USC University of Southern California

RMC

Reservoir Monitoring Consortium (RMC)
Semi-Annual Review Meeting Meeeting
University of Southern California

Fred Aminzadeh

USC Campus, July 22, 2015

INTRODUCTION

On July 22, 2015 the University of Southern California (USC) held its semi- annual Reservoir Monitoring Consortium (RMC) meeting at Ronald Tudor Hall at USC. The report follows the agenda given in Appendix 1. We provide (when available) an abstract of the presentation and a representative figure. All comments and questions raised during the talks are included. We also highlight the Strategic and Technical Advisory Board meeting and the subsequent brain storming session. The overview talk given by Prof. Aminzadeh can be accessed at the RMC website. Full presentations can be found at the "member's only part" of the website: http://rmc.usc.edu/

The meeting attendees and their contact information are given in Appendix 2, Attendees were from current sponsors, potential sponsors; members with observer status, and guest speakers. The organizations represented included: California Institute of Technology (Caltech), University of Toronto, Universität, Leoben (Austria), Massachusetts Institute of Technology, California Resources Corporation (CRC), Optasense (formerly SR2020), , Gas Technology Institute (GTI), , California State Land, Petroleum Institute of Abu Dhabi, Saudi Aramco, Sinopec, Ayres Group LTD, Kuwait Oil, KMS Technology, Aera Energy., Japan National Oil Company (JOGMEC, and USC.

PRESENTATIONS, ABSTRACTS, AND COMMENTS

The RMC Semi Annual Review meeting began with a brief over view of the accomplishments of RMC. This was followed by presentations from the USC students and post-doctoral with more specifics on the accomplishments and the plans through the end of the cycle (October). The program also included several presentations by guest speakers and past or future potential collaborators. The, agenda in Appendix 1 shows all the presentations including a Strategic and Technical .Advisory Board meeting was chaired by Cynthia Black of CRC and Martin Karrenbach, of Optasense This was followed by a brain storming session and some discussions on future plans. .. Upon the conclusion of the ISC review meeting a dinner reception was held that was also attended by the California Well Stimulation.(CWS) Forum scheduled for the following day. The dinner speaker was John Gibson, the former president of Halliburton Services, currently with Tervita an Environmental Service Company, who also is on the USC Global Energy Advisory Board (http://gen.usc.edu/assets/002/94923.pdf).

8:15 –8:35- An Update on Reservoir Monitoring Consortium (RMC): F. Aminzadeh (USC)

A brief status report of the annual RMC was provided. Given that many participants were new to the consortium, the following objectives were highlighted:

- Identify the current key technology gaps
- Focus on interfaces between different disciplines
- Integrate data, information, expertise and work-flow

- Maintain a balance between the short term high impact research and long term needs
- Develop dynamic reservoir monitoring (DRM) work-flow

Although all types of reservoirs are considered, the current focus areas are: shale and carbonate reservoirs, , mature fields and deep water reservoirs. The unique feature of the consortium is the possibility for the RMC Base membership and/or membership for Individually Sponsored Projects (ISP). RMC Base members receive access to general results of Base RMC (see Introduction), the ability to vote on Base Project priorities and partial access to ISP projects (with ISP member concurrence). The ISP members, in addition to having access to RMC Base project results, can define their own project focus area that lies within the general objectives of RMC. It gives them the opportunity to have the RMC address their technical issues and the flexibility to limit the distribution of their own data and delay distribution and publication of the results within USC guidelines. ISP members also enjoy increased interaction between ISP members and USC students and faculty. Below are the six ongoing projects for RMC Base:

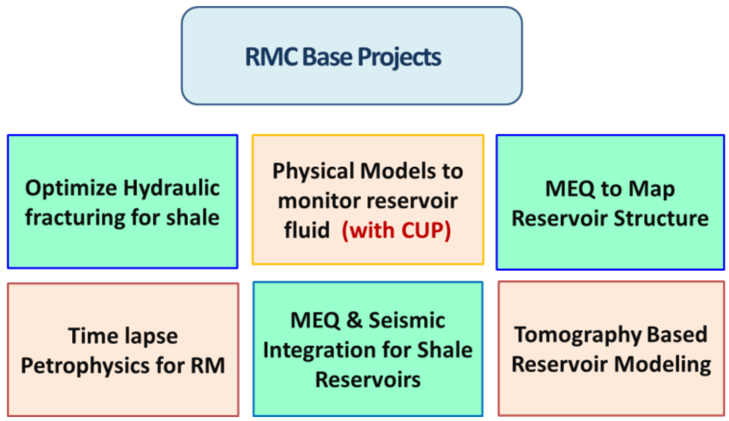


Figure 1- The RMC Base Projects Listing

ISP membership structure is based on the specific needs and requirements of the funding organization. They include various national and international oil companies, service companies, and national laboratories. The following are some examples of ISP Projects that are either ongoing, at the later stages of confirmation, or those still being discussed (noted by TBD):

- Real-time EOR Monitoring Using Smart Tracer Technology (KOC)
- Monitoring Kick and Overpressure (NETL- Saudi Aramco)
- Next Generation Visualization (TBD)
- In situ Stresses for Hydraulic Fracturing (Saudi Aramco)
- Monitoring Risk for Oil Spill (NETL)
- HCI with Absorption and Anisotropic AVO (TBD)
-
- MEQ and EM Data for Shale Reservoirs Monitoring (TBD)
- Advanced Hydraulic Fracturing Test Bed (DOGGR?)

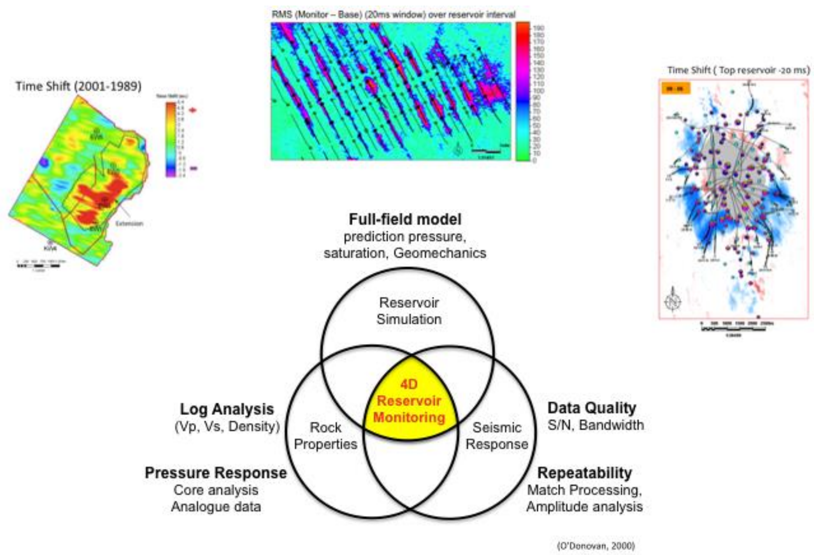
Exposure to and the opportunity for possible collaboration with other ongoing USC programs are among other RMC membership benefits. Among the complementary programs are: GEN2020 campaign (https://ignite.usc.edu/project/550c8ca114bdf77e29bb0a43), t he Induced Seismicity Consortium (ISC.usc.edu), Center for Geothermal Studies (CGS.usc.edu) and the Center for Reservoir Development and Modeling Systems (RDMS.usc.edu).

8:35 - 9:00: Reservoir Monitoring with 4D Seismic-Three Case Histories, Yesser HajNasser (USC)

Abstract
The benefits of time-lapse (or 4D) seismic monitoring have been well recognized across the industry worldwide. This work presents three case studies to illustrate the use of 4D seismic data for reservoir surveillance.

