出國報告（出國類別：開會）

參加國際油氣增產技術研討會

服務機關：台灣中油公司探採研究所
姓名職稱：吳柏裕　鑽井採油組組長
派赴國家：美國
出國期間：101 年 10 月 08 日 至 101 年 10 月 14 日
報告日期：102 年 1 月 11 日

摘要

101.10.9~10：參加油氣增產技術研討會（美國 SPE-2012-ATCE），共有 370 篇論文發表，取回此次油氣技術研討會光碟，供鑽採工作同仁共享最新之油氣增產技術資料，以及非傳統須液裂增產之緻密氣、頁岩氣、油砂等之最新之油氣增產技術資料。

101.10.11 赴本公司今年參加美國 Austin 德州大學經濟地質局二氧化碳地下封存研究機構 GCCC，討論執行 CCS 二氧化碳地下封存工作實務進展與技術，對本公司正在注 CO_2 甚有助益。

101.10.12 赴本公司 Houston 之 OPIC 辦公室，取得 PetroSkills 公司有關液裂增產「Hydraulic Fracturing Applications」訓練課程資料，鑽採工作同仁可儘早共享此最新之油氣增產技術資料。

本次與會攜回之有關資料已繳存於台灣中油公司探採研究所技術圖書室內，供公司內相關業務同仁參考。

目錄

壹、 目的

參加油氣增產最新發展技術研討會(San Antonio)、赴美國 GCCC(Austin)討論執行 CCS 工作實務技術、訪 OPIC 收集研討本公司在美國參加緻密油氣田礦區權益，施作液增產相關評估技術與資料(Houston)。

貳、 過程

101 年 10 月 8 日　臺北啓程

101 年 10 月 9 日　清晨抵達美國德州 San Antonio 市
報到參加油氣增產技術研討會[美國石油工程師協會 Society of Petroleum Enguneers ,SPE, 2012 年年會 Annual Technical Conference and Exhibition, ATCE]

101 年 10 月 10 日　續參加油氣增產技術研討會[美國石油工程師協會 Society of Petroleum Enguneers ,SPE, 2012 年年會]

101 年 10 月 11 日　訪 GCCC(Austin)討論執行 CCS 工作實務技術

101 年 10 月 12 日　訪 OPIC 收集研討本公司在美國參加緻密油氣田礦區權益，施作液裂增產相關評估技術與資料

101 年 10 月 13-14 日　返程抵達台北

參、 心得

一、 101.10.9~10：參加油氣增產技術研討會（美國 SPE-2012-ATCE），共有 370 餘篇論文發表，取回此次油氣技術研討會光碟，供鑽採工作同仁共享最新之油氣增產技術資料，以及非傳統須液裂增產之緻密氣、頁岩氣、油砂等之最新之油氣增產技術資料。

以下依發表日期順序概要介紹與本公司目前工作較爲相關之研討論文

SPE#159346

Hydraulic Pumping Units Proving Very Successful in Deliquifying Gas Wells in East Texas *Jess A. Babbitt, Devon Energy; Kenny Vincent, Lufkin Industries*

此篇介紹 Devon 公司在美國東德州利用一種 Hydraulic Pumping Units 成功完成氣井舉生方式使伴產液體氣井再生產之案例(原先用 Plunger, Soap, velocity string 仍無法復產)，值得我們對出水停產復產工作參考。(但目前國內陸上氣井伴產水苦於無足夠伴產水還原井可用)。

(Fig.2)，或許永和山 6 號井伴產凝結油之油柱壓影響產氣問題可參考解決。(Fig.5)

(HPU : Lufkin Industries 公司產品)(World Oil, May 2012, pp.79-85)

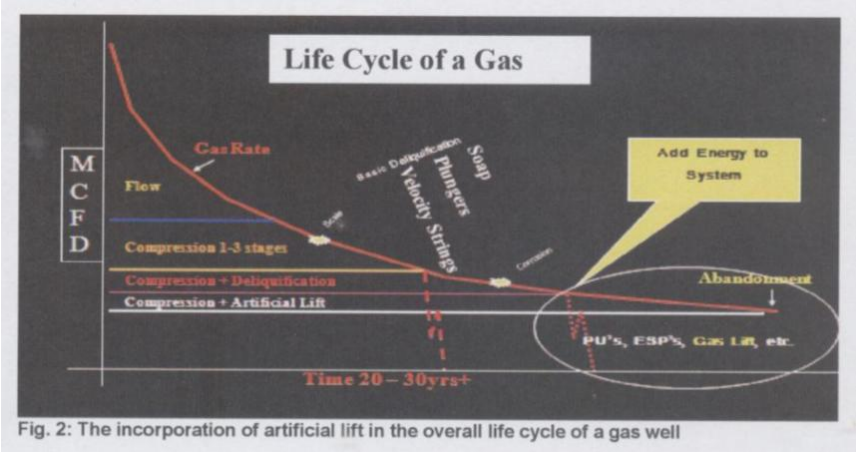


Fig. 2: The incorporation of artificial lift in the overall life cycle of a gas well

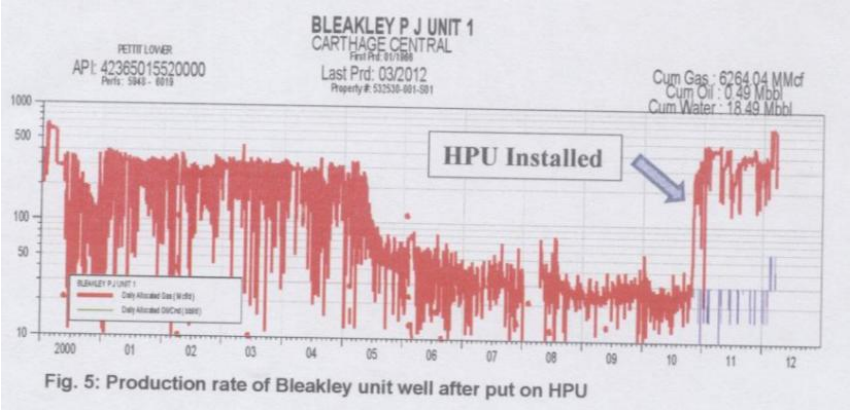


Fig. 5: Production rate of Bleakley unit well after put on HPU

SPE#158935

Hydraulic Fracture Geomechanies and Mircoseismic Source Mechanisms

N.R. Warpinski, M.J. Mayerhofer, K. Agarwal, J. Du, Pinncale--A Halliburton Service

