The applications of Distributed Fiber Optic Sensing (DFOS) technology for improving safety in mines

2024 Mining Health and Safety Conference

Sudbury, Ontario
April 2024

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A LUNA company

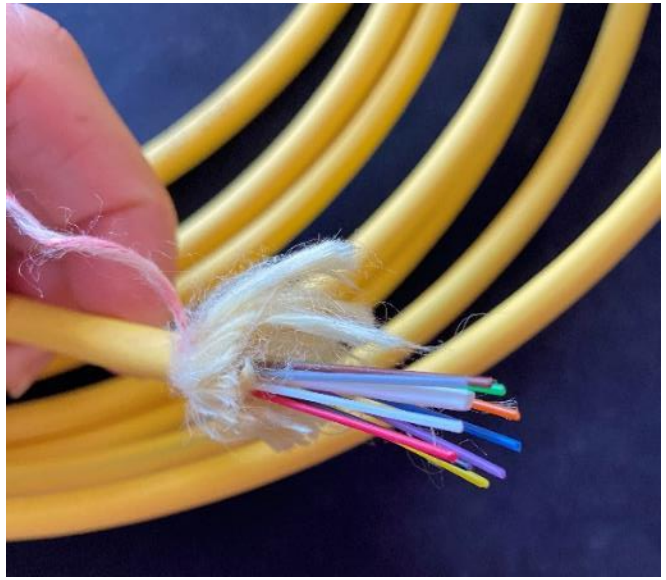
Workplace Safety North™

Outline

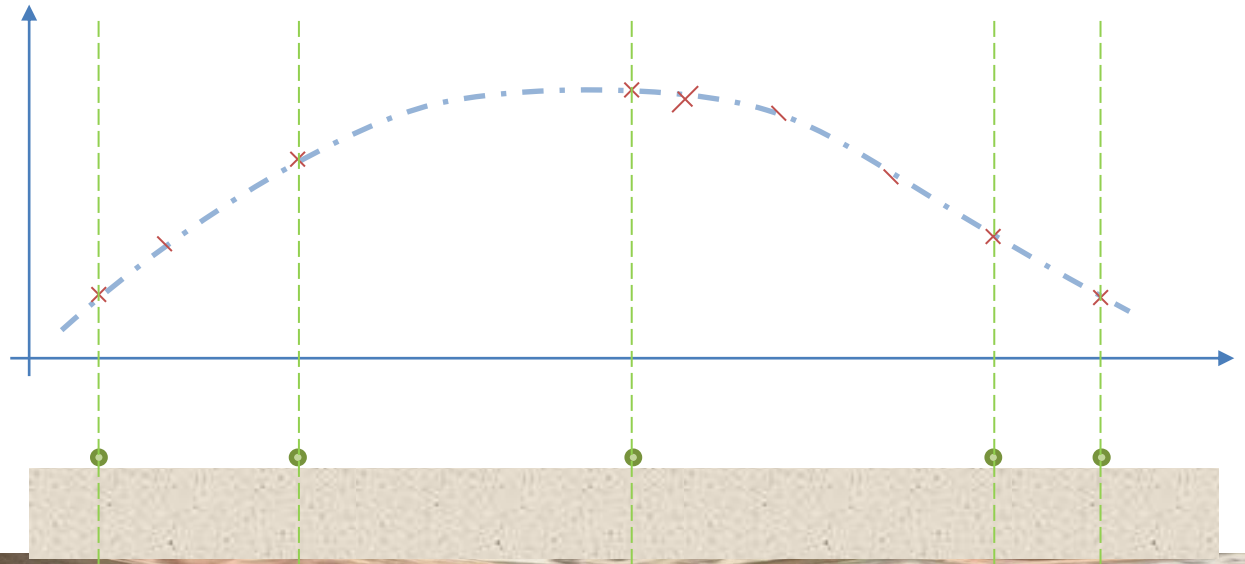
- Distributed Fiber Optics Sensing (DFOS)
- Mining Applications
- Rockmass Response Monitoring
- Tailings Dam Monitoring
- Summary

Distributed Fiber Optics Sensing Technology (DFOS)

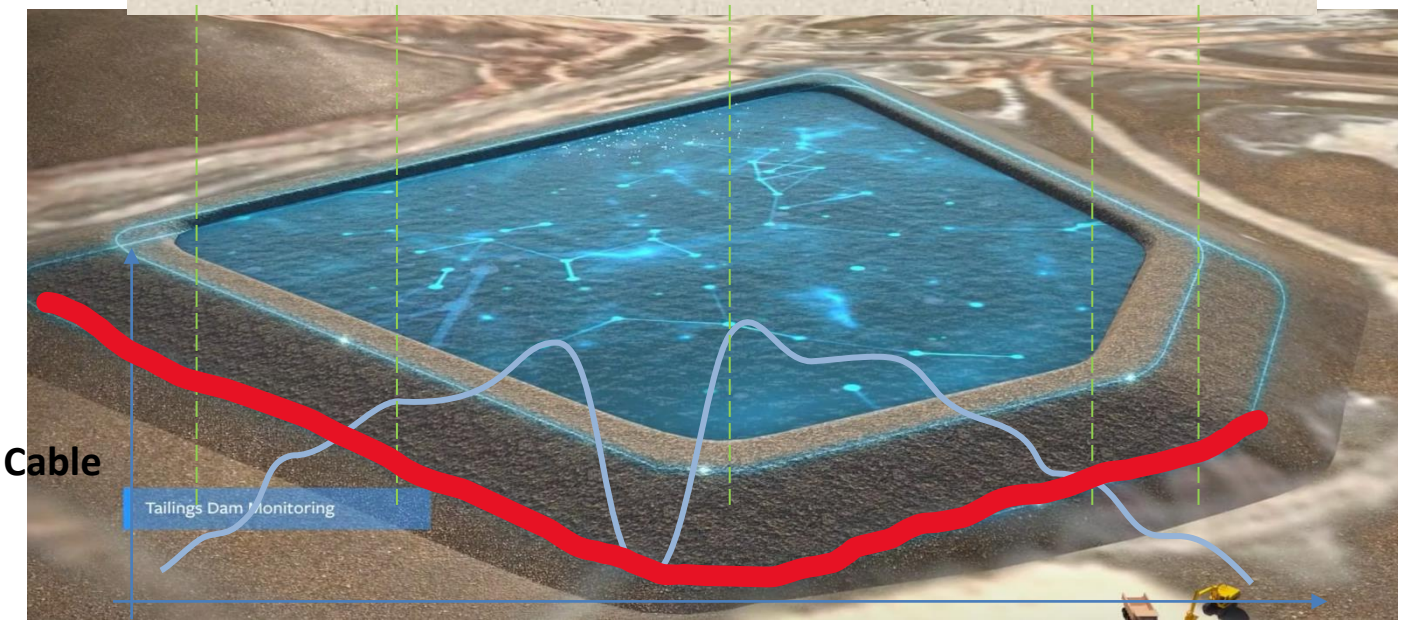
- DFOS makes use of a continuous length of standard Fiber Optics Cable (FOC)
- FOC is both the sensor and the data transfer medium
- Often multiple fibers inside one cable



Distributed vs pointed sensors



Point sensors



Distributed Sensing FO Cable

DFOS:

- To monitor large volumes: such as TSF or Rockmass
- High spatial resolution
- Lower operational cost and maintenance
- Continuous or on-demand use

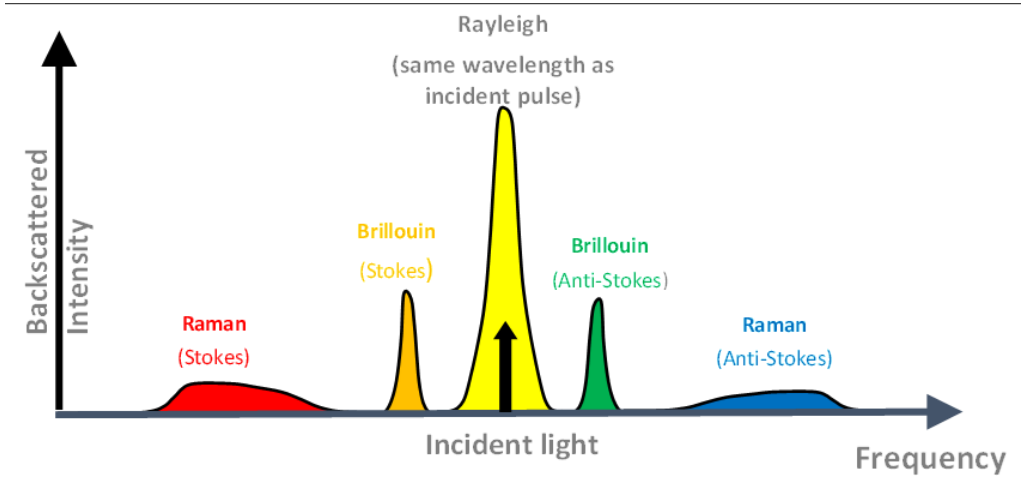
How does DFOS work?

