UNEXMIN

AN AUTONOMOUS UNDERWATER EXPLORER FOR FLOODED MINES

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THE FUTURE OF EXPLORATION IN MINING

UNIV.-PROF. DR.-ING. HELMUT MISCHO, PR. ENG. (ECN)

NEMO 33, UNEXMIN FINAL CONFERENCE

26TH SEPTEMBER 2019

This project has received funding from the European Union's Horizon 2020research and innovation programme under grant agreement No 690008.

EXPLORATION IN MINING – A DEFINITION

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- The term “exploration” refers to a wide variety of activities around a mining operation
  - First stages of the geological research and assessment of the deposit before mining starts
  - Ongoing geological exploration during the mining operation
  - …
  - Exploration of underground mines after incidents, fires, gas-breakouts…
  - Exploration of old and abandoned mine sites for different reasons

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GEOLOGICAL EXPLORATION IN MINING

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- Increasing knowledge and confidence level about the geological deposit
- Base information for mine layout, mine planning, grade distribution model,…
- Detection of additional geological reserves, which may have not been found during first stage exploration
- Increase of life of mine

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GEOLOGICAL EXPLORATION IN MINING

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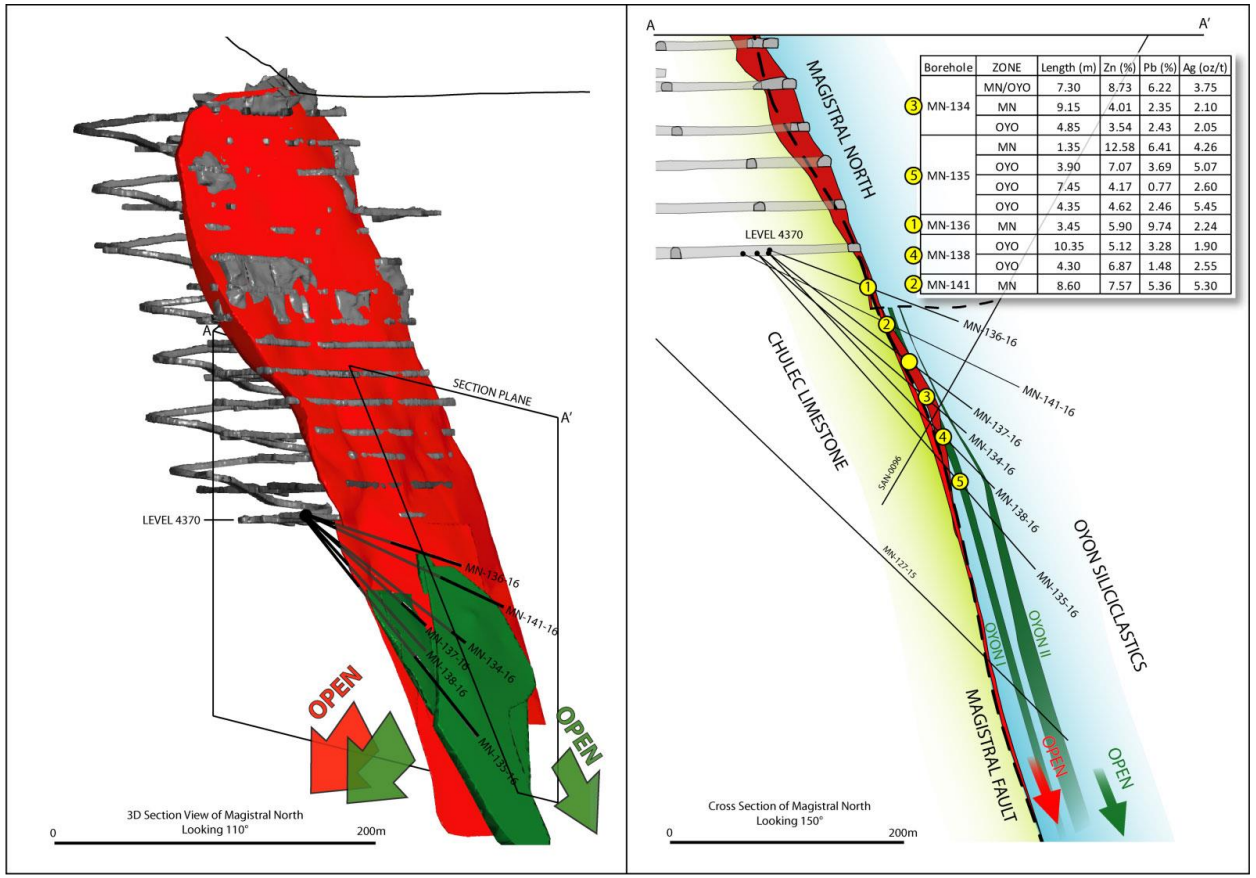
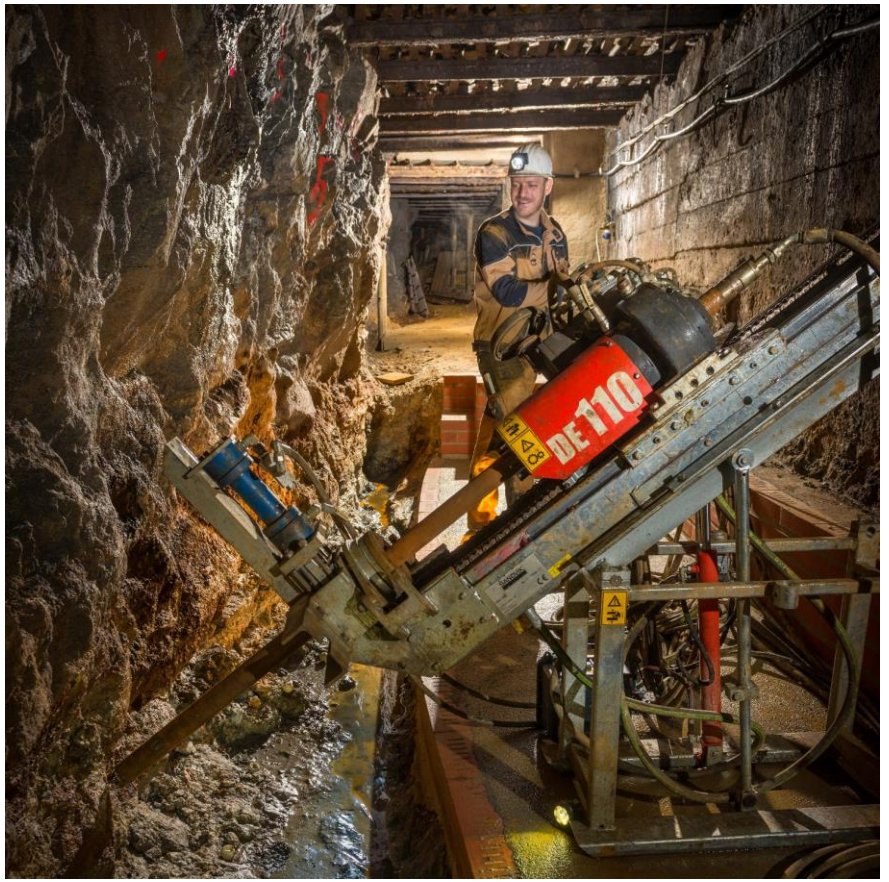


Borehole	ZONE	Length (m)	Zn (%)	Pb (%)	Ag (oz/t)
3 MN-134	MN/OYO	7.30	8.73	6.22	3.75
	MN	9.15	4.01	2.35	2.10
	OYO	4.85	3.54	2.43	2.05
5 MN-135	MN	1.35	12.58	6.41	4.26
	OYO	3.90	7.07	3.69	5.07
	OYO	7.45	4.17	0.77	2.60
	OYO	4.35	4.62	2.46	5.45
1 MN-136	MN	3.45	5.90	9.74	2.24
4 MN-138	OYO	10.35	5.12	3.28	1.90
	OYO	4.30	6.87	1.48	2.55
2 MN-141	MN	8.60	7.57	5.36	5.30



