Yukon-Tanana Terrane in southwestern Frances Lake area (105H/3, 4 and 5), southeastern Yukon

Donald C. Murphy[1]
Yukon Geology Program

Murphy, D.C., 2001. Yukon-Tanana Terrane in southwestern Frances Lake area (105H/3, 4 and 5), southeastern Yukon. *In:* Yukon Exploration and Geology 2000, D.S. Emond and L.H. Weston (eds.), Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p. 217-233.

ABSTRACT

Yukon-Tanana Terrane (YTT) in Frances Lake area consists of three domains, the Money/Jules Creek thrust sheet, the footwall of the Jules Creek thrust, and a northeastern domain defined primarily by Permian (?) conglomerate. The Money/Jules Creek thrust sheet comprises chert, dark argillite and limestone, Mississippian meta-volcanic and meta-plutonic rocks, and Pennsylvanian carbonate. A dark argillite, chert, and coarse clastic unit of probable Pennsylvanian age unconformably overlies both the hanging wall and footwall of the Money Creek thrust. The footwall of the Jules Creek thrust comprises a lower unit of dark argillite, chert, chert-pebble conglomerate, and rare sandstone, limestone and variegated chert, and unconformably overlying conglomerate and basalt. The Pennsylvanian-Permian Campbell Range basalt overlies, probably unconformably, rock units of both domains. The northeastern domain comprises mainly Permian (?) polymictic conglomerate and sandstone. Conglomerate clasts come from YTT, implying an unconformable relationship.

The back-arc rocks of YTT that host the Finlayson Lake volcanogenic massive sulphide (VMS) deposits are truncated by the Money Creek thrust; however, VMS-style prospects occur in coeval volcanic arc rocks in the Money Creek thrust sheet, attesting to the potential for new deposits in these rocks.

RÉSUMÉ

Le Terrane de Yukon-Tanana (TYT) dans la région de Frances Lake comprend trois domaines : la nappe de Money/Jules Creek; le mur du chevauchement de Jules Creek; et un domaine nord-est défini principalement par un conglomérat d'âge Permien (?). La nappe de Money/Jules Creek est constituée de chert, d'argilite noire et de calcaire, de roches métavolcaniques et métaplutoniques d'âge Mississippien, et de carbonate du Pennsylvanien. Une unité d'argilite noire, de chert et de roches clastiques grossières, probablement du Pennsylvanien, repose en discordance à la fois sur le toit et le mur du chevauchement de Money Creek. Le mur du chevauchement de Jules Creek comprend une unité inférieure composée d'argilite noire, de chert, d'un conglomérat à galets de chert et d'un peu de grès, de calcaire et de chert bigarré, surmonté en discordance d'un conglomérat et de basalte. Le basalte de Campbell Range d'âge Pennsylvanien-Permien repose, probablement en discordance, sur les unités lithostratigraphiques des deux domaines. Le domaine nord-est se compose principalement de grès et d'un conglomérat polymictique d'âge Permien (?). Les constituents du conglomérat proviennent du TYT, indiquant une relation de discordance.

Les roches d'arrière-arc du TYT qui renferment les gisements de sulfure massif volcanogénique (SMV) de Finlayson Lake sont recoupées par le chevauchement de Money Creek; toutefois, des zones d'intérêt pour des gisements de type SMV se retrouvent dans les roches d'arc volcanique contemporaines dans la nappe de Money Creek, attestant de la possibilité d'y découvrir de nouveaux gisements.

[1]*don.murphy@gov.yk.ca*

INTRODUCTION

Geological mapping in Yukon-Tanana Terrane south of Finlayson Lake by Yukon Geology Program (Fig. 1) has had two goals since its inception in 1996: 1) to understand the geological setting of the volcanogenic massive sulphide deposits and prospects in the area, and 2) to extend this insight into less understood areas. The 2000 field season was directed toward this latter goal with new mapping in areas south and east of the core of the Finlayson Lake district. Parts of Klatsa River (105H/3), 'Tuchitua River North' (105H/4) and Money Creek (105H/5) areas were mapped at 1:50 000 scale (Figs. 1, 2; Murphy, 2000a, b, c). This report documents the stratigraphy of Yukon-Tanana Terrane in this area and outlines areas underlain by volcanic rocks with potential for volcanogenic massive sulphide deposits. A new interpretation of the nature of ultramafic rocks in the area is also presented, one with implications for the exploration for Ni-Cu-PGM deposits. Finally, the setting of eclogite-facies metamorphic rocks in Klatsa River (105H/3) area is addressed.

PREVIOUS WORK

The geology of Yukon-Tanana Terrane in Frances Lake map area has not been documented at scales better than 1:250 000. Blusson (1966a, b, 1967) reported on 1:250 000-scale mapping of the Frances Lake map area, including the southwest corner. Mortensen (1983) and

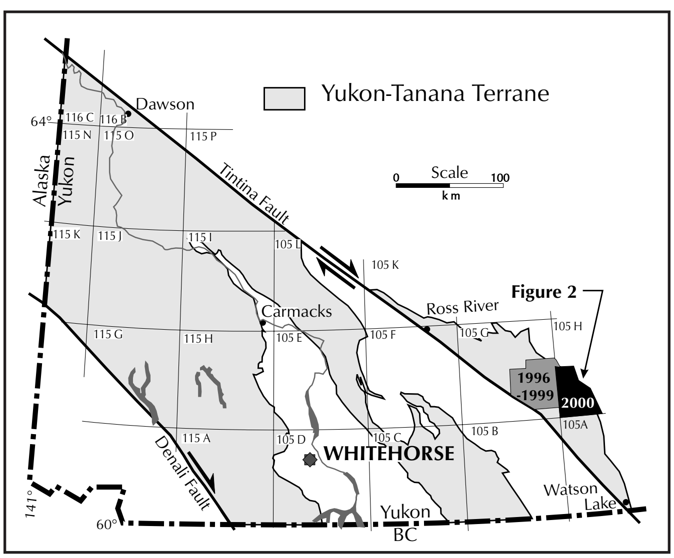

Figure 1. Map of southern Yukon showing location of Figure 2 with respect to distribution of Yukon-Tanana Terrane.

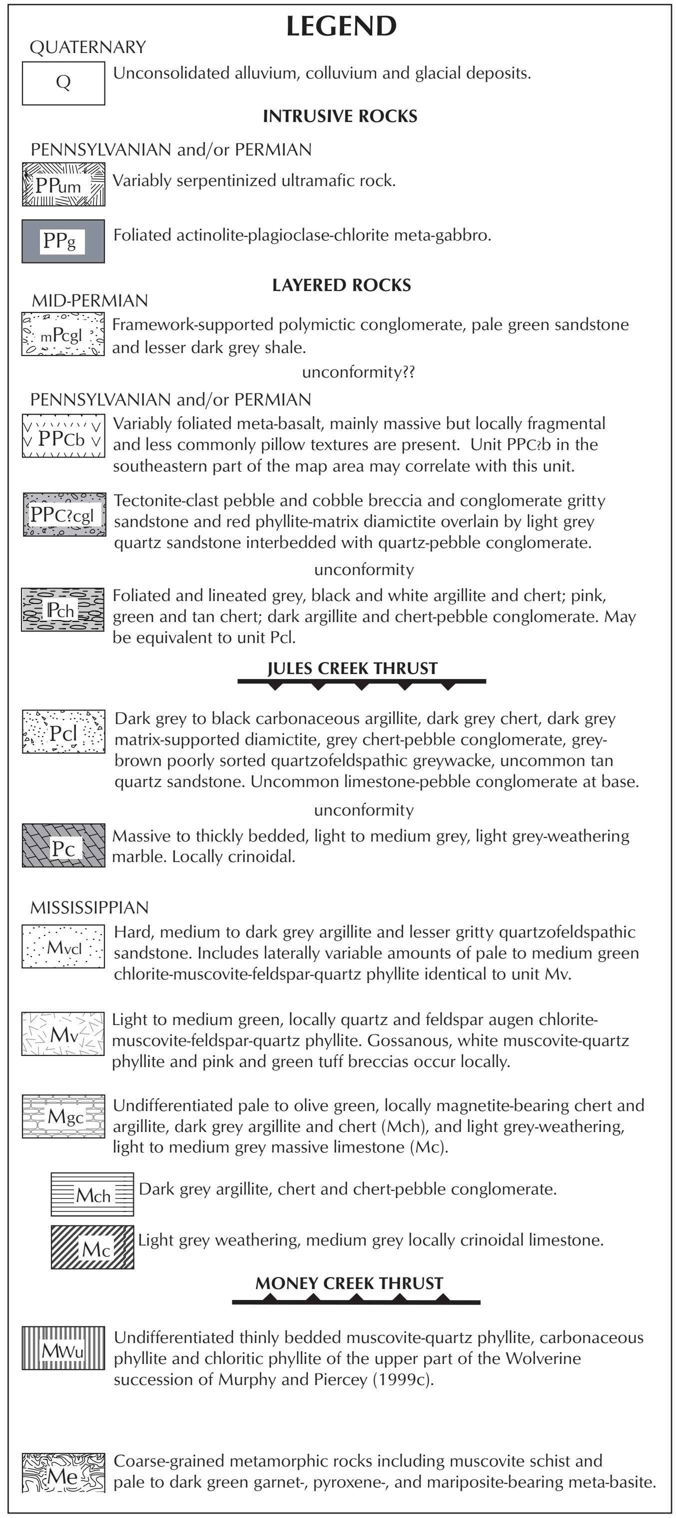

Figure 2 (above and on next page). Simplified compilation map of new geological mapping in southwestern Frances Lake area (Murphy, 2000a,b,c). Regional stream-sediment samples (Hornbrook and Friske, 1988), with anomalous Ni and Cu contents, are superimposed on the geology in the southeastern part of the area.

