Preliminary observations on the geology of the Anvil Lake area (parts of NTS 105K/11 and 12), central Yukon

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ABSTRACT

The Anvil Lake area consists of mostly contact-metamorphosed siltstone and sandstone having lesser interbedded volcanic and carbonate units that belong to the Early Paleozoic Selwyn basin, thrust northward over the Devono-Mississippian Earn Group and Carboniferous to Triassic formations. These are intruded by the mid-Cretaceous Anvil batholith. The mapped area surrounds the Keg, a disseminated silver-base metal deposit of current interest; new bedrock information will increase the efficiency of exploration of silver bearing veins noted along stratigraphic and structural contacts regionally. It is the first season of an investigation aiming to provide more detailed revision of regional maps, with further paleontology, geochronology, and structural analysis.

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INTRODUCTION

Grassroots mineral exploration, north and northwest of the town of Faro, has expanded regionally from the Keg deposit (MINFILE 105K 078; discovered in 1966, assessed through the 1970s). Since 2010, a trend of high-grade silver-bearing occurrences has been delineated, roughly parallel to a NW-trending fold-thrust belt that includes the Keg deposit.

Bedrock maps of the region stem from field work in the 1980's (Gordey, 2013a,b; at scales of 1:100 000 and 1:250 000). The mapped area lies immediately north of a regional compilation of the Anvil district (Pigage, 2004). More thorough coverage of the bedrock exposure will add structural and stratigraphic detail, and may elucidate the setting of these occurrences. In 2013 the Yukon Geological Survey initiated detailed revision mapping surrounding the Keg occurrence. The results of paleontology, geochronology, compositional, and structural analyses are pending; the intent is to continue mapping along the structural trend to the northwest.

GEOLOGICAL FRAMEWORK

The Anvil Lake area is located in the center of Yukon, 30 km north of the previously mined Faro deposit (Fig. 1). The mapped area is the heart of Selwyn basin, a broad region underlain by mostly lower Paleozoic deep water clastic, cherty and less common thin carbonate strata (Gabrielse, 1967; Gordey and Anderson, 1993; Gordey, in prep). The Selwyn basin depocenter ceased by middle Devonian. Devono-Mississippian greywacke, conglomerate, and siltstone, sourced primarily from the northwest (Abbott *et al.*, 1986; Gordey and Anderson, 1993) were unconformably deposited on the lower Paleozoic strata. The Anvil Lake area also preserves, in down faulted blocks and in the foot wall of thrusts, remnants of the Carboniferous through Jurassic shelf succession, also dominantly clastic. Regional unconformities separate these successions, although they are not exposed in the mapped area.

Central Yukon is in the Omineca structural province that is characterized by north and northeast-verging folds and thrust faults, some of which can be traced across the mapped area (Fig. 2). These reflect northeastward shortening generally accepted to have resulted from collision of continental fragments and arc assemblages with the western margin (present coordinates) of Laurentia in Middle Jurassic (Colpron *et al.*, 2006; Mair *et al.*, 2006). Remnants of the subducted exotic terrains (Yukon Tanana, Slide Mountain; Fig.1) lie 25 km south of the mapped area. In the late Early Cretaceous, granitic plutons, including the 60-km-long Anvil batholith, perforated the structurally telescoped and thickened Selwyn basin strata; those exposed in the mapped area belong to the Selwyn plutonic suite (Gordey and Anderson, 1993; Rasmussen, 2013). The Tintina fault, a northwest trending structure, along which 430 km dextral slip has occurred since mid-Cretaceous, lies 25 km southwest of the mapped area (Gabrielse *et al.*, 2006; Roddick, 1967). No systematic fault offset or brittle features related to it are recognized in the mapped area.

In summary the southern half of the mapped area consists of Cambrian to Silurian Selwyn basin strata that have been thrust over Devonian to Triassic strata in the northern half. Tight folds in the Devonian to Triassic strata are kinematically linked to northwest-striking thrust faults. Granitic plugs and the Anvil batholith intrude both successions and thrust faults, imposing a contact metamorphic aureole several kilometres wide.

STRATIGRAPHY

The Anvil Lake area is underlain by Selwyn basin strata of Lower Cambrian to Silurian age. These are: Mount Mye formation, Vangorda formation, and Menzie Creek formation, and an as-yet uncorrelated limestone unit of probable pre-Devono-Mississippian age. These are unconformably overlain by a Devonian through Triassic sequence including several lithologic divisions of the Earn Group, the Tay Formation, an as-yet uncorrelated sandstone of probable Carboniferous to Permian age, the Mount Christie Formation, and Jones Lake Formation (Fig. 3).

UPPER PROTEROZOIC TO SILURIAN ROCKS

Clastic and volcanic strata in the southern half of the mapped area, interpreted to be upper Proterozoic to Silurian, were designated as Gull Lake Formation, Rabbitkettle Formation, and overlying Menzie Creek formation on reconnaissance maps (Gordey, 2013a,b). Currently, however, local workers use the informally named Mount Mye formation (uPCMM), Vangorda formation (COV), and Menzie Creek formation (OSMC) (Jenning and Jilson, 1986; Pigage, 2004) for the same strata within the Anvil District. This informal terminology has been adopted to describe most of the rocks in the north part of the Anvil district.

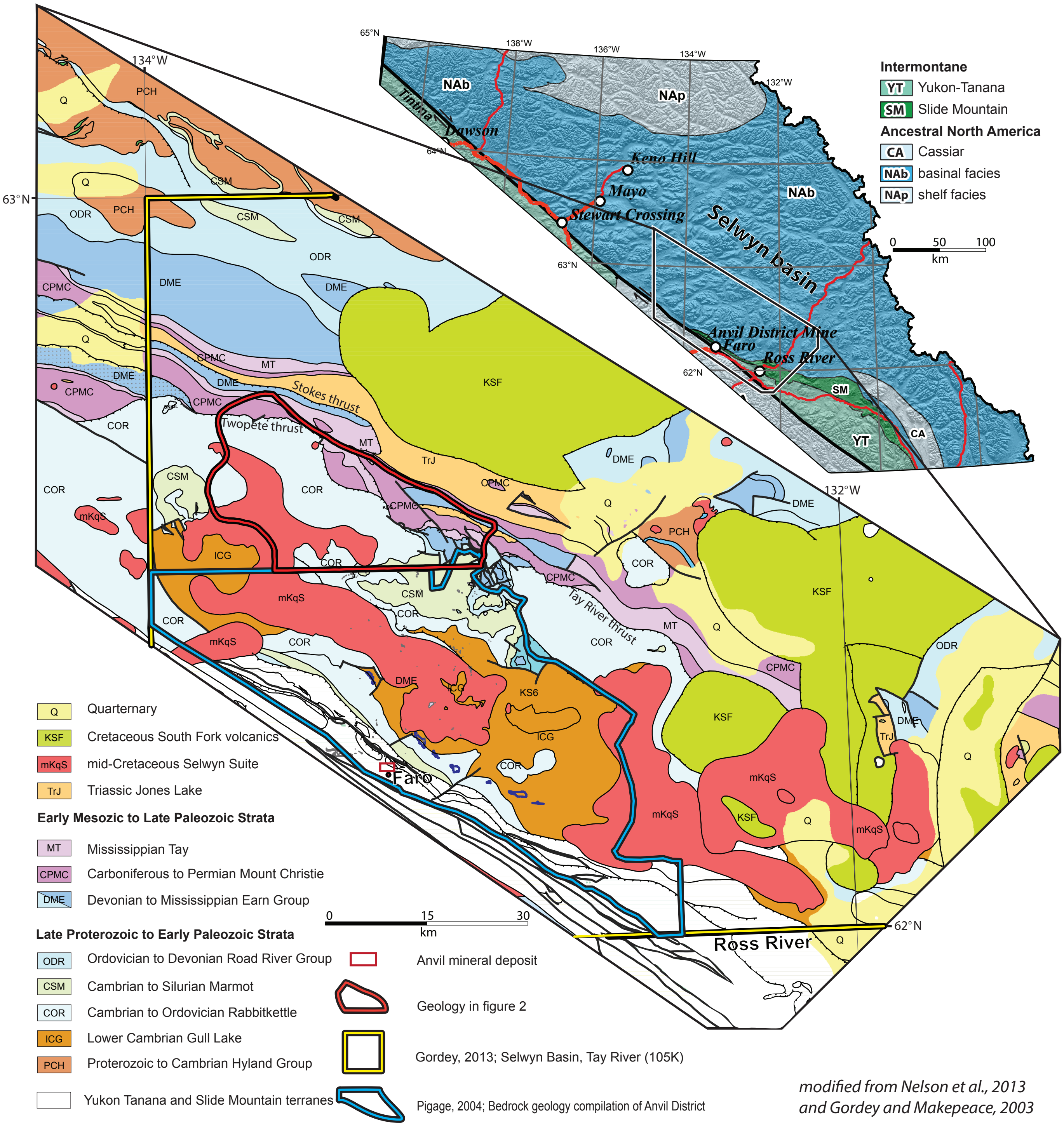
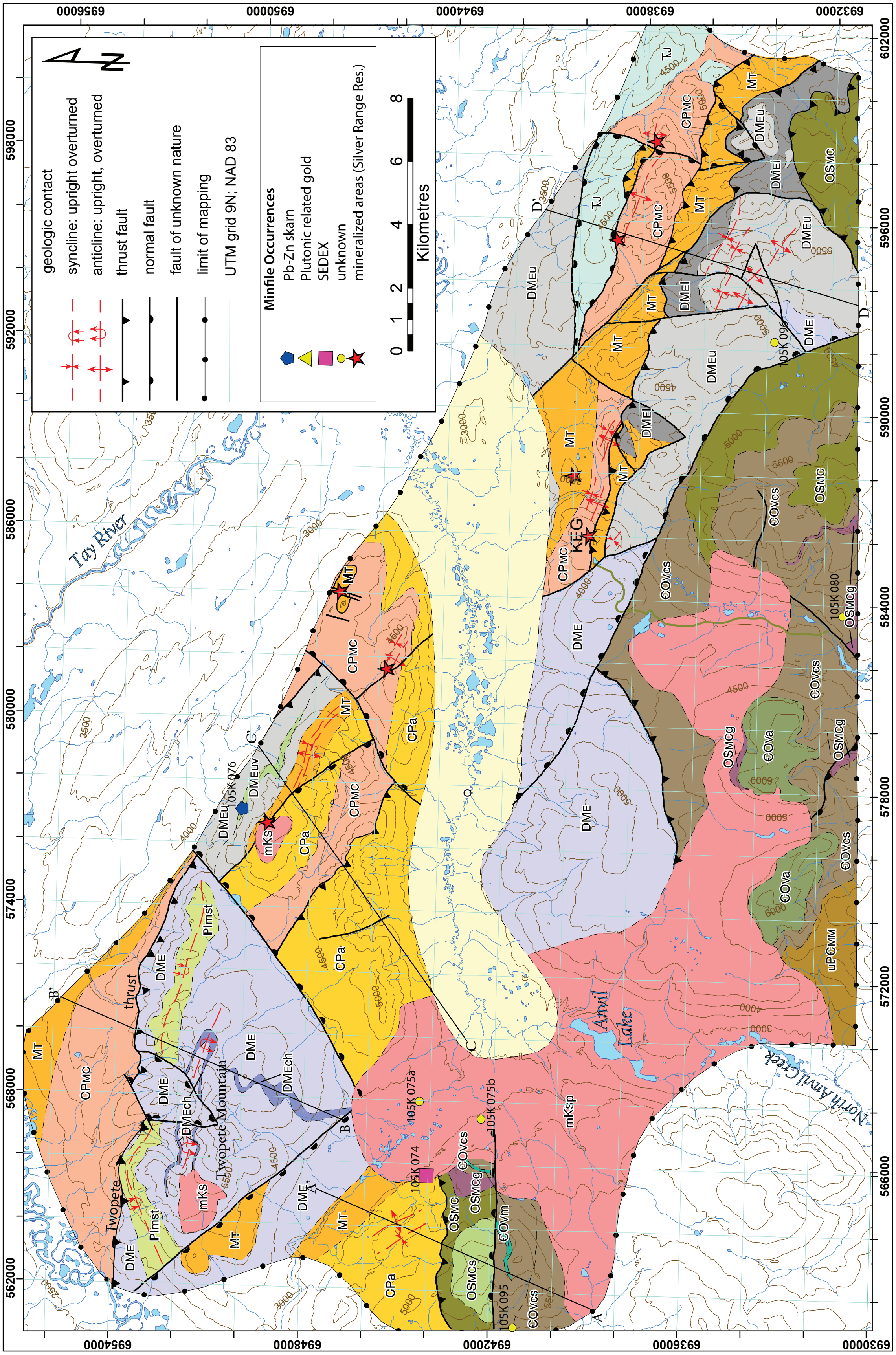


