Hierarchical length-scale studies in paleo-geobiology by scanning X-ray imaging

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Scanning X-ray imaging provides unique insight into micro- and nanoscale geochemical heterogeneities of a large range of samples. Recent methodological and technological advances fostered the development of simultaneous complementary multi length-scale and multi-technique scanning imaging techniques. The simultaneous application of these multi-scale tools allows revealing a wide array of textural, mineralogical and redox state information of ancient rock records, microfossils or their modern analogues. The large, >100 μm, penetration depth permits to detect these characteristics in buried structures and also in three dimension (scanning tomography). Moreover, the non-destructive nature of these techniques makes their application possible to unique palaeontological specimens. As such, they provide a valuable help to extract paleo-geobiological information from ancient geological and microfossil records and to contribute exploring the coupled evolution of life and the Earth surface system.

The Nanoscopium beamline at Synchrotron Soleil (St Aubin, France) is dedicated to such multi-modal, hierarchical length-scale X-ray imaging studies. Namely, during the same experiment large field of view studies of some mm2 sample areas with micrometre spatial resolution can be combined with high, ~300 nm, resolution investigations of a sample sub-region. As such, the beamline aims to bridge the gap between millimetre- and sub-micron-scale observations, providing simultaneous information on the distribution of major and trace elements, sample morphology and chemical speciation.

In this presentation we present some of the latest methodological developments including non-invasive multi-scale data of the morphology and trace element content, distribution and speciation of individual (micro)fossils and living and fossil microbial mats embedded in complex organo-mineral matrices. Together with a knowledge of the environmental conditions of formation, these data provide new means of characterizing present-day and ancient bio-geochemical pathways in the Earth record.