National Virtual Core Library (NVCL) – Spectral Mineralogy of Queensland Cores

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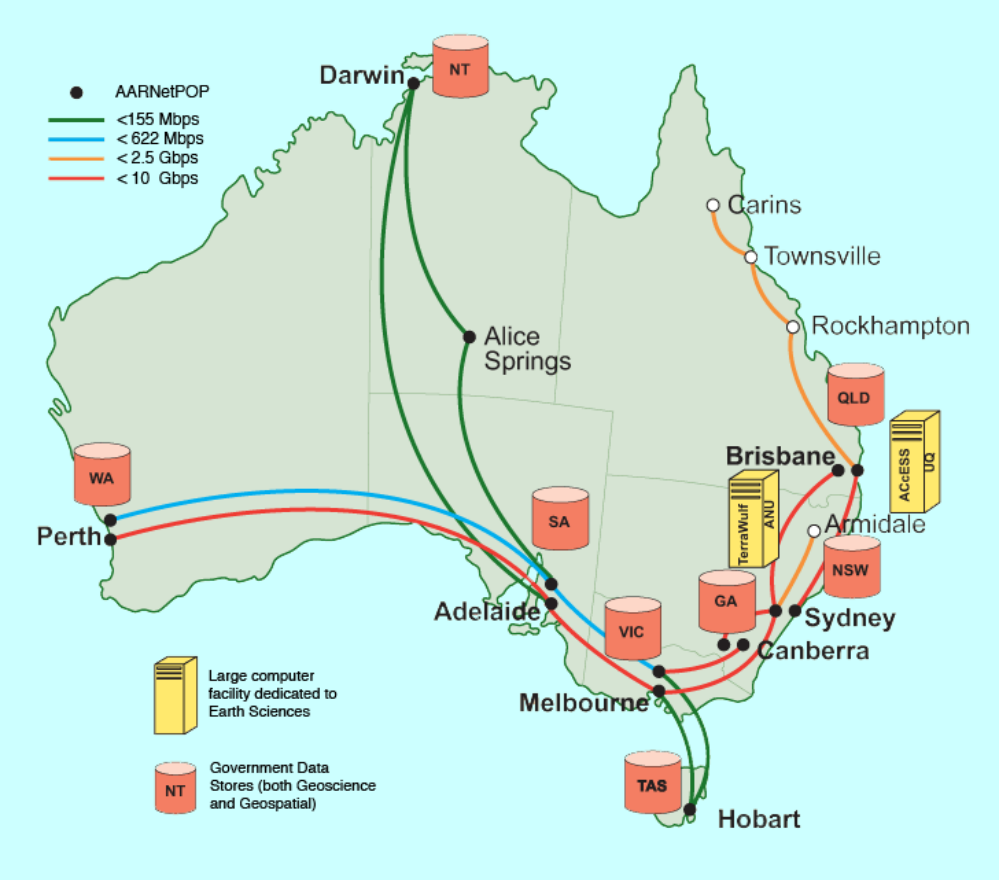
Introduction

- Drilling is still the ultimate exploration test but the drilled materials are grossly under-utilised. There is much valuable information on local/regional mineralogy in these drill cores and chips.
- There are millions of meters of cores in public and company repositories throughout Australia with vast potential to be value added and made accessible.
- The AuScope National Virtual Core Library (NVCL) is a collaborative research project funded by the federal government's National Collaborative Research Infrastructure Strategy (NCRIS) and implemented by CSIRO and GSQ.
- Hyperspectral and high resolution photographic scanning of core delivered online.
- Quantitative representation of mineralogy (detectable) in the scanned cores.

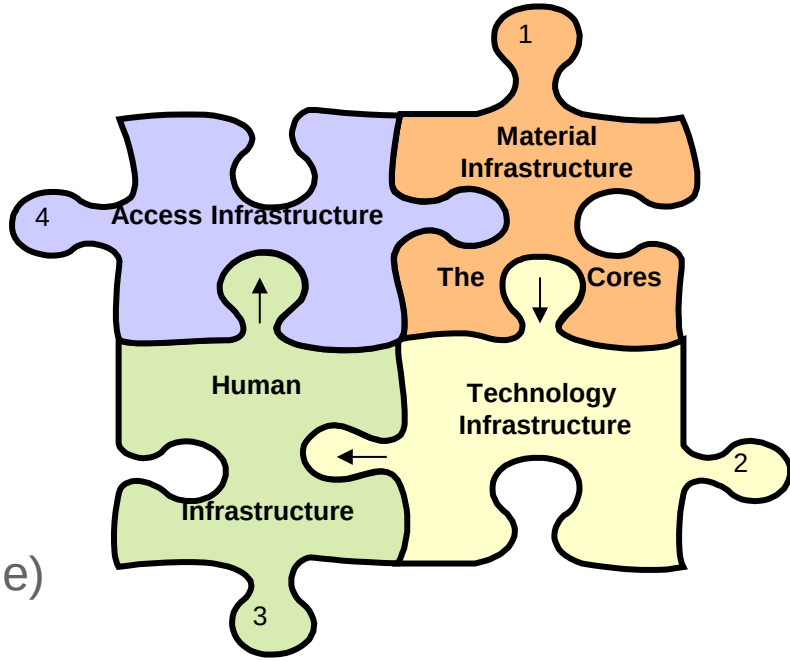
AuScope Grid

- Building an Earth Science e-Research infrastructure.
- Key challenge: link major geoscience and geospatial data stores of the government agencies with HPC resources and high bandwidth networks of the academic community.
- e-Research infrastructure – build online, ‘virtual’ communities of globally dispersed researchers.



NVCL Components

- Material Infrastructure
  - State based core libraries and company core farms
- Hardware Infrastructure
  - Sensing hardware (HyLogger-3 series)
- Software (Interpretation) Infrastructure
  - TSG-Core interpretation engine
- NVCL Operations (State nodes)
  - 7 nodes and supporting staff
- Storage Infrastructure
  - Databases
- Discovery & Delivery Infrastructure
  - AuScope Grid Teams Portal - (NVCL page)
- Research (access & interoperability)
  - Academia, Agency, Company, Individual



Why HyLogging…

- Uses reflective spectroscopy to map mineralogy of drill cores.
- Three different sensors covering the geologically relevant visible – near – shortwave & thermal infra-red regions.
- High-resolution imagery of drill cores.
- TSA algorithm compares the Hylogger derived spectra against a standard Australian reference library to derive mineralogy.
- Much clearer than ordinary core logging process.
- More information – less time.

