

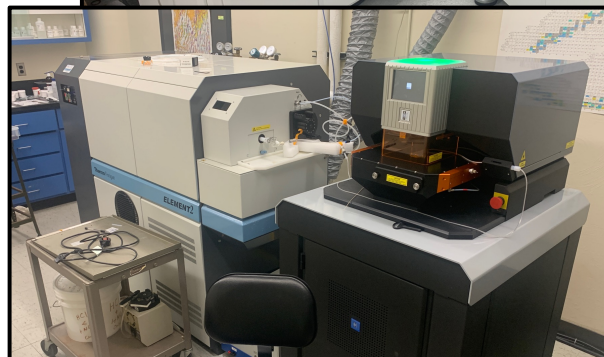
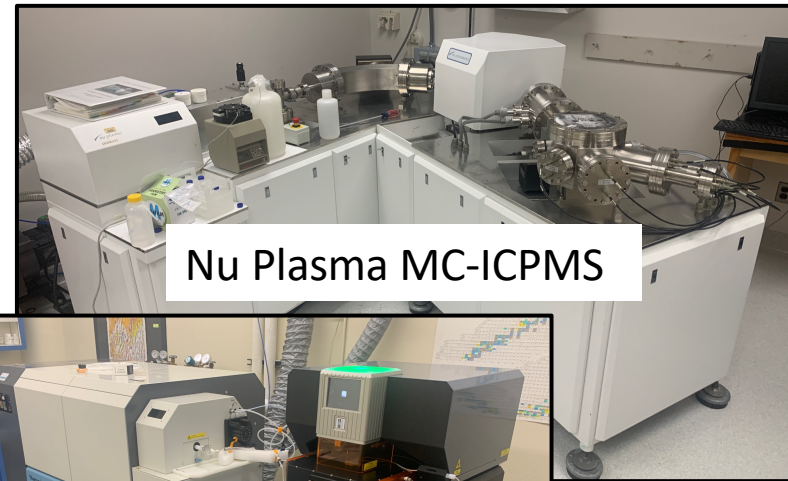
Mark Barton

- Director, Lowell Institute for Mineral Resources
Professor of Geosciences (Geology and Geochemistry)
- Interests:
 - Energy and mass transfer in the lithosphere with focus on mineral systems (e.g., ore deposit characterization and genesis)
 - Fundamentals of mineralogy, petrology and geochemistry
 - Long-term sustainable approaches to mineral resources across the full life cycle of materials use
 - Contributing to the role that universities need to play in achieving that



FY22 – Advancing UA mineral resources and gem science analytical capabilities via Laser Ablation ICP-MS

- 10 faculty + staff from GEOS, MGE, ENVS, ANTH, HAS
- Key goals:
 - (1) general: development of a state-of-the-art shared "Mineral Characterization Facility"
 - (2) specific: upgrade and install new, separately funded femto-second laser, multicollector mass spectrometer, etc.
- *Laser purchased and installed; labs have been refurbished; purchased and installed our 'new' Nu Plasma MC-ICPMS*



Get Involved! Become a member.

School membership is a non-salaried, non-tenure eligible faculty joint appointment within the School of Mining and Mineral Resources (SMMR). Members are interested in promoting the education, research and innovation mission of the SMMR and the University of Arizona. These appointments recognize, encourage, and advance collaboration between educators and researchers in areas related to mineral resources at UArizona.

BENEFITS

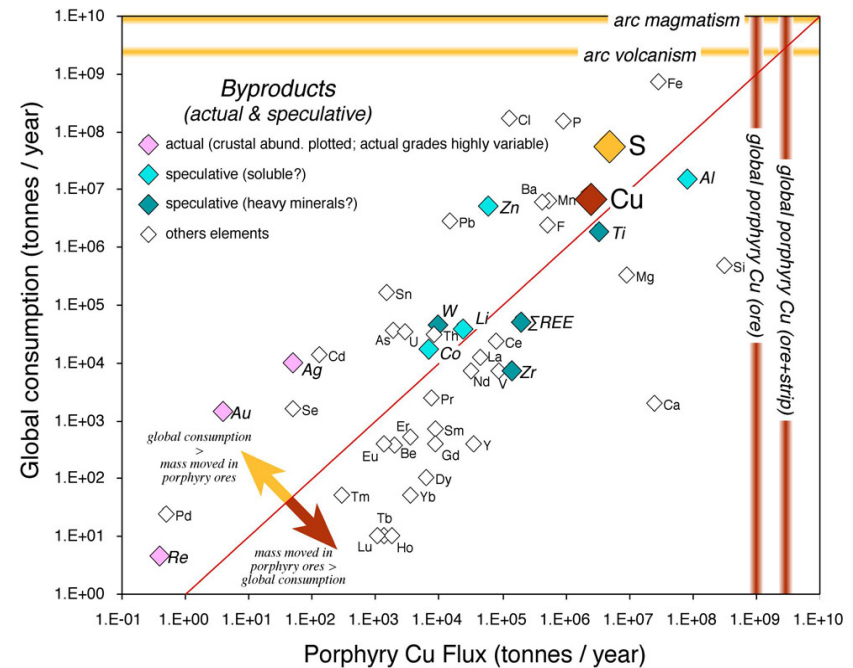
- Recognition as an SMMR Faculty Member
- Priority use of shared resources, equipment, and services of the SMMR, including:
 - Marketing and communications support to
 - help promote member research
 - help promote member education initiatives
- Assistance in
 - development of relationships between SMMR members and external partners
 - event planning as appropriate
- Support for minerals-related education development, promotion and management for
 - graduate and undergraduate courses and curricula
 - professional development programs
 - undergraduate research initiatives
- Ability to apply for
 - interdisciplinary seed grants
 - graduate student support
- Opportunities to participate in
 - collaborative research projects
 - SMMR-sponsored programs and events

