

# USGS National Crustal Model for Seismic Hazard Studies: Geologic Framework Model

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U.S. Department of the Interior  
U.S. Geological Survey



National Crustal Model (NCM)

# OVERVIEW





# USGS National Crustal Model for Seismic Hazard Studies

- Profiles defined on 1-km grid across the conterminous United States from the surface to below the Mohorovičić discontinuity (Moho)
  - Geology and petrology
  - Geophysics
    - $K$ , Bulk Modulus
    - $G$ , Shear Modulus
    - $\rho$ , Density
    - $1/Q_P$ ,  $P$ -wave attenuation
    - $1/Q_S$ ,  $S$ -wave attenuation
    - $T$ , Temperature
    - $\phi$ , Porosity

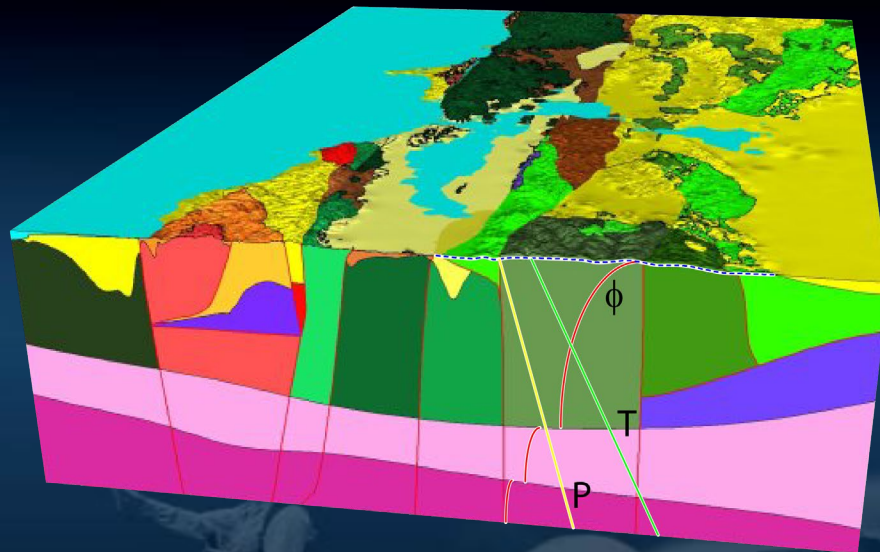
# How is it constructed?

Biot-Gassmann and mineral physics theory

→  $K, G, \rho$

*Requires*

- Three-dimensional (3D) geologic model
- Petrologic and mineral physics database
- Pressure, temperature, and porosity as functions of depth
- Water table depth



