Human, Machine and Data:
Innovative Data Analytics for Mineral Explorers

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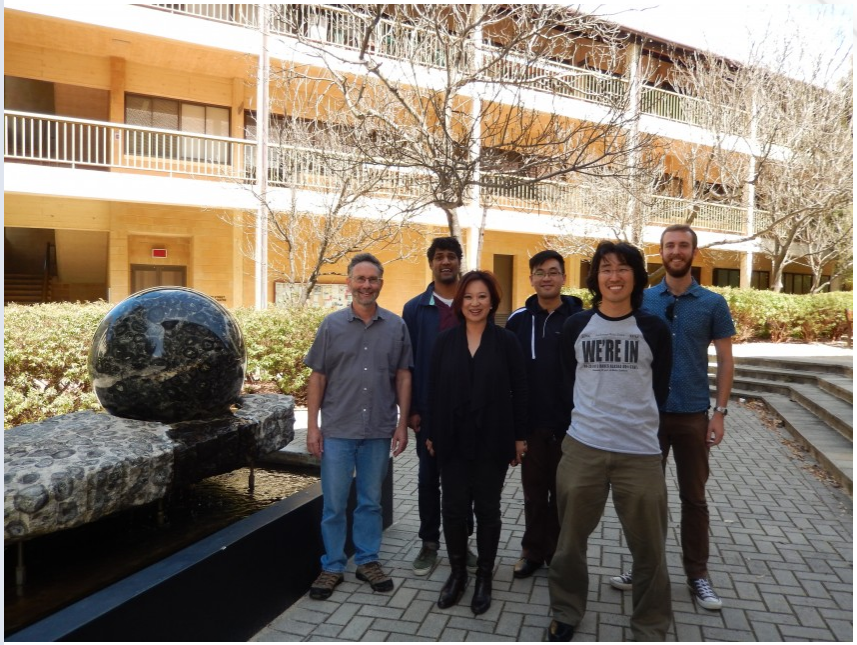
Geodata Algorithms Team

The Centre for Exploration Targeting, School of Earth and Environment

The University of Western Australia



Team members:
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THE UNIVERSITY OF WESTERN AUSTRALIA

Centre for EXPLORATION TARGETING

Mineral Exploration & Data

Frodeman (1995) on Geological Reasoning

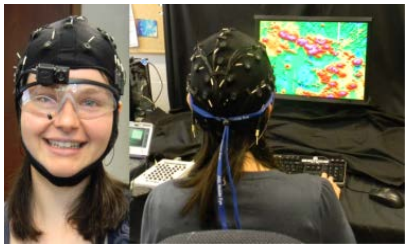
"We are seldom in possession of all the data we would like for making a decision, and it is not always clear that the data we possess are unbiased or objective. We are forced to fill in the gaps in our knowledge with interpretation and reasonable assumptions that we hope will be subsequently confirmed."

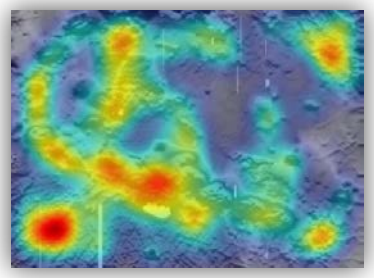
Geological reasoning; geology as an interpretive and historical science.
R. **Frodeman**1995 Geological Society of America Bulletin v. 107, no. 8, p. 960-968.

Human & Data

Interpreters 'filling in the gaps' - highly uncertain outcomes (Bond et al. 2005)

Pattern Recognition/ Target Spotting



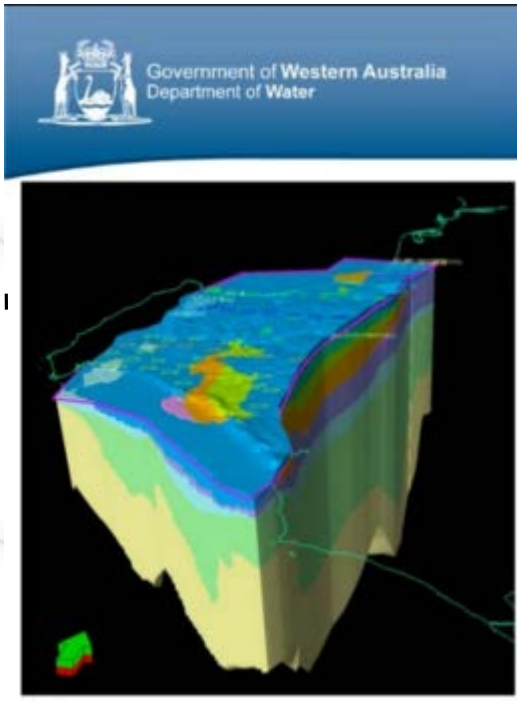


Uncertainty in human-data interactions (Sivarajah et al. 2012, 2014)

- ***High variability*** in visual target search
- ***Visual attention*** for high contrasting features

Inattentional blindness (Drew et al. 2013)

Presuppositions
Expectations
Biases



Highly variable BUT smart decisions can be made based on observation, common sense, experiential learning and INTUITION

Machine & Data

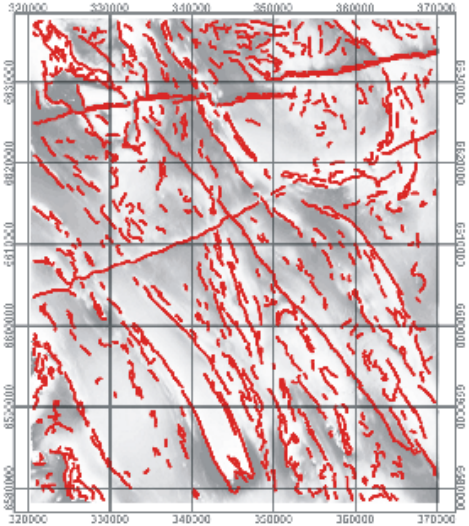
Pros
- Fast
- Objective
- Reproducible results

Cons
- False positives
- Challenging to model geological meaning and feasibility

→ *Lack of confidence in the uptake*

Example: **Structural interpretation of magnetic data**

Structures are associated with discontinuities within data



CET Grid Analysis Extension for Geosoft Oasis Montaj

- Automated first pass analysis can minimise human biases
- Geological interpretation
  - Different types of geological features
  - Chronological order of structures

Challenging to model 'implicit/tacit' knowledge that connects 'the dots'

