Water Distribution in the Montney Tight Gas Play: Insights from Integrated Analysis of Core and Log Data

James M. Wood, Encana Corporation, Calgary, Alberta, Canada
james.wood@encana.com

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Introduction

Water distribution is a key parameter that influences many aspects of resource development in the Triassic Montney tight gas play of NE British Columbia and NW Alberta. Integration of bulk volume water data acquired from preserved, oil-based cores with other core and log data has led to new insights on water distribution in the Montney Formation.

Bulk Volume Water Distribution

Water saturations and porosities obtained from full-diameter, oil-based core samples show that Lower Montney cores and Upper Montney cores have different bulk volume water (BVW) characteristics. BVW is less than 1% in Lower Montney cores and shows little variation with porosity (Figure 1). BVW is commonly 1 to 3% in Upper Montney cores and shows a positive correlation with porosity (Figure 2). These relationships of BVW to porosity indicate that Lower Montney rocks are at irreducible water saturation whereas Upper Montney rocks commonly contain water exceeding irreducible water saturation (mobile water).

The different BVW characteristics of the Lower and Upper Montney sections reflect, in part, how effectively water was swept up-dip through tight siltstones of the Montney Formation during expansion of the basin-centered gas accumulation (cf. Burnie et al., 2008). Low-angle clinoforms with few shaly zones allowed a "clean sweep" of mobile water from the Lower Montney section resulting in irreducible water saturations. Higher-angle clinoforms with common shaly zones impeded the up-dip sweep of water from the Upper Montney section resulting in residual mobile water.

BVW within Upper Montney clinoforms is influenced by depositional fabric: strongly bioturbated rocks generally have higher water saturation than laminated rocks of similar porosity. Water saturation can vary systematically both vertically and laterally (proximal to distal) within some Upper Montney clinoforms due to relatively simple trends in shoreface deposition. In other clinoforms water saturation variation is more complex due to influences on deposition such as paleostructure and proximity to point sources that supplied sediment to the shoreface.

BVW–Resistivity Relationship

Deep resistivity values from logs show a good correlation with BVW from cores (Figure 3; R^2 = 0.70 for raw unedited data) implying electrical conductivity is directly related to the volume of water in the formation. This relationship is attributed to the presence of hypersaline formation water (20 to 25% salinity) in relatively homogeneous rock with restricted size range of grains (medium to coarse silt), pores and pore throats. BVW derived directly from log resistivity can be divided by porosity to estimate water saturation. This simple water saturation calculation provides an alternative to the traditional

Archie method and has been found to give reliable results over a wide area of the Montney tight gas fairway.

Effective Gas Permeability

A method for determining effective gas permeability was developed by combining relationships of (1) absolute permeability to porosity and (2) gas relative permeability to water saturation. Both of these relationships were determined from net overburden (NOB) core data at confining pressures equivalent to reservoir conditions. Encana's experience has shown that effective gas permeability logs are essential for selecting target zones for horizontal wells. Effective gas permeability lines can be added to a Pickett plot (resistivity-porosity log-log plot) to provide an effective tool for comparing reservoir quality of different Montney zones.

Implications for Resource Development

Accurately determining the distribution of water in the Montney Formation is crucial for many aspects of resource development including selection of geographic areas for development with capital intensive multi-well programs, selection of target zones for horizontal wells, calculating reserves, estimating permeability and understanding variability in production of gas and water. The cost of focused coring programs is a prudent investment given the capital required for full-scale development.

Reference

Burnie Sr., S. W., B. Maini, B. R. Palmer, and K. Rakhit, 2008, Experimental and empirical observations supporting a capillary model involving gas generation, migration, and seal leakage for the origin and occurrence of regional gasifers, in S. P. Cumella, K. W. Shanley, and W. K. Camp, eds., Understanding, exploring, and developing tight-gas sands— 2005 Vail Hedberg Conference: AAPG Hedberg Series, no. 3, p. 29– 48.