Sources: Trevali Mining / TUBAF

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TECHNICAL EXPLORATION IN MINING - ACTIVE MINES

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- Underground mines are not accessible after incidents like mine fires, gas breakouts, major rock falls…
- The conditions in the mines are dangerous due to conditions like unbreathable/explosive atmosphere or unstable roof
- These conditions in the mine may last for months (gas breakout, water inflow) or even up to years (underground coal fires), if not attended to
- This may put the whole investment into the mine at risk

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TECHNICAL EXPLORTION IN MINING - ACTIVE MINES

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- After incidents immediate life rescue operations may be necessary
- Also the securement of the investments may need immediate activities underground
- Necessary technical exploration is usually conducted by highly trained mine rescue personnel under special protective equipment (breathing apparatus)
- Still a high personal and health risk remains

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MINE DISASTER

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Unterbreizbach Potash Mine 2013 after CO_2-Outbreak

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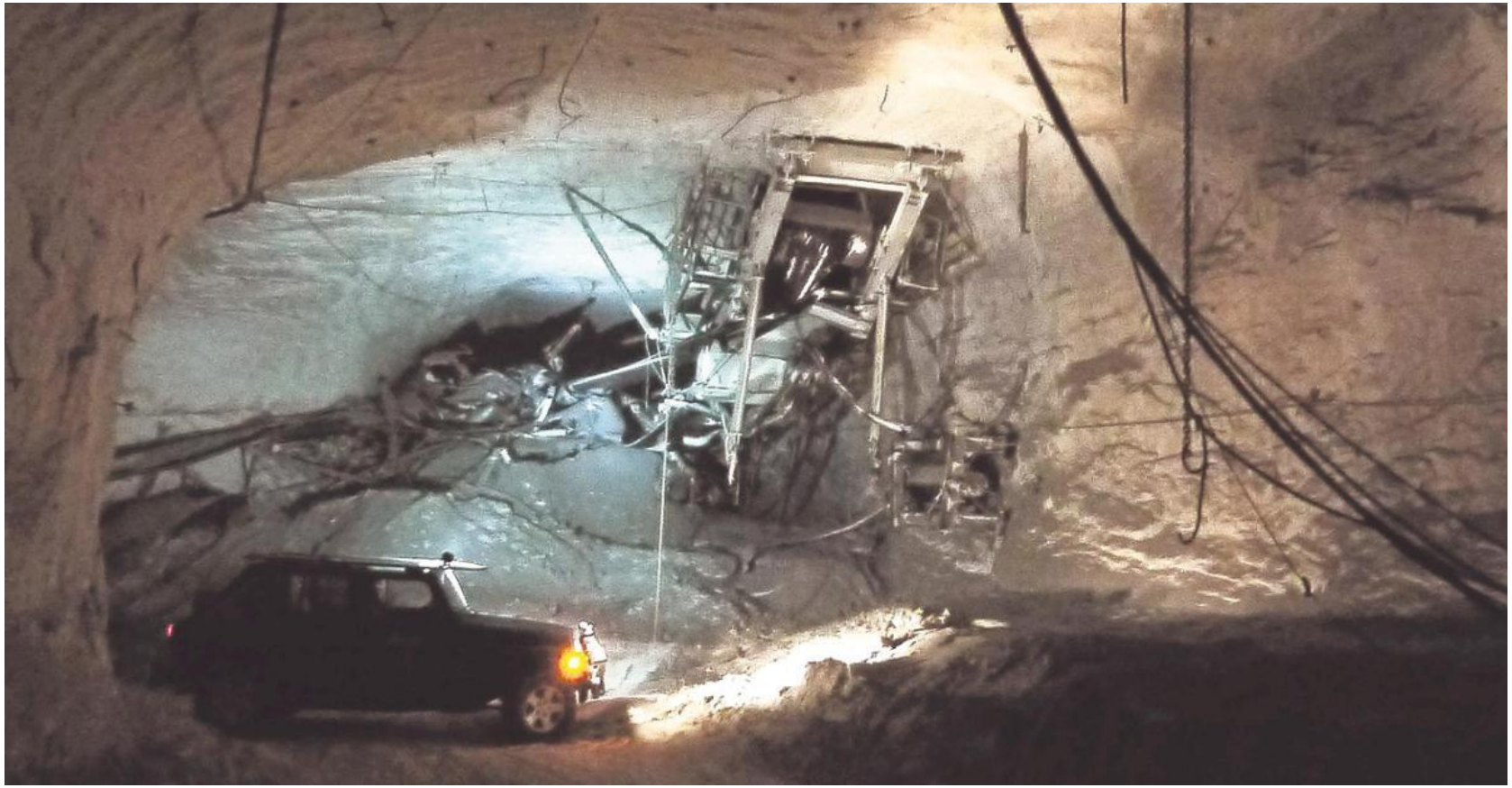
Remnants of 680 m belt conveyor



