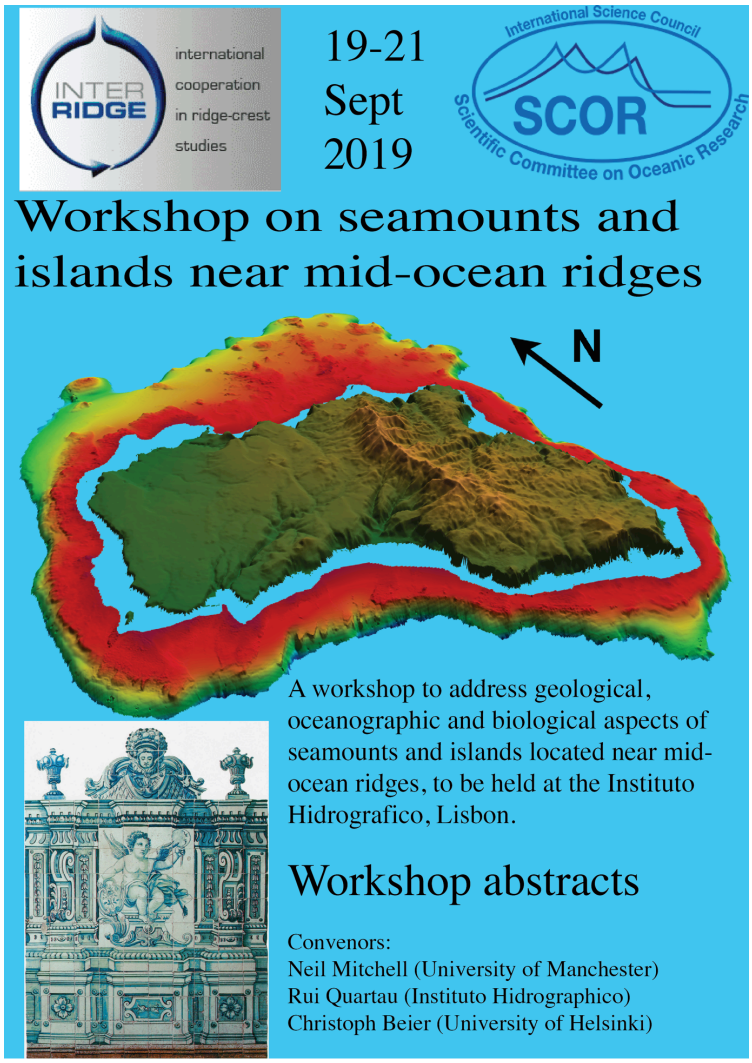
# InterRidge Workshop on Seamounts and Islands Associated With Mid-Ocean Ridges (19-21 September 2019)

## Workshop participants[1]




Seamounts are large underwater mountains, here considered more than 1 km high, which can be formed by either volcanic or tectonic processes. Seamounts and islands associated with mid-ocean ridges are sites of great interest for researchers from a variety of scientific disciplines. Researchers commonly require data and knowledge from other disciplines to make progress, hence work can be highly multidisciplinary in this field. A workshop was therefore convened to address these special environments and the interdisciplinary nature of the research, with a particular focus on future work. The workshop was held over three days at the Convento das Trinas, a former convent now occupied by the Instituto Hidrográfico, the Portuguese Hydrographic Office in Lisbon. For the first day and a half, researchers presented talks and posters. Subsequently, the attendees worked on subject-specific priorities within breakout groups and

[1] See end of report for participants list

finally discussed collectively ways for the community to move the subjects forward through collaboration, new fieldwork, and data and knowledge sharing.

Following a welcome address by the director of the Instituto Hidrográfico, talks in the mornings of the first and second day addressed geological origins of these structures, their oceanography and biology, as well as funded and planned research programmes:

Update on InterRidge activities - Kamil Szafrański
Introduction to this working group, workshop tasks, and some geological known unknowns of seamounts and islands - Neil Mitchell
Seamounts and oceanic igneous features in the Northeast Atlantic: A Link between plate motions and mantle dynamics - Carmen Gaina
Mid-ocean ridge islands and seamounts: current challenges and future directions - Ricardo Ramalho
The study of insular shelves as a key for understanding the geological evolution of volcanic islands: examples from the Azores archipelago - Rui Quartau
Deep-sea soft-bottom benthic communities: Exploring biogeography and genetic connectivity of southeast Pacific Seamounts - Eduardo Quiroga
The biogeographic Azorean paradox and the contribution of physical oceanography - Sérgio Ávila
The evolution of oceanic intraplate volcanoes close to mid-ocean ridges: the Azores islands - Christoph Beier
Seamounts at the 69¯N SPAR offset, Kolbeinsey Ridge, N-Atlantic - Bryndís Brandsdóttir
The Global Seamounts Project: building on past seamount research to go forward on a global scale - Malcolm Clark
Global Oceans equipment capabilities - Jim Costopulos
The NOAA ASPIRE program - Kasey Cantwell
The iAtlantic project - Telmo Morato

