



YGS Open File 2026-1

Geology of the McQuesten Lake area (parts of 106D/2, 3, 6 & 7), central Yukon

D.R. Skipton¹ and J.L. Crowley²

**with contributions from R.B. Blodgett³, S.A. Gouwy⁴, M. Orchard⁴, J. Strauss⁵
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**Yukon**

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Front cover: Southwest-dipping sandstone of the Yusezyu Formation (Hyland Group) occurs in the foreground of the photo, located approximately 13 km north–northeast of McQuesten Lake in central Yukon. The ridge in the distance, to the east–southeast, consists of southwest-dipping sandstone, siltstone, shale and limestone of the Yusezyu Formation. Photo credit: Diane Skipton.



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Abstract

The McQuesten Lake area is located in the Selwyn fold belt of central Yukon, along the northern boundary of the Selwyn basin. This report describes the geology of the McQuesten Lake area based on 1:50 000-scale bedrock mapping conducted from 2019 to 2022 by the Yukon Geological Survey, and presents U-Pb zircon data, whole-rock geochemistry, fossil identifications and carbon and oxygen isotopic data ($^{13}\text{C}_{\text{carb}}$ and $^{18}\text{O}_{\text{carb}}$) from rock samples collected during mapping. The McQuesten Lake area consists of at least five thrust sheets that define an overall southwest-dipping architecture, which includes parts of the Robert Service thrust, the Tombstone thrust, and the Dawson fault. The study area is mostly comprised of siliciclastic and lesser carbonate rocks that belong to the Ediacaran to Cambrian Hyland Group, the Cambrian Gull Lake Formation, the Ordovician to Silurian Road River Group, the Ordovician to Devonian(?) Bouvette Formation, the Devonian to Mississippian Earn Group, and the Carboniferous Tsichu Group (Keno Hill Quartzite). The U-Pb dating of detrital zircon (CA-TIMS) indicates maximum depositional ages of 664.66 ± 0.36 Ma and 367.79 ± 0.25 Ma for the Yusezyu Formation (Hyland Group) and Keno Hill Quartzite, respectively, in the study area. Jurassic siliciclastic rocks, with a maximum depositional age of 166.85 ± 0.13 Ma, and Pennsylvanian(?) to Permian limestone of the Tahkandit Formation lie in the footwall of the Tombstone thrust. Volcanic and volcanoclastic rocks occur in the hanging wall of the Dawson fault, are overlain by the Road River Group, and likely correlate with lithologically and geochemically similar rocks of the Upper Cambrian Old Cabin Formation in the McKay Hill area to the northwest. In the McQuesten Lake area, the Hyland Group and Upper Cambrian volcanic–volcanoclastic rocks are intruded by Cambrian to Silurian(?) gabbro to melanocratic hornblende diorite, and the Earn Group and Keno Hill Quartzite are intruded by Triassic gabbro sills of the Galena suite. Rocks in the study area record at least two regional deformation events (D1 and D2), which occurred at greenschist facies conditions. The D1 deformation event produced a bedding-parallel foliation, whereas D2 involved northeast-vergent thrust faulting, widespread and pervasive folding, and development of crenulation lineations and axial-planar foliation.

Plain language summary

The McQuesten Lake study area, located in central Yukon, forms part of the Cordilleran orogen (mountain belt), which developed on and near the margin of the North American tectonic plate, adjacent to the Pacific Ocean basin. The McQuesten Lake area is mostly underlain by rocks that were deposited in an ancient ocean basin (the Selwyn basin) that formed along the North American margin. This report describes the geology of the McQuesten Lake area based on 1:50 000-scale bedrock mapping conducted from 2019 to 2022 by the Yukon Geological Survey and presents the results of laboratory analyses that were conducted on rock samples to determine the ages and chemical compositions of the rocks. The study area is mostly comprised of sandstone, fine-grained clastic sedimentary rocks (siltstone, shale), and lesser amounts of carbonate rocks (e.g., limestone) that form parts of more regionally-extensive groups of rocks that were deposited in the Selwyn basin. Rocks with a volcanic origin occur in the northern part of the mapped area and are likely equivalent to those in the McKay Hill area to the northwest of the study area. Isotopic (uranium-lead) analyses of sandstone samples indicate that some of the sedimentary rocks were deposited sometime after ~664 million years ago and other sedimentary rocks were deposited after ~368 million years ago. The study area also includes younger sandstone, deposited after ~167 million years ago. Additionally, iron and magnesium-rich (mafic) rock called gabbro occurs in several localities, and formed from intrusions of molten rock (magma) into some of the sedimentary rocks. As tectonic plates moved towards each other and formed mountains (the Cordilleran mountain belt), the rocks in the McQuesten Lake area were compressed during the Cretaceous time period (approximately 100–160 million years ago). This deformation caused the rocks to be folded, tilted towards the southwest, and

stacked on top of each other along planes of weakness, termed thrust faults, which include the regional-scale Robert Service thrust, Tombstone thrust, and Dawson fault.

Introduction

This report presents the results of 1:50 000-scale bedrock mapping conducted by the Yukon Geological Survey in 2019, 2021 and 2022 in the McQuesten Lake area of central Yukon, including parts of NTS sheets 106D/2, 3, 6 and 7 (Skipton, 2024). The McQuesten Lake area is located along the northern boundary of the Selwyn basin (Gordey and Anderson, 1993), where the Neoproterozoic to Cambrian Hyland Group is juxtaposed against Paleozoic slope and shelf rocks of the Ogilvie platform along the Dawson fault (Figs. 1 and 2; Green, 1972a,b; Abbott, 1997a,b; Colpron et al., 2013). The surrounding region hosts several mineral deposits (Fig. 2), including carbonate-hosted intrusion-related Au-Ag (Tiger; Yukon MINFILE 106D 098;

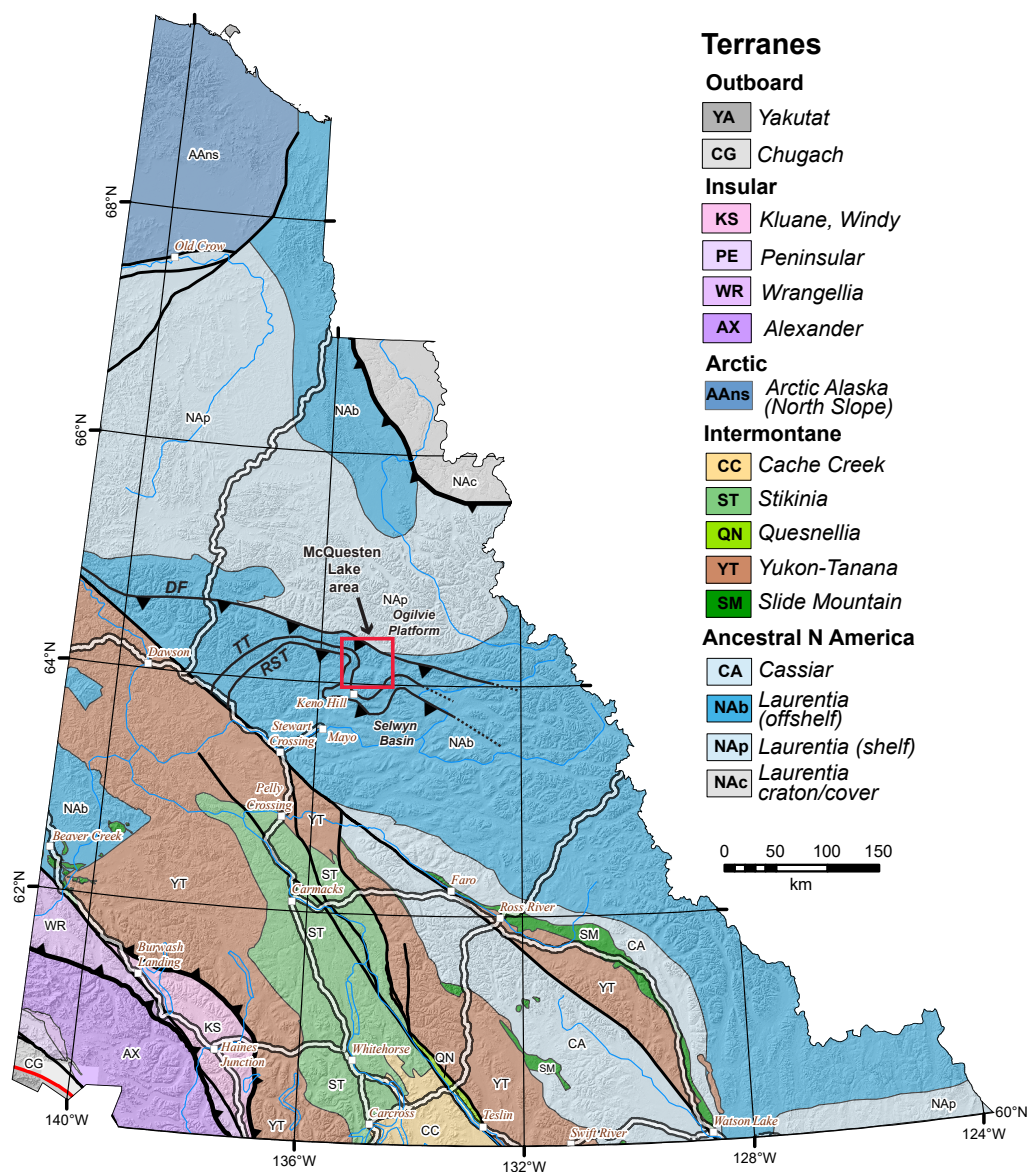


Figure 1. Terrane map of the Yukon (modified after Yukon Geological Survey, 2020). The McQuesten Lake study area (outlined in red) is located in central Yukon. DF = Dawson fault; TT = Tombstone thrust; RST = Robert Service thrust.

Yukon Geological Survey, 2010), epithermal Au-Ag-Cu (McKay Hill; Yukon MINFILE 106D 038; Yukon Geological Survey, 2010), manto Ag-Pb-Zn (Clark; Yukon MINFILE 106D 011; Yukon Geological Survey, 2010), plutonic-related Au (Dublin Gulch; Yukon MINFILE 106D 025; Yukon Geological Survey, 2010), vein polymetallic Ag-Pb-Zn+/-Au (Keno; Yukon MINFILE 105M 001; Yukon Geological Survey, 2010) and volcanogenic massive sulphide Cu-Pb-Zn (Marg; Yukon MINFILE 106D 009; Yukon Geological Survey, 2010).

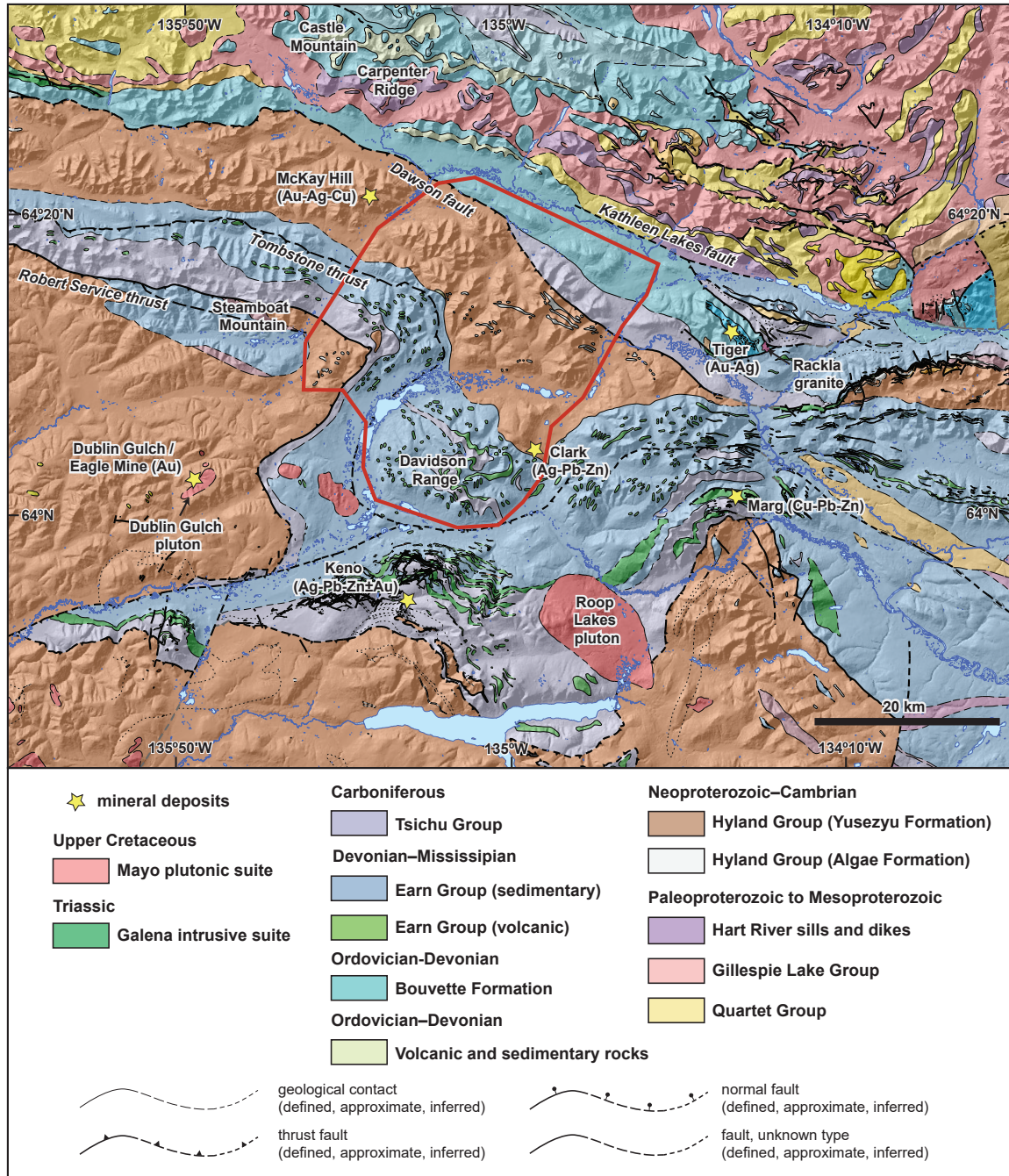


Figure 2. Geological map of Paleoproterozoic to Carboniferous sedimentary rocks and younger intrusions along the northern margin of the Selwyn basin in the region of Keno, Tiger and McKay Hill mineral deposits (from the digital compilation map of the Yukon; Yukon Geological Survey, 2022). The area mapped in detail (Skipton, 2024), and discussed in this report, is outlined in red.

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b)

Legend

QUATERNARY	
Q	unconsolidated alluvial, colluvial, fluvial and glacial deposits
NORTH OF DAWSON FAULT	
ORDOVICIAN TO DEVONIAN(?)	
ODBu	BOUVETTE FORMATION, UPPER: dolostone, dolomitic sandstone and mudstone, pebble conglomerate
ODBmv	BOUVETTE FORMATION, MIDDLE, volcanic member: basalt, volcanoclastic rocks
ODBmc	BOUVETTE FORMATION, MIDDLE, undivided: limestone, dolostone
ODBl	BOUVETTE FORMATION, LOWER: limestone, dolostone, quartzite
NEOPROTEROZOIC (EDIACARAN)	
PRG	RACKLA GROUP, GAMETRAIL FORMATION: dolostone, dolomitic siltstone/sandstone and limestone, carbonate-clast breccia, shale
SOUTH OF DAWSON FAULT	
MESOZOIC	
MTp	quartz porphyry and granite porphyry; sill-like bodies or dikes
Mgr	quartz monzonite, granodiorite, granite or quartz diorite
Mqm	quartz monzonite(?) with intense carbonate-quartz alteration
JURASSIC	
Jss	quartz arenite
Jsh	shale, local siltstone interbeds
TRIASSIC	
TG	GALENA SUITE: gabbro sills
PENNSYLVANIAN(?) TO PERMIAN	
PPT	TAHKANDIT FORMATION: limestone, local pebble conglomerate
CARBONIFEROUS	
CTKHQ	TSICHU GROUP, KENO HILL QUARTZITE: quartz arenite (quartzite), local siltstone, shale, phyllite
CTKHOS	TSICHU GROUP, KENO HILL QUARTZITE, shale member: shale, local phyllite
DEVONIAN TO MISSISSIPPIAN	
DMEsl	EARN GROUP, siltstone member: siltstone, local fine-grained sandstone
DMEq	EARN GROUP, quartzite member: quartz arenite (quartzite)
DMEc	EARN GROUP, carbonate member: interbedded dolostone, sandstone, shale, chert
DMesh	EARN GROUP, shale member: shale, graphitic phyllite, siltstone
PALEOZOIC TO MESOZOIC(?)	
PMm	mafic rock with intense carbonate-chlorite alteration
ORDOVICIAN TO SILURIAN	
OSR	ROAD RIVER GROUP, undivided: interbedded mudstone, siltstone, chert
OSRsh	ROAD RIVER GROUP, shale member: shale, phyllite, local chert
OSRc	ROAD RIVER GROUP, chert member: chert
UPPER CAMBRIAN	
Cvsh	shale
Cv	mafic volcanoclastic rocks, basalt, mafic tuff
CAMBRIAN TO SILURIAN(?)	
Cg	gabbro sills and plugs, local melanocratic hornblende diorite
CAMBRIAN	
GL	GULL LAKE FORMATION: interbedded siltstone and shale
NEOPROTEROZOIC (EDIACARAN) TO LOWER CAMBRIAN	
PCHn	HYLAND GROUP, NARCHILLA FORMATION, undivided: shale, siltstone, phyllite, local sandstone
PCHnss	HYLAND GROUP, NARCHILLA FORMATION, sandstone member: sandstone, local shale, siltstone, phyllite
NEOPROTEROZOIC (EDIACARAN)	
PHYul	HYLAND GROUP, YUSEZYU FORMATION, LIMESTONE UNIT: limestone, local dolostone
PHYm	HYLAND GROUP, YUSEZYU FORMATION, "MIXED" UNIT: siltstone, phyllite, shale, sandstone
PHYss	HYLAND GROUP, YUSEZYU FORMATION, SANDSTONE UNIT, undivided: sandstone, local shale, siltstone, phyllite
PHYsc	HYLAND GROUP, YUSEZYU FORMATION, SANDSTONE UNIT, calcareous member: sandstone with dolomitic cement, local limestone, dolostone, shale
PHYssm	HYLAND GROUP, YUSEZYU FORMATION, SANDSTONE UNIT, "mixed" member: interbedded sandstone, shale, phyllite, limestone, dolostone

c)

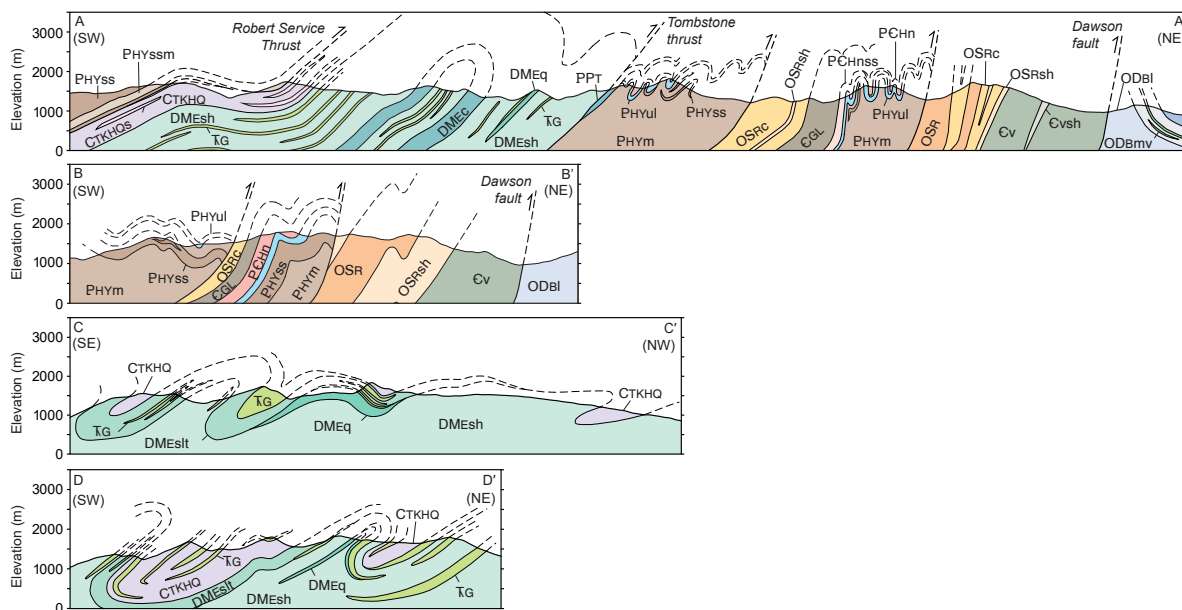
Cross-sections

Figure 3. b) Legend corresponding with Geological map of the McQuesten Lake area and **c)** cross-sections (simplified after Skipton, 2024). For presentation purposes, the cross-sections are scaled to 1.5x the scale of the map.

The McQuesten Lake area was initially mapped at 1:250 000-scale by the Geological Survey of Canada as part of a regional mapping project that included the Nash Creek, Larsen Creek and Dawson areas (NTS 106D, 116A, 116BC; Green, 1971, 1972a,b), as well as detailed (1:50 000-scale) mapping of the Davidson Range (Green, 1971). Several 1:50 000 and 1:75 000-scale mapping projects have improved our understanding of regional stratigraphic and structural relationships across the Dawson fault zone in the Ogilvie and Wernecke mountains (Abbott, 1990a,b, 1997a–c; Colpron et al., 2013; Moynihan, 2014, 2016a) and across the Tombstone and Robert Service thrust zones in the McQuesten River and Mayo areas (Murphy, 1997; Roots, 1997). However, the McQuesten Lake area has not seen upgraded bedrock mapping until this study, which involved 1:50 000-scale mapping to address outstanding questions regarding stratigraphy, structural evolution and mineral potential. Targeted mapping (1:50 000-scale) of the northern part of the Davidson Range (Fig. 2) was also conducted to investigate the stratigraphy and deformation history in that area. The bedrock map (Fig. 3; Skipton, 2024), lithostratigraphic and structural frameworks presented herein supersede those presented by Skipton and Maw (2020) and Skipton (2022a,b).

This report includes detailed lithologic descriptions of each map unit shown on the accompanying Geoscience Map 2024-1 (Fig. 3; Skipton, 2024), as well as descriptions of deformation fabrics, faults, metamorphism, and mineralization in the mapped area. Additionally, this report presents new U-Pb geochronology on detrital zircon from six samples, whole-rock geochemistry from intrusive and volcanic rocks in the study area, fossil identifications, and isotopic ($\delta^{13}\text{C}$ and $\delta^{18}\text{O}$) compositions of carbonate rocks.

Regional geological setting

The McQuesten Lake area dominantly comprises sedimentary rocks that were deposited along the western Laurentian continental margin. These include clastic, volcanoclastic and carbonate rocks ranging from Neoproterozoic to Jurassic in age, as well as Cambrian and Triassic intrusive rocks (Figs. 2 and 3; Green, 1971, 1972).

The study area forms part of the Selwyn fold belt, which trends northwest–southeast across central Yukon, and formed in response to Jurassic to Cretaceous shortening during the Cordilleran orogeny (Gordey and Anderson, 1993). Hyland Group strata have been juxtaposed over Ordovician to Devonian(?) platformal carbonate rocks of the Bouvette Formation across the Dawson fault (Figs. 3 and 4), which extends northwest–southeast across central Yukon (Figs. 1 and 2; Yukon Geological Survey, 2022). Detailed mapping in the Rackla belt to the east (Colpron et al., 2013; Moynihan, 2014, 2016a) has shown that, rather than a single structure, the Dawson fault is a zone that comprises a series of moderately to steeply-dipping thrust imbricates, with a combined width of at least ~500 m and up to 2–4 km locally. Movement along the fault zone may have initiated as an extensional or strike-slip fault in the Neoproterozoic, with reactivation in the Paleozoic (Cobbett et al., 2025), and later displacement as a reverse or thrust fault during Mesozoic shortening associated with Cordilleran orogenesis (e.g., Abbott, 1997a; Colpron et al., 2013).

The McQuesten Lake area includes several additional northwest–southeast-striking thrusts. Southwest of the Dawson fault, previous maps show that the Hyland Group has been juxtaposed over the Devonian to Mississippian Earn Group and Carboniferous Tsichu Group by the Cretaceous Robert Service thrust, and the Earn Group has been repeated by the Cretaceous Tombstone thrust (Figs. 1 and 2; Green and Roddick, 1962; Tempelman-Kluit, 1970; Anderson, 1987; Roots, 1988; Thompson et al., 1990; Murphy, 1997). In the Keno and Mayo areas, the hanging wall of the Tombstone thrust and part of the hanging wall of the Robert Service thrust

are affected by a several-km thick interval of intensely deformed, lower to middle-greenschist-facies metasedimentary rocks (including the Devonian Earn Group and the Keno Hill Quartzite of the Carboniferous Tsichu Group), termed the Tombstone high-strain zone (Murphy, 1997).

Lithological descriptions

The study area is mainly underlain by siliciclastic and carbonate rocks that occupy several southwest-dipping thrust panels (Figs. 3 and 4). Based on lithofacies mapping and comparisons with stratigraphic relationships in the broader Selwyn basin and surrounding region (e.g., the eastern Wernecke Mountains, the Hyland River area, the Ogilvie Mountains, the McQuesten River and Mayo areas; Abbott, 1997a–c; Murphy, 1997; Roots, 1997; Colpron et al., 2013; Moynihan, 2014, 2016b), most of the sedimentary rocks are considered equivalent to the Ediacaran to Terreneuvian Hyland Group, the Cambrian Gull Lake Formation, the Ordovician to Silurian Road River Group, the Devonian to Mississippian Earn Group, and the Carboniferous Tsichu Group. These stratigraphic correlations are preliminary and may be refined following additional geochronology or bedrock mapping. All units described herein have been affected by regional deformation and greenschist facies metamorphism, although the Gametrail and Bouvette formations, which are located north of the Dawson fault, are notably less deformed or metamorphosed.

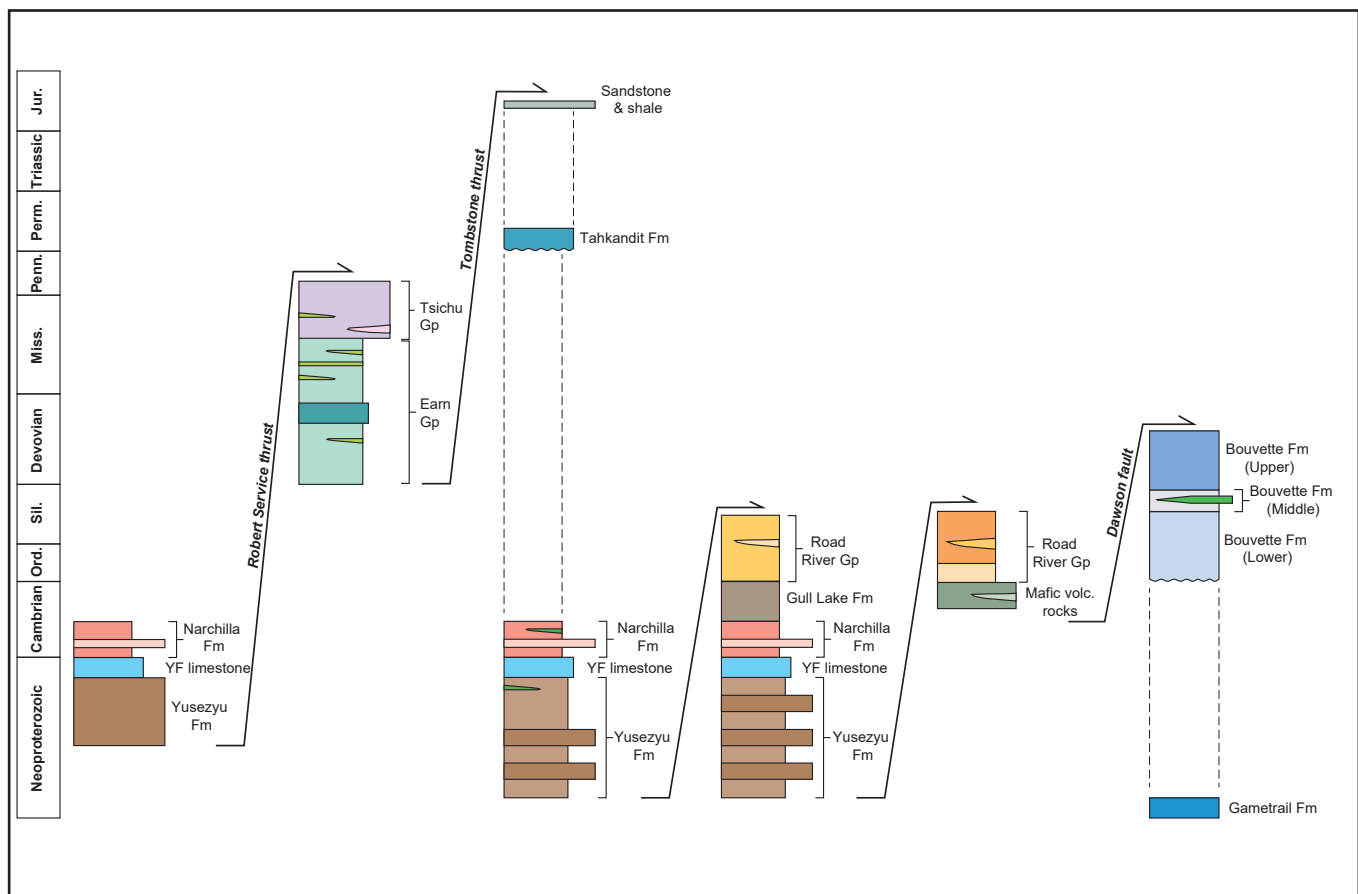


Figure 4. Schematic diagram illustrating the interpreted stratigraphic framework and thrust relationships in the McQuesten Lake area. Fm = Formation; Gp=Group; YF limestone = Yusezyu Formation limestone unit.

North of the Dawson fault

Ediacaran Rackla Group: Gametrail Formation (PHG)

East of the study area, preliminary mapping northeast of the Dawson fault and west of the Tiger Au deposit (Fig. 2) by Skipton and others (S. Israel, R. Cobbett, M. Colpron, pers. comm., 2021) has shown that the Bouvette Formation (discussed below) unconformably overlies the Gametrail Formation (PHG) of the Ediacaran Rackla Group (Moynihan et al., 2019). The Bouvette and Gametrail formations are inferred to extend northwest along-strike into the Beaver River valley (Fig. 3; Skipton, 2024). The Gametrail Formation is composed of mostly orange, yellow and grey-weathered dolostone that is typically planar or cross-laminated, as well as carbonate-clast breccia and conglomerate (Figs. 5 and 6). Based on stratigraphic relationships defined in the eastern Rackla belt (Moynihan, 2014), the Gametrail Formation is considered part of the Rackla Group, which underlies the Blueflower and Yusezyu formations.

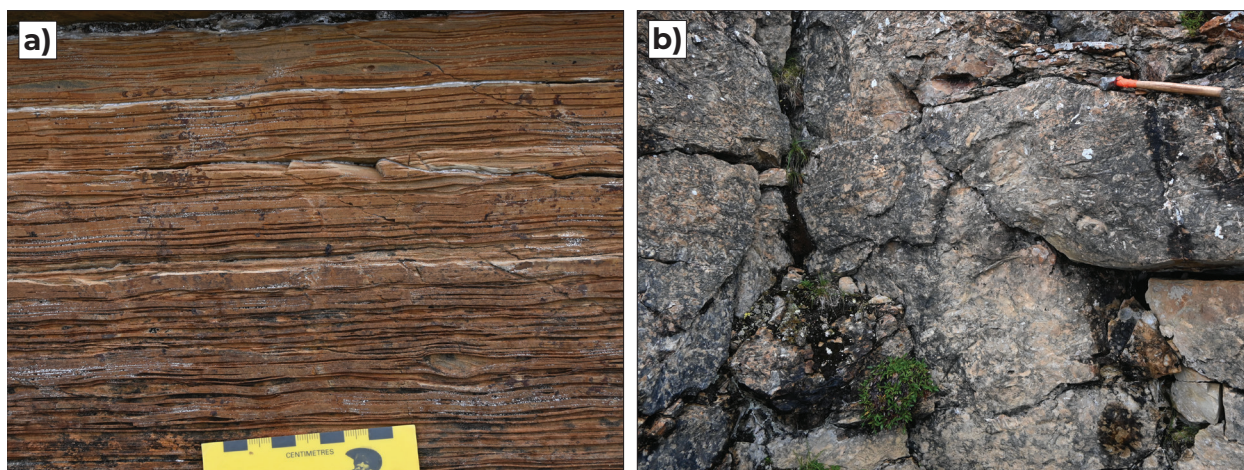


Figure 5. Field photographs of the Gametrail Formation (Rackla Group), located ~8 km northwest of the Tiger Au deposit. **a)** Orange-weathered, thin-bedded, planar laminated dolostone. **b)** Medium to thick-bedded, orange-grey-weathered carbonate-clast breccia. Hammer for scale is 40 cm long.

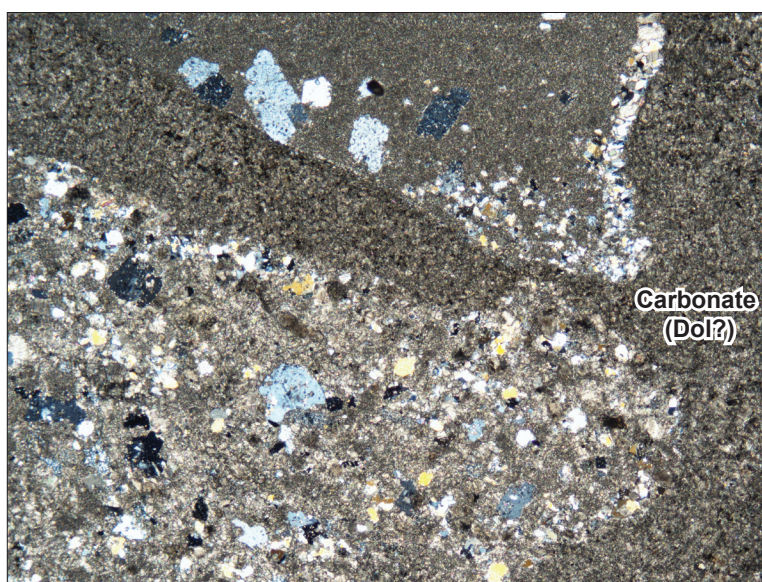


Figure 6. Photomicrograph of carbonate-clast breccia from the Gametrail Formation (Rackla Group). The breccia consists of a fine-grained carbonate matrix surrounding pebble-sized clasts of carbonate ($\pm$ quartz; XPL; sample 21DS-230-1-1). Dol = dolomite.

Ordovician to Devonian (?) Bouvette Formation (ODBl, ODBmc, ODBu, ODBmv)

The Bouvette Formation (Figs. 7 and 8) consists of carbonate platformal rocks and forms limited exposures in the Beaver River valley in the northeastern part of the map area (Fig. 3). These exposures consist of light grey weathered limestone and dolostone (Fig. 7a, b) with fine to medium-grained crystalline fresh surfaces. The dolostone contains abundant quartz and/or carbonate veins (Fig. 7b). Based on lithological similarities and stratigraphic relationships in the Bouvette Formation along-strike to the east (e.g., Tiger deposit area; Fig. 2; Abbott, 1990a; Colpron et al., 2013; Yukon Geological Survey, 2022) and northwest (Castle Mountain area; Fig. 2; Cobbett, 2020, 2022a,b), the carbonate rocks encountered in this study in the Beaver River valley are inferred to be part of the lower Bouvette Formation of Cobbett (2022a,b).

Mafic volcanic rocks (ODBmv) occur in isolated hilltop outcrops in the Beaver River valley (Figs. 3, 7c) and comprise fine-grained mafic volcanic breccia and basalt with pyroxene phenocrysts (Figs. 7d, 8). Although the contacts are poorly constrained, the location of these rocks suggests that they represent a volcanic interval within the Bouvette Formation, perhaps equivalent to similar mafic volcanic rocks in the middle Bouvette Formation near the Tiger Au deposit (Abbott, 1990a; Colpron et al., 2013; Yukon Geological Survey, 2022) and Castle Mountain (Cobbett, 2020, 2022a,b) areas, and in the southern Wernecke Mountains (Ambrose and Bowie, 2020). Volcanism within the Bouvette Formation near Castle Mountain has been dated at ca. 453–445 Ma, based on biostratigraphy and U-Pb zircon dating of tuffaceous and volcanoclastic sandstone (Cobbett et al., 2025).

The middle (ODBmc) and upper (ODBu) parts of the Bouvette Formation (e.g., Cobbett, 2022a,b) were not encountered during mapping, but are inferred to lie in the Beaver River valley (Fig. 3), based on along-strike stratigraphic relationships in the Tiger and Castle Mountain areas (Abbott, 1990a; Colpron et al., 2013; Cobbett, 2022a,b; Yukon Geological Survey, 2022). In those areas, the upper Bouvette Formation mainly consists of grey to buff-weathered limestone and dolostone, and contains two-hole crinoids that indicate a Middle Devonian age (Abbott, 1990a; Colpron et al., 2013; Cobbett, 2020).

South of the Dawson fault

Sedimentary and volcanic rocks

Ediacaran to Cambrian Hyland Group: Yusezyu and Narchilla formations (PHYm, PHYss, PHYsc, PHYssm, PHYul, PCHn, PCHnss)

Ediacaran to lower Cambrian strata of the Hyland Group are extensive in the study area, and predominantly include Ediacaran sandstone, fine-grained siliciclastic rocks and limestone of the Yusezyu Formation (Figs. 9–18). Based on lithofacies associations, the Yusezyu Formation in this study has been divided into five map units.

The heterogeneous ‘mixed’ unit (PHYm) is the predominant map unit of the Yusezyu Formation in the study area (Fig. 3). It consists of approximately equal proportions of green-grey siltstone and grey, green or maroon shale to phyllite, with lesser amounts (~15% of total) of medium-bedded brown-grey quartz grit sandstone, medium-grained quartz arenite (Figs. 9 and 10) and rare quartz-pebble conglomerate. Siltstone, shale/phyllite and sandstone typically form alternating intervals that range from approximately 3 m to tens of metres thick (Fig. 9a). In places, sandstone and siltstone are rhythmically interbedded, forming medium to thick-beds (Fig. 9d). Sandstone locally contains cross-beds or ripple cross-laminations (Fig. 9e). In several localities, phyllite contains dark brown crystals up to ~2 mm in size, which are inferred to be

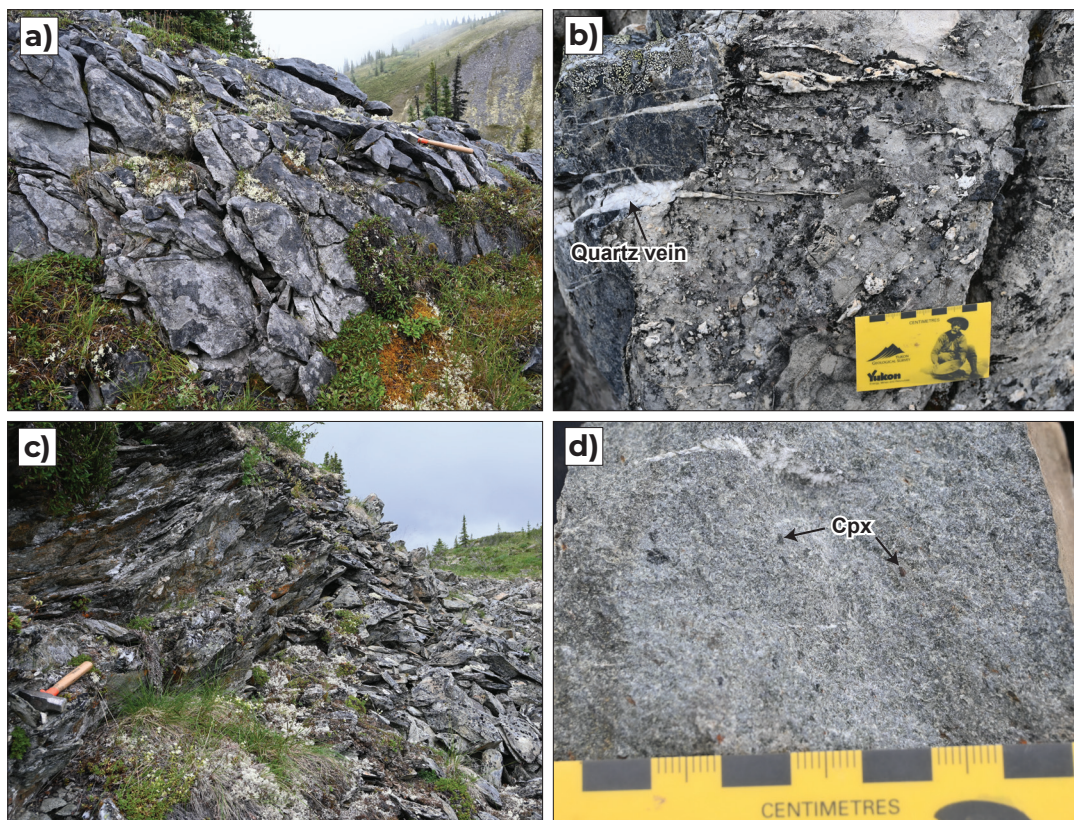


Figure 7. Field photographs of the lower Bouvette Formation (ODBl), including: **a)** outcrop of grey-weathered limestone; **b)** light grey-weathered limestone with quartz veins. **c)** Field photograph of fine-grained mafic volcanic rock (ODBmv) in the Bouvette Formation. **d)** Fresh surface of the mafic volcanic rock shown in c). Hammer for scale in a) and c) is 40 cm long. Cpx = Clinopyroxene.

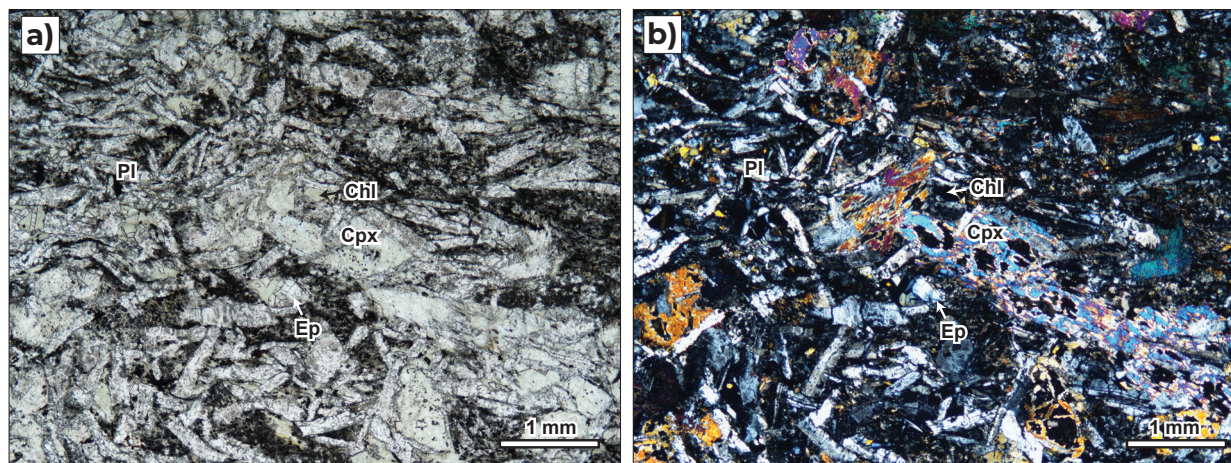


Figure 8. Photomicrographs of clinopyroxene-phyric basalt (ODBmv) in the Bouvette Formation (sample 21DS-148-1-1). **a)** Plane polarized light (PPL). **b)** Cross-polarized light (XPL). Clinopyroxene phenocrysts have been extensively replaced by greenschist-facies minerals, including chlorite. Chl = chlorite; Ep = epidote; Pl = plagioclase.

altered (oxidized) diagenetic pyrite or siderite (Fig. 10a). Detrital zircon U-Pb geochronology performed on a sample of quartz grit sandstone (19DS-002-1-1; Fig. 3a) from the 'mixed' unit (PHYm) yielded a maximum depositional age of 664.66 ± 0.36 Ma (presented below in the "U-Pb zircon geochronology" section). As this is the youngest maximum depositional age among the three detrital zircon samples from the Yusezyu Formation analyzed in this study, it represents the best estimate of the depositional age of the Yusezyu Formation in the map area.

