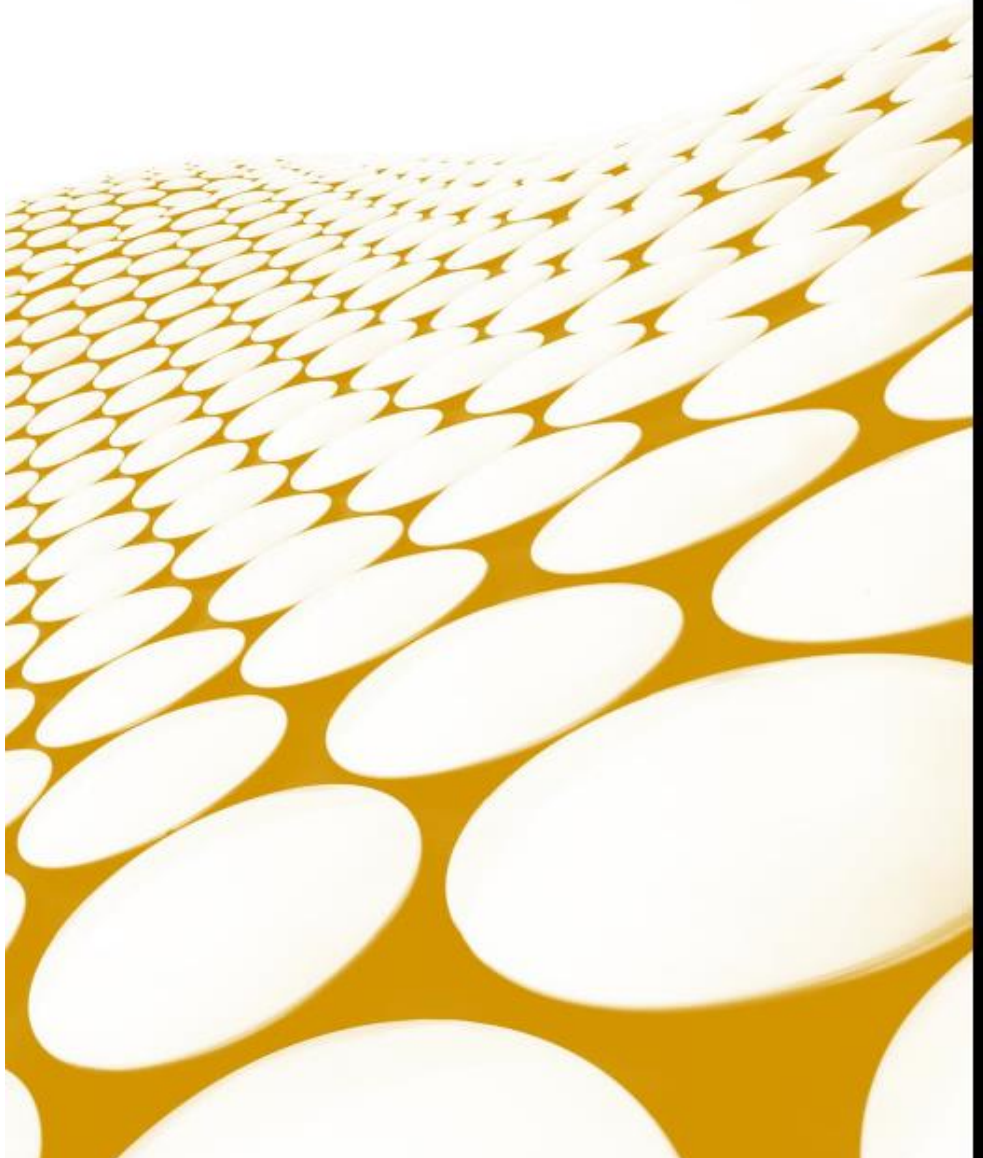


GOLDENEYE

SUMEX Clustering Workshop

VTT Technical Research Centre of Finland
Sanna Uusitalo
16.06.2021

GOLDENEYE:
EU H2020 funded project

- VTT coordinated Innovation Action
- Project duration: 05/2020-05/2023
- Consortium of 16 partners including:

  3 Mining solution providers
  7 Sensor companies
  4 Mining sites
  3 Universities
  1 Research Institute (Coordinator)

PROJECT CONSORTIUM

VTT
OPT/NET
timegate
beak CONSULTANTS
SITEMARK
SINERGISE
radai
CUPRUMIN
DARES
Galileo Satellite Navigation Ltd.
EARTH OBSERVING SYSTEM
UNIVERSITATEA TEHNICĂ DIN CLUJ-NAPOCA
SANDVIK
UNIVERSITY OF OULU
AKG
ОД. КАМЕНОГОРСКИЙ

GOLDENEYE project

Development of multisource **EO and sensing DATA** platform to **IMPROVE**

- Mine safety
- Environmental footprint
- Profitability

Platform is a **TOOLKIT** for the mines to **MONITOR**:

- OPEN PIT mine slope stability
- WASTE pile stability
- TAILINGS bond stability
- UNDERGROUND mine activity

Platform is a **TOOLKIT** for the mines to **IMPROVE**:

- Mineralogical mapping of mine site ground surfaces
- Mineralogical analysis of drill cores for exploration and ore processing
- Mineralogical analysis of underground mine shafts

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No [869398]

Technologies of **GOLDEN AI platform**

EOD sensing with satellite sources:

- Sentinel-1 Synthethic Aperture Radar Imagery
- Sentinel-2 Multispectral Imagery
- Sentinel-3, Sentinel-5P, Landsat-8, MODIS
- Airbus / Plejades Satellite Imagery & DEM
- TerraSAR-X Radar Imagery

➢ **SAFETY:**

Ground deformation and slope stability in open pit mines and tailing dams

➢ **ENVIRONMENTAL FOOTPRINT:**

Changes of ground cover and surface waters

Golden AI assistant for easy analysis

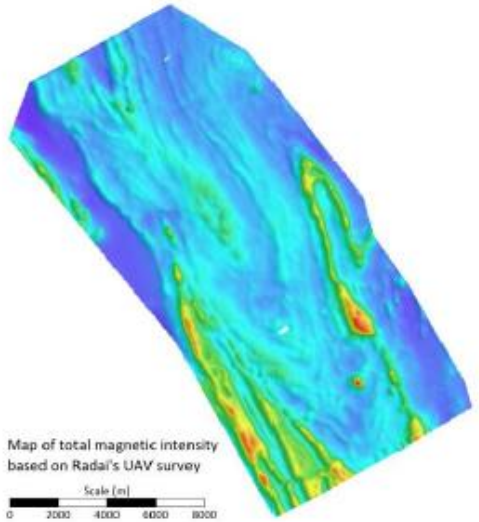
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No [869398]

GOLDENEYE

Technologies of
GOLDEN AI platform

Drone (UAV) based sensing:

- Geophysical analysis using devices such as fixed wing drones
- Electromagnetic (EM) field measurements
- Multispectral imaging



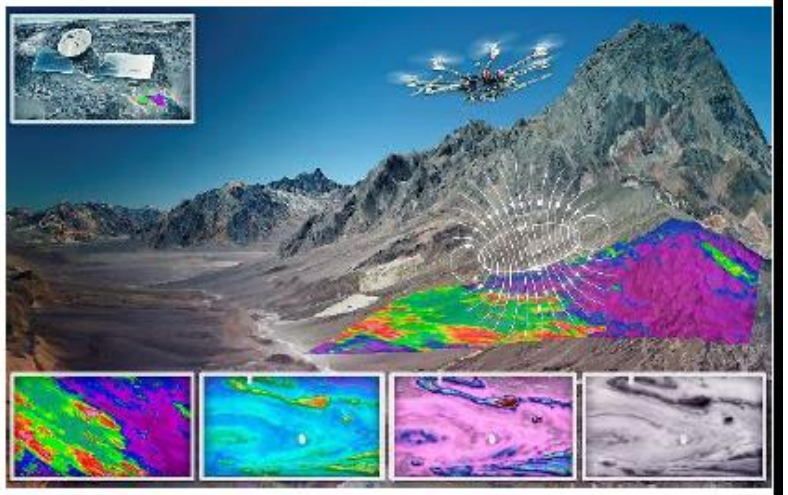
➢ **ENVIRONMENTAL FOOTPRINT:**

Detection of contaminated lands and vegetation

Changes in land elevation

➢ **MINERAL EXPLORATION:**

Geophysical data will calibrate the satellite-based sensors for more accurate prediction of 3D geology of mine site



GOLDENEYE

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Technologies of
GOLDEN AI platform

Innovative proximal sensing:

- Time-gated Raman sensor integration to drilling unit
- Time-gated Raman sensing for field exploration
- Active hyperspectral imaging for field exploration
- GNSS geolocation based on cellular positioning

➢ **SAFETY:**

Precise location of underground mining activities

➢ **MINERAL EXPLORATION:**

In-situ analysis of minerology during ore exploration and extraction
On-site analysis of mineralogy as a reference for satellite and drone data analysis
Precise GNSS location of data recorded mineralogical data
Precise GNSS location of data gathered by underground sensors

