Paleogeography and Paleotectonics of the Western Interior Seaway, Jurassic-Cretaceous of North America*

Ron C. Blakey¹

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¹Colorado Plateau Geosystems, Phoenix, AZ (http://cpgeosystems.com/paleomaps.html) (rblakey@cpgeosystems.com)

Abstract

The Western Interior Seaway dominated North American paleogeography during much of the Mesozoic. Beginning as a narrow body in a back arc basin along the British Columbia-Alberta border the Early Jurassic, the seaway expanded and contracted numerous times during the remaining Mesozoic. From the Cenomanian through most of the Campanian, the seaway extended from the Arctic to the Gulf of Mexico, at times covering nearly half of North America. An extensive volcanic signature in the rock record including ash beds (bentonites), detrital zircons, and local volcanic flows coupled with a robust fossil record, excellent, widespread outcrops, and voluminous subsurface data have provided the basis for basin-wide, detailed correlation.

From the Middle Jurassic through the Coniacian, Cordilleran subduction, magmatism, and thrusting generated a classic retro-arc foreland basin that orchestrated subsidence and sedimentation patterns in the Western Interior Basin that in turn controlled the geometry of the Western Interior Seaway. However, from the Santonian through the Maastrichtian, subsidence and sedimentation patterns changed in response to shallowing subduction angles and subduction of a thick oceanic slab. The subducted slab eventually caused regional uplift, partitioning of the Western Interior Basin into Laramide uplifts and basins, and withdrawal of the Western Interior Seaway.
The rock record of these events contains some of the greatest paleontologic and economic resources on Earth – dinosaurs, hydrocarbons, and coal. Paleogeographic maps prepared over tightly spaced time slices provide a basis for presenting this complex geologic history in an easily understood manner.

References Cited


Cretaceous Seas and Shores -- Western Interior Seaway

Tectonic Setting and Paleogeography of Widespread Sedimentary Rocks, West-central North America

Ronald C Blakey
Professor Emeritus, Northern Arizona University
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Author contact information:

Rblakey@cpgeosystems.com

cpgeosystems.com/index.html
Outline of Presentation

• Geologic Setting
• Brief Overview of History of Western Interior Basin
• Paleogeographic Maps
• Example of Transgressive-regressive History – Detailed Paleogeography
General Geologic Setting Western Interior

- Classic foreland basin adjacent to Sevier orogeny
- Coarse to fine sediment supplied by Sevier highlands to west
- Sand and mud supplied by NA Craton
- Limestone deposited in clear, offshore settings
- Well developed asymmetric transgressive-regressive sedimentary cycles; overall regressive sequence through Late Cretaceous
Coniacian Facies/Tectonic map
Late Cretaceous Chronostratigraphic Section

White areas represent missing rocks

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Example of well-exposed Cretaceous section

Tropic Shale and Straight Cliffs Formation, Brigham Plains, Kaiparowits Plateau, Utah
Western Interior Seaway terminated by Laramide tectonics

- Laramide uplifts
- Laramide basins
- Cenozoic volcanics
Correlating Major Events

• Radiometric dating
  – Plutonic-volcanic events – internal and external
  – Metamorphic events – external
  – Structural events – internal and external
  – Bentonites – internal

• Biostratigraphic dating (coupled with dating techniques above)
  – Marine record
  – Terrestrial record
Brief History of Western Interior Seas

Jurassic – Seas expand in Middle Jurassic with repeated T/R events; fluvial deposits close Jurassic sedimentation

Early Cretaceous – Narrow seas restricted to NW Canada early; sea expands to south and east during Aptian; late Albian Skull Creek Seaway bisects NA from Arctic to Gulf

Cenomanian-Turonian – major regression at Albian/Cenomanian boundary followed by major transgression that culminated with extensive Greenhorn Seaway in early Turonian; major deltaic progradation in Late Turonian

Coniacian-Santonian – repeated T/R events but seaway remains continuous from Arctic to Gulf

Campanian – major swings in shoreline during several T/R events; seaway closed in late Campanian north of Gulf region

Maastrichtian – early transgression followed by protracted regressive event that filled basins and ended reign of seaway; Western Interior Basin partitioned into basins and uplifts during late Maastrichtian-Paleocene

Laramide Orogeny
The following 26 maps portray the overall history of the Western Interior Seaway

All maps ©Ron Blakey, Colorado Plateau Geosystems, Inc.
Middle Jurassic –
Gypsum Springs
Seaway
Late Jurassic – Swift-Upper Sundance Seaway
Late Jurassic – Morrison fluvial system
Early Cretaceous – Berriasian
Early Cretaceous – Aptian
Early Cretaceous – Albian Fall River Seaway
Early Cretaceous – Albian Skull Creek Seaway
“Mid” Cretaceous – Mowry Seaway
“Mid” Cretaceous – Mowry-Graneros Seaway
Late Cretaceous – Turonian Greenhorn Seaway
Late Cretaceous – Turonian Frontier/Ferron regression
Late Cretaceous – Coniacian Mancos Seaway
Late Cretaceous – Coniacian
Mancos Seaway – Gallup regression
Late Cretaceous – Santonian
Pierre-Mancos Seaway
Campanian regressive sequence, Book Cliffs, UT

