[PS]An Oil-Source Rock Correlation Examining the Potential of the Chattanooga Shale as a Source Rock for Oil within the Spivey-Grabs-Basil Field, Kingman and Harper Counties, Kansas*

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Abstract

The Spivey-Grabs-Basil oil field, located in south-central Kansas, is one of the most productive fields in the state. Compartmentalization in this relatively small geographic area provides an opportunity for experimentation in a more controlled setting than other areas of the mid-continent, and is the reason why this field was chosen for an oil source rock correlation. This research is formatted to attempt to begin to answer the question: is the oil in Kansas being locally sourced, or is it migrating north from the Anadarko Basin?

An oil source rock correlation is loosely defined as a study that can offer either a positive or negative correlation between oils and potential source rocks using organic biomarkers. While traditional methods are being used in this research, additional methods using inorganic biomarkers are being attempted as well in an attempt to extend and verify the pre-established methods. This research compares source rock results to oil analysis previously completed by Evans et al, 2011. Methods used for source rock analysis include Gas Chromatography and Mass Spectrometry (GCMS), and Pyrolysis.

AN OIL-SOURCE ROCK CORRELATION EXAMINING THE POTENTIAL OF THE CHATTANOOGA SHALE AS A SOURCE ROCK FOR OIL WITHIN THE SPIVEY-GRABS-BASIL FIELD, KINGMAN AND HARPER COUNTIES, KANSAS

Meagan Wall; Matthew Totten; Sambhudas Chaudhuri; Drew Evans; Brianna Kwasny; Brian Jarvie; Additional contributors: R. Paul Philp and University of Oklahoma; GeoMark Research, TX

ABSTRACT

The Spivey-Grabs-Basil oil field, located in south-central Kansas, is one of the most productive fields in the state. Compartmentalization in this relatively small geographic area provides an opportunity for experimentation in a more controlled setting than other areas of the mid-continent, and is the reason why this field was chosen for an oil source rock correlation. This research is formatted to attempt to begin to answer the question: is the oil in Kansas being locally sourced, or is it migrating north from the Anadarko Basin (as shown in Figure 1)?

An oil source rock correlation is loosely defined as a study that can offer either a positive or negative correlation between oils and potential source rocks using organic biomarkers. While traditional methods are being used in this research, additional methods using inorganic biomarkers are being attempted as well in an attempt to extend and verify the pre-established methods. This research compares source rock results to oil analysis previously completed by Evans et al, 2011. Methods used for source rock analysis include Gas Chromatography and Mass Spectrometry (GCMS), and Pyrolysis.

METHODS

TOC → GCMS

TOC was completed on individual samples to test their viability as a possible source rock.

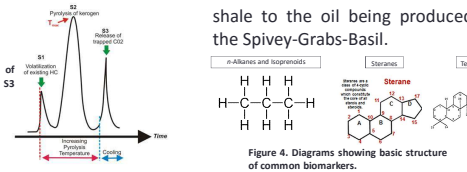


Figure 3. Example of Pyrolysis S1, S2, and S3 curves.

GCMS was run, once viability was ascertained, to compare the biomarkers from the Chattanooga shale to the oil being produced in the Spivey-Grabs-Basil.

Figure 4. Diagrams showing basic structure of common biomarkers.

SAMPLE SELECTION

1. The KGS website was used to search our well-logs that penetrated the Chattanooga shale.
2. Gamma-ray logs were used to correlate appropriate depths with well-cuttings, as well as to verify profile similarity to the Woodford shale in the Anadarko Basin.
3. Cuttings were picked up from the KGS library in Wichita, KS, and shale selected from cuttings and crushed for TOC and GCMS testing.

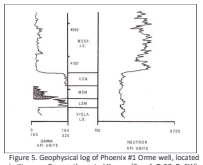


Figure 5. Geophysical log of Phoenix #1 Orme well, located in Kingman Co., south-central Kansas (Sec. 4, T. 28, R. 6W). Depth below surface (ft.) is shown in the central column. Three shale members of the Chattanooga Shale are shown. LSM=lower shale member, MSM=middle shale member, and USM=upper shale member (Lambert et al., 1994).

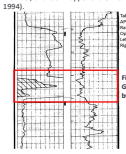


Figure 6. Wire-line Gamma-ray log, provided by KGS.

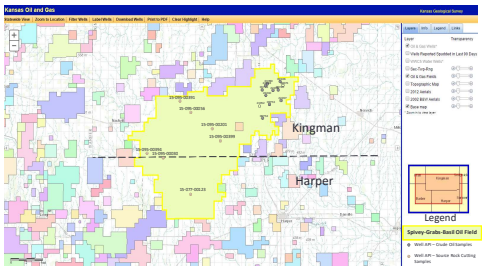


Figure 7. This map, modified from the KGS website, shows the wells from which the source rock cutting samples were extracted. ~20 wells in the Spivey-Grabs-Basil actually penetrated the Chattanooga, and of those, I found 7 with enough sample for all of the tests necessary for an oil-source rock correlation.

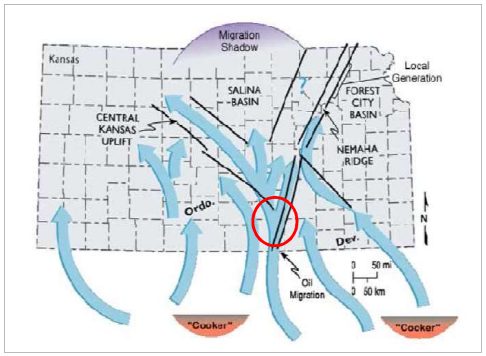


Figure 1. Location of Spivey-Grabs-Basil field circled in red. Map showing potential oil migration from the Anadarko Basin. (Modified from Gerhard, 2004.)

