DD-MET

Advanced methane drainage strategy-technology employing underground directional drilling technology for major risk prevention and greenhouse gases emission mitigation

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Deformation analysis in the surroundings of the roadway ahead of longwall mining, Staszic-Wujek Mine, Poland

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Introduction

Introduction

Why is knowledge of rock mass stress/deformation important?

The knowledge of stress state in rock mass is very important in mining geomechanics. Generally, the accurate knowledge of the stress strain state of the rock mass in the neighbourhood of the mining galleries and underground openings is absolutely critical for their optimum support design.

Measurement (investigation) of the rock stress is usually carried out by interpretation of the rock mass deformation processes. To measure initial in situ stress in RM, the **Compact Conical ended Borehole Overcoring** (CCBO) method was used. To measure stress changes in the state of stress in the RM, the **Compact Conical ended Borehole Monitoring method** (CCBM) was used.

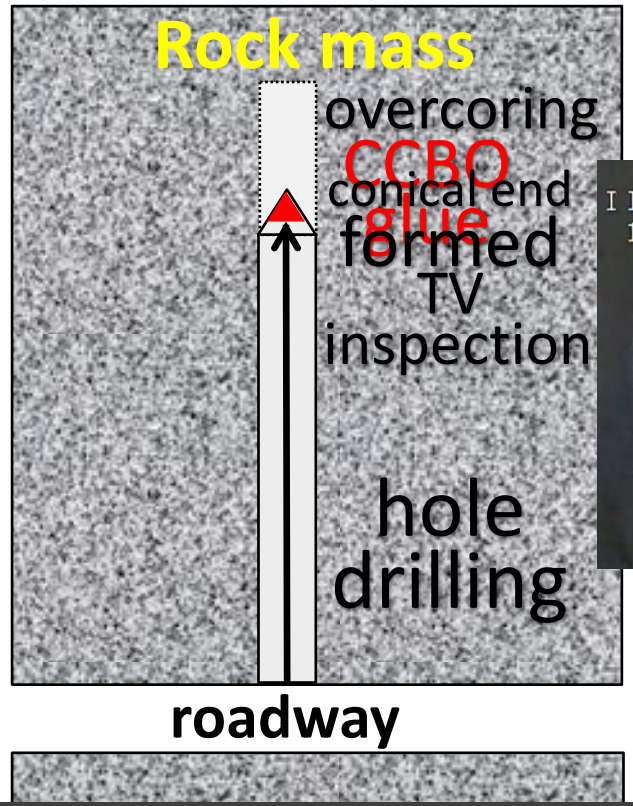
The deformation analysis of roadway at the monitoring station was carried out using a pulse **3D laser scanner**. The purpose was to capture deformation changes ahead of the advancing longwall face; specifically, at five stages in the ± 20 m section on each side from the station.

Deformation analysis in the surroundings of the roadway ahead of longwall mining

Staszic-Wujek Mine, Poland

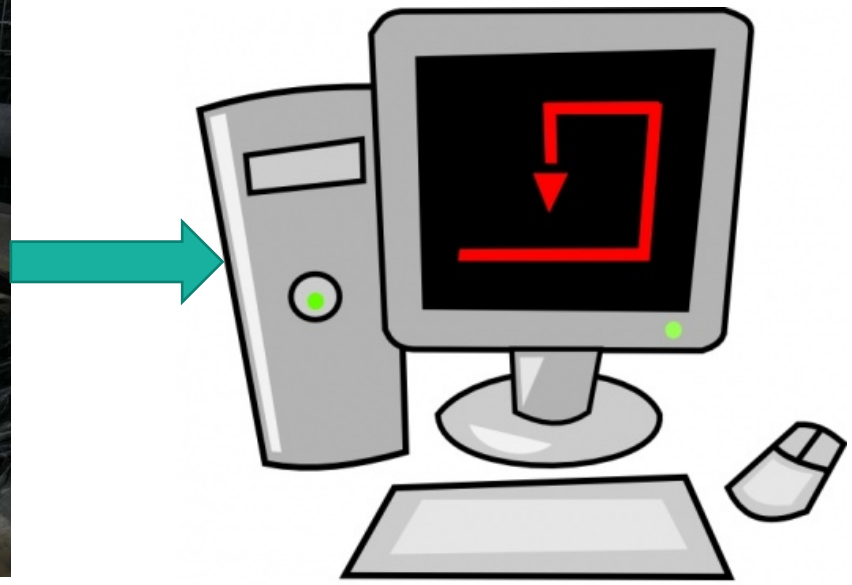
Methodology of measurement

Initial in situ stress



CCBO probe (Compact Conical ended Borehole Overcoring) installation

Transmission data to computer



Calculation of initial stres in Sigma software

Methodology of measurement

Stress state change monitoring

CCBM (Compact Conical Borehole Monitoring) probe installation with same principles as CCBO probe without overcoring process