- The interrogator sends a series of laser (light) pulses into the fibre and records the return of the naturally occurring scattered or reflected signal against time

Common types of Interrogators

1. **DTS**: Distributed **Temperature** Sensing
2. **DAS**: Distributed **Acoustic** Sensing
3. **DSS**: Distributed **Strain** Sensing

Each or all three interrogators can be used for monitoring



Role of DFOS in ESG

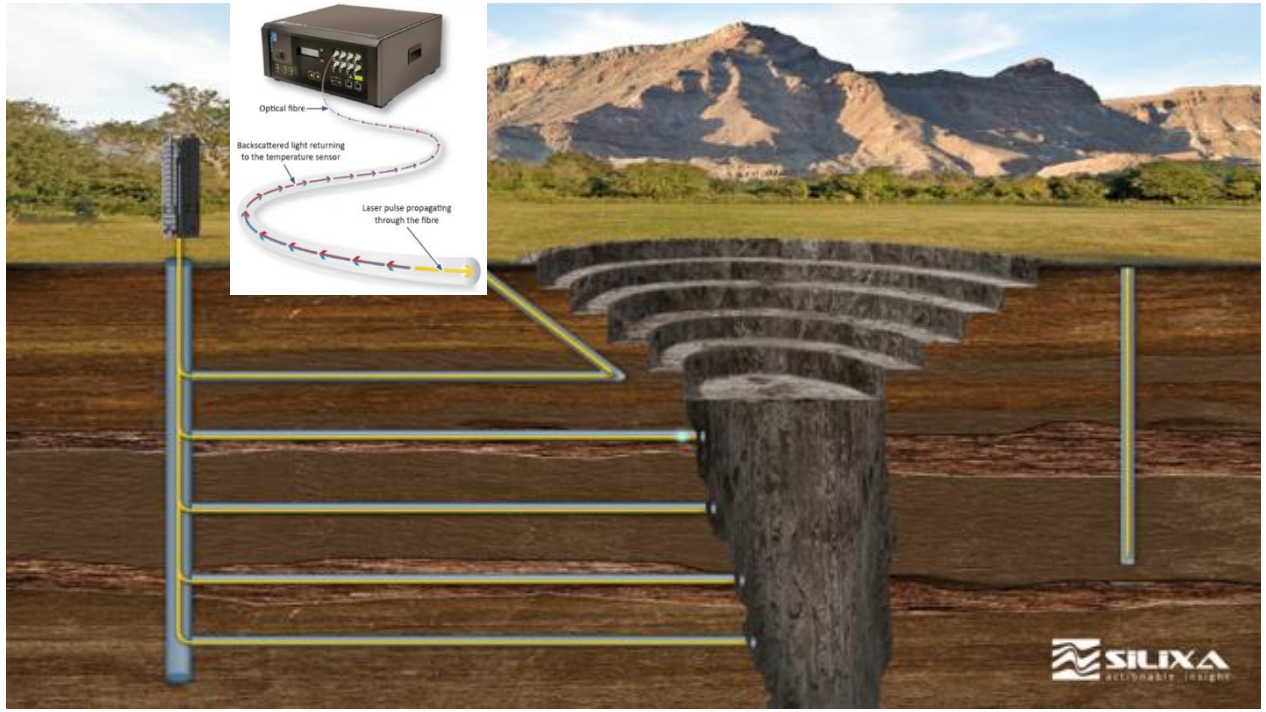
- Mining leaders advancing the development of their company's ESG credentials, & disclosing performance and risks to stakeholders
- Mine operators looking to enhance sustainable resource extraction & minimize environmental footprint.
- Among key areas: Waste management, water resources optimization, net zero initiatives, mitigate environmental impacts & safety risks.
- Health and safety of workers and communities is a key ESG pillar under social engagement
- Mines looking to adopt new technologies to facilitate ESG implementation strategies

DFOS enables operators to improve environmental performance, enhance work safety, optimize resource utilization

Rockmass Response Monitoring (DFOS)

Where:
- Tailings Storage Facilities
- Underground mining
  - Block caving
  - Soft rock, Coal, salt, Potash
  - Hard rock mines
  - Shaft sinking
- Open pit/ slope monitoring
- Infrastructure

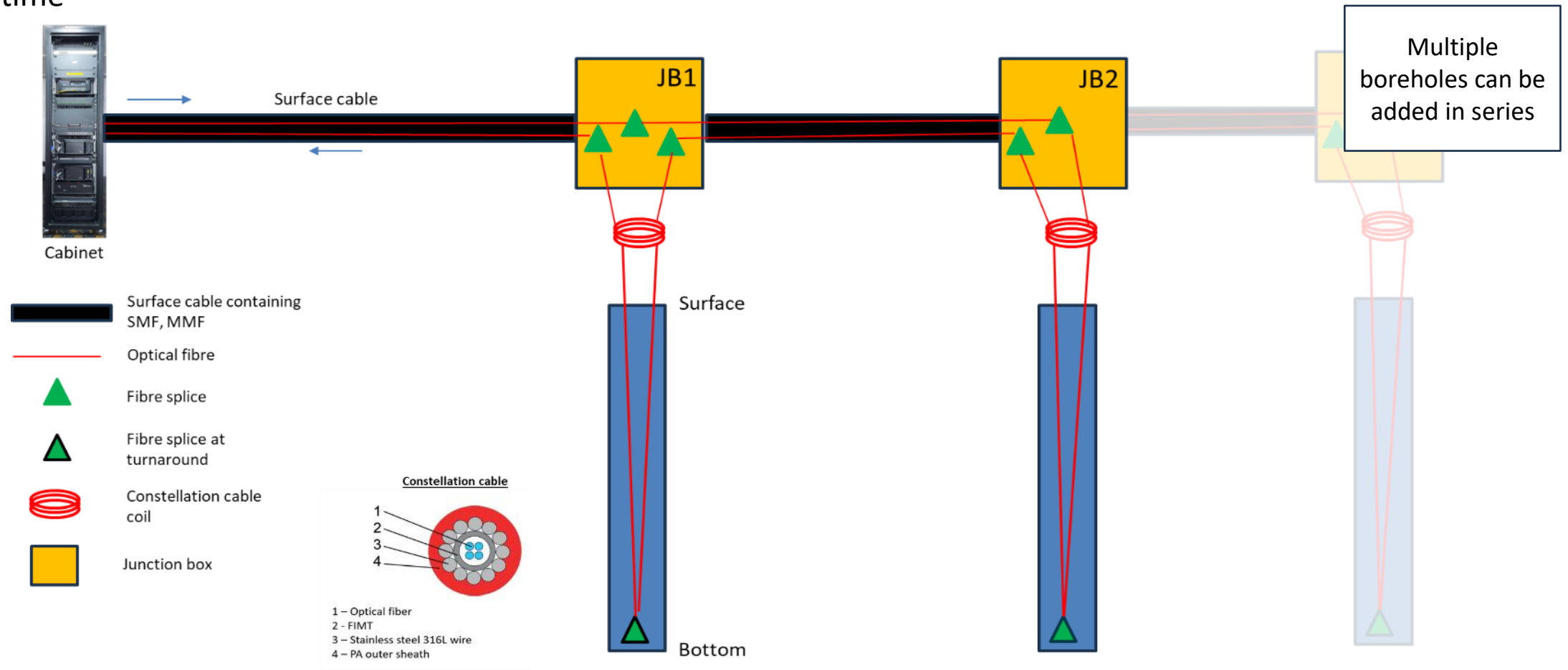
Output:
- Deformation monitoring
- Fracture network monitoring
- Microseismic Monitoring
- Seismic imaging and tomography
- Blast Monitoring
- Geothermal gradient and temperature monitoring



