SUMMARY OF FIELD ACTIVITIES IN THE WESTERN LIARD BASIN, BRITISH COLUMBIA

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ABSTRACT

The second and final year of a regional bedrock mapping program within the Toad River map area (NTS 094N) was completed in 2012. The program will result in three– 100 000 scale maps of the northwest, northeast and southeast quadrants of 094N and with four 1:50 000 scale maps covering the southwest quadrant. Surface samples were also collected for Rock Eval™, reflective light thermal maturity and apatite fission-track analysis. Cuttings from several petroleum wells in the map area were also sampled for Rock Eval analysis and vitrinite reflectance.

Composite sections of the Besa River Formation were measured in the southern Caribou Range and along the Alaska Highway, south of Stone Mountain. Approximately 170 m of the Besa River Formation were measured in three separate sections in the southern Caribou Range. Lithological, gamma-ray spectrometry and lithogeochemical data are similar to those observed in other sections of the formation, suggesting similar depositional conditions within the western Liard Basin. Changes in abundances of several trace elements, particularly, V, Mo, Ba and P, suggest variations in redox conditions during the deposition of the formation. Radiolarian and conodont fragments from the upper part of the section in the Caribou Range indicate a mid-Tournaisian age. Characteristics of the lower Besa River Formation observed along the Alaska Highway south of Stone Mountain are similar to the Evie member of the Horn River Formation.

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Key Words: Besa River Formation, Liard Basin, Horn River Basin, Toad River, regional mapping, shale gas, lithogeochemistry, gamma ray spectrometry, measured section, radiolarians, Caribou Range, British Columbia, Yukon, Northwest Territories.

INTRODUCTION

The British Columbia Geoscience and Strategic Initiatives Branch participated in two co-operative geosciences programs in the western Liard Basin during the summer of 2012 (Fig. 1): 1) regional mapping within the Toad River map area (NTS 094N) and 2) examination of the Besa River Formation in the western and northern Liard Basin. The regional mapping program is in its second year (McMechan et al., 2012) and is part of the Geological Survey of Canada's (GSC) ongoing Geomapping for Energy and Minerals (GEM) Yukon Sedimentary Basins project. Examination of the Besa River Formation is in its third year and in 2012 was conducted as part of a multijurisdictional project between the governments of Yukon, Northwest Territories and British Columbia. This work was also supported by the GEM program through use of analytical laboratories at the Geological Survey of Canada (GSC).

Besa River stratigraphy exposed along the western margins of the Liard Basin contains equivalents to the Horn River Formation, currently being developed for its shale gas potential in the eastern Horn River Basin (Fig. 2; Ferri

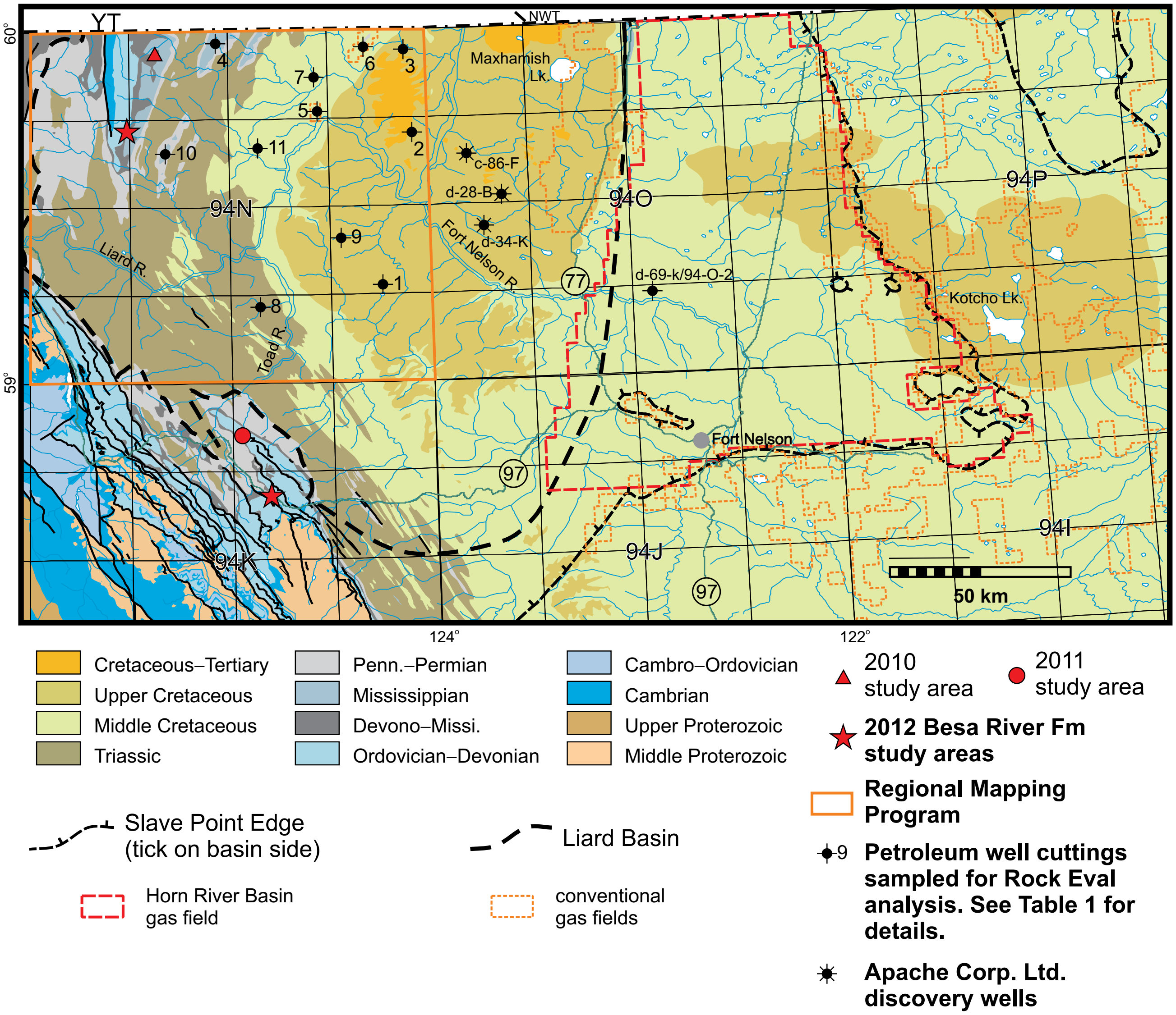

Figure 1. Regional geological map of northern British Columbia showing the location of the regional mapping project in the Toad River map area (094N) and stratigraphic sections of the Besa River Formation measured in the southern Caribou Range and along the Alaska Highway, southeast of Toad River. Geological database from Massey et al. (2005). The edge of Horn River Basin follows the Slave Point edge as defined by Petrel Robertson Consulting Ltd. (2003). Well locations refer to data in Table 1.

et al., 2011, 2012). The recent announcement by Apache Canada Ltd. of initial, average one-month production of 21.3 million cubic feet (mmcf; 6.03×10^5 m^3) per day from a well within the central Liard Basin (d-34-K; Figure 1) underscores the potential for shale sequences in this area to hold significant potential. This well was drilled to a depth of 3800 m and laterally almost 900 m into the upper Besa River Formation. Apache Canada Ltd. estimates ultimate production of 17.9 billion cubic feet (5.06×10^8 m^3) from this well and suggests a net resource of 48 trillion cubic feet (1.36×10^{12} m^3) on its 430 000 acre (174 021 Ha) land holdings (Apache Corporation Ltd., 2012; Macedo, 2012).

Rocks of the Besa River Formation represent western shale equivalents of Middle Devonian to Early Mississippian carbonate and shale sequences of the Western Canada Sedimentary Basin (Fig. 2). Ferri et al. (2011, 2012) summarize the regional geological setting and stratigraphic framework of these rocks.

TOAD RIVER MAPPING PROJECT (094N)

This is the second year of a regional mapping program within the Toad River map area, spearheaded by the GSC. A summary of the geological setting, and stratigraphic and structural framework, together with initial interpretations, can be found in McMechan et al. (2012).

Two weeks were spent collecting field data within the Toad River map area (094N) from base localities in Fort

