SLOPESTABILITY
2018

The Spanish **Mining Council** is organising the 2018 International Symposium in Slope Stability in Open Pit Mining and Civil Engineering at the XIV International Congress for Energy and Resource Mining in Seville.

# Core Orientation: Comparison of televiewer and traditional methods to highlight inaccuracies in old data

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# Introduction

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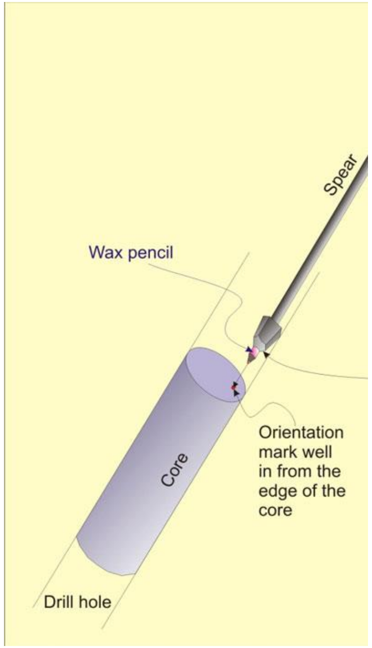
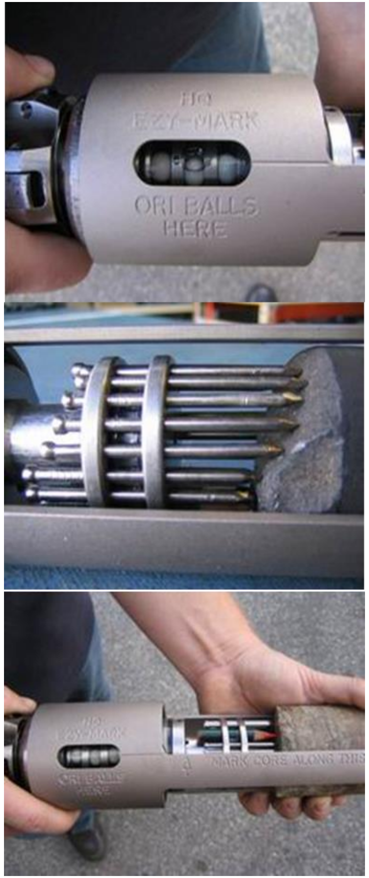
- All mining excavations should have an appropriate geotechnical design that takes into account the rock mass structure
- Acoustic Televiewers (ATV) and Optical Televiewers (OTV) provide rapid and accurate high resolution orientated images of the borehole walls in both cored and open holes
- Traditional manual core orientation tools and televiewers have been used on projects and provide the opportunity to compare the output for both methods and assess the consistency, reliability, and accuracy of the different systems
- The projects demonstrate the much improved accuracy of the televiewer systems and, importantly, identifies cases where the data from traditional methods, originally considered to be good, have serious systematic errors leading to inappropriate design

# Traditional (Manual) Core Orientation Tools

- Systems have been available for many years
- Recover core to determine the orientation of structures
- Measure the alpha ("α") and beta ("β")
- Use reference line to calculate dip and azimuth
- Triple tube core drilling improved marking of core



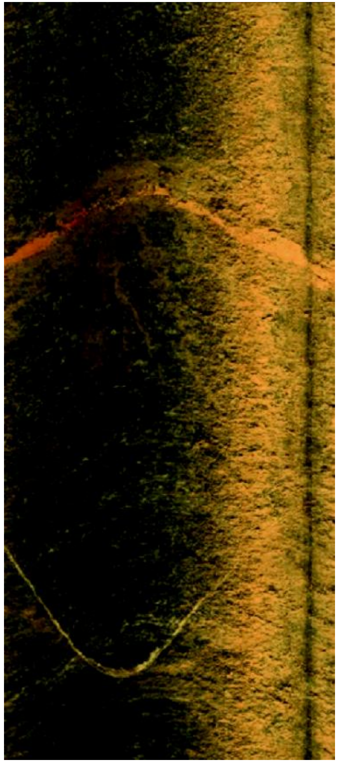


Left : Spear Tool.
Middle: Core Frame.
Right: Ezy Mark Tool.
Far Right: ACE core Tool

