Multivariate Statistical Analysis to Correlate Heterogeneous Production Data (Generalizing the Workflow to Incorporate 3D Sesismic in 2017)

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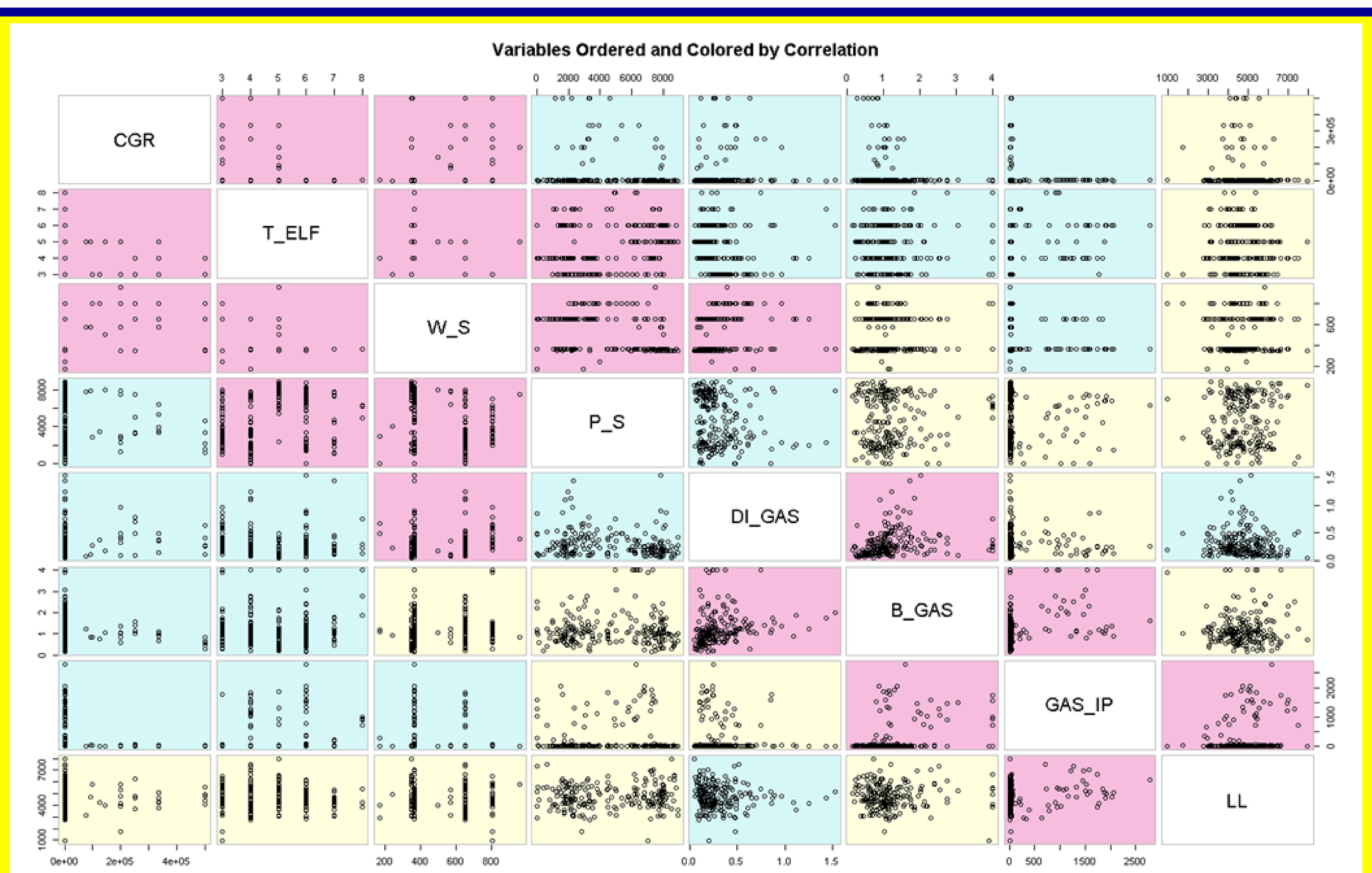
Introduction:

In this poster, I demonstrate the use of multivariate analysis workflow to better explain production heterogeneity. I demonstrate the workflow using data set from the Eagle Ford Shale. My analysis contains input parameters such as petrophysical properties, completion, and reservoir engineering. In future I intend to include seismic attributes in the analysis. The output of the analysis is the variation in expected ultimate recovery (EUR) across the field. Arp's (1945) modified hyperbolic decline curves are used to calculate the EUR's in the study.



