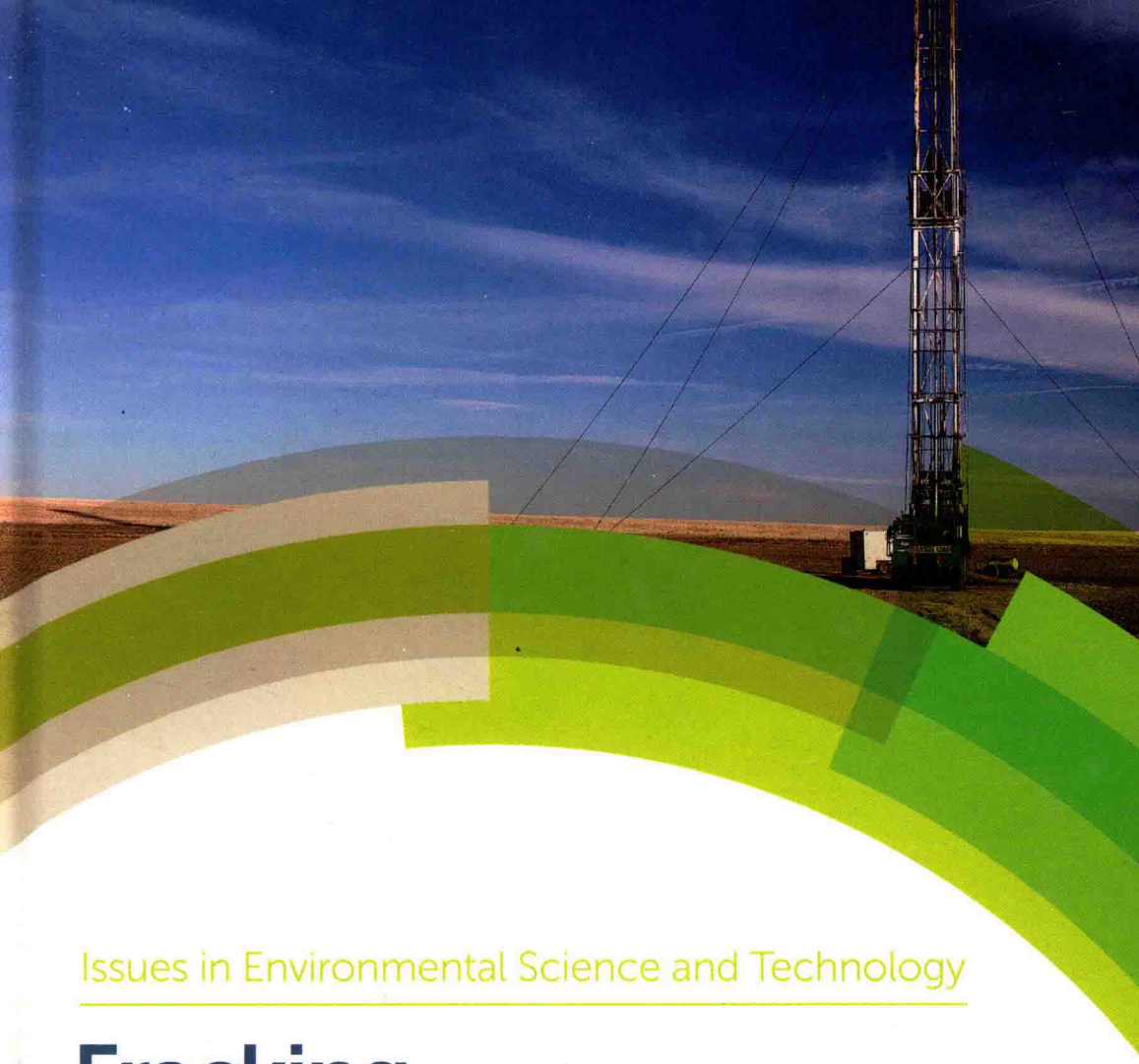

Issues in Environmental Science and Technology

Fracking

Volume 39

Edited by R E Hester and R M Harrison

ROYAL SOCIETY OF CHEMISTRY

ISSUES IN ENVIRONMENTAL SCIENCE AND TECHNOLOGY

EDITORS: R.E. HESTER AND R.M. HARRISON

39
Fracking

Issues in Environmental Science and Technology No. 39

Print ISBN: 978-1-84973-920-7
PDF eISBN: 978-1-78262-055-6
ISSN: 1350-7583

A catalogue record for this book is available from the British Library

Published by The Royal Society of Chemistry,
Thomas Graham House, Science Park, Milton Road,
Cambridge CB4 0WF, UK

Registered Charity Number 207890

For further information see our web site at www.rsc.org

Printed and bound by CPI Group (UK) Ltd, Croydon, CR0 4YY

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Preface

The depletion of reserves of conventional natural gas has led to the development of a new technology involving deep horizontal drilling and the injection of high pressure water containing various chemicals and sand in order to release unconventional gas from underground shale deposits. Hydraulic fracturing of shales to release the trapped gas has become known as 'fracking'. The technology has been developed in the USA in recent years where it has been applied on a commercial scale and is credited with many benefits, including lowered energy costs and increased national security associated with reduced dependence on imports of oil and gas. However, this development has not been without controversy. Contamination of water supplies, causing minor earthquakes and contributing to climate change are among the accusations leveled at the fracking industry.

