Tidal Deposits of the Campanian Western Interior Seaway, Wyoming, Utah, and Colorado*

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Abstract

The large-scale effects of tidal waves entering the Cretaceous Western Interior Seaway from the Gulf of Mexico have previously been modeled, but the field evidence for tidal processes in the Cretaceous successions has never been assembled. Field data from the southwestern reaches of the seaway in Utah, Colorado, and Wyoming indicate that tidal influence was prominent along the Campanian coastlines in two stratigraphic settings: (1) tidal currents strongly influenced or dominated the distal regressive segments of many deltaic cycles (sites where low relative sea level caused the seaway to narrow and possibly be restricted to the north), in contrast to the storm wave-dominated facies of proximal reaches (sea-level highstand sites) of the same deltaic transects; (2) tidal influence was relatively strong during the transgressive development of many shorelines, at most sites across 100-km-wide transgressive tracts; thin transgressive veneers as well as thicker estuarine deposits (some in valleys, some not) are documented. Tidal effects in the second setting are well known and may be due to increased tidal prism as sea level rose across a landward-shallowing shelf or because the increase of shelf width with sea-level rise brought the system closer to tidal resonance. In the regressive setting the common cross-shelf trend from wave-dominated to tide-dominated shorelines may possibly have resulted from tidal amplification as the seaway narrowed or became partially restricted to the north during relative lowstand periods. In addition, there was a remarkable increase in tidal influence along all of the 77.5-75-Ma shorelines, not restricted to lowstand positions. These generally more embayed shorelines in this period are likely due to irregular but widespread shallowing around embryonic, subaqueous basement-involved topography, as the seascape adjusted to a slight basinward tilt (as opposed to the earlier back-tilt of the foreland basin) and a much more irregular, shallow bathymetry during the Sevier-Laramide transition.

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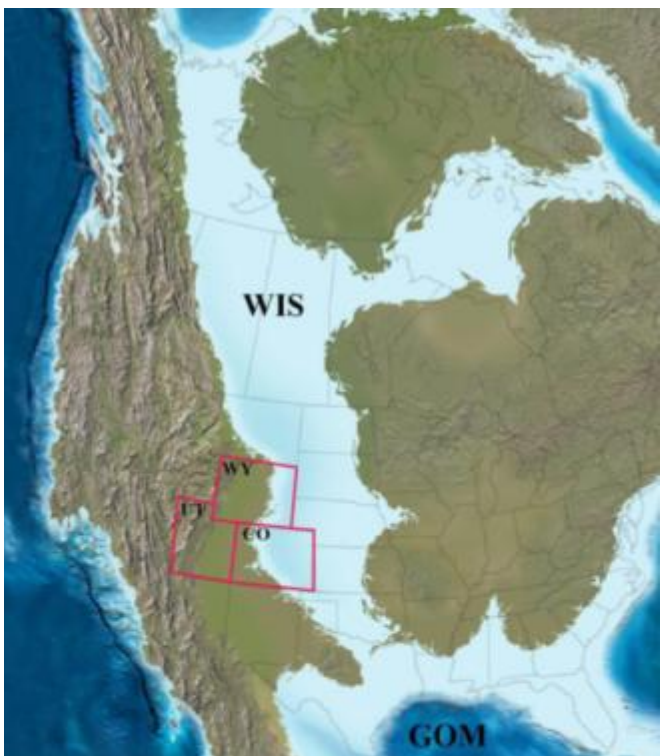
TIDAL DEPOSITS OF THE CAMPANIAN WESTERN INTERIOR SEAWAY, WYOMING, UTAH & COLORADO

Ron Steel, University of Texas at Austin

Piret Plink-Bjorklund & Jennifer Aschoff, Colorado School of Mines



1. Tideless Epeiric Seas (Shaw, 1964)
2. Mid-60s, recognition of tidal signals (Weimar, 1966; Masters, 1966, & agreed importance of tides in shelf seas (Klein & Ryer, 1978)
3. Key papers documenting transgressive estuaries (Rahmani ,1988; Cross, 1988; Devine, 1991; Van Wagoner, 1991) at tops of regressive cycles

TIDAL RESEARCH IN WESTERN INTERIOR SEAWAY (USA)

Key Themes impacting tidal research from early 90s

1. Shannon Sst (Suter & Clifton, 1999) & Sego Sst (Willis & Gabel, 2001) debates: incised valleys, lowstand shorelines or estuaries
2. Tidal deposits important for correlation from shorelines back into non-marine strata (Shanley et al., 1992), within clastic wedges.
3. Haystack Mts Fm study showed that the most *basinward* shorelines were strongly tide-influenced (Mellere & Steel, 1995, 2000; Hampson, 2010)

MODELING OF THE WIS

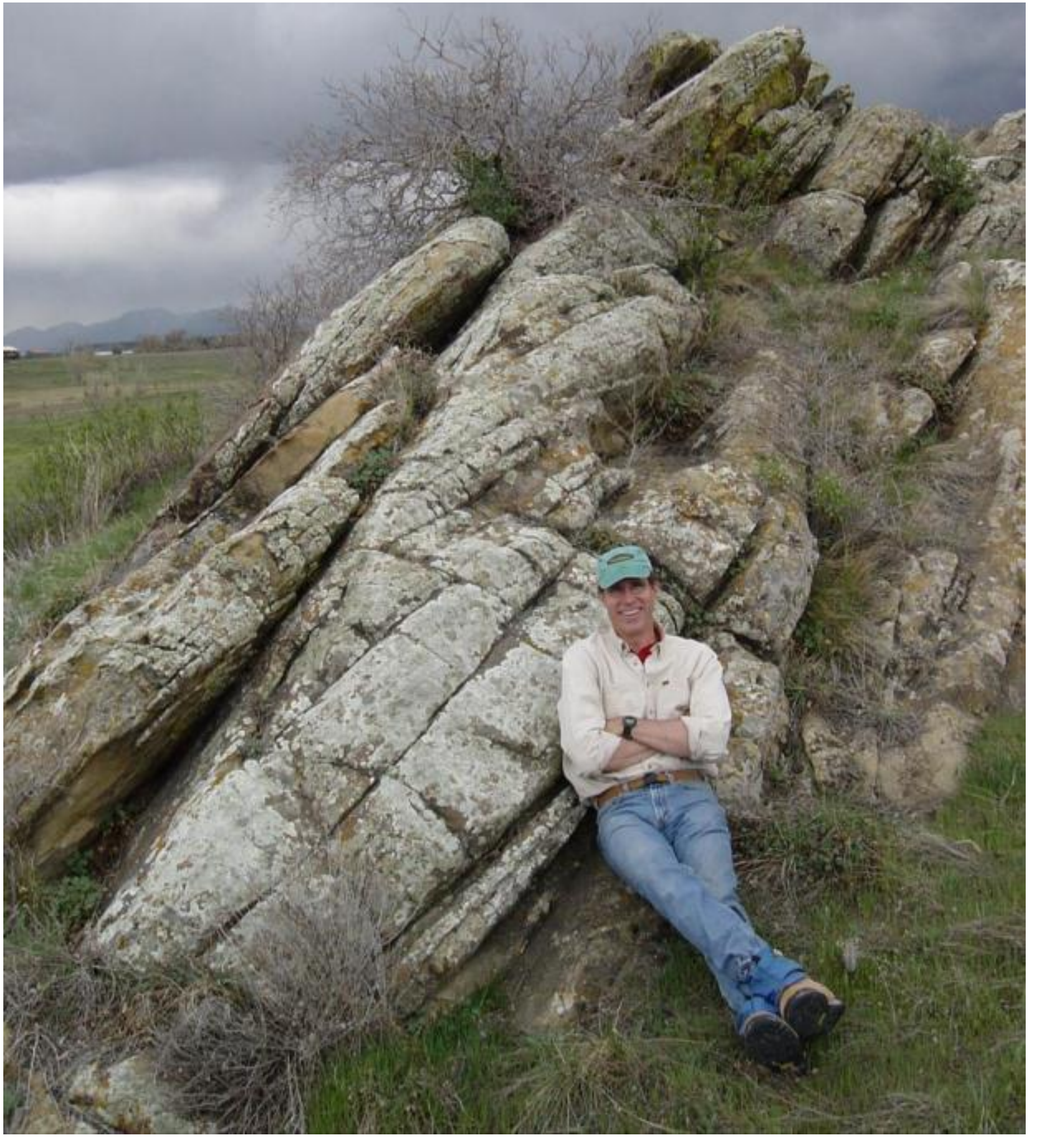
- Tides entering the epeiric WIS did not propagate far; rapid attenuation of tidal-wave energy (Keulegan & Krumbein, 1949)
- Resonance of tides at certain shelf widths (Klein & Ryer, 1978)
- Today there is agreement that tides can be locally very important even in large microtidal sea, due to funneling, resonance, Coriolis acceleration & amphidromic circulation
- Modeling of storm and tidal conditions in entire seaway (Ericksen & Slingerland, 1996)
- Normal surface circulation in WIS was a counterclockwise gyre; added storms produced enhanced southward-directed currents along western shorelines (Slingerland et al., 1990; Slingerland & Keen, 1999)

