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Open File 3216

"BASAL BELLY RIVER" SANDSTONE CYCLES, SOUTHERN ALBERTA AND SOUTHWESTERN SASKATCHEWAN

(extension and revision of Open File 2672)

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ABSTRACT

This report represents an extension of mapping of Basal Belly River Cycles into southwestern Saskatchewan. This work required some rationalization and minor revision of several Cycle boundaries and thicknesses from those presented in Open File 2672, and these are included here.

Previous regional subsurface correlation of the Basal Belly River (approximately the lower 25-75 m of the Campanian Belly/Judith River clastic wedge) throughout southern and central Alberta and southwestern Saskatchewan suggested the unit can be divided into a series of at least seven stacked composite progradational cycles, separated by marine flooding surfaces.

Each cycle has continental/coaly deposits to the west, a central belt internally comprised of stacked shoreline-related sandstones, and downlaps and shales-out to the east. Mapping reveals that the locus of sandy deposition of each successive cycle is located eastward of, and stratigraphically higher than, the preceding one. This indicates that the balance between sediment supply from the west and subsidence of the Campanian foreland basin allowed overall eastward, but non-continuous, progradation of the clastic wedge over more than 400 km across Alberta during Basal Belly River time (2-5? Ma).

Each cycle encloses a specific set of gas pools, and production is obtained from both shoreface- and channel-related facies. As the geographic limits, thickness, facies distribution, and sedimentological characteristics of each cycle vary, the predictive implications for reservoir exploration and exploitation are significant. Large areas of thick sandstone with no known pools are present in each cycle.

INTRODUCTION

The prime objectives of this report are 1) to extend earlier work into southwestern Saskatchewan, and 2) to revise the boundaries and geographic limits of several Cycles as presented in previous reports, as a result of further study.

STUDY AREA AND DATA BASE

The area covered in this study includes the subsurface of most of southern and central Alberta from townships 6 to 58, Ranges 1W4 to 2W5 in the south and Ranges 1W4 to 24W5 in the north, and the subsurface of southwestern Saskatchewan from Townships 1 to 46, Ranges 19W3 to 30W3. The study area is bounded on the west and southwest by the approximate limit of Foothills deformation, and on the northeast and south by outcrop of the base of the Belly River Group. To the east the "Basal Belly River" strata shale out or pass behind drill hole casing. Due to the low angle of regional dip in eastern Alberta and western Saskatchewan, there is a wide zone near each outcrop belt with no subsurface control because the pertinent strata are behind surface casing, and therefore not logged in petroleum wells. However, about one well per Township was used, resulting in a total data base of over 2250 wells.

A series of west-east Gamma Ray-Porosity log cross sections was constructed and correlated, using one well per township spacing, for each Township. Correlations for each well were made by referring to all surrounding wells on adjacent cross sections and resulted in definition of seven composite "Cycles" within the "Basal Belly River" sandstone units. Thicknesses of "clean sandstone" (using a 50% GR cut-off) were mapped and contoured for each resulting cycle. Subsequently, gas pools were assigned, by individual inspection, to the correct cycle and plotted on the appropriate clean sandstone isopach map.

This report is only a summary of this material, although all background material is retained on file for inspection at GSC (Calgary). Hamblin and Abrahamson (1993) included background discussion of geology, study methods, cross sections and general results. Simplified clean sandstone isopach maps, with appropriate gas pools indicated, are presented for each of the seven cycles. A subsurface tops and thickness data file is included as an Excel 4.0 spreadsheet on two diskettes, including tops, subsea depth, thickness and clean sandstone thickness for each Cycle. This is revised from that presented by Hamblin (1993). The second diskette also lists all "Basal Belly River" gas pools, arranged by Cycle. Since these displays are self-evident and represent an extension of previous work, little discussion is included.

CLEAN SANDSTONE ISOPACH MAPS

Thicknesses of "clean sandstone" for each cycle at each of the original cross section wells were plotted and contoured at 5 m intervals (Figs. 1-7). In addition, all gas pools were assigned to

the stratigraphically-correct Cycle and are shown on the isopach maps. Mapped extents and geographic positions of Cycles 4-7 are similar, but somewhat altered from those included in Hamblin and Abrahamson (1993).

