Analysis of Appalachia's Geology on Completion Designs

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Agenda

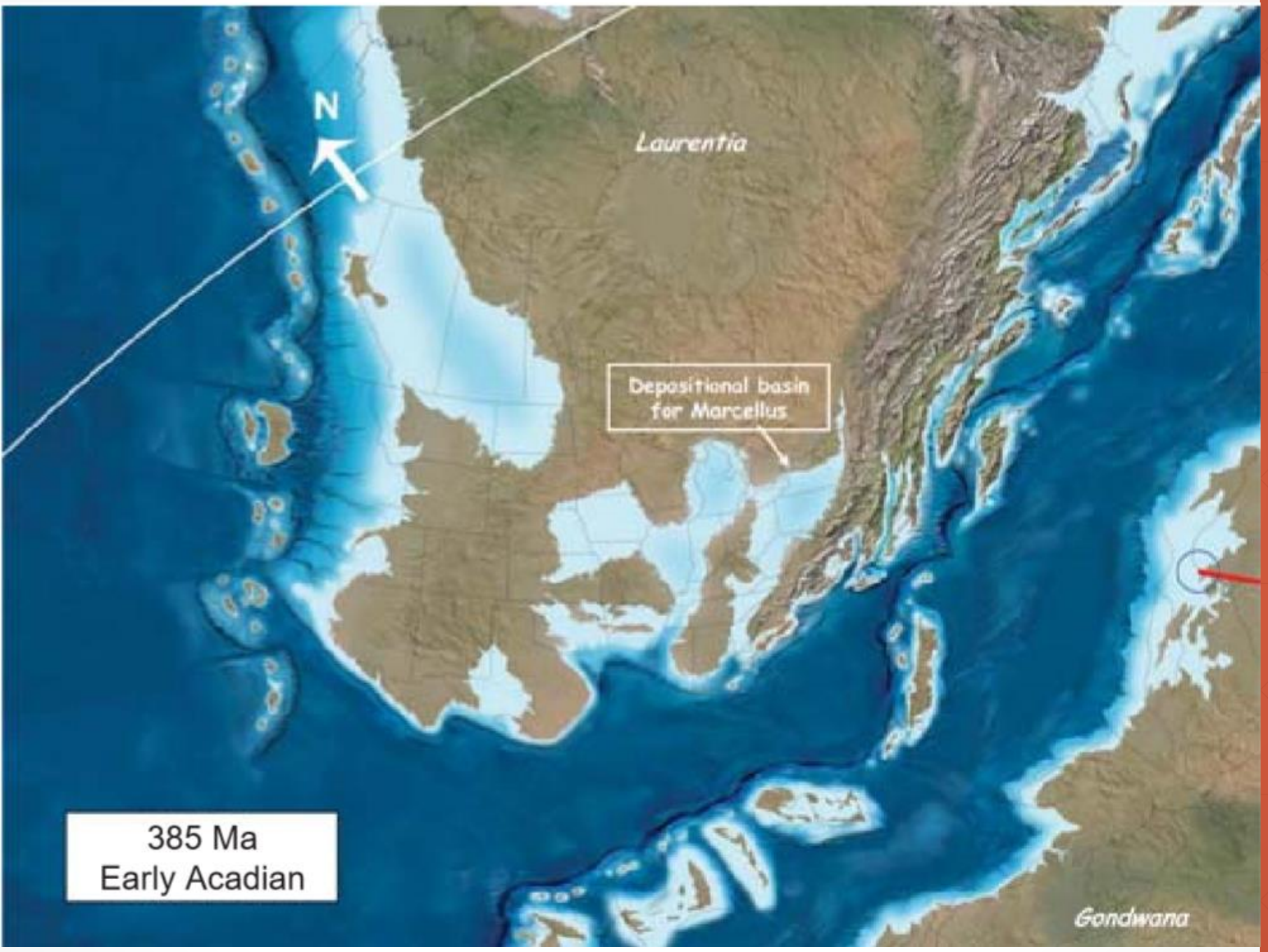
- Geologic History
- Description of Variables
- Methodology
- Results
- Conclusions

