A Review of the 2012 SCA Workshop in Aberdeen

By Arjen Cense and Doug Ruth

WHAT: Workshop on "Cross Innovation as a Way to Improve Core Analysis"

WHEN: Monday, August 27, 2012

WHERE: Aberdeen Exhibition and Conference Center

WHO: 170 participants

On Monday August 27, before the start of the Annual Symposium of Core Analysts 2012, a half-day workshop was organized on *Cross Innovation as a Way to Improve Core Analysis*. The workshop was organized by Patrick Egermann (Gaz de France) and Evren Unsal (Total). The workshop was chaired by Doug Ruth (University of Manitoba) and Arjen Cense (Norske Shell).

By cross innovation we not only mean integration of techniques from other disciplines than regular SCAL, such as geochemistry and hydrology, but also integration of the different petroleum engineering disciplines when interpreting SCAL results.

The workshop was kicked off by presentations of four speakers, followed by a (central) discussion amongst the participants after each of the four presentations. At the end of the workshop, four rather controversial statements were shared with the audience to trigger discussion.

Gerald Hamon (Total) spoke about *combining skills and techniques for reservoir engineering studies*. He presented a number of examples where *integration* or a *multidisciplinary approach* has been identified as a key to success. He first talked about examples where porosity estimations were improved by combining conventional core analysis with logs and with mineralogy. Then he discussed the issues of missing data in core analysis reports and lack of quality of the data. Subsequently, he showed how, by combining data, the understanding of a field can improve significantly: how the combination of NMR, single well chemical tracer tests and core analysis showed that the residual oil saturation from resistivity was wrong. After measuring the Archie exponent during forced imbibition, an Archie exponent of 5 was determined, and the data from different sources agreed very well. As a last example, a field study was mentioned where a multidisciplinary workflow starting from a seismic survey to a geological model, upscaling to the reservoir model, flow modeling , integration of production data and back to the geological model resulted in a fairly accurate production prediction of most wells. By including 4D seismic, the production mismatch (timing of water break through) could be identified. The conclusion of Gerald's presentation was that

- combining core data, log data and field data leads to better understanding of the reservoir
- duplicating reservoir properties measurements using different techniques, or independent sources of data, results in better quality check of data; data from Special Core Analysis experiments is not always valid

- combining data from different disciplines leads to better communication between the disciplines

It was discussed amongst attendees that young people should know the basics, but at the same time they should keep their eyes open. It was questioned whether there is a multi-disciplinary tool that stores all data. The audience was not aware of this, but it was mentioned that often data is measured and lost. Also, people look at data without knowing what it means. An improvement that could be seen was related to the workflow. Often Special Core Analysis programs, or the result interpretations, are kicked off too late, resulting in a quick and dirty approach to experiments and/or interpretation of results.

Ted Braun (ex-ExxonMobil) talked about *Geochemical Issues in Special Core Analysis*, an example of horizontal integration of another discipline in SCAL. Wettability is governed by the affinity of a fluid to a surface (rock). Almost all SCAL techniques measure wettability in a rather indirect way, using spontaneous imbibition or centrifuge techniques. Geochemistry looks at surface interactions, and is therefore a key to understand which components in crude oil are important and whether crude oil can change the wettability from water-wet to oil-wet. Unfortunately, components in the drilling fluid can influence the native wettability state of the rock, as many of these components are surface active. The workaround is to clean our cores to presumably water-wet conditions, and then age them with the reservoir crude oil. It adds a lot of work and reduces the confidence in data. It was postulated by Ted that there are geochemistry methods that would do a smarter job of choosing solvents to remove the specific types of contaminants from the drilling mud, instead of doing it by trial and error. He then showed an example of core that could not be cleaned to a water-wet state. After consultation of a geochemist it turned out that oil in the reservoir underwent thermal cracking at higher temperatures, leaving pyrobitumen on the sand grains behind, which is very difficult to remove. In another case, they used stable isotopes to determine how much strontium was precipitated in a core plug when seawater was coming into contact with formation water. The presentation highlighted that there are numerous core analysis issues that may be explained/resolved using standard geochemical analysis.

A comment from the audience was related to low salinity waterflooding, where injection of water with a lower salinity than formation water salinity potentially leads to more oil production. As the mechanism of this technique is still not well understood, the question was whether geochemistry techniques may help in unraveling the mechanism behind low salinity waterflooding.

