

## GEODYNAMICS AND STRUCTURAL GEOLOGY

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The research-line is devoted to the study of past and present active margins. Active margins are lithospheric sites where structural, stratigraphic, igneous, and metamorphic settings are re-organised. This topic is approached with the application of structural analysis and mapping, integrated with petrological, geochemical, and stratigraphic techniques. This approach also permits the localisation of strategic mineral resources in the Earth crust and mantle. Thus, this research-line is developed in “Earth System” and “Georesources” curricula.

### ***Active margins***

In the last two decades, active margins have been investigated with increasing detail by means of the integration of structural, petrologic, stratigraphic, and geophysical techniques. In addition, the refinement of quantitative geodynamic modelling shed light on the dominant tectonic mechanisms. The study of deformation-metamorphism and deformation-magmatism relationships allows inferring the geodynamic evolution of wide portions of orogenic belts, such as the Alps. The crucial point is separating rift-related from subduction-collision-related tectonic imprints by reconstructing the thermal regimes characterising successive tectonic phases.

Recent evidence indicates that single litho-tectonic units of orogens may display contrasted thermal and structural evolutions, often diachronic and therefore corresponding to different tectono-metamorphic units. The thermo-mechanical memory of these units may be deciphered by analysing the mineral-scale fabric and related mineral assemblages of crustal fragments piled up in mountain belts. In this way, crustal portions that underwent the same tectono-metamorphic evolution can be individuated, and the evolving architecture of tectonic units may be evidenced.

The comparison between structural data from collisional belts with data acquired on present day cases becomes fundamental to infer the past tectonic settings. For example in order to infer the pre-subduction evolution the idea that the modern analogue of the western Jurassic Tethys are the Atlantic-type margins has been refined with the support of more recent data acquired on the Iberian and Newfoundland margins. They actually seem to show good structural, igneous, metamorphic and sedimentary affinities with Alpine-type contexts.

### ***Deformation mechanisms and Georesources***

Deformation mechanisms active at different structural levels and geodynamic settings are key-tools to locate concentration of strategic elements (as Li, REE, PGE) in the Earth's lithosphere. Multiscale structural analysis can be finalised to the 3D reconstruction of discrete structures, which are the pathways of fluids responsible for dissolution-transport-precipitation of ore minerals. Therefore, the structural mapping and the identification of mega to micro scale deformation heterogeneities is the fundamental support for this georesources-oriented structural analysis.

### **Topics:**

Enrolled students may take challenge on the following topics:

- A) Meso and micro-structural data acquisition through detailed structural fieldwork: this comprises structure individuation, description, and their relative chronology assessment to get structural maps of foliation trajectories. These observations can be integrated with microstructural and petrographic analyses in order to individuate field strain gradients, useful to verify the interaction of fabric evolution, progress of metamorphic reactions, and fluid pathways. Finally modelling of the superposed structures will be critical to reconstruct complex polydeformed geometries and to evaluate the dimensions of tectono-metamorphic units and economic mineral concentrations.

- B) Quantitative analyses of microstructures, to reconstruct the Shape and Lattice Preferred Orientation of minerals marking fabrics, at different PT conditions. The quantitative microstructure analysis will improve the knowledge of dominant deformation mechanisms active at granular scale in each polycrystalline aggregate in convergent and extensional settings.
- C) Micro-structural, SEM, and WDS-EDS EMPA analyses of structurally characterised rocks to infer physical metamorphic conditions of successive deformation stages.
- D) Evaluation of volumes of tectono-metamorphic units (based on meso- and micro-structural analyses), reconstructions of strain gradients, petrologic evolution, and ages of successive re-equilibration stages; relationships between tectono-metamorphic and lithostratigraphic units to improve the confidence in the reconstruction of rock paths within active margins.
- E) Geodynamic modelling supporting quantitative tectonic interpretation will be reinforced by the comparison with the synthesis proposed for present-day subduction zones and passive margins, derived by morpho-tectonic, seismic, and drilling data from the Integrated Ocean Drilling Program.

*On-going projects:*

Students admitted to the PhD program benefit of laboratories and equipment available at the Department of Earth Sciences "Ardito Desio" of Università degli Studi di Milano and will be supported by research grants available to the tutors.

The active international projects are:

Variscan geodynamic reconstructions in the External Crystalline Massifs of the Western Alps (Université de Nice-Sophia Antipolis; Geoazur-OCA, France)

Individuation of tectono-metamorphic units in the Monashee Complex, Omineca Belt, Canadian Cordillera. (University of New Brunswick - Department of Earth Sciences, Canada; Colorado School of Mines - Department of Geology and Geological Engineering, USA)

Quantitative 3-dimensional lattice (LPO) and shape (SPO) preferred orientation analysis of naturally deformed rocks (ENS d'Ingenieurs de Caen, Institut Laue-Langevin, Grenoble, France; Elettra Sincrotrone, Trieste, Italy)

Integration of structural-microstructural constraints and isotopic signature in HP metamorphic terranes (Department of Earth and Environmental Sciences, Lehigh University, Bethlehem, PA, USA)

Geochemistry and tectonics (Department of Earth and Atmospheric Sciences, University of Huston, USA).