Geologic History

Brittany Martin

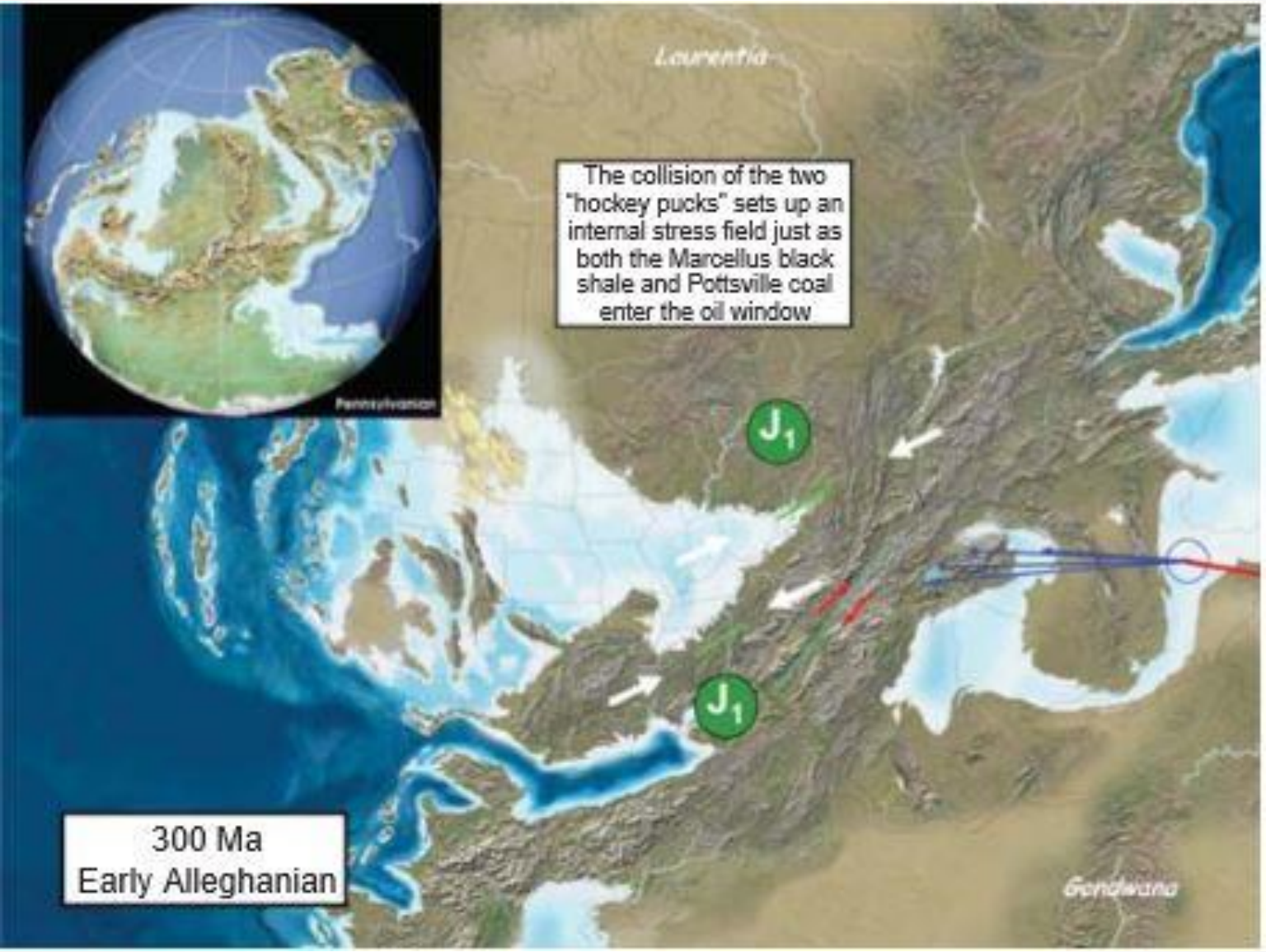
Utica/Point Pleasant Formation

- Ordovician aged black shale
- Taconic Orogeny began the formation of the Appalachian Mountains