The HyLogger™

- Semi-automatic, robotically sampled, continuously scanning
- Visible – near – shortwave – thermal infrared spectrometers
- Spectrometers – ~8mm spatial resolution
- Digital imagery – ~0.1mm spatial resolution
- Field of view over core – 10mm x 18mm
- Laser profilometer – measures core height with 0.25 mm resolution
- Measurement – around 250 m per day
- Data acquisition – The Spectral Geologist(TSG)™ software suite.

Quality data

- Quality assurance at various points
- White calibration plate & internal black standard (VNIR/SWIR) Gold calibration plate and real-time RT measuring (TIR) – radiometrically calibrates to an absolute standard.
- Test rocks of standard minerals sampled 2 times a day.
- TSG Core QC checks for illumination and measurement discrepancies.
- Laser profilometer accounts for core quality and breakage.
- Spectral comparison against standard Spectralon® plate.
- Instrumental variations monitored occasionally (0.2nm @2155nm in 6 months).

TIR Interpretation constraints

- More complicated than that of SWIR data, and not nearly as advanced.
- TSG is capable of processing and displaying TIR data. Interpretation engine is still being refined.
- In general, the level of confidence of interpretation will be less than that for VIS/SWIR. User interrogation from multiple perspectives and close interaction with CSIRO and AuScope HyLogging community is required to advance the state of knowledge and understanding in this area.
- Co-registered data from VIS/SWIR/TIR spectrometers will be an important asset for the earth science community.

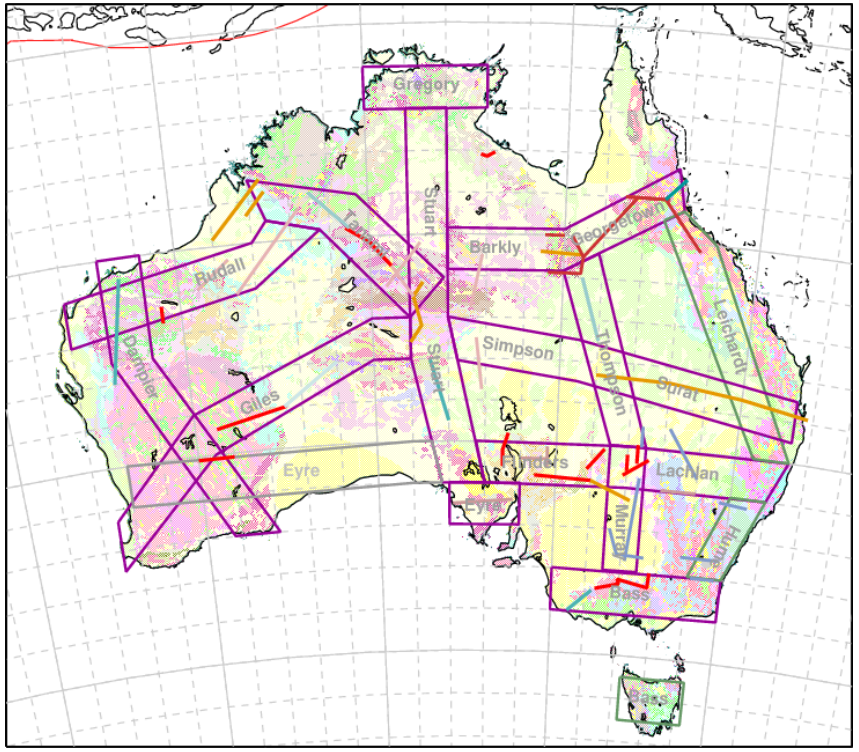
Disclaimer

- *Results from TSA (SWIR) is a general unmixing algorithm and trained on a relatively small subset of commonly occurring minerals. It does not make the right identifications all of the time. TSA abundances are relative abundances, with a reporting mixtures-of-two for SWIR (3 for TIR). If there are more than 2 minerals actually present in the sample then this is not reflected AT ALL in the 2 reported abundances. The SWIR wavelength identifies hydrous silicates and carbonates. So it does not reflect the TOTAL mineralogy of the sample. The TIR wavelength TSA is still at Beta stage. Any TSA results from the TIR should be used with caution as algorithms and TSA libraries are in a constant state of revision.*

Queensland NVCL node

- Our commitment:
  - Scan both mineral and stratigraphic cores in our core libraries
  - Based on AuScope Geotransects
  - Newly drilled holes like Geothermal, Carbon Geosequestration cores are also included
  - Regularly scan company/private cores

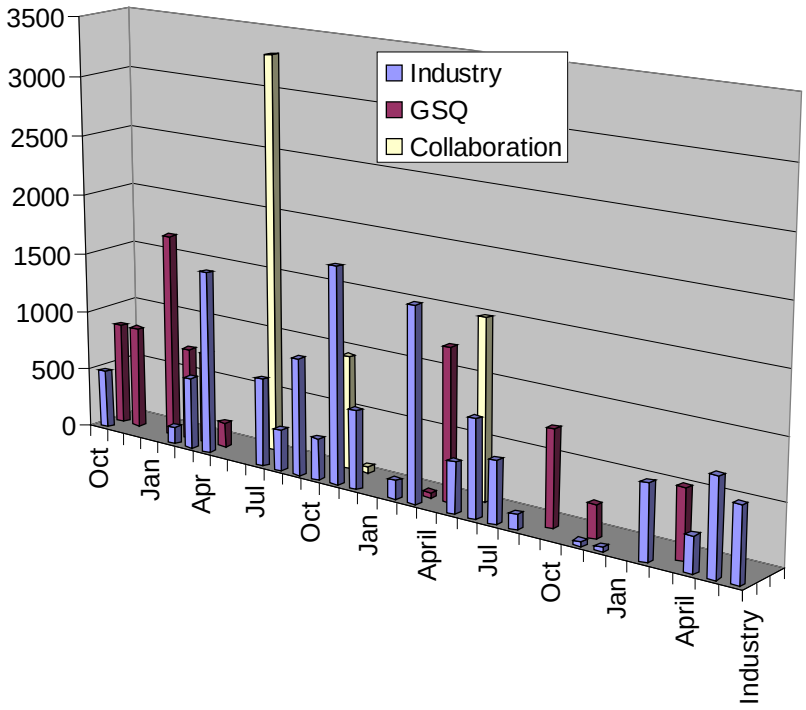
- Initially cover the cores from Exploration Data Centre, Zillmere.
- Will go to John Campbell Miles Drill Core Storage Facility, Mount Isa



Configuration of Geotransects across Australian continent based on the seismic reflection profiles.
(Ref.: http://rses.anu.edu.au/seismology/ANSIR/AuScope/transect.html)

