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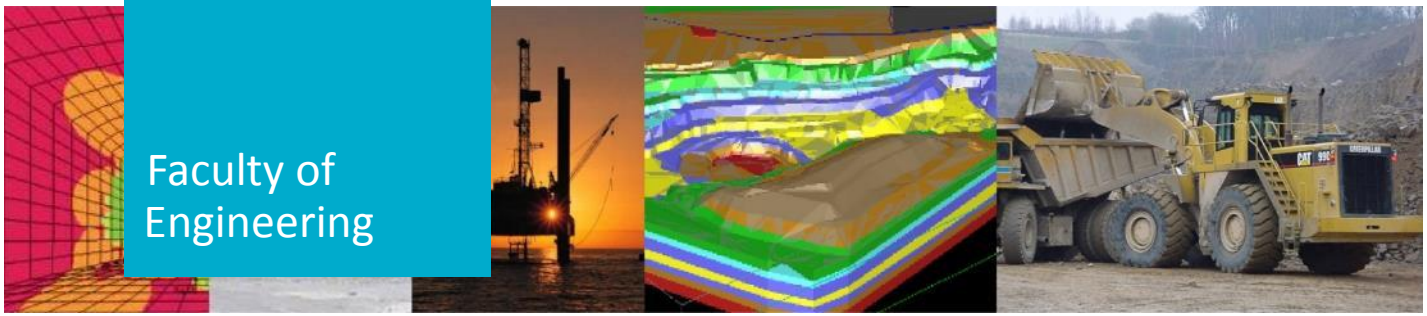

Stability assessment of an abandoned underground chalk quarry

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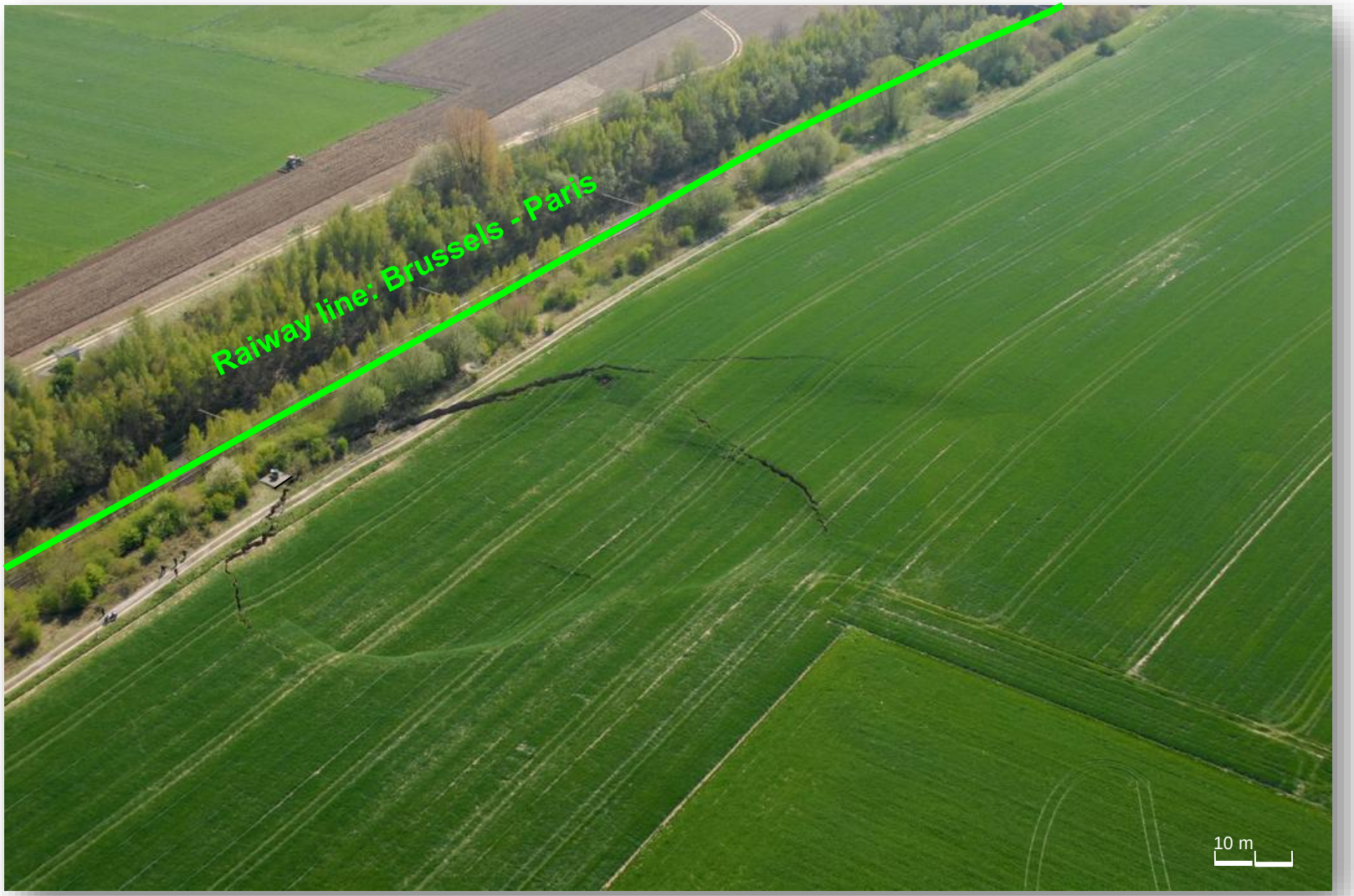
POLYTECH MONS