Each Cycle thins, becomes more shaley and downlaps to the east, as it gradually passes laterally into the equivalent portion of the Lea Park Formation marine shale. Each succeeding Cycle overlies and is located eastward of the preceding one. These cycles are interpreted as successive shoreline-related facies complexes, including both shoreface and channel/valley-fill depositional environments. Clearly, the locus of shoreline-related sand deposition shifted eastward across the Basin through Belly River time. It is also apparent that the eastward shifts of these loci decreased through time, resulting in a more pronounced vertical stacking of the sandy facies in later Cycles. However, the top of the Foremost Formation remains nearly horizontal thus producing the overall eastward thinning of the clastic wedge from the base, and the diachronous younging of the base of the Belly River Group. Each Cycle passes laterally to the west into nonmarine interbedded sandstone, siltstone and coal making up the bulk of the Foremost Formation.

Similarly, the locus of gas entrapment shifted eastward and upward through the stratigraphy of the Foremost Formation. Within each Cycle, the bulk of identified gas pools correlate with areas of 10 to 20 m clean sandstone thickness. Yet within each Cycle there are areas with few designated gas pools, suggesting further opportunities exist for exploration in the "play areas" of each Cycle. It is also clear that exploration in different Cycles should be concentrated in different areas, and conversely that exploration in different areas will encounter different Cycles. Further analysis of gas potential in Basal Belly River strata is presented in Hamblin and Lee (in press).

Each Cycle is actually a composite of several thinner, individual, generally coarsening-upward, units which mimic the eastward thinning, fining and downlap trends of the larger Cycles. These units could be considered as parasequences. No attempt was made in this study to correlate and define these individual units, which likely comprise separate reservoirs.

CONCLUSIONS

1. The "Basal Belly River" unit (Belly River Group) of southern Alberta and southwestern Saskatchewan comprises at least seven stacked, regionally-identifiable, composite progradational Cycles, each dominated by shoreline-related sandstones (both shoreface and channel deposits), and each a composite of several lesser parasequences (individual reservoirs).

2. The locus of clean sandstone deposition of each successive Cycle is located eastward of, and stratigraphically higher than, that of the preceding one and enclosed gas pools are primarily located in the region of 10-20 m clean sandstone. Each Cycle has potential for further gas pool discoveries of small to moderate size.

3. The locus, boundaries and thicknesses of clean sandstone deposition presented here for Cycles 4-7 are typically shifted eastward some distance from those presented by Hamblin and Abrahamson (1993) and Hamblin (1993).

ACKNOWLEDGEMENTS

We gratefully acknowledge the able, and cheerful, assistance of Ping Tzeng and Peter Neelands in production of the maps presented here.

LIST OF FIGURES

1. "Basal Belly River" Cycle 1, clean sandstone isopach map, with gas pools.

2. "Basal Belly River" Cycle 2, clean sandstone isopach map, with gas pools.

3. "Basal Belly River" Cycle 3, clean sandstone isopach map, with gas pools.

4. "Basal Belly River" Cycle 4, clean sandstone isopach map, with gas pools.

5. "Basal Belly River" Cycle 5, clean sandstone isopach map, with gas pools.

6. "Basal Belly River" Cycle 6, clean sandstone isopach map, with gas pools.

7. "Basal Belly River" Cycle 7, clean sandstone isopach map, with gas pools.

LIST OF DISKETTES

1. a) "Basal Belly River" tops and thickness data, Excel 4.0 spreadsheet, southern Alberta, Townships 1 - 34.

   b) "Basal Belly River" tops and thickness data, Excel 4.0 spreadsheet, southern Saskatchewan, Townships 1 - 46.

2. a) "Basal Belly River" tops and thickness data, Excel 4.0 spreadsheet, northern Alberta, Townships 35 - 60.

   b) "Basal Belly River" gas pool data, listed by Cycle, for Cycles 2 - 7.

REFERENCES

Hamblin, A.P. and Abrahamson, B.,
1993: Offlapping progradational cycles and gas pool distribution in the Upper Cretaceous "Basal Belly River" sandstones, Judith River Group, southern and central Alberta. Geological Survey of Canada, Open File 2672, 19p.

Hamblin, A.P.,
1993: Subsurface tops and thickness data for "Basal Belly River" progradational cycles, Judith River Group, southern Alberta. Geological Survey of Canada, Open File 2752, 40p.

Hamblin, A.P. and Lee, P.J.,
In press: Uppermost Cretaceous, Post-Colorado gas resources of the Western Canada Sedimentary Basin, Interior Plains. Geological Survey of Canada Bulletin.

