ARC-L New Stratigraphy and Geostatistics for Gas and Water Resources

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Introduction

The ARC-L project is designed to better understand the environment of hydraulic systems of parts of the Great Artesian Basin. The outcome will help to protect groundwater resources and decision making of the Coal Seam Gas industry.

The Project consists of three key topics:

- **Isolation and completion decision**: What parts of the "Springbok Sandstone" are permeable ➔ calibrated brine flow properties in sandstone and non-sandstone
- **Local area (field scale) modelling**: How could we handle heterogeneity? What does this mean for local pressure transmission?
- **Long range, wide area (groundwater scale) modelling**: How could we correlate "Springbok Sandstone" over longer distance? How could we handle upscaled heterogeneity? How would this impact pressure transmission?

This poster is presenting results of the research commenced within the first two key topics.

Heterogeneity – Comparing Log "Signals"

We compare sections of wireline logs by calculating the **Euclidean distance** between them (Fig. 1).

- Lower Euclidean distance indicates more similar signals (Zero would indicate identical signals)
- This is just about similarity – any output needs to be sense checked based on geological understanding

Rather than just comparing one well to all the wells, we can compare each well to it's neighbours, then move to the most similar signal and repeat the process (Fig. 2). Using this sequential correlation method we generally identify the same tops as the geological picks.

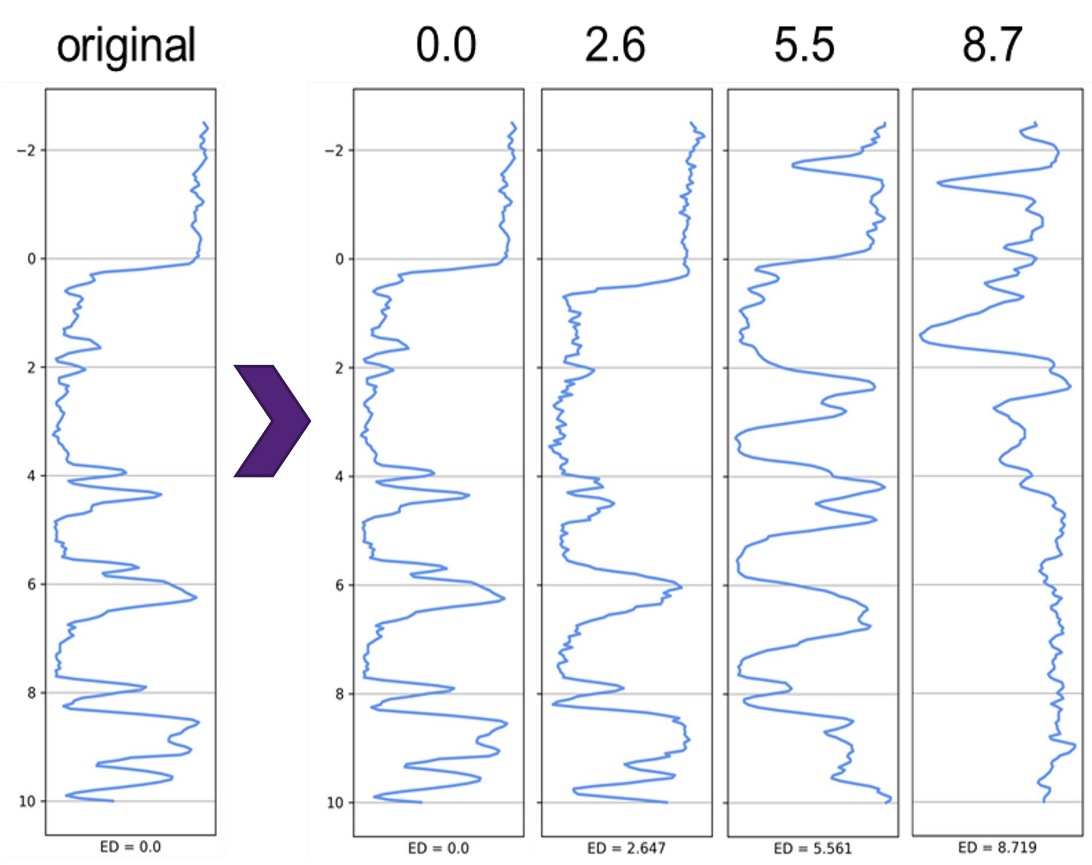

Figure 1: Example for Euclidean distance variations in density logs of four wells situated close to each other. Similarity decreases from left to right (lower to higher Euclidean distance value on top of each well).

Statistical Correlation

We were looking for a more objective and repeatable way to distinguish between the Walloons and Springbok. Log data (and pick for Walloons-Springbok Interface) indicated Springbok had generally lower density in the "non coal" lithologies (Fig. 3).

