Index

A
abandonment, well, 581, 585–586, 585 (table), 586 (figure), 591, 593
above ground factors, offshore development cost, 613, 613 (figure)
aboveground storage tanks. See storage
absolute open flow (AOF), 401–404, 401 (table), 402 (figure), 403 (figure), 403 (table)
absolute permeability, 11, 13–14
absolute porosity, 10, 55
accidents, 543, 553, 553 (figure), 706, 708. See also safety accumulation history. See hydrocarbon migration and accumulation history simulation
acid rain, 538
acids, microbial, 470
acoustic logging, 17
acoustic resonance technique (ART), 489
active solar energy, 684
actual models, numerical reservoir simulation, 191
additives
asphaltene deposition treatment, 498–499
hydraulic fracturing, 325, 326 (table), 352, 365–366
adsorption
asphaltene, 493
polymer, 260 (table)
surfactant, 281–283, 282 (table)
adsorption isotherms, capillary pressure by, 78–79, 78 (figure)
aerobic microorganisms, in oil reservoirs, 462, 467, 468. See also microbial enhanced oil recovery
Africa, regulatory framework in, 536–537
air emissions. See emissions alarms, emergency, 561–562
Alberta Taciuk Process (ATP), 339–340, 339 (figure)
Albian's process, 317
Alcaligenes strains, in MEOR, 473
algorithms, decomposition costing, 585–591
conductor severance and removal, 586–587, 587 (figure)
fixed platform removal, 589–590, 590 (table)
floating structure removal, 590–591, 590 (table)
overview, 584
pipeline decomposition, 587–588, 588 (table)
umbilical, flowline, and riser removal, 588–589, 589 (figure)
well plugging and abandonment, 585–586, 586 (figure)
alkaline flooding, 285
alkaline-surfactant-polymer (ASP) flooding, 285–286
alkanes, 65
ambient conditions, asphaltene precipitation in, 486–488
American Petroleum Institute (API), 547
American Petroleum Institute (API) gravity, 3, 36, 65, 302–303, 302 (table), 508
American Shale Oil, 386
Amott test, 72–73, 72 (figure)
amphoteric surfactants, 278 (table)
anoxic microorganisms, in oil reservoirs, 462–463. See also microbial enhanced oil recovery
analogies estimates, reserve, 44
ancient geothermal fields. See geothermal field evolution simulation
anionic surfactants, 278 (table)
anisotropic (directional) permeability, 6, 10
anisotropic geothermal field 3D dynamic simulation, 117–118, 118 (figure)
anisotropy, 88–89, 89 (figure)
annular pressure risk, semisubmersible project, 618
annular preventer, BOP stack, 204, 205 (figure)
antifreeze, preventing hydrate formation with, 241–242
apatite fission track method (AFT), 121
appended geothermal field, 116
aqueous stability tests, 279
aquifer activity, Messoyakha deposit, 454, 456, 456 (figure)
Arbuckle reservoir, polymer gel system in, 268, 270
Archie's equations, 60
Arctic development, deepwater, 302, 343–344, 344 (figure), 345 (table), 347
Arctic environments, methane hydrate accumulation in, 333, 334 (figure)
areal sweep efficiency, 256–258, 257 (figure), 257 (table)
aromatics, 65, 485–486, 486 (figure)
Arps decline forecasting, 367, 367 (table), 368–369, 368 (figure)
Arps equation, 60
artificial intelligence. See artificial neural networks; oil field data mining
artificial islands, 225, 226 (figure), 227 (figure)
artificial lift, 337, 681
arrestor, 483–484
arylsulfonic acid, 298–299
articulated gravity platform, 617
artiﬁcial neural networks
Dongying Sag petroleum system example, 144–145, 145 (figure), 145 (figure)
hidden layers, 150, 150 (figure), 151
input layer, 150, 150 (figure), 151
mechanics of operation, 150–152, 150 (figure), 151
output layer, 150, 150 (figure), 151
overview, 149
petroleum migration and accumulation simulation, 123–124, 126–130, 126 (figure), 127 (figure), 131 (figure)
production optimization
data availability and statistical analysis, 168–170, 169 (table), 170 (table)
data-driven modeling, 170–173, 171 (figure), 172 (figure)
full-asset type curve analysis, 174, 175 (figure)
single-well, single-parameter sensitivity analysis, 173, 173 (figure)
single-well, type curve analysis, 173, 174 (figure)
single-well uncertainty analysis, 174–175, 175 (figure)
reservoir characterization
synthetic model, 155 (figure), 155 (table), 156–159, 156 (figure), 157 (figure), 158 (figure), 158 (table), 159–161 (figure), 161 (table)
Asia
associations pertaining to oil and gas industry, 547–548
regulatory framework in, 534–535

asphaltene deposition, 483–499
case study, 497–498, 497 (figure), 498 (figure)
current research areas, 499
definition and classification of asphaltenes, 483–485, 484 (figure), 485 (table)
experimental determination of, 492–495
impact on oil production, 483
mitigation and remediation strategies, 498–499
modeling methods to predict, 495–497, 496 (figure)
SARA analysis, 485–486, 486 (figure)
See also asphaltene precipitation
asphaltene deposition inhibitors, 498–499
asphaltene onset pressures (AOPs), 488–489
asphaltene precipitation, 486–492
case study, 492, 492 (figure)
experimental determination of, 486–490
modeling methods to predict, 490–492
overview, 486, 607
associated gas, 377
associations for health, safety, and environment, 547–548
Atlantis project, 653. See also semisubmersibles
atmospheric effects
environmental concerns, 537–538, 537 (figure), 538 (figure)
minimizing, 554
See also emissions
Australia, regulatory framework in, 536
average angle method, 221–222, 222 (figure)
average molecular weight. See molecular weight
average temperature and compressibility method, 406
axial coring, 61
axial load distribution, drill string, 198–199, 201 (figure)
axially vibrating drilling tools, 225

**B**

Bacillus strains, in MEOR, 471–472, 473
back-propagation algorithm, 152
backward-difference approximation, 183, 183 (figure)
bacteria, in oil reservoirs, 462–463. See also microbial enhanced oil recovery
Bahrain, regulatory framework in, 534–535
Barnett Shales play, 322, 322 (figure), 328
basin simulation. See 3D dynamic simulation of pool-forming
Beggs and Brill correlation for multiphase flow, 409–411, 409 (table)
below ground factors, offshore development cost, 612–613, 613 (figure)
bending force, 224, 224 (figure)
benthic ecosystems, environmental concerns in, 542–543
biodegradation, oil, 462, 466, 467
bioemulsifiers, 472
biofilms, 470
biofuels, 33, 40, 40 (figure), 40 (table)
biological hazards, 547, 561
biological neural networks, 149, 150 (figure)
biological stability of polymers, 261 (table)
biochemical treatment of wastewater, 556 (table)
biology. See microbiology of petroleum reservoirs
biopolymers, 470, 471
bioremediation, oil, 466
biosurfactants, 286, 287, 466–467, 469–473
Biot coefficient, 89–90
bit hydraulics optimization, 210
bit-operating conditions, 197
bits, drill, 205–207, 206 (figure), 207 (figure)
bit-side forces, 224, 224 (figure)
bitumen
classification of, 287 (table)
energy future, 37–39, 38 (figure), 38 (table)
oil sands mining
bitumen extraction, 317
bitumen upgrading, 318–319, 320 (figure), 320 (table)
challenges of, 319, 320 (figure)
general discussion, 345–346
oil sand tailings, 317–318, 318 (figure), 318 (table), 319 (table)
overview, 302, 316–317
overview, 9
physical properties of, 302–303, 302 (table)
production overview, 531
worldwide distribution of, 303–304, 303 (figure), 304 (figure)
See also specific recovery methods; thermal recovery methods
black oil, 3, 68, 68 (figure), 68 (table)
black-oil formulation, numerical reservoir simulation, 179, 179 (table), 180, 181
Blind Faith development, 654. See also semisubmersibles
blind rams, 205, 205 (figure)
block-centered gridding, in numerical reservoir simulation, 185, 185 (figure)
blocks and tackle, 199 (figure), 199 (table)
blowout preventer (BOP) stack, 204–205, 205 (figure), 226
blowouts, 546, 558, 558 (figure), 618
Bohai oil field, polymer flooding in, 263–264
booster stations, 510–511, 510 (figure), 511 (figure)
borate, 358–359, 358 (figure)
bottom-founded systems, 225–226, 226 (figure), 227 (figure), 228 (figure), 229 (figure)
bottomhole assembly (BHA), 198, 200 (figure), 224, 224 (figure)
bottomhole pressure (BHP), 406–407, 417
bottom-up cost estimation, 582–583
bottom-up models, reserve depletion estimation, 47–48
boundary types, in numerical reservoir simulation, 185–187, 186 (figure), 187 (figure)
boundary-dominated flow (BDF), 399, 400, 416, 419
bow-tie analysis, 551, 551 (figure)
Boyle’s law, 13, 55
Brazil, regulatory framework in, 535
Brazilian Indirect Tensile Strength Test, 98, 98 (figure)
breaker-free fracturing fluids, 363, 364 (figure)
brackers for fracturing fluids, 359–360, 361 (figure), 362
Bright Water™ microgels, 267
bubble-point pressure, 3, 66–67, 67 (figure)
Buckley-Leverett equation, 75
Buffalo Valley Field. See synthetic model, reservoir characterization; Valley Field reservoir characterization
build-up production period, gas field, 421–422, 421 (figure)
bulk modulus, 88, 88 (figure), 95
bulk-foam systems, 265
Bullwinkle platform, 573, 574 (figure), 576 (figure), 591
C
 calibration
data set for, artificial neural networks, 151, 158 (figure), 158 (table)
of models to actual field data, 102
in numerical reservoir simulation, 193
Canada, regulatory framework in, 533
capacity
pipeline, 510–511
semisubmersible production, 631, 636 (table)
capacity-reserves relations, 635, 636, 637 (figure), 638 (figure)
capillary hysteresis, 70–71, 71 (figure)
capillary number, 71, 71 (figure), 276–277, 276 (figure)
capillary pressure, 69–73
capillary hysteresis and saturation history, 70–71, 71 (figure)
core analysis, 14
and corresponding height above free water level, 70 (figure)
dilute surfactant flooding, 283, 285 (figure)
effect of IFT on oil recovery, 277, 277 (figure)
interfacial tension and contact angle, 69
by isotherms, 78–79, 79 (figure)
Leverett J-function, 70, 71 (figure)
nonwetting phase trapping and capillary number, 71, 71 (figure)
numerical reservoir simulation, 181–182
trapping residual oil, 272, 272 (figure)
unconventional reservoirs, 78–79, 78 (figure)
Young-Laplace equation, 69–70, 70 (figure)
capillary resistance, 125
capillary viscosimetry method, 487–488
capillary-gravity-pressure equilibrium, 187, 187 (figure)
capital spending, semisubmersible project, 616, 616 (figure)
caprock, 1
carbon capture, utilization, and storage (CCUS), 706
carbon dioxide (CO2) emissions, 658–659, 659 (figure), 659 (table), 681–683, 681 (figure), 682 (table), 683 (figure), 683 (table)
carbon dioxide (CO2) flooding, 8, 274–276, 294, 294 (figure)
carbon dioxide (CO2) foam, 363
carbon dioxide (CO2)-enhanced CBM production, 332, 332 (figure)
carbon dioxide (CO2) flooding, 8, 274–276, 294, 294 (figure)
carbon dioxide (CO2) hysteresis, 70–71, 71 (figure)
carbon dioxide (CO2) emissions, 658–659, 659 (figure), 659 (table), 681–683, 681 (figure), 682 (table), 683 (figure), 683 (table)
carbon dioxide (CO2) flooding, 8, 274–276, 294, 294 (figure)
carbon dioxide (CO2) foam, 363
carbon dioxide (CO2) enhanced CBM production, 332, 332 (figure)
carbonate rocks, 2, 6, 10–11, 55, 58. See also reservoir rock
cased-hole logging, 16
casing installation, 211, 213, 213 (figure), 680–681
casing schedules, 210–211, 212 (figure)
casing whipstocks, 219, 220 (figure)
catalytic upgrading process in situ (CAPRI), 315, 315 (figure), 345
catenary moorings, 601–602, 601 (figure). See also mooring systems, floating platforms
cathodic protection, 524, 524 (figure), 687–688, 688 (figure)
cationic surfactants, 278 (table)
Caustic and Effect Diagram, 551
cell-based models, hydraulic fracturing, 355, 356 (figure)
cement, for in situ permeability reduction, 267 (table)
central flooding, 251, 252 (figure)
central-difference approximation, 182–183, 183 (figure), 184
channel system evaluation model, 127–130
check valves, 511, 512 (figure)
chemical flooding, 276–286
alkaline flooding, 285
alkaline-surfactant-polymer flooding, 285–286
overview, 276–277, 276 (figure), 277 (figure), 468
surfactant flooding, 277–285, 277 (figure), 278 (table), 279 (figure), 280 (figure), 282 (table), 284 (table), 285 (figure)
Chemical Hazard Analysis, 551
chemical stability of polymers, 261 (table)
chemical surfactants, 469–470. See also chemical flooding
chemicals
asphaltene deposition treatment with, 498–499
characteristics of fracturing fluid, 365–366
control of gas hydrates with, 437–439, 438 (figure), 440
degradation of guar-based solutions, 359–360
in produced water, 238, 238 (table)
used in hydraulic fracturing, 388, 540, 540 (figure)
in wastewater discharge, 538–540, 538 (figure), 539 (figure)
wastewater treatment with, 556 (table)
workplace hazards, 543, 546, 559
Chen’s formula, 405
China. See Dongying Sag petroleum system simulation
gas, 432, 433, 434 (figure)
choke, flow control, 237, 241
choke line, BOP stack, 205
chokepoints, world oil transit, 518, 518 (figure), 518 (table)
chronologic methods, SARA analysis, 485, 486
clastic rocks, 2, 5–6, 11, 55. See also reservoir rock
clay hydrates. See gas hydrate deposits; natural gas hydrates
clay-dominated disseminated methane hydrate deposits, 334
clay-dominated fracture reservoirs, methane hydrates in, 334
carbonates, formation damage and, 75
cleats, coal, 7–8
climate change, 708. See also environmental concerns
coal, 34–35, 34 (figure), 657, 658 (figure)
coal rank, 7, 329, 330 (figure)
colbalkatmethane (CBM), 329–332
defined, 321
eynergy future, 40–41, 41 (figure), 42 (table)
field development, 332, 333 (figure)
gas composition in reservoirs, 329
general discussion, 346
overview, 7–8, 8 (figure), 302, 329, 329 (figure)
production techniques, 331–332, 331 (figure), 332 (figure)
properties of, 330–331
coal-to-liquids (CTLs), 39, 40 (figure), 40 (table)
coating, pipeline and tank, 523–524
Cognac platform removal cost estimate, 590
Colebrook formula, 405
collection platforms (CPs), 679
colloidal models of asphaltene, 483, 485, 490, 491–492
colloidal-dispersion gels (CDGs), 267
combination drive, 5, 250 (table)
compaction correction for stratum thickness, 115–116, 115 (figure)
compaction failure, 94
compaction flow, 125
compaction yielding, 91
completion
as phase of production, 530
smart, 609
well, 680–681
compliant towers, 600 (figure)
decommissioning cost, 591–593, 591–592 (table), 593, 595, 595 (figure)
decommissioning stages, 581–582
deepwater inventory, 573, 574–575 (table), 576 (figure), 576–577
comprehensive evaluation of trap, 133, 146, 146 (table)
compressibility
average temperature and compressibility method, 406
formation, 61
ideal gas, 62
oil, 66
petroleum product, 508–509
pore, 61, 61 (figure)
pore volume, 97–98
real gas, 63
reservoir rock, 60–61, 61 (figure)

comprehensive evaluation of trap, 133, 146, 146 (table)
compressibility
average temperature and compressibility method, 406
formation, 61
ideal gas, 62
oil, 66
petroleum product, 508–509
pore, 61, 61 (figure)
pore volume, 97–98
real gas, 63
reservoir rock, 60–61, 61 (figure)

