Exploration Significance of the Iskut River Fault

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KEYWORDS: *Regional mapping, structure, Iskut River, Pitman fault, Iskut River fault, mineral exploration, Eskay Creek.*

SUMMARY

Large-scale aeromagnetic lineaments reveal major faults that cut across northern British Columbia, extending from the Coast Plutonic Complex in the west to the northern Rocky Mountain Trench in the east. These faults are significant because:

- they are part of the record of Tertiary regional-scale tectonic readjustments within the Canadian Cordillera
- they characteristically occur as a set of parallel faults
- they have a predictable orientation, sense of offset, and amount of offset
- they pass near major mineral deposits, offsetting prospective strata. Determination of fault offset allows focused exploration efforts on the offset block.

INTRODUCTION

An aeromagnetic map of northern British Columbia (Figures 1 and 2), contoured and enhanced by low-angle oblique illumination, was prepared by RGI (Resource Geoscience and Imaging) in Vancouver. This map highlights two 500-kkilometre-long east-trending magnetic lineaments that transect the Canadian Cordillera. Along most of its length, the northern magnetic lineament coincides with a mapped fault, the Pitman fault (Figure 3), however, the extent of the coincident aeromagnetic anomaly indicates that the Pitman fault continues westward well beyond its mapped limits. A fault corresponding to the southern magnetic lineament (Figures 2 and 3), the Iskut River fault, is documented for the first time in this paper.

PITMAN FAULT

The Pitman fault is located along latitude 57º 50’ N (Figures 2 and 3). There is 3 kilometres of left-lateral offset along the fault, measured where it offsets the Thudaka and Kutcho faults (Gabrielse, 1985). Vertical offset is minor with a small amount of north-side-down offset recorded along the western part of this fault. Movement occurred during Eocene to Oligocene time. The sinistral offset along the Pitman fault and the angular relationship (~75º) between the Pitman fault and dominant northwest-striking dextral faults (Kechika, Finlay, Ingenika, Northern Rocky Mountain Trench) are consistent with the interpretation that this is an antithetic fault associated with the continental-scale displacement along the Northern Rocky Mountain Trench (Gabrielse, 1985). Antithetic faults characteristically occur in parallel sets, and there are other faults in the region with similar orientation, attitude, and offset, including a set of subparallel faults that trend east from the north end of Dease Lake (Gabrielse, 1985).

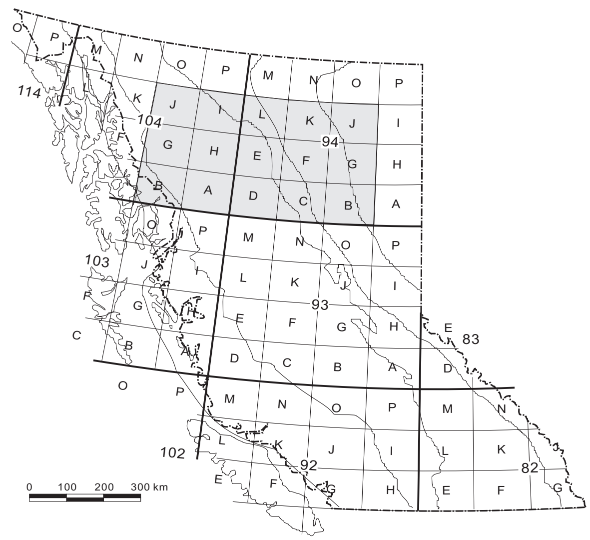

Figure 1. Location of this study. Shading corresponds to the area of Figures 2, 3, 7 and 9.

ISKUT RIVER FAULT

The southern magnetic lineament is located along latitude 56º 40’ N (Figures 2 and 3). The possibility of a fault lying along the lower (west-flowing) section of the Iskut River has been debated for several years. Features favouring the existence of an east-striking fault are the linearity of the river valley, and it’s abrupt dogleg turn from southwest-flowing to west-flowing at the junction with Volcano (Palmière) Creek (Figures 4 and 5). However, arguments for existence of a fault have been difficult to support because there is no unequivocal evidence for offset of lithologic units across the lower Iskut River.

