Regional Mapping and Reservoir Analysis of the Upper Devonian Shale in Pennsylvania*

Jared M. VanMeter[1]

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[1]Range Resources - Appalachia, LLC, Canonsburg, PA (jvanmeter@rangeresources.com)

Abstract

Although the Devonian Shale of the Appalachian Basin has been producing gas since the early 1800s, only recently has it become a giant play. In 2004, Range Resources, using analogues with geology and completion techniques in the Barnett Shale, began producing gas from a Marcellus Shale well in Washington County, Pennsylvania. Since then other organic shale packages both above and below the Marcellus have attracted industry interest considerably. The Upper Devonian Shale in Pennsylvania is one of these viable plays and is the centerfold for this research.

The main purpose of this investigation is to define the distribution of the organic-rich facies of various Upper Devonian Shale intervals above the Tully Limestone within Pennsylvania. The analysis is based on well log data, primarily gamma-ray logs, which are the most common and well calibrated, and bulk density logs, where available. Extensive stratigraphic correlations have been conducted to trace key formation tops across the study area. Detailed log analysis has been performed to normalize the logs and define key reservoir quality indicators.

The following maps were generated over the study area.

- Gross Thickness Isopachs of the Rhinestreet Shale, Cashaqua Shale, Middlesex Shale, Genesee Shale, and Burkett Shale
- 200 API Gamma-ray Net Pay maps of the Rhinestreet Shale, Cashaqua Shale, Middlesex Shale, Genesee Shale, and the Burkett Shale
- 160 API Gamma-ray Net Pay maps of the Rhinestreet Shale, Cashaqua Shale, Middlesex Shale, Genesee Shale, and the Burkett Shale

These observations and others portrayed on this new series of maps provide a better understanding of the development of the Upper Devonian Shale in the Appalachian Basin. Refining our knowledge of the geology with this series of geologic maps will allow the flexibility of relatively easy revisions and rapid dissemination of continuously evolving geologic knowledge, while further advancing industry exploration of the Upper Devonian Shale within Pennsylvania.

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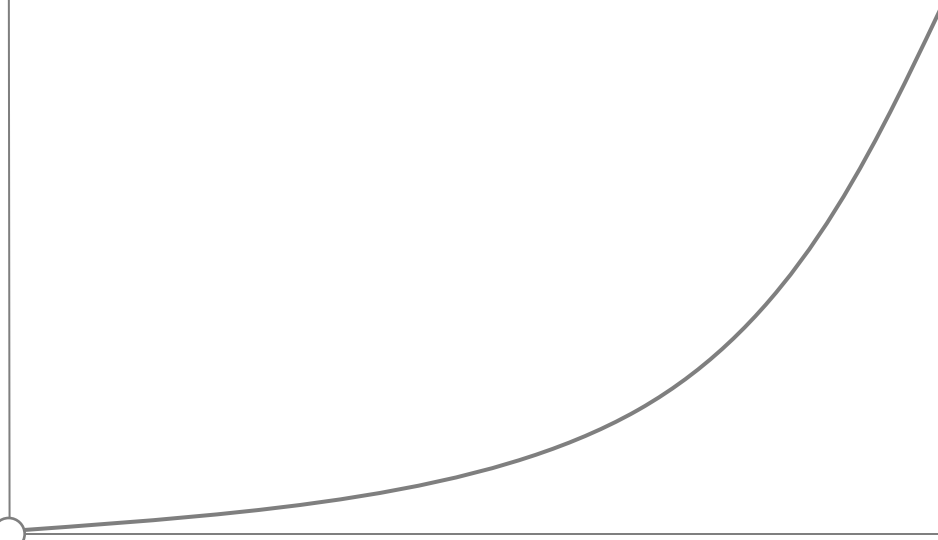

INFLECTION POINT

"An event that results in a significant change in the progress of a company."

-Investopedia

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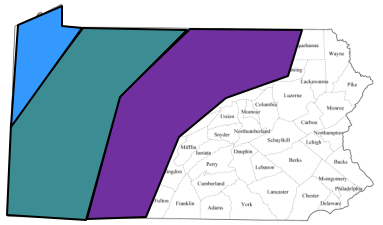
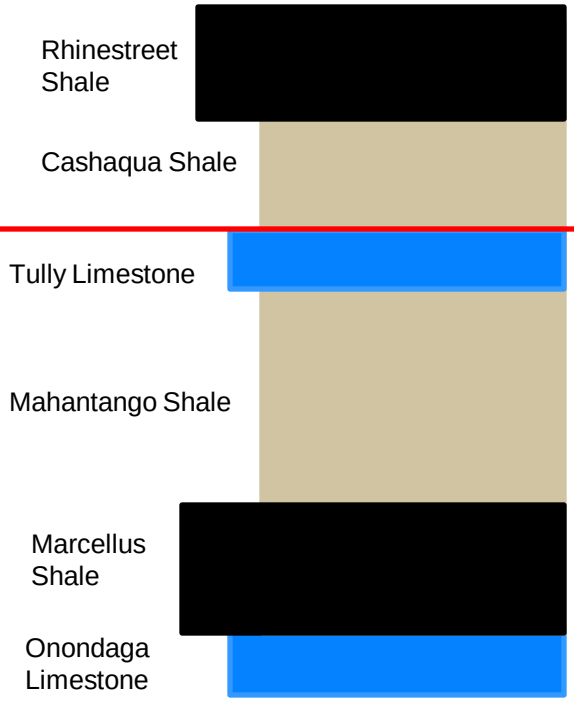
Introduction

- The Upper Devonian Shale has produced gas since 1980s in West Virginia
  - Vertical wells targeting fractures were hit and miss in low pressure area.
- Since then organic packages, above and below the Marcellus attracted industry interest
  - Advances in drilling and multistage fracture technology in Marcellus and Barnett Shale have made this possible
- Upper Devonian Shale is a viable economic play
  - Stacked potential reservoir over a widespread area
  - Currently being tested by industry
  - 2009 Range produced from the first horizontal Upper Devonian Shale well in Pennsylvania
- The main purpose of this investigation is to define and map distribution of organic-rich facies in various Upper Devonian Shale intervals above Tully Limestone