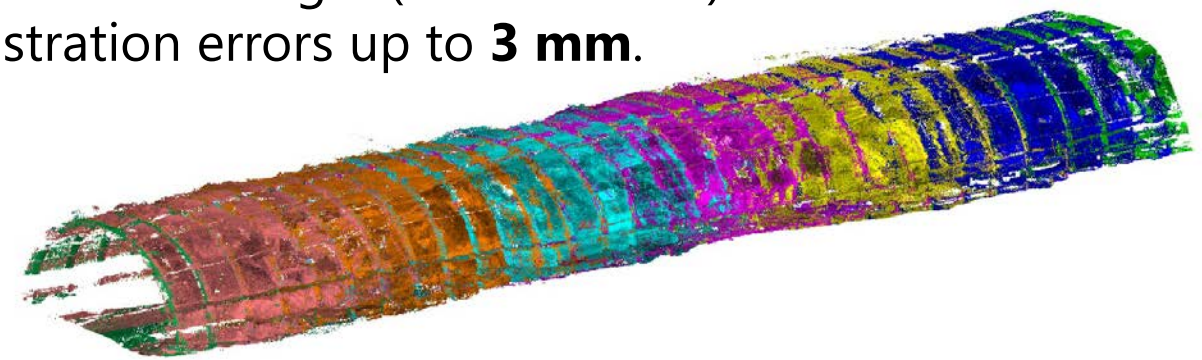
Daily reading by handheld computer

Data evaluation in Sigma software

Methodology of measurement

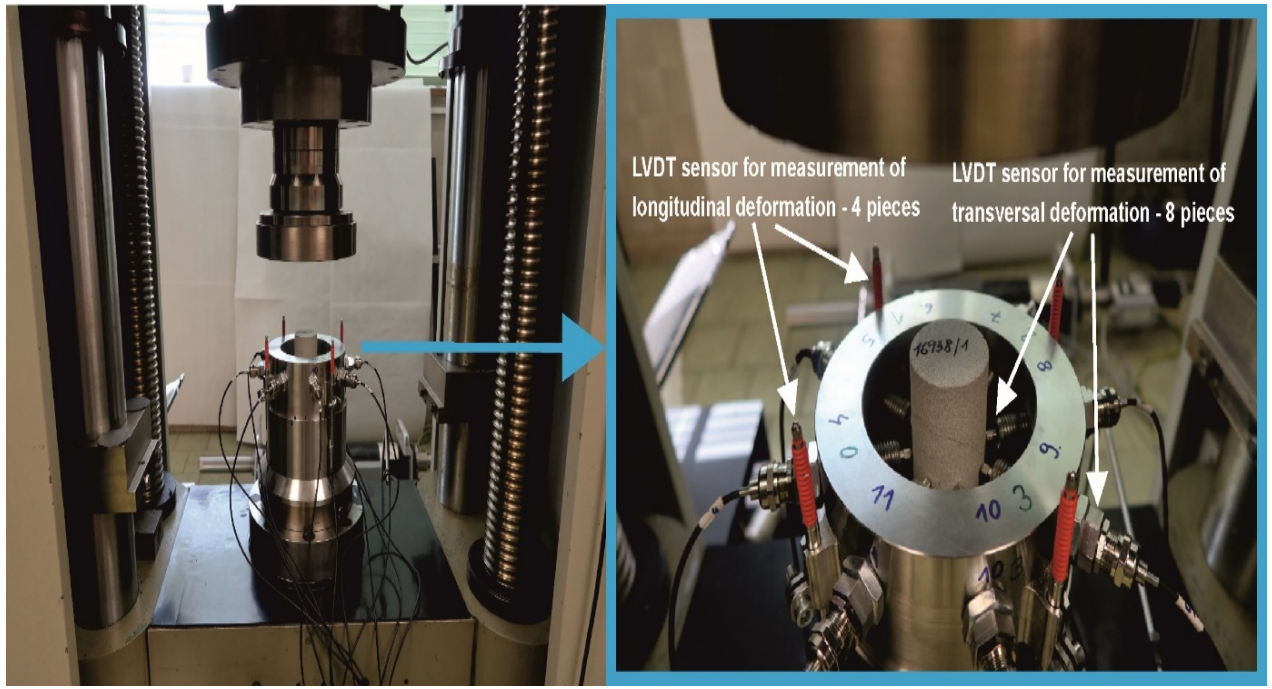
Evaluation of roadways deformation

- The **Faro Focus S 350** scanner was used as part of scanning the roadways.
- Monitoring of deformation changes in front of the advancing longwall, within a distance of **± 20 m** in each direction from the geotechnical station.
- Initial scans after the installation of the geotechnical station x scanning of the geotechnical station at four distances in front.
- The step between the positions was set at **5 m**.
- Reference spheres with a diameter of 140 mm and checkerboard target (200x200 mm) were used.
- Registration errors up to **3 mm**.



Methodology of measurement

Determination of deformation and mechanical properties of rocks

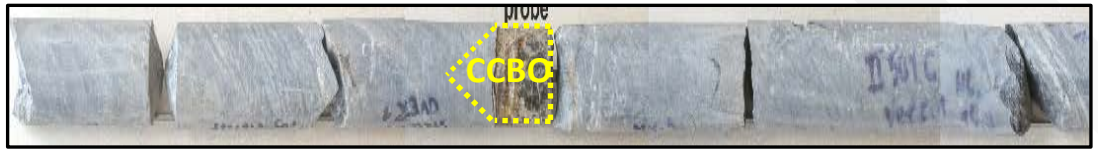


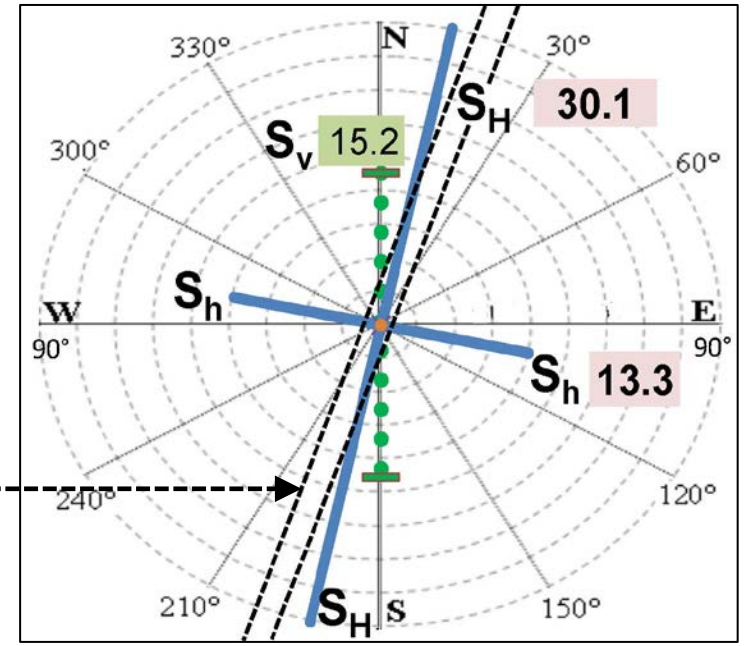
- The compressive strengths and deformation properties of rocks were tested using the **ZWICK 1494** mechanical press machine with the special load cell using the LVDT (Linear Variable Displacement Transformer) sensor).
- The bulk density ρ_0 the uniaxial compressive strength (**UCS**) σ_D, Young's modulus **E**, and Poisson's ratio μ were defined from core samples.

