

U.S. Department of Energy • Office of Fossil Energy National Energy Technology Laboratory

# Journal of Energy & Environmental Research



3610 Collins Ferry Road P.O. Box 880 Morgantown, WV 26507-0880

626 Cochrans Mill Road P.O. Box 10940 Pittsburgh, PA 15236-0949

National Petroleum Technology Office Williams Center Tower 1 One West Third Street Tulsa, OK 74103-3519

www.netl.doe.gov



Vol. 2, No. 1 February 2002

# **Carbon Sequestration II**

- 4 About This Issue
- 4 Editorial Board; Production Staff
- **5** Journal Papers

#### Journal Papers—Geologic Sequestration

5 Engineering and Economic Assessment of Carbon Dioxide Sequestration in Saline Formations Lawrence A. Smith, Neeraj Gupta, Bruce M. Sass, and Thomas A. Bubenik Ba ttelle Memorial Institute

**Charles Byrer** and **Perry Bergman** U.S. De partment of Energy, National Energy Technology Laboratory

- 23 Interaction of Rock Minerals with Carbon Dioxide and Brine: A Hydrothermal Investigation Bruce M. Sass, Neeraj Gupta, and Jennifer A. Ickes Bat telle Memorial Institute Mark H. Engelhard and Donald R. Baer U.S. Dep artment of Energy, Pacific Northwest National Laboratory Perry Bergman and Charles Byrer U.S. De partment of Energy, National Energy Technology Laboratory
- 32 Issues Related to Seismic Activity Induced by the Injection of CO<sub>2</sub> in Deep Saline Aquifer Joel Sminchak and Neeraj Gupta B attelle Memorial Institute Charles Byrer and Perry Bergman U.S. De partment of Energy, National Energy Technology Laboratory
- 47 A Perspective on the Potential Role of Geologic Options in a National Carbon Management Strategy

David A. Beecy U .S. Department of Energy, Office of Environmental Systems Vello A. Kuuskraa Adv anced Resources International, Inc. **Charles Schmidt** U.S. Depa rtment of Energy, National Energy Technology Laboratory

54 Sequestration of Carbon Dioxide in Coal Seams
 Karl T. Schroeder U.S. Dep artment of Energy, National Energy Technology Laboratory
 E. Ozdemir and B.I. Morsi U niversity of Pittsburgh

# 64 Sequestration of CO<sub>2</sub> in a Depleted Oil Reservoir: An Overview H. Westrich, J. Lorenz, S. Cooper, C. Jove Colon, and N. Warpinski U.S. Dep artment of Energy, Sandia National Laboratories D. Zhang, C. Bradley, P. Lichtner, and R. Pawar U.S. Department of Energy, Los Alamos National Laboratory Bruce Stubbs Pecos Petroleum Engineering, Inc. R. Grigg and R. Svec N ew Mexico Tech University Charles Byrer U.S. Department of Energy, National Energy Technology Laboratory

The Department of Energy makes no warranty, express or implied, nor assumes any liability for use of information contained in this publication. Reference to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof.

 75 Translating Lessons Learned From Unconventional Natural Gas R&D to Geologic Sequestration Technology Vello A. Kuuskraa Adv anced Resources International, Inc. Hugh D. Guthrie U.S. Depa rtment of Energy, National Energy Technology Laboratory

#### Journal Papers—Modeling

- 87 Engineering Feasibility of CO<sub>2</sub> Capture on an Existing US Coal-Fired Power Plant Nsakala ya Nsakala, John Marion, Carl Bozzuto, Gregory Liljedahl, and Mark Palkes ALSTOM Power Inc.
   David Vogel and J.C. Gupta ABB Lum mus Global Inc.
   Manoj Guha Am erican Electric Power
   Howard Johnson Ohio Coal Development Office
   Sean Plasynski U.S. Depa rtment of Energy, National Energy Technology Laboratory
- 99 Experimental and Computational Studies of Fluid Flow Phenomena in Carbon Dioxide Sequestration in Brine and Oil Field Chuang Ji and Duane H. Smith U.S. Dep artment of Energy, National Energy Technology Laboratory Goodarz Ahmadi: Clarkson University
- 109 Pore-Level Modeling of Carbon Dioxide Infiltrating the Ocean Floor Grant S. Bromhal and Duane H. Smith U. S. Department of Energy, National Energy Technology Laboratory M. Ferer West Virginia University
- 120 Pore-Level Modeling of Carbon Dioxide Sequestration in Brine Fields
   M. Ferer West Virginia University
   Grant S. Bromhal and Duane H. Smith U. S. Department of Energy, National Energy Technology Laboratory
- 133 Pore-Level Modeling of Carbon Dioxide Sequestration in Oil Fields: A study of viscous and buoyancy forces
   Grant S. Bromhal and Duane H. Smith U. S. Department of Energy, National Energy Technology Laboratory
   M. Ferer West Virginia University

#### **Journal Papers**—Ocean Sequestration

140 Formation of Hydrates from Single-Phase Aqueous Solutions and Implications for Oceanic Sequestration of CO<sub>2</sub>
 G. Holder and L. Mokka Univ ersity of Pittsburgh
 Robert P. Warzinski U.S. Dep artment of Energy, National Energy Technology Laboratory

The Department of Energy makes no warranty, express or implied, nor assumes any liability for use of information contained in this publication. Reference to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof.

## **About This Issue**

This is the second issue of the *Journal of Energy & Environmental Research*. The Journal highlights work being conducted by U.S. Department of Energy, National Energy Technology Laboratory (NETL) researchers, in collaboration with investigators from industry, academia, and other national laboratories. This issue focuses on carbon sequestration, as did Volume 1, Number 1. The papers included in these first two issues were presented at the First National Conference on Carbon Sequestration, May 14 to 17, 2001 in Washington, D.C.

NETL s programs assist in providing the United States with acceptable, affordable, and available energy. They also provide the quality science that contributes to the development of sound energy policies. The challenge we face in addressing our Nation s energy issues is formidable. Our academic, scientific, and technological communities must continue to share information to develop solutions to this challenge. We hope that this technical journal facilitates information sharing among these communities.

Your comments, questions, and suggestions for future issues are welcome. We look forward to hearing from you. Please feel free to contact the Editor in Chief, Edward J. (Jerry) Boyle, at <u>edward.boyle@netl.doe.gov</u> or 304-285-4000.

# **Editorial Board**

Anthony V. Cugini Division Director Fuels & Process Chemistry Division Office of Science & Technology

John S. Halow Division Director Simulation & Multi-Phase Analysis Division Office of Science & Technology

#### **Robert L. Kleinmann**

Division Director Environmental Science & technology Division Office of Science & Technology

David J. Wildman Division Director Separations & Gasification Engineering Division Office of Science & Technology

**Curt M. White** Division Director Clean Air Division Office of Science & Technology

## **Production Staff**

**Edward J. Boyle** Editor in Chief

Vicki L. Harbaugh Design

Michelle L. Henderson Design

William A. Kawecki Production

Katherine B. Lessing Managing Editor

The Department of Energy makes no warranty, express or implied, nor assumes any liability for use of information contained in this publication. Reference to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof.