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A just-published book co-edited by Schlumberger Scientific Advisor Oliver Mullins promotes a new paradigm in reservoir understanding.

Asphaltenes, Heavy Oils, and Petroleomics, co-edited by Oliver Mullins, Schlumberger Wireline reservoir domain champion and scientific advisor based in Houston; Eric Y. Sheu, Science Advisor, Lawrence Livermore Laboratory, California; Ahmed Hammami, Schlumberger New Venture Director, Advanced Technology Centre, Edmonton; and Alan G. Marshall, professor of Chemistry, Florida State University, is being published this month by Springer.

In this interview, Mullins explains how he and his partners envision using the "petroleome" of crude oil to address reservoir issues.

Q: What is the meaning of "petroleomics"?
A: Petroleomics is a new field my co-editors and I are launching through this publication. "To understand function, study structure," said Francis Crick, Nobel Prize winner for revealing the chemical structure of DNA, a discovery that led to genomics. We envision petroleomics being to petroleum science what genomics is to medical science. In short, medicine traditionally treats patients based on symptoms, and the vision of genomics is to predict and treat medical concerns even before symptoms appear. Petroleum science has, similarly, been phenomenological. Establishing structure-function relationships has been precluded in petroleum science because nobody knew the petroleum chemical structure.

This is all about to change. Petroleomics promises the ability to predict petroleum properties by elucidating the chemistry of all constituents in a crude oil. In addition, in this book, we show how Downhole Fluid Analysis (DFA), a new Schlumberger product line, exploits petroleum chemistry to understand reservoir architecture.

Q: What constitutes a petroleome?
A: The petroleome is the complete listing of all chemical constituents in a crude oil, the "genome" you might say of a crude oil. There has been no debate about the significance of understanding light end chemistry. Does my oil have H_2S or CO_2? These are chemical questions of great concern. However, for heavy ends, there has been no consensus as to what the chemistry is.

In this book, we demonstrate that the chemistry of heavy ends is now largely resolved, a major accomplishment. Furthermore, we show the evolution of the petroleome — which consists of approximately 40,000 chemical constituents. Achieving the petroleome is now feasible with the advent of the ultra-high-resolution mass spectroscopy co-invented by one of my co-editors, Professor Alan Marshall, also utilizing Electro-Spray ionization (ESI), invented by John Fenn, for which he won the Nobel Prize in 2002.

Q: Is there a "Global Petroleome Project", similar to the Human Genome Project?
A: Excellent question. At this stage, there are many players on the sidelines. When we first launched petroleomics, many scoffed at the idea. Heavy end analysis had been considered intractable. Our laboratory has shown that heavy ends are not as complicated as first thought. These results are being confirmed in laboratories around the world and are documented in our book. Now, petroleomics is being taken much more seriously.

Nevertheless, there is one more major development needed. By far the biggest problems in the upstream oil business have to do with the reservoir. What is the reservoir architecture? What will be produced by sweeping extended transition zones in giant fields? But the petroleum chemistry community has been focused on flow assurance — admittedly a significant problem, but one which pales in comparison to reservoir issues. We are linking state-of-the-art chemical developments with the reservoir through Downhole Fluid Analysis (DFA). Once we show the application of advanced chemistry to reservoir concerns, operating companies will adapt in reasonable time. For example, a senior reservoir engineer with a major operator recently stated that use of DFA for reservoir fluid mapping should be as common as gamma ray logging for stratigraphy (which is done in every well). When advances in science and technology contribute to solving the industry's biggest problems, acceptance is rapid.