Nancy, February 2019

Interreg France-Wallonie-Vlaanderen

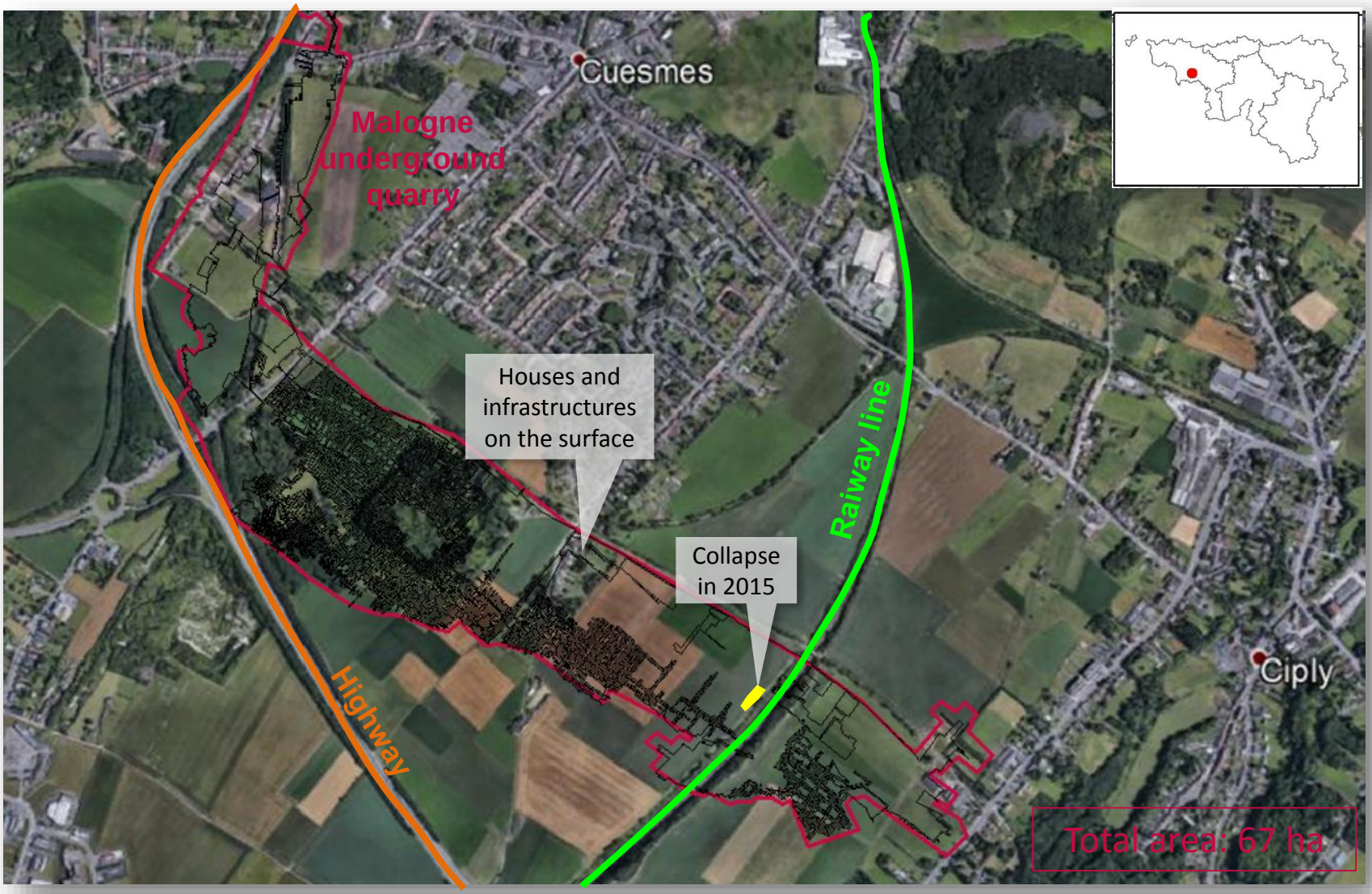
Projet "RISSC"

Big collapse in 2015



Aerial photograph of the collapse of April 22, 2015 (CACEff, 2015).

