[PS]An Investigation into the Sedimentary Organization of the Walloon Sub-Group via BHI's*

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Abstract

Despite more than a decade of intensive coal seam gas exploration and development in the Surat Basin, fundamental aspects surrounding the sedimentary organisation of the Middle Jurassic Walloon Subgroup remain unresolved. While generally agreed to have been deposited on a waterlogged alluvial plain contradictory models describe the Walloon Subgroup as an internally draining fluvio-lacustrine system or alternatively as a southerly prograding axial trunk drainage. The former, somewhat analogous to the Fort Union Formation in the Powder River Basin, invokes a radially organised fluvial system feeding a basin centre lake. Along the eastern Surat sediment dispersion and proximal-to-distal facies, relationships are predicted to be oriented from east to west. In contrast, a prograding trunk drainage system assumes an axial system flowing southward towards a distant paleo-coastline. In this model (perhaps similar to the East African rift system), the prevailing sediment dispersal pattern and facies transitions are parallel to the basin axis, largely from north to south (with minor lateral inputs from east to west). Without a unifying conceptual model elucidating the controls on Middle Jurassic deposition, predictions about the spatial or temporal distribution of coal-mires or other sub-environments within the Walloon Subgroup are difficult.

This study tests previous hypotheses surrounding the Walloon Subgroup's sedimentary organisation by reconstructing regional sediment dispersal patterns and variations in alluvial plain architecture. The workflow builds on previous studies to integrate image log interpretation allowing for a regional exploration into the character of in-channel processes throughout the basin. Borehole image logs (BHI) are high-resolution wireline tools, which record up to 192 oriented micro resistivity measurements within a wellbore. During processing individual traces are unwrapped, normalised, and interpolated to generate a pseudo 3D image of the wellbore annulus. Subsequent BHI interpretation involves modelling and classifying the features resolved in the unwrapped image, which may be interpreted to represent structural (fault/fracture) or sedimentological (lamination/textural) features. Via detailed interpretation, multiple sedimentological structures were resolved, augmented by calibration with core descriptions and distributions of bedding plane dip, azimuth, and bedset thicknesses. These insights allowed for the delineation of three distinct in-channel sandstone facies, previously unrecognized in core or wireline logs.

An Investigation into the Sedimentary Organization of the Walloon Sub-Group via BHI's.

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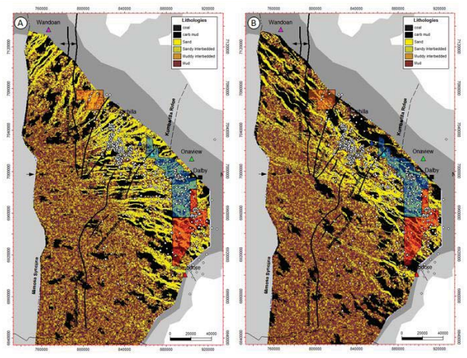
Hypothesis: The fluvial sandstones of the Walloon Subgroup were deposited by a centrally draining meandering river system (Exon 1976).

Alternate Hypothesis: Walloon fluvial sandstones were deposited by an southerly prograding axial trunk drainage system (Leblang *et al.* 1981, Sliwa & Esterle 2008).

INTRODUCTION

- Despite an extensive body of existing research, fundamental aspects surrounding the sedimentary organisation of the Middle Jurassic Walloon Subgroup remain unresolved.
- While generally agreed to have been deposited on a waterlogged alluvial plain (Yago 1996, Hamilton 2011, Sliwa & Esterle 2011, Scott 2012, and Martin 2012) contradictory models describe the Walloon Subgroup as either an internally draining fluvio-lacustrine system (Exon 1976, Swarbrick 1974) or alternatively as a southerly prograding axial trunk drainage (Leblang 1981, Sliwa & Estrele 2008, Scott 2008, Hamilton 2011).

