# Using the HI Cell Over coring Technique to Measure Local Stress Magnitude and Orientation

*Engineering Geology and Innovation: Research – Infrastructure - Sustainable Development*

(I.A.E.G)

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**Skouries Geological-Geotechnical Dpt.**

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- Data collection
- Data analysis
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# Introduction

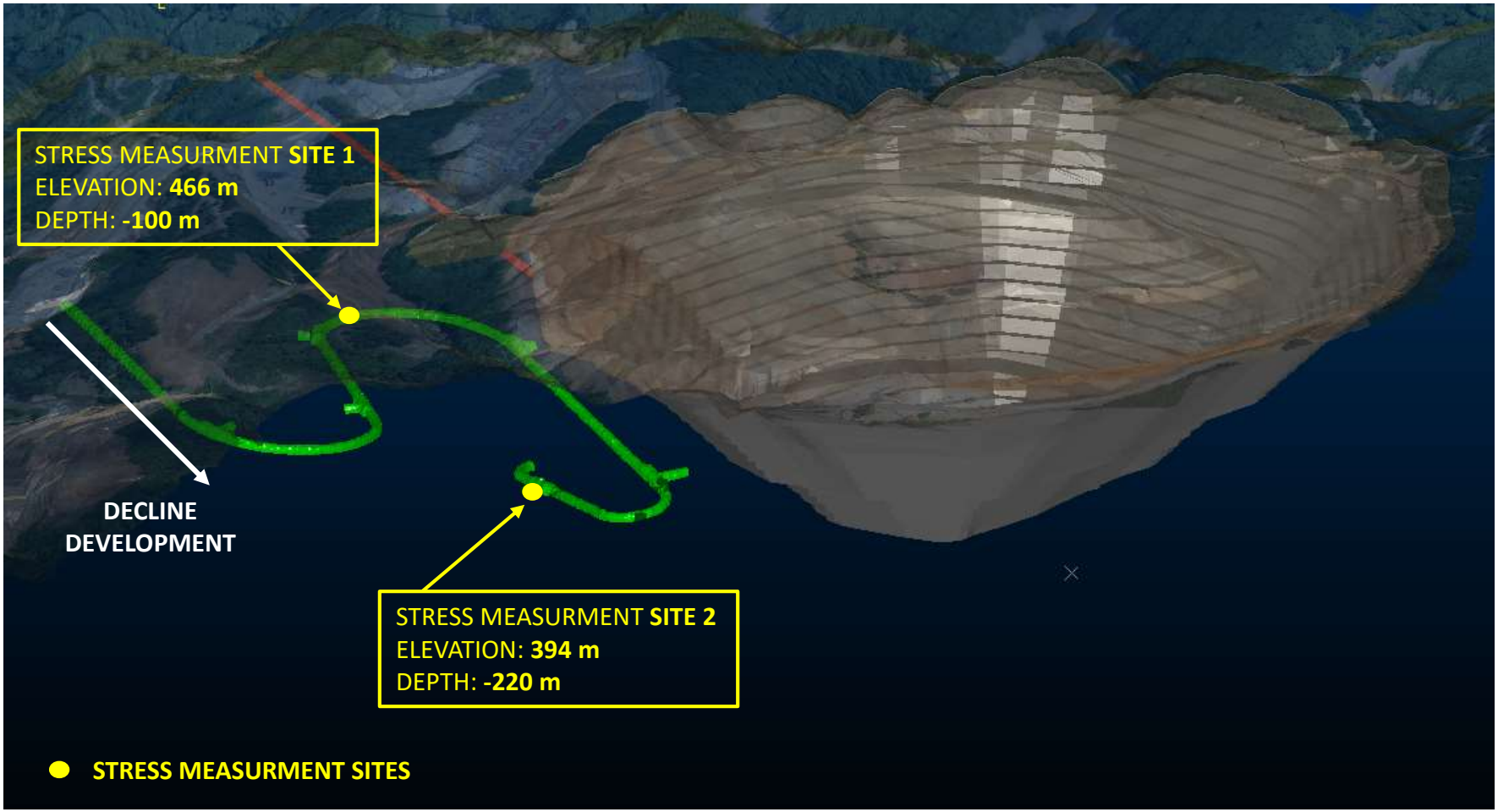
- Stress tests conducted at Skouries site –in the decline- in order to find out **vertical** and **horizontal in situ stresses**