compressors, for pipelines, 511, 512 (figure)
computational fluid dynamics (CFD), 496
conceptual models, numerical reservoir simulation, 191
condensate reservoirs, 3–4, 68, 68 (figure), 68 (table)
condensing-gas process, MCM, 273
condensing-vaporizing-gas process, MCM, 274
conductivity method, asphaltene precipitation studies, 487
conductor severance and removal
decommissioning cost, 585 (table), 586–587, 587 (figure), 592
overview, 582
confined spaces, workplace hazards in, 546, 560
connectivity factor, polymer flooding, 262–263
constant bottomhole pressure (CBHP), 214, 215 (figure)
consumption
energy future, 31–35, 31 (figure), 32 (figure), 33 (figure), 34 (figure)
natural gas, 26 (figure), 29–31, 29 (figure), 30 (table), 669, 671 (figure)
oil, 22 (figure), 24–26, 25 (figure), 26 (table), 666, 667 (figure)
prospective outlook on, 21
contact angle, 69, 69 (figure), 73
contact injuries, 543, 560
contamination. See environmental concerns
continuity equation, numerical reservoir simulation, 180, 181
continuous gas injection, 270, 270 (figure), 271 (figure)
continuous materials
assumption of continuity, 83, 84 (figure)
basic geomechanical parameters for, 95–96
continuum approach, flow equations, 180
contracts, offshore development, 614, 615
control systems, pipeline, 512–513, 514, 515 (figure)
convection, thermal, 117
conventional reservoirs, 6, 319, 321
conventional triaxial compression (CTC) test, 93 (figure), 96–97, 96 (figure), 97 (figure)
conversion processes, crude oil refining, 531
cooling water environmental concerns, 540
coordinates, directional well trajectory, 221–222, 221 (figure), 222 (figure)
Corbett method, SARA analysis, 485
core analysis
fluid saturations measurement, 14
limitations of, 15–16
overview, 11, 12, 61–62
permeability measurement, 13–14
porosity measurement, 13
routine, 13
special, 14–16
core tests, geomechanical, 96–101, 96 (figure), 97 (figure), 98 (figure), 99 (figure), 100 (figure)
core-flood experiments
asphaltene deposition studies, 494
to determine surfactant retention, 283
MEOR, 470–473
relative permeability, 74, 74 (figure)
Corey model, 75
coring, 11, 12, 61. See also core analysis
coriolis meters, 246–247, 246 (figure)
corner-point grid model
Dongying Sag petroleum system simulation, 137, 137 (figure)
fault displacement elimination and recovery, 112–113, 112 (figure), 113 (figure)
overview, 110–112, 111 (figure)
structural deformation recovery, 113–116, 113 (figure), 114 (figure), 115 (figure)
corrosion
by gas hydrates, 439, 440, 441, 441 (figure)
tank and pipeline, 523–524, 524 (figure)
costs, semisubmersible project
cost relations, 627–628, 628 (figure), 629 (figure), 629 (table), 630 (figure)
decommissioning, 626–627, 627 (table)
development, 625–626, 627 (table)
development, 625–626, 627 (table)
development, 625–626, 627 (table)
leases, 623–624, 625 (table)
revenue–cost relation, 638, 640 (figure), 641 (figure)
well, 624–625, 626 (table), 627 (table)
See also decommissioning cost estimation in deepwater GOM
Couette device, 493
coupling equation, heat conduction and convection, 117
creep, 92, 92 (figure)
cricondenbar, 3, 67
cricondentherm, 3, 67
critical micelle concentration (CMC), 278, 279 (figure)
critical point, reservoir fluid phase behavior, 3, 3 (figure), 66, 67, 67 (figure)
critical stress intensity factor. See fracture toughness
crosslinked polymer, for conformance control, 266 (figure), 266–270, 267 (figure), 267 (table), 268 (table), 269 (table)
cross-linked-gel fracturing, 325
cross-linking of guar, 358–359
cross-well seismic data, 154
crude oil
asphaltene deposition, effect on production, 483
classification of, 3
composition of, 64 (table)
dehydration of, at topsides facilities, 610–611
energy future, 31–33
GHG emissions related to type of, 683 (table)
history of, 529
major producers of, 529
overview, 461–462
pipelines for, 513, 513 (figure)
production process overview, 529–531, 530 (figure)
production stages, 249–255, 250 (figure), 252 (figure), 253 (figure), 254 (figure)
refining, 531
as reservoir fluid, 65–66, 66 (figure)
INDEX 715

reservoir rock wettability, 71–72, 71 (figure)
SARA analysis, 485–486, 486 (figure)
See also microbiology of petroleum reservoirs; petroleum geomechanics; specific entries under "hydrocarbon"; specific oil types; specific production and recovery processes; upstream oil supply chain
crude oil tankers, 517–518, 517 (figure), 517 (table)
crust thermal structure analysis, 118–120, 119 (table), 120 (table)
cryogenic tanks, 522–523, 523 (figure)
cryogenic tanks, 522–523, 523 (figure)
crystalline silicon PV (CSP) technology, 684, 684 (figure), 685 (figure), 686
crystals, gas hydrate, 429, 444, 444–445 (figure), 445
cubic EOS, 67

cubic equations of state, solubility models, 491

cubic-plus-association (CPA) model, 491
Cullender and Smith method, 406–410, 409 (table)
culture-dependent microbiology techniques, 463–464, 465

See metagenomics
culture-independent microbiology techniques.
cumulative production function, 418
curve-fitting models, reserve depletion estimation, 46
cyclic MEOR, 286
cyclic steam stimulation (CSS)
field applications, 307

general discussion, 287–288, 288 (figure)

doing recovery mechanisms, 305 (table)
overview, 9, 344
process characteristics, 304, 306 (table), 306–307
reservoir selection, 304, 305 (table)
SAGD/CSS Hybrid, 311
stages of, 304, 304 (figure)
cycloalkanes (naphthenes), 65

cycle looped system, subsea wells, 610, 611 (figure)
Daqing oil field, polymer flooding in, 262 (table), 263
Darcy units, 2
Darcy's law, 13–14, 56–57, 71, 73, 181, 398–400
data acquisition system, drill rig, 205
data mining. See oil field data mining
data-driven modeling for production optimization, 170–173, 171
(figure), 172 (figure)
Davy, Sir Humphry, 432
decks, floating platforms, 577, 578 (figure), 582, 590, 601, 601 (figure)
decline curve analysis (DCA)
hydraulic fracturing, 366–369, 367 (table), 368 (figure), 368
(table), 369 (figure)
natural gas reserves, 415, 416–419
reserve estimation, 45
decline production period, gas field, 421 (figure), 422–423
decommissioning
life-cycle stages, 652
options for, 557, 557 (figure)
risk involved, 617 (figure)
semisubmersible projects, cost of, 626–627, 627 (table)
decommissioning cost estimation in deepwater GOM, 571–597
cost estimation
algorithms for, 584, 585–591, 586 (figure), 587 (figure), 588 (table), 589 (figure), 590 (table)
challenges, 583–584
fixed platforms, 591–593, 591–592 (table)
floaters, 593, 594 (table)
methodology, 584, 584 (table), 585 (table), 586 (table)
top-down versus bottom-up, 582–583
total exposure, 593, 595, 595 (figure), 596 (figure), 597
uncertainty range, 583
work breakdown structures, 583
decommissioned structures, 571, 573 (table)
decommissioning requirements, 572 (table)
decommissioning stages, 581–582
deployment inventory
compliant towers, 573, 574–575 (table), 576 (figure), 576–577
data source, 573
fixed platforms, 573, 574–575 (table), 574 (figure), 576 (figure)
floaters, 577–578, 577 (figure), 578 (figure), 579–580
(table), 579 (figure), 580–581, 580 (figure), 581 (figure)
overall, 571–573, 572 (figure), 572 (table), 573 (table)
decommissioning for stratum thickness, 115–116, 115 (figure)
deployment development
Arctic, 302, 343–344, 344 (figure), 345 (table), 347
deployment geology, 603, 605–606, 607 (figure)
deployment systems, 606–607, 608 (figure)
deployment energy future, 35–36, 36 (figure)
deployment offshore components, 607–611, 609 (figure), 611 (figure), 612 (figure), 612 (table)
overview, 599–600
structure types used in, 599, 600 (figure)
See also deployment commissioning cost estimation in deployment GOM;
deployment systems; semisubmersibles
deployment offshore reservoirs, 302, 341–342, 341 (figure), 342
(table), 343 (figure), 344 (figure), 346–347
deflection tools, 219, 220 (figure)
deployment monitoring, 102
overview, 83–85, 84 (figure), 85 (figure)
parameters for, 95–96
recovery of structural, 113–116, 113 (figure), 114 (figure), 115 (figure)
degradation
of guar-based solutions, 359–360, 361 (figure)
oil, 462, 466, 467
dehydration
of gas hydrates, 437
natural gas, 244–245, 244 (figure)
in topsides facilities, 610–611
deliability and inflow performance analysis, 398–404, 401
(table), 402 (figure), 403 (figure), 403 (table), 404 (figure)
deliverability testing, gas well, 401
Delta House project, 655. See also semisubmersibles
density
crude oil, 65, 66, 66 (figure)
ideal gas, 62
petroleum product, 508
real gas, 63
stock tank oil, 65
density diffusivity equation, 398
density-based PDA method, 418–420, 419 (figure), 420 (figure)
denudation volume estimation, 115, 115 (figure)
deployment drive, 4, 4 (figure), 250 (table)
deposition, asphaltene. See asphaltene deposition
depositional environments, reservoirs, 5–6
depressurization
  in hydrate control, 437, 439–440
  reservoir, for methane hydrate production, 334–335
density, reservoir, 1, 2 (figure)
derrick, 199 (figure), 199 (table)
desalination, 366
desorption, coalbed methane, 8
desorption isotherms, capillary pressure by, 78–79, 78 (figure)
deterministic methods, reserve estimation, 44
development
  as life-cycle stage, 652
  natural gas field, plan for, 420–425, 421 (figure), 422 (figure),
  424 (figure), 425 (figure), 425 (table)
semisubmersible project
  cost of, 612–616, 613 (figure), 614 (figure), 615 (figure),
  625–626, 627 (table), 643
  development wells, 619, 620–621 (figure)
  drilling schedule, 619, 622, 622 (figure), 622 (table)
  flowline, umbilical, export pipeline, 623, 624 (table),
  625 (figure)
  risk involved, 617 (figure)
  well counts and footage drilled, 622, 623 (figure)
  well type, 623, 624 (table)
deviation, well trajectory, 223–224, 224 (figure)
Devonian period, 378, 378 (figure)
dew-point pressure, 3, 66–67, 67 (figure)
Diadema oil field, polymer flooding in, 264–265
diamond drag bits, 205–206, 207 (figure)
Dietz shape factors, 399, 400
dilute surfactant flooding, 283, 285 (figure)
directional drilling, 215–225
  directional well trajectory coordinates, 221–222, 221 (figure),
  222 (figure)
  measuring well trajectories, 219
  overview, 215–216, 216 (figure)
  planning trajectory changes, 223, 223 (figure)
  shale- and mudstone-hosted oil and gas, 373
  subsurface steering tools, 219–221, 220 (figure), 221 (figure)
  for tight gas, 322–323, 324 (figure)
  torque and drag, 224–225, 225 (figure)
  well trajectory terminology, 216–217, 217 (figure), 218 (figure),
  219 (figure)
directional permeability, 6, 10
  Dirichlet-type boundary condition, 186, 186 (figure)
disasters, 706, 708. See also safety
discharging practice, safe, 526, 526 (figure)
discretized form of flow equations, 182–185, 182 (figure), 183
  (figure), 185 (figure)
disproportionate permeability reduction (DPR), 268
dissipative QCM, 493
dissolved-gas drive, 4, 4 (figure)
documentation, numerical reservoir simulation, 193–194
Dongying Sag petroleum system simulation, 134–146
  analysis on petroleum system, 134–136, 134 (figure), 135
  (figure), 135 (table)
  artificial neural network simulation, 144–145, 144 (figure),
  145 (figure)
degeneracy
  in hydrate control, 437, 439–440
  reservoir, for methane hydrate production, 334–335
dehydrate control, 332–333
  reservoir, for methane hydrate production, 332–333
geothermal field evolution simulation, 138–140, 139 (table),
  140 (table), 141 (figure)
hydrocarbon expulsion history, 142–144, 143 (figure),
  143 (table)
hydrocarbon generation history, 140–142, 142 (figure),
  142 (table)
structure-stratum framework evolution, 136–138, 136 (figure),
  137 (figure), 138 (figure), 139 (figure)
trap evaluation example, 145–146, 145 (figure), 146 (table)
downhole rotary systems, 200–201, 203 (figure), 204 (figure)
downhole sensors, 702–703, 703 (figure)
downstream oil production processes, 679
drag, in directional drilling, 224–225, 225 (figure)
drag bits, 205–206
drag coefficient, 233
drainage conditions, poroelasticity, 90
draw works, 199 (figure), 199 (table)
drill bits, 205–207, 206 (figure), 207 (figure)
drill rig systems, 197–205
  hoisting system and drill strings, 198–199, 199 (figure), 199
  (table), 200 (figure), 201 (figure)
  mud circulation system, 201–202, 202 (table), 204 (figure)
  overview, 197–198, 198 (figure)
  power system, 198
  rotary systems, 199–201, 202 (figure), 203 (figure), 204 (figure)
  well control system, 202, 204–205, 205 (figure)
  well monitoring system, 205
drill ships, 227–228, 230, 230 (figure)
drill strings, 198–199, 199 (figure), 200 (figure), 201 (figure)
drilling
  as phase of production, 530
  in USOSC, 680–681
  waste from, 538–539, 539 (figure), 542, 555, 555 (figure)
  See also drilling technology methods: specific drilling
techniques
  drilling barges, 227, 230 (figure)
  drilling efficiency, 208–209
  drilling fluids, 207–208, 208 (figure)
  drilling optimization, 208–210, 209 (figure)
  drilling schedule, semisubmersible projects, 619, 622, 622 (figure),
  622 (table)
  drilling specific energy (DSE), 209, 209 (figure)
  drilling technology methods, 197–230
  directional drilling
    deviation, wander, and BHA design, 223–224, 224
    (figure)
    directional well trajectory coordinates, 221–222, 221 (figure),
    222 (figure)
    measuring well trajectories, 219
    overview, 215–216, 216 (figure)
    planning trajectory changes, 223, 223 (figure)
    shale- and mudstone-hosted oil and gas, 373
    subsurface steering tools, 219–221, 220 (figure), 221 (figure)
    for tight gas, 322–323, 324 (figure)
    torque and drag, 224–225, 225 (figure)
    well trajectory terminology, 216–217, 217 (figure), 218 (figure),
    219 (figure)
employee training, in health and safety management systems, 552
emulsifiers, 438, 439
emulsions, treating, 235–236, 236 (figure)
end-to-end flooding, 251, 252 (figure)
energized fracturing fluids, 362–363
energy conservation for flow, 510
energy consumption
reducing, 555
in USOSC, 679, 681
energy control techniques, 560
energy dissipation and supply, pipelines, 513, 513 (figure)
energy flow optimization model (EFOM), 49 (table)
energy future, 31–41, 693–709
deep-water oil and gas outlook, 35–36, 36 (figure)
enhanced oil recovery, 698–701, 700 (figure), 701 (figure)
fuel production and consumption, 31–35, 32 (figure),
33 (figure), 34 (figure)
geopolitics and environment, 706–708, 707 (figure)
overview, 693
technological advancements and innovation, 704–706, 704
(figure), 705 (figure)
total world energy consumption, 31 (figure)
unconventional resources
gas, 40–41, 41 (figure), 42 (table)
general discussion, 697, 697 (figure), 698 (figure), 699 (figure)
oil, 36–40, 37 (figure), 38 (figure), 38 (table), 39 (figure),
39 (table), 40 (figure), 40 (table)
upstream resources and reserves, 693–694, 694 (figure), 695
(figure), 696, 696 (figure)
well, reservoir, and facility management, 701–704, 702 (figure),
703 (figure)
energy market, global, 657, 658 (figure). See also specific energy
sources
energy studies on natural gas hydrates, 434–435
energy systems models
electricity system models, 52
examples of, 49–50 (table)
hybrid models, 51, 52 (figure)
opimization models, 50–51, 50 (figure)
overview, 48
simulation models, 51, 51 (figure)
Enform, 547
ingineering studies on natural gas hydrates, 434
enhanced microbial water floods, 286
enhanced oil recovery (EOR), 249–294
energy future, 698–701, 700 (figure), 701 (figure)
foam flooding, 265–266, 265 (figure)
global status of, 294, 294 (figure)
immiscible gas displacement processes, 276
implementation of processes, 293–294, 293 (table)
low-salinity water flooding, 291–292
miscible displacement processes, 271–275, 272 (table), 273
(figure), 275 (figure), 276 (figure)
mobility-control processes, 256
overview, 255–256, 461
performance of, 256, 256 (figure)
in situ conversion processes, 292, 293 (figure), 340
in situ permeability modification processes, 266 (figure),
266–270, 267 (figure), 267 (table), 268 (table), 269 (table)
solar energy in, 688–689, 688 (figure), 690 (figure)
stages of crude oil production, 249–255, 250 (figure),
252 (figure), 253 (figure), 254 (figure)
techniques for, 468, 469 (table)
water-alternating gas process, 270–271, 270 (figure), 271 (figure)
See also chemical flooding; microbial enhanced oil recovery; polymer flooding; thermal recovery methods
enriched-gas process, MCM, 273
Enterobacter cloacae in MEOR, 473
environmental concerns, 537–543
associations for, 547–548
atmospheric effects and emissions, 537–538, 537 (figure), 538 (figure)
ecological effects, 541–543 and energy future, 708
fracturing fluids, 365–366
gas hydrates, 435–436
groundwater contamination, 540, 540 (figure)
hydrate control, 440
hydraulic fracturing, 388–389, 673, 675
land and soil effects, 540–541, 541 (table)
misalignment and recovery of, 112–113, 112 (figure), 113 (figure)
fault displacement, elimination and recovery of, 112–113, 112 (figure), 113 (figure)
fault tree analysis, 551
faults, in 3D static geological modeling, 111–112, 111 (figure)
field development plan, for natural gas, 420–425, 421 (figure), 422 (figure), 424 (figure), 425 (figure), 425 (table)
field testing, methane hydrate production, 335
filling practice, safe, 526, 526 (figure)
filtration method
asphaltene precipitation studies, 487
HPHT, 489
filtration units, removing trace oil with, 240–241
finite-difference approximation, 182–184, 183 (figure)
fire flooding. See in situ combustion
fire hazards, 546, 557–558
fire prevention and extinguishing, 525
first contact miscible (FCM), 271–273, 272 (figure), 272 (table), 273 (figure)
fissure track, 121
fissure zone evaluation, 128–129
fixed platforms, 600 (figure)
decommissioning cost, 585 (table), 589–590, 590 (table), 591–593, 591–592 (table), 595, 595 (figure)
decommissioning stages, 581–582
deepwater inventory, 573, 574–575 (table), 574 (figure), 576 (figure)
fixed roofs, storage tank, 521, 521 (figure)
flaring, 557, 559, 559 (figure)
flexible piping system, storage tank, 520
flexible wiper seals, 520
flexural-slip mechanism recovery method, 113–114, 113 (figure)
floating force, 125
floating production, storage, and offloading (FPSO) vessels, 600 (figure)
deep offshore reservoirs, 341–342, 343 (figure), 344 (figure)
deepwater inventory, 578, 579 (figure)
overview, 577, 577 (figure)
floating roofs, storage tank, 519
floating systems (floaters)
decommissioned, 571, 573 (table)
decommissioning cost, 585 (table), 590–591, 590 (table), 593, 594 (table), 595, 596 (figure)
decommissioning stages, 581–582
deepwater inventory, 577–578, 577 (figure), 578 (figure), 579–580 (table), 579 (figure), 580–581, 580 (figure), 580 (table), 581 (figure)
ofshore drilling, 226–228, 229 (figure), 230, 230 (figure)
overview, 600 (figure), 600–602
structural components, 601–602, 601 (figure), 602 (figure)
See also semisubmersibles
flows, liquid-level control, 238, 238 (figure)
flooding processes. See specific processes
Flory–Huggins regular-solution-based models, 490
flow
in deliverability and inflow analysis, 398–404
wellbore and outflow performance analysis, 404–411
flow assurance, for gas production from hydrates, 437
flow control, gravity separator, 237–238, 237 (figure)
flow equations, in numerical reservoir simulation
discretized form of, 182–185, 182 (figure), 183 (figure), 185 (figure)
numerical solution of linear systems of equations, 188–189, 188 (figure), 189 (figure), 189 (table)
overview, 180
in rectangular coordinates, 180–182, 180 (figure)
flow patterns/flow regimes, 408
flow rate
calculating achievable, 412–413
pipelines, 510–511
flow test, permeability measurement through, 13
flowback of fracturing fluid, 327–328
flowing material balance (FMB) methodology, 418, 420, 420 (figure)
flowlines
decommissioning cost, 582, 585 (table), 589 (figure), 593
deepwater systems, 610
semisubmersible projects, 623
flue gas, 272, 276
fluid electric properties, reservoir rock and, 59–60, 60 (figure)
fluid inclusion, 121
fluid potential, 125
fluid saturation, 14, 55–56, 181–182
fluid separation. See gravity separation
fluids
drilling, 207–208, 208 (figure)
hydraulic fracturing
breaker-free, 363, 364 (figure)
chemicals found in, 540, 540 (figure)
cleanup, 354, 359–360
composition example, 364–365, 364 (table), 365 (table)
energized, 362–363
environmental aspects of, 365–366
flowback, 327–328
guar alternatives, 363
guar-based, 358–360, 358 (figure), 361 (figure)
overview, 351–352
potential for technology improvement, 390
rheological properties of, 363
slickwater, 360–361, 362 (figure)
for tight gas production, 325–328, 326 (table), 327 (table), 336
viscoelastic surfactant-based, 361–362, 362 (figure)
natural gas, separation of, 531
in well performance analysis, 412, 412 (figure)
See also reservoir fluids
foam flooding, 265–266, 265 (figure)
foam systems, as fracturing fluids, 362–363
foam-assisted W AG (FAWAG) process, 271, 271 (figure)
footage drilled, semisubmersible projects, 620–621 (figure), 622, 623 (figure)
Forchheimer’s equation, 398, 400
forecasting, field production
build-up production period, 421–422, 421 (figure)
decline production period, 422–423, 422 (figure)
example of, 423–425, 424 (figure), 425 (figure), 425 (table)
plateau production period, 422
formation damage, 75
formation fluid, separation of, 530
formation pore fluid pressure, 210–211
formation volume factor, 65–66, 66 (figure)
formation water, 62, 69, 456. See also reservoir fluids
forward ISC, 314
forward-difference approximation, 183, 183 (figure)
fossil fuels
comparative analysis between renewables and, 657–660, 659 (figure), 659 (table), 660 (table)
role in world energy production, 301, 657, 658 (figure)
See also specific fossil fuels
foundation, storage tank, 522
four-dimensional (4D) seismic monitoring, 703 (figure), 703–704
fracture pressure, 210–211, 211 (figure), 212 (figure)
fracture toughness, 95, 96, 98, 357
fractured reservoirs, 11, 17–18, 58, 58 (figure)
fractures
as form of failure, 94–95, 95 (figure)
polymer flooding as causing, 260–261
and stress determination in subsurface, 100 (figure), 100–101
See also hydraulic fracturing
fracturing-fluid flowback, 327–328
framework modeling, 110. See also structure-stratum framework simulation
free gas, in GHDs, 450–451
free water knockouts, 235, 236 (table)
freeze wall, 292, 293 (figure)
friction factors, 405, 409, 410
Front Runner umbilical, flowline, and riser removal cost, 588–589
frasht treatment, bitumen extraction process, 317
Fuel-to-Liquid energy future, 39–40
fugitive emissions, 537–538, 554, 682
full-asset type curve analysis, 174, 175 (figure)
full-field models, numerical reservoir simulation, 191
fully 3D models, hydraulic fracturing, 356, 357 (table)
function-based approach, metagenomics, 465, 466–467
future economics, semisubmersible projects, 645, 647 (table)
future of energy industry. See energy future
fuzzy comprehensive evaluation of trap, 132
gamma-ray tools, 16

