Petroleum exploration and production research in the Middle East

M.R. Riazi, R.C. Merrill, G.A. Mansoori

(Authors addresses at the end of this paper)

1. A brief history of petroleum exploration and production

The major oil-producing countries in the Middle East include Saudi Arabia, United Arab Emirates (UAE), Iran, Iraq, Kuwait, Oman, Qatar and Bahrain. Geographical location of these countries in the Persian Gulf area is shown in Fig. 1.

Proved oil reserves in the Middle East total 685 billion barrels which represents approximately 65% of proved oil reserves in the world (Oil and Gas Journal Data Book, 2002; BP Statistical Review of Energy, 2003). Daily production in 2002 for the Middle East stood at almost 21 million barrels, representing over 28% of global production. Saudi Arabia has the largest production capacity and produced 8.7 million bbl/day (mmstb/d) throughout 2002.

Commercial production in the region began in 1908 with the discovery of commercial quantities of oil in Iran. This production was quickly followed by other discoveries, although production remained low as a fraction of world production for the first half of the last century. However, the discovery of very large oil fields in Kuwait (1937) and Saudi Arabia (1938) set the stage for substantial production enhancement as world demand grew in later years.

By the early 1970s, the region accounted for a significant portion of world oil production. Many of the countries in the region have used the wealth created by oil to support infrastructure projects. This included the establishment of petroleum-related research universities in the region.

Most of the production in the Middle Eastern countries is subject to production quotas set by the Iran’s petroleum resources. Organisation of Petroleum Exporting Countries (OPEC) members in the Middle East included the control of Iraq Petroleum which has its roots in the Turkish Petroleum Company (TPC) which

UAE with a combined production of approximately 18 million barrels per day. National Oil Companies play an important role in the mapping of strategy and the production of petroleum.

Saudi Arabia produced 8.6 million barrels per day (mmstb/d) in 2002, down from a peak of 9.4 mmstb/d in 1998. Saudi Aramco, the national company for Saudi Arabia, has its roots in an exploration concession in the eastern part of the country which was formed in 1933 by a subsidiary of Standard Oil of California (now ChevronTexaco). Texaco acquired 50% of the company in 1936. Both Socony and Standard Oil of New Jersey (both now Exxon Mobil) acquired a share in the company in 1948. The Saudi Arabian government acquired a 25% share of Aramco in 1973; by 1980, the government share of the company stood at 100%. Saudi Aramco now operates all production and refining in Saudi Arabia and has marketing and refining interests in the Philippines, Greece and the United States.

Production from Iran averaged 3.4 mmstb/d in 2002. The National Iranian Oil Company (NIOC) was formed in 1951 to acquire and operate concessions in Iran from foreign companies [principally Anglo–Iranian (now BP), Shell, Total, Mobil and Standard Oil of New Jersey]. In 1953, a consortium of companies which formed the Iranian Oil Participants, ran the oil production in Iran. IOP continued until 1973 when NIOC regained control of oil exploration and production. Since the mid-1990s, NIOC has concluded a number of agreements with foreign oil companies to speed the development of oil fields. In 2002, production from Iraq averaged 2.0 mmstb/d.
Petroleum exploration and production research in the Middle East

Editorial

Fig. 1. Map of oil-producing countries in the Middle East and Persian Gulf region.

(a) Map of Middle East

(b) Oil Rich Countries in the Gulf Region

Fig. 1. Map of oil-producing countries in the Middle East and Persian Gulf region.
was formed in 1912 in the last years of the Ottoman Empire. No concession was awarded to TPC until 1925, and the company changed its name to Iraq Petroleum in 1929. The company was active in exploration throughout the Gulf and created subsidiaries in Basrah, Mosul and Abu Dhabi. Iraq completed acquisition of all privately held shares in 1973.

The total production from the United Arab Emirates was 2.3 mmstb/d in 2002. Each of the oil-producing Emirates in the UAE has its own national oil company. The largest of these is ADNOC, the Abu Dhabi National Oil. Oil production from Abu Dhabi is by means of individual operating companies which oversee the development of one or more reservoirs or fields. The two largest operating companies are ADMA and ADCO which are involved in offshore and onshore development. ADNOC is a majority shareholder in these companies which oversees the day-to-day operation of the fields. The private partners in these operating companies, which include Exxon Mobil, Total, JODCO and BP, play an active role in the operations.