In the first case study we address the integration of geomechanics and pressure diffusion into the 4D seismic analysis. Geomechanical modelling and conversion of model results to synthetic seismic time shifts allows quantitative comparison of models with the observed 4D signature. This comparison helps calibrate the stress changes in the geomechanical model, allowing more confidence in identifying drilling geohazards. In the second case study we present the application of a new interpretation method of analysing the LoFS 4D seismic signature. This technique consists correlating the time-sequences derived from production data and the multi-vintage 4D seismic data. This helps to quantify the link between the 4D seismic signature and the well activity and hence enhances the dynamic interpretation of the reservoir. In the third case study we show an example of fracture detection using 4D seismic data. In this case study, we extend conventional 4D simulation-to-seismic forward modeling to include fractured media. The results show that fracturing can introduce 4D velocity changes significantly larger than would be expected from using velocity pressure trends from core measurements alone.

The analysis of the three different cases studies raises the need for a close integration between reservoir simulation, petrophysical data, and seismic signature in order to maximize the learning from 4D seismic data.

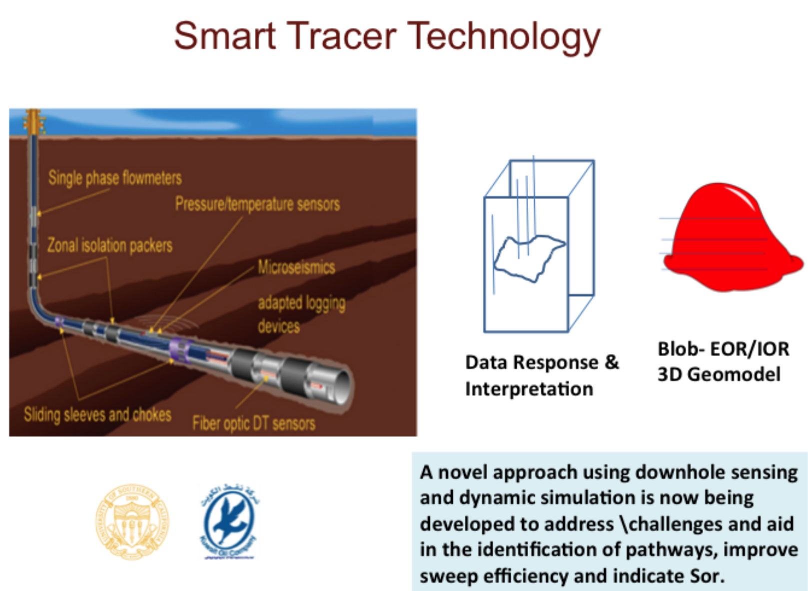


9:00 – 9:25: Advanced Tracer Analysis for EOR and Reservoir Monitoring, Noha Najem (Kuwait Oil)

Abstract

Today's oil companies are looking into implementing EOR in its mature fields. Since it s use , past implementation of Interwell tracers has shown much success , however approaches were traditional and did not address all challenges.

A fundamental technique for the monitoring of reservoirs is the application of iterwell tracer tests. The deployments of Interwell tracers are an essential to investigate reservoir flow performance and reservoir properties that control gas and water displacement processes. Tracer data has been used to reduce uncertainties attributed to well-to-well



communications, vertical and horizontal flow, and residual oil saturation. There are several types of tracers which are used in the petroleum industry. These are radioactive tracers, non-radioactive tracers and partitioning tracers.

The objective of this research is to find a novel approach to the implementation of interwell tracers for complex carbonate reservoirs in order to be used as an application for improvement of pathway identification, heterogeneity analysis, sweep efficiency, and an indication of the remaining oil saturation. To address these challenges, a novel approach using **downhole sensing** and **dynamic simulation** is now being developed to address these challenges and aid in the identification of pathways, improve sweep efficiency and indicate Sor.

Comments

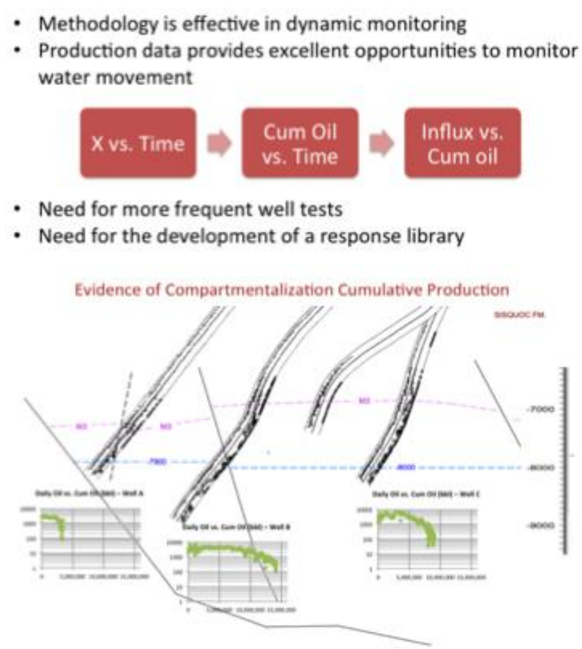
Question By:
Bill Ayres: Is the technology available in the industry for downhole sensing for the presented work?

Responses by:
Noha Najem: Currently the ESP is used to send basic information like pressure and temperature. For the presented work a permanent downhole gauge is needed to inform about the incoming flow. This technology is not available in Kuwait.
According to the research done by Noha a chemical based Tracer is available but not for downhole applications. Not mentioned during the meeting but Joe Iovenitti believes that there may be environmental industry downhole tools that can be adapted to do what Noha would like to see achieved. If we can obtain specifics on what exactly Noha wants to measure, the frequency and resolution required, Joe Iovenitti can investigate what is available from the environmental community.

Iraj Ershaghi: thought assured that the sleeve can be made available when and where necessary in the near future.

9:25 – 9:50: Use of Production Geology Data to Monitor Water Influx, Xiaoxi Zhao and Iraj Ershaghi

Abstract
It is important to monitor aquifer influx or injected water movement during the reservoir monitoring. Various technologies, such as 4D seismic, tracer test, and transient test, can be applied to solve monitoring problem. However, it is always significant to find other way to confirm the water influx results. X-plot methodology published by Dr. Ershaghi et al. in 1987, was used in this research. The method requires plotting x, which is related to water cut, vs. cumulative oil production. A linear plot is obtained for water cut values above 50%. The slope of this straight line can be used to calculate water influx value for different water cut. A case study of a compartmentalized fracture reservoir in offshore California, completely