gas
  in coal, 7
  gravity separator emissions, 238
  microbial, 470
  permeability, 57, 57 (figure), 58 (figure)
  phase behavior, 66–67, 67 (figure)
  relative permeabilities, 73
  See also greenhouse gases; natural gas; reservoir fluids; specific
  unconventional resources

gas condensate reservoirs, 3–4, 68, 68 (figure), 68 (table)

gas constraint, gravity separator design, 234

gas diffusivity equation, 398–399

gas exchange, methane hydrate production, 335

gas expansion reservoirs, 5

gas flooding
  continuous, 270, 270 (figure), 271 (figure)
  immiscible displacement processes, 276
  miscible displacement processes, 271–275, 272 (table), 273
    (figure), 275 (figure), 276 (figure)
  overview, 468
  in secondary oil recovery, 250–251
  WAG process, 270–271, 270 (figure), 271 (figure)

gas flotation units, removing trace oil with, 240–241, 240 (figure)

gas formation volume factor, 63

gas hydrate deposits (GHDs)
  formation of, 445
  hydrate formation zones, 446–447, 448 (figure), 449 (figure)
  location of, 447–448, 450–451, 450 (figure)
  overview, 429, 430 (figure)
  See also methane hydrates; natural gas hydrates

gas reservoirs
  classification of, 3
  conventional versus unconventional, 319, 321
  drive mechanisms in, 5
  original gas in place, 76–77
  See also reservoirs; specific resources derived from gas reservoirs

gas shale, 8–9, 376. See also shale gas

gas-cap drive, 4–5, 250 (table)
gas-to-liquids (GTLs), 40, 40 (figure), 40 (table)
gate valves, 511, 512 (figure)
Gaussian curve-fitting models, 46
gelled foam, 266
generation history, 3D dynamic simulation of, 121–122

genomic analysis of biological assemblages, 464–467,
  464 (figure)
geological evaluation of trap, 130–132, 145–146, 146 (table)
geological modeling
  in reservoir characterization, 190
  3D, 109–112, 110 (figure), 111 (figure)
geology, deepwater, 603, 605–606
gemechanics. See petroleum geomechanics
geophysical technologies, 16–17, 336. See also well logging
geopolitics, and energy future, 706–708, 707 (figure)
geopressured reservoirs, 5
geo-statistical modeling, 190
geothermal field evolution simulation
  Dongying Sag petroleum system example, 138–140, 139
    (table), 140 (table), 141 (figure)
heat flow, in geothermal field evolution simulation
calculating value of, 118–120, 119 (table), 120 (table)
status of, 116–117
heat requirements, emulsion treater, 236
heavy oil, 302–316
classification of, 3, 287 (table)
overview, 9, 287
physical properties of, 302–303, 302 (table)
worldwide distribution of, 303–304, 303 (figure), 304 (figure)
See also thermal recovery methods
Herschel–Buckley (HB) rheological behaviors, 363
heterogeneous reservoirs, 11, 16, 17–18
high-performance liquid chromatography (HPLC), 485
high-pressure air injection (HPAI), 314
high-pressure gas drive, MCM, 273
high-pressure high-temperature (HPHT) conditions, asphaltene
precipitation in, 488–489
high-pressure microscopy (HPM), 489
high-temperature high-pressure (HTHP) drilling fluids, 207–208
high-temperature high-pressure (HTHP) drilling fluids, 207–208
precipitation in, 488–489
hydrocarbon accumulations in unconventional locations, 301.
See also deepwater development; deepwater offshore reservoirs
hydrocarbon expulsion history
Dongying Sag petroleum system simulation, 142–144, 143
(figure), 143 (table)
3D dynamic simulation of, 122–123, 122 (figure)
hydrocarbon gases, 62. See also gas; natural gas; specific gases
hydrocarbon generation history
Dongying Sag petroleum system simulation, 140, 142, 142
(figure), 142 (table)
generation from source rocks, 377–378, 378 (figure), 379
(figure), 380 (figure)
3D dynamic simulation of, 121–122
hydrocarbon migration and accumulation history simulation,
123–130
artificial intelligence model, 126–130, 126 (figure), 127 (figure)
concept model, 123–124
driving mechanism and mathematic model, 125
phase judgment submodel, 124–125
hydrocarbon reservoirs. See numerical reservoir simulation;
reservoir fluids; reservoir rock; reservoirs
hydrocarbon resource distribution, 301, 302 (figure). See also
specific hydrocarbon resources
hydrocarbon source rock. See reservoir rock; shale- and mudstone-
hosted oil and gas; source rock
hydrocarbon transmission ratio, 129–130
hydrocyclones, removing trace oil with, 239
hydrodynamic retention, polymer, 260 (table)
yieldpower, 35
hydrostatic weighing, 13
Index

hyperbolic decline, 367, 367 (table), 416–417

hysteresis
  capillary, 70–71, 71 (figure)
  contact angle, 69, 69 (figure)
  relative permeability, 73

I

Iatroscan method, SARA analysis, 485, 486

ideal gas law, 62–63

ignition sources, 525, 557

immiscible gas displacement processes, 276

implicit-pressure, explicit-saturation (IMPES) formulation, flow equations, 184–185

implicit-scheme formulation, flow equations, 184, 185 (figure)

improved oil recovery (IOR) processes, 255

in situ combustion (ISC), 290–291, 291 (table), 292 (figure), 313–315, 314 (figure), 315 (figure)

in situ conversion processes (ICPs), 292, 293 (figure), 340

in situ deformation monitoring, 102

in situ permeability modification processes, 266–270, 266 (figure), 267 (figure), 267 (table), 268 (table), 269 (table)

in situ reactive gel system, 266–267

in situ retorting, 384–386, 385 (figure)

in situ stress, 87, 99–101

in-capule retorting, 386

incident indicators, 552, 552 (figure)

incident management, 552

incidents, major, 544–546 (table), 561–562, 563 (figure)

inclination, well trajectory, 216

incremental oil recovery factor, 256, 256 (figure)

Independence project, 653–654. See also semisubmersibles

indirect deformation monitoring, 102

indirect method, asphaltene precipitation studies, 488

induction tools, 16

inelasticity, 91–92, 91 (figure), 92 (figure)

inference rules, artificial neural networks, 126

infinitesimal deformations, 84

inflow performance analysis, gas reservoirs, 398–404, 401 (table), 402 (figure), 403 (figure), 403 (table), 404 (figure)

inflow performance relationships (IPRs)
  deliverability and inflow analysis, 399–404, 401 (table), 402 (figure), 403 (figure), 403 (table), 404 (figure)

well performance analysis, 411–414, 411 (figure)

infrared (IR), SARA analysis with, 485

inherently safe design, 561, 561 (figure), 562 (figure)

initial conditions, numerical reservoir simulation, 187, 187 (figure), 192

initial production rates, semisubmersible projects, 630, 635 (table), 636 (figure)

injection processes. See specific flooding processes

injection wells, 251

injuries. See safety inspections, worksite, 552

instrument air systems, solar-powered, 689–690

integrated oil sands mining operations. See oil sands mining interaction matrix, 551

interfacial tension (IFT)
  asphaltenes precipitation studies, 488
  effect on oil recovery, 277, 277 (figure)
  overview, 69, 69 (figure)

intergranular-intercrystalline porosity systems, 6

isotherm, reservoirs, 9–10

isothermal compressibility, 60–61, 62, 66

isothermal pressure versus specific volume (p-V) diagram, 67, 67 (figure)

isotherms, capillary pressure by, 78 (figure), 78–79

isotropic elasticity, 87, 88

iterative solution methods, numerical reservoir simulation, 188–189, 188 (figure)

J

Jack project, 655. See also semisubmersibles

jacket removal, 582

jackups, 225–226, 228 (figure)

J-function (JF), Leverett, 70, 71 (figure)

Johnson-Bossler-Naumann (JBN) method, 75

J-shaped well configuration, SAGD, 311

K

kelly pipes, 199–200

Kelvin’s equation, 78

kerogen, 337–341
  commercial development, 341
  composition of, 338–339, 338 (tablet), 339 (figure)
  defined, 375
  general discussion, 346
  operational challenges, 340–341
  overview, 302, 337–338
  production processes, 339 (figure), 339–340
  resource estimate, 339