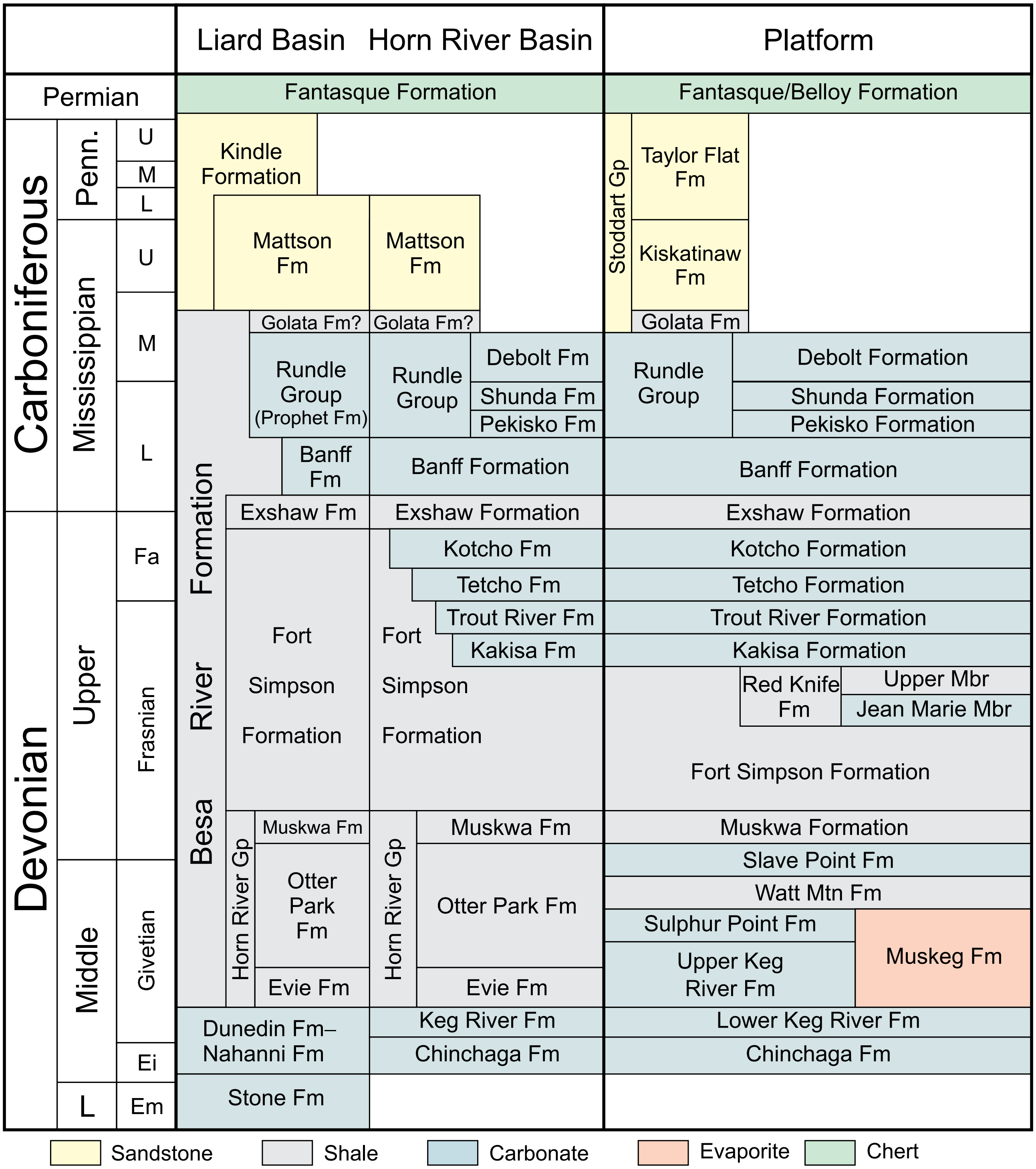

Figure 2. Stratigraphic chart showing the relationship of the Besa River Formation to other shale units and carbonates within the Western Canada Sedimentary Basin.

Nelson and at the small community of Liard River. A total of 260 field stations were added during the 2012 field season, resulting in a total of nearly 1200 localities (Fig. 3). This includes BC Hydro coverage from the early 1980s along the Liard River corridor and published and unpublished GSC data from the 1940s and late 1990s. In addition, approximately 75 samples were collected for fossil identification (unit age determination), thermal maturation via reflective light microscopy, Rock Eval analysis and apatite fission track analysis for low-temperature thermal modelling (i.e., burial and uplift history; Fig 3b).

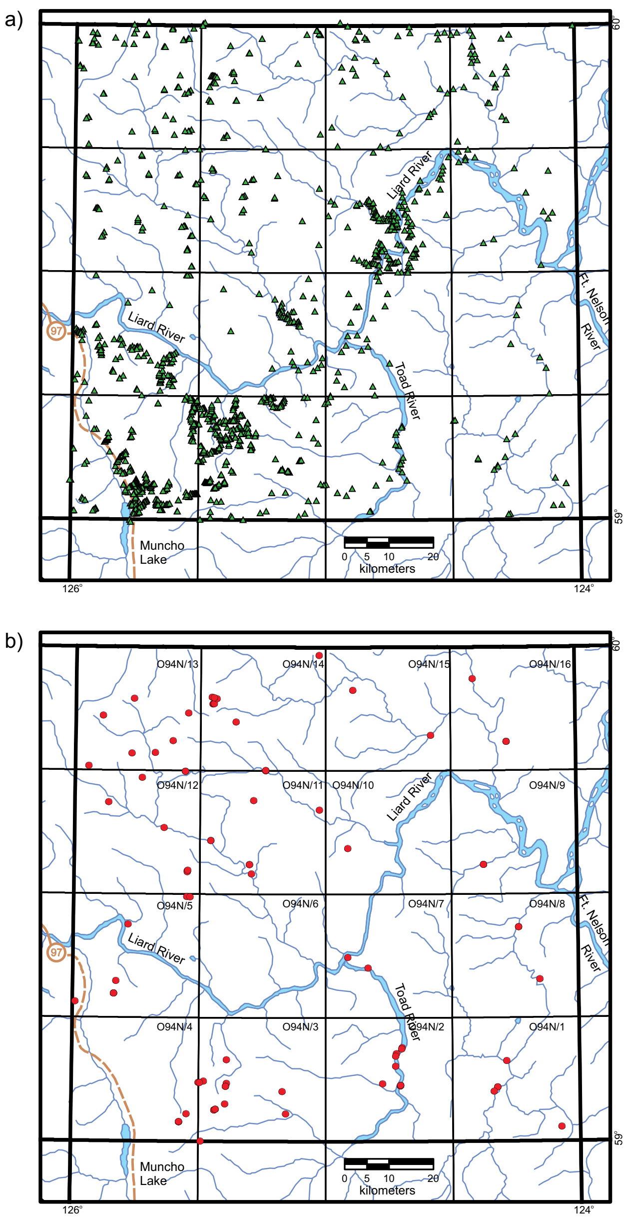

Figure 3. a) Station locations and b) 2012 sample locations of the regional mapping program in the Toad River map area.

Cuttings from the Garbutt, Toad-Grayling and Besa River shale successions in 11 oil and gas wells were also sampled for Rock Eval analysis and vitrinite reflectance (Table 1). Results of this sampling and analyses will be released in a future publication.

The primary goal of this project is to update the surface geological database through the production of three 1:100 000 scale maps of the northeast, southeast and northwest quadrants and four 1:50 000 scale maps of the southwest quadrant of the 094N map area. This data will also be available online in GIS format.

BESA RIVER FORMATION

This is the third year of a detailed stratigraphic and lithogeochemical examination of the Besa River Formation within the western Liard Basin (Ferri et al., 2011, 2012). In 2012, this project was carried out as part of a cooperative undertaking between the British Columbia Geoscience and Strategic Initiatives Branch, the Yukon Geological Survey and the Northwest Territories Geoscience Office. Because Besa River rock types occur in all three jurisdictions, an approach using data from throughout this area would not only present a more complete picture of this emerging shale gas succession, it would also highlight the economic potential within all three regions.

During the 2012 field season, all three organizations combined efforts and measured sections of the Besa River Formation, or its equivalent, in each jurisdiction (Fig. 4). This report will summarize initial results from 2012 investigations within British Columbia and include a summary of lithogeochemical data from 2011 sampling of the Besa River Formation in the Stone Mountain area, just east of Toad River (Ferri et al., 2012; Fig. 1). The reader is referred to Fraser et al. (2013) and Fiess et al. (2013) for a summary of 2012 activities within the Yukon and Northwest Territories, respectively. In addition, this report summarizes data collected along a section of the lowermost Besa River Formation that was measured by the senior author along the Alaska Highway, south of the section described by Ferri et al. (2012) and east of Toad River (Fig. 1).

Much of the analytical work in this investigation (Rock Eval, X-ray diffraction and thermal maturation through reflective light microscopy) and some field assistance (gamma-ray spectrometer) was supported through the GSC's GEM program, specifically the Yukon Sedimentary Basins project. The following is the procedure for data collection and analysis of samples that was carried out during the 2010 and 2011 field seasons, specifically

- detailed measurement and description of the section,
- acquisition of gamma ray spectrometer data (total counts; U, Th and K concentrations) on a 1 m spacing and
- representative chip samples of the section collected on a 2 m spacing that were crushed, split and analyzed for Rock Eval and lithogeochemistry (inductively coupled plasma–emission spectrometry [ICP-ES] and inductively coupled plasma–mass spectrometry [ICP-MS]).

A smaller representative subset of samples will be analyzed for semi-quantitative mineral composition through X-ray diffraction and a level of thermal maturity by reflective light microscopy.

TABLE 1. WELL CUTTINGS SAMPLED FOR ROCK EVAL ANALYSIS.

Well Name	Location	Location Figure 1	Unit Sampled–Cutting Intervals (original units) Garbutt Fm.	Toad–Grayling Fms	Besa River Fm
Suncor et al Dunedin	a–039–B 094–N–08	1	1700–1760 m		
Suncor Westar La Jolie	b–037–I 094–N–09	2	1885–2005 m	2020–2055 m	
Talisman Beaver	b–037–I 094–N–16	3	1395–1690 m	2010–2385 m	
TPOC Clark Beavercrow	b–067–I 094–N–14	4			1020–4270 ft
Devon NEC Crow	c–016–A 094–N–15	5	700–780 m	1290–1490 m	2515–3640 m
Pan Am Beaver	c–045–K 094–N–16	6		1110–1830 ft	9520–11870 ft
Amoco Chevron Crow	d–036–H 094–N–15	7	1000–1500 ft	2850–3750 ft	7480–11980 ft
KMCL Shell Toad	d–057–K 094–N–02	8			7430–10016 ft
IOE Dunedin	d–075–E 094–N–08	9	5930–7260 ft	8800–10380 ft	11130–12050 ft
Shell E Grayling	d–095–F 094–N–11	10			1330–4010 ft
Oakwood IOE et al. Scatter	d–098–F 094–N–10	11	420–1700 ft	3850–4830 ft	7650–11 880 ft

