



LAST SEEN HEADING SOUTH: EXTENSIONS OF THE YUKON-TANANA TERRANE INTO NORTHERN BRITISH COLUMBIA

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INTRODUCTION

Kudz Ze Kayah (KZK) and Wolverine are volcanogenic massive sulphide deposits hosted by Early Mississippian meta-rhyolites, marine metasedimentary rocks and intermediate to mafic metatuffs of the Yukon Tanana Terrane in the Simpson Range, southern Yukon (Figure 1). This project aims to pinpoint, within central northern B.C., stratigraphy favorable to the formation of Early Mississippian volcanogenic massive sulphide deposits similar to Kudz Ze Kayah and Wolverine, and also Devono-Mississippian sedex environments in basal stratigraphy west of the Cassiar batholith.

In the Simpson Range, the Yukon-Tanana Terrane forms a large klippe cut off to the southwest by the Tintina Fault. Figure 2 illustrates the history of the terrane and the elements that make up its distinctive character, based on geology by Mortensen and Jilson (1985). Besides the crucial Early Mississippian rocks that host the volcanogenic massive sulphide deposits, the Yukon Tanana Terrane is characterised by pre-Mississippian continentally-derived siliciclastic metasediments, Early Mississippian intrusions that are coeval and probably cogenetic with the volcanic stratigraphy, Pennsylvanian and Permian limestone, Permian volcanic and plutonic rocks, and cross-cutting Early Jurassic plutons. This capsule geologic history provides a "thumbprint" of the terrane that can be used to help identify its correlatives.

The closest "look-alikes" to the Yukon-Tanana Terrane in north-central B.C. are the Dorsey Terrane, the Teslin Tectonic Zone (called the Big Salmon Complex in the Jennings River Map Area), and the Rapid River Tectonite in the Sylvester Allochthon (Figures 1, 2, 3). Although modern geologic map coverage in these areas is rudimentary at present, they all are known to bear sufficient similarities to the Yukon Tanana Terrane to warrant investigation for Early Mississippian volcanogenic environments. For the 1996 field season, targets were picked within these terranes, with consideration of added encouraging indicators, such as rhyolites or known exhalative mineralization (Figure 3). The specific targets and the rationales for their selection are as follows (listed in order of mapping):

1. **COT claims, along Cottonwood River, 104O/8**
Known sedex mineralization, in rocks described as Earn Group (Cathro 1985; Gal and Nicholson 1992)
2. **Dorsey Terrane near Blue Light claims, 104O/9 and 10**
Quartz-sericite schist and Early Mississippian limestone encountered during 1986 field visit by the author
3. **Dorsey assemblage near McNaughton Creek (104O/15)**
Possible stratigraphic equivalent of Target 2.
4. **Big Salmon Complex, Hazel Ridge, 104O/15**
Piedmontite schist (R. Stevens, personal communication); perhaps a metamorphosed Mn-rich exhalite?
5. **Nizi claims near Nizi Creek in the Rapid River tectonite, 104P/14-15**
Felsic volcanics reported to host epithermal veins (Bond 1993) and by E&I Regional Geologists Paul Wodjak (personal communication 1994)
6. **Southern Rapid River Tectonite near Cry Lake, 104P/15**
Felsic metavolcanic float reported by H. Gabrielse, G.S.C. (personal communication 1996)

RESULTS

Mapping of meta-rhyolite at two of the targets, #2 in the Dorsey Terrane and #4 in the Big Salmon Complex, shows that these two tectonic units are likely to contain appropriate stratigraphy to host KZK/Wolverine-type VMS deposits.

In target area #2, pyritic quartz-sericite schist (meta-rhyolite tuff) forms two tabular bodies within metamorphosed mafic to intermediate tuff, interbedded with limestone from which one Early Mississippian conodont age was obtained in 1986 (see Table 1). On Hazel Ridge (target #4), quartz-sericite schist occurs in transitional contact with piedmontite-hematite-bearing meta-chert. This meta-rhyolite/meta-iron formation couplet is identical to the stratigraphic setting of the Wolverine deposit. At target #1, extensive outcrops of siliceous black argillite strongly resemble the Earn

