Preliminary report on the bedrock geology southwest of Big Salmon Lake (parts of NTS 105F/3, 4, 5, 6), south-central Yukon

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Abstract

Two contrasting lower Paleozoic units underlie the region southwest of Big Salmon Lake in south-central Yukon. The lower unit comprises dolomitic quartzite, quartzite, dolostone, dolomitic shale, siltstone and sandstone, and their metamorphosed equivalents. Two-holed crinoid ossicles indicate an Early–Middle Devonian age for the dolostone. These dolomitic rocks are overlain by largely carbonate-free, dark, fine-grained and siliceous strata. Rock types include graphitic phyllite, siltstone, metachert and porphyroblastic metapelitic schist. The two units are correlated with the Askin and Earn groups, respectively. An interval of metabasaltic schist locally marks the boundary between the Askin and Earn groups. Mafic and ultramafic rocks are intermittently exposed beneath the Askin Group in parts of the region.

The lower Paleozoic metasedimentary units are crosscut by deformed Devonian–Mississippian two-mica augen gneiss and by largely undeformed mid-Cretaceous megacrystic biotite granite to monzogranite. Deformation prior to the mid-Cretaceous produced close to tight folds that trend northwest. The associated axial-planar cleavage/schistosity dips northeast at moderate to steep angles, away from the crest of a major antiformal structure.

Introduction

The Yukon Geological Survey began mapping part of the southern Big Salmon Range at 1:50 000 scale in 2020. The study area includes parts of the Teslin Lake (NTS 105D), Quiet Lake (NTS 105F) and Laberge (NTS 105E) map areas. Its boundaries include the Teslin fault in the southwest, Big Salmon Lake in the northeast, and the South Canol Highway in the southeast (Fig. 1). Preliminary observations from southwestern parts of this region are presented in Moynihan and Crowley (2022) and Moynihan (2023). This paper summarizes observations made during the summer of 2023 in northeastern parts of the study area. Two areas were mapped: the region southwest of Big Salmon Lake (Figs. 1 and 2), and a small area in the headwaters of the Boswell River (Fig. 1).

Previous work and regional geology

Wheeler *et al.* (1960) carried out preliminary bedrock mapping of the Quiet Lake map area (NTS 105F) at a scale of 1:250 000. Tempelman-Kluit led more extensive work during the 1970s and a revised map of the Quiet Lake area was released (Tempelman-Kluit, 1977). Related information on the geology of the area became publicly available when an early draft of a manuscript, initially intended as a Geological Survey of Canada memoir, was released as an open file (Tempelman-Kluit, 2012).

The southwestern part of the Quiet Lake map area is dominated by the Quiet Lake batholith, which occupies

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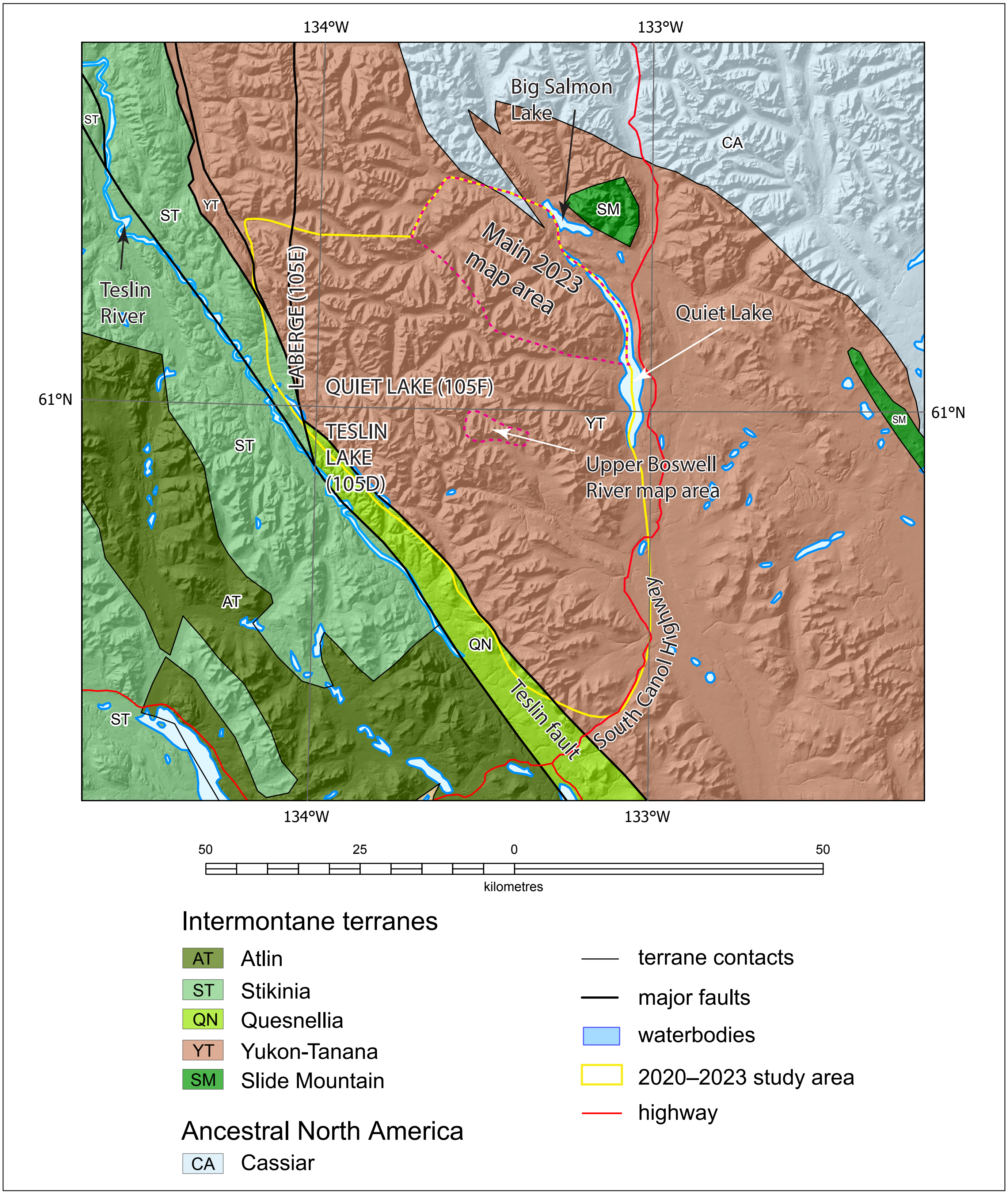