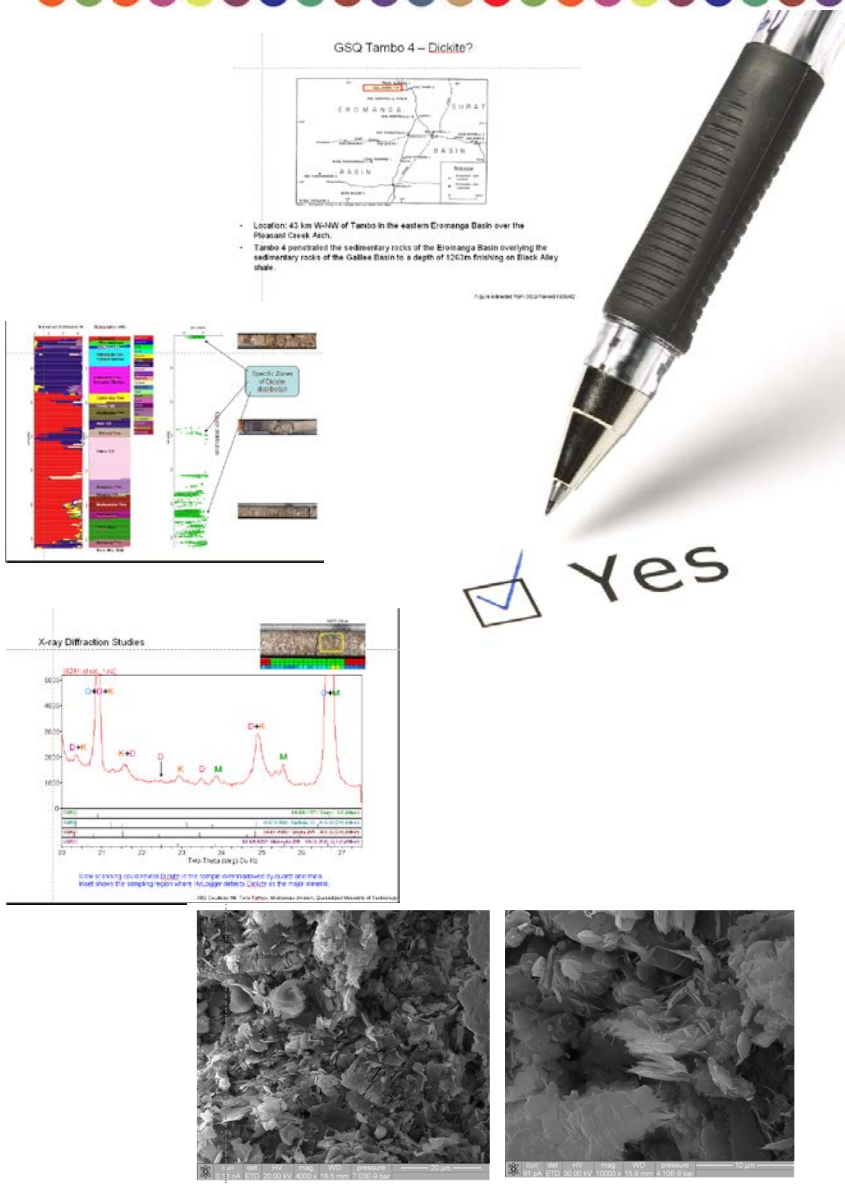
Queensland NVCL node

- Covered most of the mineral holes in and around the Geotransects within Queensland.
- Scanning stratigraphic holes now.
- Statistics since September 2009:
  - 74685 m; 23440 trays; 315 holes.
- Steady increase in external requests
  - 13554 m for Industry
  - 8075m for University and GSQ
  - 5752m for GSQ/Industry collaborations



Validation studies

- Another integral aspect in NVCL program
- Secondary form of validation using standard analytical methods supplement the quality of the HyLogger data.
- GSQ compared HyLogging results from selected holes with X-ray diffraction and Scanning Electro Microscopy with Energy Dispersive X-ray analysis.
- Elemental composition collected using portable X-ray Florescence analyser (*Niton XL3T-500*) complements HyLogger data, thus value adding the mineral information.



GSQ Tambo 4 – Dickite?

- 43 km W-NW of Tambo in the eastern Eromanga Basin, over the Pleasant Creek Arch.
- Intended to provide a fully cored and wireline logged reference of the sedimentary rocks of the Eromanga and Galilee Basin sequences, ending up at Black Alley Shale.
- Determine the influence of the Pleasant Creek Arch on sedimentation.