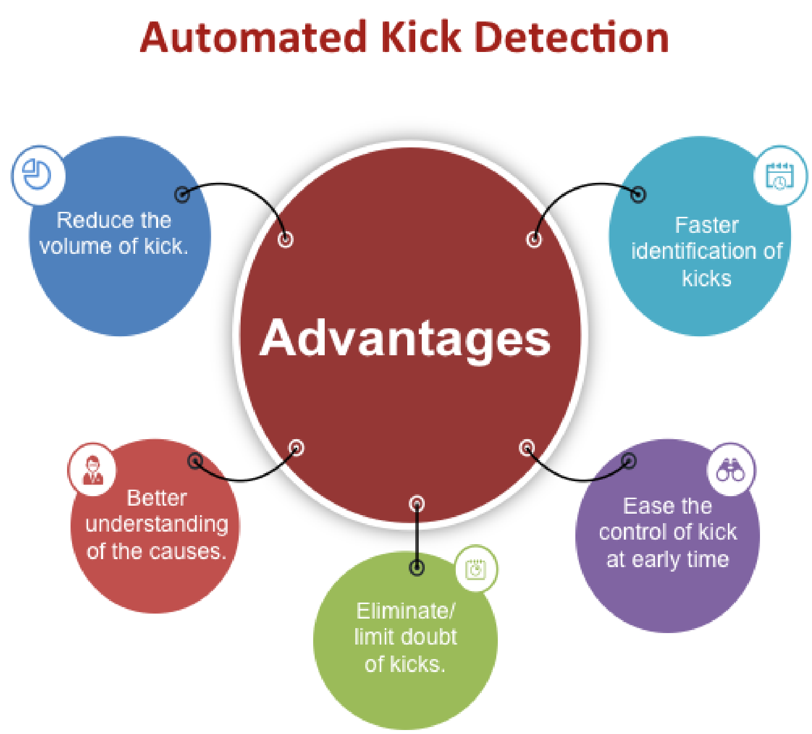
demonstrate the x-plot methodology. Well performance data of three nearby wells has been compared, and water influx has been calculated, moreover, the results shows that production data can provide excellent opportunities for monitoring water movement. Also more frequent well tests need to be done for visualize accuracy. The development of a response library for different heterogeneous reservoirs can be concerned as direction of future work.

10:05 – 10:30: Wellbore: Monitoring for Kick Detection and Plans for Field Testing in a Saudi Aramco Field, Hazza Otaibi, (Aramco) , Kelly Rose (NETL) Brian Tost (NETL) and Ahmed Bubshait(USC/Aramco)

Abstract

Among the key drilling risks are abnormal pressure and kick. Timely detection of these reservoir conditions and operational aspects of drilling with potential occurrence of kick will be the subject of this project. We will develop software for prediction and monitoring of kick and abnormal pressure and test the software using real data. Blowouts are unfortunate incidents which happen when a kick goes undetected. The development of a robust tool for kick detection will provide rig personnel early warning of fluid influx so that quick decisions can be made to prevent the catastrophe brought by a blowout. Furthermore, the proposed project will lead into a new era of research into kick detection methods beyond the conventional use of pressure/geo-pressure and mud tank returns. This will provide the oil and gas industry with more and earlier warning signs of a kick to look out for.

Existing kick detection methods are focused on detecting pressure changes, the use of mud returns or drilling parameters in order to determine kick. The proposed work will incorporate non-pressure-sensitive measurements. Specifically the first focus is kick detection on the near-bit area. Second, we will optimize delivery of kick-sensitive data to the surface.



For downhole kick detection we propose exploring different methods and the integration of these methods to develop an integrated workflow/alarm for kick detection for high detection accuracy and therefore very low probability of false-positives. Integration will also enable the grading/ranking of an influx situation based on risk-level as low, medium or high risk.

One method is the use of artificial neural networks. Unexplained fluctuations in drillpipe pressure, positive differences between the static annular pressure and the static pressure, pit gain and change in flow rate may indicate a kick. Since this is a non-linear problem and for real-time data, a dynamic neural network will be trained to recognize measured data and then make the predictions. With the feedback from the model the driller can know whether the current situation is indicating a kick or not and so take well control measures to kill the kick. The second method uses signal processing methods such as template matching. This is an automated method which compares a known template signal (in this case, indicative of a kick) to a larger portion of continuous data to provide signal correlations as an output. The use of wavelet transforms is also a viable signal processing method which will be used to analyze the data for kick-representative signals.

Question by:

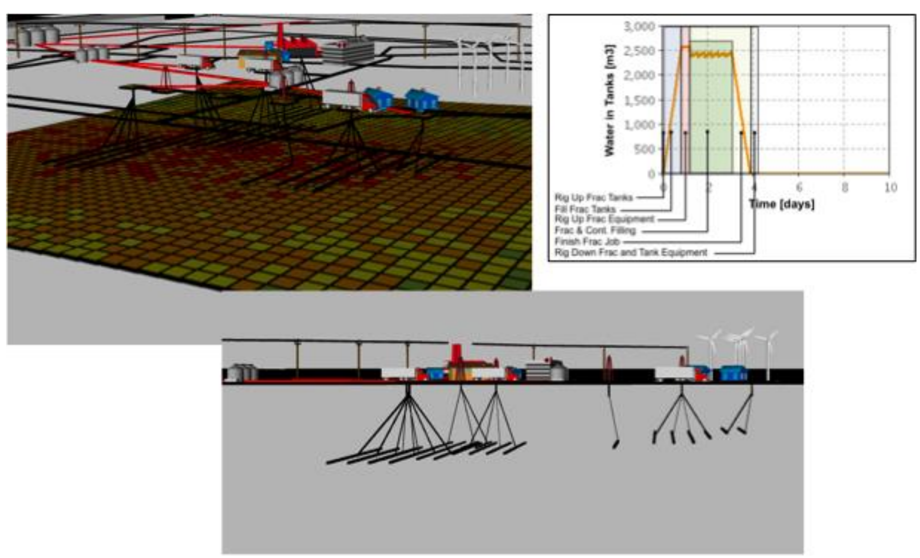
Kurt Strack: What causes changes in electrical resistivity? Kurt reported that changes in electrical resistivity are not seen in the mud pit.

Responses by:
Hazza Otaibi: Explanation for kicks is still being investigated. Saudi Aramco will be providing data to use in the investigation. Hazza Otaibi will be at USC to work on the project scope.

Fred Aminzadeh: We will be using all data available to identify the presence of kicks.

10:30 - 10:55: Modeling Field Development Strategies and Their Associated Resource Requirements, Michael Prohaska, University of Leoben, Austria

Abstract
Following the public debate in Europe about the surface impact of a potential exploitation of its own unconventional shale oil and gas resources, an approach was required in order to capture the various aspects of such a development.
Therefore a model that combines subsurface – geological and reservoir characteristics – and the surface GIS data was formulated. This allows efficiently testing various field development strategies and comparing the options against each other. The outcome of different drilling methods and fracturing technologies can be compared and an assessment can be made of the resulting local and temporal water consumption as compared to availability, logistical impacts with regard to truck transportation, land use due to pad design options, etc. This kind of approach is very well suited for water scarce areas, for densely populated areas, and for environmentally sensitive areas, as in many parts of Europe. As there are numerous similarities in California in that respect, research of surface impacts will contribute significantly to the understanding of the ongoing fracturing debate as well.



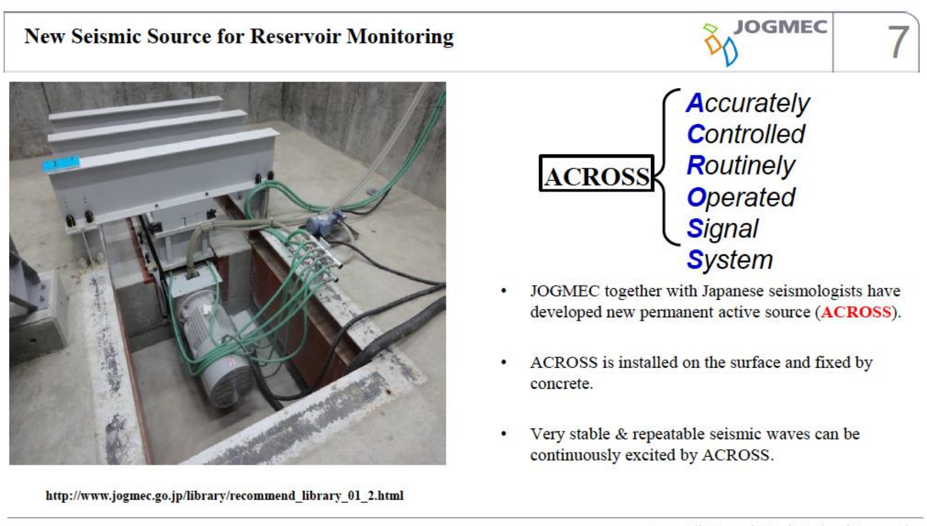
Question by:
Kurt Strack: Why is ground water not being used for this purpose? In West Texas, trucked water is destroying the road network due to the enormous truck traffic in hauling water.