*Adapted from Aagaard and others (2010)*





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# GEOLOGIC FRAMEWORK MODEL

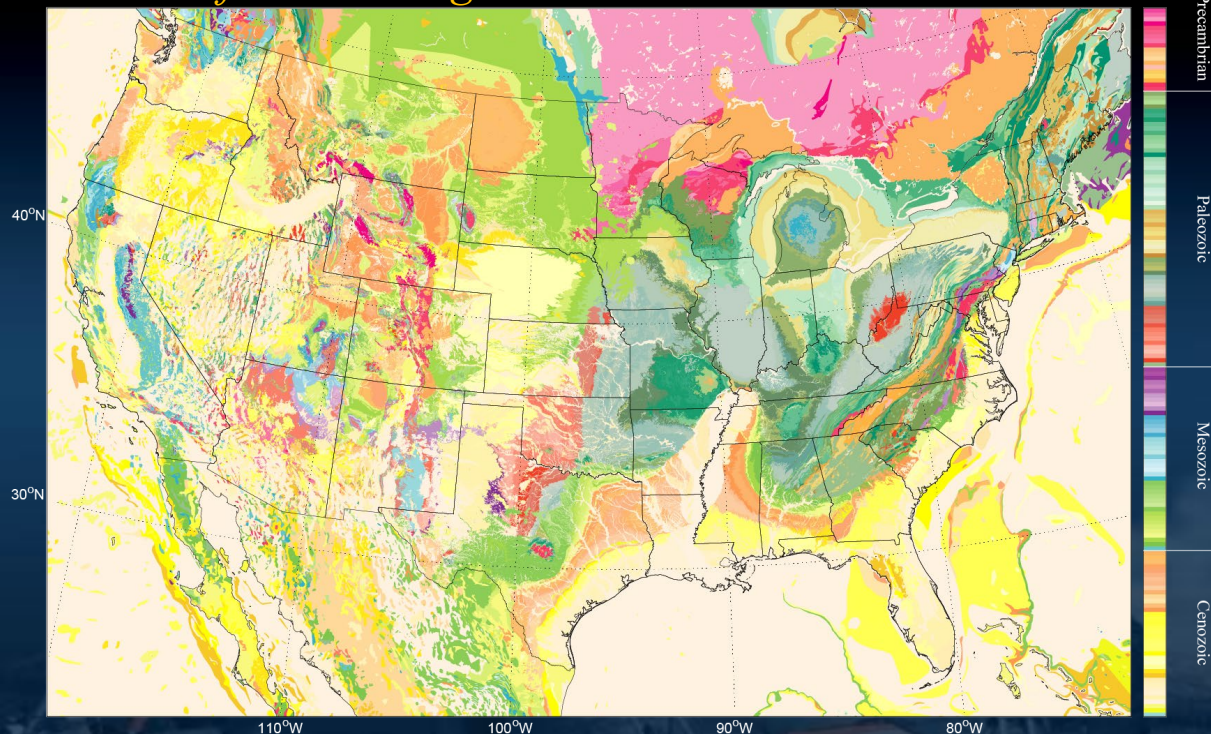


# 3D Geologic Framework Model

Constructed from:

- Geologic maps
- Depths to significant subsurface contacts
  - Bedrock, basement, mid crust, Moho, top of the oceanic plate
- No explicit representation of faults

*Near Surface Rock Age*



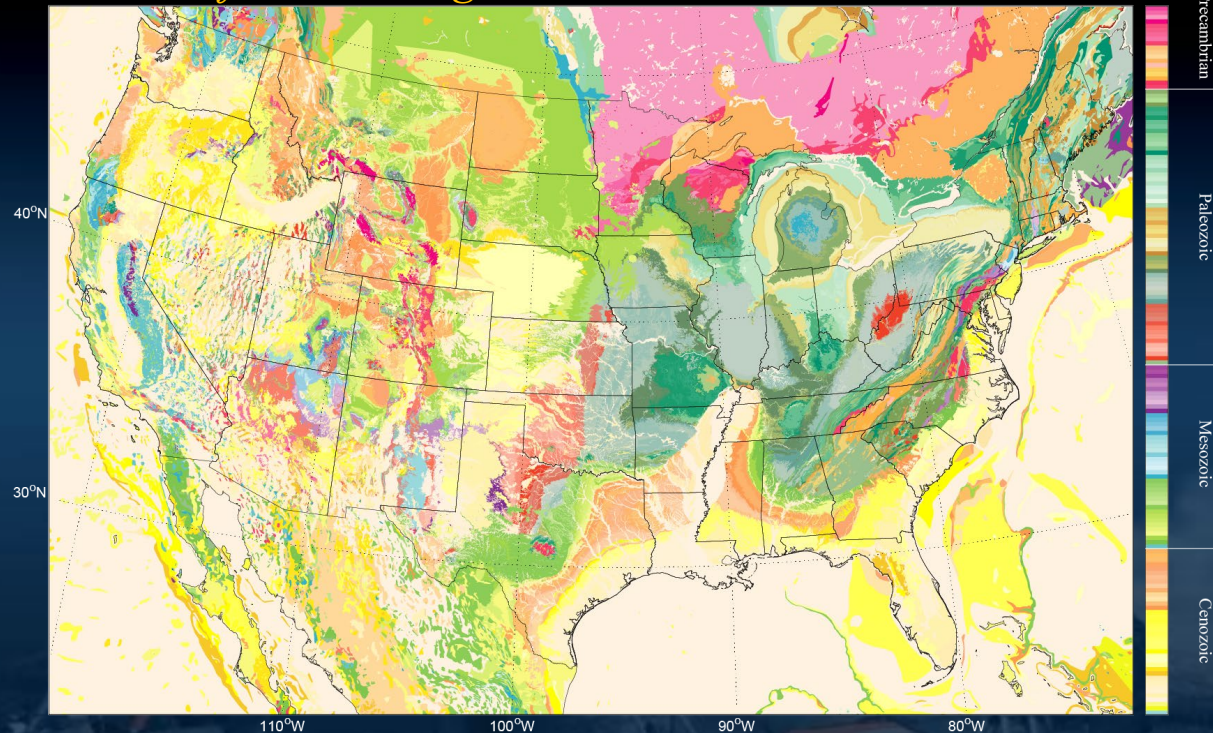
*Boyd and Sweetkind (in review)*



# 3D Geologic Framework Model

- Maps of geology and age near and below the Earth's surface
  - State Geologic Maps Compilation
  - Geologic Map of North America
  - Whitmeyer and Karlstrom (2007) Basement Geology

