Assessment of Shallow Natural Gas Potential in North Dakota

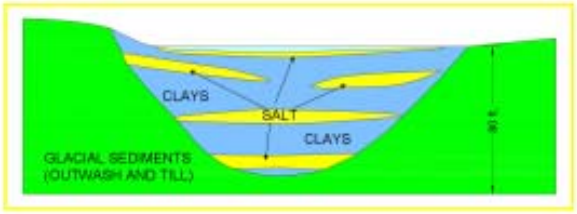
By Fred J. Anderson

The North Dakota Geological Survey recently began a series of investigations into the study and assessment of the potential for shallow natural gas occurrence in North Dakota. Shallow natural gas occurrence can be generally defined as natural gas that occurs within the unconsolidated glacial sedimentary cover and shallow (near-surface) bedrock of North Dakota (i.e. Cretaceous and younger).

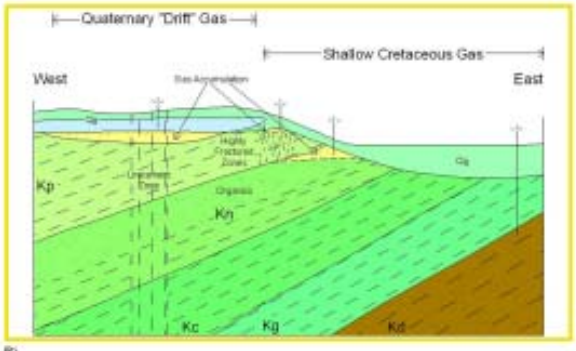
Fig. 1. Gas flowing from a well in north central North Dakota during the 1920's

Recent Survey Activities

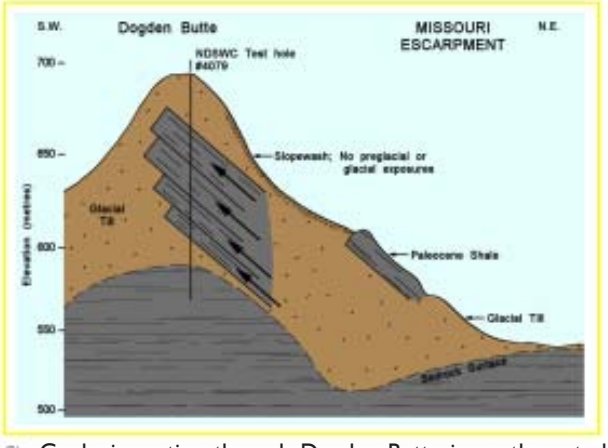
The Survey has completed numerous activities related to the assessment of the shallow gas potential of the state. In January of 2005 the Survey began compiling where shallow gas had been encountered in the state. This activity resulted in the Survey producing a series of talks at the 39th meeting of the North Central Section of the Geological Society of America in Minneapolis, Minnesota related to shallow gas. Survey geologists, Fred Anderson and Ed Murphy presented results of studies regarding two unconventional sources of methane in North Dakota at the meeting. Shallow gas encountered in the playa lake setting (fig. 2A) in northwestern North Dakota and anthropogenic (landfill) gas (fig. 2D) was



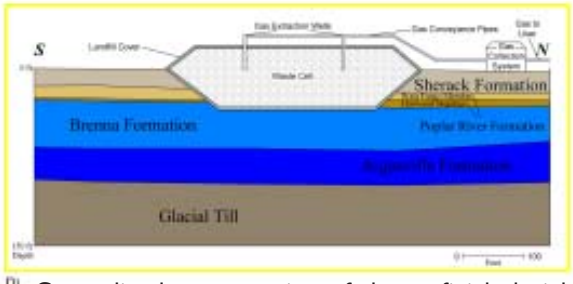
A) Simplified cross section of playa lake setting in NW North Dakota.



B) Conceptual geologic section depicting two types of potential shallow gas occurrences in North Dakota.



C) Geologic section through Dogden Butte in north central North Dakota depicting the vertical relationship of thrusted material to underlying bedrock.