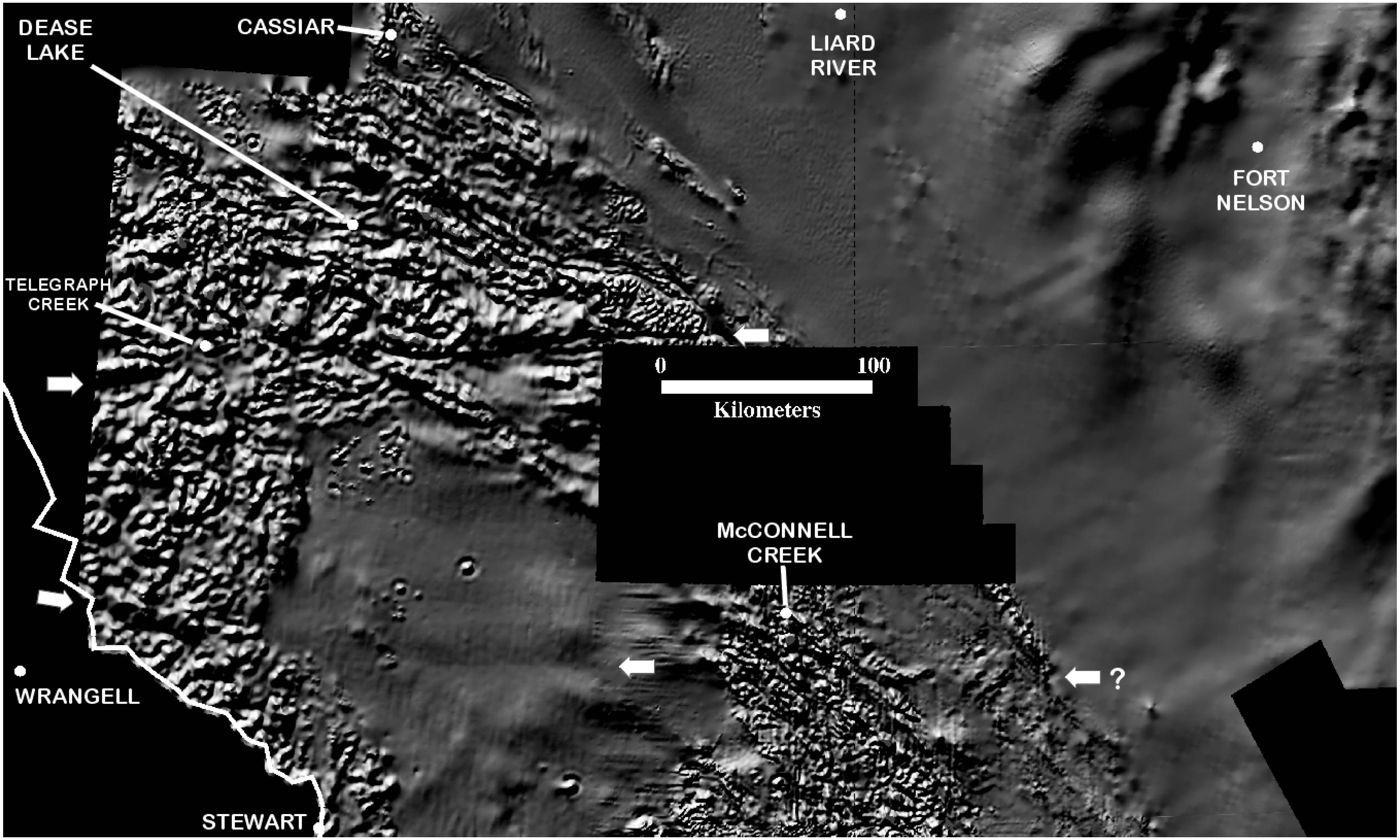

Figure 2. Contoured aeromagnetic map enhanced by low-angle oblique illumination. The two sets of opposing arrows mark the ends of the magnetic anomalies correlated with the Pitman fault (northern set of arrows) and the Iskut River fault (southern set of arrows).

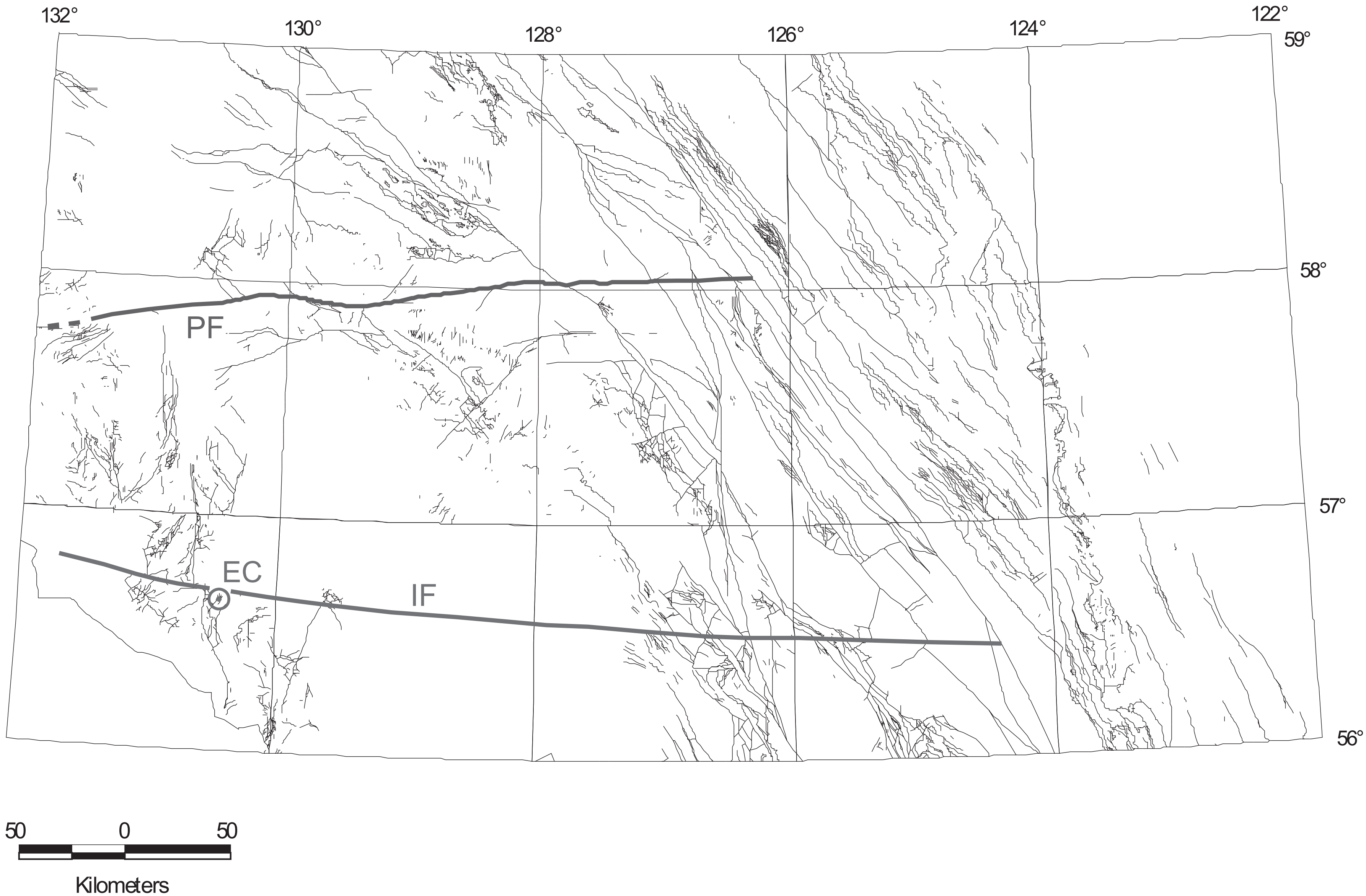

Figure 3. Major faults of north central British Columbia (complied from the maps of the British Columbia Mineral Potential Project). This map matches the area and map projection of Figure 2. PF is the mapped Pitman Fault. IF is the interpreted location and extent of the Iskut River Fault. EC is the Eskay Creek minesite.