The sandstone-dominated unit (undivided member; PHYss) of the Yusezyu Formation includes medium to thick-bedded, medium-grained, brown-grey quartz arenite and quartz grit sandstone with local quartz-pebble conglomerate (Figs. 11 and 12) and rare interbeds

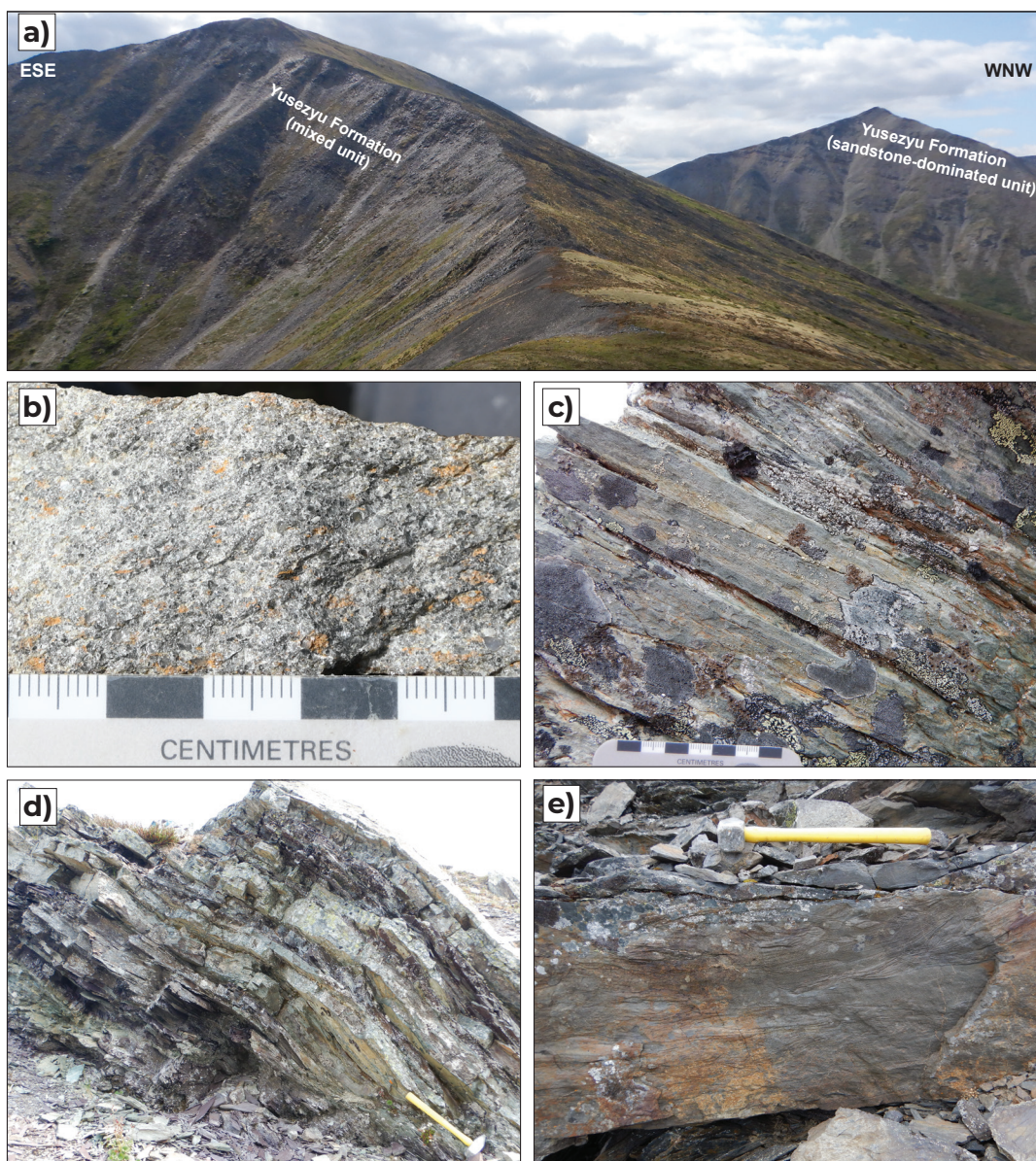


Figure 9. a) Field photograph illustrating recessively weathered siltstone and shale and non-recessively weathered sandstone in the Yusezyu Formation 'mixed' unit (PHYm) in the foreground, and competent sandstone beds in the Yusezyu Formation sandstone-dominated unit (PHYss) in the background (horizontal field of view is ~3 km). (b–e) Field photographs of the 'mixed' unit (PHYm) in the Yusezyu Formation, including: b) fresh surface of quartz grit sandstone; c) thinly interbedded light grey and pale green siltstone; d) interbedded maroon shale, light grey siltstone and light grey fine-grained sandstone; e) ripple cross-laminations in a fine-grained sandstone bed. Hammer for scale in d) and e) is 40 cm long.

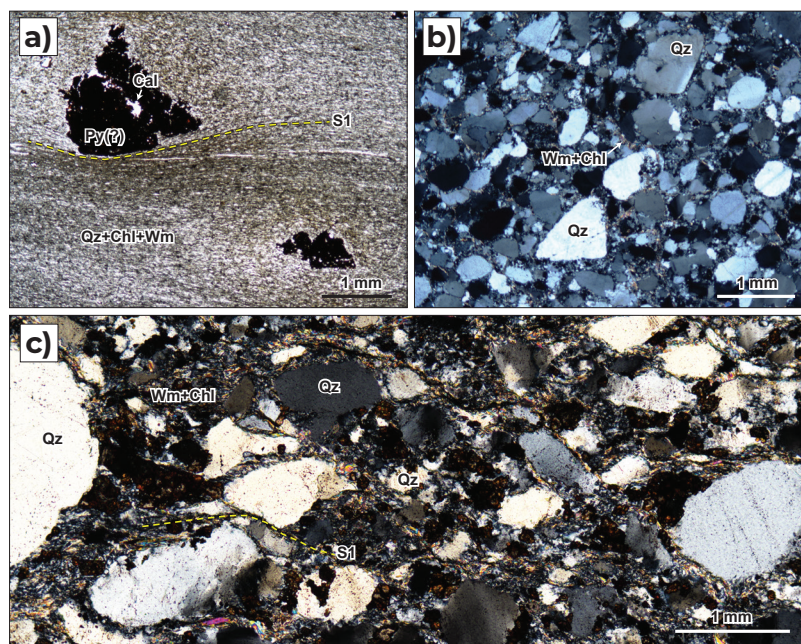


Figure 10. Photomicrographs from the Yusezyu Formation mixed unit (PHYm). **a)** Phyllite that consists of a matrix of mostly quartz, chlorite and white mica surrounding larger crystals of an altered (oxidized) opaque mineral, which may have been diagenetic pyrite or siderite. Foliation (S1; yellow dashed line) is defined by aligned chlorite and white mica (plane-polarized light, PPL; sample 19DS-001-2-1). **b)** Quartz arenite, which comprises subrounded quartz clasts with secondary chlorite and white mica (cross-polarized light, XPL; sample 19DS-104-1-1). **c)** Quartz arenite, with S1 foliation defined by aligned quartz clasts and secondary chlorite and white mica (XPL; sample 21DS-042-2-1). Qz = quartz; Cal = calcite; Py = pyrite; Wm = white mica.

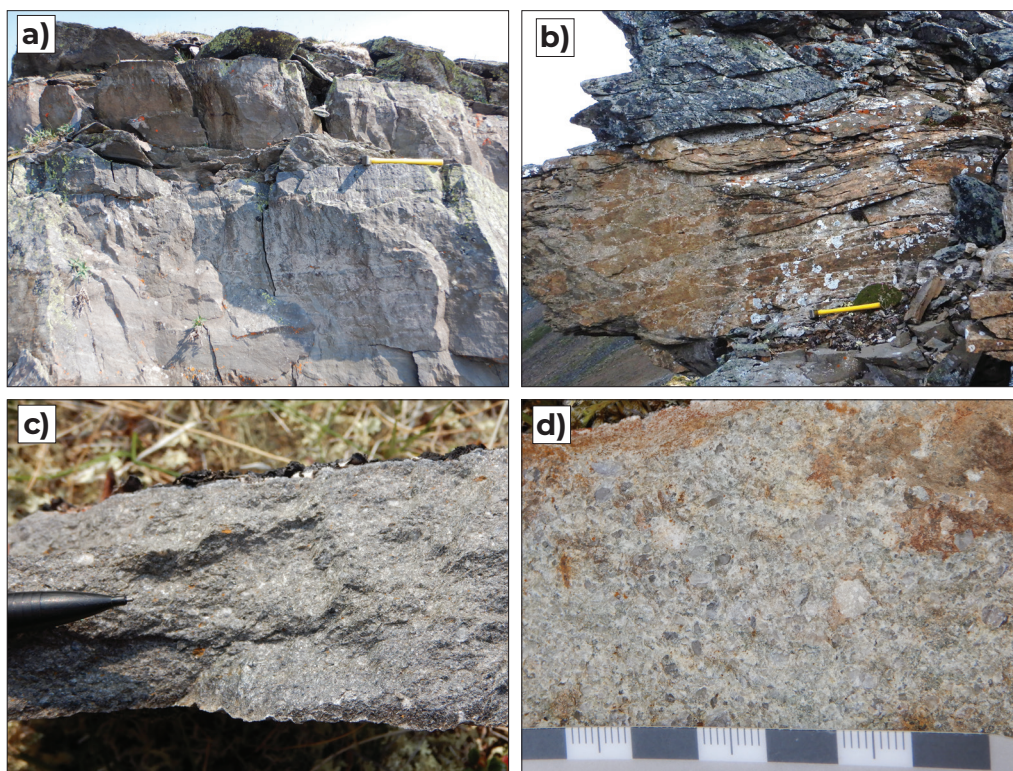


Figure 11. Field photographs of the undivided sandstone unit (PHYss) in the Yusezyu Formation. **a)** Medium to thick-bedded, brown quartz arenite. **b)** Medium-bedded, brown-to-grey quartz arenite to quartz grit. **c)** Brown-to-grey fresh surface of quartz grit. **d)** White to light grey fresh surface of quartz pebble conglomerate. Hammer for scale in **a)** and **b)** is 40 cm long. Pencil tip for scale in **c)** is 2 cm long.

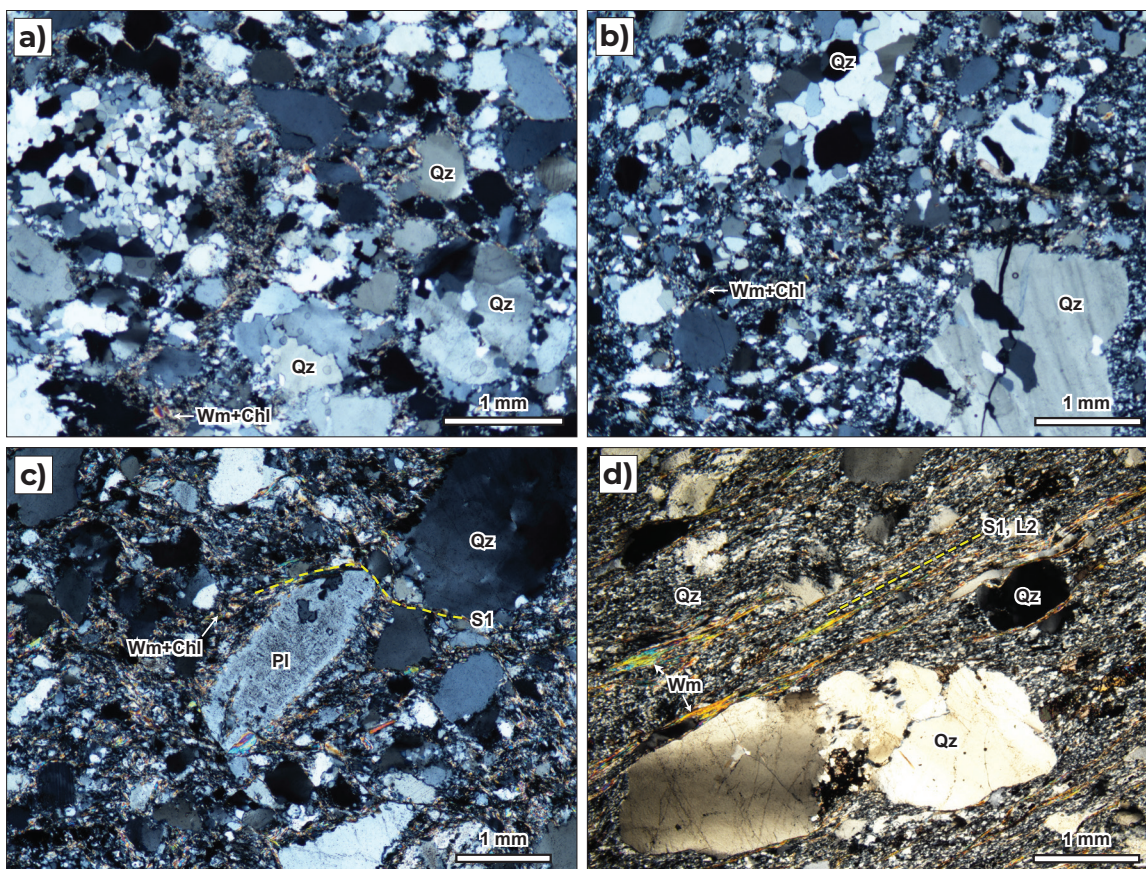


Figure 12. Photomicrographs of sandstone samples from the undivided member of the Yusezyu Formation sandstone-dominated unit (PHYss). **a)** Quartz arenite with secondary white mica and chlorite (XPL; sample 19DS-029-1-1). **b)** Quartz grit sandstone containing quartz clasts with variable sizes, including several large (>1 mm) quartz clasts, and secondary white mica and chlorite (XPL; sample 19DS-051-2-1). **c)** Quartz grit sandstone containing variably-sized quartz clasts, and a rare plagioclase grain. Secondary white mica and chlorite define a weak S1 foliation, delineated by the yellow dashed line (XPL; sample 19DS-077-1-1). **d)** Quartz grit sandstone from the hanging wall of the Robert Service thrust, with a strong bedding-parallel (S1) foliation defined by aligned quartz clasts and secondary white mica. The plane of the thin section is oriented parallel to L2 lineation, which is defined by aligned white mica (XPL; sample 21DS-228-2-1). The yellow dashed line indicates the S1 foliation and L2 lineation.

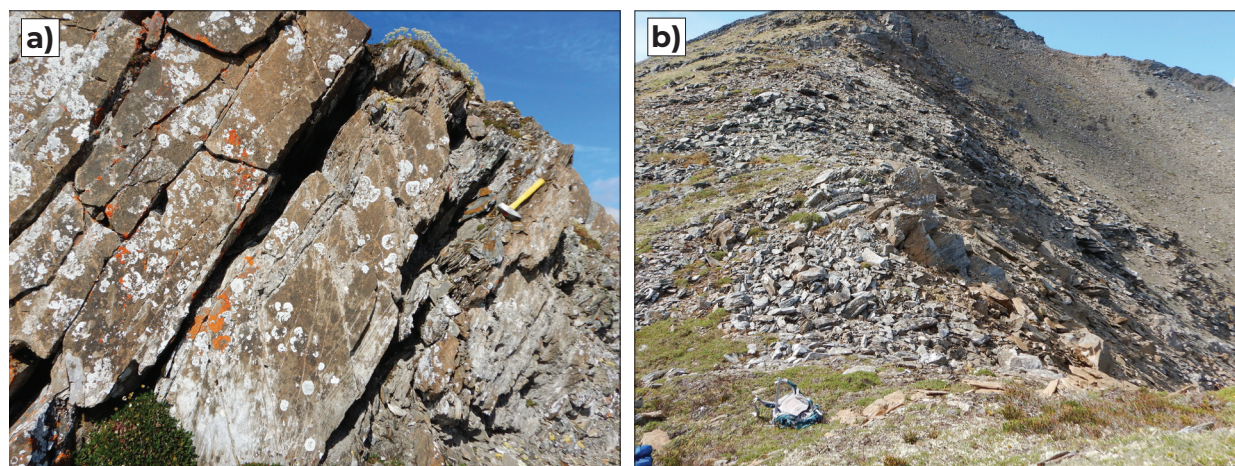


Figure 13. Field photographs of the calcareous member of the sandstone unit (PHYsc) in the Yusezyu Formation. Both photographs show medium to thick-bedded, orange-weathered quartz-rich sandstone with dolomite cement. Hammer for scale in a) is 40 cm long. Backpack for scale in b) has a diameter of 40 cm.

of grey-green shale and siltstone. Sandstone locally exhibits ripple cross-laminations or cross-bedding. Quartz grit sandstone consists of a fine-grained, quartz-rich matrix that surrounds quartz clasts, which form ~5–20 vol. % of the rock and are generally ~0.5–2 mm in size (Figs. 11b, 12b–d). Both the clast assemblages and matrices of all sandstone types in this unit are dominantly comprised of quartz, and plagioclase clasts occur rarely (Fig. 12). Field relationships suggest that the sandstone-dominated unit forms laterally discontinuous layers at different stratigraphic levels within the ‘mixed’ unit and may represent channel-fill deposits. In places, the sandstone-dominated unit (PHYss)

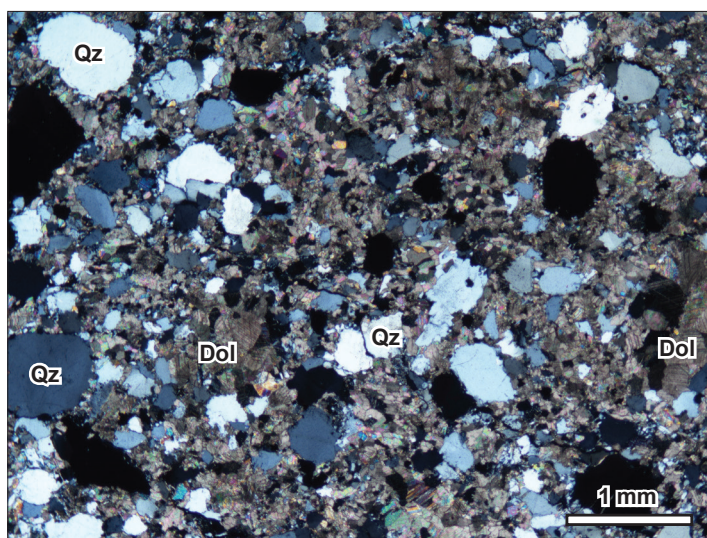


Figure 14. Photomicrograph of the calcareous member of the sandstone unit (PHYsc) in the Yusezyu Formation, indicating quartz clasts surrounded by a fine-grained quartz-bearing matrix with dolomite cement (XPL; sample 19DS-107-1-1).

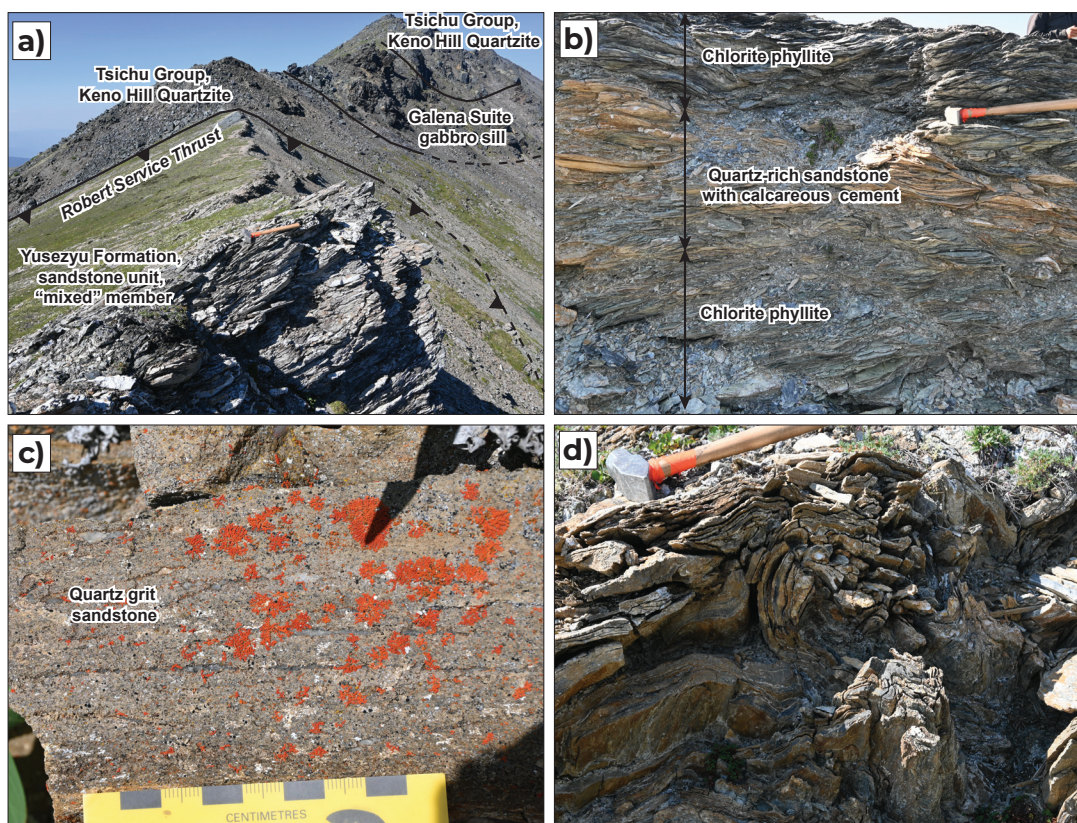


Figure 15. a) Looking west in a klippe of the Yusezyu Formation above the Robert Service thrust, with Keno Hill Quartzite and Galena Suite gabbro sill in the footwall. The outcrop in the foreground comprises thinly interbedded quartz grit sandstone ($\pm$ calcareous cement) and limestone of the ‘mixed’ member of the Yusezyu Formation sandstone unit (PHYssm). (b–d) Field photographs of the ‘mixed’ member of the Yusezyu Formation sandstone unit (PHYssm), including: b) strongly foliated chlorite phyllite and quartz-rich sandstone with calcareous cement; c) detail of quartz grit sandstone; and d) complexly folded, thinly interbedded quartz-rich sandstone with calcareous cement, and chlorite phyllite. Hammer for scale in a), b) and d) is 40 cm long.

contains sections of predominantly calcareous rocks (calcareous member; PHYsc). These sections comprise medium to thick-bedded, orange-weathered quartz-rich sandstone with dolomite cement (Figs. 13 and 14) and lesser intervals (<3 m thick) of grey limestone, orange-weathered dolostone and/or green-grey shale.

In the hanging wall of the Robert Service thrust, the sandstone-dominated unit (PHYss) of the Yusezyu Formation contains intervals ~20–40 m thick of thinly interbedded siliciclastic and calcareous rocks ('mixed' member; PHYssm; Figs. 15 and 16). These interbedded rocks include thinly to medium-bedded, grey to tan-coloured quartz grit sandstone, dark green-grey siltstone to phyllite (or, locally, schist; Fig. 16), orange-weathered quartz grit sandstone with dolomite cement, grey limestone and orange-weathered dolostone.

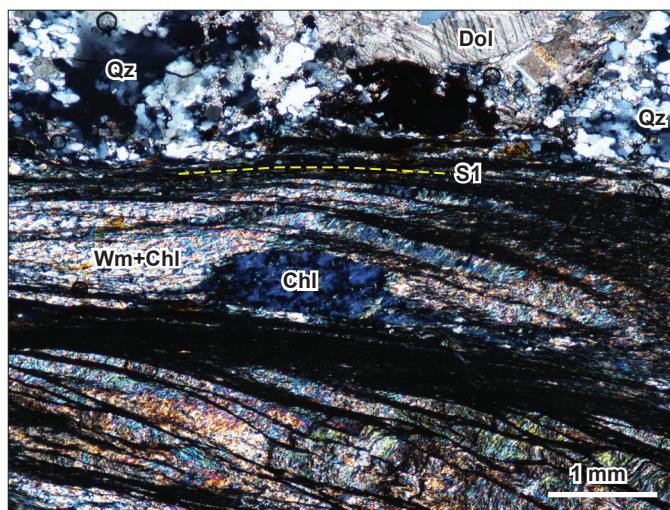


Figure 16. Photomicrograph of white mica-chlorite schist in the 'mixed' member of the Yusezyu Formation sandstone unit (PHYssm). The schist consists of white mica and chlorite-rich layers alternating with quartz-rich layers, with local secondary carbonate (dolomite?; XPL; sample 21DS-182-3-1). Yellow dashed line indicates S1 foliation.

Siliciclastic rocks of the Yusezyu Formation (PHYm, PHYss) are overlain by fine-grained grey limestone (limestone unit; PHYul; Figs. 17 and 18) along a sharp contact. The limestone unit is fine-grained, massive to medium-bedded (Fig. 17a), laminated in places, and locally contains minor proportions of fine-grained, medium-bedded orange-weathered dolostone. In places, the limestone contains up to ~20% quartz clasts that are typically angular (Fig. 18b). The limestone may correlate with the lithologically similar Algae Formation of the eastern Rackla Belt, which occupies a similar stratigraphic level between Ediacaran clastic rocks (Blueflower Formation) and the Narchilla Formation (Fig. 19; Moynihan, 2014). The limestone unit exhibits a light grey weathering colour that is distinctive from the overlying Narchilla Formation and underlying Yusezyu units, which have dark grey-brown weathering colours overall (Fig. 17). The limestone unit in the study area has an estimated observed thickness of ~30 to 50 m, although the thickness is poorly constrained in several localities due to complex folding (Fig. 17c,d). In places, the thickness of the limestone is variable (e.g., tapering from ~45 to ~7 m thick across a lateral [bedding-parallel] distance of ~300 m; Fig. 17e), suggesting that the limestone is locally discontinuous or cut out by an erosional unconformity (e.g., Moynihan, 2014).

The Narchilla Formation (undivided; PCHn; Figs. 19 and 20) overlies the limestone unit of the Yusezyu Formation (PHYul) along a sharp contact (Fig. 17b–e), and comprises fine-grained siliciclastic rocks, including dark grey, green and maroon shale and grey-green siltstone to phyllite (Figs. 20a,b, 21). Phyllite locally contains fine to medium-grained crystals of secondary carbonate or magnetite (Fig. 21c,d). The Narchilla Formation contains lesser amounts of fine-grained white, thinly-bedded sandstone with local ripple cross-laminations (Fig. 20c), interbedded green-grey to white fine-grained sandstone and siltstone, and rare interbeds of brown-grey quartz grit to quartz arenite. The Narchilla Formation locally contains sandstone-rich horizons (sandstone member; PCHnss), which dominantly comprise medium-bedded brown-grey quartz grit sandstone (Fig. 20d) and lesser quartz arenite. In the McQuesten Lake area, the Narchilla Formation (PCHn, PCHnss) represents the highest known stratigraphic level

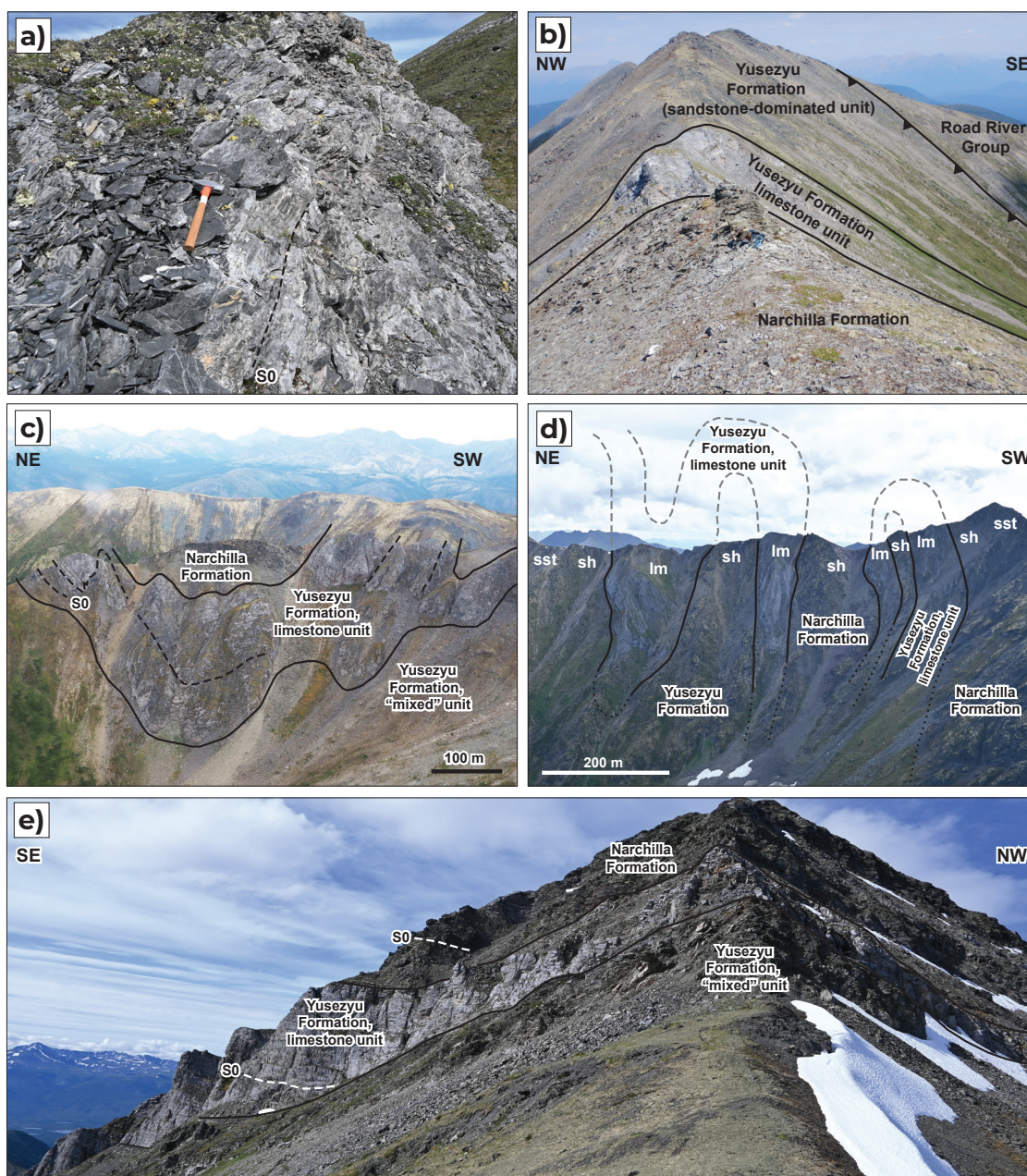


Figure 17. **a)** Field photograph of the limestone unit (PHYul) in the Yusezyu Formation, comprised of light to dark-grey weathered, thin to medium-bedded limestone with calcite veining. Black dashed line delineates bedding (S0). Hammer for scale is 40 cm long. **b)** Light grey limestone of the Yusezyu Formation limestone unit (PHYul) overlain by siltstone of the Narchilla Formation (PCHn) and underlain by the sandstone-dominated unit of the Yusezyu Formation (PHYss). The Yusezyu and Narchilla formations overlie the Road River Group (OSR, OSRsh) along a thrust contact. Geologist sitting in the foreground measures approximately 1 m. **c)** Folded strata of the Yusezyu and Narchilla formations with a broadly synclinal geometry. Smaller folds occur within limbs of the syncline, including a synclinal chevron fold in the northeastern limb (left side of photo). Solid black lines indicate geological contacts and black dashed lines delineate bedding (S0). **d)** Steeply dipping, isoclinally folded strata of the Yusezyu and Narchilla formations. Bedding dip measurements along the ridgetop range from ~80°NE to 80°SW. The rock types mapped along the ridgetop are indicated as follows: sh = grey, green and/or maroon shale and lesser grey siltstone; sst = grey to brown quartz arenite and/or quartz grit; lm = grey limestone. Black lines represent geological contacts as mapped along the ridgetop (solid line) or as inferred from remote observations (dotted line). Grey dashed lines represent interpreted pre-erosional geological contacts. **e)** Narchilla Formation and Yusezyu Formation limestone (PHYul) underlain by the 'mixed' unit of the Yusezyu Formation. The limestone thins towards the northwest, from ~45 m to ~7 m. Horizontal field of view is ~300 m. White dashed lines delineate bedding (S0).

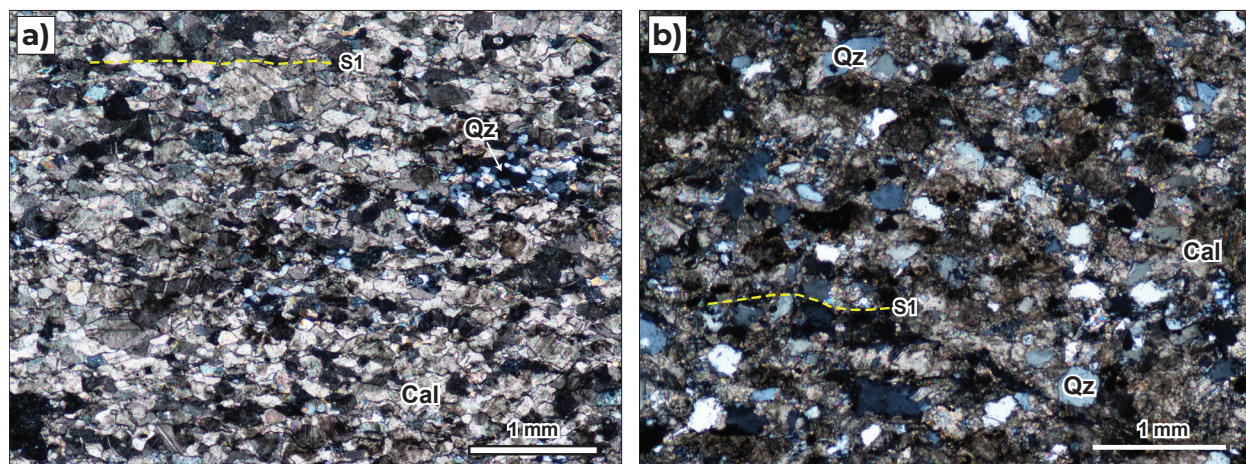


Figure 18. Photomicrographs of the limestone unit (PHYul) in the Yusezyu Formation. **a)** Limestone containing minor quartz. S1 foliation (yellow dashed line) is defined by aligned calcite crystals (XPL; sample 19DS-020-1-1). **b)** Limestone containing ~15% quartz clasts, with a weak S1 foliation defined by aligned calcite and quartz (XPL; sample 19DS-125-1-1).

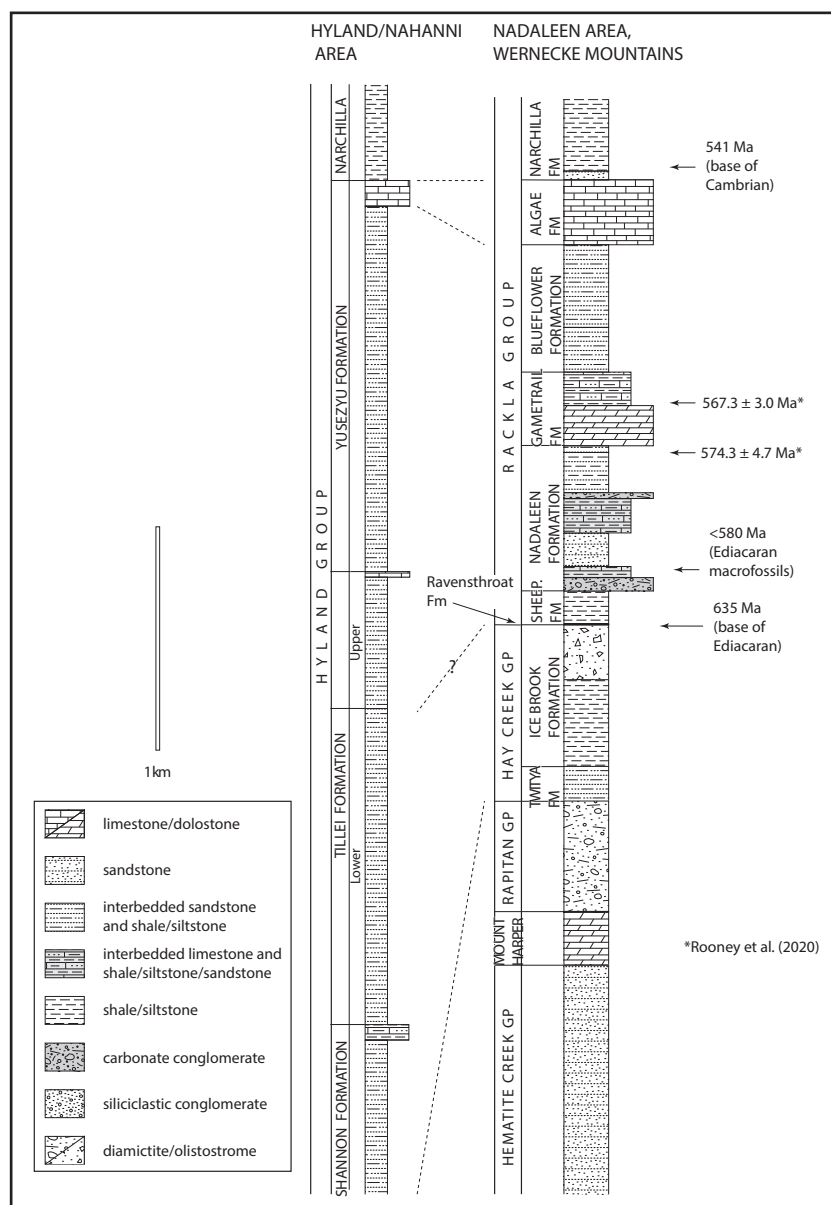


Figure 19. Stratigraphic correlations between Neoproterozoic–Cambrian basinal rocks in the Hyland/Nahanni area of southeast Yukon and the Nadaleen area of east-central Yukon (modified after Moynihan, 2014; Moynihan et al., 2019).

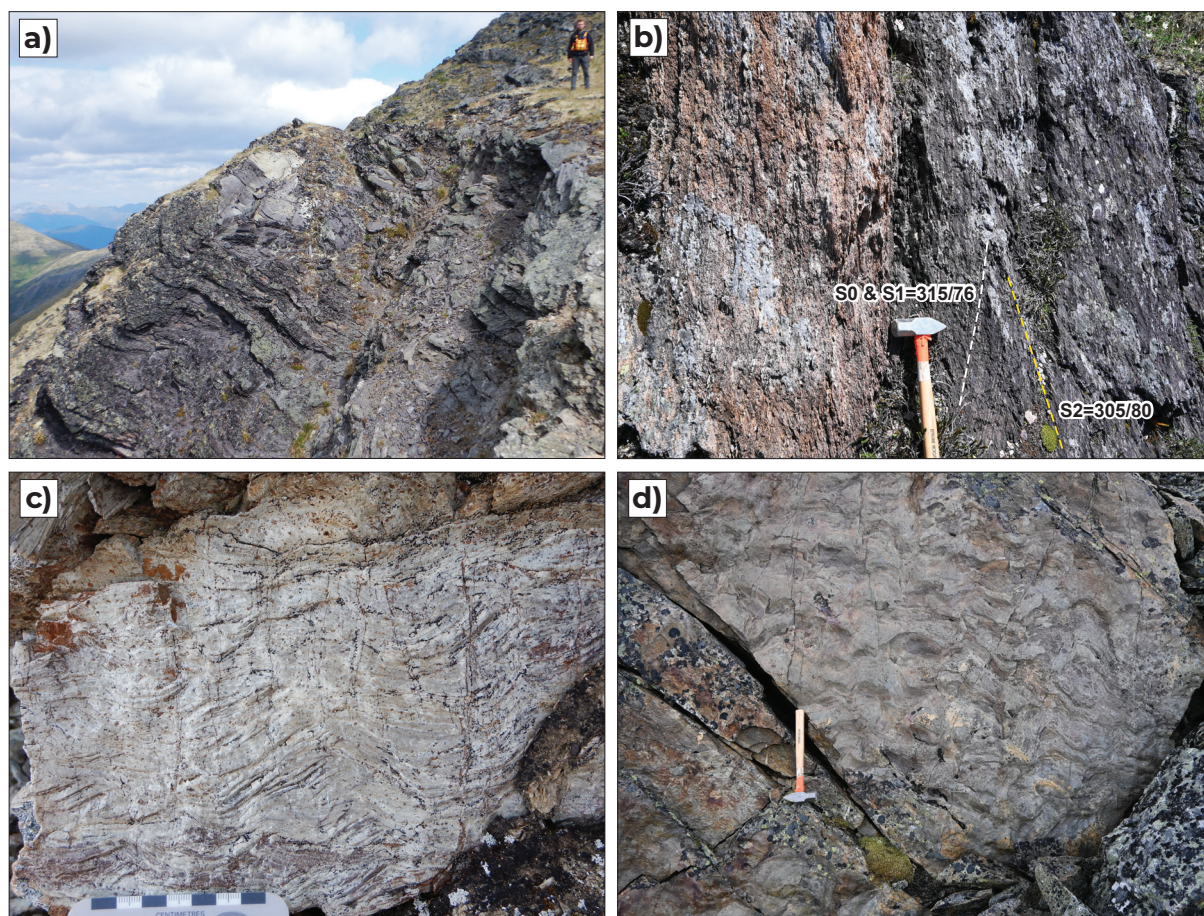


Figure 20. Field photographs of the Narchilla Formation. **a)** Maroon and green shale (PCHn). Geologist for scale is approximately 1.8 m tall. **b)** Thinly bedded beige siltstone (left) and dark grey to maroon shale (right), with a well-developed foliation (S2, delineated by the yellow dashed line) oriented at an angle to bedding (S0) and bedding-parallel foliation (S1, delineated by the white dashed line) (PCHn). Planar structural measurements are presented in right-hand rule format (strike/dip) here and throughout the manuscript. **c)** White-weathered, thin bedded, fine-grained sandstone with ripple cross-laminations (PCHn). **d)** Ripple marks on the bedding plane of quartz grit sandstone (sandstone member, PCHnss). Hammer for scale in b) and d) is 40 cm long.

of exposure of the Hyland Group, and it is commonly exposed in synclinal keels (Fig. 17c,d). As such, the thickness of the Narchilla Formation is poorly constrained in the map area, but it is estimated to be at least 500 m thick. Although not observed in the study area, *Oldhamia* trace fossils have been reported in the upper Narchilla Formation elsewhere in the Selwyn basin in eastern and northern Yukon (Hofmann et al., 1994; MacNaughton et al., 2016), indicating a Lower Cambrian depositional age (Herbosch and Verniers, 2011).

