Stratigraphic framework for syngenetic mineral occurrences, Yukon-Tanana Terrane south of Finlayson Lake: A progress report

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ABSTRACT

Yukon-Tanana Terrane in Grass Lakes map area south of Finlayson Lake consists of highly deformed though regionally mappable metasedimentary and metavolcanic rocks. Four newly revised map units and various subunits have been traced throughout the area. These include unit 1, a quartz-rich metaclastic unit with felsic metavolcanic rocks at its lowest exposed level and a middle calcareous marker; unit 2, a mafic metavolcanic unit with lesser carbonaceous metasedimentary rocks; unit 3, a carbonaceous phyllite and quartzite and felsic metavolcanic unit, and unit 4, an upper unit of carbonaceous phyllite, mafic metavolcanic rocks and coarse-grained quartzofeldspathic metaclastic rocks. Units 2 and 4 have been redefined from a previous report based on new observations and a consideration of the provenance of coarse-grained quartzofeldspathic metaconglomerates now included in unit 4. In the current interpretation, the metaconglomerate-bearing strata north of and overlying the felsic meta-volcanic rocks hosting Kudz Ze Kayah are considered to unconformably overlie them.

Three of these map units are associated with mineral occurrences or deposits. Rusty, locally malachite-stained muscovite-quartz schist at Arcturus Resources' First Base claims and Expatriate Resources' Blue Line and Winger claims belong to the felsic metavolcanic part of unit 1. Columbia Gold's Fyre Lake deposit is hosted in unit 2 mafic metavolcanic rocks, possibly associated with a synvolcanic fault. Cominco's Kudz Ze Kayah deposit occurs in unit 3 felsic metavolcanic rocks. Gossans on Cominco's Cobb claims, Expatriate's Overtime and NHL claims, and Atna/Westmin's Pack claims and anomalous copper in soils at Arcturus' Bas claims are also spatially associated with this unit.

RÉSUMÉ

Le terrane de Yukon-Tanana, dans la région cartographique de Grass Lakes au sud du lac Finlayson, comprend des roches métasédimentaires et métavolcaniques très déformées mais cartographiables à l'échelle régionale. Quatre unités cartographiques récemment révisées et diverses sous-unités ont été identifiées dans la région. Parmi celles-ci figurent l'unité 1, unité métaclastique riche en quartz comprenant une unité métavolcanique felsique à son niveau inférieur exposé ainsi qu'un niveau repère calcaire; l'unité 2, unité métavolcanique mafique renfermant en quantités moindres des roches métasédimentaires carbonées; l'unité 3, qui comprend des phyllades carbonés, des quartzites et des métavolcanites felsiques; et l'unité 4, unité supérieure composée de phyllades carbonés, de roches métavolcaniques mafiques et de métaconglomérats à cailloux quartzofeldspathiques. Les unités 2 et 4 ont été redéfinies relativement à un rapport publié antérieurement sur la base de nouvelles observations et eu égard à l'origine des métaconglomérats quartzofeldspathiques à grain grossier, désormais inclus dans l'unité 4. Selon l'interprétation actuelle, on considère que les strates contenant les métaconglomérats, qui reposent au nord des roches métavolcaniques felsiques encaissant le gisement de Kudz Ze Kayah et sur ces dernières, reposent en fait en discordance sur elles.

Trois de ces unités cartographiques sont associées à des occurrences ou à des gisements minéraux. Des schistes felsiques rouillés à muscovite et quartz renfermant localement de la malachite sur les claims de First Base, de la société Arcturus Resources, et sur les claims de Blue Line et Winger, de la société Expatriate Resources, appartiennent à la partie métavolcanique felsique de l'unité 1. Le gisement de Fyre Lake, de la Columbia Gold, est inclus dans les roches métavolcaniques mafiques de l'unité 2, en association possible avec une faille synvolcanique. Le gisement de Kudz Ze Kayah, de la Cominco, est situé dans les roches métavolcaniques felsiques et les chapeaux de fer de l'Unité 3, ainsi que sur les claims de Cobb, de Cominco, sur les claims d'Overtime et NHL, d'Expatriate, et sur celles de Pack d'Atna/Westmin; les concentrations pédologiques exceptionnelles de cuivre dans les claims de Bas, d'Arcturus Resources, sont spatialement associées à cette unité.