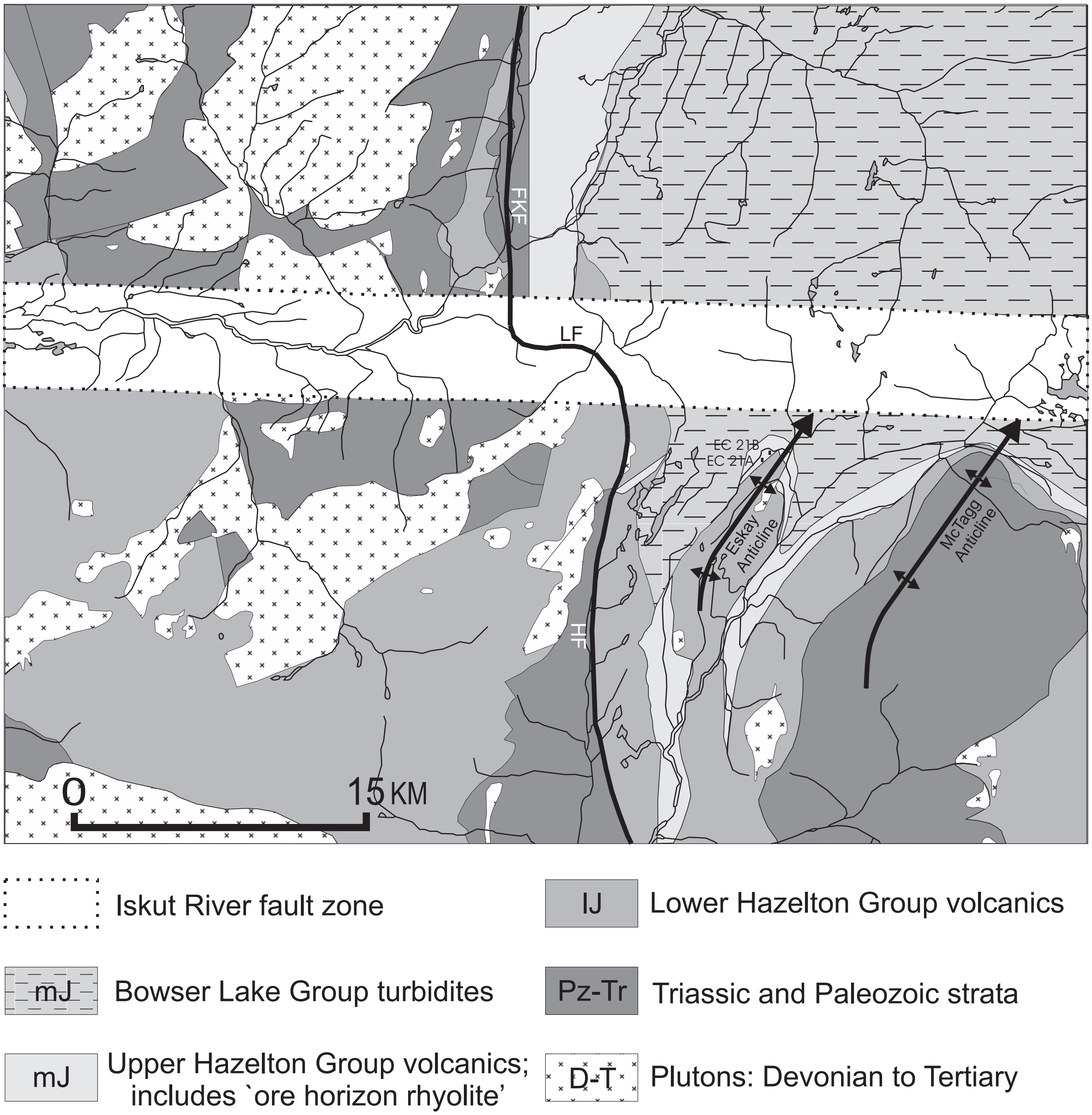

Figure 4. Simplified geology of the Eskay Creek mine area (adapted from Alldrick and Britton, 1992; Lewis, 1996; Logan and Drobe, 1997 and Read *et al.*, 1989). Note abundance of west- and east-flowing streams within the Iskut River fault zone in contrast to surrounding territory. **EC21B**-Eskay Creek 21B zone; **EC21A**-Eskay Creek 21A zone. **FKF-LF-HF** = Forrest Kerr-Leroy Creek-Harrymel Creek faults. All other faults and Pleistocene-Holocene lava flows have been removed.