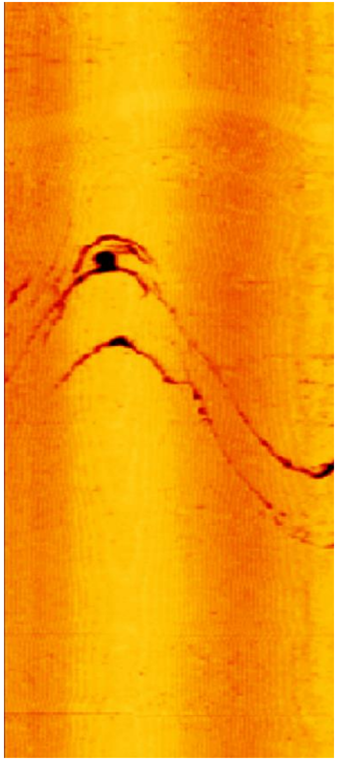
# Optical and Acoustic Televiewer Tools

- Televiewer systems utilize optical or acoustic waveforms within a probe to produce a photographic-like image of borehole
- Presented in 2D - borehole wall is rolled out
- Computer software packages such as WellCAD used to fit traces to the structures to calculate dip and azimuth
- Probe is deployed after the drillhole is complete
- OTV can be used in dry or clean holes
- ATV used in fluid and can penetrate PVC casing if in poor ground

