Research, Teaching and Industry Activities in the School of Petroleum Engineering

THE UNIVERSITY OF NEW SOUTH WALES

SYDNEY · AUSTRALIA

Faculty of Engineering

The University of New South Wales

PPS27358

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1. Introduction

This booklet contains a description of the capabilities and experience of the School of Petroleum Engineering ("SCOPE") at the University of New South Wales, Sydney, Australia.

Research

SCOPE is the foremost provider of research to the upstream Australian oil and gas Industry. It conducts internationally recognised leading edge research in a wide range of subjects of relevance to the upstream oil and gas business.

The School operates a number of well-equipped laboratories: a PVT and core flooding laboratory, a petrophysical laboratory, a drilling fluid and cementing laboratory, a borehole stability analysis and fracture mechanics laboratory. The School also has a well-equipped computer laboratory and a comprehensive range of software in reservoir simulation, well testing, well log analysis, reservoir characterisation, reservoir simulation, borehole stability analysis, well drilling and completion, petroleum economics and risk analysis.

Degree programmes

Since its inception SCOPE has been the major source of new graduates in petroleum engineering in Australia. It is recognised in the Asia / Pacific region as the leading petroleum engineering school and has internationally recognised research programmes which lead to the award of ME and PhD degrees and post graduate diplomas. It has attracted many students from Asia and Europe.

SCOPE also offers Open Learning degree programmes.

Industry training

SCOPE has a strong industry short course programme with courses for professionals covering the complete range of upstream oil and gas industry activities. SCOPE also operates internationally accredited non-degree programmes in well control.

SCOPE also offers industry short courses and internet courses as part of our Open Learning programme.

Consulting

The staff at SCOPE have been consulting to the international oil and gas industry for many years. Not only is this a recognised part of SCOPE activities in its own right, but it also gives considerable benefits and credibility to SCOPE's teaching and research programmes.

Industry Advisory Committee

The School has an advisory committee which is composed of senior managers from Australian and international oil and gas companies, Government departments and academic institutions. The committee meets on a regular basis to ensure that the school's activities remain relevant to the changing needs of industry. The purview of the committee is wide and includes planning student entry numbers (to match the employment requirements of industry), advising on the course programme and research activities and arranging scholarships.

Further information

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http://www.petrol.unsw.edu.au

2. Reservoir Engineering

Improved oil and gas recovery

The objective of this programme is to develop improved secondary (waterflooding) and tertiary (immiscible and miscible) recovery technologies through a better understanding of rock microstructure, pore-scale displacement mechanisms and scale-up from the pore-scale to laboratory core, log and simulator grid-block scales. The outcomes from this programme include:-

- development of a virtual core laboratory which allows the simulation of special core analysis tests commonly used by industry to measure two and three-phase residual oil saturations, relative permeabilities, and capillary pressures,
- characterisation of heterogeneity from the pore-scale to the core-scale.

These provide an independent verification and extension of limited laboratory test data and greatly reduce the level of uncertainty associated with the design of secondary and tertiary field-scale floods.

Characterising core scale heterogeneity

We use high resolution (~5 microns) X-ray CT scanning to produce detailed 3-dimensional images of the pore-space in core plugs cut from reservoir rock. These images allow direct measurement of pore and throat sizes, coordination numbers and the spatial distribution of these parameters.

These studies have shown that rocks exhibit correlated heterogeneity at the core-scale down to the pore-scale. The correlations have a major impact on residual hydrocarbon saturation and the scale-up behaviour of the residual from the laboratory core plug to log or reservoir simulator grid-block scales. We characterise these correlations using truncated Fractional Levy and Fractional Brownian Motion statistics.

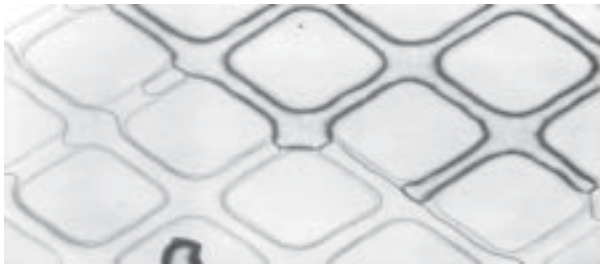
Pore-scale displacement mechanisms

Using glass-micromodels of porous media, we have studied pore-scale displacement mechanisms for two and three-phase displacements. We have placed particular emphasis on the injection of immiscible gas to recover waterflood residual oil. The double-displacement mechanisms identified in this work form the basis of all current fundamental descriptions of three-phase flow in porous media.

The three-phase studies have shown the importance of rock-fluid (wettability) and fluid-fluid (spreading) interactions in determining oil recovery. In three-phase flow, wetting and spreading films together with the morphology of the pore-space determine the connectivity of oil and the resulting residual saturation. Under gravity stabilized conditions, where film flow is important, waterflood residual oil saturations of the order of 30% may be reduced to below 10% by tertiary immiscible gas flooding.

Large scale network modelling

We have developed large-scale percolation-type or rule-based network models for the study and scale-up of multi-phase flow through porous media. These models use pore and throat size distributions from X-ray CT scans and pore-scale displacement mechanisms to simulate two and three-phase laboratory displacement tests.



Conventional network simulators require computational times ($\sim N^2$). We have developed a new algorithm which is much faster ($\sim N\log(N)$). This allows us to run grids in excess of a billion pores and therefore to simulate scale-up behaviour from the laboratory core plug scale to the full-core or log resolution scales. The network models allow us to simulate all the special core analysis tests allow us to simulate all the special core analysis tests normally used by industry to evaluate the potential of improved oil recovery processes. These include drainage and imbibition displacement tests to determine two and three-phase relative permeability, capillary pressure and residual saturations and constant rate and constant pressure mercury porosimetry. More importantly, the models can be used to scale-up these parameters to provide simulators with more realistic input data for more meaningful predictions of field performance.

2. Reservoir Engineering

PVT, core flood laboratory and X-ray CT scanning facility

We operate a fully equipped PVT laboratory specifically designed to assess miscible and immiscible gas flooding. We can perform oil swelling tests and slim-tube displacement tests to determine minimum miscibility pressure and critical gas enrichment. In addition to conventional PVT liberation tests, we measure gas-water, gas-oil and oil-water interfacial tensions and spreading coefficients at reservoir conditions.

Imbibition and drainage capillary pressure tests are performed using a state-of-art Bekman rock ultracentrifuge. We conduct restored state tests at reservoir temperature. We use the Penn State method for measuring relative permeability and perform gravity stable two and three-phase core floods on full-diameter core and composite cores at reservoir conditions.

We have access to two high resolution X-ray CT scan facilities and are in the process of building our own facility. We are in the forefront of the development of computer based techniques to extract quantitative information characterising rock microstructure from three-dimensional high resolution CT-scan data.

Selected publications

C Arns, M A Knackstedt, W V Pinczewski. Accurate estimation of transport properties from microtomographic images. Geophysical Research Letters, (2001).

M A Knackstedt, S J Marrink, W V Pinczewski, M Sahimi, A P Sheppard. Invasion Percolation on Correlated and Elongated Lattices: Implications for the Interpretation of Residual Saturations in Rock Caves. Transport in Porous Media (2001).

M A Knackstedt, S J Marrink, W V Pinczewski, M Sahimi, A P Sheppard. Invasion Percolation on Correlated and Elongated Lattices: Implications for the Interpretation of Residual Saturations in Rock Caves. Transport in Porous Media (2001).

W.V. Pinczewski. Tranport in Porous Media: Editor of Book (2001).

Kagan M. and Pinczewski W.V. Menesci in a Wedge and Slit for Incomplete Wetting Conditions. Journal Colloid & Interface Science to appear (1999).

Knackstedt M.A., Sheppard A.P., and Pinczewski W.V. Simulation of Mercury Porosimetry on Correlated Grids. Phys. Rev.E. American Institute of Physics, USA, R6923-R6926, No.58 (1999).

Kagan M and Pinczewski W.V. Meniscus and contact angle in an eye-shaped capillary. Journal Colloid & Interface Science, Journal Colloid & Interface Science. Academic Press, USA, 379-382, No.203 (1998).

Paterson L, Painter S, Zhang X and Pinczewski W.V. Simulating residual saturation and relative permeability in heterogeneous formations, SPE Journal Society of Petroleum Engineers, USA, 211-218, No.3 (1998).

Kagan, M. Stevenson M.D. and Pinczewski, W.V. Evaluation of the Low Energy Value for the Adsorption Energy Distribution Function, Journal Colloid & Interface Science, 190, 258-260, (1997).

Paterson L., Lee J.-Y., and Pinczewski W.V. Three-Phase Relative Permeability in Heterogeneous Formations, SPE 38882, presented at the SPE Annual Technical Conference & Exhibition, San Antonio, 5-8 October (1997).

Pereira G.G., Pinczewski, W.V., Paterson L., Chan D.Y.C. and Oren, P.E. Pore-Scale Network Model for Drainage Dominated Three-Phase Flow in Porous Media, Transport in Porous Media, 24, 167-201 (1996).

Kagan, M. and Pinczewski, W.V. Meniscus in a Narrow Slit, Journal Colloid & Interface Science, 180, 293-295 (1996).

Paterson L., Painter S., Knackstedt M.A., and Pinczewski W.V. Pattern of Fluid Flow in Naturally Heterogeneous Rocks, Physica A, 233,619-628 (1996)

Paterson L., Painter S., Zhang Xiadong., and Pinczewski W.V. Simulation of Multiphase Flow in Naturally Heterogeneous Rocks, 5th. European Conference on the Mathematics of Oil Recovery, Leoben, Austria Sept. 3-6 (1996).

Paterson, L., Painter, S., Zhang, X. and Pinczewski, W.V. Simulating residual saturation and relative permeability in heterogeneous formations, SPE 36523, presented at the SPE Annual Technical Conference & Exhibition, Denver, 6-9 October (1996).

Kagan, M., Pinczewski, W.V., and Oren, P.E. Two-Dimensional Meniscus in a Wedge, Journal Colloid & Interface Science, 170, 426-431 (1995).

3. Reservoir Characterisation

The objective of this programme is to provide a spatial description of petrophysical properties in heterogeneous reservoirs. We do this by integrating geology (geological rules and experience), geophysics, petrophysics, reservoir and production engineering. The programme aims to derive static properties (porosity and permeability) in wells and inter-well regions at log scale, or at grid-block scale. When coupled with dynamic properties at grid-block scale (see Reservoir Engineering), the result is a reliable simulation model which can be used to improve performance prediction in relatively new fields. It can also be used to rejuvenate old fields by locating by-passed and undrained hydrocarbons.

Formation evaluation and petrophysics

SCOPE's capabilities in formation evaluation and petrophysics include the following:

- Conventional log analysis.
- Log analysis in complex reservoirs.
- Lithology identification.
- Identifying the nature of hydraulic units based on the integration of core and log analysis.
- Constructing 3-D models based on geological and petrophysical data to improve reservoir management and enhance hydrocarbon recovery.

We have the latest computer hardware and software to assist in carrying out the studies set out above.

SCOPE's current research in formation evaluation/ petrophysics covers the following:

- determining the basic properties and relationships of petrophysical parameters,
- integrating geological data, routine or special core analysis results and well test data to characterise the mineralogy, rock properties, fluid distribution and production capabilities of reservoirs.
- the study and development of new methodologies to investigate and interpret petrophysical characteristics from well logs that contribute to resolving subsurface geological and engineering problems.
- generating evaluation techniques particular to the nature of the problem. We have solved several such problems in Australian onshore and offshore fields.