ALBERTA / SASKATCHEWAN

BASAL BELLY RIVER CYCLE 1
CLEAN SANDSTONE ISOPACH MAP

5 — *Total clean sandstone thickness (metres) contoured at 5m intervals.*

INNISFAIL — *Gas field name.*

Discovery well location for each pool.

1/103 — *Number of BBR pools / total gas-in-place ($x10^6 m^3$).*

0 km 100

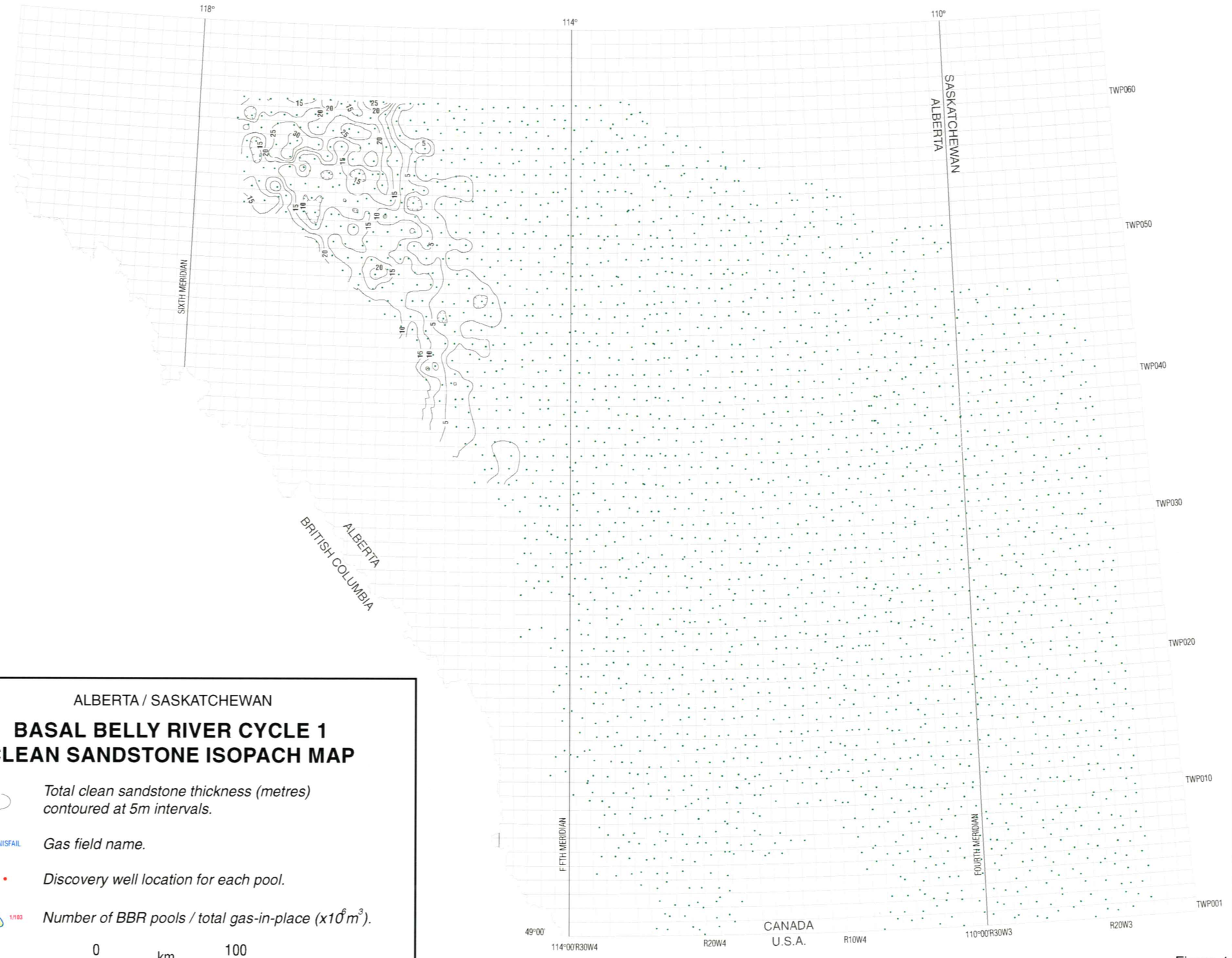

Figure 1

ALBERTA / SASKATCHEWAN

BASAL BELLY RIVER CYCLE 2
CLEAN SANDSTONE ISOPACH MAP

5 — *Total clean sandstone thickness (metres) contoured at 5m intervals.*

INNISFAIL — *Gas field name.*

Discovery well location for each pool.

