Ancient Pacific Margin: A preliminary comparison of potential VMS-hosting successions of the Yukon-Tanana Terrane, from Finlayson Lake district to northern British Columbia[1]

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ABSTRACT

In the inaugural year of the joint Geological Survey of Canada – British Columbia Geological Survey Branch – Yukon Geology Program Ancient Pacific Margin NATMAP project, substantial progress was made in documenting the nature of Yukon-Tanana Terrane in Yukon and northern British Columbia and how the different parts may have been linked paleogeographically. When ca. 425 km of displacement on the Tintina Fault are restored, the Finlayson Lake massive sulphide district lies north of and along strike from the Glenlyon and Wolf Lake – Jennings River study areas. Stratigraphic sections from the component study areas illustrate similarities and differences along strike; both the similarities and differences with the Finlayson Lake stratigraphy affirm the potential of this belt to host volcanogenic massive sulphide mineralization.

RÉSUMÉ

La première année du programme CARTNAT de la marge pacifique ancienne (un programme conjoint des Commissions géologiques du Canada et de la Colombie Britannique, et du Service géologique du Yukon) a mené à de grands progrès dans la documentation de la nature et des liens paléogéographiques possibles entre divers éléments du terrane de Yukon-Tanana, situé au Yukon et dans le nord de la Colombie Britannique. Lorsque l'on enlève quelque 425 km de rejet horizontal le long de la faille de Tintina, la ceinture de sulfures massifs de Finlayson Lake se retrouve au nord des régions à l'étude de Glenlyon et de Wolf Lake – Jennings River. Les colonnes stratigraphiques pour les diverses régions à l'étude illustrent les similarités et les différences entre les différentes portions du terrane. Une comparaison des ressemblances ainsi que des différences entre la stratigraphie de la région de Finlayson Lake et celle des régions à l'étude démontre le potentiel pour des minéralisations de sulfures massifs volcanogènes le long de cette ceinture.

[1]*Contribution to the Ancient Pacific Margin NATMAP project.*

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INTRODUCTION

The Yukon-Tanana Terrane of Yukon, Alaska and northern British Columbia consists of poorly understood, lithologically diverse successions of metasedimentary and metavolcanic rocks, and voluminous Mid- and Late Paleozoic granitic metaplutonic bodies (Mortensen and Jilson, 1985; Mortensen, 1992). Significant volcanogenic massive sulphide deposits occur in the terrane in the Delta and Bonnifield districts in Alaska and in the Finlayson Lake district in southeastern Yukon, and the potential for further discoveries is considered to be high. However, exploration for new deposits has been hindered by the paucity of stratigraphic information from the terrane as a whole.

One of the goals of the Ancient Pacific Margin NATMAP (National Mapping Program) project is to address the deficiencies in stratigraphic information from the Yukon-Tanana Terrane. The central component of the Ancient Pacific Margin Project, which spans both Yukon and British Columbia, includes bedrock geological mapping of the Finlayson Lake district (Murphy and Piercey, 1999b and c; this volume; location 1 on Fig. 1), the Glenlyon area in central Yukon (Colpron, 1998, 1999c; Colpron and Reinecke, this volume; locations 2 and 3 on Fig. 1), the Big Salmon Complex in northern Jennings River map area (Mihalynuk et al., 2000; location 4 on Fig. 1), the Wolf Lake/Jennings River map area straddling the Yukon/B.C. border (Roots et al., 2000a and b; locations 5a and 5b on Fig. 1), and the southeastern Dorsey Terrane in south-central Jennings River map area (Nelson, 2000; location 6 on Fig. 1). The Finlayson Lake district is currently separated from the other areas by the Tintina Fault. Restoration of about 425 kilometres of displacement on the fault (Roddick, 1967; Murphy, Mortensen and Abbott, in prep.) aligns all of these areas in a continuous belt from the Finlayson Lake area to the southern Jennings River (Fig. 1). The Yukon-Tanana Terrane along this belt represents a target for volcanogenic massive sulphide deposits that extends over 500 kilometres of strike length.