The positive aspects of fracking in the USA have led to its take-up elsewhere in the world, notably in Europe, Australia and China. The negatives, however, also are vigorously debated and have been judged unacceptable by some countries. The UK government has given its strong support but there is a powerful environmental movement opposing the development and a growing list of countries that have effectively banned fracking, including France and Germany. The reasons underlying the controversy are explored in detail in this book, with contributions from all sides of the argument and with an international and expert authorship.

The book opens with an introduction and overview of the shale gas development written by Peter Hardy of the UK Institution of Gas Engineers and Managers. The geological requirements and the technology of deep horizontal drilling are described in considerable detail, as are the additives used in the water: chemicals to modify pH, surface tension and viscosity, for example, and sand to prop open the fissures in the shale rock caused by injection of fluid at high pressure. Wells are drilled vertically through the rock strata, including those bearing water (the 'water table'), to reach shale deposits at depths of up to several kilometers. Multiple horizontal channels

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Published by the Royal Society of Chemistry, www.rsc.org

that can extend a further 1–1.5 km are then drilled into the shale. Many such wells are usually required in each location, the number of multi-well pads being typically 9 per square mile in the USA. Thus there is considerable above-ground activity associated with fracking, in addition to drilling, with storage of large quantities of both clean and contaminated water and water additives, gas storage, movement of heavy vehicles in the vicinity, *etc.* Particular attention is given in this first chapter to recent developments in the UK and differences from the US experience are discussed.

Wallace Tyner and his colleagues from the Dept. of Agricultural Economics at Purdue University examine the economic impacts of shale oil and gas in the USA in Chapter 2. Using economic modeling, they conclude that the shale boom will have resulted in a 3.5% increase in GDP over the period 2008–2035, coupled with welfare benefits and employment gains. These gains depend, however, on the restriction of gas exports and are accompanied by higher emissions.

Iain Scotchman has written on the important subject of exploration for unconventional hydrocarbons in Chapter 3. As an industry insider working for Statoil, though writing here in a personal capacity, he describes the technical requirements for shale 'plays' to be commercially exploitable. Estimated ultimate recovery factors are given for both biogenic and thermogenic shales and the different structures of the so-called hybrid reservoirs from which shale ('tight') oil may be extracted also are discussed. Areas of potential shale resources are defined by screening of outcrop geochemical data, augmented by test drill cuttings and seismic attributes, with the aim of identifying 'sweet spots' with the characteristics of high organic content, maturity, mineralogy suitable for fracking, thickness and depth.

John Broderick and Ruth Wood of the Tyndall Centre for Climate Change Research at the University of Manchester, UK, consider the climate change impacts of shale gas production in Chapter 4. The internationally agreed target for restricting greenhouse gas emissions to levels needed to avoid dangerous climate change, defined and agreed as more than 2 °C increase in global mean surface temperature above pre-industrial levels, militates against shale gas. There may be a case for its use as a 'transition fuel' but the US experience indicates that even this is unlikely and investment in shale-gas exploration and associated gas infrastructure is, in effect, likely to be an investment in a stranded asset.

The hydrogeological aspects of shale gas extraction in the UK are the subject of Chapter 5 by Robert Ward and colleagues from the British Geological Survey. Given that the areas likely to be exploited for shale gas are overlain in many cases by aquifers used for drinking water supply and for supporting baseflow to rivers, the vulnerability of groundwater and the wider water environment must be taken very seriously. Experience from the US is not encouraging in that many incidences of contamination have been reported. This experience needs to inform a risk management strategy for the UK industry if the potential problems are to be avoided.

In Chapter 6 Alan Randall, Professor of Agricultural and Resource Economics at the University of Sydney, Australia, explores the economic, environmental and policy issues associated with the recovery of gas from coal seams. Although dewatering is the main method used, fracking often is required at least in the later stages of gas extraction and the associated environmental problems are similar to those encountered with shale gas. Empirical findings are presented from a recent case study of the economics of competition and coexistence of coal seam gas and agriculture on prime farmland.

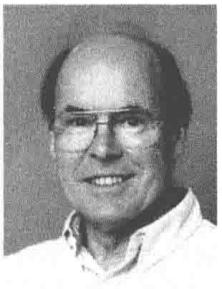
The prospects for shale gas development in China are examined by Shu Jiang of the University of Utah, USA, in Chapter 7. China has the largest estimated quantity of recoverable shale gas in the world and, inspired by the shale gas revolution in the USA, is trying to replicate that country's experience to produce shale gas to power its economy and mitigate the pressure felt from being the world's biggest greenhouse gas emitter. China's government is providing strong financial and policy support for this development but, in addition to the environmental problems encountered elsewhere, difficult geological and water resource conditions need to be faced.

