CALL FOR INTEREST XXXVII CYCLE - GEOLOGICAL SCIENCES

SSD: GEO/02

Title: **Very-high resolution Distributed Acoustic Sensing data for monitoring natural and induced seismicity**

Supervisor: Nicola Piana Agostinetti (Tutor UniMiB: E. Garzanti; Tutor INGV: G. Saccorotti)

Short description: Distributed Acoustic Sensing (DAS) data are obtained through the monitoring of optical fibre cables, and they can reach unprecedented resolution (<1m), not reachable with standard seismic equipment. Such characteristics can potentially reduce the threshold of detection of tiny earthquakes occurring on near-surface faults or induced by human activities and improve their location. In this PhD research, (1) we will compare recordings obtained using a DAS interrogator to standard geophone records in the context of mining induced seismicity and natural seismicity related to glacier movements. Moreover, (2) such measurements will be used to develop ad-hoc tools based on data redundancy (like automatic seismic event recognition and continuous cluster activity). The research will include 30% fieldwork time to acquire DAS recordings. The research will be in collaboration with Istituto Nazionale di Geofisica e Vulcanologia (Italy) and Lulea Technical University (Sweden).

SSD: GEO/02

Title: **A chemical and geological study of detrital and authigenic minerals in loess deposits: a key tool to reconstruct the glacial-interglacial climate of Northern Italy**

Supervisor: Sergio Andò

Short description: This multidisciplinary research topic involves quantitative investigation of the link between sediment mineralogy, chemical processes, and the effects of climatic changes during the glacial and interglacial periods of the Quaternary, as recorded by the composition and structure of different soil profiles in loess of Northern Italy. The proposed study requires an integrated geochemical and geological approach to define and quantify the processes of alteration in outcrop sediments, soils, and wind-blown sediments (loess) that have recorded climatic changes in the Po Valley (Italy) in the last 2 million years. The proposed research involves intensive use of multiple techniques and equipment for the analysis of the mineral and organic fractions in sediments (e.g., optical microscope observations in transmitted and reflected light, Raman spectroscopy, FTIR, electronic microprobe, ICP-OES and chromatographic techniques, luminescence dating). The project indicatively includes 20% field and 80% laboratory activity, and will be carried out in collaboration with Thomas Stevens (Dept. Earth Sciences, University of Uppsala, Sweden) for geochemical, mineral magnetic and particle size analyses facilities and with Jan-Pieter Buylaert (Dept. Physics, Danish Technical University) for quartz and feldspar-based luminescence dating during the (6 months) expected period abroad, and with Roberto Comolli, Giovanni Vezzoli, Marina Lasagni and Fabio Gosetti at DISAT.

SSD: GEO/02

Title: **The effect of climate-induced weathering on sand composition**

Supervisor: Eduardo Garzanti

Short description: Our aim is to investigate the effect of climate-induced weathering on sediment composition. Suitable sites include the Alborz Mountains in northern Iran, the northern and southern flanks of which are characterized by contrasting humid (north) and dry (south) climate. The project includes sampling of sediments from all major rivers draining both sides of the orogenic belt and determine their mineralogical and geochemical composition by applying both classical and innovative techniques (e.g., point-counting, Raman-counting, SEM, EDS). The project indicatively includes 20% field and 80% laboratory activity and will be carried out in collaboration with research centers in Iran and, if needed, in other countries (China, UK). Period spent abroad include time dedicated to sampling in the field and to learn suitable complementary techniques in International institutions.

SSD: GEO/03

Title: **Characterization and modelling of fracture networks with applications to the circulation and storage of geofluids**

Supervisor: Andrea Bistacchi

Short description: Fracture networks represent the most common reservoir and pathway for circulation of fluids in the lithosphere, and particularly in its brittle upper layers. Fracture networks have been studied for years mainly for their importance in oil and gas reservoirs, but recently a renewed interest blossomed for applications in deep groundwater reservoirs (that can be more resilient in a climate change scenario with respect to shallow aquifers), geothermal fluids, and subsurface storage of H_2, "green" CH_4 and CO_2. Our experience in this research field suggests that there is still a gap between the characterization of fracture networks and their modelling since (i) some fracture network parameters, that are easily and routinely characterized in the field, are not the most important in models, (ii) other parameters, that are very important in modelling, are quite often ignored or poorly characterized, and (iii) many modelling algorithms are not able to deal with the complexity of natural fracture networks. The main goal of this project will be to improve the connection between characterization and modelling of fracture networks in different tectonic and lithological contexts. Various collaborations (listed below) will allow tackling specific goals that include (i) the quantitative characterization of fracture networks with modern techniques including 3D photogrammetric Digital Outcrop Models, statistical and geostatistical analyses, etc.; (ii) the interdisciplinary characterization of vein systems (petrography, geochemistry, etc.) that are considered representative of deep fluid reservoirs and pathways; (iii) the comparison of fracture modelling algorithms, using natural and synthetic datasets, in terms of their ability to successfully model complex natural fracture networks, and the assessment the input data needed and the relative weight of different parameters; (iv) the development of workflows and algorithms to perform upscaling of various parameters from the outcrop scale to the scale of 3D reservoir models. Ongoing and new collaborations that can be usefully exploited by the PhD candidate include researchers from the Universities of Parma and Modena-Reggio Emilia, from the École Nationale Supérieure de Géologie - Université de Lorraine, Nancy (possibility to spend a period abroad in France), and from IGAG-CNR.