1/103 — *Number of BBR pools / total gas-in-place ($x10^6 m^3$).*

0 km 100

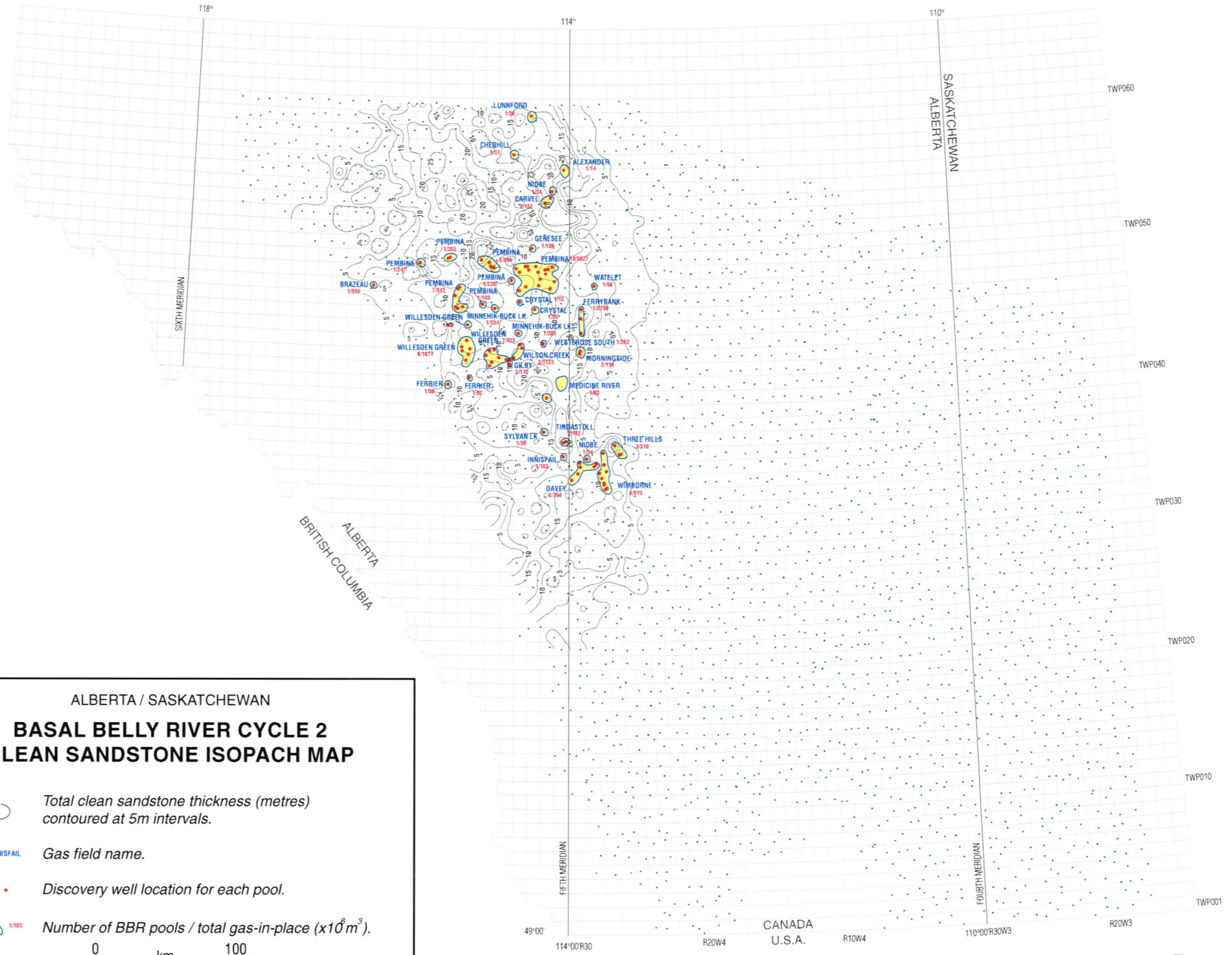

Figure 2

ALBERTA / SASKATCHEWAN

BASAL BELLY RIVER CYCLE 3
CLEAN SANDSTONE ISOPACH MAP

Total clean sandstone thickness (metres) contoured at 5m intervals.

