

# **GEOTECHNICAL CENTER OF EXCELLENCE**

A N N U A L R E P O R T



THE UNIVERSITY OF ARIZONA  
School of Mining  
& Mineral Resources

# **2022-23**

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# LETTERS

## FROM DIRECTORS



**JULIA  
POTTER**

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**BRAD  
ROSS**

It's great to see how far the Geotechnical Center of Excellence (GCE) has come since its inception just over five years ago. Our initial vision was to create a center that would lead in holistic geotechnical research, offer unparalleled training, and be the go-to place for employers seeking talented graduates, and to tackle complex geotechnical problems. We are not just on the path to achieving these objectives; we are living them.

**Holistic Research:** The core strength of the GCE lies in its interdisciplinary approach. By engaging with multiple departments across the University of Arizona, from Mining and Geological Engineering to Public Health, we've widened our research scope. Our collaboration with Thermal Imaging Research, under a NIOSH contract, is a notable example. This work has led to data collection from eight different mines in the western U.S. and Canada, yielding invaluable insights to enhance miner safety and operational productivity.

**World-class Training:** While the pandemic posed a considerable challenge, it also presented an opportunity for innovation. Today, the GCE offers four distinct classes, each equivalent to a 3-credit college course. The participation of industry and academic experts has only enriched these courses. I'm proud to report that we have nearly 2,000 registrants, with 75% hailing from countries outside the United States.

**Employing Skilled Graduates:** Our commitment to providing research opportunities extends from graduate to undergraduate students. Through practical research topics such as direct shear variability and radar monitoring data analysis, we're producing graduates who are not just academically competent but also industry-ready.

**Solving Real-world Problems:** Our research is not confined to theory; it's practice-oriented and addresses problems that matter to the industry. For instance, our first published paper demonstrating how InSAR can detect large failure mass over time at the Bingham Canyon Mine has set a precedent in applied research.

In some ways, the GCE has gone above and beyond the original goals. The Slope Stability Symposium that we hosted in 2022 set a new standard in surface mining geotechnical conferences. The GCE has been totally self-funded after just 4 months of its inception, and it has become highly regarded within the industry for its practical approaches and ability to complete projects in a timely manner.

The GCE has made remarkable strides in the last five years, all while navigating through the challenges posed by the COVID-19 pandemic. None of this would have been possible without the unwavering support from our industry members, collaborators, and the hard work and dedication of the GCE team. We look forward to further elevating the GCE's contributions in the years ahead. Thank you for your continued support in making this vision a reality.

# MISSION

## STATEMENT

The University of Arizona's Geotechnical Center of Excellence (GCE) is an industry-funded and stakeholder-led organization committed to bridging gaps that exist within and between ACADEMIA, INDUSTRY, and FIELDS OF STUDY through a pragmatic, collaborative approach to geotechnical research and education.

## KEY

## OBJECTIVES

The GCE's key organizational objectives include:



### CONNECT

by providing a forum for companies, departments, and fields of study to share experiences and lessons learned (link to section)



### INNOVATE

through member prioritized research focused on solving important, real-world geotechnical problems (link to section)



### EDUCATE

by filling knowledge gaps through professional development and supporting the delivery of trained graduates (link to section)

# OUR

## TEAM

### GCE STAFF



**JULIA POTTER**  
LOREM IPSUM

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**BRAD ROSS**  
LOREM IPSUM

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**ALLISON BRUSIE**  
LOREM IPSUM

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**GILLIAN NOONAN**  
LOREM IPSUM

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**JAMES McNABB**  
LOREM IPSUM

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**BENJAMIN MEYER**  
LOREM IPSUM

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**BOBBY PRESCOTT**  
LOREM IPSUM

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**CHAD WILLIAMS**  
LOREM IPSUM

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### STUDENT EMPLOYEES



**MARIA FRANCO**  
LOREM IPSUM

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**DAOUDA BERTHA**  
LOREM IPSUM

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*Dedicated to ensuring that geotechnical and safety considerations advance at the same rate as technology and environmental priorities, the GCE is focused on finding innovative solutions to the most critical and complex geotechnical problems facing the mining industry today. We also lead the industry's most robust professional development program for surface mining geotechnical professionals.*