SSD: GEO/03

Title: **Probing links between Cenozoic geodynamics and climate changes**

Supervisor: Pietro Sternai

Short description: At timescales of millions to tens of millions of years, the geological carbon cycle modulates the storage of carbon into rocks and the release of carbon into the ocean and atmosphere, thereby linking the evolution of climate and life to plate tectonics. This call gathers projects aimed at constraining the extent to which major Cenozoic geodynamics events (e.g., closure of the Neo-Tethyan margin, opening of the north-eastern Atlantic, Mediterranean Messinian salinity crisis, etc.) are entailed with the long-term climate trends. Analytical methods include, but are not limited to, studies of Melt Inclusions within target magmatic products (e.g., Raman spectroscopy and/or SIMS), analyses of mercury (Hg) anomalies within target sedimentary sequences and geochronology (e.g., LA-ICPMS U-Pb zircon dating) on already available or newly sampled rocks. The newly produced observational constraints will be used to calibrate state-of-the-art numerical geodynamic and climate modeling to quantitatively and rigorously assess causal relationships between Cenozoic geodynamics and climate changes (expected work allocation: ~0-10% field sampling, ~45-50% analytical work and 45-50% numerical modeling). Projects will be held in collaboration with Rosario Esposito and Claudia Pasquero at DISAT and with external partners (e.g., J. Koornneef, University of Amsterdam, VU; P. Bouilhol, CRPG-Nancy, University of Lorraine; S. Castelltort, University of Geneva; Y. Donnadieu, CEREGE-Aix-en-Provence; P. Ballato, University of Roma TRE; J. Dai, University of Beijing; F. Farina, University of Milano), who will provide access to the analytical facilities in external Institutes and additional suitable rock samples during the (6-12 months) expected periods abroad.

SSD: GEO/03

Title: **The rift-related Jurassic fault system of the central Southern Alps and its re-activation during the Alpine shortening**

Supervisor: Andrea Zanchi

Short description: The project aims to understand the evolution of regional scale faults through space and time analyzing their geochemical fingerprints, based on the definition of brittle structural facies. A multidisciplinary approach based on field structural analyses will be largely integrated with the microstructural analysis of fault rocks and geochronology (K-Ar and Ar-Ar on phyllosilicates and clay minerals). The aim of the project is to understand faults nucleation, growth and subsequent re-activation in the central Southalpine domain, with special emphasis on the major thrust structures and on the Permian and Jurassic rift-related fault systems and their reactivation. Expected collaborations with the University of Milan (Prof. Berra, La Porta; Roma La Sapienza, Prof. Carminati; Bologna, Prof. Viola and Vignaroli; Geological Survey of Norway (NGU) for K-Ar dating of fault gouge.

SSD: GEO/05

Title: **Time series analysis and interpretation of spatio-temporal correlation between ground motion, rainfall and groundwater level fluctuations**

Supervisor: Giovanni Battista Crosta

Short description: Subsidence and ground surface uplift phenomena may be related to natural processes and human activities and may determine strong socioeconomic and environmental impacts, both in rural and metropolitan areas. The aim is to perform time series analysis of ground deformation measurements and of geological/environmental variables to characterize the effect of different boundary conditions on soil behavior, to detect subsidence and uplift phenomena and the possible influence on natural elements and anthropogenic structures stability. Complementary numerical analysis may provide further validation and interpretation of the spatio-temporal behavior of soil displacement.

SSD: GEO/05

Title: **Application of new generation high-resolution optical satellite imagery for landslide motion and detection**

Supervisor: Giovanni Battista Crosta

Short description: New high-resolution satellite data provide improving capacity for the study of landslides. The project aims at exploiting these new capacities to monitor the landslide motion through the analysis of image time series, in order to describe surface deformation and the spatio-temporal behavior of landslides. At the same time, optical imagery can be used to detect landslides, also for the development of susceptibility and hazard models. In situ field analysis and monitoring and drone-based surveys will be used to validate the approach. The project will be developed in collaboration with BRGM, Orleans.

