Optimizing Marcellus Formation Field Development, Well Performance, and Operations by Integrating Geologic and Engineering Data into a Volumetric Geologic Model

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Acknowledgements

- Thank you to Noble Energy for the use of this data

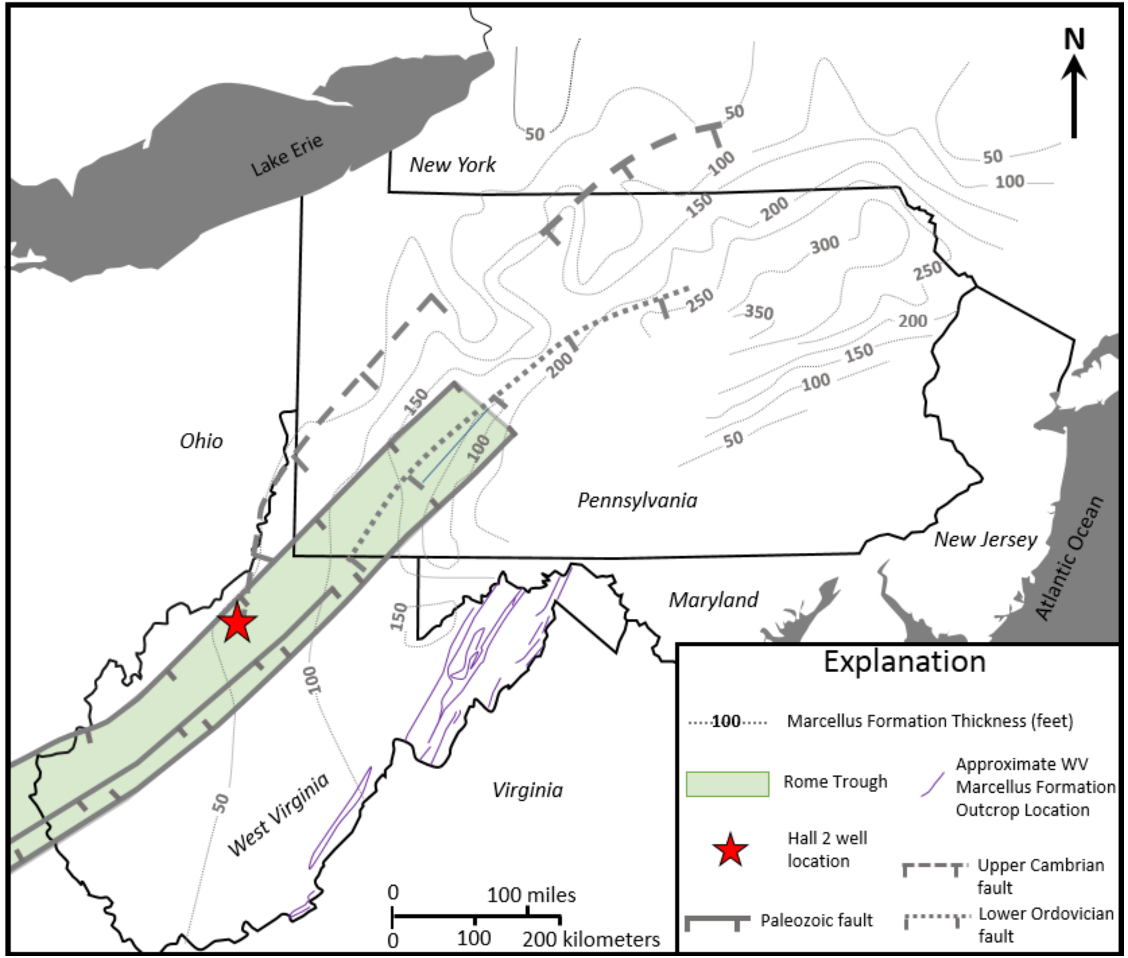
Motivation

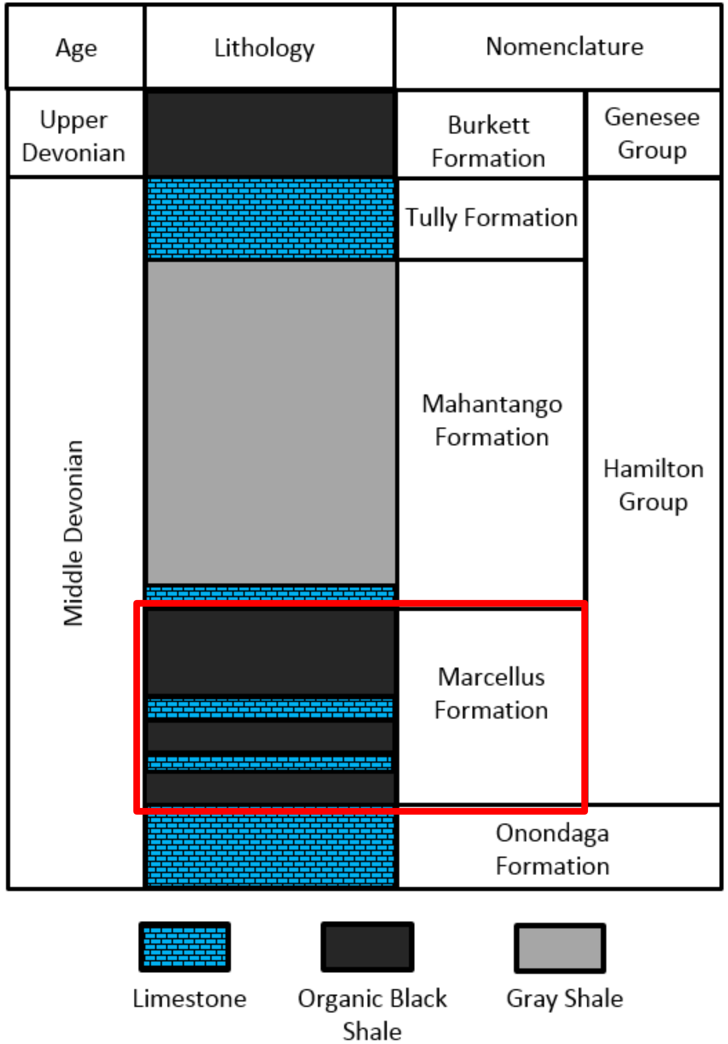
- **Use geocellular modeling as a tool to filter on ‘big levers’ that affect operations and production in an unconventional reservoir**
  - Petrel is a tool that can integrate huge data sets
    - Drilling, completion, geology, and production data
  - Can I predict completion trends and issues?
    - EIA – average capital Marcellus completion cost ~ $3.8 million (2015)
  - Develop a workflow to:

    1) Import and integrate all data into a model

    2) Provide real-time operational recommendations

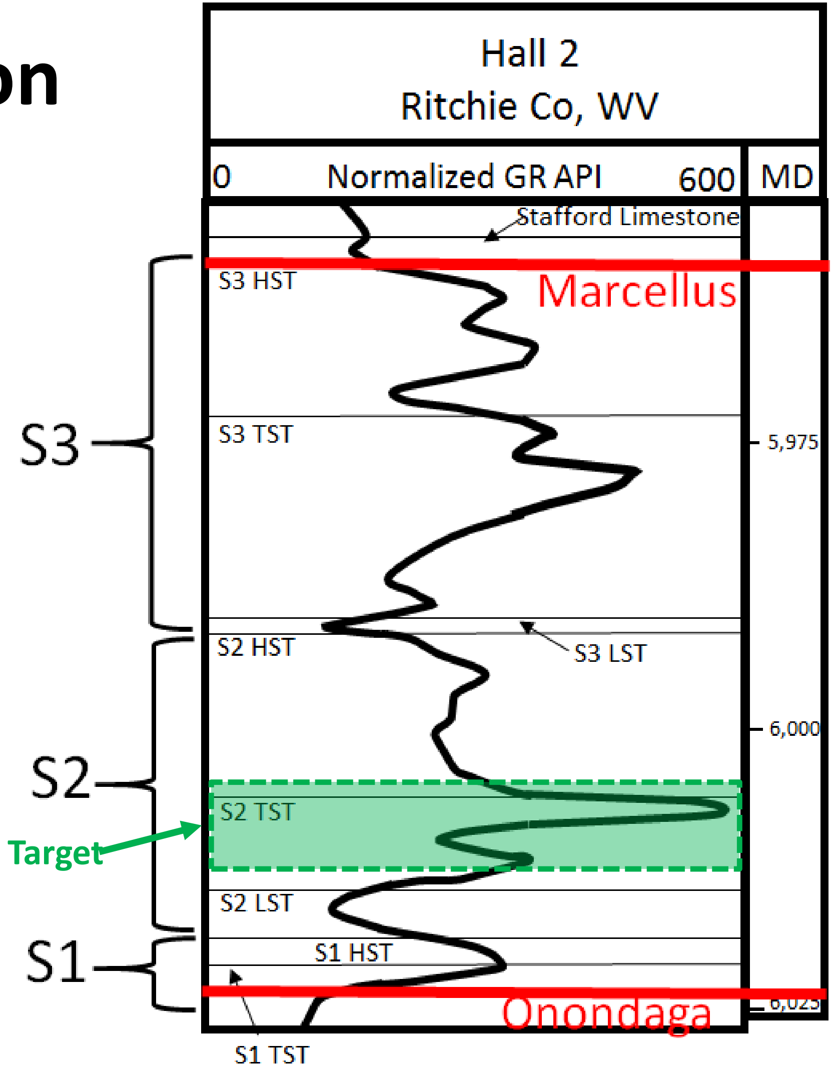
Reservoir: Marcellus Formation





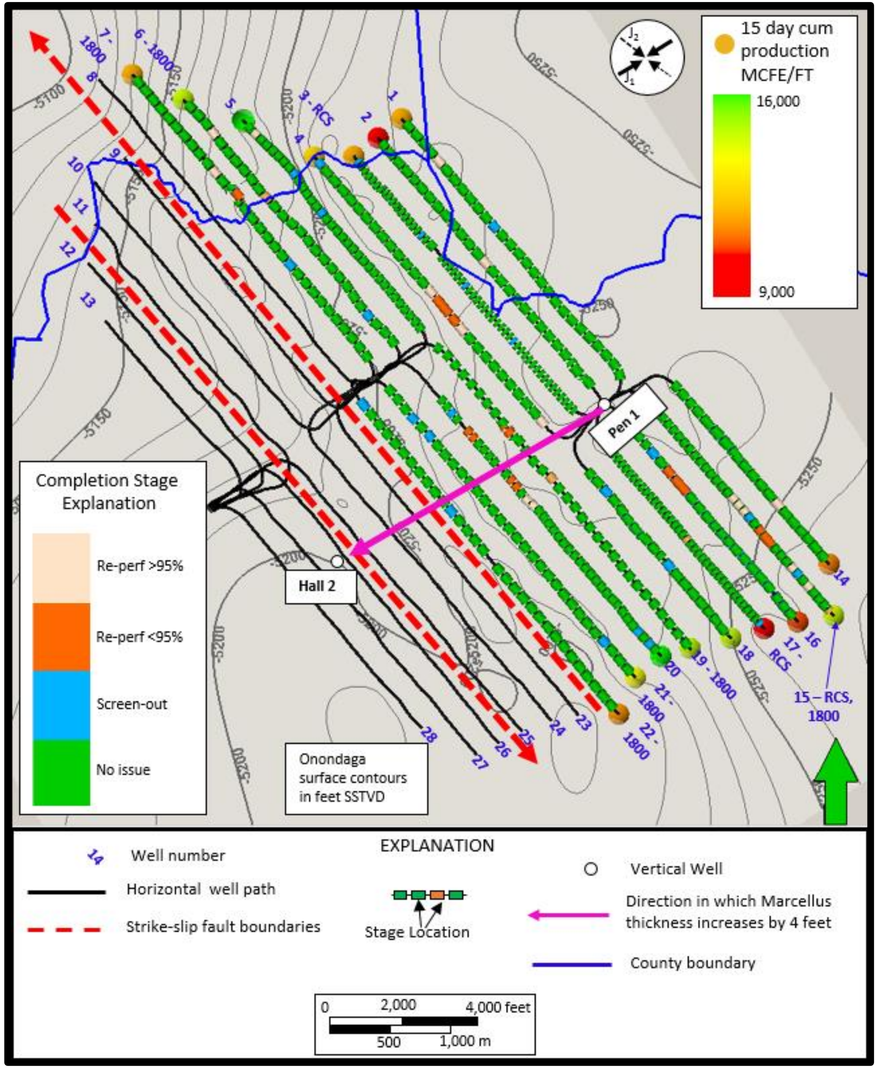
Reservoir: Marcellus Formation

- 3 stratigraphic sequences
  - Each sequence divided into LST, TST, HST
- ~60’ thick
  - Horizontal drilling target 10’ thick interval primarily in S2 TST
    - High TOC, low clay