The rocks that underlie the Narchilla Formation are referred to as the Yusezyu Formation in this study, as they are lithologically similar to the Yusezyu Formation of the Hyland Group in the Selwyn basin of the Little Nahanni River and upper Hyland River areas of southeastern Yukon (e.g., Gordey and Anderson, 1993; Moynihan, 2016). Using Hyland Group nomenclature follows historical precedent in this area and the surrounding region along the northeastern margin of the Selwyn basin (e.g., Abbott, 1990 a,b, 1997a–c; Colpron et al., 2013; Yukon Geological Survey, 2022). However, the rocks included in the Yusezyu Formation in the McQuesten Lake study area also share lithological similarities with the Blueflower Formation and the overlying, carbonate-dominated Algae Formation of the Rackla Group in the Nadaleen River area of the eastern Rackla Belt (e.g., Moynihan, 2014), and it is uncertain if they correlate more closely with those units than with the Yusezyu Formation. A stratigraphic affinity with

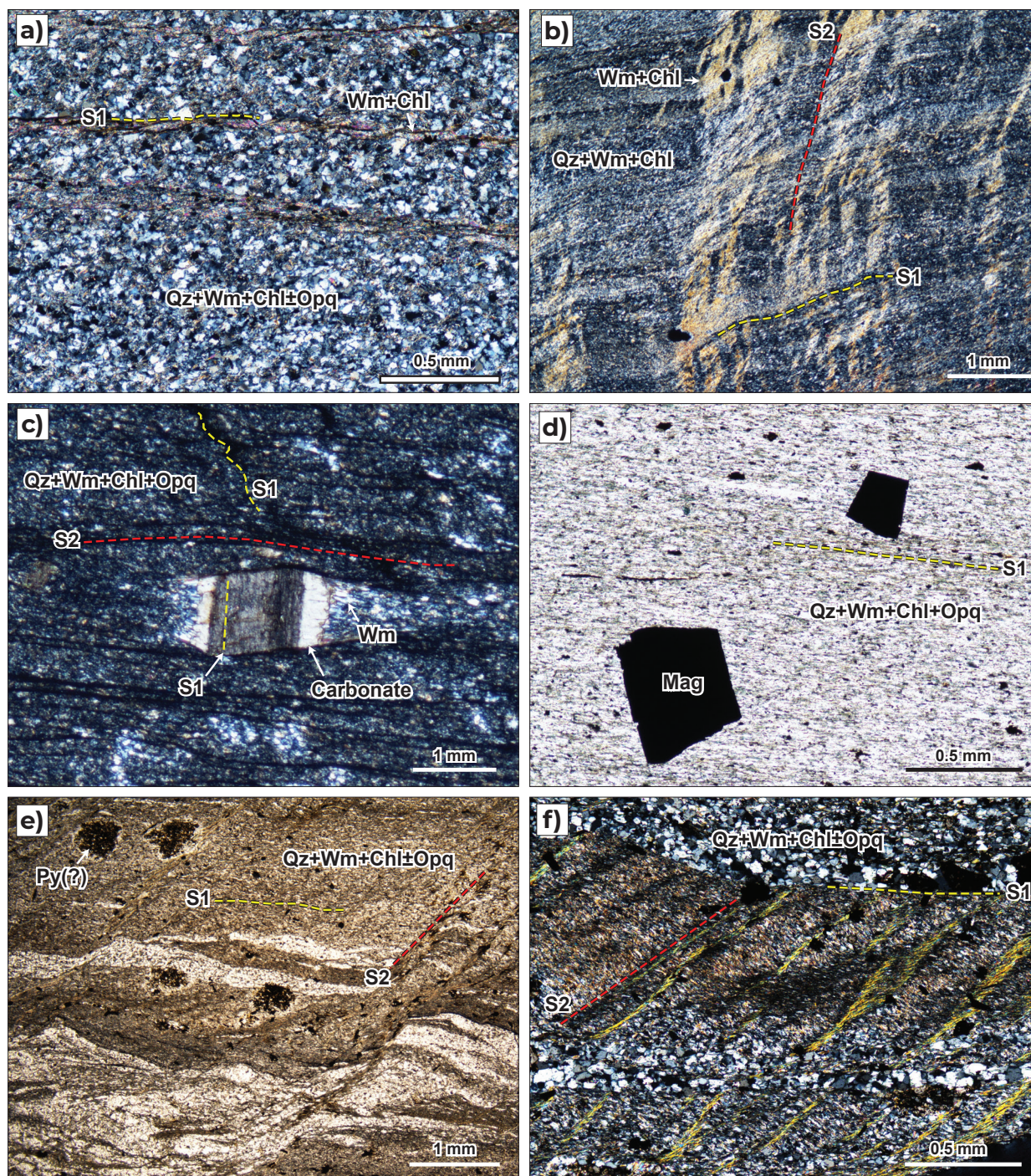


Figure 21. Photomicrographs of the Narchilla Formation. **a)** Quartz-rich siltstone containing white mica + chlorite-rich layers. S1 foliation (yellow dashed line) is defined by compositional layering and aligned white mica and chlorite (XPL; sample 19DS-027-1-1). **b)** White mica + chlorite-rich phyllite with bedding-parallel S1 foliation, and later crenulation cleavage (S2; red dashed line; XPL; sample 19DS-044-1-1). **c)** Phyllite comprised of mostly quartz, white mica, chlorite and opaque mineral (graphite?). A secondary carbonate porphyroblast is aligned parallel to S2 and contains S1-aligned inclusions (XPL; sample 19DS-032-1-1). **d)** Phyllite containing secondary magnetite crystals (PPL; sample 19DS-037-1-1). **e)** Siltstone consisting of alternating quartz-rich and white mica + chlorite-rich layers (beds). S1 foliation, defined by aligned white mica and chlorite, is crosscut by S2 crenulation cleavage (PPL; sample 19DS-061-1-2). **f)** Detail of siltstone in e), showing white mica and chlorite along S2 cleavage planes (XPL). Opq = opaque minerals (undivided). Mag=magnetite.

the Rackla Group may be supported by the presence of the Gametrail Formation in the study area, albeit in the footwall of the Dawson fault. The Blueflower and Algae formations in the Nadaleen River area have been considered stratigraphically equivalent to the Yusezyu Formation in southeastern Yukon, whereby the Algae Formation is equivalent to the limestone member that marks the top of the Yusezyu Formation (Fig. 19; Moynihan 2014, 2016b).

Cambrian Gull Lake Formation ( GL)

The Gull Lake Formation ( GL; Fig. 22) overlies the Narchilla Formation (P Hn, P Hnss) along a sharp contact (Fig. 22a). It consists of thinly, rhythmically interbedded light to dark grey weathering siltstone and dark grey to brown weathering shale (Fig. 22b–d). The fresh surfaces of shale beds are dark grey, and those of siltstone are typically light grey. Shale beds weather recessively relative to the siltstone beds, giving the unit a ridged appearance in outcrops. The

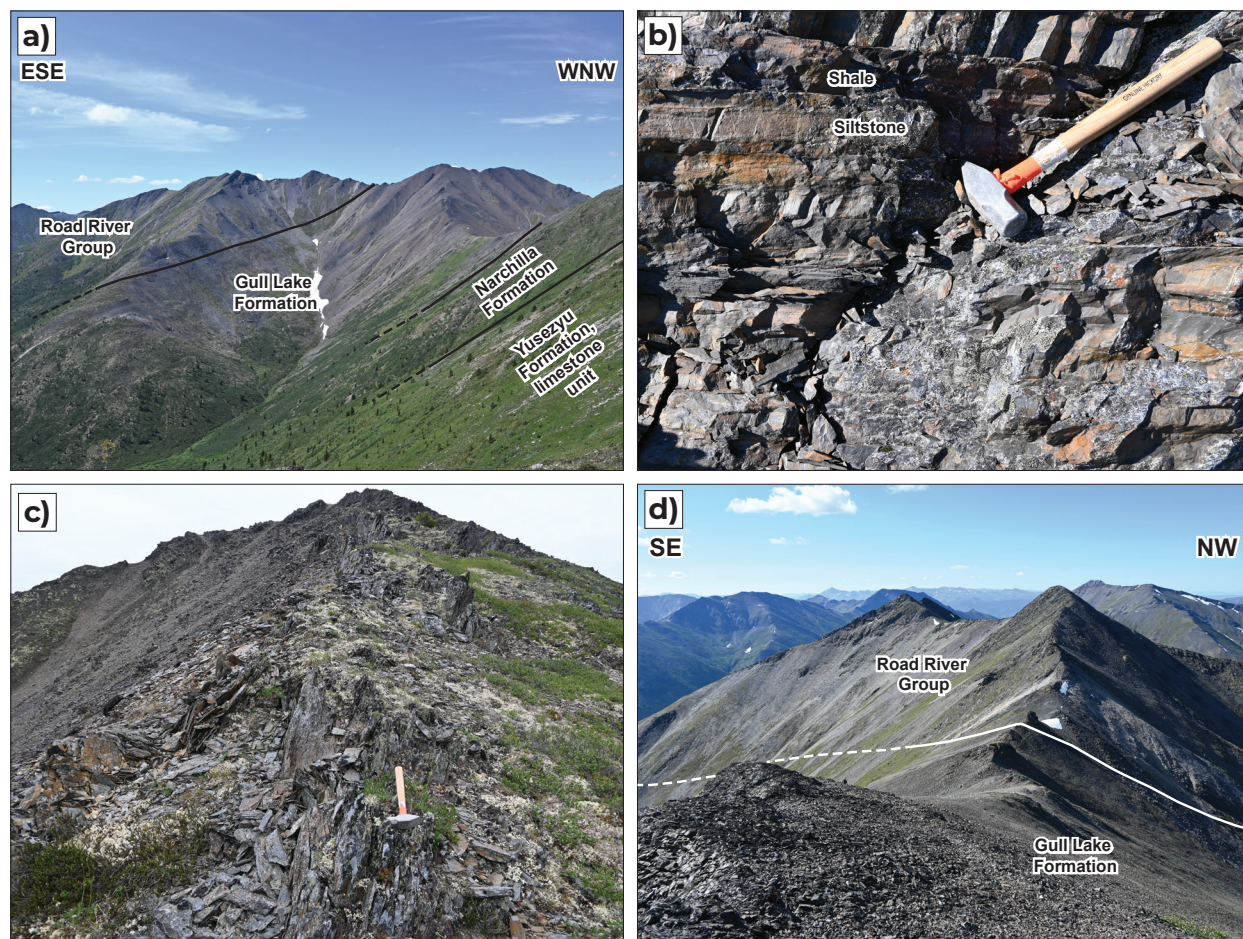


Figure 22. **a)** Chocolate-brown-weathered scree slopes formed by the Gull Lake Formation ( GL), overlain by chert and shale of the Road River Group (OSRC, OSRsh) and underlain by siliciclastic and carbonate rocks of the Narchilla and Yusezyu formations, respectively. Defined and inferred contacts are indicated by solid and dashed black lines, respectively. The horizontal field of view (along the ridgetop in the middle of the photo) is approximately 3 km. **b)** Thin, rhythmic interbeds of dark grey to brown-weathered siltstone and dark grey shale (Gull Lake Formation;  GL). **c)** Outcrop of thinly interbedded siltstone and shale (Gull Lake Formation;  GL). **d)** Chocolate-brown-weathered scree slope formed by the Gull Lake Formation ( GL), overlain by chert and shale of the Road River Group (OSRC, OSRsh). The solid and dashed white lines delineate the defined and inferred contact, respectively. In d), the horizontal field of view (along the contact indicated in the middle of the photo) is approximately 500 m. Hammer for scale in b) and c) is 40 cm long.

unit forms both ridgetops and saddles, but in both cases generally forms scree slopes, which exhibit a distinctive chocolate-brown colour from a distance (Fig. 22a). Siltstone and shale are typically in equal proportions, but the unit is locally siltstone-rich (up to ~70%). Although no trace fossils were observed in the study area, the Gull Lake Formation in the eastern Rackla Belt has a Cambrian depositional age constrained by *Oldhamia* in the upper part of the formation and archaeocyathid-bearing clasts at the base of the formation (Moynihan, 2014).

Upper Cambrian volcanic rocks (Cv, Cvsh)

A sequence of volcanic and volcanoclastic rocks (Cv) crops out in the northeastern part of the map (Fig. 3), overlain by the Road River Group (discussed below) along a sharp contact to the south, and is cut off by the Dawson fault to the north (Figs. 3 and 4; discussed in more detail below). The sequence consists of dark green and dark grey-brown-weathered volcanoclastic rocks and lesser amounts of mafic volcanic rocks (Figs. 23 and 24). These rocks are locally interstratified with silver-weathered shale with a black fresh surface (Cvsh). The volcanoclastic rocks comprise a fine to medium-grained mafic matrix that surrounds subrounded to angular pebble to cobble-sized clasts of mostly mafic to intermediate volcanic rocks (Figs. 23b–e, 24a,b). The matrix of some volcanoclastic rocks has an intermediate composition and weathers reddish-brown with a grey fresh surface (Fig. 23d). The volcanoclastic rocks locally contain chert clasts (Figs. 23e, 24a,b). The volcanic rocks include basalt and mafic volcanic breccia, some of which contain medium to coarse-grained phenocrysts of pyroxene or amphibole, partially replaced by secondary amphibole, chlorite and epidote ($\pm$ oxides; Figs. 23f, 24c,d). Some mafic volcanic rocks contain lath-shaped plagioclase(?) phenocrysts that have been pervasively replaced by sericite and other secondary minerals (Fig. 24e). Locally, mafic volcanic rocks contain amygdules, which are typically up to ~2 mm in size and filled with calcite ($\pm$ chlorite; Figs. 23g, 24f). The volcanic sequence has been pervasively altered by greenschist facies minerals, including calcite, chlorite, sericite, leucoxene and amphibole (Fig. 24).

The volcanic/volcanoclastic rocks mapped here (Cv) are lithologically similar to and located along-strike from those exposed on McKay Hill to the northwest, which are considered part of the Old Cabin Formation (Fig. 2; Cobbett, 2022a, 2022b). They also share similar whole-rock geochemistry (see "Whole-rock geochemistry" section), suggesting that they are part of the same sequence. The volcanic rocks (Cv) are inferred to be Upper Cambrian (Furongian), based on a U-Pb zircon maximum depositional age of ca. 498 Ma from volcanoclastic rocks at McKay Hill (Cobbett et al., 2025).

The southeastern extent of the volcanic/volcanoclastic sequence (Cv, Cvsh) is poorly constrained due to poor outcrop exposure and limited mapping coverage along the southwestern edge of the Beaver River valley in the study area. The volcanic sequence was not identified on previous geological maps of the study area and surrounding region (e.g., Green, 1972a; Abbott, 1990a). The volcanic sequence corresponds to a southeast-trending aeromagnetic high that extends from McKay Hill to the study area and continues southeastward (Fig. 25; Kiss, 2020), suggesting the volcanic rocks may also extend to the southeast.

Ordovician to Silurian Road River Group (OSR, OSRc, OSRsh)

The Road River Group (Figs. 26 and 27) is exposed in two southeast-striking bands across the northeastern part of the map area (Fig. 3), which are separated by a thrust fault. The northernmost band overlies Cambrian volcanic rocks (Cv; Fig. 26a), whereas the band to the south overlies the Hyland Group, and the upper contacts of both intervals of the Road River Group are marked by thrust faults.

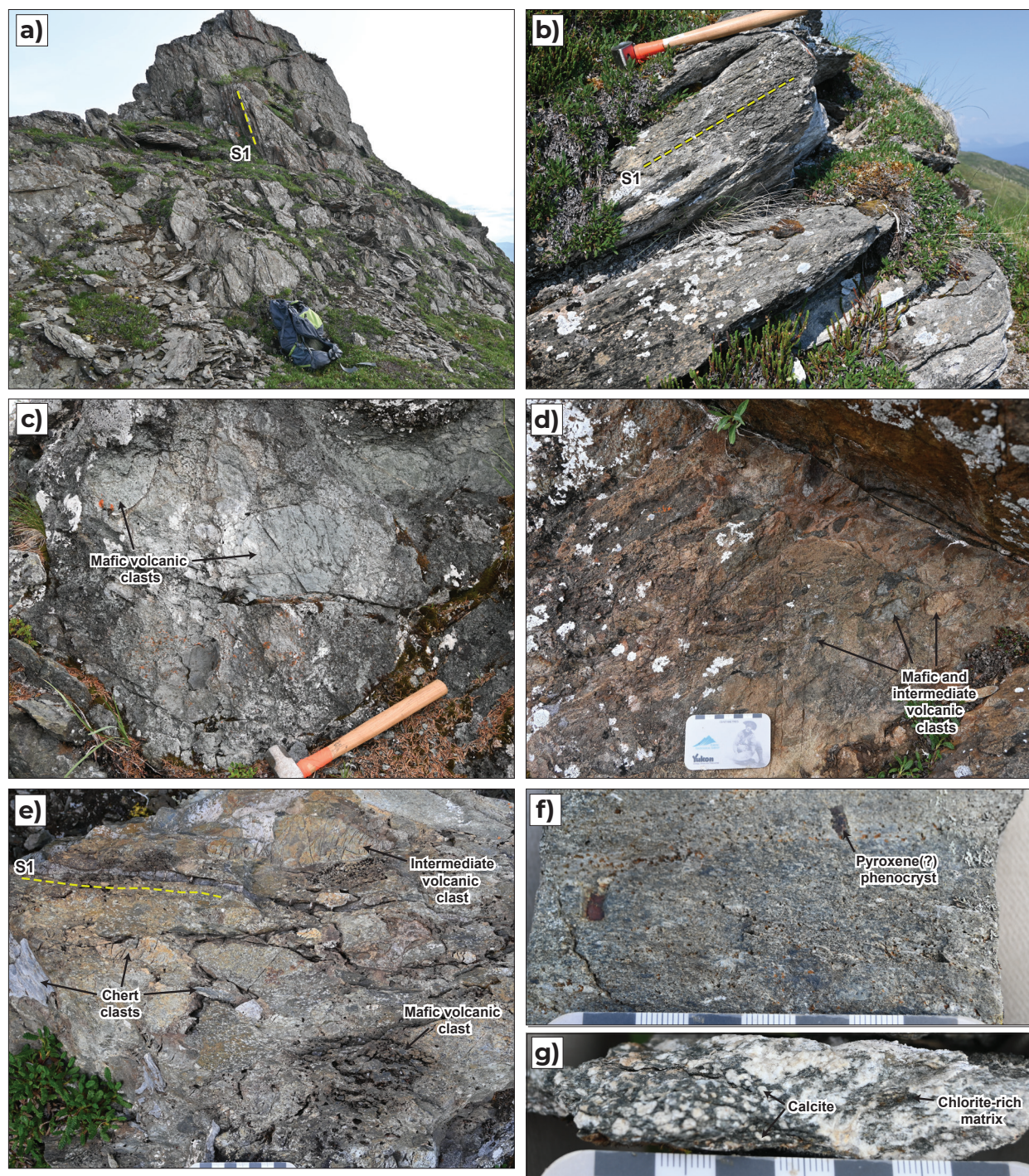


Figure 23. Field photographs of upper Cambrian volcaniclastic and volcanic rocks (Cv). **a)** Outcrop of strongly foliated fine-grained mafic volcanic rocks. Yellow dashed line indicates the trace of the S1 foliation plane. Backpack for scale is approximately 80 cm tall. **b)** Dark green-grey-weathered mafic lapilli tuff breccia, with S1 foliation. **c)** Volcaniclastic rock comprising green-weathered clasts of hornblende-porphyrific mafic volcanic rocks in a green-grey-weathered sandy mafic matrix. **d)** Volcaniclastic rock comprising black, light brown and light grey-weathered mafic and intermediate clasts in a reddish-brown-weathered intermediate matrix. **e)** Mafic tuff breccia, consisting of clasts of mafic to intermediate volcanic rocks and chert within a fine-grained mafic matrix. Clasts are attenuated parallel to S1 foliation. **f)** Detail of fresh surface of fine-grained mafic volcanic rock containing euhedral, brown phenocrysts of an altered mafic mineral (likely pyroxene). **g)** Detail of fresh surface of a mafic volcanic or volcaniclastic rock with pervasive calcite and chlorite alteration. Hammer for scale in b) and c) is 40 cm long.

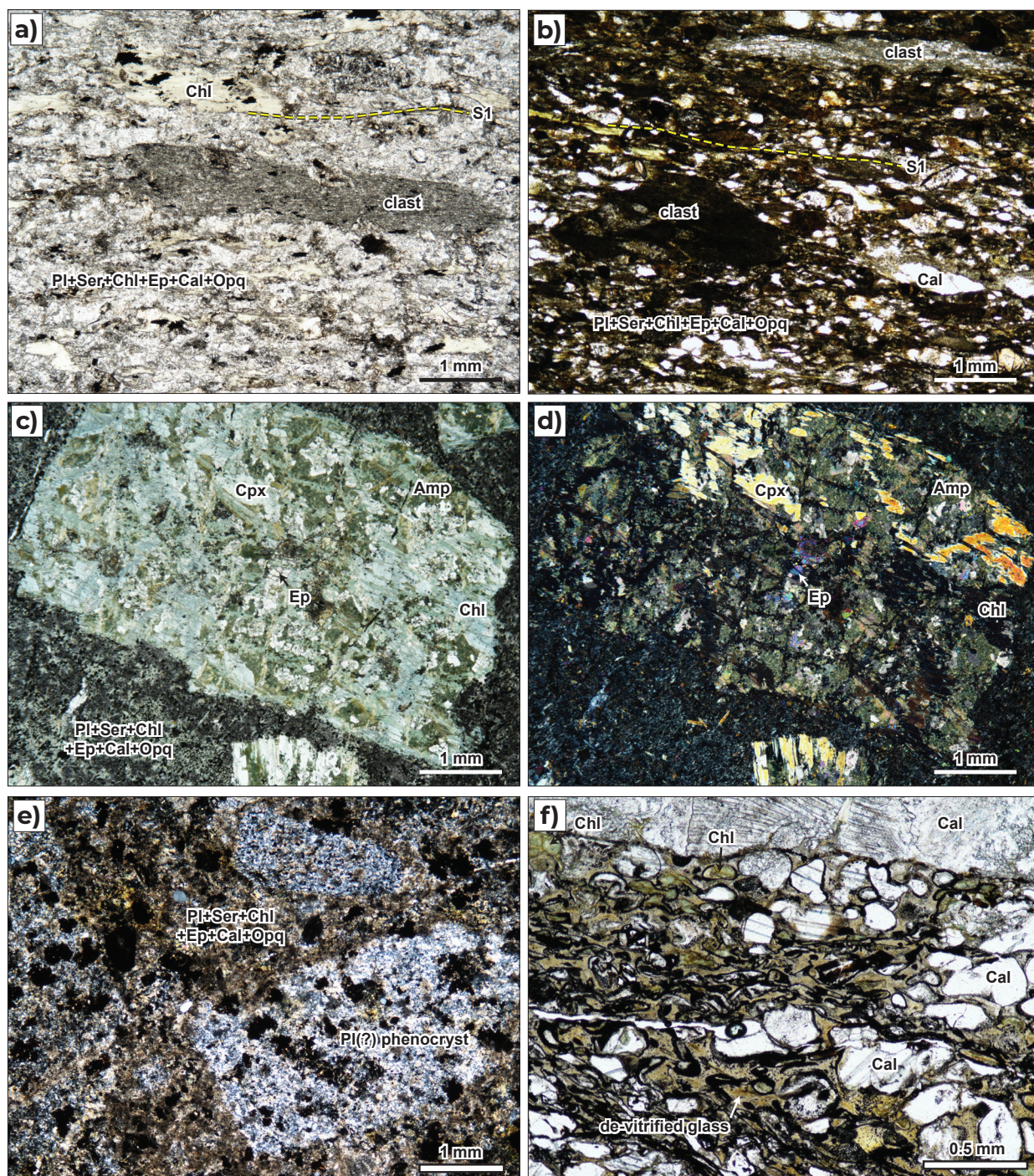


Figure 24. Photomicrographs of upper Cambrian volcaniclastic and volcanic rocks (Cv). Primary minerals and volcanic textures have been partially to fully replaced by secondary minerals (Ser, Chl, Ep, Cal, Amp, leucoxene). **a)** Mafic volcaniclastic rock containing clasts of chert(?) and chlorite aggregates in a fine-grained matrix (PPL; sample 21DS-077-2-1). **b)** Mafic volcaniclastic rock containing clasts of chert(?) (top right) and a mafic volcanic rock(?) (PPL; sample 21DS-089-1-3). In a) and b), the S1 foliation (yellow dashed line) is defined by aligned clasts and matrix minerals. **c)** Mafic volcanic rock containing a clinopyroxene phenocryst that has been mostly replaced by amphibole, chlorite and epidote (PPL; sample 21DS-147-1-1). **d)** XPL image of c). **e)** Mafic volcanic rock containing plagioclase(?) phenocrysts that have been replaced by sericite and other minerals (XPL; sample 21DS-078-1-1). **f)** Mafic volcanic rock comprised of a very fine-grained, green mineral aggregate that is inferred to be de-vitrified volcanic glass, and encloses calcite ± chlorite-filled amygdules. A calcite vein occurs at the top of the photo (PPL; sample 21DS-094-1-1). Ser = sericite; Amp = amphibole.

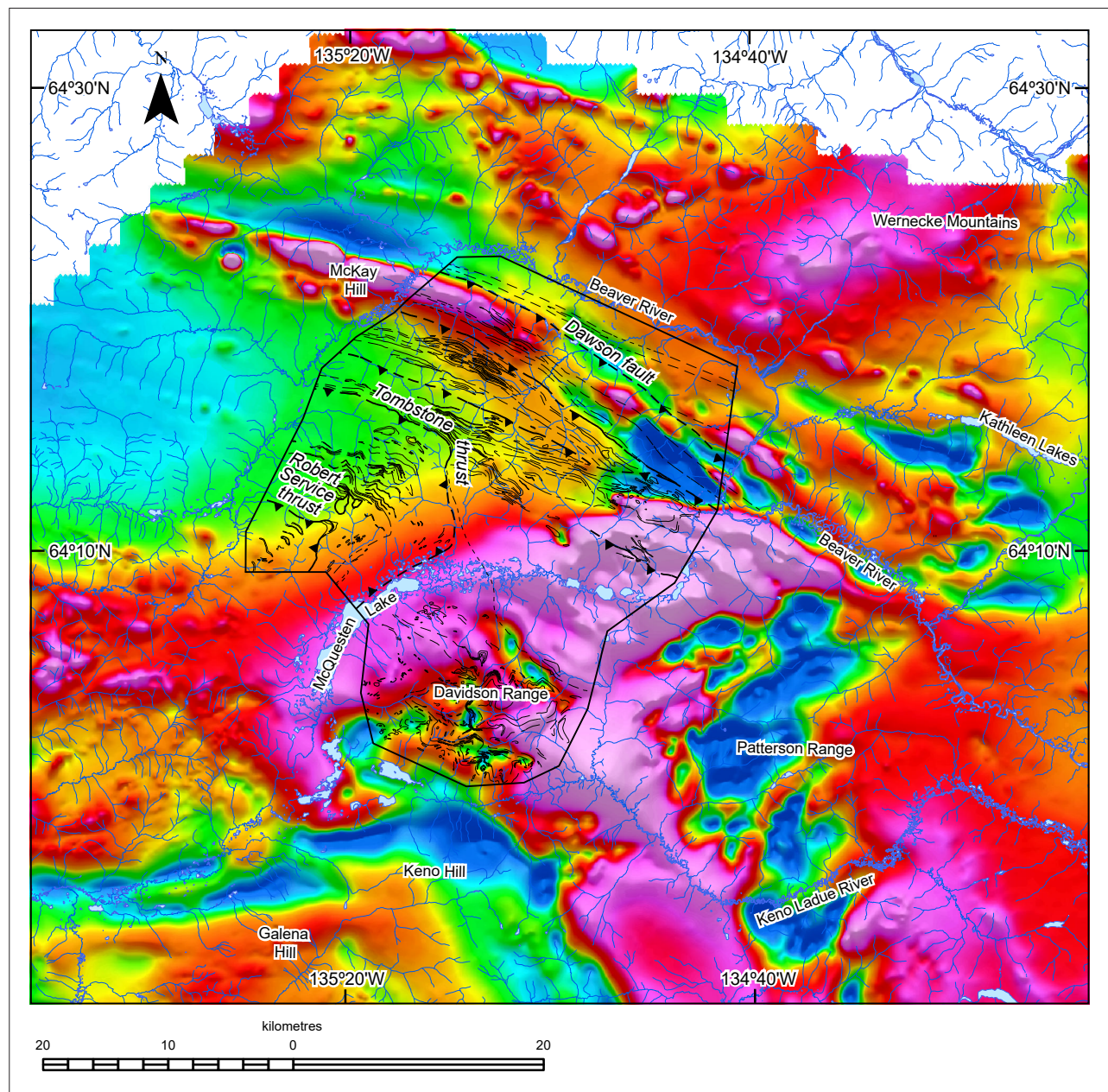


Figure 25. Residual total field aeromagnetic map of the McQuesten Lake study area (outlined in black) and the surrounding region (from Kiss, 2020). In the study area, thrust faults (thick black lines with teeth) and geological contacts (thin black lines) are shown for reference; for details, refer to Figure 3a.

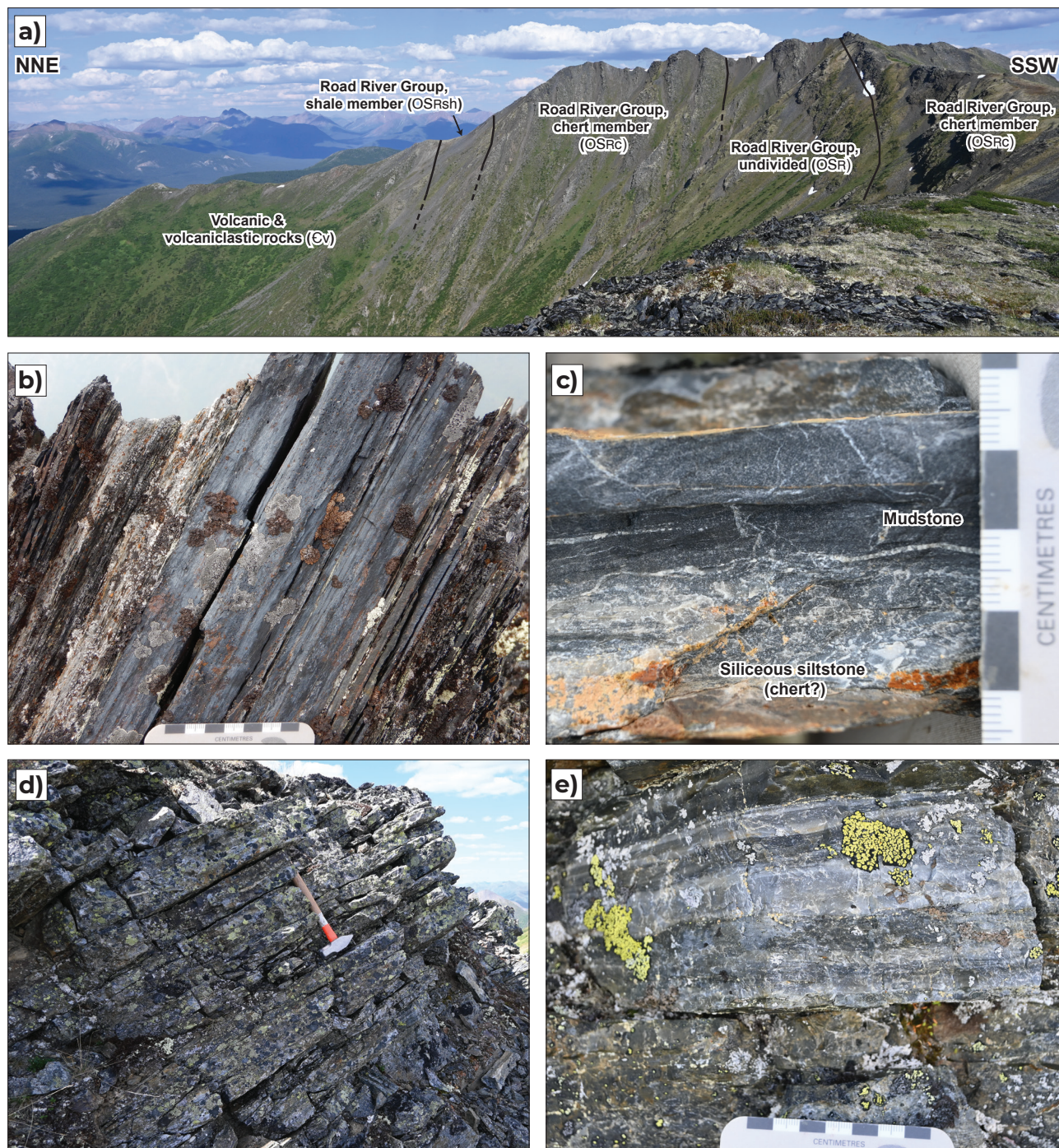


Figure 26. a) Shale, siltstone and chert of the Road River Group (OSR, OSRc, OSRsh) overlying Cambrian volcanic and volcanoclastic rocks (Cv). Solid and dashed black lines delineate defined and inferred geological contacts, respectively. Horizontal field of view (along the ridgetop) is approximately 2 km. (b–e) Field photographs of the Road River Group, including: b) thin bedded to laminated dark grey to light grey mudstone with minor light grey siltstone interbeds (OSR). c) Thinly interbedded black mudstone and light grey siliceous siltstone (or chert?; OSR). d) Thin to medium-bedded, dark grey-weathered chert (OSRc). Hammer for scale is 40 cm long. e) Thin to medium-bedded chert with thin, rhythmic, dark and light grey interbeds (OSRc).

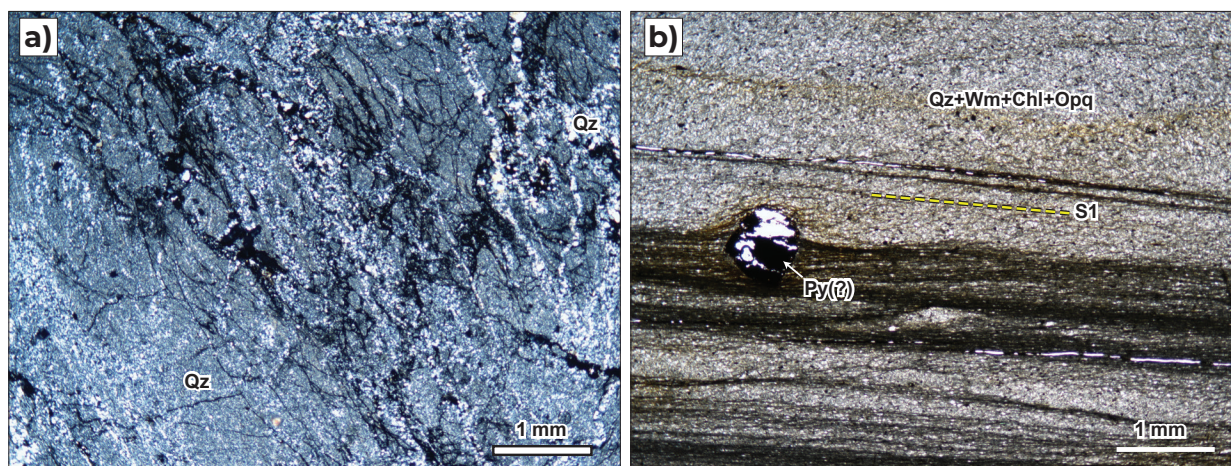


Figure 27. Photomicrographs from the Road River Group (OSR, OSRsh). **a)** Chert with cataclastic texture and quartz veins (XPL; sample 21DS-066-2-1). **b)** Phyllite with light (quartz-rich) and dark-coloured laminations, and a weak S1 foliation (yellow dashed line) defined by aligned chlorite and white mica. The large, dark crystal (left) is inferred to be an altered iron-rich mineral, probably of diagenetic origin (pyrite?; PPL; sample 21DS-077-1-1).

The undivided unit of the Road River Group (OSR) comprises thinly, rhythmically interbedded, grey-weathered mudstone with dark grey to black fresh surfaces, as well as grey siliceous siltstone and chert (Figs. 26b,c; 27a). These rocks locally contain horizons of chert ~250–400 m thick (chert member; OSRc), which is the dominant lithology in southwestern exposures of the Road River Group in the study area. The chert member of the Road River Group consists of thin to medium-bedded chert with rhythmic dark grey and light grey interbeds ~1–3 cm thick (Fig. 26d, e). It generally exhibits a dark grey weathering colour (Fig. 26d) but is locally light grey to white-weathered. In places, the chert member is medium to thick-bedded and the beds are internally massive. The Road River Group (OSR, OSRc) locally contains interstratifications of shale ranging from ~100 to ~1500 m thick (shale member; OSRsh), which include grey-green shale to phyllite (Fig. 27b), dark grey to black shale, and local maroon shale.

The age of the Road River Group is constrained by Lower Ordovician to late Silurian graptolite faunas elsewhere, including in the Nahanni area and Misty Creek embayment in eastern Yukon (Cecile, 1982; Gordey and Anderson, 1993).

Devonian to Mississippian Earn Group (DMesh, DMEc, DMEq, DMeslt)

The Devonian to Mississippian Earn Group (Figs. 28–35) occurs in the southwestern part of the study area. The westernmost part of the Earn Group in the study area has been juxtaposed over Jurassic sandstone (Jss) and fossiliferous limestone of the Pennsylvanian(?) to Permian Tahkandit Formation (PPT) by the Tombstone thrust (these units and the Tombstone thrust are discussed in detail below; Fig. 3). The southernmost exposures of the Earn Group in the study area (in the Davidson Range; Fig. 3) unconformably overlie quartz grit sandstone of the Yusezyu Formation (Hyland Group). The unconformity between the Earn and Hyland groups has also been documented along-strike outside the study area on previous regional maps (e.g., Green, 1971, 1972a).

The Earn Group in the study area is subdivided into four map units based on lithofacies associations. The shale member (DMesh) is the predominant unit in the Earn Group. The shale member mostly consists of dark brownish-grey-weathered, thin-bedded to laminated dark grey shale and graphite or chlorite + white mica-bearing phyllite (Figs. 28a–c, 29). It tends

to form dark brownish-grey-coloured scree slopes (Fig. 28d), subcrops and relatively sparse, broken (slumped) outcrops. The shale member locally contains minor amounts (<10%) of grey-brown siltstone to very fine-grained sandstone interbeds ~1–10 cm thick. A ~1–2 m thick interbed of medium-grained, white-weathered, beige quartz arenite was observed at one locality in the southwestern part of the map area. In contrast with similar shale-dominated sections of the Earn Group in the surrounding region (e.g., Tiger area and Rackla belt; Abbott, 1990a; Colpron et al., 2013), neither chert nor chert-pebble conglomerate interbeds were observed in the shale member in the study area. The shale member has an estimated (deformed) thickness of ~1500 m.

In the southwestern part of the map area, the Earn Group shale member (DMesh) contains two ~350 m thick intervals of rhythmically interbedded dolostone, sandstone, dark grey-green mudstone and minor chert (carbonate member; DMEc). This unit has gradational stratigraphic contacts with the underlying and overlying Earn Group shale member (DMesh). The Earn Group carbonate member is thin to medium-bedded and has a distinctive, orange-and-grey

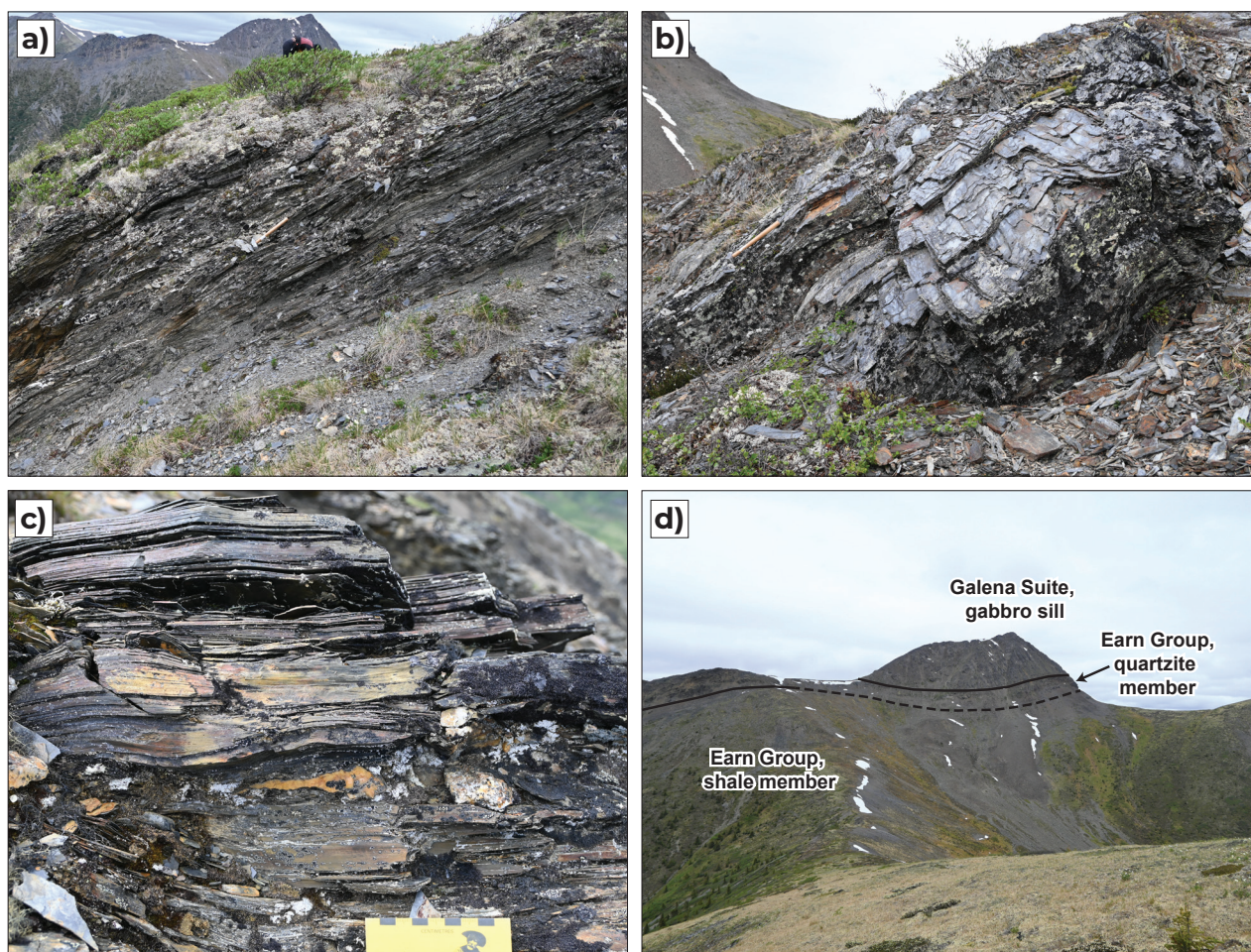


Figure 28. Field photographs of the shale member (DMesh) in the Earn Group. **a)** Outcrop of strongly cleaved, dark brownish-grey-weathered shale. **b)** Outcrop of dark grey-weathered shale, strongly cleaved parallel to bedding planes. Cleavage surface is shiny and greenish-grey-coloured due to very fine-grained chlorite aligned on cleavage planes. Hammer for scale in a) and b) is 40 cm long. **c)** Detail of thinly interbedded, laminated shale. **d)** Dark brownish-grey-coloured scree slope formed by the Earn Group shale member, overlain by the Earn Group quartzite member (DMEq) and a gabbro sill of the Galena Suite. Field of view is ~1 km across, and the gabbro sill has a vertical thickness of ~80 m.

