EMRGe Research Center:
Energetic Materials, Rock Characterization, and Geomechanics

21 Faculty/Investigators
2 Technicians
1 Administrative Assistant
2* Postdocs
15 Graduate students

emrge.mst.edu
Energetic materials

Investigators:
> Dr. Catherine Johnson
> Dr. Kyle Perry
> Dr. Phil Mulligan

Selected research areas:
> Traumatic brain injuries
> Coal dust explosion suppression
> Explosives and Soybeans: Meeting the Need for a more Environmentally Friendly Explosive
> Concrete seals in coal mines

Research capabilities

Traumatic brain injuries
- Assessing blast effects resulting from routine military explosives operations
- Relating observed blast effects to primary blast induced traumatic brain injury (bTBI)
- Diagnosis, prevention, and cure through histology; behavior; MRI scan development; biomarkers etc.

Propellant mixing
- Developing high and low explosive based solid rocket motor propellants
- Characterization testing to maximize safety and performance

Additive manufacturing
- Examining materials to explosive loading
**Detonation synthesis**
- Detonation as a novel synthesis mechanism for diamonds, diamondoids, and other ceramic nanopowders: SiC, c-BN, BC
- Materials characterization using XRD, Raman Spec., and TEM/SAED

**Soybean based explosives**
- Less toxic
- Larger particle size (less air travel)

**Design and testing of Improvised Explosives**
- Explosively formed projectile
- Improvised linear shaped charge
- Buried explosive charges
- Breach charge penetration performance

**Armor design**
- Vehicle protection from EFPs & buried IEDs
- Light weight ballistic armor
- RPG armor

**Simulations of explosive events**

**Coal dust explosion suppression**
- Different rock dust types (wet/dry/hydrophobic)
- Limit respirable dust to workers

**Blasting & Highwall stability**
- Seismographs and laser scanning

**Coal mine seal designs**
- Must resist 50-120 PSI explosion
Energetic Materials: center facilities

Explosives and ballistics testing:
- 3+ Blast chambers capable of up to 8 lbs. TNT equivalent
- Experimental mine: – two underground entries with capabilities up to 17 lbs. TNT equivalent. Surface site with capabilities up to 2 lbs. TNT equivalent.

Data acquisition:
- Digital high speed imaging (Phantom HSI)
  - 22,500 frames per second at megapixel resolution
  - Up to 1 Million frames per second at reduced resolutions
  - Monochrome and Color imaging of detonation
- Synergy-P portable DAQ
  - Portable unit with 16 channels sampled at 2 MHz
  - Integrated Electronics Piezo-electric amplification and signal conditioning at 10 mA constant current

Underground surface characterization:
- LiDAR void scanning of subsurface openings
- Real-time modeling/navigation for underground workings

Numerical simulation of explosive events:
- ANSYS
- CTH
- IMPETUS
**Rock Characterization**

**Research areas**

- Enhanced oil recovery
  - Polymer flooding
  - Petrophysical characterization of tight oil sands
- Asphaltene precipitation from crude oil during gas injection
- Lake sediment analysis for study of:
  - Climate change
  - Tectonics
  - Biosystems
  - Flooding associated contamination
- Critical minerals: supply chain resilience
  - Linking fundamental geoscientific research to mining industry applications
  - Enhance extraction of rare earth elements
- Engineering characterization and modeling of cementitious materials
- Space mining
  - Heating asteroids to mine water and other volatiles

**Investigators:**

- Dr. Baojun Bai
- Dr. Mingzhen Wei
- Dr. Abdulmohsin Imqam
- Dr. Jonathan Obrist-Farner
- Dr. Marek Locmelis
- Dr. Ryan Smith
- Dr. Lana Alagha
- Dr. Jenny Liu
- Dr. Leslie Gertsch
- Dr. Weicheng Zhang

**MINERS DIG DEEPER**
ICDP (International Continental Scientific Drilling Program) workshop on: Lake Izabal Basin Research endeavor

- Co-funded by NSF
- Workshop to be held in Guatemala in 2021
- More than 60 international experts
- Seismic data set by Shell (~$2M)
Rock Characterization research capabilities and collaboration opportunities

**Rock core / cement core physical property characterization:**
- Porosity, permeability, TOC
- Elastic properties
- Strength properties
- Cement sheath pore pressure (pressure cell system)
- Cement elastic properties (Ultrasonic)
- In situ (downhole conditions) cement core preparation system

**Shallow lake sediment core extraction and analysis:**
- Contaminant analysis using geochemical techniques
- Earthquake induced sedimentation events
- Paleoclimate reconstruction (pollen, geochemistry, etc.)

