

Ichnofabrics vs. Ichnofacies: A Field-Based Test of Spatial Recurrence in Shallow-Marine Successions

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Introduction

In recent years, ichnofabric analysis has been presented as a high-resolution ichnological technique for effective characterization of the subsurface (e.g., Taylor *et al.*, 2003). The ichnofabric contention is that ichnofacies analysis is outdated and too generalized to permit refined interpretations of facies. To the ichnofacies analyst, however, ichnofabric characterizations reflect only bed-scale changes in ichnogenera within the facies and focus on the spatially variable overprinting of largely contemporaneous biogenic structures. Such an approach fails to accommodate the ethological commonality of such variations, and therefore obscures facies-level mapping of the successions.

In order to test the usefulness of the ichnofabric technique, analyses of 35 sections were undertaken from the Early Permian Wasp Head, Pebbly Beach and Snapper Point formations, south Sydney Basin, Australia (Figures 1 and 2; Bann *et al.*, 2004). These units are exquisitely exposed along the coast, owing to wave washing during high tide, which cleans the sections and affords near core-quality expressions. The facies successions selected represent offshore to shoreface, prodelta to distal delta front, shelf to lower offshore, and estuarine-embayment settings.

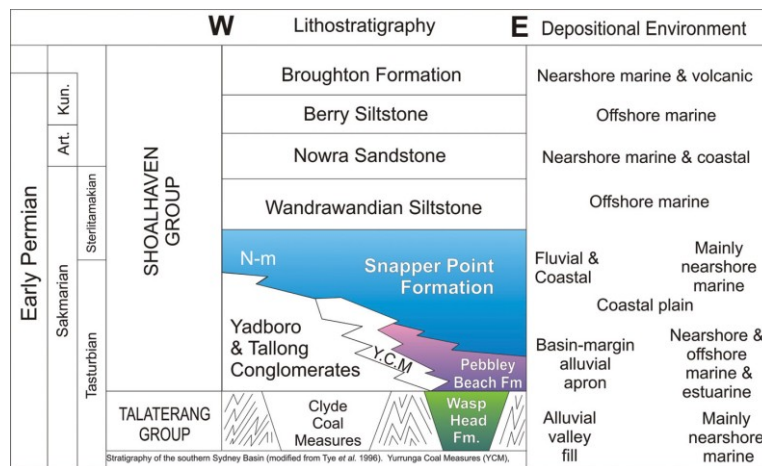


Figure 1: Stratigraphic relationships of the Early Permian, south Sydney Basin, Australia (modified after Tye *et al.*, 1996).

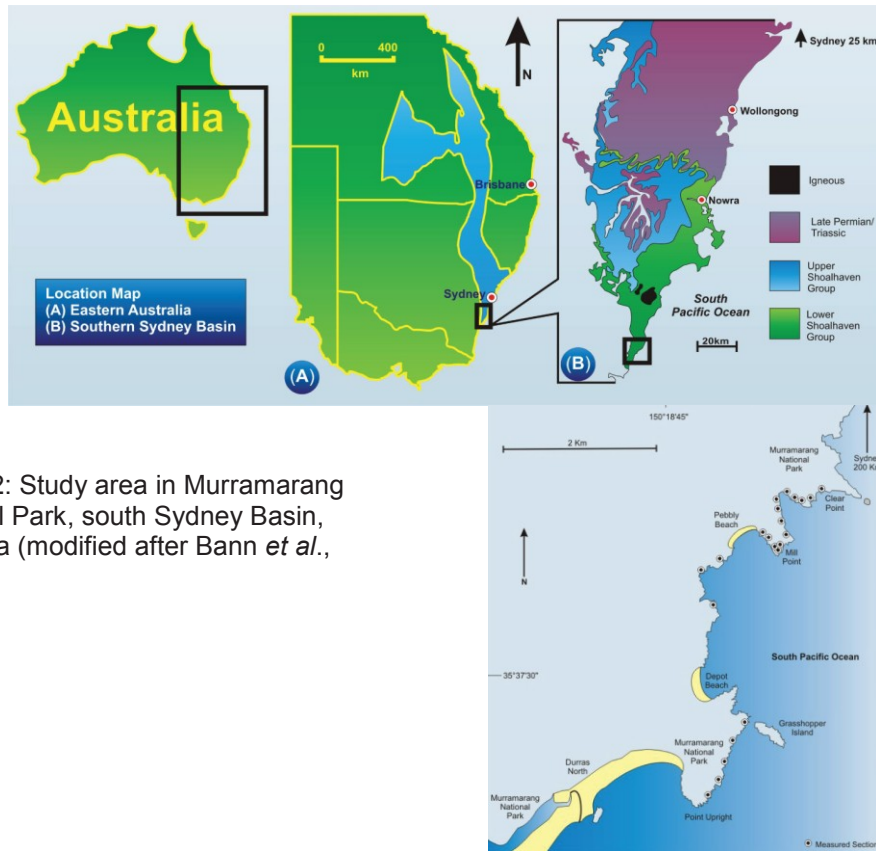


Figure 2: Study area in Murramarang National Park, south Sydney Basin, Australia (modified after Bann *et al.*, 2004).