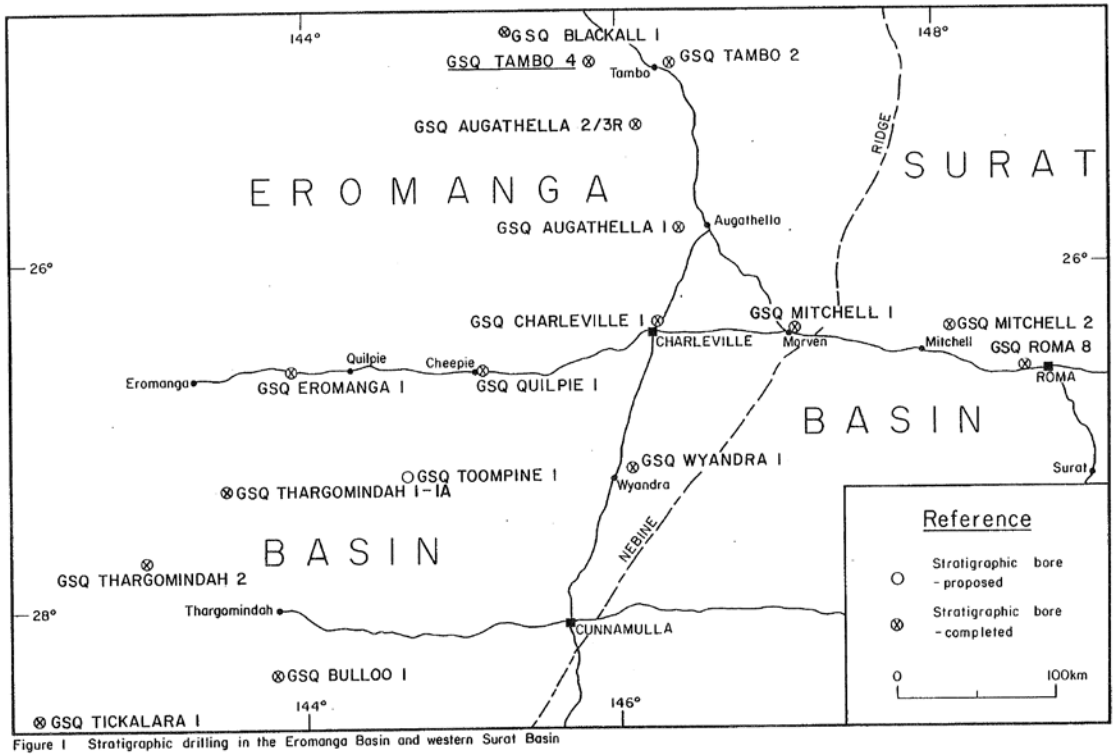
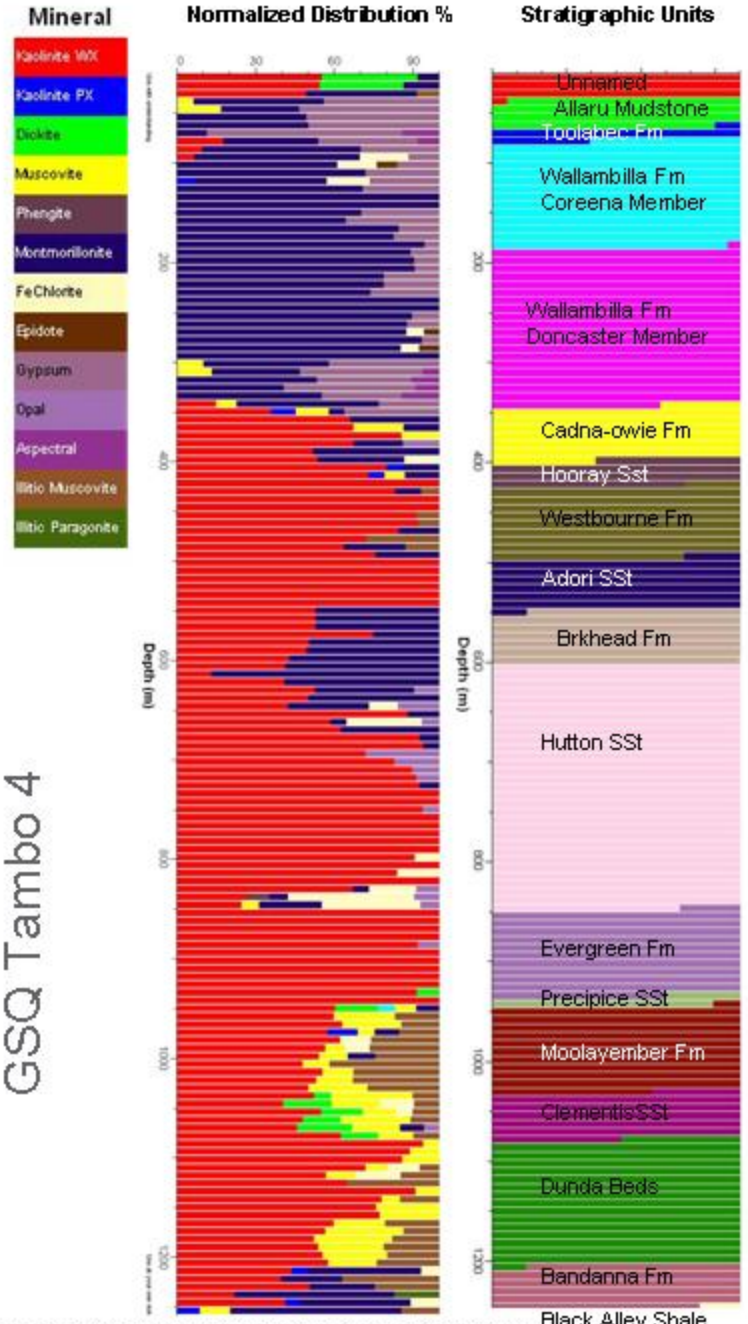
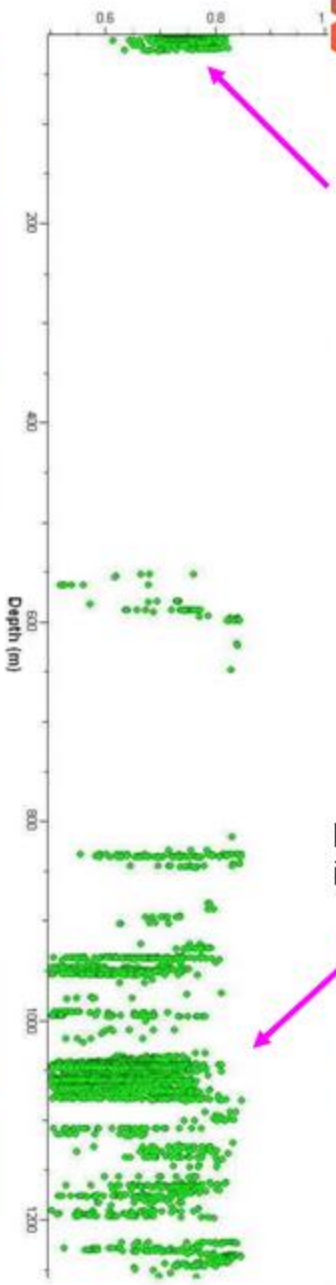


Figure 1 Stratigraphic drilling in the Eromanga Basin and western Surat Basin





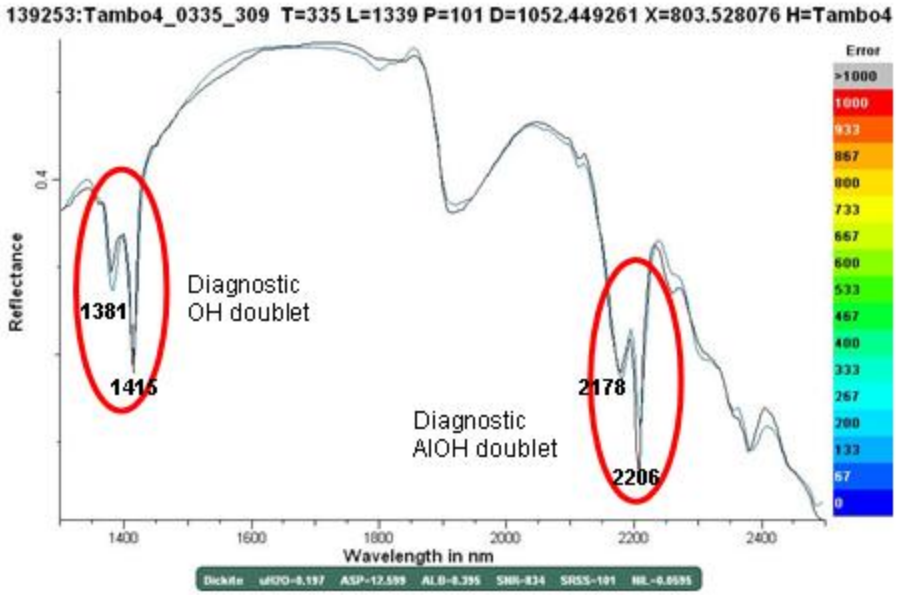
Dickite in the surface?