The final chapter is by Tony Bosworth of Friends of the Earth, who claims that shale gas is not only unconventional but also is "unburnable and unwanted". A well-documented case is made for the environmental concerns associated with fracking outweighing any potential benefit and an alternative model for the future of energy supplies is proposed, based on renewables and reduced waste.

In summary, this book presents a critical but balanced and authoritative analysis of developments in the technology, economics, environmental and health concerns associated with fracking. It illuminates the public controversy over the further development and wider application of this process through factual and evidence-based examination of the arguments both in favour of it and against it. The book should be required reading for all concerned with future energy policy development and will be of great value to anyone looking for an in-depth account of this subject which has already attracted so much attention in the popular news media. Students undertaking courses in science, engineering and environmental science will find it of particular value, as will professionals working in the energy industries, the water industry, in land management and climate change.

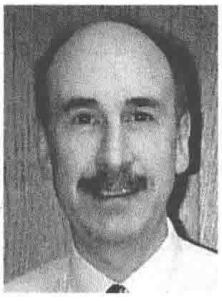
R. E. Hester
R. M. Harrison

Editors



Ronald E. Hester, BSc, DSc (London), PhD (Cornell), FRSC, CChem

Ronald E. Hester is now Emeritus Professor of Chemistry in the University of York. He was for short periods a research fellow in Cambridge and an assistant professor at Cornell before being appointed to a lectureship in chemistry in York in 1965. He was a full professor in York from 1983 to 2001. His more than 300 publications are mainly in the area of vibrational spectroscopy, latterly focusing on time-resolved studies of photoreaction intermediates and on biomolecular systems in solution. He is active in environmental chemistry and is a founder member and former chairman of the Environment Group of the Royal Society of Chemistry and editor of 'Industry and the Environment in Perspective' (RSC, 1983) and 'Understanding Our Environment' (RSC, 1986). As a member of the Council of the UK Science and Engineering Research Council and several of its sub-committees, panels and boards, he has been heavily involved in national science policy and administration. He was, from 1991 to 1993, a member of the UK Department of the Environment Advisory Committee on Hazardous Substances and from 1995 to 2000 was a member of the Publications and Information Board of the Royal Society of Chemistry.



Roy M. Harrison, BSc, PhD, DSc (Birmingham), FRSC, CChem, FRMetS, Hon MFPH, Hon FFOM, Hon MCIEH

Roy M. Harrison is Queen Elizabeth II Birmingham Centenary Professor of Environmental Health in the University of Birmingham. He was previously Lecturer in Environmental Sciences at the University of Lancaster and Reader and Director of the Institute of Aerosol Science at the University of Essex. His more than 400 publications are mainly in the field of environmental chemistry, although his current work includes studies of human health impacts of atmospheric pollutants as well as research into the chemistry of pollution phenomena. He is a past Chairman of the Environment Group of the Royal Society of Chemistry for whom he has edited 'Pollution: Causes, Effects and Control' (RSC, 1983;

Fourth Edition, 2001) and 'Understanding our Environment: An Introduction to Environmental Chemistry and Pollution' (RSC, Third Edition, 1999). He has a close interest in scientific and policy aspects of air pollution, having been Chairman of the Department of Environment Quality of Urban Air Review Group and the DETR Atmospheric Particles Expert Group. He is currently a member of the DEFRA Air Quality Expert Group, the Department of Health Committee on the Medical Effects of Air Pollutants, and Committee on Toxicity.

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Introduction and Overview: the Role of Shale Gas in Securing Our Energy Future

PETER HARDY

ABSTRACT

The phenomenon of shale gas is both topical and controversial. Its proponents claim that it is a clean, environmentally friendly and abundant source of cheap natural gas; its opponents believe the opposite. In several countries it is a fast-growing industry and operations have begun in the UK.

With conventional reserves of natural gas being quickly depleted, gas prospecting is turning to "unconventional resources", one example being gas found in shale. Uncommon technologies, notably hydraulic fracturing and horizontal drilling, are necessary for shale extraction to be economical.

Shale gas has faced some difficulties over concerns regarding environmental pollution. In the US, *Gasland*, an influential film was released alleging that waste fluid from hydraulic fracturing, "flowback water", was polluting groundwater. While it is possible for methane to enter groundwater through a faulty well completion, in the UK it is the responsibility of the Environment Agency and HSE to ensure regulation is adequate to prevent risks to the environment or human health.

There have been two earthquakes in Lancashire thought to have been caused by shale gas operations. The results of an investigation into these have been accepted as revealing that they were caused by hydraulic fracturing operations and new guidelines are being proposed to reduce the risk of this happening again.

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