If you have questions about membership, or the application process please contact Mark Barton, Director Lowell IMR at mdbarton@arizona.edu



FY23 – Novel sources of critical minerals from porphyry copper deposits

- UA: Isabel Barton, Frank Mazdab, Jason Kirk
external: Freeport-McMoRan + others
- Key goals:
 - (1) preliminary assessment of mineralogical and geological distribution of critical elements in porphyry copper mass flow as novel sources
 - (2) develop industry consortium and government (USGS, NSF) funding
- *proposal is pending*



Comparison of global consumption of many elements compared to the amount moved in the mining of porphyry copper deposits. For many elements more is moved by this type of mining than is consumed globally.



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Isabel Barton

- Assistant Professor, Mining & Geological Engineering
- Minerals-related interests / activities:
 - Geometallurgy: process mineralogy and characterization methods
 - Economic geology and geochemistry
 - History of mineral resource use around the world
 - History of mining, metallurgy, and geology



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Matching funds for R&D consortium on hyperspectral imaging applications to mining

- Collaboration with Dean Riley (MGE), David Brady (Optics), and Kamel Didan (BE/Remote Sensing)
- Objective: Create a consortium to optimize hyperspectral imaging for minesite and metallurgical applications
 - Self-sustaining and integrated across all relevant industry sectors
 - Springboard for longer-term efforts in geometallurgy consortium
- Progress to date:
 - Matching funds obtained from the Society for Mining, Metallurgy, & Exploration
 - Soft-launched this fall; formal launch in January
 - Committed general and partner members: Freeport-McMoRan, BHP, AngloAmerican, Asarco
 - Research underway!



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Calvin Mako

Title: Researcher at the Arizona Geological Survey (AZGS)

Minerals Interests:

General bedrock geologic mapping

Research in tectonics, structural geology and ore deposits



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Geochronology of REE-bearing Proterozoic pegmatites in AZ

Participants: Calvin Mako and Carson Richardson

Goals: Establish the age of REE-bearing pegmatites

- Begin to identify chronologic and geochemical trends

Progress: Funding just awarded

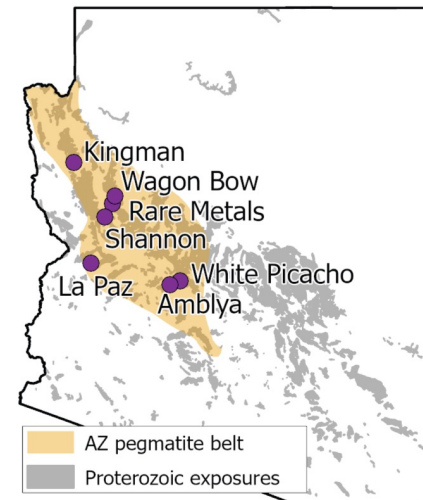


Figure 1: Map of Arizona with known Proterozoic exposures and the Arizona pegmatite belt shown. Locations of pegmatites that we propose to date are marked by purple dots.



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Hannah Budinoff

- Assistant Professor, Systems and Industrial Engineering
- Additive manufacturing
 - Metal powder bed fusion (e.g., titanium and aluminum alloys)
 - Polymers (e.g., PLA, ABS, PETG)
 - Reducing waste & energy consumption during manufacturing
- Engineering design process
 - Material selection & manufacturing process selection
 - Design for sustainability
 - Promoting sustainable design decisions with design tools & methods



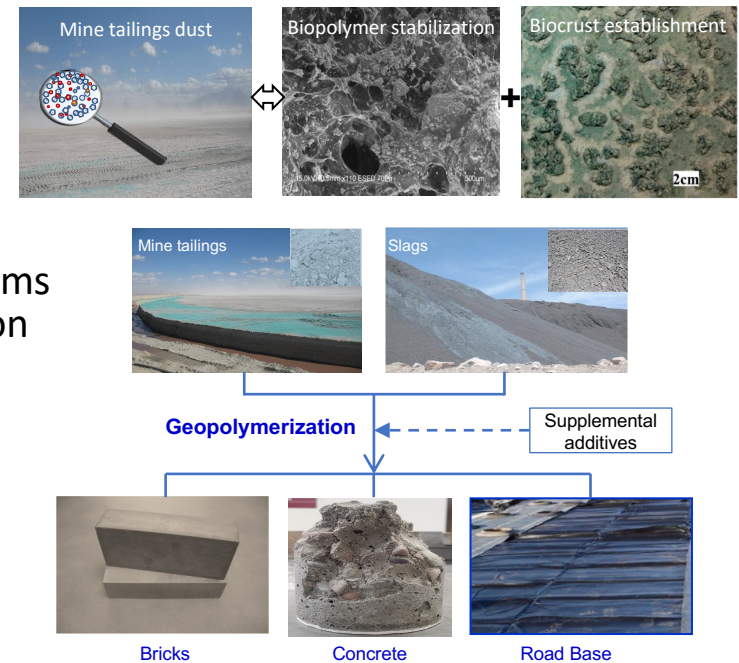
Translating sustainability metrics into engineering decisions: Exploring strategies for sustainable material use in design and manufacturing