- Tests undertaken by **Golder Associates (UK) Ltd (Golder)**

- Time period: 12/2016 & 01/2017
- 2 stress measurement sites → 8 measurements

- SM site 1: 3 measurements
- SM site 2: 5 measurements

# Introduction



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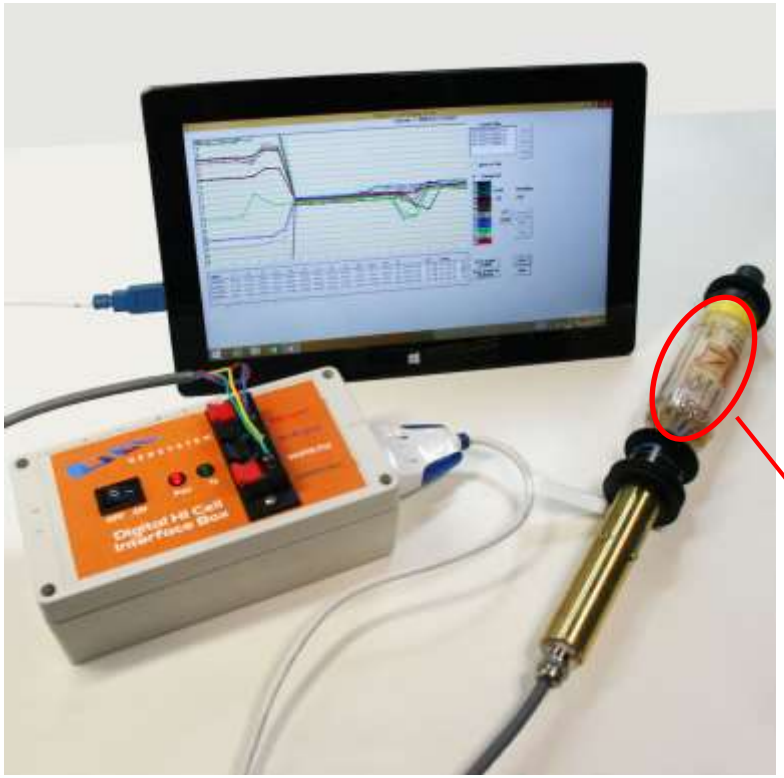
# Methodology

- Instrument used: **CSIRO Hollow Inclusion Digital Stress Cell** (CSIRO HI Stress Cell)