*Near Surface Rock Age*

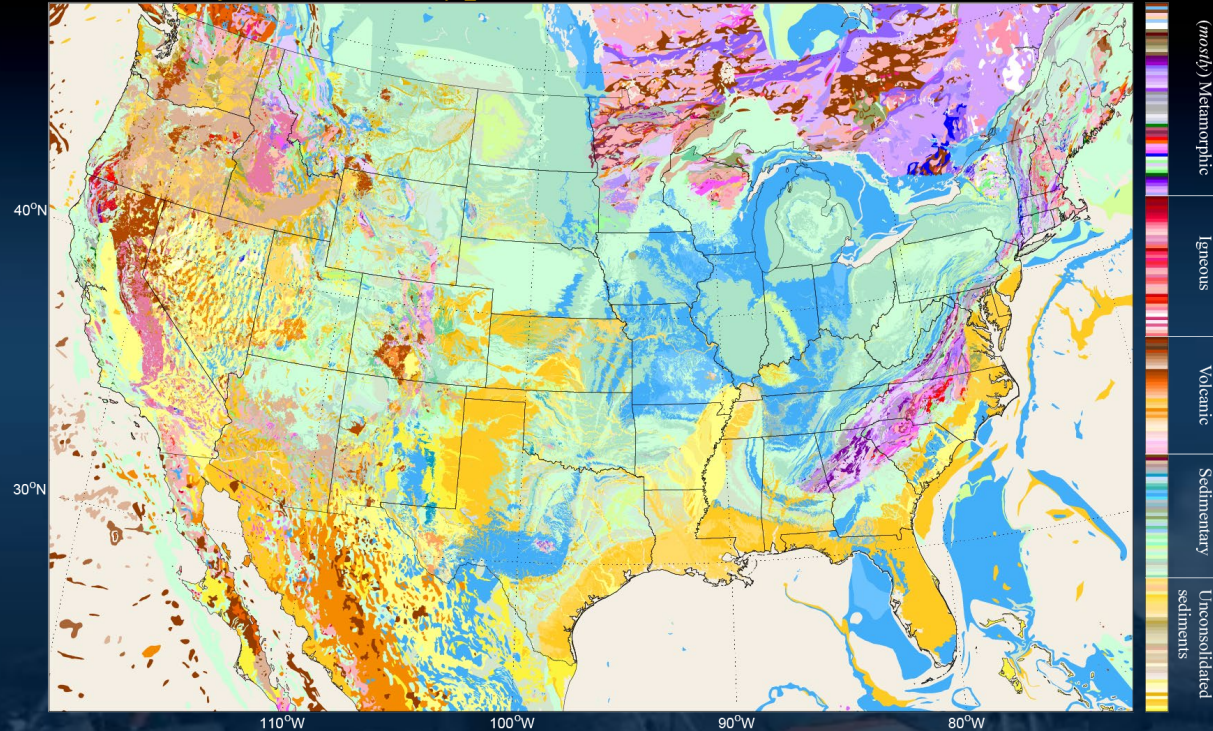


*Boyd and Sweetkind (in review)*

# 3D Geologic Model: Lithology

- Maps of geology and age near and below the Earth's surface
  - State Geologic Maps Compilation
  - Geologic Map of North America
  - Whitmeyer and Karlstrom (2007) Basement Geology