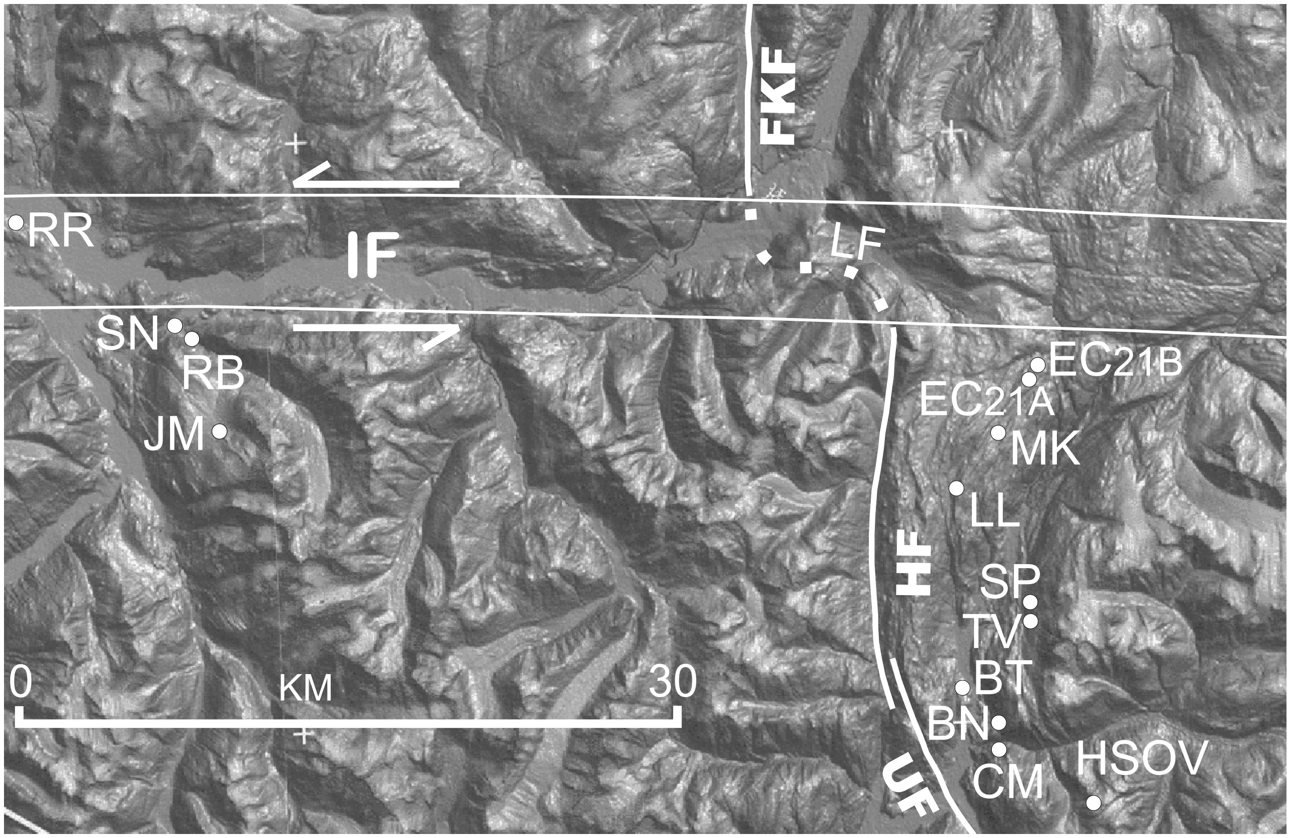

Figure 5. Trace of the Iskut River fault zone in the Eskay Creek mine area plotted on a contoured DEM (topo) map from Resource Geoscience and Imaging, Vancouver. Width of indicated fault zone exaggerated here by 20% to avoid obscuring east-trending topographic lineaments with linework. Left-lateral movement along the Iskut River fault is interpreted from the 6 kilometre offset of the Forrest Kerr fault (FKF)-Leroy Creek fault (LF)-Harrymel Creek fault (HF)-South Unuk River fault (UF) trend. Mineral deposits: RR-Rock and Roll; SN-Snip; RB-Red Bluff; JM-Johnny Mountain; EC21B-Eskay Creek 21B zone; EC21A-Eskay Creek 21A zone; MK-Mackay adit; LL-Lulu; SP-Springer; TV-TV zone; BT-Battlement; BN-Bench; CM-Cumberland; HSOV-HSOV zone.

Three factors have made these apparent contradictions difficult to resolve:

1. An expectation that any fault that localizes a major topographic depression such as the Iskut River valley must have major offset;
2. The 1.8-kilometre-wide gravel-filled valley floor for the lower Iskut River inhibits recognition and documentation of fault offsets; and
3. East of the broad Iskut River valley, the fault trace cuts through the extensive, monotonous turbidite succession of the Bowser Lake Group, where recognition of this fault is difficult.

Several features support the interpretation of an east-striking, left-lateral fault extending along the lower Iskut River valley and continuing eastward:

- A prominent, coincident east-trending linear negative magnetic anomaly that extends from the Stikine River (western limit of aeromagnetic coverage) to the northern Rocky Mountain Trench (Figure 2).
- Development of two major river valleys (the Iskut River and an unnamed western tributary of Ketchum Creek) along this easterly trend is in sharp contrast to the regional drainage directions (Figures 4 and 5).
- Left-lateral offset of the Forrest Kerr and Melville Glacier-Harrymel Creek fault zones, two offset segments of a single major north-striking normal fault (Figures 4 and 5)
- Features such as the sinusoidal Leroy Creek fault are consistent with left-lateral offset (Figures 4 and 5)
- Within terrain underlain by Bowser Lake Group strata, drainage directions are strongly influenced by the inclined bedding of variably weathering siltstone and sandstone. However, within the Iskut River fault zone there are several minor, deeply-incised, straight, east-trending gullies which contrast with local drainage directions (Figure 5).
- Similar magnetic signature, orientation, sense of offset, and scale of offset as the mapped Pitman fault, 130 kilometres to the north (Figures 2, 3 and 8).
- When placed in a tectonic context, the fault displays the characteristic features of an antithetic fault (Figures 6 and 7). The existence of additional, parallel antithetic faults distributed along the entire

length of the continental-scale Kaltag-Tintina-Rocky Mountain Trench fault system is predicted by the tectonic model for formation of these structures.

The Iskut River fault (Figures 2, 3, 4 and 5) is a four-kilometre-wide zone that displays features suggesting periods of both ductile and brittle offset. The distinctive s-shaped outcrop pattern of the Leroy Creek fault (Figures 4 and 5, and Alldrick and Britton, 1992) that trends between the southern end of the Forrest Kerr fault and the northern end of the Harrymel Creek fault demonstrates ductile deformation (Davis, 1984, p.228-230; Hodgson, 1989; Ramsay, 1980; Simpson, 1986). Several narrow, east-trending gullies are evident on the DEM and Landsat images in the area lying between the Unuk and Iskut rivers (northwest of the Eskay Creek mine, Figures 5 and 10). These suggest additional parallel linear breaks indicative of brittle deformation. The offset of the Forrest Kerr and Harrymel Creek faults indicates that the total left-lateral offset is 6 kilometres across the 4 kilometre width of the Iskut River fault zone. Incremental offset within this broad fault zone is illustrated schematically in Figures 5 and 10.

North of this study area, a twin for the unusually shaped Leroy Creek fault has been documented near Telegraph Creek. The northward continuation of the Forrest Kerr fault is called the Mess Creek fault zone (Figure 7). Combined, these two north-trending co-linear structures extend 130 kilometres from the Iskut River fault to the Pitman fault. South of the village of Telegraph Creek, Souther (1972) mapped a curved fault trace (Figure 8) where the younger Pitman fault cuts across the older Mess Creek fault. This small fault segment is similar in scale, shape and sense of offset to the outcrop pattern of the Leroy Creek fault, and is interpreted as a drag-folded (ductily deformed) segment of the Mess Creek fault zone that was deformed during left-lateral offset along the Pitman fault. The postulated north-striking continuation of the Mess Creek fault, on the northern side of the Pitman