GOLDENEYE

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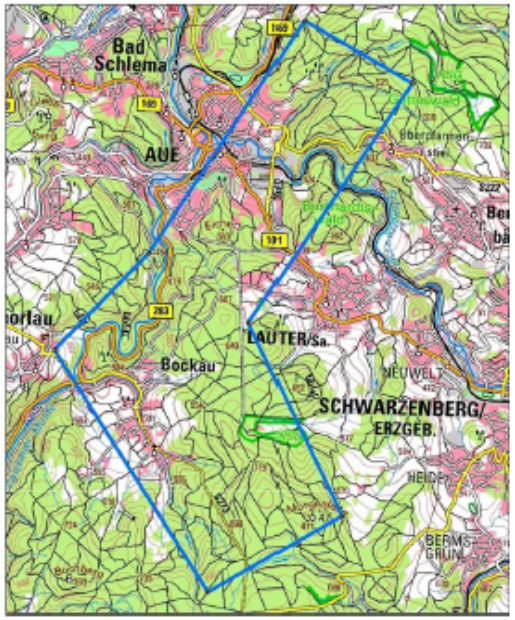
Field trials for piloting **GOLDEN AI platform**



Exploration in Germany:

- The Erzgebirge district, Bockau region
- Target for exploration are skarn-hosted Sn (tin) mineralization
- The exact location of drilling targets has not been identified
- Need for high-resolution mineralogical data

AIM: mineralogical knowledge

- Integration of high-resolution UAV data with satellite data to help to identify drilling targets
- New proximal sensors for calibration of spectral analysis

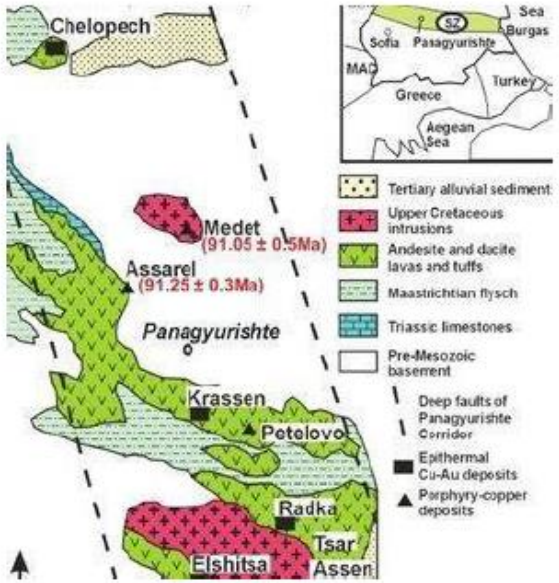
GOLDENEYE

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No [869398]

Field trials for piloting **GOLDEN AI platform**

Exploration in Bulgaria:

- The Panagyurishte ore district
- Target for exploration are porphyry-copper and epithermal gold occurrences
- The target mapping has lacked high-resolution data to identify the geometry of the alteration mineral assemblages and ore controlling



AIM: mineralogical knowledge

- IR and Multi-spectral UAV data will be produced together with GIS based maps of alteration mineral assemblages for each target
- New proximal sensors for calibration of spectral analysis

GOLDENEYE

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No [869398]

Field trials for piloting **GOLDEN AI platform**

Open pit extraction in Romania:

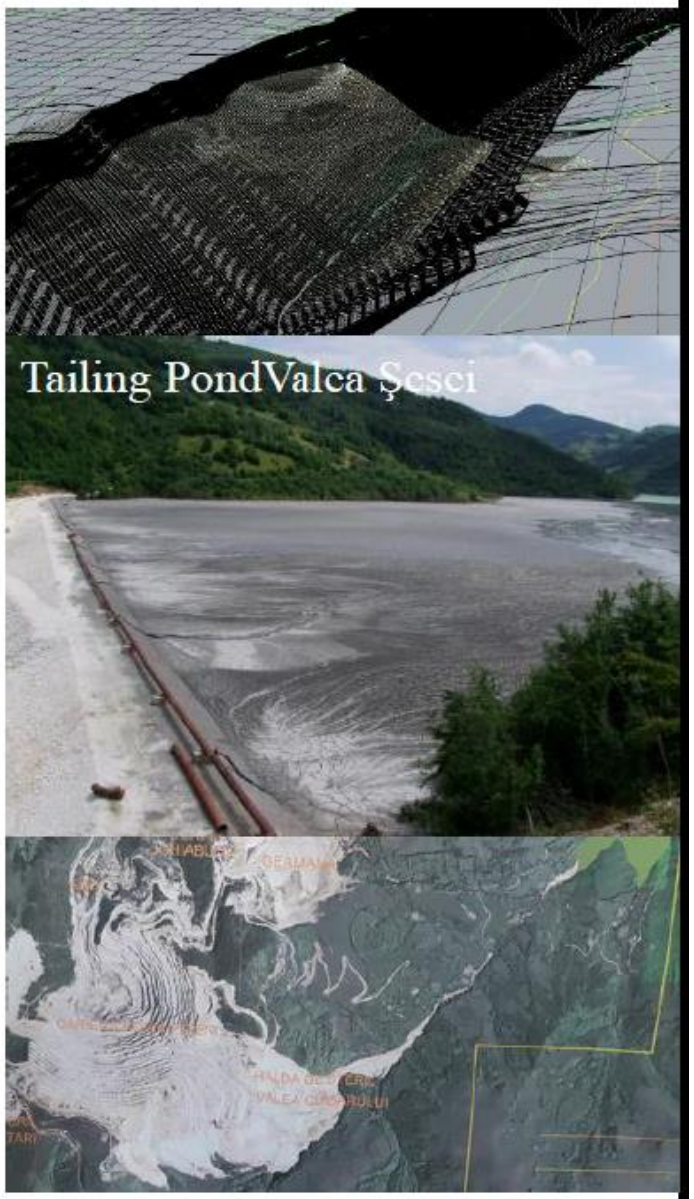
- The Roşia Poieni district
- Extraction of the copper ore
- The exact location of Cu deposit has not been found so far due to expensive drillings

AIM: mineralogical knowledge

- The integration of satellite data and drone or proximity data to improve mineral predictions

AIM: Open pit mine safety

- The integration of satellite data and drone data for modelling of open pit slope stability and tailings pond stability



GOLDENEYE

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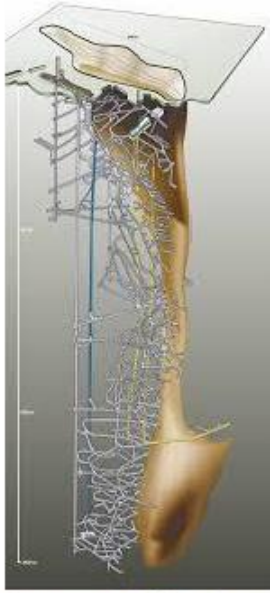
Field trials for piloting **GOLDEN AI platform**



Underground extraction in Finland:

- Pyhäsalmi deposit
- Mineralogy copper-zinc sulphide
- One of the deepest underground mines in Europe
- At the end of mine life-cycle

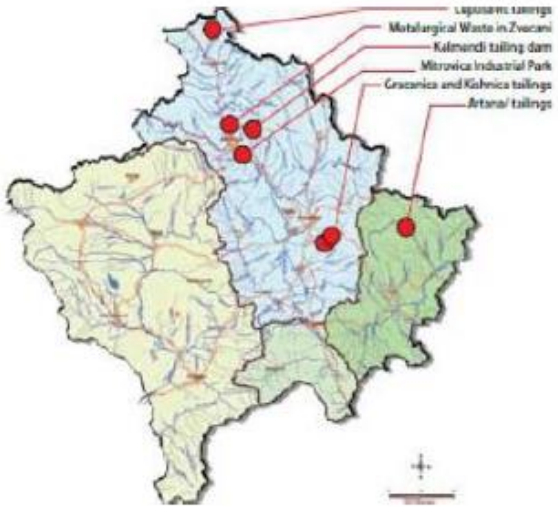
AIM: safety for mine re-use

- Integration of high-resolution drone data with satellite data to monitor slope integrity, both open pits and tailing ponds
- GNSS geolocation in underground mine to ensure the re-user safety

GOLDENEYE

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No [869398]

Field trials for piloting **GOLDEN AI platform**



Post Closure in Kosovo:

- The Trepča Mines Complex
- 8 tailings ponds owned by the government of Kosovo
- Target secondary raw material extraction in the tailing areas
- Heavy legacy of toxic waste

AIM: Safety and environmental monitoring

- Monitor the stability of the tailings and evaluate the degree of Acid Mine Drainage