*Near Surface Rock Type*



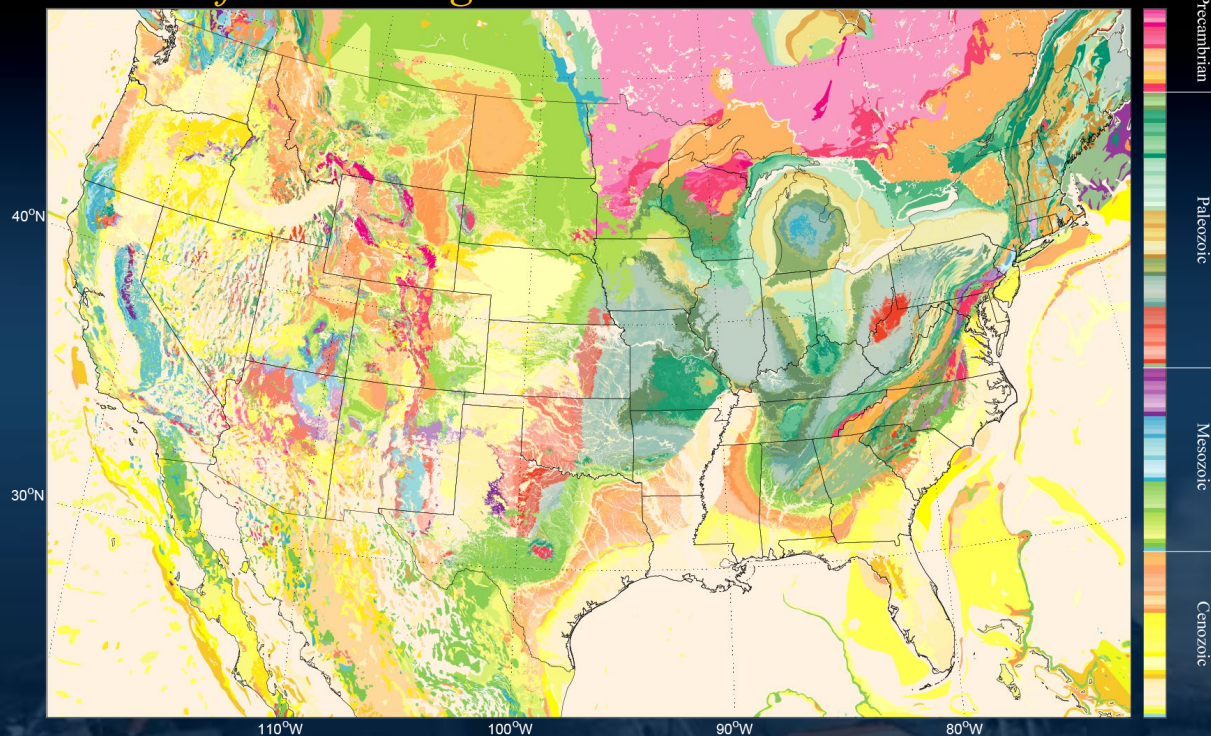
*Boyd and Sweetkind (in review)*



# 3D Geologic Model: Subsurface

- Subsurface geology built by iteratively stripping sedimentary and extrusive volcanic units, ordered by age, and then using nearest neighbors to fill in the gaps of age and rock type.

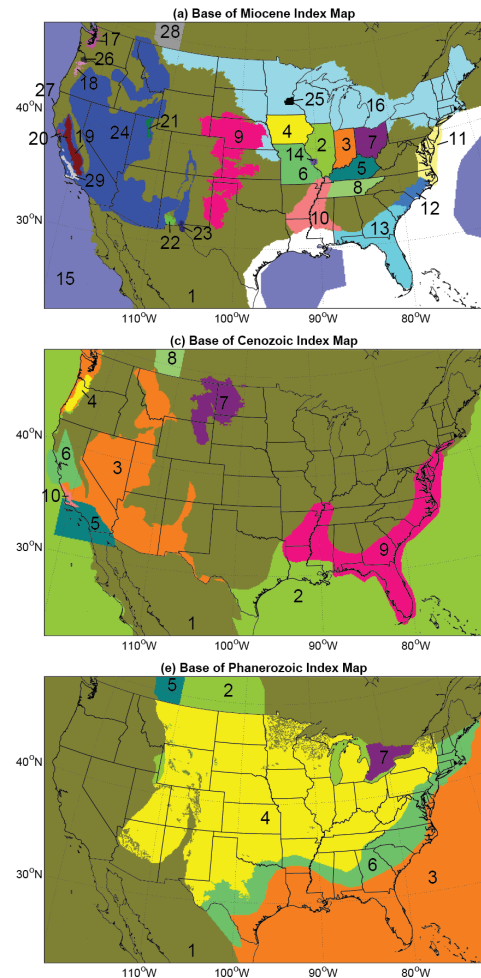
*Near Surface Rock Age*



*Boyd and Sweetkind (in review)*

# 3D Geologic Model: Depth

- Primary surfaces include depth to base of Miocene, Cenozoic, Phanerozoic, midcrustal discontinuities, and Moho.
- Most surfaces comprised of multiple studies.
- Where no studies are present for the base of Cenozoic and Phanerozoic (Index #1), depth is a function of distance to older or igneous outcrop, scaled based on local information.