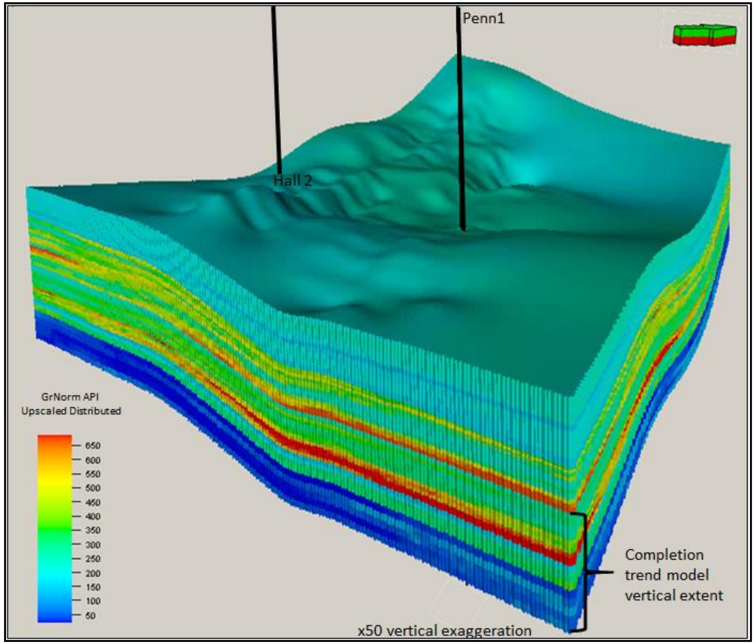
Field Area

- Western WV
  - 3 Units, 28 horizontal wells
  - 1.5 units completed with slick water plug and perf stimulation
    - Some RCS wells
- Geology
  - 4’ reservoir thickening to the west
  - Structure: 0.3°SE – Onondaga surface
  - Small scale folds, strike-slip fault
  - Structural complexity increases west
  - 15 day cum production/ft affected by both thickness and structural complexity