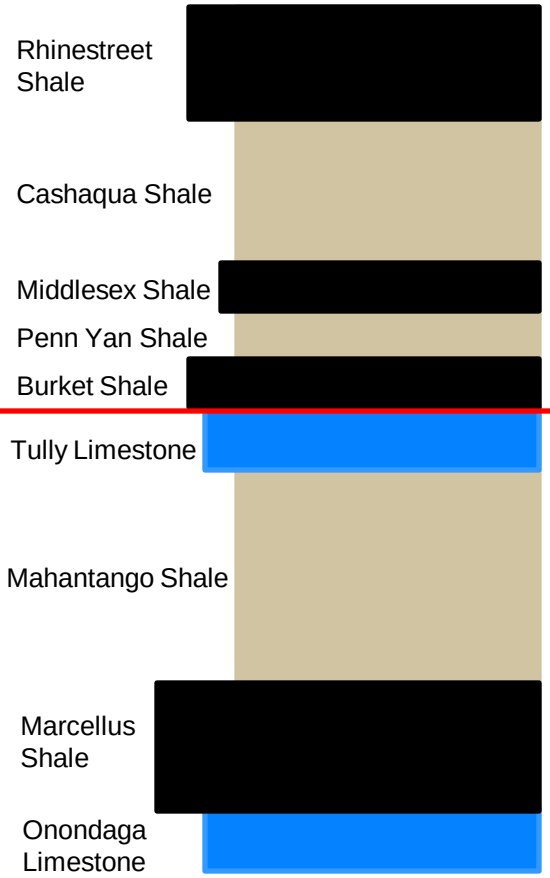
Stratigraphy of Pennsylvania



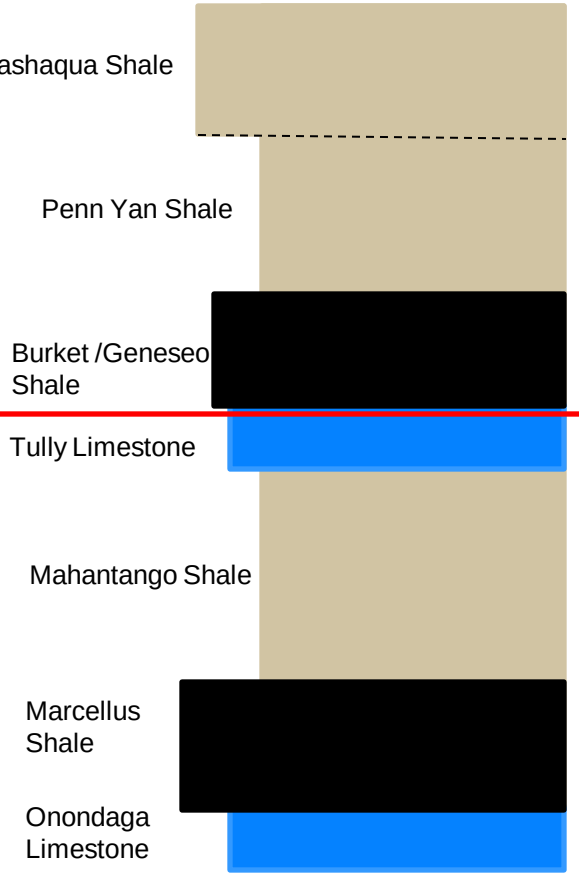
Northwestern PA



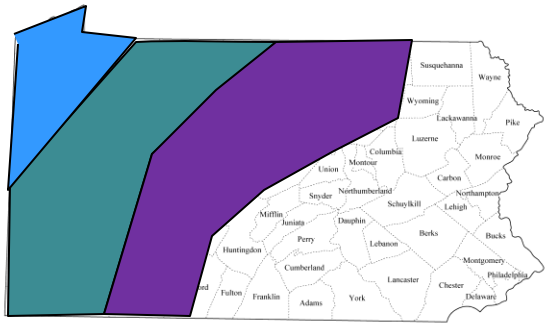
Southwestern PA – Central PA



Central PA - Northeast PA

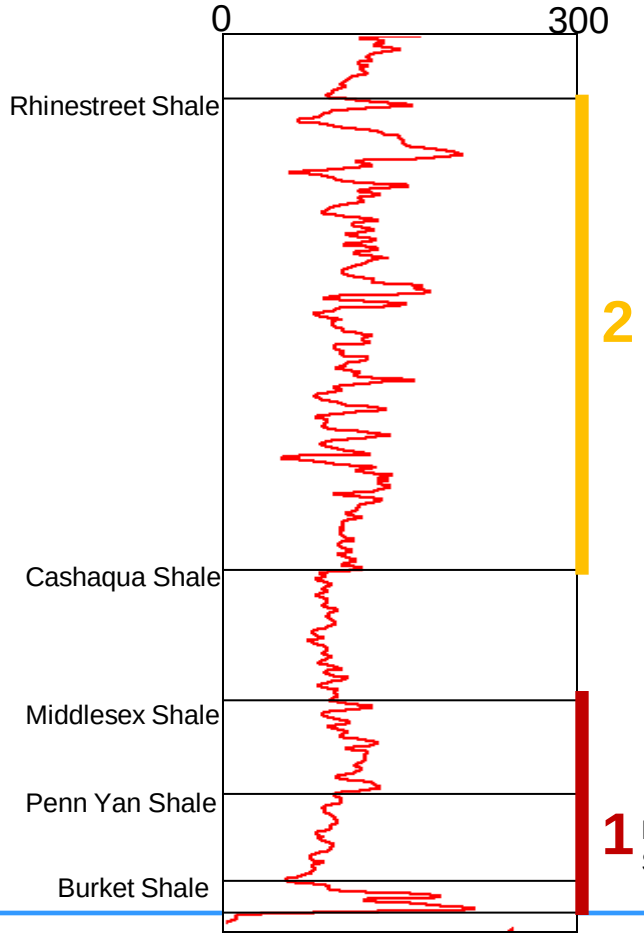


Regional Log Signatures of Upper Devonian Shale

