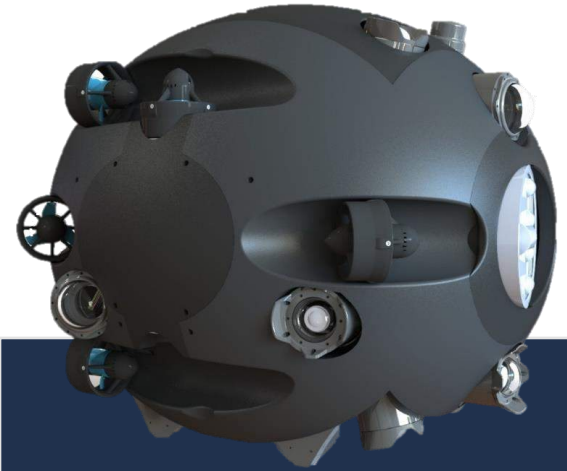
UNEXMIN

GEOROBOTICS



UX-1Neo - A robotic explorer for flooded mines, caves and tunnels

About us

The Unexmin Georobotics Ltd. (UGR) is a start-up provides surveying services for flooded underground environments. Our technology is uniquely developed to handle these harsh environments.

UNEXMIN GEOROBOTICS

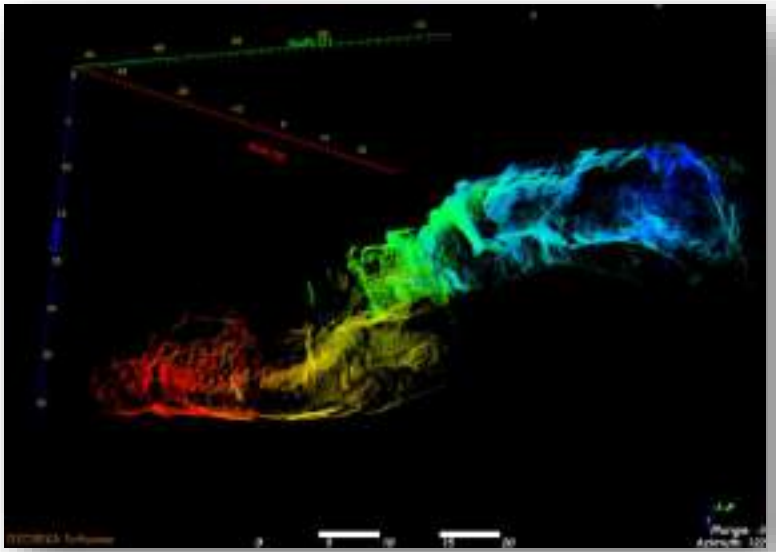
Pioneers in robotic solutions for flooded enviroments

About us

- Total of **5 robots**: UX1a, UX1b, UX1c, UX1-Mara, UX1-Neo
- Total of **8 different sites**: Kaatiala (Finland), Idrija (Slovenia), Urgeirica (Portugal), Ecton (UK), Molnár János (Hungary), Csór (Hungary), Solotvyno (Ukraine), South Crofty (UK)

Summary of all missions:

- Over **18 missions** in 8 different sites
- Over **80 dives**
- Over **300 hours** of diving
- More than **2 million** captured images



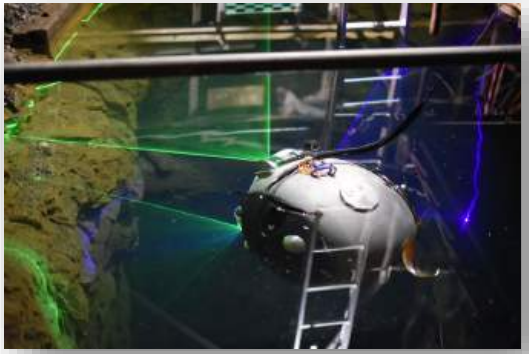
Our technology

Characteristics

- **Modular**
- Swappable batteries
- Removable disk enclosure
- HDPE frame
- 10 Gb fibre optical umbilical
- **Depth: 500m (target depth: 1500m)**
- 2600 Wh
- **>8h operation**
- Dimensions: 700 x 620 mm
- Approx. Weight: <90kg

