ECHO

Outstanding Student Chapter 2014 & 2015

SPE Suez University Student Chapter Magazine

Issue 8 | February 2016

INTERVIEW WITH MS. JANEEN JUDAH
2017 SPE INTERNATIONAL PRESIDENT

ESTIMATION OF OIL ISOTHERMAL COMPRESSIBILITY
A NEW DEFINITION!

INTEGRATED MODEL STUDIES

PORE LEVEL DISPLACEMENT MECHANISMS DURING NANOFLUID FLOODING

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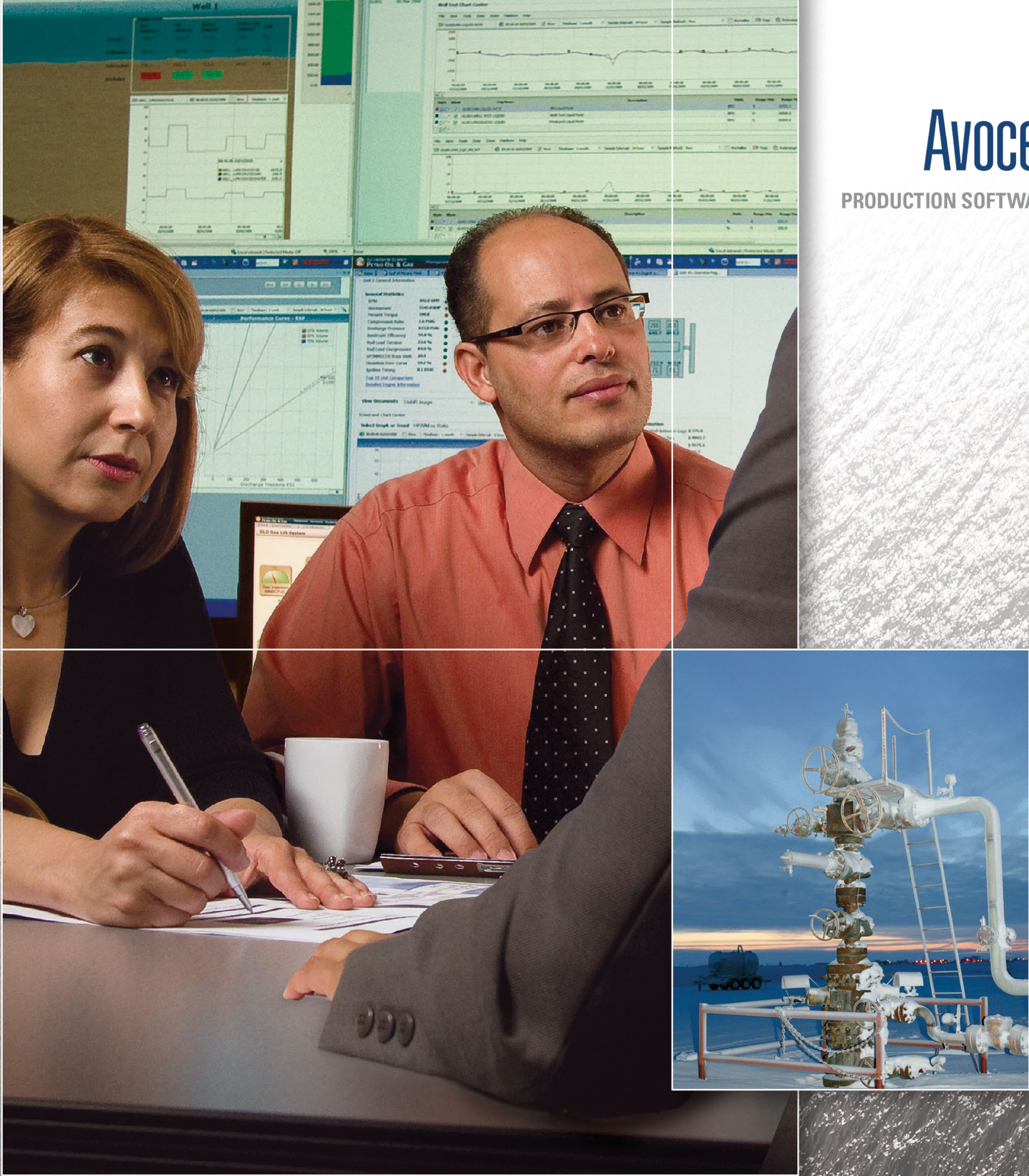
Society of Petroleum Engineers
Suez University Student Chapter



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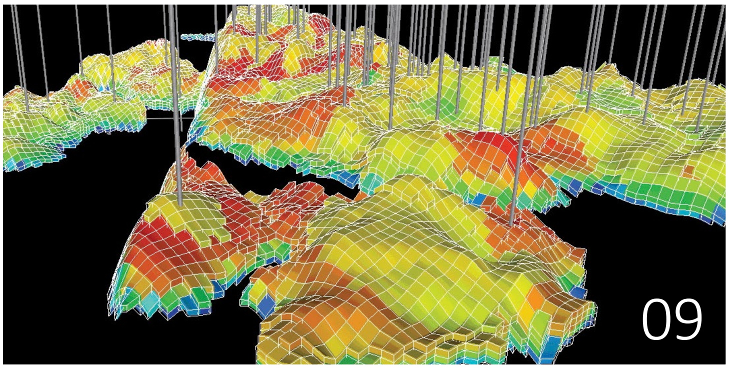

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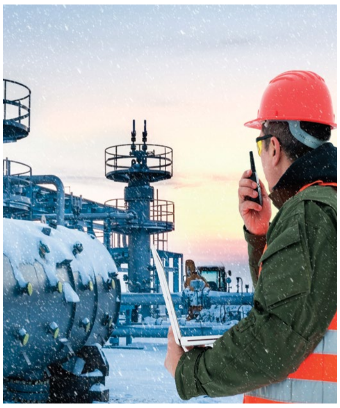

Worker at an oilfield in the winter. Natural Gas pipelines and storage tanks are present in the background.

VISIT OUR WEBSITE

Mohamed A. Elkasaby
Chapter President

Values Define You!

"If it is important to you, you will find a way, if not, you will find an excuse", this is my own anecdote in life. What defines the importance of something or someone in your life? I do not mean the reasons for existence of someone or doing a particular thing nor your life goals. Otherwise, I intend to mean what is beyond these goals.

"The value of life is not about doing what you want. It is about being useful, honorable, compassionate, and to have it make some difference that you have lived and lived well" — Ralph Waldo Emerson. Everybody should ask themselves about their purposes; what am I doing here? And what makes life worth living? When you ask yourself these questions, you need to stop for a while to think about your deep and profound motivators. In fact, you will discover that these motivators arise from a superior source; your eternal values. Yes, it is your values that define your character and sense of purpose to live and work.

Referring to the history of petroleum industry since its boom in the middle of 19^{th} century, we will find that there had been a rush to extract petroleum from the underground - like the gold rush - as people believed it will bring them much money. Hence, it was called "Black Gold". Yet when petroleum had been discovered, people divided into two teams, one with an evil intent of using petroleum for war purposes. On the other hand, another team made best use of petroleum pushed with noble values of improving humanity's life and developing the modern world.

Exploring the history of petroleum industry and technology evolution, since the first well was drilled by Edwin Drake in 1859 in Pennsylvania, you will discover how the continuous advancements in the industry innovation unfolded rapidly aiming to lift living standards globally and make the world go round.

This is how I feel about both SPE and ourselves as individuals of the petroleum industry world. Our honorable values make us motivated to work every day taking the responsibility of providing safe and affordable energy to empower the world. We try to help seven billion people receive one of their substantial daily needs seeking to improve the quality of life on Earth. So imagine if we all have such a sense of purpose, what a magnificent and noble value we will have in our lives!

Keeping in touch with your values is a lifelong practice of identifying what you believe matters to you, what you stand for, and deep down, they are the thermometer you use to tell if your life is turning out the way you want it to be. Many people think that values are ethics or morals; they are not. According to your values, your definition of success is set. Moreover, values are usually unstable and do not have boundaries. As you go through life, your definition of success may change. For example, when you start your career, success is measured by money and status. But after you have a family, bringing up your children and making a work-life balance will be what you value most. However, remember well "Try not to become a man of success but rather try to become a man of value." - Albert Einstein.

After a four-season journey at SPE Suez, I have been elected to carry the most noble responsibility; leading the chapter stimulated with values of faith in what we do, serving people, and helping others learn new things. Moreover, adding moral values to their lives to be capable of leading a life illuminated with a precious sense of purpose. I believe that leading with values is a leadership philosophy that surpasses measuring success by prestige or authority. Besides, it makes leadership become easy. Just think of values as a tree; values are your roots that keep you committed to what is acceptable to you. The strength of values determines the strength of the trunk, branches, leaves and fruits. A strong tree supports the ecosystem around it; a leader with strong values supports the organization's culture.

Ultimately, I would like to thank everyone who made efforts for the sake of our chapter since its initiation until now. Also, I appreciate every leader I worked with and taught me priceless things that has truly guided me to reshape my mindset and remodel my character to be a person of a real value to myself, my family, friends and people I work with. Hereby, I have to show gratitude to the chapter's high board members who are the reason behind our current status of brilliance and uniqueness. I cannot find a better occasion to mention their splendid support throughout this season. Last but not least, allow me to proudly say "Thank You!" to ECHO Team for this glamorous issue which you will enjoy its elegant articles collected from pioneers in the petroleum industry.

And again, always keep in mind to make your life meaningful, as life is a whole different experience when you understand what VALUES shall guide you; LOVE, COMPASSION and SHARING!

Nazih Gamal Azer
Chapter Vice President

Oil is Found in the Minds of Men

Decades ago, the pioneering petroleum geologist Wallace Pratt pointed out that oil was first found in the human mind. There is an authentic resemblance between the human mind generating innovative ideas and the oil exploration.

Each great discovery begins as an idea, an unsystematic thought that popped into someone's head. It is perceived that discoveries were not made as much by those whose ideas were innately superior, but by those who had the passion and the confidence to follow through with their own ideas. We all have ideas that pop into our heads unbidden. You neither decide to have an idea, nor prevent ideas from flowing in your subconscious mind; it happens simultaneously. The key lies in what we do with our ideas once inspiration strikes!

Our subconscious mind is a potent tool. While we are busy working away on our quotidian chores, our subconscious mind is occupied with our future goals. Of course, this can happen only if we are clear about, and regularly review our goals. Our subconscious mind is a fertile ground for generating ideas; we simply have to sow the seeds. The pin point here is setting our goals and reviewing them regularly with systematic checkpoints, which grow up those seeds fruitfully. It will then be put in the working phase. We just have to be willing to capture those ideas, appraise them, and proceed.

Recently, oil price has dropped down in a shocking way, and suddenly pessimism covered the whole petroleum field. We cannot deny that massive problem; but is it a dead end? Of course not! Oil and Gas Industry has started in the very beginning as a simple idea for providing an operative source of energy to the whole domain and contributing in the vast revolutionary progress of the worldwide technologies. We all have the responsibility of putting up on the stated string of success that started from scratch.

The first law of success is called the law of pure potentiality: "The source of all creation is pure consciousness; pure potentiality seeking expression from the hidden to the manifest."
We must have passion and be polarized towards the value of our work as petroleum engineers and energy providers.

Setting effective goals and reviewing them regularly keep our momentum moving forward. We also have to set our goals and strategies to get over this crisis and commit ourselves to the execution phase, in order to realize the desired situation in our fields. When we realize that our true self is one of pure potentiality, we can align with the power that manifests everything in the universe.

"The universe goes through dynamic exchange; giving and receiving are dissimilar facets of the flow of energy in the universe." This is the second spiritual law of success; the law of giving.
In our willingness to give that, which we pursue, we keep the abundance of the creation circulating in our lives. What we can give to the petroleum industry is our 'minds'.

To give our minds is to be impeccably mindful of our role, give all our time and all our alertness while facing one of the biggest challenges that we may encounter; to save our 'barrel'. We have to pay much more interest to creativity and innovation, and to catch the ideas that pop continuously into our heads. No substitute for hard work; nobody is great without work. We should believe that if we find the field where we are naturally granted, we will be great from day one; but it does not happen. There is no confirmation of high-level performance without knowledge or running-through. We have to strive for building up our own experience, by practicing and enriching our concentrations.

Literally, in the name of all Egyptian students, I would like to say that it is time to take the step, carry on our responsibility, and be always on board, to reach our united spot. I would like to express my gratitude to the members in our chapter, especially ECHO Editorial Team who always have devotion to their duty.

The challenge now is to encourage skeptics of theories which state that peak production has been reached, or soon will be, to hail a new golden age of exploration and supply.
"Prospecting for oil is a dynamic art. The greatest single element in all prospecting past, present and future, is the man willing to take a chance..."