Responses by:
Mathias Mitschanek: We just used the facility for the conceptual model. It is not that ground water cannot be used but while assuming for the conceptual model the facilities nearby where taken into consideration.

Kurt Strack: Well if the road management costs (due to track wear) is considered, which is really high, we need the right geophysical techniques to find adequate ground water in West Texas.

10:55 – 11:20: Permanent seismic source for continuous reservoir monitoring, Isao Kurosawa, Ayato Kato JOGMEC (Japan National Oil)

Abstract
Time-lapse seismic monitoring survey of oil, gas, Enhanced Oil Recovery (EOR), and carbon capture storage (CCS) is a well-known important technology of understanding temporal changes at the reservoir. Time-lapse seismic monitoring could be is very difficult when reservoir rock is stiff and the physical property change caused by injection is small. We, JOGEMC, developed ultra-high repeatability permanent seismic source called Accurately Controlled and Routinely Operated Signal System (ACROSS), which enable to observe small underground changes. In this presentation, we introduce a demonstration experiment of the Aquistore CCS site in Saskatchewan, Canada. Baseline data before CO_2 injection showed promising results on the high repeatability of the new seismic source.



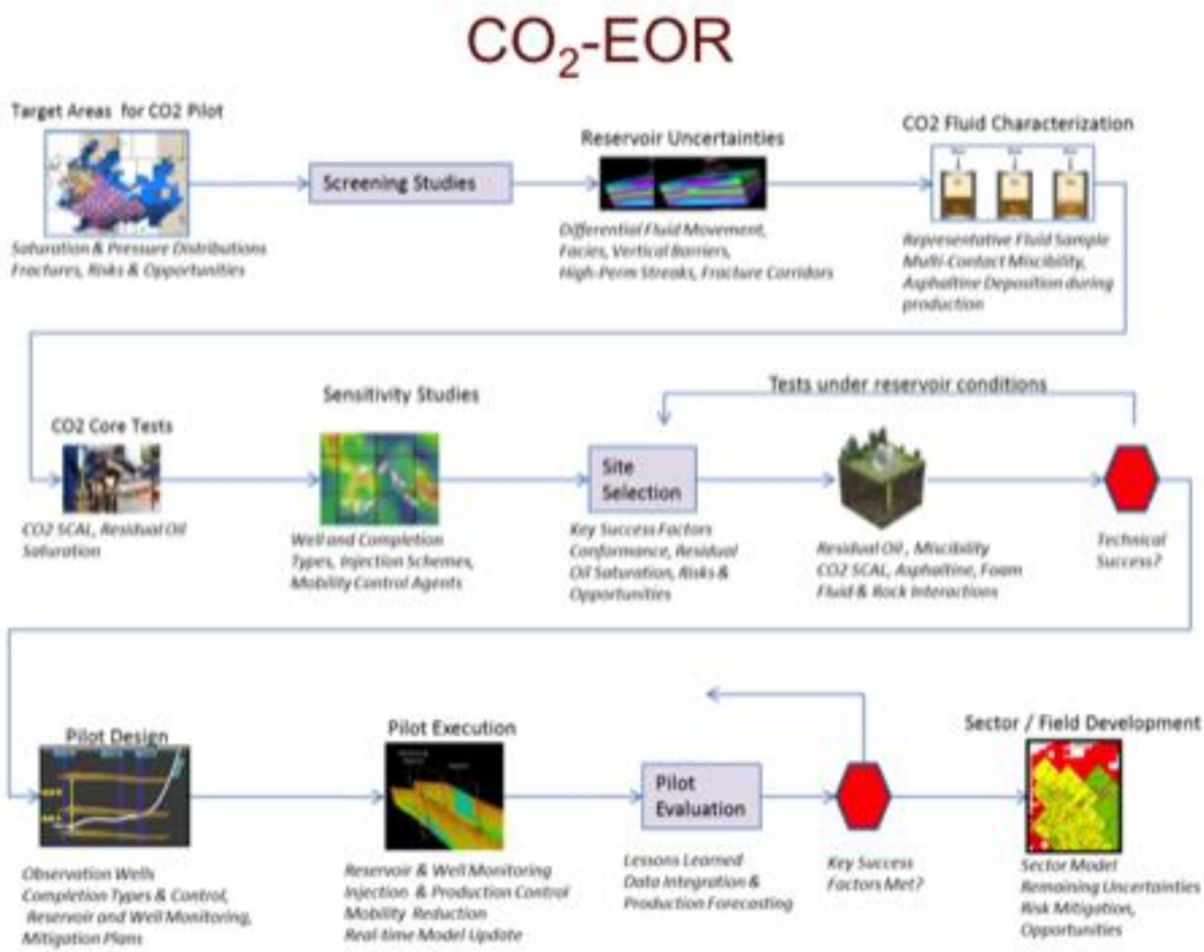
Question by:
Fred Aminzadeh: Rough cost estimates?
Kurt Strack: Operations and equipment costs?

Response by:
Isao Kurosawa: Will get back to you after getting details.

11:20 – 11:40: Research Directions for CO2-EOR Applications, Metin Karakas, USC

Abstract

CO_2-EOR has been identified as one of the most effective EOR methods, in particular for a large number of Middle Eastern Carbonate Reservoirs. There are several challenges to overcome for a successful commercial application such as viscous fingering, gravity override, and reservoir channeling which may require direct intervention. Pilot applications provide an opportunity to detect and mitigate these undesirable effects through the deployment of mechanical control and mobility control agents. In this process, Reservoir Monitoring is a crucial part of any successful commercial implementations. Earlier investigations show that pressure pulsing methods can be used to monitor and detect CO_2 fronts in Miscible CO_2 floods. However, the mapping of the CO_2 front is non-unique and requires integration with other reservoir imaging measurements such as time-lapse Seismic and EM. Both theoretical and laboratory investigations may be required to validate and integrate these different measurements, and in particular to address the associated uncertainties.



Question by:

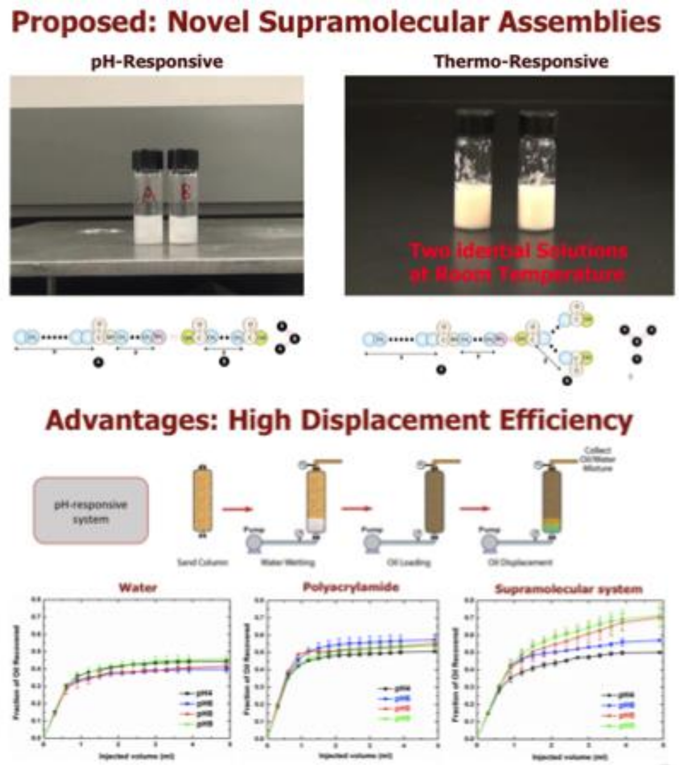
Mohammed Haroun: Can you elaborate on the CO_2 vs the water mobility control in the heterogeneous reservoir?