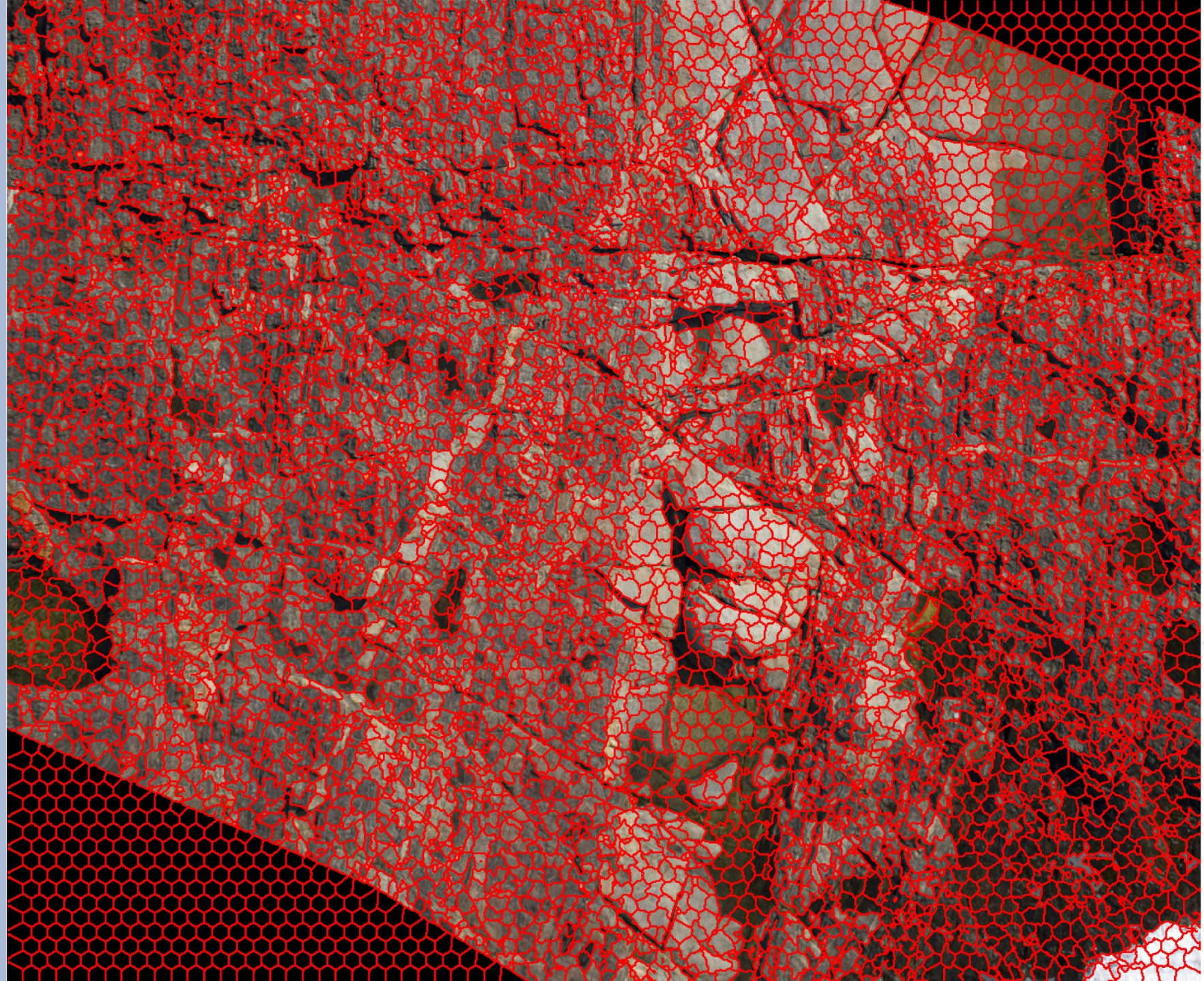
Student:
Vasuki
Yathunanthan

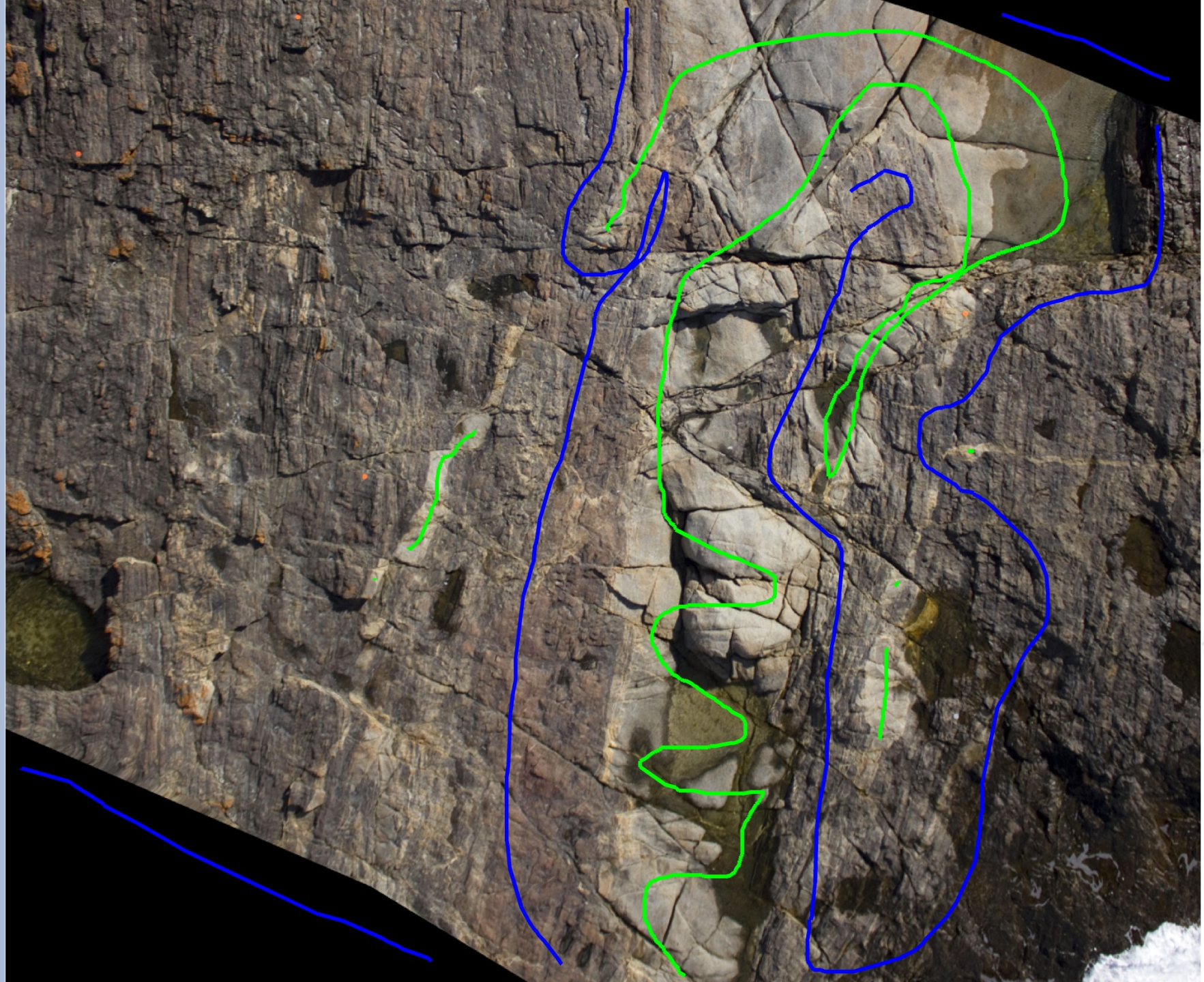
Semi-automated Lithology Mapping

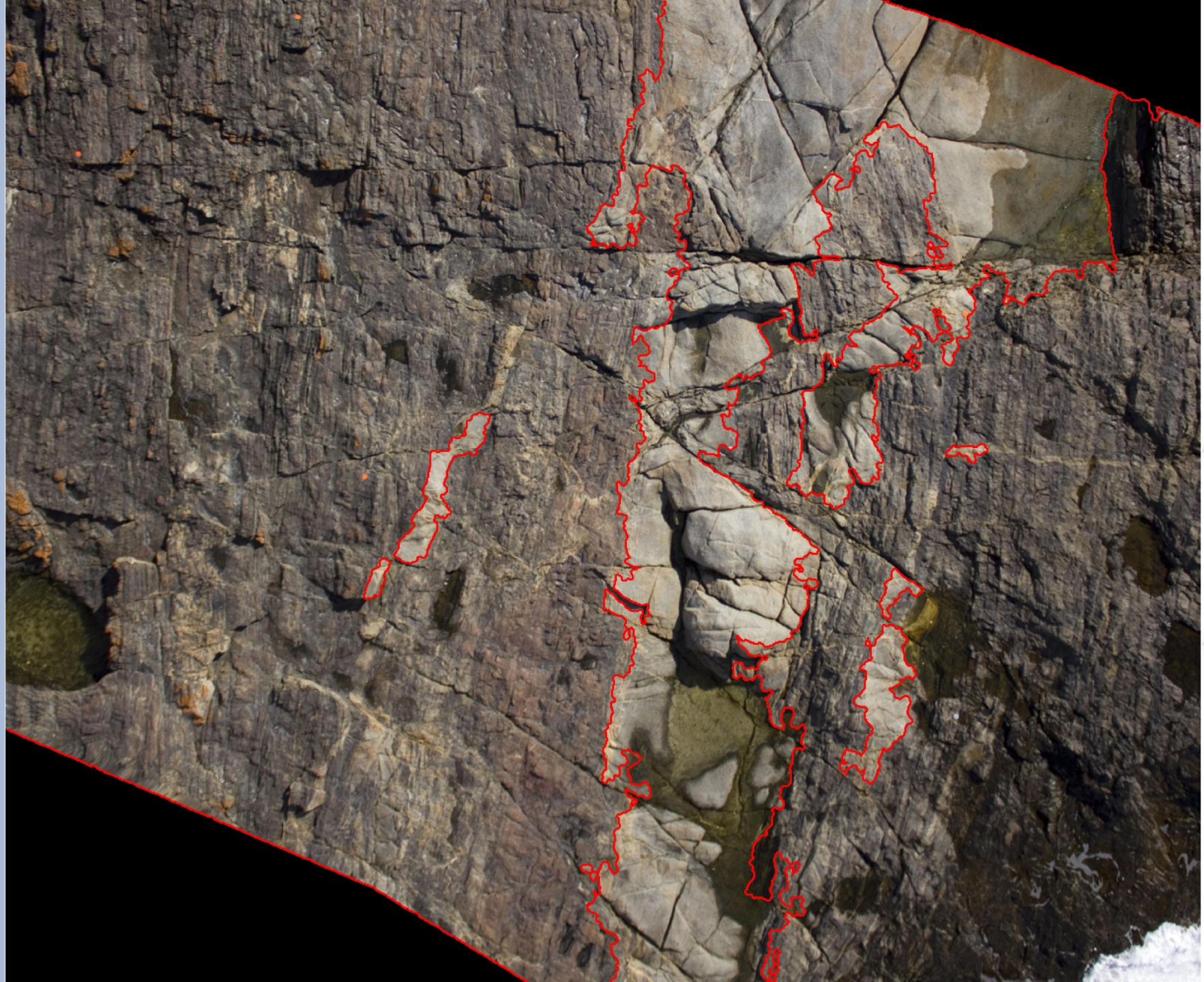
Oktokopter fitted with Canon 550D

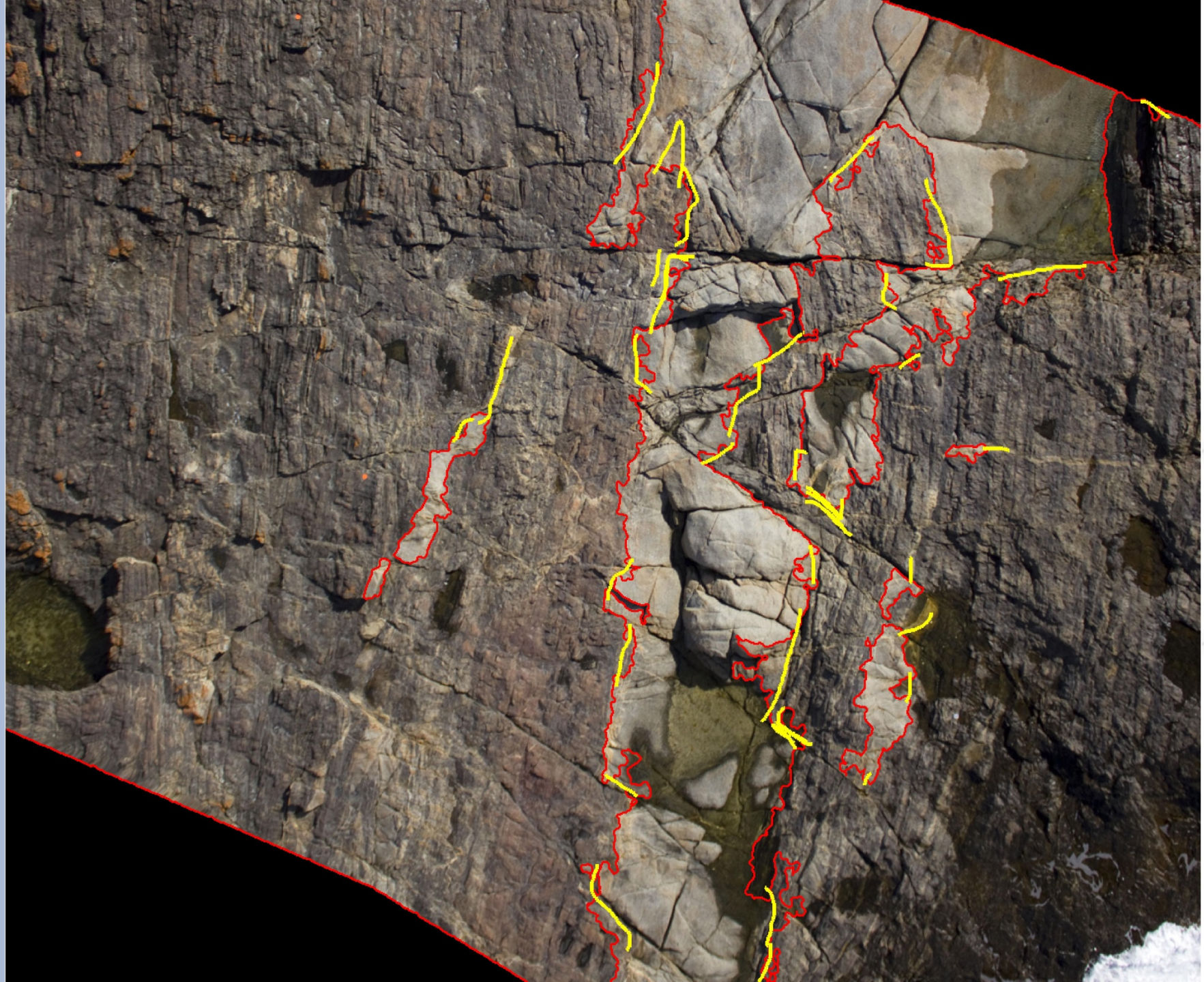
Survey was flown by Darren Turner & Arko Lucieer from University of Tasmania

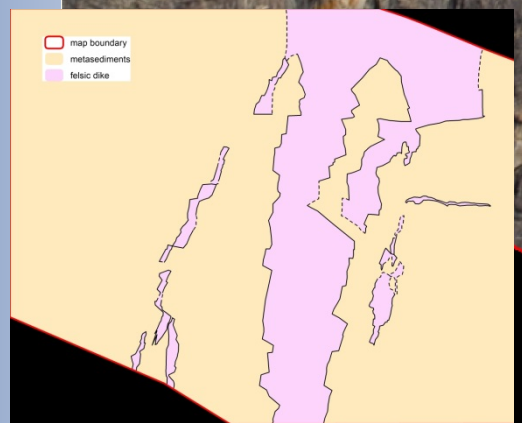
Manual interpretation of Steve Micklethwaite



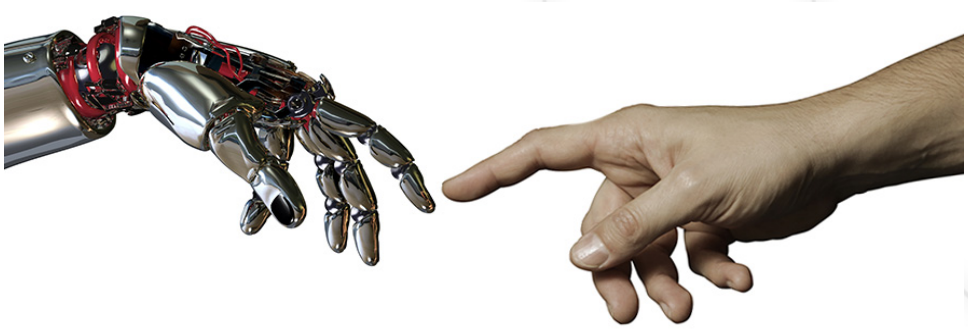







map boundary
metasediments
felsic dike

Our Approach to Geological Knowledge Discovery