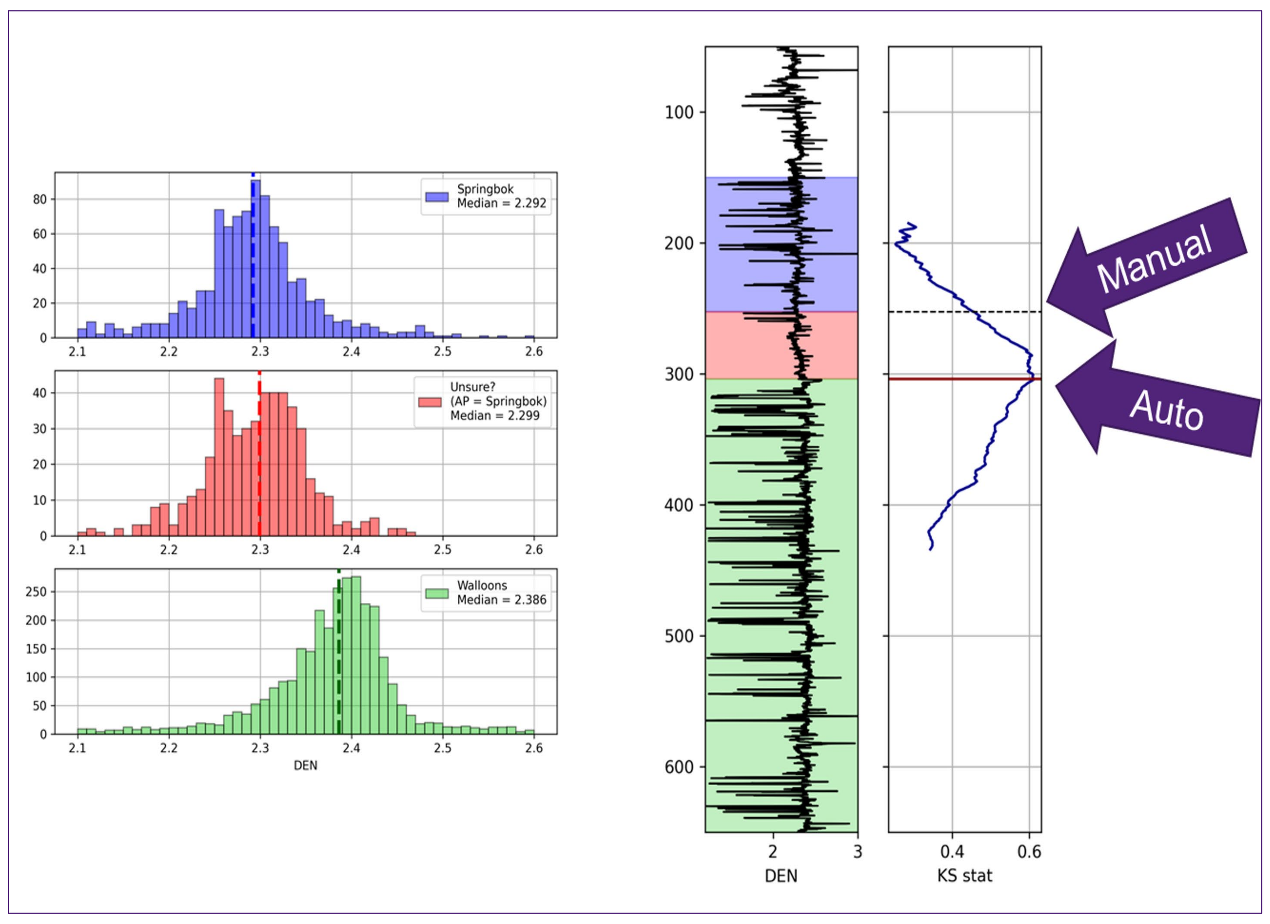

Figure 3: Statistical comparison and introduction of Blue and Green zones. The data within the Red Zone appears more "Blue-like" and will be automatically put into the Blue Zone.

Petrophysical Analysis

Data Set:

Nine CSG well are sampled over the Blue and Green Zones to determine petrophysical properties.

110 plugs are analysed for ambient porosity, air permeability and grain density. 75 of these plugs are tested for overburden corrected porosity and gas permeability. 47 are tested to derive Klinkenberg permeabilities. 45 are finally tested for overburden corrected brine permeabilities

Workflow:

- Ambient to Overburden conditions for all core data
- Overburden corrected gas permeability correlates with measured brine permeability
- Brine permeability link to total overburden porosity
- The binned data and average porosity and P10, P50, P90 and Swanson mean brine permeabilities are calculated for each porosity bin.
- These are used to generate trend lines to calculate brine permeability directly from total porosity.
- The uncertainty of the calculated brine permeability is given by the P90-P10 range.
- Brine permeabilities are calculated for sections of the nine sampled project wells to identify flow potential of sandstone horizons of the Blue and Green Zones (Fig. 4).

