Sabbatical Activities Report

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During my sabbatical in the Spring 2025 semester, I focused on advancing research collaborations, mentoring undergraduate researchers, expanding educational methodologies, and enhancing analytical workflows in structural geology. The semester was highly productive and impactful both in terms of student engagement and scholarly dissemination.

Undergraduate Research and Scientific Presentation

A significant portion of my sabbatical was dedicated to mentoring four undergraduate research students on a project investigating chemical-mechanical deformation in carbonate rocks. Together, we explored the microstructural signatures of deformation processes in calcite-bearing rocks such as limestone and marble. This work integrates both **natural sample analysis** and **laboratory deformation experiments**, particularly examining the influence of fluid chemistry on deformation behavior.

Our efforts culminated in a research presentation at the **Geological Society of America (GSA) Cordilleran Section Meeting**, held in April in Sacramento, CA. The abstract, *Unraveling Chemical-Mechanical Fault Deformation Processes in Carbonate Rocks*, detailed how manganese-doped experiments revealed an increase in dislocation creep, supported by imaging, crystallographic vorticity analysis, and low-angle misorientation clusters. This result challenges some conventional expectations regarding twin formation and creep behavior under fluid-mediated conditions, pointing to nuanced chemical control over plastic deformation mechanisms. Our presentation was well received and provided excellent visibility for undergraduate-led research in a professional setting.

Advancing Structural Geology Education with VR

In collaboration with two Sonoma State University colleagues (Sara Kassis, Physics and Engineering, and Gurman Gill, Computer Science) and an additional student researcher, I co-led a second research presentation at the same GSA conference. The poster, *Transforming Structural Geology Education: Enhancing Mapping Skills and Spatial Reasoning with Virtual Reality*, presented a pilot study on the integration of VR modules into a Structural Geology course.

The VR experience allowed students to revisit digital outcrops and analyze 3D geologic structures using LiDAR and photogrammetry-derived terrain models. Quantitative pre- and post-activity surveys showed measurable improvements in student confidence and conceptual understanding. Students found the immersive interface particularly helpful for visualizing spatial relationships, refining field maps, and reviewing complex geologic features like folds and faults. Despite some interface learning curves, the

module was overwhelmingly successful and is now informing our broader curriculum design strategies for field-based education.

Development of Image Analysis Techniques

Throughout the semester, I also developed and refined a suite of image processing and analysis tools for microstructural and strain analysis using **Mathematica**. These workflows enable automated recognition of grain-scale features from EBSD and Laue diffraction datasets, computation of GROD (Grain Reference Orientation Deviation) angles, and the analysis of spatial patterning using clustering algorithms, Fry plots, and FFT-based strain inference.

The techniques I developed were instrumental in interpreting deformation patterns in both natural and experimental samples, including metrics for spatial anisotropy, cluster distribution, and local strain magnitudes. I also introduced a framework for applying spatial autocorrelation functions (e.g., Local Moran's I) to identify patterns of mechanical coherence and heterogeneity. These tools are currently being compiled into a formal methodology for future publication and broader research use.

Student Field Enrichment and National Lab Engagement

In addition to research and curriculum work, I organized and led two student field visits to **Lawrence Berkeley National Laboratory (LBNL)** and **Lawrence Livermore National Laboratory (LLNL)**. These excursions provided invaluable exposure to applied geosciences and high-performance imaging techniques. Students engaged with researchers working on subsurface modeling, materials deformation, and geochemistry—broadening their academic perspectives and potential career interests.

Conclusion

My sabbatical afforded focused time for scientific development, student mentorship, and curriculum innovation. The results include two conference presentations, novel analytical tools, enhanced instructional design, and meaningful student experiences. One original goal had been to prepare a proposal for the Department of Energy's FAIR (Funding for Accelerated, Inclusive Research) program. However, this was not possible due to two external developments: Sonoma State University's decision to eliminate the Geology Department and the absence of a FAIR solicitation this year, stemming from shifts in federal policy on diversity, equity, and inclusion (DEI).