PGE 383 Project Update #3 - Team 01

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1 Executive Summary

The Reservoir Subsurface Team 1 has continued with the evaluation of spatial continuity of the reservoir. This update includes efforts taken to identify the primary directions of spatial continuity as well as their associated ranges.

Based on data from all 271 wells, it was found that an azimuth of 22.5/112.5 maximized the range of spatial continuity in both the major and minor directions. After developing variograms for Sandstone, it was found that the facies had a range of correlation up to 500 meters. It was found that the sandstone facies is cyclic in the 022 direction with a range of correlation up to 200 meters. We believe this cyclicity may represent the sinuous geometry of the channel. Moving forward, it is the belief of our asset team that the facies specific variogram models contained within this report should be used throughout the spatial estimation process.

2 Description of Workflows and Methods

The following steps were carried out in a Jupyter Notebook workflow:

1. From the initial dataset, outliers in well data were removed via the Tukey method
2. Next, the porosity and permeability data were transformed to standard Gaussian distributions with a mean of 0 and variance of 1
3. A variogram map was constructed to identify the primary direction and range of spatial continuity
4. An indicator transform was applied to develop an experimental variogram outlining continuity by-facies in the reservoir
5. Experimental variograms of porosity and permeability were constructed to validate the findings from the variogram map and establish azimuthal directions for major and minor axes of continuity in the reservoir
6. Model variograms were fit to the experimental variograms and interpreted

3 Results

3.1 Variogram Map for porosity

Variogram map was made for the property of porosity in order to determine primary directions and possible ranges of the spatial continuity. That analysis was done for the data without out-layers for each facies and both facies as well. The first visual approach to the distribution of the reservoir does not have a clear direction. As well as the acoustic impedance map also shows a weak directionality. However, the variogram map for sand facies, which is displayed in Figure 1 has shown a primary direction SW to NE with an azimuth in the major direction of 22.5 degrees and 112.5 degrees in the minor direction. The initial ranges in major and minor direction are 250 meters and 90 meters respectively.

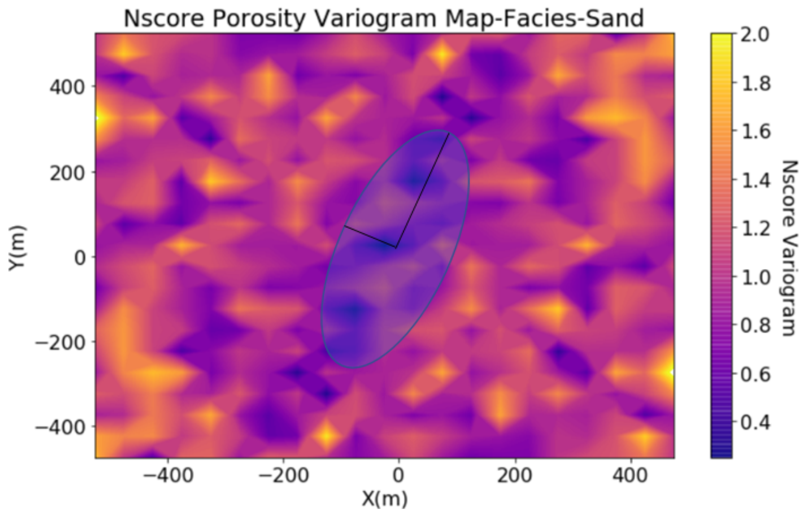


Figure 1: Variogram Map based on porosity data

3.2 Isotropic and Directional Variograms

Isotropic and directional variograms were calculated for facies, porosity and permeability. An indicator transform was applied to develop facies variograms. The isotropic variogram for permeability figure shows that the range of correlation for the sandstone facies is 250 m, due to the confinement of sandstone within the channel belt. This estimation of channel belt width agrees with the visual estimation based on the acoustic impedance map. The variogram of the shale facies behaves well until the lag distance of 250m, possibily due to lack of pairs beyond this point. From all directional variograms, we determined that the major and minor directions for porosity and permeability are 22.5 degrees and 112.5 degrees, respectively.

