Geology and mineral potential of Yukon-Tanana Terrane in the Livingstone Creek area (NTS 105E/8), south-central Yukon

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ABSTRACT

Yukon-Tanana Terrane in the Livingstone Creek area comprises five successions of metasedimentary and metavolcanic rocks which range in age from pre-Upper Devonian to Lower Mississippian. They are correlated with Lower Mississippian and older strata in the Glenlyon and Finlayson Lake areas. Yukon-Tanana rocks are intruded by at least five plutonic suites, ranging in age from Late Devonian to Late Cretaceous. The structural style of the area is dominated by a transposition foliation which is axial planar to isoclinal folds of an earlier foliation. The transposition foliation is itself folded by northeast-verging open folds. The d'Abbadie fault zone, a 1-km-wide zone of imbricate fault slices in the eastern part of the area, is characterized by multiple generations of ductile fabrics overprinted by younger cataclastic breccia zones. Deformation along d'Abbadie fault is in part constrained by syn-tectonic emplacement of a *ca.* 96 Ma granite pluton along the western margin of the fault zone. Two new showings are reported here: a Pb-Ag vein occurrence and a pyrrhotite skarn. In addition, anomalous Cu-Zn values in graphitic phyllite associated with chloritic schist suggest potential for volcanogenic massive sulphide- (VMS) or hybrid VMS-sedimentary-exhalative-style mineralization in the area.

RÉSUMÉ

Dans la région du ruisseau Livingstone, le terrane de Yukon-Tanana comprend cinq successions de roches méta-sédimentaires et méta-volcaniques dont les âges varient d'avant le Dévonien supérieur au Mississippien inférieur. Ces successions sont corrélées avec des strates d'âge mississippien et plus vieilles des régions de Glenlyon et du lac Finlayson. Les roches de Yukon-Tanana sont recoupées par au moins cinq cortèges plutoniques, dont les âges varient du Dévonien tardif au Crétacé tardif. Le style structural de la région est dominé par une foliation de transposition de plan axial à des plis isoclinaux d'une foliation antérieure. La zone faillée d'Abbadie correspond à une zone d'écailles imbriquées de plus d'un kilomètre de large dans la partie orientale de la région. Elle est caractérisée par plusieurs générations de fabriques de déformation ductile recoupées par des brèches cataclastiques plus jeunes. La déformation le long de la faille d'Abbadie est en partie datée par la mise en place syn-tectonique d'un pluton de granite datant d'environ 96 million d'années le long de la marge occidentale de la zone faillée. Deux nouveaux indices minéraux sont signalés ici : une veine de quartz plombifère et argentifère, et un skarn à pyrrhotite. De plus, des concentrations anormales en cuivre et en zinc sont signalées dans un phyllade graphiteux associé à un schiste chloriteux, suggérant la possibilité d'une minéralisation en sulfures massifs volcanogènes (SMV) ou de type SMV-SEDEX (sédimentaire exhalatif) hybride dans la région.

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INTRODUCTION

The Livingstone Creek area, 80 km northeast of Whitehorse (Fig. 1), is a placer camp which has seen intermittent mining operations since the 1898 discovery of gold in the area (Bostock and Lees, 1938; Levson, 1992). A lode source for the placer gold remains, however, elusive. Published bedrock geology maps of the area are limited to reconnaissance-scale studies of Bostock and Lees (1938; 1:253 440) and Tempelman-Kluit (1984; 1:250 000 scale). Subsequent studies of the Livingstone Creek and surrounding areas provided more detailed descriptions of the bedrock geology. They primarily focused on the structural evolution of the region (e.g., Hansen, 1989; Harvey *et al.*, 1996; 1997; Gallagher *et al.*, 1998; de Keijzer *et al.*, 1999; Gallagher, 1999; de Keijzer, 2000). Detailed structural and geochronological studies in the Livingstone Creek area were most recently conducted by Harvey *et al.* (1996; 1997) and Gallagher (1999).

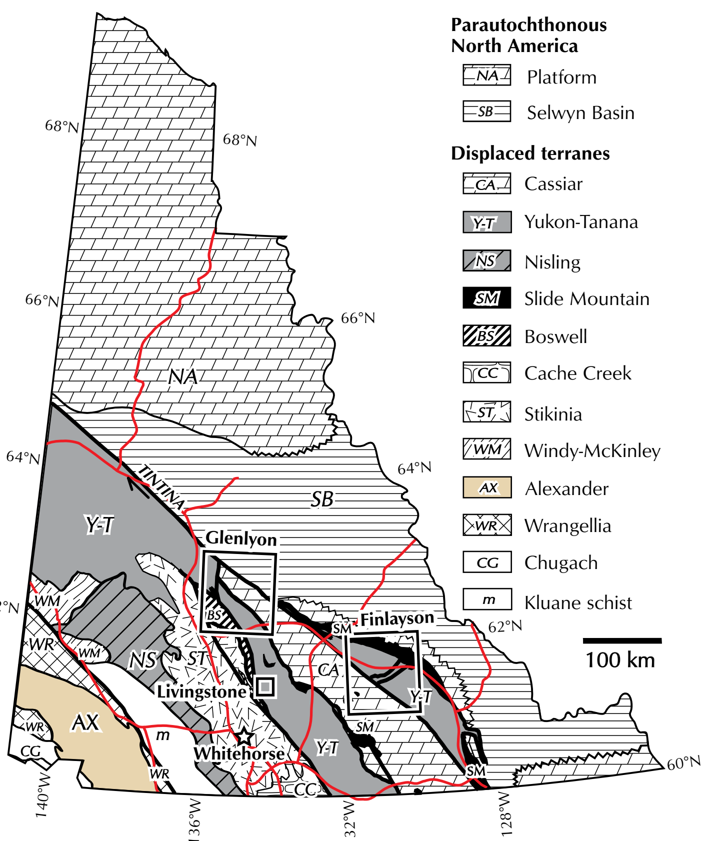

Figure 1. *Terrane map of Yukon showing the location of the Livingstone Creek area with respect to the Glenlyon and Finlayson Lake areas (modified after Wheeler et al., 1991).*

The Livingstone Creek area is underlain primarily by metasedimentary and meta-igneous rocks of Yukon-Tanana Terrane (YTT; Figs. 1 and 2). West of the South Big Salmon River, YTT is juxtaposed against late Paleozoic volcanic and sedimentary rocks of the Semenof Block along the Big Salmon fault (Simard, 2003; Simard and Devine, 2003). Interbedded meta-sandstone and meta-argillite of the Loon Lake succession (Barresi, 2004), which crops out southwest of the South Big Salmon River and south of Livingstone fault (Fig. 2), as well as sporadic outcrops of meta-argillite along the flanks of the South Big Salmon valley, are likely part of YTT as well. The eastern part of the Livingstone Creek area is dissected by the north-striking d'Abbadie fault zone (Fig. 2). Meta-sedimentary rocks in the east and northeast part of the area were previously assigned to Cassiar Terrane. For reasons outlined in this paper, I suggest that these rocks are also part of YTT.

