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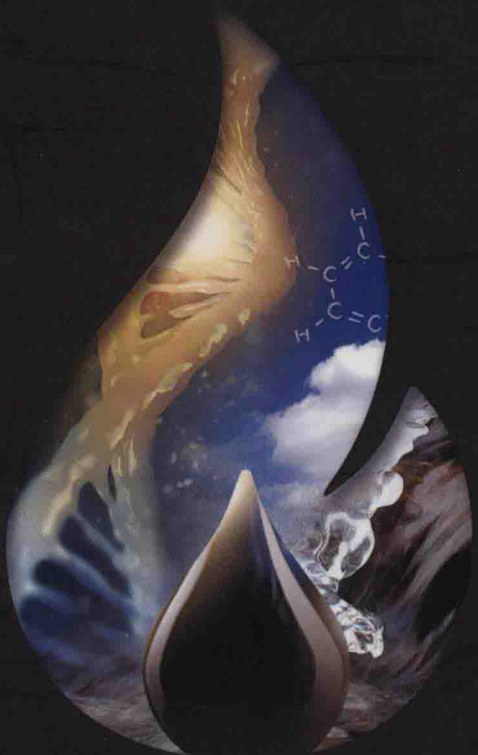
SUSTAINABLE SHALE OIL AND GAS

Analytical Chemistry, Geochemistry, and Biochemistry Methods

VIKRAM RAO
ROB KNIGHT



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DEDICATION

To *Campastimes*, the Indian Institute of Technology Madras magazine, sadly now defunct, where I cut my baby teeth in writing 54 years ago.

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FOREWORD

The ability of the United States to utilize domestic unconventional oil and gas is the energy issue of the day. Cheap energy from these sources is driving manufacturing growth in the country and suppressing fuel costs throughout the economy, the utility sector is moving rapidly from coal generation to natural gas, and the carbon dioxide emissions from the utility sector have dropped to their lowest since the 1990s. A fierce debate, however, has arisen over whether this transition is a net good for the environment. In particular, many question whether the climate, air, and water impacts from acquiring oil and gas through unconventional processes overshadow any benefits from the use of a cleaner fuel.

The ferocity of this political debate has clearly outpaced policymakers' understanding of the problem, as well as the assessment of the potential solutions. Also, the speed of technological development continues to accelerate past the government's knowledge of how to monitor and assess the problem. We thus are left with a policy challenge laced with emotion but lacking the information needed to make wise policy.

Wise environmental policy cannot be constructed under this circumstance. To properly evaluate and weigh the options, policymakers need clear-eyed assessments of both the scale of the issue and the potential solutions to the risks.

In this book, Rao and Knight succinctly summarize the state of knowledge on the management of the environmental risks of accessing shale oil and gas. By standing on shoulders of the investments of entities such as the US Department of Energy and the Environmental Defense Fund, and also the research of many experts in the academy (including many of my colleagues at Duke University), the authors seek to create a library of knowledge that should be the "raw material" for wise policy. They also explore new measurement technologies by which we might inform regulation.

Energy is the lifeblood of the economy—and natural gas is a game changer in that it may provide that blood to our economy for years to come. Unconventional natural gas, on the other hand, could prove to be too environmentally challenging to make it a longer term solution to our energy needs. Which future we pursue, in the end, will depend on the issues explored in this book.

Tim Profeta

PREFACE

The last sentence of this book reads, "That which cannot be measured, cannot be regulated or otherwise controlled or exploited." This embodies the essential motivation for the book. To put that in perspective, I quote the last lines from a previous book of mine:

> *Low-cost energy is a tide that lifts all boats of economic growth. Shale gas is a powerful such tide. It has burst upon us so unexpectedly that we have become rattled by the flotsam it carried with it. This author concludes that the flotsam is manageable, allowing us to enjoy the benefits of the tide.*

By flotsam, I meant the environmental baggage. Although I still subscribe to this conclusion, I have increasingly come to believe that current measurement techniques are inadequate for the special circumstances surrounding this resource, which now importantly includes oil, in addition to the gas mentioned in the quote.

When I was approached about a book in this space, I viewed it as an opportunity to draw attention to the deficit in available measurement capability and do something to address it. I was in the enviable position of advising two exciting developments that were right on point. One is a shoebox-size mass spectrometer with the resolution of a laboratory machine, thus enabling detection and speciation of all manner of molecules, not the least of which are volatile organic chemicals (VOCs). VOCs are not currently regulated at well site perimeters. In fact, only recently, in 2016, has there been promulgation of benzene regulation on refinery perimeters. The portable mass spectrometer could well be a case of better measurement emboldening legislation, as well as voluntary compliance.

The second development is the use of subsurface DNA sequencing to characterize oil and gas reservoirs through studies of microbial populations. This is expected to improve recovery economics, thus addressing another leg of the sustainability stool. My co-author, Rob Knight, a world authority on microbiomes in humans and developer of many of the key data analytical techniques, was vital for doing justice to that part of the book.

Fugitive methane emissions from oil and gas operations are being scrutinized, and the issue is somewhat controversial. The Environmental Defense Fund has taken a lead in funding the quantification of the problem. It and the US Advanced Research Projects Agency–Energy (ARPA-E) of the US Department of Energy have funded innovation to improve detection methods. Both the quantification and the developments are described in some detail.

In the face of a future with low oil prices, sustainability importantly includes measures to drive down the cost per barrel produced. Although the price to play certainly includes environmental compliance, resiliency to severe drops in the world price is required. The analytical methods in support of improving recovery economics comprise an interesting blend of chemistry, geochemistry, and biochemistry. Nevertheless, there is no suggestion of a comprehensive recipe for success. This is merely an attempt to fill the toolbox of the folks looking to address this objective.

The entire book has a solutions flavor, in the belief that regulations are more likely to be adhered to if cost-effective alternatives exist. Voluntary compliance will also be encouraged. Process means to monetize the gas that would otherwise be flared is an example of a solution that is not a simple substitution of better performing equipment. In general, the book is intended to be technical but approachable.

Vikram Rao

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Many contributed with references, reviews of the text, and other manner of support. Those with significant contributions are identified by chapter here. All comments that follow are those of the lead author (VR).

Jason Amsden (Duke University) provided much insight and material, including figures, for Chapter 4, Particulate Matter and Volatile Organic Chemicals. David Vinson (University of North Carolina at Charlotte) conducted an exhaustive and informative review of early drafts of Chapters 5, Methane in Groundwater, and 6, Potential for Liquid Contamination of Groundwater, keeping me honest on the geochemistry. Joel Walls (Ingrain Inc.) made valuable contributions to the text, and provided many of the figures, for Chapter 7, Illuminating the Reservoir. Luke Ursell and Nicole Scott (Biota Technology) were very influential with regard to Chapter 9, Subsurface DNA Sequencing: A New Tool for Reservoir Characterization. Jonathan Thornburg, Dorota Temple, and Brian Stoner (all RTI International) provided key insights for Chapters 3, Detection of Methane and Amelioration, and 4, Particulate Matter and Volatile Organic Chemicals.

Gerald T. Pollard (Howard Associates, LLC) patiently edited the copy; his lasting contribution was my introduction to Strunk and White, no doubt a feeble attempt at reducing the load of future copy editors. Dayle Johnson (RTI International) endured artistic suggestions from the engineer author and outdid himself with a brilliant cover design.

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