Figure 1. *Location of the 2020–2023 study region. Areas mapped in 2023 are outlined by dashed magenta lines. The base map shows the interpreted terrane assignment for this part of southern Yukon (Yukon Geological Survey, 2023). Inclusion of the 2023 mapping area in Yukon-Tanana terrane follows the interpretation of Westberg (2010).*

the core of a structural arch (Tempelman-Kluit, 2012). Most of the country rock in the area is highly deformed and metamorphosed, but Wheeler *et al.* (1960) noted an area of 'unmetamorphosed' rocks southwest of Big Salmon Lake, from which they recovered non–age-diagnostic fossils. Wheeler *et al.* (1960) recognized two units with sedimentary protoliths, which they traced across the Pelly Mountains (Cassiar platform). The older of the two is dominated by dolomitic rocks and quartzite (their unit 4; Silurian–Devonian) and is overlain by dark fine-grained clastic rocks (their unit 5; Devonian–Mississippian). Tempelman-Kluit (2012) included all of these rocks in his Silurian–Devonian Askin Group. Informally named subunits that are exposed in the study area include the Hogg formation (dolomitic sandstone and orthoquartzite) and the Nasina formation (dark, fine-grained clastic rocks with lenses of carbonate/quartzite). Westberg (2009, 2010)

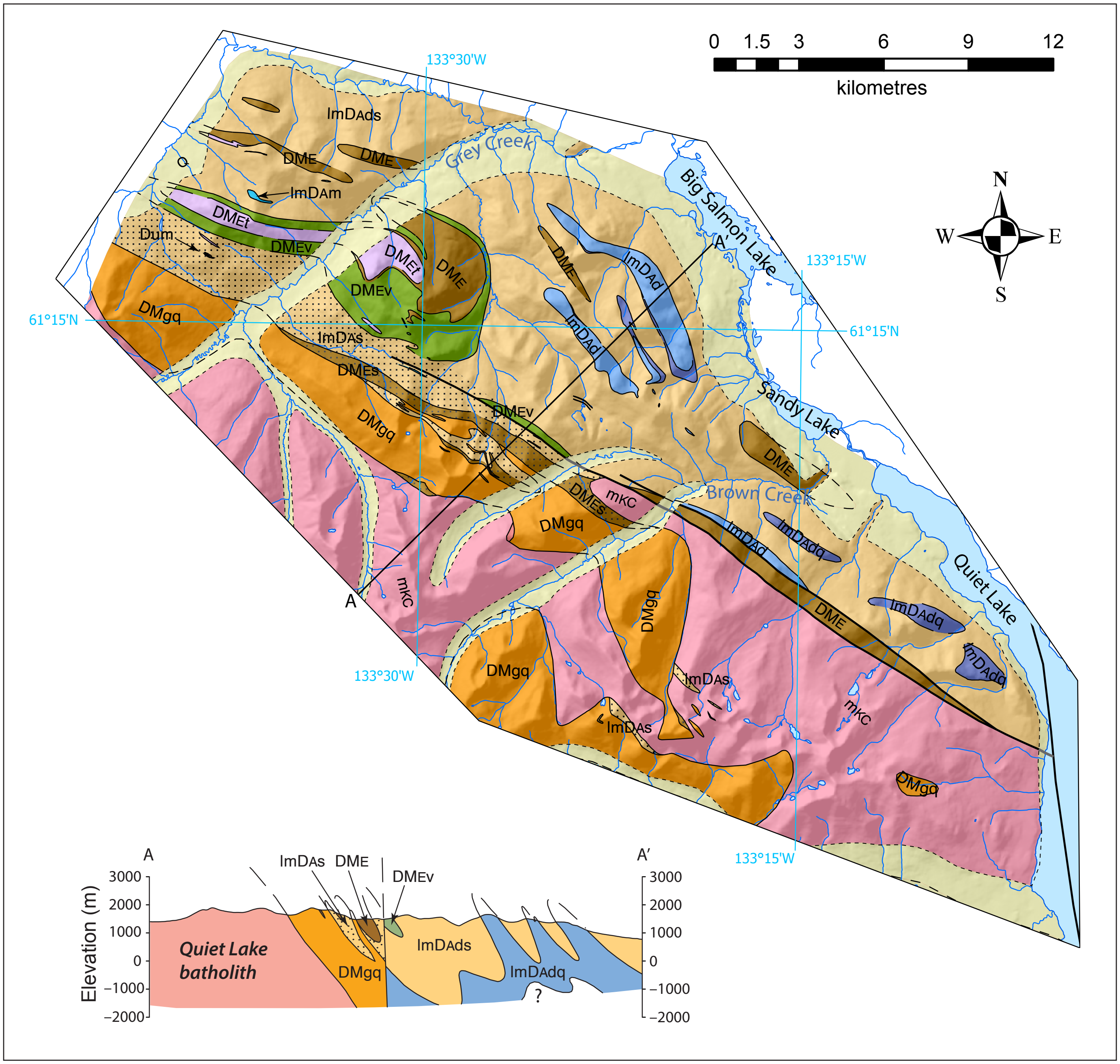

***Figure 2a.** Simplified geological map and cross section of the area southwest of Big Salmon Lake.*

mapped equivalent clastic and mixed clastic-carbonate rocks in the area along strike to the northwest; she interpreted the rocks as part of the Yukon-Tanana terrane rather than the Cassiar terrane, in contrast with earlier works.

The revised terrane assignment of Westberg (2010) is not adopted here because rocks in the study area are lithologically identical to, and apparently physically continuous with, those elsewhere in the Cassiar terrane. Following Tempelman-Kluit (1977, 2012),