Figure 1*. Geological terranes (from Nelson et al., 2013) shown in top right map; mapped area lies in Selwyn basin. Larger map shows geology of the Anvil district (modified from Gordey and Makepeace 2003) with colored lines delineating regional mapping by Gordey, 2013 (yellow), Pigage, 2004 (blue), and this study (red).*


geologic contact
syncline: upright overturned
anticline: upright, overturned
thrust fault
normal fault
fault of unknown nature
limit of mapping
UTM grid 9N; NAD 83
Minfile Occurrences
Pb-Zn skarn
Plutonic related gold
SEDEX
unknown
mineralized areas (Silver Range Res.)
0 1 2 4 6 8
Kilometres
Tay River
Anvil Lake
North Anvil Creek
Twopete Mountain
KEG
MJ
105K 074
105K 075a
105K 075b
105K 076
105K 080
105K 095
105K 096

LEGEND

QUATERNARY

- **Q** — glacial, glaciofluvial and glaciolacustrine deposits

INTRUSIVE ROCKS

MID CRETACEOUS

- **mKs** — ANVIL BATHOLITH: biotite +/- hornblende granodiorite
- **mKsp** — ANVIL BATHOLITH: porphyritic biotite +/- hornblende granodiorite

ORDOVICIAN AND SILURIAN

- **OSMCg** — MENZIE CREEK gabbro: medium grained, dark green pyroxene bearing gabbro sills and dikes

LAYERED ROCKS

MIDDLE TO UPPER TRIASSIC

- **TRJ** — JONES LAKE FORMATION: light grey, calcareous sandstone, locally cross laminated; grey limestone and silty limestone

CARBONIFEROUS TO PERMIAN

- **CPMC** — MOUNT CHRISTIE FORMATION: rusty orange to brown weathering, grey, green, maroon and black bedded chert with siltstone interbeds
- **CPa** — Arenite: light grey quartz arenite, locally interlayered with dark grey siltstone and beige weathering, calcareous arkose; black weathering chert

MISSISSIPPIAN

- **MT** — TAY FORMATION: grey-brown siltstone interbedded with calcareous sandstone, locally fossiliferous; dark grey siltstone interbedded with silty limestone

DEVONIAN AND MISSISSIPPIAN

EARN GROUP

- **DME** — UNDIFFERENTIATED: sandstone and siltstone rhythmically bedded and may belong to DMP
- **DMEch** — UNDIFFERENTIATED chert: black chert; siliceous siltstone
- **DMEuv** — UPPER FORMATION volcanics: grey-green feldspar +/- pyroxene-phyric andesitic flows
- **DMEu** — UPPER FORMATION: recessive dark grey and black, variably carbonaceous shale; sandstone; chert conglomerate; local volcanic and volcaniclastic interbeds
- **DMEl** — LOWER FORMATION: recessive dark grey and black, variably carbonaceous shale; medium bedded black chert and siltstone

ORDOVICIAN AND SILURIAN

- **OSMCs** — MENZIE CREEK FORMATION sandstone: dark weathering greywacke; grey-brown weathering siltstone and sandstone; buff weathering siltstone
- **OSMC** — MENZIE CREEK FORMATION: dark green amygdaloidal basalt, locally pillowed; basalt breccia, heterolithic volcanic conglomerate, tuffaceous siltstone and tuffaceous sandstone

UPPER CAMBRIAN AND ORDOVICIAN

- **PImst** — Limestone: light grey limestone and calcareous sandstone; hetergeneous limestone boulder conglomerate
- **€OVa** — VANGORDA FORMATION amphibolite: dark green amphibolite with lesser interlayered with calc-silicate hornfels and schist
- **€OVm** — VANGORDA FORMATION marble: light brown-grey marble and calcareous sandstone
- **€OVcs** — VANGORDA FORMATION calc-silicate schist: green, purple and beige striped calc-silicate hornfels and schist

UPPER PROTOERZOIC TO CAMBRIAN

- **uP€MM** — MOUNT MYE FORMATION: porphyroblastic (dominantly cordierite) biotite-muscovite schist

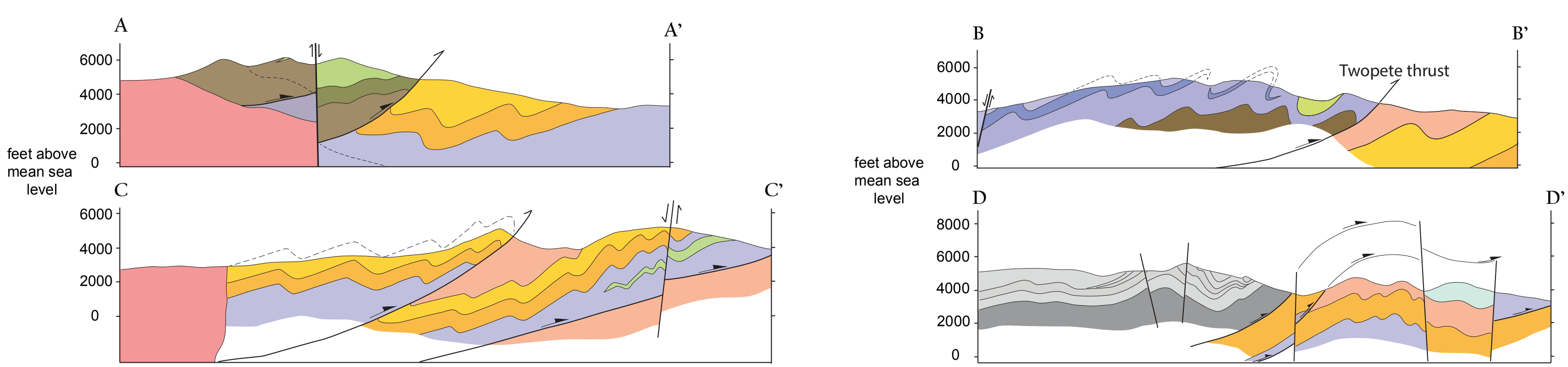


Figure 2. Geologic map, cross sections, and legend for the Anvil Lake area.