Correlation matrix of decline parameters :

Correlation matrix for Arp's decline parameters. It can be observed from the figure that the decline parameters correlate simultaneously with many parameters and hence the problem of correlating EUR's is multivariate.

Input parameters :

Classification parameters:

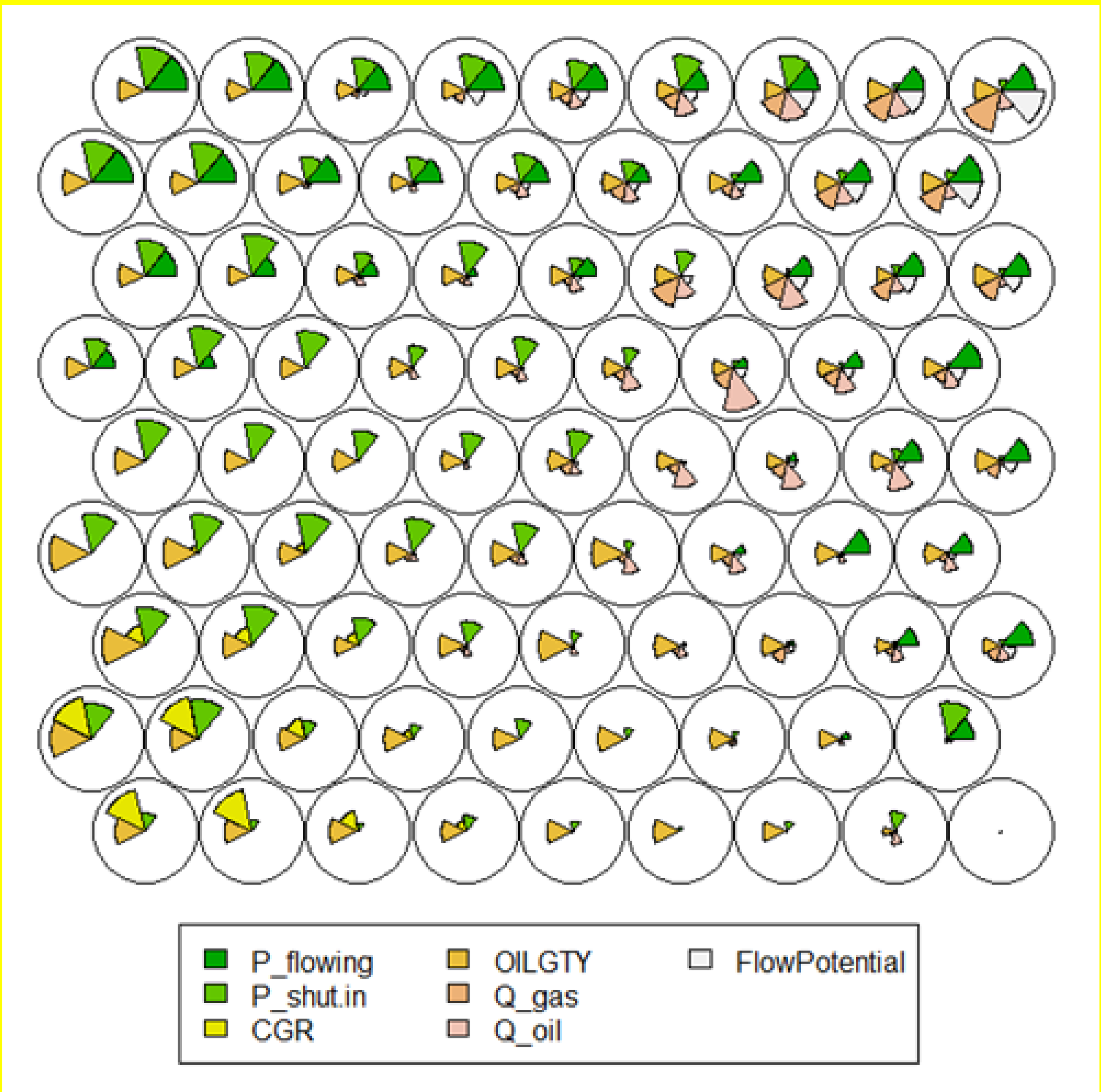
- 3D seismic attributes such as spectral components, coherence, dip-azimuth, RMS amplitude or a combination of all i.e. multi attribute (future inputs)
- Seismic inversion parameters such as Poisson's ratio, closure stress etc. (future inputs)
- Geological parameters such as geological setting, position of wells related to faults or any other discontinuity, abnormal pressure and presence of natural factures