SSD: GEO/05

Title: **Impact of climatic variables change on the occurrence and propagation of shallow landslides and debris flow**

Supervisor: Paolo Frattini

Short description: debris flows, and other shallow rapidly moving landslides are among the most frequent and damaging natural hazards in mountain regions; their triggering mechanisms are controlled by climatic variables such as rainfall and temperatures, whose trends are influenced by climate changes. The aim of this project is to analyze these phenomena and their correlation with climatic variables, exploiting both laboratory tests and field observations to obtain characteristic relationships; numerical models will also be implemented for the simulation of these events. The PhD will be held in collaboration with the Northwestern University, Evanston, IL, USA

SSD: GEO/06

Title: **Simulation of space weathering processes by high-energy pulsed laser ablation techniques**

Supervisor: Marcello Campione

Short description: Silicate nanoparticles, otherwise referred to as very small grains (VSGs), occur in various astrophysical environments being the most common dust species. During its lifetime in the interstellar medium, dust experiences extreme events such as grain-grain collisions, irradiation, and shocks. The structure and chemical evolution together with the origin of these grains is still poorly understood and intensively debated. This research program consists in a laboratory-focused activity aimed at the production of an analogue material for astronomical silicate VSGs by pulsed laser ablation techniques applied on mineral targets in different environments, followed by a multimethodological characterization of both target sample and ablated nanoparticles taking advantage of optical spectroscopy analyses, x-ray photoemission spectroscopy, and high-resolution transmission electron microscopy and analysis. The photoemission spectroscopy analyses will be performed in collaboration with the Department of Physics, Politecnico di Milano. A six-month period to be spent at the University of Jena under the supervision of Prof. Falko Langenhorst is also envisaged.

SSD: GEO/06

Title: **Fluorcarbonates of Ca and Rare Earth Elements: Model structures for the study of polysomatism and polytypism and ore minerals for green energy applications**

Supervisor: Giancarlo Capitani

Short description: The Ca-REE-fluorcarbonates are the most important ore minerals for REEs, fundamental elements in modern green technology applications, that range from wind turbines to electric vehicles. The Ca-REE-fluorcarbonates are also important from a mineral crystallography point of view as they form syntactic intergrowths on a nanometer scale. The goal of this project is to establish a connection between the basic mineralogical-crystallographic research and applied research fields, such as ore mineral genesis and exploitation, mineral processing, and recycling. Advanced characterization techniques such as Scanning Electron Microscopy (SEM), Wave Dispersive Spectrometry (WDS), Electron Back-Scattered Diffraction (EBSD), High Resolution Transmission Electron Microscopy (HRTEM) available in-house will be employed for the project. A training period focused on experimental mineralogy and/or REE ore mineralogy to spend in a foreign university is envisaged. In this respect, a collaboration with the Research School of Earth Sciences of the Australian National University College of Science (Canberra) and The Eskisehir Osmangazi University (Turkey) are under definition. Several other opportunities in European countries are possible.

SSD: GEO/07

Title: **Relationships between compressional tectonics, magmatic intrusions, and porphyry-Cu-type mineralization: the case of northern Chile**

Supervisor: Alessandro Cavallo

Short description: porphyry-Cu are magmatic-hydrothermal ore bodies, characteristic of a magmatic arc related to subduction zones, in converging plate margins. Through the study of the porphyry-Cu systems of northern Chile we aim to clarify the characteristics of magmatic feeding systems in compressive tectonic environments, using a multidisciplinary approach. Reconstructing the magma path would allow us to understand the characteristics of the local tectonic stress field, which prevented the magma from "escaping", thus solidifying in a sub-volcanic environment, allowing the accumulation of metals such as Cu, Mo, Re, and Au thanks to hydrothermal phenomena. The project will benefit from collaboration with Chilean mining companies; the PhD candidate will carry out a significant field activity abroad (Chile).

SSD: GEO/07

Title: **Evolution, characterization and origin of the magmatic vapor phase associated to magmas erupted at active calderas**

Supervisor: Rosario Esposito

Short description: The evolution and the type of the magmatic vapor phase (MVP) directly exsolving from natural melts play an important role in the behavior of the eruptive style and the bradyseism of active calderas, the global volatile cycles, and the formation of ore deposits. Although many studies have determined the composition of deep MVP based on fumarole geochemical analysis and geochemical thermodynamic modeling, samples of a direct natural deep degassed MVP is lacking. New studies have revealed that is possible to measure directly the MVP using bubble in droplet of melts trapped in phenocrysts forming below volcanoes, better known in literature as melt inclusions. The main goal of this project is to better understand the correlation between the evolution of the MVP and (1) the vertical ground motion, (2) the eruptive style, and (3) the global volatile cycles. For this project, the doctoral student will characterize the magmatic vapor phase at active caldera systems (e.g., Campi Flegrei and Yellowstone). The training associated to this PhD project will initially include field work. The rest of the PhD project will be mainly focused on laboratory techniques such as fluid and melt inclusion analysis, Raman spectroscopy, chemical microanalysis, and stable isotope analysis. The student research will be based at UniMiB but possibly will spend time at other Italian/international laboratories (e.g., University of Alberta, Canada).