

University of Milano-Bicocca
 PhD Course in Chemical, Geological and Environmental Sciences
Call for Interest 40th cycle – session I - Curriculum Geological Sciences

n. 1		Supervisor	Federico Agliardi
Title	The mechanics of large creeping rockslides: experimental and numerical modeling of hydro-mechanical interactions in basal shear zones		
<p>Large rockslides evolve by progressive rock failure and strain localization in basal shear zones, with a time-dependent macroscale behavior ("creep") anticipating catastrophic collapse. Nonetheless, existing forecasting and Early Warning approaches are often based on empirical descriptions of observed creep styles not accounting for the microscale physical processes governing the transition to collapse. In particular, hydro-mechanical interactions in basal shear zones and their sensitivity to hydrological forcing, especially in climate change scenarios, remain elusive.</p> <p>This PhD project will explore the effects of mineralogy and evolving texture on the magnitude, timing, and velocity dependence of rockslide shear zone response to stress and pore pressure perturbations. To this end, innovative laboratory creep experiments on natural shear zone materials will be combined with state-of-art constitutive and numerical techniques) e.g. PFEM, MPM), able to model large deformation and strain localization.</p> <p>We seek a candidate with an engineering geological background, motivated to work in a multi-disciplinary team with strong geological, geotechnical, and computational expertise to improve our understanding of large landslide behavior in a risk reduction perspective. The research will be carried out in collaboration with Sapienza University of Rome (Rock Mechanics and Earthquake Physics Lab) and the Universidad de Los Andes (Chile), where the PhD student will spend a research period.</p> <p>The PhD student will be co-supervised by Matteo Ciantia (UniMIB).</p>			
Supervisor webpage: https://www.unimib.it/federico-agliardi			

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n. 2		Supervisors	Elisa Malinverno & Sergio Andò
Title	Integrating continental and marine sedimentary archives to reconstruct Plio-Pleistocene climatic cycles in Antarctica and the Southern Ocean		
<p>This research focuses on the analysis of marine sediments (sediment cores) and continental records (dust in ice cores) with a perspective on lithogenic and biogenic particles. A high-resolution chemical and mineralogical study of aeolian dust in ice cores will be compared with the mineralogy of marine sediments sampled during oceanographic expeditions. This approach requires a single-grain approach, combines different methods (optical microscopy and Raman spectroscopy, atomic emission spectroscopy) and will benefit from IODP samples collected in the Ross Sea Exp. 374 and Ice cores collected in Antarctica (EUROCOLD), representing a unique opportunity to reconstruct the glacial-interglacial variations in particle transport and deposition, as related to climate changes through the Plio-Pleistocene.</p> <p>Paleoclimatic-paleoceanographic reconstructions will be carried out in the Pacific sector of the Southern Ocean, a particularly sensible area where IODP samples from Exp. 383 with a detailed age model are available. Micropaleontological (calcareous nannofossils, diatoms, silicoflagellates) and geochemical (stable oxygen isotopes, trace elements) proxies will be used to reconstruct the shifts in oceanographic fronts of the Antarctic Circumpolar Current through the Plio-Pleistocene.</p> <p>The PhD activity will include practical work in the lab for sample preparation, quantitative observations under the light and scanning electron microscope, geochemical analyses, and integration with shipboard data. Optical and spectroscopic analyses will be performed at the Provenance centre and the chemical modelling will be processed at DISAT. The sampling of ice cores and relative analyses will be realised at EUROCOLD and sediments from Antarctica will be provided by IODP repositories and OGS (Dr. Laura De Santis). The PhD position may lead to a double degree, in co-tutorship with the University of Bremen/Alfred Wegener Institute for Polar Sciences, and may include a 1.5 year work in Bremen with prof. Frank Lamy and Oliver Esper on microfossil and geochemical proxies, and a shorter visit at the University of Portsmouth (Prof. Saavedra-Pellitero) for nannofossil calcite analyses. The PhD student will be co-supervised by Fabio Gosetti, Daniela Basso, and Barbara Delmonte (UniMIB).</p>			
Supervisor webpage: https://www.unimib.it/sergio-ando https://www.unimib.it/elisa-malinverno			
Notes: shortlisted for the Department of Excellence TECLA position on “Study of the evolution of the climate in the past” (Studio dell’evoluzione del clima nel passato)			