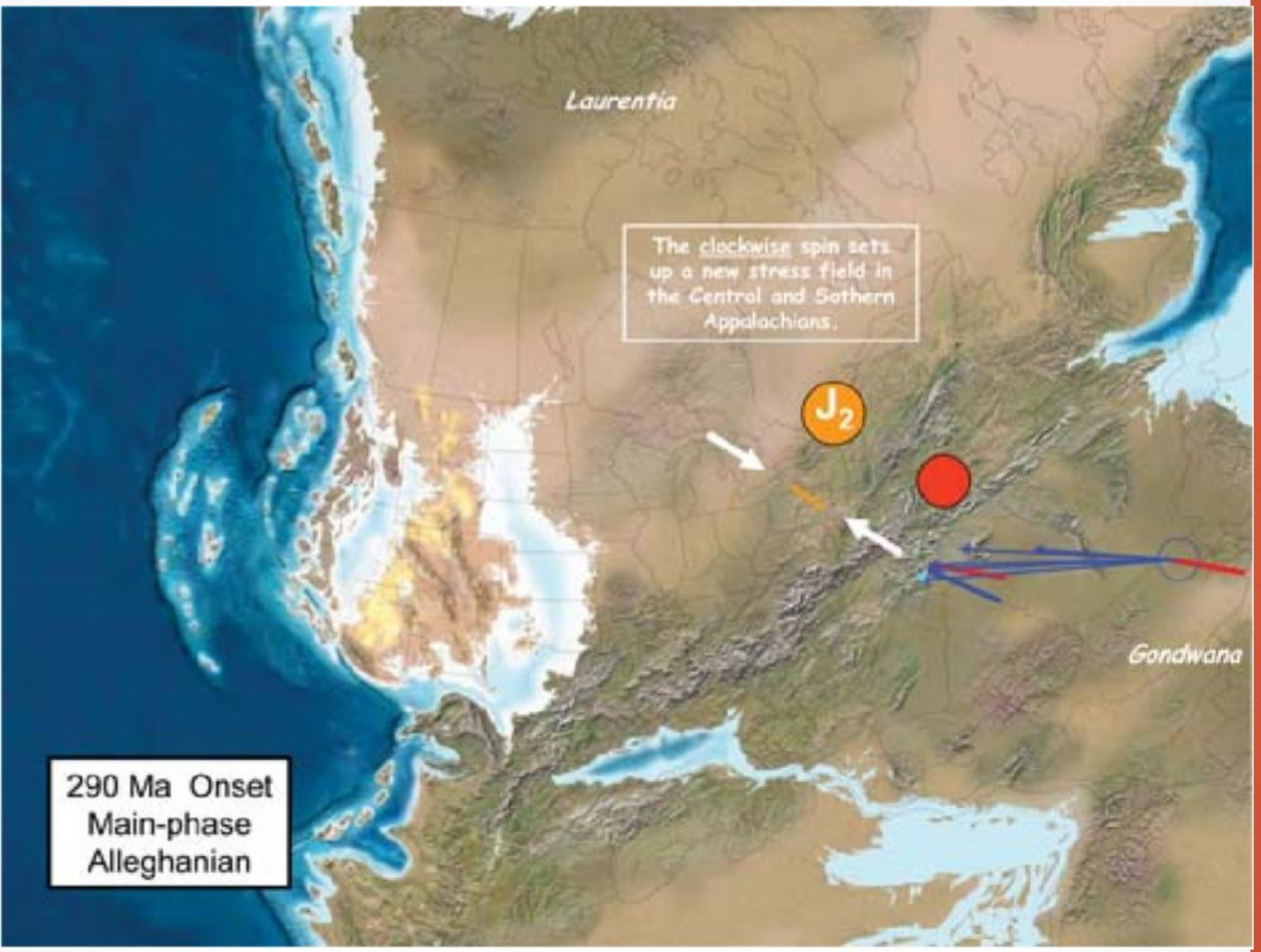
Deposition of Marcellus Formation

- Shallow seawaters covered Southeastern Ohio, West Virginia, and Pennsylvania
- The Acadian Orogeny continued creating the Appalachian Mountains
- Organic-rich sediments were deposited in deep water during the collision



Formation of First Joint (J_1)