Stress state of rock mass

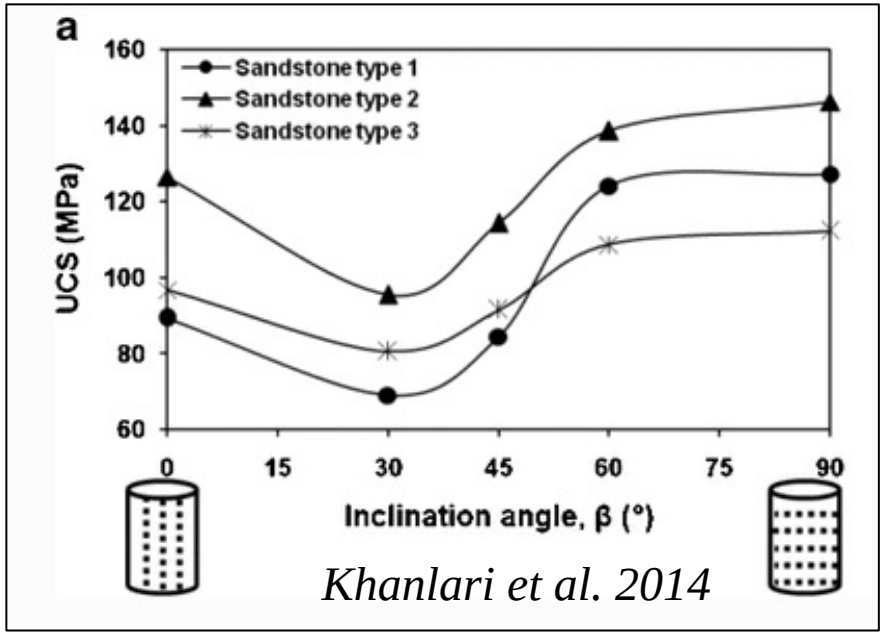
Initial in situ stress

overcoring core





roadway orientation



- Theoretical value of the vertical stress ~ 21 MPa x Sv 15,2 MPa => influence of the properties assessment - sedimentation foliation at inclination of 38° to the compression axis - 30% reduction in value.
- Maximal horizontal stress component (S_H) **twice** the vertical stress (S_v).
- The orientation of the maximum horizontal stress is **almost identical** to the orientation of the roadway.