Lithofacies recognition from well logs

Lithofacies constitute the fundamental building blocks of a reservoir model. They provide an indication of reservoir quality and improve well-to-well correlation of lithohydraulic units. This programme uses conventional and modern well logs to identify lithofacies and their vertical ordering. We do this by improving our understanding of electrofacies and regional geology through the use of advanced classification algorithms in *soft computing* (neurocomputing, fuzzy systems, evolutionary computing and probabilistic reasoning). These technologies have shown great promise in many formation evaluation studies.

Predicting reservoir quality

This programme aims to predict flow-related properties (porosity and permeability) from well logs through the use of soft computing. It provides practical solutions to many core-log integration problems. We use advanced data sampling strategies and neural architecture to produce *multiple* predictions or a *distribution* of predictions, rather than a single "deterministic" prediction. The accuracy and precision of the predictions can be used to determine the prediction confidence. This is particularly useful for quantifying reservoirs with rapid facies changes and thin beddings.

Knowledge-rich reservoir modelling

When wells are few and sparse, the statistical interpretation of the well data is unlikely to result in a representative picture of the reservoir. We overcome this problem by developing *knowledge-rich* reservoir models based on geological rules and previous experience. The most tangible forms of geological knowledge are hand-drawn geological maps. These maps indicate the complexity of structural, sedimentary and diagenetic patterns. We

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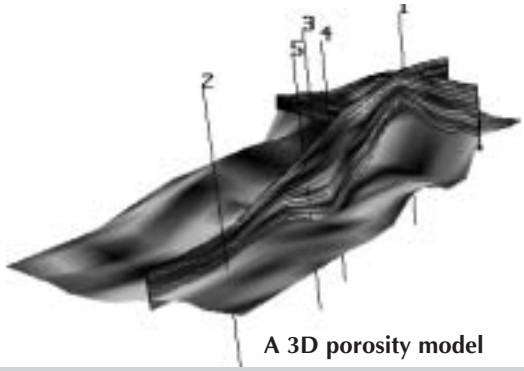
use *soft computing* and *geostatistics* to extract higher-order information hidden in such maps. We also incorporate this information with conventional data (log-derived properties and seismic attributes) to improve stochastic modelling practices.

Experimental Design and the Art of Measurement

Given that we can now represent reservoirs using geological models which correspond to different possible scenarios in uncertain depositional environments, we now aim to quantify parameters within these scenarios.

Using experimental design techniques, we can test the sensitivity of each scenario to different parameters in the geological model. We can use this to construct parametric forms of the reservoir to assist in quantification and also to assess the true uncertainty of the reservoir modelling away from the observed data.



A 3D porosity model

Selected publications

Wang, L., Wong, P.M. and Shibli, S.A.R. (1999) Modelling porosity distribution in the A'nan Oilfield: Use of geological quantification, neural networks and geostatistics. SPE Reservoir Evaluation and Engineering: in press.

Wang, L., Wong, P.M., Kanevski, M. and Gedeon, T.D. (1999) Combining neural networks with kriging for stochastic reservoir modelling. In Situ, 23(2): 151-169.

Wong, P.M. (1999) Permeability prediction from well logs using an improved windowing technique. Journal of Petroleum Geology, 22(2): 215-226.

Tamhane, D., Wang, L. and Wong, P.M. (1999) The role of geology in stochastic reservoir modelling: The future trends. SPE Asia Pacific Oil and Gas Conference and Exhibition, Jakarta, Apr. 20-22, SPE 54307, 5 pp.

Zhang, Y., Salisch, H.A. and McPherson, J.G. (1999). Identification of depositional facies from well logs – A case study of an interbedded sand-shale sequence, N.W. Shelf, Australia. Presented at the Conference for Geological Applications of Wireline Logs, London, Jan. 20-21.

Wong, P.M. and Shibli, S.A.R. (1998). Use of interpolation neural networks for permeability estimation from well logs. The Log Analyst, 39(6): 18-26.

Wong, P.M., Henderson, D.J. and Brooks, L.J. (1998). Permeability determination using neural networks in the Ravva Field, offshore India. SPE Reservoir Evaluation and Engineering, 1(2): 99-104.

Zhang, Y. and Salisch H.A. (1998) Evaluation of permeability from geophysical logs in the Barrow Field, Western Australia. First Break, 16(7): 243-250.

Zhang, Y. and Salisch H.A. (1998) Application of neural networks to the evaluation of reservoir quality in a lithologically complex formation. APPEA Journal, 38(1): 776-784.

Wong, P.M., Tamhane, D. and Wang, L. (1997). A neural network approach to knowledge-based well interpolation: A case study of a fluvial sandstone reservoir. Journal of Petroleum Geology, 20(3): 363-372.

Zhang, Y., Lollback, P.A., Salisch, H.A. and Schulz-Rojahn, J. (1997). Determination of permeability transforms from geophysical logs using statistical pattern recognition: the Mardie Greensand. Exploration Geophysics, 28(1&2): 181-184.

Wong, P.M., Taggart, I.J. and Jian, F.X. (1996). Integration of acoustic impedance into genetic reservoir characterisation: A synthetic model study. Exploration Geophysics, 27(4): 187-196.

Wong, P.M., Taggart, I.J. and Jian, F.X. (1995). A critical comparison of neural networks and discriminant analysis in lithofacies, porosity and permeability predictions. Journal of Petroleum Geology, 18(2): 191-206.

Wong, P.M., Gedeon, T.D. and Taggart, I.J. (1995). The use of fuzzy ARTMAP for lithofacies classification: A comparison study. SPWLA 36th Annual Logging Symposium, Paris, Jun. 26-29, Paper "U".

4. Drilling and Well Technology

It is now well established fact that the contemporary drilling technology is an essential requirement for drilling and completing high angle wells, extended reach horizontal wells, multilateral wells, high pressure and high temperature wells and under balanced drilling operations as well as deep water drilling operations. Such technology offers significant capital cost savings in drilling and production operations, and increases rates of production and percentage recovery.

Introduction of this technology, however, requires an improved understanding of:

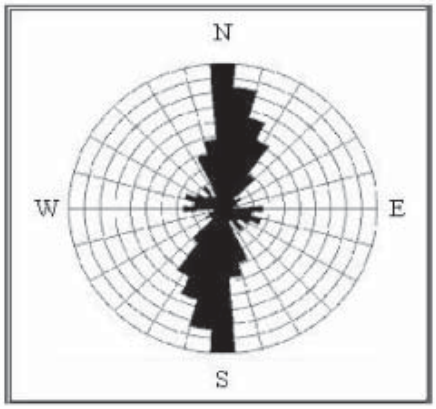
- drilling mud and mud chemistry,
- drilling mud and rock interaction and
- rock mechanics.

Currently, economic development of many potentially significant fields is being delayed by low formation permeability and damage caused by drilling and completion operations. Significant advances in all these areas may be made by developing a fundamental understanding of drilling mud related formation damage mechanisms and proper reservoir stimulation technology in these fields. The School of Petroleum Engineering (SCOPE) has established world-class facilities in the following specific areas.

In-situ stress characterisation

Geomechanical modelling is a recent technique used to characterise the Earth's stresses. Wellbore stability and hydraulic fracture initiation and propagation are very much affected by the orientation and magnitude of the in-situ stresses. In general, In-situ stresses are characterized using the magnitudes of vertical stress, maximum horizontal stress and minimum horizontal stress and the direction of horizontal stress. We have developed a comprehensive geomechanical model and rock mechanics laboratory to characterize stresses for geologically complex region including coal bed methane.

- **Determination of horizontal stress orientation.** Horizontal stress orientation is determined based on the wellbore breakout analysis. Due to the compressive stress concentration at the wellbore, compressive stress failures (break outs) occur at the azimuth of the least principal horizontal stress. By analysing borehole televiewer logs, dip meter logs and calliper logs, we develop a rose diagram and determine the stress orientation.
- **Determination of in-situ stress magnitudes.** We have developed a comprehensive geomechanical model based on the theory of geomechanics to determine in-situ stresses. By integrating data from different sources (hydraulic fracturing tests, observations of wellbore breakouts, well logs, laboratory rock mechanics test, etc.), the magnitudes of in-situ stresses (vertical, minimum and maximum horizontal stresses) are constrained to a satisfactory range.



Wellbore stability Analysis

Wellbore instability related problems have a severe impact on drilling schedule and budget, with estimates suggesting that in excess of US$1 billion is lost each year. Wellbore stability analysis has therefore been included at planning stage of many operation companies. Factors that influence the wellbore instability are stress-induced failure of wellbore (mechanical) and failure of wellbore due to mud-related interactions (chemical).

Mechanical wellbore instability depends on numerous factors, including trajectory of the wellbore, orientation and magnitude of the in-situ stress field, rock mechanical and strength properties, in-situ and induced pore pressures, and mud pressure. Therefore, the wellbore stability study can be very complex and time-consuming. Consequently, many wellbore stability analyses take only a few of the factors into account. As a result, the analyses may yield error and misleading predictions.

When drilling shaly formations, including shales, mudstones, siltstones, claystones, etc., mud pressure penetrate progressively into the formation. Penetration of small volume of mud filtrate alters significantly the pore pressure and hence reduces the effective mud support to the wellbore resulting in borehole instability. Membrane efficiency water based mud can alleviate borehole instability problems through a combination of osmosis

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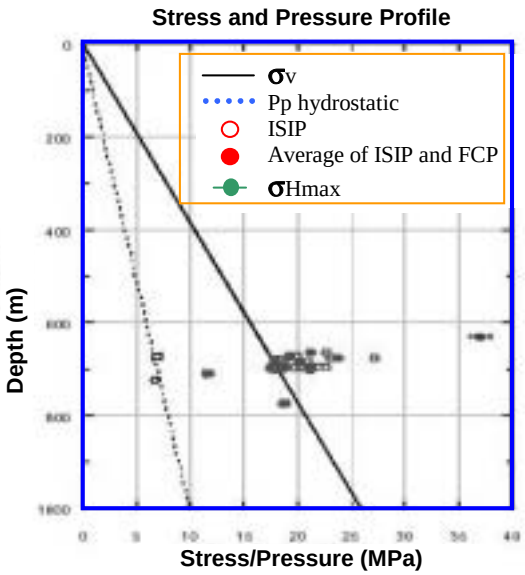
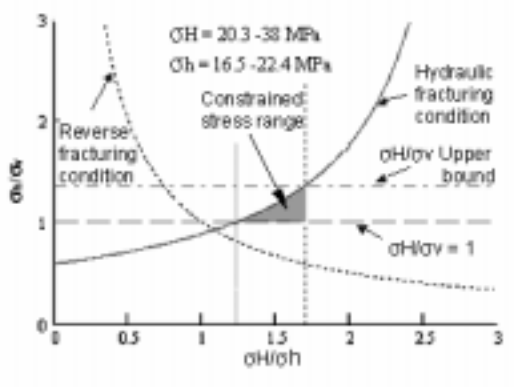
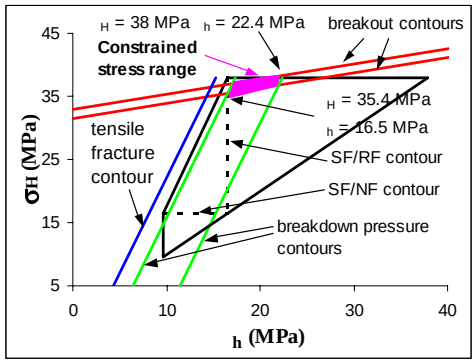
outflow of pore fluid (chemical potential) and minimisation of mud pressure penetration.