- Participant(s): Hannah Budinoff, Hongyue Jin, David Manford
- Key goals:
 - Explore how environmental impact information affects engineers' **decision making** during the engineering design process
 - Pilot engineering decision making study for **additive manufacturing** using open-source software for environmental impact estimations
- Progress to date:
 - Experimentation and literature review to build a **life cycle assessment** database to estimate sustainability metrics for FFF 3d printing
 - Developing models to predict material usage and energy usage during FFF process
 - Identified potential collaborators in Eller College of Management



Lianyang Zhang, Ph.D., P.E., F.ASCE

- Professor, Department of Civil Engineering
- Minerals-related interests / activities
 - Management of mine wastes
 - Ecofriendly control of mine tailings dust
 - Reuse of mine wastes as construction material
 - Geotechnical safety program for mine tailings dams
 - Carbonation of mine wastes for CO₂ sequestration
 - Treatment of acid mine drainage (AMD)
 - Mine ground control
 - Enhancement of pumpable roof supports
 - Refining open pit rock slope stability analysis
 - Mining rock expert system (MRES) for enhanced rock mass characterization



Accelerated mineral carbonation for acid mine drainage treatment, mine tailings stabilization and carbon dioxide sequestration

- Participants: Lianyang Zhang (PI) and Sahand Motameni (GSA) in collaboration with ASARCO and Freeport McMoRan
- Key goals: (1) better understand the innovative idea of using accelerated mineral carbonation to treat acid mine drainage, stabilize mine tailings, and sequester carbon dioxide (CO₂) at the same time, and (2) generate preliminary data for preparing competitive proposals to secure external fundings.
- Progress to date: Revised proposal submitted and currently under review

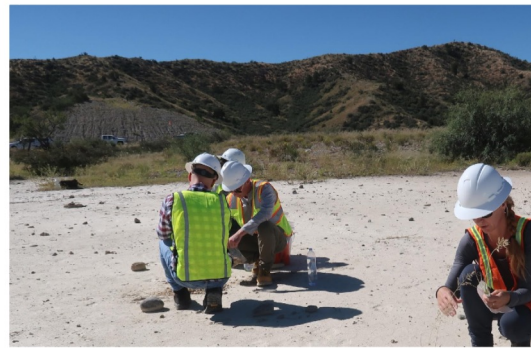


Alicja Babst-Kostecka

- Assistant Professor, ENVS Department, UA
- Co-Director Center for Environmentally Sustainable Mining (CESM), UA



Natural succession at legacy mine sites



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CESM Repurposing mine waste strategic innovation: Identification of metal-hyperaccumulating plants as polymetallic systems for ecocatalysis

Participants:

- Julie Neilson, Director CESM & Associate Research Professor, ENVS
- BHP Copper Legacy Assets Team
- one doctoral student & two to three undergraduate students

Key goal(s): conduct a survey of the plant community at the BHP Solitude tailing site to identify native metal hyperaccumulating plants to be used in a novel metal-capture strategy

Progress to date: Project just started



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Chris Earnest

- Education Outreach Coordinator – School of Mining and Mineral Resources
- K-12 Mineral Resources Education Outreach throughout AZ
- Outreach Program recognized with the Prazen Living Legend Award in fall 2022



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Mineral Resource Discovery Outreach

- School of Mining and Mineral Resources Outreach Team, Flandrau Planetarium and Science Center, SHPE, Kate Willa Brown, Gillian Noonan
- Goals to bring in more collaborators for mining and mineral resources outreach and improve mineral resource discovery workshop activities.
- So far: 3 new activities, 3 videos in production.
- Future: Restart Mineral Resource Discovery Workshop



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Dr. Ananya Mallik

- Assistant Professor (The RealReal Inc. Endowed Chair), Geosciences
- Experimental Petrology – investigating mineralogical and petrological processes in Earth and planetary interiors; Gem Science



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GemHub: One-stop destination for geochemical proxies of gemstone provenance at the University of Arizona

- PI – Dr. Ananya Mallik (GEOS), co-PI – Dr. Jason Kirk (GEOS)
- Collaborators – Dr. Isabel Barton (MGE), Dr. Hervé Rezeau (GEOS), Dr. Joaquin Ruiz (GEOS), Dr. Susan Leib (GMM), Dr. Aaron Palke (GIA)
- Develop new geochemical proxies for provenance determination of colored gemstones
- To begin in Spring 2023



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Raina Maier

- Professor, Department of Environmental Science
- Revegetation of mining waste, recovery of metals from aqueous mining waste streams, research translation to stakeholders, education



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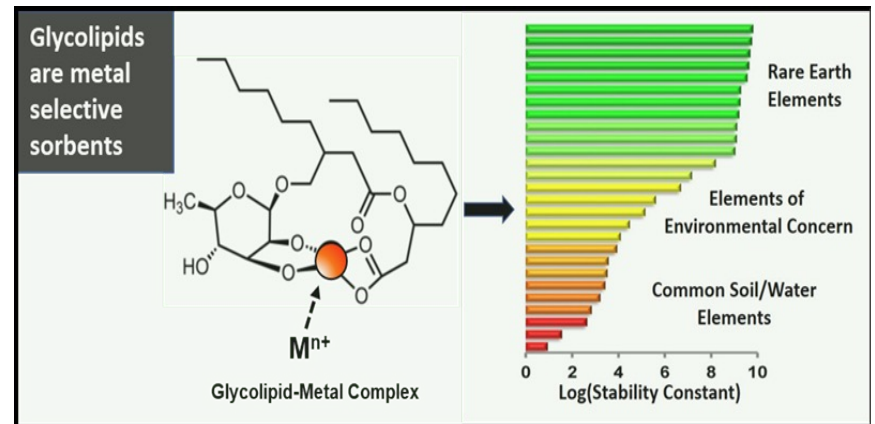
Separation and Recovery of Energy-Critical Metals from Aqueous Sources by a Selective Sorption Technology Platform

Raina Maier, David Hogan, Douglas Loy, Susan Perez, Vidula Lokugama

The **goal** is to develop a sustainable approach for aqueous-phase separation and recovery of metals from saline water sources and brines as a supplement/alternative to traditional hardrock mining with a focus on energy-critical metals including rare earth elements.