Navigational Instruments

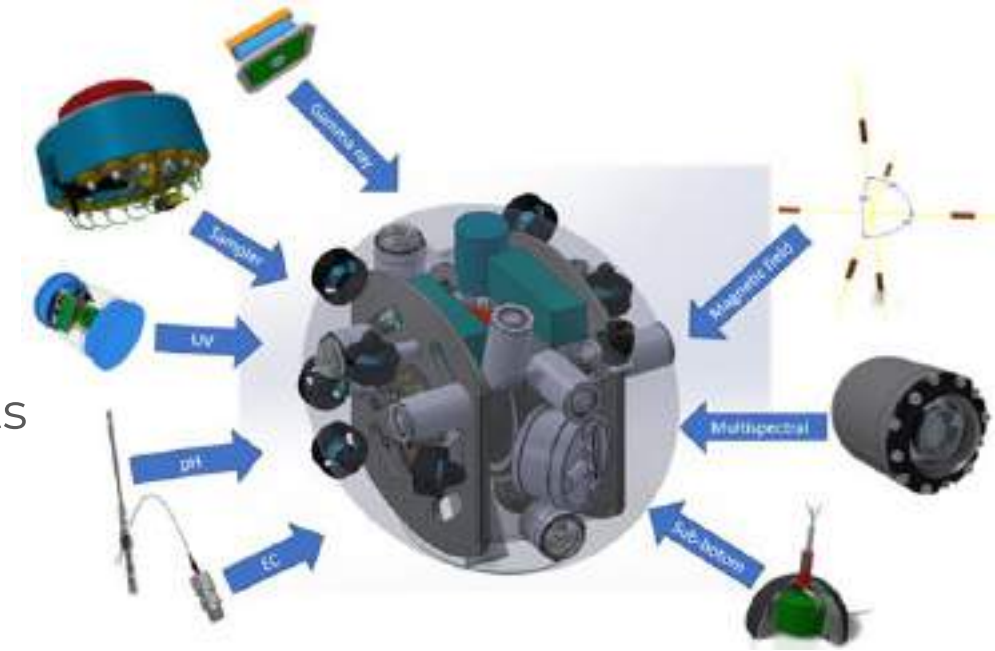
- **Multibeam sonar**
- 2 scanning sonars
- **6 cameras with onboard processing**
- Flotation foam
- **Full 6 DOF thrusters control**
- **6 structures light system (SLS) units**
- Pressure tolerant pendulum
- Underwater connectors and cabling



Our technology

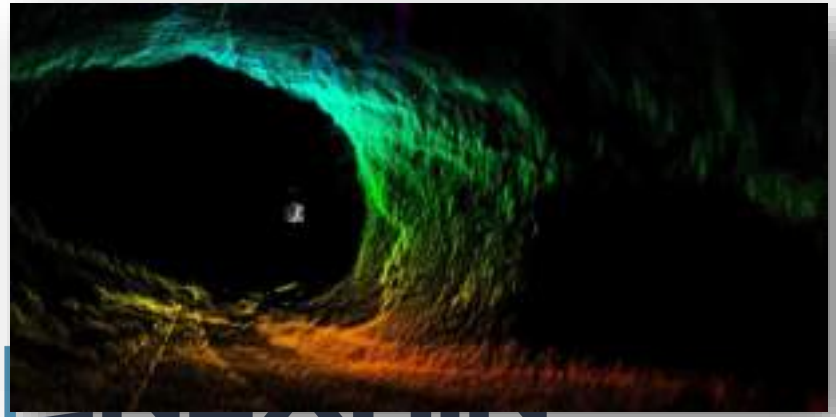
Geoscientific instrumentation

- Multi/hyperspectral imaging
- Sub-bottom sonar
- Water parameter measurements
- Water sampling
- Underwater rock sampling
- Gamma measurements
- Flux-gate magnetometer



Field work - Kaatiala Mine, Finland

- Open-pit, flooded pegmatite mine
- **Open-surface water**
- **Underwater tunnels** with hugh openings



Field work - Idrija Mercury Mine, Slovenia

- UNESCO World Heritage
- Underground mine
- **90% of the mine workings are flooded**
- Water surface is **176 m below the surface**
- Dirty, opaque water
- Several underwater obstacles

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Field work - Urgeiriça Uranium Mine, Portugal

- Remediated, closed **uranium mine**
- Underground mine workings
- **All the tunnels and shafts are flooded**
- Water surface is 5 m below the surface
- Clear water from ~20 m depth

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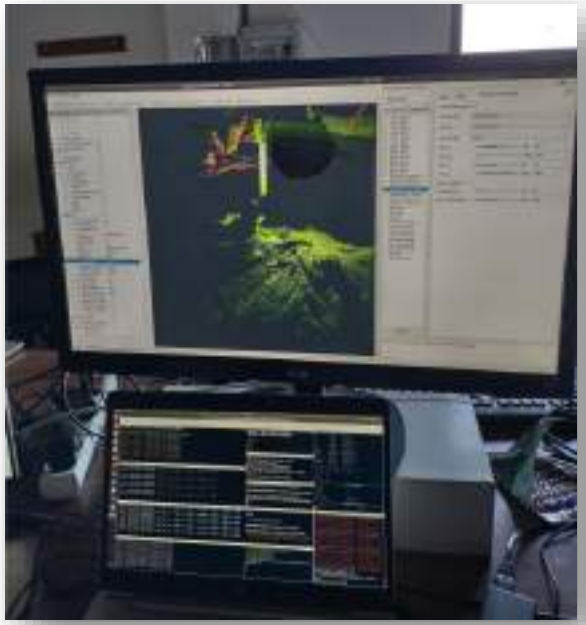
Field work - Urgeiriça Uranium Mine, Portugal



The UX-1Neo reached the bottom at 186 m (view from down camera)

