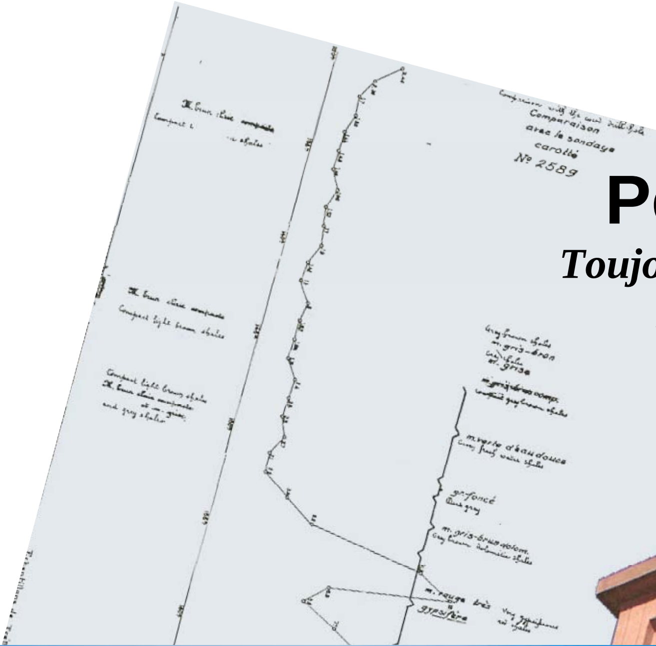
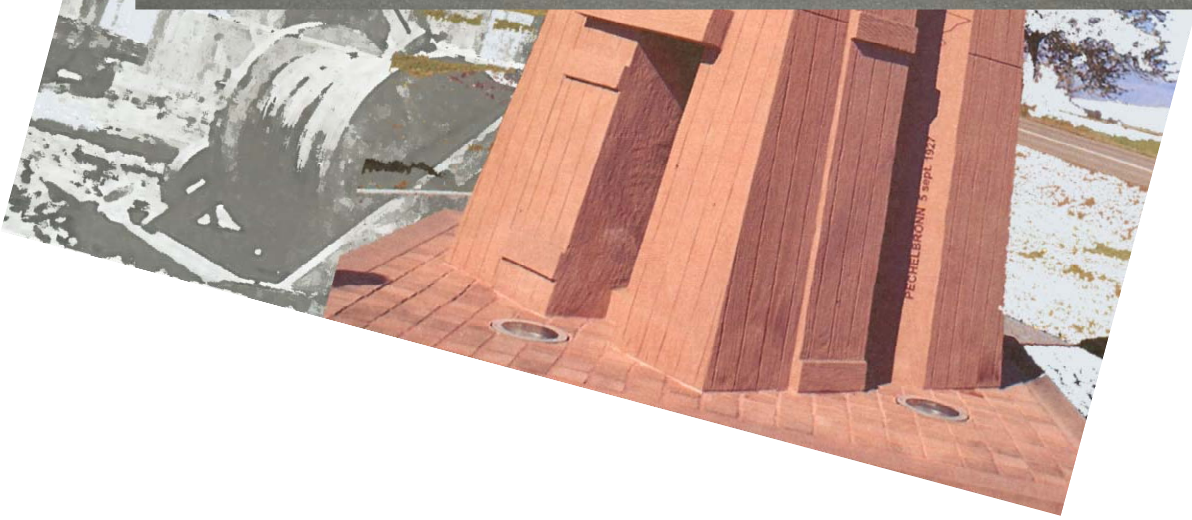


SAID
Pechelbronn 80

Toujours Repousser les Frontières
Always Search Further

27 – 29 septembre 2007
(France)



SAID
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A l'occasion du 80ième anniversaire des premières mesures de diagraphies faites dans un forage , le 5 septembre 1927, La SAID a organisé une réunion de 3 jours, les 27, 28 et 29 septembre 2007.

La première journée, le 27 septembre, était consacrée à des exposés.
A la Maison des Centraliens qui nous avait accueillie nous avons pu entendre de nombreux orateurs prestigieux, certains nous ont rappelé l'étape décisive qu'avait été ce premier log pour l'industrie du pétrole, d'autres nous ont parlé de l'avenir, de nos besoins en énergie, de la gestion de notre environnement. Suivie par plus de 60 personnes cette journée de réflexion a été pour les 23 étudiants présents l'occasion de se familiariser avec ces techniques et de découvrir le potentiel de ces moyens d'investigation.

Le 28 septembre, nous avons eu le privilège de pouvoir accéder à la Maison du Val Richer en Normandie, où Conrad Schlumberger avait en 1912 fait des mesures montrant qu'il est possible de déterminer la structure du sous-sol par des mesures électriques.
Cette magnifique demeure, accessible au publique uniquement pendant les journées du patrimoine, garde encore les traces de ces premières expériences. Une visite au Musée de Crèvecœur nous a aussi permis de retrouver quelques appareils témoins de cette naissance d'une technique.

Le 29 septembre, nous avons accédé au site de Pechelbronn, au sud-est du village de Dieffenbach-lès-Woerth, lieu de cette première opération de logging. L'endroit exact du puits, Diffenbach 2905 tour 7, est actuellement dans un champ, mais le village se propose de marquer cet emplacement et, par ailleurs, a fait ériger une stèle, réplique de la tour de forage, qui rappelle cet événement.
La visite du Musée Français du Pétrole, à Merkwiller-Pechelbronn, a clôturé ces journées en nous rappelant tout ce que fut pendant des siècles l'activité principale du Nord Alsace.
Une visite à Soultz, non loin de là, nous a orientés vers cette nouvelle forme d'énergie qu'est la géothermie profonde, ce qui s'inscrit bien dans le projet Terre Profonde de l'année de la Terre.

Suivi par plus de 60 personnes qui ont exprimé leur intérêt et leur satisfaction, cet évènement est retracé dans les pages qui suivent, dans l'article de Don Lyle publié dans E and P Hart's, et dans celui de Ph. Theys "Le *first*Log" du numéro de Décembre 2007 de Petrophysics. Vous y trouverez également les abstracts des présentations de la journée du 27 Septembre.

Mme D.Chapellier
SAID President

E&P Journal
November 2007

Logging celebrates 80th anniversary

A three-man crew in the Alsace region of France rewrote the oil-finding textbook.

By DON LYLE, Executive Editor

Logging is personal at Schlumberger. It grew from the dedication of Conrad and Marcel Schlumberger to technology through bathtub experiments in the back yard through the first downhole application into an industry that helped operators find billions of barrels of oil and trillions of cubic feet of gas that might otherwise have been overlooked.

Paul Schlumberger, already well-to-do from a thriving leather goods business, had sent his sons to the best technological schools in France. Conrad, the inventor, had an idea that an electrical current sent through the earth and returned to receivers could help identify subsurface objects through their resistance to the flow of the current. Using ore samples with different conductivities in a bathtub filled with mud, the brothers were able to outline the shape of objects by means of equipotential measurements traced on paper stretched over the rim of the tub.

Their father drew up a contract. It read (in English), "I agree to disburse to my sons, Conrad and Marcel, the funds necessary for research study in view of determining the nature of the subsurface in amount not exceeding 500,000 francs…they must devote themselves to it entirely. The scientific interest in research must take precedence over financial interests."

His sons honored that contract devoting many hours to measurements from the surface.

From the bathtub experiments starting around 1911, Marcel and Conrad expanded to their first truck in 1912. Surface measurements were helping find anticlines, faults, metal ore deposits, salt domes and other structures.

They started a worldwide patent barrage that included Brazil and Mexico in 1913, Czechoslovakia in 1923 and the Belgian Congo the following year. By 1935, they had patents on every continent but Australia.

During this period of experimentation and development, over lunch one day, Conrad Schlumberger shared the success of these surface measurements with a classmate from the Ecole Polytechnique. The colleague, who ran a drilling company, said he would be more interested if the measurements were taken in his wellbores.

By 1921 the brothers were taking electrical measurements at the bottom of wells to establish correlations with the surface measurements. That led to the idea that they might be able to move the logging equipment up the borehole for a detailed profile of a well. Conrad Schlumberger, a board member of the Pechelbronn oilfield company in Alsace, quickly got permission to test the new equipment on a working well, according to the records of Roger Jost, who ran the first well log on September 5, 1927, with Henri-Georges Doll, who was Conrad Schlumberger's son-in-law, and Charles Scheibli, an engineer with the logging company, then called Société de Prospection Électrique, nicknamed Pros. The three men lowered the logging sonde (fish) to 915 ft (279 m) in the **Diefenbach 2905** well and used a 36-volt battery to send electricity down the hole.

Translated, Jost wrote, "I am operating the potentiometer: measurements of current and voltage difference. Doll, in front of me, writes down the values I give him onto a handbook. Two quick computations on his sliding rule and the triumph of this first measure point resounds: It works! We stop every meter, going up, and this over 140 m (459 ft) For a while, the resistivity changes have been minimal, because the sonde had been surveying calcareous shales, then the resistivity began to dance because rock type was changing. Doll quickly adds the points on the chart paper and draws the curve.

This early logging kit in the Schlumberger museum showed a simple setup with the black box that measured resistivity and reels that handled the cables. (Photos by Don Lyle)

"After this period of trial and error, we are now confident and our three faces are glowing with satisfaction… Scheibli is everywhere. He looks after the sheaves, the wires, the cable drum."

The whole operation took 5 hours.