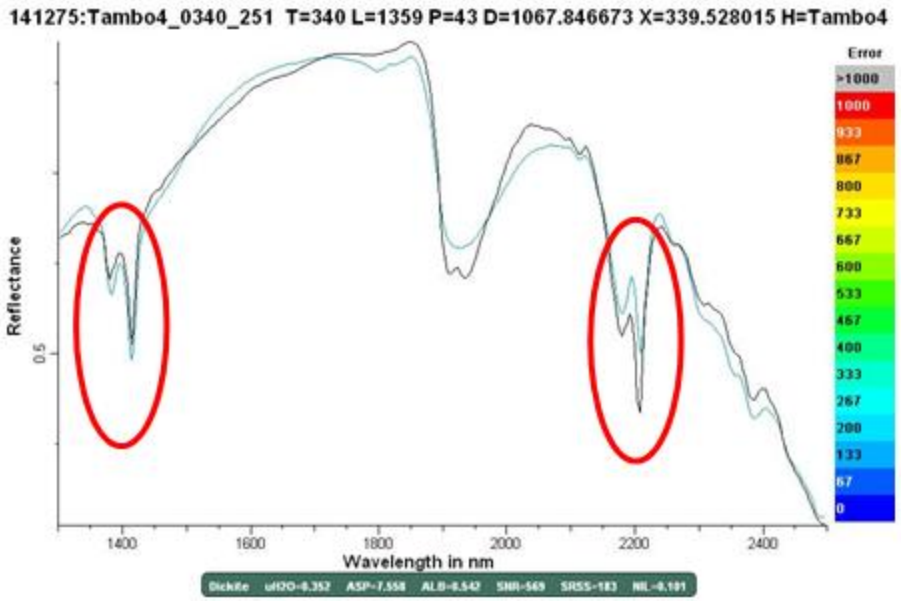
Dickite at depths are consistent with increasing pressure/temperature conditions.

GSQ Tambo 4

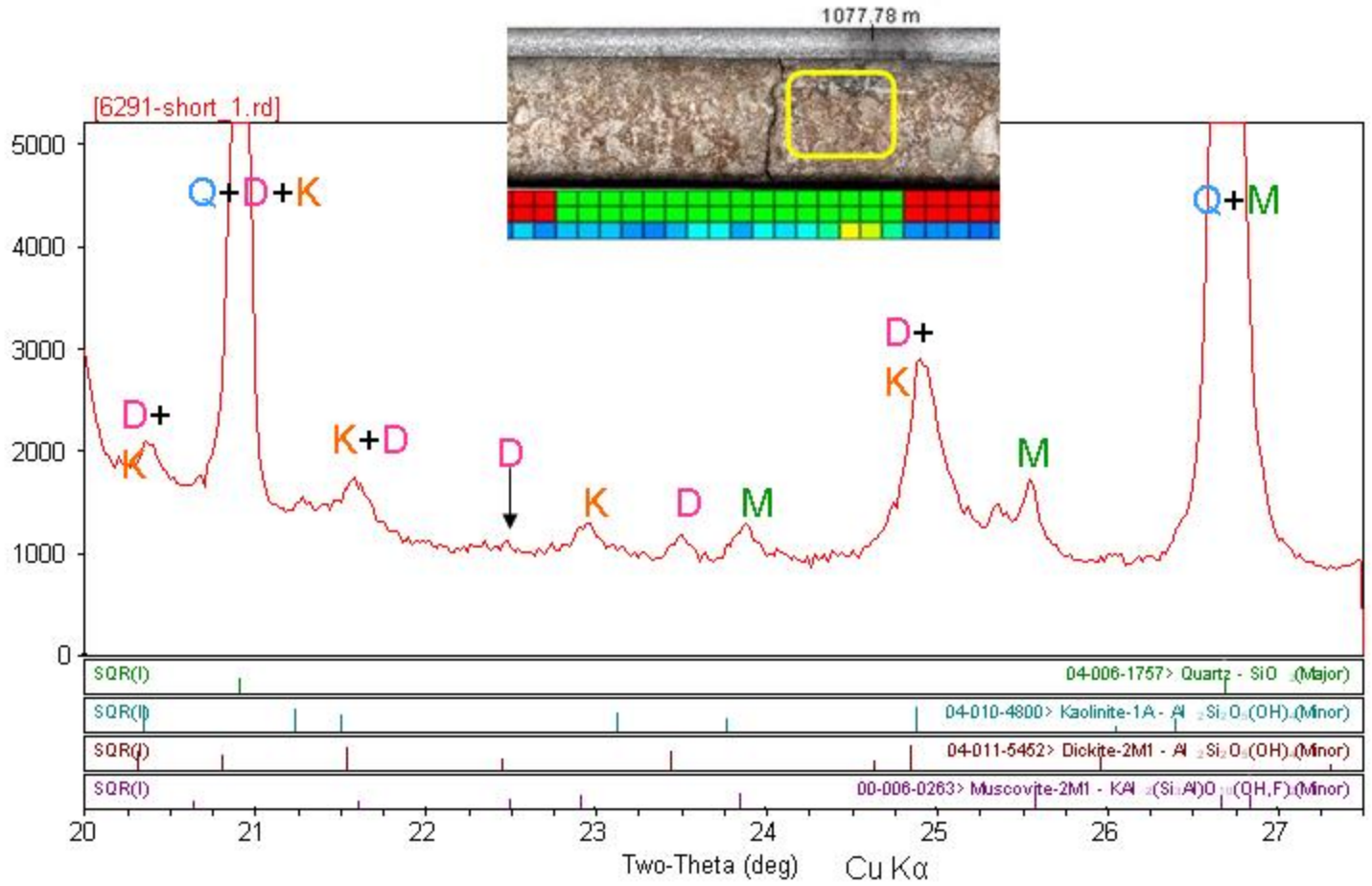
GSQ Tambo 4 – Dickite?