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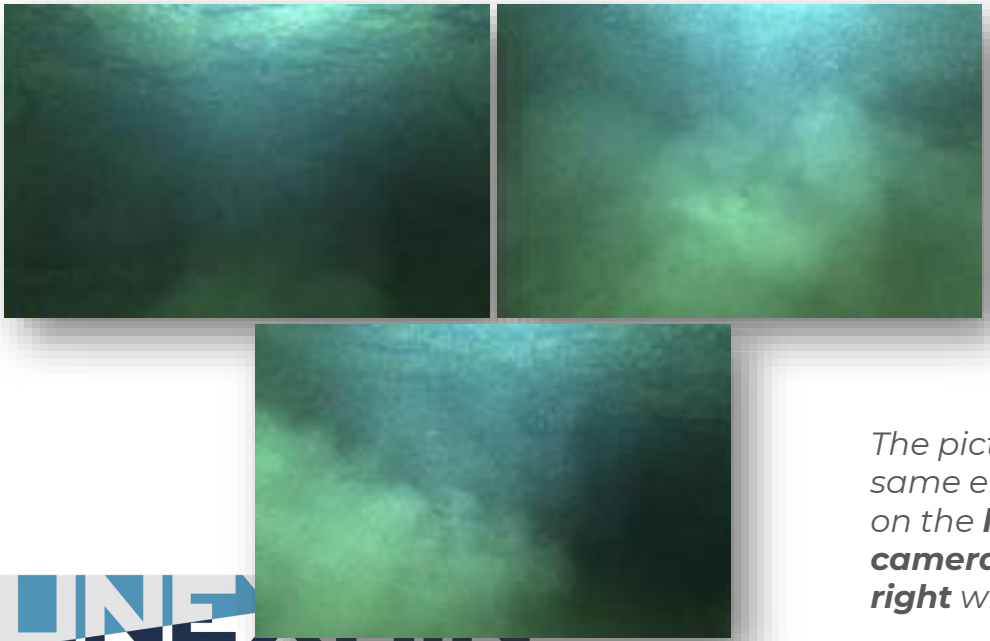
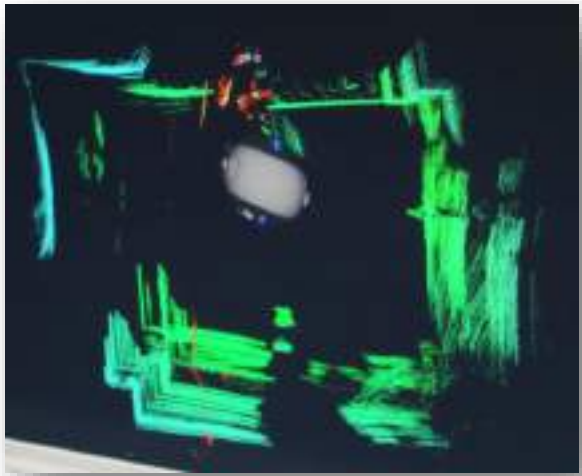
Field work - Urgeiriça Uranium Mine, Portugal

RGB cameras



*In case of **low visibility**, the robot **can** still **navigate** using **laser** and **sonar** information*

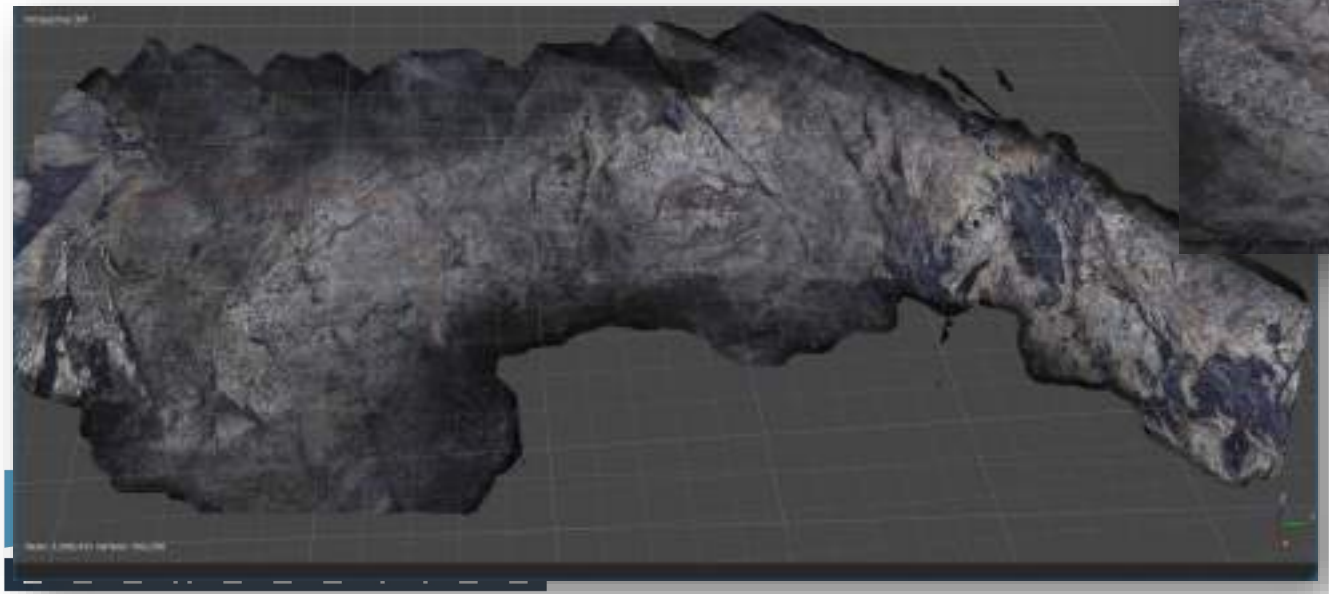
Raw data from lasers (SLS)



*The pictures show the same environment, but on the **left** seen with the **cameras**, and on the **right** with the **laser data***