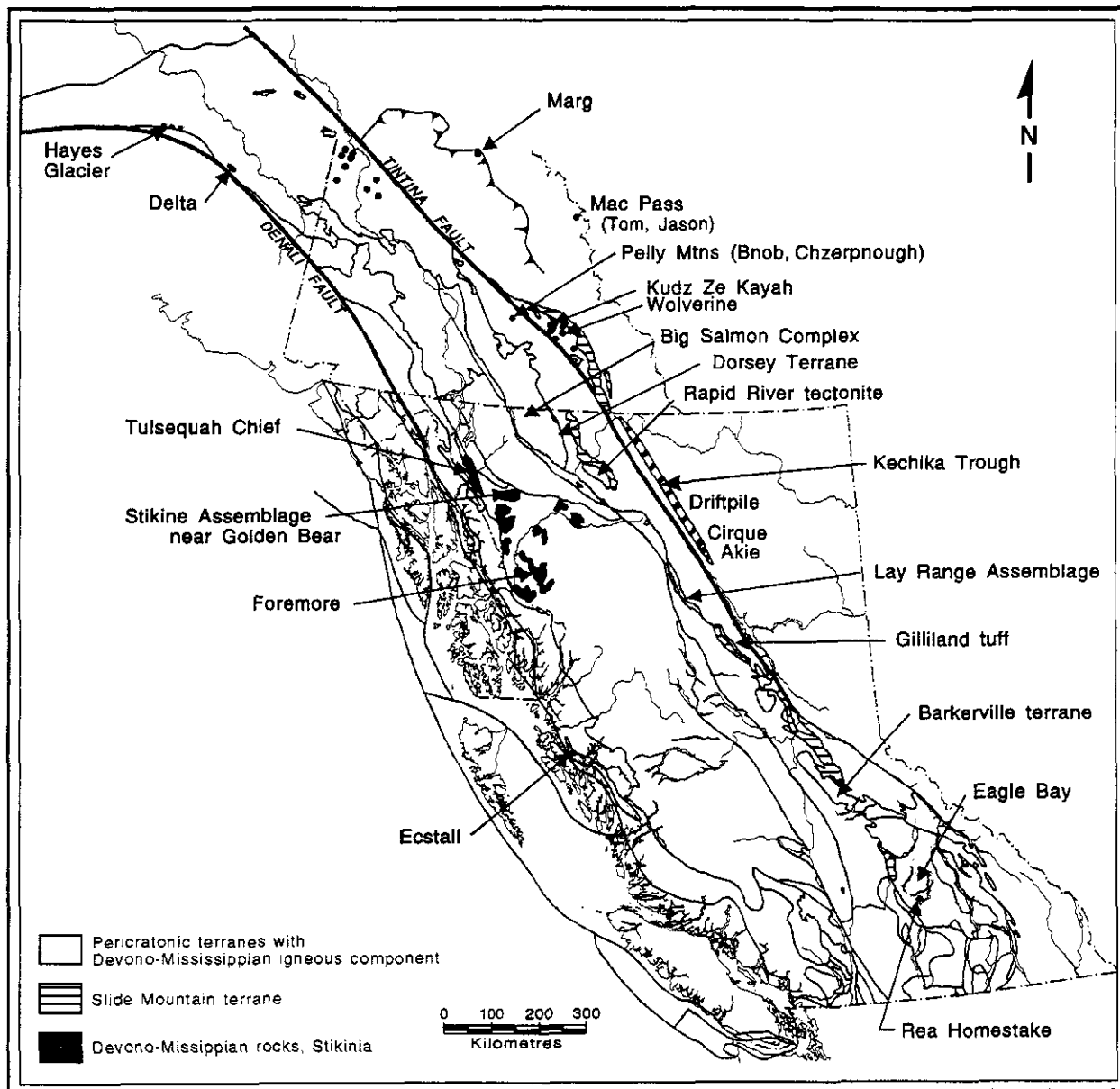


Figure 1. Map of the Canadian Cordillera showing pericratonic and continental margin assemblages known to host syngenetic volcanogenic and sedimentary exhalative massive sulphide deposits of Late Devonian to Early Mississippian age. The shaded areas include both North American marginal and more allochthonous terranes: both are prospective for Devonian-Mississippian deposits. The Stikine Assemblage of Stikinia is included because it hosts Tulsequah Chief, a late Mississippian volcanogenic massive sulphide, and because there is evidence for indirect linkages between it and pericratonic terranes to the west.

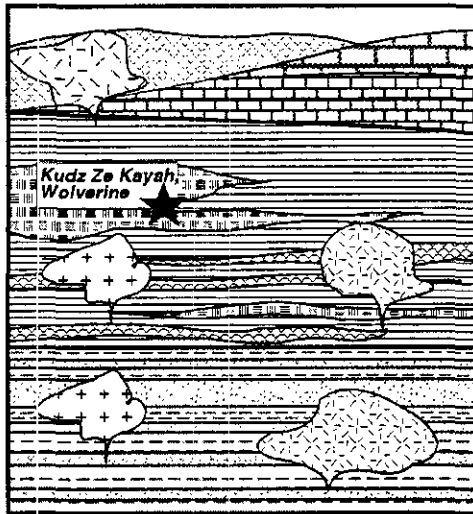
Group in the Kechika Trough, as suggested by earlier workers (Cathro, 1985; Nicholson and Gal, 1992). Widespread wispy pyrite laminae, baritic chert, elevated barium contents in lithochemical samples, and disseminated sphalerite and galena in the argillites suggest a sedimentary exhalative environment.

At the other targets, no evidence of appropriate Early Mississippian volcanic environments was found, although observations were made that contribute to our understanding of the relationships of the Yukon Tanana Terrane with other tectonic elements of the Cordillera.

The local geology of each of the targets is described below, in order of mapping.

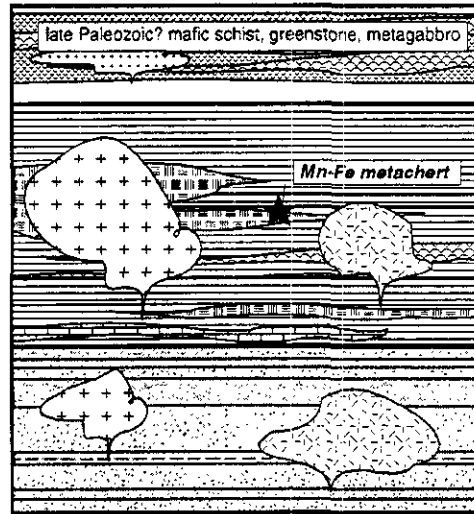
TARGET 1

The area east of the Cottonwood River and north of the the headwaters of the Blue River is underlain by metamorphosed, highly deformed black argillite with limestone and pyritic chert (exhalite?) interbeds. Previous work on the property outlined geochemical anomalies in Pb, Zn, and Ba, and disseminated sulphides in black argillite (Gal and Nicholson, 1992; Cathro, 1985). Field observations this season confirmed



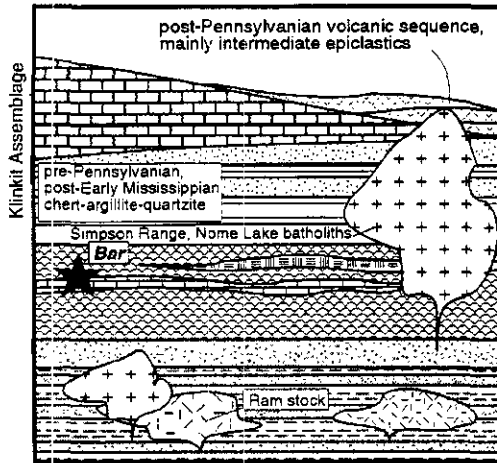
Yukon Tanana Terrane

(after Mortensen and Jilson 1985; Mortensen 1990)