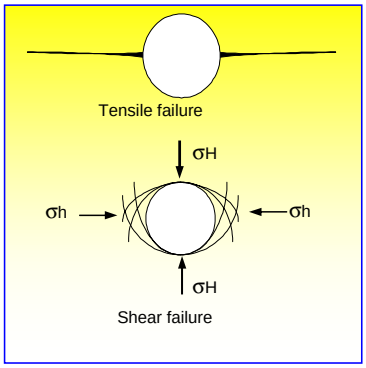
Our wellbore stability program is to develop a fundamental understanding of the causes of wellbore instability induced by physical and chemical interactions between drilling fluid and wellbore rocks and to optimise well planning and drilling fluid design to manage wellbore instability problem.

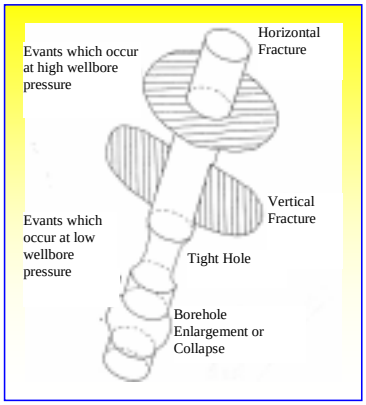
- Test facilities:
  Standard and high pressure, high temperature testing equipments to study rheology and dynamic filtration of drilling fluid, shale/claystone membrane efficiency, interfacial tension of drilling and completion fluids, mud pressure penetration characteristics in shales, friction coefficient of drilling fluids etc.
  High precision triaxial test equipments to determine mechanical properties of rocks.
- Drilling fluid chemistry:
  We have developed a number of laboratory test facilities and procedures to study chemical interactions between drilling fluid and rocks, including pore pressure and stress changes due to pressure penetration, chemical potential and swelling effects. We have established extensive laboratory and computer modelling capabilities to develop environmentally friendly drilling fluids, which maintain functional performance for a wide range of well conditions.
- Wellbore stability analysis.
  A comprehensive analytical and numerical modelling facility has been developed to study borehole instability problems and develop practical guidelines. This model

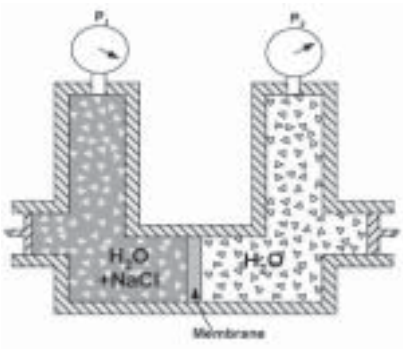


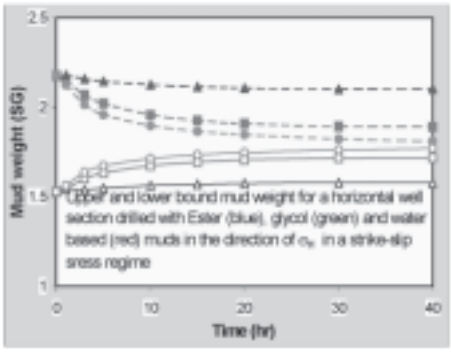












determines optimum mud weight stability profiles and critical mud weight contour plots. The optimum mud weight stability profiles can be used for designing mud weight and casing point programs for a well. The critical mud weight contour plots can be used to determine optimum wellbore profile, and lower and upper bound mud weights for all combinations of inclination and azimuths in all key formations. These practical tools can be used by engineers in routine mud weight design for efficient wellbore instability management. They can also be used as research tools to identify the dominant instability mechanisms and evaluate their significance for a given set of conditions.

Selected publications

Helstrup, O.A., Rahman, M.K, Chen, Z. and Rahman, S.S., Poroelastic Effect on Borehole Ballooning in Naturally Fractured Formations, paper SPE 79849, SPE/IADC Drilling Conference held in Amsterdam, The Netherlands, 19-21 February 2003.

Rahman, S.S., Hodge M.O., Chen Z. and Tamhane D., 'Geomechanical modelling and its implications on well design and hydraulic fracture treatment with reference to gas and coal bed methane reservoirs', 5th International Petroleum Conference and Exhibition, New Deli, India, January 9-12, 2003.

Helstrup, O.A., Rahman, M.K. and Rahman, S.S., A Practical Method for Evaluating Effects of Fracture Charging and/or Ballooning when Drilling High Pressure, High Temperature (HPHT) Wells, paper SPE 67780, 2001 SPE/IADC Drilling Conference, Amsterdam, The Netherlands, Feb.27-Mar.1, 2001.

Rahman, M.K., Naseby, D. and Rahman, S.S., 'Borehole Collapse Analysis Incorporating Time-dependent Pore Pressure Due to Mud Penetration in Shales', Journal of Petroleum Science & Engineering, Vol.28, No.1-2, pp.13-31, 2000.

Rahman, M.K., Chen, Z. and Rahman, S.S., "Pore Pressure Change due to Mud Penetration and its Time-Dependent Effects on Wellbore Stability in Shales: Experimental and Analytical Investigations", presented at the ASME ETCE/OMAE joint Conference, New Orleans, LA, Feb.14-17, 2000.

Naseby, D., Yang, Z., Rahman, S.S., and Tan, C.P., Optimum Mud Weight and Trajectory Planning - Key to Avoiding Borehole Instability in Highly Stressed and Shaley Formations, SPE paper 47788, Proc. of the Asia Pacific Drilling Technology Conference (not included in the conference proceedings), Jakarta, Indonesia, Sept. 7-9, 1998.

Tan, C.P., Chen, X., Willoughby, D.R., Wu, B., and Rahman, S.S., Wellbore Stability Analysis and Guidelines for Effective Shale Instability Management, SPE paper 47795, Proc. of the Asia Pacific Drilling Technology Conference, Jakarta, Indonesia, Sept. 7-9, 1998, pp. 165-174.

Naseby, D., Yang, Z., Rahman, S.S., and Tan, C.P., Two-phase Flow Simulation of Mud Pressure Penetration, SPE paper 47233, Proc. of the SPE/ISRM Eurock'98 held in Trondheim, Norway, Jul. 8-10, 1998, pp. 115-121.

Tan, C.P., Richards, B.G., Rahman, S.S. and Andik, R., Effects of Swelling and Hydrational Stress in Shales on Wellbore Stability, SPE paper No. 38057, Proc. of the SPE Asia Pacifi Oil and Gas Conference, Kuala Lumpur, Malaysia, Apr. 14-16, 1997, pp. 345-349.

Tan, C.P., Richards, B.G., and Rahman, S.S., Managing Physico-Chemical Wellbore Instability in Shales with the Chemical Potential Mechanism, SPE Paper 36971, Proc. of the SPE Asia Pacific Oil and Gas Conference, Adelaide, Australia, Oct. 28-31, 1996, pp.107-116.

Zenaly-Andabilty, E.M., Chen, H., Rahman, S.S., and Tan, C.P., Management of Wellbore Stability in Shales by Controlling the Physico-Chemical Properties of Muds, SPE Paper 36396, Proc. of the SPE Asia Pacific Drilling Technology Conference, Kuala Lumpur, Malaysia, Sep. 9-11, 1996, pp. 253-261.

Drilling fluid formulation and management

The petroleum industry is facing a plethora of issues concerning the environmental impact of drilling wastes disposal and the functional performance of environmentally friendly drilling fluids. Sophisticated drilling fluid design is a prerequisite for extended long-reach wells, wells drilled through sensitive formations and high temperature wells to reduce the risks and costs of drilling problems. Traditionally drilling fluids have been based on synthetic materials, which are not environmentally friendly.

We have established extensive laboratory and computer modelling capabilities to develop environmentally friendly drilling fluids, which maintain functional performance for a wide range of well conditions.

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- Test facilities:
  Standard and high pressure, high temperature testing equipments to study rheology and dynamic filtration of drilling fluid, fluid/shale chemical potential and osmosis flow, interfacial tension of drilling and completion fluids, mud pressure penetration characteristics in shales, friction coefficient of drilling fluids etc.
- Testing of mud chemical and functional properties of mud according to API standard.
- Screening of formation compatible drilling fluid system: API mud property measurement, dynamic filtration and mud cake analysis, pore fluid-mud compatibility analysis, measurement of friction coefficient of mud/rock/steel, mud/steel/steel system, chemical analysis of the mud system, etc.

Selected publications

Rahman, M.K., Chen, Z. and Rahman, S.S., 'Use of Appropriate Drilling Fluids is a Key to Avoiding Time-dependent Wellbore Collapse in Shales', CADE/CAODC Drilling Conference, Calgary, Alberta, Canada, Oct.22-24, 2001.

Tan, C.P., Rahman, S.S., Richard, B.G., and Mody, F.K., Integrated Approach to Drilling Fluid Optimisation for Efficient Shale Instability Management, SPE paper 48875, Proc. of the 8th International Oil & Gas Conference and Exhibition held in Bejing, China, Nov. 2-8, 1998, pp. 441-456.

Azizi, T. and Rahman, S.S., Management of Wellbore Instability and Formation Damage by Improved Drilling Mud Design, SPE Paper 49251, Proc. of the IADC/SPE Asia Pacific Drilling Technology Conference, Jakarta, Indonesia, Sept. 7-9, 1998, pp.113-123.

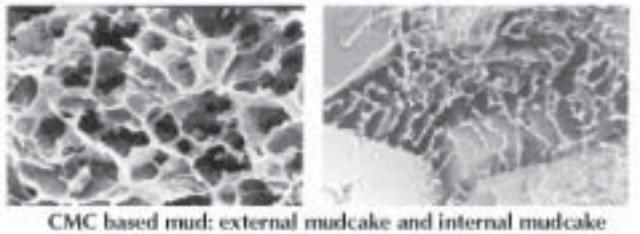
Tan, C.P., Rahman, S.S., Richard, B.G., and Mody, F.K., Integrated Rock Mechanics and Drilling Fluid Design Approach to Manage Shale Instability, SPE paper 47259, Proc. of the SPE/ISRM Eurock'98 held in Trondheim, Norway, Jul. 8-10, 1998, pp. 291-300.

Tan, C.P., Wang, G.Y., Zenaly-Andabily, E.M., Rahman, S.S., A Novel Method of Screening Drilling Mud Against Mud Pressure Penetration for Effective Borehole Wall Support, SPE Paper No. 36401, SPE Asia Pacific Drilling Technology, Kuala Lumpur, Malaysia, Sep. 9-11, 1996, pp.287-294.

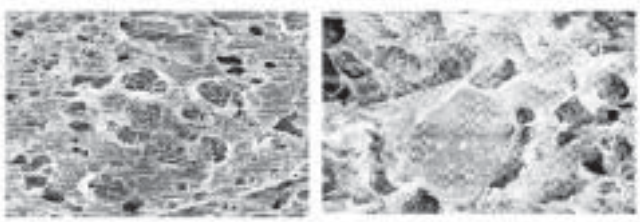
Formation damage prevention and acid stimulation

Formation damage during drilling and completion operations in oil and gas wells is a common problem in the petroleum industry. It is now widely recognised that formation damage is mainly caused by adverse fluid-rock interaction due to changes in pore fluid chemistry caused by the invading mud filtrate. A common but simplistic approach has been to match the chemistry of the mud filtrate to that of the formation water. Acid treatment is an effective stimulation technique to remedy formation damage in the near wellbore region and enhance reservoir productivity. We have established comprehensive laboratory and computational facilities to study the mechanism of formation damage and technique to remove the permeability impairment due to mud filtrate invasion.