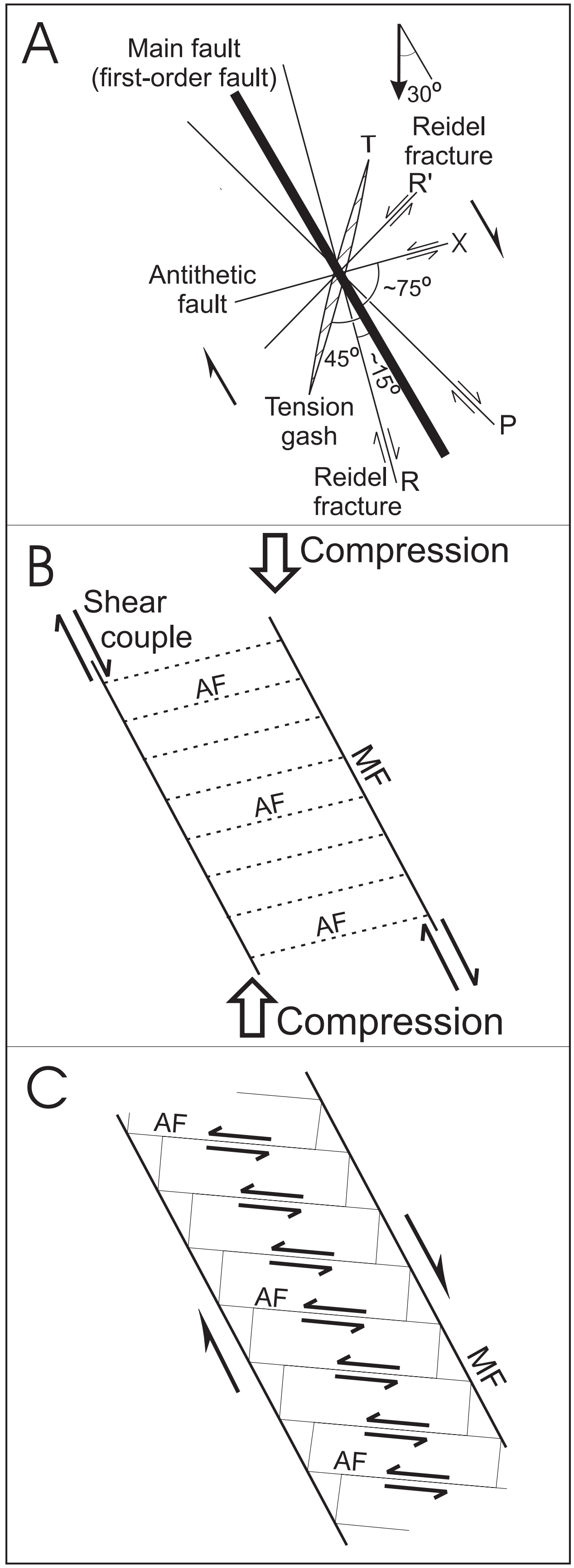

Figure 6. Physics and mechanics of antithetic faults (adapted from Nicolas, 1987; Wilson, 1982; and McClay, 1987). 6a: Geometric relationships between first-order and second-order fractures in a compressional regime. These different fractures are not all activated at the same time. P, T and X fractures develop if the stress on the main fault plane is relatively small, due to low confining pressure (shallow depth), low effective pressure (high fluid pressure), or if the fault follows a pre-existing plane of anisotropy at a low angle to the direction of compression. In contrast, Reidel fractures R and R' predominate in deep or dry faults or where the angle between the fault plane and the direction of compression is large (Nicolas, 1987). 6b: Geometric relations at the moment of failure. Sets of antithetic faults (AF) develop at an angle of 75º to the main fault (MF). 6c: Sense of movement along antithetic fault sets. The amount (distance) of fault offset along antithetic faults is always minor compared to that of the main fault. The individual fault blocks (`dominoes') pivot around at their point of contact with the wall of the main fault, so the absolute amount of movement depends upon the amount of rotation of the blocks and the distance between the antithetic faults.

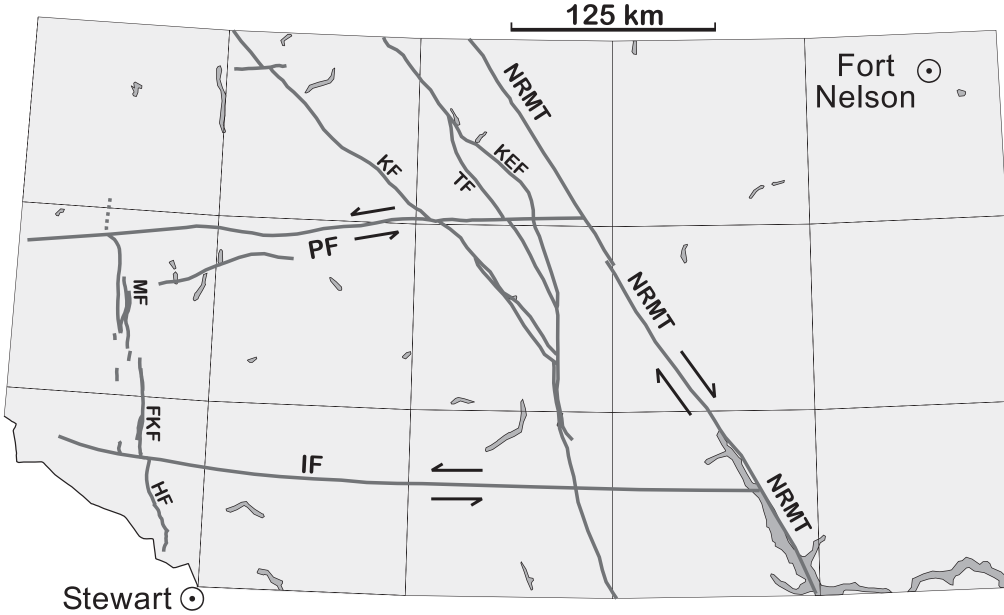

Figure 7. Major faults of north-central British Columbia, simplified from Figure 3, showing their angular relationships and the relatively minor, sinistral offset along the Pitman (PF) and Iskut River (IF) faults. MF-Mess Creek fault zone; FKF-Forrest Kerr fault; HF-Harrymel Creek fault; KF-Kutcho fault; TF-Thudaka fault; KEF-Kechika fault; NRMT-Northern Rocky Mountain Trench.