OTV Image



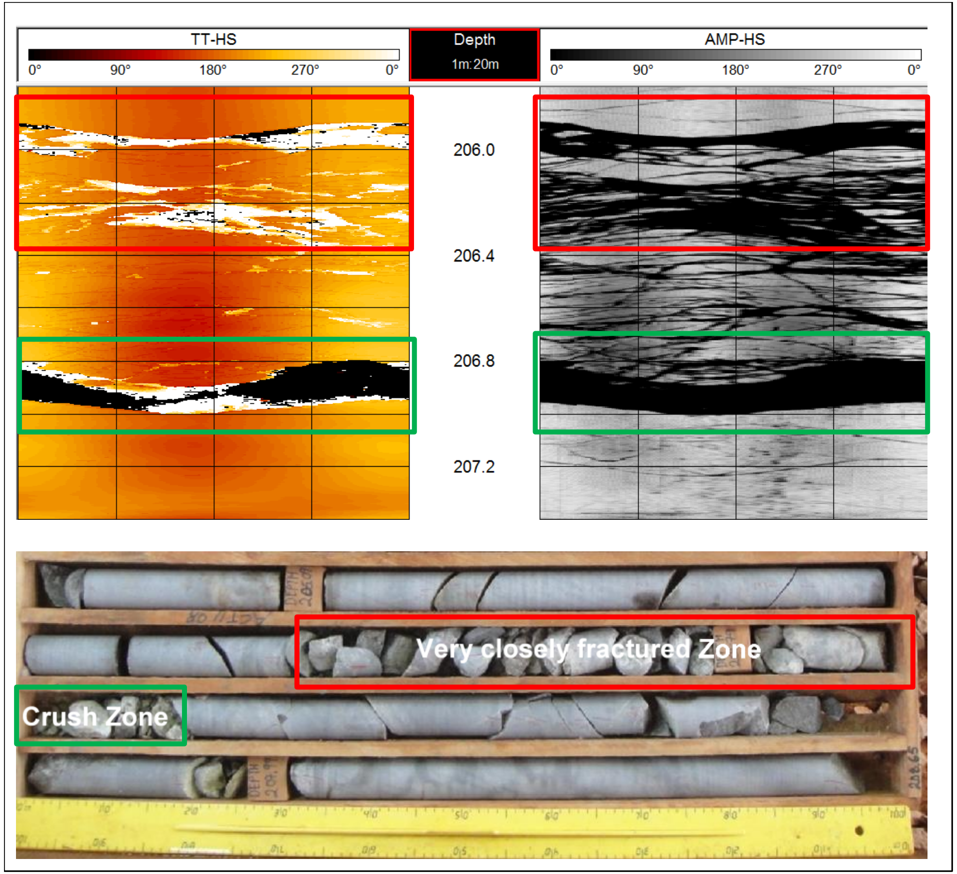
ATV Image



Note: Not the same structure

# Case Study 1: Improved data confidence - steeper slope design

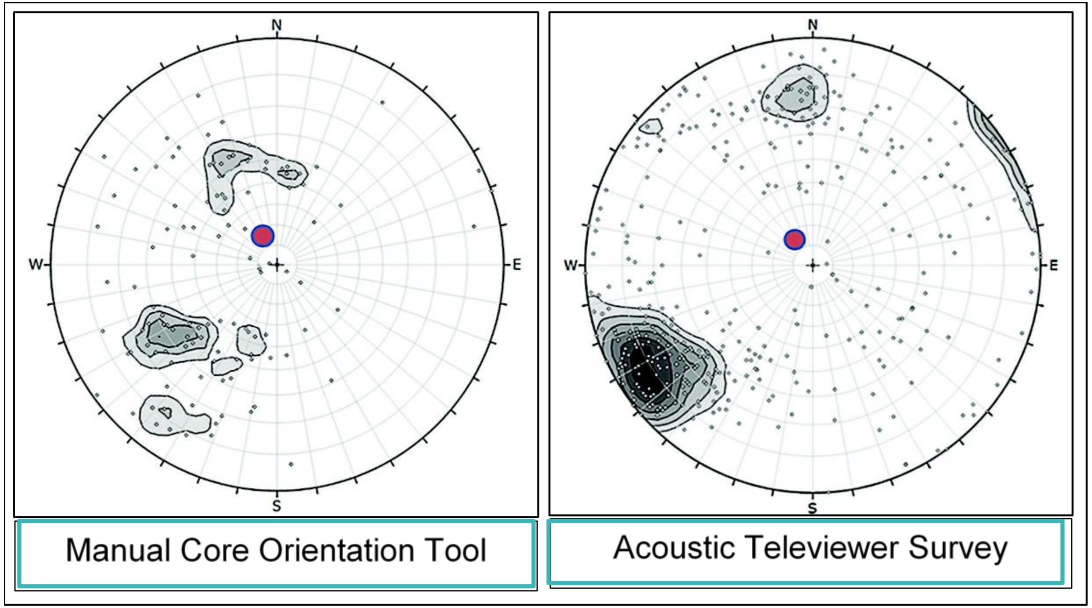
- Iron Ore Open Pit PFS
  - Slope heights in excess of 600m
- Slope design governed by structure
  - Good Rock Mass Rating ($RMR^{89}$)
  - Strong rock
- Footwall contained an adversely orientated through-going fault and closely jointed zones
- Geotechnical logging identified the heavily jointed and crushed rock
- Televiewer captured the exact depth, thickness, and orientation of the fault zones
  - Increased confidence in understanding the engineering characteristics of the fault



# Case Study 1: Improved data confidence - steeper slope design

- Small scale structure used for kinematic assessment
- Stereonets show different joint sets
- Manual tool – results indicate shallower benches and wider berms required
- ATV – more data, smaller contour, high quality data.
- Steepen inter-ramp angle
- Lower waste strip ratios, increase in reserve and reduced operating costs

- Low amount of confidently orientated core runs
- Significantly fewer data measurements – 25% of ATV data set
- Difference of 20° in dip and 10° to 30° in azimuth