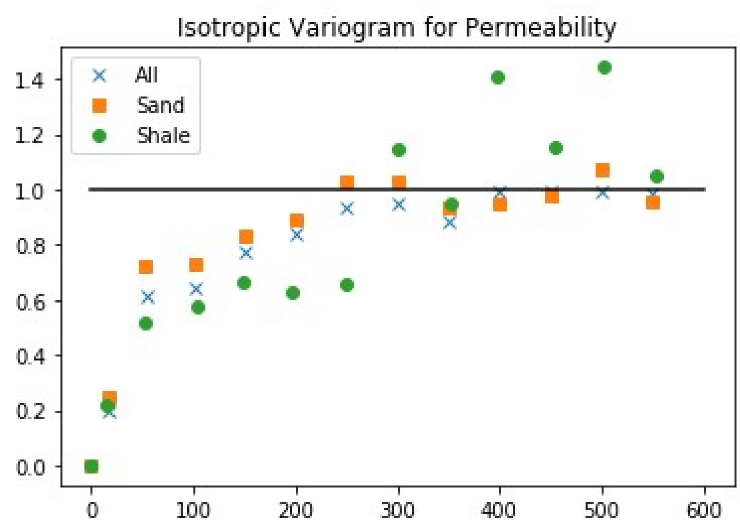
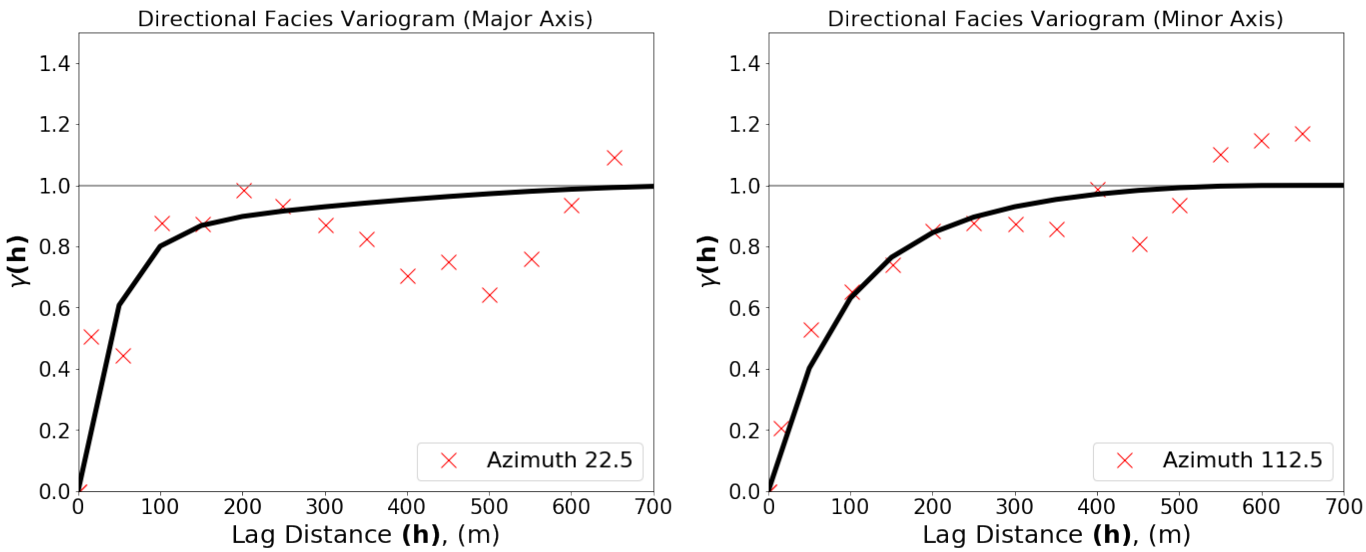


