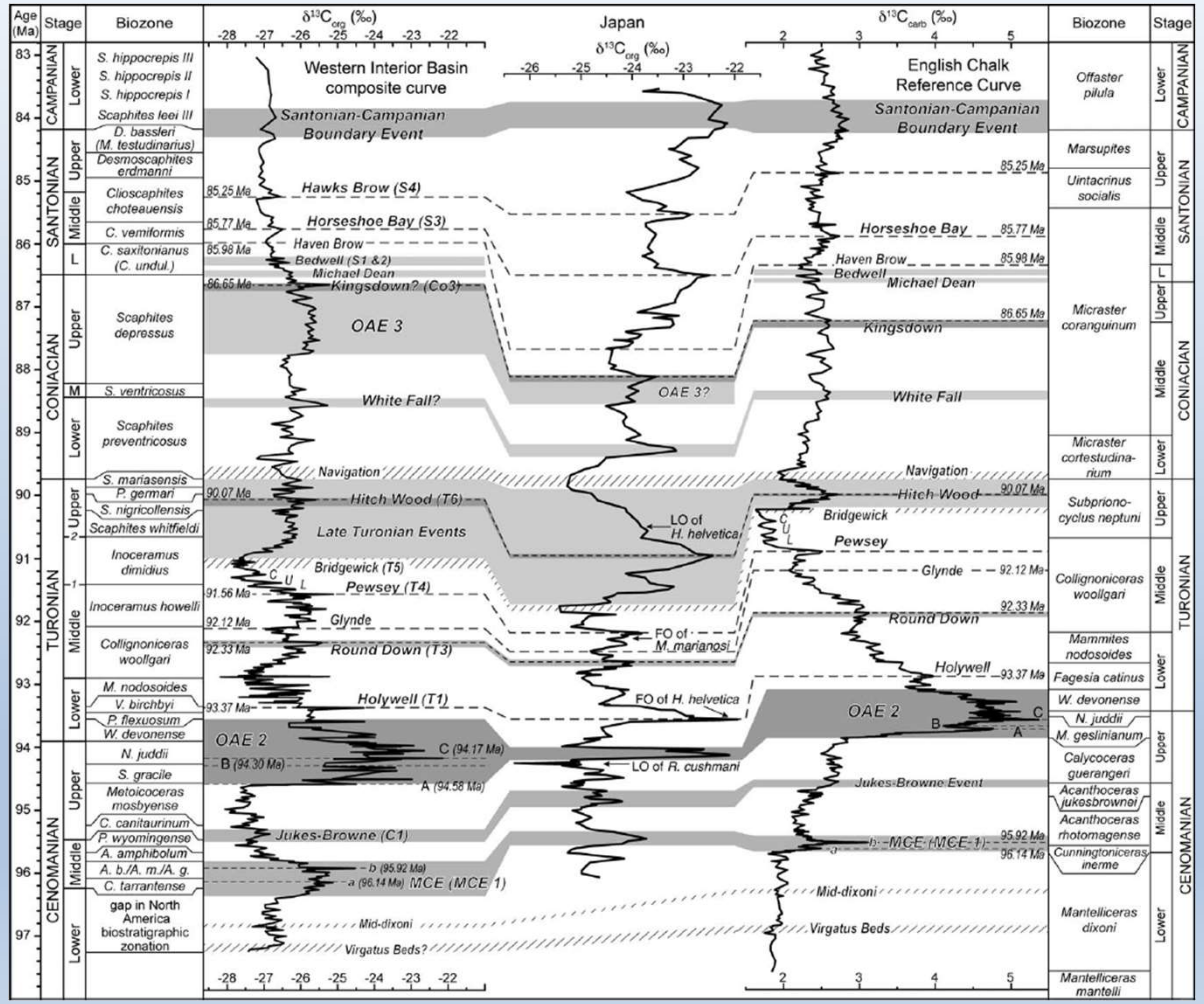

Emre Cankut Kondakci Ph.D. Candidate Summer 2022

# GEOCHEMISTRY OF OAE III IN THE NIOBRARA FORMATION

# Outline

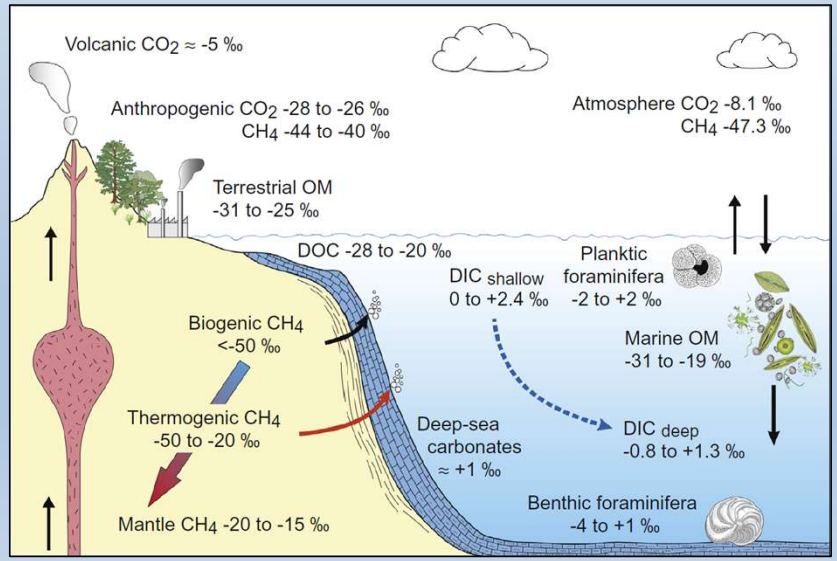
- Introduction
- Ocean Anoxic Events – Global vs. Regional
- Paleoredox Stages and Conditions During OAE III
- Changes in Organic Matter Composition
- Nutrient Recycling – Paleoproductivity
- Paleoclimate – Hydrographic Nature of WIS
- Conclusions
- Future Research Suggestions

# Ocean Anoxic Events



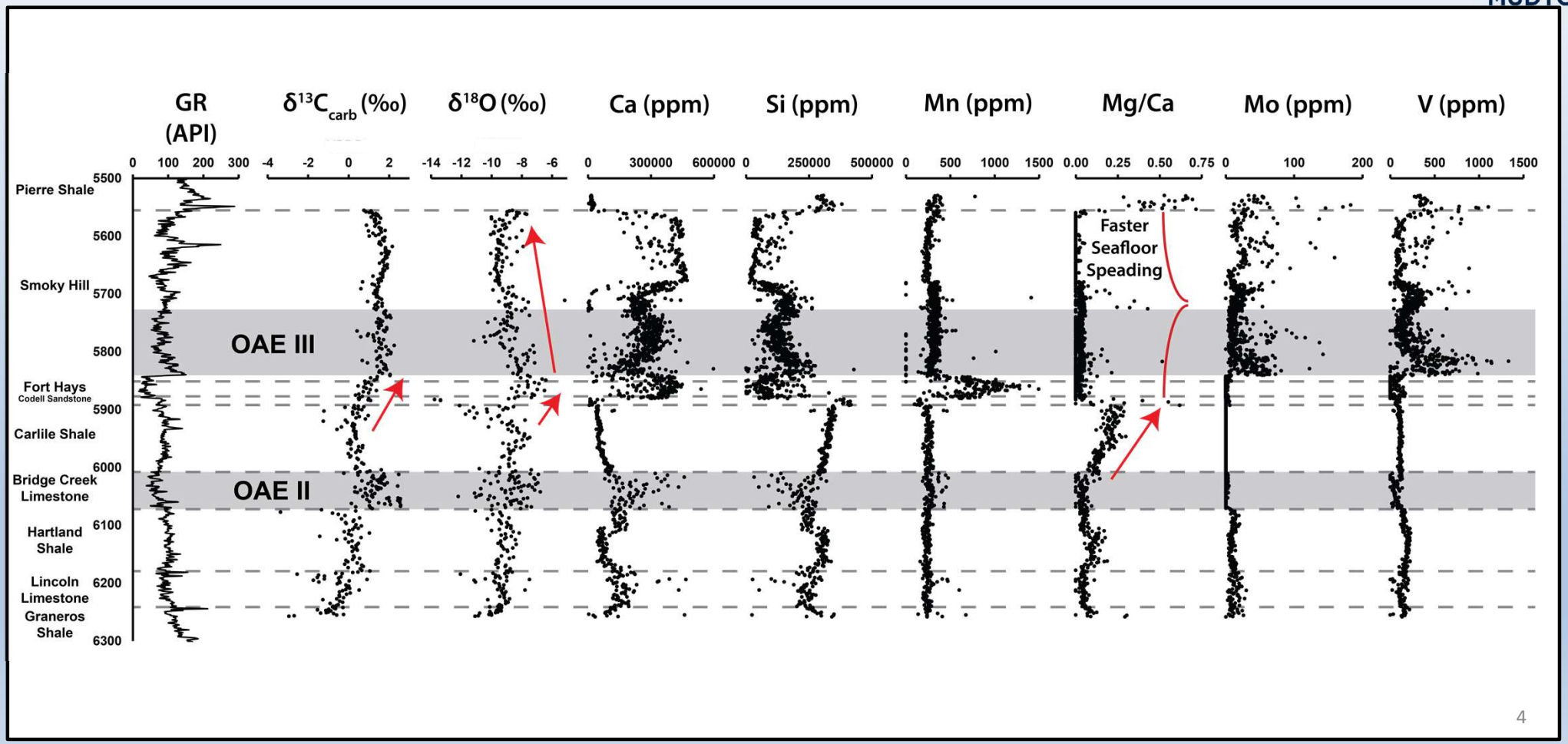

(Joo and Sageman, 2014)

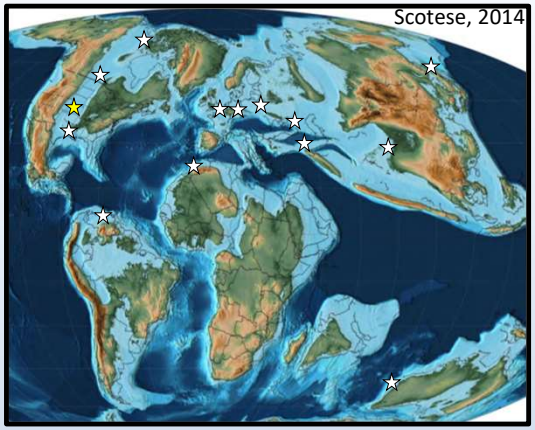
- Stable isotopes can be correlated across continents
- Useful for understanding changes in carbon balance
- Increasing $\delta^{13}C$ values indicate increased productivity
- Niobrara Formation involves OAE III




(Mackensen and Schmiedl, 2019)