Regional studies of YTT have shown that the terrane is composed of a series of mid- to late-Paleozoic arc and back-arc successions built upon a metasedimentary basement of continental margin affinity (Colpron *et al.*, 2006). In the Livingstone Creek area, YTT was previously considered to be only ~10-15 km wide and corresponded to the Teslin Suture Zone of Tempelman-Kluit (1979), a zone of highly strained rocks which were interpreted to have developed in a subduction zone setting during early Mesozoic convergence of Stikinia and North America (e.g., Tempelman-Kluit, 1979; Hansen, 1989; 1992). Subsequent studies of this portion of YTT have shown that ductile deformation features in the Teslin zone are the result of development of an early (late Paleozoic?) transposition foliation, superposed by younger (early Mesozoic?) northeast-verging folds (e.g., de Keijzer *et al.*, 1999; Gallagher, 1999).

Bedrock mapping of the Livingstone Creek area at 1:50 000 scale was undertaken by the Yukon Geological Survey in 2004-2005 to establish the stratigraphic framework of YTT in the area, and to place the Livingstone Creek area within the context of recent studies of YTT in the Finlayson Lake and Glenlyon areas of Yukon (e.g., Colpron *et al.*, 2006; Fig. 1). This study provides the basis for compiling earlier observations made by Gallagher (1999) and unpublished data collected by J.L. Harvey in 1995-1996. This report summarizes observations of YTT geology in the Livingstone Creek area made during the 2005 field season. It builds on preliminary observations reported by Colpron (2005a) and complements the 1:50 000-scale map of the area

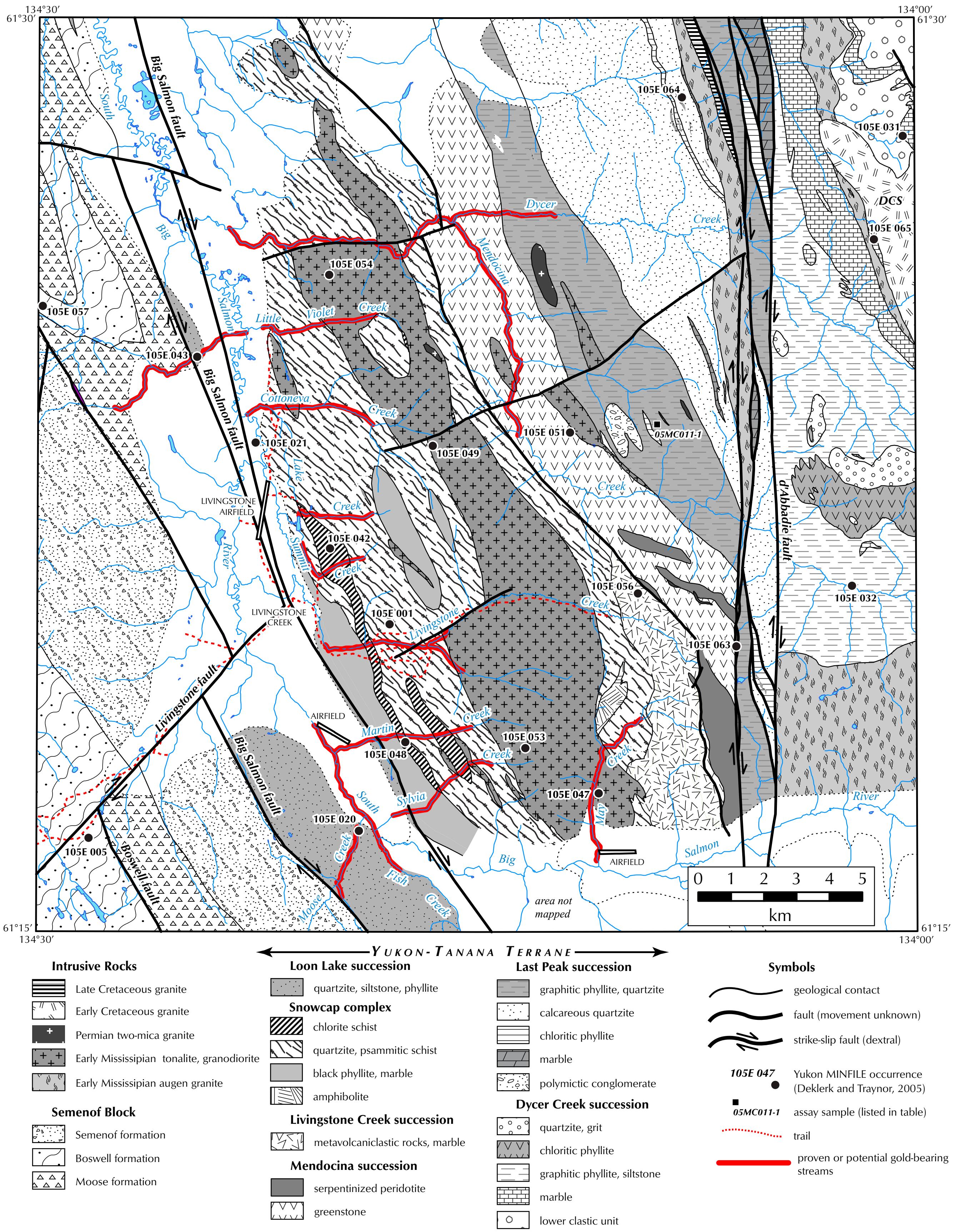

Figure 2. *Bedrock geology map of the Livingstone Creek area (simplified from Colpron, 2005b). Placer potential from Lipovsky et al. (2001). DCS = Dycer Creek stock.*

(Colpron, 2005b). The following observations are restricted to exposures of YTT to the east and north of the South Big Salmon River. Descriptions of the geology of the Semenof Block and the Loon Lake succession are presented in Simard and Devine (2003), and Barresi (2004), respectively.

YUKON-TANANA TERRANE

Yukon-Tanana Terrane east and north of the South Big Salmon River comprises five successions of metasedimentary and metavolcanic rocks: the Snowcap complex, and the Livingstone Creek, Mendocina, Last Peak and Dycer Creek successions (Fig. 2). These occur in two structural domains separated by d'Abbadie fault. The Dycer Creek succession occurs east of the fault; all other succession occur west of the fault.

SNOWCAP COMPLEX

The Snowcap complex (Colpron *et al*., 2002, 2003) occupies a northwest-trending belt immediately east of the South Big Salmon River (Fig. 2). It consists predominantly of micaceous quartzite, quartzite and quartz-muscovite-biotite schist, with subordinate amounts of carbonaceous phyllite and schist, calcareous chloritic schist, marble and amphibolite. Carbonaceous phyllite is most abundant in the southwest part of the area, between Sylvia and Summit creeks, where it is locally calcareous; the most prominent marble band in the Snowcap complex occurs within carbonaceous phyllite between Martin and Livingstone creeks (Fig. 2). Carbonaceous phyllite along alpine ridges at the headwater of Lake and Summit creeks is more siliceous.