Malogne underground quarry – impact on the surface



Methodology

Geometrical and geological 3D model
- Geological data
- 3D Model

Rock mass characterisation
- In situ
- Laboratory analyses

Geomechanical classification systems

Rock mass mechanical properties

Empirical approach

Numerical modeling

Behaviour of the underground openings and understanding of failure mechanisms

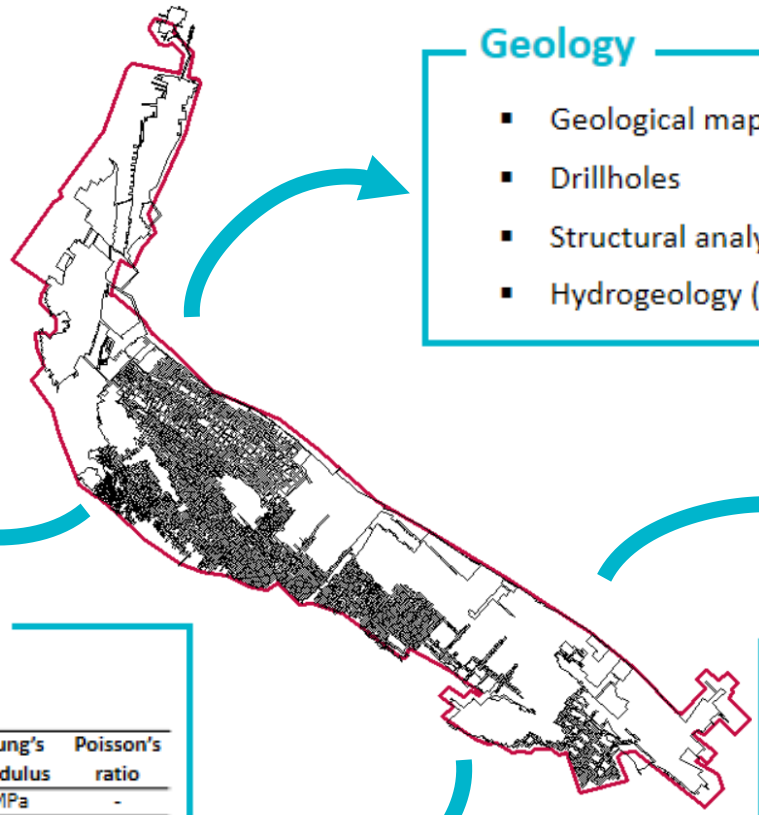
Data collection for Malogne quarry

Geometry

- Topography: 1865, 2013 (Lidarmap)
- Quarry: hangingwall
  footwall
  pillars geometry (2D map)

Geology

- Geological map
- Drillholes
- Structural analysis
- Hydrogeology (piezometric data)



Geomechanical properties

- Laboratory analyses

Property	Unit Weight	Tensile Strength	Friction Angle	Cohesion	Young's Modulus	Poisson's ratio
	MN/m3	MPa	deg.	MPa	MPa	-
Hardground	0.019	0.065	35.37	0.39	1 429	0.14
Phosphate Chalk	0.017	0.03	32.5	0.31	474	0.34

- In situ characterization

Land management

- Land ownership and access permition
- Roads, railway, buildings

Total area: 67 ha

Collected data for the Malogne quarry

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- Quarry: hangingwall
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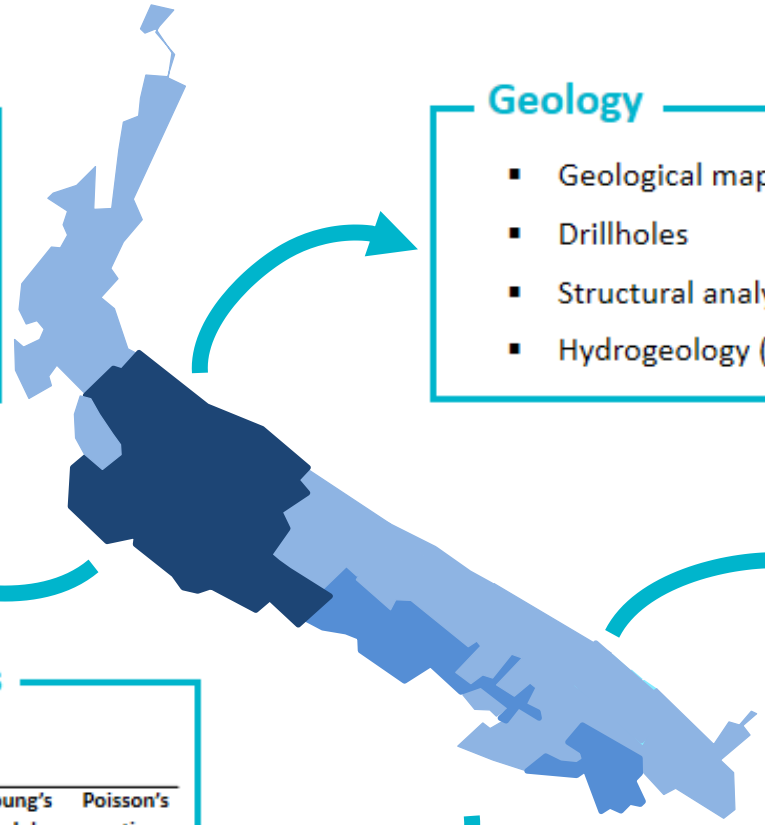