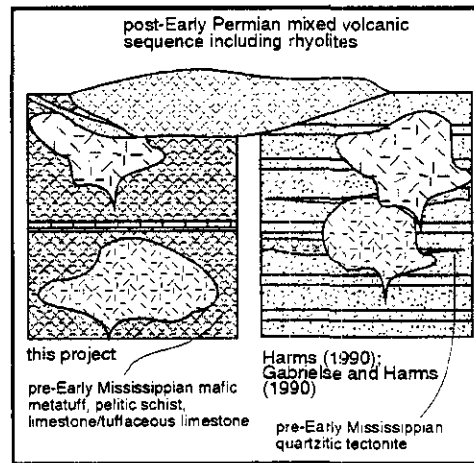
Teslin Tectonic Zone/ Big Salmon Complex

(after Stevens and Erdmer 1993; Gordy and Stevens 1994; Creaser et al. 1995; this project)



Dorsey Terrane

(Stevens, 1995; this project)



Rapid River Tectonite

Yukon Tanana Terrane Thumbprint	Teslin Tectonic Zone	Dorsey Terrane	Rapid River Tectonite
Early Jurassic intrusions (circa 185 Ma)	✓	✓	
mid-Permian intrusions (calc-alkalic, 261-262 Ma)		✓	✓
Permian rhyolite			?
Early Permian limestone			
Pennsylvanian limestone			
Early Mississippian intrusions: S- and I-type	✓	✓	✓
Early Mississippian rhyolite	✓	✓	✓
mafic tuff ★ VMS deposits	?	✓	
carbonaceous metaseds		✓	
Early Paleozoic (and Precambrian?) sedimentary rocks of continental affinity: pelite, quartzite, siltstones	✓	✓	✓

Figure 2. The lithotectonic "thumbprint" of the Yukon Tanana Terrane, as it appears in the Simpson Range and Klondike area. The presence of shared elements, in particular Early Mississippian igneous rocks, qualifies other terranes as possible equivalents. Some of these, the Big Salmon Complex, the Dorsey Terrane and the Rapid River Tectonite, are discussed in the text.

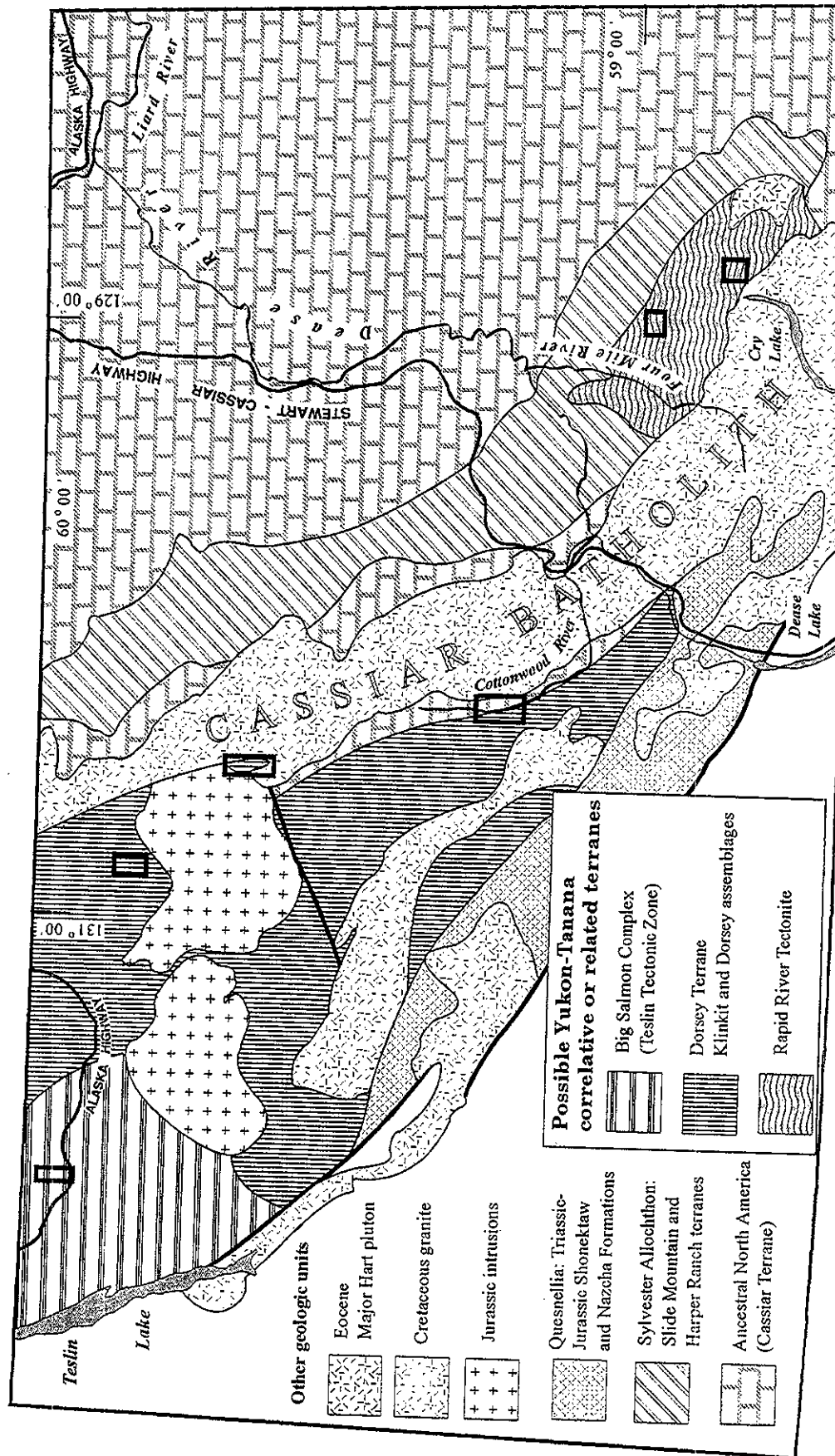


Figure 3. Pericratonic and adjacent terranes of northern British Columbia, with 1996 targets shown.

