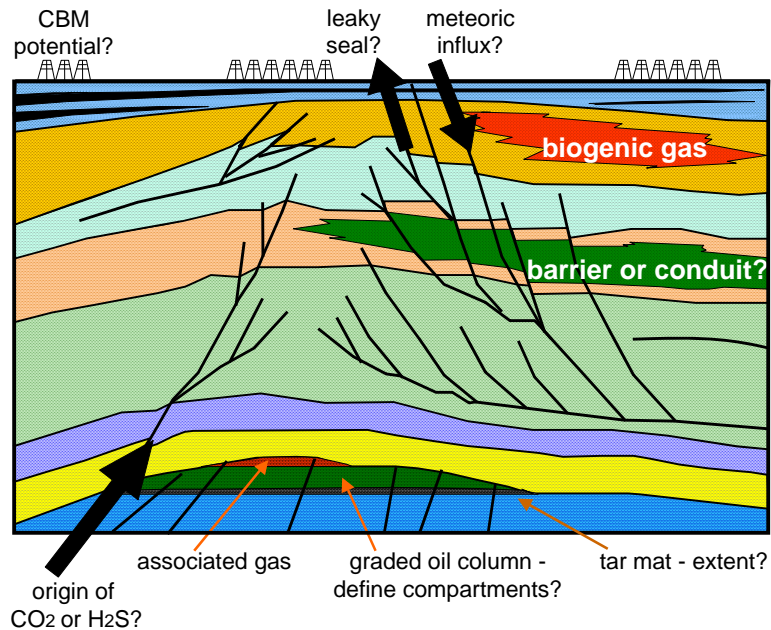




Petroleum Systems International, Inc.
interpretive and analytical services



Prospectus for Reservoir Geochemistry

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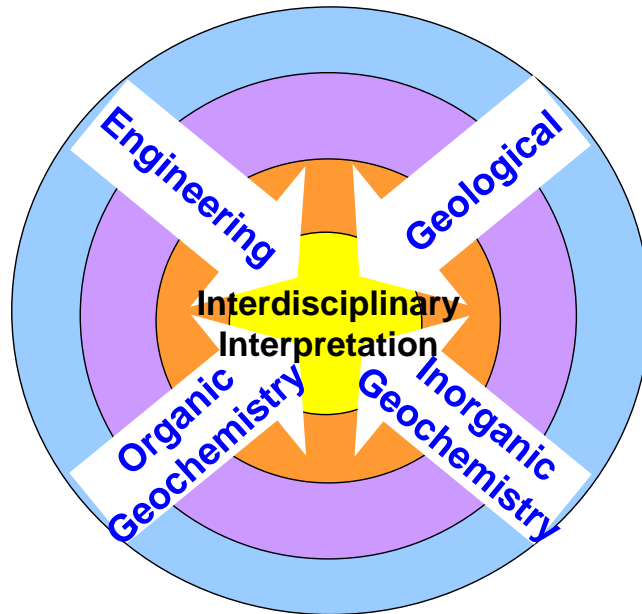
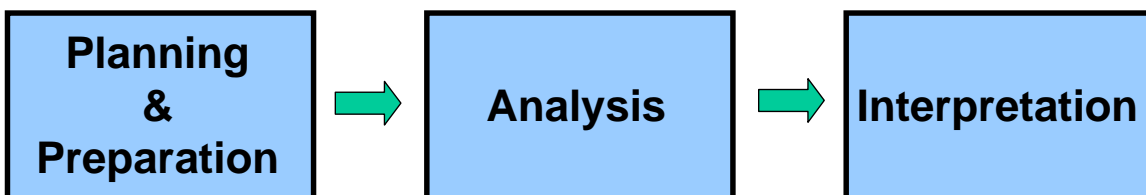