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n. 3		Supervisor	Andrea Bistacchi
Title	Tectonic evolution of shear zones in the basement of the north-western Alps		
<p>Recent structural geology mapping projects have outlined a network of still poorly documented shear zones in the basement of the north-western Alps. The kinematic and chronological evolution of these shear zones, and the mechanical conditions of deformation, are of great interest in the regional geological framework and for understanding deformation processes typical of collisional orogens in general.</p> <p>The PhD candidate will complete an advanced structural analysis project in the field and in the lab, using up-to-date optical and electronic microscopy techniques, and radiometric dating, in order to characterize one or more case studies, which will be useful to better understand the regional tectonic framework and above all to delve deeper, also with advanced modelling, into the topic of shear zones that develop within large basement nappes, controlling their tectonics and with it the rheology of collisional orogens.</p> <p>The PhD student will work in a multidisciplinary team and spend one or two periods abroad as part of a collaboration with the University of Oslo.</p>			
Supervisor webpage: https://www.unimib.it/andrea-luigi-paolo-bistacchi			

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n. 4		Supervisor	Valentina Alice Bracchi
Title	Sclerochronology and sclerochemistry applied to Quaternary Mediterranean bivalves		
<p>Marine biogenic carbonates (=shells) are natural archives of environmental and paleoenvironmental information and provide high-resolution proxy records of past and present ocean climate variability, such as temperature, trophic state, oxygen conditions and pollution of the benthic environment. The use of the growth increment data (sclerochronology) and relative geochemical information (sclerochemistry, such as major and trace elements and stable isotopes) from mollusks, and in particular bivalves, allows monitoring modern marine environments, as well as reconstruct trends and variations of recent and past marine conditions through time and space.</p> <p>This doctoral project aims at studying Quaternary bivalves with sclerochronological and sclerochemical techniques, in order to investigate climate, oceanographic and sedimentological changes and trends. Samples include both specimens collected from present-day coastal waters and deep sea, and the Quaternary fossil records, covering species that live under variable oceanographic conditions (temperature, PH), or having different trophic needs (chemosynthetic fauna).</p> <p>The candidate will carry out her/his/its research by learning and applying different analytical techniques and data elaboration, both in the research laboratories of the University of Milano-Bicocca, and in other top labs in Italy and abroad (University of Leipzig, University of Tromsö), where to consider a period abroad of 6-month stay.</p>			
Supervisor webpage: https://www.unimib.it/valentina-alice-bracchi			

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n. 5		Supervisor	Marcello Campione
Title	Study of the carbonation reaction of Mg- and Ca-bearing minerals under hydrothermal conditions and microwave irradiation		
<p>Mineral carbonation is a widely investigated method for CO₂ mitigation enabling its capture and storage with production of secondary raw materials in the form of carbonates and hydroxycarbonate hydrates. Weathering of Mg- and Ca-bearing minerals is a well-known natural process allowing for the long-term capture of CO₂ under environmental conditions. This research program consists in a laboratory focused activity aimed at the study of enhanced weathering processes of minerals under mild hydrothermal conditions and exploiting thermal and non-thermal effects triggered by irradiation with microwaves. Model samples will be purposely selected for evaluating the influence of stoichiometry and composition on the carbonation mechanism and kinetics. Optimized processes developed with model samples will be tested on waste products of cement industries and of quarries in the territory of Italy and Austria. Carbonation reaction will be carried out with a dedicated apparatus enabling pressure, temperature, and irradiation energy programming and monitoring, whereas the characterization of the products will be performed by X-ray diffraction, vibrational spectroscopy, electron microscopy, and scanning probe microscopy methods.</p> <p>The microscopy analyses will be performed in collaboration with the Politecnico di Milano. A six-month period to be spent at Montan University, Leoben, Austria (Prof. Philip Hartlieb, Chair of Mining Engineering and Mineral Economics) is envisaged.</p>			
Supervisor webpage: https://www.unimib.it/marcello-campione			