Modeling successfully reproduced the storm-wave-dominated highstand shorelines along west side of seaway, and counter-clockwise current gyre, but not the tide-influenced shorelines in basin center

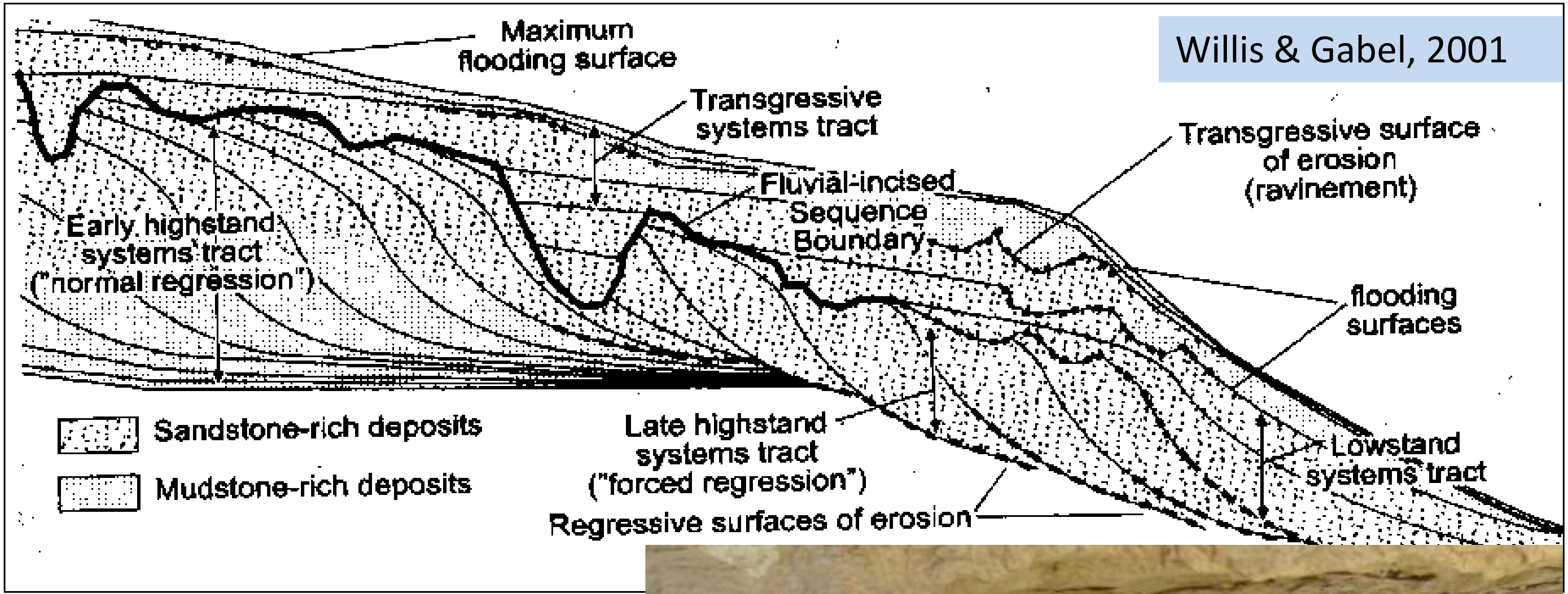

Thickly stacked tidal dunes.
Delta front: Seminoe Sst.
Courtesy S. Ahmed

Compound dunes with internal bi-directional dunes, Hatfield Sandstone, S. Wy.

