Analysis of methane in shallow aquifers overlying oil and gas production in Pennsylvania and Colorado

Rebecca Warner, Geology

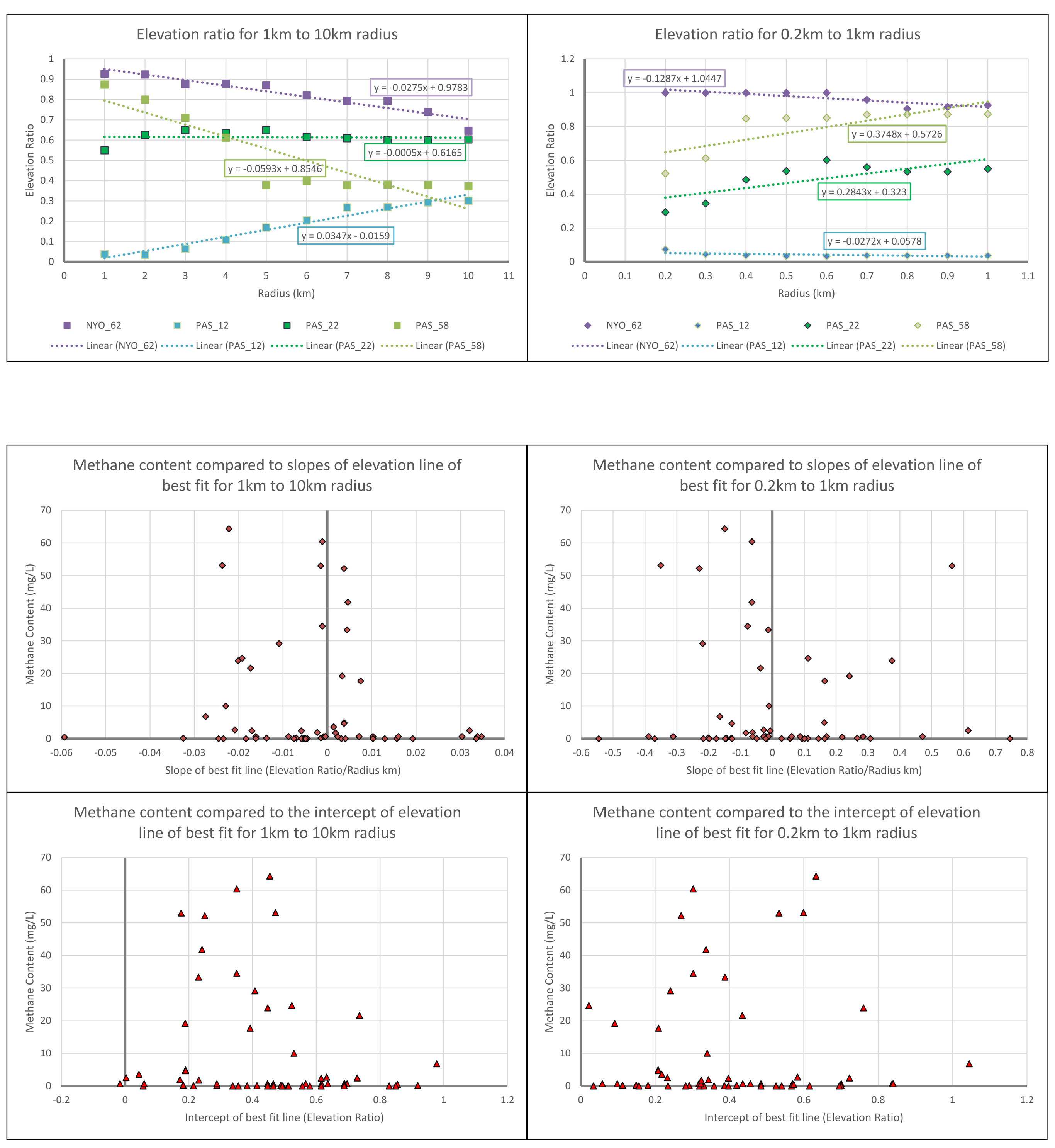
Mentor: Dr. Stephen Osborn

Kellogg Honors College Capstone Project

Abstract:

High concentrations of shallow aquifer methane overlying deep oil and gas reservoirs has garnered public concern in recent years as hydraulic fracturing and horizontal drilling technologies have proliferated. There is still uncertainty as to the sources of methane. Studies (Osborn et al., 2011 and Jackson et al., 2013) of groundwater wells in Pennsylvania and New York concluded that there was a correlation between the proximity to oil/gas-wells and methane content in some shallow aquifer wells. Other subsequent studies claim a combination of shallow flow paths and local topography are the cause. This study seeks to use publicly available shallow aquifer methane data from the Colorado Oil and Gas Conservation Commission and data collected by Osborn from areas of oil/gas production in Pennsylvania and Colorado to assess methane concentrations against proximity and topography. ArcGIS was used with data from the United States Geological Survey to find the highest and lowest elevation points for various radii around the wells to compare the differences of local topography with methane content. The elevations of these points were gathered and compared to the well's elevation to determine its relative topography as a ratio between the high and low locations and then compared to methane levels.

Pennsylvania Data



Future Research:

As a response to Molofsky's studies this project only looked at topography as a factor in methane content. To fully examine Osborn's data with Molofsky's proposed causes for higher methane concentrations would require an examination of the local rock units in addition to the topography. It might be advantageous to complete a study comparing Osborn's methane data to the area's geology.

In examining possible causes for increased methane content in the sampled locations for the data from Colorado, it would be interesting to do a study examining the methane content as compared to the proximity to oil/gas wells in Colorado. Essentially repeating the calculations from Osborn's 2011 study with data from Colorado.

Acknowledgments:

I would like to thank Dr. Stephen Osborn for his data and the opportunity to expand my skills. Colorado Oil and Gas Conservation Commission also deserves thanks for the data supplied and the USGS is owed thanks for the Digital Elevation Models. I would like to thank Cal Poly Pomona and Geological Sciences Department as well as the Kellogg Honors College for the support and learning opportunities. Esri should also be thanked for its ArcGIS program.