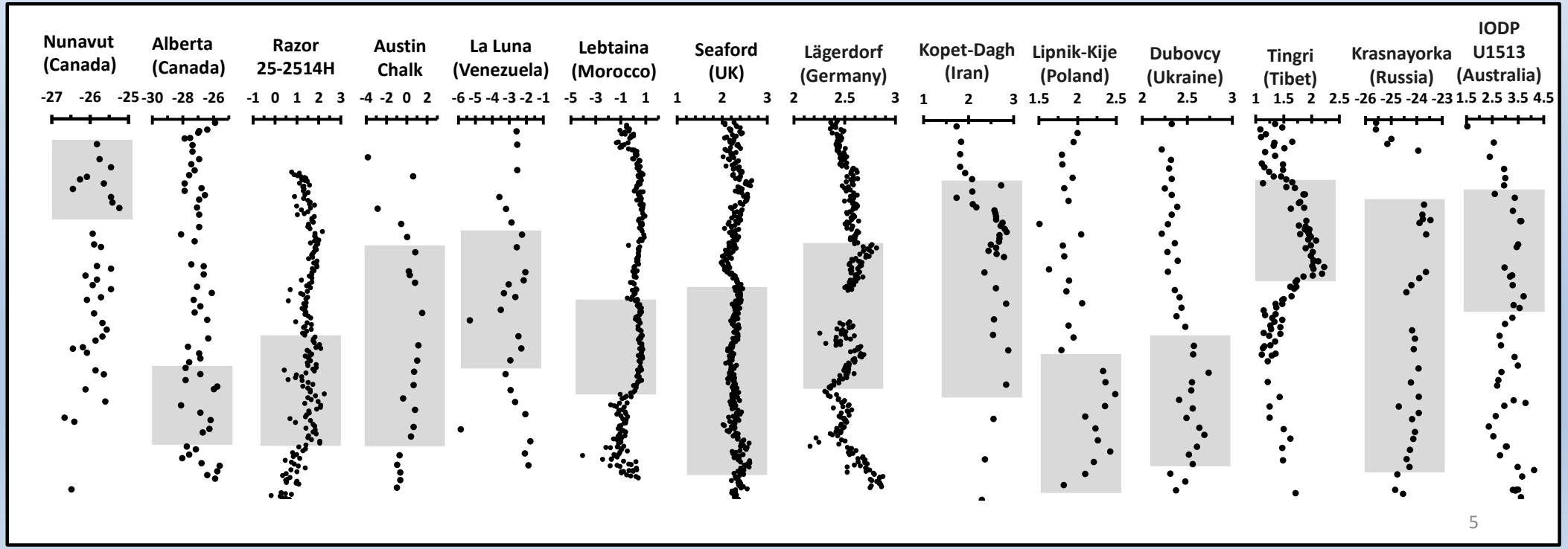
# Ocean Anoxic Event III






# Ocean Anoxic Event III

- Global vs. regional nature of the OAE III requires reassessment
- Carbon isotope trends can be correlated
- The anoxia is not global
- Positive carbon isotope excursion is global



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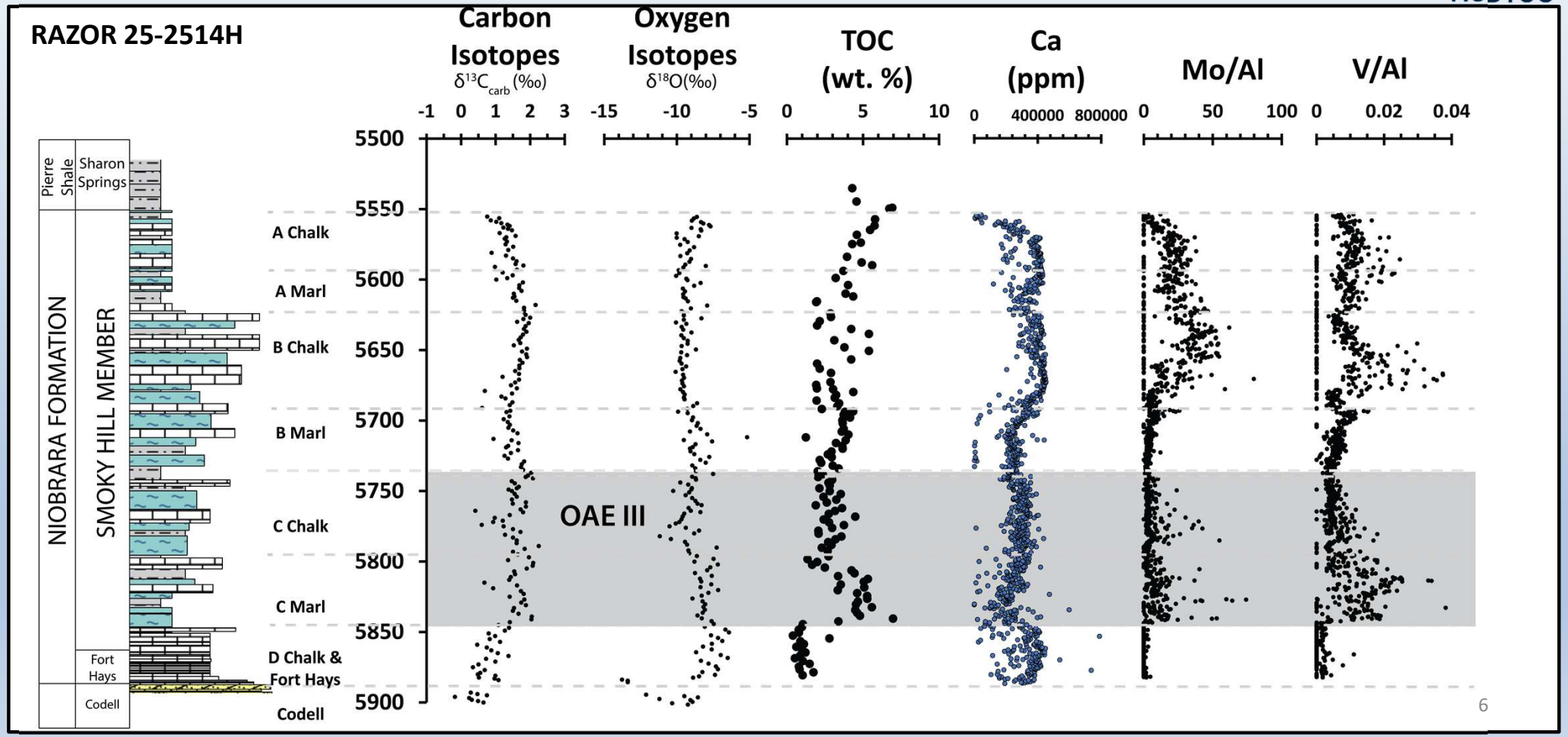
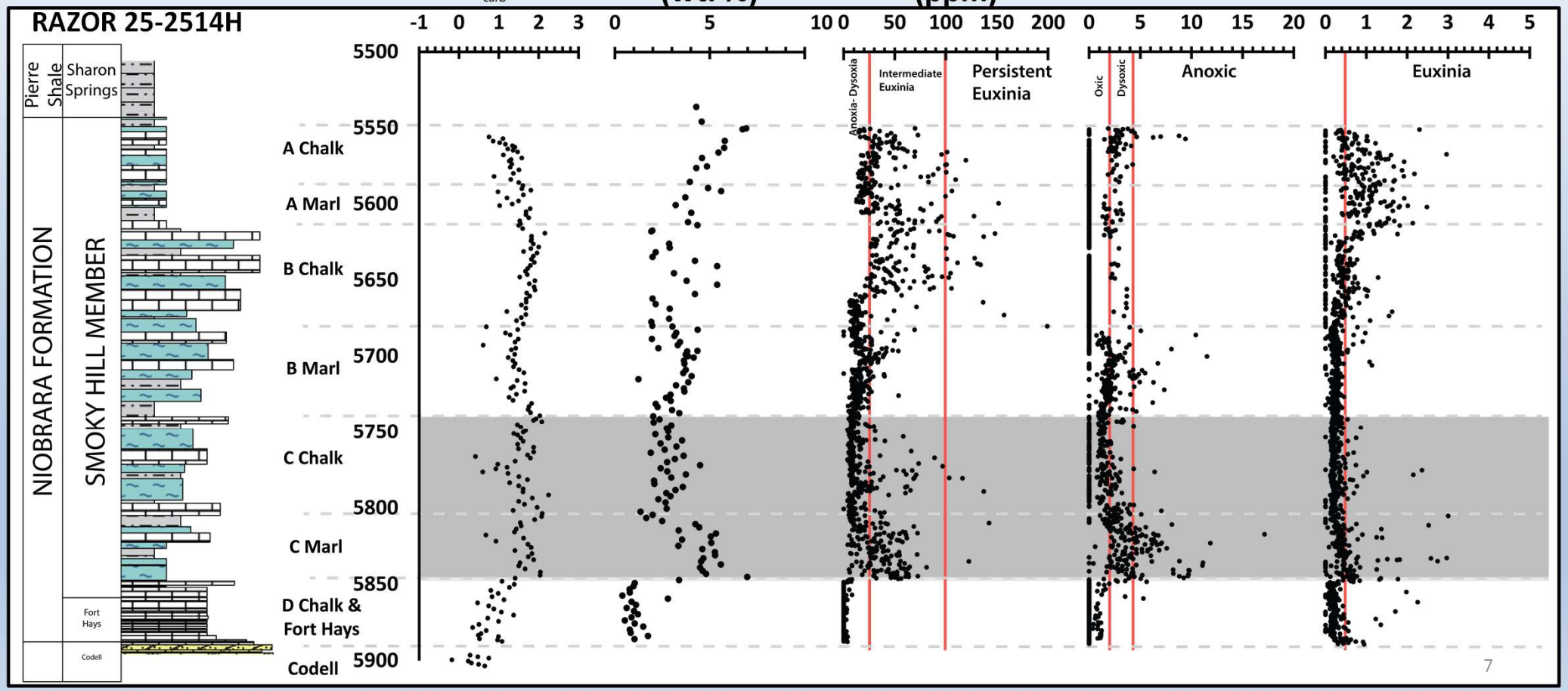
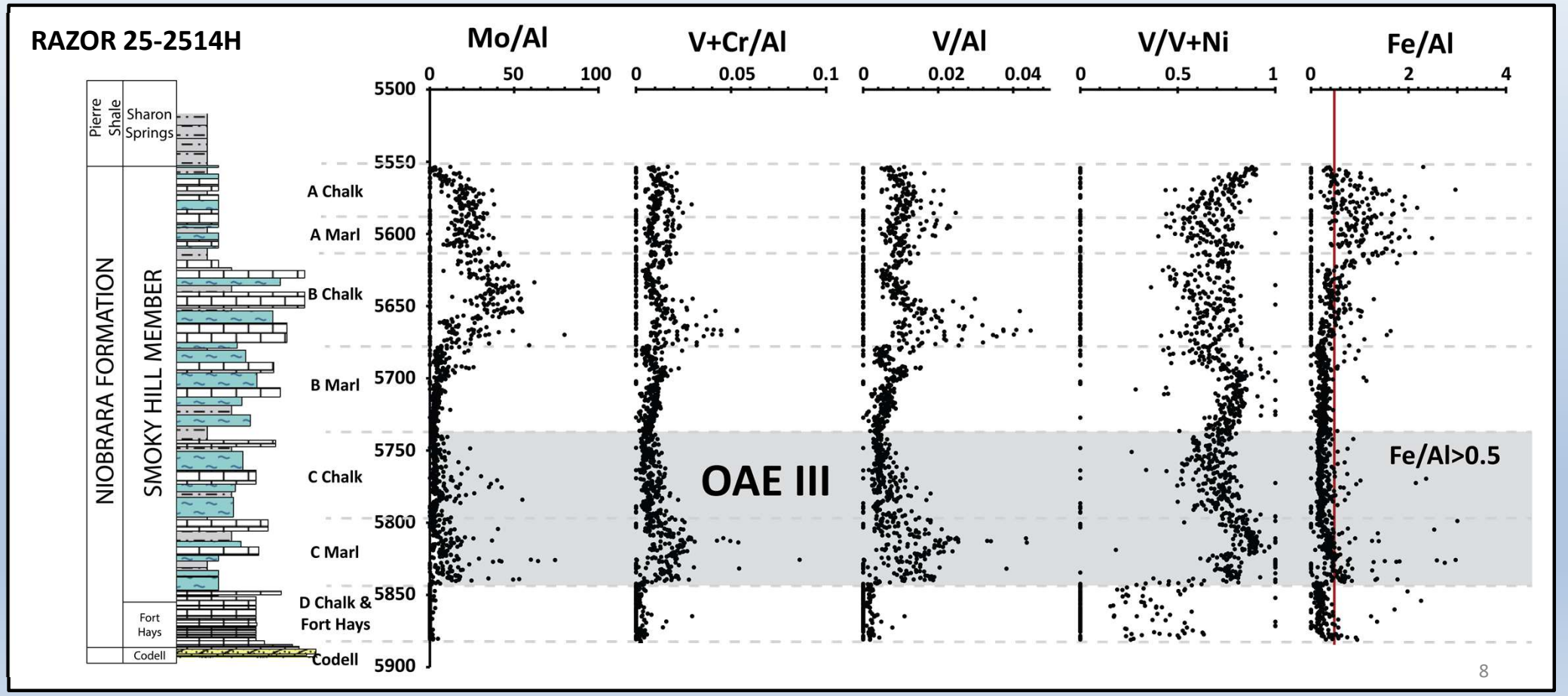