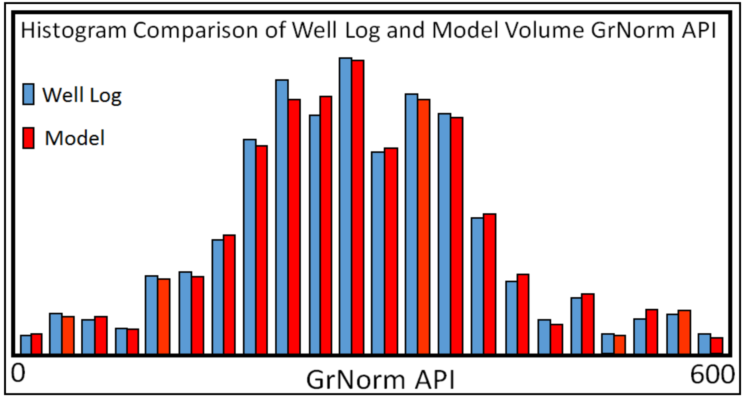
Geocellular Model

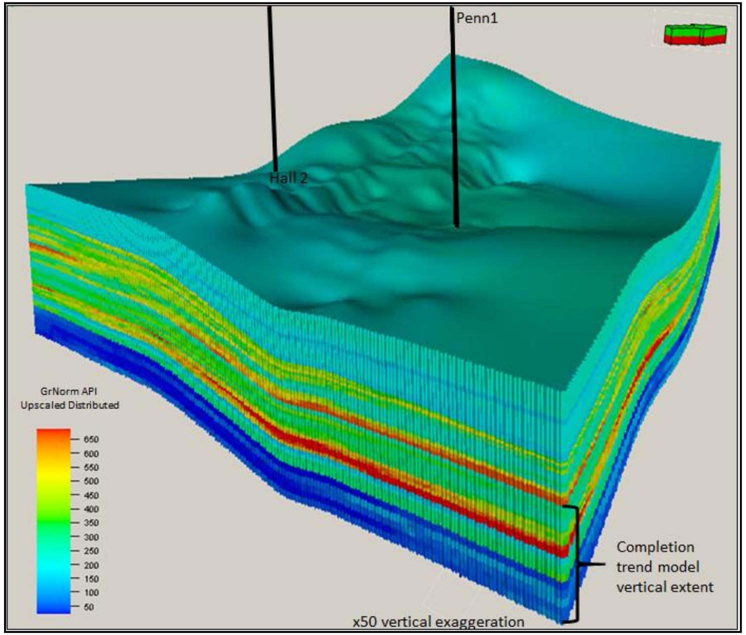
- Why?
  - Many initial, broad questions that I couldn't answer with my model that lead me to a more specific questions, such as….
  - Can I predict completion trends on a field-scale?
    - Answer: Yes!...Let's take a look at treating pressures
  - Can I relate stratigraphic interval to completion trends?
    - Answer: Yes!…Let's take a look at treating pressures

