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Geology of the Mount Martin, Fisherman Lake, and Mount Flett map areas, Yukon Territory and Northwest Territories[1]

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Abstract: Regional mapping in Fort Liard and La Biche River (NTS 95 B, 95 C) was initiated during 2000 at a scale of 1:50 000 in the Mount Martin, Fisherman Lake, and Mount Flett map areas. In the Mount Martin area, a primary focus was the recognition and documentation of three stratigraphic units: the Permian Tika map unit, the Triassic Toad-Grayling Formation, and the Lower Cretaceous Sikanni Formation. Facies changes and sub-Cretaceous erosion are major controls on the distribution of these units within the project area.

Although the regional distribution of rock units on existing reconnaissance maps is broadly appropriate, our new mapping already has resulted in substantial revisions and updates. The distribution of major structures is also being significantly revised as a result of our more detailed investigations.

Résumé : La cartographie régionale à l'échelle de 1/50 000 à Fort Liard et à la rivière La Biche (SNRC 95 B, 95 C) a débuté en l'an 2000 dans les régions cartographiques du mont Martin, du lac Fisherman et du mont Flett. Dans la région du mont Martin, on s'est essentiellement attardé à reconnaître et à documenter l'existence de trois unités stratigraphiques : l'unité cartographique Tika du Permien, la Formation de Toad-Grayling du Trias et la Formation de Sikanni du Crétacé inférieur. Les changements de faciès et l'érosion sub-crétacée sont les principaux éléments contrôlant la répartition de ces unités dans la région du projet.

Bien que la répartition régionale des unités cartographiques figurant sur les cartes de reconnaissance existantes soit *grosso modo* exacte, la nouvelle cartographie donne déjà lieu à des révisions et à des mises à jour substantielles. La répartition des grandes structures fait également l'objet de révisions importantes suite à la réalisation de nos études plus approfondies.

[1] Contribution to the Central Foreland NATMAP Project

INTRODUCTION

In four weeks of mapping based out of Fort Liard, Northwest Territories (Fig. 1), 1:50 000 scale mapping was initiated as part of the Central Foreland NATMAP Project in four areas of the Fort Liard (NTS 95 B) and La Biche River (NTS 95 C) map areas. Three eastern areas, Mount Martin (95 C/1; Fig. 2); Fisherman Lake (95 B/5), and Mount Flett (95 B/12; Fig. 2, 3) were mapped by GSC personnel. Our partners from the Yukon Geoscience Program focused on Pool Creek (95 C/5) map area. Results of the work in Pool Creek will be reported separately (Allen et al., in press).

The Fort Liard and La Biche River map areas lie at the southern termination of the Mackenzie Mountains and are part of the Foreland fold and thrust belt. Topography in the area is structurally controlled, with anticlines underlying the ranges, and synclines underlying the valleys. The eastern half of the La Biche River area and the west half of the Fort Liard area are known to hold important gas reserves in structural plays, as exemplified by the Beaver River, Kotaneelee, Pointed Mountain, and La Biche fields.

STRATIGRAPHY

In the outer foothills near Fort Liard, the exposed strata range from the Late Devonian–Carboniferous Besa River Formation to the Late Cretaceous Wapiti Formation. Much of the area is underlain by Carboniferous and Permian strata of the Prophet, Flett, Mattson, and Fantasque formations (Richards, 1989). With the exception of local exposures of Triassic strata, the upper Paleozoic succession is unconformably overlain by Lower Cretaceous rocks of the Chinkeh Formation (Leckie et al., 1991) and younger units. New data pertinent to the distribution of late Paleozoic through Cretaceous rock units were documented during fieldwork and are outlined below.