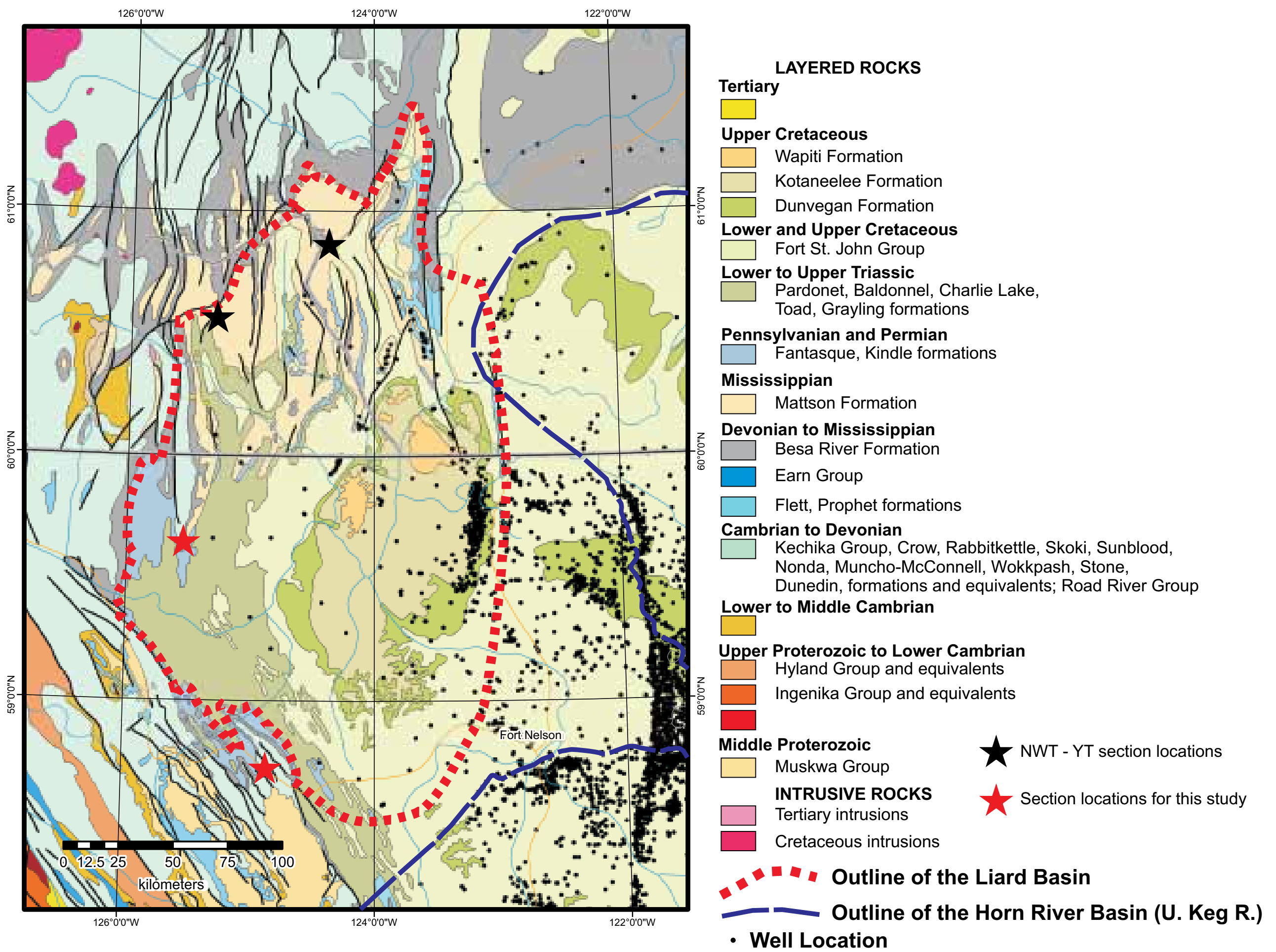

Figure 4. Regional geological map of northern British Columbia, southeastern Yukon and southwestern Northwest Territories with locations of Besa River Formation sections measured in each jurisdiction. Also shown are the outline of the Liard Basin and the eastern margin of the Horn River Basin as defined by the Upper Keg River Formation. Geological database from Wheeler and McFeely (1991).

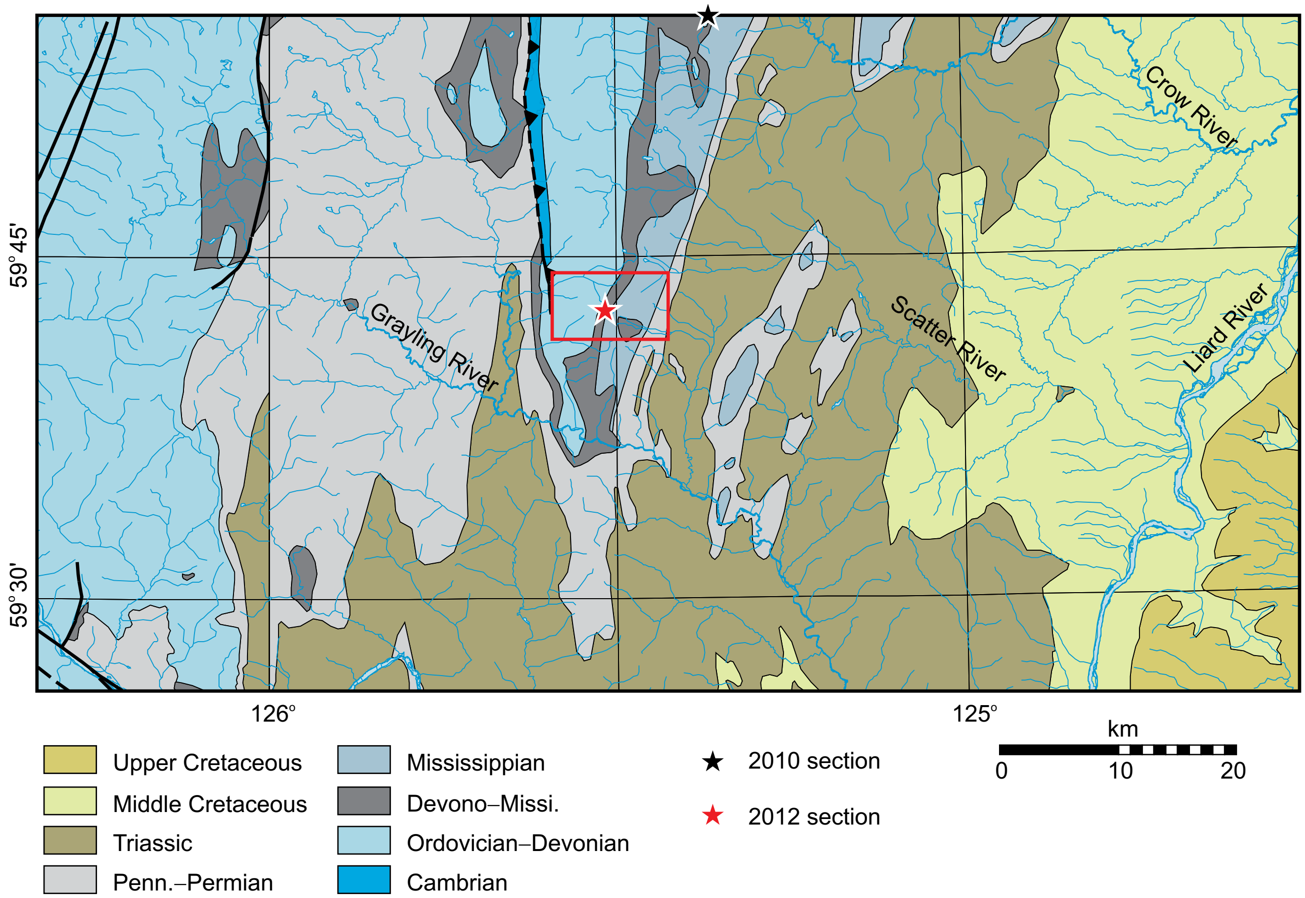

Figure 5. Geology of the southern Caribou Range showing locations of the sections measured in 2010 and 2012. Red rectangle shows the location of Figure 6. Geological database from Massey et al. (2005).

Location

Two composite sections of the Besa River Formation were measured in the western Liard Basin during the 2012 field season: 1) approximately 190 m of semicontinuous exposure within the southern Caribou Range, approximately 45 km south of the section measured in 2010 (Figs. 5, 6; Table 2) and 2) approximately 25 m of the lowermost Besa River Formation located along the north side of a creek, approximately 100 m east of the Alaska Highway, approximately 50 km south-southeast of the 2011 section (Figs. 1, 7; Table 2).

TABLE 2. SECTION COORDINATES

Section	Level above base	Easting	Northing
CR - Section 1	0 m	358534	6622051
CR - Section 1	10 m	358560	6622048
CR - Section 2	0 m	358622	6622055
CR - Section 2	3 m	358630	6622051
CR - Section 3	0 m	358662	6621990
CR - Section 3	170 m	358961	6621893
AH	0 m	395145	6505895
AH	27 m	395099	6505887

NAD 83, Zone 10
CR - Caribou Range; AH - Alaska Highway

CARIBOU RANGE

Lithology

In the Caribou Range, nearly 190 m of lower and middle Besa River stratigraphy was measured in three separate sections (Figs. 8–10). Although correlations based on lithology, lithogeochemistry and gamma-ray scintillometer profiles suggest that there is approximately 60 m of unexposed stratigraphy between the three measured sequences, it is difficult to precisely position the middle section (section 2) within Besa River stratigraphy. The barite nodules found at the 115 m level of the upper section are likely equivalent to the barite nodules observed in the upper parts of the sections measured in 2010 and 2011 (Ferri et al., 2011, 2012). This is further corroborated by the up-section increase in barium levels beginning at this horizon (observed in all three sections) and the location of these nodules stratigraphically above vanadium anomalies (also seen in all three measured