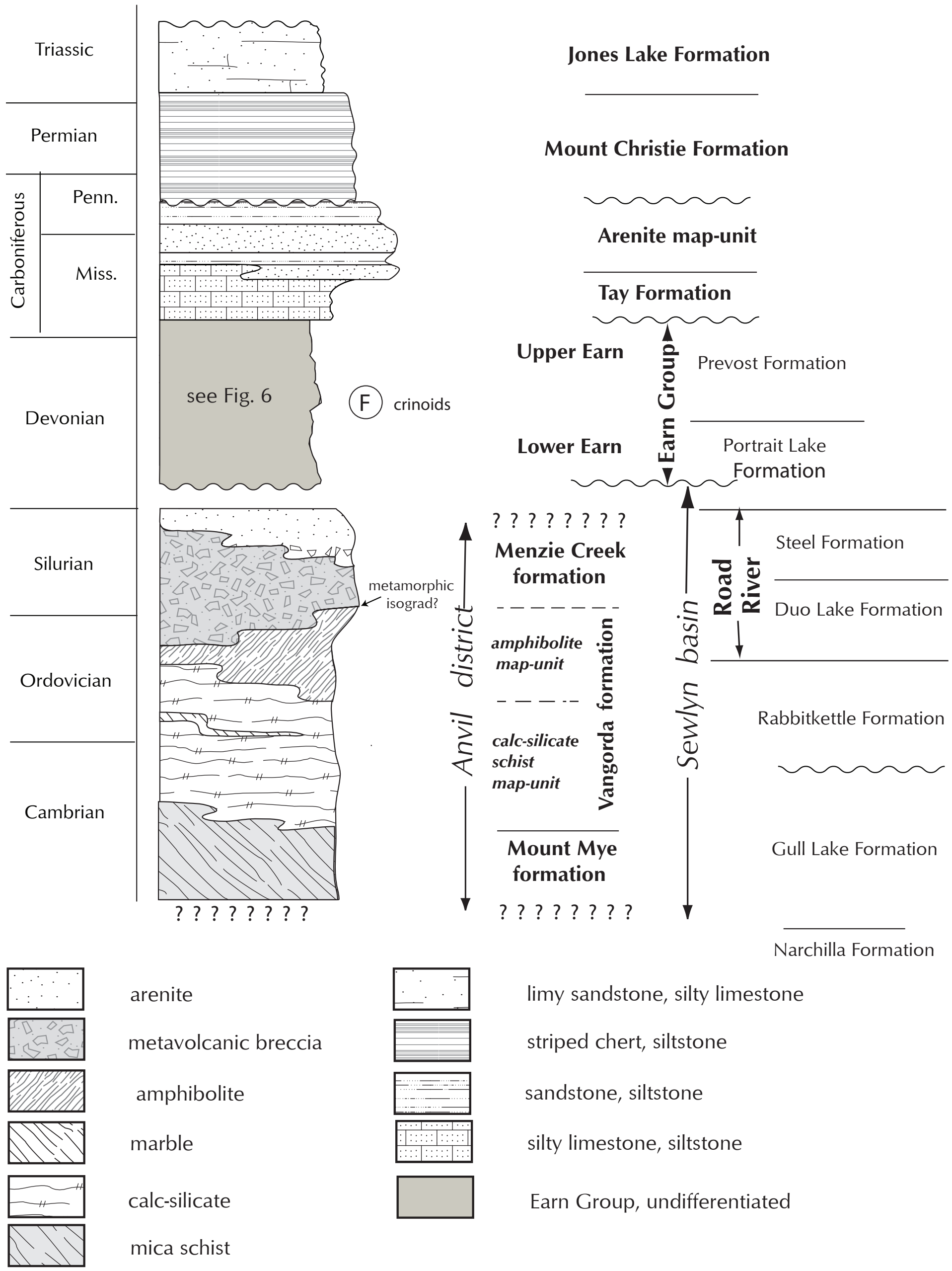


***Figure 3.** Lithostratigraphy of Anvil Lake area; units in bold face are used in this paper. Names from Gordey and Anderson (1993), Pigage (2004), and Gordey (2013a,b).*

MOUNT MYE FORMATION

Biotite-muscovite schist, containing porphyroblasts of cordierite up to 1 cm across, is exposed in the southwestern part of the mapped area (Fig. 2). Brown weathering, fine and medium-grained schist (Fig. 4a) is interlayered with calc-silicate schist at the top of the Mount Mye formation, forming a gradational boundary with the overlying Vangorda formation. The top of the Mount Mye formation at its contact with the overlying Vangorda formation is exposed to a thickness of approximately 100 m at the base of a line of cliffs (Fig. 4b). The lower contact of the schist is not exposed within the mapped area and therefore an estimate of total thickness is not possible. The current thickness is greater than 100 m assuming the unit is not internally folded. The outcrops of this unit are within 2 km of exposed Anvil batholith and reflect its contact metamorphism.

This rock unit is presumed to extend south of the mapped area, where it was assigned to the Rabbitkettle Formation (Twopete facies) by Gordey (2013a), and interlayered Menzie Creek and Vangorda formations by Pigage (2004). The observed lithology however, more closely resembles that of the Mount Mye formation as described by Pigage (2004). If so, this unit is of upper Proterozoic to Cambrian age.

VANGORDA FORMATION

Calc-silicate (COVcs)

Purple, green, and beige striped, fine-grained calc-silicate schist and hornfels dominate this unit in the south-central part of the map area, as well as in a hill near the western edge. Rare purplish-grey, calcareous phyllite crops out near the upper part of the succession. The lower contact with the Mount Mye formation is gradational. The upper contact with Menzie Creek volcanics is gradational and characterized by thickly interlayered volcanic and volcaniclastic rocks with calc-silicate schist. The thickness of the calc-silicate schist varies from an estimated 150 m in the southwest corner of the map area, where it sits conformably between Mount Mye formation and Vangorda amphibolite, to an estimated greater than 500 m in other parts of the mapped area. Except for the southwest exposure, the base of the Vangorda formation is not exposed. The lack of basal exposure and internal folding make a true thickness impossible to ascertain.

The calc-silicate rocks contain quartz, temolite-actinolite, plagioclase, biotite ± diopside ± calcite ± epidote (Jennings and Jilson, 1986).

In color and lithology these exposures match the description of the more highly metamorphosed variety of the Vangorda formation described by Pigage (2004). No age data have been attributed to this unit although it must be older than Early to Middle Ordovician Menzie Creek formation that overlies it.

Amphibolite (COVa)

Dark green and brown, fine-grained amphibolite ± biotite schist and phyllite, commonly cut by garnet-pyroxene ± calcite veins, are interlayered with calc-silicate schist (Fig. 4c). In the south-central part of the map area a very distinct, medium-grained, meta-igneous (?) rock and stretched porphyroclasts (?) are interlayered with amphibolite-biotite schist.

Minor, waxy, dark green to black weathering, amphibolite schist has a well-developed foliation defined by aligned feldspar grains. Light green, sub-spherical features, 3 to 8 mm across, occur rarely in streaks and patches (Fig. 4d) within massive amphibolite. These small structures are similar in appearance to amygdules in volcanic rock.

An exposed thickness of this unit is greater than 200 m. The lower contact is gradational with Vangorda calc-silicate schist and an upper contact with younger rocks is not exposed.

The metamorphosed mafic rock occurs within the upper part of the Vangorda formation. A similar unit is widely exposed south of the Anvil batholith where it contains 15-20% chloritic phyllite and amphibolite (Jennings and Jilson, 1986). The hilltop exposures in the Anvil Lake area are sufficiently large and coherent

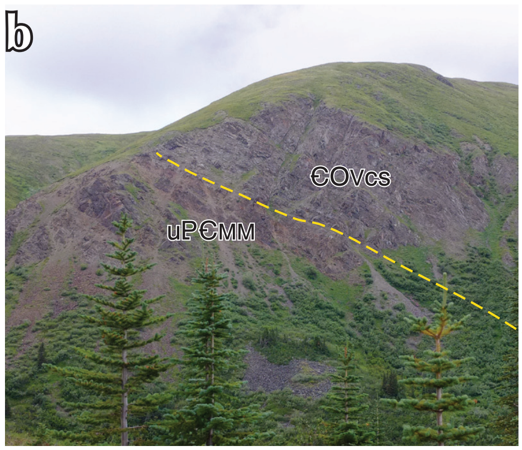


Figure 4. *Cambrian to Silurian rocks: (a) mica schist with well-developed crenulation. Mount Mye formation (574205E; 6932067N); (b) view looking north at cliffs showing contact between Mount Mye and Vangorda formations. (574694E; 6931588N); (c) amphibolite schist cut by garnet pyroxene veins (brown streaks). Grey pen is 11 mm wide. Vangorda formation (580602E; 6933294N); (d) massive amphibolite with light green spherical features resembling amygdules. Vangorda formation (579177E; 6932331N); and (e) thinly interbedded marble and calcareous sandstone. Vangorda formation (563726E; 6941531N).*

enough to warrant being mapped as a separate unit, but is considered coeval with it.

Marble (COVm)

Well bedded marble crops out in the far western part of the mapped area. Light brownish-grey weathering, thinly interbedded marble, and fine-grained, calcareous sandstone occur as a narrow horizon within calc-silicate schist (Fig. 4e). The upper and lower contact with calc-silicate schist was under cover and therefore not examined. The marble reaches a thickness of 80 m, however, it is deformed by polyphase folding suggesting the true thickness may be significantly less. The marble pinches out to the west.