Kurt Strack: Were the entire parameters used scalar? Scalar parameters are good for an isotropic medium but the reservoir is anisotropic and therefore there is a need for tensor measurements. Kurt recommends using his measurement system.

Response by:
Metin Karakas: We see that practically the breakthrough is quicker than expected based on theory. We need more info to completely study this and we need permanent pressure gauges to monitor high resolution events. All the parameters used were Tensors as the reservoir was anisotropic. Different horizontal and vertical permeabilities were considered in order to account for the flow directionality.

11:40 - 12:00: A New Method to Analyze Displacement of Fluids in EOR, Cenk Temizel, Aera Energy

Abstract
This project is primarily aimed at developing novel supramolecular assemblies with adjustable viscosity and interfacial properties that have robust tolerance against high temperatures and salinities. Such supramolecular assemblies will be used to significantly improve the feasibility and cost-effectiveness of displacement fluids used in EOR.



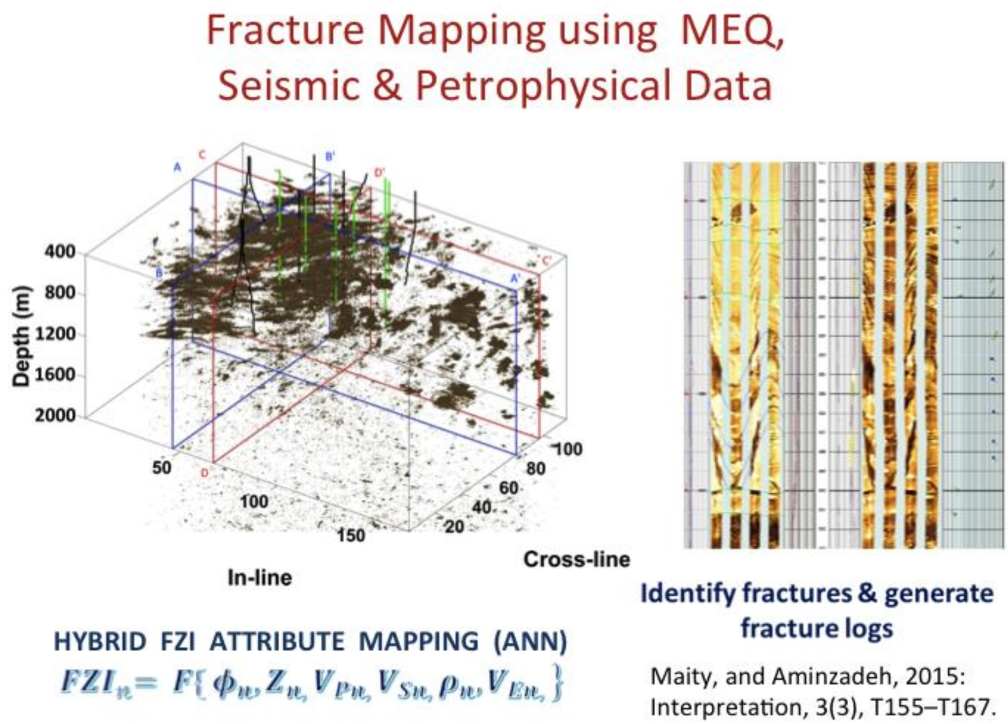
Water injection increases the percentage of recovery by means of providing pressure support and displacing the oil from injectors to producers. In such a displacement process, mobility ratio is important for a more efficient displacement of oil by the injected fluid where mobility ratio can be improved using the fluids involving supramolecular gelling agents, resulting in increased volumetric sweep. Supramolecular solutions have two key advantages over polymer solutions. First, while polymers degrade and break up upon experiencing sudden extreme shear stresses and temperatures, supramolecular solutions merely disassemble and re-assemble. Therefore, supramolecular solutions can be considered as healable polymer solutions in a way. Second, supramolecular solutions can adapt to the confining environment. For instance, when a height molecular weight polymer macromolecules are forced to flow into narrow channels and pores, molecular scission processes can take places. On the other hand, when building blocks of supramolecular assembly are forced into narrow channels and pores, they can assemble to form smaller nanostructures and maintain their molecular integrity. This translate into enhanced longevity and reusability of supramolecular solutions over polymer solutions. Supramolecular solutions can have significant impact on the cases where thermal methods cannot be used for some viscous oils due to thin zones, permafrost conditions and environmental constraints. Overall, there is a significant potential for application of supramolecular solutions in the US and throughout the world. This is especially important considering that the current analysis indicates that 50% of the oil produced in the USA and world will be through EOR technologies in the next 10-15 years.

Questions by:
Haroun Otaibi: Figure 10 in the presentation has a displacement efficiency increase by 10% average because of shifted pH? Even though the injection stopped at 5 PV the slope still kept on increasing.
Kurt Strack: Does the petrophysical model show that the polymer flooding changes resistance?

Response by:
Cenk Temizel: Details can be seen in the published SPE paper 169904. Assuming least interaction between the salts and sond so less change assumed. But on the whole, resistance was not checked and it needs to be checked for exact details.

1:00 - 1:30: Fracture Zone Identification and Permeability Prediction, Debotyam Maity, Gas Technology Institute

Abstract
We have characterized a promising geothermal prospect using an integrated approach involving microseismic monitoring data, well logs, and 3D surface seismic data. We have used seismic as well as microseismic data along with well logs to better predict the reservoir properties to try and analyze the reservoir for improved mapping of natural and induced fractures. We used microseismic-derived velocity models for geomechanical modeling and combined these geomechanical attributes with seismic and log-derived attributes for improved fracture characterization of an unconventional reservoir. We have developed a workflow to integrate these data to generate rock property estimates and identification of fracture zones within the reservoir. Specifically, we introduce a new “meta-attribute” that we call the *hybrid-fracture zone-identifier attribute* (FZI). The FZI makes use of elastic properties derived from microseismic as well as log-derived properties within an artificial neural network framework. Temporal analysis of microseismic data can help us understand the changes in the elastic properties with reservoir development. We demonstrate the value of using passive seismic data as a fracture zone identification tool despite issues with data quality.



Comment by:
Kurt Strack: The geophysical datasets do not provide any insights into the geological conditions of the site.