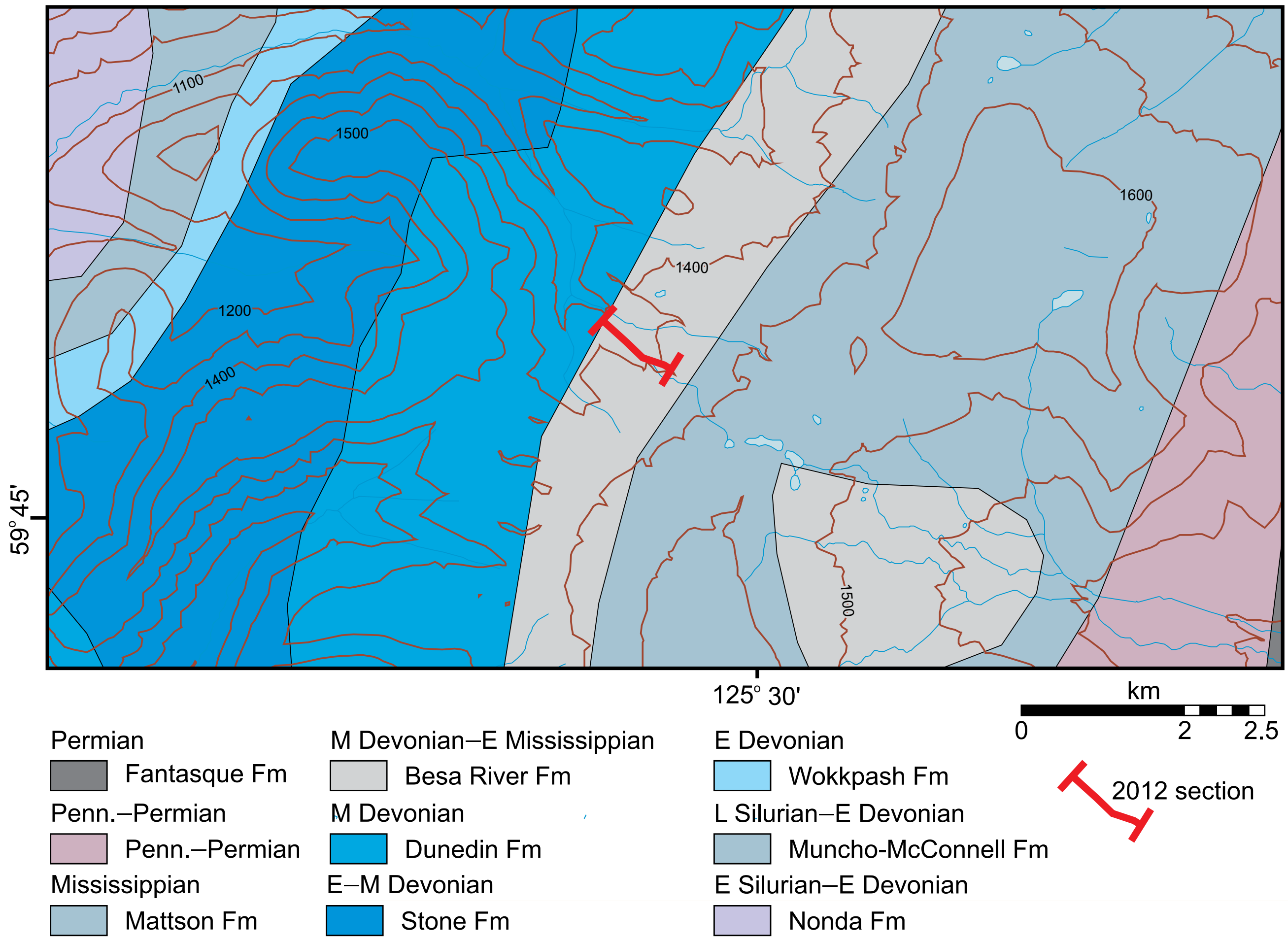

Figure 6. Location of the 2012 Besa River Formation section measured in the southern Caribou Range with respect to the local geology.

successions). In the northern Caribou Range and Stone Mountain, these nodules occur above a resistive section of silty mudstone to mudstone that has higher silica contents, a feature also observed in the 2012 section.

Resistive, black silty mudstone dominates the lower two sections of the Besa River Formation in the southern Caribou Range (Figs. 11, 12). The more recessive, tentaculitid-bearing carbonaceous shales sitting on the Dunedin Formation at the Alaska Highway section (see below) were not exposed. The lower 30 m of the upper section contains more recessive silty mudstone with a large portion of the section consisting of papery shale to platy siltstone (Figs. 11, 12). Above this is nearly 70 m of more resistive, blocky mudstone up to 15 cm thick, separated by thinner, shalier horizons up to several centimetres in thickness (Fig. 12). Barite nodules up to 20 cm in diameter, which are fetid when broken and display hollow cores with prismatic crystals, were found at the top of this mudstone section (115 m level, upper section; Fig. 12). These are very similar in morphology to those seen in the 2010 section in the northern part of the Caribou Range and to barite nodules in the Stone Mountain section measured in 2011. The succeeding 45 m of the section is dominated by more recessive crumbly to fissile shaly sequences punctuated by several horizons of silty mudstone in the upper part.

The character of the succession above the barite nodules in section 3 of the southern Caribou Range is very similar to unit 6 of Ferri et al. (2010) from the northern Caribou Range. The underlying resistive and siliceous section (see Fig. 8) below these nodules has overall similarities with units 4 and 5 of the northern Caribou Range (Ferri et al., 2010), although the light grey weathering rocks of unit 4 are not observed in the south. Blocky to platy, silty mudstone and shale in the lowermost part of section 3 has similarities to unit 3 of the northern Caribou Range (Ferri et al., 2010).

Gamma ray spectrometry

Gamma ray spectrometer data of total counts and uranium, thorium and potassium concentrations across the three sections in the southern Caribou Range, are shown in Figure 13. The trace of total counts (or dose) mimics that for uranium, similar to observations in the other sections of the Besa River Formation (Fig. 13; Ferri et al., 2011, 2012). Uranium levels decrease upsection and are less than or

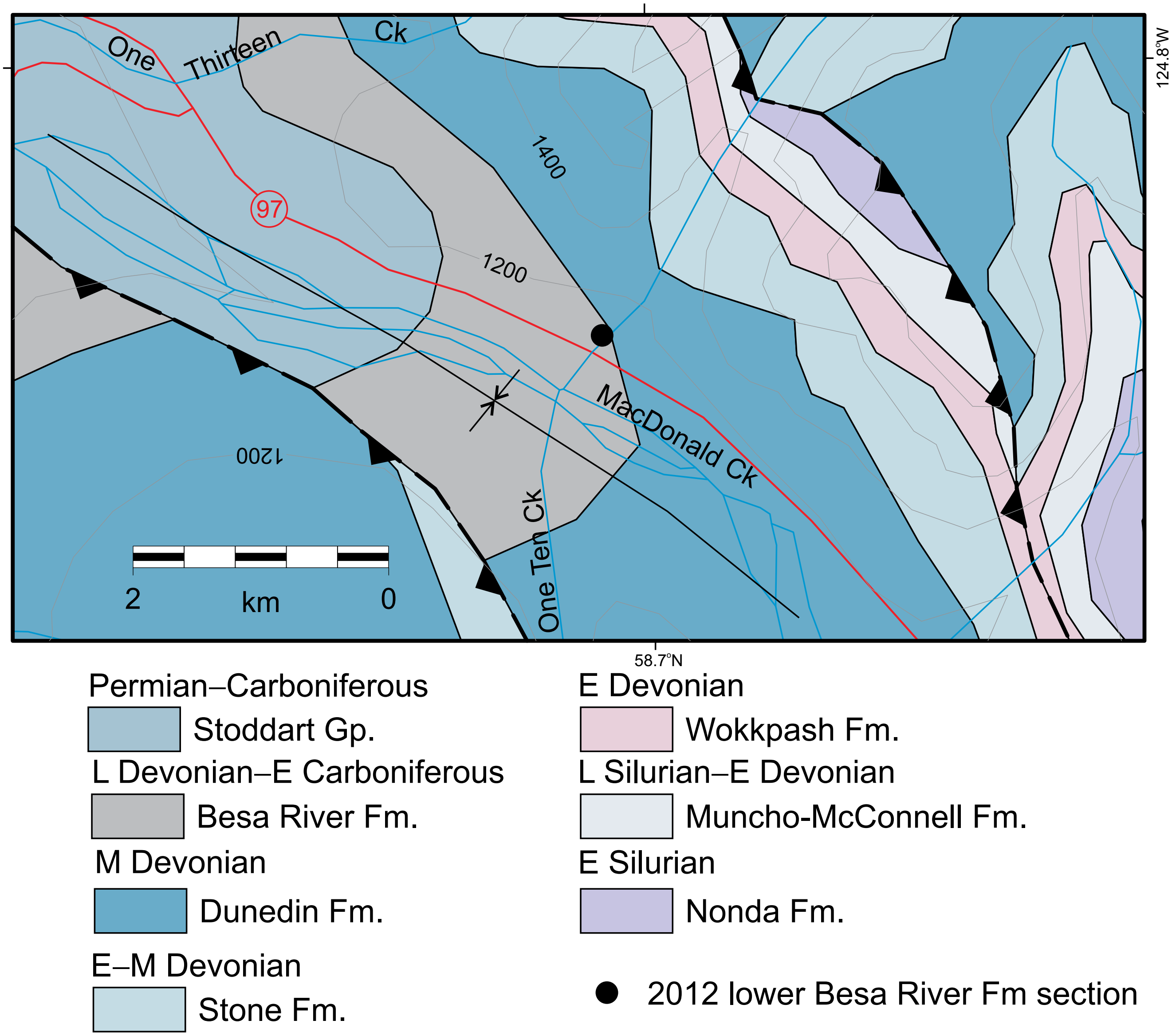

Figure 7. Local geology in the vicinity of the Besa River Formation section measured along the Alaska Highway, southeast of Toad River. Geological database from Massey et al. (2005).

equal to thorium values at the top of the upper section. Uranium concentrations appear to be highest in the lowest parts of the Besa River Formation and within the middle part of the upper section (60–110 m level). Although no Rock Eval data was available prior to publication, based on experience with the Besa River Formation and other shale sequences, the trace of organic carbon levels will likely mimic the trace of uranium concentrations and will be highest where uranium levels are at maximum levels. Potassium concentrations increase upsection, which is likely an indication of higher clay content.

Lithogeochemistry

Preliminary results of 2012 lithogeochemistry are presented in a format similar to that used in Ferri et al. (2011) in order to compare the two datasets (Figs. 14, 15). In addition, lithogeochemistry results from 2011 sampling, which were not available prior to publication of Geoscience Reports 2012, are also shown in Figure 16.