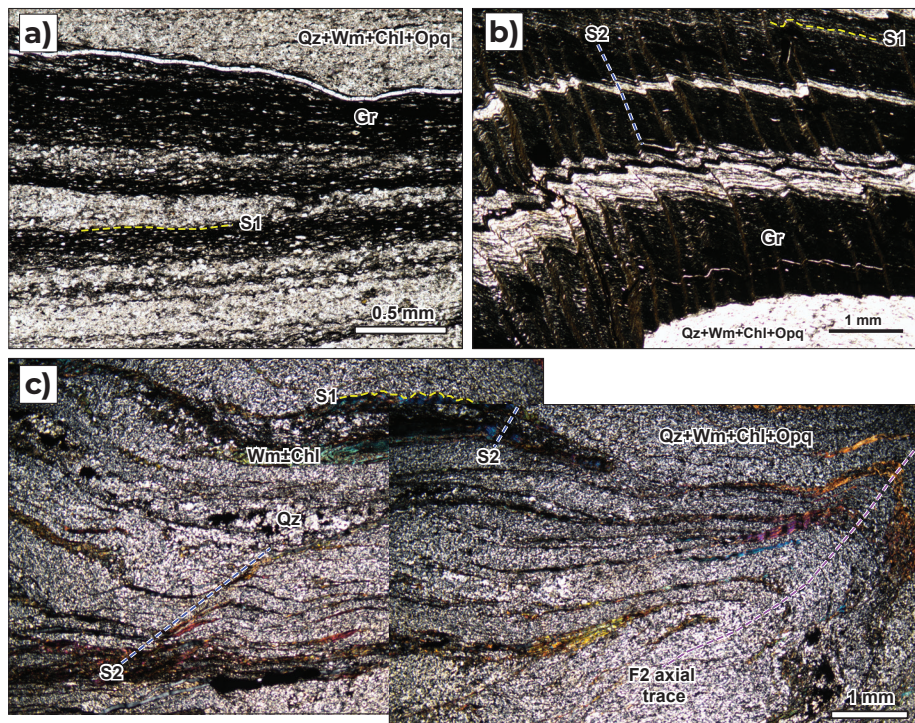


Figure 29. Photomicrographs of the shale member (DMEsh) in the Earn Group. **a)** Shale with graphitic laminations and a bedding-parallel foliation (S1), delineated by the yellow dashed line (PPL; sample 21DS-010-1-1). **b)** Graphitic phyllite with tightly spaced crenulation cleavage (S2; blue dashed line; PPL; sample 22DS-013-1-1). **c)** Chlorite + white mica-bearing phyllite with S2 crenulation cleavage oriented axial planar to F2 fold (axial trace of F2 fold indicated by purple dashed line; XPL; sample 21DS-165-1-2). Gr = graphite.

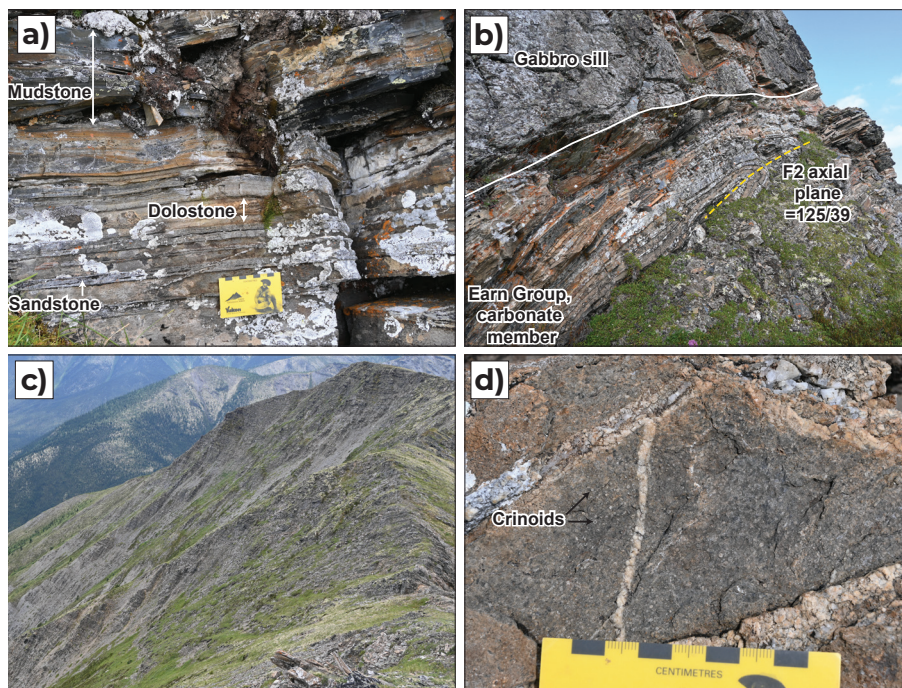


Figure 30. Field photographs of the carbonate member (DMEc) in the Earn Group. **a)** Thinly interbedded mudstone, dolostone and very fine-grained sandstone. **b)** Isoclinally folded (F2; trace of axial plane indicated by yellow dashed line), thin interbedded dolostone, sandstone (± chert) and mudstone of the Earn Group carbonate member (DMEc), hosting a gabbro sill (Galena Suite). Hammer for scale is 40 cm long. **c)** Cliff exposures of the Earn Group carbonate member exhibiting the orange and white striped appearance that is characteristic of the unit. Horizontal field of view is ~600 m. **d)** Crinoids in a dolostone bed.

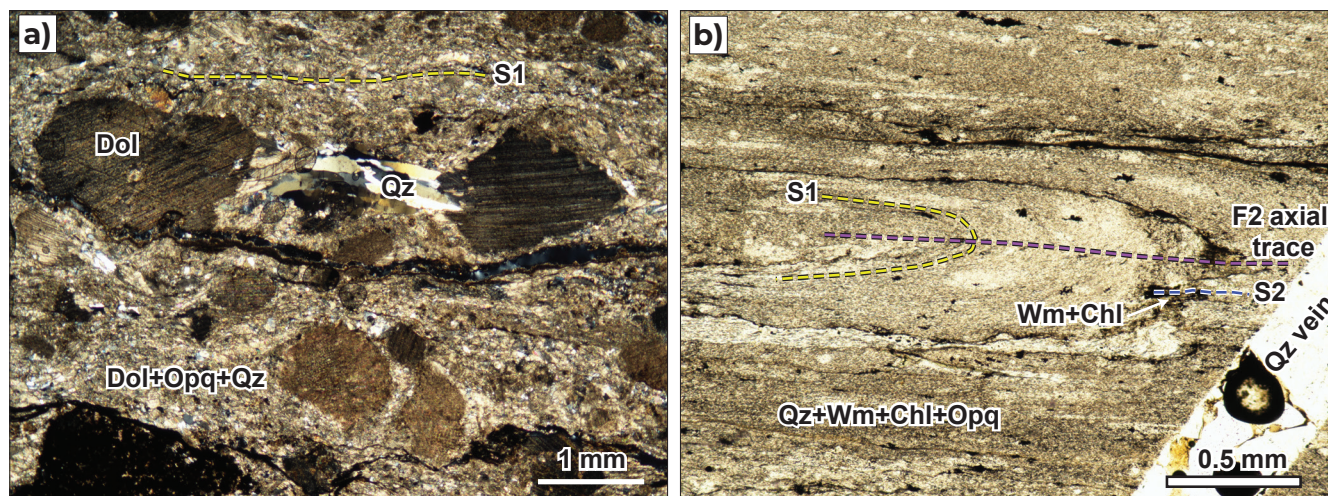


Figure 31. Photomicrographs of the carbonate member (DMEc) in the Earn Group. **a)** Dolomite that consists of medium-grained dolomite crystals/grains in a fine-grained matrix of dolomite, quartz and opaque minerals. A strong S1 foliation (yellow dashed line) is defined by attenuated dolomite crystals with quartz infill, and by aligned matrix minerals (XPL; sample 21DS-155-2-1). **b)** Very fine-grained, quartz-rich sandstone. The S1 foliation is defined by aligned white mica and chlorite, and is folded by an F2 fold (trace of axial plane is delineated by the purple dashed line). A weak, discontinuous S2 foliation (blue dashed line) is developed in the F2 fold hinge, defined by aligned white mica and chlorite (PPL; sample 21DS-158-3-1).

striped appearance (Fig. 30a–c). Dolomite beds are orange-weathered, have a grey fresh surface with a fine to medium-grained crystalline texture (Figs. 30a,b, 31a), and locally contain crinoids (Fig. 30d). Sandstone beds are very fine-grained, and white-weathered with a grey fresh surface (Figs. 30a, 31b). Structural relationships (discussed below in the "Deformation" section) suggest that the Earn Group in the southwestern part of the map area (in the hanging wall of the Tombstone thrust) has been isoclinally folded about a southwest-dipping axial surface, which is supported by outcrop and micro-scale folds (Figs. 30b, 31b). As such, the two intervals of the carbonate member are interpreted to be on separate fold limbs (as shown by cross-section A–A' in Figure 3). Thus, the carbonate member has an estimated (deformed) thickness of ~350 m.

In the Davidson Range, which lies in the southern part of the map area (in the footwall of the Tombstone thrust; Fig. 3), the stratigraphically highest part of the Earn Group mostly consists of light to medium-grey-coloured, thin-bedded siltstone with dark grey laminations and minor dark grey shale (siltstone member; DMEslt; Figs. 32 and 33). In places, the siltstone member includes fine-grained sandstone (Figs. 32d, 33e), which is quartz-rich and locally has cross-beds that are up to 1.5 cm thick. The siltstone member has a gradational contact with the shale member (DMesh) and sharp contacts with the Earn Group quartzite (DMEq; described below) and Keno Hill Quartzite (CTKHQ, described below). The siltstone member has an estimated (deformed) thickness of ~150–200 m, ranging up to ~600 m.

The Earn Group locally contains intervals of quartzite (quartzite member; DMEq) with (deformed) thicknesses of ~40–60 m. The quartzite member has sharp contacts with underlying and overlying strata, which include the shale member (DMesh; e.g., Fig. 28d) and the siltstone member (DMEslt). The quartzite member consists of medium grey to brown-weathered, fine to medium-grained, equigranular, thin to medium-bedded quartz arenite with a crystalline texture (Fig. 34). The quartzite tends to have a dark grey fresh surface. It is generally graphitic and contains secondary chlorite and white mica (Fig. 35a,b). In the eastern part of the Davidson Range, it locally contains biotite (Fig. 35c,d).

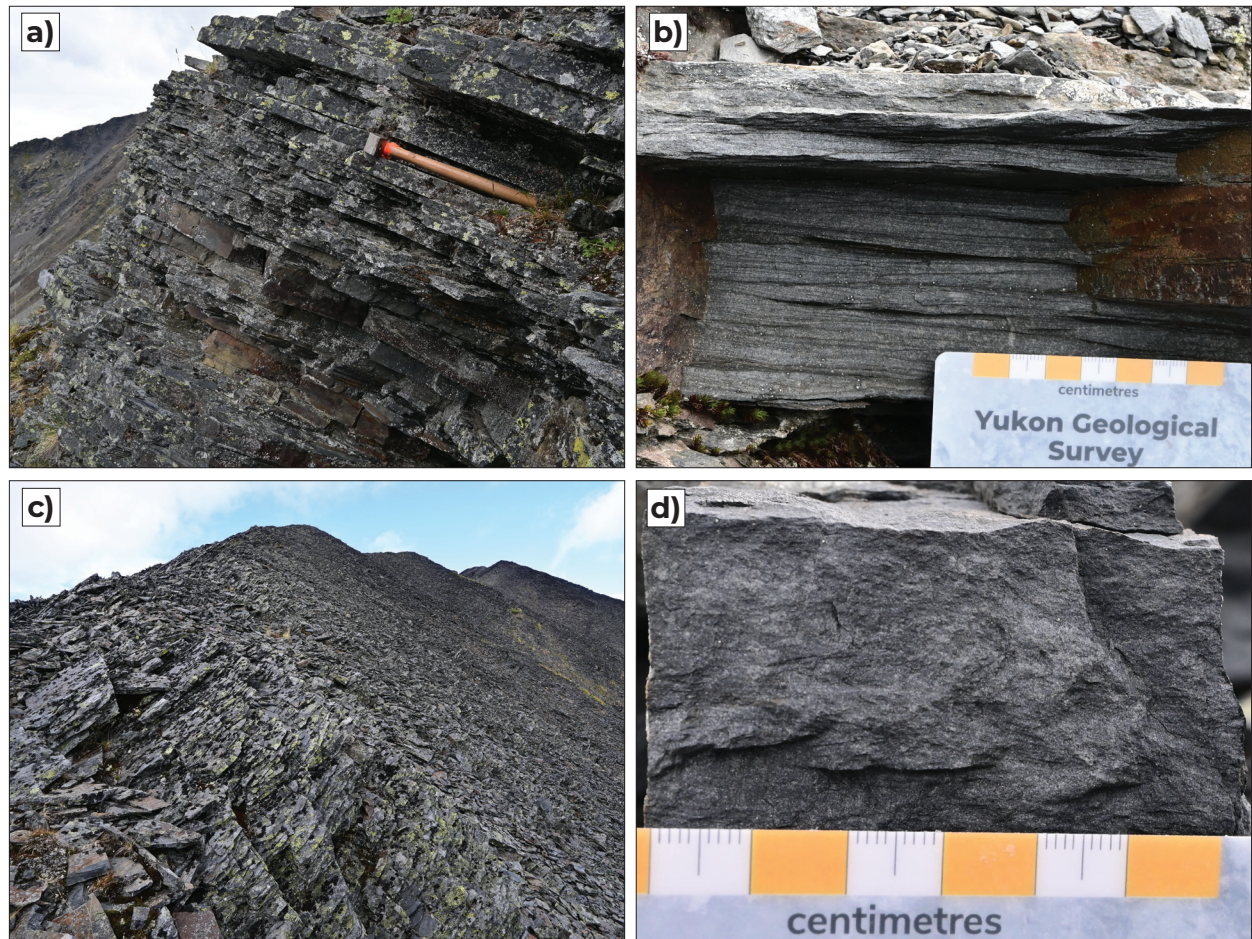


Figure 32. Field photographs of the siltstone member (DMEslt) in the Earn Group. **a)** Outcrop of thin-bedded, grey-weathered siltstone. Hammer for scale is 40 cm long. **b)** Detail of light grey coloured fresh surface of thin-bedded siltstone with dark grey laminations. **c)** Rubbly outcrop and scree slope formed by siltstone and minor shale in the Earn Group siltstone member. Horizontal field of view in foreground (bottom of photo) is approximately 3 m. **d)** Detail of fresh surface of grey coloured, fine-grained sandstone bed in the Earn Group siltstone member.

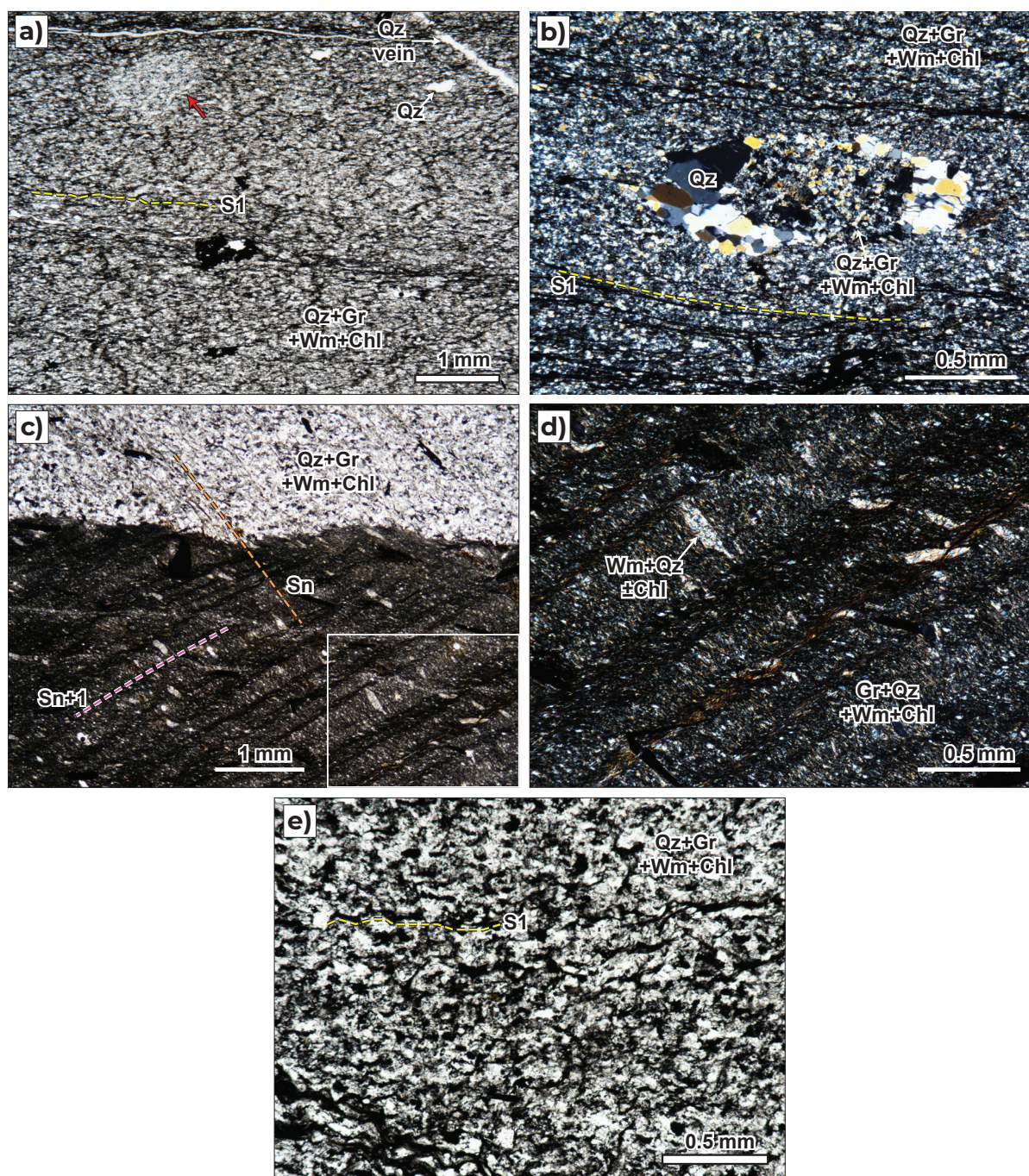


Figure 33. Photomicrographs of the siltstone member (DMEslt) in the Devonian to Mississippian Earn Group. All samples shown in the photomicrographs consist of mainly quartz, opaque minerals (including graphite), white mica and chlorite. **a)** Siltstone containing a ~1 mm-sized, S1-aligned quartz-rich aggregate (red arrow) that may be a lithic clast or, alternatively, a pseudomorph of a pre-existing mineral (PPL; sample 22DS-006-1-1). The S1 foliation is delineated by the yellow dashed line. **b)** A fine-grained, quartz-rich aggregate (clast, or pseudomorph?) surrounded by secondary quartz, aligned parallel to S1 foliation. In hand sample, these mineral aggregates are white and plate-shaped, giving the siltstone a spotted appearance (XPL; sample 22DS-006-1-1). **c)** Siltstone comprised of alternating quartz-rich and graphite-rich beds. An early foliation defined by aligned white mica and chlorite (Sn; orange dashed line) is crosscut by a later crenulation cleavage (Sn+1; pink dashed line; PPL; sample 22DS-008-1-1). White rectangle indicates the area shown in XPL image in d). Aggregates of quartz and white mica (± chlorite) in d) are aligned parallel to S1 and may be pseudomorphing a pre-existing mineral. **e)** Fine-grained sandstone containing abundant opaque material, including graphite (PPL; sample 22DS-003-1-1).

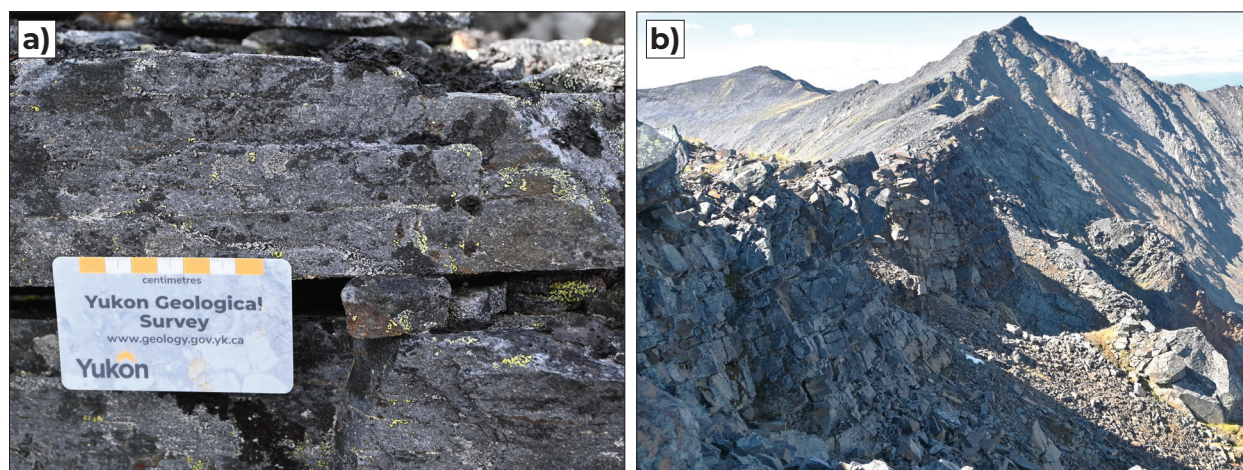


Figure 34. Field photographs of the quartzite member (DMEq) of the Earn Group. **a)** Detailed view and **b)** outcrop of thin to medium-bedded, grey-weathered quartz arenite (quartzite). In the foreground in **b)**, the outcrop of quartzite is ~2.5 m tall.

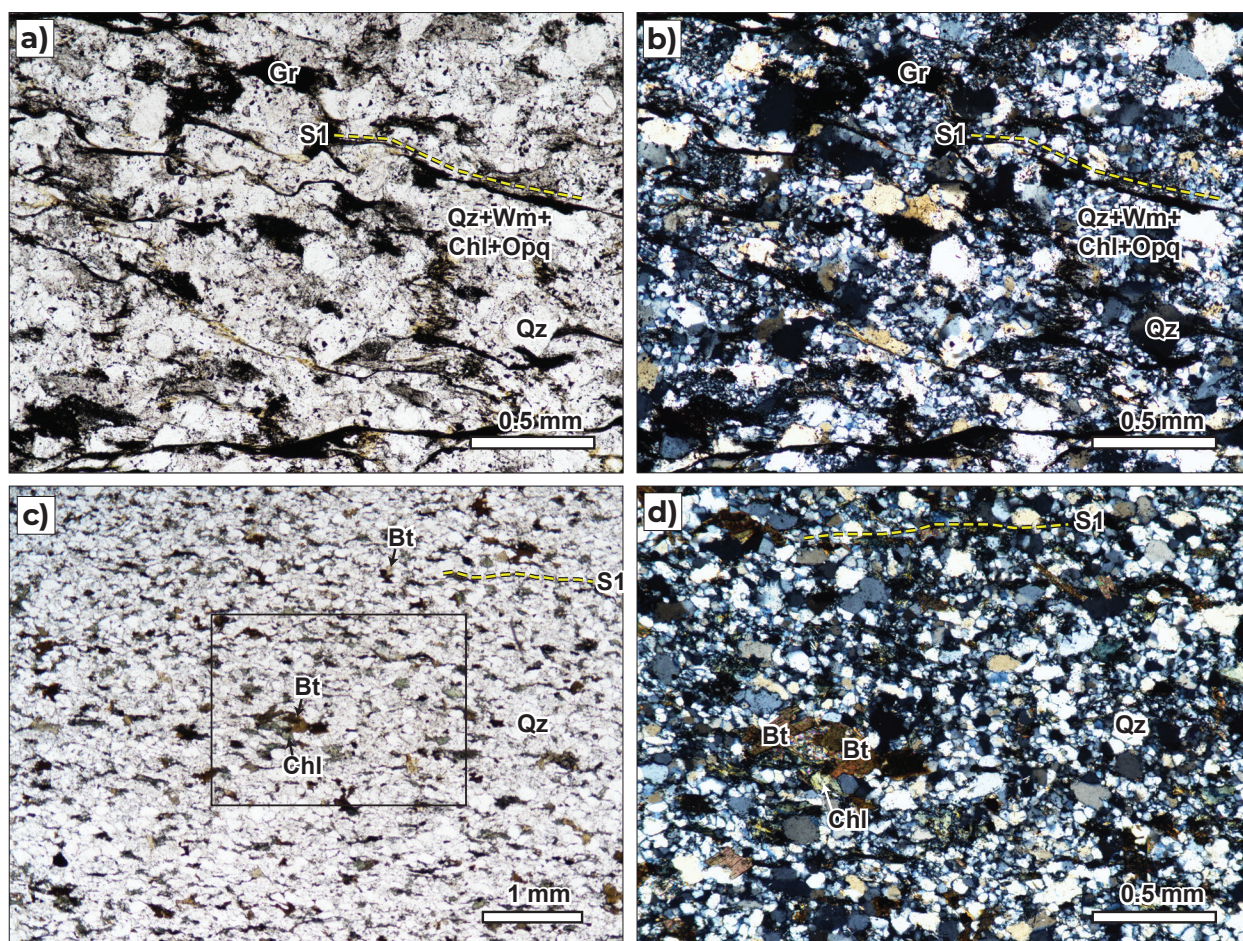


Figure 35. Photomicrographs of the quartzite member (DMEq) of the Earn Group. **a)** Fine to medium-grained quartzite containing graphite, chlorite, and white mica (PPL; sample 22DS-043-1-1). **b)** An XPL image of **a)**. **c)** Fine to medium-grained quartzite containing biotite and chlorite (PPL; 22DS-011-2-1). **d)** XPL image of the area within the black rectangle shown in **c)**. The S1 foliation is delineated by the yellow dashed line. Bt = biotite.

The Earn Group hosts numerous Triassic gabbro sills (Galena Suite; discussed below), which provide a minimum age limit on the Earn Group in the McQuesten Lake area. In the surrounding region, the age of the Earn Group has been constrained by Lower to Upper Devonian and Lower Mississippian fossil collections (Campbell, 1967; Gordey and Anderson, 1993; Gordey, 2013, Cobbett et al., 2021) and by Upper Devonian U-Pb zircon dates from sandstone and tuff (Cobbett et al., 2021).

Carboniferous Tsichu Group: Keno Hill Quartzite (CTKHQ, CTKHQs)

The Carboniferous Keno Hill Quartzite (CTKHQ; Figs. 36 and 37) occurs in the hanging wall and footwall of the Tombstone thrust in the map area (Fig. 3), exhibiting a sharp contact with the underlying Earn Group. It is comprised of medium to thick-bedded, medium-grained quartz arenite with a light to dark grey weathered surface (Fig. 36a,b). Beds are typically internally massive but exhibit fine laminations in places (Fig. 36b). The quartzite has a light to medium-grey fresh surface and locally contains minor (<5%) clasts of dark grey fine-grained mudstone (Fig. 36c). The quartzite has a crystalline texture that appears equigranular in hand sample (Fig. 36c) but is in fact typically comprised of fine to medium-sized quartz clasts within a very fine-grained quartz-rich matrix (Fig. 37). The Keno Hill Quartzite forms prominent ridges and talus piles (Fig. 36a,e), with a distinctive, steel-grey weathering colour from a distance (Fig. 36e).

In a few places in the hanging wall of the Tombstone thrust in the map area, and very rarely in the footwall, the Keno Hill Quartzite includes intervals (≤ 3 m thick) of orange-weathered, medium-bedded, medium-grained quartz-rich sandstone with dolomite cement (Fig. 36d). Dark grey shale (CTKHQs) forms ~30–70 m thick intervals that are interstratified with the quartzite in the hanging wall of the Tombstone thrust (Fig. 36e). The shale is locally green-weathered and rich in chlorite $\pm$ white mica (phyllitic). In this area, the Keno Hill Quartzite and shale interstratifications have a combined (deformed) thickness of ~600 m.

In the footwall of the Tombstone thrust (i.e., in the Davidson Range; Fig. 3), the Keno Hill Quartzite has several characteristics that are different from its occurrence in the hanging wall. For instance, the Keno Hill Quartzite in the footwall contains more graphite (Fig. 37c–f) and thin (~1–20 cm, locally up to 1 m thick) interbeds of dark grey graphitic phyllite. Also, several quartzite beds within the lowermost ~40 m of the unit (overlying the Earn Group) contain abundant white-coloured, angular to subrounded quartz clasts (Fig. 37e,f). These beds may be equivalent to the ‘crush breccias’ described at this location by Green (1971). Whereas the Keno Hill Quartzite in the hanging wall of the Tombstone thrust is nearly uniformly medium to thick-bedded, the bed thicknesses in the footwall are more variable, typically ranging from ~3–20 cm, and are up to ~1 m thick in places. In the footwall, the Keno Hill Quartzite has an estimated (deformed) thickness of ~500–1000 m.

Detrital zircon U-Pb geochronology conducted on a sample of quartzite from the Keno Hill Quartzite (sample 22DS-019-1-1; Fig. 3a) produced a maximum depositional age of 367.79 ± 0.25 Ma (presented below in the “U-Pb zircon geochronology” section). Regionally, the depositional age of the Keno Hill Quartzite is constrained by a middle Mississippian to lower Pennsylvanian (late Viséan to Bashkirian) conodont collection from the Ogilvie Mountains (~145 km west of the study area; GSC collection C-101675; Thompson et al., 1994). Three collections west of Steamboat Mountain (~20 km west of the study area) also yielded middle Mississippian to lower Pennsylvanian conodonts (late Viséan to Bashkirian; GSC collections C-103021, C103032, C103033; Orchard, 1992) but were not assigned to a specific stratigraphic unit. The area was mapped in part as Keno Hill Quartzite and shale of the Earn Group (Fig. 2; Green and Roddick, 1972) but these conodont collections suggest more extensive exposure of Keno Hill Quartzite in this region.

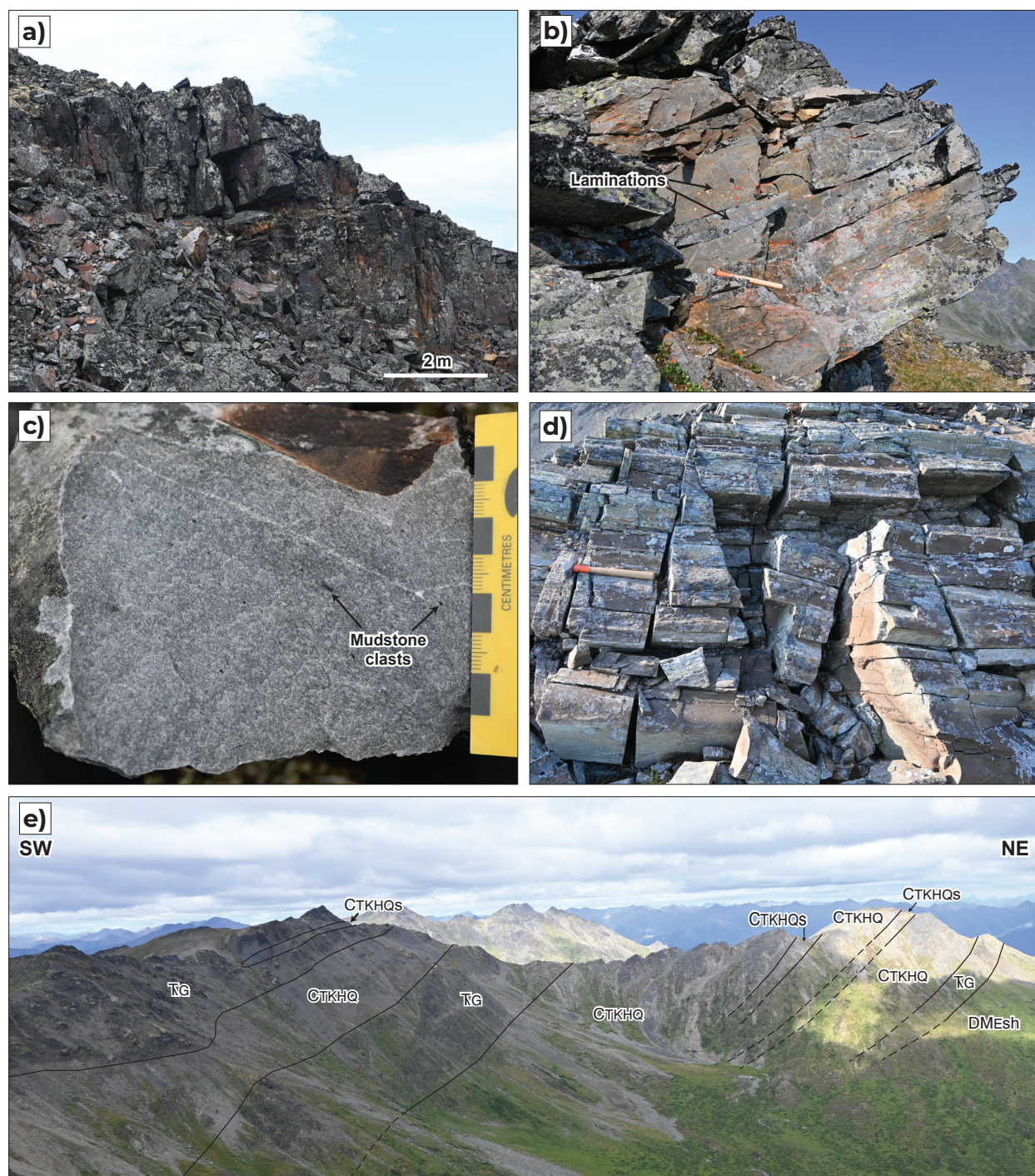


Figure 36. Field photographs of the Keno Hill Quartzite (CTKHQ). **a)** Typical field habit of Keno Hill Quartzite, comprising an outcrop of dark grey-weathered, medium to thick-bedded quartzite surrounded by blocks of quartzite talus. **b)** Outcrop of medium to thick-bedded, brownish-grey-weathered quartzite, with laminations visible on weathered surface. **c)** Light grey fresh surface of quartzite, with mm-sized, angular clasts of fine-grained, dark grey-to-black mudstone. **d)** Orange-weathered beds of quartz arenite with dolomite cement, forming a ~3 m-thick interval in quartzite. Hammer for scale in **b)** and **d)** is 40 cm long. **e)** Ridge exposure of southwest-dipping Keno Hill Quartzite (CTKHQ) hosting gabbro sills (Galena Suite; TG) and interstratifications of shale/phyllite (CTKHQS), underlain by the Earn Group shale member (DMesh). Horizontal field of view is ~2 km. Black solid and dashed lines indicate defined and inferred contacts, respectively.

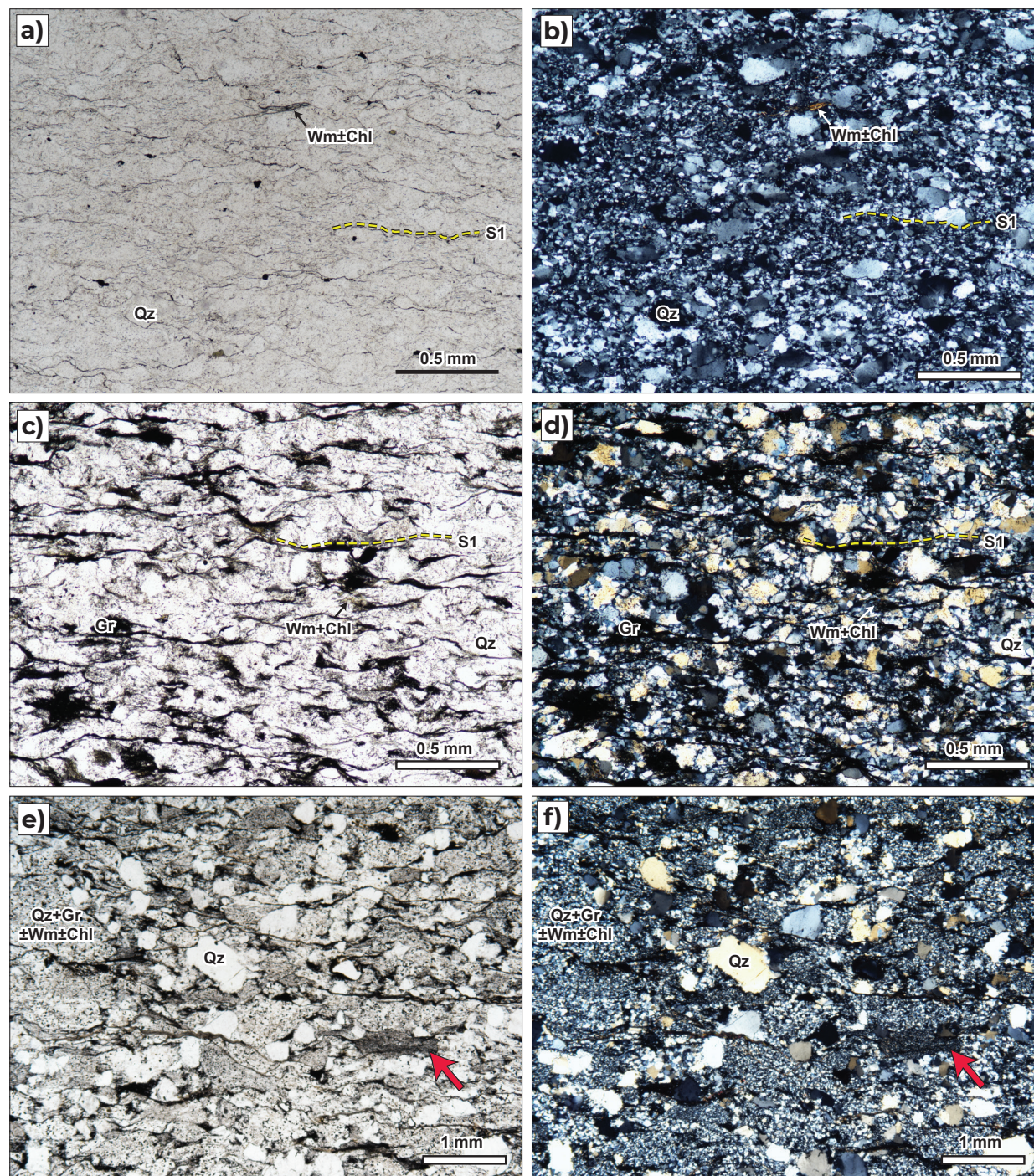


Figure 37. Photomicrographs of the Keno Hill Quartzite (CTKHQ). All samples displayed in the photomicrographs consist of mainly quartz, opaque minerals (including graphite), white mica and chlorite. The S1 foliation is delineated by the yellow dashed line. **a)** Quartzite from the southwestern side of the map area (PPL; sample 21DS-177-1-1). **b)** An XPL image of a). **c)** Graphite-rich quartzite from the Davidson Range (PPL; sample 22DS-027-1-1). **d)** An XPL image of c). **e)** Quartzite from near the base of the Keno Hill Quartzite in the Davidson Range, containing angular to subrounded quartz clasts within a fine-grained quartz-rich matrix. A possible lithic clast is indicated by the red arrow (PPL; sample 22DS-019-1-1). **f)** An XPL image of e).

Pennsylvanian(?) to Permian Tahkandit Formation (PPT)

The Pennsylvanian(?) to Permian Tahkandit Formation (PPT; Figs. 38 and 39; Tempelman-Kluit, 1970; Norris, 1997) forms several outcrops of fossiliferous limestone in the west-central part of the map area, where it overlies sandstone, siltstone and shale ('mixed' unit; PHYM) of the Yusezyu Formation (Hyland Group) in the footwall of the Tombstone thrust (Figs. 3, 38a). This relationship suggests that stratigraphically higher levels of the Hyland Group (Yusezyu Formation limestone unit, Narchilla Formation) may have been eroded at this location prior to deposition of the Tahkandit Formation (refer to cross-section A–A' in Figure 3c). Although the contacts of the Tahkandit Formation limestone are covered by grass and scree, bedding orientations are concordant with those in underlying strata of the Hyland Group, suggesting a disconformity.

The Pennsylvanian(?) to Permian Tahkandit Formation in the map area consists of fine-grained, medium-bedded grey limestone (Figs. 38b–d, 39a–c), and is distinguished from the Yusezyu Formation limestone unit (PHYul) primarily on the presence of fossils (Fig. 38b,c), although macrofossils are not abundant and are generally poorly preserved. Part of this limestone was first mapped in the 1960s and interpreted as Permian based on fossil identifications, although it was noted that the fossils "are poorly preserved and the identifications are uncertain" (Green, 1971). Fossils from this limestone are discussed in detail in Appendix A, and pertinent highlights are as follows: brachiopods suggest a Pennsylvanian age; conodonts in one sample were identified as Asselian to Sakmarian (early Permian), and in a second sample as Permian to Triassic or possibly early to middle Permian. Altogether, the fossil identifications suggest that the limestone is Pennsylvanian(?) to Permian.

Unlike the limestone in the Yusezyu Formation (PHYul), the fossiliferous limestone (PPT) generally has a strong fetid odour and, in places, it contains black chert nodules (Fig. 38b), chert interbeds, and/or white-weathered bedding-parallel bands of diagenetic silica. The limestone locally contains pebble-conglomerate interbeds that are each up to ~0.5 m thick and comprise a fine-grained grey limestone matrix surrounding clasts of quartz crystals, dark grey chert, and fine or medium-grained quartz arenite (Figs. 38e, 39d,e).

The Tahkandit Formation also occurs ~165 km to the west of the McQuesten Lake study area, in the Ogilvie Mountains, where it underlies Jurassic strata (the 'Lower Schist') in the footwall of the Tombstone thrust (Tempelman-Kluit, 1970; Thompson et al., 1994).

Jurassic siliciclastic rocks (Jss, Jsh)

The Tahkandit Formation limestone (PPT) is overlain by a package of siliciclastic rocks comprising sandstone and lesser shale (Fig. 40), with a total estimated (deformed) thickness of ~700 m. The sandstone (Jss) consists of fine to medium-grained, medium-bedded, grey-brown weathered quartz arenite and has a grey-brown fresh surface with a shiny, sugary texture (Figs. 40b,c, 41). The sandstone contains ~10–50 m thick interstratifications of dark grey-brown-weathered shale (Jsh; Fig. 40a,d), which locally contains thin interbeds of dark grey-brown siltstone. The shale also occurs at the base of the siliciclastic package, overlying the Tahkandit Formation limestone.