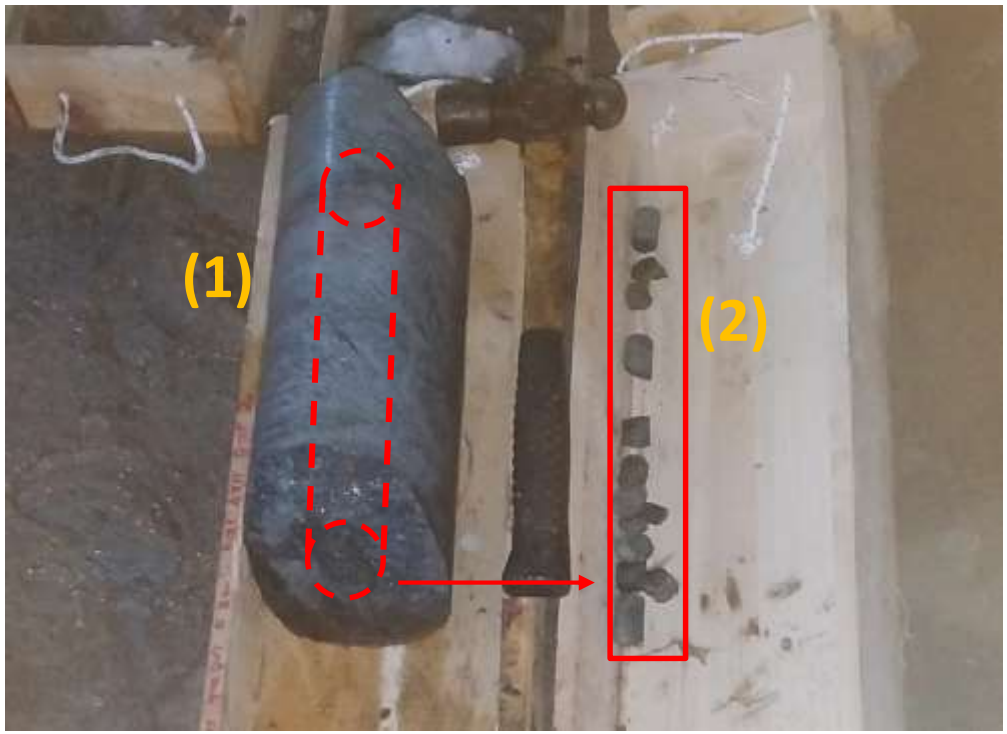



- The instrument consists of **12 gauges** for measuring the in situ stresses

Measuring area.
Gauges are observed

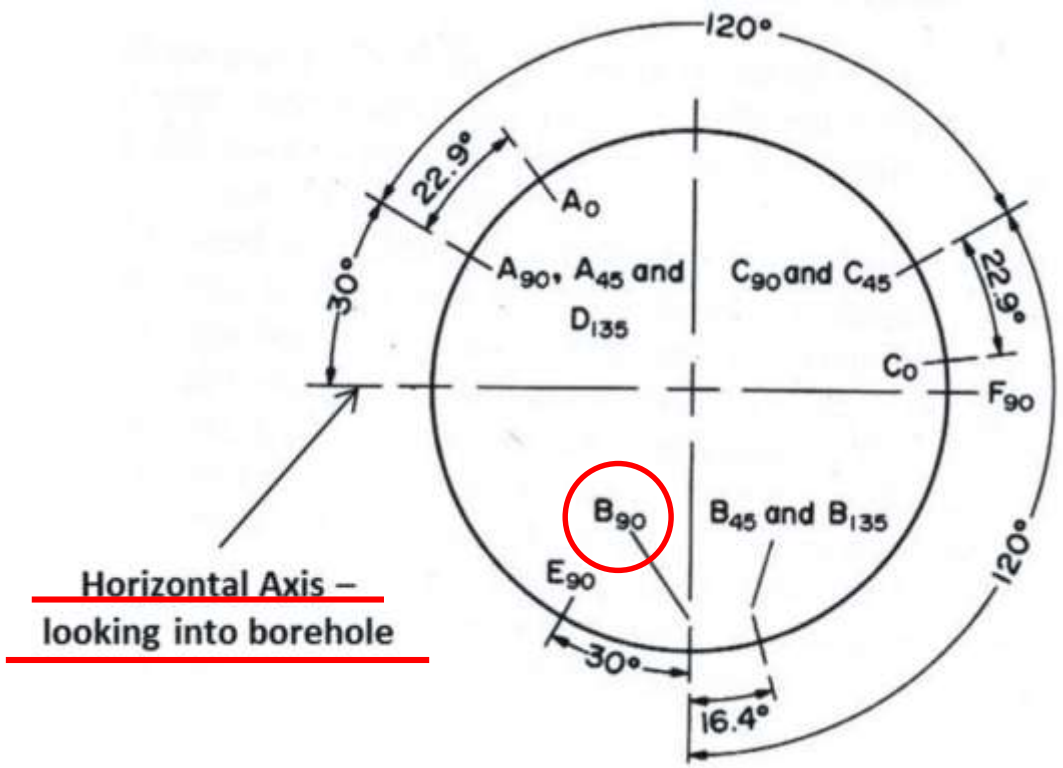
# Methodology

- **First phase:** 152 mm access hole [approximately 12-15 m] (1)
- **Second phase:** 38 mm pilot hole [approximately 0.30-0.40 m] (2)
- **Third phase:** Instrument installation