In the southern Caribou Range, the SiO_2 content averages 78 wt.% and is greater than 68 wt.%. There are peak values more than 87 wt.% in the lower and upper part of the upper section (Fig. 14). The concentration of Al_2O_3 mirrors that of SiO_2 and becomes highest in the upper part of the section. The concentration of Ca and Na is generally very low (<1 wt.%), although there are anomalous values above 2 wt.%, likely related to thin carbonate beds. This

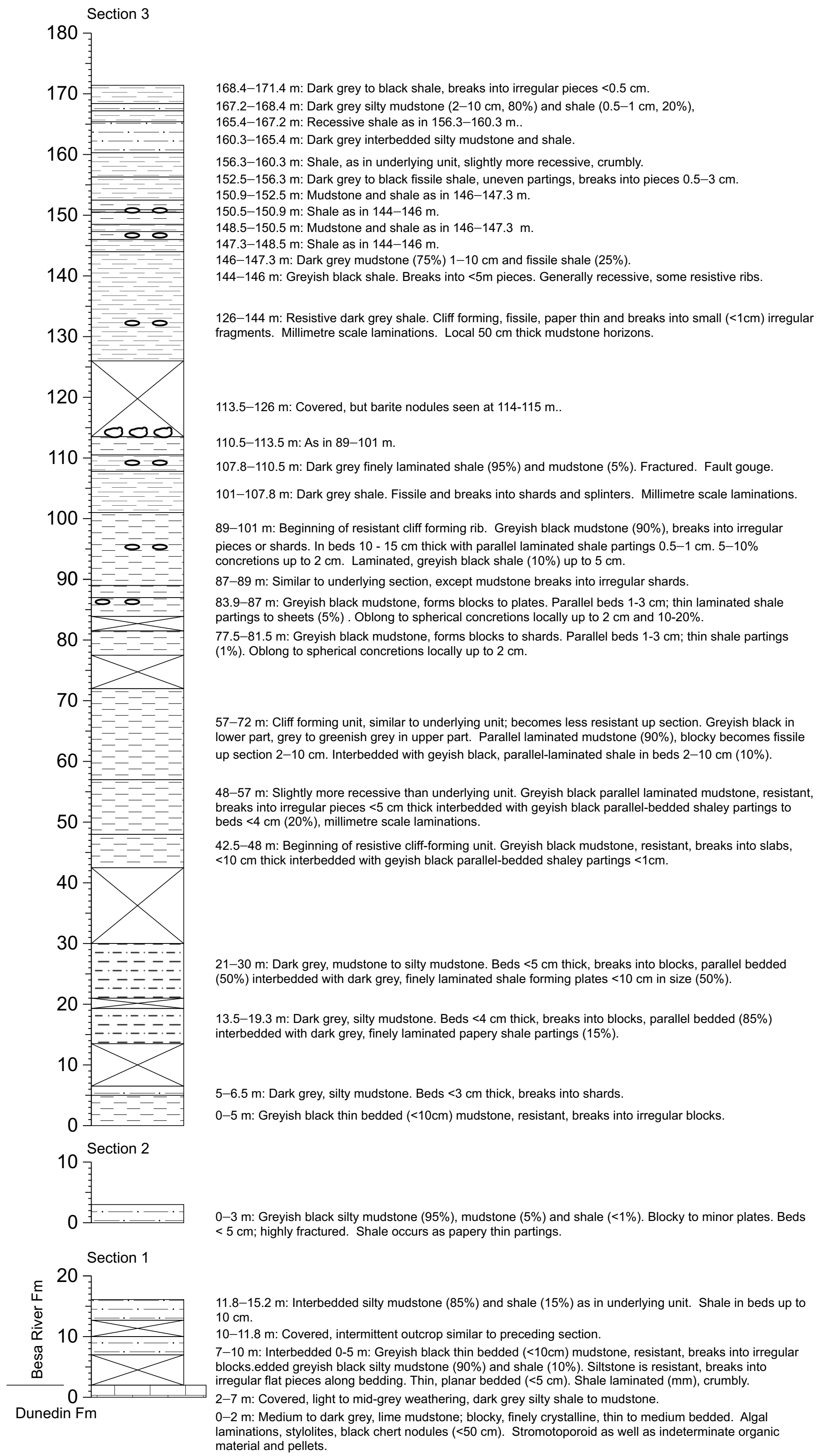

Figure 8. Lithological description of three separate sections of Besa River Formation measured in the southern Caribou Range. Although the three sections are in relative stratigraphic order, the exact distance between each is not known. The legend is the same as Figure 17.

100 m

Figure 9. Areal view of the three sections of the Besa River Formation measured in the southern Caribou Range. Arrows indicate viewing direction of photographs for sections 1 and 3 shown in Figures 10a and b.

Figure 10. a) Looking south at section 1 of the Besa River Formation showing the lowermost 15 m of this formation sitting on top of Dunedin Formation carbonate rocks; b) Looking northwest at the upper section 3 of the Besa River Formation.

is also displayed in data from the 2011 section near Stone Mountain, where Ca and Na concentrations are greater than 10 wt.%. Thicker, cleaner carbonate horizons in the Stone Mountain area may be a reflection of closer proximity to the carbonate bank edge (Figs. 1, 16). The Mn and Fe levels are low, <0.01 wt.% and 5 wt.%, respectively, indicative of the reducing environment during deposition of the shales (Ferri et al., 2011). The Fe levels increase in the upper part of the section, suggesting a less reducing water column.

Redox-sensitive elements, such as Mo, V, Ba and P, show varying concentrations within the section. The Mo and V concentrations display elevated values below the 120 m level of the upper section, suggesting highly reducing conditions. The V concentrations are greater than or near 1000 ppm between 70 and 110 m level of the upper section, suggesting euxinic conditions (Quinby-Hunt and Wilde, 1994). These drop to well below 500 ppm above this horizon. There are elevated values of Mo below the 110 m level of the upper section, but as with V, concentrations drop considerably above this horizon, to less than 5 ppm. Phosphorous concentrations are also highest across this horizon (i.e., 70 to 110 m level, upper section; Fig. 15).

Figure 11. a) Lowermost few metres of section 1 in the southern Caribou Range, showing fault-offset contact between carbonate rocks of the Dunedin Formation and light grey weathering shale of the lower Besa River Formation; b) Interbedded rusty weathering, dark grey mudstone and shale of the Besa River Formation in the upper part of section 1; c) Rusty weathering, grey-black silty mudstone and thin shale partings in the Besa River Formation of section 2; d) Greyish black, thin bedded mudstone in the lower 5 m of Besa River Formation, section 3; e) Rusty to tan weathering, dark grey, thin bedded silty mudstone of the Besa River Formation at the 25 m level of section 3; f) Tan to rusty weathering, greyish black mudstone of the Besa River Formation at the 44 m level of section 3. This rock type is resistant because of its higher silica content.

Figure 12. a) Looking southwest at blocky, greyish black parallel laminated resistive mudstone of the Besa River Formation between the 57–72 m level of section 3. These rocks become less resistive upsection; b) Blocky, resistive, greyish black mudstone between of the Besa River Formation between 110–113 m of section 3. Barite nodules are found weathering out of the covered section just above this (inset); c) Nodules within greyish black mudstone of the Besa River Formation at the 88 m level of section 3; d) Dark grey, fissile shale of the Besa River Formation at the 105 m level of section 3; e) Looking southwest at Besa River Formation rocks between the 120–170 m level of section 3; f) Rusty weathering, dark grey to black, silty mudstone and thinly interlayered shale of the Besa River Formation at the 150 m level of section 3; g) Dark grey to black shale of the Besa River Formation at the 154 m level of section 3. Rocks shown in f) and g) are dominant in the upper 40 m of section 3.

