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Hybrid Event Beds in the Lower Triassic Montney Formation Unconventional Play of the Elmworth Area, Western Alberta

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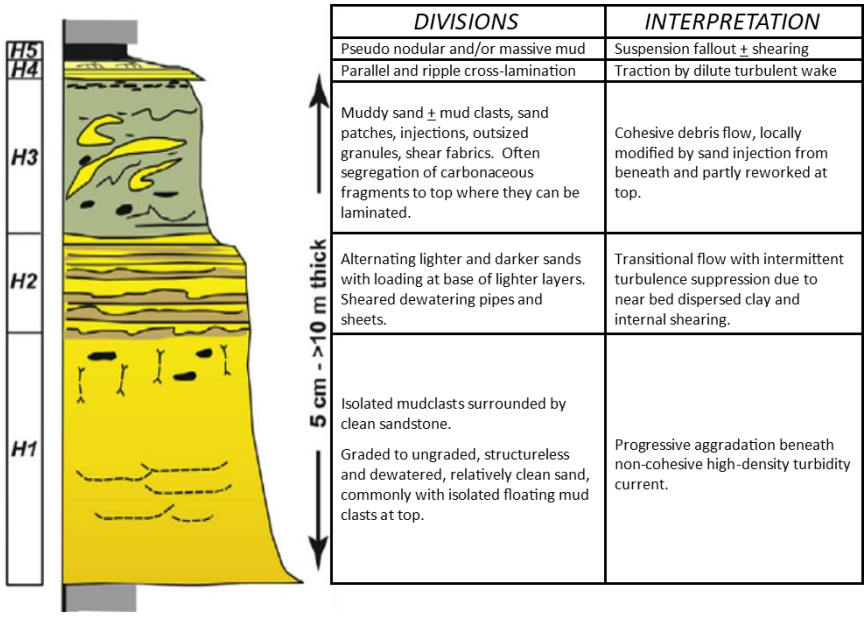
Summary

Hybrid event beds have been recognized in a thick and laterally extensive stratigraphic interval of the Lower Triassic Montney Formation in the Elmworth Area. The term hybrid event bed was introduced by Haughton et al., 2009 to describe a common bed motif (Figure 1) in deep-water successions occurring alongside more familiar turbidity current deposits such as turbidites. The ideal hybrid event bed records the passage of an initial turbulent region of a subaqueous sediment gravity flow that deposits the basal division (H1). This is followed by the onset of transitional flow conditions (depositing the H2 division), and then the arrival of sections of the flow where turbulence was dampened or never fully developed, resulting in a deposit that was emplaced en masse essentially as a cohesive debris flow (H3 division). The ideal hybrid event bed is completed by a dilute turbulent wake from the same flow event (depositing H4) and finally, by fallout of suspended mud depositing an H5 division (Pierce et al., 2018).



DIVISIONS	*INTERPRETATION*
Pseudo nodular and/or massive mud	Suspension fallout ± shearing
Parallel and ripple cross-lamination	Traction by dilute turbulent wake
Muddy sand ± mud clasts, sand patches, injections, outsized granules, shear fabrics. Often segregation of carbonaceous fragments to top where they can be laminated.	Cohesive debris flow, locally modified by sand injection from beneath and partly reworked at top.
Alternating lighter and darker sands with loading at base of lighter layers. Sheared dewatering pipes and sheets.	Transitional flow with intermittent turbulence suppression due to near bed dispersed clay and internal shearing.
Isolated mudclasts surrounded by clean sandstone. Graded to ungraded, structureless and dewatered, relatively clean sand, commonly with isolated floating mud clasts at top.	Progressive aggradation beneath non-cohesive high-density turbidity current.

Figure 1 - Schematic log showing ideal organization of a typical five-part hybrid event bed (Haughton et al., 2009). All five divisions (H1–H5) are deposited from the same flow event. The cohesive debris flow deposit (H3) within the hybrid event bed contains mud clasts. Specifically, the presence of mud clasts within this unit is the key to recognizing hybrid event beds in the Montney and other formations.

