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Real time fluid imaging with an integrated single well seismic/EM system

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Abstract:
The DeepLook consortium of oil companies (bp, Conoco, Chevron, Texaco, Shell) has put forth the vision to improve recovery factor from below 35% to about 70% in the next decade. To achieve that numerous technologies including downhole sensors, surface sensors, integration and modeling are needed. Here we focus on integrating downhole measurements for fluid typing and structural definition, namely electromagnetics and seismics.

Borehole seismics has made progress that single well systems are now commercially available. The key issues in terms of modeling and acquisition have been resolved or a path forward defined. Borehole electromagnetic methods have been used in the mining industry very successfully, in the oil industry technological hurdles as well system limitation such as depth of investigation and vertical resolution have to resolved. Progress in technology in recent years allows us for the first time to address this problem and integrate an electromagnetic system with a seismic system.

Introduction:
The DeepLook consortium was formed to identify technology that would significa ntly improve the recovery factor of the oil industry and set a technological goal for a long time to come. Members are bp, Chevron, Conoco, Shell and Texaco. One of its objectives is to identify 'sweet spots' away from the wellbore. Figure 1 show an example of the translation of these objectives to map a hydrocarbon volume in commercial quantities up to 200 m away from the well bore. The reservoir to be mapped extends for about 200 m but is only 10 m thick. The problem on hand is to measure the reservoir fl uid properties and to monitor fluid movements within the reservoir. In addition the requirements include the prediction of (rock) properties between 10 to 200 m from existing wells.

In order to achieve these objectives one can use technology from inside a borehole and monitor changes in the reservoir with time or develop new technologies, which allow direct determination the physical parameters. A way to measure the technology is to look at the recovery factor, which is for many wells below 35% as indicate d in Figure2. The DeepLook consortium has the Mission in this to spawn projects and nurture them to a point when commercial interests take over the funding. For the single well seismic/electromagnetic project DeepLook is funding the conceptual design and setting up of an industrial consortium. In the case of this project, we selected to address the DeepLook objectives with a single well seismic and electromagnetics system. This selection is based on their track record in borehole applications of defining

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structural changes with high accuracy with seismic and fluid change with electromagnetic measurements,

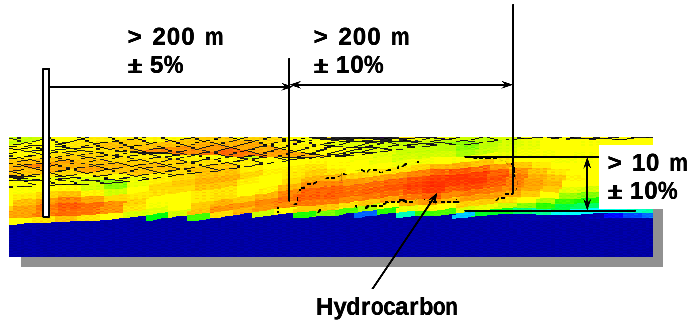

Figure 1: Illustration of the DeepLook consortium objective to map a reservoir up to 200 m away from the wellbore including its fluid properties and fluid movements (After DeepLook website www.DeepLook.com).

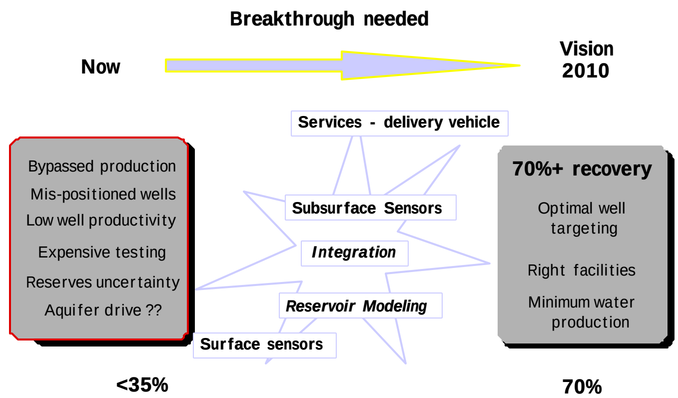

Figure 2: Overview of today's status and future target, which require Breakthrough technologies (After DeepLook website www.DeepLook.com).

Problem description:

While the general objective is to look directional away from the wellbore, it is important to focus specific technologies on specific high value problems. In cooperation with the DeepLook members several classes of problems were derived. Some of them are displayed in Figure 3. The first class concerns structural and stratigraphic problems mainly associated with exploration and appraisal of a reservoir. We are looking at salt 'blanket' layers masking the sediments below on the left and salt domes structures on the right. In the center of the diagram a typical crosswell (or single well) scenario is shown where porosity changes are to be mapped away from the wellbore. The second

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class in the diagram is related to production issues where water flooding and water coning extend is to be determined. The third class of problems is related to deep geosteering applications where the boundary of oil-water contact and oil-gas contact needs to be defined.

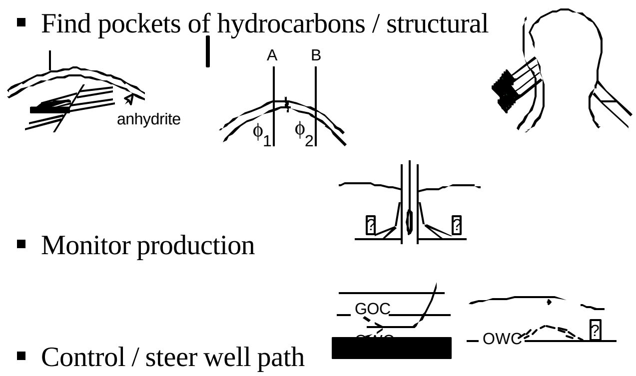

Figure 3: Example of some classes of high value problems for deep reading devices.