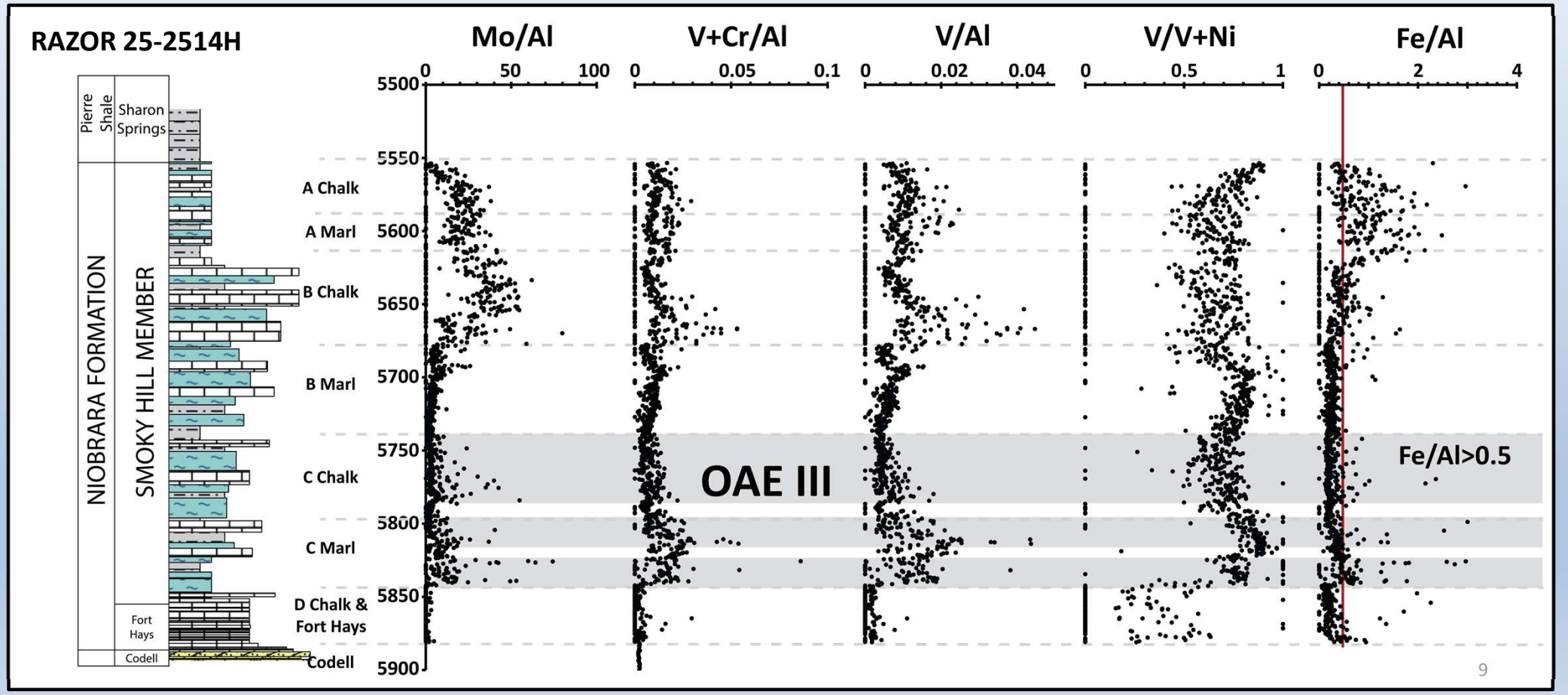
# Paleoredox Stages



# Paleoredox Conditions During OAE III



# OAE III Subdivision



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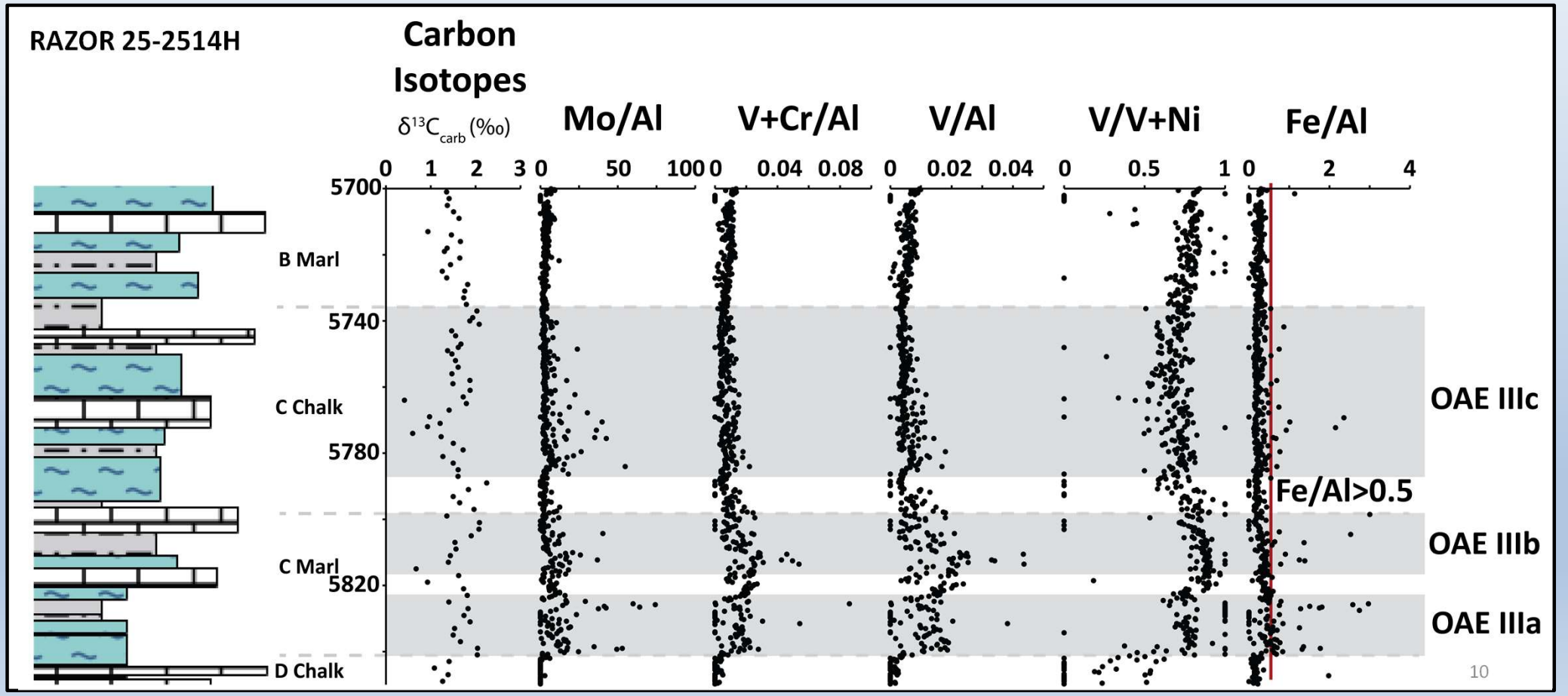
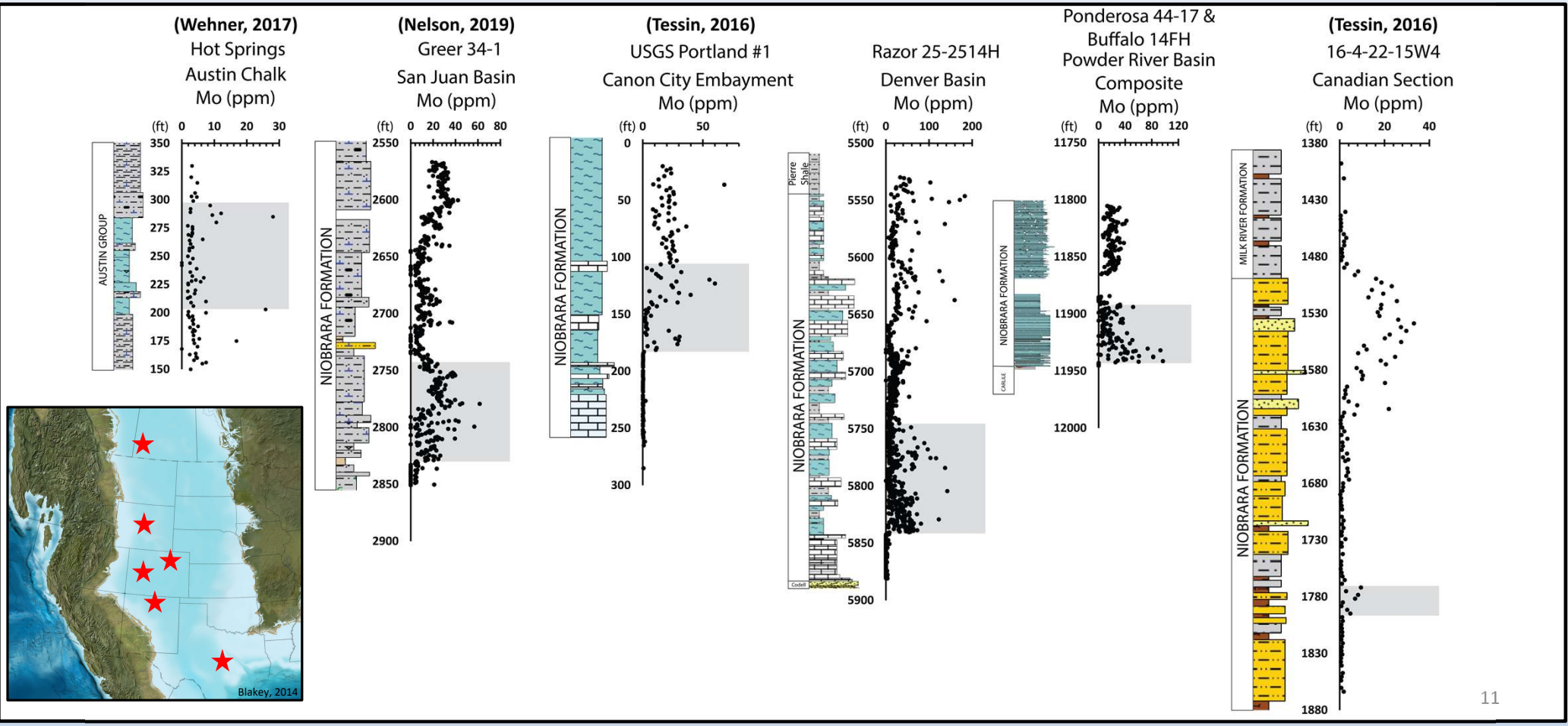
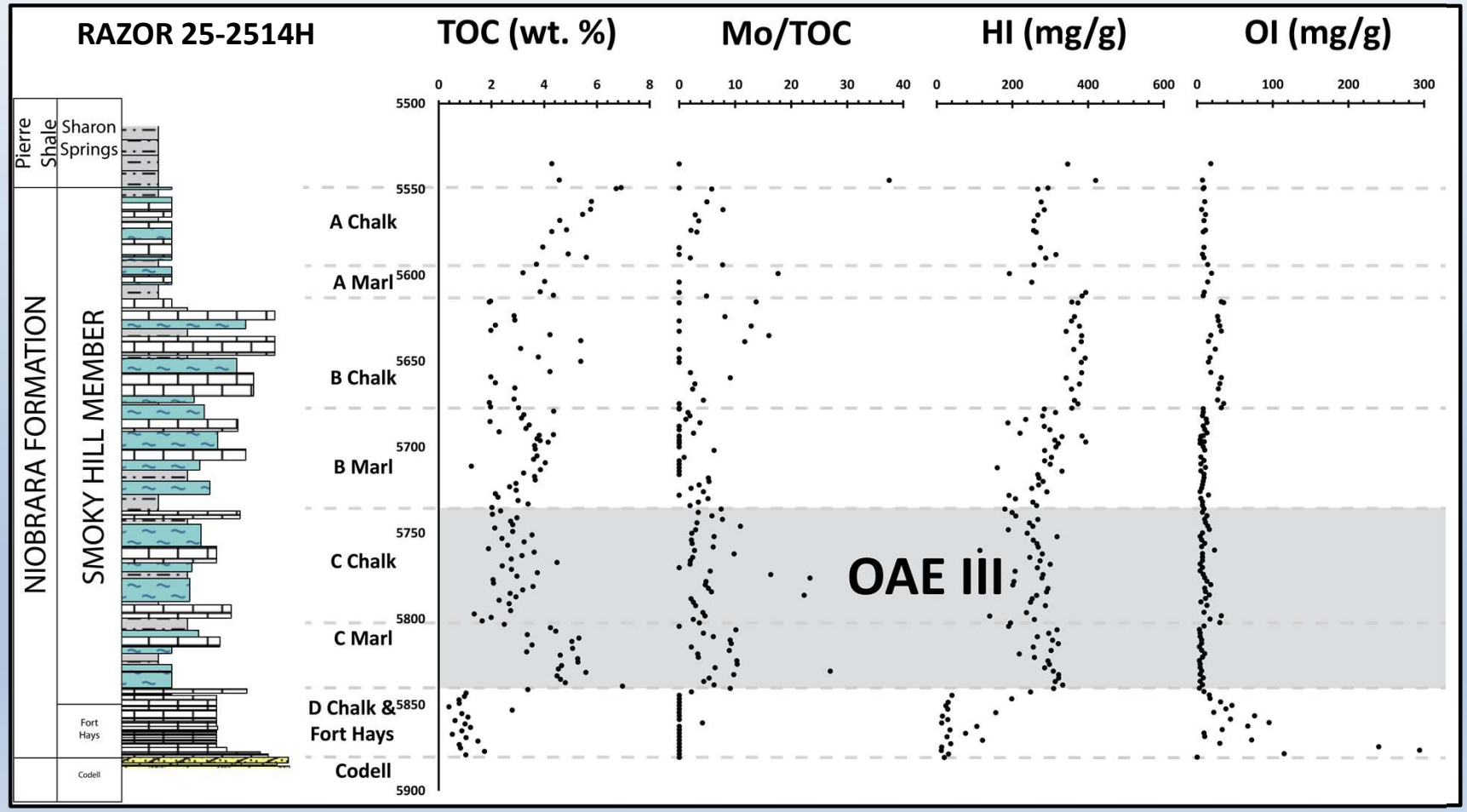