Chloritic schist of the Snowcap complex occurs along a narrow belt, structurally below the carbonaceous phyllite and extending more than 6 km between Sylvia and Lake creeks. A second, shorter band of chloritic schist is found at higher elevation between Sylvia and Livingstone creeks (Fig. 2). The chloritic schist is light to medium green, fine- to medium-grained and variably siliceous, suggesting a meta-volcaniclastic protolith for this rock. The chloritic schist is locally associated with dolomitic marble. Dark green to black, fine-grained amphibolite of the Snowcap complex is restricted to a few exposures north of May Creek (Fig. 2).

Rocks of the Snowcap complex are intruded by a large body of Early Mississippian tonalite gneiss. The Snowcap complex is therefore constrained to be Lower Mississippian or older in the Livingstone Creek area. Regionally, the Snowcap complex is constrained to be of pre-Upper Devonian in age (Colpron *et al*., 2006).

LIVINGSTONE CREEK SUCCESSION

The Livingstone Creek succession (Harvey *et al*., 1997) is restricted to the southern part of the area, between Livingstone Creek and the South Big Salmon River (Fig. 2). It consists of light green to light grey quartzite, quartz-muscovite-plagioclase-chlorite schist, minor chlorite schist and dolomitic marble (Colpron, 2005a). No new observations of the Livingstone Creek succession were made in 2005. Colpron (2005a) suggested correlation of the Livingstone Creek succession with the Lower Mississippian Little Kalzas formation in the Glenlyon area to the north (Colpron *et al*., 2002, 2003) on the basis of lithological similarities.

MENDOCINA SUCCESSION

Greenstone of the Mendocina succession (Harvey *et al*., 1997) forms a 2- to 3-km-wide, northwest-trending belt which generally follows the Mendocina valley in the centre of the map area (Fig. 2). The greenstone is typically fine-grained and phyllitic, rarely massive. Patches of medium- to coarse-grained plagioclase-hornblende-rich greenstone occur sporadically in the finer grained rocks and likely represent dismembered gabbro dykes. Metagabbro is most common in proximity to, and within, the serpentinite bodies. Serpentinite occurs mainly at the southern end of the belt of Mendocina succession, near the d'Abbadie fault, the largest body forming a massif at the headwater of May Creek (Figs. 2 and 3). The rock is bottle-green in colour and soft, although silicification patches within the serpentinite are common. Coarse magnetite commonly occurs within the silicified ultramafic rock.

Marble occurs locally within greenstone of the Mendocina succession, the most prominent exposures being north of Mendocina Creek where marble is associated with calcareous and carbonaceous schist. Carbonaceous schist also occurs sporadically south of Mendocina Creek in proximity with serpentinite bodies.

In the northern part of the area, greenstone of the Mendocina succession is intercalated with a calcareous quartz-muscovite-chlorite-biotite schist of probable volcaniclastic origin. This rock resembles metavolcaniclastic rocks of the Livingstone Creek succession

Figure 3. *Looking east at the serpentinite massif (DMMu) at the headwater of May Creek. Lower ridges in foreground are underlain by meta-volcaniclastic quartzite and phyllite of the Livingstone Creek succession (DMLCv).*

suggesting that the Livingstone Creek succession may be a lateral (distal?) facies of the Mendocina succession.

The contact relationships between the Mendocina succession and adjacent map units are difficult to assess due to poor exposures along contacts and the strong transposition fabric which characterizes the area (see Structure and Metamorphism below). Its southwestern contact with the Snowcap complex and Livingstone Creek succession is inferred to be a fault, because of apparent map truncation of these units along the contact (Fig. 2). However, this relationship may prove invalid if the Livingstone Creek succession is indeed a lateral volcaniclastic facies equivalent of the Mendocina greenstone. Between May Creek and the South Big Salmon River, the contact between serpentinite and greenstone of the Mendocina Creek succession and marble of the Livingstone Creek succession is marked by brecciated greenstone suggesting a brittle fault contact (Fig. 4). The northeastern contact with the Last Peak succession is intruded by meta-granodiorite of probable Early Mississippian age north of Mendocina Creek (Fig. 2).

The age of the Mendocina succession is not well constrained. It is apparently intruded by strongly foliated quartz diorite to granodiorite, inferred to be Early Mississippian in age. The felsic schist reported by Colpron (2005a) from the Mendocina succession is here reinterpreted as a dyke intruding the older greenstone; preliminary results of U/Pb analyses on zircon indicate a Permian age for this rock (S.D. Carr, pers. comm., 2005). Colpron (2005a) suggested that the association of greenstone, meta-gabbro, serpentinite and minor carbonaceous phyllite resembles the Upper Devonian Fire Lake formation of the Finlayson Lake district (Murphy *et al.*, 2001, 2002).

LAST PEAK SUCCESSION

Rocks of the Last Peak succession (Harvey *et al.*, 1997) occupy a south-tapering wedge in the north-central part of the map area, bounded on the east by d'Abbadie fault and on the west by greenstone of the Mendocina succession (Fig. 2). The Last Peak succession consists primarily of two mappable units: (1) a graphitic phyllite and quartzite, which grades easterly into (2) a calcareous quartzite and schist unit. The graphitic phyllite is variably siliceous and locally intercalated with <2-m-thick buff-weathering, dolomitic marble. North of Mendocina Creek, chloritic phyllite is locally intercalated with the graphitic phyllite. Layer-parallel disseminated sulphide (mainly pyrite) horizons and pyrite-malachite veins locally occur in proximity to exposures of chloritic phyllite (see Mineral Potential below).

A distinctive, strongly foliated polymictic pebble meta-conglomerate overlies the graphitic phyllite unit at one locality north of Mendocina Creek. The metaconglom-erate is poorly sorted and contains clasts of white quartz, dark grey to black phyllite and quartzite, buff- to brown-

Figure 4. *Looking south at contact between Mendocina serpentinite (DMMu) and greenstone (DMMv) and marble of the Livingstone Creek succession (DMLCm). Greenstone closest to the contact is brecciated.*

weathering marble, and rare felsic metavolcanic rocks, supported by a matrix of arkosic meta-grit (Fig. 5a). Most of the clast compositions are consistent with local derivation for this meta-conglomerate.

Carbonaceous rocks of the Last Peak succession become more siliceous to the east where they pass progressively into a tan-weathering, micaceous and calcareous quartzite. The micaceous quartzite is typically strongly foliated and platy. It is locally intercalated with calcareous quartz-muscovite±chlorite schist, massive black, grey and white quartzite horizons (1-20 m), and minor tan-weathering marble. Thicker (10-30 m) white marble horizons define mappable units along the eastern part of the micaceous quartzite unit. A distinct, brown-weathering silicified grey marble occurs invariably at the contact between micaceous quartzite of the Last Peak succession and Early Mississippian augen granite to the east, wherever this contact has been observed. This unique marble is characterized by abundant dismembered boudins of quartzite which impart a "knobby" appearance to the rock (Fig. 5b).