Large compound dunes Hygiene Sst, Denver Basin



SEGO TIDAL ESTUARIES & DELTAS

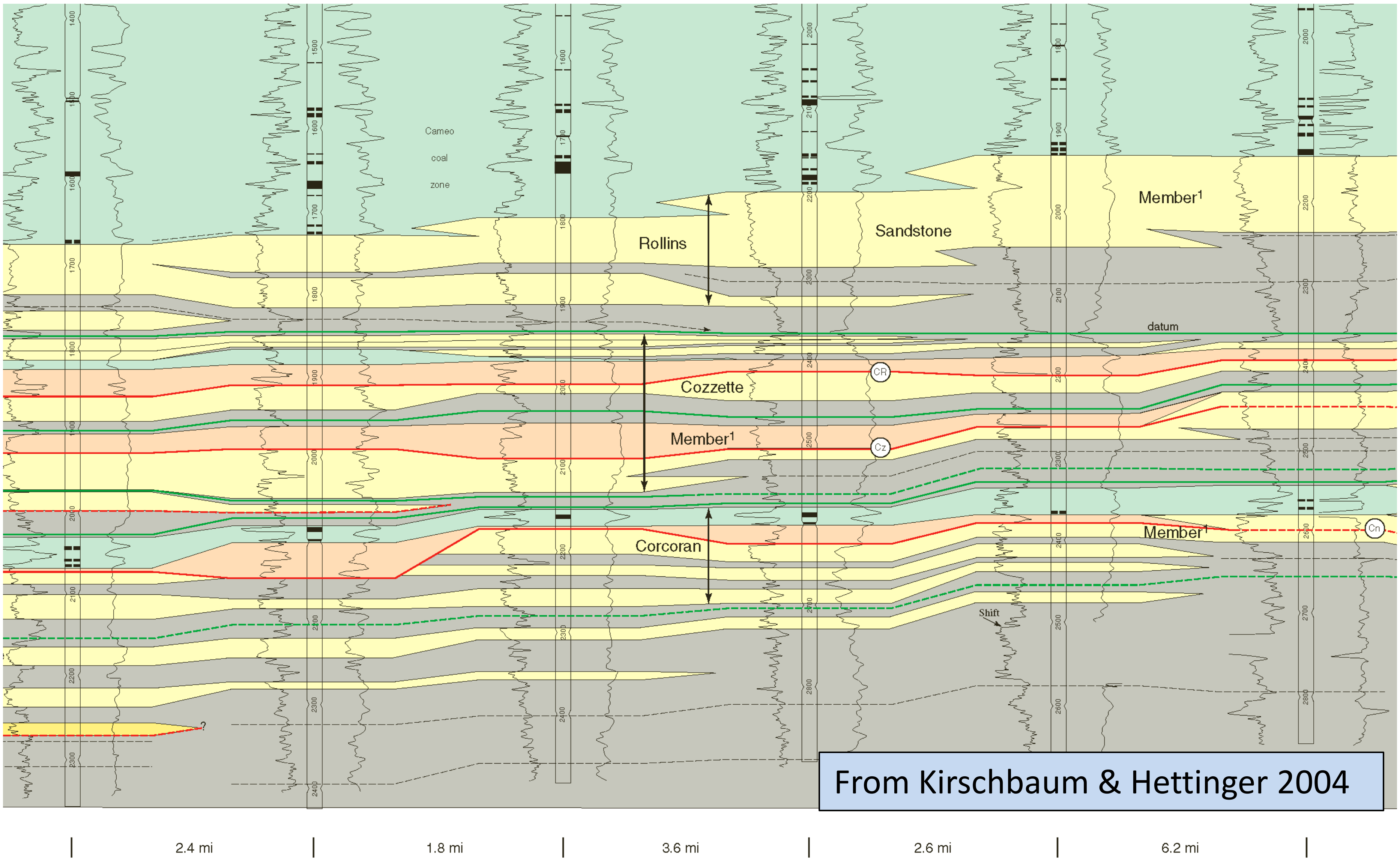


Willis & Gabel, 2001

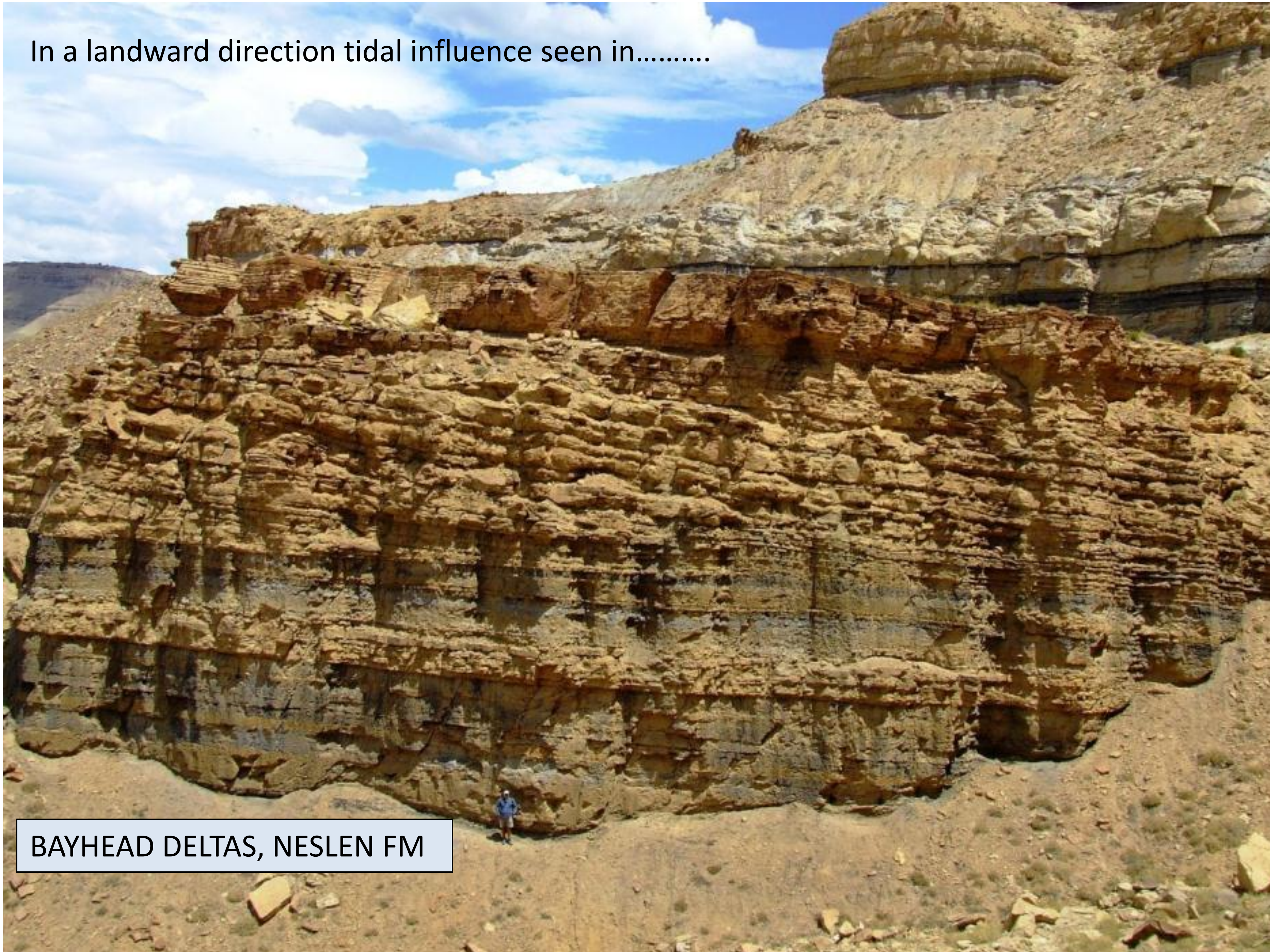
Thick mud drapes

Tidal dunes with double mud drapes

Sego/Corcoran/Cozette: mixed wave-tide shorelines



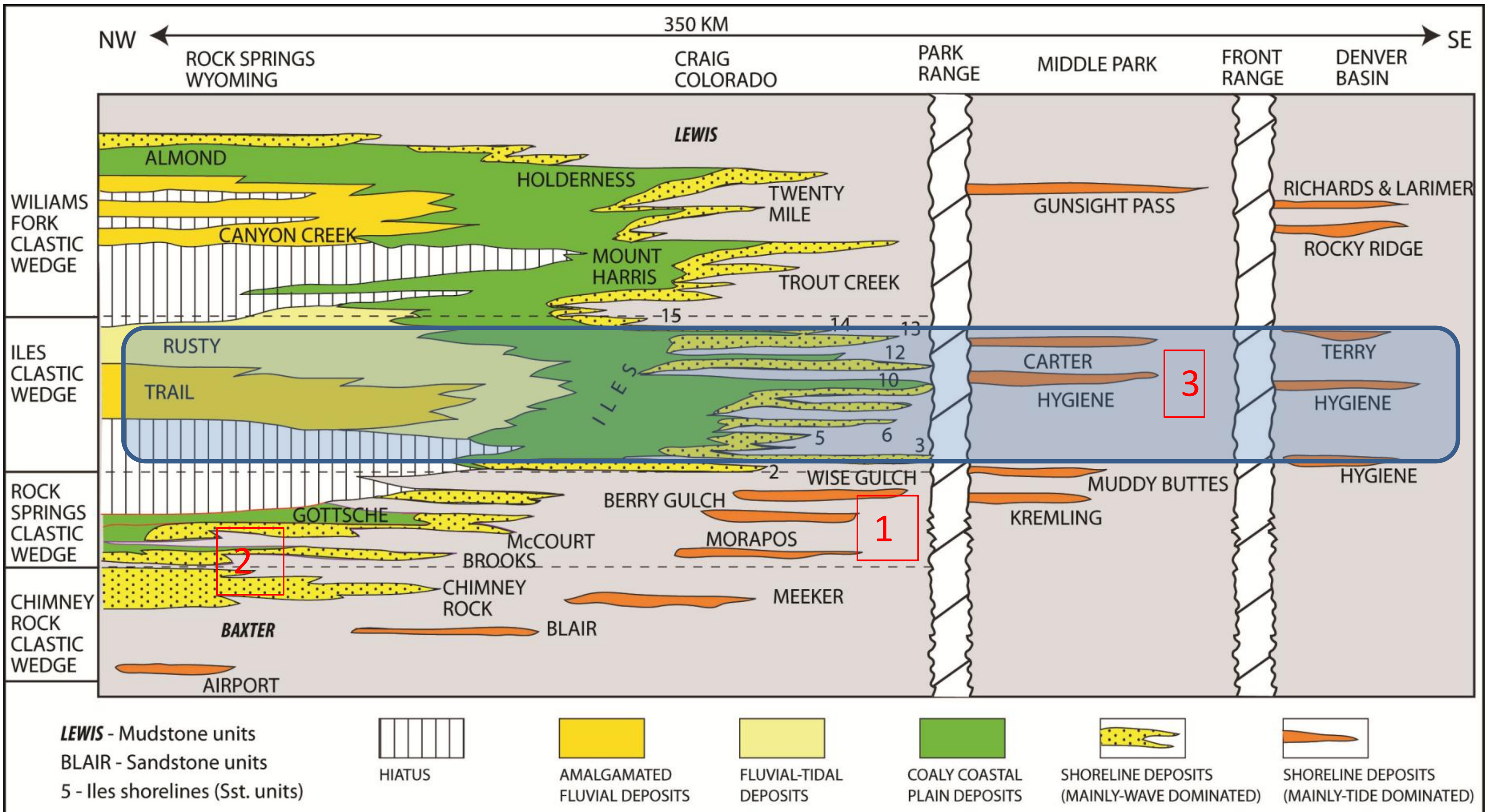
From Kirschbaum & Hettinger 2004


In a landward direction tidal influence seen in……….
