Ptychography: A powerful X-ray imaging tool

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Ptychography is a form of diffractive imaging in which overlapping regions of a specimen are illuminated by coherent radiation, the resulting scatter patterns recorded, and an image formed using iterative algorithms [1, 2]. The method is currently undergoing a renaissance as a tool for X-ray imaging [3, 4], since its genesis as an electron microscopy technique in the late 1960s.

The principal benefit of ptychography is its experimental simplicity: no focussing optics are required in a ptychographic experiment, with resolution being limited only by the angular width of the recorded scatter patterns. Despite being successfully demonstrated only recently in the X-ray regime, ptychographic imaging has advanced to a stage where sub 50nm resolution is obtainable using hard X-rays [5]. Ptychography also produces quantitative phase images that in the x-ray regime can be used to measure electron densities accurately. By varying the beam energy ptychography can provide chemical contrast and it can be combined very effectively with tomography to produce three-dimensional images [6].

Here we will introduce the ptychographic method and describe how it works. We will discuss the merits and drawbacks of the technique relative to more established methods such as Scanning Transmission X-ray Microscopy (STXM), and we will present results from recent soft X-ray experiments at the ELETTRA synchrotron in Trieste, where ptychography was used to image iron nanoparticles within cells.

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Detailed field relations of pre-3.85 Ga zircon bearing metasediments from southern Montana (USA)

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Paleoarchean fuchsitic detrital quartzites in the Bearthtooth Mountains (Wyoming craton, southern Montana, USA) are one of the few documented localities that host Hadean (>3.85 Ga) detrital zircons [1]. Our high-resolution mapping (1:250) revealed several other rock-types in the area that include intrusive granitoids and mafic dikes, banded iron-formation (BIF), paragneisses, and a possible meta-conglomerate. Zircon geochronology from quartzites and paragneisses [1; this study] reveals several age populations: >3.6-4.0 Ga; 3.4-3.6 Ga; 3.2-3.3 Ga; 3.0-3.1 Ga; and 2.7-2.8 Ga. Some of these are coincident with known metamorphic events [2] responsible for discordant ages seen in much of the data. We find that there is no obvious correlation between degree of discordance and zircon-bearing lithology.

Zirconiferous quartzites are Cr- (40-360 ppm) and SiO_2- (93-95 wt.%) rich with low Zr (37-81 ppm). Paragneisses resemble the quartzites (Cr: 230 ppm), but with less SiO_2 (75 wt.%) and more Al_2O_3 (14 wt.%) and high Zr (348 ppm); paragneisses and quartzites follow expected weathering trends for a mixed granitoid + mafic source [3]. A candidate conglomerate (SiO_2 77 wt.%; Al_2O_3 14 wt.%) and (intrusive) granitoids (SiO_2 73 wt.%; Al_2O_3 15 wt.%) resemble the paragneisses, but the conglomerate has 70 ppm Cr and 49 ppm Zr, whereas the intrusive felsite body is Cr-poor (<D.L.), with typical orthogneissic Zr (167 ppm). The BIF is Fe_2O_3-rich (51 wt.%) with low SiO_2 (44 wt.%) and minor Al_2O_3 (3 wt.%), Cr (50 ppm) and Zr (26 ppm) pointing to a detrital component; multi-element plots compared to other BIFs and normalized to NASC shows a similar positive slope, but with no Eu anomaly and low (but still superchondritic) Y/Ho (28.7). In PM-normalized spider diagrams, detrital and igneous 'felsic' lithologies show enriched LILE, negative Nb anomalies, with depletions in Sr and Ti.

Ancient detrital/xenocrystic zircons confirm that older crustal components existed in the area, suggestive of a genetic link between the Beartooth quartzites and the geology of the Western Slave Province [1] and perhaps the Thelon Basin in Nunavut [3] and the Assean Lake Complex (Manitoba; [4]).

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