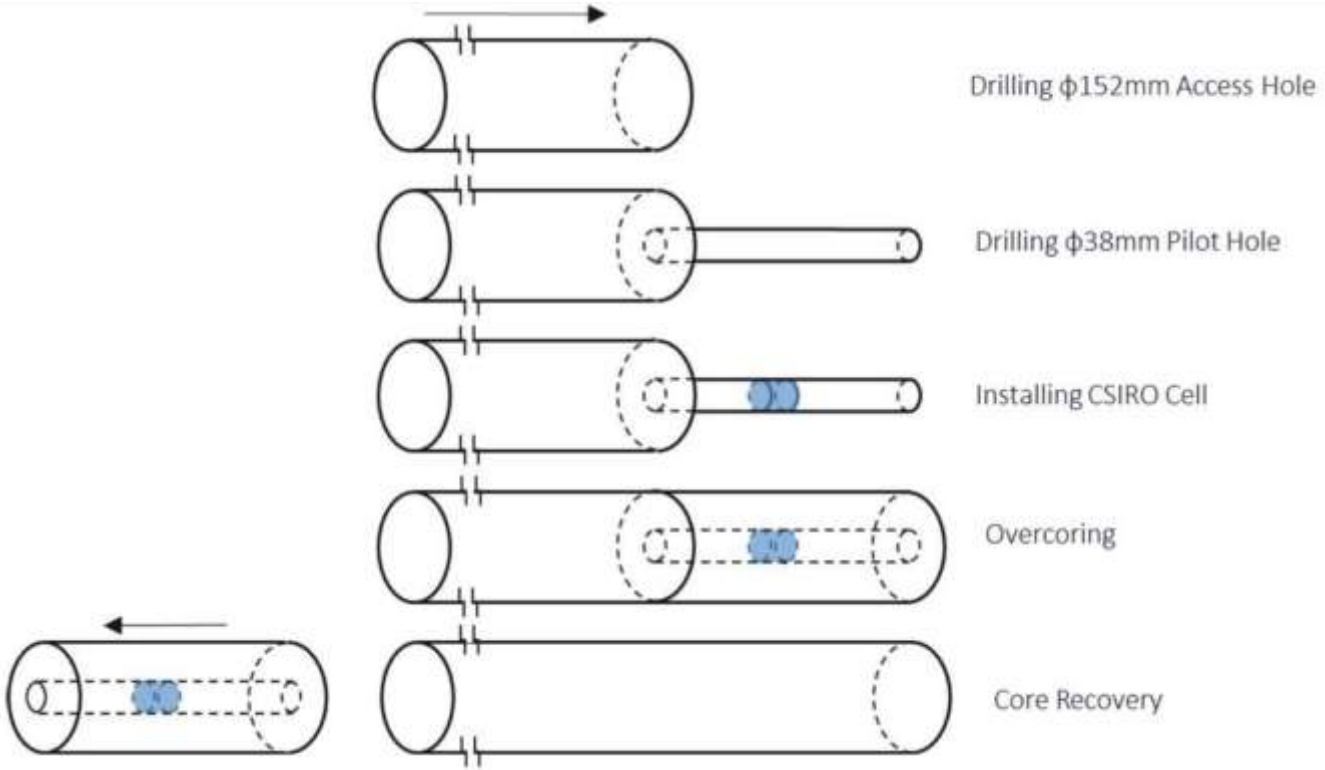
# Methodology

- **Orientation of the instrument** with the B90 gauge at the bottom of the borehole.