Most of the operation went well, but the team did encounter a learning experience. According to Jost, "We continued till we reached the casing shoe. Then we pulled the tool back to surface and rigged down. We removed the lead ballast from the sonde hanging from the derrick. Splash! The

People celebrating the 80th anniversary of downhole logging gathered at the monument to the first logging job at Pechelbronn in Alsace, France.

drilling mud that was filling the bakelite tubes poured down. I believe that Doll received the most extensive shower from head to toe."

Doll left for Paris to report to the Schlumberger brothers, while Schiebli and Jost continued logging wells in the field.

"On the third day, I remember that we went into some kind of trouble. We had dropped the wires in the well and when we hooked them back to the drum, it became a ball of wires. A kitten would not have done worse with a ball of wool. The same day, we added some adhesive tape every 10 or 15 m (32 to 49 ft) around the wires so that they would behave in a more orderly manner," concluded Jost.

This event marked a turning point for the fledgling oil and gas industry. "Electric logs showed (the location of) oil. Before then, logging was used as a correlation tool. A revolution in the oil business was under way," said Ian Strecker, former executive vice president and chief technology officer for Schlumberger, during his keynote presentation at the Société pour l'Avancement de l'Interprétation des Diagraphies (SAID) meeting, the French chapter of the Society of Petrophysicists and Well Log Analysts (SPWLA).

SAID honors logging

Some 80 people celebrated the first downhole logging celebration this year at a special SAID conference in Paris attended by active members, industry veterans and students under the direction of Schlumberger retiree Philippe Theys. It was particularly significant for Schlumberger, since the company, with its worldwide patents, held a monopoly on logging until 1938.

Among the veterans, the conversation with strangers inevitably started with the questions, "Where (in the world) did you take your training?" The loggers would reel off the names of exotic, often remote and dangerous places they had taken their logging tools. Among the long-timers, many of them retired, the conversation would come around to personal ties with the Schlumberger brothers, Doll and other pioneers.

A favorite story recalls the time rival Halliburton had gotten logging patents from Humble Oil and started a competing logging business. This was a particularly grating issue, since Erle Halliburton had offered to buy the company for $10 million as World War II smothered operations everywhere in the world except the United States. Marcel Schlumberger turned him down flat, according to the book "The Art of Corporate Success: The Story of Schlumberger" (1984) authored by Ken Auletta.

Schlumberger sued Halliburton in Houston and won the first court round under a decision by Judge Thomas Kennerly. A higher court later reversed the decision on appeal. According to the company veterans, Marcel Schlumberger fell back on a couch in despair when he heard the news. Doll, however, said something like, "Fine. We've lost the patent protection. Now, we've just got to be better — we will stay ahead through technical innovation."

Leading the day-long SAID meeting, which featured 12 technical presentations, Strecker looked at the progress the industry has made and how technology drives efficiency. Twenty-five percent recovery was the best achievable 50 years ago. Now, rotary steerable drilling equipment and logging-while-drilling tools allow Saudi Aramco to put a main horizontal well bore with eight branches totaling up to 7.6 miles (12.3 km) of well bore precisely in a producing formation. The same technology allows ConocoPhillips to get 60% higher production from its **Alpine** field on the North Slope of Alaska, he added.

Le first *Log*

In the first months of 2007, SAID, Société pour l'Avancement de l'Interprétation des Diagraphies, the French chapter of SPWLA, embarked in a historical project, the commemoration of the 80th anniversary of the first log, performed on September 5th, 1927. Why? The 70th anniversary was not far away and the 100th was just a matter of being patient. Nevertheless, by blowing 80 candles, SAID saw the unique opportunity to gather the old timers who had the chance to meet the founders of the industry, the active employees still working for the oil industry and the students that will soon be the spring of innovation and dynamism of the energy segment. There was no time to spare.

The Pechelbronn 80 conference was launched. It was based on a mix of technical and historical contents. Experts on oil, gas, coal, waste sequestration and even on nuclear energy were approached. Energy-related companies were solicited to sponsor students from Europe. Universities and Engineering schools were contacted. The guardians of the sites where the logging industry was born generously accepted to make the event memorable. And in the last days of September, from the 27th to the 29th, the conference took place leaving all the attendants with a sense of pride and prestige.

But, let us come to the details. Eighty-seven participants originating from sixteen countries attended the conference. Twenty students accepted the opportunity to liaise with the balding and graying crowd that was telling war stories to the 40-50 year old generations.

The first day was dedicated to a survey of the existing and future techniques that will shape the energy horizon in the next forty years. Extended abstracts for most of the presented papers have been spontaneously volunteered by the authors. Just let your fingers do the walking. Do not miss the unconventional topics. Coal is not hydrocarbon, but there is quite some future for it; and it does not need to be a dirty one. For many, nuclear energy rimes with Chernobyl and Three-Mile Island, but it will likely, if not surely take an important role in the grand energy scheme. So, it is no wonder that the presentation on 4th generation nuclear reactors and on controlled fusion attracted great interest from the audience. At one point, our planet was found too small a territory for the audience and Mars was considered for their curiosity. In addition, astute use of competition, investment in technology and in people, networking, innovation were also recurring themes of the technical conference that was generously held in the prestigious site of Maison des Centraliens, in the meeting rooms bearing the name of Bleriot, the famous pilot who first crossed the Channel, and Eiffel, the well-known architect of the Parisian landmark.

After so much food for our brains, it was time to feed the rest of the bodies with a sumptuous icebreaker sponsored by Schlumberger in the very building where many of the experiments attempted by Conrad and Marcel were performed, at the corner of rue Fabert and rue St Dominique.

The next morning, most of the congresspersons were on their way to Normandy, West of Paris. Why were we going 180° from Pechelbronn? Because, the Schlumberger brothers, the founders of the logging industry, though born in Alsace, were raised in Val Richer, a beautiful mansion in the heart of Normandy. The great-grand father, Francois Guizot, of the famous pair was a key character in the cabinet of Louis-Philippe, the last king in France. He "just" invented compulsory school in France and developed the organization that manages the French heritage, the "*monuments historiques*" This is the culturally challenging environment where the brothers thrived. The congresspersons were lucky to have access to the site generally closed to public, and to have no one other than the grand niece of Conrad and Marcel, Pauline Lartigue, for *cicerone*. After a visit of the building, it was time for a group picture. There was no better place than the lawn where Conrad performed the first surface electrical measurements, in 1912. The wind of history could be felt blowing around us.

The day was completed with a visit of the Schlumberger museum in Crévecoeur-sur-Auge, a stone throw from Val Richer. Visitors could see the bathtub used for the first electrical measurements, and many participants could relive their field engineering careers through the perusal of pre-computer electronic equipment.

The next morning, the congresspersons were on their way to Alsace, the French province at the border with Germany. The high speed train, TGV, *train grande vitesse*, took them 487 km (300 miles) away from Paris to Strasbourg, in 2 hours and 19 minutes. On the same track, Alstom had won the world train record at a speed of 575 km/h (357 miles/h) six months earlier. A bus took them to Dieffenbach, a small city, where the party gathered around a commemorative sculpture, representing Pechelbronn 27, the rig where the first electrical log was recorded, in pink sandstone. The mayor of the town, Al Atzenhoffer, welcomed us, delivered a moving speech and presented SAID with a 2-ft tall replica.

Another surprise was in store. We learned that the sculpture was not located at the exact site of the original rig. The mayor and his team indicated that it had been built close to the town for convenient access. The whole party was then transported a few km away to the exact location of rig 27, where the first log on that fall day of September 1927 was performed. We could recognize the neighboring wood described by Roger Jost in his account of this historical day, but nothing else. Meadows had taken over what used to be the Pechelbronn oilfield. Incidentally, we learned that the Pechelbronn oil had been exploited as early as 1740 by Compagnie d'Asphalte, more than hundred years before Colonel Drake drilled his discovery well in Pennsylvania. The mayor made a few approximate length measurements, stopped and said: "This is THE place". SAID quickly decided to participate in the financing of a stele to be erected at this very location.

After these emotional moments, the group gathered to test the local cuisine, exemplified by a superb *choucroute royale*. Later on in the afternoon, the Pechelbronn oil museum and the geothermal plant of Soultz-sous-Forets were visited. The whole party then rejoined Strasbourg then Paris by train before taking their way back home loaded with memories of a great gathering. SAID proved once more its organizing skills when the conference committee brought dinner to the participants as the train rolled at a speed of 320 km/h (200 miles/h).

This summary is an opportunity to thank SAID for the hard work in the preparation of the conference. (literally thousands of emails were exchanged in the process), Pauline Lartigue, descendant of Francois Guizot and Paul Schlumberger for an exceptional hospitality in Val Richer, Al Atzenhoffer, for guiding us to the right places in Alsace, Christophe de Ceunynck, who opened the Crévecoeur museum, Ian Strecker for a stimulating key-note address, le Commissariat à l'Energie Atomique for allowing Claude Renault to open our minds on non-oil related topics, Jeremy Lofts for courageously braving a Schlumberger-dominated crowd and Vicki King for registering participants from far away Houston. The companies who accepted to sponsor the participating students, Andra, Beicip and Total are also deeply thanked as are all the presenters of the technical day in Paris, they put a tremendous effort to enlighten their audience, and Ecole Centrale de Paris, who spontaneously opened its reception area in the very center of Paris. It is obvious that, without Schlumberger, who generously provided student grants, presented participants with a unique commemorative book and opened their headquarters reception rooms in Paris, the Pechelbronn 80 conference could not have flown well.

