PROGETTO BORSA PREMIALE

SSD: GEO/05

Title: **Integrating multi-platform remote sensing, fracture network modeling and historical data for rockfall risk analysis**

Supervisor: Federico Agliardi

Short description: Rockfalls pose high risk to life and infrastructures in alpine areas subjected to increasing anthropogenic pressure. Although advanced quantitative risk analysis methodologies exist, their practical application is often hampered by a lack of site-specific knowledge of the rate, probability and magnitude distributions of expected failure events, in different lithological and structural settings. The PhD project will develop original and widely applicable approaches to generate template inventories of occurred and potential rockfall events, representative of typical rock types and structural settings of the axial alpine regions between Italy and Switzerland. Datasets will be constructed for selected study sites in Lombardia and Switzerland, by exploiting remote sensing approaches (LiDAR, photogrammetry, infrared thermography from terrestrial and drone-based platforms), structural and geomorphological analysis, and statistical and numerical modelling of fracture networks constrained by historical and field data. These techniques will be integrated through innovative methodologies to provide key information on fracture patterns, rock mass damage, block shape and size distributions, event rates and magnitude-frequency scaling for instantaneous and progressive failure mechanisms. The results will be directly useful as input to QRA of rockfalls in alpine regions. The research will be carried out in joint supervision with the University of Lausanne (UNIL, Switzerland), where the PhD student will spend one year.

CALL FOR INTEREST – GEOLOGICAL SCIENCES

SSD: GEO/01

Title: **Reconstruction and monitoring of recent paleoenvironmental variations with benthic foraminifera**

Supervisor: Elisa Malinverno

Short description: Benthic foraminifera are well known as tools to track changes in environmental parameters, such as the temperature, trophic state, oxygen conditions and heavy metal pollution of the benthic environment. The aim of the research is to study benthic foraminifera in bottom samples from both already existing sample collections mainly from the Mediterranean and from the Maldives: they will include modern samples, to monitor the current environmental status and its modifications, and sediment cores spanning the late Pleistocene-Holocene to track recent paleoenvironmental changes. The candidate will carry out its research in the laboratories of Milano-Bicocca, on the field and at other institutions (e.g. University of Athens)

SSD: GEO/01

Title: **Assemblage variations of calcareous nannofossils to track the Plio-Pleistocene dynamics of the Antarctic Circumpolar Current**

Supervisor: Elisa Malinverno

Short description: The research is based on the sediment core material collected during IODP383 scientific drilling expedition, in the Pacific sector of the Southern Ocean. The overall aim of the project is to reconstruct, at high resolution, paleoceanographic variations related to the shifts of the Antarctic Circumpolar current during the climatic fluctuations of the Plio-Pleistocene using a multiproxy approach. The candidate will focus on the quantitative study of calcareous nannofossils from the core samples, to reconstruct paleoceanographic shifts. Collaboration with other universities (e.g. University of Birmingham) and participation in workshops of the project is expected.

SSD: GEO/02

Title: **Provenance analysis of modern continental to marine sediments using classical and innovative techniques**

Supervisor: Eduardo Garzanti or other supervisors depending of the specific project

Short description: The research carried out by the Laboratory of Sedimentary Provenance aims at quantitatively defining the processes that control the mineralogical, geochemical, and geochronological composition of orogenic and anorogenic sediments and at tracing sediment transport and dispersal at the continental and transcontinental scale. Study areas include central and southern Asia, the Middle East, Africa, South America and southern Europe. Methods involved include mineral separation in the lab, optical microscopy, Raman spectroscopy, scanning electron microprobe, major element, trace element and isotope geochemistry, fission-track analysis, and detrital geochronology. Time dedicated to field work highly depends on the target area of study. Research is routinely carried out in strict collaboration with Chinese (e.g., Nanjing, Shanghai, Wuhan, Lanzhou, Beijing) and European Universities (e.g., UCL, Manchester, Lancaster, Erlangen, Genève, Grenoble) and Research Centers (e.g., Ifremer, Marum, GFZ, CRPG Nancy), and occasionally oil and service companies. Periods spent abroad in these or other institutions depend on the target area of study.