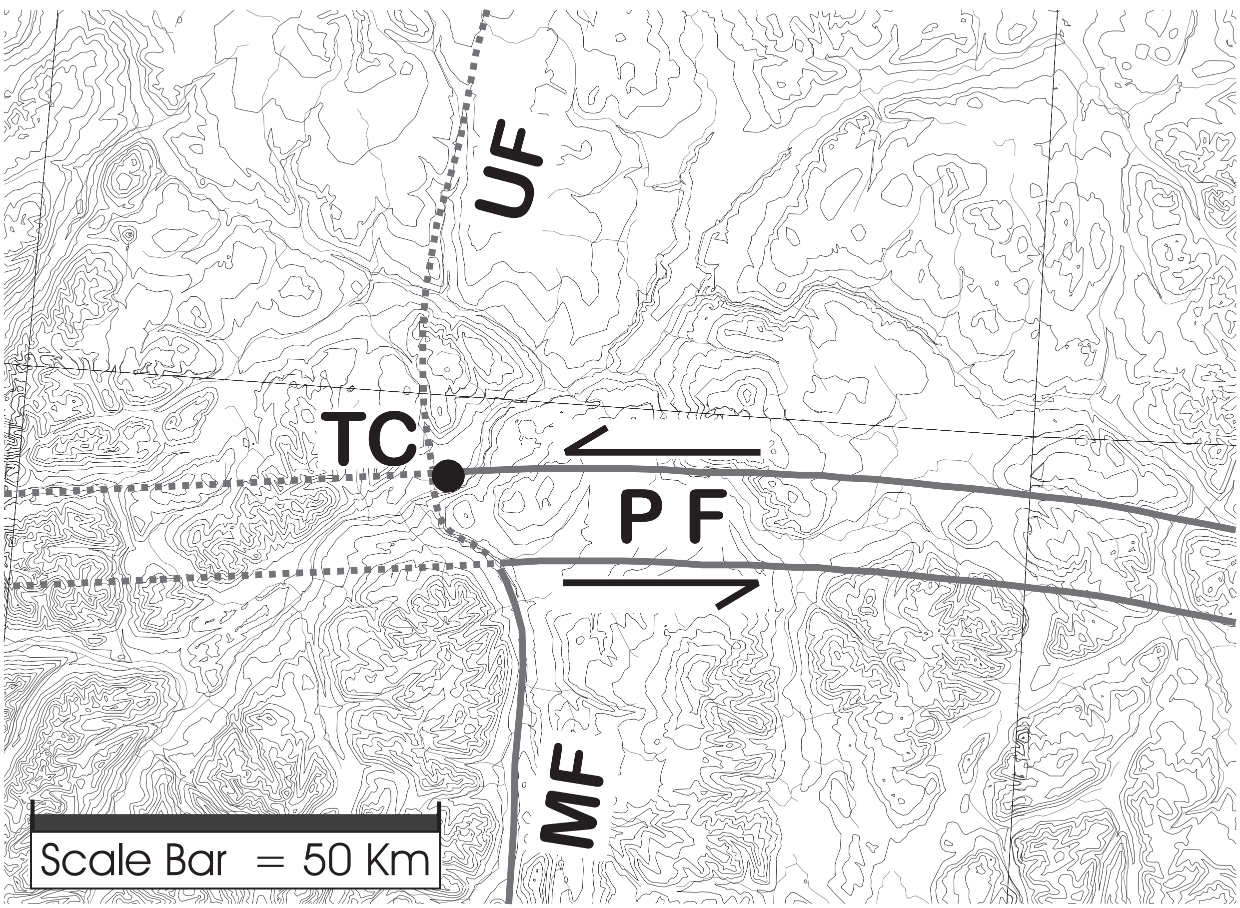

Figure 8. Simplified fault relationships near the village of Telegraph Creek (TC), showing the Mess Creek fault (MF) offset by the younger Pitman fault (PF). The stippled northern continuation of the Mess Creek fault (UF for `unmapped fault') and the western continuation of the Pitman fault have not been identified in the field.

Fault, has not been identified in the field. The westward continuation of the Pitman fault, to the west of Telegraph Creek, has not been mapped either, but this trend coincides with a strong west-trending magnetic anomaly (Figure 2).

TECTONIC SIGNIFICANCE

Both the Pitman and Iskut River faults display the angular relationships, direction of offset, and amount of offset that are consistent with their development as antithetic faults associated with major dextral fault offset during a compressional regime (Figure 6).

Anithetic faults are minor, subsidiary faults which form adjacent to larger faults that have developed due to oblique compression or `transpression' (Figure 6a). The amount of displacement along an antithetic fault is always minor compared to the displacement along the main fault; this difference can be an order of magnitude or more. Antithetic faults typically occur as sets of parallel faults (Figure 6b). The terms `tiling' and `domino effect' have been applied to describe the sense of movement and the accompanying minor block rotation (Nicolas, 1987; McClay, 1987).

The conceptual models for antithetic fault geometry and sense of movement shown in Figure 6 can be compared to the actual fault patterns documented in north-central British Columbia (Figure 7). The models (Figures 6b and 6c) predict that, outside the present study area, there should be additonal east-trending antithetic faults crossing the Canadian Cordillera.

EXPLORATION SIGNIFICANCE

Knowledge of these faults can be applied to mineral exploration work:

- Faults that pass near mineral deposits offset prospective terrain. Determination of the direction and amount of fault offset will enable exploration efforts to focus on the offset block.
- North of the study area, east-striking faults are loci for gold-quartz veins. This suggests that similar Tertiary age structures elsewhere may be prospective for precious metal mineralization.

Fault Offset of Prospective Geology

Figure 9 shows the distribution of mineral occurrences that lie near the trace of the Pitman and Iskut River faults. For stratabound deposits like the Eskay Creek (MINFILE 104B 008) and the Rock and Roll (MINFILE 104B 377) volcanogenic massive sulphide deposits (Figure 5), calculation of the direction and amount of fault offset will permit re-location of faulted-off favourable stratigraphy. For other deposit-types, resolution of fault displacement will allow investigations to continue within the offset segment of favourable geologic tracts.