Interrogators applicable:
- DAS/Carina
- DSS
- DTS
- Combined platform: DAS, DSS, DTS

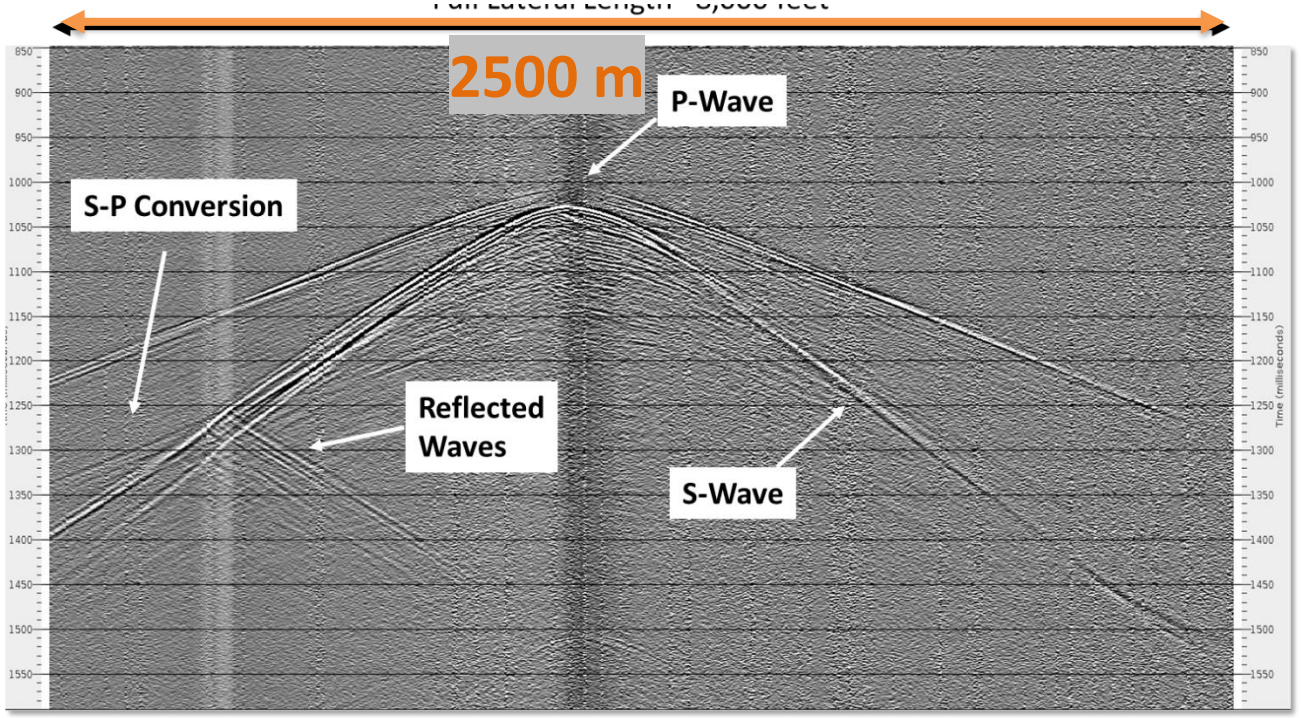
Rockmass Response Monitoring- Daisy chaining fiber cable in boreholes

- Cable layout is flexible. Multiple cables with multiple fibers in each for strain, temperature and seismicity
- Cable can be designed to follow the fracture growth and with extended lifetime



DAS- Seismic Monitoring and Subsurface Imaging

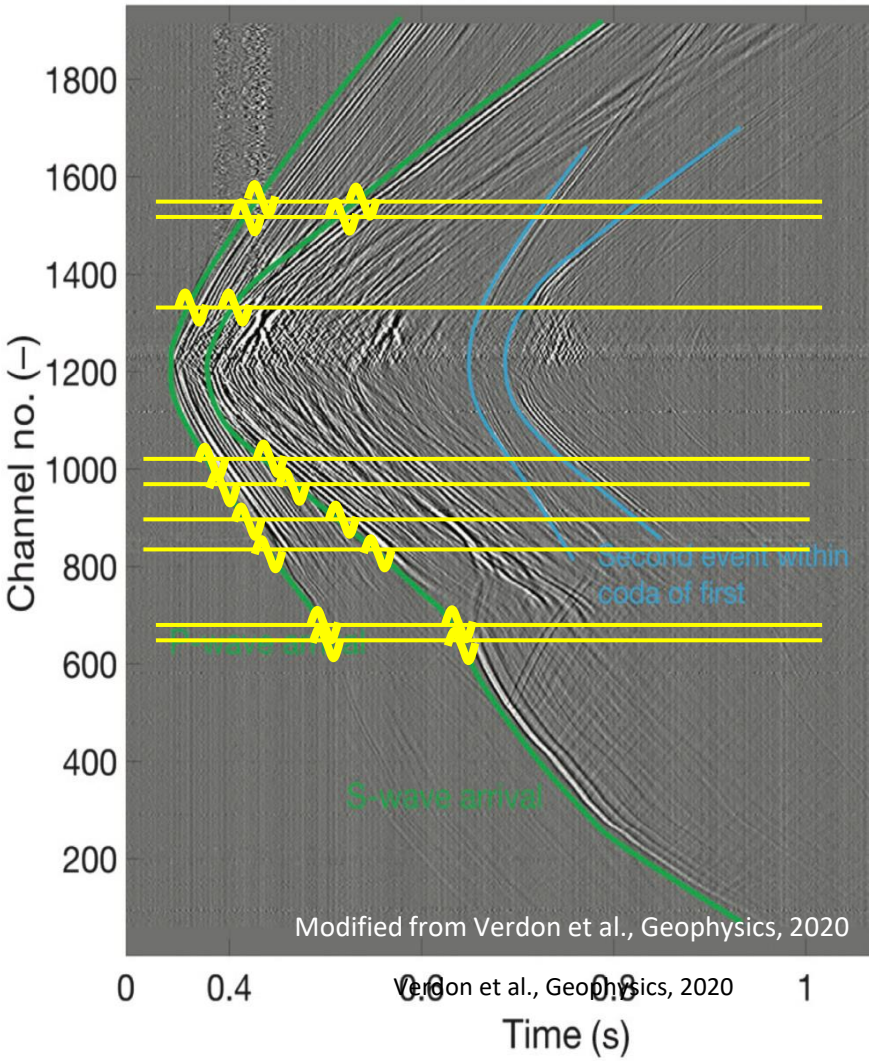
DAS records acoustic signals along many kilometers of fiber, as if it were a string of geophones