Regression parameters:

- Matrix permeability , reservoir pressure, condensate gas ratio fracture half lengths, porosity, water saturation

Type Curve area classification Methods:

- K means clustering
- Self organizing maps (SOM)
- Neural networks



SOM codes plot to generate type curve/ production areas

A series of attributes (3 D seismic in future) can be inputted into any of the three methods to classify the wells into different type curves. Choice of method should be made on comparative basis and degree of accuracy required.

K - means clustering is easier use and code. In Contrast, neural networks may provide better results but they are difficult to code and require training

Optimization

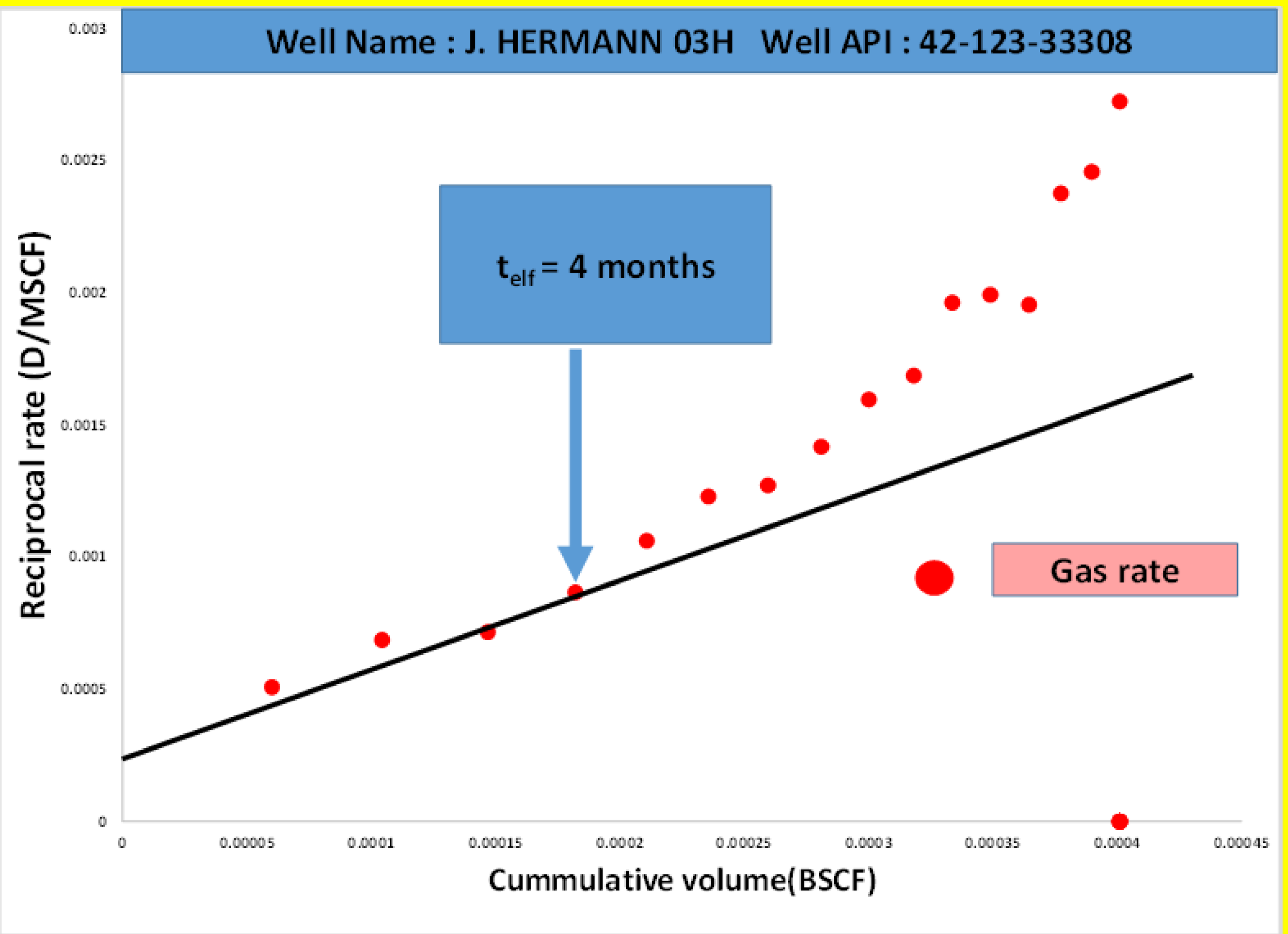
Variable Reduction:

- Principal Component Analysis (PCA)
- Factor Analysis (FA)

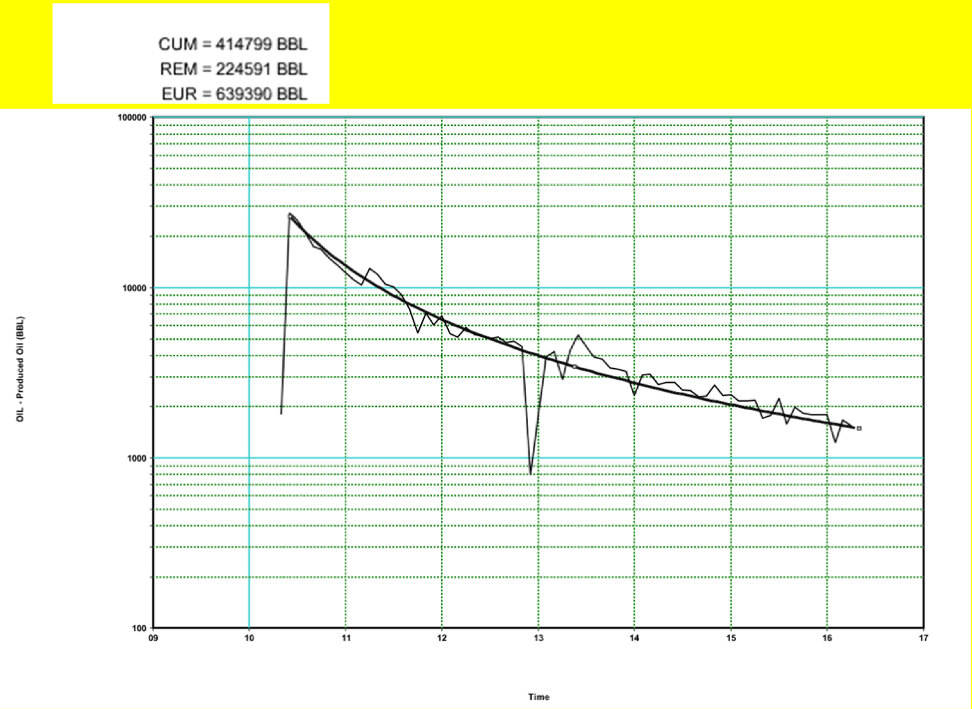
Predictive Modeling:

- Multiple Regression
- Neural Networks

EUR Prediction



Linear flow analysis for flow regime identifications. Wells in boundary dominated flow only can be used for EUR prediction



Prediction of EUR's using modified hyperbolic decline curves

Value :

- Well spacing optimization
- Completion optimization
- Reserves reconciliation
- Acreage prioritization in areas covered by 3D seismic but with limited well control

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