

* [***Download Product Flyer***](https://www.wiley.com/en-ie/Acoustic+and+Vibrational+Enhanced+Oil+Recovery-p-9781119760177#download-product-flyer)
* [***Description***](https://www.wiley.com/en-ie/Acoustic+and+Vibrational+Enhanced+Oil+Recovery-p-9781119760177#description-section)
* [***Digital Evaluation Copy***](https://www.wiley.com/en-ie/Acoustic+and+Vibrational+Enhanced+Oil+Recovery-p-9781119760177#evaluation-copy-section)
* [***About The Author***](https://www.wiley.com/en-ie/Acoustic+and+Vibrational+Enhanced+Oil+Recovery-p-9781119760177#author-section)
* [***Permissions***](https://www.wiley.com/en-ie/Acoustic+and+Vibrational+Enhanced+Oil+Recovery-p-9781119760177#permission-section)
* [***Table Of Contents***](https://www.wiley.com/en-ie/Acoustic+and+Vibrational+Enhanced+Oil+Recovery-p-9781119760177#content-section)

Selected type: **E-Book**

**€173.99**

[Request Digital Evaluation Copy](https://professor.wiley.com/CGI-BIN/LANSAWEB?PROCFUN+PROF5+PR5FN05+FUNCPARMS+CWIL(A0010):N+LANG(A0010):1+ISBN(A0090):119760178+S1APRDTYP(A0030):V)

**Acoustic and Vibrational Enhanced Oil Recovery**

[George V. Chilingar](https://www.wiley.com/en-ie/search?pq=%7Crelevance%7Cauthor%3AGeorge+V.+Chilingar), [Kazem Majid Sadeghi](https://www.wiley.com/en-ie/search?pq=%7Crelevance%7Cauthor%3AKazem+Majid+Sadeghi), [Oleg Leonidovich Kuznetsov](https://www.wiley.com/en-ie/search?pq=%7Crelevance%7Cauthor%3AOleg+Leonidovich+Kuznetsov)

ISBN: 978-1-119-76017-7 May 2022 432 Pages

**DESCRIPTION**

**ACOUSTIC AND VIBRATIONAL ENHANCED OIL RECOVERY**

**Oil and gas is still a major energy source all over the world, and techniques like these, which are more environmentally friendly and inexpensive than many previous development and production technologies, are important for making fossil fuels more sustainable and less hazardous to the environment.**

Based on research they did in the 1970s in Russia and the United States, the authors discovered that oil rate production increased noticeably several days after the occurrence of an earthquake when the epicenter of the earthquake was located in the vicinity of the oil producing field. The increase in oil flow remained higher for a considerable period of time, and it led to a decade-long study both in the Russia and the US, which gradually focused on the use of acoustic/vibrational energy for enhanced oil recovery after reservoirs waterflooded. In the 1980s, they noticed in soil remediation studies that sonic energy applied to soil increases the rate of hydrocarbon removal and decreases the percentage of residual hydrocarbons. In the past several decades, the use of various seismic vibration techniques have been used in various countries and have resulted in incremental oil production.

This outstanding new volume validates results of vibro-stimulation tests for enhanced oil recovery, using powerful surface-based vibro-seismic sources. It proves that the rate of displacement of oil by water increases and the percentage of nonrecoverable residual oil decreases if vibro-energy is applied to the porous medium containing oil.

**Audience:**

**Petroleum**Engineers, Chemical Engineers, Earthquake and Energy engineers, Environmental Engineers, Geotechnical Engineers, Mining and Geological Engineers, Sustainability Engineers, Physicists, Chemists, Geologists, and other professionals working in this field

**ABOUT THE AUTHOR**

**George V. Chilingar, PhD,** is Professor Emeritus of petroleum, civil and environmental engineering at the University of Southern California (USC). He received his Bachelor’s and Master’s Degrees in Petroleum Engineering, and PhD in Geology at the University of Southern California. Professor Chilingar is Academician, USC International Ambassador, Member of the Russian Academy of Sciences, founder and past President of the Russian Academy of Natural Sciences USA Branch, Honorary Professor of Gubkin University, Russia, and Honorary Consul of Honduras in Los Angeles, CA. In 2021, Professor Chilingar was given the Society of Petroleum Engineers (SPE) Honorary Membership award in Dubai for outstanding service to SPE and distinguished scientific and engineering achievements. The results of his investigation are presented in over 500 research articles and 73 books in the fields of petroleum and environmental engineering and petroleum geology.