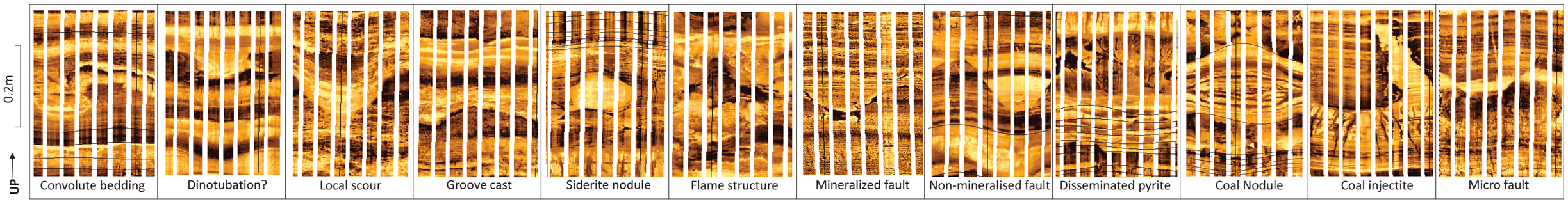


A: Hypothesis; B: Alternate hypothesis

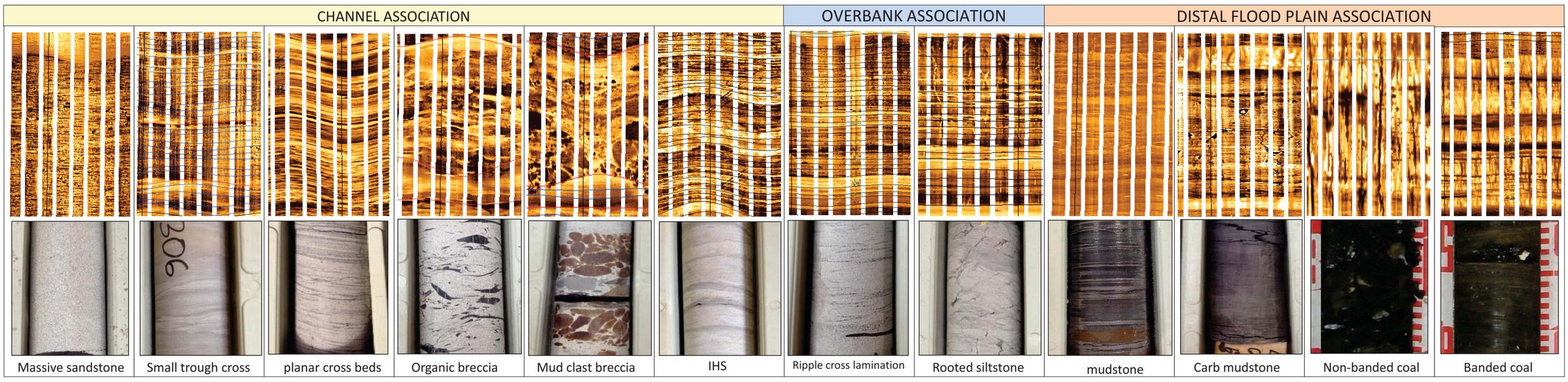
METHODS & OBSERVATIONS

- Bore hole Image (BHI) logs are high resolution micro-resistivity wireline tools used to generate an image like representation of a borehole annulus. Once calibrated to core, the interpretation of these "images" allows for improved insights into the nature of Walloon sediments, particularly in-channel sandstones.
- Integration of core descriptions with BHI interpretation and distributions of dip magnitude, scatter and bedset thickness has allowed for the identification of three distinct styles of in-channel sandstone:
  1. Inclined heterolithic stratification (IHS) due to lateral accretion of point bars;
  2. Trough cross stratification due to migration of 3D dunes;
  3. Inclined planar tabular stratification due to migration of 2D dunes.
- The fluvial styles recognized in BHI reflect systematic changes in depositional process; reconstruction of which is useful in elucidating the regional organization of fluvial styles contained within the Walloon alluvial system.