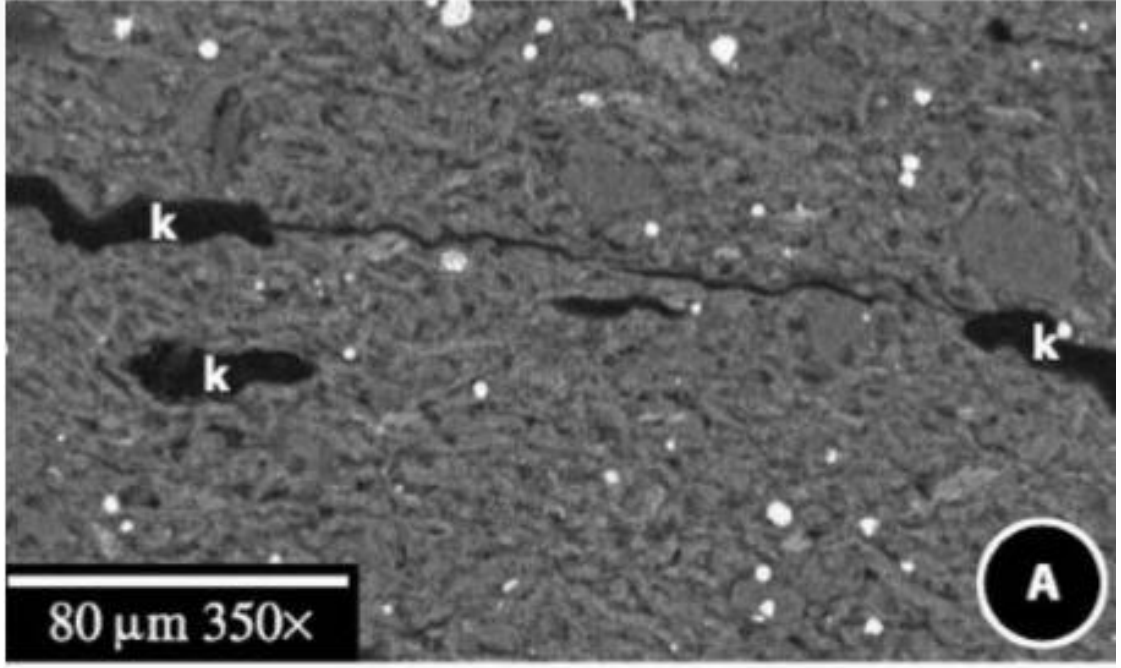
- Collision of Gondwana and Laurentia caused a natural stress to form.
- This stress created joints (J_1)

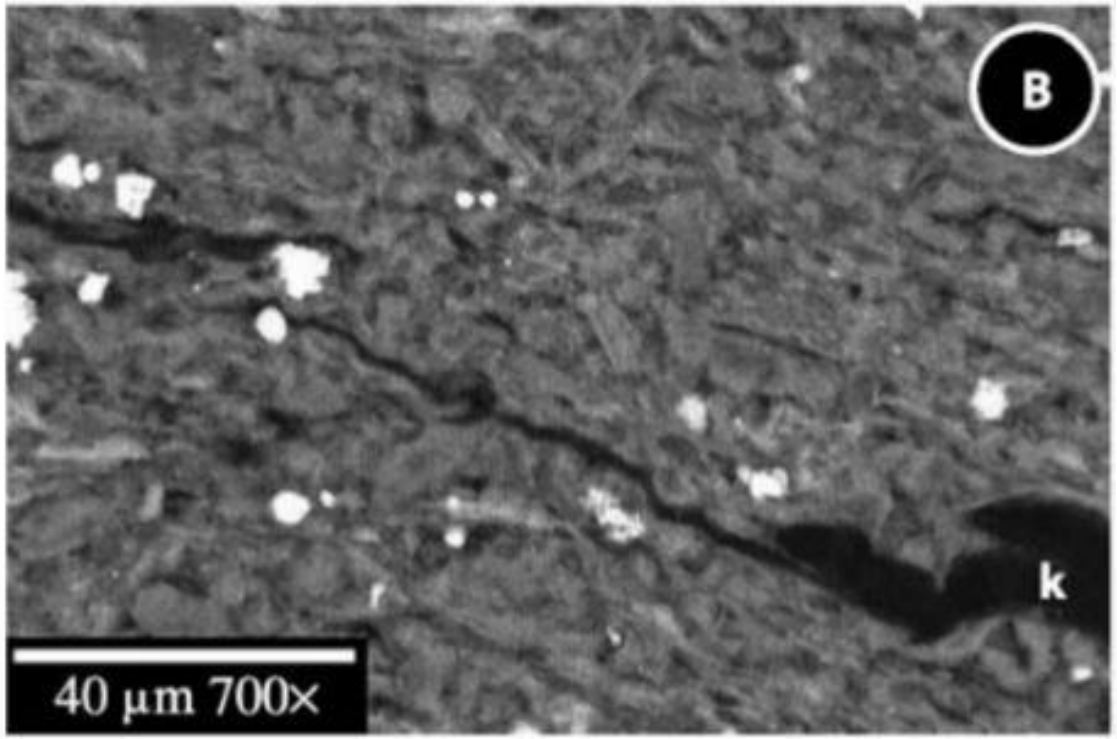


Formation of second Joint (J_2)

- Gondwana and Laurentia were locked in place and continued to pivot creating another stress field.