Sufficient geological mapping and uranium-lead dating have now been done to construct preliminary stratigraphic sections for areas scattered along the extent of the southeastern Yukon-Tanana Terrane (Fig. 2). In the Finlayson project, Murphy and collaborators have covered the area of the Fyre Lake, Kudz Ze Kayah and Wolverine volcanogenic massive sulphide deposits. Their work provides a preliminary stratigraphic template that is useful for workers throughout the terrane where the potential for volcanogenic massive sulphide deposits is less known. This template is used in this paper as a point of comparison for the stratigraphic columns farther south along the restored pericratonic belt. Figure 2 shows fundamental similarities between these areas and the Finlayson Lake district, as well as highlighting significant differences in the ages of volcanism along the belt.

FINLAYSON LAKE DISTRICT

(Fig. 2, column 1) Stratified rocks in the Finlayson Lake massive sulphide district have been subdivided into three first-order successions, each hosting volcanogenic massive sulphide deposits and prospects (Murphy and Piercey, 1999; Fig. 2). The lower succession comprises pre-Late Devonian quartz-rich metaclastic rocks, marble and pelitic schist; Late Devonian to early Missisissippian mafic metavolcanic rocks with lesser amounts of carbonaceous metaclastic rocks, felsic metavolcanic and volcaniclastic rocks, and marble; early Mississippian felsic metavolcanic and volcaniclastic rocks, and carbonaceous phyllite; and early Mississippian carbonaceous phyllite, quartzite, quartz-feldspar pebble meta-conglomerate and mafic metavolcanic rocks. These units were intruded by early Mississippian peraluminous granitic metaplutonic rocks, then deformed, and re-intruded by slightly younger, late-kinematic, early Mississippian granitic metaplutonic rocks, before the unconformable deposition of the overlying middle stratigraphic succession. The lower succession hosts both the Fyre Lake Cu-Co-Au deposit and the Kudz Ze Kayah Cu-Pb-Zn-Au-Ag deposit, the former in the Late Devonian to early Mississippian mafic metavolcanic unit and the latter in overlying early Mississippian felsic metavolcanic rocks.

The middle succession, also of probable early Mississippian age, comprises carbonaceous metaclastic rocks, felsic schist and quartz-feldspar metaporphyry of volcanic, volcaniclastic and subvolcanic intrusive protolith. A distinctive, laterally persistent felsic tuff and exhalite unit caps the middle succession. The Wolverine Cu-Pb-Zn-Au-Ag deposit occurs near the top of the unit, just below the tuff/exhalite unit.

The upper succession corresponds to the Campbell Range belt of Mortensen and Jilson (1985). It consists of two intervals of basaltic volcanic and volcaniclastic rocks separated by a lithologically diverse and laterally variable unit of carbonaceous phyllite, greywacke, diamictite, variegated chert, chert-pebble conglomerate and limestone. Mid-Pennsylvanian to Early Permian radiolaria have been obtained from chert in the upper basalt (Harms, in Plint and Gordon, 1997) and Pennsylvanian conodonts were obtained from limestone (M.J. Orchard, in Tempelman-Kluit, 1979). The Money occurrence is hosted by the upper Campbell Range basalt and the Ice Cu-Au volcanogenic massive sulphide deposit occurs in lithologically similar rocks about 70 kilometres northwest along strike from the Campbell Range succession.

GLENLYON AREA

(Fig. 2, columns 2, 3) Detailed mapping in Glenlyon map area has identified two mid-Mississippian volcanic arc sequences of slightly different ages (Colpron, 1998, 1999a, 1999c; Colpron and Reinecke, this volume). In Little Kalzas Lake area, to the