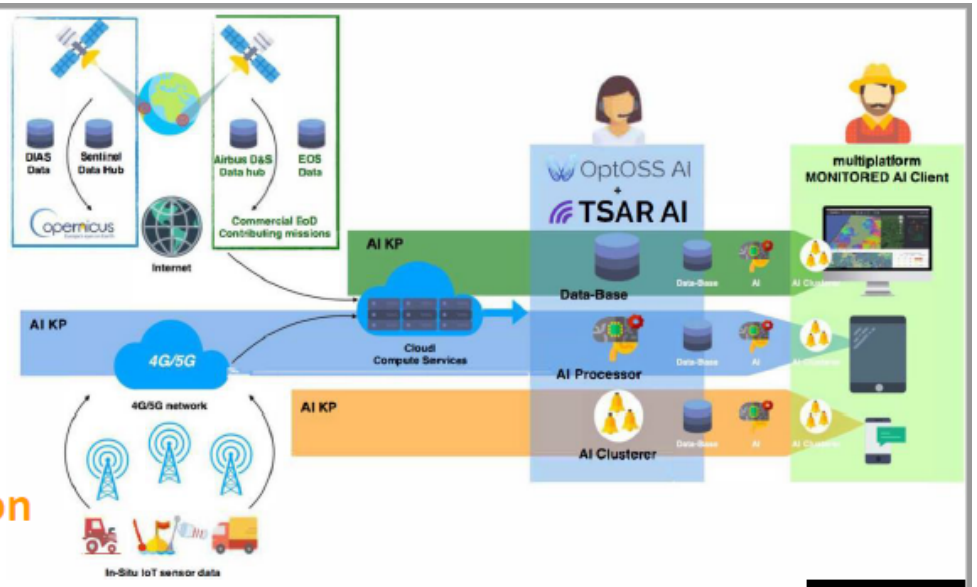
AIM: Mineralogical knowledge

- Evaluate the secondary extraction potential of tailings

GOLDENEYE

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No [869398]

GOLDEN AI platform



EO data ✚ Drone data ✚ sensor data

➔ More precision into the mine site analysis

- **3D spectral data and mineralogy in extraction/exploration**
- **Monitor ground alterations and changes with precision**

- Golden AI platform is managed using AI Knowledge Packs
  - **The Knowledge Packs enable to fuse different types of data**
  - **The EO data analysis can be improved using the input from drones and proximal sensors**
  - **The aim is to get better ground/height resolution and improve mineralogical calibration**
- The platform is pre-trained by different user groups: experts, administrators, operators, editors, auditors and super-users
- After training, platform **will learn to perform** data selection, preparation, processing and analysis of the time-series **autonomously**

GOLDENEYE

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No [869398]

Challenges in bringing digitalization and sensing to the mining industry

- Automation can be see as a threat to employment
- New technology an additional thing messing up the routine and getting on the way
- There can be a history of unsuccessful trials with the new technologies
- Nobody wants to be the first one to take up a new technology
- Miners do not have a common language with Tech/Digi people, this causes a lot of change resistance
- New technology seems complicated, unreliable and time consuming to the mining people with low benefits
- Many technologies cost money and for the mine the benefit should reduce costs
- The benefits might be far in the future, the mine might do cost optimization and not take up new technology
- There is lack of expertise in digitalization among mines:
  - Mines would need new employees to take up the technology
  - Young people tend to have prejudice against mining industry as an interesting employer

GOLDENEYE

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No [869398]

How is GOLDEN AI platform tackling the challenges

- Golden AI platform integrates open data, commercial data as well as the data acquired during Goldeneye project and presents the **results as visual maps**
- Output helps mines and authorities to visualize the mining environment and track the effect of the mine to the surrounding environment
- The Goldeneye-project will provide **an open public demonstrator**, which illustrates the benefits of the Golden AI platform for mining industry
- A basis for a robust, scalable and cost efficient solution
  - **Flexible and open for new imaging and sensing technologies in the future**
- The project will arrange discussions with mines in- and outside the project consortium to seek new ways for providing a desirable digital tool

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No [869398]

Thank you for your attention

GOLDENEYE

SUMEX clustering workshop
H2020 project: NEMO

Andrea Di Maria

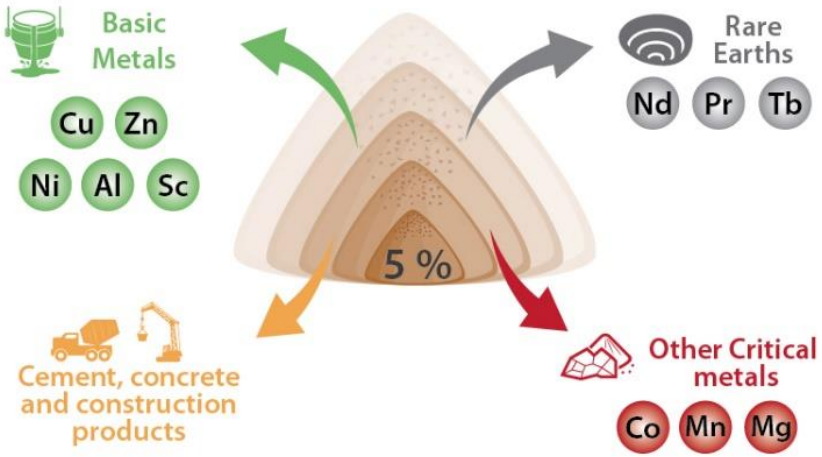
Lieven Machiels

The NEMO project

"Near-zero-waste recycling of low-grade sulphidic mining waste for critical-metal, mineral and construction raw-material production in a circular economy"

Expected benefits:

- Recovery of:
  1) critical raw materials (Co, REE, Sc and Mg),
  2) base metals (Cu, Ni, Zn, Ag),
  3) minerals (CaO and $(NH_4)_2SO_4$),
  4) construction raw materials for cement and concr production.



- Reducing Europe's dependence on imports.

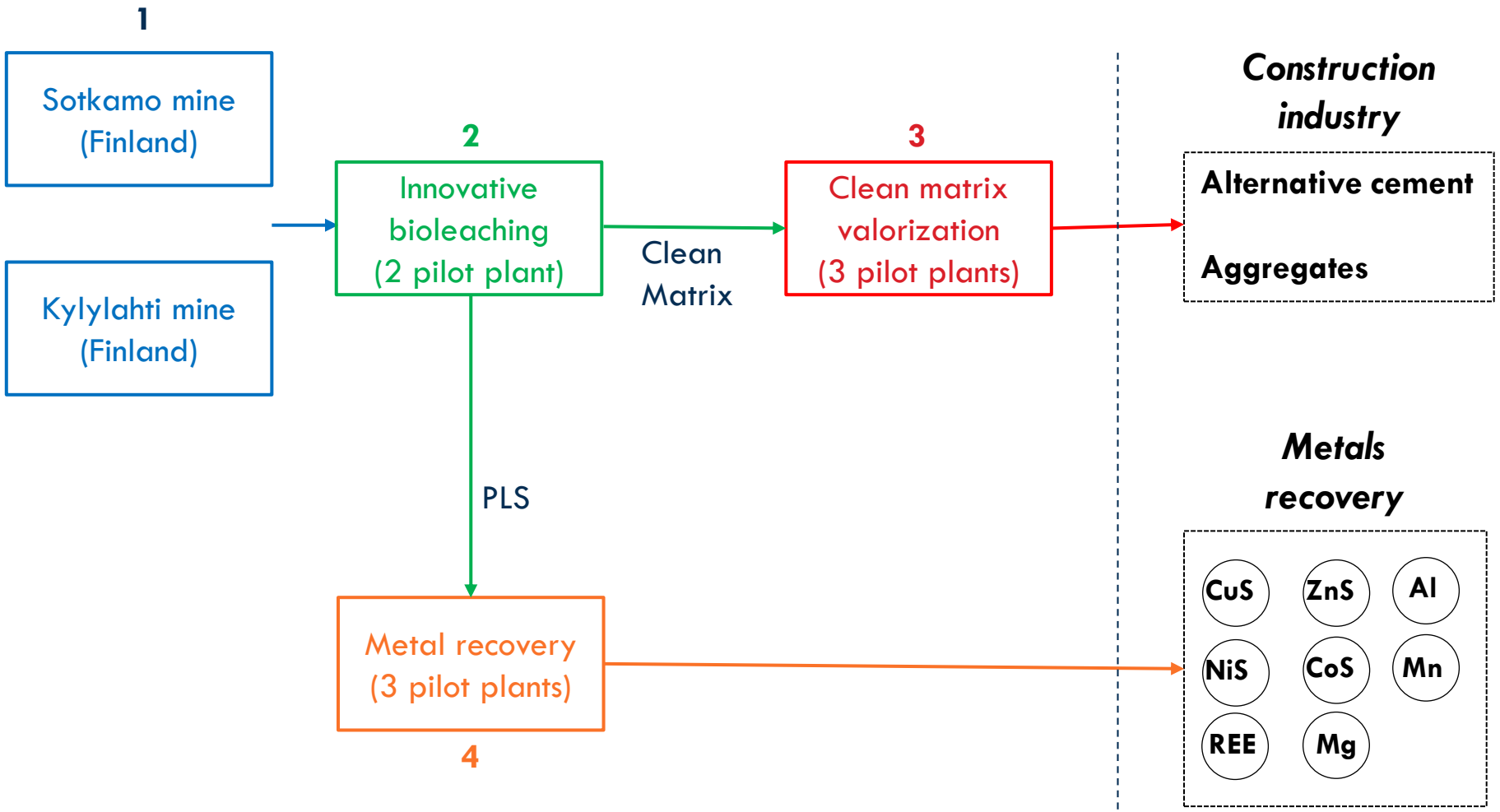
* *Output products might be different depending on the case study*

The NEMO project

Case study: Sotkamo mine (Finland)

Ni-Cu-Zn-Co mine

The NEMO Framework



The NEMO Partners

INPUT

Sotkamo mine (Finland)