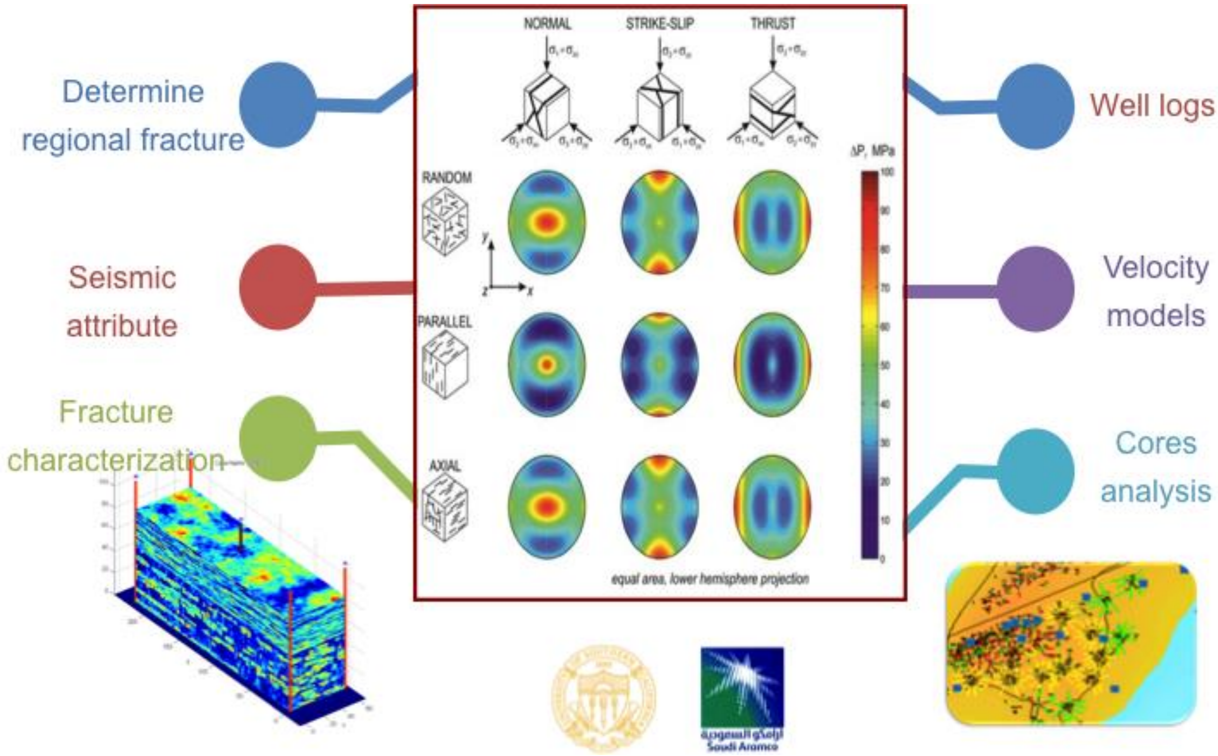
Fred Aminzadeh: The comment by Kurt Strack was contested by Fred Aminzadeh and he and Kurt Strack agreed to disagree.

1:30 - 2:00: Analysis of In-situ Stress in Hydraulic Fracturing, Ahmed Bubsheit, USC

Abstract
The ability of a well to produce hydrocarbons or receive injection fluids is limited by the reservoir's natural permeability and near wellbore changes that result from drilling or other operations. Hydraulic fracturing, also known as hydraulic stimulation, improves hydrocarbon flow by creating fractures in the formation that connect the reservoir and wellbore. In situ stresses control the orientation and propagation direction of hydraulic fractures. These fractures are tensile, and open in the direction of least resistance. The three principal stresses increase with depth; the vertical gradient is defined by the rate of increase of that depth.

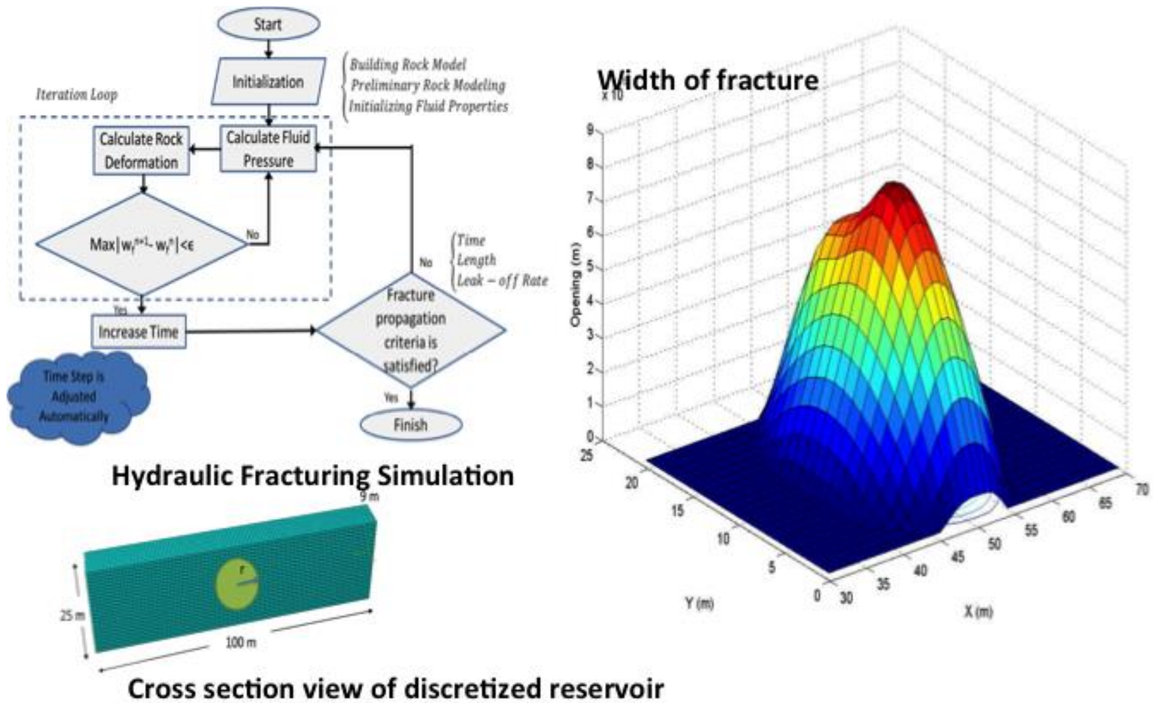
During the ISH project, in situ stress of a carbonate reservoir will be provided by using hydrofracturing techniques. We will examine core analyses provided by Saudi Aramco and perform complementary work in order to better understand the rock/core properties, and their expected response to fracturing, in conjunction with other data. The principal stresses -- vertical, maximum horizontal and minimum horizontal -- and the elastic moduli related to rock brittleness, such as Young's modulus and Poisson's ratio, will be estimated from both the core analyses and wide-angle, wide-azimuth seismic data. We will

use a small 3D seismic survey that has already been processed, and partial angle gathers, as well as azimuthal gathers which have been generated, to establish seismic data. Ultimately, the integrated information can be used to optimize the placement and direction of horizontal wells and hydraulic fracture stimulations. In addition, numerical optimization algorithms will be developed, which, when combined with flow simulation, can improve the design and implementation of hydraulic fracturing, leading to increased productivity and net value. Moreover, the RMC plan to develop novel methodologies for more effective integration of microcosmic data into reservoir and fracture models, which will enhance characterization and the long term production from tight reservoir.



2:00 – 2:30: Early Time Analysis of Hydraulic Fracturing Using Extended Finite Element Method, Arman K. Nejad, USC

Abstract
A novel algorithm is developed and tested to model early time of hydraulic fracturing initiation. It utilizes a numerical technique to enhance the accuracy of the modeling. It integrates various mechanisms in hydraulic fracturing to offer a realistic model of fracture initiation and propagation.



Question by:
Mathias Mitschanek: Can you elaborate on the cell size used?