Research Progress: The SMMR funding has been critical to allow us to continue to build our team's research and granting efforts related to characterization and novel applications for metal-binding glycolipids.

Leveraging: Our Rio Tinto Pioneer Portal preproposal was selected to move forward to a full proposal and after review, we have recently been chosen for funding, \$1.3M for 2 years. We submitted an NSF STC grant (\$30M for 5 years). Our preproposal was selected to move forward, and we are awaiting a decision on whether we will have a site visit.



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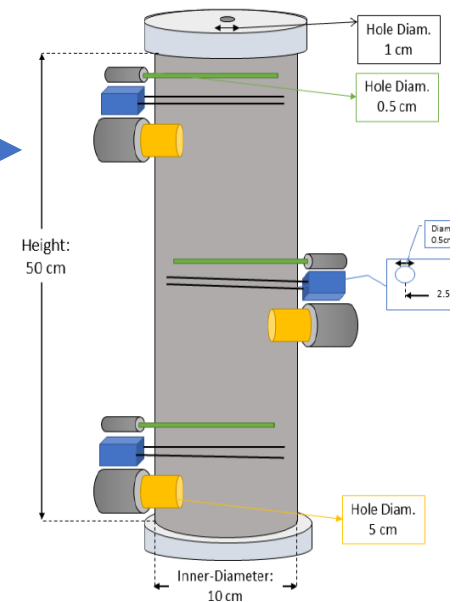
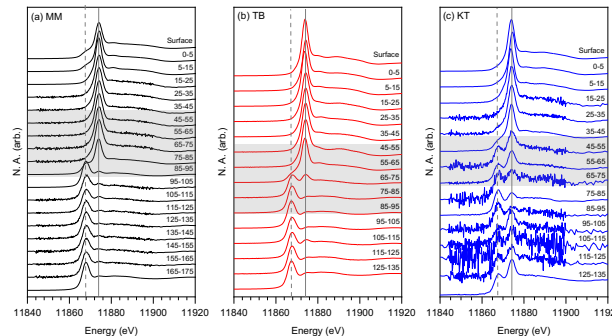
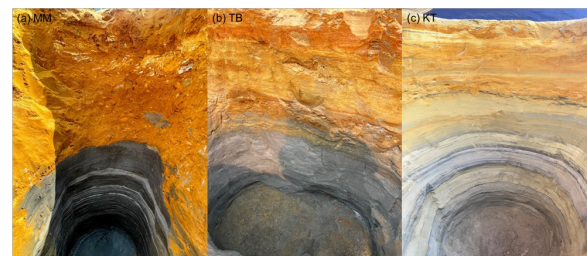
Jon Chorover

- Professor and Head, Department of Environmental Science (ENVS)
Director, Arizona Laboratory for Emerging Contaminants (ALEC)
- Minerals-related interests / activities:
 - Environmental Chemistry and Geochemistry
 - Application of mass spectrometry and molecular spectroscopy methods to environmental materials
 - Low temperature (bio)geochemical processes that control
 - Transport and fate of toxic metal(loid)s
 - Changes in molecular speciation
 - Impacts of speciation on bioavailability
 - Stabilization and sequestration of carbon, metal(loid)s, and organic pollutants



Measurement and modeling of sulfide tailings diagenesis in controlled experimentation: Implications for mine waste remediation

- Jon Chorover (PI), Bo Guo, Rob Root, Mark Brusseau, **Xenia DeGracia**
- Measure the reactions controlling oxidative transformation of sulfide tailings in *real-time* with *in-situ* sensing and sampling.
- Sampled tailings sites throughout the west, conducted geochemical and molecular speciation analysis



Julie Neilson

- Associate Research Professor ENVS Dept
- Director, Center for Environmentally Sustainable Mining (CESM)



cesm.arizona.edu



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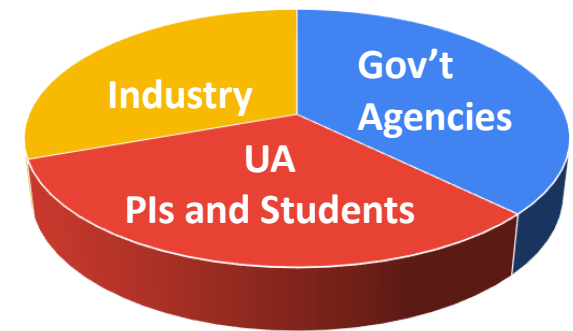
Center for Environmentally Sustainable Mining Strategic Development

- Co-PI(s):
Alicja Babst-Kostecka, Raina Maier, Mónica Ramírez-Andreotta
- FY23 Industry Partners:
 - Resolution Copper - Brad Lingard - \$40,000 (2014 – 2022)
 - BHP Copper - Daphne Place-Hoskie/Brian Moravec Legacy Asset Management - \$80,000 (2019 – 2023)
- Project Goals
 - Expand CESM capacity to network with government agencies and new industry partners
 - Facilitate research translation and professional development opportunities; program coordinator support (*Bethany Obernesser*)
 - Expand graduate & undergraduate student research participation in CESM research
 - *Sierra Lauman (PhD, SNRE) and Ana Soto (Undergrad, ENVS)*