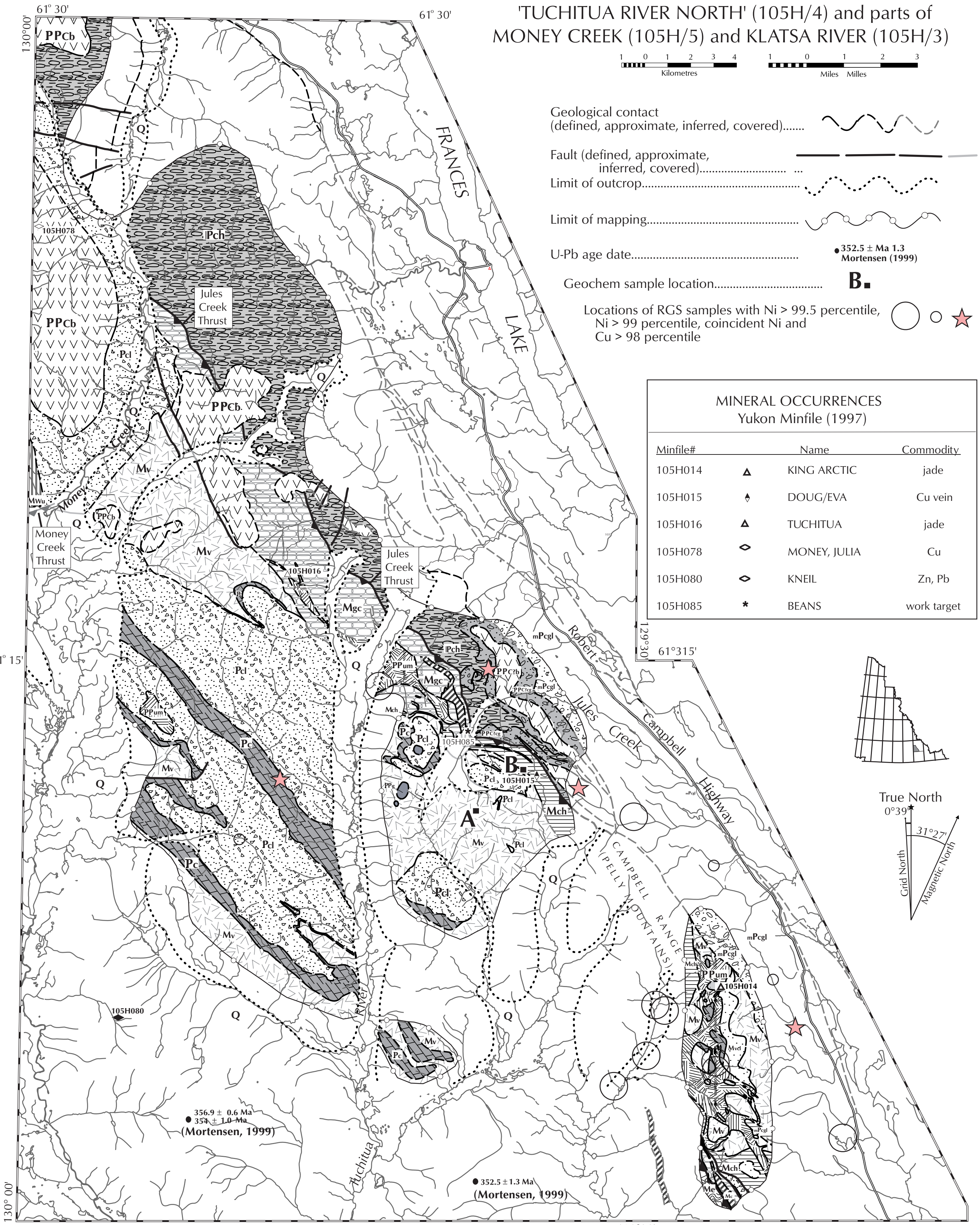

Figure 2 *continued.*

Mortensen and Jilson (1985) mapped this part of Frances Lake map area in the course of regional reconnaissance of Yukon-Tanana Terrane north of the Tintina Fault. Mortensen (1983, 1992, 1999) reported U-Pb age dates from meta-volcanic and meta-plutonic rocks from this area. Erdmer et al. (1998) reported on investigations of eclogite facies metamorphic rocks in this area.

Small parts of Frances Lake map area are included in a 1:100 000 compilation (Murphy and Piercey, 1999a) of recent mapping in the Finlayson Lake massive sulphide district (Murphy, 1997; Murphy and Piercey, 1999b). This work has shown that most of the deposits of the district (Kudz Ze Kayah, GP4F and Wolverine) occur in two felsic meta-volcanic rock units of Devono-Mississippian and

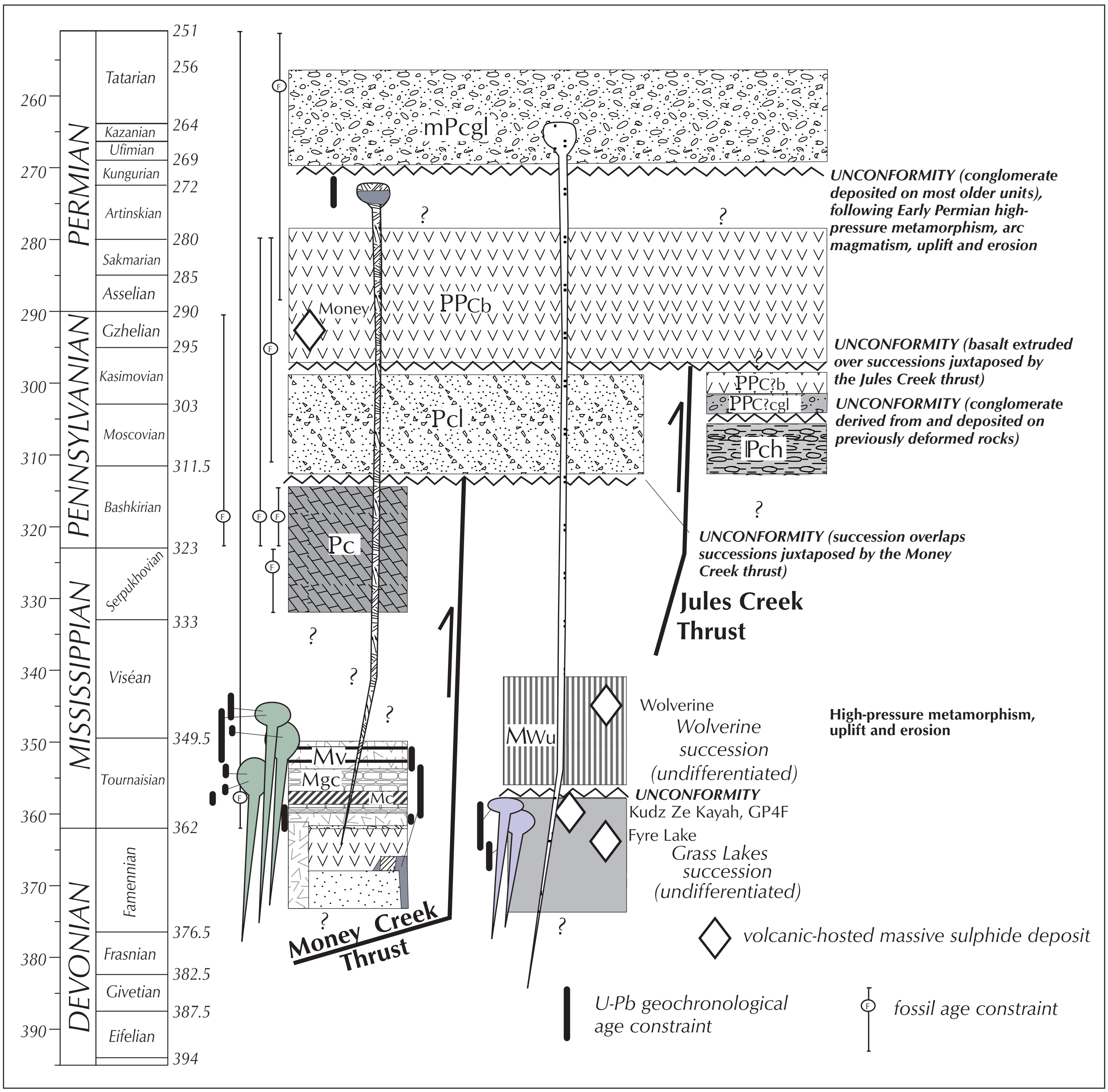

Figure 3. *Summary of stratigraphy and stratigraphic relationships in southwestern Frances Lake area. Legend same as in Figure 2.*

early Mississippian age that likely formed in an ensialic back-arc region (Murphy and Piercey, 1999c; Piercey et al., 2000, in review). This region was overthrust from the south-southwest along the Money Creek thrust by a sequence of rocks including coeval mafic to felsic meta-volcanic rocks with geological and geochemical characteristics of arc volcanic rocks. The back-arc strata trend southeastwardly out of the area of the known deposits; however, the Money Creek thrust trends eastwardly where last mapped and appears to truncate these highly prospective back-arc strata. A major goal of the 2000 field season was to determine the extent of these rocks in the Frances Lake area.

YUKON-TANANA TERRANE IN SW FRANCES LAKE AREA

Yukon-Tanana Terrane in southwestern Frances Lake area consists of several fault- or unconformity-bound successions (Figs. 2 and 3). The most extensive succession is found in the Money Creek thrust sheet. Rocks of the Money Creek thrust sheet are bounded by the Money Creek thrust and unconformably overlying rocks on the north, the Jules Creek thrust on the northeast, and extend out of the area to the south and west. A succession of dark chert and meta-clastic rocks unconformably overlies the Money Creek thrust sheet. A similar, possibly correlative, chert-rich succession occurs in the footwall of the Jules Creek thrust where it is overlain unconformably by a succession of coarse, post-orogenic meta-clastic rocks and meta-basalt. The Campbell Range basalt and lesser chert overlies, probably unconformably, different units belonging to all of these successions. The easternmost succession, extending into the broad Frances Lake lowlands, consists primarily of a distinctive mid-Permian to possibly Triassic polymictic conglomerate and sandstone unit that is inferred, based on clast composition, to unconformably overlie the other successions. This succession lies between rocks of Yukon-Tanana Terrane and ancestral North America, making it an important key to the understanding of the relationship between these elements. In addition to meta-sedimentary and meta-volcanic rocks, mafic and serpentinized ultramafic meta-plutonic rocks occur in all but the latter succession (except as clasts).