D) Generalized cross section of the surficial glacial sediments in the Red River Valley and a typical landfill design concept.

Fig. 2. Conceptual models of Shallow Natural Gas Occurrence in North Dakota.

presented (Anderson and Murphy, 2005). John Bluemle presented a talk on the relationships of glaciotectonic ice-thrust features related to the possibility of trapping natural gas in the shallow subsurface and as an exploration tool (fig. 2C).

Following the GSA meeting in the Spring of 2006 the Survey launched a shallow gas project web page constructed specifically to serve as a focal point for the project and to allow for the public to contribute anecdotal information or stories related to shallow gas shows to the Survey for inclusion in the Survey's planned online database of shallow gas occurrences in North Dakota (fig. 3). For example, *a story from the Edgeley area in the early 1900's highlights an early shallow gas occurrence and use in the area:*

> "In 1906 Miss Soby installed a lighting system in the Northern Hotel. Fifteen lights and a heater were maintained for two years. The type of gas storage tank, used at this location and elsewhere, was an inverted cylinder of sheet-iron about 15 feet in diameter. The well pipe conducted the water directly underneath the inner tank where the gas escaped from the water and was caught. Once the tank was filled, surplus gas would readily escape. The top of the tank was sufficiently weighted to produce the requisite pressure to force the gas into the house…"

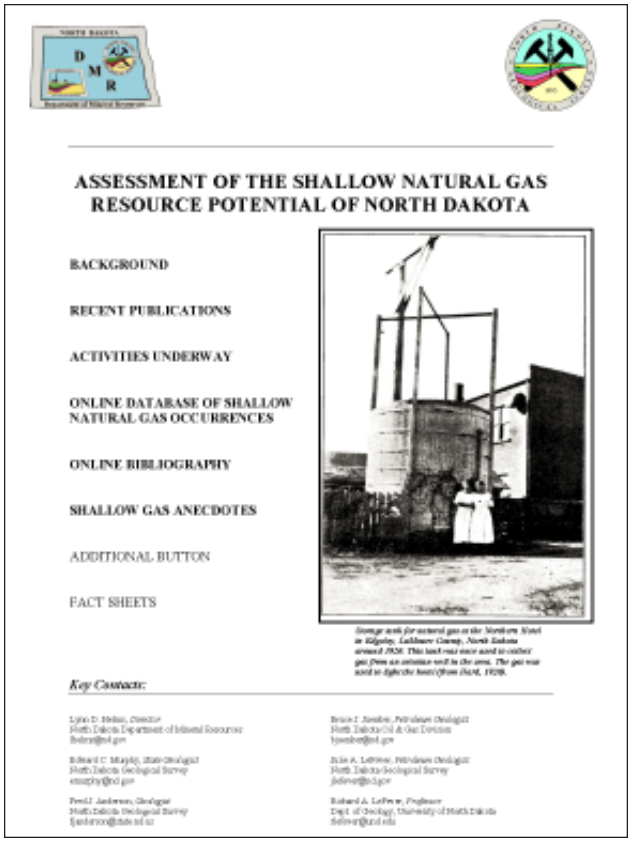


Fig. 3. Shallow gas project web page layout.

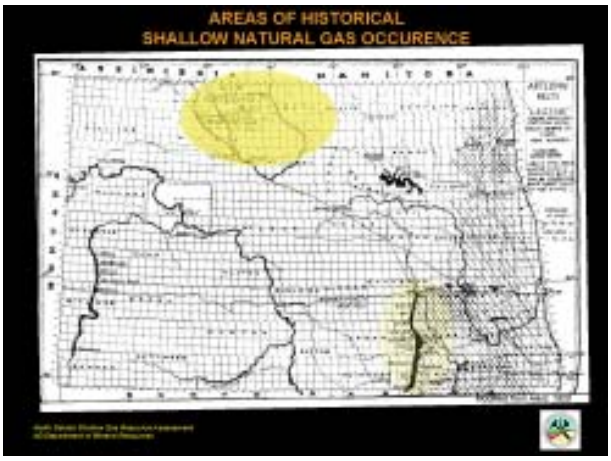


Fig. 4. Map of historical artesian well areas in North Dakota with areas of historical shallow gas occurrence highlighted from presentation given at the North Dakota Water Well Drillers Association Annual Meeting in Bismarck, ND in early Spring of 2006.

