

## Environmental molecular geochemistry developed by fluorescence XAFS using high energy resolution fluorescence X-ray detection

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X-ray absorption fine structure (XAFS) is an elemental speciation method that is highly element-selective and provides information on the valence and local structure of almost all elements. The fluorescence XAFS method allows the speciation of elements at lower concentrations and has therefore been applied to the speciation of elements in various natural samples and to the elucidation of chemical elemental processes in laboratory experiments simulating natural conditions. Thus, fluorescence XAFS is now an essential method in space geochemistry and environmental chemistry (Takahashi et al., 2025). This presentation will show (i) examples of the application of fluorescence XAFS methods to elements that are difficult to detect by conventional methods, and (ii) examples how new chemical species information has been obtained by increasing the energy resolution of the X-ray fluorescence (XRF) detection system to obtain XAFS. In particular, a new spectroscopic technique called High Energy Resolution Fluorescence Detection (HERFD)-XANES has been developed in recent years, which is obtained by detecting XRF with an energy resolution higher than the lifetime width of the electron orbitals (the energy resolution is 1 eV or better). This method is powerful in detecting new species in terrestrial materials, such as U(V) species adsorbed on iron oxides (Yomogida et al., 2024). Although the use of the crystal analyzer is the main method to increase the high energy resolution detection of fluorescence X-rays, recent advances using high energy resolution energy dispersive detectors are also given. In particular, the transition-edge sensor (TES) detector is a powerful detector with the energy resolution better than 5 eV, although the count rate of this detector is low such as 10 cps/element. Therefore, the multi-element TES detector is important to obtain XAFS spectra with better signal-to-noise ratio. The 5 eV energy resolution is not sufficient to obtain HERFD-XANES for various elements, but the TES detector is still useful to detect XRF with better signal-to-background (S/B) ratio. In particular, the detection of trace elements whose XRF peak overlaps with that of major elements is very useful to obtain XAFS spectra for trace elements (Konagaya et al., 2021; Li et al., 2023). By making full use of these techniques, it is possible to understand physicochemical information at the atomic level and various elemental chemical processes based on this information. This information, in turn, will contribute to a better understanding of the Earth's material cycles and elemental cycles at different scales (= molecular geochemistry).

### References

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