Finally, it is appropriate to congratulate once more five men, Conrad and Marcel Schlumberger, Henri Doll, Roger Jost and Karl Scheibli. Their work 80 years ago gave us the opportunity for a great gathering. Their achievement cannot be better described than by Marvin Gearhart, a person not biased by blue-and-white blood, who was unable to join. He sent the following message a few days before the conference:

> "It is significant that these men remembered the details of this day somewhat like we now remember Pearl Harbor or the 911 bombing of the World Trade Center and where we were and what we were doing at the time. To me, it is simply unbelievable they could accomplish all the things that had to be done to make the first well log in the short time they used to accomplish the tasks and make that first log. First, they had to make the well logging cable, then the draw works to lower and raise the tool into and out of the hole, the depth measuring system for recording the depth and most important of all, the tool itself to make the measurements. In other words, their invention created a whole new industry that has come along ways since that date but the basic principles of the "technique" remain the same today.
>
> The industry will change more in the next 20 years than it has in the first 80 years and yet, I expect that the spirit of the Schlumberger brothers will continue to lead the progress for new tools and techniques the industry will be using in 2027. With the advancements of our new technological age using integrated circuits, computers, nano-materials and data storage and processing techniques, the question of what will happen to the well logging industry as we know it is a good one. Artificial intelligence may replace some of the original thinking of the Schlumberger brothers, but without them, we probably would not enjoy the technology we have today for another 20 years or more."

1. Ian Strecker delivering the keynote address. 2. Mike Green speaking on coal gasification. 3. Jacques Bosio leaving Powerpoint aside, but impressing the audience with his prop, a mockup of a Bottom Hole Assembly. 4. Bernard Montaron with an ironic look at Archie's equation. 5. Jean Gartner, a long-time Schlumberger engineer and researcher. 6. Adrien Marante learning at an early stage what service is all about. 7. Child's bathtub at Val Richer museum that is similar to the one used in Conrad's and Marcel's original experiments. 8. Valérie Testelin (left) and Joséphine Durand (right) from Ecole et Observatoire des Sciences de la Terre. 9. Craig Tingey on the TGV to Pechelbronn. 10. Jeremy Lofts, impressed by OLD technology. 11. The mayor of Diefenbach. 12. Conferees at Val Richer museum. 13. The group at the Diefenbach monument. 14. The real site. Under the crowd is the original location of well 27. 15. Dominique Chapellier, President of SAID, receives a scale-down version of rig 27. 16. Carved angelic face of Marcel Schlumberger on a cupboard built for his parent's 50th wedding anniversary 17. Conrad Schlumberger **18.** Allegory of the industry on the same cupboard at Val Richer museum. *Photos courtesy Philippe Theys and Andre Hossin.*

Pechelbronn 80 Technical Program

The French chapter of SPWLA, SAID, sponsored the recent special conference on the roots of logging that honored the 80th anniversary of the first well log measured at Pechelbronn. The organizers planned a one-day technical program as part of the conference with presentations that covered a wide range of topics that included historical reviews, current developments and future opportunities. The non-reviewed abstracts and extended abstracts are included here to give the readers a flavor of the conference's activities. [Editor].

Technology Drives Efficient and Responsible E&P

Ian Strecker

Technology has always played a key role in making oil and gas producible at affordable prices. Fifty years ago, recovery of 25% was considered the best achievable. Now, the development of most new fields requires a recovery greater than 50%. What will the next 50 years bring? The world has produced and consumed about one trillion barrels of oil. The next trillion will last until 2030. Where this next trillion comes from depends on the accessibility of the various hydrocarbon environments and the cost of exploiting them. This address concentrates on the contribution of technology and new responsibilities shared by the oil industry and governments.

Technology innovations addressed include the extensive use of multi-laterals to boost production, the ability to dramatically increase the precision of real-time geosteering, the ability to image below salt using advanced seismic techniques, the recent integration of electromagnetic prospecting, including continuous source electromagnetics (CSEM), with seismics to improve exploration success (Figures 1 and 2), and lastly the ability of using fiberoptics to measure well temperature in heavy oil exploitation.

The address continues by examining the key factors that nourish technology and inspire innovation. Factors include ready access to oil fields to experiment and test new ideas, such as was the case in the Pechelbronn field for the Schlumberger brothers. Also key is teamwork made possible in Schlumberger from the earliest days by excellent two-way communication of new ideas even to remote areas. Another factor is the importance of healthy competition.

The address finishes by assessing the new responsibilities facing the industry and governments. Energy demand for the foreseeable future will be supplied by oil, gas and coal, with coal increasing at the greatest rate. Given the right economics, our industry can play a key role in pumping produced CO_2 back underground. Both public and politicians must realize the incredible impact of technology on oil and gas productivity over the last century and how technology will also help resolve today's environmental issues. There is every reason to be proud of our achievements and excited by what the future will bring.

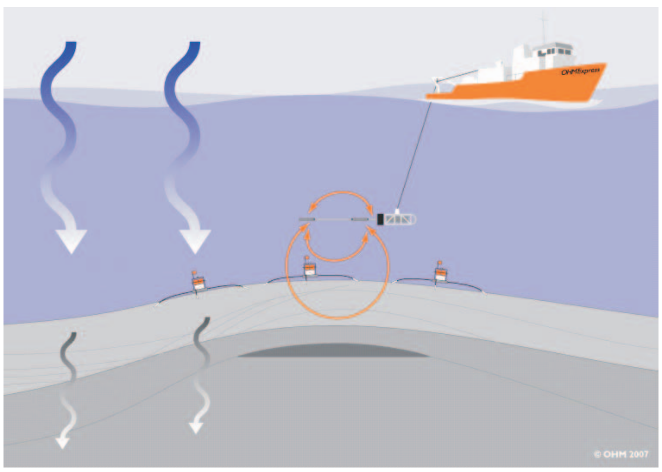

FIG. 1 Illustration of CSEM with 8 m sensors deployed on the seabed and a 0.1 Hz source towed 30 m above. A combination of 28 sensors spaced 1000 m apart creates a measurement much like an early-style electrical survey. Courtesy of Offshore Hydrocarbon Mapping."

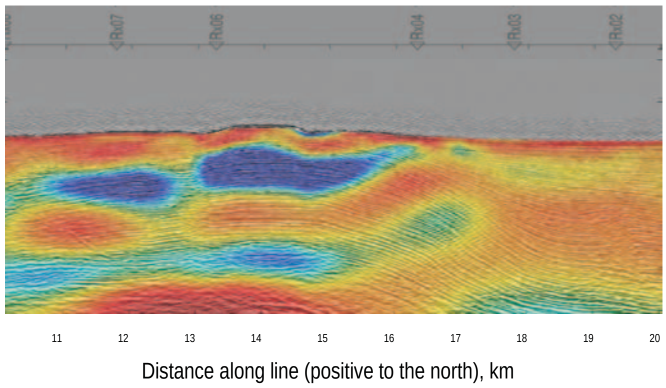

FIG. 2 The raw CSEM data was processed without reference to the seismic data using the simplest solution model. The dark blue areas are those of highest resistivity and show the possible existence of shallow hydrates. The presence of the fault is also confirmed. Deeper in the section, there is another resistive area which overlays the seismic data and strongly indicates the presence of hydrocarbon. Courtesy of Terra Energy Services.

CO_2 Sequestration

Laurant Jammes: Schlumberger Carbon Services

Since the beginning of the industrial age the average temperature of the Earth has increased by about one degree Celsius while the CO_2 concentration in the atmosphere has risen from 260 up to 380 ppm. According to the IPCC (Intergovernmental Panel on Climate Change) it is very likely that most of the observed increase in average temperature is due to the increase in anthropogenic greenhouse gas concentration, possibly as a result of the development of transport and industrial activities, energy production, land-use changes, or the production of steel, aluminum and cement. These gases include CO_2 and it is recognized that the associated climate change will adversely impact the society.

Reducing CO_2 emissions cannot be achieved without deploying a full portfolio of solutions, including the development of renewable energy sources, improvement of energy efficiency, nuclear energy and CO_2 Capture and Storage (CCS). This last solution consists in capturing the CO_2 emitted by large-scale point emitters, such as coal-fired power plants, and transporting it through pipes for storage in an underground formation.

Our organization advocates a holistic approach to CO_2 geological storage, which is based on a Performance and Risk management methodology. A typical CO_2 storage project can be split in different phases:

pre-operational, operational and post-injection. The first phase includes in preliminary studies such as site selection and characterization, followed by field design, (e.g. injection and monitoring wells). The operation phase starts with well(s) drilling and completion, and the installation of surface facilities and infrastructures. It is followed by the injection of CO_2. Monitoring activities have different objectives, including (1) monitoring the injection operation, (2) monitoring for verification and (3) monitoring of the environment. For each monitoring measurement, baseline conditions will be recorded before injection. Finally, at the end of the injection phase, the site will be prepared for closure and liabilities will be transferred.

The development of such an integrated approach has required a significant research and development effort, which started in 2001. Teams of researchers and engineers adapted oilfield technologies, and in parallel, developed new tools and concepts applicable to CO_2 geological storage (e.g. monitoring measurements, modeling tools, well construction technologies). Since then, our organization has joined most of the international research collaborations (e.g. GCEP, CCP-2, CO2SINK, CO2ReMoV, etc.) on CO_2 Capture and Storage, and now participates actively in almost all storage pilot projects (e.g. Ketzin, Otway, etc.), contributing to the development of knowledge in this new domain. Among the subjects currently investigated through collaborations are (1) methodologies for site characterization & performance prediction, (2) monitoring and verification, and (3) technologies for storage containment, which will be illustrated with examples from on-going projects.

