IMWA 2010 – “Mine Water and Innovative Thinking”

The importance of geotechnical and structural characterisation in predicting fracture flow to mines

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Introduction

- Accurate inflow predictions allow efficient and safe mining below the natural gwl.
- Multi-disciplinary studies = more data and more (varied) experience.
- How can geotechnical and structural assessment help with inflow predictions particularly wrt EPM modelling approach.

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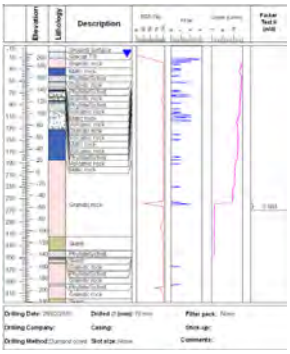
Geotechnical Characterisation



Non-orientated:
- RQD, FF, aperture, other props.
- Most useful in conjunction with local-scale hydraulic testing.
- During field campaign to identify intervals for hyd. testing

Orientated (α, β):
- To evaluate major joint set orientations and resulting anisotropy e.g. K tensor.
- Non- orientated data can be used to filter orientated data...

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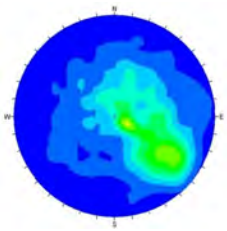
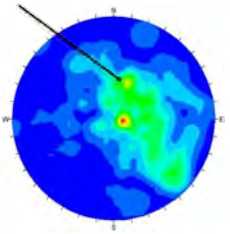
Geotechnical Characterisation

Filtering out gouge filled and small aperture fractures can help to pick out “hidden” but hydrologically significant fracture sets



a) Fisher concentrations contoured stereoplot of orientated fractures logged from acoustic televiewer logging of a diamond drilled borehole



b) As a) but filtered for clean/sand/gravel filled fractures only with an aperture of >5mm

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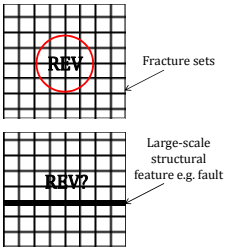
Geotechnical Characterisation

Major Limitations:

1) Scale of investigation. If borehole scale data sufficient to characterise the rock mass at the scale of our model? Is an EPM approach even valid?

2) If not, how do we upscale appropriately?

Assessment of brittle deformation at a regional scale required to supplement local scale geotech. data.



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Structural Characterisation

Data sources:
- Any cored drilling data. Risk of non-unique interpretations. Combine with other data such as:
- Field mapping of outcrops/existing excavations
- Geological survey maps
- Geophysics
- Remote sensing
- Hydrological test results e.g. boundary effects in a pumping test response, spinner tests.

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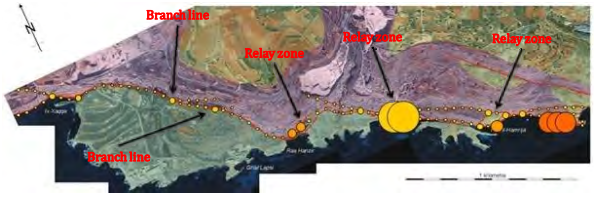
Structural Characterisation

- Faults are not homogeneous along their length.
- Bonson et al. (2004) found more intense fracturing to be associated with fault bends, branch lines and relay zones.



Map of the Maghlaq Fault, a south-dipping normal fault in SW Malta with fracture frequency displayed as scaled circles

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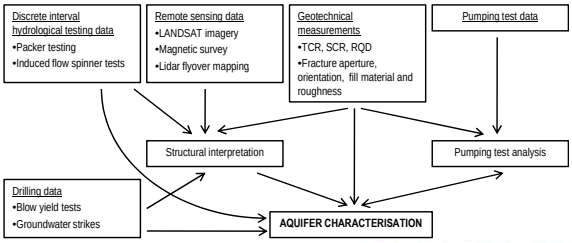
Example Approach

- 2 sites, both in fractured meta-sedimentary rocks dipping at around 50°. Inflow prediction for planned open-pit mine.
- Initial desk study identified several regional-scale structures at both sites→ targeted drill and testwork campaign:



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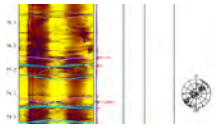
Example Approach

Geotechnical data:
- Orientated diamond drilling
- Manual logging: RQD, FF, α, β, infill, roughness.
- Acoustic televiewer: α, β, aperture, infill.

Compare

Hydrological testing:
- Bulk hyd. props and anisotropy investigated with **pumping tests** (multiple observation wells)
- Direct measurements of fractures and fault zones with **packer tests**
- Flow from identified fractures and fault zones, and general flow/depth profile investigated using **spinner tests**



Acoustic televiewer log

Spinner testing

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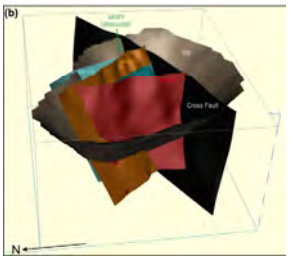
Example Approach

Two scales of structural characterisation:
1) Mapping of structures from resource and geotechnical drilling.



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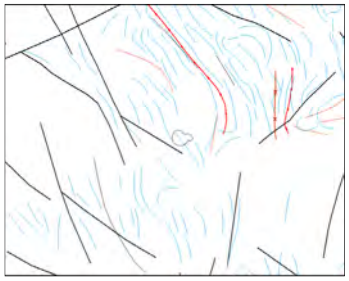
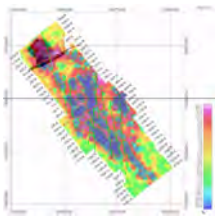
Example Approach

2) Field mapping of structures in conjunction with magnetic survey data and geological survey data.





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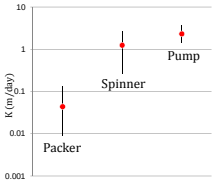
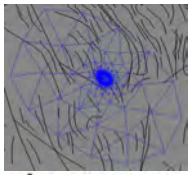
Example Approach

Aquifer Characterisation:
- Clean, steeply dipping faults identified as lineaments of high permeability at both sites.
- K tensor estimated from local and regional scale fracture distribution and associated hyd. testing.
- Analytical and numerical FE models constructed for both sites.
- FE model anisotropic (grid aligned to main K tensor axes).





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Example Approach

Inflow prediction:

- Site 1: structurally controlled anisotropy present but not significant enough to materially affect predicted inflows.
- Site 2: taking into account anisotropy (Kx=Kz>Ky) reduced inflows by ~20% due to a change in the interaction with a CHB (large river) and predominant flow along strike of pit (where cross-section open to flow is lower).
- Whether or not it effected the final inflows, a structural characterisation was critical in both cases in order to validate EPM approach ...

Summary

- Scale dependence of the properties (physical and hydraulic) of fractured media requires that any hydrogeological investigation programme in fractured rock should acquire **data over a range of scales**.
- Data from geotechnical investigations can provide us with local-scale fracture properties, which is most useful when complemented with discrete interval hydrological testing.
- **But** local-scale information must be taken in the context of the wider structural setting such that these measurements can be up-scaled to suit the mine water flow model domain.