Unprocessed Carina iDAS Microseismic Event

Traditional geophones

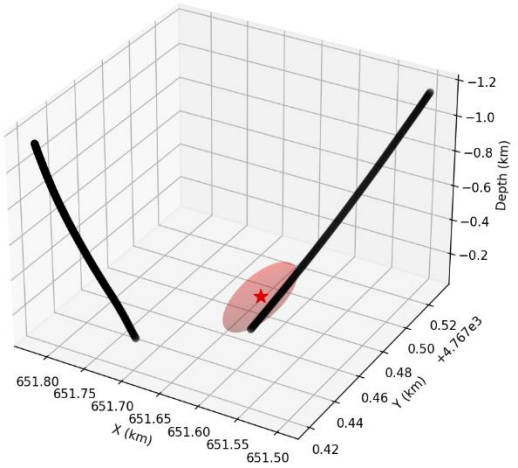
Potential DAS vs Geophone Arrivals

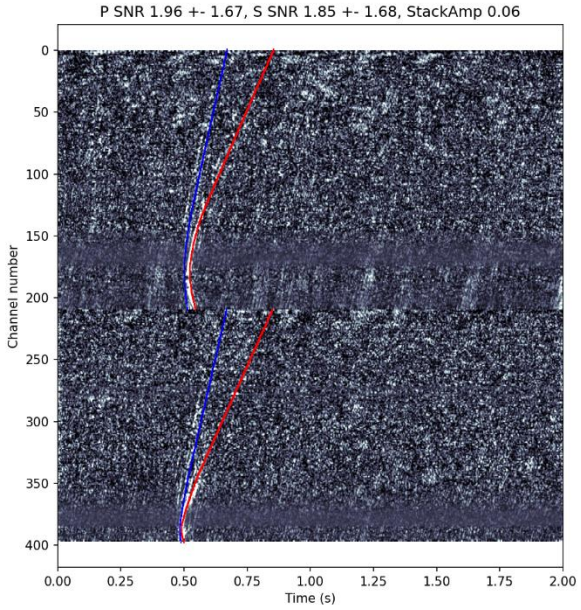


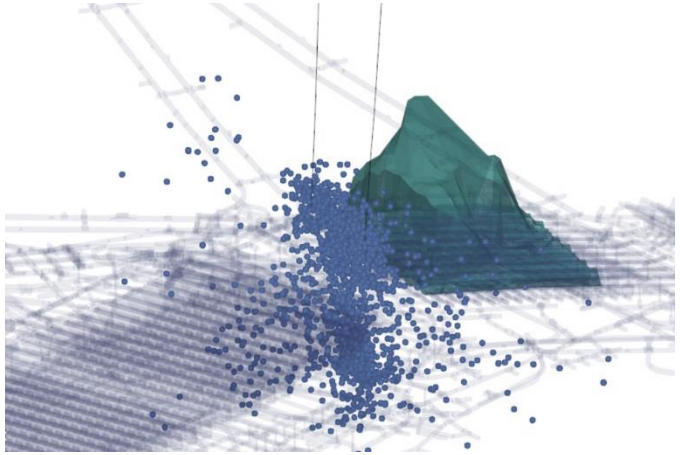
Verdon et al., Geophysics, 2020

Microseismic Monitoring

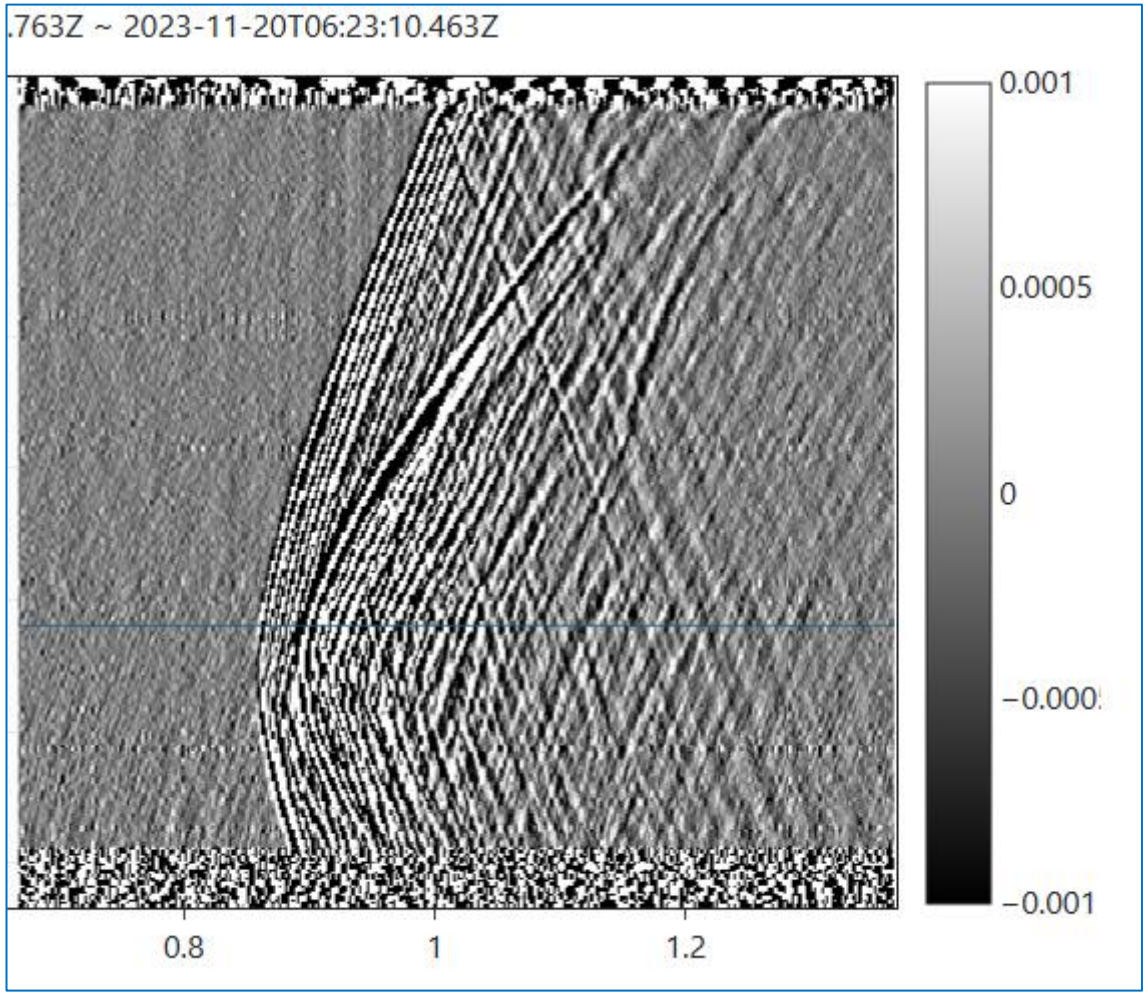
Seismic events located on two boreholes





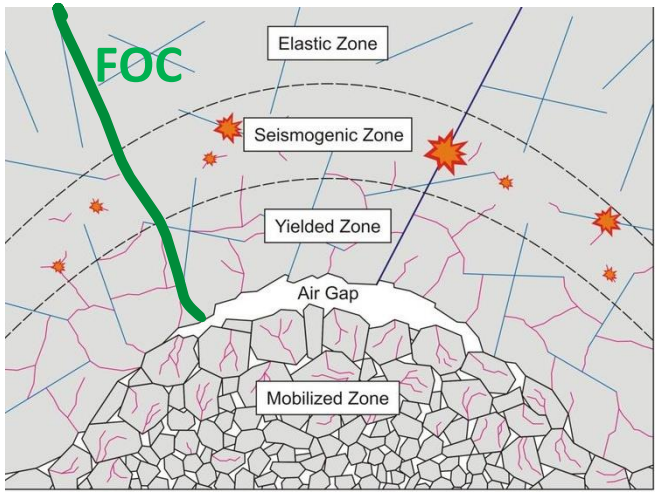


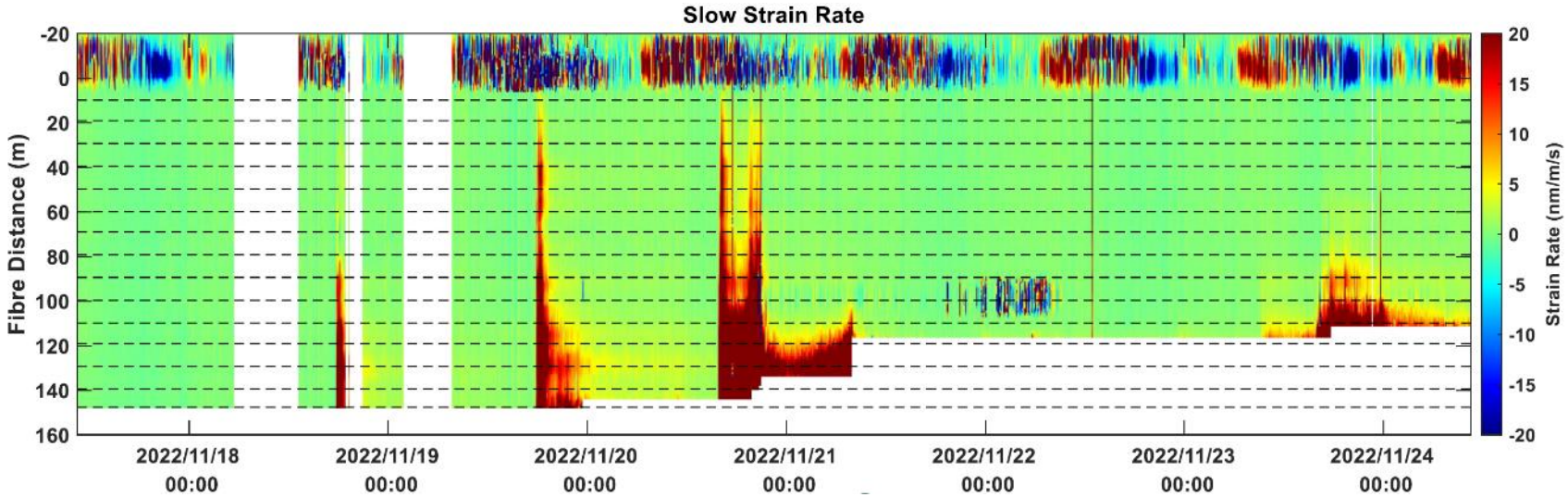
Seismic event over 1200 meters, showing p-s and surface reflections



DAS slow strain

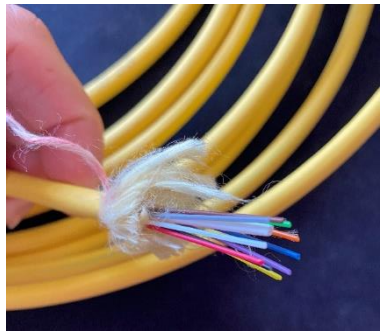
- Real time output into TARP
- Strain rate build up before each cave/cable break