Example of J_1 and J_2





Formation of Natural Fractures

- Solid kerogen organic matter converts to liquid crude oil during catagenesis.
- This increases the amount of fluid, while porosity remains constant; therefore, pore fluid pressures increase.
- This results in natural hydraulic microfracture

Case Study

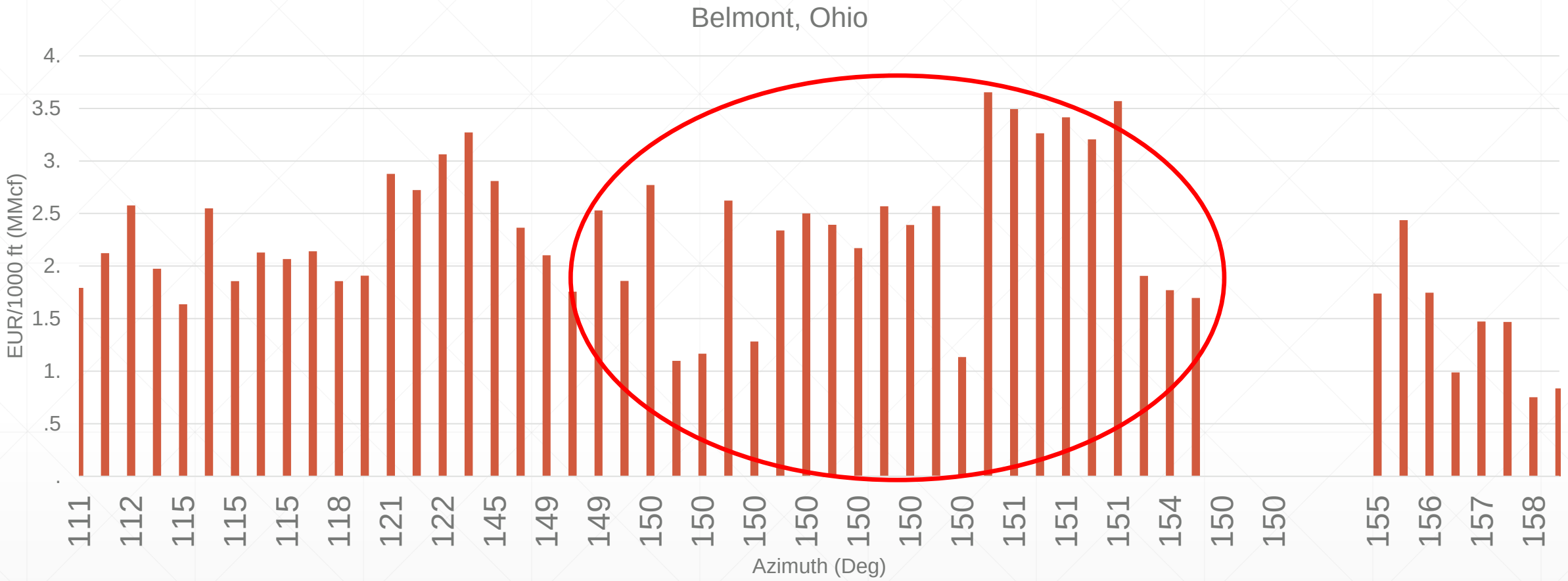
Nicholas Cuaresma

The Variables We Chose

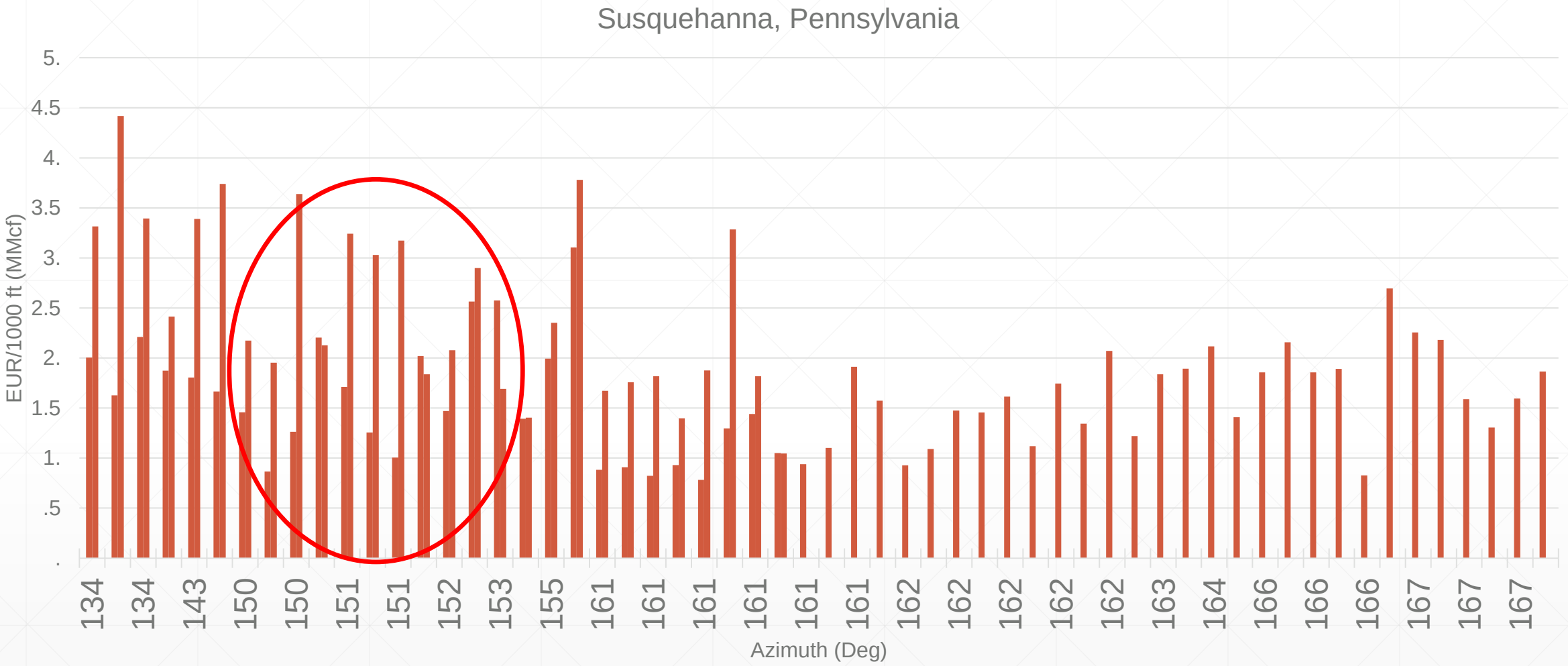
- The variables were hypothesized to each have a major impact on production with a linear fit
- Water
  - Defined as bbl of water pumped in frac job
  - Compared water vs. sand and to see which was the most important variable to optimize
- Sand
  - Defined as pound of sand/proppant pumped in frac job
  - Compared water vs. sand and to see which was the most important variable to optimize
- Azimuth
  - Defined in degrees
  - Wanted to see what the plane of optimized azimuth was and how far it could be deviated from without major losses

