A Tephrostratigraphic Approach to Understanding Subsurface Sedimentary Architecture. An Example from Permian Fort Cooper Coal Measures, Bowen Basin, Queensland, Australia.

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Summary

This study developed a stratigraphic architecture of a late Permian Fort Cooper Coal Measures and its equivalents (FCCM) in the Permian Bowen Basin, using a tephrostratigraphic approach. The study identified and correlated tuffs of more than 1m thick within the FCCM across the basin, over 450km and across 500 boreholes. The correlations and resulting stratigraphy was validated by absolute age dating using CA-IDTIMS (Chemical Abrasion - Isotope Dilution Thermal Ionization Mass Spectrometry) that expanded the understanding of variable coal seam geometry and sedimentation rates (Ayaz et al, 2016).

Introduction

Late Permian FCCM is complex stratigraphic unit of the foreland Bowen Basin characterized by an abundance of tuff layers interbedded with coal seams, sandstones, and siltstone beds. The FCCM vary in their geometry and lithology across different morphotectonic zones of the basin (Anderson 1985; Ayaz et al, 2015). Despite thermally mature and gassy coal seams in some regional areas, the stratigraphic, sedimentological and depositional variation of the FCCM was not well understood due to its complex splitting patterns and multiple tuffs. However, FCCM is distinguished by a regional marker bed called the Yarrabee tuff that separates it from the overlying Rangal coal measures (Anderson 1985; Ayaz et al, 2015).

Method

500 open file wells are used for wireline correlation, identifying the key accessory tuff horizons underpinning the coal seam geometry and sedimentary architecture. Within the stratigraphic section, four key wells located in different morphotectonic zones of the basin were selected for tuff dating (Figure 1). Among the key wells, four tuff samples of the Yarrabee Tuff and eight samples of the accessory tuffs were collected to date zircons using high precision U-Pb CA-IDTIMS technique, following the procedures of Mattinson (2005) and Schoene (2014). The age bounded intervals were processed through decompaction exercise in order to estimate the sedimentation rates. The decompaction was performed separately for each lithology using compaction ratio of 1:10 for coal to peat (McCabe 1984), 1:1.5 for siltstone to silt (Fielding 1986) and 1:1.1 for sandstone to sand (Nadon 1998).

Results

Regionally, from north to south, the FCCM are split into coal bearing Burngrove and Fair Hill formations by a marine-derived BlackAlley shale formation (Figure 1). The internal architecture of the coal seams varies regionally with the morphotectonic zones of the basin. Thick coal seams occur in the areas of low accommodation sites while split coal seams with interburden occur in areas of high accommodation sites (Ayaz et al, 2015). The Yarrabee Tuff dated at a range of 252.69 ± 0.16Ma - 253.07± 0.22Ma (Figure 1). Three accessory tuffs within the Burngrove Formation have an upper range of 252.85 ± 0.16Ma – 253.12 ± 0.12Ma and a lower range of 253.57± 0.18Ma – 253.77 ± 0.17Ma (Figure 1). This places them into the upper Changhsingian Stage. One of the accessory tuff from Fair Hill Formation has an age of 254.03 ± 0.03Ma and belongs to the lower Changhsingian Stage. Using tuff dates, the sedimentation rates of the Burngrove formation was estimated to be 234.5 - 224.5m/Ma in the areas of high accommodation contrary to the rates of 112m/Ma in the areas of low accommodation.

