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Qualitative Assessment of the Plateau Fault (Mackenzie Mountains, NWT) as a Conceptual Hydrocarbon Play

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ABSTRACT

The Plateau Fault (Mackenzie Mountains, Northwest Territories) has been suggested as a possible dry-gas hydrocarbon play, based on its interpreted character as a low-angle overthrust of regional extent. Qualitative assessment of its hydrocarbon potential has been carried out, based on archival data and new data derived from bedrock mapping and sampling. Thermal-maturity data, mainly from microfossils, indicate some potential for dry-gas generation and preservation within the Mackenzie Platform succession and younger strata. The only likely source rocks, however, are in shale-dominated, Upper Devonian strata, in particular the Hare Indian and Canol formations. Argillaceous limestone of the Middle Devonian Headless Formation is expected to act as a seal, preventing downward charging of potential reservoirs in the Mackenzie Platform succession. Sandstone beds in the Upper Devonian Imperial Formation may have reservoir potential. Geological data permit the Plateau Fault to be interpreted as a low-angle thrust. Even the most favourable overthrust scenario, however, does not permit significant preservation of potential reservoirs of Silurian to Upper Devonian age beneath the hanging-wall panel. Based on these considerations, the Plateau Fault is unlikely to constitute a large-scale hydrocarbon play, although there may be limited trapping potential beneath its leading edge.

TABLE OF CONTENTS

INTRODUCTION

The Plateau Fault is a major structural feature of the northern and west-central Mackenzie Mountains of the Northwest Territories (Figure 1), where it can be traced along strike for approximately 400 km (e.g., Gabrielse et al., 1973; Cecile, 1980; McMechan et al., 1991). Cecile et al. (1982) suggested the Plateau Fault as a large-scale hydrocarbon structural play in the central Mackenzie Mountains, a region commonly discounted as prospective for hydrocarbon exploration (Gabrielse et al., 1973; Aitken and Cook, 1974; Morrow, 1991). This report presents a qualitative assessment of Plateau Fault's prospects as a conceptual play. It will be argued that the Plateau Fault is unlikely to be a large-scale hydrocarbon play, but that there may be limited trapping potential beneath the fault along its leading edge.

To ensure timely production of the present report, it has been necessary to include data from several works in progress, which are cited accordingly. Although such data are provisional, any changes are anticipated to be minor and the conclusions of the present report are unlikely to be affected. Data are current as of March 31, 2008.

THE PLATEAU FAULT AS A CONCEPTUAL PLAY

The Model

Cook (in McMechan et al., 1991) subdivided the Mackenzie Mountains into northern, central, and southern regions characterized by distinct structural styles. The central Mackenzie Mountains have been considered to present poor prospects for hydrocarbon exploration (see review by Cecile et al., 1982). Structural style generally is not conducive to trap development (Cecile et al., 1982) and potential reservoir units commonly are breached by erosion (Gabrielse et al., 1973; Aitken and Cook, 1974).

Cecile et al. (1982) suggested that the Plateau Fault might constitute a viable, large-scale trap for hydrocarbons. They based this suggestion on an interpretation of the Plateau Fault as a low-angle overthrust of regional extent (approximately 4000 km^2), beneath which essentially the entire Paleozoic succession of the Mackenzie Mountains was interpreted to have been preserved (Cecile and Cook, 1981). They defined the overthrust area to be the area between the trace of the Plateau Fault at surface and the flexure to the southwest where bedding dips in the hanging-wall increase from very shallow to moderate or steep. Based on limited thermal-maturity data for the central and eastern Mackenzie Mountains (Meijer Drees, 1980; Cecile et al., 1982; Feinstein et al., 1988; Morrow, 1991), the Plateau Fault would be a dry-gas play. No reserves have been documented and no discoveries have been reported, thus this is a conceptual play (cf. Hannigan et al., 2001, p. 8).

Testing the Model

A crucial element in the conceptual play model of Cecile et al. (1982) is their interpretation of the Plateau Fault as a low-angle overthrust with up to 35 km of overlap between hanging-wall and footwall. Map patterns suggest that the greatest potential overlap may be present in the central part of NTS 95M (Wrigley Lake map area; Figure 1). For this reason, efforts at testing the model were focused on this area. These included detailed bedrock mapping along the Plateau Fault, collation of data from published and unpublished sources, and laboratory work on microfossils and organic geochemistry to clarify thermal maturity and source-rock potential. Published and unpublished data from adjacent map areas also have been incorporated where appropriate. Field work was undertaken during the summers of 2006 and 2007 in partnership with the Sekwi Mountain Mapping Project of the Northwest Territories Geoscience Project.

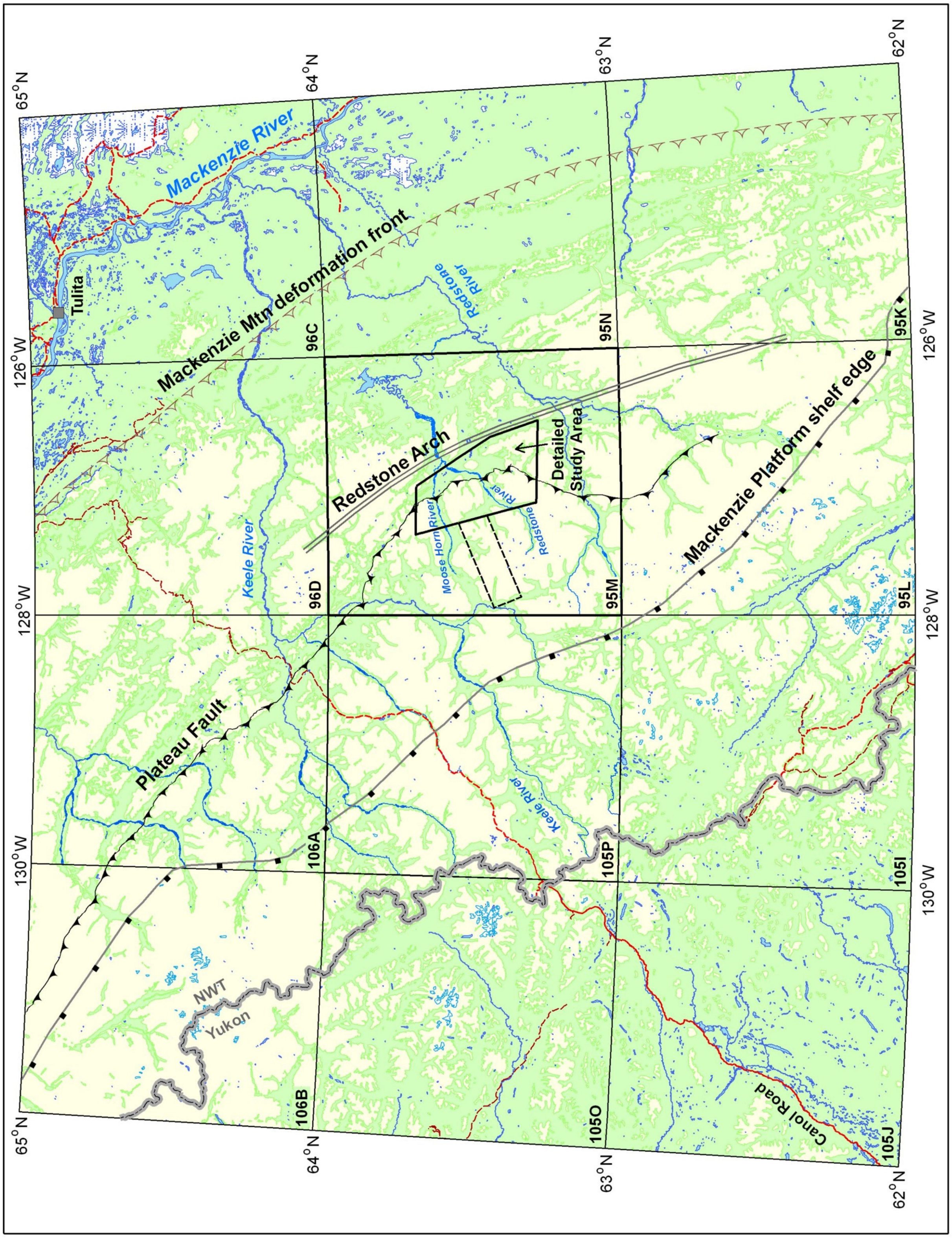

Figure 1. Location map for central Mackenzie Mountains, with NTS map sheets labeled. North is to the left. Red lines are roads, maintained (solid lines) or unmaintained (dashed lines). Note trace of Plateau Fault and of Cordilleran deformation front. Positions of Redstone Arch and western margin of Mackenzie Platform are modified after Morrow (1991). New work described in this report was focused on NTS 95M. Within that map sheet, area of new mapping and map compilation is outlined by solid polygon (indicated by arrow); dashed polygon outlines area recompiled based on air photo analysis and published data.

GEOLOGICAL SETTING OF THE PLATEAU FAULT

Structural Setting

The Mackenzie Mountains are part of the Foreland Belt of the northern Canadian Cordillera and comprise a convex-eastward fold-and-thrust belt with an arcuate length of 950 km (Norris, 1985). Structural style is dominated by thrust faults and by a combination of tight, short-wavelength folds and broad, open folds, depending on the mechanical properties of the strata involved; easterly and westerly verging structures are present (Gabrielse et al., 1973; Cook, in McMechan et al., 1991). The fold-and-thrust belt developed during Late Cretaceous to Early Tertiary compression (Eisbacher, 1981; Cook, in McMechan et al., 1991) that produced 45–55 km of shortening (Gordey, 1981; Cecile et al., 1982). The Mackenzie Mountains are bounded to the east by the Franklin Mountains and to the west by the Selwyn Mountains. Summary overviews of the structural geology of the region are provided by Norris (1985), Cook (in McMechan et al., 1991), and Hyndman et al. (2005).

Stratigraphic Setting

The stratigraphic record of the Mackenzie Mountains (Figure 2) is dominated by Tonian (Neoproterozoic) to Devonian units (Fritz et al., 1991; Narbonne and Aitken, 1995), with minor outliers of Cretaceous strata (Blusson, 1971). Regional overviews on the stratigraphy of the Mackenzie Mountains were provided by Fritz et al. (1991) for the Cambrian–Devonian succession and by Narbonne and Aitken (1995) for Proterozoic units. Other key references include Gabrielse et al. (1973), which established much of the stratigraphic nomenclature for the central Mackenzie Mountains, and Morrow (1991), on the Silurian–Devonian succession.

This account of stratigraphic setting focuses on NTS 95M. The stratigraphic succession recognized during mapping is shown in Figure 3. Distribution of map units for the central portion of the map area is shown in Figure 4.

The oldest units exposed in NTS 95M belong to the informally defined Mackenzie Mountains supergroup (Narbonne and Aitken, 1995). In ascending order, these are the Tsezotene Formation (shale with lesser sandstone and carbonate; Gabrielse et al., 1973), Katherine Group (alternating, formation-scale, sandstone- or shale-dominated packages; Aitken et al., 1978), and Little Dal Group (six informal map units: Mudcracked formation, Platform carbonate assemblage, Grainstone formation, Gypsum formation, Rusty shale formation, and Upper carbonate formation; Aitken, 1981). Katherine Group supersedes the "Tigonankweine Formation" of Gabrielse et al. (1973).