Figure 2: Isotropic variogram for permeability

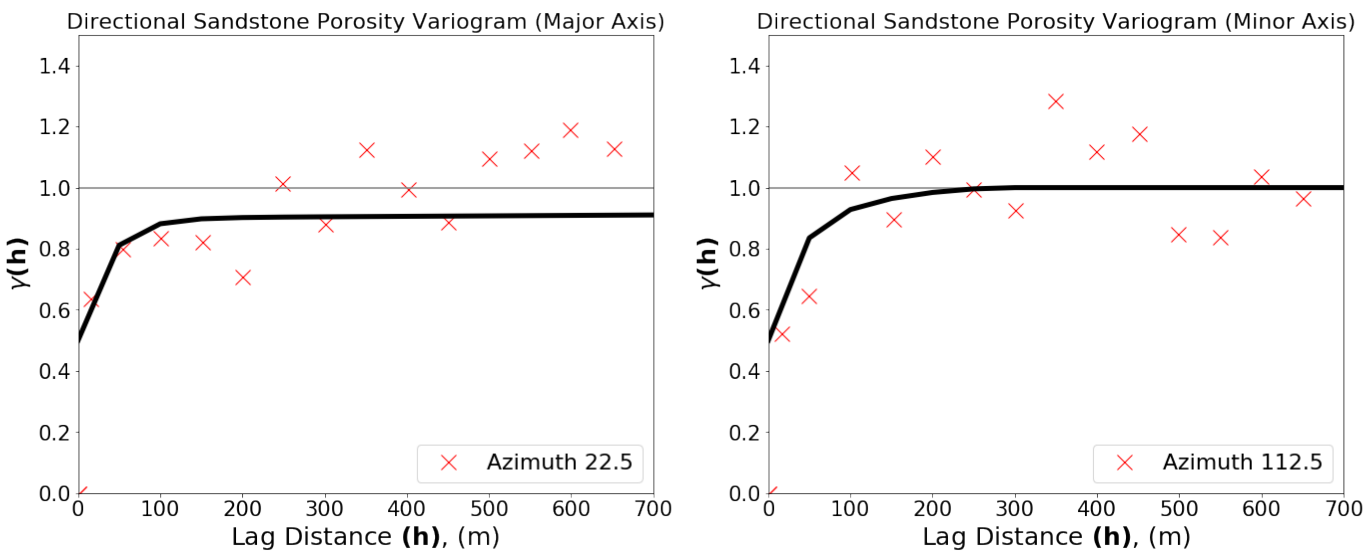
3.3 Semivariogram Models

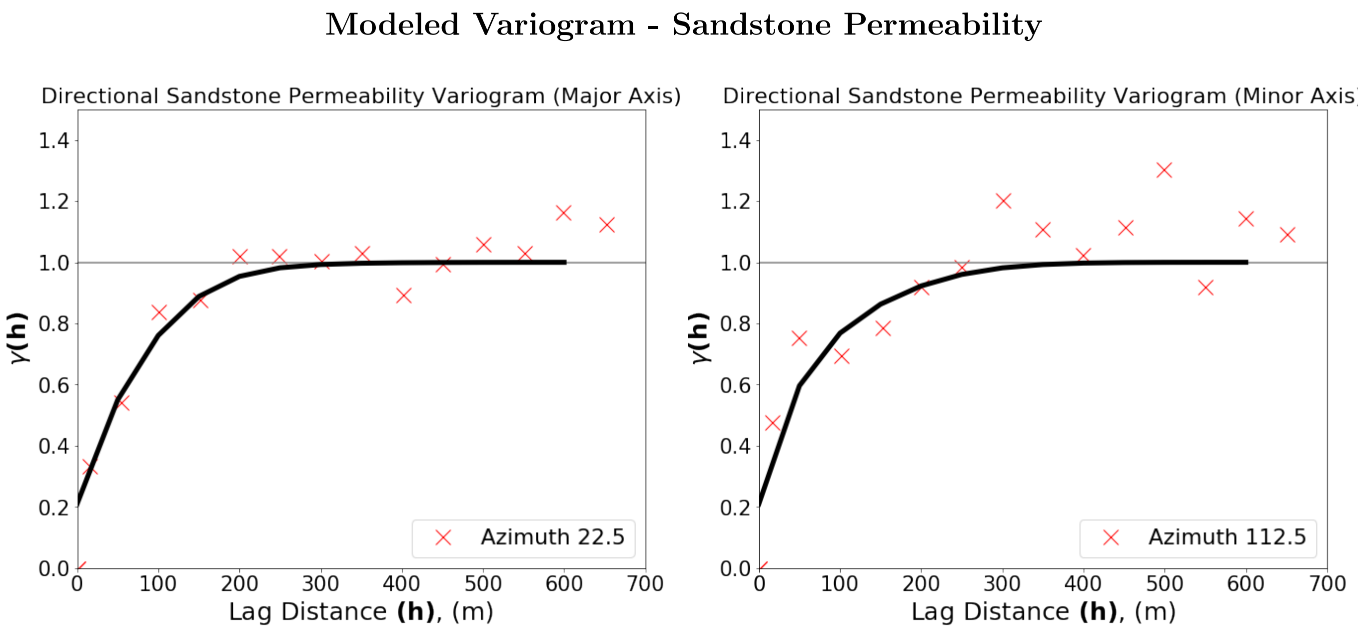
A model variogram was fit to the experimental variograms for the major and minor axes for both the porosity and permeability data. Both the porosity and permeability variograms appeared to be subject to a nugget effect. In the porosity variogram the nugget effect accounted for 40% of the variance, and in the permeability data the nugget effect was determined to be about 21% of the variance. The porosity variogram was modeled with 2 nested structures, an exponential and spherical model. The permeability variogram was also modeled with 2 nested structures, an exponential and Gaussian model.

Modeled Variogram - Facies Continuity



Modeled Variogram - Sandstone Porosity