The third speaker was **Roland Lenormand** (Cydarex) who presented a *review of pore network modeling*. He questioned whether “digital SCAL” – where the flow of oil and gas is simulated in a microscopic model of the rock – can be used to reduce costs or to reduce the time scale to deliver results (compared to conventional, or experimental, SCAL). He mentioned that Digital SCAL is not cheap either. In order for digital SCAL to play a role, it must be a proven technique. There are examples of excellent matches between experiment and simulation in literature as well as not so good matches, so it is difficult to make a black and white statement. The current view is that ‘it depends’ whether digital SCAL can be predictive. It depends on the samples, the fluid system, and on the parameters that we want to predict (i.e. porosity or permeability, relative permeability or capillary pressure, drainage or imbibition situations). It is clear that it is impossible to predict imbibition parameters as wettability information is needed. Current understanding is that this information needs to come from the laboratory. Roland then took us back in history and showed many important contributions that led to the current level of understanding, including simulation on pore and tube (ball and stick) models, experiments in transparent micromodels leading to many important observations, two-phase flow vs. three-phase flow, static vs. dynamic pore network modeling, imaging of the microstructure leading to more realistic pore geometries and flow calculations done directly on these 3D imaging. He showed applications of PNM to gain understanding of steady state/unsteady state core floods (Oren et al., 2012), hysteresis on capillary pressure and relative permeability (Jerauld and Salter, 1990), role of surfactants in oil production (Hammond and Unsal, 2012), heavy oil production and gas nucleation (Yortsos). He concluded with a question: whether we can save time using fast laboratory experiments in combination with "digital SCAL". His suggestion of using measured end point relative permeabilities for this was challenged by the audience, as the distribution of oil and water in the pore space (after drainage) may change during ageing, hence giving different values for the end point relative permeability.

The last speaker was **Jos Maas** (Independent consultant), who talked about *improvements made in SCAL techniques in the past, state-of-the-art of SCAL techniques, and about future demands*. He started his presentation discussing the introduction of X-rays in the SCAL discipline. It was used to monitor the saturation in core plugs during flow experiments. From a safety perspective, X-rays are easier to handle than gamma rays, simply because you can turn them off. It was challenged by the audience whether X-rays can provide the same quality results as gamma rays (gamma rays were believed to give higher contrast). The response was that at Shell, measurements of saturation profiles with X-rays, without the use of dopants, was made possible. Another application of X-rays discussed was the medical CT scanners that are used nowadays to screen and select core plugs from whole cores. A third example was micro-CT scanners which are used to visualize the three-dimensional pore structure of reservoir rocks on a microscopic scale. Another technique applied to our discipline is ESEM, or environmental scanning electron microscopy. This methodology allows one to image rock surfaces at a very high resolution with water being present. The advantage is that the wetting state of rock minerals can be observed from the contact angle of the water droplets with the minerals. It is not straightforward to use this information to a wettability model of a whole core plug. Jos continued his presentation with improvements made on centrifuge experiments: automation of centrifuge data gathering (i.e. production of fluids) and correction of capillary end effects by using simulation (e.g. SCORES, Cydarex, Sendra). By correcting for capillary end effects in flooding experiments, he stressed that multiple experiments can be described by a common set of relative permeabilities and capillary pressures. This was acknowledged by various attendees in the audience. Another alternative for Pc measurements is SPRITE NMR, where the capillary pressure is obtained from 'frozen' saturation profiles after centrifugation with Nuclear Magnetic Resonance imaging (NMR). Jos concluded his presentation with some possible future developments: down-hole *in situ* wettability tool, down-hole *in situ* SCAL using Mars (space) technology, pressure sensitive sheets around core plugs to pick up detailed pressure profiles for SCAL on heterogeneous plugs and possible gains by interaction of the SCAL community with the hydrology community.

The workshop ended with a spirited discussion around the following statements:

1. My company is structured in such a way to encourage multi-disciplinary discussion
2. We are not using simulation to maximize the information we can obtain from core experiments

3. We are not combining core analysis with downhole field data to maximize the utility of both
4. The role of digital SCAL is to supplement laboratory SCAL, thereby reducing turnaround time
5. We are not using techniques currently in common use in other disciplines

Most attendees agreed with item 1. They believed that their companies encouraged a multi-disciplinary way of working by working in multi-disciplinary teams. Most attendees acknowledged item 2. The importance of simulation of core flow experiments is under-used. By simulating core flow experiments it is possible to reconcile data sets obtained using different measurement techniques and also it is possible to check assumptions (e.g. whether the core is homogeneous). The use of CT scanners during core flooding tests allows one to obtain data from in-between-saturations, that is, when there is not a real shock front. The audience agreed on item 3: the community should strive more to combine SCAL data with field data as much as possible to optimize the impact of Special Core Analysis in our industry. There was a lot of discussion on item 4. Just like the workshop held in 2006 in Trondheim, there were three opinions ventilated: the first is that digital SCAL is still in a research phase and cannot be used for field applications, the second is that there may be specific problems or applications where digital SCAL can be used to improve our understanding for processes in the reservoir, and the third is that digital SCAL has matured enough that it can deliver similar quality results as regular, or laboratory, SCAL. There was a lot of discussion on this item, with participants supporting the three view points, leaving no time to discuss item 5.