Geological Survey
of Canada

CURRENT RESEARCH
2002-A1

Bedrock geology of Yukon–Tanana terrane in southern Stewart River map area, Yukon Territory

J.J. Ryan and S.P. Gordey

2002

Natural Resources Canada
Ressources naturelles Canada

Canada

Catalogue No. M44-2002/A1E-IN
ISBN 0-662-31435-2

A copy of this publication is also available for reference by depository libraries across Canada through access to the Depository Services Program's website at http://dsp-psd.pwgsc.gc.ca

A free digital download of this publication is available from the Geological Survey of Canada Bookstore web site:

http://gsc.nrcan.gc.ca/bookstore/

Click on Free Download.

Authors' address:

J.J. Ryan *(jryan@nrcan.gc.ca)*
S.P. Gordey *(sgordey@nrcan.gc.ca)*
Geological Survey of Canada
101-605 Robson Street
Vancouver, B.C. V6B 5J3

Bedrock geology of Yukon–Tanana terrane in southern Stewart River map area, Yukon Territory[1]

J.J. Ryan and S.P. Gordey
GSC Pacific, Vancouver

Ryan, J.J. and Gordey, S.P., 2002: Bedrock geology of Yukon–Tanana terrane in southern Stewart River map area, Yukon Territory; Geological Survey of Canada, Current Research 2002-A1, 11 p.

Abstract: Polydeformed and metamorphosed Paleozoic rocks of the Yukon–Tanana terrane underlie a large part of the Stewart River area, Yukon Territory. Quartz-rich metaclastic rocks (quartzite, quartz-mica schist, psammite) are regionally widespread, and are locally interstratified with, as well structurally interdigitated with, metavolcanic rock (mafic and intermediate garnet-amphibolite). Mafic to felsic orthogneiss is almost exclusively associated with the amphibolite, and rarely with metasiliciclastic rock. Complexes of mafic-ultramafic rock and associated orthogneiss are exposed at structurally high levels, and are thought to be part of an erosionally dismembered, originally continuous tectonic sheet, emplaced on top of the metasiliciclastic rock. Emplacement occurred prior to regional transposition deformation and metamorphism. Post-tectonic Early Jurassic and (?)mid-Cretaceous plutons crosscut the older fabrics. Sporadically preserved, fault-disrupted felsic to mafic volcanic rocks of the late Cretaceous Carmacks Group unconformably overlie all older units. Local felsic porphyritic intrusions (? mostly dykes) are probably Eocene.

Résumé : Des roches polydéformées et métamorphisées du Paléozoïque appartenant au terrane de Yukon-Tanana s'étendent à une grande partie de la région de la rivière Stewart (Territoire du Yukon). Des roches clastiques métamorphisées riches en quartz (quartzites, micaschistes à quartz, psammites) sont répandues dans la région et, par endroits, s'y intercalent stratigraphiquement et structuralement des roches volcaniques métamorphisées (amphibolites à grenat de compositions mafique et intermédiaire). Des orthogneiss mafiques à felsiques sont associés presque exclusivement aux amphibolites et, dans de rares cas, aux roches silicoclastiques métamorphisées. Des complexes de roches mafiques ou ultramafiques et des orthogneiss associés affleurent à des niveaux structuraux élevés. Il semble que ces unités forment les parties disjointes par l'érosion d'une nappe tectonique à l'origine continue, qui aurait été mise en place sur les roches silicoclastiques métamorphisées avant la déformation par transposition et le métamorphisme d'étendue régionale. Des plutons post-tectoniques du Jurassique précoce et du Crétacé moyen (?) recoupent les fabriques plus anciennes. Préservées ici et là, des roches volcaniques mafiques à felsiques du Groupe de Carmacks du Crétacé supérieur aujourd'hui disloquées par des failles surmontent en discordance toutes les unités plus anciennes. Des intrusions felsiques à texture porphyritique d'étendue limitée (surtout des dykes?) remontent probablement à l'Éocène.

[1] Contribution to the Ancient Pacific Margin NATMAP Project

INTRODUCTION

Geological mapping in the Stewart River area is a component of the Ancient Pacific Margin NATMAP Project (Fig. 1), initiated by the Geological Survey of Canada, Yukon Geology Program, and British Columbia Geological Survey Branch. The NATMAP Project seeks to understand the composition, relationships, and metallogeny of poorly understood pericratonic terranes lying between the ancestral North American margin and those known with more certainty to be tectonically accreted (Thompson et al., 2000; Colpron et al., 2001). The Stewart River component focuses on the Yukon–Tanana terrane, comprising complexly deformed, mostly (?)Paleozoic meta-igneous and metasedimentary rocks. Previous work in the Stewart River area is summarized in Ryan and Gordey (2001a, b).

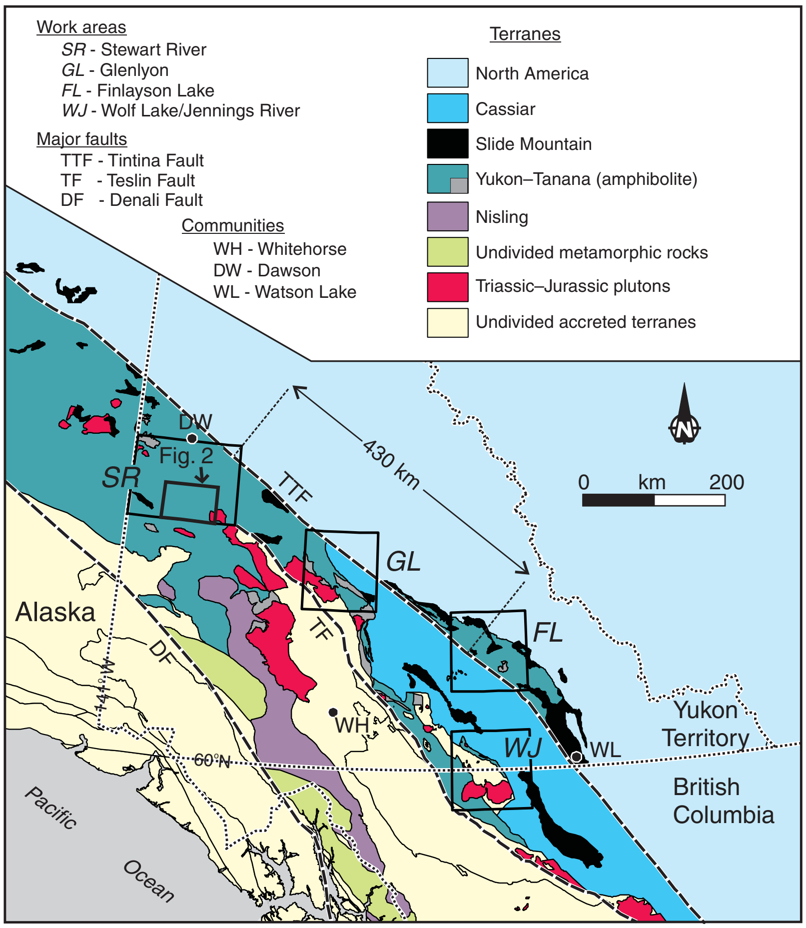
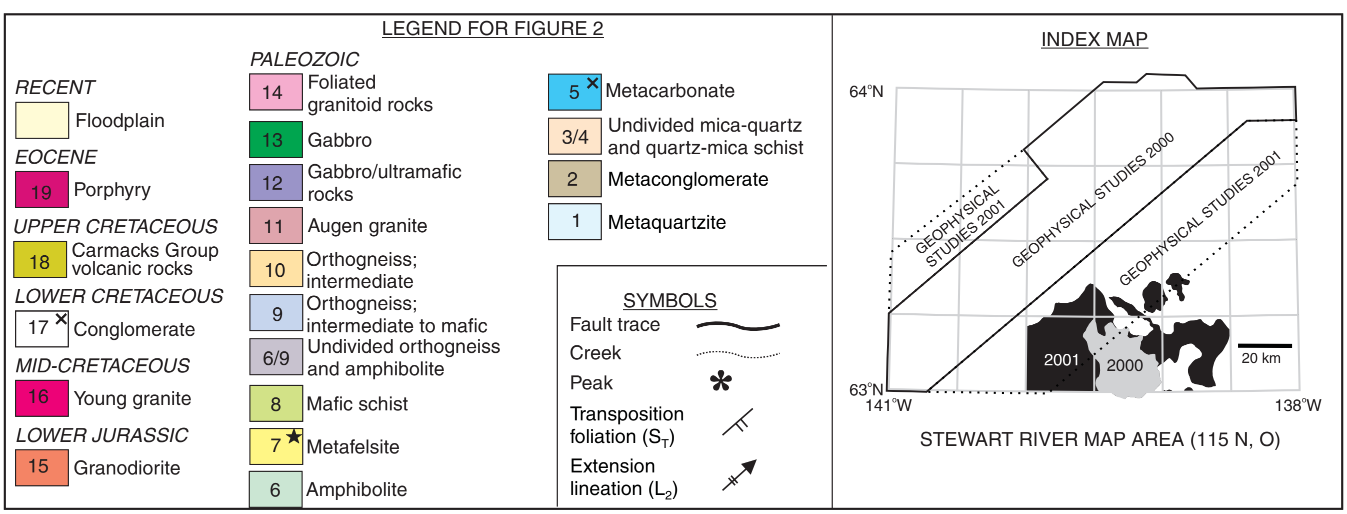


Figure 1.

Location of the NATMAP project areas in Yukon Territory and northern British Columbia. Restoration of Cretaceous–Tertiary dextral offset of about 425 km (Dover, 1994) along Tintina Fault would place the Stewart River area in close proximity to the Finlayson Lake area. A project in southern British Columbia (not in figure) comprises the southern component of the NATMAP Project (Thompson et al. (2000) and references therein).



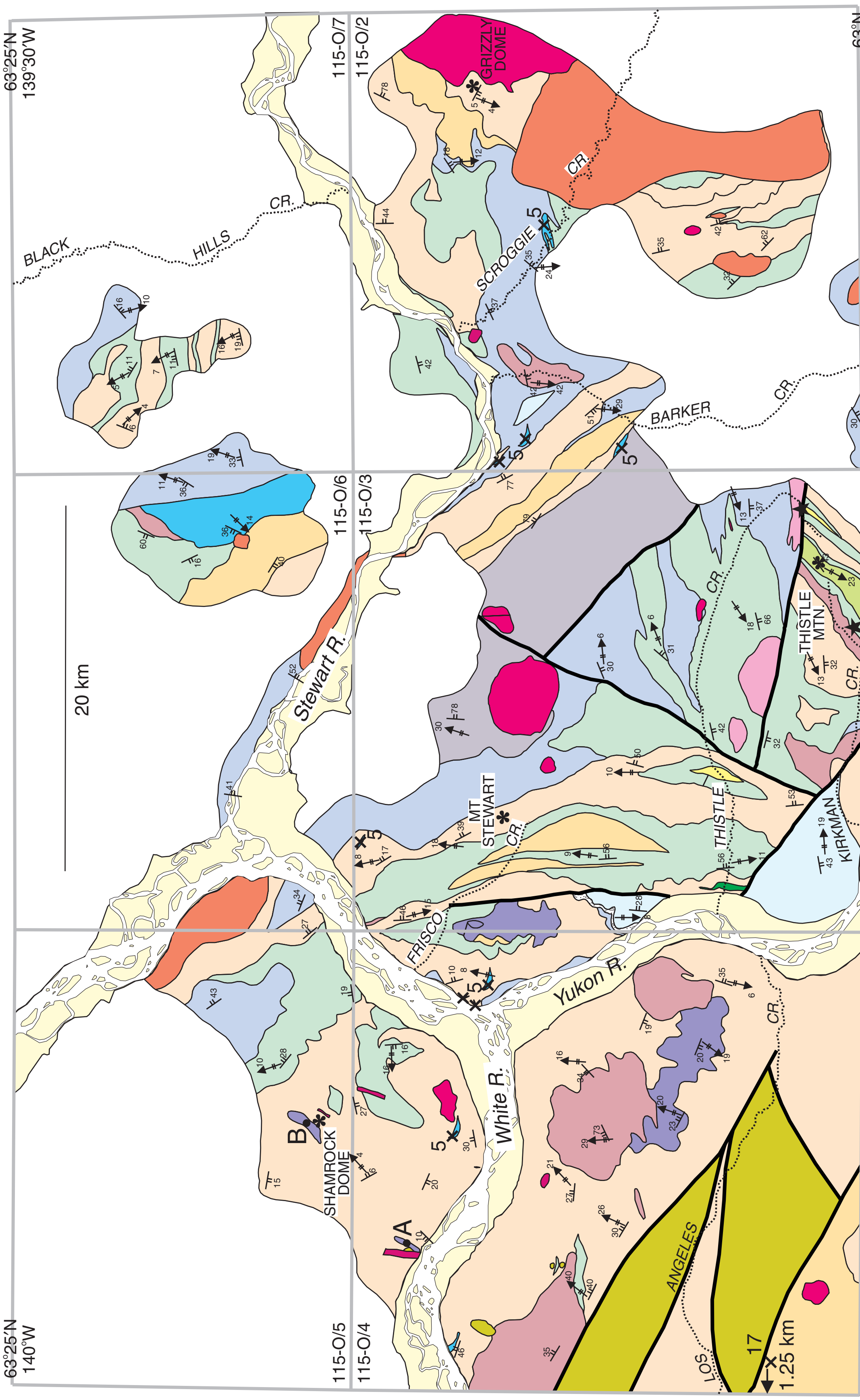


Figure 2. *Simplified geological map of the southern Stewart River area; 'A' and 'B' are localities referred to in text. Note that unit 17 conglomerate is 1.25 km west of the map area shown here (approximately 63°2'42"N, 140°1'27"W). Outline of geophysical studies from Shives et al. (2001) and R.B.K. Shives, J.M. Carson, K.L. Ford, P.B. Holman, S.P. Gordey, and G. Abbot (unpub. data, 2001).*

The objective of the Stewart River project is to investigate the stratigraphic, structural, and tectonic history and the economic framework of the Yukon–Tanana terrane, by mapping parts of the eastern two-thirds of the area over a four- year period. New data and previous work will be synthesized into a new geological map of the Stewart River area.