這一篇介紹在Marcellus Sh.施做液裂，利用微震測源監測技術收集液裂裂隙開展情況之相關技術。(Fig.1)(Fig.18)

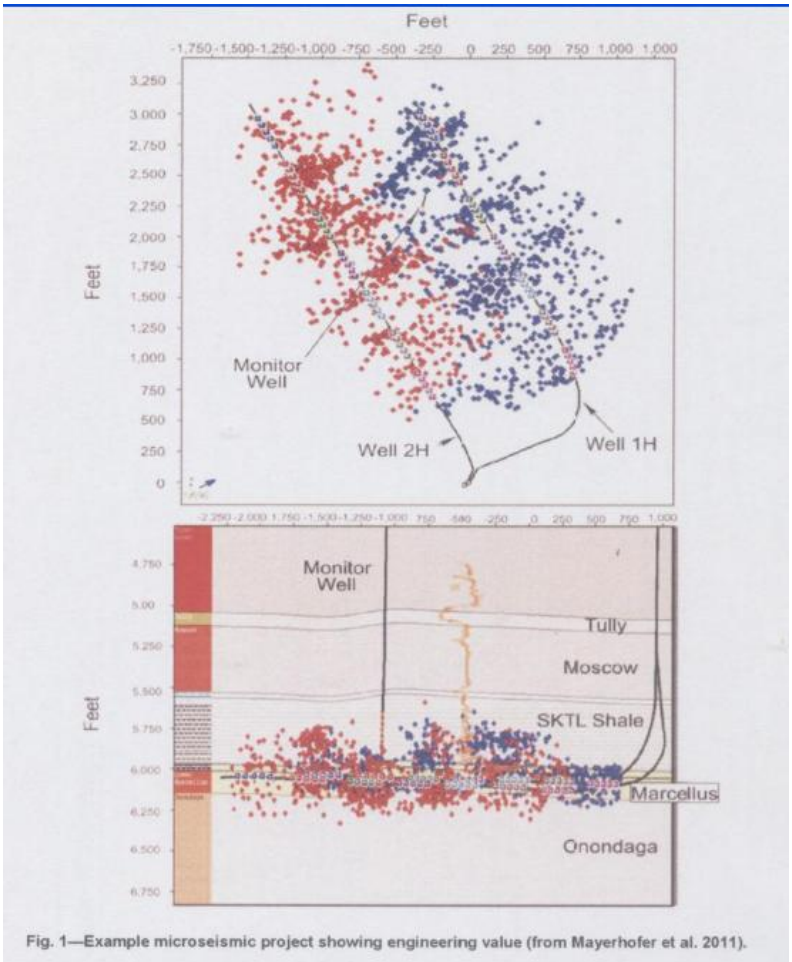


Fig. 1—Example microseismic project showing engineering value (from Mayerhofer et al. 2011).

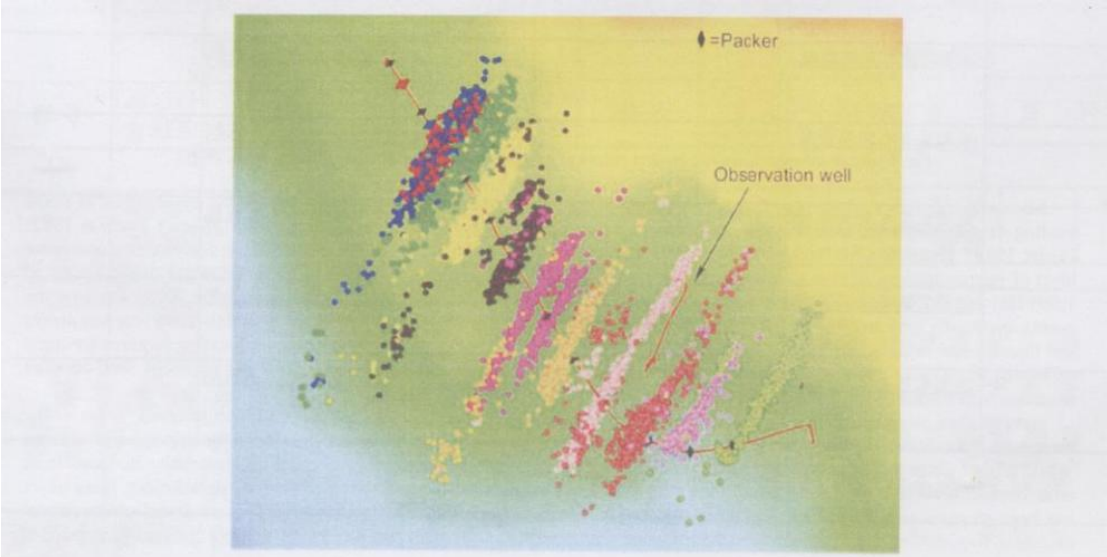


Fig. 18—Example microseismic monitoring of a horizontal well with packers and ports showing details of separate fracture initiation and growth (after Shaffner et al. 2011).

#159670

Subsurface To Surface Microseismic Monitoring for Hydraulic Fracturing

Olivier Peyret, Julian Drew, Mark Mack, Keith Brook, Shawn Maxwell, Craig Cipolla

此篇與#158935 類似，但重點在試圖利用地表或近地表方式監測液裂之微源，看能否以較少之井內井底監測配合地面監測即可達成足夠監測液裂微震源。

（Fig.1）用較少的井內監測可降低監測費用。

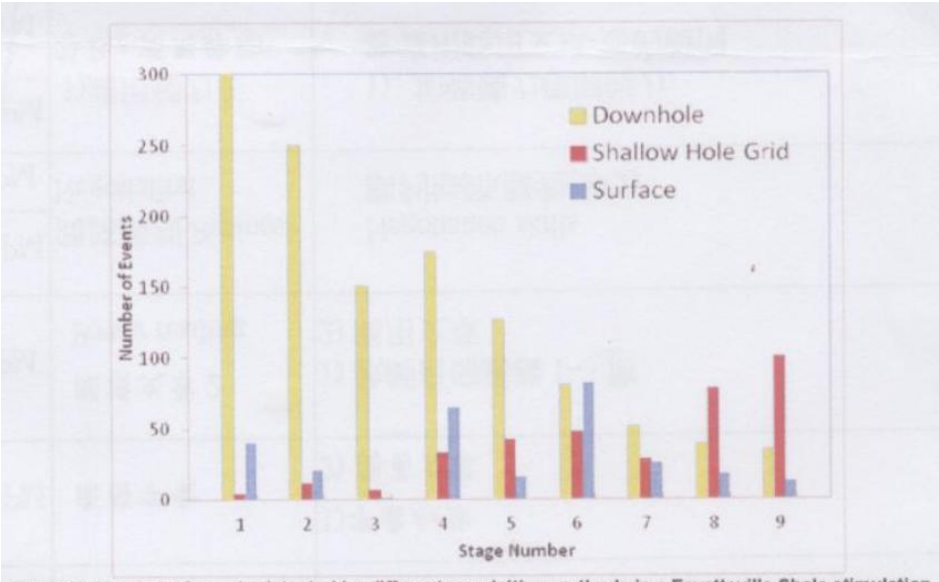


Figure 1 Number of events detected by different acquisition methods in a Fayetteville Shale stimulation.

#159536

Stimulated Shale Volume Characterization: Multiwell Case Study from the Horn River Shale: I. Geomechanics and Microseismicity

O. Hurd, and M.D. Zoback, SPE, Stanford University

此爲類似#158935，是Horn River Basin Sh.求Sh. Volume之案例（Fig.1）

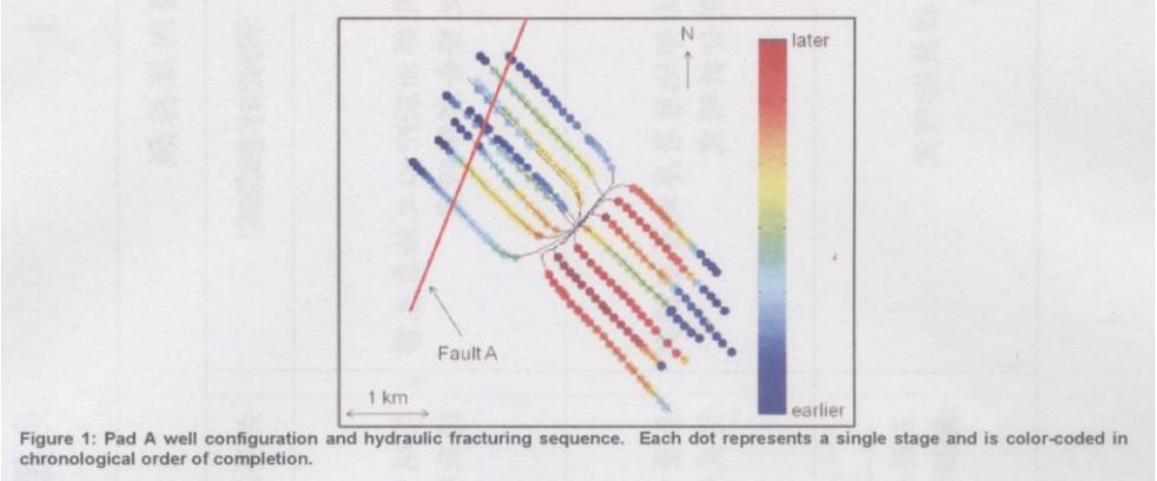


Figure 1: Pad A well configuration and hydraulic fracturing sequence. Each dot represents a single stage and is color-coded in chronological order of completion.

#160169

Reappraisal of the G Time Concept in Mini-Frac Analysis

R.C. Bachman, Taurus Reservoir Solutions Ltd., D.A. Walters, Taurus Reservoir Solutions Ltd., R.A. Hawkes, Pure Energy Services Ltd., Fabrice Toussaint, Dinova Petroleum Ltd., A. Settari, University of Calgary

這篇介紹 mini-frac 理論上如何利用暫態壓力分析（PTA）觀念來推展鑑定液裂生產井各種流動情況（various flow regimes），結合 Bourdet log-log 微分壓力圖與基本微分壓力（Primary pressure derivative, PPD）來建立能進一步確認流動情境。目的在進一步決定封閉壓力（Closure pressure determination）。

#159174

Quantifying Proved Undeveloped Reserves in the Woodford Shale: A Seamless Integration of Statistical, Empirical, and Analytical Techniques

Kulkarni, Madhav M.; Cox, Stuart A.; Woods, Marcelyn E.; Van Meter, Gregory M.; Jensen, Timothy, R.; Altemus, Rebecca L.; Marathon Oil Corporation

這一篇是 Marathom Oil 公司對他們在 Woodford Sh.礦區如何設法定量頁岩區「證實未開發蘊藏量」(Proved Undeveloped Reserves)，如何以統計、經驗、解析技術三方面來整合的做法說明。(References)

#159360

Framework Increases Effectiveness of M&A Teams When Acquiring, Validating and Analyzing Information from Data Rooms