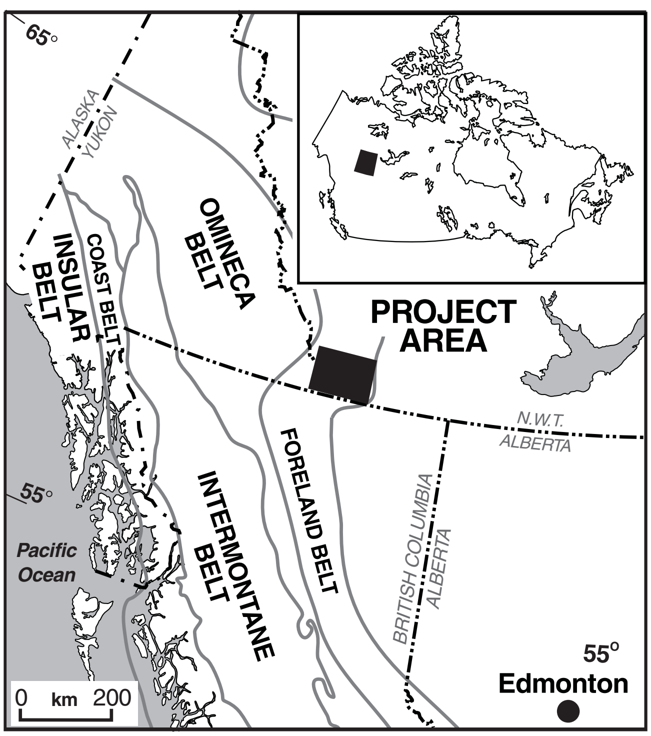

Figure 1. *Location map.*

Permian Tika map unit

Recent mapping in NTS map areas 95 C/8 and 95 C/9 has documented a thin-bedded silty limestone unit above the Carboniferous Mattson Formation and below the Permian Fantasque Formation (Currie et al., 1999a, b). This unit was informally named the Tika map unit based on its occurrence at Tika Creek in NTS map area 95 C/10 (B. Richards, pers. comm., 2000). The Tika map unit has been mapped on the east limb of the Kotaneelee anticline and the east limb of the La Biche anticline on map areas 95 C/8 and 95 C/9 suggesting it is a regionally mappable unit. It has not yet been recognized on the west limb of the Kotaneelee anticline. Poor exposure in the interval between the upper member of the Mattson Formation and the Fantasque Formation has hindered the recognition of the Tika map unit in 95 C/1. However, silty limestone and calcareous sandstone that could be attributed to the Tika map unit have been found locally in this interval.

A calcareous breccia 10–50 cm thick, typically found at the base of the unit in map areas 95 C/8 and 9 and at the Tika Creek section, has not been found in 95 C/1. This suggests that the breccia may not be regionally characteristic of the unit's basal contact, and complicates the identification of the base of the unit in 95 C/1. Mapping of the upper Mattson–Tika contact is further complicated by the presence of calcareous siltstone, similar to the Tika map unit, within the upper member of the Mattson Formation in map areas 95 B/5, 95 B/12, and 95 C/1. This lithofacies is atypical of the Mattson Formation, but its relationship with the overlying Tika map unit is unclear.

The previously documented thickness for the Tika map unit is 50 to 120 m (Currie et al., 1998). This would be consistent with the thickness in the La Biche Range in 95 C/1, but the map unit thins to 20–50 m in the Kotaneelee Range in 95 C/1 and has yet to be reliably documented by mapping in 95 B/5 and 95 B/12 (Fig. 2).

Triassic

The geological map of the La Biche River (NTS 95 C) map area by Douglas (1976) infers the presence of a recessive-weathering Triassic unit by projecting Triassic occurrences north from the Toad River (NTS 94 N) map area (Taylor and Stott, 1999). Mapping at 1:50 000 scale in the Mount Martin (95 C/1) map area (Fallas, in press) has documented occurrences of this unit in the 95 C map area and permits field description of the unit.

The unit is shale- and siltstone-dominated, with interbeds of fine-grained sandstone. Fresh and weathered surfaces vary from red to green or grey in colour in the shale and siltstone, and light to medium orange-brown in the sandstone beds.