Field work - Urgeiriça, Portugal - Photogrammetry example

The **2k resolution** RGB camera images can be used for **underwater photogrammetry**

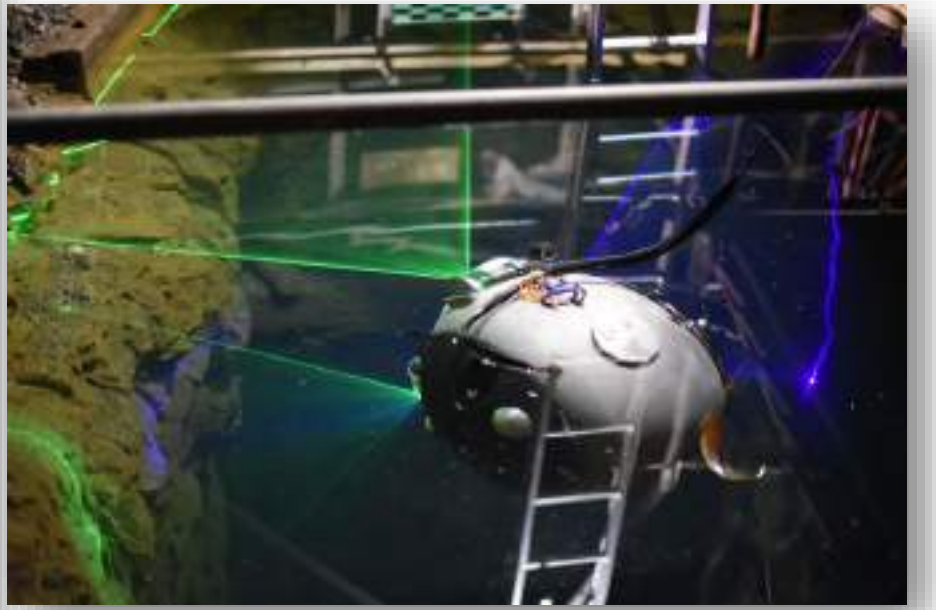


The **georeferred photogrammetric models** can be used for detailed geological interpretation

Field work - Ecton Mine, United Kingdom

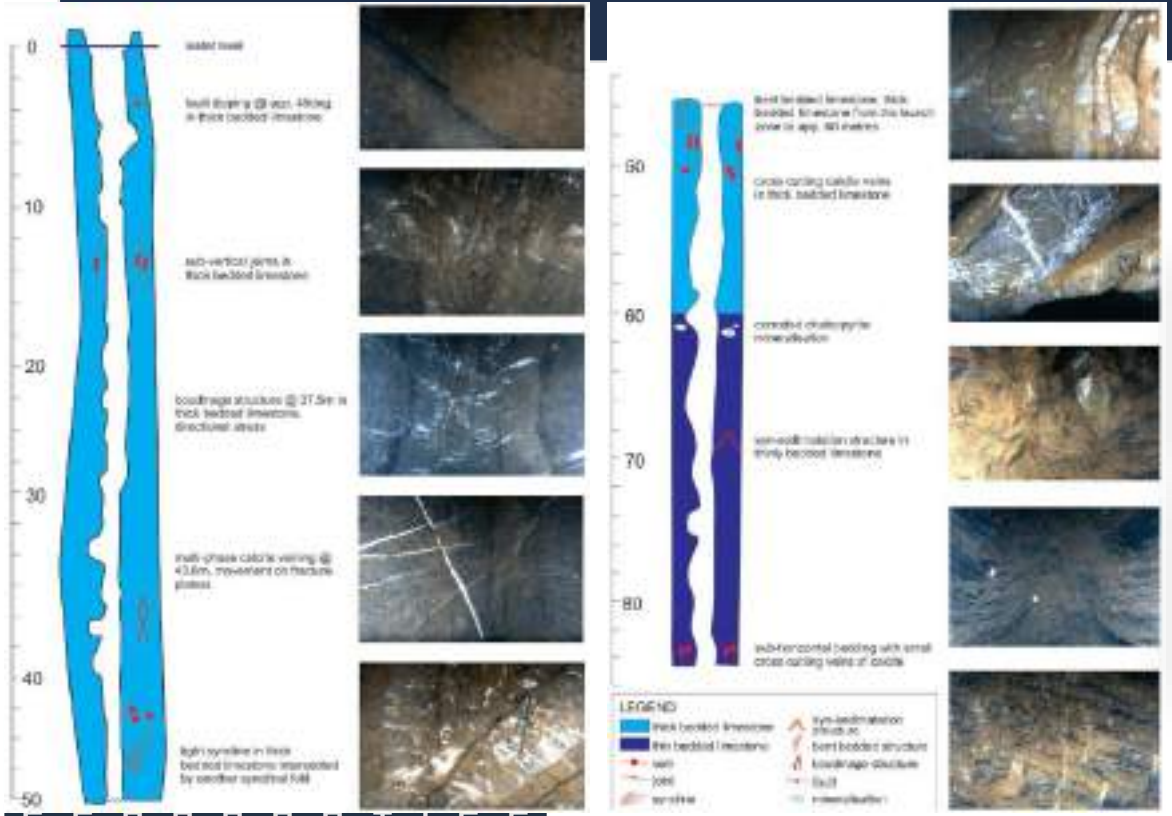
- Deep Ecton Mine was one of the most important **copper mine**s in Britain in the **18th century**.
- There are large flooded workings that extend down to over -300m below river level.
- These **had not been seen since the later 1850s** after the mine pumps were turned off, until the UNEXMIN project provided information on some of the flooded workings by the use the **UX-series submersibles**.