See also oil shale; shale oil

Kerrobert Pilot, THAI process, 315

Kristianovic, Geertsma, and de Klerk (KGD) model, 355, 355 (figure), 357 (table)

kick detection, 213–214

kill line, BOP stack, 205

kinetic hydrate inhibitors (KHI), 437–438, 439

kinetics of asphaltene precipitation, 490

Klinkenberg effect, 8, 13–14, 57, 57 (figure)

Kropp, safety, 560

labour studies
  core sample electric properties, 60, 60 (figure)
  microbial enhanced oil recovery, 470–473
  relative permeability, 74–75, 74 (figure)
biopolymers and biofilms, 470
biosurfactants, 286, 287, 469–470
cyclic, 286
ergy future, 706
enhanced water flooding, 286
field trials, 473–475
fundamentals and mechanisms, 468–470, 469 (table)
laboratory studies, 470–473
microbial gases, solvents, and acids, 470
organic oil recovery, 286–287
overview, 286–287, 468
microbiology of petroleum reservoirs, 461–475
culture-dependent study techniques, 463–464
future perspectives, 475
metagenomics, 464 (figure), 464–467
overview, 461–463, 463 (table)
problems associated with studying, 467–468
See also microbial enhanced oil recovery
microemulsion phase behavior, 278–280, 279 (figure), 281
microemulsion polymer flooding systems, 284 (table)
minimum miscibility pressure (MMP), 275, 275 (figure), 276 (figure)
minimum miscibility enrichment (MME), 275, 276 (figure)
mineralogy of shale and mudstone, 376–377, 376–377 (figure)
See migration history.
microseismic monitoring, 373, 388
microscopy, in asphaltene precipitation studies, 487, 489
microscopic sweep efficiency, 276 (figure), 277
Miocene trend, 605, 607 (figure)
microspheres, 267–268
Middle East
energy future, 706–707
EOR technique implementation in, 699–700
oil production, 661, 662, 662 (figure), 663, 663 (figure), 664 (figure)
midstream oil production processes, 679
migration history. See hydrocarbon migration and accumulation
history simulation
mineralogy of shale and mudstone, 376–377, 376–377 (figure)
minimum miscibility enrichment (MME), 275, 276 (figure)
minimum miscibility pressure (MMP), 275, 275 (figure), 276 (figure)
mini-tension leg platforms (MTLPs), 578, 579–580 (table), 580 (figure), 590–591, 590 (table), 600 (figure)
Miocene trend, 605, 607 (figure)
miscible gas injection processes, 271–275
carbon dioxide flooding, 274–275
first contact miscible, 271–273, 272 (figure), 273 (figure)
minimum miscibility enrichment, 275, 276 (figure)
minimum miscibility pressure, 275, 275 (figure), 276 (figure)
multiple contact miscible, 273–274
overview, 271, 271 (table)
WAG process, 270
miscible injectant stimulation (MIST), lateral, 272–273, 273 (figure)
Mississippian Limestone Play (MLP), 368–369
mitigation strategies, asphaltene deposition, 498–499
mixed porosity system reservoirs, 6
mobile offshore drilling units (MODUs)
floating, 226–228, 229 (figure), 230, 230 (figure)
overview, 225
semisubmersible, 227, 230 (figure)
submersible, 225, 227 (figure), 228 (figure)
mobile offshore production units (MOPUs), 578, 579 (figure), 601.
See also floating systems; semisubmersibles
mobile oil zone (MOZ), THAI process, 314, 314 (figure), 315
mobility ratio, 257–258
mobility-control processes, in EOR, 256, 265–266. See also
crude oil flooding
mobility-induced viscous fingering, 258, 258 (figure)
model for analysis of demand (MAED), 49 (table)
model for energy supply strategy alternatives and their general
environmental impacts (MESSAGE), 49 (table)
model for optimization of dynamic energy systems with time-
dependent components and boundary conditions (MODEST),
49 (table)
modeling, reservoir, 18. See also specific modeling types
modular energy system analysis and planning (MESAP), 49 (table)
Mohr circle diagram, 86–87, 87 (figure), 93, 93 (figure)
Mohr–Coulomb failure criterion, 93–94, 93 (figure), 94 (figure)
moisture control, gas hydrates, 437
molecular weight (MW)
thatene, 484–485
crude oil, 65
gas, 63
polymer, 260, 264 (table), 269 (table)
monitoring, in environmental management, 548–549. See also
monitoring, in environmental management, 548–549
monitoring system, drill rig, 205
monoborate, 359
monobore well technology, 213
monoethylene glycol (MEG), 438–439
mooring systems, floating platforms
decommissioning cost, 590–591, 593
overview, 577, 578 (figure), 601–602, 601 (figure)
removing, 582
Morpeth MTLP, 591
morphology of hydrate crystals, 444, 444–445 (figure)
mud circulation system, drill rig, 201–202, 202 (table), 204 (figure)
mud pressure bounds, 210–211, 210 (figure), 211 (figure), 212 (figure)
mud-pulse-telemetry (MPT), 219
mudrock, 375
muds, drilling, 530, 538–539, 555, 555 (figure)
mudstone
mineralogy of, 376–377 (figure), 376–377
oil and gas production from, 387–389
overview, 375
See also shale- and mudstone-hosted oil and gas
multicycle curve-fitting models, 46
Multidrain SAGD, 311
multiphase flow
hydrate control and, 441
well performance analysis, 412
wellbore and outflow performance analysis, 408–411
multiphase problems, numerical reservoir simulation, 187
multiple contact miscible (MCM), 271, 272 (table), 273–274
multiple linear regression, 171, 171 (figure)
multiproduct pipelines, 513, 513 (figure)
multiscale geothermal field, dynamic simulation of, 117–118,
118 (figure)
multiscale modeling, 111, 111 (figure)
multistage hydraulic fracturing, 388
multistage triaxial compression test, 97

N
Na Kika project, 653. See also semisubmersibles
nanoparticle-modified VES systems, 362, 362 (figure)
nanoscale aspects of hydrates, 441, 442 (figure)
naphthenes, 65
naphthenic acids, 317
national energy modeling system (NEMS), 49 (table)
natural bitumen. See bitumen
natural gas
  compression, 242–244, 243 (figure), 244 (figure)
  consumption, 26 (figure), 29–31, 29 (figure), 30 (figure),
  30 (table), 669, 671 (figure)
  data reliability, 41–43
  deepwater, 35–36, 36 (figure)
  dehydration, 244–245, 244 (figure), 610–611
  depletion estimation, 45–48
  energy future, 33–34, 33 (figure), 34 (figure)
  generation from source rocks, 377–378, 378 (figure),
  379 (figure), 380 (figure)
  gravity separator emissions, 238
  history of, 529
  liquefied, 666, 669–671, 671 (table)
  major producers of, 529
  overview, 21, 26–27
  phase behavior, 66–67, 67 (figure)
  pipelines for, 513–514
  price of, 667, 668 (figure), 671
  production history, 666–669, 668 (figure)
  production process overview, 529–531, 530 (figure)
  production rates, 26 (figure), 29–31, 29 (figure), 30 (figure),
  30 (table), 669, 669 (figure), 670 (figure)
  refining, 531
  reserves
    contemporary, 669, 669 (figure), 670 (figure)
    energy future, 694, 696, 696 (figure)
    estimation methods, 43–45
    general discussion, 27–29
    historical data, 27 (figure), 28 (figure)
    overview, 26 (figure)
    top ten countries, 27 (table)
    reserve-to-production ratio, 26 (figure), 28–29
  as reservoir fluid, 62–63, 62 (table), 63 (figure)
  role in world energy market, 657, 658 (figure)
  semisubmersible production of, 628, 631 (table),
  632 (figure)
  storage, 523, 523 (figure)
  in USOSC, 680
See also natural gas production engineering; reservoir fluids;
  specific production techniques; specific unconventional
  resources; unconventional hydrocarbon resources
natural gas from coal. See coalbed methane
  commercial production, 452–454, 453 (figure), 454–456
  (figure), 456–458, 457 (figure)
  decomposition of, 442–443
  dissociation conditions, 432 (figure)
  dissociation prediction, 431 (figure)
formulation of
  conditions for, 241, 242 (figure)
  and location of deposits, 447–448, 448 (figure)
  overview, 442, 442 (figure), 443 (figure)
  properties of hydrate, 445–446
  results of studying, 451–452, 451 (table)
  history of research on, 431–435
hydrate control, 436–442, 438 (figure), 439 (figure),
  440 (figure), 441 (figure), 442 (figure)
  location of deposits, 447–451, 450 (figure)
morphology of hydrate crystals, 444, 444–445 (figure)
  overview, 9, 241–242, 429–430, 442
  phase diagram, 431 (figure)
  preventing formation of, 241–242, 242 (figure), 242 (table)
  properties of, 445–446, 445 (figure)
  and regional ecology and global changes, 435–436
  removal of, 439–440
  thermal properties, 446
  zone of formation, 446–447, 448 (figure), 449 (figure)
See also methane hydrates
natural gas production engineering, 395–425
  field development and performance prediction, 420–425, 421
  (figure), 422 (figure), 424 (figure), 425 (figure), 425 (table)
  overview, 397 (figure), 397–398
  reserves assessment, 415–420, 416 (figure), 419 (figure), 420
  (figure)
  reservoir deliverability and inflow performance analysis,
  398–404, 401 (table), 402 (figure), 403 (figure), 403 (table),
  404 (figure)
  well and system performance analysis, 411–414, 411 (figure),
  412 (figure), 413 (figure), 413 (table), 414 (figure), 414
  (table)
  wellbore and outflow performance analysis, 404–411,
  409 (table)
naturally fractured reservoirs, 11, 17–18, 58, 58 (figure)
naturally occurring radioactive material (NORM), 238–239,
  560, 560 (figure)
near-infrared (NIR), 485, 487, 489
negative salinity gradient, 283
Neumann-type boundary condition, 186, 186 (figure)
nearby networks. See artificial neural networks
neutron radiation, 16
Newtonian fracturing fluids, planar-3D model for, 356–358
Newtonian liquids, 208, 208 (figure)
Newton's Law, 233, 234
Nigeria, regulatory framework in, 536
nitrate reducers, 463
nitrogen (N2)
  enhancing recovery of CBM with injection, 8
  in FCM, 272
  in immiscible gas flooding, 276
  in MCM, 274
nitrogen foam, 363
Niuzhuang–Wangjiagang region. See Dongying Sag petroleum
  system simulation
NODAL Analysis®, gas well, 411–414, 411 (figure), 412 (figure),
  413 (figure), 413 (table), 414 (figure), 414 (table)
noise hazards, 546
nonfossil fuels, 33, 34–35, 34 (figure). See also renewable energy
  sources
nonionic surfactants, 278 (table), 282
non-Newtonian liquids, 208, 208 (figure)
nonrenewable energy sources, 657–660. See also specific energy
  sources
nonwetting phase, defined, 69
nonwetting phase trapping, 71, 71 (figure)
normal geothermal field, 116
normal strain, 84–85, 85 (figure)
normal-compaction section submodel of thermal evolution, 117
Index

North America
 associations pertaining to oil and gas industry, 547
 energy future, 706–707
 major incidents in, 544–546 (table)
 regulatory framework in, 532–533
 N-SOLV technology, 316, 345
 nuclear magnetic resonance (NMR) method, 488
 nuclear power, 35
 nucleation, natural gas hydrates, 445
 nucleic acids extraction, 465–466
 numerical reservoir simulation, 177–195
 discretized form of flow equations, 182–185, 182 (figure), 183 (figure), 185 (figure)
documentation, 193–194
 flow equations in rectangular coordinates, 180–182, 180 (figure)
 formulations, 180
 fundamentals of, 180
 general discussion, 194–195
 gridding, boundary types, and conditions, 185–187, 185 (figure), 186 (figure), 187 (figure)
 model selection and construction, 190–192, 191 (figure), 192 (table)
 numerical solution of linear systems of equations, 188–189, 188 (figure), 189 (figure), 189 (table)
 overview, 177–180, 178 (figure)
predictions, 193, 194 (figure)
 properties required to construct, 178, 179 (table)
 reservoir characterization, 190
 statement and prioritization of objectives, 189–190
 validation, 192–193, 192 (table), 193 (figure), 194 (figure)

oblique shearing mechanism, 114, 114 (figure)

occupational hazards
 health and safety management systems, 549–553, 550 (figure), 551 (figure), 552 (figure), 553 (figure)
 minimizing, 557–562, 558 (figure), 559 (figure), 560 (figure), 561 (figure), 562 (figure), 563 (figure)
 overview, 543, 546–547
 See also safety
 Occupational Health and Safety Advisory Services (OHSAS), 553
 Offset SAGD, 312
 offshore conditions, gas hydrate formation in, 449 (figure)
 offshore drilling
 bottom-founded systems, 225–226, 226 (figure), 227 (figure), 228 (figure), 229 (figure)
 floating systems, 226–228, 229 (figure), 230, 230 (figure)
 overview, 225
 See also decommissioning cost estimation in deepwater
 GOM; deepwater development; semisubmersibles
 offshore pipelines, 514, 514 (figure)
 offshore reservoirs, deepwater, 302, 341–342, 341 (figure), 342 (table), 343 (figure), 344 (figure), 346–347
 oil
 consumption, 22 (figure), 24–26, 25 (figure), 26 (table), 666, 667 (figure)
data reliability, 41–43
deepwater, 35–36, 36 (figure), 343–344
depletion estimation, 45–48
generation from source rocks, 377–378, 378 (figure)
in Messoyakha gas hydrate deposit, 456, 457 (figure)
numerical reservoir simulation, 177–195
 overview, 461–462
 price of, 661, 662, 663, 663 (figure), 693, 694 (figure)
 production
 contemporary, 664–666, 666 (figure)
historical data, 25 (figure)
history of, 660–664, 662 (figure), 663 (figure), 664 (figure)
 overview, 22 (figure), 24–26
 top ten countries, 26 (table)
 prospective outlook on, 21
 relative permeability, 73
 reserves
 contemporary, 664–666, 665 (figure)
ergy future, 693–694, 695 (figure), 696
 estimation methods, 43–45
 historical data, 23 (figure), 24 (figure)
 overview, 21–24, 22 (figure)
 top ten countries, 23 (table)
 reserve-to-production ratio, 22, 22 (figure), 23, 24 (figure), 695 (figure)
as reservoir fluid, 64 (table), 65–66, 66 (figure)
 reservoir rock wettability, 71–72, 71 (figure)
 role in world energy market, 657, 658 (figure)
 semisubmersible production of, 628, 631 (table), 632 (figure)
 trace, removal from wastewater, 239–241, 240 (figure)
 See also energy future; microbiology of petroleum reservoirs;
 petroleum geomechanics; reservoir fluids; specific entries under “hydrocarbon”; specific oil types; unconventional hydrocarbon resources; upstream oil supply chain
 oil field data mining
 artificial neural networks, 149–152, 150 (figure), 151 (figure)
 production optimization
 data availability and statistical analysis, 168–170, 169 (table), 170 (table)
data-driven modeling, 170–173, 171 (figure), 172 (figure)
 full-asset type curve analysis, 174, 175 (figure)
single-well, single-parameter sensitivity analysis, 173, 173 (figure)
single-well, type curve analysis, 173, 174 (figure)
single-well uncertainty analysis, 174–175, 175 (figure)
 reservoir characterization
 overview, 152–153, 152 (figure)
 seismic survey, 154
 seismic to well logs, 153–154, 153 (figure)
synthetic model, 154–161, 155 (figure), 155 (table), 156 (figure), 157 (figure), 158 (figure), 158 (table), 159–161 (figure), 161 (table)
 Valley Field case study, 161–164, 162 (figure), 163 (figure), 164 (table), 165–168 (figure), 165 (table)
oil recovery factor
 incremental, 256, 256 (figure)
 secondary oil recovery, 255
 oil reservoirs
 See also microbiology of petroleum reservoirs; reservoirs
 oil sands mining
 bitumen extraction, 317
 bitumen upgrading, 318–319, 320 (figure), 320 (table)
 challenges of, 319, 320 (figure)
ergy future, 37–38, 38 (figure)
environmental concerns, 537
general discussion, 345–346
 oil sand tailings, 317–318, 318 (figure), 318 (table), 319 (table)
 overview, 302, 316–317
optimization, drilling, 208–210, 209 (figure).
See also optimal renewable energy model (OREM), 49 (table)
optimal depletion theory, 48
operating pressures
   gravity separator, 236–237, 237 (figure)
topsides facilities, 610, 612 (table)
operator liability, decommissioning, 597
optimal depletion theory, 48
optimal renewable energy model (OREM), 49 (table)
optimization, drilling, 208–210, 209 (figure). See also production optimization, data mining for
optimization energy systems modeling platforms, 49 (table), 50–51, 50 (figure)
 optimum offtake pattern, 425
 optimum salinity concentration, 280–281
 Ordovician period, 378, 379 (figure)
organic oil recovery, 286–287
Organization for Economic Co-operation and Development (OECD) countries
   natural gas consumption, 29, 29 (figure), 33, 33 (figure), 34 (figure)
   natural gas production, 30 (figure)
   natural gas reserves, 27–28, 27 (figure)
nonfossil fuels in, 35
oil consumption, 25 (figure)
oil production, 25 (figure)
oil reserves, 23 (figure)
   projected energy consumption, 31, 31 (figure), 32 (figure)
share of consumption for fuel types, 34 (figure)
Organization of Petroleum Exporting Countries (OPEC)
oil production, 25 (figure), 661, 662
oil reserves, 22–23, 23 (figure)
projections of liquid fuel production, 32, 32 (figure)
orifice meters, 246, 246 (figure)
original-gas-in-place (OGIP), assessment of, 76–77, 415, 416, 416 (figure), 418, 419–420, 419 (figure), 420 (figure)
outflow performance
well performance analysis, 411–414, 411 (figure)
wellbore performance analysis, 404–411, 409 (table)
overbalanced drilling fluids, 207–208, 208 (figure)
overcompaction section submodel of thermal evolution, 117
overtraining, neural network, 151
ownership, semisubmersible projects, 644
oxidizers, as breakers for fracturing fluids, 359, 360

