## Project 9

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| **Name/title of the PhD course** | **BIOLOGY** |
| **Name of the PhD coordinator** | Prof. Sergio Esposito |
| **Name/Title of the PhD project** | ***The Microbiome of Shallow-Water Hydrothermal Vents: Metabolic Diversity, Biogeochemistry and Coevolution*** |
| **Department of reference** | The department of Biology of the University of Naples Federico II is one of the largest in the country with over 300 people between Faculty, Technicians and Postdocs, about 60 PhD students. The Department is highly interdisciplinary, spanning all domains of life sciences. Serving a student population of about 1,500 hosts and organized courses in both Italian and English in all major Life Science disciplines, and it is the home of two international Master Degree Programs in Marine Biology" and in the "Biology of Extreme Environments". The departments is equipped with all major modern instruments and facilities, from electron microscopy, to a vivarium, large computational clusters both hosted internally and in collaboration with the SCOPUS supercomputer consortia. The Department is also part of several university-wide Task Forces, including the task force Microbiome, Marine Science and Computational Biology. |
| **Working conditions, research team, infrastructures, equipment** | The PhD candidate will work mainly with the team of Prof. Donato Giovannelli. The Giovannelli Lab (www.donatogiovannelli.com) is composed of ca. 20 people working at the interface between microbial ecology and planetary evolution, combining classic microbiology techniques with fieldwork and molecular and computational approaches. The Lab was recently awarded a ERC Starting Grant to study the role of trace elements in shaping microbial diversity, and it has recently acquired new large instruments, including a state-of-the-art IRMS and a ICP-MS. Projects in the Giovannelli Lab include Arctic permafrost, continental and marine subsurface, relationships between tectonics, geothermal areas and microbial diversity and the microbiology of underground hydrogen storage. |
| **Scientific context** | Shallow-water hydrothermal vents are widespread marine ecosystems with metabolically diverse microbial communities that significantly contribute to biogeochemical cycling. Contrary to their deep-sea counterpart, in shallow-water hydrothermal vents chemolithotrophic and phototrophic processes co-occur, making these high energy environments. Shallow vents are widely distributed globally in close proximity to continental margins and volcanic areas up to a depth of 200 meters. Given the fluxes of nutrients and trace metals associated with shallow-water hydrothermal vent emission, these can significantly contribute to local and and mesoscale primary productivity, providing potentially limiting nutrients to neighboring ecosystems. Additionally, due to the diverse community that can be found associated to shallow vent emission, these constitute hot spots of diversity and compounds of potential biotechnological interest. Despite their relevance, little information are available on the microbial diversity of these ecosystems. Several studies have shown that the microbial diversity present in the investigated shallow water vents responds to the different geochemical regimes. However, the studies published focus on a limited number of shallow vents worldwide. In addition, often the identified geochemical drivers are not interpreted in the larger context of the geological processes in the area. Recent work by the Giovannelli Lab and collaborators has demonstrated that different geological settings, mainly linked to the type of tectonic settings or the nature of the volcanism in the area, directly influence microbial diversity and composition. This is certainly mediated by the different geochemical regimes resulting from diverse water-rock interactions at depth and mixing with surface processes. Aim of the project is to investigate a large number of shallow-water hydrothermal vents coupling geochemical and microbiological investigations across diverse geological settings. |
| **Project Research plan** | The project aims to constrain the taxonomic and functional diversity of microbial communities in shallow-water hydrothermal vents associated with different geological settings and geochemical regimes. The work will include fieldwork to sample diverse shallow vents as well as laboratory work to analyze the obtained samples. Analysis include investigating the taxonomic and metabolic diversity of the microbiome of shallow vents using shotgun metagenomic approaches coupled with stable isotope incubations and cultivation approaches. Geochemical analysis of the fluid and sediments will complement the microbial work, including organic matter composition, major ions, trace elements and gas composition. Possible shallow vent location sampled include the Campania Region, the Aeolian Islands, the Greek Volcanic Arc and the Azores. |
| **Research and Training Innovative aspects** | The results will unravel the taxonomic and functional diversity of shallow vents microbial communities and their role in biogeochemical cycling, advancing our knowledge of the role of vent ecosystems in the functioning of the oceans. Using a large scale approach recently developed by the Giovannelli Lab and collaborator to investigate microbial processes on large geological scale, it will be possible to link the microbial diversity at shallow vents with ecosystem functioning at large spatial scales and potentially inferring the shallow vent microbial metabolism coevolution with the environments in deep time. Additionally, the information obtained for a diverse set of shallow water vents will provide unique opportunities for future biotechnological studies, paving the way for future blue technologies. |