- We use dynamic filtration test to study permeability impairment due to mud filtrate invasion.
- Advanced electronic microscopy, analytical equipment and other specialised facilities are used to study the effect of mud chemistry on the microscopic structure of mud-cake and mud caking process, which control water loss, and fluid-rock interaction at the pore level.
- Acid stimulation test to remove permeability impairment and/or enhance reservoir productivity.



CMC based mud: external mudcake and internal mudcake



Glycol based mud: external mudcake and Internal mudcake

4. Drilling and Well Technology

Selected publications

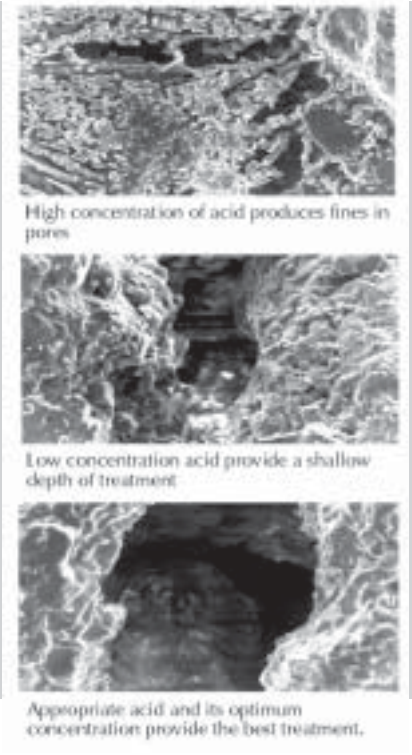
Chen, Z., Nguyen, D. and Rahman, S.S., A 3-D Numerical Model for Designing and Planning of Matrix Acid Stimulation in Low-Permeability Rocks, paper SPE 64403, SPE Asia Pacific Oil and Gas Conference and Exhibition, Brisbane, Australia, Oct.16-18, 2000.

Azizi, T, Rahman, M.M. and Rahman, S.S., Design and Planning of Low Permeability Reservoir Stimulation by Acid Treatment: An Integrated Laboratory Analysis, APPEA Journal, Vol. 39, Part-I, 1999, pp.548-561.

Azizi, T., Jin, W. and Rahman, S.S., Management of Formation Damage by Improved Mud Design, SPE paper No. 38039, Proc. of the SPE Asia Pacific Oil and Gas Conference, Kuala Lumpur, Malaysia, Apr. 14-16, 1997, pp. 203-217.

Hatcher, G.B., Chen, H. and Rahman, S.S., Evaluating Formation Damage Risk in a Glanconitic Sandstone Reservoir, SPE paper 37014, Proc. of the SPE Asia Pacific Oil and Gas Conference, Adelaide, Australia Oct. 28-31, 1996, pp.461-475.

Rahman, S.S., Nguyen, D. and Wang, G.Y., Acidising Kinetics and its Application to Reservoir Stimulation and Formation Damage, APEA Journal, Vol. 35, Apr., 1995, pp. 707-715.



High concentration of acid produces fines in pores

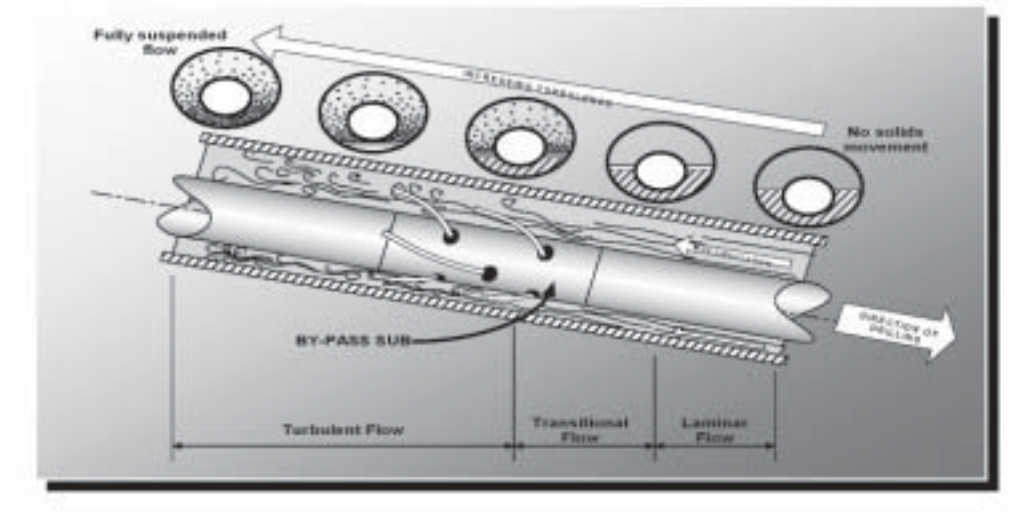
Low concentration acid provide a shallow depth of treatment

Appropriate acid and its optimum concentration provide the best treatment.

Directional, multilateral and extended reach well drilling and completion

The cost of extended and horizontal drilling has remained high due to the difficulty in maintaining directional control, weight on bit, borehole cleaning and allowable frictional drag. This remains a key problem in developing marginal fields. SCOPE has developed a theoretical and numerical modelling capability to address the following issues:

- Design optimum wellbore trajectory based on reservoir characteristics, wellbore stability, torque and drag and hydraulic analyses.
- Design and optimise equipments, including bottomhole assembly (BHA) configuration, mud motor, dynamic stabilisers, bent subs etc. to effectively steer and control the bit.
- Prediction of borehole cleaning based on drilling fluid hydraulics. Based on the theory of particle transport and fluid mechanics, we have developed a numerical model to simulate the effects on cuttings



transportation of various operational conditions, hole geometry and fluid properties. It can be used to optimise drilling hydraulics design.

- Torque and drag analysis considering BHA configuration, drilling fluid properties and wellbore condition.

These techniques can assist drilling engineers to drill deviated wells with a minimum number of directional corrections and maximise lateral displacement.

Selected publications

Nguyen, D. and Rahman, S.S., A Theoretical Study of the Effect of Rotation on Annular Displacement of One Non-Newtonian Fluid by Another in Horizontal Concentric Annuli, Chemical Engineering Communications, Vol. 189, No. 9, pp. 1283-1295, 2002.

Nguyen, D. and Rahman, S.S., A Computational Algorithm for Calculating Displacement Efficiency in Horizontal Annuli - Eccentric Case, Chemical Engineering Communications, Vol. 189, No. 5, pp. 695-709, 2002.

Nguyen, D. and Rahman, S.S., A Mathematical Model for Laminar Displacement of One Non-Newtonian Fluid by Another in Horizontal Concentric Annuli, Chem. Eng. Comm., 2000, Vol. 177, pp.215-230.

Nguyen, D. and Rahman, S.S., A Three-Layer Hydraulic Program for Effective Cuttings Transport and Hole Cleaning in Highly Deviated and Horizontal Wells, SPE Paper 51186, SPE Drilling & Completion, Sep., 1998, pp. 182-189.

Agawani, M.M., Rahman, S.S., and Maidla, E.E., BHA Design Algorithm for Extended Reach Wells, SPE 35993, Proc. of the SPE Computer Conference, Jun. 2-5, 1996.

Nguyen, D., Agawani, M. and Rahman, S. S., Drilling Highly Deviated and Horizontal Wells Through Tectonically Stressed and Fractured Coal Reservoirs, Int. Symposium cum Workshop on Management and Control of High Gas Emission and Outbursts in Underground Coal Mines, Wollongong, Australia, Mar.20 - 24, 1995.

Agawani, M.M., Rahman, S.S., and Heisig, G., Design Criteria for Selecting Rotary and Steerable Assembly for Highly Deviated to Extended Reach Drilling, 10th Ofshore South East Asia Conference and Exhibition, Singapore, Dec. 6-9, 1994, pp. 319-331.

Agawani, M.M., Rahman, S.S. and Maidla, E.E., A New Approach to Selecting Optimum Bottomhole Assembly Configuration for Any Given Well Trajectory, SPE paper 28774, Proc. of the SPE Asia Pacific Oil and Gas Conference and Exhibition, Melbourne, Australia, Nov. 7-10, 1994, pp.327-335.

Agawani, M.M., Rahman, S.S. and Maidla, E.E., BHA Design and Steerability Optimisation for Extended Reach Drilling, SPE paper 28328, 1994.

Agawani, M.M., Maidla, E.E. and Rahman, S.S., Trajectory Control - A Key Issue, Offshore Australia Conference and Exhibition, Melbourne, Australia, Nov. 23-26, 1993, Vol1-SecVI.

Drill pipe stability analysis (including lightweight pipes)

Fatigue is a major concern in rotary drilling. It is important to be able to determine the conditions at which torsional, tensile and buckling loads become critical and prevent buckling by assessing the structural requirements of the drillstring. This is especially critical for drilling slim, deviated and lateral wells. We have developed analytical and numerical computational capabilities to model not only failure conditions including drill pipe fatigue life, but also to optimise operational conditions and material properties to avoid fatigue failure.

Selected publications

Rahman, M.K., Hossain, M.M. and Rahman, S.S., Stress Concentration Incorporated Fatigue Analysis of Die-marked Drill Pipes, International Journal of Fatigue, Vol. 21(8), 1999, pp. 799-811.

Rahman, M.K., Hossain, M.M. and Rahman, S.S., Survival Assessment of Die-marked Drill Pipes: Integrated Static and Fatigue Analysis, Journal of Engineering Failure Analysis, Vol. 6(5), 1999, pp. 277-299.

Akgun, F., Gelfgat, M. and Maidla, E.E., Aluminum Application in Drilling? SPE 49957, SPE Asia Pacific Oil & Gas Conference and Exhibition, Perth, Australia, Oct.12-14, 1998.

4. Drilling and Well Technology

Akgun, F., Maidla, E.E., Basovich, V. and Gelfgat, M.Y., Why Not Use Aluminum in Drilling, IADC/SPE Paper 47823, Proc. of the Asia Pacific Drilling Technology Conference, Jakarta, Indonesia, Sept. 7-9, 1998, pp.311-317.

Hossain, M.M., Rahman, M.K., Rahman, S.S., Akgun, F. and Holger Kinzel, Fatigue Life Evaluation: A key to avoid drillpipe failure due to die-marks, IADC/SPE Paper 47789, Proc. of the Asia Pacific Drilling Technology Conference, Jakarta, Indonesia, Sept. 7-9, 1998, pp. 125-136.

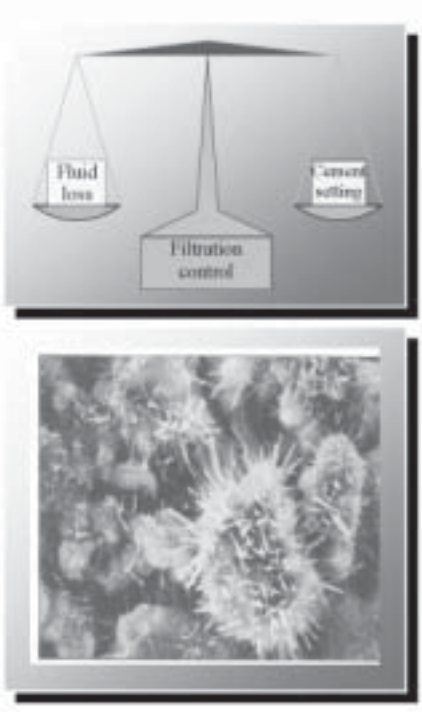
Akgun, F., Gurakin, G., Mitchell, B.T., Euster, A., and Rahman, S.S., Theoretical and Experimental Evaluation of Drill Pipe Stability Conditions in Slim Holes, SPE paper 37392, Proc. of the SPE Asia Pacific Oil and Gas Conference, Adelaide, Australia, Oct. 28-31, 1996, pp.641-655.