INTRODUCTION

This report presents an update on the stratigraphy of Yukon-Tanana Terrane northwest of the Tintina Fault (Fig. 1) as elucidated during one and a half field seasons of 1:50 000-scale geological mapping in Grass Lakes map area (105G/7, Fig. 2). The area was mapped at 1:250 000-scale by the Geological Survey of Canada in the 1950's (Wheeler et al. 1960), in the early 1970's (Tempelman-Kluit, 1977, 1979) and in somewhat greater detail as part of a doctoral thesis (Mortensen, 1983; Mortensen and Jilson, 1985; Mortensen, 1992a). A re-investigation of the geology of this region was considered appropriate in light of the reconnaissance nature of previous work and the high level of mineral exploration activity in Yukon-Tanana Terrane stimulated by the Cominco's 1994 discovery of the Kudz Ze Kayah massive sulphide deposit. A map and report on the northeast third of Grass Lakes map area was published in 1997 (Murphy and Timmerman, 1997a,b); this report and accompanying map (Murphy, 1997) supercedes and extends the previous work.

STRATIGRAPHY OF GRASS LAKES MAP AREA

In Grass Lakes map area, strongly foliated and lineated layered metasedimentary and metavolcanic rocks occur sporadically in a roof setting above and between bodies of Early Mississippian granitic orthogneiss and weakly foliated mid-Cretaceous granite. Murphy and Timmerman (1997a) reported a four-fold subdivision of the layered rocks in the northeastern third of the map area. This subdivision has now been extended over the entire area with some significant modification resulting from new observations and interpretations (Fig. 3).

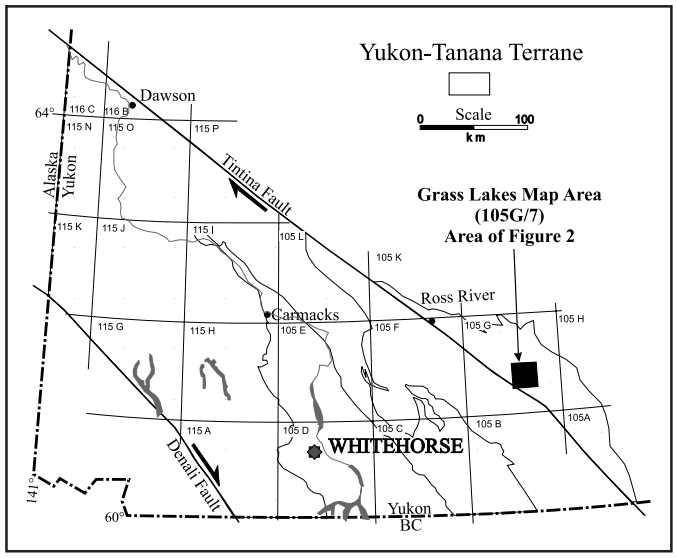

Figure 1. *Grass Lakes map area (105G/7) with respect to the distribution of Yukon-Tanana Terrane in Yukon.*

UNIT 1

The lowest unit in the Yukon-Tanana Terrane stratigraphy in this area is a quartz-rich metaclastic unit with a lower felsic metavolcanic member and a middle laterally variable calcareous member. Most of the unit is tan to brown and locally rusty-weathering, (garnet)-biotite-muscovite-quartz schist and psammite, (staurolite-chloritoid)-garnet-biotite-quartz-muscovite metapelitic schist and rare quartz-pebble conglomerate. Lesser rock types include metre-scale layers of locally calcareous biotite-feldspar-chlorite schist and siliceous carbonaceous phyllite and quartzite.

The lowest stratigraphic unit in the map area, exposed in the network of ridges west of the southernmost Grass Lake and tracking westward to the western edge of the map area, is a locally rusty and malachite-stained muscovite-quartz schist and feldspar-quartz augen schist member (unit 1f, Fig. 4). On the ridge west of the southernmost Grass Lake, the felsic schist unit is overlain by a few tens of metres of biotite-feldspar-chlorite schist (unit 1m, not differentiated in Figs. 2 or 3). This unit passes laterally westward into a fine-grained sulphide-bearing rock of indeterminate protolith. Arcturus Resources' First Base and Expatriate Resources' Blue Line and Winger claims cover rusty felsic schist of unit 1f.