PALEOZOIC LIMESTONE:

Limestone conglomerate, that grades upwards into a very thinly interbedded limestone and calcareous sandstone, cores an east trending anticline in the northwest corner of the map area (Fig. 2). It sits topographically above a hornfelsed, laminated siltstone unit of undifferentiated Earn Group. The contact between the limestone conglomerate and siltstone is exposed for approximately 20 m northeast of Twopete Mountain and is undulating and irregular (Fig. 5a). The thickness of the conglomerate and the limestone together is estimated to be 200 to 250 m.

The conglomerate contains pebble to boulder sized clasts of limestone, calcareous sandstone, and chert, floating in a muddy to sandy matrix that has flow textures (Fig. 5b). It is always matrix-supported and very poorly sorted. This unit grades upwards into a moderately sorted limestone conglomerate and is capped by thinly interbedded limestone and calcareous, fine-grained sandstone (Fig. 5c).

Thin bedded limestone has been described elsewhere in the Selwyn basin within the Rabbitkettle Formation (Fig.3) (Gordey and Anderson, 1993; Cecile, 2000). Gordey (2013b) assigned all rocks that crop out on Twopete Mountain (this unit together with undifferentiated Earn Group in Figure 2) to the Twopete facies of the Rabbitkettle Formation. However, he does not include the rocks described here in his regional description of Rabbitkettle.

The structural interpretation presented in Figure 2 (cross section B-B'), including the contact shown in Figure 5a, suggests the Paleozoic limestone stratigraphically overlies parts of the Earn Group. Correlation of the Paleozoic limestone unit to a regional formation is pending until further studies are complete.

MENZIE CREEK FORMATION

Interbedded with the upper parts of the Vangorda formation are mafic volcanic and volcaniclastic rocks. Monolithic basalt breccia, vesicular and amygdaloidal basaltic flows, and minor pillow basalts are interbedded with minor tuffaceous sandstone and siltstone and lesser conglomerate (Fig. 5d). The most notable exposures of these rocks are in the immediate hanging wall of thrust faults in both the easternmost and westernmost parts of the map area. A rounded ridge in the western part of the map area is underlain by dark grey-green weathering, thin bedded, medium-grained greywacke; grey-brown weathering, thin-bedded to laminated siltstone; buff weathering, laminated, mildly hornfelsed, fine-grained sandstone; and siltstone (OSMCs). This exposure is topographically higher than Menzie Creek volcanic rocks. The contact with Menzie Creek volcanic rocks is not exposed but, if conformable, this section is part of an upper, clastic phase of Menzie Creek formation. In the south-central part of the map area, contacts with Menzie Creek and Vangorda formation are nowhere exposed. Based on the map pattern, Menzie Creek formation is very thickly interlayered with Vangorda schist, and is estimated to be up to 300 m thick. In the western part of the map area, contact with Vangorda schist is obscured by a grabbo body.

The sequence described above is assigned to the Menzie Creek formation (Jennings and Jilson, 1986). Fossils found in the Menzie Creek formation, northeast of the Anvil batholith indicate an age of Ordovician to Silurian (Pigage, 2004). The Vangorda amphibolite schist occurs above and interlayered with Vangorda calc-silicate schist and has rare volcanic-like textures suggesting it may be a higher metamorphic grade equivalent of Menzie Creek formation.

EARN GROUP

Fine to coarse clastic sediments, interbedded locally with volcanic and volcaniclastic rocks, underlie the southeastern part of the mapped area (Fig. 2). The best exposure is a south-trending ridge where a limestone lens within shale contains two-holed crinoid fossils.

The bedrock exposure and relatively straightforward structure along this ridge allows a crude stratigraphic section to be constructed (Fig. 6). The lowest unit is a dark grey to black, variably carbonaceous siltstone. It is overlain by quartz-feldspar-phyric, intermediate, crystal tuff (Fig. 7a), hereafter referred to as the 'lower volcanic unit'. Above is a dark grey to black, carbonaceous shale that has black chert horizons and uncommon limestone beds

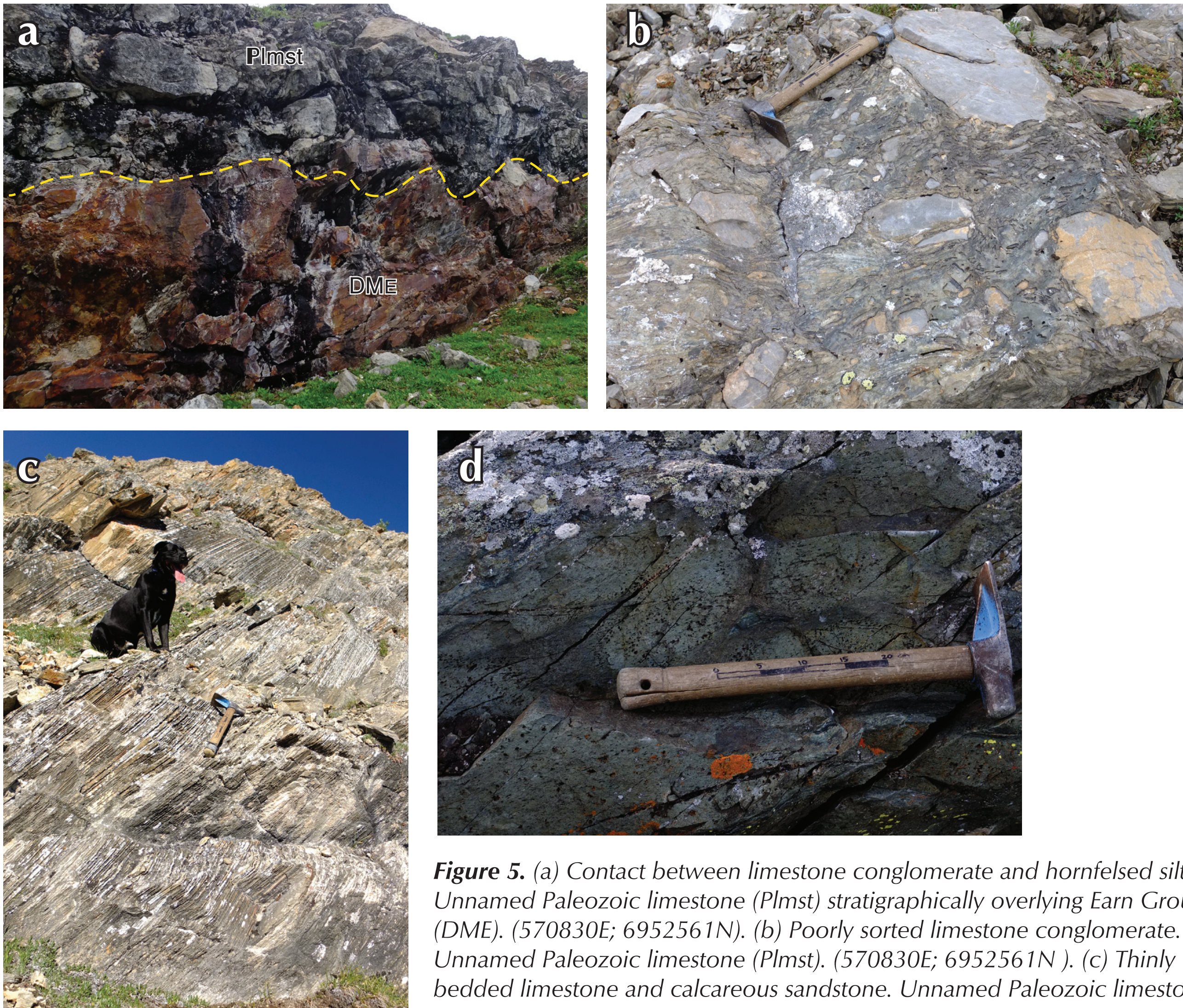


Figure 5. *(a) Contact between limestone conglomerate and hornfelsed siltstone. Unnamed Paleozoic limestone (Plmst) stratigraphically overlying Earn Group (DME). (570830E; 6952561N). (b) Poorly sorted limestone conglomerate. Unnamed Paleozoic limestone (Plmst). (570830E; 6952561N). (c) Thinly bedded limestone and calcareous sandstone. Unnamed Paleozoic limestone (Plmst). (565819E; 6953233N). (d) Monolithic basalt breccia, provisionally assigned to Menzie Creek formation (OSMC). (588040E; 6931926N).*

containing two-holed crinoids (Fig. 7b). It is succeeded by laterally discontinuous, resistant, dark grey weathering, chert conglomerate that grades upwards into coarse-grained, cross–bedded, quartz rich sandstone (Fig. 7c). The conglomerate ranges in thicknesses from 0 to 50 m across a couple kilometres. Several thick but lenticular beds of quartz arenite stratigraphically overlie the conglomerate, succeeded by an orange-brown weathering siltstone interbedded with fine-grained sandstone and minor fossiliferous dolomitic siltstone (Fig. 7d). The siltstone/sandstone is characterized by soft sediment deformation such as ball-and-pillow and flame structures. The highest unit in the succession is a medium-grained tuff of intermediate composition, and lesser felsic-to-intermediate, amygdaloidal flows (Fig. 7e), here termed the 'upper volcanic unit'.

Exposures in the western half of the mapped area lack stratigraphic context. Buff-weathering, variably hornfelsed, fine-grained sandstone, thinly interbedded with muddy siltstone are commonly rhythmically bedded with local massive cherty sections. A useful marker is a black, medium-bedded chert with minor dark grey siltstone (DMEch) within the rhythmically bedded fine clastic rocks: it outlines large scale folds within Twopete Mountain, and ranges in estimated thickness from 20 to 100 m (Fig.2, cross section B-B').