http://www.hit-counts.com/future-human-machine-conversation/

- Finding a middle ground for human and machine intelligence
- Build computational algorithms and integrate them in geologists' workflow to improve efficiency and robustness of interpretation

Interpreter driven and computer assisted analysis

Integrated Exploration Platform

Funded by ***Geological Survey of WA*** *(GSWA) (EIS phase 2, 2013-2016);* ***Australian Research Council (ARC) linkage*** *(LP140100267, 2014-2017)*

Innovative data interpretation platform to support robust interpretation

1. *Visualisation tools to support multiple 2D and 3D data (A suite of image blenders)*
2. *Intelligent interpretation support tools to provide* ***interpreter driven & computer assisted*** *analysis*
    - *On-going research in interpretation spell & grammar check based on 'data evidence'*

SOFTWARE LAUNCH: GSWA OPEN DAY 2016 (waexplorationplatform.edu.au)

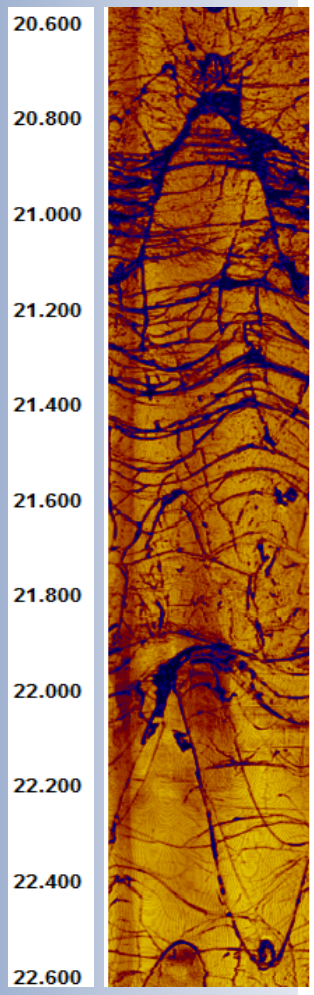
This Talk

- Structure analysis using downhole televiewer images
- Lithology and alteration prediction & validation