**Kazem Majid Sadeghi, PhD,** has a Bachelor of Science in chemistry from the University of California, Santa Barbara (UCSB), a Master of Science in environmental engineering from the University of Southern California (USC), an Engineer Degree in Civil Engineering USC, and PhD in geography from UCSB. Professor Sadeghi has been researching and teaching for many years at UCSB and California State Polytechnic University, Pomona. He has over 30 years of civil and environmental engineering and consulting experience, including hazardous waste management, pollution prevention assessments, design of industrial wastewater pretreatment facilities and gas collection/treatment systems, treatment of carbonaceous materials, soil remediation, and enhanced oil recovery.

**Oleg Leonidovich Kuznetsov, Grand PhD in Engineering**, is a graduate from Moscow Geological-Prospecting Institute. Upon graduation he worked at the Institute of Geology and Mining of Fossil Fuels of the Academy of Sciences and All-Union Institute of Nuclear Geophysics and Geochemistry. He worked in the All-Russia Institute of Geosystem and is a professor at M.V. Lomonosov Moscow State University.  In addition, he is a professor at Dubna State University working on research development and teaching.  Professor Kuznetsov is President of Russia’s Academy of Natural Sciences. He is the author of a number of papers and books on applied geophysical technology and several monographs.

**PERMISSIONS**

[**Request permission**](https://s100.copyright.com/AppDispatchServlet?publisherName=wiley&publication=Book&title=Acoustic%20and%20Vibrational%20Enhanced%20Oil%20Recovery&bookTitle=Acoustic%20and%20Vibrational%20Enhanced%20Oil%20Recovery&publicationDate=JUN+2022&author=George%20V.+Chilingar+Kazem%20Majid+Sadeghi+Oleg%20Leonidovich+Kuznetsov&sc=US&numPages=0&copyright=&contentID=978-1-119-76015-3&orderBeanReset=True)**to reuse content from this site**

