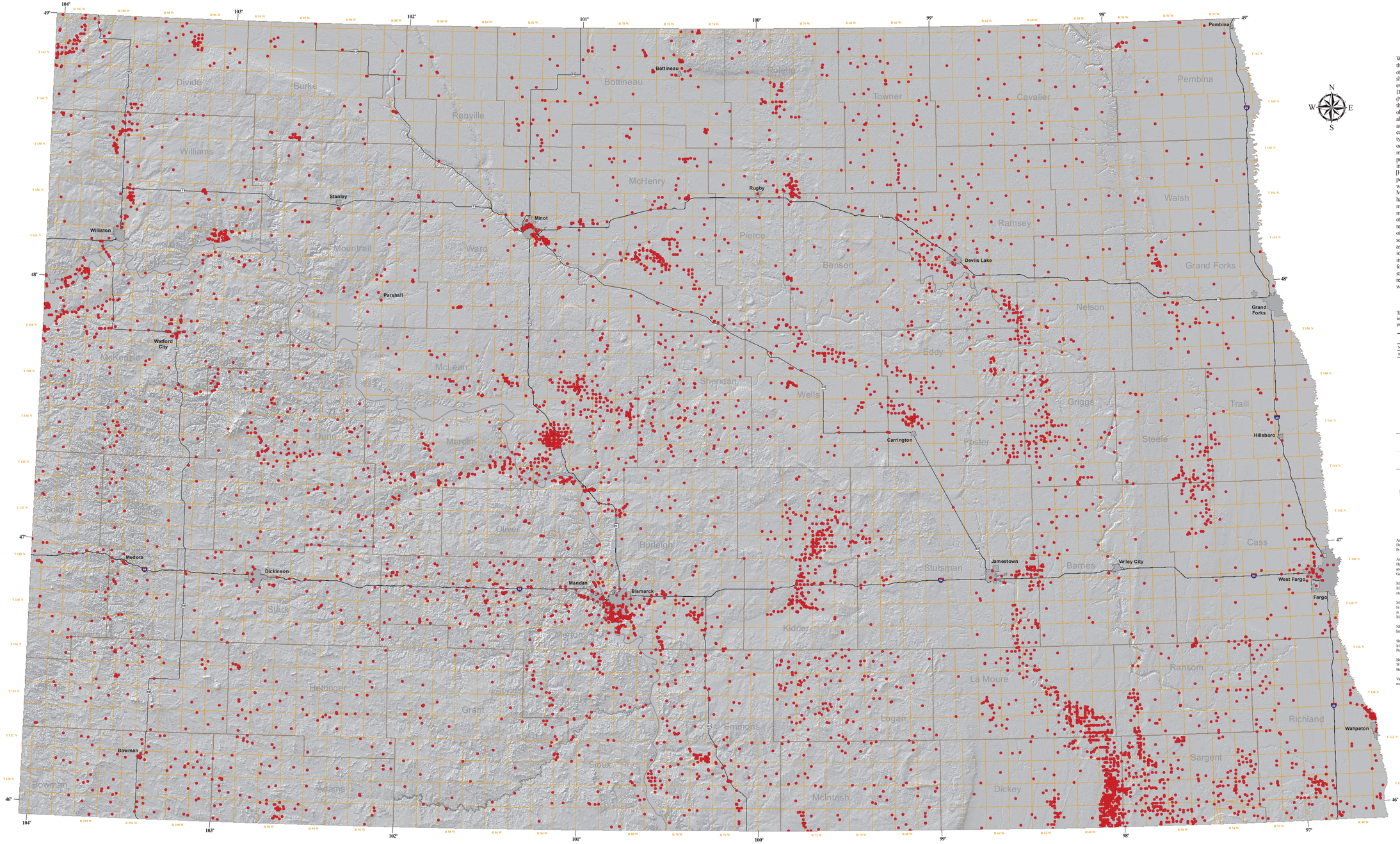
North Dakota Geological Survey
Geologic Investigations No. 92

Edward C. Murphy, State Geologist
Lynn D. Helms, Director Dept. of Mineral Resources

Shallow Gas Geochemical Exploration Indicators in Ground-Water Wells in North Dakota