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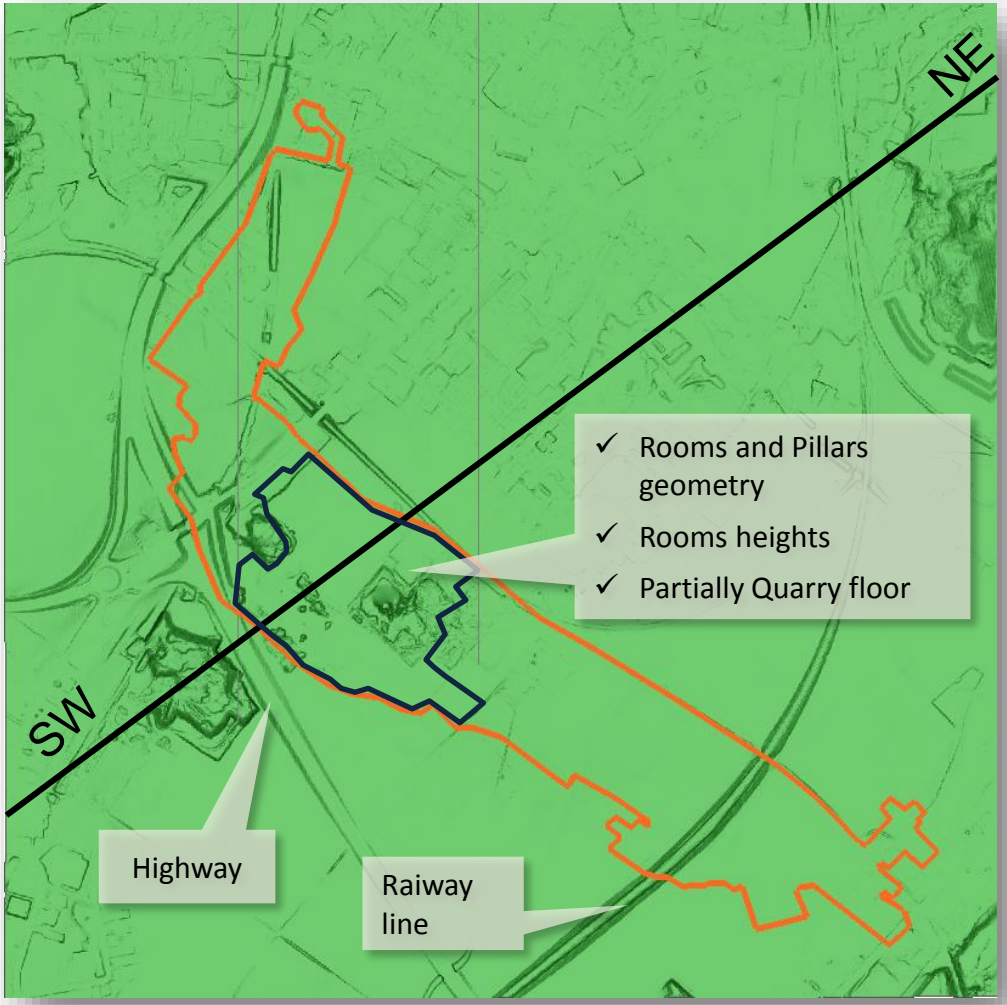
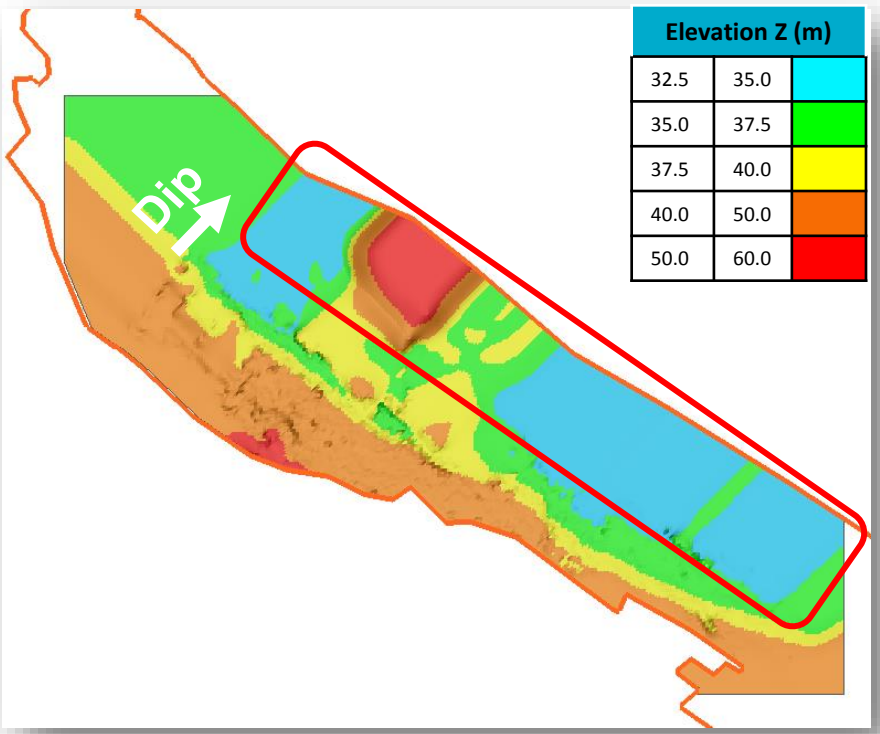
Numerical modeling – Target area