Table 1. Conodont identification by M.J. Orchard, Geological Survey of Canada

Conodont sample from Dorsey assemblage near Little Rancheria River

Field Number: 86-JN-28-6-1

GSC Number: C-117562

UTM: 417200E, 6611600N

Rock unit: limestone with thin green tuffaceous laminae; overlies green tuffaceous chert

Conodont taxa:

"*Hindeodella*" *segaformis* Bischoff (1)

CAI: 5

Age: Early Carboniferous ?late Tournaisian

the strong resemblance between these rocks and the siliceous black argillites of the Earn Group. In general they are at a somewhat higher metamorphic grade than the Earn Group, and they show several phases of intense minor folding. At the main, Dakota showing on the property, laminated chert contains pyrite and barite. In thin section, coarse barite grains intergrow with a mosaic of quartz grains that have recrystallized from the original siliceous mud. Six limestone samples were collected for conodont dating through Suzanne Paradis and Steve Irwin of the Geological Survey of Canada, as part of an ongoing cooperative study of Devonian-Mississippian sedex deposits. One sample of galena from a cross-cutting early sphalerite-banded quartz vein, folded by F2(?) deformation, has been submitted for Pb-Pb analysis in order to compare it to Cassiar Terrane and Kechika Trough sedex occurrences.

TARGET 2

South of the Little Rancheria River, the structurally lowest exposures of the Dorsey Terrane are cut off by the Cassiar Batholith. They consist primarily of metamorphosed, strongly deformed mafic to intermediate tuff, volcanic flows and/or high level intrusions, limestone, chert and two prominent bands of pyritic quartz-sericite schist (Figure 4). An Early Mississippian (Tournaisian) age was obtained in a conodont sample collected from the limestone in 1986 (Table 1). The quartz-sericite schist bands average 5 metres thick and are continuous for more than a kilometre along strike (Figure 4). They appear to be metatuffs, and grade into chert with sericite partings. In thin section they are seen to contain broken crystals of plagioclase and quartz in a highly foliated, fine grained matrix of quartz and sericite.

These meta-rhyolite tuffs represent a more distal volcanic environment than that at Wolverine and Kudzu Ze Kayah, where coarsely porphyritic sills and

spherulitic flows are present; however their presence is encouraging in that stratigraphically equivalent but more proximal felsic volcanic environments may occur along strike in the lower levels of the Dorsey Terrane. In order to check the Early Mississippian age suggested by the conodont sample, a sample was collected from the meta-rhyolite for uranium-lead dating.

TARGET 3

This area near McNaughton Creek (Figure 5) is underlain by strata from the upper part of the Dorsey Terrane, structurally and possibly stratigraphically higher than the possible Yukon-Tanana equivalents within it, which are described at target #2 (see above). A tripartite stratigraphy, repeated by thrust faults, includes a lower unit of weakly deformed chert, argillite and quartz (-feldspar) sandstone; a middle limestone of probable early to middle Pennsylvanian age by correlation with limestones mapped by Stevens (1995) along the Yukon border; and an upper unit of intermediate lapilli and crystal-lithic tuff. These rocks in general correlate with the upper part of the Dorsey Terrane near the Seagull Batholith (middle and upper units of Stevens, 1995), informally referred to as the Klinkit Assemblage (R. Stevens and T. Harms, personal communication, 1996). The stratigraphic succession is strikingly similar to that described by Ferri (in press) in the Lay Range Assemblage type section. The Klinkit Assemblage is intruded regionally by Early Jurassic plutons (Gabrielse, 1969) and locally by acicular hornblende porphyry dikes that are texturally identical to Early Jurassic intrusions in central Quesnellia near Nation Lakes (Nelson and Bellefontaine, 1996). Tekla Harms, who is also studying the Dorsey Terrane under a Lithoprobe grant, is planning to chemically analyse and date samples of the dikes to test this correlation. Conodont samples were collected from the limestone to aid in comparing it to limestone in the Lay Range.