Access into the southern Stewart River area (Fig. 2) is afforded by boat along the Yukon and Stewart rivers. Helicopter access is largely restricted to the high ground due to extensive tree cover. This year's 1:50 000-scale mapping concentrated on mapping in areas NTS 115-O/2, 4 and the southern portions of NTS 115-O/5, 6, and 7, and completing mapping of NTS 115-O/3 (Fig. 2). Mapping was undertaken mainly by foot traverses from boat on the Yukon, White, and Stewart rivers, and eight short helicopter camps in higher elevation areas. All-terrain vehicles were used on placer mining access roads along Frisco, Scroggie, and Barker creeks. Helicopter spot checks were completed in widely separated areas where foot traverses or fly camps were impractical.

Similar to the area mapped in 2000, bedrock mapping during 2001 was hampered by a thick (~1 m) soil veneer, thick gravel, and loess deposits in valley bottoms, and by thick cover of forest, moss, and lichen. The best bedrock exposure is along the main rivers and large creeks, and on ridges of high elevation. Because most of the Stewart River area is unglaciated, float was used with confidence to help locate bedrock contacts. Detailed aeromagnetic and gamma-ray surveys now being conducted under the Targeted Geoscience Initiative will provide additional information to constrain interpretation of bedrock geology. Fieldwork planned for 2002 and 2003 will expand to the north across the footprint of the geophysical surveys (Shives et al., 2001) (Fig. 2).

The older rocks in the area (?Paleozoic) are generally schistose or gneissic, and exhibit a shallowly inclined, high-strain regional foliation (S_T), formed through transposition of bedding (S_0), unit contacts, an earlier foliation (?S_1), and minor quartz veins. Later folds steepen the foliation at the local scale, and impart large open warps at the map scale. Younger intrusive rocks (mainly (?)Mesozoic) are massive to only weakly deformed. Young metaclastic and volcanic rocks ((?)late Cretaceous–Tertiary) unconformably overlie Paleozoic and Mesozoic rocks. Most geological boundaries on the map (Fig. 2) are portrayed as relatively straight and simplistic, due chiefly to the poor quality of bedrock exposure. It is difficult to accurately locate the trace and ascertain the dip of most contacts. The following is a brief summary of the geology mapped during 2001, with emphasis on rock types or relationships not described in Ryan and Gordey (2001a, b).

GEOLOGICAL UNITS

Until regional correlations are more thoroughly understood, the unit names of Bostock (1942), Tempelman-Kluit (1974), and Mortensen (1996), are discontinued in favour of a more descriptive classification (i.e. Ryan and Gordey, 2001a, b); however, we retain the name for the well established Carmacks

Figure 4. Layers of pin-head size garnet in transposed dirty quartzite (unit 1). Pencil for scale. May represent recrystallized chert.

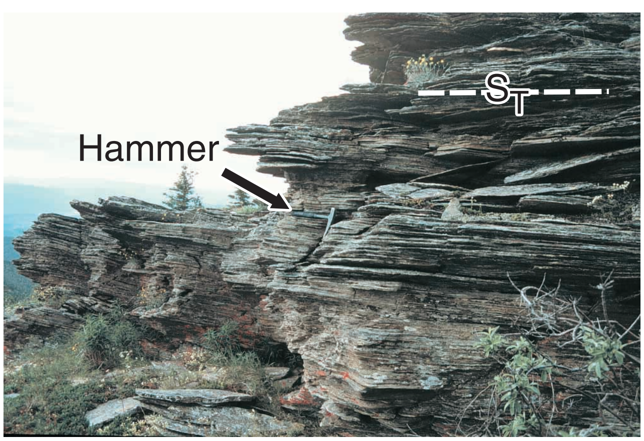


Figure 3. *Highly fissile and banded nature of highly strained, interlayered quartzite and quartz-mica schist, above contact with ultramafic lozenge (hammer for scale).*

Figure 5. *Cliff-side exposure of a 20 m thick, shallowly dipping, grey-buff banded marble (unit 5). Person for scale.*

the quartzite units can take on a highly fissile character (Fig. 3), and are more correctly termed quartz mylonite. Graphitic quartzite is more common on the west side of the Yukon River, particularly near the White River. For the most part, the quartzite appears to have a clastic origin, but local rhythmic layering (Ryan and Gordey, 2001a, Fig. 4), or rare garnetiferous bands (Fig. 4) suggest a bedded chert origin for some.

Unit 3 includes mica-quartz schist and paragneiss of psammitic, semipelitic, and rare pelitic origin. Although transposed, they generally preserve primary compositional layering. These mica-bearing metasedimentary rocks almost ubiquitously contain garnet, whereas other index minerals such as staurolite or aluminum silicate minerals are very rare.

Unit 4 consists of quartz-mica (muscovite and biotite) schist, and differs from unit 3 by a much higher quartz content. It commonly grades between semipelite, psammite, and quartzite. In many places units 3 and 4 are strongly interstratified, and not divisible at the scale of mapping.

Metacarbonate of unit 5 forms a minor component of south Stewart River area. The unit is dominated by coarse-grained (~5 mm) marble, with lesser calc-silicate schist. Where recrystallization has been less severe (grain size <1 mm), bedding is locally preserved. Marble horizons are generally less than 20 m thick (Fig. 5), with a couple of exceptions east of Scroggie Creek and north of the Stewart River (Fig. 2) where 75 m and more are present.

Metavolcanic and volcaniclastic rocks (units 6–8)

Unit 6 comprises amphibolite schist and/or gneiss of highly variable composition and state of strain. Amphibolite units generally contain the mineral assemblages hornblende-plagioclase or garnet-hornblende-plagioclase±quartz± epidote (Fig. 6), with local chlorite-biotite. Ryan and Gordey (2001a) reported that amphibolite occurs in two main associations: 1) interstratified with the metasedimentary rocks described above, and 2) with an orthogneissic complex (units 9 and 10). The amphibolite units were intensely tectonized, and underwent extreme grain-size coarsening during regional metamorphism, making it difficult to discern the protolith.