Unit 1 strata above the felsic metavolcanic unit have been traced throughout much of the central, southern and northwestern part of the map area. Directly overlying the felsic metavolcanic member is about 200 m of tan, locally cliff-forming quartzose psammite and metapelite and lesser biotite-chlorite schist (unit 1qsl). This unit is overlain by a laterally variable calcareous unit that forms a prominent marker throughout much of the map area. In the fault-bound southwestern corner of the map area and the northwestern corner of the map area, the calcareous unit (unit 1cls) consists of finely foliated, grey garnet-bearing (locally cm-scale porphyroblasts) calcareous schist and metapelite, thin-bedded to massive metre-scale grey marble, lesser calcareous psammite and rare carbonaceous phyllite. Elsewhere in the map area, calcareous psammite (unit 1clp) predominates in this unit with lesser marble and locally significant amounts of calcareous biotite schist and calcsilicate. Overlying the calcareous member is a variable thickness of quartz-rich metaclastic rocks similar to those below the calcareous member but with upwardly increasing amounts of biotite-feldspar-chlorite schist (unit 1qsu). The uppermost part of unit 1qsu is locally marked by carbonaceous and siliceous phyllite.

The intense deformational overprint has generally obliterated primary features in unit 1. Psammitic (metasandstone) beds in unit 1 locally have one sharp contact and one transitional contact with adjacent metapelite beds, suggesting a graded character (Fig. 5). Such rare indications of younging direction consistently indicate that unit 1 is the oldest exposed stratigraphic unit of the terrane in Grass Lakes map area.