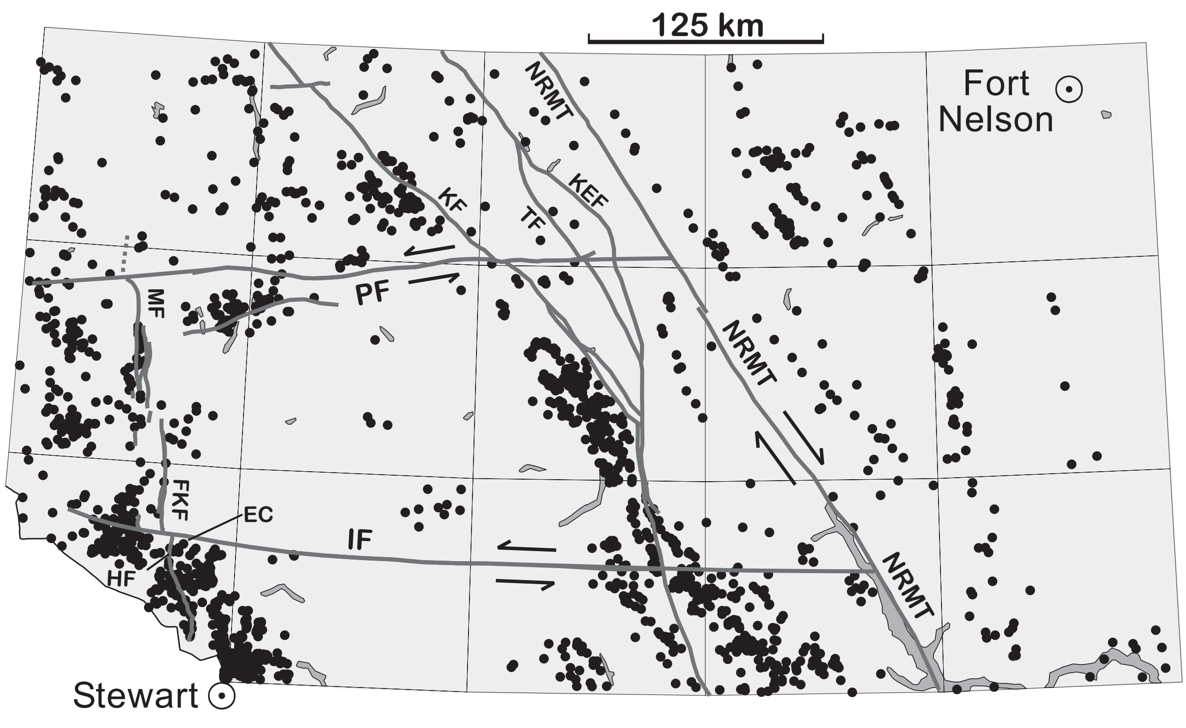

Figure 9. Mineral occurrences (from BC MINFILE) and major faults of north-central British Columbia. EC-Eskay Creek minesite; PF-Pitman fault; IF- Iskut River fault; MF-Mess Creek fault zone; FKF-Forrest Kerr fault; HF-Harrymel Creek fault; KF-Kutcho fault; TF-Thudaka fault; KEF-Kechika fault; NRMT-Northern Rocky Mountain Trench.

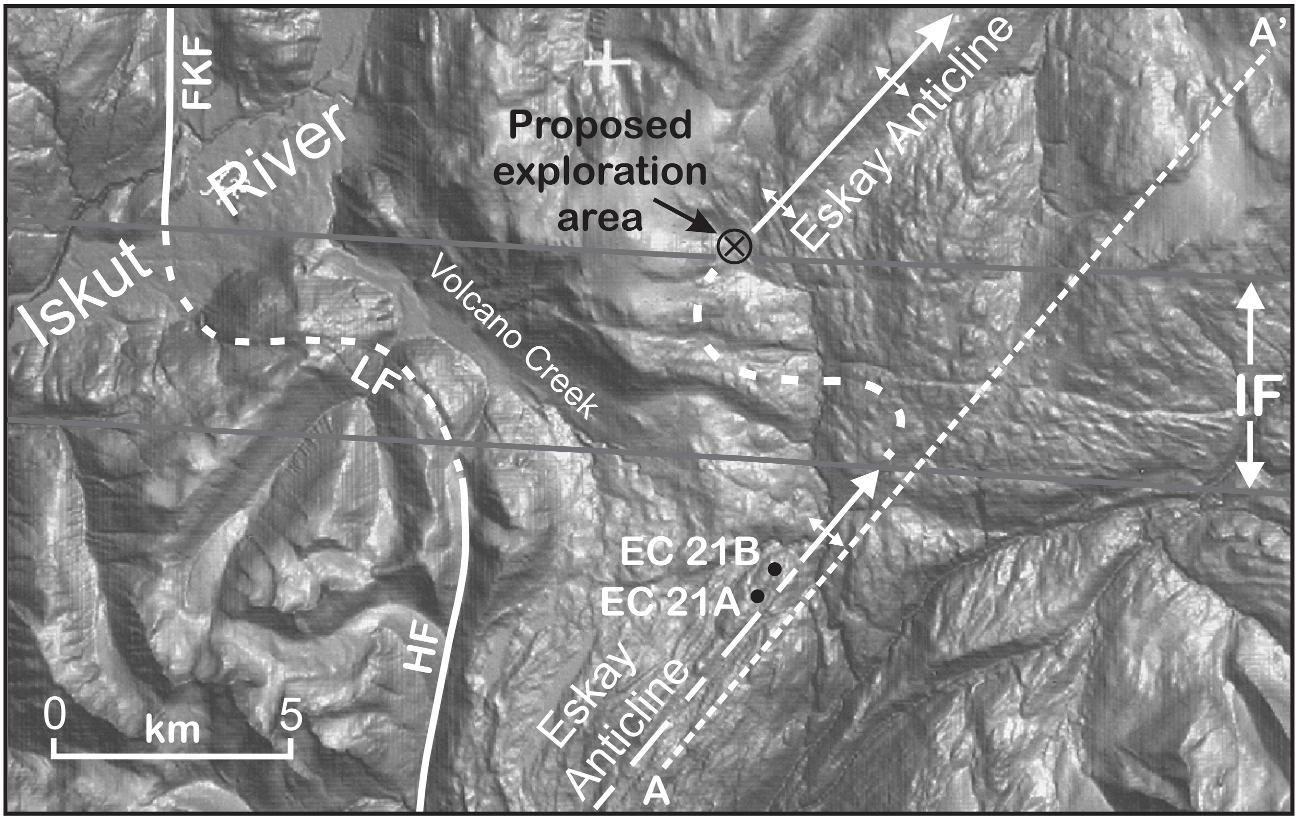

Figure 10. Close up of Figure 5 around the Eskay Creek mine, showing the interpreted sinistral offset of the Eskay Anticline along the Iskut River fault zone and a recommended exploration area. Cross-section A-A' is shown in Figure 11. Width of indicated fault zone exaggerated here by 10% to avoid obscuring east-trending topographic lineaments with linework. FKF-Forrest Kerr fault; LF-Leroy Creek fault; HF-Harrymel Creek fault; IF-Iskut River fault zone; EC 21B- 21B orebody at Eskay Creek mine; EC 21A - 21A deposit at Eskay Creek mine.