Key Progress: **2022 Conference for Government Agencies, Phoenix AZ, November 3**

- Conference Title: *UA Center for Environmentally Sustainable Mining: Applied Industry Research and Information Sharing*
- Conference Objective: Identify priorities associated with environmentally sustainable mining and discuss how diverse stakeholders from government agencies, industry, and academia can collaborate to accelerate the development of technologies that address sustainability priorities
- Agency Stakeholders present: ADEQ, BLM, US Forest Service, AZ State Mine Inspector, Salt River Project, diverse industries
- Industry Conference Sponsorships: (\$6000) BHP, American Rare Earth Elements, South32, KGHM International, Salt River Materials Group, Drake Cement
- Deliverables: Facilitated dialog between diverse stakeholders and research translation to new industries. Participants requested an annual forum and professional development courses aligned with current CESM research.



59 Participants



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Minkyu Kim

- Assistant Professor, Materials Science & Engineering and Biomedical Engineering
- Dust control materials development and air quality control related to mining (hardrock, aggregate, and coal).



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Bioinspired Green Glycolipids as Fugitive Mining Dust Mitigation Agents

Minkyu Kim, David Hogan, Raina Maier, Chris Rodriguez, Damask Grinnell, Ben Pershing, Francisco Martinez

The goal is to test glycolipid-based dust suppressants to mitigate dusts from mine tailings and vehicular traffic on unpaved haulage roads. Our team focuses on aggregate and hardrock mining in semi-arid climatic regions with real world samples provided for testing by our partners in the mining industry.

Research progress: We have tested 19 different glycolipids. Eight of these meet EPA good and six meet EPA moderate Air Quality Index standards. Results show that glycolipid chain length, number of chains, and sugar head group affects efficacy.

Leveraging: We were recently awarded a NIEHS Phase I SBIR grant “*Bioinspired Green Glycolipids as Fugitive Dust Mitigation Agents*” (\$173,075). The SMMR funding was critical for giving us a head start on the Phase 1 and is allowing us to plan to submit the Phase 2 application in April 2023. The team has also recently submitted a USDA grant (\$649,000) to explore agricultural dust.



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Pedro Lopez

Hazard Recognition in underground mines application - HUMApp



Nathalie Risso
Assistant Professor MGE



Angelina Anani
Associate Professor MGE



Edward Wellman
Adjunct Lecturer MGE



Pedro Lopez
Research Assistant



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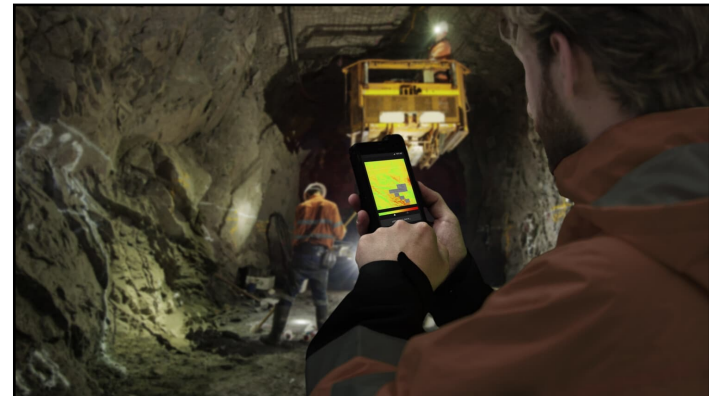


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Goal: Develop a Computer Vision App to improve safety by automatically detecting structural hazards in underground mines

Expected Outcomes:

- ✓ Labeled images dataset for underground mines hazards.
- ML computer vision-based model to identify geotechnical hazards.
- Prototype of a mobile app for real-time prediction.



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Hervé Rezeau



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**School of Mining
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Virtual Ore Microscopy: an interactive application to learn optical properties of ore minerals

- **PI: Hervé Rezeau** - Assistant professor & Lundin Chair in Economic Geology at the Department of Geosciences.
- **Co-PI: Leonard D. Brown**- Assistant Research Professor at the Community, Environment and Policy Department.
- **Partners: Mark Barton** - Professor at the Department of Geosciences & Director of the LPEG / **Frank Mazdab** - Senior Research Mineralogist at the Geosciences department.
- SMMR Funding of \$24,954 (previous SMMR seed funding of \$21,400)
- This follow up project aims:
 1. to achieve the final cloud development of the Virtual Ore Microscopy platform
 2. to build its preliminary interactive user data base.



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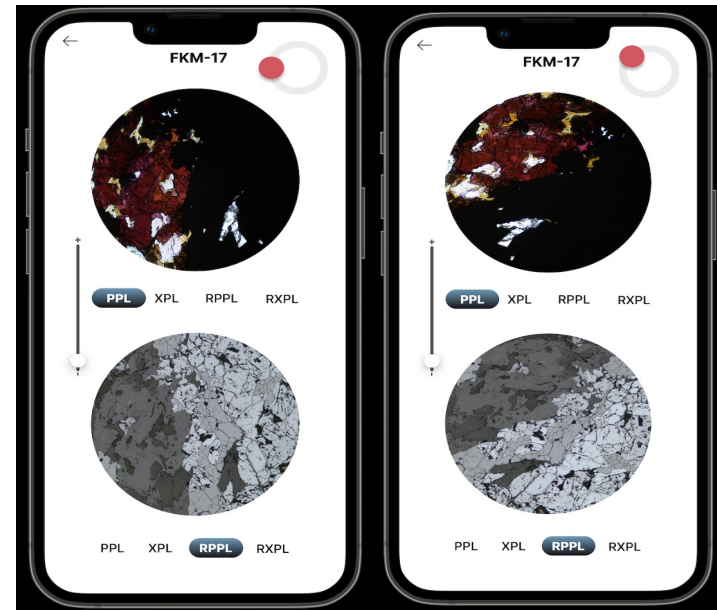
MINERAL RESOURCES