Terrafame

Innovative Bioleaching

brgm, University of Exeter, idener, Finnish Minerals Group

Metals and minerals recovery

idener, KU LEUVEN, VTT, Finnish Minerals Group, Skyscape

Clean material residues recycling

vito, Jacobs, thyssenkrupp, Resourceful

Sustainability analysis

KU LEUVEN

Environment

catapa

Social LCA

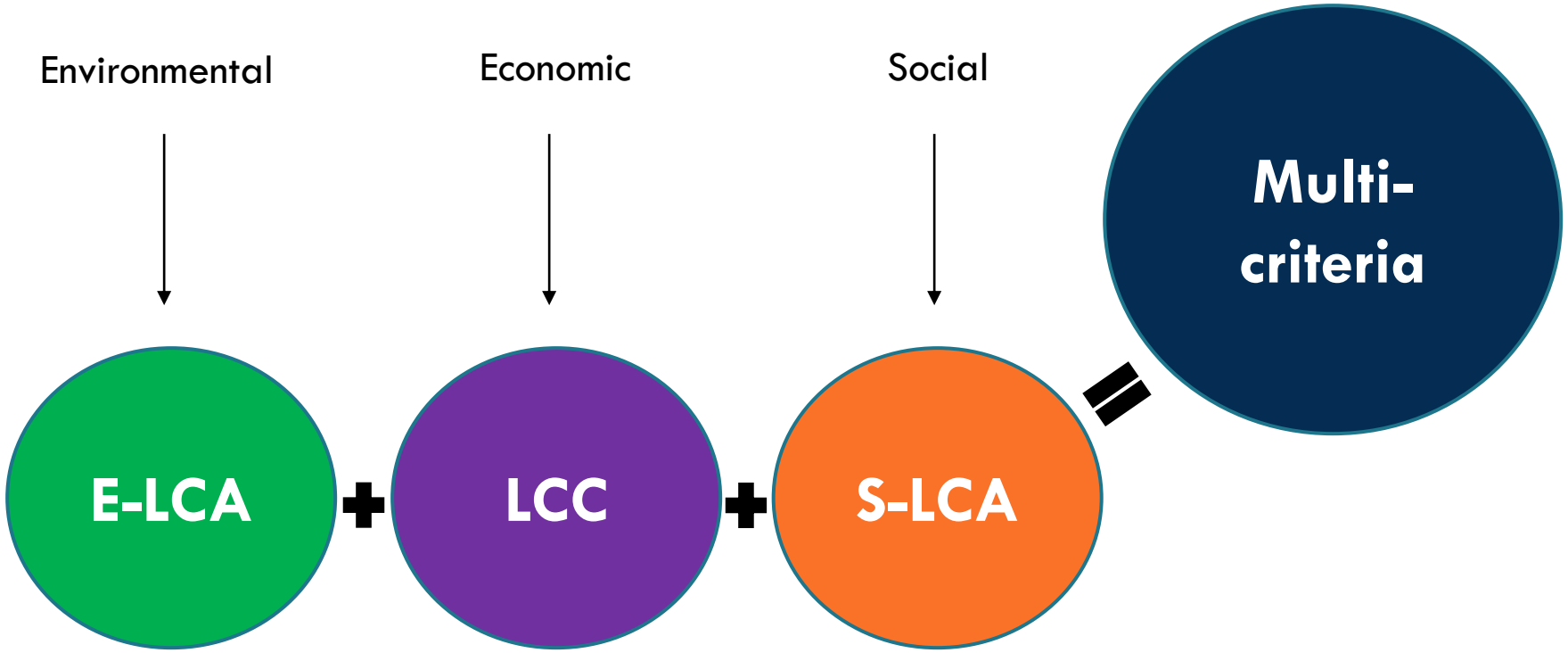
Society

DMT

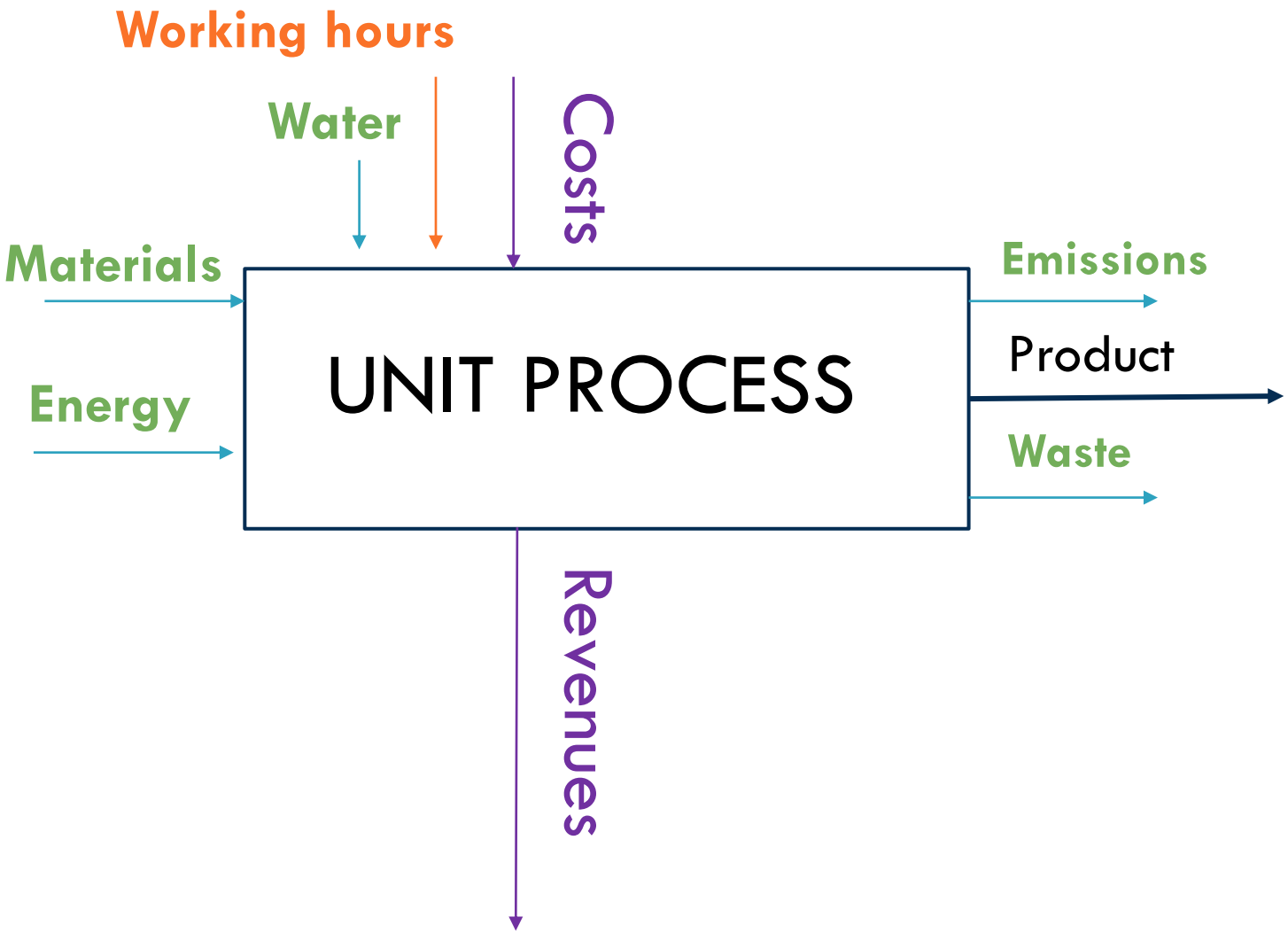
Economy

The structure of sustainability

Parallel analysis



Data collection (technological lens)



The social impact assessement

	Stakeholder categories	Impact categories	Subcategories	Inventory indicators	Inventory data
✓	Workers	Human rights			
✓	Local community	Working conditions			
✓	Society	Health and safety			
✗	Consumers	Cultural heritage			
✗	Value chain actors	Governance			
✓	Children	Socio-economic repercussions			

PSILCA database

Source: UNEP, 2020 Guidelines for Social Life Cycle Assessment of Products and Organisations 2020.

Sustainability analysis

Some of the previously identified topics

Environment	Economy	Social
•Air and water pollution	•Capital expenditure	•Health issues
•Use of water resources	•Operating expenditure	•Safety issues for public (after closure)
•Ecosystem alteration	•Reagent loss	•Stakeholder perception
•Land footprint	•Energy cost	•Cultural impacts
•Emissions (e.g. GHG)	•Closure cost	

Final considerations and lesson learned

How can NEMO contribute to the development of environmental-social assessment for the mining sector ?

- Focus on technology
- Integration with local data needed
- Needs for a clear metric to define social impacts
- Integration between environmental and social analysis
- Transparent communication

THANK YOU FOR YOUR ATTENTION!

https://h2020-nemo.eu/

This project has received funding from the European Union's EU Framework Programme for Research and Innovation Horizon 2020 under Grant Agreement No 776846

NEXT

New Exploration Technologies

New Exploration Technologies and Social Acceptance

Local understandings and perceptions

Karin Beland Lindahl , Associate professor, Political Science, Luleå University of Technology

Leena Suopjärvi, Adjunct Professor, Sociology, University of Lapland

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 776804 — H2020-SC5-2017

The NEXT Project

New Exploration Technologies for a More Efficient, Economic and Environmentally Friendly Ore Exploration

NEXT WP5: Social License to Explore (SLE) and Operate (SLO)

Understanding the importance of sensitive exploration technologies (and other factors) to SLE (and SLO) in three selected localities in Finland and Sweden

- Interviews to explore local actors' understandings and attitudes
- Quantitative surveys of local citizens' attitudes

NEXT is ending in September 2021

Factors influencing local actors' and citizens' attitudes to exploration?