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n. 6		Supervisor	Giancarlo Capitani
Title	Development of advanced electron microscopy techniques and application to minerals		
<p>The project focus on the development of two advanced transmission electron microscopy techniques and their application to selected mineral groups relevant for geological processes or mineralogy applications. The first of these techniques is the Continuous Rotation Electron Diffraction Tomography (CR-EDT). The method allows the acquisition of 3D electron diffraction data with quasi kinematic intensities, which in principle can be employed for structure solution of crystals smaller (tens of nm) than usually required for single crystal X-ray analysis (tens of μm). CR-EDT is therefore effective for systems where crystalline domains occurs almost exclusively at sub-microscopic scale, such as clays, serpentine minerals, micas or systems where exsolutions or syntactic intergrowths occur at a comparable scale, as in spinel and REE-fluorcarbonates, respectively. CR-EDT is also suitable for the characterization of very small reaction products that may occur during mineral alteration, either in nature or in laboratory, as for instance carbonation reaction in CO₂ sequestration experiments.</p> <p>The second technique is the Time Resolved Transmission Electron Microscopy (TR-TEM), which adds a further dimension, the time, to the nanoscale information currently delivered by TEM. The technique allows the study of ultrafast transient states of mater using sub-picosecond electron pulses generated by a laser and may be suitable for the study of phase transitions and ordering processes in minerals. A large number on minerals such as feldspars, pyroxenes, silica polymorphs, show ordering processes and phase transitions induced by changes in pressure and temperature that convey important information on the history of the host rock and related geological processes. Most of these processes pass through a number of metastable or unquenchable states that may complement the information. With TR-TEM is possible to shed a light on these transient states.</p> <p>The instrumental equipment necessary for the project is fully available at the Platform of Microscopy of Milano-Bicocca, as well as the research samples. Stages at Italian and foreign microscopy facilities are envisaged. Possible centers could be the Department of Earth Science, University of Pisa (ITA), the Institute of Physics, Czech Academy of Sciences of Prague (CZE), the École Polytechnique Fédérale de Losanne (CH)</p>			
Supervisor webpage: https://www.unimib.it/giancarlo-capitani			

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n. 7		Supervisor	Valerio Cerantola
Title	The role of plastic in carbon, hydrogen and oxygen geological cycles		
<p>Reports of plastic-rock complexes (plastistone) and macro- and micro-plastics in sediments worldwide are increasingly frequent. Anthropogenic polymers, therefore, effectively enter the geological cycles of C, H, and O, but to date a holistic understanding, from diagenesis to the final fate of these plastic forms in the regional and global geodynamic framework is missing. Focusing on the Mediterranean area, a closed basin at the center of densely populated regions, the project aims to take a first step towards understanding short/medium/long-term anthropogenic effects on the C, H, and O cycles resulting, for example, from domestic waste or marine activities.</p> <p>This project foresees an experimental and modelling approach. The stability fields of synthetic plastistone rocks of different compositions will be investigated experimentally at different pressure-temperature conditions, using autoclaves, piston cylinders and diamond anvil cells techniques. Analytical methods include x-ray diffraction, Mössbauer and Raman spectroscopy. The modelling approach involves estimating flows, transformations, and contributions to the geological cycles of C, H, and O of anthropogenic plastic on time scales from centennial to geological using petrological-thermodynamic-thermomechanical codes calibrated on stability maps obtained experimentally.</p> <p>The PhD student will be co-supervised by Nadia Malaspina (UniMIB). The project includes internal (PROVENANCE group at DISAT) and external collaborations at the national level. Furthermore, the PhD student is expected to spend a period of 6-12 months abroad, where possible destinations may include the European Synchrotron (France), the Bayerisches Geoinstitut (Germany) or other international institutions linked to the project</p>			
Supervisor webpage: https://www.unimib.it/valerio-cerantola			