Source: K+S

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Trapped Miners @
734 m underground
in Chile (05.08.2010)

Source: ISSA Mining

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MINE DISASTER

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Borken Lignite Mine – collapsed drift after methane explosion 1988

Source: ISSA Mining

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TECHNICAL EXPLORATION IN MINING - OLD AND ABANDONNEND MINE SITES

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- Old and abandonned mines are in general not safely accessible:
  - Flooded/filled with mud
  - Unknown/unstable roof conditions (detoriated roof support)
  - Unbreathable/dangerous atmospheric conditons (CO_2, Radon, CH_4, H_2S …)
- Old and abandonned mines may pose a serious risk at the surface
  - Sudden rockfalls/ground collapses/surface breaks
  - Radon/CH_4/H_2S exhalation
  - Unsecured/open mine openings, adits and shafts

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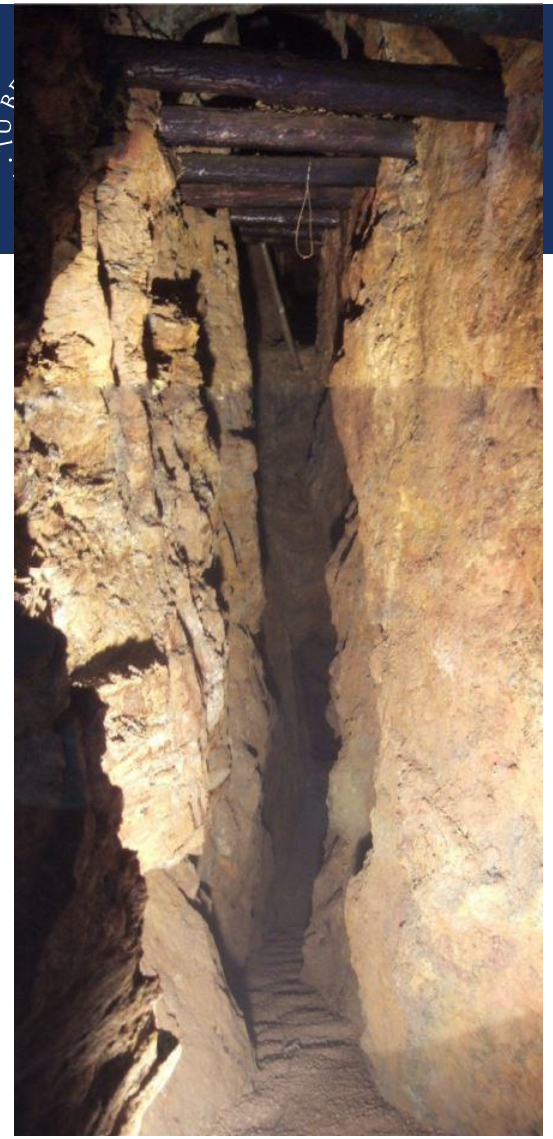
OLD MINES – INSTABLE SUPPORT