INNISFAIL *Gas field name.*

Discovery well location for each pool.

1/163 *Number of BBR pools / total gas-in-place ($x10^6 m^3$).*

0 km 100

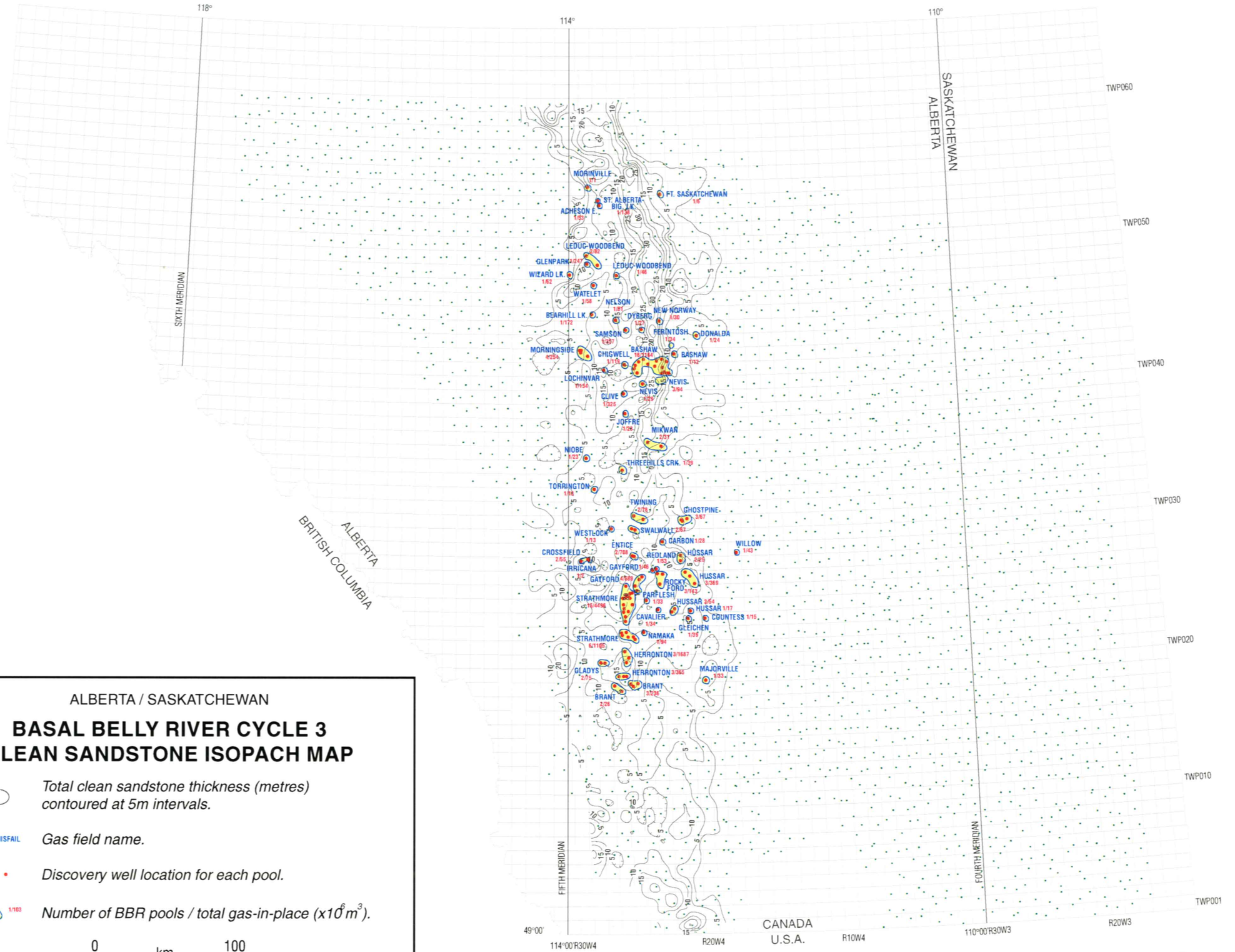

Figure 3

ALBERTA / SASKATCHEWAN

BASAL BELLY RIVER CYCLE 4
CLEAN SANDSTONE ISOPACH MAP

5 — *Total clean sandstone thickness (metres) contoured at 5m intervals.*

INNISFAIL — *Gas field name.*

• — *Discovery well location for each pool*

1/103 — *Number of BBR pools / total gas-in-place ($x10^6 m^3$).*

0 km 100

Figure 4

ALBERTA / SASKATCHEWAN