MONEY CREEK THRUST SHEET

The Money Creek thrust was originally documented in the southern part of Finlayson Lake area (Murphy and Piercey, 1999a, b, 2000; Piercey and Murphy, 2000; the thrust sheet includes the Money and North Klippe of Tempelman-Kluit (1979) and its trace incorporates the trace of a thrust inferred by Mortensen and Jilson (1985)). In southern Finlayson Lake area, the thrust sheet is made up of Devono-Mississippian mafic and felsic meta-volcanic rocks, mafic and ultramafic meta-plutonic rocks and lesser meta-chert, dark phyllite and limestone; these rocks are intruded by variably foliated early Mississippian hornblende-bearing granitic meta-plutonic rocks. Hanging-wall rocks have been traced eastwardly into southwestern Wolverine Lake area (105G/8, Murphy and Piercey, 1999b) and northeastern Waters Creek area (105G/1; Murphy and Piercey, 1999a) where they disappear into the broad valley occupied in part by Money Creek and in part by an un-named tributary to the Tuchitua River. The easterly or eastward trend of the rocks in the thrust sheet cuts across the southeastward trend of the early Mississippian and older Grass Lakes and Wolverine successions in the footwall.

Rocks east of this broad valley resemble the hanging-wall rocks in southern Wolverine Lake area. They consist of a succession comprising a lower unit of meta-chert, dark meta-clastic rocks and limestone (units Mgc, Mch and Mc); intermediate to felsic meta-volcanic rocks (unit Mv); and a laterally continuous, crinoidal limestone (unit Pc). The oldest rocks in the Money Creek thrust sheet in Frances Lake map area occur along the eastern edge of the sheet, along the Jules Creek thrust (Fig. 2). Unit Mgc is composed primarily of locally magnetite-bearing, laminated pale green and tan chert and waxy tan and greenish-grey argillite (Fig. 4). The presence of magnetite

Figure 4. *Unit Mgc: pale green chert and lesser tan chert and argillite.*

Figure 5. *Unit Mc: marble and garnet diopside skarn in unit Mc along contact with ultramafic rocks.*

and the lack of visible radiolaria and ribbon bedding typical of radiolarian chert suggests that this unit is not of biogenic origin and likely is a volcanogenic deposit, possibly a distal tuff. With pale green chert above and below it, unit Mc, a variably thick, pale-grey-weathering, medium grey limestone, occurs as a member within unit Mgc. Unit Mc locally is metamorphosed to coarse-grained diopside-epidote rock along contacts with ultramafic rocks (Fig. 5). Dark chert, argillite and lesser quartzite of unit Mch (Fig. 6) overlies unit Mgc north of Jules Creek; southeast of Jules Creek, unit Mch appears to be laterally equivalent to unit Mgc. Intermediate and locally felsic meta-igneous rocks, either sub-volcanic feeders to unit Mv or meta-volcanic rocks, occur locally in units Mgc, Mc and Mch.

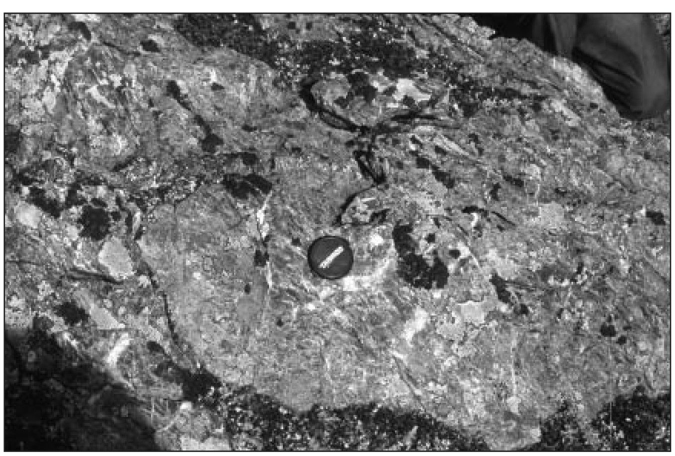

Figure 6. *Unit Mch: medium grey siliceous argillite and quartzite.*

Units Mgc, Mc and Mch are indirectly constrained to be early Mississippian in age. They are overlain by volcanic rocks of unit Mv from which an early Mississippian U-Pb age date was obtained (Mortensen, 1999; see below). In the western part of the Money Creek thrust sheet, similar pale green chert and dark argillite overlies mafic and lesser felsic meta-volcanic rocks of Devono-Mississippian age (Murphy and Piercey, 2000).

Dark chert and meta-clastic rocks of unit Mch are overlain by intermediate to felsic meta-volcanic rocks of unit Mv. This unit extends southward from Money Creek to south of Jules Creek. It was also found in Klatsa River area (105H/3) and likely continues southward into Watson Lake area (105A; Mortensen and Jilson, 1985). Unit Mv comprises mainly medium green chloritic phyllite with less common muscovite-quartz phyllite (Fig. 7a). Quartz and feldspar augen occur locally in the chloritic phyllite

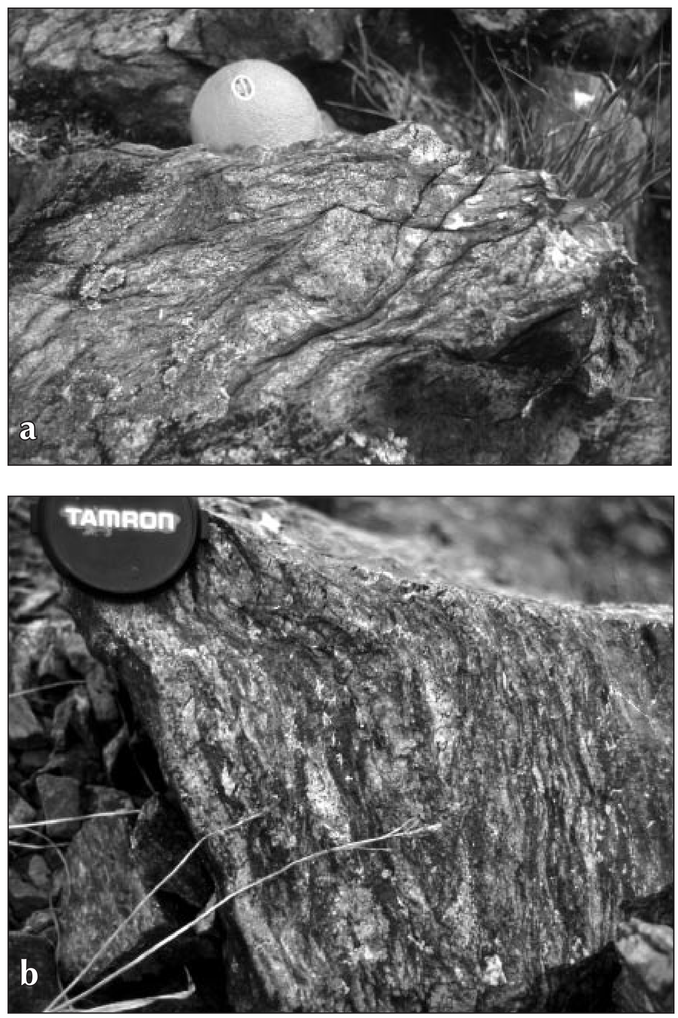

Figure 7 (above and right). *Unit Mv: (a) chloritic phyllite; (b) foliated fragmental rock; (c) rhyodacitic tuff breccia.*

and fragmental textures are locally well preserved (Fig. 7b). In its western outcrop belt in 'Tuchitua River North' area, unit Mv also contains foliated pink and whitish-green rhyodacitic tuff breccia (Fig. 7c). Pyrite is locally abundant in chloritic phyllite and muscovite-quartz phyllite; the latter commonly host laterally extensive gossans south and east of Jules Creek. The age of unit Mv is constrained by one U-Pb age date of 352.5 ± 1.3 Ma obtained from samples of rhyodacitic tuff breccia (Mortensen, 1999).

A laterally extensive limestone unit (unit Pc) overlies unit Mv, with sharp contact (Figs. 2, 8a). Unit Pc consists primarily of foliated and recrystallized, light grey-weathering, medium grey limestone. Randomly oriented crinoid fragments and disarticulated columnals occur in many outcrops suggesting that the unit is bioclastic in origin (Fig. 8b). Intraformational breccia also occurs locally. Bedding is typically massive and thick (m-scale); locally decimetre-scale bands of white to tan quartz of probable replacement origin occur parallel to a compositional layering that is likely bedding. The age of unit Pc is loosely constrained in this area by one early Pennsylvanian to Early Permian conodont collection (Bashkirian-Sakmarian; M. Orchard and J.K. Mortensen, *in:* Poulton et al., 1999). Similar limestone in Watson Lake area contains Bashkirian (early Pennsylvanian) conodonts (Poulton et al., 1999) and in Finlayson Lake area, Serpukhovian conodonts (late Mississippian; J. Hunt, pers. comm., 1998; identification by M. Orchard). A late Mississippian to early Pennsylvanian age is therefore favoured based on the inferred ages of overlying rocks discussed below.