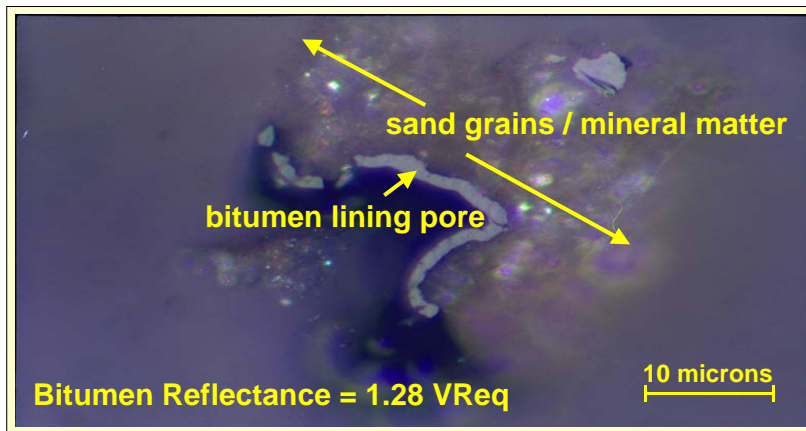
Illustration of interdisciplinary relationships between project team members. Each concentric circle represents increasing sophistication of technologies used by each team member.

Reservoir-Scale Geochemistry

PSI conducts studies of reservoir-scale geochemistry on a global basis, and advocates using this technology with related disciplines. The discipline is conveniently divided into three primary topics - exploration, appraisal, and production - which depend on the client-defined objectives. Our projects commonly impact the needs of multiple work groups (engineering or geological), and can address goals at different spatial scales. Reservoir geochemistry can address kilometer-scale questions of faults acting as barriers vs. conduits, meter-scale problems of assessing the interconnectivity of individual sand lobes in a deltaic sequence, or micron-scale issues concerning the impact of solid reservoir bitumen to the economic reserve analysis. We combine off-the-shelf technology with expertise in developing *creative solutions* to provide products that reduce drilling and development expenditures, increase hydrocarbon recovery efficiency, and increase confidence in the decision-making process. We emphasize attention to detail, multi-dimensional visualization, mass balance, and rapid communication of results.



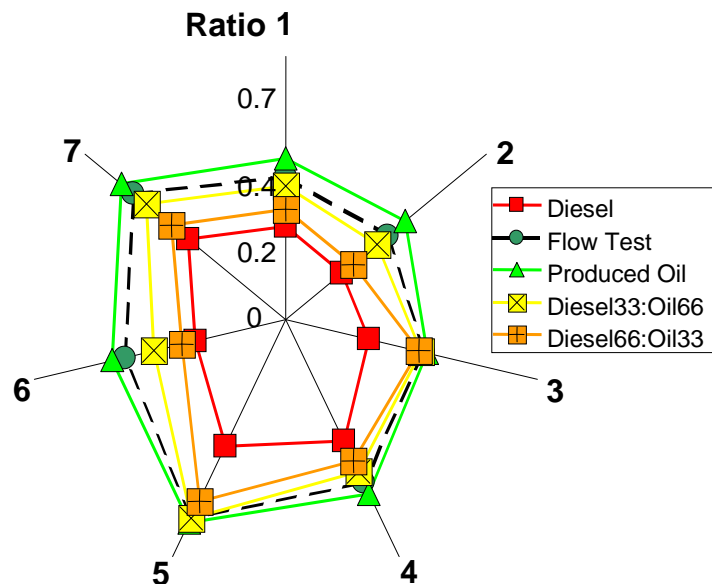
Systematic methodologies apply to each step in the work flow process



