North Dakota Geological Survey
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Geochemical Characterization of Natural Gas Occurrences in Selected Ground-Water Wells in North Dakota

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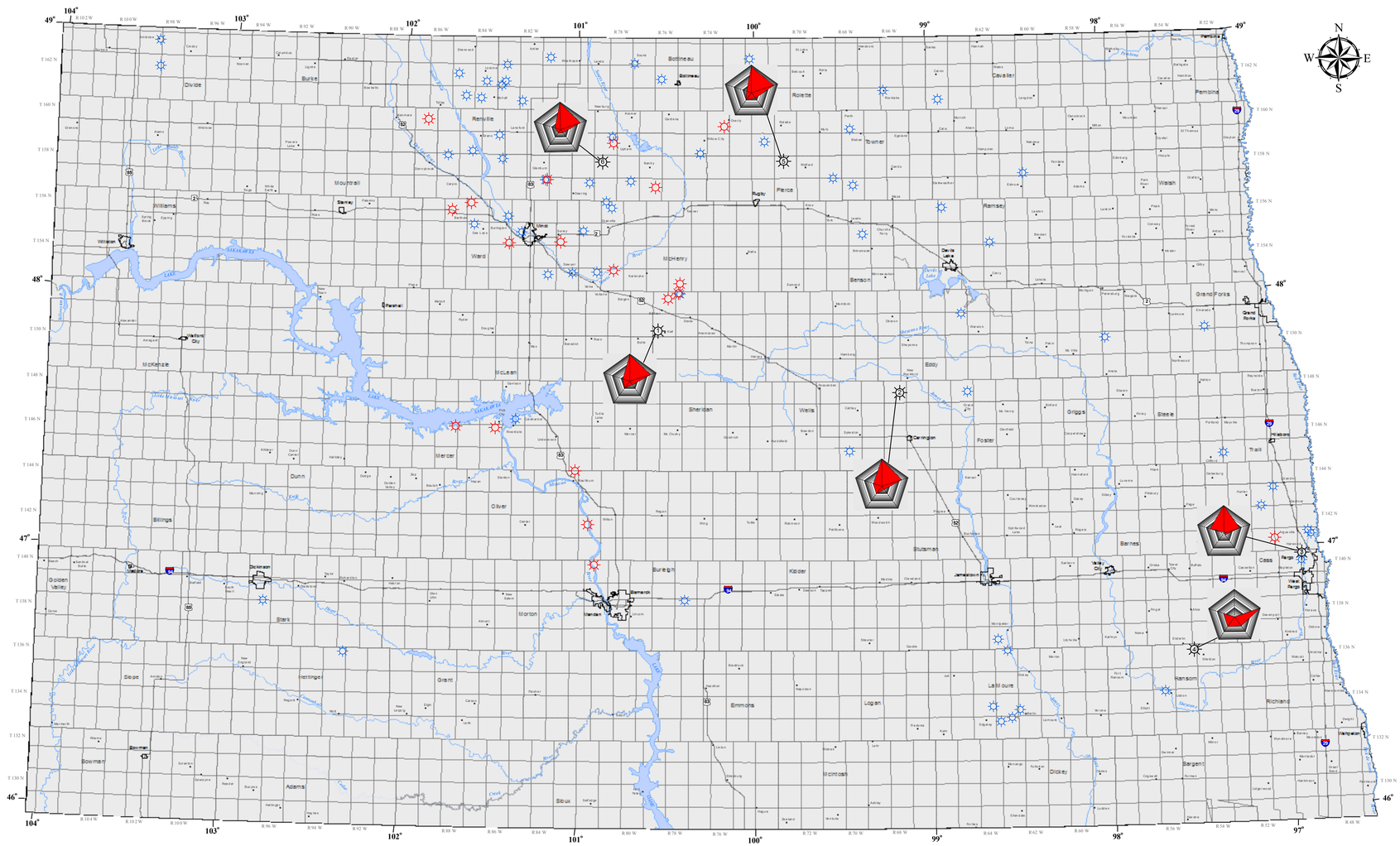


INVESTIGATION SUMMARY

The occurrence of natural gas in shallow ground-water wells has been reported from as early as the 1900's and on up to today across North Dakota. Numerous reports from the public have been received from private water supply well owners, dominantly in central and eastern North Dakota, over the last decade as a result of ongoing hydrogeological investigations into the occurrence and potential of North Dakota shallow gas resources conducted at the North Dakota Geological Survey (NDGS). The NDGS has received over 100 reports of natural gas occurrence in shallow ground-water wells which are depicted on this map at a scale of 1:1.000.000.