BAYHEAD DELTAS, NESLEN FM

TIDAL & BRACKISH WATER SIGNALS IN BOTH ERICSON AND CASTLEGATE SANDSTONES

THREE CAMPANIAN SETTINGS W/STRONG TIDAL INFLUENCE:

1. Distal shoreline sands (lowstand) on wedge fringe
2. Transgressive tracts on most high-frequency sequences
3. All parts of anomalous clastic wedge 77.5-75Ma



1. DISTAL LOWSTAND SHORELINES: HAYSTACK MTS

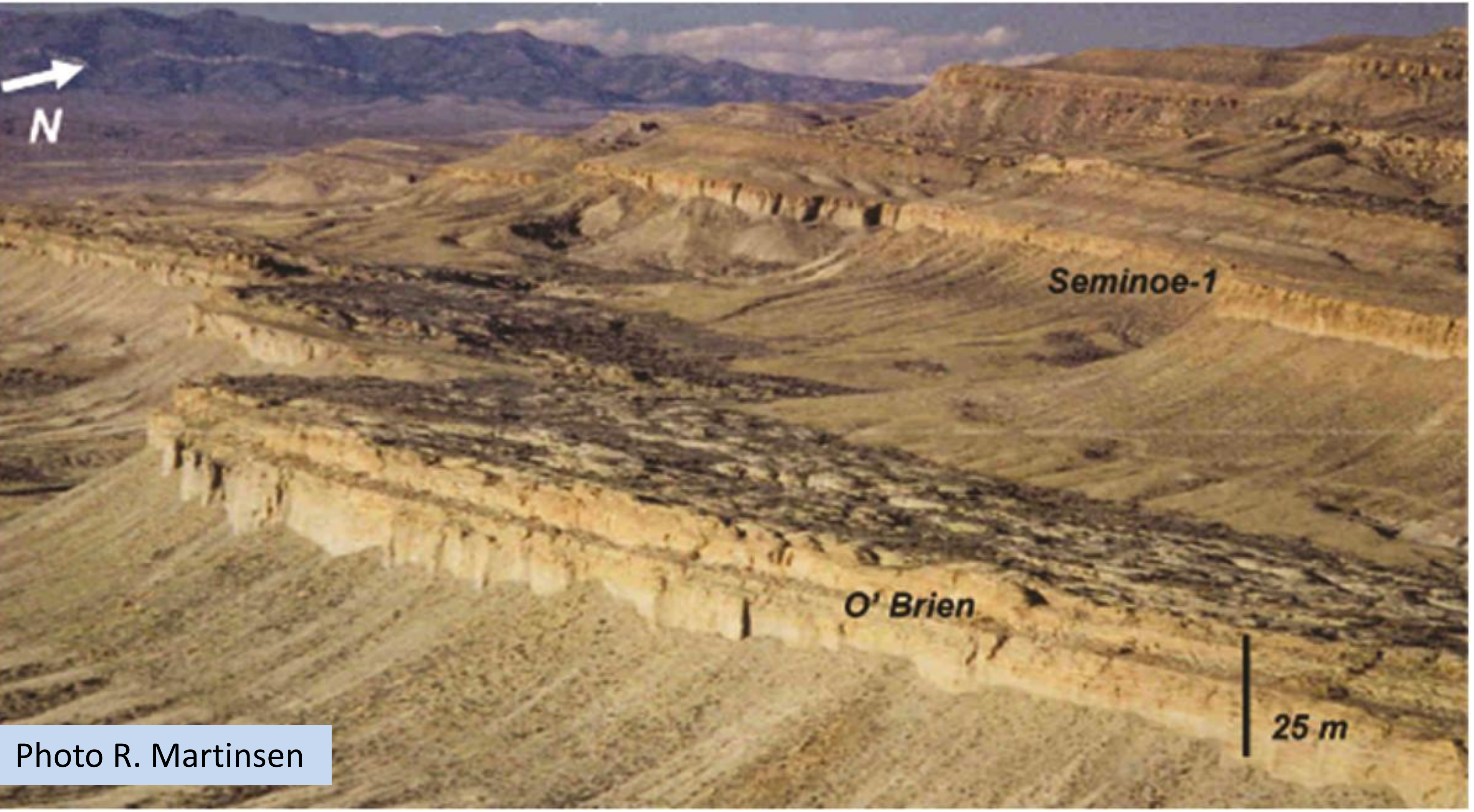
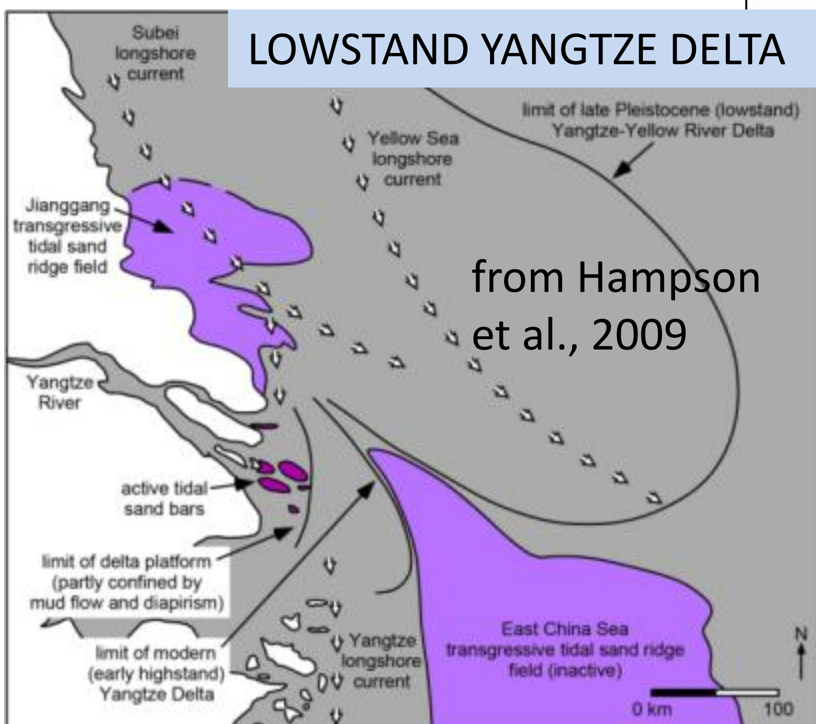