Interview with Ms. Janeen Judah

2017 SPE International President

By Mohamed Alaa Elkasaby and Abdelrahman Elhosany

Janeen Judah is the General Manager for Chevron's South African Business Unit. She currently serves on the SPE Board of Directors as Vice President of Finance. She has served as President of Chevron Environmental Management Company and General Manager of Reservoir and Production Engineering for Chevron Energy Technology Company. Also, she worked for Texaco and ARCO in various upstream petroleum engineering positions, starting in Midland in 1980. Judah holds BS and MS degrees in petroleum engineering from Texas A&M University, an MBA from The University of Texas of the Permian Basin, and a JD from the University of Houston Law Center. Judah will serve as 2017 President of Society of Petroleum Engineers.

Ms. Janeen Judah, I would like to congratulate you for being 2017 SPE President.

1. First of all, we would like to know about your unique journey at SPE, and how glorious is it to be one of the industry pioneers helping the world receive their daily energy needs?

Petroleum engineers bring energy to the world. I don't think American engineers truly appreciate the magnitude of what we do until we travel to other parts of the world that do not have cheap, widely available electricity and fuel. Travelling to rural Africa and India showed me what remains to be done. Even in the USA, universal energy is still a relatively recent development; electricity was not widely available in parts of rural Texas until after WWII, and the US natural gas pipeline system was built mostly in the 1960's. Just as the Aswan Dam accelerated Egypt's development through cheap electricity, development of new oil and gas resources will do the same for other parts of the world. Engineers make that happen.

2. What are the secrets of your success to reach such a marvelous achievement of being 2017 SPE President?

Perseverance, endurance, and the ability to "roll with" changes in business. For example, I've consistently been involved with SPE regardless of my employer or supervisor, through good times and not so good times. I started as a student section officer at Texas A&M University. I moved to Midland after college & volunteered with the local section, starting with the Scholarship Committee. I moved up through offices of the Permian Basin Section, becoming Chairman at age of 29. I returned to Houston in 1990, and started the path again with the Scholarship Committee, and eventually, Chairman of the Gulf Coast Section in 2001. This is my third time on the international board, as I've served as the Regional Director for Gulf Coast North America, and Financial Vice President. I've been consistently involved with SPE throughout my career, both for my own development, and to give back to the profession of petroleum engineering.

3. As there is a global trend towards gender diversity in the oil and gas industry, how do you see the role of women in our industry?

Gender equity issues are societal issues and not unique to the oil and gas industry. In my involvement with the Society of Women Engineers over the last several years, I've seen that gender issues extend across all engineering professions, and may extend even to non-industrial careers.

The technological challenges we face in oil and gas require innovation and creative thinking, that's why we can't ignore half the brains in our society if we want to solve the big problems. Doing things the way we have always done it won't cut it anymore.

For unique aspects, I have special obligations as a woman president of a more than 90% male organization. I am the first woman president in 11 years, so the younger engineers hired in this last upturn have never seen a woman in the position. I know that women look to me as a role model, so I take a special effort to make myself visible to them, both in person and through social media. Follow me @JaneenJudah – I often tweet on career development issues.

In my early career, gender bias was overt, but now is more subtle and unconscious. Women especially should let their supervisors know what opportunities they want – otherwise others can make assumptions and limit your options for you. I believe the most significant challenge for women is not dealing with children, but rather with dual career issues, since our industry highly values mobility. However, the most important factor for career success is a sponsor – impress someone high up in your company with your ability to do a great job.

4. I know that you visited Egypt before. Can you share your experience in Egypt, and your impressions about the Egyptian culture with us?

Egypt is the cradle of civilization, but nothing prepares you for seeing Giza for the first time. I've told many friends that Egypt is a place everyone must see at least once in their lifetime. Our trip to Egypt was for my 50th birthday and I celebrated in the very hot Luxor!

I look forward to returning to Egypt and seeing places that I missed on my first trip. I am an avid Scuba Diver and would like to dive in the Red Sea at Sharm El-Sheikh. I would also like to see Santa Chatherina monastery in Sinai and Bibliotheca Alexandria.

5. Referring to your life as a student, what were your professional career goals? And how did you plan to achieve these goals?

I graduated with my masters' degree in Petroleum Engineering at another low point in the industry – 1983. I was just happy to get a job. The first 20 years of my career were during hard times, so my usual annual goal was simply to increase my skills and stay employed. I didn't have many grand career plans.

6. What about degrees and majors you hold, and how does these degrees help you in each stage of your career?

I am naturally a lifelong learner, but the real reason for all my extra education was insurance. The first 20 years of my career were characterized by rounds of layoffs nearly every two years. So mostly, it was a time of decreasing opportunity. I had to keep my technical ability sharp and add to my bundle of skills just to stay employed. Sometimes, I do a presentation on Graduate School Options since I have graduate degrees in petroleum engineering, business and law. My usual recommendation (at least to US employees) is to get an MBA while they are working. We are in the oil business, and better understanding of business analysis and management is always useful.

7. Could you share your aspiration for SPE this season with our readers?

The most important responsibility for me in my tenure will be to help SPE navigate the rough waters of this downturn, while still providing our excellent services to our members. Like everyone else, SPE is evaluating its portfolio of meetings and services, and we will make some adjustments both for the market and for technology advances.

8. How do you see the granted Outstanding Student Chapter Award for the second time in a row, what would you like to tell our Chapter's members?

Remember, I started my SPE career as a student section officer. The skills you learn in student section leadership will serve you well throughout your career:

- Leading without authority
- Volunteering work and networking
- Public speaking

I hope that all of you will stay involved in SPE and take on leadership roles in local sections.

9. How does SPE plan to support the oil and gas industry in its current drop down?

The oil business is cyclical, just like almost every other business. As leaders, we need to encourage our employers to take a longer-term view, and use this downtime in investment to step back and analyze data for our fields.

10. In your opinion as a leader, how can the world collaborate to survive the current downturn in industry?

If the past is a predictor of the future, then we have seen innovation come out of hard times, because we were forced to. The US Shale Revolution had its roots in the hard times of the late 1990's. Hydraulic fracturing in shale was developed out of necessity, not out of excess. Step-change innovations in the oil industry have usually been developed during down cycles, and I look forward to seeing what will come out of this one.

11. What would you like to tell senior students who are frightened of graduation and are anxious about their career opportunities in the industry?

We should remember that we didn't bring new people into the industry, especially in the United States, for about 15 years starting in 1985. The industry is paying now, as the baby boomer generation is reaching retirement age.

My advice is to look hard for a job and not be too concerned about landing your dream job – just get your foot on the ladder. The oil price will swing back up again, and the 'baby boomer' generation will retire, both of which will create new opportunities. If you can't get a position now, consider adding skills through graduate school in business or computer sciences/information technology. The next big things are likely to be big data analytics and the internet of things. As we collect massive real-time data on our fields, we need people who can manage, interpret, and leverage it.

12. What do you think of ECHO Magazine as a student product by SPE Suez University Student Chapter?

It's a great outreach effort for both the university community and your alumni. It's also an indication of persistent students who are mindful of their career goals and have wide aspirations and potentials. I wish you all ultimate success!

"The technological challenges we face in oil and gas require innovation and creative thinking, that's why we can't ignore half the brains in our society if we want to solve the big problems. Doing things the way we have always done it won't cut it anymore."

Ms. Janeen Judah During Her Visit to Luxor in Her 50th Birthday

Stress Profiling With Microfracturing and Sonic Logs in Antelope Shale

Mayank Malik - Formation Testing Expert at Chevron, Houston, Texas

Shale development has changed the landscape of hydrocarbon production and dynamics. "Getting it right", however, requires picking optimum lateral landing points and knowing the stress profile across the reservoir. The following article describes a case study on successful integration of microfracture testing with sonic logs in Antelope Shale.

Antelope Shale is a silica-rich diatom deposition, which produces from reservoirs in all three silica phases: Opal A (Diatomite), Opal CT, and Quartz. While the Opal A has heavy oil that has been successfully produced, Opal CT and Quartz resources have largely been locked. Due to recent advancement in unconventional completions and hydraulic fracturing, there is a renewed interest in CT/ Quartz phases for testing economic production capabilities. Well logs, cuttings, and sidewall cores indicate the reservoir is vertically continuous but structurally complex. Matrix permeability is very low (< 0.1 md), and thereby requiring extensive stimulation to produce. As a result, hydraulic fracturing has been selected as the suitable stimulation methodology for both Opal CT and Quartz phases. To achieve effective stimulation of all pay zones and to avoid fracture overlaps, the two critical decisions were the number of hydraulic fracture stages in vertical wells, and their placement. The vertical stress profile is a key input parameter for design and optimization of hydraulic fractures using a 3D simulator.

Stress Profiling in Antelope Shale *(Calibration of Stress Profile with Microfracture Test)*

Microfracturing measurements were acquired at seven discrete depth intervals across the Opal CT and Quartz intervals. Test locations were identified by sonic logs to verify target reservoir and bounding layers. Fig. 1 shows a typical pressure vs. time plot acquired for one test in the Quartz phase. Injection was maintained at a low and fairly constant rate of ~4 cc/sec. The breakdown pressure was approximately 900 psi higher than the propagation pressure, as it takes more energy to initiate a new fracture rather than extending an existing fracture. Finally, the pump was stopped and the falloff cycle 1 started. Injection and falloff cycles were repeated two additional times to validate the repeatability of measurements. The total volume of fluid injected in the formation was 2.5 gallons, and the test duration was 150 minutes.

Fig. 2 displays the pressure vs. time data acquired in the Opal CT interval. Fracture closure and re-opening pressures are highlighted on the plot, and indicate very close agreement across the injection/falloff cycles. Pressure transient data was analyzed in real-time (Fig. 3) to identify changes in the flow regime as the fracture closes. There is a change in slope of the G-function derivative when the fracture closes, and the highlighted red circle shows the corresponding closure pressure. Since the closure pressure from the first and second cycles were consistently repeatable, the third cycle was used to confirm reopening pressure. Test duration in Opal CT was 127 minutes. Three successful tests were performed in the Opal CT interval, and four successful tests were performed in the Quartz interval.

Calibration of Stress Profile with LOT / FIT Results

The Leak-off Test (LOT) and Formation Integrity Test (FIT) data for Well 1 were plotted on a pressure vs. depth chart along with the data from offset wells. Microfracture data from Well 1 was used to calculate closure stress, and results were plotted to compare with LOT and FIT data (Fig. 4). Pore pressure was estimated from the pressure/temperature surveys in off-

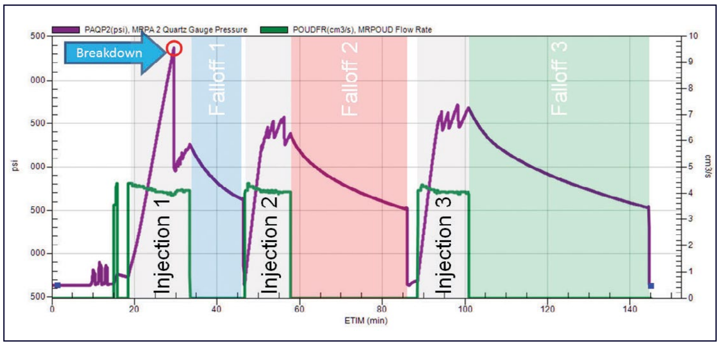

Fig. 1 - Microfracture Test Performed in the Quartz Interval

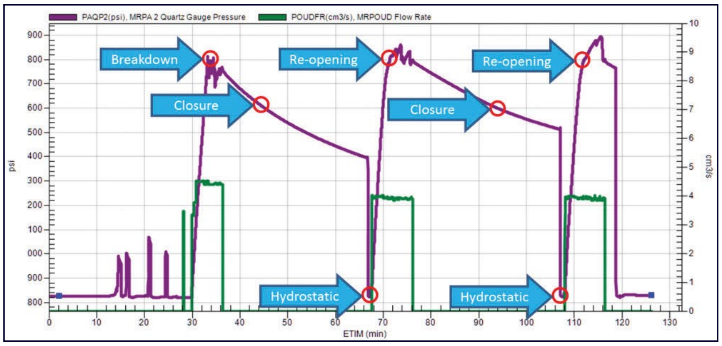

Fig. 2 - Microfracture Test Performed in the Opal CT Interval

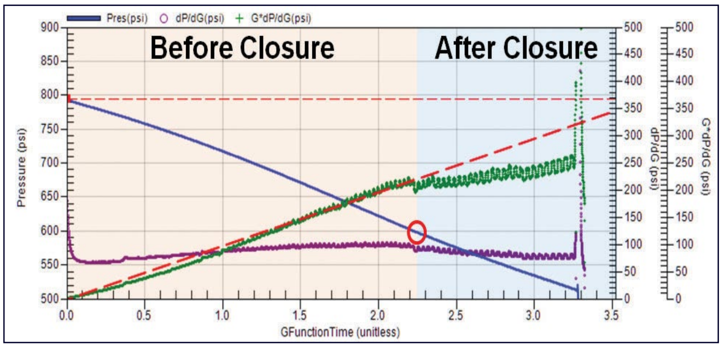

Fig. 3 - Pressure Transient G-function Plot for Identifying Fracture Closure in the Opal CT Interval

set wells before the Antelope Shale wells were drilled. A FIT was run at each casing shoe to estimate the fracture gradient and identify the available window for mud weight. It was desired to keep the mud weight above pore pressure but less than fracture pressure. The mud weight range to drill Well 1 was 9.8 – 10.5 ppg. In essence, both the FIT and LOT refer to formation strength, except that FIT pressures did not actually break the formations, while LOT pressures did break the formation.