Two-hole crinoid fossils are diagnostic of the late Early Devonian to early Middle Devonian (Emsian-Eifelian; Johnson and Lane, 1969; Fig. 7b). This known age within the stratigraphy is depicted in Figure 6; the dark, dominantly clastic lithology and presence of volcanic rock, all point toward an Earn Group succession. In the eastern half of the mapped area, Earn Group reveals a lower, siltstone-dominated succession, and an upper coarse clastic, limestone and volcanic succession (Fig. 2).

In the western part of the mapped area, areas assigned to undifferentiated Earn Group (Fig. 2) were previously interpreted as Rabbitkettle Formation (*c.f.*, Gordey, 2013a). The younger designation suggested within this paper is based on local occurrences of foliated crystal tuffs that look very similar to the lower volcanic unit, and relative stratigraphic position above the Paleozoic limestone unit.

TAY FORMATION

Grey and brown weathering, medium-bedded, variably fossiliferous, silty limestone evenly interbedded with dark grey, variably siliceous siltstone is exposed across the northern half of the map area (Fig. 2). In the eastern part of the map area the Tay Formation unconformably overlies the lower Earn Group or is bounded by thrust faults. This unit has an estimated minimum thickness of 350 m.

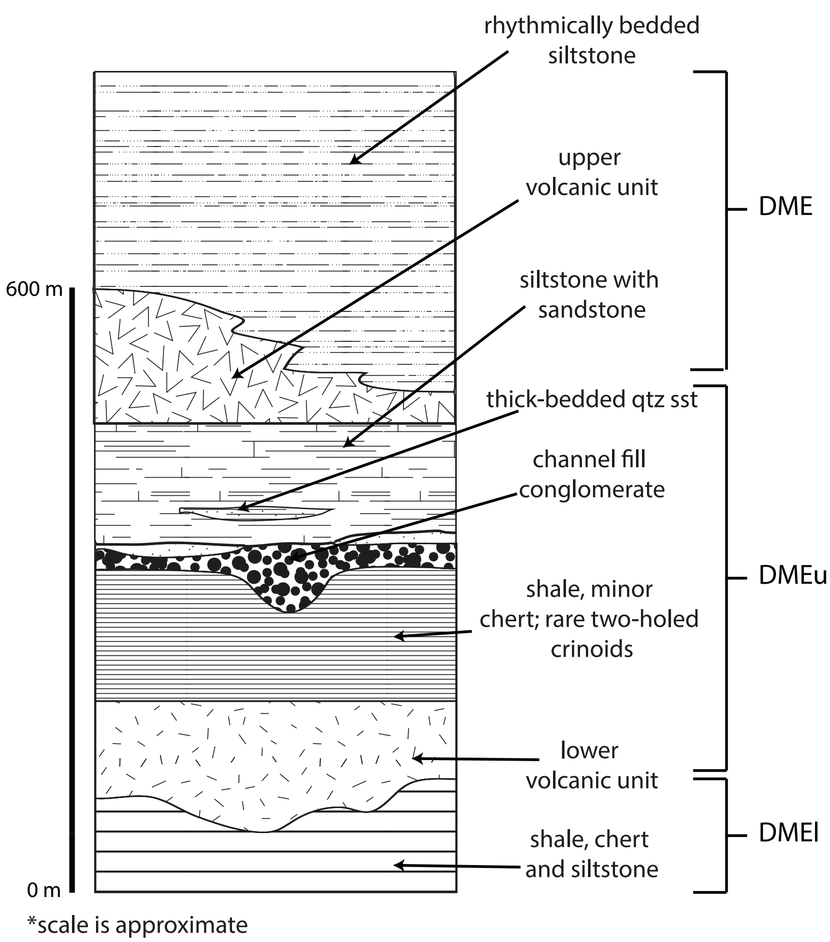


Figure 6. *Schematic stratigraphy of Earn Group. Section constructed from exposures in the southeast part of the mapped area, near 594000E; 6934500N.*

Southwest of Twopete Mountain this unit unconformably overlies the Earn Group. Fossils are common within limestone beds and rare within siltstone beds, and include coral, bivalves, and crinoids.

Numerous fossil occurrences in the eastern half of the map area constrain the Tay Formation to the Mississippian. Western exposures are correlated with the Tay Formation based on its similarities in lithology and stratigraphic position beneath the younger Mount Christie Formation.

CARBONIFEROUS TO PERMIAN (?) ROCKS (CPA)

Resistant, thick-bedded quartz arenite (Fig. 8a) interbedded with mildly carbonaceous, dark grey, variably fossiliferous siltstone; dark grey siliceous siltstone; medium-bedded black chert; and beige weathering, calcareous arkosic sandstone form prominent ridges and steep walls of deep canyons in the east and center of the map area (Fig. 8b). An internal stratigraphic section for this group of rocks is difficult to construct due to lack of continuous outcrop and folding. Locally, 30 m of black weathering, medium-bedded chert sit topographically below dark grey weathering, fine-grained, vitreous quartz arenite that forms beds several metres thick (Fig. 8c). A dark and light grey weathering, thin-bedded quartzose siltstone to fine-grained sandstone that is locally burrowed, crops out at the top of a short south trending ridge. Further south along this ridge (and conformably underlying the siltstone) is mildly carbonaceous siltstone containing rare plant stem and bivalve fossils. A thick bed (at least 1 m thick) of beige weathering, medium–grained, calcareous arkose, made up of well-rounded quartz and feldspar grains cemented by calcite, crops out down section to the south and is succeeded by light grey and beige weathering, thick-bedded quartz arenite. The overall thickness of this group of rocks is difficult to ascertain, but based on construction of cross sections has a crudely estimated minimum thickness of 1000 m.

Based upon its distribution, this unit is stratigraphically above the Tay Formation and overlain by a distinctive lithology assigned to the Mount Christie Formation. If correct, the unit must be of Carboniferous to early Permian age, and therefore cannot be Rabbitkettle Formation, as previously mapped (Gordey, 2013a,b). Micro and macrofossil collections

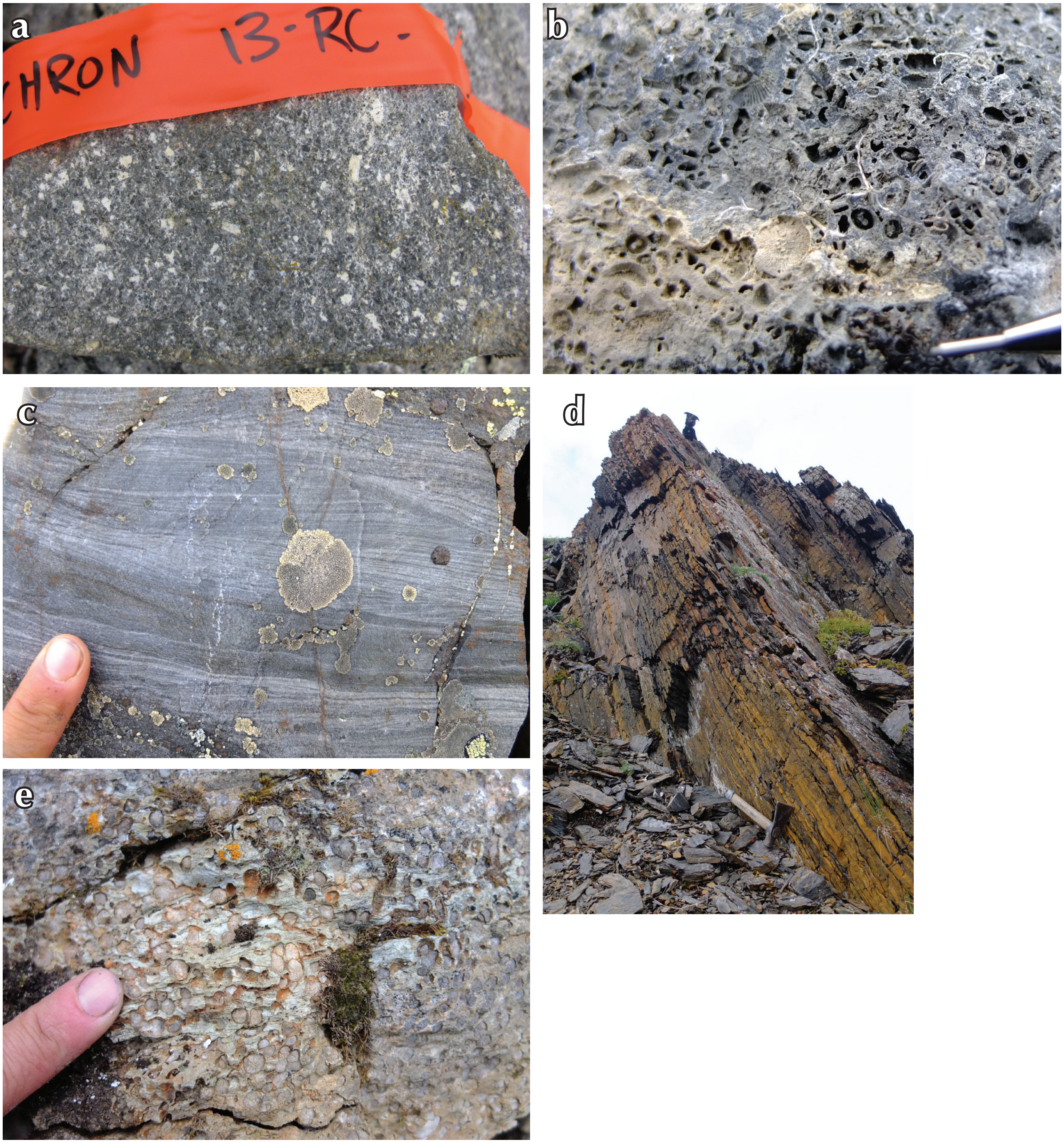


Figure 7. *Earn Group rocks: (a) quartz-feldspar-phyric crystal tuff. Orange tape is 2 cm wide. Lower volcanic unit (DMEu). (590189E; 6936759N); (b) limestone within shale of unit DMEu; contains two-holed crinoids. Steel cylindrical tip of pencil at lower right, is 5 mm long. (594786E; 6933413N); (c) coarse-grained, quartz-rich, cross-bedded sandstone of unit DMEu. Note that the cross-beds indicate stratigraphic tops are towards the top of the photograph which is taken of an outcrop that is sitting in place. (577736E; 6949337N); (d) interbedded fine-grained sandstone and muddy siltstone, unit DMEu. Figure on top is 0.5 m high. (594762E; 6934938N); and (e) amygdaloidal felsic flow in upper volcanic unit (DMEu), (593059E; 6931859N).*

have been submitted to attempt to constrain the age of this unit.

