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The Exploited: Ichnologic Analogs for Multi-Lateral Horizontal Oil Drilling Strategies in the Lower Cretaceous Grand Rapids and Clearwater Formations, Upper Mannville Group, Alberta, Canada

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Over the past three years, the Lower Cretaceous (Albian) Clearwater Formation oil play in northern Alberta has grown from its infancy into one of the most economically attractive plays in Canada. Drilling techniques in the Marten Hills area evolved as operators experimented to find the most efficient and profitable way to exploit the resource. This evolution progressed from unsuccessful vertical wells, through using short horizontal wells, to the current design of closely spaced, multi-lateral horizontal wells. Drilling activity during 2018 in the Lower Cretaceous (Albian) undifferentiated Lower Grand Rapids in the Wolf Lake/Garth field area has similarly evolved. The multi-lateral well patterns in both these play areas bear a striking resemblance to those exhibited by the ichnogenera *Chondrites* and *Oldhamia*. These analogous approaches to the efficient substratal exploitation of resources both evolved as a mechanism to survive and thrive in hostile or extreme environments.

Chondritid burrow systems (ichnogenus *Chondrites*) are generally downward branching (ramifying) deposit-feeding structures associated with low oxygen, reducing conditions, wherein the trace-making animal exploits a subsurface environment where food resources were presumably low. The low-resource environment required the *Chondrites* tracemaker to adapt and develop a chemosymbiotic relationship with a microbial biomass that in turn allows it to efficiently exploit and extract maximum solutes from the surrounding pore-water through a subterranean network of branching tubes (Seilacher, 2007; Fig. 1: Schematic model of *Chondrites*). A similar exploitation technique is being employed in the Wolf Lake/Garth Field area of central Alberta, where the operator is likewise exploiting Albian-aged undifferentiated Lower Grand Rapids Formation heavy oil using a branching horizontal drilling pattern (Fig. 2: Plan view and 3D view of wells in Wolf Lake/Garth area).

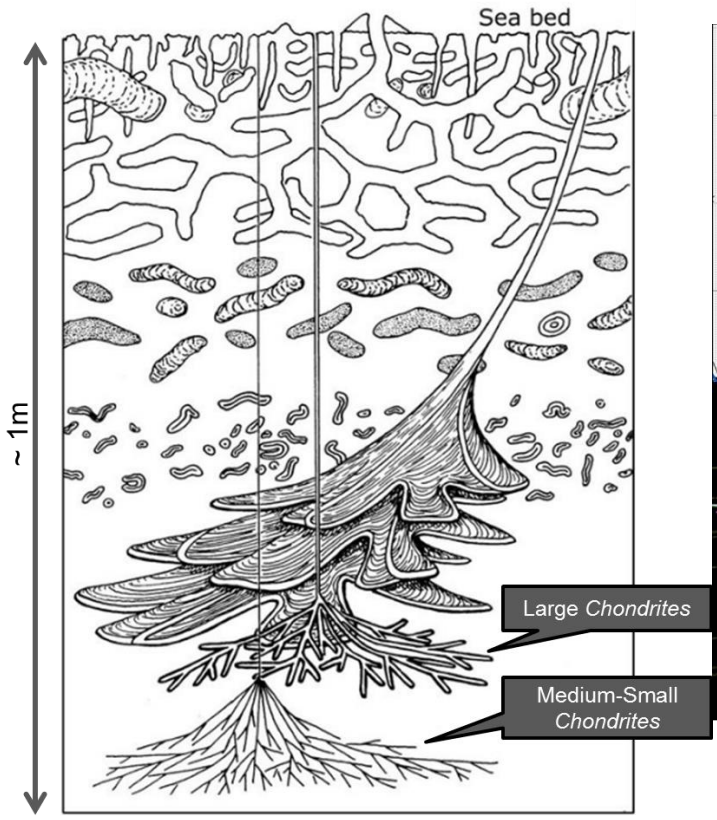

Fig. 1: Schematic of *Chondrites*; note vertical connection to surface plus horizontal and branching morphology in resource-rich feeding layer; Burrows are an extension of the sediment-water interface that provide animals with a means of exploiting sub-sea bed resources (modified from Bromley & Ekdale, 1986)

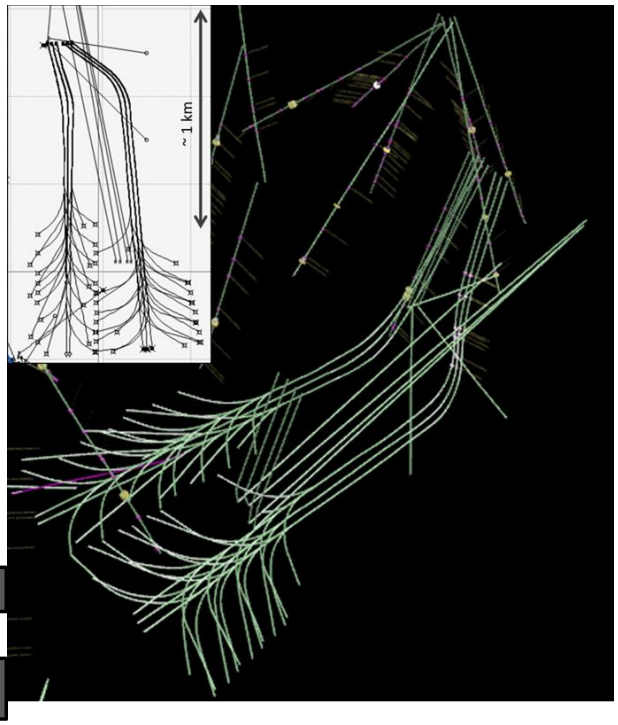

Fig. 2: Branching horizontal exploitation pattern for heavy oil production in the Albian-aged Upper Mannville (3D & Plan Views); drilled from 100/9-32-63-6W4M Surface location to Bottom hole locations in 28,29,32-63-6W4M in the Wolf Lake/Garth area, central Alberta. Exploitation pattern similar to *Chondrites*; note vertical connection to surface plus horizontal and branching morphology in heavy oil bearing Upper Mannville (Undifferentiated Lower Grand Rapids at ~325m TVD)