DARK CHERT AND CLASTIC UNIT (Pcl)

The rock units of the Money Creek thrust sheet and the Wolverine succession in the footwall of the Money Creek thrust are overlain by a regionally extensive heterogeneous unit of dark chert, meta-clastic rocks and rare limestone (unit Pcl). Unit Pcl consists primarily of locally sooty, probably carbonaceous dark argillite with laterally and vertically variable amounts of thin- to medium-bedded grey and grey-green chert (Fig. 9a) and a variety of meta-clastic rocks. Pink and green argillite and ribbon chert occur locally in the lower part of the unit, with beds of light grey-weathering, medium grey limestone up to 5 m thick and rare fine-grained green

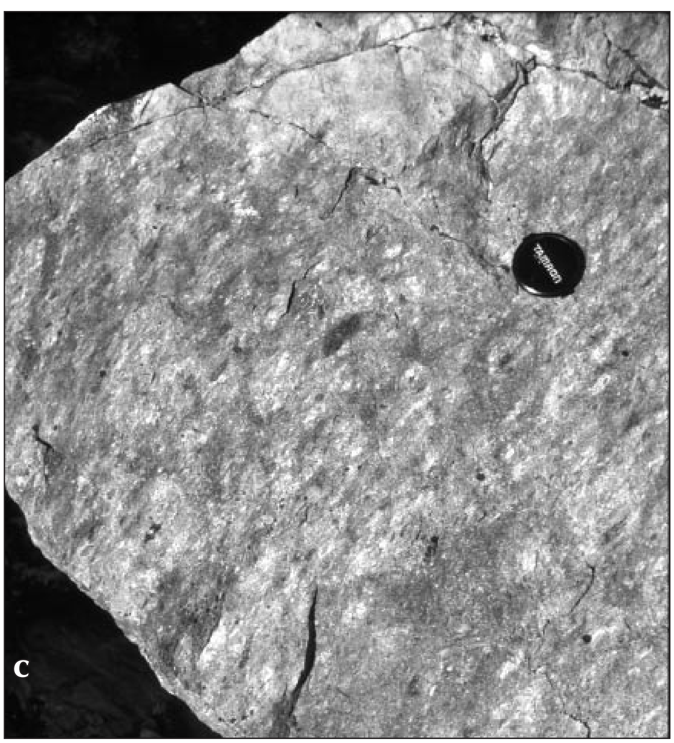

Figure 7 *continued.*

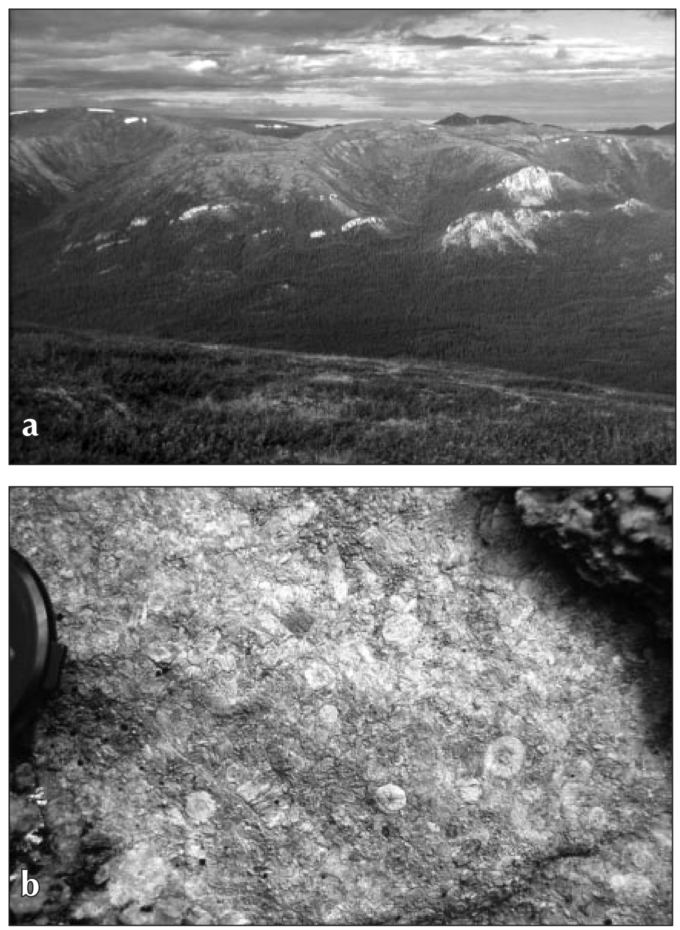

Figure 8(above). *Unit Pc: (a) laterally continuous exposures; (b) bioclastic crinoid fragments.*

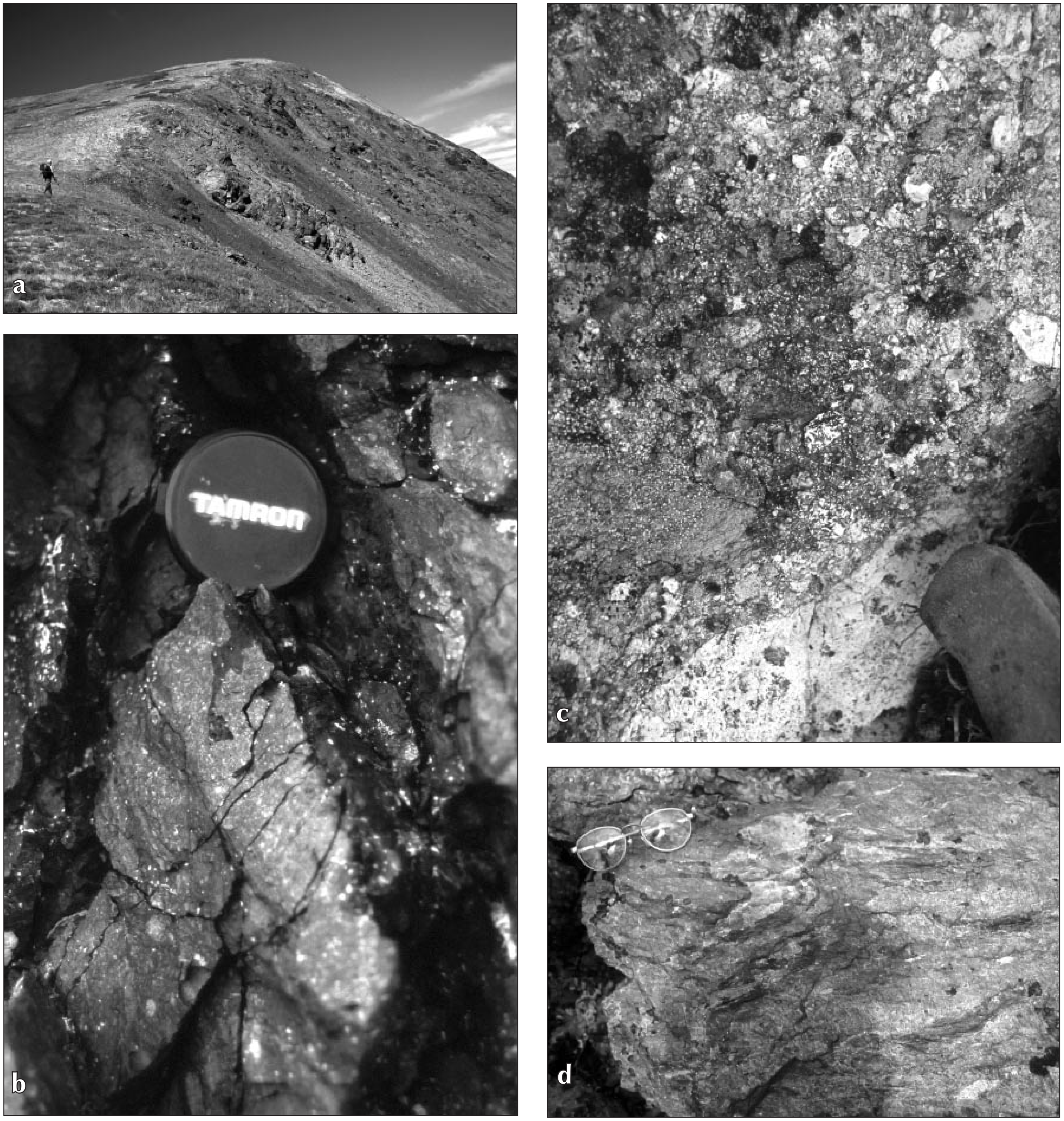

Figure 9. *Unit* Pcl*: (a) chert and argillite; (b) greywacke; (c) volcano-lithic pebble conglomerate; (d) sand-matrix diamictite; (e) argillite-matrix diamictite; (f) limestone-clast conglomerate.*

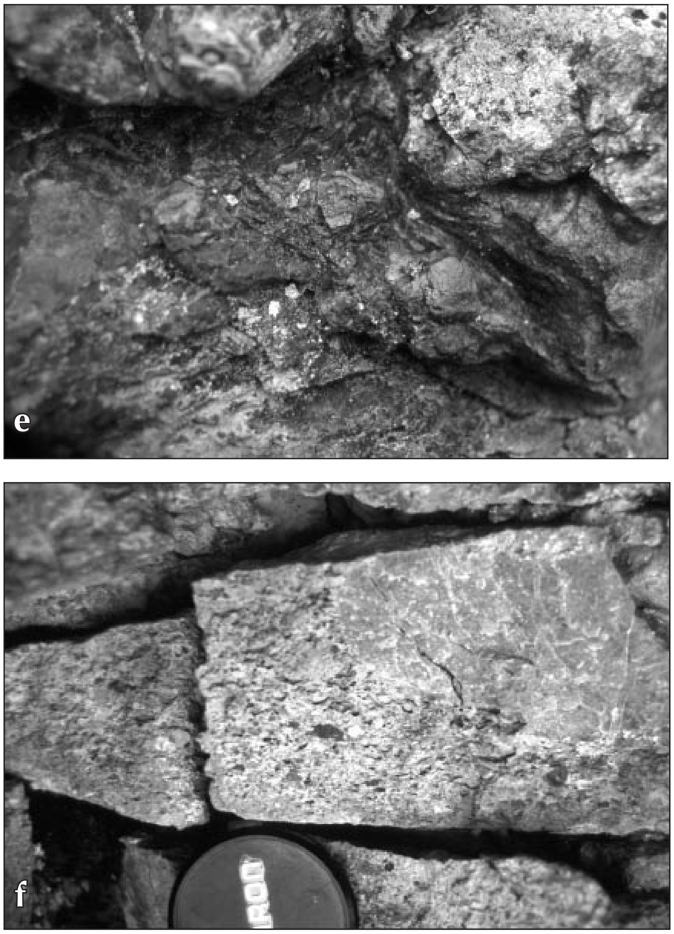

***Figure 9** continued.*

siliceous rock of possible tuffaceous origin. Common coarse-grained meta-clastic rocks include mottled grey-white chert-pebble conglomerate, pebble to cobble diamictite, greenish-grey quartzofeldspathic and volcano-lithic greywacke (Fig. 9b) and pebble conglomerate (Fig. 9c), and rarely tan clean quartz sandstone. Two types of diamictite have been observed, a sand-matrix variety where pebbles and cobbles of intermediate to felsic meta-volcanic rock and volcano-lithic greywacke with dark argillite clasts float in a greywacke matrix (Fig. 9d), and an argillite-matrix variety where the same types of clasts float in a matrix of locally sooty, dark grey argillite (Fig. 9e). A conglomerate consisting of pebbles to cobbles of medium grey limestone and tan quartz identical to the replacement quartz in unit Pc occurs locally near the base of the unit (Fig. 9f).

