

## Two contrasting occurrences of the trace fossil *Lockieia* from Alberta, and their palaeoenvironmental significance

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### Summary

An outcrop from the Oldman Formation in Dinosaur Provincial Park exposes the celebrated “clam bed”, comprising numerous specimens of the bivalve resting trace *Lockieia amygdaloides*, made by Campanian unionids. The bed is capped by fugichnia as the bivalves climbed upwards through sediment deposited during a flash flood. The traces occur in a striking, dull orange, series of point bar deposits associated with a meandering channel.

A second outcrop of the Paleocene Porcupine Hills Formation, exposed on the banks of the Bow River in Cochrane, also exposes *Lockieia*, although the morphology of the trace fossils and depositional setting are very different. Rather than the almond shaped traces observed in Dinosaur Provincial Park, the *Lockieia* specimens from the Paleocene outcrop are symmetrical, inverted frustra, around 10 cm in diameter. They occur in tabular, fluvial sandstone deposits, interpreted as having been deposited in a low sinuosity channel associated with crevasse splay deposits. It is believed that this species of *Lockieia* has not previously been described. It is postulated that the contrasting fluvial channel morphologies may explain the differing character of the associated bivalve dwelling traces

### Theory and methodology

Bivalve resting traces representing two different species were recognized at two outcrops of different stratigraphic ages in Alberta, both of which were deposited in fluvial settings. A series of sedimentological logs were measured at each outcrop and interpreted in terms of their depositional settings, demonstrating that the Cretaceous outcrops were deposited in a meandering fluvial setting (Noad 1993; Hamblin 1997), while the Paleocene outcrop were deposited in a low sinuosity channel setting, possibly indicating a steeper palaeo-gradient.

The contrasting morphologies of the two bivalve resting traces were also recorded, and attempts made to explain their contrasting character based on the differences in depositional settings.

### Observations

The outcrops in Dinosaur Provincial Park extend for more than 2 km and represent the point bars deposited by a single meandering channel. They are characterized by thinly interbedded, dull orange coloured, lateral accretion surfaces. The basal portion of the channel deposit features abundant unionid fossils and steinkerns, overlain by inclined heterolithic stratification

(IHS). These beds typically dip at 5 to 20 degrees, and are composed of interbedded siltstone and mudstone beds, ranging from a few centimetres to more than 50 cm in thickness.

Bivalve domichnia are abundant over the interval with IHS (Johnson and Hendy 2005), and range from dwelling traces to interpreted fugichnia, with stacked *Lockiea* fossils. These fossils are interpreted to indicate possible flooding and rapid deposition of sandy sediment that forced the bivalves to ascend through the sediment. Modern counterparts to the unionid bivalves that created these structures prefer sluggish rivers with muddy substrates, which may indicate a generally low flow regime.

The outcrop in Cochrane is thought to be from the Paleocene Porcupine Hills Formation, based on fossil mammal remains collected from a lag at the base of one of the channels. It is believed that the outcrop is preserved within the Triangle Zone affecting the foreland basin termed the Western Canada Sedimentary Basin. The outcrop has not been described in the literature and exposes smaller nested channels and more sheet-like channel deposits. A bed with striking bivalve domichnia, closely associated with unionid body fossils, occurs near the base of one of the sheet-like sandstone beds.

The channel sandstone beds are made up of trough cross-bedded sandstone, which may indicate a braided flow regime, in contrast to the channel deposits seen in Dinosaur Provincial Park. The fossil occur on a single bedding plane around 20 cm above the base of one of the sheet-like sandstone beds, in association with a variety of other trace fossils indicating a pause in deposition.

The *Lockiea* fossils have the appearance of small inverted volcanoes (frustra), with the unionid preserved within the central crater. These structures are typically around 10 cm in diameter. They appear to be restricted to a single bedding plane, protruding a few cm downward from this plane. They have smooth sloping surfaces which narrow towards the basal dwelling area. They are believed to be a previously undescribed species, which here are termed *Lockiea pembertoni*, after the late, great ichnologist George Pemberton, who recently passed away.

## Interpretation

The contrasting style of the bivalve traces is interpreted to relate to the different depositional settings. Clearly deposition in both channels was slow enough to allow the unionids to flourish, with slow flowing currents. In the case of Dinosaur Provincial Park, the abundant, almond shaped, *Lockiea amygdaloides* are thought to have formed on the bed of a slow moving, meandering channel. The lateral extent suggests a stable channel gradually avulsing through time. At one point, a flood is interpreted to have led to vertical stacking of the domichnia.

The Paleocene deposits from Cochrane feature a completely different type of *Lockiea* trace fossil. The large, robust structures were clearly created by unionids (as shown by the presence of steinkerns at the centre of some of the frustra), but their large size indicates sorting. This may relate to faster currents in a low sinuosity channel, which washed away smaller bivalves, leaving

the larger forms behind. These bivalves may have held themselves more vertically within the sediment, creating a more symmetrical form.

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## References

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Figure 1. *Lockiea pembertonii* fossils