Our Methodology

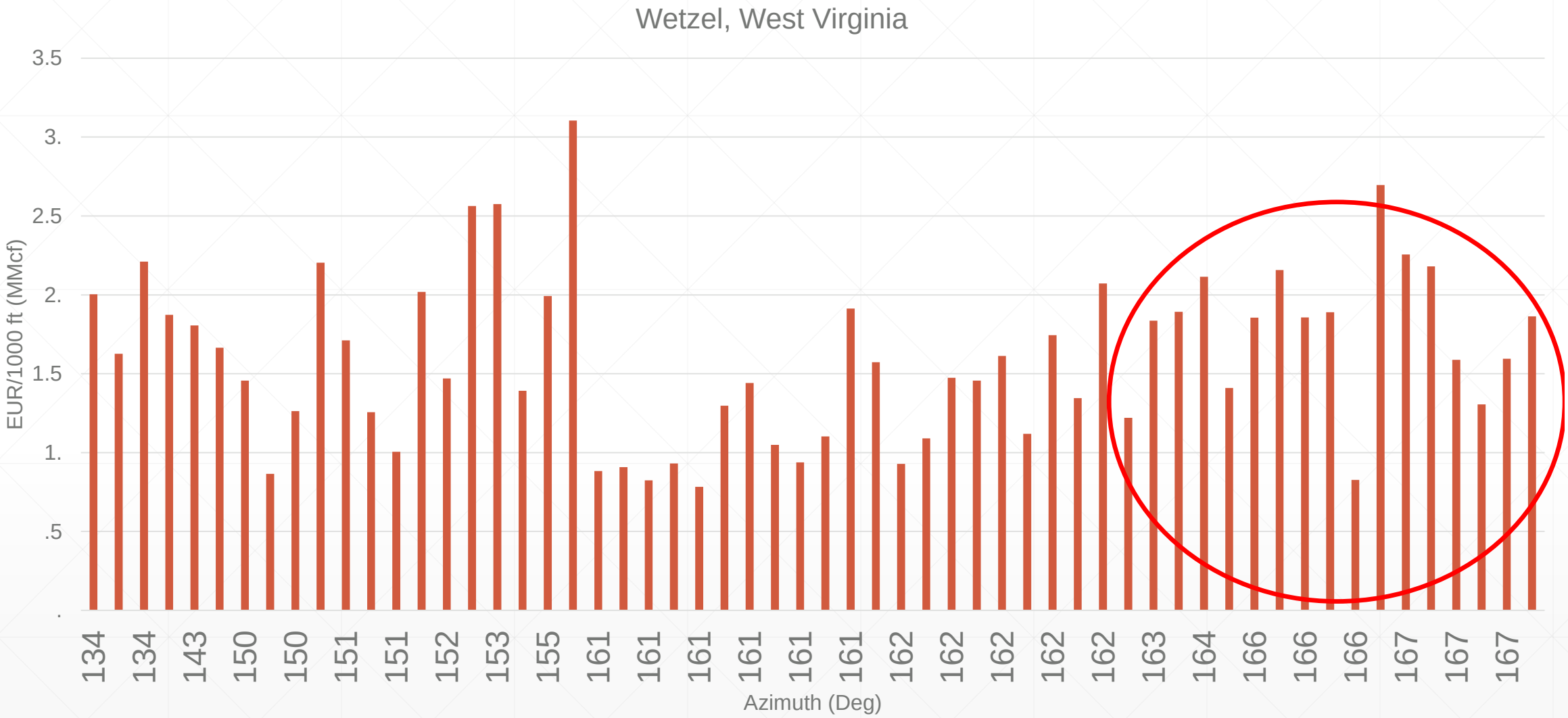
- Trendlines
  - Plotted Water and Sand vs. Production
  - Graphed Production vs. Azimuth
- Multiple Variable Regression
  - Using excel, ran multi-variable regression that analyzed sand, water, and azimuth vs. the respective production value simultaneously
  - Removed variables that did not have p-values less than .05
  - Remaining variables were the most impactful variables
  - Output equation removed variables that had p-value greater than .05



- **Wellbore Azimuth: 149-154**



Wellbore Azimuth: 150-155



- **Wellbore Azimuth: 163-168**

Our Results

- Variables listed left to right from most important to least important
- Ohio
  - $Y = 1.18 + 3.8*10^{-8} * X1$
  - Water, Sand, Azimuth
- West Virginia
  - $Y = 1.31 - 3.4*10^{-8} * X1 + 4.11*10^{-8} * X2$
  - Sand, Water, Azimuth
- Pennsylvania
  - $Y = 3.14 – 2.8*10^{-7} * X1 + 3.23 * 10^{-7} * X2$
  - Water/Sand, Azimuth

Key	
X1	Water
X2	Sand
X3	Azimuth

What Do the Results Mean for Vertical and Horizontal Operations?

Vertical

- Ibrahim et al.,2018
- Stated multistage fracturing completions is still applicable and better than typical plug and perf
- More cost savings and quicker flowback
- Study was done in Oman

Horizontal

- Utica
  - Water is the most important variable to maximize and optimize
- Marcellus
  - Sand is the most important variable to maximize and optimize
- Belmont: (149-154 degrees)
- Susquehanna: (150-155)
- Wetzel: (163-168)

Questions?