Posters presentations further expanded the background:

Tectonic implication on seafloor geomorphology, upper slope, Western Niger delta - Ashiru O.R. & Wu S
Geomorphological evolution of the Chilean volcanic oceanic islands and seamounts - Laura Becerril & Luis E. Lara
The evolution of oceanic intraplate volcanoes close to mid-ocean ridges: the Azores islands - Christoph Beier, René H.W. Romer and Karsten M. Haase
Threats from submarine landslides around mid-ocean ridge volcanic islands: the central Azores - Yu-Chun Chang, Neil Mitchell & Rui Quartau
Surface deformation of the Azores Islands measured by Copernicus Sentinel-1 SAR interferometry - Eric J. Fielding
Slope Instability on Oceanic Core Complexes - Aggeliki Georgiopoulou, Bramley Murton, Maria Judge, Paraskevi Nomikou, Steve Hollis, Oisin McManus, Sebastian Krastel, Isobel Yeo & the TOSCA team
Reflection seismic and bathymetric study of underwater volcanoes of the Azores Plateau - Christian Hübscher, Paraskevi Nomikou, Josefine Stakeman, Pedro Terrinha & Christoph Beier

St. Paul Transform System earthquakes: an example of seismicity originated by transpressive transform fault and fracture zone reactivation - Guilherme de Melo, Marcia Maia, Aderson do Nascimento, Julie Perrot, Alexey Sukhovich & Thomas Campos

Last Interglacial fossiliferous sequences from Santiago Island (Cabo Verde Archipelago): palaeoecology of Nossa Senhora da Luz Bay, a rare example of a protected bay in volcanic oceanic islands - Carlos S. Melo, Ana C. Rebelo, Ricardo S. Ramalho, José Madeira, Esther M. González, Alfred Uchman, Patrícia Madeira, Carlos M. da Silva & Sérgio Ávila

Gondwana rifting associated with the formation of a new Large Igneous Province in the southwestern Indian Ocean? - Christine Meyzen, Marcia Maia, Jason Morgan, Tod Waight, Christophe Hemond, Andrea Marzoli, Anastassia Borisova, Hiroshi Sato & Matteo Massironi

Contourite drifts off oceanic islands? A high-resolution archive for climate and oceanographic changes and tectono-magmatic activity - C. Roque, F.J. Hernández-Molina, P. Madureira & R. Quartau

Post-rift ridge-"plume" interaction: The case of Madeira-Tore Rise - A. Rita Rosa, Luísa Pinto Ribeiro, Pedro Madureira & João Mata

Gravitational, erosional, sedimentary and volcanic processes on the submarine environment of Selvagens Islands (Madeira Archipelago, Portugal) - Rúben Santos, Rui Quartau, António Brum da Silveira, Ricardo Ramalho & Aurora Rodrigues

Submarine slope failure caused by seamount subduction at the Java Trench - new insights from Five Deeps Expedition - Heather Stewart, Joana Gafeira, Alan J. Jamieson & Cassie Bongiovanni

The Saint Peter and Saint Paul Archipelago (Equatorial Atlantic Ocean): The tectonic joint system as evidence of compressive present-day active tectonism - Thomas F da C Campos, Guilherme de Melo, Susanna Sichel, Marcia Maia, Daniele Brunellis, Kenji Motoki, Akihisa Motoki, Estefan Fonseca & Thais Vargas

Submarine Platform Development by Erosion of a Surtseyan Cone at Capelinhos, Faial Island, Azores - Zhongwei Zhao, Neil C. Mitchell, Rui Quartau, Fernando Tempera & Lucy Bricheno

Coastal erosion rates of lava deltas around oceanic islands - Zhongwei Zhao, Neil C. Mitchell, Rui Quartau & Ricardo S. Ramalho

