EXPERIMENTING THE EARTH

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Experimenting on minerals, fluids, rocks and magmas have contributed significantly to our better understanding of geological processes. Mineral transformations, solid-fluid reactions, devolatilization and melting processes, kinetic evolution are approached at the Department of Earth Sciences in Milano, profiting of a variety of experimental techniques, ranging from high temperature furnaces at room pressure to high and ultra-high pressure gas and solid-media machines. A comprehensive list of laboratory equipment available can be found here. We approach the non-ambient conditions moving from mineral physics and petrology perspectives. Understanding of the processes is completed by the crystal-chemical study of akin chemical natural proxies to the phases obtained in experimental runs.

Mineral physics and crystallography at extreme conditions

A full understanding of the physical and chemical properties of natural materials at the high-pressure and high-temperature conditions of the deep interior of our planet is fundamental to formulate so a coherent model of structure and evolution of the Earth as to link with each other the many constraints from seismology, geochemistry, petrology, mineralogy and geodynamics. Such knowledge underlies both our general understanding of the Earth, and our capacity to best exploit the many natural resources available. Among the current research topics receiving nowadays considerable attention in Mineral Physics one may reckon:

- elasticity, thermoelasticity and equations of state (EoS: relationship between pressure-volume-temperature) of solids
- phase transitions and transformations of mineral phases triggered by pressure and temperature
- incorporation of water, carbon and other volatiles in high-pressure phases and their effects on the physical properties and deep Earth processes
- crystal structure determination of new phases stabilized at lower mantle pressures and temperatures
- valence and spin configuration of transition metals, and especially iron, at extreme pressures

We are mainly interested in phase-stability, thermo-elastic properties and P/T-induced structure evolution (at the atomic scale) of natural crystalline materials and their synthetic counterparts, and in particular:

oxides
carbonates
sulphides
feldspathoids
phyllosilicates
inosilcates
ciclosilicates
sorosilicates
high-pressure hydrous materials
calcium aluminates

with in situ single-crystal and powder X-ray/neutron diffraction experiments at extreme P/T-conditions, performed with in-house lab equipment and at synchrotron and neutron large scale facilities.

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Petrological and tectonic evolution of the lithospheric mantle in extensional settings.

The formation of the oceanic lithosphere is controlled by melt transport from the mantle to the surface. A research project is dedicated to better constrain melt focusing toward the spreading ridges and melt accumulation processes at and across the mantle-crust boundary.

We use experimental techniques to investigate the temperature and melt flow conditions on the origin of the olivine-rich troctolites, the reactive primitive gabbroic series which mark the transition from mantle to crustal processes in the oceanic lithosphere. Experimental data are combined with field based microstructural and geochemical studies of mantle-crust sections exposed in ophiolite areas (Alpine-Apennine chain, Oman).

Along its subsolidus path, we further investigate the progressive mineral chemical variations in response to the spinel- to plagioclase-facies transition to constraints the pressure evolution of the lithosphere.

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Volatile transfer at convergent plate margins: COH fluids/melts heterogeneities in subduction zones

The dynamics of the Earth's mantle is largely governed by the mutual relationships of volatile-bearing compounds. Elemental recycling, mantle melting, and volcanism are affected by volatile speciation, notably C-O-H species. The fate of volatiles closely depends on the stability of hydrates and carbonates, which in turn is related to the redox state. While H_2O is extremely mobile in fore- and sub-arcs, experiments and phase relations indicate that C is stably fixed in carbonates, being released in carbonatite magmas in the deep mantle. High CO_2 emissions from supra-subduction volcanoes and findings of carbonate-bearing xenoliths however do indicate that C is also released at shallower depths. This research topic is currently focusing on the conditions for fluid-absent and fluid-present melting in COH-bearing mafic- and ultramafic rocks as well as on dissolution and speciation in COH-fluids, to provide a better understanding of volatile cycling at subduction zones. In addition, REE-bearing hydrous carbonatites are modelled in simple chemical systems and investigated at high pressure in order to unravel phase relations, chemical-physical, transport properties and crystal chemistry of REE-carbonatites liquids and minerals of relevance for improving our knowledge on strategic georesources.

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