The maximum depositional age of the sandstone (Jss) is Middle Jurassic (166.85 ± 0.13 Ma; Bathonian) based on detrital U–Pb zircon geochronology (sample 21DS-134-1-1; presented below in the "Uranium-lead (U–Pb) zircon geochronology" section). Jurassic siliciclastic rocks also occur in the footwall of the Tombstone thrust in the Ogilvie Mountains, ~100–170 km west of the study area, where they contain fossils that range in age from Middle Jurassic to early Upper Jurassic (Bathonian to Oxfordian; the 'Lower Schist' of Tempelman-Kluit, 1970; Poulton and Tempelman-Kluit, 1982).

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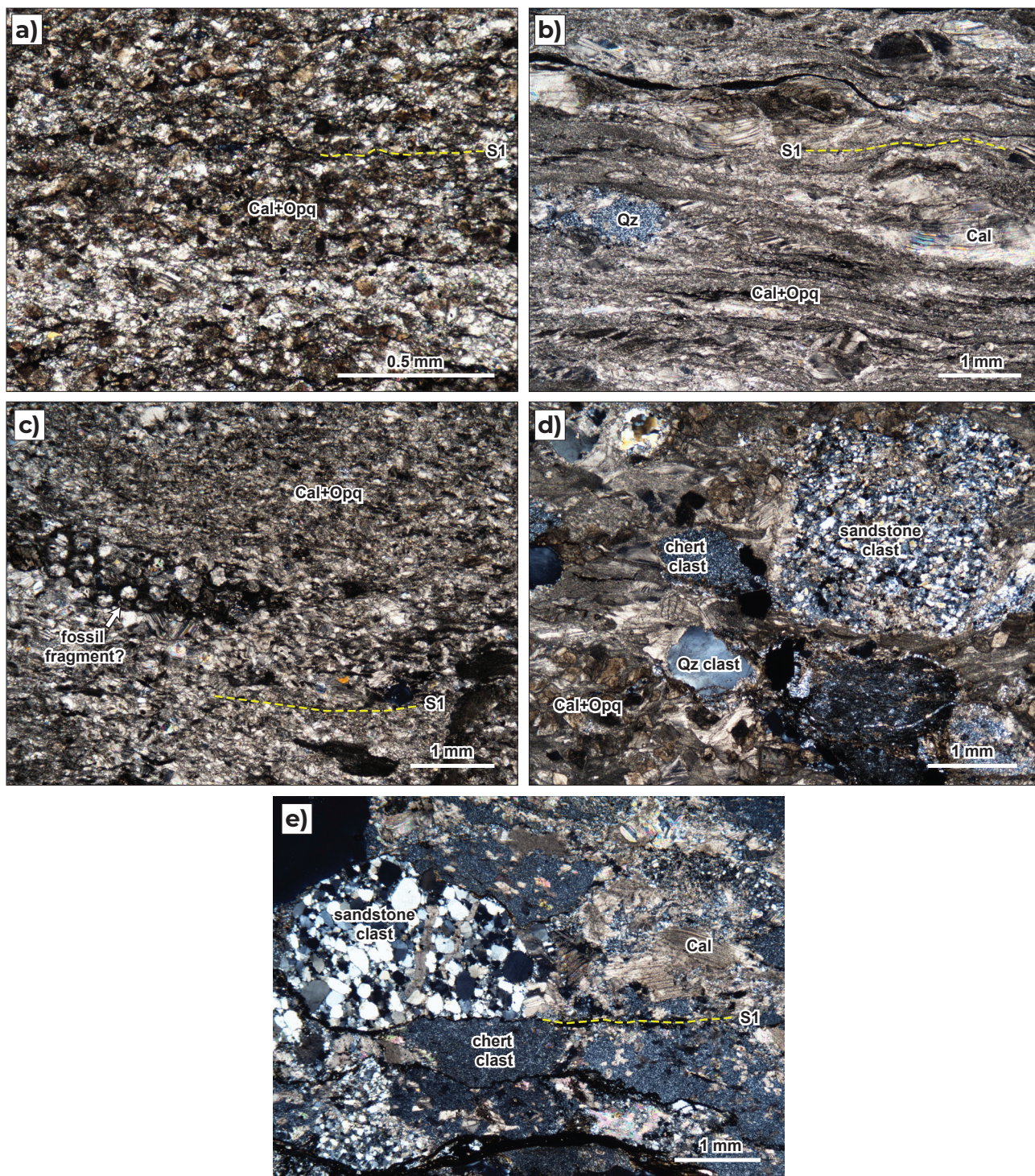


Figure 39. Photomicrographs (XPL) of the Tahkandit Formation (PPT). **a)** Limestone comprised of mainly equigranular calcite, with alternating light-coloured (calcite-rich) and dark-coloured beds that are rich in opaque material (graphite?). Yellow dashed line delineates S1 foliation (sample 21DS-002-1-3). **b)** Limestone with medium-grained calcite crystals surrounded by a fine-grained matrix (sample 21DS-027-1-1). **c)** Limestone containing a possible fossil fragment (sample 21DS-135-1-4). **(d,e)** Limestone conglomerate containing clasts of medium and fine-grained sandstone, chert and quartz (samples 21DS-026-3-1, 21DS-135-1-3, respectively).

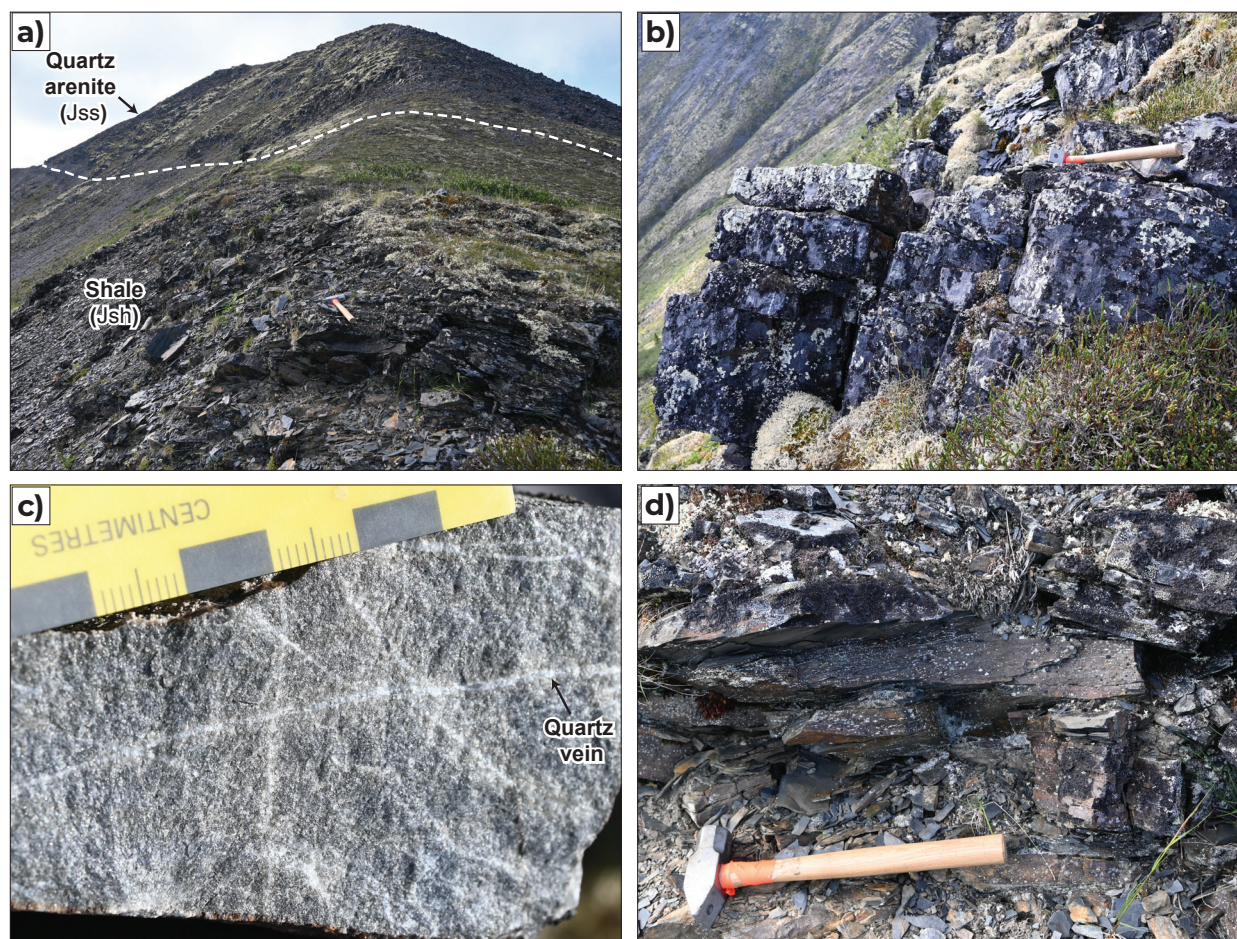


Figure 40. Field photographs of Jurassic sandstone (Jss) and shale (Jsh). **a)** Dark brown-grey-weathered, medium-bedded quartz arenite (Jss) overlying dark brown-grey-weathered shale (Jsh). The white dashed line indicates the approximate location of the contact. **b)** Grey-weathered, medium-bedded quartz arenite (Jss). **c)** Detail of grey-brown fresh surface of fine to medium-grained quartz arenite (Jss), with mm-thick quartz veins. **d)** Dark brown-grey-weathered, thinly interbedded shale (Jsh). Hammer for scale in a), b), and d) is 40 cm long.

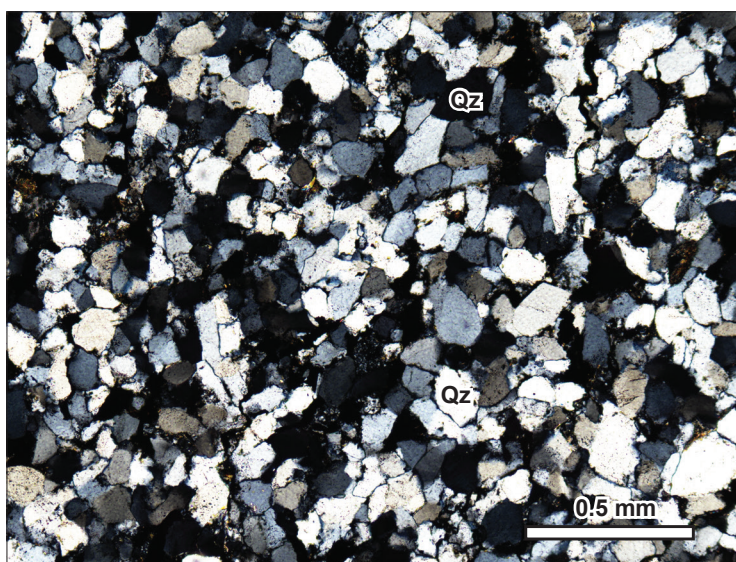


Figure 41. Photomicrograph of Jurassic quartz arenite (Jss), which mostly consists of medium-grained, equigranular quartz grains (XPL; sample 21DS-134-1-1).

Notably, the field appearance (e.g., colour, bedding habit) and quartz-dominated mineralogy of the Jurassic sandstone in the McQuesten Lake area (Jss) are similar to those of the Keno Hill Quartzite (CTKHQ). The shale (Jsh) is not readily distinguishable from other shales in the field area, including the shale member of the Earn Group (DMesh) and the shale (CTKHQs) that is interstratified with the Keno Hill Quartzite.

The upper limit of the Jurassic siliciclastic package is considered to be the upper contact of the quartz arenite (Jss), beneath dark brown-grey-weathered shale that is inferred to belong to the shale member of the Earn Group (DMesh). This contact is interpreted to be the Tombstone thrust (discussed below in the "Deformation" section), which transported Devonian to Mississippian rocks of the Earn Group (and overlying Keno Hill Quartzite) over the Jurassic sandstone and shale.

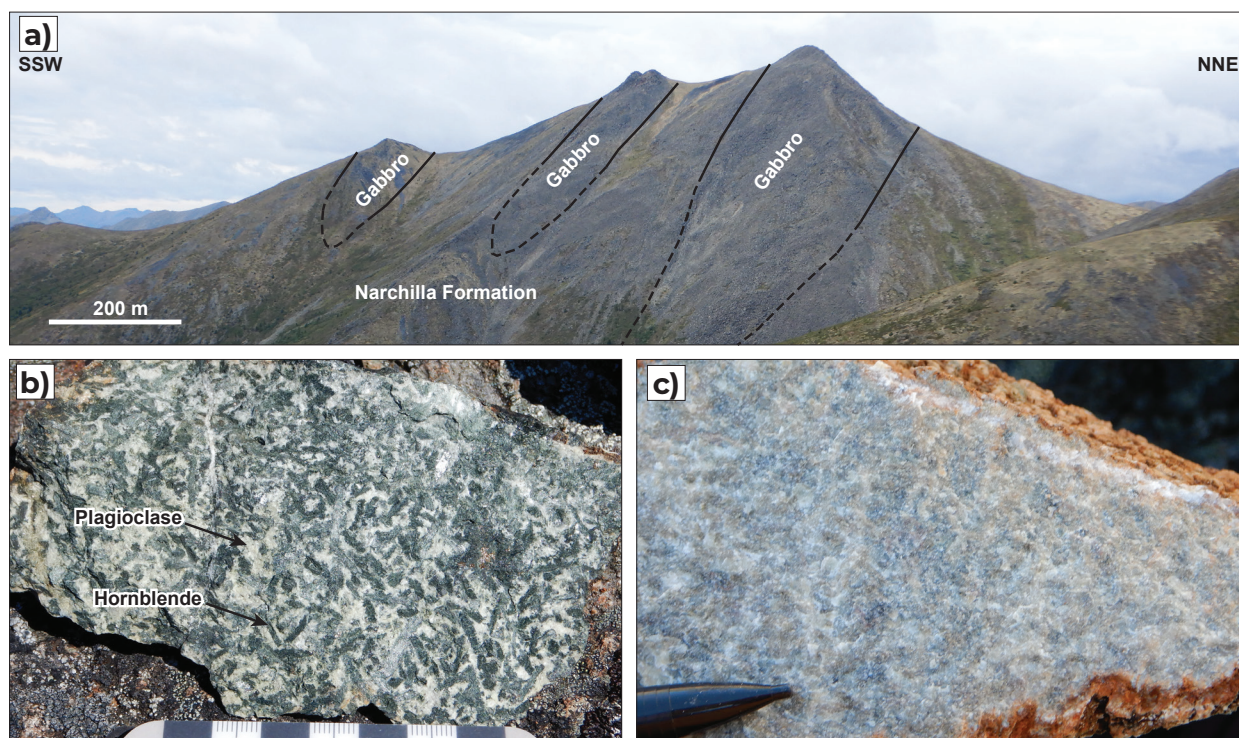


Figure 42. Field photographs of Cambrian or younger gabbro and hornblende diorite intrusions (Cg) hosted by the Narchilla or Yusezyu formations. **a)** Gabbro intrusions hosted by shale and siltstone of the Narchilla Formation. Gabbro contacts constrained by mapping are represented by solid black lines; black dashed lines indicate covered (inferred) contacts. **b)** Fresh surface of medium to coarse-grained melanocratic hornblende diorite with primary igneous texture exhibited by plagioclase and hornblende. Hornblende has been mostly replaced by chlorite. **c)** Medium to coarse-grained gabbro that has been mostly replaced by greenschist-facies minerals (chlorite, epidote) and intense carbonate alteration, resulting in a pale green fresh surface that lacks igneous textures and a pitted, orange weathered surface. Pencil tip for scale is 2 cm long.

Intrusive rocks

Cambrian to Silurian(?) gabbro (Єg)

Gabbroic intrusions (Єg; Figs. 42 and 43) were emplaced into siltstone and shale of the Ediacaran to lower Cambrian Narchilla Formation and the Ediacaran Yusezyu Formation on the eastern side of the map area, forming discontinuous sills and plugs with maximum dimensions estimated to be ~200 m at the bedrock surface (Fig. 42a). A gabbro intrusion (Єg) also occurs in the sequence of Upper Cambrian volcanic rocks (Єv) in the northern part of the study area. The gabbroic intrusions are mostly medium-grained (Figs. 42b,c, 43a–d) and are typically foliated along intrusion margins, as well as in the interiors of smaller intrusions. They have been extensively replaced by greenschist facies minerals (chlorite, actinolite, epidote) and carbonate alteration (Figs. 42b,c, 43). Igneous textures have been preserved locally and relics of igneous crystals are visible in thin section (Figs. 42b, 43). In places, igneous hornblende occurs instead of clinopyroxene (Fig. 43c,d), indicating that the intrusions have a compositional range from gabbro to melanocratic hornblende diorite. As the intrusions are hosted by the Narchilla Formation (PCHn) and Upper Cambrian volcanic rocks (Єv), they are inferred to be Cambrian or younger.

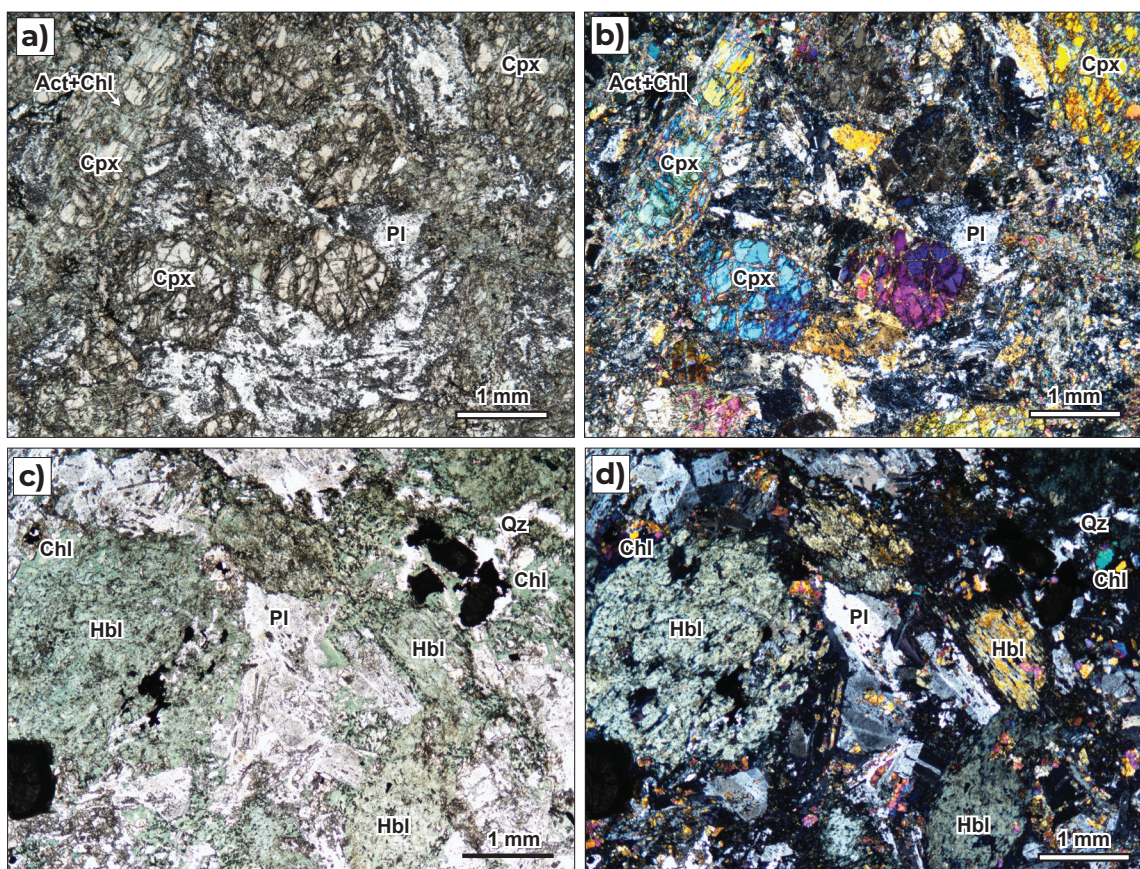


Figure 43. Photomicrographs of Cambrian or younger gabbro and hornblende diorite intrusions (Єg). In all images, igneous minerals have been significantly replaced by secondary minerals, including chlorite, actinolite, carbonate or leucoxene. **a)** Medium-grained, clinopyroxene-bearing gabbro (PPL; sample 19DS-007-1-1). **b)** An XPL image of a). **c)** Medium-grained melanocratic hornblende diorite (PPL; sample 19DS-006-2-1). **d)** An XPL image of c). Act = actinolite, Hbl = hornblende.

Paleozoic to Mesozoic(?) mafic intrusion (PMm)

A dark brownish-green, fine to medium-grained mafic intrusion (**PMm**) is hosted by the chert member of the Ordovician to Silurian Road River Group near the centre of the map area. The intrusion is exposed in sparse outcrops across an area of ~30 m on the end of a ridgetop and its size and extent are poorly constrained. It is mainly comprised of secondary minerals including chlorite, carbonate, opaque minerals, leucoxene(?) and lawsonite (Fig. 44), and contains minor plagioclase. In places, the intrusion contains ~1–3 mm sized, tabular-shaped, chlorite-rich pseudomorphs of mafic phenocrysts (likely pyroxene; Fig. 44).

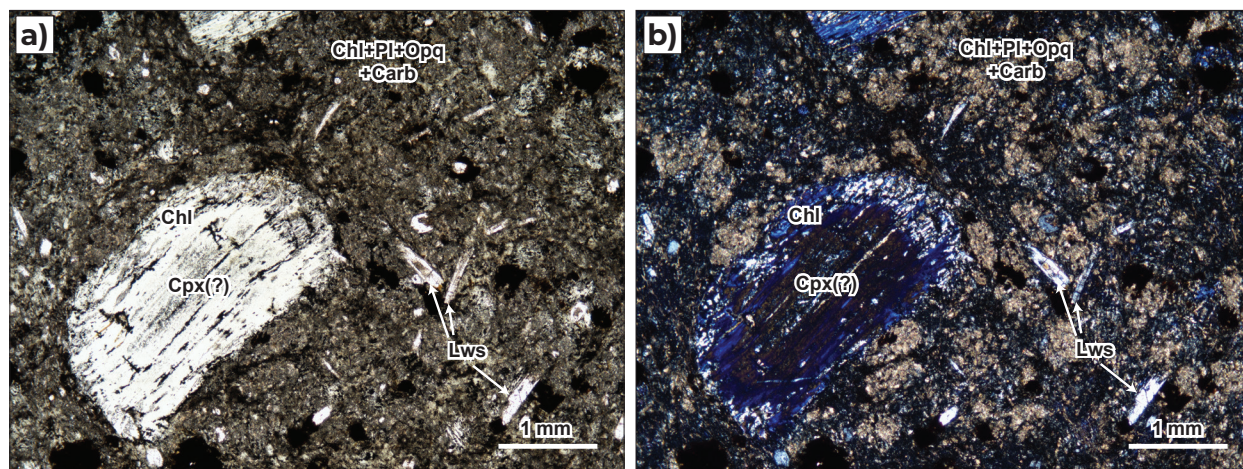


Figure 44. Photomicrographs of a Paleozoic to Mesozoic(?) mafic intrusive rock (**PMm**). **a)** Mafic rock comprised of a fine-grained mafic matrix that surrounds ~1–2 mm-sized phenocrysts of clinopyroxene(?) pseudomorphed by chlorite. Secondary lawsonite laths occur in the matrix (PPL; sample 19DS-115-2-1). **b)** An XPL image of a). Carb = carbonate; Lws = lawsonite.

Triassic Galena suite: gabbro sills (TG)

Gabbro sills of the Triassic Galena suite (**TG**; Figs. 45 and 46) are emplaced in the Devonian–Mississippian Earn Group and the Carboniferous Tschu Group (Figs. 3, 28d, 30b, 36e, 45a). The sills form prominent ‘ribs’ of outcrop that stand out from recessive Earn Group host rocks, including shale and siltstone (**DMEsh**, **DMEslt**) and the carbonate member (**DMEc**). The sills have a similar weathering habit and dark grey colour as the Keno Hill Quartzite (**CTKHQ**) and quartzite in the Earn Group (**DMEq**; Figs. 28d, 36e, 45a). Where hosted in the Keno Hill Quartzite (**CTKHQ**), the sills locally anastomose within and between shale horizons (**CTKHQs**; Fig. 36e). Intrusion margins exhibit sharp contacts with sedimentary host rocks, and the intrusion margins are typically foliated, whereas the interiors of the sills are generally non-foliated.

The gabbro sills mostly range from ~2 to 15 m in thickness, but are locally up to ~100 m thick (Fig. 28d). Gabbro sills are dark grey-weathered with a dark green fresh surface and are generally medium-grained and equigranular (Figs. 45b, 46a–d). In places, particularly near intrusion margins, they are fine-grained and locally contain euhedral to subhedral, plagioclase phenocrysts ~2–5 mm in size (Figs. 45c, 46e,f).

Two very coarse-grained gabbro sills belonging to the Galena Suite in the Ogilvie Mountains (Tombstone Range; ~150 km to the west of the study area) yielded U-Pb zircon and baddeleyite dates of ca. 232 Ma and 230.5 Ma, interpreted as crystallization ages (Mortensen and Thompson, 1990; Yukon Geological Survey, 2023a).

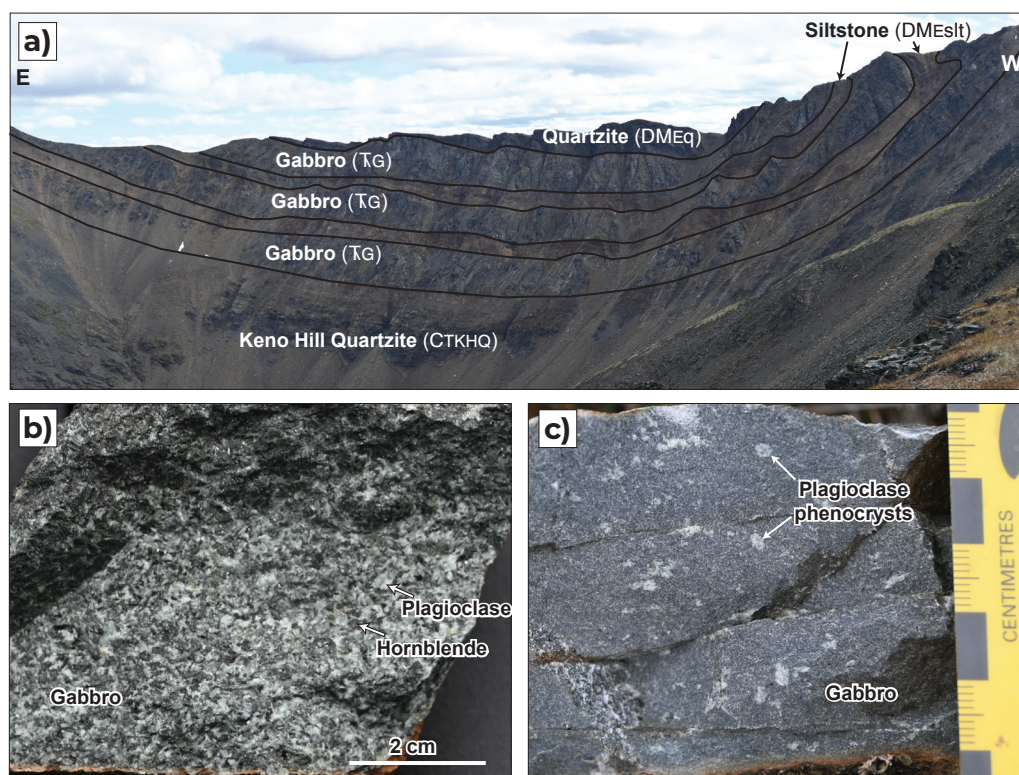


Figure 45. Field photographs of gabbro sills of the Galena Suite (TG). **a)** Gabbro sills (TG) hosted by the Keno Hill Quartzite (CTKHQ) and siltstone and quartzite of the Earn Group (DMeslt, DMEq). Horizontal field of view (along the ridgetop) is approximately 1.5 km. The black lines indicate defined geological contacts. **b)** Medium-grained gabbro (TG) containing subhedral plagioclase and hornblende. **c)** Fine-grained gabbro (TG) with clusters of subhedral to euhedral plagioclase phenocrysts.

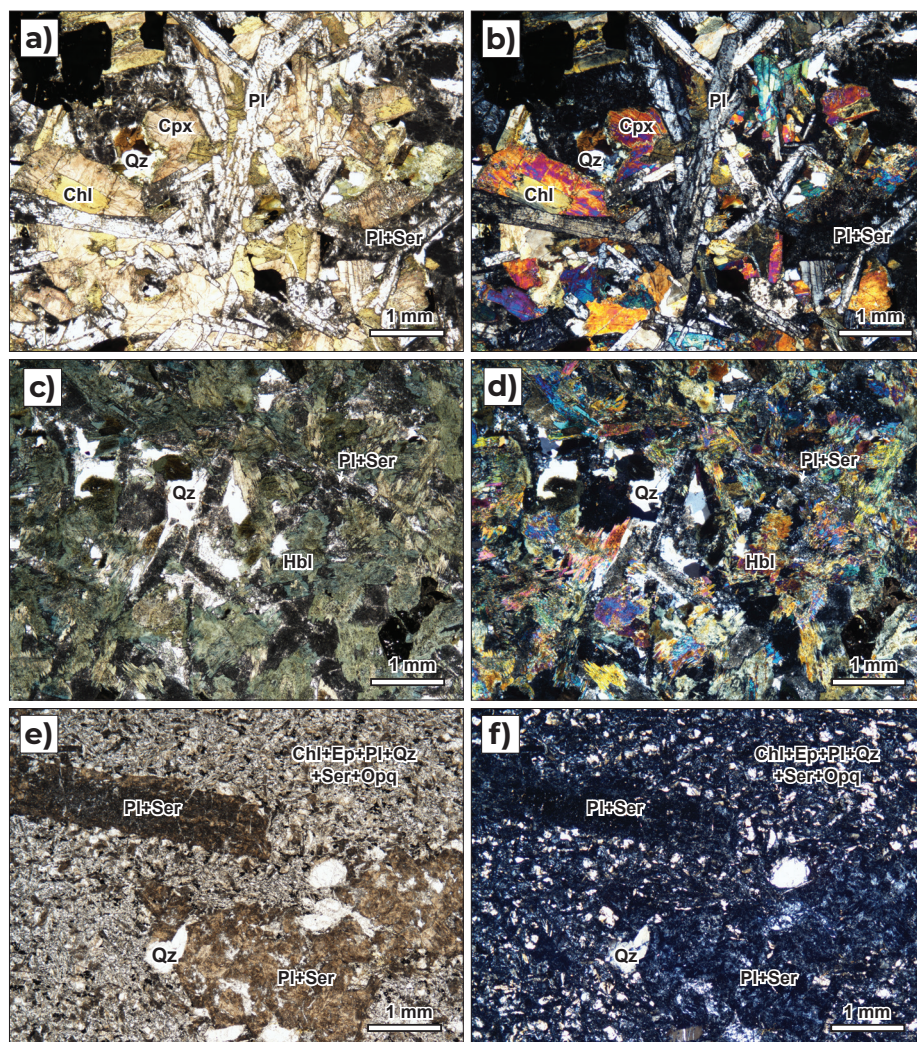


Figure 46. Photomicrographs of gabbro sills in the Galena Suite (TG). Igneous minerals have been significantly replaced by secondary minerals, including chlorite, actinolite and sericite. **a)** Clinopyroxene and plagioclase in medium-grained gabbro (PPL; sample 21DS-017-1-1). **b)** An XPL image of a). **c)** Hornblende and plagioclase in medium-grained gabbro (PPL; sample 22DS-010-1-1). **d)** An XPL image of c). **e)** Gabbro comprising strongly sericitized plagioclase phenocrysts in a fine-grained matrix. Plagioclase forms euhedral, lath-shaped phenocrysts (left) and clusters of smaller, subhedral phenocrysts (right; PPL; sample 21DS-154-1-1). **f)** An XPL image of e).

Mesozoic(?) quartz monzonite(?) (Mqm)

Foliated, altered quartz monzonite(?) (Mqm; Figs. 47 and 48) occurs in the southern part of the map area, hosted in siltstone of the Yusezyu Formation 'mixed' unit (Fig. 47a). The intrusion's extent is poorly defined, mainly owing to poor outcrop exposure. It has a pitted, orange-brown weathered surface (Fig. 47b) and an orange-green fresh surface (Fig. 47c). The intrusion contains medium to coarse-grained K-feldspar, plagioclase feldspar and minor quartz (Fig. 48). It has undergone pervasive carbonate, quartz and sericite alteration and hosts abundant carbonate ($\pm$ quartz) veins (Figs. 47b,c, 48). Therefore, its igneous protolith is uncertain but it is tentatively classified as a quartz monzonite.

The age of the intrusion is unknown. In contrast with the undeformed Dublin Gulch (ca. 93 Ma; Murphy, 1997), Roop Lakes (ca. 94 Ma; Yukon Geological Survey, 2023a) and Rackla (ca. 63–59 Ma; Kingston et al., 2010) intrusions in the surrounding region, the quartz monzonite (Mqm) is strongly foliated.

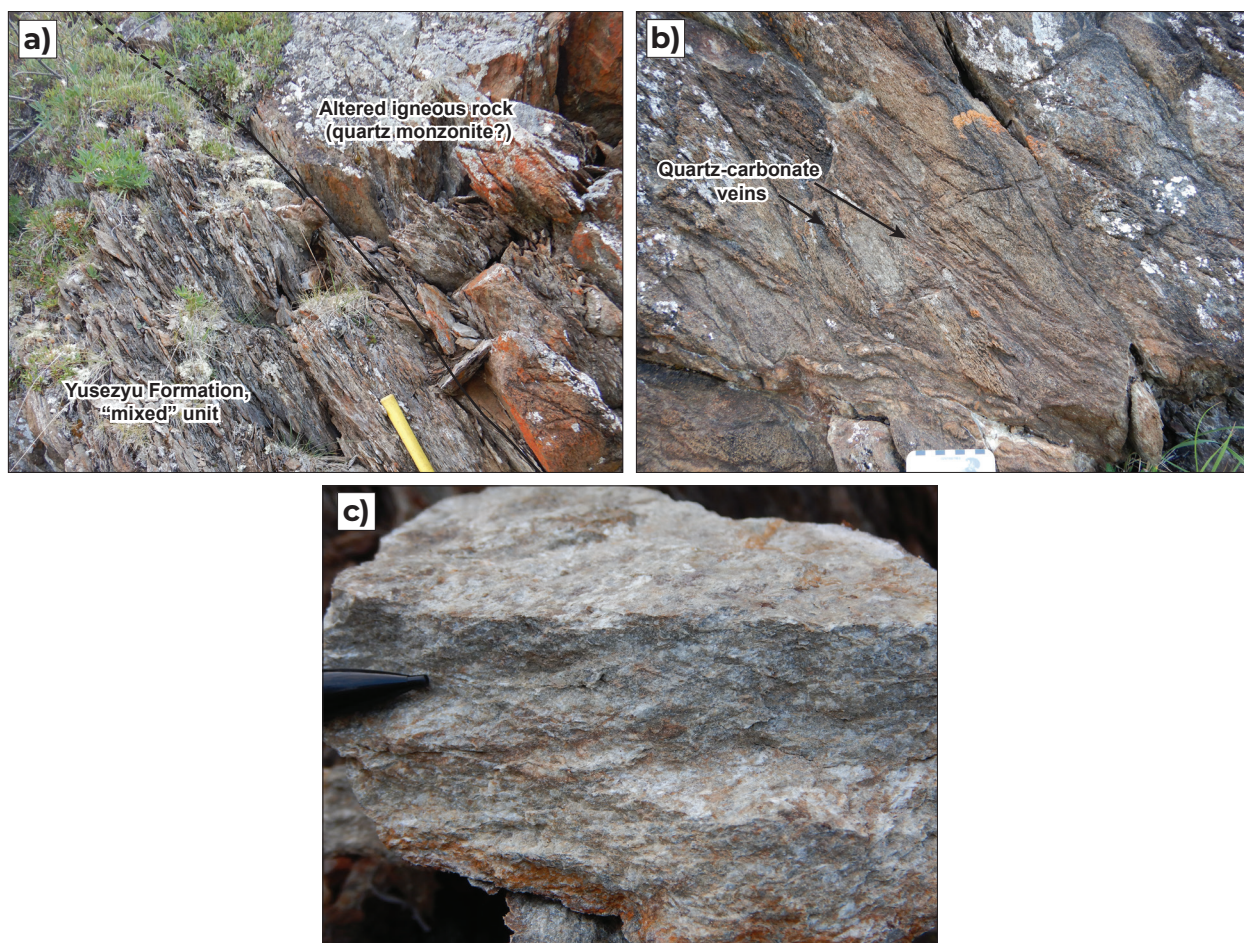


Figure 47. **a)** Sharp intrusive contact (black line) between siltstone of the Yusezyu Formation 'mixed' unit (PHYm) and Mesozoic(?) quartz monzonite(?) (Mqm). Both rock units are foliated. Yellow hammer handle is ~20 cm long. **b)** Pitted, orange-brown weathered surface of quartz monzonite, with several quartz-carbonate veins. **c)** Orange-green fresh surface of quartz monzonite, in which original igneous minerals are barely identifiable due to intense carbonate-quartz alteration and sericitization. Pencil tip for scale is approximately 1.5 cm long.

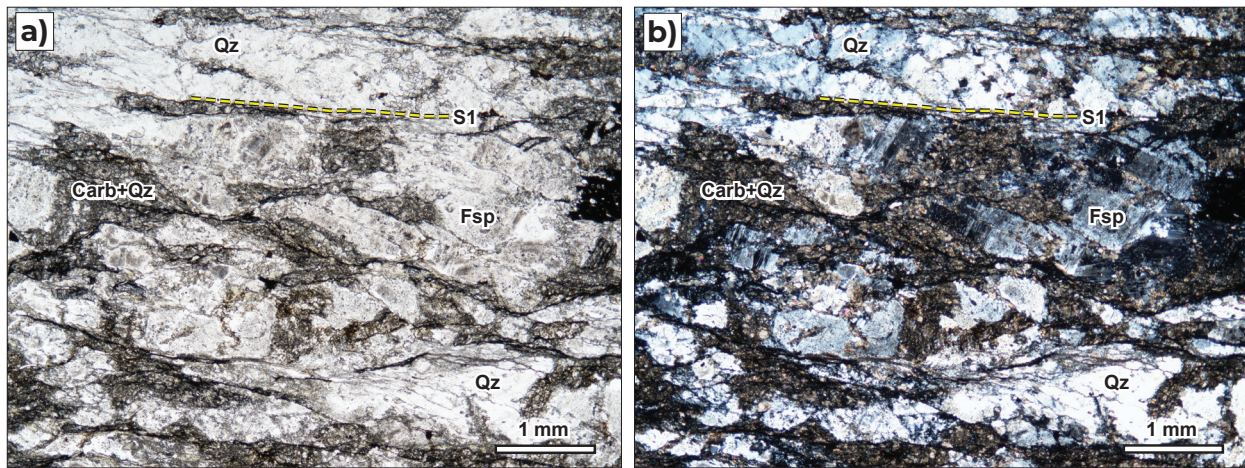


Figure 48. Photomicrographs of Mesozoic(?) quartz monzonite (**Mqm**) in PPL a) and XPL b), displaying medium to coarse-grained quartz and feldspar, with abundant secondary carbonate, quartz and sericite. A strong foliation (S1; yellow dashed line) is defined by aligned quartz and feldspar crystals (sample 19DS-148-1-1). Fsp = feldspar.

*Mesozoic (Cretaceous?) granitic rocks (**Mgr**)*

Cretaceous granitic rocks (**Mgr**) were mapped by Green (1971) in the southern part of the Davidson Range and in the Mayo Lake and McQuesten Lake map areas. This map unit was not encountered in the current study, but it is included in the compilation map that accompanies this report (Geoscience Map 2024-1; Skipton, 2024). The Cretaceous granitic rocks are described in detail by Green (1971), where they are referred to as 'unit 10', and a summary is given here.

In the southern part of the Davidson Range (135.1533°W, 64.0194°N), the Cretaceous granitic unit (**Mgr**) forms two intrusions that measure ~30 and 60 m². They are emplaced in the shale member of the Devonian–Mississippian Earn Group (**DMesh**) and in a gabbro sill (Triassic Galena Suite; **TG**) and inferred by Green (1971) to be Cretaceous. As described by Green (1971), the Cretaceous granitic intrusions in the region are generally grey, medium-grained and consist of quartz monzonite, granodiorite, granite or quartz diorite. They are mostly composed of varying proportions of K-feldspar, plagioclase feldspar, quartz, biotite and hornblende. The 'unit 10' of Green (1971) also includes the Mayo Lake batholith (also known as the Roop Lakes pluton), an undeformed intrusion that crystallized at ca. 93–94 Ma (Roots, 1997; Yukon Geological Survey, 2023a).

*Mesozoic to Tertiary(?) porphyritic rocks (**MTp**)*

Mesozoic to Tertiary(?) porphyritic rocks (**MTp**) were mapped by Green (1971) in the northern part of the Davidson Range and elsewhere in the Mayo Lake, Scougale Creek and McQuesten Lake map areas. This map unit was not encountered in the current study, but it is included in the compilation map that accompanies this report (Geoscience Map 2024-1; Skipton, 2024). The Mesozoic to Tertiary(?) porphyritic rocks are described in detail by Green (1971), where they are referred to as 'unit 11', and a summary is given here.

In the northern part of the Davidson Range (135.1064°W, 64.1224°N), Green (1971) mapped a 35 by ≥130 m-sized body of porphyritic rocks (**MTp**) that occurs within a gabbro sill, which is interpreted to belong to the Triassic Galena Suite. As described by Green (1971), the porphyritic rock unit comprises sill-like bodies of white to cream-coloured, buff-weathering quartz porphyry and granite porphyry. In addition to ≤2 mm-sized phenocrysts of quartz

and feldspar, some porphyritic rocks also contain muscovite and biotite phenocrysts. The porphyritic rocks contain secondary muscovite and significant secondary carbonate. The intrusions are typically parallel with the foliation of the host rocks, but locally crosscut foliation.

Deformation

The McQuesten Lake area records a complex compressional deformation history that produced a predominantly southeast-striking, southwest-dipping structural architecture. The area records at least two regional deformation events (D1 and D2). The D1 deformation event produced a regional, greenschist facies, bedding-parallel foliation (S1). Regional compression (D2) produced several thrust faults, widespread and pervasive folding, and development of crenulation lineations and axial-planar foliation at greenschist facies conditions. The map area includes at least five southwest dipping thrust sheets bounded by D2 thrusts, between the hanging wall of the Robert Service thrust in the southwest and the footwall of the Dawson fault in the northeast (Fig. 3).