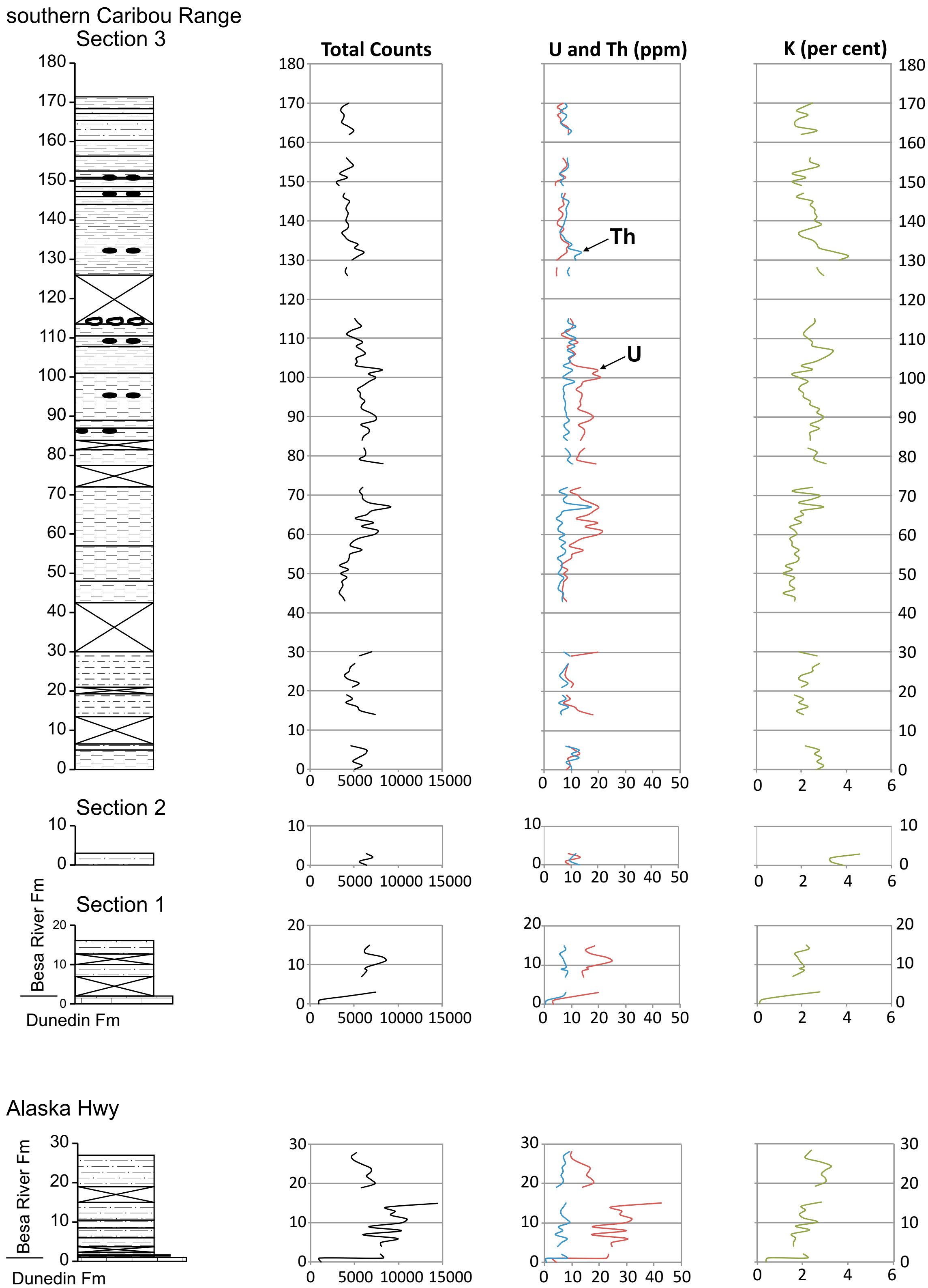

Figure 13. Gamma ray spectrometer data showing trace of total counts, uranium, thorium and potassium concentrations across the sections of the Besa River Formation measured in the southern Caribou Range and along the Alaska Highway.

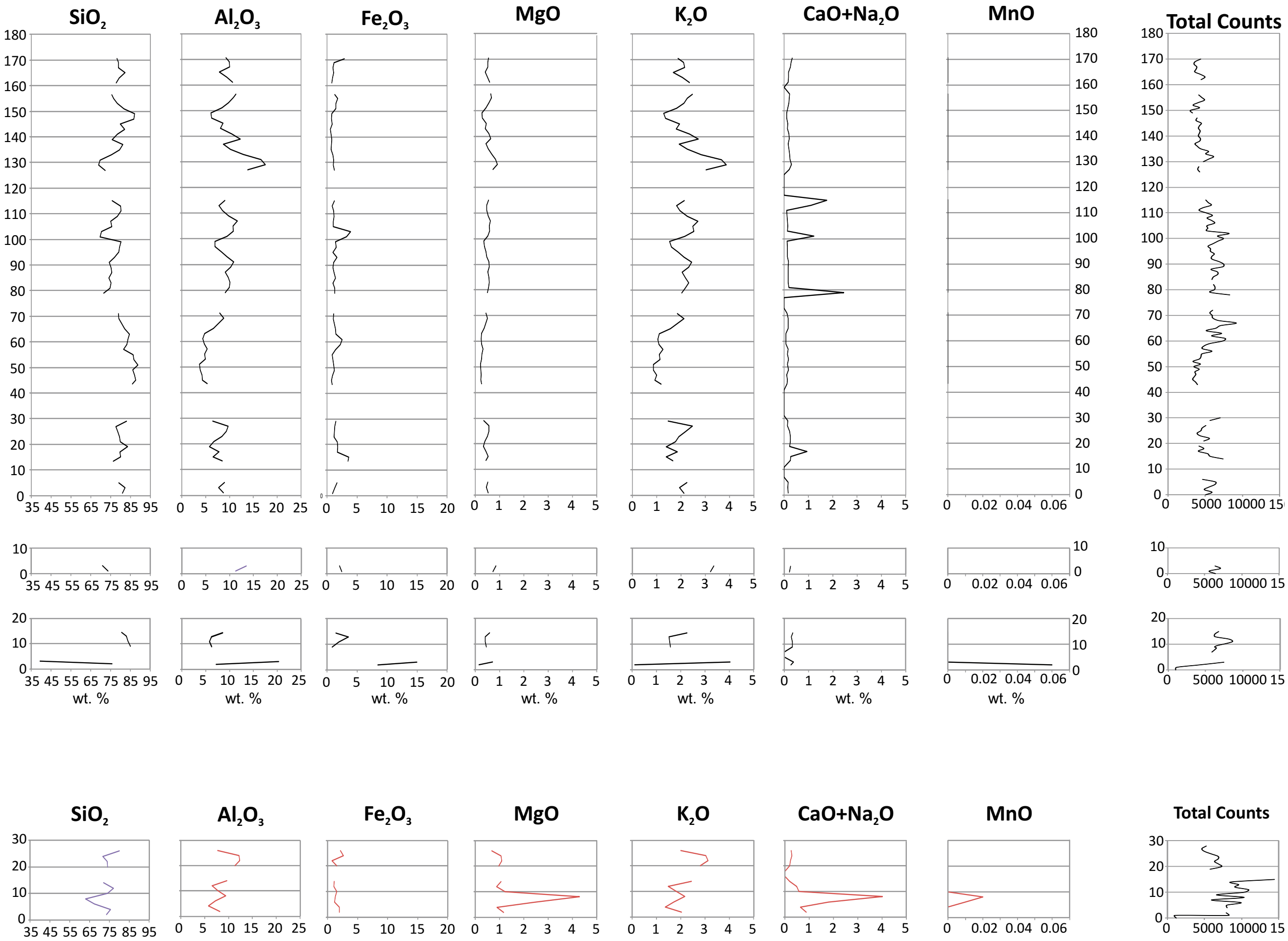

Figure 14. Major elemental abundances across the sections of the Besa River Formation measured in the southern Caribou Range and southwest of Toad River.

Barium is generally less than 2000 ppm below the 110 m level of the upper section but then increases to values in excess of 3000 ppm above this stratigraphic horizon. This increase in Ba within the sediments roughly corresponds to the occurrence of barite nodules at the 115 m level of the upper section. Barite nodules suggest that Ba may be precipitating from the water column due to a greater availability of sulphate. Below this stratigraphic level, conditions were likely more reducing, leading to the conversion of sulphate to sulphide. The Ba found in this environment would have accumulated in the water column, but would have started to precipitate out when sulphate became more abundant due to less reducing conditions. In this model, Ba levels in the water column would have been highest just before redox conditions changed, thus leading to an initial spike of barite precipitation represented by the barite nodules (Jewell, 2000; Huston and Logan, 2004; Griffith and Paytan, 2012).

Micropaleontology

Two samples of Besa River rocks (from the 43.5 m level and 151 m level of the upper section) were taken for processing and extraction of radiolarians for age determination. Although radiolarians were recovered from the 43.5 m level, these were flattened parallel to bedding and unidentifiable. Well-preserved radiolarians and a conodont ramiform element were recovered from the 151 m sample, which suggests a Frasnian to Tournaisian age, with the conodont fragment possibly of late Tournaisian age (Cordey, 2013; M. Orchard, pers comm, 2013).

ALASKA HIGHWAY SECTION

Lithology

Approximately 26 m of the lowermost Besa River Formation were measured immediately south of Stone Mountain, approximately 100 m north of the Alaska Highway and on the north side of a creek flowing into MacDonald Creek (Figs. 7, 17 and 18). Besa River shales sit sharply

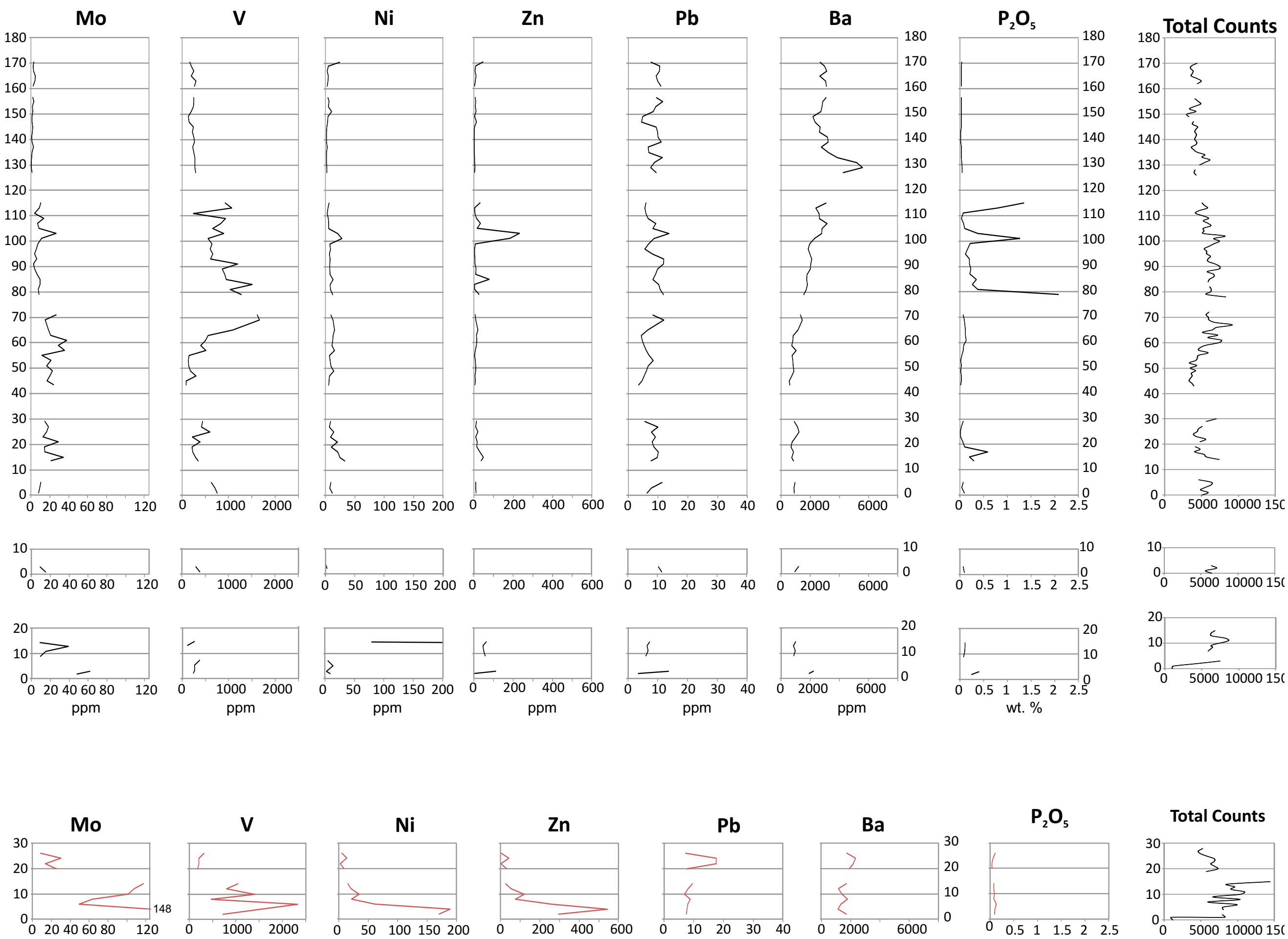

Figure 15. Minor and trace elemental abundances across sections of the Besa River Formation measured in the southern Caribou Range and southeast of Toad River.