# Case Study 2: Errors avoided by use of ATV



- Iron Ore Open Pit FS
  - Slope heights in excess of 550m
- Slope design governed by structure
  - Fair Rock Mass Rating (RMR$^{89}$)
  - Strong rock
- Systematic errors leading to poor quality and low confidence PFS data set
- Unusable for the FS rock mass characterisation


- Initial orientation marking inaccuracy
- Badly drawn orientation line
- Equipment deficiencies

# Case Study 2: Errors avoided by use of ATV

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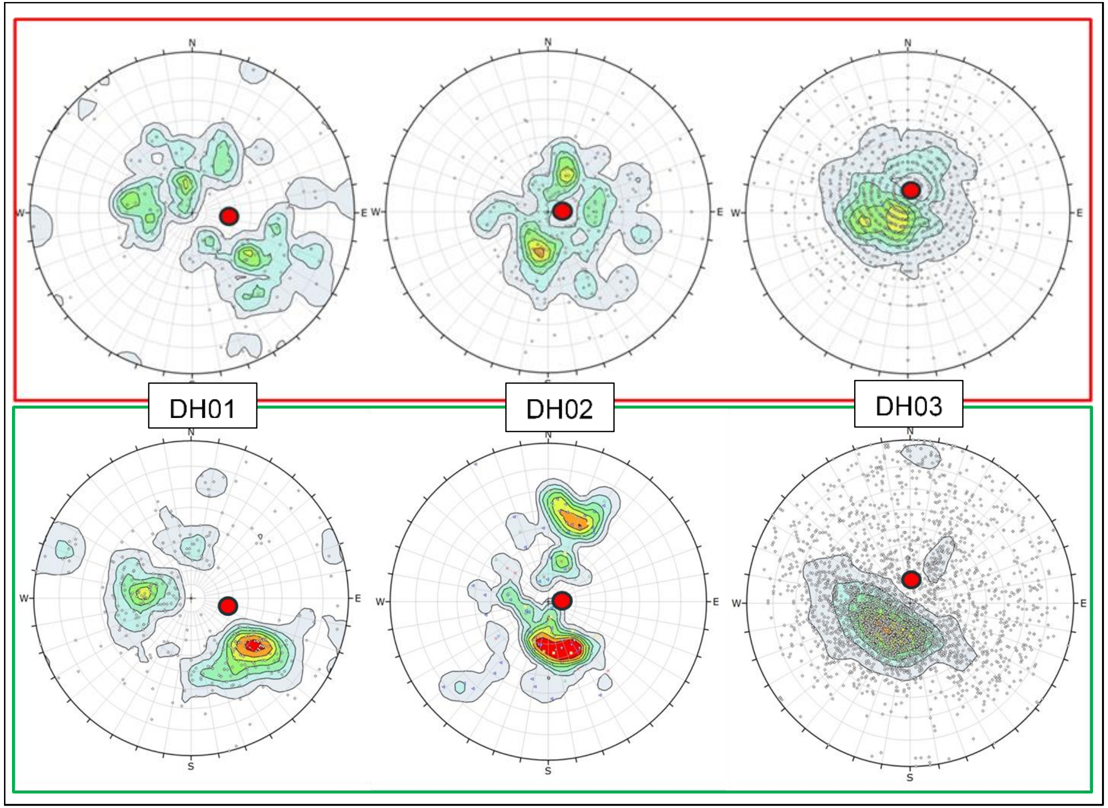
- Systematic errors identified in PFS data
  - "Small circle data distribution"
  - "Cluster contouring"
  - "Concentric rings"
  - "Bull's eyeing"
- Unsatisfactory core orientation
- Overall Slope Angles were increased from 48° at PFS level to 55° at FS level
- Hugely improved economics for the project




