ELECTROFACIES ANALYSIS USING HIGH-RESOLUTION WIRELINE GEOPHYSICAL DATA AS A PROXY FOR INERTINITE AND VITRINITE DISTRIBUTION IN LATE PERMIAN COAL SEAMS, BOWEN BASIN

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OBJECTIVE: To develop a method and workflow for advanced reservoir characterisation using borehole geophysical logs and wellbore images, and apply these methods to bowen basin coal measures formations in order to assist in inertinite and vitrinite distribution analysis in the Bowen Basin.

INTRODUCTION

Previous research studies which were focused on the Bowen Basin coal measures (Beeston, 1986; Hunt and Smyth, 1989; Hunt, 1989 and others) relied on the physical presence of core material. Coal was investigated visually in core samples or by coal proximate analysis and maceral analysis. Although these methods are accurate and representative, their results could be sparse due to the lack of core data. In turn, wellbore data have been collected for many years but are extremely underutilised in the coal industry. Establishing a method and workflow of coal characterisation based on the wellbore data would help solve the problem of the scattered character of coal characterisation results.

BACKGROUND

There were some attempts to utilise wireline borehole geophysical data for coal characterisation (Esterle and LeBlanc Smith, personal communication). Although these studies provided very good results with regard to determination of dull and bright coal, they were not successful at distinguishing between inertinite-rich and vitrinite-rich coal.

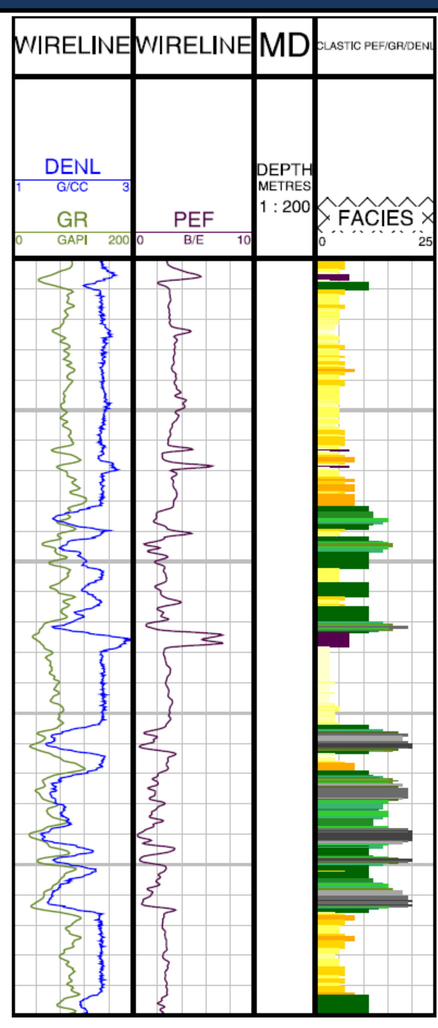
CHALLENGE: none of the conventionally used wireline logs (resistivity, gamma-ray, bulk density) can help to distinguish between inertinite-rich coal and vitrinite-rich coal.

SOLUTION: photoelectric factor (PEF) curve is used for inertinite-rich coal determination

METHODOLOGY

APPROACH: The problem of coal characterisation is treated as an analogue of the lithology determination problem.

METHOD: *ELECTROFACIES ANALYSIS*
Electrofacies analysis involves partitioning a set of log data into electrofacies units, and presenting them in a manner that is comparable to that used by geologists for either outcrop or core description



Example of electrofacies analysis: GR, bulk density, photoelectric factor logs (left side) and facies: sandstone (yellow), mudstone (green), coal (grey), sandstone with siderite cement (purple)

INPUT DATASET: PEF, gamma ray, bulk density, resistivity

WORKFLOW:
DATA PREPARATION: Data should be organised into two sets: reference set and application set. The reference set consists of the deepest wells which contain good quality data and represent the whole geological profile of the studied area; reference set is used for electrofacies analysis
- Data collection
- Data organisation
- Data analysis