Examples of Hybrid Event Beds in the Montney Formation at Elmworth

All of the H1–H5 divisions and sedimentary features described in Figure 1 have been observed in hybrid event beds (HEB) in the Elmworth Area. Typically, however, each HEB in Elmworth is made up of a H1, H3, H4 and H5 division, and the H2 division is absent (Figures 2, 3, and 4). The poor development or absence of a H2 division suggests that the transition from turbulent flow to cohesive debris flow was rapid within that particular event (Fonnesu et al., 2015). HEBs at Elmworth are 20–40 cms thick and occur within a stratigraphic interval that is up to 45 m thick. HEBs have been observed in cores over a vast region, covering at least 65 townships.

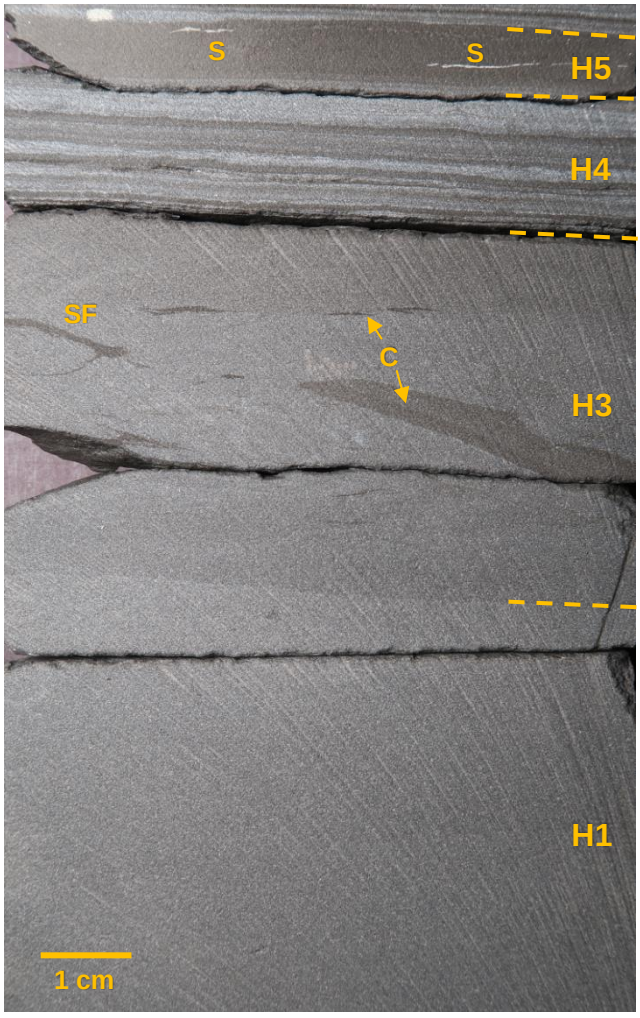


Figure 2 - Hybrid event bed from 2793.8 m in well 13-6-69-8-W6M. **H1**-Basal structureless (i.e. massive) relatively clean siltstone deposited from the initial turbulent region of a flow (only a portion of H1 is shown). **H3**-Chaotic division of argillaceous siltstone with mudstone clasts and siltstone clasts (C) deposited as a debrite as the flow evolved from a turbulent flow into a cohesive debris flow. At SF is an example of a shear fabric, a characteristic of H3 divisions, produced while the debris flow was moving. Shearing within the flow resulted in silt being injected into the dark clast and tearing/delaminating the clast. H3 is darker than the underlying H1 due to increased argillaceous content (i.e. clay minerals) and organic content derived from erosion of the sea floor by the flow. **H4**-Parallel laminated siltstone deposited by the dilute turbulent wake that trailed the debris flow. **H5**-Massive mudstone that was deposited as clay size particles and *Claraia* shells (S), scoured from the seabed and suspended by the flow into the water column, settled immediately after the flow had passed. Beds H1–H5 were deposited by the same flow event. (Mudstone is underlined to emphasize that the H5 bed is distinctly finer grained than the siltstones below it and above it).