Application of Stress Profiling

(Number of Fracture Stages Optimization)

Multiple pay zone intervals in Well 1 were selected on basis of rock properties (e.g., porosity, oil saturation and permeability). Calibrated and corrected vertical stress profile across the pay interval was used in 3D fracture simulator to identify potential fracture boundary and optimum number of stages, to stimulate all pay zone intervals effectively (Fig. 5). Different combinations of fracture pumping schedule, proppant quantity, fracturing fluid type, and pump rate were modeled with 3D fracture simulator to better define the fracture growth and identify fracture boundaries. The optimized 3 fracture stages across Quartz phase and 4 stages across Opal CT phase effectively cover pay zones with good proppant placement at the end of fracture closure (Fig. 5). Simulation also assured that fracture would not communicate with the water wet formation on top of Quartz.

Perforation and Fracture Placement Optimization

Perforation placement and fracture initiation depth for an individual fracture stage is critical to achieve effective wellbore connectivity, after proppant settling in shale formation. Various low stress sections were identified to select the preferred location for maximum fracture conductivity across perforation, which will result in good wellbore connectivity. The perforation strategy of single vs. multiple clusters was evaluated for each fracture stage (Fig. 6). Fracture growth resulting from the 3D fracture simulator indicated that in Opal CT, single cluster is the preferred option to achieve longer fracture half-length and confined propped fracture, which improves connectivity at the perforations. However, in the multiple cluster scenarios, the fracture had the tendency to grow upwards from top perforations, achieving longer fracture height but less fracture half length.

In Quartz phase, two options to achieve effective stimulation coverage were evaluated with 3D fracture simulation. Stress profiling was very critical in this scenario, as the deeper pay zone had low stress gradient. In the case of single large size fracture stage across multiple pay zones, the 3D fracture simulation results show that fracture grows preferentially in the lower pay zone, thereby the upper pay zone stays understimulated. By comparison, in the individual small size fracture stage, both upper and lower pay zones were optimally stimulated, as fractures achieve longer propped length and good wellbore connectivity with high proppant placement at perforations (Fig. 7). Thus, individual small fracture stages were selected as the preferred stimulation option.

Mud Weight Adjustment

The well was drilled with 9.8 - 10.5 ppg mud, which was selected on the basis of LOT/FIT and predicted pore pressure data. It was desired to keep the equivalent mud weight below the fracture pressure to minimize fluid loss due to formation. The calibrated stress profile from Well 1 along the drilled depth helped decide a reliable mud weight range for different sections of the wellbore (Fig. 4). This was further useful in narrowing down the mud weight range while drilling subsequent wells.

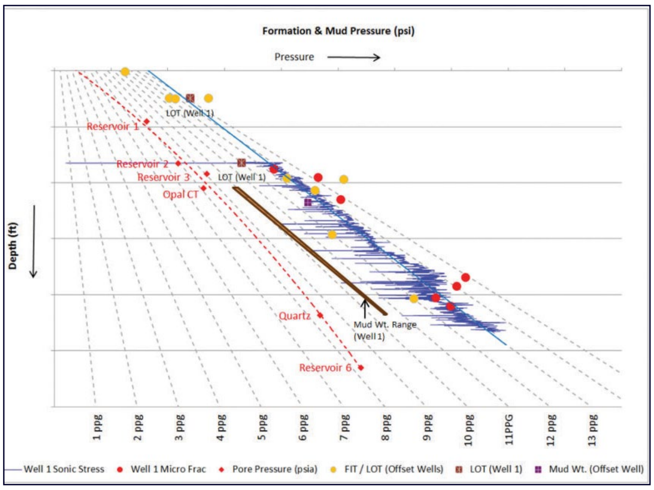

Fig. 4 - Cross Plot of Pressure vs. Depth

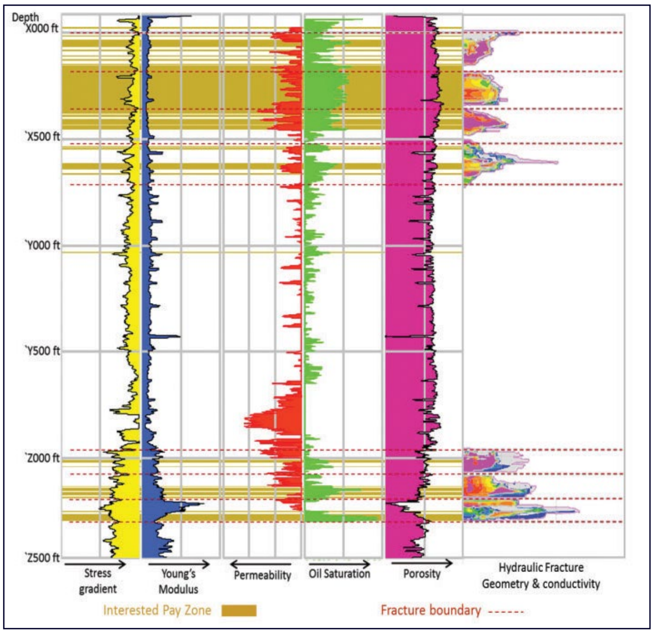

Fig. 5 - Selection of Pay Zone on Well 1 and Identification of Fracture Boundary to Determine Optimum Number of Fracture Stages

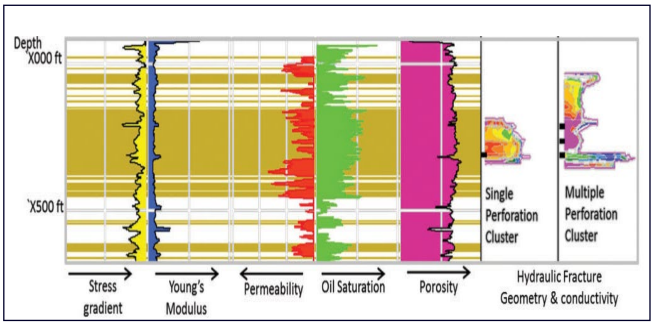

Fig. 6 - Comparison of Perforation Cluster Option (Single Cluster VS Multiple Cluster) and Impact on Fracture Growth and Proppant Placement

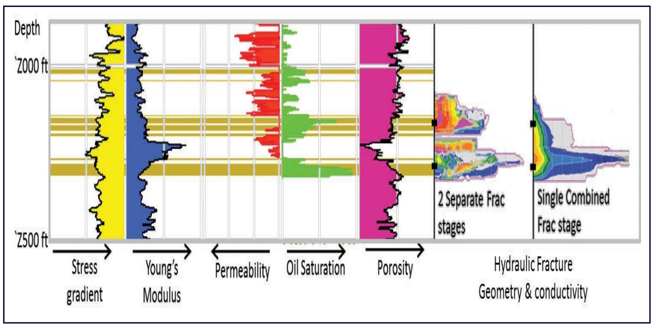

Fig. 7 - Comparison of Fracturing Stages (Separate Fracture Stage VS Combined Fracture Stage) and Impact on Pay Zone Coverage, Effective Stimulation and Proppant

Integrated Model Studies

Kelly Edwards - Reservoir Engineering Advisor, Korean National Oil Corporation, Canada

What is an Integrated Model Study?

An integrated model study is a reservoir simulation study carried out using all available data from all sources and disciplines that relate to the reservoir. Data comes not only from the engineering realm, but may also come from geologists, geophysicists, and petrophysicists. Simulation modes are generally full-field models used to model the geology, and cover the full history of the reservoir. They can range in size from small models with few wells and little production data, to models of giant reservoirs with billions of barrels of oil, hundreds of wells, and immense amounts of production, completion and pressure data. Data requirements for large models can reach tens or hundreds of millions of numbers. When building an integrated model, data from different disciplines, measured at immensely different scales, must be integrated. This is not an easy process, and specialized software is necessary. Prior to building the model, much time and effort goes into data collection and quality control. The collection and QC of data can consume a substantial portion of study time.

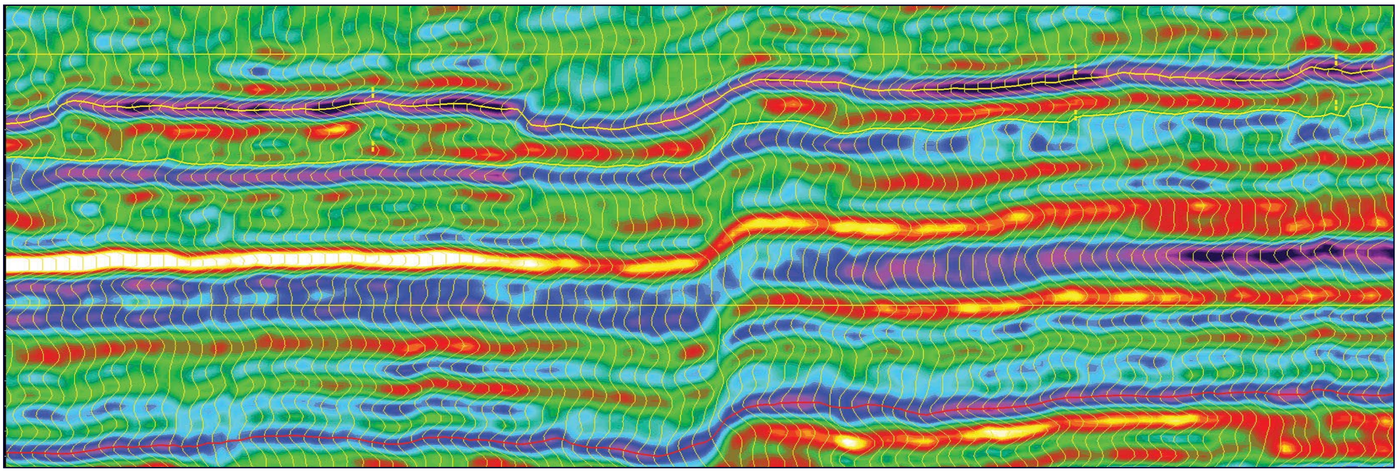

Fig. 1 - Seismic Section Showing Top and Base of Reservoir Zone (Faint Yellow Lines), and a Fault (in the Middle of the Section)

What are Integrated Models Used for?

Integrated full-field models can be created at any time during the reservoir life cycle. Early in the life cycle, there is little data, and models can be used to evaluate uncertainty in OOIP, reserves, and production rates. In addition, it can be used to determine an optimum development plan in the light of uncertainties. As the reservoir becomes more developed, more data goes into the models, but questions to be answered by the models become typically harder to answer. Later in the reservoir life cycle, models can be used to evaluate infill locations, field development scenarios, or predict incremental recovery for a change in process (e.g., waterflooding a reservoir on primary production, or converting a waterflood to an EOR process).

An integrated model must be validated before it can be used to make predictions. This is done through the process of history matching, where changes are made to the model inputs so that production rates from each well in the model match actual production rates. When each well shows a good match on oil, water and gas rates, and model pressures match measured pressures, we can achieve a good history match. If the match is poor, adjustments are made to the input parameters to drive the model towards a better match. History matching is an important process because it increases confidence in the predictive capabilities of the model. History matching can also highlight deficiencies or errors in the input data, as well as provide valuable insight into reservoir characterization.

What Data Goes into Integrated Models?

Any, or all, of the following data types can be incorporated into a typical integrated model. This list is not exhaustive, but covers the most common types.