**TABLE OF CONTENTS**

List of Contributors xiii

**1 Introduction 1**

1.1 Origin and Migration of Oil 5

1.1.1 Seismicity 6

1.1.2 Electrokinetics 7

1.1.3 Earth Tides 9

1.1.4 Compaction 9

1.1.5 Migration in a Gaseous Form 10

1.2 Seismic Vibration Techniques 11

1.2.1 Producing Well Experiments 11

1.2.2 Mechanisms of Interaction of Fluid Flow With the Vibro-Energy in Porous Media 12

References and Bibliography 13

**2 Wave Spreading Patterns in the Porous Media 19**

2.1 Spread of Vibration in Reservoir 19

2.2 Effect on the Wave Spread in the Oil Accumulations by the Geologic-Geophysical Conditions 26

2.3 Wave Spreading From the Vibrating Surface of the Reservoir Matrix Into the Saturated Medium 30

2.4 Excitation of Vibration in Oil Reservoirs 42

References and Bibliography 51

**3 Directional Displacement of a Dispersed Phase 55**

3.1 Simplest Models of the Vibrational Directional Displacement 55

3.2 Physical Mechanisms and Major Types of Asymmetry Causing Vibratory Displacement 61

3.3 Directed Motion of the Dispersed Phase in Vibrating Pore Channels 69

3.4 Directional Motion of the Vibrating Dispersed Phase in Pore Channels 82

References 87

**4 Formation Damage Control and Cement Sheath Stability 89**

4.1 Status of the Reservoir 89

4.2 Vibration Effect on the Reservoir’s Heat Properties 95

4.3 Decolmatation of the Near-Bottomhole Zone in the Vibration Field 104

4.4 Cement Sheath Stability Around a Well in the Vibration Field 113

References and Bibliography 118

**5 Effect of Vibration on Improving Oil Yield and Various Tertiary Recovery Technologies 123**

5.1 Major Causes of Incomplete Oil Recovery From the Subsurface 123

5.1.1 Oil Displacement by Miscible Hydrocarbons 128

5.1.2 Oil Displacement by a High-Pressure Dry Gas 129

5.1.3 Oil Displacement by an Enriched Gas 130

5.1.4 Oils Displacement by Liquefied Petroleum Gas 131

5.1.5 Oil Displacement With Carbon Dioxide 132

5.1.6 Oil Displacement by Polymer Solutions 133

5.1.7 Oil Displacement by Micellar Solutions 135

5.1.8 Thermal Methods 138

5.1.9 The Vibroseismic Method 148

5.2 A Study of the Residual Formation Pressure in the Vibration Field 150

5.3 A Study of the Oil Capillary Displacement in the Vibration Field 163

5.4 Studies of the Oil and Water Gravity Flow in the Vibration Field 168

5.4.1 Absolute Permeability Effect 170

5.4.2 An Effect of Oil Viscosity 172

5.4.3 The Capillary Pressure Effect 173

5.4.4 The Oil and Water Phase Permeability Effect 173

References 179

**6 Vibration Effect on Properties of Saturating Phases in a Reservoir 181**

6.1 Changes in Interfacial Tensions and Rheological Parameters 181

6.1.1 A Newtonian Liquid 182

6.1.2 A Viscoplastic Liquid 182

6.2 Permeability Changes 186

6.2.1 A Single-Phase Flow 186

6.2.2 Two-Phase Flow 189

6.2.3 Three-Phase Flow 200

6.3 Capillary Pressure Changes 201

6.4 Interformational Oil Degassing and a Decline in the Formation Water Saturation 203

References 212

**7 Energy Criteria 215**

7.1 Parameters of Oscillatory Treatment and Conditions for Manifestation of Useful Effects in Saturated Geological Media 217

7.2 Wavelike Nature of the Oil-Saturated Geological Media Stress-Energy Exchange. Elastic Oscillations as an Energy Exchange Indicator and Regulator 220

7.2.1 Manifestation of Seismoacoustic Radiation in Oil-Saturated Media Exposed to Internal Stress Disturbance and Elastic Oscillation Treatment 221