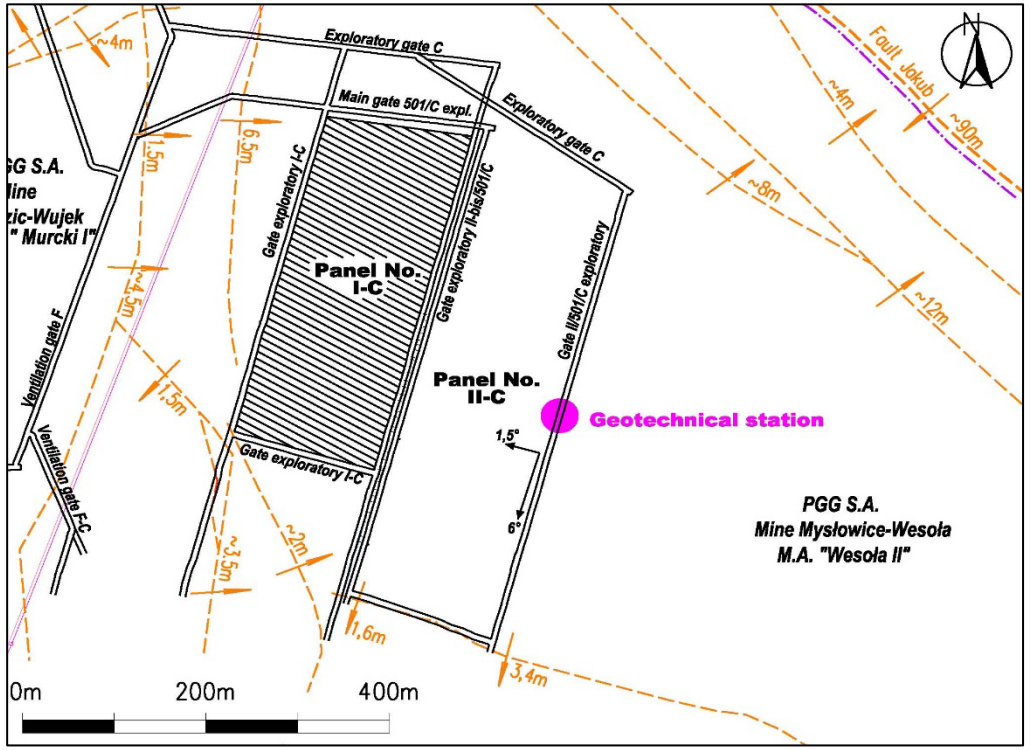
Stress state of rock mass

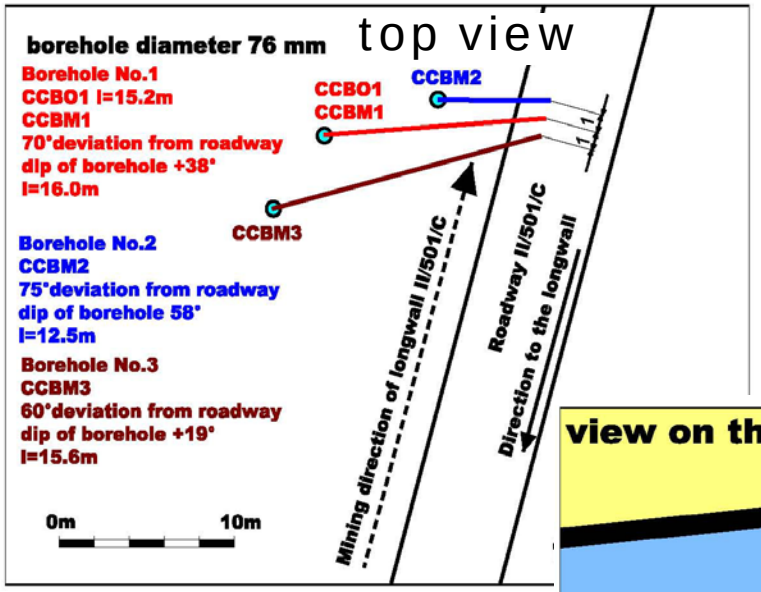
Initial in situ stress

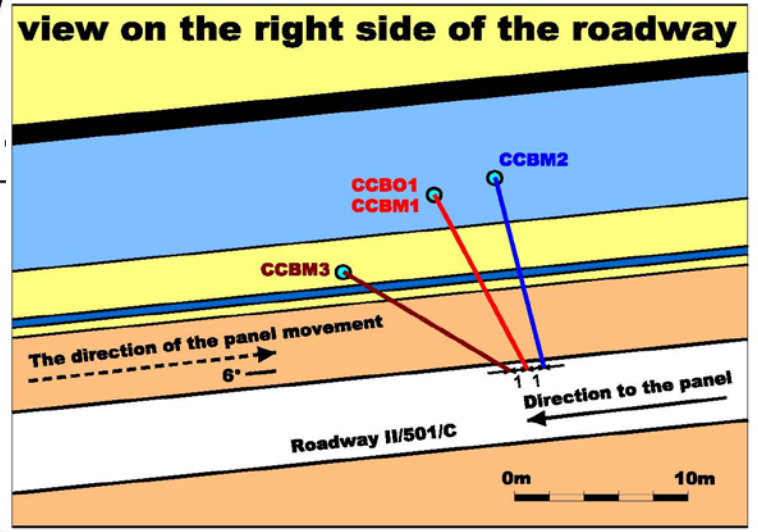
- The significance of the effect of the maximum horizontal stress component SH was also confirmed by the observed **borehole breakout**.
- These borehole breakouts were recorded during the video inspection of exploratory borehole T1 and the installation boreholes No.1 and 2 at the monitored location.

Stress state change monitoring and roadways deformation

Monitoring project of the longwall II/501/C



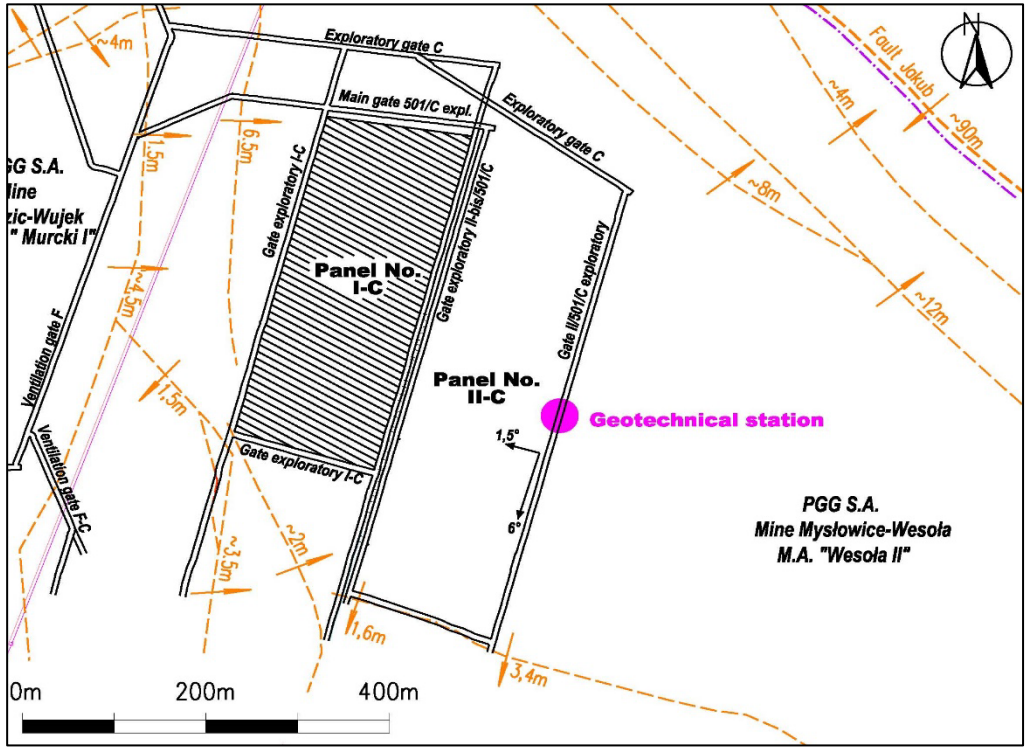


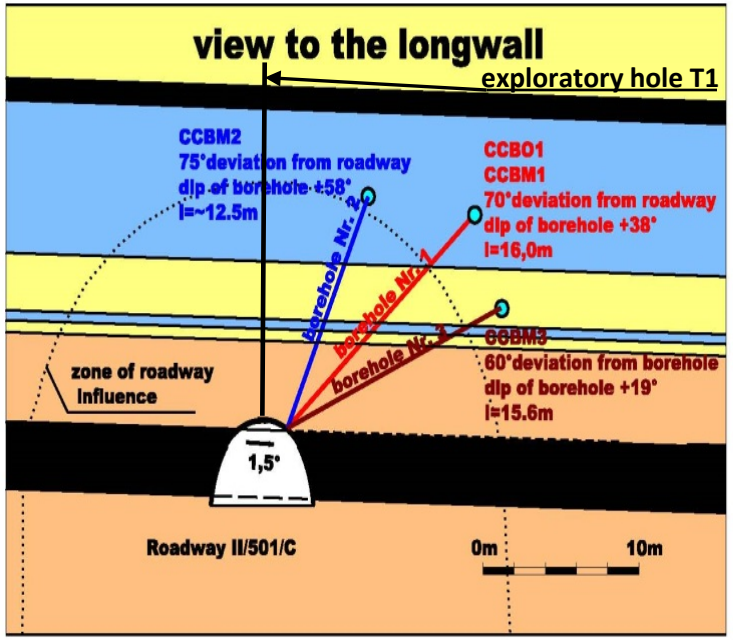


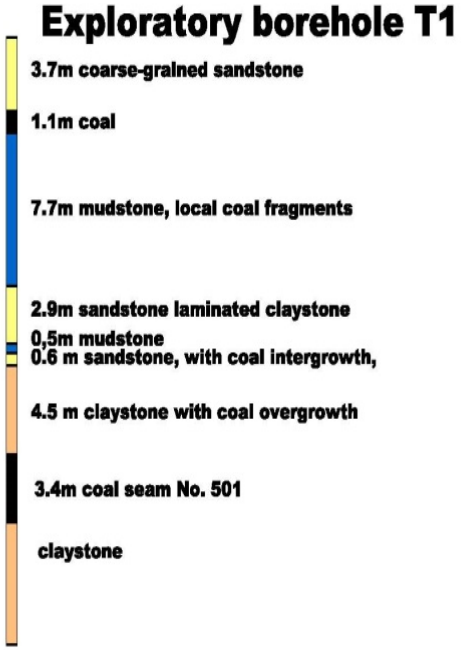
- Depth ~ **890 m** below the surface.
- Seam thickness ranges from **3.05** to **3.65 m**.
- The incline of the layers is approx. **7°** to the South-East.