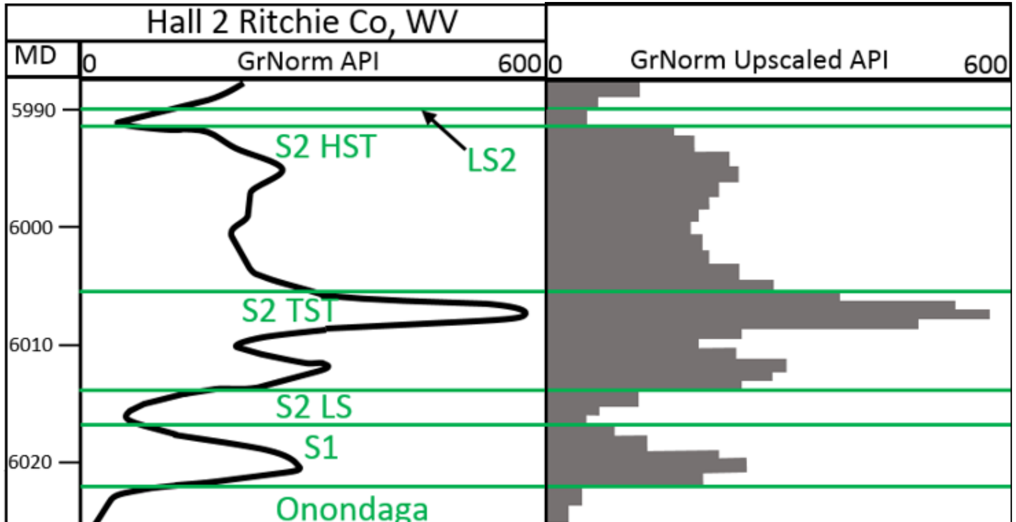


Model Construction

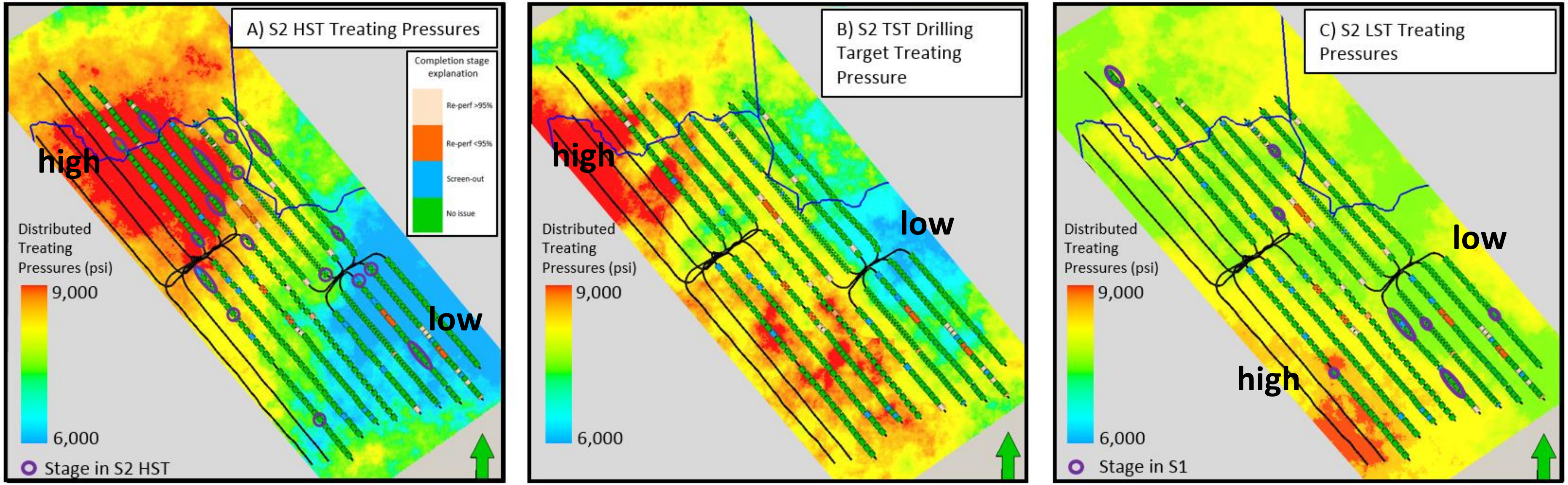
- Fill volumetric grid so it is geologically and statistically accurate
- Layer model and upscale data
- Distribute rock properties and completion data throughout volumetric grid
  - Gaussian random function simulation