Campanian regressive sequence, Mesa Verde, CO
Late Cretaceous – Campanian
Late Cretaceous – Maastrichtian
K-T Boundary
Paleogeographic Maps -- Sources of Data

Excellent, widespread outcrops
Robust subsurface data
Voluminous radiometric data
Unequalled biostratigraphic data

The above have yielded a rich collection of publications and other types of shared information
Cretaceous Turonian facies, Paleo-oceanography

Arthur and Sageman, 2004, SEPM Sp Pub 82

Palinspastic-structural restoration, Turonian, DeCelles, 2004, Am Jour Sci
Cretaceous paleogeography, RMAG Rocky Mtn Strat Atlas

Cretaceous paleogeography, Western Canada Strat Atlas

A -- 93 - Tropic-Dakota-Greenhorn-Frontier
B -- 91 - Tropic-Greenhorn-Frontier
C -- 90 Ma - Tropic-Mancos-Ferron-Juana Lopez-Tibbit Canyon
D -- 90-89 - Juana Lopez-Mancos-Smoky Hollow-Carlile-Gallup

Example of Detailed Paleogeography

Cenomanian-Turonian transgression
Variations in Shoreline Depositional Systems, Cretaceous Western Interior Seaway

Incised Valleys -- Marine Lowstand Depositional Systems

“Forced regression”

- shelf edge/break
- river mouth near shelf edge
- submarine fan
- possible shoals at shelf break
- marine sheet sands
- broad, complex sand splay
- broad, thin deltas
- broad shelf and/or no shelf break
- submarine slumps
- well-drained soils
- sediment-starved beaches
- low sea cliffs
- lowstand delta
- braid plain delta
- former highstand shoreline
- platform from last highstand
- shelf break
- submarine canyon
- fan-turbidite system
- incised valleys
- lowstand shoreline
- submarine slumps
- braid plain delta
- braid plain
Prograding Shoreline Depositional Systems
Sediment influx > accommodation space

- Prograding beaches
- Prograding fluvial-dominated delta
- Prograding wave-dominated delta
- Shoreface steepens as sediment progrades into deeper water
- Sediment accommodation space reduced on coastal plain
- Submarine slumps as delta slopes steepen

Shoreline at Maximum Transgression Depositional Systems
Marine highstand, possible stacking of depo systems

- Maximum shoreline advance
- Prograding beaches
- Prograding fluvial-dominated delta
- Wave-dominated delta
- Barriers attach to shoreline as lagoons fill in with sediment
- Prograding major delta system
- Sediment accumulation on coastal plain
Transgressive Depositional Systems
Thin shoreline sands; sed trapped in estuaries; mud near shoreline; clear water promotes limestone depo;
Accommodation space > sed rate
SECTION B -- B’ NC Arizona to NE New Mexico
BLACK MESA ZUNI BASIN SAN JUAN BASIN MESA FARMINGTON CHAMA S RATON BASIN

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Lower Turonian Facies
The following 12 maps detail the Cenomanian-Turonian transgressions and regressions across the Western Interior. Note tight spacing of time slices.

All maps ©Ron Blakey, Colorado Plateau Geosystems, Inc.
Late Albian
Muddy Ss lowstand
Albian-Cenomanian transgression – Mowry Seaway
Early Cenomanian
Mowry Seaway
Middle Cenomanian
Graneros Seaway;
AOE event
Middle Cenomanian
Graneros Seaway;
AOE event
Late Cenomanian Transgression; AOE event
Late Cenomanian transgression
Early Turonian maximum Transgression (Cretaceous global Highstand)
Middle Turonian maximum Transgression (Cretaceous global Highstand)
Middle Turonian regression
Late Turonian transgression
Late Turonian Regression – delta progradation
Significance

- Vast resources – petroleum, coal
- Significant fossil resources – dinosaurs, ammonites, forams
- Critical academic studies – principles of transgression/regression, sequence stratigraphy, principles of biostratigraphy
- Hydrologic resources
- Scenic resources – many National Parks and other scenic areas
Summary

• A huge stratigraphic, paleobiologic, and structure-tectonic database has generated vast knowledge of Cretaceous rocks deposited in and around the Western Interior Seaway.

• Paleogeographic maps are a powerful tool for displaying this information in a clear, concise, readily understood manner.

• For list of References as downloadable PDF, go to: http://cpgeosystems.com/wispaleogeography.html
Oyster bed, Dakota Ss, Cenomanian transgression near Paria, Utah
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