Data interpretation

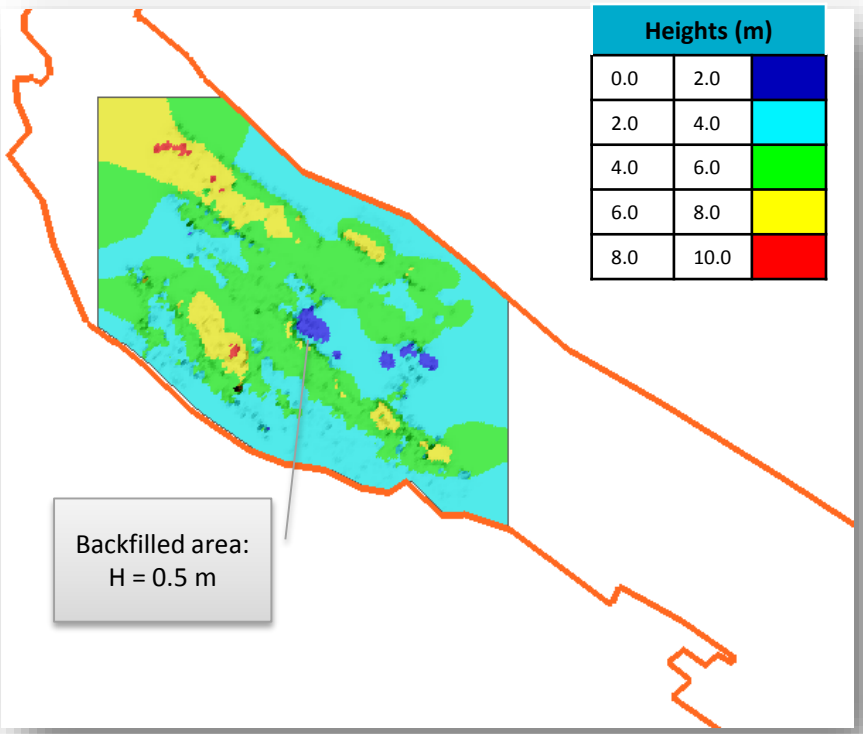
Footwall interpolated

- **6957** points with X, Y, Z were proceeded

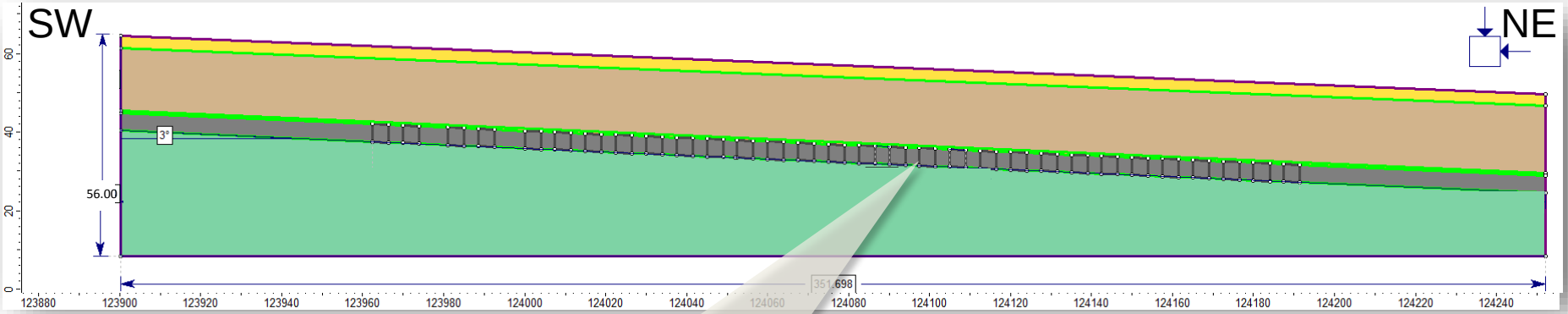


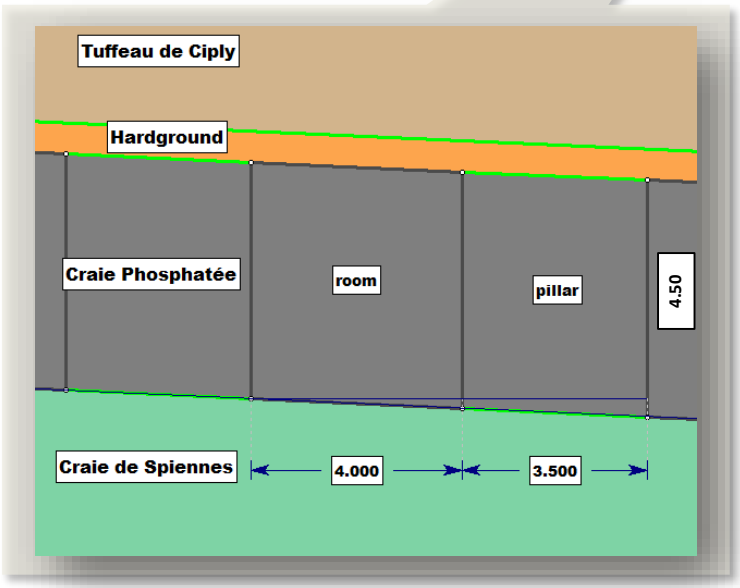
Hangingwall interpolated