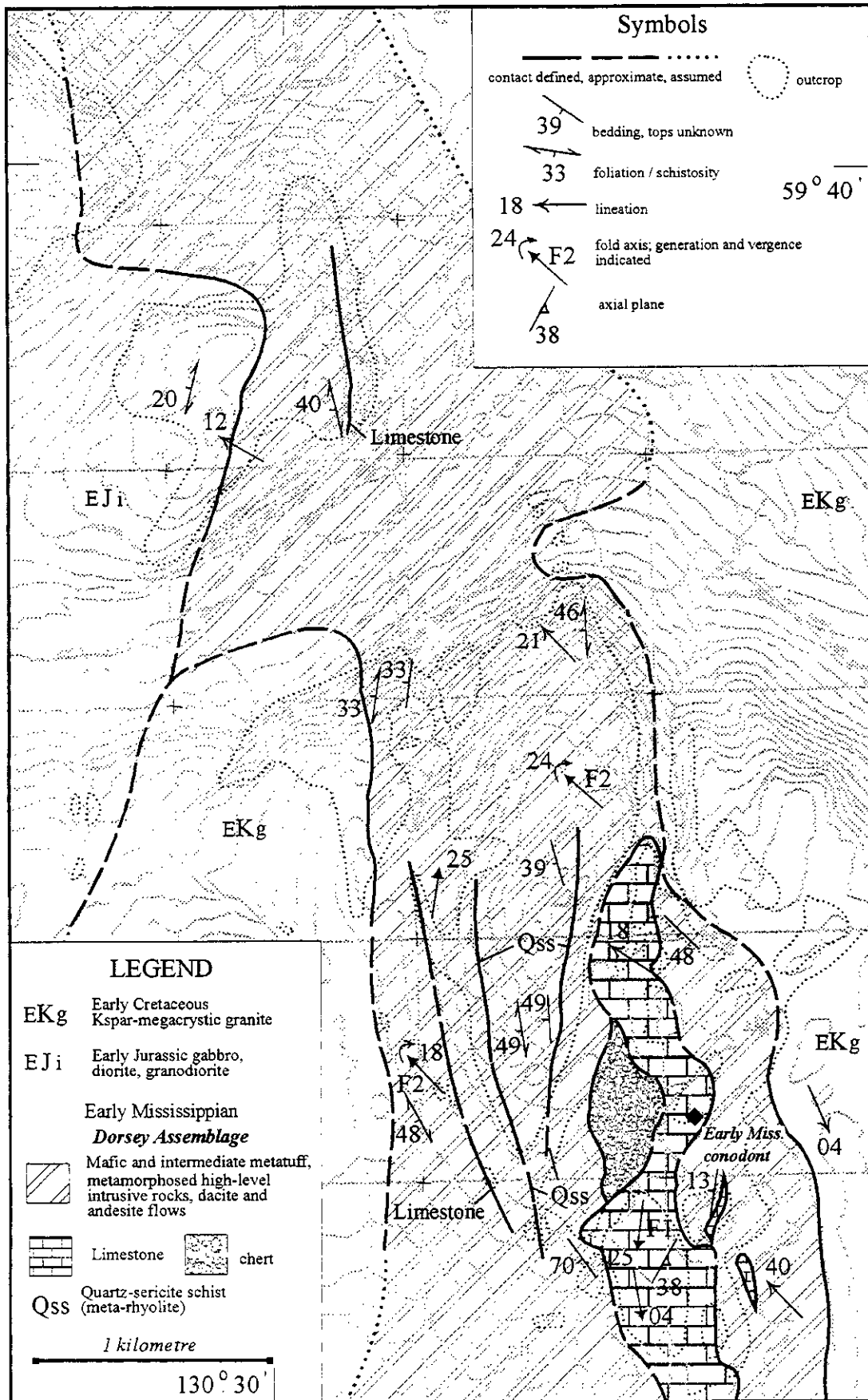


Figure 4. 1:25,000 geologic map of Target 2, near the Little Rancheria River.