In 2002, the production from Kuwait averaged 1.9 mmstb/d. Kuwait Petroleum oversees production, refining, marketing and shipping of petroleum products through its wholly owned subsidiaries. Kuwait Oil (KOC) is the subsidiary concerned with onshore production from Kuwait. KOC has its roots in a 1934 joint venture between BP and Gulf (now Chevron Texaco). The State of Kuwait acquired complete ownership of KOC in 1975.

Oman produced at an average daily rate of 0.9 mmstb/d in 2002. Petroleum Development Oman (PDO) is the primary producer of hydrocarbons from the Sultanate of Oman. PDO was originally a partnership between Shell, CFP (now Total) and Partex which was formed in 1937. The government of Oman now controls 60% of PDO, but the private partners remain active participants. Production from Qatar averaged 0.7 mmstb/d. Their national oil company is Qatar Petroleum (QP).

It is believed that large quantities of undiscovered offshore oil reserves may be available under the waters of the Persian Gulf. Even without such reserves, the proved oil reserves in this area are more than two-thirds of the world oil reserves, and the production in this area may continue long after production declines in other parts of the world.

2. Research institutions

Oil revenues have been used to create a number of research and teaching universities throughout the Middle East. Many of the papers in this issue were submitted by professors from these institutions. The largest university in the region is the University of Tehran with over 30,000 students in several locations. The university was founded in 1934 and has an extensive teaching and research programme which includes the awarding of Masters and PhD degrees. Shiraz University, also in Iran, has 25 advanced programmes and over 12,000 students.

Most of the other universities in the Middle East were founded in the past 40 years. King Fahd University of Petroleum and Minerals was founded in Saudi Arabia in 1963. It currently has over 10,000 students and offers Bachelors and Masters degrees in engineering. Kuwait University (KU), with over 17,000 students was founded in 1966. The College of Engineering and Petroleum at KU has enrolment of 2200 students and was founded in 1975. This college offers BSc and MSc degrees and consists of eight departments: Architecture, Chemical, Civil, Computer, Electrical, Industrial, Mechanical and Petroleum. UAE University, founded in 1976, has over 15,000 students, of which, over 1000 are enrolled in Engineering.

3. About this special issue

Given the statistics from the preceding sections, it was appropriate to showcase the research efforts which are of interest to investigators in the Middle East region. This region produces over half of the world’s oil; topics of interest or concern in this region are by their nature of global interest. Efforts for the preparation of this special issue began in August 2002. More than 30 abstracts were received from different researchers working in various research centres and universities in Kuwait, United Arab Emirates (UAE), Qatar, Saudi Arabia and Iran. Because research activities in Iran were included in a previously published special issue of this journal [26, Issues 1–4, May 2000], only joint papers with other researchers in the region were considered for inclusion in this issue. A total of 15 papers were
accepted for inclusion in this special issue which include four from UAE, five from Kuwait, two from Saudi Arabia and four from Qatar and Iran. Among these papers, one paper is from Kuwait Oil, one paper from the petroleum research centre in Iran and 11 papers from universities in the region. UAE University in Al-Ain, UAE with four papers and Kuwait University with five papers are major organizations contributing to this issue. In addition, two papers from King Fahd University of Petroleum and Minerals (Dhahran, Saudi Arabia), one joint paper from Tehran and Qatar Universities and another joint paper between Shiraz and Qatar Universities have been included in this issue. The titles and authors of papers in this issue are given below where corresponding authors are specified by *:

1. “Modern E&P Data Management in Kuwait Oil”
   G. Haveluck Harrison* and Fadel Safar, Kuwait Oil Company, Kuwait.

2. “Probabilistic Methods in Petroleum Resource Assessment, with Some Examples Using Data from the Arabian Region”
   Rao S. Divi, Department of Earth and Environmental Sciences, Kuwait University.

3. “Investigation of in-situ Low-Temperature Oxidation as a Viable Sand Consolidation Technique”

4. “A Finite Element Model for Analyzing Horizontal Well BHA Behavior”
   F. Akgun, United Arab Emirates University, Chemical and Petroleum Engineering, Al-Ain, UAE.