Regionally, a rift-related unconformity caps the Little Dal Group. The oldest deposits above this unconformity belong to the Coates Lake Group and geographically are restricted to inferred rift grabens (Eisbacher, 1981; Narbonne and Aitken, 1995). Coates Lake Group contains three formations (Jefferson and Ruelle, 1986). The basal, Thundercloud Formation (fanglomerate, mudstone, sandstone, and minor carbonate) has not been mapped in NTS 95M but the Redstone River (evaporites, mudstone, fanglomerate) and Coppercap (shallow-marine to deeper-water carbonate) formations are present in the hanging-wall panel of the Plateau Fault. Coates Lake Group is considered the basal part of the Windermere Supergroup by some workers (Aitken, 1991; Narbonne and Aitken, 1995) but is excluded from it by others (Jefferson and Parrish, 1989).

Above Coates Lake Group, formations of the Windermere Supergroup record the transition from rift to drift phases and the establishment of a miogeocline (Narbonne and Aitken, 1995). The siliciclastic-dominated Rapitan Group (Mount Berg, Sayunei, and Shezal formations) was deposited in widening, rift-related depressions during a glacial interval (Yeo, 1981). Shezal Formation, in particular, is a thick succession dominated by tillite (Eisbacher, 1981; Yeo, 1981). Rapitan Group is preserved in both the footwall and hanging-wall panels of the Plateau Fault. Current usage of the name Rapitan Group is more

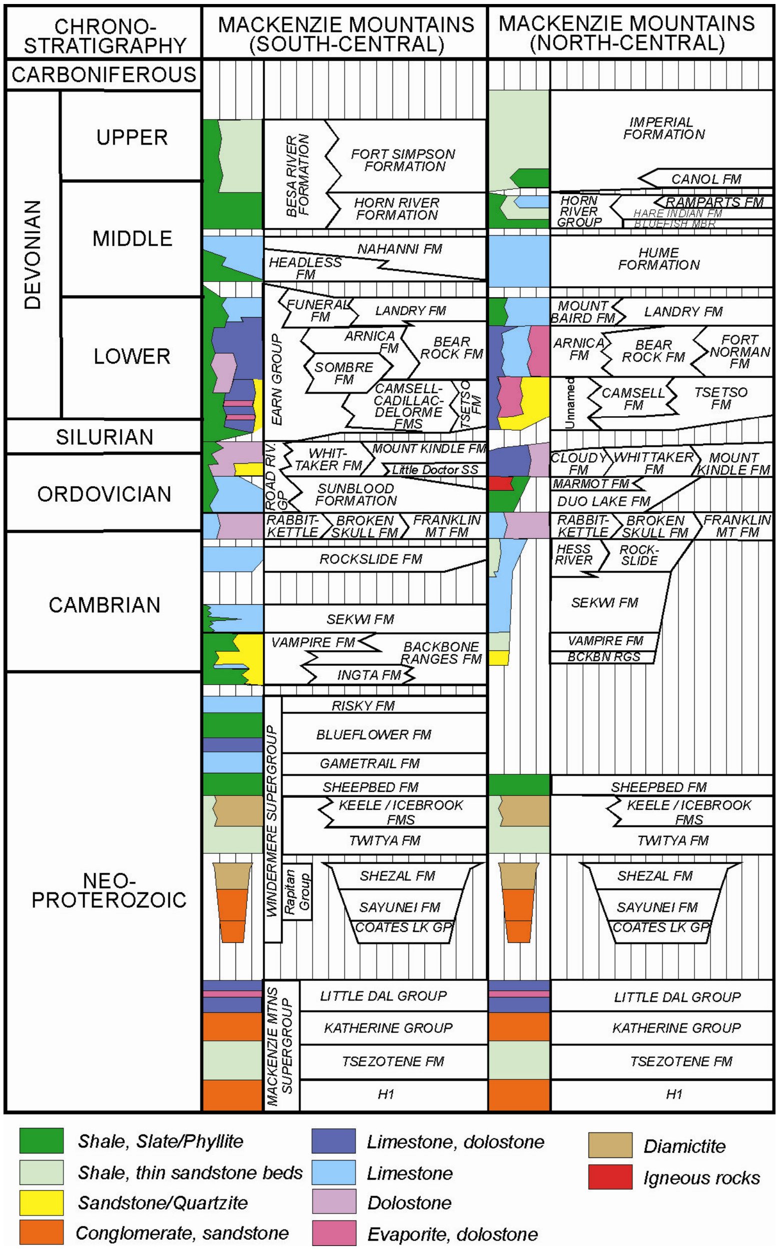

Figure 2. *Stratigraphic columns for the Mackenzie Mountains, modified after Dewing et al. (2006).*

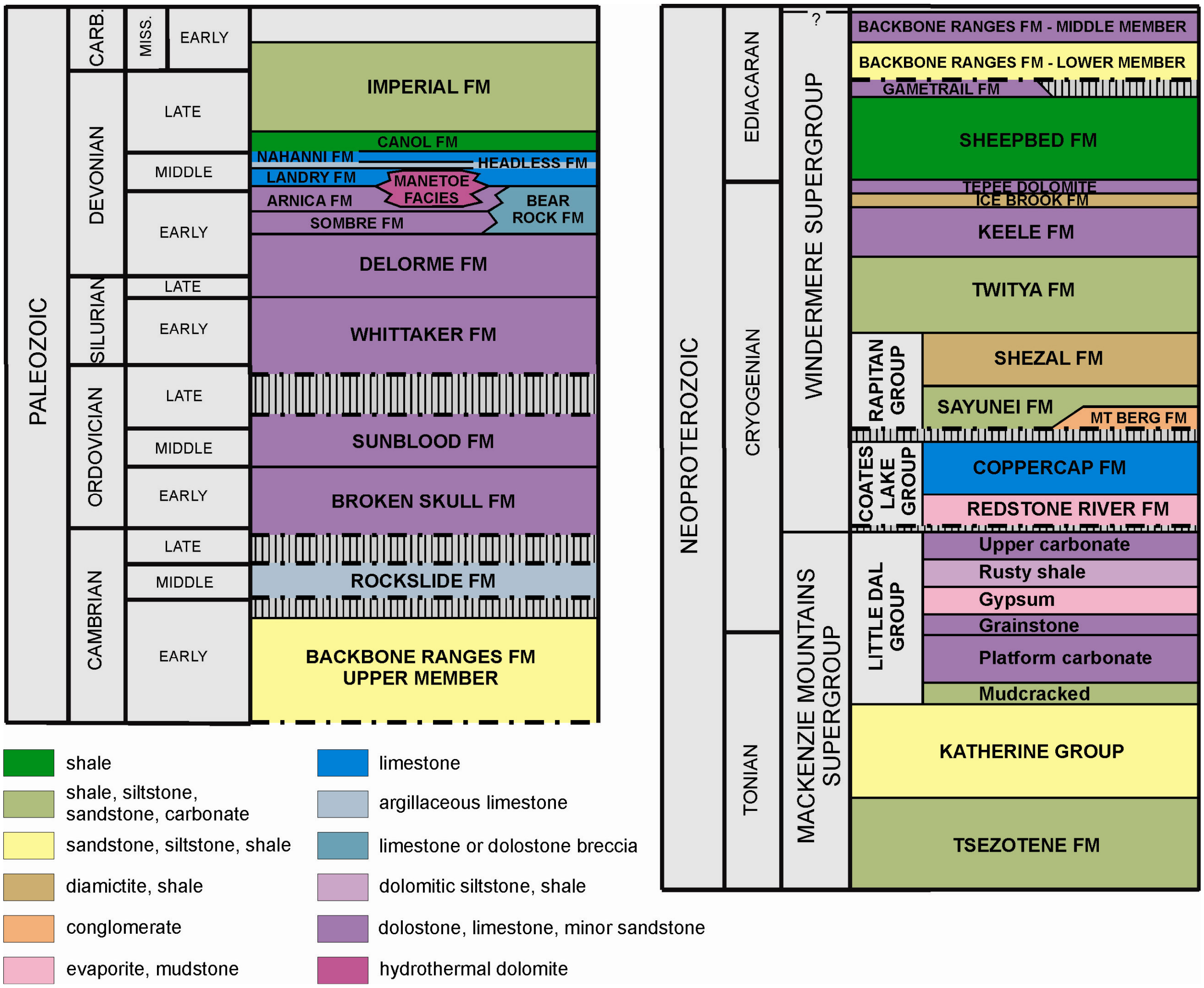

Figure 3. *Stratigraphic column of formations recognized along the Plateau Fault in NTS 95M. Note that breakdown of rock types is more detailed in this figure than in Figure 2. Stratigraphy mainly follows Gabrielse et al. (1973), with modifications after Eisbacher (1978), Aitken (1981, 1989), Narbonne and Aitken (1995), Fritz et al. (1991), and observations by the authors.*