above fossiliferous (coral, crinoids and shell fragments) limestone of the Dunedin Formation (Fig. 18a). The basal 6 m of the Besa River Formation consists of dark grey to black, tentaculitid-bearing (less than 5 mm long), soft, friable, carbonaceous shale (Fig. 18b). A thin, dark grey to black, carbonaceous limestone bed is found 1 m above the Dunedin Formation contact. These soft shales grade upward into 5–20 cm thick, carbonaceous mudstone to silty mudstone beds separated by thin shale horizons (Fig. 18c). The uppermost part of this section is massive (i.e., no bedding planes observed) and breaks into uneven, shard-like pieces (Fig. 18d).

Gamma ray spectrometry

The trace of total counts per second across the section has similarities to the lower part of the 2012 section investigated in the southern Caribou Range (Fig. 13). Uranium concentrations are higher than thorium and the profile of this concentration across the section mimics the total counts.

Lithogeochemistry

Major element abundances within the Alaska Highway section of the Besa River Formation are similar to those seen in the Caribou Range and within the 2011 section (Figs. 14, 15). Trace elements, including Mo, V, Ni and Zn, show elevated concentrations within the lower radioactive zone (2–15 m). These abundances are similar to those seen within the upper part of the succession in the southern Caribou Range (70–110 m level of section 3) and are at similar concentrations to those in Besa River sections sampled in 2010 and 2011. These abundances suggest very reducing (euxinic) conditions and likely will be accompanied by high organic carbon contents.

DISCUSSION

Lithological and geochemical characteristics of the Besa River Formation within the southern Caribou Range have overall similarities with sections measured in the northern Caribou Range and within the Stone Mountain area, suggesting uniform depositional conditions over a

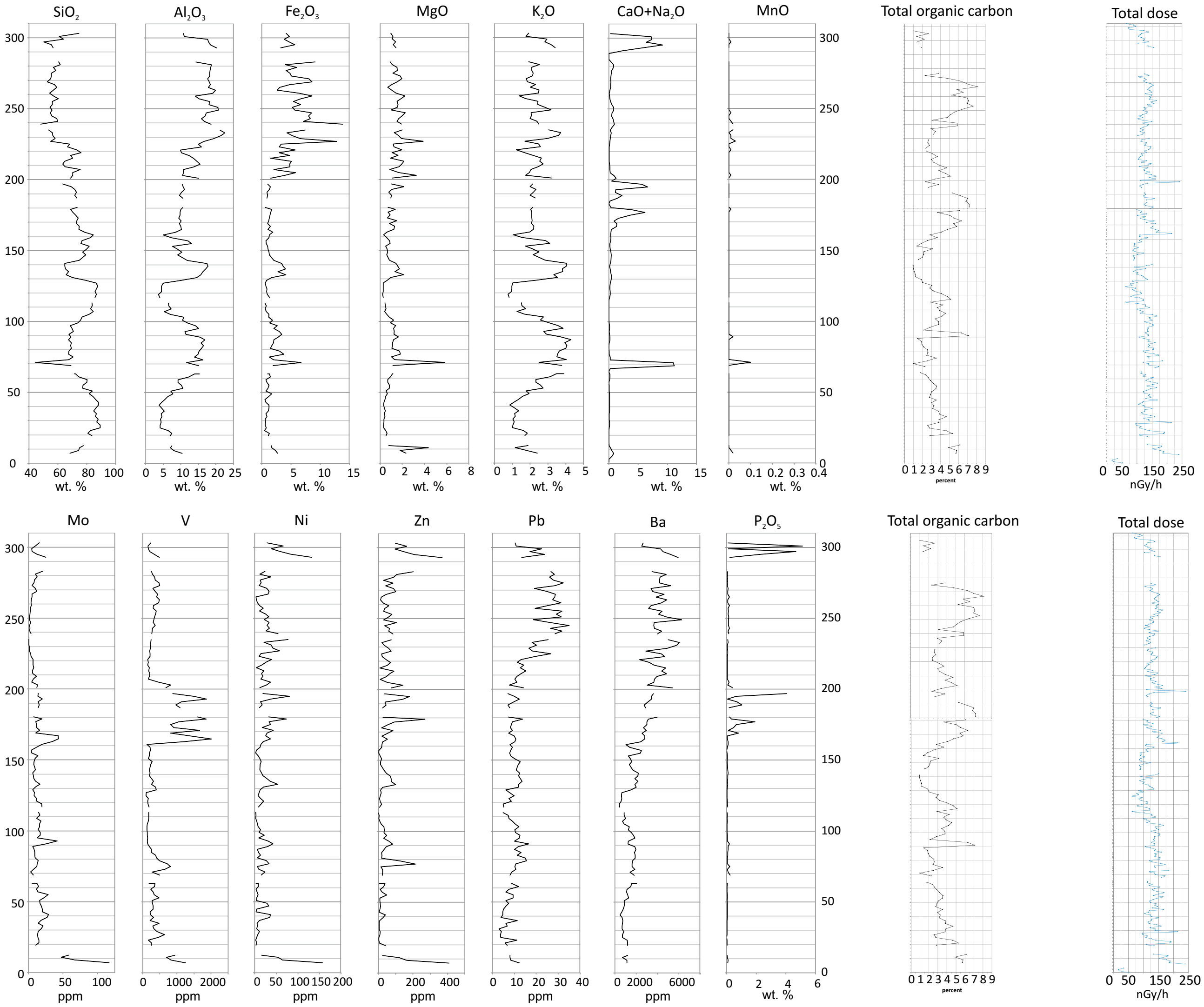

Figure 16. Major, minor and trace element abundances across the section of Besa River Formation measured in the Stone Mountain area by Ferri et al. (2012).

widespread area. Tentative correlation of the section in the southern Caribou Range with other sections is shown in Figure 19. Note that the 70–110 m portion of the upper section is tentatively correlated with rocks that are believed to be equivalents to the Exshaw Formation in the subsurface (Ferri et al., 2011, 2012). The postulated late Tournaisian age for radiolarian and conodont taxa from the 151 m level of the section would corroborate this because the Exshaw Formation has been shown to be late Famennian to middle Tournaisian in age (Richards et al., 2002).

The radioactive, tentaculitid-bearing shale section seen along the Alaska Highway is similar to Evie rocks observed by the senior author within the Imperial Komie, d-69-K/94-O-2 well of the Horn River Basin (Figs. 1, 18). This further supports the correlation of Horn River Basin rocks westward into the lower parts of the Besa River Formation (Ferri et al., 2011, 2012).

Rocks of the Besa River Formation in the Yukon have overall similarities to those of the Caribou Range and Stone Mountain area (Fraser et al., 2013). Although scintillometer and lithogeochemical data may assist with correlation of the sections, the Besa River Formation in the Yukon is much thicker, suggesting either (or a combination of) shale-out of underlying Dunedin Formation limestone, localized depositional thickening or structural complications.

The Golata Formation in the Northwest Territories (Fiess et al., 2013) contains rocks similar to those observed in the upper Besa River Formation within British Columbia (Ferri et al., 2011, 2012). Golata Formation rocks in the Northwest Territories are located immediately southeast of the Prophet Formation shale-out into rocks of the Besa River Formation.

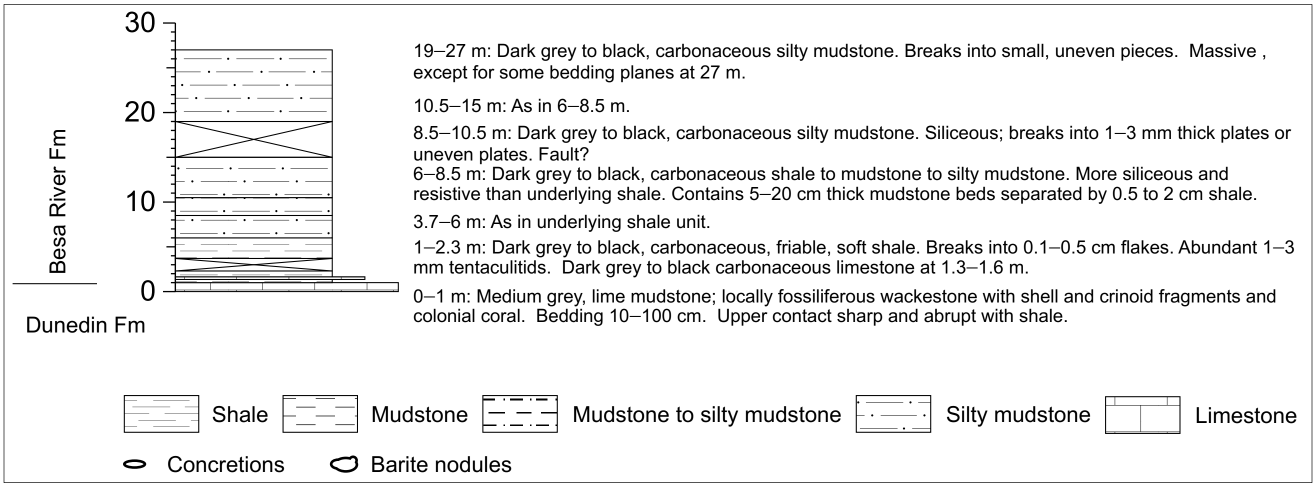

Figure 17. Lithological description of the Besa River Formation measured along the Alaska Highway, southeast of Toad River.