Virtual Ore Microscopy: an interactive application to learn optical properties of ore minerals

Accomplishments from the first SMMR round:

- Cataloged 100s of samples & made new polished thin sections (n=114) from 8 ore deposit types.
- Established a systematic workflow for rock descriptions and digital macro and microphotography acquisition.
- Developed a conceptual prototype for the future VOM digital platform.

Interactive picture of minerals



- virtual 360° movement
- 2 types of light at a time



Virtual Ore Microscopy: an interactive application to learn optical properties of ore minerals

Next steps

- Keep digitizing samples to feed the data base.
- Create an automated workflow to store, upload, and curate digital archives.
- Program a front-end app that is compatible with mobile devices and desktop computers

Outcomes

Development of a new “ore microscopy” class that crosses the disciplines of mineralogy, economic geology, mineral processing, and geometallurgy.
Self-sustaining business model through the development of industry-focused ore microscopy short courses



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Thank you.



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Dr. Victor Tenorio

*Active Learning in Mining:
Using Robotics to prepare the next generation of
Digital Miners*



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COLLEGE OF ENGINEERING

Mine Automation
& Autonomous Systems
Laboratory



Marcos Andreu
Grad student



Dr. Victor Tenorio
PI



Dr. Nathalie Risso
Co-PI

Department of Mining and Geological Engineering,

Contact information: nrisso@arizona.edu

This research was financed by the School of Mining and Mineral Resources,
The University of Arizona 2022-2023



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Active Learning in Mining: Using Robotics to prepare the next generation of Digital Miners



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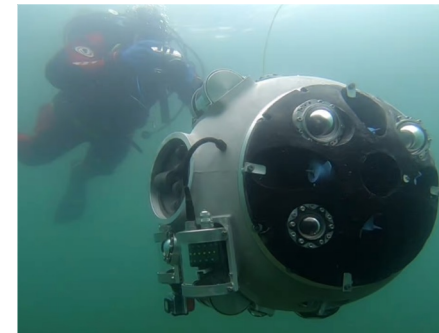
Mine Automation
& Autonomous Systems
Laboratory

Goal: Generate training material for mining engineering students for expected mining industry needs related to automation

Progress to date: Literature review and participation on NASA's BTIL Challenge

What we are doing: Search for current applications of robotics in the mining industry and design learning material

Challenges: Increasing hazardous underground environment, Increasing demand for minerals and rising production costs



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Dr. Nathalie Risso

Camera Aided Technology for Underground Mine Safety (CAT-UMS)



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Mine Automation
& Autonomous Systems
Laboratory



Carlos Olmos de Aguilera¹
Grad student



Dr. Nathalie Risso¹
PI



Dr. Angelina Anani¹
Co-PI



Dr. Hee-jeong Kim²
Co-PI

Department of Mining and Geological Engineering¹,
Department of Civil and Architectural Engineering and Mechanics²

Contact information: nrisso@arizona.edu

This research was financed by the School of Mining and Mineral Resources,
The University of Arizona 2022-2023



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Camera Aided Technology for Underground Mine Safety (CAT-UMS)



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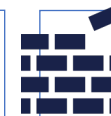
Mine Automation
& Autonomous Systems
Laboratory



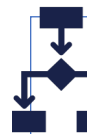
Goal: Develop a system for automatic PPE detection for industrial and underground mining environments.



Impact: Automate safety monitoring.



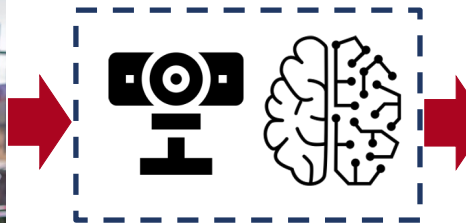
Progress to date: Preliminary results for automatic hardhat detection.



How It works: We use a regular camera and **Machine Learning** to detect if a person is wearing a hardhat.



Challenges: Underground environment (dust, vibration, low light, scarce energy, etc.). Bias due to lack of diversity in dataset.



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Flurin Babst

Assistant Research Professor
School of Natural Resources and the Environment
babst@arizona.edu; 520 621 1071; ENR-2 N444

Interests:

- Exploring the potential of mining-impacted lands to contribute to nature-based climate solutions
- Develop the scientific basis needed for monetizing the re-vegetation process towards carbon credits
- Establish carbon sequestration in long-lasting vegetation as a sustainability criterion for site reclamation



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Towards monetizing the climate benefits of mine site re-vegetation: assessing the carbon sink capacity of woody biomass on mining-impacted lands

Flurin Babst, SNRE (PI); Julia Neilson, ENVS (co-PI); Alicja Babst-Kostecka, ENVS (co-PI); Willem van Leeuwen, SNRE (co-PI)

Key goals:

- Quantify and scale C sequestration in woody biomass using field observations and LiDAR
- Identify key drivers of vegetation productivity, including soil biogeochemistry, vegetation parameters (structure, composition, age, etc.), and climate
- Develop a predictive framework for C sequestration that can be informed with a manageable number of key parameters measured at mining-impacted sites

→ Strategic Initiative proposal pending



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Gillian Noonan

- Senior R&D Engineer - UA SMMR GCE
- Grad Student - Hydrology (HAS)
- Interests/research focus –
 - geological engineering, geophysics, mining hydrogeology, pit slope and underground mine design, monitoring, and management
 - Thesis: how coupled water-rock interactions affect the geotechnical stability of pit slopes



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'Water in Mining – Arizona' Outreach Video

- PI/Co
- Goal
- Starr



Davis de Dios Media



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Status –

- Filming completed in June/July; Video editing and quote selection completed Aug – Oct
- On pause awaiting approval to move forward; received glowing approval and appreciation last week from Kathleen Meixner; final video edits are in progress.