- **3724** measurements for the rooms heights were proceeded



Numerical modeling – Geometry

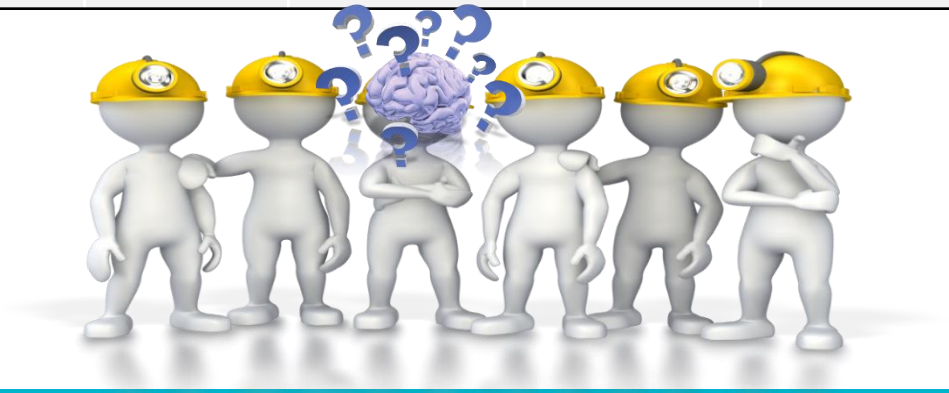




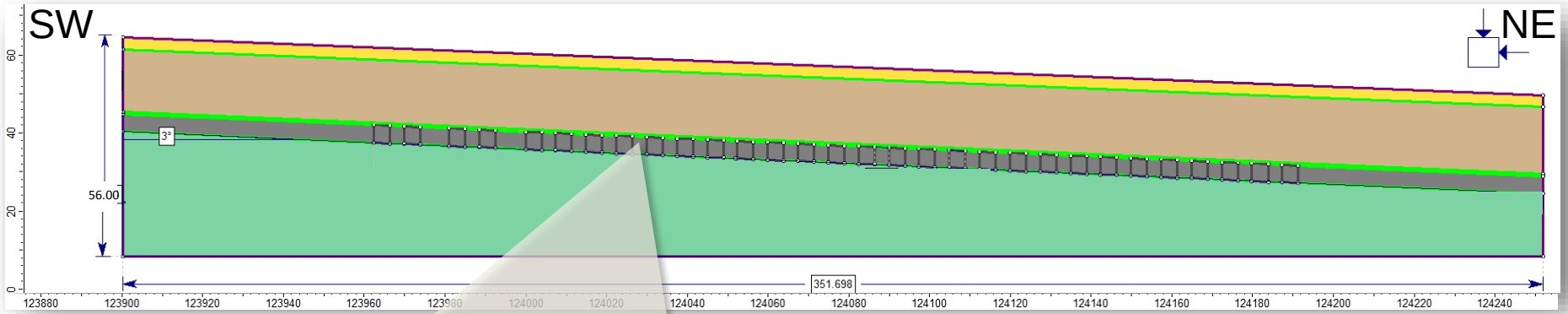
- Pillar width = 3.50 m
- Pillar w/h ratio = 0.78
- Room width = 4.00 m
- Room height = 4.50 m
- Dip = 3˚

