid and solid products can be traced at kilometers depths in the seafloor, close or at subducting plate interface. On the brink of the Mariana Trench, in the western North Pacific, more than 20 mud volcanoes exist, with unique characteristics: they are the biggest such structures in the world and the only ones composed mainly of blue serpentine mud and peridotite clasts.

Hydration of the mantle wedge (with consequent serpentinization) is driving the Marianas mud volcanoes, while the highly fractured nature of the forearc and the thermal state of the subducting plate set the perfect condition for the ascent of the buoyant serpentinite mud towards the surface. The mud volcanoes can therefore be used as “natural boreholes” to trace the fluid-rock interactions in the Philippine and Pacific plates as the subducting slab’s angle steepens. The extrusive products foster complex biological communities, with extremophiles organisms feeding on the high-pH slab fluids. The microbial communities are also sustained by the abiotically-produced methane, originating from the hydrogen released from the serpentinization process.

Since the IODP 366 in 2016, renewed interest has sparked on the study of these features and their link with subduction zone earthquakes, elements cycles and the origin of life, driving new lines of investigations and marine expeditions [SO292/2 (2022), Mariana CORK-Lite (2022)], aiming at monitoring such geo-biological processes in situ.

IODP EXPEDITION 402: THE TYRRHENIAN MAGMATISM & MANTLE EXHUMATION (TIME)

Zitellini N., Ranero C. R., Garrido C. J., Brunelli D., Sallares V., Grevemeyer I., Prada M., Raffi I., Ligi M., Tinivella U., Cannat M., Perez-Gussinyé M., Barckhausen U., Morishita T., MacLeod C., Minshull T., Andreani M., Malinverno A., Lugli S., Loreto M. F.

IODP Expedition 402 will take place on the Tyrrhenian Basin on 9 February - 8 April 2024 and it is the outcome of the IODP proposal 927-Add3 “Tyrrhenian Magmatism & Mantle Exhumation” (TIME). Expedition 402 aims at studying the time and space evolution of a continent-ocean transition (COT), from breakup to robust magmatism and subsequent mantle exhumation with closely time-related magmatism. The Tyrrhenian basin is the youngest basin of the Western Mediterranean, with formation initiating in the late Miocene. Recent geophysical and seismic data support the presence of magmatic rocks formed during the early COT phase, and of presumably subsequently exhumed mantle. The youth of the basin results in a modest sediment cover, facilitating sampling, with unprecedented spatial resolution, the peridotitic and magmatic basement across the conjugated COT of the basin. The drilling program of Expedition 402 is designed to target six sites along a west-east and north-south transect. Drill cores will recover peridotitic basement at each site, followed by downhole logging. The recovered material and data will address the five primary scientific objectives: (1) Determine the kinematics and geometry in space and time of the extensional deformation in the basin. (2) Establish the timing and origin of the associated magmatism. (3) Establish the rheology, deformation patterns and timing of mantle exhumation. (4) Determine the compositional evolution and heterogeneity of the mantle source.

LONG-TERM MONITORING BY FIXED-POINT SEAFLOOR OBSERVATORY CONTRIBUTION TO THE KNOWLEDGE OF THE IONIAN SEA GEODYNAMICS

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The seafloor observatory NEMO-SN1 is located in the Western Ionian Sea off Eastern Sicily, Italy, and it was the 1st real-time multiparameter observatory operating in Europe in cabled configuration since 2005. NEMO-SN1 is a fully integrated system for multidisciplinary deep-sea science, which includes the real-time acquisition and distribution of data to the scientific community and to the general public. It is one the Regional Facilities of the European Research Infrastructure EMSO ERIC. Its technical configuration is under enhancement thanks to the project PON-InSea and to the funds of the PNRR. The data collected by this seafloor observatory are significantly contributing to the knowledge of the Ionian Sea geodynamics. In fact, it contributes to a new insight of the offshore seismicity, to a new perspective on the monitoring of the Mt. Etna volcanic eruptions, and - finally - to collect clues of non-earthquake phenomena. Examples are presented to contribute to the discussion.

IODP EXPEDITION 357: Atlantis Massif Serpentinization and Life

Boschi C. & the IODP Expedition 357 Science Party

The Atlantis Massif (AM), located at 30°N at the inside corner of the eastern intersection of the Mid-Atlantic Ridge with the 75 km, left-laterally slipping Atlantis Transform Fault (ATF), is a 1.5–2 my-old gabbro and peridotite massif that is interpreted as an oceanic core complex. This fault bounded, dome-like massif is 15–20 km across and is part of a 25-km-long, morphologically continuous ridge that defines the western side of the median valley of the MAR. The Lost City Vent Field (LCVF) lies on a terrace at the top of the AM southern ridge and hosts numerous active and inactive carbonate-brucite chimneys that tower up to 60 m above the seafloor. LCVF was discovered in 2000 during the MARVEL cruise and it is the first documented off-axis hydrothermal vent site in the oceanic crust. It is distinctly different from typical mid-ocean ridge black-smoker vents in terms of its vent composition, fluid chemistry, and biology. Expedition 357 “Atlantis Massif Serpentinization and Life” was the first Mission Specific Platform (MSP) expedition implemented by the ECORD Science Operator (ESO) in the current phase of the International Ocean Discovery Program (IODP). An east-west transect across the southern wall of the Atlantis Massif was cored to study the links between serpentinization processes and microbial activity in the shallow subsurface of highly altered ultramafic and mafic sequences that have been uplifted to the seafloor along a major detachment fault zone. Seventeen holes were drilled at nine sites across the Atlantis Massif, recovering more than 57 m of core, with borehole penetration ranging from 1.3 to 16.4 meters below seafloor and core recoveries as high as 75% of total penetration. The cores show a highly heterogeneous lateral and vertical distribution of ultramafic, mafic, and sedimentary rocks with a wide range of alteration styles and extensive alteration and deformation. Of the core recovered from six sites across the southern wall (from west to east: M0071, M0072, M0069, M0076, M0068, M0075), serpentinized ultramafic rocks are predominant (44% by length of core). Other major rock types include basaltic rocks and metadolerites (combined 24%) and schistose metasomatic rocks with varying proportions of talc, amphibole and chlorite (11%). Minor lithologies include calcareous sedimentary units (8%) and gabbroic rocks (4%). The rock types, textural characteristics and proportion of gabbroic rocks recovered during Expedition 357 are distinctly different from the 1400 m-long core of gabbroic rocks recovered during IODP Expedition 304/305 at the central dome of the Atlantis Massif. The ultramafic rocks are dominated by harzburgites punctuated by intervals of dunite and minor pyroxenite veins; gabbroic rocks occur locally as zones of melt impregnation and veins, all of which provide information about multiple magmatic processes and evolution in the southernmost portion of the Atlantis Massif. On-going geochemical studies aim to provide a detailed description of these drilled rock sequences to estimate the conditions of alteration and their scales of heterogeneity during the detachment faulting at the slow-spreading ridges.

FLUID GEOCHEMISTRY IN MARINE SEDIMENTARY ENVIRONMENTS

Hensen C., Schmidt C.

Submarine mud volcanoes and cold seeps represent important geochemical pathways along which volatiles and mobile elements are recycled from deeply buried sediments into the ocean. Clay mineral transformation and other types of dehydration reactions are major fluid forming processes at many deep-rooted seep locations, specifically along continental margins. Typically, a large number of other diagenetic processes such as the leaching of evaporites, tapping of buried brines, precipitation and recrystallization of minerals, weathering, hydrocarbon formation, etc. alter the fluid composition and may be deciphered by the thorough analysis of element and isotopic anomalies. In specific settings, even the interaction with the underlying oceanic crust or the occurrence of mantle serpentinization could be demonstrated. In this presentation we will provide a general overview on the interpretation of the geochemical composition obtained from deep-rooted seep-fluids with a particular focus on geochemical signals affected by serpentinization.

SUBSURFACE MICROBIAL LIFE AND SERPENTINIZATION: OPPORTUNITIES AND OPEN QUESTIONS

Bastianoni A., Cordone A., Giovannelli D.

Microbial life living in the Earth's crust is sustained by mineral-mediated chemical reactions that provide usable energy resources in the form of redox disequilibria. Although serpentinization creates a suite of very challenging conditions for life to sustain itself (pH>10, low concentrations of C, Na + and H +), it also provides abundant reductant species like H 2 and CH 4 and small chain organic acids (SCOAs) that can be used by microbes for growth. This makes serpentinization one of the geological processes potentially sustaining large portions of the subsurface biomass and potentially a way to sustain life elsewhere in the solar system. A large amount of work has been focused in defining the diversity of microbial life in deep subsurface serpentinizing systems, both marine and terrestrial . However, most of the more intense geochemical and microbiological analyses have been carried out in serpentinizing fluids sampled at the surface. Additionally, since most of the microorganisms thriving in serpentinizing environments have yet to be cultivated, scenarios describing the influences and linkages between geochemical parameters, microbial community structure and genetic makeup remain largely uncharacterized, especially at depth. In this presentation, I will review some of the main findings linking microbial diversity to serpentinization processes to date, highlighting the questions that still need answers, and how the study of the Calabrian Arc Serpentinite Diapirs could fit into these.