# OAE III in the WIS



# Organic Matter Composition Change



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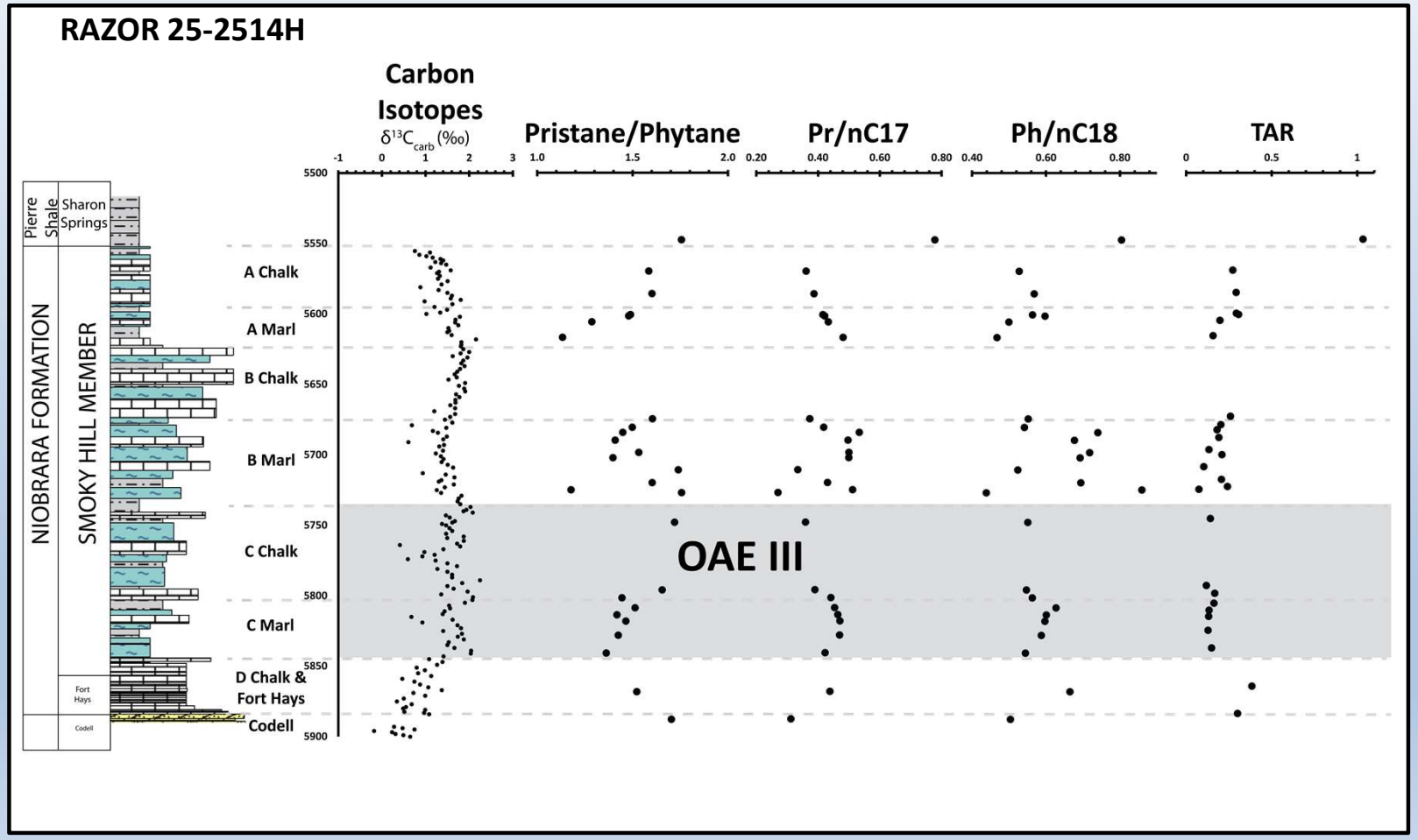
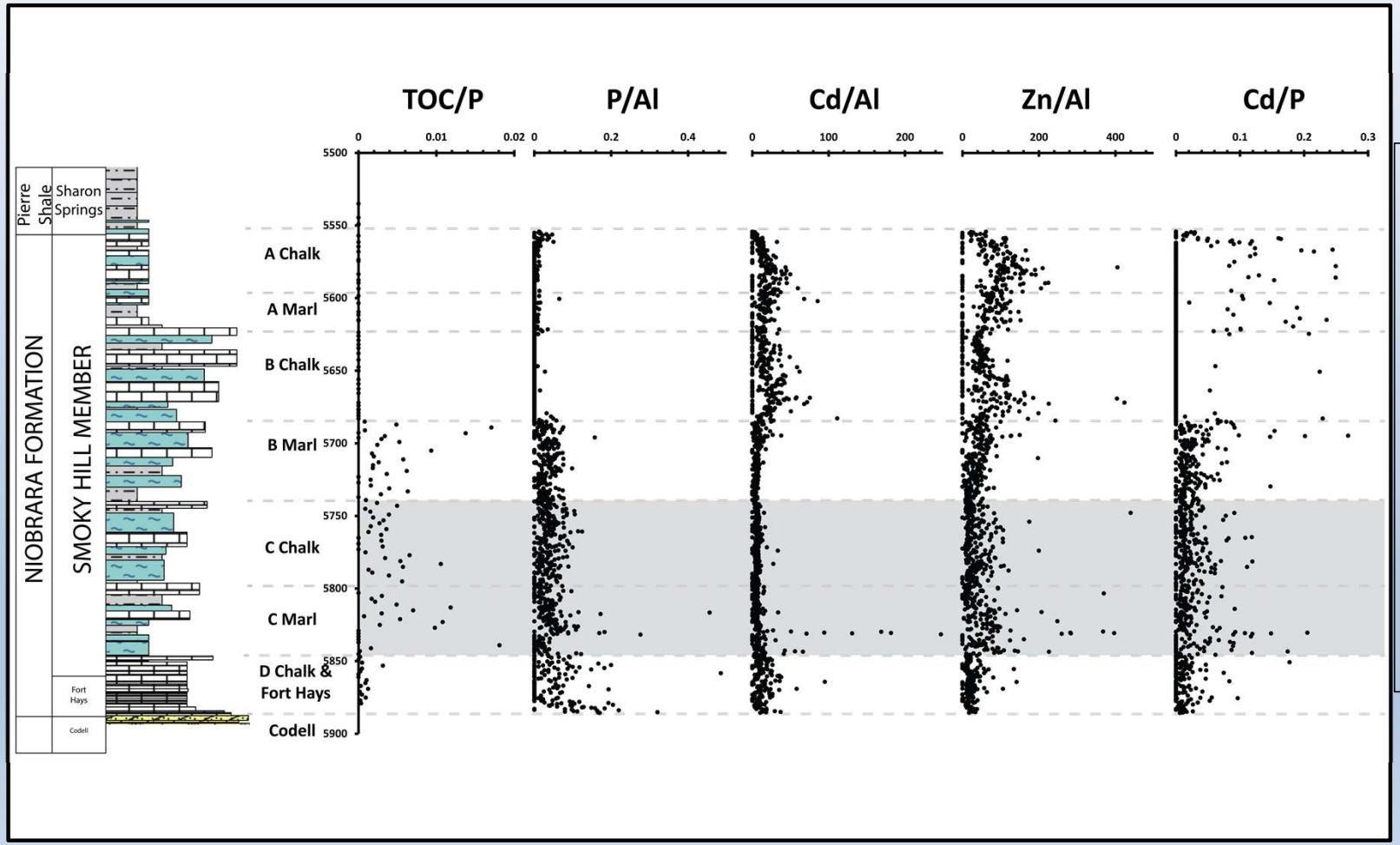