Resistant, strongly foliated and lineated, siliceous chloritic phyllite defines a continuous band which extends more than 10 km from Dycer Creek northward to the Big Salmon River in the adjacent Teraktu Creek map area (NTS 105E/9; M. Colpron, unpublished map, 2005). The chloritic phyllite is characterized by well-developed, mm-thick laminations of quartzofeldspathic- and epidote-rich layers along the dominant foliation (Fig. 5c). Pyrrhotite and locally magnetite are common constituents of this rock.

The age of the Last Peak succession is only constrained by the Early Mississippian plutons that intrude it. Carbonaceous rocks of the Last Peak succession were originally considered to be part of Cassiar Terrane (Tempelman-Kluit, 1984; Gordey and Makepeace, 2000). They are here considered part of Yukon-Tanana Terrane because they are intruded by calc-alkaline Early Mississippian plutons characteristic of Yukon-Tanana, but unknown in Cassiar Terrane. Based on the abundance of carbonaceous lithologies, the Last Peak succession is most likely correlative with uppermost Devonian-Mississippian strata of Yukon-Tanana Terrane elsewhere in Yukon (e.g., Grass Lakes and Wolverine Lake groups in Finlayson district; Murphy *et al.*, 2006; Colpron *et al.*, 2006). Micaceous quartzite, graphitic phyllite, marble, and siliceous chloritic phyllite and meta-siltstone that occur in fault slivers within the d'Abbadie fault zone are tentatively assigned to the Last Peak succession.

DYCER CREEK SUCCESSION

The Dycer Creek succession (Gallagher, 1999) comprises all metasedimentary rock units east of d'Abbadie fault (Fig. 2). It includes a lower clastic unit in the northeast corner of the map area, overlain by marble, calcareous carbonaceous phyllite, chlorite schist and quartzite. The lower clastic unit comprises coarsely recrystallized pelitic, psammitic and calc-silicate schists, quartzite and marble. Pelitic and psammitic rocks commonly have coarse, post-tectonic andalusite and/or garnet (Fig. 5d), presumably as a result of contact metamorphism imposed by the Early Cretaceous Dycer Creek stock to the south. The

Figure 5. (a) *Polymictic meta-conglomerate, Last Peak succession;* ***(b)*** *'knobby' marble at contact between Last Peak succession and Early Mississippian augen meta-granite;* ***(c)*** *strongly foliated chlorite schist of the Last Peak succession;* ***(d)*** *coarse-grained, post-tectonic andalusite in psammitic schist of the lower clastic unit, Dycer Creek succession, northeast of Dycer Creek stock;* ***(e)*** *finely intercalated tan-weathering quartzite and green chlorite phyllite, Dycer Creek succession north of Mendocina Creek;* ***(f)*** *strongly foliated quartzite in upper part of Dycer Creek succession.*

lower clastic unit is intruded by numerous 1- to 3-m-thick sills of augen meta-granite, similar to granite dated as Early Mississippian to the east (*ca.* 355 Ma; Hansen *et al.*, 1989; Gallagher, 1999). The contact between the lower clastic unit and the overlying marble is everywhere concealed by Early Mississippian and Early Cretaceous granite intrusions in the map area (Fig. 2).

Marble of the Dycer Creek succession forms a prominent marker with an apparent thickness of ~1 km in the northeast corner of the map area (Fig. 6), and also occurs as 1- to 10-m-thick horizons within the lower clastic unit. The marble is typically light grey to white, coarsely recrystallized and locally contains coarse garnet-diopside-epidote-tremolite and skarn-style mineralization (pyrite-pyrrhotite±scheelite) near the Early Cretaceous granite. The marble passes gradationally into black calcareous meta-siltstone and carbonaceous phyllite to the west (Fig. 6), the most extensive unit of the Dycer Creek succession.

A chlorite phyllite unit occurs within the carbonaceous phyllite of the Dycer Creek succession north of Mendocina Creek (Fig. 2). This greenstone unit was previously unrecognized in the area (Tempelman-Kluit, 1977, 1984). It commonly contains up to 2% magnetite octahedrons and corresponds to a magnetic high on the regional aeromagnetic survey (Lowe *et al.*, 1999). The chlorite phyllite is locally intercalated with mm- to cm-scale horizons of carbonaceous phyllite or tan-weathering quartzite (Fig. 5e). The chlorite phyllite is gradationally overlain by quartzite, the structurally highest unit of the Dycer Creek succession.

Quartzite of the Dycer Creek succession is restricted to ridge-top exposures between Mendocina and Dycer creeks (Fig. 2). It is light greenish-grey, fine- to medium-grained, and typically displays mm- to cm-thick laminations parallel to an early foliation (Fig. 5f). The quartzite is locally gritty and arkosic, and interbedded with recessive grey phyllite.

Preliminary results of U/Pb isotopic analyses of detrital zircons from this unit suggests a primary derivation from a Late Devonian source and recycled Proterozoic and Archean cratonic sources (M. Colpron and G.E. Gehrels, unpublished data, 2005). This detrital zircon data, together with occurrences of *ca.* 355 Ma granite intruding the lower part of the succession, indicate a Lower Mississippian age for the Dycer Creek succession.

As is the case with the Last Peak succession, rocks of the Dycer Creek succession were previously assigned to Cassiar Terrane (with exception of the quartzite unit which was considered a klippe of Yukon-Tanana Terrane; Tempelman-Kluit, 1977, 1984; Gordey and Makepeace, 2000). These rocks are here re-assigned to Yukon-Tanana Terrane because (1) they are intruded by Early Mississippian granite; (2) they are in part derived from a Late Devonian arc source; and (3) all units have gradational contacts with adjacent units. Carbonaceous phyllite and quartzite of the Dycer Creek succession are probably correlative with similar rocks in the Last Peak