- Kaolinite (1Tc) & Dickite ($2M_1$) are the two most widespread polytypes of Kaolin group.
- Kaolinite – product of low temperature (<150ºC) weathering or epithermal process.
- Dickite – higher temperature (150-250ºC) product of hydrothermal alteration and medium-high grade diagenetic sedimentary conditions.
- Indicators of Paleothermometric reconstructions
- Kaolinite more stable at ambient temperature while dickite is stable above 150-200ºC.
- Possible that the kinetically controlled dissolution and precipitation processes could be the reason for the dominance of kaolinite at surface conditions.





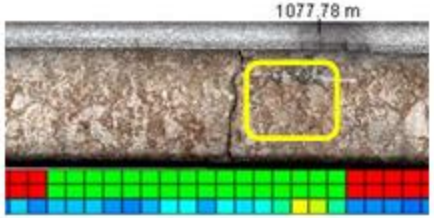
X-ray Diffraction Studies

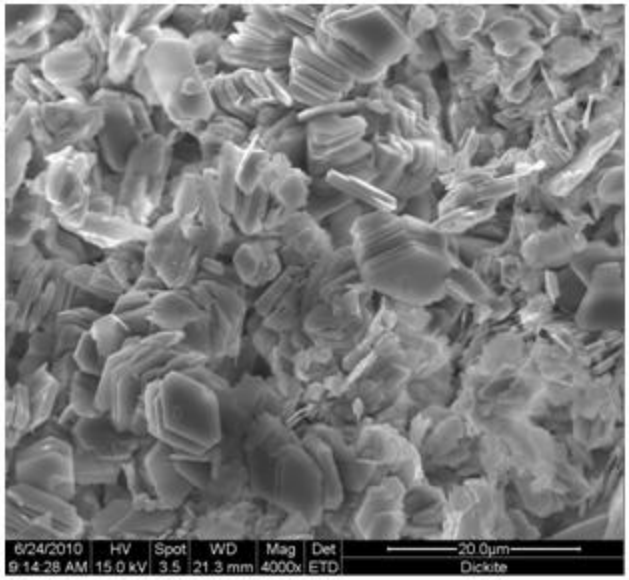


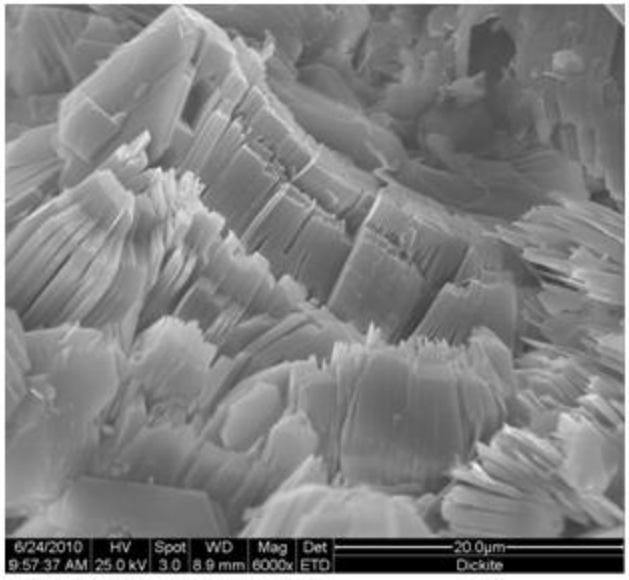
Slow scanning could reveal Dickite in the sample overshadowed by quartz and mica.
Inset shows the sampling region where HyLogger detects Dickite as the major mineral.

XRD Courtesy: Mr. Tony Raftery, Microscopy division, Queensland University of Technology.

Scanning Electron Micrographs



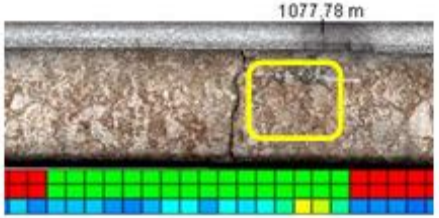


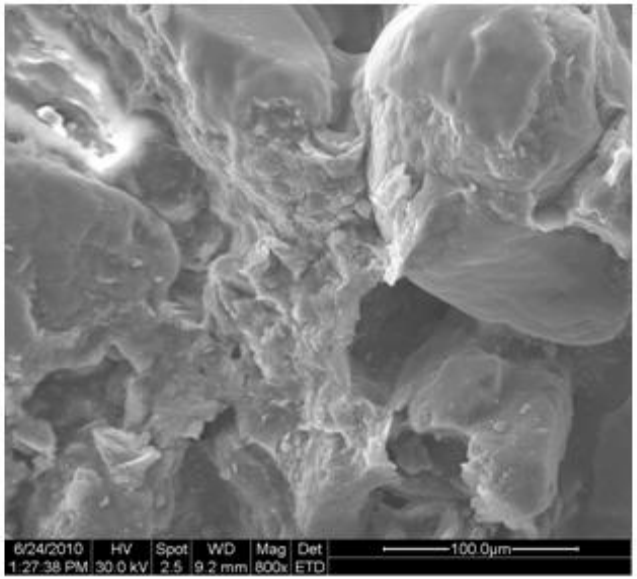


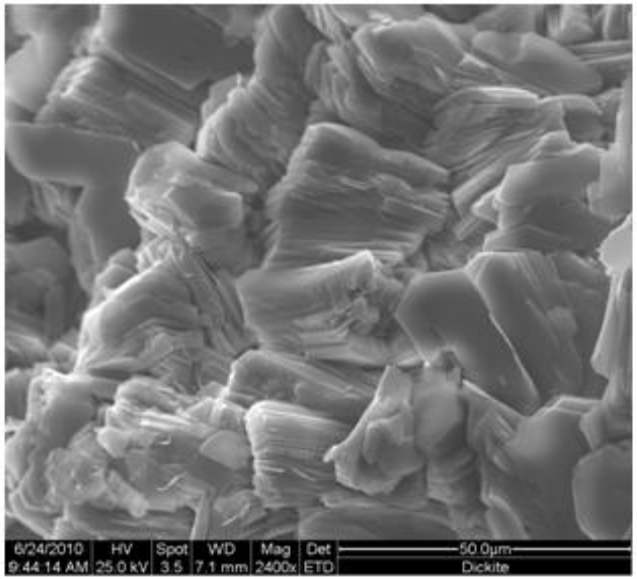
Dickite is seen along with kaolinite in GSQ Tambo 4 sample at a depth of **1077m**.
Vermcuilitc structure is suggestive of authigenic formation.

SEM Courtesy: Dr. Loc Duong, Microscopy division, Queensland University of Technology.