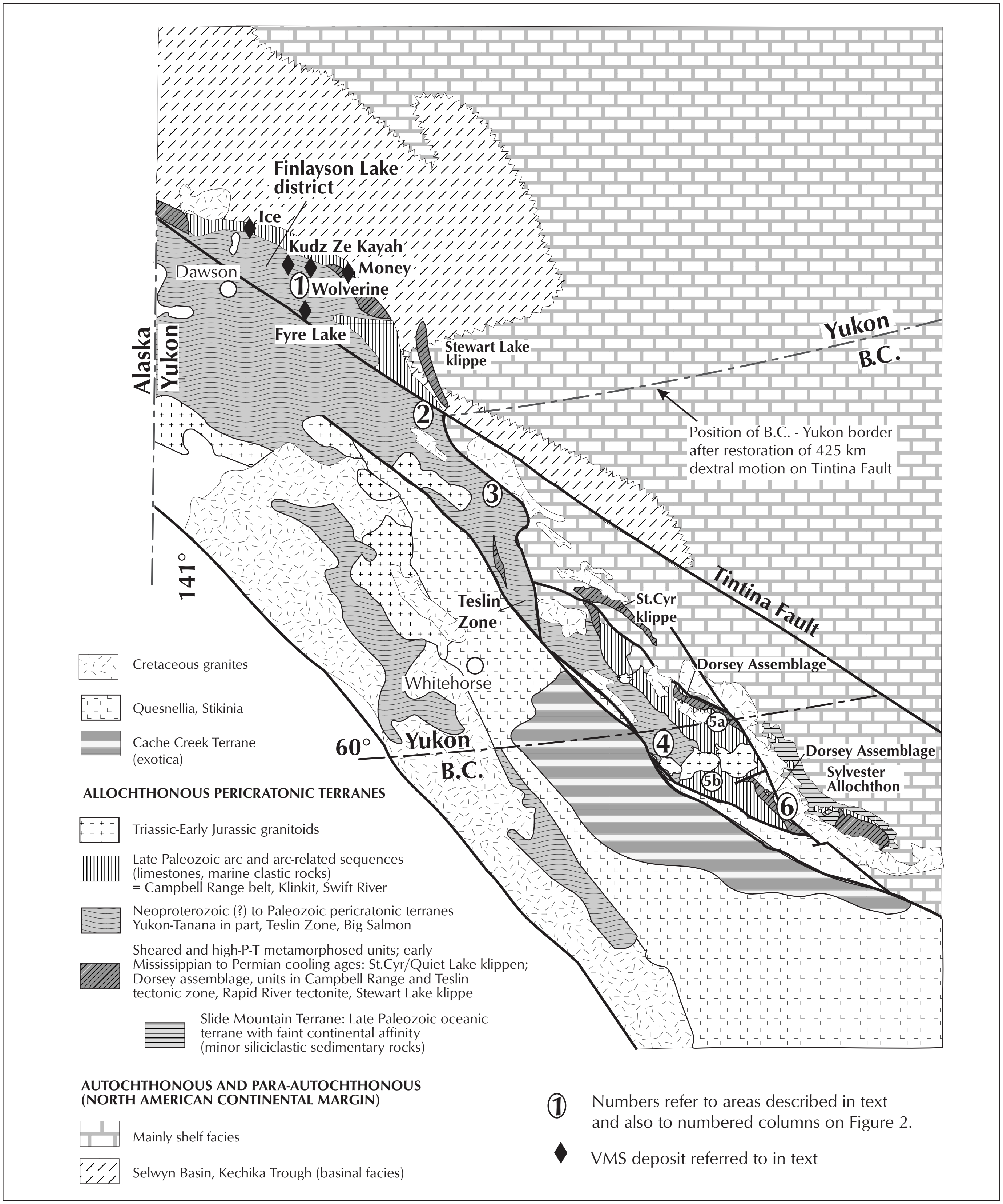

Figure 1. *Generalized terrane map of northern British Columbia and Yukon prior to ~425 km of dextral displacement along Tintina Fault. Areas discussed in text and in Figure 2 are indicated by numbers.*