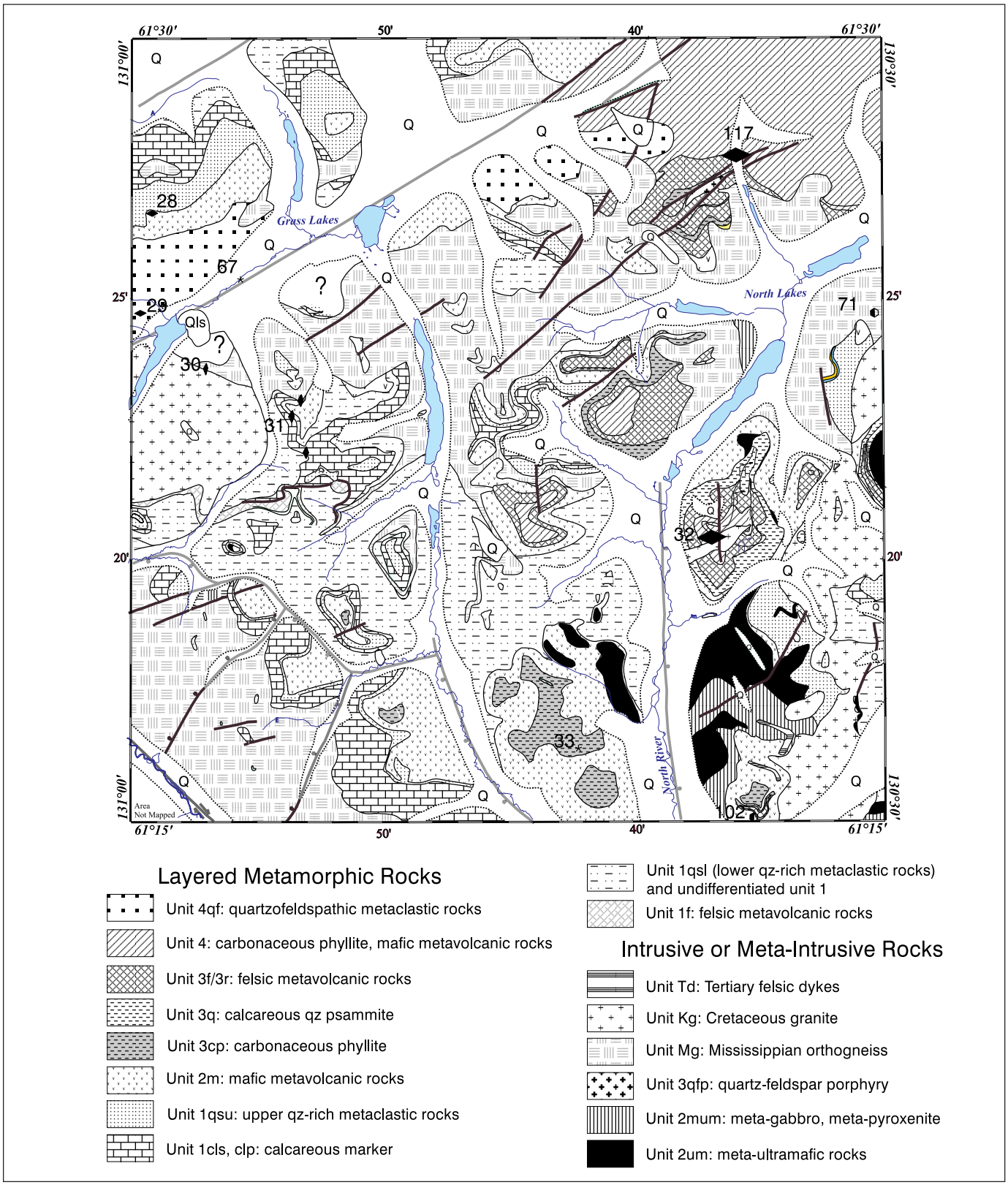

Figure 2. *Bedrock geological map of Grass Lakes map area. Heavy dark and shaded lines are defined and inferred faults respectively. Numbers denote mineral occurrences as enumerated in Yukon Minfile for map area 105G: 028, Gyp; 029, Gee; 030, Pit; 031, Rob; 032, Pack; 033, Tak; 067, Lawn; 071, Myda; 088, Cookie; 102, Howdee (Rife); 117, Tag (Kudz Ze Kayah).*

The age of unit 1 is unknown. Samples of unit 1f felsic metavolcanic rocks have been collected for radiometric dating.

UNIT 2

Overlying unit 1qsu across a narrowly transitional contact zone is intermediate to mafic schist and phyllite of unit 2m. Throughout much of the map area, unit 2m consists of dark brown to black plagioclase-quartz-chlorite-biotite schist. In the network of ridges west of the North River, in the south-central part of the map area, and also in the northwestern corner of the map area, unit 2m comprises medium green to olive green biotite-porphyroblastic plagioclase-actinolite-chlorite schist and phyllite. The areas marked by biotite schist are marginal to the voluminous Grass Lakes and Houle River orthogneisses and the apparent higher grade may be due in part to proximity to the intrusions. Other rock types in unit 2m are carbonaceous phyllite and quartzite and rarely light grey coarsely crystalline marble.

The mafic mineralogy of unit 2m suggests a mafic volcanic or sedimentary rock protolith. Primary textures are generally overprinted by intense foliations although fragmental textures appear locally (Fig. 6) and bedding occurs in less highly deformed rocks in the northern part of the map area. Unit 2m rocks contain variable amounts of quartz, plagioclase, biotite, epidote, titanite or rutile suggesting that both sedimentary rock and volcanic rock protoliths are represented in Grass Lakes map area.

Preliminary assessment of trace element geochemical data from eight unit 2m samples collected in Grass Lakes map area shows that unit 2m is composed primarily of low potassium tholeiitic andesite or basaltic andesite with island arc affinity (6 samples). Two samples consistently plot as subalkaline basalts with MORB affinities. A comprehensive analysis of the geochemical characteristics of Yukon-Tanana Terrane metavolcanic rocks is currently in progress (Hunt et al. in prep.).

