



Earthquakes as Probable Causes of Chaotic and Deformed Stratigraphy in an Ancient River Meander Deposit, Dinosaur Provincial Park, Alberta

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Abstract

An ancient (Upper Cretaceous, 77-76.5 Ma, Oldman Formation) river meander deposit, exposed in the Steveville Badlands of Dinosaur Provincial Park, AB., exhibits extensive deformed and chaotically bedded strata. The most impressive features are large scale rotations of inclined heterolithic stratified (sandstone and shale) blocks, up to 6 m high and 50 m long, dipping in the opposite direction to that of the lateral accretion trend (Fig. 2). We observe three separate sets of reversely dipping beds along one badland gully, oriented parallel with the direction of lateral accretion. The large reverse cross-stratified structures rest on shale failure planes, suggesting the structures formed as back-rotational slumps of inclined heterolithic strata that slid down an active point bar slope into the channel before it was buried by subsequent lateral accretion sediments. Chaotic and disturbed sandstone and shale blocks, soft sediment deformation, and evidence for sediment foundering in the upper 3 m of point bar stratigraphy are common throughout the ancient meander bend, atypical of meandering river deposits (Fig. 1). Some of the broken and blocky sandstone strata displays a domino-like effect, with all blocks leaning in the same direction. Overturned sandstone beds resting on interpreted failure planes, attributed to slumping, are suggestive of down-slope failures (Fig. 3). Faulting represents the final form of deformation of stratigraphy with displacements of up to 2 m, and the hangingwall always on the channel side of the meander lobe (Fig. 4). We interpret all of these structures as having been caused by large magnitude earthquakes and tremors associated with Laramide thrusting. The three sets of reversed inclined heterolithic strata encased within normal lateral accretion bedding, are interpreted to record three major seismic events, separated by periods of relative

quiescence. The nearly continuous 3 m of chaotic uppermost strata of point bar and overbank sediments of the former alluvial plain may reflect frequent tremors also associated with orogenic activity, focused at least 250 km to the west. To our knowledge these are the first deformed fluvial deposits attributed to the hypothesis of earthquake shaking in the Western Canada Foreland Basin.

Earthquake-induced deformation structures present in the subsurface could cause misleading interpretations of core and wireline log data, resulting in inaccurate delineation of prospective hydrocarbon plays in fluvial deposits. Meander belt deposits are common in both the Mannville and Belly River groups, which in turn, were deposited during periods of orogenic activity in the Cordillera.



Figure 1. The spatially ubiquitous loading structures (white arrow) in the upper 3 m of muddy point bar and overbank sediments of sandstone and mudstone within the entire meander lobe are interpreted to have been caused by frequent tremors. Note the overlying coaly horizon identified by the black arrow.