The basal contact of unit Pcl is inferred to be a profound regional unconformity. The unit overlies different rock units in different areas, mainly sitting on unit Pc but also lying directly on unit Mv. Upward variation in conglomerate clast compositions suggest progressively deeper erosion of underlying rocks; conglomerate near the base of the unit contains clasts of limestone and replacement silica identical to unit Pc and the youngest exposed conglomerate is full of volcano-lithic detritus similar to unit Mv. Sandstone and greywacke contain distinctive smoky grey quartz grains throughout that resemble quartz phenocrysts in unit Mv and older volcanic rocks of the Money Creek thrust sheet. Unit Pcl also overlies the Wolverine succession in the footwall of the thrust. As the dark clastic unit is apparently not offset by the thrust, thrusting therefore pre-dates this unit.

The age of unit Pcl is indirectly and loosely constrained as Pennsylvanian. It overlies unit Pc of late Mississippian to early Pennsylvanian age and underlies the Campbell Range basalt, which has mid-Pennsylvanian to Early Permian radiolaria (T. Harms *in:* Plint and Gordon, 1997, p. 124; see below). Displacement on the Money Creek thrust is therefore constrained to be Pennsylvanian in age.

FOOTWALL OF JULES CREEK THRUST

Although the Jules Creek thrust is inferred to extend at least as far north as Money Creek, rocks in its footwall are only reasonably well exposed on ridge networks northwest and southeast of Jules Creek. Northwest of this area, the only area of significant exposure occurs north of Money Creek. Elsewhere, exposure is poor except for isolated hilltops that are underlain by outliers of Campbell Range basalt. The footwall succession consists of a lower unit similar to unit Pcl (unit Pch) and an unconformably overlying sequence of meta-conglomerate (PPc?cgl) and meta-basalt (PPc?b).

Unit Pch

Underlying generally poorly exposed ground from the northern edge of Money Creek area (105H/5) to the ridge northwest of Jules Creek, unit Pch is not well documented. At the northern edge of Money Creek area, the unit comprises tan, pink and green chert and lesser argillite and a poorly exposed underlying member of dark argillite, chert and chert-pebble conglomerate. Immediately north of Money Creek, the unit comprises dark argillite, thin-bedded to massive greyish-green chert, and less commonly mottled grey and white chert-pebble conglomerate (Fig. 10a), meta-basalt or diabase, and rarely medium-grained greywacke and pods of crinoidal limestone. Between Money Creek and the ridge northwest of Jules Creek, pink, green and tan chert and dark argillite have been observed. On either side of Jules Creek, the unit also comprises greyish white siliceous phyllite and dark argillite with rare brown dolomitic siltstone (Fig. 10b). The thickness of unit Pch is not known.

The age and correlation of unit Pch are not known. The unit resembles unit Pcl but lacks the distinctive diamictite units, and volcano-lithic detritus is so far limited to the one greywacke bed north of Money Creek. As unit Pch occurs on the opposite side of the Jules Creek thrust from unit Pcl, they may be distal facies equivalents.

Unit PPC?cgl

Unit Pch is unconformably overlain by coarse-grained meta-clastic rocks of unit PPC?cgl. The basal strata of unit

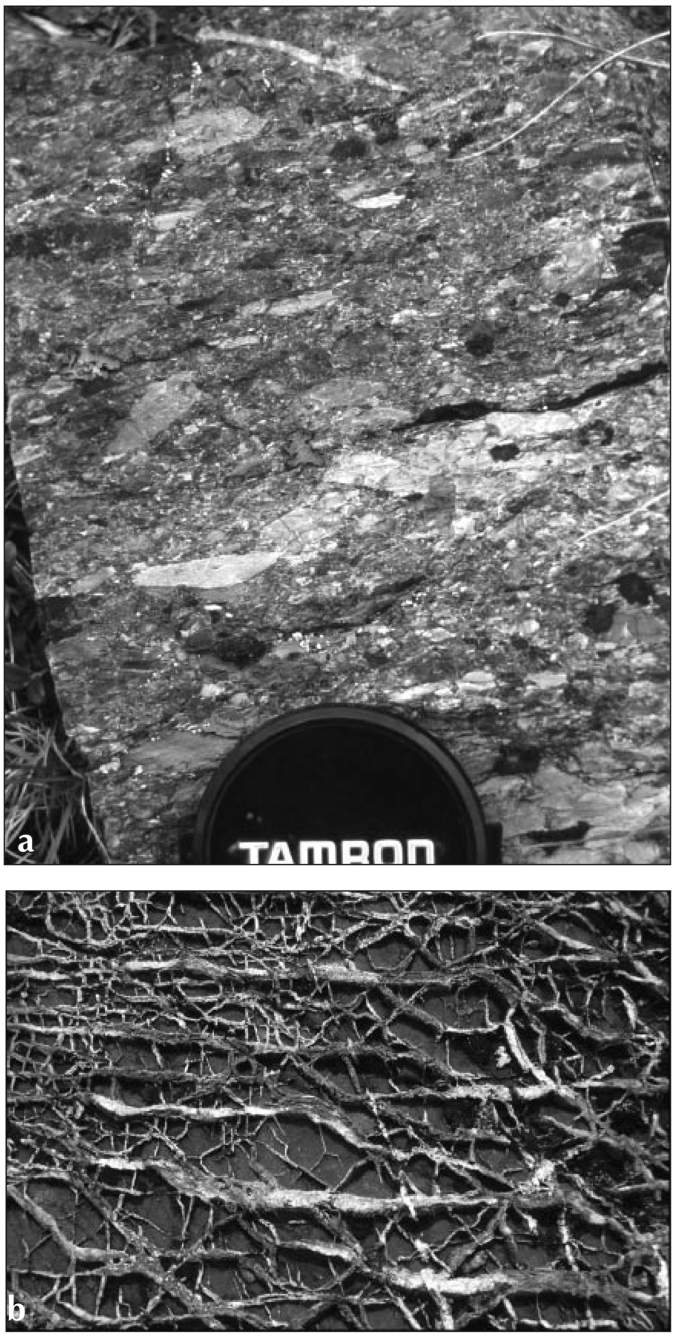

Figure 10. *Unit Pch: (a) chert-pebble conglomerate; (b) dolomitic siltstone with net-textured veins.*

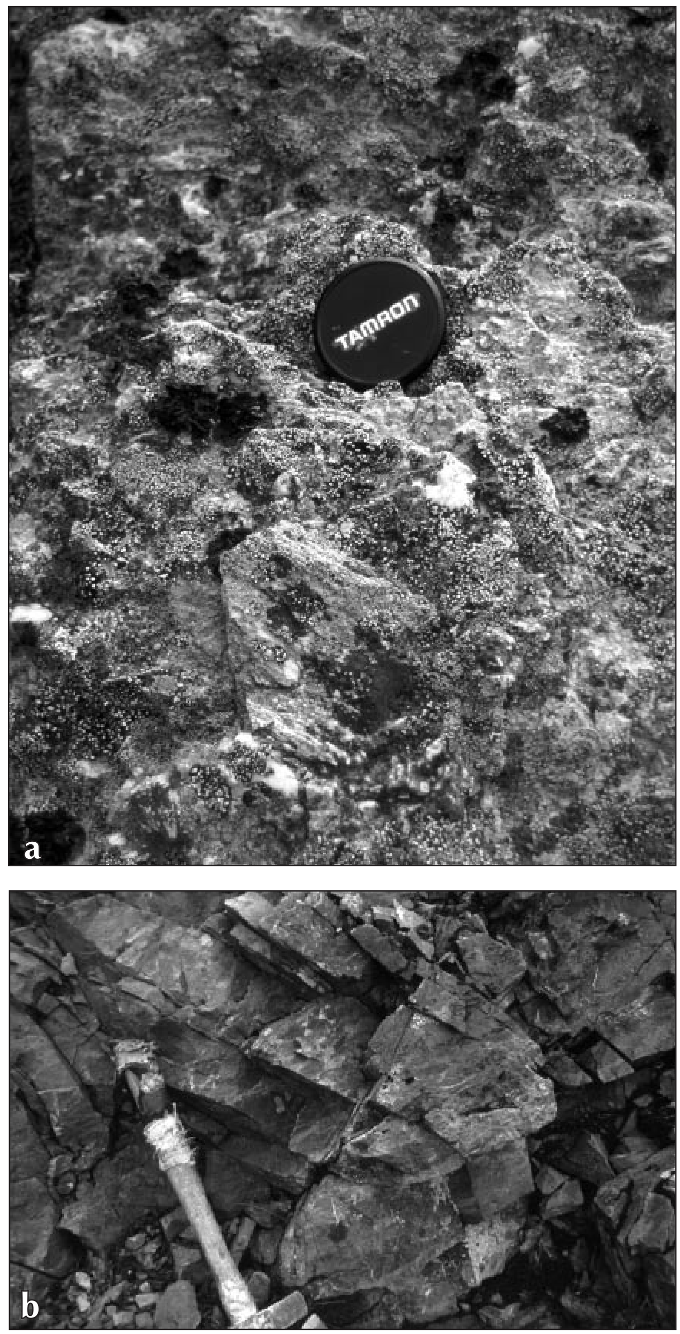

Figure 11. *Unit PPC?cgl: (a) tectonite-clast conglomerate; (b) massive, locally cherty carbonate interval within coarse-grained clastic rocks.*

PPC?cgl consists of weakly foliated grey pebble- to cobble-breccia made up of randomly oriented angular clasts of foliated and lineated rocks from unit Pch (Fig. 11a). Over a few metres, these strata pass into pink ferruginous pebbly breccia, sandstone and argillite and khaki to brown sandstone and conglomerate with angular siliceous phyllite clasts and rounded clasts of white quartz. Local float of quartz-eye felsic meta-volcanic rock occurs in this part of the section but was never found in outcrop. Further up section, sandstone and argillite turn grey and are intercalated with tan-black cherty carbonate and calcareous chert (Fig. 11b).