In the south-central and southeastern parts of the map area, unit 2m mafic schists are spatially associated with coarse-grained whitish-green leucoamphibolite (metagabbro), medium to dark green amphibolite (meta-pyroxenite) (both shown together as unit 2mum in Fig. 2) and aeromagnetically prominent dun-coloured meta-ultramafic rocks made up of talc, magnetite, serpentine, tremolite, phlogopite, and relict olivine,

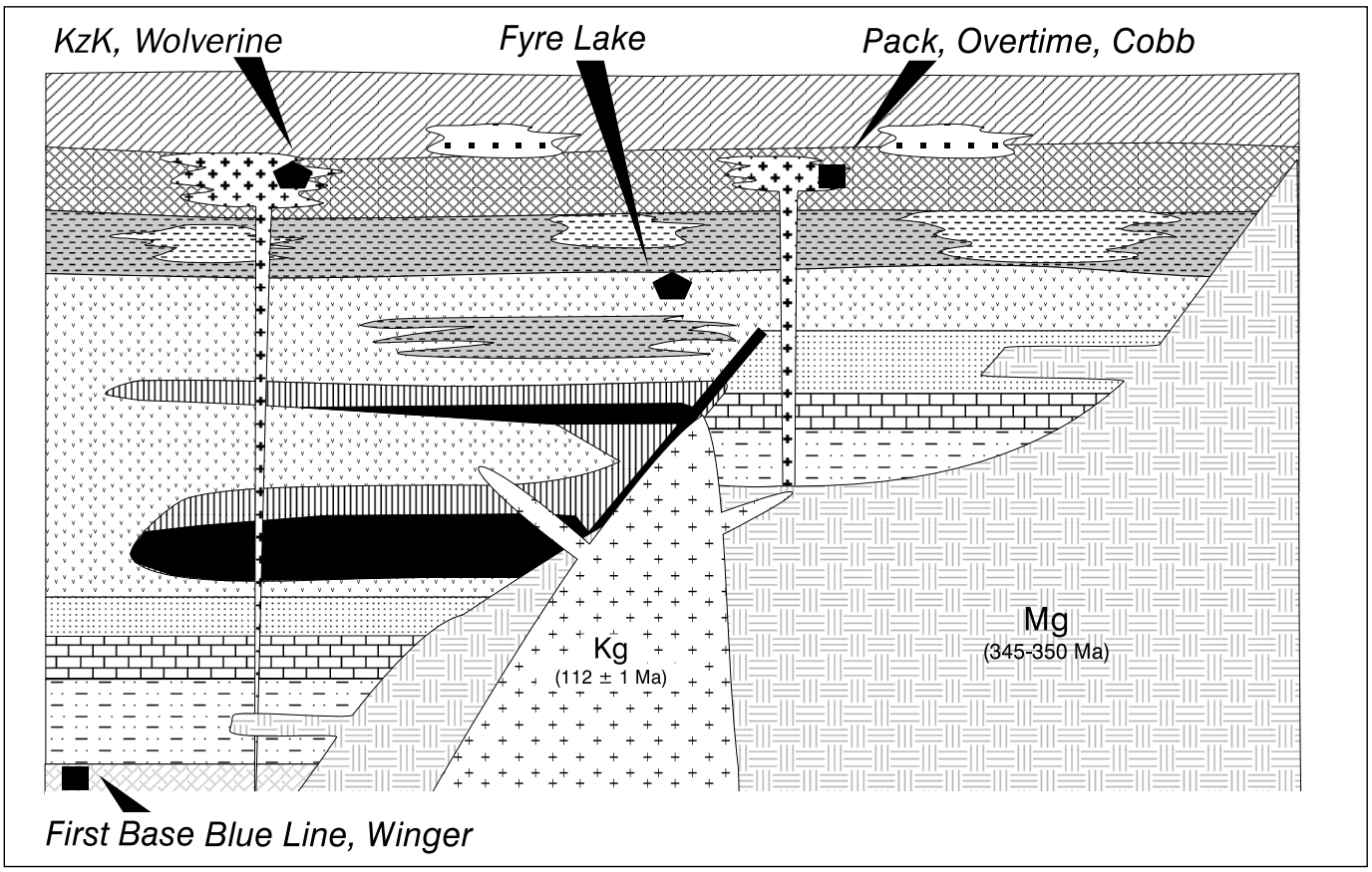

Figure 3. *Schematic illustration of stratigraphy and field relationships in Grass Lakes map area. All map units, except for the weakly foliated Cretaceous granite, are strongly foliated and lineated. Symbols are as in Figure 2, except heavy '+' pattern which is meant to represent felsic cryptodome and dyke.*

