# Application of Seismic Technology to Develop Hydrogeological Model in Petrel – The Alberta Application

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The rapid and intensive development of Alberta's energy resources is placing pressure on our provinces existing water resources. Under current available technologies, recovery of heavy oils from oil sands requires in the order of 3 barrels of water for each barrel of heavy oil produced. In addition, in order to avoid potential conflict with existing groundwater users and public policy, groundwater resource evaluation is being conducted at depths that extend beyond the capability of classical hydrogeological tools. As a result of this pressure to maximize utilization of our groundwater resources on a regional basis, technologies previously discounted by the scientific community as being un-usable have been found to be usable in the development of water sources for SAGD and other heavy oil developments. These technologies, become powerful tools in the hands of hydrogeologist when coupled with Advanced Hydrogeological tools such as Petrel H20.

Seismic is an established tool in the exploration in the oil and gas business. Introduced to the energy sector as an exploration tool in the 1950s, seismic technology has undergone continual improvement in both data acquisition and processing and today is a mainstay technology in energy exploration and development Attempts to apply seismic technology has limited results due to cost and limited resolving ability.

Early attempts to use seismic technology in Alberta to map shallow hydrogeological features has met with limited success. As a result, other geophysical methods such as resistivity are more commonly used by hydrogeologists to map subsurface features.

A recent case study regarding the use of seismic for hydrogeogical exploration and evaluation on a SAGD project in Western Canada is discussed. On this project, seismic was run for purely reservoir characterization purposes. The seismic data was looked at later in the process of preparing the application, and has been effectively used to map pre-glacial channels that are incised into bedrock surface. These channels play an important role in the hydrogeological setting, and need to be recognized and defined as early as possible in the project development process. Seismic reflectors in Quaternary were very well defined over local areas; able to identify channel-like features running for miles.

Features seen in 3D are smaller in scale than the well spacing in the area—so not predictable from well information alone.

Conclusions reached in this paper include:

- Siesmic data can be used cost effectively integrated into the definition of the hydrogeological regime on projects such as SAGD.
- The definition of hydrogeolgical features such as channel aguifers can dramatically influence development planning of SAGD projects, therefore it is important that the seismic data be integrated early in the project history.
- Digital Oilfield data is most effectively integrated into the hydrogeological model using a more powerful computer package such as PETREL as opposed to Visual ModFlow
- More effective use of the seismic technology can be made if there is recognition at the planning stage that the results will be used for hydrogeological characterization as well as reservoir characterization.
- Much of the cost associated with seismic acquisition and processing will already have been spent as part of the oilsand development. Aquifer modeling can benefit from the use of much higher cost data than would otherwise be available.
- Extensive 3D coverage. Over prospective reservoirs, acquiring 3D seismic is the norm.. The 3D parameters used to optimize resolution in the oilsand units also apply to a great extend to aquifer units above the target reservoir
- Improved vertical and horizontal resolution. Ability to provide information on a scale as thin as 1 meter (vertically) and as small as 5 meters (horizontally)
- Seismic processing techniques are much more sophisticated: AVO, spectral decomposition, attribute calculation, etc. are potentially applicable to the aquifer units.

- Technology in real time. Most seismic interpretation and much of the processing techniques are run at the interpreter's computer. Speed and power of computers let the interpreter run many "what if" analysis.
- Higher frequency content. Shallower seismic surveys typically have better preservation of high frequencies in seismic traces. Higher frequencies translate into thinner bed resolution.
- Taken together, these improvements will identify horizons in shallower depths and with better vertical and horizontal resolution than ever before.
- Improved seismic velocity estimation and inversion. Used to identify location of aquifers and breakdown major facies accumulations (sand, shale) within an aquifer.
- Calibration to other datasets. Oilsands developments have large ancillary datasets that improve the accuracy of seismic interpretations, reducing risk and uncertainty.

Given this successful application, can we then correlate zones of high porosity on wireline logs to zones of high porosity and permeability as identified from the seismic data in the Clearwater and Grand Rapids Aquifers? Are heterogeneities in the hydraulic

conductivity in these Cretaceous units identifiable as mapable units from the seismic? While there is not a definitive answer to this question, one can easily make the mental extrapolation that if reservoir characteristics of bitumen bearing formations can be mapped and determined from a combination of petrophysics and seismic data integrated through the application of Petrel computer technology, then aquifer characteristics can similarly be interpolated and built into a regional static model (conceptual hydroeological model)

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Ken Campbell is a Senior Hydrogeologist in Schlumberger Water Services. Ken began his career in hydrogeology more than 35 years ago at the Research Council of Alberta. His subsequent career path has included a wide variety of hydrogeologic projects, such as groundwater supply programs, regional hydrogeological mapping, mine dewatering, environmental impact studies, groundwater contamination investigations and remediation. His experience encompasses all aspects of consulting; including project management, senior technical review, regional and site investigations, design and implementation, liaison with clients and regulatory agencies, participation in public meetings, hearings, and reporting. Ken's Canadian projects have been located in Alberta, British Columbia, Saskatchewan, Manitoba, and the Yukon. His international experience includes projects in India, Vietnam, Sultanate of Oman, El Salvador, Chile, Peru, and more than 150 projects in the United States.

Supplementing his project experience, Ken has participated in a variety of groundwater-related initiatives; including the Alberta Water For Life Initiative, Alberta Hazardous Chemical Advisory Committee, Alberta Groundwater Allocation Policy, and participated as Senior Scientist on the Acid Deposition Research Project