Field work - Ecton Mine, United Kingdom



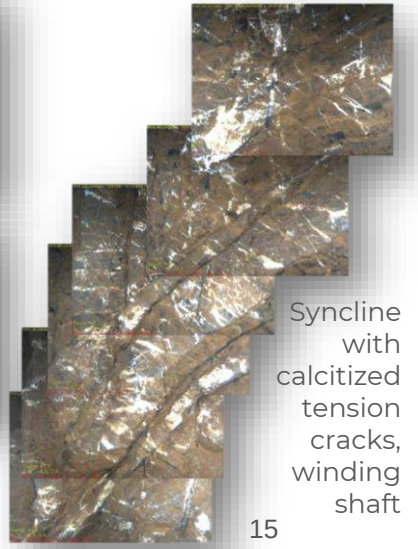
Field work - Ecton Mine, United Kingdom

Field work - Ecton Mine, UK – Geological interpretation



The **geological interpretation** was easily done after the collected data was processed

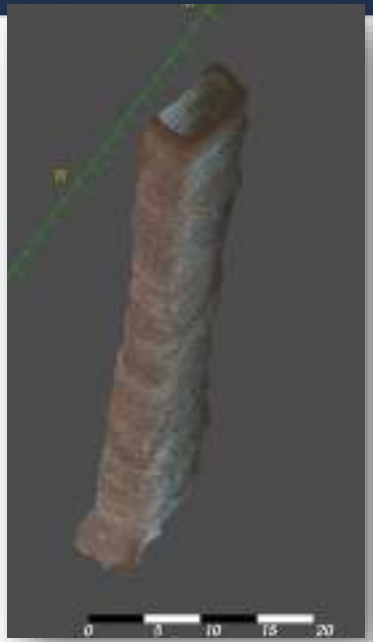
Stockwerk calcite veins on **RGB** (top) and **UV** (bottom) **images**

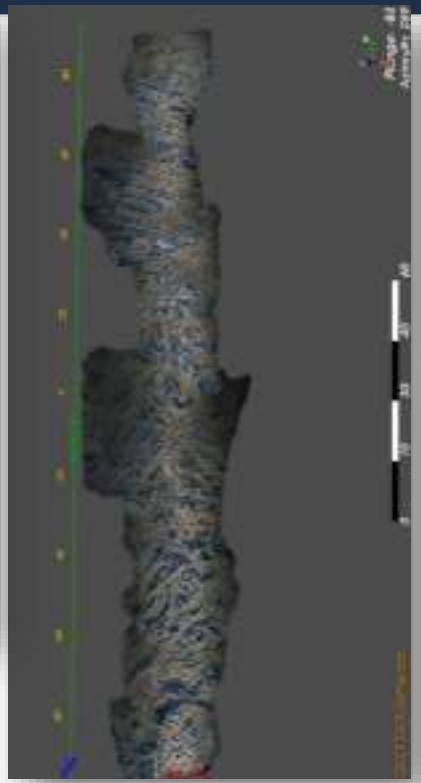


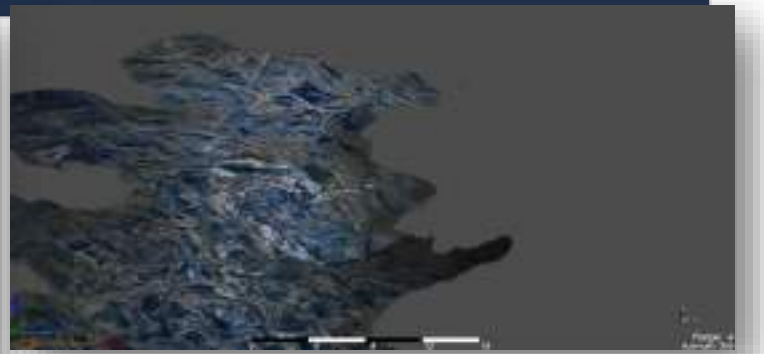
Syncline with calcitized tension cracks, winding shaft

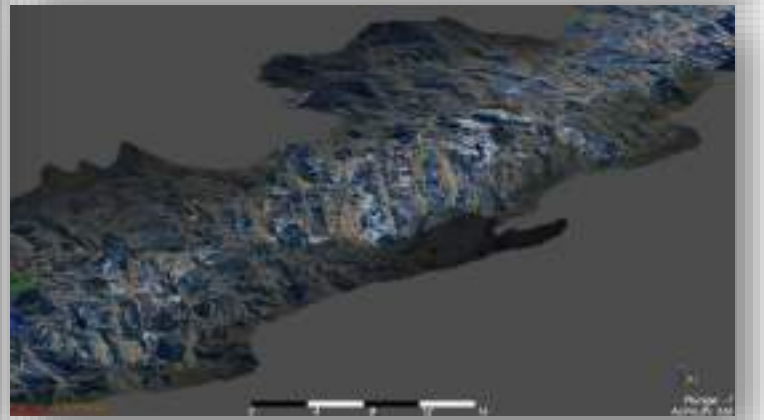
Field work - Ecton Mine, UK – 3D modelling