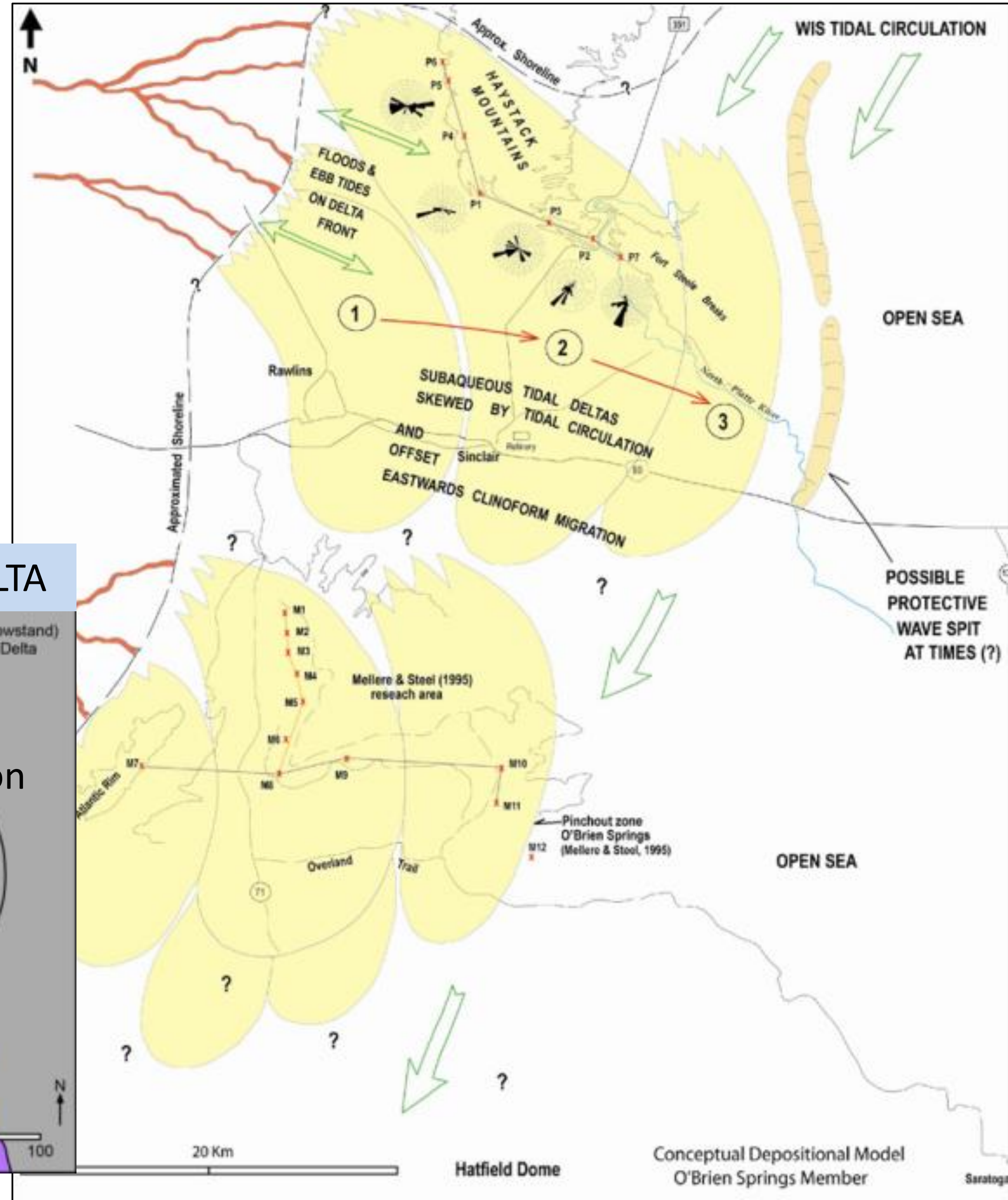
Photo R. Martinsen

O’BRIEN SPRINGS TIDE-DOMINATED DELTAS

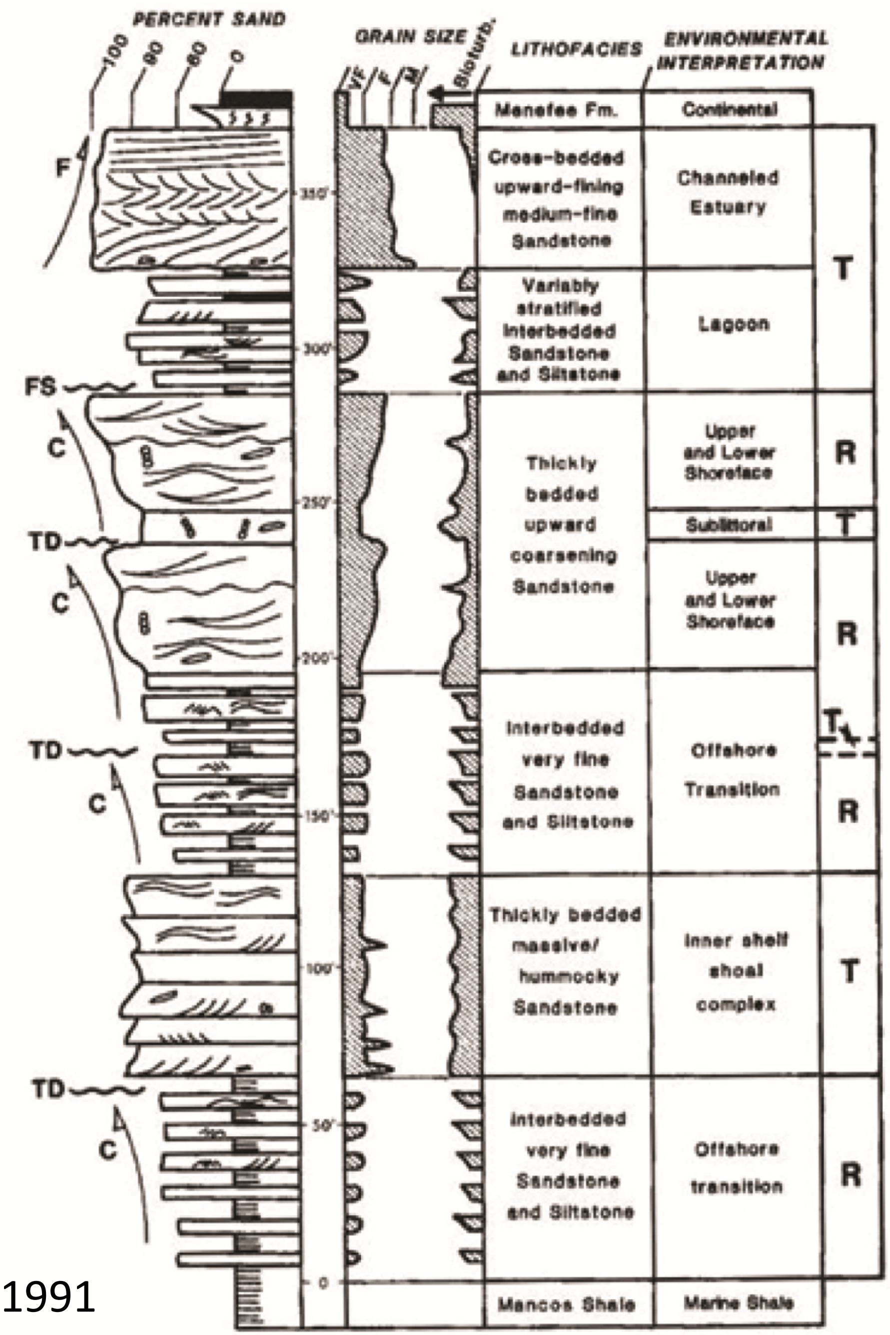
LOWSTAND DELTAS ARE SKEWED SOUTHWARDS



from Hampson et al., 2009