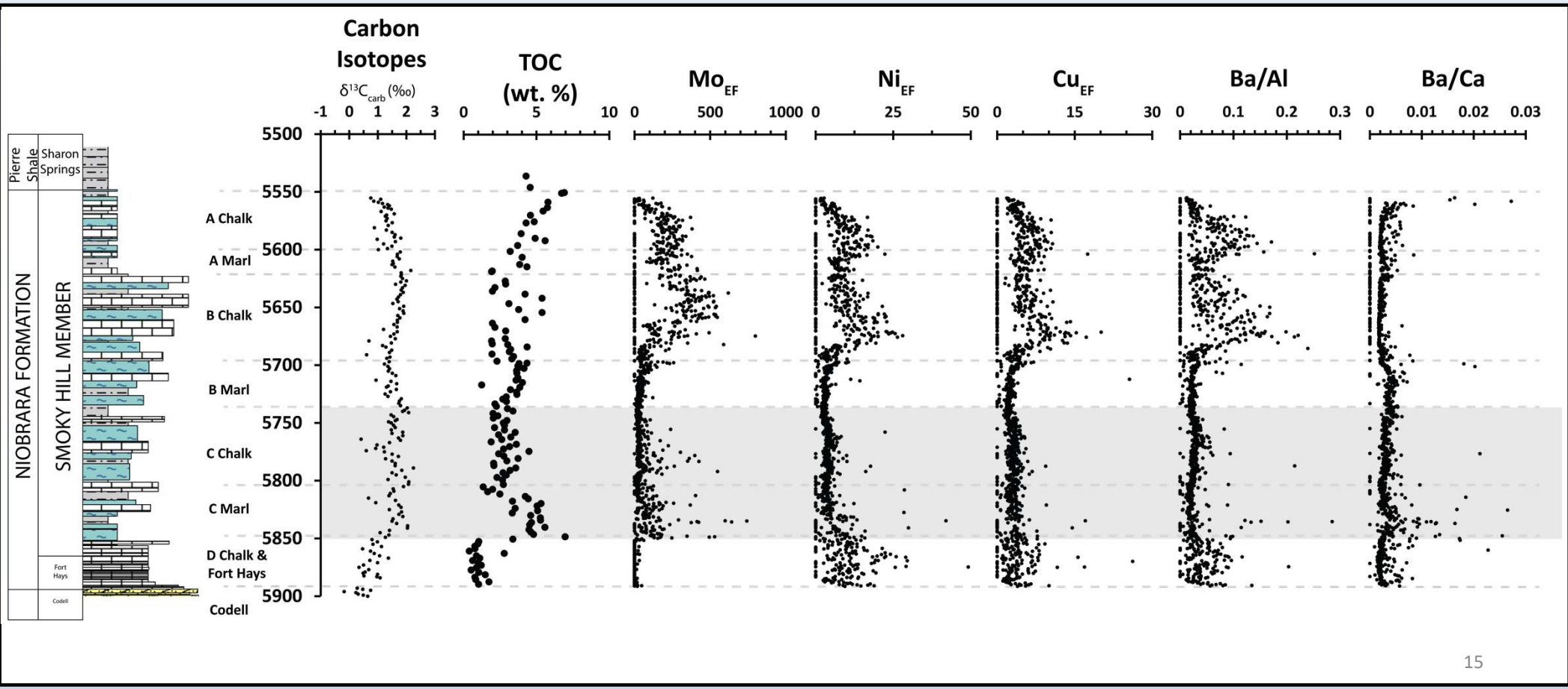

- Pr/Ph indicate oxygen depletion
- Pr/Ph not a reliable indicator
- OM composition changed
- More algae influence

# Nature of Nutrient Recycling

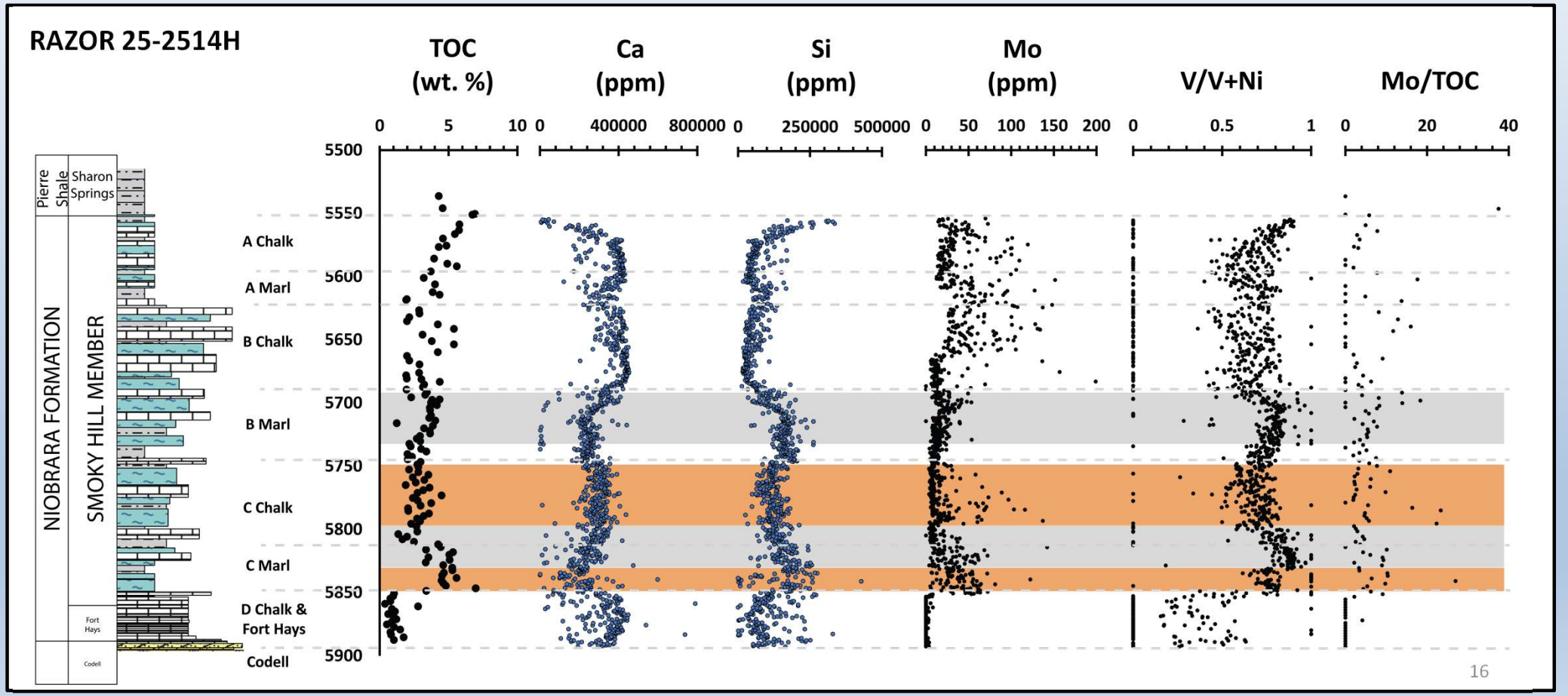



- P and Cd loss/retention
- Nutrients leave pore waters
- Continuous nutrient recycling = Increased Surface Production
- P associated with redox
- Cd nutrient-like behavior
- Pre-OAE Ph, Eh, and Salinity
- Zn increase – Algal population increase and increased rates of continental weathering
- ZnS or [Zn, Fe]S