Methodology and Results

Measured sections were described across 10 cm widths, equivalent to that provided by a standard (4 inch-diameter) hydrocarbon exploration core. Successions were evaluated from both an ichnofabric and ichnofacies perspective. Following the published protocols of Bromley (1996) and Taylor *et al.* (2003), ichnofabric analysis included: 1) assessment of Bioturbation Index; 2) characterization of trace-fossil tiering relationships; and 3) construction of constituent diagrams (Fig. 3). Ichnofacies analysis identified trace-fossil suites, relative proportions of ichnogenera, Bioturbation Index, uniformity of burrowing, and an ethological evaluation, following the protocols of Pemberton *et al.* (1992).

For each comparison, two sections, lying 0.5 - 4.3 m apart, were measured within the same bedsets. Sections in heterolithic units were spaced more closely than those typified by uniform facies intervals, in order to minimize bed-scale changes. Lithofacies correlations exceeded 90% consistency in most examples.

In most instances, each bed intersection yielded a unique ichnofabric. Virtually no predictable recurrence of ichnofabrics could be established between section stations, *even within the same bed*. The highest recurrence detected was in the unburrowed beds (BI 0). Deltaic units of the Wasp Head showed spatial recurrence of ichnofabrics that varied from 0%-14% across distances of only 0.5-1.5m (Fig. 4). Unit 7 (on the left column) correlates lithologically to Unit 6 (on the right column), but they possess discrete ichnofabrics (*Rosselia-Palaeophycus* ichnofabric compared to *Planolites-Chondrites* ichnofabric). More uniform facies of the lower shoreface, offshore and inner shelf from the Snapper Point Formation showed ichnofabric recurrence of 8-12% across distances of 1.0-4.3m. The marked lack of ichnofabric recurrence calls into question the utility of the approach in subsurface studies where wells are spaced hundreds of meters to kilometers apart.

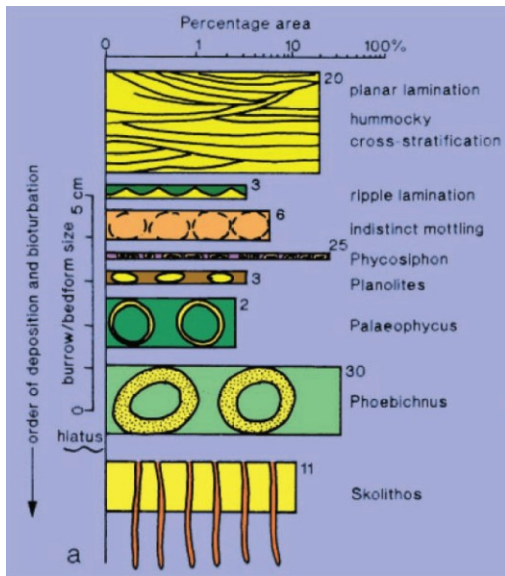


Figure 3: Example of a constituent diagram constructed for a single unit, in order to assign ichnofabric (modified from Bromley, 1996). This example would be described as a *Phoebichnus-Phycosiphon-Skolithos* composite ichnofabric.

An ichnofacies designation would correspond to a low-diversity archetypal expression of the *Cruziana* Ichnofacies marking recolonization following tempestite emplacement. The facies is cross-cut with palimpsest softground *Skolithos*, reflecting recolonization of the substrate under higher energy conditions.

Additionally, ichnofabric description rates for heterolithic sections of the Wasp Head Formation varied from 1.1-2.9 hours/m (average 1.8 hrs/m). Uniformly burrowed Snapper Point facies ranged from 1.3-3.7 hours/m (average 2.3 hrs/m). The ichnofabric approach is clearly temporally impractical for routine outcrop mapping or core evaluation, particularly given their lack of spatial recurrence.

By contrast, ichnofacies analyses yielded trace-fossil suites that not only recur between the measured sections, but extend for considerable distances along depositional strike as well. Datasets permitted characterization of sedimentary facies, depositional conditions, and paleoenvironmental interpretations. Ichnofacies assessments were also time efficient, averaging 0.3 hours/m and could be integrated with the sedimentological data as the sections were logged. This combination indicates that the ichnofacies approach is effective for both outcrop and subsurface studies.

Conclusions

This field-based test demonstrates that there is no basis for depositional interpretations and bed correlations founded solely upon an ichnofabric dataset. The multiple ichnofabrics identified do not recur and ultimately must be grouped together, independent of their cross-cutting relationships. Only by evaluating the ichnofabrics ethologically in the context of the ichnofacies paradigm can they be utilized in any meaningful way to characterize the paleoenvironment.