Detailed, **high-resolution photogrammetric models** from the flooded parts of the mine









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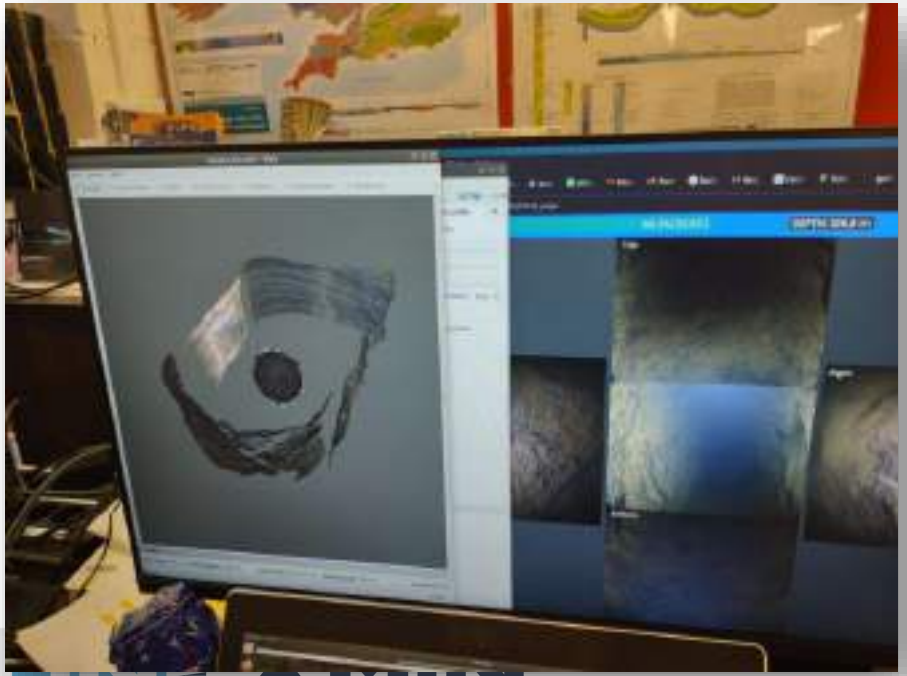
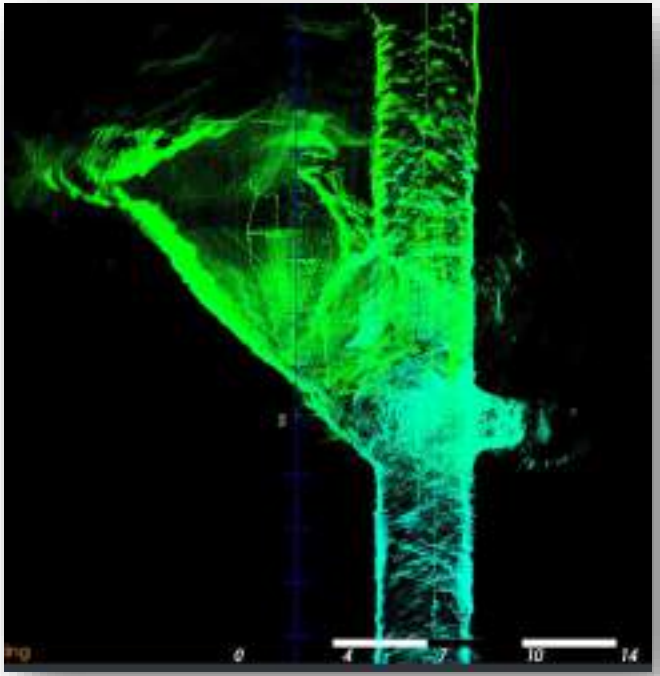
Field work - Ecton Mine, UK – 3D modelling



In case of good visibility, **laser** and **sonar based 3D point clouds** can be created **simultaneusly** and the **immediate result** can be observed **during the dive**



Field work – Csór freshwater well, Hungary

- **Primary water source** of Székesfehérvár, Hungary
- **5 cm accuracy 3D map** is required to be able to lower a new equipment to the bottom of the well
- The **water pumps were working constantly** during the work
- **Human contact with water was prohibited**
- One-day mission
- ~66 m depth

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Field work – Csór freshwater well, Hungary

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After the special disinfection the UX-1Neo robot optained the precise 3D map of the well

Field work – Molnár János cave, Hungary

- The Molnár János Cave is a **thermokarstic** water-filled **cave system**
- The **deepest** sections reach **100 metres**, while the **total length** of explored sections is currently **5.5 kilometres**
- The cave is well-known for cave-divers due to the **warm** (20-28 Celsius degrees), **crystal clear water**. There are **no strong currents** within the cave, the water flows very slowly.