Boyd and Sweetkind (in review)

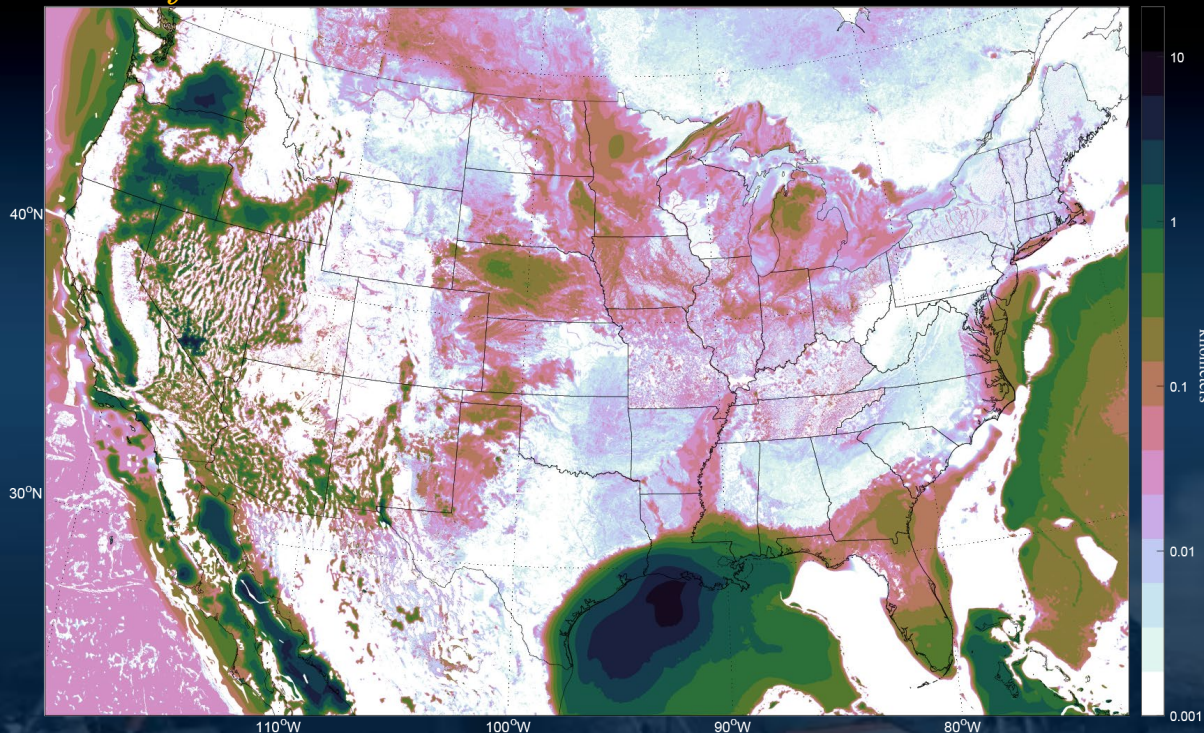


# 3D Geologic Model: Depth

## Base of Miocene

- 100's of meters thick fluvial and glacial sediment in the central U.S.
- Kilometers thick Miocene deposits in the Gulf of Mexico
- Kilometers thick sedimentary and volcanic deposits in the western U.S.

