Shale Gas Assessment in Southern Ontario

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Summary

In northeastern North America, a large number of private or public research studies have helped confirm and evaluate the shale gas potential of this region. However, in Ontario, despite the presence of stratigraphically equivalent bedrock units that have shown shale gas promise in adjacent provinces and states, little research and exploration work has been completed in the province. This lack of work to assess shale gas potential is due in part to the current lack of scientific data. Consequently, the Ontario Geological Survey (OGS) initiated in 2009 a multi-year project to assess the shale gas potential of southern Ontario.

Previous work has identified various bedrock formations and members found in southern Ontario that are potential shale gas reservoirs (Hamblin, 2006). The most promising units consist of the Ordovician Collingwood Mb, Eastview Mb, Blue Mountain and Billings Fms as well as the Devonian Marcellus Fm and the Kettle Point Fm. As part of the current project, a compilation of all existing data on pertinent parameters (total organic carbon, mineralogy, maturity, depth, thickness) from previous researches has been completed. Next steps in the project involve the analysis of a large number of previously collected samples using Rock-Eval techniques and drilling of new boreholes to acquire new data including; total organic carbon, maturity, rock mechanics and adsorption isotherms along with gas content, composition and calorific value. For now, the research is focused mainly on the Devonian Kettle Point Formation, but the OGS wishes to characterize all potential units in future years.

Introduction

In southern Ontario, Hamblin (2006) identified a number of organic-rich shale units with gas production potential. In southwestern Ontario, the Upper Ordovician Collingwood Member of the Lindsay Formation is defined as organic-rich interbedded calcareous shales and limestones reaching a thickness of 11 m (Russell and Telford, 1983; Armstrong and Carter, 2006). With TOC values up to 11% and an average quartz content of about 40%, this unit has also been identified previously as a potential oil shale and as a possible source rock in the region (Powell et al., 1984; Snowdon, 1984; Churcher et al., 1991). It crops out and/or subcrops beneath a cover of glacial sediments over an area of about 200 by 200 km in south-central Ontario (Hamblin 2006).

The overlying unit, the Blue Mountain Formation, is described as a grey-brown shale with thin, minor interbeds of limestone and siltstone that reaches a thickness of up to 60 m (Johnson et al., 1992; Armstrong and Carter 2006). At its base, it incorporates the Rouge River Member, a 2 to 15 m organic-rich interval (Hamblin 2006). The Blue Mountain Formation has TOC values up to 9%, is thermally mature and is composed of 50% to 60% of SiO_2 (Barker, 1985; Obermajer, 1997; Armstrong and Sergerie, 2003). In both the Collingwood Member and the Blue Mountain Formation, vertical fracture sets are well developed (Hamblin 2006). These Upper Ordovician shales are the equivalent of the Utica shale in Quebec, one of the most promising shale gas units in eastern North America (Hamblin, 2006; Lavoie et al., 2008; Thériault, 2008).

In eastern Ontario, the Eastview Member of the Lindsay Formation is up to 10 m thick and comprises interbedded black shale and petroliferous limestone. This bedrock unit is the

equivalent of the Collingwood Member found in southwestern Ontario (Williams, 1991; Hamblin, 1998). The overlying Billings Formation, the equivalent of the Blue Mountain Formation, consists of up to 60 m of black shale with a few thin limestone beds (Williams 1991). The few available thermal maturity and total organic content data indicate mature to overmature levels with a maximum organic content value of 2.7% for the Eastview Member and 4.2% for the Billings Formation (Legall et al., 1981; Barker, 1985). In the Ottawa region, the major fracture patterns that are present may prove to be an important criterion in assessing shale gas potential (Hamblin 2006).

The black bituminous Marcellus shale (late Middle Devonian) can be defined as interbedded grey shale layers and fine carbonates (Musial, 1982; Johnson et al. 1992). Limited to south of the Algonquin Arch, it does not crop out in southern Ontario. The unit reaches a thickness of nearly 25 m and contains excellent organic-rich source rock intervals with TOC up to 4% indicating immature to mature levels (Obermajer 1997; Hamblin 2006). It consists of about 40-50% of SiO_2 (Johnson et al., 1989).

The Upper Devonian Kettle Point Formation is the equivalent of the highly productive Antrim shale in the USA (Hamblin 2006). It consists of up to 65 m of dark brown to black, organic-rich shale, silty shale and siltstone and subordinate organic-poor, grey-green silty shale and siltstone interbeds (Armstrong, 1986; Armstrong and Carter, 2006). It is thermally immature, reaches TOC values up to 15% and contains more than 70% of quartz (Obermajer, 1997). In addition, fractures sets are well developed and the presence of gas in water wells drilled into Kettle Point strata has been reported (Hamblin, 2006).

Preliminary investigation indicates that other bedrock units in southern Ontario may possess shale gas potential. These units include the Shadow Lake, Blue Mountain, Carlsbad, Cabot Head and Rochester formations, as well as some shale-rich units in the Salina, Hamilton and Port Lambton groups. However, the first stages of the current project will focus on the most promising shale gas units as described above.

Methods and Future Work

The main objective of the project is to examine the potential of the above described units by obtaining new crucial data. This will be accomplished in various phases. The first component of the project involved the compilation of existing information and data. 96 rock samples (drilling cuttings, outcrops), were collected from core or chip samples stored at the Oil, Gas & Salt Resources (OGSR) Library of Ontario or were obtained in the field. These were analyzed using Rock-Eval techniques. Also, field work cannot be overlooked since it allows the collection of additional samples and allows information on the presence and character of fractures in the shales, a decisive issue with shale gas reservoirs, to be gathered. Simultaneously, isopach and elevation maps will be produced for each unit by using data from the OGSR Library concerning all previously drilled wells in southern Ontario. All of these considerations will help designate the most interesting areas for shale gas exploration.

The next major phase of this project is to obtain new rock and gas samples throughout the various units. This will be accomplished by drilling the various shale gas units and collecting core and gas samples. The first unit to be studied is the Devonian Kettle Point Fm. During early 2010, two boreholes are to be drilled and core samples will be collected in canisters through the formation. In the following months, rock and gas samples will be analyzed for rock mechanic properties, total organic content, maturity, adsorption isotherms as well as for gas content, composition and calorific value. Furthermore, geophysical logs will be run in both holes. All of these parameters will allow for the identification of the various members of the Kettle Point Fm and their characteristics. In upcoming years, the Ontario Geological Survey wishes that the same strategy will be dedicated to other prospective shale gas units of southern Ontario.

Conclusions

Previous reports and initial data obtained as part of this project indicate the presence of potential shale gas units in southern Ontario. Taking in to account maturity data, southwestern Ontario shale gas plays would probably be classified as shallow biogenic plays. However, in eastern Ontario, the geological history of the area suggests a thermogenic shale gas play.

The OGS expects that past or future work completed as part of this project will convince the shale gas community that southern Ontario represents a worthy prospect.

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