Q: So much is already known about the chemical structure of oil and about its behavior… How would petroleomics change how we address reservoir issues?
A: The key is to link petroleomics with the reservoir through DFA. For example, we recently showed in one reservoir that 1) we have an asphaltene gravitational gradient, 2) the asphaltenes are present in the crude oil as nanoaggregates, 3) in contradiction to a 70-year-old presumption in petroleum science, resins are NOT associated with this colloidal asphaltene, and 4) new wells drilled into the field's large reservoirs must exhibit the same gradient. None of this was known in the literature prior to this reservoir study. In fact, the existence of asphaltene nanoaggregates in a model system was first established in our laboratory in 2005. Now a reservoir study has elucidated for the first time the colloidal characteristics of asphaltene in a crude oil. Item four in the above list addresses the biggest unknown in this multibillion-dollar development — reservoir connectivity.

Q: Your area of expertise is asphaltenes. How does this further the literature on that subject?
A: I have been fortunate to have expert students in my laboratory as well as collaborators in universities, national laboratories, and operating companies around the world. The most cited work from my laboratory resolved that the molecular weight of asphaltenes is quite small. Putatively leading universities were in error on this issue by up to a factor of one million. In addition, we were the first to show that asphaltenes form nanoaggregate colloids. We showed 10 years of literature was incorrect by a factor of 10. And we recently established that the 70-year-old paradigm of resin-asphaltene association is incorrect. When this book is circulated, I believe we will look like the Seattle Space Needle in a lightning storm — we will spark controversy here.

Q: Explain further the significance of Downhole Fluid Analysis in petroleomics.
A: It is the link between our knowledge of alphaltenes and DFA that will allow petroleomics to blossom. Breakthrough scientific developments are best linked with breakthrough technology to foment real change. DFA is a rapidly growing technology, yet is only provided by Schlumberger. DFA is impacting the reservoir which is where most of the uncertainty lies. For example, a reservoir can be like a kitchen sponge where all voids are connected, or like a spool of bubble wrap, where cells are not connected. Seismics cannot tell the difference. Near well bore measurements do not reveal the difference. Pressure communication can be established on geologic time so does not prove flow communication. New solutions are needed.

DFA has found compartments by finding fluid density inversions, that is, higher density fluids higher in the column. DFA has identified surprises in reservoir structure which are then sorted out by running more DFA measurements. Decisions impacted can exceed $10 billion in investment. This gets everybody's attention.

Any DFA discovery regarding reservoir fluids must be placed in the context of petroleum science. Are the DFA interpretations consistent with the foundations of petroleum science? This will be an evolving process. As our vision penetrates the veiled mysteries of petroleum, new questions will emerge. As long as DFA embeds these questions in the reservoir, the pressure to find solutions will be immense.

Q: Who are your key audiences for this book?
A: We have tried to provide a vision of how understanding petroleum science paves the way to optimal resource utilization in all spheres, including producing hydrocarbons, upgrading hydrocarbons, transporting hydrocarbons, and manipulating hydrocarbon feedstocks. This covers many trillions of dollars per annum. In addition, chapter 1 is written for the layperson. We try to explain the importance of the science and technology of petroleum within the context of understanding other material properties. For example, we compare petroleum science with the science of understanding another liquid of interest on earth — water!

Q: What ultimately is your message to the scientific community? To the oil and gas industry?
A: Scientists love to reveal truths of nature; this is our passion and our challenge. Science is expensive and mandates significant societal resources. As such, we must solve big problems — and this often requires that we broaden our scope beyond comfort to address the seemingly unknowable.

Petroleomics is a vision whose time has come. The foundations of asphaltene molecular structure are established; the hierarchy of petroleum colloidal structure is being revealed. We are now emboldened to address enormous problems, in particular via DFA. Petroleum science is now ready to join the pantheon of other scientific disciplines which abide by Francis Crick's axiom, "to understand function, study structure."

The oil and gas industry has a reputation — in my view, undeserved — for being slow and conservative. In fact, the oil and gas industry rapidly tests and utilizes new technology. Nevertheless, to exploit optimally the latest developments, we need a partnership of visionaries in both operating and service companies to focus on overall production objectives. We cannot be impeded by archaic adversarial relationships. In this way, we all benefit from new science and technology.

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