# Methodology

- **Over coring** and **strain response** of the cell monitored as the stress on the core is relieved



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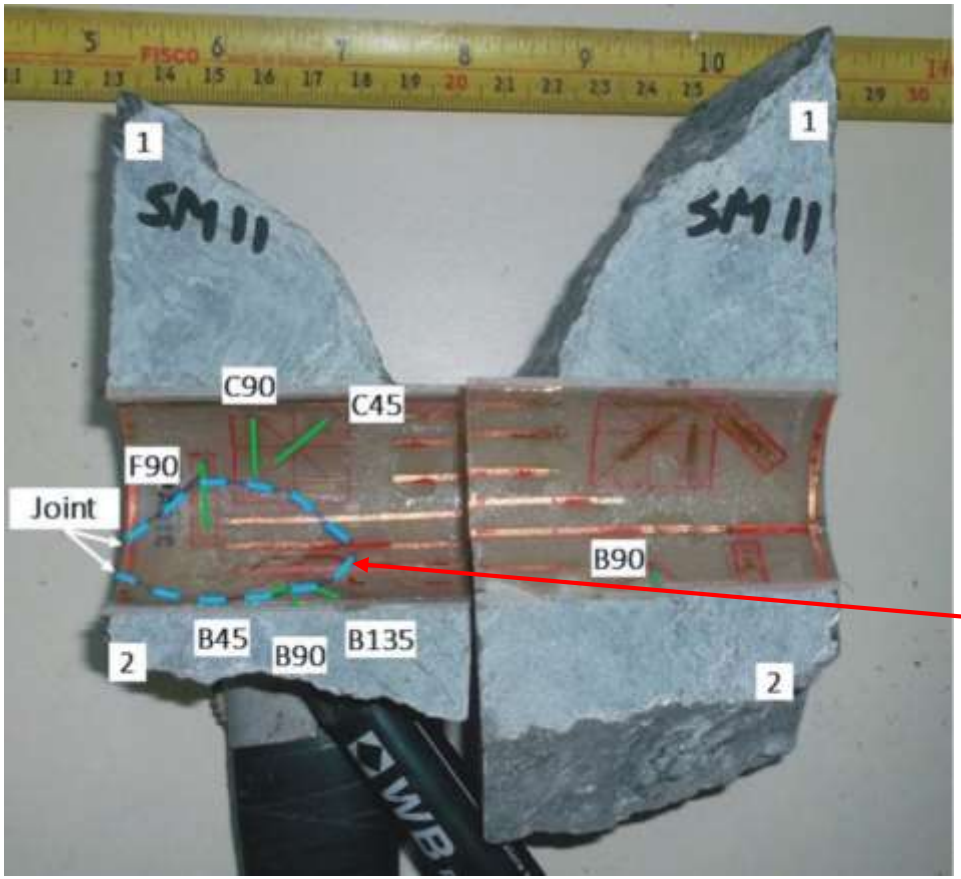
# Data collection

- The over core is placed in a **biaxial pressure cell** to verify the **strain response** for a known stress change
- **Elastically behavior of rock** is considered

# Data collection

- The cores are sectioned using a diamond saw.




Inspected for:

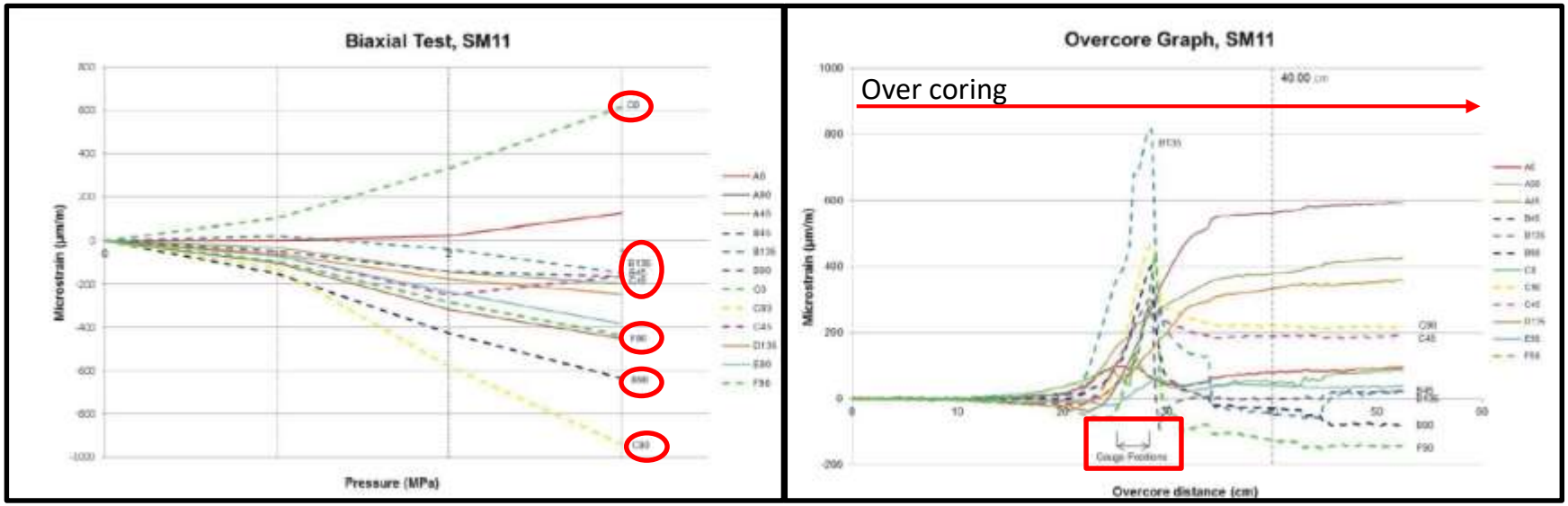
- Well bonding of cell
- Air bubbles
- Joints and cracks
- Intrusions
- Borehole breakout

Joint affecting the gauge response

Only **6 gauges are needed** in order to construct the 3 dimension stress model

# Data collection

- Some gauges extracted from the analysis due to unusual behavior: B45, B90, B135, C45, C90, F90.



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# Data analysis

- Elastic properties of the material in terms of the **Young's modulus** and **Poisson's Ratio**
- **Statistical analysis** and measurement of the **confidence level** of the measured strain changes is conducted
- Stress measurement test procedures complies with the **ISRM suggested methods**

  (ISRM Suggested Methods for rock stress estimation – Part 2: overcring methods. Sjoberg J, Christiansson R and Hudson JA, 2003, International Society for Rock Mechanics. Commission on Testing Methods. The Complete ISRM Suggested Methods for Rock Characterization, Testing and Monitoring: 1974-2006, 385 396)
- Strain changes analysis (elastic, isotropic) complies with the **Duncan-Fama and Pender solution technique**

  (Analysis 0f the Hollow-Inclusion Technique for Measuring In-Situ Rock Stress. Duncan-Fama ME and Pender MJ. Int. Journal of Rock Mechanics and Mining Science, 17:136 – 146, 1980)