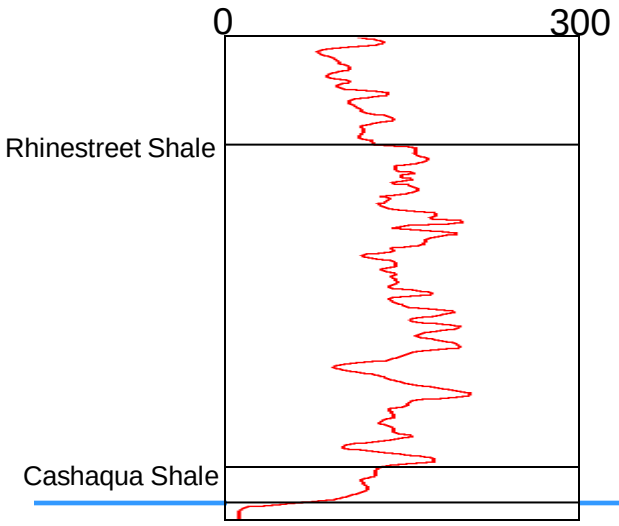


Central PA - Northeast PA

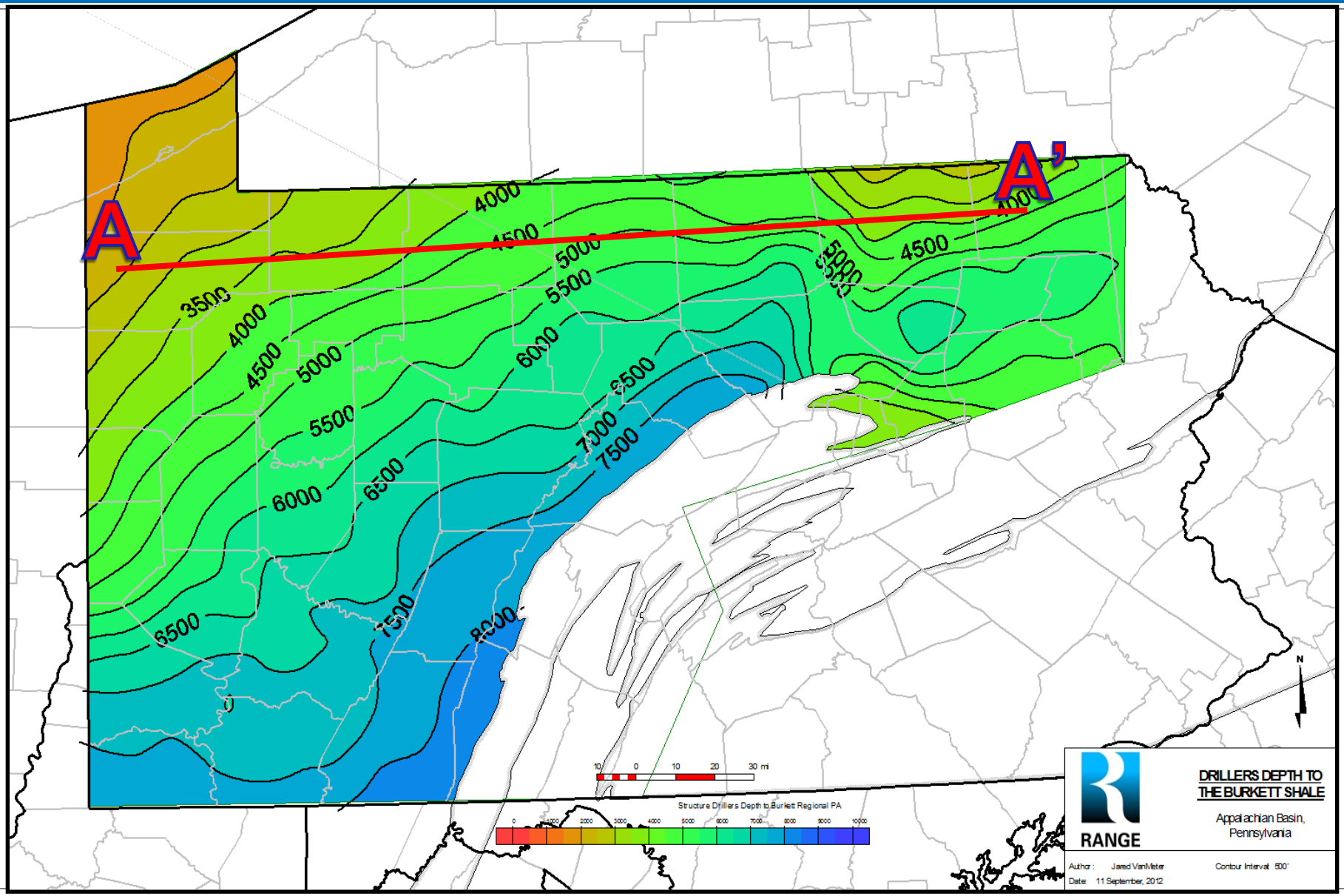
Southwestern PA – Central PA



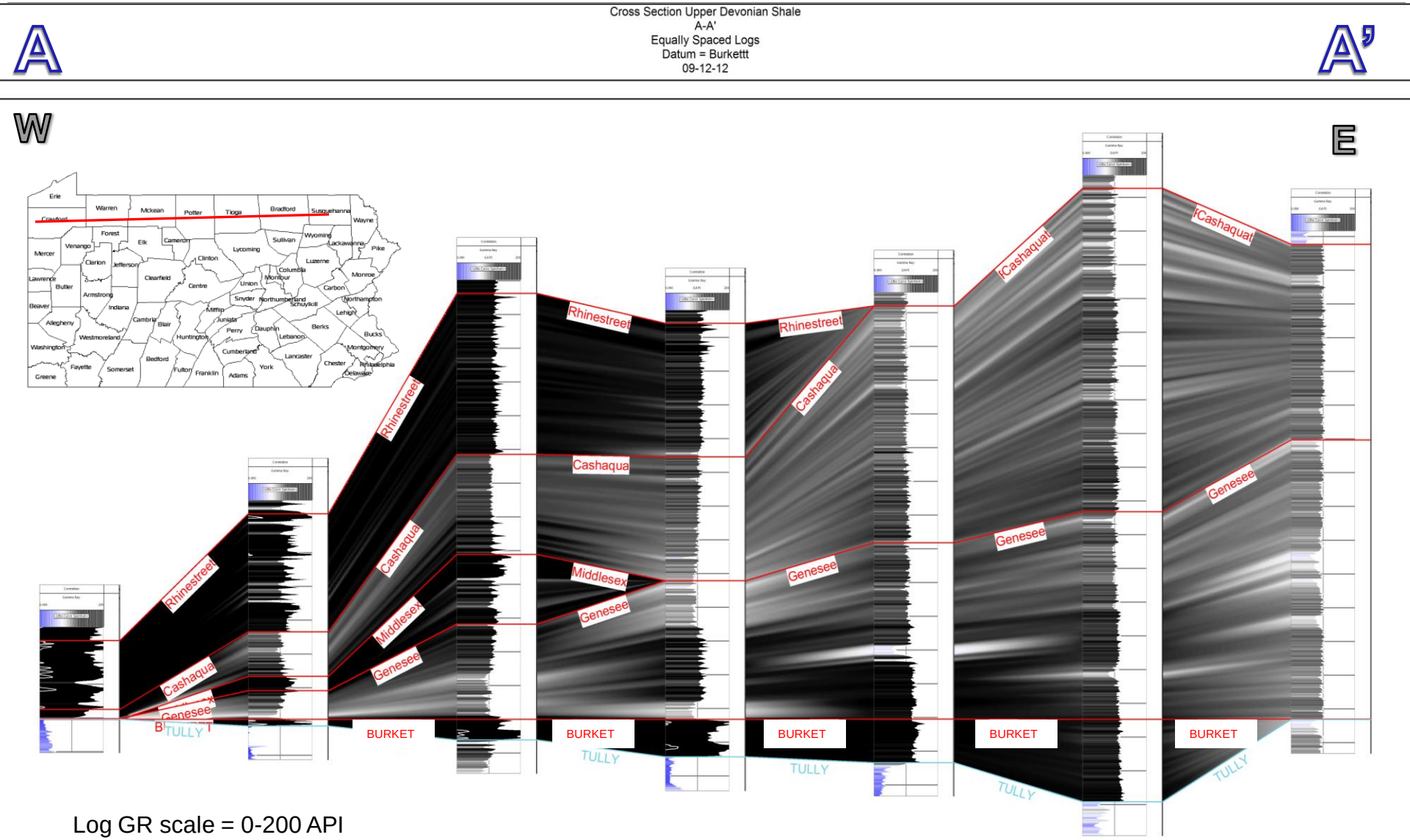
Northwestern PA



Burkett Driller's Depth Structure Map

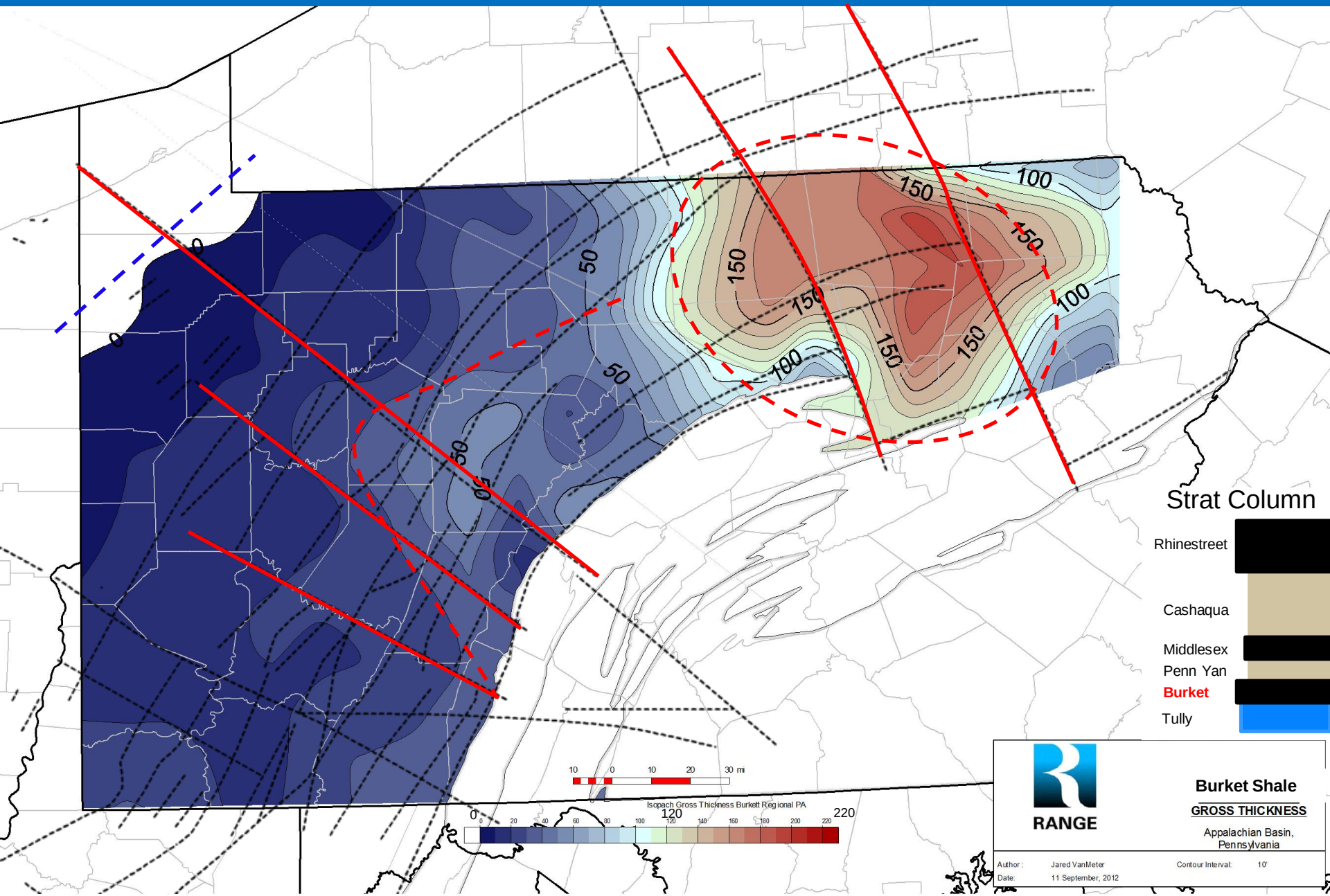


Type Section A-A’

