Technical Session Agenda
2016 SPEE Annual Meeting

Tuesday, June 7, 2016          2016 SPEE Technical Session 2          Salon I/II

8:40 AM  Utilizing Advanced Data Analytic Methods for Secondary Recovery Methods  Chad Kronkosky

BIOGRAPHY
Chad E. Kronkosky – CEK Engineering LLC

As President of CEK Engineering LLC (CEK), formed in 2012; Mr. Kronkosky is solely responsible for coordinating and supervising technical personnel of the company in ongoing reservoir evaluation studies conducted by CEK. Prior to forming CEK, Mr. Kronkosky served in various engineering positions with A.C.T. Operating Company and Bold Operating LLC.

Mr. Kronkosky earned a Bachelors and Masters of Science degrees in Petroleum Engineering from Texas Tech University in 2006 and 2009 respectively. He is currently pursuing a Ph.D. in Petroleum Engineering part-time at Texas Tech University with anticipated candidacy in the Fall of 2016. His doctoral dissertation work involves the Application of Data Science to Advance Petroleum Engineering Topics.

Mr. Kronkosky is a Licensed Professional Engineer in the State of Texas, a member of the Society of Petroleum Engineers (SPE), and is an Associate Member of the Society of Petroleum Evaluation Engineers (SPEE) and American Association of Petroleum Geologist (AAPG).
Utilizing Advanced Data Analytic Methods for Secondary Recovery Estimates

Chad E. Kronkosky, P.E.

Doctoral Aspirant
Bob L. Herd Department of Petroleum Engineering

April 29, 2016
Presenter Bio

**Education**

B.S. Petroleum Engineering (TTU 2006)  
M.S. Petroleum Engineering (TTU 2009)  
PhD. Petroleum Engineering (TTU - Anticipated Spring 2017)

**Industry Experience**

**CEK Engineering LLC**, President (2012 - Present)  
Professional Engineering Consulting Firm servicing Large Private Equity Management Teams to Small Independent Oil and Gas Operators. Project experience in Texas, Louisiana, New Mexico, Kansas, Colorado Montana, and North Dakota, but our primary focus is the Permian Basin of West Texas.  
[www.cekengineering.com](http://www.cekengineering.com)

**Bold Operating LLC**, Reservoir Engineer (2010 - 2012)  
Small Private Equity Management Team (EnCap) solely focused in the Permian Basin; Grow By The Bit Company. Gained valuable financial experience; worked with lending institutions, private equity analysts/managers. Prepared the reserve/geological study (complex carbonate) that was instrumental in selling most of the companies assets.

**A.C.T. Operating Company**, Graduate Petroleum Engineer (2006 - 2010)  
Worked under Marshal Watson, Ph.D, P.E., Past SPEE President and Current Chair of the Bob L. Herd Department of Petroleum Engineering. Experience encompassed: Secondary Recovery Project, CBM, Corporate Management, Prospect Development, etc. (almost anything you could imagine, especially for a two man company).

Marshall, thank you for your guidance throughout my career... and for letting me make boneheaded mistakes; on yours and Don’s dime! They’ve been committed to memory!
1. Introduction

2. Data-Driven Predictive Analytics

3. Application of Data Analytics to Historical Secondary Recovery within the State of Texas

4. Example

5. Project Status \ Software Development
Outline

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- Drilling Engineering
- Completion Engineering
- Production Engineering
- Reservoir Engineering
- Formation Evaluation
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53rd Annual SPEE Conference, Lake Tahoe, June 4-9, 2016
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- Petrophysical Well Log interpretation (e.g. rock-type classification; K-means cluster analysis)
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Data-Driven Predictive Analytic approach (DDPA)

Data-Driven Predictive-Analytic Approach

**Data Mining** is the science of extracting valuable knowledge from large databases.

**Data Collection and Database Construction**

**Big Data** requires developing systematic approaches to acquisition and assimilation of relevant information from multiple heterogeneous sources.

**Data Collection** and **Archiving** must remove errors to insure data quality. Despite careful safeguard measures, human data entry and measurement sensors are common sources of data-quality issues.

**Exploratory Analysis**

The **Exploratory Analysis** phase determines the relationships among the variables. Various statistical techniques are utilized to help identify causal variables (process inputs) that are potentially good predictors of response variables of interest.

**Predictive-Modeling Development and Calibration**

A **Predictive Model** is a virtual process that is developed directly from the data created in data preparation and the correlation structures obtained in the exploratory analysis.
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We abstract the DDPA approach (as outlined) and apply it to three research topics involving underground injection within the State of Texas.
What makes this an important topic for the industry?