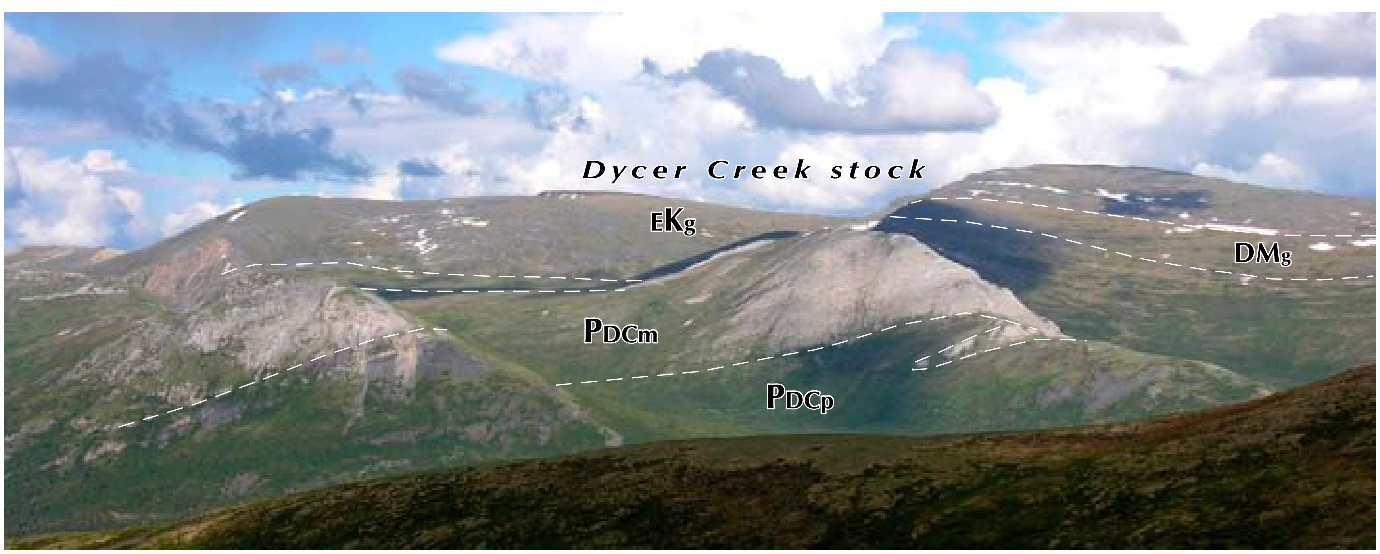

Figure 6. *Looking northeast across Dycer Creek at marble (PDCm) and black phyllite (PDCp) of the Dycer Creek succession. High ridge in background is underlain by peraluminous Early Cretaceous granite of the Dycer Creek stock (EKg) which intrudes the metasedimentary rocks and Early Mississippian meta-granite (DMg).*

succession west of d'Abbadie fault. The abundance of carbonaceous rocks and the Lower Mississippian age indicated for this sequence also suggest correlation of the Dycer Creek succession with either the Grass Lakes or the Wolverine Lake groups of the Finlayson Lake district (Murphy *et al.*, 2006; Colpron *et al.*, 2006).

INTRUSIVE ROCKS

At least five distinct suites of plutonic rocks intrude Yukon-Tanana Terrane in Livingstone Creek map area (Fig. 2). These are differentiated on the basis of composition, degree of deformation and age. They range in age from Late Devonian to Late Cretaceous.

The oldest suite includes Late Devonian to Early Mississippian augen meta-granite intruding rocks of the Last Peak and Dycer Creek successions. K-feldspar augen meta-granite, dated at *ca.* 358 Ma, forms an elongate body stretching more than 19 km along the western edge of d'Abbadie fault zone (Mendocina orthogneiss of Gallagher, 1999). This granite is generally coarse-grained, with K-feldspar augen up to 2 cm long, and is invariably strongly foliated and locally mylonitic (Fig. 7a). Biotite, muscovite, and locally garnet, occur as a metamorphic assemblage within the granite, presumably in part as the result of intrusion of a Late Cretaceous granite along d'Abbadie fault to the east (Last Peak granite of Gallagher, 1999). The western contact of the augen meta-granite with metasedimentary rocks of the Last Peak succession is typically transposed. Another similar augen meta-granite dated at *ca.* 355 Ma (Hansen *et al.*, 1989; and S.D. Carr, pers. comm., 2003) intrudes the lower clastic unit and marble of the Dycer Creek succession in the northeast corner of the map area. There, augen meta-granite occurs as a narrow tabular body which extends more than 10 km along the eastern contact of the marble unit (Little Lake granite of Gallagher, 1999) and as numerous 1- to 2-m-thick sills concordant with layering and the dominant foliation in the lower clastic unit (Fig. 7b).

Variably foliated K-feldspar porphyritic diorite to granodiorite is exposed in the southeast corner of the map area, between Mendocina Creek and the South Big Salmon River; the granodiorite yielded an imprecise U/Pb zircon age of *ca.* 369 Ma (Hansen *et al.*, 1989), and is likely, in part, from the same plutonic suite as Early Mississippian augen granites further north. However, as noted in Colpron (2005a), preliminary observations suggest that this body may consist of multiple intrusive phases, some of which may be related to the Early Cretaceous Quiet Lake batholith.

The largest intrusive body in the Livingstone Creek area consists of strongly foliated and locally gneissic tonalite to granodiorite which intrudes metasedimentary rocks of the Snowcap complex (Fig. 2, Colpron, 2005a). The rock is generally fine-grained and light to medium grey. Hornblende and biotite are common constituents and are locally concentrated in melanocratic bands up to 10 cm wide. Preliminary results of U/Pb analyses on zircons indicate an Early Mississippian age for this body (S.D. Carr, pers. comm., 2005), confirming correlation with the 345-355 Ma Simpson Range plutonic suite (e.g., Mortensen and Jilson, 1985; Colpron, 2005a).

Weakly foliated two-mica granite of Permian age (S.D. Carr, pers. comm., 2005) is a volumetrically small but widespread intrusive suite in the Livingstone Creek area (see Colpron, 2005a). It intrudes meta-tonalite in the Snowcap complex, as well as rocks of the Mendocina and Last Peak successions. The rock is usually white, medium- to coarse-grained and locally pegmatitic. Dykes of two-mica granite are typically 10-20 cm wide (up to 40 cm locally) and concordant with the dominant foliation. The dykes are invariably weakly foliated and locally display pinch-and-swell structures suggesting that the granite was emplaced during development of the dominant foliation.

The Dycer Creek stock, along the northeastern edge of the map area (Fig. 2), consists of medium- to coarse-grained, equigranular two-mica granite dated at *ca.* 112 Ma (U/Pb zircon, Gallagher, 1999). This granite is undeformed, although a weak mica foliation of magmatic origin is locally developed. Small, euhedral garnet also occurs locally. A contact metamorphic aureole, caused by emplacement of the Dycer Creek stock, extends a few kilometres away from the intrusion. Along its western sides, contact metamorphism is most notable by development of coarse-grained garnet-diopside-epidote skarn mineralogy in marble near the intrusion. Farther west, contact metamorphism is more subtle and expressed by local talc-tremolite assemblage in the marble. Contact metamorphism is more obvious north of the pluton, where coarse-grained garnet-biotite-andalusite assemblage in pelite and psammite (Fig. 5d), and coarse garnet-diopside-epidote skarns in calc-silicate and marble are widespread.