Geological Model – Geologists formulate a model of processes that created the reservoirs. These models are usually conceptual, and, at some point during the study, must be transformed

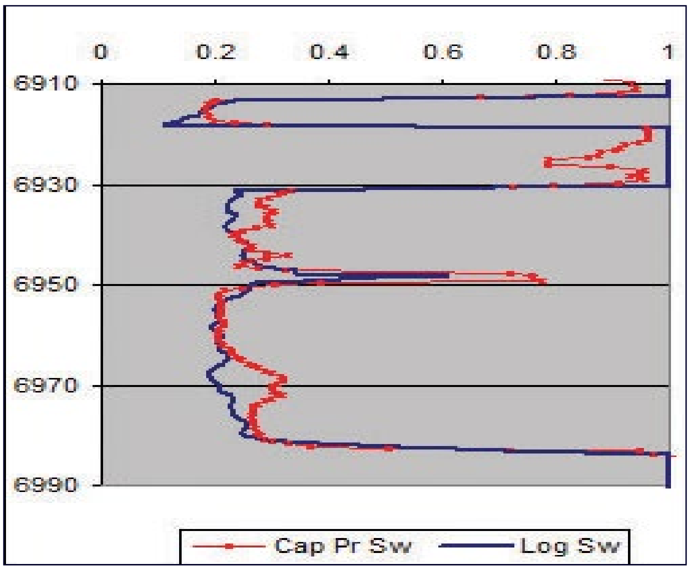

Fig. 2 - Match of Log S_w (Blue) Using J-Functions (Red). J-Functions Were Used to Initialize S_w in This Integrated Model

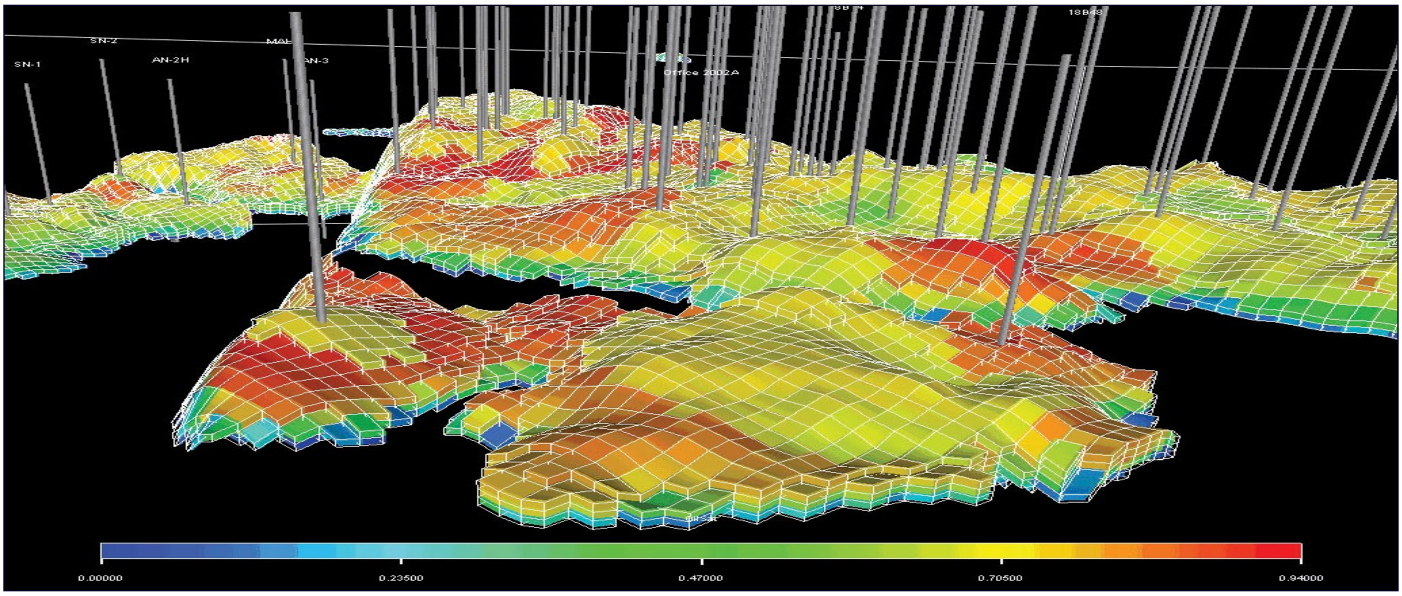

Fig. 3 - An Integrated Model Showing a Number of Individual Oil Pools and Well Locations. All Pools Sit on an Aquifer, Which Is Not Shown

into the realm of numbers to be used in the simulator.

Seismic Data – Seismic information is often used to build the structural framework of the reservoir, such as the top and base, internal units, and faults. In some cases, seismic attributes can be determined, which help characterize reservoir properties or saturations within the reservoir itself. Seismic information provides detail of the interwell space, where we typically have no other data.

Petrophysics – Petrophysical data is the foundation of an integrated model. Porosity and water saturations are necessary to estimate original hydrocarbon volumes. Estimates of permeability, from any source, are fundamental for estimating production rates.

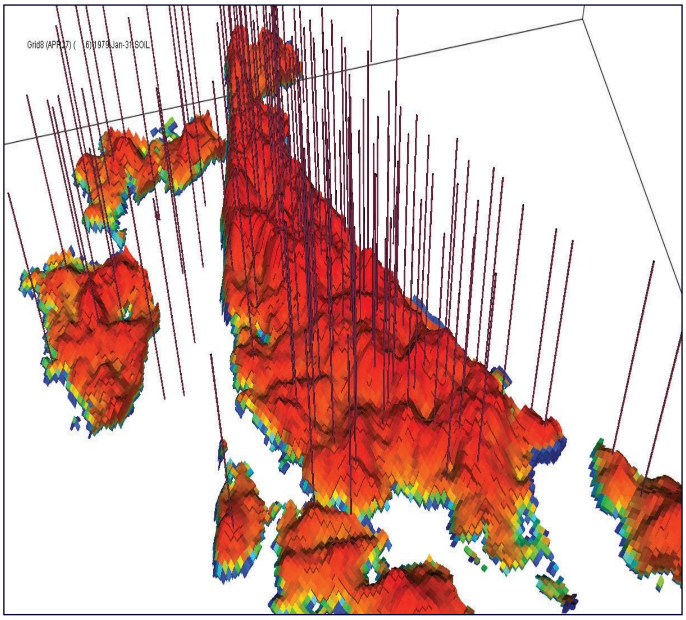
Fig. 4 - An Integrated Model Showing a Number of Individual Oil Pools, and Well Locations. All Pools Sit on an Aquifer, Which Is Not Shown

Well Test Data – Well test data provides estimates of formation permeability, completion skin and distance, and orientation of reservoir boundaries.

Core Data – Core data is fundamental to petrophysics, rock physics, and geological model.

Rock Physics Data – Relative permeability is necessary to model multi-phase fluid flow. Capillary pressure data, which is measured in the laboratory, is required to initialize saturations.

Fluid Properties – Physical properties of all reservoir fluids must be appropriately described. This data comes from PVT tests or correlations, and includes information such as viscosity, density, bubble point pressure, and GOR.

Production Data – Produced volumes of all fluids from every well throughout the life of reservoir must be included. Typically, production is reported in monthly increments. Generally, companies are only interested in oil or gas production, because revenue is derived from their sale. However, the reservoir engineer is concerned with all fluids, whether they have value or not. For example, injected and produced volumes of substances used in an EOR process, such as CO_2, must also be measured.

Completion Data – Completions vary in time and space. Over the lifetime of a well, completions can be opened, abandoned, moved to different zones, lengthened, or shortened. All these changes must be accounted for in the integrated model.

Wellbore Trajectories – Wellbore trajectories are required to determine completion intervals in the model. Completions in vertical wells are easy to define. However, full wellbore trajectories are necessary to define completions in deviated and horizontal wells.

Pressures – Pressures are important for material balance calculations, to estimate zonal allocations, define aquifer properties, and calculate completion skin.

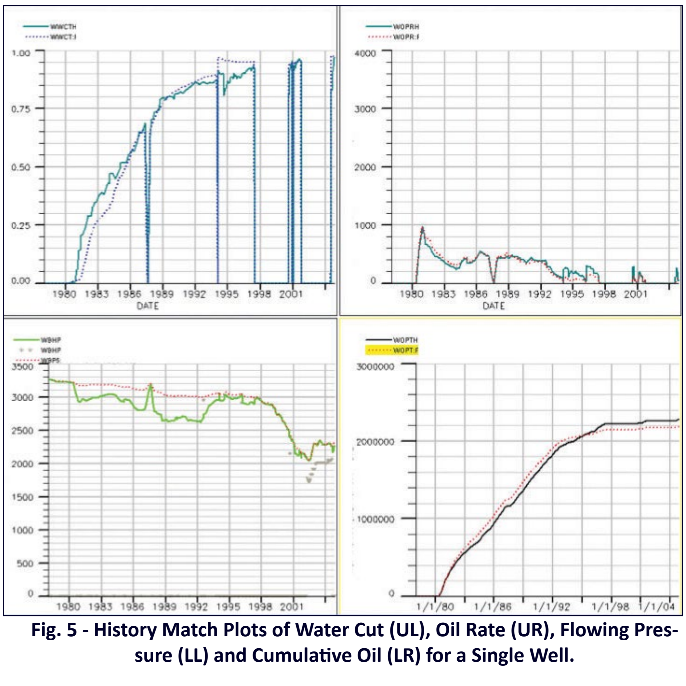

Fig. 5 - History Match Plots of Water Cut (UL), Oil Rate (UR), Flowing Pressure (LL) and Cumulative Oil (LR) for a Single Well.

Smart Completion Wells, The Future Oil Fields Management Solution – I Fields

Salma Chaabani - Completion & Wellbore Interventions Manager for West-North Africa, Baker-Hughes

Completions that enable reservoir engineers to monitor and control production or injection in at least one reservoir zone are known as intelligent completions. Such technology is proving to be a reliable and cost-effective way for better reservoir management. It protects operations from the risks associated with early water or gas breakthroughs, and from cross-flow between producing zones in the same well. Moreover, the technology helps operators to increase production rates, extend field life, and reduce the need for well interventions.

Fit-for-purpose completion technology is now successfully applied to lower productivity wells in a variety of applications. Increasingly, the Middle East is using the technology to manage uncertainty in carbonate reservoirs. However, other applications for intelligent completions include gas lift optimization and sand management.

Specifically when related to production allocation for several superposed zones and for waterfront advancement surveillance issues, managing uncertainties in reservoirs is a major challenge. This explains the need of dedicating observer wells for some strategic fields zones, as these wells allow long-term reservoir data acquisition for the different production/injection levels.

For the past decades, the notion of I-Fields has been swiftly developed, basically among oil field operators. Industry-wide, companies realized that implementing promising technologies and integrating the huge influx of data is the way to cope with the existing production challenges.

"The basic idea of the I-Field is to have an instrumented and information-intensive environment for operating oil fields. As you increase the number of sensors and controls, it allows you to connect the reservoir down the value chain and make the oil field look more like a factory", said Don Paul, Chevron CTO, defining the term I-Field.

Despite the variant names that operators attach to I-Fields, they share three fundamental components: Technology, Data and People. I-Fields promote downhole and surface assets, which allow better decisions. Oil companies, which have invested in I-Field solutions, typically see a sustained production increase of 1-2%. However, some reports show increase as large as 5-10%. Additionally, the I- Field solution has given better awareness of reserves in place and can affect the balance sheet of an operator.

For an oil company having a huge potential and big declining oil fields, the implementation of such concept will be a big gain for the production management, reservoir awareness & reserves allocation.

For operators coping with complex technical and economic challenges, Intelligent Production Systems (IPS) are delivering numerous advantages, such as accelerated production and cashflow, reduced workover, and increased ultimate recovery. IPS has economic advantages such as reduced CAPEX and OPEX as well as increased NPV and ROI.

The most challenging limitation to overcome is to produce sequentially, avoiding zones cross-flow. Moreover, we need to follow governmental regulations, which need accurate production allocation for each zone. In the past, oil fields were exploited by tapping into single zone formations or drilling through several formations, but perforating and producing one at-a-time. Another limitation is the restricted number of feedthrough ports within the tubing hanger, due to the commercial cost impact on changing the wellhead design.

Hydraulic & Electric Control Intelligent Well Systems were developed to produce measurable benefits for hydrocarbon assets. This allows a selective single-zone active control within multilevel well completions.

Challenges:

- Declining Wells Production Management.
- Reserves Allocation.
- Reservoir Uncertainties awareness.
- Remote Areas.
- Horizontal Wells:
    - Uneven water/gas influx (heel-toe effect).
    - Heterogeneities along the wellbore.
    - Challenging production logging inside lateral.
    - Difficult well intervention operations.

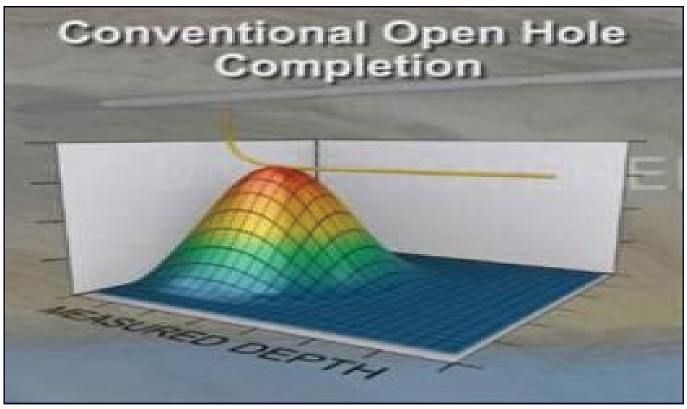

Fig. 1 - Conventional Completion Challenges: Uneven Water/Gas Influx (Heel-Toe Effect), Heterogeneities Along the Wellbore, Challenging Production Logging inside Lateral, and Difficult Well Intervention Operations

Pore Level Displacement Mechanisms During Nanofluid Flooding

Abdelrahman Ibrahim El-Diasty - Reservoir Engineer at Technical Petroleum Services (TPS)

The nanofluid process has been considered in the oil and gas industry as a promising enhanced oil recovery method. However, practical application of this process is rather restricted. The main limitation of nanofluid field application is the complexity of its flow behavior in porous media.

Recent research studies show three different illustrations of the displacement mechanisms of the nanofluid flooding process.