The age of unit PPC?cgl is unconstrained. If the underlying rocks correlate with unit Pcl, and the overlying rocks correlate with unit PPCb (see next section), then unit PPC?cgl would be late Pennsylvanian. The unconformity at the base of unit PPC?cgl would therefore reflect uplift and erosion following a late Pennsylvanian regional deformation.

Unit PPC?b

Meta-basalt of unit PPC?b overlies the meta-clastic rocks of unit PPC?cgl with sharp, apparently conformable contact. Unit PPC?b comprises variably foliated, variably calcareous greenschist and greenstone. On the eastern limb of the syncline that encloses unit PPC?b on both sides of Jules Creek, the unit comprises chloritic phyllite with pods and lenses of calcite. The unit is less foliated up section and is a massive greenstone. Calcareous pods and lenses occur at this stratigraphic level as well.

The age of unit PPC?b is not directly constrained. It is lithologically similar to unit PPCb, which is likely late Pennsylvanian, or Early Permian in age (see below).

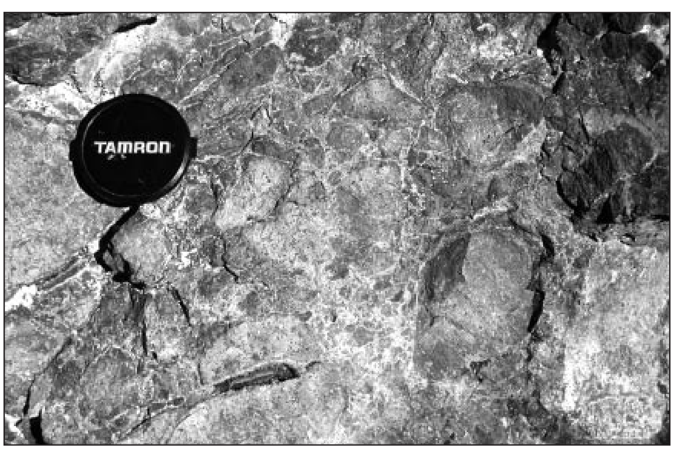

Figure 12. *Unit PPCb: fragmental texture in basalt below contact with tan chert.*

CAMPBELL RANGE BASALT (UNIT PPCb)

The Campbell Range basalt is found in Money Creek area (105H/5) on either side of Money Creek. Northwest of Money Creek, the unit crops out as a continuous slab across the northeastern part of Wolverine Lake area (105G/8; Murphy and Piercey, 1999b,c). Southwest of Money Creek it occurs in a few isolated hilltop exposures. The unit consists mainly of unfoliated to weakly foliated light- to dark-green-weathering, dark green basalt and rare pink and green chert. Basalt is mainly massive although fragmental textures (Fig. 12) and pillows occur locally.

The Campbell Range basalt is inferred to overlie a profound unconformity. It is less foliated and not folded to the same extent as underlying rocks. Furthermore, it overlies different rock units in different parts of the map area. It overlies unit Pcl in Wolverine Lake area (105G/8) and the western part of Money Creek area (105H/5), and is inferred to overlie units Mv, Mch and Mgc in southwestern Money Creek area and unit Pch in the footwall of the Jules Creek thrust in northern and central Money Creek area. Hence, it appears to post-date motion on the Jules Creek thrust. However, if unit PPC?b correlates with the Campbell Range basalt, an inconsistency arises as Unit PPC?b is overthrust along the Jules Creek thrust. The relation between the Campbell Range basalt and the Jules Creek thrust is not confidently documented so the correlation with unit PPC?b remains uncertain.

The Campbell Range basalt is probably late Pennsylvanian to early Early Permian. It is interbedded near its base with pink radiolarian chert from which early Pennsylvanian to Early Permian radiolaria have been obtained (Atokan-Wolfcampian; T. Harms, *in:* Plint and Gordon, 1997, p. 124) and it is intruded by a ca. 274 Ma leucogabbro in McEvoy Lake area (105G/9; Mortensen and Murphy, unpublished data). However, it overlies unit Pcl, which is younger than Bashkirian (early Pennsylvanian).

POLYMICTIC CONGLOMERATE (mPcgl)

Southeastward from near 99 Mile Creek, the eastern flank of the Campbell Range is underlain by a unit of foliated, poorly sorted, mottled grey-green, polymictic pebble- to boulder-conglomerate, greywacke and medium grey argillite. At the five stations where this unit was observed, conglomerate occurs in massive beds at least 2 m thick with interbedded coarse sandstone and argillite in 10- to 30-cm-thick beds. The proportion of conglomerate to sandstone and argillite could not be determined except at one location where conglomerate made up about 60% of the outcrop, greywacke, 30% and dark argillite, 10%.

Conglomerate clast content varies along strike. At one locality along the Campbell Highway (470192E, 6791538N), clasts include grey muscovite-quartz phyllite, chloritic phyllite, massive porphyritic basalt/andesite, aphyric massive basalt similar to the Campbell Range basalt, round white quartz pebbles, single crystal feldspars, and angular quartz sand in the matrix (Fig. 13a). At an isolated location in the Campbell Range in Klatsa River map area (105H/3), clasts are mainly meta-sedimentary including black chert, green chert, tan chert, grey carbonate, and muscovite-quartz phyllite (Fig. 13b). A similar conglomerate on strike in Watson Lake area comprises clasts of massive greenstone, gabbro, anorthosite, serpentinite, quartzite, quartz-mica schist, amphibolite, eclogite and blueschist with Permian cooling ages, massive mid-Permian dacite and andesite (Mortensen et al., 1997, 1999).

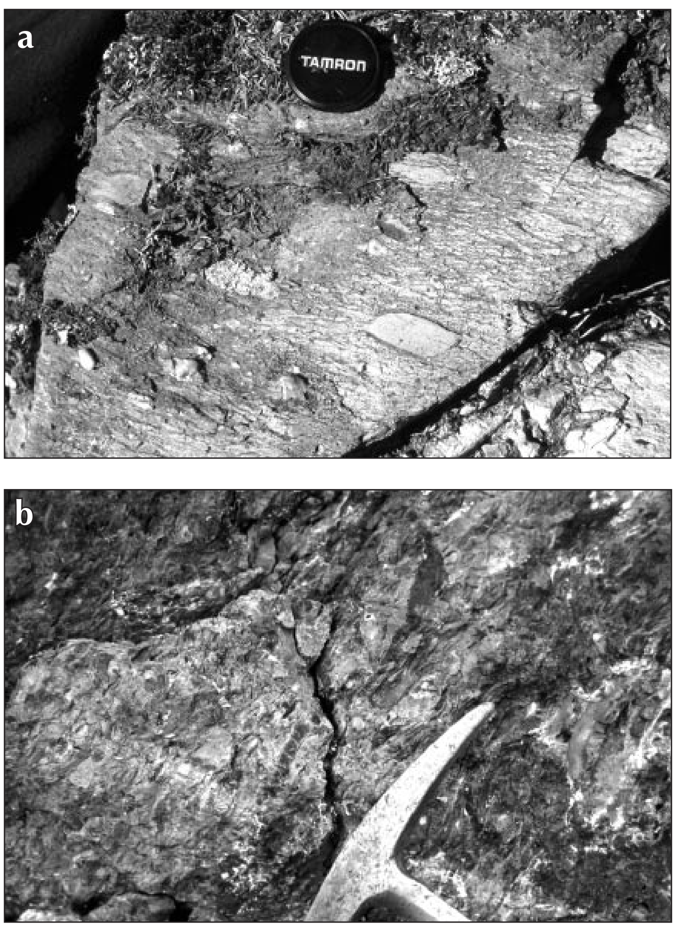

Figure 13. *Unit mPcgl: (a) polymictic conglomerate in exposure along Campbell Highway; (b) limestone and chert clasts in an isolated exposure of polymictic conglomerate about 5 km south of King Arctic jade mine.*

The contact of the conglomerate with Yukon-Tanana Terrane rocks to the west is not exposed. The conglomerate is adjacent to a number of different rock units along its trend, implying either a fault or an unconformity. As clasts in the conglomerate include many of the rock types of Yukon-Tanana Terrane, the original contact was likely an unconformity; however, the current contact may be a fault. On the northeast, the conglomerate is in contact with a massive tan chert. This contact has been crossed in only one locality and its nature has not been determined. Neither the age nor the paleogeographic affinity of the chert is known.

The age of the conglomerate in Frances Lake area is indirectly constrained to be Permian, possibly ranging into the Triassic. If the basalt clasts in the conglomerate were derived from the late Pennsylvanian to early Early Permian Campbell Range basalt then the conglomerate must be younger than that. The conglomerate resembles and is on strike with a polymictic conglomerate in Watson Lake area that is likely mid-Permian in age based on:
1) Permian conodonts have been extracted from argillaceous limestone beds in the conglomerate unit near Simpson Lake in Watson Lake area (J.K Mortensen, pers. comm., 1999; identification by M.J. Orchard, report MJO-1998-5), 2) metamorphic and dacite clasts have mid-Permian to earliest Triassic K-Ar mineral dates (Mortensen et al., 1997, 1999), and 3) felsic meta-volcanic rocks in the same sequence have mid-Permian U-Pb ages (ca. 264 Ma, J.K. Mortensen, pers. comm., 2000). However, the Watson Lake and Frances Lake conglomerates resemble a polymictic conglomerate near Faro with limestone interbeds containing Triassic conodonts (Tempelman-Kluit, 1979; Mortensen and Jilson, 1985; Mortensen et al., 1997, 1999). A mid-Permian age for the conglomerate in Frances Lake area is almost certain based on the on-strike continuity with the dated conglomerate in the Watson Lake area; however, an age ranging into the Triassic cannot be ruled out.