PRELIMINARY RESULTS OF CALCAREOUS NANNOFOSSIL INVESTIGATION OF SEDIMENT CORES FROM THE CALABRIAN ARC DIAPIRIC FIELD.

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We analyzed the calcareous nannofossil assemblages of selected samples from two cores collected on top of two diapiric features intruding the Calabrian Arc subduction complex with the aim of achieving the sediment age as well as the stratigraphic range of reworking. All samples contain abundance and well preserved nannofossils that indicate a Pleistocene age. More specifically one core is dated between 0.58 and 0.96 Ma, with possibly an older age (0.96 – 1,24 Ma) at the base.
A hiatus was identified in the second core: the top sample is latest Pleistocene in age (0.26 - 0.46 Ma) while the section below is dated as early Pleistocene (older than 1.6 Ma).
In all samples there are frequent to common reworked specimens from both the Cenozoic and Mesozoic. Specifically, Neogene, Miocene, Oligocene, Eocene nannofossils are present along with variable amounts of Cretaceous, mainly Campanian-Santonian specimens. The Cenozoic reworking is essentially the same commonly found in deep-sea Mediterranean sediments. On the contrary, Cretaceous nannofossils are not usually found in Pleistocene sediments cored in the Mediterranean. It is important to note that two samples contain Hauterivian (Early Cretaceous) nannofossils with a poor state of preservation contrary to the other Cretaceous specimens which are generally well preserved. Such a peculiar finding might suggest a deep provenance and further data might discriminate between a source area from the upper or lower plate.

Thursday 22nd September – afternoon session

IODP PROPOSAL 968-PRE: SERPENTINITE DIAPIRS IN THE CALABRIAN SUBDUCTION SYSTEM RETURN LOWER PLATE MANTLE FROM EARTH'S OLDEST OCEAN (SCYLLA)

Polonia A., Gasperini L., Asioli A., Bonatti E., Hensen C., Lever M., Morgan J., Vannucchi P., Ruffine L.

The Calabrian Arc is the only place on Earth where mantle rooted diapirs in the external subduction complex might derive from the lower plate. This process is driven by arc orthogonal rifting, the collapse of the accretionary wedge, and deep fragmentation of the subduction system driven by pre-existing Mesozoic transform faults. Here, serpentinite diapirism creates a tectonic window into the oldest known in situ oceanic basement, bringing basement materials to depths that can be drilled and sampled. SCYLLA will investigate the composition, origin, timing and triggering mechanism of diapirs that rise from the lower plate's mantle at a convergent plate boundary to intrude the forearc region of the upper plate. This will provide an opportunity to sample recently exhumed material from a downgoing Mesozoic plate's crust and mantle. Information gathered from this study will be used to provide a record of: i) the true age and nature of the Tethyan Basement; ii) the mechanisms that expose altered products of inherited mantle peridotite at the seafloor long after their formation; iii) the chemosynthetic activity of microorganisms sustained by water-ultramafic rock reactions linked to serpentinization.

FUTURE PERSPECTIVES OF SCIENTIFIC OCEAN DRILLING

Camerlenghi A.

Scientific Ocean Drilling is approaching an important milestone. The IODP-2 phase of the program (2013-2023) has been extended until 2024 with the current structure and organization and the post-2024 scientific Ocean Drilling is under discussion, with different levels of uncertainties at the present date. ECORD and Japan, two of the operators and members in the current phase of the program, have announced a joint venture after 2024, centered on the implementation of a revewed concept of Mission Specific Platforms (MSP). The goal is offering to the scientific communities continued opportunities to sample, log and monitor the seafloor in all seas and oceans with an increased synergy with the International Continental Drilling Program. The 2050 Science Framework will be the guiding document for the scientific objectives of drilling. All kinds of available tools will be considered to implement, with flexibility, successful drilling proposals.

Friday 23rd September – morning session

DEEPSEEP: AN ERC-FUNDED PROJECT TO ASSESS DEEP ENERGY FORMATION IN SUBDUCTION ZONE SERPENTINITES

Vitale Brovarone, A.

This contribution aims at introducing the research goals and preliminary results of DeepSeep, an ERC-funded project aimed at improving our knowledge on deep H2 and abiotic hydrocarbons forming in response to deep serpentinization in subduction zones. The presentation will give the opportunity to present the current strategies deployed by our research group to constrain high-pressure serpentinization pathways and their fluid sources, deep H2 and CH4 formation mechanisms and chemical signatures, and global fluxes of these unconventional energy sources at depth. Preliminary, potential implications on global carbon cycling and deep microbial life will also be presented.