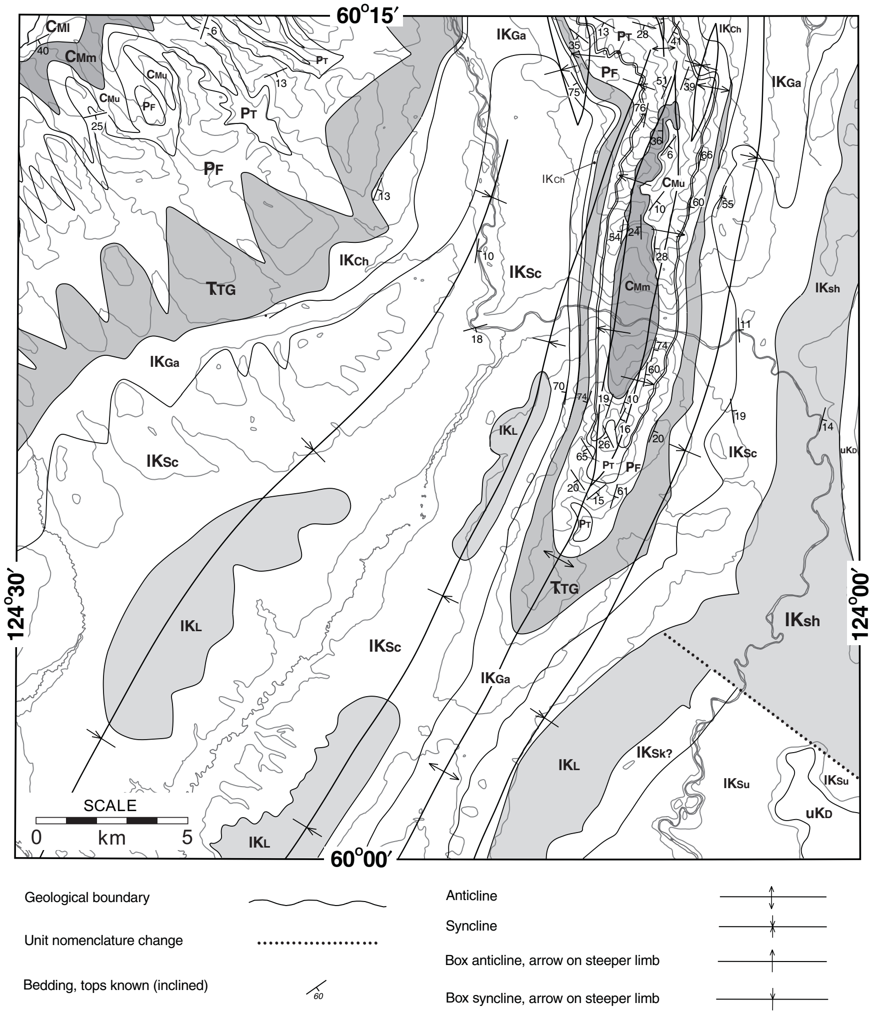

Figure 2. *Geological map of the Mount Martin area (95 C/1).*

LEGEND FOR FIGURE 2

MESOZOIC		**UPPER CRETACEOUS**
	uKD	DUNVEGAN FORMATION: *light grey to buff sandstone, pebble conglomerate, dark grey silty shale, and coal; sandstone is massive with crossbedding.*
		LOWER CRETACEOUS
		FORT ST JOHN GROUP (lKSu - lKCh)
	lKsh	Lower Cretaceous shale, undivided: *dark grey shale and siltstone with sideritic concretions.*
	lKSu	SULLY FORMATION: *dark grey shale and siltstone with sideritic concretions.*
	lKSk	SIKANNI FORMATION: *greenish-grey sandstone, siltstone, and shale; sandstone is thick-bedded, commonly calcareous or glauconitic, typically finely laminated and crossbedded.*
	lKL	LEPINE FORMATION: *dark concretionary mudstone and black fissile shale with thin siltstone beds.*
	lKSc	SCATTER FORMATION: *resistant, flaggy to thick-bedded, glauconitic greenish-grey laminated sandstone interbedded with silty concretionary mudstone.*
	lKGa	GARBUTT FORMATION: *grey shale and siltstone with sideritic concretions; may include Chinkeh Formation.*
	lKCh	CHINKEH FORMATION: *chert pebble conglomerate, bioturbated quartz arenite with variable chert content, and argillaceous siltstone.*
		TRIASSIC
	TTG	TOAD-GRAYLING FORMATION: *red, green, and grey shale interbedded with brown sandstone.*
PALEOZOIC		**PERMIAN**
	PF	FANTASQUE FORMATION: *rhythmically bedded chert, minor shale and siliceous siltstone.*
	PT	*Tika map unit: buff-weathering, light to medium brown, fine-grained silty limestone, silty dolostone, and calcareous quartz arenite.*
		LOWER CARBONIFEROUS
		MATTSON FORMATION
	CMu	UPPER MEMBER: *grey quartz arenite, fossiliferous limestone, sub-chert-arenite, and shale; locally crossbedded; may include Tika map unit.*
	CMm	MIDDLE MEMBER: *thick-bedded, poorly to well indurated, grey to buff quartz arenite with minor interbedded siltstone, dark shale, and coal; medium- to large-scale crossbedding.*
	CMl	LOWER MEMBER: *thin-bedded, rusty-weathering, buff, fine- to medium-grained quartz arenite interbedded with siltstone and shale; locally bioturbated.*
	CG	GOLATA FORMATION: *dark grey or black shales to argillaceous limestone.*
	CF	FLETT FORMATION: *grey fossiliferous limestone; shale.*
	CP	PROPHET FORMATION: *buff-weathering, dolomitic or calcareous black shale and siltstone; siliceous or spicularitic locally; thin-bedded and planar-laminated.*
		DEVONIAN TO LOWER CARBONIFEROUS
	DCBR	BESA RIVER FORMATION: *dark grey to black shale; minor interbedded siltstone and sandstone increasing upsection.*