ECLOGITE FACIES METAMORPHIC ROCKS (Me)

An isolated exposure of coarse-grained metamorphic rocks, inferred to have been exposed to eclogite facies conditions, occurs in Klatsa River area (105H/3; Mortensen and Jilson, 1985; Erdmer et al., 1998). Standing in distinct contrast to nearby greenschist grade meta-sedimentary and meta-volcanic rocks, these rocks comprise light-brown-weathering, light brown to rusty coarse-grained white mica quartz schist and medium green massive to weakly foliated garnet amphibolite locally containing a pale green mineral resembling clinopyroxene (samples await thin section analysis). Erdmer et al. (1998) reported that retrograde minerals predominate in the rock and no primary peak metamorphic phases remain; garnet is largely replaced by clinozoisite and chlorite and no primary clinopyroxenes were noted. The geochemical character of meta-basite from this locality is that of normal mid-ocean ridge basalt (Creaser et al., 1999) with hints of an arc influence (S. Piercey, pers. comm., 2000).

The setting of these rocks with respect to nearby rocks remains unresolved. They occur at the end of a ridge overlying weakly metamorphosed dark grey argillite, gritty chert-quartz sandstone and pebble conglomerate, and diamictite correlated with unit Pcl, which, in turn, overlie pale green chert and limestone of units Mgc and Mc, respectively. Massive chert and chert-pebble conglomerate, possibly of unit Pcl, are found in isolated outcrops to the west and up structural section from the schist. Neither the upper nor lower contacts of the coarse-grained schist are exposed. Similar coarse-grained metamorphic rocks occur across a 50 m interval along the next ridge to the north; their extent farther to the north or south could not be established.

The age of the protolith of these coarse-grained metamorphic rocks is constrained to be pre-early Mississippian. A 344 ± 1 Ma Ar^{40}/Ar^{39} plateau cooling date (346 ± 1 Ma integrated date) was obtained from white mica extracted from samples from this locality (Erdmer et al., 1998), implying peak metamorphism before this time and an even older protolith age. On the basis of geochemical similarity, Creaser et al. (1999) suggested that the protoliths of eclogite from the Campbell Range and Stewart Lake localities might correlate with geochemically similar rocks in the 365-360 Ma Fire Lake meta-basite unit (unit 2 of Murphy, 1998; unit DMF of Murphy and Piercey, 1999a).

ULTRAMAFIC AND MAFIC INTRUSIONS (PPum)

Numerous bodies of serpentinized ultramafic rock, gabbro and diabase, ranging in size from a few metres wide to several square kilometres in area, occur throughout the Campbell Range in Frances Lake area. The largest one, in Klatsa River area (105H/3), hosts the King Arctic jade mine (Yukon MINFILE #105H 014). Ultramafic rocks typically comprise waxy pale green to brown, massive to coarsely foliated serpentinite, locally with ghosts of igneous olivine and/or orthopyroxene. Talc, tremolite/actinolite (green amphibole), and magnetite are also present. Fish-scale serpentinite occurs locally. Gabbro and diabase occur in small bodies less than 0.5 square km in area and are less common. They generally are found near bodies of ultramafic rock. Diabase is commonly found in or near exposures of the Campbell Range basalt.

A combination of contact features and geometric relationships supports the interpretation that these bodies are intrusions into Yukon-Tanana Terrane, not thrust slices of ophiolitic upper mantle as has been previously interpreted (Tempelman-Kluit, 1979; Mortensen and Jilson, 1985; Mortensen, 1992; Erdmer et al., 1998). Contacts are commonly sharp and not associated with a greater degree of deformation than away from the contact (Fig. 14a). Near their contact with ultramafic rocks, carbonate rocks are calc-silicate hornfels or skarn (Fig. 14b): green, coarse-grained and contain porphyroblasts of tremolite-actinolite, garnet and locally diopside. Dark argillite of unit Mvcl is harder and more massive near the contacts with ultramafic rocks, resembling pelitic hornfels. Geometrically, outliers of meta-sedimentary or meta-volcanic rocks within ultramafic rocks are roof pendants, with bedding and foliation of a similar character and orientation with rocks outside the bodies. Locally, contacts can be mapped up to one side of an ultramafic body and continued out the other side with minimal deviation. There are no observations that would permit placing a crust-penetrating thrust fault along any of the contacts with ultramafic rocks, a requirement of the ophiolite interpretation.

The age(s) of the ultramafic intrusions in Frances Lake area are not directly constrained. Together with gabbro, diabase, and leucogabbro, ultramafic intrusions define a magmatic corridor along the length of the Campbell Range, crosscutting all units described in this report, including the late Pennsylvanian to Early Permian

Campbell Range basalt. A ca. 274 Ma U-Pb age date has been obtained from a leucogabbro in McEvoy Lake area (105G/9) along this trend (J.K. Mortensen and D.C. Murphy, unpublished data). Plagiogranite from serpentinite-matrix melange in northwestern Finlayson Lake area, on strike from the Campbell Range trend, has been dated at 274.3 ± 0.5 Ma (Mortensen, 1992b). An upper age limit for the ultramafic intrusions is provided by the mid-Permian age of the polymictic conglomerate, which contains clasts of serpentinized ultramafic rock (Mortensen et al., 1997, 1999).

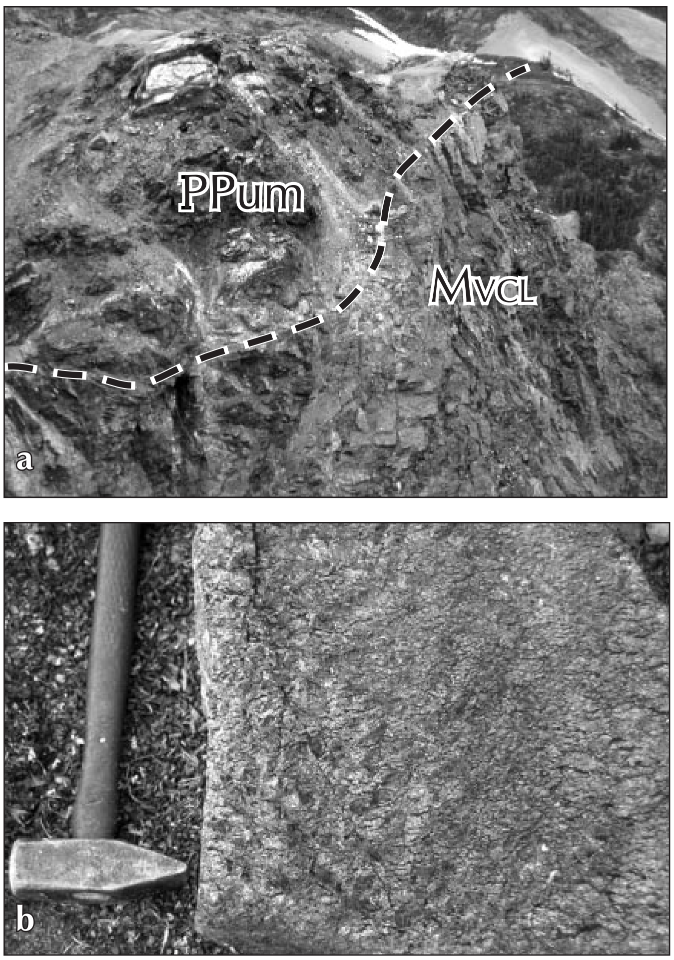

Figure 14. *Unit PPum: (a) sharp contact at base of ultramafic rocks, King Arctic jade mine; (b) skarn and marble near contact with ultramafic rocks of unit PPum.*

MINERAL OCCURRENCES AND POTENTIAL

Several types of mineral occurrences have been found in this part of Frances Lake area (Yukon MINFILE, 1997). Basalt-hosted volcanogenic massive sulphide (VMS) occurs in the Campbell Range basalt at the Money/Julia (#105H 074). Although just outside the area mapped, felsic volcanic-hosted massive sulphide is known at the Kneil (#105H 080) prospect. The King Arctic jade mine (#105H 014) is hosted in a large ultramafic body in Klatsa River area (105H/3) and Tuchitua property (#105H 016) is a former jade producer in an extensive ultramafic body straddling the Tuchitua River near its head. The Doug occurrence (#105H 015) is described as a Cu vein.

The fertile back-arc rocks of Yukon-Tanana Terrane that host the Finlayson Lake volcanic-hosted massive sulphide deposits are truncated by the Money Creek thrust in this area; however, VMS-style prospects occur in coeval volcanic arc rocks in the Money Creek thrust sheet, attesting to potential for new deposits in these rocks. In addition to the Kneil occurrence in Frances Lake area, barite and altered felsic meta-volcanic rocks with sulphides occur on the EXPO and TY claims of Cominco Ltd. and Atna Resources, respectively, and pyritic chlorite schist occurs on Expatriate Resources' SHUTOUT claims; all of these occur in Waters Creek map area (105G/1). Further indications of potential include numerous gossans in unit Mv in Frances Lake area, especially southeast of Jules Creek. These are underlain by altered and pyritic intermediate to felsic volcanic rocks with local base metal enrichments. A grab sample from one such gossan contained 373 ppm Cu, 3805 ppm Pb, 562 ppm Zn, 2.6 ppm Ag, 1980 ppm Mn, 109 ppm V and 14 ppb Au (A in Fig. 2, 466237E, 6783919N, NAD27, Zone 9; ICP-ES analysis by Acme Analytical Laboratories, Vancouver). Altered intermediate meta-igneous rocks also occur in unit Mch. These are weakly anomalous in base metals (B in Fig. 2, 58 ppm Cu, 8 ppm Pb, 110 ppm Zn, 31 ppm Ni, 41 ppm Co, 1213 ppm Mn, and 352 ppm V; 469888E, 6784385N, NAD27, Zone 9; analysis as above).

The new interpretation of mafic and ultramafic rocks in the area as intrusions opens up the possibility of magmatic Cu-Ni-PGM deposits. Sediments in local streams with ultramafic bodies in their catchment areas are highly anomalous (greater than 99.5 percentile for Yukon RGS dataset, Hornbrook and Friske, 1988) in Cu and Ni (Fig. 2). No sulphide concentrations were observed in the course of mapping.