Foliations

Two regional foliations were identified during mapping (S1 and S2). An early foliation (S1) is oriented parallel to bedding in sedimentary and volcanic rocks (Figs. 20b, 23a,b,e, 49) and is defined by aligned greenschist facies minerals and, in many cases, by aligned primary minerals. The S1-aligned primary minerals (e.g., quartz in siliciclastic rocks, calcite in carbonate rocks, igneous minerals in volcanic rocks) exhibit various intensities of dynamic recrystallization and flattening or attenuation parallel to S1 (Figs. 10a,c, 12c,d, 16, 18, 21, 24a,b, 27b, 29, 31, 33a,b,e, 35). The S1-aligned greenschist facies minerals include mainly white mica and chlorite in sedimentary rocks and amphibole in mafic rocks, as well as quartz and carbonate. The S1-aligned greenschist facies minerals are interpreted to have grown during S1. Bedding and S1 generally dip shallowly to steeply towards the southwest, although they dip with variable steepness towards the northeast in places (Fig. 50), due to reorientation by subsequent folding (F2, discussed below). The early, bedding-parallel foliation (S1) is inferred to record burial during initial crustal thickening.

The S2 foliation is interpreted to have formed as an axial planar foliation to F2 folds, as it is oblique to bedding (and S1) at angles up to 90° (Figs. 20b, 21b,c,e,f, 29b,c, 49), a relationship that is typical of axial planar cleavage that formed in fold hinge zones (Figs. 29c, 31b, 49c,d) or in limbs of inclined folds. In sedimentary rocks, the S2 foliation is defined primarily by aligned fine-grained white mica ($\pm$ chlorite) and commonly forms a crenulation cleavage in fine-grained siliciclastic rocks (Figs. 21b,c,e,f, 29b,c). In sandstone, S2 typically presents as a spaced cleavage (Fig. 49b). The S2 foliation generally dips shallowly to steeply towards the southwest, but it dips steeply or (rarely) moderately towards the northeast in places (Fig. 50).

The variable dip directions and angles of S2 are interpreted to have resulted from the compounded effects of cleavage fanning and refraction in lithologic units of variable competencies (e.g., shale vs. siltstone vs. sandstone). The S2 crenulation cleavage in some fine-grained rocks is sufficiently penetrative and tightly spaced that bedding and S1 are indiscernible (or are only identifiable microscopically; e.g., Fig. 21c), precluding measurements of bedding-cleavage relationships in the field and, therefore, distinction of S1 vs. S2 in the field. Conversely, many rocks record only a bedding-parallel foliation (S1) and lack a non-bedding parallel foliation (S2), even at the micro-scale. This apparent absence of S2 is not grain size, lithology or competency-dependent, suggesting that S2 may not be uniformly pervasive or penetrative throughout different stress-strain regimes within F2 folds. Additionally, S2 is bedding-parallel in some areas (i.e., in the limbs of isoclinal folds [Fig. 49c,d], or in upright limbs of inclined folds), such that it transposes and is indistinguishable from S1.

Nonetheless, for ease of discussion in this report, foliation that is oriented parallel to bedding is

referred to as 'S1', and foliation that cross-cuts S1 and is axial planar to F2 folds is referred to as 'S2'. Foliation that lacks these relationships and is of unknown generation occurs rarely and is referred to as 'Sn' (e.g., Fig. 33c).

Folds

The F2 folds occur from the micro-scale to map-scale, have southeast-striking axial planes, and fold axes that plunge shallowly to moderately towards the northwest or southeast (Fig. 50). The F2 crenulations have wavelengths as small as 0.25 mm (Figs. 21b,c,e,f, 29b,c), and form northwest or southeast-plunging crenulation lineations (L2, discussed below). At the outcrop-scale, F2 folds generally have wavelengths of ~10–60 cm (Figs. 15d, 30b, 49, 51). Larger folds are common, with wavelengths ranging from tens of metres to ~3 km (Figs. 3, 17c,d). The F2 folds form several different types: open (Figs. 17c, 51a,b) to isoclinal (Figs. 17d, 30b, 49c,d), symmetric and asymmetric (Fig. 51b–d), cylindrical and non-cylindrical, harmonic

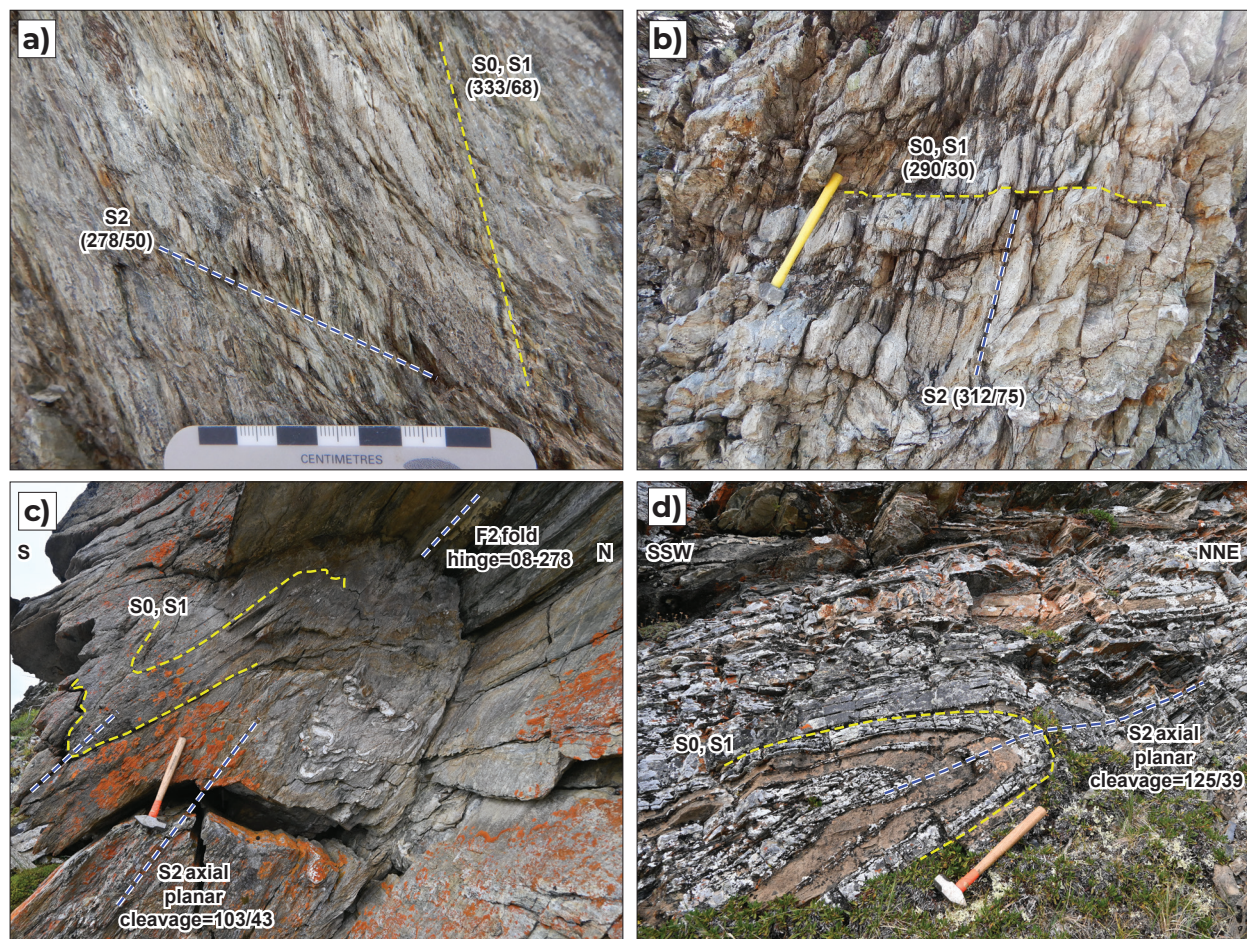


Figure 49. Field photos of S1 and/or S2 foliations. **a)** Bedding (S0) and bedding-parallel foliation (S1; yellow dashed line) crosscut by S2 foliation (blue dashed line) in thinly interbedded siltstone (Narchilla Formation). **b)** Bedding (S0) and bedding-parallel foliation (S1) crosscut by spaced cleavage (S2) in siltstone to fine-grained sandstone in the hinge zone of a map-scale synclinal F2 fold (Narchilla Formation). **c)** Southwest-dipping isoclinal anticline in quartz grit sandstone (Yusezyu Formation, PHYss) in the hanging wall of the Robert Service thrust, with numerous parasitic folds and well-developed S2 axial planar cleavage. **d)** Isoclinally folded (F2), interbedded carbonate, white-weathered sandstone ($\pm$ chert) and dark grey shale (Earn Group carbonate member, DMEc). S2 axial planar cleavage is well-developed in the shale. Hammer for scale in (b–d) is 40 cm long.

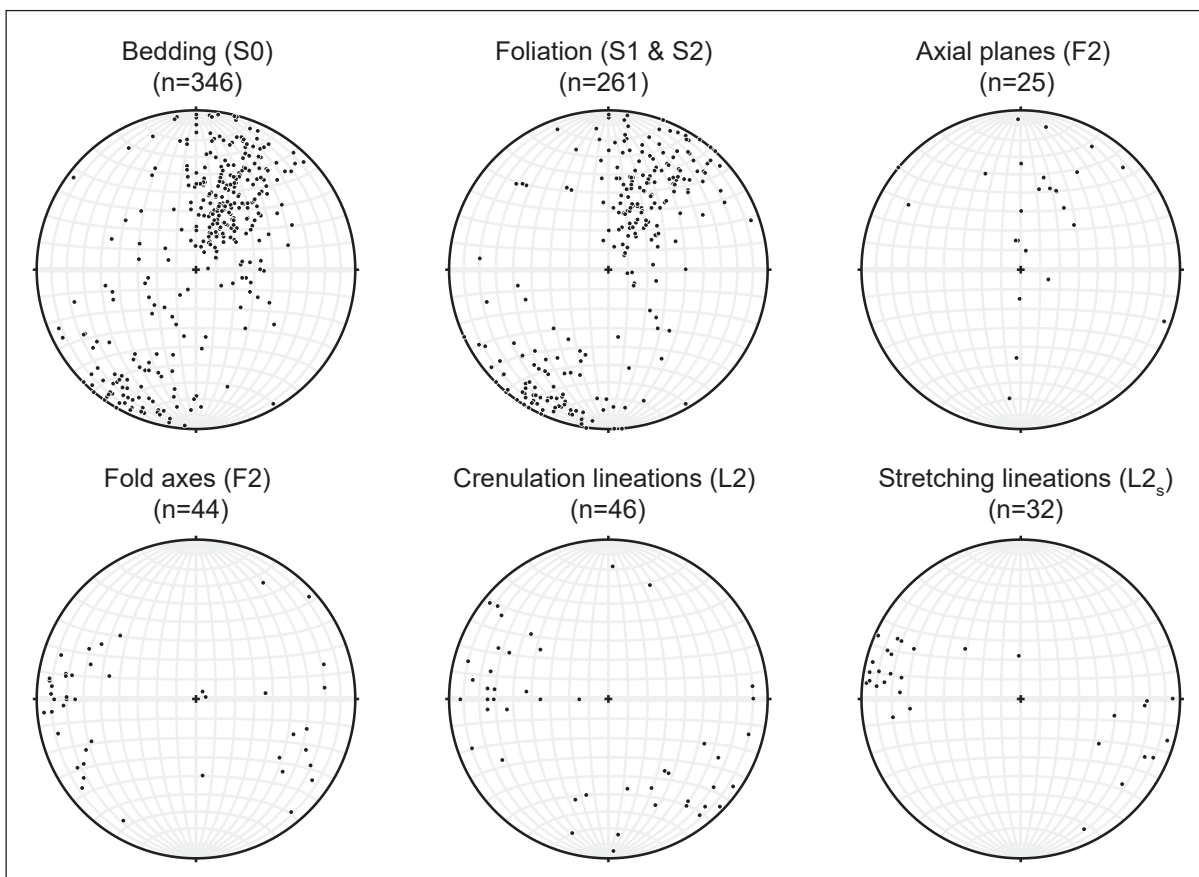


Figure 50. Structural fabrics from the McQuesten Lake area plotted on equal-area stereonets (lower-hemisphere projection). Planar fabrics are plotted as poles to planes. The S1 and S2 foliations have similar overall orientations. The plots were constructed using Stereonet v. 10.0 (R. Allmendinger, <https://www.rickallmendinger.net/stereonet>).

and disharmonic (Fig. 51d), upright (Fig. 17c,d) to inclined (Figs. 49c,d, 51b–d), and chevron (Fig. 17c). The northeastern limbs of asymmetric F2 folds are short and steeply-dipping (Fig. 51b–d), suggesting northeast vergence, consistent with the southwestern dip of F2 axial planes. The F2 folds are interpreted to have formed during the same northeast-vergent compressional event (D2) that produced the thrust faults in the map area.

In folded sequences of the Hyland Group, map-scale folds have preserved upper stratigraphic levels in synclinal keels (e.g., the Yusezyu Formation limestone unit and the Narchilla Formation; Figs. 3, 17c,d) and revealed lower stratigraphic levels in antiformal cores (e.g., Yusezyu Formation 'mixed' unit and sandstone unit; Figs. 3, 17d). In areas where fold closures have been covered or eroded away, large-scale folds are interpreted from the repetition of stratigraphy, together with the presence of parasitic folds on the micro to outcrop-scale and the associated axial planar cleavage (S2). Several units are discontinuous along-strike (Fig. 3) due to non-cylindrical map-scale folds with northwest or southeast-plunging axes, in combination with lateral facies changes and topographic relief.

Lineations

Crenulation lineations (L2) are the dominant type of lineation in the map area, typically occurring in fine-grained siliciclastic rocks, and are oriented parallel to F2 fold hinges

(Fig. 52a,b). They plunge shallowly towards the northwest or southeast (Fig. 50).

Additionally, stretching lineations (L2s) occur in a few places in rocks of the Earn, Tsichu and Hyland groups located in the hanging walls of the Tombstone and Robert Service thrusts. The stretching lineations are defined by quartz and chlorite and/or white mica (Fig. 52c–f), and plunge shallowly, or (less typically) moderately, towards the southeast or northwest (Fig. 50). The L2s lineations are particularly well-developed in the Hyland Group rocks in the immediate hanging wall of the Robert Service thrust (within ~100 m of the thrust), where they are defined by stretched, dynamically recrystallized quartz clasts and aligned white mica (Figs. 12d, 52c). At this locality, L2s lineations form the dominant structural fabric in places, and S2 foliation is comparatively weakly developed (i.e., $L>S$). As the L2s lineations are oriented parallel to F2 fold hinges, they may record the non-ideal component of simple shear during (north–northeast-vergent) F2 folding and D2 thrust faulting. Alternatively, they may record late- to post-D2, west–northwest-directed shearing.

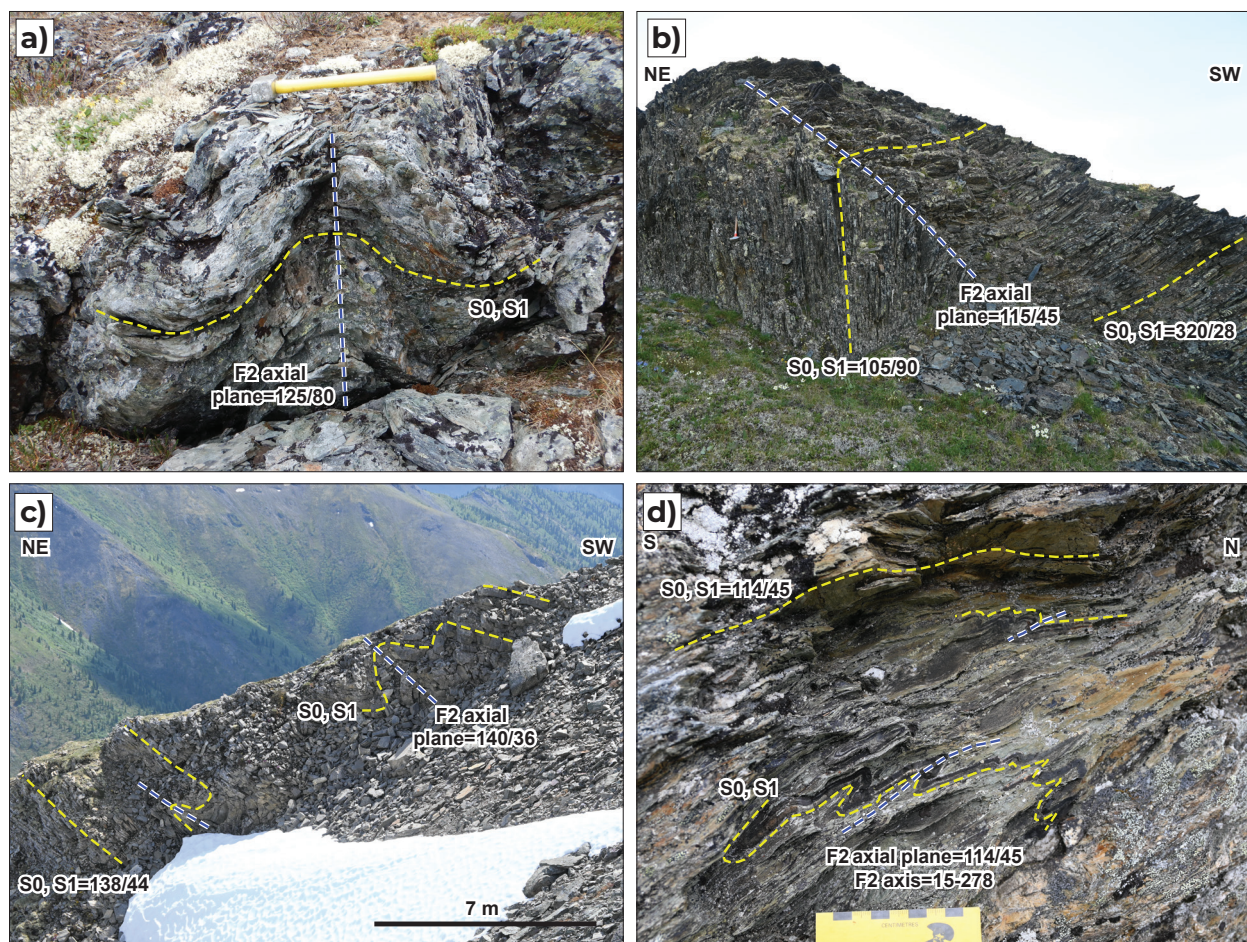


Figure 51. Field photos of F2 folds. **a)** An upright, open F2 fold in siltstone (Yusezyu Formation mixed unit, PHM), with a southeast-plunging axis (36–125). Linear measurements are given in plunge–trend format here and throughout the manuscript. Bedding and the S1 foliation are indicated by the yellow dashed line, and the trace of the F2 axial plane is delineated by the blue dashed line. **b)** Thinly interbedded black mudstone and chert (Road River Group, OSR) folded by an open southwest-dipping anticline. Hammer for scale in a) and b) is 40 cm long. **c)** Asymmetric, tight, southwest-dipping folds of limestone beds (Yusezyu Formation limestone unit, PHL), suggesting vergence towards the northeast. **d)** Tight, disharmonic, asymmetric folds of bedding (and S1) in interbedded dark grey mudstone and grey-green phyllite (Earn Group shale member, DMESH) in the footwall of the Robert Service thrust. Southwest-dipping axial planes and steep, short northern limbs indicate vergence towards the north–northeast.

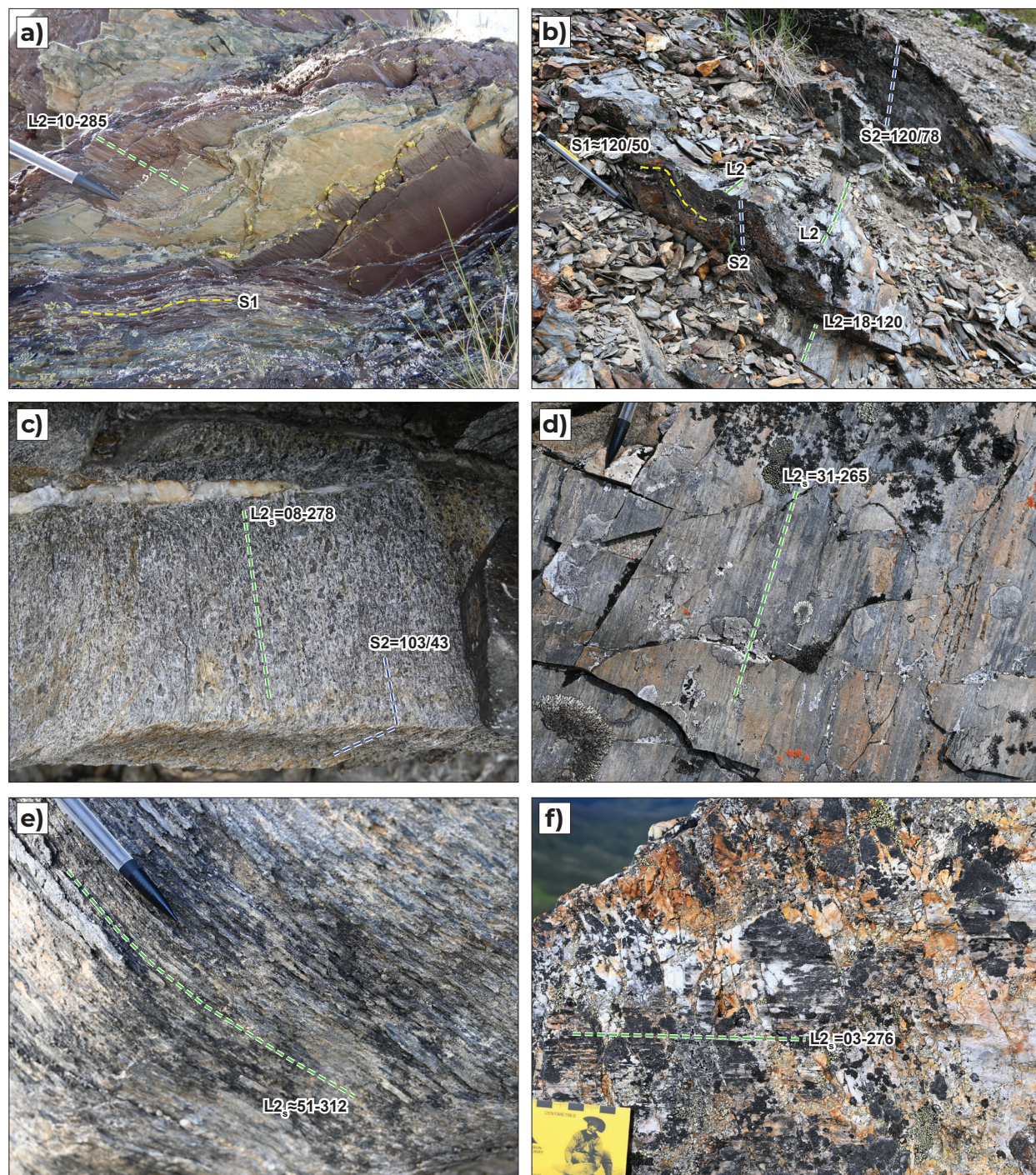


Figure 52. Field photos of L2 lineations. **a)** Crenulation lineations (L2; green dashed line) in maroon to light-green shale (Yusezyu Formation mixed unit, PHYM). **b)** Centimetre-scale F2 crenulations with associated L2 crenulation lineations and S2 axial planar cleavage (blue dashed lines) in the Earn Group shale member (DMesh). The S1 foliation is delineated by the yellow dashed line. **c)** Stretching lineations (L2s; green dashed line) defined by aligned quartz clasts and white mica in quartz grit sandstone (Yusezyu Formation sandstone unit, PHYss) in the hanging wall of the Robert Service thrust. The part of a hammer head shown at the right side of the photo is 10 cm long. **d)** Stretching lineations (L2s) defined by chlorite and quartz in phyllite in the Earn Group carbonate member (DMEc). **e)** Stretching lineations (L2s) defined by chlorite and quartz on the bedding (+S1) plane between carbonate and phyllite in the Earn Group carbonate member (DMEc). **f)** Stretching lineations (L2s) defined by quartz on the margin of a quartz vein in the Keno Hill Quartzite (CTKHQ). The pencil for scale in a), b), d) and e) is shown at its full length (15 cm) in b).

Faults

Robert Service thrust

Initially mapped by Green (1972), the locations of the Robert Service thrust and klippen have been refined based on the detailed mapping conducted in this study (Figs. 3, 53a). The Robert Service thrust juxtaposes Ediacaran–Cambrian Hyland Group rocks over the Carboniferous Keno Hill Quartzite (CTKHQ). Bedding orientations and the presence of klippen indicate that the thrust surface dips shallowly to moderately toward the south–southwest overall and has been folded by an open anticline-syncline pair with west to northwest-striking axial planes (Fig. 3a,c).

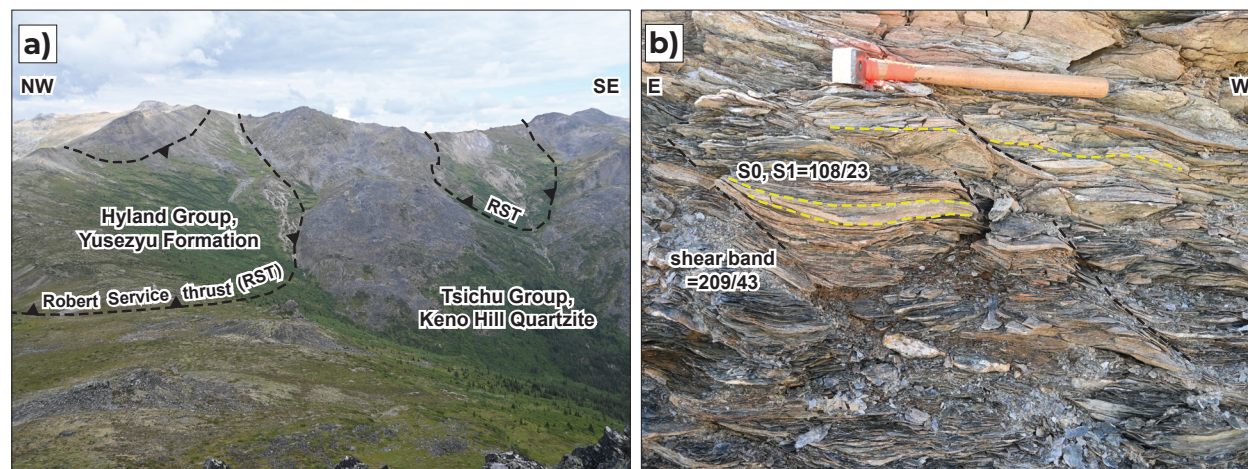


Figure 53. a) Tan-weathered quartz grit sandstone and phyllite of the Yusezyu Formation (PHYss, PHYssm) in the hanging wall of Robert Service thrust occur in klippen juxtaposed over grey-weathered Keno Hill Quartzite (CTKHQ) in the footwall. Horizontal field of view (along the ridgetop) is ~1.7 km. b) Thinly interbedded dark green phyllite and orange-weathered dolostone and quartz grit with carbonate cement (Yusezyu Formation, PHYssm) with west-dipping shear bands (black dashed lines) offsetting bedding and bedding-parallel foliation (S0, S1; yellow dashed lines) in the hanging wall of the Robert Service thrust. Hammer for scale is 40 cm long.

Hyland Group rocks in the hanging wall of the Robert Service thrust are intensely deformed, especially within ~100 m above the thrust. The rocks are strongly lineated (L2s; discussed above), and the S2 foliation is defined mainly by muscovite ($\pm$ chlorite) and is axial planar to moderately south–southwest-dipping F2 folds (Fig. 49c). Bedding orientations are variable, but generally dip shallowly to moderately towards the south–southwest. In places, hanging wall rocks have been overprinted by late to post-D2 west-dipping shear bands that imply late top-to-the-west movement (Fig. 53b).

In the footwall of the Robert Service thrust, the Earn Group (DME, DMEc) and the margins of gabbro–diorite sills (TG) are strongly foliated, and the Earn Group rocks locally exhibit isoclinal folds with well-developed S2 axial planar cleavage (Fig. 49d). Earn Group phyllite within ~100 m below the thrust exhibits tight, disharmonic, asymmetric, north-vergent F2 folds of bedding and the early bedding-parallel (S1) foliation (Fig. 51d).

The maximum age of the Robert Service thrust is interpreted as late Jurassic (Bathonian to Oxfordian), the age of the youngest rocks in the footwall to the west in the Ogilvie Mountains (Green and Roddick, 1962; Poulton and Tempelman-Kluit, 1982; Thompson et al., 1994). Movement along the Robert Service thrust is considered to have ceased by ca. 94 Ma, as the thrust is plugged by the ca. 94–93 Ma Roop Lakes pluton in the Keno area (Fig. 2; Roots, 1997; Yukon Geological Survey, 2022).

Tombstone thrust

In previous interpretations of the Tombstone thrust in the McQuesten Lake study area, which were based on extrapolations from the surrounding region and aeromagnetic patterns, the Tombstone thrust was inferred to occur within the northeastern (lower) part of the Earn Group and along the McQuesten Lake valley (Fig. 2; Yukon Geological Survey, 2022). The detailed mapping presented in this report (and Skipton, 2024), together with U-Pb geochronology ("Jurassic siliciclastic rocks" section and "Jurassic sandstone, sample 21DS-134-1-1 [135.2717816°W 64.2804348°N]" section) and fossil identifications ("Pennsylvanian(?) to Permian Tahkandit Formation" section, Appendix A), show that the Tombstone thrust juxtaposes the Devonian-Mississippian Earn Group (DMEsh) and Carboniferous Tsichu groups (CTKHQ; intruded by Triassic gabbro sills of the Galena suite) in its hanging wall over Jurassic sandstone and shale (Jss) and Pennsylvanian(?) to Permian limestone (PPT; Tahkandit Formation) in its footwall (Fig. 3). The Tombstone thrust exhibits a similar relationship at its type-locality in the Ogilvie Mountains (~150 km west of the study area), where it transported the Mississippian Keno Hill Quartzite over Jurassic siliciclastic rocks of the 'Lower Schist' unit and carbonate of the Permian Tahkandit Formation (Thompson et al., 1994).

To the south and west of the study area, the Keno and Mayo areas have been overprinted by the Tombstone high-strain zone, a zone of intense deformation that has been interpreted to overlie the Tombstone thrust and is characterized by dominantly top-to-the-northwest shear sense indicators (Murphy, 1997). In the McQuesten Lake study area, however, the Tombstone thrust and the rocks in its direct hanging wall (and footwall) exhibit deformation fabrics that are consistent with northeast-directed compression. At a structurally higher level (~5 km above the Tombstone thrust), late top-to-the-west-northwest shear is indicated by well-developed, west-northwest-dipping, late to post-D2 shear bands that occur in a few localities in the immediate hanging wall of the Robert Service thrust (Fig. 53b). These shear bands are relatively rare, both on the map-scale along the Robert Service thrust and on the scale of the outcrops in which they occur. West-northwest or east-southeast-plunging stretching lineations (L2s) are strongly developed in some places in the immediate hanging wall of the Robert Service thrust (Fig. 52c). As discussed above, these lineations may have formed during late- to post-D2, top-to-the-northwest shear, or, alternatively, may have been produced by the non-ideal component of simple shear during D2. The L2s lineations also occur in a few localities in the Earn and Tsichu groups in the footwall of the Robert Service thrust (Fig. 52d–f), at structural levels ranging from ~3 to 5 km above the Tombstone thrust. Together, the L2s lineations and post-D2 shear bands may signify a late-to post-D2 overprint of northwest-vergent strain. The sparse distribution of these fabrics suggests that the McQuesten Lake study area was only weakly and/or locally overprinted by late northwest-vergent shear. As the shear bands were observed exclusively in the direct (within ~20 m) hanging wall of the Robert Service thrust, where the L2s lineations are also most abundant and exhibit the strongest intensity of deformation, the overprint of northwest-vergent strain is inferred to have affected the Robert Service thrust more strongly than elsewhere in the study area. The late northwest-vergent overprint could possibly represent the lower-strain, far-field effects of the Tombstone high-strain zone of Murphy (1997), although there does not appear to be a direct relationship between this overprint and the Tombstone thrust in the McQuesten Lake study area.

Muscovite from the hanging wall of the Robert Service thrust located south-southwest of Keno (Fig. 2), which is considered to have been overprinted by the Tombstone high-strain zone, yielded $^{40}\text{Ar}/^{39}\text{Ar}$ dates of ca. 104–100 Ma that have been interpreted to date the latest Tombstone thrust deformation in that area (Mair et al., 2006).

Thrusts located between the Tombstone thrust and Dawson fault

In the footwall of the Tombstone thrust, the Hyland Group has been repeatedly thrust over the Road River Group (OSR, OSRc, OSRsh) to form a northeast-vergent imbricate thrust stack (Figs. 3 and 4). The two thrusts in this stack are steeply-dipping splays from a common thrust located in the eastern side of the map (Fig. 3a). The southernmost thrust is in part delineated by truncations of the Road River Group and Gull Lake Formation toward the southeast (Fig. 3a). In the thrust sheets bounded by these thrusts, the rocks dip towards the southwest overall, and record S1 and S2 foliations, F2 folds and L2 lineations. The thrusts are inferred to have formed as part of the Robert Service thrust, Tombstone thrust or Dawson fault systems.

Dawson fault

To the east of the McQuesten Lake study area, the Dawson fault juxtaposes the Ediacaran to Cambrian Hyland Group over the Devonian to Mississippian Earn Group, which overlies platformal carbonate rocks of the Ordovician to Devonian(?) Bouvette Formation (Fig. 2; Colpron et al., 2013). To the west, the Dawson fault separates the Cambrian Gull Lake Formation in the hanging wall from the Ordovician to Silurian Road River Group and the Ordovician to Devonian(?) Bouvette Formation in the footwall (Abbott, 1997a–c). Previous maps of the McQuesten Lake study area document the Hyland Group in the hanging wall of the Dawson fault, over the Ordovician to Devonian Bouvette Formation in the footwall, or include the Carboniferous Tsichu Group locally in the immediate footwall (Fig. 2; Green and Roddick, 1962; Green, 1972a; Yukon Geological Survey, 2022). Based on the detailed mapping presented herein, rocks formerly assigned to the Tsichu Group in the footwall of the Dawson fault in the study area are considered to belong to the Ordovician to Silurian Road River Group, and the Dawson fault is interpreted to separate the Upper Cambrian volcanic rocks (€v; and overlying Road River Group, OSR, OSRsh, OSRc) in the hanging wall from the Bouvette Formation (ODBl) in the footwall (Fig. 3; Skipton, 2024). This fault marks a clear boundary in the study area, between basinal rocks to the south and platformal rocks to the north. Furthermore, the Dawson fault truncates the Gametrail Formation (Fig. 3) and corresponds to a prominent aeromagnetic low (Fig. 25) that follows the Beaver River Valley.

Structural domains

Map-scale variations in fold types and stratigraphic dips between and within thrust sheets define distinct structural domains (Fig. 54).

Structural Domain 1 is located in the southwestern part of the study area and comprises the Hyland Group in the hanging wall of the Robert Service thrust, as well as the Earn and Tsichu groups located north of McQuesten Lake in the hanging wall of the Tombstone thrust (Fig. 54). This domain is characterized by tight-to-isoclinal F2 folds with moderately southwest-dipping axial planes, and the strata dip moderately towards the southwest overall (Fig. 3), suggesting that the dominant deformation event that affected Domain 1 was compression towards the northeast. Unlike the rest of the study area, Domain 1 locally contains stretching lineations (L2s) and, in the Robert Service thrust zone, west–northwest-dipping, late- to post-D2 shear bands that may suggest a late, non-pervasive component of top-to-the-west–northwest shear.

Structural Domain 2 is located in the Davidson Range (south of McQuesten and Clark lakes; Fig. 54) in the footwall of the Tombstone thrust and comprises the Earn and Tsichu groups intruded by gabbro sills (Galena suite). The stratigraphy dips shallowly to moderately towards the southwest overall, and the rocks record northwest-plunging F2 folds and L2 crenulation lineations that are similar to those elsewhere in the study area. The Keno Hill Quartzite is preserved in synclinal keels bounded by the Earn Group, a relationship that has also been documented to the south, in the Keno Hill area, where the Keno Hill Quartzite and Earn Group

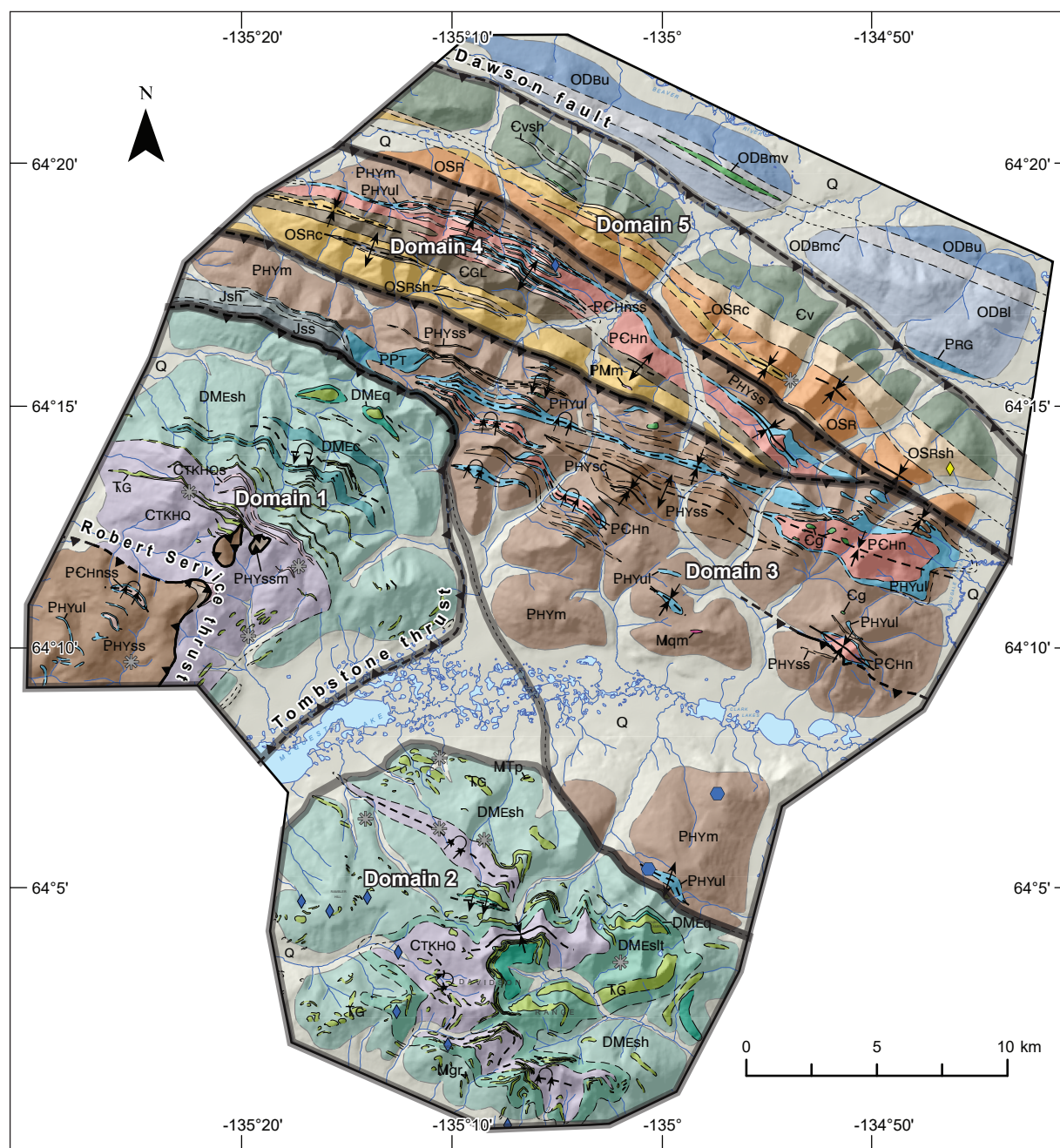


Figure 54. Geological map of the McQuesten Lake study area (simplified after Skipton, 2024), showing the locations of the structural domains discussed in the text (Structural domains section). Refer to Figure 3b for map legend.

are exposed in synclinal keels and antiformal cores, respectively, of multiple southwest-dipping, northeast-vergent isoclinal folds (Murphy, 1997; Read et al., 2020). In the Davidson Range, the Keno Hill Quartzite and Earn Group are interpreted to have been tightly-to-isoclinally folded about shallowly southwest-dipping, non-cylindrical F2 folds with ~1–3 km-scale amplitudes (cross-sections C–C' and D–D' in Figure 3). This scenario could have produced the 'S-shaped' map pattern formed by rocks in the Davidson Range (Fig. 3; Green, 1971), rather than the single, map-scale, tight-to-isoclinal, recumbent, southwest-plunging fold proposed by previous mappers (see Section C–D in Figure 17 of Green, 1971). Map-scale F2 folding is consistent with the prevalence of northwest-plunging F2 folds and L2 crenulation lineations. Although rare, west-southwest-plunging crenulation lineations and

decimetre-to-metre-scale folds do occur in the Davidson Range. Consequently, a component of northwest-vergent shear is not ruled out, and may represent late, localized deformation.

Structural Domain 3 is located in the centre of the study area and comprises Hyland Group rocks that are in the footwall of the Tombstone thrust and have been thrust over the Road River Group (in Domain 4) to the north (Fig. 54). The Hyland Group rocks in the northwestern part of Domain 3 dip moderately towards the southwest overall, and form several tight-to-isoclinal, southwest-dipping, map-scale F2 folds (Figs. 3, 38a). In the southeastern part of Domain 3, Hyland Group rocks in the same thrust panel form upright, open map-scale F2 folds (Figs. 3, 17c) and have variable southwest–northeast-dipping bedding orientations.

Structural Domain 4 consists of the thrust panel below Domain 3, and includes the Road River Group, Gull Lake Formation and Hyland Group (Fig. 54). The rocks in Domain 4 strike northwest–southeast, but, in contrast with structural domains to the south, they dip subvertically. Bedding orientations range from ~80°NE to ~80°SW, varying about tight-to-isoclinal F2 folds with subvertical axial planes (Figs. 3, 17d).

Structural Domain 5 comprises the thrust sheet beneath Domain 4, forms the hanging wall to the Dawson fault (discussed above), and consists of the Road River Group and Cambrian volcanic rocks (Fig. 3). Bedding in Domain 5 mostly dips steeply towards the southwest, but orientations are variable due to tight F2 folds.

The distinct structural domains are interpreted to have resulted from protracted thrusting and variably overlapping strain footprints in a northeast-vergent thrust stack. Overall, the southwestern dip of bedding and planar fabrics steepens toward the northeast of the study area (cross-sections A–A', B–B' in Figure 3), which is consistent with the southern margin of the Ogilvie platform acting as a rigid backstop for northeast-vergent thrusts that formed as part of the Jura-Cretaceous Selwyn fold belt. The Hyland Group on the northwestern side of the study area has tighter F2 folds and is more steeply dipping than to the southeast. This implies that the northwestern part of the study area may have been compressed more tightly, possibly related to its closer proximity to the Robert Service and Tombstone thrusts. Each structural domain records S2 foliation, F2 folds and L2 lineations, indicating that northeast-vergent folding and thrusting (D2) was the predominant regional deformation event, coincident with greenschist facies metamorphism. Fabrics that are consistent with later northwest-vergent shear (e.g., shear bands, L2s lineations) occur locally in the southwestern part of the map area, suggesting that this area was affected by late- to post-D2, non-pervasive, northwest-vergent shear.