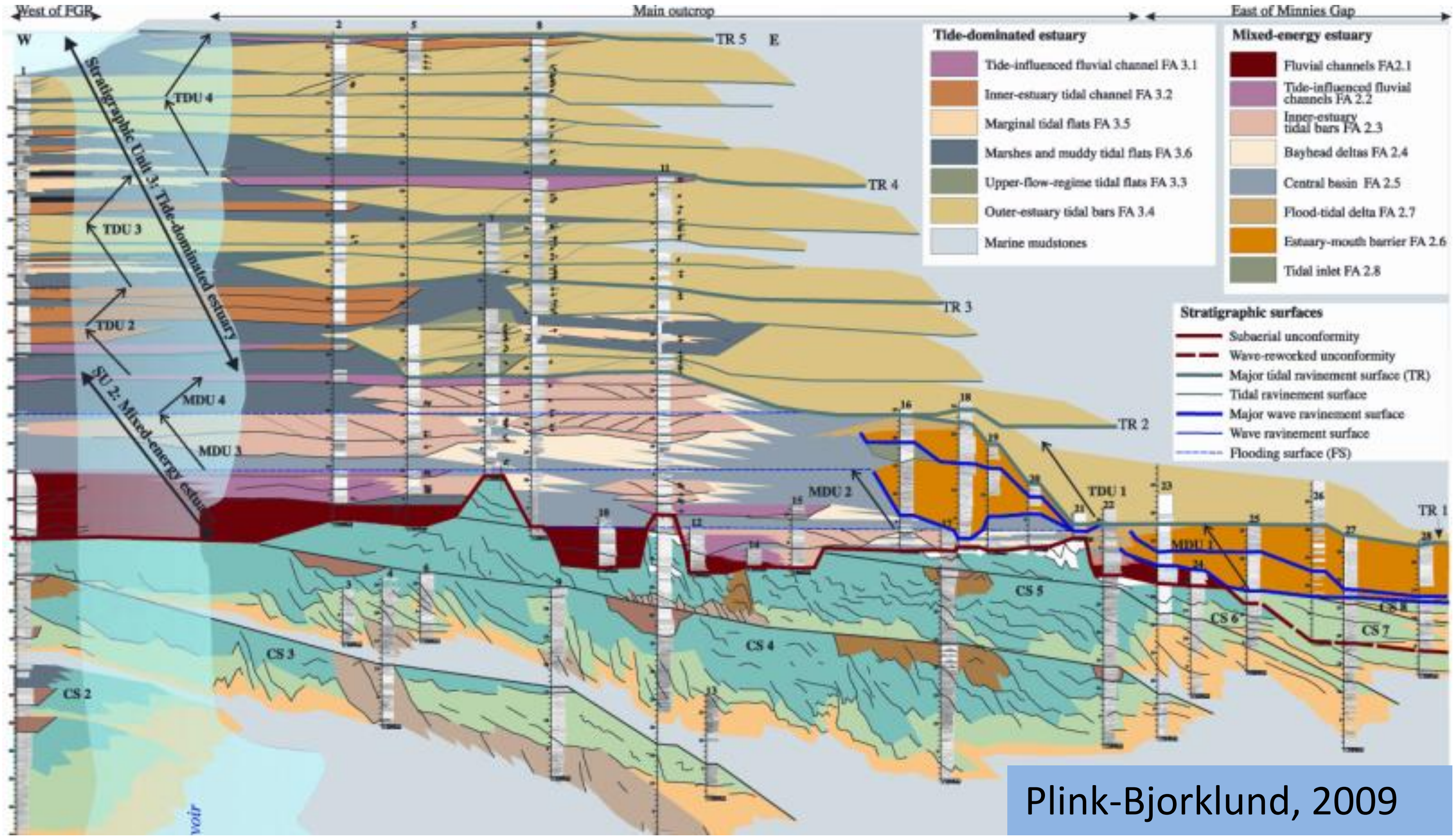


2. Tide influence in estuary deposits as upper parts of Upper Cretaceous shoreline sequences



Devine, 1991

UNUSUALLY THICK TIDAL TRANSGRESSIVE TRACT: CHIMNEY ROCK, WYOMING-UTAH BOUNDARY



