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Glossifungites-Demarcated Stratigraphic Surfaces: Landward Limits of the Omission Suite Paradigm

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Summary
One of the most important contributions S. George Pemberton made to the field of ichnology was the identification of important sequence stratigraphic surfaces where they are colonized by fauna generating firmground burrows associated with the *Glossifungites* Ichnofacies. The study herein considers a field example from the Turonian Ferron Sandstone of central Utah, where suites of the *Glossifungites* Ichnofacies are preserved spatially close to marginal-marine settings, but may have been colonized in channels under low salinity conditions. The importance and implications of these firmground trace fossil occurrences are considered.

The recently re-erected ichnogenus *Glossifungites* is a horizontal to oblique, passively-filled, scratch-marked, tongue-shaped trace fossil with a depressed central area (Belaústegui et al. 2016). It is a noted component of *Glossifungites*-demarcated stratigraphic discontinuities associated with erosion, followed by brackish-water to marine conditions over the exhumed stiff/firmground (Vitális 1961; Pemberton and Frey 1985; MacEachern et al. 1992; Pemberton et al. 1992; Nouidar and Chellaï 2002; Rodríguez-Tovar et al. 2007; Savrda et al. 2016). Typically, these trace suites are related to erosional nearshore processes or, less commonly, submarine channel development offshore (Dasgupta and Buatois 2012). In this study, occurrences of the *Glossifungites* Ichnofacies are seen along three surfaces at the bases of small channels in two locations. These channels are encased in coastal plain, weakly developed gleyed paleosols containing coal, suggesting a more landward affinity than previously reported assemblages of the ichnogenus *Glossifungites*.

Results, Observations, Conclusions
The *Glossifungites*-based channels lie below the “I” and “J” Coal intervals of the Last Chance depocenter in the upper Ferron Sandstone. These intervals are linked to the basinward Parasequence Sets 5 and 6 that represent retrogradation of the Ferron shoreline before complete inundation of the region (Garrison and van den Bergh 2004). These channels are several hundred meters wide, with sandbodies less than nine metres thick that display trough cross-beds and little mud content in the basal portion of the interval. No distinctive *in situ* trace fossil indicators of brackish-water or marine conditions are observed in the overlying strata, but *Teredolites*-bored clasts are present sporadically. Along the channel bases, the firmground-associated trace fossils are sparse to moderate in abundance. By contrast, the cutbank margins are pervasively burrowed (Figure 1a,b). *Glossifungites* specimens are 1.5-5.3 cm wide, up to 7 cm long, and commonly <1 cm thick. Millimetre-wide bioglyphs (scratch marks) radiate out from the center of the trace fossils in a criss-cross, net-like pattern (Figure 1c). Their sizes are inconsistent with the diminutive u-shaped traces noted for firmground colonizers in modern examples, which respond to short-term autogenic depositional processes (Gingras et al. 2001; Hodgson et al. 2015). However, one of the studied outcrops does display two stacked sandbodies, each characterized by a *Glossifungites*-demarcated base, which may represent autogenic events or the stacking of discrete allogenic discontinuities. Five facies underlie the