Akgun, F., Mitchell, B., and Rahman, S.S., Application of Pipe Stability Model for Predicting Critical Loading Conditions in Slim Holes, OSEA 96003, 11th Offshore South East Asia Conference, Singapore, Sep. 24-27, 1996.

Akgun, F., Estrella, D., Rahman, S.S., Mitchell, B.T. and Euster, A.W., Selection of Drill Pipe Based on Critical Loading Conditions, SPE paper No. 36405, Proc. of the IADC/SPE Asia Pacific Drilling Technology Conference, Kuala Lumpur, Malaysia, Sep. 9-11, 1996, pp.313-323.

Cementing

The most important prerequisites to a good primary cementing job include sufficient mud displacement, maximum strength of set cement, low water separation in high side of annulus, low filtration/fluid loss and no gas migration during cementing production liner. This becomes more challenging in highly deviated to horizontal wells where the casing tends to lie on the low side of the wellbore creating an eccentric annular geometry.



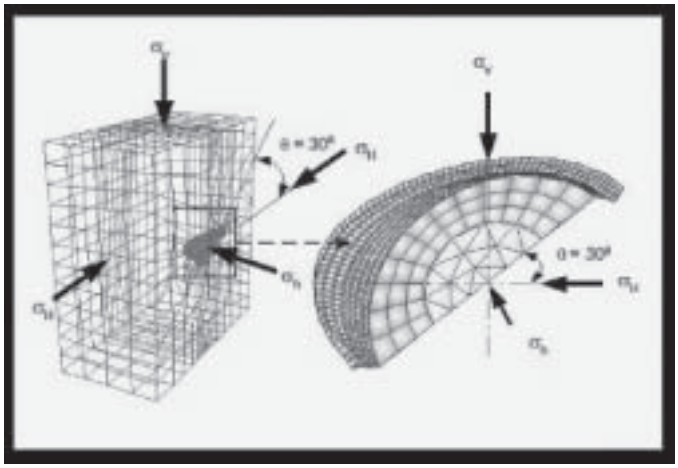
- Based on the theory of particle transport and fluid mechanics, we have developed a numerical model to simulate the effects on mud displacement of various operational conditions, hole geometry and fluid properties. This enables engineer to optimise the cementing job.
- We have done intensive study on overcoming gas migration during cementing production casing/liner, and developed cement slurry design criteria. Our studies show that proper design of cement slurry by choosing proper additives is the key to overcome short term and long-term gas migration. Short-term gas migration can be overcome by additives that increase thixotropic properties of cement slurry (eg. Gypsum), additives that absorbs gas as it percolates (such as activated charcoal) and siliceous materials to strength and reduce porosity and permeability. It is also important to reduce the materials in the slurry that do not form a part of the cement, and that prevent cement dehydration, such as bridging and filtration loss additives. Long term gas migration can be overcome by careful design of cement slurry, use of special additives (ettringite-based cements), squeeze cementing, etc.
- We have developed facilities for cementing test based on API standards, including High temperature and High pressure rheology, water loss, consistency, strength, etc.

Managing the total drilling system

The use of extended reach wells, multilaterals, slim holes and monobores are becoming commonplace for reservoir developments. A significant part of the development costs is spent in drilling and completing these wells. Operators have now recognised that the greatest scope for drilling cost reduction lies in the management of the drilling database. SCOPE has been working on the development of a planning tool based on geological data, drilling and completion data and past experience on well problems. This data can assist in the selection of hole size, mud programme, cement programme, bit programme, casing programme, chemical additives and material properties to be used in each programme, and provide an estimate of drilling time and costs. It is estimated that such a capability could lead to cost savings of up to 10% in a typical medium-size field development programme.

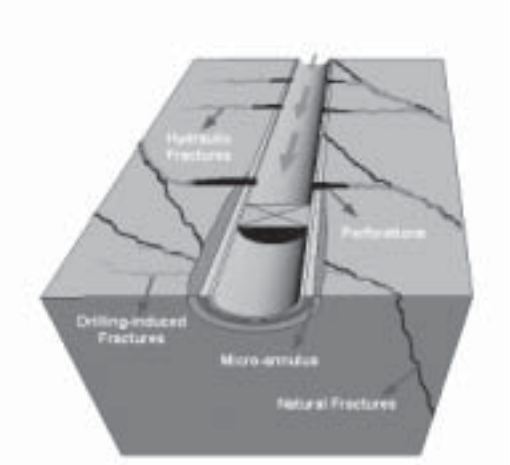
4. Drilling and Well Technology

Hydraulic Fracturing treatment design



Production of gas, at economic rates, from low permeability gas reservoirs and coal bed methane reservoirs can benefit from the effective application of hydraulic fracturing treatment. The efficiency of hydraulic fracturing treatment depends on reservoir conditions and treatment parameters. Hydraulic fracture treatment design is, therefore, to optimise the operation parameters and fracture geometry for a given reservoir condition to maximize hydrocarbon production from reservoir and economic benefit. We have developed a theoretical and numerical modelling capability to address the following issues:

- Minimum horizontal in situ stress is the single most important parameter in hydraulic fracture designs. However, the stress regimes in many parts of the world, including Australia, range from normal faulting to reverse faulting within a short distance. In addition to highly variable stress regimes, common features of tight gas reservoirs are reservoir heterogeneity caused by the presence of natural fractures and coal laminations, which are manifested as multiple fractures or fracture reorientation (fracture twisting and turning). This requires high fracture initiation and propagation pressures and often leads to premature screen-out. SCOPE has established sophisticated laboratory and computer simulation capabilities to study the causes of fracture twisting and turning and premature screen-out. This capability is being used to design fracture treatments for formations, which are characterised by complex stress regimes and reservoir heterogeneity. The research has gained international recognition by industry and academia.



Hydraulic fracture turning and twisting

- SCOPE has developed multivariate fracture treatment optimisation technique for enhanced hydrocarbon production from tight reservoirs. The optimization model integrates various treatment and fracture parameters, operational limitations, fracture growth control requirements, potential design objectives and a suitable optimization algorithm. The model thus optimizes the fracture geometry and operation parameters to maximize hydrocarbon production from reservoir.
- SCOPE has also developed multiple-well fracture treatment and production optimisation technique for the development of the whole reservoirs.

Selected publications

Rahman, M.M., Hossain, M.M., Crosby, D.G., Rahman, M.K. and Rahman, S.S., Analytical, Numerical and Experimental Investigations of Transverse Fracture Propagation from Horizontal Wells, Journal of Petroleum Science and Engineering, Vol. 35, No. 3-4, pp. 127-150, 2002.

Crosby, D.G., Rahman, M.M., Rahman, M.K. and Rahman, S.S., Single and Multiple Transverse Fracture Initiation from Horizontal Wells, Journal of Petroleum Science and Engineering (In press).

Rahman, M.M., Rahman, M.K. and Rahman, S.S., An Analytical Model for Production Estimation from Hydraulically Fractured Tight-Gas Reservoirs, paper SPE 77901, 2002 SPE Asia Pacific Oil & Gas Conference and Exhibition, Melbourne, Australia, Oct 8-10, 2002.

Rahman, M.M., Rahman, M.K. and Rahman, S.S., Control of Hydraulic-Fracturing-Induced Formation Damage by Optimizing Treatments With Constraints, paper SPE 73754, 2002 SPE International Symposium and Exhibition on Formation Damage Control, Lafayette, Louisiana, Feb. 20-21, 2002.

4. Drilling and Well Technology

Rahman, M.M., Rahman, M.K. and Rahman, S.S., Multivariate Fracture Treatment Optimization for Enhanced Gas Production From Tight Reservoirs, paper SPE 75702, SPE Gas Technology Symposium held in Calgary, Alberta, Canada, 30 April–2 May 2002.

Crosby, D.G., Yang, Z. and Rahman, S.S., Methodology to Predict the Initiation of Multiple Transverse Fractures from Horizontal Wellbores, Journal of the Canadian Petroleum Technology, Vol. 40, No. 10, pp. 68-75, 2001.

Rahman, M.M., Rahman, M.K. and Rahman, S.S., An Integrated Model for Multi-objective Design Optimization of Hydraulic Fracturing, Journal of Petroleum Science and Engineering, Vol. 31, No. 1, pp.41-62, 2001.

Rahman, M.K., Rahman, M.M. and Rahman, S.S., A Decision Support System for Improving Hydraulic Fracture Treatment for Hydrocarbon Reservoirs, APPEA Journal, pp.633-648, 2001.

Hossain, M.M., Rahman, M.K. and Rahman, S.S., Hydraulic Fracture Initiation and Propagation: Roles of Wellbore Trajectory, Perforation and Stress Regimes, Journal of Petroleum Science and Engineering, Vol. 27(3-4), 2000, pp.129-149.

Rahman, M.M., Rahman, M.K. and Rahman, S.S., The Recognition and Alleviation of Complexity with Hydraulic Fracturing Onshore Australia, APPEA Journal, 2000, pp.469-480.

Hossain, M.M., Rahman, M.K. and Rahman, S.S., A Comprehensive Monograph for Hydraulic Fracture Initiation from Deviated Wellbores Under Arbitrary Stress Regimes, Proc. of the SPE Asia Pacific Oil and Gas Conference and Exhibition, Jakarta, Indonesia, 20-22 April 1999.

Crosby, D.G., Yang, Z., and Rahman, S.S., The Successful Use of Transverse Hydraulic Fractures from Horizontal Wellbores, SPE paper 50423, Proc. of the 1998 SPE International Conference on Horizontal Well Technology held in Calgary, Alberta, Canada, Nov. 1-4, 1998, pp. 335-343.

Crosby, D.G., Yang, Z., and Rahman, S.S., Transversely Fractured Horizontal Wells: A Technical Appraisal of Gas Production in Australia, SPE paper 50093, Proc. of the 1998 SPE Asia Pacific Oil & Gas Conference and Exhibition held in Perth, Australia, Oct. 12-14, 1998, pp. 315-326.

Naseby, D., Narayan, S.P., Yang, Z., and Rahman, S.S., Combination of Horizontal Well Technology and Multiple Stage Transverse Fracturing - A New Strategy to Exploit Tight, Naturally Fractured Formations in Central Australia, APPEA Journal, Mar., 1998, pp. 880-887.

Akgun, F., Yang, Z., Crosby, D.G., and Rahman, S.S., Factors Affecting Hydraulic Fracture Initiation in High in-Situ Stress Conditions: A Wellbore Stress Modelling Approach, SPE paper 38631, Proc. of the 1997 SPE Annual Technical Conference and Exhibition held in San Antonio, Texas, Oct. 5-8, 1997, pp. 621-633.

Yang, Z., Crosby, D.G., Akgun, F., Khurana, A.K., and Rahman, S.S., Investigation of the Factors Influencing Hydraulic Fracture Initiation in Highly Stressed Formations, SPE paper 38043, Proc. of the SPE Asia Pacific Oil and Gas Conference held in Kuala Lumpur, Malaysia, Apr. 14-16, 1997, pp. 247-258.

Yang, Z, Crosby, D.G., Khurana, A.K., Multivariate Optimisation of Hydraulic Fracture Design, APEA Journal, 1996, pp.516-527.