5. “Thermal Transients During Non-Isothermal Fluid Injection into Oil Reservoirs”
   Ibrahim Kocabas, Chem. and Pet. Eng. Dept., UAE University, Al Ain, UAE.

   S.A. Mousavi-Dehghani, National Iranian Oil, RIPI, Tehran, Iran; M.R. Riazi, Department of Chemical Engineering, Kuwait University, Safat, Kuwait; M. Vafaie-Sefti, Department of Chemical Engineering, Tarbiat-Modarress University, Tehran, Iran; and G.A. Mansoori*, Department of Chemical Engineering, University of Illinois at Chicago, Chicago, IL, USA.

7. “A New Single Well Model for Asphaltene Precipitation and Deposition Around Production Wells”
   R.A. Almehaideb, Chemical and Petroleum Engineering Department, UAE University, Al-Ain, UAE.

   Abdulrazag Y. Zekri* and Shedid Ali Shedid, Chemical and Petroleum Engineering Department, UAE University, Al Ain, UAE.

9. “Use of Reservoir Simulation for Optimizing Recovery Performance”
   Ridha B.C. Gharbi, Department of Petroleum Engineering, College of Engineering and Petroleum, Kuwait University.

    M.R. Riazi, H. A. Al-Adwani, A. Bishara, Department of Chemical Engineering, Kuwait University, Safat, Kuwait.

11. “Evaluation of Empirically Derived PVT Properties for Middle East Crude Oils”
    Muhammad Ali Al-Marhoun, Department of Petroleum Engineering, King Fahd University of Petroleum and Minerals, Dhahran 31261, Saudi Arabia.

12. “Application of an Improved Equation of State to Reservoir Fluids: Computation of Minimum Miscibility Pressure”
    Kh. Nasrifar1, M. Moshfeghian2,* 1Institute of Petroleum Engineering, University of Tehran, Tehran, Iran. 2Department of Chemical Engineering, University of Qatar, Doha, Qatar.

13. “Use of a Novel Surfactant for Improving the Transportability/Transportation of Heavy/Viscous Crude Oil”
    Yousef Al-Roomi1*, Reena George1, Ahmed Elgibaly2 and Ali Elkamel1, 1Chemical Engineering Department, College of Engineering and Petroleum, Kuwait University, Kuwait. 2Department of Petroleum Engineering, College of Engineering and Mining, Suez—Egypt.

14. “Intermittent Gas-Lift in Aghajari Oil Field, a Mathematical Study”
    Shahaboddin Ayatollahi a, Mostafa Narimani a
and Mahmood Moshfeghian\textsuperscript{a,b,*} \textsuperscript{a} School of Chemical and Petroleum Engineering, Shiraz University, Shiraz, Iran. \textsuperscript{b} Department of Chemical Engineering, University of Qatar, P.O. Box 2713, Doha, Qatar.

15. “Wettability Evaluation of Iranian Carbonate Formations”
M.R. Esfahani, Iran Research Institute of Petroleum Industry, Tehran, Iran; Manouchehr Haqhi\textsuperscript{*}, Center of Excellence for Petroleum Engineering Studies at University of Tehran, Tehran, Iran.

The 1st paper by Harrison and Safar of Kuwait Oil Company (KOC) presents a method of management of exploration and production data gathered over the past 50 years in Kuwait. The data classes range from seismic, geological, petrophysical, drilling, production operations, production and injection volumes, surface and downhole facilities, PVT, well surveillance and others. The development of decision support systems for converting stored data to information is also presented in this paper.

The 2nd paper by R.S. Divi from the Department of Earth Sciences at Kuwait University presents the appropriate selection of probability methods at different stages of assessment and exploration activities. The methodologies are illustrated with examples from different parts of the world including the Arabian Region.

Sand control is the subject of the 3rd paper by Aggour et al. from Saudi Arabia. The results of the laboratory development phase of a project to develop a sand control technique to overcome the technical and economic limitations associated with existing methods of sand control are discussed.

In the 4th paper by Akgun of UAE University, the production rate in horizontal wells is analyzed through a finite element model. Professor Akgun discusses reasons for lower production rates in comparison with vertical wells.