Underground Coal Gasification as a Clean Energy Option based on Oil and Gas Technology

Michael Green: UCG Partnership Ltd

Underground coal gasification (UCG) has made a considerable revival over the last couple of years. UCG is an extraction and coal conversion in one step, which converts coal to gas which is readily usable at the surface in gas turbines for power generation, (Figure 1), gas to liquids production and the manufacture of chemical products.

Security of energy supply and high gas prices have been the principal driving forces for the renewed interest in coal and UCG. Led by the US, which has the largest coal reserves in the world, coal usage for power production is on the increase, and a great deal of effort is being applied to making transportation fuels, hydrogen and even synthetic natural gas (SNG) from indigenous coal. Europe is also concerned about energy supply and its growing dependence on Russian gas. Coal usage is increasing and clean coal technology with carbon capture and storage, ranks alongside renewable and nuclear energy, as the major future energy options.

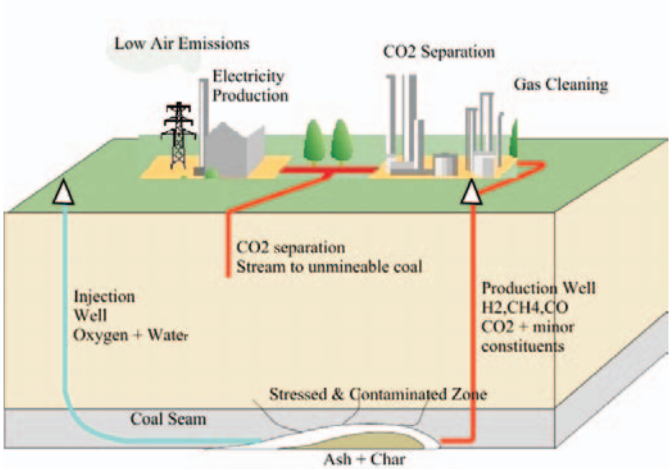

FIG. 1 UCG Commercial layout for power production.

UCG offers a method of recovering energy from coal, without the safety and high cost of men underground and the environmental impacts of coal and ash movement at surface. The process has been around and used commercially for over 40 years but only in recent years has the advanced technology of oil and gas production been applied and adapted to provide the control reliability and environmental protection, required of a modern clean coal process. The most important improvement has been the introduction of steered inseam drilling, to connect the vertical process wells, and the use of moveable injection within the lateral well to position the injection gases and optimize the gasification process. This was first developed in the US trials and extended to greater depth in the two European UCG trials at Thulin, Belgium and El Tremedal, Spain. Pressure control of the gasification chamber is also vital to avoid the spread of contaminants.

Reviews of the technology, field trials and assessments of the potential resources for UCG have been undertaken in most coal producing countries (Figure 2). The US, Europe and Australia have traditionally led the technology developments, but developing countries like China and India have been quick to recognize the advantages of UCG and build plans for its commercialization into National Plans. At least half a dozen coal fields and basins around the world are the subject of studies and pre-commercial trials. Schemes in the 100 MW to 1200 MW range are being developed. Many of these activities are in the hands of entrepreneurs, or industrial organizations, which unlike the public sector in the past, treat their activities as confidential. It is known that project expenditure on UCG has increased markedly in 2007 and this presentation, will give an overview of the latest developments and projects in UCG and generalize the case studies. It is presented by the UCG Partnership, which in two years, has become the world's forum for UCG through its international conferences, web-based public information and its comprehensive data base for members.

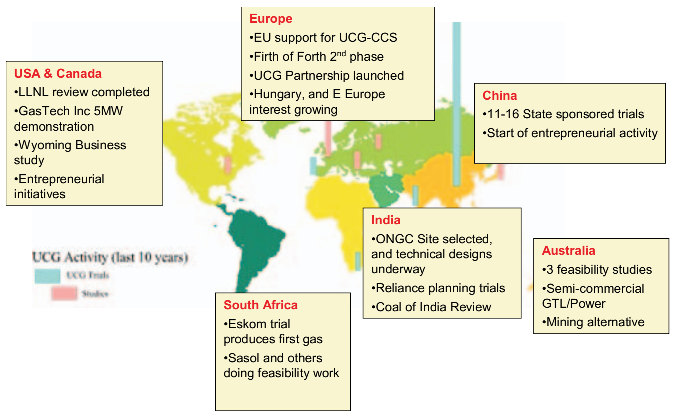

FIG. 2 UCG activity around the World 2006-2007.

Horizontal Wells, Innovation and Professional Societies

An account of Jacques Bosio presentation (P. Theys)

Jacques Bosio, previously head of research of Elf and the first non-US president of SPE, the Society of Petroleum Engineers wanted to limit the Powerpoint poison intake by the audience and made a presentation without slides. His entertaining talk started with the beginning of the horizontal drilling adventure, then went on to cover the need to network through professional societies.

Jacques explained the premises of horizontal drilling. In the late 1970s, Elf Italiana had a field, Rospo Mare that was producing well below expectation. Production could be expressed in tens or hundreds of barrels. Hydrocarbons could only be flowed from vertical fractures that were seldom crossed by traditional vertical wells. Deviated wells were recommended but the huge resistance from the drillers, whose objective was to achieve as much vertical true vertical depth as possible, was overwhelming. Drilling highly deviated wells was against nature or even the consequence of poor skills. Jacques stated that it was much more difficult to turn people's mind by 90° than wells!

Almost by shear luck, an experimental horizontal well was drilled in the Lacq field in France. It showed excellent potential, but people were only lukewarm. Finally, wells were drilled in the Rospo Mare field and supplied excellent results. Additional production was beyond expectations and costs were not as high as expected. Elf Italiana only survived because of this stubbornness of Elf Research. This success was not immediately recognized. The first technical meetings about horizontal wells did not attract crowds. Jacques mentioned a few names of people who were very resistant to the idea. We will not mention them (they have family). But by the end of the 1980s, the idea finally became accepted.

At that point, Jacques explained the role of professional societies in the adventure of horizontal drilling. He stated that you are not alone if you have a technical problem. It is likely that somebody else on Earth is just facing the same challenge and making some progress. Through the channel of professional societies, it is possible to learn from others and unite on a common front.

Jacques turned to the students in the room and offered some advice. Join professional societies as early as you can! Start your networking now! Some of your comrades in your chapter (with whichever society) will be department head, Vice President or even Chairman of the board in the years to come. He then turned to the Presidents in the room and added: "Just watch the ones active in professional societies. They are your best employees".

Wireline Logging – Then and Now

Charles Woodburn: Schlumberger

In 1911 Conrad Schlumberger began experimenting with surface resistivity measurements in the bathtub, among other places, at the family's summer house in Val Richer, France. Word was disrupted by the First World War, yet he pushed on and his brother Marcel joined him in 1919. A man with a passion for science and innovation, Conrad decided to resign his professorship at École de Mines de Paris to turn his full attention to geophysical measurements. The two brothers were eager entrepreneurs and scientists, and moved swiftly over the ensuing three years, conducting geophysical surveys in Romania, Serbia, Canada, South Africa, the Congo and the United States. In 1926 the new company, Société de Prospection Électrique, or "Pros" as it was nicknamed, was launched.

It was on September 5th, 1927, in a field near the village of Diefenbach, France that Henri Doll, Roger Jost, and Charles Scheibli conducted the first electrical logging operation in well #2905 of the Pechelbronn oilfield over an interval of 140 meters. They started from a depth of 279 meters, and the resistivity logging operation took approximately five hours. Henri Doll recounted the operation noting:

> "The well was 500 meters deep…We began making our measurements. Someone had to unplug the connector, someone else turned the winch. Someone had to run on the rig floor to look at the counter on the sleeve…I wrote down the measurements on a pad, together with the depth…Then it was unplug, roll up…one meter at a time…we were able to make 50 stations per hour."

International expansion of operations followed and by 1929, logs had been run in Argentina, Ecuador, Japan, Venezuela, and the US. Conrad and Marcel published their first article on the new technology, known then as "electrical coring".

"Pros" grew into three international companies that ultimately became the global organization that Schlumberger is today. Although the first subsurface logging operation was successful, the brothers continued surface electrical mapping for several more years. Logging innovation progressed in 1931 with the discovery and measurement of spontaneous potential, which offered a way to distinguish permeable reservoir rock from impermeable rock. Logging reached farther east to more remote locations in the early 1930s, Malaysia, Indonesia, Russia, etc. India saw its first electric wireline log in 1933 in the Digboi field, the world's oldest continuously producing oil field.

The resistivity surveys, along with the surface geological mapping, helped advance field development to a scientific approach. Not only did the log help distinguish sand from shale and oil from water, but it also guided geological correlations and structural interpretations. Quantitative log analysis then took a step forward with comparison of the physical properties of rocks measured in the laboratory and log data, as famously published by Gus Archie, demonstrating the intense interest of advancing the science among those using wireline logging measurements.

Logging applications began to expand beyond formation evaluation. For example, in 1946 the casing collar locator was first deployed. These measurements facilitated log correlation between open-hole and cased-hole logs from the same wellbores.

Another initiative begun in 1956 survives today—the assignment of senior technical staff in support of field operations. Roger Jost, one of the three people who ran the first log at Pechelbronn, was assigned to the Paris office, where he answered questions for young field engineers and tested equipment before it was deployed.