First, the unique enabling mechanism of disjoining pressure. The nanoparticles in nanoparticle dispersion (NPD), nanofluid, form a self-assembled wedge-shaped film on contact with a discontinuous phase. This wedge film acts to separate formation fluids from the rock surface, thereby recovering more fluids than previously possible with conventional additives or fluids. The energies that drive this mechanism are Brownian motion and electrostatic repulsion between the nanoparticles. The electrostatic repulsion force between those particles will be bigger when nanoparticle size is smaller. When the amount of the nanoparticles increases, the force will also increase, as shown in Fig. 1.

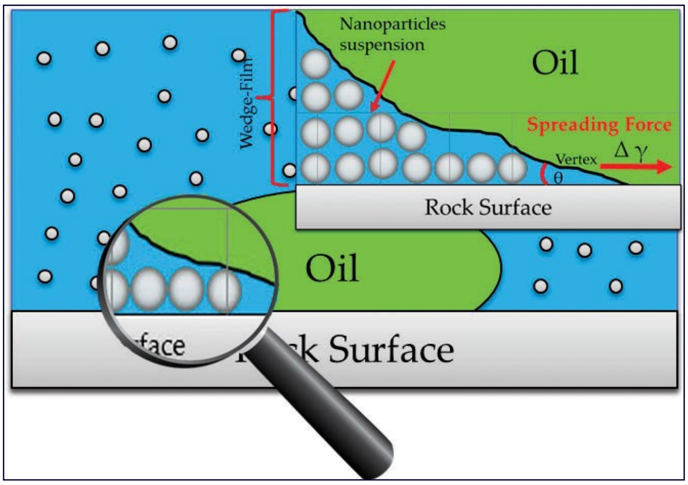

Fig. 1 - Nanoparticles Structuring in the Wedge-film Resulting in Structural Disjoining Pressure Gradient at The Wedge Vertex

This arrangement will exert additional pressure at that interface more than that in the bulk liquid. Particles present in the bulk fluid exert pressure, forcing the particles in the confined region forward and imparting the disjoining pressure force. When this force is confined to the vertex of the discontinuous phases, displacement occurs in an attempt to regain equilibrium.

Second, in the very small pore throats, the density difference between the particles and the water slows particles movement, causing their accumulation. Pressure builds up in the adjacent pores, forcing out the oil. Once the oil is freed, the surrounding pressure drops and the blockage gradually dissolves and the particles commence flowing with the water. This can be considered as temporary log-jamming, as illustrated in Fig. 2.

Third, the most widely used nanoparticles are silicon nanoparticles with a different wettability such as hydrophobic-lyophilic polysilicon nanoparticles (HLPN), lyophobic-hydrophilic polysilicon nanoparticles (LHPN) and neutral wet polysilicon nanoparticles (NWPN). The base fluids for stabilized dispersion depend on the nanoparticles' wettability (alcohol was selected to disperse NWPN and HLPN, while water is the best for LHPN in the formation, etc.). The main role of nanofluid is the wettability alteration from oil wet to neutral wet or water wet or vice versa. Wettability alteration is achieved by adsorption of nanoparticles of the desired wettability on the rock. The HLPN alter the rock from water wet to oil wet, LHPN alter the rock from oil wet to water wet and NWPN alter either oil wet or water wet rock to neutral wet. The author suggests that the three different approaches for understanding the displacement behavior of nanofluids are not conflicting. They may all occur simultaneously. The adsorption of the particles acts at the same time the wedge-film effect takes place. On the other hand, the temporary log-jamming in the very small pores helps the water base fluid to take other less permeable paths through the rock, where there is oil. It will be forced out with the water flow.

The main factor in this process is the nanofluid system, in terms of particles size, concentration and chemical modification. Hence, the nanofluid system should be accurately seleced depending on the candidate reservoir properties, because at the time when the total surface area per unit bulk volume of the porous media is completely covered by particles that have been adsorbed on pore surfaces or entrapped at pore throats, wettability is determined by nanoparticle properties. As a result, further deposition of particles will only lead to reduction in porosity and permeability.

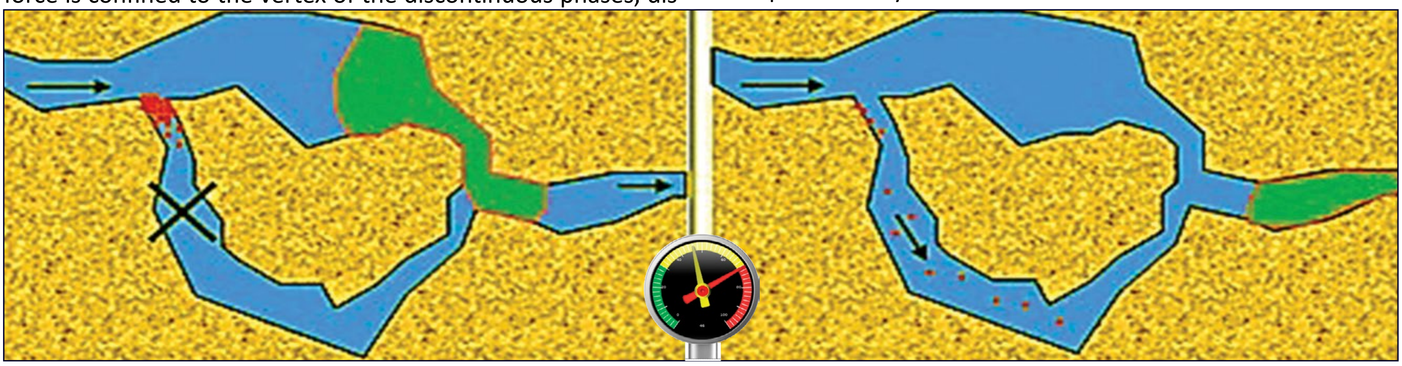

Fig. 2 - Temporary Log-Jamming

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Estimation of Oil Isothermal Compressibility

Muhammad Ali Al-Marhoun - SPE, Reservoir Technologies, Saudi Arabia

Oil compressibility plays an important role in reservoir simulation, material balance calculations, design of high-pressure surface-equipment, and interpretation of well test analysis, specifically for systems below bubble point pressure. Accurate information on the oil fluid compressibility above and below bubble point pressure is very important for reservoir evaluation.

The conventional definition of isothermal oil compressibility below bubble point pressure is being questioned on its scientific merit and challenged against the basic compressibility definition and the general trend of physical behavior of compressibility. This article presents a new derivation based on the basic compressibility definition to calculate oil compressibility below bubble point pressure. It is found that oil compressibility above and below bubble point according to the new definition is continuous and differentiable except at the original bubble point pressure cusp.

Coefficient of Isothermal Compressibility of Oil, C_o

By definition, single phase isothermal compressibility is defined as the unit change in volume with pressure. It is usually expressed as 1/psi. This definition is valid if and only if the single phase composition is constant. Compressibility can be calculated from the slope of relative volume versus pressure of a single phase liquid. In equation form, the point function oil compressibility, C_o, is defined as:

$$c_o = -\frac{1}{v_o}\frac{\partial v_o}{\partial p} = -\frac{1}{B_o}\frac{\partial B_o}{\partial p} = \frac{1}{\rho_o}\frac{\partial \rho_o}{\partial p} \quad (1)$$

Correlations of C_o above Bubble Point

Typical relationship of isothermal oil compressibility, C_o, with pressure above the bubble point is shown in Fig. 1.

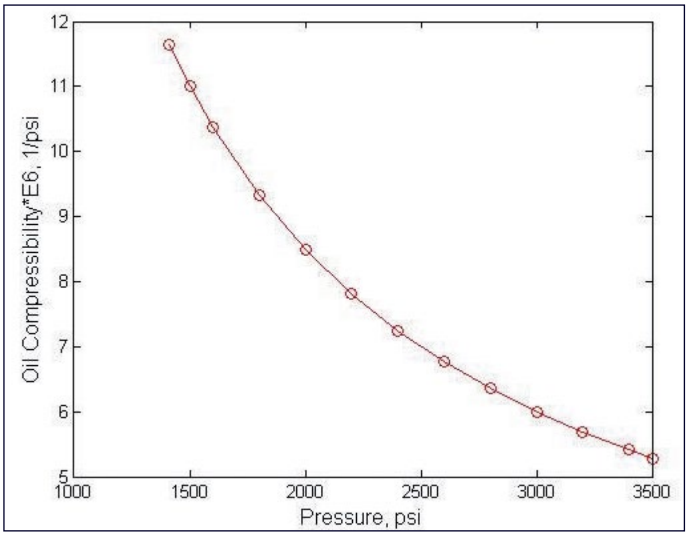

Fig. 1 - Typical Oil Compressibility Curve above Bubble Point

The isothermal oil compressibility factor above Bubble Point pressure can be estimated to an accuracy of 5% with:

$$\ln c_o = a_1 + a_2/\gamma_{ob} + a_3(p - p_b)/\gamma_{ob}^3 + a_4/(T + 460) \quad (2)$$

Where;

a1=-14.1042, a2=2.7314, a3=-56.0605*10-6, a4=-580.8778

$$\gamma_{ob} = (\gamma_o + 2.18x\,10^{-4} R_{sb} \quad \gamma_g)/B_{ob} \quad (3)$$

Conventional Definition of C_o below P_b

At pressures below the bubble point, volume of oil decreases with reduction in pressure, contrary to the behavior at pressures above the bubble point. Moreover, density of oil increases with the decrease in pressure due to the liberation of gases. Therefore, the profile of volume and density of liquid oil are opposite to the normal trends in single-phase, constant-composition fluids. A direct application of the general definition of isothermal compressibility of oil below the bubble point will lead to negative compressibility.

$$c_o = -\frac{1}{B_o}\left(\frac{\partial B_o}{\partial \mathrm{P}} - B_g\frac{\partial R_s}{\partial \mathrm{P}}\right) \quad (4)$$

The typical relationship of C_o according to Eq. 4 for pressures below the bubble point pressure is shown in Fig. 2.

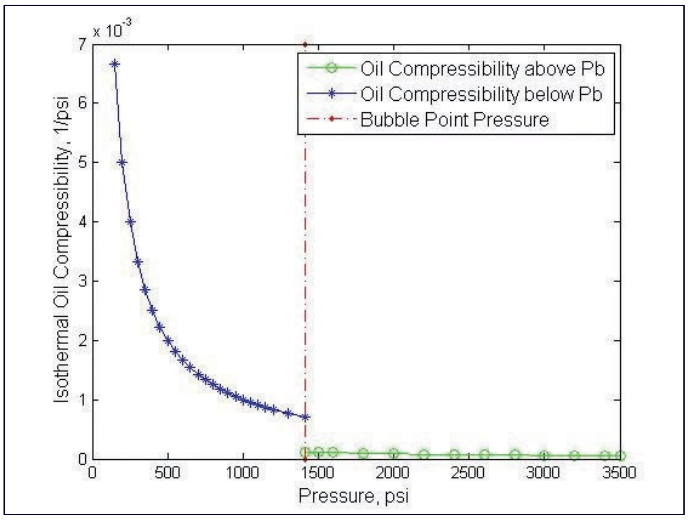

Fig. 2 - Typical Oil Compressibility Curve

Eq. 4 is the definition of C_o below the original bubble point pressure accepted by petroleum engineers and stated in text books and petroleum technical papers as a fact. The expansion effect of gas coming out of solution expressed in Eq. 4 is wrong, because the gas formation volume factor, B_g, is also changing with pressure. The gas expansion term should be:

$$\text{Gas expansion} = -B_g\frac{\partial R_s}{\partial \mathrm{P}} + (R_{sb} - R_s)\frac{\partial B_g}{\partial \mathrm{P}} \quad (5)$$

Compressibility, as stated in Eq. 1, is defined for constant composition fluids only. Below bubble point pressure, the liquid oil composition changes as pressure decreases. There is no definition of compressibility for such fluid with changing composition.

Correlations of C_o below Bubble Point:

Below the original bubblepoint pressure, the oil composition changes as pressure changes. Therefore, the oil compressibility, C_o, below the original bubblepoint cannot be calculated as a continuous function.

Fortunately, the limit of volume derivative with respect to pressure, as pressure approaches bubblepoint pressure, is defined. Since every point below the original bubblepoint is a bubblepoint for a new fluid with new composition, therefore the locus of C_o below the original P_b could be estimated.

Eq. 1 is valid for single phase oil liquid above P_b as well as below P_b. The only condition required is that oil volume, density or formation volume factor and their derivatives with respect to pressure have to be taken along constant composition curve. In this case, the curve of constant composition is not clear and it is not even drawn below bubblepoint pressure.

Fig. 3 shows several bubblepoints for new fluids of different composition below the original bubblepoint. Fig. 3 could be obtained experimentally if a composite liberation test is performed. Oil volume, density and formation volume factor versus pressure curves are the locus of these properties at saturation pressures for changing oil compositions.

Oil compressibility at any bubblepoint pressure below the original P_b is the extrapolation of C_o curve of pressures above that particular saturation or bubblepoint pressure. Therefore, the locus of C_o below the original bubblepoint corresponds to the locus of C_o at saturation pressures corresponding to the pressure curve for the oil formation volume factor as shown in Fig. 4.

