



INTRODUCTION

Petrel Robertson Consulting Ltd. undertook an assessment of “tight gas” production and exploration potential in British Columbia in early 2003, for the British Columbia Ministry of Energy and Mines, Resource Development Division, New Ventures Branch. This report summarizes the project, and addresses several key areas:

- Definition of tight gas, and overview of its history and recent development in British Columbia;
- Geology and reservoir characteristics of major tight gas units in B.C.;
- Analysis of future exploration and development potential;
- Comparison with analogue basins;
- Application of current exploitation strategies, including modern drilling and completions technologies, to exploit tight gas reservoirs

This project is a regional overview for the purpose of assessing tight gas potential and highlighting opportunities. Isopach maps have been generated by direct interpretation of well logs from selected wells, to show regional patterns. Test, production, and reserves data are derived from commercial databases and government documents; we have not examined individual well records for this information.

DEFINITIONS

“Tight gas” lacks a formal definition, and usage of the term varies considerably. Law and Curtis (2002) defined low-permeability (tight) reservoirs as having permeabilities less than 0.1 millidarcies. Many explorationists think of tight or low-permeability reservoirs as occurring only within basin-centred, or deep basin settings. Law (2002) confirmed that low-permeability reservoirs characterize basin-centred gas accumulations, but can also occur elsewhere.

For the purposes of this study, and to be as inclusive as possible, we define “tight gas” reservoirs as those that are regionally extensive, and typically of sub-economic reservoir quality by normal completion and production standards. Although much of this rock fits the Law and Curtis definition ($K < 0.1$ md), we have not adhered strictly to this cut-off. Much, but not all, tight gas is found within the Deep Basin, where it occurs as regionally pervasive, gas-saturated, abnormally

pressured accumulations lacking downdip water contacts. Isolated “sweet spots” within tight gas units may feature conventional (economic) reservoir quality; these account for most current Deep Basin production.

Fractured shale-gas systems have been defined using a distinct set of parameters by Curtis (2002), and are not considered in this assessment.

TIGHT GAS REGIONS IN BRITISH COLUMBIA

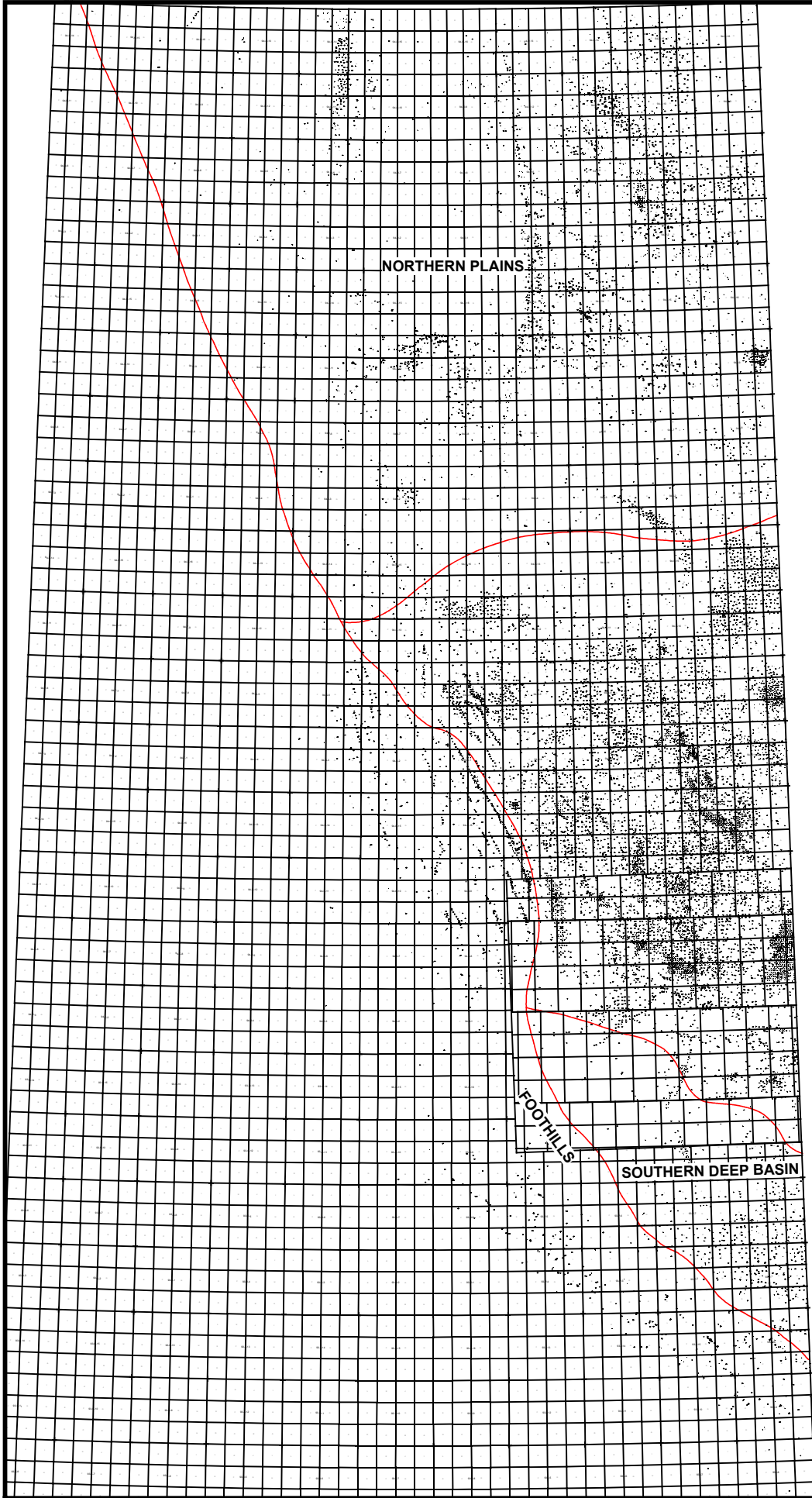
Tight gas reservoirs occur throughout northeastern British Columbia. Three distinct regions can be recognized, based upon structural and stratigraphic characteristics (Map 1).