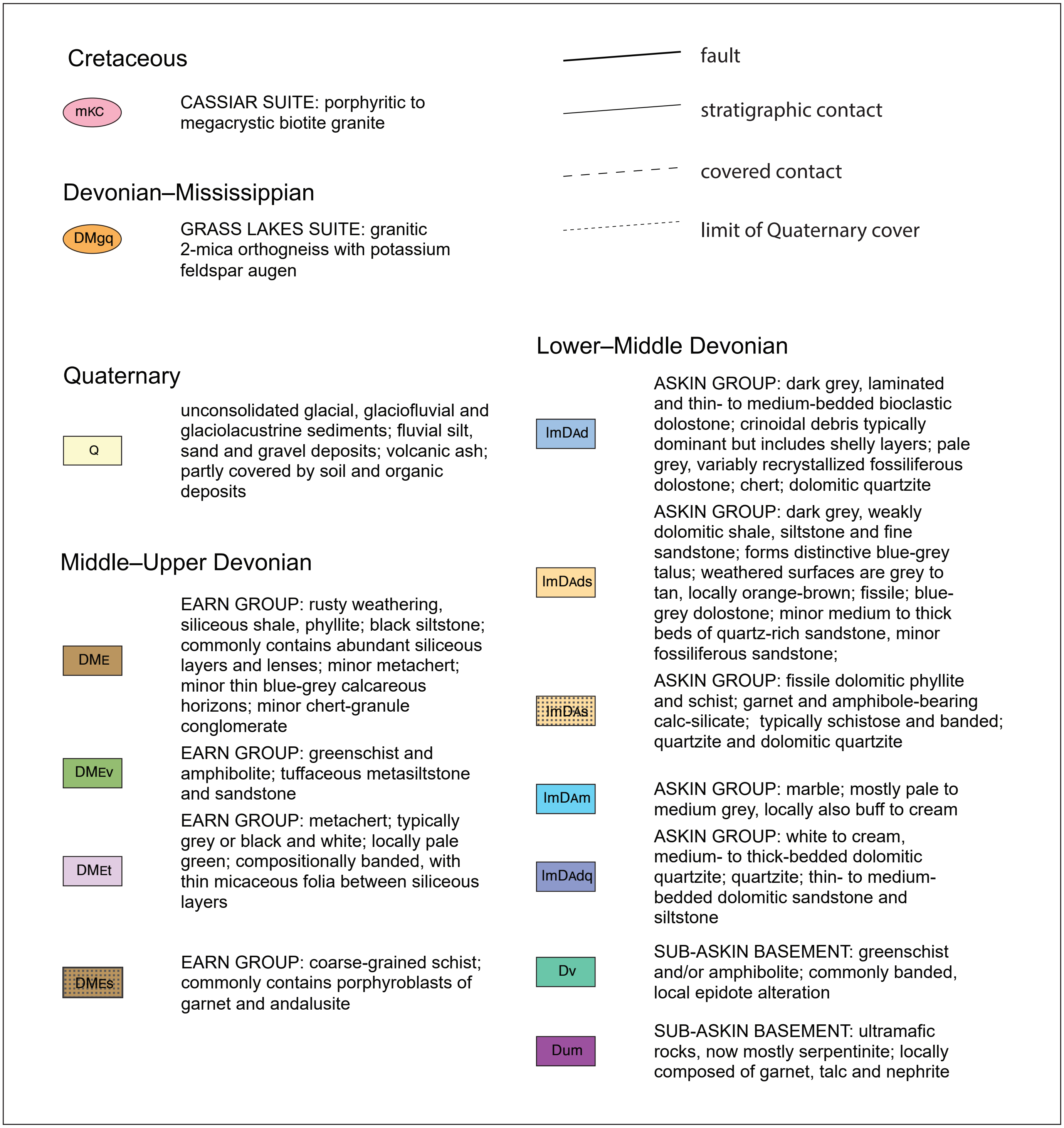

Figure 2b. *Legend for Figures 2a and 5.*

dolomitic and quartzite-rich units are referred to as the Askin Group, whereas the fine-grained clastic rocks are assigned to the Earn Group (Campbell, 1967), based on their stratigraphic position and lithology. Gabrielse (1998) and Gordey and Makepeace (1999) correlated similar rocks elsewhere in the Cassiar platform region with the Earn Group. The term 'Nasina formation' (Tempelman-Kluit, 2012) is not used here because this name is currently applied to rocks of the Yukon-Tanana terrane in western Yukon (Mortenson, 1992; Colpron et al., 2006).

Rock units

Askin Group

Pale-grey and white-weathering dolomitic and/or quartz-rich rocks are exposed in the cores of anticlines southwest of Big Salmon, Sandy and Quiet lakes (lmDAdq and lmDAd; Fig. 2). These are overlain by finer grained, mixed siliciclastic-dolomitic rocks, which underlie much of the area between the lakes and the Quiet Lake batholith (lmDAds; Figs. 2, 3).

Dolomitic quartzite (lmDAdq; equivalent to the Hogg formation of Tempelman-Kluit [2012]) forms thick to very thick, resistant intervals that are white, pale grey and cream weathering (Fig. 4a, b). Very thick beds have some planar-laminated tops but are otherwise structureless, whereas cross-bedding is developed in some of the thick beds. A pitted texture and faint to distinct ribbing parallel to layering results from differential weathering of dolomitic cement (Fig. 4b). Calc-silicate minerals (tremolite, diopside) are locally developed within this unit.

Where well preserved, dolostone is medium to dark grey, mostly thin to medium-bedded, commonly planar-laminated dolomitic wackestone and grainstone that contains abundant fossil detritus (lmDAd; Fig. 4c). Most layers are dominated by crinoid fragments, but in rare cases layers are composed almost entirely of shelly debris with convex surfaces that systematically face downward. Thin to medium-bedded rocks mostly contain fragments less than 5 mm in diameter, but some thicker layers contain intact crinoid stems up to 5 cm long and 1 cm in diameter, as well as larger

