

The Changing Role of Water in the Petroleum Geologist's "Unconventional" World

Brad J. Hayes, Petrel Robertson Consulting Ltd., Calgary, Alberta
bhayes@petrelrob.com

Summary

When most of us started our careers as petroleum geologists, we explored for oil and gas while doing our best to avoid finding water. Now, in a world dominated by unconventional plays, water is a critical element of every successful project, and we must devote as much effort to securing water supplies and disposal zones as we do to developing and drilling our oil and gas plays.

The "Good Old Days" of Petroleum Exploration

Before the late 1970's, petroleum geologists explored for and developed oil and gas fields using tried-and-true methods. Oil and gas was found in structural or stratigraphic traps, usually lying above water. We spent a great deal of effort in mapping those traps, assessing the reservoir quality, ensuring the adequacy of the seal, and checking that source rocks and migration pathways were in place. We drilled vertical wells to penetrate thick oil and gas columns, which we could complete for high flow rates. If we hit water, some element of our prospecting had failed, and our water well was a "dry" hole.

As the 1980's rolled around, basin-centred oil and gas accumulations (the Deep Basin) became increasingly important. We still wanted to avoid discovering water, but we did so by drilling in a hydrocarbon-saturated regime where there was no free-flowing formation water. Conventional plays were still important, and we became more adept at avoiding water in those plays by using 3D seismic, and by drilling early-generation horizontal wells targeted to avoid underlying water zones.

Dealing with water during these times was becoming more important, but primarily in re-injection of produced waters to maintain reservoir pressure, or in implementing waterfloods to maximize oil recoveries. Important stuff, but the engineers could handle it.

The "Unconventional" World – Where Water is an Essential Play Element

The evolution of horizontal drilling and multi-frac stimulation technology beginning in the early 2000's made oil and gas production possible from low-permeability reservoirs, including shales. Subsurface thermal technologies were also evolving, allowing economic extraction of bitumen from sandstone and carbonate reservoirs too deep to access by surface mining. Huge new petroleum resources thus became available, and petroleum geologists had to update their thinking and skill sets to find and develop them.

With all this, the role of water hadn't changed much in finding and delineating unconventional hydrocarbons. Most tight gas and oil plays are in hydrocarbon-saturated regimes, and water production is generally not a major concern. Water zones in bitumen reservoirs are an operational concern, but generally must be avoided as we avoid them in conventional plays.

The big change is that now we need water to make unconventional plays go. Tight oil and gas plays need multi-frac stimulations to induce sufficient permeability to support economic flow rates and recoveries. Large volumes of water are consumed in stimulating each wellbore, and there are many wellbores required to develop a regionally-extensive tight play. In bitumen plays, bitumen must be heated to reduce viscosity to the point that it can flow from a wellbore. This is accomplished in most projects by using the SAGD (steam-assisted gravity drainage) or CSS (cyclic steam stimulation) processes, which inject up to three or more barrels of water in the form of steam to produce a barrel of bitumen.

Water disposal is also increasingly important. Spent frac fluids, limited amounts of formation water, and condensed steam are produced with the hydrocarbons, and much can be recycled. Some must be disposed, however, and in a manner that does not endanger the environment.

What does this mean for the petroleum geologist? In the early days of these projects, these were simply operations issues – finding water of sufficient quality and in sufficient quantities was relatively easy. Only limited quantities were needed, and surface waters or shallow aquifers were adequate in most cases. As more projects come on stream and existing projects move into large-scale production mode, water demands have escalated, and operations people are looking to geologists to find more water. Surface and shallow water is often not the answer – supplies are limited and other stakeholders are concerned about their water supply and quality. Water disposal is best accomplished in deep saline aquifers, and with increasing volumes to handle, petroleum geologists must find sufficient deep saline aquifer capacity.

Finding Adequate Water Supplies and Disposal Zones

Water supplies and disposal have become key considerations for the petroleum geologist in evaluating and developing unconventional plays. What are the potential water sources at the surface, in shallow aquifers, and in deep saline aquifers? How much is available, what is the quality, and how do we transport it to the wellsite and make it suitable for use in frac fluids or steam generation? How will use of these waters affect other stakeholders in the area? Where are the deep saline aquifers to accept waste water, and how do we develop them?

Surface water specialists, Quaternary geologists, and hydrogeologists can provide insights on surface and shallow waters. Locating and characterizing adequate supplies and planning for their exploitation on the scale required for unconventional development is an evolving skill set, however, and a major operational issue in most projects. Deep saline aquifers are increasingly being seen as an excellent alternative water source, and petroleum geologists and reservoir engineers possess most of the skills required to map and characterize them – it's really not too different from exploring for conventional oil and gas! Much of this same mapping and characterization serves to support delineation of deep disposal sites as well.

Major operators have recognized these issues for several years, and are addressing water supply issues on both project-specific and regional scales. The Horn River Basin Producer's Group commissioned Geoscience BC in 2009 to map and characterize deep saline aquifers in the Horn River Basin. Today, the most intensive shale gas development centres around the Encana/Apache water facility. It extracts most of the water needed for fracs from the deep saline Debolt Formation, which was identified in the Geoscience BC project. Development is proceeding more slowly elsewhere in the basin where the Debolt aquifer is of poorer quality.

In the Montney play fairway of northeastern B.C., producers are using a number of different water sources, including local surface waters, pipelines from Williston Lake, treated waste water from Dawson Creek city, and deep saline water from the Peace River Formation. Producers are being guided by the

Montney Water Project sponsored by Geoscience BC, which characterized surface, shallow, and deep saline waters across the entire play fairway.

What's Next?

As new unconventional plays are identified and explored, petroleum geologists consider water sourcing and disposal as a key play element and cost component. Individual companies, groups of companies, and government agencies recognize the importance of water in unconventional play development and are moving proactively.

Systematic study of potential water resources are undertaken very early in the exploration process – sometimes before the first wells are drilled. The Northwest Territories Geoscience Office has commissioned regional deep saline aquifer characterization projects in both the Central Mackenzie Valley, where the Canol Shale is now being drilled, and in Deh Cho territory to the south, where unconventional exploration has not yet taken place. In west-central Alberta, a group of eight exploration companies and PTAC are sponsoring a regional examination of surface waters and shallow and deep aquifers to guide them in accessing water supplies and disposal zones in the Montney and Duvernay play fairways.

In the past, petroleum geologists needed to understand source, migration, trap and seal. Now, we also need to have a much more fundamental understanding of disciplines such as geochemistry, rock mechanics, and fluid properties. We must also develop a deep appreciation for water, as it is becoming as important to oil and gas production as the hydrocarbons themselves.

Acknowledgements

My thanks to Mark Rabin for inviting and inspiring me to make this presentation.

References

- Hayes, B.J.R. and Dunn, J., 2012. Deep subsurface saline aquifer characterization, Central Mackenzie Valley, Northwest Territories. NWT Open File 2012-07.
- Hayes, B.J.R. and Stewart, R., in press. Deep subsurface saline aquifer characterization, Deh Cho Territory, Northwest Territories. NWT Open File.
- Hickin, A.S., 2011. Preliminary bedrock topography and drift thickness of the Montney play area. Geoscience BC Report 2011-7.
- Petrel Robertson Consulting Ltd., 2010. Horn River Basin aquifer characterization geological report. Geoscience BC Report 2010-11.
- Petrel Robertson Consulting Ltd., 2011. Deep subsurface aquifer characterization in support of Montney tight gas development: geological report (NTS 93O, 93P, 94A, 94B, 94G & 94H). Geoscience BC Report 2011-11.