If one can address the issue of reading away from the wellbore with sufficient volume resolution capability, chances are high that one can address several of these problems.

The System

In designing a system one needs to have already the deliveryvehicle in mind. Borehole information is usually acquired either in LWD (Logging While Drilling) mode, wireline mode or as borehole seismics. Any new technology will be easier deployed if integrated into these standard technologies. In recent year a new b orehole seismic system has appeared on the market: single well seismic. It has shown already very promising results and since it operated from the same well bore its volume of investigation is very similar to the one an electromagnetic system would cover (Majer et al., 1997; Ziolkowski, 1999). A schematic of the system is show in Figure 4. using the seismic backbone additional electromagnetic transmitters and receivers can be added. This will allow us to sense the fluid parameters in addition to deriving the structure from the seismic data.

As part of the vision of the expected results we are comparing the new integrated system with some a modeling experiments done earlier (Strack, 1992). Figure 5 shows the results of the experimental. The diagrams show at the top on the left and right a reservoir cross-section with porosity changes from 5% to 30% at depth in steps of 5%. On the left side the synthetic data calculated from the reservoir model was used as input in an inversion process. The synthetic logs from the section were uses as starting models and the inversion was run in unsupervised and unconstrained mode. The left column shows the results obtained when using the starting model from the well on the left side of the section and the right column came from the right well as starting model, respectively. The different simulations are for different electromagnetic methods. Note that both columns resemble more the starting model than the original reservoir model. On the right side of the diagram the structural information has been constrain using seismic data. Otherwise the inversion was carried out in the same fashion. Clearly, two of the three different acquisition options allow us to define the resistivity and thus porosity changes in the reservoir. This clearly indicates the synergy obtained when combining seismic and electromagnetics. Other combination examples can be found in Strack and Vozoff (1996).

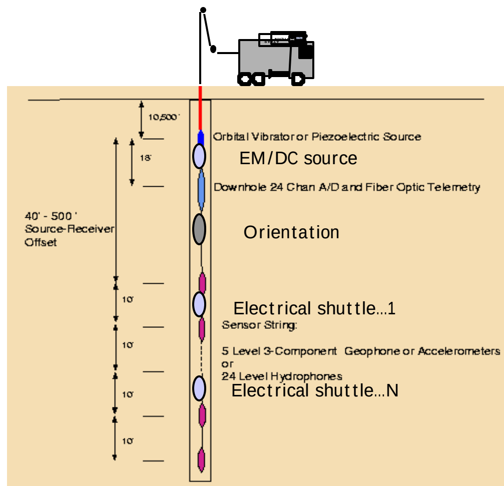

Figure 4: Schematic of the LBL single well seismic system with the added electromagnetic modules for the future integrated seismic/EM system.

Outlook:

We consider the integration of seismic and electromagnetics feasible for a borehole system. Presently, efforts are underway to define the details of the system and to continue the demonstration to a level of a field test. Value evaluations from the DeepLook consortium have shown that if successful this has a high potential to add significant value to the industry by allowing to delineation additional reserves in existing fields.

While the initial prototype is only for demonstration of the concept during all phases we will select technologies that can be automated along the path to an LWD version of the tool.

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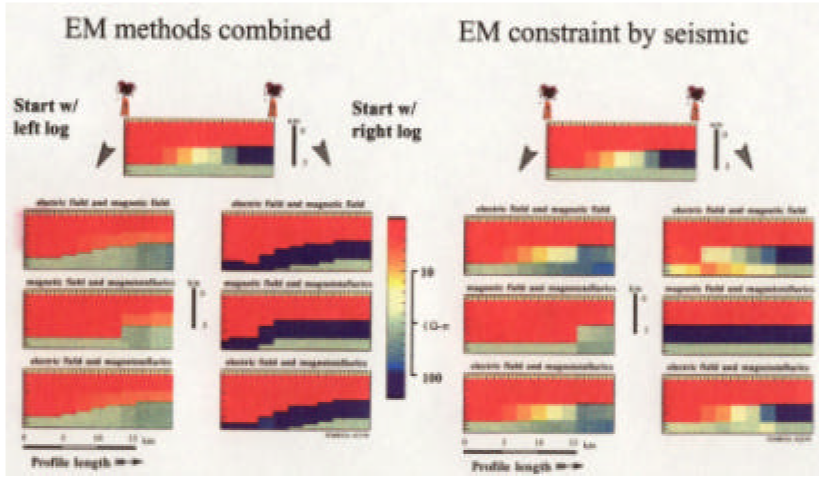

Figure 5: Modeling experiment to simulate the synergy obtained by combining seismic and electromagnetics. At the top is the resistivity section for the reservoir. Below are two set on simulation results: On the left the results for different electromagnetic data set and inverting the data with the well logs as starting model. On the right the geometry boundary have been fixed from seismic data.

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References:

DeepLook website: www.DeepLook.com

Majer, E.L., Peterson, J.-E., Daley, T., Kaelin, B., Myer, L., Queen, J., D'Onfro, P. and Rizer, W., 1997, Fracture detection using crosswell and single well surveys, Geophysics 62, 495-504.

Strack, K.-M., 1992, Exploration with deep transient electromagnetics, Elsevier, 373 pp. (reprinted 1999)

Strack, K.-M., Vozoff, K., 1996, Integrating long-offset transient electromagnetics (LOTEM) with seismics in an exploration environment, Geophysical Prospecting 44,99-101.

Ziolkowski, A., 1999, Multiwell imaging of reservoir fluids, The Leading Edge 18, 1371-1376.

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