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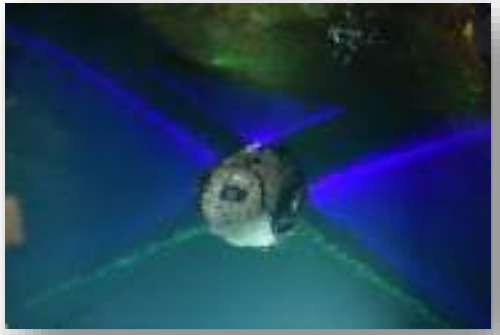
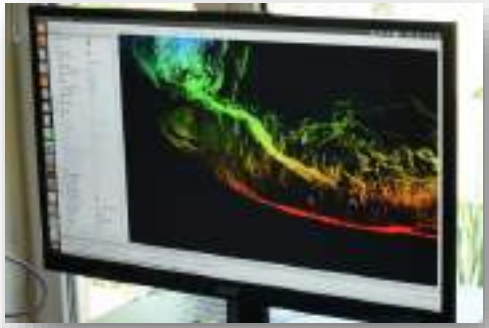
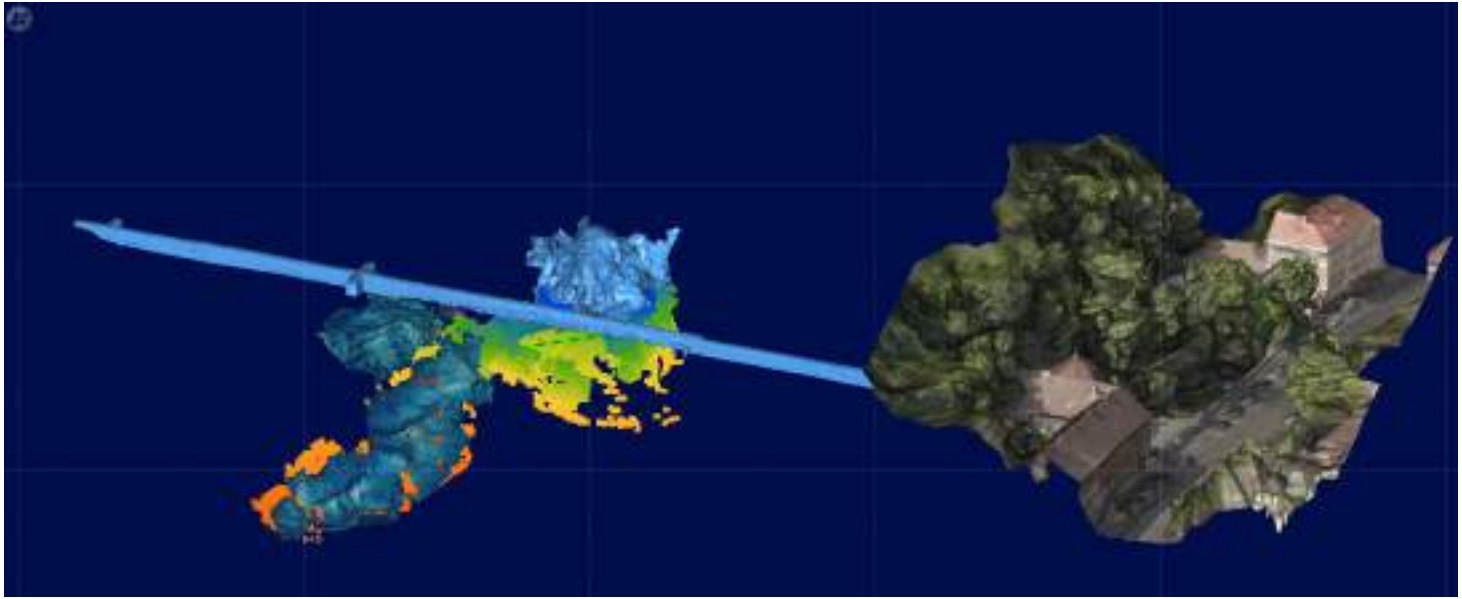
Field work – Molnár János cave, Hungary





Field work – Molnár János cave, Hungary



Complex 3D model were obtained from the first part of the cave:

- Underwater photogrammetry
- Aerial photogrammetry
- Laser point cloud
- Sonar point cloud
- Aerial LiDAR

Solotvyno, Ukraine

- Commercial field trial
- Risk of catastrophic saltwater contamination of River Tisza
- Investigate stability and water conditions within the mines
- Dives in shafts 9 & 10 with the UX1-Neo robot
- Dives in lakes 7 & 8 and shaft 10 with Water Chemistry Unit

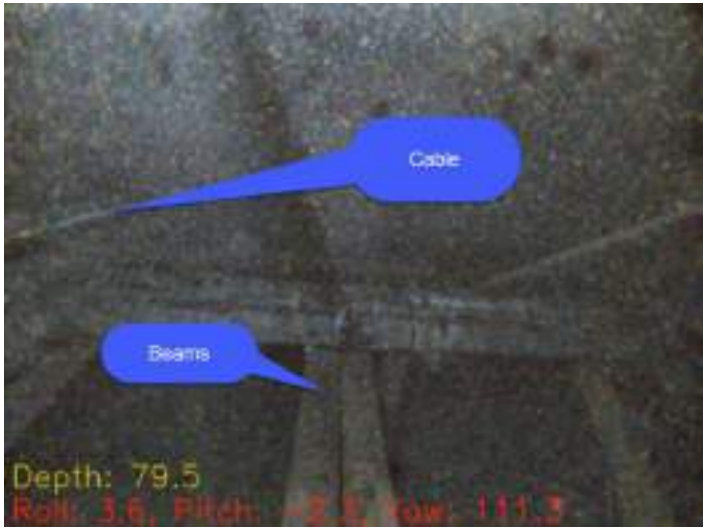
Shaft 10

Solotvyno, Ukraine

Solotvyno, Ukraine

- **Shaft 9**
  - Dive to 80m
  - Low visibility
  - Many obstacles

- Shaft 10
  - Dive to ~450m
  - Better visibility
  - No obstacles
  - Saturated brine