Stress state change monitoring and roadways deformation

Monitoring project of the longwall II/501/C





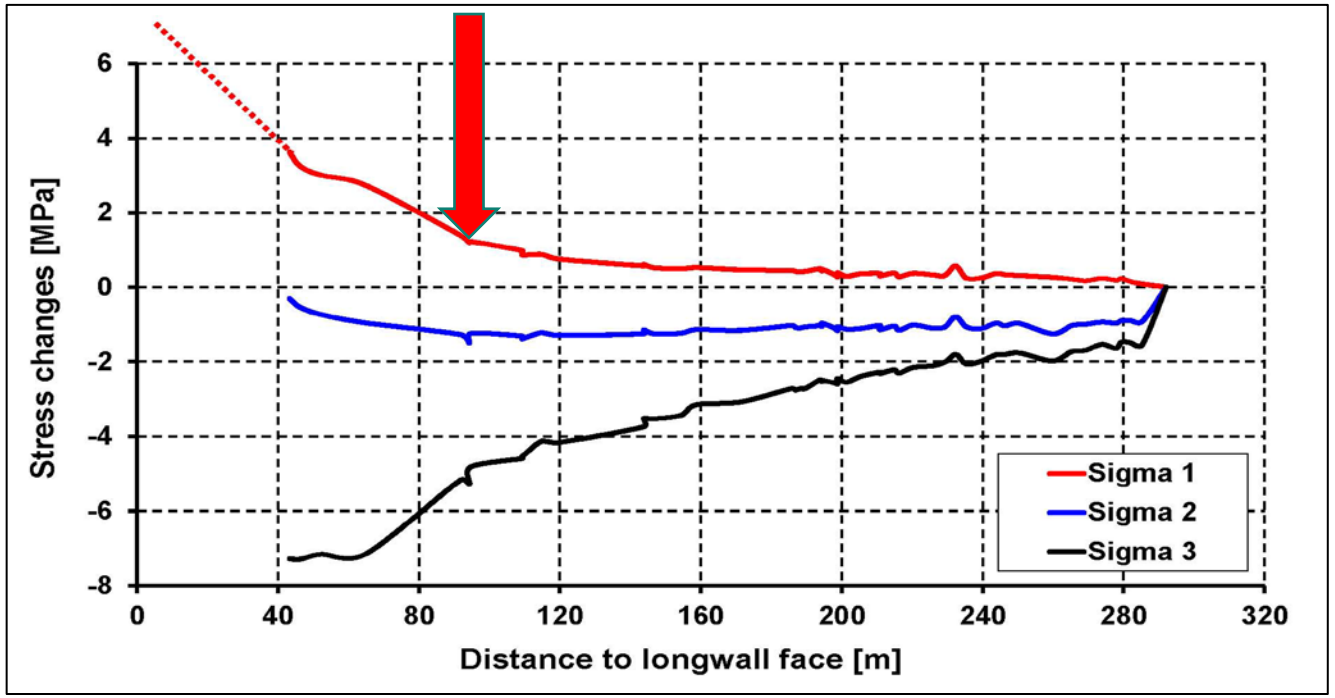


- Distance of the geotechnical station from the longwall after installation 296 m.
- Average value of **RQD 65 -94 %** => rock quality category „fair" to „excellent".
- Average simple compression strength **53 MPa**; deformation modulus **23 GPa**.