BASAL BELLY RIVER CYCLE 5
CLEAN SANDSTONE ISOPACH MAP

5 — *Total clean sandstone thickness (metres) contoured at 5m intervals.*

INNISFAIL — *Gas field name.*

• — *Discovery well location for each pool*

1/103 — *Number of BBR pools / total gas-in-place ($x10^6 m^3$).*

0 km 100

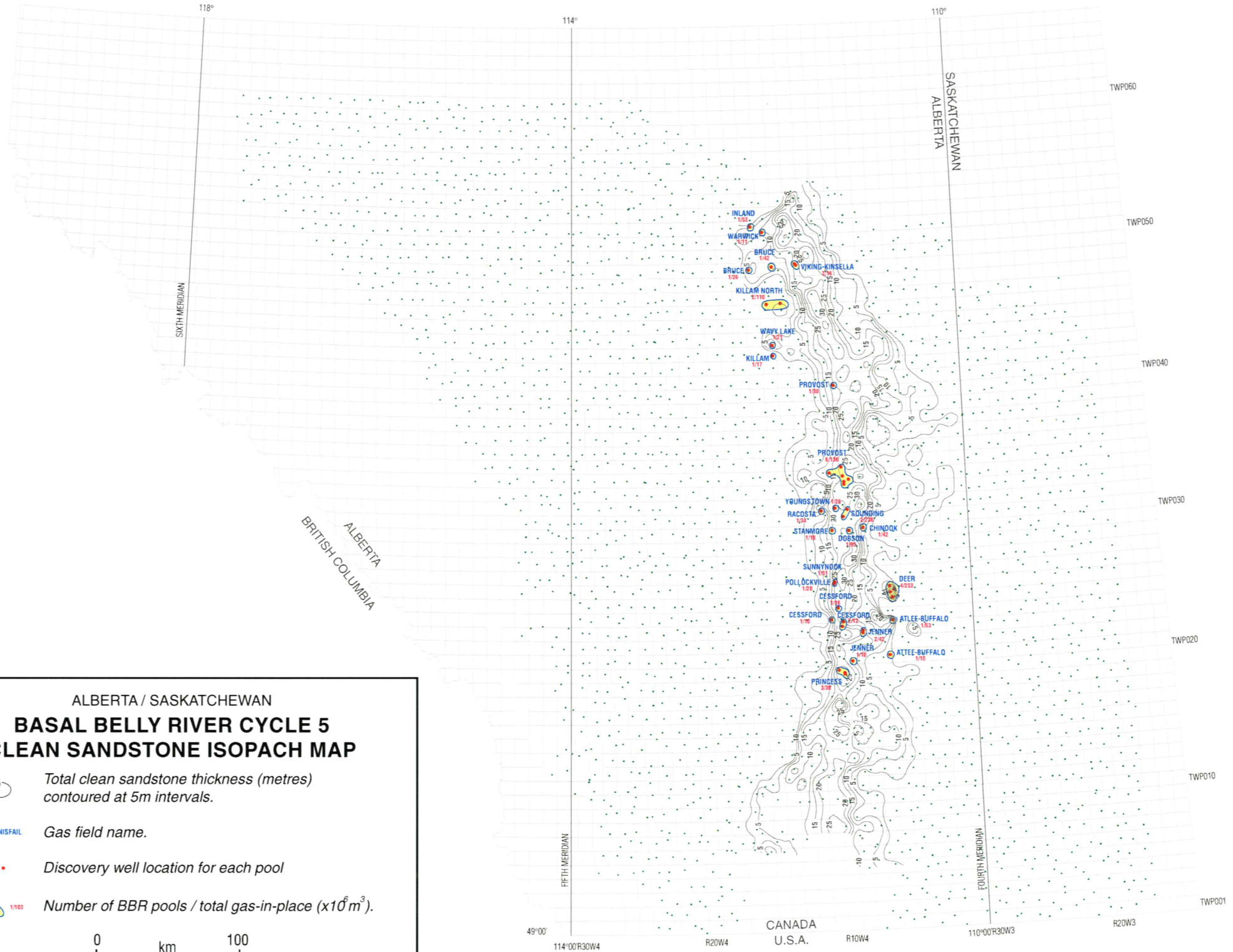

Figure 5

ALBERTA / SASKATCHEWAN

BASAL BELLY RIVER CYCLE 6
CLEAN SANDSTONE ISOPACH MAP

5 — *Total clean sandstone thickness (metres) contoured at 5m intervals.*

INNISFAIL — *Gas field name.*

Discovery well location for each pool.