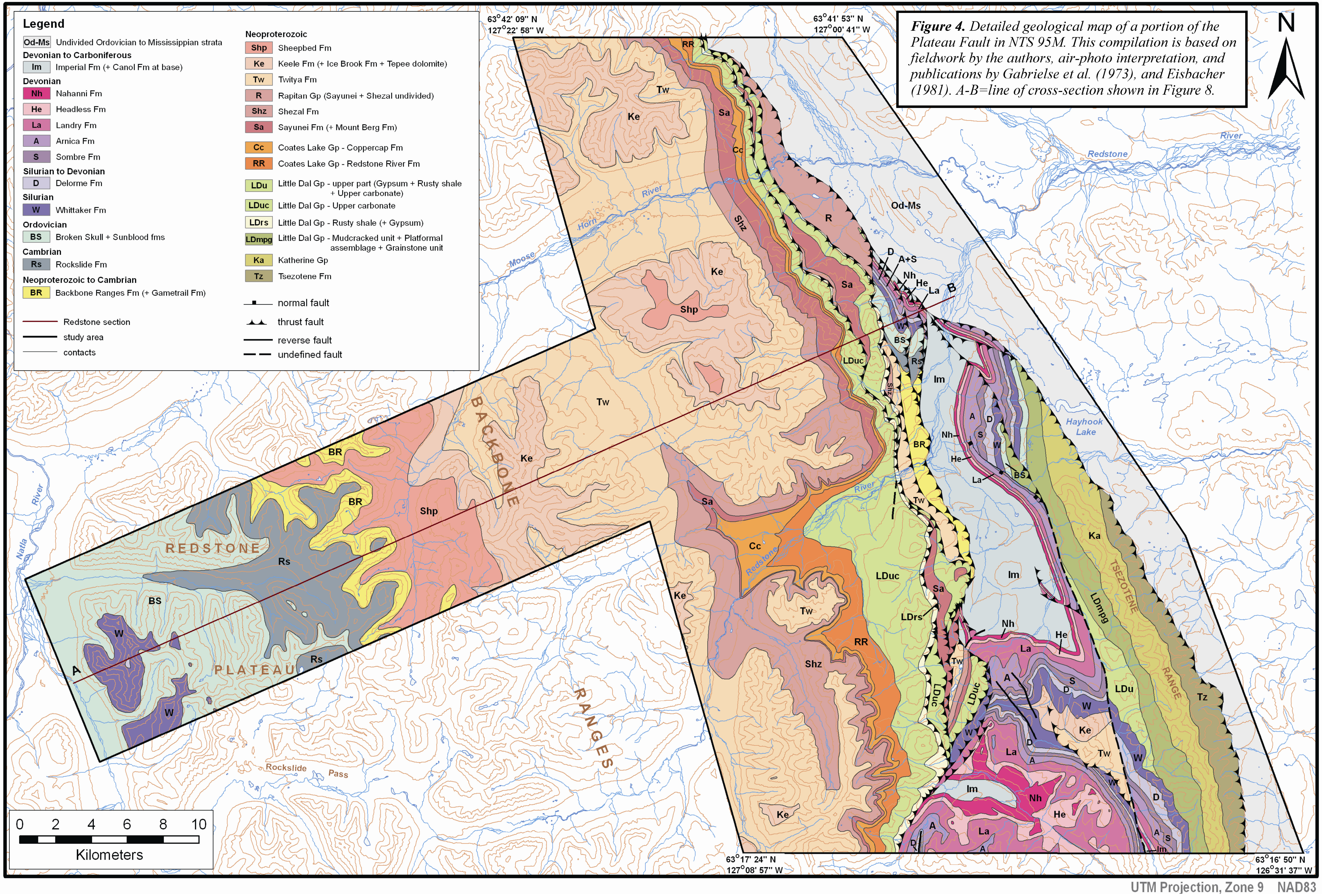

Figure 4. *Detailed geological map of a portion of the Plateau Fault in NTS 95M. This compilation is based on fieldwork by the authors, air-photo interpretation, and publications by Gabrielse et al. (1973), and Eisbacher (1981). A-B=line of cross-section shown in Figure 8.*

restrictive than that originally envisaged by Gabrielse et al. (1973; also Eisbacher, 1978), who included in it strata subsequently assigned to the Twitya Formation.

The balance of the Windermere Supergroup, as currently recognized in NTS 95M, consists of two "grand cycles" (Aitken, 1989; see also Narbonne and Aitken, 1995), each consisting of a lower formation dominated by deep-marine shale and an upper, carbonate dominated formation. The lower grand cycle includes the Twitya Formation (deep-marine shale; Eisbacher, 1978) and Keele Formation (mainly shallow-marine carbonate; Gabrielse et al., 1973; Day et al., 2004). It is capped by a second glacial and post-glacial succession consisting of the diamicite-dominated Ice Brook Formation (Aitken, 1991) and by unusual carbonate lithofacies of the Ravensthroat and Hayhook "formations" (James et al., 2001), which correspond to the "tepee dolomite" of earlier reports (e.g., Aitken, 1991). The second grand cycle consists of the Sheepbed Formation (deep-marine shale; Gabrielse et al., 1973) and the overlying Gametrail Formation (platform carbonate; Aitken, 1989), which is incompletely preserved (Aitken, 1989). Additional Windermere strata (Blueflower and Risky formations), which comprise a third grand cycle, are preserved further to the west (see Aitken, 1989; MacNaughton et al., 2000). The Windermere Supergroup is capped by a regional unconformity (Aitken, 1989).

In NTS 95M, the Proterozoic succession in the hanging wall of the Plateau Fault (Figure 3) consistently preserves the interval from the Rusty shale formation, which generally is the lowest hanging-wall unit, to Sheepbed Formation (Gabrielse et al., 1973). Gametrail Formation is locally preserved beneath an erosional unconformity (Aitken, 1989; RBM, personal observation), and is most likely included at the base of the Backbone Ranges Formation in Figure 4. It should also be noted that for the map compilation (Figure 4) Mount Berg Formation is included with Sayunei Formation, and Ice Brook Formation and "tepee dolomite" are included in Keele Formation. In the footwall of the Plateau Fault, erosion related to uplift on Redstone Arch has removed progressively older Proterozoic units to the east, such that basal Paleozoic deposits in Tigonankweine Range and Tsezotene Range lie uncomformably upon Little Dal Group, whereas farther northeast they lie upon Katherine Group (Gabrielse et al., 1973).

Basal Paleozoic strata in the Mackenzie Mountains are progressively younger to the east (Blusson, 1971; Gabrielse et al., 1973). They record a proximal-to-distal transition in depositional setting, from the Mackenzie Platform in the east and northeast to the Selwyn Basin in the west and southwest. This platform–basin configuration endured until the Devonian (Fritz et al., 1991; Cecile et al., 1997).

Paleozoic stratigraphy in NTS 95M has been affected by the presence of the Redstone Arch. In the hanging-wall and immediate footwall of the Plateau Fault, the sandstone-dominated Backbone Ranges Formation (?Neoproterozoic to Lower Cambrian) marks the base of the Paleozoic succession (Figure 3). Above Backbone Ranges Formation lies the Middle Cambrian Rockslide Formation (argillaceous limestone and calcareous siltstone; Gabrielse et al., 1973) and the Upper Cambrian–Ordovician Broken Skull Formation (dolostone, limestone, sandstone; Gabrielse et al., 1973). Backbone Ranges and Rockslide formations are mapped only west of Tsezotene Range; Broken Skull Formation is more widely distributed, although it may be absent through much of Tsezotene Range (Gabrielse et al., 1973). To the northwest, in NTS 106A, it passes laterally into the Franklin Mountain Formation.

The Middle Ordovician Sunblood Formation is not shown on the map by Gabrielse et al. (1973) for NTS 95M, although those authors mentioned the formation's likely presence in the southwestern corner of the map area. In the immediate footwall of the Plateau Fault, approximately 10 km northwest of Hayhook Lake, the authors (KMF, RBM) mapped a unit of well-bioturbated, sandy dolostone that lay stratigraphically between Broken Skull and Whittaker formations. We have assigned these strata to the Sunblood Formation (Figure 4) but their full extent is not known.

The oldest Paleozoic unit to be present uniformly across NTS 95M is the Ordovician-Silurian Whittaker Formation (dark-weathering, fossiliferous, cherty dolostone and limestone; Gabrielse et al., 1973). The base of Whittaker Formation delineates a regional unconformity (Gabrielse et al., 1973; Fritz et al., 1991.

A regional unconformity also separates Whittaker Formation (and correlative strata) from an overlying, Silurian-Lower Devonian succession (Fritz et al., 1991; Morrow, 1991). In NTS 95M, this comprises, in ascending order, the Delorme, Sombre, Arnica, Bear Rock, Natla, and Landry formations (Gabrielse et al., 1973). Each formation is carbonate dominated; for detailed descriptions, see Gabrielse et al. (1973). Bear Rock Formation is an interval of carbonate breccia. Manetoe Facies dolomitization is developed locally in Arnica and Landry formations (see below). Regionally, the lithostratigraphy of this interval is complex (Figure 2; see also Morrow, 1991).

The uppermost, carbonate-dominated package in the Mackenzie Platform succession is of Middle Devonian age and presents a more straightforward stratigraphy than the Silurian–Lower Devonian succession. In NTS 95M (Gabrielse et al., 1973), the Headless Formation (argillaceous, fossil-rich carbonate) is overlain by the Nahanni Formation (thick-bedded, massive carbonate). These formations correspond approximately to the lower (muddy) and upper (clean) intervals of the Hume Formation, as mapped further north in the Mackenzie Mountains (Figure 2; see also Fritz et al., 1991). The base of the Middle Devonian succession is disconformable in some parts of the Mackenzie Mountains (Fritz et al., 1991; Morrow, 1991).

Basinward of the Mackenzie Platform succession, the Selwyn Basin (Figure 1) was a locus for deposition of deep-water strata (Gordey and Anderson, 1993). The basinal succession is shale-dominated and consists of the Ordovician-Silurian Road River Group and the Devonian Earn Group (Gordey and Anderson, 1993).

During the Late Devonian and earliest Carboniferous (Frasnian to Tournaisian), the region of the former Mackenzie Platform-Selwyn Basin system became the site of a deep-water, siliciclastic-dominated "turbidite basin" (Gordey and Anderson, 1993). The influx of siliciclastic material into the study area represents the onset of Ellesmerian mountain building and uplift in the north (Ziegler, 1969). Upper Devonian strata in the study area consist of the Hare Indian, Canol and Imperial formations. Hare Indian Formation in the study area is dark grey to black, slightly calcareous shale with local limestone interbeds; it is less than 20 m thick and sits disconformably upon Nahanni (or Hume) Formation. Canol Formation is a yellowish, bluish, and rusty brown weathering, organic-rich shale. To the northeast of NTS 105P, it is 4–20 m thick. To the west, however, it thickens to nearly 100 m. Canol Formation is the known source rock to the Kee Scarp Reef oil field at Norman Wells (Snowdon, 1987; Feinstein et al., 1988). Imperial Formation consists of alternating units of sandstone and silty mudstone. The sandstone is very fine-grained in the lower part of the formation and very fine- to fine-grained in the upper part. Imperial Formation is more than 700 m thick in the west and tapers to approximately 300 m in the east as a result of pre-Cretaceous erosion. Imperial Formation lies upon Canol Formation with apparent gradational contact.

Younger strata are not known from NTS 95M. Mississippian, Permian, and Triassic formations are present well to the west and southwest, near the continental divide (Blusson, 1971; Gordey and Anderson, 1993). Outliers of Albian (Cretaceous) siliciclastic strata are present in NTS 105P (Blusson, 1971).

PETROLEUM GEOLOGY

Potential Reservoir Units

Cecile et al. (1982) suggested that several carbonate units in the Mackenzie Platform succession might have reservoir potential. No systematic study of porosity and permeability for this interval has been published but several workers have made note of porosity in individual units (see below). This report will focus on units known to be present in the footwall of the Plateau Fault in NTS 95M (Figures 3 and 4).

Proterozoic and Basal Cambrian

Proterozoic and basal Cambrian units are known to be overmature with respect to hydrocarbon preservation (see below) and thus are unlikely to be reservoirs. Sandstone units in this part of the succession tend to be tightly cemented or quartzitic (e.g., Backbone Ranges Formation; Gabrielse et al., 1973).

Cambrian and Ordovician

Rockslide, Broken Skull, and Sunblood formations tend to be carbonate-dominated but heterolithic, containing notable volumes of silty, argillaceous (including shale), finely crystalline, or cryptocrystalline lithofacies (Gabrielse et al., 1973). Sandstone intervals of appreciable thickness occur in several of these units (Gabrielse et al., 1973). Where we examined such strata during fieldwork, they appeared to be tightly cemented.

Ordovician-Silurian

Vuggy porosity has been reported from Whittaker Formation in NTS 95M (Gabrielse et al., 1973; Olfert, 1976a, b) and NTS 105P (Royle, 1974). Several examples were noted by the authors (RBM, KMF) during field work. Gabrielse et al. (1973) noted a possible reef facies of the Whittaker Formation, with vuggy porosity, but they documented this particular facies only in the hanging-wall panel of the Plateau Fault. We were unable to confirm the presence of reefs in the footwall succession, but did observe large, unfilled vugs associated with stromatoporoids (Figure 5).