The NDGS visited each of the anecdotally reported well locations during the 2012 field season in order to assess the viability of contemporary testing and validation of the continued presence of natural gas in the well. From this work, 25 well locations had an existing well that could be tested for the presence of natural gas and were confirmed to have positive shows of methane in the water produced from the wells. (Figure 1). Confirmation of the presence of natural gas (as methane) was tested using a portable Flame Ionization Detector (FID) specifically calibrated to detect methane. Wells at the other locations visited had either been abandoned or destroyed many years earlier or were no longer in service, and as a result were unable to produce water for further testing and analysis.

From the wells that were confirmed (by FID field testing) to contain methane, six wells were selected for continued ground-water geochemical testing and methane isotope analyses, in order to provide clues as to the possible origins of the natural gas occurring in these shallow ground-water wells. The six wells selected ranged from locations in north-central to eastern to southeastern North Dakota. The wells tested produced groundwater from likely aquifer sources ranging from Cretaceous to Quaternary age. The depths of tested wells were commonly in the range of 120-620 feet (Table 1).

Methane concentrations detected in the groundwater from these selected wells range in concentration from approximately 62% to 90% methane (Mol %) with minor amounts of ethane (Table 2). No longer chain hydrocarbons (e.g. pentane) were detected in any of the samples tested. Methane isotope analyses revealed values (Table 3) consistent with other studies (Pantano, 2012 - Whiticar, 1999) that were suggestive of shallow natural gas of a biogenic character (Figure 2) originating from a coal substrate (either as shallow bedded coals or detrial lignites) which are common in shallow bedrock and buried-valley aquifers arcoss the state. The data presented here support the conclusion that shallow natural gas occurrences in these types of wells originate from naturally occurring organics present within the shallow aquifer systems and not from deeper migrated or other anthropogenic sources.

Figure 1. Ground-water sample collected from a shallow private ground water supply well in south central McHenry County, North Dakota (15107729ADD). Dissolved natural gas bubbles, consisting primarily of methane, coming out of solution give the upper portion of the water a cloudy or "milky" appearance. Samples like this one, obtained from shallow Cretaceous to Quaternary age aquifiers, in many areas of the state are commonly ignitable.

Table 1. Ground-Water Well and Samples Collected Location Summary

Well Name\ID	Location[1] Longitude	Latitude	Approximate Well Depth (ft bls)	Date Sampled	Time Sampled
15107729ADD	-100.54432	47.87029	210	6/12/2013	14:10
14806723BAA	-99.17126	47.63044	245	6/13/2013	12:15
14004906CDC	-96.92703	46.96507	150	6/12/2013	19:00
13605512CCA	-97.54799	46.60399	620	6/13/2013	09:30
15907215AAD	-99.92955	48.59295	220	6/13/2013	20:30
15807909CBB	-100.88477	48.52381	120	6/14/2013	09:15

[1]Longitude and latitude values displayed in World Geodetic System 1984 (WGS84) coordinates.