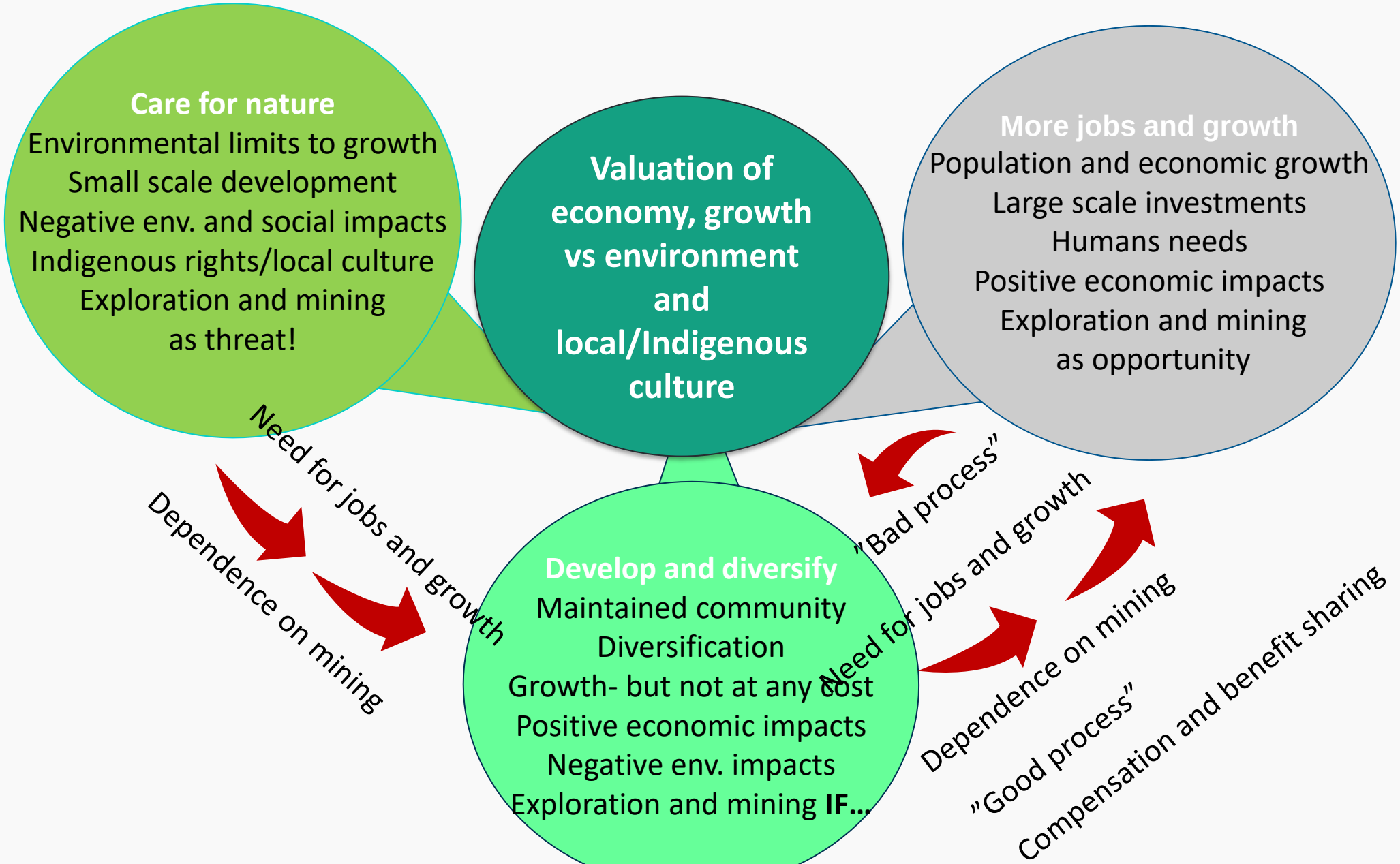
- Local actors' knowledge vary – exploration and mining understood as interlinked and attitudes follow each other
- Values about nature, economy and sustainable development shape attitudes – differ!
- Perceived balance between positive and negative impacts of exploration – and mining – seems to be most important!
- Experiences of the regulatory system affects trust and legitimacy
- Information and company-community engagement important and can affect attitudes
- Less intrusive technologies are welcome
  – but other factors are more important

Expectations about future economic benefits

Anxiety about environmental impacts and risks

This project is funded by the European Union

Everybody wants sustainable development – but it means different things



Are new technologies affecting local perceptions of impacts?

- People's perceptions of impacts differ!
- How impacts are perceived depends on context and lifeworld
- What the technology can "accomplish" hang on needs, livelihoods, understandings of SD - and how/where it is used…

"I have been hunting there sometimes and haven't seen [traces of[anything. Impacts are non-existent at this moment if you compare to clear-cutting – you can see it much more." (Village resident, Rovaniemi)

"Mining is what it is, a damage that already exists – exploration is something that is associated with uncertainty about what is going to happen… It is an anxiety…first about the direct damage and then the psychological damage [associated with anxiety for a possible mine] which one has to live with…" (Sami Reindeer herder, Gällivare)

This project is funded by the European Union

Health and safety?

- Exploration is not in itself associated with major health and safety risks
- But give rise to uncertainty about the future development of the community; anxiety for environmental risks or expectations about economic benefits associated with a possible mine development.

Lessons learned

- Understanding local context and factors shaping attitudes to exploration – and mining – is key
- Timely information and high-quality company community engagement is important and can affect attitudes
- Environmentally sensitive technologies reduce environmental footprint of exploration but is not very important to local attitudes!

This project is funded by the European Union

PACIFIC

Passive seismic techniques for environmentally friendly and cost-efficient mineral exploration

PACIFIC Project

Dr Aoife Braiden

ESRI

The EU Framework Programme for Research & Innovation 2014-2020

HORIZON 2020

PACIFIC has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 776622.

Geological Survey
Suirbhéireacht Gheolaíochta
Ireland | Éireann
An Roinn Comhshaoil, Aeráide agus Cumarsáide
Department of the Environment, Climate and Communications

PACIFIC innovative approach

PACIFIC is developing two radically new and complementary seismic techniques to discover new deposits and expand known deposits. Both are based on **passive seismic imagery**. These techniques must have:

- Sufficient **accuracy** and **resolution** for the minerals industry
- A **relatively low cost** and
- Have **a minor impact on the environment**

- 9 Partners – 8 countries
- Start: June 2018
- Duration: 3.5 years
- EU contribution: 3.2M€

PACIFIC also conducts research on **social acceptance** and public perception of risk for mining activities.

https://www.pacific-h2020.eu/

PACIFIC

Expected impacts

Develop a cost-effective, environmentally friendly exploration tool

Deliver another method to explore for buried ore deposits

Decrease the environmental footprint of mineral exploration

Inform geoscientists about passive seismic methods

Bridge the gap between geophysical and geological models of ore deposits

Improve public awareness and acceptance of mineral exploration

Help ensure a sustainable supply of raw materials for the EU

Reduce the EU's dependence on imported mineral products

HORIZON 2020

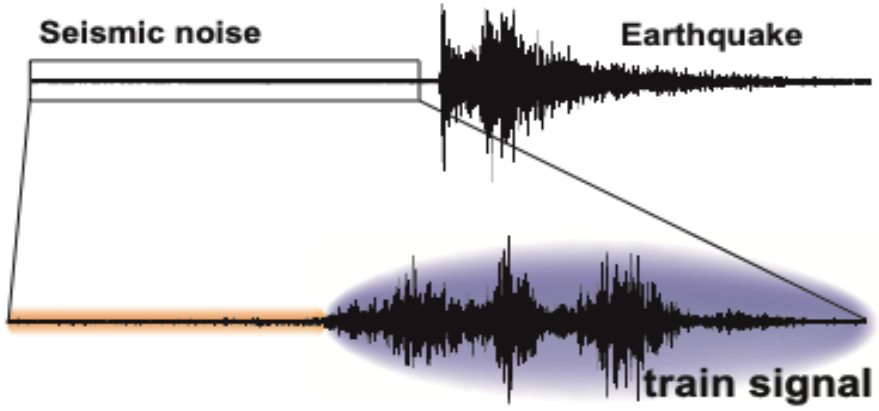
Some recent publications

- High-frequency ambient noise surface wave tomography at the Marathon PGE-Cu deposit (Ontario, Canada) *Teodor et al*
- Retrieving reflection arrivals from passive seismic data using Radon correlation. *Hariri et al*
- Humming Trains in Seismology: An Opportune Source for Probing the Shallow Crust. *Pinzon-Rincon et al*
- Understanding Seismic Waves Generated by Train Traffic via Modeling: Implications for Seismic Imaging and Monitoring. *Lavoué et al*
- Virtual Sources of Body Waves from Noise Correlations in a Mineral Exploration Context. *Dales et al*
- Noise-based ballistic wave passive seismic monitoring. Part 1: body waves & Part 2: surface waves. *Brenguier et al/ Mordret et al*
- …….