To the north and northwest, Mount Kindle Formation is a correlative of Whittaker Formation. It is a unit of resistant, fossiliferous dolostone, with fair to good, vuggy porosity in some beds (Aitken and Cook, 1974; Sekwi Mountain Project database) and intense fracturing of siliceous intervals (Aitken and Cook, 1974).

Silurian-Lower Devonian

Delorme Formation is microcrystalline to finely crystalline (Gabrielse et al., 1973), rarely with visible porosity in outcrop (Sekwi Mountain Project database).

Gabrielse et al. (1973) documented local vuggy porosity in Arnica Formation. In some outcrops, vugs were up to 4 cm by 2 cm and lined with white dolomite crystals but in other outcrops vugs were filled with calcite. Landry formation is largely micritic in NTS 95M (Gabrielse et al., 1973) and also to the north, where Aitken and Cook (1974) noted that it displayed little porosity. In the southern part of NTS 95M, Landry and Arnica formations have been affected by Manetoe Facies dolomitization (Morrow et al., 1990), notably at the ADYJO mineral property (Olfert, 1976a) and at CAP/KAP and adjacent properties (Olfert, 1976b; Cook, 1979; Leighton, 1987; McCartney and Olfert, 1995; McCartney, 1996). Manetoe Facies corresponds to the “Manetoe Formation” of earlier workers (e.g., Gabrielse et al., 1973) and is a diagenetic feature characterized by white, sparry dolomite, commonly with significant diagenetic porosity (Morrow et al., 1990). In the southern Mackenzie Mountains, it is a significant reservoir facies (Beaver River, Kotaneelee, and Pointed Mountain gas fields) and up to several hundred metres thick. Significant Manetoe Facies porosity has been reported locally in NTS 95M (Leighton, 1987) but occurrences are only 50–100 m thick. These occurrences mark the northernmost extent of the facies, at about 63º20’N latitude (Morrow et al., 1990).

Carbonate breccia of Bear Rock Formation typically is porous and cavernous, with carbonate cement (Gabrielse et al., 1973; Aitken and Cook, 1974), and has been interpreted as the product of solution collapse (Morrow, 1991).

Figure 5. *Visible porosity in the Whittaker Formation, northwestern NTS 95M (western flank of Tigonankweine Syncline; see Gabrielse et al., 1973). Outcrop is near coordinates 582320E, 7078973N (UTM Zone 9, NAD83), along approximate track of measured section 28A of Gabrielse et al. (1973). Marks on hammer handle are 10 cm apart.*

Parts of Natla Formation are massive, coarse-grained, crinoidal limestone that commonly is fetid (Gabrielse et al., 1973). This lithofacies might be expected to preserve porosity, but this has not been documented to our knowledge and the formation has been mapped only in the hanging-wall panel of the Plateau Fault (Gabrielse et al., 1973).

Middle Devonian

No prospective reservoirs are known from Middle Devonian strata. Nahanni Formation is a resistant, well-bedded, finely to medium-crystalline limestone (Gabrielse et al., 1973). During Sekwi Mountain Project mapping, it was rarely noted to display visible porosity (Sekwi Mountain Project database). Farther north, correlative strata of upper Hume Formation are similarly massive and resistant and are considered unpromising as a reservoir facies (Aitken and Cook, 1974).

Upper Devonian

One of the authors (WZ) currently is studying the Upper Devonian siliciclastic succession regionally; the following data are from this work. In the northeast corner of NTS 106A, sandstone beds in the basal 50 m of Imperial Formation had porosities from 0.5–2.7% and permeability of less than 0.01 mD. Further north (NTS 106H and 96E), sandstone beds in the upper Imperial Formation have porosity values from 15–20 % and locally greater than 20 %. In outcrop sections in NTS 106A, 105P and 95M, the upper part of Imperial Formation is not exposed. It thus is not known whether porous sandstone is present, or whether the upper interval is even present.

Summary

In the central Mackenzie Mountains, reservoir facies are most likely to be: porous zones within Whittaker Formation; intervals of Landry and Arnica formations affected by Manetoe Facies dolomitization; and porous breccia in Bear Rock Formation. If the upper Imperial Formation is preserved, it may contain porous sandstone beds, by analogy with its outcroppings further north, but the presence of such beds has not been demonstrated.

Source Rocks

Published data on source-rock potential in the Mackenzie Mountains are limited (see below). During work on the Plateau Fault, samples were collected from several mudstone and carbonate units. These, and a number of samples archived at GSC-Calgary, were analyzed by Rock-Eval6 pyrolysis methods. These analyses are being prepared for publication (MacNaughton, Fallas, and others, work in progress; Zantvoort, work in progress); references to them in the present report should be considered preliminary.

Cut-off values of total organic carbon (TOC) for prospective source rocks are not universally agreed upon. Some workers (e.g., Barker, 1979) consider that most source rocks have TOC values between 0.8–2.0 %, with 0.4 % TOC being an approximate minimum for a shale to be a source rock. Other workers (e.g., Fowler et al., 2005) consider 2.0 % TOC to be a more likely minimum value. Below, we group low-end TOC values into those less than 0.4 %, those between 0.4–1.0 %, those between 1.0–2.0 %, and those greater than or equal to 2.0 %. Only units returning at least some analytical values of 0.4 % TOC or greater are discussed.

Proterozoic

Data relevant to source-rock potential of Proterozoic units come in part from two published studies (Strauss and Moore, 1992; Narbonne et al., 1994) that provided only TOC values. Unpublished Rock-Eval results were kindly shared with the authors by D.G.F. Long (personal communication, 2007). A number of samples collected during the present work also were studied by Rock-Eval.

Shale samples from Tsezotene Formation, Katherine Group, and Little Dal Group rarely return values greater than 0.4 % TOC and never reach 1.0 % TOC; most values are much lower (Strauss and Moore, 1992; D.G.F. Long, personal communication, 2007). Analyses from Coppercap Formation can exceed 1.0 % TOC (maximum reported value 1.4 % TOC) but generally are less than 0.4 % TOC (Strauss and Moore, 1992). Values for shale in Twitya Formation generally are less than 0.4 % TOC (Strauss and Moore, 1992; this work) but one slightly fetid outcrop section yielded samples with values up to 1.34 % TOC. Sheepbed Formation appears to be the most consistently organic-rich Proterozoic unit exposed in the Mackenzie Mountains. Shale samples commonly return values greater than 0.4 % TOC but values do not exceed 1.0 % TOC (Strauss and Moore, 1992; this work).

All Proterozoic samples analyzed by Rock-Eval for the present work returned very low S2 values (much less than 0.2 mg HC/g Rock in nearly all cases), suggesting that the samples are post-mature with respect to oil generation.

Cambrian-Middle Devonian (Mackenzie Platform)

Sample coverage is sparse and unsystematic for units of the Mackenzie Platform. Narbonne et al. (1994) gave TOC values for Lower Cambrian carbonates and Cecile et al. (1982) provided TOC values for three samples of Devonian carbonate. During the present work, some samples were collected from fetid or shaly carbonates. Excluding analyses of samples with visible pyrobitumen, no Mackenzie Platform unit has returned a value greater than 2.0 % TOC. Only one sample each from Delorme, Headless, and possible Broken Skull formations has returned a value greater than 0.4 % TOC.

Notably, samples from fetid outcrops of some units, including Whittaker Formation, returned extremely lean TOC values (less than 0.1 % TOC). In such outcrops, fetor presumably reflects the presence of relict sulphur compounds rather than hydrocarbons (L. Stasiuk, personal communication, 2006).

Cambrian-Middle Devonian (Selwyn Basin)

Analyses were carried out on samples collected from Road River Group by the Sekwi Mountain Project and earlier GSC parties. Five samples returned values between 2.0–4.0 % TOC and one sample reached 8.2 % TOC. Additional samples gave values between 1.0–1.9 % TOC (n = 5) or less than 1.0 % but greater than 0.4 % TOC (n = 5). The balance of the samples (n = 6) returned values less than 0.4 % TOC.

Nearly all Road River Group samples had S2 values that were much less than 0.2 mg HC/g Rock and likely are post-mature with respect to oil generation. Additionally, it is important to note that Road River Group has not been mapped in the immediate hanging-wall panel of the Plateau Fault and so is unlikely to be a prospective source for a Plateau Fault play unless it is present as unmapped tongues in the footwall.

Upper Devonian

Upper Devonian siliciclastic units in the central and northern Mackenzie Mountains are currently being studied by one of the authors (W. Zantvoort, work in progress). Preliminary results of that work are summarized here.

Within NTS 95M and 105P, TOC values from Hare Indian Formation ranged from 0.6–4.1% TOC but were too few (n = 3) to permit conclusions on regional trends. Twenty-five samples were collected from Canol Formation across NTS map sheets 95M and 105P. These have yielded values ranging from 0.28–6.52 % TOC; values were lowest in the east and increased to the west. Two samples from Imperial Formation in NTS 95M yielded values of 0.20 and 0.23 % TOC. To the west, on NTS 105P, Imperial Formation samples (n=4) returned values between 0.33–1.09% TOC.

Seals

Numerous shale-dominated or otherwise impermeable formations punctuate the Proterozoic and basal Paleozoic depositional record in the Mackenzie Mountains (Narbonne and Aitken, 1995; Fritz et al., 1991). Although the Little Dal Group is overmature (see below), its Gypsum and Rusty shale formations may be significant to any hydrocarbon trapping beneath the Plateau Fault. The main detachment surface of the Plateau Fault follows these formations (Cecile and Cook, 1981; this work) and they reasonably can be anticipated to provide a seal (see descriptions by Aitken, 1981).

Although the Mackenzie Platform succession is carbonate-dominated, it contains a number of units that are rich in siliciclastic mud or tightly cemented by micrite (see above; also see Gabrielse et al., 1973; Aitken and Cook, 1974) and thus may act as seals. Headless Formation may be of particular note in this regard (Figure 6). It is a recessive-weathering, argillaceous, commonly micritic to finely crystalline carbonate (Gabrielse et al., 1973) that we anticipate has sealed underlying strata from downward charging by hydrocarbons generated from Upper Devonian shale.