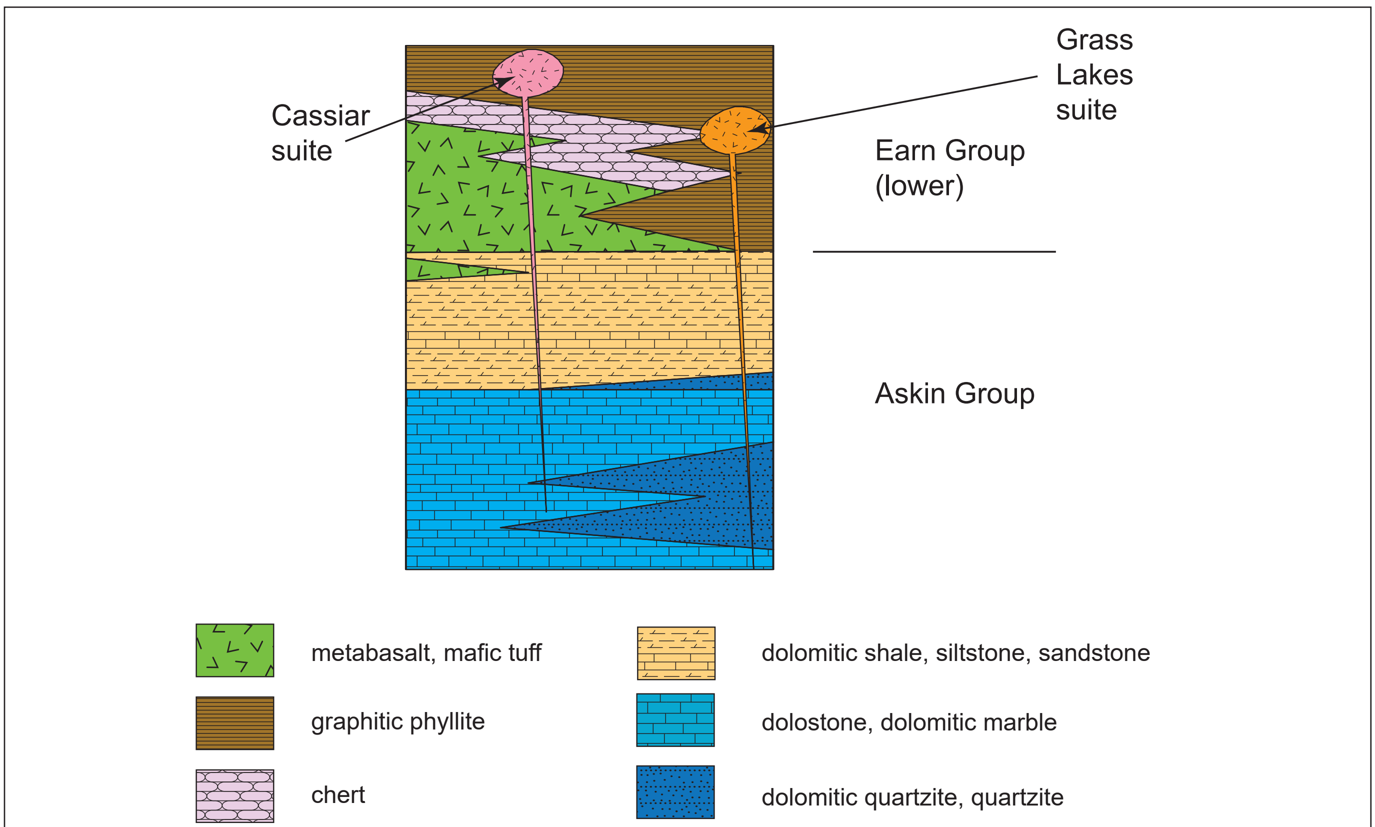

Figure 3. *Schematic stratigraphy of the area southwest of Big Salmon Lake. Not to scale.*