1/163 — *Number of BBR pools / total gas-in-place ($x10^6 m^3$).*

0 km 100

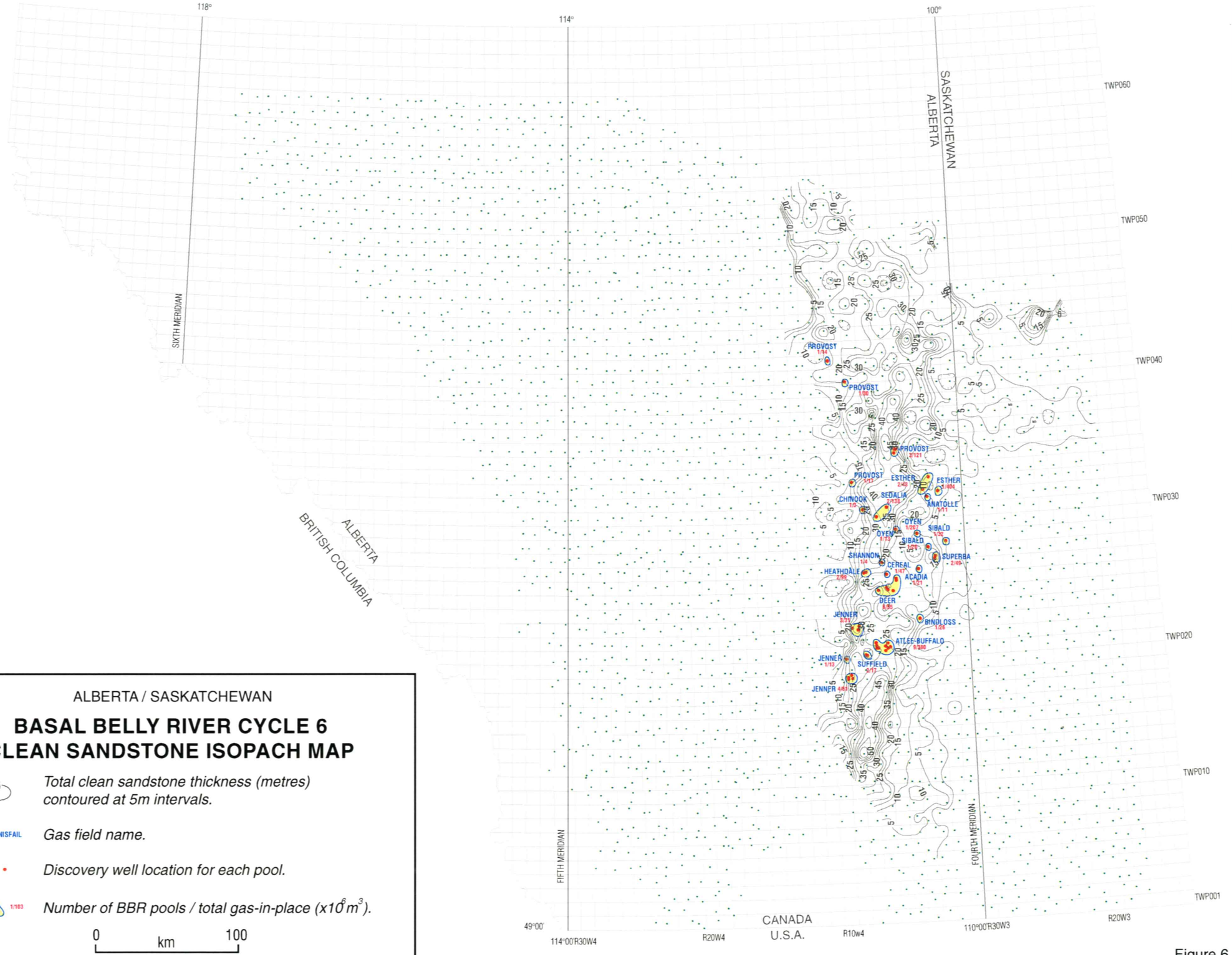

Figure 6

ALBERTA / SASKATCHEWAN

BASAL BELLY RIVER CYCLE 7
CLEAN SANDSTONE ISOPACH MAP