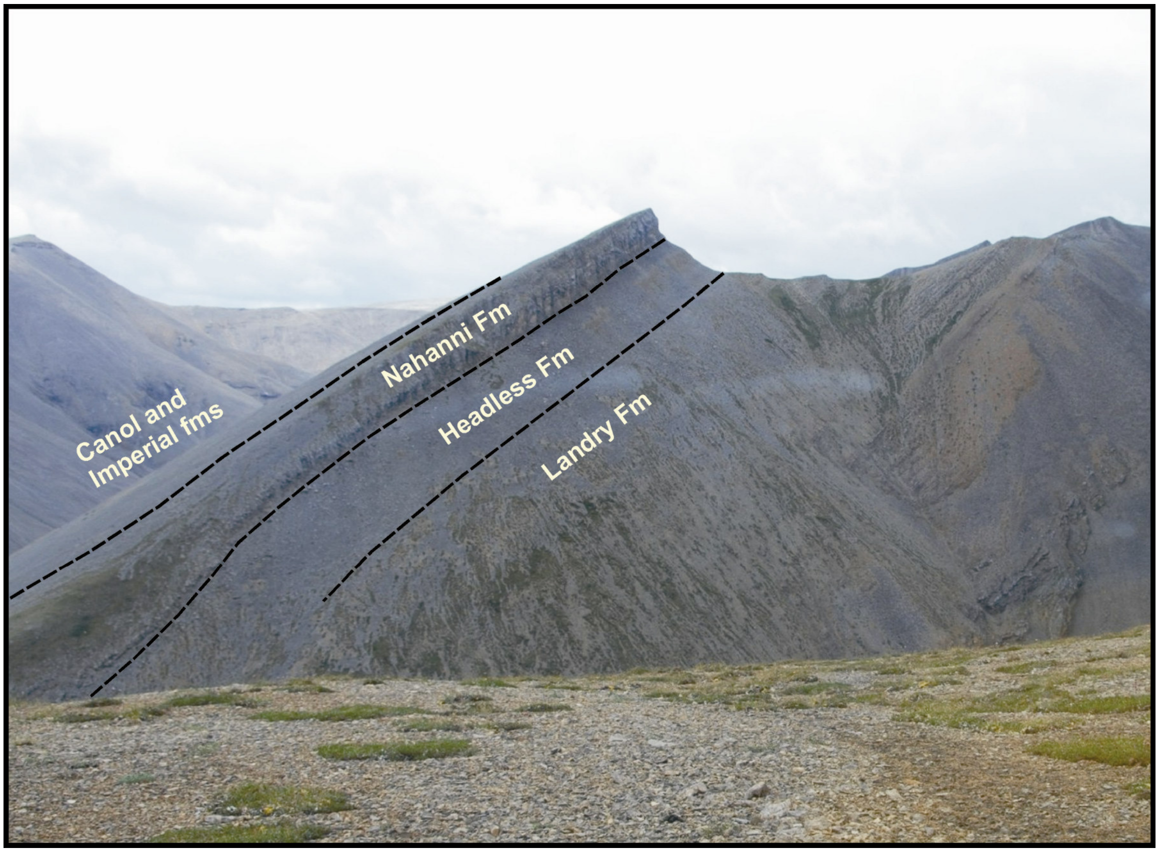

Figure 6. *Flatiron section exposing uppermost part of Devonian carbonate succession. Note recessive-weathering, shale-rich Headless Formation, which would likely prevent downward migration of any hydrocarbons generated from Upper Devonian shale. Photo was taken looking northwest from 588714E, 7073812N (UTM Zone 9, NAD83). Nahanni Formation in this area is approximately 40 m thick (Gabrielse et al., 1973).*

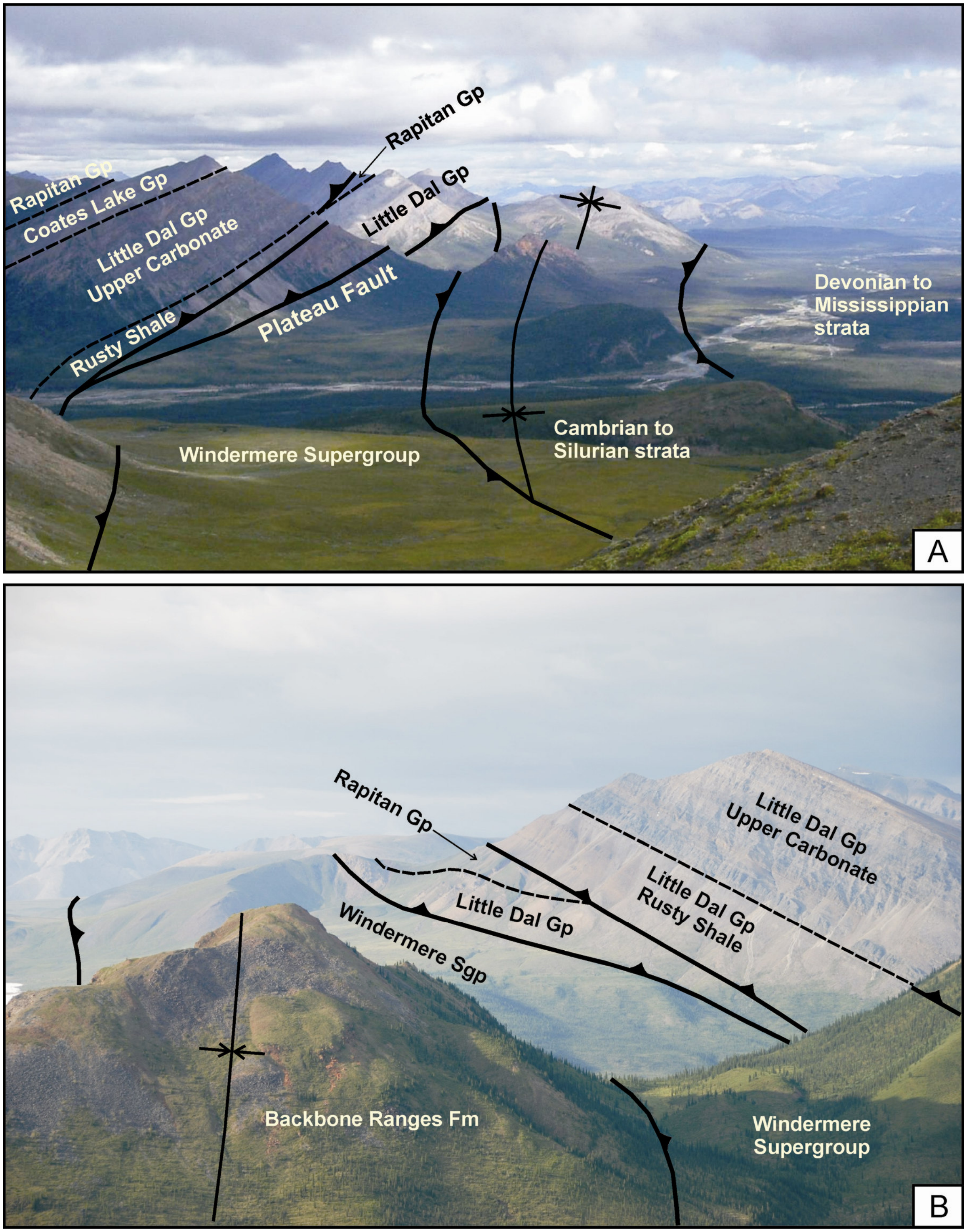

Figure 7. *Photographic views of the Plateau Fault. Note low to moderate dip of fault surface in both photographs and thrust-style repeats of Proterozoic strata. A. View of Plateau Fault, looking northwest from 603816E, 7037253N (UTM Zone 9, NAD83). Note the exhumed Paleozoic succession in the footwall. B. View of Plateau Fault, looking south-southeast from 601306E, 7047194N (UTM Zone 9, NAD83).*

Plateau Fault Geometry and Trapping Potential

The Plateau Fault has been interpreted as either a shallow thrust with substantial (approximately 30 km) eastward transport (Cecile and Cook, 1981) or as a steep reverse fault (Gordey, 1981). The fault's viability as a hydrocarbon trap depends crucially on which is the correct interpretation. Fieldwork in NTS 95M was aimed, in part, at resolving this question. The following is a summary of that work, the details of which are being prepared for publication elsewhere (Fallas, work in progress).

In NTS 95M, it was noted that a hanging-wall flat geometry was indicated by a parallel relationship between hanging-wall bedding and the trace of the fault, and by the consistent stratigraphic position of the Plateau Fault within the Rusty shale formation in the hanging-wall (Figure 7A and B). Footwall bedding is truncated at a high angle. Bedding measurements and the trace of the fault indicate a fault dip of 30º–45º at surface. Along the leading edge of the fault there are structural imbrications (Figure 7A and B) that repeat hanging-wall stratigraphy (Little Dal and Rapitan groups). Footwall strata delineate a series of tight folds involving Paleozoic carbonate and siliciclastic strata (Figure 7A). These folds are broken in places by moderately west-dipping faults. Folds in the footwall are locally overturned to the east and are clearly truncated by the Plateau Fault. Stratigraphic differences across the fault indicate a more complete stratigraphic section in the hanging-wall (including Coates Lake Group and Windermere Supergroup), compared to the footwall (where Coates Lake Group and upper Windermere Supergroup are missing). This last feature can be interpreted to indicate either long-distance transport on a thrust fault (Cecile and Cook, 1981) or that the Plateau Fault is a reactivated normal fault with pre-Paleozoic movement. Considering the evidence for significant eastward shortening in the footwall, combined with the hanging-wall flat geometry and moderate dip of the fault plane, a thrust-fault geometry is favoured.

A second crucial point in the structural interpretation is whether or not appropriate source and reservoir strata are trapped in the footwall. To test this, cross-sections were drawn through the study area to clarify geometric constraints on the footwall.

First, a cross-section was drawn to test the play model of Cecile et al. (1982). As in that model, the cross-section (Figure 8) incorporates a long hanging-wall flat. Cecile et al. (1982; also Cecile and Cook, 1981) produced a cross-section that suggested there was more than 20 km of overlap between the hanging-wall and the Silurian–Upper Devonian source-rock and reservoir units (Whittaker to Imperial formations) that were inferred to be present in the footwall. A significant difference between the two cross-sections relates to the strata outcropping at surface in the footwall of the Plateau Fault. In Figure 8, the full Silurian–Upper Devonian succession crops out, whereas in the Cecile et al. (1982) cross-section only Upper Devonian siliciclastic strata are present at surface.

In Figure 8, the hanging-wall flat is placed within the Rusty shale formation (Little Dal Group). The fault is drawn parallel to hanging-wall bedding; the depth of the fault plane is determined by stratigraphic thicknesses of hanging-wall strata. Steepening of the dip in the hanging-wall, shown approximately 20 km southwest of the surface trace of the Plateau Fault, is attributed to a footwall ramp. Based on map patterns, changes in stratigraphic preservation between fault panels in the footwall have been represented as reflecting a reactivated normal fault; the changes also could be due to erosional truncation. To maintain consistency with hanging-wall stratigraphy, upper Windermere Supergroup formations that are missing at surface in the footwall are reintroduced gradually westward beneath Cambrian strata.