In the mid-60s scientists and engineers were developing density logs to improve the understanding of lithology and porosity, saturation measurements through casing, computer-processed dipmeter logs, and digital tape processing in a logging truck.

During the 1970s and 80s several truly revolutionary new measurements were developed for the oil field. These include borehole imagers that provide seemingly photographic images of the borehole, and formation testers that measure reservoir pressure and collect fluid samples. In addition to supplying new measurements, scientists and engineers improved mature measurements.

The 1990s brought the development of a new generation of nuclear magnetic resonance logging tools. Measurements of the nuclear magnetic properties of formation hydrogen enable petrophysicists to calculate total porosity, pore-size distributions, and volumes of free fluid and bound fluid and to estimate permeability.

This decade has seen advances in formation evaluation in cased well, such as cased-hole formation resistivity, cased-hole dynamics tester, and the reservoir saturation monitoring. Advances in production logging in deviated and horizontal wells also were developed with their multiple spinners and probes that extend along the wellbore and allow for fluid flow measurements that distinguish oil, water and gas regimes.

Our vision of today is no different from the early years, we continue to focus on technology development by trying to understand and anticipate client needs. We strive to achieve excellence in service delivery, safety and environmental performance, and finally, we rely on the creativity of our people to innovate and adapt, always imagining new things we can do at the end of the wireline.

Characterization of Clay Properties Variability by a Geostatistical Analysis of Log Data and High Resolution FMI® Data (Callovian-Oxfordian Clay, Meuse, France)

Marie Lefranc: ANDRA

One of the main lines of research of the National Radioactive Waste Management Agency (ANDRA) is to provide data for assessing the feasibility of a deep geological waste repository. ANDRA has conducted studies in its Meuse/Haute-Marne underground research laboratory located at a depth of about 490 m in a 155-million-year-old argillaceous rock (argillite), the Callovo-Oxfordian formation.

From the analysis of logging measurements, particularly gamma ray, resistivity, and sonic, different patterns can be observed and correlated at different scales between seven wells. Log correlations are coherent with stratigraphic and biostratigraphic correlations. From these data, local sedimentation rate variations can be observed. FMI® data (Fullbore Formation MicroImager) are also available. They give high-resolution images of microresistivity formation in water-base mud. The FMI data reveal clear carbonate-clay interbedding that can be matched with core data. These interbedded layers display a cyclicity on FMI images. These cycles can be counted and their thickness estimated. Condensed levels, confirmed by biostratigraphic data, are also present on FMI images.

Geostatistical tools, such as the variogram, enable this cyclical behaviour to be more precisely characterized. The variogram analysis of classical log data in homogeneous intervals shows a cyclicity, which is the same for the various tools but varies vertically and laterally between 1 and 5 m. The FMI images are analyzed to get a better resolution, particularly the 'background conductivity' and the "conductive inclusion proportion", (i.e. BorTex results). Three periods are observed on the experimental variograms. The thickest cycles seen with the FMI are similar to the cycles observed on conventional logs. A better resolution is obtained with the conductive inclusion proportion; 30 cm thick cycles are observed on variograms. The modeling of the various vertical variograms requires the use of three periodic components. These periods vary vertically in a well, and laterally from one well to the other, but ratios between these three periods are stable and similar to ratios between orbital cycles, (i.e. Milankovitch cycles). This is confirmed by a factorial kriging analysis of these three components of the logs. These results suggest that the periods observed from log analysis correspond to the effects of eccentricity (100,000 years), obliquity (38,000 years) and precession (20,000 years).

Since the duration of the orbital cycles is known, depth intervals can be converted into geological-time intervals, and the data can be placed in a geochronological reference system. This improves the geostatistical study of the vertical and lateral variations of clay properties, which are more clearly expressed in the geochronological reference system than in the present geographical system. This allows us to better study the variation in sedimentation rate, the eventual presence of hiatuses and to propose the revision of the duration of the Callovo-Oxfordian ammonite zones.

On the Connectivity of Water in Porous Rocks and Archie's Equation

Bernard Montaron: Schlumberger

In the famous Archie's equation, the conductivity of reservoir rocks is a simple function of formation water conductivity σ_w, porosity ϕ and water saturation S_w, such that $\sigma = \sigma_w S_w^n \phi^m$. This empirical equation introduced by Gus Archie in 1942 has been a key factor in the successful application of logging measurements for quantitative evaluation of formations in the oil and gas industry. However, there are rocks that refuse to comply with this model and which are often referred to as "non-Archie rocks". Shaly sands are a mild example of these disobedient rocks. However, shaly sands are civilized enough to accept to comply with a modified version of Archie's equation introduced by Waxman and Smits, and improved by Clavier. In contrast, some carbonate formations contain defiant rocks that behave in strange ways.

Water is not distributed randomly in rocks pores. At the pore scale capillary forces dominate over all other forces and the water distribution tends to self-organize in order to remain connected down to very low saturations. This behavior is built in Archie's equation since the conductivity remains positive for any value of S_w as small as it may be. There is no percolation threshold. That is characteristic of so-called water-wet rocks.

In oil-wet rocks the connectivity of the conductive phase, (i.e. the water film) is reduced. Pore surfaces occupied by oil interrupt the water film in many places. In so-called strongly oil-wet rocks there are so many such "cuts" in the water film that connectivity may be lost if there is not enough water in the system. Such rocks, which include some carbonates, do not match Archie's equation at low water saturation.

A complete theory for the connectivity of water can be developed this way based on ideas borrowed from percolation theory, fractal geometry and effective medium physics. This approach leads to a very simple model called appropriately the "connectivity equation" that has, like Archie's equation, only two parameters. They are the "conductivity exponent", μ and the "water connectivity index", $\sigma = \sigma_w (S_w \phi - \chi_w)^\mu$(Montaron, 2007). This model seems to apply to all observed rock resistivity behaviors for drainage curves including of course Archie rocks and shaly sands, but also low resistivity pay carbonates, and strongly oil-wet rocks. This model was tested on several data sets and shown to match experimental results for two opposite cases; Shaly sands, and oil-wet carbonates. The model reverts back to Archie's equation when $\chi_w = 0$. Obviously, the resistivity index curve obtained with the connectivity equation is a straight line in log-log scale for $\chi_w = 0$. The curve has a negative curvature for negative values of $\chi_w = 0$ and a positive curvature for positive values of χ_w covering the full range observed for non-Archie rocks (Figure 1).

Using a modified modified complex refractive index model (CRIM) mixing law where the exponent 0.5 is replaced by $1/\mu$, we can model the water connectivity index as a function of rock parameters. For example in shaly sands χ_w takes negative values, typically between 0 and -0.05, and is a function of the counterion concentration (Figure 2). In strongly oil-wet rocks χ_w is positive and is a linear function of the volume fraction of oil-wet zones in the rock. The water connectivity index can therefore be used to provide a continuous wettability index log. A good correlation was observed in a Middle East carbonate reservoir between χ_w or equivalently the critical saturation defined as $S_c = \chi_w / \phi$ derived from logs and wettability measured on cores (Montaron, 2007). Figure 3 shows the data set from Sweeney and Jennings (1960) with a carbonate rock rendered water-wet (black dots) and then strongly oil-wet (blue and red dots). We hardly see such extreme behavior in real rocks, but we use this example to emphasize the positive curvature generated by oil-wetness. A saturation exponent $n = 8$ would be needed to try to match the red dots. With the connectivity equation the same exponent $\mu = 1.6$ can be used to match the rock when it is water-wet – with $\chi_w = 0$ – and the same rock rendered strongly oil-wet (red dots) with χ_w +0.07. This 'stability' of the conduc-

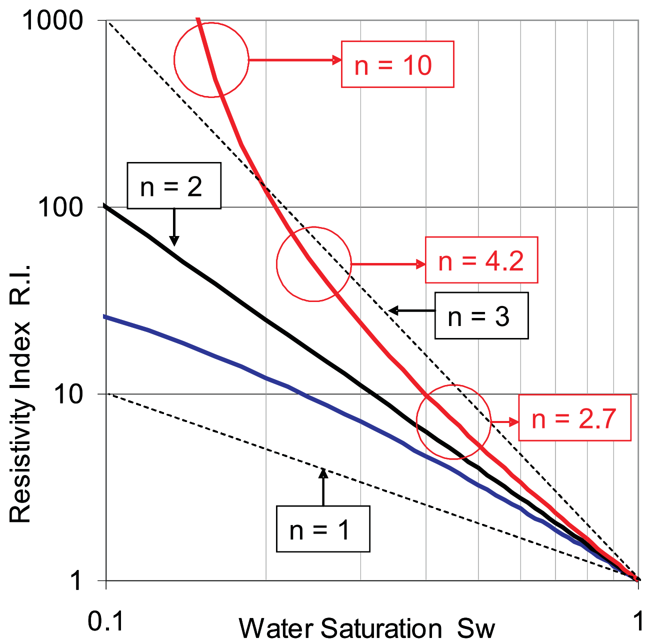

FIG. 1 Resistivity index versus water saturation in log-log scale. The black straight line corresponds to Archie's equation with a saturation exponent of 2. The blue curve is typical of shaly sands. The red curve is characteristic of strongly oil-wet rocks. These curves cannot be modeled with Archie's equation.