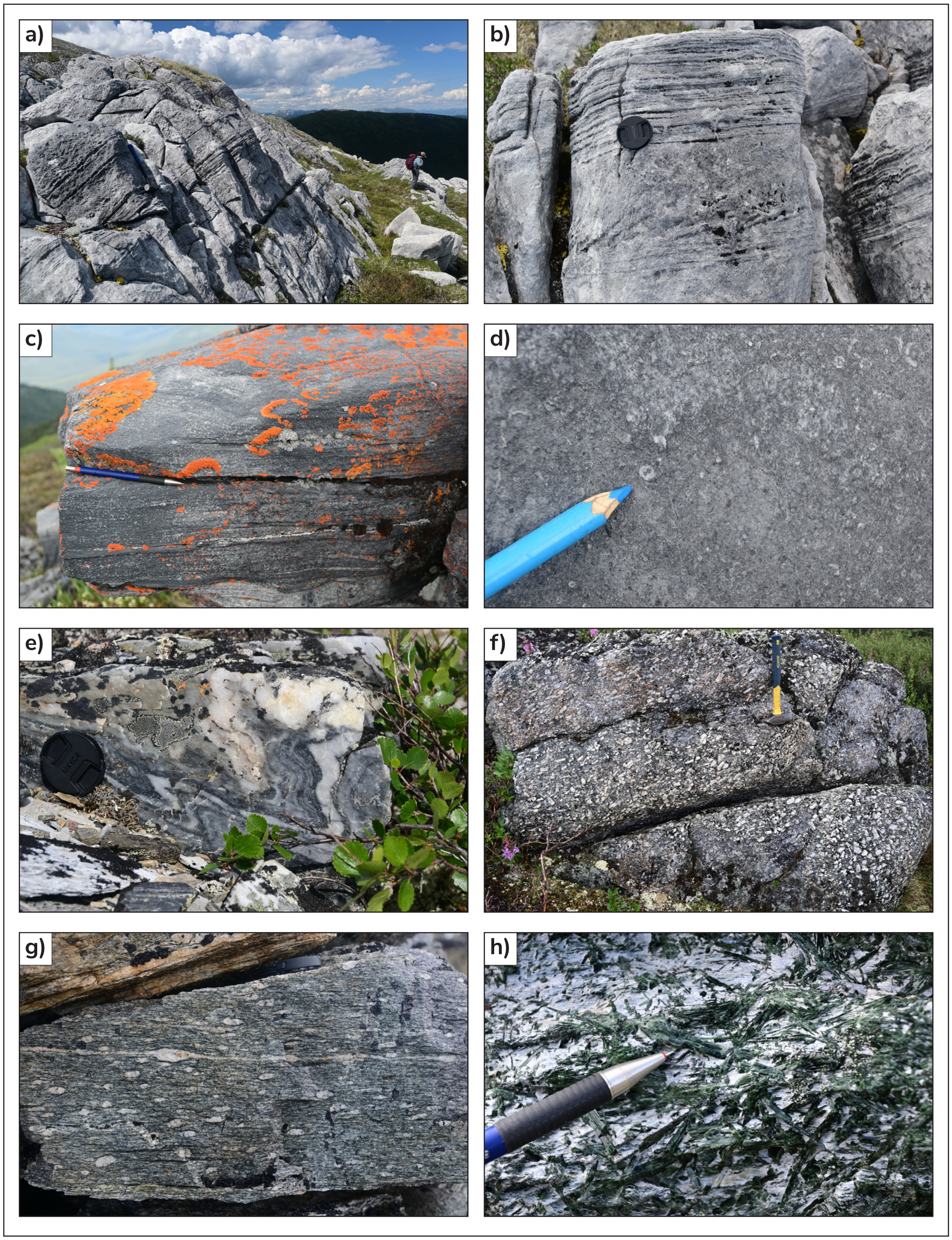

Figure 4. *Representative photographs of rock units in the study area:* **a)** *resistant, pale-weathering dolomitic quartzite of the Askin Group (person for scale);* **b)** *close-up view of the outcrop in* **a)***; planar laminations and cross-bedding are accentuated by variations in carbonate content (lens cap for scale);* **c)** *dark grey bioclastic dolomitic wackestone with abundant crinoidal debris (pencil for scale);* **d)** *two-holed crinoid ossicles are common in well-preserved dolostone (pencil for scale);* **e)** *folded layering in metachert from the lower part of the Earn Group (lens cap for scale);* **f)** *megacrystic phase of the mid-Cretaceous Quiet Lake batholith (hammer for scale);* **g)** *deformed two-mica orthogneiss with K-feldspar porphyroclasts (augen; lens cap on its side for scale);* **h)** *jade-green nephrite (amphibole) and talc in altered ultramafic rock northwest of Grey Creek (pencil for scale).*

unidentified fossil fragments. Two-holed crinoid ossicles are common in many well-preserved outcrops, which indicates an Early–Middle Devonian age (Fig. 4d; Johnson and Lane, 1969; Nelson, 1975). Well-preserved dolostone grades laterally into more recrystallized, white-weathering dolostone with sugary texture. Fossil outlines in these rocks are indistinct and chert layers/lenses with irregular outlines are common.

The stratigraphic relationship between dolomitic quartzite (lmDAdq) and dolostone (lmDAd) is complex (Fig. 3). Dolomitic quartzite (lmDAdq) is the stratigraphically lowest unit present in the area immediately southwest of Big Salmon Lake (Fig. 2), but similar rock types locally form part of higher stratigraphic levels (Fig. 3). In several locations, a discrete interval rich in quartzite and dolomitic quartzite approximates the boundary between pale-weathering, relatively resistant dolostone (lmDAd) and overlying, finer-grained units (lmDAds). Beds in this interval range from thick to thin in upward-fining sequences. Medium and thin beds exhibit planar and cross-lamination, whereas thick beds are weakly