SSD: GEO/03

Title: **Megathrusts at the front of the Penninic collisional wedge**

Supervisor: Andrea Bistacchi; *Co-supervisor*: Steve Smith, University of Otago (New Zealand)

Short description: Mega-thrusts bounding the inner (metamorphic) domains of mountain belts with respect to the outer (non- or weakly-metamorphic) ones, are large-scale thrusts with long-lived activity, continuous for hundreds of kilometers, that accommodate most of the deformation associated with continental collision and are comparable to active megathrusts that result in M > 7 crustal earthquakes (e.g. the April 2015 Gorkha earthquake in Nepal). Continental megathrusts show common compositional and structural features, and are generally characterized by weak phyllosilicate-rich fault rocks with low-grade metamorphism (at least at the time of semi-brittle deformations that we are considering here), where deformation along more or less localized shear zones is characterized by the alternance of (i) aseismic semi-brittle and pressure-solution mechanisms, and (ii) seismic runouts (including slow earthquakes), sometimes characterized by large and continuous ruptured areas (i.e. large-magnitude earthquakes). The goal of the project is to study this kind of deformation processes using the world-class case study provided by major thrust faults broadly bounding the Austroalpine-Penninic wedge of the NW Alps (e.g. the Briançonnais and Penninic Frontal Thrusts), using up-to-date methodologies from the scale of the field exposure (3D digital mapping and structural characterization) to the micro- and nano-scale (e.g. FE-SEM-EBSD, EDS/CL, transmission Kikuchi Diffraction, X-ray microCT, etc.). Field ≈10%, lab, analyses, data processing and interpretation ≈90%. The project will be carried out in collaboration with Prof. Steve Smith and Dr. Marianne Negrini (University of Otago - NZ) who will offer (i) assistance and guidance in the field and in the lab (particularly for

microstructural analysis with FE-SEM-EBSD etc.), (ii) short courses at UniMib (during their sabbatical in Europe), and (iii) lab facilities and funding (e.g. for lab analyses) for the PhD candidate during one or more periods abroad in New Zealand.

SSD: GEO/03

Title: **Open source technologies for 3D geomodelling**

Supervisor: Andrea Bistacchi; *Co-supervisors*: Guillaume Caumon (École Nationale Supérieure de Géologie - Université de Lorraine, Nancy, France); Matteo Massironi (Università di Padova, Italy)

Short description: Geology and geological processes are inherently 3D, but traditionally studied with 2D tools, however in the last two years we are seeing a transition in 3D geomodelling from an "old-school" situation where the access to 3D geomodelling was strongly mediated by the industry (particularly the oil industry), to a progressive diffusion and "vulgarization" thanks to the development of open-source software projects that are greatly broadening the audience and the scope of 3D geological modelling methods. The main goal of this project will be to further develop open source 3D geological modeling tools – a research topic that we have started this year at UniMib (thanks to two funded projects) after 15 years of using (and studying in details) different commercial software packages; we are particularly interested in software tools that will facilitate reconstructing geological models from field data, with research and technical goals that range from tectonics and structural geology to applications to rock mechanics, hydrogeology and subsurface fluid flow in general, etc. The goals include developing innovative algorithms and software tools for (i) large-scale 3D geological modelling (one km- to tens of km-scale) and (ii) outcrop-scale modelling of fracture networks and fault systems (meters- to one km-scale), based on a common interface and software development platform that is at the moment being developed thanks to a collaboration with the University of Padova. Fieldwork (≈10% of the project) will be carried out to support 3D models development. The project will be carried out in collaboration with the University of Padova (Prof. Matteo Massironi and co-workers) and the École Nationale Supérieure de Géologie (ENSG) of Nancy (Prof. Guillaume Caumon and co-workers), who will cooperate in every stage of the project. In addition to their unique world-class experience in the field of 3D geomodelling, colleagues of ENSG Nancy will provide guidance during periods abroad spent by the PhD candidate in their labs, as in previous positive experiences. We look forward to making this a co-tutored PhD, thanks to the already-existing agreements with France.