These rocks are provisionally assigned unit CPa, pending better understanding of their age. Correlation with other quartz-rich strata is yet to be determined. A similar succession of rocks in the Lansing map area (about 120 km north northwest of the mapped area) contains Early Carboniferous and Permian microfossils (Roots, 2003). The Heritage Trail Formation (Cecile, 2000) consists of grey-white quartzite and minor shale, and calcareous quartzite beds, and is probably of early Mississippian age. In the southeastern part of Selwyn basin, Gordey and Anderson (1993) describe the Carboniferous Tsichu formation as grey and white weathering, resistant quartz sandstone interbedded with recessive black shale and siliceous shale.

MOUNT CHRISTIE FORMATION

Rusty orange to brown weathering, grey, grey-green, maroon, and black, thin-bedded chert (Fig. 8d) interbedded with light grey siltstone, is well exposed in the northeast part of the mapped area. In the northwest, east of Twopete Mountain, minor grey limestone with thin interbeds of dark grey siltstone, and cross-bedded calcareous sandstone occur as 5 to 10 m sections within chert. The upper contact with the Jones Lake Formation was not examined during this study, but is regionally mapped as conformable (Gordey, 2013a,b). A lower contact, exposed in the north central part of the map area, places well bedded grey-green chert conformably on light grey weathering, massive quartz arenite (CPa). The chert is commonly tightly folded and in fault contact with other units making estimates of thickness difficult. A crudely estimated minimum thickness for this unit is 250 m.

Several fossil occurrences, located in the far northwest corner and the northeast part of the map area, bracket this formation to the Carboniferous or Early Permian. On the basis of the fossil ages and distinctively colored chert, this package is assigned to the Mount Christie Formation (Gordey, in press; Gordey and Anderson, 1993). Areas of the map assigned to Mount Christie Formation that do not have fossil age control are based upon lithologic similarities to known Mount Christie Formation aged rocks and a conformable contact with the Tay Formation. Numerous samples of chert were collected for microfossil analysis in an attempt to better constrain the age of this unit and its spatial distribution across the mapped area.

JONES LAKE FORMATION

Light grey weathering, fossiliferous, silty limestone and calcareous sandstone with cross-bedding (Fig. 8e) are exposed only along the eastern edge of the mapped area. Very limited exposure was examined during this study; snail-like fossils (spiral in cross section) were found in these outcrops. A minimum thickness of 80 m is estimated for this unit; however, nowhere are both the upper and lower bounds exposed.

The friable, nondescript lithology, and several fossil occurrences indicate a good match for the Jones Lake Formation (Gordey and Anderson, 1993). Fossil collections elsewhere from this unit constrains the age as Middle to Upper Triassic.

INTRUSIVE ROCKS

PRE-CRETACEOUS INTRUSIVE ROCKS

Several bodies, ranging in width from approximately 50 to 500 m and extending in length up to several kilometres, of dark green pyroxenite bearing gabbro are exposed near the southern limit of mapping; they extend further south and match well with previous mapping (Pigage, 2004). They intrude Cambrian to Silurian strata, and were not mapped in younger strata. One small exposure of an intermediate plagioclase-phyric intrusion was observed on the south side of Twopete Mountain. The body is approximately 100 by 500 m (too small to show on Fig. 2). Its purplish color and induration may be attributed to contact metamorphism of the nearby Anvil batholith.

ANVIL BATHOLITH

Light grey, medium-grained porphyritic (potassium feldspar) biotite ± hornblende granodiorite is a prominent feature in the central part of the mapped area (Fig. 2). Its contact with layered rocks is highly irregular and commonly shallowly dipping based on its relation to topography. Several smaller, non-porphyritic biotite granodiorite bodies occur north of the batholith and are presumed to be coeval.

These exposures are part of a much larger body called the Anvil batholith (Tempelman-Kluit, 1972). Within the Anvil batholith two phases have been mapped and are distinguished based on lithology, petrography, and geochemistry (Pigage and Anderson, 1985; Pigage

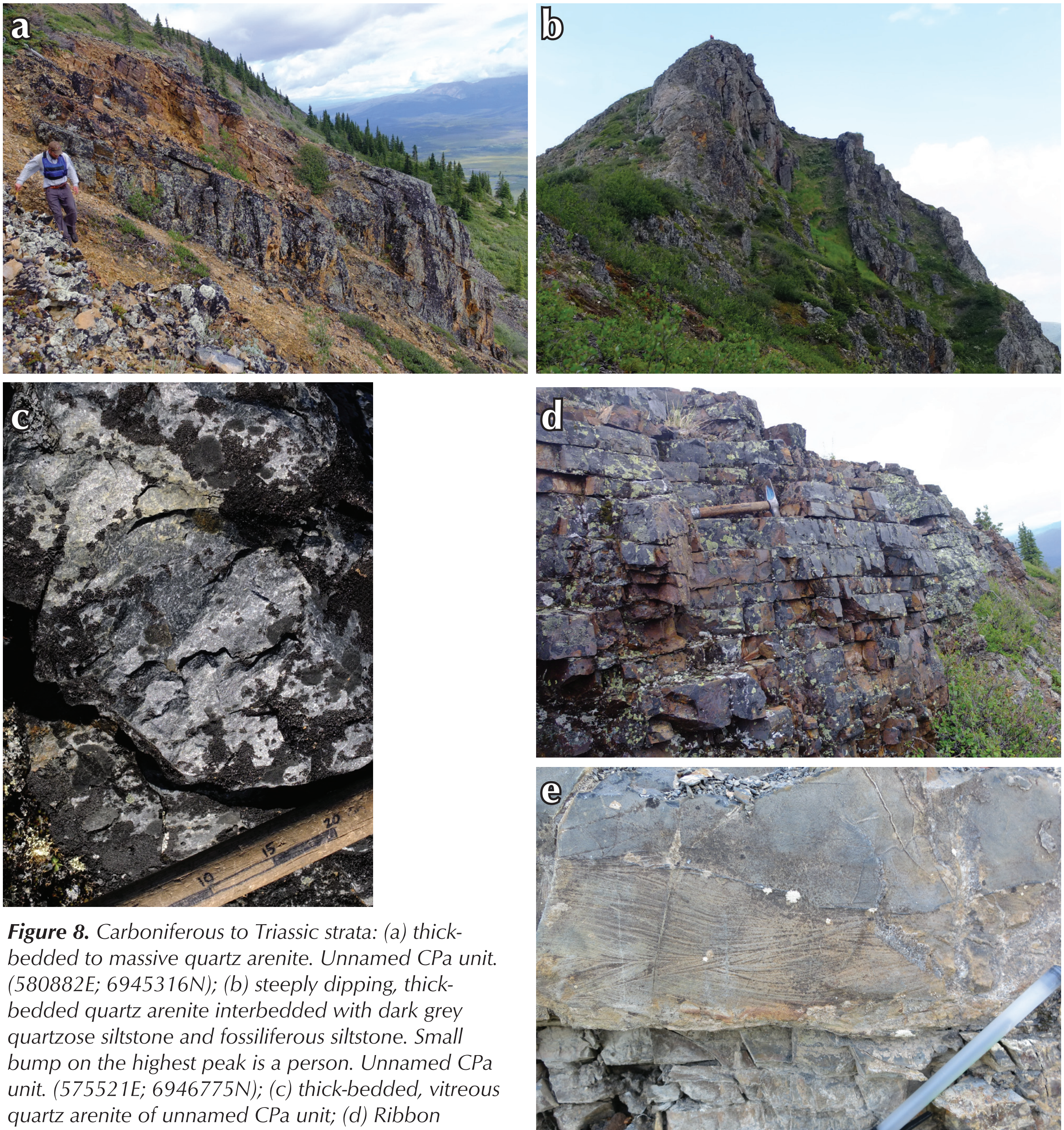


Figure 8. *Carboniferous to Triassic strata: (a) thick-bedded to massive quartz arenite. Unnamed CPa unit. (580882E; 6945316N); (b) steeply dipping, thick-bedded quartz arenite interbedded with dark grey quartzose siltstone and fossiliferous siltstone. Small bump on the highest peak is a person. Unnamed CPa unit. (575521E; 6946775N); (c) thick-bedded, vitreous quartz arenite of unnamed CPa unit; (d) Ribbon banded, black chert. Mount Christie Formation. (582013E; 6945328N); and (e) Cross-bedded, calcareous sandstone interbedded with silty limestone. Pen width is 7 mm. Jones Lake Formation (TrJ). (~600700E; 6937100N).*

2004). The extent of the Anvil batholith, shown in Figure 2, is similar to the Orchay phase (necessitating a jog in the contact projected northward from Pigage, 2004) that has an age range of 99 to 115 Ma (Pigage and Anderson, 1985; Rasmussen, 2013). Based on lithology and age it is part of the Selwyn plutonic suite (Gordey and Anderson, 1993).