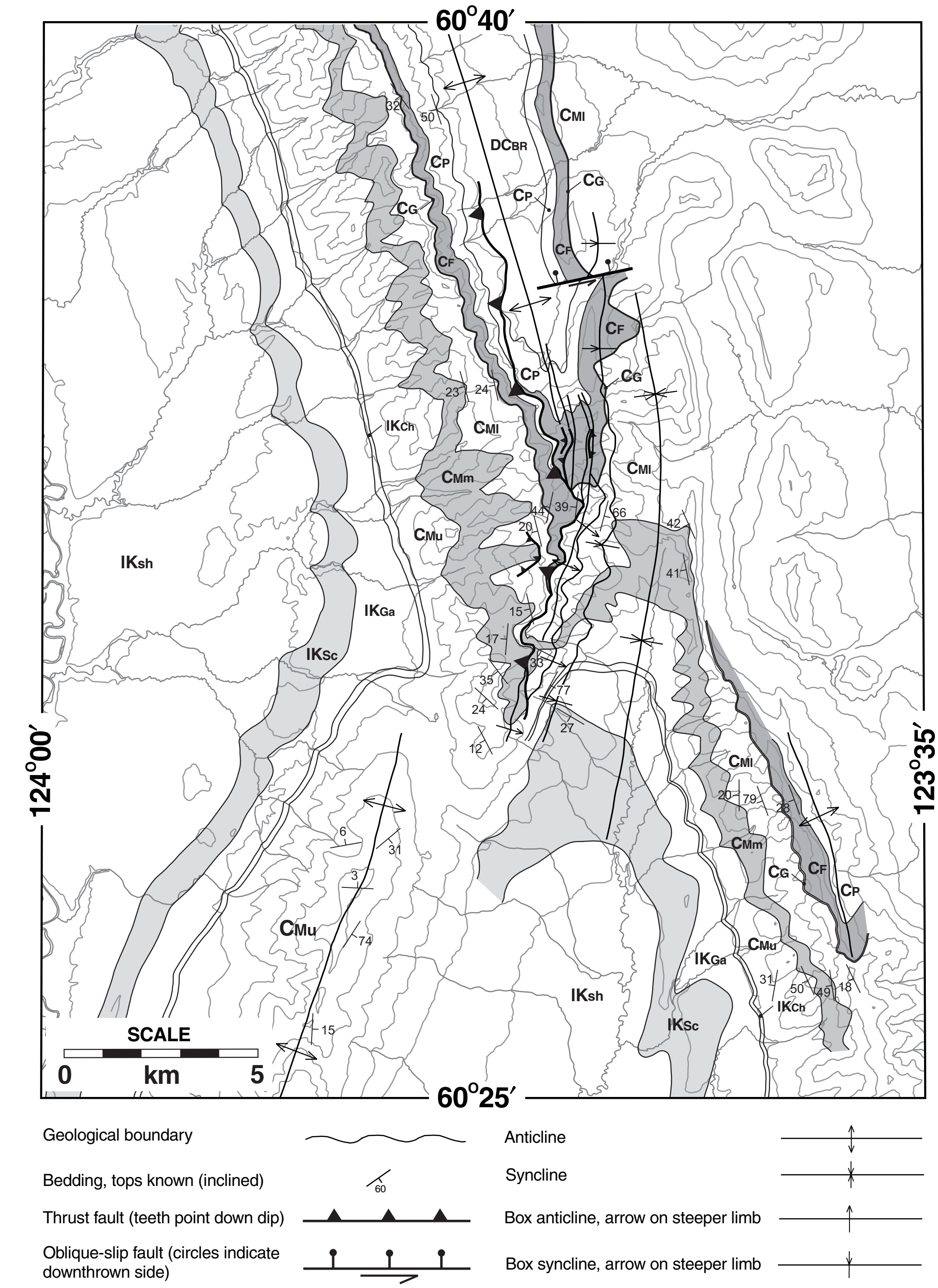

Figure 3. *Geological map of parts of the Fisherman Lake (95 B/5) and Mount Flett (95 B/12) areas.* See *Figure 2 for legend.*

Sandstone beds make up 10–30% of the unit and are interbedded with the shale and siltstone on a scale of 10–100 cm. Individual sandstone beds vary from 5–50 cm in thickness. Upward-coarsening packages, consisting of a shaly basal unit that passes up through siltstone into sandstone over approximately 50 cm, occur sporadically. More commonly, sandstone beds lie upon the shale with an abrupt, erosional contact (Fig. 4). Erosional relief on these contacts varies from a few centimetres to a few tens of centimetres. Sedimentary structures include oscillation ripples, current ripples, hummocky cross-stratification, tool marks, and ball-and-pillow structures. These characteristics suggest a shallow-marine environment of deposition, above storm-wave base. Body fossils were not observed in these exposures, but a low-diversity assemblage of trace fossils occurs sparsely at the bases or tops of sandstone beds.

The thickness of this unit is 350–400 m based on a creek exposure on the west side of Mount Martin in 95 C/1, where upper and lower contacts are exposed. The lower contact of this unit is gradational with the underlying Permian Fantasque Formation. The upper contact is erosional where the unit is unconformably overlain by conglomerate of the lower Cretaceous Chinkeh Formation.

Fossil evidence to constrain the age of this unit is currently lacking, although biostratigraphic analysis is underway. Therefore this unit is assigned to the Triassic Toad-Grayling Formation, based on homotaxial lithological correlation and regional stratigraphic constraints.

Cretaceous

Resistant sandstone of the Lower Cretaceous Sikanni Formation occur throughout the Toad River map area (NTS 94 N; Taylor and Stott, 1999). Based on exposures in the northeast corner of the Toad River map area (NTS 94 N/16), the Sikanni Formation was projected into the Mount Martin map area by Douglas (1976). A sandstone outcrop on the La Biche River in the southeast corner of the Mount Martin map area may be the only expression of the Sikanni Formation on this map sheet, as it is not developed along strike to the north.

The outcrop is a 2 m high exposure of buff-coloured, medium- to coarse-grained sandstone with pebbly layers and trough crossbedding (Fig. 5). No shale is seen interbedded with the sandstone at this outcrop. This differs from the description of the Sikanni Formation given by Stott (1982) for the Liard–La Biche region. Stott's measured sections in the area typically describe the Sikanni Formation as a succession of interbedded fine-grained, laminated and

Figure 4.