Bob Harrison, Senergy Limited

此篇介紹對有意願取得某公司礦區權益之 data room 如何有效取得資料，應規劃如何進行，應遵循執行之架構。如何不遺漏執行 DD，不論是 Data room 爲 Physical 或 Virtual，進入前、檢視中、執行後應如何做，都提出了詳實的建議。(Table2, 3, 4, 5, 6, 7, 8)

Data Priority	Relative Importance	Comment
1	**essential**	**absolute minimum of info needed to complete any study**
2	valuable	nice-to-have, info that can reduce uncertainty in key parameters or helps to accelerate the study
3	*beneficial*	*background, non-essential info that can help the study*

Table 1: Hierarchy of data requirements

Priority	Drilling & Completion Data
1	**Drilling & completion reports for every well in the asset portfolio, including offset wells.**
1	**Curves of drilled depth, budgeted cost, actual cost vs. time for every well.**
1	**Schematics of completed wells with sizes of OH sections & casing strings.**
1	**Details of leak off tests, squeeze jobs, plug backs**
2	Drill bit records
3	*Daily drilling operations reports*
3	*Drilling & completion fluid properties*

Table 2: Driller's priority list

Priority	Geological, Geophysical & Geochem Data
1	**maps (structure, isopach, petrophysical)**
1	**structural & stratigraphic cross sections**
1	**seismic interpretations**
1	**composite logs**
2	imaging & dipmeter data
2	previous depositional/environmental studies
2	whole core descriptions
3	*past studies of all types (geochem, biostrat)*
3	*petrology (SEM, thin sections, water analysis)*

Table 3: Geoscientist's priority list

Priority	Petrophysical Data
1	**digital log data for all wells**
1	**routine core analysis**
1	**log depth to TVDSS conversion**
1	**log header info especially temperatures, mud resistivities & surface locations.**
1	**ensure perforated intervals & well test/production rates of oil, water & gas are recorded.**
1	**SCAL I data (Kr curves, Pc-height)**
2	SCAL II data (RI, FF, hydrostatic compaction, CEC)
2	previous CPIs with petrophysical summaries

Table 4: Petrophysicist's priority list

Priority	Oil , Gas & Water Production
1	monthly well production & injection records
	Fluid Properties
1	original lab reports on reservoir fluid PVT, same for injection fluids.
1	lab separator test results (original report & interpretations)
1	crude assay & water analysis
2	summaries of previous PVT or fluid property treatments, oil chemistry
	Core Data
1	routine core analysis & SCAL
	Pressure Data
1	production tests, WFTs, DSTs, transient & static data
2	results of pressure analysis
	Reservoir Studies
1	check input assumptions to models & QC history matches

Table 5: Reservoir Engineer's priority list

Priority	Completion Data
1	**schematic of completion with dimensions of casing & tubing**
1	**perforations (type & depths)**
1	**workover results of acid washes & acid/hydraulic fracture jobs**
1	**field bottom hole pressure surveys with date & measurement depth datum**
2	Stimulation treatment data - slurry schedules, rate schedules
3	*daily well operations reports, completion fluid properties*
Priority	**Oil, Gas & Water Production & Injection**
1	**monthly production & injection records**
1	**field separator operating conditions over time**
1	**allocation formula for tank batteries or gathering centres**
2	results of interference testing (if performed)
2	results from observation wells (if available)
2	results of inter well chemical tracer tests (if performed)
Priority	**Surface Facilities, Flow Line Constraints & Operating Environment**
1	**description of field facility, including overall capacity & layout.**
1	**design & operating parameters for each element, including flow rates & pressures.**
1	**supporting infrastructure including export systems.**
1	**capex including phasing.**
1	**opex.**
1	**government regulations concerning field development.**
2	national infrastructure including pipeline, rail, power & road systems.
3	*local equipment suppliers & fabricators.*

Table 6: Production/Facilities Engineer's priority list

Priority	Commercial Data
1	**fixed/variable costs or economic limit per well, for a group of wells, & for the field.**
1	**E&P license terms (including any tax arrangements)**
1	**gas contract obligations**
1	**Oil & gas prices realised in local markets and elsewhere**
2	cost of drilling & completing a typical well to each major horizon
2	well opex
2	platform opex

Table 7: Economist's priority list

		Asset / Field Name	Asset value/portfolio importance decreases to right as per Pareto Analysis!!		
Due Diligence Item		Field C	Field B	Field A	Exploration Prospect X
COUNTRY RISK	Safe, stable business environment?				
VENDOR RISK	Trust vendor + his claims?				
DEAL RISK	Intent to do deal? Can we close?				
SUBSURFACE	Regional Geology/data	Limited regional data integrated	Build better reservoir model?	Comparison w/ regional wells	Passable fit to proven plays?
	Geophysics/mapping	QC seismic/well tie?- is crest updip of well?	QC seismic/depth conv? Does ODT match closure?	Awaiting revised maps/QC seismic/well tie	Reliance ?
	Petrophysics	discovery well logs analysed	Re-evaluated Pilot Hole: ODT	Await answer MD/TVD discrep	Reliance ?
	Reservoir/geology	Proven disc./play type- 1 well	Re-evaluate n/gphi frac picture	Integrate regional data above	Proven play/analogues?
	Volumetrics/risk analysis	Completed but using Seller maps- await geophys review	Re-visit based on geophys?	Awaiting requested maps to finalise net pay/GRV inputs	Reliance ?
	Q/C Reserve Audit	Ext Auditor view unchanged	Auditor considered optimistic	Audit prior to App success	Reliance ?
	Production Hist. match/ DCA / MBAL	n/a	Unchanged- DCA based	n/a	n/a
	Well type, DD profile/EUR	Awaiting final MBAL model	Unchanged- DCA based	Update audit based on regional well	Reliance ?
	FDP concept	Need for 3D seismic pre drill?	Re-evaluate number of wells?	Review need for 3D seismic	Reliance ?
FACILITIES COSTS	Well/drilling costs	large risk on cost + timing	Update	Needs Review post wildcat	Reliance ?
	Facilities Costs	Update with revised well count	Update with revised well count	Needs Review post wildcat	Reliance ?
	Opex/transport costs	Can we export by barge?	Update	Needs Review post wildcat	Reliance ?
	Timing etc.?	CAN WE DRILL BY JULY 09? Else we lose license? Timing to approval dev't EIA + permit?	Update	Needs Review post wildcat	Reliance ?
ECONOMICS	Economic model	Update as per above - include stock options in model			
	Tax	Updated tax asset base			
	Financial Statements/Accounts	Update			
	Miscell.	Convertible notes update			
LEGAL / COMMERCIAL	Licence/Title/Expiry	Check title to area outside blk	ANH excl. zones/blk boundary		
	Permitting etc.	Check permit drill/produce?			
	Crude Oil Sales Agreements	Check			
	Commitments/Work Programme etc.	Drill by July 09? Risk missing deadline? Cost of committed work program next phase?			
HSE	Regulatory Compliance	Check during field visit			
	Environmental	Check EIS completed/approved- national park issues			