graded. Grading in dolomite content results in variation in colour and resistance across individual beds and through multi-bed packages. Dolomitic quartzite commonly has a pitted texture and weathers white, grey, cream and tan, whereas relatively pure quartzite is pale grey and weathers white and grey to pale brown. A distinctive variety is composed of large (>1 cm) fossil fragments in a medium to coarse sandstone with a weakly dolomitic matrix; this has resulted in a pockmarked appearance on weathered surfaces. Dolomitic quartzite and quartzite is interbedded with dolomitic shale and siltstone, which weathers tan, brown, cream and grey. These finer-grained intervals are planar and locally cross-laminated and are compositionally heterogeneous. They commonly contain lamellae and lenses of siltstone to sandstone, which form resistant ribs; these resistant silty and sandy layers die out up section into the overlying unit.

The upper part of the Askin Group comprises relatively recessive, weakly dolomitic shale, siltstone and lesser fine sandstone (lmDAds). These rocks have a dull lustre and are typically medium to dark grey on fresh surfaces. In some alpine exposures, weathered surfaces are tan, buff, brown or creamy orange and differential weathering accentuates the compositional layering; elsewhere the rocks weather grey or black. Talus slopes below creek cuts and other cliffs have a distinctive blue-grey colour. The rocks are laminated and thin bedded; locally, some minor cross-bedding is also developed. Dolomitic argillite and lesser siltstone dominate this unit, but some intervals of dolomitic siltstone to fine sandstone are also preserved. The unit contains scattered layers of dark fetid dolostone, mostly less than 1 m thick, and rare layers of olive-green–brown to grey-weathering sandstone. A single example of pockmarked, fossil-rich, weakly dolomitic sandstone/quartzite, similar to that developed in the underlying unit (lmDAdq), was also observed. Cleaved and recrystallized varieties of this unit are brown, locally chloritic, fissile, crumbly carbonate-bearing phyllite.