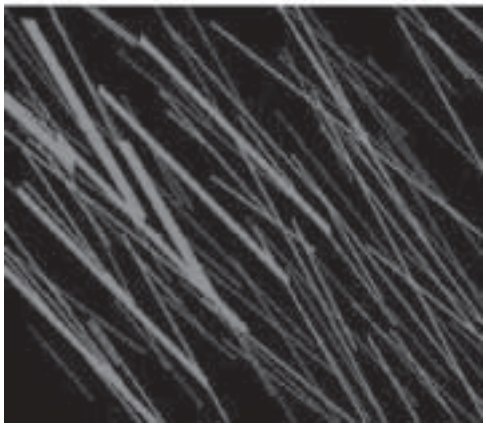
D.G. Crosby, D. Tamhane, Z. Yang, A K Khurana, V A Kuuskraa, A Review of the U.S. Tight Gas Industry from the Perspective of Selected Australian and New Zealand Basins, APEA Journal 1995.

Naturally Fractured Reservoir Simulation and Stimulation

Naturally fractured reservoirs have recently attracted intensive research attention. This is because the world market is increasingly under pressure to exploit energy from non-conventional sources. A substantial portion of the world's petroleum reserves are contained within naturally fractured reservoirs (NFR), e.g. giant fields in the Middle East and America. In Australia, an estimated amount of 30 trillion cubic feet of natural gas is stored in NFR in the Cooper Basin alone, together with a significant portion of hot dry rock (HDR) resources. Thus, it is of great benefit to develop appropriate simulation and stimulation techniques for developing naturally fractured reservoirs. We have developed the capability to simulate natural fracture system and stimulate naturally fractured reservoir by using shear-dilation based hydraulic fracturing technique, which include: :

- **Modelling of Natural Fracture Networks.** Novel nested neuro-fractal-stochastic and simulated annealing models based on the integration of statistical and artificial intelligence techniques have been developed to model fracture networks in naturally fractured reservoirs.

4. Drilling and Well Technology



- **Shear-Dilation Based Hydraulic Fracturing Stimulation of Naturally Fractured Reservoirs.** We have developed an alternative hydraulic stimulation technique called 'shear-dilation' based hydraulic fracturing stimulation for naturally fractured reservoirs in which conventional hydraulic fracturing is relatively inefficient. By employing shear-dilation principles, a hydraulic fracturing stimulation can be achieved by activating the network of pre-existing natural fractures, instead of creating conventional two-wing coplanar massive fractures. This technique has been found to be successful in stimulating natural gas and coalbed methane reservoirs around the world.
- **Simulation of Fluid Flow and Estimation of Permeability of Naturally Fractured Reservoir.** The boundary integral method has been used to model fluid flow through rock blocks with discrete fractures of arbitrary density, orientation, permeability, shape and area extent embedded within the matrix and estimate permeability tensor in a naturally fractured reservoir.

Selected publications

Hossain, M.M., Rahman, M.K. and Rahman, S.S., A Shear Dilation Stimulation Model for Production Enhancement from Naturally Fractured Reservoirs, Society of Petroleum Engineers Journal, June, pp. 183-195, 2002.

Tran, N.H., Rahman, M.K., Wong, P.M. and Rahman, S.S., A Nested Neuro-Fractal-Stochastic Technique for Modeling Naturally Fractured Reservoirs, paper SPE 77877, 2002 SPE Asia Pacific Oil & Gas Conference and Exhibition, Melbourne, Australia, Oct 8-10, 2002.

Rahman, M.K., Hossain, M.M. and Rahman, S.S., A Shear-Dilation-Based Model for Evaluation of Hydraulically Stimulated Naturally Fractured Reservoirs, International Journal for Numerical and Analytical Methods in Geomechanics, Vol. 26(5), pp.469-497, 2002.

Hossain, M.M., Rahman, M.K. and Rahman, S.S., Modelling of Hydraulic Fracture Propagation by Boundary Element Method as Coupled Fluid Flow-Deformation Problems, Proc. First Asian-Pacific Congress on Computational Mechanics, Sydney, Nov.20-23, Vol. 2, pp.1341-1346, 2001.

Chen, Z., Narayan, S.P., Yang, Z. and Rahman, S.S., An Experimental Investigation of Hydraulic Behaviour of Fractures and Joints in Granitic Rock, International Journal of Rock Mechanics and Mining Sciences, Vol. 37(7), 2000, pp.1061-1071.

Hossain, M.M., Rahman M.K. and Rahman, S.S., Volumetric Growth and Hydraulic Conductivity of Naturally Fractured Reservoirs During Hydraulic Fracturing: A Case Study Using Australian Conditions, paper SPE 63173, Proc. of the SPE Annual Technical Conference and Exhibition, Dallas, Texas, Oct.1-4, pp.545-560, 2000.

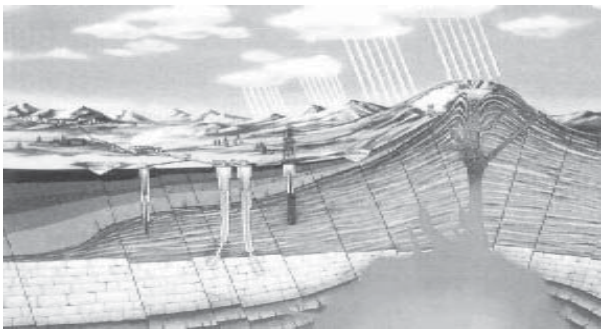
Hossain, M.M., Rahman, M.K. and Rahman, S.S., Application of HDR Stimulation Technology to Develop Tight Gas Reservoirs, paper SPE 64484, presentated at the SPE Asia Pacific Oil and Gas Conference and Exhibition, Brisbane, Australia, Oct.16-18, 2000.

Rahman, M.K. and Rahman, S.S., An Innovative Stimulation Technology for Enhanced Gas Recovery from Tight Reservoirs, presentated at the 21st Annual International Energy Agency Workshop and Symposium, Edinburgh, Scotland, Sept.19-22, 2000.

Narayan, S.P., Yang, Z., and Rahman, S.S., Propant Free-Shear Dilation: An Emerging Technology for Exploiting Tight to Ultra-Tight Gas Resources, SPE paper 49251, Proc. of the 1998 SPE Annual Technical Conference and Exhibition held in New Orleans, Louisiana, Sept. 27-30, 1998, pp. 687-701.

4. Drilling and Well Technology

Hot dry rock geothermal reservoir development



Potential geothermal resources

Australia has about 28 million petajoules of hot dry rock (HDR) geothermal resources — equivalent to 4,000 billion barrels of oil. This resource is about 7,500 times Australia's present rate of annual energy consumption. HDR geothermal energy is virtually pollution free. It involves extracting heat from rocks at temperature up to 300°C a few kilometers below the earth's surface. This is achieved by injecting cold water through one well and recovering steam from an adjacent well, with the two wells linked by means of stimulated natural fractures. Unlike conventional oil and gas fracturing, the dominant mode of HDR fracture stimulation is sliding, which manifests itself as shear displacement on a macro scale. Little or no propant is required to keep the dilated fracture faces open.

In cooperation with industry and the Federal Government, SCOPE has developed an HDR geothermal programme which includes comprehensive laboratory and numerical modelling capabilities to study fracture stimulation mechanisms in HDR reservoirs. This facility can assist industry to develop HDR geothermal energy.

Selected publications

Tran, N.H., Rahman, M.K., and Rahman, S.S., Developing a HDR Reservoir in Australia by Hydraulic Stimulation: A Shear-Dilation Model for Design and Evqluation, GRC 2002 Annual Meeting (GRC Transactions, Vol. 26), Reno, Nevada, Sept. 22-25, 2002

Rahman, M.K., Hossain, M.M. and Rahman, S.S., A Shear-Dilation-Based Model for Evaluation of Hydraulically Stimulated Naturally Fractured Reservoirs, International Journal for Numerical and Analytical Methods in Geomechanics, Vol. 26(5), pp.469-497, 2002.

Hossain, M.M., Rahman, M.K. and Rahman, S.S., Modelling of Hydraulic Fracture Propagation by Boundary Element Method as Coupled Fluid Flow-Deformation Problems, Proc. First Asian-Pacific Congress on Computational Mechanics, Sydney, Nov.20-23, Vol. 2, pp.1341-1346, 2001.

Chen, Z., Narayan, S.P., Yang, Z. and Rahman, S.S., An Experimental Investigation of Hydraulic Behaviour of Fractures and Joints in Granitic Rock, International Journal of Rock Mechanics and Mining Sciences, Vol. 37(7), 2000, pp.1061-1071.

Rahman, M.K., Hossain, M.M. and Rahman, S.S., An Analytical Method for Mixed-mode Propagation of Pressurized Fractures in Remotely Compressed Rocks, International Journal of Fracture, Vol. 103(3), 2000, pp.243-258.

Narayan, S.P., Jing, Z., Yang, Z. and Rahman, S.S., Influence of Natural Fractures and in situ Stresses on Proppant-free Hydraulic Stimulation of Hot Dry Rock Reservoirs, Proc. of the 21st New Zealand Geothermal Workshop, edited by S.F. Simons, O.E. Morgan and M.G. Dunstall, 1999, pp. 83-88.

Narayan, S.P., Dumbrell, R. and Rahman, S.S., HDR Geothermal Energy Resources in Australia: Prospects and Progress, Journal of Geothermische Energie, Vol. 22-23, 1999. 1998.

Yang, Z., Rahman, S.S., and Narayan, S.P., Potential Application of Hydraulic Stimulation in the Geothermal Industry, Proc. of the 20th Geothermal Workshop, Auckland, New Zealand, Nov.11-13, 1998, pp. 381-386.

Narayan, S.P., Yang, Z., Rahman, S.S., Zhenzi, J., and Hashida, T., HDR reservoir development by fluid induced shear dilation: A numerical study of the Soultz and the Cooper Basin granite rock, Proc. of the 4th International Hot Dry Rock (HDR) Forum, Strasbourg, France, Sep. 28-30, 1998.

Narayan, S.P., Naseby, D., Yang, Z., and Rahman, S.S., Petroleum and Hot Dry Rock: Two Types of Energy Sharing Commonalities, APPEA Journal, Mar. 1998, pp. 830-848.

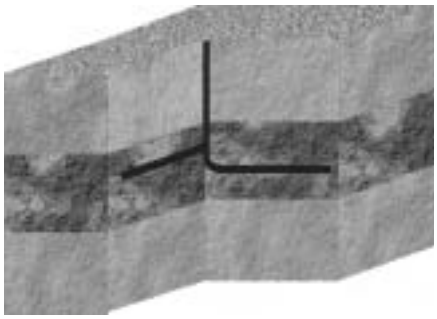
Narayan, S.P., Naseby, D., Yang, Z., and Rahman, S.S., Creation of HDR Reservoirs under Australian In-situ Stress Conditions, Proceedings, Proc. of the Twenty-third Workshop on Geothermal Reservoir Engineering, Stanford University, Stanford, California, Jan., 1998, pp. 322-329.

5. Production Engineering

The production of hydrocarbons from petroleum reservoirs to surface storage units at economic levels requires simultaneous consideration of: -

- reservoir inflow performance
- wellbore deliverability
- surface facilities

The inappropriate selection of parameters such as completion type, perforation interval, tubing size, flowing bottom hole pressure, operating wellhead pressure, length of the wellbore within the pay can reduce the well productivity significantly.