Table 8: Due diligence 'traffic light' table

#162520

New Guidelines Document Assists With PRMS Applications

W. John Lee, University of Houston; Satinder Purewal, Energy Equity Resources; D. Ronald Harrell, Ryder Scott

本篇是關於Reserve and resource之全球性定義系統AG（Guidelines for Application of Petroleum Resource Management System）關於PRMS（Petroleum Resources Management System）文件最新增補的說明。

#158053

The Effect of Water-Induced Stress to Enhance Hydrocarbon Recovery in Shale Reservoirs

Perapon Fakcharoenphol, Sarinya Charoenwongsa, Hossein Kazemi, and Yu-Shu Wu, Colorado School of Mines

這一篇是討論建立一個數值模式，來研究注水，包括水沖注水、頁岩油藏液裂、CO2 EOR…等等，因提昇地層孔隙壓力，引生天然巨觀裂隙（Natural macrofracture）再發展或產生新的巨觀裂隙。或降低溫度在岩基塊（Matrix block）表面產生小的微裂隙，可以增加油氣採收。

#160002

Integration of Microseismic Data, Fracture and Reservoir Simulation into the Development of Fractured Horizontal Wells in the Cardium Formation – A

Tight Oil Case Study

David Quirk and Ali S. Ziarani, Trican Well Service; Scott Mills, SPE; and Kevin Wagner, Nuvista; Cheney Chen, Trican Well Service

這是一篇加拿大 Cardium 緻密油層如何整合微震與水平井液裂資料，並進行 3D 油層模擬結果之工作流程（Workflow）報告。

#158501

Eagle Ford Shale: Hydraulic Fracturing, Completion, and Production Trends: Part II

Sergio Centurion, SPE, Randall Cade, SPE, Xin "Lucy" Luo, Baker Hughes

這一篇延續之前 SPE#249258，整理了美國 Eagle Ford Shale 200 口井以上，3,000 階段（Stages）液裂之分析工作，包括其完井型式、油氣體積、效率等之分析，並擴增至生產數據、化學液裂添加劑，此文建議這些資料對於 Eagle Ford 及類似頁岩之瞭解與完井最佳化應極具價值。

#159892

Eagle Ford Shale: Hydraulic Fracturing, Completion, and Production Trends: Part II

Sergio Centurion, SPE, Randall Cade, SPE, Xin "Lucy" Luo, Baker Hughes

這是一篇整理過去 10 年用微震來監測頁岩氣礦區，來深入瞭解液裂的文章。關於如何用取得資料來估計複雜的 Discrete Fracture Network(DFN)，及估計 Enhance Fluid Flow（EFF），再用 DFN 與 EFF 之空間分佈與裂隙之互連性來求更實際之液裂參數如 Stimulated Reservoir Volume（SRV）。

#159956

Analysis of Unsteady Responses of Natural Gas Reservoirs via a Universal Natural Gas Type-Curve Formulation

Ayala H., Luis F. and Ye, Peng, SPE, The Pennsylvania State U.

一般天然氣田生產下降曲線分析是利用油井的 Fetkovich 典型曲線改成 Pseudo-pressure 與 pseudo-time 再配合 rate（產率）-time（時間）生產數據之經驗曲線湊合（fitting）來使用，本篇提出單線、萬用典型曲線來做受邊界影響流動（Boundary dominated flow, BDF）天然氣井未穩態之分析，可用來分析預測未來氣井的生產動態並可靠地估算蘊藏量，估得參考。(可用在錦水深部剩餘蘊藏量估算）（Fig.2）