**Geophysical characterization:**
- Towed electromagnetic system (100-500m depth)
  - Incorporate data into groundwater models
- Shallow geophysical characterization
  - GPR, geophone array
- LIDAR
  - Rock surface characterization (joints, fractures)

**Geochemical characterization:**
- Elemental distribution (SEM)
- Fast- semi-quantitative element analysis (SEM)
- Minor & Trace element analysis (LA-ICP-MS, solution ICP-MS)
- Bulk rock compositional analysis (XRF/XRD)
- Rock mineral identification (digital high-res microscopes)
Rock characterization: center facilities & equipment

Rock preparation equipment:
• Rock saws, crushers, mills
• Core driller
• Rock sample polishing and mineral separation

High Pressure Water jet lab:
• High-precision waterjet cutting
  • depth-cut control
  • surface preparation of many kinds and materials
  • multi-axis milling in mining and manufacturing

• Applicable for:
  • erosion prevention
  • fundamental studies of two- and three-phase flow
  • mechanics of fluid jet generation
  • high speed phenomena
  • physics of fluid impact

Rock strength testing:
• MTS load frame
  • Uniaxial & triaxial compression test
• Direct shear test
• Brazilian strength test (tensile strength)
Geomechanics

Investigators:
> Dr. Taghi Sherizadeh
> Dr. Kwame Awuah-Offei
> Dr. Jeremy Maurer
> Dr. Leslie Gertsch
> Dr. Guney Olgun
> Dr. Xiong Zhang
> Dr. Steve Gao
> Dr. Kelly Liu
> Dr. Andreas Eckert
> Dr. Ryan Smith
> Dr. Weicheng Zhang

Research areas

> Shear wave splitting
  - Mantle flow investigations

> Geodetic (InSAR) data analysis
  - Surface deformation analysis

> Ground control & mining hazards
  - Rib stability in coal mines
  - Ground movement monitoring near excavations using FOS

> Mining equipment – rock interaction

> Geotechnical earthquake engineering
  - Dynamic response of soils

> Warming and thawing of permafrost soil
  - Development of geotechnical hazard map

> Wellbore integrity
  - Assessment of cement sheath failure under in situ conditions
Geomechanics research capabilities and collaboration opportunities

Large scale geomechanics:
• Mantle flow and associated crustal deformation
• Strain localization (seismic, InSAR)
• Earthquakes:
  • Fault stability analysis & seismic hazard
  • Slow earthquakes
• Forward simulation of geologic deformation:
  • Fault kinematics/dynamics
  • Evolution of salt structures
  • Evolution of buckle folds

Reservoir geomechanics (hydrocarbon, aquifer, mines)
• Sedimentation, compaction & overpressure development
• Induced seismicity (waste water, CO₂, geothermal)
• Seal integrity analysis
• Reservoir subsidence
• Wellbore integrity
  • Cement system characterization, testing and simulation
  • Failure prediction

Mining geomechanics
• Slope stability
• Ground control

Constitutive modeling of rock mass behavior
• Theoretical and numerical

Cm to μm geomechanics
• Grain contact interaction & fracture initiation
• Rock fabric characterization, simulation and interaction
• Rock rheology and plasticity

Numerical modeling software capabilities:
• ABAQUS (separate license pool)
• ITASCA suite (FD, DEM)
• ANSYS
• PARAGEO (FEMDEM)
• SedSimX (sedimentological process modeling package)
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Why join EMRGe? -- Key resources

Staff

> Jeff Heniff (research engineering technician)
  - Certificate in explosives engineering
  - State of Missouri Licensed Blaster
  - Certified for Royex Explosives

> Jed Nowak (research engineering technician)
  - B.S. in Civil Engineering- US Military Academy, West Point
  - M.S. in Explosives Engineering- S&T
  - Engineer Officer Basic Course, US Army Fort Leonard Wood
  - Trained EMT- Basic
  - FHWA Certified Bridge Inspection
  - Firefighter Certification
  - Registered EIT (Engineer in training)

> Stacey Fuller (Admin Asst.)
Web page, news & outreach, grant administration, grant finances, proposal submission, student contracts & payroll, purchasing, many more

Fully equipped machine shop:
> Providing expertise in mechanical design and fabrication
> “Mobile shop”

MINERS DIG DEEPER
Why join EMRGe? -- Benefits

- Active multi- and interdisciplinary **TEAM** environment → work together on bigger proposals/projects
- Access to equipment, facilities and research support staff time
- Free support from Centre administrative staff
- Collaboration with Centre Post-Doc (Energetics)
- 7% of generated F&A will be invested in EMRGe infrastructure
- 7% of generated CAREER grants (NSF, DOE, NASA) will be returned to PI
- Travel supplements to conferences
- Seminars
- Internal proposal review circle
- Benefit from EMRGe established industry connections