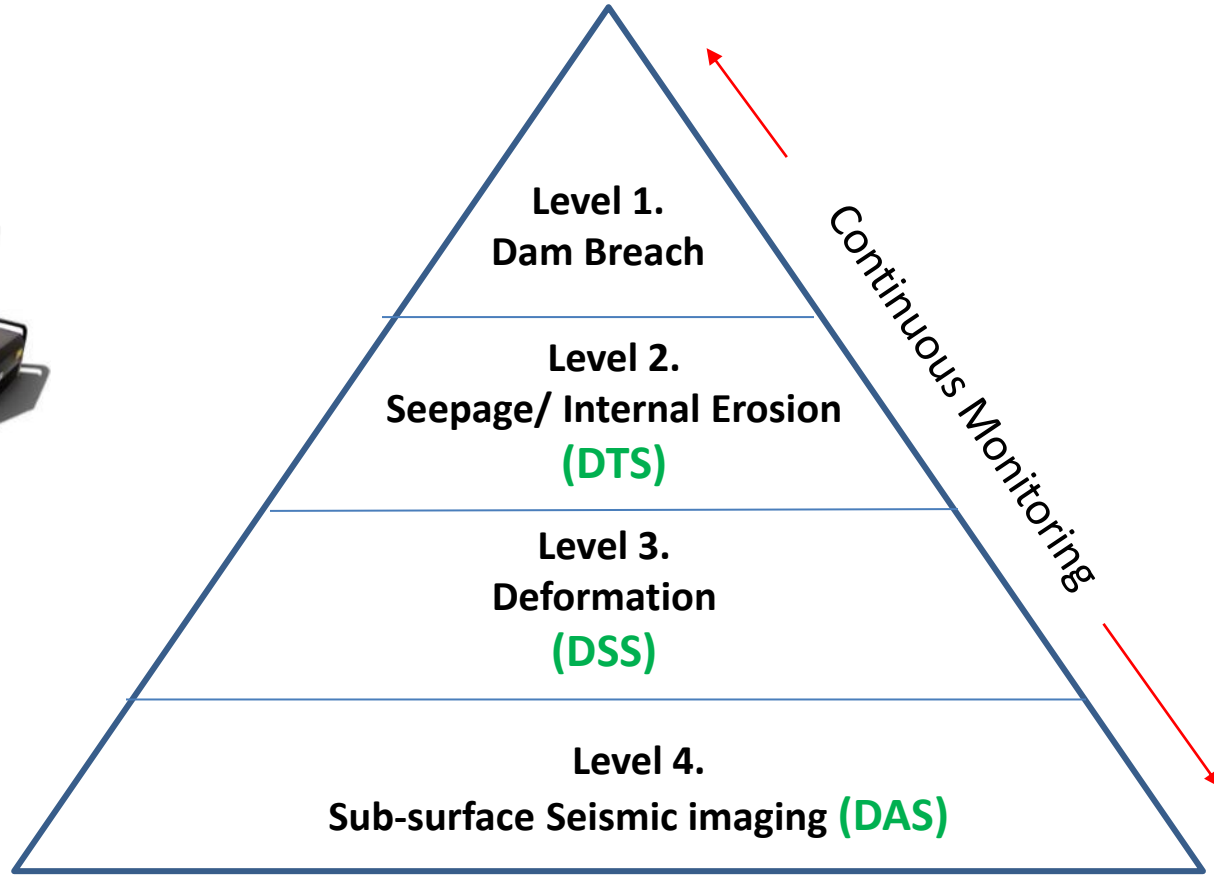




DamPulse Tailings Monitoring

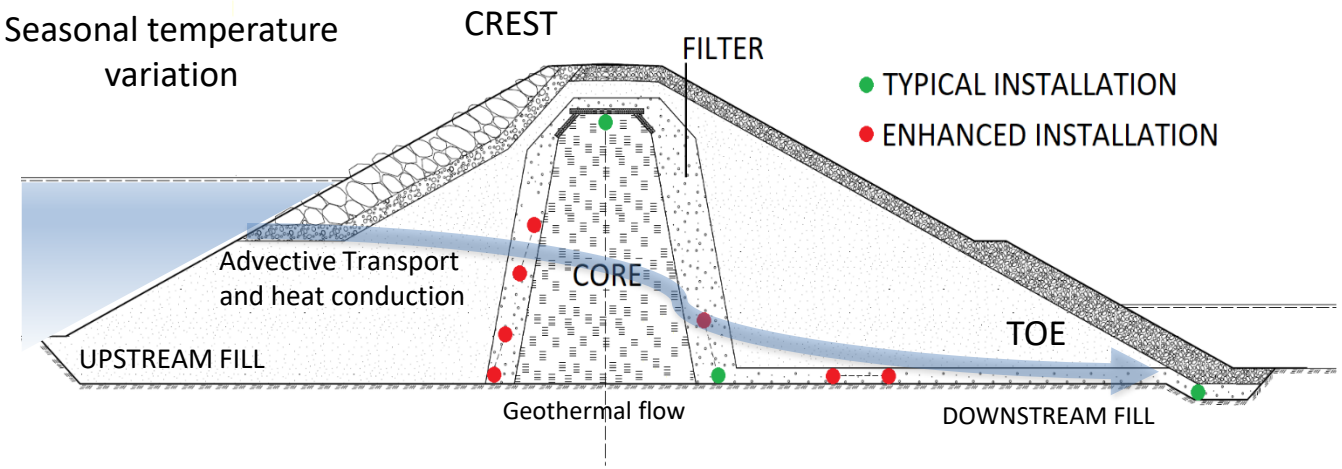
Fiber Optics Cable

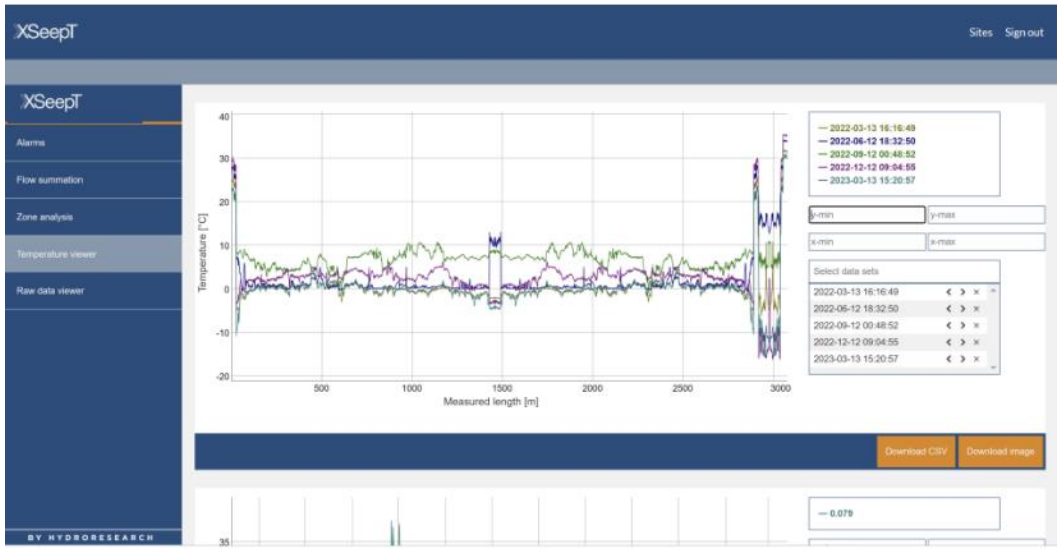


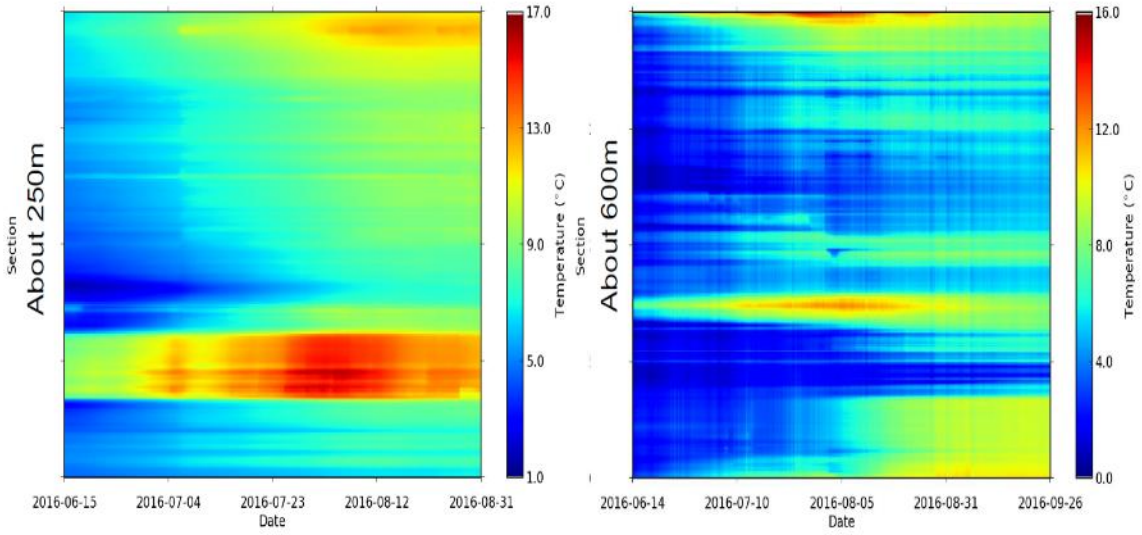


On one Fiber cable!

DTS- Seepage Monitoring based on Temperature







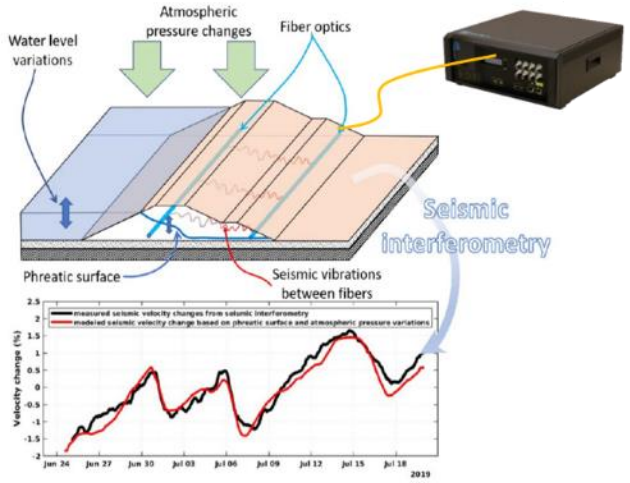
Early detection of internal erosion; Determining when and where 0.01^C and 65 cm

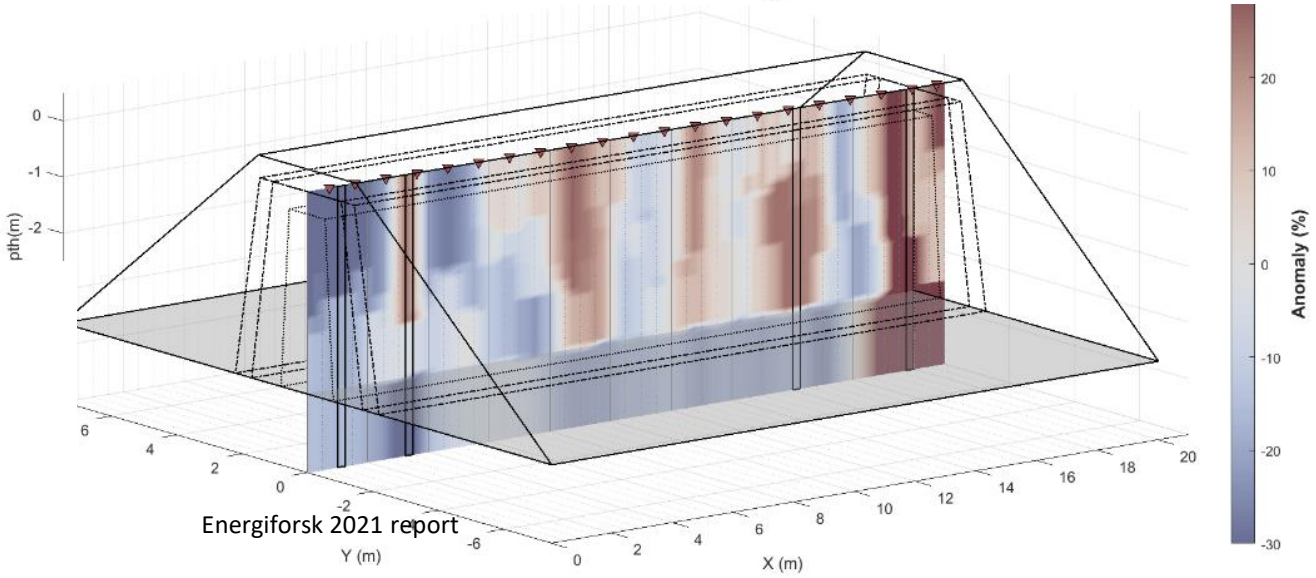
HydroResearch

DAS- TSF Seismic Monitoring and Subsurface Imaging

Ambient Noise Interferometry

- Recordings and processing of background noise is used to create a sub-surface image.