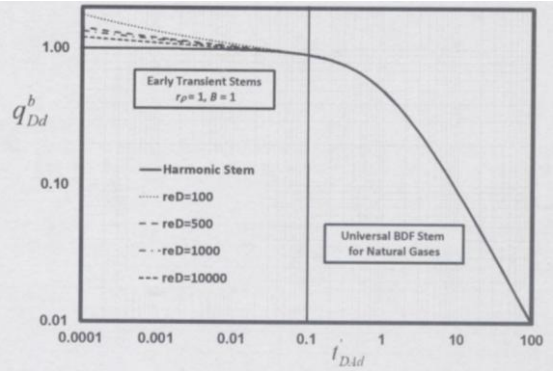


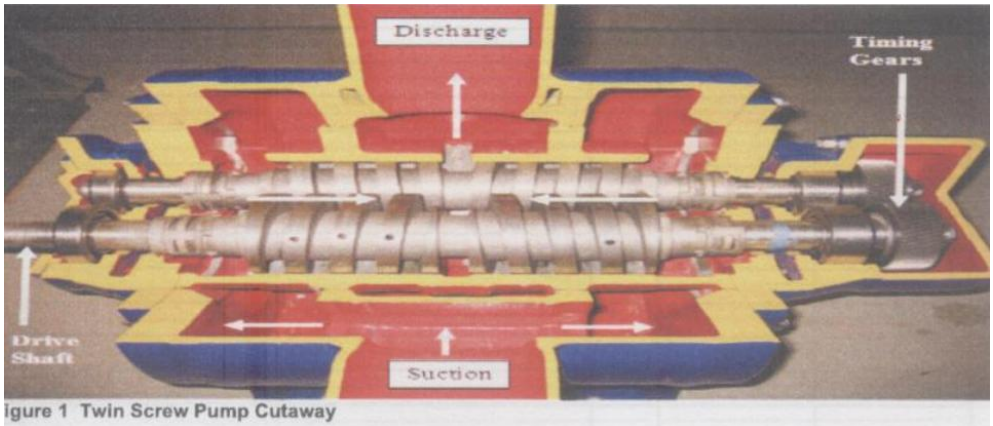
Figure 2: A universal type-curve for BDF analysis of gas well decline

#159910

Experimental Investigation of Wellhead Twin-Screw Pump for Gas Well Deliquification

Gerald L. Morrison, Ryan Kroupa, Abhay Patil – TAMU; Jun Xu, SPE, & Stuart Scott – Shell; Sven Olsen – Leistritz

這一篇介紹將 Leistritz 的雙螺旋 pump 用在有液體貯積氣井之適用裝置，值得進一步瞭解可否引進台灣陸上出水氣井或永和山 6 號伴產凝結油之井。(Fig.1, 2)



igure 1 Twin Screw Pump Cutaway

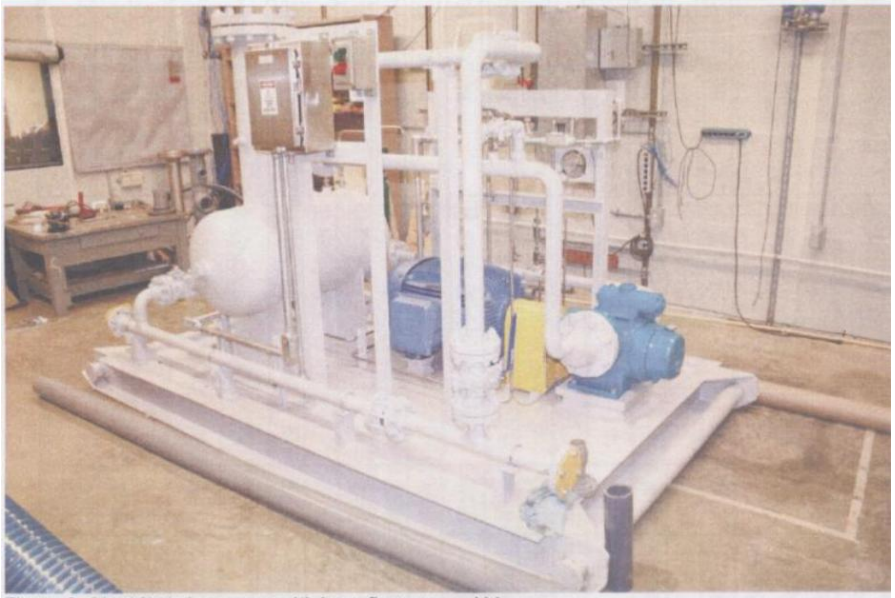


Figure 2. Lieztritz twin screw multiphase flow pump skid.

#159147

Gas Well Dewatering Pump for 2⅜ inch Production Tubing

Kenneth Sears, ZiLift Ltd

這篇是介紹ZiLift公司開發出一種不必修井可爲低產率氣井除水之pump，可以不必鑽機，放入2 3/8吋油管內使用。可考慮引進國內陸上出水氣井或永和山6號伴產凝結油之舊井。(Fig.1, 7)

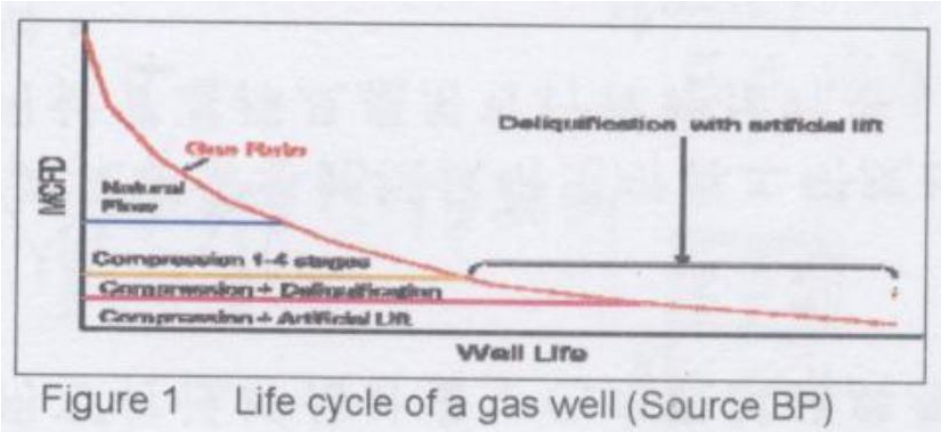


Figure 1 Life cycle of a gas well (Source BP)

#160045

A New Family of Nanoparticle Based Drilling Fluids

Mukul M. Sharma, The University of Texas at Austin; R. Zhang, China University of Petroleum; M.E. Chenevert, The University of Texas at Austin; L. Ji, Q. Guo, J. Friedheim, M-I SWACO

本篇提出鑽頁岩層時使用全奈米顆粒水基泥漿之測試評估結果，此種奈米顆粒泥漿可大幅降低泥漿與頁岩發生反應，大爲減少鑽井通過頁岩層遭遇的嚴重問題，此種奈米顆粒泥漿可試著從M1-SWACO公司取來試驗，對國內鑽井過頁岩層之問題應有很大幫助。

#135155

Numerical Modeling of Induced Fracture Propagation: A Novel Approach for Lost Circulation Materials (LCM) Design in Borehole Strengthening Applications of Deep Offshore Drilling

Saeed Salehi, University of Louisiana at Lafayette, Runar Nygaard, Missouri University of Science and Technology

本篇提出利用3D有限元素法對於鑽井造成漏泥時分析如何強化井孔之機制，以分析鑽井引生裂隙之問題如何防阻，包括實驗室中求出漏泥段岩心滲透率，抗張強度之重要性，以及滲透試驗數據庫對井孔強化之應用。

#156188

Pushing the Limits of Downhole Sand Control: E Field

J. Thilagalingam, SPE, Natasha M.S, SPE, M Jadid, SPE, Petronas Carigali Sdn Bhd

本篇是Petwnas公司在防砂工作上，關於28號井運用裸孔礫石防砂或僅用篩網(Stand along screen, SAS)的研究報告，值得我們在完井防砂工作上之參考。

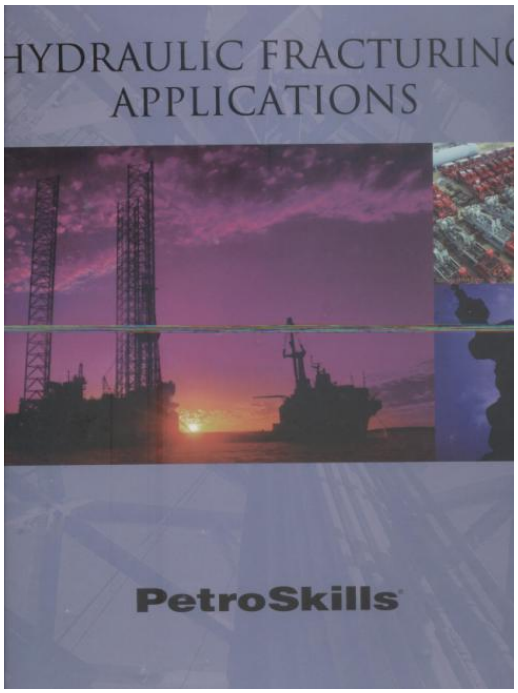
#159273

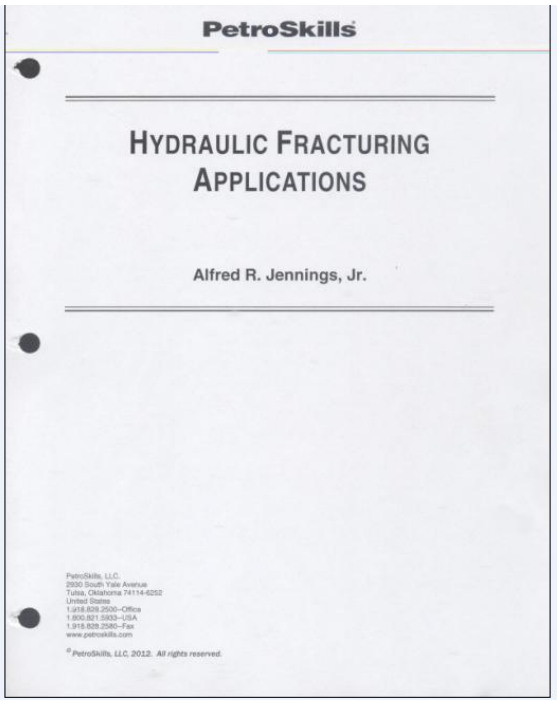
A New Method for Earlier and More Accurate EUR Prediction of Haynesville Shale Gas Wells *Xueying Xie, Michael D. Fairbanks, Kevin S. Fox, Rena L. Koinis, Shell Exploration & Production Company*

本篇是關於頁岩氣井如何估算最終採收量（Estimated Ultimate Recovery, EUR）之探討，提出一個將傳統Arps下降曲線分析（Decline Curve Analysis, DCA），使用壓力正規化氣產率（Pressure Normalized rate）取代只用實際產氣率（real rate）的方法，對於緻密氣層之EUR估算應頗具參考價值。

二 、 101.10.11赴本公司今年參加美國Austin德州大學經濟地質局二氧化碳地下封存研究機構GCCC，討論執行CCS二氧化碳地下封存工作實務進展與技術，對本公司正在永和山注CO2甚有助益。(返國後10月17日爲國內第一次順利注入CO2約3.3噸)。

三、 101.10.12 赴本公司 Houston 之 OPIC 辦公室，取得 PetroSkills 公司有關液裂增產「Hydraulic Fracturing Applications」訓練課程資料，鑽採工作同仁可共享此最新之油氣增產技術資料。

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HYDRAULIC FRACTURING APPLICATIONS

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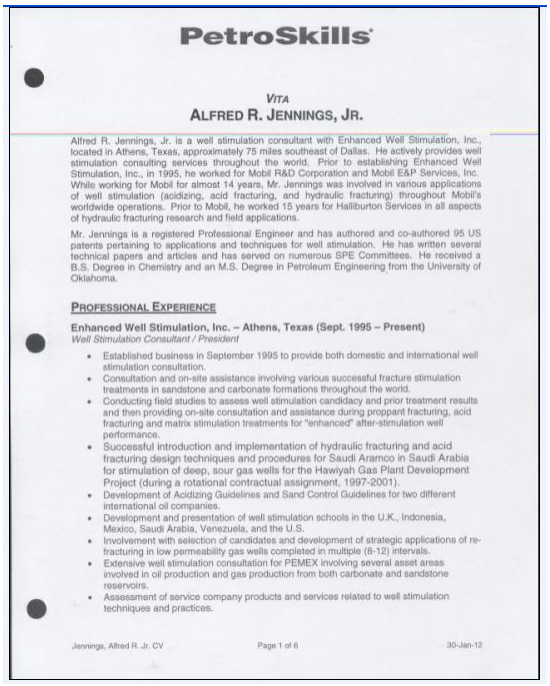
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VITA

ALFRED R. JENNINGS, JR.