Stress state change monitoring and roadways deformation

Stress development in the rock mass in front of the longwall face

CCBM1

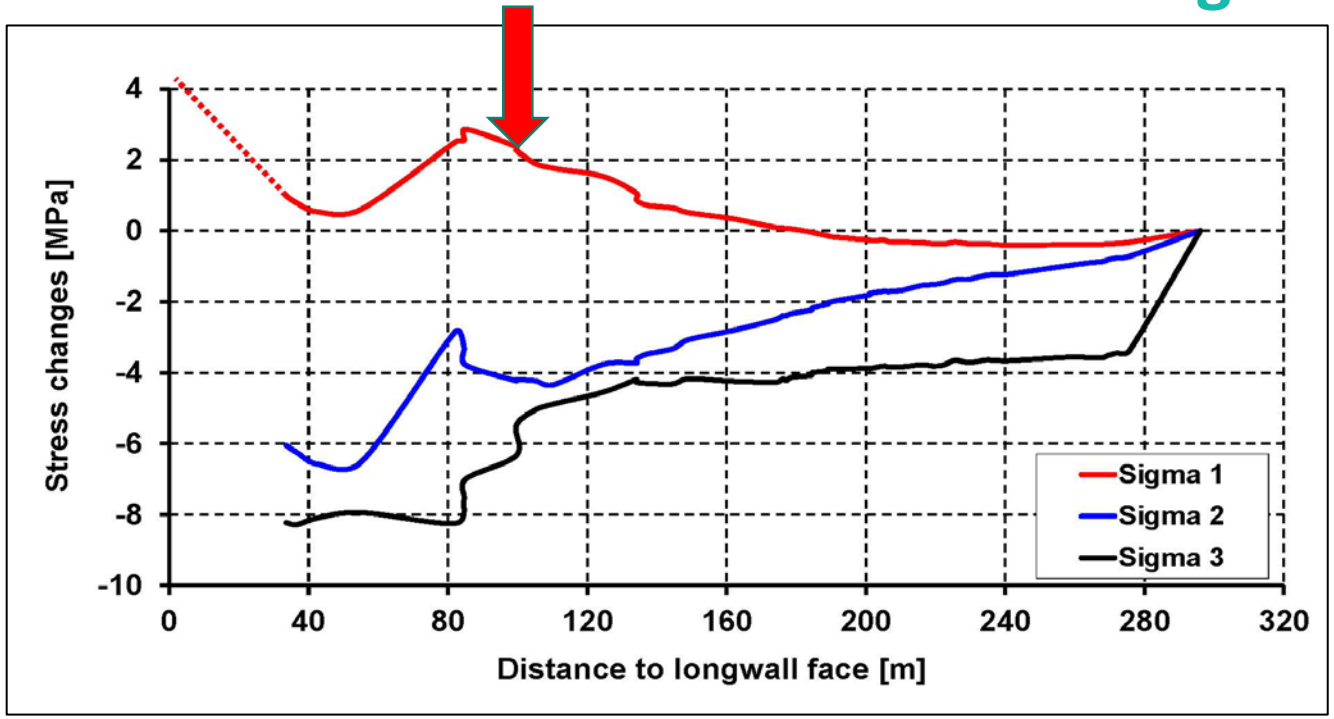


- Increase of significant stress changes started **90 m** ahead of the longwall face.
- The maximum stress component reached its maximum **3.7 MPa** at the distance 43 m from the longwall face. Unfortunately, the monitoring of this probe could not continue because the power supply cable was **damaged**. Repairs of the power supply cable were not allowed for mining safety reasons.

Stress state change monitoring and roadways deformation

Stress development in the rock mass in front of the longwall face

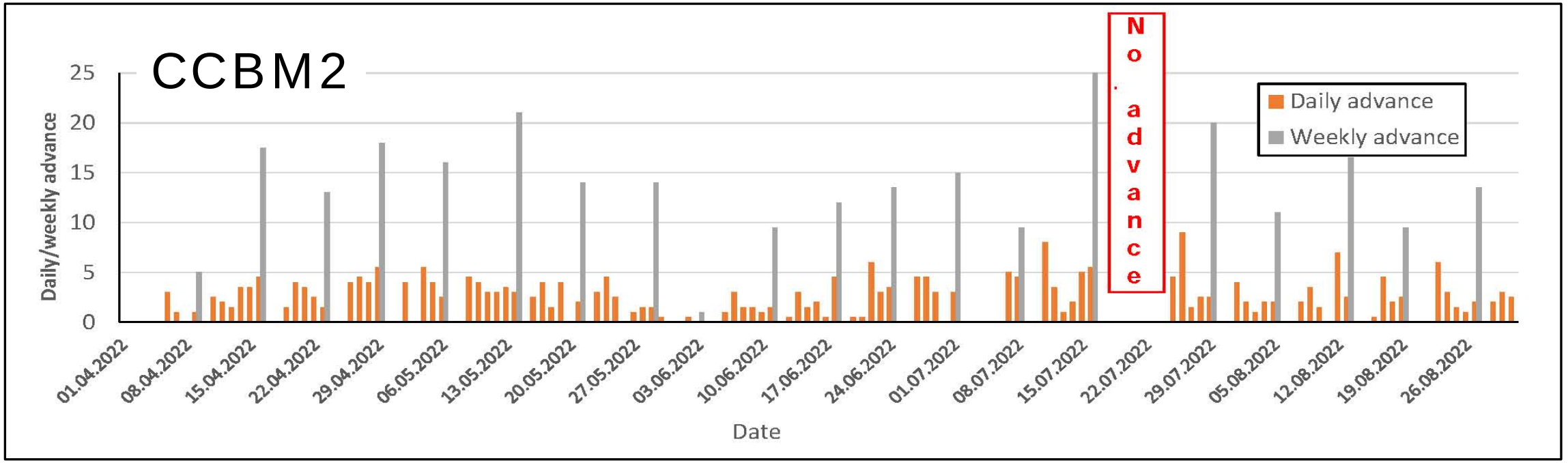
CCBM2



- Increase of significant changes in stress at a distance of approx. **95 m** from the front of the wall.
- The maximum stress component of Sigma 1 increased by **3 MPa** when 85 m ahead of the face.
- At the distance of approximately 85 m from the longwall face, there was a **rapid drop** in all stress components.

Stress state change monitoring and roadways deformation

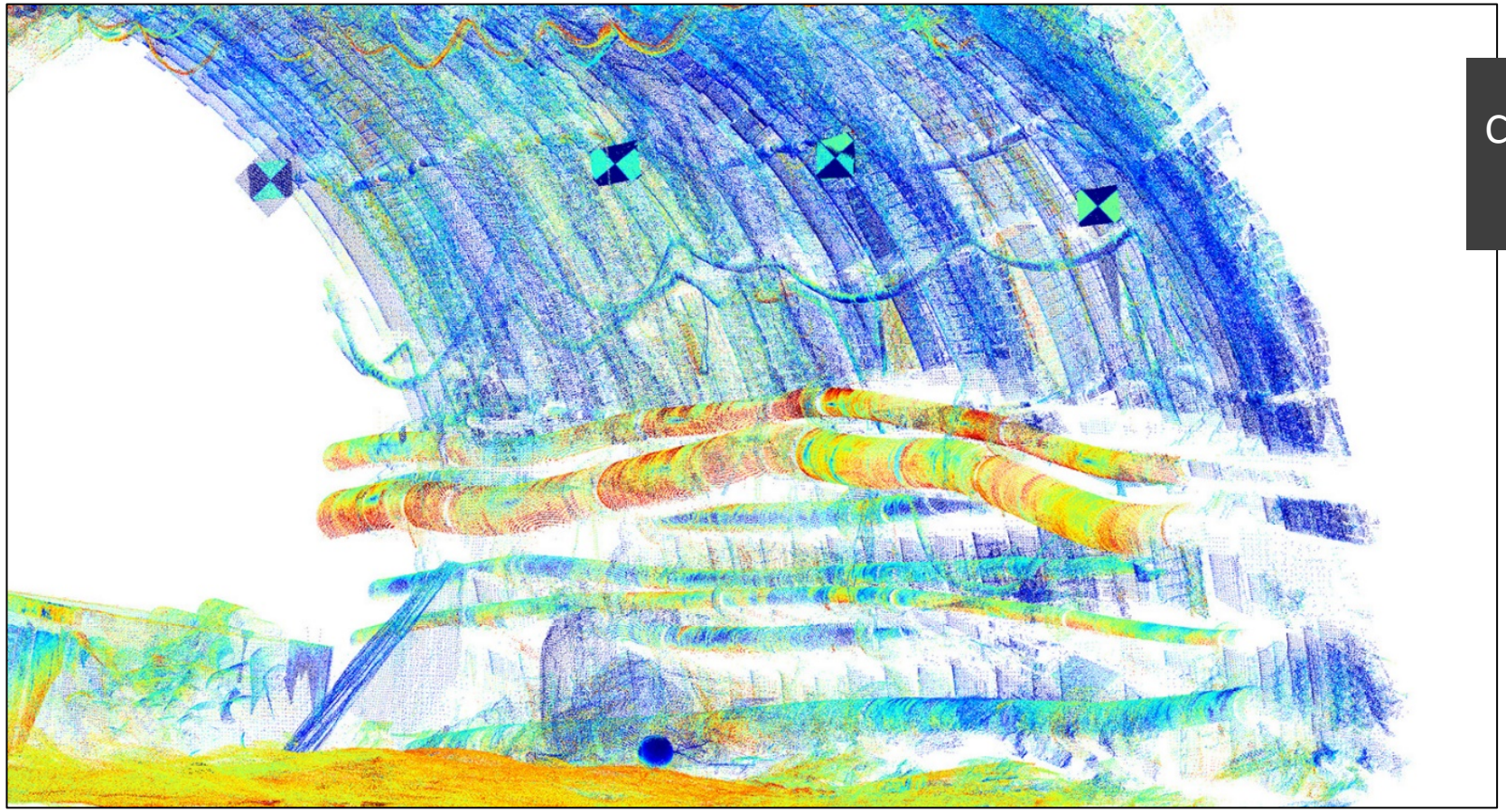
Stress development in the rock mass in front of the longwall face



- This decrease is related to the **stoppage of the longwall** due to geological problems experienced in the previous week.
- The power supply cables of CCBM2 probe was also **damaged**, as in the case CCBM1 probe.
- The **CCBM3** probe **failed** due to technical damage in the initial monitoring stage.

Stress state change monitoring and roadways deformation

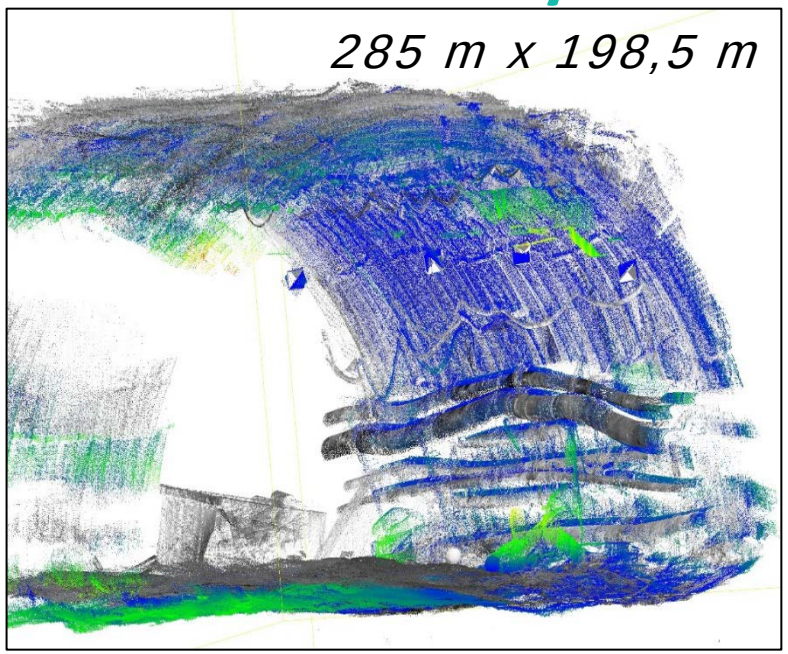
Deformation analysis of the maingate – longwall II/501/C



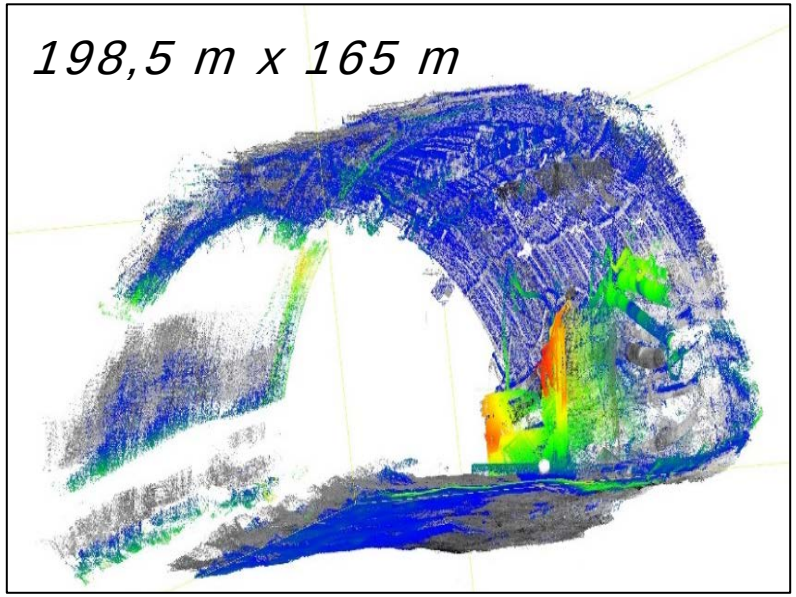
Checkerboard targets applied to align scans more accurately.