*Base of Miocene*



*Boyd and Sweetkind (in review)*

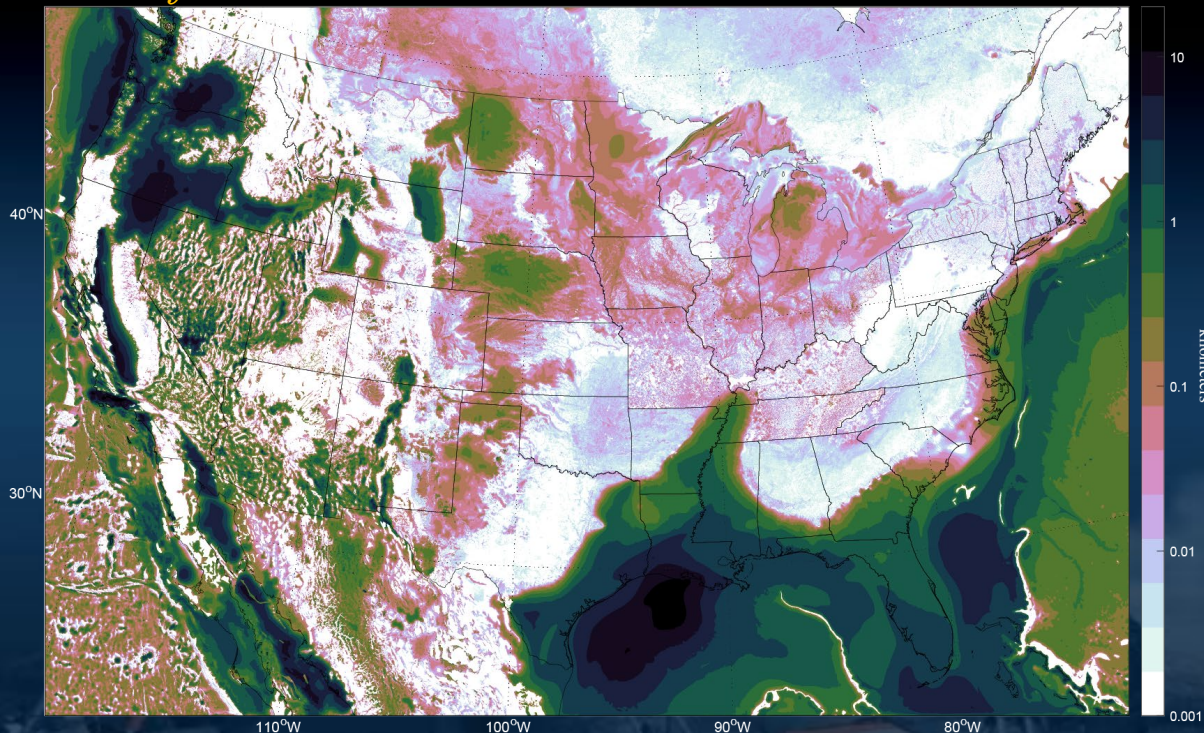


# 3D Geologic Model: Depth

## Base of Cenozoic

- Base of Miocene and Cenozoic coincide in much of the central U.S.
- Atlantic and Gulf Coastal Plains host thick Paleogene deposits
- Basins along the Rocky Mountains and into the western U.S. have thick Cenozoic deposits.

*Base of Cenozoic*



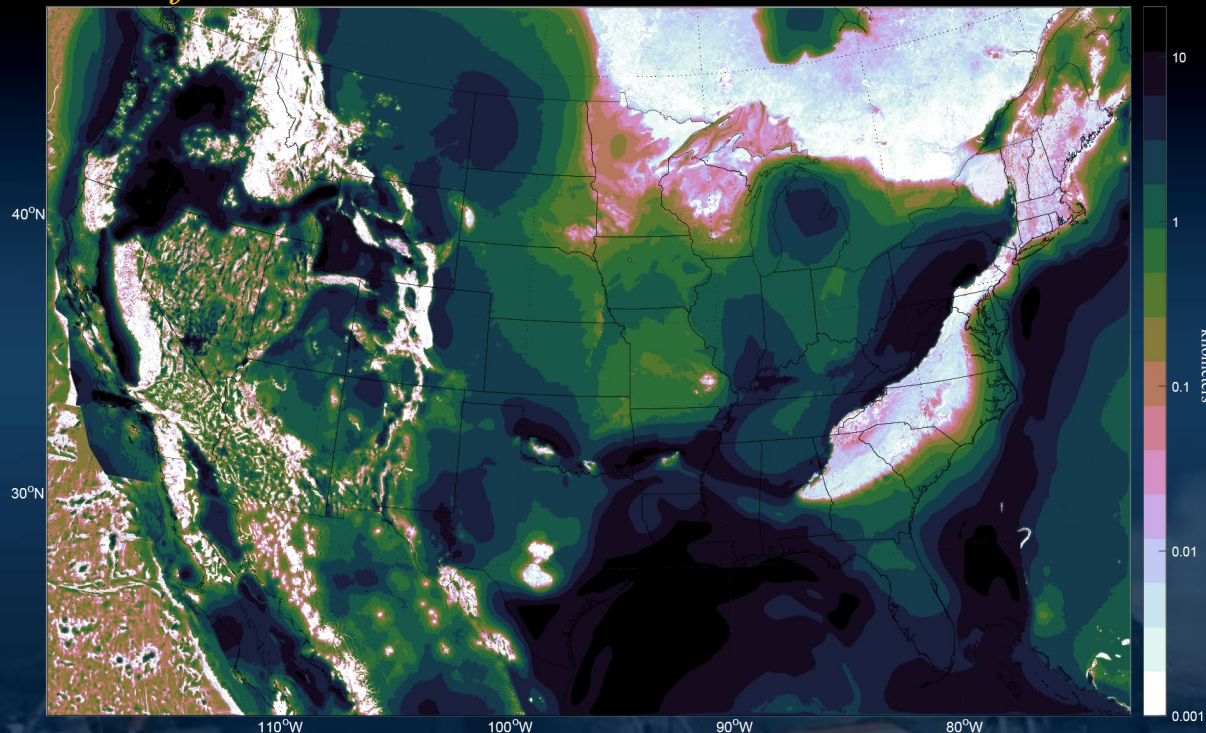
*Boyd and Sweetkind (in review)*

# 3D Geologic Model: Depth

## Base of Phanerozoic

- Significant role in the central U.S. and on to the Colorado Plateau.
- Depth unknown in many parts of the western U.S.