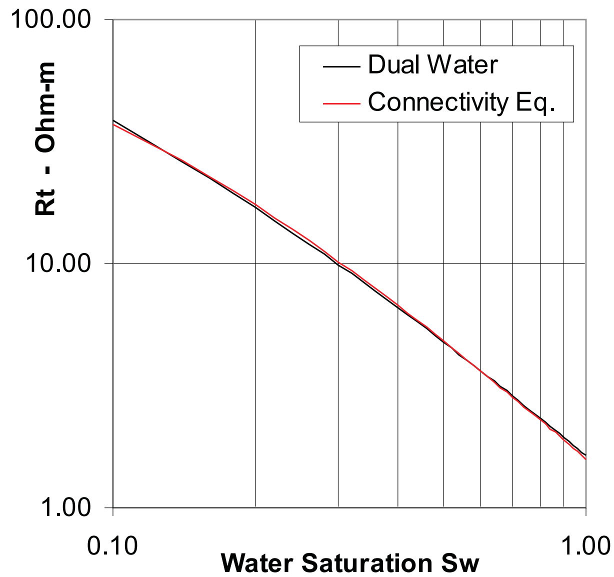

FIG. 2 The black curve is the resistivity versus water saturation for a shaly sand using a data set from Clavier et al. The red curve is the connectivity equation. The match is obtained by adjusting slightly the counterion concentration.

tivity exponent indicates that it is a function of the pore network geometry and not a function of the wettability. This greater stability is also observed in the case of shaly sands similar to what was noted by Clavier et al. in their Dual-Water model.

Finally we finish with the example of mixed-wet carbonate rocks such as found in transition zones (Figure 4). Here large pores are occupied by oil and are oil-wet, while small pores (e.g. less than 3 microns) are water-wet and 100% water filled. The water connectivity in the micritic grains is enhanced by the regular size distribution of small micrite crystals similar to a bead pack. However the oil-wetness of large pores has the opposite effect. The resulting value for the water connectivity index depends on the relative strength of the two opposite connectivity trends. If the micrite content is sufficient it can compensate the oil-wet impaired connectivity effect and the rock may behave exactly as predicted by Archie's equation.

Great progress was achieved with logging technology in the 65 years following Archie's paper, but many questions still remain open in petrophysics and some rocks still keep their secrets ! More research is required on the physics of conductivity of porous media to answer these difficult questions.

REFERENCES

Archie, G. E., 1942, Electrical Resistivity Log as an Aid in Determining Some Reservoir Characteristics: *AIME Trans.*, 146, p. 54–62.

Clavier, C., Coates, G., and Dumanoir, J., 1984, Theoretical and Experimental Bases for the Dual-Water Model for Interpretation of Shaly Sands: *SPE Journal*, April, p. 153–168.

Montaron, B., 2007, A Quantitative Model for the Effect of Wettability on the Conductivity of Porous Rocks: SPE 105041.

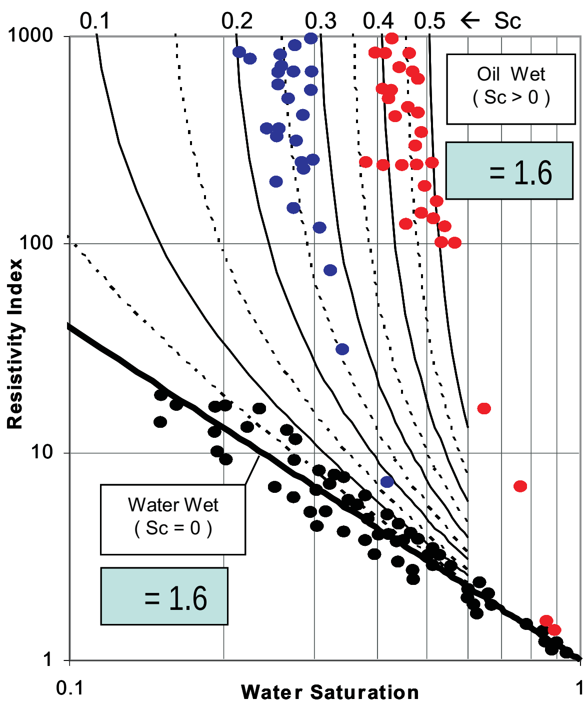

FIG. 3 Carbonate rocks rendered water-wet (black dots) and then strongly oil-wet (blue and red dots) by Sweeney and Jennings. Overlayed is the connectivity equation with increasing positive values of the critical saturation.

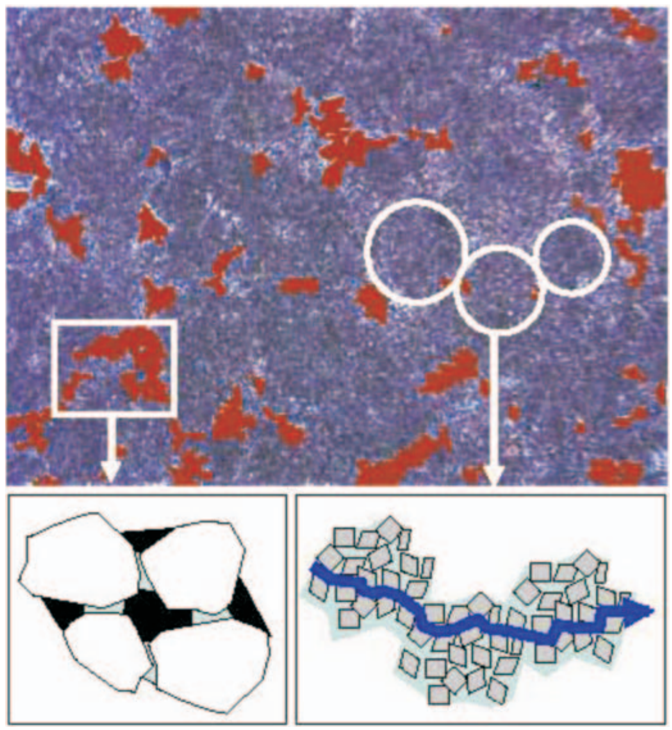

FIG. 4 Thin section of a mixed-wet micritic carbonate from a Middle-East reservoir. The oil shown here in the large pores is fake. Two competing mechanisms are at play here: Enhanced connectivity through water-saturated micritic grains against impaired connectivity due to oil-wetness in large pores.

Sweeney, S.A. and Jennings, H.Y., 1960, The Electrical Resistivity of Preferentially Water-Wet and Preferentially Oil-Wet Carbonate Rock: *Producers Monthly*, vol. 24, no.7, p. 29–32.

Subsurface Formation Evaluation on Mars: Application of Methods from the Oil Patch

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Philippe P. Theys

After drilling is performed vertically, then horizontally, sometimes sideways, to explore Earth in three dimensions, what are the challenges left to the industry? The answer is "Get away from planet Earth". This has already been achieved with some limited exploration on the Moon. The Luna program undertook drilling down to two meters. A more exciting project consists in visiting Mars.

The ability to drill 10- to 100-meter deep wells on Mars would allow for evaluation of shallow subsurface formations enabling the extension of current interpretations of the geologic history of this planet. Subsurface access is likely to provide direct evidence to determine if water or permafrost is present. Water is a common thread intertwined with life, climate and geology. Spacecrafts and down-to-Mars rovers have been able to send pictures that allude to possible erosion, fluid or lava flows.

Methodologies for evaluating sedimentary rocks using drill holes and in situ sample and data acquisition are well developed here on Earth. Existing well log instruments can measure K, Th, and U from natural spectral gamma-ray emission, compressional and shear acoustic velocities, electrical resistivity and dielectric properties, bulk density (Cs^{137} or Co^{60} source), photoelectric absorption of gamma-rays (sensitive to the atomic number), hydrogen index from epithermal and thermal neutron scattering and capture, free hydrogen in water molecules from nuclear magnetic resonance, formation capture cross section, temperature, pressure, and elemental abundances (C, O, Si, Ca, H, Cl, Fe, S, and Gd) using 14 MeV pulsed neutron activation, with more elements possible with supercooled Ge detectors. Additionally, high-resolution well bore images are possible using a variety of optical, electrical, and acoustic imaging tools. In the oil industry, these downhole measurements are integrated to describe potential hydrocarbon reservoir properties: lithology, mineralogy, porosity, depositional environment, sedimentary and structural dip, sedimentary features, fluid type (oil, gas, or water), and fluid amount (i.e., saturation). In many cases it is possible to determine the organic-carbon content of hydrocarbon source rocks from logs (if the total organic carbon content is one weight percent or greater), and more accurate instruments likely could be developed.

Since Martian bore holes will likely be drilled without using opaque drilling fluids (as generally used in terrestrial drilling), additional instruments can be used such as high resolution direct downhole imaging and other surface contact measurements (such as IR spectroscopy and x-ray fluorescence). However, such wells would require modification of some instruments since conventional drilling fluids often provide the coupling of the instrument sensors to the formation (e.g., sonic velocity and galvanic resistivity measurements).

The ability to drill wells on Mars opens up new opportunities for exploration but also introduces additional technical challenges. Currently it is not known if all existing terrestrial logging instruments can be miniaturized sufficiently for a shallow Mars well, but the existing well logging techniques and instruments provide a solid framework on which to build a Martian subsurface evaluation program.

In addition, the mere question of a trade off between robots and human explorers still requires an answer. It has been pointed out that what a rover can survey in a year, a geologist could do in 20 seconds. Sending a geologist to Mars may be a challenge, but if you can ask enough 20-second questions, it might be worth it. But one has to be practical. A human flight to Mars, using conventional chemical fuel, would take a minimum of 21 months, leaving our geologist with a diminished heart and skeleton, which would not survive a return to Earth.