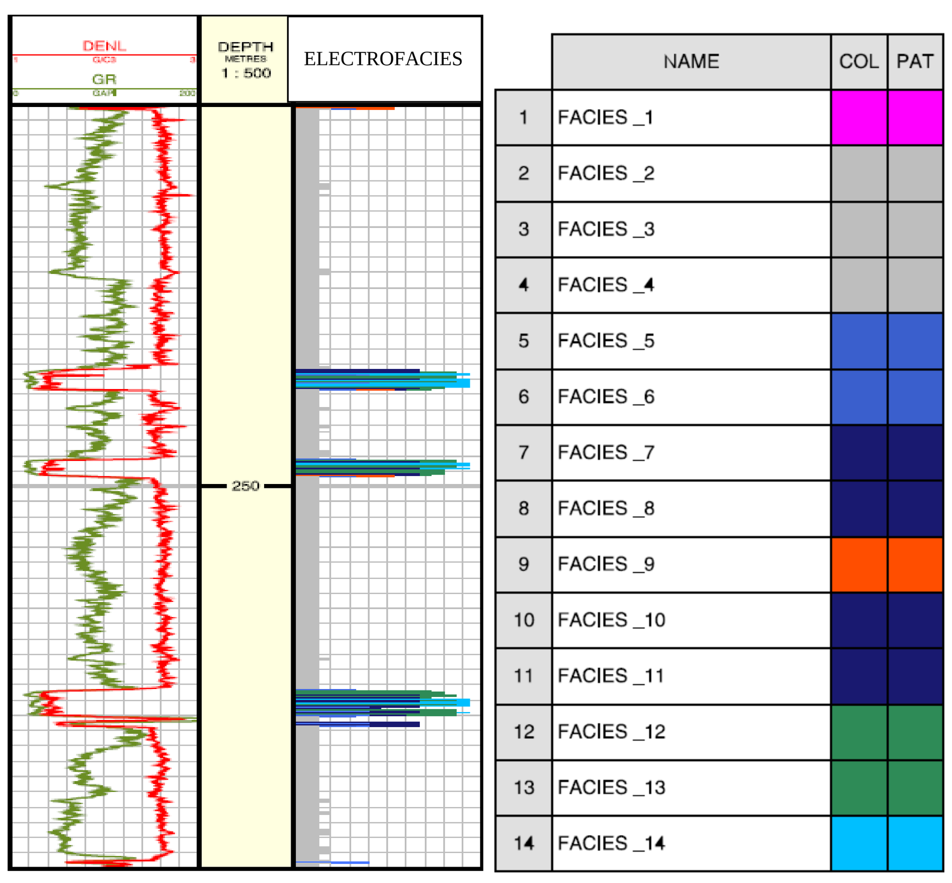
ELECTROFACIES ANALYSIS:
- Data clustering
- Electrofacies classification

MODEL PROPAGATION: The results of electrofacies analysis are propagated on all wells which form the application set

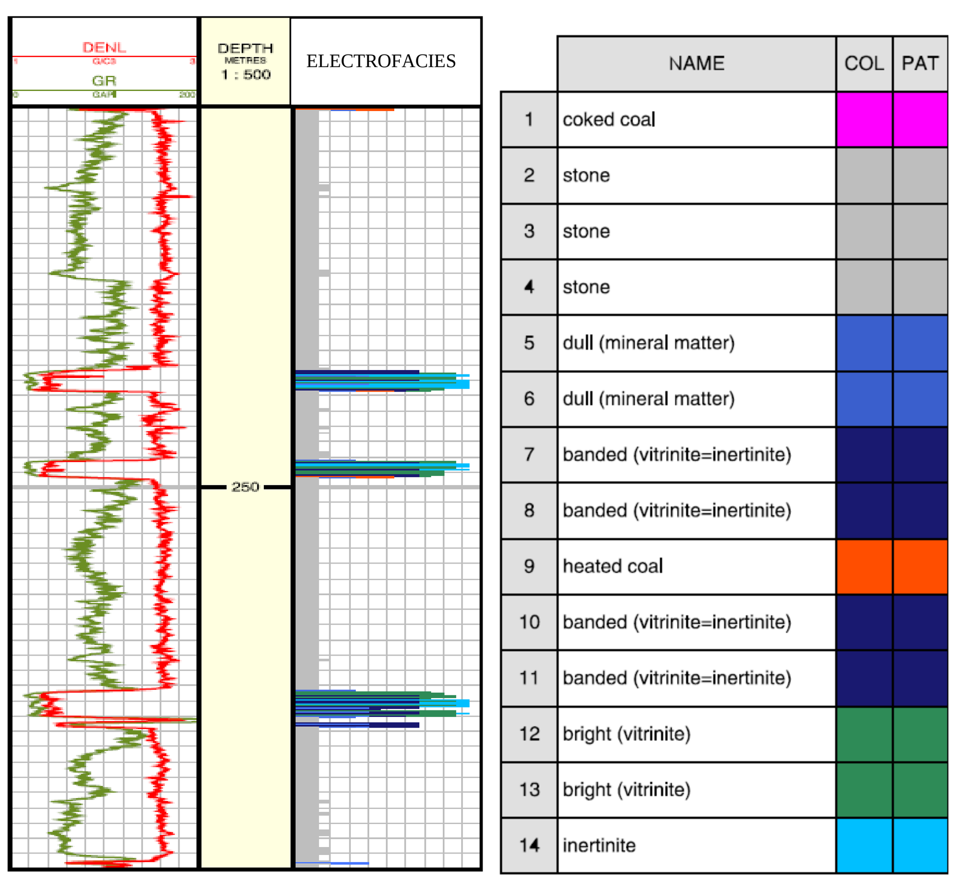
DATA CLUSTERING:

Multi-Resolution Graph-Based Clustering (MRGC) is used for electrofacies analysis. MRGC automatically determines the optimal number of clusters, yet allows the user to control the level of detail actually needed to define the electrofacies.

The resulting electrofacies don't have any geological meaning; the geological labelling is performed during the electrofacies classification procedure.



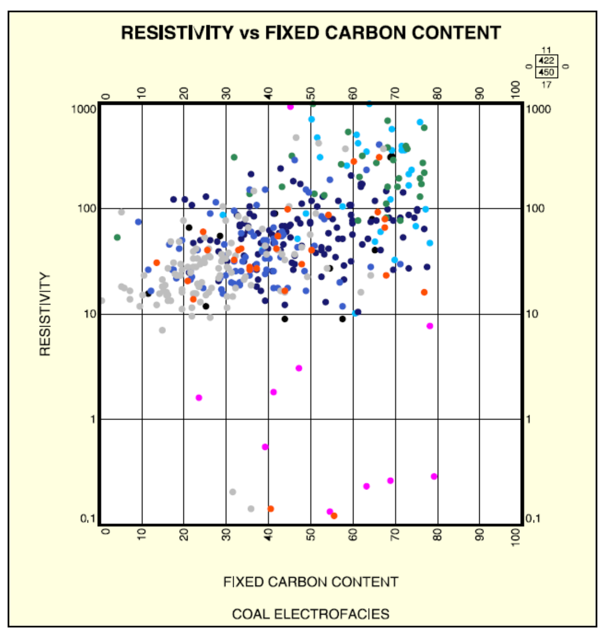
Example of DATA CLUSTERING result: a set of wireline logs is partitioned into electrofacies units which don't have any geological meaning yet



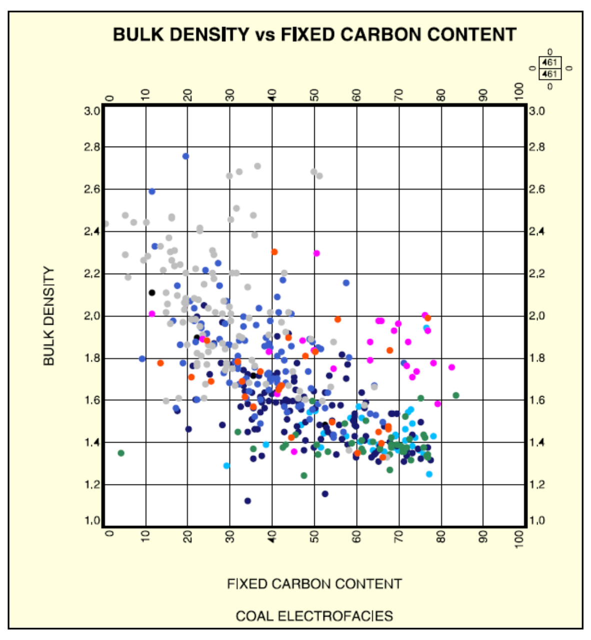
Example of ELECTROFACIES CLASSIFICATION result: geological labelling has been assigned to each electrofacies now