Figure 6. *Garnet-amphibolite (unit 6), where some garnet is altered to plagioclase. Pencil for scale.*

Figure 7. *Large rosettes of hornblende radiating on the foliation surface of an intermediate amphibolite (unit 6). Pencil for scale.*

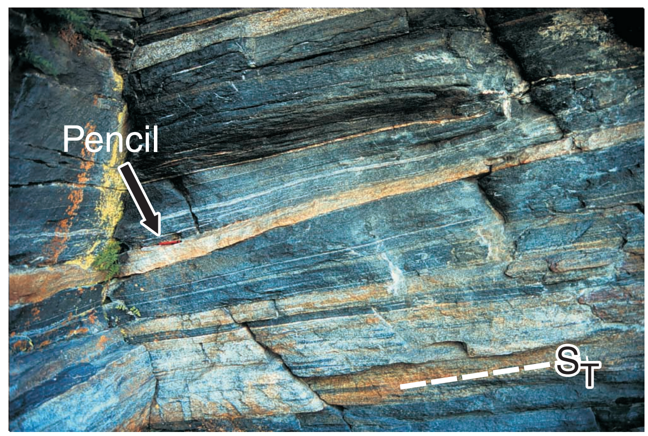


Figure 8. *Compositionally heterogeneous, highly strained layered orthogneiss (unit 9) composed of diorite, tonalite, and granodiorite. Pencil for scale, by arrow.*

Group. Apart from the relatively young intrusive, sedimentary, and volcanic rocks, the stratigraphic succession remains uncertain, and awaits ongoing geochronological study.

Metasedimentary rocks (units 1–5)

Unit 1 comprises sequences of grey to white, banded quartzite of variable thickness. It is generally strongly recrystallized, and has metamorphic grain size in excess of 1 mm. Varieties range from black to rusty brown. The thickest and cleanest quartzite units are in a large block southwest of the mouth of Thistle Creek (Fig. 2). Although largely fault bounded, those quartzite units are demonstrably interstratified with quartz-mica schist units, and a metaconglomerate (unit 2; *see* Ryan and Gordey (2001a)) that also contains clasts of tonalite; stratigraphic younging cannot be deciphered there due to structural transposition. Elsewhere the quartzite tends to be impure with between 5% and 20% content of minerals other than quartz, such as mica and feldspar, and usually grades into psammite. In high-strain zones,

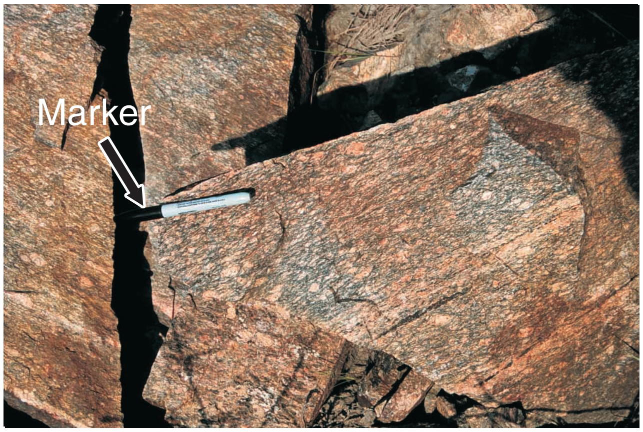


Figure 9. *Red potassic feldspar augen granite of unit 11. Marker for scale.*

They are proportionally more abundant in the Thistle Creek area (Fig. 2; Ryan and Gordey, 2001a). Preserved volcanic textures that might shed light on their origin are rare; a mafic volcanic to volcaniclastic protolith is likely.

Spectacular examples of more intermediate varieties of amphibolite were mapped southwest of Scroggie Creek, west of Black Hills Creek, and in the Shamrock dome region (Fig. 2). These contain large hornblende porphyroblasts that commonly exhibit spectacular decussate texture, or occur as spaced rosettes (Fig. 7) that are as large as 15 cm, in a matric of plagioclase, epidote, and quartz. For these rocks an intermediate composition metavolcanic and volcaniclastic protolith is likely. Complete gradation is seen between the mafic and intermediate compositions of amphibolite, and some grade locally to mafic psammitic schist, probably derived from greywacke.

Some amphibolite horizons are more clearly derived from sills or dykes of diabase, gabbro, or diorite. They are generally boudinaged, and locally preserve contacts oblique to layering.

Unit 7 comprises quartz-sericite schist or metafelsite, possibly derived from felsic volcanic rocks or hypabyssal intrusions. Unit 8 is a conspicuous mafic schist composed of biotite-hornblende$\pm$plagioclase-quartz, with blocky books of biotite. These units were described previously in the Thistle Creek area (Ryan and Gordey, 2001a, b); no new occurrences were mapped this year.

Orthogneissic rocks (units 9–11)

Unit 9 comprises an intrusive complex of intermediate to mafic orthogneiss of variable state of strain. It is composed chiefly of grey-weathering tonalite to diorite sheets (commonly 5–50 cm thick) and veinlets, giving the rock an intensely layered and banded appearance (Fig. 8). More homogeneous bodies of tonalite and diorite are grouped with the orthogneiss, but perhaps would be better referred to as strongly foliated rather than truly gneissic. We interpret the orthogneiss complex as subvolcanic intrusions to the volcanic pile(s) represented by amphibolite (unit 6) with which it is intimately associated, essentially forming a volcano-plutonic complex. Where exposure was too poor, or interlayering was at too fine a scale, units 6 and 9 are undivided on Figure 2. As yet there is no geochronological constraints on the age of the orthogneiss complex. Ages determined for similar rocks elsewhere (e.g. Mortensen, 1992) in Yukon–Tanana terrane are late Devonian or early Mississippian.

Felsic to intermediate orthogneiss of unit 10 is composed of pink- to orange-weathering granite to granodiorite sheets and veinlets. In detail, these crosscut the diorite and tonalite sheets, with which they were transposed. Gneissic granitic sheets observed outside of the intrusive complex are presently grouped in unit 10, although a similar age is not yet proven. Some of these sheets may be associated with augen granite of unit 11 (below).

