

Chemical Analyses of Formation Waters in Northeastern British Columbia

Introduction

The sedimentary succession in northeastern British Columbia is part of the Western Canada Sedimentary Basin (WCSB), which spans the provinces of British Columbia, Alberta, Saskatchewan, and Manitoba and is in a mature stage of petroleum exploration. In British Columbia, 10,744 samples of formation water (Table 1) were analyzed from 4945 wells (see Figure 1 for distribution). The formation water samples were collected mainly by the petroleum industry. The chemical analyses data are submitted in their raw form to the B.C. Ministry of Energy and Mines, and data up to 2002 were electronically entered in two phases into a database by the Alberta Geological Survey of the Alberta Energy and Utilities Board. The first phase included water analyses submitted by the industry approximately until 1993 and in the second phase data were added that were submitted from 1993 to 2002.

Data entry	All chemical analyses	Culled analyses*	Good analyses*
Up to 1998	3546	880	2666
1998 to 2002	7198	1873	5325
Total	10744	2753	7991

Table 1: Number of chemical analyses of formation water submitted to the B.C. Ministry of Energy and Mines until 2002. (* see Table 2 for culling criteria).

The chemistry of formation waters can be used to determine water origin and evolution, and to interpret fluid flow within the sedimentary succession. This can be further applied to the study of mineralization processes, and the prediction of chemical reactions within reservoirs used for the geological sequestration of carbon dioxide, acid gas, and other hazardous wastes.

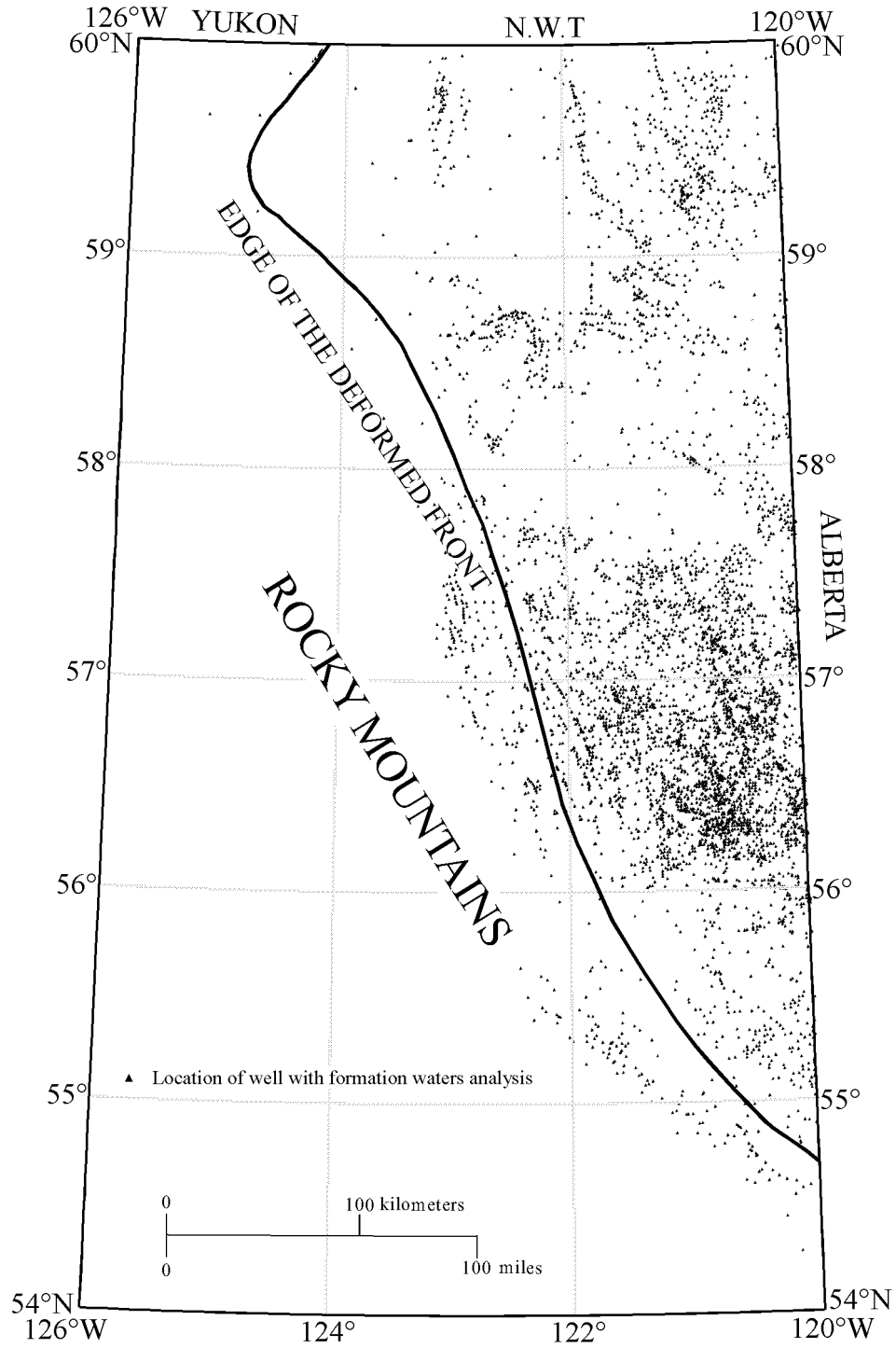


Figure 1: Location of wells with chemical analyses of formation waters in northeast British Columbia.