paraffin wax control, 441
parallel plate coalescer, removing trace oil with, 239–240, 240 (figure)
passive solar energy, 684
pattern flooding, 251, 252 (figure), 253, 253 (figure)
PDC bits, 205, 206, 206 (figure)
peak production to reserves ratio, semisubmersible projects, 631, 635, 637 (table)
penndulum force, 224, 224 (figure)
Peng–Robinson (PR) EOS, 67
perceptrons, 149
performance forecasting, gas field
   build-up production period, 421 (figure), 421–422
   decline production period, 422 (figure), 422–423
   example of, 423–425, 424 (figure), 425 (figure), 425 (table)
   plateau production period, 422
performance indicators, environmental, 548
peripheral flooding, 251, 252 (figure)
Perkins, Kern, and Nordgren (PKN) model, 355, 355 (figure), 357 (table)
permafrost areas, gas hydrate deposits in, 447–448, 450–451, 450 (figure)
permeability
   absolute, 11, 13–14
   CBM reservoirs, 8, 330–331
core analysis, 13–14
directional, 6, 10
effective, 11, 73, 74
fracture, 58
   grain size and pore size distributions, 58–59
   horizontal, 10–11, 14
in situ permeability modification processes, 266–270, 266 (figure), 267 (figure), 267 (table), 268 (table), 269 (table)
liquid, 56–57
   maximum, 14
reservoir, polymer flooding as reducing, 259–260
reservoir rock, 2, 10–11, 56–57, 56 (figure), 57 (figure), 58 (figure)
unconventional reservoirs, 77–78, 78 (figure)
vertical, 10–11, 14
See also relative permeability
perturbed chain form of the statistical associating fluid theory (PC-SAFT) equation of state, 491, 492, 492 (figure)
petrographic classification of kerogen constituents, 338 (table)
petroleum accumulation. See hydrocarbon migration and accumulation history simulation
petroleum expulsion. See hydrocarbon expulsion history
petroleum generation. See hydrocarbon generation history
petroleum geomechanics, 83–103
   application considerations, 101–102, 101 (figure), 102 (figure)
basic parameters for continuous materials, 95–96
caracterization, 95–102
   deformation and strain, 83–85, 84 (figure), 85 (figure)
elasticity, 87–89, 88 (figure), 89 (figure)
failure, 92–95, 93 (figure), 94 (figure), 95 (figure)
inelasticity, 91–92, 91 (figure), 92 (figure)
overview, 83
poroelasticity, 89–90
sources for geomechanical parameters, 96–101, 96 (figure), 97 (figure), 98 (figure), 99 (figure), 100 (figure)
stress, 85–87, 86 (figure), 87 (figure)
surveillance, 102–103
thermal effects, 90–91
petroleum migration history. See hydrocarbon migration and accumulation history simulation.

petroleum pipelines. See pipelines.

petroleum reservoirs. See microbiology of petroleum reservoirs; reservoirs.

petroleum system simulation. See 3D dynamic simulation of pool-forming.

petroleum transmission ratio, 129–130

Petronius compliant tower, 576 (figure)

phase behavior

numerical reservoir simulation, 181–182

reservoir fluids, 66–69, 67 (figure), 68 (figure), 68 (table)
surfactant, 278–281, 280 (figure)

phase trapping, surfactant, 283

photovoltaic (PV) solar energy, 684, 684 (figure), 685 (figure), 686

physical treatment, wastewater, 556 (table)

pipe rams, 204–205, 205 (figure)

pipelines, 509–516

asphaltene deposition in, 492–493, 495–496, 496 (figure)

basic conceptions about pipe flow, 510, 510 (figure)
corrosion prevention, 523–524, 524 (figure)
decommissioning cost, 585 (table), 587–588, 588 (figure), 588 (table), 592–593
decommissioning stages, 581–582
export, 607, 608 (figure), 611, 623, 624 (table), 625 (figure)
filling and discharging practice, 526, 526 (figure)
fire and explosion hazards, 546
fire prevention and extinguishing, 525

general design, 510–511, 511 (figure)
groundwater protection, 524–525, 525 (figure)

history of, 507, 508 (figure)
issues with, 666

leak detection, 524

maintenance and repairs, 525–526, 525 (figure)

major components, 511, 512 (figure)
natural gas and LPG, 513–514

offshore, 514, 514 (figure)

operations, 512–513, 513 (figure)

SCADA and pipeline control system, 514, 515 (figure)
in USOSC, 680

in world, 516

piping, analysis of, 404–411

planar 3D models (PL3D), hydraulic fracturing, 356–358, 357 (table)

plastic viscosity (PV), drilling fluids, 208, 208 (figure)

plasticity, 91–92, 91 (figure), 92 (figure)

plateau production period, gas field, 421 (figure), 422, 423–424

platform deformation, monitoring, 102

plug analysis, 12, 13, 16

plugging

microbial, 470, 472

well, 581, 585–586, 585 (table), 586 (figure), 591, 593

plugs, gas hydrate, 439 (figure), 439–441, 440 (figure)

point-distributed gridding, in numerical reservoir simulation, 185, 185 (figure)

point-the-bit RSS, 220, 221 (figure)

Poiseuille's equation, 59

Poisson's ratio, 88, 88 (figure), 95, 99, 99 (figure)

pollution. See environmental concerns

polyborate, 359

polymer flooding, 256–265

ASP flooding, 265–268

design of, 262–263

field applications, 263–265

flow of polymers through porous media, 258, 259 (figure)
general screening guidelines, 261–262, 262 (table), 263 (table)

mechanisms of oil recovery by, 258–260, 259 (figure), 260 (table)

overview, 256

polymer stability, 260–261, 261 (table), 264 (table)

recent trends, 263, 264 (table)

reservoir conformance and volumetric sweep efficiency, 256–258, 257 (figure), 257 (table), 258 (figure)
surfactant flooding and, 281

polymer gels, for conformance control, 266 (figure), 266–270, 267 (figure), 267 (table), 268 (table), 269 (figure)
polymer retention, 259–260, 260 (table)
polymerase chain reaction (PCR), 465

polymer-enhanced foams, 266

polymeric fracturing fluids, 351

Pompano platform, 573, 591

pool-forming simulation. See 3D dynamic simulation of pool-forming.

popping and swelling microgels, 267

pore collapse, 91, 94

pore compressibility, 61, 61 (figure)

pore pressure, 89, 90, 210–211, 211 (figure), 212 (figure)
pore size distribution, reservoir rock, 58–59, 59 (figure)
pore space, reservoirs, 9–10

pore systems, 6, 89

pore volume compressibility, 97–98

poroelasticity, 89–90, 95

porosity

absolute, 10, 55

in CRM reservoirs, 8

core analysis, 13
defined, 89
decomposition parameters, 95
dual-porosity systems, 11, 17
effective, 10, 55
fracture, 58
grain size and pore size distributions, 58–59
primary, 11, 55
reservoir rock, 2, 10, 53, 56 (figure)
secondary, 6, 11, 55
storage, 6

total or absolute, 10

porosity-depth curve model, 115–116, 115 (figure)

porous media

asphaltene deposition in, 493–495, 496–497

flow of polymers through, 258, 259 (figure)

foam flooding, 265–266

gas hydrate formation in, 442, 443 (figure)

positive displacement mud motor (PDMM), 200–201, 203 (figure)

power swivel rotary systems, 200, 203 (figure)