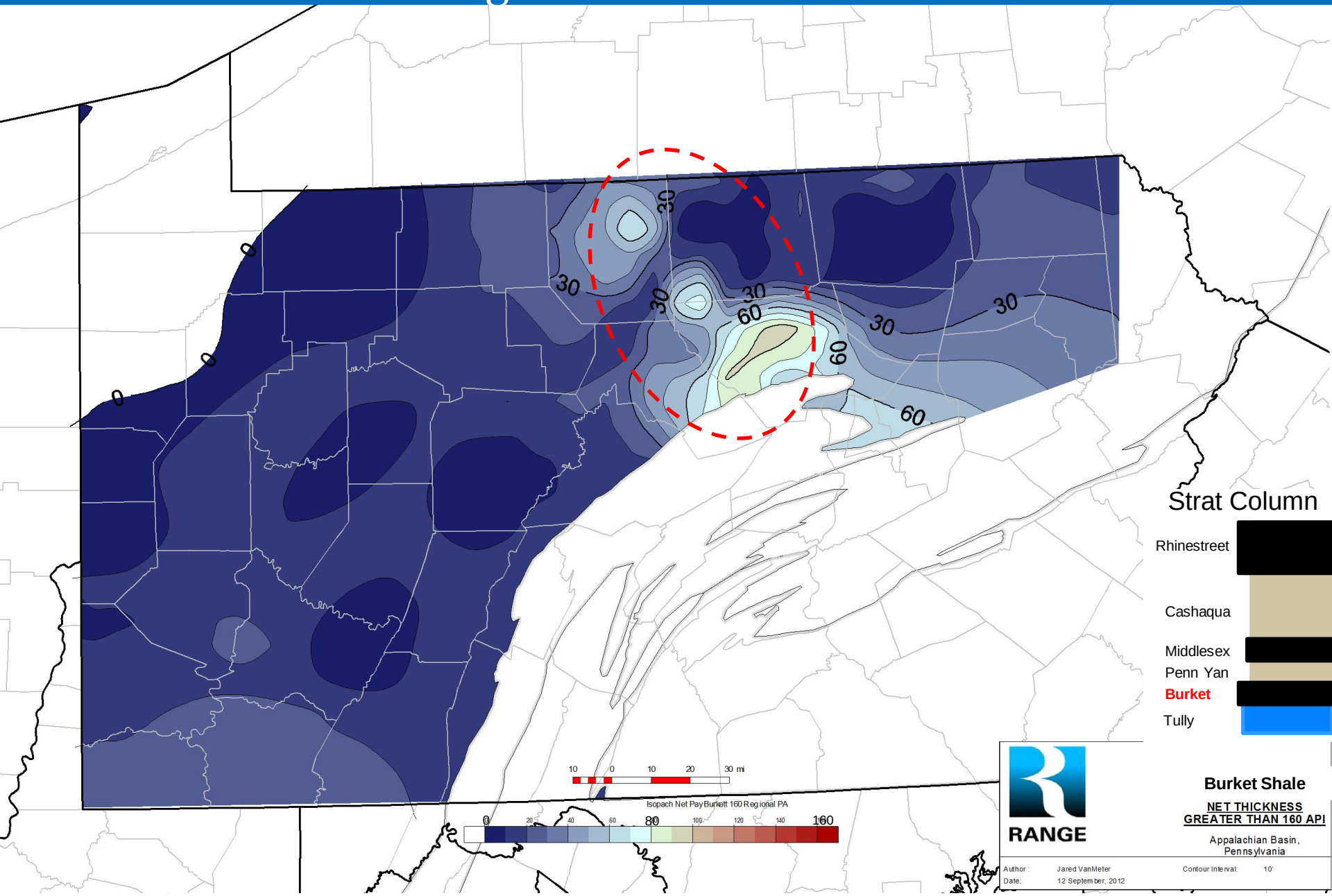


Log GR scale = 0-200 API

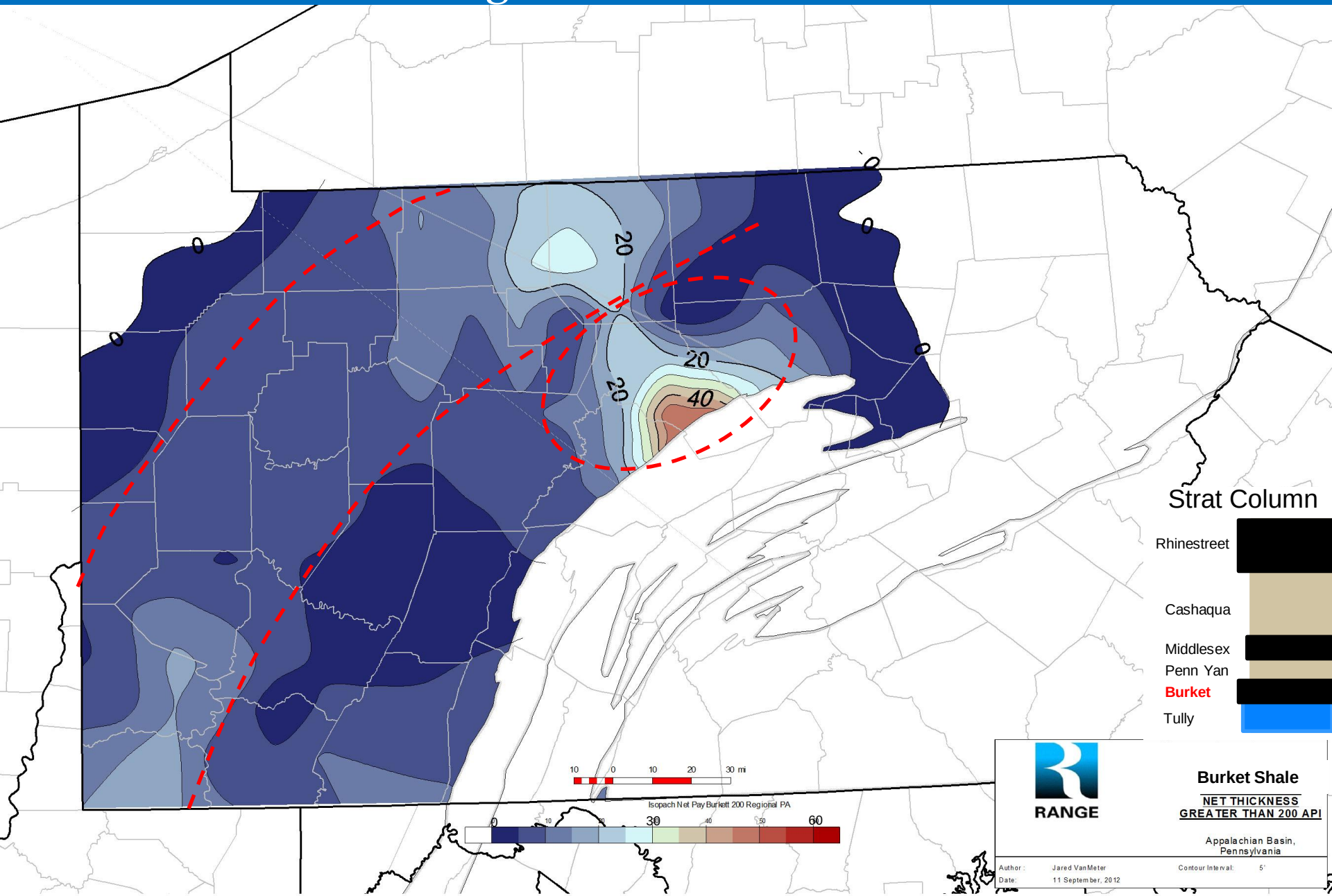
Burket Shale Gross Thickness



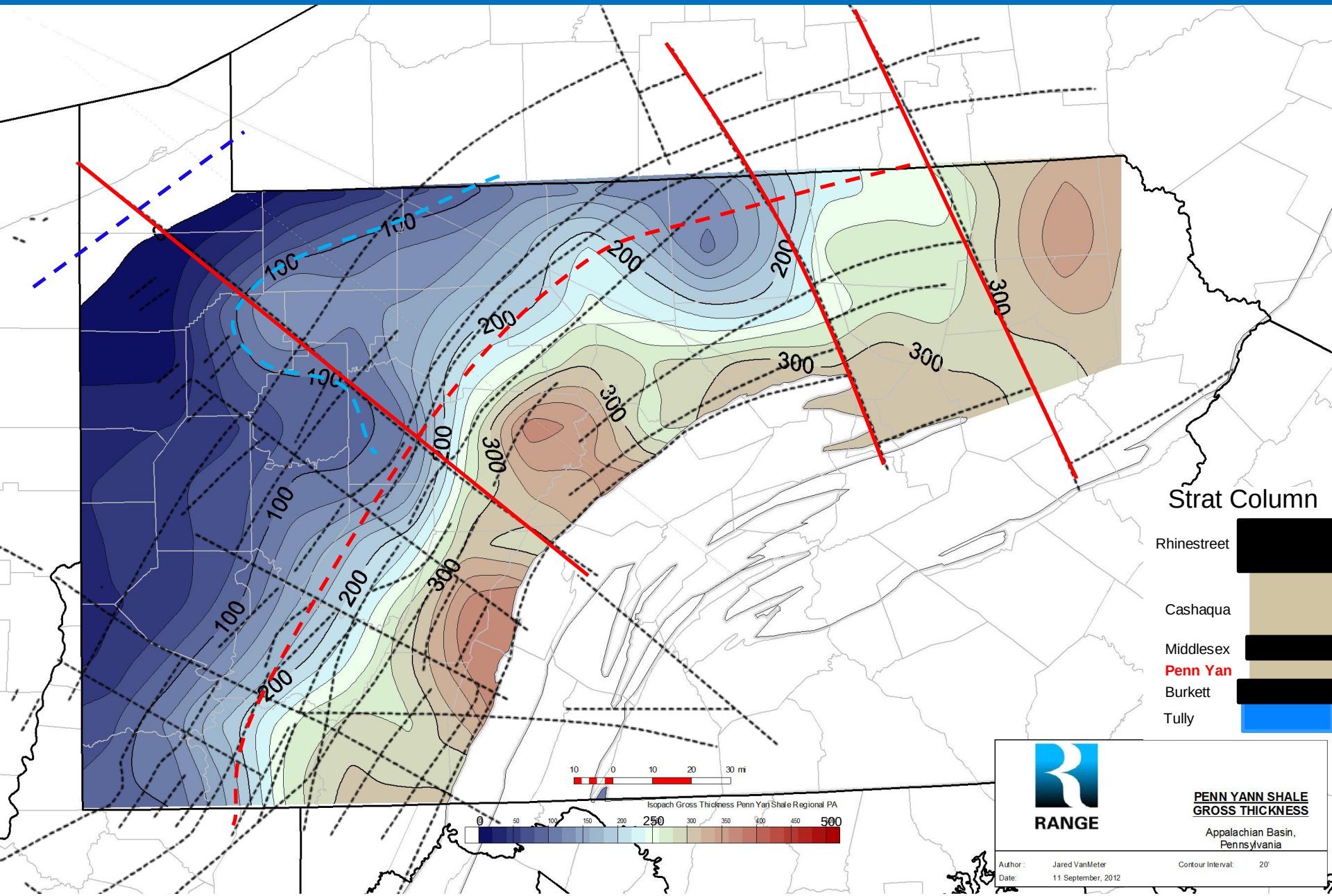
Burket Net Thickness greater than 160 API



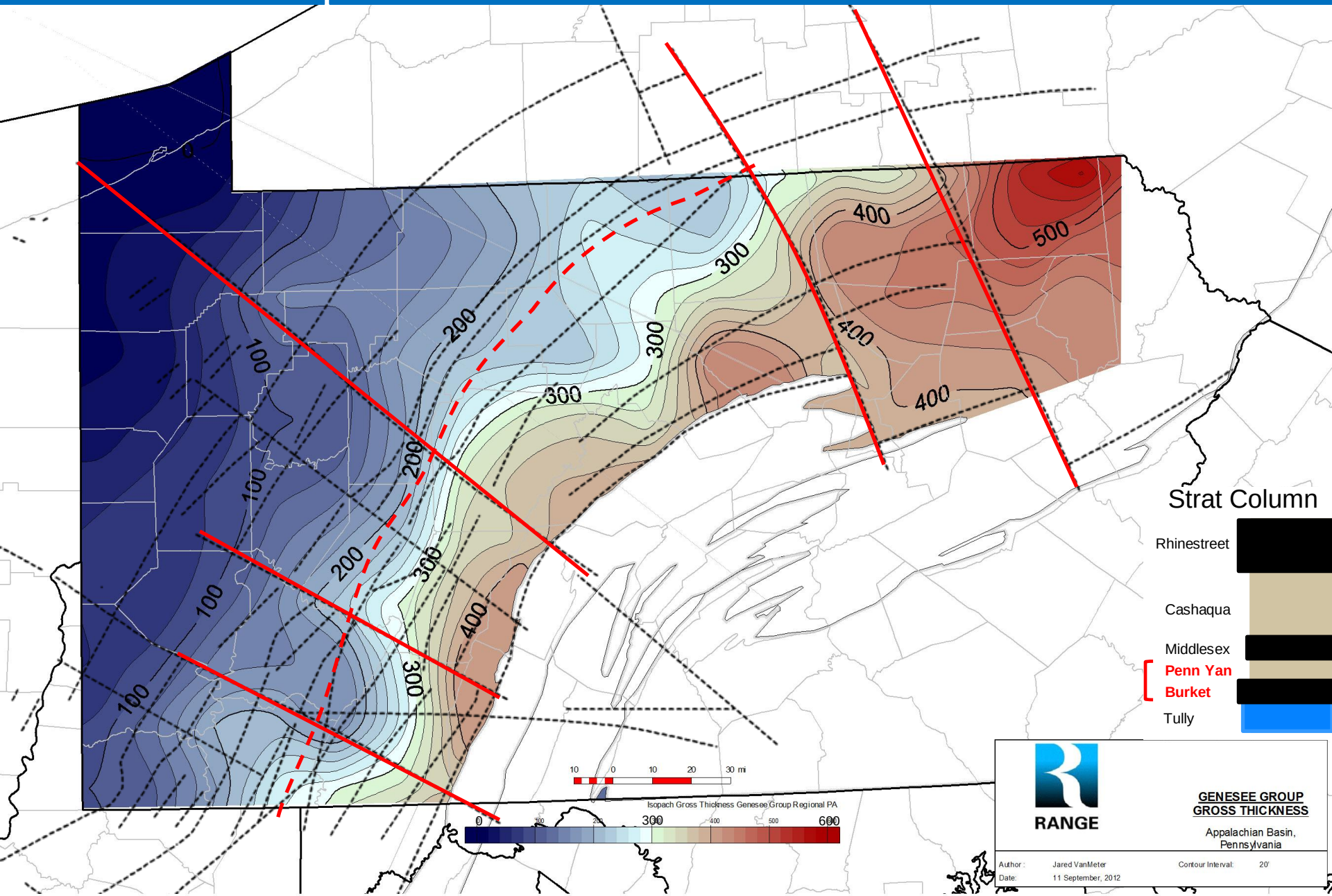
Burket Net Thickness greater than 200 API