Plink-Bjorklund, 2009

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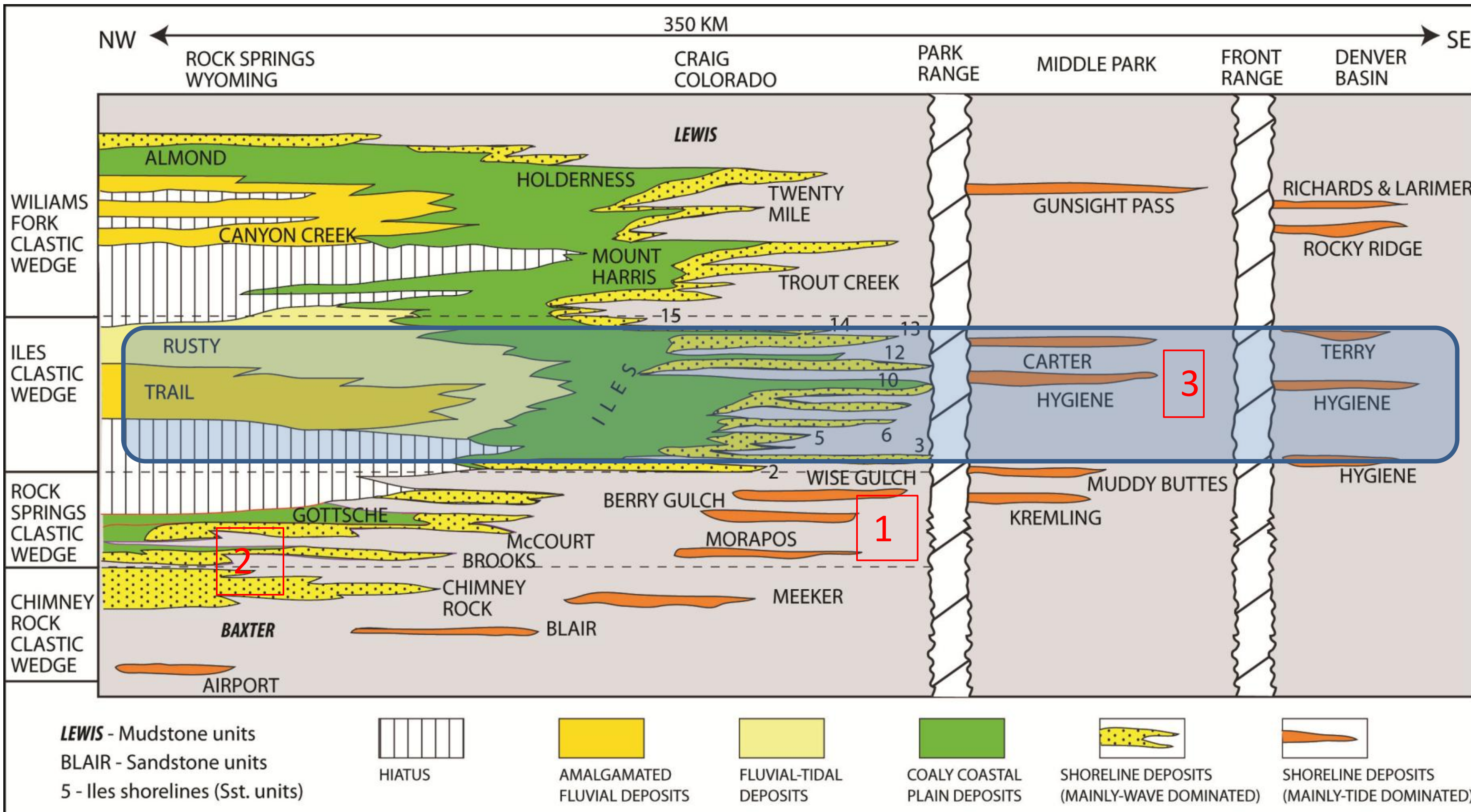
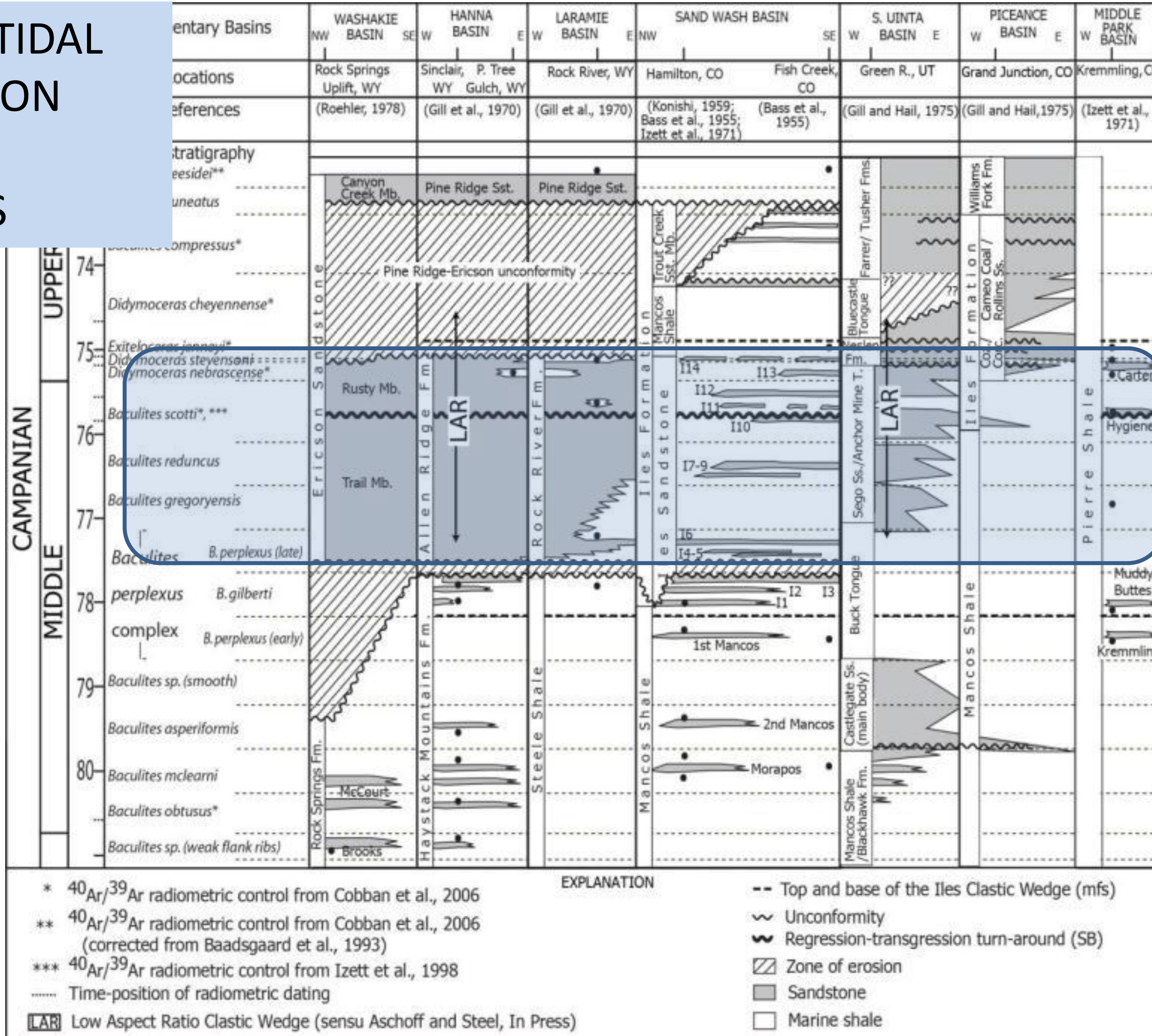
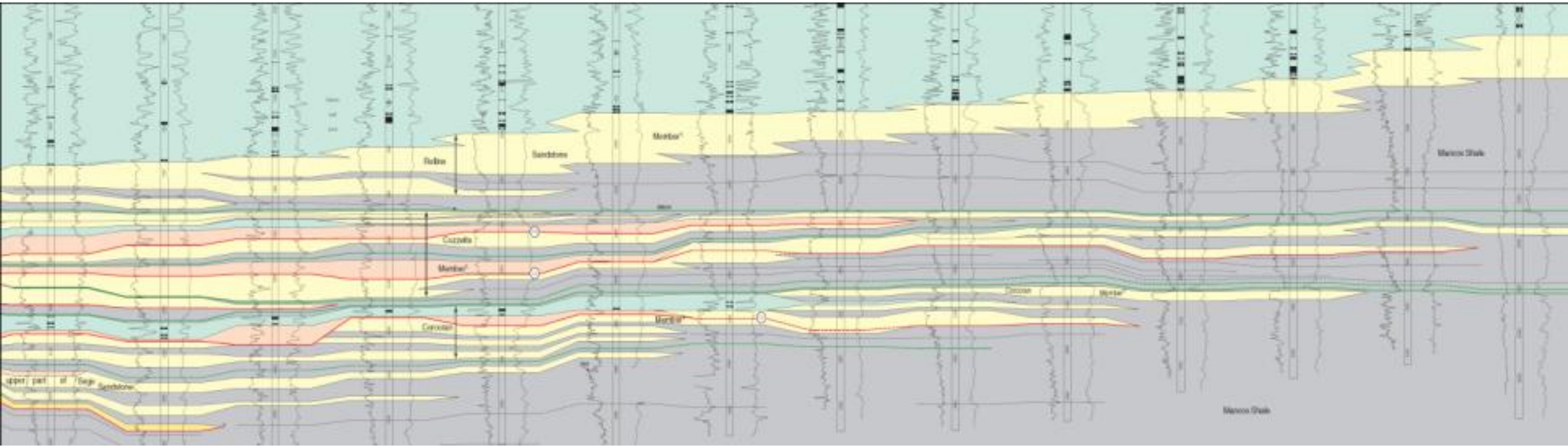