Figure 4. *View to west of rusty felsic metavolcanic rocks of unit 1f (to left) in thrust contact with stratigraphically younger rocks of unit 1qsu. Arcturus Resources' First Base claims.*

orthopyroxene and chromite (unit 2um). West of the North River, such mafic and ultramafic rocks occur as a stratabound sheet within unit 2m which extends eastwardly from a lateral termination in a peak west of the North River (Fig. 7) across the North River into the southeastern corner of the map area. The sheet increases in thickness from zero at its westwardly lateral termination to over 500 metres east of the North River. In the southeasternmost corner of the map area, the amount of unit 2m mafic schist between the meta-intrusive rocks and the top of unit 1 decreases to zero and, uniquely to this area, ultramafic rocks also appear at different levels in unit 1, occurring in unit 1qsu west of the Cretaceous granite and in unit 1qsl at the same structural level east of the granite (Fig. 2). Southeast of the map area, the combined thickness of units 2m, 2mum and 2um decreases to less than 100 m.

Tempelman-Kluit (1977, 1979) included the unit 2m mafic schists in the southeastern corner of the map area and mafic and ultramafic meta-intrusive rocks in the Anvil Allochthon, a sheet of obducted oceanic crust. Mortensen (1992a,b) also inferred the ultramafic rocks in this area to be allochthonous, correlating them with Slide Mountain Terrane. The relationships between the mafic and ultramafic meta-intrusive rocks and units 1 and 2m are, however, compatible with the interpretation that these rocks are *in situ*, possibly co-magmatic intrusions. Neither the rocks at the base of the meta-intrusive sheet nor the narrowly transitional contact between units 1qsu and 2 are more deformed than rocks elsewhere in the region, suggesting that these contacts are not faulted. Unit 2m is regionally extensive, and if its lower contact is a major fault where associated with mafic and ultramafic meta-intrusive rocks, it would have to be a thrust fault in other places; there is no evidence in support of this interpretation. Alternatively, the stratabound character of the meta-intrusive rocks for much of their extent is reminiscent of a sill. West of the North River, unit 2mum and 2um could be a single differentiated sill. East of the North River where more than one level of ultramafic rock is present, more than one sill or level of cumulate development may be represented. The characteristics of the ultramafic rocks in the southeasternmost corner of the

Figure 5. *Psammite bed in unit 1qsu with sharp base and gradational top suggestive of upright grading.*

Figure 6. *Rounded compositionally distinct domains in biotite-chlorite schist of unit 2m suggestive of fragmental texture.*