Instable roof and support conditions in old and abandonned mines



Sources: Wismut / GNU Commons

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OLD MINES – COLLAPSED ROOF

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Collapsed roof and support conditions in old and abandonned mines

Source: Wismut

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OLD MINES - GROUND COLLAPSE

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Smaller surface breaks are occuring on a daily basis (~250/a in Saxony)

Source: Bergbau Sachsen

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TECHNICAL EXPLORATION IN MINING - OLD AND ABANDONNEND MINE SITES

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- Access to old and abandonned mines will be neccessary in order to safely secure the surface situation
  - Rehabilitation of rockfalls/daybreaks
  - Installation of dams and sealings
  - Installation of Radon/CH4 drainage systems
- Old and abandonned mines may hold the key to strategic mineral deposits:
  - Todays target minerals were not in the focus of the mining activities in the past (e.g. yesterday‘s tin mining versus today‘s tantalum rush)
  - Mines have been closed due to technical reasons or lack of funds

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HOW DO WE CONDUCT TECHNICAL EXPLORATION?

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- Boundary conditions
  - No electricity
  - No data communication
  - No ventilation – unbreathable/explosive atmosphere
  - Zero visibility
  - Blocked passage (rockfalls, mud, destroyed support and equipment)
- Traditional approach
  - Deployment of highly trained specialists (mine rescue teams, divers)
  - Very slow, dangerous and time consuming approach
  - High time delay between exploration and availability of data

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WHY DO WE CONDUCT TECHNICAL EXPLORATION?

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- Collection of information on
  - General conditions underground
  - Damages/obstructions
  - Passability of existing drifts and galleries
  - Quality of mine air
  - Threads and risks
  - Special information (e.g. water quality, oil spillages, mineralogy, grade control)
  - …

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GOAL OF TECHNICAL EXPLORATION

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- Collection of information and data as a basis for immediate and short- to midterm decisions
- Processing these data accordingly and making them available to decision makers
- Real-Time approach

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TECHNICAL REQUIREMENTS FOR FUTURE TECHNICAL EXPLORATION - I

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- Autonomous robots or units
  - Position systems
  - Mapping / georeferencing / tracking
  - Range control
  - Autonomy vs. radio controlled
- Self contained power supply
  - Sufficient range
  - Suitable for extreme enviromental conditions (temperature, humidity, …)
  - Rechargebility
  - Atex approved

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TECHNICAL REQUIREMENTS FOR FUTURE TECHNICAL EXPLORATION - II

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- Capable of overcoming obstructions
  - Recognition of obstructions
  - Decision making on overcoming obstructions
- Capable of collecting information
  - Sensors (gases, water, ph-Value, rock radar,…) – interchangeability of sensors
  - Sampling
  - Manipulation device

