Paleogeographic Reconstructions of the Circum-Arctic Region since the Late Jurassic*

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Abstract

We present paleogeographic maps describing the distribution of mountains, lowlands, shallow seas and deep ocean basins in the Circum-Arctic region since the Late Jurassic, with emphases in the Late Mesozoic. These maps are part of a set of 30 paleogeographic reconstructions that describe the development of the Circum-Arctic Region during the last 150-160 my. These paleogeographic maps are based on a plate tectonic model for the Arctic produced by the PALEOMAP Project. This ArcGIS model (PaleoGIS) describes the plate tectonic evolution of the North Atlantic, Eurasia and Makarov basins, Canada Basin, Canadian Cordillera, South-Central Alaska, Northeast Siberia, and the North Pacific. The plate tectonic model provided the framework upon which a 3D digital elevation model was constructed for each time slice. A paleo-digital elevation model (PaleoDEM) is a quantitative description of topographic and bathymetric features that describes the evolution of the seafloor, the tectonic development of island arcs and back-arc basins, the subsidence of lowland areas, and the uplift and erosion of mountain ranges. Each "pixel" in the PaleoDEM represents a 10 km x 10 km square on the map. Vertical resolution is 40 m. Both the plate tectonic model and the paleogeographic maps are important tools for understanding the evolution of sedimentary basins and the development of hydrocarbon systems in the Circum-Arctic Region. The 3D paleogeographic models also provides a framework for further paleoclimatic and paleooceanographic modeling.

Reference

Paleogeographic Reconstructions of the Circum-Arctic Region since the Late Jurassic

“A Case for an Amerasian Subduction Zone”

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16 Paleogeographic Reconstructions from the Late Jurassic to the Recent
Thanks to PaleoAtlas Sponsors

- Shell 2002*
- Anadarko 2003*
- BHP 2003
- ChevronTexaco 2003*
- (KerrMcGee 2003)
- Oxy 2003
- Total 2003*
- Petrobras 2004
- Pioneer 2004
- ExxonMobil 2004
- Marathon 2004
- BP 2005
- StatOil (Hydro) 2005*
- Woodside 2005
- ConocoPhillips 2006
- Cobalt Int 2006
- ENI 2007*
- (Devon 2006)
- Vale 2008
- Petronas 2008*
- Apache 2010
- Noble Energy 2011
PALEOMAP PaleoAtlas Time Intervals

- Cenozoic 10
- Cretaceous 8
- Jurassic 6
- Triassic 4
- Late Paleozoic 12
- Early Paleozoic 10
- Neoproterozoic 3
High Resolution Paleogeography

Aptian
120 Ma
PALEOMAP Project Approach

Hydrocarbon Systems

PALEOCLIMATE

PALEOGEOGRAPHY

PLATE TECTONIC MODELING

GANDOLPH Source Rock Project

FOAM Simulations (19/53)

PleoDEM ( +50)

Global Plate Model (PaleoGIS)
Iceland Hotspot Track
PALEOGEOGRAPHIC RECONSTRUCTIONS

"Interpreting the rock record to map past distribution of lithofacies and environments of deposition.”
Simplified Paleogeography

Aptian
120 Ma
Lithofacies (U. Chicago, Ziegler et al., 2003)
Environments of Deposition (Ziegler et al., 2003)
Digital Elevation Model

Resolution of Paleogeographic Maps
Horizontal = .1x.1 degrees
Vertical = 40 m

Temporal Resolution
Nearest Sequence Boundary and Maximum Flooding Surface
Lithological Data - Stage
Let’s Go Back to the Tectonic Model

Evolution of the Amerasian Basin
The Key to the Arctic is the Amerasian Basin (Canada Basin + Makarov + Chukchi)

• To Solve Problem of Amerasian Basin, you must first solve:
  – North Atlantic, Labrador Sea, Eurasian Basin
  – North American Cordillera
  – NE Asia
  – Paleozoic History of Laurentia, Baltica, Siberia, and Kazakhstannia
The Key to the Tectonics of the Amerasian Basin

• Two-Part Opening History

• Part 1. 155 Ma (Late Jurassic) – 115 (mid-Cretaceous) Canada Basin Opens

• Part 2. 115 Ma – 65 Ma (mid-Late Cretaceous) Open Makarov – Chukchi Basin.
Part 1. Opening of (Greater) Canada Basin

- Opens in latest Jurassic-earliest Cretaceous as a result of northward directed subduction beneath North Slope/Chukotka block
- Essentially a back-arc basin
- Rotation ends when North Slope - Chukotka block collides with central Alaska closing Angayucham Ocean, ~115 Ma – 100 Ma.
Late Jurassic
~150 Ma

Wrangellia

Omolon

Angayucham Ocean

Kolyma Loop

Mongol-Oxhoisk Ocean

North Slope / Chukotka

CR Scitesce PALEOMAP Project
middle Aptian
~120 Ma
Part 1. Opening of the (Greater) Canada Basin

Opening of the Amerasian Basin (part 1)
Part 2. Opening of Makarov – Chukchi Basins
(mid-Late Cretaceous, ~100 Ma – 65 Ma)

- Alpha –Mendeleev Ridge was originally located adjacent to Lomonsov Ridge
- Subduction beneath Alpha-Mendeleev Ridge resulted in “roll-back” extension (like the Tyrhennian Sea) opening Makarov Basin
- Continued Rollback resulted in extension of Alpha-Mendeleev Ridge and Chukchi Plateau
- Subduction ended as a result of “collision” of trench with NW Alaska (Pt. Barrow).
Two Styles of Subduction

- **“Conveyor Belt”**
  - Active
  - Fast (8 – 10 cm/yr)
  - MOR- coupled
  - Effect on Adjacent Continent: Compression
  - Lots of Volcanism
  - Long-lived (10’s – 100’s my)
  - Length of subducted slab:
    - 5,000 – >10,000 km
  - Examples: Circum-Pacific “Ring of Fire”, Tethyan Margin

- **“Roll-Back”**
  - Passive
  - Slow (2-5 cm/yr ?)
  - No Ridge, landlocked
  - Effect on Adjacent Continent: Extension
  - Almost no Volcanism
  - Length of subducted slab:
    - 100’s - < 2000 km
  - Short –lived (10’s my)
  - Tyrhennian Sea, Pannonian Basin, Amerasian Basin
Opening of the Eurasian Basin

Opening of the Amerasian Basin (part 2)
Evidence and Consequences

- High Arctic Large Igneous Province is the result of excess volcanism due “roll-back” extension.
- There is a major dextral strike-slip boundary beneath the North Chukchi and East Siberia Sea.
- The collision of the Amerasian Trench with NW Alaska (~65 Ma) resulted in Pt. Barrow uplift.
Questions & Conclusions

- OK, so where is this supposed subduction zone?
- Why can’t we “see” it?
- Where is the island arc that goes with it?
- Why did it stop subducting?
- How can we test this hypothesis?