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Leonard D. Brown

- Assistant Research Professor, Public Health
 - Director, Western Mining Safety & Health Training Resource Center
 - Affiliate Faculty, School of Information (iSchool)
- **Interests**
 - **Occupational Safety and Health**
 - **Geotech Controls and Applications**
- **Activities**
 - **Training and Performance Evaluation**
 - **Virtual Environments and Digital Twins**
 - **Analytics, Modeling, Machine Learning**



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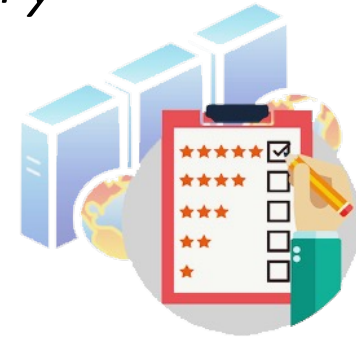
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R&I Grant: Using Predictive Analytics to Model Operators' Health and Safety Trajectory

• **Participants**

- Hong Cui, Professor, School of Information
- Tuan Bui, R&D Engineer, Public Health
- Aadithya Dinesh, Grad Student (MIS)



• **Goals & Progress:**

1. ***Classifier for six injury types:*** Developed, tested 4 Natural Language Processing (NLP) models using transfer learning with MSHA dataset
2. ***Mining of leading indicators:*** ARM used to identify leading indicators
3. ***Collaborative H&S dashboard:*** Use AWS to test with more operators
4. ***Sustainability of initiatives:*** Professional dev. courses & NIOSH BAA





Jodi Banta

Sustainable Mineral Resources Undergraduate Minor

Suitable for ALL majors!

- Choice of tracks
- Flexible pathways to completion
- Internships and Scholarships
- Skills employers want most – like working and communicating with people of different backgrounds!



SCHOOL OF MINING & MINERAL RESOURCES



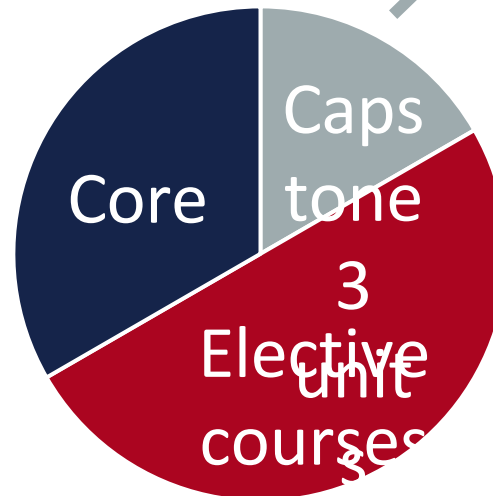
THE UNIVERSITY OF ARIZONA
Lowell Institute for

Minor Structure

18-units total

Foundational Knowledge

- Three 3-unit options
- One upper division
- All Gen Ed
- One course completed before starting electives (exceptions allowed with School approval)



Bringing it all together

Two pathways:

- 1) Capstone Course, or
- 2) Combination of:
 - Seminars
 - Internship
 - Research Project

One unit must be completed in final semester

Deeper dive into key interest area(s)

- 7 tracks
- 63 courses
- 26 departments
- 7 colleges



Sustainable Mineral Resources Minor

Study the interconnected environmental, social, technical, and economic issues surrounding the sustainable and responsible production and use of non-renewable mineral resources. Learn to work with people and value beliefs across disciplines, cultures, and national borders from diverse faculty. Implement critical thinking, effective communication, and data-driven decision making to bridge the gap between humans' ever-increasing demand for minerals and societies' changing priorities toward the environment and communities.



THE UNIVERSITY OF ARIZONA
School of Mining & Mineral Resources

Customize your track!

Core Courses

Minimum of 6 units of core coursework

One core course must be completed before starting electives (exceptions may be allowed with School approval)

- MNE/ANTH 201 Nonrenewable Resources and World Civilizations – Gen Ed Fall 2022
- MNE/ENGR 422 Perspectives of Sustainability: Supplying Mineral Resources for Society – Gen Ed Fall 2022
- MIN 236 Materials, Societies, & Choices – New, Gen Ed Spring 2023