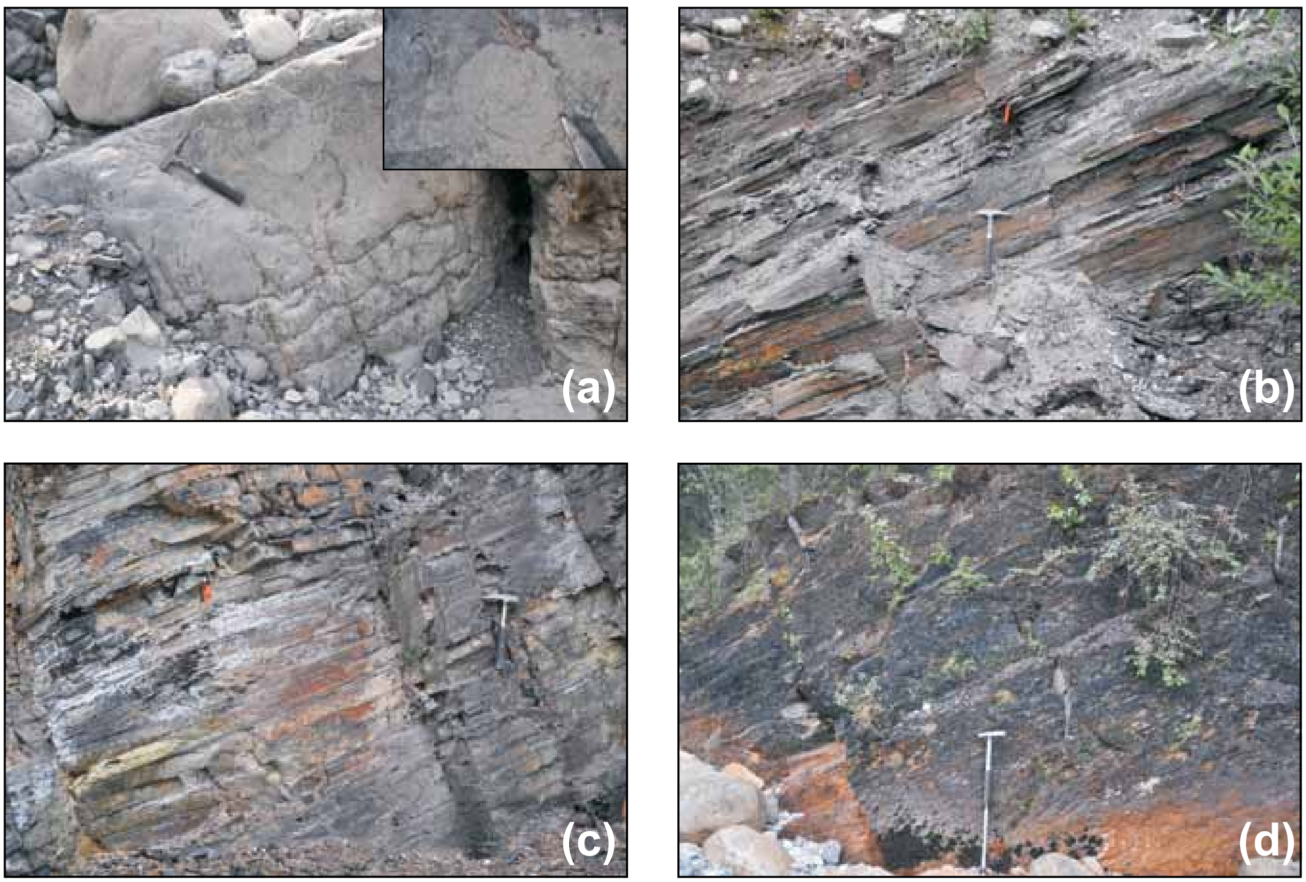

Figure 18. a) Upper two metres of fossiliferous limestone belonging to the Dunedin Formation within the section measured along the Alaska Highway, southeast of Toad River. Inset shows coral on the bedding surface immediately below the contact with the Besa River Formation; b) Lower several metres of tentaculitid-bearing soft shales of the Besa River Formation along the Alaska Highway section; c) More resistive, blocky shales to siltstone with fissile partings across the 11–13 m part of the Besa River section measured just north of the Alaska Highway; d) Splintery shale to siltstone in the upper part of the Besa River section just north of the Alaska Highway.

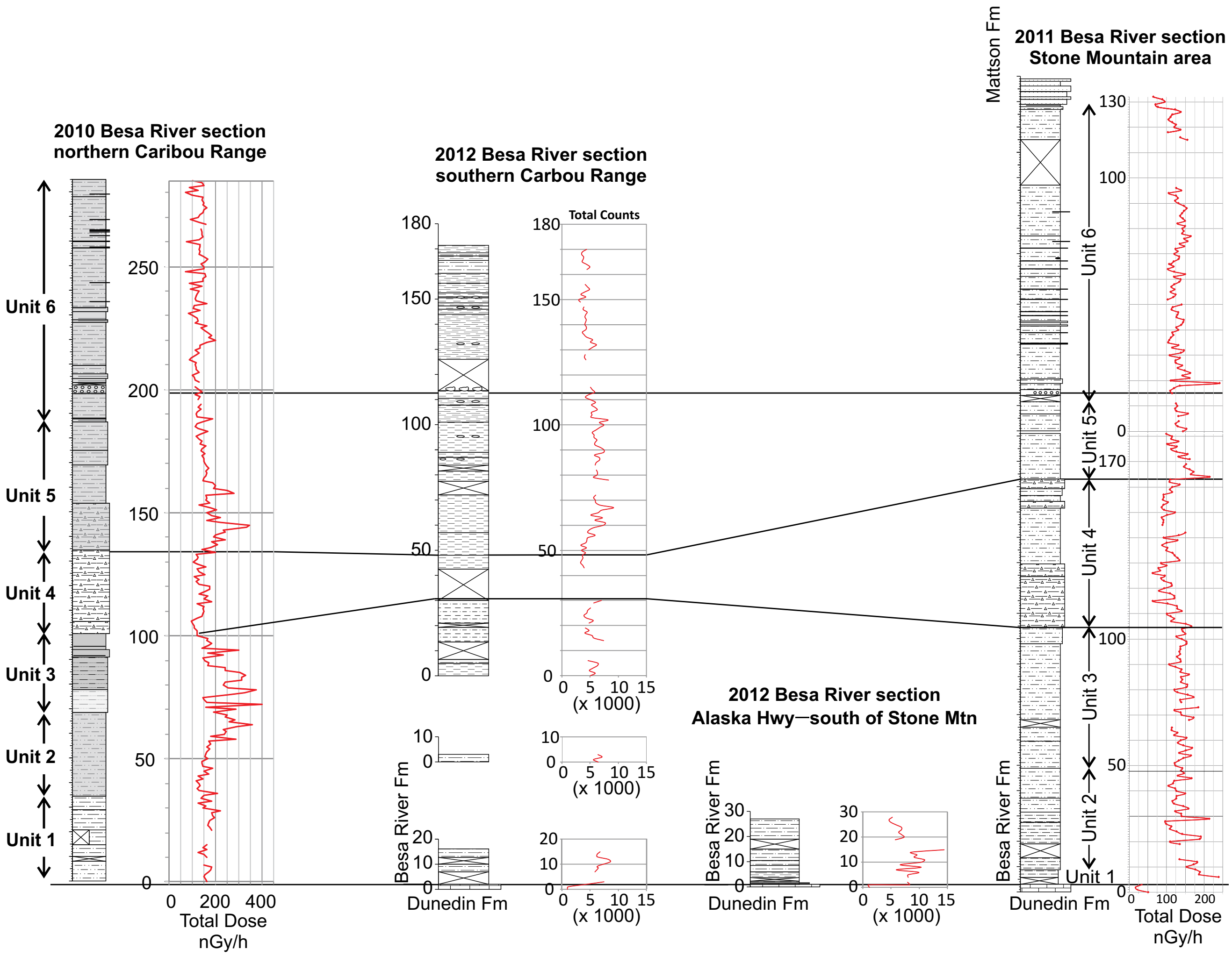

Figure 19. Correlation of Besa River Formation sections measured in this study with Besa River Formation sections measured in the northern Caribou Range and the Stone Mountain area by Ferri et al. (2011) and Ferri et al. (2012), respectively.

SUMMARY

- Regional mapping was concluded in the Toad River map area (NTS 094N) and will lead to the production of 1:100 000 scale maps of the northeast, southeast and northwest quadrants and 1:50 000 scale maps of 094N/3, 4, 5 and 6. This is a co-operative program with the GSC.
- Several composite sections of the Besa River Formation were measured in the southern Caribou Range and along the Alaska Highway, south of Stone Mountain. Data collection follows the methods used by Ferri et al. (2011, 2012). This was part of a larger project looking at sections of the Besa River Formation in the Yukon and its equivalents in the Northwest Territories (Fiess et al., 2013; Fraser et al., 2013).
- Overall lithological, gamma-ray spectrometry and lithogeochemical data across the Besa River Formation in the southern Caribou Range are similar to those observed in the northern Caribou Range and the Stone Mountain area, suggesting similar depositional conditions over a wide area.
- Lithogeochemistry indicates changes in redox conditions during deposition of the Besa River Formation.
- Radiolarian and conodont fossils collected from the top of the section indicate a late Tournaisian age.
- Characteristics of the lower Besa River Formation observed along the Alaska Highway south of Stone Mountain are similar to the Evie member of the Horn River Formation.

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