Fred J. Anderson

2010



DISCUSSION

Well locations with ground-water constituent chemistries favorable for the occurrence of methane are plotted on this map with a background of surficial topographic shaded relief. The locations of the 7,503 wells shown on this map, date historically over 77 years to 1932, and were extracted and reported here *as is* from the databases of the North Dakota State Water Commission in Bismarck, North Dakota (NDSWC, 2010). Data are reported from all types of wells found across the state and include: domestic, stock, production, municipal, industrial, observation, and irrigation wells. Wells described as "unknowns" were also included here for completeness. Well depths range from as shallow as three feet to as deep as 3,277 feet with the majority of wells (>80%) completed to depths less than 300 feet. Clustering of wells occurs typically where shallow surficial or buried-valley aquifers are known to occur as most of the wells depicted on this map were installed to either monitor or extract shallow ground-water for water supply purposes. In the absence of direct detection of methane (CH_4) through instrumental or analytical means, Sulfate [SO_4^{-2}] and Bicarbonate [HCO_3^-] ion concentrations can be used as proxy indicators for potential occurrences of methane in the shallow subsurface. Previous workers (Anderson, et al., 2006, Martini, et al., 2003, McIntosh and Martini, 2008, Shurr, et al., 2006, Shurr, 2008, VanVoast, 2003) have demonstrated that sulfate ion concentrations less than 500 mg/L coupled with bicarbonate ion concentrations greater than 400 mg/L correlate with groundwater containing detectable concentrations of methane. Well locations are plotted on this map, using this relationship of ground-water constituent geochemistry, for the purpose of shallow gas exploration. The data depicted on this map are from several different individual sampling events and include data from as far back as 1932. Any well sampled with sulfate and bicarbonate ion chemistry meeting the exploration criteria described here is included on this map. Within the selected ion concentration ranges for sulfate of 0 to 500 mg/L and bicarbonate of 400 mg/L to 2800 mg/L, statistical means of 203 mg/L and 639 mg/L were determined, respectively, from a data set of 20,662 values (Table 1). Sample data was included from 1932 to 2009.

Table 1. Descriptive statistical summary of sulfate[SO_4^{-2}] and bicarbonate [HCO_3^-] ion concentrations, from wells shown on this map, within the shallow gas exploration indicator ranges of <400 mg/L sulfate and >500 mg/L bicarbonate.

Constituent	n	Selected Ion Concentration in Groundwater (mg/L)					Sampling Dates
		Range	Minimum	Maximum	Mean	Std. Dev.	
Sulfate [SO_4^{-2}]	20,563	400.9	0.1	500	203	131.8	1932 -2009
Bicarbonate [HCO_3^-]		2,400	400	2800	639	265.6	

EXPLANATION

- **Ground-Water well with CH_4 exploration indicators:** Well location where sulfate ion [SO_4^{-2}] concentration is <500 mg/L coupled with bicarbonate ion [HCO_3^-] concentration >400 mg/L in sampled groundwater.
- County Boundaries
- Township Boundaries
- Highways
- Cities

REFERENCES

Anderson, F.J., 2009, Methane Occurrence in Glacial Buried-Valley Aquifer Systems in North Dakota, Geological Society of America 2009 Annual Meeting & Exposition, Abstracts with Programs, Vol. No. 41, No. 7, p. 214.

Anderson, F.J., Shurr, G.W., and Fischer, D.W., 2006, History, Geology, and Potential Hydrogeochemical Indicators of Natural Gas Occurrence and Production from Quaternary-Glacial and Upper-Cretaceous Sedimentary Bedrock in North-Central North Dakota, North Dakota Geological Survey, Geologic Investigations No. 33, 25 p.

Martini, A.M., Walter, L.M., Ku, T.C.W., Budai, J.M., McIntosh, J.C., and Schoell, M., 2003, Microbial production and modification of gases in sedimentary basins-a geochemical case study from a Devonian shale gas play, Michigan basin: AAPG Bulletin, p. 1355-1375.

McIntosh, J.C., and Martini, A.M., 2008, Hydrogeochemical Indicators for Microbial Methane in Fractured Organic-Rich Shales: Case Studies of the Antrim, New Albany, and Ohio Shales, *in* Hill, P. Lillis, and J. Curtis, eds., Gas Shale in the Rocky Mountains and Beyond: Rocky Mountain Association of Geologists 2008 Guidebook CD, p. 162-174.

NDSWC, 2010, North Dakota State Water Commission Online Ground-Water Information System: http://www.swc.state.nd.us

Shurr, G.W., Hagger, T., and Chadima, S.A., 2006, Exploration Strategies for the Ultra-Shallow Microbial Methane on the Eastern Margin of the Williston Basin, American Association of Petroleum Geologists, National Meeting Abstracts Volume, Houston TX, p.99.

Shurr, G.W., 2008, Shallow Biogenic Gas in Cretaceous Shale on the Eastern Margin of the Williston Basin, *in* Hill, P. Lillis, and J. Curtis, eds., Gas Shale in the Rocky Mountains and Beyond: Rocky Mountain Association of Geologists 2008 Guidebook CD, p. 176-198.

VanVoast, W. A., 2003, Geochemical signature of formation waters associated with coalbed methane: AAPG Bulletin, v. 87, p. 667-676.

Cartographic Compilation: Elroy L. Kadrmas