Alfred R. Jennings, Jr. is a well stimulation consultant with Enhanced Well Stimulation, Inc., located in Athens, Texas, approximately 75 miles southeast of Dallas. He actively provides well stimulation consulting services throughout the world. Prior to establishing Enhanced Well Stimulation, Inc., in 1995, he worked for Mobil R&D Corporation and Mobil E&P Services, Inc. While working for Mobil for almost 14 years, Mr. Jennings was involved in various applications of well stimulation (acidizing, acid fracturing, and hydraulic fracturing) throughout Mobil's worldwide operations. Prior to Mobil, he worked 15 years for Halliburton Services in all aspects of hydraulic fracturing research and field applications.

Mr. Jennings is a registered Professional Engineer and has authored and co-authored 95 US patents pertaining to applications and techniques for well stimulation. He has written several technical papers and articles and has served on numerous SPE Committees. He received a B.S. Degree in Chemistry and an M.S. Degree in Petroleum Engineering from the University of Oklahoma.

PROFESSIONAL EXPERIENCE

Enhanced Well Stimulation, Inc. – Athens, Texas (Sept. 1995 – Present)
Well Stimulation Consultant / President

- Established business in September 1995 to provide both domestic and international well stimulation consultation.
- Consultation and on-site assistance involving various successful fracture stimulation treatments in sandstone and carbonate formations throughout the world.
- Conducting field studies to assess well stimulation candidacy and prior treatment results and then providing on-site consultation and assistance during proppant fracturing, acid fracturing and matrix stimulation treatments for "enhanced" after-stimulation well performance.
- Successful introduction and implementation of hydraulic fracturing and acid fracturing design techniques and procedures for Saudi Aramco in Saudi Arabia for stimulation of deep, sour gas wells for the Hawiyah Gas Plant Development Project (during a rotational contractual assignment, 1997-2001).
- Development of Acidizing Guidelines and Sand Control Guidelines for two different international oil companies.
- Development and presentation of well stimulation schools in the U.K., Indonesia, Mexico, Saudi Arabia, Venezuela, and the U.S.
- Involvement with selection of candidates and development of strategic applications of re-fracturing in low permeability gas wells completed in multiple (8-12) intervals.
- Extensive well stimulation consultation for PEMEX involving several asset areas involved in oil production and gas production from both carbonate and sandstone reservoirs.
- Assessment of service company products and services related to well stimulation techniques and practices.

肆、 結論與建議

一、 本次與會之 2012-SPE-ATCE 論文發表會，有關油氣增產技術等共有 370 餘篇論文發表，取回此次研討會光碟，供公司探採工作同仁共享最新之油氣工程技術資料，以及非傳統須液裂增產之緻密氣、頁岩氣、油砂等之最新之油氣生產/增產技術資料。

二、 本次與會携回之有關資料將繳存於中油公司探採研究所技術圖書室內，供公司內相關業務同仁參考。

三、 SPE#159346 介紹在美國東德州利用一種 Hydraulic Pumping Units 成功完成氣井舉生方式使伴產液體氣井再生產之案例(原先用 Plunger, Soap, velocity string 仍無法復產)，值得我們對出水停產復產工作參考或許永和山 6 號井伴產凝結油之油柱壓影響產氣問題可參考解決。#159910 介紹將 Leistritz 的雙螺旋 pump 用在有液體貯積氣井之適用裝置，也是值得進一步瞭解可否引進台灣陸上出水氣井或永和山 6 號伴產凝結油之井。#159147 介紹 ZiLift 公司開發出一種不必修井可爲低產率氣井除水之 pump，可以不必鑽機，放入 2 3/8 吋油管內使用。亦可考慮引進國內陸上出水氣井或永和山 6 號伴產凝結油之舊井。

四、 頁岩氣資源量評估是公司參加國外頁岩氣礦區權益重要技術，SPE_#159174 對如何設法定量頁岩區「證實未開發蘊藏量」(Proved Undeveloped Reserves)，如何以統計、經驗、解析技術三方面來整合的做法說明，值得相關業務同仁參考。#159273 是關於頁岩氣井如何估算最終採收量（Estimated Ultimate Recovery, EUR）之探討，提出一個將傳統 Arps 下降曲線分析（Decline Curve Analysis, DCA），使用壓力正規化氣產率（Pressure Normalized rate）取代只用實際產氣率（real rate）的方法，對於緻密氣層之 EUR 估算應頗具參考價值。

五、 公司參加國外頁岩氣礦區權益對於對方公司查核執行 DD 爲極重要工作，#159360 介紹對有意願取得某公司礦區權益之 data room 如何有效取得資料，應規劃如何進行，應遵循執行之架構。如何不遺漏執行 DD，不論是 Data room 爲 Physical 或 Virtual，進入前、檢視中、執行後應如何做，都提出了詳實的建議，值得相關業務同仁參考。

六、 #159956 提出單線、萬用典型曲線來做受邊界影響流動（Boundary dominated flow, BDF）天然氣井未穩態之分析，可用來分析預測未來氣井的生產動態並可靠地估算蘊藏量，可用在錦水深部剩餘蘊藏量估算，值得參考。

七、 #160045 提出鑽頁岩層時使用全奈米顆粒水基泥漿之測試評估結果，此種奈米顆粒泥漿可大幅降低泥漿與頁岩發生反應，大爲減少鑽井通過頁岩層遭遇的嚴重問題，此種奈米顆粒泥漿可試著從 M1-SWACO 公司取來試驗，對國內鑽井過頁岩層之問題應有很大幫助。