The Earth Science Program at NSLS-II Tender and Hard X-ray Microprobes TES & XFM

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What we do: Microbeam and bulk X-ray absorption spectroscopy (XAS), X-ray fluorescence (XRF) imaging, chemical speciation mapping, and microdiffraction, in heterogeneous natural materials.
Earth's Critical Zone: we and our users study the distribution, associations, chemistry, speciation, structures, transformations, abiotic and biotic redox reactions, transport and cycling, of essential nutrient elements such as P, K and Fe, and important contaminants such as As and U, in soils and sediments. These materials, and the (bio)geochemical and physical processes occurring in them, are heterogeneous at the grain scale, as well as at various temporal scales from minutes to millennia. Critical Zone systems are highly sensitive to manipulation by e.g. plant roots, microbes and fungi, and show complex responses to perturbations due to human activity, agriculture, flooding, climate change, and sea-level rise. The geologic and biomineral record preserves much information about paleoclimate, but needs to be decoded.
Shallow to deep crustal processes and Critical Materials: projects span various magmatic, volcanic, fluid-rock interaction, hydrothermal and metamorphic processes, focusing on redox, mineralogical changes, and/or the mobilization and concentration of trace elements. Our close affiliation with FIRST (Facility for Isotope Research and Student Training, an EAR-funded laboratory at SBU) enables correlated chemical/structural (synchrotron) and source/fractionation/dating (isotope) studies at comparable microscale. Several studies address NSF-defined Critical Materials, such as REE in US deposits.
Deep Earth processes: studies of the deeper Earth include the role and fate of volatiles, phase relations and site disorder particularly involving Si and Fe, oxybarometry, and trace elements.

What we have: two beamline facilities co-designed as complementary Earth/enviroscience resources.
TES is a tender energy beamline optimized for 1.2-5.5 keV, and designed to deliver XAS including full EXAFS, from bulk to microbeam scales, as well as XRF imaging and chemical speciation imaging with user-tunable spot size down to ~2 um. Beam position at the sample is decoupled from energy, enabling EXAFS, or XANES of several different elements, of particles or domains *the same size as the probe beam*. Sample environment is helium at 1 atm, for samples that are not vacuum tolerant.
XFM is a hard X-ray microprobe optimized for 5-17 keV (full range 2.4-23 keV), and also offering XAS (including EXAFS), XRF imaging and chemical speciation mapping, with spatial resolution down to ~2 um. The higher energy range at XFM enables fluorescence tomography for 3-D imaging, as well as microdiffraction. In addition, XFM has a pink beam mode with very high flux for rapid 2-D and 3-D XRF imaging.
Many Earth and environmental science experiments require multimodal measurements at both TES and XFM, and we have developed interchangeable sample mounts and cross-registration protocols. *More than 50% of Earth/enviroscience user proposals at TES and XFM request access to both beamlines*.

What we need:

User support and outreach efforts require Earth and environmental science expertise. Since the facilities are operational, and EAR-IF and others have already invested in the instrumentation, the required budget is only for scientific effort to operate the facilities and to support EAR users. It is essential to guide user experiments, and tune beamline capabilities for these experiments, in order to make efficient and effective use of synchrotron facilities for EAR science and training.