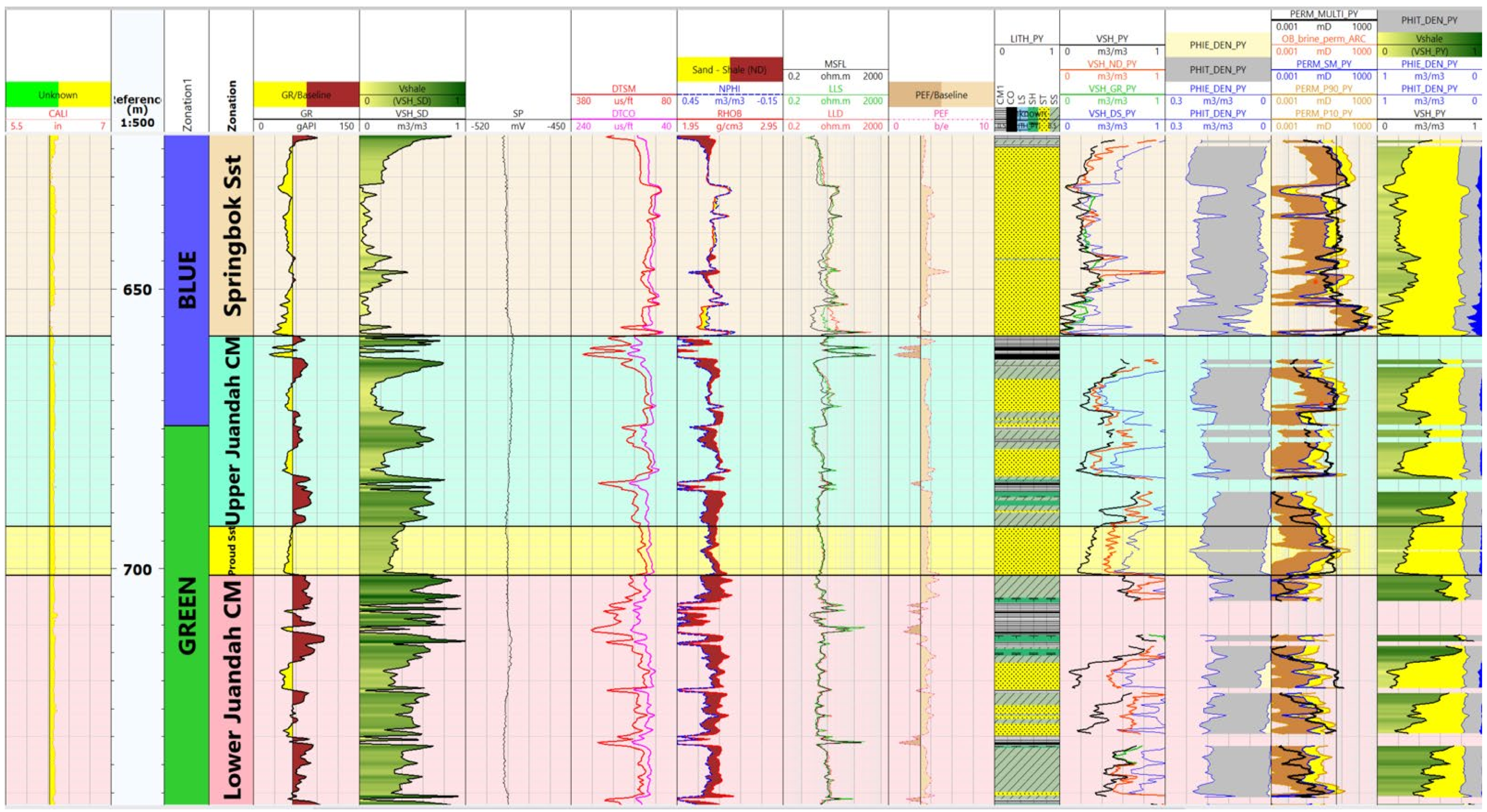

Figure 4: The deterministic interpretation of logs for one of the project wells. Calculating effective porosity in these strata is problematic as the range of clays varies significantly. The ratio of NMR effective porosity to NMR total porosity was calculated. A function to link shale volume to the ratio of effective and total porosity is generated for the blue and green zones. This function allows effective porosity directly to be calculated from total porosity and shale volume. The P10, Swanson mean, and P90 brine permeabilities are plotted in the second track from the right. Measured horizontal plug brine permeabilities are plotted as red dots in the same track.