- Estimation and classification of reserves is predicated on data quality and quantity. Because many aspects of reserve evaluation are based on limited or indirect information, it is important that evaluators compare all reserve parameters from analogous reservoirs.
- Public data vendors provide extremely limited injectivity data sets for the State of Texas.
- EOR dates back to the early 1930’s in Texas... there is a significant gap in digital injection information available.
- Injection information from this gap (50 years) is vital to developing appropriate analogy models (S:P).
Historical Underground Injection within the State of Texas

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What data sets are available (Digital\Hard Copy)?

To the best of our knowledge there are two datasets which provide an accurate underground injection history for the State of Texas. RRC UIC Database & RRC “Bulletin 82”.

- **RRC UIC Database** – (Digital Cobol Hierarchical File)
  IHS is the only major public data vendor which provides injection information. This data set is the backbone of IHS's injection information for the State of Texas.

- **“RRC Bulletin 82”** – (Hard Copy & Partially Digital)
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    - Gary S. Swindell provided us a limited dataset of this information. This information contains cumulative volumes instead of annual volumes.
  - Project Field Summary Information
  - Injection Pattern & Problems Information
What are Secondary to Primary Ratios (S:P)? How are they applied?

S:P is the ratio of secondary oil production to primary oil production.
What are Secondary to Primary Ratios (S:P)? How are they applied?

For this particular project:

\[
\frac{2750 - 1750}{1750} = 0.57
\]
For Fields\Leases which have not undergone an EOR process we can utilize offset analogous S:P ratios to estimate EOR reserves.
Presently, S:P ratio are typically estimated for a few nearby analogous projects and then averaged.

Incorporating geospatial\multivariate statistics; we believe better estimates of S:P ratio can be made to estimate EOR reserves.

Additionally, data science principles support automation techniques which can be applied to petroleum engineering workflows.
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How can Data Science principles be applied to this topic?

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Additionally, data science principles support automation techniques which can be applied to petroleum engineering workflows.
We apply the abstracted DDPA approach to study this particular problem.
Construct MDM (PPDM 3.9) and ETL SQL procedures for the following data sets:
- RRC UIC Database
- RRC Wellbore Database
- RRC “Bulletin 82” Gary S. Swindell data
- IHS production data

Construct various summary\spatial queries
- Cum injection\production by leases\units
- Generate spatial polygons for leases\units
- Generate a spatial filtering queries

Construct various statistical analyses\inference on summary queries
- Generate spatial statistical inference procedures
- Incorporate a predictive model, machine learning algo, to estimate S:P
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Methodology\保证流程

- 构建MDM（PPDM 3.9）和ETL SQL程序，用于以下数据集：
  - RRC UIC数据库
  - RRC井筒数据库
  - RRC“Bulletin 82” Gary S. Swindell数据
  - IHS生产数据
- 构建各种汇总空间查询
  - 累积注水/生产按租赁单位
  - 生成租赁单位的空间多边形
  - 生成空间筛选查询
- 构建各种统计分析
  - 生成空间统计推断程序
  - 集成预测模型，机器学习算法，以估计S:P

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Example Project Workflow – Spatial Analysis

Carbonate Field in the Permian Basin

14 Units \ Leases in Field with EOR
Projects within the Field

Approximately 50 Analogous Units \ Leases within 20 miles of the Field (Same/Similar Reservoir and Depositional Environment)
Example Project Workflow – Spatial Analysis

Incorporate GIS to delineate Units\Leases (not a requirement but helps visualize project bounds).

Data Vendors (IHS, DI, Tobin, etc.) may/may not have this information digitally; can typically be found in scanned regulatory filings with minimal effort.

Spatial distances can be incorporated into the statistical model (i.e. spatial distance weight parameter).
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Example Project Workflow – DCA

**Unit A**
Rate-Time Analysis

**Unit A**
Rate-Cum Analysis
Example Project Workflow – DCA

Chad E. Kronkosky, P.E.
53rd Annual SPEE Conference, Lake Tahoe, June 4-9, 2016
Example Project Workflow – DCA

Unit B
Rate-Time Analysis

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Rate-Cum Analysis

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A Multivariate Statistical Analysis is performed, based on Spatial DCA RRC Bulletin 82 Parameters, to generate S:P confidence intervals (P90, P50, P10).

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<th>Unit</th>
<th>Lease ID</th>
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<th>Spacing</th>
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Example Project Workflow – Statistical Analysis

A Multivariate Statistical Analysis is performed, based on Spatial\DCA\RRC Bulletin 82 Parameters, to generate S:P confidence intervals (P90, P50, P10).
We have been working over the last year to develop ETL procedures to load several GB’s of information for several data sets (4 file types with several hundred fields)... the ETL procedures are \( \sim 90\% \) complete.

- Scanned all RRC “Bulletin 82” volumes... plan to release to Texas State Library and Archive for preservation.
- In the process of writing SQL queries and “R” statistical/visualization scripts; semi-automated at this point.
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Questions?

I appreciate everyones time this morning; and special thanks to Mr. Floyd Siegle for allowing me the opportunity to speak with you.