power system, drill rig, 198

precipitation

polymer, 260 (table)
surfactant, 281

See also asphaltene precipitation
prediction stage, numerical reservoir simulation, 193, 194 (figure)
pressal, 673
present value curves, semisubmersible projects, 645, 647 (figure)
pressure
bottomhole, 406–407, 417
bubble-point, 3, 66–67, 67 (figure)
constant bottomhole, 214, 215 (figure)
in deliverability and inflow analysis, 398–404
dew-point, 3, 66–67, 67 (figure)
formation pore fluid, 210–211
fracture, 210–211, 211 (figure), 212 (figure)
maximum operation, 510–511, 510 (figure)
minimum miscibility, 275, 275 (figure), 276 (figure)
operating, 236–237, 237 (figure), 610, 612 (table)
pipe flow basics, 510, 510 (figure)
pore, 89, 90, 210–211, 211 (figure), 212 (figure)
reservoir fluid phase behavior, 66–67, 67 (figure)
reservoir fluid phase diagram, 2-4, 3 (figure)
saturation, 3
subsurface, 1
vapor, 509
well performance analysis, 411
wellbore, 210–211, 210 (figure), 211 (figure), 212 (figure)
wellbore and outflow performance analysis, 404–411
See also capillary pressure
pressure control, gas hydrates, 437, 439–440
pressure coring, 12
pressure transient testing (well testing), 12, 17
pressure vacuum vent valve, 521, 521 (figure)
pressure versus temperature (p–T) diagram, 67, 67 (figure)
pressure-matching process, 192, 193 (figure)
pressure-transient analysis (PTA), 417
pressurized mud cap drilling (PMCD), 214–215, 215 (figure)
price variation risk, semisubmersible project, 618
Priestley, Joseph, 433 (figure), 433–434
primary porosity, 11, 55
primary production facilities, 233–247
changing conditions, 247
dehydration, 244–245, 245 (figure), 245 (table)
gas compression, 242–244, 243 (figure), 244 (figure)
hydraulic fracturing water, 241
meters, 246–247, 246 (figure)
natural gas hydrates, 241–242, 242 (figure), 242 (table)
solids separation, 241, 241 (figure)
trace oil removal from wastewater, 239–241, 240 (figure)
See also gravity separation
primary recovery, 249, 250 (figure), 461, 530, 699, 700 (figure)
principal component analysis (PCA), 485
process controls, 559–560
process heating and cooling, topsides facilities, 610
processing
environmental concerns related to, 537
offshore, 606, 608 (figure), 610
processing plants, 540, 559, 559 (figure)
produced water
CBM development, 331–332
characteristics and compositions of, 539 (table)
defined, 538
environmental concerns, 538, 538 (figure), 539 (table)
gravity separation, 238–239, 238 (table)
hydraulic fracturing, 328, 366, 366 (table)
Messoyakha gas hydrate deposit, 456
polymer flooding, 263, 264 (table)
recycle and reuse of, 554–555
topsides facilities, 611
producing wells, semisubmersible projects, 629, 634 (figure)
product tankers, 517–518, 517 (figure), 517 (table)
production
crude oil, stages of, 249–255, 250 (figure), 252 (figure), 253 (figure), 254 (figure)
decline analysis, 416–417
deepe water oil and gas, 35–36, 36 (figure)
ergy success, 31–35, 31 (figure), 32 (figure), 33 (figure), 34 (figure)
life-cycle stages, 652
Messoyakha gas hydrate deposit history, 453–454, 454 (figure)
natural gas
contemporary, 669, 669 (figure), 670 (figure)
history, 666–669, 668 (figure)
process overview, 529–531, 530 (figure)
rates of, 26 (figure), 29–31, 29 (figure), 30 (figure), 30 (table)
oil
contemporary, 664–666, 666 (figure)
historical data, 25 (figure)
history of, 660–664, 662 (figure), 663 (figure), 664 (figure)
overview, 22 (figure), 24–26
top ten countries, 26 (table)
process overview, 529–531, 530 (figure)
prospective outlook on, 21
reservoir classification based on, 4–5, 6–9
risk involved, 617 (figure)
semisubmersible projects
capacity-reserves relations, 636, 637 (figure), 638 (figure)
initial production rates, 630, 635 (table), 636 (figure)
oil and gas, 628, 631 (table), 632 (figure)
peak production to reserves ratio, 631, 635, 637 (table)
producing wells, 629, 634 (figure)
production capacity, 631, 636 (table)
production cost, 644
revenue, 638 (table), 639 (figure), 640 (figure), 641 (figure)
scale of, 628–629, 632 (figure), 633 (figure)
unit production, 630, 634 (figure)
unconventional gas, 40–41, 41 (figure), 42 (table)
unconventional oil, 36–40, 37 (figure), 38 (figure), 38 (table), 39 (figure), 40 (figure), 40 (table)
See also primary production facilities; specific production stages and techniques
production data analysis (PDA), 415, 416–420, 419 (figure), 420 (figure)
production engineering. See natural gas production engineering
production facilities. See primary production facilities
production optimization, data mining for, 168–175
data availability and statistical analysis, 168–170, 169 (table), 170 (table)
data-driven modeling, 170–173, 171 (figure), 172 (figure)
full-asset type curve analysis, 174, 175 (figure)
single-well, single-parameter sensitivity analysis, 173, 173 (figure)
single-well, type curve analysis, 173, 174 (figure)
single-well uncertainty analysis, 174–175, 175 (figure)
production periods, gas field
build-up, 421–422, 421 (figure)
decline, 421 (figure), 422–423
plateau, 421 (figure), 422, 423–424
See also specific production stages and techniques
See also production data analysis
production platforms, 679. See also specific platform types; specific platforms
productivity index (PI), gas well, 399, 400, 418, 420 (figure)
profitability, semisubmersible projects, 645, 647 (figure), 647 (table), 648, 648 (figure)
propane, PVT relations of, 67, 67 (figure)
property modeling, 110
proppants, hydraulic fracturing, 325–327, 326 (table), 327 (table), 336, 351
propped hydraulic fracturing, 354–358
derivation of planar-3D model, 356–358
model comparison, 357 (table)
overview, 354–355
pseudo-3D and 3D models, 355–356, 355 (figure)
prospective outlook on long-term energy systems (POLES), 49 (table), 52 (figure)
prospective outlook on world oil and gas reserves, 21–52
data reliability, 41–43
efficiency
deep-water oil and gas outlook, 35–36, 36 (figure)
fuel production and consumption, 31–35
unconventional gas, 40–41, 41 (figure), 42 (table)
unconventional oil, 36–40, 37 (figure), 38 (figure), 38 (table), 39 (figure), 39 (table), 40 (figure), 40 (table)
energy systems models, 48, 49–50 (table), 50–52
estimation methods, 43–48, 43 (figure), 47 (figure)
fuel production and consumption, 31–35, 32 (figure), 33 (figure), 34 (figure)
natural gas, 26–31, 26 (figure), 27 (figure), 27 (table), 28 (figure), 29 (figure), 30 (figure), 30 (table)
oil, 21–26, 22 (figure), 23 (figure), 23 (table), 24 (figure), 25 (figure), 26 (table)
total world energy consumption, 31 (figure)
protective equipment, 561
proved reserves, 693–694, 695 (figure), 696 (figure). See also reserves
pseudo-3D models, hydraulic fracturing, 355–356, 356 (figure), 357 (table)
Pseudomonas aeruginosa strains, in MEOR, 472
pseudo-pressure approach
 deliverability and inflow analysis, 398, 400–401, 402–403, 403 (figure), 403 (table)
well performance analysis, 411–412
pseudo-steady state (PSS) flow, 399, 400
pseudo-time concept, MB, 417–418
pseudo-time variable, deliverability and inflow analysis, 399
pulse decay method, 78
pump-off test (POT), 210
pumps
for pipelines, 511, 512 (figure)
solar, 689
purification, natural gas, 531
push-the-bit RSS, 220–221, 221 (figure)
pyrolysis, 339–340, 339 (figure), 377–378
Q
quality maps, for well configuration, 254–255, 254 (figure)
quantitative evaluation of traps, 130–133, 132 (figure), 145–146, 145 (figure), 146 (table)
quartz crystal microbalance with dissipation (QCM-D) experiments, 493
quartz crystal resonator (QCR) technique, 488, 489
R
radial fluid flow, 56, 56 (figure), 57
radiation exposure, 546, 560, 560 (figure)
radioactive heat generation rate, 119, 119 (table)
radioactive logging, 16
radioactive material
in produced water, 238–239
in waste, 541, 541 (table)
ramp preventers, BOP stack, 204–205, 205 (figure)
rate of penetration (ROP), 209–210, 209 (figure)
rate-of-return curves, semisubmersible projects, 645, 648, 648 (figure)
rate-transient analysis (RTA), 415, 416–419
Rawlins and Schellhardt analysis, 400–401, 403–404, 404 (figure)
reactive control strategy, 254
real gas, 63, 63 (figure)
reciprocating compressors, 243, 243 (figure)
reclamation, oil sand tailings, 318, 319 (table)
recovery. See production; specific hydrocarbon resources; specific recovery techniques
recovery factor, 255, 256, 256 (figure)
recovery phases, 461, 699, 700 (figure). See also specific recovery phases
recovery technology, reservoir classification based on, 6–9
rectangular coordinates, flow equations in, 180–182, 180 (figure)
recycling
fracture-fluid, 328
wastewater, 554–555
Red Hawk spar, 571
redevelopment, risk involved, 617 (figure)
reduced-pressure desorption, CBM production through, 331–332, 331 (figure), 332 (figure)
refined product pipelines, 513, 513 (figure)
refining
environmental concerns, 537
environmental management, 549, 549 (figure)
in production process, 531
wastewater discharge from, 540
refractive index (RI) method, 487
regional ecology, effects of gas hydrates on, 435–436
regional energy scenario generator (RESGEN), 49 (table)
regression models, decommissioning cost algorithms, 586, 587, 588, 589
regulations, and decommissioning cost algorithms, 584
regulatory framework, 532–537
relative permeability
defined, 11, 73
factors affecting, 73–74
laboratory measurements of, 74–75, 74 (figure)
numerical reservoir simulation, 182
of reservoir rock, 14–15
and rock wettability, 73–74, 74 (figure), 74 (table)
three-phase, 73, 74
two-phase, 74–75, 74 (figure)
relative permeability modification (RPM), 268, 268 (table)
release prevention barriers (RPBs), 524–525, 525 (figure)
releveling, storage tank, 522
remediation strategies
asphaltene deposition, 498–499
in environmental management, 549
remote terminal units (RTUs), solar, 687, 687 (figure)
renewable energy sources
comparative analysis between fossil fuels and, 657–660, 659 (figure), 659 (table), 660 (table)
energy future, 35
technical potential of, 683 (figure)
trends in focus on, 663
See also specific renewable energy sources
repairs, storage and transportation, 525–526, 525 (figure)
representative elementary volume (REV), 180, 180 (figure)
reserves
data reliability, 41–43
depletion estimation, 45–48, 47 (figure)
energy future, 693–694, 694 (figure), 695 (figure), 696, 696 (figure)
estimation methods, 43–45, 43 (figure)
of gas in GHDs, determining, 448, 450–451
Messoyakha gas hydrate deposit, 453–454, 454 (figure)
natural gas
contemporary, 669, 669 (figure), 670 (figure)
energy future, 694, 696, 696 (figure)
estimation methods, 43–45
general discussion, 27–29
historical data, 27 (figure), 28 (figure)
overview, 26 (figure)
top ten countries, 27 (table)
oil
contemporary, 664–666, 665 (figure)
energy future, 693–694, 695 (figure), 696
estimation methods, 43–45
historical data, 23 (figure), 24 (figure)
overview, 21–24, 22 (figure)
top ten countries, 23 (table)
semisubmersible projects
capacity-reserves relations, 635, 636, 637 (figure), 638 (figure)
peak production to reserves ratio, 631, 635, 637 (table)
project costs, 627–628, 628 (figure)
remaining, 640–641, 643 (table), 644 (table)
reserves–production trajectories, 641, 645 (figure)
well reserves, 641, 646 (figure)
unconventional gas, 41 (figure)
unconventional oil, 37 (figure)
validating, in numerical reservoir simulation, 192
See also natural gas production engineering
reserve-to-production (R/P) ratio
natural gas, 26 (figure), 28–29
oil, 22, 22 (figure), 23, 24 (figure), 695 (figure)
reserve depletion estimation, 45
reservoir characterization
defined, 18
numerical reservoir simulation, 190
oil field data mining in
overview, 152–153, 152 (figure)
seismic survey, 154
seismic to well logs, 153–154, 153 (figure)
synthetic model, 154–161, 155 (figure), 155 (table), 156 (figure), 157 (figure), 158 (figure), 158 (table), 159–161 (figure), 161 (table)
Valley Field case study, 161–164, 162 (figure), 163 (figure), 164 (table), 165–168 (figure), 165 (table)
reservoir complexity, 612
reservoir conformance, polymer flooding, 256–258, 257 (figure), 257 (table), 258 (figure)
reservoir engineering. See numerical reservoir simulation
reservoir fluids, 62–75
capillary pressure and wettability, 69–73, 69 (figure), 70 (figure), 71 (figure), 72 (figure)
crude oil, 64 (table), 65–66, 66 (figure)
fluid saturation, 55–56
formation damage, 75
formation water, 69
gas, 62–63, 62 (table), 63 (figure)
phase behavior, 66–67, 67 (figure), 68 (figure), 68 (table)
properties of, 65–66
relative permeability, 73–75, 74 (figure)
reservoir classification based on initial state of, 2–4, 3 (figure)
rock and fluid interactions, 69–75, 69 (figure), 70 (figure), 71 (figure), 72 (figure), 74 (figure)
reservoir management, 177–178, 251, 252 (figure), 253–255, 254 (figure)
reservoir rock, 2 (figure)
capillary pressure and wettability, 69–73, 69 (figure), 70 (figure), 71 (figure), 72 (figure)
characteristics of, 9–16
compressibility, 60–61, 61 (figure)
core acquisition and analysis, 61–62
defined, 375
depositional environments, 5–6
evaluation of, 11–16
and fluid electric properties, 59–60, 60 (figure)
fluid saturation, 55–56
formation damage, 75
fracture permeability and porosity, 58, 58 (figure)
grain size and pore size distributions, 58–59, 59 (figure), 59 (table)
heterogeneous, 11, 16
overview, 2
permeability, 2, 10–11, 56–57, 56 (figure), 57 (figure), 58 (figure)
porosity, 2, 10, 55, 56 (figure)
relative permeability, 73–75, 74 (figure)
rock and fluid interactions, 69–75, 69 (figure), 70 (figure), 71 (figure), 72 (figure), 74 (figure)
total organic content, 76, 76 (table), 77 (figure)
unconventional reservoirs, 75–79
See also petroleum geomechanics; specific rock types
reservoir simulation, 45. See also numerical reservoir simulation
reservoirs, 1–18
classification of
depositional environments, 5–6
initial state of fluids, 2–4, 3 (figure)
pore systems, 6
production/drive mechanism, 4–5
recovery/product technology, 6–9
conventional, 6
cyclic steam stimulation, selecting for, 304, 305 (table)
deepwater offshore, 302, 341–342, 341 (figure), 342 (table), 343 (figure), 344 (figure), 346–347
deliverability and inflow performance analysis, 398–404, 401 (table), 402 (figure), 403 (figure), 403 (table), 404 (figure)
depressurization, for methane hydrate production, 334–335
depth, 1, 2 (figure)
Dongying Sag petroleum system, 135–136, 135 (figure)  
geophysical well logging, 16–17  
heterogeneity and performance of, 17–18  
hydrocarbon source rock, 1  
modeling, 18  
overview, 1–2  
permeability reduction caused by polymer flooding, 259–260  
steam flooding, selecting for, 308, 308 (table)  
steam-assisted gravity drainage, selecting for, 309, 310 (table)  
structure, 1  
unconventional, 6–9, 75–79  
volumetrics, 415  
well, reservoir, and facility management, 701–704, 702 (figure), 703 (figure)  
well testing, 17  

See also  
microbiology of petroleum reservoirs; numerical reservoir simulation; reservoir characterization; reservoir fluids; reservoir rock; specific reservoir types

resilient toroid seals, 520, 521 (figure)  
resins, 267 (table), 485–486, 486 (figure)  
resistivity, 15, 16, 60  
restored wettability, 72  
restored-state core analysis, 14, 15  
restrictions, gas hydrate, 439–441, 439 (figure), 440 (figure)  
retorting  
kerogen, 339 (figure), 339–340  
oil shale, 384–387, 385 (figure)  
retrograde condensation, 3–4  
retrograde gases. See gas condensate reservoirs  
reusing wastewater, 554–555  
revenue, semisubmersible production, 638 (table), 639 (figure), 640 (figure), 641 (figure)  
reverse ISC, 314  
reversibility, asphaltene precipitation, 489–490  
reversible-micellization model, 491  
rheology  
drilling fluids, 208, 208 (figure)  
fracturing fluids, 363  
*Rhodococcus* strains, in MEOR, 472  
rig-based rotary systems, 199–200, 202 (figure)  
right-hand walk (RHW), 224  
rim seals, storage tank, 519–520, 520 (figure)  
riserless drilling, 215, 216 (figure)  
risers  
decommissioning cost, 582, 585 (table), 589 (figure), 593  
deepwater systems, 610  
floating systems, 577, 578 (figure)  
offshore pipelines, 514, 514 (figure)  
semisubmersibles, 601, 601 (figure)  
risk, semisubmersible project, 616–618, 616 (figure), 617 (figure), 618 (figure), 641  
risk analysis, 550 (figure), 550–552  
risk matrix, 617–618, 618 (figure)  
rock and liquid expansion drive, 5, 250 (table)  
rock stratum evaluation submodel, 127  
rock stratum temperature, ancient, 120–121  
rocks  
radioactive heat generation rate of, 119 (table)  
surfactant retention in rock formations, 281–283, 282 (table)  
See also petroleum geomechanics; reservoir rock; specific rock types

roller cone (RC) bits, 205, 206, 206 (figure)  
roofs, storage tank, 519–521  
rotary control device (RCD), 214, 214 (figure)  
rotary drilling, 197, 197 (figure)  
rotary screw compressors, 243  
rotary speed, 209, 209 (figure)  
rotary systems, drill rig, 199–201, 202 (figure), 203 (figure), 204 (figure)  
rotary table and kelly system, 199–200, 202 (figure)  
rotary vane-style compressors, 243, 244 (figure)  
rotary-percussion drilling, 197, 197 (figure)  
rotary-steerable systems (RSS), 220–221, 221 (figure)  
routine core analysis, 13  
royalty payments, semisubmersible projects, 644  
runoff, stormwater, 539, 559  
Russell volumeter, 55, 56 (figure)  
Russian Federation, regulatory framework in, 534

S
safeguarding, 560  
safety  
associations for, 547–548  
concerns and issues, 543, 544–546 (table), 546–547  
handling of petroleum product, 523–526  
health and safety management systems, 549–553, 550 (figure), 551 (figure), 552 (figure), 553 (figure)  
hydrate control, 439–440  
minimizing hazards, 557–562, 558 (figure), 559 (figure), 560 (figure), 561 (figure), 562 (figure), 563 (figure)  
regulations, 532–537  
St. Malo project, 655. See also semisubmersibles
salinity  
microbiology of petroleum reservoirs, 462  
negative salinity gradient, 283  
Salsa platform removal cost estimate, 590  
salt plugs, 440, 440 (figure)  
salts, in hydrate control, 438, 438 (figure)  
sanctioning of offshore development projects, 614, 615 (figure)  
sand-dominated reservoirs, methane hydrates in, 333–334  
sand-pack columns experiments, MEOR, 470–473  
sandstone. See reservoir rock  
SARA analysis, 485–486, 486 (figure)  
saturates, 485–486, 486 (figure)  
saturation  
capillary hysteresis and, 70–71, 71 (figure)  
fluid, 14, 55–56, 181–182  
numerical reservoir simulation, 181–182  
relative permeability measurement and, 15  
saturation pressure. See bubble-point pressure  
saturation-matching process, 192–193, 194 (figure)  
scale  
inhibiting formation of, 440  
of semisubmersibles, 628–629, 632 (figure)  
scale economies, semisubmersible projects, 628, 629 (table), 630 (figure)  
sea transportation, 516–518, 516 (table), 517 (figure), 517 (table), 518 (figure), 518 (table)  
seabed chemical injection, for hydrate control, 439  
seafloor assembly (SFA), 226–227, 229 (figure)  
seafloor deformation monitoring, 102  
seafloor massive methane hydrate deposits, 334  
secondary containments, 525
semisubmersibles, 599–648

self-heating retorting process, 340

selective plugging, 470, 472

seismic activity, and hydraulic fracturing, 329, 388, 541

seismic data
  correlation of surface seismic with VSP, 156–157, 156 (figure), 157 (figure)
  correlation of VSP with well logs, 157–159, 157 (figure), 158 (figure), 158 (table), 159–161 (figure), 161 (table)
  modeling of well logs from, 153–154, 153 (figure)
  seismic surveys, 154
  synthetic models derived from, 155 (figure), 155 (table), 156 (figure)
  Valley Field case study, 161–162
  seismic surveys, 154, 530, 703–704, 703 (figure)
  selective plugging, 470, 472
  self-heating retorting process, 340

semisubmersibles, 599–648

  cost, 623–627, 625 (table), 626 (table), 627 (table)
  cost relations, 627–628, 628 (figure), 629 (figure), 629 (table), 630 (figure)
  decommissioning cost algorithms, 590–591, 590 (table)
  deepwater geology, 603, 605–606, 607 (figure)
  deepwater inventory, 578, 579 (figure)
  deepwater systems, 599, 606–607, 608 (figure)
  development, 619, 620–621 (figure), 622–623, 622 (figure), 622 (table), 623 (figure), 624 (table), 625 (figure)
  development cost, 612–616, 613 (figure), 614 (figure), 615 (figure)
  expected ultimate recovery, 640–641, 642 (figure), 643 (table), 644 (figure), 645 (figure), 646 (figure)
  exploration, 618–619, 619 (table)
  floating production units, 600–602
  Gulf of Mexico inventory, 602–603, 603 (figure), 603 (table), 604 (figure), 605 (figure), 606 (figure)
  history of, 600–601
  methodology for economic evaluation, 641, 643–444, 646 (figure)
  MODUs, 227, 230 (figure)
  offshore components, 607–611, 609 (figure), 611 (figure), 612 (figure), 612 (table)
  overview, 577, 577 (figure), 599–600
  production
    capacity-reserves relations, 636, 637 (figure), 638 (figure)
    initial production rates, 630, 635 (table), 636 (figure)
    oil and gas, 628, 631 (table), 632 (figure)
    peak production to reserves ratio, 631, 635, 637 (table)
    producing wells, 629, 634 (figure)
    production capacity, 631, 636 (table)
    production cost, 644
    revenue, 636–638, 638 (table), 639 (figure), 640 (figure), 641 (figure)
    scale of, 628–629, 632 (figure), 633 (figure)
    unit production, 630, 634 (figure)
    profitability, 645, 647 (figure), 647 (table), 648, 648 (figure)
    project risk, 616–618, 616 (figure), 617 (figure), 618 (figure)