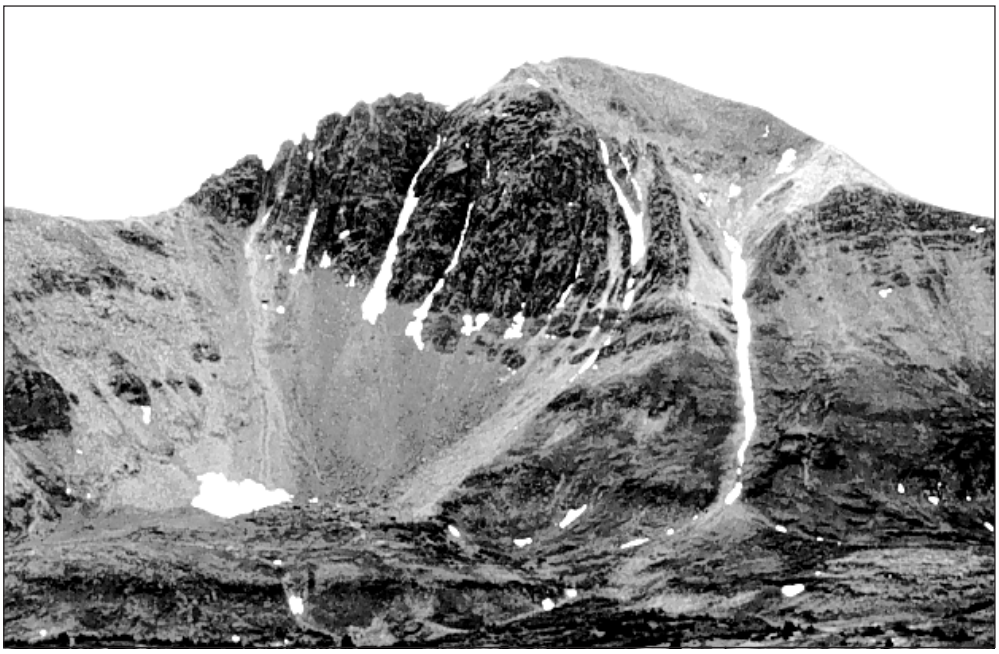

Figure 7. *View to south of lateral termination of meta-ultramafic body enveloped by actinolite-chlorite schist of unit 2m. Note how deformation has wrapped the underlying unit 1 and 2 rocks around its westward termination.*

map area suggest a discordant character, possibly marking the locus of transition from a sill to a feeder dyke. In this area, the base of the ultramafic sheet occurs progressively lower in unit 2 and, uniquely to this area, ultramafic rocks appear at different levels in unit 1. Furthermore, as this zone of apparent discordance is marked by the juxtaposition of different stratigraphic levels of unit 1 and a dramatic drop in the combined thickness of units 2m, 2mum and 2um, the dyke may have intruded along a syn-volcanic fault.

It should be noted that the Fyre Lake Cu-Co-Au massive sulphide deposit (Foreman et al., this volume; Hunt, this volume) occurs in the upper part of unit 2m along strike from this area of discordance, stratigraphic juxtaposition and thickness change and increase in volume of co-magmatic(?) intrusions, suggesting a possible genetic association. Synvolcanic faults, thickness changes of volcanic rocks and increases in abundance of comagmatic(?) intrusions are all considered to be pathfinders to the proximal portions of volcanic systems where volcanic-hosted massive sulphide deposits typically reside (e.g. Gibson et al. 1997).

The age of unit 2m has not been determined directly but possibly comagmatic gabbro and diorite have yielded Devono-Mississippian U-Pb ages (Mortensen, 1992a and pers. comm. 1996).

UNIT 3

Rocks overlying unit 2m are found mainly in the central network of ridges between the North River and the prominent valley hosting Big Campbell Creek and the largest of the Grass Lakes, and in the northwestern and east-central parts of the map area. Unit 3 and younger units have been removed by erosion from the western part of the map area. In the central network of ridges, mafic schist of unit 2m is succeeded by a laterally diverse unit of carbonaceous phyllite (unit 3cp), calcareous quartzose psammite (unit 3q), rare light grey marble and light-coloured, locally rusty quartz-muscovite schist and massive fine-grained siliceous rock locally with amygdules indicating a felsic volcanic heritage (unit 3f/3r). In the southern part of Grass Lakes map area and northern part of the adjacent Fire Lake map area, the lower part of this unit (up to 200 m) is primarily strongly foliated siliceous and carbonaceous phyllite with rare lenticular bodies of rusty quartz-muscovite schist and other quartzofeldspathic rock types of indeterminate heritage. To the north, the lower part of the unit includes increasing amounts of felsic metavolcanic rock, and locally, calcareous quartzose psammite and quartzite as at Atna/Westmin Resources' Pack property (Yukon Minfile 105G 032). Minor amounts of mafic schist occur locally. The thickest accumulation of felsic metavolcanic rock in the map area occurs at Cominco's Kudz Ze Kayah deposit (Schultze, 1996; Yukon Minfile 105G 117)

Figure 8. *Interbedded quartz-feldspar pebble meta-conglomerate and darker carbonaceous phyllite of unit 4. Bedding is upright, dipping steeply to right.*

where a few metres of carbonaceous phyllite and quartzose psammite are overlain by over 2km (structural thickness) of felsic muscovite-quartz schist, cherty amygdaloidal meta-rhyolite, variably altered quartz-feldspar augen schist (possibly a subvolcanic intrusion) and lesser carbonaceous phyllite and intermediate to mafic schist. Substantial accumulations of felsic metavolcanic rock also occur on Cominco's Cobb claims, Expatriate's Overtime claims, Arcturus Resources' Bas claims and Atna/Westmin's Pack claims; in these areas, felsic metavolcanic rocks are associated with gossans, anomalous soil geochemistry, and sulphide showings.