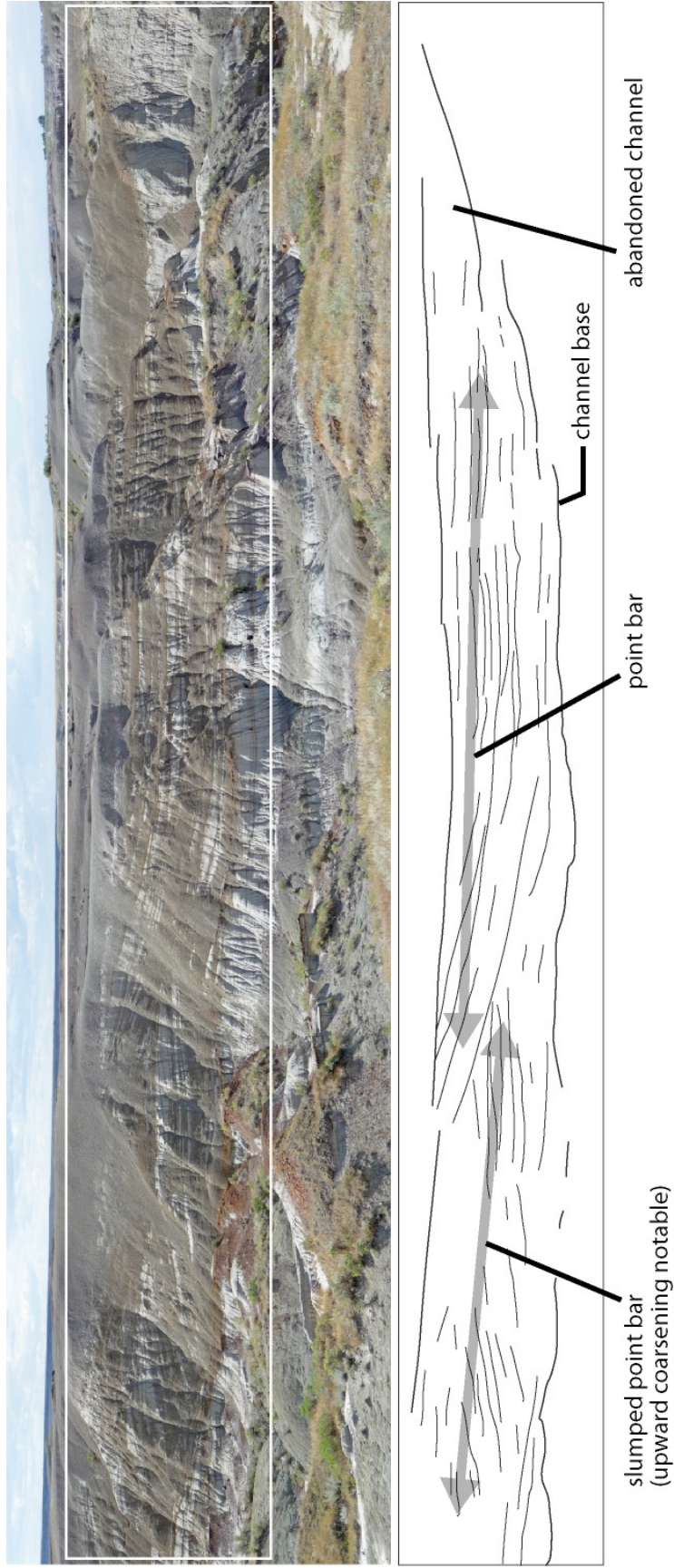


Figure 2. Overview photograph and line-drawing trace of point bar deposits highlighting stratigraphic relationships in the study area. Large scale rotated blocks (labeled as slumped point bar) of inclined heterolithic strata are overlain by mudstone-dominated lateral accretion deposits. Note the upward-coarsening apparent in the slumped point bar deposit, which rests on a failure plane. These large back-rotational slope failures are interpreted to have been caused by large magnitude earthquakes.

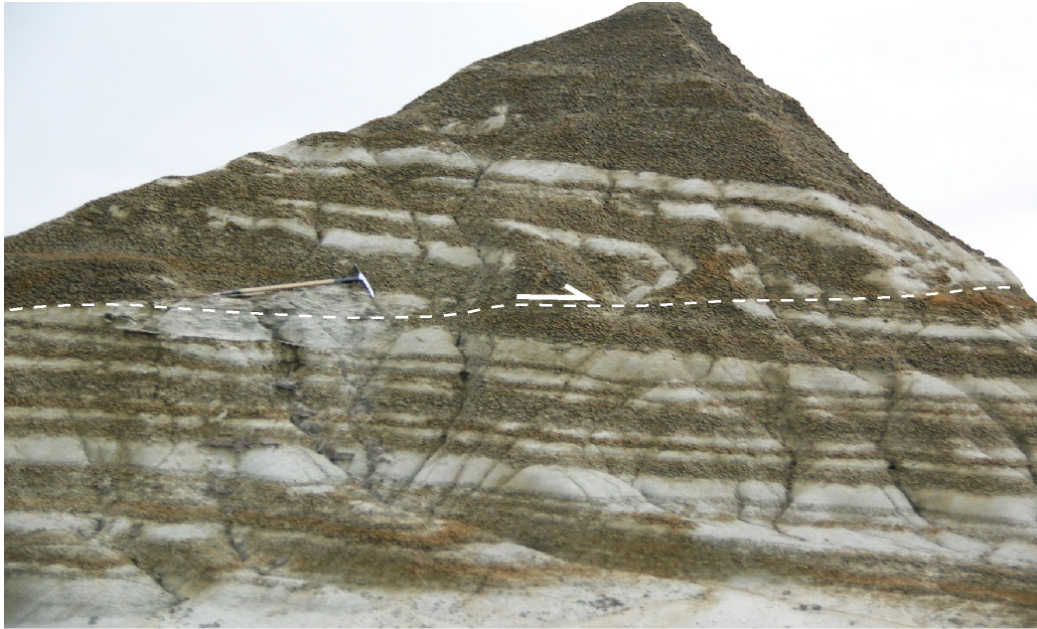


Figure 3. Overturned slump overlying failure plane (indicated by dashed white line) within a mud-dominated point bar deposit. Structures are interpreted to have been generated from seismically-induced failure. The direction of failure was to the right. Note ice axe for scale.

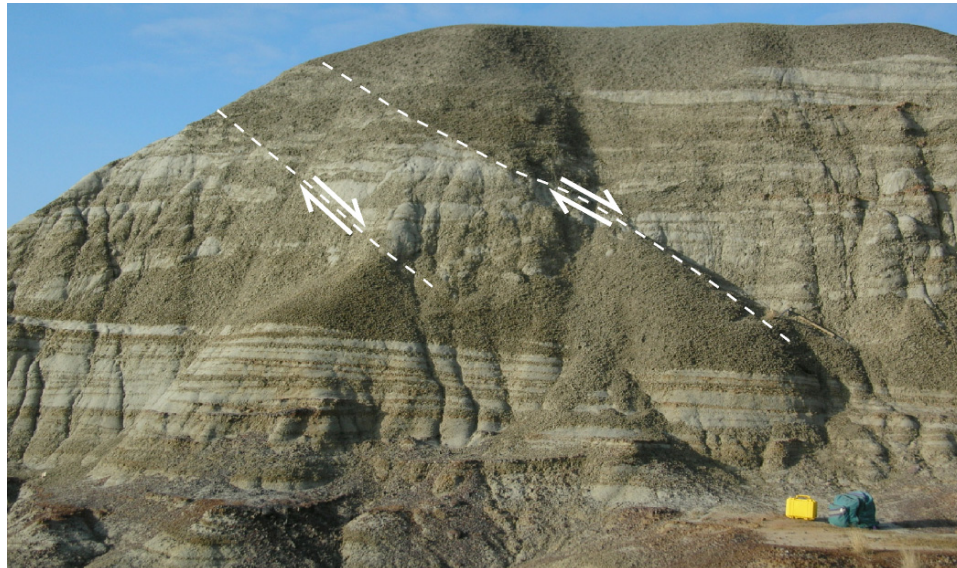


Figure 4. Small scale normal faulting (< 2 m displacement) is common throughout the disturbed meander belt deposit. The hanging wall is always located closest to the former active meander channel (to the right, beyond edge of area photographed). This suggests that muddy inclined heterolithic strata are prone to failure if located close to an active channel and triggered by earthquakes.