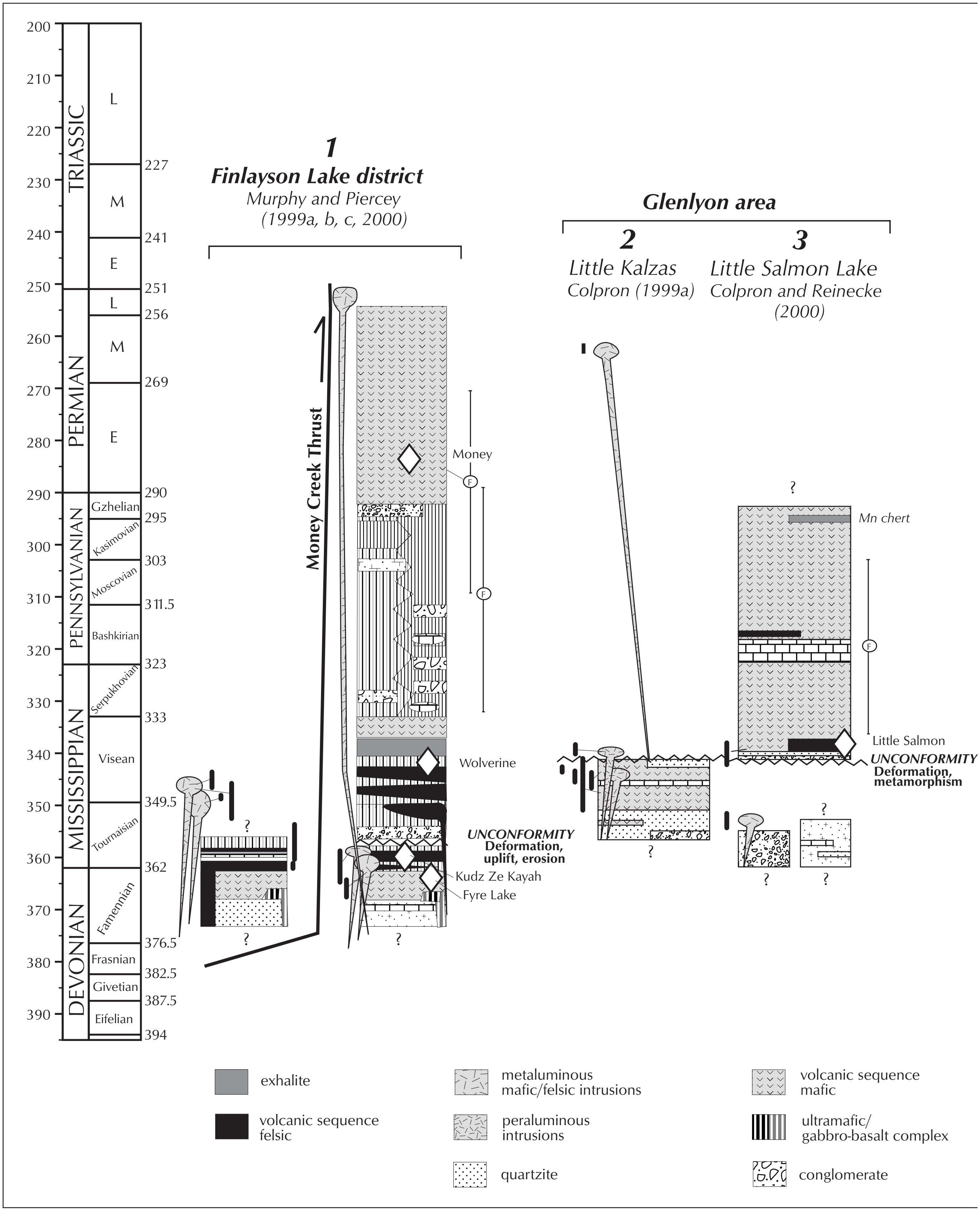

Figure 2. *Comparative stratigraphic columns for the various areas discussed in the text and located on Figure 1.*