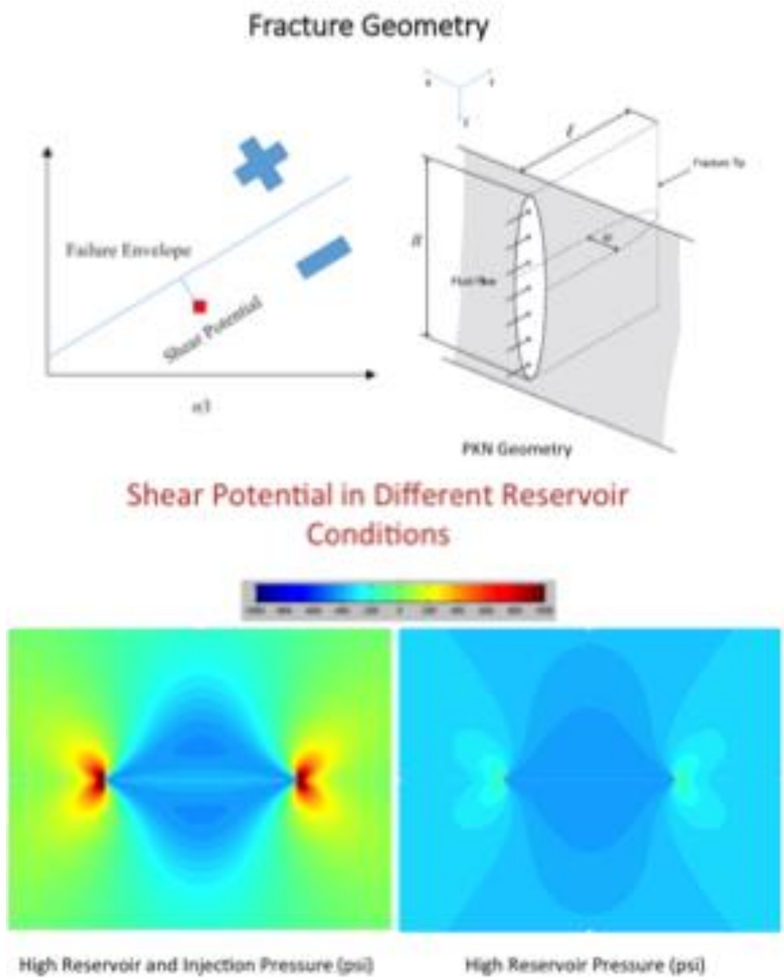
Response by:
Arman Nejad: The cell size used was 1m x 1m x 1m. If Finite Element Method (FEM) was used then the a smaller cell size would be needed but since an Extended FEM is used which considers 2 extra parameters namely Fracture tip behavior and Discontinuity inside the fracture, the size 1m x 1m x 1m works fine at this stage and future analysis will be done to see the optimum grid size.

2:45 – 3:15: A Geomechanical Approach to Microseismic Fracture Mapping, Mehran Hosseini, USC

Abstract

Hydraulic fracturing plays an important role in economical oil and gas production from unconventional resources. It has been more than a decade since the idea of ideal bi-wing hydraulic fractures is challenged by observations from microseismic data and other sources (Rutledge et al. 2003; Warpinski et al. 2004; Agharazi et al. 2013). Most of the analysis and interpretations regarding the direction of hydraulic fracture propagation deals with associating a microseismic event with a specific step in the hydraulic fracturing process. However, based on numerous past studies, it is established that direct association, without considering reservoir geomechanics and pore pressure perturbation due to leak-off, may not be realistic. For instance induced seismicity created by waste water injection, fluid accumulation in dams, and flow in geothermal reservoirs are all cases where seismic and microseismic activities were observed in the absence of hydraulic fracturing (McClure and Horne, 2014). In this work, using Mohr-Coulomb

failure criteria, we study the change in effective stress and subsequent shear failure as the mechanism behind microseismic events. Among different mechanisms of thermal stress, pore pressure change, compaction induced stresses, and stress change around a fracture; pore pressure change and stress change around a fracture are the two main mechanisms involved in hydraulic fracturing microseismicity. By solving the pressure diffusion equation and solving for the stress field around a hydraulic fracture, we show that the pore pressure change due to leak-off can affect the reservoir in a large scale. By coupling both the pore pressure change and stress change due to fracturing, we study the expected microseismic behavior around a propagating hydraulic fracture.



3:15 - 3:45: Microseismic/Electromagnetics for Reservoir Monitoring, Kurt Strack, KMS Technologies

Abstract

For reservoir monitoring application the knowledge of the reservoir fluid, their quantities and location are essential. To image the reservoir fluid, electrical methods are the first choice and for the determination of the location of the reservoir seismic methods prevail. Over the past two decades the borehole technology progressed that surface electromagnetic methods can now be calibrated with borehole methods and subsequently with the petrophysical reservoir parameters. Microseismic has also show that it can contribute to reservoir monitoring.

Electromagnetics (EM) has been applied to hydrocarbon and geothermal exploration since the mid-1960s. While Controlled Source ElectroMagnetics has always been more powerful, with time magnetotellurics (MT) emerged as viable exploration tool because it is operationally less complicated. In India, land CSEM has been successful in sub-basalt imaging (Strack and Pandey 2007) an increased interest in EM. CSEM has also been successful in the marine environment. The real reason of CSEM not becoming a mainstream geophysical tool on land lies on the technical side: anisotropy, old hardware and technology, noise sensitivity, low spatial resolution, and foremost-unknown information focus. With the solid success of the marine industry, the emerging use of borehole anisotropy logs, the support from the value chain is sufficient to address the remaining issues.

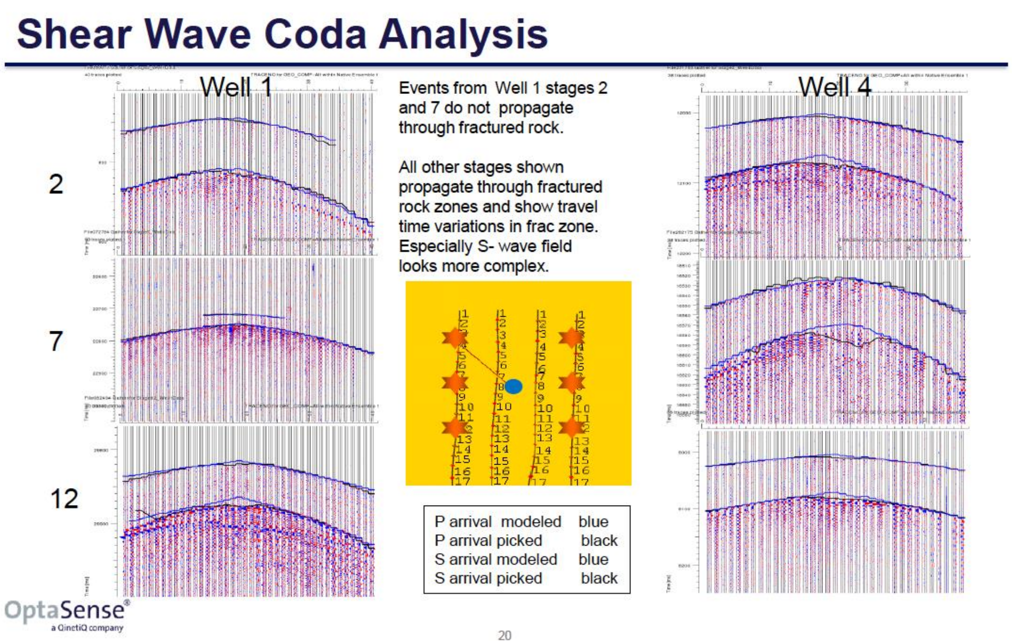
Anisotropy is also a pivotal technical parameter in the unconventional scenario. We developed over the past decade an array electromagnetic system that acquires all types of electromagnetics data, while allowing dense spatial sampling at lower cost. After developing borehole and land combined seismic and EM systems, we recently completed the marine nodal receiver. The system architecture is broadband similar to seismic nodes. All system can be used as conventional EM systems and also as large channels count acquisition system with full integration of borehole, land and marine.