Top: Manual Core Orientation Bottom: ATV Data

# Case Study 3: Misinterpreted fractures using manual tools

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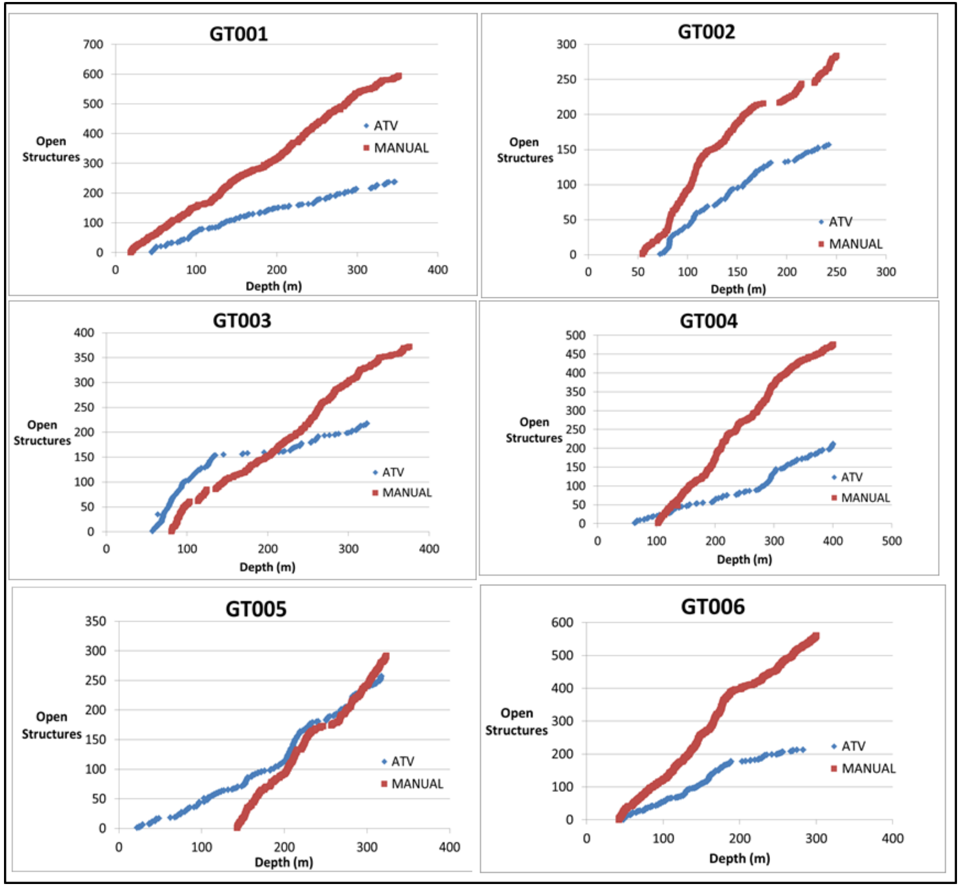
- Manganese Open Pit PFS
  - Slope heights in excess of 400m
- Slope design governed by structure
  - Fair Rock Mass Rating ($RMR^{89}$)
  - Strong rock
- Many drilling breaks and cemented or healed joints opened
- “Open structures” are major input to RMR
- Errors in the primary geotechnical logging data



# Case Study 4: Project cost considerations

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- Underground Gold Mine PFS in Europe
- Stope design governed by structure
  - Fair Rock Mass Rating ($RMR^{90}$)
  - Moderate rock mass strength
- Current perception is that downhole ATV is expensive
- Similar costs between ATV and manual except in poor ground