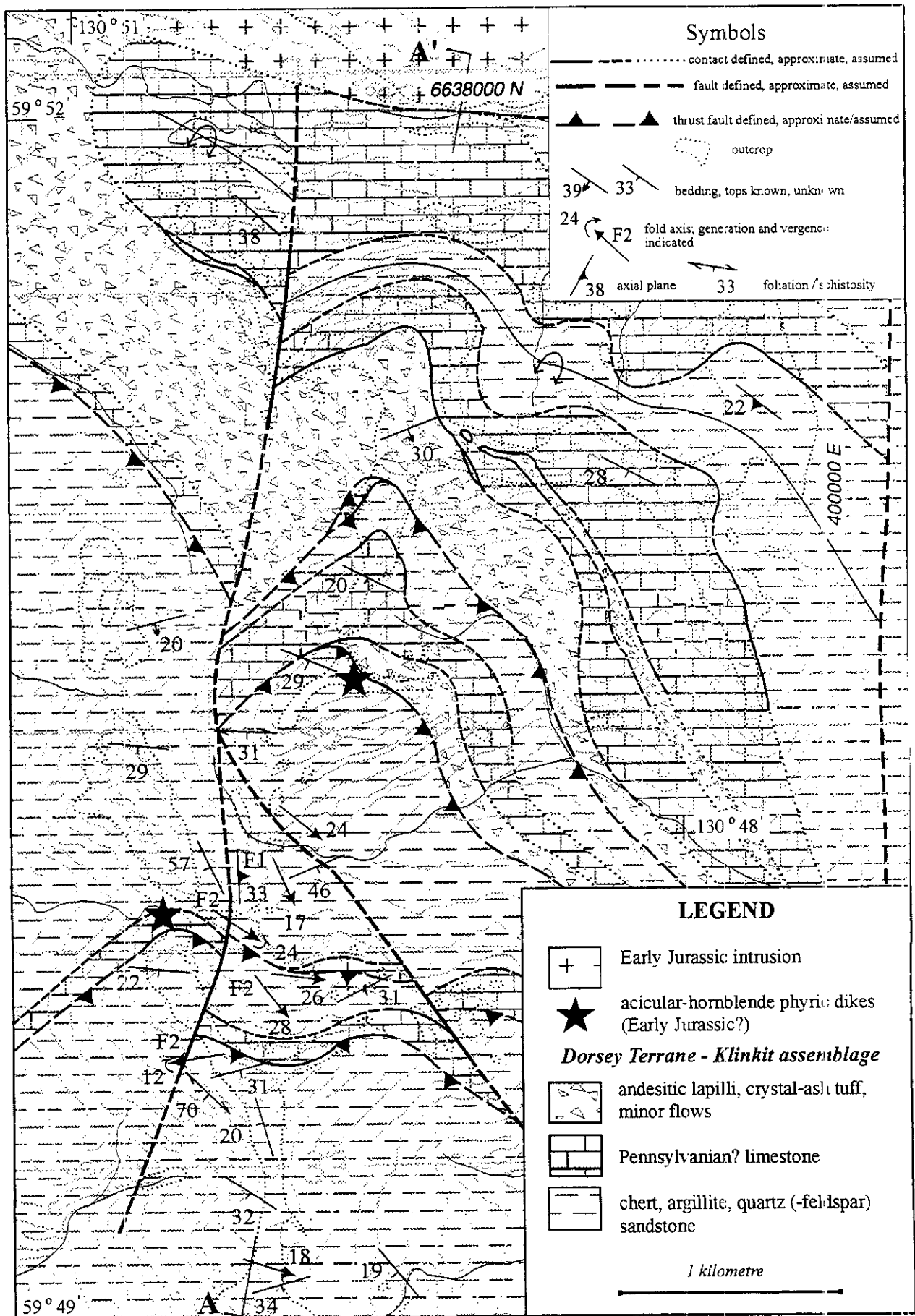


Figure 5. 1:25,000 geologic map of target #3, near McNaughton Creek

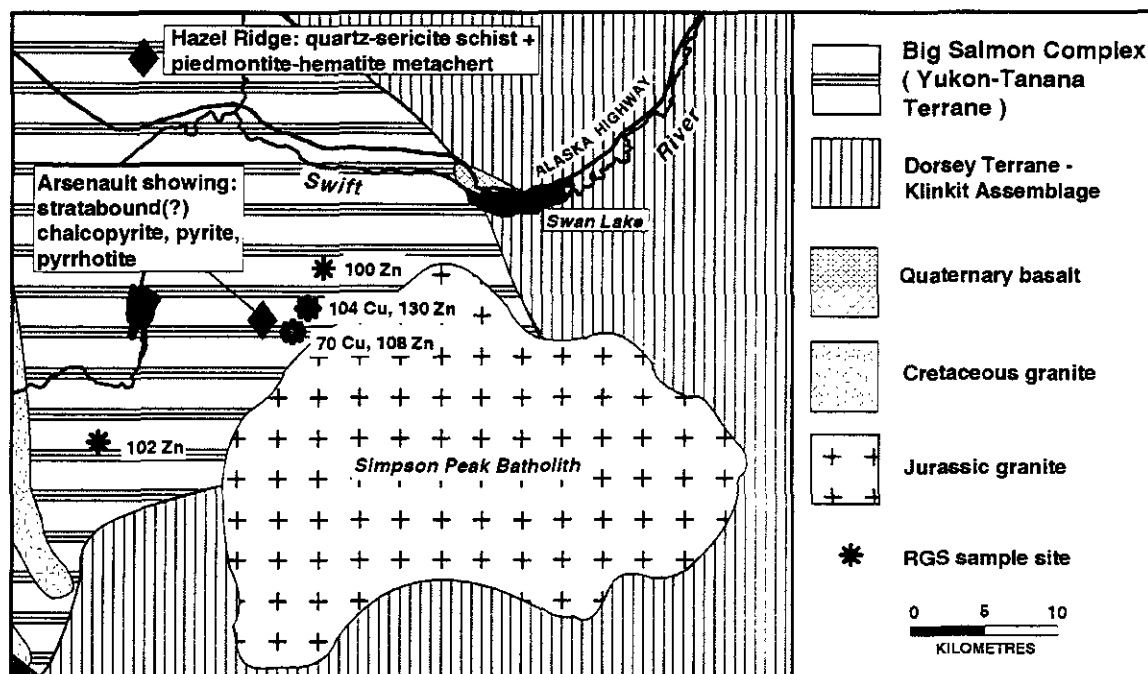


Figure 6. Regional map of the Big Salmon Complex in northwestern Jennings River map area (104O). The geochemical anomalies are from the Regional Geochemical Survey, Geological Survey of Canada Open File 561.

TARGET 4.

A single traverse on Hazel Ridge encountered the most favorable stratigraphy for hosting Kudz Kayah/Wolverine type deposits of the entire project: an enclave of meta-rhyolite and banded bright red piedmontite and grey hematitic meta-chert, surrounded by intermediate to felsic metaplutonic rock. These rocks are located on the southernmost and highest point on the ridge, next to a geodetic survey marker. The meta-rhyolite is a white, glossy, coarse grained quartz-muscovite schist. It grades into piedmontite-hematite meta-chert over several metres, with the disappearance of muscovite and intensification of color from pale rose pink to deep carmine. The meta-chert is a medium grained quartzite with pronounced piedmontite and/or hematite layers and laminae. Yellow magnesian garnet accompanies the piedmontite.

At Wolverine, the massive sulphide horizon lies above quartz-sericite schist and below a chert iron formation. Although the iron at Wolverine is in magnetite and that on Hazel Ridge is in hematite, the stratigraphic similarity is very close. The Hazel Ridge rocks lie within the Big Salmon Complex of Gabrielse (1969), an assemblage of metavolcanic, meta-sedimentary and metaplutonic rocks that lies east of Teslin Lake in the Atlin (104N) and Jennings River (104O) map areas (Figure 3). To the north, the Big Salmon Complex strikes into the Teslin Tectonic Zone (usage of Creaser *et al.*, 1995; also referred to as Kootenay Terrane by Stevens and Erdmer, 1993; Gordey and Stevens, 1994), which forms the eastern margin of the Yukon-Tanana Terrane against the Cassiar Terrane, truncated to the north by the Tintina Fault (Figure 1). Restoration of 450 kilometres of strike

slip motion on the Tintina places the Teslin Tectonic Zone directly on strike with the Simpson Range volcanogenic massive sulphide district of the southern Yukon.

The Arsenault base metal showing (104O-011), located 15 kilometres south-southeast of Hazel Ridge (Figure 6) is described in part as a stratabound chalcopyrite-pyrite-pyrrhotite occurrence, remobilized into fold hinges (Phendler, 1982). A number of stream sediment copper and copper-zinc RGS anomalies are associated with it (Geological Survey of Canada, 1978). Except for local mapping in assessment reports, the Big Salmon Complex has never been geologically analysed and subdivided. The presence within it of rock units strongly similar to those associated with volcanogenic massive sulphides in the Simpson Range, and of possible stratabound sulphide mineralization, make it a highly prospective target.

TARGET 5

The rocks that host epithermal vein mineralization on the Nizi property, located south of the headwaters of Nizi Creek (Figure 3) are a varied sequence of volcanics that range from hornblende phyric andesites through plagioclase phyric dacites to white, pyritic rhyolite. Although previously included within the Rapid River Tectonite (Gabrielse, 1994), they are undeformed and only weakly metamorphosed. Dikes related to them cut a coarse grained plutonic body, which is thought to be of Early Permian age, based on its resemblance to the Early Permian Nizi Creek Pluton that outcrops southwest of Nizi Creek (H. Gabrielse, personal communication, 1996). The plutonic rocks in

turn contain rafts of garnet amphibolite, which form part of the Rapid River Tectonite. Equivalent amphibolite along strike to the southeast in map area 104I/15 has returned an Early Mississippian K-Ar hornblende age (Gabrielse, 1994). Field relationships suggest that the volcanic rocks on the Nizi property are post-Early Mississippian and probably post-Early Permian, much too young to be equivalent to the Simpson Range meta-rhyolites. A sample for uranium-lead dating has been collected from the Nizi rhyolite. Results will be published in a more detailed geological report on the property in 1997 (McMillan and Nelson, in preparation).