From these variogram models, the heterogeneity in the field appears to be roughly isotropic. The range in the major and minor axes is often quite similar for the different features measured in the wells and subsequently modeled.

4 Conclusions

Based on the data and analyses done, the reservoir was found with a weak primary directionality of SW - NE. The minor axis was found to be orthogonal to this direction and has an azimuth of 112. Directional variograms suggest that there is cyclicity in the 022 direction. We believe this cyclicity may represent the sinuous geometry of the channel shown in figure 3. Variogram models for the shale facies were developed and will be used during the spatial estimation process. Porosity and permeability variograms for the shale facies were also developed but have been excluded in an attempt to convey the most relevant information for our conventional reservoir.

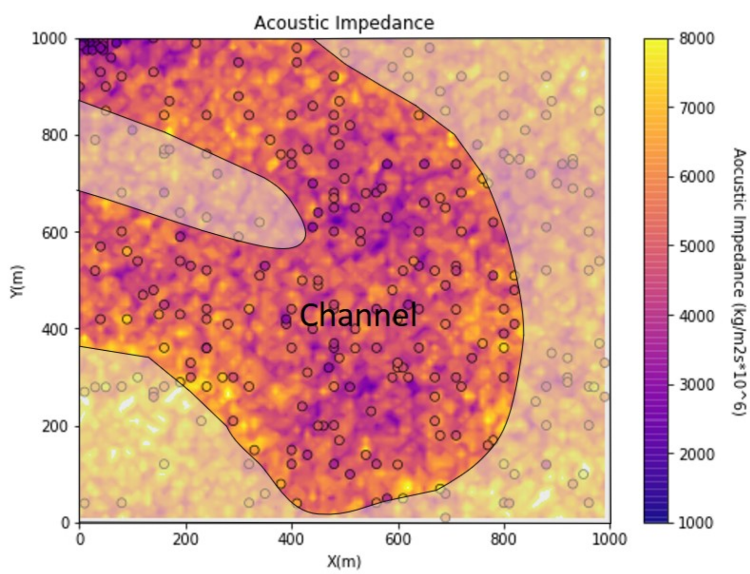


Figure 3: Interpretation of depositional setting