Figure 1: Lower Montney porosity-bulk volume water scatter chart

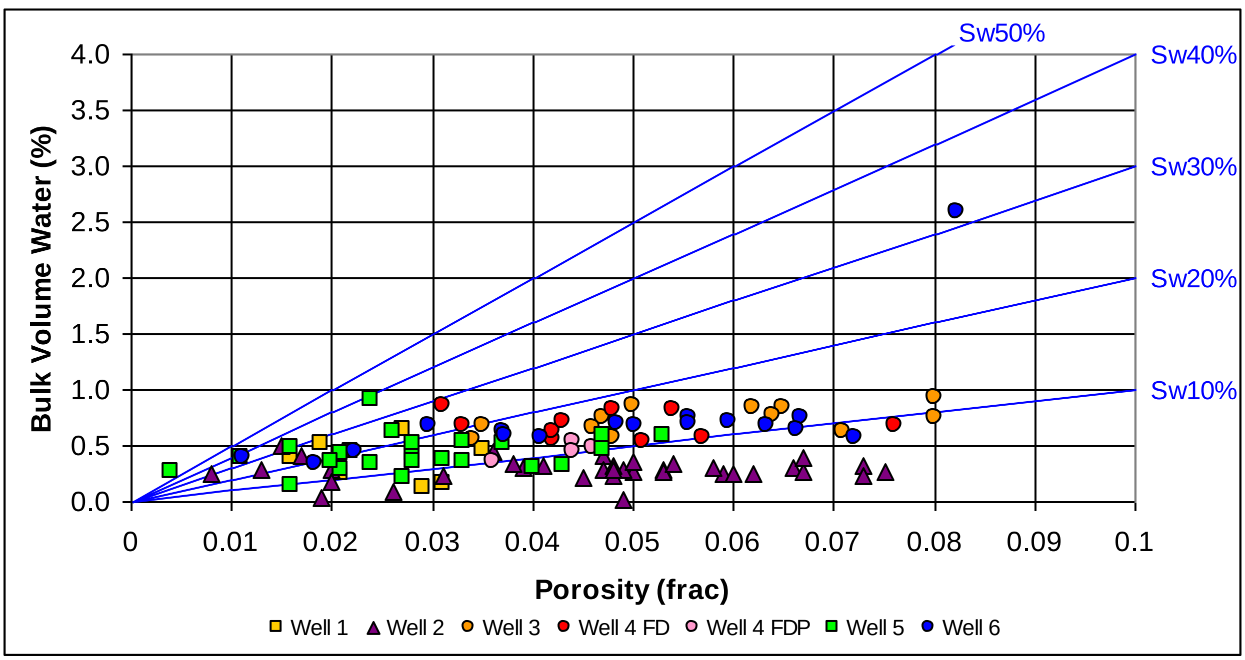

Figure 2: Upper Montney porosity-bulk volume water scatter chart

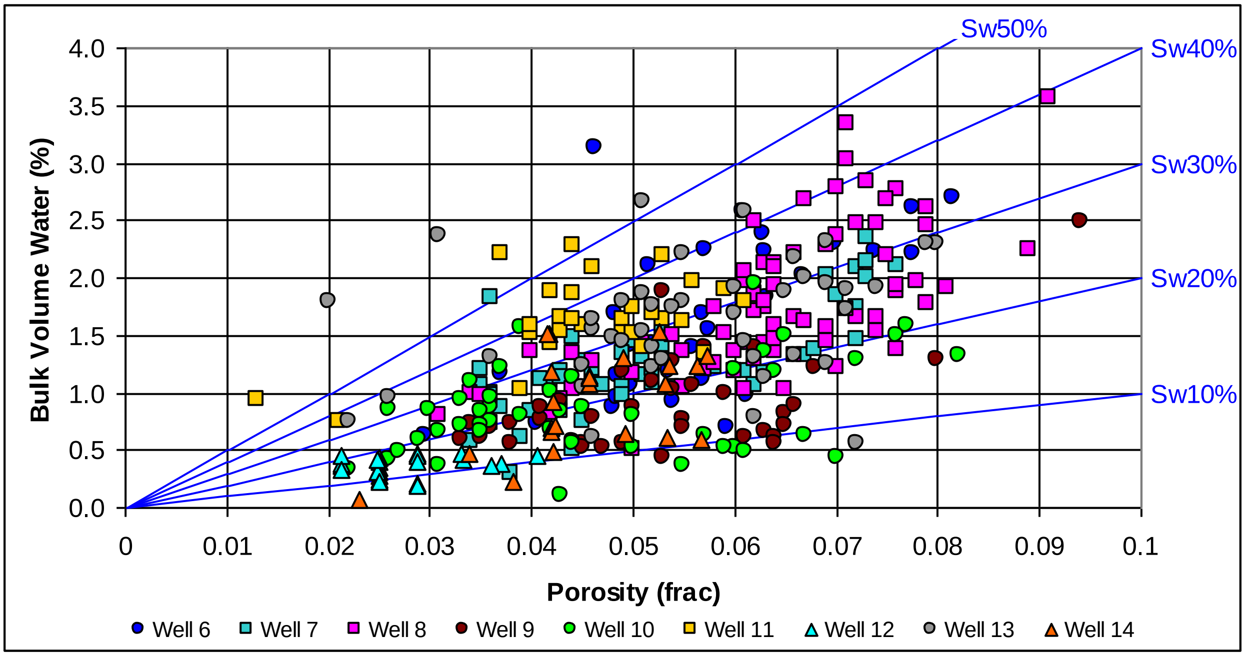

Figure 3: Montney deep resistivity-bulk volume water scatter chart