Stress state change monitoring and roadways deformation

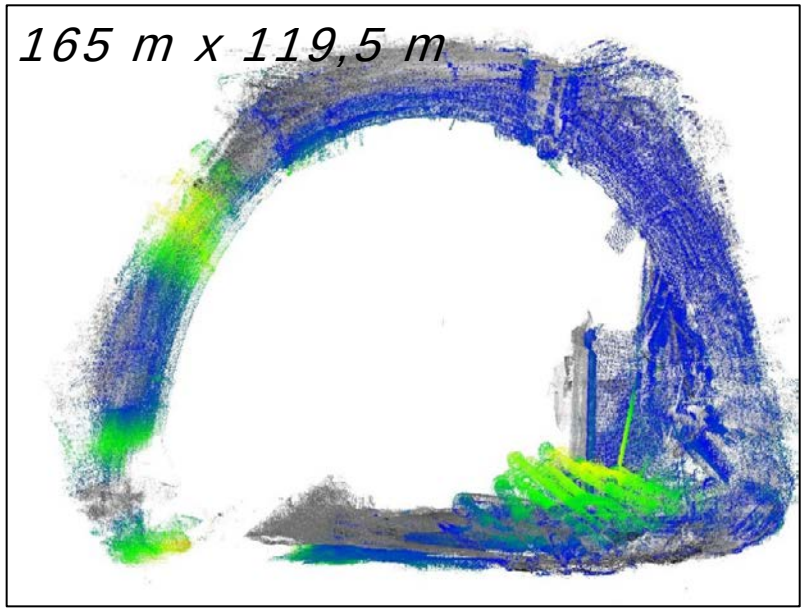
Deformation analysis of the maingate – longwall II/501/C



Changes only on the cable line and on the pipeline.



Changes only in the new imported devices.

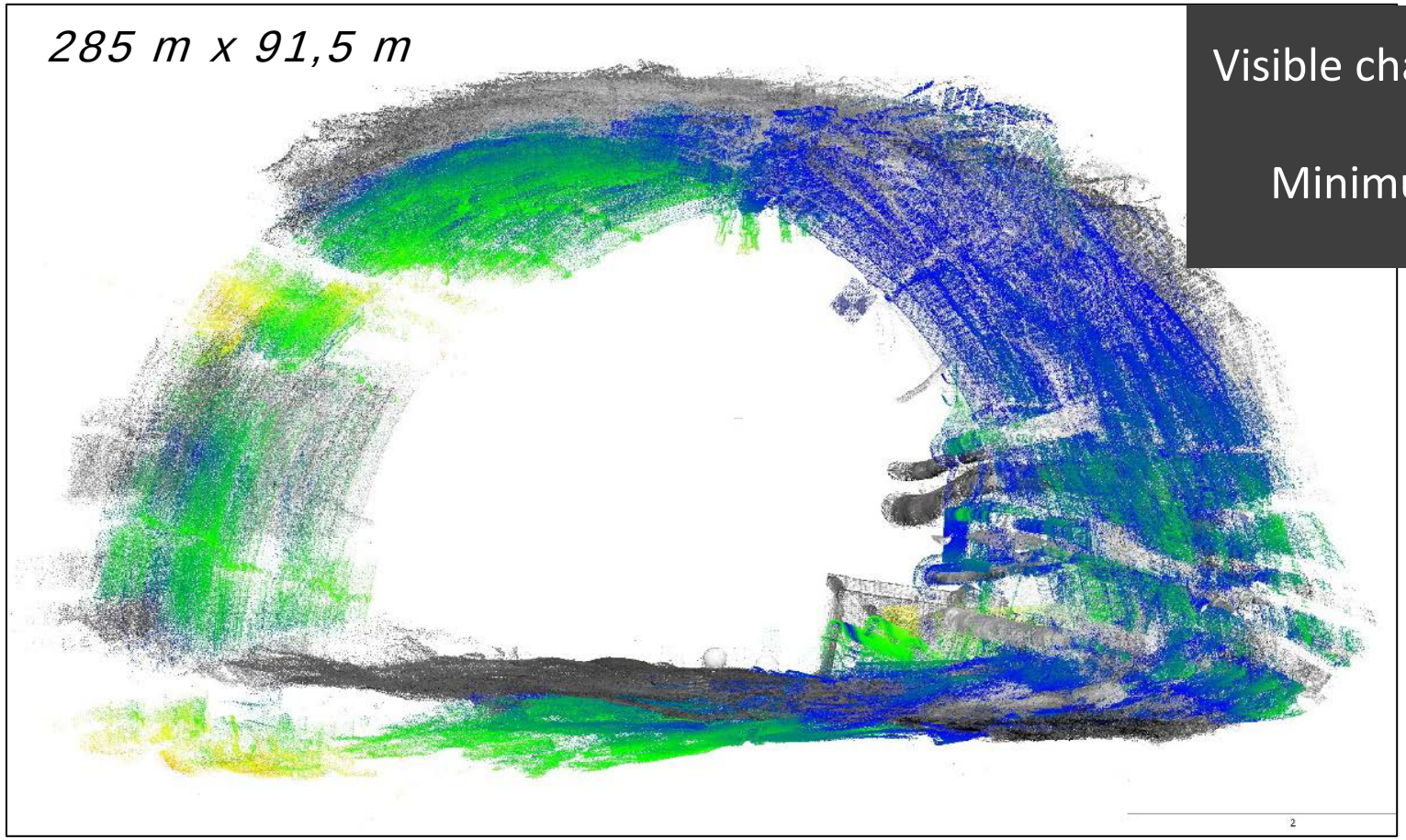


Changes only in the new transported material.

The deformations of the steel arch reinforcement are not visible!!!

Stress state change monitoring and roadways deformation

Deformation analysis of the maingate – longwall II/501/C



Visible changes in the floor of roadway (~20cm).

Minimum deformation of ribside (0-12cm)

Results

- The maximum horizontal stress component SH is approximately **2 times** higher than the observed vertical stress Sv. The previously observed trend that the maximum stress value is caused in the almost horizontal plane was thus confirmed.
- Based on the evaluation of CCBM probe, the increase of significant stress changes started at the distance of **90 - 95 m** from the longwall face. The longwall II/501/C were equipped by power loader technology with seam thickness from **3.05** to **3.65 m**.
- Decrease of all stress components at the distance of approximately 85 m from the longwall face is related to the **stoppage of the longwall due to geological problems** experienced in the previous week.
- Since the orientation of the maximum horizontal stress is **almost identical** to the orientation of the monitored roadway, **minimal deformations** of the roadway analysed on the basis 3D laser scanning were recorded.
- These findings correspond to the measured direction of the main horizontal stress SH, which is almost parallel to the mine roadway II/501/C. It is **first confirmation** of this theory within Carboniferous rock mass of Upper Silesian Coal Basin.


3D laser scanning image