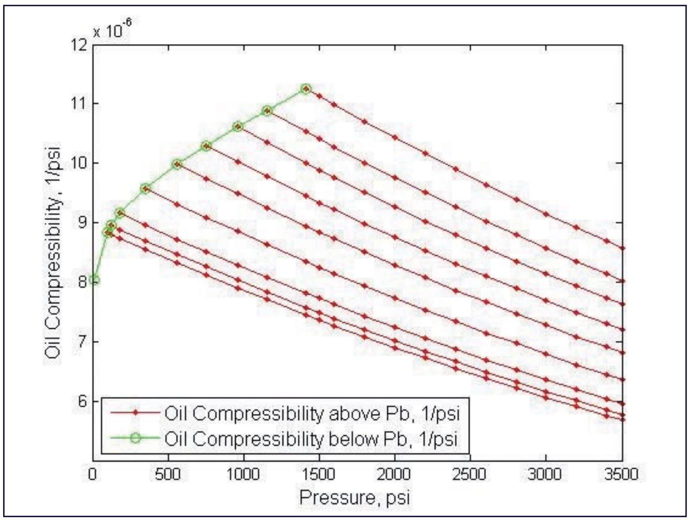

Fig. 3 - Locus of Bubble Point Oil Formation Volume Factor – Green Curve

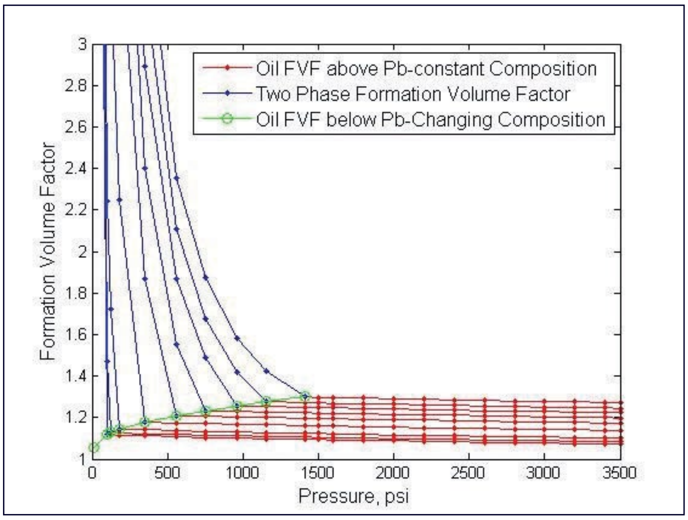

Fig. 4 - Locus of Oil Compressibility Below the Original Bubble point Pressure – Green Curve.

Estimation of Saturated Oil Compressibility

Eq. 2 can be used for single point estimation of C_o at saturation pressure with the observation of the correct evaluation of the oil relative density at the saturation pressure of interest as follows:

$$\ln c_{ob} = a_5 + a_2 / \gamma_{ob} \qquad \textbf{(6)}$$

In general for any pressure, P, below original bubble point pressure, C_{op} is estimated by:

$$\ln c_{op} = a_5 + a_2 / \gamma_{op} \qquad \textbf{(7)}$$

Where:

$$a_5 = a_1 + a_3(p - p_b)/\gamma^3{}_{ob} + a_4/(T + 460) \qquad \textbf{(8)}$$

Since any point below the original bubble point is a new bubble point for a new fluid, the term (P- P_b) in Eq. 8 is equal to zero for any pressure below the original bubble point pressure. Eq. 8 is rewritten as:

$$a_5 = a_1 + a_4 /(T + 460) \qquad \textbf{(9)}$$

By combining Eq. 6 and Eq. 7, C_o at any pressure below the original bubble point pressure can be calculated in terms of C_o at the original bubble point pressure, and live relative oil densities at pressure of interest and the original bubble point pressure as follows:

$$\ln c_{op} = \ln c_{ob} + a_2\left(\frac{1}{\gamma_{op}} - \frac{1}{\gamma_{ob}}\right) \qquad \textbf{(10)}$$

Fig. 5 clearly shows that the oil compressibility above and below bubble point according to the new definition is continuous and differentiable except at the original bubble point pressure cusp.

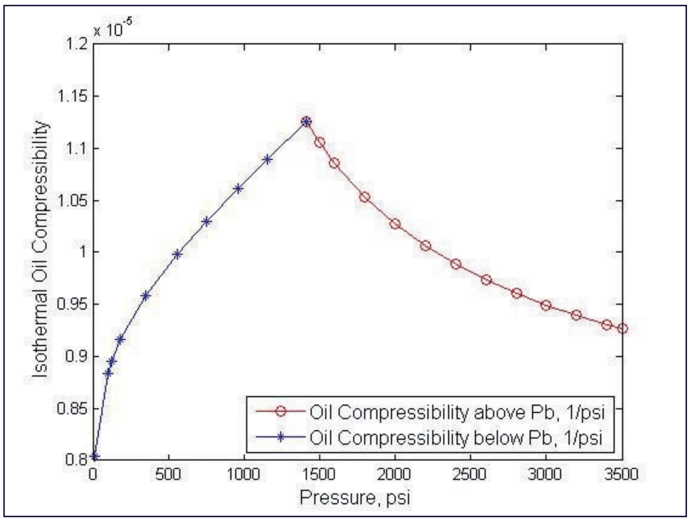

Fig. 5 - Typical Oil Compressibility Curve

Nomenclature

a_i = i[th] coefficient of equations
P_b = bubble point pressure, psi (kPa)
B_g = gas FVF , rcf/scf (m^3/m^3)
R_s = solution gas oil ratio, scf/stb (m^3/m^3)
R_{sb} = solution gas oil ratio at P_b, scf/stb (m^3/m^3)
C = compressibility, psi^{-1} (kPa^{-1})
C_o = oil compressibility, psi^{-1} (kPa^{-1})
C_{ob} = oil compressibility at P_b, psi^{-1} (kPa^{-1})
C_{op} = oil compressibility at p, psi^{-1} (kPa^{-1})
γ_{ob} = bubble point oil relative density(water= 1)
B_o = oil FVF, rb/stb (m^3/m^3), B_{ob} = oil FVF at P_b, rb/stb (m^3/m^3)
P = pressure, psi (kPa), γ_o = oil relative density (water= 1)
T = temperature, °F (K), ρ_o = oil density, lbm/ft³ (kg/m³)
V_o = oil volume, stb (m^3), γ_{op} = oil relative density at p (water= 1)

Non-Radioactive Detectable Proppant First Applications in Algeria for Hydraulic Fracturing Treatments Optimization

Luca Dal Forno - ENI, SPA

Bir Rebaa Nord (BRN) and Bir Sif Fatima (BSF) fields, operated by Groupement Sonatrach-Agip (GSA, a JV between ENI and Sonatrach), are located in the Berkine basin in North-Eastern Algeria. These fields are characterized by oil-bearing sandstone reservoirs with low to medium petrophysical properties. During the development phase, to counteract the effect of pressure depletion, water and gas injections were implemented for reservoir pressure maintenance. Hydraulic fracturing has been implemented to improve well performance, both in terms of productivity and injectivity for oil producers and water injectors respectively.

Hydraulic fracturing has been implemented in GSA since year 2000 to improve well performance, both in terms of productivity and injectivity for oil producers and water injectors respectively. The fracturing process has been improved over the years regarding operational procedures, enhanced reservoir knowledge, and implementation of new technologies towards resolving the many uncovered challenges. Changes to the perforation strategy, fracturing fluids formulation, rock mechanics studies, and design of proppant schedules are examples of enhancement to the fracturing practice that have been implemented recently.

One of the uncharted matters in GSA, coming out from the post-job data re-processing, was the necessity of a precise characterization of the hydraulic fractures vertical coverage. The presence of several sandstone layers with different properties brought questions if the fracture had grown into an unwanted zone, or may had not properly covered the entire target formation.

This article describes the successful implementation on two water injector wells of a novel non-radioactive detectable proppant for the first time in Algeria. The taggant material within the proppant has been located by comparing the pulsed neutron cased-hole logs before and after hydraulic fracturing treatments. The detectable compound does not affect proppant properties, and its non-radioactive nature reduces the duration of materials delivery. Moreover, it eliminates the HSE risks linked to other tracing methods.

Pulsed neutron measurements evaluation provided valuable information regarding fractures confinement, avoidance of contact with undesired layers, and possible presence of cement channeling. Furthermore, combined with sonic logs and cores data, it helped refining the geomechanical model for future interventions design in the same reservoirs.

Having an accurate fracture height measurement was central to the optimization process. A number of technologies for fracture height measurement are available to the oil and gas industry nowadays, which can be broadly divided in far-field and near wellbore techniques. While microseismic and tiltmeters can be counted in the first category, temperature logs, radioactive tracers, and sonic logs methods belong to the second one. Each category has its advantages and disadvantages, making them complementary rather than competing options. Indeed, while far-field methods give a better indication of the hydraulic fracture azimuth, length and symmetry, near wellbore techniques provide more accurate height measurement, as well as proppant location.

Traceable Proppant

Instead of measuring the hydraulic fracture propagation, that may or may not be propped, a near wellbore technique, indicative of where proppant had been placed, was desired. The technology selected for this project incorporates a high thermal neutron capture compound (HTNCC) at low concentrations throughout all proppant grains in the manufacturing process.

This low concentration produces no detrimental effects on any proppant physical property, including strength, and most importantly, fracture conductivity. The proppant containing HTNCC is pumped downhole and placed in the hydraulic fracture, as it is done with any standard proppant. Its detection is based on the effect that the HTNCC will have on Standard Compensated Neutron logs (CNLs) or Pulsed Neutron Capture (PNC) tools. In the case of CNL, the presence of the HTNCC will reduce the neutron count rate recorded in the detectors; while in the case of PNC, the presence of the HTNCC will reduce capture gamma ray counts and increase the computed formation capture cross sections. If run on carbon-oxygen mode, PNC logs can also determine the elemental yield of the HTNCC.

Comparison of before-frac and after-frac logs in both PNC and CNT methods is straightforward, and clearly indicates the presence of HTNCC tagged proppant when other parameters are relatively constant. If the borehole environment changes between log runs, different tools are utilized for the two log runs, or the neutron outputs of the sources used in the before-frac and after-frac logs are different, log responses may need to be normalized utilizing logged intervals outside the fractured interval(s). It is also possible in some situations to eliminate the before-frac log entirely, if a PNC or CNT log had previously been run in the well.

Field Applications

The first case study considers water injector well BRN-27. The fracure treatment was designed based on the available information from well BRN-27 and past fracturing experience in the same area. In order to assess if the upper sand layer would be affected by the hydraulic fracturing treatment, well BRN-27 was selected as candidate for implementing the non-radioactive detectable proppant.

The main fracture treatment was successfully conducted, placing a total of 84 klbs in formation at a maximum concentration of 7.4 ppg. Following the treatment flowback, the well was logged with a PNC tool for the traceable proppant placement interpretation.

Formation sigma and captured gamma ray, which count rate measurements for both pre and post fracture conditions, were compared and analyzed for tagged proppant identification. The strong attenuation of neutron counts and increase in formation

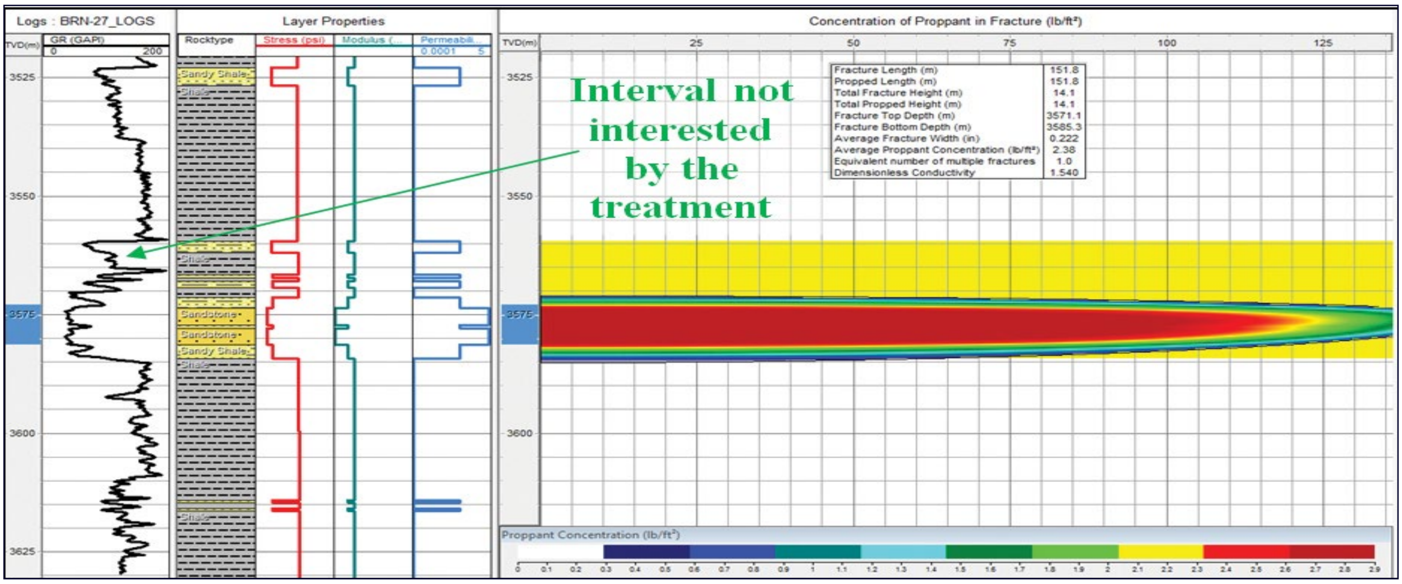

Fig. 1

sigma between the pre and post fracture logs suggest a wide fracture. From the interpretation, it was also evidenced that the fracture propagated in a very confined mode within the boundaries of the perforated sand body.