The subject breakout groups addressed four broad subject areas. Within the first group, the majority of the geochemical and geodynamic hypotheses that members considered important to test concerned processes linking deep, mantle and crustal processes with those at the surfaces of seamounts and islands. Research questions encompassed the structure of the lithosphere and asthenosphere of the regions around seamounts and islands and the lateral extents of the zones of mantle melting underneath them. The tectonic regimes that may influence the formation and evolution of seamounts close to mid-ocean ridges vary significantly from a local to regional scale. This variation is of great importance in interpreting existing and new geodynamic and geochemical data. Further deep, mantle-imaging geophysical studies are needed to reveal the structures within and underlying seamounts on scales of 100s to 1000s of

kilometres from seismic tomography, reflection and refraction capable of resolving velocity anisotropy. The working group agreed that bridging between methods and spatial scales of geophysics and geochemistry should be a major aim. Properties that should be targeted include thermal state and heat flow, the timing and rates of melt ascent, as well as crustal morphology and composition. One major focus will be improving the understanding of the ascent through and stagnation of magmas within the crust, in particular how those movements are affected by local and regional stress fields. The implications arising will be of great importance for processes at the surface including eruption dynamics, the formation of hydrothermal systems and microbial communities.

The second group considered the higher-level structural architectures of seamounts and islands. Internal structures are potentially revealed at "tectonic windows", deep fault escarpments exposing their internal features. Geological hazards to populations and infrastructure are expected to arise in these islands because of costal erosion, landslides, volcanic eruptions and tsunamis. It is still unclear how much these phenomena affect areas in the far field. It also remains unclear what conditions lead to landslide movements or triggers of movements, or how frequently they occur. It is unclear how loading of the underlying lithosphere by volcanoes affects lithospheric stress and the geometries of active faults. We currently do not know if this implies significant uncertainty in predicting threats of earthquakes to local populations. The group recommended that future research efforts should focus on combining land and offshore datasets to address these problems. In particular, efforts are needed to collect data in nearshore areas that are often neglected in marine surveys for safety and efficiency reasons. Geophysical and geological data from diverse research groups should be combined to provide better syntheses. More effort is necessary to make these data freely available to the scientific community after embargo periods. Greater use of instruments is needed that can record active geological processes, such as GPS and InSAR on land and ocean bottom seismometers and pressure sensors underwater.

The third group considered the sediments overlying and surrounding seamounts and islands, their influences and the varied information that they provide. Deposition and erosion of sediments are affected by ocean currents and by oscillating currents from surface waves. Physical oceanographic modelling of currents has improved greatly, potentially helping us to explain patterns of sediment deposition, though is still dependent on the resolution of bathymetry data, which are highly varied in mid-ocean ridge settings. Data from ocean current meters and other sensors are needed to validate those models. Numerical ocean models could be useful to test information obtained from sediments on past paleoceanographic and paleoclimatic conditions. For example, species capable of dispersion only by rafting can suggest the presence of surface currents that are very different from modern currents. Sediment cores could be valuable for revealing how currents at the seabed have changed over time (effects on grain sizes and hiatuses) and how conditions in the overlying surface ocean have changed, exploiting new developments in organic carbon and other environmental proxies. The stratigraphy within sediments around tectonic seamounts (oceanic core complexes and transform "push-ups")

could help in working out their developments. Mid-ocean ridge islands are useful for paleoclimate work simply by virtue of their central positions within the ocean basins, so lake and other sediment records can fill spatial gaps in the global paleoclimate record.

The fourth group considered biological aspects. As these can be broad ranging, discussion was focused on a central theme that would align with the geological and oceanographic interests, addressing biological and ecosystem functioning characteristics and differences between mid-ocean ridge peaks, mid-ocean ridge island slopes, and seamounts. More complete information is needed on the occurrences of deep-sea species and on the biodiversity distribution patterns within and between these habitats, but also in understanding how environmental properties cause variations in these patterns. Environmental data are needed at higher spatial and temporal resolution for this to be effective, which can potentially now be collected using gliders, moorings and floats. Another important knowledge gap discussed relates to the spatial scale of connectivity patterns along and across the ridges, seamounts and island slopes. The group considered an important question: what are the distances of such connectivity and what determines those distances? Genetic approaches to these problems will be important, but need to be complemented with studies of reproductive biology and larval dispersal and settlement. Hence, future research needs to address whether mid-ocean ridge seamounts play an important role in larval retention (e.g., of hydrothermal vent fauna), facilitating recruitment on other adjacent habitats. It needs to address temperature and depth barriers to connectivity (e.g., for sponges), and the role of ocean currents in connectivity. The broad question has implications for the resilience of communities to climate change. The group identified three further important research questions that address the distribution and connectivity of populations associated with mid-ocean ridge habitats: Does the trophic architecture (measured by isotopic studies) differ between seamounts, ridge peaks and seamounts? What is the sphere of influence of the different habitats and faunal communities? How widespread is the input of chemosynthetic production from hydrothermal vent systems that occur along mid-ocean ridges, what is its variability and what drives it? These questions address both fundamental ecological issues, as well as being requirements for robust management of human activities in these areas. They require a structured survey design that addresses both spatial and temporal variability, and multi-disciplinary studies. A key input from other sections of the InterRidge Working Group is information on the substrate type, and geochemical composition.

