Analysis of Appalachia’s Geology on Completion Designs

Nicholas Cuaresma and Brittany Martin
Marietta College
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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 (J₁)

- Collision of Gondwana and Laurentia caused a natural stress to form.
- This stress created joints (J₁)
Formation of second Joint (J₂)

- 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
  - $Y = 1.18 + 3.8 \times 10^{-8} \times X_1$
  - Water, Sand, Azimuth
- West Virginia
  - $Y = 1.31 - 3.4 \times 10^{-8} \times X_1 + 4.11 \times 10^{-8} \times X_2$
  - Sand, Water, Azimuth
- Pennsylvania
  - $Y = 3.14 - 2.8 \times 10^{-7} \times X_1 + 3.23 \times 10^{-7} \times X_2$
  - Water/Sand, 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?