Mining & Recycling	Leadership & Communication	Business & Economics	Data Analytics & Automation	Environmental	Health & Safety	Society & Policy
<ul style="list-style-type: none"> • *GEOS 251 Physical Geology (4 units) • GEOS 446 Economic Mineral Deposits • MNE 205 Introduction to Mining Engineering • MNE 210 Mineralogy and Petrology for Engineers • MNE 411 Mineral Processing • *MNE 427 Geomechanics (3-4 units) • MSE 450 Materials Selection for the Environment • MIN XXX: Recycling and Reclamation 	<ul style="list-style-type: none"> • BNAD 302 Human Side of Organizations • COMM 117 Culture and Communications • COMM 201 Introduction to Public Relations • COMM 312 Applied Organizational Communications • COMM 404 Communications and Leadership • ENVS 415 Translating Environmental Science • PR 423 Crisis Communication and Public Relations 	<ul style="list-style-type: none"> • ACCT 250 Survey of Accounting or BNAD 304 (3 units) Survey of Finance • GEOG 305 Economic Geography • GEOG 362 Environment and Development • MNE 205 Introduction to Mining Engineering • MNE 430 Mine Examination and Valuation • MGMT 202 Ethical Issues in Business or PHIL 322 (3 units) Business Ethics • SIE 265 Engineering Management I • SIE 422 Engineering Decision Making Under Uncertainty 	<ul style="list-style-type: none"> • ESOC 214 Introduction to Data Science • GEOG 222 Working with Numeric, Spatial, and Visual Data Fundamental Geographic Techniques • GEOS 280 Programming and Data Analysis in the Earth Sciences • RNR 403 Application of Geographic Information Systems • *ISTA 131 Dealing with Data (4 units) • ISTA 321 Data Mining and Discovery • ISTA 322 Data Engineering 	<ul style="list-style-type: none"> • EHS 426 Topics in Environmental Justice or ENVS 310 Ecosystem Health and Justice • ENVS 305 Pollution Science • ENVS 340 Environmental Chemistry • ENVS 482 Reclamation and Redevelopment of Impacted Lands • HWRS 201 Water science and the Environment • HWRS 350 Principles of Hydrology • PA 484 Environmental Management • SIE 466 Life Cycle Analysis for Sustainable Design and Engineering 	<ul style="list-style-type: none"> • EHS 375 Introduction to Environmental & Occupational Health or EHS 484 Fundamentals of Industrial and Environmental Health • EHS 418 Introduction to Human Risk Assessment • MNE 424 Miner Health: Fitness-for-Duty, Mitigating, Exposures, and Managing Disease Risk • MNE 423 Historic and Contemporary Role of US Regulatory Agencies (OSHA, MSHA, EPA) or PHP 421 Introduction to Public Health Law and Ethics • *MNE 297A Underground Mine Safety (1 unit) • *MNE 297B Operation and Maintenance of Heavy Mining Equipment (1 unit) • *MNE 297C Fundamentals of Mine Rescue (1 unit) • MNE 426 Health and Safety in Mining • MNE 425 Mine Emergencies and Disasters: Prevention, Response, and Recovery 	<ul style="list-style-type: none"> • AIS 220 Contemporary American Indian Issues or GEOG 250 Environment and Society in the Southwest Borderlands • AIS 441A Natural Resource Management in Native Communities or ANTH 331 Anthropology and Development • GEOG 462 Environmental Law, Geography, and Society or RNR 480 Natural Resources Policy and Law • PA 482 Environmental Governance • PHIL 323 Environmental Ethics • RNR 485 The Economics & Social Connections to Natural Resources • SBE 201 Sustainable Design and Planning • SOC 307 Environmental Sociology

- Minimum of 9 units from one or two tracks
- At least 6 units must be upper division
- Substitutions allowed for elective courses (must be approved by School advisor, program coordinator, or program manager)
- Encouraged, but not required, to take courses from outside student's major and other minors
- Elective tracks are not officially notated on student transcripts/diplomas

All courses are 3 units unless marked with an *. The number of units for courses marked with an * are given in parenthesis.

Capstone Experience

Minimum 3 upper division units (one unit completed in final semester)

Two pathways

- 1 Complete MIN 4XX: Capstone Course
 - *MIN 4XX: Seminar 1 (1 unit)
 - *MIN 4XX: Seminar 2 (1 unit)
 - *MIN 4XX: Seminar 3 (1 unit)
 - *MIN 4XX: Research Project (1 unit)
 - *MIN 4XX: Internship (1-2 units)
 - Requires alignment with interdisciplinary goal of School
 - Must be outside major
 - Approval from School advisor, program coordinator, or program manager
- 2 Complete a combination of an internship, seminars, and/or research project.



SCHOOL OF MINING & MINERAL RESOURCES

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Curricular Needs Assessments in Progress:

Courses & certificates for undergraduate and graduate students, and professionals

Subject Area	Focus	Next Steps
Mineral Resources (Core)	A holistic minerals and mining course covering core minerals and mining knowledge + exposure to all 7 tracks and their interconnectedness	Development of an Introduction to Sustainable Mineral Resources course for (1) undergrads and (2) communities or other interest groups Add option for 1 credit teaching GEOS to minor capstone options Create a version for K-12 teacher continuing ed hours
Analytics & Automation	Incorporating Artificial Intelligence and Big Data Analytics into our Mining Engineering and overall mineral resource education program	(1) Introduction to Automation & Controls (2) Applied Automation for Mining (3) Automation Project (4) IOT System Design for Mining Applications (5) Data Analysis for Mining & Geology Applications (6) Data-Driven Modeling (7) Data Analytics & Automation Management
Society & Policy	Industry x Community x NGO x Government engagement	(1) Core course above (2) Certificate and short course on Laws and Standards (3) Certificate and short course on Community Engagement (4) Seminar on ... (many, many options here!) (5) 3 x undergrad courses mixing learning objectives from Minerals and Mining basics, Community Engagement, Laws & Standards, Social Structures & Group Dynamics
Economic Geology	Produce mining-ready Geoscience BS	(1) Economic Geology track for GEOS BS (2) Core shack at SX Mine (for skills like core logging)
Environment x Mining	Exploratory – Air, Water, Biodiversity	Coming Soon!