Here I extend the presentation to more general reservoir monitoring beyond the one of Strack and Aziz (2013) on applying electromagnetics to shale reservoirs. I also include further 3D results leading to potentially disruptive methodology. In addition, new hardware components allow the integration of land and marine, surface and borehole. The system has gone beyond the concept stage and a first 200-channel system with a 100 KVA transmitter has been built and field-tested on 3 occasions in the USA. It is now on its way to Asia for a more permanent installation.

3:45 - 4:15: Experimenting with Microseismic Monitoring, Martin Karrenbach, Optasense

Abstract

Not available at the time this report was prepared.



4:15-4:45: FINAL DISCUSSION & Q/A (Brain Storming Session)

Iraj Ershaghi: Asked for areas to focus attention that were not discussion in the meeting as well as areas that the participants may recommend for USC to focus.

Fred Aminzadeh: Summarized students work.

Joe Iovenitti: Identified the need for a geologic setting for some of the work conducted to place it in a geologic context.

Iraj Ershaghi: Made a comment on the geologic model of the areas being studied but the comment was not noted.

Kurt Strack: Studies are not measuring reservoir properties. For example, in the equivalent media, scaling was allowed but limited data on scaling is available. One can take the basic principal logs to identify scaling to demystify the interpretation problem.

Sensitivity depends on size and distance and other such parameters. Data points contribute to the analysis. Each program plays an important role in highlighting these.

Although, we do have good models for "geomechanical models". The main problem is that there are no right models that are available for the reservoir parameters and as we all know that each parameter plays an important role. Certain physical quantities are measured but they aren't reservoir parameters.

Volumetric calculations are done but they are not satisfactory. The university needs to look at how individual scales interact but still the data collected to create models to interpret the reservoirs are not working .65% of the money is spent on up scaling which the university needs to try and demystify .

Iraj Ershaghi: The University is not in the business of dissipating field data. We can only improve. We develop the tools for you and comprehensible studies cannot be done as the tools and scales results do not match. As the whole data is not available the university can only make individual solutions and even though one puts all the individual solutions together one cannot consider it to be whole and comprehensive

Joe Iovenitti: Without calibrating nothing is final. Publishing papers doesn't mean the analysis being discussed is correct and that it can be used in the field. One cannot spend millions as we don't even know if the work is properly calibrated, calibrated to what condition, and will work on the field.

Iraj Ershaghi: We can only assume a model as only a part of the data is available to us, hence we assume a 2layer/3 layer /fault, etc. so we take the data and see if it fits the given reservoir.

Michael Prohaska: Data needs to be interpreted with feedback and we need to know the mechanism behind the phenomenon .We liked the consortium as we come from a mechanical background .Good progress in the geo-mechanical model and the frac models .We need to better understand what the field data says.

Iraj Ershaghi: We take the data, extract ,but as we don't have all the data we end up assuming a system, generate data and then test on the field. So basically we generate a few algorithms and you check which one fits your field and then we reverse model.

Michael Prohaska: Finding geologic meaning behind the work is needed.

Kurt Strack: Good progress has been made in understanding.

Iraj Ershaghi: Need to setup the data, extract the data and assume a system, develop the tools to analyze the system, and report on the tools. Re-emphasized the point that the university is not in the business of interpretation. Not mentioned by Iovenitti during the discussion but if the system being assumed can be described so a geological context is provided that may resolve the issue raised.

Isao Kurosawa: Recommended work at the nano-scale, e.g., reservoir monitoring.

Fred Aminzadeh: Expressed concern that it is not always clear how to scale from nano to field. USC already has some ongoing work going on in the nano field .USC has a very advanced Lab for Nano Technology which is currently busy with Medical work. We look forward to using it in the future.

Iraj Ershaghi: Are you talking about micro CT or Converting and linking nano parameters to field parameters? No data measurements are available from companies yet as far as nano scale is considered. Hence sponsors need to provide so as more study can be done in this field.

Birendra Jha: Agrees with Mr. Kurt and says that it's his area of interest .He says it's important to recognize the geomechanics to understand the reservoir.

Martin Karrenbach: Recommended addressing microseismicity and flow measurements. The specifics on how to connect then in-situ is not known and needs to be explored more. Scaling up may be an area for future research also.

Joe Iovenitti: Discussed what portion of the newly created fracture domain identified through microseismic monitoring is or would be controlling the actual flow?

Kurt Strack: Questioned Sinopec on why they were not using electro-magnetics (EM) in their work more extensively.

Sinopec responded (through a student translator) by stating they have used EM in identifying shallow layers but they do not believe that EM would be useful under certain geologic conditions.

Sinopec: Found the consortium interesting

Iraj Ershaghi: Concluded discussion by stating that it is important to understand the comments and needs of the sponsors. Not mentioned by Iovenitti in the meeting but he recommends sending the sponsoring a questionnaire to elicit responses on their meeting comments and needs.

USC University of Southern California

RMC

Appendix 1

Table 1. Reservoir Monitoring Consortium Meeting Agenda

8:00-8:15	Registration-Breakfast	
8:15-8:35	An Update on Reservoir Monitoring Consortium (RMC)	Fred Aminzadeh
8:35– 9:00	Reservoir Monitoring with 4D Seismic- Three Case Histories	Yesser HajNasser, USC (formerly ConocoPhillips)
9:00 – 9:25	Advanced Tracer Analysis for EOR and Reservoir Monitoring	Noha Najem (Kuwait Oil)
9:25-9:50	Use of production geology data to monitor water influx	Xiaoxi Zhao, Iraj Ershaghi
9:50 – 10:05	Coffee Break	
10:05 –10:30	Wellbore Monitoring for Kick Detection and Plans for Field Testing in a Saudi Aramco Field	Hazza Otaibi , Ahmed Bubsheit Aramco
10:30 -10:55	Modeling Field Development Strategies and Their Associated Resource Requirements	Michael Prohaska university of Leoben, Austria
10:55 –11:20	Permanent seismic source for continuous reservoir monitoring	Isao Kurosawa, Ayato Kato JOGMEC (Japan National Oil)
11:20 –11:40	Research Directions for CO_2-EOR Applications	Metin Karakas, USC
11:40- 12:00	A New Method to Analyze Displacement of Fluids in EOR	Cenk Temizel , Aera Energy
12:00 – 1:00	Lunch	
1:00 – 1:30	Fracture Zone Identification and Permeability Prediction	David Maity, Gas Technology Institute
1:30 – 2:00	Analysis of In-Situ Stress in Hydraulic Fracturing	Ahmed Bubsheit (USC)
2:00 – 2:30	Optimizing Operational Parameters for Real Time Monitoring of Hydraulic Fracturing	Arman K. Nejad, (USC)
2:30 – 2:45	Coffee Break	
2:45- 3:15	A Geomechanical Approach for Microseismic Fracture Mapping	Mehran Hosseini (USC)
3:15- 3:45	Microseismic/Electromagnetics for reservoir monitoring	Kurt Strack (KMS Technology)
3:45- 4:15	Experimenting with Microseismic monitoring	Martin Karrenbach (Optasense)
4:15- 4:45	Discussion/ Q&A	All
4:45- 5:00	Concluding Remarks	Fred Aminzadeh

Appendix 2

Table 2. RMC Meeting Attendees

Name	Company	Contact Details
Bill Ayres	Ayres Group LTD.	bill@ayresgl.com
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