Horizontal wells increase production

We have established capabilities to analyse the productivity of a given production system (reservoir – wellbore – surface facilities) and can deliver: -

- Inflow Performance Curves (IPR) which account for reservoir driving force for both oil and gas reservoirs.
- Impact of the skin effect (near-wellbore damage), partial completion, completion elevation and well deviation on the productivity of reservoir using the concept of the effective wellbore radius and based on Cinco-Ley's semi-analytical method.
- Optimum gravel and screen sizes using Schwartz and Soucier correlations and productivity of gravel packed wells.
- Optimum values for tubing sizes, well head pressures, flow rates, and gas liquid ratios by producing vertical lift performance curves (VLP) of wells for single phase and multi-phase flow, and by simultaneously evaluating IPR and VLP curves. The Beggs and Brill method and modified Hagedorn and Brown methods are used to generate VLP curves.
- Stimulation treatment type (acidising or fracturing) and design to increase productivity depending on reservoir properties. This is accomplished by evaluating possible reductions in the skin effect with the treatment type and by assessing subsequent increase in the productivity index of well.
- Optimum gas injection pressure, power requirement for compressors, gas injection flow rate, choke sizes, and depths (for multi injection points) for gas lift wells by developing and evaluating Gas-Lift Performance Curves.
- Optimum size of down hole pumps, effective plunger stroke length and prime mover power requirements in the case of pump assisted lift.

Selected publications

Akgun, F., etc. al., Prediction of Microannulus Behind Casings Due to Ballooning Effect-A Key Problem in Gas Wells, Australian Petroleum Production & Exploration Assoc. Journal, APPEA 1996, page 575-579. (Paper presented on APPEA conference in Darwin, Australia, 16-21 June, 1996)

Lollback, P.A., Wang, G.Y., and Rahman, S.S., An Alternative Approach to the Analysis of Suck-Rod Dynamics in Vertical and Deviated Wells, Journal of Petroleum Science & Engineering, Vol. 17, 1997, pp. 313-320.

Lollback, P.A., Wang, G.Y. and Rahman, S.S., A Model for Predicting the Viscous Damping Coefficient Using Dynamometer Cards, International Conference on Flow Interaction cum Exhibition, Hong Kong, Sep. 5-9, 1994, pp. 254-257.

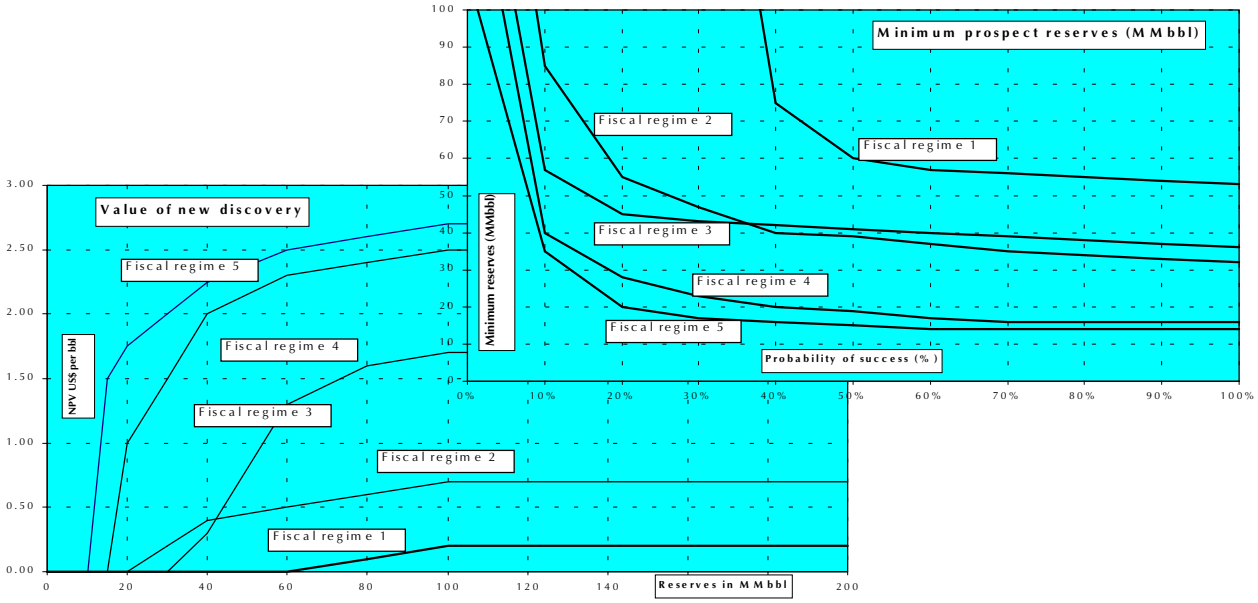
6. Petroleum Economics

The Petroleum Economics Department at SCOPE is active in the areas of research described below.

Fiscal analysis

The effect of petroleum fiscal terms on the economics of field development and exploration is usually as important if not more important than that of technical factors such as reserves, production and costs of development. The way in which a country's fiscal regime operates can make or break the viability of marginal field development and exploration in the less attractive geological basins. It can seriously affect the relative attractiveness of individual countries for investment from the oil and gas industry.

SCOPE has considerable expertise and experience in modelling the detailed economic effects of petroleum fiscal regimes. Our experience includes analytical studies of petroleum fiscal regimes in all countries in the Asia / Pacific region. Based on our fiscal and economic modelling capabilities, we have conducted studies for and advised governments and oil and gas companies on the detailed design of fiscal terms for oil and gas exploration and development.



Comparison of the economics of petroleum fiscal regimes

Oil industry economic modelling

Crude oil price movements, environmental legislation, technological and fiscal changes can all have a dramatic effect on the overall profitability of the oil and gas industry in a particular country. These factors can also affect the scale and timing of Government tax revenues from oil and gas production – often in unexpected ways. Using its petroleum economic modelling capabilities, SCOPE is well placed to study independently the effects of economic and environmental changes at the country or basin level.

Risk analysis of oil and gas projects

SCOPE is at the forefront of industry practice in the application of risk analysis across a range of disciplines including reserves assessment and petroleum property evaluation. Founded on the use of decision analysis and Monte Carlo simulation techniques, we have the capability to carry out individual oil and gas field as well as basin-wide and countrywide evaluations taking into full account the uncertainties in input data.

6. Petroleum Economics

The economics of CO_2 storage in Australia

SCOPE is actively involved in a research programme undertaken by the Australian Petroleum Cooperative Research Centre on the geological storage of carbon dioxide produced as a by-product of natural gas extraction. The study as a whole is concerned with locating suitable traps for CO_2 injection and examining the geological, environmental and economic impact of the process. Given its petroleum economics and related capabilities, the School's role is to study the economic viability of CO_2 injection at specific sites and across Australia as a whole and the environmental and economic impact on the country in the long term.

Selected publications

Allinson WG, Nguyen V . Comparison of the economics of deepwater exploration and development in India and other countries" Petrotech 2003 conference in Delhi, India, January 2003

Allinson WG, Nguyen V co-authored "The Economics of CO2 Capture and Geological Storage", Society of Petroleum Engineers Conference, October 2002

Allinson WG, Nguyen V co-authored "The Potential for Geological Sequestration of CO2 in Australia: Preliminary Findings and Implications for New Gas Field development, APPEA Conference, April 2002.

Allinson WG, Nguyen V co-authored "The search for sites for geological sequestration of CO2 in Australia: A progress report on GEODISC". APPEA Conference, April 2001.

Allinson WG, Nguyen V. The Economics of CO_2 Sequestration in Australia. Fifth Greenhouse Gas Conference. August 2001.

Allinson WG. The effect of fiscal terms on prospect evaluation. AIC Prospect Evaluation Conference, May 1997.

Allinson WG. Good oil flows stimulate interest in the Timor Gap. Petromin, June 1995.

Allinson WG. Australia and Indonesia - Licensing & Fiscal Terms. IBC Petroleum Acquisitions Conference, April 1995.

Allinson WG. Acquisition of Petroleum Properties. IBC Petroleum Acquisitions Conference, April 1995.

Allinson WG. SE Asia Risks and Rewards in Petroleum Exploration. IBC Asia Pacific Conference, September 1994.

Allinson WG, Elliston M. Economics of Petroleum Exploration offshore Australia and SE Asia. APEA Conference, March 1994.

Allinson WG. Economics of Petroleum Exploration and Development in Vietnam. American Oil and Gas Reporter, January 1994.

Allinson WG. Economics of Petroleum Exploration in Thailand, and SE Asia. Institute for International Research Conference, Bangkok, November 1993.

Allinson WG. Economics of Petroleum Exploration in Vietnam, Laos and Cambodia. Institute for International Research PSC Conference, Singapore 1993.

Allinson WG. Analysis of PSC terms in the Far East, South America, North Africa and Russia. Institute for International Research Annual PSC Conference, Singapore 1992.

Allinson WG. Economic of Gas Field Development under existing PSC terms in Indonesia and SE Asia.

Gas Markets Conference, February 1992.

Allinson WG. Economic of Petroleum Exploration in the Timor Gap and SE Asia. SE Asia Australia Offshore Conference, 1991.

Allinson WG. The Economics of Petroleum Exploration and Development in the Timor Gap. Indonesian Petroleum Association 1990. (Best Economics Paper Award).

Allinson WG. Petroleum Exploration and Development in SE Asia. Australian Investment Conference 1990.

Allinson WG. The Comparative Effect of Petroleum Taxation on Field Development - A Comparison of Indonesia, Malaysia and Thailand, Indonesian Petroleum Association Conference, 1989.

7. Degree Programmes

Since its establishment in 1985, SCOPE has provided the only fully accredited, professional and internationally recognised undergraduate degree programmes in Petroleum Engineering in Australasia. Scope also offers ME and PhD degrees.

As at the end of 1998, almost 150 students had graduated from SCOPE.

Programmes offered

SCOPE offers the following programs:-

- BE (Hons) (Petroleum Engineering)
- BE (Petroleum Engineering / M.Com.)
- ME (Petroleum Engineering)
- PhD (Petroleum Engineering)
- Graduate Diploma in Petroleum Engineering

The BE (Hons) (Petroleum Engineering) degree program lasts four years, while the Graduate Diploma program takes one year.

In the first two years of the undergraduate degree, the students study fundamental courses in mathematics, physics, chemistry and engineering science. However, in these two years they also acquire a basic knowledge of petroleum geology and geophysics, petroleum engineering, communication skills and international oil and gas industry business practices.

In years three and four, although the students primarily study in-depth petroleum engineering subjects, they also spend a large part of their time taking petroleum economics, business and management subjects. In their final year, they prepare a thesis, which integrates their skills and knowledge of science, engineering and management subjects to solve engineering and commercial problems typical of those they will meet in the petroleum industry.

Open Learning Programme

SCOPE also offers distance-learning programmes through the Internet. These programs lead to Graduate Certificate, Graduate Diploma and MEngSc awards. The Open Learning programme began in 1999 and now is offering comprehensive program in petroleum engineering.

All courses in the programs are delivered in electronic format through the Web and are designed to be undertaken externally by professionals currently working in the areas of petroleum engineering, geology and geophysics on a part-time self-paced-learning basis.

Current students are located in Australia, New Zealand, Indonesia, Malaysia, Singapore, Vietnam, Brunei, China, India, South Africa, UK, Holland, Canada and USA. For more information, please visit website:

www.petrol.unsw.edu.au/online/oplearn.html

Interaction with industry

The School's degree programmes include:-

- Extensive field trips to Australian oil fields
- Visits to industry training facilities
- Visits to manufacturing facilities
- Presentations by practicing engineers
- Participation in engineering society functions
- Participation in engineering society functions

By courtesy of the Australian Institute of Petroleum

8. Industry Training

Since its inception, SCOPE has provided the upstream international oil and gas industry with training services. The school has now established a range of short courses, which covers the full spectrum of upstream oil and gas industry activities.

Flexibility

We have designed our courses with sufficient flexibility to cater for the particular needs of individual clients. We can tailor any of our courses to fit the needs of the beginner or the advanced practitioner who needs to round out his or her knowledge.

We have conducted individual short training courses for the general public. We have conducted in-house courses for oil and gas companies, Government departments and financial institutions. For several clients we have designed and conducted integrated short course programmes lasting up to several months. We have also provided on-the-job training services.