3. STRONG TIDAL INFLUENCE ON 77.5-75 Ma COASTLINES

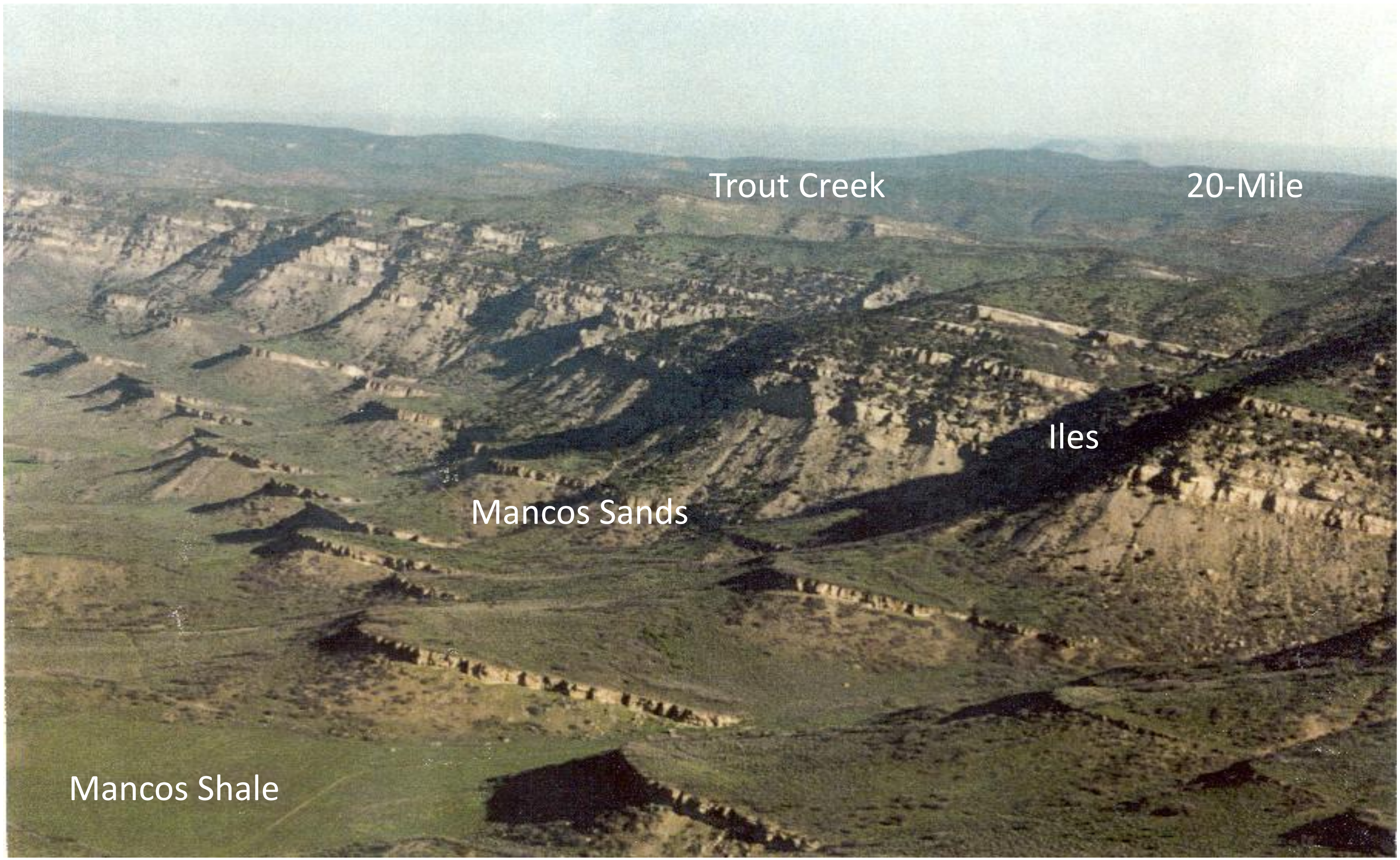


EXAMPLE OF TIDE-INFLUENCED, LOW-ACCOMMODATION, ANOMALOUS WEDGE (77.5-75Ma)

- Coastlines were strongly tide-influenced and incised
- Regressive shoreline transits were extensive & rapid
- Compare Sego/Corcoran/Cozette with Rollins shoreline behaviour



Anomalous low-accommodation interval: Iles Fm



CONCLUSIONS

1. Distal belt of tide-influenced shorelines possibly caused by constriction of WIS at sea-level lowstands
2. Anomalous 77.5-75Ma interval with widespread tide influence likely due to embryonic Laramide uplifts