Metamorphism

The southern Nash Creek area has been regionally metamorphosed at greenschist facies conditions (chlorite zone; e.g., Spear, 1993). Metamorphic assemblages in siliciclastic rocks are characterized by fine-grained white mica and chlorite ($\pm$ epidote $\pm$ calcite $\pm$ graphite). Metamorphic minerals in carbonate rocks include recrystallized calcite and/or dolomite and fine-grained white mica. Metamorphic mineral assemblages in gabbro include chlorite, epidote, actinolite, calcite and white mica ($\pm$ titanite $\pm$ apatite). Throughout the map area, the S1 and S2 foliations and L2 and L2s lineations are defined by greenschist facies minerals (discussed above in the "Deformation" section), suggesting that they formed during regional greenschist facies metamorphism. The colour alteration index of 4.5–5.0 from a conodont sample from Tahkandit Formation limestone (PPT; Appendix A) suggests peak metamorphic temperatures of at least 300°C (e.g., Epstein et al., 1977).

In siliciclastic rocks within a few hundred metres of the Robert Service thrust, metamorphic white mica ($\pm$ chlorite), which defines the S2 foliation and L2s lineations, is generally more abundant and coarser-grained than elsewhere. The metamorphic mineral assemblages suggest greenschist facies conditions, similar to the rest of the mapped area. The coarser grain size and elevated abundance of white mica ($\pm$ chlorite) proximal to the Robert Service thrust may be attributed to: (i) the Robert Service thrust zone having slightly higher peak metamorphic temperatures than the rest of the study area, although the mineral assemblages indicate that greenschist facies conditions were not exceeded; or (ii) increased fluid circulation along the Robert Service thrust zone.

Some mafic intrusions (Cg, Tg) are surrounded by narrow ($\leq 1\text{--}2$ m) contact metamorphic aureoles in their siliciclastic host rocks. The aureoles are subtly different from the host rocks that are farther from the intrusions and are characterized by a lighter green or grey colour and higher contents of white mica and chlorite. Rarely, the aureoles contain $\sim 1\text{--}2$ mm-wide, grey, oval-shaped aggregates of chlorite and quartz, which may represent former porphyroblasts.

To the east-southeast of the Davidson Range, previous regional mapping identified a higher-temperature metamorphic belt along the Keno Ladue River and Rankin Creek valleys, characterized by widespread biotite and staurolite, with local garnet, andalusite, kyanite and feldspar (Green, 1971). Biotite, the most common metamorphic mineral in the belt, forms “ragged plates up to one millimeter in diameter oriented perpendicular to the bedding” (Green, 1971). The Keno Ladue River and Rankin Creek valleys were not mapped in the current study,

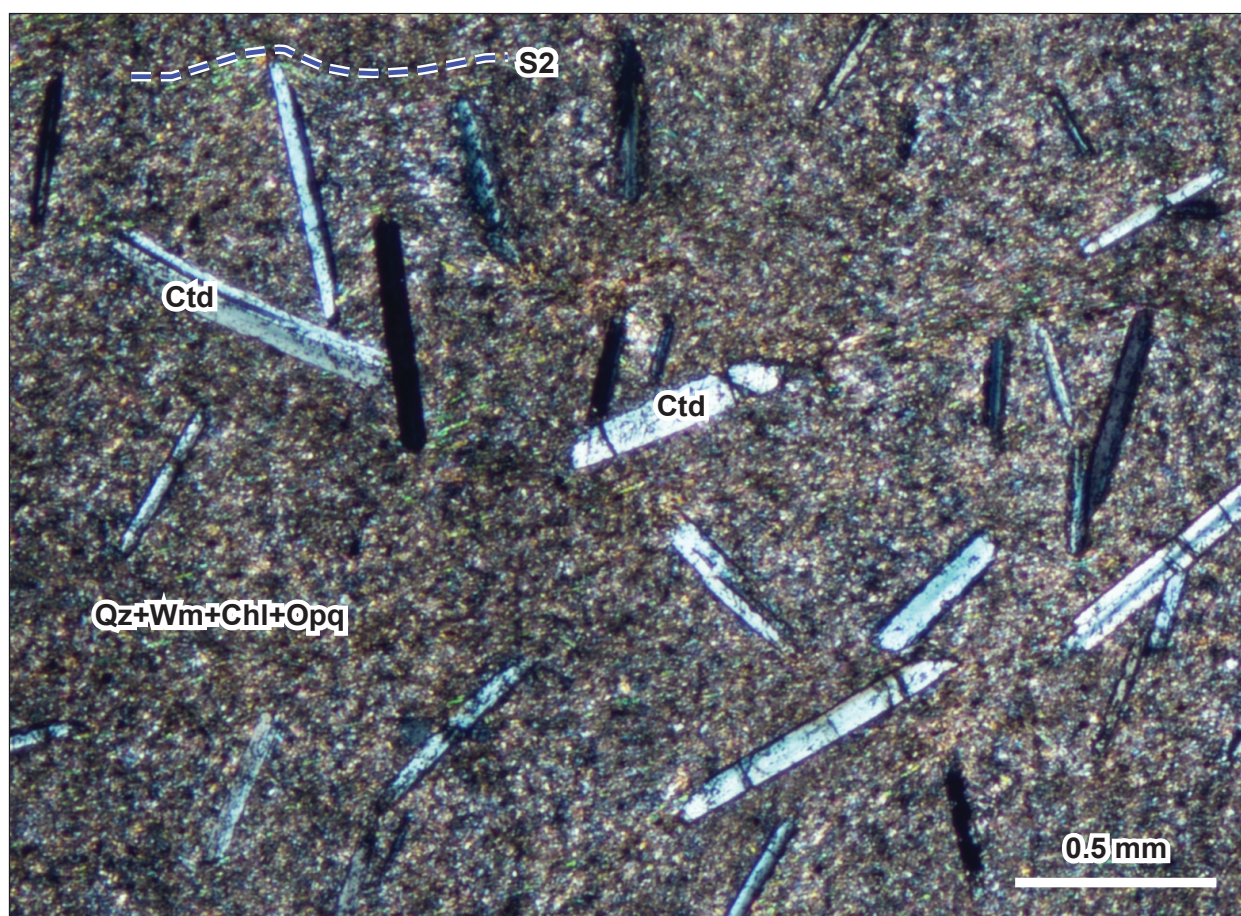


Figure 55. Photomicrograph of a chlorite + white mica-rich phyllite containing chloritoid porphyroblasts, located on the eastern side of the study area, ~ 4 km northeast of Clark Lakes (XPL; sample 19DS-051-1-1). The S2 foliation is indicated by the blue dashed line. Ctd = chloritoid.

but unique mineral assemblages were observed in places along the eastern edge of the study area. Quartzite (DMEq) on the eastern side of the Davidson Range (Mount Cameron) contains fine-grained biotite that generally forms S1-aligned grains and clots, as well as non-S1-aligned grains (Fig. 35c,d). Approximately 4 km northeast of Clark Lakes, a chlorite + white mica-rich phyllite (PHYm) locally contains euhedral-to-subhedral chloritoid porphyroblasts that are up to 1 mm in length (Fig. 55). The chloritoid porphyroblasts are variably oriented, and are wrapped by a weakly developed, bedding-perpendicular foliation (S2) defined by white mica (Fig. 55). As biotite and chloritoid generally grow at higher temperatures than the greenschist facies conditions implied by mineral assemblages elsewhere in the study area (e.g., chlorite–white mica), these rocks may record localized higher-temperature metamorphism, and could possibly represent the edge of the metamorphic high mapped by Green (1971). Local contact metamorphism is not ruled out, as gabbro intrusions occur near both localities, although biotite or chloritoid-bearing assemblages are absent from rocks that host gabbro elsewhere. More investigation is required to resolve the origin of biotite or chloritoid-bearing assemblages encountered in the study area, including additional mapping and petrographic analysis of metamorphic rocks discovered by Green (1971) in the Keno Ladue River and Rankin Creek valleys.

Mineralization

The McQuesten Lake area is located between several Au and polymetallic mineral deposits (Fig. 2), and rock units that are stratigraphically equivalent to some of those mapped in the McQuesten Lake area are known to host mineral deposits in the surrounding region. For example, the Hyland Group hosts the past-producing polymetallic manto-style Clark deposit (Yukon MINFILE 106D 011; Yukon Geological Survey, 2010; Fig. 2). The McKay Hill polymetallic vein deposit (Yukon MINFILE 106D 038; Yukon Geological Survey, 2010; Fig. 2) is hosted by a sequence of Upper Cambrian volcanic and sedimentary rocks (Cobbett, 2022a) that are likely equivalent to those mapped in the study area (Cv; discussed in the “Upper Cambrian volcanic rocks” subsection within the “Whole-rock geochemistry” section).

Quartz veins are common in the mapped area, and typically contain calcite, white mica and/or chlorite. Sulphides are rare and generally comprise pyrite, although several veins contain a reddish-brown material, which is likely a product of weathering or alteration of sulphides. Some wall rocks exhibit gossanous weathering. Quartz veins are predominantly hosted by siliciclastic rocks in the Narchilla and Yusezyu formations of the Hyland Group (Fig. 56a,b), by chert in the Road River Group (OSRc) and by the Keno Hill Quartzite (CTKHQ; Fig. 52f). Less commonly, they are hosted by gabbro (Cg; Fig. 56c) and by the Yusezyu Formation limestone (PHYul) where it has been intruded by gabbro (Fig. 56d,e; Skipton and Maw, 2020). The quartz veins dominantly strike northwest–southeast, parallel to the regional structural grain, but they have variable orientations and locally form networks. As some vein surfaces are lineated (L2; Fig. 52f), regional D2 deformation outlasted vein emplacement in some cases.

Assay results from grab-samples of several quartz veins and altered (e.g., silicified or gossanous) rocks are presented in Skipton (2022a). Anomalously high contents of Au, Ag, Cu, Zn and other elements were detected in a sample from a southeast-dipping quartz vein that contains blue and green minerals (azurite and malachite?; Fig. 56b) and is hosted in quartz arenite (Narchilla Formation, PCHnss), located ~4 km southwest of the Dawson fault (Yukon MINFILE 106D 128; Yukon Geological Survey, 2010).

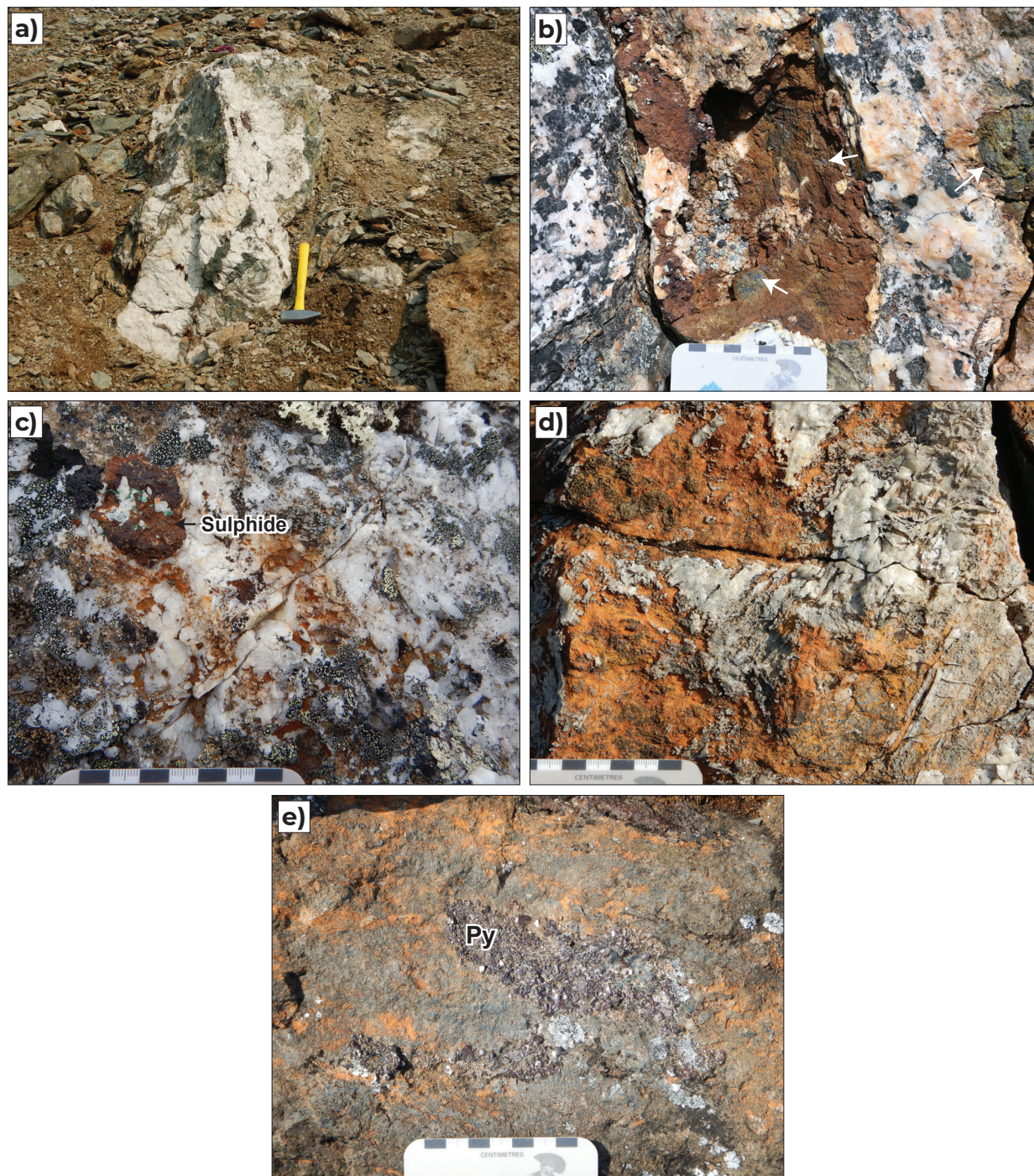


Figure 56. Field photographs of quartz veins with associated alteration and/or mineralization in the McQuesten Lake area. **a)** A northwest-striking, steeply dipping, 1 m-wide quartz vein hosted in green phyllite of the Narchilla Formation (PCHn), containing chlorite, carbonate, and minor rust-coloured alteration material. Hammer for scale is 40 cm long. **b)** Quartz vein containing a reddish-brown alteration material and blue and green minerals (azurite and malachite(?); indicated by white arrows). The quartz vein is southeast-dipping and is hosted in quartz arenite (Narchilla Formation, sandstone member, PCHnss). **c)** Red-brown-weathered sulphide (likely pyrite) in a 2–3 m-wide quartz vein hosted in gabbro (Cg). **(d,e)** Quartz-carbonate veins in orange-weathered carbonate of the Yusezyu Formation limestone (PHYul) near the contact with gabbro (Cg), with locally associated pyrite.

Uranium-lead (U-Pb) zircon geochronology

Laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) methods

Radiometric analyses were conducted at Boise State University (Boise, Idaho, USA). Zircon grains were separated from rocks using standard techniques at Boise State University or, in the case of sample 22DS-019-1-1, at GeoSep Services (Moscow, Idaho, USA). For three of the samples (19DS-002-1-1, 19DS-051-2-1, 19DS-091-1-1), zircon grains with a broad spectrum of representative morphologies were picked using tweezers under a microscope. For the other samples (21DS-177-1-1, 21DS-134-1-1, 22DS-019-1-1), large abundances of zircon grains were placed on the grain mounts indiscriminately, avoiding selection bias (i.e., the 'sandbox method'). A subset of sharply faceted grains was picked from 22DS-019-1-1 and mounted separately. Zircon grains were annealed at 900°C for 60 hours in a muffle furnace, and mounted in epoxy and polished until their centres were exposed. Cathodoluminescence (CL) images were obtained with a JEOL JSM-300 scanning electron microscope and Gatan MiniCL.

Zircon was analyzed by laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) using two different instruments. Samples 19DS-002-1-1, 19DS-051-2-1, and 19DS-091-1-1 used a ThermoElectron X-Series II quadrupole ICP-MS and New Wave Research UP-213 Nd:YAG UV (213 nm) laser ablation system. In-house analytical protocols, standard materials, and data reduction software were used for acquisition and calibration of U-Pb dates and a suite of high field strength elements (HFSE) and rare earth elements (REE). Zircon was ablated with a laser spot of 25 μm wide using fluence and pulse rates of 5 J/cm² and 5 Hz, respectively, during a 45 second analysis (15 sec gas blank, 30 sec ablation) that excavated a pit ~15 μm deep. Ablated material was carried by a 1.2 L/min helium (He) gas stream to the nebulizer flow of the plasma. Dwell times are given in Table A1 in Appendices B–D. Samples 21DS-177-1-1, 21DS-134-1-1, and 22DS-019-1-1 used an iCAP RQ Quadrupole ICP-MS and Teledyne Photon Machines Analyte Excite+ 193 nm excimer laser ablation system with HelEx II Active two-volume ablation cell. In-house analytical protocols, standard materials, and data reduction software were used for acquisition and calibration of U-Pb dates and a suite of HFSE and REE. Zircon was ablated with a laser spot of 20 μm wide using fluence and pulse rates of 3 J/cm² and 10 Hz, respectively, during a 35 second analysis (15 sec gas blank, 20 sec ablation) that excavated a pit ~8 μm deep. Ablated material was carried by a 0.5 L/min He gas stream in the inner cell and a 1.1 L/min He gas stream in the outer cell. Dwell times are given in Appendices E–G.

Background count rates for each analyte were obtained prior to each spot analysis and subtracted from the raw count rate for each analyte. Ablations pits that appear to have intersected glass or mineral inclusions were identified based on titanium (Ti) and phosphorous (P). The U-Pb dates from these analyses are considered valid if the U-Pb ratios appear to have been unaffected by the inclusions. Analyses that appear contaminated by common Pb were rejected based on mass 204 being above baseline. For concentration calculations, background-subtracted count rates for each analyte were internally normalized to ²⁹Si and calibrated with respect to NIST SRM-610 and -612 glasses as the primary standards. Temperature was calculated from the Ti-in-zircon thermometer (Watson et al., 2006). Because there are no constraints on the activity of TiO₂, an average value in crustal rocks of 0.8 was used.

Data for Yusezyu Formation samples (19DS-002-1-1, 19DS-051-2-1, 19DS-091-1-1) were collected in three experiments in July 2020 and one experiment in August 2020. There were two rounds of analysis. In the first round, each grain was analyzed once. Based on the results from the first round, eight grains were analyzed in a second round with 2–3 additional spots in

each grain. Data for samples 21DS-177-1-1 (Keno Hill Quartzite) and 21DS-134-1-1 (Jurassic sandstone) were collected in two experiments in November 2022 and two experiments in December 2022. Data for sample 22DS-019-1-1 (Keno Hill Quartzite) were collected in five experiments in June 2023.

For U-Pb and $^{207}\text{Pb}/^{206}\text{Pb}$ dates, instrumental fractionation of the background-subtracted ratios was corrected and dates were calibrated with respect to interspersed measurements of zircon standards and reference materials. The primary standard Plešovice zircon (Sláma et al., 2008) was used to monitor time-dependent instrumental fractionation based on two analyses for every ten analyses of unknown zircon. A secondary correction to the $^{206}\text{Pb}/^{238}\text{U}$ dates was made based on results from the zircon standards Seiland (531 Ma, unpublished data, Boise State University) and Zirconia (327 Ma, unpublished data, Boise State University), which were treated as unknowns and measured once for every ten analyses of unknown zircon. These results (Appendices B–G) showed a linear age bias of several percent that is related to the ^{206}Pb count rate. The secondary correction is thought to mitigate matrix-dependent variations due to contrasting compositions and ablation characteristics between the Plešovice zircon and other standards (and unknowns).

Radiogenic isotope ratio and age error propagation for all analyses includes uncertainty contributions from counting statistics and background subtraction. For groups of analyses that are collectively interpreted from a weighted mean date, a weighted mean date is first calculated from equivalent dates (probability of fit [POF] >0.05) using Isoplot 3.0 (Ludwig, 2003) with errors on individual dates that do not include a standard calibration uncertainty. A standard calibration uncertainty is then propagated into the error on the date. This uncertainty is the local standard deviation of the polynomial fit to the interspersed primary standard measurements versus time for the time-dependent, relatively larger U/Pb fractionation factor, and the standard error of the mean of the consistently time-invariant and smaller $^{207}\text{Pb}/^{206}\text{Pb}$ fractionation factor. These uncertainties are given in Appendices B–G.

Age interpretations are based on $^{207}\text{Pb}/^{206}\text{Pb}$ dates for analyses with $^{207}\text{Pb}/^{206}\text{Pb}$ and $^{206}\text{Pb}/^{238}\text{U}$ dates >1500 Ma; otherwise, interpretations are based on $^{206}\text{Pb}/^{238}\text{U}$ dates (e.g., Spencer et al., 2016). Analyses with discordance, defined as the relative difference between the $^{207}\text{Pb}/^{235}\text{U}$ and $^{206}\text{Pb}/^{238}\text{U}$ dates, outside of uncertainty of 5% were placed at the bottom of Table A2 in Appendices B–G with strike-throughs, and were not considered in age interpretations. For grains with multiple LA-ICP-MS spot analyses (i.e., in the Yusezyu Formation samples), the weighted mean age of the spots ($\pm 2\%$ error) was used as the age of each grain on probability density plots. Errors on the dates are at 2σ . The LA-ICP-MS data are presented in Appendices B–G.

Chemical abrasion isotope dilution thermal ionization mass spectrometry (CA-TIMS) methods

The U-Pb dates were obtained by the chemical abrasion isotope dilution thermal ionization mass spectrometry (CA-TIMS) method from analyses composed of single zircon fragments or whole individual zircon grains, modified after Mattinson (2005). Zircon was removed from the epoxy mounts for dating based on LA-ICP-MS data. For samples from the Yusezyu Formation (19DS-002-1-1, 19DS-051-2-1, 19DS-091-1-1), the grains were broken, and two fragments were analyzed separately. For samples from the Keno Hill Quartzite (21DS-177-1-1, 22DS-019-1-1) and Jurassic sandstone (21DS-134-1-1), whole individual zircon grains were analyzed separately.

Zircon was put into 3 ml Teflon PFA beakers and loaded into 300 μl Teflon PFA microcapsules. Fifteen microcapsules were placed in a large-capacity Parr vessel and the zircon partially dissolved in 120 μl of 29 M HF for 12 hours at 190°C. Zircon was returned to 3 ml Teflon PFA

beakers, HF was removed, and zircon was immersed in 3.5 M HNO_3 , ultrasonically cleaned for an hour, and fluxed on a hotplate at 80°C for 1 hour. The HNO_3 was removed and zircon was rinsed twice in ultrapure H_2O before being reloaded into the 300 μl Teflon PFA microcapsules (rinsed and fluxed in 6 M HCl during sonication and washing of the zircon) and spiked with the Boise State University mixed ^{233}U - ^{235}U - ^{205}Pb tracer solution (BSU-1B). Zircon was dissolved in Parr vessels in 120 μl of 29 M HF with a trace of 3.5 M HNO_3 at 220°C for 48 hours, dried to fluorides, and re-dissolved in 6 M HCl at 180°C overnight. Uranium and Pb were separated from the zircon matrix using an HCl-based anion-exchange chromatographic procedure (Krogh, 1973), eluted together and dried with 2 μl of 0.05 N H_3PO_4 .

Lead and U were loaded on a single outgassed Re filament in 5 μl of a silica-gel/ H_3PO_4 mixture (Gerstenberger and Haase, 1997), and U and Pb isotopic measurements made on a GV Isoprobe-T multicollector thermal ionization mass spectrometer equipped with an ion-counting Daly detector. Lead isotopes were measured by peak-jumping all isotopes on the Daly detector for 160 cycles, and corrected for $0.16 \pm 0.03\%$ /a.m.u. (1σ) mass fractionation. Transitory isobaric interferences due to high-molecular weight organics, particularly on ^{204}Pb and ^{207}Pb , disappeared within approximately 60 cycles, while ionization efficiency averaged 10^4 cps/pg of each Pb isotope. Linearity (to $\geq 1.4 \times 10^6$ cps) and the associated deadtime correction of the Daly detector were determined by analysis of NBS982. Uranium was analyzed as UO_2^+ ions in static Faraday mode on 10^{12} ohm resistors for 300 cycles, and corrected for isobaric interference of $^{233}\text{U}^{18}\text{O}^{16}\text{O}$ on $^{235}\text{U}^{16}\text{O}^{16}\text{O}$ with an $^{18}\text{O}/^{16}\text{O}$ of 0.00206. Ionization efficiency averaged 20 mV/ng of each U isotope. Uranium mass fractionation was corrected using the known $^{233}\text{U}/^{235}\text{U}$ ratio of the Boise State University tracer solution.

The U-Pb dates and uncertainties were calculated using the algorithms of Schmitz and Schoene (2007), calibration of BSU-1B tracer solution of $^{235}\text{U}/^{205}\text{Pb}$ of 77.93 and $^{233}\text{U}/^{235}\text{U}$ of 1.007066 for, U decay constants recommended by Jaffey et al. (1971), and $^{238}\text{U}/^{235}\text{U}$ of 137.818 (Hiess et al., 2012). The $^{206}\text{Pb}/^{238}\text{U}$ ratios and dates were corrected for initial ^{230}Th disequilibrium using $D_{\text{Th/U}} = 0.20 \pm 0.05$ (1σ) and the algorithms of Crowley et al. (2007), resulting in an increase in the $^{206}\text{Pb}/^{238}\text{U}$ dates of ~ 0.09 Ma. All common Pb in analyses was attributed to laboratory blank and subtracted based on the measured laboratory Pb isotopic composition and associated uncertainty. The U blanks are estimated at 0.013 pg.

For samples from the Keno Hill Quartzite (21DS-177-1-1, 22DS-019-1-1) and Jurassic sandstone (21DS-134-1-1), the dates quoted in the text and figures are $^{206}\text{Pb}/^{238}\text{U}$ dates of individual grains. For samples from the Yusezyu Formation (19DS-002-1-1, 19DS-051-2-1, 19DS-091-1-1), weighted mean $^{206}\text{Pb}/^{238}\text{U}$ dates are calculated from equivalent dates (POF > 0.05) using Isoplot 3.0 (Ludwig, 2003) from the two fragments per grain. Errors on weighted mean dates are given as $\pm x / y / z$, where x is the internal error based on analytical uncertainties only, including counting statistics, subtraction of tracer solution, and blank and initial common Pb subtraction, y includes the tracer calibration uncertainty propagated in quadrature, and z includes the ^{238}U decay constant uncertainty propagated in quadrature. Internal errors should be considered when comparing our dates with $^{206}\text{Pb}/^{238}\text{U}$ dates from other laboratories that used the same tracer solution or a tracer solution that was cross-calibrated using EARTHTIME gravimetric standards. Errors including the uncertainty in the tracer calibration should be considered when comparing our dates with those derived from other geochronological methods using the U-Pb decay scheme (e.g., LA-ICP-MS). Errors including uncertainties in the tracer calibration and ^{238}U decay constant (Jaffey et al., 1971) should be considered when comparing our dates with those derived from other decay schemes (e.g., $^{40}\text{Ar}/^{39}\text{Ar}$, ^{187}Re - ^{187}Os). Errors are at 2σ . The CA-TIMS data are provided in Appendix H.

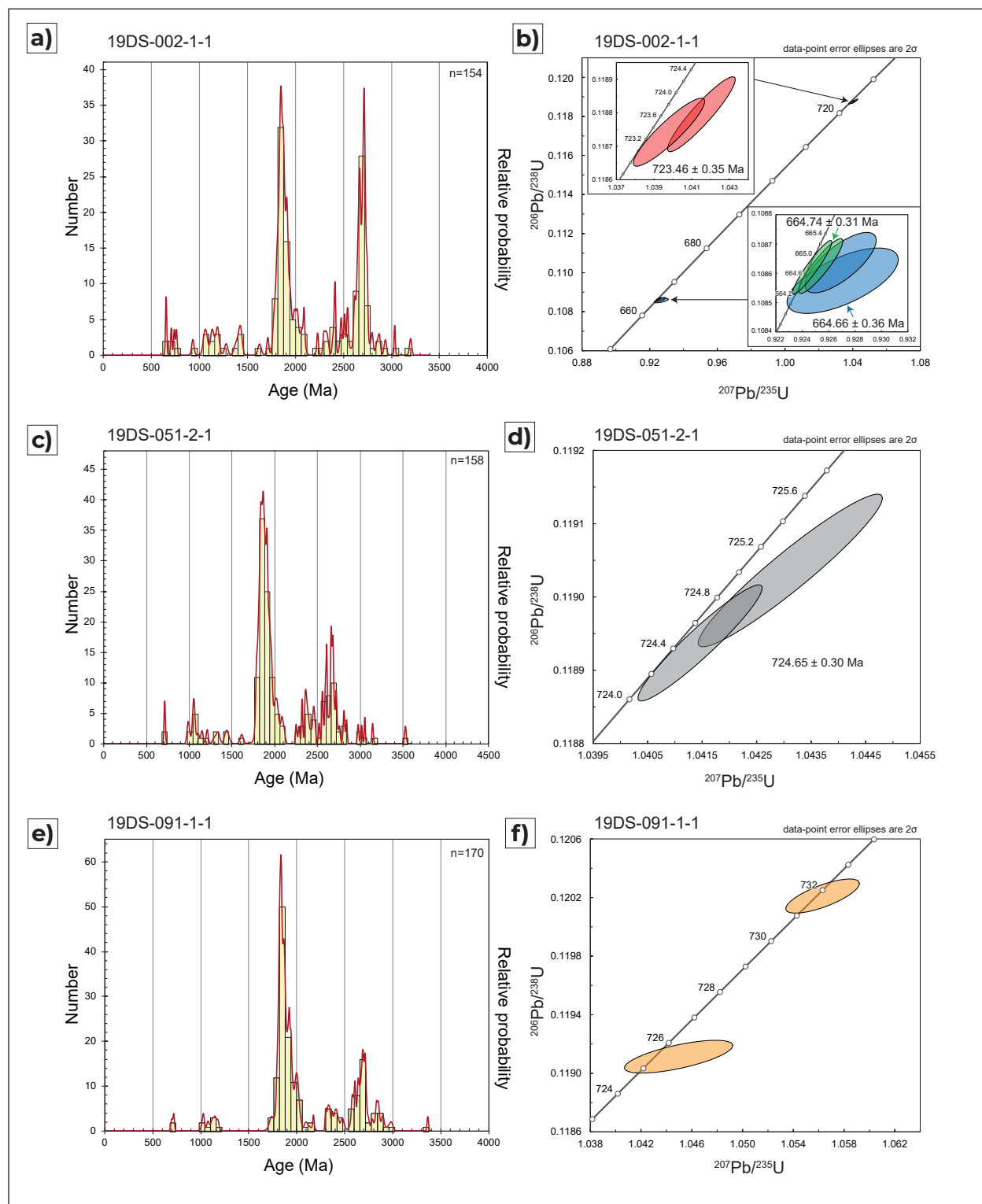


Figure 57. Probability density (a,c,e) and Concordia (b,d,f) plots of detrital zircon U-Pb geochronological data for three sandstone samples from the Yusezyu Formation, including two quartz grit sandstones (19DS-002-1-1, 19DS-051-2-1) and a subarkose (19DS-091-1-1). Probability density plots present laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) data, and histogram bin width is 60 Myr. Concordia plots present chemical abrasion isotope dilution thermal ionization mass spectrometry (CA-TIMS) data for the youngest zircon grains that were first dated by LA-ICP-MS. Each ellipse represents data from a grain fragment, and ellipses that share the same colour correspond to fragments from the same grain. The ages presented on the Concordia plots are weighted mean $^{206}\text{Pb}/^{238}\text{U}$ ages ($\pm 2\sigma$ uncertainties) of analyses from each pair of grain fragments.

Zircon uranium-lead (U-Pb) geochronology results

Hyland Group, Yusezyu Formation

Zircon U-Pb geochronology was conducted on three sandstone samples from the Yusezyu Formation to determine maximum depositional ages and characterize the detrital source populations. The samples are from the northeastern part of the McQuesten Lake study area (Fig. 3) and, together, they form a south-to-north transect through the Hyland Group rocks in the study area that are located between the Tombstone thrust and the Dawson fault.

Sample 19DS-002-1-1 (134.8635350°W 64.2139110°N)

Sample 19DS-002-1-1 consists of quartz grit sandstone from the Yusezyu Formation 'mixed' unit (PHYM; Fig. 3). One hundred forty-nine zircon grains from sample 19DS-002-1-1 yielded dates between 3195 ± 23 and 930 ± 24 Ma, and the main peaks in the population are at ca. 2.1–1.7 Ga and ca. 2.8–2.6 Ga (Fig. 57a). Five additional grains that were analyzed 3–4 times each yielded weighted mean dates of 759 ± 14 Ma (Mean Square of the Weighted Deviates [MSWD] = 0.6, POF = 0.54), 736 ± 12 Ma (MSWD = 1.2, POF = 0.30), 705 ± 14 Ma (MSWD = 0.3, POF = 0.75), 652 ± 12 Ma (MSWD = 0.2, POF = 0.87), and 651 ± 12 Ma (MSWD = 0.9, POF = 0.47). The grains that yielded the three youngest weighted mean dates were each broken and two fragments were analyzed separately by CA-TIMS. The weighted mean dates from the CA-TIMS analyses are: $723.46 \pm 0.35 / 0.49 / 0.89$ Ma (MSWD = 0.8, POF = 0.38), $664.74 \pm 0.31 / 0.44 / 0.81$ Ma (MSWD = 0.0, POF = 0.94), and $664.66 \pm 0.36 / 0.48 / 0.83$ Ma (MSWD = 1.0, POF = 0.32; Fig. 57b). The youngest date of 664.66 ± 0.36 Ma is interpreted to be the maximum depositional age.

Sample 19DS-051-2-1 (134.8637500°W 64.1774530°N)

Sample 19DS-051-2-1 comprises quartz grit sandstone (Fig. 12b) from the Yusezyu Formation sandstone-dominated unit (PHYSS; Fig. 3). One hundred fifty-six zircon grains from 19DS-051-2-1 yielded dates between 3527 ± 19 and 984 ± 26 Ma, with the main peaks in the population at ca. 2.1–1.7 Ga and ca. 2.8–2.5 Ga (Fig. 57c). Two additional grains that were analyzed 3–4 times each yielded weighted mean dates of 713 ± 10 Ma (MSWD = 0.0, POF = 1.00) and 707 ± 13 Ma (MSWD = 1.1, POF = 0.35). The grain that yielded the 713 ± 10 Ma weighted mean date was broken and two fragments were analyzed separately by CA-TIMS. The weighted mean date from the CA-TIMS analyses is $724.65 \pm 0.30 / 0.45 / 0.87$ Ma (MSWD = 3.4, POF = 0.06; Fig. 57d). This date (724.65 ± 0.30 Ma) is the interpreted maximum depositional age.

Sample 19DS-091-1-1 (134.8923480°W 64.2456980°N)

Sample 19DS-091-1-1 consists of subarkose from the Yusezyu Formation sandstone-dominated unit (PHYSS; Fig. 3). One hundred sixty-eight zircon grains from 19DS-091-1-1 yielded dates between 3365 ± 16 and 1022 ± 36 Ma, with the main peaks at ca. 2.1–1.7 Ga and ca. 2.9–2.5 Ga (Fig. 57e). In addition, one grain that was analyzed three times yielded a weighted mean date of 721 ± 11 Ma (MSWD = 0.73, POF = 0.51), and another grain that was analyzed once yielded a date of 700 ± 19 Ma. The grain that was analyzed three times was broken and two fragments were analyzed separately by CA-TIMS. The CA-TIMS dates are 731.77 ± 0.55 and 725.46 ± 0.53 Ma (Fig. 57f). The disagreement between the dates indicates that the grain has an inherited component or that Pb loss was not mitigated by chemical abrasion. Considered together, the LA-ICP-MS and CA-TIMS dates from the youngest grains suggest a maximum depositional age of ca. 730–720 Ma.

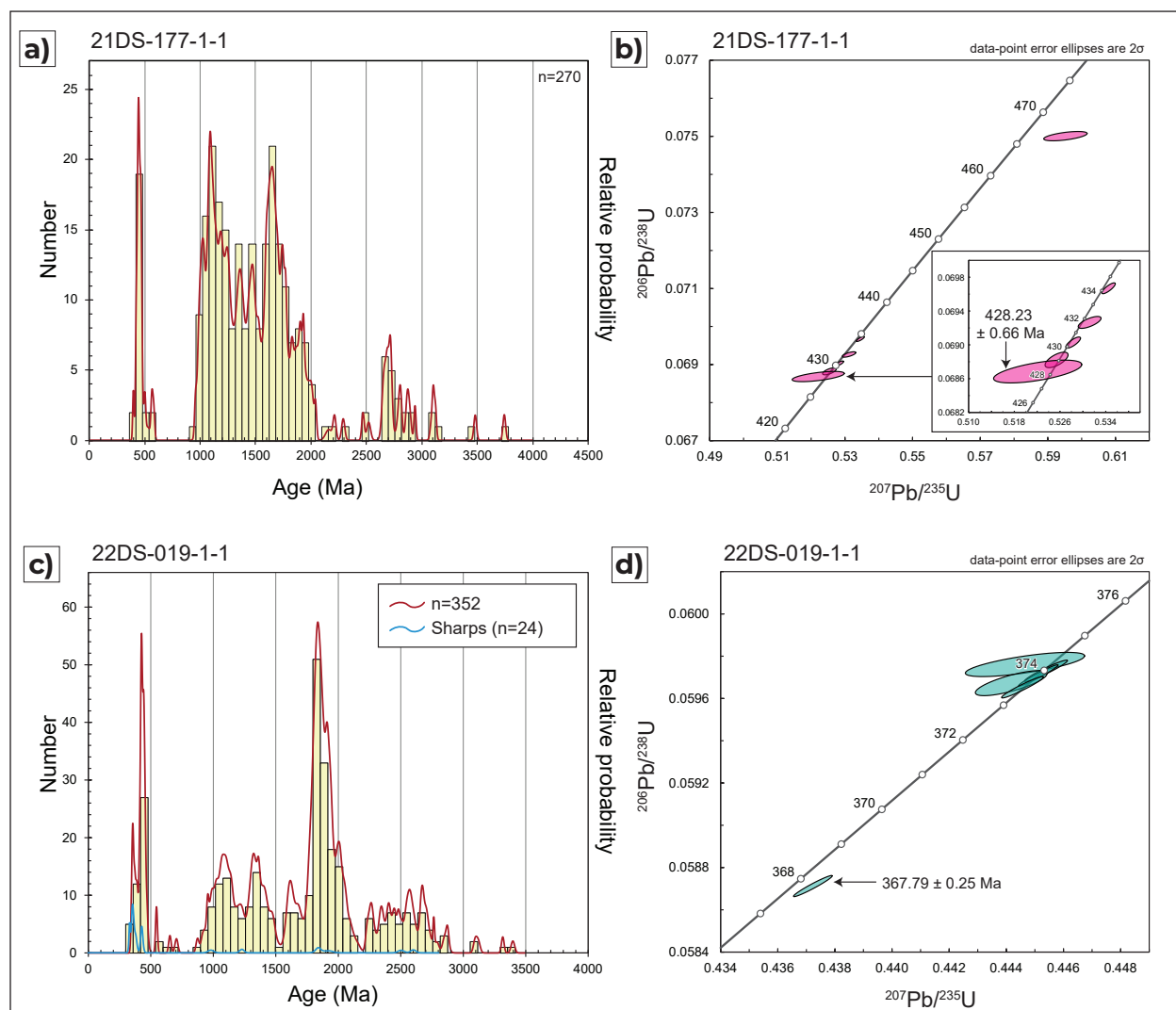


Figure 58. Probability density (a,c) and Concordia (b,d) plots of detrital zircon U-Pb geochronological data for two quartzite samples from the Keno Hill Quartzite (21DS-177-1-1, 22DS-019-1-1). Probability density plots present LA-ICP-MS data, and histogram bin width is 60 Myr. In c), the blue curve (with no corresponding histogram) is the probability density curve for sharply faceted zircon grains ('sharps'). Concordia plots present CA-TIMS data for selected zircon grains that were first dated by LA-ICP-MS. Each ellipse represents data from an individual zircon grain. The ages presented on Concordia plots are $^{206}\text{Pb}/^{238}\text{U}$ ages ($\pm 2\sigma$ uncertainties) of single ellipses, which correspond to the youngest zircon grain dated by CA-TIMS in each sample.

Tsichu Group, Keno Hill Quartzite

Zircon U-Pb geochronology was conducted on two quartzite samples from the Keno Hill Quartzite (CTKHQ; Tsichu Group) to determine maximum depositional ages and characterize the detrital source populations. Sample 21DS-177-1-1 was collected from the Keno Hill Quartzite in the southwestern part of the study area, located in the footwall of the Robert Service thrust, and in the hanging wall of the Tombstone thrust (Fig. 3). Sample 22DS-019-1-1 was collected from near the base of the Keno Hill Quartzite in the southern part of the map area (Davidson Range), located in the footwall of the Tombstone thrust (Fig. 3).

Sample 21DS-177-1-1 (135.3501704°W 64.2141459°N)

Sample 21DS-177-1-1 consists of fine to medium-grained, relatively equigranular quartzite (Fig. 37a,b). Two hundred sixty-nine zircon grains from sample 21DS-177-1-1 yielded dates between 3742 ± 24 and 420 ± 13 Ma, and the main peaks in the population are at

ca. 600–420 Ma, ca. 2100–900 Ma and ca. 3.1–2.6 Ga (Fig. 58a). An additional grain yielded a date of 395 ± 13 Ma, a younger date that may reflect Pb loss. Six grains from among those yielding young LA-ICP-MS dates were analyzed using CA-TIMS, and yielded dates of 466.24 ± 0.60 Ma, 434.16 ± 0.31 Ma, 431.73 ± 0.35 Ma, 430.29 ± 0.33 Ma, 429.05 ± 0.45 Ma and 428.23 ± 0.66 Ma (Fig. 58b). The grain that produced the oldest CA-TIMS date of ca. 466 Ma is interpreted to have contained an inherited core. The grain that yielded the youngest LA-ICP-MS date of ca. 395 Ma was not dated by CA-TIMS because it was lost during plucking. The youngest CA-TIMS date of 428.23 ± 0.66 Ma is interpreted as the maximum depositional age of the sample.

Sample 22DS-019-1-1 (135.0433920°W 64.0658879°N)

Quartzite sample 22DS-019-1-1 consists of a fine-grained quartz matrix that surrounds fine to medium-grained, angular to subrounded quartz clasts (Fig. 37e,f). Three hundred fifty-two zircon grains yielded LA-ICP-MS dates between 3397 ± 29 and 347 ± 14 Ma, with the main peaks in the population at ca. 500–350 Ma and 2.2–1.6 Ga (Fig. 58c). Additionally, twenty-four sharply faceted grains yielded LA-ICP-MS dates between 2596 ± 42 and 330 ± 14 Ma ('sharps' in Fig. 58c). Six sharply faceted grains from among those yielding young LA-ICP-MS dates were analysed using CA-TIMS, producing dates of 374.17 ± 0.28 Ma, 373.99 ± 0.25 Ma, 373.85 ± 0.25 Ma, 373.63 ± 0.29 Ma, 373.52 ± 0.25 Ma and 367.79 ± 0.25 Ma (Fig. 58d). The youngest CA-TIMS date of 367.79 ± 0.25 Ma is interpreted as the maximum depositional age of the sample.