As noted by Wheeler et *al.* (1960), rocks southwest of Big Salmon Lake, though deformed, have undergone relatively little recrystallization. Rocks closer to the Quiet Lake batholith are more highly deformed and have undergone complete recrystallization during higher-grade metamorphism. Rocks of the Askin Group in this region are represented by calc-silicate schist and marble. Calc-silicate schist typically contains varying proportions of quartz, plagioclase, green amphibole, biotite, garnet and minor minerals. Amphibole ranges from less than 1 mm to greater than 1 cm and forms radiating splays on some surfaces. Calc-silicate rocks commonly have a strongly banded appearance and weather pale green to grey. Marble is coarse grained, pale-grey/white to cream weathering and locally contains calc-silicate minerals such as tremolite and diopside.

Earn Group

Dark, fine-grained, non–carbonate-bearing rocks that overlie dolomitic units are assigned to the lower part of the Devonian–Mississippian Earn Group (DME). The group is dominated by rusty weathering, dark grey to black siliceous phyllite, siltstone and metachert.

The base of the group includes an interval of foliated mafic metavolcanic and minor intrusive rocks (DMEv) on either side of Grey Creek (Fig. 2); elsewhere, siliceous rocks are in direct contact with dolomitic siltstone/calc-silicate schist of the upper Askin Group. The metavolcanic rocks are greenschist or epidote amphibolite, which locally host small metagabbro bodies. They are medium to dark green and weather grey green.

Some thin layers of pale-green chlorite schist, biotite-bearing greenschist, and compositionally banded biotite-magnetite–bearing greenschist are in contact with calc-silicate rocks of the Askin Group outside of the main belt of metavolcanic rocks. The stratigraphic position of these layers is difficult to determine due to multiple structural repetitions, but they appear to be part of a gradational boundary between the Askin Group and the metavolcanic unit. The upper contact of the greenschist with overlying rocks is sharp. Tempelman-Kluit (2012) included the mafic metavolcanic rocks in the 'Grey Creek formation', a local unit of presumed Cambrian age that was not recognized elsewhere. Westberg (2009) included similar rocks along strike in a 'greenstone-quartzite' unit, which she interpreted to be Mississippian or younger.

Metachert directly overlies metavolcanic rocks northwest of Grey Creek and passes laterally into siliceous slate and phyllite to the southeast. Siliceous phyllite and siltstone is dark grey to black, laminated, and contains abundant white siliceous layers and lenses. These are typically approximately 1 mm to 1 cm thick. Outcrops commonly have a rusty weathering rind, and some weather to pale blue. Some varieties of metachert exhibit grey to white, fine colour banding (Fig. 4e), whereas others are uniformly white to pale green. In each case, micaceous folia are regularly spaced less than 1 cm apart. Yellow-weathering, siliceous rock (quartzite or metachert) is common at the contact between greenschist and overlying metachert.

Resistant porphyroblastic metapelitic schist adjacent to the Quiet Lake batholith is interpreted as a more highly metamorphosed part of the Earn Group. Garnet porphyroblasts or their pseudomorphed remnants are ubiquitous and some rocks also contain slender andalusite porphyroblasts in a matrix composed of biotite, muscovite, quartz, plagioclase and accessory minerals. Most garnet is replaced by chlorite and other secondary minerals.

Ultramafic and mafic rocks in contact with the Askin Group

Northwest of Grey Creek, altered ultramafic rock (Dum) is exposed adjacent to a band of dolostone (Askin Group). The rock weathers jade green to white and is mostly composed of serpentinite, talc and nephrite. The body is cut by a mesh-textured network composed entirely of pale-pink garnet. A zone of acicular nephrite crystals in a talc-rich matrix is prominent on its upper boundary with pale-green, chlorite-rich Askin Group schist (Fig. 4h). Dolostone with well-preserved crinoidal detritus is preserved approximately 30 m downslope from the ultramafic rock.

Dark, rusty-weathering siliceous schist (Earn Group) and grey to pale green, amphibole and biotite-bearing calc-silicate schist (Askin Group) are exposed near the headwaters of the Boswell River (Fig. 5). The Askin Group dips under a band of epidote amphibolite (Dv), whose upper contact is with altered ultramafic rock (mostly dun-weathering serpentinite). The boundary between the amphibolite and calc-silicate appears gradational, as it is characterized by thin to medium interbeds of clastic, volcaniclastic and carbonate metasedimentary rocks This band of mafic schist extends approximately 30 km to the northwest, along the southwestern margin of the Quiet Lake batholith; it is in contact with, and ostensibly marks the base of, the Askin Group throughout this region.