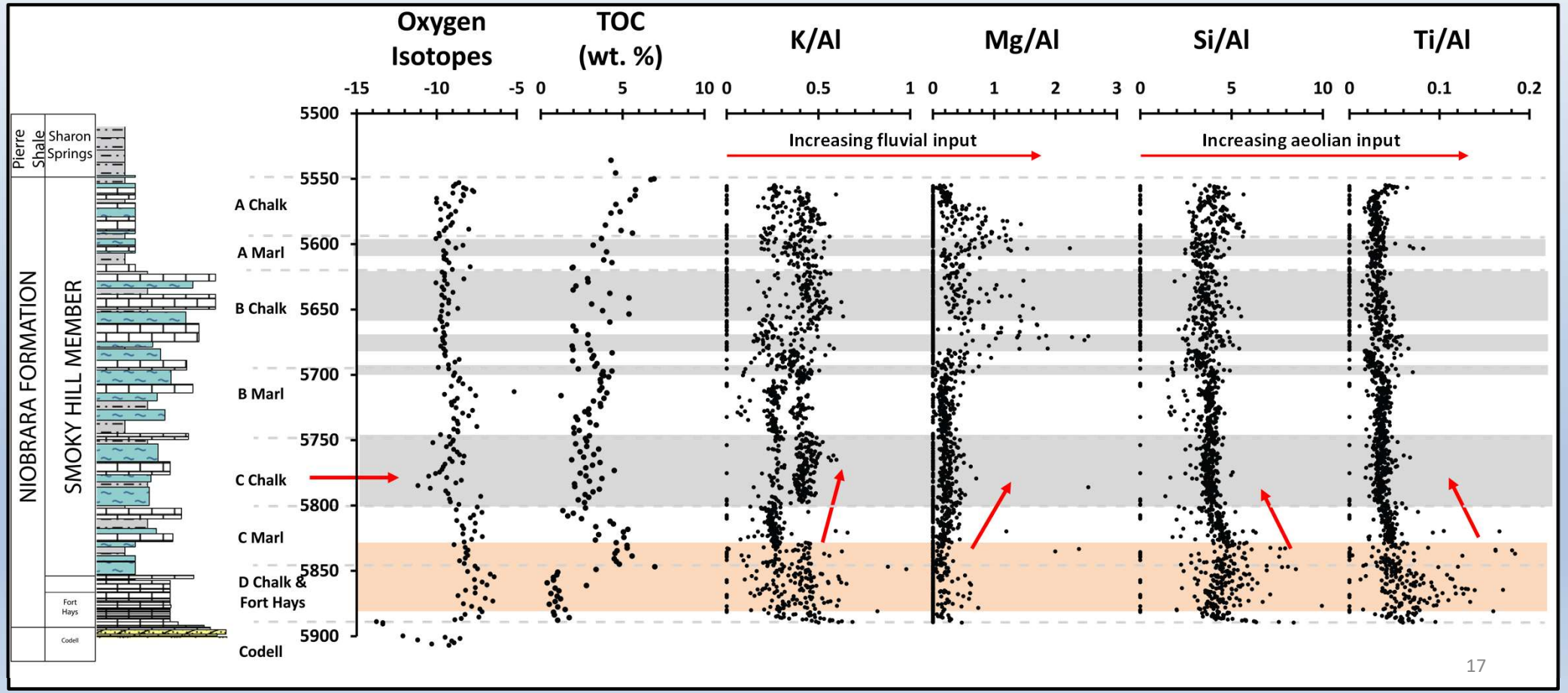
# Paleoproductivity



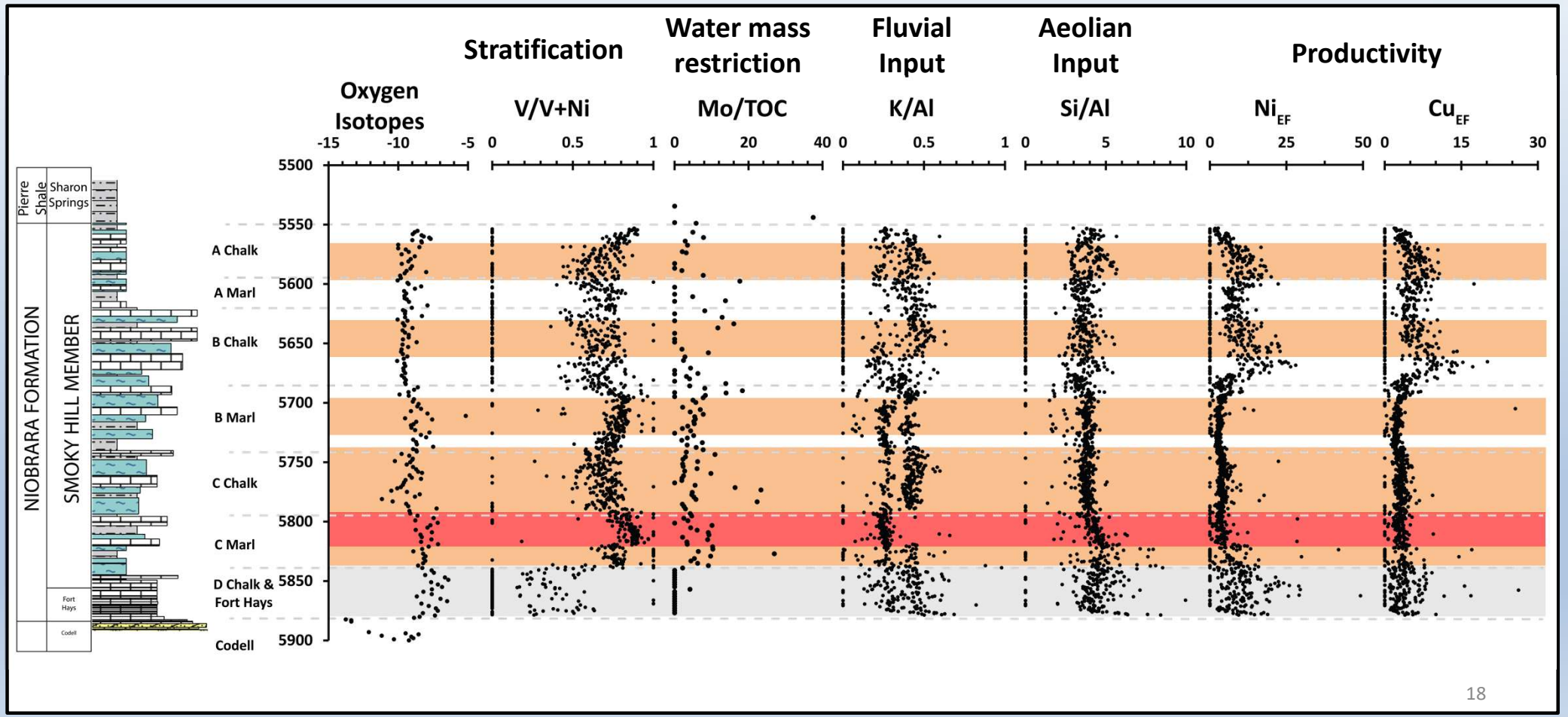
# Water Column Stratification and Water Mass Restriction



# Paleoclimate – Dry vs. Wet/Humid



# Hydrographic Nature of WIS



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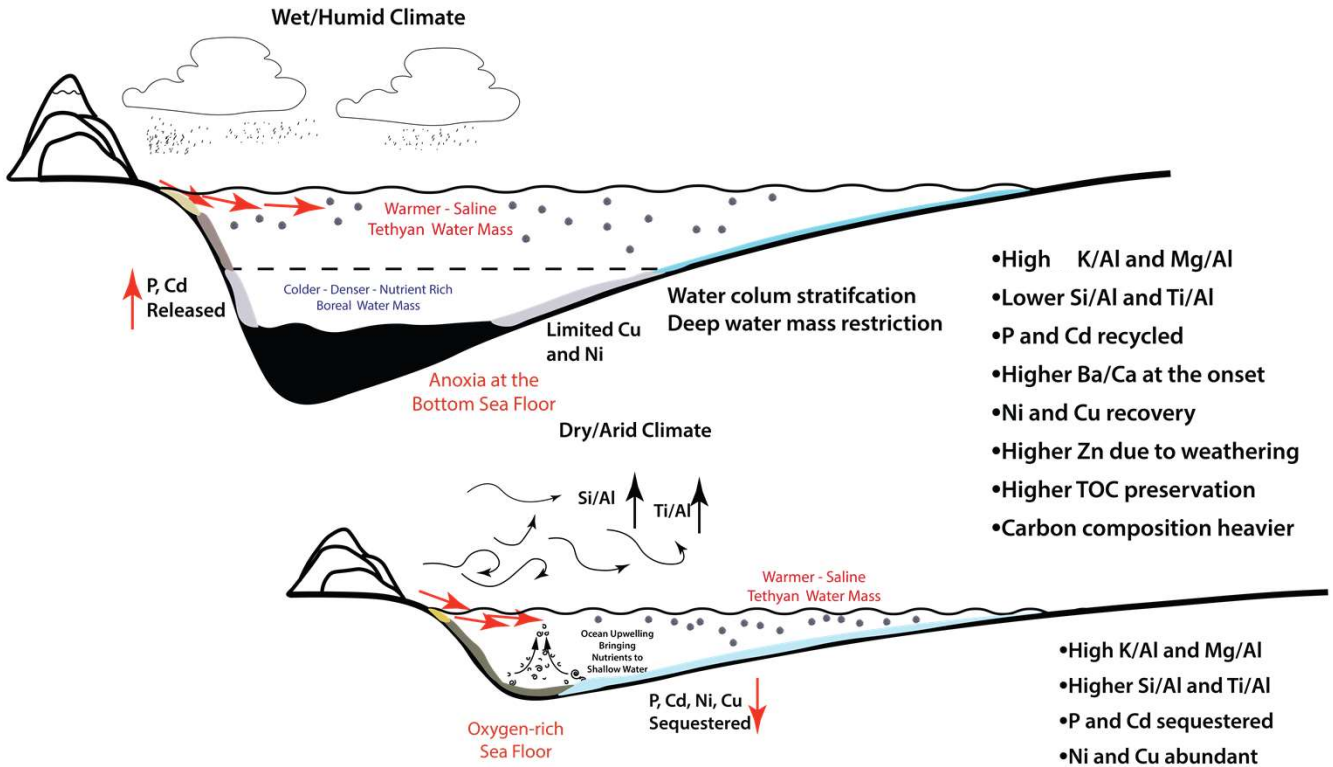
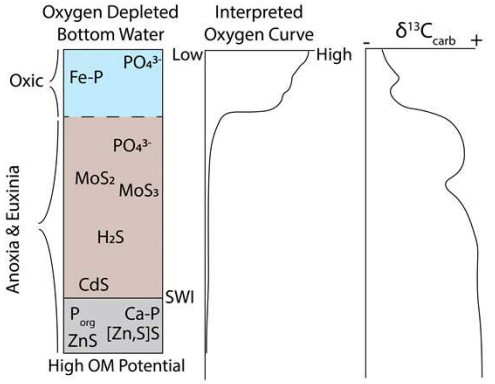
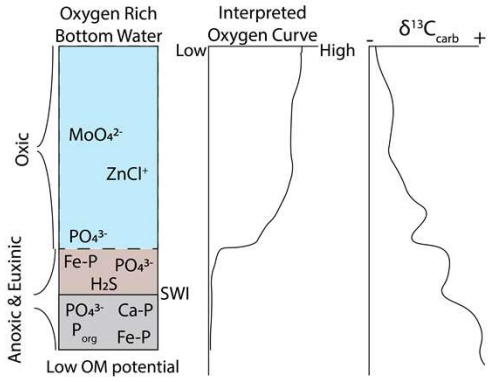



- High K/Al and Mg/Al
- Lower Si/Al and Ti/Al
- P and Cd recycled
- Higher Ba/Ca at the onset
- Ni and Cu recovery
- Higher Zn due to weathering
- Higher TOC preservation
- Carbon composition heavier




- High K/Al and Mg/Al
- Higher Si/Al and Ti/Al
- P and Cd sequestered
- Ni and Cu abundant
- Low Zn - Lesser degree of continental weathering
- Lower TOC preservation
- Carbon composition lighter



# Conclusions

- OAE III is better accentuated in WIS
- Stable carbon isotopes used for correlation show a possible global event – anoxia needs to be studied in high-resolution
- Oxidizing conditions prevalent before OAE III in WIS
- WIS becomes oxygen depleted during OAE III – Oxic to Euxinic – At least three (3) distinct anoxic stages
- Mo trend correlate across WIS but with varying intensities
- OM composition changes during OAE III, more algal OM contribution is observed based on SRA parameters and biomarkers
- Nutrients (P and Cd) are recycled leading to productivity
- Cu and Ni limited at the onset of OAE III but recovered during C Marl deposition
- Water column stratification and deep-water mass restriction were established
- Dry vs. humid/wet climate can be resolved based on K, Mg, Si, and Ti – Onset of OAE III fluvial systems are rebalancing
- OAE III in WIS a result of sustained productivity following WIS deepening

# Suggested Future Work

- Higher resolution data
  - Continuous XRF
  - Stable isotopes
- Trace metal, S, and P isotopes to better understand nutrient recycling
  - Mo, S, P, Cd, Zn
- Biostratigraphic studies
  - Age constraint
  - Basin restriction
- Sr isotopes for continental weathering rates