Table 2. Ground-Water Sample Gas Composition Analysis Summary

Well Name\ID	Gas Composition (Mol %) Methane CH_4	Ethane C_2H_6	Nitrogen N_2	Argon Ar	Oxygen O_2	Carbon Dioxide CO_2	Helium He	Hydrogen H_2	Carbon Monoxide CO	Ethylene C_2H_4	Propane C_3H_8	Propylene C_3H_6	Butane[3] C_4H_{10}	Pentane[3] C_5H_{12}	Hexane+ C_6H_{14}+	BTU/ft^3 Dry	Specific Gravity[2]
15107729ADD	74.38	0.0190	23.79	0.307	0.83	0.62	0.0513	--	--	--	--	0.0001	--	--	--	754	0.665
14806723BAA	78.76	0.0031	18.96	0.281	1.06	0.92	0.0117	--	--	--	0.0002	0.0006	--	--	--	798	0.649
14004906CDC	89.77	0.0019	6.34	0.167	0.076	3.65	--	--	--	--	--	--	--	--	--	910	0.617
13605512CCA	0.0973	--	94.39	1.660	2.04	1.81	NA	--	--	--	--	--	--	--	--	1	0.986
15907215AAD	62.04	0.0198	36.15	0.540	0.87	0.36	0.0170	0.04	--	--	--	0.0002	--	--	--	629	0.716
15807909CBB	79.37	0.0209	19.59	0.268	0.29	0.43	0.0298	--	--	--	--	--	--	--	--	805	0.643

-- Not detected
NA = Not Analyzed
1 Includes n- and iso- compounds
2 calculated values
Note: Reported chemical compositions are normalized to 100%. Mol. % is approximately equal to Vol. %.

Table 3. Gas Composition Isotopes Summary

Well Name\ID	$\delta^{13}CO_2$ ‰	$\delta^{13}CH4$ ‰	$\delta^{13}DCH_4$ ‰	^{14}C pMC
15107729ADD	-12.92	-81.35	-278.3	<0.2
14806723BAA	-6.81	-81.02	-286.4	<0.2
14004906CDC	-5.77	-78.34	-310.7	<0.2
13605512CCA	-14.3	NA	NA	<0.2
15907215AAD	-17.3	-83.58	-279.8	<0.2
15807909CBB	-19.5	-79.51	-262.6	<0.2

‰ - per mil (parts per thousand)
Note: Isotopic composition of carbon is relat ve to the Vienna Peedee Belemnite standard (VPDB).
NA = Not Analysed

Geologic Symbols

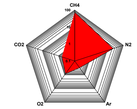
Ground-Water Wells Sampled for Methane Isotope Analyses

- 15107729ADD
- 14806723BAA
- 14004906CDC
- 13605512CCA
- 15907215AAD
- 15807909CBB

Ground-Water Well with FID Confirmed Anecdotal Shallow Gas Occurrence

Ground-Water Well with Reported Anecdotal Shallow Gas Occurrence

Gas Composition Radar Diagram



Scale is logarithmic in Mol %.

Misc Symbols

- Water
- Selected Major Rivers or Creeks
- County Boundaries
- Township Boundaries
- City/Town Boundaries
- Interstate Highway
- City/Town Locations
- US Highway

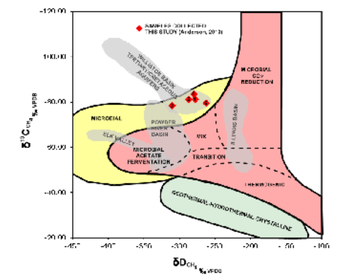


Figure 2. Methane isotope results from this study (red numbered diamonds) plotted with ranges of results from previous studies focused on the origin of natural gas in other basins. Samples collected from this study fall in the range previously identified from other studies to be of microbial methanogenic origin (modified from Pantano, 2012 and Whiticar, 1999).

SELECTED REFERENCES

Anderson, F.J., 2014, Index Map of Ground-Water Wells Investigated for Shallow Gas Occurrence in North Dakota, North Dakota Geological Survery, Miscellaneous Map No. 41, 1:400,000.

Pantano, C.P., 2012, Hydrogeochemical Controls on Microbial Coalbed Methane Accumulations in the Williston Basin, North Dakota, M.S. Thesis, Department of Hydrology and Water Resources, University of Arizona, 77 p.

Whiticar, M.J., 1999, Carbon and hydrogen isotope systematics of microbial formation and oxidation of methane. Chemical Geology 161, 291-314.

Cartographic Compilation: Elroy L. Kadrmas