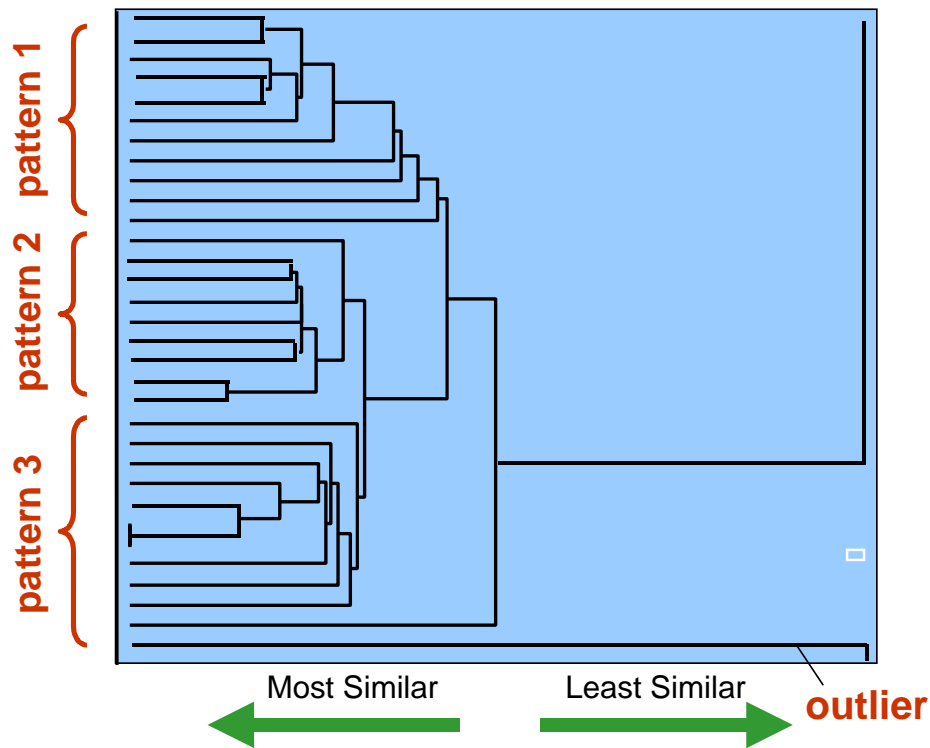
Distribution of solid reservoir bitumen (viewed in reflected white light) can be critical to resource evaluations.

Exploration Impact

The exploration impact from a reservoir-scale geochemistry project can be enormous, and these studies illustrate that a single project can benefit multiple work groups. Examples of topics include identification of the respective source rock, determining hydrocarbon generation temperatures, identifying alternative sources of gas vs. oil, definition of fill direction, migration pathways, seal efficiency, and identifying associated risks such as biodegradation. Whenever possible, we advocate the use of existing data and technology to make the *initial* assessments as this allows us to *increase the value of preexisting data*, and optimize input for tool selection in the new analytical programs. The existing data often provides critical details from samples that may no longer be available for analysis.



Quantification of pay zone vs. oil-based mud signals with axes defined by chemometric data processing.



Hierarchical cluster analysis to identify compositional variation related to reservoir compartments.

Appraisal Efforts

Appraisal projects define critical issues of hydrocarbon quality and quantity. The focus may be issues of associated non-hydrocarbons, predicting down-dip oil, or even communication across faults. Newly developed mud gas logging systems provide a powerful tool for many of these applications. There are also a number of new tools (e.g., FastGC, TEGC, etc.) available at the laboratory, that may also be deployed at the well site. Important traits of *new generation geochemical methods* are minimal sample preparation, rapid communication of results, and high value / impact. Advancements are also made in the interpretation techniques as new data provide novel insights and can be used to redefine the prevailing paradigms. The results of our studies provide critical input to testing decisions and resolve uncertainty in formation evaluation.

Production Solutions

A number of problems encountered in routine production can be mitigated with a geochemical approach. *Proper diagnosis is a key step* in the problem-solving workflow. Wax/paraffin and asphaltene (e.g. sludge) are routinely addressed, but other problems include adamantanes, emulsions, and hydrates. When proper diagnosis is combined with physical factors that promote the problem, adjustments in the facilities can often be made that lead to an increase in operation efficiency.

Technical Capabilities:

1. *Reservoir Compartment Delineation*
- oil, condensate, and gas systems
2. *Non-hydrocarbon Gas Origin and Risk*
- hydrogen sulfide, carbon dioxide, nitrogen
3. *Reservoir Compartment Fingerprinting*
- comingled pay allocation, surveillance
4. *Flow Assurance Assistance*
- waxes, asphaltenes, sludge, adamantanes
5. *Statistical Methods - Chemometrics*
- principal component, hierarchical cluster analyses
6. *Solid Reservoir Bitumen Characterization*
- define origin, extent, timing of emplacement
7. *Fluid Property - Quality Prediction*
- API gravity, viscosity, sulfur, mass balance
8. *Well Site and Operations Service*
- mudgas logging, development well placement
9. *Pay Zone Assessment*
- water-, synthetic-, and oil-based mud systems
10. *Shale, Gas, Shale Oil, and Coal Bed Methane*
- resource potential, thermogenic vs. biogenic
11. *Optimization of Well Test Budgets*
- completion and testing strategies
12. *Complete Water Analysis*
- compositional and isotopic, age-dating
13. *Compilation / Integration of Databases*
- increase value of public or proprietary data
14. *Global Database of Reference Oils & Source Rocks*

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About Us:

David A. Wavrek, Ph.D.

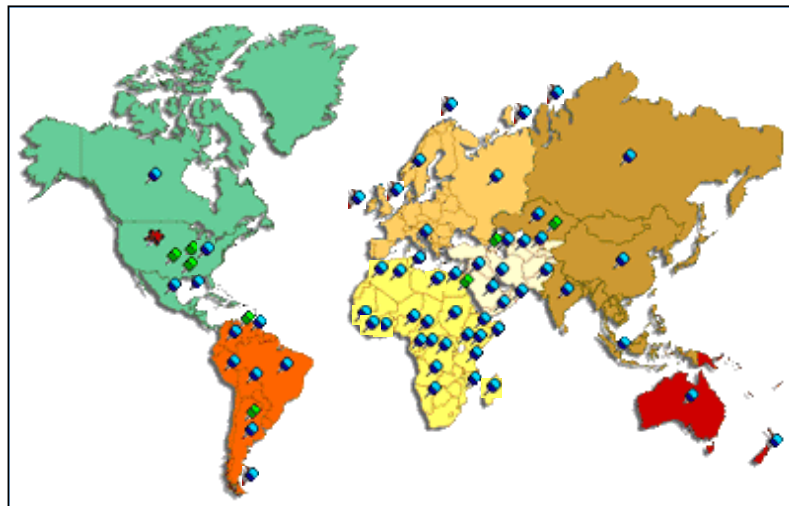
David Wavrek received his Ph.D. from the University of Tulsa in 1992, where he developed geochemical technologies that refine the quantitative aspects of petroleum systems analysis. Since the mid-80's, he has been conducting geochemical and petroleum systems analysis throughout the world (30+ countries) for clients that span mega-majors to independents. He has served as a Continuing Education instructor for the AAPG (2000-2007) in the disciplines of petroleum systems and reservoir geochemistry. He is currently president of *Petroleum Systems International, Inc.* – an oil field services company that develops and applies timely solutions to energy company problems by integrating disciplines of geochemistry, geology, and engineering.

Strategic Affiliates

The strategic affiliates of PSI represent a group of premier service providers in key international markets that work cooperatively as an integrated project team. Their global presence provides PSI clients with a competitive advantage of working with an organization that combines global experience, the latest technologies, and local knowledge. The affiliate companies provide expertise in all geologic disciplines, biostratigraphy, petrophysics, geophysics, and operations.

More Information

Additional details about the PSI project team are available at www.petroleumsystems.com. This includes a graphic display of our global expertise to the basin-scale, prospectus for various non-exclusive spec studies, and a summary of our professional activities in the form of down-loadable abstracts and papers.



Geographic summary of our global experience base ◆ , strategic affiliates ◆ , and headquarters ★

Summary of global experience in petroleum systems and reservoir
geochemistry projects