During further investigative work, it was determined that communicating the intent of the Survey's shallow gas project to those who drill holes every day for a living would be beneficial. In order to learn what information or stories these folks might have, a presentation entitled Historical Shallow Gas Occurrences in North Dakota and the Assessment of the Potential for Shallow Gas in the State was given in March of 2006 at the North Dakota Water Well Drillers 2006 Annual Conference a presentation (fig. 4). A wealth of information was extracted from that meeting in which many of the seasoned water well drillers had numerous stories of wells that "blew my hat off" and the like. The Survey was very fortunate to have an opportunity to present to this group and looks forward to continuing discussions as the project progresses.

The Survey also presented the culmination of four different investigative aspects of shallow gas occurrence in the state and the relationship to the state's glacial sedimentary cover and shallow bedrock in April of 2006. This work resulted in the creation of Survey Geological Investigations No. 25 entitled: Shallow Natural Gas Occurrences in Quaternary Deposits in North Dakota (fig. 5). This work was presented at the 2006 Annual Meeting of the American Association of Petroleum Geologists in Houston, Texas (Anderson and others, 2006). This investigative work highlighted natural gas occurrence within four geologic systems including: playa lakes in northwestern North Dakota, subglacial/bedrock settings of north central North Dakota, glaciotectonic ice-thrust features and anthropogenic gas from North Dakota landfills.

A contemporary interpretation of the structure on top of several of the Cretaceous and upper-Jurassic units is currently underway by scientists from the North Dakota Geological Survey, the North Dakota Oil and Gas Division, and the University of North Dakota. Statewide and detailed structure maps are critical components of the oil and gas exploration

Fig. 5. Survey Geological Investigations No. 25 presented at the AAPG 2006 annual meeting and convention in Houston, Texas in the Spring of 2006.

process. The wealth of interpreted stratigraphic tops information provides an opportunity to analyze and interpret the stratigraphy and stratigraphic controls that support an interpretation of the structure associated with the Cretaceous and late-Jurassic units in North Dakota (fig. 6). We recently completed a preliminary structure contour map, drawn on the top of the Cretaceous Greenhorn Formation in North Dakota (Anderson and Juenker, 2006) (fig. 7). This 1:1,000,000 map utilizes over 11,900 individual stratigraphic data points in addition to interpreted geologic knowledge of the subsurface.

Immediately following the completion of this map, the author and Oil and Gas Division geologist Bruce Juenker completed Geological Investigations No. 26 entitled Assessment of Potential Shallow Natural Gas Resources in North Dakota. This document provides an overview of the shallow gas investigative work being conducted at the Survey and highlights several of the ongoing investigative and research components (fig. 8).

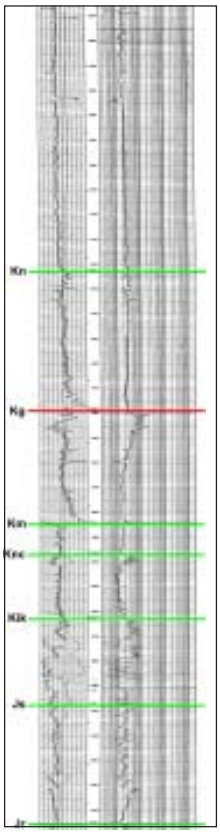


Fig. 6. Portion of a stratigraphic "type log" highlighting selected formation tops picks that are used in the creation of individual formation stratigraphic tops data.

Geological Investigations No. 25 and 26 were both featured in the North Dakota Department of Mineral Resources booth at the 14th Williston Basin Petroleum Conference and Prospect Expo in Minot, North Dakota in early May of 2006 (fig. 9).