The youngest dated intrusive suite is represented by the *ca.* 96 Ma granite body which occurs along the western edge of the d'Abbadie fault zone in the northern part of

Figure 7. (a) *C-S fabrics and shear band in Early Mississippian augen granite indicate dextral ductile shear along d'Abbadie fault;* ***(b)*** *Early Mississippian augen granite intruding Dycer Creek succession in northeast corner of the map area;* ***(c)*** *Late Cretaceous porphyritic granite (LKg, right) near d'Abbadie fault is less penetratively deformed than Early Mississippian granite (DMg, left);* ***(d)*** *photomicrograph of cataclastic texture in Late Cretaceous granite along d'Abbadie fault. Plane-polarized light. The cataclastic fabric cuts across an earlier ductile foliation, shown along the upper and lower parts of the photo;* ***(e)*** *galena-bearing quartz vein at the RK showing (Yukon MINFILE 105E 064);* ***(f)*** *semi-massive to massive pyrrhotite horizon at the Dycer skarn showing (Yukon MINFILE 105E 065).*

the map area (Fig. 2, Last Peak granite of Gallagher, 1999). This pluton extends from near Dycer Creek to north of the Big Salmon River in the adjacent Teraktu Creek map area (NTS 105E/9). It is composed of medium- to coarse-grained, leucocratic K-feldspar porphyritic granite. The rock is variably foliated and locally protomylonitic along its eastern margin. This Late Cretaceous granite clearly intrudes Early Mississippian augen meta-granite and metasedimentary rocks of the Last Peak succession to the west. These latter rocks are more strongly foliated than the *ca.* 96 Ma granite (Fig. 7c) indicating that the granite was emplaced after part of the ductile strain was acquired by the older rocks. The Late Cretaceous granite imposes a contact aureole (hornfels) which extends more than 1 km to the west. A quartz-plagioclase pegmatite dyke and associated north-northwest-trending quartz veins occur approximately 1 km west of the intrusive contact and are probably related to the Late Cretaceous granite. They are undeformed and cross-cut all fabrics in the country rocks.

Finally, undated monzonite dykes and a small andesite porphyry plug observed in 2004 south of Livingstone Creek are likely related to one of the two Cretaceous intrusive suites.

STRUCTURE AND METAMORPHISM

Rocks of Yukon-Tanana Terrane in the Livingstone Creek area are penetratively deformed by at least three generations of ductile fabrics. Outcrop-scale structures are typically characterized by a pervasive transposition foliation (e.g., Fig. 5c,f) which commonly contains a well-developed elongation lineation. The transposition foliation generally strikes to the northwest and dips moderately to steeply to the southwest or northeast. It is axial planar to tight or isoclinal folds of an earlier foliation or metamorphic layering (*cf.* Colpron, 2005a). These structures control the map pattern west of d'Abbadie fault where lithologic contacts parallel the dominant foliation. East of the fault zone, the map pattern is the result of interference of two phases of non-coaxial tight to isoclinal folds. In this region, primary layering is locally preserved. The dominant foliation is everywhere folded by northeast-verging open folds. Further details of structural styles and evolution of Yukon-Tanana Terrane in the region are presented in Gallagher (1999) and de Keijzer (2000).

Rocks of Yukon-Tanana Terrane in the area are generally metamorphosed to upper greenschist facies (biotite grade). Garnet-grade assemblages (amphibolite facies) are locally present in rocks of the Snowcap complex. In the southern part of the area, garnet is syntectonic with respect to the transposition foliation and typically partially retrograded to chlorite. North of Mendocina Creek, garnet is post-tectonic, euhedral and fresh, suggesting that this part of the region was subjected to a later thermal event (concealed intrusion?). Garnet-grade assemblages are also developed in the contact aureole of the Cretaceous plutons.

D'ABBADIE FAULT

The north-trending d'Abbadie fault zone is the most striking structural feature in Livingstone Creek map area (Fig. 2). It is an approximately 1-km-wide zone of imbricate fault slices, which run the length of the map area near its eastern edge. It juxtaposes rocks of the Dycer Creek succession on the east against Mendocina and Last Peak successions to the west. The d'Abbadie fault zone is characterized by multiple generations of ductile fabrics and younger brittle structures, all of which are associated with shallow north-plunging stretching lineations (or slickenlines, on brittle fault planes). Ductile deformation along the fault was consistently dextral, as indicated by C-S fabrics (e.g., Fig. 7a), shear bands and rotated porphyroclasts. Mylonitic fabric is best developed in the Early Mississippian augen meta-granite which bounds the d'Abbadie fault zone to the west (Fig. 2). The mylonitic fabric in the augen meta-granite is locally cross-cut by lesser deformed Late Cretaceous granite, suggesting that ductile deformation along d'Abbadie fault began before 96 Ma (Fig. 7c). Development of a protomylonitic fabric along the eastern edge of the Late Cretaceous granite indicates that ductile deformation continued during and after emplacement of this granite. In addition, ductile strain extends more than 1.5 km in rocks west of the d'Abbadie fault zone along the northern half of the map area, where Late Cretaceous granite occurs along the fault; this suggests that heat from the granite facilitated development of ductile fabrics along the fault zone. Faulting continued after cooling of the Late Cretaceous granite as indicated by development of cataclastic breccia (Fig. 7d) and chlorite-coated brittle faults with dextral step-fibres.

Displacement along d'Abbadie fault is poorly constrained. Dextral displacement in the order of ~4 km has been suggested by Harvey *et al.* (1996) on the basis of offset of structural features.

MINERAL POTENTIAL

An estimated 50,000 ounces (1.6 million grams) of gold has been recovered from placers of the Livingstone Creek area since 1898 (W. LeBarge, pers. comm., 2004); however, its lode source remains elusive. The gold typically occurs as coarse (>1 cm) nuggets and is commonly associated with magnetite suggesting a nearby source and potentially a skarn style of mineralization. It is noteworthy that placer streams in the Livingstone camp generally occur around the large Early Mississippian meta-tonalite body that intrudes Snowcap complex in the western part of the area. Skarn-style mineralization associated with this intrusion may represent a lode source for the Livingstone gold. Evidence for skarn development near this intrusion was only locally noted during regional mapping.

Two new showings were discovered during regional mapping in 2005. The RK showing (105E 064, new showings listed here will be added to Yukon MINFILE, Deklerk and Traynor, 2005) consists of galena mineralization in a quartz vein (Fig. 7e). The galena occurs as fine- to medium-grained pods less than 2 cm-wide randomly distributed in the quartz vein. This vein forms part of a system of north-northwest-trending quartz veins that occurs approximately 1 km west of, and parallels, the western edge of d'Abbadie fault zone along the northern part of the area. These veins are typically 2-4 m wide, discontinuous and extend for some 7 km north into the Teraktu map area (NTS 105E/9). Assay results from three grab samples containing galena in quartz returned anomalous values in lead and silver (Table 1, 05MC085-1, -2, -3).

The Dycer showing (Yukon MINFILE 105E 065) corresponds to a 1-m-thick horizon of semi-massive to massive pyrrhotite, which occurs in association with skarn-style mineralogy (garnet-diopside-epidote) in marble of the Dycer Creek succession near the contact with the Early Cretaceous Dycer Creek stock (Fig. 7f). Assay results from four grab samples show anomalous values in copper and lead (Table 1, samples 05MC101-3, 05MC105-1, -2, -3).