The actual fracture height of 13 m derived from the tagged proppant interpretation was then considered as a fixed input to the fracture model for net pressure matching. In order to satisfy the measured fracture height, closure stress and Young's Modulus of the shale thin layers above the perforated interval were considerably increased, compared to the values used in the design phase. As it can be observed in (Fig. 1), the resulting geometry is extremely confined within the main interval, not contacting the upper sand layer with poorer petrophysical properties.

The second case history is dedicated to well BSF-11, drilled in 2013 as a water injector in the Lower TAGI formation. The main objective of this well was to provide pressure support to the close oil producer, open in the same interval. Since BSF-11 was the only injector in the field specifically dedicated to this target formation, it was extremely important for the hydraulic fracturing treatment to remain confined within that interval. For this reason, non-radioactive detectable proppant was selected for this well.

The main fracturing treatment was performed placing a total of 55 klbs of traceable proppant in formation, at a maximum concentration of 7.5 ppg. Tip screen-out occurred shortly before the designed end of the job, creating an extremely compacted proppant pack, and therefore increasing the final fracture conductivity. Once the underflushed proppant in the wellbore was cleaned up and all the treating fluids were flowed back, a second run of PNC log was performed on the same interval of the pre fracture run.

Pre and post fracture PNC curves were compared and analyzed, in order to assess the placement of the non-radioactive proppant within the formation. Clear proppant signals were detected in the interval from 2984 to 3010 mMD. After-fracture near and far detector count rate logs decrease, and the after-fracture formation sigma log increases simultaneously, suggesting the presence of a wide and deep fracture. From 3010 to 3015 mMD, the after-fracture near count log decreases but the after-fracture formation sigma log hardly changes. This suggests that in this interval, some tagged proppant might be only present in a near-wellbore region, such as cement annulus. Therefore, the actual fracture height can be interpreted at around 26 m, extending from 2984 to 3010 mMD.

With the accurate height measurement, the fracture model was re-calibrated to match the actual created geometry (Fig. 2). The upper shale layer closure stress was slightly increased in order to satisfy the actual propped height. The Middle TAGI formation was not contacted by the stimulation, confirming the achievement of the primary treatment.

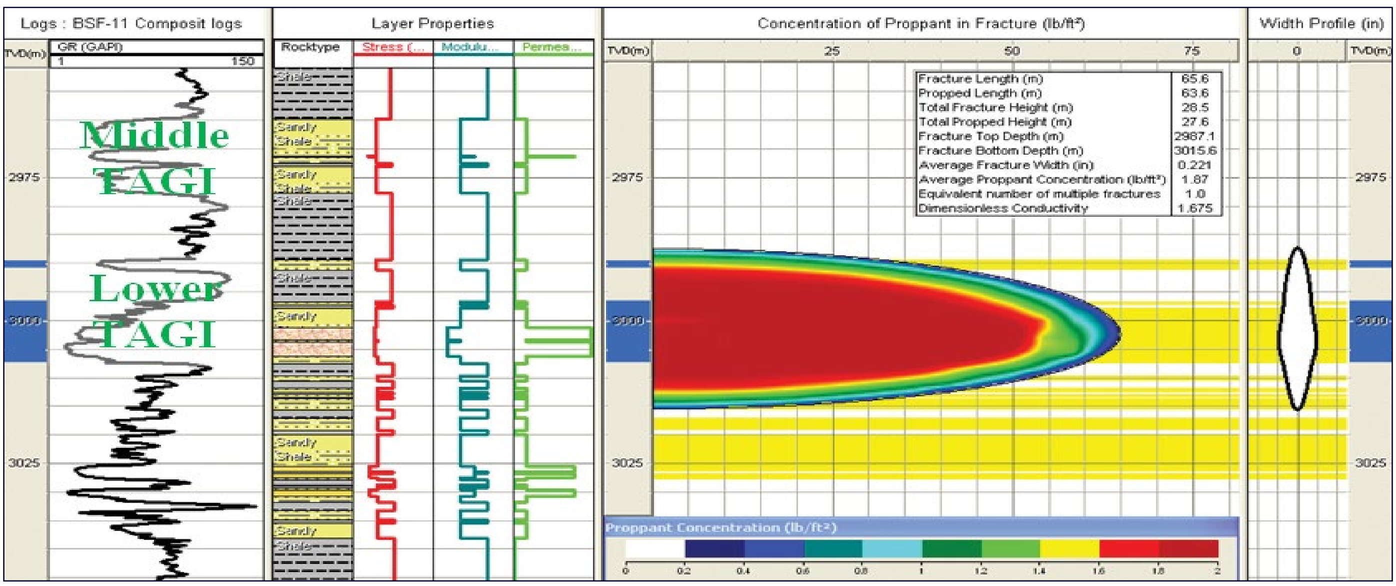

Fig. 2

A Fast-Tracked Development Plan of Alpha Reservoir (A Partially Appraised Field) Through Integrated Studies

Lawrence Ahiwe - Geosciences and Petroleum Engineering, University of Benin

Determination of the viability of a reservoir for development often requires building confidence around key decision parameters. The objective of this project is to eliminate extra costs associated with full reservoir appraisal by establishing confidence on identified uncertainties, managing, and building models to capture them.
MAR A field is a green field with limited well penetrations. The objective reservoir is a relatively shallow one, with 5 well penetrations. Two of the wells are wet, while the rest penetrated hydrocarbon bearing intervals. Neutron-density logs acquired in one of the wells (MAR 15) that penetrated the hydrocarbon interval show the presence of gas. In addition, assessment of sidewall samples and ditch cuttings further validates the presence of gas in the reservoir. However, no contact has been logged from any of the wells. This, and other subsurface uncertainties, were managed with new technologies in order to achieve the aim of the project.
3D static modeling captured static uncertainties (i.e. structure, stratigraphy and rock properties) of the reservoir, following identification of limitations to reservoir development. The impact of dynamic properties on fluid recovery determined the outcome of the production forecast of the selected development concept. Impacting uncertainties in reservoir development have been managed and reduced sufficiently for development. Fluid contact uncertainty has been reduced to 20ft (from 103ft), thus eliminating presence of a producible oil rim, and managing structural uncertainty. For optimal recovery, the selected development concept targets a single well (with a pilot appraisal hole), and tubing size of 4.5", at a rate of 50MMScf. Preliminary economic evaluations estimate a capex of $68.6m on the proposed development well, against $93.6m in a full appraisal to development scenario. The development project is viable even in the low case outcome. This study eliminates additional costs (about $25m) that would have been incurred by appraisal and fast-tracks reservoir development.

Oil and gas industry is well established as a high-cost, high-risk venture, where successes when achieved, are fulfilling. Usually, companies employ cost-cutting strategies (that do not undermine operational safety) to maintain a reasonable bottom-line and margin, especially since the current uncertainty and bust in crude prices and revenue from petroleum products. The main thrust of this work is on cost reduction techniques, focused on the pre-production phase of reservoir development.

Background of Study

The reservoir under study is the Alpha reservoir, one of 16 reservoirs in a partially appraised field (MAR A field) in the Central Swamp depobelt of the Niger Delta basin, Nigeria. The MAR A field was discovered in 1971, and, up to the time of this work, was a green field. 3D seismic data has revealed the field as a fault-bounded simple roll-over structure, with a relatively low relief. It also has minor intra-field listric faults, particularly a large fault which segments the field at some levels.

The focus is to fast-track the field development using current technology to delineate possible fluid contact(s) against dedicated appraisal well(s), to establish the presence or absence of an oil-rim. This in effect, will reduce costs associated with drilling more appraisal wells and building additional facilities (except flow-lines, pipelines and manifolds). As a partially appraised field, a set of uncertainties were identified for management. These include:

1. Structural uncertainty due to sparse well control.
2. Uncertainty in fluid types and depth of fluid contact.

Data Availability

The MAR A field faces the challenge of sparse information and large data gaps. The field data review is enumerated below:

1. Seismic data
2. Core samples/Biostratigraphic information
3. PVT data: No fluid samples were obtained from the wells, and hence no experimental PVT data. As a result, existing correlations were used.
4. Pressure data

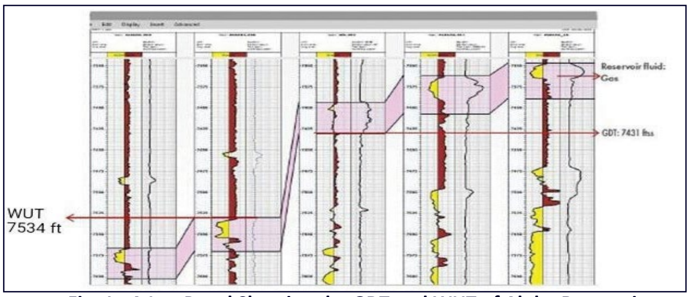

Fig. 1 - A Log Panel Showing the GDT and WUT of Alpha Reservoir

Methodology

The methodology employed to fast-track reservoir development from field appraisal was that of an integrated, multi-disciplinary approach. Pressure gradient analysis is the method adopted in this study for the investigation of a possible oil rim within the objective reservoir. The theory is based on the variation in fluid gradient especially around the GOC. In testing the possibility of an oil rim in the objective reservoir column, where a gas column has been established, different possible oil gradients were plotted below the gas gradient line, against an established hydrostatic line. Different depth realizations were tested below the established Gas-Down-To (GDT) in order to evaluate the possibility of a GOC/OWC. The idea was that, should an oil rim exist within the interval of investigation, the different pressure gradients of oil and gas will establish a pressure gradient profile. For example, the oil gradient line will intersect the hydrostatic line above the Water-Up-To (WUT) line. The model was also calibrated with data from reservoirs with established GOCs.

Results and Discussion

From the oil-rim investigation done, analysis showed that at depths below the GDT up to 20ft above the WUT line, there was no intersection of the oil and water lines for any of the possible oil gradients (0.2 - 0.38psi/ft). The implication is that, within the 103ft. of unknown fluid column, the maximum column of oil-rim possible is just 20ft above the WUT. Even at this depth, the possible oil gradient of 0.2psi/ft. intercepts with the hydrostatic line just above the WUT line. Oil accumulation with such gradients will be very light oil. In addition, the column of possible oil-rim of about 20ft. is not economical enough to be developed, so it is negligible. As a result, the gas gradient line was extended below the Gas-Down-To (GDT) to intercept the hydrostatic line at 7529 ft. This becomes the established Gas-Water-Contact (GWC), and a reference point for reservoir pressure estimation and hydrostatic initialization. With this established, the development strategy adopted was that of a gas reservoir. This can be shown in Fig. 2a and 2b respectively.

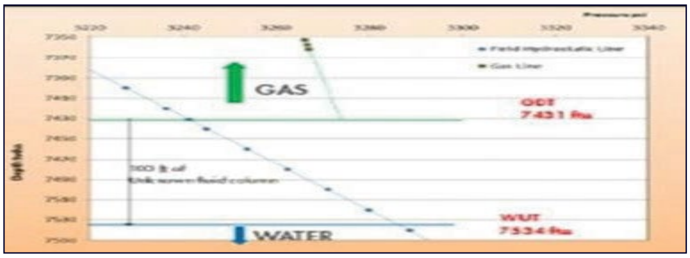

Fig. 2a - Investigation for Possible Oil-Rim Within Unknown Fluid Column

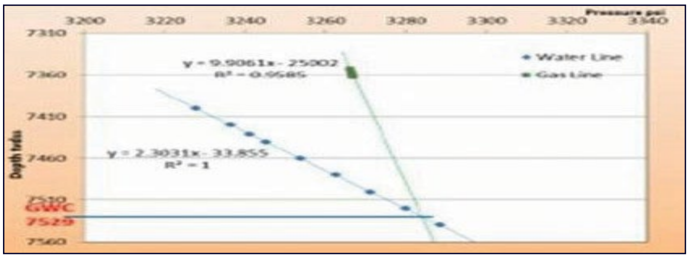

Fig. 2b - Establishment of Alpha Reservoir Contact

In-Place Volumes

Due to the uncertainties in the data set used for this study, realizations were built to manage these uncertainties. As a result, low, base and high case volumes were determined to account for the possible scenarios of in-place hydrocarbon volumes. Below is a table summarizing the in-place volumes for different realizations.

Table 1: Volume of Gas Initially in Place (GIIP)

LC	BC	HC
GIPP (BSCF)	GIPP (BSCF)	GIPP (BSCF)
226	263	295

The gas-in-place volumes of the initialized grid model was compared to that of the static model, and the model was initialized accurately.