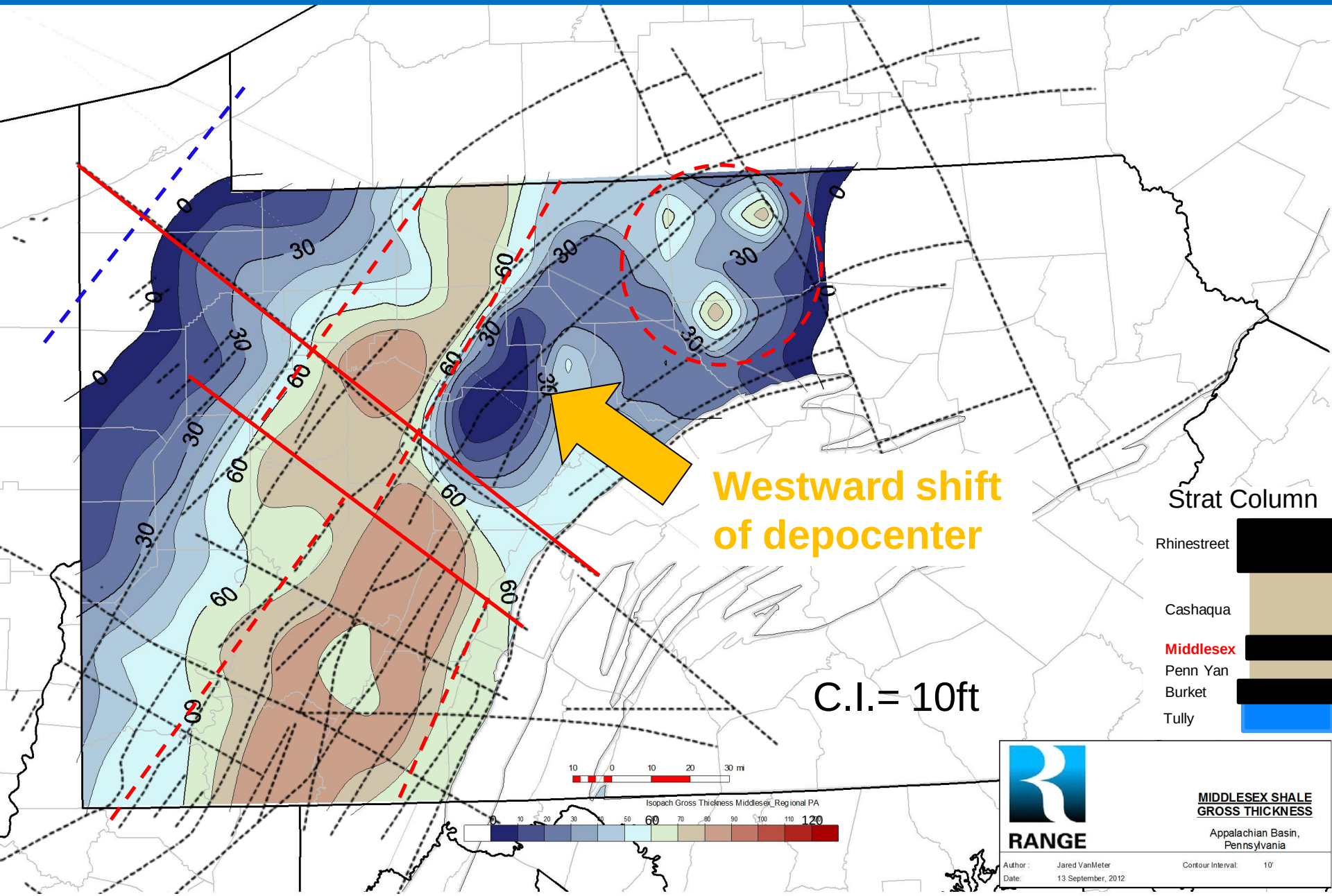
Penn Yan Shale Gross Thickness



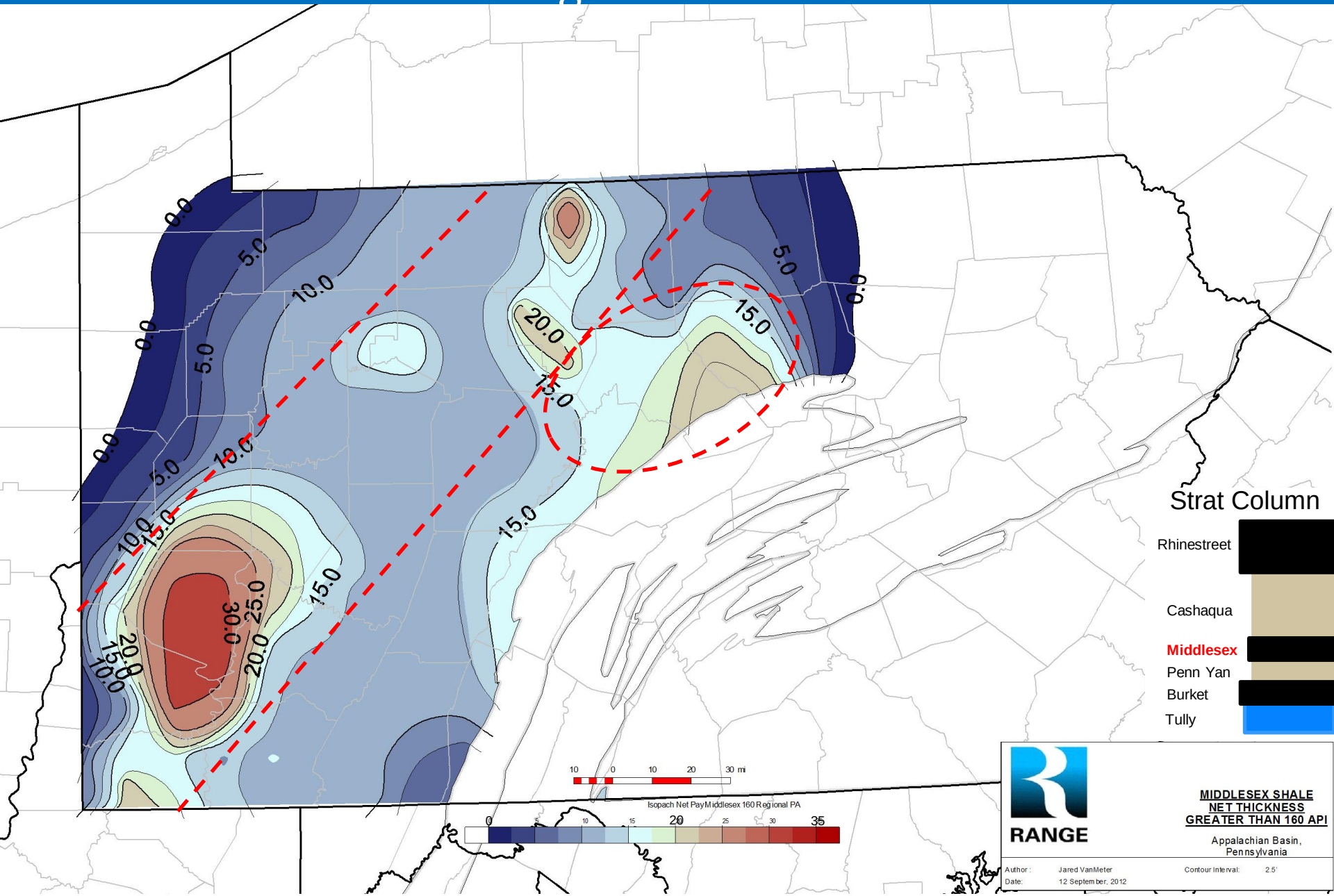
Genesee Group Gross Thickness



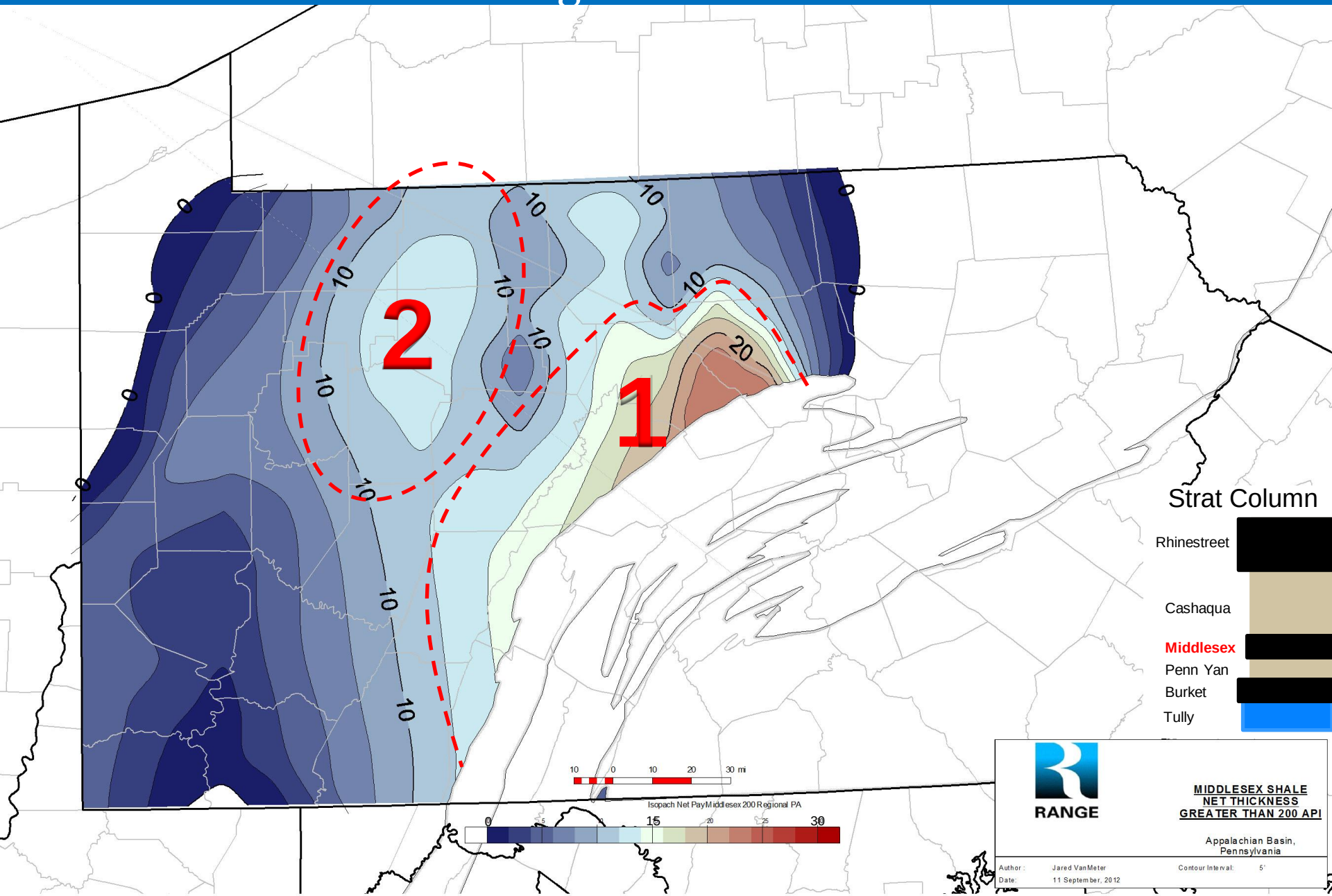
Middlesex Gross Thickness



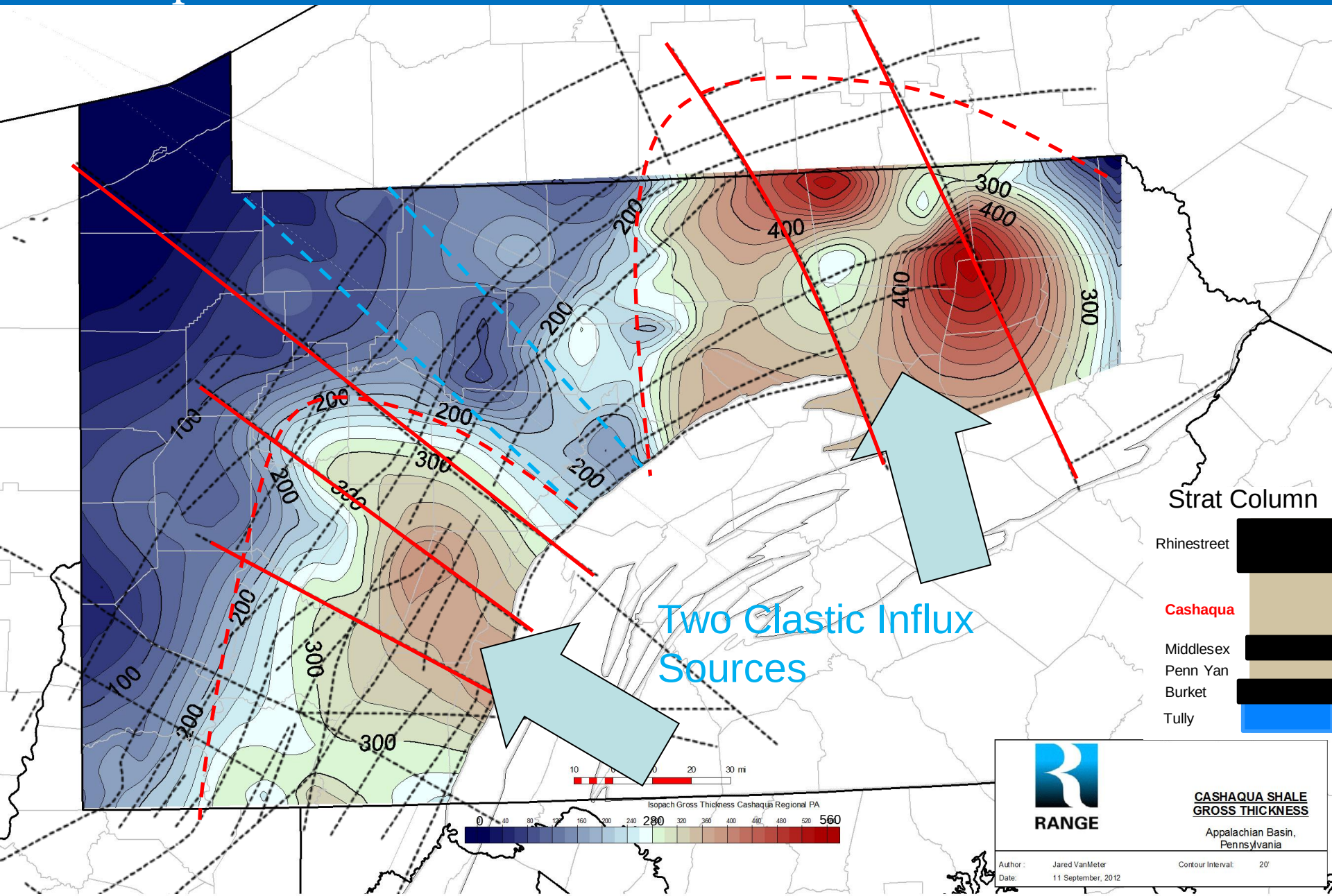
Middlesex Net Thickness greater than 160 API



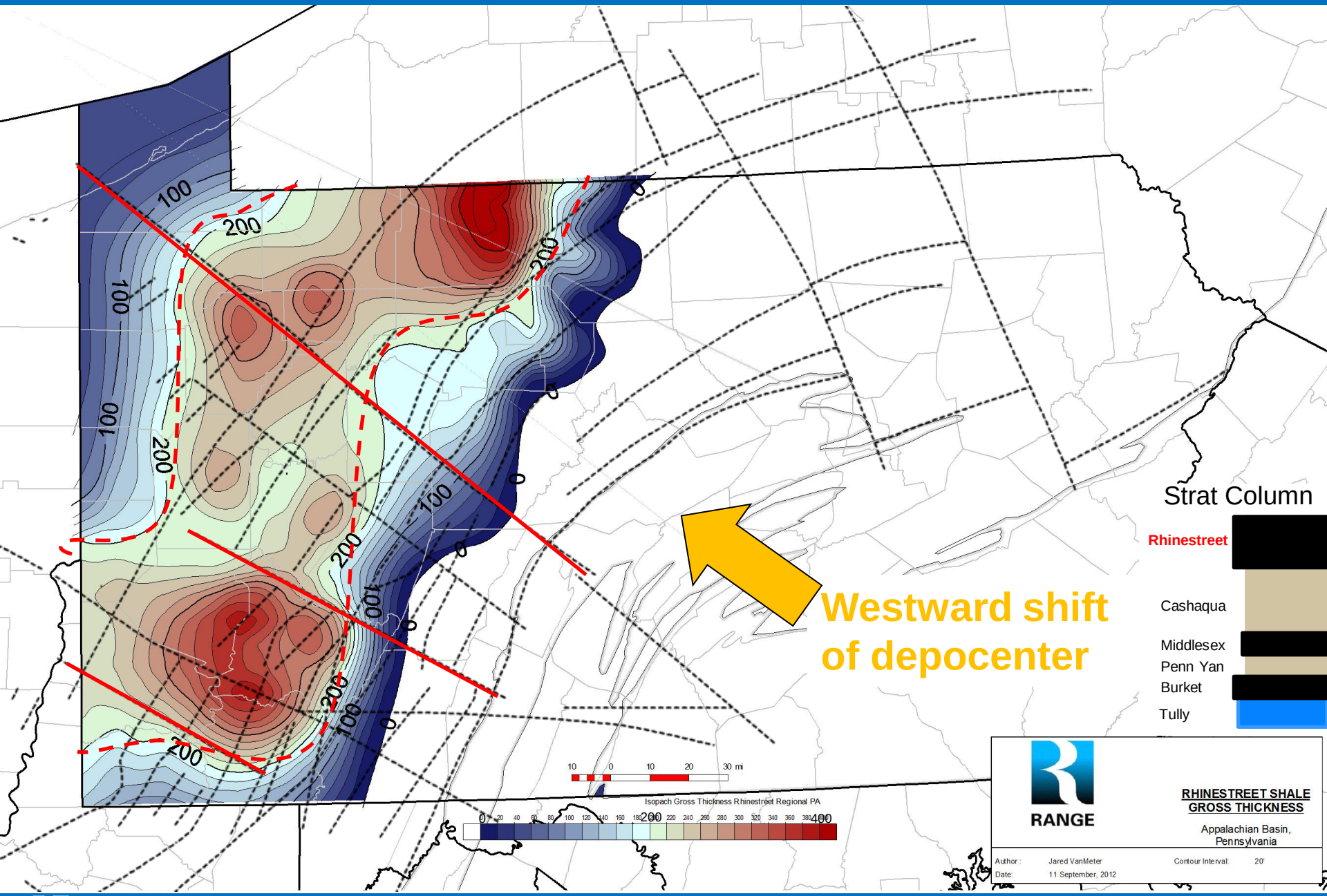
Middlesex Net Thickness greater than 200 API