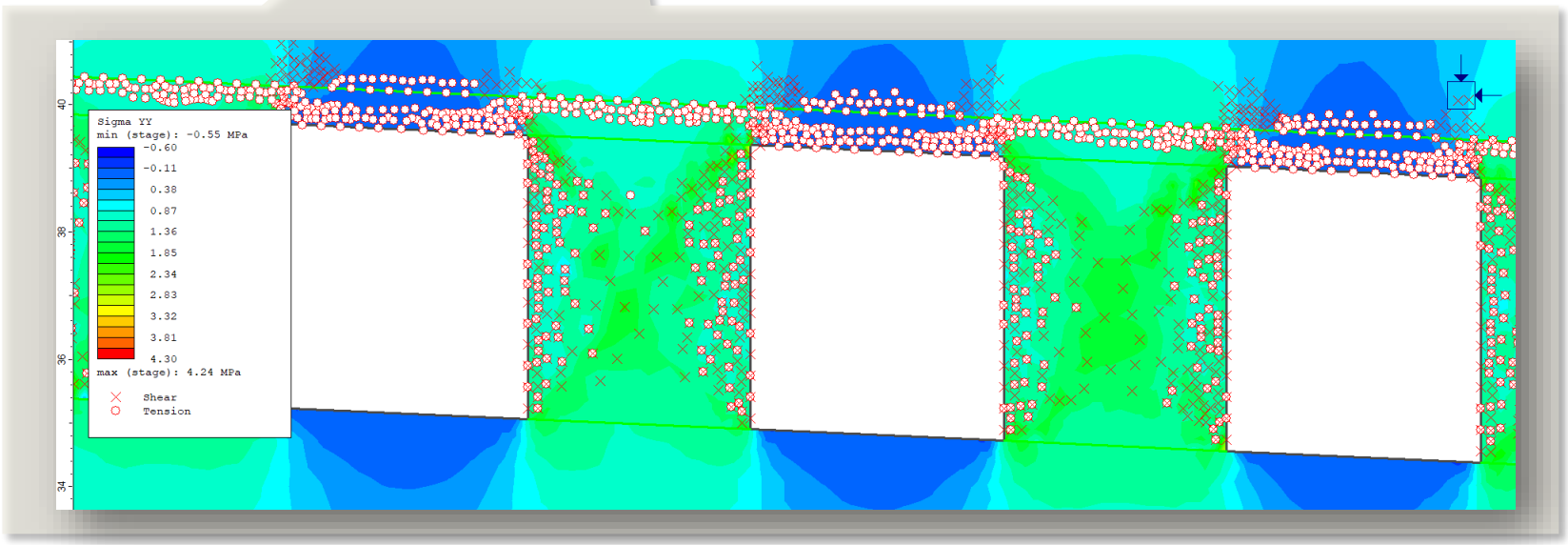
Rock mass properties preliminary estimation

Property	Unit Weight	Tensile Strength	Friction Angle	Cohesion	Young's Modulus	Poisson's ratio
	MN/m3	MPa	deg.	MPa	MPa	-
Limon	0.015	0	30	0	20	0.33
Tuffeau de Ciply	0.015	0.01	31.9	0.16	243	0.33
Hardground	0.019	0.065	35.37	0.39	1429	0.14
Phosphate Chalk	0.017	0.03	32.5	0.31	474	0.34
Spiennes Chalk	0.017	0.32	58	0.45	912	0.34



Numerical modeling – preliminary results



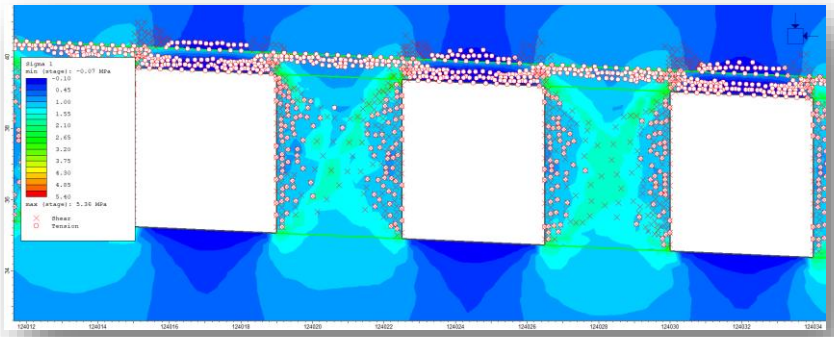


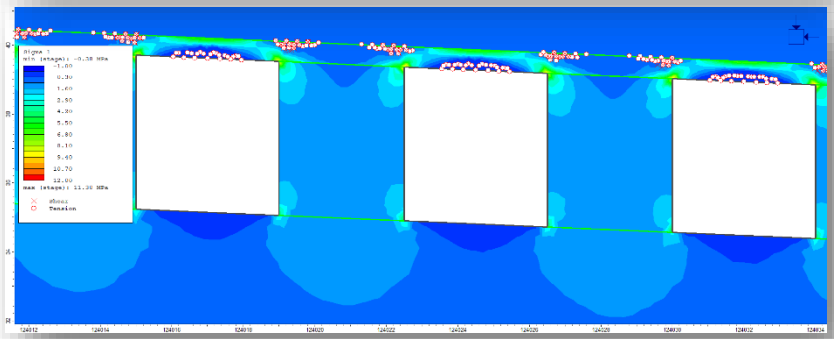
Perfect plastic modeling of pillars (vertical section) with data about the vertical stress and yielded elements