Scanning Electron Micrographs

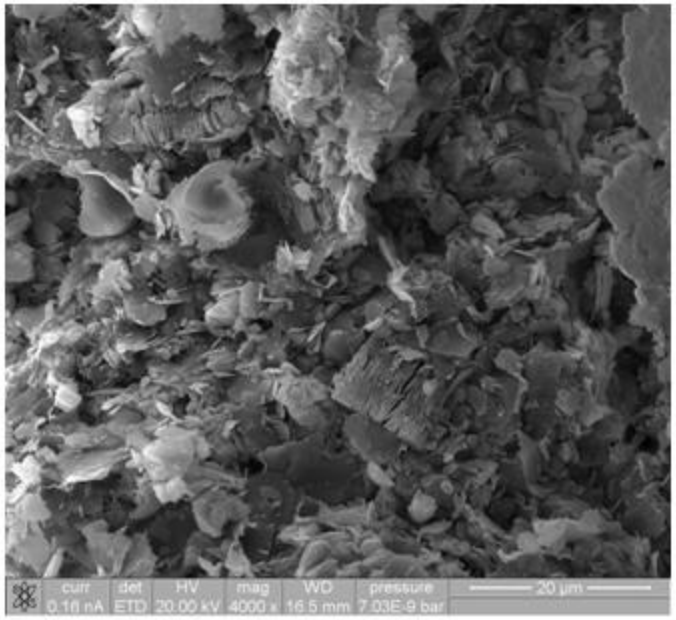


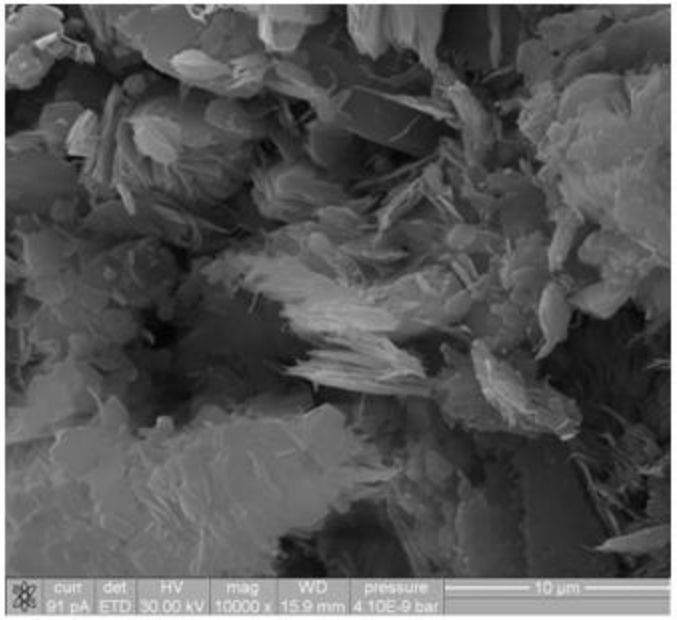




Dickite is seen as a surface coating in sandstone in GSQ Tambo 4 sample at a depth of **1077m**. Coexistance of kaolinite and dickite indicates authigenic transformation.

Scanning Electron Micrographs



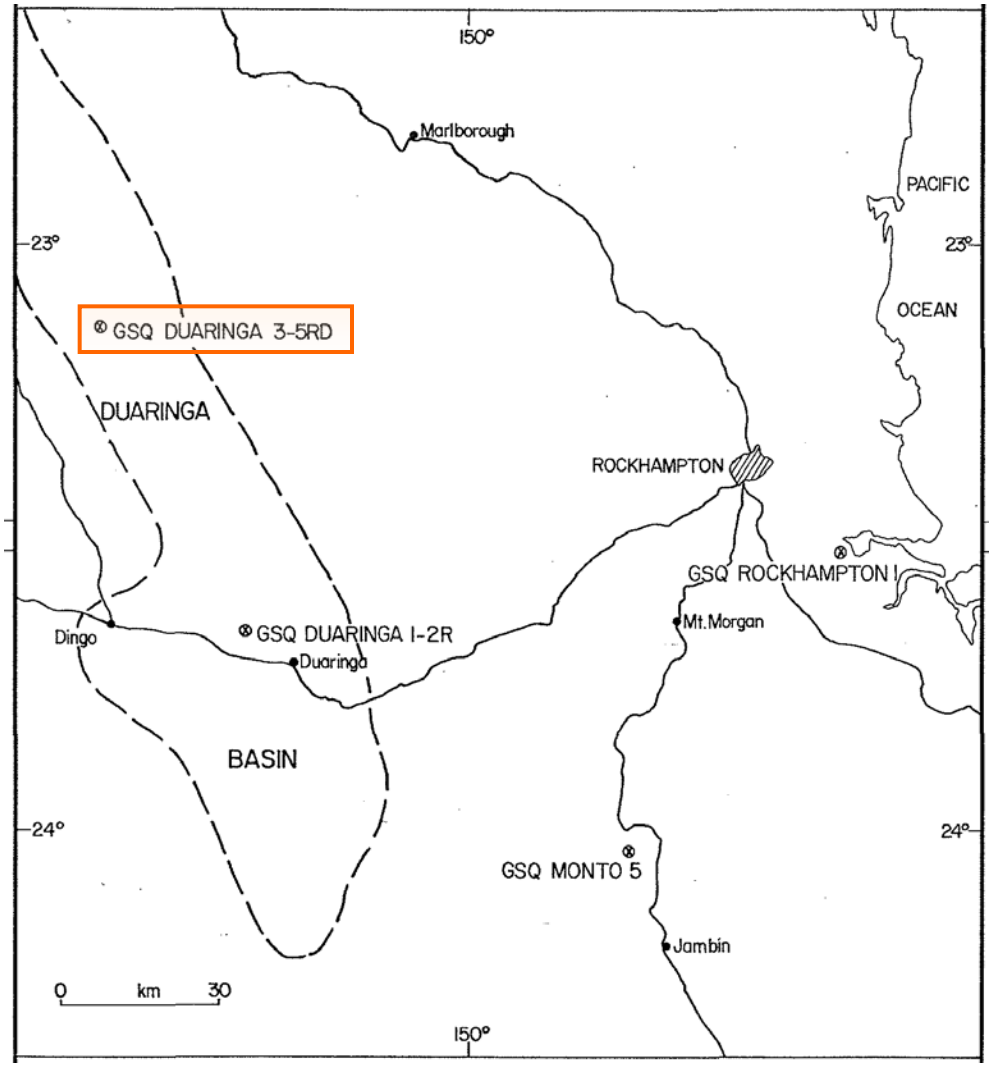


Dickite/Kaolinte mixture is seen in this GSQ Tambo 4 sample at a depth of **~15 m** from the surface. Second picture shows alteration to a fibrous clay, probably illite. Inset shows the sampling point.