Finally, a sample of pyrite-malachite vein (<1 cm wide) was collected near an occurrence of chlorite schist in graphitic phyllite of the Last Peak succession (sample 05MC011-1 on Fig. 2). The graphitic phyllite in the immediate area is commonly rusty weathering and contains disseminated pyrite-pyrrhotite. The assay analysis of this grab sample is anomalous in copper and zinc (Table 1, sample 05MC011-1). Occurrences of disseminated sulphide minerals in graphitic phyllite near metavolcanic rocks suggest the potential for volcanogenic massive sulphide- (VMS) or hybrid VMS-sedimentary exhalative-style mineralization in the Last Peak succession. Possible correlation of these rocks with the Grass Lakes or Wolverine Lake groups of the Finlayson Lake district further enhances the mineral potential of this unit.

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Table 1. *Selected assay results from the Livingstone Creek map area.*

Element	05MC011-1	05MC085-1	05MC085-2	05MC085-3	05MC101-3	05MC105-1	05MC105-2	05MC105-3
	pyrite-malachite vein	galena in quartz vein			pyrrhotite skarn			
Mo (ppm)	0.24	0.65	1.63	0.45	16.22	3.62	1.76	1.5
Cu (ppm)	998.31	35.03	120.53	21.5	1883.65	369.7	1081.17	964.71
Pb (ppm)	13.66	2.03%	7.78%	2.63%	594.64	400.06	68.87	30.22
Zn (ppm)	3132.2	5.8	42.8	3.5	324	40.9	92.9	115.8
Ag (ppb)	535	53 530	108 252	52 468	2912	1315	1586	1456
Ni (ppm)	8.9	5.2	6.5	2.8	7.8	61.5	31	28.9
Co (ppm)	27.1	1.3	2.6	0.6	57.5	92.7	60	48.4
Mn (ppm)	3257	24	812	32	1345	617	1163	1768
Fe (%)	4.83	0.7	1.64	0.6	34.84	36.82	19.33	20.9
As (ppm)	1.4	1.7	<.2	<.2	4.2	0.7	5.8	2
U (ppm)	<.1	0.1	0.6	<.1	1.3	4.2	8.2	3.9
Au (ppb)	15.7	<.100	<.100	<.100	<.100	<.100	<.100	<.100
Cd (ppm)	14.82	4.8	48.93	7.96	1.16	0.17	0.41	0.46
Sb (ppm)	0.07	4.04	10.08	4.56	0.19	0.09	0.11	0.06
Bi (ppm)	0.2	124.06	257.82	130.25	6.86	5.15	2.5	2.2
Cr (ppm)	5.4	6	24	18	8	16	21	11
W (ppm)	<.1	0.1	0.3	<.1	0.2	0.6	50.1	2.7
Zr (ppm)	0.8	2.1	7.6	2.5	3.1	7.7	22.2	11.4
Sn (ppm)	0.1	0.9	2.5	1	1.7	2.5	10.3	3.2
S (%)	0.14	0.48	1.38	0.63	>10	>10	7.86	>10
Y (ppm)	3.99	0.4	19.9	1	2.2	21.3	53.2	34
Ce (ppm)	3	1.13	9.65	0.26	18.66	62.8	97.77	81.36
Hf (ppm)	0.03	0.08	0.22	0.06	0.11	0.28	1	0.38
Li (ppm)	17.5	1.9	2.2	0.3	28	12.5	17.4	28.8
Easting	545490	546228	546228	546228	552213	552047	552047	552047
Northing	6806368	6816345	6816345	6816345	6812029	6812107	6812107	6812107
Yukon MINFILE (Deklerk and Traynor, 2005)		105E 064	105E 064	105E 064	105E 065	105E 065	105E 065	105E 065

Notes: Sample 05MC011-1 was analysed by ICP-MS (inductively coupled plasma mass spectrometry) on a 30-g split digested by aqua regia method; all other samples were analysed by ICP-MS on a 0.25-g split prepared by a 4-acid digestion method. Percent-level analyses for samples 05MC085-1, -2, -3 were analysed by ICP-ES on a 1-g split digested by aqua-regia method. All samples are grabs of mineralized material. All samples analysed at Acme Laboratories in Vancouver, B.C. Coordinates for all samples are given in Universal Transverse Mercator projection, Zone 8v, North American Datum 1983.

REFERENCES

Barresi, T., 2004. Sedimentology, structure, and depositional setting of the Loon Lake sedimentary rock unit, southern Semenof Hills, central Yukon. Unpublished B.Sc. Honours thesis. Saint Mary's University, Halifax, Nova Scotia, 85 p.

Bostock, H.S. and Lees, E.J., 1938. Laberge map-area, Yukon. Geological Survey of Canada, Geological map (105E), 1:253 440 scale, and report, 33 p.

Colpron, M., 2005a. Preliminary investigation of the bedrock geology of the Livingstone Creek area (NTS 105E/8), south-central Yukon. In: Yukon Exploration and Geology 2004, D.S. Emond, L.L. Lewis and G.D. Bradshaw (eds.), Yukon Geological Survey, p. 95-107.

Colpron, M., 2005b. Geological map of Livingstone Creek area (NTS 105E/8), Yukon (1:50 000 scale). Yukon Geological Survey, Open File 2005-9.

Colpron, M., Nelson, J.L. and Murphy, D.C., 2006. A tectonostratigraphic framework for the pericratonic terranes of the northern Cordillera. *In:* Paleozoic Evolution and Metallogeny of Pericratonic Terranes at the Ancient Pacific Margin of North America, Canadian and Alaskan Cordillera, M. Colpron and J.L. Nelson (eds.), Geological Association of Canada, Special Paper 45, in press.

Colpron, M., Murphy, D.C., Nelson, J.L., Roots, C.F., Gladwin, K., Gordey, S.P. and Abbott, J.G., 2003. Yukon Targeted Geoscience Initiative, Part 1: Results of accelerated bedrock mapping in Glenlyon (105L/1-7, 11-14) and northeast Carmacks (115I/9,16) areas, central Yukon. *In:* Yukon Exploration and Geology 2002, D.S. Emond and L.L. Lewis (eds.), Exploration and Geological Services Division, Yukon Region, Indian and Northern Affairs Canada, p. 85-108.

Colpron, M., Murphy, D.C., Nelson, J.L., Roots, C.F., Gladwin, K., Gordey, S.P., Abbott, G. and Lipovsky, P.S., 2002. Preliminary geological map of Glenlyon (105L/1-7, 11-14) and northeast Carmacks (115I/9,16) areas, Yukon Territory (1:125 000 scale). Exploration and Geological Services Division, Yukon Region, Indian and Northern Affairs Canada, Open File 2002-9; also Geological Survey of Canada, Open File 1457.

de Keijzer, M., Williams, P.F. and Brown, R.L., 1999. Kilometre-scale folding in the Teslin zone, northern Canadian Cordillera, and its tectonic implications for the accretion of the Yukon-Tanana terrane to North America. Canadian Journal of Earth Sciences, vol. 39, p. 479-494.

de Keijzer, M., 2000. Tectonic evolution of the Teslin zone and the western Cassiar terrane, northern Canadian Cordillera. Unpublished Ph.D. thesis, University of New Brunswick, Fredericton, New Brunswick, 391 p.