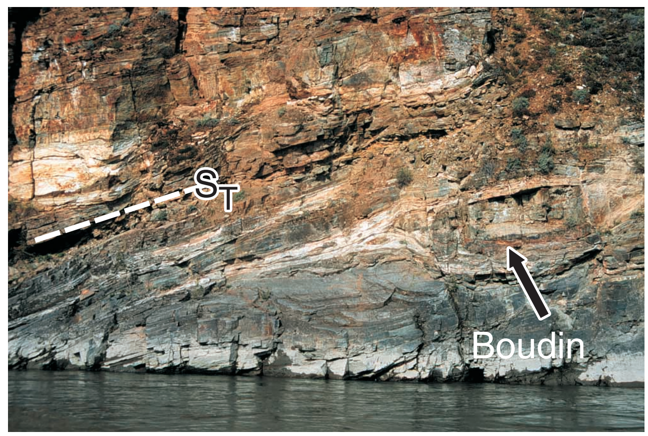


Figure 10. *Ultramafic boudin (3 m across) wrapped by the foliation in high-strain marble band (unit 5) within amphibolite (unit 6).*

Figure 11. *Fissile, high-strain amphibolite tectonite on margin of ultramafic lozenge (unit 12, locality B), with ribbons of quartz and epidote. Pencil for scale.*

metagabbro and metapyroxenite, with little to no serpentenite. The gabbroic portion of this sheet is intruded by grey orthogneiss sheets. It is possible that both bodies of mafic-ultramafic rocks were once part of a continuous relatively flat-lying sheet of much greater thickness and extent, now separated by erosion. Given an additional 200 m of erosion, there would be little record of the unit left.

A spectacular exposure of ultramafic rocks lies on the north side of Shamrock dome (location B, Fig. 2), and appears to form a 75 m thick, shallowly dipping, high-strain lozenge within a shallowly dipping, very high-strain panel (shear zone) of quartz-rich metasedimentary rock (Fig. 3) below an amphibolite package. The lozenge is intensely sheared, and is compositionally layered. The uppermost layer in contact with quartz mylonite is an amphibolite tectonite, with highly attenuated quartz-epidote ribbons (Fig. 11). Below this is a white-weathering layer of talc-siderite-magnetite± magnesite-feucite schist wherein magnetite and siderite clots

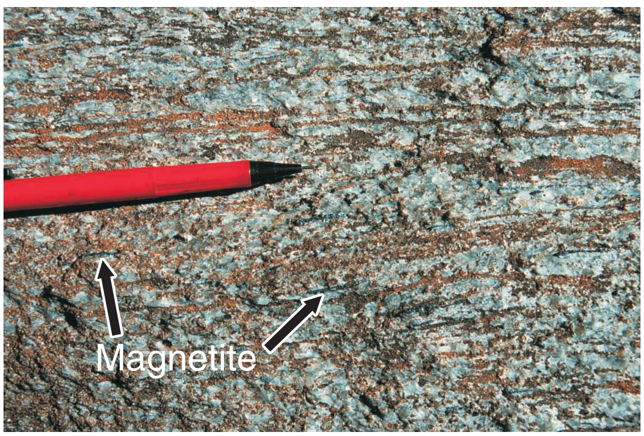


Figure 12. *Intense stretching lineation defined by clots of magnetite and siderite within coarse-grained talc schist, in ultramafic lozenge (unit 12, locality B). Pencil for scale.*

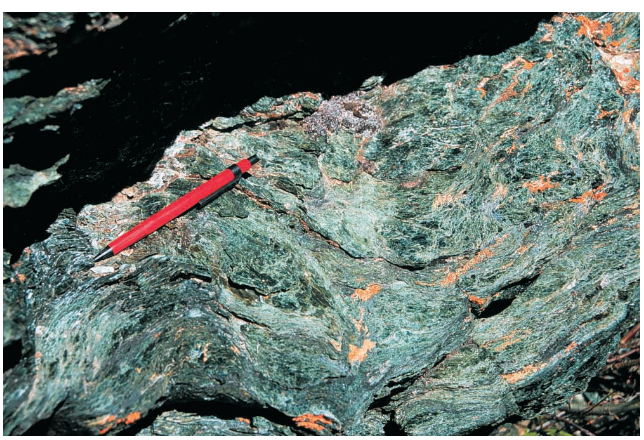


Figure 13. *Folded and crenulated, scaly, bright-green serpentinite layer in ultramafic lozenge (unit 12, locality B). Pencil for scale.*

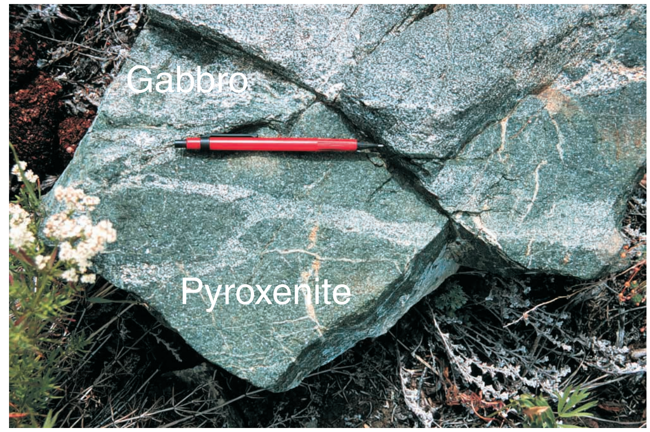


Figure 14. *Actinolitic metapyroxenite intruded by gabbro, demonstrating relative ages of phases in the mafic-ultramafic complex (unit 12). Pencil for scale.*

Potassic feldspar augen granitic orthogneiss comprises unit 11. This unit is pink- to grey-weathering, and forms one of the more texturally distinct rock types across the area (Fig. 9). For the most part, these rocks are highly strained, but low-strain vestiges of porphyritic monzogranite do occur. Ryan and Gordey (2001a) postulated that the augen gneiss may correlate with a suite of Mississippian augen granitic rocks dated regionally at ca. 360 Ma (Mortensen, 1992); however, for one body near Kirkman Creek a Permian age is suggested (M. Villeneuve, unpub. data, 2001). Unit 11 is regionally widespread, and a variety of mid- to Late Paleozoic ages could be represented.

Mafic and ultramafic rocks (unit 12)

A diverse assemblage of mafic to ultramafic rocks make up unit 12, an important unit in deciphering the tectonic evolution of this portion of the Yukon–Tanana terrane. It is dominated by highly deformed, amphibolite-facies metagabbro, with lesser associated metapyroxenite, and rare serpentinite and talc-siderite schist. Hornblende is the chief metamorphic mineral in the metagabbro, whereas the metapyroxenite is made up almost exclusively of coarse-grained (0.5–10 cm) actinolite. Hornblende in the metagabbro helps define a strong foliation, whereas actinolite in metapyroxenite is randomly oriented. The actinolitic rocks tend to form boudins within the foliation (Fig. 10), and therefore have experienced the high strain. The random orientation of actinolite reflects later growth (or recrystallization), which probably occurred during retrograde metamorphic conditions.