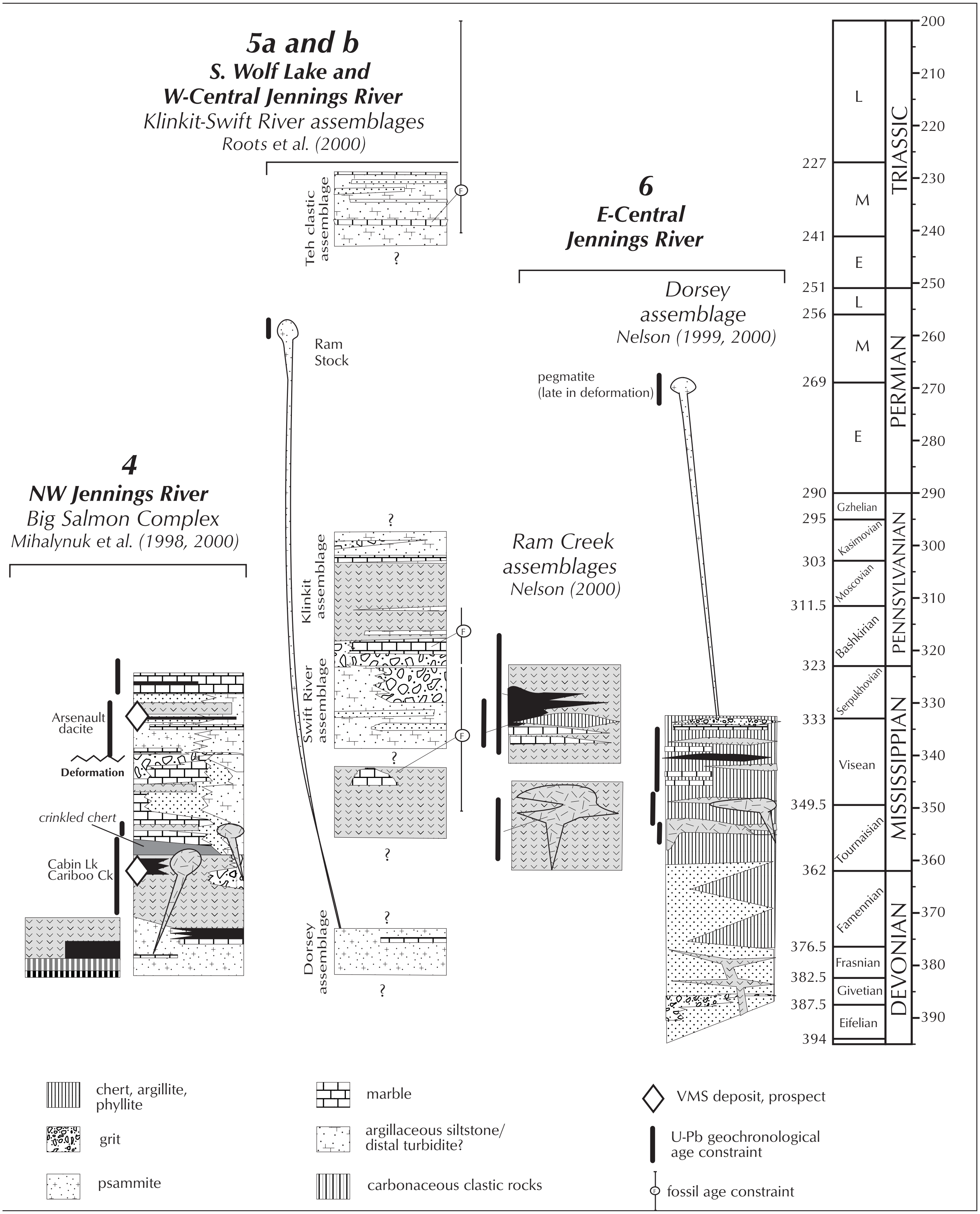

***Figure 2.** continued*

northwest, early Visean calc-alkaline volcanic and volcaniclastic rocks conformably overlie a thick orthoquartzite unit (location 2 on Fig. 1). This sequence was apparently deformed and metamorphosed prior to intrusion of the Tatlmain batholith in mid-Visean time. To the southeast, in Little Salmon Range, mid-Visean (and younger) volcanic and volcaniclastic rocks have mixed calc-alkaline and alkaline affinities (location 3 on Fig. 1). The Little Salmon volcanic sequence rests unconformably on two different clastic units, exposed on the east and west limbs of a gentle synclinorium. On the east, it overlies arkosic grit intruded by a 353 Ma pluton (Oliver and Mortensen, 1998). On the west, it overlies a heterogeneous sequence of unknown age, which consists of quartzite, psammitic and pelitic schists, marble, greenstone and abundant discontinuous sills of meta-igneous rocks. The Little Salmon volcanic sequence contains Mn chert horizons and hosts a massive sulphide occurrence (Colpron, 1999b).