Considering the arguments in favor of the oil migrating from the Anadarko Basin in Oklahoma, as well as counter-arguments that compartmentalization of the region would not allow for such migration and mixing to take place, the question this research has been formatted to address is: **can we ascertain whether the oil in the Spivey-Grabs field came from a local source rock, or was the oil externally sourced?**

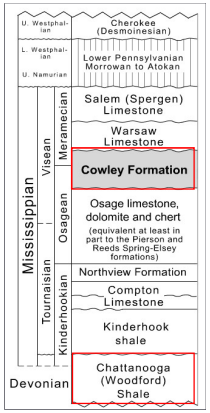
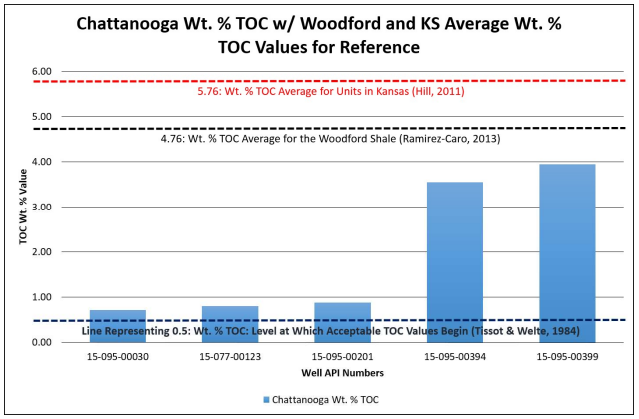


Figure 2. Stratigraphic column depicting southern Kansas and northern Oklahoma geological units (Mazzullo et al., 2009).

REGIONAL TOC COMPARISON

A comparison of multiple TOC studies, against rock cuttings found in the Spivey-Grabs-Basil, have been combined in chart form and indicate that the TOC values in this field are well within reasonable parameters to further examine the underlying Chattanooga shale for source rock potential.



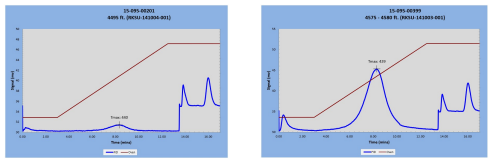


Figure 8. Chart created to show comparative percentages of TOC from surrounding locales such as the Woodford shale in Payne Co., OK and various formations across the state of Kansas. All samples were above the accepted level of TOC values that indicate potential for production (Tissot & Welte, 1984). Below are examples of pyrograms supplied by GeoMark that illustrate the S2 curves as they correlate to %TOC.

BIOMARKER RESULTS & CORRELATION

Steranes:

- %Concentration is commonly used in local source correlations.
- Between 27 and 30 carbon atoms (base unit).
- Sourced by eukaryotic organisms.
- Spatial alignment changes within structures are indicative of maturity.

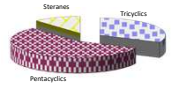


Figure 9. This is a pie chart from GeoMark outlining the concentration of biomarkers in the Chattanooga.

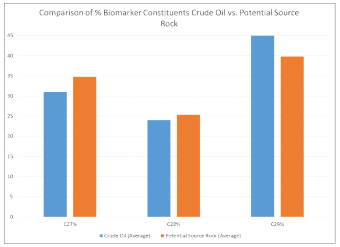


Figure 10. Chart showing correlation of steranes between the crude oil and the Chattanooga shale in the Spivey-Grabs-Basil.

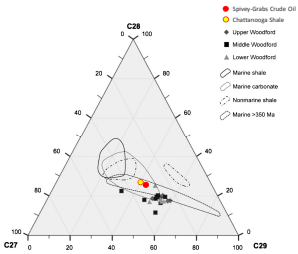


Figure 11. Ternary diagram of C_{27}, C_{28}, and C_{29} steranes Woodford Shale samples, with Spivey-Grabs-Basil field data added (Woodford values by Philp, 2012, and plot template from Moldowan et al., 1985).

Terpanes:

- Like steranes but more variable in ring structures.
- Structurally altered during catagenesis and diagenesis, but overall resistant to additional change—a decent biomarker.
- Substructural groups:
  - **Pentacyclic terpanes** (most common)
  - **Hopanes**: derived from prokaryotic organisms, are pentacyclic triterpenoids and are dominated by stereoisomers.
  - Tricyclic terpanes (most complicated)

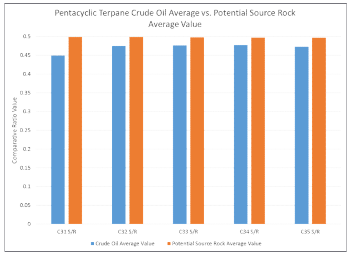


Figure 12. Chart showing correlation of tricyclic terpanes between the crude oil and the Chattanooga shale in the Spivey-Grabs-Basil.

CONCLUSIONS & RECOMMENDATIONS

- The biomarker comparisons are conclusive that most, if not all of the oil in the Spivey-Grabs-Basil is genetically the same or very similar to the Chattanooga shale which underlies it.
- The combined results from this study, and others like it, show no reason why Kansas would not be capable of generating its own oil based on the organic potential of source rocks.
- ***In order to further substantiate the results found here, I recommend***:
  - A biomarker study comparing the Woodford shale to the Chattanooga preferably in north-central Oklahoma near the Spivey-Grabs, and then increasingly further away.
  - Additional oil-source rock correlations within the state of Kansas, particularly in units with higher TOC values. Units with core sample would prove to be more exact.
  - Oil to oil correlations across Kansas, especially in fields with compartmentalization. An investigation in biomarkers and biomarker maturity might prove surprising, as they did in Evans (2011).
  - The potential of the Chattanooga shale as an unconventional resource should be explored.

GeoMark

The University of Oklahoma