LATE PALEOZOIC GEOLOGICAL HISTORY

As indicated by the rocks and relationships described in this report, Yukon-Tanana Terrane was an exciting place to be during the Late Paleozoic. The geological record during this time included:

1. Mississippian arc and back-arc magmatism and high-pressure metamorphism;
2. Early Pennsylvanian bioclastic carbonate sedimentation;
3. Pennsylvanian tectonism, sedimentation and magmatism including:

   a. thrusting along the Money Creek thrust (and possibly other structures to the south and west);

   b. deposition of flysch-like sediments and chert as an overlap onto the shortened terrane;

   c. ongoing deformation of the terrane, including the overlap sequence; uplift, erosion and sedimentation of the conglomerate in the footwall of the Jules Creek thrust;

   d. extrusion of basalt of unit PPC?b;

   e. thrusting on the Jules Creek thrust;
4. Late Pennsylvanian to Early Permian extrusion of the Campbell Range basalt as an overlap on the previously deformed terrane; coeval and younger intrusion of mafic and ultramafic rocks;
5. An Early Permian history recorded by the mid-Permian conglomerate which includes (Mortensen et al., 1997, 1999; J.K. Mortensen, pers. comm., 2000):

   a. high-pressure metamorphism of part of the terrane (clasts have same range of ages as *in situ* eclogite and blueschist at Faro, Ross River and in the St. Cyr Klippe);

   b. arc volcanism (clasts have similar ages to Permian Klondike Schist);

   c. uplift, erosion and deposition of the mid-Permian conglomerate.

CONCLUSIONS

1. The rocks and relationships described above attest to a previously undocumented period of intra-terrane deformation that occurred predominantly in the Pennsylvanian. This was between the periods of Mississippian and Permian events of arc- and back-arc magmatism and local high-pressure metamorphism that had been previously documented in Yukon-Tanana Terrane.
2. Although the contact relationships are unclear, coarse-grained high-pressure metamorphic rocks with early Mississippian cooling ages are clearly embedded within rocks of Yukon-Tanana Terrane. In southwestern Frances Lake area, they occur neither along the boundary with ancestral North America nor as part of Slide Mountain Terrane as previously inferred (Erdmer et al., 1998).
3. Numerous gossanous areas and known mineral showings attest to the potential for volcanic-associated mineral deposits in unit Mv.
4. The re-interpretation of ultramafic rocks as *in situ* intrusions rather than thrust slices opens up the possibility for magmatic Ni-Cu-PGM deposits in this area.

ACKNOWLEDGEMENTS

I would like to thank Terry Tucker of Expatriate Resources Ltd. for sharing his knowledge of the geology of this area, providing access to geophysical data and geological maps, and hospitality at Expatriate's Wolverine Lake camp; and Jim Mortensen for sharing his extensive knowledge of the 'Banana'. Joshua Bailey provided excellent field assistance. Karl Ziehe and Trevor Boxall of Helidynamics and Robin Ostertag of Conair provided safe, reliable and uneventful helicopter service. Manuscript was critically reviewed by Maurice Colpron.

REFERENCES

Blusson, S.L., 1966a. Sekwi Mountain, Nahanni, and Frances Lake map-area. *In:* Report of Activities, May to October 1965, S.E. Jenness (ed.), Geological Survey of Canada, Paper 66-1, p. 38-41.

Blusson, S.L., 1966b. Frances Lake, Yukon Territory and District of Mackenzie. Geological Survey of Canada, Map 6-1966, 1:253 440 scale.

Blusson, S.L., 1967. Sekwi Mountain, Nahanni, and Frances Lake map-area. *In:* Report of Activities, Part A: May to October 1966, S.E. Jenness (ed.), Geological Survey of Canada, Paper 67-1, p. 44-45.

Creaser, R.A., Goodwin-Bell, J.S. and Erdmer, P., 1999. Geochemical and Nd isotopic constraints for the origin of eclogite protoliths, northern Cordillera: Implications for the Paleozoic tectonic evolution of the Yukon-Tanana Terrane. Canadian Journal of Earth Sciences, vol. 36, p. 1697-1709

Erdmer, P., Ghent, E.D., Archibald, D.A. and Stout, M.Z. 1998. Paleozoic and Mesozoic high-pressure metamorphism at the margin of ancestral North America in central Yukon. Geological Society of America Bulletin, vol. 110, p. 615-629.

Hornbrook, E.H.W. and Friske, P.W.B., 1988. National geochemical reconnaissance stream sediment and water geochemical data, Yukon 1988. Geological Survey of Canada, Open File 1649, NGR 114-1988, NTS 105H.

Mortensen, J.K., 1983. Age and evolution of the Yukon-Tanana Terrane, southeastern Yukon Territory. Unpublished Ph.D thesis, University of California, Santa Barbara, 155 p.

Mortensen, J.K., 1992. Pre-Mid-Mesozoic tectonic evolution of the Yukon-Tanana Terrane, Yukon and Alaska. Tectonics, vol. 11, p. 836-853.

Mortensen, J.K. (comp.), 1999. YUKONAGE, An isotopic age database for the Yukon Territory. *In:* Yukon Digital Geology, S.P. Gordey and A.J. Makepeace (compilers), Geological Survey of Canada, Open File D3826, and Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, Open File 1999-1(D).

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.

Mortensen, J.K., Erdmer, P. and Ghent, E.D., 1997. Westerly-derived Upper Triassic clastic sedimentary rocks in southeastern Yukon: Evidence for Early Mesozoic terrane interaction with the western margin of ancestral North America. *In:* 1997. Slave – Northern Cordillera Lithospheric Evolution (SNORCLE) Transect and Cordilleran Tectonics Workshop Meeting, Abstracts, F. Cook and P. Erdmer (compilers), Lithoprobe Report No. 56, p. 76.

Mortensen, J.K., Erdmer, P., Piercey, S.J. and Ghent, E.D., 1999. Evidence for Late Triassic terrane accretion in the northern Canadian Cordillera in southeastern Yukon. Geological Survey of Canada/Geological Association of Canada, Terrane Paths 99, Circum-Pacific Terrane Conference, Abstracts and Program, p. 55

Murphy, D.C., 1997. Preliminary geological map of Grass Lakes area, Pelly Mountains, southeastern Yukon (105G/7). Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, Open File 1997-3, 1:50 000 scale.

Murphy, D.C., 1998. Stratigraphic framework for syngenetic mineral occurrences, Yukon-Tanana Terrane south of Finlayson Lake: A progress report. *In:* Yukon Exploration and Geology 1997, Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p. 51-58.

Murphy, D.C., 2000a. Preliminary geological map of part of Klatsa River area (105H/3), southeastern Yukon. Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, Open File 2000-15, 1:50 000 scale.

Murphy, D.C., 2000b. Preliminary geological map of part of 'Tuchitua River North' (105H/4), southeastern Yukon. Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, Open File 2000-16, 1:50 000 scale.

Murphy, D.C., 2000c. Preliminary geological map of part of Money Creek area (105H/5), southeastern Yukon. Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, Open File 2000-17, 1:50 000 scale.

Murphy, D.C. and Piercey, S.J., 1999a. Geological map of parts of Finlayson Lake (105G/7, 8 and parts of 1, 2, and 9) and Frances Lake (parts of 105H/5 and 12) areas, southeastern Yukon. Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, Open File 1999-4, 1:100 000 scale.

Murphy, D.C. and Piercey, S.J., 1999b. Geological map of Wolverine Lake area, Pelly Mountains, southeastern Yukon (105G/8). Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, Open File 1999-3.

Murphy, D.C. and Piercey, S.J., 1999c. Finlayson Project: Geological evolution of Yukon-Tanana Terrane and its relationship to Campbell Range belt, northern Wolverine Lake map area, southeastern Yukon. *In:* Yukon Exploration and Geology 1998, C.F. Roots and D.S Emond (eds.), Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p. 47-62.

Murphy, D.C. and Piercey, S.J., 2000. Syn-mineralization faults and their re-activation, Finlayson Lake massive sulphide district, Yukon-Tanana Terrane, southeastern Yukon. *In:* Yukon Exploration and Geology 1999, D.S. Emond and L.H. Weston (eds.), Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p. 55-66.

Piercey, S.J. and Murphy, D.C., 2000. Stratigraphy and regional implications of unstrained Devono-Mississippian volcanic rocks in the Money Creek thrust sheet, Yukon-Tanana Terrane, southeastern Yukon. *In:* Yukon Exploration and Geology 1999, D.S. Emond and L.H. Weston (eds.), Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p. 67-78.

Piercey, S.J., Murphy, D.C., Mortensen, J.K. and Paradis, S.A., 2000. Arc-rifting and ensialic back-arc basin magmatism in the northern Canadian Cordillera: Evidence from the Yukon-Tanana Terrane, Finlayson Lake region, Yukon. *In:* 2000. Slave-Northern Cordilleran Lithospheric Evolution (SNORCLE) Transect and Cordilleran Tectonics Workshop Meeting, F. Cook and P. Erdmer (compilers), University of Calgary, Lithoprobe Report, No. 72, p. 129-138.

Piercey, S.J., Paradis, S.A., Murphy, D.C. and Mortensen, J.K., in review. Petrological constraints on the tectonic setting of felsic volcanic-hosted volcanogenic massive sulfide (VMS) mineralization in the Finlayson Lake district, Yukon, Canada. Economic Geology, submitted.

Plint, H.E. and Gordon, T.M., 1997. The Slide Mountain Terrane and the structural evolution of the Finlayson Lake fault zone, southeastern Yukon. Canadian Journal of Earth Science, vol. 34, p. 105-126.

Poulton, T., Orchard, M.J., Gordey, S.P. and Davenport, P., 1999. Selected Yukon fossil determinations. *In:* Yukon digital geology, S.P. Gordey and A.J. Makepeace (compilers), Geological Survey of Canada, Open File D3826, and Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, Open File 1999-1(D).

Tempelman-Kluit, D.J., 1979. Transported cataclasite, ophiolite and granodiorite in Yukon Territory: Evidence of arc-continent collision. Geological Survey of Canada, Paper 79-14, 27 p.

Yukon MINFILE, 1997. Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada.