

Landscape Evolution of the Pre-Cretaceous Unconformity in the Western Canada Sedimentary Basin: Assessing the Relationship between Antecedent Pre-Cretaceous Topography and Overlying Cretaceous Deposits

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In the Athabasca Oil Sands (AOS) area of the Western Canada Sedimentary Basin (WCSB), the topography of the Pre-Cretaceous Unconformity (PKU) is an important control on the nature and distribution of overlying McMurray Formation (McMurray) deposits, which host the vast bitumen resources of the AOS. The PKU is also likely a conduit for fluid flow, affecting the movement of oil, gas, and water into the system, and, ultimately, the distribution and quality of the bitumen reservoir.

A robust methodology was developed using ArcGIS to query, process, and analyze the large quantity of data necessary to generate a high-resolution regional map of the PKU. The data used are well isopach values from the PKU surface to the base of a maximum flooding event observed regionally during the Albian/Aptian transition. Isopach values were inverted and hung from a datum matching approximately the present-day elevations observed near the zero-edge of the WCSB. Since the PKU landscape evolved under sub-aerial conditions, an interpolation algorithm developed specifically for deriving a hydrologically-correct surface was chosen to grid the PKU surface. The topography of the PKU was subsequently analyzed by a suite of hydrology tools and described in terms of drainage basins.

Many results emerged from visual inspection and spatial analysis of the topography of the PKU. Firstly, as mapped, the topography of the PKU must be the preeminent control on the early accommodation and orientation of the incipient McMurray deposits. Secondly, the topography of the PKU is a structurally controlled landscape, with drainages oriented along two principal axes. The primary axis is approximately coincident with both the bitumen edge and salt dissolution edge; the secondary axis is characterized by trellis drainages. The PKU strongly influenced karsting of the antecedent carbonate units, impacting development of the McMurray and porosity in the bitumen-bearing Grosmont Formation. Thirdly, flow accumulation gridding shows interior drainages: probably lacustrine rather than through-flowing basins. Fine-grained deposition in key paleolows indicates that the McMurray was “passively” infilled and was not responsible for much of the erosional topography of the PKU. Finally, while SAGD projects concentrate along the confluence of major tributaries into the main drainage, it is notable that there does not exist a one-to-one relationship between bitumen thickness and paleo-elevation of the PKU.