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MAPPING, GEOREFERENCING & OVERCOMING OBSTRUCTIONS

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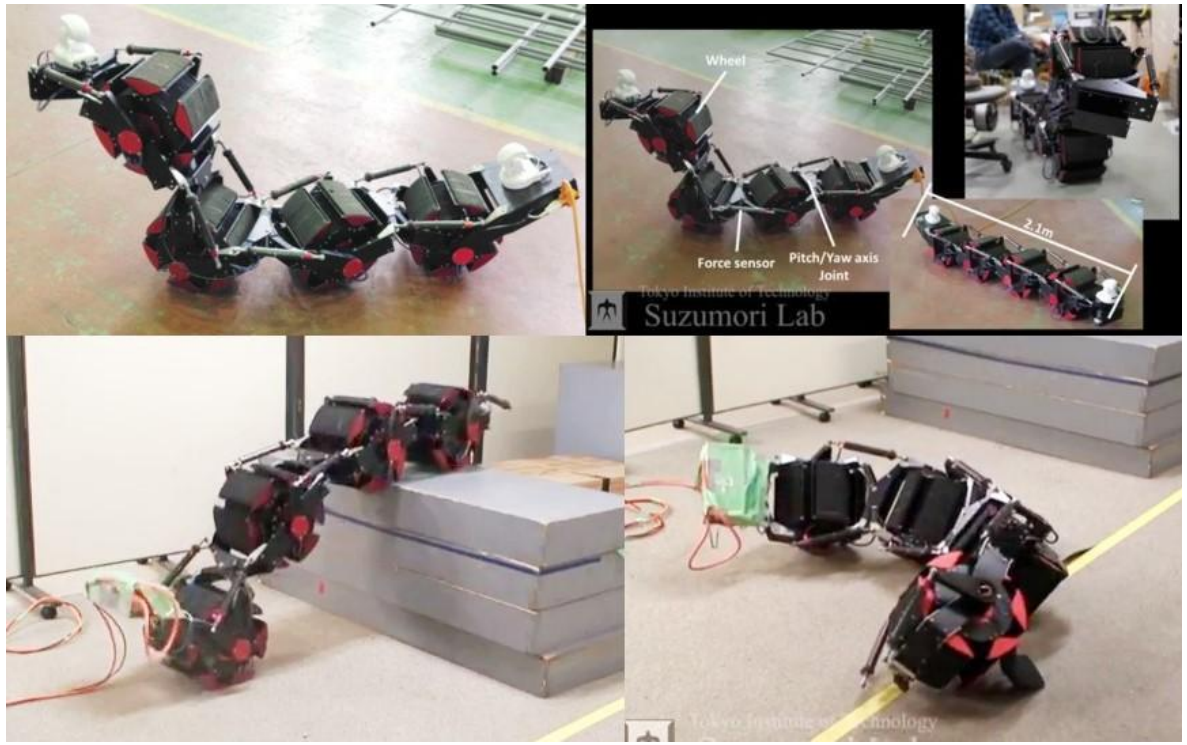

Sources: TUBAF / Suzimori

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MANIPULATION DEVICE & SAMPLING

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Sources: TUBAF / NIOSH

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TECHNICAL REQUIREMENTS FOR FUTURE TECHNICAL EXPLORATION - III

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- Capable of conveying collected informations
  - Delivery upon return (time delay !)
  - Real-Time delivery
    - Cable hooked (highly reliable, but limited range)
    - Setting up a reliable data and communication network (WiFi, Mesh, TTE)
    - Sensor and sample analysis on board? (limitation of data package size)

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HOW TO USE THE INFORMATION

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- Real-Time approach
- All information must be processed immediatly after collecting
- All information must be formatted in a widely accessible format
- All information must be stored and safed in a reliable data base
- All information must be accessible to decision makers at any given time (e.g. access through a mine control station in an active mine)

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SUMMARY – FUTURE IN EXPLORATION IN MINING

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- Automated
- Autonomous
- Reliable
- Connected
- Real Time Data Approach

And what do we do when the mine is filled with water?

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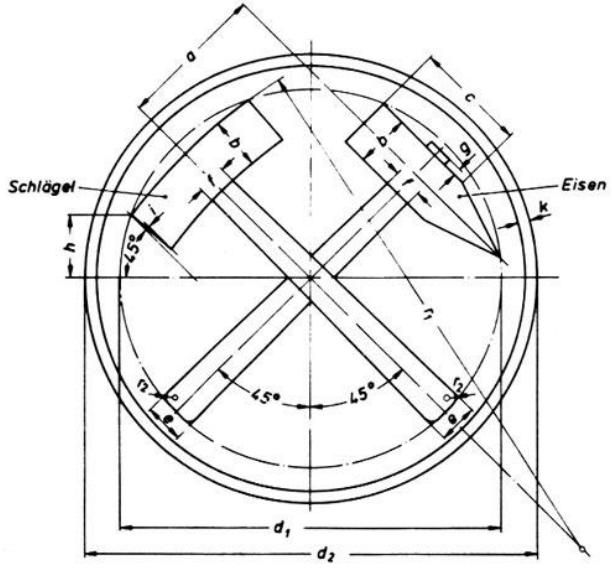
Thank You for Your Attention and



GLÜCK AUF!

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