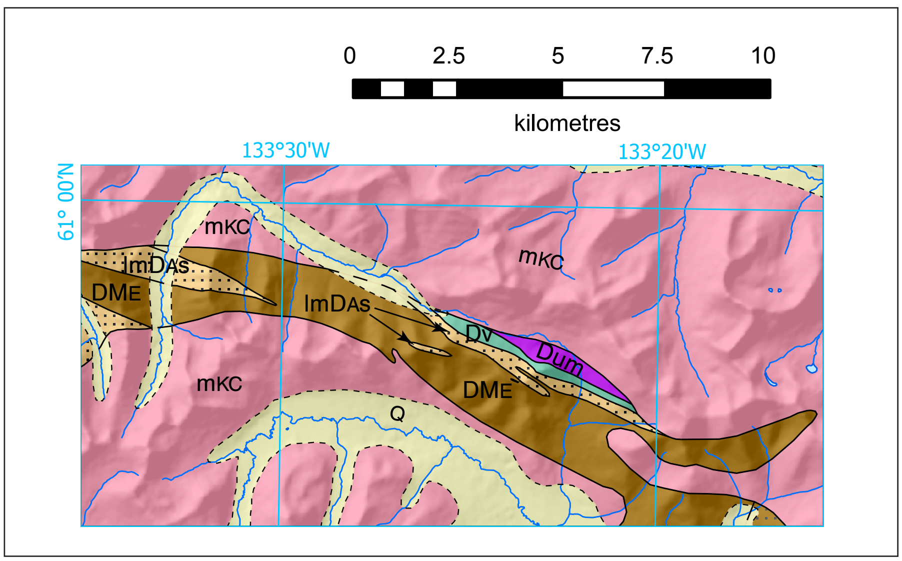

***Figure 5**. Simplified geology of the headwaters of the Boswell River. A thin band of metabasalt separates altered ultramafic rock from calc-silicate schist of the Askin Group. See Figure 2b for legend.*

Quiet Lake batholith

The Quiet Lake batholith is dominated by coarse-grained, typically porphyritic biotite granite and quartz monzonite of the mid-Cretaceous Cassiar suite (mKc; Fig. 4f). These rocks are not penetratively foliated, but locally there is a scaly cleavage and weak alignment of K-feldspar phenocrysts. Phenocrysts are typically 1–2 cm long, but are locally up to 5 cm. On the Tower claims, near the eastern boundary of the Quiet Lake batholith, pegmatite is rich in tourmaline and garnet, and also contains yellow-green beryl (Jilson, 2007). This pegmatite is located along or near the contact between megacrystic granite of the Cassiar suite and a screen of metasedimentary rock. Dikes and small plutons of fine to medium-grained hornblende-biotite (grano-)diorite were noted within and adjacent to the main phase of the Quiet Lake batholith. They are equigranular and have matted intergrown mafic phases and quartz-filled amygdules.

The Cassiar suite intrudes deformed orthogneiss along much of its eastern boundary. The orthogneiss (DMgq) is mostly grey and brown weathering and typically contains two micas. Rounded to rectangular K-feldspar porphyroclasts (augen) are characteristic (Fig. 4g), though they are sparsely distributed in some areas. A less voluminous phase is white to pale-grey weathering, finer grained, and only mildly porphyritic. The augen gneiss is correlated with the Grass Lakes suite of the Finlayson district (Mortensen, 1992) and similar intrusive rocks that are exposed in para-autochthonous regions of western Yukon (Ryan et *al.*, 2021). Westberg (2010) obtained several preliminary U-Pb laser ablation–inductively coupled plasma–mass spectrometry (LA-ICP-MS) dates from these intrusions in the area along strike to the northwest. The dates range from 360.5 ± 3.7 Ma (weighted mean of four analyses) to 348.0 ± 3.8 Ma (weighted mean of six analyses). Gallagher previously reported a U-Pb zircon thermal ionization mass spectrometry (TIMS) date of 359 ± 7 Ma from the same area.

Structure

The structure of the area is dominated by close to tight, northwest-trending folds. The main cleavage/foliation is axial-planar to these folds and mostly dips steeply to moderately steeply to the northeast, away from the axial trace of a major antiformal structure called the Quiet Lake arch (Tempelman-Kluit, 2012). This deformation affected all units except Cretaceous intrusions.

The boundary zone of the Quiet Lake batholith is irregular due to numerous northeast-dipping screens of metasedimentary rock and orthogneiss in the area northwest of Brown Creek (Fig. 2). In contrast, southeast of Brown Creek the boundary is straight and sharp. The batholith is interpreted to be truncated by a steeply dipping, northwest-trending fault that coincides with a prominent aeromagnetic low. Crinoidal dolo-wackestone (lmDAd) is in direct contact with siliceous phyllite of the Earn Group across this fault, unlike elsewhere, where these two units are separated by dolomitic shale, siltstone and fine sandstone (lmDAds).

Summary and future work

Metasedimentary rocks on the northeastern side of the Quiet Lake batholith are interpreted to correlate with the lower Paleozoic Askin and Earn groups. These units, which form the Cassiar platform, are widely distributed in the Pelly Mountains. Geochronological, geochemical and paleontological studies on samples from the area are underway; the information gathered will be used to test this correlation and refine stratigraphic interpretations.

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