Also featured at the Minot conference was a talk prepared by the author and the technical advisor to the ND Oil and Gas Research Council, Dave Fischer (Fischer and Anderson, 2006). The talk focused on the historical perspective of shallow natural gas potential in north central North Dakota (fig. 10).

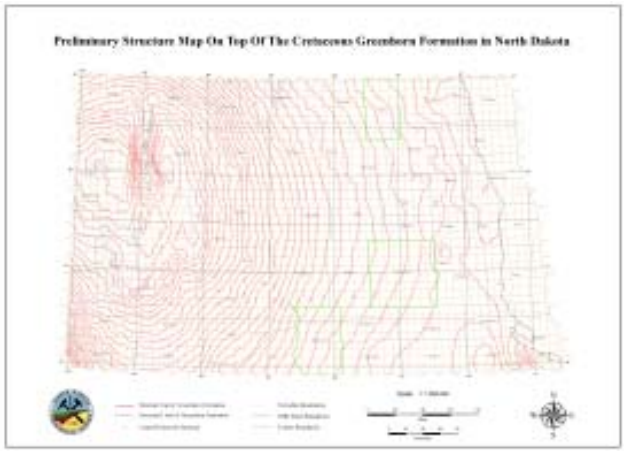


Fig. 7. Preliminary structure contour map drawn on the Cretaceous Greenhorn Formation.

The Survey continues its work on the interpretation and construction of structure contour maps for selected Cretaceous and Jurassic Formations. Cretaceous stratigraphic units currently being interpreted are the Greenhorn, Mowry, and Inyan Kara Formations. Other stratigraphic intervals planned include the Swift and Rierdon Formations (fig. 11). These structure contour maps are all planned for completion at scales of 1:1,000,000 each with selected larger scale maps (1:100,000) for selected counties.

Following the planned completion of structure contour maps in the winter of 2006, Survey geologist Julie LeFever and professor Richard LeFever (University of North Dakota) will be completing a series of stratigraphic sections across the Cretaceous in North Dakota (fig. 12). Planned for tentative completion in the Spring of 2007, these sections will provide a contemporary interpretation of the correleation of Cretaceous strata across the state. This interpretation is fundamental to accurate and consistent interpretation of Cretaceous structure.

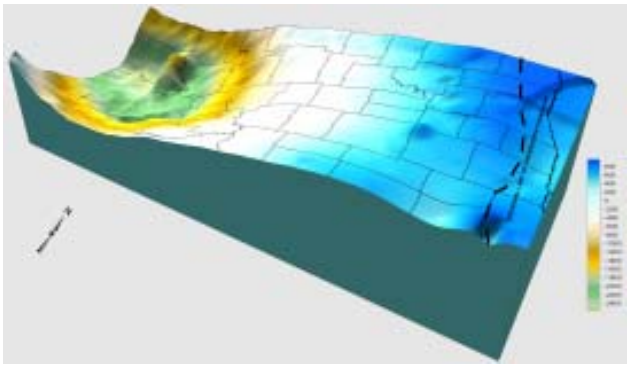


Fig. 8. Conceptual 3D surface model of the top of the Cretaceous Greenhorn Formation in North Dakota created to provide an enhanced view of the evolving structural interpretations of the Greenhorn surface throughout the state.

Fig. 9. Survey Geologist Fred Anderson (far left) and Oil and Gas Division Geologist Bruce Juenker (far right) discussing aspects of shallow natural gas occurrence in the state with interested visitors to the Department of Mineral Resources informational booth at the 14th Williston Basin Petroleum Conference and Prospect Expo in Minot, North Dakota.