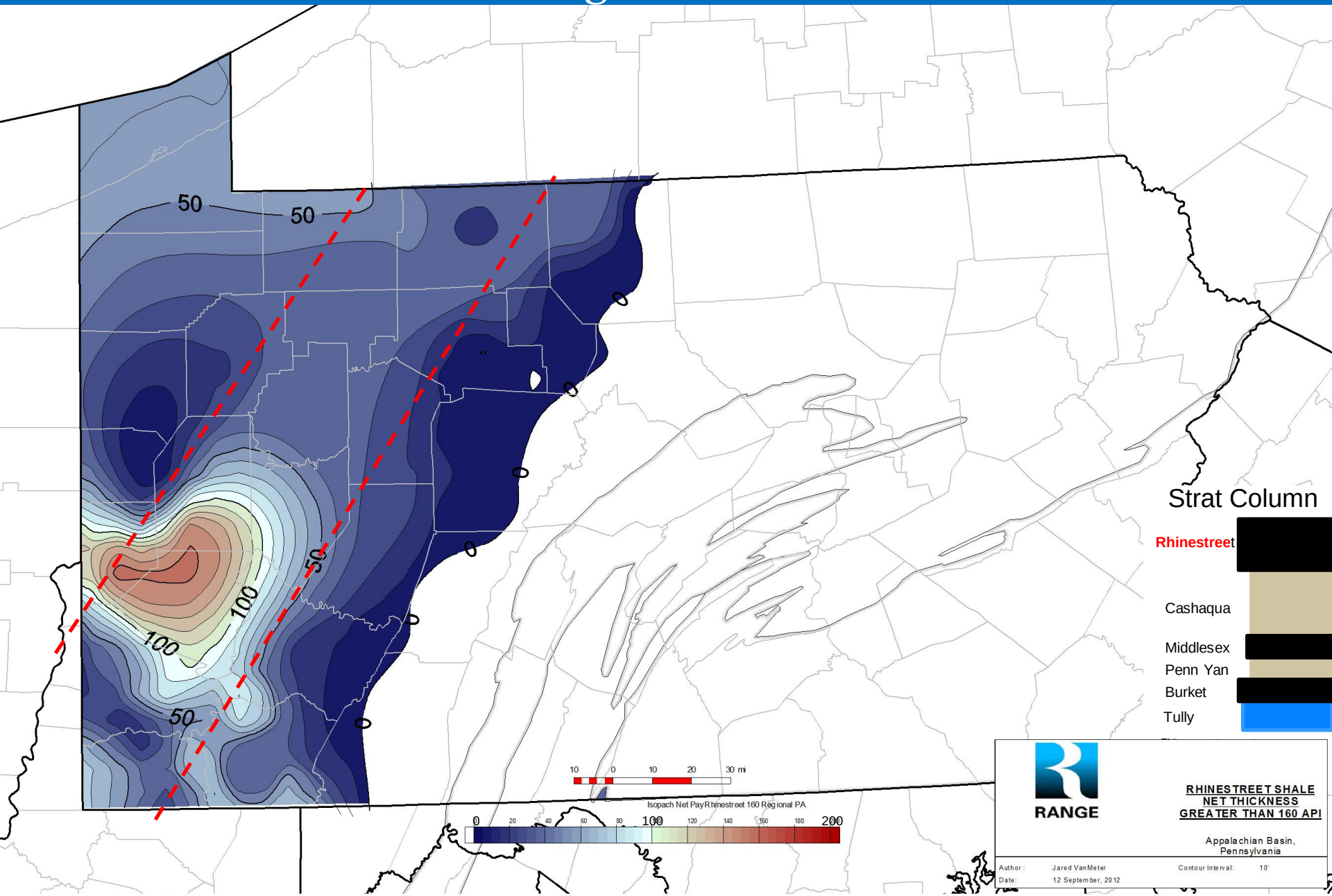
Cashaqua Gross Thickness



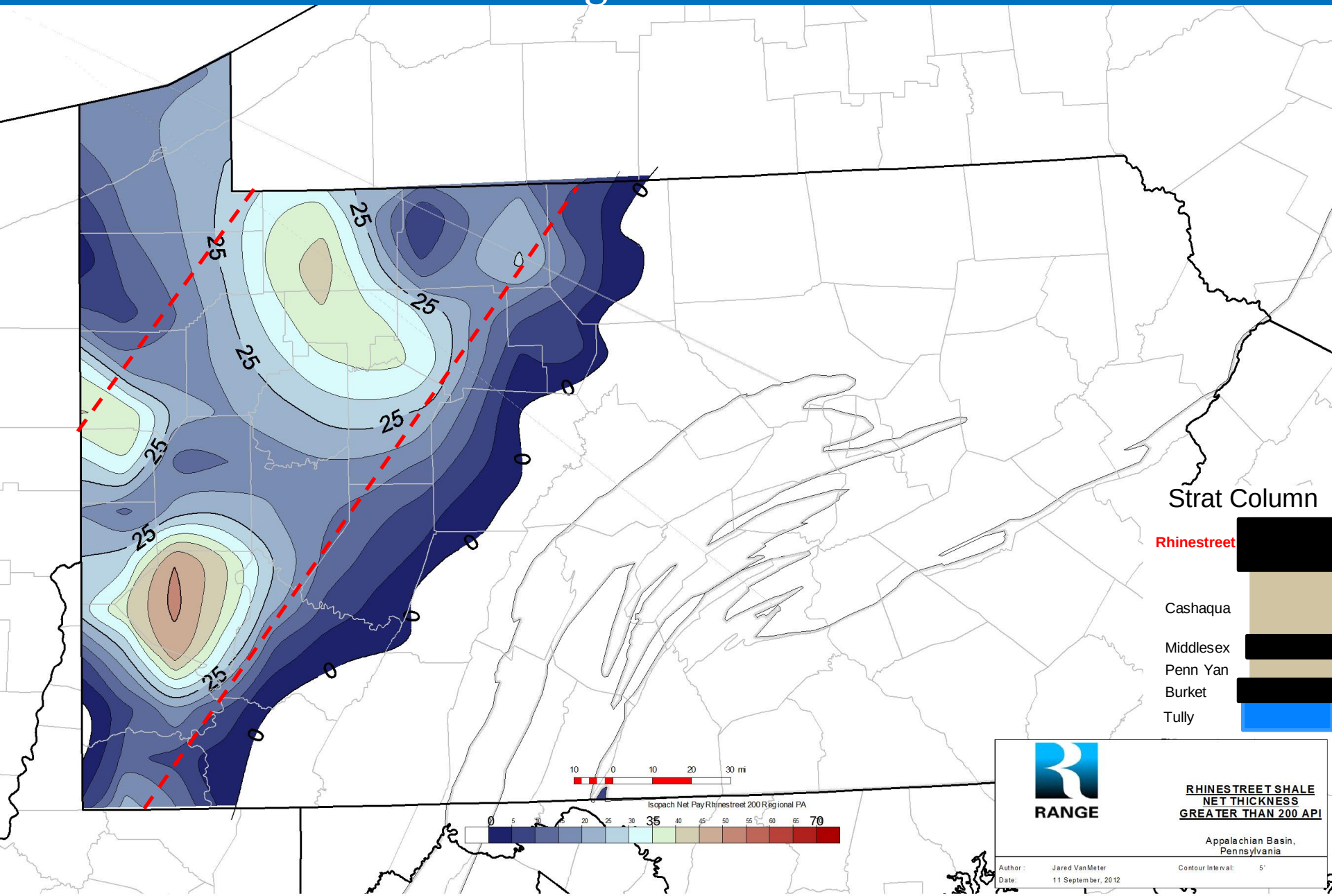
Rhinestreet Gross Thickness



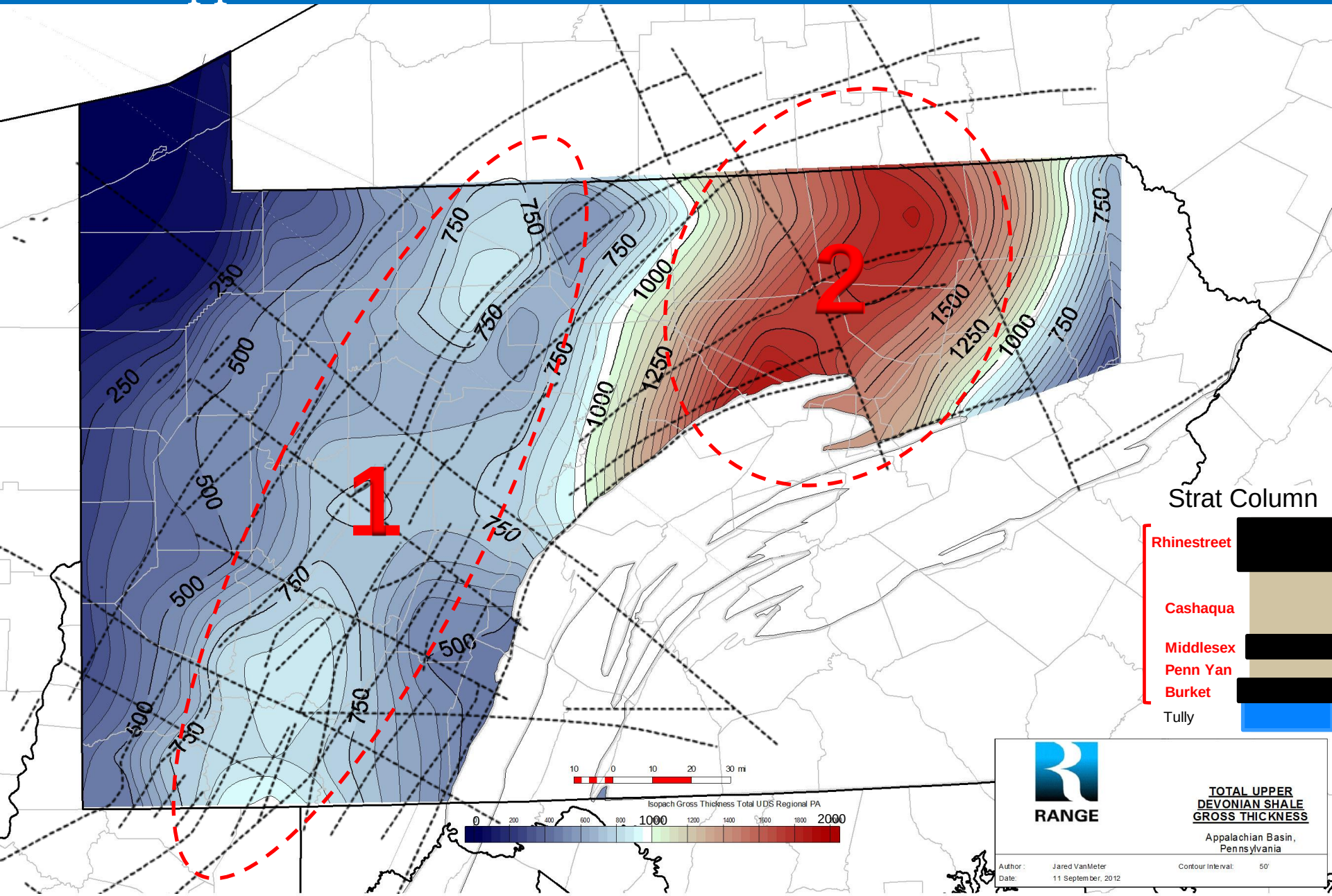
Rhinestreet Net Thickness greater than 160 API



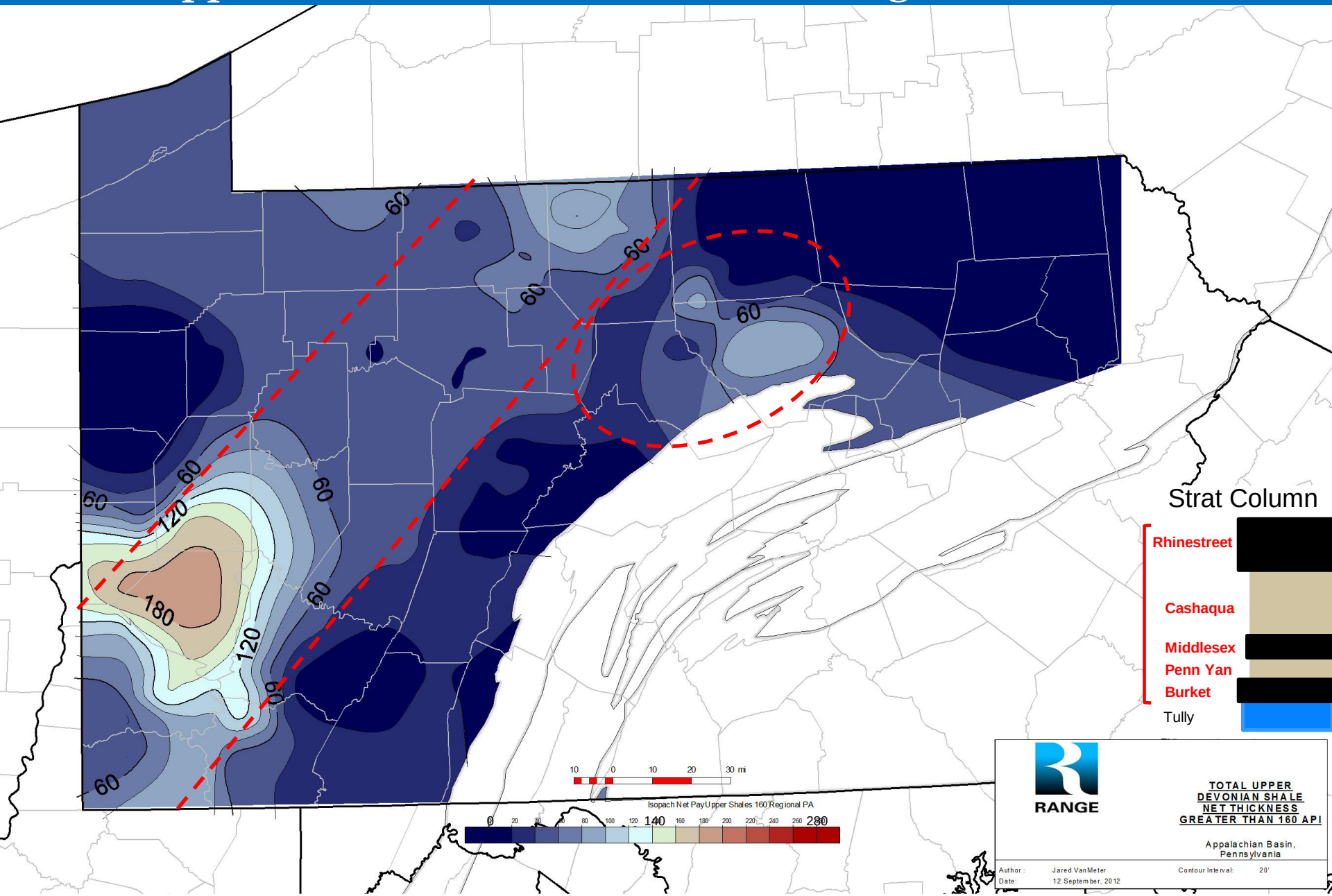
Rhinestreet Net Thickness greater than 200 API