https://www.pacific-h2020.eu/publications/

PACIFIC

A new workflow for passive seismic imaging using *opportune* signals (e.g. trains)



Standard ambient noise correlation workflow

- Pre-processing of continuous noise
- Compute cross-correlation
- Stack
- Measurement and analysis (Imaging / monitoring)

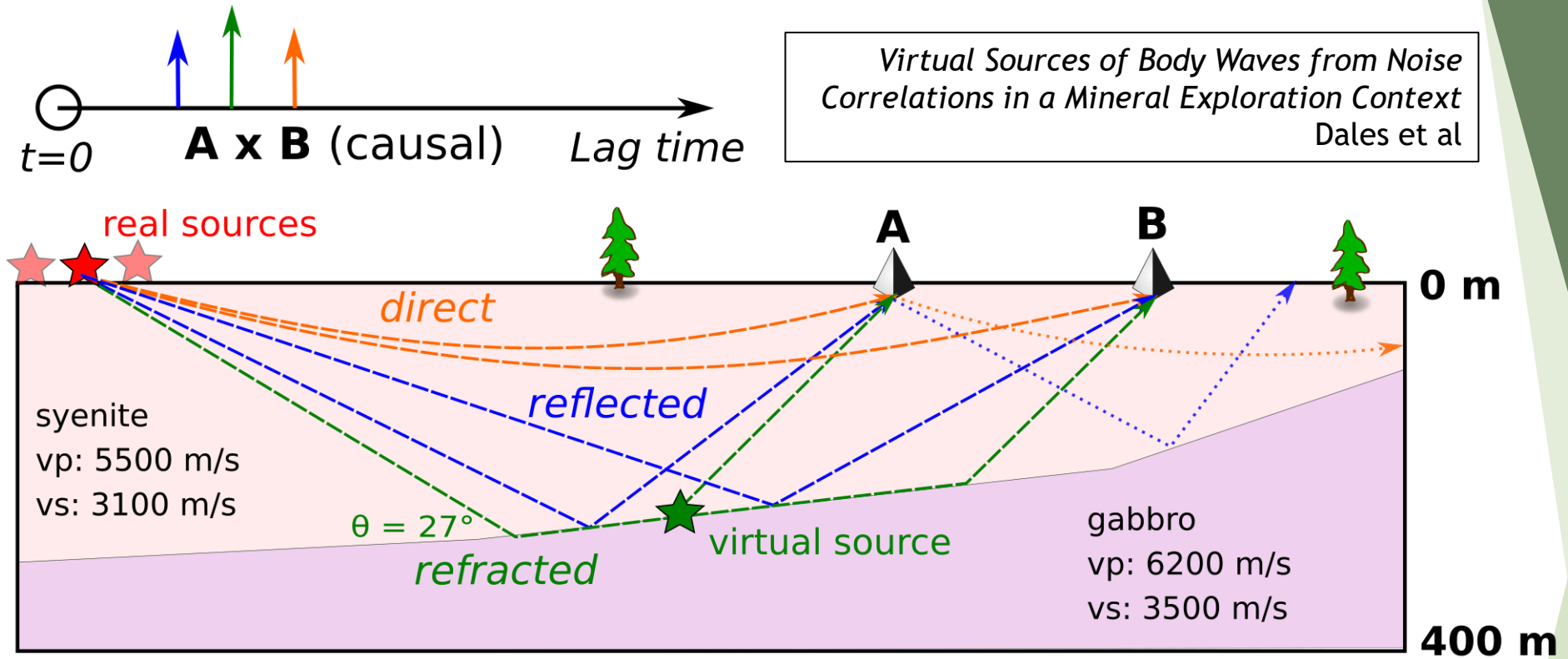
Opportune sources workflow

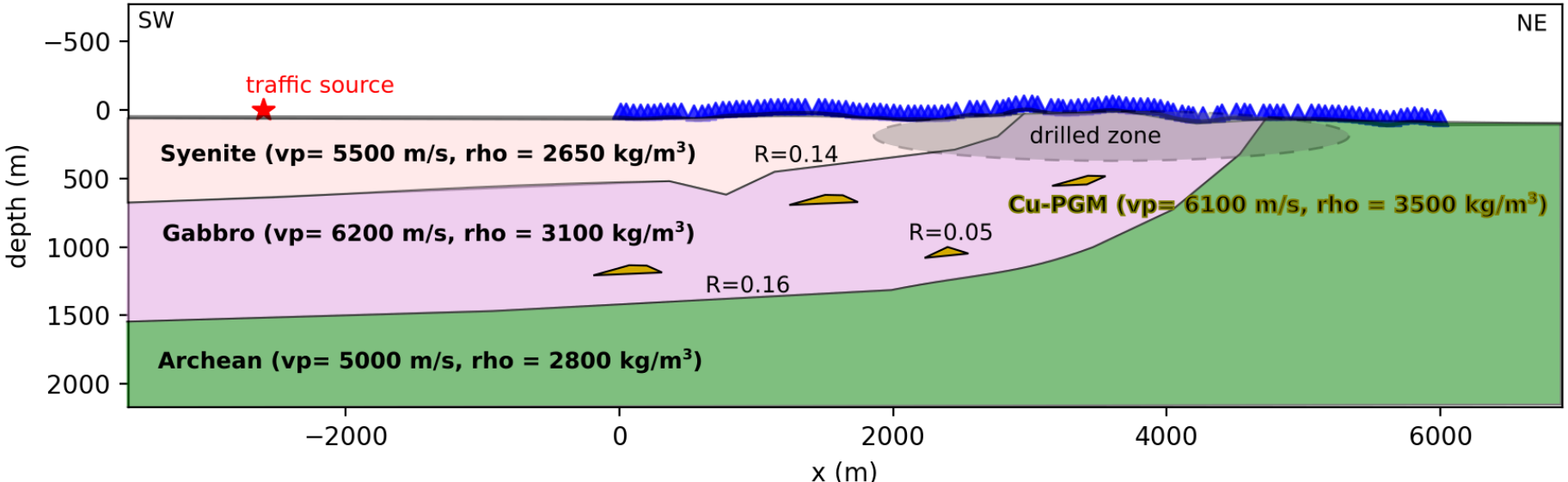
- **Source detection and characterization (Modeling, Machine learning, array methods)**
- **Time window selection Station pair selection**
- **Compute cross-correlation for selected station pair / time window**
- **Stack (by events, by azimuth)**
- **Measurements and analysis (Imaging / monitoring)**

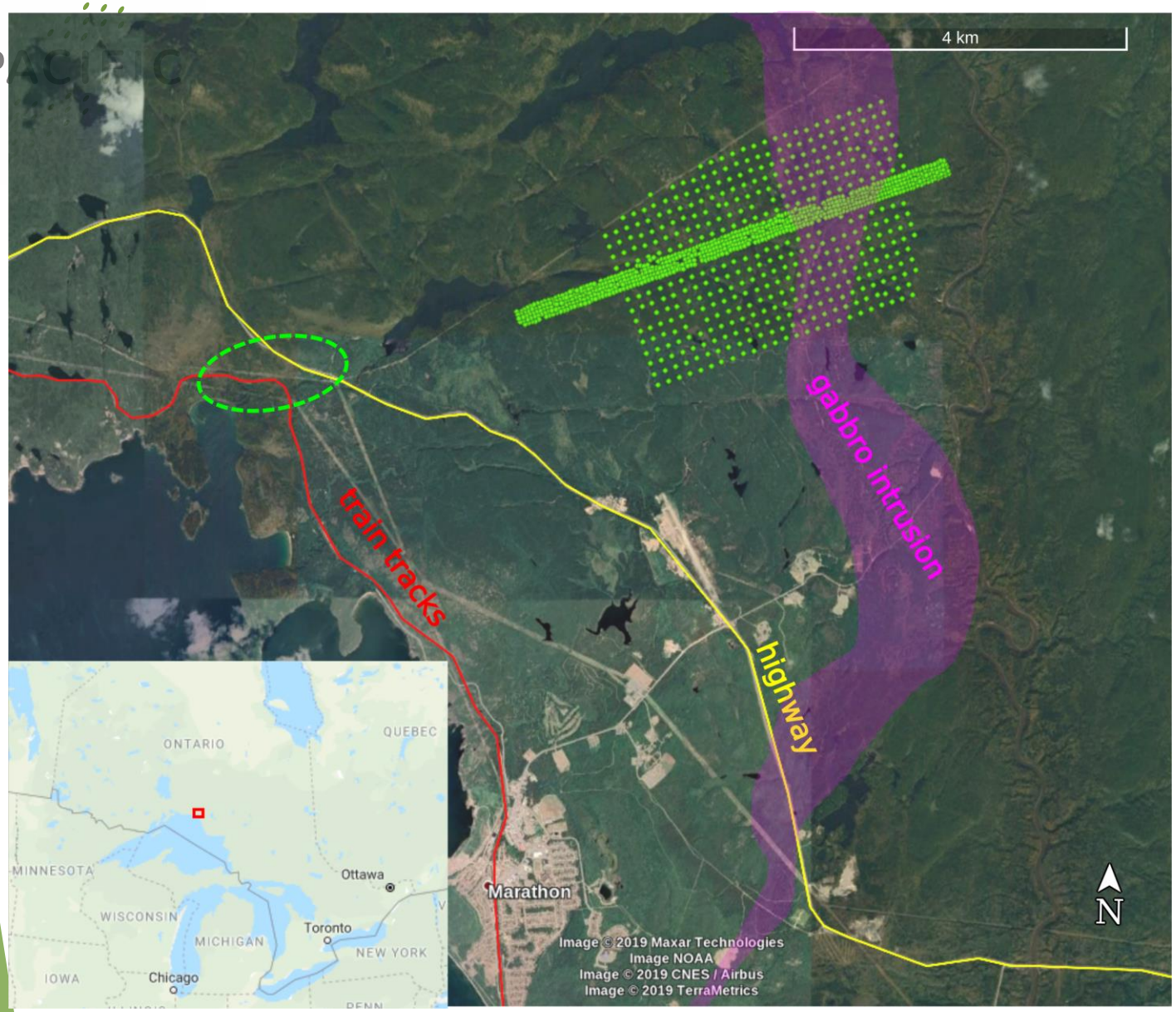
(Pinzon-Rincon et al., 2021)