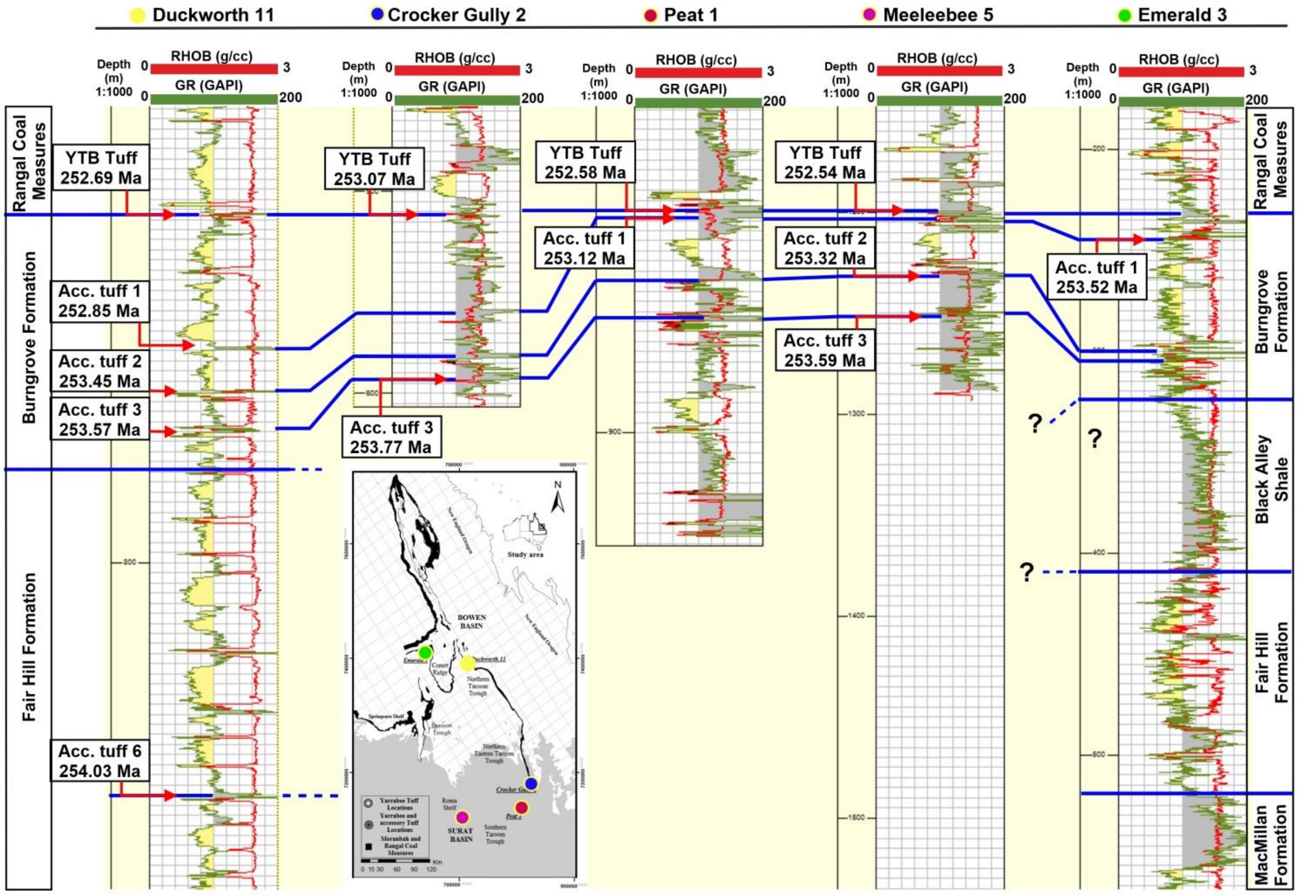

Figure 1. Lithostratigraphic correlation panel showing gamma ray and density wireline logs from studied wells and Meeleebee 5, displayed with stratigraphic divisions of FCCM. Green log shows gamma ray, higher values of which represent tuff in a sequence. Red log shows density, lower values of which represent coals. Sample locations of the Yarrabee and Accessory Tuffs with their weighted mean ages are shown. Among the studied wells, Accessory Tuffs 4 and 5 are only recognized in Duckworth 11 well. A total of 10 age dates from this study are presented and the remaining 2 age dates are under revision. Age dates of Meeleebee 5 well are from Metcalfe et al. (2014). A map of Bowen Basin is shown for reference with marked well locations.

Interpretation and Conclusion

The results highlight the interplay of sedimentation with variable accommodation setting during basin evolution. High sedimentation rates of the Burngrove Formation associated with fragmented coal seams reflect excessive sediment income interrupting the peat formation during the foreland loading phase of the Bowen Basin. Coal seam splitting can result from various factors including but not limited to small fault movements, compaction controlled subsidence, basinward increase in epeirogenic subsidence or channel sedimentation (Fielding 1987). Contrary to this, at low accommodation sites, slow sedimentation rates of the Burngrove Formation favored the formation of thick coal seams and reduced sediment thickness reflecting a possibility of condensed section, erosion or sediment bypass. Similar conclusions were made by Wadsworth et al. (2002) in the Western Canadian Sedimentary Basin. The study reveals that the sedimentation and coal seam geometry is directly controlled by the basin tectonics and associated subsidence of the late Permian time.

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