The bulk of the mafic-ultramafic rocks occur as flat-lying sheets at high elevation in two areas: one west of the Yukon River, north of Los Angeles Creek, and the other on the west side of Mount Stewart, south of Frisco Creek (Fig. 2). They lie structurally above metasedimentary rocks of units 3 and 4, and their contact appears to have predated gneissosity development. The easterly sheet also contains a body of highly magnetic, brown- to bright green-weathering serpentinite. Abundant boulders of similar lithology are found along Frisco Creek. The westerly sheet comprises mainly help define an intense lineation (Fig. 12). Some siderite porphyroblasts clearly postdate the fabric. Below the talc schist is a thick layer of brilliant green-weathering, magnetite-bearing, scaley serpentinite (Fig. 13). The strongly anastomosing schistosity in the serpentinite is strongly folded and crenulated. It contains abundant boudins and layers of the coarse-grained actinolitic schist. The lowermost layer is another talc-siderite schist, and is in high-strain contact with underlying quartz-mica schist and quartzite. The intense stretching lineation within the ultramafic lozenge trends at a 90° angle to the lineation in the tectonite that bounds the lozenge and the regional lineation in the surrounding schist; the intense stretching lineation in the lozenge predates the regional lineation and foliation.

A panel of metamorphosed gabbro and pyroxenite (containing hornblende and actinolite respectively), occurs above tectonized quartz-rich schist on the north bank of the White River (near location A, Fig. 2). Despite being manifest as an amphibolite schist at the base of the mafic-ultramafic panel, the lower-strain upper portion exhibits excellent primary relationships wherein actinolitic metapyroxenite is intruded by the gabbro (Fig. 14).

Younger plutonic rocks (units 13–16)

Units 13 and 14 includes a variety of monzogranite, granodiorite, quartz monzonite, and locally gabbro intrusions. These crosscut the regional gneissosity, but are themselves moderately to strongly foliated. Their lesser state of strain relative to the orthogneiss units (units 9, 10, and 11) suggests a younger age ((?)Permian to (?)Jurassic).

Unit 15 includes a variety of intrusions ranging from chlorite-altered hornblende to biotite-bearing granodiorite and monzogranite, quartz monzanite, and monzodiorite. These bodies have little to no tectonic fabric. Their age is not known with certainty, but intrusions of similar composition and character dated elsewhere in the Yukon–Tanana terrane are Jurassic (Mortensen, 1992; and J.K. Mortensen, unpub. data, 2001).

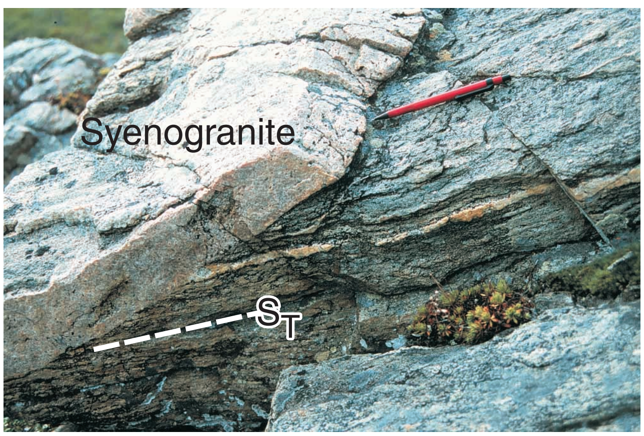


Figure 15. *Syenogranite dyke at margin of larger, probably Cretaceous body (unit 15), cutting across S_T foliation in metapsammite (unit 3). Pencil for scale.*

Figure 17. *Subhorizontal flaggy splitting habit in aphanitic rhyodacite of Carmacks Group, reflecting cryptic primary flow fabrics. Pen for scale.*

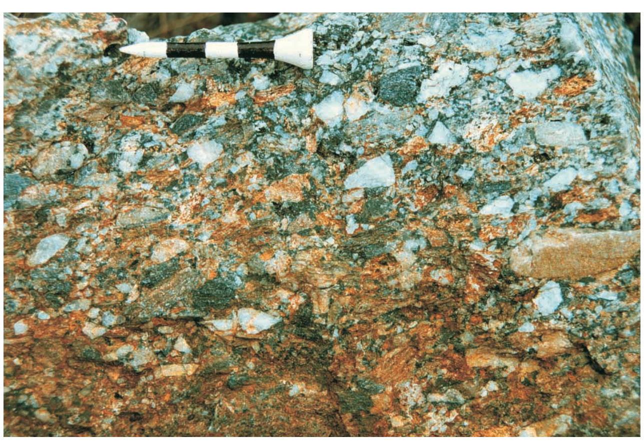


Figure 16. *Rounded to highly angular clasts of vein quartz and foliated quartzite in conglomerate (unit 17) below Carmacks Group. Golf tee for scale.*

Figure 18. *Flattened vesicles demonstrating flow fabrics in Carmacks Group andesitic basalt, 20 cm above Carmacks basal unconformity. Pencil for scale.*

Unit 18 comprises a number of localized occurrences of quartz and/or potassic feldspar phyric rhyolite commonly exposed in small, blocky felsenmeer rather than intact bedrock. Quartz phenocrysts from 1–5 mm, but as large as 12 mm (Fig. 19), vary from clear, to smoky grey, and smoky blue-grey. Most occurrences appear to be dykes rather that flows, a few of which are measured as north trending and subvertical. An exceptionally well exposed pair of dykes outcrop on a south-facing cliff (Fig. 20) on the north bank of the White River (location A, Fig. 2). The dykes are relatively narrow, one being about 50 m thick and the other 20 m thick, however, the lateral extent of associated felsenmeer rubble inland from the top of the cliff is more than 300 m wide. At this locality, the dykes clearly cut across the unconformity at the base of the Carmacks Group volcanic rocks (which show flow fabric in vesicles at the contact with underlying gneiss and schist units). The location of these two porphyry dykes coincides with the location of an approximately 25 km long by 1 km wide linear anomaly in regional radiometric data (potassium, uranium, and thorium highs) (e.g. *in* Shives et al.,

Figure 19. *Porphyritic quartz-potassic feldspar rhyolite, with inclusions of Carmacks Group andesite. Quartz phenocrysts are mantled by feldspar. Pencil for scale.*

Figure 20. *Vertical, 50 m wide porphyritic rhyolite dykes (outlined by dotted lines on photograph) in cliff side, which cut through Carmacks Group volcanic rocks and its underlying basement.*

Unit 16 comprises a suite of syenogranite to monzogranite plutons, and/or dykes (Fig. 15) which are massive, unmetamorphosed, and locally cut unit 14. These may be mid-Cretaceous, Late Cretaceous, or Tertiary.

Cretaceous–Eocene rocks (units 17–19)

In the greater Stewart River area Cretaceous clastic and volcanic rocks (Bostock, 1942; Tempelman-Kluit, 1974; Lowey, 1984; Lowey and Hills, 1988) unconformably overlie rocks like those previously described. The lower part is a succession of interbedded sandstone, shale, conglomerate, and minor coal correlated with the Tantalus Formation. A middle Albian age is suggested based on spore, pollen, and dinoflagellate assemblages (Lowey and Hills, 1988). This is in turn overlain by interbedded conglomerate, sandstone, shale, with minor limestone and tuff, and voluminous basalt and andesite flows assigned to the lower Carmacks Group (Lowey and Hills, 1988). Palynomorphs and fossil leaves from the clastic rocks and isotopic ages from the volcanic rocks indicate a late Cretaceous–Paleocene age (Lowey et al., 1986; Lowey and Hills, 1988).