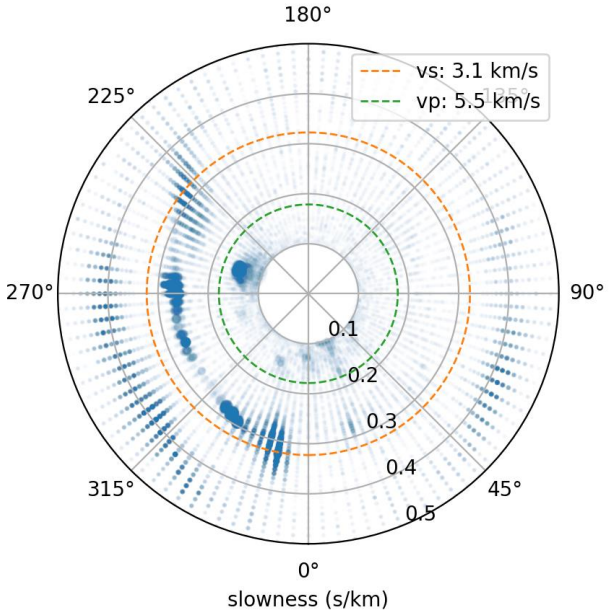
PACIFIC

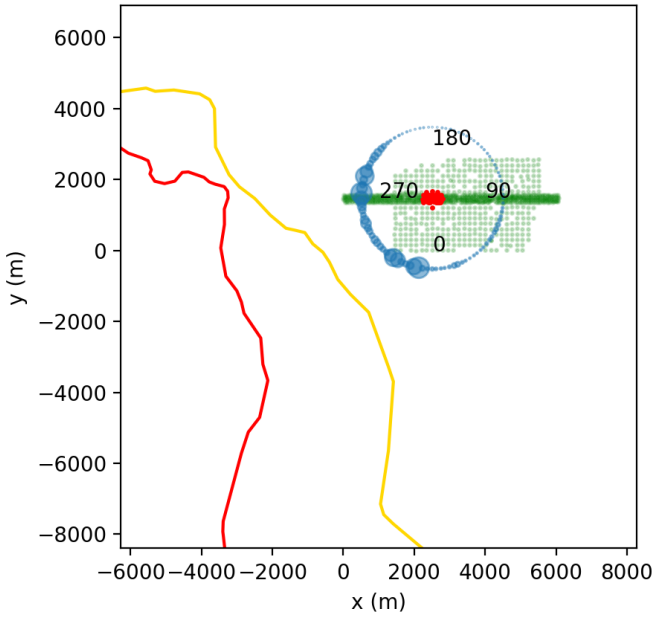
Virtual Sources of Body Waves from Noise Correlations in a Mineral Exploration Context
Dales et al





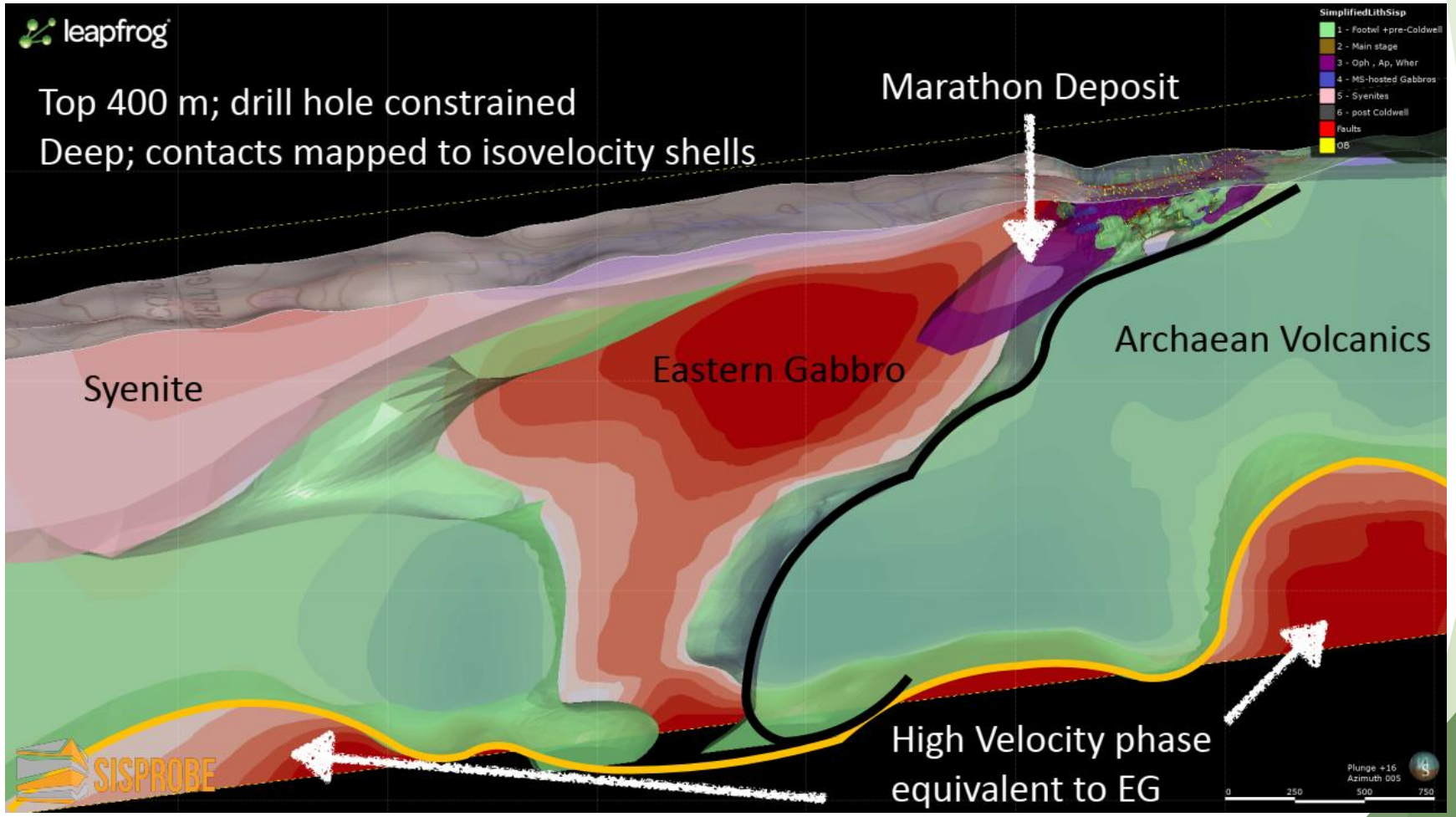






PACIFIC

Ambient-noise seismic tomography



institute of mine seismology

GENERATIONPGM

UNIVERSITÉ Grenoble Alpes

DIAS

HORIZON 2020

PACIFIC

Social Acceptance & Public Perception of Risk

Two key aspects:

- **GSI**: Generalised survey to assess opinion on mining & exploration in Ireland

Geological Survey
Suirbhéireacht Gheolaíochta
Ireland | Éireann
An Roinn Comhshaoil, Aeráide agus Cumarsáide
Department of the Environment, Climate and Communications

- **ESRI**: Computerised experiments to assess how people comprehend information, assess risk & make decisions (i.e. psychological mechanisms)

ESRI

HORIZON 2020

PACIFIC

Online questionnaire

Geological Survey
Suirbhéireacht Gheolaíochta
Ireland | Éireann
An Roinn Comhshaoil, Aeráide agus Cumarsáide
Department of the Environment, Climate and Communications

Online questionnaire (GSI):

- 1000 responses
- 36 questions;
  - Section 1: Opinions on mining in general
  - Section 2: Knowledge of mining in Ireland
  - Section 3: Perceived benefits/risks of mining
  - Section 4: Experience of exploration for minerals
  - Section 5: Regulation of mining activities (i.e. trust)
  - Section 6: Demographics
  - Optional feedback

- Questions designed to be applicable to other countries/regions

HORIZON 2020

PACIFIC

Computerised experiments

Experiment 1 - Research questions:

- RQ1: Does the method of online information provision affect people's **comprehension** of mining-related activities and their implications for their local area?
- RQ2: Does the method of online information provision affect people's **evaluation** of that information?
- RQ3: Do the **effects**, if any, of the method of online information provision **depend on the source** of that information?

