Imaging of Organic Substances by Time-of-Flight Secondary Ion Mass Spectrometry (ToF-SIMS): Potentials for Biogeochemistry

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Time-of-Flight Secondary Ion Mass Spectrometry (ToF-SIMS) is an analytical tool for surface analysis. Applying ToF-SIMS the impact of primary ions leads, among others, to the desorption of secondary ions that are characteristic for the composition of the sample's surface. These secondary ions are mass separated and detected by a Time-of-Flight analyzer.

ToF-SIMS offers brilliant imaging options as it is possible to focus the primary ion beam and to raster it over the surface of the sample: The intensity of each detected secondary ion in each rastered pixel can be displayed according to a colorscale. Thus, information on the distribution of elemental as well as organic chemical components can be gained.

Whereas most inorganic components can already be analyzed routinely by this technique ToF-SIMS has developed into a mature technique for the characterization of biomaterials. Nevertheless, imaging applications in this area have been sparse due to the fact that the achievable lateral resolution is not only a function of the primary beam diameter but also of the achievable secondary ion yields (i.e. the number of generated secondary ions per impacting primary ion) of the respective materials. Up to a few years ago typical values for the lateral resolution routinely obtained were in the order of some micrometers using monoatomic primary ion sources. This value can be improved tremendously using recently developed polyatomic primary ions: Just as well as their monoatomic counterparts these projectiles can be focussed down to 50 nm but – more importantly – show a remarkable enhancement of secondary ion yield for molecular secondary ions. Therefore, organic imaging well in the sub-µm range now becomes possible as it could already be shown for a number of samples, e.g. in the field of biochemistry and pharmaceutics.

This paper will show the state-of-the-art on ToF-SIMS imaging of biomaterials. Starting with an overview on the general principle of the technique it will focus on the possibilities and limitations regarding the analysis of substances and samples of interest for biogeochemistry.

Petrogenesis and geochronology of jadeitites from the Cycladic blueschist belt, Greece

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Jadeitite is a relatively rare rock type which is usually found in association with high-pressure/low temperature rocks and serpentinites in subduction zone settings. The formation of this rock type is yet not fully understood but precipitation from aqueous fluids or fluid-assisted metasomatic alteration of a pre-existing rock represent the most plausible petrogenetic concepts (Harlow & Sorensen, 2005). In the Cycladic blueschist belt jadeitites have been recognized as minor constituents of eclogite- to epidote blueschist-facies mélange sequences on the islands of Syros, Tinos and Andros. These jadeitites commonly are zircon-bearing and thus are suitable targets for U-Pb geochronological studies. Correct interpretation of zircon ages requires in-depth understanding of the jadeitite-forming process. In order to unravel the origin of these occurrences, we have initiated a study that combines field observations with petrological, geochronological and geochemical aspects, including trace element compositions of zircon.

Preliminary mass balance calculations indicate substantial metasomatic addition of Na to meta-igneous and meta-sedimentary mélange blocks on Syros. These observations are consistent with experimental results which show that Na concentrations can be considerable in subduction zone fluids (Topper and Manning, 2004). It is possible that these Na-rich fluids were also important for jadeitite formation.

New ionprobe $^{206}Pb/^{238}U$ results for two samples from Syros yielded weighted mean averages of 80.6 ± 1.7 Ma and 82.0 ± 2.1 Ma, respectively. Two samples from Tinos provided $^{206}Pb/^{238}U$ ages of 82.3 ± 1.7 Ma and 78.4 ± 1.8 Ma. These results further corroborate the geological significance of a previously reported Cretaceous age group for mélange blocks. Work in progress aims to document unambiguously the jadeitite- and zircon-forming process and to link U-Pb ages to a specific stage in the evolution of this rock type.

References

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