Energiforsk 2021 report

- DAS is far-field and can record data every meter, generating large volumes of data
- It requires power and data infrastructure
- Requires further development of imaging techniques

HydroResearch

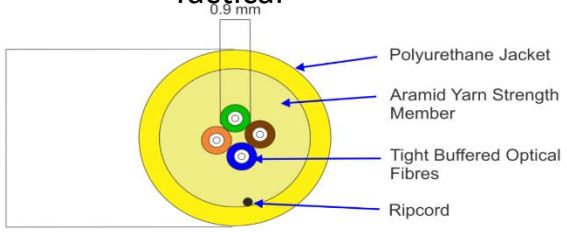
SISPROBE by egis

Fiber Cable Installation

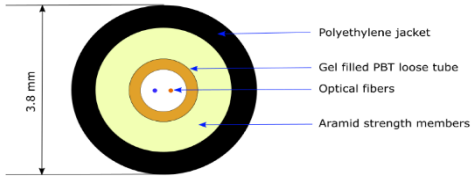
- FOC layout and location is designed based on objectives
- Military grade, operates for decades, proper installation is critical
- Can be handled mostly by mines will little supervision.

Durability

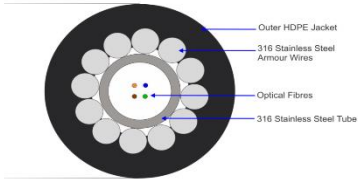
Tactical



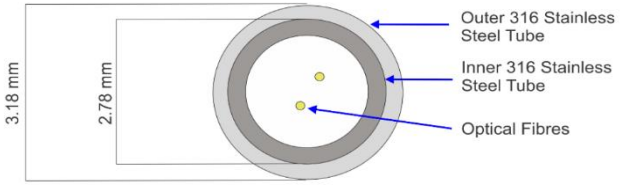
Loose Tube



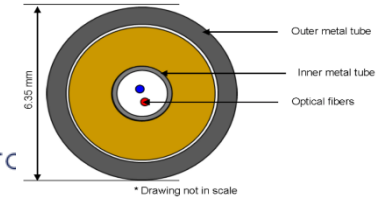
Armored FIMT



1/8” or 4mm Double-Tube



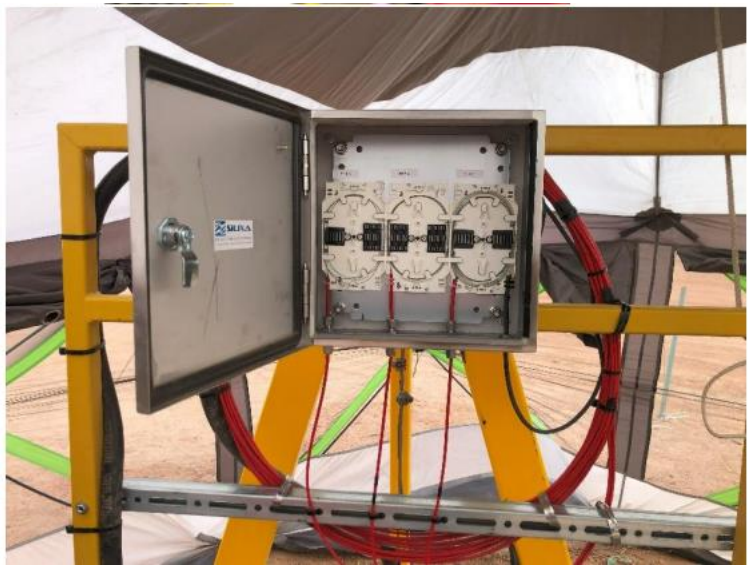
1/4” Downhole



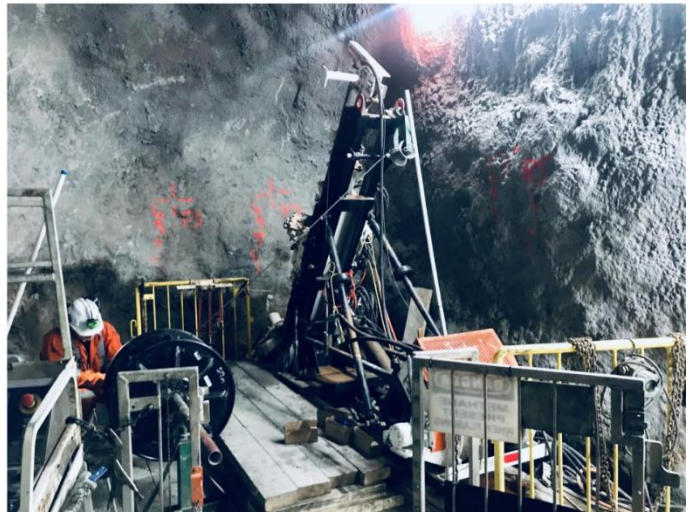
Deep borehole installation

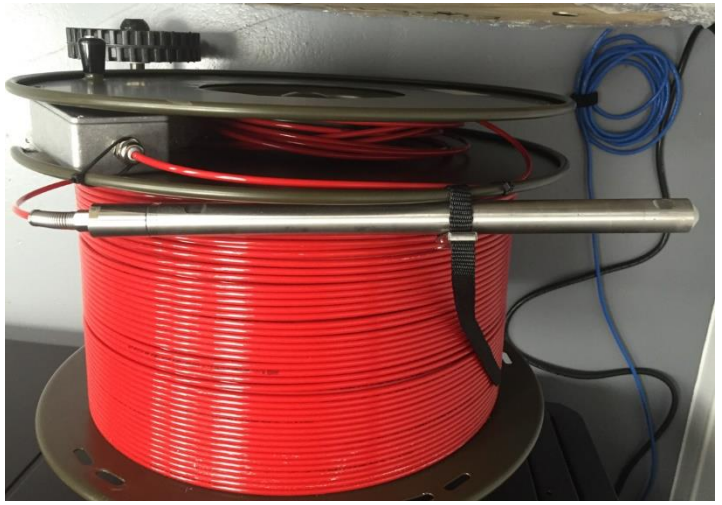
Fibre reels for 3 different depths

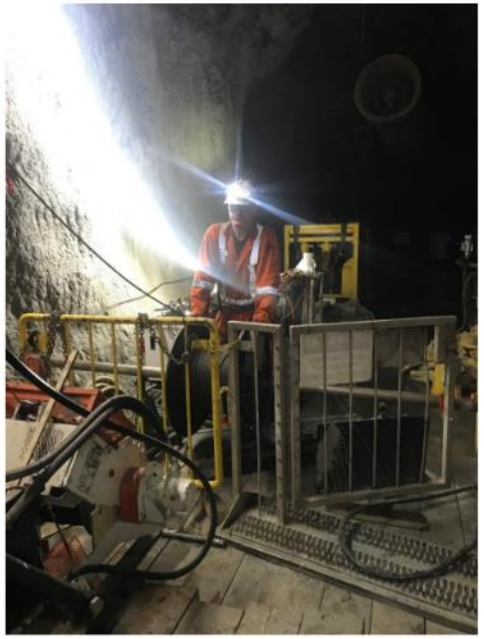
Bottom hole assembly



Underground installation

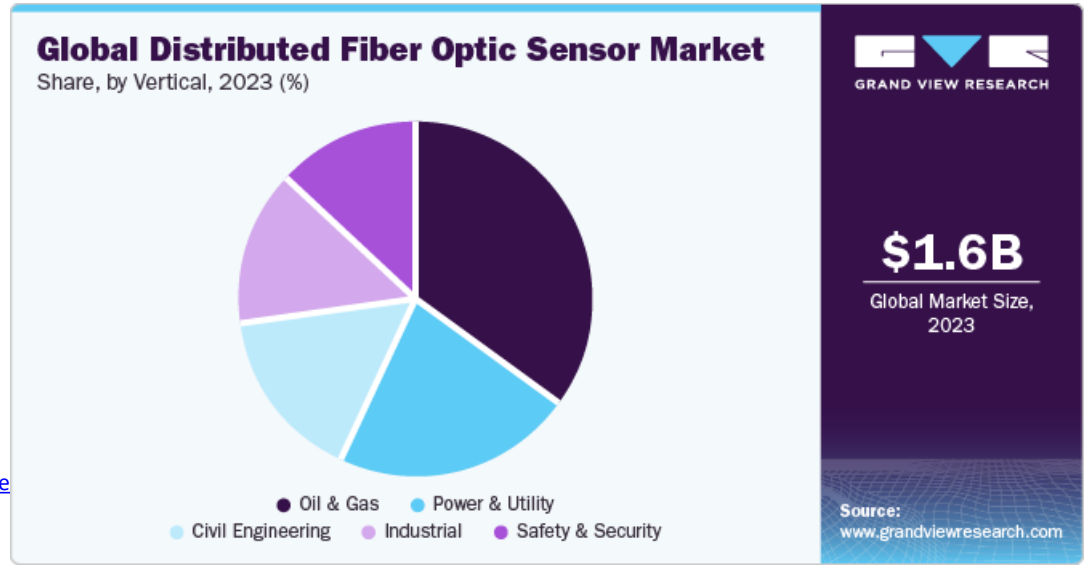


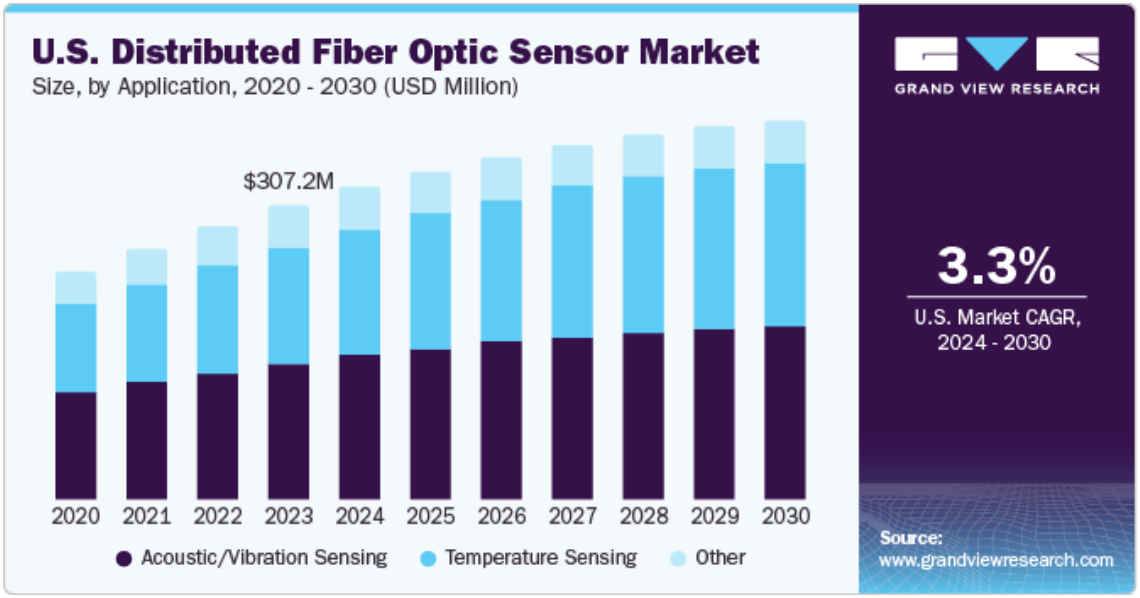




State of DFOS technology

- “The global distributed fiber optic sensor market is expected to grow at a compound annual growth rate of 6.5 % from 2024 to 2030 to reach USD 2.53 billion by 2030.”*
- Highly-integrated cost-effective, power-efficient centralized monitoring platform
- Rapidly maturing technology due to increasing investment and R&D by prominent parties and rising applications in Civil Eng., O&G and transportation