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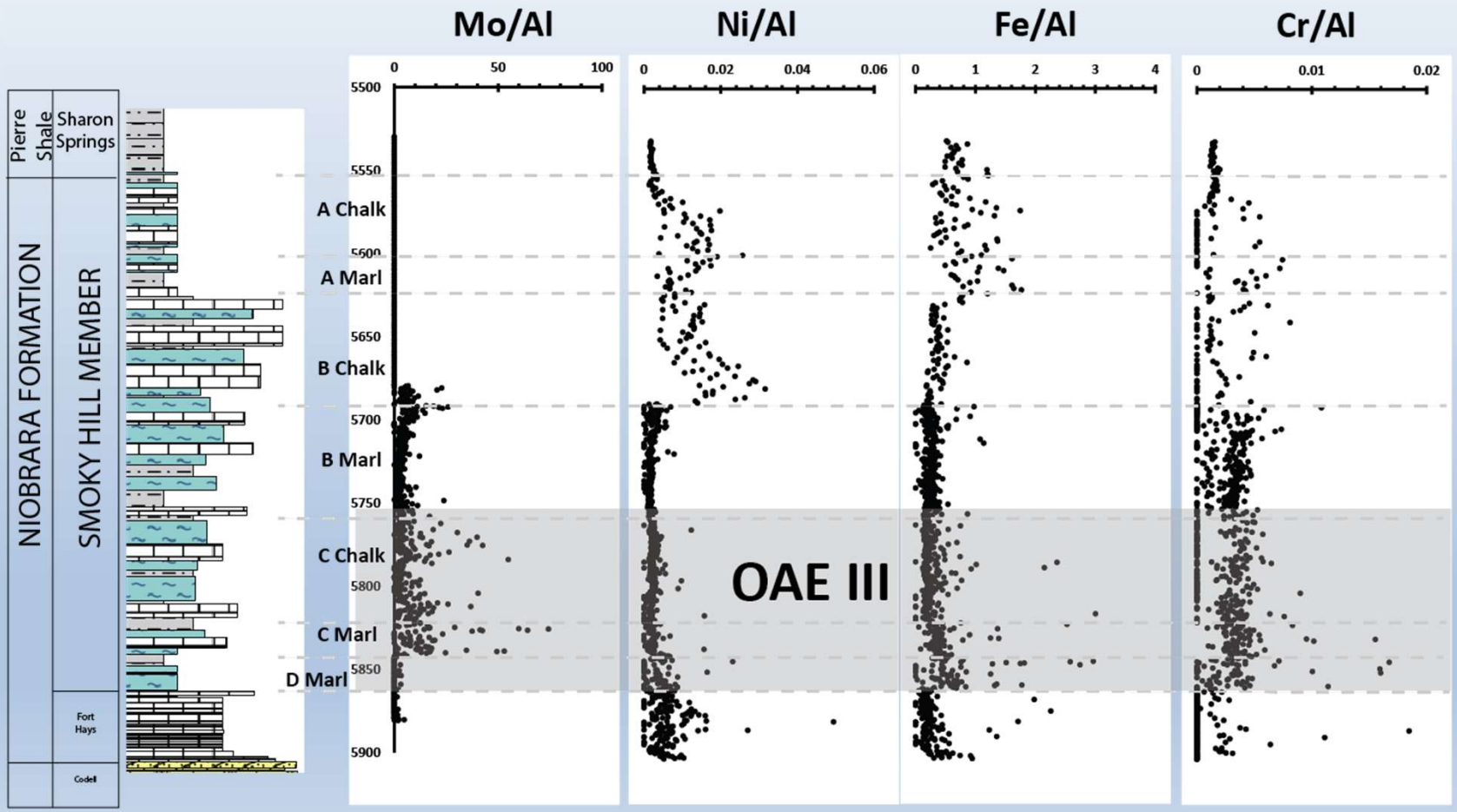
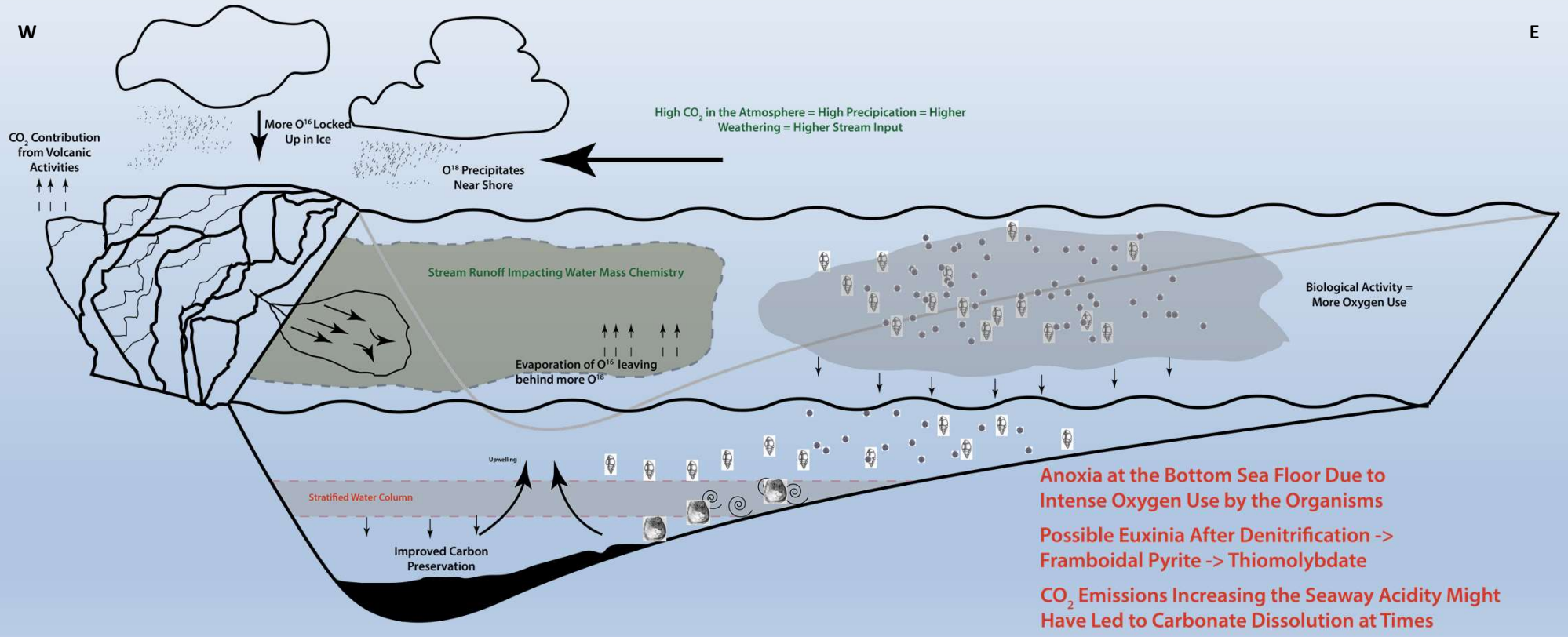
# Paleoredox Conditions During OAE III



# Geochemistry of OAE III



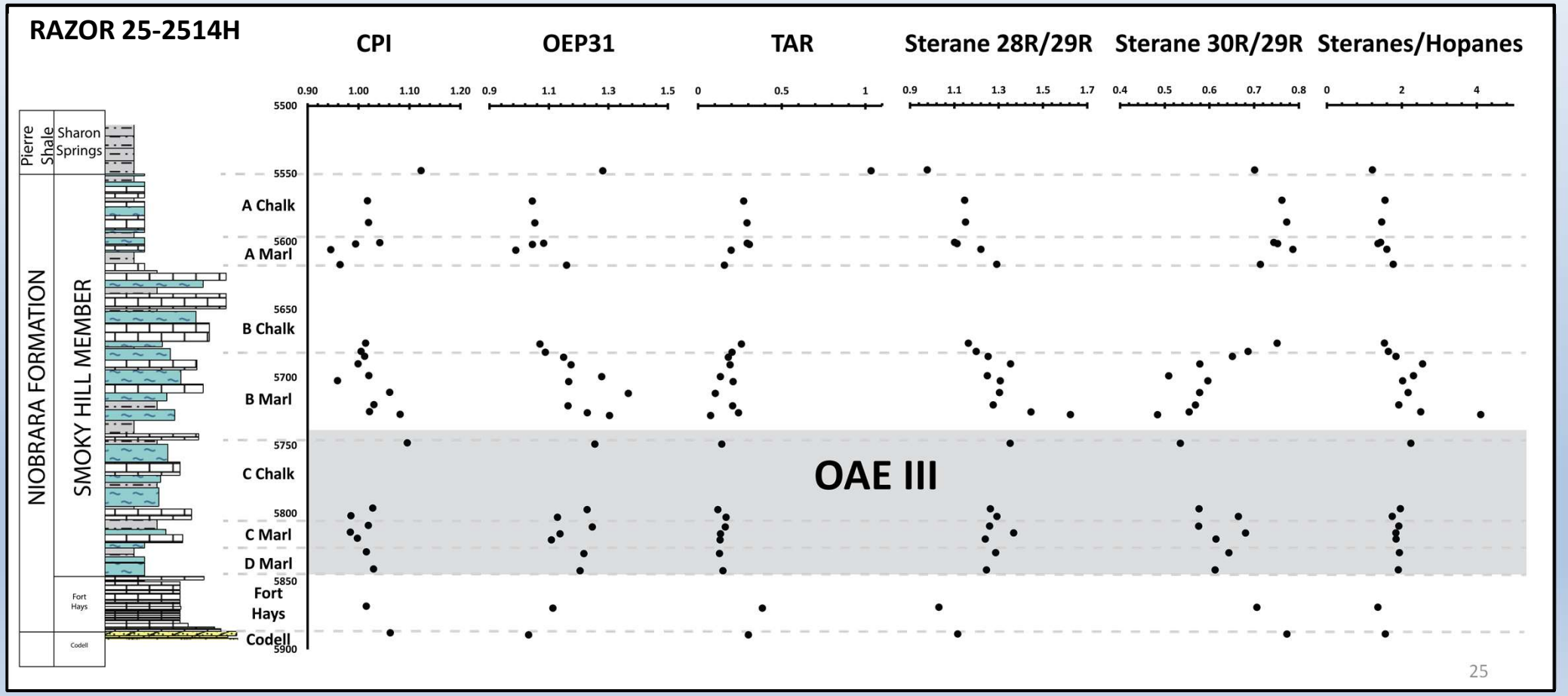

Anoxia at the Bottom Sea Floor Due to Intense Oxygen Use by the Organisms

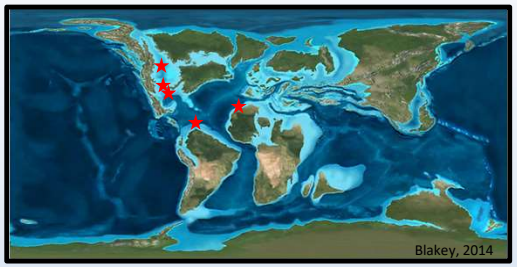
Possible Euxinia After Denitrification -> Framboidal Pyrite -> Thiomolybdate

$CO_2$ Emissions Increasing the Seaway Acidity Might Have Led to Carbonate Dissolution at Times