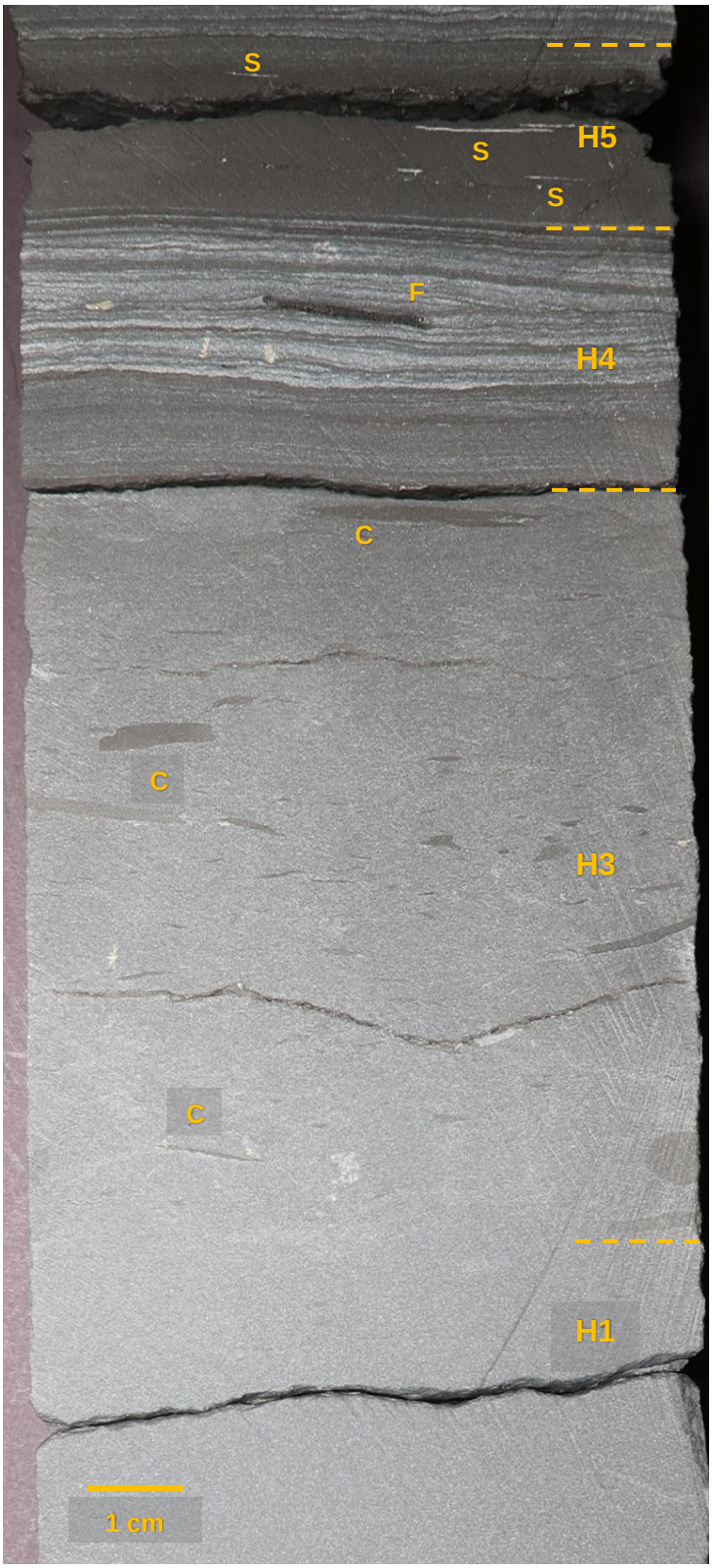


Figure 3 - Hybrid event bed from 9 m deeper in the same well (13-6-69-8-W6M) at 2802.7 m. **H1**-Basal structureless relatively clean siltstone deposited from the initial turbulent region of a flow (only a portion of H1 is shown). **H3**-Chaotic division of argillaceous siltstone with mudstone clasts and siltstone clasts (C) deposited as the turbulent flow evolved into a cohesive debris flow. **H4**-Parallel laminated siltstone deposited by the dilute turbulent wake that trailed the debris flow. **H5**-Massive mudstone that was deposited as clay size particles and *Claraia* shells (S), scoured from the seabed and suspended by the flow into the water column, settled immediately after the flow had passed. The *Claraia* shells were generally deposited in the concave-up settling position. Also note the fossilized bone or plant fragment (F) with a delicate angular edge, interpreted as evidence that the fragment was sheared (i.e. torn apart) within the flow. The H2 division is absent, presumably because within this particular flow event, the transition from turbulent flow to cohesive debris flow was rapid.

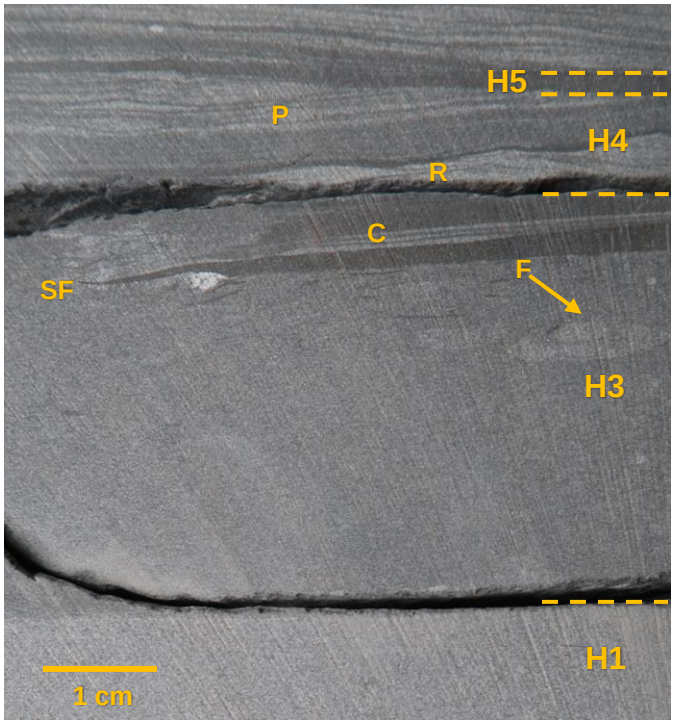


Figure 4 - Hybrid event bed (HEB) from 2362.6 m in well 13-23-68-5-W6M. This HEB is in the same stratigraphic interval as the previous two examples, but is 35 km distant. **H1**-Basal structureless relatively clean siltstone deposited from the initial turbulent region of a flow (only a portion of H1 is shown). **H3**-Chaotic division of argillaceous siltstone with mudstone clasts and siltstone clasts (C) deposited as the flow evolved from a turbulent flow into a cohesive debris flow. Note on the left side of the clast (SF) the very 'delicate', thin and angular edge preserved. This is another excellent example of a shear fabric, which is a characteristic of H3 divisions. The clasts are sheared (i.e. torn apart) within the flow or from the sea floor, but then not subjected to much further erosion within the flow (i.e. the eroded angular clasts were preserved as they were transported in a cohesive debris flow). H3 is darker than the underlying H1 due to higher argillaceous (clay minerals) and organic contents. Bed foundering (F), which will be presented in further detail at the Core Conference. **H4**-Current ripple (R) and parallel laminated (P) siltstone deposited by the dilute turbulent wake that trailed the debris flow. **H5**-Massive mudstone that was deposited as clay size particles settled immediately after the flow had passed.

Conclusions

To the author's knowledge this is the first time that hybrid event beds have been recognized in the Western Canada Sedimentary Basin. The hybrid event bed depositional model is a likely solution to the puzzle of how 'delicate', angular, soft mud clasts were deposited in the Montney Formation. During the Core Conference additional information will be presented regarding the unique sedimentology of hybrid event beds including: bed foundering, dewatering structures, and outsized clasts. The author will also present photographs and observations compiled during a geological field trip to examine hybrid event beds in County Clare of western Ireland.

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