ELECTROFACIES CLASSIFICATION:

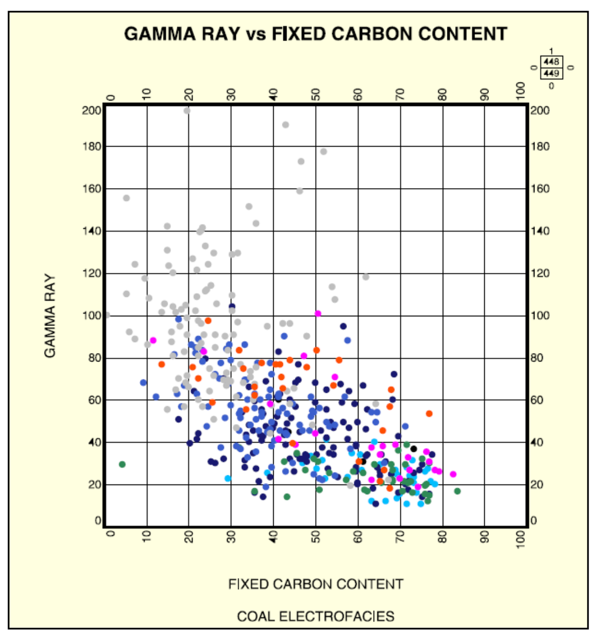
Number of 2D plots and frequency distribution plots were used to perform electrofacies labelling. Gamma ray, bulk density, resistivity and PEF wireline data were plotted versus fixed carbon content data (from coal proximate analysis) in order to determine coal electrofacies.



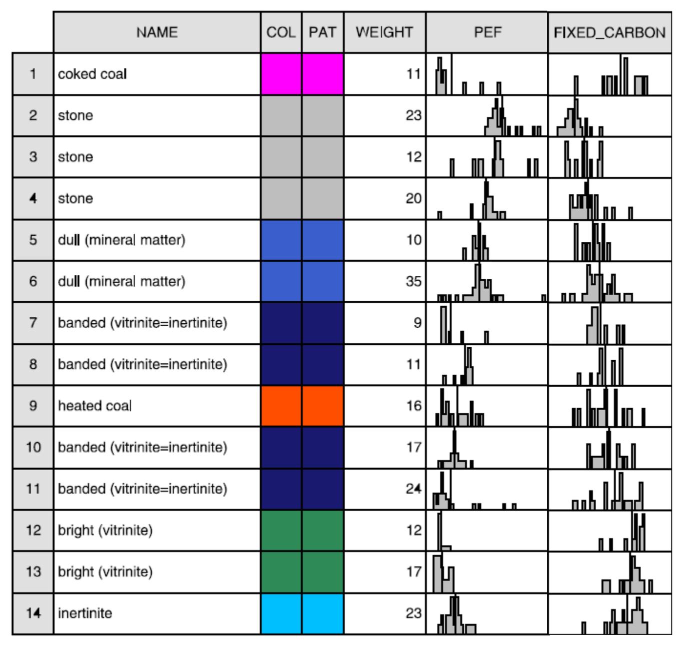
Resistivity increases from dull to bright coal. It's not possible to distinguish inertinite-rich coal; however, coked coal is noticeable.



Bulk density decreases from dull to bright coal. It's not possible to distinguish inertinite-rich coal; however, coked coal is noticeable.



