EORI Newsletter

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FROM THE DESK OF THE DIRECTOR

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The past several years have been an exciting time for application of new technology to recover stranded oil in Wyoming. A favorable economic environment for use of advanced technology has been sustained by world oil prices that have fluctuated between $70 and $85 per barrel.

EORI sponsored our annual Improved Oil Recovery (IOR) Conference during September. Approximately 50 petroleum professionals participated. Dr. Larry Lake, a long time professor in the Petroleum Engineering Department at the University of Texas, and a member of the National Academy of Engineering, stated during his presentation, that “The EORI Improved Oil Recovery meeting is the best conference in which he participates.” Dr. Lake and others presented “cutting edge” approaches for use of IOR. Key presentations addressed recovery of oil from Residual Oil Zones (ROZs), case studies related to use of IOR in a variety of Wyoming reservoirs, conformance improvement, and a number of other topics important to recovery of tertiary oil in Wyoming. Please refer to the EORI website to review presentations from the conference.

The center piece of this newsletter is Dr. Norm Morrow’s summary of recent findings for application of low salinity flooding. Norm discovered low salinity flooding at the University of Wyoming and has been researching the mechanisms for how it works since 1996. Dr. Morrow’s lab work has demonstrated successful recovery of incremental oil using core materials from Wyoming reservoirs. He has recommended that single well field pilots be implemented in Wyoming to prove that low salinity flooding can be used to economically recover incremental oil on a field scale. Please see his newsletter for the details.

EORI is currently developing screening criteria for identifying candidate reservoirs for implementation of low salinity single well field tests. Current plans include providing the screening criteria in our next newsletter in January 2011. EORI plans to provide technical support and a portion of the cost required to identify, plan, and implement single well field tests at up to four sites. We plan to complete the screening early in 2011, and the field test during the summer of 2011.

Thank you for interest in these issues. If you have questions regarding our programs please contact me or our Outreach Manager, Lon Whitman, at: lwhitma3@uwyo.edu
By Geoffrey Thyne

While we at EORI are always looking at the latest in technological advances to help recover Wyoming’s stranded oil, sometimes the basics are the key to success. An example is the Minnelusa fields in the Powder River Basin. Most of these fields were discovered and developed from 1955 to 1990. The fields usually had a short period of primary production before the start of waterflooding. Most are still producing, but water cut has reached 95+%. An ongoing study to develop a quantitative basis to calculate the effect of chemical flooding uncovered an interesting variability in performance of these fields. EORI analyzed the recovery factors for 71 fields for which OOIP estimates were publically available. Forty-one of the fields had polymer floods performed, while the remaining fields were standard waterfloods.

After initial analysis it became clear that the performance of the waterfloods, as measured by calculated recovery factor, formed two groups. One group of 11 fields have recovery factors between 14 and 30% OOIP with an average of 25%, while the remaining 19 fields have recovery factors between 39 and 79% OOIP with the average of 53%. On further investigation we found that the principle difference between these two sets of fields is the degree of connectivity between injectors and producers.

The Minnelusa fields are formed by a series of sand dunes deposited millions of years ago. The basic reservoir unit in these eolian sandstones is the dune set. Injection of water or chemical solutions into these dune fields is much more efficient when the production well is located within the same dune set. Dune sets have regular geometric features including length, width, and height. Individual dune sets are oriented with the long axis roughly perpendicular to wind directions and may amalgamate into larger units. Modern analogs to the Minnelusa such as the Qatar dune fields in the Persian Gulf have dune sets with dimensions on the order of 2700X600X30 feet (L-W-H).

Many of the Minnelusa fields are developed using a standard well spacing, between 40 and 80 acre spacing (2640-3733 feet between wells). It appears that this spacing did not always incorporate the geologic constraint of dune geometry. We are now evaluating strategies such as re-arrangement of existing injector-producer pairs or infield drilling to ensure maximum connectivity in the fields with low recovery factors. The ultimate goal is to increase recovery factors to values similar to the other fields. The low recovery group of fields has an OOIP of 37,553,687 BBS. If this strategy increases the average recovery factor from 25% OOIP to 50% OOIP, the increased recovery could be as much as 9 million additional barrels of oil. Not bad for a low tech solution.
LOW SALINITY WATERFLOODING

By Norman Morrow

Waterflooding has been practiced for over 100 years and is by far the most widely applied method of improved oil recovery. The choice of injection water in field operations has long been determined by local availability. Studies have been made on the effects of brine/rock interactions that cause permeability reduction, but little consideration was given to the effect of brine composition on the efficiency of oil recovery by waterflooding. Research into the effect of lowering the salinity of the injection brine was pioneered at the University of Wyoming in the late 1990’s. In 1996, Tang and Morrow reported laboratory results that showed oil recovery by waterflooding to residual oil saturation (Sor).

Confirmation of improved recovery by industry laboratories was followed by highly encouraging field trials reported in 2004 and 2005. Low salinity waterflooding is now widely accepted as the lowest cost IOR process. Investigation by industry of case histories for reservoirs where low salinity water had already been applied, because it was the most convenient source of injection water, also showed increased recoveries. At the Society of Petroleum Engineers Improved Oil Recovery Symposium, beginning in 2006, a technical session has been devoted to Low Salinity Waterflooding. Recent rapid growth in public-domain information on this process is reflected by the histogram (Figure 3) showing the number of publications by year. The filled area of each column indicates publications from UW all of which were supported by EORI; these include post 2001 joint publications between UW and industry and other institutions. Successful application has been reported for Kuwait, the North Slope of Alaska, and the North Sea. Numerous reservoirs are under consideration. In 2006 British Petroleum reported that Low Salinity Waterflooding could increase its oil reserves by over a billion barrels.
Response to low salinity flooding has been observed for clastic clay-bearing formations for salinities below 5000 ppm. Factors that affect the efficiency of secondary or tertiary waterflooding include rock mineralogy and pore structure, crude oil properties, brine composition and temperature. Several mechanisms for improved oil recovery have been proposed. They include restricted clay migration, reduced interfacial tension, multi-component cation exchange, emulsion and lamella formation, mineral dissolution, and wettability alteration. Special attention is now being given at UW to screening of outcrop rocks, to identify suitable candidates for mechanistic studies of crude oil/brine/rock interactions. Further improvements in recovery will likely follow from learning how to optimize the injection brine composition.

The cost of low salinity water still features strongly in the economics of application. In Wyoming, in addition to fresh water aquifers, particularly in the Powder River Basin, low salinity water is produced in abundance in association with Coal Bed Methane (CBM). Studies of crude oil/brine/rock interactions for essentially clay-free Tensleep sandstone showed that injection of CBM water gave reduction in residual oil saturation. In a collaborative study with the Department of Applied Mathematics at the Australian National University micro X-ray CT imaging provided direct demonstration of dissolution of soluble inter granular cement in Tensleep rock by CBM water. Recently, Minnelusa sandstones and Cottonwood Creek dolomite, which also contain soluble cements, were found to give reduction in residual oil by low salinity flooding.

The PSC group at UW continues to be highly involved in research into the mechanism of low salinity waterflooding. One outgrowth of this work arose from investigation of the reproducibility of recovery of crude oil. It was found that, even without change in salinity, decrease in residual oil was usually observed for sequential floods. A new approach to oil recovery based on these observations has been patented. Laboratory observations are highly encouraging and justify moving to single well pilot testing. Recent and future conference presentations are: invited presentations at the 14th Annual Gulf of Mexico Deepwater Technical Symposium on both low salinity waterflooding and sequential waterflooding, in New Orleans, August 19th; presentations at the 11th International Symposium on Reservoir Wettability, Calgary, Sept. 6-9, 2010; a presentation on Wyoming reservoirs that feature increased recovery associated with dissolution of anhydrite at the Society of Petroleum Engineers Annual Technical Conference, Florence, Italy, Sept. 20th; presentations at the International Society of Core Analysts Annual Meeting, Halifax, NS, Oct. 3-8, 2010, and an invited SPE Distinguished Author paper on the subject to be submitted later this year. All publications and presentations by the PSC group are available on their website: http://wwweng.uwyo.edu/economic/psc/publications.htm.
GETTING TO KNOW GLEN

MURRELL

Glen is a New Zealander. He grew up in the small rural town of Opotiki, in the eastern Bay of Plenty, on the North Island; a region which is renowned in New Zealand for being one of the poorest areas in the country. His family has a lower-middle class ethos where hard work is deemed the only means for betterment and this was taught to him by very hard working parents at a very early age. The town where he grew up doesn’t have much going for it apart from being an uncannily perfect region for growing kiwifruit and having a spectacular beach and coastline. It was on this coastline that Glen spent most of this youth surfing, swimming, diving, fishing or generally just messing about.