Challenge

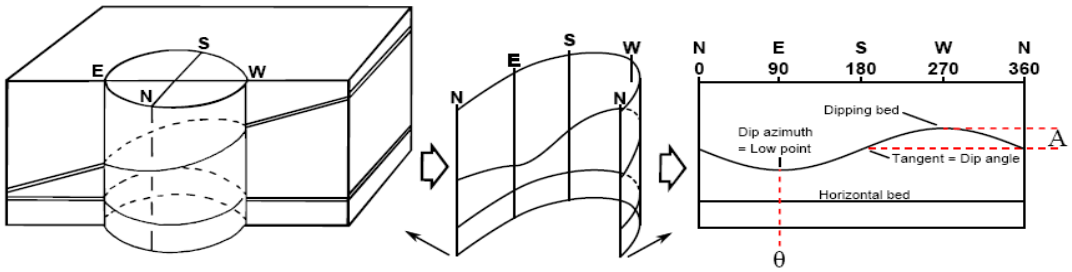
Televiewer Image Analysis

*Funded by **Rio Tinto Iron Ore** (2010-2013)*
*Commercialised by **Advance Logic Technology**,2015*



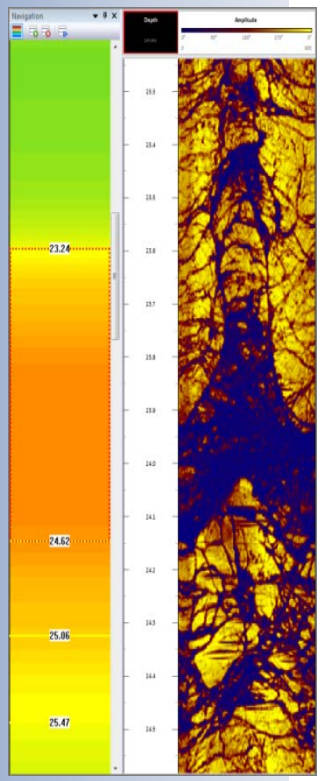
Televiewer images are used for structure analysis for structural geos and geotechnical engineers. Hundreds of kilometres of televiewer data to analyse a year creating a bottleneck in industry workflow.

Develop a software platform to provide automated structure analysis & workflow

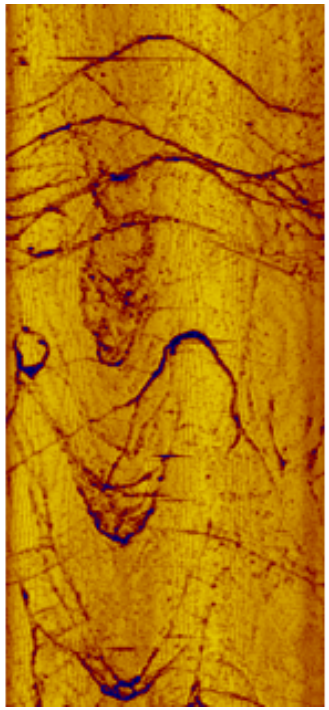


Malcolm Rider, The Geological Interpretation of Well Logs.