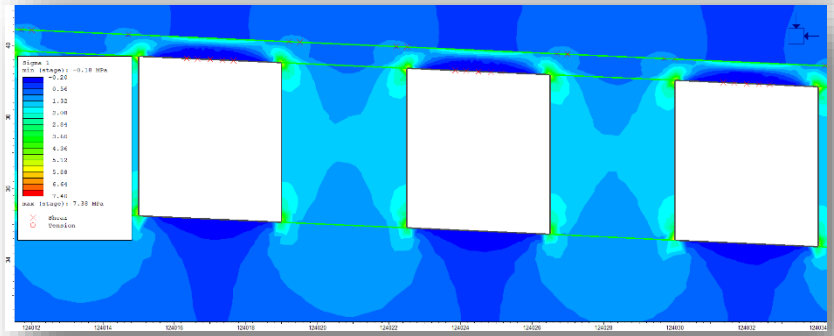
Data set – parametric study

	Property	Unit Weight	Tensile Strength	Friction Angle	Cohesion
		MN/m3	MPa	deg.	MPa
Set data 1 (laboratory)	Limon	0.031	0	30	0
	Tuffeau de Ciply	0.032	0.01	31.9	0.16
	Hardground	0.04	0.065	35.37	0.39
	Phosphate Chalk	0.017	0.03	32.5	0.31
	Spiennes Chalk	0.017	0.32	58	0.45
Set data 2	Limon	0.031	0	30	0
	Tuffeau de Ciply	0.032	0.01	31.9	0.16
	Hardground	0.04	**1.8**	**40**	**2.0**
	Phosphate Chalk	0.017	**0.6**	**35**	**1.5**
	Spiennes Chalk	0.017	0.32	58	0.45
Set data 3	Limon	0.031	0	30	0
	Tuffeau de Ciply	0.032	0.1	**33**	**0.3**
	Hardground	0.04	**3.00**	40	2.0
	Phosphate Chalk	0.017	**1**	35	**1.9**
	Spiennes Chalk	0.017	0.32	58	0.45

Numerical modeling – parametric study







Perfect plastic modeling of pillars (vertical section) with data about the maximum principal stress

Poor rock mass:

- Laboratory data for the rock mass properties
- Yielded rock mass

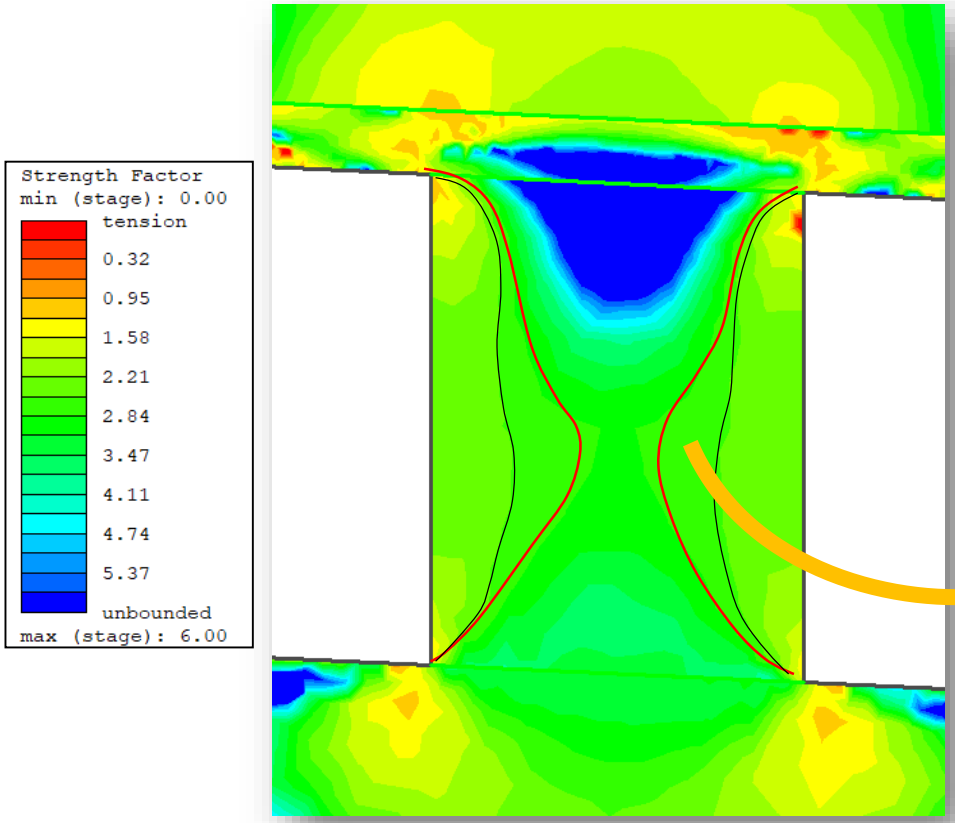
Fair rock mass:

- Slightly increased rock mass properties
- Several yielded elements

Good rock mass:

- Increased rock mass properties
- Sporadic yielded elements

SF evaluation vs. In situ observation



Numerical modeling of pillar (vertical section) with data about the Strength Factor

Photo of slender pillar from Malogne underground quarry

Future tasks

Understanding of failure mechanisms

Rock mass characterization: in situ and laboratory analysis

Rock Mass classification systems

Structural study

Numerical modeling: 3D geological and geotechnical models

Effect of water

Coal mining activities influence!

Risk management solutions

THANK YOU FOR YOUR ATTENTION!

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