SEDIMENTARY STRUCTURES IN BHI

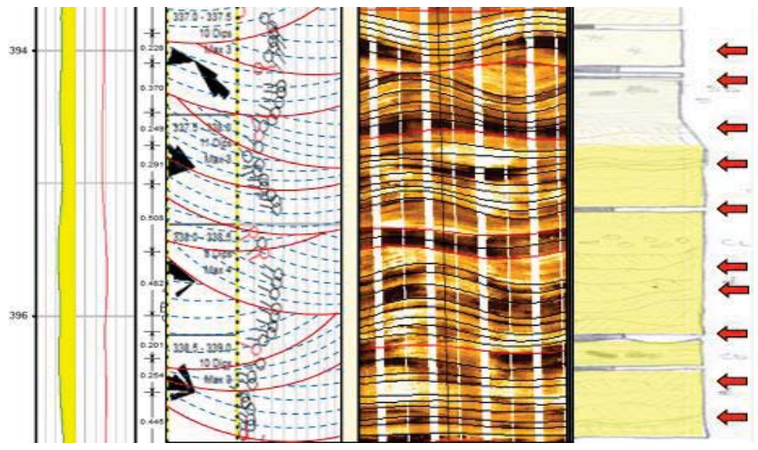


WALLOON ENVIRONMENTS & CONSTITUENT LITHOFACIES



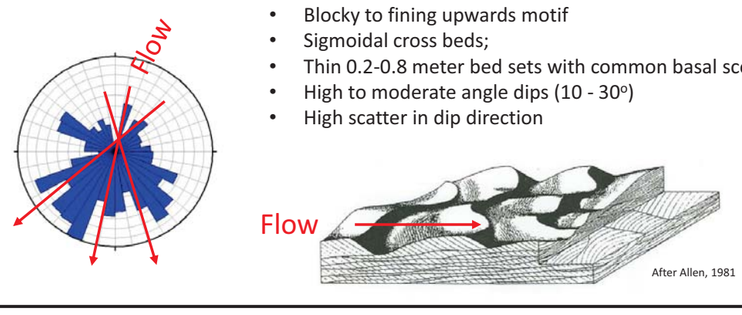
INTERPRETATION OF FLUVIAL PROCESS

TROUGH CROSS STRATIFICATION

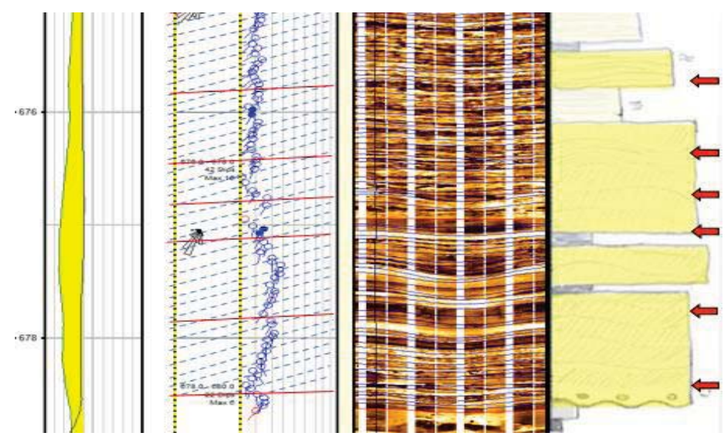


LINGUOID DUNE MIGRATION

- Blocky to fining upwards motif
- Sigmoidal cross beds;
- Thin 0.2-0.8 meter bed sets with common basal scour
- High to moderate angle dips (10 - 30°)
- High scatter in dip direction