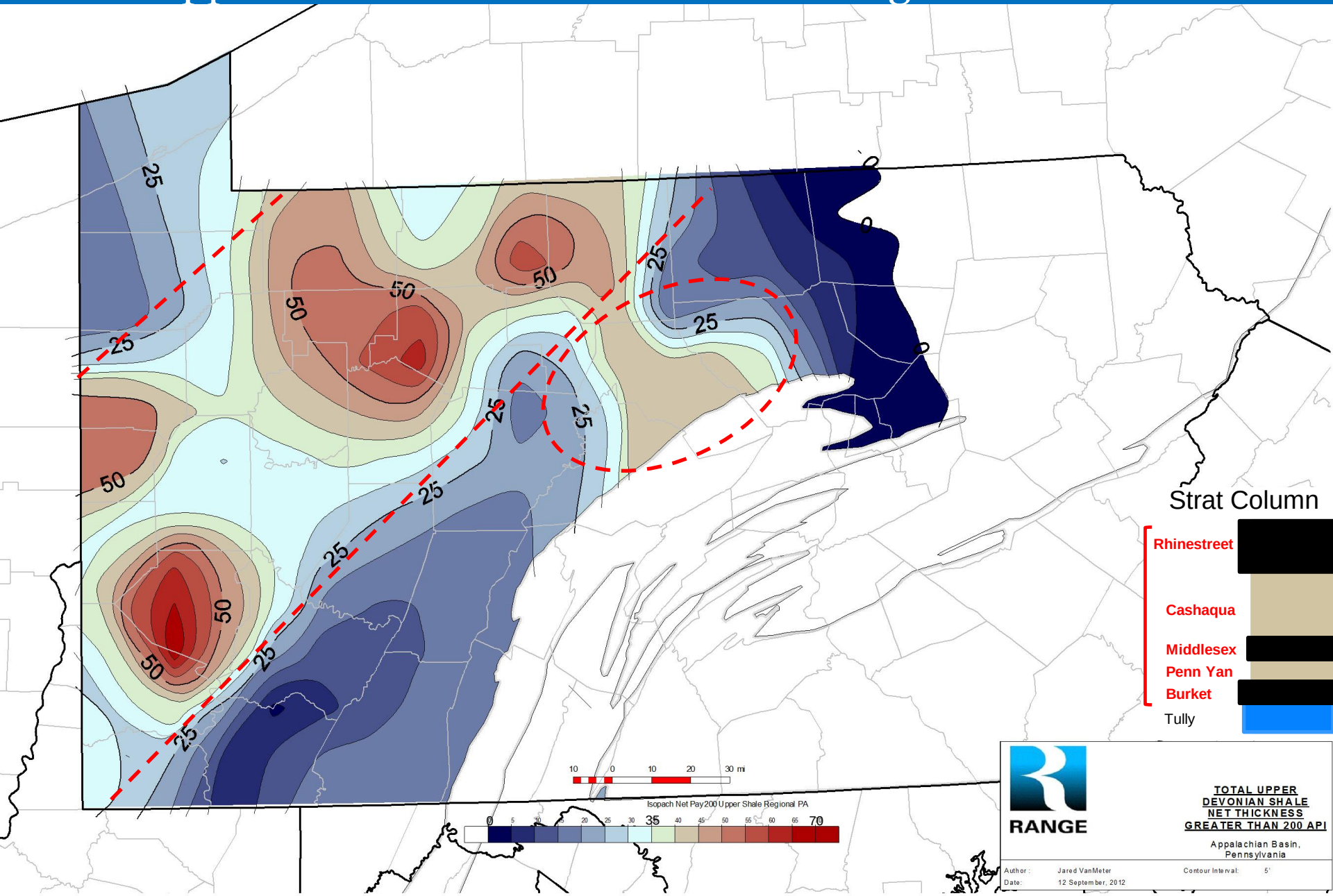
Total Upper Devonian Shale Gross Thickness



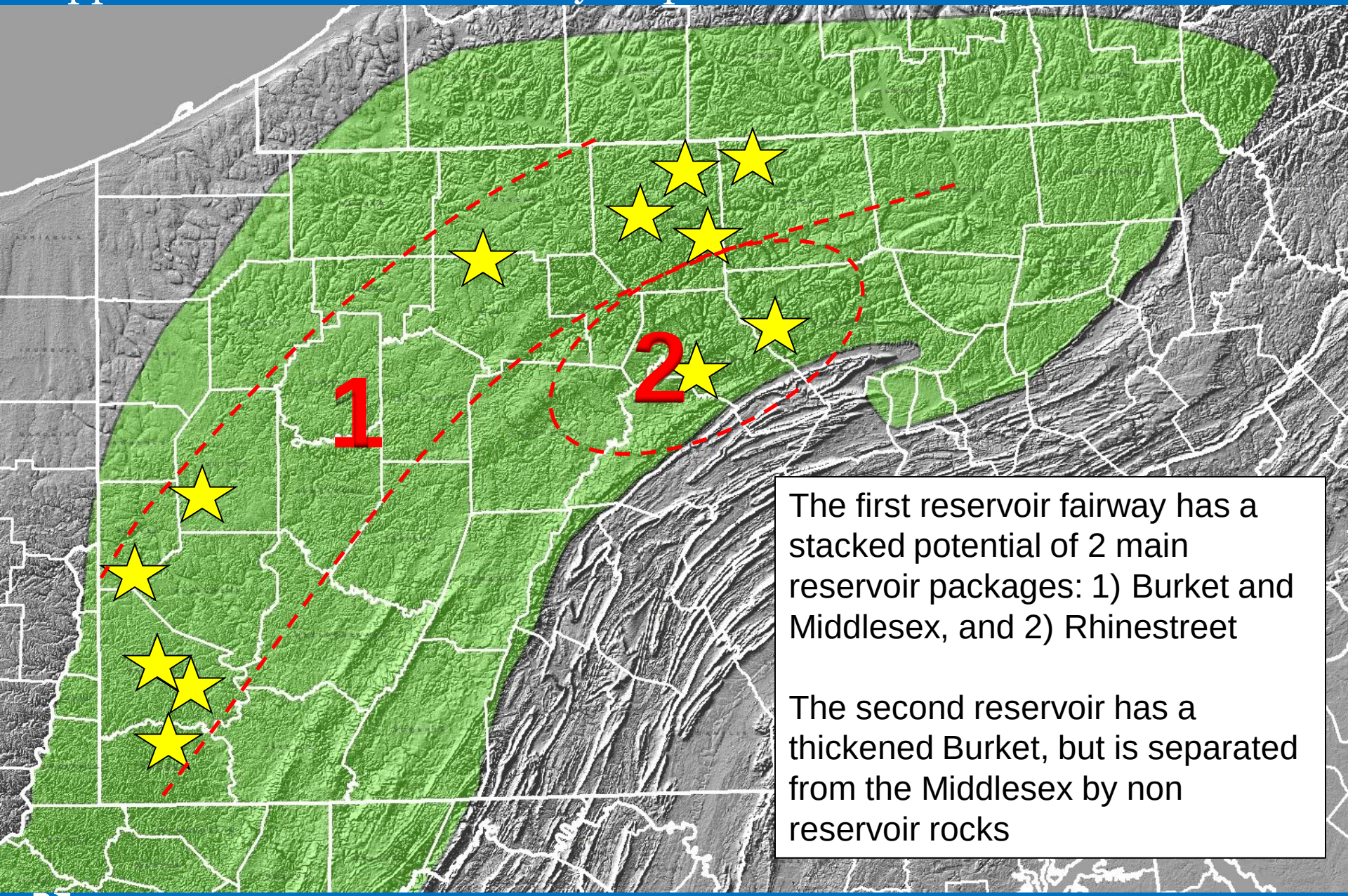
Total Upper Devonian Shale Net Thickness greater than 160 API



Total Upper Devonian Shale Net Thickness greater than 200 API



Upper Devonian Shale Activity Map



The first reservoir fairway has a stacked potential of 2 main reservoir packages: 1) Burket and Middlesex, and 2) Rhinestreet

The second reservoir has a thickened Burket, but is separated from the Middlesex by non reservoir rocks

Conclusions

- Gross Thickness mapping shows the following:
  - Mapping indicates that basin dynamics caused gross thickness of organic members to shift westward over time.
  - Mapping indicates two clastic sources fed the basin in Upper Devonian time
  - Regional basement faults and lineaments had an effect on the deposition of the formations and different cross strikes activated at different times
  - Foreland bulge paleostructural high caused lack of deposition and/or erosion of Burket, Penn Yan, and Middlesex in NW PA
- Reservoir mapping indicated two reservoir “fairways” in Pennsylvania.
  - In southern PA there are two reservoir packages, whereas in northeastern PA the Burkett is the main reservoir.
- Upper Devonian Shale is being explored by multiple companies for potential oil and gas reserves and is a viable play with many successful test wells already drilled