Meanwhile, the technology is closely monitored with NASA attributing TRLs, Technology Readiness Levels to different projects. Drilling arms are able to gently touch Mars at depths between 0 and 1 m. In 2003, drilling went down to 2.7 mm, a distance that would not please a Earth logging engineer paid in line with depth. Augers (Archimedes' screws) seem to be able to go down to 20 m. These techniques are currently being tested on Earth and are likely to be tried by NASA and also by ESA, the European Space Agency.

The History, Contribution and Value Proposition of Logging While Drilling (LWD)

Jeremy (Jez) Lofts: Baker-Hughes INTEQ

In celebration of 80 years of logging, we take a look at the history of Logging While Drilling (LWD). Today LWD is an important method of finding and evaluating reservoirs, although something far from the minds of the first field engineers 80 years ago. We look at its value proposition and the drivers that have led to its creation and implementation. A discussion follows on what we are achieving today while-drilling, as well as a look forward to future implementations and applications.

Since its inception circa 80 years ago, Directional Drilling has seen some key breakthrough technologies that have delivered step changes. From novel borehole surveying and directional drilling techniques in the 30s, to downhole motors in the 40s, to the first commercial Directional MWD and steerable motors in the late 70s, we have seen a movement to the use of the "while drilling" environment to acquire formation evaluation measurements. These have culminated in the recent advent of the Rotary steerables, and a complete slew of advanced Logging While Drilling (LWD) technology.

So what brought on this move to "while drilling", what is its value proposition and how has it affected the logging world?

THE WEDGE

LWD accounted for greater than a third of formation evaluation data acquisition in 2006 and its use continues to grow. More complete suites of measurements are available on LWD and their acceptance continues to grow. This growth has segmented the FE market by fractionating the traditional wireline use (Figure 1). Drivers for continued and unique wireline use include high rig spread costs, where the emphasis is on risk reduction for data acquisition in exploration and appraisal type wells (area 3 Figure 1), and very low spread costs where the emphasis is high efficiency/cost-reduction for data acquisition from land based rigs (area 1). These choices remain primarily in the wireline domain today. The driving "wedge" is the proposition of being able to acquire actionable data in real-time (area 2) where the LWD provides a unique service.

There are two areas (areas 4 and 5) where there is a choice of acquir-

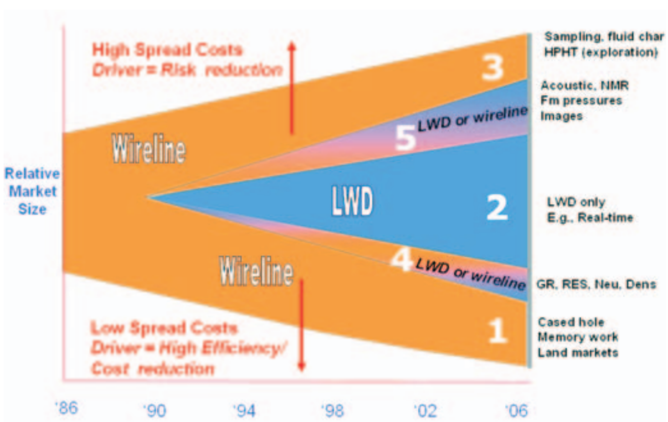

FIG. 1 FE Market Segmentation -- "The Wedge".

ing data either by wireline or LWD. These areas have seen high growth and resulting encroachment on wireline use by LWD at an amazing pace. This results from increasingly deviated development wells, as well as increasing rig spread rates, particularly offshore in development wells. Common data acquisition questions have become, "What is the most cost effective way to acquire data that is needed to fulfill reservoir characterization"? and "Can this be achieved without an increase in data uncertainty, or in fact with reduced uncertainty".

THE VALUE PROPOSITION

The challenges facing operators are many but two key ones are operating expenditures (OPEX) reduction to the reservoir (wells have to be drilled safely. Non productive time (NPT) often at +30% of well cost, has to be reduced) and maximizing net present value (NPV) in the reservoir where positioning the wellbore in reservoir "sweet spots" using all available LWD sensors such that the productivity of the well being determined while the well is being drilled.

This leads to three compelling applications area for LWD in areas 2, 4 and 5:

1. Complement or replace traditional wireline **Formation Evaluation.** Especially attractive on expensive rigs (Deepwater rigs can be more than $700k/day); or in deviated wells or where well conditions are unfavorable for wireline logs; or for confirming a dry well (lack of reservoir) leading to canceling/minimizing further data acquisition.
2. Accurate **Wellbore Placement**. Informed decisions while-drilling and Reservoir Navigation in horizontal and difficult trajectory wells (effective well productive length, sumps, etc.).
3. **Performance Drilling and Safety** in drilling operations to reduce rig days and avoid drilling hazards (a kick on a deepwater well has a minimum associated cost of around US$ 1 million).

These three categories have a degree of time evolution associated with them, originating with attempting "traditional reservoir characterization" or "Formation Evaluation" (complementing or replacing wireline) as an early driver, and more towards today's overwhelming value proposition of being able to achieve the "answers- while-drilling" of area 2, 4 and 5.

CAPABILITY TODAY

LWD sensor technology has accelerated at a pace especially over the last five years. Today, commercial systems can largely collect the petrophysical data sets that are now widely accepted to the extent that some operators have almost eliminated wireline, with the exception fluid sampling. Notable breakthroughs include a true acoustic shear measurement, formation pressure testing, high definition borehole imaging and stable T_1 and T_2 NMR measurements while drilling. Deeper reading (17-20 ft) 'look around' azimuthally sensitive resistivity technology is the latest technology introduction clearly falling in area 2.

GOING FORWARD

Development areas for each of the three proposition categories are not limited to but likely to include:

Traditional Formation Evaluation

- Fluid characterization: Fluid Sampling, downhole fluid characterization. Real-time T_2 NMR.
- Detailed mineralogy to determine production related properties of the rock.
- Highly accurate porosity without radioactive sources.
- Improved interpretation of Petrophysics in horizontal wells.

Wellbore placement

- Very Deep look-ahead/look around for optimum well placement to achieve best production.
- 'Petro-steering' for optimum well placement based on rock property and fluid analysis.
- 'Sedimentary and structural steering' to help steer and stay in the most productive zones.

Performance drilling and safety

- Distributed sensors up the pipe-BHA to monitor changes and optimizing drilling conditions.
- Pore pressure analysis ahead-of-the-bit for kick and fluid loss prevention.
- Geomechanics applications using all of this information for preventing wellbore integrity issues, stuck-pipe NPT and lost-in-hole.

Common technology development/innovation themes across these three categories will include:

- Improved tool reliability for better NPT.
- Higher temperature capabilities.
- Depth/positioning accuracy for placing completions, stimulations and workovers, and improved reserves assessment.
- Data transmission (bandwidth) rates while-drilling for optimum real-time information; using improved and new technologies such as wired drill pipe (Reeves et al., 2006, Manning et al., 2007).
- Keeping the measurements (sensors) as close-to-the-bit end of the BHA as possible for the earliest possible drilling and reservoir information.

ANSWERS WHILE DRILLING

Data bandwidth is at the edge of a paradigm change, with improvements to both conventional mud pulse telemetry and with also the introduction of 'wired pipe'. Future LWD application will adopt this bandwidth like internet users adopted broad band for high speed media applications.

Any vision going forward has to include these telemetry advances, as well as the ability to incorporate and integrate advanced LWD sensors with next-generation drilling systems. Resulting applications may include perhaps smart look-ahead systems that will allow safe automated drilling, accurate well landing, and increased reservoir exposure, all while being able to fully interpret petrophysical data in the horizontal environment, something (as an aside) we still aspire to today.

REFERENCES

Reeves, M., Macpherson, J., Zaeper, R., Bert, D., Shursen, J., Armagost, K., Pixton, D., Hernandez, M., 2006, High-Speed Drillstring Telemetry Network Enables New Real-time Drilling and Measurement Technologies, paper IADC/SPE 99134, presented at the IADC/SPE Drilling Conference, Miami, Florida.

Manning *et al.*, 2007, Processing Wired Pipe LWD-FE Data in Real Time – Experiences and Lessons Learned, paper MMM, in 48th Annual Logging Symposium Transactions: Society of Petrophysics and Well Log Analysts.

New Hydrogeophysical Sensors for Salt-Water Intrusion in Coastal Aquifers

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The **ALIANCE** European research program ended in 2005, after four years aimed at improving the hydrogeophysical characterization and monitoring of coastal aquifers for vulnerability assessment. **ALIANCE** has developed and tested a set of new down-hole approaches for a quantitative evaluation of brine intrusion. At end-member sites in terms of hydrogeological behavior, this includes state-of-the-art geological, geochemical, petrophysical, logging and hydrological investigations, and the design of new geophysical and hydrodynamical logging/testing and monitoring sensors that yield new data for model validation.

The new down-hole hydrogeophysical sensors include new sources for hydrodynamical in-situ testing, and new borehole geophysical tools for crosswell experiments. Examples of these new tools are the "Controlled Fluid Injection System" (**CoFIS**) for controlled fluid injection in terms of either pressure, flow rate, fluorescine content or salinity, or the "Multi Sensor Electrical Tool " (**MuSET**) for measurement of down-hole electrical spontaneous potential (SP) in conjunction with fluid pressure, temperature, pH and electrical conductivity. These tools were tested at the new experimental sites developed within ALIANCE. Active in-situ tests from short and longer-term injections with variable salinity fluids to simulate overdrafting or saline water intrusion were conducted.