SSD: GEO/03

Title: **Assessing correlations between climate-driven growth and decay of large ice sheets, sea level changes and magmatism**

Supervisor: Pietro Sternai

Short description: Geologic observations at global and local scales suggest that climate-driven growth and decay of large ice sheets can influence the eruptive timing and behavior of proximal and distant volcanic edifices, also via global sea level changes. This project aims at producing better mechanistic and quantitative constraints regarding this and other proposed links between surface and deep Earth processes by means of numerical modeling. Coupled surface processes and geodynamic numerical models will be calibrated based on available and newly produced data reporting on the timing and fluxes of magma from key target settings such as (non-exhaustive list) the Mediterranean, the Andes or Antarctica. The project will involve collaborations with colleagues from the University of Geneva, the ETH-Zurich, the Sorbonne University and several other national and international Institutes, and the PhD candidate is expected to spend periods for work abroad in one or more of these institutes.

SSD: GEO/03

Title: **Relations between active faults and fluid emission as a function of multiple tectonic, volcanic and seismic parameters**

Supervisor: Alessandro Tibaldi

Short description: The project focuses on better understanding the various seismotectonic parameters that influence the movement of magma and gas along active faults, in different geological-structural contexts. The goal is to assess the role of the local crustal properties (host rock properties, geometry of the intrusion, magma-induced stress perturbation) and of the regional parameters (structure geometry and kinematics, tectonic stress state, seismicity) in dictating the vertical vs horizontal propagation or arrest of magma and volcanic gases. The research will be carried out in different volcanotectonic settings (Mt Etna, Northern Volcanic Rift-Iceland, Hellenic volcanic arc) using a multidisciplinary approach and dataset: i) geological-structural data collection through field mapping and UAV surveys; ii) numerical and analogue modelling, iii) seismological data and iv) gases and magma discharge data from local monitoring networks in cooperation with INGV (Italy), Icelandic Meteorological Office (Iceland), Earthquake Planning & Protection Organization (Greece) (field activity 30%, lab activity 70%). The research activity will benefit from the EU NEANIAS project (www.neanias.eu) and its consortium. Particularly, the collaboration with the University of Athens (Greece), and the other partners, is already planned and the PhD student will spend 4 to 6 months abroad, especially in Iceland and Greece.

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 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), is under definition. Several other opportunities in European countries are possible.

SSD: GEO/07

Title: **Carbon enrichment and transport in the lithospheric mantle: characteristics and significance for the deep carbon cycle**

Supervisor: Maria Luce Frezzotti

Short description: Earth CO_2 degassing has been modulating the physical, chemical, and biological processes impinging the complex Earth's system since the onset of plate tectonics. Although most studies concentrate in subduction zones, where near-surface carbon is cycled to upper mantle depths, recent research has revealed that the lithospheric mantle could represent an under-considered Earth's

carbon reservoir. The overall aim of this project is to reveal and evaluate the processes of carbon enrichment, transport, and release in the lithospheric mantle in oceanic intraplate settings in the frame of magmatic and tectonic activity. The doctoral student will determine the chemical and physical characteristics and significance of carbon in lithospheric mantle rocks sampled at different localities, exploring the pathways of incorporation and transport by fluids and melts, and the links with shallow volcanic carbon emissions. The Ph.D. student training will consist of both field and laboratory techniques, including fluid and melt inclusion analysis, Raman spectroscopy, chemical microanalysis, and stable isotope analysis. The student will be based at UNIMIB but will spend time at the Università di Palermo and INGV laboratories, and at other laboratories abroad.

SSD: GEO/07

Title: **The dynamic mass transfer from slabs to the mantle wedge**

Supervisor: Nadia Malaspina

Short description: The mass transfer at slab-mantle interface takes place in mélange zones, located on top of the subducting plate, consisting of hydrated mixture of sediments, oceanic crust, serpentinised mantle and mantle-peridotites. Garnet-bearing peridotites associated with crustal rocks play a key role for the investigation of crust-mantle interaction at ultrahigh pressure conditions. This project aims at studying the mechanisms controlling the sampling of mantle-peridotites from Monte Duria (Central Alps, Italy), Ulten Zone (Eastern Alps, Italy) and Pohorje (Eastern Alps, Slovenia) into the subducted lithosphere with a twofold approach: (i) petrology and geochemistry (30%) and (ii) multi-scale characterisation of rheological properties of rocks and minerals by a detailed field study (30%) and by specific techniques such as EBSD (40%). Main international collaborations: University of Ljubljana (part of the field work – 1 month/year) and University of Oslo (implementation of EBSD technique and data interpretations, particularly in the frame of melt-rock reactions during deformation – at least 6 months the 2nd year).