Driven by a strong urge to escape “Smalltownsville” he took on a Physics degree at the University of Waikato in Hamilton, NZ. This quickly deteriorated to an Earth Sciences degree when he realized his Math simply wasn’t good enough to become the next Stephen Hawkings. With that one in the bag, he decided to stay on and do a Masters in Sedimentology. Fortunately, the program he enrolled in was titled “Coastal Engineering”, which obviously sounds significantly more interesting than “Sedimentology”. His Masters was on the lithostratigraphic architecture of a pliocene shallow marine sequence in the Wanganui Basin, NZ. After this he decided to try to obtain a Ph.D. and travel at the same time. After a little investigation, he was offered some brilliant opportunities in Australia and a rather boring PhD topic in Amsterdam. For some reason he chose Amsterdam.

Five long tedious years later he finished (“the Long-term Thermal Evolution of Fennoscandia”) and subsequently decided never to have anything to do with Geology ever again. Instead he ended up doing market research in Berlin. This is where Glen learned that his education was not a complete loss and that fundamentals are applicable to any discipline. He also learned the absolute perfect combination of Pilsner and Bratwurst. After four years in Berlin he suddenly had to try and find a job in Laramie (due to external female influences; long story, don’t ask), which is how he ended up at the EORI after Jim Steidtmann decided to take pity on him. Initially Glen was hired to do marketing stuff. However, slowly but surely he was drawn into other programs and eventually he was asked to finish the job that was started by Shaochang Wo and get the EORI database up and running. He also found himself conducting screening projects, which were a natural outgrowth from his market research experiences. Currently, Glen is our resident ‘jack-of-all-trades’ and he is typically tasked to solve problems that don’t naturally fall inside the scope of other programs in the Institute. He also seems to be inexorably drawn to management and often times is asked to take care of tasks that are more related to admin than research.

Glen is a keen snowboarder and mountain biker, a beginner climber, listener of blues/rock, drinker of Sierra Nevada and all-time greatest fan of the All Blacks.
NEW STAFF

Dr. Haifang Jiang will begin work with the EORI mid-October. He will incorporate his skillsets with those currently working in the Chemical Flooding lab to investigate improved methodology for various types of chemical flooding, design, execution and interpretation of lab experiments. He will also assist in converting lab results into quantitative geochemical reactive transport models for reservoir production. Dr. Jiang received his Ph.D. from the Daqing Petroleum Institute in Daqing, China in 2008 and has been working with Dr. Hertanto Adidharma at the University of Wyoming conducting EOR experiments and MMP measurements since 2008. We look forward to having Dr. Jiang join the Institute team.

Vandy Jones, native of Buffalo, Wyoming, moved to Laramie to attend the University of Wyoming in 1991. After earning a Bachelors’ of Science in History in 1995 Vandy worked various jobs in Laramie before returning to the University of Wyoming for a Bachelors’ of Science in Geology in 2007. While attending the University of Wyoming she worked for the Wyoming Geological Survey as a GIS technician and helped in the digitizing for several state geological maps. She then went to work for Neutron Energy, Inc. as a consulting geologist doing research and field studies for uranium reserves in Wyoming. The main area of study during her time with Neutron Energies, Inc. was in the Wind River Basin near Copper Mountain in the northern part of the basin. Research in the libraries of the university and in the Anaconda collection facilitated remote sensing and field studies of the area. In April of 2009, Vandy joined the EORI staff as a research geologist and has done database work since her start there. Her areas of interest in geology are sedimentology and structural geology. In her spare time she enjoys reading, camping, rock-hounding, fossil hunting, hiking, and spending time with her family.