A new downhole method for long-term monitoring and brine intrusion prevention was also developed and tested with success in the field. The principle of the observatory is based on the electrical probing of the subsurface. Deployed in June 2004, it has been functioning on a daily basis since April 2004. In the near future, such an observatory might be placed at the center of a retroactive loop for decision making applied to water abstraction in coastal aquifers.

Acquisition of Multi-Offset Oriented Three and Four Component VSP for Seismic Imaging of Faults in the Deep Geothermal Granite Basement Reservoir of Soultz

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A. Gérard, N. Cuenot, J. Place:, EEIG-Soultz
Maria del Mar: MESA SALGADO, Gaz de France

One of the most important problems encountered in geothermal site development is the understanding and detection of the fluid-flow path within the reservoir surrounding the wells and between wells. Since reflection surface seismic methods are unable to image subsurface structures within the crystalline basement, the borehole seismic techniques constitute an attractive way to collect spatial information about the major and potentially permeable structures in the vicinity of the development wells drilled in Soultz, Alsace, eastern France.

As the processing results of a VSP recorded in 1993 in the old 3500 m deep GPK-1 well intersecting a confirmed permeable fault evidenced a genuine converted P-S reflection at the same depth, the authors felt confident for recording a heavy multi-offset/multi-azimuth VSP campaign in the spring of 2007, with the aim to illuminate the full vicinity of the 5 km deep deviated wells GPK-3 and GPK-4 drilled from the same cluster platform. The present paper emphasizes on the following points:

- Motivation behind the choice of the VSP method for seismic exploration of the well vicinity up to several hundreds of meter away from the wells.
- Specific VSP acquisition planning, taking in account that no rig was present, the boreholes could be accessible for a one month period, and night work was excluded, within fixed budget limits.
- Acquisition disposal and field operations: double borehole operation, field equipment, including the 200°C temperature rated analog VSP tool equipped with three component gimballed geophones and a HT hydrophone, and simultaneous Vibroseis recording technique used to maximize production.
- Description of pre-processing operations and preliminary results.

Towards 4th Generation Nuclear Reactors

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Why do we need a 4th generation of nuclear reactors? While the world faces fossil resources shortage and global warming, nuclear energy is an attractive solution implemented in France through Pressurized Water Reactors (2nd generation), providing the country with a high level of energetic independence today. The 3rd generation reactors, with the EPR concept developed in France, should guarantee energy supply for several decades.

So why go further? For the long term, many published scenarios predict at the planetary scale a substantial increase of the energy needs with subsequent increase of the nuclear share in the energy mix, while fossil resources would stabilize or even decline. The IAE-2003 postulates such an increase for nuclear energy from 370 GWe today to 1500 GWe by 2050. In a perspective of sustainability, new reactor designs must be contemplated in order to optimize uranium usage and further minimize the quantity and toxicity of nuclear waste.

Several options are competing on the international scene. The Generation IV International Forum (GIF), initiated in 2000 by the USA, gave initial impetus to the development of this new generation of nuclear reactors. At the beginning, ten countries declared their interest to the GIF; USA, UK, France, Switzerland, Japan, Korea, South Africa, Argentina, Brazil. Under the banner of Euratom, European community countries soon contributed to the definition of the best technologies to be deployed by 2040. Russia and China became partners in GIF in 2006. The major challenge of the management of nuclear fuel was early recognized by GIF and led to the consideration of the 4th generation reactors as nuclear "systems" (reactor, fuel and fuel cycle) to be optimized as a whole.

The French strategy, shared by the CEA (Commissariat à l'Energie Atomique) and its industrial partners EDF (Electricite de France) and AREVA, gives first priority to fast neutron reactors with two promising candidates, the Sodium-cooled Fast Reactor (SFR) and the Gas-cooled Fast Reactor (GFR). The presidential declaration beginning of January 2006 and the bill on waste management of June 2006 are in agreement to promote the construction of a 4th generation prototype to be operated by 2020 in France. The SFR has been chosen as the reference technology (Figure 1), in consideration of the large existing experience. The GFR is considered a promising alternative track to the SFR. The attractiveness of the GFR relies on the benefits from helium as a coolant with the potential for high temperature applications. A common advantage fo the SFR and GFR approaches is their potential as fast neutron systems for nuclear waste (with an integrated recycling of actinides).

In addition to its drive to implement the fast neutron reactor strategy,

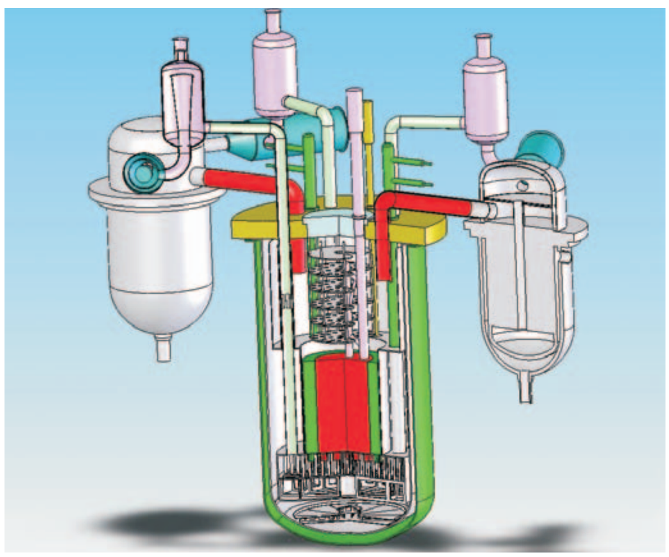

FIG. 1 SFR loop-type modular concept (500 MWe) with gas conversion system

CEA brings a continuous support to AREVA for the development of the HTR/VHTR system, that is a thermal neutron reactor operating at high, or very high temperature (between 850°C and 1050°C, equivalent to 1500°F to 1900°F). The interest to HTR/VHTR is essentially driven by its potential for a large scope of process heat applications ranging from low to very high temperature, such as water desalination, production of hydrogen or synthetic fuels, and possibly other industrial applications like oil refining and shale oil and tertiary oil recovery. ANTARES (600 MW, 850°C) is the HTR/VHTR concept promoted by AREVA (Figure 2).

In order to take the right decisions, an innovative R&D program has been undertaken to identify the technologies, equipment and design options enabling the conformance to the specifications set for 4th generation systems. In the long term, demonstration or prototype reactors are scheduled to validate at the realistic scale the options that are eventually selected. This matches the French President decision to complete a 4th generation reactor prototype before 2020.

With the decision to complete ITER in France in a large international partnership, controlled fusion is confirmed as another avenue in the nuclear-derived energy production. Fission and fusion do not compete, but can be understood as a two-face long term strategy to meet the ever-increasing energy needs of the world.

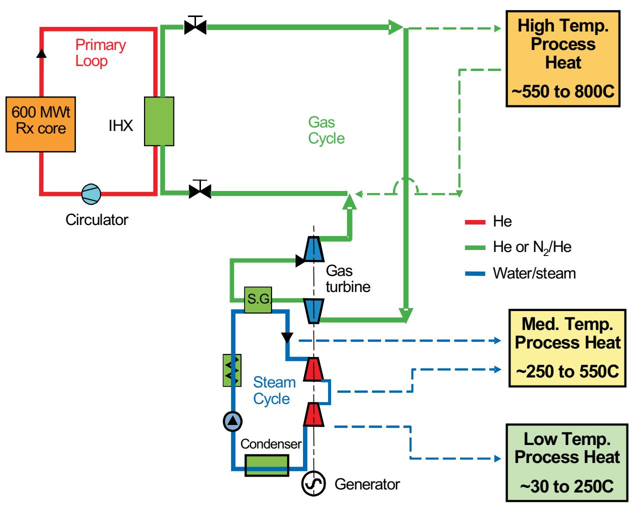

FIG. 2 AREVA's ANTARES VHTR concept (600 MW, 850°C)

A Selective Neural Network Ensemble for rhe Estimation of Porosity

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A single neural network model may encounter the problem of robustness and lack of generalization because of restricted accessibility and the unevenness of the training for porosity estimation. Neural network ensembles have been used increasingly in recent years to improve the ability to generalize estimates of petrophysical properties. A neural network ensemble is generated by training component neural networks for a same task and then combining their predictions. We introduce a selective neural network ensemble that uses only some of the component neural networks instead of using all of the component neural networks. In this approach, each neural network is assigned a weight computed by a genetic algorithm. This weight describes the likelihood of each network being included in the ensemble. Neural networks that have weights larger than a predefined threshold are then chosen to join the ensemble. Executing the proposed method and testing the results are discussed through case study. Compared with a single neural network, the selective neural network ensemble is more robust in estimating porosity from only gamma ray and sonic well logs. The method developed from this study has the potential to be used in other applications.

A Genetic Algorithm Optimized Fuzzy Approach for Classifying Porosity Types

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Intelligent computing approaches are frequently used to interpret well logging data. This is mainly due to the need to process well logs where complete data and information, (e.g. core data) do not exist. We use fuzzy logic for the task of classifying the porosity types by exploiting the well log data of the studied field located in the Iranian offshore of Persian Gulf. The classification of porosity types is based upon the pre-established classification of log data from two wells into primary, cavernous and micro-fractures porosity classes. Each fuzzy class defined is considered as a union of several fuzzy sets, such that each set is also achieved by the intersection of correspondent membership functions. We define a classification that is used by a genetic algorithm in order to optimize it. The analysis of the obtained results shows that the fuzzy logic approach optimized by genetic algorithm we developed can compensate for the absence of exact information with preserving the precision of data analysis and decreasing costs at the same time.