SYNCHROTRON RADIATION IN THE EARTH SCIENCES

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Currently, a significant part of the research in the fields of the Earth, Environmental and Planetary Sciences takes advantage of synchrotron radiation (SR) sources, of the unique characteristics of the emitted radiation, and of the advanced beamline instrumentation to investigate at an atomic level the chemical, physical and crystallographic properties of geological materials. Most of these mineralogical, petrological and geochemical studies are performed in the energetic range corresponding to hard X-rays, even if the use of soft X-rays and UV and IR radiations is also extremely useful, for example to study the structural environment of light elements and for the characterization of mineral-fluid interfaces.

In the Earth Sciences studies, SR can be used through two main different approaches: a) for applications of conventional techniques, already widely used in mineralogical investigations, but by which we intend, for instance, to study extremely small volumes, or to obtain better resolution, signal-to-noise ratio and detectability limits with respect to conventional sources; b) as an unique radiation source, necessary for specific techniques such as XAFS spectroscopy on trace elements, XAFS and X-ray diffraction under extreme P and T conditions, anomalous scattering, in-situ kinetic studies of phase transitions and synthesis reactions, X-ray fluorescence microanalysis with high spatial resolution and low detectability limits, X-ray topography and tomography.

Since Earth materials are often heterogeneous, X-ray microbeam studies are valuable in unraveling this complexity. Most SR-X-ray based methods can be applied with high spatial resolution, including X-ray fluorescence, X-ray absorption fine structure, X-ray diffraction, and computer microtomography. Moreover, by applying these techniques in a nearly simultaneous fashion, it is possible to produce elemental maps with sub-part-per-million sensitivity and determine the speciation and mineralogy at selected locations in the material.

This lesson will review some applications and developments in the fields of SR-based Earth Sciences research. Some of the main problems of modern mineralogy, petrology and geochemistry will be discussed and a number of recent case studies will be presented to show what extent synchrotron radiation can contribute to their solution.