Data quality

The database of formation water chemistries contains analyses of varying quality, including incomplete analyses and analyses from samples contaminated with drilling mud. The quality of chemical analyses should be evaluated before using the data in any hydrogeological investigation, because it is important to use good-quality and uncontaminated analyses. For example, by using a sequential mechanical culling procedure as described by Hitchon & Brulotte (1994) (Table 2), initially only 7991 analyses out 10,744 pass as “good analyses”.

Flag #	Culling Criteria
1	Any of Ca, Mg, Cl, HCO ₃ (or alkalinity), or SO ₄ missing
2	Mg-concentration > Ca-concentration
3	10.0 < pH < 5.0
4	OH reported
5	CO ₃ reported
6	Calculated Na-concentration < 0
7	Density < 1000 kg/m ³
8	$([\text{cation}] - [\text{anion}] / ([\text{cation}] + [\text{anion}]) > 0.15$
9	No sample depth interval reported
10	Method of production from excluded class
11	Sampling point from excluded category
12	Fe > 100 mg/l in separator or treator
13	Analysis from multiple drillstem tests

Table 2: Culling criteria for formation water analyses used in the automatic culling procedure (from Hitchon & Brulotte 1994).

The rejection criteria act on the data set in successive order of their individual importance. Herein, incomplete analyses for example are considered of the highest culling priority, because important ion concentrations are missing and these analyses cannot be hydrochemically balanced. This will affect mainly analyses where only one

component (most often chloride) is reported. Drilling and production methods are considered of a lesser priority, because they might suggest a high possibility of sample contamination due to their technical nature, but the quantitative influence on the analysis cannot be defined. Additional data culling by a geochemist is necessary, taking in account the specific chemical characteristics of formation water in various aquifer units, regional geology and flow of formation water.

Allocation of chemical analyses of formation waters

The sedimentary succession in northeastern B.C. overlies the crystalline Precambrian basement and consists of Cambrian to Lower Jurassic, dominantly marine sediments (carbonates, shales, evaporites), and Upper Jurassic to Cretaceous, foreland basin siliciclastics (sandstones, siltstones, shales). Based on the general lithology distribution, the entire succession can be subdivided into various regional aquifer (carbonates, sandstones) and aquitard (shales, evaporites) units (see Figure 2). The number of chemical analyses in various hydrostratigraphic units is related to the occurrence of hydrocarbon reservoirs. Therefore, the main hydrocarbon-producing intervals, i.e., Lower Mannville, Triassic, Mississippian, and Devonian, have the largest number of formation water analyses (Figure 2).

Reference:

Hitchon, B., and Brulotte, M. (1994): Culling Criteria for “Standard” Formation Water Analyses. *Applied Geochemistry*, v. 9, 637-645.

		Stratigraphic Nomenclature		Hydrostratigraphy	# of samples*	
Period		Group	Formation			
Quaternary		Pre and glacial drift		Surficial aquitard		
Tertiary						
Cretaceous		Dunvegan		Dunvegan aquifer	13	
		Shaftesbury	Cardium	Shaftesbury aquitard	6	
			Paddy/ Cadotte	Paddy aquifer	256	
		Ft. St. John	Harmon	Harmon aquitard		
			Notikewin & Falher	Upper Mannville aquifer	107	
			Wilrich	Wilrich aquitard		
	Bullhead		Lower Mannville aquifer	2173		
Jurassic				Jurassic aquitard		
Triassic		Baldonnel		Baldonnel aquifer	4229	
		Charlie Lake		Charlie Lake aquiclude		
		Halfway		Halfway aquifer		
		Montney		Montney aquitard Montney aquifer		
Permian				Permian aquifer	349	
Carboniferous		Stoddart		Carboniferous aquifer	1243	
		Rundle Group				
		Banff		Exshaw-Banff aquitard		
		Exshaw				
Devonian	U	Wabamun Group		Wabamun aquifer	53	
		Upper Devonian aquitard system				
		Winterburn Group		Jean Marie	Jean Marie aquifer	221
		Woodbend Group		Fort Simpson	Fort Simpson aquitard	
		Beaverhill Lake Gp.		Waterways	Horn River aqt.	Slave Point aquifer
	Horn River		Slave Point			
	M	Watt Mtn.		Sulphur Point aquifer	Muskeg Aquitard	1063
		Sulphur Point				
		Keg River		Keg River aquifer		
		Chinchaga		Elk Point aquitard system		
Cold Lake Salt						
Ernestina Lake						
Basal Red Beds						
Silurian						
Ordovician						
Cambrian		Granite Wash		Cambrian aquitard ?	17	
		Basal SS ?		Basal aquifer ?		
Precambrian				Basement		

■ salt □ aquifer

Figure 2: Stratigraphic and hydrostratigraphic nomenclature of the sedimentary succession, northeastern British Columbia. (*) Number of samples is based on the formation names in the chemistry report (where given), and represents a bulk estimate for the various hydrostratigraphic units.