TARGET 6

No felsic metavolcanic material was seen in this area, located east of Cry Lake near the western margin of the Rapid River Tectonite (Figure 3). Assemblages there include metaplutonic amphibolite, basalt metatuff with interbedded limestone, metapelite, meta-chert and possibly granite conglomerate. All are highly deformed and metamorphosed, with metamorphic grades ranging from upper greenschist to garnet amphibolite facies. The sequence is imbricated by thrust faults marked by ultramafic slivers. It is cut by megacrystic granite sills, which are themselves highly deformed, as well as a large body of metagabbro. The mafic nature of this sequence is in sharp contrast to the "siliceous tectonites" described by Harms and Gabrielse (1990) on the ridge immediately south of the Dease River. Clearly the Rapid River Tectonite is a complex entity. Our limited field examination did not locate any meta-rhyolites likely to be of Early Mississippian age within it; however they may exist in other areas.

IMPLICATIONS FOR MINERAL EXPLORATION

Metamorphosed rhyolites of probable Early Mississippian age were found in two of the terranes examined in this reconnaissance project. Meta-rhyolite accompanied by metamorphosed iron formation occurs on within the Big Salmon Complex, which is equivalent to the Teslin Tectonic Zone, the southern strike equivalent of the Yukon Tanana Terrane in the Simpson Range northeast of the Tintina Fault. These rocks, like the meta-rhyolites near Kudz Ze Kayah (D. Murphy, personal communication, 1996), are intruded by now highly deformed intermediate to felsic plutonic rocks of probable Early Mississippian age. The strong similarity of the geology on Hazel Ridge to the host rocks of the Kudz Ze Kayah and Wolverine deposits suggests that this largely unknown and long-neglected terrane deserves exploration attention.

The presence of Early Mississippian meta-rhyolite tuffs was also confirmed at target #2, in a mixed metavolcanic-marble sequence near the structural base of the Dorsey Terrane. This assemblage potentially

extends along the eastern edge of the Dorsey Terrane, tens of kilometres south, where helicopter reconnaissance shows that terrane resting on black argillite of possible Earn Group affinity in the mountains west of the Cottonwood River (Figure 7). In part of that belt, west of the headwaters of the Cottonwood River, strong multielement stream sediment anomalies from the RGS survey (Figure 7; data from Geological Survey of Canada, 1978) led to claim staking and follow-up geochemical work and prospecting (Smith and Gillan, 1980). No source for the anomalies was discovered, but strong northwest-trending soil anomalies were defined. Near target #1, 10 kilometres south of the anomalous area, the basal part of the Dorsey Terrane is very complex, but contains, among many other structurally slivered rock types, nearly mylonitized felsic intrusions. A sample of one of these was collected for uranium-lead dating, to ascertain whether it is coeval with the Early Mississippian(?) rhyolite at target #2.

The base of the Dorsey Terrane crosses the Yukon border near 131° west longitude (Figure 3). North of the Yukon border, the Dorsey Terrane is well exposed near the Seagull Batholith, where Stevens (1995) characterized its basal unit as consisting mainly of metamorphosed siliciclastic rocks intruded by highly deformed plutonic bodies (possibly Early Mississippian, personal communication, 1996). R. Stevens and T. Harms (personal communication, 1996) refer to this unit as the Dorsey Assemblage. These rocks are directly overlain by weakly metamorphosed strata of the Klunkit Assemblage. The Early Mississippian volcanic rocks appear to be missing. They may reappear farther north in the southeast Teslin map area, where the Bar stratabound Pb-Zn-Ag-barite occurrence is hosted by a succession of shale, chert, chert sandstone and minor volcanics that overlies Mississippian limestone (K. Dawson in Gordey, 1992).

IMPLICATIONS FOR TERRANE CORRELATIONS

The sequence observed on Hazel Ridge is close enough in character to Early Mississippian units in the Simpson Range to support the idea that this characteristic and definitive component of the Yukon Tanana Terrane extends southward across a restored Tintina fault into the Big Salmon Complex of far northern British Columbia. Locally, the nature of the structural contact of the Big Salmon Complex with the Dorsey Terrane is not known, but in Teslin map area north of the Yukon border these rocks, referred to as Kootenay Terrane by Gordey and Stevens (1995), rest above unmetamorphosed late Paleozoic sedimentary and volcanic strata that are on strike with the upper part of the Dorsey Terrane near the Seagull batholith.

The upper part of the Dorsey Terrane, the Klunkit assemblage, consists of a structurally repeated tripartite