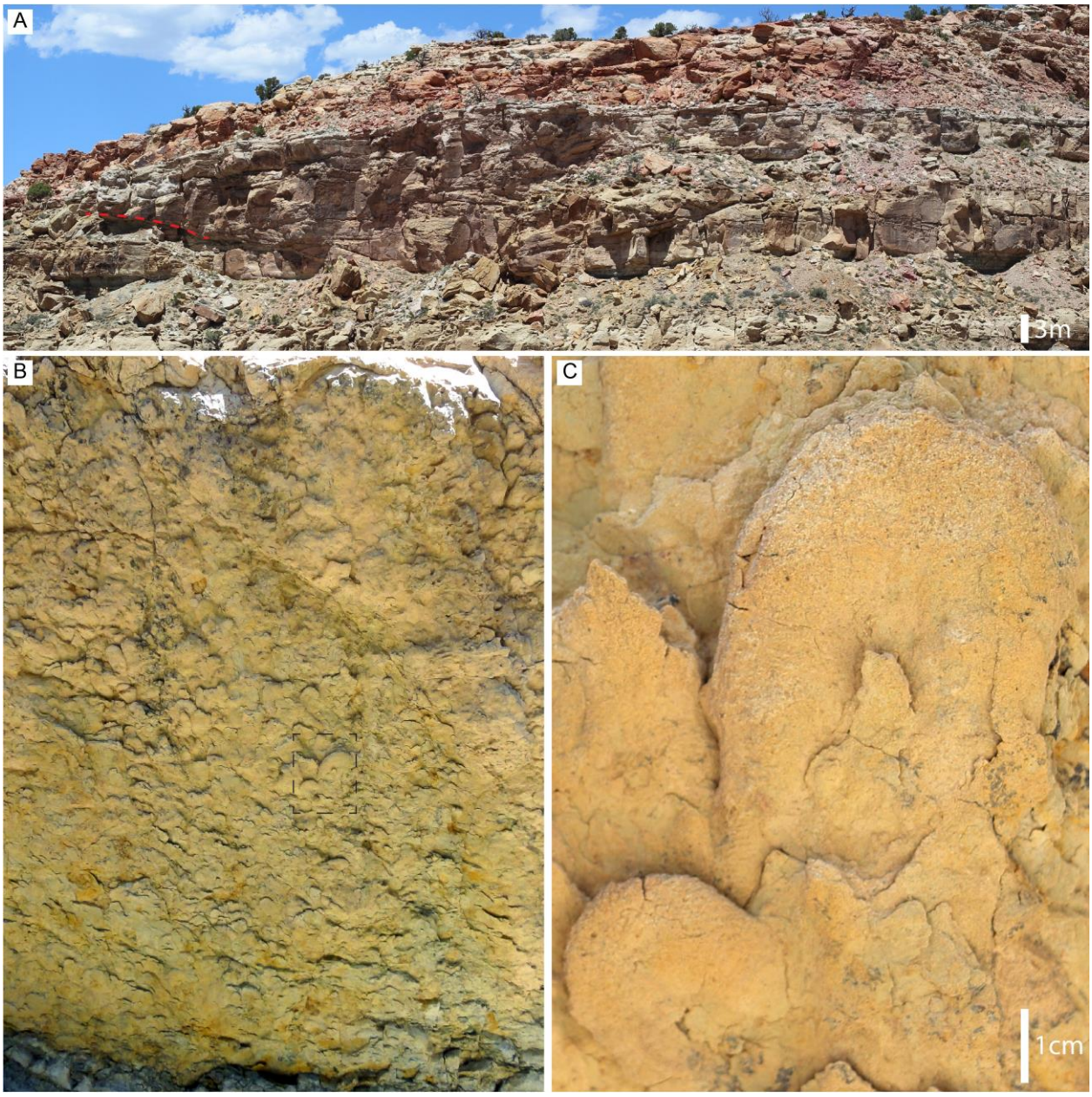

Figure 1: *Glossifungites* in the Ferron Sandstone: A) Location of high-density *Glossifungites* along channel cutbank (red dashed line), B) Photo of the underside of this surface with near complete coverage by *Glossifungites*, black box marks location of the photo in 1c, and C) Close-up of scratch marked *Glossifungites*.

three *Glossifungites*-demarcated surfaces, representing gleyed, weakly developed paleosols, mud-dominated channel heterolithics, and local tidal channel heterolithics dominated by *Lockeia*. This study potentially expands our view of *Glossifungites* Ichnofacies occurrences, which is important, because examples of *Glossifungites* closely related to channel sandbodies are less common than associated with wave-cut discontinuities. Additionally, these examples open the door to important sedimentological and ichnological questions about estuarine facies models in relation to sand-dominated constituents, why there is a lack of colonization or preservation of trace fossils in these channels where marginal-marine trace suites of *Glossifungites* Ichnofacies models comprise the base, and whether these surfaces tie into the local or regional stratigraphy.

These monospecific assemblages in the Ferron Sandstone share similar low-diversity, high-abundance ichnofauna typically associated with the *Glossifungites* Ichnofacies of Frey and Pemberton (1984) and

Gingras et al. (2001). However, along the bases of these channels, the *Glossifungites* are either of moderate to high abundance, or sparse to absent, which appears to be related to a factor such as slope of the channel. Where there is a slope, *Glossifungites* is abundant, but in flatter profiles, *Glossifungites* may be absent. This indicates an ethological preference or perhaps a barrier – the need to have the burrow roughly horizontal to flow.

Novel/Additive Information

This study shows evidence of monospecific *Glossifungites* assemblages more landward than previously reported examples in the literature. These *Glossifungites*-demarcated surfaces delineate basal contacts of small channel bodies that appear to represent estuarine conditions. These examples from the Ferron Sandstone expand the known *Glossifungites* Ichnofacies models, which is to the benefit of deciphering localized *Glossifungites*-demarcated surfaces when viewed in core.

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