1. **Deep Basin** – Characterized by stacked Mesozoic clastic reservoirs, each regionally extensive and gas-saturated, containing abnormally-pressured gas accumulations lacking downdip water contacts. The updip (northeastern) boundary of the Deep Basin varies throughout the stratigraphic column, as each reservoir unit has its own updip edge.
2. **Foothills** – Tight gas reservoirs of various ages and types produce where structural deformation creates extensive natural fracture systems. To the east, reservoir quality tends to be more conventional, and fracturing plays a lesser role.
3. **Northern Plains** – Laterally extensive tight gas reservoirs produce where relatively subtle natural fractures can be exploited with horizontal drilling and advanced stimulation techniques. Only one unit, the Jean Marie platform carbonate, is an established producer. The Jean Marie appears to be a geographically-distinct basin-centred gas accumulation.

TIGHT GAS EXPLORATION AND EXPLOITATION

Current Situation – Until recently, Canadian tight gas reservoirs have been regarded as uneconomic, and have received relatively little attention. Masters (1979) tabulated up to 440 TCF (12,500 e⁹m³) of recoverable tight gas resource in the western Canadian Deep Basin, assuming substantial price escalation and technological advances over time. Neither price nor technology has advanced sufficiently to recognize more than a small fraction of these volumes. Today, British Columbia Deep Basin gas reserves total about 100 e⁹m³, and occur almost exclusively in reservoir “sweet spots”. Gas in Deep Basin tight sands is regarded as a future possible resource, not as reserves.

Outside of the Deep Basin (as recognized by Masters), fractured tight carbonates have been prolific producers along the Bullmoose-Sukunka Foothills structural trend since the 1970’s. Natural fracturing also plays a role in productivity of tight

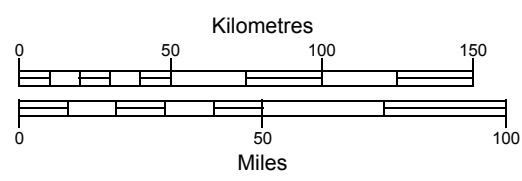


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EXPLORATION ASSESSMENT OF
TIGHT GAS PLAYS,
NORTHEASTERN BRITISH COLUMBIA

**TIGHT GAS REGIONS,
NORTHEASTERN
BRITISH COLUMBIA**

GEOLOGIST: BRAD J. HAYES 1:2 500 000 MAP 1
DRAWN BY: KRISTA WALKER FEBRUARY 2003
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to marginal reservoirs in the outer Foothills to the north, at Beg-Jedney-Bubbles. In addition, horizontal drilling has accessed large gas accumulations within tight platformal carbonates of the Jean Marie Member in the northern B.C. Plains. Discovered gas in place was estimated at $11.6 \text{ e}^9\text{m}^3$, with an additional $24.0 \text{ e}^9\text{m}^3$ to be found; however, recent discoveries will likely increase these numbers.

Exploration and Exploitation – Today, most B.C. tight gas exploration and exploitation activity takes place within the context of the three play areas discussed above:

- Stratigraphic mapping to discover Deep Basin “sweet spots”, featuring conventional reservoir quality within coarse-grained clastics. Tight sands encompassing the sweet spots contribute some gas as pressures are drawn down by production.
- Structural mapping of Bullmoose-Sukunka fractured reservoirs, with emphasis on delineating structural configurations that optimize reservoir fracturing. Outer Foothills fractured reservoirs at Beg-Jedney-Bubbles are also targeted along structural culminations.
 - recent discoveries suggest that similar play models may be pursued successfully in other low-permeability reservoir units
- Horizontal drilling in Jean Marie platformal carbonates
 - EnCana is now extending this play into new, previously uneconomic areas, using economies of scale, and drilling and completion technology advances