Development Concept Selection

In a bid to determine the development concept or strategy to adopt, the following considerations were made:

i. Rate of production from the reservoir.
ii. Number of development well(s) to use for optimal recovery.
iii. Type of well that will optimally drain the reservoir.
iv. The best tubing size to use in the well.

Sensitivities were carried out on various possible development concepts to understand how they will each affect the total recovery. In considering these development concepts, however, it is important to point out that the biggest constraint to the volume of hydrocarbon produced from the well at any given time is the fact that production from the well will be evacuated to a shared surface processing facility (i.e., where production from wells in other locations will also be sent). The study concluded that the optimum subsurface development concept will involve drilling one vertical development well (including pilot hole for further appraisal), completing with a 4.5-inch tubing made preferably from chrome, and an uptake rate of 50MMSCF/Day.

Production Forecast and Economics

Deterministic low, base and high case subsurface realizations were built using the selected development concepts to determine the low, base and high case expected recoveries. Results are shown in table 2.

Table 2: Low, Base and High Case Recoveries

	LC	BC	HC
Gas (BSCF)	147	170	190
RF (%)	65.8	64.6	64

Relative to the volumes initially in-place, volumes recovered from the reservoir give a recovery factor of approximately 65% for the low, base and high case scenarios.

First Pass Economics

In order to demonstrate the project's viability, we made an attempt to carry out a preliminary economic assessment. In doing this, the following assumptions were made:

• Gas Price = $2/MMSCF
• Well Cost (including pilot hole for appraisal) = $35M
• Cost of Flow Line/Pipelines = $2.4M/Km = $33.6M
• No additional facilities to be built other than pipelines and flow lines.
• The fields already supplying gas to the processing facility would have entered their decline phases by the time the project comes on stream. This will create enough allege in the processing facility to accommodate production from the reservoir.

Using Net Present Value (NPV) as an index of project economic performance and viability, the following values were obtained for 0% discount rate and 10% discount rate respectively.

Table 3: Summary of Project Economic Assessment

	Low Case (LC)	Base Case (BC)	High Case (HC)
NPV (0%) Discount rate	$121M	$143M	$164M
NPV (10%) Discount rate	$20M	$26M	$30M

Conclusion

No substantial oil-rim was established in the reservoir. A new GWC was thus established, and the necessity of additional appraisal well(s) eliminated. The development strategy of a gas reservoir was adopted. The key impacting uncertainties are: Structure, and contact. The identified uncertainties have been managed by building realizations to adequately capture the possible outcomes. The optimum subsurface development concept is one vertical well with a 4.5-inch tubing size. Preliminary project economics evaluation show that the project is viable even in the Low-Case scenario. The project is therefore recommended for development. However, management of uncertainty around fluid type and contact, using amplitude extracted from reflectivity volume, was not possible due to poor amplitude expression on amplitude map. This does not invalidate the analysis used in this work; it would only have supported results from pressure analysis.

Recommendation

A C-O log should be acquired to further validate the estimated contacts and help narrow down contact uncertainties.

"The Earth Is Not Running out of Oil and Gas", BP Says

Oil and gas companies have invested heavily in squeezing the maximum from existing reservoirs by using chemicals, super computers and robotics. The halving of oil prices since last June has further dampened their appetite to explore for new resources, with more than $200bn-worth of projects scrapped in recent months.

By applying these technologies, the globally proved fossil fuel resources could increase from 2.9 trillion barrels of oil equivalent (BOE) to 4.8 trillion BOE by 2050 , nearly double the projected 2.5 trillion BOE required to meet global demand until 2050.

US Shale Oil Production Decline

The decline of US shale oil production is to continue with a projected drop of 116,000b/d in February, adding to an overall decline of about 640,000b/d since the production peak in March 2015. Shale oil production has dropped over crude prices collapse and analysts predict that seeing a fall in oil prices to $20 a barrel is possible. As a result, drilling companies have idled 64% of their oil rigs and will keep undermining the levels of shale production in months to come. Some analysts estimate that around 50% of US shale oil producers could go bankrupt before the crude market reaches equilibrium.

UAE's Gulf Energy to Purchase Share in US Helium Gas Field

Gulf Energy Corporation has signed an agreement to purchase a share in the deep gas development well in the US state of New Mexico to be drilled in 2017. The field has proven reserves of helium gas in commercial quantities. Global demand for helium gas has increased since 2013, making it an attractive investment opportunity.

Aramco Will Not Reduce Oil and Gas Investments

Saudi Aramco announced that it would not reduce its new investment in oil and gas production capacity despite the financial strain caused by low oil prices. Aramco's Chairman, Khalid Al-Falih, explained that the company had been able to cut costs enough to maintain the current levels of investment. He said that Saudi Arabia could survive a low oil price for "a long, long time."

"The objective of the Aramco IPO sale was not to generate cash for the Saudi government, but to promote the Saudi private sector", Al-Falih insisted, according to Trade Arabia. He added that global oil supply and demand will eventually balance at a "moderate" price.

DEA Appoints New Head for Egypt

The Egyptian subsidiary of DEA Deutsche Erdoel AG, the German upstream company, has appointed Dr. Thomas Radwitz as its new General Manager. Upon appointment, Dr. Radwitz said that "at our own operated onshore gas development project Disouq, in 2016 we continue to invest in infrastructure, like pipelines and the gas treatment plant, to add the already discovered gas fields to production. Production of the West Nile Delta project is scheduled to start next year and we are working full steam with our partner to get this important project on stream."

Dr. Radwitz is a petroleum engineer. In his previous posts, he was responsible as a Managing Director for the Suez Oil Company (SUCO), the joint venture of DEA and the Egyptian General Petroleum Corporation (EGPC) from 2006 to 2008. He was also in charge of DEA's operations as General Manager in Libya between 2008 and 2014, and most recently in Turkmenistan between 2014 and 2015. In the last three decades in Egypt, DEA has produced over 640m barrels of crude as an operator in the Gulf of Suez. In 2013, DEA started production from the own operated Disouq gas development project.

Gazprom Envisions Rise in Gas Supplies to Europe

Gazprom, the Russian natural gas producer is seeking to increase gas supplies to Europe and Turkey by 2% to record levels in 2016. Gas exports to most of the EU countries and Turkey is seen to rise to the level of 162.6bcm this year, up from 159.4bcm in 2015. Gazprom is likely to face emerging competition within two years, when the currently tumbled EU domestic gas production may recover, and Moscow will be forced to cut its supplies. Gazprom said that US LNG exports to Europe – expected to start in first quarter of 2016 – will cost European countries more than gas purchased on the spot market.

Halliburton Launches Electrohydraulic Subsea Safety System

Halliburton has announced the release of the Dash 3-in. Subsea Safety System, a complete solution for electrohydraulic control of Halliburton's subsea safety tree. Previously, control was provided through direct hydraulic pressure from the surface. This latest edition to the Dash series employs the speed of electrohydraulic actuation where it matters most —core safety functions— while still providing full direct hydraulic, redundant control of all functions. This helps to increase reliability and provide more cost-efficient operation and maintenance.

Italy to Upgrade Egypt's MIDOR and Other Energy Projects

Italy has agreed to upgrade Egypt's Middle East Oil Refinery (MIDOR), participate in building a complex for petrochemical industries in Ain Sokhna, and update a number of combined-cycle power plants. Italian Minister of Economy, Federica Guidi previously said that Egypt is keen on attracting Italian investments. Italian companies are expected to participate in large-scale projects, such as the Golden Triangle, Al-Robeky City for leather industries, and the furniture city in Damietta.

Outstanding Student Chapter Award 2015

SPE Suez University board members received the Outstanding Student Chapter Award for the 2015 season in SPE Annual Technical Conference and Exhibition (ATCE) in Houston, Texas. It was the second time in a row after receiving this award for the 2014 season. Indeed, this is a super motivation to the whole chapter members to do their best this season to achieve the triplet in a row. Our chapter's representatives showed a distinguished level of engagement and interaction during the officers' workshop held at the conference. They also had precious moments with D. Nathan Meehan, SPE 2015 President.

SPE North Africa Technical Conference (NATC) 2015

SPE Suez University Chapter board members participated in SPE North Africa Technical Conference (NATC) 2015 held in Cairo, Egypt in September 2015. The conference was a great opportunity for our chapter officers to attend different technical sessions and scientific papers' presentations. It was also a great opportunity to them to make new connections and develop their professional career network through meeting industry professionals in North Africa. Our representative Abdelrahman El-Diasty was a speaker where he presented a paper about advancements of Nano-Technology in Enhanced Oil Recovery (EOR).

Halliburton Hydraulic Fracturing Forum & Workshop

It was one of the most important mega events of the first semester where this forum discussed everything regarding hydraulic fracturing such as uses, importance, techniques and design. The forum ended with a workshop on how to prepare samples of proppant and how it functions. Proppant is a solid material, typically sand, treated sand or man-made ceramic materials, designed to keep an induced hydraulic fracture open during or following a fracturing treatment. It was a worthy forum and a great opportunity for undergraduate Petroleum Engineering students to refuel their technical knowledge about one of the important techniques at the industry.

Introducing New Human Resources Management & Marketing Systems

Our slogan this season is "Feel the Unique Brand". New ideas are being initiated for both human resources and marketing segments at the chapter. Starting with human resources segment, we have implemented an Integrated Talent Management System for our members, which aims at developing the member through a training strategy. This strategy is composed of a cycle of processes which will include mentoring, team experience and development workshops covering soft and functional skills according to the needs of each committee. we have also introduced Inbound Marketing Strategies through our offline and online marketing channels. These new strategies have unprecedentedly developed our reach and interaction with our customers through an integrated marketing plan; a plan reflecting our brand nationally and internationally by making best use of all the chapter resources (i.e., official website and e-learning library), as well as providing strong technical programs and mega events.

E4ME Workshops

We managed to visit El-Galaa Secondary Private School in Suez to hold the first energy awareness workshop for this season. It mainly focused on making students recognize the value of renewable energy and its methods of extraction. Our E4ME team made models for different energy resources and introduced them to students with simple presentations about how they function, clarifying advantages and disadvantages. This workshop aimed at raising the awareness of the youth in Suez to the importance of green energy and saving it.

Egypt Petroleum International Conference (EPIC) 2016

EPIC is the biggest student-run annual international conference in Egypt's oil and gas scene, organized by SPE Suez in conjunction with SPE American University in Cairo. EPIC 2016 is the second edition of the conference, where we contemplate to create an enriching experience that adds to both bright students and esteemed professionals who attend the conference. The second edition this year includes new features and programs simulating SPE International Conferences, including parallel sessions, Gala Dinner, paper contest, e-poster presentations, cultural show, and Petropharaoh Competition.

EPIC
Egypt Petroleum International Conference

Food Bank Visit

This season SPE Suez has expanded its community services through some charity events. Our extracurricular team has managed to organize a visit for 15 members to the Food Bank. A wide campaign was held to raise donations for the Food Bank and SPE Suez University Chapters prepared 1500 food bags for this visit. The Food Bank staff was very pleased by this visit and they encouraged the chapters to repeat this visit again due to its great impact proven by strong engagement between students in the university, as they interacted positively with it. Our university Dean appreciated our team visit and encouraged us for more charity activities.

Schlumberger Courses

Through Schlumberger-EEG University Relations Manager, our chapter has successfully made a deal with Schlumberger Egypt to provide 12 opportunities for a package of training courses for petroleum engineering students at Suez University. These courses will be at Schlumberger Training Center, along the second semester of 2016, and will include:
- ECLIPSE.
- Petrel Reservoir Engineering.
- History Matching and Conditioning Reservoir Models to Dynamic Data.

Courses are to be completed by the end of April, 2016.

Schlumberger Well Integrity and Production Logging School

Through our academic sponsor, Schlumberger-EEG, we organized a two-day school of well integrity and production logging school at Suez University. The first day was about well integrity. The school covered:
- Cement Evaluation.
- Sonic Tool Overview and Applications.
- Ultrasonic Tools Overview and Applications.
- Corrosion Evaluation.
- PL Sensors.
- Applications.

Geology of Egypt Seminar

A five-hour seminar and workshop provided through our academic sponsor, Technical Petroleum Services (TPS). The seminar covered geology of Egypt in its three provinces (Gulf of Suez, Nile Delta and Western Desert) and how petroleum engineers and reservoir engineers make use of this geologic data and information in their work. It was followed by a workshop about making use of geologic interpretations in reservoir engineering applications.

Halliburton Courses

Halliburton has bestowed four technical courses each with 20 opportunities for Suez University students at Halliburton training center at their headquarters. The first two courses were held in the first semester and they were about well completion and well control. The remaining courses are to be held in the second semester. The courses are followed by practical workshops to get a close and real exposure to these techniques in the oilfield.

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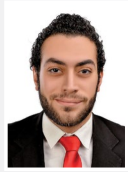

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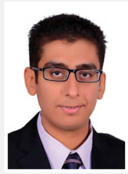

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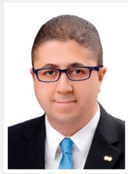

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