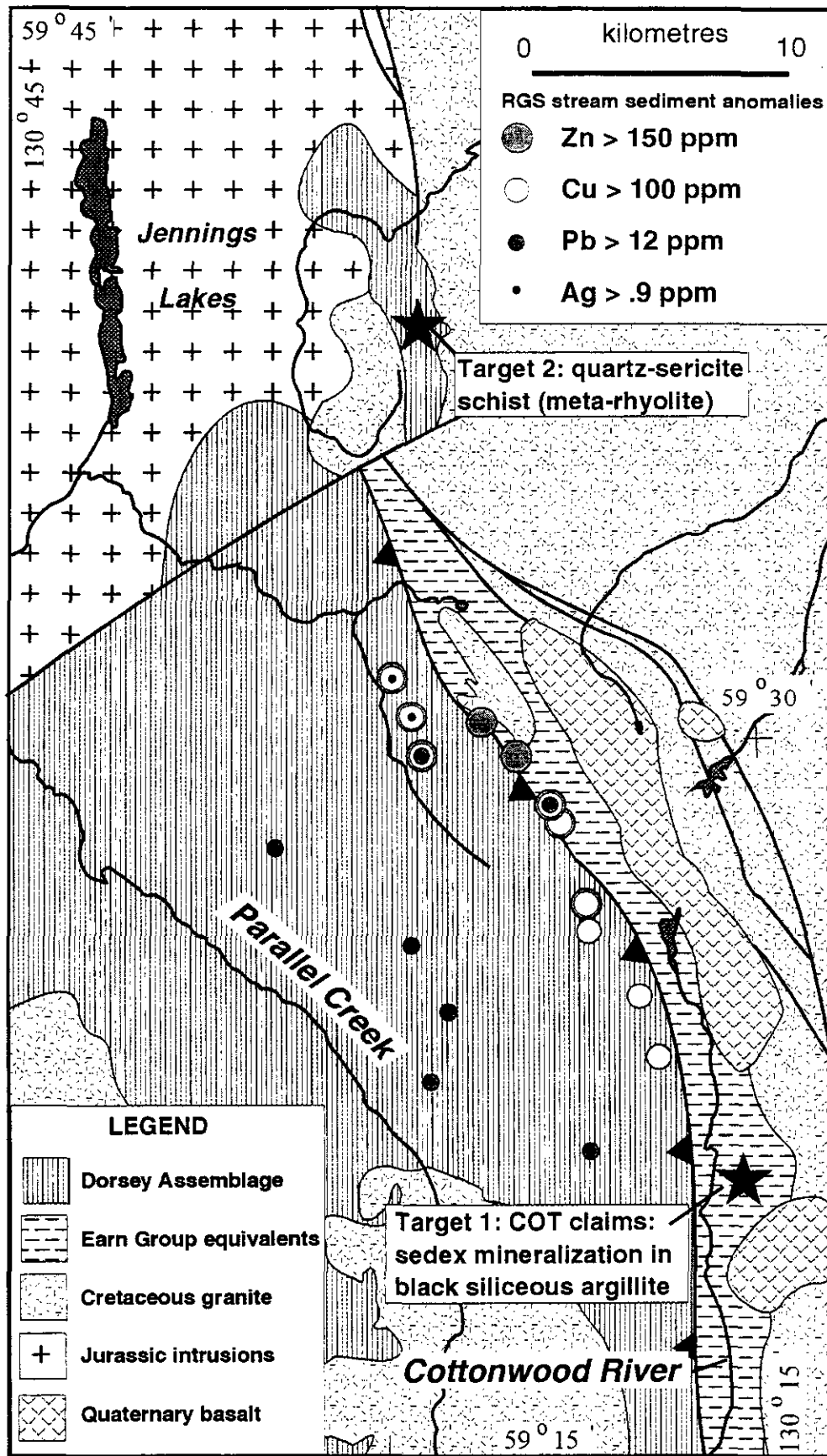


Figure 7. Regional map of the lower Dorsey Terrane, showing the location of Targets #1 and #2.

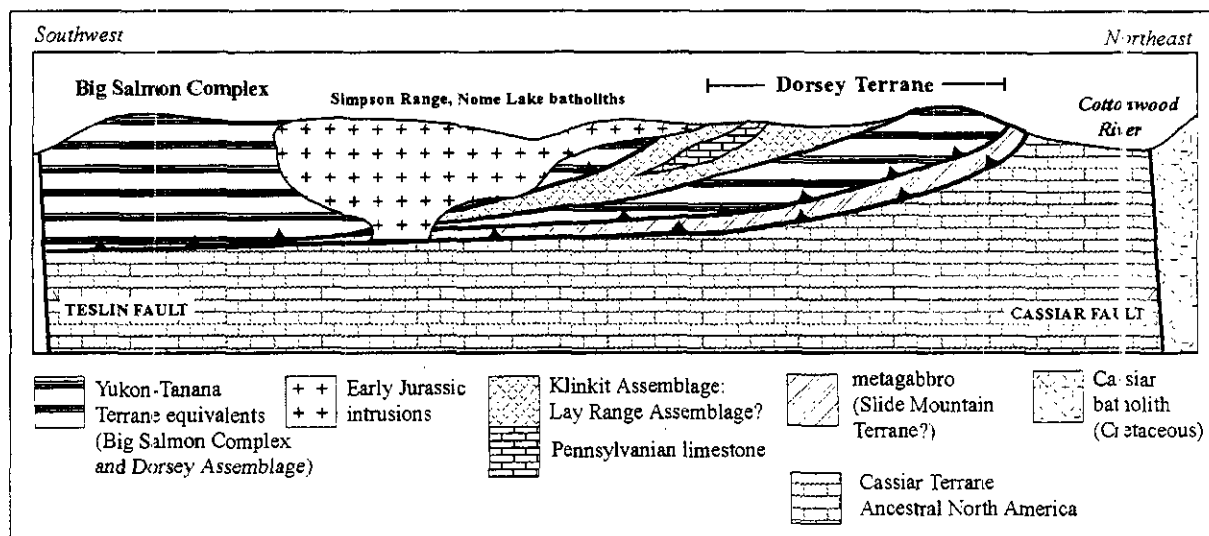


Figure 8. Cartoon cross section of the Big Salmon Complex and Dorsey Terrane in the Jennings River map area.

stratigraphic sequence that bears strong resemblance to the Lay Range Assemblage in its type area. This sequence is intruded by Early Jurassic plutons and by dikes that are texturally identical to extrusive lithologies in the Triassic-Jurassic Takla Group. Thus the upper part of the Dorsey Terrane may be equivalent to Quesnellia. Its structural (and possibly stratigraphic) underpinnings, the Dorsey assemblage, include Early Mississippian limestones interbedded with mafic to felsic metatuffs at target #2 as well as metamorphosed siliciclastic sedimentary rocks. The Dorsey assemblage is a possible Yukon-Tanana analogue. West of the Cottonwood River near target #1, it rests on a gently west-dipping structural contact above a body of highly foliated layered metagabbro and quartz gabbro, which in turn lies structurally above black meta-argillites that are considered to be possible Earn Group equivalents.

Figure 8 summarizes these structural relationships. Because the contact between the Big Salmon Complex and the Dorsey Terrane is cross-cut by an Early Jurassic batholith, it is depicted as a pre-Jurassic thrust fault. The age of displacement on the fault that separates the Dorsey Terrane from the Cassiar Terrane is less well constrained and may be somewhat younger, since in the Jennings River area, at least, it marks an eastern limit to the suite of Early Jurassic intrusions. This cross section shows an Early Mesozoic Quesnellia arc constructed on an imbricated basement of Yukon-Tanana and Lay Range Assemblage. Internal relationships in the Dorsey Terrane can be interpreted to indicate that the Yukon Tanana Terrane formed basement to the Lay Range Assemblage. This would imply that the late Paleozoic and Quesnellia arcs draped across some part of an older pericratonic crustal block characterised by Early Mississippian arc-type volcanism and, at least locally, groups of syngenetic massive sulphide deposits.

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