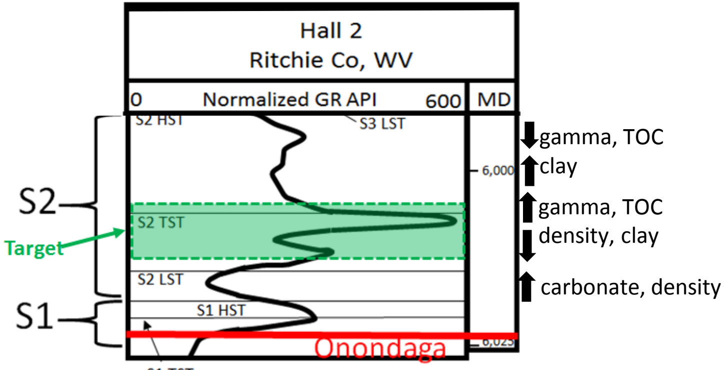






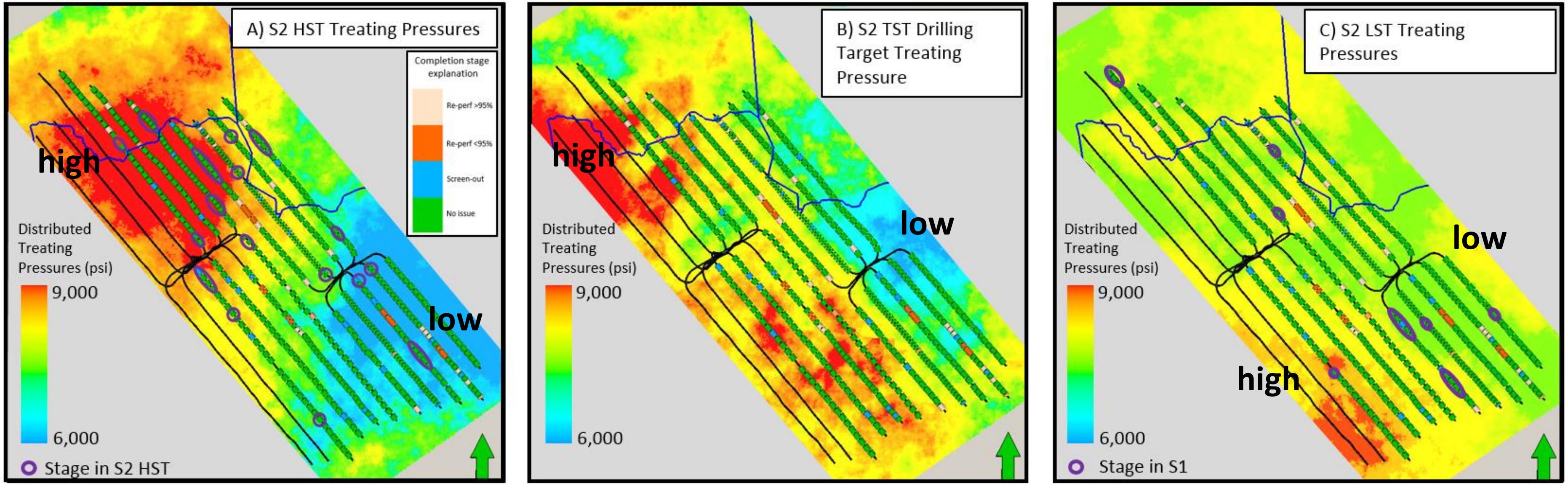
Model Results – Treating Pressure

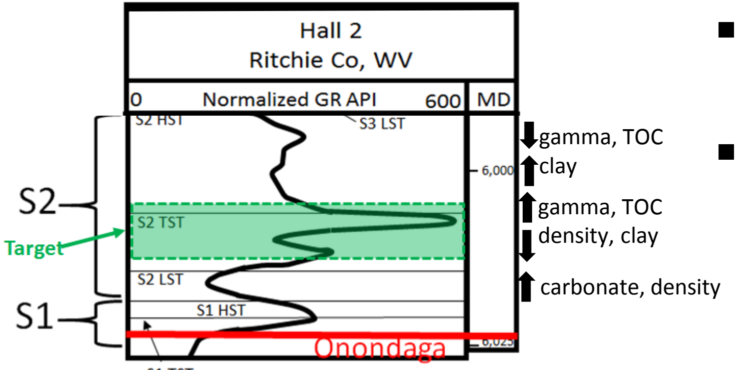




- Geologic differences between S2 HST, S2 TST, and S2 LST
- Less data in S2 HST (44 stages, 9%) and S2 LST (22 stages, 4%)

Model Results – Treating Pressure





- Similar trends in S2 HST and TST
  - similar to structure and thickness trends
- S2 LST treating pressures more consistent
  - function of lack of data?
  - geology of S2 LST stages is more consistent
  - hot spot cuts through entire S1 and into Onondaga

Observations and Conclusions I

- Accurate geocellular models with high horizontal well density can be created in a timely fashion

- Engineers and geologist can be friends ☺

- Completion data can be incorporated into and distributed throughout geocellular model

Observations and Conclusions II

- Treating pressures distribution trends
  - Follow geologic structure and thickness trends
  - Values and trends appear to vary among stratigraphic sequences
    - S2 LST trends different from S2 TST/HST
    - Data distribution is skewed among sequences and tracts
  - Also populated production, drilling, and other completion data (proppant, water) into geocellular models
    - Highlight localized problem areas consistent with joint orientation
- Geologic models can be used to predict engineering trends and provide real-time recommendations
  - Increase operational efficiency, decrease costs

Thank you!