### *Base of Phanerozoic*



*Boyd and Sweetkind (in review)*





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# PROFILE COMPARISONS



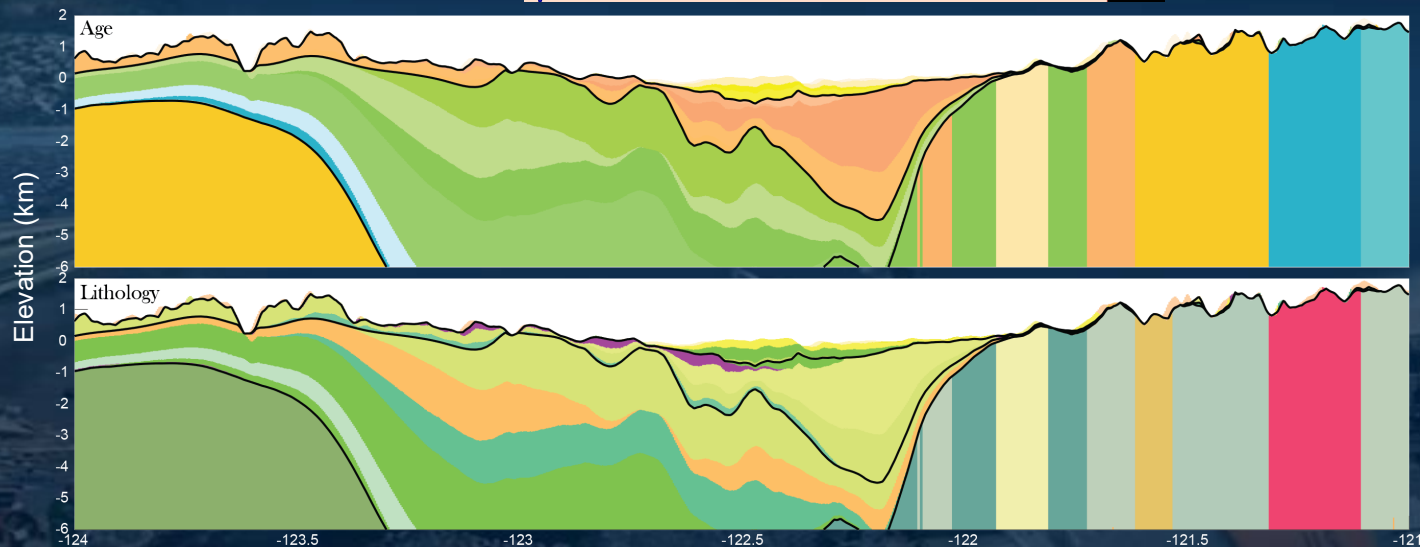
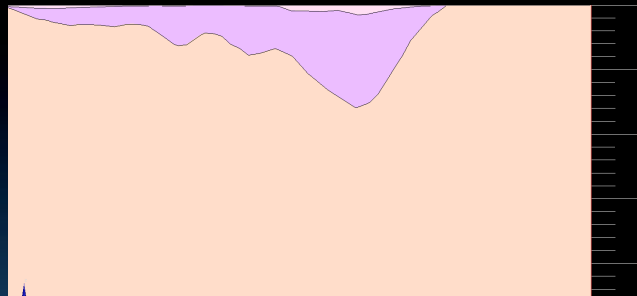