Outcrop of Triassic Toad-Grayling Formation on the east limb of the La Biche anticline in 95 C/1. ***a)*** *Green siltstone coarsening upward into brown fine-grained sandstone with ripple crosslaminations; hammer 30 cm long.* ***b)*** *Sharp-based sandstone bed cutting down into underlying shale and siltstone.* ***c)*** *Interbedded sandstone and shale; Cory Bass for scale, approximately 2 m high.v*

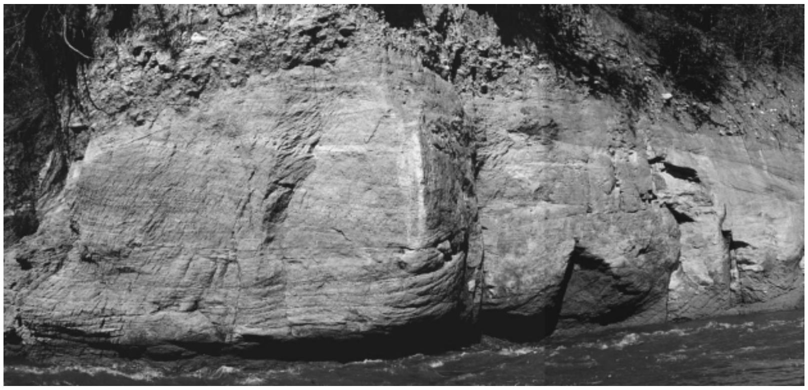

Figure 5.

(?)Cretaceous coarse-grained, pebbly, cross-bedded sandstone outcrop, interpreted either as the Sikanni Formation or the Dunvegan Formation, on the La Biche River in the southeast corner of 95 C/1. Outcrop is 2–3 m high, and is overlain by Quaternary sediments.

crosslaminated, glauconitic sandstone, and concretionary black mudstone. Coarser grained sandstone and conglomeratic sandstone were noted by Stott (1982) in one section northeast of Lepine Creek in the Toad River map area.

This discrepancy in character between the La Biche River outcrop in the Mount Martin map area and the description of the Sikanni Formation by Stott (1982) raises some doubt as to the affinity of the La Biche River outcrop. In fact, the characteristics of this outcrop are more in line with those of the Upper Cretaceous Dunvegan Formation. However, structural constraints remain ambiguous and this outcrop may correlate with the Sikanni Formation, represent a facies variant within the formation. Ongoing sedimentological and stratigraphic work on the Cretaceous rocks in the area will clarify this issue.

STRUCTURE

The Mount Martin (95 C/1) map area encompasses the Kotaneelee and La Biche ranges. Each of these mountain ranges is underlain by an anticline cored by Carboniferous rocks of the Mattson Formation (Fig. 2). The intervening valley is occupied by Lower Cretaceous rocks in the La Biche syncline. On the east edge of the map area, Cretaceous rocks dip gently eastward into the Liard syncline.

The La Biche anticline in the Mount Martin area is the southern end of a structure that extends with a sinuous trace from north to south across the La Biche (95 C) map area (Douglas, 1976). The axis of the anticline lies to the west of the Mount Martin area, and so, in the Mount Martin area, the La Biche Range is underlain by the anticline's gently dipping east limb. This anticline has been documented farther to the north in 95 C/8 and 9 (Currie et al., 1998) as a compound structure made up of en échelon detachment box folds.

Much like the La Biche anticline, the Kotaneelee anticline is a sinuous feature that extends from north to south, the length of the La Biche map area (Douglas, 1976). At the south end, the Kotaneelee anticline is continuous with the gas-bearing Beaver River anticline in the Toad River (94 N) map area. At the map boundary with 95 C/8 to the north, the trend of the Kotaneelee Range changes from NNE in 95 C/1 to NNW in the southern portion of 95 C/8. This change in trend is the expression of a set of en échelon folds that step to the west along the range to the north. These en échelon folds were first recognized by Currie et al. (1999a) in 95 C/8, and have been traced into 95 C/1 during the current work. The furthest east of these major folds becomes the dominant fold to the south in 95 C/1. Although this fold plunges to the NNE at the north end of the map area, the plunge reverses to the SSW south of the La Biche River.

A box-fold geometry is readily apparent in the Mount Martin area, with shallow bedding dips in the hinge zone, steeply dipping panels on the east and west limbs, and shallowly dipping panels in the synclines. Some minor fold pairs are noted on the limbs of the major anticline. These folds have been interpreted as detachment folds and the detachment level has been calculated to be near the base of the Besa River Formation based on a cross-section in 95 C/8 (Currie et al., 1998).

On the La Biche River (95 C) map of Douglas (1976), east-verging thrust faults are shown on the east side of the Kotaneelee Range. Instead of finding direct evidence of faulting, current mapping indicates a normal stratigraphic succession on the steeply dipping east limb of the Kotaneelee anticline. Similarly, another thrust fault to the east within the Cretaceous strata could not be confirmed. Remarkably, significant faults of any kind do not occur in the 95 C/1 map area.

The Liard Range trends south-southeast through Mount Flett (95 B/12) and Fisherman Lake (95 B/5). In these map areas, the range is formed by three distinct culminations (Fig. 3) that converge near the southern edge of Mount Flett map area. The Pointed Mountain anticline in the southwest is a doubly plunging, north-northeast-trending symmetrical culmination. Aligned en échelon with the Pointed Mountain anticline, with a right-stepping offset, is the Flett Anticline. This structure is cored by shale of the Besa River Formation. Its west limb, underlain by Mattson Formation, forms the northern segment of the Liard Range. This structure is detached and partly disrupted by a thrust fault that is presumed to have its roots in shale of the Besa River Formation (Fig. 3). This thrust fault loses displacement southward and dies out near the southern termination of the anticline. Previous reconnaissance mapping projected a second thrust fault extending southward from this vicinity along the east flank of Pointed Mountain into the Mount Martin map area (Douglas and Norris, 1976). Although mapping is incomplete east of

Pointed Mountain, we could find no evidence to justify this interpretation at the southern end of the Flett Anticline, at the south end of Pointed Mountain, or westward into the Mount Martin area.

The previous interpretation of a thrust fault on the east flank of Pointed Mountain may have its origin in two pieces of evidence. First, bedding dips locally exceed 70° in the vicinity of the en échelon transfer from the Flett to the Pointed Mountain structures, due to the box-fold geometry of the Flett structure. The exposed dip slopes create a sharp airphoto lineament at this locality. Also, the Lower Cretaceous Scatter Formation normally has a readily identifiable topographic expression, which is absent on the east flank of Pointed Mountain (Fig. 3). Accordingly, a small fault in this vicinity cannot be disproved at the present stage of mapping. If a fault does exist east of Pointed Mountain, it is much less extensive than previously suggested.

A third anticline constituting the southeastward continuation of the Liard Range is outlined by the Mattson and Flett formations (Fig. 3). This structure has yet to be mapped in any detail.

SUMMARY

Stratigraphic units used herein correspond closely with those of Douglas (1976) and Douglas and Norris (1976), with two notable exceptions. Calcareous siltstone at the top of the Upper Mattson have been split out as the Tika map unit, and the Chinkeh Formation conglomerates and sandstones have been recognized at the base of the Cretaceous succession. The presence of Triassic rocks in the La Biche River area, as indicated by Douglas (1976), has also been confirmed. Conversely, the presence of the Cretaceous Sikanni Formation is very much in doubt.

The structural style in the eastern foothills comprises a series of en échelon folds with a box-fold geometry controlled largely by the competence of the Mattson Formation. Nearly vertical bedding dips on the flanks of several structures may have led previous mappers to interpret thrust faults in some of these areas. In at least some cases, these interpreted faults are not required by the distribution of the map units.

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