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n. 8		Supervisor	Fabio De Blasio
Title	Polar regions as analogues for planetary icy bodies: data and modelling of ice-rock mixtures		
<p>Planetary ice is widespread in the Solar System. Understanding the properties and behaviour of ice in such extreme conditions is a fundamental issue from various perspectives. The properties of icy bodies (e.g. Europa, Enceladus, Iapetus, Mars polar regions, Pluto and Snowball Earth to name the most important ones) have been studied since the '70, focusing also on the nature and possible habitability of these surfaces and sub-surfaces. Remote sensing allows the observation of the optical and thermal properties of cryosphere not only on Earth but also on planets and moons. The recent advances in remote sensing technology are fundamental to set the stage for future studies based on space missions.</p> <p>In particular, dirty ice on Earth is known to host microbial life both in the Arctic and in Antarctic. Life detection is an active field of research in planetary sciences. The availability of field and remote sensing data collected in polar regions represents a great opportunity for the development of models that includes the effect of impurities on ice.</p> <p>The aim is to model the ice surface in different planetary environments. The work will estimate the radiative forcing induced by dust and debris, and it will evaluate the possibility of microbial life forms on icy surfaces. Field and satellite spectroscopy data acquired during recent polar campaigns in Antarctica and Greenland will be used to test the model. The work will also provide further data and modelling of the rheology properties of ice-rock mixtures useful for issues such as crater degradation, creep, and other properties of the planetary soils.</p> <p>The PhD student will be co-supervised by Biagio Di Mauro (CNR-ISP).</p> <p>Part of this research will be conducted in collaboration with NASA-JPL, where we expect the candidate would spend his/her period abroad.</p>			
Supervisor webpage: https://www.unimib.it/fabio-vittorio-de-blasio			
Notes: shortlisted for the position on "Polar Sciences"			

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n. 9		Supervisor	Paolo Frattini
Title	Soil moisture monitoring for rainfall-induced landslide assessment		
<p>Soil moisture is a key parameter for flood, landslide and atmospheric processes. Despite this key role in hydrogeological risk, soil moisture is poorly monitored, with a lack of an institutional monitoring network. On a large scale, spatially distributed and time-continuous soil moisture information is provided by satellite data (SMAP, ESA CCI, and AMSR2) through measurements based on visible/infrared and microwave bands. However, these products have a good retrieval of soil moisture only for shallow depths (0–5 cm), which are insufficient to characterize landslide risk; furthermore, the spatial resolution is coarse, and there is a lack of ground validation data over Italy. On the other hand, a handful of monitored sites in northern Italy are available at the local scale, typically not networked and usually targeted to specific research or purposes.</p> <p>The PhD candidate will be asked to develop satellite data analysis tools and to contribute to the construction of an in-situ monitoring network, both for validating satellite data and for improving the modelling of hydrological models of runoff, infiltration, and slope stability. The network will be built with the involvement of the community, with a Citizen Science approach, in order to collect spatially-distributed data and to involve and raise awareness in society, and new generations in general, about hydrogeological risk and the scientific approach in general. Collaboration with the University of Padova (prof. Stevenato) and the USGS (PhD Ben Mirus) will be established. The PhD student will be co-supervised by Giovanni B. Crosta, Federico Agliardi, Micol Rossini and Roberto Colombo.</p>			
Supervisor webpage: https://www.unimib.it/paolo-frattini			