7.2.2 Mechanism of Receptive Accumulation of Mechanical Stress Energy in Failing Oil-Saturated Media 233

7.3 Justification of Rational Wave Treatment for the Near-Wellbore Zone and Entire Reservoir 237

7.3.1 Reservoir Treatment With Elastic Oscillations 245

References and Bibliography 257

**8 Types of Existing Treatments 261**

8.1 Integrated Technologies of the Near-Wellbore Zone Vibrowave Treatment 264

8.1.1 Downhole Equipment 265

8.1.2 Integrated Vibrowave, Overbalance/ Pressure-Drawdown, and Chemical Treatment (VDHV) 271

8.1.3 Vibrowave and Foam Treatment (VPV) 275

8.1.4 Deep Chemical-Wave Reservoir Treatment (GRVP) 276

8.1.5 Remediation of Troubles When Shutting Off Water and Gas Entries 280

8.1.6 Coiled Tubing Wave Technologies (KVT) 282

8.1.7 Tubing and Bottomhole Cleanout Technology 284

8.1.8 HydroVibroSwabbing Technology 284

8.1.9 Hydraulic Fracturing Technology Combined with Vibrowave Treatment (HydroVibroFrac) 285

8.1.10 Hydraulic Fracturing Operations 287

8.1.11 Integrated Treatment of Water Production Wells 291

8.2 Enhanced Oil Recovery Technologies Based on Vibroseismic Treatment (VST) 293

References and Bibliography 308

**9 Laboratory Experiments 311**

9.1 Laboratory Experiments 311

9.1.1 Oil and Water Saturations of the Porous Medium Exposed to Elastic Waves 311

9.1.2 Rate of Displacement of Oil by Water and Effect of Elastic Waves on Relative Permeability to Oil 313

9.1.3 Degassing of Fluids by the Applied Vibro-Energy 313

9.2 Displacement of Oil by Gas-Free Water in the Presence of Elastic Waves 315

9.3 Displacement of Oil by CO2-Saturated Water in the Presence of Elastic Waves 316

9.4 Modeling of Oil Displacement by Water in Clayey Sandstones 317

References and Bibliography 318

**10 Oil Field Tests 321**

10.1 Abuzy Oil Field 321

10.2 Changirtash Oil Field 321

10.3 Jirnovskiy Oil Field, First Stage 323

10.4 Jirnovskiy Oil Field, Second Stage 324

References and Bibliography 326

**11 Electrokinetic Enhanced Oil Recovery (EEOR) 327**

11.1 Introduction 327

11.2 Petroleum Reservoirs, Properties, Reserves, and Recoveries 329

11.2.1 Petroleum Reservoirs 329

11.2.2 Porosity 329

11.2.3 Reservoir Saturations 329

11.2.4 Initial Reserves 330

11.2.5 Primary Oil Production and Water Cut 330

11.3 Relative Permeability and Residual Saturation 331

11.4 Enhanced Oil Recovery 332

11.5 Electrokinetically Enhanced Oil Recovery 332

11.5.1 Historical Background 333

11.5.2 Geotechnical and Environmental Electrokinetic Applications 334

11.5.3 Direct Current Electrokinetically Enhanced Oil Recovery 335

11.6 DCEOR (EEOR) and Energy Storage 336

11.6.1 Mesoscopic Polarization Model 337

11.7 Electrochemical Basis for DCEOR 339

11.7.1 Coupled Flows and Onsager’s Principle 339

11.7.2 Joule Heating 341

11.7.3 Electromigration 341

11.7.4 Electrophoresis 342

11.7.5 Electroosmosis 342

11.7.6 Electrochemically Enhanced Reactions 342

11.7.7 Role of the Helmholtz Double Layer 343

11.7.7.1 Dissociation of Ionic Salts 343

11.7.7.2 Silicates 344

11.7.7.3 Phillosilicates and Clay Minerals 345

11.7.7.4 Cation Exchange Capacity 346

11.7.7.5 Electrochemistry of the Double Layer 347

11.8 DCEOR Field Operations 351

11.8.1 Three-Dimensional Current Flow Ramifications 352

11.8.2 Electric Field Mapping 353

11.8.3 Joule Heating and Energy Loss 353

11.8.4 Comparison of DC vs. AC Electrical Transmission Power Loss 354

11.9 DCEOR Field Demonstrations 356

11.9.1 Santa Maria Basin (California, USA) DCEOR Field Demonstration 356

11.9.2 Lloydminster Heavy Oil Belt (Alberta, Canada) DCEOR Field Demonstration 359

11.10 Produced Fluid Changes 362

11.11 Laboratory Measurements 363

11.11.1 Electrokinetics and Effective Permeability 366

11.11.2 Sulfur Sequestration 367

11.11.3 Carbonate Reservoir Laboratory Tests 367

11.12 Technology Comparisons 368

11.12.1 Comparison of DCEOR and Steam Flood Efficiency 368

11.12.2 Comparison of DCEOR and Steam Flood Costs 368

11.12.3 Comparison of DCEOR to Other EOR Technologies 369

11.13 Summary 371

11.14 Nomenclature 371

References 373

Addendum 381

Nomenclature 383

Symbols 385

About the Authors 391

Index 395