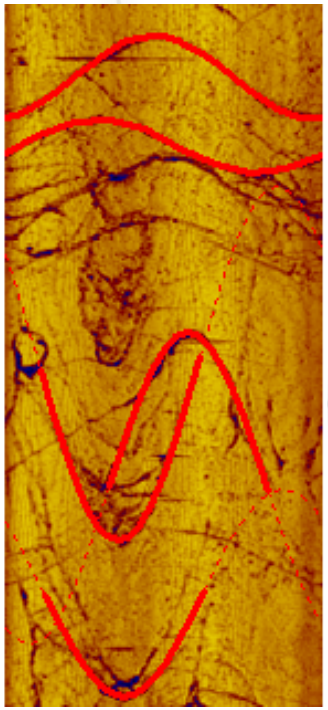
Televiewer Image Analysis



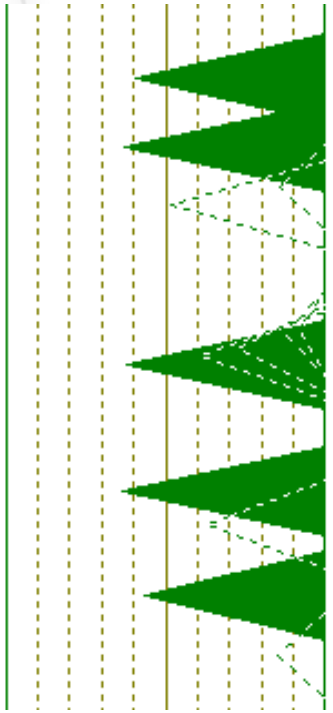
ATV image



Structures



Structure conf



Tadpole plot

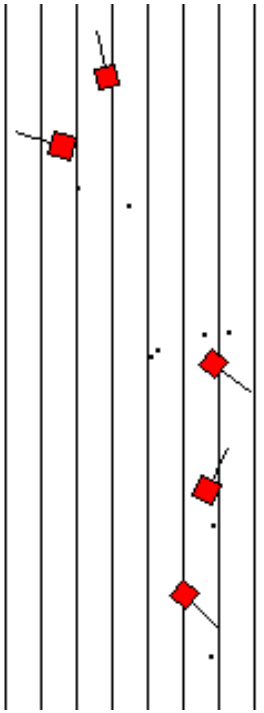
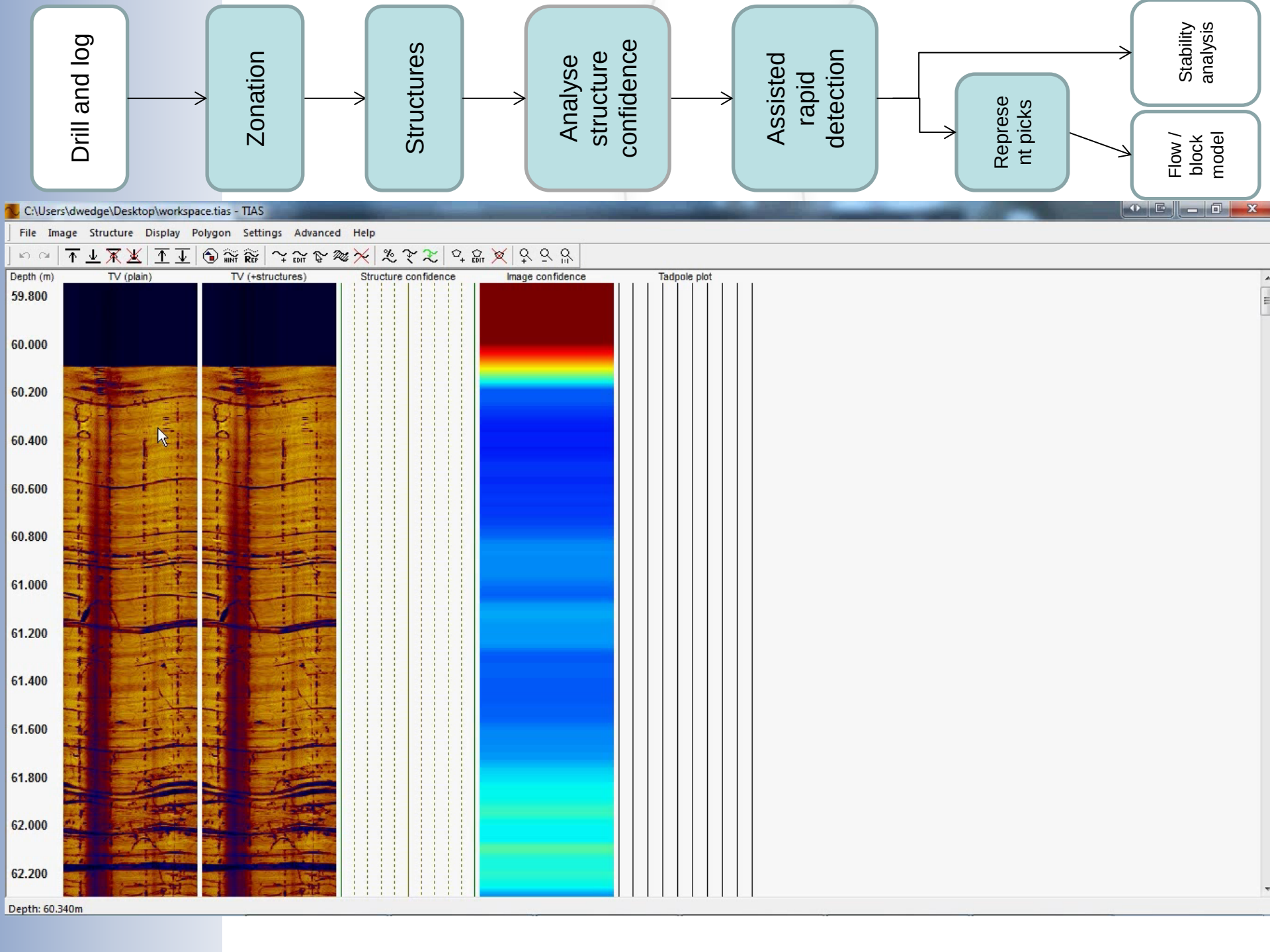


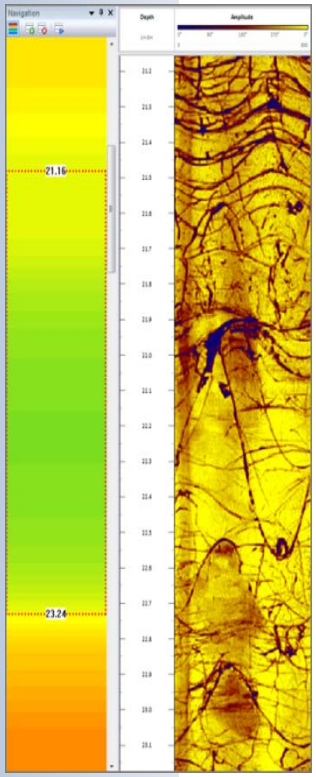
Image complexity zoning algorithms (~RQD, geological domain)

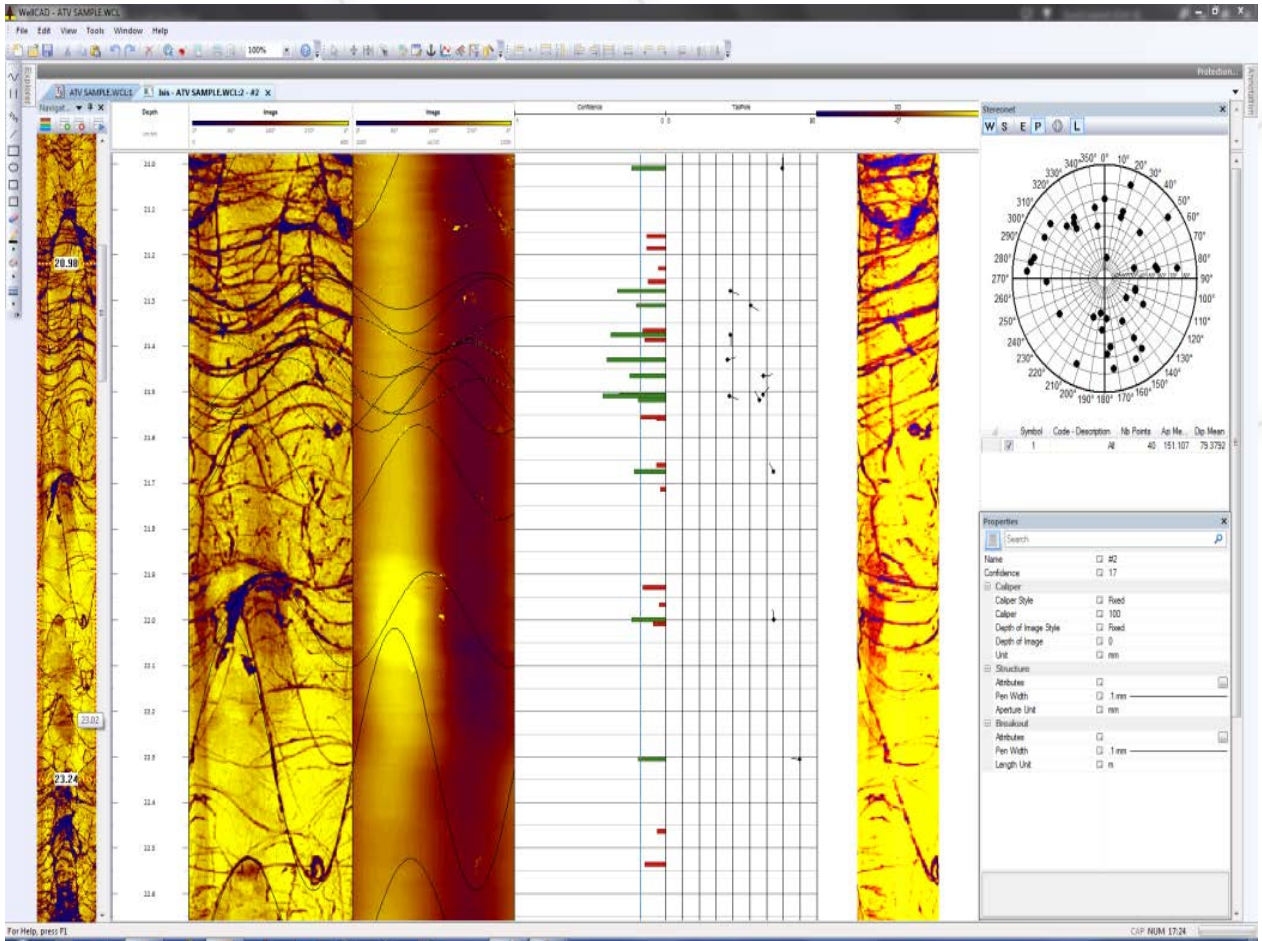
Sinusoid detection and structure orientation estimation algorithms


Drill and log
Zonation
Structures
Analyse structure confidence
Assisted rapid detection
Represe nt picks
Stability analysis
Flow / block model
C:\Users\dwedge\Desktop\workspace.tias - TIAS
File
Image
Structure
Display
Polygon
Settings
Advanced
Help
Depth (m)
TV (plain)
TV (+structures)
Structure confidence
Image confidence
Tadpole plot
59.800
60.000
60.200
60.400
60.600
60.800
61.000
61.200
61.400
61.600
61.800
62.000
62.200
Depth: 60.340m

Televiewer Image Analysis

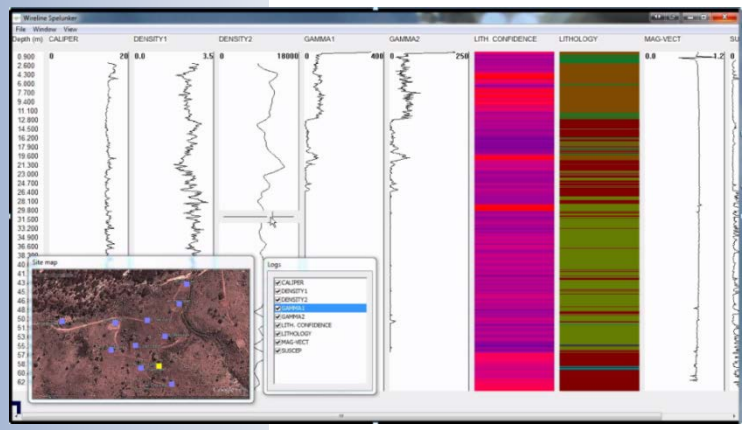
- Integrated into Image & Structure Interpretation Module for WellCAD (v5.1) by Advanced Logic Technology (ALT)

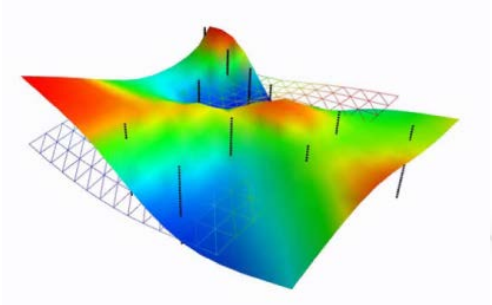




Drill Hole Data Interpretation

- Understanding lithology, alteration, mineralogy
- Pattern recognition seeks buried patterns within big data
  - statistics, machine learning, artificial intelligence, visualisation, information retrieval





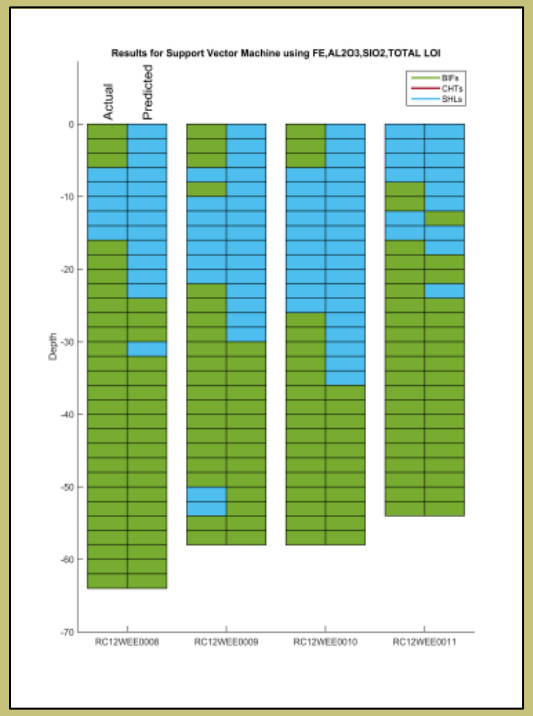
CET team “50 grades of shale” at Hackathon, 2014

- Integrated data analysis (*Rio Tinto Iron Ore, 2014-2017; First Quantum student sponsorship, 2014-2017)*
  - How to apply and build confidence in pattern recognition methods for geo’s workflow
  - How to fully utilise all available data (at varying scales)