* grandvie

DFOS Value Add in Mining

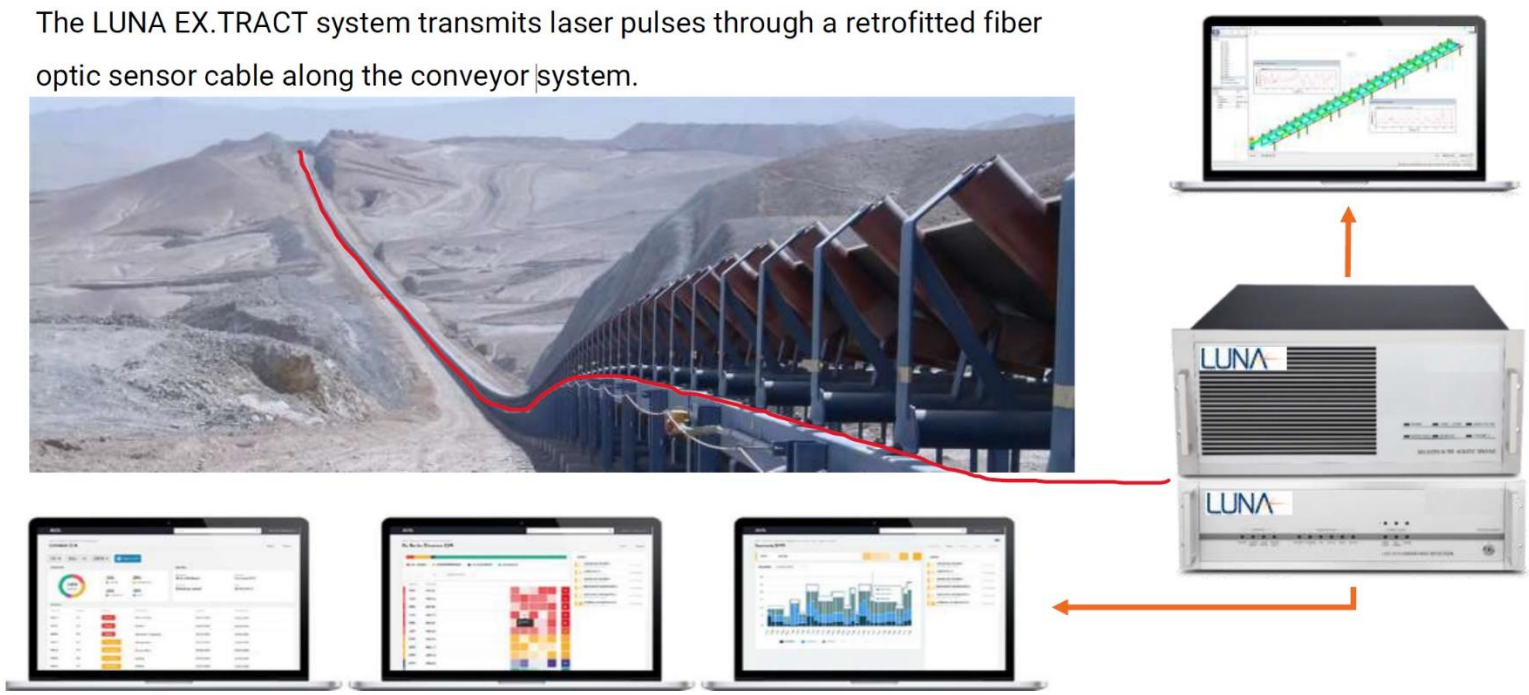
- **DFOS in mining operations**
  - Real-time monitoring, early detection of geotechnical hazards,
  - comprehensive asset integrity management: fire prevention for conveyance and electrical infrastructure, pipeline monitoring
- **Small footprint, large volumes, low maintenance**
- **Light-based**, No electrical interference- low maintenance
- **Simultaneous measurement** of Temperature, Strain, Acoustics on one cable
- DFOS sill in development in mining sector

A platform for ESG compliance by mitigating environmental and operational risks and ensuring worker safety

DFOS current applications in Mining

- Certified fire prevention
- Conveyor belt monitoring
- Pipeline monitoring
- Flow metering
- Exploration seismic survey
- Tailings Dam Monitoring
- Rockmass Response Monitoring

The LUNA EX.TRACT system transmits laser pulses through a retrofitted fiber optic sensor cable along the conveyor system.



Questions

Thank you for listening!
Any questions?

DFOS:

- Provides accurate, continuous data on asset integrity and environmental parameters.
- Contributes to transparent reporting, compliance with ESG standards, and enhancing safety practices and standards
- DFOS applications in mining are advancing and require further development and commercialization

Thank you for listening!
Any questions?

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