5 — *Total clean sandstone thickness (metres) contoured at 5m intervals.*

INNISFAIL — *Gas field name.*

• — *Discovery well location for each pool.*

1/103 — *Number of BBR pools / total gas-in-place ($x10^6 m^3$).*

0 km 100

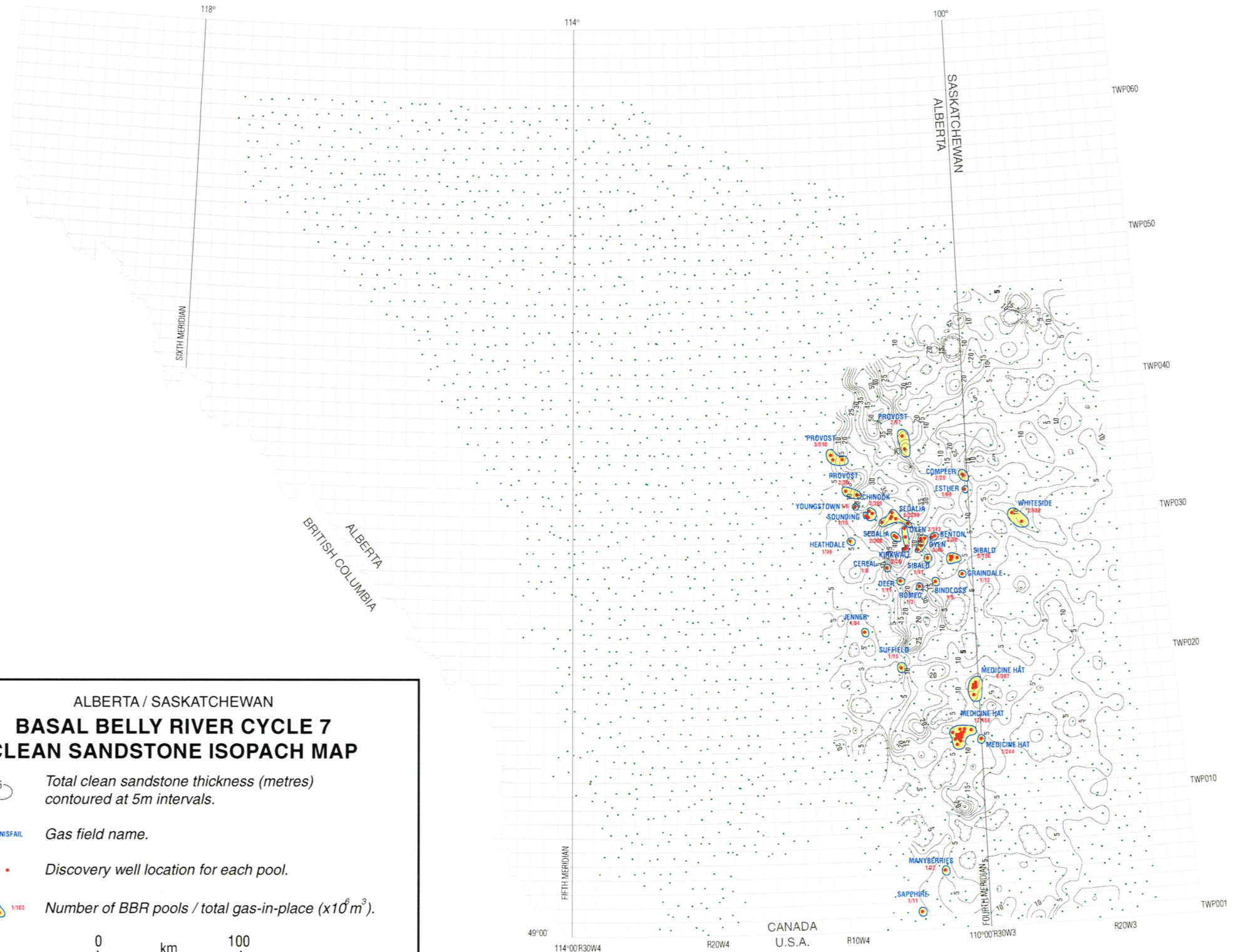

Figure 7