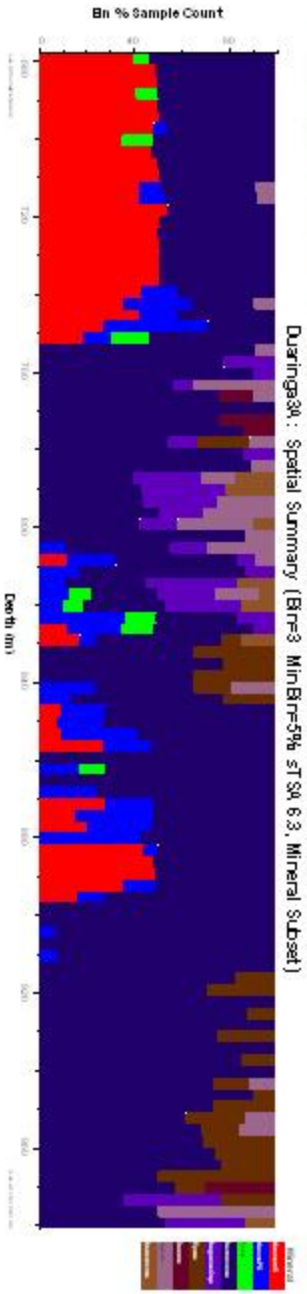
SEM Courtesy: Dr. Loc Duong, Microscopy division, Queensland University of Technology.

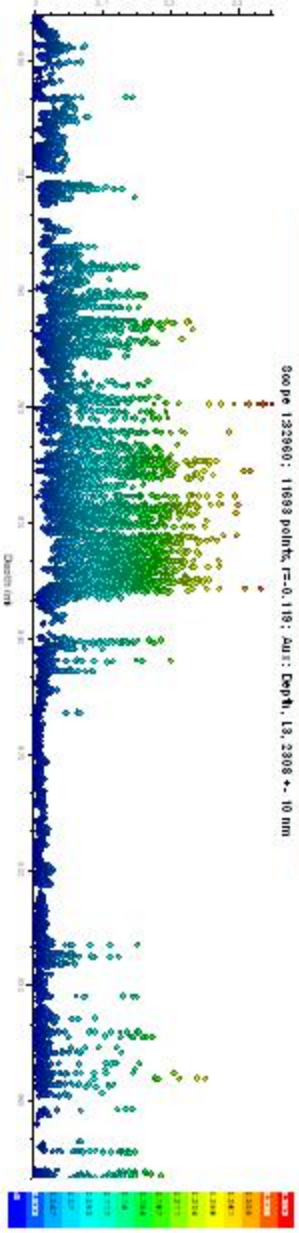
GSQ Duaringa 3A

- 43 km W-NW of Tambo in the eastern Eromanga Basin, over the Pleasant Creek Arch.
- Intended to provide a fully cored and wireline logged reference of the tertiary sequence in the Duaringa Basin. Underlain by the Permian rocks of the Bowen Basin.
- Oil shales are soft, greenish grey mudstones.
- Kerogen reported – algal origin deriving Type I Kerogen.



GSQ Duaringa 3A

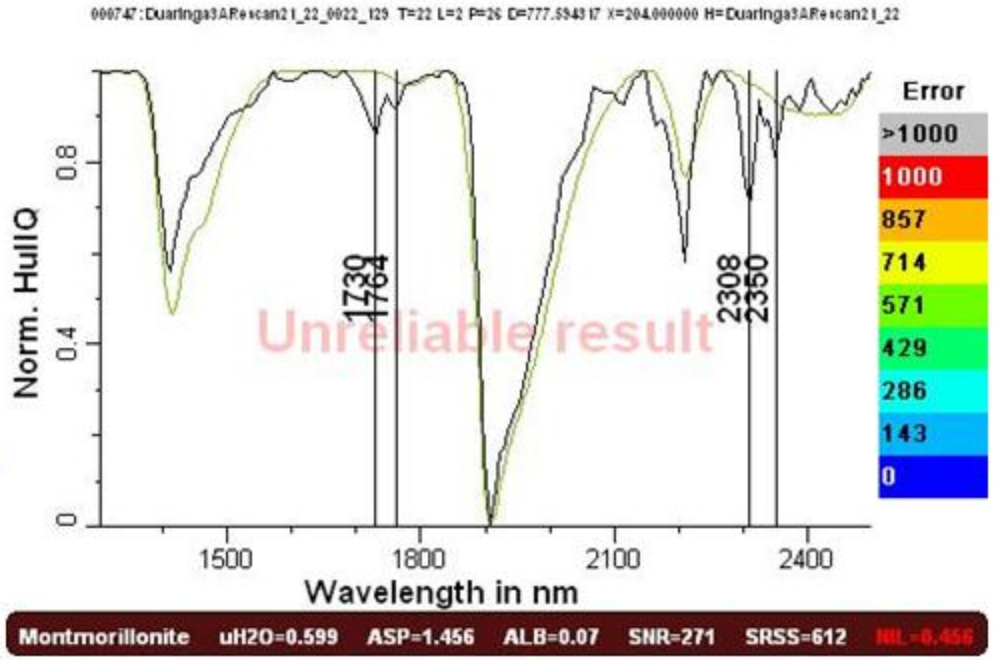




A mosaic of Duaringa 3A is compared alongside HyLogger derived mineralogy.

The distribution of Kerogen is represented by plotting the intensity of 2308nm peak.

Image mosaic for Duaringa3ARescan21_22



The characteristic doublets at 1730 and 2300 distinguishes Kerogen.

Since Kerogen signatures are not in the library, TSA is trying to compare the spectra with montmorillonite.

Conclusion

- HyLogger™ is a novel, robotic core-logging technology that can deliver high-quality digital hyperspectral information quickly and much efficiently.
- National Virtual Core Library (NVCL) is a unique concept that integrates geological drill-core information from all around Australia and delivers them via an online database.
- Validation studies form an integral aspect of NVCL to confirm the mineralogy identified from the HyLogger data by the TSA algorithm.
- Dickite identified by TSA towards the surface of GSQ Tambo 4 was characterised using XRD and SEM studies.
- The characteristic doublets observed in the GSQ Duaringa 3A spectra, which went undetected by TSA was found to be Kerogen.

Acknowledgements

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