NORTHWESTERN JENNINGS RIVER

(Fig. 2, column 4) The Big Salmon Complex is the southernmost projection of assemblages now considered to be equivalents of the Yukon-Tanana Terrane in the Teslin Zone. It underlies the northwestern corner of the Jennings River map area and northeastern corner of the Atlin map area in far northern British Columbia (Fig. 1), and is bounded to the west by the Teslin Fault. Three distinctive units form a marker succession within it (Mihalynuk et al., 1998; 2000). Based on new isotopic and geologic constraints, their stratigraphic order, from oldest to youngest, is:

1. thick, tuffite-dominated greenstone, intruded by the 362 Ma Hazel orthogneiss (Mihalynuk et al., 2000).
2. thin buff- to grey-weathering limestone with metre-thick tuffaceous and thin, centimetre to decimetre, quartzite layers; and
3. thinly bedded, finely laminated manganiferous ‘crinkle chert’/ quartzite with muscovite partings.

The three-part marker succession persists in southeast and northwest 104O/13, and south-central 104O/12. In northern 104N/16, a hybrid unit of felsic tuff mixed with crinkle chert occurs in place of the crinkle chert unit.

Two other, more broadly defined, rock packages are also recognized; both lie stratigraphically high in the sequence, above the greenstone unit. They include:

4. ‘dirty clastics’: brown to tan wacke, stretched quartzite-pebble and granule conglomerate and slate; and
5. heterolithic, quartz-rich clastic rocks interbedded with thin limestone and mafic and felsic tuffs, including late Mississippian dacite.

This general stratigraphy projects north across the British Columbia/Yukon border into southwestern Wolf Lake and probably Teslin map areas (Roots et al., 2000). Vigorous continental arc volcanism in the Late Devonian to early Mississippian (ca. 370-360 Ma) resulted in the accumulation of voluminous, submarine, dominantly mafic tuff and tuffite on a substrate of pericratonic strata. A pulse of felsic volcanism and arc rifting at the end of the magmatic cycle resulted in formation of exhalative chert (the crinkle chert), as well as coeval clastic facies (dirty clastics) preserved in fault-bounded basins. Felsic volcanic intervals with pyritic quartz-sericite schist occur in the greenstone unit immediately beneath the crinkle chert, for instance at the Cabin, Caribou and Mor properties in southern Yukon: they are specific targets for volcanogenic massive sulphide exploration.

SOUTHERN WOLF LAKE AND WEST-CENTRAL JENNINGS RIVER AREA

(Fig. 2, column 5) This section is derived from two areas, one straddling the Yukon/British Columbia border near Swift River, Yukon (location 5a on Fig. 1), and one in the west-central Jennings River map area, B.C. (location 5b). It spans the Ram Creek, Dorsey, Swift River and Klinkit assemblages (Harms and Stevens, 1996). As suggested by Harms and Stevens, and corroborated in 1999 field mapping (Roots et al, 2000), each assemblage consists of related sedimentary and volcanic strata that are mappable and lithologically distinct from adjacent assemblages.

The oldest known rocks are included in the Dorsey assemblage (location 5a, Fig. 1), which is exposed as a narrow, elongate strip near the northeastern side of the pericratonic belt. It is a siliceous succession including quartzite and quartzo-feldspathic metasedimentary protoliths, interspersed with quartz-augen felsic meta-tuff and marble layers, as well as foliated, sill-like leucocratic intrusions. It is characterized by a medium- to high-pressure metamorphic mineral assemblage. The Dorsey assemblage in the Yukon was deformed prior to the emplacement of the mid-Permian Ram Stock (Stevens and Harms, 1995). Its oldest protoliths are probably pre-Devonian-Mississippian, the age of intrusions in southern Dorsey assemblage in British Columbia (see below).

The Swift River assemblage comprises several hundred metres, in structural thickness, of dark meta-siltstone and argillite with interbeds of quartzite; and thick-bedded, dark coloured chert. There is no age control, except that a distinctive chert-pebble conglomerate facies at the top interfingers with, and is conformably overlain by Carboniferous (in part lower Pennsylvanian) Screw Creek limestone.