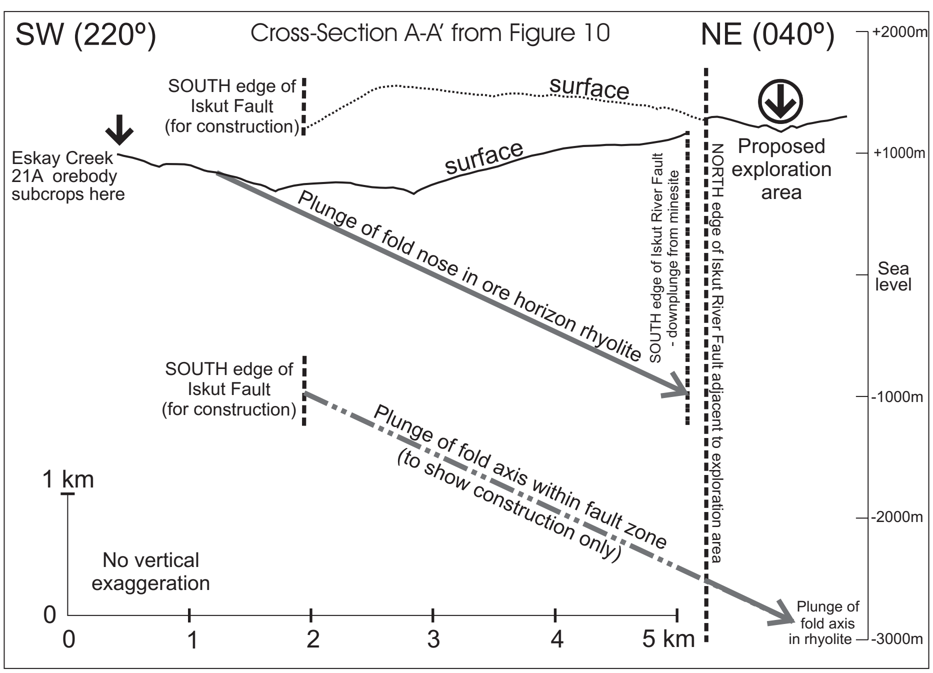

Figure 11. Cross-section along the fold axis of the Eskay anticline, looking WNW (310º). Two separate, overlapping, cross-sections are projected onto this diagram (see Figure 10), showing the plunge of the fold nose within the ore horizon rhyolite down-plunge from the mine area (a) on the south side of the Iskut River fault zone, and (b) on the north side of the Iskut River fault zone. These two lines of section are separated by 6 kilometres of sinistral offset at an oblique angle to the line of section. Some construction lines are shown.

Exploration Example - Eskay Creek Camp

At the Eskay Creek minesite, the 21A deposit subcrops at an elevation of 1000 metres. The Eskay Creek precious-metal-rich ore deposits lie along the western limb of a flat-lying to northeasterly-plunging anticline, the Eskay anticline (Figures 4 and 10). In the mine area this anticline plunges 25º on an azimuth of 040º. With this plunge, the depth to the `ore horizon rhyolite' increases by about 450 metres for every additional kilometre of horizontal distance (Figure 11).

If these angular relationships remain constant, the anticline would be cut by the Iskut River fault zone 4.0 kilometres down-plunge to the northeast of the minesite, at a depth below surface of about 2200 metres (Figures 10 and 11). Assuming the width of the Iskut River fault zone as 4 kilometres based on the interval of the Leroy Creek fault that is drag-folded (*see* Figure 10), and allowing for a progressive (incremental) left-lateral offset totalling 6 kilometres across this fault zone based on the measured offset between the Harrymel and the Forrest Kerr faults, the northeastward projection of the Eskay Creek anticline is predicted to exit the northern side of the Iskut River fault zone underneath a steep east-facing slope located 7000 metres north of the 21A zone on a bearing of 354º (Figures 10 and 11). Surface elevation at this point is 1300 metres - well above treeline. Just 600 metres northeasterly from this point, along the projected 040º trend of the Eskay Creek anticline, the topography drops down into a stream drainage which offers exposure of stratigraphically lower units.

At this point the distance from surface to the projected depth of the fold nose within the ore horizon rhyolite along the crest of the Eskay anticline is about 4000 metres (Figure 11). A program of mapping, deep-penetration geophysics and mercury geochemistry in this area could provide information necessary to justify an exploration drill program to a maximum depth of 4000 metres. However, this calculated depth is too great for routine exploration drilling and too great for all but the deepest mining scenarios. The two following arguments are presented in favour of conducting exploration work on this hillside:

1. The Eskay anticline plunges northeastward at 25º in the immediate mine area. South of the mine area the fold axis flattens abruptly and the Eskay anticline is flat-lying for more than 30 kilometres to the southwest (Lewis, 1996; Alldrick and Britton, 1992; Alldrick *et al.*, 1989). If the fold axis of this anticline also rolls flat down-plunge to the northeast of the minesite, then the depth to the ore horizon rhyolite will be substantially less than 4000 metres.

2. In the immediate mine area, the down-plunge extensions of the orebodies have been tested by an extensive grid drilling program. This work revealed that there are a series of minor southward-verging thrust faults to the north of the mine that lift the ore horizon slightly closer to surface than predicted by calculations based solely on the measured plunge of the fold axis (T. Roth, pers. comm., 1999).

Either or both of these situations would place the ore horizon at a shallower depth below the proposed exploration area than the depth of 4000 metres calculated in this study.

Fault-Hosted Mineralization

Tertiary antithetic faults like the Iskut River and Pitman faults may be prospective for precious-metal mineralisation. East-trending faults to the north of the study area are loci for gold-quartz veins (Mihalynuk *et al.*, 1994, p.192; Smith *et al.*, 1993, Smith and Mihalynuk, 1992, p.141). The western part of these structures, closer to the Tertiary Coast Range batholith and its satellite plutons, will be more prospective.

CONCLUSIONS

Low-angle oblique illumination of contoured federal government aeromagnetic maps has revealed anomalies that coincide with mapped regional-scale geologic structures. Faults identified in this study are key components of the structural and tectonic history of the Canadian Cordillera.

In the Iskut River area, these faults offset highly prospective strata. Resolution of the direction and amount of fault offsets enables focused, property-scale exploration work to continue onto the offset block. Fault zones may also be a locus for precious-metal mineralisation.

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