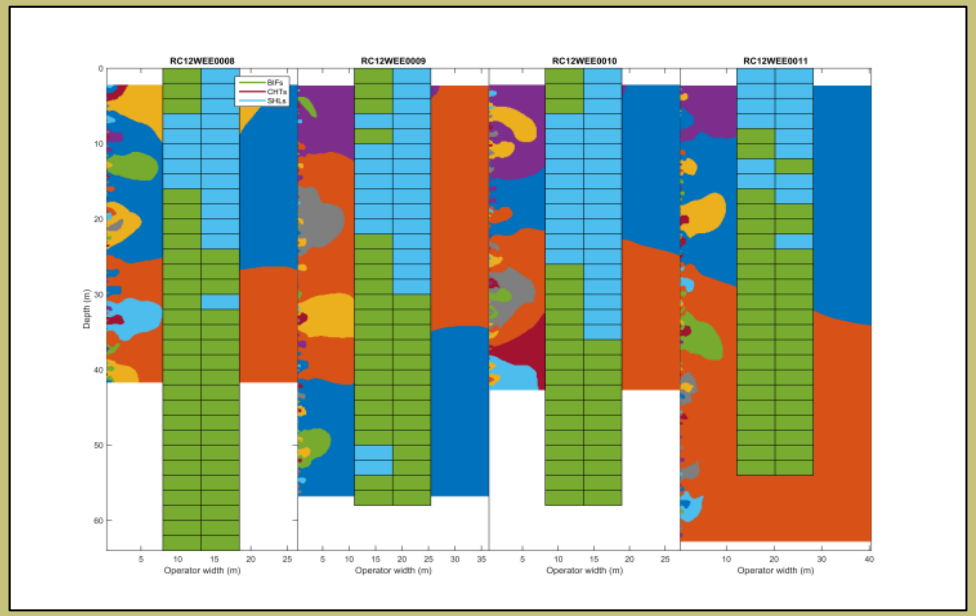
Drill Hole Analysis for Iron Ore Exploration

- Host rock detection - alteration analysis
- Geochem host rock classification - validated using wireline density

Host rock classification Using geochem

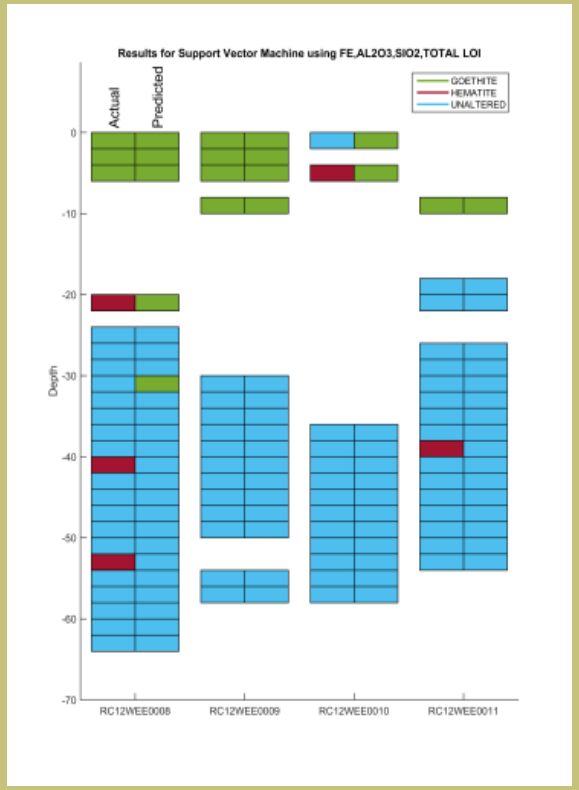


Validation using wireline density – rock boundary analysis

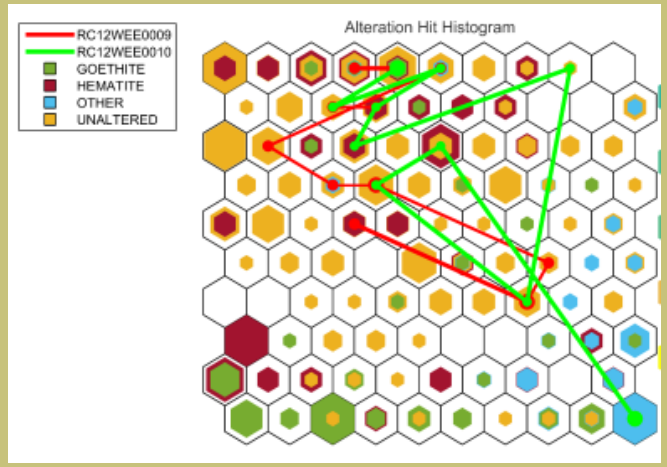


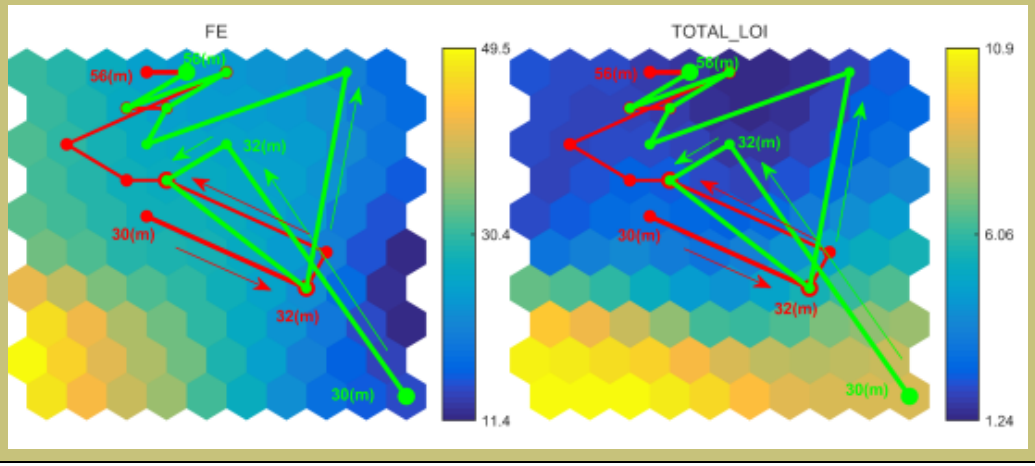
- Alteration type (Hematite; Goethite) classification for a host rock type (BIF)
- ‘Data clustering’ to validate manual and automated logging

Alteration type classification for BIF



Validation of manual & automated logs using data clustering





Summary

- **Interpreter driven and computer assisted workflow to empower interpreters**
- Drill hole data interpretation and integration tools
- **Delivering** new tools and workflows to the resource industry
- **Multi-disciplinary research & training** spanning the boundaries of geoscience and computational science, and the boundaries of academia and industry, resulting in practical outcomes for the resource industry