Gallagher, C., Brown, R.L. and Carr, S.D., 1998. Structural geometry of the Cassiar Platform and Teslin zone, Dycer Creek area, Yukon. *In:* Slave-Northern Cordillera Lithospheric Evolution (SNORCLE) Transect and Cordilleran Tectonic Workshop Meeting, F. Cook and P. Erdmer (eds.), Lithoprobe Report No. 64, p. 139-151.

Gallagher, C.S., 1999. Regional-scale transposition and late large-scale folding in the Teslin Zone, Pelly Mountains, Yukon. Unpublished M.Sc. thesis, Carleton University, Ottawa, Ontario, 199 p.

Gordey, S.P. and Makepeace, A.J., 2000. Bedrock geology, Yukon Territory. Exploration and Geological Services Division, Yukon Region, Indian and Northern Affairs Canada, Open File 2001-1; also known as Geological Survey of Canada, Open File 3754, 1:1 000 000 scale.

Hansen, V.L., 1989. Structural and kinematic evolution of the Teslin suture zone, Yukon: Record of an ancient transpressional margin. Journal of Structural Geology, vol. 11, p. 717-733.

Hansen, V.L., 1992. Backflow and margin-parallel shear within an ancient subduction complex. Geology, vol. 20, p. 71-74.

Hansen, V.L., Mortensen, J.K. and Armstrong, R.L., 1989. U-Pb, Rb-Sr, and K-Ar isotopic constraints for ductile deformation and related metamorphism in the Teslin suture zone, Yukon-Tanana terrane, south-central Yukon. Canadian Journal of Earth Sciences, vol. 26, p. 2224-2235.

Harvey, J.L., Brown, R.L. and Carr, S.D., 1996. Progress in structural mapping in the Teslin suture zone, Big Salmon Range, central Yukon Territory. *In:* Slave-Northern Cordillera Lithospheric Evolution (SNORCLE) Transect and Cordilleran Tectonic Workshop Meeting, F. Cook and P. Erdmer (eds.), Lithoprobe Report No. 50, p. 33-44.

Harvey, J.L., Carr, S.D., Brown, R.L. and Gallagher, C., 1997. Deformation history and geochronology of plutonic rocks near the d'Abbadie fault, Big Salmon Range, Yukon. *In:* Slave-Northern Cordillera Lithospheric Evolution (SNORCLE) Transect and Cordilleran Tectonic Workshop Meeting, F. Cook and P. Erdmer (eds.), Lithoprobe Report No. 56, p. 103-114.

Levson, V., 1992. The sedimentology of Pleistocene deposits associated with placer gold bearing gravels in the Livingstone Creek area, Yukon Territory. *In:* Yukon Geology, Exploration and Geological Services Division, Yukon Region, Indian and Northern Affairs Canada, Volume 3, p. 99-132.

Lipovsky, P.S., LeBarge, W., Bond, J.D. and Lowey, G., 2001. Yukon placer activity map. Exploration and Geological Services Division, Yukon Region, Indian and Northern Affairs Canada, Open File 2001-30, 1:1 000 000 scale.

Lowe, C., Kung, R. and Makepeace, A.J., 1999. Aeromagnetic data over Yukon Territory. *In:* Yukon digital geology, S.P. Gordey and A.J. Makepeace (eds.), Exploration and Geological Services Division, Yukon Region, Indian and Northern Affairs Canada, Open File 1999-1(D); also known as Geological Survey of Canada, Open File D3826.

Mortensen, J.K. and Jilson, G.A., 1985. Evolution of the Yukon-Tanana terrane: evidence from southeastern Yukon Territory. Geology, vol. 13, p. 806-810.

Murphy, D.C., Colpron, M., Roots, C.F., Gordey, S.P. and Abbott, J.G., 2002. Finlayson Lake Targeted Geoscience Initiative (southeastern Yukon), Part 1: Bedrock geology. *In:* Yukon Exploration and Geology 2001, D.S. Emond, L.H. Weston and L.L. Lewis (eds.), Exploration and Geological Services Division, Yukon Region, Indian and Northern Affairs Canada, p. 189-207.

Murphy, D.C., Mortensen, J.K., Piercey, S.J., Orchard, M.J. and Gehrels, G.E., 2006. Mid-Paleozoic to Early Mesozoic tectonostratigraphic evolution of Yukon-Tanana and Slide Mountain terranes and affiliated overlap assemblages, Finlayson Lake massive sulphide district, southeasternYukon. *In:* Paleozoic Evolution and Metallogeny of Pericratonic terranes at the Ancient Pacific Margin of North America, Canadian and Alaskan Cordillera, M. Colpron and J.L. Nelson (eds.), Geological Association of Canada, Special Paper 45, in press.

Murphy, D.C., Colpron, M., Gordey, S.P., Roots, C.F., Abbott, G. and Lipovsky, P.S., 2001. Preliminary bedrock geological map of northern Finlayson Lake area (NTS 105G), Yukon Territory (1:100 000 scale). Exploration and Geological Services Division, Yukon Region, Indian and Northern Affairs Canada, Open File 2001-33.

Simard, R.-L., 2003. Geological map of southern Semenof Hills (part of NTS 105E/1,7,8), south-central Yukon (1:50 000 scale). Yukon Geological Survey, Open File 2003-12.

Simard, R.-L. and Devine, F., 2003. Preliminary geology of the southern Semenof Hills, central Yukon (105E/1,7,8). *In:* Yukon Exploration and Geology 2002, D.S. Emond and L.L. Lewis (eds.), Exploration and Geological Services Division, Yukon Region, Indian and Northern Affairs Canada, p. 213-222.

Tempelman-Kluit, D.J., 1977. Quiet Lake (105F) and Finlayson Lake (105G) map areas, Yukon Territory. Geological Survey of Canada, Open File 486, 1:250 000.

Tempelman-Kluit, D.J., 1979. Transported cataclasite, ophiolite and granodiorite in Yukon: evidence of arc-continent collision. Geological Survey of Canada, 27 p.

Tempelman-Kluit, D.J., 1984. Geology, Laberge (105E) and Carmacks (105I), Yukon Territory. Geological Survey of Canada, Open File 1101, 1:250 000 scale.

Wheeler, J.O., Brookfield, A.J., Gabrielse, H., Monger, J.W.H., Tipper, H.W. and Woodsworth, G.J., 1991. Terrane Map of the Canadian Cordillera. Geological Survey of Canada, Map 1713A, 1:2 000 000 scale.