Based on these inferences, the cross-section (Figure 8) suggests that there is insufficient room in the footwall to preserve Silurian to Upper Devonian strata in the subsurface. Even assuming a shallow overthrust, the youngest strata likely to be preserved in the footwall are of Cambrian age. Note, too, that to draw the Plateau Fault as an overthrust, problematic structural relationships must be invoked in the subsurface. To construct a cross-section with any Paleozoic strata preserved in the subsurface footwall, a truncated or 'beheaded' anticline is required in the footwall at the leading edge. This introduces a geometry in which the fault cuts downsection in the direction of transport. Such a geometry commonly is

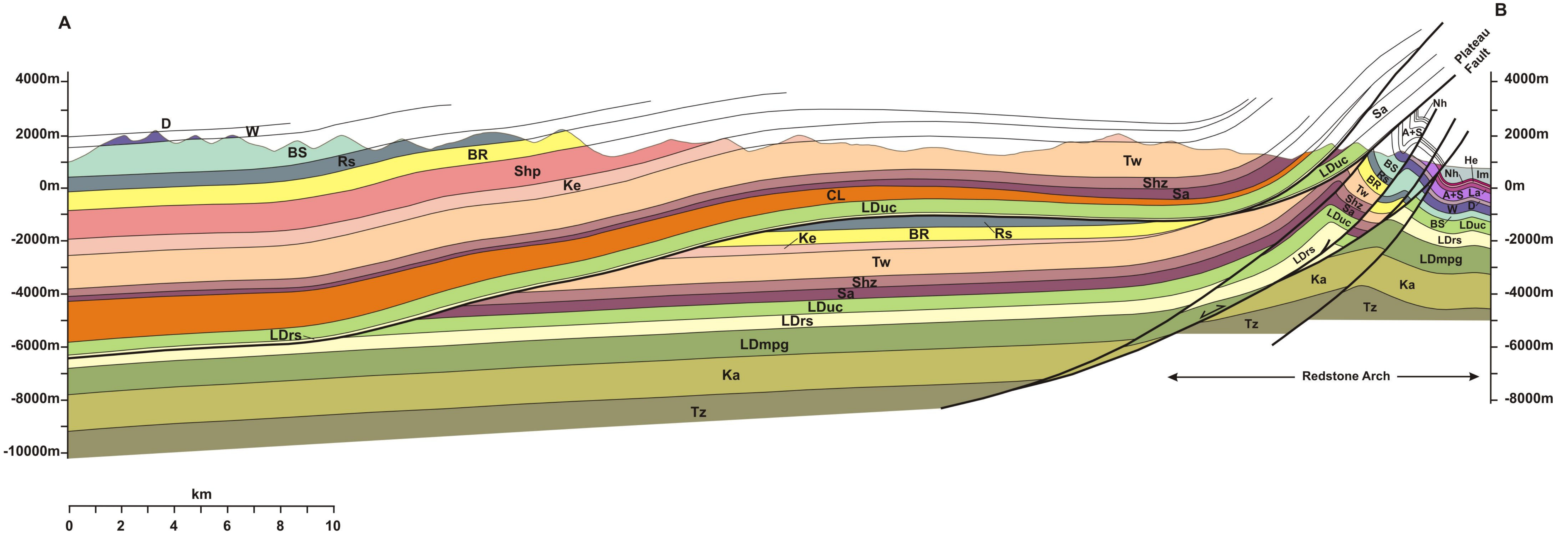

Figure 8. *Unbalanced, true-scale structural cross-section across the Plateau Fault. Cross-section uses a shallow overthrust model with a long hanging-wall flat within the Rusty shale formation (Little Dal Group), similar to the section presented by Cecile and Cook (1981). Line of cross-section and unit abbreviations are shown in Figure 4; additionally, CL = Coates Lake Gp. Base of the Paleozoic succession lies within (Fritz et al., 1991) or at the base of (Aitken, 1989, 1991) the Backbone Ranges Formation (shown in yellow). See text for additional discussion.*

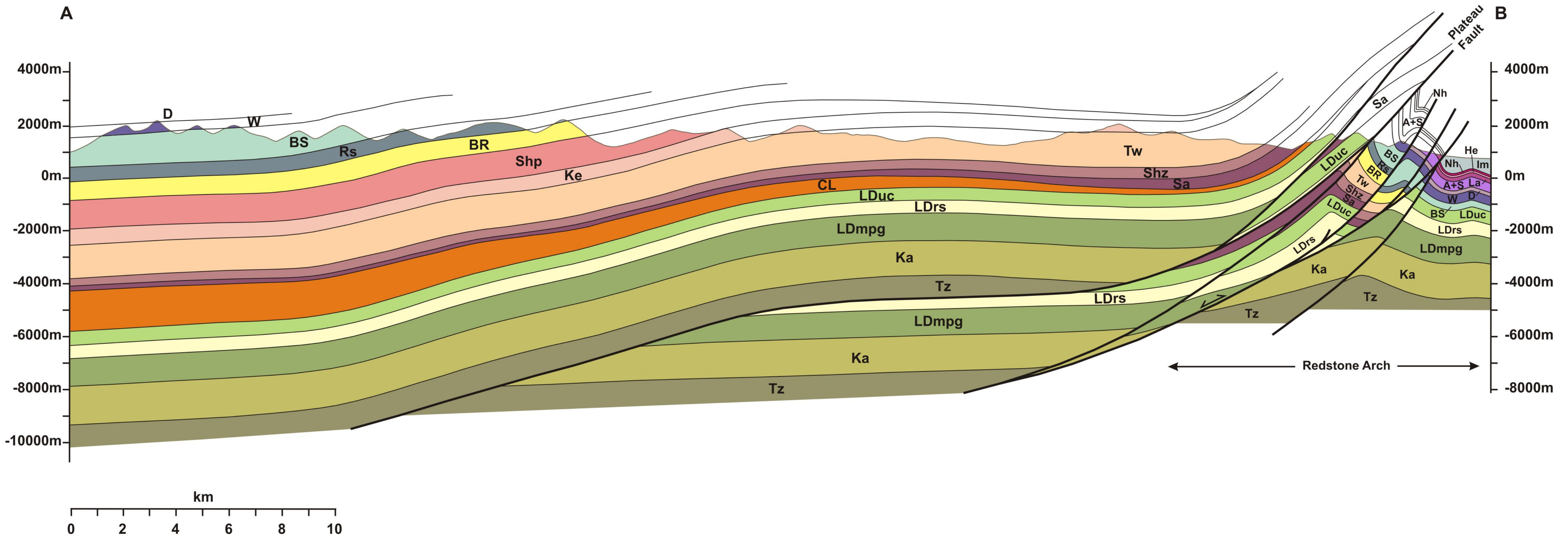

Figure 9. *Unbalanced, true-scale structural cross-sections across the Plateau Fault. Cross-section uses a thrust model involving a shorter hanging-wall flat and a steeper fault trajectory than that invoked in Figure 8. Line of cross-section and unit abbreviations are shown in Figure 4; additionally, CL = Coates Lake Gp. Base of the Paleozoic succession lies within (Fritz et al., 1991) or at the base of (Aitken, 1989, 1991) the Backbone Ranges Formation (shown in yellow). See text for additional discussion.*

avoided during construction of balanced cross-sections (Dahlstrom, 1969) because it violates the in-sequence, foreland-directed progression of deformation that is considered to characterize the Foreland Belt of the Canadian Cordillera. Thus, in the resulting cross-section, the Plateau Fault is out of sequence.

Several points regarding the cross-section in Figure 8 are worth examining further. It is possible to draw the same line of cross-section with more contractional deformation in the subsurface footwall, but this would bring older strata to a higher structural position, further decreasing the likelihood of Silurian or younger strata being preserved in the footwall. More room for Paleozoic strata may be available in the footwall if Windermere Supergroup units younger than the Twitya Formation are not present in the footwall. This, however, would equate to the absence of an already-thinned Keele Formation (Figure 8), and probably would not yield sufficient space for preservation of Whittaker Formation or younger units. Post-Devonian normal faults also could create room for younger strata in the footwall. This scenario is permissible based on the regional faulting pattern (Gabrielse et al., 1973). There is, however, no direct evidence for the presence of normal faults underneath the Plateau Fault. A greater westward dip of the footwall strata also could lead to preservation of Silurian or younger strata in the footwall near the middle of the section. However, a relatively flat regional dip is implied by the consistent exposure of strata no younger than Mississippian in the cores of synclines across NTS 95M. Southwest of Redstone Arch, this may increase to a very gentle southwest dip near the leading edge of the Plateau Fault, based on the southwestwardly increase in thickness of preserved Ediacaran and Cambrian strata (Cecile and Cook, 1981; Gordey, 1981). While this southwest thickening wedge of strata likely indicates an increase in the regional dip of bedding at the level of the Mackenzie Mountain Supergroup, this is unlikely to create space for Silurian or younger strata beneath the fault.

In view of these difficulties with the overthrust model of Cecile et al. (1982), an alternative cross-section along the same line was prepared. In this cross-section (Figure 9), a steeper fault trajectory is used near the leading edge; this requires a thicker Proterozoic succession in the hanging-wall. A footwall flat is still required in the Rusty shale formation to correspond to the hanging-wall flat at surface, and this is used to explain the sub-horizontal dips in the hanging-wall in the middle of the section. A footwall ramp is again used to explain the increased dips in the hanging-wall on the southwestern side of the section, but in this case the ramp cuts through Mackenzie Mountain Supergroup strata rather than Windermere Supergroup and Paleozoic strata (compare with Figure 8). Unlike the overthrust version, this cross-section follows the general principles of balanced cross-section construction (Dahlstrom, 1969). From the perspective of testing the Plateau Fault as a hydrocarbon play, a crucially important feature is the lack of footwall strata younger than Little Dal Group along most of the cross-section (Figure 9). If, as we think probable, the geometry of the Plateau Fault more closely resembles the geometry shown in Figure 9, then trapping potential for Silurian–Upper Devonian strata is limited to the vicinity of the leading edge.

Although the overthrust model of Cecile et al. (1982) is not supported by the present work, there may be limited trapping potential in the footwall of the Plateau Fault. In regions where Silurian-Devonian platform strata are not exhumed at the fault's leading edge, the footwall cutoff must still be present in the subsurface. Figure 10 illustrates a hypothetical trapping geometry in which contractional faults in the footwall might juxtapose platform carbonates against Upper Devonian source rocks. Note, however, that for Whittaker Formation to be juxtaposed against Hare Indian or Canol formation, Imperial Formation must exceed 1.5 km in thickness. This is twice the greatest known thickness of Imperial Formation in the study area (see above).

If the structures in Figure 10 exemplify what structures could be present in the subsurface, then a narrow belt of potential structural traps, involving Silurian-Devonian reservoirs, may be developed directly west of the leading edge of the Plateau Fault. The necessary geometry may exist in two regions northwest of the detailed study area. Between Moose Horn and Keele rivers, where the Plateau Fault overrides Imperial Formation (Gabrielse et al., 1973), the region of potential trap development extends 50 km along the strike of the fault and is not likely to extend more than 4 km southwest of the leading edge. A second region extends approximately 100 km northwest from central NTS 106A to northeast NTS 106B; it was not assessed in detail during the present work.