An analytical model of thermal transients is presented in the 5th paper by Kocabas of UAE University. This model permits the calculation and analysis of temperature gradients and heat flux during nonisothermal fluid injections into oil reservoirs. This sort of analysis is required to improve the determination of thermal efficiency during fluid injection into oil reservoirs, e.g., in improved oil recovery.

In the 6th paper, various methods of determination of asphaltene onset are analyzed. The 7th and 8th papers, both from UAE University, present models for asphaltene precipitation around production wells and reduction of permeability caused by asphaltene precipitation. Many oil fields in the Persian Gulf region contain significant asphaltene levels and/or tar mats, and this area of research is burgeoning in the region.

The 9th paper authored by Gharbi of the Petroleum Engineering Department of Kuwait University discusses an expert system to optimise the oil recovery from a carbonate reservoir. This system integrates a three-dimensional finite-difference reservoir simulator and an EOR expert system. The system is then used to determine optimal reservoir management and production strategies.

The 10th paper from Kuwait University discusses the impact of characterization methods on the properties and phase behavior of reservoir fluids. It is shown that selection of a characterization scheme in a reservoir simulator may have a significant impact on the accuracy of calculated properties. Application of a distribution model when minimum data are available for a crude oil or reservoir fluid is also demonstrated in this paper. The 11th and 12th papers examine fluid properties in the Persian Gulf Region. Al-Marhoun reports various PVT correlations which have been evaluated against Middle East crude oil data, and he makes recommendations regarding appropriate selections. In the 12th paper, Moshfeghian et al. applies a recently developed equation of state to the task of predicting Minimum Miscibility Pressure (MMP). The results are compared with predicted values from other equations of state.

In the 13th paper by Roomi et al. of Kuwait University, application of a newly designed surfactant molecule for enhancing the flow properties of heavy/viscous crude oils has been presented. In this paper, the rheological behavior of heavy crude oil/aqueous solutions of surfactant emulsions as well as heavy crude oil/surfactant emulsions have been investigated using a programmable viscometer.

In the 14th paper, a new intermittent gas-lift simulator is developed. This simulator considers the
temperature differences between the injected and produced fluids. The model then is used to study the Aghajari oil field. Finally, in the last, 15th, paper, an experimental study of the wettability characteristics of carbonate rock samples from Iranian formations is reported.

Acknowledgements

We would like to express our appreciation to the authors for their contributions to this special issue. We also would like to express our sincere thanks to the reviewers of papers in this issue who are the leading world experts in their field who, despite their heavy schedules, enthusiastically participated in the review process. Their suggestions and criticisms greatly enhanced the quality of this issue. We would like to thank particularly Paul Adair (BP), David Tiffin (BP), Alfred W. Eustes (Colorado School of Mines), Ergun Kuru (University of Alberta), Frederik P. Agterberg (Geological Survey of Canada), L.J. Drew (U.S. Geological Survey), Abbas Firoozabadi (Yale University), Turgay Ertekin (Pennsylvania State University), Brian F. Towler (University of Wyoming), Jill Buckley (New Mexico Institute of Mining and Technology), Ibrahim Kocabas (UAE University), Phillipe Baldy (Total FinaElf), Colin Swaine (BP), S.M. Farouq Ali (PERL Canada), R. Gharbi (Kuwait University), S.T. Lee (BP), Khaled Aziz (Stanford University), Vijay Pothapragada (BP), A.Y. Dandekar (University of Alaska), Djebbar Tiab (University of Oklahoma), Faruk Civan (University of Oklahoma), A.K.M. Jamaluddin (Schlumberger), Mehran Pooaladi (U. Calgary), Harvey Yarranton (U. Calgary), Henry Nickens (BP) and Malcolm Greaves (University of Bath). We also would like to thank Tirza van Daalen and Linda Versteeg of Elsevier for their help and encouragement to complete this special issue.

Mohammad-Reza Riazi
Chemical Engineering Department
Kuwait University,
P.O. Box 5969, Safat 13060, Kuwait
E-mail address: Riazi@kuc01.kuniv.edu.kw

Robert C. Merrill
BP Kuwait, Ltd.,
P.O. Box 29335, Safat 13039, Kuwait
E-mail address: merrilrc@bp.com

G.Ali Mansoori
Chemical Engineering Department,
University of Illinois at Chicago, (M/C 063) Chicago,
IL 60607-7052, USA
E-mail address: mansoori@uic.edu