# 3D Geologic Model: Comparison

- Seattle profile at 48°N

Stephenson et al., 2017

NCM, v240205



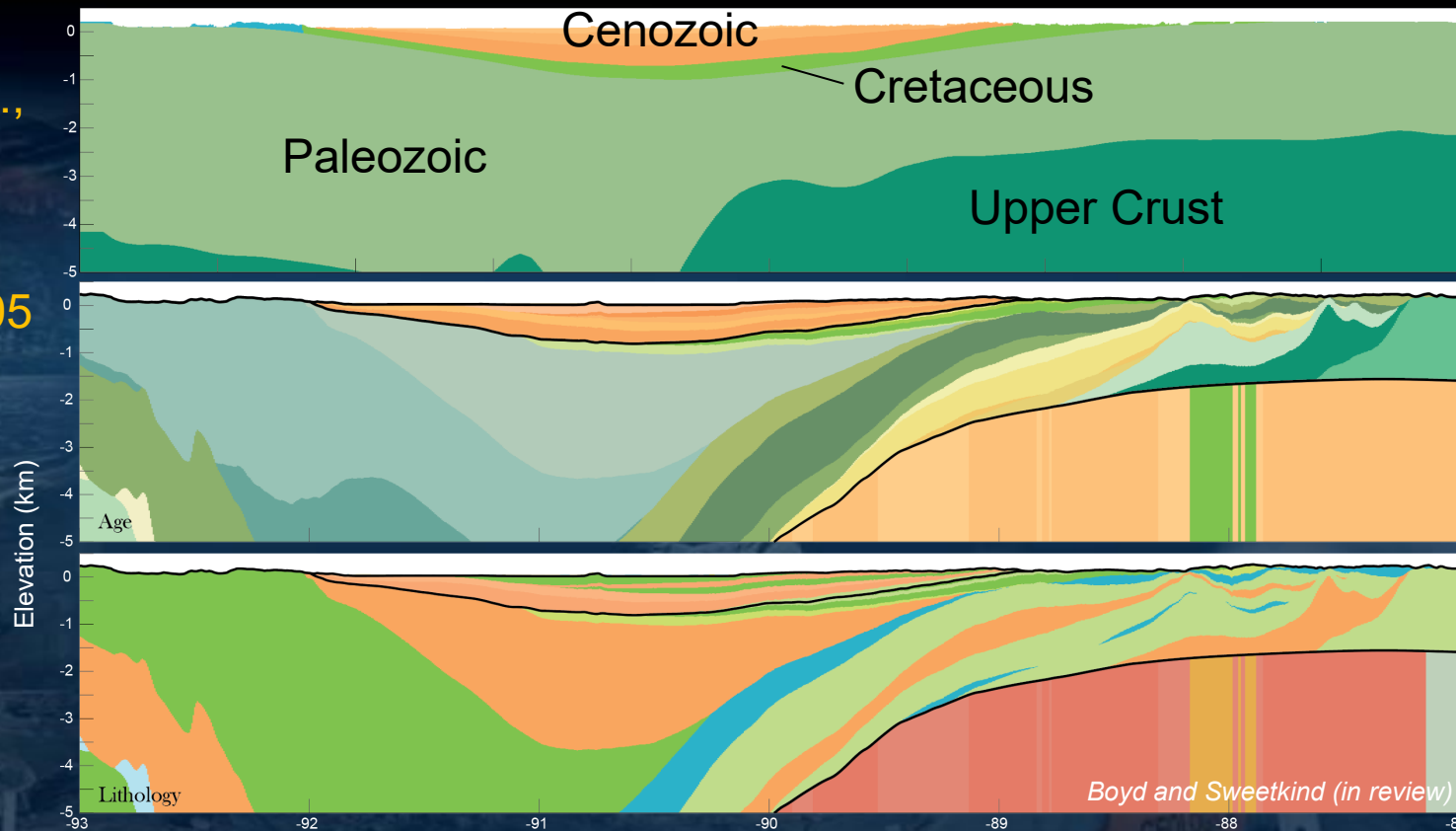
Boyd and Sweetkind (in review)

# 3D Geologic Model: Comparison

- Embayment profile at 35°N

Ramirez-  
Guzman et al.,  
2012

NCM, v240205



A background image showing USGS field workers at a construction site. In the foreground, a worker in a hard hat and orange vest with 'U.S. GEOLOGICAL SURVEY' on the back is visible. Another worker in a hard hat and safety vest is holding a map. In the background, a large bridge is under construction, and a worker is operating a surveying instrument on a tripod. The scene is set against a dark, blue-tinted background.

# Thank you

For more information, contact:  
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# References

- Aagaard, B.T., Graves, R.W., Rodgers, A., Brocher, T.M., Simpson, R.W., Dreger, D., Petersson, N.A., Larsen, S.C., Ma, S., and Jachens, R.C., 2010, Ground motion modeling of Hayward fault scenario earthquakes, Part II: Simulation of long-period and broadband ground motions: Bulletin of the Seismological Society of America, v. 100, no. 6, p. 2945–2977, <https://doi.org/10.1785/0120090379>.
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