The Anvil batholith, within the mapped area, has a contact metamorphic aureole approximately 2.5 km wide characterized by phyllitic and schistose Selwyn basin rocks, and hornfelsed Late Paleozoic rocks. Southeast of this study area, previous workers documented up to amphibolite grade, coarse-grained schistose rocks within the Anvil batholith aureole, and peak metamorphism that occurred during intrusion at approximately 300 MPa pressure, and heated country rocks to between 600 and 620°C (Smith and Erdmer, 1990). The wide aureole comprising coarsely schistose and high grade metamorphosed rocks makes this mid-Cretaceous event atypical in this region (Smith and Erdmer, 1990).

STRUCTURE

Early Paleozoic strata (the southern half of the map area) constitute structural domain 1, and Late Paleozoic to Early Mesozoic strata (in the northern half of the map area; Fig. 9a) constitute structural domain 2. Domain 1 is characterized by a folded penetrative foliation defined by purple, beige, and green stripes in calc-silcate schist and hornfels, and by layers of biotite and mafic minerals in amphibolite schist (Fig. 10a,b). The Anvil batholith, where observed during this study, is undeformed and cuts all structures except one steep normal fault in the western part of the mapped area (Fig. 2).

Bedding is preserved locally within domain 1. The competent nature of the Menzie Creek volcanic rocks preserves beds of tuffaceous siltstone and sandstone between thick layers of volcanic breccia and basalt flows. Volcanic breccia commonly displays elongated clasts, and flows exhibit vesicles stretched parallel to the regional foliation. Bedding is also preserved in rare marble horizons that crop out within Vangorda calc-silicate schist.

In domain 1 outcrop-scale, tight to isoclinal folds deform the penetrative foliation and exhibit a closely spaced axial planar cleavage that is visible in hinges (Fig. 10c). The cleavage is generally steeply dipping to the south and northeast (Fig. 9b). Intersection between the foliation and the cleavage creates a prominent lineation in micaceous layers within calc-silicate schist and amphibolite. It plunges shallowly to the southeast throughout the map area (Fig. 9c).

Domain 2 encompasses Late Paleozoic to Early Mesozoic rocks that are faulted against the Early Paleozoic strata in the southern part of the map area (Fig. 2 and 9a). Primary textures are always preserved; in addition some pelitic rocks display moderately-developed foliation. These rocks are tight to isoclinally folded in outcrop and on a regional scale with folds becoming tighter and overturned to the NNE. Folds are asymmetric, and have a steeper north-dipping limb and a shallow south-dipping limb (Fig. 9d). Folds commonly display a well-developed axial planar cleavage that on average strikes southeast and dips shallowly to moderately SW (Fig.11a). Folding is kinematically linked to northeast-verging thrust faults (Fig. 11b). On Twopete Mountain closely spaced brittle fracture sets are oriented steeply east dipping and steeply southeast dipping (Fig. 11c). Within domain 2 several thrust faults (including western parts of Gordey's Twopete thrust) imbricate the Late Paleozoic rocks (Fig. 2, cross sections BB', CC', DD').

The thrust fault separating domain 1 from domain 2 is similar to Gordey's (2013b) Twopete thrust in that it separates Cambro-Ordovicain strata from Late Paleozoic strata; however, based on re-assignment of Cambro-Ordovician strata within the mapped area, this fault traces out further south than shown on Gordey's map. Studies on the geologic history that accounts for the structural and metamorphic differences in domain 1 and domain 2, and the timing and nature of their juxtaposition, are in progress.

Variably oriented normal faults cross cut folding and thrusting, and occur for the most part within domain 2. Offset along these structures varies from an estimated 30 to 1000 m. In the central part of the mapped area a normal fault separates domain 1 from domain 2, dropping the north side down and truncating a thrust fault that was the original domain 1-domain 2 boundary. Orientation and intersection of some of these normal faults create graben-like features in the eastern part of the map area suggesting extension followed fold-and-thrust deformation (Fig. 2, cross section D-D').

MINERAL OCCURRENCES AND EXPLORATION

The Keg occurrence (Yukon MINFILE 105K 078) is a bulk tonnage silver-polymetallic base metal deposit with an inferred resource of 38.8 million tonnes containing Ag, Zn, Pb, and Cu. It is modelled to be a 150–m-wide linear zone of mineralization that dips moderately to the southeast. The highest silver grades (>50 g/t) are at, or near the surface, and decrease at depth (*www.silverrangeresources.com*). This study postulates that the host unit closely resembles chert belonging to the Mount Christie Formation, structurally below and stratigraphically above limestone correlated with the Tay Formation (Fig. 2).

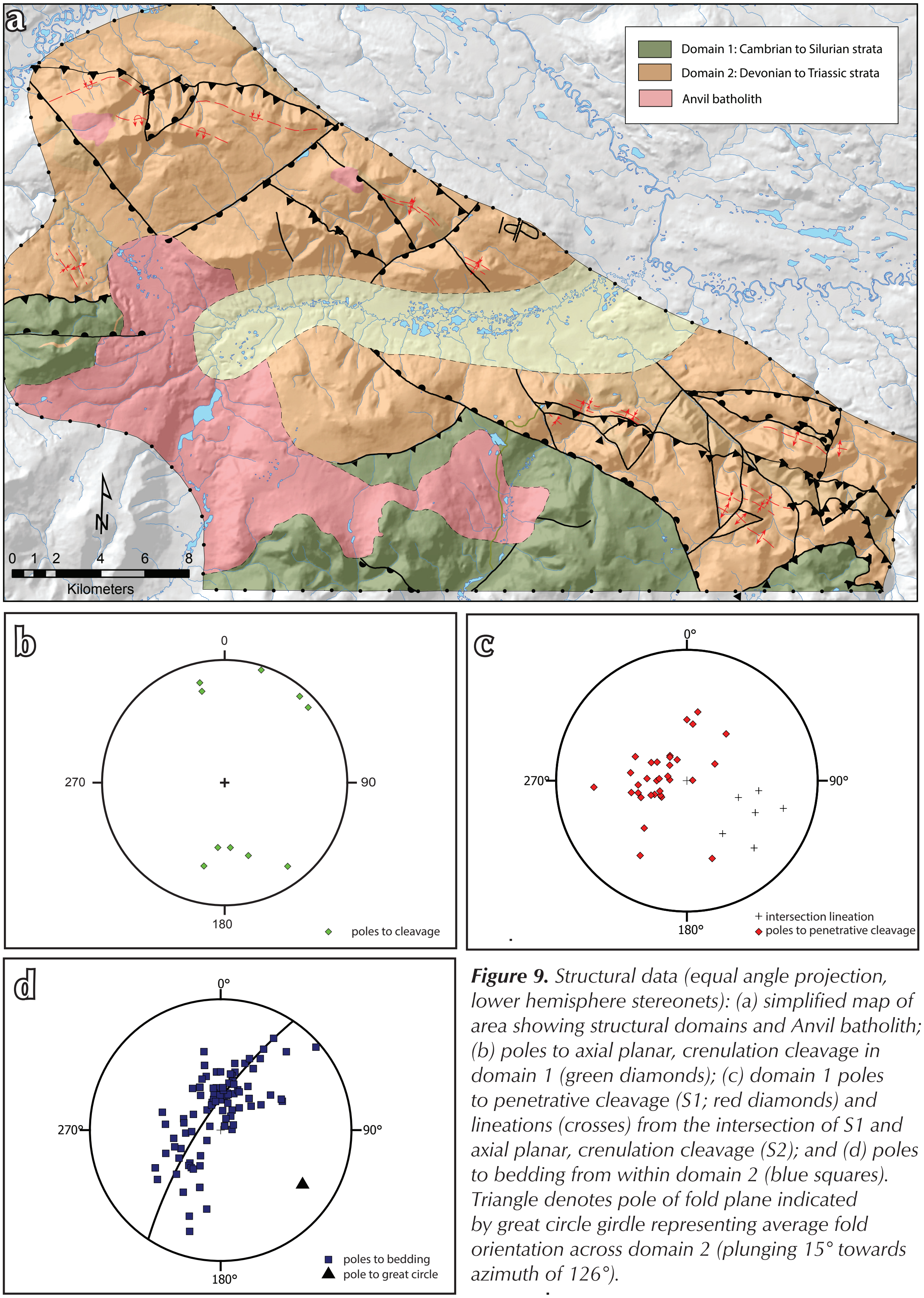
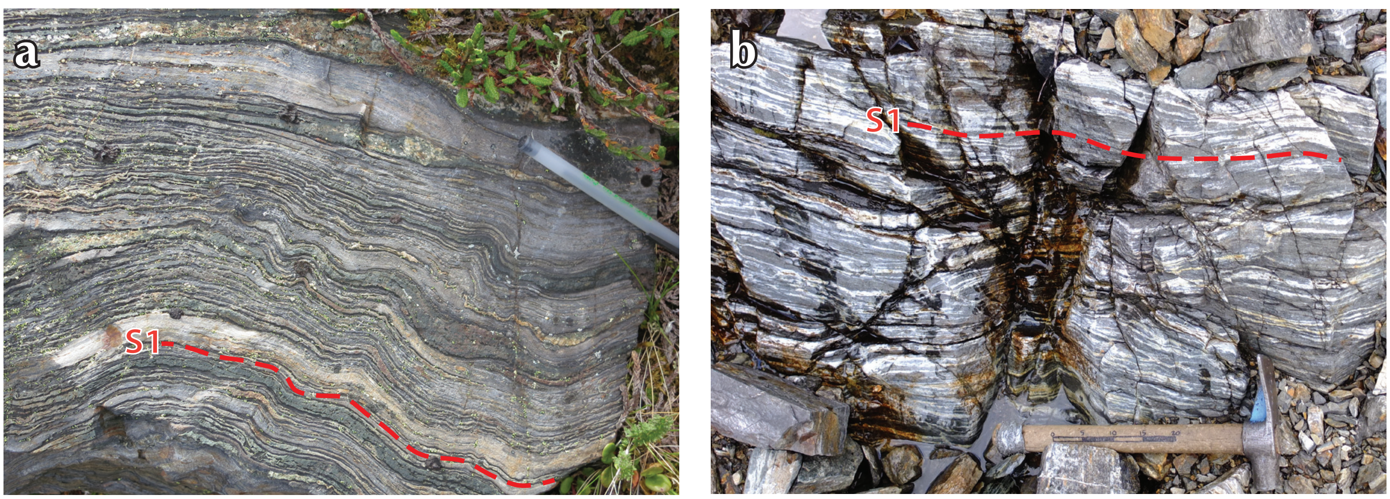