Clastic sedimentary and volcanic rocks similar to those described above are sporadically and discontinuously exposed near Los Angeles Creek in the southern part of the area mapped (Fig. 2). A conglomerate horizon (unit 17) mapped below Carmacks Group rocks 1.25 km west of the west edge of NTS 115-O/4 (Fig. 2) is largely clast supported, and contains rounded to angular clasts of dominantly vein quartz and foliated quartzite (Fig. 16). Unit 17 may correlate with the Tantalus Formation as described in Lowey and Hills (1988).

Unit 18 consists of volcanic rocks of the Carmacks Group dominated by rhyodacite, dacite, rhyolite, with lesser andesite and basalt. They may correlate with the lower Carmacks Group in the Sixty Mile River area, although as described there (Lowey, 1984) the sequence is dominated by basalt and basaltic andesite. Bedrock exposure of these rocks is poor, making it difficult to ascertain their depositional setting (i.e. flows versus hypabyssal intrusions). Locally, however, primary fabrics such as flow banding in rhyodacite (Fig. 17) or flattened vesicles in andesitic basalt (Fig. 18) demonstrate they are extrusive. It appears that the stratigraphically higher (and thus younger) parts of the volcanic sequence have high magnetic susceptibility as measured in the field, whereas the older portions have low magnetic susceptibility. There is good correlation between distribution of Carmacks volcanic rocks mapped in this study (as well as by Bostock (1942), Tempelman-Kluit (1974), and Lowey (1984)) and anomalies in the regional geophysical data.

The distribution of the Carmacks Group is largely controlled by faults synchronous with and postdating Carmacks Group rocks. On their downdropped sides, large thicknesses of Carmacks Group rocks are preserved, whereas on the upthrown blocks, the Carmacks Group is preserved as small scattered outliers.

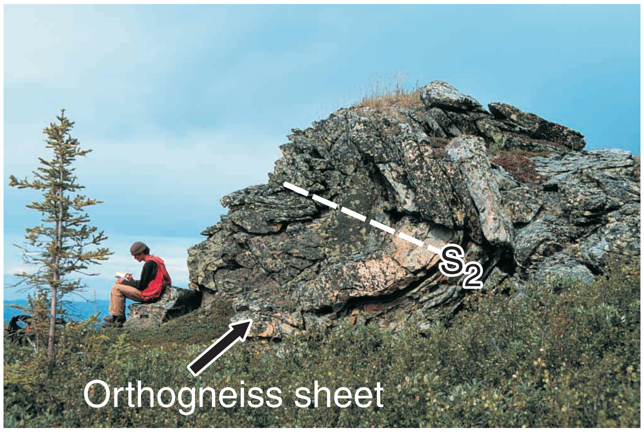


Figure 21. *Shallowly inclined F_2 fold of quartzite (including a tonalite sheet), with a strong axial plane foliation, parallel to S_T. Person for scale.*

2001; R.B.K. Shives, J.M. Carson, K.L. Ford, P.B. Holman, S.P. Gordey, and G. Abbott, unpub. data, 2001). The width of the anomaly is puzzling with respect to the narrow width of the dyke. It is possible that the narrow dykes are feeders to widespread felsic flows in the higher ground; however, a component of this width may reflect detritus from the dykes dispersed in the soil through weathering.

The age of these felsic porphyry bodies is not known, other than being younger than the lower Carmacks Group. They look similar to felsic porphyry mapped in the northernmost part of the Stewart River map area described as early Tertiary (Mortensen, 1996), and we interpret the porphyry bodies in the southern Stewart River area to be early Tertiary as well.

DEFORMATIONAL STRUCTURES

Observations and interpretations of the regional structures from this summer's mapping are consistent with those of last year, and the reader is referred to Ryan and Gordey (2001a) for this background. We reiterate some important points, and add some new findings below.

Regional foliation

Almost all probable Paleozoic rocks in the field area exhibit the regional foliation (S_T), characterized by high-strain transposition of layering in gneiss and schist, with abundant intrafolial isoclinal folds that are commonly rootless. The intensity of strain within the regional foliation locally grades to mylonite. Primary compositional layering (S_0) in metasedimentary rocks, unit contacts (e.g. dyke margins), and a pre-existing foliation (S_1) can be recognized around closures of the transposition folds, indicating that they are at least F_2 structures. The F_2 folds are generally recumbent to shallowly inclined, close to isoclinal, long-wavelength structures. Large F_2 folds are well outlined in quartz-rich metasedimentary rocks (Fig. 21) west of Black Hills Creek, where a strong axial-planar S_2 is present, parallel to the regional S_T. As pointed out by Ryan and Gordey (2001a) in the Thistle Creek area, F_2 structures commonly lack an axial planar foliation. A regional extension lineation (L_2) is parallel to the F_2 axes. This relationship helps distinguish F_2 and F_3 folds, which can have very similar style (Ryan and Gordey, 2001a).

Faults

The map area is affected by faults of various significance (Fig. 2). Most of these could not be observed directly, but are interpreted to help explain abrupt changes in rock type, and/or structural grain. Some of these are also well delineated by prominent physiographic and aeromagnetic lineaments. Locally, fault breccia and slickensides provide direct evidence of fault contacts (e.g. Ryan and Gordey, 2001a).

Mapping across the White and Yukon rivers shows no appreciable change in bedrock composition across these valleys, ruling out any significant offset along them. Future mapping will test the significance of the pronounced lineament trending northwestward from Scroggie Creek, through the Stewart, Yukon, and Sixty Mile rivers.

METAMORPHISM

No quantified study of metamorphism has been done in the field area, and little additional understanding of regional metamorphism has been gained since that reported in Ryan and Gordey (2001a). Mafic rocks in the area typically exhibit the middle amphibolite-facies assemblage garnet+hornblende. Other than the presence of kyanite in the Grizzly dome area, the lack of aluminum silicate minerals in the aluminous metasedimentary rocks remains puzzling.