Jurassic sandstone

Sample 21DS-134-1-1 (135.2717816°W 64.2804348°N)

Zircon U-Pb geochronology was conducted on quartz arenite (Jss; sample 21DS-134-1-1) that overlies Pennsylvanian(?) to Permian limestone of the Tahkandit Formation. The main objectives for geochronological analysis were to determine the maximum depositional age of the sandstone, and whether it may share affinity with the overlying Earn Group, or forms part of a younger sedimentary sequence. Sample 21DS-134-1-1 is a quartz arenite that mostly consists of medium-grained, equigranular quartz grains (Fig. 41). Five hundred eleven zircon grains yielded dates ranging from 3225 ± 34 to 150 ± 4 Ma, with major peaks in the population at ca. 700–300 Ma, ca. 2100–900 Ma, and ca. 3.0–2.5 Ga (Fig. 59a). Nine grains with LA-ICP-MS dates ranging from Silurian to Jurassic were analysed by CA-TIMS, and yielded dates of 537.78 ± 0.41 Ma, 433.54 ± 0.32 Ma, 384.57 ± 0.28 Ma, 347.19 ± 0.25 Ma, 325.53 ± 0.27 Ma, 256.23 ± 0.19 Ma, 251.78 ± 0.18 Ma, 192.58 ± 0.16 Ma and 166.85 ± 0.13 Ma (Fig. 59b–f). The oldest grain dated by CA-TIMS produced a discordant analysis with a $^{206}\text{Pb}/^{238}\text{U}$ age of ca. 538 Ma and contains an inherited core. The youngest CA-TIMS date of 166.85 ± 0.13 Ma is interpreted to be the maximum depositional age of the sample.

Whole-rock geochemistry

Methods

Forty-nine whole-rock samples from the McQuesten Lake study area were analyzed for major and trace elements at ALS Canada Ltd. (Vancouver, BC). The sample suite consists of ten samples from Upper Cambrian volcanic rocks (Cv), six samples from Cambrian to Silurian(?) gabbro and hornblende diorite intrusions (Cg), one sample from volcanic rocks in the Ordovician to Devonian(?) Middle Bouvette Formation (ODBmv), one sample from a Paleozoic to Mesozoic(?) mafic intrusion (PMm), and twenty-one samples from Triassic

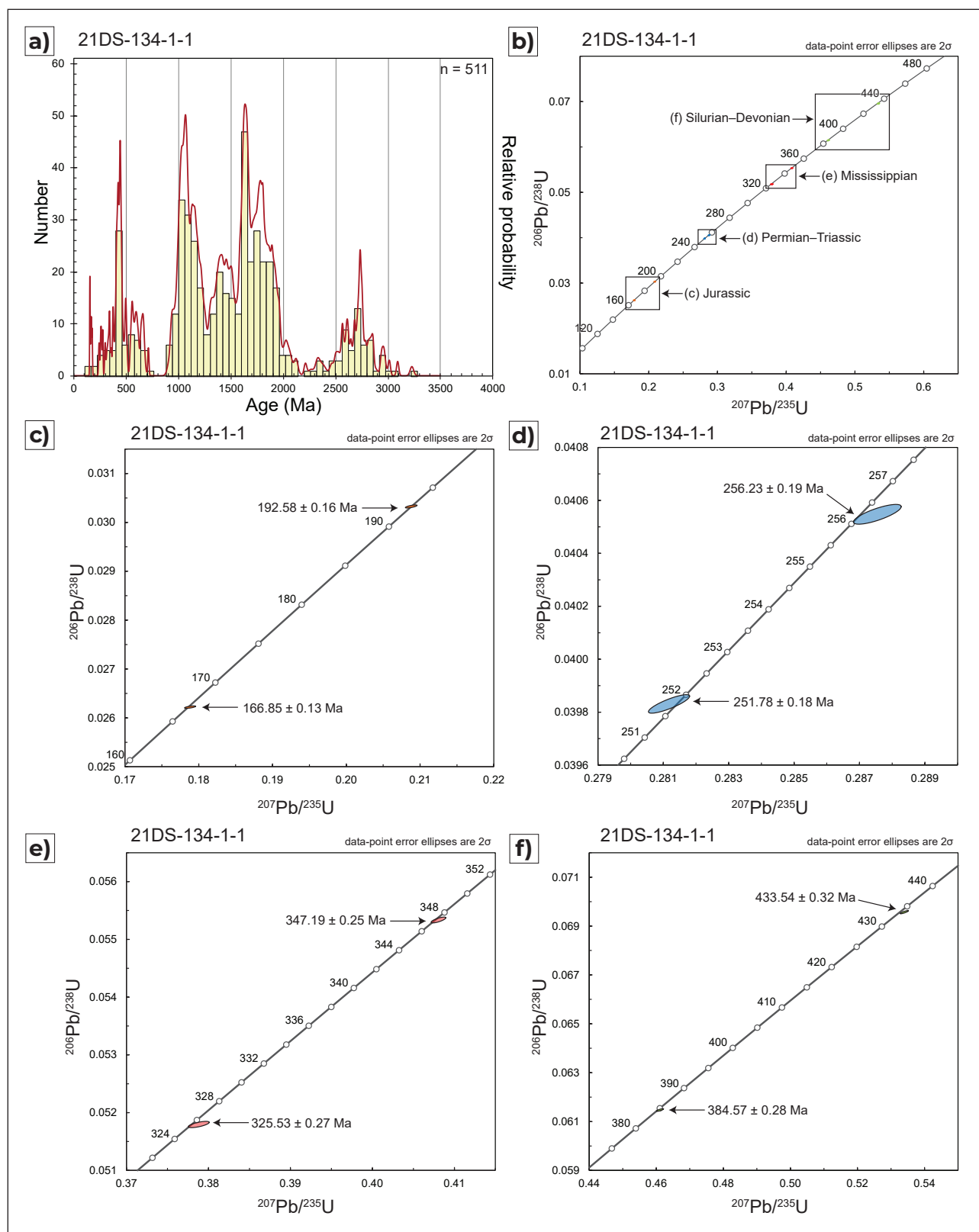


Figure 59. Probability density a) and Concordia (b–f) plots of detrital zircon U–Pb geochronological data for quartz arenite sample 21DS-134-1-1. The probability density plot presents LA-ICP-MS data, and histogram bin width is 60 Myr. Concordia plots present CA-TIMS data for selected zircon grains that were first dated by LA-ICP-MS. Each ellipse represents data from an individual zircon grain. Concordia plot in b) shows all CA-TIMS data for the sample, except for one discordant analysis with a $^{206}\text{Pb}/^{238}\text{U}$ date of ca. 538 Ma. More detailed Concordia plots in (c–f) present the CA-TIMS data by age group. The ages presented on Concordia plots are $^{206}\text{Pb}/^{238}\text{U}$ dates ($\pm 2\sigma$ uncertainties) of single ellipses.

gabbro sills of the Galena suite (TG). Major elements were analyzed using X-ray fluorescence (XRF). Trace elements were determined using lithium borate fusion prior to acid or aqua regia dissolution and analyses by inductively coupled plasma mass spectrometry (ICP-MS). Whole-rock geochemical data are provided in Appendix I. A preliminary discussion of whole-rock geochemical results is provided below. A more comprehensive geochemical interpretation would require additional comparisons with geochemical datasets from the region and, in some cases, additional geochemical samples from the McQuesten Lake area.

Alteration

Major elements, especially the alkalis, are mobile in fluids associated with hydrothermal alteration and metamorphism, whereas most HFSE (e.g., Ti, Zr, Hf, Nb, Ta), the REE (e.g., La, Lu, and to a lesser extent, Eu) and some trace elements (e.g., Cr, Ni, Sc, V) are comparatively immobile (e.g., Piercey et al., 2006; English et al., 2010). Therefore, the discussion of whole-rock geochemical results provided below uses mainly trace element compositions to characterize each rock unit and investigate tectonic affinities. The compositions are plotted on the total-alkali vs. silica (TAS) diagram of LeBas et al. (1986) for reference, however, given the mobility of major elements, the Nb/Y vs. Zr/Ti diagram of Pearce (1996, after Winchester and Floyd, 1977) is considered more reliable for rock classification. Significant alteration is indicated by elevated loss-on-ignition (LOI) values in several samples (e.g., LOI > 4%), especially those from the Upper Cambrian volcanic sequence (Cv) and from Cambrian to Silurian(?) gabbroic intrusions (Cg; Appendix I). Intense alteration is also indicated by the abundance of secondary minerals (including chlorite, carbonate, and sericite) in the analyzed rock units, as documented in petrographic and field descriptions (provided above; Figs. 8, 24, 42c, 43, 44, 46). The altered samples are included in the preliminary discussion of geochemical results presented in this report. For more in-depth interpretations, the effects of alteration on the igneous compositions of the samples should be considered (e.g., Spitz and Darling, 1978; Piercey et al., 2002).

Results

Upper Cambrian volcanic rocks (Cv)

The whole-rock geochemistry samples from Upper Cambrian volcanic rock unit (Cv) include seven mafic volcanoclastic rocks and three mafic volcanic rocks. The whole-rock compositions of the volcanic and volcanoclastic rocks plot in the tephrite/basanite, basalt and foidite compositional fields on the total-alkali vs. silica diagram of LeBas et al. (1986; Fig. 60a) and span the boundary between the alkali basalt and foidite compositional fields on the classification diagram of Pearce (1996, after Winchester and Floyd, 1977; Fig. 60b). Tectonic discrimination diagrams suggest that the Upper Cambrian volcanic rocks (Cv) have alkaline compositions that are similar to those of within-plate alkali basalts (Fig. 61). The Upper Cambrian volcanic rocks (Cv) from the McQuesten Lake area have similar trace element compositions (Fig. 60c) and overlapping compositional fields on classification diagrams (Fig. 60a,b) and tectonic discrimination diagrams (Fig. 61) as the Upper Cambrian volcanic rocks from McKay Hill (Old Cabin Formation; dark grey field in Figures 60 and 61; Cobbett et al., 2025). Together with evidence from field mapping and aeromagnetic data (discussed above in the "Upper Cambrian volcanic rocks" section), these geochemical similarities support a correlation between the two units. The Upper Cambrian volcanic rocks at McKay Hill have been interpreted as a component of more extensive, rift-related magmatism that occurred broadly along the Dawson fault during the final breakup of Rodinia in the late Cambrian (Cobbett et al., 2025).

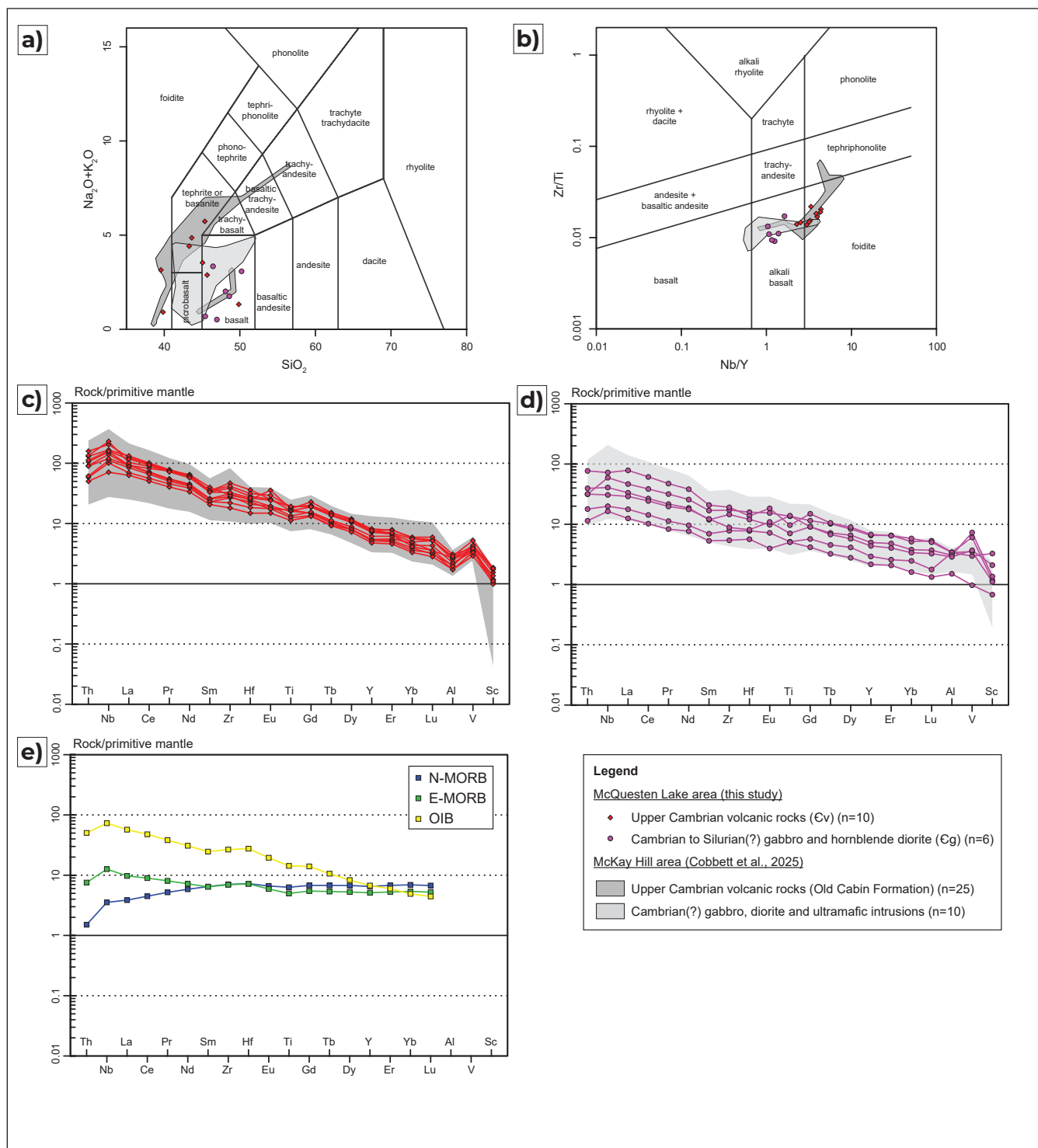


Figure 60. (a–d) Whole-rock geochemical compositions of Upper Cambrian volcanic rocks (Ev; red diamonds) and Cambrian to Silurian(?) gabbro and hornblende diorite (Cg; pink circles) from the McQuesten Lake area. The compositional fields of Upper Cambrian volcanic rocks of the Old Cabin Formation (dark grey) and Cambrian or younger mafic-to-ultramafic intrusions (light grey) from the McKay Hill area are shown for comparison (from Cobbett et al., 2025). **a)** Total alkali-silica diagram of LeBas et al. (1986). Two Upper Cambrian volcanic rock samples (Ev) are not shown, as they contain <35 wt% SiO_2 . **b)** Zr/Ti vs. Nb/Y diagram of Pearce (1996), after Winchester and Floyd (1977). **(c,d)** Multi-element plots showing selected trace element compositions normalized to the primitive mantle values of McDonough and Sun (1995). **e)** Multi-element plot showing representative trace element compositions of normal mid-ocean ridge basalt (N-MORB), enriched mid-ocean ridge basalt (E-MORB) and oceanic island basalt (OIB) from Sun and McDonough (1989), for comparison with whole-rock compositions in this study.

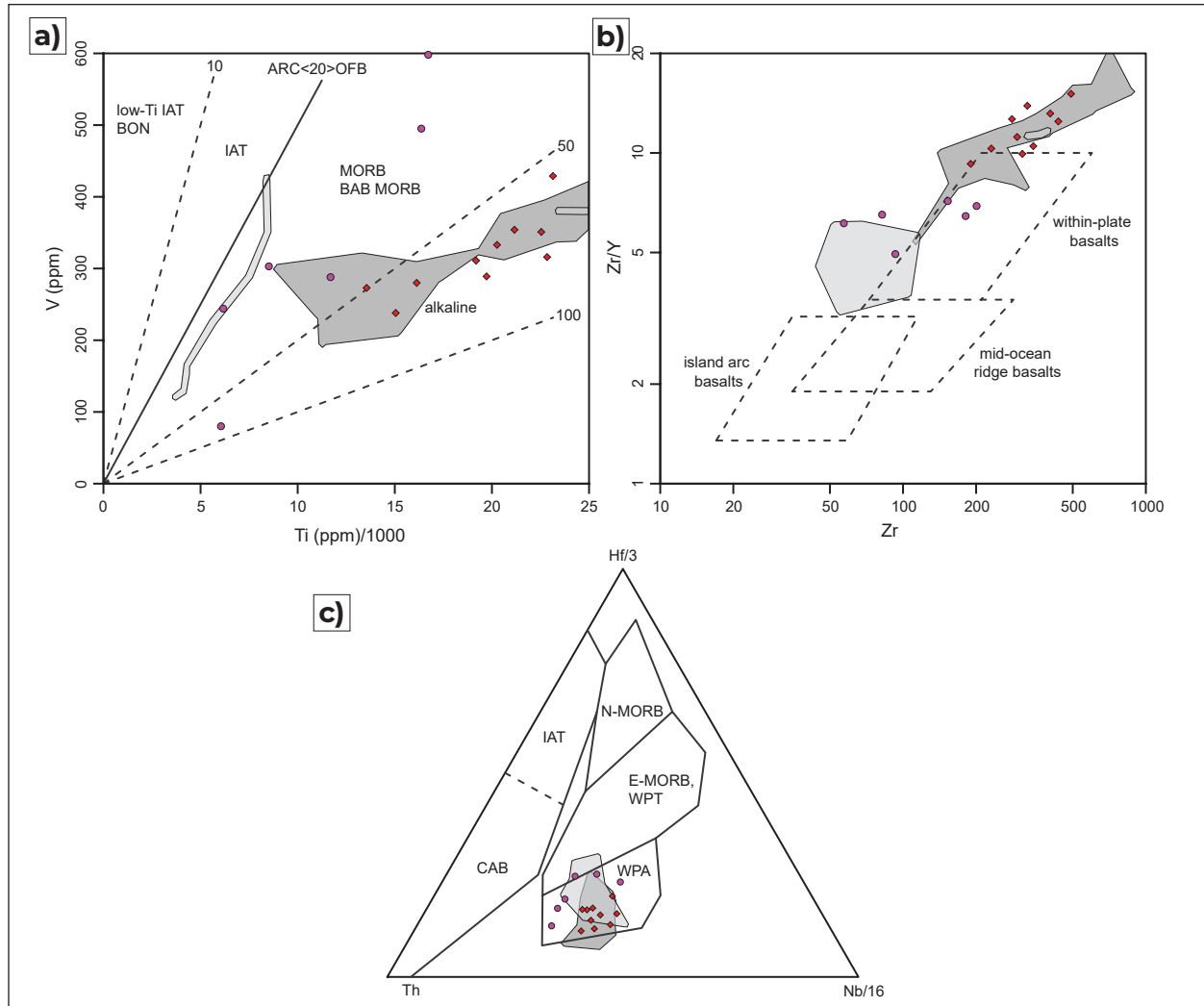


Figure 61. Whole-rock geochemical compositions of Upper Cambrian volcanic rocks (€v; red diamonds) and Cambrian to Silurian(?) gabbro and hornblende diorite (€g; pink circles) from the McQuesten Lake area plotted on tectonic discrimination diagrams of a) Shervais (1982), b) Pearce and Norry (1979) and c) Wood (1980). The compositional fields of Upper Cambrian volcanic rocks of the Old Cabin Formation (dark grey) and Cambrian or younger mafic to ultramafic intrusions (light grey) from the McKay Hill area are shown for comparison (from Cobbett et al., 2025).

Cambrian to Silurian(?) gabbro (€g)

The whole-rock geochemistry samples from the Cambrian to Silurian(?) gabbro unit (€g) comprise five gabbro samples and one sample of melanocratic hornblende diorite. The whole-rock geochemistry suggests that the gabbro and hornblende diorite intrusions have alkali basaltic compositions (Fig. 60a,b), with trace element patterns that are transitional between those of typical oceanic island basalt and enriched mid-ocean ridge basalt (Fig. 60d,e). Tectonic discrimination diagrams suggest that the gabbro and hornblende diorite samples have compositions that are transitional between those of within-plate alkali basalt and enriched mid-ocean ridge basalt (Fig. 61). In general, the samples are geochemically similar to gabbro intrusions hosted by Hyland Group and Road River Group strata and Old Cabin Formation volcanic rocks in the McKay Hill area (light grey field in Figures 60 and 61; Cobbett, 2022; Cobbett et al., 2025), suggesting that the two groups of intrusions may be equivalent.

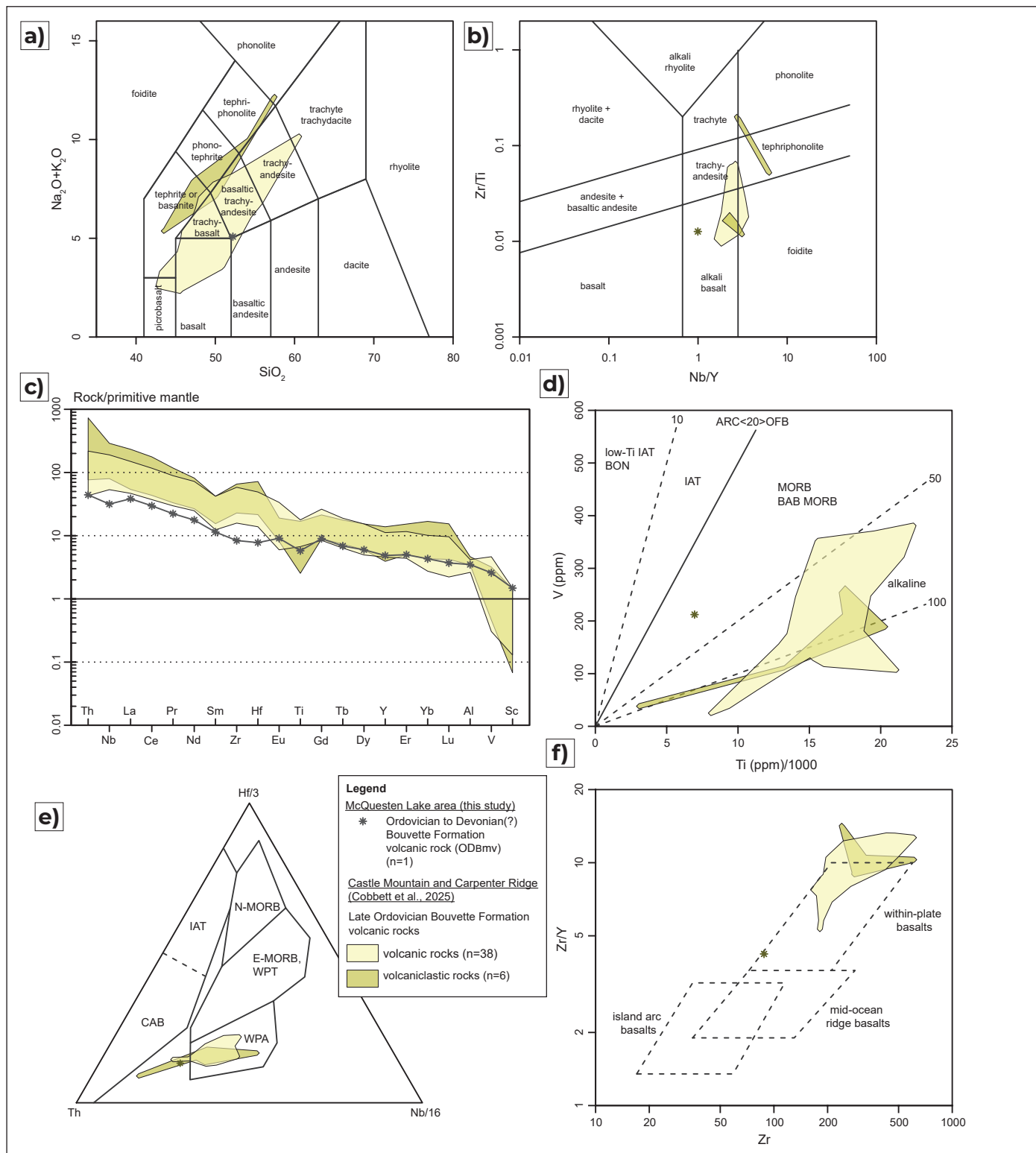


Figure 62. Whole-rock geochemical composition of a mafic volcanic rock from the middle Bouvette Formation (ODBmv; grey asterisks) from the McQuesten Lake area. **a)** Total alkali-silica diagram of LeBas et al. (1986). **b)** Zr/Ti vs. Nb/Y diagram of Pearce (1996), after Winchester and Floyd (1977). **c)** Multi-element diagram showing selected trace element compositions normalized to the primitive mantle values of McDonough and Sun (1995). **d)** $\text{Ti}/1000$ vs. V tectonic discrimination diagram of Shervais (1982). **e)** Th - $\text{Hf}/3$ - $\text{Nb}/16$ tectonic discrimination diagram of Wood (1980). **f)** Zr vs. Zr/Y tectonic discrimination diagram of Pearce and Norry (1979). The whole-rock geochemical compositional fields of volcanic and volcaniclastic rocks from the Bouvette Formation at Castle Mountain and Carpenter Ridge (data from Cobbett et al., 2025) are shown for comparison.

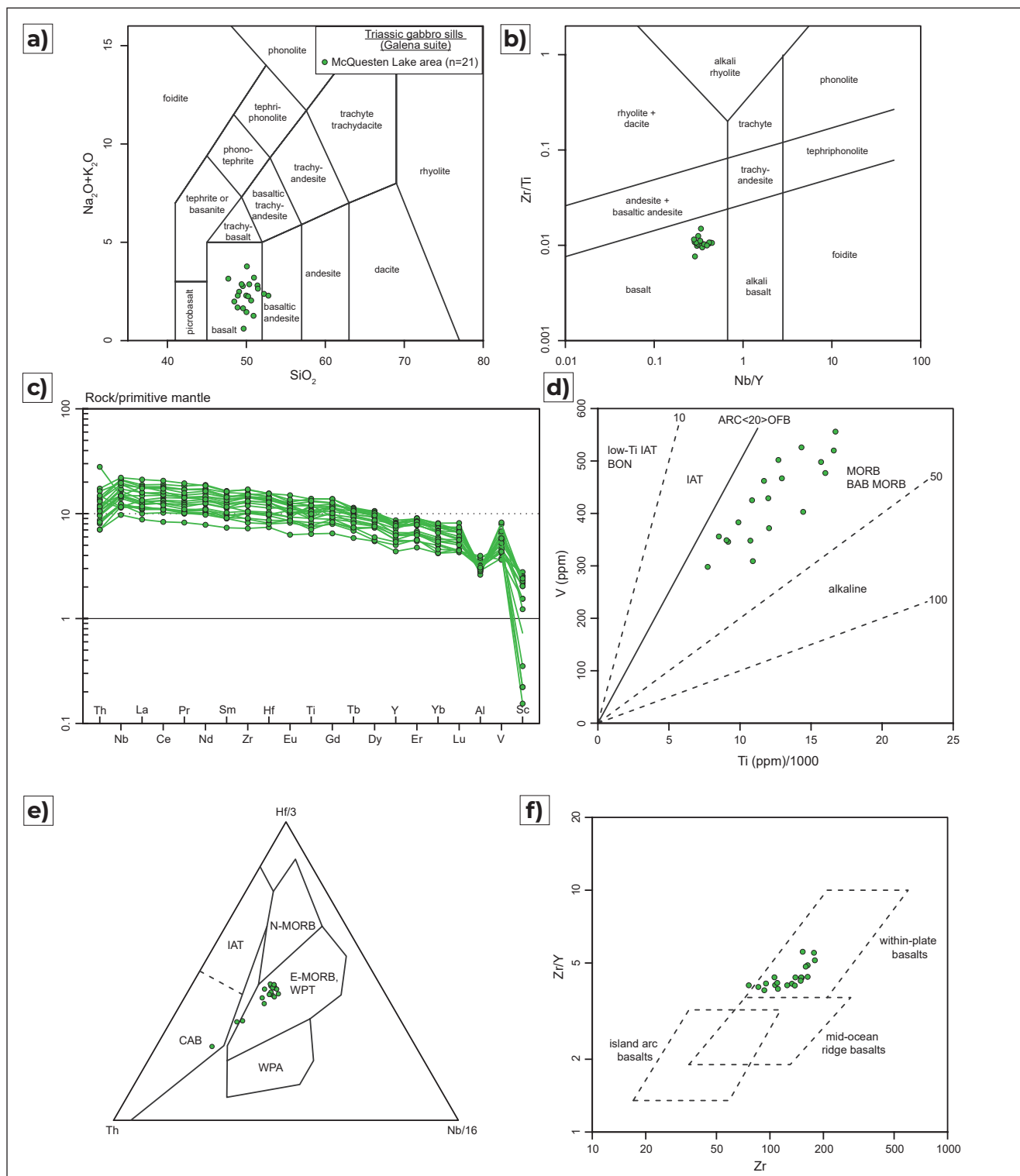


Figure 63. Whole-rock geochemical compositions of gabbro sills of the Galena suite (TG; green circles) from the McQuesten Lake area. **a)** Total alkali-silica diagram of LeBas et al. (1986). **b)** Zr/Ti vs. Nb/Y diagram of Pearce (1996), after Winchester and Floyd (1977). **c)** Multi-element plots showing selected trace element compositions normalized to the primitive mantle values of McDonough and Sun (1995). **d)** Ti/1000 vs. V tectonic discrimination diagram of Shervais (1982). **e)** Th-Hf/3-Nb/16 tectonic discrimination diagram of Wood (1980). **f)** Zr vs. Zr/Y tectonic discrimination diagram of Pearce and Norry (1979).

Ordovician to Devonian(?) middle Bouvette Formation volcanic rocks (ODBmv)

Whole-rock geochemical analysis was conducted on one sample of clinopyroxene-phyric basalt (Fig. 8) from the middle Bouvette Formation (ODBmv) in the Beaver River Valley. The whole rock composition suggests that it has an alkali basalt composition (Fig. 62a,b) that is transitional between the compositions of typical within-plate alkali basalt and mid-ocean ridge basalt (Fig. 62c–f). The sample shares some geochemical similarities with other mafic volcanic and volcanoclastic rocks from the Bouvette Formation from north of the Beaver River Valley (Castle Mountain and Carpenter Ridge; locations illustrated in Figure 2; yellow fields in Figure 62; data from Cobbett et al., 2025), including in total alkali-silica (Fig. 62a) and trace element patterns (Fig. 62c). However, compositional differences between the McQuesten Lake sample and the Castle Mountain/Carpenter Ridge samples are highlighted by tectonic discrimination diagrams (Fig. 62d,f). Additional whole-rock geochemistry samples are required from the volcanic rock unit in the middle Bouvette Formation in the McQuesten Lake area to evaluate its tectonic affinity and potential correlation with other volcanic or intrusive units.

Paleozoic to Mesozoic(?) mafic intrusion (PMm)

Whole-rock geochemical analysis was performed on one sample from a mafic intrusion (**PMm**) of unknown age (assumed Paleozoic to Mesozoic[?]), hosted by the Ordovician to Silurian Road River Group. The sample is mostly comprised of secondary minerals, including abundant chlorite and carbonate (Fig. 44). As there is only one geochemistry sample from this unit and it is strongly altered (LOI = 10.73%), its geochemistry is not discussed here (the data are provided in Appendix I).

Triassic Galena suite: gabbro sills (TG)

Whole-rock geochemical compositions suggest that the Triassic gabbro sills of the Galena suite in the McQuesten Lake area have basaltic to basaltic-andesitic compositions (Fig. 63a,b). The REE compositions of the sills are similar to that of typical enriched mid-ocean ridge basalt (Fig. 63c). On tectonic discrimination diagrams, the sills plot in compositional fields that correspond to mid-ocean ridge basalt, within-plate tholeiite, and within-plate basalts (Fig. 63d–f).

Carbon and oxygen isotopes

Methods

Carbon and oxygen isotopic analyses were conducted on thirty-nine carbonate rock samples collected from thirty-five different localities (field mapping stations) to enable preliminary isotopic characterization of carbonate-bearing rock units in the study area, including the Gametrail Formation (PHG; four samples), the Yusezyu Formation limestone unit (PHYul; twenty-one samples), the Yusezyu Formation sandstone-dominated unit ('mixed' member; PHYssm; one sample), the Bouvette Formation (ODBl; seven samples), the Earn Group carbonate unit (DMEC; two samples) and the Takhandit Formation (PPT; four samples). The samples were cut perpendicular to bedding (+ foliation) and ~5–10 mg of powder was drilled from each sample using a drill press with a dental carbide drill bit, avoiding secondary features such as veins, cements and siliciclastic components. Fourteen samples of Yusezyu Formation limestone unit were analyzed in 2020 at the Stable Isotope Geochemistry Laboratory at Dartmouth College (Hanover, New Hampshire, USA) and the remainder of the samples were analyzed in 2022 at the Pacific Centre for Isotopic and Geochemical Research at the University

of British Columbia (UBC; Vancouver, BC). The carbon and oxygen isotopic data are provided in Appendix J.

For the samples analyzed at Dartmouth College, carbonate powders were reacted with phosphoric acid (H_3PO_4) at 70°C on a GasBench preparation device, which was attached to a continuous flow isotope ratio mass spectrometer (ThermoFinnigan DeltaPlus XL). The $\delta^{13}\text{C}_{\text{carb}}$ and $\delta^{18}\text{O}_{\text{carb}}$ isotopic data were acquired simultaneously and are reported in standard delta notation as the per mil difference from Vienna Pee Dee Belemnite (VPDB). Standards were run to monitor precision and accuracy, using 11-3 sample-standard bracketing. Two international standards (NBS-18 and Elemental Microanalysis Carrara Marble) were used, as well as one internal laboratory standard. Sample measurements were made relative to an internal CO_2 gas standard and then converted to the VPDB scale, based on the known composition of NBS-18 ($\delta^{13}\text{C}_{\text{carb}} = -5.01$; $\delta^{18}\text{O}_{\text{carb}} = -23.20$) and Elemental Microanalysis Carrara Marble ($\delta^{13}\text{C}_{\text{carb}} = 2.10$; $\delta^{18}\text{O}_{\text{carb}} = -2.01$). The measured precisions (1σ) were 0.15‰ and 0.2‰ for $\delta^{13}\text{C}_{\text{carb}}$ and $\delta^{18}\text{O}_{\text{carb}}$, respectively.

For the samples analyzed at UBC, the $\delta^{13}\text{C}_{\text{carb}}$ and $\delta^{18}\text{O}_{\text{carb}}$ isotopic analyses were carried out using the gas bench and a Delta Plus XL mass spectrometer in continuous flow mode. The samples were acidified with 99% phosphoric acid (H_3PO_4) in helium-flushed sealed vials, and the headspace gas was measured in a helium flow. The analyses were corrected for fractionation using repeat analyses of UBC internal carbonate standards BN 13, BN 83-2 and H6M, which have been calibrated against NBS international standards 18 and 19. The $\delta^{13}\text{C}_{\text{carb}}$ and $\delta^{18}\text{O}_{\text{carb}}$ isotopic data were corrected to VPDB and VSMOW, respectively, based on an average of multiple analyses of NBS international standards 18 and 19. To enable direct comparison with the data collected from Dartmouth College and other studies, the VSMOW-corrected $\delta^{18}\text{O}_{\text{carb}}$ values were converted to VPDB-corrected values using the equation $\delta^{18}\text{O}_{\text{VPDB}} = 0.97001 * \delta^{18}\text{O}_{\text{VSMOW}} - 29.99\text{‰}$.

Results

Ediacaran Rackla Group, Gametrail Formation (PHG)

Four carbon and oxygen isotopic samples were collected from the Gametrail Formation northeast of the Dawson fault, from an area located ~6.5 km east of the limit of mapping in this study and ~8 km west-northwest of the Tiger Au deposit (Fig. 2). The samples yielded $\delta^{13}\text{C}_{\text{carb}}$ and $\delta^{18}\text{O}_{\text{carb}}$ values of -11.5 to -10.0‰ and -12.4 to -10.3‰, respectively. The large negative $\delta^{13}\text{C}_{\text{carb}}$ values, as well as the $\delta^{18}\text{O}_{\text{carb}}$ values, are similar to those of the lower Gametrail Formation in the Nadaleen area to the east (-13.0 to -8.0‰; Moynihan et al., 2019). The large negative carbon isotope excursion hosted by the lower Gametrail Formation has been correlated globally with the ca. 579–551 Ma Shuram-Wonoka anomaly (Macdonald et al., 2013; Moynihan et al., 2019).

Ediacaran Yusezyu Formation, limestone unit (PHYul)

Carbon and oxygen isotopic analyses were conducted on twenty-one samples from the Yusezyu Formation limestone unit, including one sample from the hanging wall of the Robert Service thrust. The $\delta^{13}\text{C}_{\text{carb}}$ and $\delta^{18}\text{O}_{\text{carb}}$ values range from -5.3 to +7.2‰ and -15.6 to -7.1‰, respectively, and the sample from the hanging wall of the Robert Service thrust yielded a slightly lower $\delta^{18}\text{O}_{\text{carb}}$ value of -6.5‰. For comparison, $\delta^{13}\text{C}_{\text{carb}}$ and $\delta^{18}\text{O}_{\text{carb}}$ values from the Algae Formation in the Nadaleen area to the east range from -0.8 to +5.9‰ and -12.1 to -1.1‰, respectively (Moynihan et al., 2019). The $\delta^{13}\text{C}_{\text{carb}}$ and $\delta^{18}\text{O}_{\text{carb}}$ data from the Yusezyu Formation limestone unit in the McQuesten Lake area are too sparsely distributed to infer a diagnostic isotopic signature or chemostratigraphic trends, but the overlap with $\delta^{13}\text{C}_{\text{carb}}$

and $\delta^{18}\text{O}_{\text{carb}}$ values from the Algae Formation in the Nadaleen area may support proposed stratigraphic correlations between the two units (discussed in the "Ediacaran to Cambrian Hyland Group: Yusezyu and Narchilla formations" section).

Ediacaran Yusezyu Formation, sandstone-dominated unit, 'mixed' member (PHYssm)

One limestone sample from the 'mixed' member of the sandstone-dominated unit of the Yusezyu Formation in the hanging wall of the Robert Service thrust produced a $\delta^{13}\text{C}_{\text{carb}}$ value of -0.2‰ and a $\delta^{18}\text{O}_{\text{carb}}$ value of -15.1‰. These values are within the ranges of $\delta^{13}\text{C}_{\text{carb}}$ and $\delta^{18}\text{O}_{\text{carb}}$ values obtained from the limestone unit of the Yusezyu Formation (PHYul), described above.

Ordovician to Devonian(?) lower Bouvette Formation (ODBl)

The $\delta^{13}\text{C}_{\text{carb}}$ values from the seven lower Bouvette Formation samples in the McQuesten Lake area range from +0.3 to +1.1‰, and the $\delta^{18}\text{O}_{\text{carb}}$ values are between -8.9 and -2.7‰.

Devonian to Mississippian Earn Group, carbonate unit (DMEc)

The two samples from the carbonate unit of the Earn Group yielded $\delta^{13}\text{C}_{\text{carb}}$ values of -0.8 and +1.3‰, and $\delta^{18}\text{O}_{\text{carb}}$ values of -10.7 and -9.1‰, respectively.

Pennsylvanian(?) to Permian Tahkandit Formation (PPT)

Four samples of limestone from the Tahkandit Formation produced $\delta^{13}\text{C}_{\text{carb}}$ and $\delta^{18}\text{O}_{\text{carb}}$ values of -1.4 to +2.8‰ and -9.7 to -7.3‰, respectively.

Summary

- The McQuesten Lake area is predominantly underlain by sedimentary rocks that are considered to belong to the Ediacaran to Terreneuvian Hyland Group, the Cambrian Gull Lake Formation, the Ordovician to Silurian Road River Group, the Devonian to Mississippian Earn Group, and the Carboniferous Tsichu Group.
- The Hyland Group is locally intruded by Cambrian to Silurian(?) gabbroic intrusions, and the Earn and Tsichu groups host Triassic gabbro sills (Galena Suite).
- Volcanic and volcanoclastic rocks occur above the Dawson fault in the northeastern part of the study area, and share lithological and geochemical similarities with Upper Cambrian volcanic rocks of the Old Cabin Formation in the McKay Hill area to the northwest.
- The McQuesten Lake area includes several southwest-dipping thrust sheets, and contains parts of the Robert Service thrust, the Tombstone thrust, and the Dawson fault.
- Two regional deformation events (D1 and D2) occurred at greenschist-facies conditions. The D1 event produced a bedding-parallel foliation, and regional compression during D2 produced thrust faults, folds, and axial-planar foliation.
- Detrital U-Pb zircon geochronology on sandstone samples from the Yusezyu Formation (Hyland Group) yielded maximum depositional ages of 724.65 ± 0.30 Ma and 664.66 ± 0.36 Ma.
- Detrital U-Pb zircon geochronology on quartzite samples from the Keno Hill Quartzite (Tsichu Group) produced maximum depositional ages of 428.23 ± 0.66 Ma and 367.79 ± 0.25 Ma.

- In the footwall of the Tombstone thrust, Jurassic sandstone that yielded a maximum depositional age of 166.85 ± 0.13 Ma overlies Pennsylvanian(?) to Permian fossiliferous limestone of the Tahkandit Formation.

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Appendices (digital)

Appendix A

Macrofossils and conodonts. This appendix is only available digitally (Microsoft Word Document).

Appendix B

LA-ICP-MS zircon U-Pb isotopic data and trace element concentrations for sample 19DS-002-1-1 (134.8635350°W 64.2139110°N). This appendix is only available digitally (Microsoft Office Excel Workbook).

Appendix C

LA-ICP-MS zircon U-Pb isotopic data and trace element concentrations for sample 19DS-051-2-1 (134.8637500°W 64.1774530°N). This appendix is only available digitally (Microsoft Office Excel Workbook).

Appendix D

LA-ICP-MS zircon U-Pb isotopic data and trace element concentrations for sample 19DS-091-1-1 (134.8923480°W 64.2456980°N). This appendix is only available digitally (Microsoft Office Excel Workbook).

Appendix E

LA-ICP-MS zircon U-Pb isotopic data and trace element concentrations for sample 21DS-177-1-1 (135.3501704°W 64.2141459°N). This appendix is only available digitally (Microsoft Office Excel Workbook).

Appendix F

LA-ICP-MS zircon U-Pb isotopic data and trace element concentrations for sample 22DS-019-1-1 (135.0433920°W 64.0658879°N). This appendix is only available digitally (Microsoft Office Excel Workbook).

Appendix G

LA-ICP-MS zircon U-Pb isotopic data and trace element concentrations for sample 21DS-134-1-1 (135.2717816°W 64.2804348°N). This appendix is only available digitally (Microsoft Office Excel Workbook).

Appendix H

CA-TIMS zircon U-Pb isotopic data for samples from the McQuesten Lake area. This appendix is only available digitally (Microsoft Office Excel Workbook).

Appendix I

Whole-rock geochemistry. This appendix is only available digitally (Microsoft Office Excel Workbook).

Appendix J

Carbon and oxygen isotopic data from carbonate rocks in the McQuesten Lake study area. This appendix is only available digitally (Microsoft Excel Workbook).

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