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n. 10		Supervisor	Eduardo Garzanti
Title	Amazon River sediments: interplay between geodynamic setting and climate		
<p>This is a call for a Research Doctorate on topics relating to study the provenance of continental and marine sediments in South America, with reference to the Amazon River basin. The study will include a quantitative mineralogical analysis with traditional and innovative techniques to reconstruct the effect of physical processes (mechanical abrasion, hydraulic selection) and chemical processes (alteration and selective leaching during pedogenesis and diagenesis) on the composition of the sediments. This study aims to improve the geodynamic, paleogeography and climate changes in the study area.</p> <p>The optical and spectroscopic analyses will be performed at the Provenance centre of the University of Milano-Bicocca; the sampling of fluvial samples and marine cores, collected in the shelf of the Amazon River, will be provided by the University of Sao Paulo, Brasile.</p> <p>The PhD student will be able to take advantage of research funds from the Provenance centre to carry out laboratory analyses and missions abroad functional to the project. Collaborations are planned with the University of Sao Paulo, Brazil.</p>			
Supervisor webpage: https://www.unimib.it/eduardo-aldo-franco-garzanti			

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n. 11		Supervisor	Valter Maggi
Title	Long-range transport of mineral and vegetal impurities to high northern latitudes and high-elevation alpine regions		
Snow and ice from polar latitudes and high-elevation mountain areas represent a precious archive for paleoclimate and paleo-atmospheric circulation reconstruction. This research aims to investigate the seasonal and the long-term variability of the atmospheric circulation at northern polar latitudes (Svalbard Islands) and to the Alps through the study of impurities (dust, volcanic ashes) and vegetal remains, primarily palynomorphs. Specific focus will be put on long-range transport of pollen, spores, mineral dust and other impurities from North Africa to the Alps and to high European latitudes. Snowpits as well as ice cores will be studied at the EUROCOLD laboratory of DISAT (UNIMIB). A period abroad of 6 months is expected.			
Supervisor webpage: https://www.unimib.it/valter-maggi			
Notes: shortlisted for the position on "Polar Sciences"			

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n. 12		Supervisor	Silvia Mittempergher
Title	Physico-chemical interactions of CO ₂ bearing fluids with fractured rocks under in situ conditions for Geological Carbon Sequestration		
<p>Geological Carbon Sequestration (GCS) is a feasible strategy for mitigating climate change. The injection of CO₂ in geological reservoirs induces multiple physico-chemical processes (e.g., fluid flow in fractures and pores, adsorption/desorption on the solid matrix, dissolution/precipitation reactions, mineral carbonation), which have positive or negative effects on the reservoir mechanical properties and CO₂ sequestration capabilities (via precipitation and adsorption) and are still underappreciated, especially in fractured rocks. We propose to simulate these chemo-mechanical interactions in fractured rock samples of different mineral compositions by using a triaxial apparatus modified to allow CO₂ injection under in situ temperature and stress. Samples will be characterized by mineralogical, petrographic, microstructural and geochemical analysis and micro-CT scans before and after the experiments (lab & analyses: 40% of time). CO₂-H₂-H₂O-CH₄ phase diagrams will be used to identify the better substrate for CO₂ capture. Analysis of CO₂ adsorption energetics on different minerals will be carried out with computational chemistry approaches (quantum and/or classical modelling at atomic resolution). Upscaling from laboratory to decametric scale will be based on the study of well-exposed outcrops showing evidence of fracture-controlled fluid-rock interactions (20% of the time).</p> <p>The candidate will spend at least six months at the Department of Geosciences and Physics of the University of Oslo. The set up of the experimental apparatus will be supported by the TECLA project.</p> <p>The PhD student will be co-supervised by Claudio Greco, Andrea Bistacchi, Nadia Malaspina and Fabio Rizza.</p>			
Supervisor webpage: https://www.unimib.it/silvia-mitterpergher			
Notes: shortlisted for the Department of Excellence TECLA position on “Monitoring of the effects of ongoing climate warming and mitigation strategies and techniques” (Monitoraggio degli effetti del riscaldamento climatico in corso e strategie e tecniche di mitigazione)			