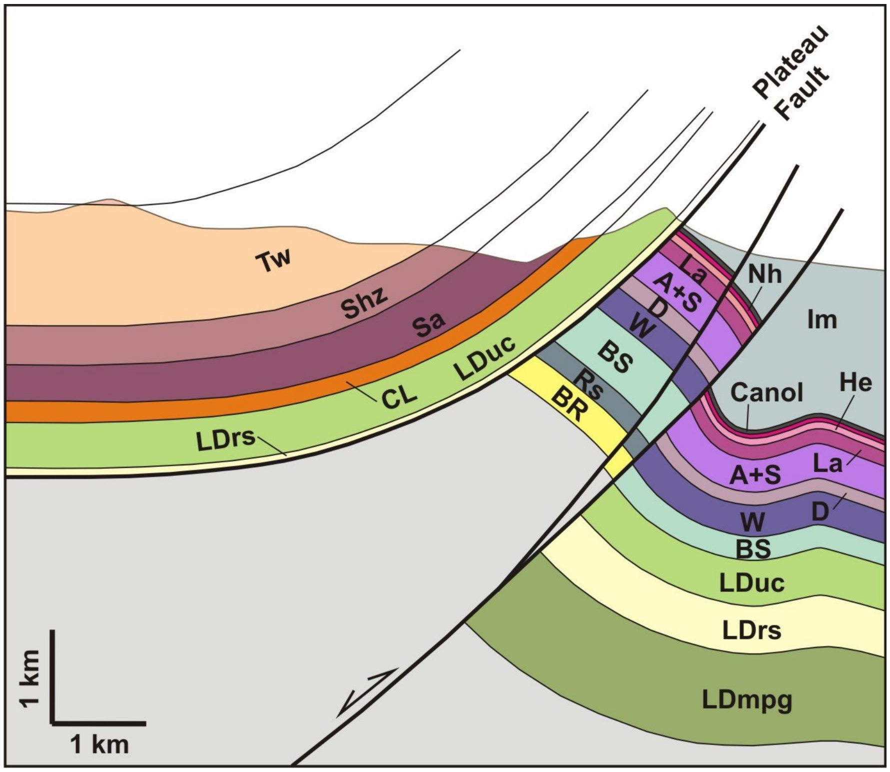

Figure 10. *Schematic cross-section through the leading edge of the Plateau Fault showing a possible footwall trap geometry involving juxtaposed reservoir and source rock units. Unit abbreviations as in Figure 4; CL = Coates Lake Gp.*

Thermal Maturity

Organic Geochemistry

For the central Mackenzie Mountains, published thermal-maturity data from organic geochemistry are sparse. Cecile et al. (1982) analyzed a small suite of samples from Arnica, Bear Rock, and Headless formations. Although results were equivocal due to storage and weathering effects, pristane/nC17 and saturate/aromatic ratios suggested the samples were mature to over-mature with respect to oil. A single Rock-Eval result was reported from Imperial Formation in the northwest corner of NTS 95M by Feinstein et al. (1988, 1991). Results for that sample (Tmax > 464; %Ro >1.40) suggested it was overmature with respect to generation of oil but not of gas. Rock-Eval results for a small number of samples from NTS 96D and 105A suggested that the thermal maturity of Upper Devonian strata decreased to the north (Feinstein et al., 1988, 1991)

During the present work, over half the Proterozoic to Middle Devonian samples submitted for Rock-Eval pyrolysis returned TOC values lower than 0.3 %, rendering the resulting Tmax values suspect (e.g., Fowler et al., 2003). Most samples with sufficiently high TOC values were deemed unreliable because they returned S1 or S2 values lower than 0.2 mg HC/g rock, or displayed a bimodal S2 peak (e.g., Peters, 1986; Fowler et al., 2003).

As regards Upper Devonian units, all samples from Hare Indian and Imperial formations returned S2 values below 0.20 mg HC/g rock, and Tmax values thus were suspect. Better data were obtained for Canol Formation; Tmax data indicate that it has reached the dry gas generating zone in NTS 95M and 105P.

Colour Alteration of Fossils

Morrow (1991) reviewed available data on conodont colour alteration indices (CAI) for the northern Mackenzie Platform. Based on published CAI values from 4–6, he concluded that Mackenzie Platform strata were overmature with respect to oil generation but had potential for dry-gas generation. From further southwest, in Nahanni map area (NTS 105I), Gordey and Anderson (1993) noted that CAI 5–6 was typical, suggesting that strata in Selwyn Basin area are overmature even with respect to gas.

GSC Paleontology Reports contain an abundance of hitherto uncollated data on thermal maturity for the Mackenzie Mountains. These archival data currently are being augmented by data from samples collected by the Sekwi Mountain and Mackenzie Corridor projects. Thermal maturity data (CAI for conodonts; TAI for palynomorphs, acritarchs, and scolecodonts) from GSC Paleontology Reports, Bulletins, and Memoirs are being compiled for publication as a GSC Open File (MacNaughton, Fallas, and others, work in progress). A summary of those data is presented here.

Data from Proterozoic and basal Cambrian units are limited to TAI assessments for a small number of acritarch collections. Surviving samples from a taxonomic-biostratigraphic study by Baudet et al. (1989) were re-examined by Utting (2007b). Acritarchs from the Ediacaran Sheepbed and Blueflower formations and the Lower Cambrian Vampire Formation were uniformly black and metallic, indicating TAI values of 5+ and marked overmaturity with respect to gas generation.

Archival data permit comment on regional trends in thermal maturity for Upper Cambrian and younger strata, although data coverage is most dense along the continental divide (i.e., along the Yukon-Northwest Territories border) and notably sparser to the east and northeast. In general, Upper Cambrian to Middle Devonian strata south of 63º N are overmature with respect to both oil and gas generation, as are many samples collected to the northwest along the continental divide (i.e., Yukon-NWT border) and from points west. To the east and northeast, however, CAI and TAI data in eastern NTS 105P and across NTS 95M suggest that Mackenzie Platform strata are overmature with respect to oil generation but have not been heated beyond the gas-generation zone (Figure 11).

Palynology data from Canol and Imperial formations are being prepared for publication by Zanvoort (work in progress; also see Utting, 2007a) and are summarized here. As is true of underlying formations, thermal maturity of Canol Formation is lowest in the east (TAI 3+) and highest in the west (TAI 4-/5); equivalent %Ro values correspondingly increase from 1.5 in the east to 3.5 in the west. Canol Formation thus is overmature in the western part of the area shown in Figure 11, most probably due to the increased thickness of the overlying clastic succession in the Selwyn Basin area. TAI values from the Imperial Formation range from 3 to 4- and correspond to vitrinite reflectance values of 1.5 to 2.0 %Ro. These data indicate conditions for dry-gas generation. Compilation of all Upper Devonian CAI and TAI data from GSC Paleontological Reports (Figure 12) indicates that thermal maturity increases to the west and southwest, in a manner similar to the pattern shown by data from the Mackenzie Platform-Selwyn Basin succession (Figure 11). This also is consistent with the regional trends in Upper Devonian thermal maturity that were deduced by Feinstein et al. (1988, 1991) based on a more limited dataset of Tmax values.

Summary of Thermal Maturity

Mackenzie Platform (Upper Cambrian to Middle Devonian) strata in the footwall of the Plateau Fault in Wrigley Lake map area have reached levels of thermal maturity permissive of dry-gas generation and preservation. Upper Devonian siliciclastic strata in the same region also have reached the dry-gas generation zone.

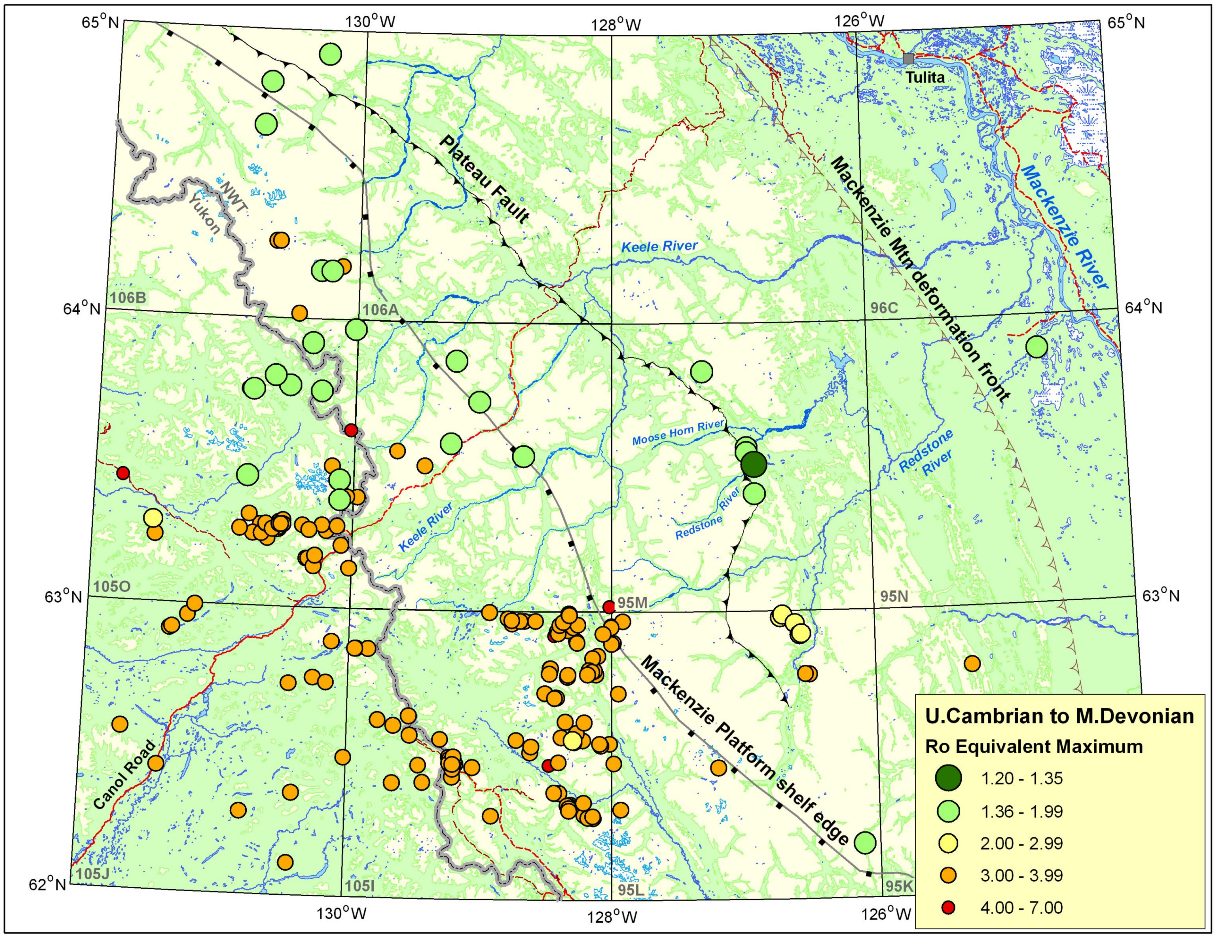

Figure 11. *Thermal-maturity of Upper Cambrian to Middle Devonian strata of Mackenzie Platform and Selwyn Basin. The %Ro values are derived from thermal-maturity data in GSC Paleontological Reports (MacNaughton, Fallas, and others, work in progress). Conversion of CAI and TAI data to %Ro values is based upon equivalencies determined by Utting et al. (1989).*