We have presented courses in Australia, New Zealand, Singapore, Indonesia, Brunei, Malaysia, Vietnam, Thailand, India, Egypt, Libya, England, Scotland, Norway, Denmark, Switzerland, USA.

Our individual course presenters have many years of experience both in teaching and in the practical application of their discipline in the international oil and gas industry. All of our presenters have industry consulting experience, which gives them a hands-on appreciation of the breadth and depth of oil and gas company problems and practices in their fields.

List of short courses

The current list of standard short courses on offer is as follows:-

Reservoir description and analysis
Fundamentals of petroleum geology
Reservoir geophysics
Reservoir rock and fluid properties
Formation evaluation
Reservoir characterisation

Reservoir engineering
Practical aspects of reservoir engineering
Well test analysis
Practical aspects of reservoir simulation
Improved oil recovery
Natural gas engineering

Drilling engineering
Rotary drilling rig equipment and operation
Well control and blow out prevention
Drilling muds – optimisation and maintenance
Directional & horizontal drilling practices
Wellbore hydraulics & optimising rate
Practical casing design and optimisation
Cementing practices
Computer models of drilling problems

Production engineering
Practical aspects of well planning and costing
Well completion and workover operations
Production operations

Management
Development design, costing and economics
Petroleum economics and risk analysis
Fiscal analysis
Oil and gas accounting
International Petroleum contracts
Natural gas contract negotiations
Acreage evaluation and management

General
Introduction to the petroleum industry
Fundamentals of the petroleum industry

9. National Drilling and Well Control Programme

The University of New South Wales' School of Petroleum Engineering in cooperation with the oil and gas industry provides expert training through its National Drilling and Well Control Program (NDWCP).

The National Drilling and Well Control Program was formed to provide vocationally based training and assessment to oilfield professionals. Through the provision of expertly written short courses, industry personnel can obtain qualifications that are both current and applicable to our ever-changing industry. Recognition and accreditation from industry bodies such as the International Association of Drilling Contractors (1ADC) and the International Well Control Forum QWCF) means that high standards are achieved and maintained via a rigorous quality assurance process.

Central to the National Drilling and Well Control Program is our Well Control and Blowout Prevention training and certification using our two Drilling Simulators DS 500 (UK). Candidates are exposed to various levels of well control training each designed to suit their current work environment. Five separate course curricula have been developed by professional industry specialists in both drilling engineering and education.

The first course deals with current standard well control practices and procedures. This course is designed to incorporate offshore and onshore drilling operations from introductory to supervisory level. It is also designed to provide training for specialised operations in either geothermal or coal-bed methane applications.

The second course provides training in High Pressure and High Temperature Well Control. Advanced well control training for this highly dangerous setting tests the candidates' understanding of tertiary as well as secondary well control techniques. The section on abnormal pressure control provides invaluable training before undertaking such drilling activities in the field.

Workover and Well Intervention Training is catered for in our third course. Normal workover operations are highlighted and the course includes snubbing, wireline applications as well as coiled tubing intervention.

The last of our short courses deals with induction training. The Rig Induction and Orientation course trains those new to the industry in operational and safety matters. This course has the endorsement of the International Association of Drilling Contractors' Rig Pass Accreditation Program. The other induction training course introduces candidates to Air Drilling operations and the procedures associated with this type of drilling.

Since the formation of the National Drilling and Well Control Program in 1997, hundreds of satisfied candidates have enjoyed the practical, relevant professional training that the courses offer. Our aim is to continue to provide the latest techniques in adult educational training. Dedication to this aim will ensure that the candidates enjoy their learning experience with us.

Further information is available by contacting our Business Manager:

Tel: 61-2-9385 5184
Fax: 61-2-9385 5182
E-mail: drilling@ unsw. edu.au

Alternatively, you may visit our website at:
www.petrol.unsw.edu.aulndwcpl

Well control training on a rig simulator

10. Consulting

SCOPE provides the international oil and gas industry with consulting services in the following areas:-

Services

- Field development geology
- Reservoir characterisation
- Conventional log analysis
- Log analyses for complex reservoirs
- Formation evaluation
- Reservoir simulation
- Reservoir engineering
- Well test analysis
- Natural gas engineering
- Drilling engineering
- Drill string failure analysis
- Improved oil recovery
- Reserves assessment and certification
- Integrated reservoir development studies
- Arbitration
- Unitisation
- Field development planning economics
- Economic evaluations
- Oil and gas company and property valuation
- Oil and gas economic modelling

The list of consulting services covers the complete range of upstream oil and gas industry reservoir appraisal, field development, economic assessment and commercial activities.

We have undertaken consulting projects throughout the Asia / Pacific region and have worked for a variety of oil and gas companies, specialist consulting groups, banks (on petroleum financing projects), legal firms and Government Departments (from resource assessment and monitoring departments to taxation offices and finance and commercial ministries).

We have been able to tie in our consulting services with specialist training programmes. We have the scope, depth and flexibility to shape our services to the exact requirements of our clients.

Clients

The clients which have used the consulting services of individuals at SCOPE include the following organisations:-

- Asamera
- Cairn Energy
- Command Petroleum
- Core Lab Indonesia
- Pertamina
- Woodside
- NSW Shelf partners
- BHP Petroleum
- National Economic Research Association
- BZW Corporate Finance
- Indonesian Petroleum Association
- Southern Petroleum
- Fletcher Challenge
- NZ Ministry of Commerce
- NZ Taxation office
- AGSO
- Ernst and Young
- Japex
- Government of Brunei
- Hartogen Energy
- Renong
- Santos
- Mobil
- Shell
- OPIC
- NSW Department of Mineral Resources
- Western Australia Petroleum (WAPET)
- Oil Company of Australia
- Gas Research Institute, USA
- Mosaic Oil
- Boral Energy
- Petrocorp
- Esso Australia
- Roc Oil
- Asian Development Bank
- Ceylon Petroleum Corporation
- Oil and Natural Gas Corporation (India)
- Asian development Bank

11. People

SCOPE has the following staff, researchers and associated members:-

Val Pinczewski

Professor and Director of Petroleum Engineering

Val Pinczewski is Professor of Petroleum Engineering and Director of SCOPE. Prior to joining the university, he worked as a Petroleum Engineer with Esso Australia. Professor Pinczewski conducts major research programs in improved oil recovery, miscible and immiscible gas flooding, rock microstructure, pore-scale displacement physics and three-phase flow through porous media. He is the author of numerous technical papers and is an active industry consultant in improved oil and gas recovery, reservoir engineering and reservoir simulation.

Lincoln Paterson

Adjunct Professor of Petroleum Engineering

In addition to his association with SCOPE, Lincoln Paterson is a Senior Principal Research Scientist in the CSIRO Division of Petroleum Resources. He received a BSc degree (honours) from Monash University and a PhD in engineering physics from the Australian National University. After graduating, he held postdoctoral positions in chemical engineering at the University of Ottawa and the University of Minnesota. He is an author of more than 40 journal papers and 30 conference papers. He is a member of the Society of Petroleum Engineers and currently secretary of the Victoria/Tasmania section.

Sheik Rahman

Associate Professor of Petroleum Engineering

Dr. S. Rahman is an Associate Professor and the Director for Postgraduate Studies and Continuing Learning Program at SCOPE. He is a specialist in Drilling and Production Engineering and has served the petroleum industry in the Middle East, Europe and Asia for over 12 years. He has developed and taught over 25 industrial training courses in Asia, Europe and Australia. He has published over 40 scientific papers in drilling related areas and a text book on casing design. He is an active member of the program committee of the SPE-IADC Asia Pacific

Conference and plays an important role in developing strategic planning and direction for the SPE-IADC programs. Dr. Rahman received a BSc in Mechanical Engineering, an MSc in Marine Technology from UK and PhD in Petroleum Engineering from West Germany.

Henry Salisch

Senior Lecturer

Henry Salisch has degrees in Geological Engineering and Petroleum Engineering (University of Oklahoma). He worked as a Geologist for Anglo-Ecuadorian Oilfields and in log interpretation with Schlumberger for over 20 years. He headed the petrophysical group (well log evaluation) of Intevep (research affiliate of Petroleos de Venezuela), as Senior Research Associate, for close to 10 years. He is Director of Undergraduate Studies at SCOPE and has published in excess of 20 papers related mainly to the integration of log, core and test data in formation evaluation. He is a member of SPE, SPWLA, EAGE, Pi Epsilon Tau.

Stephen Tyson

Visiting Lecturer

Stephen Tyson received a BSc in Physics from Imperial College, London. He is currently the Director of Technology Development for Geovisual Systems, a company which specialises in visualisation and modelling software for the petroleum industry. His research interests are in artificial intelligence tools and their application to exploration risk, experimental design and validation of AI techniques. He is a Chartered Mathematician and a member of SPE.

11. People

Guy Allinson

Senior Lecturer

Guy Allinson is a Senior Lecturer at SCOPE. He conducts undergraduate and postgraduate courses in petroleum economics and business practices and carries out research into the petroleum industry in the Asia Pacific region. He has also given frequent presentations to oil and finance industry seminars and conferences and has conducted many oil industry short courses in petroleum economics and PSC/fiscal analysis worldwide. Before joining SCOPE, Guy held various petroleum economics and commercial positions in the oil and gas industry. He has advised companies and Governments in the Asia/Pacific region on petroleum PSC and fiscal terms. He has valued many petroleum properties and companies for acquisition and sale, prepared economics research reports on the oil and gas industry and has provided commercial support for oil field operations and investments worldwide.

Desmond Nguyen

Senior Research Associate

Dr. Desmond Nguyen specialises in wellbore hydraulics. His research interests include cutting transport and cement displacement in horizontal wells and hydraulic fracture stimulation for gas recovery. Prior to joining SCOPE, he worked for Santos Ltd as a Petroleum Engineer.

Mark Knackstedt

Senior Research Associate

Mark Knackstedt received his BSc from Columbia University and his PhD in Chemical Engineering from Rice University. Since then he has held research fellowships at the Department of Applied Maths at the Australian National University and at SCOPE. His research interests include the prediction of properties and characterisation of disordered composite materials, and the study of multi-phase flow and displacement properties of sedimentary rock.

Michael Kagan

Research Associate

Michael has a B.Sc (Hons) degree in physics from Leningrad State University and an M.Sc (Hons) from Macquarie University. His research interests include the hydrodynamics of ferrofluids, sedimentation and capillary phenomena in porous rock. His major interest is in capillary phenomena and the distribution of the liquid phase in pores. He is also involved in the improved oil recovery and wellbore engineering programmes where he assists with mathematical modelling problems.

Dilip Tamhane

Research Associate

Dilip Tamhane received an M.Sc. degree in petroleum geology from the MS University in India. He has worked as a development and exploration geologist with the National Oil Company of India for 24 years. He was associated with the Australian Tight Gas Project at SCOPE. He has provided consultancy services to Australian and New Zealand companies. He is involved in research on incorporating geological uncertainties into reservoir modelling, has published many papers and given numerous presentations to industry.

Zhixi Chen

Senior Research Associate

Dr. Zhixi Chen received his PhD in Petroleum Engineering from the University of Petroleum in China. He specialises in rock mechanics and its application in petroleum engineering. His research interests include physical and numerical modelling of wellbore stability and hydraulic fracturing/stimulation of hydrocarbon and geothermal reservoirs, determination of in-situ stresses, measurement of mechanical and petrophysical properties of rock materials, acid stimulation of reservoir and well planning. Prior to joining SCOPE, he worked as an associate professor at the University of Petroleum, China.