The Screw Creek limestone is white, thick-bedded, and contains abundant macrofossil debris. As mass flow deposits from a reef environment, this limestone is not a direct stratigraphic marker, but the Bashkirian conodonts (Abbott, 1981) provide an approximate age.

The Klinkit assemblage in central Jennings River area (location 5b, Fig. 1) contains dark coloured, thick-bedded chloritic meta-tuffs and breccias, volcanic-derived meta-siltstone and minor mafic flows, light-coloured limestone and siltstone-argillite layers. One or two prominently red quartzite (possible metamorphosed chert) layers lie several tens of metres above the base, which is locally a limestone that contains Carboniferous macrofauna, correlated with the Screw Creek limestone. The top of Klinkit assemblage, as used here, is a variable succession of meta-siltstone through quartzite with chloritic meta-tuff layers of unknown age.

The Triassic succession in west-central Jennings River area (Teh clastic assemblage; location 5b, Fig. 1) consists of interbedded black argillite, meta-siltstone and quartzite, with minor chert, fetid limestone and conglomerate (T. Harms, pers. comm., 1999). One limestone bed yielded a single Triassic conodont (M. Orchard, pers. comm. to T. Harms, 1997). This single age is considered preliminary. Moreover, although rocks that visually resemble this lithologic succession are found in several places in direct contact with Klinkit assemblage, field evidence for their stratigraphic relationship and even their stratigraphic order remains to be found.

EAST-CENTRAL JENNINGS RIVER

(Fig. 2, column 6) In east-central Jennings River area, rocks of the Big Salmon Complex disappear eastwards below less-metamorphosed younger strata of the Klinkit and Swift River assemblages. Possible equivalents, including Mississippian felsic volcanic units, reappear from beneath these to the east. They are assigned to the Dorsey and Ram Creek assemblages (Location 6 on Fig. 1). The Dorsey assemblage, also described in the Wolf Lake map area (Location 5a), structurally overlies the Ram Creek assemblage across a post-mid Permian thrust fault (Nelson, 2000). For this reason, sections from these two assemblages are presented separately (Fig. 2). The Dorsey assemblage is a metamorphic complex containing a variety of protoliths that range from siliciclastic to basinal sedimentary rocks and tuffs, with isolated metabasic and ultramafic bodies. It is intruded by early Mississippian deformed granitoids. Early Mississippian intrusions also form part of the underlying Ram Creek assemblage. It is possible that during Mississippian time, the Dorsey assemblage was basement to the Ram Creek magmatic arc (Nelson, 2000). The Ram Creek assemblage contains tracts of mafic to rhyolitic meta-tuffs with local limestone and chert sequences. Two uranium-lead dates from the felsic tuffs are late Mississippian, coeval with tuffs in the Big Salmon Complex (Fig. 2, column 4) and Little Salmon Lake sequence (Fig. 2, column 3).

CONCLUSIONS

The columns described above demonstrate both the integrity and the variability of the southeastern Yukon-Tanana Terrane. Mafic to felsic arc activity in a pericratonic setting ranges in age from early Mississippian (ca. 360-350 Ma) to late Mississippian-early Pennsylvanian (ca. 335-320 Ma). The Finlayson Lake district contains significant volcanogenic massive sulphide deposits associated with the early Mississippian event (Murphy and Piercey, this volume). This syngenetic event is represented in the Big Salmon Complex near the British Columbia-Yukon border by the crinkle chert, a siliceous meta-exhalite containing anomalous barium and manganese, and by small felsic accumulations with associated base-metal geochemical anomalies (Mihalynuk et al., 2000). Late Mississippian felsic tuffs occur in the Ram Creek assemblage, in the upper part of the Big Salmon Complex, and near Little Salmon Lake, where a small massive sulphide showing and cherty exhalite like the “crinkled chert” are also reported (Colpron, 1999b; Colpron and Reinecke, this volume). The late Mississippian volcanic suite, not apparently present in the Finlayson Lake district, represents a new, largely unexplored host for volcanogenic massive sulphide deposits in northern British Columbia and south-central Yukon.

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