  structural components, 601–602, 601 (figure), 602 (figure)
  See also floating systems
  sensitivity analysis, 173, 173 (figure)
  separation processes
    crude oil refining, 531
    natural gas refining, 531
    topsides facilities, 610, 612 (figure)
    in USOSC, 679, 680
  See also gravity separation

  sequence-based approach, metagenomics, 465–466
  sequential-solution method, flow equations, 185
  settlement, storage tank, 522
  Shaft and Tunnel Access (SATAC), 311
  shale (rock)
    capillary pressure by isotherms, 78–79, 78 (figure)
    defined, 375
    mineral composition of, 75–76, 76 (table)
    mineralogy of, 376–377 (figure), 376–377
    original gas in place, 76–77
    permeability, 78, 78 (figure)
    potential resources, 382, 382 (figure), 383 (figure)
    total organic content, 76, 76 (table), 77 (figure)
    See also gas shale; kerogen; oil shale; shale gas; shale oil
  shale- and mudstone-hosted oil and gas, 373–390
  extraction methods
    oil shale retorting, 384–387, 385 (figure)
    overview, 383–384
    production from thermally mature mudstone, 387–389
    generation of hydrocarbons from source rocks, 377–378, 378 (figure), 379 (figure), 380 (figure)
    overview, 373–374
    potential for technology improvement, 390
    potential resources, 378–383, 381 (figure), 382 (figure), 382 (table), 383 (table)
    production projections, 389–390
    terminology, 374–377, 374 (figure), 376 (figure), 377 (figure)
  shale gas
    defined, 321, 377
    development in United States, 673–674, 674 (table)
    developments related to, 672–673, 672 (figure), 673 (figure)
    energy future, 40–41, 41 (figure), 42 (table)
    environmental concerns, 537, 675
    fracturing-fluid flowback, 327–328
    horizontal or directional drilling, 322–323, 324 (figure)
    hydraulic fracturing fluids and proppants, 325–327, 326 (table), 327 (table)
    hydraulic fracturing overview, 325, 325 (figure)
    operational challenges, 328–329
    overview, 8–9, 302, 374–375, 374 (figure)
    potential resources, 382–383, 383 (table)
    production overview, 531, 532 (figure)
    production projections, 389–390, 389 (figure)
    recent developments, 329
    See also hydraulic fracturing
  shale oil
    advances in production, 337
    defined, 377
    energy future, 39, 39 (figure), 39 (table), 697
    field development, 336–337
    general discussion, 346
    geophysical technologies, 336
    operational challenges, 337

  See also gas shale; kerogen; oil shale; shale gas; shale oil
  See also gas shale; kerogen; oil shale; shale gas; shale oil
over view, 302, 335–336, 373
potential resources, 379–380, 381 (figure)
production projections, 389
unconventional production wells, 336
See also kerogen; oil shale; tight gas
shallow-water flows, 609
shape factors, 399, 400
shear deformation, 84, 84 (figure)
shear failure, 93–94, 93 (figure), 94 (figure)
shear modulus, 88, 88 (figure)
shear rams, 205, 205 (figure)
shear strain, 85, 85 (figure)
shearing mechanism recovery method, 114–115, 114 (figure)
shear-thickening behavior of polymer solutions, 259, 259 (figure)
shear-thinning behavior of polymer solutions, 258–259, 259 (figure)
Shell In Situ Conversion Process, 384–386, 385 (figure)
shipping industry, 516, 516 (table)
shutdown, emergency, 562
shut-in procedures, 213–214
sidewall coring, 12, 61
sieve analysis, grain size distribution by, 59, 59 (table)
siltstone, 375
simulation models
energy systems models, 49 (table), 51, 51 (figure)
reserve depletion estimation, 46–47, 47 (figure)
See also numerical reservoir simulation; 3D dynamic simulation of pool-forming
single steel drilling caisson (SSDC), 225, 228 (figure)
single-parameter sensitivity analysis, 173, 173 (figure)
single-phase flow
deliverability and inflow analysis, 398–400
numerical reservoir simulation, 181, 187
well performance analysis, 411
wellbore and outflow performance analysis, 405–408
single-phase liquid, 3, 73
single-well, single-parameter sensitivity analysis, 173, 173 (figure)
single-well, type curve analysis, 173, 174 (figure)
Single-Well SAGD (SW-SAGD), 311
single-well uncertainty analysis, 174–175, 175 (figure)
site clearance and verification, 582
slick drill string, 198, 200 (figure)
slickwater fracturing fluid, 325, 327 (table), 352, 360–361, 362 (figure)
slim-tube displacement tests, 275, 275 (figure)
slips, as workplace hazard, 543
smart completions, 609
smart field configurations, 702, 702 (figure)
smart pigs, 525, 525 (figure)
smart water flooding, 701
Soave-Redlich-Kwong (SRK) EOS, 67–68
soil contamination, 540–541, 541 (table)
solar energy
background of, 683–684, 683 (figure)
challenges faced by, 686
economics of, 685–686
potential of, 685, 686 (figure)
storage, 686
technologies, 684, 684 (figure), 685 (figure)
in upstream oil supply chain, 686–690, 687 (figure), 687 (table), 688 (figure), 690 (figure)
solid scale, inhibiting formation of, 440
solid waste management, 541
solids separation, 241, 241 (figure)
solubility models of asphaltenes, 483, 490–491
solubilization ratio, 280–281
solution gas, 62, 62 (table)
solution gas–oil ratio, 65–66, 66 (figure)
solution-gas drive reservoirs, 4, 4 (figure)
solvent-mediated processes, 316, 317 (figure)
solvents
for asphaltene deposition treatment, 498–499
FCM, 272, 273
microbial, 470
sonic logging, 17
sour fluids, topsides facilities, 611
source rock
defined, 1, 375
generation of hydrocarbons from, 377–378, 378 (figure), 379 (figure), 380 (figure)
See also reservoir rock; shale- and mudstone-hosted oil and gas
South America, regulatory framework in, 535–536
spatial discretization, 182, 182 (figure), 183–184
special core analysis, 14–16
specific gravity, 63, 65
spectroscopy, 487
spontaneous imbibition method, 73
stable flow condition, 412, 412 (figure)
stable isotope probing (SIP), 465
staged hydrocarbon expulsion model, 122, 122 (figure)
stages of separation, topsides facilities, 610, 612 (figure)
static geological modeling, 3D, 109–112, 110 (figure), 111 (figure)
static parameters, geomechanical, 96, 99, 99 (figure)
statistical analysis, 171, 171 (figure)
steady-state (SS) flow, 14–15, 74, 74 (figure), 400
steam and gas push (SAGP), 311
steam flooding/steam drive, 288–289, 288 (figure), 289 (table), 307–309, 307 (figure), 308 (table), 344
steam generation from solar power, 688–689, 688 (figure)
steam soak. See cyclic steam stimulation
steam-assisted gravity drainage (SAGD), 9, 289–290, 290 (figure), 309–313, 309 (figure), 310 (table), 312–313 (table), 344
steerable assemblies, 219–220, 220 (figure)
steering tools, subsurface, 219–221, 220 (figure), 221 (figure)
stimulation, unconventional production wells, 336. See also hydraulic fracturing
stochastic methods, reserve estimation, 44–45
stock tank oil density, 65
Stone model, 73
storage, 518–523
corrosion prevention, 523–524, 524 (figure)
cryogenic tanks, 522–523, 523 (figure)
emission, 521–522, 522 (figure)
filling and discharging practice, 526, 526 (figure)
fire prevention and extinguishing, 525
fixed roofs, 521, 521 (figure)
flexible piping system, 520
floating roofs, 519
foundation, 522
fundamentals, 518–519
general design, 519
groundwater protection, 524–525, 525 (figure)
history of, 507
hot tanks, 522
leak detection, 524
maintenance and repairs, 525–526, 525 (figure)
natural gas, 523, 523 (figure), 666
properties of petroleum products, 508–509
rim seals, 519–520, 520 (figure), 521 (figure)
roofs, 519–521, 520 (figure)
safe handling of petroleum product, 523–526
settlement and leveling, 522
solar energy, 686
standards and regulations, 507
ventilation, 521, 521 (figure)
storage porosity, 6
storativity coefficient, 11, 17
stormwater runoff, 539, 559
strain, 83–85, 84 (figure), 85 (figure)
strain hardening, 92
stratigraphic traps, 1
stratum framework model, 110
See also structure-stratum framework simulation
strength parameters, in petroleum geomechanics, 96
stress
change monitoring, 103
effective, 8, 89–90, 93–94
fluid potential, 125
gradients, expressing components as, 87, 88 (figure)
overview, 85–87, 86 (figure), 87 (figure)
parameters for, 96
in situ, 87, 99–101
subsurface measurement of, 100 (figure), 100–101
thermal, 90–91
total, 89
yield, 91, 91 (figure)
stress intensity factor, PL3D hydraulic fracturing model, 357
strip-mining techniques, oil sands, 531. See also oil sands mining
structural deformation recovery, 113–116, 113 (figure), 114 (figure), 115 (figure)
structural traps, 1
Structure 23800 pipeline decommissioning cost, 588
structures
deepwater
decommissioning, 582, 593, 597
overview, 599, 600 (figure)
reservoir, 1
See also specific structure types
structure-stratum framework simulation
3D dynamic, 112–116, 112 (figure), 113 (figure), 114 (figure), 115 (figure)
3D static, 109–112, 110 (figure), 111 (figure)
Dongying Sag petroleum system example, 136–138, 136 (figure), 137 (figure), 138 (figure), 139 (figure)
submersible MODUs, 225, 227 (figure), 228 (figure)
subsalt wells, 609
subsea equipment, umbilicals, risers and flowlines (SURF)
deepwater systems, 606, 609–610, 611 (figure)
semisubmersible projects, 623, 624 (table), 625 (figure)
subsea pipelines, 514, 514 (figure)
subsea systems, 600 (figure)
subsurface steering tools, 219–221, 220 (figure), 221 (figure)
subsurface structure, reservoirs, 1
Suez Canal, 516
Sukkar and Cornell method, 406
sulfate-reducing bacteria (SRB), 462–463, 463 (table), 470–471
sulfur dioxide (SO2) hydrates, 433, 434 (figure)
Sumed pipeline, 516
supervised neural networks, 150
supervisory control and data acquisition (SCADA) systems, 512–513, 514, 515 (figure), 687
supply chain. See upstream oil supply chain
surface deformation, monitoring, 102
surface piercing articulating risers (spars), 600 (figure)
decommissioning cost algorithms, 590–591, 590 (table)
deepwater inventory, 580–581, 581 (figure)
overview, 577, 577 (figure)
See also floating systems
surface processing, oil shale, 384
surface seismic
correlation with VSP, 156–157, 156 (figure), 157 (figure)
synthetic models derived from, 155–156, 155 (figure), 155 (table), 156 (figure)
surface-prepared gels, 267, 267 (figure)
surfactant flooding, 277–285
adding polymer to, 281
ASP flooding, 285–286
critical micelle concentration, 278, 279 (figure)
field applications, 283–285, 285 (figure)
microemulsion viscosity, 281
overview, 277, 277 (figure)
phase behavior, 278–281, 279 (figure), 280 (figure)
retention in rock formations, 281–283, 282 (table)
surfactant classification, 277, 278 (table)
trends in, 283, 284 (table)
See also biosurfactants
surveillance, of petroleum geomechanics, 102–103
sustainable source energy, 658
sweep efficiency, FCM, 272–273, 273 (figure)
Syncrude and Suncor froth treatments, 317
synthetic crude oil (SCO), 318–319
synthetic model, reservoir characterization, 154–161
methodology, 156–159, 157 (figure), 158 (figure), 158 (table), 159–161 (figure), 161 (table)
model output, 156
overview, 154–155, 155 (table)
surface seismic and VSP-derived models, 155 (figure), 155 (table), 155–156, 156 (figure)
synthetic-based mud (SBM), 207
system design, 3D dynamic simulation of pool-forming, 109, 133–134, 133 (figure)
system performance analysis, gas well, 411–414, 411 (figure), 412 (figure), 413 (figure), 413 (table), 414 (figure), 414 (table)
systems simulation, reserve depletion estimation, 46–47, 47 (figure)