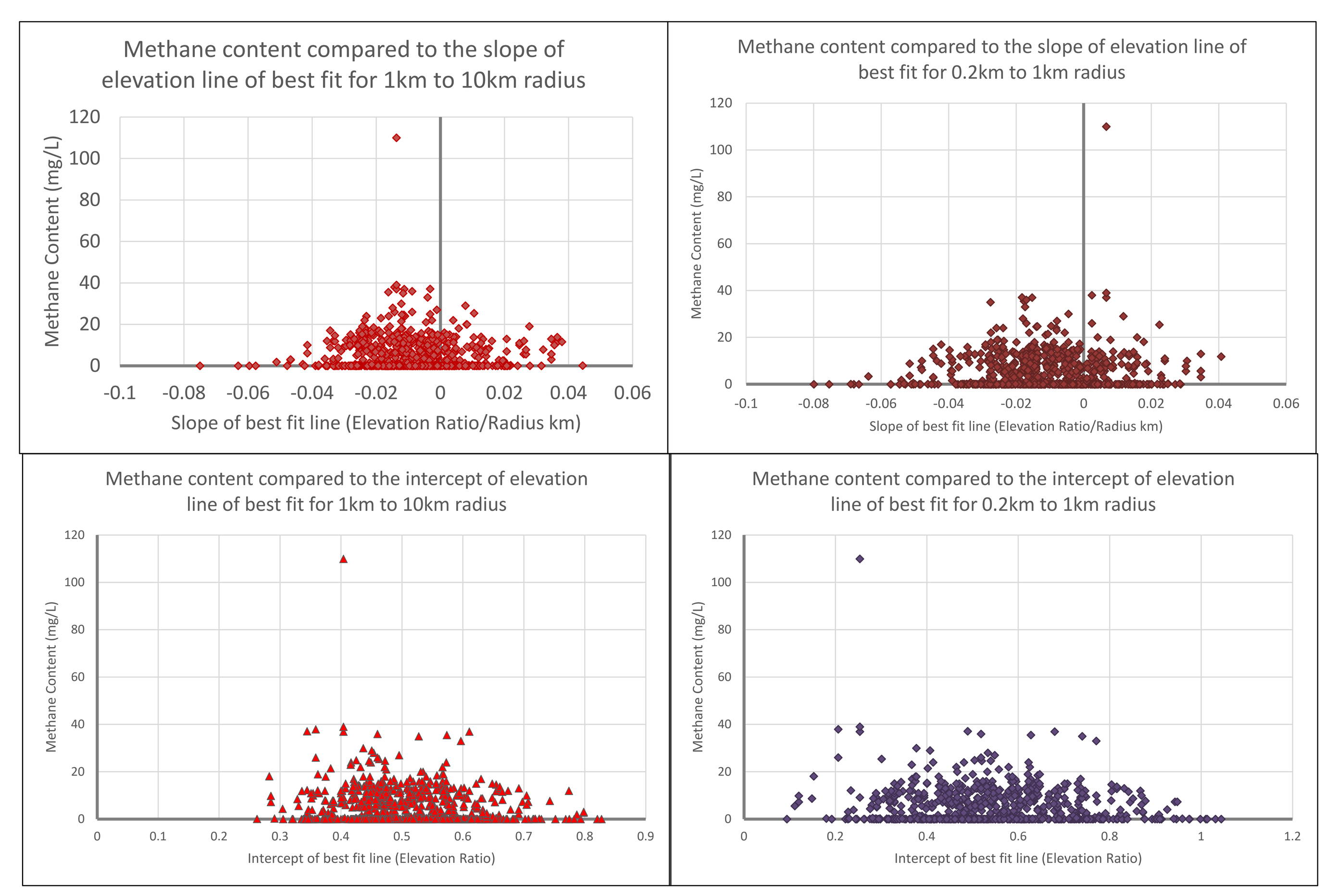
Methods:

In order to gain a quantifiable visualization of the local topography at the sample locations, the highest and lowest elevations were found within multiple radii around the sample location. ArcPy was used in conjunction with ArcGIS to write a code in the Python scripting language that would take the latitude and longitude of each point and create a circle feature class for a specified radius around that point. The Spatial Analysis feature of ArcGIS was then used to extract a raster from a Digital Elevation Model (DEM) that conformed to the previously formed circle. The elevation values in this raster were then used to determine the highest and lowest elevations within the circle. Theses elevation values were extracted and then written into an excel file.

Once the highest and lowest elevations were extracted, the elevation of the sample location were also found using ArcGIS and added to the excel file. To find the elevation ratio of the sample locations within the radii, the minimum elevation was subtracted from the sample site elevation and this values was then divided by the difference between the maximum and minimum elevation. This calculation was done for radii ranging from 0.2km to 1km with a circle every tenth of a kilometer and from 1km to 10km with a circle every kilometer. The two differing radii ranges were selected in an effort to see if near topography (within 1km) or local topography (within 10km) differed in how they effected the methane content of the sample.

The elevation ratios were then graphed against the circle radii they were aquired from and a line of best fit was calculated. From this line of best fit, the slope and intercept were then gathered and graphed against the methane content of the samples.

Colorado Data



Results and Conclusion:

As shown in the above graphs, neither the Pennsylvania Data nor the Colorado Data show any strong correlation between methane content and slope or intercept. It would appear that there is little to no relation between local topography and methane content according to the methods used in this study.

The first two graphs in the Pennsylvania Data show the Elevation Ratio to Radius relation and subsequent line of best fit from which the slope and intercept are aquired. Only four data points are displayed for clarity.

The four final graphs of the Pennsylvania Data and the graphs of the Colorado Data show methane content compared to slope and intercept for the different radii segments. While there is some skew in the data, there is nothing showing strong relation with the methane content.

References:

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