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n. 13		Supervisor	Riccardo Castellanza
Title	Extreme precipitation changes: local drivers and impacts		
<p>Climate change is affecting the occurrence and the intensity of extreme weather and climatic events. In this project, the focus will be on extreme precipitations and on the identification of the drivers of their change, separating large scale dynamical and thermodynamical mechanisms from more local processes. Previous research highlighted the existence of a different rate of change of extreme daily precipitation in nearby rain gauge stations, depending on the elevation and on the degree of urbanization at or near the station location. Goal of this project is to identify possible mechanisms responsible for this different response. To this aim, different means through which urbanization is known to affect local climate will be considered, including the role of urban heat islands, surface friction modifications, evapotranspiration effects, and aerosol loadings. Impacts at the regional and local scales will also be investigated, in order to provide tools for a seamless risk assessment plan, that goes from the identification of the hazard provided by the anomalous precipitations to the effects on local infrastructures. Different types of data will be used for the project, including observations from stations and remote sensing, reanalysis, and modeling outputs.</p> <p>The PhD student will be co-supervised by Claudia Pasquero (UniMIB). The work will contribute to the identification of urban planning and management strategies that can mitigate the effects of climate change on heavy rainfalls (strategic objective 4, action 3). It nicely complements active research projects (PRIN – PNRR LocCLIMA, PNRR MUSA) and will be performed in close collaboration with prof. F. D’Andrea of the Ecole Normale Supérieure de Paris, where the candidate is expected to spend 12 months. It is foreseen that a joint PhD agreement (cotutelle) will be signed by the two Universities, with the possibility of awarding a double PhD degree.</p>			
Supervisor webpage: https://www.unimib.it/riccardo-pietro-castellanza			

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n. 14		Supervisor	Matteo Ciantia
Title	Experimental and numerical study of Artificial Ground Freezing (AGF): assessing various technologies and their environmental impact in real-world applications		
<p>Artificial Ground Freezing (AGF) serves as a relevant ground improvement technique supporting both open-pit and underground construction projects. This method reduces soil temperature using heat exchangers, commonly referred to as freezing pipes, which are supplied with various liquid coolants such as liquid nitrogen, brine, or liquid CO₂.</p> <p>The primary objectives of this study are to gain comprehensive insights into the physical processes underlying artificial ground freezing through a combination of experimental testing and 3D numerical modeling. The project unfolds across three distinct phases:</p> <p>Phase 1 focuses on conducting experimental studies to clarify the process of artificial freezing and thawing of soils. This involves the development of freezing pipes fed with different refrigerants, the design of a versatile testing system capable of accommodating varied conditions, and the execution of tests with comprehensive evaluation using strategically positioned temperature sensors. Insights gained from this phase will inform improvements in experimental methodologies.</p> <p>Phase 2 regards the application of numerical models, particularly finite element modeling (FEM) codes, to compare with experimental results and real-world case studies. Through this phase, we aim to validate numerical calculation codes against experimental observations and extend their applicability to practical scenarios.</p> <p>Phase 3 addresses the environmental impact assessment and sustainability considerations of the AGF technique. With a detailed understanding of the artificial freezing and thawing processes, we shift focus towards evaluating the method's sustainability and resilience, particularly concerning climate change mitigation and CO₂ emissions reduction.</p> <p>By systematically progressing through these phases, this research is aimed to enhance our understanding of AGF, bridge the gap between experimental and numerical approaches, and contribute valuable insights towards the sustainable application of this technique in construction projects</p>			
Supervisor webpage: https://www.unimib.it/matteo-oryem-ciantia			
Notes: High apprenticeship position at Groutfreezlab s.r.l.			