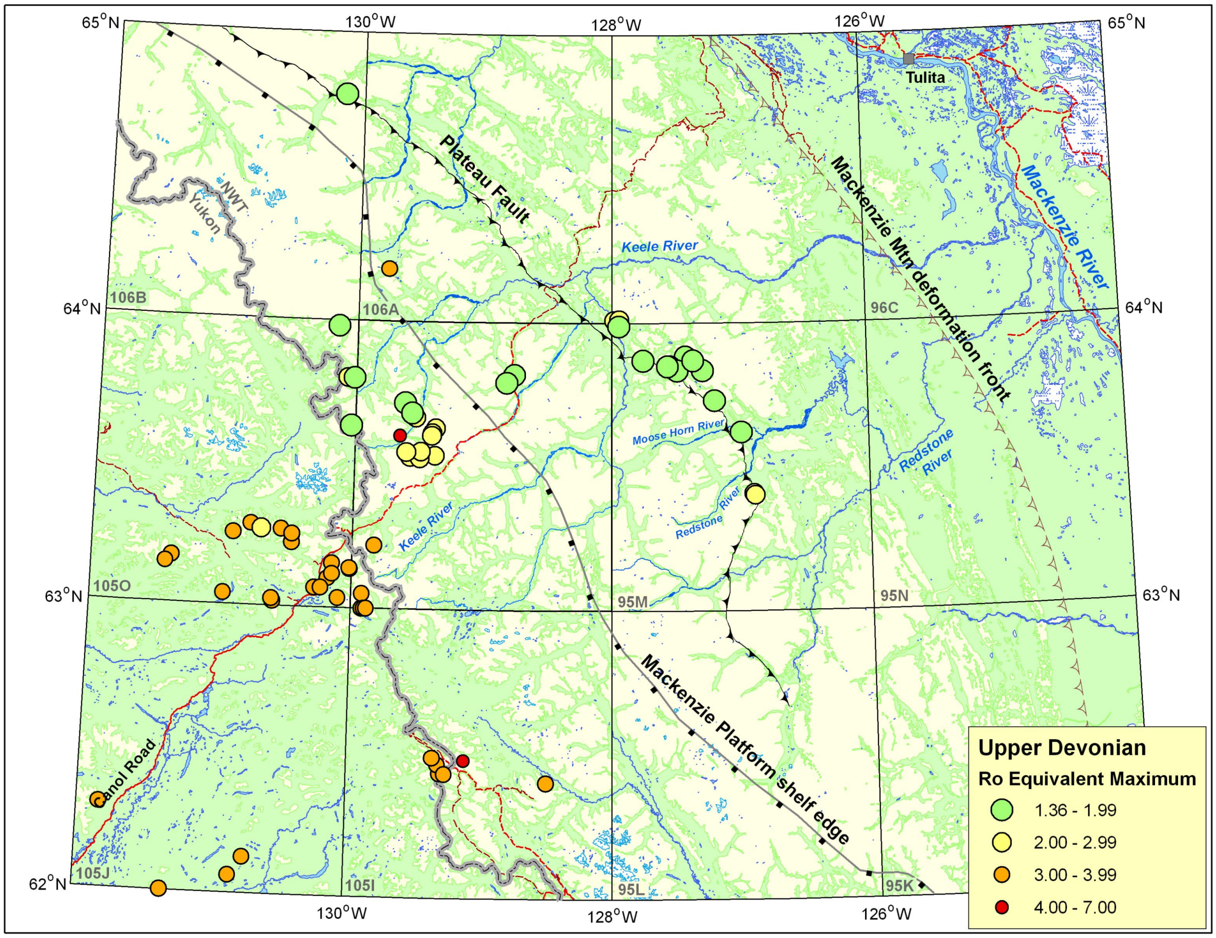

Figure 12. *Thermal-maturity data for Upper Devonian siliciclastic strata (Hare Indian, Canol, and Imperial formations and their basinward correlatives). Ro values are derived from thermal-maturity data in GSC Paleontological Reports (MacNaughton, Fallas, and others, work in progress) and from Zanvoort (work in progress). Conversion of CAI and TAI data to %Ro values is based upon equivalencies determined by Utting et al. (1989).*

Hydrocarbon Shows

Hydrocarbon staining has been reported from the Mackenzie Platform carbonate succession, but most such occurrences are of black, solid hydrocarbon residue (Figure 13), probably pyrobitumen (P. Risbey, personal communication, 2006). During the Sekwi Mountain Project, hydrocarbon staining or solid hydrocarbons were observed in Nahanni, Hume, Arnica and Bear Rock formations, and in probable Lower to Middle Devonian outcrops of uncertain lithostratigraphic identity.

Figure 13. *Pyrobitumen staining in an outcrop of Devonian carbonate (Arnica Formation?) at 507682E, 7134300N (UTM Zone 9, NAD83).*

Bitumen (pyrobitumen?) has been reported in association with Manetoe Facies dolomitization at some mineral properties (Olfert, 1976a; Leighton, 1987). Where Manetoe Facies has been studied in detail, bitumen occurs as a coating on saddle dolomite crystals and there is no intracrystal bitumen (Olfert, 1976a; Leighton, 1987; Morrow et al., 1990). This indicates that hydrocarbon migration followed formation of Manetoe Facies dolomite (Morrow et al., 1990). Manetoe dolomite probably was precipitated in the Late Devonian (Morrow et al., 1990) and this is a maximum age-limit for hydrocarbon migration through affected strata.

In NTS 96D, dolostone breccia of Bear Rock Formation commonly is petroliferous (Aitken and Cook, 1974).

A petroliferous or fetid smell has also been reported from several units in the central Mackenzie Mountains. During Sekwi Project mapping, it was noted that units with hydrocarbon staining commonly were fetid when broken open. A fetid smell also characterized some outcrops of units that lacked hydrocarbon staining, notably the Whittaker Formation. One of the authors (RBM) also has visited fetid outcrops of the Proterozoic Coppercap and Twitya formations elsewhere in the Mackenzie Mountains. However, analysis of fetid samples from Whittaker and Twitya formations by Rock-Eval pyrolysis has not indicated elevated values of total organic carbon (see above).

Gabrielse et al. (1973) noted the following units as being fetid: Whittaker Formation (particularly in 95M); basal Sunblood Formation (in a section at Flood Creek in 95L); middle member of Sombre Formation; Arnica Formation (in Thundercloud Range); and a basal interval of Natla Formation in its type section. Aitken and Cook (1974) reported that Bear Rock Formation commonly is fetid in NTS 96D.

SYNTHESIS AND CONCLUSIONS

For the Plateau Fault to be considered viable as a conceptual play in terms of the overthrust model of Cecile et al. (1982), the following questions must all be answered in the affirmative:

1. Is the Plateau Fault a low-angle thrust fault with an appropriate sealing mechanism?
2. Are appropriate reservoir strata likely to be preserved in the footwall?
3. Can a source rock be identified?
4. Is thermal maturity appropriate to have generated and preserved hydrocarbons?
5. Does the timing relationship between hydrocarbon generation and trap formation permit hydrocarbon retention?

The first question can be answered in the affirmative, with qualifications. The present work demonstrates that in NTS 95M the Plateau Fault can be interpreted as a low-angle thrust fault with significant northeast-directed transport. This is not the only permissible fault geometry, however, and work by the Sekwi Mountain Project further to the northwest (in NTS 106A) suggests that higher-angle fault morphologies also are developed along the Plateau Fault (as seen by KMF). Less controversially, the Rusty shale and Gypsum formations provide the main detachment level in the hanging-wall of the Plateau Fault and could be a seal to reservoir strata in the footwall.

The most likely reservoir facies in the Mackenzie Mountains appear to be: porous intervals within Whittaker Formation; intervals of Bear Rock Formation with cavernous porosity; intervals of Arnica and Landry formations affected by Manetoe Facies dolomitization; and sandstone beds in the upper part of Imperial Formation. In NTS 95M, only the porous facies of the Whittaker Formation are known to be widespread; Manetoe Facies is known to be of limited extent and upper Imperial Formation has not been recognized in outcrop. Yet more problematic for a Plateau Fault play is the likelihood that the fault, along much of its length, rides too deeply within the Mackenzie Platform succession or older strata to preserve reservoir units beneath the hanging-wall. In general, then, the Plateau Fault fails the second test outlined above.

The third question deals with the presence of a likely source rock. No promising source rocks have been identified below Hare Indian and Canol formations. Some Proterozoic units (notably Sheepbed Formation) may have generated hydrocarbons during their history, but are now overmature. The same largely is true of Road River Group. No source rocks have been identified in the Mackenzie Platform succession, even in fetid units such as Whittaker Formation. Canol Formation probably has some remaining generating potential, but likely is sealed off from Mackenzie Platform strata by the argillaceous Headless Formation. Until upper Imperial Formation can be recognized reliably in the study area, the Canol Formation amounts to a source without a demonstrated reservoir to charge.

Thermal maturity data for Mackenzie Platform strata and for Upper Devonian siliciclastic units suggest potential to preserve (and at least locally generate) dry gas. Thus, the fourth question can be answered in the affirmative. However, in the absence of source rocks below the level of the Hare Indian and Canol formations, and of a verified trapping configuration beneath the Plateau Fault, permissive thermal-maturity data merely suggest that gas could have been generated.

Available data do not permit us to answer rigorously the final question, i.e., the relative timing of hydrocarbon generation and of formation of the Plateau Fault. If all occurrences of bitumen were generated during the same event, then, as was discussed above, they must postdate formation of Manetoe Facies dolomite. Generation thus cannot predate the Middle Devonian (Morrow et al., 1990). Morrow and Aulstead (1995) presented burial-maturation models based on a well in Beaver River gas field (Pan Am Beaver River YT G-01, at 60.00069°N/124.2633°W, near Fort Liard) to argue that oil maturation and migration into Manetoe Facies reservoirs occurred during the Carboniferous. Similar modeling has not been done for the Mackenzie Mountains. Because control on the minimum age of hydrocarbon generation is lacking, the relative timing of hydrocarbon generation and movement on the Plateau Fault is ambiguous.

In summary, the Plateau Fault may be a low-angle thrust but its detailed geometry largely is unfavourable for trapping hydrocarbons. Thermal-maturity data are permissive of generation/preservation of dry gas but the only likely source rocks are stratigraphically isolated from the possible reservoir units, unless the presence of upper Imperial Formation sandstone can be demonstrated. In our opinion, the likelihood of the Plateau Fault constituting a viable hydrocarbon play in terms of the overthrust model of Cecile et al. (1982) is extremely low.

We do not completely rule out the possibility of gas pools in the central Mackenzie Mountains. Two additional speculative plays may merit further study. Both require a Canol or Hare Indian formation source. The first, already described earlier in this report, focuses on areas where the Plateau Fault overrides Upper Devonian siliciclastic strata. In such areas, there may be a narrow target zone of footwall cut-offs directly southwest of the fault's leading edge. A second possibility, alluded to by Gabrielse et al. (1973), would involve trapping within upper Imperial Formation by anticlinal traps within broad synclinoria in northeast NTS 95M and elsewhere.

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