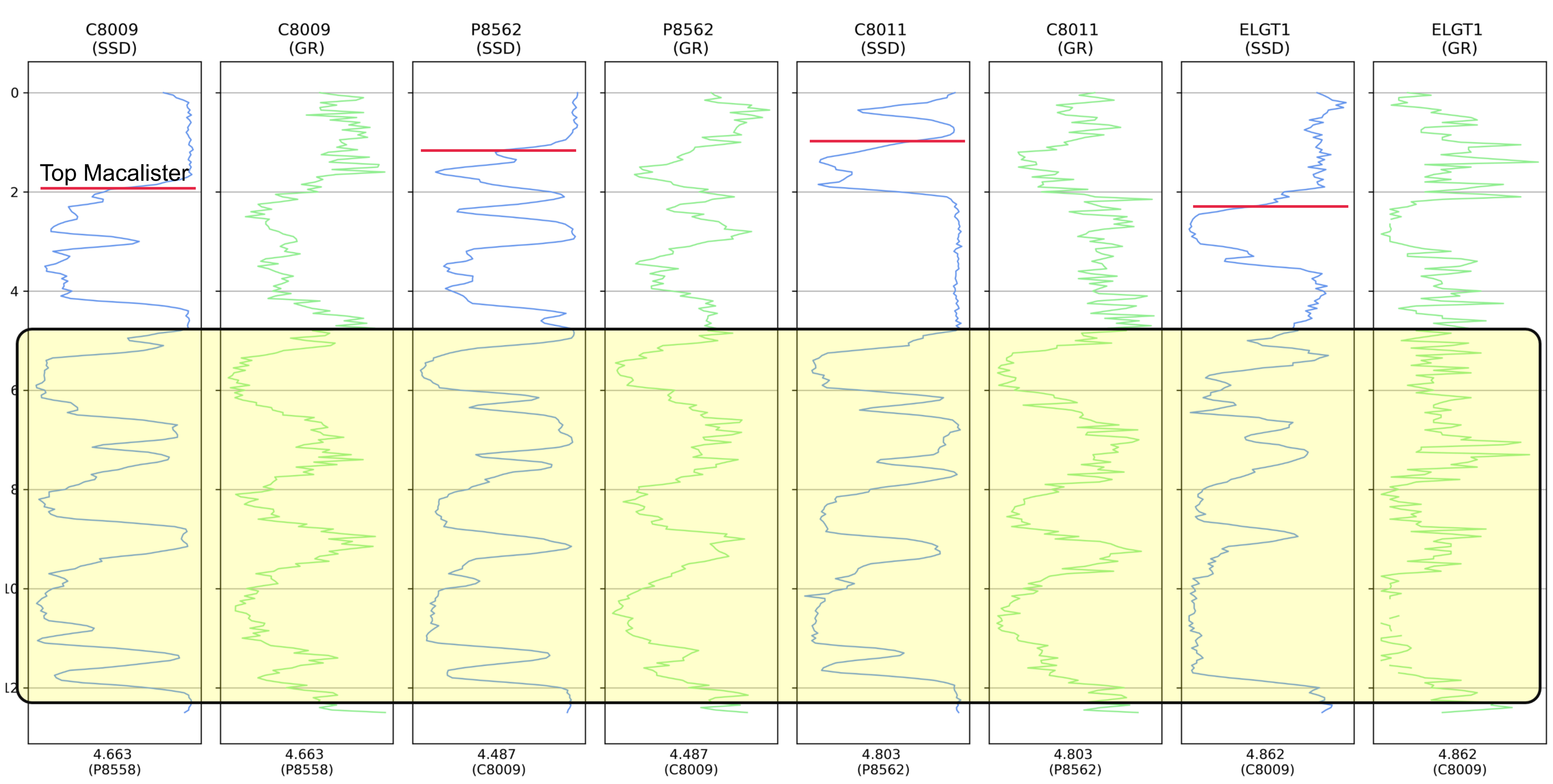

Figure 2: Density (blue) and gamma ray logs (green) of four wells show that minimises Euclidean distance (i.e. the full section shown in this zoomed-in plot) doesn't start at the manually picked Top Macalister (red line) because the deeper part of the signal appears more consistent.

Conclusions

Heterogeneity analysis:

- Euclidean distance can determine similarity of wireline logs
- Independent evidence to support geological picks and representation of spatial dependence (pseudo-variogram)

Statistical Correlation:

- Statistical method to distinguish geological units
- Objective and repeatable

Petrophysical analysis:

- Multimin/ELAN model gives a high-quality log interpretation in intervals where the mineral assemblage is well resolved by high quality logs (incl. ECS and NMR)
- The total porosity can be predicted with approximately the same accuracy from the deterministic and Multimin models.
- The permeability is determined from the total porosity / core permeability correlation.
- The simpler and more transferrable deterministic model provides a fit-for-purpose interpretation.

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