During the final day, the participants discussed the range of issues identified by the breakout groups, and refined the aims of the overall working group towards improved understanding of the pathways of material and energy flow on seamounts and islands associated with mid-ocean ridges and their roles in acting as conduits or barriers. The definition of the working group was also reshaped as acting as an umbrella for fundamental and applied research on large edifices that formed in proximity to mid-ocean ridges, excluding those that formed in intraplate environments. The roles of seamounts during cycling of material and energy in the framework of plate tectonics are still largely unknown due to a lack

of data and samples. However, the pathways of material and energy through seamounts and the surrounding crust are essential for the hydrosphere and biosphere. Information on them would link the research of the InterRidge working group to the Global Seamounts Project, a major initiative that aims to characterize and model the ecologies of distant seamount habitats. All participants agreed that progress in the subject would benefit from continued networking. They suggested focus sites for the NOAA Aspire initiative and recommended establishing a stable network, to operate globally. The workshop finished by evaluating the possibilities for developing a larger networking proposal. This will be the subject of a second workshop to be held in 2020.

Acknowledgements: The participants thank support for this workshop from the InterRidge and Scientific Committee on Ocean Research. In particular, we thank the Portuguese Instituto Hidrográfico for kindly allowing us to occupy some rooms of the Convento das Trinas for the three days of this workshop.

The workshop was convened by Neil Mitchell, Rui Quartau and Christoph Beier. The participants were: Ana Rita Rosa (Universidade de Lisboa, Portugal), Aggeliki Georgiopoulou (University of Brighton, UK), Bryndis Brandistottir (University of Iceland), Carlos Melo (Universidade de Lisboa), Carmen Gaina (University of Oslo, Norway), Christine Meyzen (Università degli Studi di Padova, Italy), Christoph Beier (University of Helsinki, Finland), Cristina Roque (Task Group for the Extension of Portuguese Continental Shelf (EMEPC), Portugal), Eduardo Quiroga (Pontificia Universidad Católica de Valparaíso, Chile), Eric Fielding (Jet Propulsion Laboratory, California Institute of Technology, USA), Fernando Ornelas Marques (Universidade de Lisboa), Guilherme de Melo (Federal University of Rio Grande do Norte, Brazil), Inês Tojeira (EMEPC), Jim Costopulos (Global Oceans, New York, USA), Joana Gafeira (British Geological Survey, UK), Joana Xavier (Universidade do Porto, Portugal), Kamil Szafrański (InterRidge, Institut de Physique du Globe de Paris, France), Kasey Cantwell (NOAA Office of Ocean Exploration and Research, USA), Laura Becerril Carretero (Geological Survey of Chile, Chile), Luísa Ribeiro (EMEPC), Malcolm Clark (National Institute of Water & Atmospheric Research, New Zealand), Nadine Le Bris (Université Pierre et Marie Curie, France), Neil Mitchell (University of Manchester, UK), Olusola Ashiru (Chinese academy of Science, Sanya, China), Paraskevi Nomikou (University of Athens, Greece), Pedro Madureira (EMEPC), Ricardo Ramalho (Universidade de Lisboa), Rúben Santos (Instituto Hidrográfico, Portugal), Rui Quartau (Instituto Hidrográfico), Sérgio Ávila (Universidade dos Açores, Portugal), Simone Innocentini (Sapienza Università di Roma, Italy), Telmo Morato (Universidade dos Açores), Teresa Rafael (EMEPC), Yu-Chun Chang (University of Manchester) and Zhongwei Zhao (University of Manchester). Remote participant: Dmitry Aleynik (Scottish Association for Marine Science, Oban, UK).