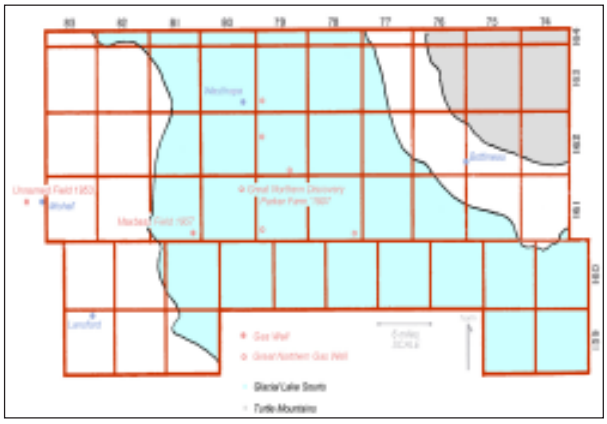


Fig. 10. Relationships of historic gas occurrence and generalized surficial geology in the Bottineau County area presented as a part of: Central North Dakota Shallow Gas Potential: A Historical Perspective, given at the 14th Williston Basin Petroleum Conference & Prospect Expo in Minot, North Dakota.

The Survey is also evaluating several of the relationships between shallow ground-water chemistry and natural gas occurrence in north central North Dakota (Bottineau County). That work will be presented in the Fall of 2006 at the Saskatchewan and Northern Plains Oil & Gas Symposium in Regina, Saskatchewan.

Selected References

Anderson, F.J., and Murphy, E.C., 2005, Two Unconventional Sources of Methane in North Dakota: Geological Society of America, Abstracts with Programs, North Central Section, Volume 37, No. 5, p. 28.

Anderson, F.J., and Juenker, B.J., 2006, Preliminary Structure Contour Map on Top of the Cretaceous Greenhorn Formation in North Dakota: North Dakota Geological Survey, plate.

Fig. 11. Cretaceous stratigraphic units to be evaluated during the shallow gas investigative program. Units include the Greenhorn, Mowry, and Inyan Kara Formations as well as selected Jurassic age stratigraphic units.

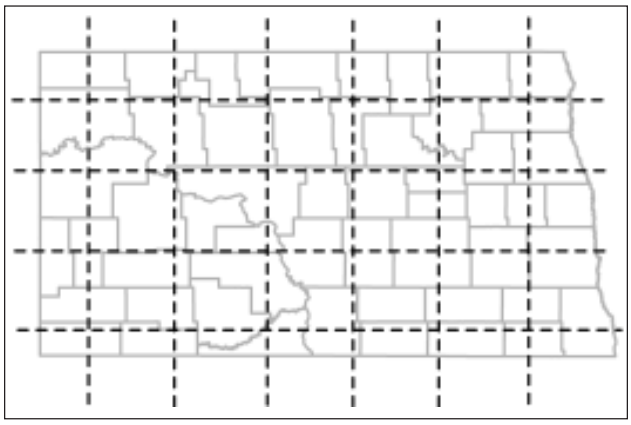


Fig. 12. Approximate lines of correlation cross sections being interpreted and constructed across the state.

Anderson, F.J., and Juenker, B.J., 2006, Assessment of Potential Shallow Natural Gas Resources in North Dakota: North Dakota Geological Survey Geological Investigations No. 26 (GI-26), plate.

Anderson, F.J., Murphy, E.C., Bluemle, J.P., and Fischer, D.W., 2006, Shallow Natural Gas Occurrences in Quaternary Deposits in North Dakota: American Association of Petroleum Geologists, 2006 Annual Convention, Abstracts with Programs, Volume 15, p. 4.

Anderson, F.J., Murphy, E.C., Bluemle, J.P., and Fischer, D.W., 2006, Shallow Natural Gas Occurrences in Quaternary Deposits in North Dakota: North Dakota Geological Survey Geological Investigations No. 25, plate.

Barry, J.G., 1908, The Bottineau Gas Field: North Dakota Geological Survey, 5th Biennial Report, pp. 247-251.

Fischer, D.W., and Bluemle, J.P., 2005, Natural Gas Production from Glacial Outwash in North Central North Dakota: Geological Society of America, Abstracts with Programs, North Central Section, Volume 37, No. 5, p. 28.