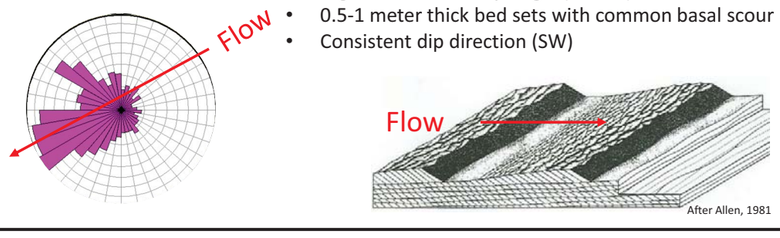


PLANAR TABULAR STRATIFICATION

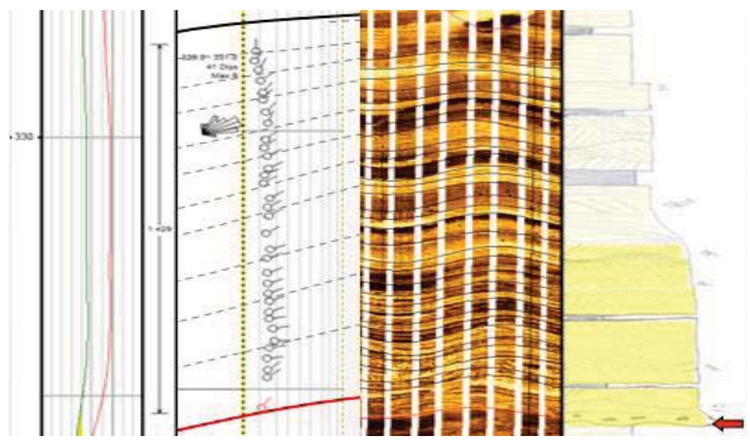


TRANSVERSE BAR MIGRATION

- Blocky to fining upwards motif
- Planer cross beds
- High to moderate dip angle (10-30°)
- 0.5-1 meter thick bed sets with common basal scour
- Consistent dip direction (SW)

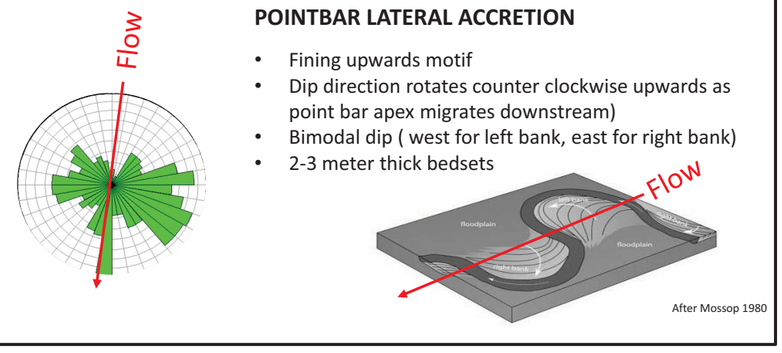


INCLINED HETEROLITHIC STRATIFICATION (IHS)



POINTBAR LATERAL ACCRETION

- Fining upwards motif
- Dip direction rotates counter clockwise upwards as point bar apex migrates downstream)
- Bimodal dip (west for left bank, east for right bank)
- 2-3 meter thick bedsets



DISCUSSION

- Core-based genetic classification of Walloon sediments has identified three overriding environments of deposition, composed of seven alluvial architectural elements:
  - Channel association: thalweg, pointbar, abandonment
  - Overbank association: splays, proximal flood plain
  - Distal flood basin: peat mires, small lakes
- In-channel sandstones were further studied via borehole image-log (BHI) analysis and classified into vertically aggrading (straight crested transverse and three-dimensional linguoidal bars) or laterally accreting (pointbar) successions. Composite successions containing both types are also present.
- Existing fluvial research (Miall 1977, Allen and Allen 1980, Rust 1987) has developed a fourfold for classification of river type based on channel sinuosity and occurrence: low sinuosity single channel (straight), high sinuosity single channel (meandering), low sinuosity multiple channel (braided), and high sinuosity multiple channel (anastomosing).
- The Walloon depositional system is complex; however spatial and temporal fluctuations in fluvial process reflect changes in the character of the overall alluvial system. Towards the central-north regions of the basin the identification of channel successions dominated by IHS deposits indicates lateral migration of point bars and suggests the presence of a southerly oriented meandering river system. In the south-eastern portions of the basin fluvial successions are dominated by small-scale vertically aggrading bar-forms, interpreted to represent sediments of a southerly oriented anastomosing or distributive fluvial system. The absence of pointbar deposits indicates that river meanders in these regions were insufficient to develop helical flow (Bridge 1995) and suggests low sinuosity fluvial system with vegetated banks. Sediment dispersion in the north eastern portion of the basin appear to be towards the west, perhaps feeding the southerly oriented anastomosing or meandering system.
- Synthesis of observations supports the alternative hypothesis with gross sediment dispersion patterns oriented predominantly towards the south and a progression from a meandering system in the north to an anastomosing system in the south.