Matt Johnson, a native of Huntsville, TX, moved to Laramie to attend the University of Wyoming earning a B.S. in Geology. Matt worked as a sales clerk at the University Bookstore before joining the team at the Enhanced Oil Recovery Institute; helping senior researchers digitize well logs, construct, edit, and correlate diverse databases on oil and gas wells for consulting purposes. During his time at EORI he has been involved with basic lab studies performing geological engineering experiments and preparing chemical mixtures for use and development in new oil recovery techniques. In the summer of 2007, he helped the University of Indiana perform paleontological and isotope work of Mesozoic specimens in the Snowy Mountain Range of Wyoming. While working at EORI, Matt worked as a staff member to the Geology and Geophysics Department and in 2008 was awarded the University Of Wyoming Board Of Visitors’ Outstanding Service award. He soon began working with Dr. Cliff Riebe, as a lab technician. During his time with Dr. Riebe, Matt prepared rock and soil samples for thin sectioning and geochemical analysis for weathering and erosion studies and accompanied Dr. Riebe in a field study to the Sierra National Forest in California. His areas of interest in geology have been centered on topics of geochemistry, structural geology and tectonics. In his spare time he enjoys fishing, fossil hunting, snowmobiling and hanging out with his dog.

Barb Jesse is a 1987 University of Wyoming Graduate. She has been working on campus for about 17 years and previous to that she worked for UniWyo FCU. She has two children; Nicholas 17, and Natalie 13. She stays active and enjoys outdoors activities such as fishing, hiking, cycling, gardening and soaking up the sunshine. She is always open to new adventures and enjoys meeting new people.
RECENT PUBLICATIONS

The following are recent presentations & publications from EORI team members. More information about these articles may be obtained by contacting EORI directly.


Loahardjo, N., Xie, X., Winoto, W., Buckley, J. & Morrow, N. R., Change in wettability associated with increased oil recovery by sequential waterflooding, presented at the International Wettability Symposium, Calgary, Canada, Sep. 6-9, 2010.

Morrow, N. R., and Mason, G., Areas of cruded oil/rock contact that govern the development of mixed wet rocks, presented at the International Wettability Symposium, Calgary, Canada, Sep. 6-9, 2010.


Mason, G., and Morrow, N. R., Spontaneous imbibition into cores with different boundary conditions, presented at the International Wettability Symposium, Calgary, Canada, Sep. 6-9, 2010.


Pu, H., Recovery of crude oil from outcrop and reservoir sandstone by low salinity waterflooding, PhD defense, Sep. 27, 2010.

Events

IOR/EOR Conference

The Enhanced Oil Recovery Institute hosted its 2nd IOR/EOR Conference “Recovering Stranded Oil Through Improved and Enhanced Oil Recovery Technologies” on September 13 & 14, 2010 at Snow King Resort in Jackson, Wyoming. Topics for the conference included:

• Geology
• EOR/IOR Technologies and Tools
• Residual Oil Zones (ROZ)
• EOR Screening
• Thermal EOR

Speakers for the conference included Steve Melzer, Melzer CO₂ Consulting, Larry Lake, University of Texas, Austin Charlie Carlisle, Chemical Tracers, Inc., Randy Seright, PRRC, New Mexico Institute of Mining and Technology. Jeremy Wagner, Citation Oil and Gas updated the conference attendees on Citation’s Steamflood Pilot at S. Casper Creek and Chris Mullen, Elk Petroleum, discussed their Grieve Field Chemical Flood. The eighty conference attendees represented industry, academia, service companies, private consulting companies, state authorities and Wyoming state government as well as members of the EOR Commission and Enhanced Oil Recovery Institute Technical Advisory Board.
Looking Ahead

EORI is active with several programs that have not been described in the newsletter to date. Our next issue will include articles discussing the following:

**Improved Conformance** - Achieving improved conformance, both vertically and laterally, means more effective recovery of secondary reserves today, and generally, more tertiary oil recovery in the future. EORI will place new focus on assisting Wyoming operators with improving conformance in their injection projects.

**Production from ROZs** - EORI is evaluating potential development of Residual Oil Zones in Wyoming. Our work is being completed with help from West Texas operators. A number of large depleted oil fields in the Permian Basin are now producing from below the oil/water contact defined by historical primary and secondary production. Production of ROZs is possible using EOR techniques including CO2 flooding. EORI is screening Wyoming fields for development of Residual Oil Zones.