| **Inter-Multidisciplinary aspects** | The project is highly interdisciplinary, integrating classic microbiology techniques with cutting the edge molecular tools and data analytics. Cultivation dependent and independent approaches will be combined with fieldwork and bioinformatic and big data analytical approaches. Recent work by Giovannelli Lab includes |

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| | the use of machine learning approaches to identify connection between microbial diversity and environmental variables. The project will also integrate microbial data with geochemical, geological and geophysical data. |
| **Secondment opportunities** | **Novamont** (ITALY). the world's leading company in the sector of bioplastics and biochemicals (www.novamont.com). **Dr. Fabio Apone**, Biotechnology Area Manager, will be the supervisor. The PhD will spend at least 3 months at their premises. **Institute of Marine Science**, **Middle Eastern Technical University** (https://ims.metu.edu.tr/). The PI, **Prof. Mustafa Yucel** (https://ims.metu.edu.tr/people/yucel-mustafa-associate-prof-dr), is an expert in the geochemistry of shallow vents will provide expertise in the analysis and interpretation of the geochemical data. The PhD candidate will spend about 3 months at METU, working to characterize the geochemical regiments of the sampled vents. |
| **Main Supervisor:** Donato Giovannelli<br>(Google Scholar ID: eYxwQpkAAAAJ: Group website: www.donatogiovannelli.com) | |
| **Brief CV** | Full professor of Microbiology at the Department of Biology. Graduated in Biology (BSc) in 2005 from the Polytechnic University of Marche, with a Master in Marine Biology (MSc, 2007) and a PhD in Applied Biology (2013), Donato has spent several years working in the USA (Rutgers University, NJ, and Institute of Advanced Studies, NJ) and in Japan (Earth-Life Science Institute) before returning to Italy in 2018. As of December 2021, Donato Giovannelli has authored or co-authored 49 international peer-reviewed publications that are currently published or in press in journals including Nature, Nature Geoscience, Nature Communication, PNAS, Annual Review of Microbiology, eLife and ISMEJ. He co-authored 5 book chapters and he is co-editor of a book (published by Springer Nature, expected in 2022) on the microbiology of the deep-sea. He edited a Special Issue cross-listed by Frontiers in Microbiology and Frontiers in Geochemistry (containing 17 articles, 85 authors) and a Special Issue in American Mineralogist (12 articles). Since 2011, he has obtained in excess of 8 million Eur in funding (including ~3 million Eur directly to his group) either as a PI or Co-PI from the European Research Council, the National Science Foundation (direct NSF funding, as well as Center for Dark Energy Biosphere Investigations), NASA, Italian Antarctic Research Program, International Continental Drilling Program, and the Deep Carbon Observatory, among others. Prof Giovanelli is regularly invited as speaker to national and international conferences and summer schools. He has participated in or organized 35 international research expeditions including 13 oceanographic expeditions in all major location worldwide, including the Pacific, Indian Ocean, Atlantic and Arctic. He is currently advisor of 4 PhD students and 2 postdoctoral fellows, co-advisor of 1 postdoctoral fellow, 1 PhD student and 3 graduate assistants, primary advisor or co-advisor of 22 master students and 30 undergraduate students at the University of Naples "Federico II". In the past he has advised or co-advised an additional 8 master students and 3 PhD students. He is member of doctoral commissions at major international universities, Including Rutgers University, the University of Tennessee at Knoxville and the Middle Eastern technical University. |
| **Publications** | **Five most significant publications***:*<br>- Cordone A, D'Errico G, Magliulo M, Bolinesi F, Selci M, Basili M, de Marco R, Saggiomo M, Rivaro P, **Giovannelli D*** and Mangoni O*. 2022. Bacterioplankton Diversity and Distribution in Relation to Phytoplankton Community Structure in the Ross Sea Surface Waters. Front. Microbiol. 13:722900. doi: 10.3389/fmicb.2022.722900<br>- Fullerton KM, Schrenk MO, Yücel M, Manini E, Basili M, Rogers TJ, Fattorini D, Di Carlo M, d'Errico G, Regoli F, Nakagawa M, Vetriani C, Smedile F, Ramírez C, Miller H, Morrison SM, Buongiorno J, Jessen GL, Martínez M, de Moor JM, Barry PH, **Giovannelli D***, Lloyd KG*. 2021. Plate tectonics drive deep biosphere microbial community structure. *Nature Geoscience*, 14, 301–306. doi: 10.1038/s41561-021-00725-0<br>- Patwardhan S, F Smedile, **D Giovannelli**, C Vetriani. 2021. Metaproteogenomic profiling of chemosynthetic microbial biofilms reveals metabolic flexibility during colonization of a shallow-water gas vent. *Frontiers in Microbiology*, 12: 638300, doi: 10.3389/fmicb.2021.638300<br>- Merino N, Aronson HS, Bojanova D, Feyhl-Buska J, Wong ML, Zhang S, **Giovannelli D***. 2019. Living at the Extremes: Extremophiles and the Limits of Life in a Planetary Context. *Frontiers in Microbiology*, 10: 780. doi: 10.3389/fmicb.2019.00780<br>- Jelen B, **Giovannelli D**, Falkowski PG, and Vetriani C. 2018. Combined comparative transcriptomic and proteomic analysis reveals the mechanism and pathway of elemental sulfur reduction in Thermovibrio ammonificans, a deep-sea vent thermophile. *Environmental Microbiology*, 20(6): 2301-2316. doi: 10.1111/1462-2920.14280 |
| **Projects participation** | *EU funded projects:*<br>- Principal Investigator ERC Starting Grant 2020 COEVOLVE. www.coevolve.eu |