DISCUSSION

Tectonostratigraphy and paleotectonic setting

Ryan and Gordey (2001a) reported that metavolcanic (amphibolite) and associated orthogneissic rocks were much more widespread than quartz-rich metasedimentary rocks in the Thistle Creek area; however, this year's work demonstrated an increase in the proportion of quartz-rich metasedimentary rocks away from Thistle Creek. Despite the high degree of strain in these rocks, and clear local evidence for structural interleaving, numerous localities demonstrate the interstratification of the metavolcanic and metasedimentary rocks. At the map scale, the metavolcanic rocks are structurally higher than the quartz-rich metasedimentary rocks, but stratigraphic way up cannot be proven. Mafic to intermediate orthogneiss units are predominantly associated with the amphibolite, and rarely with the metasedimentary rocks. We believe that this lithological distribution is consistent with a volcano-plutonic complex, of possible island-arc affinity, built upon a detrital quartz-rich (possibly continental) margin. Regional constraints indicate that this arc was probably of

Devono-Mississippian age. The age of the marginal sedimentary rocks are unknown ((?)Proterozoic, (?) early Paleozoic, (?)mid-Paleozoic).

The tectonic significance of the mafic-ultramafic complex is unclear. Some are clearly lozenges in high-strain zones, and the strain has removed most evidence of their original disposition. It is possible that they merely represent intrusive complexes (possibly Alaskan type) into the quartz-rich metasedimentary rocks, and were broken up and segmented during high-strain transposition of the stratigraphy during orogenesis. An alternative interpretation is that they represent dismembered portions of an originally more extensive structural sheet that was thrust on top of the metasedimentary rocks. Their internal compositional heterogeneity is reminiscent of dismembered ophiolitic fragments. Likewise, the 90° angle between pre-existing lineation in the talc-siderite schist, and the regional lineation in the surrounding schist near Shamrock Dome, is a relationship similar to that in peridotite that preserves deformation prior to ophiolite emplacement (e.g. Lewis Hills massif, western Newfoundland (Suhr and Cawood, 1993)).

Economic framework

Ryan and Gordey (2001a) reported that the Thistle Creek area is dominated by a volcano-plutonic (?)arc complex with implied potential for volcanogenic massive sulphide-type mineralization, and noted that metafelsite units were rare. No additional metafelsite units were mapped this summer, and siliciclastic rocks were found to be more abundant than metavolcanic rocks in the western portion of the area. By this reasoning the area mapped east of the Yukon River (Fig. 2) remains the most prospective for massive sulphide mineralization.

Mid-Cretaceous (105–90 Ma) and Late Cretaceous (70–65 Ma) plutons and their country rock are still considered prospective targets for intrusion-related gold deposits in Yukon Territory and Alaska (e.g. Hart et al., 2000). We have mapped a number of young-looking granite bodies in the southern Stewart River area, and have made an attempt at dividing them into probable Jurassic and Cretaceous suites. We believe that all of these bodies have potential for occurrences of intrusion-related gold.

ACKNOWLEDGMENTS

Dave Lister, Adrian Manlagnit, and Olwyn Bruce are thanked for assistance in the field. We thank Eric Stretch for providing a camp site at Frisco Creek, and exceptional freighting services. Lionel Jackson and Kaz Shimamura kindly helped with field logistics. Karl Scholz and Adam Morrison are thanked for helicopter services. Mike Villeneuve and Jim Mortenson are thanked for geological discussion and access to preliminary geochronology. Digital compilation by Alexander Miskovic and Adrian Manlagnit of the 1935–1937 field notes of H.S. Bostock has been very helpful. Andrew Okulitch is thanked for a constructive review of the manuscript.

REFERENCES

Bostock, H.S.
1942: Ogilvie, Yukon Territory; Geological Survey of Canada, Map 711A, scale 1:250 000.

Colpron, M. and Yukon-Tanana Working Group
2001: Ancient Pacific Margin – an update on stratigraphic comparison of potential volcanogenic massive sulphide-hosting successions of Yukon-Tanana Terrane, northern British Columbia and Yukon; *in* Yukon Exploration and Geology 2000; Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p. 97–110.

Dover, J.H.
1994: Geology of part of east-central Alaska; *in* The Geology of Alaska, (ed.) G. Plafker and H.C. Berg; Geological Society of America; The Decade of North American Geology, v. G-1, p. 153–204.

Hart, C.J.R., Baker, T., and Burke, M.
2000: New exploration concepts for country-rock-hosted, intrusion-related gold systems: Tintina gold belt in Yukon; *in* The Tintina Gold Belt: Concepts, Exploration, and Discoveries; Special Volume 2, Cordilleran Roundup 2000, B.C. Chamber of Mines, Vancouver, British Columbia, p. 145–172.

Lowey, G.W.
1984: The stratigraphy and sedimentology of siliciclastic rocks, west-central Yukon, and their tectonic implications; Ph.D. thesis, University of Calgary, Calgary, Alberta, 620 p.

Lowey, G.W. and Hills, L.V.
1988: Lithofacies, petrography and environments of deposition, Tantalus Formation (Lower Cretaceous) Indian River area, west-central Yukon; Bulletin of Canadian Petroleum Geology, v. 36, no. 3, p. 296–310.

Lowey, G.W., Sinclair, W.D., and Hills, L.V.
1986: Additional K-Ar isotopic dates for the Carmacks Group [Upper Cretaceous], west-central Yukon; Canadian Journal of Earth Sciences, v. 23, no. 11, p. 1857–1859.

Mortensen, J.K.
1992: Pre-mid-Mesozoic tectonic evolution of the Yukon-Tanana Terrane, Yukon and Alaska; Tectonics, v. 4, p. 836–853.
1996: Geological compilation maps of the northern Stewart River map area, Klondike and Sixtymile districts; Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, Open File 1996-1(G), scale 1:50 000.

Ryan, J.J. and Gordey, S.P.
2001a: New geological mapping in Yukon-Tanana terrane near Thistle Creek, Stewart River map area, Yukon Territory; Geological Survey of Canada, Current Research 2001-A2, 18 p.
2001b: Geology of the Thistle Creek area (105-O/3), Yukon Territory; Geological Survey of Canada, Open File 3690, scale 1:50 000.

Shives, R.B.K., Carson, J.M., Ford, K.L., Holman, P.B., Gordey, S.P., and Abbott, G.
2001: Airborne multisensor geophysical survey, Stewart River area, Yukon, Phase 1 (portable document format (PDF) files); Geological Survey of Canada, Open File GSC D4009 (*also* Yukon Exploration and Geological Services Division Open File 2001-30D).

Suhr, G. and Cawood, P.A.
1993: Structural history of ophiolite obduction, Bay of Islands, Newfoundland; Geological Society of America, Bulletin, v. 105, no. 3, p. 399–410.

Tempelman-Kluit, D.J.
1974: Reconnaissance geology of Aishihik Lake, Snag and part of Stewart River map-areas, west-central Yukon; Geological Survey of Canada, Paper 73-41, 97 p. (including maps).

Thompson, R.I., Nelson, J.L., Paradis, S., Roots, C.F., Murphy, D.C., Gordey, S.P., and Jackson, L.E.
2000: Ancient Pacific Margin NATMAP Project, year one; Geological Survey of Canada, Current Research, 2000-A1, 8 p.

Geological Survey of Canada Project 990002-03