

COMMUNITY-DRIVEN MANAGEMENT OF SYNCHROTRON-BASED MINERAL PHYSICS FACILITIES

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Many areas of geoscience have benefited profoundly from the development of synchrotron light sources as user facilities, but none more so than mineral physics. A large majority of experimental mineral physics research relies on synchrotron applications, so much so that a highly impactful and productive program can be managed with relatively modest experimental preparation capabilities in the home laboratory, leveraging access to the powerful X-ray sources at user facilities. Early recognition of the importance of synchrotron tools led U.S. mineral physics researchers to develop cooperative funding structures that benefit the community broadly, which stimulated rapid growth in mineral physics research and high-impact unraveling of the mineralogy, structure, and evolution of Earth's deep interior. This community-focused development of funding and management structures continues to benefit not only the mineral physics community but an ever-increasing range of synchrotron geoscience applications.

Cooperative synchrotron access for the mineral physics community in the U.S. began with CHiPR, the NSF-funded Center for High-Pressure Research organized in 1991 by researchers at Stony Brook University, the Carnegie Institution of Washington, and Princeton University. This effort helped spur a revolution in high-pressure science, based largely on technical developments that exploited synchrotron-based probes of in situ high-pressure, high-temperature experiments. Several years afterward, the organization of the Center for Advanced Radiation Sources (CARS) at the Advanced Photon Source similarly made synchrotron access available for geoscience users of an even broader range of techniques. Again, mineral physicists were highly represented among the GeoSoilEnviroCARS (GSECARS) user base, because of the natural coupling of powerful X-ray sources with high-pressure, high-temperature experimental apparatuses.

Recognizing the potential of making these resources even more available to the broader mineral physics community, the Consortium for Materials Properties Research in Earth Science (COMPRES) emerged in 2002, eventually leveraging synchrotron beamline access at three different synchrotron facilities—the Advanced Photon Source, the National Synchrotron Light Source(-II), and the Advanced Light Source. In both the COMPRES and GSECARS models, virtually all of the beam time managed by these organizations was awarded on the basis of General User programs; these NSF-funded organizations democratized synchrotron access for the growing mineral physics community.

Synchrotron Earth and Environmental Science (SEES), which formed in 2023, continues in this tradition and builds upon the lessons learned from these predecessor organizations. SEES manages NSF funding for Earth and environmental science research operating at more than 15 beamlines across four synchrotron facilities, including all of the GSECARS and former COMPRES beamlines, many of which focus on mineral physics applications. This new management structure integrates technical expertise across the facilities and aids strategic planning to better serve the research needs of the community.

The benefit of these organizations to mineral physics has been not only in providing access, but also the investment made in equipment and software, and in people. Because key infrastructure that high-pressure experimentalists need is installed and ready at the beamline, visiting users became much more efficient in their use of beam time, so many more researchers can be accommodated each year. (This has been a great step forward over my own experience as a postdoc in the 1990s, during which all components for a laser heating optical system

were brought to the beamline and reassembled for each synchrotron visit.) Skilled beamline staff specializing in supporting Earth science applications promote efficient use of the facility and, moreover, train users in the latest technical developments. In this way, beamline scientists are playing a key role in the development of the next generation of geoscientists.

A distinguishing feature of SEES, like GSECARS and COMPRES before it, is that it operates on behalf of the Earth science general user community as a whole, rather than preserving beamtime for itself. SEES leverages its NSF-funded investment of staff and equipment to negotiate agreements with the synchrotron facilities to support mineral physics and other geoscience research. This strategy is novel among the sciences at U.S. synchrotrons, and is increasingly appreciated by the facilities as a model to promote the broadest, most competitive research in the discipline.

The synchrotron facilities themselves continue to evolve, and SEES aims to leverage the facility improvements to the maximum extent possible. The Advanced Photon Source completed its APS-U upgrade in 2024, and SEES has been investing in instrument upgrades to take full advantage of the enhanced brightness and resolution of the new X-ray source. The ALS now plans to begin its upgrade in 2027, and SEES is positioning to maximize the benefit to geoscience users of ALS-U. Additionally, SEES staff are engaging the conversation at NSLS-II for an eventual upgrade that may further enhance hard X-ray brightness for in situ high pressure mineral physics applications. Organizations like SEES, who channel the voice of a large and impactful population of researchers, are valuable partners in the long range planning at synchrotron facilities.

This history of cooperating to form community-driven management structures for mineral physics research at synchrotron facilities has, in parallel, generated many opportunities to bring researchers and students together to learn from one another, share experiences, and network. In fact, COMPRES was not only a user facility management organization but also a mineral physics society, and its annual meeting was especially effective at promoting early career researchers. Sponsored workshops have been important venues for training researchers in a variety of high-pressure and synchrotron-based techniques. SEES continues to provide a foundation for these connections among mineral physicists and other geoscientists, as well as outreach and education activities to promote our science more broadly. Building upon common interests to support mineral physics and related research is a legacy that SEES thrives on, and we welcome partnerships in building our research community.

For more information about SEES, or to contact us or join our mailing list, please visit <https://seescience.org/>.

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