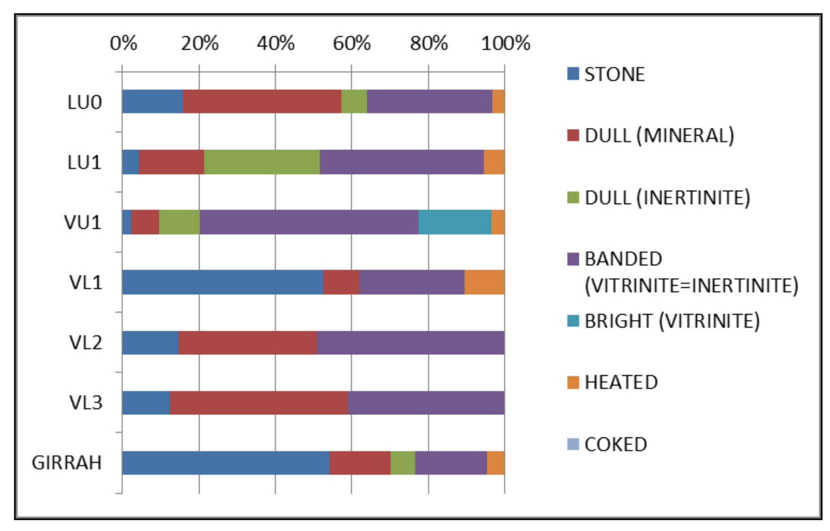
Gamma ray decreases from dull to bright coal. It's not possible to distinguish either inertinite-rich coal or coked coal.



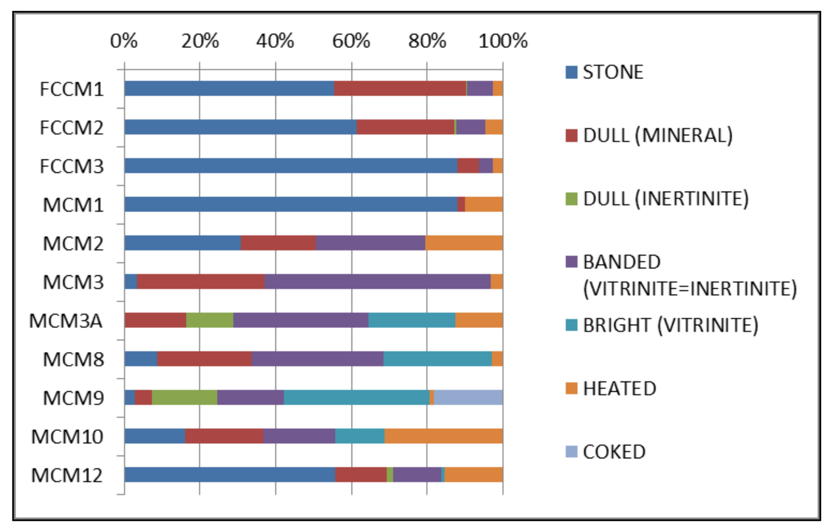
PEF has slightly higher values for inertinite-rich dull coal than for vitrinite-rich bright coal while fixed carbon content is equal for those two coal types.

RESULTS and VALIDATION:

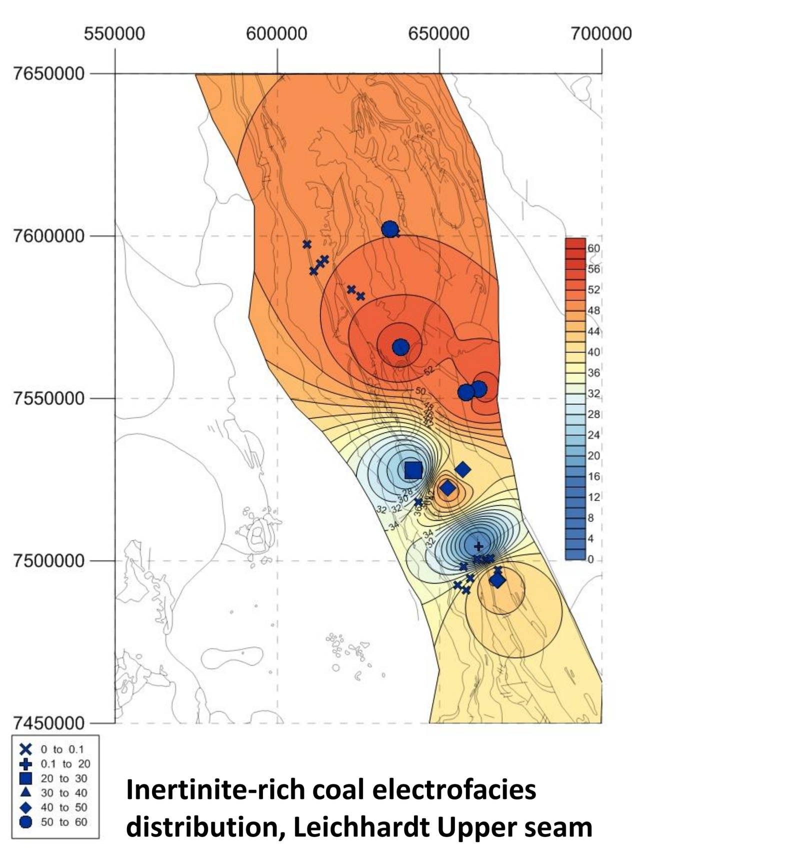
- Inertinite-rich coal electrofacies (cyan colour on the legend) were used as a proxy for inertinite matter
- Vitrinite-rich coal electrofacies (dark green colour on the legend) were used as a proxy for vitrinite matter
- Inertinite- and vitrinite-rich coal electrofacies distribution was analysed stratigraphically by mean of charts analysis and geographically by help of 2D maps
- Stratigraphical distribution of coal electrofacies analysis shows that inertinite-rich coal increases from MCM towards RCM, among all coal seams Leichhardt Upper contains the highest amount of inertinite-rich coal; MCM, in turn, is characterised by very high vitrinite-rich coal amount
- Geographical distribution of coal electrofacies analysis reveals an increase of inertinite-rich coal from the south to the north and increase of vitrinite-rich coal from the north to the south.



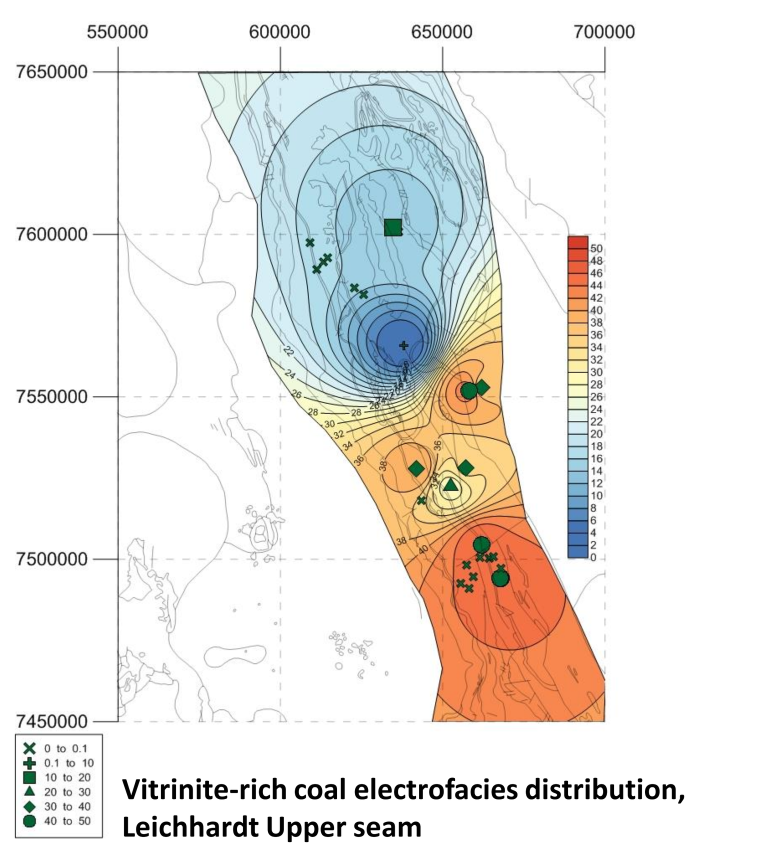
Coal electrofacies distribution in RCM and GIRRAH seam



Coal electrofacies distribution in Lower FCCM and MCM



Inertinite-rich coal electrofacies distribution, Leichhardt Upper seam



Vitrinite-rich coal electrofacies distribution, Leichhardt Upper seam

The results of the study are in conjunction with previous study of Hunt (1989) who explained such distribution by subsidence rate increase towards the south.