T
tailings, oil sand, 317–318, 318 (figure), 318 (table), 319 (table)
tailings ponds, 540, 542
tanker transportation, 517–518, 517 (figure), 517 (table)
tar balls, 541
tar sands, 9. See also bitumen; oil sands mining
taut moorings, 601–602, 601 (figure)
Taylor’s Theorem, 182
technically recoverable resources (TRR), 352
technogenic gas hydrates, 430
technological advancements and innovation, 704–706, 704 (figure), 705 (figure)
telecommunication, solar energy in, 686–687, 687 (figure)
Telemark project, 654. See also semisubmersibles
temperature
  average temperature and compressibility method, 406
  emulsion treater, 236
microbiology of petroleum reservoirs, 462
in petroleum geomechanics, 90–91
reservoir fluid phase behavior, 2–4, 3 (figure), 66–67, 67 (figure)
subsurface, I
See also geothermal field evolution simulation
temporal discretization, 182, 182 (figure), 184, 185 (figure)
tendon systems, floating platforms
decommissioning cost, 590–591, 593
overview, 577, 578 (figure), 601, 601 (figure)
removing, 582
tensile failure, 93
tensile strength testing, 98, 98 (figure)
tension leg platforms (TLPs), 600 (figure)
decommissioning cost algorithms, 590–591, 590 (table)
deepwater inventory, 578, 580, 580 (figure)
overview, 577, 577 (figure)
See also floating systems
terminal velocity, 233
Terra Nova FPSO, 341–342
tertiary recovery, 530, 699, 700 (figure). See also enhanced oil recovery
Terzaghi effective stress, 89
thermal conduction, 116, 117
thermal convection, 117
thermal effects, in petroleum geomechanics, 90–91, 96
thermal expansion testing, 98
thermal field evolution. See geothermal field evolution simulation
thermal recovery methods
cyclic steam stimulation, 287–288, 288 (figure), 304, 304 (figure), 305–306 (table), 306–307 (table)
electro-thermal dynamic stripping, 315
expanding solvent SAGD, 289, 290 (figure)
for methane hydrate production, 335
overview, 287, 287, 303–304, 468, 531
in situ combustion, 290–291, 291 (table), 292 (figure), 313–315, 314 (figure), 315 (figure)
steaming flooding or steam drive, 288–289, 288 (figure), 289 (table), 307–309, 307 (figure), 308 (table)
steaming-assisted gravity drainage, 289–290, 290 (figure), 309–313, 309 (figure), 310 (table), 312–313 (table)
thermal-assisted gravity drainage, 315–316
VAPEX, 289, 290 (figure)
thermal solar energy, 684, 686
thermal stability of polymers, 261 (table)
thermal structure analysis, 118–120, 119 (table), 120 (table)
thermal treatments, asphaltene deposition, 499
thermal-assisted gravity drainage (TAGD), 315–316
thermally mature mudstone, oil and gas production from, 387–389
thermodynamic conditions, locating HFZs by, 447, 448 (figure), 449 (figure)
thermodynamic inhibitors, 437, 438 (figure), 439
thermodynamic models of asphaltenes, 485, 490, 491–492, 496
thermodynamics, pipe flow, 510
thickened ice pads, 227, 229 (figure)
3D dynamic simulation of pool-forming
geothermal field evolution, 116–121, 117 (figure), 118 (figure), 119 (table), 120 (table)
hydrocarbon expulsion history, 122–123, 122 (figure)
hydrocarbon generation history, 121–122
hydrocarbon migration and accumulation history, 123–130, 126 (figure), 127 (figure), 131 (figure)
relationship of all portions of model, 110 (figure)
static geological modeling, 109–112
structure-stratum framework simulation, 112–116
system design, 109, 133–134, 133 (figure)
theory, 109
trap quantitative evaluation, 130–133, 132 (figure)
See also Dongying Sag petroleum system simulation
3D models, hydraulic fracturing, 355–356, 357 (table)
three-phase numerical reservoir simulation, 181–182
three-phase relative permeability, 73, 74
three-phase separators, 234–235, 235 (table), 236 (table)
Thunder Hawk project, 654. See also semisubmersibles
Thunder Horse project, 629, 653. See also semisubmersibles
tight gas, 321–329
defined, 321
defined, 321
energy future, 40–41, 41 (figure), 42 (table)
field development, 321–322, 321 (figure), 322 (figure), 323 (figure), 324 (figure)
fractioning-fluid flowback, 327–328
horizontal or directional drilling, 322–323, 324 (figure)
hydraulic fracturing fluids and proppants, 325–327, 326 (table), 327 (table)
hydraulic fracturing overview, 323, 325, 325 (figure)
operational challenges, 328–329
overview, 302, 377
recent developments, 329
See also hydraulic fracturing
tight gas sands, 7, 77–78, 78 (figure), 377
tight oil
advances in production, 337
defined, 377
defined, 377
field development, 336–337
general discussion, 346
geophysical technologies, 336
operational challenges, 337
overview, 302, 335–336, 374–375, 374 (figure)
potential resources, 380, 382, 382 (table)
production projections, 389, 389 (figure)
rock formations producing, 376
unconventional production wells, 336
See also hydraulic fracturing
time-lapse seismic monitoring, 703–704, 703 (figure)
titanate, 358
toe-to-heel air injection (THAI), 291, 292 (figure), 314–315, 314 (figure), 345–344
toolface angle, 222, 223 (figure)
top drive rotary systems, 200, 203 (figure)
top-down cost estimation, 582–583
topsides, deepwater systems, 606, 608 (figure), 610–611, 612 (figure), 612 (table)
torque, in directional drilling, 224–225, 225 (figure)
total (absolute) porosity, 10, 55
total organic content (TOC), 76, 76 (table), 77 (figure)
total stress, 89
Toxicity
of hydraulic fracturing fluids, 366
oil sand tailings, 317–318, 318 (table)
See also environmental concerns; waste; wastewater
trace oil removal from wastewater, 239–241, 240 (figure)
tractions, 85–86, 86 (figure)
training, in health and safety management systems, 552
trajectories, directional. See well trajectories, directional
trans-Alaska pipeline, 516
transient PI method, 418, 420, 420 (figure)
transient testing, 12, 17
transmissibility coefficients, 184
transportation
corrosion prevention, 523–524, 524 (figure)
environmental concerns, 537
filling and discharging practice, 526, 526 (figure)
fire prevention and extinguishing, 525
groundwater protection, 524–525, 525 (figure)
history of, 507, 508 (figure)
leak detection, 524
maintenance and repairs, 525–526, 525 (figure)
modes of, 509, 509 (table)
natural gas, issues with, 666
in production process, 530–531
properties of petroleum products, 508–509
safe handling of petroleum product, 523–526
by sea, 516 (table), 516–518, 517 (figure), 517 (table), 518 (figure), 518 (table)
standards and regulations, 507
See also pipelines
trap quantitative evaluation, 130–133, 132 (figure), 145–146, 145 (figure), 146 (table)
traps, classification of, 1
traveling block, 199 (figure), 199 (table)
treatment
crude oil refining, 531
of produced water, 328
of waste, 554–555, 555 (figure)
of wastewater, 554–555, 556 (table)
triaxial compression testing, 93 (figure), 96–97, 96 (figure), 97 (figure)
triethylene glycol (TEG), 438–439
trips, as workplace hazard, 543
TSP bits, 206, 206 (figure)
tubing
well performance analysis, 412, 413–414, 413 (table), 414 (figure), 414 (table)
wellbore and outflow performance analysis, 404–411
turbine meters, 246, 246 (figure)
turbodrills, 201, 204 (figure)
turbulent flow, 398, 400
Turkey, regulatory framework in, 535
two-dimensional (2D) models, hydraulic fracturing, 355, 355 (figure), 357 (table)
two-phase flow, Beggs and Brill correlation for, 410–411
two-phase relative permeability, 74–75, 74 (figure)
two-phase separators, 234, 234 (figure), 234 (table), 235 (figure)
two-segment procedure, decline curve analysis, 368–369, 368 (figure), 369 (figure)
type curve analysis, 173–174, 174 (figure), 175 (figure)
type-curve matching PDA method, 417–418, 420, 420 (figure)

U
U.S. Bureau of Mines (USBM) method, 72 (figure), 73
Uinta Basin, 378, 381 (figure)
utra-large crude carriers (ULCC), 517 (table), 518
ultraviolet (UV), asphaltene precipitation studies with, 487
umbilicals
decommissioning cost, 582, 585 (table), 588–589, 589 (figure), 593
deepwater systems, 609–610
semisubmersible projects, 623, 624 (table)
uncertainty
cost estimation, 583
decommissioning cost algorithms, 584
semisubmersible project costs, 624–625, 626, 627
uncertainty analysis, 174–175, 175 (figure)
unchanged plane-length mechanism, 114–115
unconfined compressive strength (UCS) test, 97, 99, 100 (figure)
unconformable plane evaluation submodel, 129
unconventional hydrocarbon resources
decline curve analysis, 368
developments in, 672–673, 672 (figure), 673 (figure)
distribution of, 301, 302 (figure)
ergy future, 697, 697 (figure), 698 (figure), 699 (figure)
gas, 40–41, 41 (figure), 42 (table), 521, 531, 532 (figure)
general discussion, 346–347
oil, 36–40, 37 (figure), 38 (figure), 39 (table), 39 (table), 40 (figure), 40 (table)
overview, 301, 397
terminology related to, 374–377, 374 (figure), 376 (figure), 377 (figure)
trends in focus on, 663–664
See also shale- and mudstone-hosted oil and gas; specific resources
unconventional locations, hydrocarbon accumulations in, 301. See also deepwater development; deepwater offshore reservoirs
unconventional production wells, 336, 337
unconventional reservoirs
capillary pressure by isotherms, 78 (figure), 78–79
defined, 301
hydrocarbon resource triangle, 302 (figure)
original gas in place, 76–77, 77 (figure)
overview, 6–9, 75–76
permeability, 77–78, 78 (figure)
total organic content, 76, 76 (table)
See also specific recovery methods; specific resources; unconventional hydrocarbon resources
underbalanced drilling (UBD), 207, 214
undercompaction section submodel of thermal evolution, 117
underground disposal, flowback water, 328
underground storage, natural gas, 523, 523 (figure)
undersaturated oil reservoirs, 4
uniaxial compaction coefficient, 95
uniaxial-strain compaction, 101, 102 (figure)
uniaxial-strain pore volume compressibility (UPVC) test, 97–98, 98 (figure)
unit development cost, semisubmersible projects, 628, 629 (figure), 629 (table), 630 (figure)
unit production, semisubmersible projects, 630, 634 (figure)
United Kingdom, regulatory framework in, 533–534
United States
economy of, 352, 353 (figure), 354 (figure)
EOR technique implementation in, 700, 701 (figure)
regulatory framework in, 532–533
shale gas development in, 673–674, 674 (table)
unconventional hydrocarbon resources in, 697, 698 (figure), 699 (figure)
Index

See also decommissioning cost estimation in deepwater GOM; Gulf of Mexico
unitization, leases, 619
unproved reserves, 693. See also reserves
unstable flow condition, 412, 412 (figure)
unstable geothermal field, 3D dynamic simulation of, 117–118, 118 (figure)
unsteady state method, 14, 74
unsupervised neural networks, 150
upgrading
bitumen, 318–319, 320 (figure), 320 (table)
kerogen, 340
upscale to field conditions, 101–102, 102 (figure)
upstream oil supply chain (USOSC), 679–690
energy consumption in, 679, 681
greenhouse gas emissions, 681–683, 681 (figure), 682 (table), 683 (table)
oilfield processes, 680–681
overview, 679–680, 680 (figure)
solar energy in, 686–690, 687 (figure), 687 (table), 688 (figure), 690 (figure)
See also energy future
Utica Shale, 378, 380 (figure)

V
validation stage, numerical reservoir simulation, 192–193, 192 (table), 193 (figure), 194 (figure)
Valley Field reservoir characterization
available data, 161–162, 163 (figure)
location of case study, 162 (figure)
methodology, 162, 164, 164 (table), 165–168 (figure), 165 (table)
valves, for pipelines, 511, 512 (figure)
vapor jet compressors, 244, 244 (figure)
vapor pressure, petroleum product, 509
vapor-assisted petroleum extraction (VAPEX), 289, 290 (figure), 316, 316 (figure), 345
vaporizing-gas process, MCM, 273
vehicular accidents, 543, 560
Venezuela, regulatory framework in, 535–536
venting, storage tank, 521, 521 (figure)
vertical drilling, for tight gas, 322–323, 324 (figure)
vertical permeability, 10–11, 14
vertical seismic profile (VSP)
correlation of surface seismic with, 156–157, 156 (figure), 157 (figure)
correlation with well logs, 157–159, 157 (figure), 158 (figure), 158 (table), 159–161 (figure), 161 (table)
overview, 154
versus seismic surveys, 154
synthetic models derived from, 155 (figure), 155 (table), 155–156, 156 (figure)
Valley Field case study, 161, 162, 163 (figure), 164
vertical sweep efficiency, 256–258, 257 (figure), 257 (table)
vertical transverse isotropy (VTI), 88, 89 (figure), 95–96
vertical wells, for water flooding, 253, 254 (figure)
vertical–horizontal wells configuration, SAGD, 311
vertical-well SAGD configuration (VSAGD), 311
very large crude carriers (VLCC), 517 (table), 518
VI wells and single HP well (VINGS-SAGD), 311–312
Virgo 113 platform plugging and abandonment cost, 586
viscoelastic surfactant (VES)–based fracturing fluid, 361–362, 362 (figure)
viscosimetry, capillary, 487–488
viscosity
bitumen, 302–303, 302 (table)
 crude oil, 66
drilling fluids, 208
floodwater, polymer flooding as enhancing, 258–259, 259 (figure)
heavy oil, 9, 302–303, 302 (table)
microemulsion, 281, 284 (table)
petroleum product, 509
real gas, 63, 63 (figure)
relative permeability and, 74
viscosity-control scheme, polymer flooding, 264 (table)
viscous fingering, mobility-induced, 258, 258 (figure)
viscous fracturing fluids, 351–352. See also hydraulic fracturing
vitrinite reflection rate, 120–121
volatile oil, 3, 68, 68 (figure), 68 (table)
volatility, petroleum product, 509
volume balance method, 112–116, 112 (figure), 113 (figure), 114 (figure), 115 (figure)
volumetric deformation, 83–84, 84 (figure)
volumetric gas reservoirs, 5
volumetric method, reserve estimation, 44–45
volumetric strain, 85
volumetric sweep efficiency, 256–258, 257 (figure), 257 (table), 258 (figure)
vugular-solution porosity system, 6

W
wander, well trajectory, 223–224, 224 (figure)
warning signs, 560. See also safety
waste
from drilling, 538–539, 539 (figure), 542, 555, 555 (figure)
management of, 555
oil sand, 317–318, 318 (figure), 318 (table), 319 (table)
solid, 541
wastewater
ecological effects, 542–543
environmental concerns, 538–540, 538 (figure), 539 (figure), 539 (table)
minimizing, 554–555
trace oil removal from, 239–241, 240 (figure)
treatment of, 554–555, 556 (table)
water
cooling, 540
environmental concerns, 540
formation, 62, 69, 456
hydraulic fracturing, use in, 241, 326–327
minimizing consumption, 554–555
used in oil shale processing, 386
See also produced water
water drive, 5, 125, 250 (table)
water flooding
enhanced, 286
low-salinity, 291–292
problems related to, 256
and reservoir microbiology of, 467
in secondary oil recovery, 250–251, 252 (figure), 253–255, 254 (figure)
smart, 701
water-alternating gas (WAG) process, 270–271, 270 (figure), 271 (figure)
INDEX 739

water-based fracturing fluids, 351. See also hydraulic fracturing
water-based mud (WBM), 207
water-oil relative permeability, 73
weather shields, 520
weather-related hazards, 546–547
weight-on-bit (WOB), 197, 198, 201 (figure), 209, 209 (figure)
weir, liquid-level control using, 237, 237 (figure)
well, reservoir, and facility management (WRFM), 701–704, 702 (figure), 703 (figure)
well control, 210–215
casing installation, 211, 213, 213 (figure)
drill rig, 202, 204–205, 205 (figure)
kick detection and shut-in procedures, 213–214
managed pressure drilling, 214 (figure), 214–215, 215 (figure)
mud pressure bounds and casing schedules, 210 (figure), 210–211, 211 (figure), 212 (figure)
and well placement configuration, 254
well logging
correlation of VSP with, 157–159, 157 (figure), 158 (figure), 158 (table), 159–161 (figure), 161 (table)
modeling logs from seismic data, 153–154, 153 (figure)
overview, 11–12, 16–17
Valley Field case study, 161, 162
well monitoring system, drill rig, 205
well performance analysis, gas, 411–414, 411 (figure), 412 (figure), 413 (figure), 413 (table), 414 (figure), 414 (table)
well placement configuration, water flooding, 251, 252 (figure), 253–255, 254 (figure)
well testing (pressure transient testing), 12, 17
well trajectories, directional
basic, 217, 217 (figure)
coordinates, 221–222, 221 (figure), 222 (figure)
measuring, 219
planning trajectory changes, 223, 223 (figure)
terminology, 216–217, 217 (figure), 218 (figure), 219 (figure)
wellbore and outflow performance analysis, 404–411, 409 (table)
wellbore models, numerical reservoir simulation, 186–187, 186 (figure)
wellbore pressure, 210–211, 210 (figure), 211 (figure), 212 (figure)
wellhead, 680, 681
wells
completion of, 680–681
for deepwater systems, 606, 607–609, 608 (figure), 609 (figure)
plugging and abandonment, 581, 585–586, 585 (table), 586 (figure), 591, 593
semisubmersible projects
cost of, 624–625, 626 (table), 627 (table)
development, 619, 620–621 (figure), 622 (figure), 622–623, 622 (table), 623 (figure), 624 (figure), 624 (table)
exploration, 619, 619 (table)
producing, 629, 634 (figure)
reserves, 641, 646 (figure)
well counts, 622, 623 (figure)
in USOSC, 680–681
Western Canadian Sedimentary Basin (WCSB), 303, 304 (figure)
Western Regional Air Partnership, 547
Western States Air Resources Council, 547
wet gas, 3, 68, 68 (figure), 68 (table), 378
wetlands, environmental concerns for, 542
wettability
ASP flooding and, 285
capillary pressure, 69–71, 70 (figure)
interfacial tension and contact angle, 69
as LSW mechanism, 292
and relative permeability, 73–74, 74 (figure), 74 (table)
relative permeability measurement and, 15
reservoir rock, 71–73, 71 (figure), 72 (figure)
restoration and measurements, 72 (figure), 72–73
wetting phase, 69
wet-tree wells
decommissioning cost, 585, 585 (table), 591
overview, 606, 608, 608 (figure), 609 (figure)
semisubmersible projects, 623, 624 (table)
whiskery crystals, gas hydrates, 444, 444 (figure)
White Sands project, 315
Who Dat project, 654–655. See also semisubmersibles
whole-core analysis, 12, 13, 16
Wien automatic system planning (WASP), 50 (table)
Wilcox trend, 605–606, 607 (figure)
wireline logs, 11–12, 98–100, 219
work breakdown structures, cost estimation, 583
worksite hazards. See occupational hazards; safety
world energy market, 657, 658 (figure). See also energy future
world energy model (WEM), 50 (table)

Y
Yamal crater, 436, 436 (figure)
yet-to-find hydrocarbon resources, 696, 696 (figure)
yield point (YP), drilling fluids, 208, 208 (figure)
yield stress, 91, 91 (figure)
Young-Laplace equation, 69–70, 70 (figure)
Young's modulus, 87, 88 (figure), 95, 99, 99 (figure)

Z
Z-factor, gas, 63, 63 (figure)
zircon fission track, 121
zirconate, 358
zwitterionic surfactants, 278 (table)