Oldhamia is another ichnogenus interpreted to represent an effective shallow mining behaviour for the purpose of exploiting resource-poor environments. In contrast to *Chondrites*, *Oldhamia* branches primarily in the horizontal direction, in order to allow the tracemaker to take advantage of food available on the underside of biomats. As such, spatially efficient mining is critical for optimization of food resource acquisition. Specifically, the undermat food resource mining morphology of *Oldhamia flabellata* (Fig. 3) serves as an excellent analog for the present-day state-of-the-art exploitation strategy employed by operators in the Clearwater Formation play in the Marten Hills, Alberta area (Fig. 4). Specifically, in both cases, the horizontal tubes do not intersect, and converge proximally to optimize the volumetric spatial recovery of the exploited resource.

Fig. 3: Plan view of cm-scale *Oldhamia flabellata*: this particular species of *Oldhamia* has a morphology very similar to the drilling exploitation pattern used in the Clearwater Formation. Note that the probes do not intersect and converge at the proximal end (Seilacher, 2007)

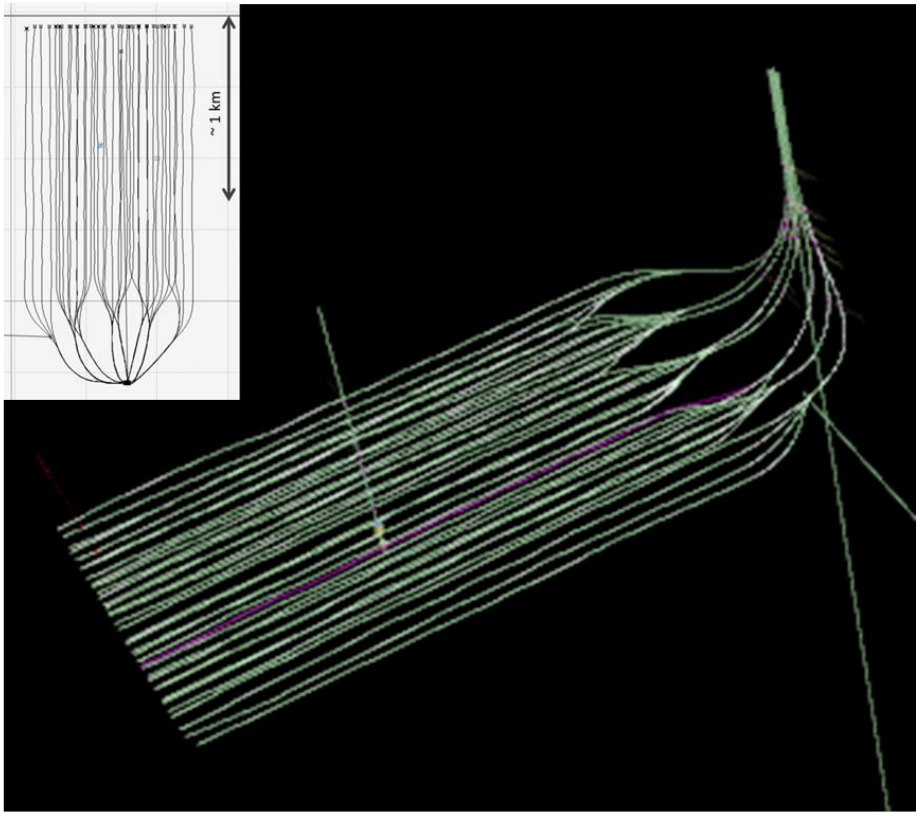

Fig. 4: Plan and 3D view of horizontal drilling and exploitation pattern for heavy oil production in the Albian-aged Clearwater Fm (3D & Plan Views); drilled from 100/11-29-73-24W4M Surface location to Bottom hole locations in 13,14,15-32-73-24W4M in the Marten Hills area, northern Alberta. Exploitation pattern similar to *Oldhamia*; note vertical connection to surface plus horizontal and non-intersecting morphology in oil bearing Clearwater Formation at ~550m TVD

The behaviours used by the *Chondrites* and *Oldhamia* tracemakers make excellent analogs for the drilling and exploitation techniques currently employed in the Western Canadian oil and gas industry today, where horizontal and multi-lateral horizontal drilling are being used similarly to exploit local resource-rich layers within overall resource-poor strata. Two examples of this parallel approach are employed today to exploit the Lower Cretaceous Grand Rapids Formation heavy oil play in the Wolf Lake/Garth field area and the Clearwater Formation oil play in the Marten Hills area.

References

Bromley, R.G. and Ekdale, A.A.,1986. Composite ichnofabrics and tiering of burrows. Geological Magazine, v. 123, p. 59-65.

Seilacher, A., 2007. *Trace fossil analysis.* Springer Science & Business Media. 226p.