A preliminary assessment of trace element geochemical data suggests that unit 3 felsic metavolcanic rocks are primarily calc-alkaline rhyodacite with lesser rhyolite and have characteristics typical of volcanic arc suites.

Mortensen (1983, 1992a, and pers. comm., 1996) reports Early Mississippian U-Pb ages for felsic metavolcanic rocks of Yukon-Tanana Terrane in the Finlayson Lake area.

UNIT 4

Murphy and Timmerman (1997a,b) included in unit 4 the succession of carbonaceous phyllite, biotite-plagioclase-chlorite phyllite and schist and quartzofeldspathic psammite overlying unit 3 felsic metavolcanic rocks in the central and eastern part of the map area. Unit 4 strata occur along the tops of ridges in the ridge network between the largest of the North Lakes and the largest of the Grass Lakes, underlying parts of Arcturus' Bas claims and Cominco's Cobb claims. Unit 4 strata also occur in the hinge zone of a recumbent north-closing fold on Atna/Westmin's Pack property (Yukon Minfile 105G 032) east of the largest of the North Lakes.

Carbonaceous phyllite, biotite-plagioclase-chlorite phyllite and schist and lenticular bodies of coarse-grained quartzofeldspathic sandstone and conglomerate north of, and physically overlying, the felsic metavolcanic rocks at Kudz Ze Kayah (Yukon Minfile 105G 117) are also currently included in unit 4 (Fig. 2). Murphy and Timmerman (1997a, b) originally considered these strata to be an inverted panel of unit 2 on the overturned limb of a syncline cored by the felsic metavolcanic rocks at Kudz Ze Kayah. The inclusion of these strata in unit 4 is based on the possibility that the conglomerates are products of the erosion of nearby coarse-grained Mississippian orthogneiss, which intrudes unit 3 felsic metavolcanic rocks. The metaconglomerate locally contains cm-sized single crystal feldspar clasts suggesting that they were fairly proximal deposits (Fig. 8). Indeed, some exposures of metaconglomerate so closely resemble Mississippian orthogneiss that they were incorrectly identified in 1996. If the metaconglomerate was derived from nearby orthogneiss, then it must be younger than unit 3 and they must mark a profound unconformity reflecting substantial uplift and erosion.

DISCUSSION

Owing to the highly strained nature of Yukon-Tanana Terrane in the Finlayson Lake district, the stratigraphic units defined herein should be considered preliminary and will likely be revised with new work. However, although preliminary and defined only in Grass Lakes map area, some speculative correlation with neighboring areas is possible. The distinctive calcareous schist and marble part of unit 1cls correlates directly with Tempelman-Kluit's (1977) unit PCsc which he has traced around large regions of the Finlayson Lake 1:250 000 map area. This unit is a regional marker that provides a starting point in the search for the overlying prospective metavolcanic stratigraphy. Unit 2 mafic schists have not been systematically traced in previous work but, given the extent to which Tempelman-Kluit (1977) traced unit 1cls, it may be relatively straightforward to locate. As previously discussed, the combination of unit 2m and ultramafic and mafic meta-intrusions may indicate local magmatic centres. Unit 3 felsic metavolcanic rocks likely correlate with felsic metavolcanic rocks at Wolverine Lake 20 km to the east in the adjoining Wolverine Lake map area based on similar U-Pb ages (Mortensen, 1992a and pers. comm., 1996) and stratigraphic position. This correlation suggests that some of the mafic meta–volcanic rocks immediately overlying the felsic metavolcanic rocks at Wolverine Lake may correlate with unit 4. However, given the uncertainty about the nature of the contact at the base of the overlying Campbell Range pillow basalt and chert sequence, any extension of this correlation to include the Campbell Range sequence should be entertained with caution.

SUMMARY

Field work during 1997 clarified the stratigraphic framework of Yukon-Tanana Terrane in a part of the Finlayson Lake district, providing firmer definition of map units and their extent. As a result, the stratigraphic position of syngenetic mineral occurrences in the area is now fairly firmly established, and in the case of Fyre Lake, some understanding of the stratigraphic setting has been gained. Finally, the new interpretation of unit 4 implies that it overlies a profound unconformity which may be a significant clue in resolving the Upper Paleozoic tectonic setting of Yukon-Tanana Terrane.

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