# OUR

# MEMBERS

## BOARD REPRESENTATIVES



**JOHN COMBS**

**FREPORT MCMORAN, INC.**

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**LUIS TEJADA**

**FREPORT MCMORAN, INC.**

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**MEGAN GAIDA**

**RIO TINTO**

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**MARTYN ROBOTHAM**

**RIO TINTO**

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**FREPORT MCMORAN, INC.**

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*Includes board and leadership-level members*

GENERAL

**MEMBERS**

ASSOCIATE

**MEMBERS**

# ADVISORY TEAM

## STRATEGIC ADVISORS



ZIP ZAVODNI  
LOREM IPSUM



PETE STACEY  
LOREM IPSUM



KAREN MOFFITT  
LOREM IPSUM

## RESEARCH

### Hydromechanical Coupling



LOREN LORIG  
LOREM IPSUM



GEOFF BEALE  
LOREM IPSUM

### Direct Shear Variability



IAN STILWELL  
LOREM IPSUM



JULIAN VENTER  
LOREM IPSUM



CHRISTIAN OBREGON  
LOREM IPSUM

### Thermal Imaging for Rockfall Detection



JOHN KEEFNER  
LOREM IPSUM



CHAD WILLIAMS  
LOREM IPSUM

## TECHNICAL ADVISORS



KAREN MOFFITT  
LOREM IPSUM

## PROFESSIONAL DEVELOPMENT

### Geotechnical Radar Monitoring



PAOLO FARINA  
LOREM IPSUM



CHAD WILLIAMS  
LOREM IPSUM

### Water in Mine Operations and Slope Stability



GEOFF BEALE  
LOREM IPSUM



JEREMY DOWLING  
LOREM IPSUM

### Slope Performance Monitoring



GEOFF BEALE  
LOREM IPSUM



JEREMY DOWLING  
LOREM IPSUM

### Structural Geology for Geotechnical Professionals



WAYNE BARNETT  
LOREM IPSUM



GEOFF OWEN  
LOREM IPSUM



AMANDA HUGHES  
LOREM IPSUM



Page summarizing the following:

- Number of professional development (PD) courses offered
- Number of PD students and # of countries they came from
- Number of papers and presentations for each research project
- Research \$\$ brought in
- Number of active research projects
- Total number of members highlighting number of new members

**PLACEHOLDER**

**2022-  
2023**  
AT A GLANCE



# CONNECT

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# TEAM

**The GCE hosts a series of meetings twice a year as part of our commitment to facilitate connections between academia, industry, and fields of study.**

- Stakeholder meeting – any and all are welcome to join this meeting, where the GCE and its affiliate organizations speak on recent projects and initiatives.
- Member meeting – this meeting is attended by representatives from our Membership group and is intended to serve as a forum for sharing of ideas.

**The fall meeting aligned with the 2022 Slope Stability Symposium and was a particularly exciting event as the majority of our Member representatives were able to join in person.**

- This meeting was held the first day of SS2022.
- We had a majority of members join in person for the first time!
- Attendees were broken up into smaller discussion groups by topic:
  - Research
  - Outreach / webinars – this group came up with three potential series topics which were later rated by the larger stakeholder group.



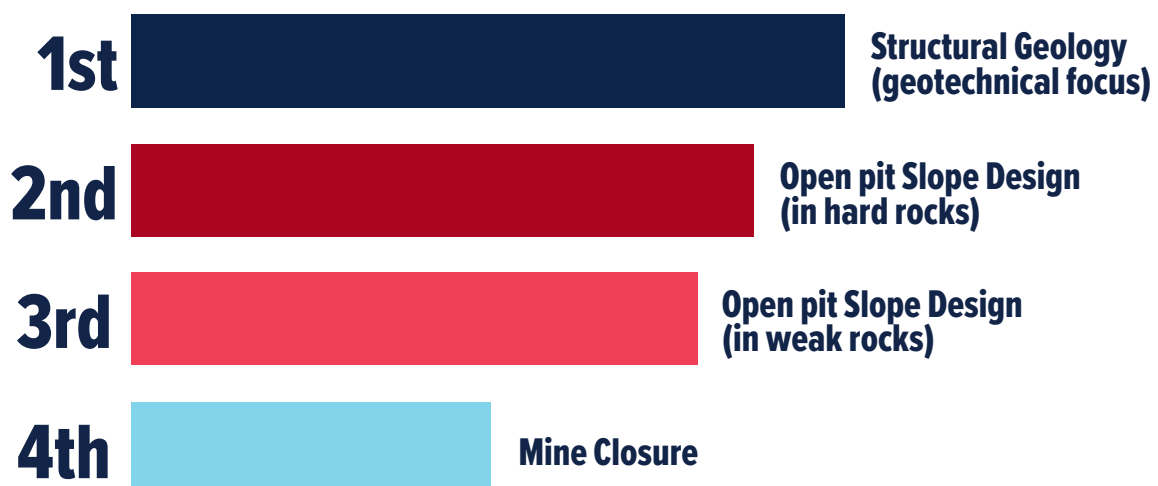
# THE GCE IS STARTING A QUARTERLY WEBINAR SERIES! WHAT TOPICS ARE YOU INTERESTED IN HEARING ABOUT?

# HELP US PICK THE TOPIC OF THE NEXT GCE PROFESSIONAL DEVELOPMENT COURSE

Education – this group prioritized a list of potential topics for future professional development courses (see below). The top-rated course was then voted on and approved by the board for development in 2023.

May 2023

- We will link the Board meeting notes and Menti results [here](#)



2022 SLOPE STABILITY

# SYMPOSIUM

## CONFERENCE HOSTED BY GCE IN OCTOBER 2022

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A close-up photograph of a hand holding a black VR controller. The controller has a circular touchpad in the center, which the index finger is touching. Above the touchpad is a small circular button with three horizontal lines. The background is blurred, showing a dark surface and a hint of a window or light source. The word "INNOVATE" is overlaid in large, bold, white capital letters across the middle of the image.

# INNOVATE

**GEOTECHNICAL  
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ANNUAL REPORT

# HYDROMECHANICALLY COUPLED RESPONSES

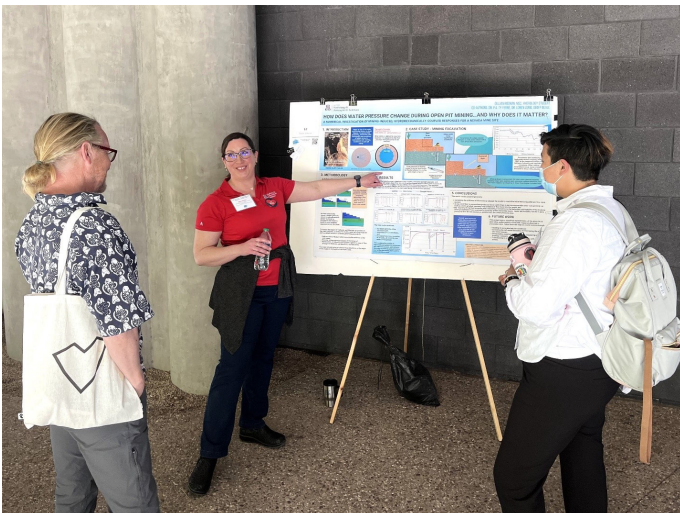
## PROJECT OVERVIEW

Gillian is working under the Itasca Educational Partnership (IEP) Research Program with Loren Lorig as mentor, Geoff Beale as industry advisor, and a mine in Nevada as data provider/collaborator to use Itasca software (FLAC) to replicate observed piezometer behaviors using a two-way coupled hydromechanical model. She is assessing the sensitivity of different governing parameters to transient pore pressure responses.

## PHASE ONE

A series of 2D models have been produced using the mine site hydrological and geological data as a base case and varying porosity, permeability, bulk and shear moduli. A poster presentation was completed for UA's El Dia Student Research Symposium in March 2023 (and won SRP best poster award).

The Phase I research was summarized in a paper that was co-authored with mentor and advisors and presented at the American Rock Mechanics Association (ARMA) conference in June 23 with a podium presentation by Gillian. Paper Title: Numerical investigation of mining-induced, hydromechanically-coupled responses for a Nevada mine site.

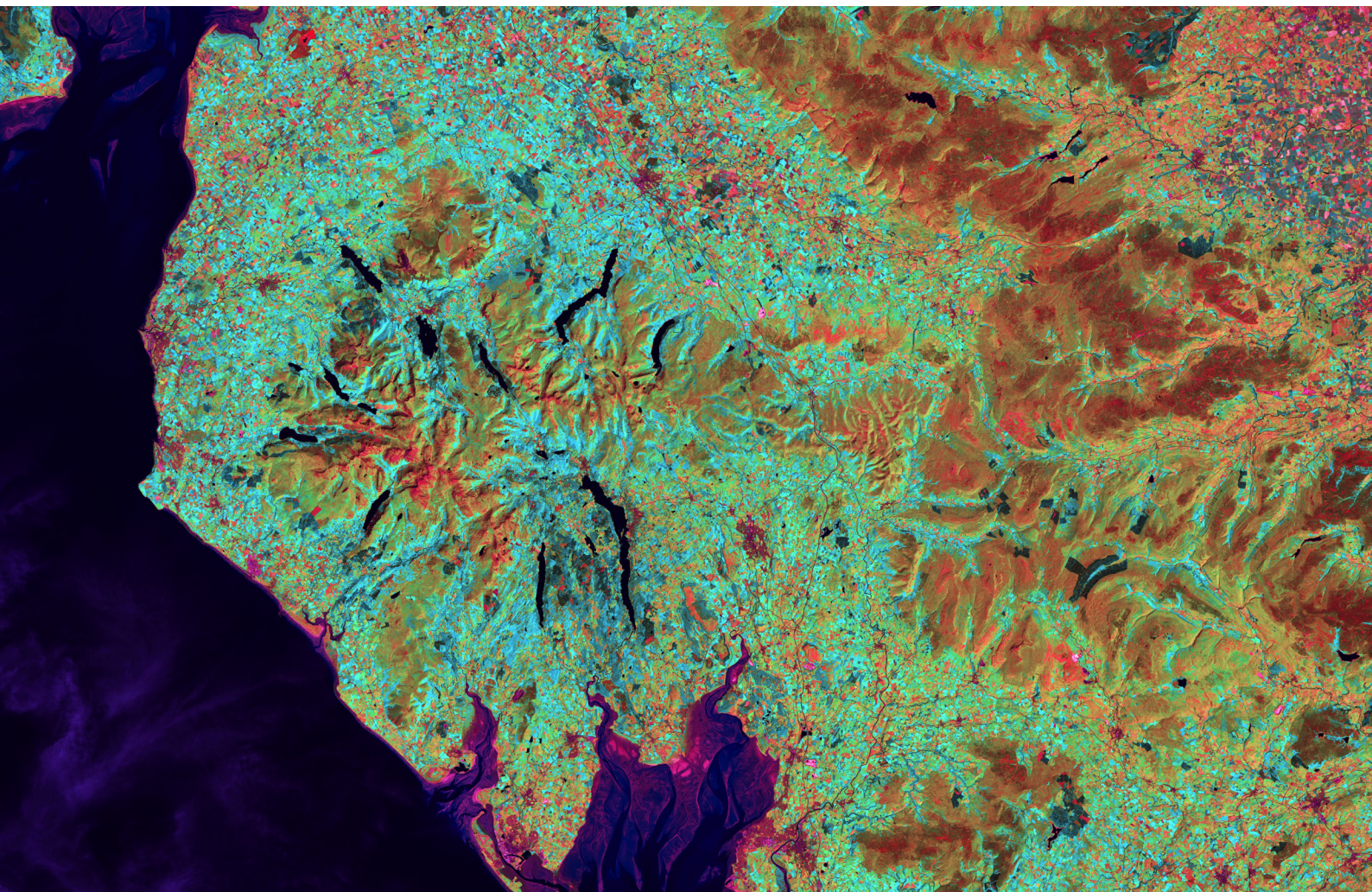


# THERMAL IMAGING FOR ROCKFALL DETECTION

The first aim of Phase 2 is to create an automated rockfall recognition algorithm using computer vision approaches. In pursuit of this goal the GCE tested a variety of motion identification and tracking techniques in order to meet the unique challenges posed by this project (low camera resolution, small amorphous targets, need to identify and alarm for hazards in real time). Using Matlab and Python and leveraging libraries such as OpenCV, we have proven that automated detection of rockfall in real time is possible.

Over the course of the year, we have made steady advancements in rockfall detection and tracking using thermal cameras, minimizing false positives due to birds and camera shakes and false negatives due to low-contrast video and erratic rockfall motion. To capture rapid, high-contrast motion from rockfall along with slower, low-contrast motion characteristic of slides or slope failures, the algorithm searches for motion in real time as well as at a slower pace (highlighting contrast from second to second rather than from frame to frame).

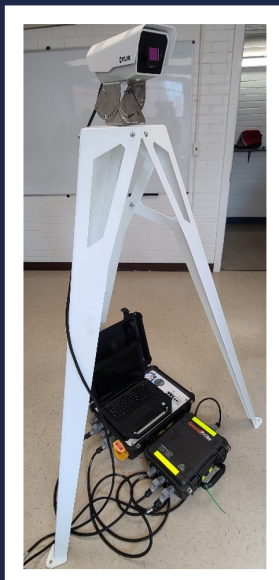
The rockfall detection algorithm is now significantly more accurate than the preliminary motion detection developed in phase 1.



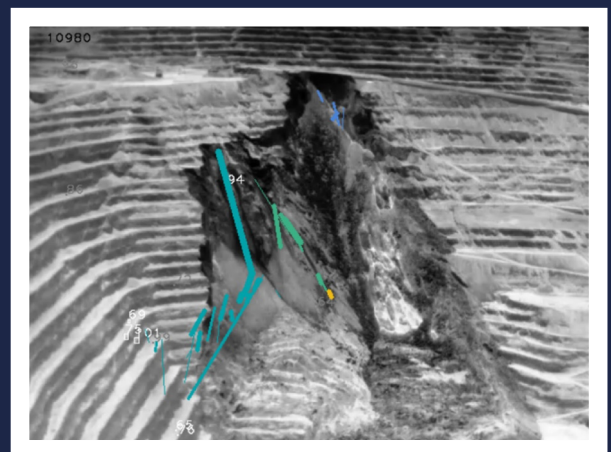
Data collection using our Mobile Monitoring Platform has resumed, and the MMP has been upgraded with a new FLIR A700 scientific thermal camera, providing better native resolution and a wider viewing angle than the previous A400 camera.

Additionally, a design for a standalone unit intended to be remotely deployable for monitoring rockfall has been created in concert with GroundProbe. The prototype physical standalone unit including a FLIR FC-632-ID thermal camera has been completed, deployed, and tested.


A preliminary graphical user interface (GUI) for interacting with the Python/OpenCV implementation of the detection algorithm has been developed, allowing users to select video sources, set parameters, and quickly create masks and fall angle overlays to designate ignored areas or expected directions of fall within the field of view.



Prototype standalone unit, including Laptop/processing unit, FLIR thermal camera, PoE switch, and heavy-duty tripod.



Detection of slow-moving rockslides in the aftermath of the previous failure

A close-up, over-the-shoulder shot of a person with dark dreadlocks and glasses, wearing a green shirt, looking at a laptop in a modern office. In the blurred background, other people are working at desks with large windows.

# EDUCATE

**GEOTECHNICAL  
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PROFESSIONAL

# DEVELOPMENT

## SUMMARIZE OUR CURRENT OFFERINGS (FOUR COURSES IN 2022-23, ONE IN DEVELOPMENT)

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- Focus on PD students (contributors covered in CONNECT section)
- PD student highlight / testimonials (Thiago?) INCLUDE MAP



The Geotechnical Center of Excellence (GCE) is an institution that has firmly established itself as a leader in the field of educating and training mining professionals. With a commitment to providing high-quality education, GCE has leveraged the power of the internet to offer its courses online, thereby extending its reach to a global audience. This approach has proven immensely successful, with over 1400 students from more than 42 countries benefiting from the knowledge and expertise imparted by the center.

Recognizing the diverse and evolving needs of mining professionals and organizations, GCE has been proactive in expanding its course offerings. In the academic year 2022-23, the center introduced four comprehensive courses, each tailored to address critical aspects of the mining industry:

## Geotechnical Radar Monitoring

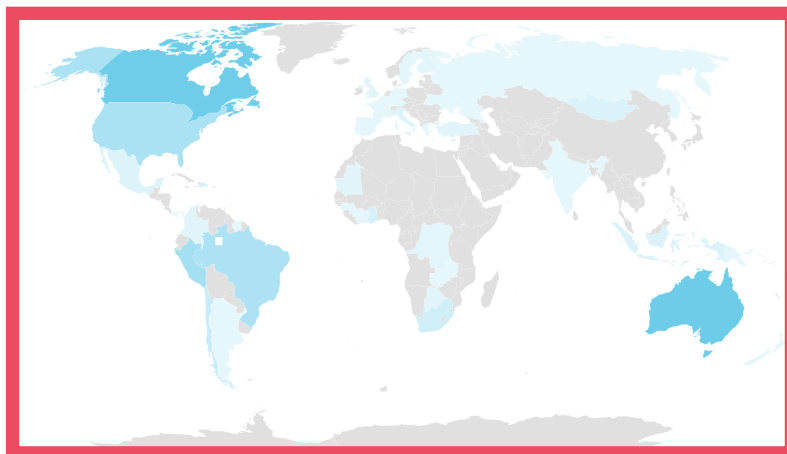
In the modern mining landscape, radar technology has become an indispensable tool for monitoring various aspects of mining operations. This course equips professionals with the knowledge needed to harness the power of different radar technologies and effectively interpret data. Understanding radar capabilities is key to optimizing mining safety and efficiency.

## Slope Performance Monitoring

Slope stability is of paramount importance in mining, and this course delves deep into the intricacies of monitoring slope performance. Participants not only gain insights into system design but also acquire valuable skills in data analysis. Real-world case studies are integral to this course, providing students with a practical understanding of the challenges associated with slope monitoring.

## Water in Mine Operations and Slope Stability

Managing water in mining operations is a critical yet often underestimated aspect of geotechnical engineering. GCE's Water Course goes beyond the surface, exploring the profound impact of water control on geotechnical slope stability. By examining relevant case studies, students are exposed to the complexities and solutions associated with water management in mining.



In addition to the courses above, the GCE is actively developing a fifth course to further broaden its educational offerings, ensuring that mining professionals stay at the forefront of industry trends and innovations. The Geotechnical Center of Excellence continues to serve as a beacon of knowledge, fostering the growth and expertise of mining professionals worldwide.

STUDENT

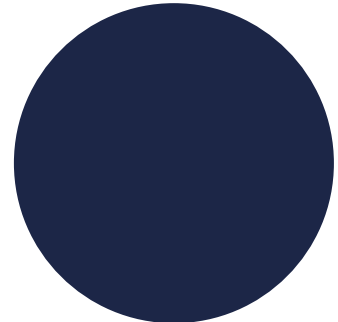
# EMPLOYEES



**GREATNESS  
OJUM**



**MARIA  
FRANCO**



**DAOUDA  
BERTHA**



# LOOKING AHEAD

**GEOTECHNICAL  
CENTER OF  
EXCELLENCE**

A N N U A L   R E P O R T

LOOKING

# AHEAD

**We are currently working towards:**

Building upon previous work using numerical modeling (FLAC) to demonstrate the dependent interaction of water and rock, or hydromechanical coupling (HMC), in a mine in Nevada, USA, and compare to similar studies.

Looking further at when HMC is important to consider for pit slopes by varying permeability and noting its effect on modeled responses. When permeability is anisotropic, we demonstrate how this impacts flow. Predicted pressure change responses with regard to a range of rock mass porosity and rock modulus values are being assessed, and the range of values with highest impact to HMC behaviors identified.





THE UNIVERSITY  
OF ARIZONA