Increased Precipitation Rates -> Increasing Weathering -> OAE

# Organic Matter Composition Change

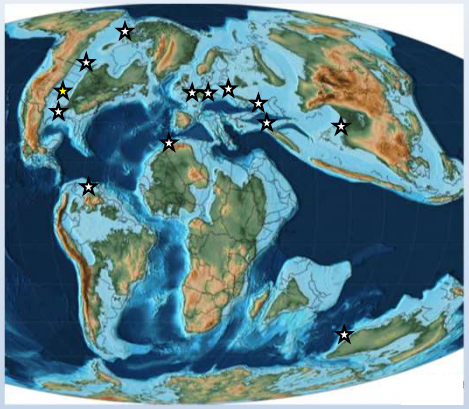




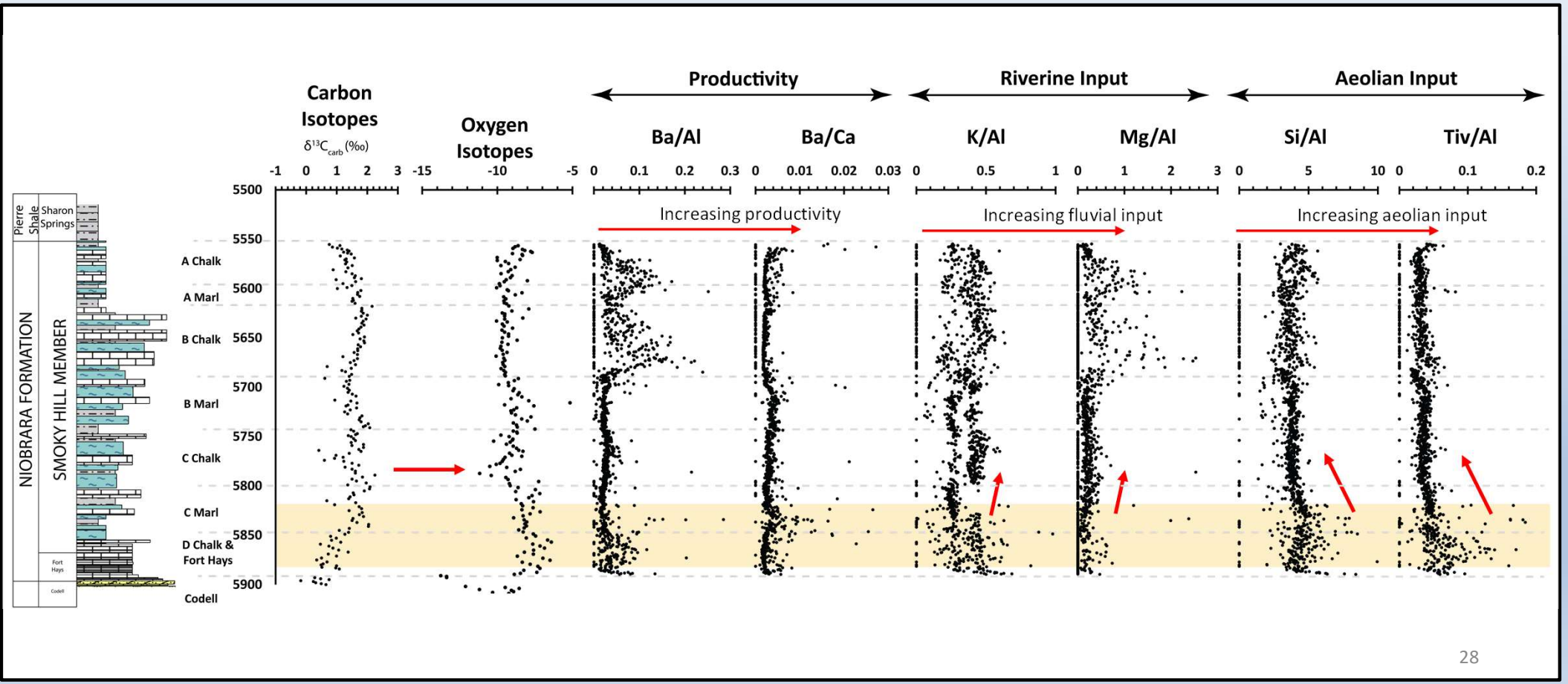

# Ocean Anoxic Event III

COLORADO SCHOOL OF MINES MUDTOC

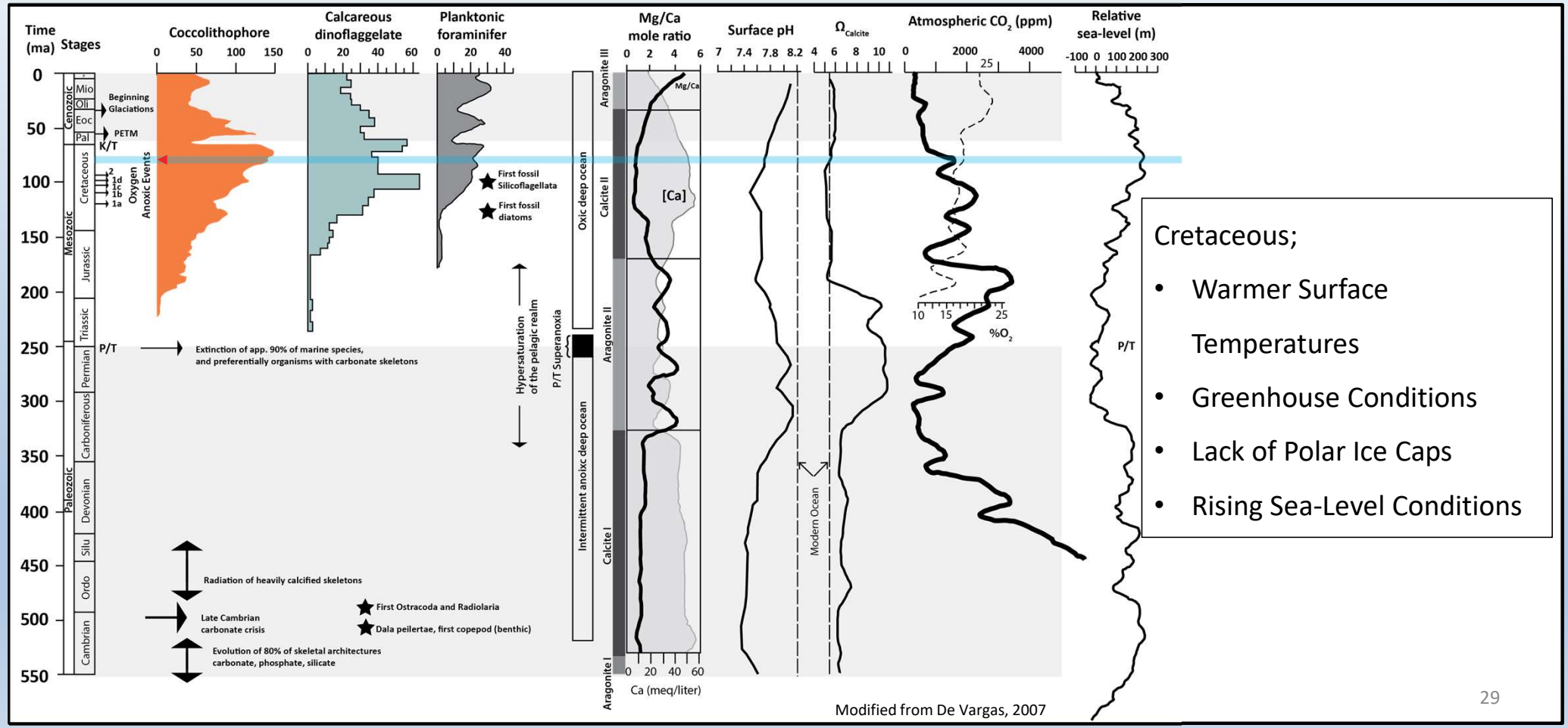
# Ocean Anoxic Events



# Paleoproductivity - Barium



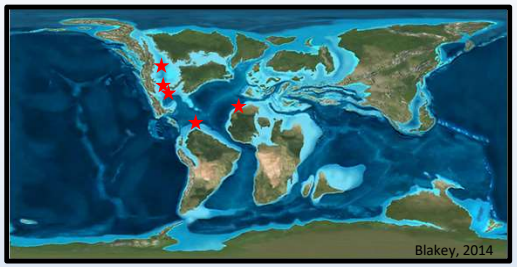
# Introduction




Modified from De Vargas, 2007

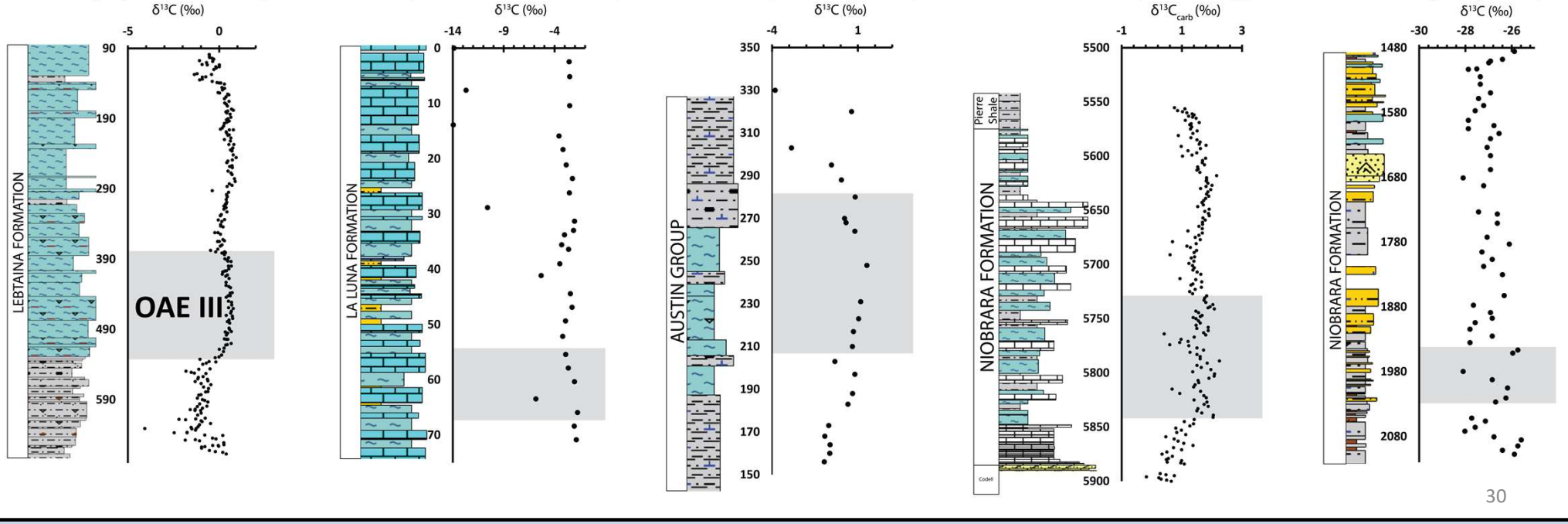
Cretaceous;

- Warmer Surface Temperatures
- Greenhouse Conditions
- Lack of Polar Ice Caps
- Rising Sea-Level Conditions

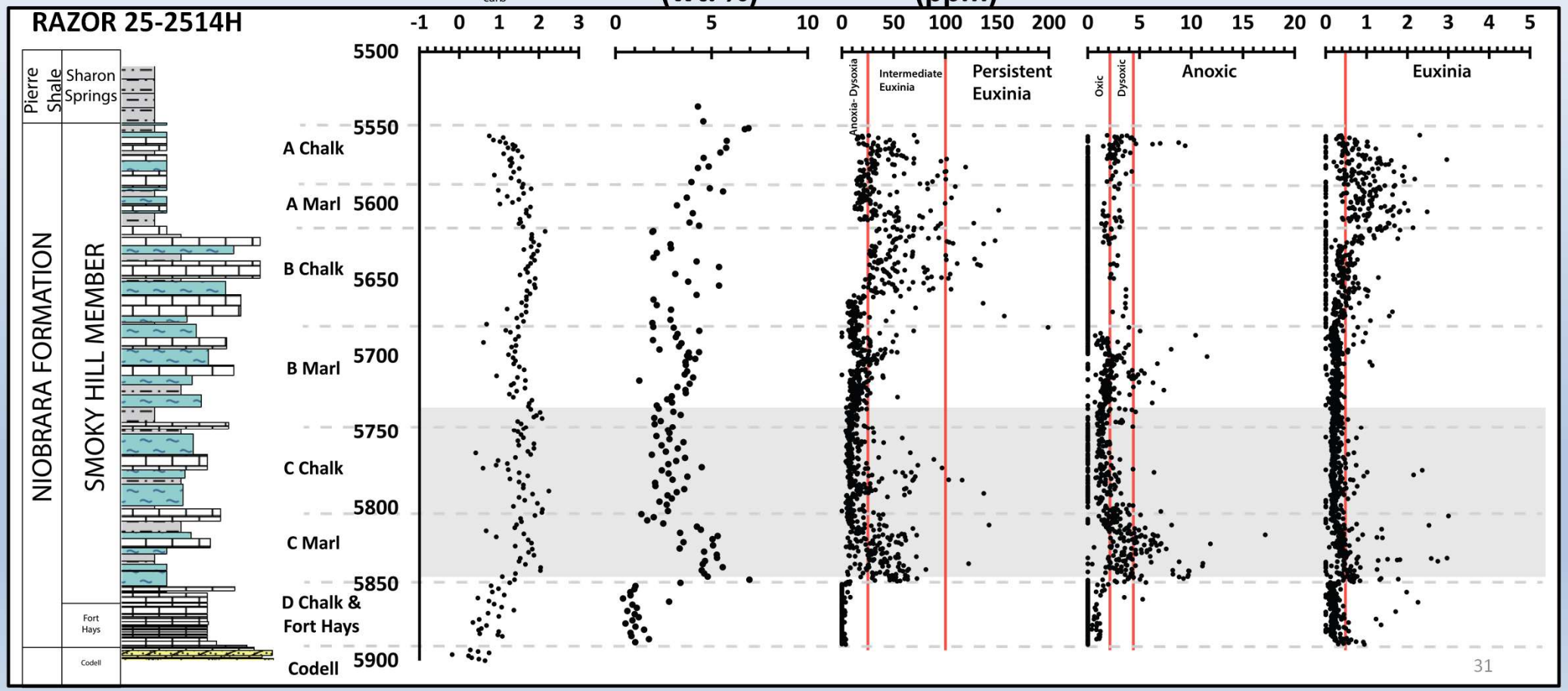



# Ocean Anoxic Event III

COLORADO SCHOOL OF MINES MUDTOC



# Redox Stages



# General Elemental Chemostratigraphic Framework