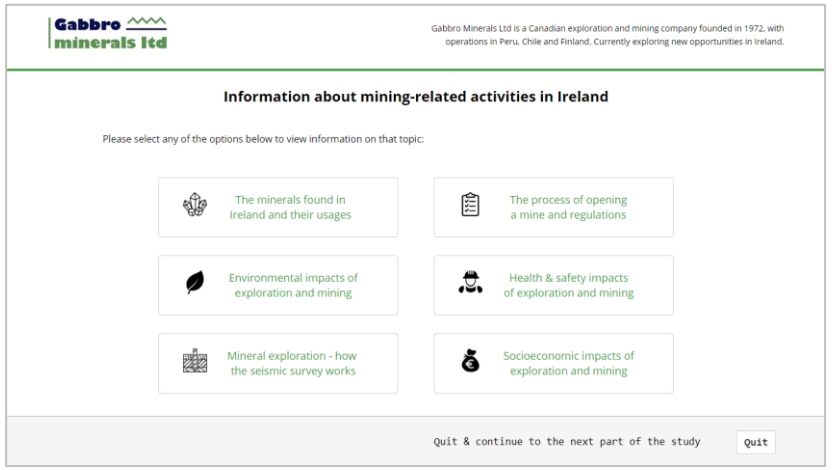
ESRI

HORIZON 2020

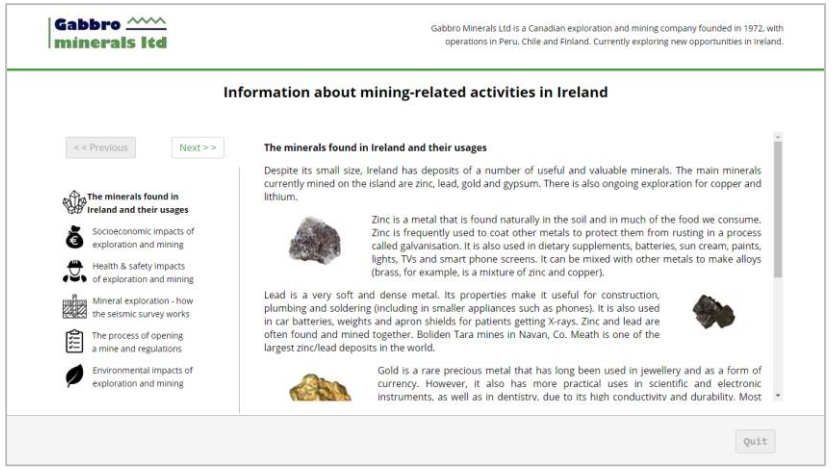
Experiment 1A: Experiments to investigate the effect of the format of information provision on the public's comprehension and perception of mining-related activities

A: Format of information provision

"search"



"see-all"



Tested theory that self-led learning leads to improved comprehension

PACIFIC

Experiment 1B: Experiments to investigate the effect of the format of information provision on the public's comprehension and perception of mining-related activities

B: Source of the information

GSI

Geological Survey
Suirbhéireacht Gheolaíochta
Ireland | Éireann

or

Fictitious Canadian mining **company**

Gabbro minerals ltd

Tested theory that information is more trusted by a neutral agent

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Experiment 2: What are the "primacy effects" (influence of first arguments seen) in opinion formation related to mining, and how to mitigate these?

How does the first information affect opinion and can the effect be changed?

Order of argument sets

Condition 1:
"Pro" arguments seen first

Condition 2:
"Con" arguments seen first

Statement of position

Condition 1:
Control (no statement)

Condition 2:
Statement of position

Balance in second set of arguments

Condition 1:
Counterarguments only

Condition 2: Counterarguments in context of original arguments

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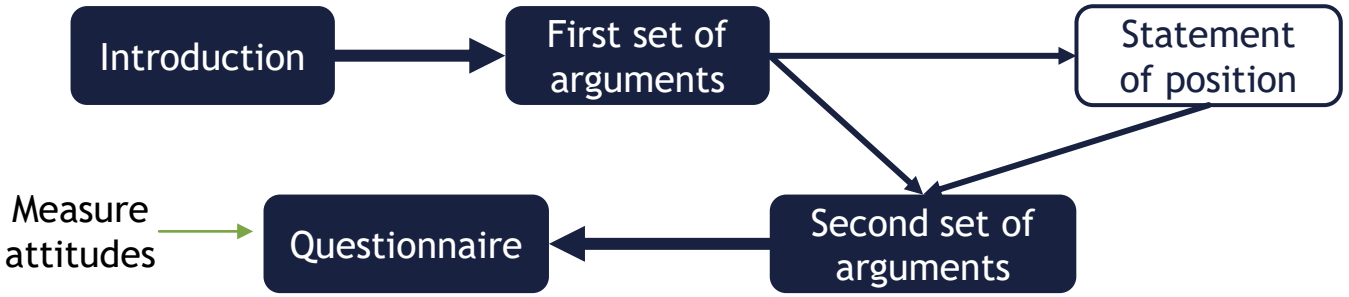

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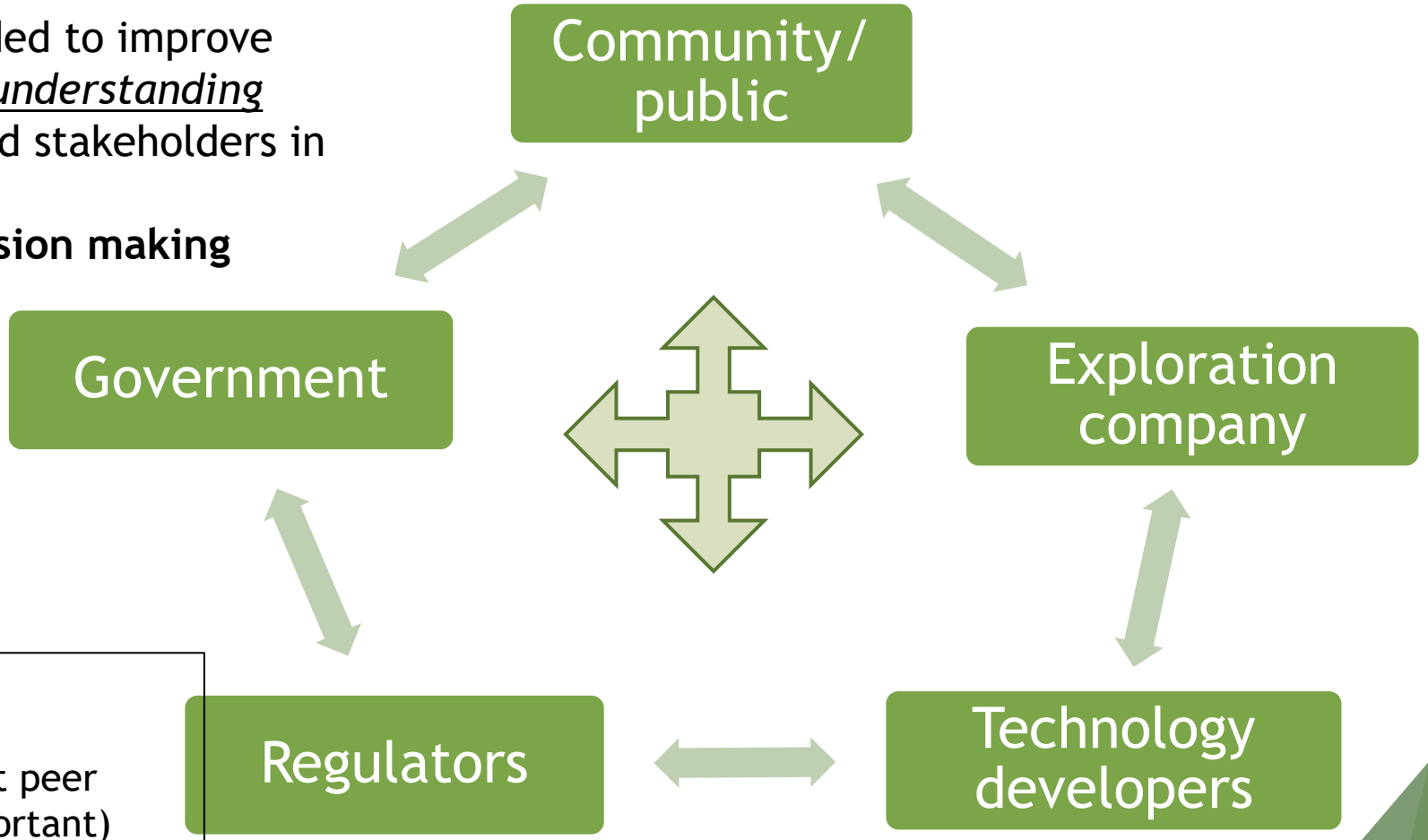
Application of the results

The results are intended to improve communications *and understanding* between all stages and stakeholders in minerals exploration.
Aim is informed decision making



Outputs:
- Academic paper re experiments (robust peer review process important)
- Online information and advice on communications

Geological Survey
Suirbhéireacht Gheolaíochta
Ireland | Éireann
An Roinn Comhshaoil, Aeráide agus Cumarsáide
Department of the Environment, Climate and Communications

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