

Micro X-ray Florescence (μ XRF): A new analytical method for non- destructive mineral analysis

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Introduction

Recent development of X-ray florescence systems permits analysis of objects at the micron-scale, i.e. μ XRF. The spacial resolution of μ XRF instruments is 10-100 μ m permitting XRF analysis of individual minerals at scales where chemical zonation can be identified. The relative strengths and limitations of this new technique for mineral analysis are discussed. Most μ XRF instruments use EDX detectors which allow entire energy spectra to be simultaneously collected. The main advantages of μ XRF over EDX equipped electron microscopes are increased background to noise ratios and greatly reduced sample preparation. Electron sources offer higher resolving power, and light element sensitivity is somewhat better due to the higher vacuums used.

Spectral Mapping

The primary use for μ XRF systems in mineral analysis is in spectral mapping. An entire thin section can be mapped in about 12 hours. Using hyper-spectral mapping routines it is possible to build elemental maps for X-ray signals anywhere between 100eV and 40 keV. Spectra from individual pixels can be combined to provide reasonably accurate, quantitative analysis of specific map sections. This data can then be coordinated with imaging techniques such as cathodoluminescence and other analytical techniques such as laser ablation ICP-MS.

Spectral Analysis

Electron interaction in most matrices is extremely limited and X-rays are therefore emitted from very localized volumes. When using an X-ray source the depth (volume) of X-ray emission is extremely variable depending on the element of interest. For example, Na X-rays will be emitted from a ~5 μ m depth, Ca X-rays from ~30 μ m, and Sr X-rays from over 2.3 mm in silicate minerals such as feldspars. This makes stoichiometric mineral analysis using the X-ray data very difficult to interpret. Some examples of procedures for quantitative μ XRF analysis using both spectral mapping and analysis routines will be presented in detail.

Triple-dating of detrital apatites and zircons from Prydz Bay, East Antarctica

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Triple-Dating Method

For detrital thermochronology, linking individual grains in time-temperature paths is desirable since it cannot be assured that mineral grains came from the same outcrops. We achieve this by dating individual grains with three systems—the high temperature (U-Th)/Pb system, the low temperature fission track system, and the lower temperature (U-Th)/He system to directly link source constraints and cooling ages of all three systems to create more robust provenance and time-temperature paths for our samples.

Gamburtsev Mountain Results

The formation of the Gamburtsev Subglacial Mountains (GSM), which is buried under ice in the interior of East Antarctica, has eluded scientists since its discovery in the 1950's. Because no outcrops rise above the ice sheet, this problem is ideal for application of our triple-dating method. We used Eocene fluvial and Quaternary glacial sediment cores from Prydz Bay to sample the GSM. High-temperature (U-Th)/Pb ages on apatite and zircon show a dominant ca. 500 Ma peak with subordinate older zircon populations, ruling out a recent volcanic formation.

(U-Th)/He ages on apatite and zircon from these samples range from 100 to 300 Ma, with zircon and apatite FT age peaks between 250 and 300 Ma. Young mountains formed by rapid uplift and erosion of old crust would be expected to show younger low-temperature cooling ages due to rapid denudation.

These data are consistent with a large pan-African GSM formation event around 500 Ma and subsequent gradual cooling. Low-temperature thermochronometer t-T modeling does not preclude lower temperature events since 500 Ma, especially at the 300 Ma FT age peak, but does imply an extremely slow overall erosion rate since ~500 Ma.