References

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These 2 sections are 0.84 m apart and show excellent bed-scale lithologic correlation.

Of the 22 beds described, however, only 4 show recurrence of ichnofabrics (18%) (Units 9 and 8; Units 12 and 10) - **But** only 2 of these are *actually* burrowed (Units 12 and 10 have a BI of 0).

Actual recurrence of ichnofabrics across 84 cm of section is 2 beds out of 22 (9%).

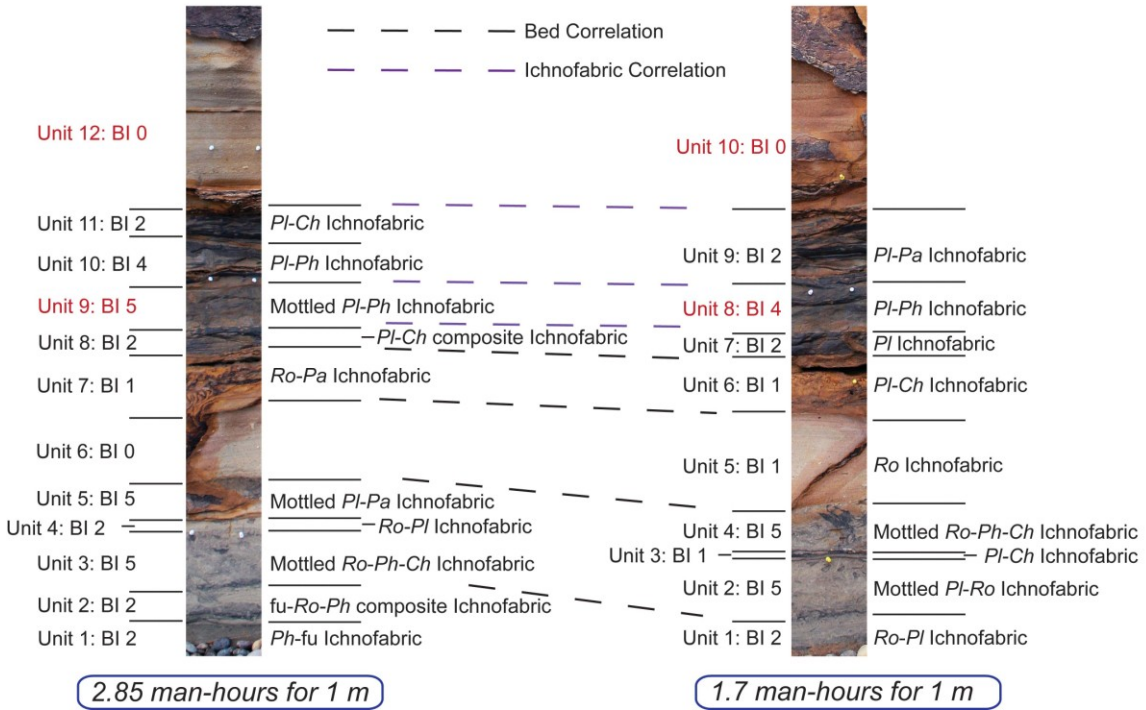
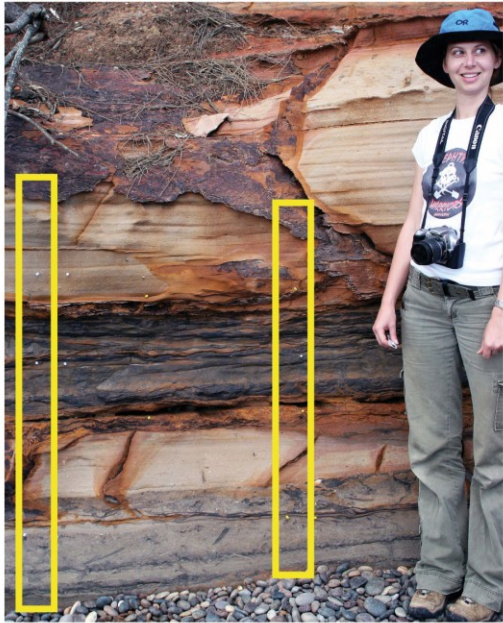


Figure 4: An example of ichnofabric variability in two closely spaced intervals of storm-influenced delta-front sandstone, Wasp Head Fm, South Pebbles Beach, Australia. BI corresponds to Bioturbation Index. *Ro* = *Rosselia*, *Pl* = *Planolites*, *Ch* = *Chondrites*, *Ph* = *Phycosiphon*, *Pa* = *Palaeophycus*, *fu* = fugichnia. Units in red type show recurring ichnofabrics (although Unit 9 shows a precursor mottled fabric unlike Unit 8). Note that Unit 12 (left column) and Unit 10 (right column) are unburrowed.