Figure 9. *Structural data (equal angle projection, lower hemisphere stereonets): (a) simplified map of area showing structural domains and Anvil batholith; (b) poles to axial planar, crenulation cleavage in domain 1 (green diamonds); (c) domain 1 poles to penetrative cleavage (S1; red diamonds) and lineations (crosses) from the intersection of S1 and axial planar, crenulation cleavage (S2); and (d) poles to bedding from within domain 2 (blue squares). Triangle denotes pole of fold plane indicated by great circle girdle representing average fold orientation across domain 2 (plunging 15° towards azimuth of 126°).*

A NW-trending zone of high-grade silver-bearing veins has been delineated based on the prospecting of numerous soil geochemistry anomalies (*www.silverrangeresources.com*) in 2011 and 2012. It is parallel to the structural grain and general trend of the upper Paleozoic units and includes the Keg deposit and several other mineralized occurrences. Silver veins commonly occur at both stratigraphic and structural contacts between Mount Christie Formation chert and Tay Formation limestone, where these rocks are tightly folded. Late normal faulting may also play a role in the location of mineralization.

Intermediate to felsic volcanics found within the Devono-Mississippian Earn Group suggest the area has potential for VMS style mineralization similar to the Marg deposit (Yukon MINFILE 106D 009) (Holbek *et al.*, 2001). Exposures of these volcanic rocks make up a small percentage of the eastern mapped area with rare exposures found in the north-central parts of the mapped area. No mineralization was found associated with them. Rare tuffs crop out within undifferentiated Earn Group in the central part of the mapped area and occur in an area of very little bedrock exposure.

The mapped area also includes a Pb-Zn skarn (Yukon MINFILE 105K 076) and a drilled SEDEX (Yukon MINFILE 105K 074) prospect (Fig. 2), although their locations may be incorrect (granitic rock is currently mapped at the given coordinates of the SEDEX prospect). Tay Formation limestone are intruded by a small granodiorite body east of Twopete Mountain, and thin marble horizons (COVm) occur within the contact aureole of the western edge of the Anvil batholith, both prospective areas for skarn mineralization. Shale within the lower Earn Group is the only host unit within the mapped area that has potential for SEDEX style mineralization.



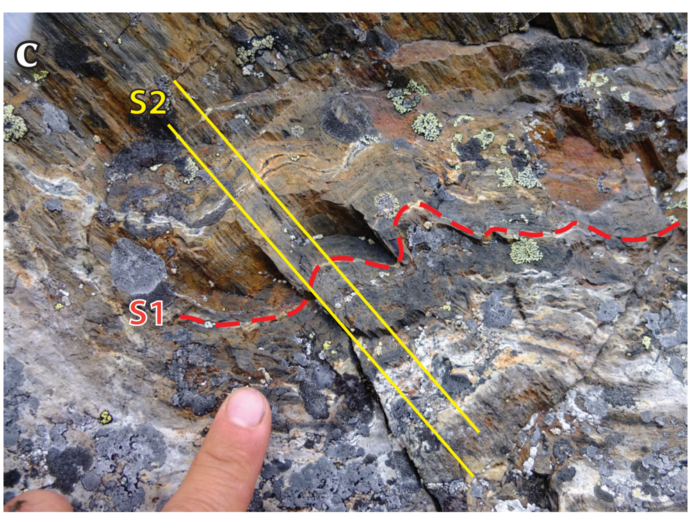
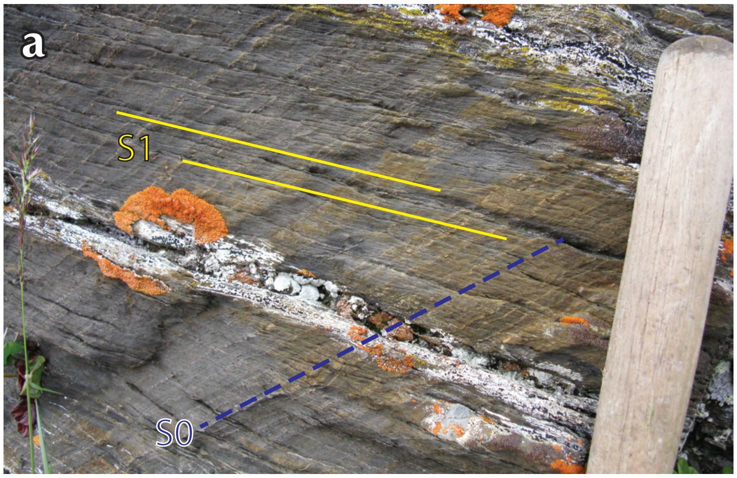


Figure 10. *Structures within domain 1: (a) penetrative foliation (S1) in calc-silicate schist outlined by dashed red line. Pen is 7 mm wide. (586500E; 6935100N); (b) penetrative foliation (S1) in schist outlined by red dashed line. (574205E; 6932067N); and (c) folded penetrative foliation (S1) with well-developed axial planar crenulation cleavage (S2) shown by yellow lines. (579755E; 6931415N).*



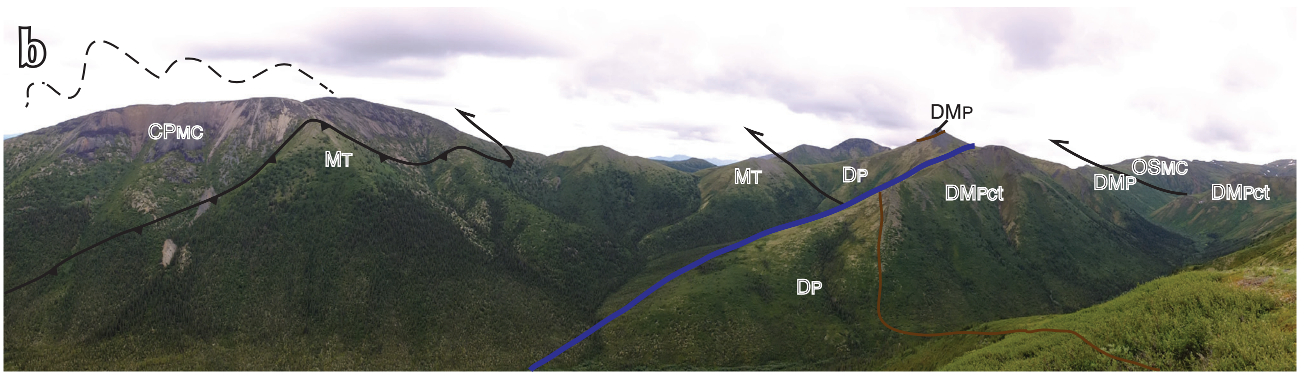


Figure 11. *Structures within domain 2: (a) bedding (S0) and cleavage (S1) in silty limestone. Tay Formation. (588871E; 6937819N); (b) profile of ridge in the southeast corner of the map area, coincident with cross section D-D′ (Fig. 2). Width of view: 8 km; north to left; and (c) closely spaced fracture set dipping steeply to the southeast. Yellow notebook is 20 cm long. Earn Group undifferentiated (566554E; 6951054N).*

CONCLUSIONS

The project area is underlain by Cambrian to Silurian Selwyn basin strata, thrust over Devonian to Triassic coarse and fine clastic, carbonate, and minor volcanic rocks. These are intruded by the mid-Cretaceous granitic Anvil batholith. A significant contact aureole surrounds the Anvil batholith, destroying primary textures in most Early Paleozoic rocks.

The area is deformed by pre mid-Cretaceous folding and north-verging thrusts and post mid-Cretaceous normal faults.

Several observations have been made based on field observations:

1. Previously mapped Rabbitkettle Formation (Cambro-Ordovician) are re-interpreted as an unnamed unit of probable Carboniferous age, possibly correlative with

quartzose strata recognized elsewhere in the Selwyn basin.

2. Intermediate to felsic volcanics found within the Devono-Mississippian Earn Group suggest the area has potential for VMS style mineralization

3. Prospective areas for high-grade silver veins occur where folded Mount Christie Formation chert is in structural or stratigraphic contact with Tay Formation limestone, subsequently dissected by normal faults.

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