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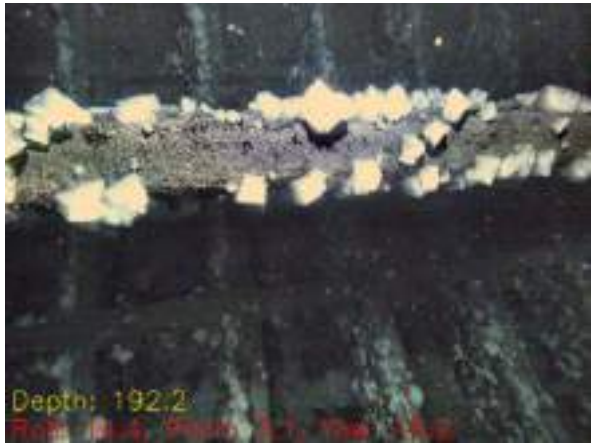

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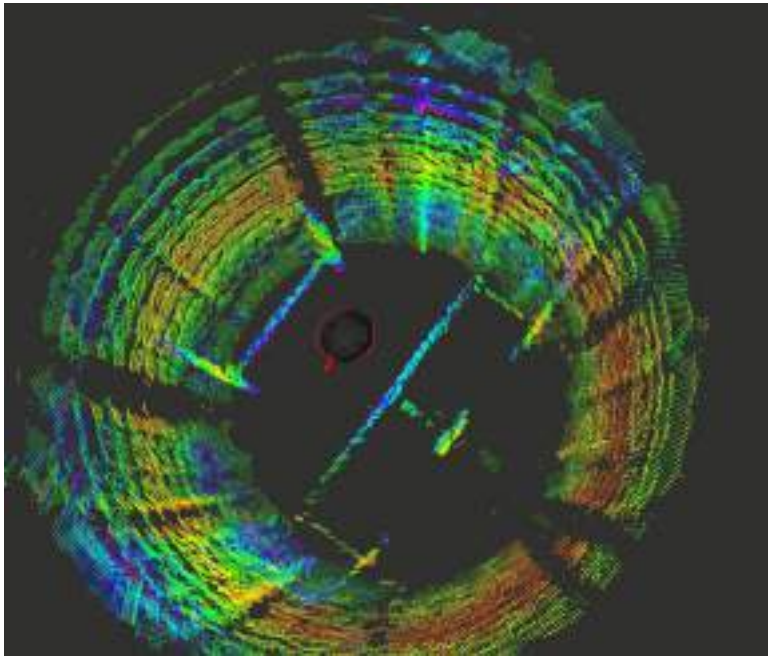

Solotvyno, Ukraine

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  - Dive to 80m
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  - Many obstacles

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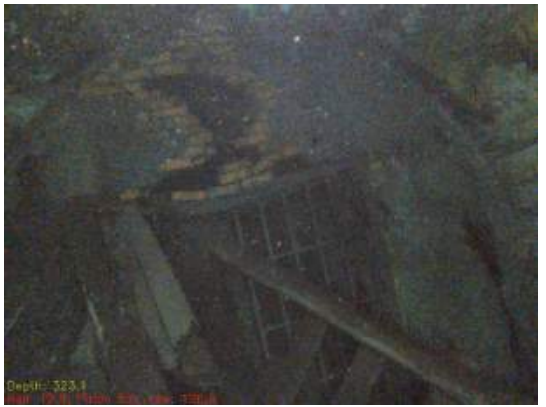
  - No obstacles
  - Saturated brine

Access blocked in the Shaft 10 at ~306m

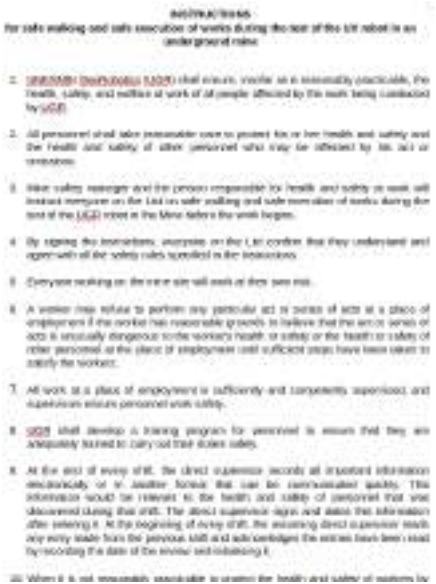
Applications of our technology

- Raw materials exploration
- Create and/or update geological models
- Make decisions on exploitation
- Water reservoirs surveying
- Cave system exploration
- Cavity measurement (e.g. salt mines)
- Geological Surveys
- Cultural Heritage sites investigation
- Risk evaluation
- Environmental monitoring



Safety protocols

- Safety instructions and protocols for field trials are available
- They comply with the Safety legislation of the country and the company for which the trials are carried out



Thank you!

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eit RawMaterials
Connecting matters

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