# Data analysis

| Elastic Modulus (GPa) | 16.63 | Poisson's Ratio | 0.207 |
|---|---|---|---|

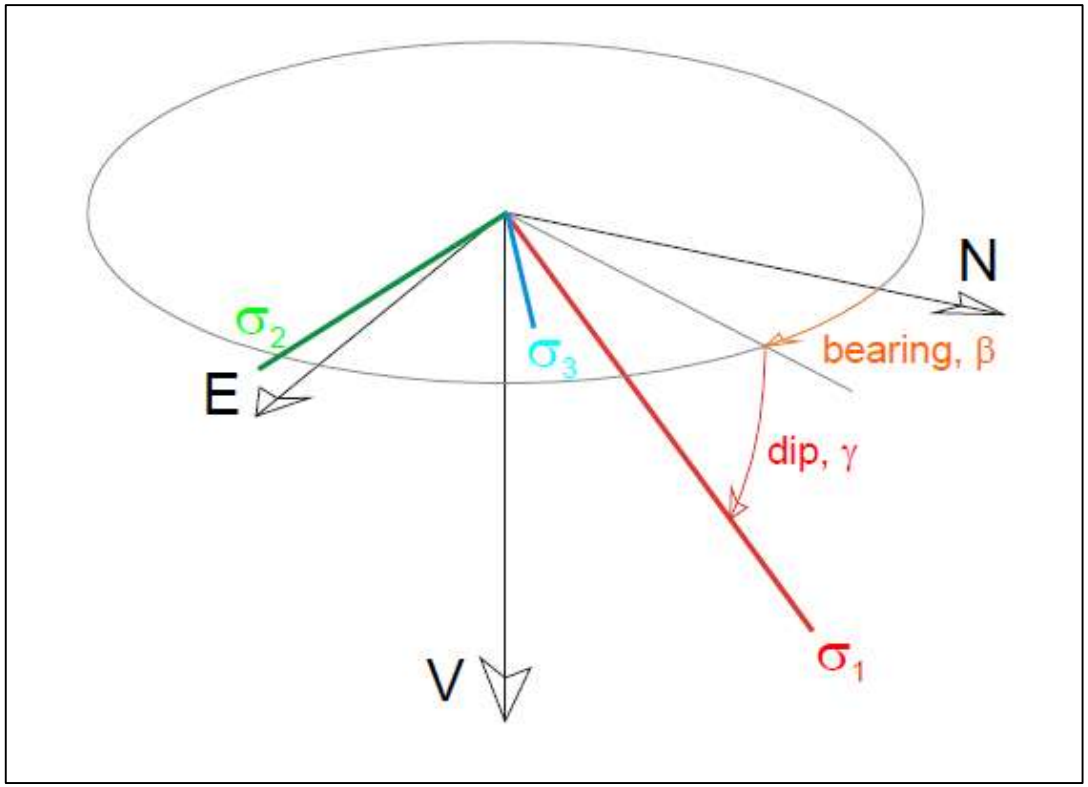
| | Principal Stress Components | | | |
|---|---|---|---|---|
| | | Magnitude (MPa) | Dip(°) | Bearing(°)* |
| σ1 | Major | 17.8 | 50 | 030 |
| σ2 | Intermediate | 3.8 | 12 | 134 |
| σ3 | Minor | 1.0 | 37 | 233 |
| Correlation Coefficient | | | 0.996 | |

* *Bearings in relation to True North*

| Cartesian Stress Components | | |
|---|---|---|
| Normal Stresses | Magnitude (MPa) | Std Error |
| N-S | 7.47 | 1.42 |
| E-W | 4.08 | 0.66 |
| Vertical | 11.12 | 0.91 |
| **Shear Stresses** | **Magnitude (MPa)** | **Std Error** |
| N-S / E-W | 1.57 | 0.50 |
| E-W / Vertical | 4.53 | 0.38 |
| Vertical / N-S | 6.79 | 0.77 |

# Data analysis

- **Normal Stresses=f(σ1, σ2, σ3)**
- **Shear Stresses=f(Normal Stresses)**



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# Conclusions

- **Discontinuities affects the response of the strain gauges** within the cell and subsequently the accuracy and reliability of the tests are -in some cases- limited.
- It is of major important the **proper selection of the drilling area** (Great rock strength and few discontinuities).
- **Many gauges could be extracted from the analysis** which decreases the reliability of the tests.
- In some tests there is a **necessity of using rock properties of a different test**. This fact cast some doubts on the stress results.
- In some cases the **vertical component could be greater or lower** than that which could be expected it due to the weight of the overburden.


THANK YOU FOR YOUR ATTENTION
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