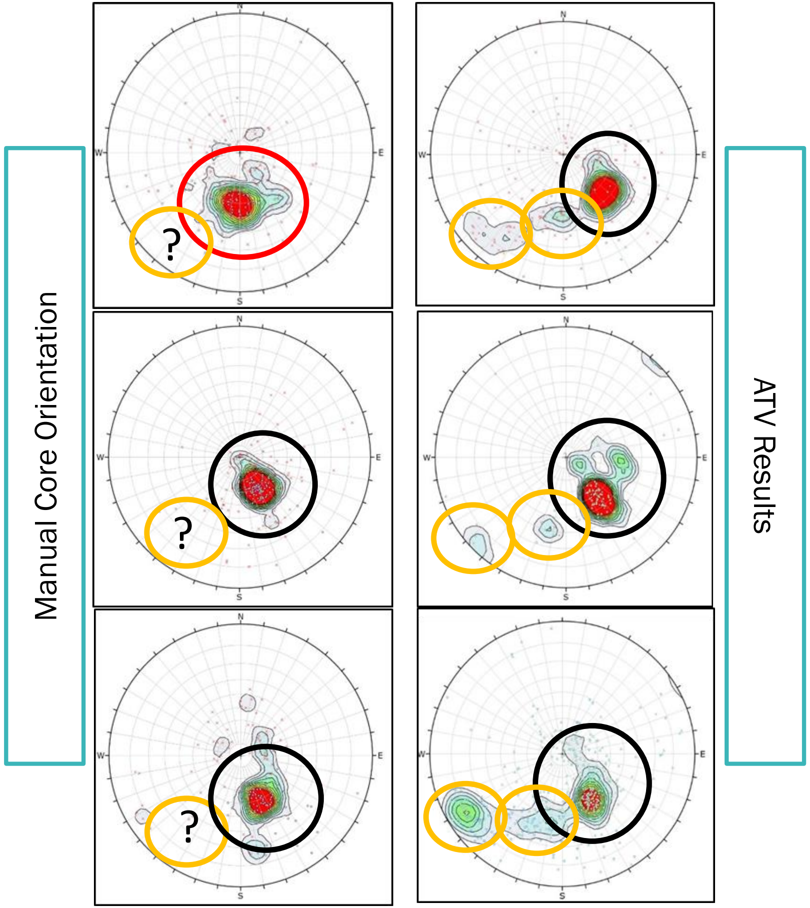
| Item | Number |
| --- | --- |
| Drillholes | 4 |
| Total drilling meterage (m) | 1500 |
| Average metres drilled per day (m) | 25 |
| Hours drilled per day (hour) | 12 |
| Total drilling days (day) | 60 |
| Total drilling hours (hour) | 720 |

| Item – ATV logging at end of drilling | Cost (€) |
| --- | --- |
| Mobilisation | 12,000 |
| Televiewer Logging | 15,500 |
| Total Cost | 27,500 |

| Item - Supervision for duration of drilling | Cost (€) |
| --- | --- |
| Geotechnician supervision of rig | 25,200 |
| Manual core orientation tool hire | 4,500 |
| Total Cost | 29,700 |

# Case Study 4: Project cost considerations (data review)

- Strong signature for the foliation in both data sets (black circles)
- Two major joint sets missing from the manual data (yellow circles).
  - Specifically a moderately dipping set to the North
- Several fault orientations missed in manual due to poor ground
- More structures were logged from the ATV
- The orientation of the foliation in SRK02 appears to have swung around 45° to dip to the north for manual (red circles)
- More consistency in the ATV results between the boreholes



# Benefits of using OTV/ATV

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- Permanent auditable record of orientation measurements
- Improved accuracy in the structural data set gives greater confidence in slope design;
- Can work in all rock masses, although heavily fractured rock masses may need to be lined with PVC and ATV used;
- Total hole coverage maximising data from drillholes; no data loss in closely jointed sections where orientation tools struggle;
- Minimal cost in relation to drill programme, expect 5% to 10% of total drill cost;
- Increase in confidence of orientation, location, width and major structure frequency;
- Better optimisation of pit slope, stope design and rock support;
- Can be done post-drilling and on old stable holes;
- Costs are similar especially when geotechnician and drilling standing times are considered.

# Conclusion

- The benefits of using televiewers can manifest themselves in greater optimisation of pit slopes and underground excavation design and support, and can lead to financial benefits when designating economically sensitive slopes and confidence when developing slopes near to critical infrastructure.
- The paper concludes that televiewers should be considered as the primary tool for data collection when considering undertaking any rock mass characterisation and that structural data obtained from core orientation should be scrutinised for potential errors before accepting it as accurate and using it in design.

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